SUSTAINABLE DEVELOPMENT AND BIOCLIMATE

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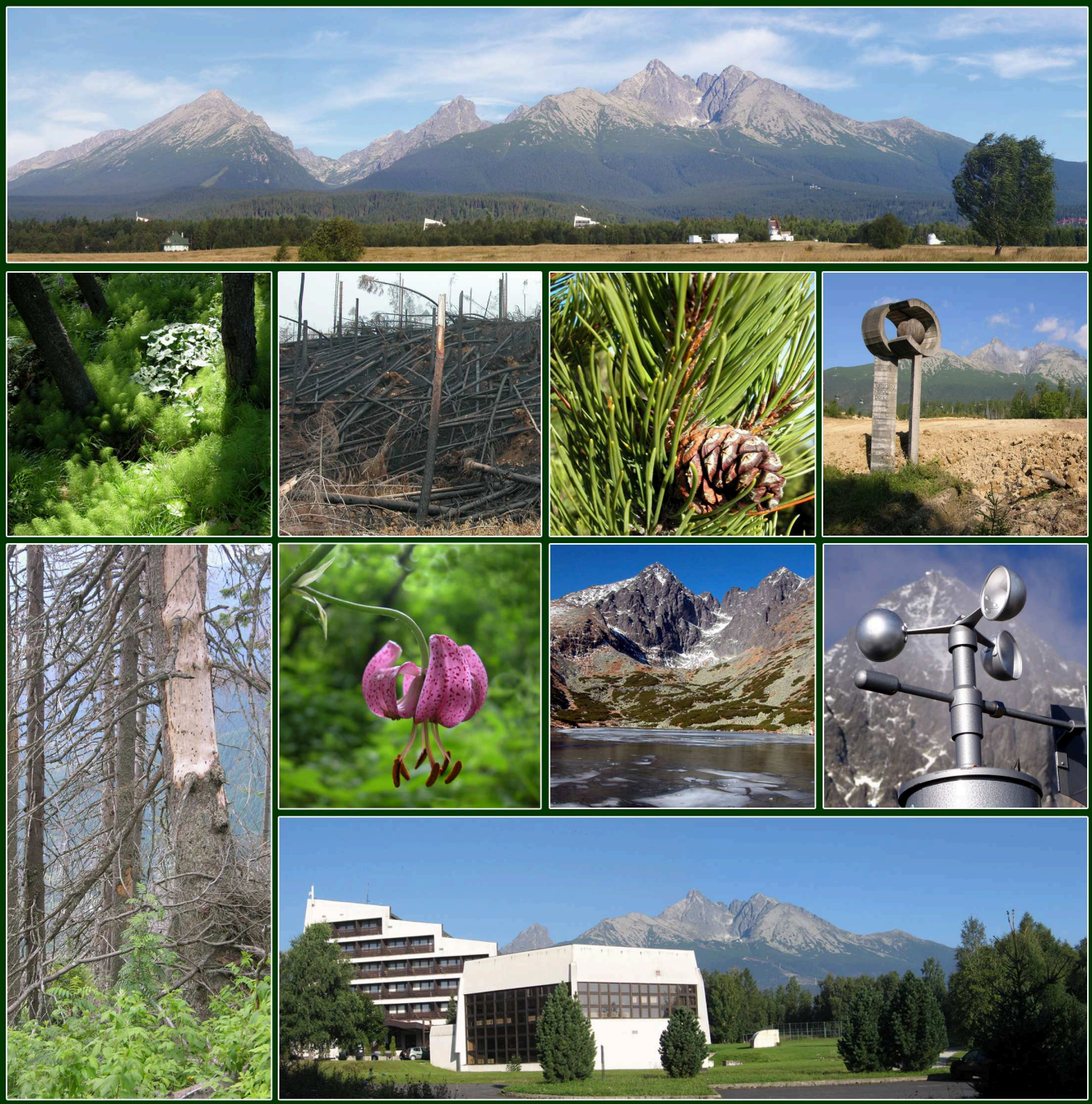
Editors: A. Pribullová, S. Bičárová



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Foreword

The conference Sustainable development and bioclimate is held in the beautiful environment of the High Tatras National Park five years after the windstorm damaged huge area of the forests. The title of the conference sounds very topically in this area but preservation of sustainable development is important anywhere the ecosystems influenced by both natural hazards and human activities face new conditions. We are still far from the full understanding of processes and relations in the complex system soil-live organisms-atmosphere and it is rather difficult to foresee all the consequences of the present activities for the future. New research and effective cooperation of scientists is needed to achieve the progress in our knowledge.

The aim of this conference is to share new information in scientific area of bioclimatology. Subjects of the Conference contributions cover the following four fields of interest:

1. **Regional aspects of climate** – including problematics of mountain climate, drought, heavy precipitations, snow cover variability, changes in the local weather patterns, quantification of changes in local climate and the climate modeling
2. **Effect of climate on forest and silviculture** – aimed with research on forest ecosystem response to hazardous weather events, forestry phenology, modeling of the chemical and biological processes in the forest environment, environmental pollution influence on the forests and special attention is devoted to results of the monitoring of the ecosystems at areas in the High Tatras damaged by the windstorm in 2004
3. **Agricultural bioclimatology** – focused on investigation of weather extremes impacts on the crops and their mitigation, modeling of the agriculture alternatives in the future climate, the soil erosion, contribution of the agriculture to changes in climate and phenology of the agricultural plants
4. **Urban climate and human bioclimatology** – targeted to solution of problems with the heat waves in the urban environment, smog episodes in the cities, influence of the climate variability on economic activities, positive and negative effects of the climate and weather on human health.

This proceeding contains 110 research papers and 4 abstracts; one of them was even prepared by a young grammar school student who was invited to the Conference due to his deep interest in climatology. The competition of the young scientists organized in the framework of the Conference has ambition to help them to recognize the strong and weak sides of their approach to research.

The organizers will believe that all participants together contribute to the pleasant atmosphere supporting the effective scientific discussions and invoking new ideas for the further research.

Finally, many thanks should be addressed to all – guarantors, contributors, reviewers and organizers - who enabled that the Conference can take place here at Stará Lesná.

In behalf of organizers: Anna Pribullová, Svetlana Bičárová, Jaroslav Škvarenina.

October 5, 2009.

Regional aspects of climate

Air temperature and atmospheric precipitation variations in the high-mountain regions of Bulgaria and Slovakia

Teodosia Andreeva[1], Marián Ostrožlík[2]

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Abstract. In the last year a great attention is paid to the problem of the long-time variability of air temperature and atmospheric precipitation because temperature and precipitation belong among the responsive indicators of climatic changes. To study the seasonal variability of air temperature and atmospheric precipitation in the high-mountain conditions of the Bulgaria and Slovakia the measurements of the mentioned elements are used. The methods of mathematical statistics are applied for the evaluation of described experimental data.

Introduction

Mountains and highlands are often referred to as natural "water towers" because they provide lowlands with essential freshwater for irrigation and food production, for industrial use, and for the domestic needs of rapidly growing urban populations. For that reason we turn the attention on winter season.

Material

Utilised data of time-series of the mean air temperatures and the sums of precipitation from three mountain stations in Bulgaria (1960-2007): at Mussala (φ = 42°10′ N, λ = 23°25′ E, h = 2925 m a.s.l.), Botev (φ = 42°43′ N, λ = 24°55′ E, h = 2376 m a.s.l.), Cherni vrah (φ = 42°33′ N, λ = 23°16′ E, h = 2286 m a.s.l.) and Slovakia: at Chopok (φ = 48°56′ N, λ = 19°35′ E, h = 2004 m a.s.l.), Skalnaté Pleso (φ = 49° 12′ N, λ = 20° 14′ E, h = 1778 m a.s.l.), and Lomnický štít (φ = 49°12′ N, λ = 20°13′ E, h = 2634 m a.s.l.) during the 1955-2007 period have been used as initial data.

Precipitation and temperature anomalies for the mountain regions in Bulgaria

The variations of the temperature and precipitation during the winters were estimated expressed in relation to the 1961-1990 period. This period was accepted taking into account the recommendation of WMO for comparative estimates. The activity of the Mediterranean cyclones was not so frequent and well manifested (Andreeva, 1998; Andreeva and Orehova, 2001; Andreeva and Zahariev, 2000). The mild winter period is favourable to assign the impact of climatic variability on the mountains regions (Figs. 1- 3). One can note that the mild winters have been prevailing since 1961 till now.

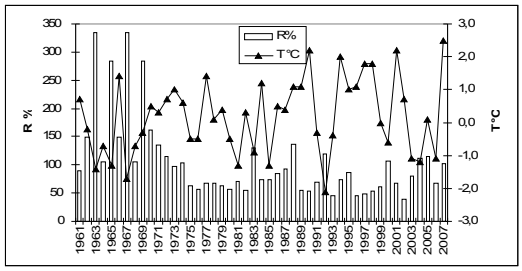

Figure 1. Deviations of winter temperature and precipitation for the station of top Mussala.

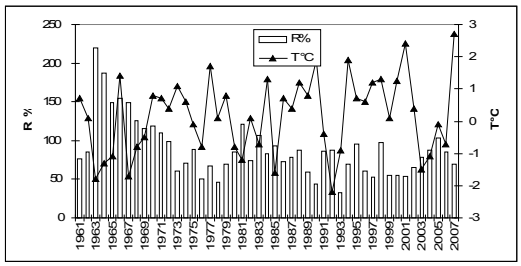

Figure 2. Deviations of winter temperature and precipitation for the station of top Botev.

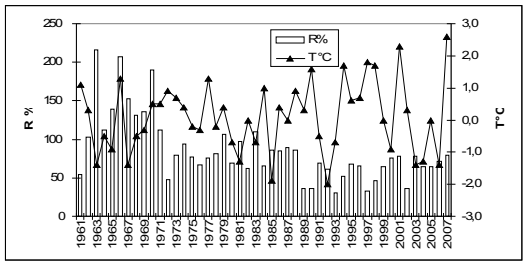

Figure 3. Deviations of winter temperature and precipitation for the station of top Cherni vrah.

In general:

- the frequency of mild winters is increased. The precipitation below norm is observed usually during the periods with positive anomalies of air temperature,
- there is the tendency for positive anomalies of air temperature to increase during winter,
- the tendency of decreasing in winter precipitation during the 1961-2007 period in Bulgaria.

Temperature and precipitation in the high-mountain regions in Slovakia

Time series of air temperature [°C] and precipitation (R ≥ 0.1 mm) at Lomnický štít, Skalnaté Pleso, and Chopok enable to estimate their tendency in the high-mountain regions of the Low and High Tatras in Slovakia.

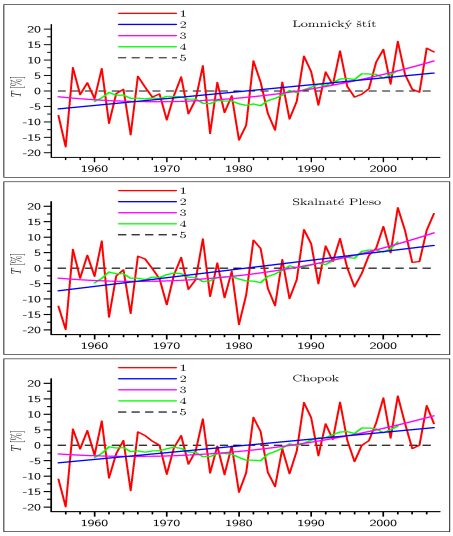

Figure 4. Course of deviations of mean annual air temperatures from the long-term average (1), the linear trend component of these deviations (2), the polynomial trend of the 2nd order (3), and course of deviations from the long-term average smoothed by eleven-year running averages (4) at Lomnický štít, Skalnaté Pleso, and Chopok during the 1955-2007 period (value 0 mm refers to the long-term average (5)).

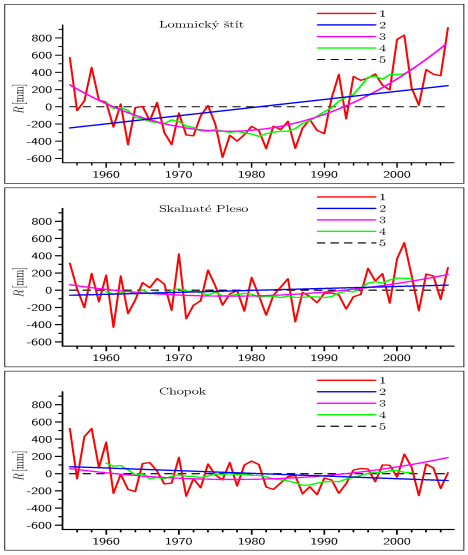

Figure 5. Course of deviations of annual precipitation totals from the long-term average (1), the linear trend component of these deviations (2), the quadratic trend (3), and course of deviations from the long-term average smoothed by eleven-year running averages (4) at Lomnický štít, Skalnaté Pleso, and Chopok during the 1955-2007 period (value 0 mm refers to the long-term average (5)).

Conclusions

Time series of air temperature and precipitation at the high-mountain stations of Western Carpathian Mountains enabled to obtain the new knowledge on the regularities of air temperature and precipitation in the high-mountain regions. Precipitation regime in Slovakia has been significantly changed in the 20th century. It was probably due to changes in the atmospheric circulation above Central Europe. Possible changes in the air pressure fields above Europe and the North Atlantic in the 21st century can essentially influence the position and variability of the polar frontal zone as well as the general circulation patterns (Hrvoľ et al., 2001; Lapin et al., 2003; Niedźwiedź, 2000, Ostrožlík, 2009). This is a factor which determines many characteristics of the climatic system, including air temperature and precipitation.

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Ozone pollution and air quality standards for protection of human health in the mountain regions

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Abstract. In this study, ozone pollution relating to air quality standards for human health protection for selected EMEP mountain stations in the Tatras (SK) and in the Alps (AT) and time period 1992-2006 has been investigated. Obtained results show that target value according to Directive 2002/3/EC and indicator of cumulative annual exposure SOMO35 developed by WHO were exceeded substantially at peak stations. Mean annual SOMO35 values at foothill areas Stará Lesná (6008 μg/m^3.days) and St. Koloman (8548 μg/m^3.days) as well as at peak Chopok (10260 μg/m^3.days) and Sonnblick (14275 μg/m^3.days) were considerably higher than characteristics presented by WHO (2008) for central and eastern Europe (3930 μg/m^3.days).

Introduction

Mountain regions are characterized by very favourable climatic conditions for healthy life and treatment of respiratory diseases and allergies as well. Reduced barometric air pressure, thermic balance, air moisture, wind, solar radiation, weather and also air quality are an important factors that determine specific features of mountain climate. Clean and fresh air is ussualy related to absence of large sources of primary emissions near surrounding hills. Nevertheless, it is suggested that ozone pollution occurred at the higher elevation is associated with the emissions drifted from long distance sources and transformed in the upper level of atmospheric boundary layer or the lower free troposphere (Bičárová and Fleischer, 2008). The lifetimes of many ozone precursors and their conversion products are sufficiently long to allow them to be transported over long distances through the atmosphere. Consequently, the large-scale ozone „background" level has a strong long-range transport component determined by a wide range of emission sources (Syri et al., 2001).

Ground-level ozone (O_3) is a powerful oxidative compound formed in the lower atmosphere by photochemistry driven by solar radiation. Owing to its highly reactive chemical properties O_3 is harmful to vegetation, materials and human health. In the troposphere, O_3 is also an efficient greenhouse gas. Ozone pollution causes irritation of breathing, triggers asthma symptoms, lung and heart diseases. The analysis of World Health Organization (WHO) indicates that ozone pollution affects the human health. It is estimated that some 21 000 premature deaths per year are associated with ozone exceeding 70 μg/m^3 measured as a maximum daily 8-hour average in 25 EU countries (WHO, 2008).

Climate change may lead to increased ozone concentrations. The most significant meteorological variables directly affected by climate change are temperature and specific humidity. Climate models suggest that the relative humidity of the atmosphere will remain roughly constant in future and, since a warmer atmosphere can hold more water vapour, this implies that the specific humidity will increase. Higher temperatures can increase the reaction rates producing ozone and reduce the amount of NO_x. Increased water vapour should increase the decomposition of ozone. Throughout most of the troposphere, the water vapour effect leads to a net reduction in ozone (Johnson et al., 2001), but close to the surface over polluted regions some climate change models project an increase in ozone pollution (Murazaki and Hess, 2006) owing to a decrease in peroxyacetyl nitrate (PAN) formation. Emissions of volatile organic compounds (VOCs) from biogenic sources (mainly forests) will also be affected by direct changes in air temperature and by changing carbon dioxide levels during growing seasons. It can be expected that population exposure will increase regardless of currently planned precursor emission reductions, owing to increasing background levels and reduced ozone depletion in urban areas (WHO, 2008).

The aim of this paper is to investigate the situation of ozone pollution in mountain regions in context of ozone standards for human health protection.

Data and methods

Mean hourly data of O_3 concentration obtained from the EMEP database http://www.emep.int/ for selected mountain stations Stará Lesná (SK), Chopok (SK), St. Koloman (AT) and Sonnblick (AT) and time period 1992-2006 were used. The O_3 measurement principle is based on the absorption of UV light at 254 nm by ozone. Statistical methods have been applied for evaluation of O_3 parameters related to O_3 standards for human health protection specified by Directive 2002/3/EC of the European parliament. Directive defines target value for the protection of human health (maximum daily 8-hour mean 120 μg/m^3 not to be exceeded on more than 25 days per calender year averaged over three years), information threshold (120 μg/m^3) and alert threshold (240 μg/m^3). WHO applies also indicator of cumulative annual exposure SOMO35 (sum of means over 35 ppb or 70 μg/m^3). It was developed for use in health impact assessment.



Figure 1. Map position of investigated EMEP mountain stations Stará Lesná (SK), Chopok (SK), St. Koloman (AT), Sonnblick (AT).

Results and disscussion

Obtained results (Tab. 1) demonstrate relevant ozone pollution differences between foothill and peak stations as well as between the Tatra (SK) and the Alp (AT) regions. Target value[5] (25 days) was overstepped particularly at Sonnblick (101 days) then at Chopok (52 days) and St. Koloman (42 days). Stará Lesná (27 days) is close to achieving the target value[5] until 2010. Information and alert thresholds were not exceeded frequently with except of extraordinary year 2003. Indicator SOMO35 (Tab. 2) shows that health risk due to ozone exposure is more serious for Alps than Tatras and increases with the altitude. Maximal ozone loads at mountain peak stations in Slovakia noticed also Kremler (2006). Comparison of mean annual SOMO35 values (Tab. 2) with the characteristics presented by WHO (2008) for central and eastern Europe (3930 $\mu g/m^3$.days) show large differences. SOMO35 values for high-altitude mountain regions are higher than values observed in southern Europe (6700 $\mu g/m^3$.days) and considerably higher than the lowest values in the northwestern region (1730 $\mu g/m^3$.days).

Table 1. Ozone pollution in mountain regions and European air quality standards according to Directive 2002/3/EC.

O_3 [$\mu g/m^{-3}$]	SK Stará Lesná, 808 m asl. 49° 9'10''N 20° 17'28''N				AT St. Koloman, 851 m asl. 47° 39'0''N 13° 12'0''N			
	[1]Mean annual	[2]nD >120	[3]mean	[6]IT/[7] AT	[1]Mean annual	[2]nD >120	[3]mean	[6]IT/[7] AT
1992	65 ±30	30	-	7/0	77 ±28	43	-	4/0
1993	63 ±23	19	-	0/0	75 ±23	49	-	0/0
1994	64 ±26	22	24	0/0	77 ±26	57	[4]50	1/0
1995	70 ±27	31	24	0/0	77 ±27	45	[4]50	4/0
1996	72 ±32	62	[4]38	0/0	72 ±32	24	[4]42	0/0
1997	51 ±21	0	[4]31	0/0	77 ±21	33	[4]34	0/0
1998	51 ±23	4	22	0/0	83 ±23	51	[4]36	0/0
1999	66 ±34	66	23	1/0	82 ±34	34	[4]39	0/0
2000	60 ±29	19	[4]30	0/0	82 ±29	44	[4]43	0/0
2001	55 ±32	24	[4]36	0/0	79 ±32	33	[4]37	0/0
2002	56 ±30	10	18	0/0	80 ±30	37	[4]38	0/0
2003	66 ±30	41	25	0/0	88 ±30	95	[4]55	**51**/0
Mean annual values for the time period 1992-2003								
	62 ±4	27	27	-	79 ±4	45	42	
2004	62 ±28	0	17	0/0	-	-	-	-
2005	70 ±27	10	17	0/0	-	-	-	-
2006	71 ±30	44	18	1/0	-	-	-	-
	SK Chopok, 2008 m asl. 48°56'38''N 19° 35'32''N				AT Sonnblick, 3106 m asl. 47° 3'16''N 12° 57'30''N			
1995	94 ±22	66	-	2/0	101 ±19	93	-	0/0
1996	88 ±21	35	-	0/0	101 ±18	92	-	0/0
1997	79 ±18	11	[4]37	0/0	98 ±17	74	[4]59	0/0
1998	85 ±20	24	23	2/0	102 ±19	108	[4]64	1/0
1999	86 ±21	56	[4]30	0/0	104 ±20	129	[4]104	0/0
2000	80 ±24	28	[4]36	0/0	104 ±18	121	[4]119	0/0
2001	-	[5]25	[4]36	-	103 ±19	117	[4]122	0/0
2002	94 ±24	92	[4]48	2/0	102 ±16	100	[4]113	0/0
2003	97 ±23	103	[4]73	2/0	107 ±21	146	[4]121	**33**/0
2004	92 ±23	63	[4]86	1/0	99 ±18	79	[4]108	0/0
2005	96 ±21	78	[4]81	0/0	101 ±18	100	[4]108	0/0
2006	93 ±21	60	[4]67	0/0	102 ±18	92	[4]90	0/0
Mean annual values for the time period 1995-2006								
	89 ±6	53	52	-	102 ±2	97	101	

[1]Mean annual 1-hour O_3 concentration [$\mu g\ m^{-3}$] ±st.dev

[2]Number of days with max.daily 8-hour mean higher than 120 $\mu g\ m^{-3}$
[3]averaged over three years [4]exceeded target value
[5](25 days) for the protection of human health

[6,7]Number of exceedances
[6]IT information threshold 1-hour average O_3 concentration >180 $\mu g\ m^{-3}$
[7]AT alert treshold 1-hour average O_3 concentration >240 $\mu g\ m^{-3}$

Table 2. The health exposure indicator SOMO35 (WHO, 2008) for identifying the ozone pollution risk in mountain regions.

[1]SOMO 35	SK Stará Lesná 808 m asl.	AT St. Koloman 851 m asl.	SK Chopok 2008 m asl.	AT Sonnblick 3106 m asl.
	$\mu g/m^3$.days	$\mu g/m^3$.days	$\mu g/m^3$.days	$\mu g/m^3$.days
1992	7097	7913	-	12730
1993	4943	7847	-	11316
1994	6062	8229	-	13685
1995	7657	7776	12099	13948
1996	8598	6914	9500	14353
1997	1775	7905	6812	13227
1998	2408	9395	8343	14689
1999	8552	9194	8920	15799
2000	5624	9074	7704	15490
2001	5424	8050	-	15073
2002	4868	8520	11485	14549
2003	7568	11758	12460	16755
2004	3651	-	11972	13431
2005	7504	-	12524	14384
2006	8398	-	11044	14698
Mean annual values				
'95-'00	5769	8376	8896	14584
'92-'06	6008	8548	10260	14275

[1]SOMO35 = $\sum$max (0, Ci – 35 ppb) = $\sum$max (0, Ci – 70 $\mu g/m^{-3}$)
Ci is the maximum daily 8-hour average concentration, i=1 to 365 days

Conclusions

Air quality is an important element of human life. Air over the mountains due to high altitude is affected by long-range transport of air pollution. Primary emissions produced by large emission sources in urban lowland urban areas are transformed into secondary air pollutants in atmospheric boundary layer in dependence on meteorological conditions. Ground-level ozone is the main marker of secondary pollution in ambient air. Results of this study show substantive excedances of ozone standards for human health protection at the higher altitude in the Tatras (SK) and the Alps (AT). It is suggested that the vulnerability of mountain regions to secondary air pollution associated with climate change is very high.

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Rainfall characteristics of a mountaneous location in western Slovenia

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Abstract. Forests in Slovenia have spread in the last decades and at present cover more than 60% of Slovenian territory. Forests are huge water consumers and at the same time reduce soil erosion, particularly on exposed sites. However surface runoff accumulates into streams with erosive forces and causes soil erosion, i.e. forest creeks, torrential gravel deposits and slope failures. In lieu of climate change in Slovenia, seasonal distributions of rainfall have changed with significant implications for patterns of vegetation growth and hence for soil erosion. Due to predicted climate change increased frequency of extreme precipitation events can be expected during the time when soil is without plant cover and exposed to the erosive forces. In addition to ample daily and several day precipitation events, water erosion occurs with heavy rainfalls that last from couple of minutes to several hours. Rainfall intensity index and rainfall erosivity was calculated for alpine region in West Slovenia for period 1991-2006.

Introduction

Vegetation protects the soil from erosion by intercepting raindrops and absorbing their kinetic energies harmlessly (Lal, 1994). However, the effectiveness of protection of vegetation cover against the rainfall erosivity is conditioned by many factors, such as soil, cover type and density, etc. In the recent decade, Slovenia has seen a reduction in the agricultural land use and consequently the increase in reforestation and urbanisation of suburban agricultural land. Forests at present cover more than 60 % of Slovenian territory. Forests are huge water consumers and at the same time reduce soil erosion, particularly on exposed sites. Thou forested cover is taken as a complete protection against soil water erosion comparing to the agricultural area (Lal, 1994), in many cases uncontrolled surface runoff accumulates into streams with erosive forces and causes soil erosion, i.e. forest creeks, torrential gravel deposits and slope failures (Mikoš, 1995). Also, tall growing vegetation may reduce ground cover completely, either directly by shading or by chemical effects through the reoots of certain woody perennials (Lal, 1994).

Climate in Slovenia has changed during last decades, air and soil temperatures have increased significantly, and water cycle is altering (Bergant et al., 2002; Bergant and Kajfež-Bogataj, 2005). Rearrangement of precipitation patterns, which exhibits in more vigorous and frequent long-duration droughts and rise of rainfall intensity, that influence noticeable erosion processes, are noticed in the past decade. There have been no significant changes in the amount of precipitation in last decades in Slovenia, but the greater intensity of showers and a lower number of days with snow cover were found. Precipitation regime within seasons has also changed; precipitation maximum in autumn is more expressive (ARSO, 2006). Regional scenarios of future climate change predict more intensive precipitation in a changed precipitation regime, more frequent and intense extreme weather events such as droughts, floods and thunderstorms during the time when soil is without plant cover and exposed more to the erosive forces (Kajfež-Bogataj and Bergant, 2005).

In view of these facts, the sasonal variability of kinetic energy of rainfall using measured rainfall rates was studied. Intensities of rainfall events for mountainous location in alpine region in West Slovenia were evaluated.

Data and methods

Precipitation data (ARSO, 2007) measured in various time intervals (breakpoints) for the 1991–2006 period were analyzed for a meteorological station in Rateče, representing alpine region in Slovenia. Meteorological definition of seasons was applied: winter from December to February, spring from March to May, summer from June to August and autumn from September to November. Following rainfall characteristics were investigated:

- Rainfall intensity index (I), calculated as a relationship between rainfall amount and number of days with rainfall in a certain period (mm/h), calculated values were compared considering average values of the index for the 1961–1990.

- Precipitation amount and number of days with rainfall amount exceeding 40 mm: Maximum precipitation amount for 30 min, 1 h, 2 h, 3 h, 6 h, 12 h and 24 h was evaluated. For the considered period we determined number of days with rainfall amount higher than 40 mm.

- Rainfall erosivity was calculated based on 30 min rainfall events (Ceglar et al., 2008).

Results and discussion

Number of days with rainfall amount over 40 mm and maximum precipitation

Fig. 1 shows the number of days with rainfall amount exceeding 40 mm. Daily rainfall amounts over 40 mm were most frequent in the autumn. In the studied 16 years period we measured over 10 days with rainfall over 40 mm in Rateče. Fig. 2 shows maximum precipitation amount for 30 min, 1 h, 2 h, 3 h, 6 h, 12 h and 24 h for the studied period (1991–2006).

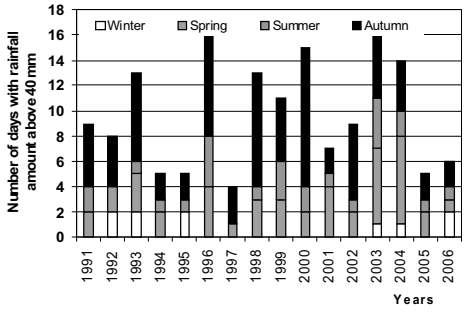

Figure 1. Number of days with rainfall amount over 40 mm for Rateče (1991 –2006).Rainfall Intensity Index

Rainfall intensity index and rainfall amount for spring and autumn in Rateče are shown on Figs. 3a and 3b. Average spring rainfall amount was 377 mm for 1961-1990 and only 291 mm for 1991-2006, trend is significantly negative. Rainfall intensity index for spring also shows negative trend, which indicates less raining days. Maximum rainfall amount was measured during spring 1975 (760 mm), and maximum rainfall intensity index in 1962, when average rainy day had about 20 mm of rainfall. For Rateče, maximum number of raining day was 42 in spring 1975 and minimum number of raining days (17) was measured during spring 2003, which shows also the highest difference between rainfall amount and rainfall intensity index.

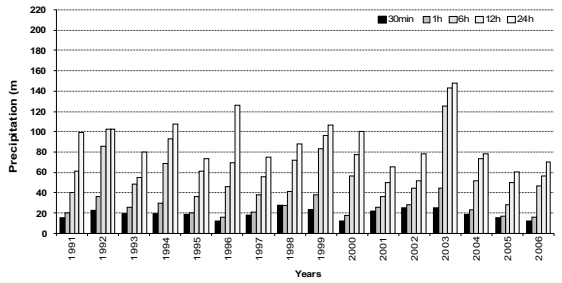

Figure 2. Maximum precipitation amount for 30 min, 1 h, 2 h, 3 h, 6 h, 12 h and 24 h for Rateče (1991–2006).

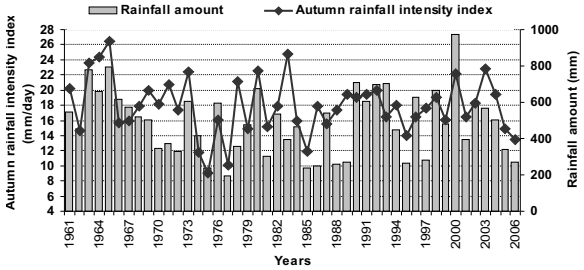

Figure 3a. Rainfall intensity index and rainfall amount for spring at Rateče (1961-2006).

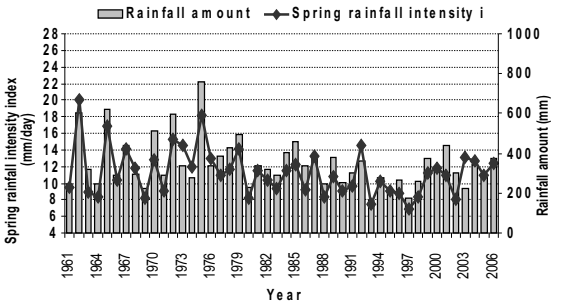

Figure 3b. Rainfall intensity index and rainfall amount in autumn at Rateče (1961-2006).

Rainfall erosivity

Monthly rainfall erosivity (EI_m) (Ceglar et al., 2008) for Rateče in West Slovenia is shown in Tab. 1 (a). Thou EI_m values for winter months are not reliable enough because snowfall causes higher error probability of the precipitation measurements winter months were considered. Between 28 and 55 % of rainfall amount is lost owing to surface flow at EI more than 140 $MJ \, . \, ha^{-1} mm \, . \, h^{-1}$, depending on characteristics of rainfall events (Ramos and Martínez- Casasnovas, 2006). In winter months and early spring the rainfall erosivity is relatively low (Tab.1a). The lowest annual EI_{ann} was in 1995, the highest in 2003 (Tab.1b).

Table 1. Average monthly rainfall erosivity (EI_m) and as percentage (%) of annual value for Rateče (1991–2006) (a) and annual rainfall erosivity (1991-2006) (b)

a) Month	EI_m	(%)	b) Year	EI_{ann}
Jan	13	0.6	1991	1551.4
Feb	16	0.8	1992	1303.1
Mar	47	2.2	1993	2487.2
Apr	58	2.7	1994	1847.7
May	104	4.9	1995	983.3
June	264	12.3	1996	1730.1
July	337	15.7	1997	1330.6
Aug	508	23.7	1998	1967.4
Sept	256	11.9	1999	2748.8
Oct	306	14.3	2000	1930.9
Nov	194	9.1	2001	1688.8
Dec	40	1.9	2002	1897.2
Sum	2144	100	2003	4844.8
			2004	2256.1
			2005	1143.8
			2006	1160.3

Conclusions

Extreme precipitation events are frequent in North-western Slovenia. Monthly rainfall erosivity for Rateče was the highest at the end of summer (month of August), which represented 23.7 % of annual rainfall erosivity. Increased frequency of extreme events can be expected due to climate change predictions. Extreme precipitation events with extreme fallouts in torrential flow should be anticipated and preventive measures undertaken. Rainfall intensity has increased recently at many locations in Slovenia (Sušnik et al., 2006). This is evident in the increased number of erosive events per year.

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Trends and actual changes in the ozone layer over Poprad-Ganovce station

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Abstract. Total column ozone trend over the Poprad-Ganovce site is calculated for the period 1950-2008. Database of the COST726 project was used for 1950-1993. In August 1993 total column ozone monitoring at the Poprad-Gánovce station started and measured data 1994-2008 was used for the rest of the processed period. In accordance with both the models and the measurements at other stations the results show that in recent years the ozone decline has not further continued. For period 1994-2008 the seasonal linear trends have been calculated. Trend in spring is significantly positive. Very small negative trends are still present in other seasons. Preliminary analysis of 2009 shows that very low annual mean of the total column ozone in 2008 affected generally increasing trend in the last decade.

Introduction

Elaboration of total ozone time series showed significant decreasing trends until the beginning of this century in area of Central Europe (Chmelík, 2000; Pribullová et al., 2006). Measurements in recent years show that total column ozone over mid-latitudes has not further declined. Ozone recovery is usually described as a process of three stages: (1) slowing of ozone decline, (2) onset of ozone increases, (3) full recovery of ozone from ozone-depleting gases. The first two stages are in progress and should be reached before 2020. Most of the models indicate full recovery of mid-latitude total ozone about 2050 (WMO, 2007).

Data and methods

To show long term course and recent changes in the ozone layer the data for period 1950-2008 has been processed. For 1950-1993 data was derived from COST-726 ozone database (Krzyścin and Borkowski, 2008). Two Slovak national projects were included to COST726 project named: "Long term changes and climatology of UV radiation over Europe" which was solved in 2004-2009. Since 1994 data has been taken directly at the Global Ozone Observing System (GOOS) station No. 331 Poprad-Ganovce (49.03N, 20.32E, 706 m a.s.l.). Measuring device is the Brewer ozone spectrophotometer MKIV No.097. Poprad-Ganovce is only station carrying out ground based total column ozone measurements in Slovakia. Short period 1994-2004 was utilized to compare and match both data-sets. For the period 1950-2008 graph monthly means of total column ozone have been calculated. For the period 1994-2008 annual and seasonal linear trends have also been calculated.

Results and discussions

In Fig. 1 long term course and 6 degree polynomial trend in total column ozone for Poprad-Ganovce station are shown. A trend curve follows the significant decline in the 1980s and early 1990s as well as the slowing of the decline in recent years. The dashed trend line corresponds to COST726 data used instead of measured data in sub-period 1994-2004.

Generally results for Poprad-Ganovce site are in compliance with findings at other stations. In last decade the ozone decline is not as apparent as in previous two decades.

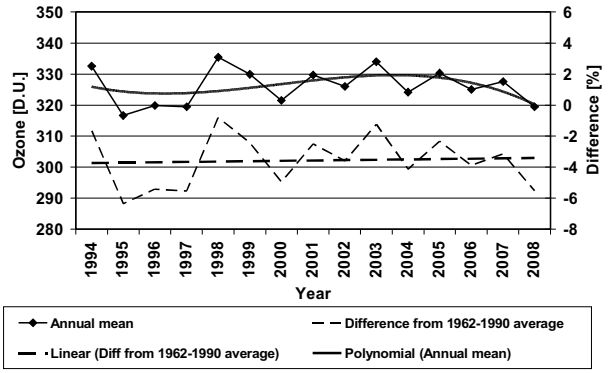

Figure 1. Long-term course of total column ozone over Poprad-Ganovce for the period 1950-2008 with 6 degree polynomial trend.

More detailed information on ozone layer behaviour over our region during last 15 years can be derived from ground based observations at Poprad-Ganovce station. All figures show that the first stage of the ozone recovery is detected. It is also obvious that at present we are about onset of ozone increases which is the 2 stage of the recovery process. On the other hand analysis indicates that it will take quite long time to confirm that stage statistically. Since 2003 the course has been slightly decreasing again. The minimal annual means of total column ozone were observed in early 1990s (1992, 1993, 1995) and hardly will be overcome in future. In the period 1995-2003 the course was significantly increased. In last decade the biannual oscillation in annual means is apparent (Fig. 2). Previously the oscillation of lower frequency can be seen. Usually 2-3 year period of the decrease alternated similar period of the increase.

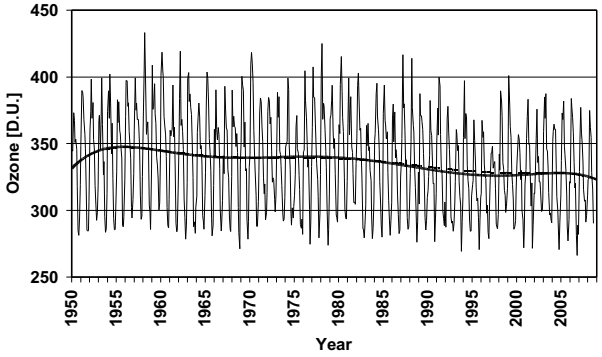

Figure 2. Total column ozone at Poprad-Ganovce 1994-2008 and difference from the long term average 1962-1990 calculated for Poprad-Ganovce site.

Seasonal courses and linear trends in total column ozone for period 1994-2008 are in Fig. 3. Very small negative trends are still present in summer, autumn and winter. Those trends are mainly caused by the low total column ozone in 2008. If that year is included from processing, trends in winter and summer will also be increasing. Very favourable is the positive trend in spring when the annual course of total ozone in our region reaches its maximum. Preliminary analysis of January-August 2009 period confirmed the positive trend in recent years. The average January-August value is of 4 percent higher than that for the equal period in 2008.

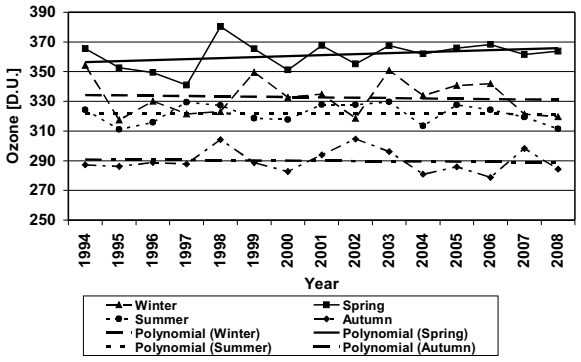

Figure 3. Seasonal courses and linear trends in total column ozone at Poprad-Ganovce 1994-2008.

Conclusions

In compliance with general findings total column ozone measurements at Poprad-Ganovce indicate the presence of the first stage of the ozone layer recovery. At present or in early future the second stage should occur but it will be confirmed statistically in next 15-20 years. Generally the positive trend in total column ozone is caused by the decrease in ozone-depleting substances. Significant short-time as well as inter-annual changes are caused mainly by the weather variability. Full recovery of mid-latitude total ozone from ozone-depleting gases is predicated for 2050. Because of the link between stratospheric ozone and climate change it is not expected ozone abundances in 2050 to be exactly the same that those observed before 1980s.

Seasonal trends at Poprad-Ganovce are in accordance with difference between recent ozone changes over northern and southern midlatitudes mentioned in WMO (2007). Whereas the changes over southern midlatitudes are nearly the same throughout the year, the changes over northern midlatitudes are larger in spring.

In WMO (2007) is noted that ozone changes over southern midlatitudes are consistent with those modelled from equivalent effective stratospheric chlorine decreases, whereas increases in ozone over northern midlatitudes are greater than the modelled ones. Lower 2006-2008 values recorded at Poprad-Ganovce station slow down the increasing trend in total column ozone which should be more consistent with models over our region.

Thanks to comply with the Montreal Protocol the recovery of ozone from ozone-depleting gases progresses. Measurements at Poprad-Ganovce total ozone station fully demonstrate a present state of this process.

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Air temperature change in the Kroměříž territory for the years 1956–2005

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Abstract. Agricultural research institute in Kroměříž has made continuous long term meteorological observations since 1954. This paper evaluates measurements of air temperature from years 1956-2005 in relation to climate change. Final conclusions reached by this research are as follows:

- average annual temperature increased by 1° C (12 %) during investigated 50 years,
- onset of period with temperature higher than 15 °C comes 14 days earlier (now on 17th May),
- the end of period with temperature higher than 15 °C comes 8 days later (now on 13th October)
- period with mean monthly temperatures higher than 15 °C was extended for 22 days during investigated 1956–2005 period.

Introduction

In March 2001, an article (Harries et al., 2001) was published in the prestigious scientific journal Nature which clearly shows a change of energy balance of Earth on the basis of 1970 and 1997 satellite measurements. Previously, the results of computer models were presented with inconclusive findings. The authors of the article also demonstrate the relationship between the increase in temperatures on Earth and the increasing amount of so-called greenhouse gases (methane, carbon dioxide and ozone). This, however, opens the whole field of issues related to the future. The humans should have foreseen the consequences of the global warming, including the impact of the loss of ice in polar areas and the consequent increase in sea levels. Change in the water cycle may lead to accumulation of water vapor and to increasing cloudiness in the atmosphere (Weart, 2003). Using improved global climate models, future development of climate on Earth could be predicted with a desired probability (Mokhov, 2002).

There is, however, a problem that in most of global models, they include the whole Earth or a relatively large areas (Hawkins, 2004) and they work in the long time scales - decades, centuries, etc. It is also important to know, how the climate has been modified at local or regional scale and how it affects the human society and natural ecosystems because heat energy is the driving force of natural processes, such as the speed of weathering of rocks, the increase in biomass production, the solubility of substances in water, etc.

The aim of this study is to statistically demonstrate a change of temperature in Kromeriz territory in the last 50 years.

Data and methods

Agricultural research institute in Kroměříž (formerly the Research Institute of Grain) has made continuous long-term meteorological observations (temperature air and soil, rainfall, wind, pressure, evaporation etc.) since 1954. Statistical data processing (calculation of selected temperatures onset) was carried out using methodologies published by Nosek (1972). We use basic data files since 1.1. 1956 to 31.12. 2005.

Results

Changes in average annual temperature

In the context of climate change are discussed mainly on the gradual warming. The linear regression analysis was applied on the average annual temperature from period 1956–2005 (50 years). Fig. 1 shows the mean annual temperature and linear trend at Kromeriz.

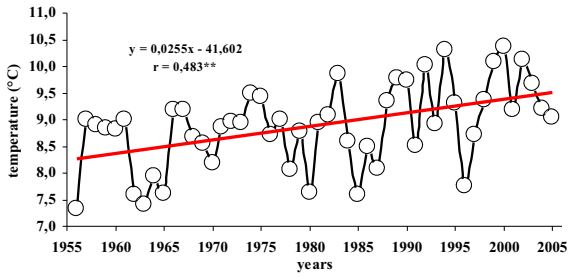

Figure 1. Average annual temperature (°C)–(circles) and its linear trend (red line) at Kromeriz, 1956–2005.

According to the line equation in Fig. 1, the average annual temperature in the last 50 years increased by 1° C: from 8.3 °C in 1956 to 9.3 °C in 2005. If one considers a temperature of the 1956-year equal to 100 %, the increase in the average annual temperature was about 12 % in the last 50 years.

Change in the monthly temperature maxima

An aim of this study was to answer on the question whether the warming is greater: in the summer or winter. Annual temperature maxima are depicted in Fig. 2.

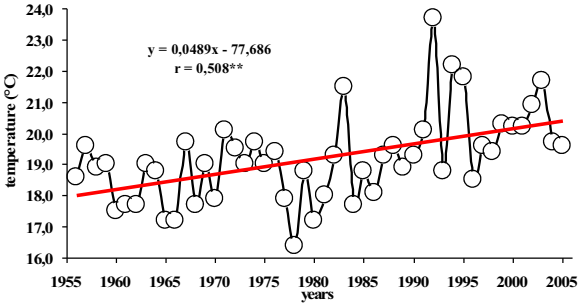

Figure 2. Yearly maxima of temperature (°C) (circles) and linear trend (red line) - Kromeriz, 1956–2005.

Statistical conclusive increase in monthly maximum temperature is high: increase in temperature maxima is about 2.2°C in last 50 years (Expressing by linear trend, the temperature maxima were changed from 18.0° C in 1956 to 20.2°C in 2005).

The onset and end of some temperature periods

Onsets of temperature periods were calculated from the daily mean temperature time series when temperature exceeds some limits of 5, 10 or 15° C. To illustrate changes in intervals when daily temperature exceeds selected limits the dates of beginning and finishing of periods with temperatures higher than 15 ° C are presented in this study (Figs. 3 and 4).

In 1956, the onset of temperature exceeding 15° C occurred (calculated from the regression equation) on 31st May. In 2005, it was already the 17th May. The shift in onset of temperatures over 15° C determined during last 50 years was of 14 days. Similarly, the temperature dropped blow 15° C on the 5th October in 1956 and on 13th October in 2005. The difference is 8 days.

From this, it is possible to conclude that the season with temperatures above 15° C was prolonged by 22 days in the last 50 years.

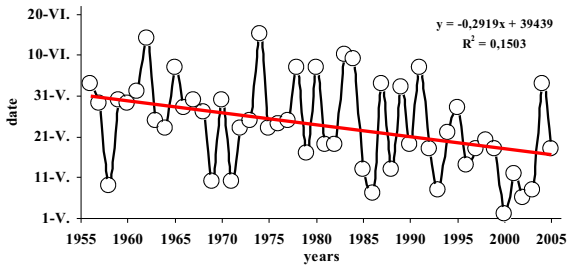

Figure 3. Dates of temperatures over 15°C onset (circles) and their linear trend (red line) at Kromeriz during 1956–2005 period.

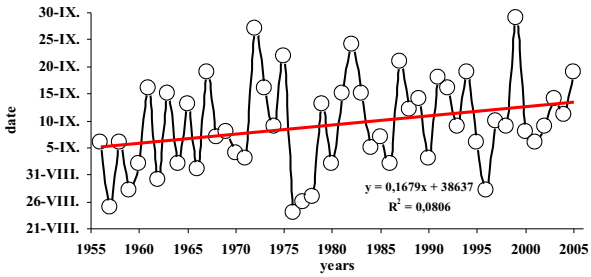

Figure 4. Dates of the last occurrence of temperatures over 15°C (circles) and their linear trend (red line) at Kromeriz-for the 1956–2005 period.

Conclusions

Evaluation of fifty years of observations (1956–2005) from the meteorological station at the Agricultural Research Institute in Kroměříž showed the basic changes in temperature:

- average annual temperature increased by 1° C (12 %) during investigated 50 years,
- increasing trend in annual maxima of temperature was detected
- onset of period with temperature higher than 15 °C comes 14 days earlier (now on 17th May),
- the end of period with temperature higher than 15 °C comes 8 days later (now on 13th October)
- period with mean monthly temperatures higher than 15 °C was extended for 22 days during investigated 1956–2005 period.

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Large-scale atmospheric circulation and sounding derived parameters associated with windstorm events in Lisbon (Portugal)

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Abstract. Prior research has allowed the building of a windstorm database in the Lisbon City Council, (LCC) Portugal (Lopes et al., 2008), based on a systematic selection of strong wind events responsible for damage, and tree falls (1241 occurrences from 1990 to 2006). The study of the atmospheric environment related with windy weather conditions in the Lisbon region is an ongoing research. The results presented in this paper evolve two main achievements. First, the results of an automatic classification of large-scale atmospheric circulation patterns associated with windstorm events in Lisbon will be presented and discussed. Secondly, results from a systematic analysis of selected sounding derived parameters, using available radionsonde data from the Lisbon/Airport station, will be carried out. These two main tasks allowed the improvement of the understanding of the main synoptic weather context and dominant thermodynamic forcing associated with windstorm events in the Lisbon region.

Introduction

Trees' benefits for the urban environment are frequently accompanied by hazards caused to the human population and infrastructure, particularly during strong wind events, due to total or partial tree falls in public and private open spaces. Windstorms damages to trees greatly depend on the physical conditions imposed by the urban environment. A windstorm database based on fallen trees occurrences in Lisbon (since 1990 and with on time updating) was constructed compiling data collected and stored by the Lisbon Fire Brigade and Rescue Services (Lopes et al., 2008). This updated windstorm inventory allows to explore this information under different perspectives. An important and ongoing research line (see more information available at http://www.ceg.ul.pt/urbklim/index.html) is the study the atmospheric environment associated with windstorm events in the Lisbon region, from the large-scale to the local scale. Windstorm events may occur in Lisbon in all seasons, but the synoptic weather controls are quite different when in compare the summer events with the episodes occurring out of the warm season. During summer, the wind regime in the city of Lisbon is dominated by a relatively strong northerly wind that occurs near the western coast of the Iberian Peninsula, the *Nortada*. This regional circulation occurs when a strong pressure gradient is maintained by a persistent thermal depression in the warm continent and the Azores anticyclone is above the cooled ocean. The upwelling of the cooler ocean waters near the shore reinforces the pressure gradient, increasing wind speeds near the ground, and sometimes triggering stronger winds. Windy weather conditions out of summer months are always related with cyclonic circulations and occur more frequently during the winter, when the westerly flow is more intense, bringing more tracks of frontal disturbances to the Portuguese latitudes. Different studies focused on the large-scale atmospheric types associated with rainfall regimes and patterns in Portugal (Santos et al 2005; Fragoso and Gomes, 2008), but remains quite unknown the atmospheric circulation controls related with windy weather conditions over this territory. A first attempt was already carried out with a preliminary classification (Fragoso and Lopes, 2008). Expecting to contribute to fill this gap, this study aims to identify the main (large-scale) atmospheric circulation patterns that promote windstorm events over the Portuguese area. Local thermodynamic conditions in Lisbon area during windstorm events will also be analysed, using the available radiosonde information, from their sounding station located at the Airport (northern part of the city).

Data and Methods

The initial information from the LCC windstorm database permitted to obtain an inventory of 128 windstorm days in Lisbon (in the 1990-2006 period). This inventory is in fact a subset of the total number of windstorm events, because we want to put in relation their large-scale atmospheric context with the thermodynamic features observed at mid-day (12:00 UTC) soundings in Lisbon/Airport, the only daily time balloon release operated at this station. Therefore, the selected 128 windstorm days are the subset of windstorm days that were associated with fallen trees damages from 9:00 UTC to 15:00 UTC, the 6 hours period that permits a more suitable and useful analysis from radiosoundings information. These 128 case events were analysed according to their atmospheric context, evolving two different sets of data, whose description and applied methods should be considered separately: atmospheric data fields and radiosonde data. Atmospheric fields concerns Sea Level Pressure (daily means) grid data from the NCEP reanalysis-2 database (Kanamitsu et al., 2002). This information is suitable to analyse the surface pressure systems that controls the wind field near to the ground. The extracted fields were limited by the latitudes of 25º and 65º N and the longitudes of 35ºW and 10º E, defining a geographical window with 323 grid points. Appling a tested methodology from earlier researches (Fragoso and Gomes, 2008), these data were used in a computational method that combines the Principal Component Analysis (PCA) and the K-means clustering, and seeks to define the fundamental large-scale circulation types associated with windstorm events in Lisbon.

On the other hand, the use of radiosounding Lisbon (Lisbon/airport station) was conducted in order to identify the dominant forcings and processes to windstorm initiation. Our focus is on the analysis and calculation of several parameters deduced from radiosonde data, trying to test their ability as indicators of wind gusts triggering. These parameters evolve well known stability indices and thermal buoyancy estimators (e.g. Lifted index, CAPE, DCAPE, among many others) and their comparative analysis may

contribute to discriminate strong wind events related with non-convective and convective storms.

Results and discussion

The main output of the automatic classification procedures may be summarised in a typology of large-scale atmospheric circulations containing three fundamental clusters (Fig. 1).

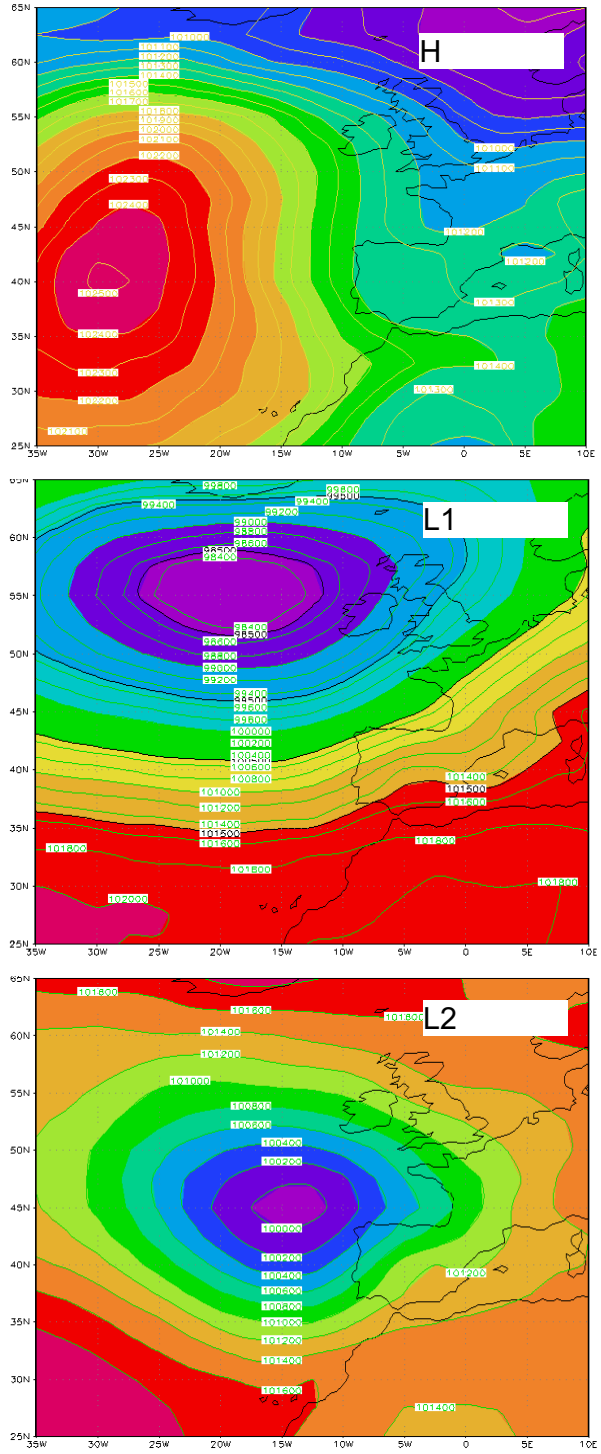

Figure 1. Large-scale atmospheric patterns (Sea Level Pressure average fields based on a coupled principal component analysis and cluster analysis classification). Source of the data: NCEP, NOAA.

The three illustrated atmospheric circulation types were obtained clustering the loadings of the 128 case events of the first 5 PC´s retained eigenvectors, explaining 80,2 % of the total variance. Type "H" corresponds to northerly windstorm events related with the combination of an anticyclone (margin) over the Eastern Atlantic and a low pressure system over the centre of the Iberian Peninsula (particularly during summer) or over the Western Mediterranean/Eastern Spain (during fall, winter and spring months). Type "L1" illustrates the windstorm events related with intense migratory cyclones tracking eastward at British Islands latitudes. These events occur more frequently during winter and promote strong W or SW winds over Portugal. A different context is represented by the "L2" type, which is associated with the influence of low pressure systems located NW or W of the Iberian Peninsula, and promoting strong SW or S winds over the Portuguese region.

Results from the statistical analysis of the sounding derived parameters are based in just 91 radiosondes/daily windstorm events, considering that there are no available soundings from 1994 until 1997. The results show a general increase of thermodynamic instability severity during the fall season, when the occurrence of convective storms is more dominant. On the opposite, winter windstorms are in general related with synoptic forcings associated with intense frontal cyclones, promoting strong gradient winds.

Conclusions

Windstorms in Lisbon are mainly related with three general main surface circulation patterns. One of them (type "H" of the classification) may correspond to a two different situations: one is typical in summer and is related with the "*Nortada*" wind regime; the other one is common out of this season, but triggers also strong northerly winds. Fall windstorms were the most frequent episodes in the analysed inventory of windstorms and are triggered, in general, under a more thermodynamic unstable environment, related with convective storms activity.

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Implementation of the dynamic variable dependences to the statistic downscaling

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Abstract. The resolution of global climatologic circulation models (GCM) or results from ERA data is about hundred square kilometres. In regard to the mountain effects, for regional analysis it is necessary to use sophistic methods to interpret model outputs. One way how to obtain suitable data is combining the dynamical and statistical methods. Upper level analyses (700hPa) of selected meteorological variables (temperature, specific humidity) for Slovak territory (the analysis is done in the point close to aerologic station Ganovce) are discussed in this article. The source of data are reanalyses from ERA 40 project and the third version of the GCM, Coupled Global Climate Model (Canadian climatic model) with IPCC SRES "A2" scenario. Statistical structure of investigates daily fields are performed by quantile characteristics, probability distribution, mean, standard deviation etc. Data are investigated in the referenced period 1961-1990 and scenario is prepared for the period 2045-2065.

Introduction

The circulation models show useful information for investigation of global atmospheric variability. This information is not usually sufficient for the regional data analysis. For this reason some sophistic methods are implemented to obtain atmospheric fields with more detailed structure than GCMs provides. On the first view, one can obtain useful results with simplest interpolation technique, however deep result analyses show the disadvantages of this method especially in the mountain area.

One suitable method to obtain dense grid, which retains a physical consistency among the meteorological variables, is applying the dynamical features by governed equations. Other approach is using statistical methods to obtain relevant results.

The differences between these two methods are significant. The adaptation and utilization are differed with respect to investigation problems in both cases. The dynamic methods are time consuming extensive, they require large scale data what consume a lot of computational time. The statistical methods are generally the simplest. They do not capture the dynamical links among the variables. The effective choice could be the combination of both approaches.

For events where significant variability of mentioned data is presented, the statistical approach is accepting and it help us to include variability to the final assumption. For estimation of eventual fluctuation of analyzed variable, it is necessary to know the final margin of variability. In cases when the combination of data with different variability enters into the process evaluation, reasonable final information can be difficult to obtain by used a classical statistical approach.

One method, which allows us to implement all variability to the final analyses, is the Monte Carlo method. In many applications of Monte Carlo method, the investigated process is simulated directly. There is no need to describe the behaviour of the investigated system, which can be advantage in some complicated systems. The only important requirement is that this system has to be described by probability density functions (PDF).

The Monte Carlo method is applied to obtain PDF for cross dependence of temperature, virtual temperature and specific humidity.

Data and methods

The background data from ERA 40 are taken for our computation. The available data are obtained from regular 2.5° x 2.5° latitude/longitude grid. For Slovakia territory it means that resolution is about 250 km in both directions. The orography with resolution above hundred square kilometres is inconvenient for investigation of observed features in regional scale. The complicated orography in Slovakia forces us to use some downscaling technique to obtain fields in denser grid.

The temperature and specific humidity from 700 hPa air pressure level is taken for this study. Reference period 1961-1990 of both measured and model data was used. Measured data are represented by ERA 40 daily data and model data are represented by Canadian climatic model with IPCC SRES "A2" scenario. The analysis is concentrated to the nearest point to Ganovce aerologic station for ERA 40 and CGCM.

The main idea is combination of statistic and dynamical approaches, in addition the statistical interdependences may be supported by physical equations. For example for the wind fields, which varied significantly in time and spatial direction, the geopotential could be auxiliary variable. With help of statistical structure of geopotential, the wind structure can be estimated from well known geostrophic relations.

We applied the same technique to the analyses of the temperature and specific humidity fields. It is well known that the vapour pressure depends on the air temperature. There is exponential dependence for the saturated vapour pressure. Before this analysis, it is important to know about existence of the mentioned relation between these variables. In the case when this dependence is not applied, unrealistic result could be obtained (over saturated state). Therefore the relation for virtual temperature **(T_v)** was applied to express this dependence. This expression: **$T_v=T(1+0.606w)$,** combines the temperature **(T)** and specific humidity **(w)** to the one equation and it creates the link between these variables.

In many cases the solved problem requires to know the values out of the regular grid. In the regular mesh, the values from model or ERA data are known. The values out of regular mesh could be obtained by interpolation or by using of other techniques. In our case we are denoting this process as transformation **(T)** from grid point value (x) to required point value **(z)**: **xT=z**. This transformation was identified by probability distribution, which is obtained

from statistical structure of model data in regular grid and measured data (in our case ERA data) in the point of the interest in the reference period 1961-1990. In this period, both data are known. The data in reference period provide the statistical structure, which was applied to the data in future, to create the scenario.

For example, the dry temperature transformation from GCM model **(x)** to ERA data **(z)** could be created from statistical structure GCM data and ERA data. The statistical structure of mentioned transformation is presented in Fig.1. The same technique could be used for preparation of specific humidity field. But to keep dependences between temperature and humidity, it is preferable to construct transformation equation for virtual temperature and for dry temperature. The transformation equation for specific humidity consequently will have modified form, which maintains cross dependence: **z=A+xT**, where term **A** represents our dependence.

The common interaction between statistical structures, which is represented by PDF, is done by Monte Carlo technique. For example interaction of **x** field and transformation **T** is done in this way. The only important requirement for this method is that the system has to be described by PDF. The PDFs were created from reference period for temperature and virtual temperature. Once the PDF's are known, the Monte Carlo simulation can proceed by random sampling technique from the PDF's. This approach works with random number generators, which have properties of desirable PDF.

Then many trials are performed and the expected result is obtained as an average over the number of values. In this case, it can be predicted the statistical structure of this simulated result (variance, kurtosis and some other higher statistical moments). From these characteristics, the estimation of the number of Monte Carlo trials can be achieved to obtain a result with an expected error.

The Monte Carlo method is based on the generation of multiple trials to determine the expected value of a random value. In our case, it can be said that this method is combination of probability distribution functions uncertainities for temperature, virtual temperature and specific humidity.

To know the uncertainty of variables, which entered our formula, the relative and absolute errors are obtained. It allows us to gauge the relevance of obtained results, eventually to explain the observed difficulties.

Results and discussion

At first, the absolute and relative errors for variables were estimated, which entered the formulae. The complicated thing was the error specification of not directly measured variables (e.g. vapour pressure). From known errors for temperature measurement (0.05K) and pressure (13.33Pa), the vapour pressure relative error was estimated to value of 0,4% and absolute error to the interval (0.20, 22.00)Pa. The absolute error is dependent on air temperature. The higher error is related to the higher temperature (about 36°C). This analysis was performed due to the difficulties with negative values for vapour pressure, which can be obtained with downscaling methods due to inaccuracy of vapour pressure.

As above mentioned, the computation methodology can be convenient in PDF analysis for temperature and virtual temperature in order to obtain the statistical structure of variables in future (2045-2065), which in our case is expressed by probability density function.

In Fig. 1, there can be seen transformation PDF between CGCM data and ERA data in the January for period 1961-1990. This PDF was substituted by normal distribution which was best fit function of the PDF. The normal distribution has following parameters: mean (0.968973) and standard deviation (0.0283732). In the same way the transformation PDF for virtual temperature was obtained. The transformation for specific humidity was constructed by PDF, which has the dependence to the ratio of virtual temperature PDF and dry temperature PDF, which is presented in Fig. 1. Obtained transformation PDF was applied to the future data.

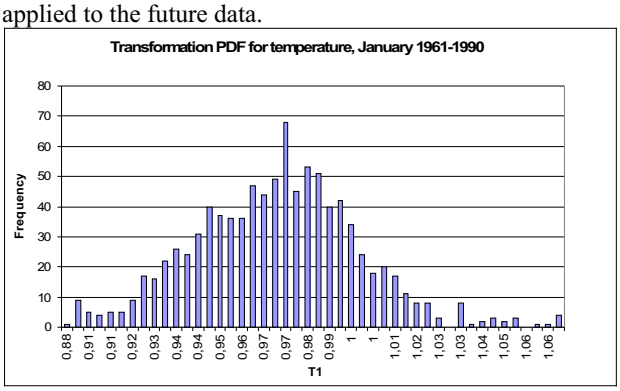

Figure 1. The transformation PDF for temperature in the period 1961-1990 in the 700hPa air pressure level.

Table 1. Statistical characteristics for temperature T (K) and specific humidity H (kg.kg^{-1}) for reference period 1961-1990 and scenario in period 2045-2065 at 700hPa.

Statistical characteristic for PDF			
PDF	Average	S.deviat.	Skew
T(61-91)	261.79	9.19	-0.10
T(45-65)	263.83	8.92	-0.02
H(61-91)	1.85e-3	1.23e-3	0.73
H(45-65)	2.21e-3	1.37e-3	0.59

The obtained result of the statistical structure of current temperature and specific humidity are presented in the Tab.1. Likewise the scenario for same variables is presented. It can be analyzed that the temperature increases about 1.9K. Asymmetry, which is expressed by skewnest parameter, decresed for both variables. These results are valid for aerologic station Ganovce and for 700hPa pressure level.

Changes in the characteristics of dry and wet spells in Central Eastern Germany

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Abstract. This study focuses on an adaptation of the precipitation-based drought indicator of deciles, developed by Gibbs and Maher (1967). The adapted concept was aditionally used for the calculation of wet spells. Long-term changes of regional drought and wet spell characteristics and patterns were analysed for Central Eastern Germany.

Introduction

Many examples from recent years have shown the vulnerability of human society towards climate extremes such as droughts, floods and storms. Especially drought is an often underestimated phenomenon in Central Europe, because its impacts are less obvious and more widespread than damages resulting from other natural hazards (Wilhite, 2000). This study works with the precipitation-based drought indicator of deciles, developed by Gibbs and Maher (1967), and adapts its concept for the calculation of wet spells. Long-term changes of regional drought and wet spell characteristics and patterns were analysed for Central Eastern Germany.

Data and methods

Analysis was done for 130 monthly precipitation series with different data availability for the period 1900 to 2006. The rain gauge stations were grouped into nine regions with similar natural landscapes and precipitation characteristics (Fig. 1). This grouping of stations was supported by correlation and cluster analysis. The poor data availability before 1951 limits the significance of some calculated long-term trends.

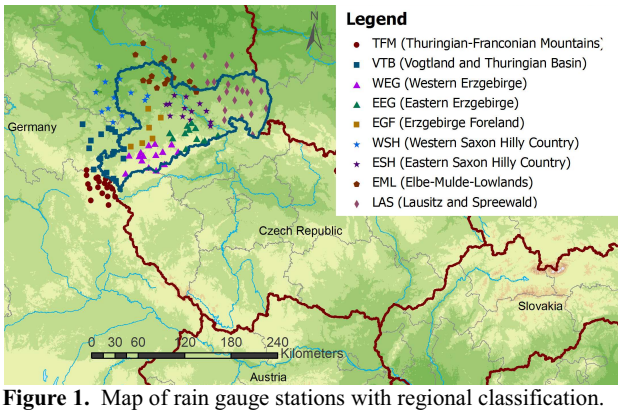

Figure 1. Map of rain gauge stations with regional classification.

The decile indicator is based on three-months-totals that are compared to the historical distribution. Beginning and end of decile dry and wet periods are determined by decile thresholds of this historical distribution (Keyantash and Dracup, 2002). A dry period starts, when the precipitation totals of the preceding three months fall within the lowest decile of the historical distribution of three month totals. A dry period ends, if a) the precipitation of the preceding month is in or above the fourth decile of the three month totals or b) the precipitation total for the past three months is in or above the eighth decile.

Similarly, a wet period starts, when the precipitation total of the preceding three months is in the highest decile. It ends when the three months total is below the fifth decile.

Trends are calculated using linear regression. The results are compared to the results of the non-linear and non-parametric Mann-Kendall test that was also applied to calculate the trend's significance.

The temporal and spatial characteristics of dry and wet spells is illustrated in Fig. 2 with monthly (x-axis) and station value (y-axis) resolution, and the colours brown and blue indicating a drought/wet period occurrence.

Results and disscussion

All nine regions covering the German federal states Saxony, Thuringia and Saxony-Anhalt show similar dry and wet period characteristics and pattern (Fig. 2). This suggests some larger scale trigger of drought and wet spell occurrence. The average decile dry period lasts, with approximately 10 months, longer than the average decile wet spell with 6.4 months. The longest drought lasted 63 months, the longest wet period 31 months. Within 50 years (1951-2000), slightly more wet periods than dry periods occurred. Decile dry spells lasting less than one year have decreased during the last century, whereas the number of dry periods exceeding 18 months has doubled. The results are opposite for wet periods – the number of short wet spells (< 6 months) has increased.

The regional coverage of wet periods is slightly below those of dry periods. The negative trends of regional coverage of decile wet periods are quite similar for all analysed periods (Fig. 4), whereas decile drought coverage trends invert from positive in 1900—2006 to negative in 1951—2006 (Fig. 3). This might be due to a change in instrumentation in the 1930s and the poor data availability at the beginning of the century. Droughts regionally seem to be more often interrupted by days or periods with heavy precipitation since the 1940s. The extent by which wet periods are triggered by large-scale processes is not as large nowadays as it has been at the beginning of the century.

Decile dry periods most often start in autumn or winter and are terminated in the summer months that are characterised by convective precipitation. The start of decile droughts has shifted between 1900 and 2000 from September and November to December and February. The number of ending decile droughts has increased in May and June.

Most decile wet periods start between April and June and end in September or October. The number of starting wet periods has decreased in April and June whereas July shows an increase. Regarding the end of wet spells, only slight changes of an increasing number have been observed in September and a decrease in October.

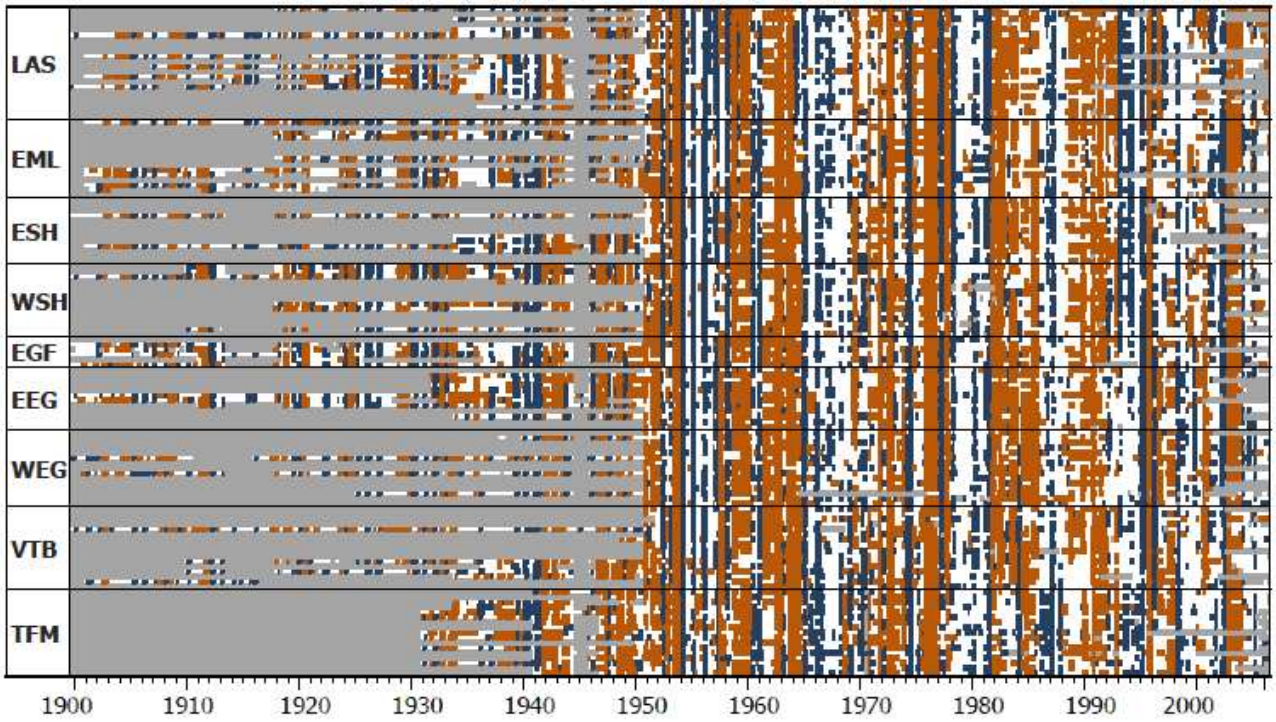

Figure 2. Timing of decile wet (blue) and dry (orange) period occurrence for 1900—2006 (grey bars indicate missing data).

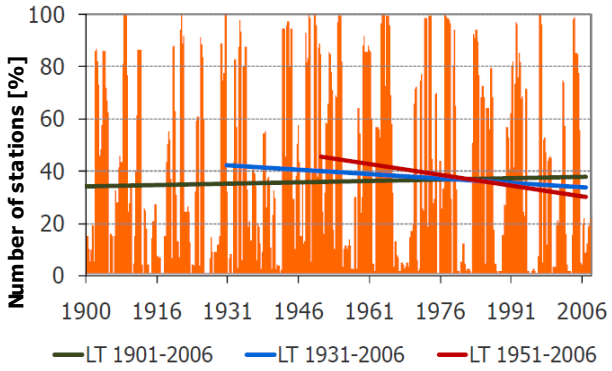

Figure 3. Spatial coverage of decile dry periods (1900—2006) with linear trends (LT) for three periods.

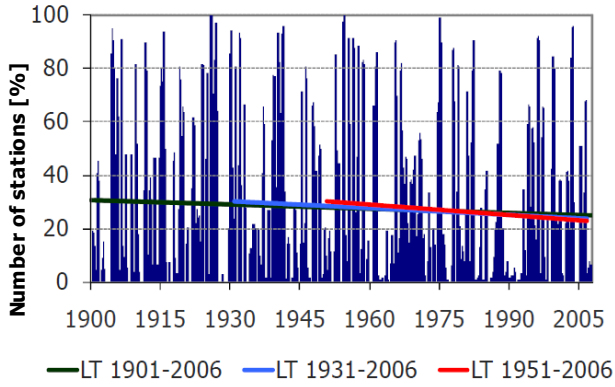

Figure 4. Spatial coverage of decile wet periods (1900—2006) with linear trends (LT) for three periods.

Conclusions

Changes of the length of decile dry and wet periods have been observed with a shift to longer droughts and shorter wet spells in South Eastern Germany. Furthermore, the characteristic months of the start and end of decile droughts and wet periods have shifted. Changes in the spatial coverage of decile dry and wet spells give evidence for changes in large scale precipitation patterns. Nevertheless, a poor data availability in the first half of the 20th century, instrumentation changes at all stations in the 1930s, and the characteristics (clustered occurrence in time) of decile dry and wet periods complicate the climatological interpretation of observed trends.

Acknowledgements The authors thank the Deutsche Bundesstiftung Umwelt DBU for financial support and Saxon State Agency for Enviroment, TU Dresden and German Meteorological Survey (DWD) for contributing the data.

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Monthly trends of daily heavy precipitation indicators from lowland to mountainous regions in Saxony, Germany

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Abstract. Significant seasonal changes have been observed in the study area, despite small annual precipitation trends for period 1951—2000 (e.g., Franke et al., 2004; Hänsel et al., 2009). Precipitation increases in winter are generally connected with more frequent and/or severe heavy precipitation events, while negative heavy precipitation trends predominantly occurred during the increasingly drier summer half of the year. A monthly trend analysis was done for 112 daily precipitation series with variable data availability within the period 1931 to 2006. Long-term trends of monthly precipitation totals and several 'Heavy Precipitation Indicators' (HPI) were calculated and compared for different periods (e.g., 1931/1941/1951 to 2006).

Introduction

The relevance of extreme climate characteristics, such as heavy precipitation and connected flood events, derives from their large impacts on human society and environment. Independent from physical changes in the frequency and intensity of heavy precipitation events, there is no doubt that the sensitivity of human society towards climate extremes is rising, as long as mankind continues to "develop" sensitive areas such as sea shores and floodplains and as long as populations in such areas increase. Changes in the natural landscapes connected to human infrastructures might furthermore aggravate the impacts of extreme climate and weather events (Karl and Easterling, 1999). It is vital to analyse and understand their variability at different spatial and temporal scales, since extremes are an expression of the variability of climate (IPCC, 2007).

Data and methods

The more extreme and thus more rare an event, the more difficult it is to identify long-term changes, simply because there are fewer cases to evaluate (Frei and Schär, 2001). Trend analyses of extremes have traditionally focused on standard and robust statistics that describe moderately extreme events (1st to 10th percentile) to avoid excessive statistical limitations (IPCC, 2007).

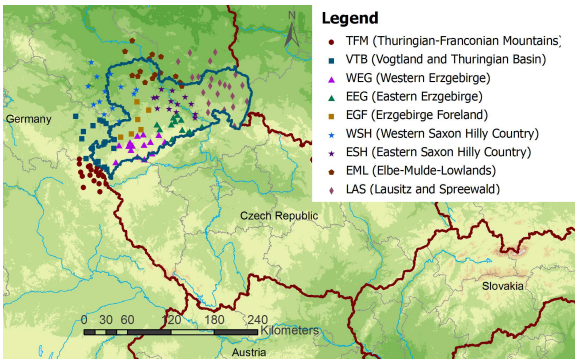

Figure 1. Map of rain gauge stations with regional classification.

A number of international workshops (Folland et al., 1999; Nicholls and Murray, 1999; Manton et al., 2001) developed indicator sets of extreme events that should be used worldwide – with the intention to ensure a global assessment of changes in extreme climate features. Within this study, 22 heavy precipitation indicators (HPI) that may be classified into the four groups "A", "I", "F" and "M", are used. "A" stands for average precipitation indicators like monthly precipitation totals and number of wet days. "I" comprises indicators measuring the precipitation intensity, like the SDPI (Simple Daily Precipitation Index) or the percentage of precipitation above the 95th percentile. The frequency of heavy precipitation events is studied by indicators in class "F", while category "M" includes indicators of heavy precipitation event's magnitude.

The indicators are calculated for 112 stations, classified into nine regions, with similar precipitation characteristics (Fig. 1). The stations show a very heterogenous data availability within the study period 1931—2006 (Fig. 2).

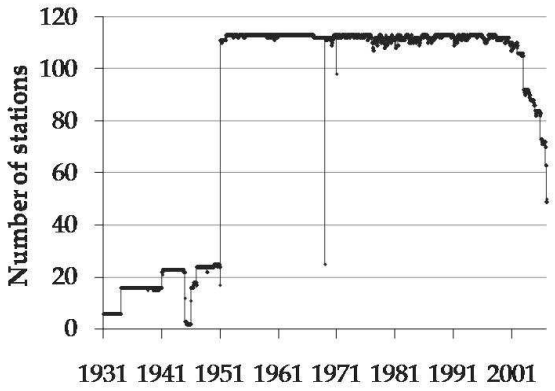

Figure 2. Digital data availability of daily precipitation totals for 1931—2006.

Trends are calculated using linear regression. The results are compared to the results of the non-linear and non-parametric Mann-Kendall test that was also applied to calculate the trend's significance.

Results and disscussion

The regional average and extreme precipitation characteristics strongly depend on the orographic structure of the study area. Regional gradients were observed for many indicators, ranging from high values for precipitation and wet extremes in the mountainous regions in the South-West of the study area (TFM, WEG and EEG) to the lowest values in regions of lower altitudes in the North-East (WSH, ESH, EML and LAS).

During the summer half year (SHY), HPI trends are predominantly negative, while positive trends dominate in the winter half year (WHY). The seasonal trends are generally less significant than the half year trends. There are different developments in individual months belonging to the same season. Figure 3 illustrates the spatial distribution of relative linear trends for exceeding the 95th percentile of daily precipitation for two exemplary months, namely March and April. The trends of two periods with different digital data

availability are compared. 1931 to 2006 is the longest studied period for daily data, and 1951—2000 is the period with the best data coverage within the study area. The trends of both periods are quite similar, although the positive trends in the northwestern lowland part of the study area (regions ESH and EML) in April is not represented in the data of 1931—2006, which might be due to the poor data coverage in that region (only one station).

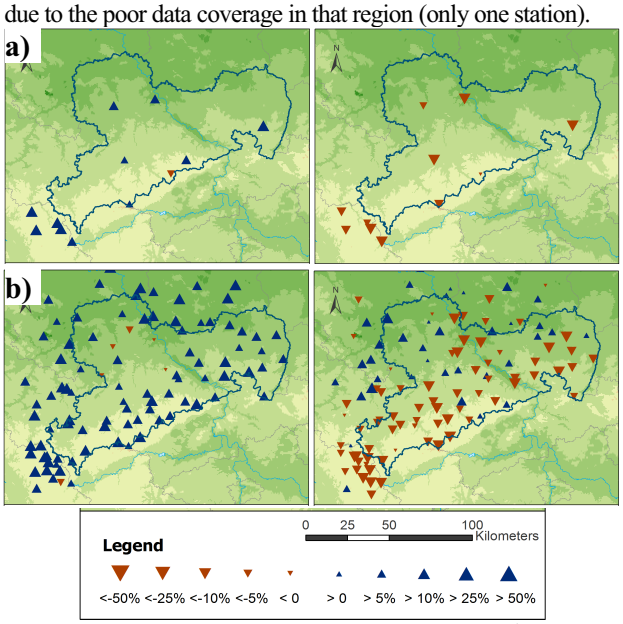

Figure 3. Relative linear trends of exceeding the 95th percentile for March and April for a) 1931—2006 and b) 1951—2000.

Most of the 22 studied indicators show similar trends in individual months. The trend direction of all indicators for the example months March and April is compared for all 112 stations within the nine regions in Fig. 4. In this illustration, every row represents a station and every column an indicator. The magnitude of the threshold (class "F") and the indicator magnitude ("M") increases from left to right.

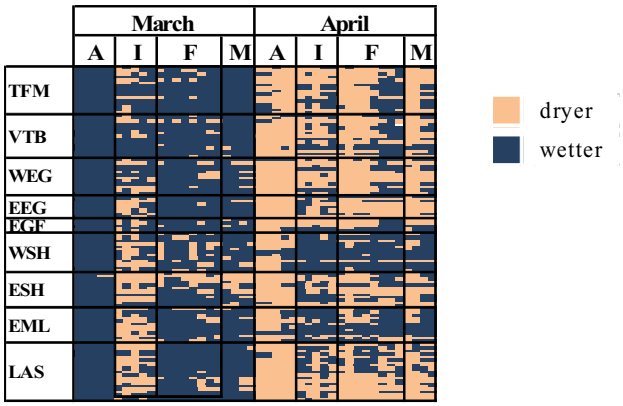

Figure 4. Comparison of the spatial trend characteristics of different HPI for March and April; 1951—2000.

Most indicators show trends similar to those of the exceedance frequency of the 95th percentile, illustrated in Fig. 3, with an increase in frequency and magnitude of heavy precipitation events in March and a decrease in April. Indicators in category "A" show the spatially most homogenous trend pattern. The trend dependency on the magnitude of the studied extremes is more pronounced for April than for March with a higher percentage of positive trends for indicators of more extreme events (thresholds: 20 mm or the 99th percentile of daily precipitation), as compared to indicators of moderately extreme events.

The spatial trend characteristic of increasing heavy precipitation events in April in the northwestern lowland regions ESH and EML, already shown for the exceedance frequency of the 95th percentile (Fig. 3), is also visible in many other indicators (Fig. 4). This development may be explained by changes in the average circulation types.

Conclusions

It has been shown that the trends of individual daily heavy precipitation indicators are quite similar and basically match the general precipitation changes, particularly for moderately wet extremes. Generally, the trends of moderate extreme heavy precipitation events are more robust (temporarily and spatially stable) and significant than those of the more extreme events, as accidental occurrences or outliers strongly influence the trends of extreme events. Succeeding months may show opposite trends as shown for the spring months March and April. The spatial pattern of many daily (extreme) precipitation indicators, as well as their connected trends, indicate a high influence of large-scale atmospheric circulation patterns. The orographic structure of the study area and surroundings influences the flow of air masses. This may result in regionally different precipitation trends with changes in the mean airflow directions. Analyses of the nature and changes of those atmospheric circulation patterns and their connection to precipitation characteristics would be very valuable.

Acknowledgements The authors thank the Deutsche Bundesstiftung Umwelt DBU for financial support and Saxon State Agency for Environment, TU Dresden and German Meteorological Survey (DWD) for contributing the data.

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Spatiotemporal Drought Characteristics in Central Eastern Germany and Southern Poland

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Abstract. Spatiotemporal drought patterns and characteristics of Central-Eastern Germany and Southern Poland were analysed for 1951 to 2006 using different meteorological drought indicators. The study area stretches over more than 1500 kilometres from the Harz-mountains in the West to the border between Poland and Ukraine in the East. The stations show similar drought characteristics in individual years and a clustered occurrence of drought events in time, suggesting some larger scale trigger of drought occurrence. This is true for very short and particularly intense dry periods (with typical duration of several weeks) as well as for longer lasting drought events (duration from several months to years). Nevertheless, also major differences between the eastern and western part of the study area occur in other years. Distinct annual and seasonal changes in the duration, severity and spatial characteristics were observed. The trend towards a lower spatial coverage of decile droughts gives evidence for changes in large scale precipitation patterns.

Introduction

Drought is considered by many to be the most complex but least understood of all natural hazards affecting more people than any other natural hazard (Hagman 1984). It arises from a natural decline in precipitation over an extended period of time, although other climate factors may significantly aggravate the severity of a drought event (Wilhite, 2000). In Central Europe, drought is often underestimated, because its impacts are less obvious and spread over larger geographical areas than damages resulting from other natural hazards. In contrast to floods, drought seldom results in structural damage. Therefore, the quantification of impacts is a far more difficult task.

Droughts basically differ in three basic characteristics: intensity, duration and spatial extent. Various drought indicators have been developed all over the world. Generally, four disciplinary perspectives in defining drought are considered (Wilhite and Glantz, 1985): 1) meteorological, 2) agricultural/ physiological, 3) hydrological and 4) socioeconomic drought. Realistic definitions must be specific for region and application or impact (Wilhite, 2000). This study focuses on the characterisation of meteorological drought and changes in spatiotemporal drought features.

Data and methods

The spatiotemporal drought characteristics from Central to Eastern Europe were studied using 44 German and Polish stations with daily precipitation time series. For some regional analysis the stations were grouped into four regions with similar precipitation characteristics (Fig. 1).

Long term drought characteristics and connected changes are assessed and compared, using several meteorological drought indicators implying different time scales. Those indicators are Rainfall Anomaly Index (RAI), decile droughts and meteorological dry periods. The latter are defined as a continuous sequence of dry days (Pd ≤ 1 mm). A daily precipitation total above 1 mm terminates the dry period although drought conditions may persist much longer. Using a threshold for the cumulated precipitation within the dry period that is increased for every continuing dry period day may overcome this shortcoming.

The RAI describes the monthly or seasonal deviations of actual from average precipitation (1961—1990), normalized by the ten most extreme precipitation events. It yields information on drought intensity. A station-based RAI of less than -3 refers to severe drought conditions. The RAI concept may also be adapted to describe drought duration. A drought event starts, when the RAI drops below -3 and ends when slightly wet conditions (RAI > 1) are reestablished.

Decile droughts are calculated by ranking the observed precipitation totals for the preceding three months against climatological records and computing the deciles for the total length of the precipitation record (Gibbs and Maher, 1967; Keyantash and Dracup, 2002). A dry period starts, when the 3-month-total falls within the lowest decile (10th percentile) of the historical distribution. It ends, when the precipitation of the preceding month is in or above the fourth decile (30th percentile) or the precipitation total for the past three months is in or above the eighth decile (70th percentile).

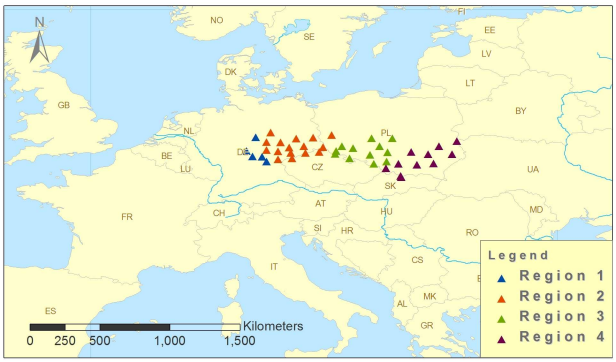

Figure 1. Rain gauge stations with regional classification

Results and disscussion

The most extreme dry years averaged over the whole study area were 1953, 1959, 1982 and 2003 according to the RAI (Fig. 2). Other years have been extremely dry only in individual regions of the study area, such as 1963/64, 1976, 1991 in regions 1 and 2, 1989 in region 3, and 1986, 1993 in region 4 (Fig. 3). The minimum and maximum RAI station values displayed in Figure 2 demonstrate the great spatial variability in drought intensity. Only two years show below average precipitation at all stations, namely 1982 and 2003. Similar developments within all regions are more common when looking into seasons and individual months.

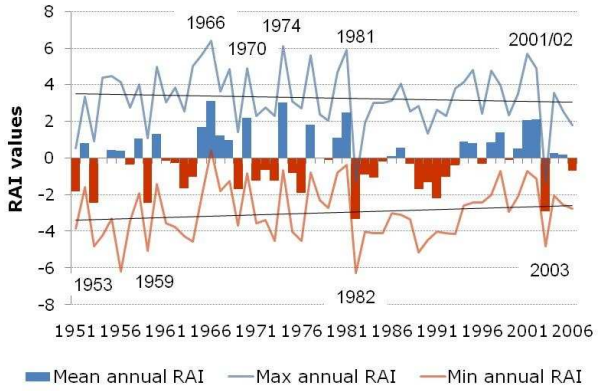

Figure 2. Regional mean, minimum and maximum RAI values for 1951 to 2006.

Fig. 3 compares the spatial characteristics of RAI and decile droughts. At times with clustered occurrence of decile droughts, intense RAI drought events have been observed, too. Differences in the spatial pattern may be partly attributed to the different time scales of the indicators (RAI: months, Deciles: three months).

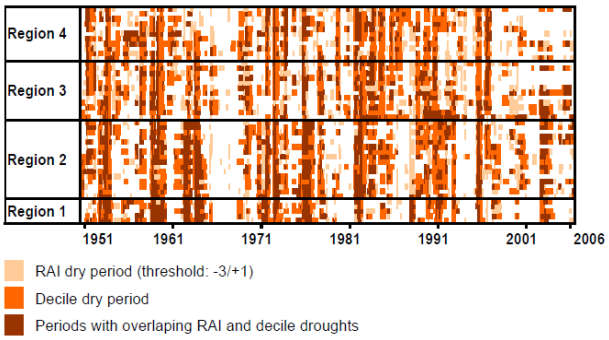

Figure 3. Comparison of the spatio-temporal drought characteristics using the drought indicators RAI and Decile droughts.

The frequency of meteorological dry periods has increased at most stations in the western regions 1 and 2 and decreased in the regions 3 and 4 during the warm half year (AMJJAS; Fig. 4; 1951—2000). Distinct increases during the cold half year (ONDJFM) have only been observed at individual stations; mainly in the East of the study area. Similar trends have been observed for the average and maximal duration of meteorological dry periods.

Conclusions

The identified droughts have different characteristics and a different spatial extent. For example, the 1982/83 drought has been one of the rare worldwide drought phenomena and occurred during an ENSO event (Glantz et al., 1987). The negative precipitation anomalies of 1962/63 and 1996 were connected with negative temperature anomalies. In contrast, a record-breaking heat wave affected the European continent in summer 2003 (Schär et al., 2004) and led to drought conditions in a number of economic sectors of many European Countries. With increasing global temperatures, drought conditions within the study area will probably be more often connected with high temperature extremes that aggravate the moisture deficits in many sectors. Thus purely precipitation based indicators may not accurately reflect the severity of future drought conditions.

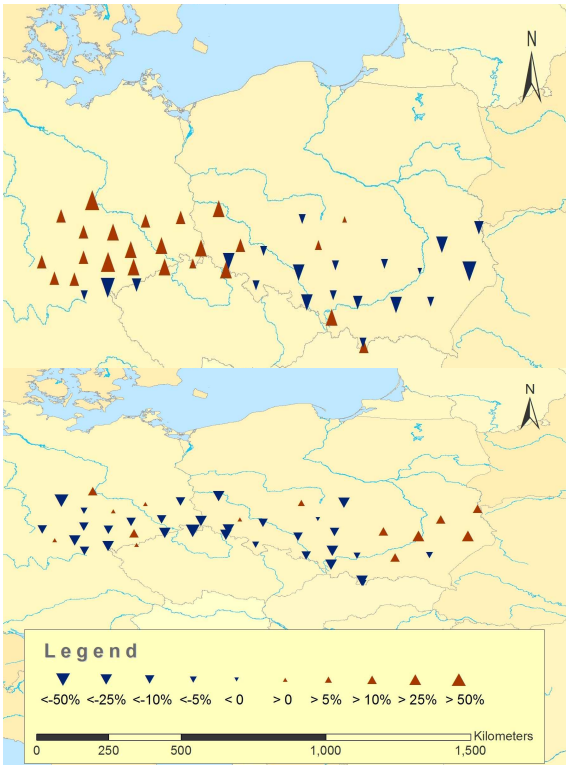

Figure 4. Relative linear trends of the frequency of meteorological dry periods for the warm (a) and cold (b) half of the year for 1951 to 2000.

The similar timing of drought events within all regions suggests some larger scale triggers of drought occurence. In some years, only part of the study area was affected by a drought event, showing the limit of the spatial drought extension. Studying a larger area would allow a more accurate determination of drought extensions. A comparison of those data to circulation characteristics could give evidence for the triggers of drought occurence.

Acknowledgements. The authors thank the Saxon State Agency for Enviroment, TU Dresden and German Meteorological Survey (DWD) for contributing the German data.

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Changes in precipitation characteristics in Central Eastern Germany – Trends of extreme precipitation and drought

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Abstract. Changes of regional precipitation characteristics within the last century are analysed for more than 100 stations in the German Free state Saxony and its surroundings with emphasis on the extremes, notably heavy precipitation and drought. The results are discussed in the context of global and regional climate change. A trend comparison of different time intervals allows qualifying the temporal representativeness of trends.

Introduction

Rising temperatures and changing precipitation pattern over Central Europe within the last century have lead to discussions about changes in the frequency and intensity of heavy precipitation and drought events. The study of such extreme events is of particular interest, because human society and ecosystems are especially vulnerable to those phenomena, as various examples over recent years have shown. Furthermore, changes in the extremes of precipitation distribution may be surprisingly high for seemingly modest mean changes.

Physically, the rising temperatures are expected to be associated with an intensification of the global water cycle, allowing more frequent and intense heavy precipitation events. Naturally occurring droughts may be aggravated by increased evapotranspiration. Precipitation changes are generally more spatially and seasonally variable than temperature changes. Different regional development scenarios are possible (Schönwiese and Rapp, 1997), as global warming effects may be intensified, compensated or overcompensated by altered weather conditions (Fricke, 2003).

The study area is situated at the interface of dominantly oceanic versus continental climate regimes. Therefore it shows precipitation characteristics and trends that are considerably different from the western parts of Germany, where the annual precipitation totals increased by just under 10% from 1901 to 2000 (Schönwiese and Janoschitz, 2005). In Saxony the annual precipitation totals show indifferent trends over the last 50 years (Franke et al. 2004; Hänsel et al., 2005, 2009); probably related to the increasing continentality of the climate. They do show, however, a distinct redistribution of rainfall during the year with drier summer half years and wetter winter half years, as Schönwiese and Rapp (1997) already noted for Germany.

Data and methods

Analysis of extreme climate events is associated with some challenges. The first one is connected to definitions since no universal definition of drought or heavy precipitation exists. Definitions highly depend on the application area and sector. The second challenge relates to the significance and robustness of statistical analysis. Detecting significant changes in the available instrumental weather records is difficult, due to the rarity of extreme events. Thus, long time series and special statistical methods are needed (Gerstengarbe and Werner, 1993). If no homogenous long time series of daily precipitation totals exist, analysis should concentrate on changes in moderately extreme events yielding enough events for reliable statistical analysis.

Generally, four disciplinary perspectives in defining drought are considered: 1) meteorological, 2) agricultural, 3) hydrological and 4) socioeconomic drought (Wilhite and Glantz, 1985). This study focuses on the characterisation of meteorological drought. Drought characteristics and changes are assessed and compared, using several meteorological drought indicators implying different time scales. These are e.g., Rainfall Anomaly Index (RAI), Percent of Normal Indicator (PNI) as well as decile and meteorological dry periods, using different threshold calculation concepts.

Changes in the frequency and magnitude of heavy precipitation events on daily, monthly and seasonal time scales are analysed using different indicators and thresholds for defining heavy precipitation extremes. Absolute thresholds are compared to percentile thresholds, defined in relation to the precipitation distribution at a particular place. Monthly and seasonal wet extremes are determined using some “drought indicators”, suitable to assess wet conditions in analogy to dry ones. The same applies for wet periods.

Analysis was done for more than 100 stations with different data availability within the study period 1901—2006. Some analysis use regional data besides calculating station trends. The stations are grouped into nine regions with similar natural landscapes and precipitation characteristics (Fig. 1). The poor data availability limits the siginificance of some regional long-term trends. Trends were calculated using linear regression. The non-linear and non-parametric Mann-Kendall test was used to calculate the significance of trends.

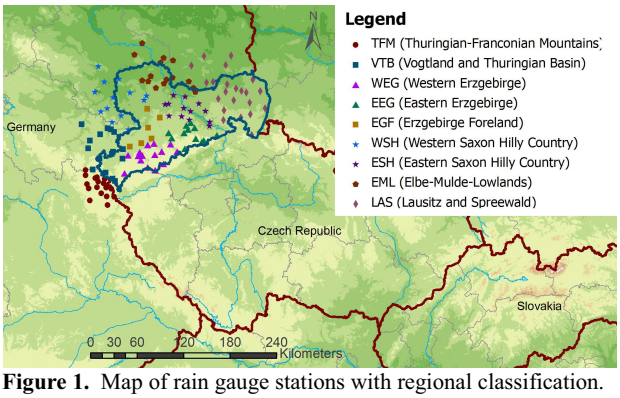

Figure 1. Map of rain gauge stations with regional classification.

Results and disscussion

Various indicators quite similarly identified the driest and wettest years, seasons and months within the study area. The years 1911, 1942/43, 1982 and 2003 have been particularly dry within most regions, while 1926/27, 1941, 1981and 2002 have been especially wet.

Most dry period indicators suggest decreases in drought duration in the second half of the 20th century. The trends of annual drought frequency were less similar for different indicators. Short meteorological dry periods (several weeks) showed regionally indifferent and small annual trends. Some indicators calculated decreases and others increases for the frequency of longer drought events (several months to years). Some indicators showed simultaneous decrease in duration and increase in frequency between 1951 and 2000 (e.g., Fig. 2). This might speak for a more frequent interruption of dry periods by periods of above average precipitation in recent times.

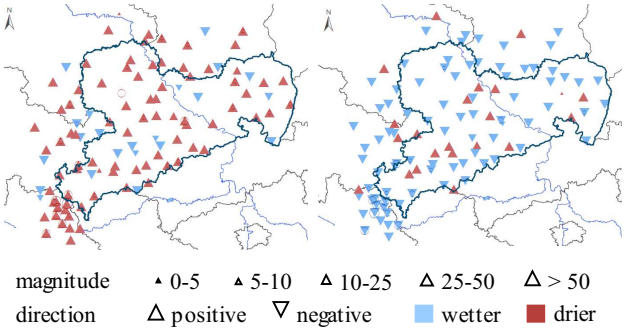

Figure 2. Linear trends of (left) frequency and (right) duration of long (> 91 days) dry spells in 1951—2000. Cumulated 75% of normal daily precipitation for the entire drought event duration was used as threshold for dry spell selection.

The trend results of daily and monthly wet extreme indicators are quite similar and basically match the general precipitation changes, particular for moderately wet extremes. Generally, the trends of moderate extreme heavy precipitation events are more robust than those of the more extreme events, as accidental occurrences or outliers strongly influence the trends of extreme events.

Comparing different thresholds for defining extreme precipitation events reveals that the trend results for the absolute threshold of 10 mm are very similar to those of the relative threshold of the 90th percentile of normal daily precipitation (Fig. 3). The same applies for the 20 mm and the 99th percentile thresholds.

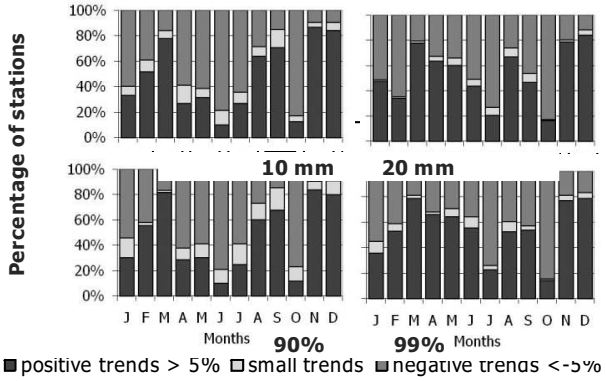

Figure 3. Direction of monthly frequency exceedance trends of daily precipitation for different thresholds for 1951—2000, column colors indicate the percentage of stations with strong positive (black), negative (grey) and small (light grey) trends.

Seasonal trends show that the summer half year (SHY: AMJJAS) is more frequently characterised by trends towards more frequent, severe and longer lasting dry periods than the winter half year (WHY: ONDJFM), matching the summer precipitation decreases. Opposite tendencies were found for the WHY with more probable increases in extremely wet events. Nevertheless, opposite trends of individual indicators are possible due to the different time scales they relate to.

Conclusions

The trends of wet and dry extremes match the general precipitation trends for most months and seasons, with increasing drought conditions in the SHY and increasing wet extremes in the WHY. Indicators of more extreme events might also indicate opposite but less robust trends. Many indicators show a spatial gradient from SW to NE in the indicator magnitude and related trends. North-eastern regions were more frequently and severely affected by droughts, while increases in wet extremes were most pronounced in the south-western parts of the study area.

The analysis showed that time frames of 50 years are far from being sufficient for reliable trend analysis of extreme drought or heavy precipitation, due to the large natural climate variability. Analysis of longer time-series revealed some similarities, but also some discrepancies to the results obtained for 1951—2006 period.

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Climatic conditions and development of skiing in the Skalnata dolina valley, the High Tatra Mountains

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Abstract. The paper is devoted to evaluation of climatic and meteorological conditions from the point of view of economical operation of skiing resorts. Analysis of measured data from Tatranská Lomnica and Skalnaté Pleso showed that criteria for economical operation of skiing resorts in the Alps (minimum snow depth 30 cm for at least 100 days) are not met in the High Tatra Mountains. Expected climate change would further deteriorate the conditions for skiing on natural snow and artificial snow production.

Introduction

The High Tatra Mountains and Bratislava are the most important tourist destinations in Slovakia. Annual number of visitors of the High Tatras varies between 300-450 000. Almost half of the visitors come from abroad (Statistical office of the Slovak Republic*)*. Winter tourism is especially important for the High Tatra Mountains. Statistical data show a significant increase of accommodation facilities in Slovakia since the beginning of the 1990'. The number of visitors increased from 2 255051 in 1991 to 4 082 645 in 2008. The data indicate a lot of investment and increasing competitiveness in the tourism business in Slovakia. Local authorities and tourist operators in the High Tatras strive to improve the conditions for winter tourism to make them comparable with the traditional destinations, e.g. the Alps. Intensive development occurred in the Skalnatá dolina valley in the year of 2008. It comprised terrain modifications, reconstruction of ski lifts and construction of snow-making facilities. Because the development took place on the territory of national park, it has attracted also the attention of environmentalists who pointed out the impacts on the environment. Success of the project depends on a number of factors, climatic and meteorological conditions being among the most important ones.

Criteria of economical operation of skiing resorts have been thoroughly analysed in many regions of the world (the Alps, North America, Australia), especially from the point of view of expected climate change. For example, the World Tourist Organization (2003) recently concluded that climate change in the European Alps will be manifested by the increase of winter temperatures, increase of snowline altitude by 100 m per decade and higher winter precipitation. It is expected that climate change will result in increased risk of avalanches and shorter skiing seasons. It was stated for example that if the climatic scenarios of the Swiss Alps for time horizon 2030-2050 are correct, only the resorts above 1600-2000 m a.s.l. will offer snow-reliable conditions. The snow-reliable conditions are defined as at least 30-50 cm of snow with duration of at least 100 days between December 1 and April 15 in seven out of 10 winters. The number of snow-reliable resorts would be reduced by 40% compared to present situation (Buerki et al., 2003). Abegg (2006) analysed the impact of climate change on 666 ski areas from Austria, Switzerland, France, Germany and Italy. He concluded that if the air temperature increases by 2ºC (what should happen approximately in 2050), only 61% of present areas would remain naturally snow-reliable. The low lying skiing areas would likely disappear, but the most important regions would be the least affected. Numerous other authors (e.g. Breiling and Charamza, 1999; Walter, 2001; Perry, 2003) came to similar conclusions. OECD Environment Directorate recently elaborated the first systematic cross-country analysis of snow-reliability of Alpine ski areas under climate change (Agrawala, 2007).

Winter tourism\skiing-oriented studies in the developed world did not stop at statement that changing climate will deteriorate conditions for economical operation of many resorts. Adaptation strategies were developed for the areas that depend on winter tourism (e.g. Agrawala, 2007). It was noted the application of the adaptation strategies will mostly need to include also other sectors such as water supply and water resources management, sanitation and natural conservation (e.g. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2007). Change of activities focus at some present skiing resorts is also expected.

In Slovakia, there are almost no analyses of the influence of climatic and meteorological conditions on the operation of skiing resorts. Holko and Kostka (2007) used mathematical modelling of snow accumulation and melt to analyse the duration of suitable snow conditions and conditions for operation of snow-making facilities for skiing resorts of central northern Slovakia for several scenarios of climate change. The results indicated that the resorts with the highest altitude should not be so seriously affected. However, it may happen that skiing conditions after Christmas which is economically the most important time will not be good. Resorts located at lower altitudes may have problems with snow in the future. Data used by Holko and Kostka (2007) were not measured directly in the studied resorts. The inputs to the mathematical model of snow cover (precipitation, air temperature) were interpolated from the standard network of Slovak Hydrometeorological Institute. The Skalnatá dolina valley is an interesting location for a more detailed study, because of the existence of several stations providing measured data. At the same time it is an important skiing resort where high investments were made recently. The objective of this study was to use measured and simulated data for the Skalnatá dolina valley to analyse skiing conditions under current and future climates.

Methodology

The study consisted of two main parts. In the first part, measured data relevant to skiing conditions from two meteorological stations situated in the Skalnatá dolina valley were analysed during periods 1971-2000 (seasonal long-term climatic normal) and 1998-2007 (last decade). Station Skalnaté Pleso represents conditions at the upper section of the ski lifts Tatranská Lomnica-Skalnaté Pleso and lower section of the

skiing slope Skalnaté Pleso-Lomnické sedlo. Station Tatranská Lomnica represents the lower section of the funicular and ski slope Tatranská Lomnica-Skalnaté Pleso. The daily data on air temperature, precipitation, snow depth, cloudiness and wind speed were analysed. Snow depth threshold of 30 cm was used to characterise suitable skiing conditions. Second part of the study was devoted to the assessment of the impact of climate change on snow depth. Mathematical model COUP (Jansson and Karlberg, 2004) was calibrated and validated by means of measured daily data from period 1998-2007 for stations Skalnaté Pleso and Stará Lesná. Data from Stará Lesná were used in the modelling because Tatranská Lomnica did not have the required data. The main input data (precipitation, air temperature) were changed after model calibration according to climate scenarios GISS for time horizons 2030 and 2075 developed by Lapin and Melo (2005). The model was run again to calculate snow characteristics for changed climate and the results were compared with those from the reference period 1998-2007.

Results and Conclusions

Analysis of measured data from meteorological station at Skalnaté Pleso in winters 1971-2000 shows that skiing on natural snow at the altitude of the station was on average possible approximately during 68 days (Tab. 1).

Table 1. Past (1971-2000), present (1998-2007) and future (2030\2075) seasonal (December-April) climatic characteristics (mean, ±standard deviation) in the Skalnatá dolina valley.

Seasonal climate normal 1971-2000			Winter seasons 1998-2007			Modelling for periods 2030 \ 2075		
t [°C]	P [mm]	Nds [day]	t [°C]	P [mm]	Nds [day]	t [°C]	P [mm]	Nds [day]
Skalnaté Pleso asl.			Lat. 49°11' N, Long. 20°14' E, Alt. 1778 m					
-3.6 ±1.1	333 ±112	68 ±43	-3.1 ±1.1	456 ±121	66 ±36	-2.1\ -0.6	479\ 539	55\4 4
Tatranská Lomnica			Lat. 49°09' N, Long. 20°17' E, Alt. 827 m asl.					
-1.1 ±1.3	197 ±65	23 ±25	-0.8 ±1.3	223 ±57	26 ±29	-	-	-
Stará Lesná asl.			Lat. 49°09' N, Long. 20°17' E, Alt. 810 m					
-			-0.8 ±1.4	200 ±46	17 ±20	0.2\ 1.6	211\ 235	8\3
t – mean air temperature, P – mean total of precipitation, Nds – mean number of day with snow depth above 30 cm								

High values of cloudiness (53 overcasted days) and wind speed (10 days with wind speed over 10 $m.s^{-1}$) may negatively influence operation of funicular or attendance of the resort. Long-term measurements (1971-2000) at station Tatranská Lomnica (Tab. 1) suggest much worse natural conditions for skiing at the lower section of the ski slope. Comparison of climate characteristics between long-term normal (1971-2000) and last winters (1998-2007) showed increases in air temperature by about 0.3-0.5°C and in precipitation by about 26-123 mm. Increase in precipitation was probably the reason of similar number of days with snow depths of at least 30 cm despite of the air temperature increase (Tab. 1). Yet, ski-seasons at both Skalnaté Pleso and Tatranská Lomnica were on average too short for economical operation of the resort if the criteria used in the Alps were applied. Data from Stara Lesná (1998-2007) showed that Stará Lesná is comparable with Tatranská Lomnica. Thus, the results of modelling performed with the data from Stará Lesná could be used to describe future conditions at Tatranská Lomnica. The modelling showed that if precipitation and air temperature follow climatic scenarios GISS, the number of days with snow depth of at least 30 cm at Skalnaté Pleso would decrease on average from 66 to 55 and 44 in time horizons 2030 and 2075, respectively (Tab. 1). Analogical results for Stará Lesná indicate a dramatic decrease from 20 to 8 and 3 days, respectively.

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Changes in the Frequency of Grosswetterlagen and their Characteristics in Saxony

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Abstract. German mean temperatures increased and precipitation patterns changed between 1901 and 2007. Changes in the frequency and character of weather patterns are important reasons for this development. Monthly, seasonal and yearly trends in the frequency of Grosswetterlagen (in the Hess-Brezowsky system) and their significance were computed. Highly significant increases of circulation types with south-western airflow from spring to autumn, southern flow in spring as well as eastern and south-eastern airflow in summer occurred, while north-western circulation types decreased in summer and north-eastern airflow regimes in spring and autumn. Recent changes in temperature and precipitation characteristics in and around Saxony, and their connection to circulation regimes, will be analyzed in a next step, comparing the two time slices 1961—1990 and 1991—2005.

Introduction

German mean temperature increased by +0.93 K between 1901 and 2007 (linear trend), with the strongest trends in the south-western and the lowest in the north-eastern part of the country. Precipitation increased by 10% during the same time period, with above average values in the western and far below average values in the eastern part. In Germany, seasonal and monthly trends vary within regions, but tend to increase in the winter half year, while the summer half year shows unequal behaviour (Müller-Westermeier, 2008). Temperature and precipitation trends in Saxony deviate from the rest of the republic, e.g., an annual precipitation decrease of 5% was observed. The position of low mountain ranges, which strengthen precipitation amounts of northern airflows and weaken those from southern directions are one of the underlying reasons (SMUL, 2005). Thus, changes in the frequency of circulation patterns are important indicators to explain alterations of climatic parameters.

Data and Methods

Weather patterns are defined as atmospheric conditions over a large area, i.e. Europe that remain relatively stable for at least a few days. The first approach to create a circulation-based model of different *Grosswetterlagen* (GWL) dates back to Baur (1944), who published the first "Kalender der Großwetterlagen Mitteleuropas" (Calendar of large-scale weather patterns in Central Europe). Several improvements followed by Hess & Brezowsky (1977). This study is based on the modified classification by Gerstengarbe & Werner (2005), who define 29 Grosswetterlagen (GWL) for Central Europe to describe the current weather situation. These are summarized in ten Grosswettertypen (GWT) according to the origin of the airflow (Table 1).

This study uses the dataset of GWL from 1881 to 2004 (Gerstengarbe & Werner, 2005), extended to 2007 with data provided by the German Weather Service (DWD). Monthly, seasonal and yearly GWL and GWT occurrences were calculated for the time period 1901-2007. First, trends were computed and illustrated for the entire episode. These were then displayed by a time-variable trend analysis for every possible start and end date. Changes in the seasonal cycle of GWL and GWT were analysed by comparing the periods 1901—1950 and 1951—2000. To cope with small datasets of some GWL and to filter random effects, data were plotted using 11 and 31 day low pass filters.

Table 1. Classification of Grosswettertypen (GWT) and Grosswetterlagen (GWL) (Gerstengarbe & Werner, 2005; Hess & Brezowsky, 1977).

Grosswettertyp (GWT)	Grosswetterlage (GWL)	
General Weather Circul.	*General Weather Pattern*	
West	WA	West Circulation, anticyclonal
	WZ	West Circulation, cyclonal
	WS	Southern West Circulation
	WW	Angled West Circulation
Southwest	SWA	Southwest Circulation, anticyclonal
	SWZ	Southwest Circulation, cyclonal
Northwest	NWA	Northwest Circulation, anticyclonal
	NWZ	Northwest Circulation, cyclonal
Central European High	HM	Central European High
	BM	Central European Ridge
Central European Low	TM	Central European Low
North	NA	North Circulation, anticyclonal
	NZ	North Circulation, cyclonal
	HNA	Norwegian Sea High, anticyclonal
	HNZ	Norwegian Sea High, cyclonal
	HB	British Isles High
	TRM	Central Europe Trough
Northeast	NEA	Northeast Circulation, anticyclonal
	NEZ	Northeast Circulation, cyclonal
East	HFA	Fennoscandian High, anticyclonal
	HFZ	Fennoscandian High, cyclonal
	HNFA	Norwegian Sea/Fennoscandia High, anticyclonal
	HNFZ	Norwegian Sea/Fennoscandia High, cyclonal
Southeast	SEA	Southeast Circulation, anticyclonal
	SEZ	Southeast Circulation, cyclonal
South	SA	South Circulation, anticyclonal
	SZ	South Circulation, cyclonal
	TB	British Isles Low
	TRW	Western Europe Trough
	U	Undefined

Changes in temperature and precipitation characteristics of every GWL/GWT were analysed with a DWD dataset, including climate data from weather stations in and around Saxony. The periods 1961—1990 and 1991—2005 were compared, using the methods of the "Saxon Climate Atlas" (SMUL, 2008).

Changes in the Frequency of GWL and GWT

Variations and trends in the occurrence of GWL/ GWT are important indicators to explain a wide range of temporal modifications in climatic parameters. Thus, characteristics and changes in the intra-annual and long term behaviour of GWL/GWT were analysed for different time frames.

Linear trends of occurrence for months, seasons and years were computed for every GWL/GWT, and their significance was tested using the t-test for the period 1901—2007 (Table 2). Significant frequency changes were found in all GWT. Some circulation types show similar behaviour throughout the entire year (increasing south-westerly and decreasing north-easterly airflow), while others have distinctive seasonal differences.

Table 2. Linear trends for days of occurrence for GWL/ GWT and their significance in the period 1901-2007 (grey: trends not tested for significance, as the data collective was below 30).

GWT	GWL	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Win.	Spr.	Sum.	Aut.
W	WA	-0,6	-0,4	0,5	-0,5	-2,0	0,4	-0,7	-0,8	0,8	-0,2	-1,8	1,1	-4,3	-0,2	-2,0	-1,1	-1,2
	WZ	4,1	1,6	1,7	-1,7	-1,9	1,4	0,1	-5,5	0,7	-0,2	2,5	2,2	5,0	7,4	-1,8	-4,1	3,0
	WS	0,2	-1,0	-1,9	-0,3	0,4	0,3	-0,6	-0,4	-0,4	-1,4	-0,4	-2,1	-7,6	-2,7	-1,8	-0,6	-2,3
	WW	-0,3	0,6	-0,3	-0,2	0,2	-0,3	0,1	-1,1	-0,1	0,3	0,6	-0,3	-0,7	0,0	-0,3	-1,3	0,8
SW	SWA	0,6	-0,1	0,9	0,5	1,2	1,4	0,4	1,2	1,2	1,7	1,1	0,2	10,2	0,8	2,6	3,0	3,9
	SWZ	0,3	0,9	1,2	1,7	2,9	1,8	2,5	1,7	2,2	4,0	0,8	0,6	20,5	1,9	5,8	6,0	7,0
NW	NWA	-2,0	-1,3	-1,1	-1,4	-0,9	-3,0	-4,5	-2,7	0,4	0,3	0,0	-1,1	-17,4	-4,3	-3,4	-10,2	0,7
	NWZ	0,9	2,9	3,7	-0,5	0,1	-0,8	-0,1	-0,8	0,5	-0,3	0,5	0,7	6,7	4,7	3,3	-1,8	0,8
HME	HM	-4,0	-4,2	-3,6	-0,2	-2,6	-0,9	-2,6	-2,6	-5,0	-2,0	-0,1	-0,7	-28,4	-8,6	-6,4	-6,1	-7,1
	BM	3,4	2,5	4,1	2,1	3,1	2,8	4,6	4,0	2,7	-0,2	-1,3	0,6	28,3	6,1	9,3	11,4	1,2
TME	TM	-1,3	0,3	-1,6	0,0	0,2	-0,1	-1,0	1,4	0,4	-0,1	-1,1	0,0	-2,9	-1,4	-1,3	0,3	-0,8
N	NA	0,3	0,2	0,0	0,2	-0,9	-0,1	-0,7	-0,5	-0,4	-0,1	-0,3	-0,1	-2,1	0,5	-0,6	-1,2	-0,8
	NZ	0,7	-0,1	-1,2	-0,8	-2,0	-3,5	-1,4	0,7	-1,4	-0,6	1,1	0,4	-8,3	1,1	-4,1	-4,2	-1,0
	HNA	0,1	-0,2	-0,9	0,2	-1,5	-2,4	-1,7	-0,3	-0,8	-1,5	-0,7	-0,2	-10,1	-0,2	-2,2	-4,5	-3,1
	HNZ	0,1	0,5	0,3	0,1	1,3	-0,1	0,5	0,4	0,1	-0,1	-0,4	0,3	3,0	0,9	1,7	0,8	-0,4
	HB	0,2	0,2	0,3	0,6	-0,4	0,6	1,6	-0,4	-0,4	0,7	0,2	0,8	3,9	1,3	0,5	1,8	0,5
	TRM	0,1	-0,3	1,3	1,0	0,5	2,3	1,7	1,7	1,8	0,5	0,8	1,5	13,0	1,1	2,8	5,7	3,1
NE	NEA	-0,6	-0,6	-1,6	-0,5	-1,0	-1,7	-2,4	0,0	-1,6	-0,8	-0,1	0,5	-10,5	-0,9	-3,1	-4,2	-2,4
	NEZ	0,0	-1,0	-0,5	-1,3	-1,2	-0,3	0,1	-0,6	-1,4	-0,1	0,4	-0,1	-6,1	-1,1	-2,9	-0,9	-1,1
E	HFA	-2,8	0,2	1,0	-1,9	-0,7	-0,9	0,4	2,6	-1,3	-2,2	0,1	-1,6	-7,0	-4,1	-1,5	2,2	-3,4
	HFZ	-0,3	0,4	0,2	1,2	0,6	0,3	0,8	0,8	0,0	0,4	0,2	0,1	4,7	0,2	2,0	1,9	0,6
	HNFA	-0,1	-0,1	0,8	-0,5	0,8	-0,2	1,3	0,2	-0,5	0,9	-0,1	-0,2	2,2	-0,4	1,1	1,3	0,3
	HNFZ	1,6	0,7	-2,0	0,2	-0,8	0,8	0,2	0,4	0,4	0,1	0,2	0,1	2,0	2,5	-2,6	1,4	0,7
SE	SEA	1,2	0,9	-1,0	-0,2	0,0	0,0	0,8	0,1	-0,5	0,0	-1,0	-0,8	-0,5	1,4	-1,2	0,9	-1,5
	SEZ	-0,9	-0,9	-0,2	-0,2	0,3	0,4	0,0	0,3	0,1	-0,2	-0,7	-0,1	-2,1	-1,8	-0,1	0,6	-0,7
S	SA	-1,1	-0,1	-0,9	-0,3	0,1	0,4	0,0	0,2	-0,3	0,6	-2,2	-1,0	-4,6	-2,1	-1,1	0,6	-1,9
	SZ	0,2	-0,7	-0,2	-0,2	0,0	0,1	0,0	0,0	0,1	-0,4	0,6	-0,6	-1,0	-1,1	-0,3	0,1	0,4
	TB	-0,1	-0,4	0,4	-0,4	0,0	-0,3	-0,3	-1,2	1,2	0,1	-0,4	-0,8	-2,2	-1,3	0,0	-1,8	0,9
	TRW	0,1	-0,3	0,6	3,6	3,8	2,2	0,8	1,2	1,5	0,8	1,4	0,3	16,0	0,2	8,0	4,1	3,7
	U	0,1	-0,1	-0,1	-0,2	0,1	-0,4	0,1	0,2	0,2	-0,1	0,1	0,2	0,1	0,3	-0,2	-0,1	0,2
GWT		**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Year**	**Win.**	**Spr.**	**Sum.**	**Aut.**
W		3,3	0,9	0,1	-2,8	-3,2	1,8	-1,1	-7,8	0,9	-1,6	1,0	0,9	-7,5	4,4	-5,9	-7,1	0,4
SW		0,8	0,7	2,1	2,2	4,1	3,2	2,9	2,8	3,4	5,7	1,8	0,9	30,7	2,7	8,4	8,9	10,9
NW		-1,1	1,6	2,5	-1,9	-0,8	-3,8	-4,6	-3,6	0,9	0,0	0,5	-0,5	-10,6	0,4	-0,2	-12,0	1,4
HME		-0,6	-1,7	0,5	1,9	0,6	1,9	2,0	1,4	-2,3	-2,2	-1,4	0,0	-0,1	-2,4	2,9	5,3	-5,8
TME		-1,3	0,3	-1,6	0,0	0,2	-0,1	-1,0	1,4	0,4	-0,1	-1,1	0,0	-2,9	-1,4	-1,3	0,3	-0,8
N		1,6	0,4	-0,2	1,3	-3,1	-3,1	-0,1	1,6	-1,2	-1,2	0,7	2,7	-0,6	4,7	-1,9	-1,6	-1,8
NE		-0,7	-1,6	-2,1	-1,8	-2,2	-2,1	-2,3	-0,7	-3,0	-0,8	0,3	0,4	-16,5	-2,0	-6,1	-5,0	-3,6
E		-1,6	1,1	0,0	-1,1	0,0	0,0	2,7	4,1	-1,4	-0,8	0,4	-1,6	1,9	-1,8	-1,1	6,8	-1,8
SE		0,3	0,0	-1,2	-0,4	0,3	0,4	0,8	0,4	-0,4	-0,2	-1,7	-0,9	-2,6	-0,5	-1,3	1,5	-2,2
S		-0,9	-1,6	0,0	2,7	4,0	2,3	0,6	0,2	2,6	1,2	-0,6	-2,2	8,1	-4,4	6,6	3,1	3,1

positive Trend p<=0,1 (low significance)
positive Trend p<=0,05 (medium significance)
positive Trend p<=0,01 (high significance)
negative Trend p<=0,1 (low significance)
negative Trend p<=0,05 (medium significance)
negative Trend with high significance (p<=0,01)

GWT changes can often be explained by looking at the GWL, since, for example, the GWL "West Circulation, cyclonal" (WZ) dominates the GWT "West" (W),. Nevertheless, a slight and insignificant annual increase of "WZ" (+5 days) is met by a decrease of -7.5 days for "W". While "W" shows an insignificant raise (+4.4 days) in winter. GWL "WZ", bringing mild, moist and windy winter weather, increased by +7.4 days with a significant raise (+4.1 days, $p \leq 0.05$) in January. In spring and summer, GWT "W" decreased significantly with a highly significant ($p \leq 0.01$) decline of GWL "WZ" in August (-5.5 days).

The frequency trends of GWT "Southwest", transporting warm air masses all year round, are positive in every month; highly significant from April to October. With more than 20 days, the annual increase of GWL "Southwest circulation, cyclonal" shows twice the amount of the anticyclonal south-western circulation.

North-western circulation types (GWT "NW"), responsible for cool temperature conditions, decreased significantly in summer (-12 days; Fig. 1). A large part of this summer decline is reflected by the anticyclonal part of the GWT (NWA) that also shows significant negative trends in winter and spring. The cyclonal part of the GWT (NWZ) rises significantly in winter and spring, resulting in just small changes in the GWT.

With a low significance, GWT "Central European High" increases in summer and declines in autumn. No change is visible in the frequency of that GWT on an annual basis, but GWL "Central European High" (HM) shows a highly significant decline with -28 days, while the GWL "Central European Ridge" (BM) increases by the same amount and significance.

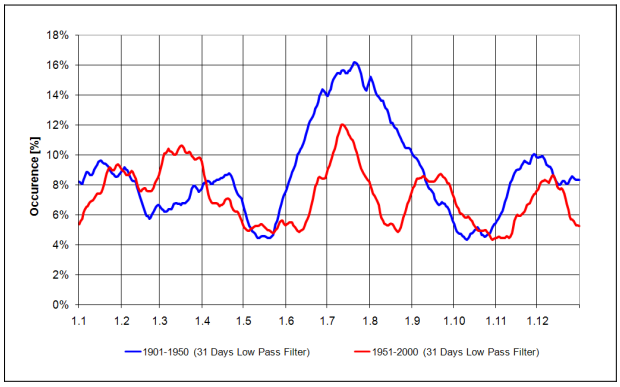

Figure 1. Changes within the seasonal cycle of the GWT „Northwest", comparing the periods 1901—1950 and 1951—2000.

Circulation types with a trough over western or central Europe ("TRM" and "TRW") increased by +29 days with a significant raise from spring to autumn, while the GWL "Central European Low" (TM) declined insignificantly.

Meridional circulation types, including all GWT´s that bring air masses from N, NE, E, SE and S, show indifferent behaviour. While north-eastern airflow events (NE) and the GWL´s "NZ", "HNA" and "HFA" declined significantly per year, others, such as trough-conditions and the GWL "HFZ", demonstrate a significant increase. Positive trends were also found for GWT "East" (E) and "Southeast" (SE) in summer and GWT "South" (S) in spring.

Conclusions

Changes in the frequency of circulation patterns were found and described. The annual rise of warm south-western airflow by more than +30 days could be one reason for the observed warming in Saxony and the decreasing precipitation amounts since 1901. Saxon Summer warming and drying could be further explained by the decline of western and north-western circulation forms in combination with the rise of south-western and eastern airflows as well as high pressure systems over central Europe. Further research will combine those findings with temperature and precipitation changes in Saxony for a recent timeframe (1961—1990 vs. 1991—2005).

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Mountain Climate Change in Saxony – Awareness of Tourism Professionals and Adaptation Strategies in Winter Tourism

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Abstract. Conditions for winter tourism in Saxon low mountain areas declined over the last decades. This trend is expected to continue. Results of a survey are presented, involving representatives of Saxon downhill skiing areas and of winter tourism municipalities. A vast majority recognize climate change as a serious issue, but 2/3 of the skiing area representatives and 1/3 of the municipality agents do not think that skiing conditions in their regions will change over the next 15-20 years. Research results indicate the opposite, suggesting the implementation of adaptation strategies to provide a less snow dependent winter tourism including new ways to attract tourists.

Introduction

Winter tourism in mid latitude low mountain ranges is highly vulnerable to warmer climate conditions because of its snow dependency. Mild winters with poor snow conditions increased in Saxony during the last decades. Altitudes below 800 m are particularly affected (Freydank, 2001). Even higher elevations, such as the Fichtelberg, Saxony's highest mountain (1215 m), experienced a 24% decrease in the average snow cover in the winter half year (November – April) in the period 1981-2008 as compared to 1951-1980 (DWD, 2009). Climate models project a strengthening of these tendencies during the 21st century (IPCC, 2007). With changing climatic conditions, tourism has to find new, creative ways to attract tourists in winter (Hoy, 2008).

Data and Methods

Saxon low mountain ranges consist of five mountainous regions that extend along the southern border of the Free State of Saxony to the Czech Republic (Fig. 1).

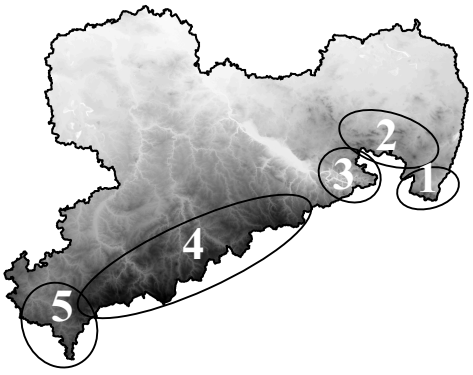

Figure 1. Digital terrain model of Saxony with the five Saxon low mountain regions (highlighted; details in text). Darker colours depict higher terrain (total elev. from 90 to 1215 m a.s.l.).

These are from east to west (region, highest point):

1) Zittau Mountains (Lausche, 793 m),
2) Oberlausitz/Upper Lusatia (Valtenberg, 587 m),
3) Saxon Switzerland (Großer Zschirnstein, 562 m),
4) Erzgebirge (Fichtelberg, 1,215 m) and
5) Vogtland (Schneehübel, 974 m).

Fifty-nine telephone interviews, with two groups of tourism professionals from these regions were carried out from January 10 to 18, 2008. Downhill skiing areas (33 agents) generate the highest touristic income – solely dependent on stable snow conditions. Touristic municipalities (28 representatives) are generally concerned with touristic income creation through (winter) tourism and the related reputation of their location. Interview partners were chosen to represent the relative touristic relevance of their region. The number of representatives of downhill skiing areas vs. representatives of municipalities from each region was: Zittau Mountains (3/3), Oberlausitz (5/4), Saxon Switzerland (2/2), Erzgebirge (18/14) and Vogtland (5/5).

This study evaluates existing and prospective new touristic offers in winter tourism, based upon a comprehensive picture of the current status of winter tourism and its marketing. Awareness and involvement of Saxon tourism professionals on climate change issues was assessed to explore internal misgivings and opportunities in Saxon winter tourism.

Awareness of Tourism Professionals

Summer tourism (May – October) is much more important than winter tourism in the lower mountainous areas of eastern Saxony (Zittau Mountains, Oberlausitz and Saxon Switzerland). Skiing areas there extend from 250 to 600 m altitude. Winter tourism, highly dependent on snow availability, clearly dominates in the higher regions of Erzgebirge and Vogtland with altitudes mostly above 600 m a.s.l.. Both cross-country and downhill skiing are seen as the key tourist magnets by 90% of the municipality representatives. Cross-country skiing is more important in respect to user numbers, while downhill skiing creates a higher financial value for the region.

Saxon mountain climate is already changing and will continue to do so (Hänsel et al., 2008). A distinct decline of snow cover and of favourable conditions for artificial snow production was predicted for Saxon mountainous areas to the year 2025, by extending the linear temperature trend of 1960-2002 into the future and by comparing the IPCC scenarios for the lowest and highest warming trends (Schneider and Schönbein, 2006). To analyse the awareness of winter tourism professionals, they were asked about their opinion on the impacts of climate change in Saxony to the year 2025 (Fig. 2).

While almost two thirds of the municipality representatives count with a decline of natural snow conditions because of climate change, only one third of the downhill skiing area

agents agrees, although they will be most affected by the related development. Many interview partners justify their opinion with their personal experience of cold or mild winters in the recent past, not with scientific observations. The representatives were asked to estimate their personal priority of the issue "climate change" on a scale from "very high priority" to "no priority" (Fig. 3).

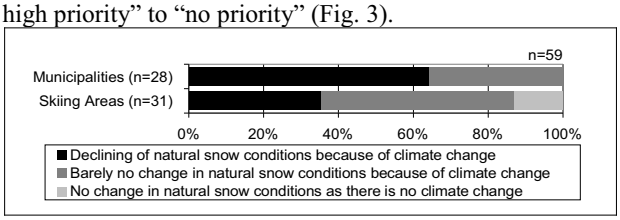

Figure 2. Representatives' opinion about possible impacts of climate change on winter tourism to the year 2025 in the Saxon low mountain ranges.

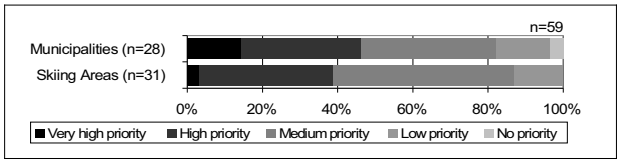

Figure 3. Personal priority of the phenomenon "climate change".

More than 80% of the interviewees consider the subject to be of medium to very high priority. Their awareness is independent of their position to expected impacts or (the existence) of climate change. Nevertheless, they are often not aware of climate change impact on their own business.

Adaptation Strategies in Winter Tourism

Possibilities of Saxon tourism suppliers to satisfy the market decline despite the existing touristic demand for skiing activities. Adaptation options are needed since "business as usual" strategies are no option with decreasing snow cover. Avoidance strategies (e.g., reduction of greenhouse-gas emissions) demand long-term global commitments, and the termination of winter tourism offers, in general, is no viable solution for sustainable development of tourism in investigated region (Fig. 4).

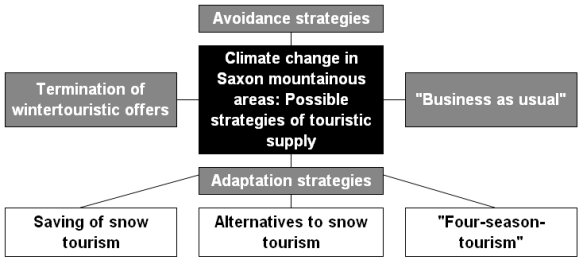

Figure 4. Strategies for winter tourism in Saxon mountainous areas reflecting the consequences of climate change.

Artificial snow production and slope management are ways to deal with limited snow availability in downhill skiing areas in the short run. These fail with increasing winter temperatures, however. Ski resorts will have to investigate, if climatic conditions are and will still be favourable for efficient investments in technical equipment to mitigate the effects of decreasing snow depth and duration. Alternative offers, such as guided snowshoe or winter walking tours, demanding less snow depth and inexpensive infrastructure, are easy ways to attract tourists, longing for a "true" winter experience. Nevertheless, attractive offers, independent of weather and climate conditions, are in demand for low mountain range winter tourism. Related activities have to be advertised with confidence and not evoke an "emergency" or "backup" character. Fun sports (e.g., grass-skiing) and trend sports (e.g., mountain biking) make use of existing ski lifts at downhill slopes. Cross-country ski trails, marked and prepared, can be used for other sport and training activities also without snow cover. Our aging society offers the opportunity to provide more options for older people. This group is less focussed on snow conditions as compared to younger generations. Low mountain range tourism can be a "winner" in other seasons as well. Particularly in hot summers, cooler areas like mountainous regions will attract visitors at the expense of tourist destinations such as the Mediterranean. "Summer retreat" is a chance to compensate possible losses in winter tourism.

Conclusions

As winter temperatures in Saxon low mountain ranges continue to rise, winter tourism needs to adapt. A big gap exists in the related awareness between representatives of the downhill skiing areas and those of municipalities, although climate change is generally seen as a top priority issue. Possible adaptation strategies are 1) technical ways to save the snow tourism or ways to reduce the necessary snow depth, 2) creation of attractive snow-independent offers and their marketing, and 3) to shift touristic revenues to other seasons.

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The maximal snow water equivalent on the altitudinal transect in Biospherical Reserve Polana in the years 2004- 2009.

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Abstract. This report presents the results of six-year project designed to monitor water equivalent of snow cover (SWE) in the area of the Polana Mountain. It compares maxima SWE in winters 2004 to 2009. The measurements took place on the northern and southern slopes of the mountainous transect, simultaneously in open areas and forested scrubs. They were performed every three weeks between January and April at altitudes from 600 to 1280 m.a.s.l. The results show that the highest snow water equivalents in open areas occured in the sequence 2006>2005>2004>2007>2009>2008. The situation was similar in the area of forested scrubs with the exception in 2007 when the maximum SWE was higher than in 2004. The snow water equivalents in the forested scrubs during its maximum were lower than in the adjacent open areas. The highest difference in maximum SWE was measured in winter 2004 where there was 50% less snow in the forests than in the open areas. The smallest difference (21%) between forested and open areas was observed in winter 2007.

Introduction

The snow situation in the mid-European temperate climate zone is marked by high interannual variability. Such situation is influenced by alteration of oceanic and continental types of winters. Since the continental climate weakens towards the mountainous areas, the mountainous areas are more often marked by snow-rich winters.
The objective of this paper is to compare maximum snow water equivalents in open and forested areas in winters 2004-2009.

Data and methods

The measurements of snow cover parameters were carried out in Polana Biosphere Reserve, since winter season 2003/04. In the present report, we evaluate the maximal values of snow water equivalent at the Polana Mountain observed at altitudes 600 to 1280 m.a.s.l in winters 2004 to 2009. A more detailed description of the research is given by Hribik (2007). Measurments were also at north and south transect obtained (Fig. 1). The water equivalent of snow cover was obtained by mass method using the snow sampling tube (model VS-43). The snow cover depth was measured by communicable and stabile laths for snow measurements.
Snow water equivalent, depth of snow and snow density were monitored in monthly intervals. This was during the time of the highest snow accumulation in mountain locations. The monitoring was performed on the altitudinal transect. Testing areas were situated both, in open areas and in forest.The measurements were carried out from south and north transekt of Polana Mts. In the forest, 5 measurements of snow water equivalent and snow density were performed. There were 3 measurements performed in an open area. There were also 20 measurements of snow depth undertaken, using snow-measurement laths. The measurements comply with the methodology standards used by Slovak Hydrometeorology Institute (Turčan, 1970).

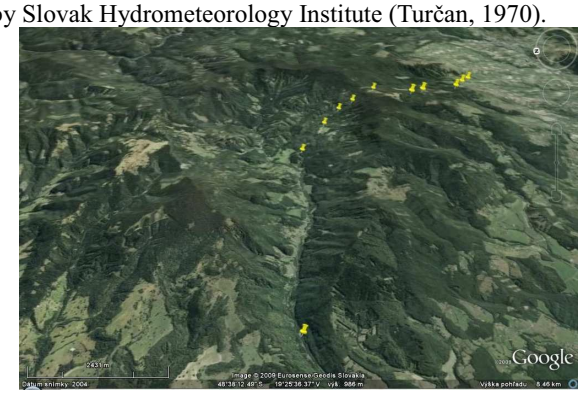

Figure 1. Research Area – Biospherical Reserve Polana.

Results and disscussion

The altitude transect contained all (from oak-beech to spruce) vegetation levels occurring in this area. Thus, it is clear that the values obtained might not come from the same time period (shown in the Tables 1, 2). These tables show the difference in snow culmination (snow water equivalent) during the years, as well as, according to the altitude and the influence of the forest scrubs. In the most experimental areas, the water equivalent of snow cover was reached at the end of February and early March. Maximum water equivalent of snow cover occurring in January was reached either in the lowest areas of Biosherical Reserve Polana, or in 2008 when the snow cover was scarce.

Table 1. The months of the occurence of maximum SWE in the open area; from the south (up) to the north (down).

elevation m a. s. l.	2004	2005	2006	2007	2008	2009
600	III	III	II	I	I	II
790	III	II	II	II	I	II
940	III	II	II	I	I	III
1000	III	III	III	II	III	II
1120	III	III	II	III	III	III
1280	III	III	II	III	III	III
1160	III	III	II	II	III	III
1040	III	III	II	II	I	III
900	III	III	III	II	I	III
780	III	III	III	I	I	II
680	I	II	II	I	I	II

Legend: january february march april

Table 2. The months of the occurence of maximum SWE in the forest; from the south (up) to the north (down).

elevation m a. s. l.	2004	2005	2006	2007	2008	2009
600	III	III	II	I	I	II
790	III	II	II	I	I	III
940	III	III	III	II	I	III
1000	III	III	III	II	III	III
1120	III	IV	III	II	III	III
1280	II	III	II	II	III	III
1160	II	III	III	II	III	III
1040	III	III	III	II	I	III
900	III	III	II	I	I	III
780	III	II	III	I	I	II
680	II	III	III	I	I	II

Legend: january february march april

Maximum SWE in winters 2004-2009 are shown in Figs. 2 and 3.

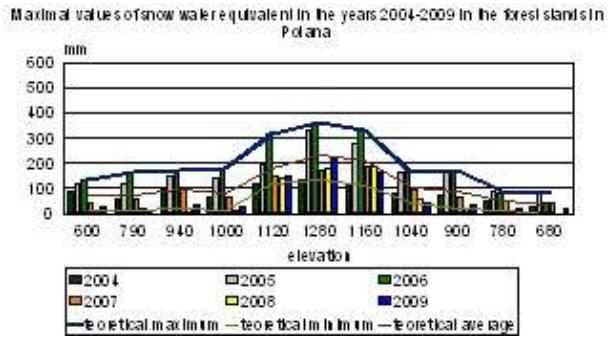

Figure 2. Maximal values of snow water equivalent in the years 2004-2009 in the forest stands.

The figures show that the highest maximum water equivalent of snow cover, in open areas of the northern transect, was reached in 2006. In areas of the southern transect was it was higher in 2005. However, in comparison with other years, these differences are negligible. Both these winters were rich in snow; interestingly, the maximal values in open areas were usually reached at the end of February and in early March. In forested areas, these values were observed in late March with a specific case in 2005 when the maximum was reached at the beginning of April. Similar results were obtained in other years in forested areas with one exception. Due to the influence of heterogeneous forested composition, also in 2006 the maximum snow water equivalent on the southern transect was the highest.
During the other years, the values in forested and open areas were 30-60% lower than in 2005 and 2006. In 2007, 2008, and 2009, the maximal values of SWE were considerable only up to altitude 1100 meters in both, northern and southern transect. They were reached in March, while the maximal values in lowlands were already reached in February (2009) or even in January (2007, 2009). This is an evidence of importance of December and January snow fall in the areas below 900-1000 meters above sea level.

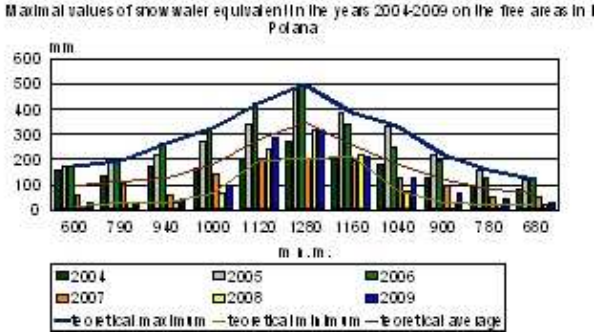

Figure 3. Maximal values of snow water equivalent in the years 2004-2009 in the open area.

The snow water equivalent was not extreme in the winter 2004, but differencies were not very high and relatively balanced. The situation in the open areas and forest was similar. In the Figs. 2 and 3, the situation which results from our six year monitoring of maximal snow water equivalent was described. For every researched area relative maximal, minimal and average values were calculated and generalized. From this, the potencial of water supply in snow cover creating during the winters with different snow content is clear.

Conclusions

The results show that the highest snow water equivalents in open areas occured in the sequence 2006>2005>2004>2007>2009>2008. The situation was similar in the area of forested scrubs with the exception in 2007 when the maximum SWE was higher than in 2004. The snow water equivalents in the forested scrubs during its maximum were lower than in the adjacent open areas. The highest difference in maximum SWE was measured in winter 2004 where there was 50% less snow in the forests than in the open areas. The smallest difference (21%) between forested and open areas was observed in winter 2007.

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To energetic possibilities of evapotranspiration and humid conditions at selected stations in Slovakia for the period 1951-2008

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Abstract. The Department of Astronomy, Physics of the Earth and Meteorology of the Faculty of Mathematics, Physics and Informatics of Comenius University in Bratislava has developed a mathematic-physical model for estimation of energy balance equation components (total radiation balance and its components, latent heat flux (potential and actual evapotranspiration), sensible heat flux). This model is based on a common solution of energy and water balance equations. The input data are: air temperature and humidity, cloudiness, number of days with snow cover and precipitation, i.e. meteorological elements regularly measured in the network of meteorological stations in Slovakia. On the basis of this model the long-term course of global and net radiation sums as well as of potential evapotranspiration totals for a year and vegetation season (April - September) is presented for 3 selected stations of Slovakia for the period 1951 - 2008. Selected station Hurbanovo represents the southern (the driest) and Oravská Lesná the northern (the most humid) part of Slovakia. Kamenica nad Cirochou is situated in the northern part of East Slovakia.

Introduction

Actual evapotranspiration from saturated soil surface is limited only by incoming energy. It is called potential evapotranspiration (E_o). In comparison with precipitation (P) as a ratio E_o/P is a suitable climatic characteristic of humid conditions.

Data and methods

In the work the data from stations Hurbanovo (φ=47°52′, λ=18°12′, H=115 m a.s.l.), Kamenica nad Cirochou (φ=48°56′, λ=22°00′, H=178 m a.s.l.) and Oravská Lesná (φ=49°22′, λ=19°11′, H=780 m a.s.l.) were used. Monthly totals of potential evapotranspiration were computed by the turbulent diffusion method from the energy balance equation of saturated soil surface. Monthly sums of global and net radiation were estimated on the basis of linear dependence on cloudiness (Hrvoľ et al., 2001).

Results and discussions

Mean and extreme annual potential evapotranspiration totals and drought index at selected stations for the used period 1951-2008 are given in Tab. 1. Annual values of drought index for the given period varied from 0.82 (1965, P = 827 mm) to 2.65 (2003, P = 333 mm) at Hurbanovo, from 0.59 (1974, P = 1010 mm) to 1.82 (1961, P = 400 mm) at Kamenica nad Cirochou, from 0.28 (1974, P = 1463 mm) to 0.56 (l959, P = 860 mm) at Oravská Lesná. Only at station Hurbanovo the long-term trends of annual and vegetation season precipitation totals are slightly decreasing (Fig-s 1 and 3). The long-term trends of annual and vegetation season values tend to increase at all 3 stations.

Table 1. Mean and extreme annual values of E_o in mm and E_o/P at selected stations for the period 1951-2008.

Station	Hurbanovo	Kam. nad C.	Or. Lesná
mean E_o	757	649	458
max. E_o	881	774	550
year of oc.	2003	2000	2007
min. E_o	668	550	392
year of oc.	1980	1980	1965
mean E_o/P	1.41	0.90	0.41
max. E_o/P	2.65	1.82	0.56
year of oc.	2003	1961	1959
min. E_o/P	0.82	0.59	0.28
year of oc.	1965	1974	1974

Conclusions

Increasing tendency in long-term trend of annual drought index values is observed only at station Hurbanovo in our dry locality (Fig. 2). Trends for vegetation season (Fig. 4) are statistically in-significant.

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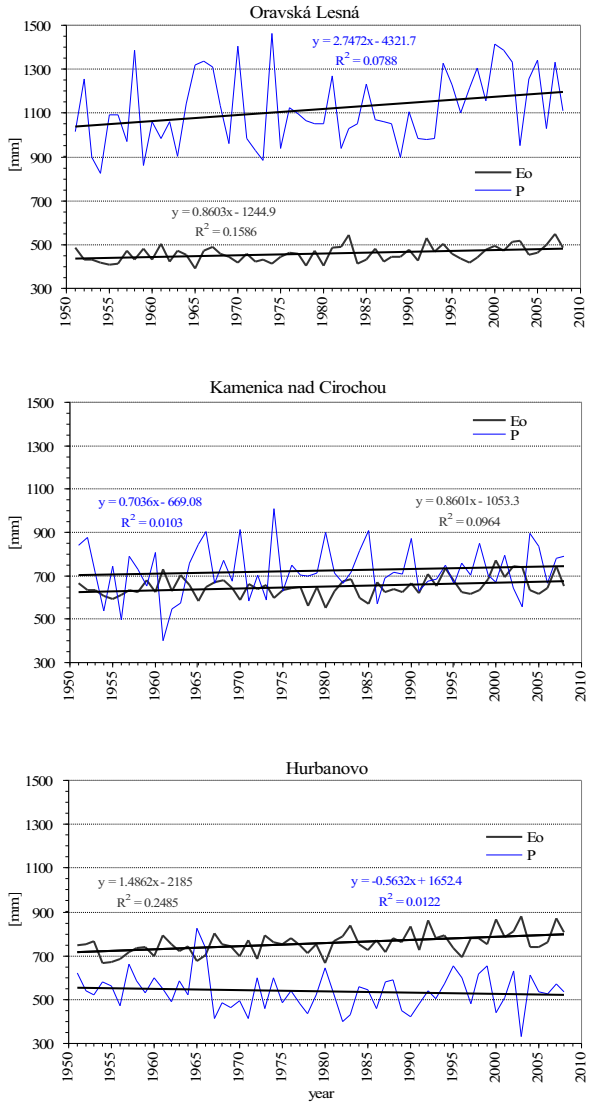

Figure 1. Long-term course of potential evapotranspiration (E_o) and precipitation annual totals (P) in mm with linear trend at Hurbanovo, Kamenica nad Cirochou and Oravská Lesná for the period 1951-2008.

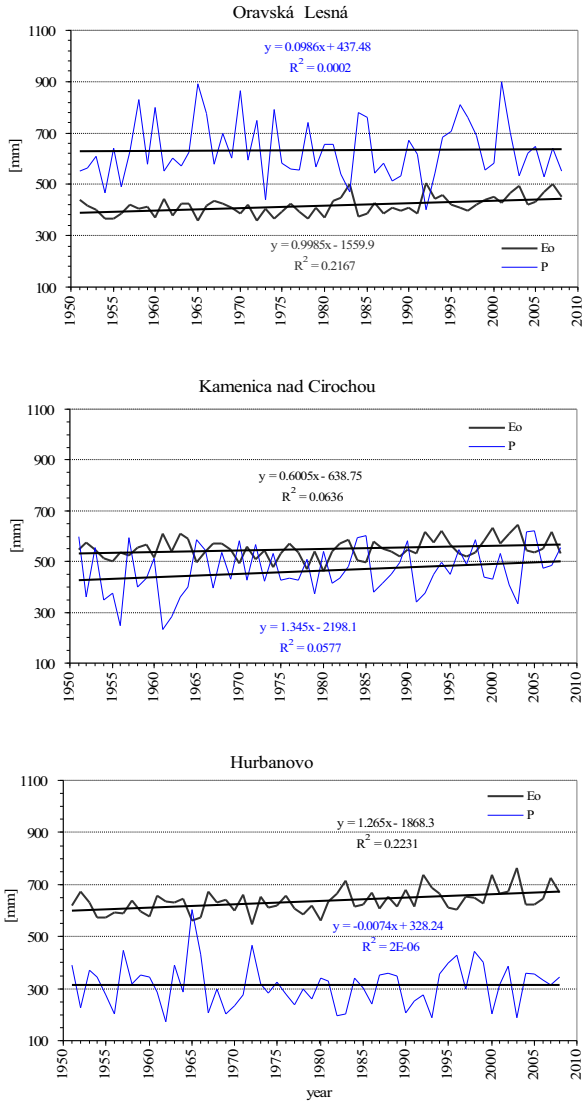

Figure 3. Long-term course of potential evapotraspiration (E_o) and precipitation totals (P) in vegetation season in mm with linear trend at Hurbanovo, Kamenica nad Cirochou and Oravská Lesná for the period 1951-2008.

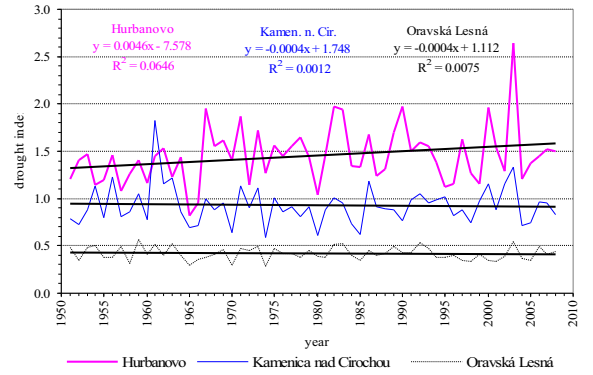

Figure 2. Long-term course of drought index annual values with linear trend at Hurbanovo, Kamenica nad Cirochou and Oravská Lesná for the period 1951-2008.

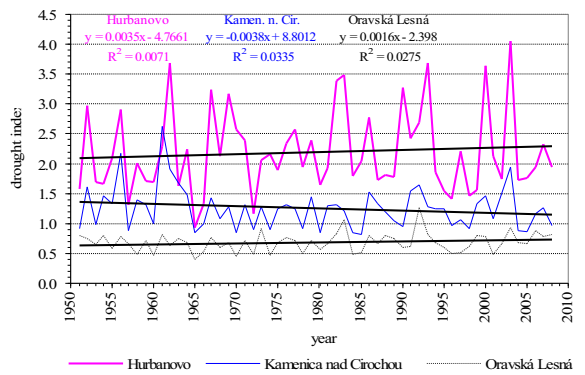

Figure 4. Long-term course of drought index vegetation season values with linear trend at Hurbanovo, Kamenica nad Cirochou and Oravská Lesná for the period 1951-2008.

Permafrost and climatic change in Mongolia

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Abstract. The permafrost area range in Mongolia is almost 1 million km^2, and can be easily divided into latitudinal and altitudinal types. The permafrost environment has changed markedly several times in central Asia. The ice wedges and permafrost formed during the Late Pleistocene are still present in central Mongolia. The lower limit of altitudinal permafrost in western Mongolia has elevated only a little (near 300m) since the last glaciation maximum. Compared with that in northern Europe and North America, latitudinal permafrost in northeastern Mongolia is less sensitive to local warming, but altitudinal permafrost, especially permafrost in the Altai and Khangai and partially also in Khentii Mountains, is sensitive to climate warming. Since the middle of the 20th century, significant permafrost degradation has occurred in Mongolia.

Introduction

Sodnom and Losev (1976) summarized the principal characteristics of permafrost in Mongolia. Although no maps have been digitized and included in the GIS-aided databases and models for cryospheric studies in Mongolia till now. During the last 10 years, permafrost studies in Mongolia have started and contributed to environmental protection. Our study has made an approached estimation for change in territorial permafrost distribution in Mongolia at the various scripts of possible change in a current climate. Further, within the 10 years of field works, new information for long-term average annual temperature of air and new borders of permafrost were found out in Mongolia.

Data and methods

Frozen ground was investigated in 2003-2009 period to study the distribution and degradation of permafrost in the selected mountains and basins, located at the northern Mongolia.

The presence of permafrost was examined by electrical and thermal soundings. The obtained data of permafrost distribution fitted to the sounding results was mapped and processed by GIS applications (Houška and Kynický, 2004). Detail temporal variations in thermal and hydrological regimes were also investigated for two years (2004, 2005) at Khentii Mountains by manual observations of air and ground temperatures, precipitation, and near-surface soil moisture and groundwater level.

Results and disscussion

Permafrost distribution

The permafrost area in Mongolia is estimated at about $0{,}804\times10^6$ km^2, accounting for 51.4% of the total Mongolian land territory. Permafrost in Mongolia is mainly in the Khubsgul, Orkhon-Selenge, Khentii, Khangai and partially also in Hutag Ull Ord Mountains and can be divided into latitudinal and altitudinal permafrost or into 7 thermal stability types. The development and distribution of permafrost in Mongolia is mainly dependent upon climatic, geographic, geologic, hydrologic and surface cover conditions. The latitude is the second important factor that influences the distribution of the mean annual air temperature (MAAT) and thus, the distribution and development of altitudinal permafrost. With southward increase in the temperature, the lower limit of permafrost ascends 200-240 m in the Khentii, 150-270 m in the Khubsgul area, 260-320 m in the Khangai, 150-210 m in the Hutag Ull Ord Mountains and 240-350m in the Altai.

Permafrost evolution during the Quaternary

Many intensive and persisting glaciation–interglaciation permafrost shifts have set in the Quaternary (Prokopenko et al., 2007). In the Early Pleistocene, permafrost developed only in high mountains (Marchenko et al., 2007). The second glacial maximum during the Quaternary occurred between 0.8 and 0.6 Ma, with a MAAT in range from −12 to −4°C, and permafrost was extensively developed, especially in the northern Mongolia. Ice-wedges, formed during the coldest stage of the Late Pleistocene, were found at several places in the Khubsgul and Khentii (Kynický, 2006).

The interglacial period was warm period, and permafrost almost completely occurred in very high mountains of Altai, probably. During the glacial periods from 330 and 200 ka, permafrost was continuously distributed identified at least four periods of permafrost expansion during the past 150 ka. The permafrost area during the last glacial maximum (16–32 ka) was estimated at 1×10^6 km^2 (Kynický, 2006).

The warm period in the Holocene occurred from 8.8 to 3.4 ka, when the MAATs were about 2–5°C higher, resulting in permafrost degradation. Sand wedges stopped developing about 9 ka, indicating the start of warming. During 8–3 ka, the climate was warm and humid, and peat and paleosols were well developed as a result (Kynický, 2006). The warmest period in central Asia was about the 8.5–5.2 ka, when the MAATs were about 3–5°C higher; the megathermal occurred at about 6–4.5 ka (Marchenko et al., 2007). Therefore, the permafrost in Mongolia is relict and has been degrading since the last glaciation. With the climatic fluctuations, the lower limits of permafrost moved up and down several times simultaneously, going down their present positions. During the Early Holocene warming, intensive and frequent flooding resulted in widely distributed gravel strata with thicknesses of 0.5–10 m overlying sediment with polygonal wedges. Permafrost north of the northern Gobi desert thawed completely.

Sensitivity of permafrost in Mongolia to past climatic changes

The southern limits of permafrost distribution in northern Europe have retreated 23–24° northward since the last glaciation and have shrunk 16–18° northward in North

America. However, in Mongolia, there have been only 5–7° retreats. This can be attributed to the combined influence of the strong and persistent inversion layer of the atmosphere up to 1500 m in elevation, controlled by the Siberia-Mongolia low pressures and local geography. In western Mongolia, the lower limits of altitudinal permafrost have risen several hundred m (Sodnom, Losev, 1976). In other words, the periglacial environment in Mongolia has been less sensitive to climate changes.

Recent permafrost degradation

As a result of climate warming about 0.4–0.5°C during the last 50 years, based on permafrost monitoring and characteristic of winter warming, extensive permafrost degradation has been interpreted and is expected in the future.

Monitoring along the transect through the Khubsgul and Khentii indicates an increasing of the MAGTs of about 0.4–0.5°C in seasonally frozen ground, taliks, and island permafrost zones, and about 0.2–0.3°C in the continuous permafrost zones. In the unstable permafrost zone, with a MAGT of −0.5–0°C, permafrost warms quickly.

The secular warming during the last 35 years was estimated at least 1.0°C in the Khentii Mountains, and the southern limit of Eurasian permafrost has retreated 20–30 km northward there. It is predicted that the northward shrinkage of the permafrost will be about 80–200 km and the MAGT will rise correspondingly, if the air temperature increases 1°C within the next 50 years.

Recent climate humidization versus aridization events

Episodes of dry/warm and cool/humid are distinctive for overall Upper Holocene. But they are of no important significance for quarternary climate history. Alternations of warm/wet optima and cool/dry pesims are more important. Occurrence of unusually strong summer monsoons brings floods into Mongolia too (Bajer et al., 2008). In contrast, following winter could be affected by heavy dry spell during El-Niňo event. Flood events in Asia do not correspond with warming cycles. That is why permafrost melting could not be attended acompanished with by the central Asia climate humidization. After permafrost melting, the huge runoff or desiccation with desertification could come. No long-term relation between humid periods and stronger Asian summer monsoons alternations was evidenced (Prokopenko et al., 2007). Permafrost degradation does not indicate other spreading of niches for vegetation. Probably for this reason a biome borders in Eastern Siberia and Mongolia still have been occurring in the same ranges since the Late glacial through strong climate changes run (Tarasov et al., 2000). Landscape of the Mongolia is still predisposed to desertification (Houška and Kynický, 2004; Samec et al., 2006; Bajer et al., 2008).

Conclusions

The area of permafrost in Mongolia has experienced recent shifts, and may have disappeared in central Mongolia, except on very high mountains, during next decades. Accelerating fluctuations of climate and permafrost have been identified during the Holocene, and most areas of permafrost in Mongolia now are relicts of cold climates and have been in degradation, especially during the past 50 years. The climate has been warming since the last glaciation, significant warming and flood events have been observed since the 1970s and 2000s, and the same trend is expected in the future.

The most important impact of permafrost degradation is on water resources. Protection of cold regions and water resources will be a key issue for the human and environment in Mongolia (Kynický, 2006; Novotná, 2008; Rukavičková, 2008).

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Air humidity and temperature change scenarios of lower troposphere and Tatra mountains

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Abstract. In 2007 the newest Canadian CGCM3.1 model with daily data outputs have been analyzed (IPCC emission scenarios SRES-A2 and B1 were applied). Selected scenarios of daily data for Slovakia are presented in the paper, all based only on the CGCM3.1 outputs and the Slovak Hydrometeorological Institute measured data (air humidity and temperature in 1961-2100 at 3 High Tatras stations (based on surface GCM outputs) and at Gánovce aerological data (AT 850 hPa at 00 and 12 UTC and AT 700 hPa at 12 UTC) based on GCM outputs for these levels).

Introduction

In Slovakia, there are very reliable measurements of all meteorological elements from about 10 stations in the mountains (from 695 to 2635 m a.s.l.). Three of them were selected (Poprad, 695 m a.s.l., Štrbské Pleso, 1360 m a.s.l., and Lomnický štít, 2635 m a.s.l.). Annual air temperature means increased by 1.4 °C in 1901-2008, annual relative air humidity means decreased in the lowlands by 5% since 1901. This decrease was less significant in the mountains. Water vapor pressure had insignificant trend in 1901-2008 in whole year round with some lower values in 1976-1993. Information on the CGCMs present Boer et al. (2000), modified outputs were applied by Damborská et al.(2004). Aerological data were elaborated by Lapin et al., 2005.

Data, methods and results

In case of air humidity there are several variables to describe climate changes (e – water vapor pressure, d – difference of saturated and actual e, U – relative air humidity, s – specific air humidity, a – absolute air humidity). The second analyzed variable is daily air temperature mean (T). In the CGCM3.1 model only the daily T and s data represent usable outputs for our limited goals. T and s outputs calculated for the level of topography (200 to 463 m a.s.l. at 4 nearest gridpoints) in 1961-2100 period and outputs for standard levels AT 850 hPa and 700 hPa at 4 nearest gridpoints around the station Gánovce in 1961-1990, 2046-2065 and 2081-2100 periods were utilized. Air humidity and air temperature are considered as very important climatic characteristics. They enable to calculate several other climatic data, like monthly relative air humidity means U, saturation deficit means d, potential evapotranspiration sums E_o (Lapin et al., 2008). Modeled T monthly means will increase up to 2100, both at A2 and B1 scenarios. More intense increase is modeled for A2 scenario (Tables 1 & 3a), mainly in the Oct. to March season (in the Growing season (GS) the increase is by about 1 °C lower, considering deviation of 2081-2100 and 1961-1990 time frames).

Relative air humidity (U) has insignificant trend up to 2100. After some decrease in 1961-2000 only changes up to –0.5% for SRES A2 and up to +1.2% for SRES B1 emission scenarios can be seen in Tab. 2. At higher altitudes and for mean maximum and mean minimum are the changes slightly greater, but not above +4.2% and below –4.7%.

Table 1. Deviations of Growing Season (GS = April - September) mean values in selected periods between IPCC SRES A2 and SRES B1 emission scenarios and between SRES A2 and measured averages (M) in 1961-1990 (T – air temperature, e – water vapor pressure, Poprad, 695 m a.s.l., Lomnický štít, 2635 m a.s.l.).

Station	Element		1961-1990	1996-2025	2016-2045	2061-2090
Poprad	T (A2-B1)	[°C]	0,00	0.01	0.20	1.06
Poprad	T (A2-M)	[°C]	0.02	0.74	1.60	2.94
Poprad	e (A2-B1)	[hPa]	0.00	-0.08	0.02	0.80
Poprad	e (A2-M)	[hPa]	0.00	0.42	0.95	2.22
Lomn. štít	T (A2-B1)	[°C]	0.00	0.00	0.19	1.02
Lomn. štít	T (A2-M)	[°C]	0.01	0.74	1.60	2.91
Lomn. štít	e (A2-B1)	[hPa]	0.00	-0.05	0.01	0.44
Lomn. štít	e (A2-M)	[hPa]	0.00	0.22	0.51	1.21

Table 2. Mean values of Growing Season (GS) relative humidity $U=e/e^*$ [%] in selected periods (Mean – average of daily U; MeMa, MeMi – average of GS maxima and minima in daily U; where e^* and e – saturated and actual atmospheric water vapor pressure 2 m above ground at stations; M1961-1990 – based on measurements, other columns – modified CGCM1.3 SRES A2 and SRES B1 model values, 2055 (2046-2065), 2090 (2081-2100)).

Station Altitude	U [%]	M1961-1990	A2 2055	A2 2090	B1 2055	B1 2090
Poprad	Mean	72.7	0.17	-0.01	1.21	0.57
695 m	MeMa	94.9	-0.68	-0.22	1.65	0.72
	MeMi	43.9	1.39	1.01	1.78	2.32
Štrb. Pleso	Mean	74.7	0.05	-0.49	1.19	0.44
1360 m	MeMa	98.5	-0.09	0.08	1.63	0.81
	MeMi	39.3	-0.42	-1.00	1.36	1.68
Lomn. štít	Mean	85.5	-1.02	-2.36	0.36	-0.71
2635 m	MeMa	100.0	0.00	0.00	0.00	0.00
	MeMi	27.3	-3.20	-4.68	-0.52	-0.78
AT 850 hPa	Mean	75.8	1.49	2.05	3.26	2.05
at 00 UTC	MeMa	99.6	0.01	0.01	0.01	0.01
	MeMi	27.1	0.06	-0.69	2.79	4.20
AT 850 hPa	Mean	63.7	1.48	2.12	3.16	1.97
at 12 UTC	MeMa	99.1	2.25	2.65	3.20	2.74
	MeMi	22.3	-0.02	-0.63	2.33	3.77
AT 700 hPa	Mean	66.1	-0.31	-1.03	1.96	0.38
at 12 UTC	MeMa	99.9	0.42	-1.06	0.19	-0.17
	MeMi	13.4	-2.29	-2.40	0.35	0.99

Conclusions

The presented method of daily variables scenarios calculation as time series is presented detailly in Lapin et al. (2004 and 2008). This method could be applied also for other Slovak localities with sufficiently reliable data. Some problems have arisen with the upper atmosphere data

modification because of gaps. Reanalyzes of AT 850 and 700 hPa in Wetterzentrale helped us remarkably.

Table 3a. Mean air temperature (*T*) scenarios in selected 20-year time frames showing *T* increase in °C compared to 1961-1990 reference M (annual course was smoothed by $(X_{i-1}+2*X_i+X_{i+1})/4$.

	M	A2	A2	B1	B1
Poprad	**61-90**	**2055**	**2090**	**2055**	**2090**
I	-5.0	2.6	4.9	2.2	3.3
IV	6.0	3.0	5.0	2.1	2.5
VII	15.5	1.7	3.0	0.8	1.7
X	6.7	2.8	4.0	1.9	2.3
Štrb.Pleso	**61-90**	**2055**	**2090**	**2055**	**2090**
I	-5.1	2.6	4.8	2.2	3.3
IV	2.8	2.9	5.0	2.0	2.4
VII	12.3	1.7	3.0	0.8	1.7
X	5.2	2.8	4.0	1.9	2.3
Lomn. štít	**61-90**	**2055**	**2090**	**2055**	**2090**
I	-11.2	2.5	4.9	2.2	3.3
IV	-5.7	3.0	5.0	2.1	2.4
VII	3.4	1.7	3.0	0.8	1.7
X	-1.8	2.8	4.0	1.9	2.3
AT 850 00	**61-90**	**2055**	**2090**	**2055**	**2090**
I	-5.3	1.9	4.3	1.6	2.7
IV	1.6	2.7	4.4	2.0	2.1
VII	10.7	1.6	2.9	0.7	1.6
X	4.6	2.7	4.0	1.9	2.2
AT 850 12	**61-90**	**2055**	**2090**	**2055**	**2090**
I	-5.2	1.9	4.3	1.6	2.7
IV	2.6	2.7	4.4	2.0	2.1
VII	11.7	1.6	3.0	0.7	1.6
X	4.8	2.7	4.0	1.9	2.2
AT 700 12	**61-90**	**2055**	**2090**	**2055**	**2090**
I	-11.3	2.1	4.2	1.8	2.8
IV	-7.2	2.8	4.5	2.0	2.3
VII	0.9	1.7	3.2	0.8	1.7
X	-2.6	2.7	4.0	1.9	2.3

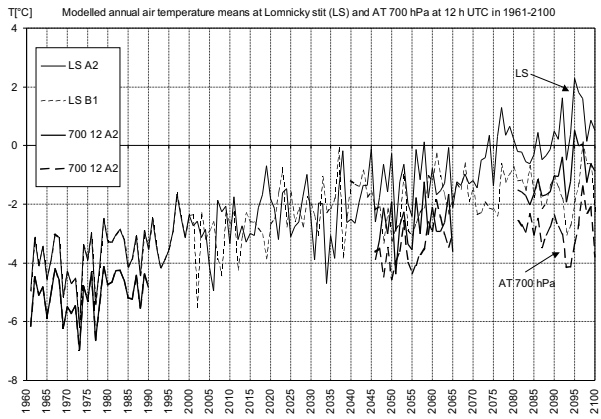

Figure 1. Trend of modelled annual air temperature for Lomnický štít (LS in 1961-2100) and AT 700 hPa level in 1961-1990, 2046-2065 and 2081-2100 (the scenarios were modified for LS according to surface CGCM3.1 outputs and measured LS data and for AT 700 hPa according to CGCM3.1 outputs for the AT 700 hPa level and measured aerological data at Gánovce in 1961-1990, emission scenarios SRES A2 and B1 were applied).

Table 3b. Mean water vapor pressure (*e*) scenarios in 20-year time frames showing *e* scenarios in % compared to 1961-1990 reference M in hPa (annual course was smoothed by $(X_{i-1}+2*X_i+X_{i+1})/4$.

	M	A2	A2	B1	B1
Poprad	**61-90**	**2055**	**2090**	**2055**	**2090**
I	3.67	122.5	146.4	118.5	128.3
IV	6.60	127.6	146.9	119.6	122.3
VII	12.74	112.3	122.9	107.9	112.2
X	7.63	120.7	130.6	115.6	117.1
Štrb.Pleso	**61-90**	**2055**	**2090**	**2055**	**2090**
I	3.39	122.4	146.2	118.7	128.3
IV	5.57	127.3	146.6	119.6	122.2
VII	10.76	112.2	122.7	107.8	112.2
X	6.68	120.7	130.7	115.6	117.1
Lomn. štít	**61-90**	**2055**	**2090**	**2055**	**2090**
I	2.07	122.9	146.7	118.9	128.5
IV	3.55	127.3	147.0	119.3	122.0
VII	7.02	112.7	123.5	107.6	112.4
X	3.98	120.4	130.5	115.5	117.1
AT 850 00	**61-90**	**2055**	**2090**	**2055**	**2090**
I	3.16	120.5	142.9	116.5	124.0
IV	4.45	128.8	145.1	121.0	122.8
VII	9.97	114.9	130.4	112.6	115.6
X	6.17	122.2	131.3	118.1	118.6
AT 850 12	**61-90**	**2055**	**2090**	**2055**	**2090**
I	2.99	121.1	143.4	117.0	124.4
IV	4.57	129.0	145.1	121.1	123.0
VII	8.73	115.2	131.3	113.8	116.2
X	5.54	122.3	131.2	118.2	118.7
AT 700 12	**61-90**	**2055**	**2090**	**2055**	**2090**
I	1.47	121.8	144.9	118.3	127.0
IV	2.20	129.5	147.1	122.3	123.8
VII	4.38	114.5	129.7	113.0	115.4
X	2.67	119.7	129.9	116.2	117.7

Acknowledgements Some parts of this paper are based on the results of project VEGA No. 1/4033/07 and the observed SHMI data.

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Climate change – saturation deficit scenarios for Slovakia

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Abstract. There are several meteorological stations (30-45, dependent on climatic element) in Slovakia with complete and good quality observations since 1951 (1961). Most of them well represent such important sub-regions like the Danubian lowland or the area around the Tatra mountain. This paper presents some details on daily air humidity and daily saturation deficit analysis from 6 stations in 1961-2008, including some information on air temperature and evaporation (5 of those stations lie in the Tatra mountains region, Hurbanovo lies in the SW Slovakia lowland). In 2007 the newest Canadian CGCM3.1 model with daily data outputs have been analyzed (IPCC emission scenarios SRES-A2 and B1 were applied). Selected scenarios of daily data in 1961-2100 and 6 stations in Slovakia are presented in the paper, all based only on the CGCM3.1 outputs and the Slovak Hydrometeorological Institute measured data.

Introduction

High quality meteorological measurements enable to calculate air temperature and precipitation trends for Slovakia since 1881. Temperature increase by 1.6°C (according to 3 stations) and precipitation decrease by 25 mm (3.1%, according to 203 stations) was registered in Slovakia in the 1881-2008 period. On the other hand, annual relative air humidity means decreased in the lowlands by 5% since 1901. This decrease was less significant in the mountains. Water vapor pressure had insignificant trend in 1901-2008 in all year round with some lower values in 1976-1993. These changes influenced regime of air humidity, potential (E_o) and actual (E) evapotranspiration, soil moisture and runoff mainly in southern Slovakia. For example, E_o increased at Hurbanovo (115 m a.s.l.) by 17.5% and at Oravska Lesna (NW Slovakia mountains, 780 m a.s.l.) by 9.8% in 1951-2008. Serious changes at most of climatic characteristics have been registered mainly since 1990. Some information on the CGCMs present Boer et al. (2000), modified outputs were applied by Halmova et al. (2006).

Data, methods and results

Saturation deficit (d – difference between saturated and actual water vapor pressure) is considered as one of the most important air humidity characteristics. It enables to calculate monthly E_o sums by several methods (Lapin et al., 2008). A common formula can be expressed as $E_o = k.d$, where k is a coefficient different for any month and any bioclimatic region. The CGCM3.1 based scenarios of E_o can be easily calculated e.g. using simple Zubenok formula. Selected data and humidity scenarios from the CGCM3.1 outputs downscaling for Slovakia are in Tables 1, 2 & 3. Modeled d means will increase up to 2100, for both at A2 and B1 scenarios. More intense increase is modeled for A2 scenario (Tables 2 & 3), mainly in the April - September season (Growing season – GS) 2071-2100 up to 20% compared to period 2001-2030 (up to 40% trend in 1961-2100), and only by 8% at the B1 scenario (up to 17% trend in 1961-2100).

Tables 3a & 3b show more detail d scenarios at 4 stations (lower and higher localities). Annual course of monthly scenarios is different. While in lowlands the highest values (greatest d increases) are in the April - May and August - October seasons, in mountains it is in the January - May and September - November seasons. The 2010 time frame (1996-2025) represents a close future period, suitable for the scenarios evaluation.

Table 1. Deviations of Growing Season (GS = April to September) mean values in selected periods between IPCC SRES A2 and SRES B1 emission scenarios and between SRES A2 scenario and measured averages (M) in 1961-1990 (T – air temperature, e – water vapor pressure, U – relative humidity, Hurbanovo, 115 m a.s.l., Strbske Pleso, 1360 m a.s.l.).

Station	Element		1961-1990	1991-2020	2021-2050	2071-2100
Hurbanovo	T (A2-B1)	[°C]	0.0	0.2	0.0	1.7
Hurbanovo	T (A2-M)	[°C]	0.0	0.7	1.8	3.9
Hurbanovo	e (A2-B1)	[hPa]	0.0	0.0	0.1	1.5
Hurbanovo	e (A2-M)	[hPa]	0.1	0.6	1.5	3.5
Strbske Pleso	U (A2-B1)	[%]	0.0	-0.9	0.0	-1.0
Strbske Pleso	U (A2-M)	[%]	0.6	0.4	-0.2	-0.2
Hurbanovo	U (A2-B1)	[%]	0.0	-1.1	0.2	-0.7
Hurbanovo	U (A2-M)	[%]	-1.0	-1.8	-1.5	-1.6

Table 2. Mean values of Growing Season (GS) saturation deficit d [hPa] in selected periods (Mean – average of daily $d = e^* - e$; MeMax – average of GS maxima in daily d; e^*, e – saturated and actual atmospheric water vapor pressure 2 m above ground; M1961-1990 – based on measurements, other columns – modified CGCM1.3 SRES A2 model values, A2-B1 – difference of d between Mean SRES A2 and Mean SRES B1 scenarios).

Station Altitude	d [hPa]	M1961-1990	1961-1990	1991-2020	2021-2050	2071-2100
Poprad	Mean	**4.0**	**4.1**	**4.4**	**4.8**	**5.3**
695 m	MeMax	11.3	11.2	12.4	13.9	14.4
	A2-B1		0.0	0.2	0.1	0.6
Telgart	Mean	**3.0**	**3.2**	**3.4**	**3.8**	**4.2**
901 m	MeMax	9.2	9.7	10.6	12.4	12.5
	A2-B1		0.0	0.2	0.1	0.5
Lipt. Hradok	Mean	**4.3**	**4.5**	**4.7**	**5.2**	**5.7**
640 m	MeMax	12.9	12.4	13.4	15.2	15.5
	A2-B1		0.0	0.2	0.1	0.7
Strbske Pleso	Mean	**3.1**	**3.2**	**3.4**	**3.8**	**4.2**
1360 m	MeMax	11.1	11.3	12.4	14.0	14.5
	A2-B1		0.0	0.2	0.0	0.6
Sliac	Mean	**5.0**	**5.2**	**5.5**	**6.0**	**6.6**
313 m	MeMax	13.2	13.2	14.3	15.7	16.4
	A2-B1		0.0	0.2	0.1	0.8
Hurbanovo	Mean	**6.5**	**6.6**	**7.1**	**7.6**	**8.7**
115 m	MeMax	17.6	17.1	18.1	19.8	22.0
	A2-B1		0.0	0.4	0.0	1.1

Table 3a. Mean saturation deficit (*d*) scenarios in selected 30-year time frames showing *d* increase in % compared to 1961-1990 reference (annual course was smoothed by $(X_{i-1}+2*X_i+X_{i+}1)/4$.

Stat./Month	A2	A2	A2	B1	B1	B1
Hurbanovo	**2010**	**2030**	**2075**	**2010**	**2030**	**2075**
I	9.7	4.9	4.4	5.7	6.9	-0.5
II	7.6	5.8	4.4	5.8	7.5	-1.3
III	4.9	9.2	12.7	4.1	7.8	5.3
IV	6.3	15.8	25.1	5.7	12.2	15.7
V	10.7	18.7	24.5	7.2	15.3	17.1
VI	13.1	16.7	15.9	5.5	13.6	11.1
VII	9.1	13.7	17.4	4.3	10.8	8.9
VIII	9.4	15.6	28.1	5.4	10.9	13.5
IX	15.5	18.9	32.9	6.0	13.5	17.0
X	14.0	15.9	28.0	5.8	13.2	14.7
XI	7.7	8.8	19.8	4.5	9.5	10.2
XII	7.2	4.4	10.3	3.7	6.3	4.3
Sliac	**2010**	**2030**	**2075**	**2010**	**2030**	**2075**
I	16.0	5.4	3.2	9.8	10.5	-2.1
II	15.0	8.6	9.0	11.3	13.5	2.2
III	7.3	8.9	13.9	5.9	10.1	5.7
IV	4.6	12.6	21.5	4.3	10.6	12.2
V	10.0	18.0	22.7	7.4	14.8	15.1
VI	13.5	18.3	14.6	7.3	13.9	9.8
VII	7.4	13.5	13.4	4.1	8.8	6.1
VIII	6.4	14.1	23.0	3.5	7.3	10.1
IX	14.3	19.0	30.7	4.9	10.7	16.6
X	14.9	16.7	27.6	5.6	11.9	15.8
XI	9.2	7.7	17.5	4.4	8.6	7.4
XII	10.1	2.3	5.5	4.6	6.4	-1.3

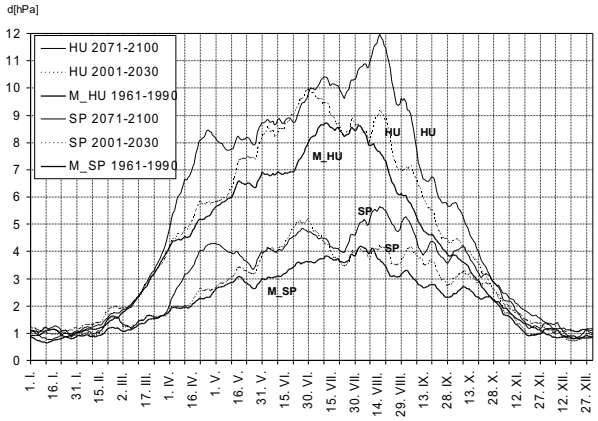

Figure 1. Annual patterns of mean saturation deficit *d* [hPa] at Hurbanovo (HU, 115 m a.s.l.) and Strbske Pleso (SP, 1360 m a.s.l.), measured (M) in 1961-1990 and modeled in 2001-2030 and 2071-2100 (modified CGCM3.1 SRES A2 model outputs), all 11-day running means, significant d increase is supposed mainly in the April - September season (GS).

If the A2 scenario will fulfill (more probable), the increase in E_o can reach even 25-30% in the GS compared to 1961-1990 averages. The *d* and E_o increase will be less significant in the mountains (Tables 2 and 3, Fig.1). Annual values of *d* will increase as well, but in cold half-year the change in water vapor is more important. Because of insignificant change in precipitation, it is expected a decrease in soil moisture up to 25% and runoff decrease up to 25%.

Table 3b. Mean saturation deficit (*d*) scenarios in selected 30-year time frames showing *d* increase in % compared to 1961-1990 reference (annual course was smoothed by $(X_{i-1}+2*X_i+X_{i+}1)/4$.

Stat./Month	A2	A2	A2	B1	B1	B1
Telgart	**2010**	**2030**	**2075**	**2010**	**2030**	**2075**
I	23.7	14.3	27.1	14.5	20.2	15.4
II	24.8	18.3	27.6	17.9	23.9	15.9
III	12.7	14.6	21.3	9.1	15.7	10.8
IV	5.8	16.0	24.7	4.7	12.9	14.2
V	11.6	22.0	24.8	8.7	17.6	16.7
VI	16.8	23.4	14.7	9.5	17.2	10.1
VII	8.5	17.2	12.5	5.0	10.5	5.2
VIII	5.4	17.0	24.2	3.1	7.2	9.8
IX	15.2	22.3	33.9	5.0	10.8	18.0
X	17.1	18.9	32.1	7.1	13.7	19.7
XI	10.3	8.9	25.3	5.4	11.9	13.2
XII	12.0	5.7	21.7	5.3	11.7	9.7
Strb. Pleso	**2010**	**2030**	**2075**	**2010**	**2030**	**2075**
I	22.0	15.5	27.6	15.1	19.2	17.9
II	24.3	19.4	27.3	18.3	23.8	17.5
III	13.9	17.3	23.9	9.7	17.3	13.1
IV	7.1	19.3	29.3	5.0	14.8	17.5
V	11.5	23.3	27.6	8.4	18.4	19.1
VI	16.2	23.3	15.6	9.4	17.5	11.1
VII	8.2	16.7	11.9	6.0	11.0	5.5
VIII	5.2	15.2	21.2	4.7	7.8	9.9
IX	13.7	19.5	29.6	5.9	10.9	17.9
X	14.9	16.8	30.3	7.5	14.1	20.8
XI	8.7	9.1	27.8	6.7	13.4	17.5
XII	10.4	7.5	24.7	6.8	12.3	14.3

Conclusions

The presented method of saturation deficit (*d*) scenarios calculation as water balance related variable (air temperature, precipitation and solar radiation scenarios are presented detailly in Lapin and Melo (2004)) could be applied also for other Slovak localities with sufficiently reliable data on air humidity and temperature (about 30 meteorological stations with observations since 1951).

Acknowledgements: Some parts of this paper are based on the results of project VEGA No. 1/4033/07 and the observed SHMI data.

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Regional Variation of Seasonal Trends using Selected Indices of Precipitation Extremes in Southern Poland and Central-Eastern Germany

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Abstract. Trends of six (moderately) extreme precipitation indices in Southern Poland and Central-Eastern Germany were analysed for 1951 to 2006, using 43 daily precipitation datasets. The analysis of the variability of the spatial extent of significant trends, their stability and average magnitude showed a strong seasonal differentiation and long-term variability. The most distinct changes in extreme precipitation occured in summer; particularly obvious in the 30-year moving periods from the mid 1960s to the mid -90s. Spatial variability of trend directions is large within the region. In the central and eastern parts, decreasing trends in extreme precipitation occurred more frequently while increasing trends prevailed in the western part of the region. This pattern also emerged in the spatial distribution of trend stability.

Introduction

General trends in climate elements receive considerable interest in current climate change research. Trends in precipitation, considered to be the most variable climate element in time and space, are spatially variable in both magnitude and direction (e.g., Alpert et al., 2002; Brunetti et al., 2001a, b; Heino et al., 1999; Klein Tank and Können, 2003). To understand changes or variability in precipitation occurrence and totals is important since precipitation has a considerable influence on different life forms including humans. Extreme precipitation is highly dependent on both circulation and local geographical conditions (relief and land-use). Therefore, the study of spatial and temporal changes and variability in extreme precipitation requires research at a regional scale and meteorological data of good quality.

This paper studies spatial and temporal variability of seasonal extreme precipitation trends in Southern Poland and Central-Eastern Germany. It focuses on the long-term variability in the regional extent of significant trends in precipitation indices as well as their stability and average magnitude.

Data and methods

Analysis was done for 43 meteorological stations (Fig. 1) with daily precipitation data for 1951-2006. The study area is characterized by a highly diversified relief (from the mountains of Harz and Erzgebirge in Germany to the Sudeten and the Tatras in Poland with their forelands and uplands) and a high variability of weather conditions resulting from the constant encounter of marine and continental air masses.

Fixed and geographically variable threshold values (percentiles) are used in climate research to select extreme precipitation (Easterling, 1999; Groisman et al., 2004; Heino et al., 1999; Klein Tank and Können, 2003; Moberg and Jones, 2005). Fixed thresholds deliver clearly determined threshold values of precipitation totals. However, they refer to events of various extremities, particularly within an area of variable altitude. Using percentile thresholds ensures that the values are extreme for every station.

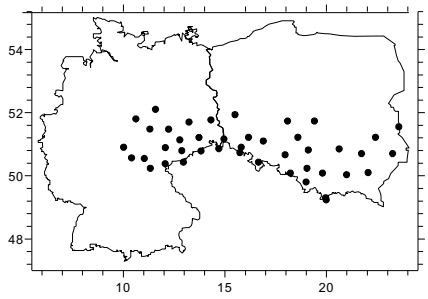

Figure 1. Location of meteorological stations.

Both threshold methods were used (Tab. 1) as the meteorological stations are located at various altitudes (from 6 m a.s.l. to 1991 m a.s.l.). The values of the 90th and the 95th percentiles were calculated separately for each season (warm half year: AMJJAS, cool half year: ONDJFM; spring: MAM, summer: JJA, autumn: SON, winter: DJF) taking into account days with precipitation ≥1.0 mm in the CLINO period 1961-1990. The regional extent of trends was expressed as a percentage of stations with statistically significant trends for each of the moving 30-year periods.

Table 1. Acronyms and definitions of extreme precipitation indices .

Acronym	Definition	Unit
90pNoD	Number of days with precipitation >90th percentile of daily precipitation amount	days
95pNoD	Number of days with precipitation >95th percentile of daily precipitation amount	days
90pT	precipitation total from events >90th percentile of daily precipitation amount	mm
95pT	precipitation total from events >95th percentile of daily precipitation amount	mm
1dayT	Greatest 1-day precipitation amount	mm
5dayT	Greatest 5-day total precipitation	mm

The stability of extreme precipitation trends was determined using the direction and statistical significance of trends over the moving 30-year periods (Mann-Kendall test; strong trend: $\alpha \leq 0.1$, weak trend: $\alpha \leq 0.2$). The station pool was divided into those with a majority of increasing trends and those with dominantly decreasing trends. The stability of such trends is expressed as a percentage of the 30-year periods during which these trends were statistically significant. The following criteria were defined (T: percentage of time with statistically significant trends, whereby time is the number of 30-year moving periods):

- unstable trends ($0\% \leq T < 15\%$),
- poor trend stability ($15\% \leq T < 25\%$),
- stable trends ($25\% \leq T < 50\%$),
- strongly stable trends ($50\% \leq T < 75\%$) and
- very strongly stable trends ($T \geq 75\%$).

An average trend magnitude was investigated by computing an arithmetic average of individual 30-year trends for 1951-2000. Linear trends were calculated for each station over moving 30-year periods. These trends were expressed as a percentage of an

average value of the index from the period 1961-1990 (Moberg et al., 2006), delivering relative trend values.

precipitation indices. Here, depending on the index, the number of statistically significant trends – mostly decreasing ones – ranged from 22.4% (90Int) to 31.4% (90T; Fig. 2). Significant trends for extreme precipitation intensity were only found more frequently in autumn for 90Int and in winter for 95Int, compared to summer. Changes in both direction and geographical extent of significant trends are clearly visible over the entire period (Fig.2). This pattern also differs seasonally.

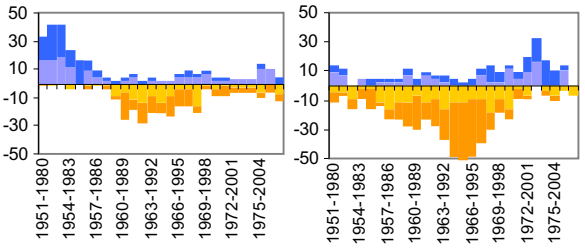

Figure 2. Percentage of stations with statistically significant trends in 90T for autumn (left) and summer (right); blue/ orange: increasing/ decreasing trends; lighter/ darker colours: weak/ strong trends.

Periods with distinct extreme precipitation trends were determined for each season. Decreasing trends in some of the extreme precipitation indices (90T, 90NoD) were observed at more than 50% of the stations in summer (Fig. 2) and more than 65% of the stations during the warm half year for 30-year periods starting in the mid 60's. 30-year trends starting in the early 1970s are more frequently positive than negative but spread only over 30% of the stations (Fig. 2). In spring, the 30-year periods within 1951 to the late 1980s, showed mainly statistically significant increasing trends (about 20% of meteorological stations). In autumn, decreasing trends in extreme precipitation were hardly noted in the 30-year moving periods between 1951 and 1984, whereas increasing trends comprised 40% of the stations (90T, 5 day). In the later period (1960 to 1997) mainly downward trends were statistically significant at about 20% of the stations.There is a clear difference of trend directions between the western and eastern part of the region in the cold seasons (cold half year, winter). This pattern also relates to other characteristics of extreme precipitation, such as average magnitude and stability of trends (Fig. 3). Generally, the stable trends were mainly negative in the eastern part of the region, in both the warm and the cold halves of a year, while the tendencies in the western part are not that clear. The greatest difference in respect to the direction of stable trends between the eastern and western part of the region was observed in winter, when the western part showed dominantly positive trends. In autumn, a stable decrease in the extreme precipitation indices occurred in the central part of the area whereas stable trends were rather increasing at stations located in both West and East.

Conclusions

The most distinct changes in extreme precipitation indices occurred in summer, particularly for the indices of moderate precipitation extremes (90T, 90NoD). Extreme precipitation intensity was less variable in time and space within 1951-2006 as compared to extreme precipitation totals and frequency. The geographical extent of statistically significant trends and their directions altered both seasonally and over the long-term period.

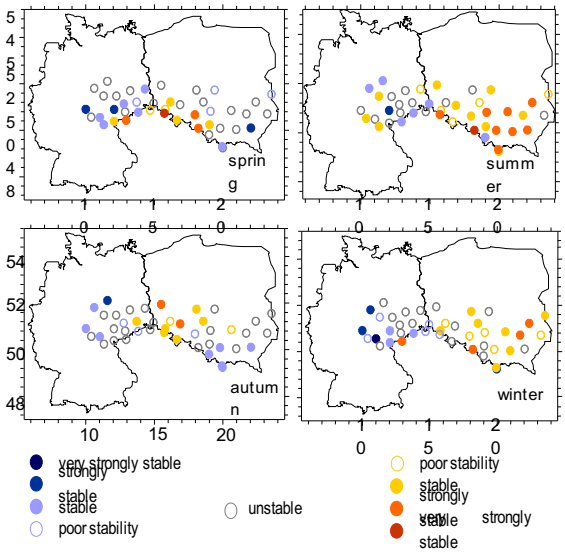

Figure 3. Trend stability the extreme precipitation index 90T (blue: increasing trends, red and orange: decreasing trends).

Decreasing trends dominated in all summer precipitation extremes in the 30-year periods between the mid-60s and the mid-90s. These trends occurred mainly at Polish stations. During some seasons (usually in the cooler part of a year) a clear difference of trends direction between the western and the eastern part prevailed. In the western part increasing trends dominated, while decreasing trends were characterisitic for the eastern part. Regional differences in the extreme precipitation trends may be due to changes in the atmospheric circulation pattern. This demands further analysis.

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Shifts in Climatic Regions in the Mountain Parts of Slovakia

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Abstract. In this contribution a territorial shifts in climate regions and subregions in the mountainous parts of Slovakia during the 20th century and at the beginning of the 21st century are studied. Analysis is based on the Konček's climatic classification. This study shows that climate in the southern part of Slovakia (lowlands) has become more arid, while, the northern part of Slovakia (mountains) has become more humid during this period. Some shifts of climatic regions and subregions towards the higher altitudes were registered in Slovakia during this period as well.

Introduction

Identification of climatic regions borders and study of their geographical shifts in time scales leads to the understanding of climate development in these territories. There are many kinds of climatic classifications (Oliver, 2008). The Climate atlas of Czechia contains three classifications: the Köppen's, Quitt's and Konček's classifications (Tolasz et al., 2007). In the Atlas of the Slovak Socialistic Republic two climatic classifications were worked out (Konček, 1980; Tarábek, 1980). The aim of this contribution is to detect territorial shifts in climate regions and subregions in the mountain parts of Slovakia during the twentieth century and at the beginning of the twenty-first century. Analysis is based on the Konček's classification of climate. It belongs to the most used climatic classifications in Slovakia.

Data and methods

In this contribution data from the Slovak Hydrometeorological Institute Bratislava (air temperature, precipitation total, wind) for some Slovak meteorological station are utilized.

Climatic regions and subregions in Slovakia by the Konček's climatic classification have been specified as follows. This classification is based on the Konček's moisture index values together with some air temperature characteristics (Konček, 1955; Konček, 1980; Lapin et al., 2002).

The Konček's moisture index is simple climatic characteristic. Its value is calculated by the formula:

$$Iz = 0.5R+r-10T-(30+v^2),$$

where R [mm] – means precipitation total in the vegetation period (April-September),
r [mm] – precipitation total exceeding in average 105 mm for winter season (December-February),
T [°C] - mean air temperature in the vegetation period,
v [$m.s^{-1}$] – mean wind speed measured at 14 h of MLT in the vegetation period.

Value Iz > 120 means very moist region, Iz in range 60-120 characterizes moist region, Iz from interval 0-60 is typical for moderately moist region, Iz from -20 to 0 was set for moderately dry region, Iz from -40 to -20 relates to dry region and Iz less than -40 means very dry region.

Based on these Iz values together with some air temperature characteristics, the climatic regions in Slovakia (in former Czechoslovakia too, at present also in the Czech Republic) have been specified (Konček and Petrovič, 1957; Konček, 1980; Lapin et al., 2002; Tolasz et al., 2007). Three regions are divided by this method (warm, moderately warm and cool regions). Warm region has 50 or more so called summer days annually in average (with daily maximum air temperature ≥25 °C), moderately warm region has less than 50 summer days annually in average (with daily maximum air temperature ≥25 °C) and the July mean temperature is 16 °C or more. Cool region has the July mean temperature < 16 °C. Warm region has 7 subregions (differences are in values of mean January air temperature and in values of Iz). Moderately warm region has 7 subregions (differences are in values of January and July mean air temperatures and in values of Iz). Cool region has 3 subregions (all three subregions are considered as very humid, differences are only in mean July temperature, 12 and 10 °C limits) (more in Lapin et al., 2002). The Konček's moisture index is suitable also as a possible indicator of the aridization trends in the land (Melo et al., 2007).

Results

Analysis based on the Konček's climatic classification shows that during the 20th century and at the beginning of the 21st century some territorial shifts in climate regions and subregions in Slovakia have appeared. We can state that during this period aridization trends were detected in the southern part of Slovakia (especially in the Danubian lowland, the East-Slovakia lowland and the Košická hollow). The northern (mountainous) part of Slovakia has become more humid in this period.

Climatic regions and subregions of Slovakia based on the Konček's climatic classification for periods 1931-1960 and 1961-1990 were presented in Konček (1980) and Lapin et al. (2002). Two new climatic subregions were classified in Slovakia between these two periods. Both relate to the warm region in the lowlands (SW and SE parts of Slovakia). Interesting shifts in climatic regions occurred in the Poprad hollow and in the surroundings of Orava water reservoir during the 20th century. Both regions are located in the northern part of Slovakia. The first moderately warm region (in 1931-1960) was transformed to the cool region (in 1961-1990). It was caused by slight decrease of mean July temperature between these two periods (at Poprad from 16.2ºC in 1931-1960 to 15.5ºC in 1961-1990). Just value of T = 16ºC is important boundary threshold between climatic regions in this classification. A moderately warm region is recorded again in these territories. Even in 1991-2008 this moderately warm region farther overspread its area from the Hornád hollow to the Poprad hollow (moderately warm and moderately humid subregion with cold winter, valley/basin) (mean July temperature T = 16.7ºC for Poprad and T = 16.9ºC for Gánovce in 1991-2007) and also in the Liptov

hollow (moderately warm and humid subregion with cool to cold winter, valley/basin) from Liptovský Mikuláš towards the higher altitudes (e.g. for Liptovský Hrádok where mean July temperature T = 15.9ºC in 1961-1990, T = 17.5ºC in 1991-2008 and T = 17.0ºC in case of the last 30–year period 1979-2008).

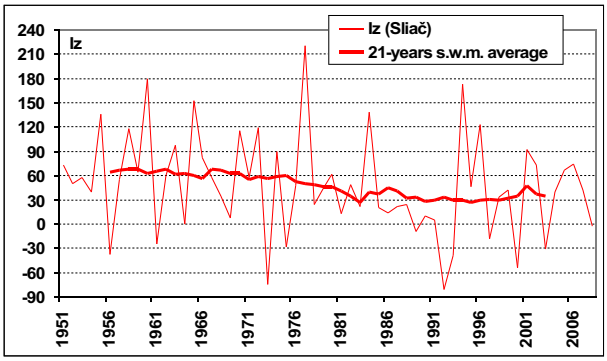

Figure 1. Values of the Konček´s moisture index (Iz) for Sliač in individual years in 1951-2008 and their smoothing by 21-years simple weighting moving average.

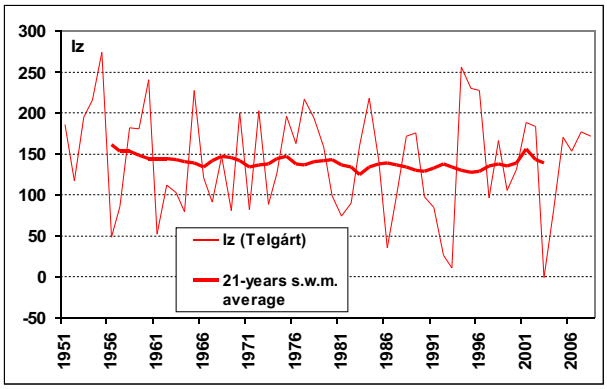

Figure 2. Values of the Konček´s moisture index (Iz) for Telgárt in individual years in 1951-2008 and their smoothing by 21-years simple weighting moving average.

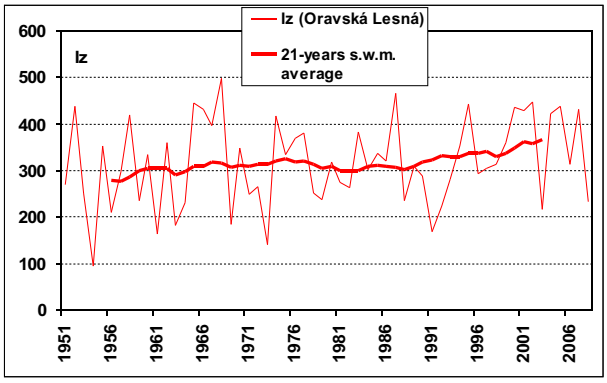

Figure 3. Values of the Konček´s moisture index (Iz) for Oravská Lesná in individual years in 1951-2008 and their smoothing by 21-years simple weighting moving average.

For some meteorological stations (Sliač, Telgárt, Poprad, Liptovský Hrádok a Oravská Lesná) values of the Konček´s moisture index in individual years in 1951-2008 were studied. In case of Sliač (warm region, warm and moderately humid subregion with cool winter) the climate is more arid in 1951-2008 (values of Iz following the smoothing by 21-years simple weighting moving average continuously decreased and after 1971 these values reached Iz < +60) (Fig. 1). Climate at Telgárt (cool region, moderately cool subregion) is without significant change in 1951-2008 (Fig. 2). On the contrary, the climate humidity increases in the northern (mountainous) part of Slovakia (with higher altitude). More significant increase of Iz values (mainly because of precipitation increase) was reached at Oravská Lesná in 1951-2008 (Fig. 3). This locality is characterized by very humid climate (cool region, moderately cool subregion). Moderately increase of Iz values was recorded in case of next stations: Poprad (with moderately humid climate) and Liptovský Hrádok (with humid climate).

Conclusions

Climate is changing in the Central European area. Certainly the climate has become warmer and more arid in the southern part of Slovakia (lowlands) during the 20th century and at the beginning of the 21st century. Also other shifts in climatic regions and subregions were registered in Slovakia. The northern mountainous part of Slovakia has become more humid during this period.

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Assessment of bioclimatic conditions of the alpine and the subalpine zone of the Giant Mts (Karkonosze)

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Abstract. The aim of this article is estimation of influence of weather conditions on possibility of the tourist and recreational activity in the highest zone of the Giant Mts (Karkonosze). The research was based on Subjective Temperature Index (STI) and human heat balance (mS) which were calculated on the basis of K. Blazejczyk's Bioklima 2.5 program. The results of the research show that bioclimatological conditions in the highest parts of the Giant Mts are significantly different from those observed in their foreland. Such a severity of weather conditions in this hypsometric zone may cause significant health hazards, especially during winter season. Consequently, information about the most important features of bioclimatic conditions in this region could be valuable for tourist traffic.

Introduction

One of the most important tourist regions in Poland are the Giant Mts which are located in Lower Silesia (SW Poland). The most important features of their climatic conditions are specific thermal and cloudiness conditions (Dubicka &Głowicki, 2000) as well as strong winds in the highest zones (Głowicki, 2005). Such conditions have a great influence on the human heat balance, which in the alpine and subalpine zone of the mountains are significantly different from observed in their foreland. On the other hand the highest parts of the Giant Mts are the most attractive regions for tourists because of their unique landscape. Therefore the main aim of this article is estimation of the influence of climatic conditions on human organism in this region with the use of Subjective Temperature Index (STI) and human heat balance (mS). Special attention was paid to extreme weather conditions. They are the most noticeable during winter months, when their severity in unique days increases the risk of hypothermia, frostbites, chilblains and cold injuries. Therefore obtained results of the research, could be an important source of information for the tourism planning in this region.

Data and methods

The characteristics of bioclimatic conditions was based on meteorological data for the 1971-2000 period. They were obtained from the meteorological stations of the Institute of Meteorology and Water Management (Mt. Śnieżka, Jelenia Góra) and from the Meteorological Observatory of the Univeristy of Wroclaw (Mt. Szrenica). The stations represented alpine area (Śnieżka), subalpine area (Szrenica) and foreland (Jelenia Góra) of the Giant Mts (Tab. 1). The data included records from 12 GMT observation term and contained air temperature, relative humidity, wind speed and cloud cover. Additionally, solar elevation was also considered.

The characteristics of the bioclimatic conditions were accomplished with the use of K. Blazejczyk's Bioklima 2.5 program which bases on MENEX_2005 model (Błażejczyk, 2006), which considers heat exchange between the human body and the atmosphere.

Table 1. Meteorological stations in the Giant Mts for 1971-2000 period.

meteorological station	geographical position	altitude [m a.s.l.]	terrain form
Jelenia Góra	50° 54'N 15° 48'E	341	concave
Szrenica	50° 48'N 15° 31'E	1331	convex
Śnieżka	50° 44'N 15° 45'E	1603	convex

The characteristics of the bioclimatic conditions were accomplished with the use of K. Blazejczyk's Bioklima 2.5 program which bases on MENEX_2005 model (Błażejczyk, 2006), which considers heat exchange between the human body and the atmosphere. Depending on mentioned meteorological data, the calculations contained: average monthly values of STI, monthly frequency of thermal senses in particular classes (7 classes in range from 'extremely cold' to 'sweltering') and average values of STI for every day of a year. For mS, its average values for every month were calculated, as well as values of its particular components – radiation balance of man (mQ), evaporation (mE), convective (mC) and respiratory heat balance (mRes). According to MENEX_2005 model, in order to calculate mS there was also considered metabolism heat production equal 135W/m^2 (the value recommended by the International Society of Biometeorology). Moreover, because of extreme cold stress observed in the highest parts of the Giant Mts during the winter season, there were selected days with the most unfavourable weather conditions, for which possible time of face and fingers frostbites was estimated. Calculations were executed with the use of the calculator of thermal senses for winter season, which bases on values of air temperature, relative humidity, wind speed and cloudiness.

Results and discussion

The typical feature of bioclimatic conditions of the Giant Mts assessed on the basis of STI index and mS is significant difference between the highest parts of the mountains (alpine and subalpine zone) and lower hypsometric zones. The average monthly values of STI index in Jelenia Góra, which is located in the foreland, range from -8.1°C (thermal senses 'cold') in December to 29.3°C ('comfortable') in August. In the highest parts of the Giant Mts, the lowest values of STI are observed in January (-24.9°C on Szrenica and -27.7°C on Śnieżka) which are equivalent of 'very cold' thermal sense. The highest values of STI are observed in August and they are in range from 10.0°C on Śnieżka to 12.5°C on Szrenica ('cool'). Such thermal senses are caused

by the low air temperature, high wind speed and big amount of cloudiness in the highest zone in winter.

The most comfortable weather conditions in whole region of the Giant Mts are observed in the warm half year (Fig. 1). The average STI values noted in the highest zone are usually equivalent of 'cool' thermal senses, while they reach 'comfortable' and even 'warm' class (in the first half of August) in the foreland Jelenia Góra. In the highest parts of the Giant Mts, the average STI values equivalent to 'cold' thermal senses are observed from the second half of October till the end of first half of November and from the second half of March till the end of April. In the winter season, average values of STI index are qualified to 'very cold' and 'extreme cold' thermal senses.

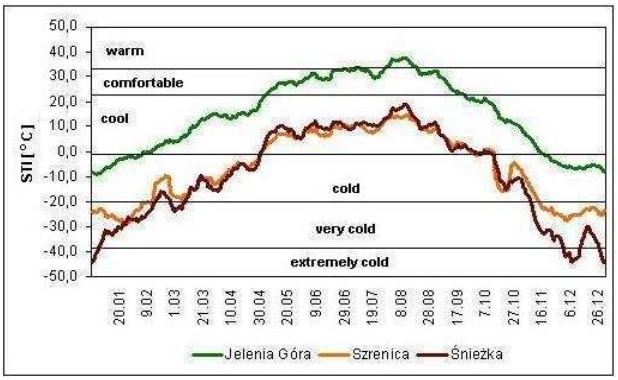

Figure 1. Average values of STI index at the selected meteorological stations of the Giant Mts during 1971-2000 period.

Frequency of days with particular thermal senses in the alpine and subalpine zone of the Giant Mts is characterized by the greatest number of days with thermal senses 'cold', 'very cold' and 'extremely cold' during winter months. They constitute over 95% of all days in January in the highest parts. Nearly 37 % of all days are qualified as 'cold' and 34% (Szrenica) to 45% (Śnieżka) as 'very cold' thermal senses, however frequency of 'extremely cold' days, in which weather conditions can be especially threatening for the human health, is also very significant here. 'Extremely cold' days constitute almost 15% of all days on Szrenica and almost 30% on Śnieżka in January. Such days are noted from November to March, but they can also appear sporadically in April and October. Thermal senses of 'cool' are dominant in May-August period on Szrenica and in May-October on Śnieżka. They especially prevail during summer months when they are observed over 50% of all days. During the warm half year, there are also noted 'cold', 'comfortable' and 'warm' days. On the other hand, days with 'hot', 'very hot' and 'sweltering' thermal senses are not observed here.

In the alpine and the subalpine zone, the values of mS are negative through all the year as well as the values of mC which is the dominant component of mS. The greatest heat losses in this process are observed in the winter months, when they reach less than -250 W/m^2 what constitutes over 75% of overall heat losses. The remaining components of mS are less significant. The maximal heat loss in both mQ and mRes processes was observed in the winter and in mE in the summer. Similarly to mC, mQ, mRes and mE average values are also negative through all the year.

Maximal average monthly values of mS are observed in the highest parts of the Giant Mts in August and they fluctuate from -65 W/m^2 on Szrenica to -80 W/m^2 on Śnieżka. The average values of mS are less than -200 W/m^2 on Szrenica and -250 W/m^2 on Śnieżka in the winter season. In some days however, during extreme weather conditions, overall heat losses can drop below -2000 W/m^2 what is comparable with values observed in polar regions (Dubicka et al., 2005) and what can cause significant threat for the human health (Tab. 2).

Table 2. Human heat balance (mS) and possible time of frostbites during selected days estimated on the basis of Bioklima_2005 program and the calculator of the thermal senses at Śnieżka. The meteorological conditions are characterised by: air temperature (T), relative humidity (U), wind speed (v), cloud cover (N).

Date	T [°C]	U [%]	v [m/s]	N [%]	mS [W/m^2]	Time of frostbites	
						Face	Fingers
07.01.1987	-21.8	94	24.0	88	-1907	3.4 min	31 s
07.01.1982	-19.0	95	27.0	100	-2518	4.1 min	36 s
02.01.1979	-19.2	95	23.2	100	-1478	4.5 min	41 s
07.03.1987	-18.6	99	25.0	100	-2492	4.5 min	41 s

Conclusions

Presented results of the research on bioclimatic conditions of alpine and subalpine zone of the Giant Mts show significant severity of weather conditions and their influence on human thermal senses and health. The most important factors are very low values of air temperature and high wind speed, which consequently lead to appearance of 'cold' thermal senses and low values of mS. It is especially noticeable during the winter season, when severe weather conditions cause a great cold stress and in some cases may constitute serious threat for the human health. According to presented STI and mS values the cold stress in the alpine and subalpine zone can also occur during the summer season, which is characterized by a great number of tourists in the Giant Mts. Therefore the results of the research can be a significant contribution to the tourism planning in this region. In consideration of intensive tourist traffic, they can provide important information about the most unfavourable weather conditions and periods of their occurrence.

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Temperature inversions in the karst canyon of the Ojców National Park (Southern Poland)

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Abstract. The paper presents results of investigation of temperature inversions in deep (100-150 m) karstic canyon of the Ojców National Park. This terrain is located on the Cracow Upland, about 15-20 km to the north from Cracow. The air temperature registrations with the interval of 10 minutes were done by two automatic weather stations, located at the valley bottom (335 m) and on the summit (482 m). Heights' difference (ΔH) between the stations was 147 m. Temperature differences (ΔT) were calculated as T_{summit}-T_{valley}. Thus, the positives represent an inversion of temperature. The frequency of daily minimum temperature inversions exceeds 68%. In extreme cases, the difference of temperature between the summit of Cracow Upland and the bottom of the karst canyon reaches 12.1K.

Introduction

In case of investigations of influences of topography on conditions of local climate, the existence of inversional distribution of the temperature in hollows of the terrain is often an essential fact (Geiger et al., 1995). The aim of investigations was to determine occurrence of temperature inversions in deep karstic canyon on Cracow Upland. The Prądnik valley 100-150 m deep, running from North to South, situated on terrain of the Ojców National Park, made up the object of investigations. It is located about 15-20 km to the north from Cracow.

Data and methods

Altitudinal distribution of temperature was obtained on the basis of field measurements. Campbell automatic weather stations were located at two sites (Tab. 1): at the valley bottom of karst canyon (Valley) and on the summit of the Cracow Upland (Summit, Fig. 1). The relatively flat bottom of the canyon was about 150-200 m wide, with steep limestone sides. Heights' difference (ΔH) between the stations was 147 m. Temperature differences (ΔT) were calculated as T_{summit}-T_{valley}. Thus, the positive values represent an inversion of temperature. Temperature sensors were placed inside small multi-plate radiation shields, 2 m above the ground surface. The registraton was done with the time-intervals of 10 minutes.Complete registration data without breaks were available for 470 days between the September 2007 and June 2009.

Statistical calculations were done for standard seasons: winter (DJF – December, January and February), spring (MAM – March, April and May), summer (JJA – June, July and August) and autumn (SON – September, October and November). To avoid the influence of difference in day and night length, also the calculations for 6-hour-day (between 09:00 and 15:00 local time) and 6-hour-night (between 21:00 and 03:00 local time) were done separately. The whole day (24h) data covered the period from 18:00 of the the previous day to 17:50 local time of the current day.

For weather conditions the circulation types, air masses and fronts were determined on the basis of synoptic maps. Average daily cloudiness (in % of sky coverage) was calculated from the nearest synoptic station in Cracow-Balice airport (WMO index 12566), situated about 15 km to the south from the observation sites.

Table 1. Geographical location of the automatic meteorological stations.

Station	Latitude N	Longitude E	Altitude m
Summit	50°12'23"	19°47'04"	482
Valley	50°12'35"	19°49'44"	335



Figure 1. Summit (482 m) Station, fot. Zbigniew Caputa.

According to ΔT, all inversions were categorized as weak (0.1-3.0K), moderate (3.1-6.0K) and strong (>6.0K). The frequency of days with the inversions of maximum, minimum and average daily temperature was calculated. Each day was also characterised by the percentage of time (based on 10-min intervals) with inversion, the maximum, the minimum and the average of temperatures' differences (ΔT). The estimation of extreme values and quantiles of distribution (p=1, 10, 25, 50, 75, 90 and 99%) has been the main result of statistical analysis. The results were also analysed according to circulation types and cloudiness conditions.

On the basis of the air amasses inflow, direction the four categories of advective anticyclonic circulation types: N+NEa, E+SEa, S+SWa and W+NWa were distingiuished for each day. Non-advective type Ca+Ka indicates anticyclone centre or a wedge of high pressure. In similar way the cyclonic situations were marked: N+NEc, E+SEc, S+SWc and W+NWc. Cyclonic category Cc+Bc concerns the centre or trough of low pressure. Days without a particular circulation type were termed unclassifiable (x).

Results and disscussion

Temperature differences between the summit and the valley bottom depend on time of a day. Generally average daily temperature on the summit was 0.8K higher than in the valley bottom, mainly according to the frequent temperature inversions. Only during midday, represented by daily maximum temperature, it was 0.8K cooler on the summit. The largest difference was found for minimum temperatures and it carried out up to 2.0 degrees in an average.

Temperature distribution in valleys depends strongly on weather conditions (Whiteman, 1982; Milionis and Davies, 2008). In the karst canyon of the Ojców National Park, the largest measured intensity of temperature inversion (ΔT) reached up to 12.1 degrees. This condition was observed on April 28, 2009 during southern anticyclonic situation (Sa) with polar-continental air masses and cloudless sky. During similar weather conditions on July 25-30, 2008 with the eastern anticyclonic situation (Ea), strong temperature inversions were observed during the all whole night (Fig. 2).

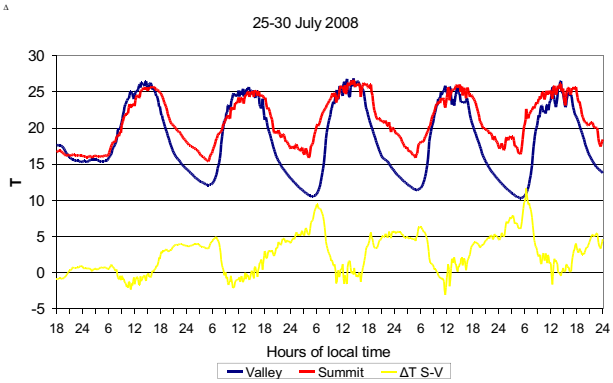

Figure 2. Daily course of the temperature (T°C) and temperature differences Summit-Valley (ΔT S-V) on 25-30 July 2008.

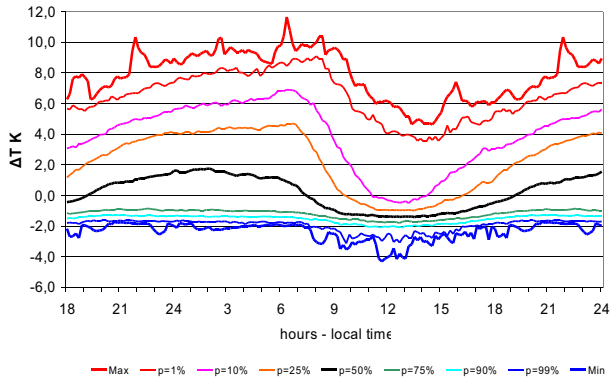

Figure 3. Daily course of the temperature differences Summit-Valley (ΔT) with different probabilities (p%).

The daily structure of temperature inversions is presented in Fig. 3. The strongest inversions, exceeding the temperature difference of 6K with occurrence probability of 10%, were observed during the second part of night, just before the sunrise. Therefore the frequency of minimum temperature inversions attained also until 68%. Inversions with the intensity greater than 3.0K happened within 38% of days and strong inversions (ΔT>6.0K) frequency exceeded 8%. The frequency of inversion of maximum temperature does not cross 15%, and moderate and strong inversions happen rarely and only in winter.The inversions of average daily temperature happened with frequency of 59%. The accumulated probability curves more precisely illustrate this problem (Fig. 4).

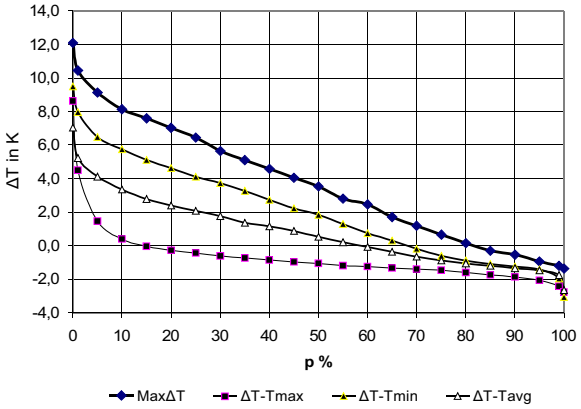

Figure 4. Cumulative probability curves of Summit-Valley temperature differences (ΔT): Max ΔT – maximum observed in 10 min. intervals, ΔT-Tmax – daily maximum temperature, ΔT-Tmin – daily minimum temperature, ΔT-Tavg – 24h temperature averages.

Conclusions

The inversions of temperature are typical features of the altitudinal temperature distribution in karst canyon. They were developed mainly during night time. The frequency of daily minimum temperature inversions exceeded 68%. Somewhat smaller was the frequency of inversions of daily average temperature (59%), and rarely appeared out the inversions of maximum temperature (15%). In extreme cases, the difference of temperature between the summit of Cracow Upland and the bottom of a karst canyon reaches 12.1K. Inversions with moderate intensity (ΔT 3.1-6.0K) happened with 30% frequency, while with strong intensity (ΔT >6.0K) only during 8% days. Most of inversions had the radiative origins and they were caused mainly by the anticyclonic circulation with polar-continental air masses, with clear skies and calm winds.

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Extreme values of precipitation and snow cover characteristics in Slovakia

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Abstract. It is widely conceived that with the increase of air temperature, the water cycling process will be sped up, which in consequence will possibly result in the increase of precipitation and fresh snowfall amount and intensity. Many outputs from Global Climate Models (GCMs) indicate the possibility of substantial increases in the frequency and magnitude of extreme daily precipitation. In the paper presented here we deal with statistical evaluation of extreme precipitation and snow cover depth values in different regions of Slovakia within the 1951-2008 period. In the case of available time series of selected characteristics of precipitation totals and snow cover we have been able to recognize statistically significant positive changes of theirs extreme values within investigated period (1951-2008).

Introduction

Trends of the precipitation in Slovakia were significantly affected by the decrease in annual totals in the last decades of the previous century, what reached the peak in the eighties and early nineties. These trends were quite strongly expressed in the Danube lowland while the mountainous area showed rather steady trends (Lapin et al., 2007a; 2007b). An analysis of annual regional precipitation totals showed increase from the fifties and later slow decrease to the same level after middle of the nineties. However, the precipitation distribution through the year has shown some changes. The newly observed feature is the change of precipitation distribution during the year as well as the cumulation of heavy rains and precipitation deficit periods through the different seasons in past two decades. The precipitation deficit periods are cumulated mainly in lowlands into the summer months and there is a notable decrease of these periods in autumn. Also the distribution of heavy rains as well as the distribution of maximal daily precipitation and cumulative k-days precipitation has been changed.

Further characteristic of the water supply is the portion of snowfall on the precipitation totals. In the mountainous areas, snowfall represents about 40 % of the annual precipitation total (Faško et al., 2007). A decreasing trend of both daily fresh snow amounts and cumulative snow cover depth was observed in the lowlands and at the foothills. The opposite trend has appeared in the mountains. The maximal annual depth of the snow cover have not been reached by step by step accumulation of daily portions of snowfall but they were rather connected with the extreme events bringing heavy snows. All these features indicate a tendency to the higher frequency of extreme events regarding the precipitation and snow cover characteristics.

Liquid, solid and mixed precipitation proportion of total precipitation value is considered to be relevant characteristic indicating sufficiently noticeable the long-term changes of temperature as well as precipitation conditions. More precisely the change of regime of particular precipitation state (liquid, solid and mixed) could be used as significant indicator of climate change evidence in specified region. In the present, the snow cover extreme events, particularly calamitous flurries of fresh snow, are occurring more frequent and theirs impact on society activities are becoming more obvious and serious in Slovakia.

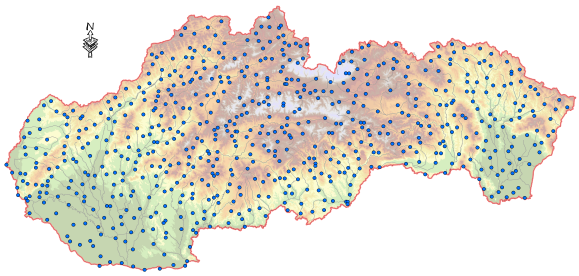

Figure 1. Spatial distribution of utilized rain gauge stations in Slovakia (1981-2008).

Data and methods

There are about 700 precipitation gauges in Slovakia since 1951 and some lower number during the 1921-1950 period. Altogether, 600 time-series are complete for 1981-2008 period (Fig. 1). In spite of shorter 30-year period, the time interval 1981-2008 is considered to be long enough to identify principal changes in snow cover and precipitation during current climate change. In the case of precipitation maxima analysis we have focused particularly on trend analysis of 2- and 5-day precipitation totals and their annal maxima. In order to identify long-term changes in snow cover extreme we decided to calculate the number of days with fresh snow cover depth ≥ 20 cm (FSC_{d20}) and n-days sum of fresh snow cover depth (FSC_d) together with precipitation state ratio at selected meteorological stations in the 1951/1952-2008/2009 winter. To analyze a spatial distribution of snow cover depth winter maxima 3D RST-interpolation method in GIS GRASS was utilized.

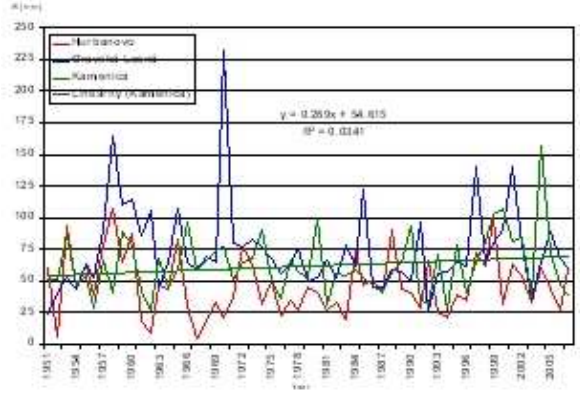

Figure 2. The summer maxima of 5-day precipitation totals at selected meteorological stations within 1951-2008 period.

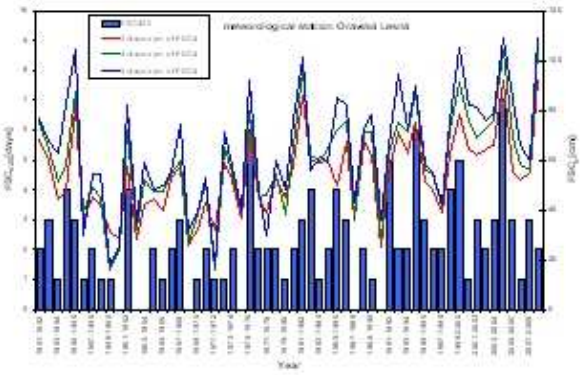

Figure 3. Number of days with fresh snow cover depth ≥ 20 cm (FSC_{d20}) and n-days sum of fresh snow cover depth (FSC_d) at meteorological station Oravská Lesná (780 m a.s.l.) in the 1951/1952-2008/2009 winter.

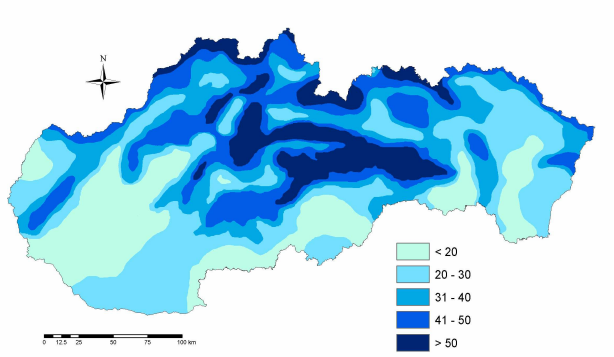

Figure 4 Fresh snow cover depth winter maxima in Slovakia within 1981-2008 period.

Results and conclusions

In the case of available time series of selected characteristics of precipitation totals and snow cover we have been able to recognize statistically significant changes of theirs extreme values within investigated period (1951-2008). Almost every year during the first decade of 21st century there have been recorded severe floods in the region of eastern Slovakia. This fact is apparent from statistical analysis results of 5-day precipitation totals where the positive trend (+2.7 mm/decade in Kamenica) has been identified (Fig. 2). The results of extreme precipitation analyses are in good agreement with conclusions of previously published papers, e.g. Faško (2006). Similarly, the results of fresh snow cover depth analysis have shown an expected increase at considered meteorological stations in Slovakia in the winter (e.g. in Oravská Lesná 3-days sum of FSC_d has risen up to 4 cm/decade, Fig. 3). The fresh snow cover depth maxima raking and its temporal occurrence support an exceptional status of the values recorded in the last decade of the 20th century and in the first decade of the 21st century, as well. In the case of n-days sum maxima (particularly 3-, 4- and 5-days sum) of fresh snow cover depth as well as the number of days with higher values of fresh snow cover depth, the statistical analysis have preliminarily detected a significant positive trend for the most of territory of Slovakia in the winter. The map in Fig. 4 represents an example of spatial analysis of fresh snow cover depth maxima evaluated for 1981-2008 period. The analysis of long-term series of precipitation state ratio (liquid, solid and mixed) at selected meteorological stations has confirmed the existence of positive trend in the case of annual liquid and mixed precipitation rate and on the contrary the negative trend of annual solid precipitation rate in the south as well as north part of Slovakia, including mountain regions. Analogous or even more expressive trends of proportion of particular precipitation state have been revealed for individual months as well as for period when solid and mixed precipitation predominate (in the cold half-year).

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Poisson modelling of the heat waves and tropical days in the Czech Republic

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Abstract. This paper presents the results of a study on the analysis temporal and spatial structure of heat waves and tropical days in the Czech Republic. Data from 55 stations for the 1977-2008 period was used. The frequency and distribution of heat waves was made by applying the Puasson's generalized model. Heat-waves are rare events that vary in character and impact even in the same location. According to the obtained results, in the end of July and August the long duration heate-waves are prevailing. The number of tropical days is increased in the last 10 years. The summer of 2006 and 2003 were characterized with the highest number of consecutive tropical days (31 and 26, respectively).

Introduction

Many research activities during the second half of the 20th century focused on extreme climate phenomena, including heat-waves, because of their influences on agriculture, water resources and human mortality (Blazejczyk et al., 1998; Huth et al., 2000; Rebetez M., 2009). Numerous biometeorological indices have been developed to account for the thermal stresses encountered by the human body in varying ambient environments. Currently, there is no standardized definition of a heat-wave. The World Meteorological Organization (WMO) has not yet defined the term. However, several approaches can be used to define a heat-wave. A heat-wave can be defined based on an absolute or a relative threshold of weather variables or as a combination of both. These definitions are based on: air temperature threshold; or air temperature threshold and minimum duration; or indices based on a combination of air temperature and relative humidity. WMO recommended heat wave duration index (HWDI) to define heat wave: the maximum period greater than five consecutive days with t_{max}>5 °C above 1961-1990 daily t_{max} normal. Heat-wave is extreme event, it is rare at a particular place and time of year. In other words, heat-wave event would normally be as rare as or rarer than the 10th % or 90th % of the observed probability density function. In climatic conditions of the Czech Republic is widely applied the definition of a heat wave used in Huth et al. (2000): it allows two periods of tropical days separated by a pronounced temperature drop below 25 °C (e.g., due to a cold front passage) are treated as separate heat-waves. The minimum duration of a heat-wave required by the definition is three days.

Data and Methods

In our analysis, we included daily maximum temperature series from a 55 of weather stations and/or the single station Prague-Karlov. We applied the method of Huth et al. (2000) for identification heat-waves. For the analysis of the spatial distribution of the number of tropical days, Kriging, which is the most appropriate method for mapping, thereby was used. For the study of the heat-waves the following items have been carried out:

- the analysis temporal structure of heat wave as rare extreme event,
- the evaluation of the spatial distribution of number of tropical days.

Heat wave time variability was estimated in accordance with rare events law, based on Puasson's generalized distribution:

$$P[(N(t+\tau)-N(t))=k]=\frac{e^{-\lambda\tau}(\lambda\tau)^k}{k!} \qquad k=0,1,\ldots,$$

where $N(t+\tau)-N(t)$ describes the number of heat waves in time interval $(t,\ t+\tau)$. Poisson process (Pp) is characterized by a rate parameter λ, such that the number of heat waves in time interval $(t,\ t+\tau)$ with associated parameter λτ>0. The exponential parameter λ is estimated to minimize the difference between the actual heat wave and its value predicted by exponential distribution. The observed heat wave frequency comes from random sampling from the relevant Pp. The estimate of λ is: λ=1/avg (k). We recall that a Pp the interval (0, 1) is a stochastic point process; one characteristic property is that the recurrence times, the times between successive occurrence points, are independent exponential random variables (Tab. 1).

Table 1. Heat wave risk assessment.

probability (λ, 1/year)	Risk level
λ.>0.2	Frequent
0.1<λ<0.2	Probable
0.01<λ<0.1	Rare

Results and disscussion

The first step in order to assess the tropical days in urban condition has been analysed for Prague-Karlov station.

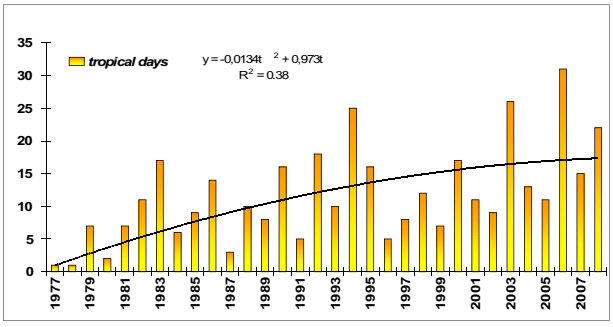
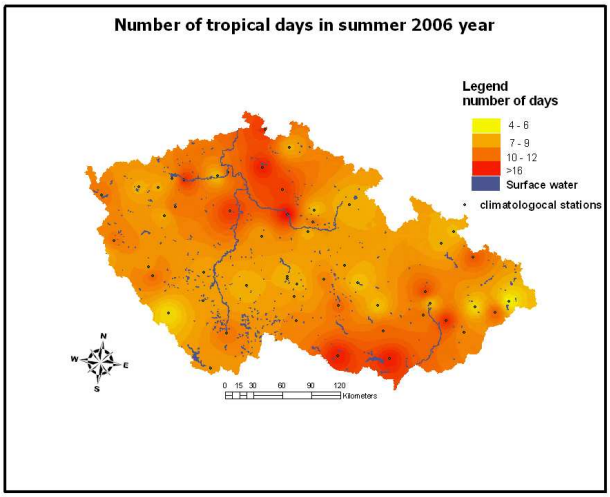
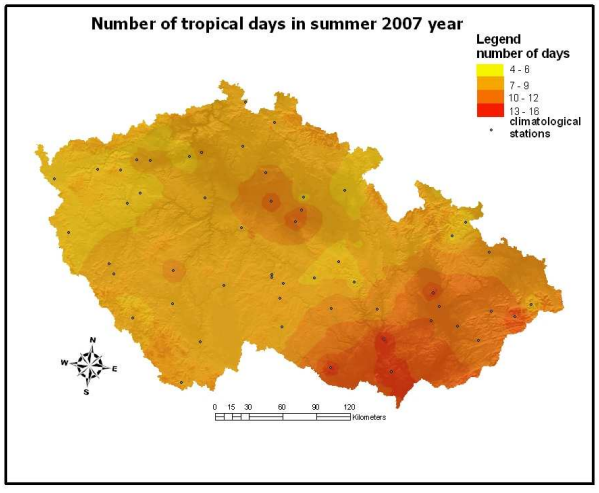


Figure 1. Time series of number of tropical days and 2nd polynomial fitting during the summer at the urban station Prague-Karlov.

The tropical days in Prague-Karlov station, for the whole examination period, present a small positive trend (Fig. 1). In the past 30 years the biggest number of tropical days in Prague-Karlov was recorded in 2006 (31 days). Then,

follow number of tropical days recorded in 2003 (26 days), 1994 (25 days) and in 2008 (22 days). The heat-waves were severe in 2003 (13 August, tmax=36.9 °C), 2006 (20 July, tmax=36.6 °C), 2007 (16 July, tmax=37.2 °C) and 2008 (1 August, tmax=33.9 °C). The longest duration heat-wave of summer 2006 started in 11th July, and, after a short break in 15th July, it rise again in 18th July until beginning of August. In this time-sequence the maximum temperature was above 30.5 °C. In July 2006, as in June and August 2003, departure of the mean temperature was more 4.7 °C over the Czech Republic. In the majority stations beginning with 5th July maximum temperature was from 27.0 to 33.0 °C, it isolated untill 37.0 °C. The peak temperature in the severe heat-wave (20th and 27th July) has been recorded 38.0 and 37.3 °C in Kopisty and Doksany stations, respectively. In the most recent study undertaken by Rebetez et al., (2009), that the 2006 heatwave was clearly located more to the north Europe than in summer 2003. Regions such as Northern France, Germany, Belgium, and the Czech Republic, which were strongly affected by the 2003 heatwave, were affected by an even more extreme heatwave in July 2006, in terms of absolute mean monthly values.





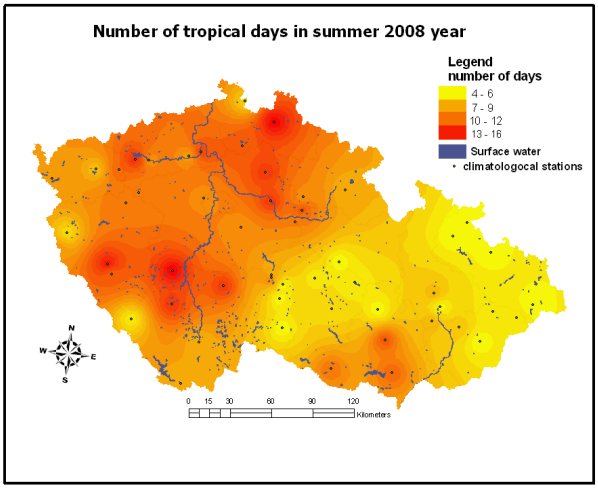


Figure 2. Spatial variability of tropical days in summers of the 2006-2008 years in the Czech Republic.

In the summer 2007 this episode occurs from 14th July to 22th July. Moreover, the specific to heat wave from 2007 are affected southern, south-eastern and central parts of the Czech Republic (Fig. 2). In particular, the highest maximum temperature of a heat wave on Central Bohemian region of exceeded 37.0 °C was recorded at the station Poděbrady (16th-17th July). With regard to the 2008 year, the maxima of tropical days are shown in the north, north-east and south-weast, while minima are observed in the south-east and particulary in the Bohemian-Moravian Upland (<5 days).

Conclusions

The highest values of daily maximum temperatures during the summer are important for human health. The final results showed statistically significant variability in frequences, duration and severity of heat-waves and number of tropival days. An increase of consecutive heat days and tropical days was detected.

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Si drought index and its potential use for monitoring of severity droughts in Central Bohemian region

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Abstract. In this research, the Si drought index was used for the Czech drought conditions. The Si drought index was developed to detect drought and wet periods and distinguish meteorological drought or agricultural drought. The most extreme drought months for the entire reference period were recorded in the following cases: April (2007, 2000), May (2002), June (2003, 2000), July (2006, 1994), August (2003, 1992), September (2006, 1982), October (2001, 1967), November (2006, 1994 and 2003), December (2006, 2000). The longest drought spells were recorded during four months in 1964 and 2003. The *Si-m* index has registered the highest positive value in August 2003 and April 2007. By contrast, the highest negative value of the *Si-m* index was reached in March 2000. During this month there was a heavy precipitation event, hence the same high values of *Si-m*≥2 were registered for the majority the weather stations. Thus, *Si-m* index has a high capacity to identify both drought and wet months on the territory of Bohemia Central region.

Introduction

The Si drought index was developed by Ped (1975) and makes it possible to determine agricultural drought. The *Si* index has been widely used for drought monitoring in the Commonwealth of Independent States and there are some attempts to use it in Central Europe as well. *Si* is usually calculated on the basis of empirical formula used to further characterize meteorological and agricultural droughts. The *Si* has a number of important advantages over the PDSI-index: it is simpler to calculate, it does not have a constant or coefficient and it can be calculated for any period and site of interest (Potop and Soukup, 2008; Potop et al., 2009).

Data and Methods

During 1961-2008, the Si index for each station was evaluated by taking into account the monthly rainfalls and temperatures of a network of 8 stations of the Czech Hydrometeorological Institute, which cover Central Bohemian region sufficiently (Fig. 1). In addition, the monthly soil moisture measurements under grass cover in the 0-40 cm layer from 1961 to 2008 (April-September) have been used. Values are expressed in percentage of AWC (available water capacity of soil). *Si* is expressed by the following equation (1-4):

$$Si(\tau)=\frac{\Delta T}{\sigma T}-\frac{\Delta R}{\sigma R}-\frac{\Delta E}{\sigma E} \quad (1)$$

where: $\Delta T = t_\tau - t_n$; $\Delta R = r_\tau - r_n$ and $\Delta E = e_\tau - e_n$

i and τ - climatological station and time, respectively
t_τ – monthly mean air temperatures in τ – a specific year
t_n – long-term monthly mean air temperatures
r_τ – monthly precipitation amounts in τ – a specific year
r_n – long-term monthly precipitation amounts
e_τ – monthly amount of moisture in a 0-100 cm soil layer in τ – a specific year
e_n – long-term amount of moisture in a 0-100 cm soil layer
σT, σR, and σE – root-mean-square deviation in monthly temperature, precipitation and moisture of soil, respectively.

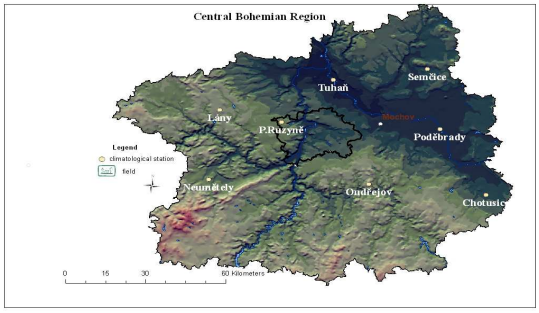

Figure 1. Map of location of the 8 weather stations used for the calculation of drought index in Central Bohemian region.

It should be noted that the soil moisture measurements and calculated values are not always available. Therefore, when calculating the index it is possible to use the simplified form without soil moisture. Then the *Si* may also be calculated by three methods (S_i-*m* - meteorological drought, S_i-*p* - pedological drought and S_i-*a* agricultural drought). Firstly, in case of the identification of meteorological drought only the first and second parameters of the equation 2 can be calculated:

$$S_i-m(\tau)=\frac{\Delta T}{\sigma T}-\frac{\Delta R}{\sigma R} \quad \text{or}$$
$$S_i-m(\tau)=\left(\frac{t_\tau-t_n}{\sigma T}\right)-\left(\frac{r_\tau-r_n}{\sigma R}\right) \quad (2)$$

Secondly, "pedological drought" (drought in the soil) can be formulated (3) as:

$$S_i-p(\tau)=\frac{\Delta E}{\sigma E} \quad \text{or}$$
$$S_i-p(\tau)=\left(\frac{e_\tau-e_n}{\sigma E}\right) \quad (3)$$

Thirdly, agricultural drought as a complex event may also be identified by equation 4.

$$S_i-a(\tau)=\left(\frac{t_\tau-t_n}{\sigma T}\right)-\left(\frac{r_\tau-r_n}{\sigma R}\right)-\left(\frac{e_\tau-e_n}{\sigma E}\right) \quad (4)$$

The Si index as well as PDSI indicate how the soil moisture compares with long-term climate conditions and are calculated based on parameters such as precipitation,

temperature, and soil moisture conditions. This index provides a measure of the long-term intensity of drought conditions derived from the precipitation and temperature anomalies and their combined effects on the soil water availability to plants. Furthermore, S_i-a determines drought conditions - if the values of parameters are as follows: $\Delta T>0$ or $\Delta T/\sigma T>0$; $\Delta R<0$ or $\Delta R/\sigma R<0$; $\Delta E<0$ or $\Delta E/\sigma E<0$, then S_i-$a>0$. Therefore, for the S_i-a, the categories interval ranges from extreme drought (S_i-$a\geq 3$) to extreme wet (S_i-$a\leq -3$), with the normal range falling between -1 and +1 (Fig. 2). The criteria for meteorological and agricultural droughts proposed in our analysis are included in Table 1.

Table 1. Drought criteria proposed for Si index and tested on the territory of the Czech Republic (Potop *et al.*, 2009).

	Drought severity classification			
	mild	*moderate*	*severe*	*extreme*
$_i$-m	$0\leq S_i\text{-}m<1$	$1\leq S_i\text{-}m<2$	$2\leq S_i\text{-}m<3$	$S_i\text{-}m\geq 3$
S_i-a	$1\leq S_i\text{-}a<2$	$2\leq S_i\text{-}a<3$	$3\leq S_i\text{-}a<4$	$S_i\text{-}a\geq 4$
S_i-p	$0\geq S_i\text{-}p>-1$	$-1\geq S_i\text{-}p>-2$	$-2\geq S_i\text{-}p>-3$	$S_i\text{-}p\leq -3$

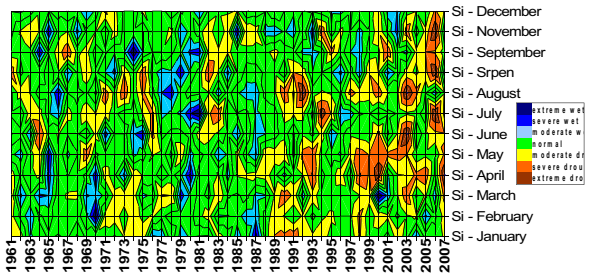

Figure 2. Evolution of the severity Si-m values for the 47-year time series in Central Bohemian region. It includes the assessment of drought spell (orange), normal spell (green) and wet spell (blue).

Results and discussion

For the existing soil moisture data the equations 1-4, were applied to calculate their statistical parameters and to identify the contribution of S_i-m and S_i-p on the S_i-a. Thus, the data analysis in Fig. 3 makes it possible to reach the following results:

- The high positive values of intensity S_i-$a\geq 2.0$ agricultural drought index are due to the positive values of S_i-$m\geq 1.5$ meteorological index and the negative values of S_i-$p<-1.0$ pedological drought index.
- The years when the values of S_i-a index had increased due to high values of S_i-m index have been observed. For example, the severe *July drought* years are related to 1983 (S_i-m=3.1 and S_i-a=4.60) and 1994 (S_i-m=3.3 and S_i-a=4.6). In the months of June (S_i-m=3.6 and S_i-a=6.0) and August (S_i-m=3.3 and S_i-a=5.0) of 2003, the highest value of the S_i-a index was recorded.
- In June, the greatest contribution to increased intensity agricultural drought S_i-a is soil moisture parameter (S_i-p). As an example, it can use the year 2007, when S_i-p index had a larger share than S_i-m (S_i-m=1.8, S_i-p=-2.0 and S_i-a=3.8). By contrast, in 1981, the S_i-p index had a positive value (it indicates normal conditions of soil moisture), which contributed to the decreasing intensity of drought (S_i-m=1.3, S_i-p=0.2 and S_i-a=1.2).

Conclusions

The advantage of the *Si* index is that its value can be calculated very accurately and simply, because it does not contain constants or coefficients that are specific to a geographical area. In this study the author proposed testing of the three methods for calculating the *Si* index: meteorological drought (S_i-m), pedological drought (S_i-p) and agricultural drought (S_i-a). In this evaluation of these methods showed that the more parameters are included in the *Si* equation, the more precisely it determines the intensity of agricultural drought (S_i-a).

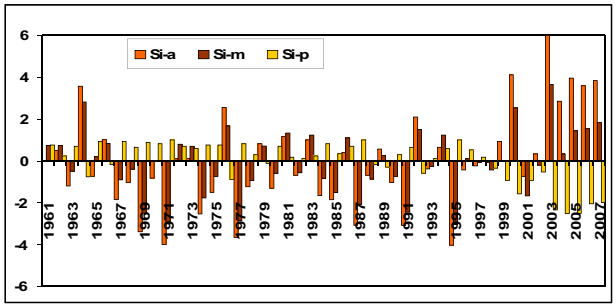

Figure 3. Example of specifying meteorological drought (S_i-m$\geq$0), pedological drought (S_i-p$\leq$0) and agricultural drought (S_i-a$\geq$1).

A large share of the S_i-a index is taken up by the soil moisture parameter. This parameter can mitigate or increase the intensity of agricultural drought. S_i-p pedological drought can be determined in different soil layers depending on the type of crop we wish to study. The advantage of the complete *Si* index (S_i-a, S_i-p, and S_i-m) is in its ability to utilize calculations that are based on available data. In this research shows that S_i-m can accurately predict a drought based on temperature and rainfall data alone. By contrast, S_i-a and S_i-p indices must be combined in order to predict an agricultural drought.

Acknowledgements This research was supported by Research Project MSM No. 6046070901.

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Estimation of UV radiation long-term variability over Slovakia

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Abstract. Time series of the erythemal UV radiation (UV_{ery}) daily doses were reconstructed using relations between UV radiation and total ozone, global radiation and sunshine duration in period 1950 – 2008 for selected places in Slovakia. The statistical model of erythemal UV radiation daily dose created during the COST-726 action was used for reconstruction in the past. The six reconstructed time series of UV_{ery} were analysed together with the time series of the calculated cloud modification factor. Increase in the annual sums of the UV_{ery} was detected nearly at all stations. The changes in local cloud attenuation affect the trends significantly what can lead to total ozone depletion effect wrapping in the UV_{ery} time series at places with increasing cloud attenuation. Significant increase was detected in March, June-July monthly doses. The increase in monthly maxima of UV_{er} was detected at all investigated places from March to September.

Introduction

Quantification of increase in the UV radiation produced by the stratospheric ozone depletion was of top interest in the past 30 years (WMO, 1997). Change of any other atmospheric parameter (e.g. cloudiness) could affect variability and trends in UV radiation more significantly than changes in the total column ozone (WMO, 2008).
The objective of this study was to estimate trends and long-term variability of UV radiation over territory of Slovakia. Analysis of the UV_{ery} radiation cloud attenuation was performed simultaneously. Total ozone (corresponded to investigated territory) trend analysis was performed by Pribullová *et al.* (2006). As history of UV radiation measurement is not very long in Slovakia, the modelled time series of erythemally weighted UV radiation daily doses were used for the analysis. The study was realized in the framework of the COST-726 action 'Long-term changes and climatology of UV radiation over Europe'.

Data and methods

Reconstruction of UV radiation time series was done at six observatories with sufficiently long measurements of global solar radiation (available at most places since beginning of 80-ties) and sunshine duration (SD) in 1950 (1953)- 2008 period: Bratislava (BA, 304 m a.s.l.) and Košice (KE, 230 m a.s.l.) represent urban lowland, Hurbanovo (HU, 115 m a.s.l.) represents rural lowland, Poprad-Gánovce (GA, 706 m a.s.l.) corresponds to valley position, Skalnaté Pleso (SP, 1778 m a.s.l.) is located at mountain slope and Lomnický štít (LS, 2634 m a.s.l.) represents the highest mountain peaks. The time period of reconstruction was restricted by the total ozone data availability (since 1950). Daily total ozone was interpolated for every station from the COST-726 database until 2004 (Krzyscin &Borkowski., 2008), measured data at Poprad-Gánovce was used for the 2005-2008 period. Cloud attenuation effect was expressed by the cloud modification factor *cmf* (a ratio between radiation observed by any cloudiness conditions and cloudless conditions). Cloud attenuation of UV_{ery} radiation (*cmfUV),* was modelled as a function of global solar radiation cloud attenuation (*cmfG*) and solar zenith angle (*SZA*):

$$cmfUV = f(cmfG, SZA) \quad (1)$$

The model regression parameters were derived using the COST-726 database (Koepke *et al*., 2006). The clear-sky UV_{ery} and global radiation daily doses were modelled by the radiative transfer models TUV (Madronich, 1993) and LibRadtran (Mayer and Kylling, 2005), respectively. The modelled clear-sky UV_{ery} and global radiation were corrected to snow reflectivity effect. The global radiation daily dose was derived from the daily sunshine duration using the Ångström-Prescott formula (linear relation between relative daily SD and global radiation) with the regression coefficients derived for every station for periods when no measurements were performed. The robust locally weighted regression was used as the smoothing technique in time series. Parametric testing of the linear trends significance was used. Normality of the data was checked by the Kolmogorov-Smirnov D-test. The trend analysis of monthly sums was restricted to period March-September only (82-89% of the annual *UVery* dose falls on the period March-September), when the *UVery* values are interesting with respect to the human health risks.

Results

The validation of modelled daily *UVery* radiation at Poprad-Gánovce in 2002-2004 period shows that the model RMS error increased negligibly when total ozone from the database was used instead of measured one (by 2 %), but the model RMS error increased by above 10% to 250 $J.m^{-2}$ (30%) when the global radiation derived from SD was used. Using the Ångström-Prescott formula, the model calculates with fixed *cmfG* values when no sunshine is registered. It leads to *cmfUV* frequency distribution differences between periods when measured and modelled global radiation was used. There is tight correlation between the modelled time series of *UVery* annual doses at different places (the correlation coefficient between BA and HU, LS and GA, LS and HU is 0.90, 0.75 and 0.63, respectively) but there are differences between average values (Fig. 1), annual cycle and frequency distributions. Periods with high annual daily doses of the *UVery* were found at the beginning of the 80-ties and since the end of 90-ties in lowlands. Extremely high annual doses (exceeding 2xSTDEV from an average) were detected at lowland stations in 2003, 2000 (extremes were detected also at LS and GA) and in 1983.
The linear trend of the *UVery* radiation annual dose was increasing at all places (insignificant decreasing tendency was detected only at SP). The most significant trend in both the *UVery* (969 Jm^{-2}/decade) and the April-August[1] *cmfUV*

[1] The April-August *cmfUV* was used because annual mean of the *cmfUV* does not correlate with the annual sum of the UV_{ery} radiation so tightly.

was found at BA (significance α = 0.01). Significant increase in the *UVery* (α=0.01) was also calculated at LS (891 Jm^{-2}/decade), GA (644 Jm^{-2}/decade) and KE (635 Jm^{-2}/decade), but *cmfUV* trends were there detected only at significance level $\alpha \geq 0.25$. Increase in the *UVery* is of less significance at HU (430 Jm^{-2}/decade, α=0.05) where the *cmfUV* trend is not significant.

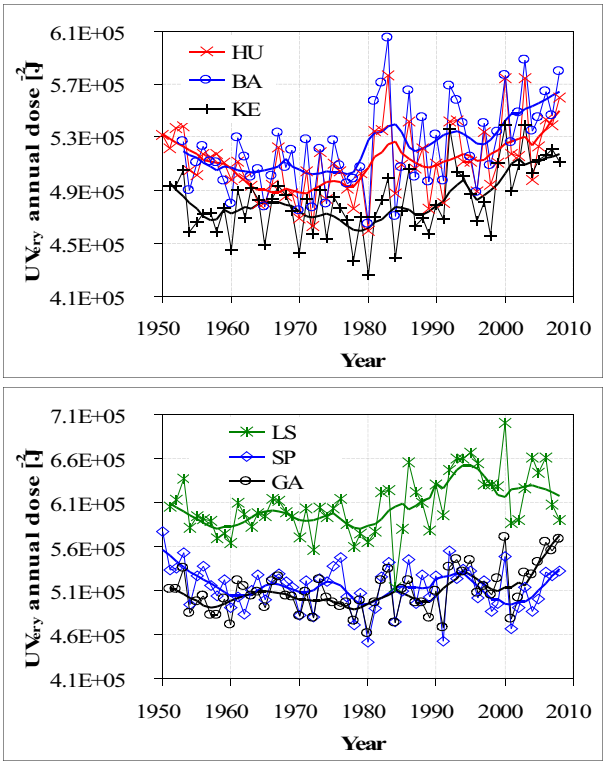

Figure 1. Annual sums of the UV_{ery} radiation (lines with points) smoothed by the RLWR method (solid lines) at investigated stations (see text for abbreviations).

In the monthly sums of the UV_{ery} radiation, very significant increase (α=0.01) was detected in March, April and in June in BA (the trends were increasing from March to August), what correlates with detected increasing tendency in the *cmfUV*. Increase in the UV_{ery} was found at all stations in March (with α in range from 0.01 at LS and SP to 0.05 at HU). The March *cmfUV* increase is significant (α<0.1) at BA, KE, SP and LS. Increase in UV_{ery} at GA and HU is less significant and it is not accompanied with increase in the *cmfUV* . In June and July, increase in *UVery* detected at all stations (exception is SP) does not correspond to increase in *cmfUV* (significant increase at α<0.25 was detected only in BA), and is probably more affected by significant decrease in total ozone found at Poprad-Gánovce (Pribullová et al., 2006). A decrease in the *UVery* detected from June to August at SP (α=0.05) correlates with significant enlargement of the summer cloud attenuation of UVradiation (significantly descending time series of the *cmfUV)*.

It was supposed, that the tendencies in monthly maxima of the *UVery* radiation will reflect the total ozone decrease and that the cloud modification effect will not affect the trends significantly (the maxima of the *UVery* are usually observed by clear-sky condition with *cmfUV* close to 1). Significant (α<0.025) increase in monthly maxima of *UVery* was detected at BA, KE (March-August), LS (March, May-July), GA (March-April, June-July), SP (March, May), HU (March). Unlike a descending trend found in monthly sums, the increase in *UVery* maxima was detected at SP from March to September. The *UVery* maxima increase is much more pronounced at BA, KE, GA and LS from May to August in comparison to trends in monthly sums of the *UVery.* Some of this monthly increasing trends still correlate with significant increase in corresponded *cmfUV* factor (so it can not be generalized that only depletion in stratospheric ozone can explain the observed trends in the UV radiation), but at some places in some months does not: LS (May-July), GA(May), KE (June- July), HU(May), SP(May). As there are different trends detected in the *UVery* maxima at investigated places and it is not probable that total ozone trends significantly differs over so small territory (Krziscin&Borkovski, 2008), maybe also local variability in aerosols affects the clear-sky *UVery* radiation.

Conclusions

Time series of the *UVery* radiation daily doses were modelled using the available ancillary data. The disadvantages of the model are usage of the SD instead of global radiation as a model input before the 80-ties and modelling with assumption of fixed aerosol.

Analyses of modelled time series showed significant trends in annual sums of *UVery* that correspond to significance of trends in the warm half-year cloud attenuation. The trends are increasing nearly at all investigated stations. Significant increase in monthly doses of the *UVery* was detected at all stations in June-July when sun culminates and the UV_{ery} reaches the highest values. The increasing trends in UV_{ery} were found at all stations in March. The descent in UV_{ery} was modelled only at one mountain station SP. More pronounced increasing tendencies were found in the monthly maxima of the *UVery* radiation.

Acknowledgements This work was supported by the Slovak VEGA grant Nr. 2/0036/08 and the COST-726 project.

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Analysis of snow cover at selected meteorological stations in the High Tatra Mountains

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Abstract. Snow conditions were evaluated at selected meteorological stations at Slovak part of the High Tatra Mountains with aim to estimate changes in snow cover (SC) with respect to requirements for skiing on natural snow. Significant increase in snow depth and duration was detected only at peak altitudes (around 2600 m) where no ski resorts are located. No significant changes in snow were found in northern part of the mountains at altitudes around 1000 m. SC depth declined at stations with altitudes close to 1000 m on south and west slopes. The snow conditions appropriate for facilitate and slope skiing were found at more elevated places on the south-east, in comparison to west slopes. More steep decrease in the SC depth was detected also on the stations at south-east slopes.

Introduction

Snow presence affects many processes in the boundary layer of atmosphere. Special attention is paid to the snow in mountains, where snow is essential for development of winter tourism due to its aesthetical role and due to development of ski activities.

Air temperature and precipitations are the principal parameters determining the quality and quantity of snow. Ski tourism and ski industry could be negatively affected by detected and predicted global increase in air temperature. Evaluation of SC over the north hemisphere showed the snow decline at lower elevated places where snow relation to the temperature variability was tighter (IPCC, 2007).

Recently, natural snow conditions were deteriorated at some Slovak mountain ski resorts (e.g. Holko and Kostka, 2007). The aim of this study is to evaluate SC change at the Slovak part of the High Tatras and to compare the present snow condition to situations in the past.

Data and methods

Climatological daily data of SC thickness from seven stations in the area of the High Tatras (Fig. 1) were analysed. Except of peak station LST, where amount of the new snow is derived from the precipitation, the snow depth was measured by snow stakes. Mountains orientation in west-east direction towards prevailing west winds affects precipitation and snow distribution. To estimate vertical profile of some parameters in the west, the stations PDB, STP and peak station LST were used. To determinate the vertical profiles at the south –east slopes, the data from POP, TAL, SKP and LST were used. Frequency of two SC depth limits over-run (50 cm and 30cm) was investigated. The snow depth of 30 cm is considered as a minimum required for the facilitate skiing and the snow depth of 50 cm is minimum for skiing on the slopes (Elsasser et al. 2001). Many authors (e.g. Elsasser and Burki, 2002) use the '100 day rule' (number of days with snow depth in range 30 - 50 cm) as a criterion for economical effectiveness of the ski resort. Some characteristics of the SC were calculated for whole winter seasons, DJF abbreviation is used for December – February, NDJFM for November – March periods.

Climatic normal (CLN) 1961-1990 (for winter seasons 1961/1962 – 1990/1991) was used in the study.

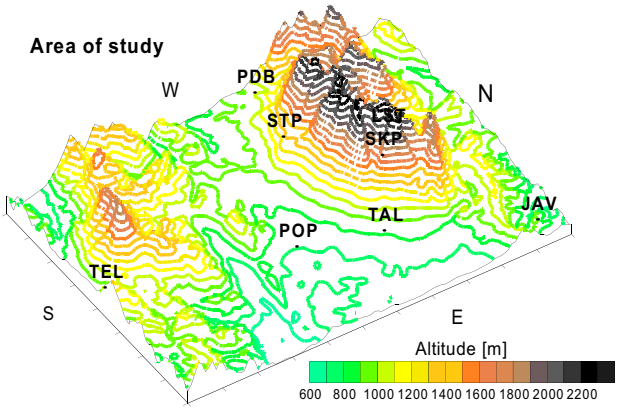

Figure 1. Topography of studied area with geographical orientation, positions and abbreviations of investigated meteorological stations.

Results

Snow cover thickness and duration

Comparison of average number of days with snow during the CLN and the winter seasons 1991/1992 – 2006/2007 showed the largest increase at LST (the difference is +37 days). Increased number of days with snow was also observed at stations STP (+12 days), SKP (+7 days), TEL (+4 days), PDB (+2 days). No difference was detected at JAV and no significant decrease was detected at POP (-2 days) and TAL (-4 days).

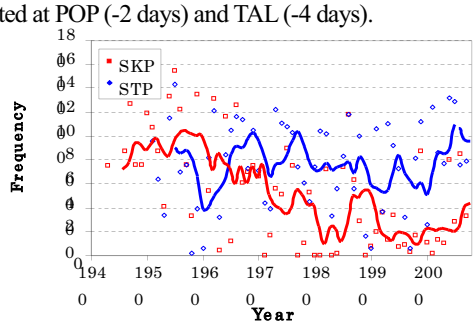

Figure 2. Seasonal frequency of snow cover thicker than 50 cm smoothed by the 5 years moving averages at SKP (south–east slope) and at STP (west slope) stations.

Increasing linear trend of seasonal number of days with SC was detected at LST (+17 days/decade) and at STP (+7 days/decade) in 1961/1962 – 2006/2007 seasons. The lower increase in days with snow (in range of ±4 days/decade) was observed at other stations.

Comparison of DJF snow thickness during the CLN and 1991/1992 – 2006/2007 period showed increase in snow depth at LST (+32 cm), JAV (+4 cm), POP (+1 cm), and decrease in average snow depth at SKP (-12 cm), TEL (-8cm), TAL (-7 cm),

STP and PDB (-6 cm).

Linear trends of the DJF snow depth in range of -2.8 – +0.6 cm/decade were calculated at POP, TEL, STP, TAL and PDB. Significant negative trend was found at SKP (-5 cm/decade). The snow depth significantly increases at LST (+16 cm/decade). Differences in annual courses of snow depth and in its distribution were detected in comparison wit CLN.

Snow depth limits

Rapid increase in days with SC thickness over 30 cm and 50 cm was detected at LST. However, it has no big impact on skiing because there are no ski resorts at altitudes above 2500 m in the High Tatras.

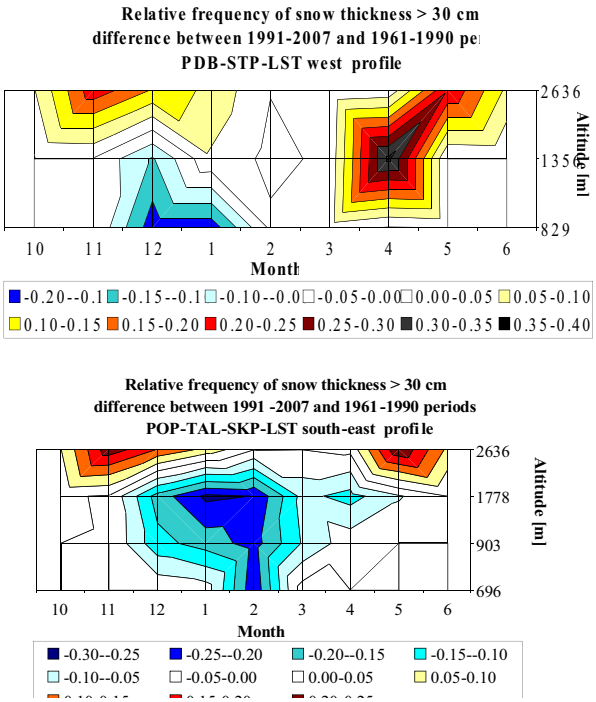

Figure3. Differences between relative frequencies of snow depth over 30 cm during 1991/1992 -2006/2007 and CLN periods as function of altitude at west and south-east vertical profiles in the High Tatras.

Fewer days with snow depth over the 30 cm and 50 cm limits (in comparison to CLN) was observed at stations:
SKP (decrease from 82 to 68 and from 47 to 29 days),
TAL (decrease from 39 to 31 and from 12 to 3 days),
PDB (decrease from 72 to 56 and from 41 to 29 days),
TEL (decrease from 39 to 31 and from 19 to 15 days)
during 1991/1992 – 2006/2007 seasons. Frequency of days with snow thicker than 50 cm decreased and number of days with snow depth over 30 cm increased (Fig. 2) at STP. No change in frequency of days with snow depth over 30 or 50 cm was detected at JAV. Number of days with snow over 30 cm is around 4 at POP. Fig. 3 documents the changes at west and south-east vertical profiles for the limit of 30 cm.

Change in altitudes where snow depth exceeds selected limits for skiing with the probabilities of 50 % and 70 % was investigated comparing condition during CLN and in the 1991-2007 period. The results are shown in Tab.1 for the snow depth limit of 30 cm.

Table 1. Altitudes in m a.s.l., where snow depth exceeds 30 cm with probabilities 50% (p50) and 70% (p70) during 1991/1992 -2006/2007 and CLN periods at west and south-east vertical profiles in the High Tatras.

snow depth > 30 cm				
1961 -1990				
Month	south -east profile		west profile	
	p50	p70	p50	p70
12	2102	2478	1216	2216
1	1378	2117	<974	<974
2	1001	1617	<974	<974
3	1340	1743	<974	1066
4	1870	2207	1794	2165
1991 -2007				
Month	south -east profile		west profile	
	p50	p70	p50	p70
12	2155	2378	1554	2058
1	2007	2259	1050	1257
2	1687	2098	<974	1004
3	1335	1910	974	1162
4	1994	2268	1269	1627

An altitudes with snow thicker than 50 cm increased by 100–213 m at the south-east profile in February-March and by 150-410 m at the west profile in January and February. At the west profile, the altitudes with SC thicker than 50 cm decreased by 395 m and 289 m with probabilities of 50% and 70%, respectively, in April.

Conclusions

Snow variability in the High Tatras has very local character. Number of days with SC and average winter SC thickness increased significantly at peak station LST due to increase in precipitation. No significant change in frequency of days with snow was detected at other stations. The mean snow depth decreased at south and west sites of mountains (SKP, TAL, TEL, PDB, and STP) in January and February. More snow (STP) or no trends were detected at these stations in March and April. No significant trends in snow were found in the north (JAV). The natural snow conditions are generally better on the west slopes of the High Tatras than on the south-east ones. The snow trends indicate possible problems with insufficiency of natural snow at SKP and TAL resorts. The only resort accomplished the'100 day rule' criterion is STP.

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Fluctuations of selected meteorological elements in mountainous regions of the Czech and Slovak Republic according to RCM ALADIN-Climate/CZ outputs in the periods 2021-2050 and 2071-2100

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Abstract. The regional climate model ALADIN-Climate/CZ is employed within the frame of the EU FP6 project CECILIA to provide high-resolution (10 km) information on future climate conditions over the region of Central Europe. The regional climate model is driven by GCM ARPEGE with the IPCC A1B emission scenario for two time slices: 2021-2050 and 2071-2100. Here we present the investigation of the scenario run results with focus on the region of the Czech Republic and Slovak Republic. Comparison among areas with highest and lowest altitudes was carried out and analyzed for future climate based on corrected RCM outputs.

Introduction

Regional climate models (RCMs) are the state of the art tools employed for downscaling information from the coarse resolution global circulation models (GCMs) on a local scale. Czech Hydrometeorological Institute (CHMI) has developed a regional climate model ALADIN-Climate/CZ that is an adaptation of ALADIN numerical weather prediction model, version CY28T3. Its description can be found e.g. in Farda et al. (2007) or Farda (2008).

Within the CECILIA project, the regional climate model ALADIN-Climate/CZ is driven by GCM ARPEGE with the IPCC A1B emission scenario and the experiments are performed for two time slices, 2021-2050 and 2071-2100. In this work, preliminary investigation of the scenario run results for the time slices 2021-2050 and 2051-2070 are presented with emphasis on the region of the Czech Republic and Slovak Republic.

Data and methods

Before the analysis of the future climate, the model data were corrected according to validation results carried out for the period 1961-1990. For this task a new gridded dataset of station observation was created. All input station observations were quality controlled and homogenized in daily scale (Štěpánek et al., 2009) and then recalculated to the ALADIN-Climate/CZ grid of 10 km horizontal resolution. Daily station measurements in a vicinity of each grid point were first reduced on the grid point's (model's) altitude by a local linear regression and then weighted averaged to a grid point location according to their distance form the grid point. The inverse distance (1/d) factor was used as a weight for air temperature, while 1/d3 factor was taken for precipitation.

Gridded dataset of station observations was then compared with the past climate (1961-1990) GCM driven ALADIN-Climate/CZ simulation in each grid point. According to relationship between these two datasets (validation details are given e.g. in Skalak et al. (2008), outputs of A1B scenario integrations of the future climate were corrected applying an approach of Déqué (2007) that is based on a variable correction using individual percentiles. After the correction, the model outputs are fully compatible with the station (measured) data.

The gridding and all data processing including the presented analysis were done by ProClimDB database software (free download from http://www.climahom.eu/) for processing of climatological datasets (Štěpánek, 2008).

For further analysis, only grid points with the higher (29 grid points) and lower altitudes (21 grid points) were selected (see Fig. 1). In the Slovak Republic, mountainous regions Vysoké and Nízke Tatry (grid points altitudes vary between 1013 – 1633 m a.s.l.) can be distinguish, in the Czech Republic smaller areas in Krkonoše, Šumava and Jeseníky (altitudes 885 – 1124 m a.s.). As for lower parts the points were selected around Labe, Morava, Dunaj and Tisa rivers (altitudes of the grid points ranges between 91 and 177 m a.s.l.).

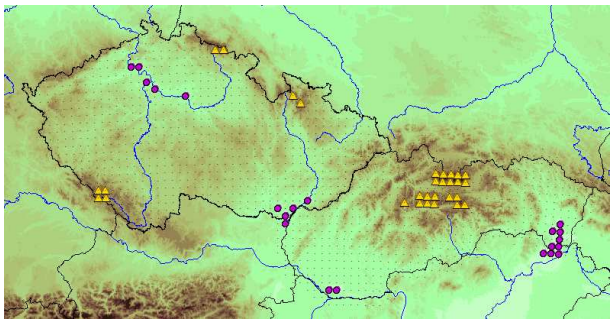

Figure 1. Studied area and selected grid points for the analysis. Yellow triangles mark mountainous regions, purple circles mark lowland regions.

Results and discussion

Comparison between mountainous and lowland regions was carried out for four meteorological parameters: mean, maximum and minimum temperatures and precipitation. Here only results for mean temperature and precipitation will be given. Results are base upon corrected RCM outputs (see previous section).

As for air temperature, characteristics for both near future (2051-2070) and far future climate (2071-2100) do not differ between lowlands and mountains (see Tab. 1). The same is valid for precipitation (Tab. 2). In near future, increase in temperature by 1.6°C while for far future it is 3.3°C (higher values occur for winter and summer than for spring and autumn) can be expected. All seasons and year show statistically significant changes (compared to reference period, using two sample t-test, significance level 0.05). In case of precipitation, differences exist among individual seasons and the two time slices but they are not statistically significant (0.05) with exception of JJA season and second time slice (2071-2100) with significant decrease of precipitation compared to 1961-1990.

Table 1. Air temperature deviations (°C) from 1961-1990 period for individual regions (average for lowlands and mountains grid points) for year and individual seasons. The bold font represents statistically significant values at $\alpha = 0.01$.

Region	Period	YEAR	DJF	MAM	JJA	SON

Lowlands	2021	2050	**1.6**	**1.9**	**1.2**	**2.1**	**1.3**
Lowlands	2071	2100	**3.3**	**3.3**	**3.0**	**4.1**	**2.8**
Mountains	2021	2050	**1.7**	**2.0**	0.9	**2.6**	**1.1**
Mountains	2071	2100	**3.3**	**3.1**	**2.7**	**4.9**	**2.6**

Table 2. Change in precipitation (%) compared to 1961-1990 period for individual regions (average for lowlands and mountains grid points) for year and individual seasons. The bold font represents statistically significant values at $\alpha = 0.05$.

Region	Period		YEAR	DJF	MAM	JJA	SON
Lowlands	2021	2050	103	94	111	97	112
Lowlands	2071	2100	96	108	110	**79**	102
Mountains	2021	2050	103	92	114	101	107
Mountains	2071	2100	96	100	116	**83**	95

Fluctuations in lowlands and mountains for air temperature are analyzed in Fig. 2. Anomalies fluctuations do not differ between the two cases with exception of JJA season, where mountainous regions show higher trend values. Higher values of trends are distinctive for DJF (0.031°C/year for lowlands, 0.030°C for mountains) and JJA season (0.036°C, 0.043°C resp.), annual values show linear trend 0.029°C (0.030°C resp.). All the values are statistically significant for confidence level 0.01.

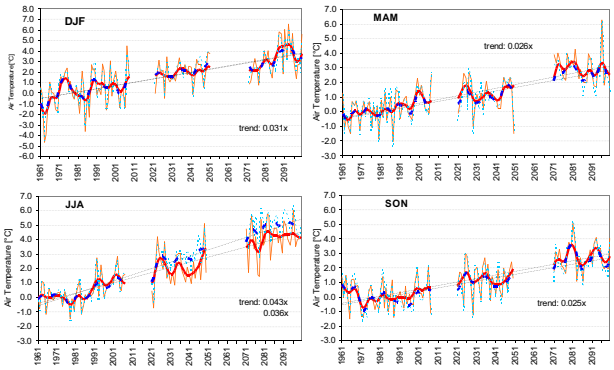

Figure 2. Air Temperature anomalies (°C) compared to 1961-1990 reference period) expressed for lowlands (solid lines) and mountains (dashed lines). Smoothed with Gaussian low-pass filter for 10 years.

Fluctuations of precipitation are shown in Fig. 3. The linear trends are statistically significant (0.05) only for JJA (decreasing trend -0.177% at lowlands and -0.161% at mountains). Linear trends of monthly values are significant only for April and August (lowlands) and May, August and September (mountains). Differences between individual areas of lowlands or mountains (e.g. eastern and western part of the studied area) were negligible.

Corrected model outputs will be further analyzed with regard to extreme events (air temperature and precipitation) applying 131 indices defined within WP4 of the CECILIA project. The obtained results will be compared to 1961-1990 reference period.

Conclusions

Corrected simulations of ALADIN-Climate/CZ RCM were analyzed for air temperature and precipitation with special focus on differences between lowland and mountainous regions of the Czech and Slovak Republic. No significant changes between the two regions were found neither for near (2051-2070) nor far future (2071-2100). The regions show similar values of change and trends.

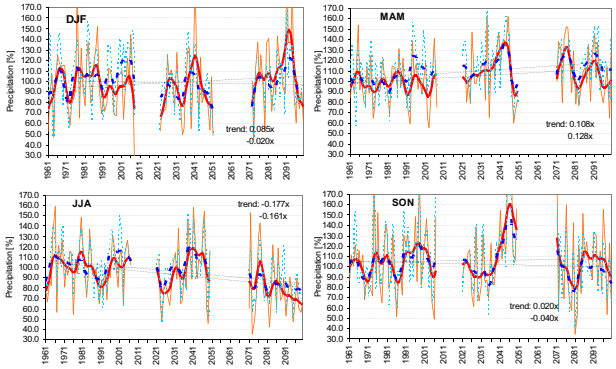

Figure 3. Change in Precipitation (%) compared to 1961-1990 reference period) expressed for lowlands (solid lines) and mountains (dashed lines). Smoothed with Gaussian low-pass filter for 10 years.

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Assessment of snow conditions for skiing on selected examples from the Polish-Czech border area in the Western Sudetes Mountains

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Abstract. The presented text brings evaluation of snow conditions for skiing on the basis of a range of indicators calculated for individual months, for defined winter seasons (December - February) and for whole winters. For indicators calculation daily data about snow depth measured at 6 a.m. GMT from selected stations of Institute of Meteorology and Water Management (IMGW) and Czech Hydrometeorological Institute (CHMI) networks in the Western Sudetes from 20 winter seasons 1987/88-2006/07 were used. The results showed that snow conditions on the southern slopes of the Western Sudetes are better than on the northern slopes. The main factor influencing snow conditions is morphological exposure of a given site.

Introduction

Snow cover significantly influences the environment, some areas of human activity and, among other, winter sports, tourism, and recreation. The Western Sudetes is an important and popular touristic region which is overspreading the Polish-Czech border area. Its importance grows depending on historical background, geographical position in Central Europe and the vicinity of densely populated areas, and also on processes of European integration (Potocki & Filipczak, 2003; Potocki, 2009). The Western Sudetes have suitable morphological conditions with a rich diversity for both downhill skiing (the Giant Mts. – long slopes with differential slants) and cross-country skiing (the Jizera Mountains – vast plateau, mild slopes, mild slants along valleys) with a rich infrastructural background. It is therefore necessary to evaluate the snow conditions affecting skiing in the Western Sudetes on both sides of the border. In both Polish and Czech climatological literature, there are still missing works dealing with the problem of a snow cover in the context of its influence on skiing conditions and former works do not use a uniform methodology. The research of conditions of a snow cover and its duration is also important for development of tourism and winter sports. Additionally, it is the precondition for rational design of supporting infrastructure in the entire border mountain area of Poland.

Data and methods

To determine the indicators daily data on snow depth measured at 06 a.m. GMT from selected 9 gauging stations of IMGW and CHMI in Western Sudetes from 20 successive winter seasons 1987/88-2006/07 were used.
Selected indicators:

- average number of days with the depth of snow cover: ≥1 cm, ≥10 cm, ≥20 cm, ≥50 cm, ≥100 cm,
- average maximum snow depth [cm],
- average seasonal cumulative snow depth [cm],
- number of periods with a stable snow depth of ≥10 cm, ≥20 cm, ≥50 cm, ≥100 cm,
- average duration of a period with a stable snow depth of ≥10 cm, ≥20 cm, ≥50 cm, ≥100 cm,
- maximum duration of period with a stable snow depth of ≥10 cm, ≥20 cm, ≥50 cm, ≥100 cm,
- average maximum duration of period with a stable snow depth of ≥10 cm, ≥20 cm, ≥50 cm, ≥100 cm,
- average amount of precipitation in winter months (XII-II),
- average date of the beginning and end of a snow cover,
- indicator of skiing snow duration (the definition is below).

For every station, probability of the occurrence of snow depth of at least 20 cm and 50 cm for the whole winter season was determined.
Selected stations are located at similar altitudes. They represent, on both sides of the mountains, the conditions in the areas of skiing resorts with supra-regional importance. Only the stations that did not significantly change their position during the research period were selected for the analysis. Intentionally, the summit stations (Tab. 1) were not included into processing because the differences in snow conditions among them are relatively small and the possibilities of skiing infrastructure development are significantly limited due to their position in protected areas (the Krkonoše National Park).

Table 1. Characteristics of the stations with snow cover measurement

Station/Abbrev./ Institution	Exposure	H [m.a.s.l.]	Area characteristics
Jakuszyce /JA/ IMGW	S	860	Polana Jakuszycka – cross-country skiing; upland of the Izera Mts.
Pec pod Sněžkou /PS/ CHMI	S	816	Vast skiing resort in the area of Pec pod Sněžkou, valley of Vlčí and Luční streams and on the slopes of Hnědý Hill
Szklarska Poręba /SP/ IMGW	N	705/645*	The largest resort of downhill skiing in Sudetes on the northern slope of Szrenica
Harrachov /HA/ CHMI	S	670	Resort of downhill and cross-country skiing on the slopes of Mt. Čertova
Dolní Dvůr /DD/ CHMI	S	610	Czech locality corresponding to the Polish resort Karpacz, between the skiing resort Jánské Lázně on the S-E slope of Mt. Černá in the area of Vrchlabí
Karpacz /KA/ IMGW	N	580	Resort of downhill skiing on the northern slopes of Kopa and Równa pod Sněžkou in the area of Złotówki
Świeradów Zdrój /ŚW/ IMGW	N	550	New resort of downhill and cross-country skiing on the slopes of Stóg Izerski
Jablonec nad Nisou /JN/ CHMI	S	495	Area of skiing resorts in Liberec
Nové Město pod Smrkem /NM/ CHMI	N	473	Czech locality corresponding to the Polish resort Świeradow Zdrój

*- station in the altitude of 645 m.a.s.l. since 28.11. 2003

The following snow depths were used as criteria to characterize the duration of skiing seasons:

- ≥10 cm – mild tourism and skiing recreation,
- ≥20 cm – cross-country skiing and a mild form of downhill skiing,
- ≥50 cm – downhill skiing and more demanding forms of cross-country skiing,
- ≥100 cm – more demanding forms of downhill skiing.

Results and discussion

The differentiation of snow conditions characteristics in the Western Sudetes, even between closely located areas, is very significant. Stations located at a similar altitude show significant differences in values of indicators which is particularly obvious in the altitudinal zone of 500-800 m a.s.l. (Sobik et al., 2009). Majority of the most important skiing resorts in the Western Sudetes is situated in the mentioned altitudinal zone. The differences in snow indicators are determined by orographic deformation of atmospheric circulation and by effects of „non-exposure" or „exposure" of the monitored place over the mountain barrier (Barry, 1992; Sobik et al., 2009).

All indicators demonstrate noticeably more favourable snow conditions in the southern part of the Western Sudetes Mountains than in the northern part. This fact is well-documented by the average number of days with a snow cover of limit heights (ANDSC) as well as the average maximum snow depth (in individual months, winters and winter seasons). ANDSC is nearly always higher in Czech than in Polish stations. These differences grow with the increase in the snow depth. The depth of snow cover necessary for a particular form of skiing persists at longest in February and March. Analogical results were achieved by the analysis of the average cumulative snow depth (ASSHS). These differences fluctuate from several tens of percent up to almost 300% for stations with southern macro-exposure. For example, ASSHS investigated in the course of twenty successive winter seasons reaches about 1440 cm at Karpacz (northern exposure with a significant morphological ridge from the south) but over 4250 cm at Dolní Dvůr (southern exposure without a morphological ridge from the south).

Moreover, short-term periods with quite a small snow depth do not exceed 20 cm, predominately in the northern part of the Western Sudetes. It often leads to total disappearance of a snow cover, even in the middle of a winter season. This phenomenon is in literature usually called a „coreless winter" (Kożuchowski, 2004).

However, even in the middle of a winter season when the snow cover is durable there are some situations when its depth reaches comparable and often even higher values on the northern side of the mountains than on the southern side. One of such cases was the situation in winter 2001/02 on 1st–6th January 2002. It was connected with advection of snow rich air masses from the north when, after heavy snowfalls, the snow depth reached 123 cm and 118 cm on in Harrachov 3rd–4th January 2002, and analogically 137 cm and 135 cm in Szklarska Poręba.

Described rules for prevailing winter advection, which is connected with relief morphology (non-exposure or exposure of a particular place), are valid not only for both sides of the main ridge of the Giant Mountains, but also for mountain areas that do not reach their height, e.g. the Jizera Mountains.

Interesting result were gained by the comparison of average values of limiting snow depths, which directly influence the conditions for practising a particular form of the skiing. The stations without a morphological ridge from the south have obviously higher limit values than the ones exposed from the north, in spite that they are located in comparable altitudes (Fig. 1).

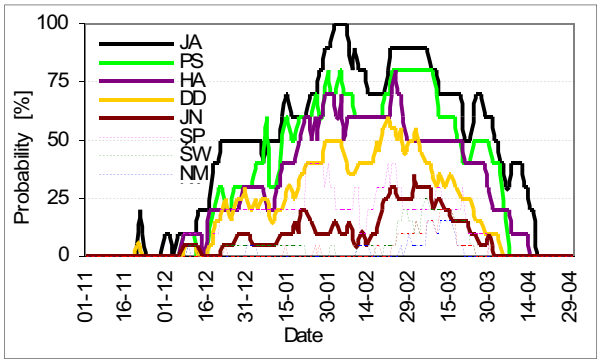

Figure 1. Probability of exceeding the snow depth of 50 cm at monitored stations (stations exposed to the south are indicated by a bold line; legend symbols are in Tab. 1).

Conclusions

It was found out that at similar altitudes the snow conditions, in skiing resorts located on the northern side of the Western Sudetes are considerably worse than in the resorts located on the southern side.

The main factor that differentiates the snow conditions is morphological non-exposure of a relevant place. Exposure or non-exposure to prevailing winter advection of air masses from the southern sector is another important factor. The snow cover in areas exposed to the north is short-term, tinier and it is characterized by frequent ablation leading to its total disappearance in the middle of winter. It significantly reduces the possibility of skiing.

Out of the monitored areas, the least favourable snow conditions for winter tourism and various forms of skiing were found out in resorts Karpacz, Świeradów Zdrój and Szklarska Poręba on the Polish side. On the other hand, there are places on the Polish and Czech sides of the Western Sudetes at the same altitudes with very good snow conditions (Jakuszyce) as well as places with very unfavourable conditions (Nové Město pod Smrkem).

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Effect of climate on forest and silviculture

Digital web camera – a tool for phenological observations in the IPG Doksany

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Abstract The International Phenological Gardens (IPG) is a unique network in Europe for wild plants observation. In all gardens genetically identical trees and shrubs are planted in order to make large-scale comparisons among the starting dates of different developmental phases of plants. The 4th International workshop about phenology was in Doksany Observatory in the year 1999. Real result was to establish phenological garden on the field of observatory. This IPG-Nr.85 is the first one in the Czech Republic. Own observations were started in spring 2001. In phenological models, interactions are expressed between plant seasonality and annual physical conditions. The cross-disciplinary nature of phenology, however, has created a risk of misinterpretation of phenological research. Especially terms like growing season length (GSL) are open to multiple interpretations. In September 2006, a year-long project of distance monitoring of phenological phases of forest-tree species was launched at the observatory. The camera Canon PowerShot S3 is located on a place, where there is an International Phenological Garden, and is connected via ethernet cable to a computer inside the observatory. The camera is fully controlled from the computer thanks to a special program; it can set the parameters of photographing, focus the camera to a particular detail, and move the camera in both vertical and horizontal direction. All images are archived on DVDs for further processing.

We expect that this project will increase objectivity and preciseness of phenological observations and will therefore increase predicative capability and accuracy of phenological information. We expect that information obtained in this project will be used for modelling and objectification of satellite information. The camera will also be used for monitoring of interesting meteorological phenomena.

Introduction

The 4th workshop about phenology in the Central European countries took place in the Observatory (OBS) Doksany in the year 1999. In the negotiations it was decided to build International Phenological Gardens (IPG) on land Observatory, garden received identifier IPG 85 Prague-Doksany (Chmielewski, 2001). Trees were a gift obtained from the Humboldt University in Berlin. OBS Doksany is located 50 km from Prague, in the Ústí region. Its altitude is 158 m above sea level, average annual air temperature 8.5 °C and average annual rainfall 450 mm.

Data and methods

List of uniform genetic material contains following species: Larix decidua, Picea abies-early, late, northern; Betula pubescent; Populus tremula, Prunus avium Corylus avellana, Sorbus aucuparia; Ribes alpinum, Salix - aurita, viminalis, smithiana; Forsythia suspension, Pinus sylvestris, Sambucus nigra.

A pilot project of annual phenological stages observations using the digital scanning camera (IPG No. 85) was launched in September 2006 . It is expected higher accuracy and increased objectification of phenological observations, and thus increase the explanatory power and precision of phenological information. Camera Canon PowerShot S3 IS was selected as an appropriate device, which can be used for acquisition of images and video. The camera has a 6 Mp CCD sensor and image sensor 1/2.5" CCD. The camera enables to use 12x optical zoom, in combination with 48xdigital zoom. Thanks to technology, IS, one can get sharp images even under poor light conditions. The evaluation of light conditions (e.g. fair use of colours, a well-functioning white balance) is the same as by the old image processor. The camera was placed in a sealed container with the glasses, which is heated inside the heating foil and attached to the Instruments. Instruments are located on land IPG. The network cable is connected via ethernet with a computer in the observatory.

Results and discussion

The results of phenological observations in European larch are available for the period 2001-2008 The smallest differences in onset of phenological stages by investigated species were observed at the beginning of foliage (29 days), the largest ones were detected in the beginning of flowering (40 days).

Similarly, in the case of deciduous trees (period 2001-2008), where the big difference was registered at the end of the growing season, slightly smaller at its beginning and the smallest during the growing season.

The smallest margin in onset of phenological stages was observed in the yellowing leaves (12 days), the bigest in the beginning of flowering (72 days) and in the flowering (69 days). Fluctuations in phenological phases in the IPG Doksany correspond with other IPG stations in Europe. In recent years, an increasing number of cases with the earlier onset of phenological phases in the spring period and their later onset in autumn lead to the extension of the GSL.

Average monthly air temperature in Doksany was +6.9 °C above the normal in January 2007, +4.3 °C higher in February 2007. January 2007 was the warmest at Doksany over the past 55 years. It is not surprising that the beginning of hazel flowering has been reported already on the January 14th and the main flowering on January 21st. Fig. 1 shows variations in the early hazel flowering for the period 2001-2008 at Doksany. There are two extremes - the year 2006, when the hazel started to flower on the March 26th and the year 2007 with the hazel flowering beginning on the January 14th.

Conclusions

With the results of IPG at OBS Doksany, the Czech Hydrometeorological Institute (CHMI) was successfully involved in entire network of the stations IPG in Europe.

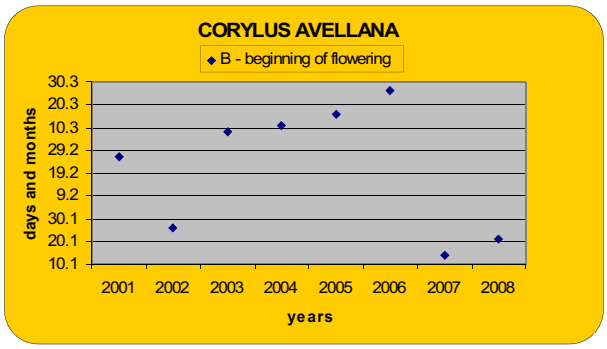

Figure 1. Fluctuations in the early flowering date of hazel (Corylus avellana) for the period 2001-2008.

The advantage of the IPG Observatory placing to Doksany is immediate access to high quality meteorological observations and the possibility of simultaneous observations in the IPG in accordance with the methodology of CHMI. With a good equipments, local phenological observations can be further improved, for example, using digital cameras for monitoring. Fluctuations in phenological phases in the IPG Doksany correspond well with other IPG stations in Europe. Despite the short observation period, there was detected an earlier onset of phenological phases in last years and thereby increase in the GSL.

Completed projects using digital cameras for monitoring of henological phases in the OBS Doksany will bring a wide range of valuable information that can be used in the preparation of future projects related to automation of phenological observations in the CHMI. The project envisages the establishment of cooperation with Swiss colleagues, who are in this direction much more experienced. The cameras are planned to use also for monitoring of the other interesting meteorological sensing phenomena.

Since the entire project is expected to increase the precision and objectification of phenological observations, a meaningful increase in the ability and accuracy of phenological information is expected in the future.

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Climate change and the phenological response of nuthatch (Sitta europaea) in Czech Republic during 1951 - 2008

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Abstract Presented study is focused on the phenology of Eurasian nuthatches (*Sitta europaea*) populations on three research plots in the Czech Republic located in full-grown, multi-aged floodplain forests with no forestry management. Phenological data were observed and collected during 1951 – 2008 and compared with mean monthly (March and April) temperature and other meteorological elements. Course of temperature has changed significantly during months March and April when the phenophases are in progress in 1951 and 2008. As well the phenological stages of birds population has developed. The first laying date (FLD) has advanced between 10.0 and 10.2 days on all research plots. The mean laying date (MLD) in birds populations has shifted to the earlier time by almost 9.5 days during years 1951- 2008.

Introduction

The nuthatches are a small resident passerine birds belonging to the family *Sittidae.* Nuthatches prefer a fairly temperate climate and Eurasian Nuthatch breeds in July when temperature range is 16–27°C (Harrap & Quinn, 1996). Phenology of birds population has been observed and describe by many authors all over the Europe (e.g. Ahola et al., 2004; Crick, 2004; Sanz et al., 2003; Visser et al., 1998; Winkel & Hudde, 1997). Crick et al. (1997) analysed 65 species (including Eurasian Nuthatch) and their trends in the distribution of laying dates of the first egg from 1971 to 1995. Leech and Crick (2007) summarize the known effects of weather conditions on woodland bird species in temperate regions. Schmidt et al. (1992) studied breeding and laying of Eurasian Nuthatches in relation to weather and other conditions.

The goal of this work is firstly to complete information about phenology of Eurasian nuthatch (Sitta europaea) with help of long term observations from previously unpublished datasets from the flood-plain forests situated in the very north of Pannonian lowland. Second aim is to compare the trend in phenological phases of nuthatches with trends in spring temperature and other meteorological elements in the same area.

Data and methods

The research of phenology of birds population Eurasian nuthatch (*Sitta europaea*) took place at three research plots in southern Moravia during 1951 and 2008. The nesting pairs were observed at plots Lednice, Lanžhot and Vranovice. All these areas represented full-grown multi-aged canopy with no disruptive forestry management measures taken during observational time and have almost the same meteorological conditions and differ relatively little in amount of precipitation. As none of the experimental sites has its own meteorological station (the closest being 4–15 km distant), daily meteorological data were interpolated using the ProClimDB software package (Štěpánek, 2007). The interpolation used a detailed digital terrain model in combination with meteorological data from 130 weather stations in the Czech Republic and 25 in adjacent regions of Austria. The daily data from each station were quality controlled, homogenized and then interpolated using a method of regionally weighted regressions as described by Štěpánek et al. (2008).

Nesting data for Eurasian Nuthatches was gathered with the help of nest boxes. The first laying date (FLD) was defined as the date when the first clutch in a given year was initiated at a given site. The mean laying date (MLD) was defined as the mean initiation date of all first clutches in the population at each site.

Any significance in observed trends for both climatological and phenological parameters was assessed using the t-test and/or the Kendall Rank Correlation test (Wilks, 1995). Coherency of a phenological series against a selected temperature series was evaluated at the 95% and 99% confidence levels according to Schönwiese (1985). The correlation between phenological stages and temperature series was assessed using the Pearson and/or Spearman correlation coefficient.

Results and disscussion

Mean annual temperature showed a significant increase of 0.19–0.22°C per decade at all sites between 1951 and 2008 (Tab.1). The timing of FLD and MLD data at all observational sites corresponds well with the average temperature in March and April. The correlation coefficient (r) ranges between values 0.817 and 0.851 (Tab. 2).

Table 1. Linear trends per decade for meteorological parameters at the three observation sites during 1951–2008. The integer value represents a linear trend (slope of linear regression line). **Bold** font represents a significant trend at $\alpha = 0.05$. Two asterisks (**) a significant trend at $\alpha = 0.001$.

Meteorological factor	Time period	Linear trends		
		Lednice	Lanžhot	Vranovice
Mean air temperature (°C)	March	0.28	0.24	0.30
	April	0.2	0.18	0.17
	Year	****0.19**	****0.22**	****0.19**
Maximum air temperature (°C)	March	0.3	0.35	0.35
	April	0.19	0.29	0.16
	Year	***0.20**	***0.26**	***0.19**
Precipitation (mm)	March	2.18	2.62	***3.43**
	April	0.51	-0.004	2.31
	Year	0.16	0.69	***1.32**

Table 2. The values of correlation coefficient between average temperature and date of onset of nuthatches phenophases.

	Lednice	Lanžhot	Vranovice
FLD	0.843	0.844	0.817
MLD	0.846	0.851	0.821

The phenophases of nuthatch has shifted to the earlier time since 1951 to 2008. The shifts of phenophases are shown in days per decade in upper right corn of pictures (Fig. 1). Our findings are very similar for other birds species whose phenophases has shifted as well. Bauer et al. (2009) determine shifting of FLD by between 1.3 and 1.7 days for Great Tit per decade and similarly MLD has advanced by 1.4 to 1.7 days per decade during 1961 - 2007 in southern Moravia. Crick et al. (1997) noted an advance in nesting by an average of 8.8 days for 20 bird species in Great Britain from 1971 to 1995. Winkel and Hudde (1997) reported the advance of Great Tit nesting by 9 days and the advance of Collared Flycatcher nesting by 3 days in Germany from 1989 to 1995. Other data and exact values about phenophases of particularly genus nuthatches are not available in the scientific literature. While there is ample information about ecology and biology of this bird species but long term observations of phenophases have not been published so far.

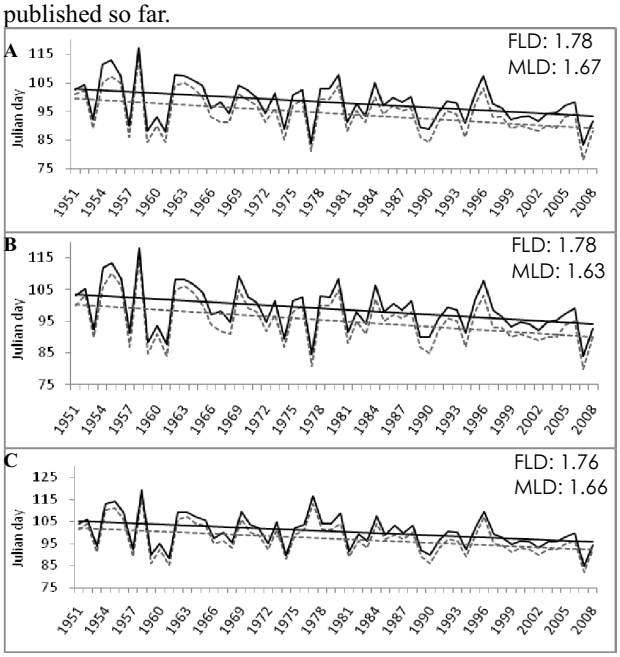

Figure 1. Annual values of the FLD (solid line) and the MLD (dashed line) with linear trends in the population of Eurasian Nuthatches. In upper right corn are values of shifts of phehophases in days per dacede for FLD (first laying date) and MLD (mean laing date). Observational sites A) Lanžhot, B) Lednice and C) Vranovice.

The coherency analyses of temperature and of onset of phenological stages (FLD and MLD) exceed the 95% and 99% confidence levels for long periods (above 60 years) (Fig. 2). Similar results find Bauer et al. (2009) for species Collared Flycatcher and Great Tit. Fig. 2 also shows very similar results over whole region. This could be explained by the relative proximity of the sites and also by the fact that all three sites belong to the same canopy of flood plain forest.

Conclusions

The phenophases of Eurasian Nuthatch (Sitta europaea) has advanced firstly in case of FLD by 10.1 days on average and in case of MLD by 9.3 days on average at three observational sites on southern Moravia during 1951 and 2008.

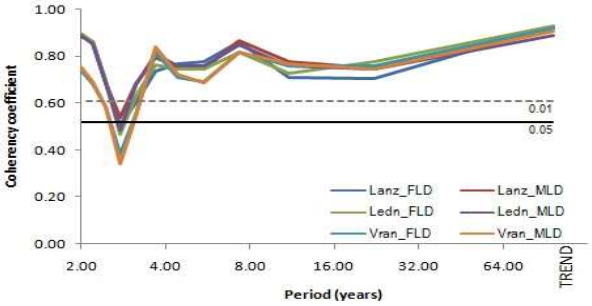

Figure 2. Coherency analyses between average temperaute during March and April and phenophases FLD and MLD of Eurasian Nuthatch.

The development of temperature during March and April correlate very well with onset of phenophases and the trends during 1951-2008 between temperature in March and April and terms of FLD and MLD correspond together very well.

Acknowledgement We gratefully acknowledge the support of research plan MSM6215648905 “Biological and technological aspects of sustainability of controlled ecosystems and their adaptability to climate change”; and the KONTAKT OC187 (linked to COST 734).

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Historical basins sediments

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Abstract. When in 2007 Malý and Veľký Kolpašský tajch were drained for reconstruction purposes it offered a great opportunity to study the original bottom of these basins and the sediments they contain for the first time after 300 years. The results obtained from research we compared to other sediment samples from historically younger basins.

Introduction

Unique technical design in water management contributed to the greatest expansion of mining and the most glorious period in history of Banská Štiavnica in the first half of 18th century when it was the third largest city in Hungary. In the years 1740-1760 14 tons of gold and 475 tons of silver was produced in the area. The first university of mining was established here as well especially due to ingenious utilization of water resources.

It was Matej Kornel Hell and especially Samuel Mikovini with his student Jozef Karol Hell junior who resolved the problem of drawing water from flooded mines. Samuel Mikovini, an excellent mathematician, cartographer and geodesist came to Banska Stiavnica in 1735 delegated by the emperor Charles VI and designed and built most of the reservoirs which outlasted to the present. He filled up these reservoirs by means of dozens of kilometres of collecting channels in relatively small area without any rivers. His system of head-water channels and a specific concept of interconnecting the reservoirs by tunnels were also ingenious.

The basis of this water-management framework was the interconnection of the reservoirs, utilization of rainfall water often from greater area than offered the river-basin and its transmit to the reservoirs. This means that we can speak of the most accomplished water utilization framework of the 18th century. No other system of this kind was able to accumulate greater amount of rainfall water than the one of Banská Štiavnica.

Rainfall water brought erosive material from the surroundings which subsided on the bottom of the reservoirs during decades.

In general sediments besides their chemical influence change the function of a reservoir by reducing its volume from the bottom and by changing its area from the sides.

The reservoirs in Banská Štiavnica – so called „tajchy“ – are historically the oldest and most influenced ones by sediments. Today their maintenance is in the competence of Slovak water-management enterprise (Slovenský vodohospodársky podnik, š. p., Odštepný závod Povodie Hrona). In the present the reconstruction of water outlets and Dam fortification in the reservoirs of Velká Kolpašská nádrž and Malá Kolpašská nádrž are being finalized.

The reconstruction works on Belianska reservoir, Rozgrund and others have already been finished and the project will continue. We can clearly observe changes in the attitude to revitalization of the reservoir system.

System of ditches that supplies both reservoirs brings deposits from surrounding areas caused by erosion. Soils there are shallow to medium deep. Soil qualities significantly affect qualities of sediments in Kolpašské tajchy. Chemical characteristics of sediments can be evaluated through relatively complicated reactions between individual stages, especially between water solution and coloid part of the sediments. We use the same characteristics to describe soils.Basic characteristics of sediments include

- soil reaction
- absorption capacity and the nature of sorption complex
- organic ratio (humus content).

After sampling we performed three analyses mentioned above, at first for the samples taken at Malý Kolpašský tajch.

One of the most important qualities of soil is its pH value. Soil reaction influences solubility of substances in soils and their efficiency for living organisms, accessibility of nutrients, adsorption and desorption of cat ions, biochemical reactions, soil structure and thereby physical characteristics. Following great complexity of relations in soil we distinguish active and interchanging soil reaction. The pH value is expressed by means of extensive scale USDA.

We made a pH analysis of the samples taken in 2008 in SPU laboratories. The results are displayed in the following Tables 1, 2.

Table 1. Results of measured values pH v KCl a H2O.

KCl		H_2O	
Sample	pH	Sample	pH
1	3.05	1	3.82
2	2.86	2	4.02
3	3.19	3	3.81
4	2.8	4	4.25
5	3.4	5	3.9
6	2.1	6	4.0
7	2.44	7	3.79
8	3.24	8	3.58
9	2.9	9	3.63
10	2.37	10	3.8
11	3.3	11	4.0
12	2.88	12	4.1
13	3.32	13	3.6
14	2.8	14	3.69
15	3.0	15	3.69
16	3.37	16	4.3
17	2.0	17	4.53
18	2.8	18	4.2
19	3.18	19	4.6
20	3.2	20	4.15

The analyses show that samples from all the sampling places are characterized as acidic or extremely acidic soil.

Proportion of organic content (humus) is the indicator of agricultural land fertility, the content of humid substances.

In the case of sediments it is an indicator of contained organic matter which has come into the sediment rather from dead planktonic organisms from dead and decomposition of other dead organic matter.
The content of humus (organic substance) is a very important parameter affecting the basic features and functions of soil. It is determined by setting of oxidizable organic carbon (COX) and multiplying by a conversion factor of 1.724 for humus. This calculation is based on the assumption that humus contains 58% carbon.

Table 2. Evaluation of the humus content in the sediment samples collected from Malý Kolpašský tajch.

sample number	Carbon content results in the average (%)	humus content conversion factor of 1.724
1	10.8753	18.749
2	10.1477	17.4946
3	10.1515	17.5011
4	5.679	9.7905
5	10.1812	17.7356
6	9.4237	16.2464
7	8.5225	14.6927
8	9.1858	15.9316
9	7.8377	13.5121
10	8.0829	13.9349
11	5.734	9.884
12	0.9003	1.5521
13	7.3925	12.7446
14	9.2411	15.9316
15	10.4346	17.9892
16	8.0744	13.9202
17	8.3317	14.3638
18	9.8091	16.9108
19	8.8131	15.1937
20	10.1117	17.4325
21	1.4312	2.4674
22	2.1375	3.685
23	4.4481	7.6685
24	3.2819	5.6579

Obtained values indicate an extremely high content of organic matter. It is caused by the residue after planktonic organisms from the reservoir. More detailed surveys of sediments clearly show their layered arrangement, where the layers of lighter minerals alternate the ones with darker minerals.

Conclusions

The work was to evaluate the formation and qualities of historical sediments of water reservoirs in Banská Štiavnica. In present time Kolpašské tajchy in Banský Studenec are under reconstruction. During maintenance works after deletion of the reservoirs they become available for exploration of sediments. After determining of their deposit and their amount, samples were taken for mechanical and chemical analysis. After their evaluation, we found out that their qualities are significantly influenced by their resources and operation. It is not only extreme soil reaction which is interesting but also a high content of organic matter. And also their large volume, despite the fact that water flows in only by means of rain ditches.

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Changes in the onset of *Fagus sylvatica*, L. phenological phases evaluated in different climate conditions

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Abstract. The changes of the meteorological factors cause consequently the change of the onset of phenological phases, which are depend on them to a large extent. The extent to which they express themselves differs with the altitude.That is the reason why we set the aim to identify the level of differences in the chosen phenological phases onset during the whole vegetation period at the two various altitudes which represent different climatic conditions. We have chosen *Fagus sylvatica*, L. as the object of our survey. The phenological phases trends were evaluated during the 22–years long period range from 1986 to 2008. The results of the analyses show in general the higher variability of the autumnal phases onset at both altitudes. The change of the spring phases onset was found out only at higher located stand Staré Hory with more favourable moisture conditions. There can be seen gradual decreasing of the spring phenological onset gradient at the different altitudes. By the autumnal phenological phases, there was found out the opposite trend.

Introduction

The onset of phenological phases is affected by the sum of the external conditions, of which the most important are meteorological factors, for example the air temperature, the sum of global radiation, precipitation amount, etc. (Menzel, 2002; Linderholm, 2006; Schieber, 2006). However, in the last years of 20th century it has come up to the change of their trends due to the global climate changes caused by the increased amount of CO_2 in the atmosphere. There is recorded the increase in the air temperature, particularly in the spring time, as well as the uneven redistribution of the precipitation during the year (Chmielewski and Rötzer, 2001; Melo et al., 2007). Nevertheless the variation of these changes intensity and gradient is related to the altitude to a large extent. In the lower areas there is the increase of the air temperature more considerable than in the higher located places. Likewise the drought onset is more likely in the low altitudes (Lapin et al., 2009). These variations modify and cause the differences in the onset trends of phenological phases. They are also influenced by the woody plant character and its stand requirements.The following work assesses the onset trends of the Fagus sylvatica, L. vegetative and generative phenological phases during the whole vegetation period between the years 1986 and 2008. It is focused on the two areas located in the different altitudes with the diverse climate conditions – Hajnáčka and Staré Hory.

Data and methods

Phenological data were taken from the Slovak Hydrometeorological Institute (SHMI) database. It was proposed to choose the widest spectrum of phenological phases so that we achieve the knowledge about their response to the ongoing changes. On the basis of the amount of data in the SHMI database following phases were selected: (1)Vegetative phenological phases – the budburst, the first leaves, the full foliation, the colouring of leaves, the end of leaf fall, (2)Generative phenological phases – the full flowering, the first mature fruits. *Fagus sylvatica,* L. is the most distributed tree in the Slovak woods. Concerning the ongoing climate changes and the water demands of this species we were focused our survey of phenological phase's trend changes just on this plant.

First monitored stand, Hajnáčka, lies at 220 m.a.s.l and the second one, Staré Hory, lies at 485 m.a.s.l. The climate conditions are characterised with the help of the adjacent meteorological stations Rimavská Sobota (Hajnáčka) and Banska Bystrica (Staré Hory) (Figs. 1 and 2).

Data were processed in STATISTICA and Microsoft EXCELL applications.

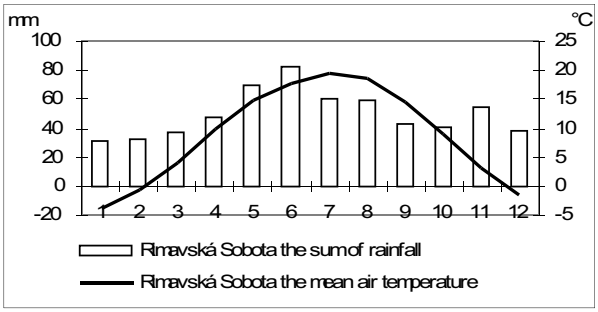

Figure 1. The climatograph of Rimavská Sobota

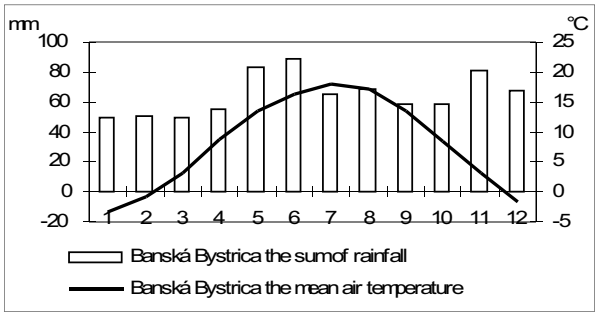

Figure 2. The climatograph of Banska Bystrica

Results and disscussion

Within the trend analysis can be concluded that the most noticeable trend during the 22 years was observed by the phenological phases the first mature fruits and the end of leaf fall at both stands – the phases delay from 10 (the first mature fruits at Staré Hory) to 40 (the end of leaf fall at Hajnáčka) days (Figs. 7 and 9). The smallest shift of the onset was found out by the phenological phases the budburst and the first leaves at Hajnáčka – the shift of 1–2 days (Figs. 3 and 4).

According to the seasons the most obvious changes occurred by the autumn phenological phases (Figs. 7–9). By the spring phases there was determined the more visible trend only at Staré Hory (Figs. 3–5). At Hajnáčka there were almost no changes within the onset of these phases. Interesting is the fact of delay of the spring phenological phases (the full foliation and the full

flowering) beginning at Hajnáčka (Figs. 5 and 6). This tendention in the course of the phases minimize in principle the time range of the phenological phases onset between the evaluated altitudes. Despite of the slight advance of the first leaves occurrence we can identify the same development by this phase, too. In general we can state that the differences of spring phenological phases onset at various altitudes have been declined during the 22 years. This decrease is caused mainly by the delay of the phenological phases onset at lower situated stand (Hajnáčka), eventually by only the slight advance of the foliation.

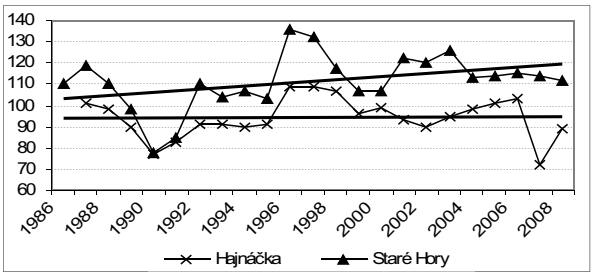

Figure 3. The onset of budburst.

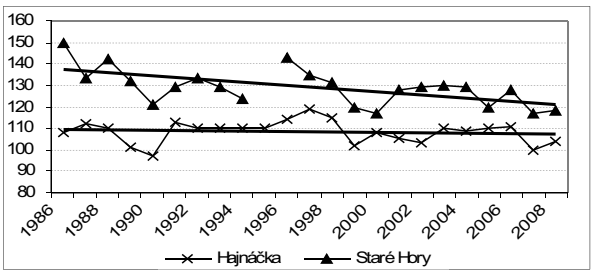

Figure 4. The onset of first leaves.

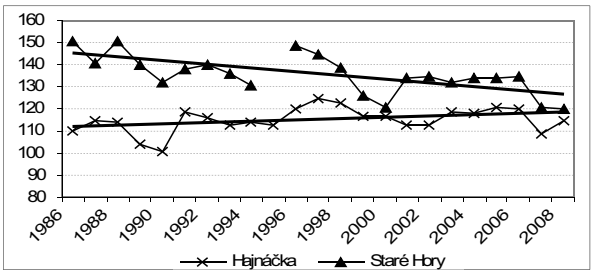

Figure 5. The onset of full foliation.

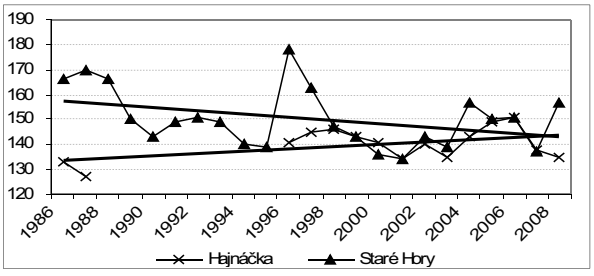

Figure 6. The onset of the full flowering.

Conclusions

The previous findings showed that the more marked changes during the 22 years were proved by the autumnal phenological phases (the colouring of leaves and the end of leaf fall) especially at Hajnáčka located in lower altitude typical by the poor total amount of rainfall throughout the year. From the phenological phases onset trend analysis arises the entire shift of autumnal phases towards the later part of the year.

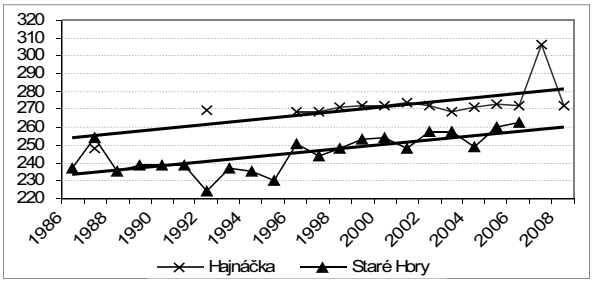

Figure 7. The onset of the first mature fruits.

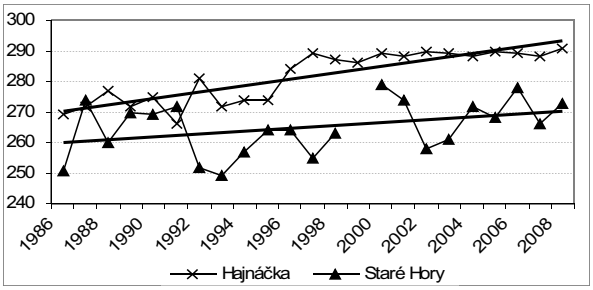

Figure 8. The onset of the colouring of leaves.

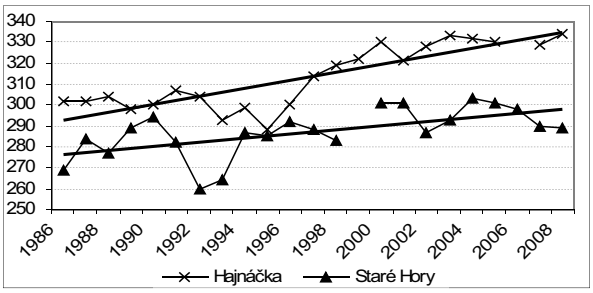

Figure 9. The onset of the end of leaf fall .

In contrast to the autumnal phases there were appeared noticeable changes at higher altitudes of Staré Hory by the spring phases. The shift of the spring phases at Hajnáčka was minimal; some phases have even proved delay of their onset during the monitored period (the full foliation, the full flowering).

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The changes of the values of ecological-stabilization functional potentials of forests in the model area Český les

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Abstract. The aim of the work was to quantificate the ecological-stabilization forest function by the method of Vyskot et al. (2003). The importance of living forests for sustainable development was discussed on many ministerial conferences. If we sustain forests permanently we will preserve permanent life. For the work the model area, a part of protected landscape area Český les, was chosen. The goal was to evaluate the real potentials of ecological-stabilization forest function and to see how the potentials are distributed in the age classes. According to these results we can discuss the previous management in the area. The map of the distribution of ecological-stabilization forest function real potentials was created.

Introduction

The goal of the work was to analyse the nature protection needs and the society needs in the forests ecosystems. Forests are the entire part of the environment. Sizeable part of Czech forests is set in protected areas. These areas are restricted in the act nr. 114/1992 Col., about the landscape and nature conservation. The whole forested area in existing protected areas is about 26.5 % in the whole area of the forests in the Czech Republic. The work was utilized on the model area, which is part of the Český les protected landscape area. The basic question was: which age classes (20 years) have the highest real potentials values of ecological-stabilization forest functions and how can we discuss the forest managament in last years. The forest function potentials were evaluated on every such a forest stand. The real potential of forest functions is quantified functional potential of forests (values of produced functions) under optimum ecosystem conditions. The forest functions are the implemented product of effects resulting from its nature and ecosystem processes.

Data and methods

For the evaluation of forest function real potentials in the model area the ecosystem method Vyskot et al. (2003) was chosen. The ecological-stabilization forest function was evaluated. The all-society forest functions are evaluated in the ecosystem units with the interaction with the forest partiation (Vyskot et al., 2003).

Ecological-stabilization potential is a quantified maximally possible functional capacity of forest ecosystems (value of the produced function) to reach the balance of energo-material flows under optimum ecosystem conditions, functioning the self-regulation processes and resistance to disturbances. Real species composition – with the increasing diversification of species composition ecological stability of the stand type also increases. Some natural communities showing high ecological stability despite low biodiversity are an exception.

The data which are used in the quantitative evaluation of all-society forest function were taken from the forest management plan. Forest management plans are created for the 10 year period in the Czech Republic. For the method are important these datas: stand type and functional target management group.

Stand types are species schemes created according to the proportion in species composition

Functional target management group specifies related higher practical units of forest ecosystem types of the real species composition characterized by limits on natural conditions.

Value classification of real potentials of forest functions goes from 0 (functional unsuitable) to 6 (extraordinary).

The cartographic data were processed in AgcGIS 9.2 and the analysis by the database task was made.

Results and discussion

The 662.4 ha of forests on the part of the Český les protected landscape area were analyzed. The values of real potentials of ecological-stabilization forest function were quantified and the surface and percentage distribution of forest in the real potential values classes was established.

From the quantitative evaluation of forests point of view the maps made in GIS have the most important predicative value. In the Fig. 1, one can see the distribution of real potential values (ecological-stabilization forest function).

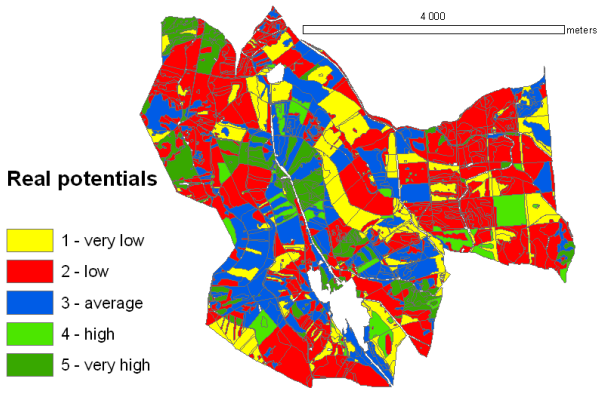

Figure 1. The distribution of real potentials values (ecological-stabilization forest function).

The results of evaluation were analysed and the distribution of the highest value of real potentials in the age classes (20 years) was determined. The results of this analysis are shown in the Tab. 1.

Table 1. The distribution of the highest value of real potentials in the age classes.

Age class	The highest value of real potential	Area of the age class in ha	Part of surface of the highest value in %
I.	5	341.4	18
II.	5	6.3	6
III.	5	34.8	2
IV.	5	31.1	9
V.	5	121.5	2
VI.	3	12.4	67
VII.	5	69.9	25
VIII.	4	17.7	19
IX.	1	9.4	100
X.	3	17.9	46

The highest achieved value of the real potential of ecological-stabilization forest function is 5, so the very high. The highest percentage surface cover is in the I. and in the VII. age class. We can partly say that the ecological ecosystem approach in the last twenty years is projected in this very high real potential of ecological-stabilization forest function and that the management was influenced, and still is, by this approach.

The needs of nature conservation are defined in the zones of the protection declaration, but the forest functions are not included. For the comparison of ecological-stabilization forest function real potentials distribution and declared zones of nature conservation distribution the Fig. 2 is enclosed.

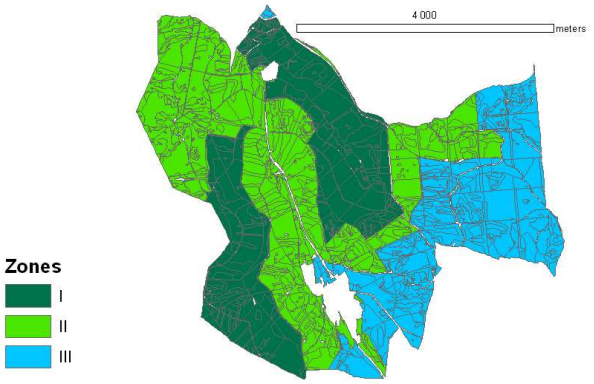

Figure 2. The declared zones of the nature conservation (I – most protected).

For the synergy of nature conservation and forest function need`s detection is the quantification of both necessary. It was necessary to interconnect known aspects of the nature conservation (projected in the zonation) with the forest function quantification.

The suggestion whether the nature conservation needs are in the conjuction with the high functional potentials of forests was very important.

The results of the quantification proved that the contemporary zonation is really one-sided and does not respect the side-run of the nature conservation needs and forest function needs.

Conclusions

The area of 662.4 ha was analysed and the real potentials of ecological-stabilization forest function were found out. The map of the distribution in GIS was created and the analysis of the highest real potential in the age classes was made. We can partly say that the ecological ecosystem approach in the last twenty years is projected in very high real potential of ecological-stabilization forest function and that the management was influenced, and still is, by this approach.

Acknowledgements The study has been supported by Research plan of Faculty of Forestry and Wood Technology Mendel University of Agriculture and Forestry in Brno - MSM 6215648902 and the project VaV Sp-2d3-56-07 Ecological and economic evaluation of social functions of alternatively structural forests.

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Law No. 114/1992 Gaz. on the protection of nature and landscape.

Measuring the seasonal dynamic and spatial variability of soil moisture in fast growing poplars plantation

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Abstract. Within the presented paper a seasonal soil moisture dynamics and spatial variability were investigated in poplar short rotation coppice culture (SRC). The goal of the overall study is finding correlations between soil moisture changes, biomass accretion rate and other meteorological, planting and ecological factors. Understanding these interrelationships could be useful to the further selection of other areas of SRC and also could improve the yield predictions.

Introduction

SRC has recently received increased attention as a renewable source of biomass for energy in EU countries. The potential to become an important source of renewable energy is mainly due to their high biomass yields, good combustion quality as solid fuel and comparatively low biomass production costs (Kauter et al., 2003). In addition to its bionergy potential, SRC has many other ecological advantages - e.g. positive impacts on biodiversity (small mammals, birds, insects, etc.), nutrient capture, soil protection from wind and water erosion) and also better water management in ecosystems (Isebrands and Karnosky, 2001). More recently, the importance of plantation forestry as a greenhouse gas mitigation option and the need to monitor, preserve, and enhance terrestrial carbon stocks have been recognized by the United Nations Framework Convention on Climate Change in the Kyoto protocol (Updegraff et al., 2004).

The largest areas of SRC (totally a few thousands of hectares) are situated in Scandinavia, Germany, UK, Italy, Belgium and France (Slatter et al., 2001; Kauter et al., 2003). The main reason why the plantations of SRC are not so widely-used is the economic situation, as there must compete with fossil fuels, other renewable energy sources, as well as residual biomass from the agriculture and wood-processing industry. Furthermore, in most cases SRC is inferior under the given economic and political conditions (Kauter et al., 2003). One of the ways to increase the SRC areas could be not only to offer recently supplied grants but also to optimize the technology of planting SRC on farmland. Selecting areas and establishing the SRC (in the case that the owner is going to put to use the grants) is ensured according to legislature in cooperation with accredited experts and in terms of the project (e.g. Weger and Havlíčková, 2003). The estimation of biomass production is subjective and mostly takes into account the genotype of the plant, while the role of meteorological, soil, phytopatological and herbological conditions at the given site is not fully appreciated. Therefore the use of production ecology methods that are based on mathematical modelling of growth and evolution of the plants seems to be a very practical solution. Such models which are based on exact measurements of the biotic processes and their linking with abiotic environment and subsequently formulated to general algorithms are very useful just for making decisions about where, how, and in some cases even which clones would be most suitable for planting. However using these tools requires a sufficient number of high-quality experimental data to calibrate and verify the models.

The aim of this paper is especially the evaluation of soil moisture dynamics and its temporal and spatial patterns at poplars plantation, which should contribute to a development of modelling schemes described above.

Data and methods

In April 2002, a high-density experimental field plantation for verification of the performance of poplar clone J-105 (P. nigra x P. maximowiczii) with the total area of 4 ha was established in Domanínek (Czech Republic, 49°32´ N, 16°15´E and altitude 530 m). The plantation was established on agricultural land previously cropped predominantly for cereals and potatoes. Hardwood cuttings were planted in a double row design with inter-row distances of 2.6 m and spacing of 0.7 m within rows accommodating a density of 10,000 trees/ha. Soil conditions at the location are representative of the wider region with deep luvic Cambisol influenced by gleyic processes and with a limited amount of stones in the profile. The site itself is situated on a mild slope of 3° with an eastern aspect and is generally subject to cool and relatively wet temperate climate typical of this part of Central Europe with mingling continental and maritime influences. Although the area does not provide optimum conditions for SRC based on Populus sp. clones, the site itself is highly suitable for planting due to deep soil profile.

In May 2007, an array of 16 access tubes was installed into the soil for portable datalogging with a PR1 profile probe – a system measuring dielectric properties of soil, which are straight depending on soil water content. The layout of access tubes is designed to record differences in soil moisture between double rows and inter-rows and the soil moisture variability itself within the investigated area. Readings were taken usually once a week. In July 2007, 2008 and 2009, soil sampling took place and the field capacity with the wilting point was determined together with other useful soil characteristics like bulk density, textural composition, etc. In the same time soil sampling to estimate soil water content through gravimetric method is carried regularly in order to increase measurement precision.

Results and discussion

Fig. 1 shows the daily intensity of precipitation. An almost one month long drought period without rains in combination with high temperatures that occurred from the second half

of August until the beginning of September (pictured in the red box).

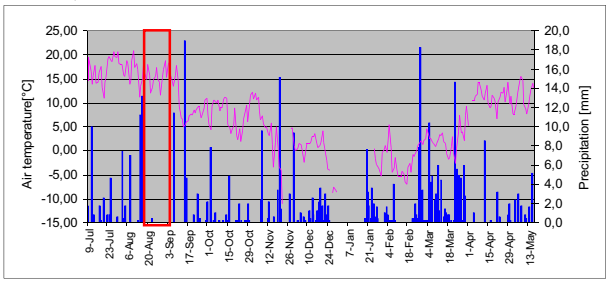

Figure 1. Daily precipitation and average air temperature in 2m.

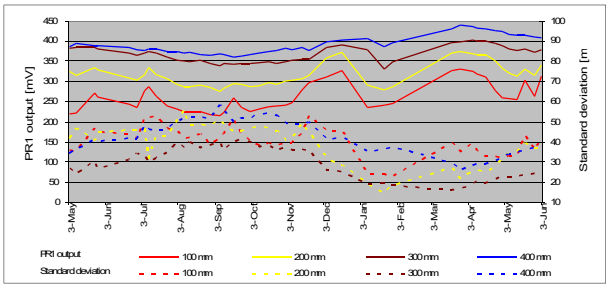

Figure 2. Seasonal dynamics of soil moisture in different depths (100 – 400 mm) and its standard deviation – both expressed to PR1 output [mV].

Throughout this interval the soil dried out and its moisture expressed as PR1 output [mV] reached the lowest values and approached the wilting point in the upper parts of the soil profile as is depicted in Fig. 2. In addition to interseasonal soil moisture dynamics, Fig. 2 shows the standard deviation, which refers to soil moisture spatial variability over the course of time. The highest variability in almost all investigated depths came in the above mentioned dry period.

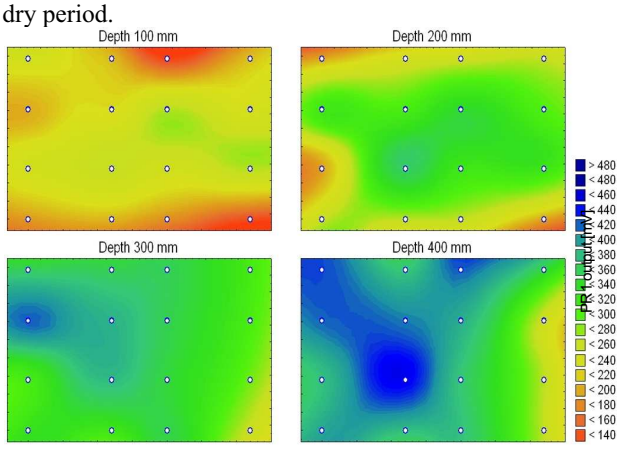

Figure 3. Top view on spatial variability of soil moisture in particular depths within the driest day (6/9/2008).

On the other hand, the lowest spatial variability of soil moisture occurred at the end of March and in early April when the soil was saturated with water above the level of the field capacity after the snow had melted. Depletion in soil moisture together with standard deviation in the course of winter months (from December to March) was left out because it was induced by freezing of soil profile, not by water deficit. Figs. 3 and 4 show top views on spatial variability of soil moisture in particular depths during the driest and dampest days. The white dots refer to respective access tubes.

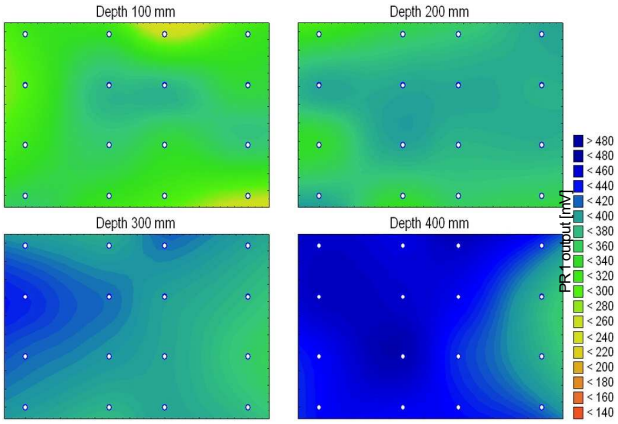

Figure 4. Top view on spatial variability of soil moisture in particular depths within the wettest date (27/3/2009).

Conclusions

This study tried to evaluate seasonal dynamics of soil moisture together with its spatial variability in fast growing poplars stand growing on luvic Cambisol in the Bohemian-Moravian Highlands. Generally, the soil water content increased with the depth from 100 mm to 400 mm. The driest period came at the end of summer within almost month-long period without any precipitation. In this time also the highest spatial variability was recorded. On the contrary, at the beginning of spring, after the snow had melted, the water content of soil profile reached its highest value and the spatial variability was the lowest.

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Carbon balance in Spruce ecosystems affected by heavy windstorm in the Tatra Mts.

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Abstract. On Novemebr 19, 2004 the area of the High Tatra foothills was stuck by a violent downslope wind "bora". More than 12 000 ha of mostly spruce ecosystems were downed. This dramatic event created conditions to study the impact of such catastrophic windthrows, and its subsequent management, on carbon dynamic of coniferous forest. Eddy covariance measurement of carbon dioxide fluxes on three sites with different disturbance and management regime (EXT-fallen trees extracted, site reforested, NEX-fallen trees left on site, no artificial reforestation, and REF-intact forest) run from fall 2005 to 2007. Data confirmed that spruce ecosystems affected by windfall turned from carbon sink to carbon source. Faster succession of herbaceous layer mitigated enhanced respiration and larger carbon losses at EXT even during the first year after the storm. Since 2009 observation continues as soil respiration monitoring using closed chamber method.

Introduction

Forests play an important role in terrestrial carbon budget. More than 28% of terrestrial carbon is stored in forest vegetation and forest soils. Long life cycle of forest is a reason for long-term carbon storage. Carbon sequestration by forest is increasingly important topic due to expected global warming conditions. Recently, the frequency of natural disturbances to forest has increased, and storms, floods, fires, insect outbreaks are expected to increase. Natural disasters may cause considerable changes in forest ecosystem with possible negative feedback on the climate system. Enhanced mineralization of soil organic matter may release carbon to the atmosphere (Don A. et al., 2006). On November 19, 2004, violent downslope wind "bora" hit south slopes of the Tatra Mts and downed 12 000 ha of mostly semi-natural spruce forest. A decision to leave 10% of windfall unmanaged offer unique opportunity to study ecological consequences of such an event under different management approaches (Fleischer 2008). To study carbon cycle in heavily damaged spruce ecosystems three study sites with comparable conditions (forest community, climate, soil, geology, altitude, slope, orientation, stand structure before windstorm) were chosen: EXT – windthrow where wood was extracted, reforestation applied, NEX – fallen wood remained on site, no further management is planned, REF – reference forest site, not affected by windfall 2004.

Data and methods

During summer 2005 three representative sites were chosen as a joint effort of involved institutions. In late fall 2005 all three sites were equipped by eddy covariance instruments to measure net ecosystem exchange. Eddy towers were erected to keep instruments 5 m above vegetation. Tower in REF forest was 33 m high. Expected "footprint" was roughly 100 ha. Instrumentation at each sites consisted of open path CO_2/H_2O gas analyzer Li-Cor 7500, Licor, USA), ultrasonic anemometer (R3-50, Gill, UK and Metek, Germany). Instruments recorded data with 20Hz frequency. Additional meteorological and soil variables were also monitored (Fleischer, 2008) and stored as 10 min averages. For data acquisition and calculation we used EddyMeas program (Kolle& Rebmann, 2007). For program control and data storage we have used datalogger CS 21x a 10x (Campbell Scientific, UK). In order to improve the quality of soil respiration data (generally understood as a weak point of EC method), ground network for manual soil respiration with portable closed chamber technique was set up (Giorgi et al., 2006). Measuring design on fixed collars was derived from prevailing wind directions, based on preliminary study (Ziegler et al., 2007). Eddy measurement lasted from fall 2005 to 2007. Since 2009 intensive soil respiration monitoring continued on fixed collars. We use closed chamber technique with IRGA Vaisala probe, model MI70 (Vaisala, Finland).

Results and discussion

Harsh climate caused that large amount of collected data on CO_2 fluxes had to be rejected due to unsuitable turbulent conditions on observed sites. In 2006 nearly 50% at EXT, 54% at NEX and 35% at REF site did not meet criteria for reliable interpretation. In 2007 64% at EXT, 59% at NEX and 54% at REF site were rejected. For calculation of half-hour and cumulated monthly fluxes missing data were filled using non-linear regression. Half-hour fluxes (Fc) showed dramatic falling of photosynthesis and carbon uptake in the two windtrow sites when compared with intact REF site. Anyway, the trend of mean daily Fc on a monthly base showed a pattern of carbon uptake higher at the EX-site rather than at the NEX-site. Also seasonality differs between the two sites as in August 2006 the uptake was more comparable. This was likely due to different vegetation succession dynamic reflecting different disturbance regime occurred at the two sites (Fig. 1).

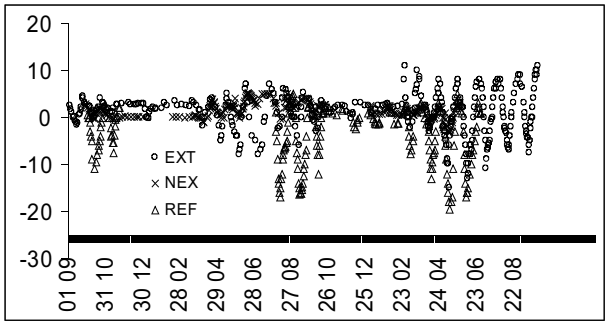

Figure1. Diurnal C fluxes at the EXT, NEX and REF sites from September 2005 to September 2007 (in μmol.m $^{-2}$).

A new vegetation community could establish more rapidly at the EXT-site rather than at the NEX-site thanks to soil disturbance caused by wood removal. Dramatic change occurred in 2007, both respiration but mostly carbon uptake by vegetation increased Cumulated monthly fluxes were obtained from progressive sum of the daily integration of half-hour fluxes (not presented). Data show different annual trend between the two windthrow sites. While NEX-site appears as a stable source of CO2 with a maximum in summer, the EXT-site has a more variable trend showing a net uptake of CO2 in June.

Carbon balance derived from daily NEE during August – December 2006 as a period with sufficient amount of reliable data presents Fig. 2.

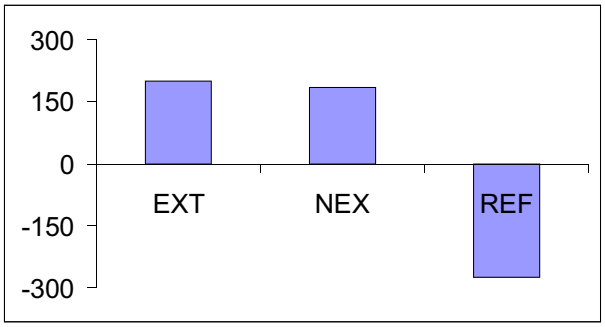

Figure 2. Net ecosystem production (g C.m^{-2}) in August-December 2006.

Soil respiration (expressed in ppm CO_2.s^{-1}) measured on ground by closed chamber method in 2009 on the same points as in 2005 (data reported by Ziegler et al. (2007)) showed rather stable conditions at NEX-site (0.45 in 2005 and 0.4 in 2009), bigger difference at EXT-site (0.37 in 2005 and 0.51 in 2009). Those changes are in accordance with the vegetation succession. The biggest difference was observed at REF-site, where former 0.48 ppm.s^{-1} increased up to 1.1 ppm.s^{-1} without notable changes in both forest and floor vegetation structure.

Conclusions

Eddy covariance measurement of C fluxes after large windfall in the Tatra Mts forests confirmed that former forest ecosystems turned from C sink to C source. Faster vegetative succession at EXT-site is responsible for higher C uptake than at NEX site. Soil respiration measured by manual closed chamber technique indicates elevated carbon release from soil in intact forest, probably caused by elevated temperature. Carbon balance in intact forest should be used as an indicator of forest ecosystem rehabilitation progress towards pre-windfall conditions.

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Selected forest soil properties after the windfall 2004 in the Tatra Mts

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Abstract. Forest on a south slope of the Tatra Mts has been continuously affected by strong winds. The last heavy windstorm in 2004 laid down 12 000 hectares of spruce forest and initiated systematic ecological research. In this paper are:

1) compared historical data on selected soil parameters inside and outside windfall area,
2) presented and discussed preliminary results from soil monitoring. Results have confirmed temporal changes in both soil temperature and moisture on sites with different disturbance regimes. Remarkable early after-storm differences show declining tendency and increasing similarity with standing (undamaged) forest. High variation of micro site conditions is the reason for great soil moisture heterogeneity on windfall area and acts as a foundation for the formation of diversified forest with higher ecological resistance.

Introduction

In November 2004 forests on the south oriented slope adjacent to the Poprad river basin were heavily damaged by bora wind. Cold downslope wind with speed exceeding 230 km /h laid down 12 000 ha (2.3 mil m^3). Destructive bora wind is part of unique anemo-orographic system and continuously but irregularly affects the same territory (Koren, 2005). The scope and intensity of forest destruction from the last windfall attracted the awareness of international research communities to study ecological consequences of such an event on remaining forest ecosystems and the surrounding countryside. Since 2005 comparative research and monitoring started on four mutual sites (all with similar topography, geomorphology, geology, vegetation and soil), with different disturbance and forest management regime (Fleischer, 2008). Soil conditions on affected areas have not yet been systematically studied. Nevertheless some soil research was performed before the windstorm 2004 (Bublinec at al.,1992). This is an important source of information which provides unpublished soil surveys by the Institute of Forest management in Zvolen performed in 1955-1957, 1970, 1982-1983 and 1994-1995. In this paper we compare selected physical and chemical soil properties taken prior to and after the windfall of 2004.

Data and methods

Spruce-larch (1000-1350m a.s.l.) and spruce-pine forest communities (750-1000 m a.s.l.) are a consequence of continuous wind disturbance. Four sites were chosen to study post-windfall development under different disturbance and management regimes. Each site is roughly 100 ha large, EXT is managed with fallen wood removal, NEX is unmanaged with fallen wood on site, FIR is windfall hit by fire and REF is reference forest, not affected by windfall 2004. Location of soil sampling sites (before 2004) and windstorm research sites (after 2004) is in Fig.1.

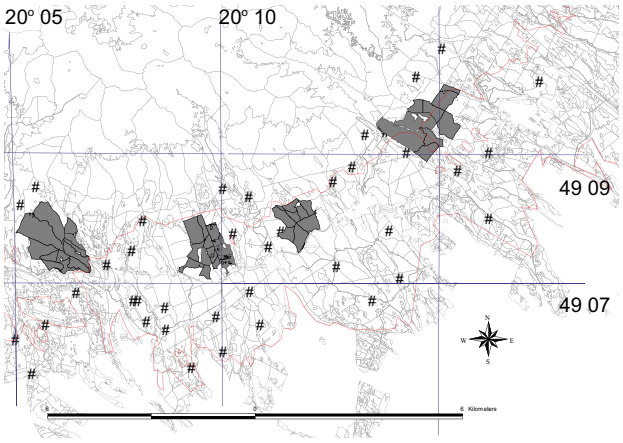

Figure1. Location of windstorm permanent research sites (stripped polygons) and soil sampling points (dots) on a forest map with windfall area.

On the windfall area the most spread soil types are podzolic cambisols and humic podzols all of which have a very low pH and mineral nutrient content. Micro topographic variation is also typical (pit and mound formation) as a sign of previous disturbances. Consequently forest disintegration is elevated due to solar radiation to the forest floor. Generally the top soil organic material hardly decomposed in closed forest and was suddenly exposed to mineralization. Organic C was mainly emitted to the atmosphere as carbon dioxide (CO_2), other matters were leached to lower soil horizons. This might be a main reason for the thinness of the mineral A horizon. Mineralization increases with soil temperature and moisture. Soil temperature and moisture, key forest soil parameters have been monitored since the summer of 2005 using theta a soil moisture probe ML2x (Delta Device, UK) and thermometers (Pt 100, Pt 107, NTC 107) in 8 and 16 (occasionally 32) cm depth. Soil heat flux is measured by heat flux plates (Hukseflux, NL). Global radiation and radiation balance by pyranometers and net radiometers (Kipp-Zone, NL), continuous precipitation (0.2 mm accuracy by electronic ombrometers Young and Davis, USA) formerly in 30 min, at present as 60 min average or sum. In 14 day intervals we sample soil for thermo gravimetric methods of water content (% volume). For spatial soil moisture analysis we use modified ML2x probe and capacitance probe (A300 Aquaterr, USA). Data presented in this paper represents the beginning of the growing season (from April 1 to June 30, 2006-2009).

Results and discussion

Analysis of soil characteristics before 2004 in larch (pine)-spruce forest community (n=55) revealed some common features. The main commonly spread soil types are podzolic cambisoil and humic podzols. Thickness of mineral humus (A) horizon at the sites with regular windfalls was 6.0 cm on average, whilst in old growth forest

(> 100y, no recent windfall) A horizon was 10.3 cm on average (p 0.05). Laboratory analysis (n=16) revealed a high proportion of stones, on average 32% in A and 44% in B horizons. According to particle content (< 2mm) prevailing grain size was loam in A and especially in B horizons. Humus ranged from 2 up to 28% (average 16% in A, 7% in B horizon). C:N ratio ranged between 10-22, 18 on average in A, and 16 in B horizon. Soil pH in A horizons ranged between 3.1 to 4.4 (median 3.7), and 3.2-4.6 (median 4.0) in B. Samples taken after the windstorm from permanent research sites showed similar values (Micuda et. al., 2006; Ziegler et al., 2006; Novak et al., 2008) and confirmed representative sampling design.

Soil temperature on monitored sites occasionally dropped below 0 °C however frozen soil hardly ever occurred. Significant soil temperature elevation occurs in May. Monthly average soil temperature recorded in 8 and 16 cm is in Tab.1.

Table1. Mean monthly soil temperature in 8 and 16 cm (°C) on permanent research sites.

		2006		2007		2008		2009	
		8	16	8	16	8	16	8	16
APRIL	EXT	5.7	5.0	6.9	6.0			7.9	7.6
	NEX	2.9	2.8	5.0	4.8			3.1	3.0
	FIR			9.0	7.6	8.0	6.1	9.8	8.2
	REF	1.7	0.6					2.2	1.3
MAY	EXT	10.0	9.4	11.6	10.7			8.3	8.0
	NEX	8.6	8.3	10.8	10.4			7.2	7.1
	FIR					11.5	9.9	12.1	10.6
	REF	5.4	4.6	7.9	6.5			6.2	5.7
JUNE	EXT	13.4	12.6	15.4	14.7			10.8	10.4
	NEX	12.6	12.1	13.0	12.9			9.8	8.9
	FIR					14.1	12.7	12.2	11.0
	REF	7.9	6.8	10.7	8.9			7.9	7.5

Soil temperature in consecutive years depends on air temperature, sun radiation, and soil heat flux. According to these criteria, differences among localities are only minor. The biggest difference is on REF site, where the air temperature was on average considerably lower (up to 4 °C) and only one third of radiation reached the forest floor when compared to the windfall (open) sites. Soil temperature drops along soil depth, at REF site 0.5 °C/10 cm. At EXT site due to the heating of unprotected upper soil the difference was 1.8 °C/10 cm. In 2009, in conjunction with remarkable grass vegetation progress, the difference dropped to 0.7 °C/10 cm. Increasing differences are observed on NEX, (former 0.6 °C /10 cm in 2006 and 2007). There is also grass expansion, which is less dense with no insulation layer in the root zone. The combination of the grass expansion with fallen trunks reduces air circulation in the ground layer and causes overheating. Vegetation development has remarkable impact on soil water content. Absence of tree canopies and interception are reasons for elevated (more than 50%) precipitation drops on the forest floor when compared to standing mature forest. We hypothesized that due to lack of tree transpiration and elevated mineralization occurrence of notable soil-hydric changes, esp. wetness. Neither monthly, nor daily course confirmed such a trend. Fast water saturation and fast water loss were observed after heavy rains on windfall sites. Further vegetation development eliminated these fast responses. This fits also for dry periods (April-May 2009) when V% dropped below 20%. On sites with grass *Calamagrostis villosa* water content was remarkably higher. Spatial observation and interpretation confirmed enormous variability of soil water content. This is a precondition for sufficient water capacity for vegetation even under longer periods with low precipitation. Natural regeneration prefers moister sites and supports a patchy structure generally understood as a key resistance parameter against both natural and human disturbances.

Conclusion

Podzolic cambisol and humic podzols are the most commonly spread soil types in the region affected by repeated windfalls. Soils are acid and stony with a thin A horizon, with a high humus share in mineral horizons. Windfall 2004 caused changes in soil temperature and hydric regime. There is a clear temporal trend of minimizing extreme values supported by vegetation succession. High spatial variation of soil moisture was confirmed.

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Soil microbial activity at selected plots in Tatra National Park – four years after windthrow

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Abstract. The overall objective of this study was examining soil microbial activity on the windthrow and fire-affected plots. Soil samples were taken from the surface organic layer and mineral A-horizon during the autumn 2008. Among microbial characteristics, basal and potential respiration, catalase activity and N-mineralization were assessed. We found statistically significant differences in most of the studied microbial characteristics. Generally, the highest microbial activity was found at the reference plot.

Introduction

Soil microorganisms play a key role in various biochemical cycles and are responsible for the cycling of organic compounds. Because of their sensitivity, they are considered early indicators of environmental changes. In November 2004, spruce stands in the Tatra National Park (TANAP) were affected by a large-scale windthrow and one year later a fire broke out on a part of this area (Fleischer *et al.,* 2007). On a part of the windthrow-affected area, all windthrow debris was left on site to study of natural processes in such ecosystems.

After disturbance events, changes in soil conditions are expected to affect the activity, structure and the function of microbial communities (Bååth *et al.* 1995). The effects of fire on soil microorganisms biomass and activity have been documented in many studies (Certini, 2005). However, the information about changes in their diversity on pre- and post-fire plots is scarce. At the same time, there is a lack of knowledge about soil microorganisms on windthrow-affected plots with different management regimes.

In this paper the differences in soil microbial activity at selected plots four years after the windthrow and fire are shown.

Data and Methods

Ten soil samples were taken from the surface organic layer (O) and top mineral horizon (A) (depth of 0–10 cm) on each study plot (reference REF, extracted EXT, fire FIR and non-extracted NEX plots) in November 2008. Soil water content (Vm) was determined gravimetrically by oven-drying fresh soil at 105 °C overnight. Soil pH was measured in water and 1 M KCl suspension. The content of soil carbon (C) and nitrogen (N) was determined using MacroVario CNS analyzer.

Basal soil respiration (BR) was measured by estimating the amount of CO_2 evolved during the incubation of soil in a closed container for 24 h (Aleff 1991). For substrate-induced respiration (SIR), 1% glucose of the moist weight of the soil sample was added to the soil samples and CO_2 evolved was determined as described above after 5 hours. N-mineralization (Nmin) was determined using the laboratory anaerobic incubation procedure described by Kandeler (1993). Catalase activity (Acat) was determined by measuring the volume of oxygen discharged after incubation of 10 g soil with 3% H_2O_2 for 10 min. according to the method of Khasijev (1976).

All the results are expressed on the oven-dry basis. Statistical analyses were done using the statistical package SAS/STAT® (SAS, 1988).

Results

Analysis of variance of soil variables and Duncan's pairwise tests of the differences of means among treatments are shown in the Tables 1 and 2, respectively. There are significant differences in most of studied soil variables between plots.

The average soil carbon content was significantly higher at the fire and reference plots (10.73 and 9.59%) than at the other plots.

Table 1. Analysis of variance of soil variables (*F*-test).

Soil variables	*F*-test
Respiration *in situ*	1.08
O-horizon (surface organic layer)	
Soil water content	1.92
Basal respiration	2.99*
A-horizon	
Soil carbon content	9.04***
Soil nitrogen content	6.83***
pH-H_2O	18.38***
pH-KCl	11.01***
Soil water content	0.57
Basal respiration	1.86
Potential respiration	3.80*
N-mineralization	1.6
Catalase activity	6.33***

*** $P > 0.999$, ** $P > 0.99$, * $P > 0.95$

The average soil nitrogen was similar for all treatments except the fire site where the highest average soil nitrogen (0.67%) was observed.

The reference site exhibited significantly higher acidity (pH-H_2O 3.35, pH-KCl 2.91) than the other treatments. At the fire and non-extracted plots, soil acidity was similar. No significant differences were found in gravimetric soil water content in the A-horizon. However, in the surface organic layer, the highest values were found at the reference plot and the lowest one at the fire plot.

Table 2. Duncan's pairwise tests of the differences of means among treatments; the treatments with the same letters do not differ significantly ($P>0.05$).

Plot	C (A)	N (A)	pH-H_2O (A)	pH-KCl (A)
REF	6.6a	0.55b	3.35c	2.91c
EXT	6.0b	0.45b	3.79b	3.53a
FIR	10.7a	0.67a	4.15a	3.19b

NEX	7.4b	0.49b	4.20a	3.45a
Plot	Re *in situ*	Vm (O)	BR (O)	Vm (A)
REF	1013a	198.9a	0.25a	50.2a
EXT	865a	155.4ba	0.22ba	41.7a
FIR	832a	116.5b	0.14b	48.7a
NEX	683a	142.3ba	0.12b	49.4a

Plot	BR (A)	SIR (A)	Nmin (A)	Acat (A)
REF	0.13ba	0.58a	11.02a	2.75b
EXT	0.11b	0.49a	12.11a	2.30b
FIR	0.17a	0.39ba	9.29a	3.81a
NEX	0.12ba	0.27b	9.18a	2.69b

Units of measurement: C (%), N (%), Vm (w/w), Re, SIR (μg C-CO_2.g^{-1}.h^{-1}), Nmin (μg N-NH_4^+.g^{-1}.$7d^{-1}$), Acat (ml O_2. g^{-1}.min^{-1}).

In the surface organic layer, the highest basal soil respiration was found at the reference and extracted plots. Surprisingly, no significant differences between plots were observed in soil respiration *in situ* probably due to a high within-plot variability.

In the A-horizon, basal respiration shows the significantly highest value at the fire site (0.17 μg C-CO_2.g^{-1}.h^{-1}) and the lowest one at the extracted site (0.11 μg C-CO_2.g^{-1}.h^{-1}). Similarly, the lowest potential respiration was observed also at the NEX site (0.27 μg C-CO_2.g^{-1}.h^{-1}), however, the differences among the other plots were non-significant. The average N-mineralization was similar for all treatments. This microbial characteristic belongs also to parameters with considerable within-treatment variation. Significantly the highest catalase activity (3.81 mlO_2.g^{-1}.min^{-1}) was observed at the FIR plot

Conclusions

The results indicate that there are differences in soil characteristics among study plots. Trends in microbial characteristics among plots are not same. Generally, the highest microbial activity was observed at the reference site, however, this plot exhibited also a high within-plot variability. The lowest microbial activity was found at the plot where timber was not extracted.

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Specification of precipitation inputs for the water balance of spruce stands in lower altitudinal vegetation zones

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Abstract. One of limiting factors for the ecological stability of spruce forests in lower forest altitudinal vegetation zones (FAVZ 3 – 6) is a sufficient amount of precipitation, which is as a rule measured by devices designed for vertical precipitation. In addition to the vertical component of the falling precipitation (rain, drizzle, snow) there is also a so called atmospheric precipitation deposition developing on assimilatory organs and on tree branches (atmospheric aerosol creating fog and low cloudiness, inducing dampness – hard rime in winter), which is referred to by non-experts as horizontal precipitation. In currently used psychrometers, the deposited precipitation can be intercepted at a negligible and closer undefined amount. Thus, the amount of vertical precipitation can be significantly underestimated in the assessment of spruce forest moisture balance. Conversely, an incorrect interception value may result in the overestimated total amount of vertical precipitation.The aim of this study is to refine the inputs to withholding water balance, i.e. to determine the amount of deposited and vertical precipitation. " Measurements made in 2008 (1 Jan. - 8 Sept.) showed that total amount of deposited precipitation reached almost 25%, representing 244.2 mm (more than 15.l) per unit area. Total amount of vertical precipitation per unit area was 753.7 mm (31.l).

Introduction

The comparison of results from model situations (Kacholia & Reck, 1997) based on the growing CO_2 concentrations in Earth's atmosphere up to a double of the current state suggests that an interval of the expected increase of average annual temperature of the ground atmosphere layer is 0.16 – 6.3 ^{o}C. The output from the Intergovernmental Panel for Climate Change (IPCC) included in the Fourth Evaluation Report indicates that most of the current estimates of climatic models anticipate the average global temperature to rise by 1.8 – 4 ^{o}C. The research of climate provides ever more data on the continual increasing of global Earth's temperature. The assumptions of climate change have been in the last ten years increasingly supported by the series of temperature and precipitation records – extreme drought in southern, western and central Europe (e.g. in 2003, 2005 and 2007), and disastrous floods in central Europe in 2002. The territory of Czech Republic lies in the temperate climatic zone in the middle of the European continent. Due to this geographical position, two climate types combine – oceanic and continental. In spite of the fact that the country is rather small (78 864 km^2), the considerable diversity of its relief and the range of elevations induce great climate differences. There are areas of nearly steppe character, areas with excessive moisture, as well as cold and warm regions. The outputs of global climatic models show that it will be exactly the territory of central Europe (and hence the territory of Czech Republic) where the climate will break rainfall and temperature records in the future. The climate changes apparently affect numerous processes within the forest ecosystems. They participate in all unexpected developmental processes of the forest ecosystem – both positive (e.g. increased gain) and negative (e.g. damage to forests by wind, snow, frost, drought, etc.). Climate extremes with decreased rainfalls and increased temperatures bring a moisture stress to forest stands. The spruce stands of lower altitudinal vegetation zones will be most endangered by these climate extremes. The goal of this study is to specify precipitation inputs into the moisture balance of spruce monoculture in Natural Forest Region 30 – the Drahanská vrchovina Upland. Refined values of the development of water balance and its effect on the moisture regime of soils may provide ground works for the assessment of growth conditions and production processes of tree species in connection with the complex evaluation of silvicultural practices used to cultivate pure spruce stands in Forest Altitudinal Vegetation Zone 5 in the context of climate changes.

Input data and methods

The water balance assessment and the subsequent derivation of evapotranspiration will be made with using the data of air temperature, global radiation and atmospheric precipitation recorded by the meteorological tower installed on the experimental plot in Rájec-Němčice. The water balance calculation will newly include also the results from the measurement of deposited (horizontal) precipitation. The issue of the formation of horizontal precipitation in the context of expected climate changes and its significance in water balance has not been resolved precisely so far. In order to specify more accurately the amount of deposited precipitation, an ombrometer was designed in cooperation with Baghirra s.r.o. Prague that measures the amount of deposited precipitation based on a passive sampling of water drops in atmospheric aerosol through free capturing on a stainles metal grid in the form of cylinder. The metal grid with a catch area of 377 cm^2 is kept at moderate temperature if the outdoor temperature falls below zero. The trapped water flows down into a funnel, which ends in a sensor (bowl) of 3 ml in volume, serving for the measurement of water volume. The instrument is installed in the research plot Rájec-Němčice on the top of a meteorological tower high 40 m, ca. 10 m above the forest stand, at an altitude of 670 m a.s.l. The locality is on a mild slope with the southeastern aspect. After testing (Hadaš, 2007) and determination of needed reduction coefficients, the rain gauge was introduced into the meteorological monitoring in January 2008. In addition to the continual measurement of precipitation deposits, the Department of Forest Ecology, Mendel University of Agriculture and Forestry Brno (MZLU Brno) takes the measurement of other meteorological parameters that affect or may affect the formation of precipitation deposits. In the top part of the meteorological tower, the continual measurements are taken of air temperature and humidity, wind direction and velocity

and vertical precipitation by means of rain gauge Model PTM 500 H with electric heating, regulator and scanning electronics supplied by BAGHIRRA, s.r.o. The rain gauge surface area is 500 cm^2 and the sensor (bowl) for measuring the amount of rainwater has a volume of 5 ml (precipitation water volume for one overturning). Regarding the fact that classical sensors to measure wind direction and velocity as well as precipitation are considerably strained and mechanically damaged in winter, the measuring system was added some new instruments making use of modern, non-traditional methods of measurement. Wind direction and velocity are measured by the ultrasonic anemometer Thies (Fig. 1) with the accuracy of 0.1 m s^{-1} and maximum range of 60 m s^{-1} (216 km hr^{-1}).

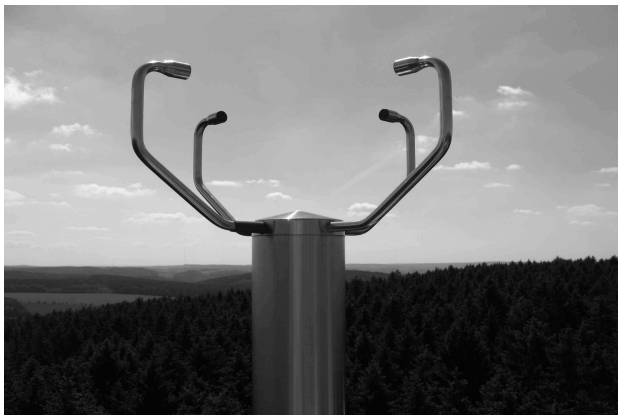

Figure 1. Ultrasonic anemometer Thies used for measuring wind direction and velocity.

In May 2009, the rain gauging instrumentation was added a disdrometer Thies (Fig. 2), measuring the precipitation amount by means of laser beam. Disdrometer can measure amounts of both liquid and solid precipitation with the accuracy of 0.01 mm, as well as the fall velocity and amount of condensation products. For the analysis of precipitation deposits, all measurement records are continually stored in a data-logger at 15-minute intervals.



Figure 2. Laser disdrometer Thies used for measuring precipitation characteristics.

Results and discussion

Fig. 3 illustrates the development of vertical and deposited precipitation. The amount of deposited precipitation intercepted from 1 January 2008 to 8 September 2008 surmounted 15 litres of water, which was –converted to surface area- 244.2 mm of precipitation. The station raingauge was used to measure the volume of vertical precipitation exceeding 31 litres, which represented – converted to surface area- 753.7 mm of meteoric water. The total sum of deposited and vertical precipitation reaches nearly 1000 mm of meteoric water. The data further indicate that the share of deposited precipitation in the total sum is nearly 25%. The behaviour of deposited precipitation amounts shows that the highest precipitation amounts occur in winter when partial sums may exceed even 14 mm of meteoric water. The volume of trapped precipitation deposited during the testing period from 10 November 2006 to 7 February 2007 exceeded 16.8 litres of water, which represented more than 18% in the volume of 91.9 litres of vertical (atmospheric) precipitation.

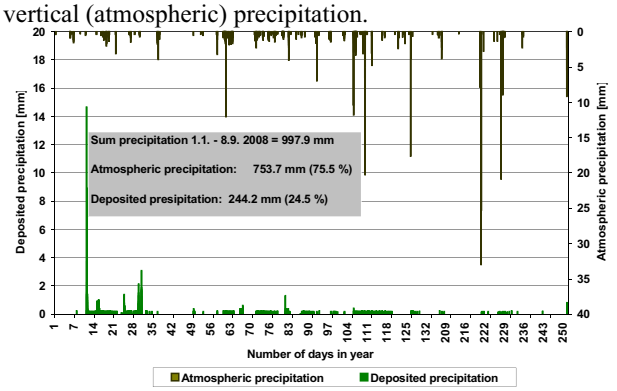

Figure 3. Development of vertical (atmospheric) and deposited (horizontal) precipitation from 1 January to 8 September 2009 at the long-term field experiment station operated by the Department of Forest Ecology, Faculty of Forestry, MZLU Brno.

Conclusions

The detected elements of precipitation inputs in water balance will be analyzed also as related to the soil moisture development of the spruce monoculture, which is measured on the research plot at a level of 10 and 30 cm. The detected statistic dependences between water balance, soil moisture and other meteorological factors (air temperature and humidity, wind direction and velocity) will be used to construct a model of the development and prognosis of moisture regime in the spruce monoculture. The next stage of the study will include a prognosis of moisture balance changes that will be focused namely on the occurrence of moisture balance deficit as a risk factor of spruce stands in lower altitudinal vegetation zones.

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Multivariation methods – tool for solving evaluation of the forest health conditions in the territory of the Jizerské hory Mts.

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Abstract. For working out multidimensional data, common analytical and statistical procedures cannot be used. Instead it is necessary to use geostatistical methods based on the application of multidimensional methods. The analysis of forest health conditions (as expressed by defoliation) and the parameters of the abiotic environment of forest stands was conducted based on the application of simple and multidimensional regression and correlation analyses. Based on the application of cluster analysis it was possible to define the spatial arrangement of five areas of the resistance potencial degrees to forest stand damage. A model explaining defoliation and forest stand conditions was compiled for each area of the resistance potencial degrees from the results of the multiple correlation and regression.

Introduction

The aim of this paper is to analyze the causal relationship between the abiotic environment and forest health conditions in the Jizerské hory natural forest region. The analysis is based on the hypothesis that health conditions are the result of draining the resistance potential of forest ecosystems, as current air pollution loads in the form of atmospheric deposition of sulphur and nitrogen in combination with climate oscillations (changes in temperature and the moisture regime) and ground-level (tropospheric) ozone conditions cause their damage (Hadaš, 2007). The resistance potential of forest stands was defined for critical acid deposition, nitrogen deposition loads and climate conditions. The atmospheric deposition of sulphur and nitrogen is still an accelerator of acidification processes in forest soil. Acidification is slower, but it has not stopped. Critical sulphur and nitrogen loads have been exceeded on many monitored sites not just in the territory of the Czech Republic. Besides the undergoing acidification, forest soil has also undergone eutrophication.

The direct and indirect effects of air pollution in forest ecosystems depend on a multiplicity of variables including the exposure intensity, abiotic and biotic environmental conditions and the natural sensitivity of the affected populations, species and communities. Therefore in order to comprehend and understand the potential influence of the pollutants SO_2 and NO_x and climate stressors on forest ecosystems, a substantial amount of data about the abiotic environment in territories in which this data has not been measured were needed to acquire. Therefore, data concerning temperature conditions, water balance, solar radiation, ozone concentrations and deposition flows of sulphur, nitrogen and hydrogen ions were derived through model applications and interpolation techniques.

It is assumed within the conducted analysis that the main vehicle of air pollution stress, resulting in the damage of forest stands, are deposition flows of sulphur, nitrogen and/or their acid depositions captured on the earth's surface or vegetation. Furthermore it is based on the assumption that extreme climate conditions and deposition flows within the synergic effect disrupt physiological processes: metabolism, photosynthesis, water and mass balances, transpiration, phenophase, nutrient uptake by the roots (Mauer&Palátová, 2001), which reflect unfavorably in changes on canopy health conditions. Changes in the health conditions of tree crowns are evaluated on the basis of assimilatory organs loss – through defoliation.

Data and methods

Within the methodological approach, derived sulphur and nitrogen deposition flow values and acid deposition above forest stands and in the stands themselves are compared with critical load values; temperature conditions are assessed in terms of frost shock, moisture conditions in terms of the water balance, the assessment of the effects of ozone air pollution in terms of the moisture conditions of the environment and the state of the ozone layer in the stratosphere. The derived data represent climate and air pollution stress and figure as independent variables in the analysis of the causal relationship between the abiotic environment and forest health conditions. At the same time the aim of this analysis was to define the resistance potencial degrees to forest stand damage on the territory of the Jizerské hory Mts.

For working out multidimensional data common simple analytical and statistical procedures cannot be used. Instead it is necessary to use geostatistical methods based on the application of multidimensional methods. The analysis of forest health conditions (as expressed by defoliation) and the parameters of the abiotic environment of forest stands was conducted based on the application of simple and multidimensional regression and correlation analyses.

The potential deposition flows of sulphur and nitrogen, and the acid deposition of hydrogen ions is calculated based on gaseous SO_2 and NO_x (as NO and NO_2) and from their dry and wet deposition flows. Calculation SO_2 and NO_x pollutants concentration is based on the Gaussian dispersion model SYMOS 97. The dry deposition of sulphur and nitrogen is ascertained by calculating the deposition velocity using a resistance model. The calculation of wet deposition of sulphur and nitrogen is based on the parameterization used in the MESOPUFF II model. The entire model calculation is based on particular data measurements (emissions, technical parameters of emissions sources, air pollutant concentrations, air temperatures, atmospheric precipitation, wind direction and velocity) and on mathematical approximations indirectly derived from these parameters for locations where measurements have not been taken. Multiple regression and interpolation methods (e.g. orographic, Lagrange interpolation) are applied. Solar radiation components as

well as parameters for calculating the water balance were likewise derived using a model calculation. Precipitation totals and ozone pollution concentrations were derived based on orographic interpolation, and the thickness of the ozone layer was derived through interpolation based on inversion distances. Calculations for 2001 were made using a lattice of 1642 grids.

Results and disscussion

Despite the decrease in SO_2 emissions the effects of local air pollution on the air pollution load in the Jizerské hory are still noticeable (on average Czech emissions sources contribute a 23.6 % share in sulphur deposition), as well as the effects of transboundary sulphur pollution (on average foreign sources contribute a 76.4 % share in sulphur deposition). Czech emissions sources of NO_x are on average responsible for a 34.6 % share in the potential nitrogen deposition, and foreign emissions sources of NO_x contribute a 65.4 % share.

The total potential sulphur and nitrogen depositions reach such high values that they can still significantly affect and deepen the effects of the natural acidification of forest stands and forest soil. The critical acid deposition load of 2000 mol. H^+ ha^{-1} per year is exceeded on more than 85 % of the studied area.

Within the procedures of cluster analysis – evaluating the distances between objects with Hemming's method and the similarity of objects using the furthest neighbor method (complite linkage) – the spatial arrangement of five areas with the resistance potencial degrees to forest stand damage was defined. Basic characteristics of the the resistance potencial degrees are in the Tab. 1. Area number 1 takes up 31 % of the territory of NFR 21, area number 2 takes up 21 % of the territory, area number 3 more then 7 % of the territory, area number 4 more than 31 % of the territory and area number 5 takes up more than 8 % of the territory. The spatial arrangements of the resistance potencial degrees to forest stand damage on the territory of Jizerské hory Mts. are shown in Fig.1.

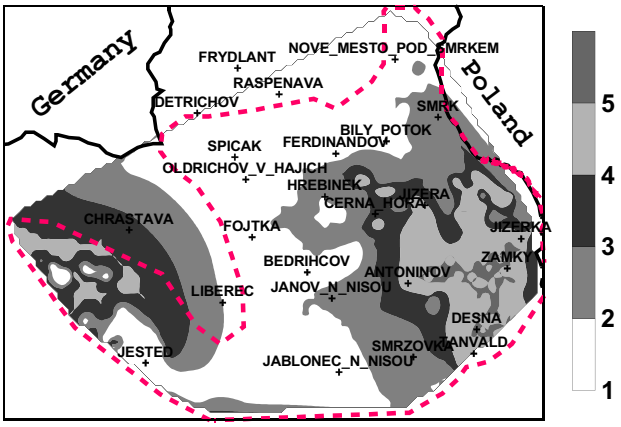

Figure 1. The spatial arrangement of the resistance potencial degrees (1-5) to forest stand damage in the territory Jizerské hory. Mts. The spatial arrangement based on the application of the gridding method natural neighbor (Surfer Demo Ver. 9, Golden Software). Research territory is represented by a red line.

A model explaining defoliation and forest stand conditions was compiled for each area of potential susceptibility from the results of the multiple correlation and regression. The highest degree of air pollution effect and climate stress on the defoliation of forest stands was reached in area number 3, where the coefficient of determination derived from the multiple regression function reaches a value of 64.2 %. This means that 35.8 % remain for other abiotic factors (e.g. soil, stand nutrition conditions, etc.).

Table 1. Basic characteristics of the resistance potencial degrees to forest stand damage on the territory of Jizerské hory Mts..

Resistance potencial degrees	Ø Deposition flows [mol H^+ ha^{-1} $year^{-1}$]		Ø Defoliation [%]	% of territory
	Sulphur	Nitrogen		
1 – high	94.9	475.1	29.6	31.6
2 – low	134.6	539.9	31.1	21.4
3 – extreme low	171.9	593.9	38.2	7.2
4 – medium	69.9	418.9	28.7	31.5
5 – very low	204.3	683.1	33.6	8.3

Conclusions

The main cause of forest decline (or dieback of individual tree or group of trees) is still the high input of acid deposition in forest soil, which exceeds the natural regeneration of the soil environment. High soil acidity affects the nutrition of forest stands. Weakened stands are more exposed to damage resulting from sudden adverse meteorological circumstances, particularly the increase or decrease in the air temperature. For example a triggering factor for large-scale defoliation may be the effect of a single extreme temperature increase or an extended dry period, or an extreme decrease in air temperature at the turn of winter and spring or autumn and winter (the winter of 2001/2002), as well as one-time acute or synergic soil damage caused by air pollution in the form of acid depositions.

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Assessment of vegetative phenological phases of European beech (Fagus sylvatica L.) in relation to effective temperature during period of 1992 - 2008 in Czechia

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Abstract. The paper presents results of long-term phenological observation of European beech (FAGUS sylvatica L.) at CHMI phenological network for period 1992 - 2008. Based on 17-years data, following vegetative phenological phases were evaluated: bud burst (BBCH07), first leaves 100% (BBCH15), leaves colouring (BBCH 92), leaves fall 100% (BBCH 97). Stations are situated at elevation from 165 m (Lednice) to 1102 (Modrava). The mean date of onset of bud burst is from April 12th to May 7th (average formation April 22nd), the mean date of onset of first leaves 100% is from April 29th to May 17th (average formation May 7th), the mean date of onset of leaves colouring is from September 12th to October 14th (average formation on September 24th) and the mean date of onset of leaves fall 100% is from October 9th to December 8th (average formation to November 7th). Variation coefficient equals 5. 1% (Lednice - bud burst), 4. 1% (Modrava - bud burst), 4.4 % (Lednice - leaves fall), 4.9 % (Modrava - leaves fall). The trend analysis of bud burst stage showed declining trend - it means the shift of phenological phases towards earlier date (5.7 days). On the other side, the phenophase of leaves fall 100% resulted in increasing trend - it means the shift of phenological phase to later date (6.1 days). The duration of vegetation season is longer. The totals of effective temperatures were used as bio-climatological criterion for phenological phase dependencies on meteorological elements. The above mentioned totals were determinated as subtotals of average daily temperatures higher than 0°C, 5°C, 8°C and 10°C (TS0, TS5, TS8, TS10). The average day of bud burst has its temperature totals of TS0 = 286.2 (Lednice, 165 m asl), TS0 = 144.2 (Modrava, 1102 m asl). Others effective temperature totals for average day of bud burst are subsequent: TS5 = 71.5; TS8 = 21.4; TS10 = 7.2 (Lednice); TS5 = 20.0; TS8 = 4.4; TS10 = 1.6 (Modrava). For average day of leaves fall has its temperature totals of TS0 = 3822.4 (Lednice); TS0 = 1845.9 (Modrava).

Introduction

The European beech belongs to wooden plants that, by its natural extension, occur in the whole area of Central Europe including Czechia. Phenological observations can serve as suitable bioindicator of environmental changes. European beech is a deciduous tree, up to 40 m high. Subsequent phenophases are observed at CHMI phenological network: bud burst, first leaves, fully leaved, inflorescence emergence, beginning of flowering, end of flowering, bud creation, first fruit visible, summer colouring, herb sprouts begin to lignify, leaves colouring, leaves fall and fully ripeness. The mean daily air temperature has high influence on bud burst of oak (Quercus robur L.) for period 1961 - 2007 in a flood plain forest of southern Moravia (Bartošová et al., 2008). At this paper phenological observation of Fagus sylvatica L. for period 1992 - 2008 in relation to air temperature (effective temperature) are presented.

Data and methods

The onset of bud burst, first leaves 100%, summer colouring and leaves fall 100% were analysed for the the period 1992 - 2008 in Czechia from 27 CHMI phenological stations at elevations from 165 to 1102 m asl. There were chosen stations with complete temporal rows. The phenological data are observed according to CHMI methodology instruction number 10 (1987). The results of phenophase onset are expressed as a date of year ; stations were analyzed separately and according to altitude. The following interphase intervals were evaluated: bud burst - leaves fall (length of vegetation period of European beech in Czechia), bud burst - first leaves 100%, leaves colouring - leaves fall 100%. All kinds of analysis were proceeded in Excel and AnClim programme. Totals of effective temperatures (subtotals of average daily air temperatures) above 0°C (TS0), 5°C (TS5), 8 °C (TS8) and 10 °C (TS10) were chosen from meteorological characteristics.

Table 1. Characterstics of phenological stations.

Station	Altitude	Longitude	Latitude
Lednice	175	16°48’	48°48’
Plzeň	328	13°23’	49°47’
Benešov	370	14°41’	49°47’
Přibyslav	533	15°45’	49°35’
Harrachov	710	15°26’	50°46’
Modrava	1102	13°31’	49°02’

Table 2. Characterstics of climatic stations.

Station	Altitude	Longitude	Latitude
Lednice	176	16°47’	48°47’
Plzeň	360	13°22’	49°45’
Netvořice	375	14°30’	49°49’
Přibyslav	530	15°45’	49°34’
Harrachov	670	15°26’	50°46’
Kvilda	1059	13°34’	49°01’

Results and disscussion

Part of statistical results of selected stations is in Tabs. 3, 4. Results are expressed as a day of year. The phenophase ‘bud burst’ records higher relative variation coefficient than phenophase ‘leaves fall’, on the other side, the variation range is larger by defoliation of leaves. The phenophase ‘bud burst’ starts earlier in lowlands, the leaves fall 100% in the mountains. The length of interphase interval ‘bud burst – leaves’ fall is on average 223 days in the lowlands and 157 days in the mountains, length of interphase interval ‘bud burst - first leaves’ 100% is on average 19.8 days in the

lowlands and 9.2 days in the mountains and length of interphase interval 'leaves colouring - leaves fall' 100% is on average 55.5 days in the lowlands and 26.4 days in the mountains.

Table 3. Statistical evaluation of bud burst phenophase onset of European beech in Czechia expressed as a day of year.

	Lednice (165 m)	Frýdlant (345 m)	Přibyslav (533 m)	Pernink (860 m)	Modrava (1102 m)
Average	104	110	103	127	126
Median	106	114	104	129	127
Upper q.	100	103	96	122	122
Lower q.	108	116	110	132	130
STD	5.3	7.6	9.0	8.9	5.2
MIN	91	96	86	107	115
MAX	110	119	116	146	132
Var. range	19	23	30	39	17
Rel. var. coeff.	5.1	6.9	8.7	7.0	4.1

Table 4. Statistical evaluation of Leaves fall phenophase onset of European beech in Czechia expressed as a day of year

	Lednice (165 m)	Frýdlant (345 m)	Přibyslav (533 m)	Pernink (860 m)	Modrava(1102 m)
Average	327	301	303	296	282
Median	325	302	302	293	282
Upper q.	318	298	299	283	269
Lower q.	333	309	310	302	290
STD	14.3	11.3	10.6	14.0	14.0
MIN	307	276	288	278	263
MAX	357	317	330	334	303
Var. range	50	41	42	56	40
Rel.var coeff.	4.4	3.8	3.5	4.7	4.9

Conclusions

The results show a wide range of variability of phenophase onset during last 17 years, it depends on weather course and location. There is dependence on altitude and on meteorological elements. The differences in totals of effective temperatures between lowlands and mountains are relatively high. The length of time duration between bud burst - leaves fall (these phenophases represent period between start and end of vegetation season) is 223 days in the lowlands and 157 days in the mountains. The sums of effective temperatures above 5°C (Fig. 1) show also a wide differences between stations due to different altitude.

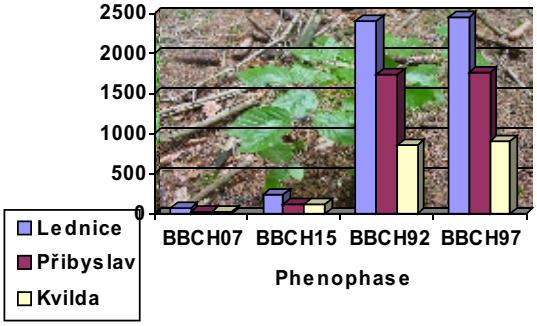

Figure 1. Sum of effective temperature above 5°C during investigated period (non-dimensional number).

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Soil pedochemical and microbiological characteristics at selected plots in the Tatra National Park (TANAP)

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Abstract. The soil sampled at different plots in TANAP after windthrow was analysed. Since year 2005 the spring, summer and autumn sampling was preceded in the areas of interest. Three specific localities were chosen. REF plot represented the reference area of stand spruce forest; EXT represented the area damaged by windthrow event in winter 2004 where all the tree biomass was removed; NEX plot area which was damaged by windthrow event but the wooden biomass was left to support ecosystem self regeneration. These papers present the value changes of chosen soil indexes resp. characteristics – carbon dioxide CO_2, nitrogen in ammonium form NH_4-N, carbon in microbial biomass C_{bio}, total nitrogen N_{tot} and oxidable carbon C_{ox}. Field sampling was done in years 2005, 2006, 2007 and 2008.

Introduction

After the windthrow event in November 2004 huge forest area of TANAP was strongly damaged. The size of this area was around 14 000 ha. Due to after-calamity land treatment, in some parts of the park the tree biomass of the fallen trees was removed. Regarding to this basically two different landscapes appeared at harmed area parts with no vegetation canopy and parts with fallen trees bodies. Comparing to the original condition of the TANAP forest ecosystem before the windthrow event, many of important physical and biological factors were changed, including light intensity, soil temperature, amount of nutrition resources and soil water content. As measurable soil characteristics reflecting changes at the damaged area oxidable carbon (C_{ox}), Amonium nitrogen (NH_4-N), total nitrogen (N_{tot}), basal and potential carbon dioxide production (B-CO_2, P-CO_2) and carbon in microbial biomass (C_{bio}) were chosen.

Data and methods

Three times a year in spring, summer and autumn time the soil sampling was proceeded. Samples were collected from humus A horizon. At each plot five random samples were collected and mixed to one representative composite sample. These composite samples were stored at +4 °C temperature till analyzing.

Percentage of oxidable carbon C_{ox} % was determined by Walkey-Black method modified by Novák and Pelíšek (Klika et al., 1954), N_{tot} % was determined acording to Kjehldahla (Hraško et al., 1962) and percentage of NH_4–N by Bengtsson (Marendiak et al., 1973). Microbial biomass carbon C_{bio} was determined by SIR method according to Schinner et al. (1993). CO_2 respiration was measured according to Bernát and Seifer pippeting method using 50g of soil (Števlíková et al., 2002).

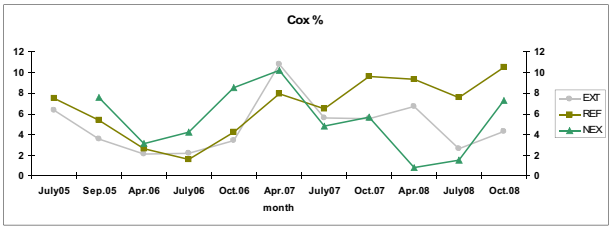

Figure 1. C_{ox} [%] values July 2005-October 2008.

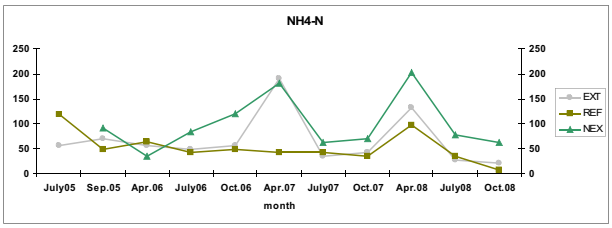

Figure 2. NH_4-N [mg.kg^{-1}] values July 2005-October 2008.

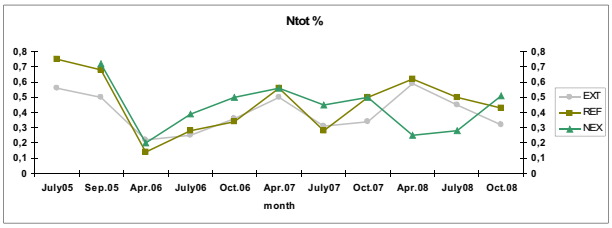

Figure 3. N_{tot} [%] values, July 2005-October 2008.

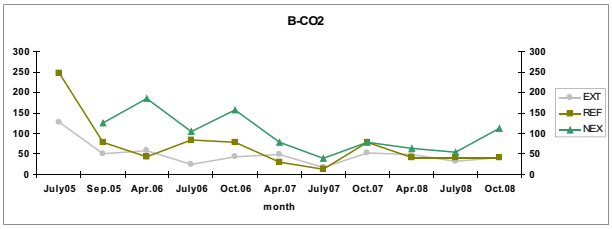

Figure. 4 B-CO_2 [mg CO_2/kg soil 24 h.] values, July 2005-October 2008.

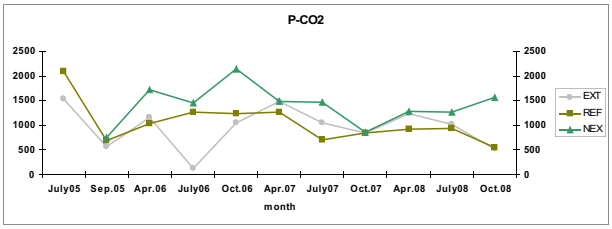

Figure 5. P-CO_2 [mg CO_2/kg soil 24 h.] values, July 2005-October 2008.

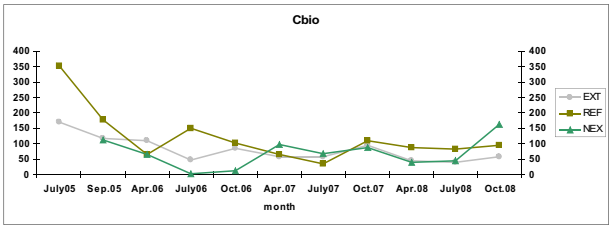

Figure 6. C_{bio} [mg C_{bio}.kg^{-1} of dry soil] values, July 2005-October 2008.

Results and discussion

Soil type was specified according to Morfogenetic classification system of the Slovak soils as cambic podzol. Analysed soils fall to the acidic and extreme acidic pH categories (Mičuda et al., 2006; Šimonovičová et al., 2007). Distinct decrease in the most of the characteristics was detected in the years after the windthrow. This trend is clearly showed by organic mater values (Fig. 1). Significant decrease in organic matter can be seen in April and July 2006 comparing to 2005. Organic matter as a main ecological factor was the resource of carbon for microorganisms. Amount of organic matter in the soil was reflected by decrease in microbial biomass and decrease in carbon dioxide production at the EXT plot comparing to REF and NEX (Figs. 4, 5, 6). REF plot represented stable stand. Comparing to EXT and NEX, appearing of extreme values of investigated characteristics is quite rare at REF plot (Figs. 2.-6.). B-CO2 and P-CO2 characteristics showed smaller differences between particular plots in 2007 and 2008 what could be indication of recurring regeneration of soil microbiota. The highest values of NH_4-N and N_{tot} comparing to other plots were measured mostly at NEX.

Conclusions

Occurrence of changes in investigated characteristics was detected regarding to conditions at every plot. Important factor is the density of the plant canopy which is directly influencing temperature and moisture at every plot. At the EXT, lower concentrations of investigated soil characteristics comparing to the NEX and the REF are expected, according to not so rich tree canopy density. Fallen trees created alternative tree canopy at the NEX plot what could cause higher amount of investigated soil compounds at least comparing to EXT plot.

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Succession of small mammals (Insectivora, Rodentia) on windfall plots in the Tatra National Park

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Abstract. Succession of small mammals was studied on windfall plots in the Tatra National Park, the High Tatra Mts. Assemblages of small mammals in wet localities had the highest species diversity (H´ = 2.177); assemblages in an intact spruce-larch forest featured the lowest species diversity (H´ = 0.659). In the first four years of the secondary succession, there was observed a distinct increase in density and biomass in small mammals on each windfall plot. Research on small mammals on the study plots confirmed the influence of the vegetation succession on distribution of these animals.

Introduction

Small mammals represent an important component of forest ecosystems. In development of forest communities, these animals play multiple roles, varying with individual successional phases. They provide a food base for predators; and participate in dispersal of plant seeds and fungal spores. Herbivorous species affect the spatial structure and species composition of vegetation; insectivorous exert predation stress on arthropods (Pearson, 1959).

Succession of small mammals is usually associated with changes in soil and hydric conditions on the locality and with succession of the local plant communities. The rate of secondary succession of small mammals on plots created by natural agents (wind, fire) is dependent on how rapidly can these animals find, colonize, and use the changed habitats (Barrett & Peles, 1999).

Material and Methods

Study area

The research was carried out in area of the High Tatra Mts in the six following localities**:**

a) **„NEX“ – Jamy:** forest stands affected by the windfall in the year 2004, no management intervention (no processing of wind-thrown and broken trees, no reforestation),
b) **„EXT“ – Danielov dom:** forest stands affected by the windfall in the year 2004, treated by common forestry measures (wood mass removed, plot forested partly),
c) **„REF“ – Smrekovec:** intact stands, so-called reference (control) plot,
d) **„FIRE 1A“ a „FIRE 3A“ – Tatranské Zruby:** two plots in forest stands affected by the windfall and later by a fire,
e) **„CVL“ (Čierny vodný les) – Nový Smokovec:** forest stands affected by the wind windfall, water-holding measures applied,
f) **„OVL“ (Oliverov vodný les) - Tatranská Lomnica:** forest stands affected by the windfall, water measures applied.

Sampling design

Small mammals were caught into non-destructive wooden traps, type *Chmela*. The method of marking and re-trap of the marked individuals (CMR) was applied. The animals were caught in years 2005–2008 (in autumn 2005, in spring and in autumn 2006–2008, and in year 2007 also in summer). Each permanent study plot (PSP), 75 x 75 m in size was provided with traps installed at fixed catch points spaced by 15 m. The traps were installed during 3 successive nights and checked every day. The caught exemplars were identified, weighed, provided with a numbered ear ring (insectivorous marked with marking colour) and released. Around each catch point was a circular plot, 2 m in diameter, for making phytocoenological records.

Results and discussion

In four growing seasons (2005 – 2008) we caught on seven permanent study plots together 571 small mammals, belonging to 9 species. From this total number, 447 individuals were marked and released, from which 176 were re-trapped (97 twice, 37 three times, 42 four and more times).

The tree diagram in Fig. 1 illustrates the results of comparison between the species spectra of micro-mammal taxocoenoses on individual PSP. The highest measure (level) of similarity between the species spectra of animal taxocoenoses on individual PSPs was obtained in case of plots NEX and FIRE 3A. On both plots, *Clethrionomys glareolus, Apodemus flavicollis*, *Microtus agrestis*, *Sorex araneus* and *S. minutes* were present. The reference plot (REF) differed from these two only by occurrence of taxons *C. glareolus, A. flavicollis* and *S. araneus*. Study plot CVL was different from the three mentioned plots due to occurrence of *Arvicola terrestris.* At the next lower level, a cluster consisted of plots EXT and FIRE 1A, differing from NEX and FIRE 3A by occurrence of *Apodemus sylvaticus.* An individual branch consisted of plot OVL alone, the only with occurrence of the aquatic taxons *Neomys fodiens* and *N. anomalus*.

Within the four-year study period, the overall density of small mammals fluctuated from 0.0 (REF - spring 2006) to 163.2 n.ha^{-1} (NEX – autumn 2008), with the lowest average density values on plot REF (12.9 n.ha^{-1}). On plots affected by forest fire, average density values of 28.2 (FIRE 3A) and 35.7 n.ha^{-1} (FIRE 1A) were obtained. The value on plot affected by wind calamity, from which the wood mass was removed and which has been partly forested (EXT), was higher (45.9 n.ha^{-1}). Higher average density values were also found in assemblages of small mammals in sites influenced by ground or surface water; CVL = 53.1, OVL =

47.9 n.ha^{-1}. The highest average density was found on plot – left to natural succession (65.1 n.ha^{-1}). The differences in average density between the plots were significant (P < 0.001).

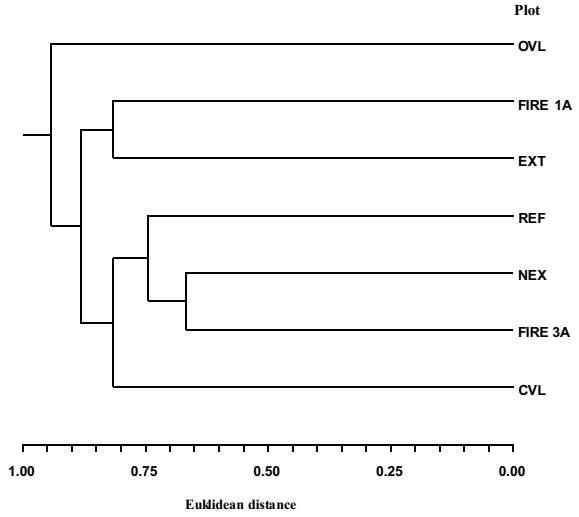

Figure 1. Tree diagram of similarity between species spectra of small-mammal assemblages (the High Tatra Mts, 2005 – 2008), **n = 571.**

The overall biomass of small mammals in the study period moved close to an average value of 678.4 g.ha^{-1}. There were observed considerable differences between the plots. The lowest average value was on reference plot (REF), the highest on PSP left to natural regeneration (NEX). The empirical values of average biomass were significantly different from the corresponding theoretical ones (P < 0.001).

Species diversity, population density and biomass of small-mammal assemblages on calamity plots in initial phases of plant succession were higher than on reference plot (REF) representing an intact mature forest stand. This fact corresponds to the succession theory according which the values of these population parameters rise during the initial and medium-advanced phases of secondary succession (Begon et al., 1997).

Analysis of spatio-temporal changes in distribution of small mammals has supported our hypothesis about significant influence of species composition as well as of horizontal and vertical structure of vegetation on successional development of small-mammal assemblages. Vegetation with a specific growth form or specific species composition provides for multiple mammal species favourable conditions: plant and animal food supply, shelters and roosts (Vlasák, 1986). Our results revealed feedback effects of herbivorous small-mammal species on spatial structure and species diversity in vegetation.

Conclusions

This research resulted in conclusion that population density, biomass and ecological distribution of small mammals during succession was influenced by changes to structure and species composition of the local vegetation.

Acknowledgement. The authors thank to Milan Kornajčík and to all their colleagues and co-workers from the Research Station and Museum of the National Forests of TANAP for their assistance in field fork. We also thank to Dr. Dagmar Kudelová from the Institute of Forest Ecology SAS at Zvolen for translating the article into English.

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An integrated forest management risk insurance model for beech stands attacked by selected climate extremes

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Abstract. The paper presents both the proposal and the evaluation of the forest property insurance model under conditions when grown beech forests are destroyed by the random occurrence of the most dangerous biotic and abiotic natural hazards as gale, drought, snow, insects, fire, funghi and icing including thefts, industrial immissions and other miscellanous social hazards. The proposed integrated risk insurance model is based on the economic analysis of vulnerability concerning growing beech in Slovakia at the assumed impact of all mentioned hazards.

Introduction

Beech forests occupy the largest proportion of forest land in Slovakia. Their area approaches 595 771 ha (30.88 %) from the total of afforested 1 929.310 ha. For the time being, the occurrence of climate extremes considerably increases the forest management risk and except the negative environmental effects also decreases the profitability of growing beech that belongs among one of the most important commercial tree-species. The insurance of forest property belongs among the efficient managerial and forest policy tools that can mitigate some of the negative impacts of the ongoing climate change by strengthening the financial stability of forest enterprises.

The objective of this paper is to propose the mathematical formulation of a reliable model for insuring the risk of forest destruction due to the occurrence of cumulative damaging agents.

Statistical analysis of data about the beech growing hazards

For the purposes of our investigation the data concerning all incidental fellings that had occurred within the Slovak forestry during the period 1993-2002 were used. These data were collected from the Slovak Forest Inventory Database belonging to the Slovak National Forestry Centre situated in Zvolen. As the measures of risk both the point and interval estimates of the expected population proportions calculated using the recorded destroyed areas in particular age classes by particular kinds of hazard were used. The following 10 kinds of hazards were investigated: gales, drought, snow, insects, fires, fungi and icing as biotic and abiotic agents followed by thefts, industrial immissions and other miscellaneous social kinds of hazard. The vulnerability of beech forest was then estimated from the sample of destroyed areas of forest stands arranged according to their age into the empirical distribution function $F_n(t)$ and fitted by the theoretical probability distribution function F(t) when the Weibull probability distribution function W(c, γ) for this purpose was chosen. The mentioned parameters of this probability distribution were estimated by the maximum likelihood method. The goodness of fit between both these distribution functions was tested by using the Kolmogorov-Smirnov test critical value $D_n(\alpha)$ when the significance level of $\alpha = 0.05$ was applied. The information about results of this test is presented in Tab. 1. But the calculatings both the point and interval estimates of integrated destruction probabilities would have been possible to carry out also by a simple use of $F_n(t)$.

Table 1. The comparison of empirical and theoretical probability distribution functions in a sample of beech stands in the territory of Slovakia during the period of 1993-2002.

AGE (years)	EMPIRICAL DISTRIBUTION FUNCTION	THEORETICAL DISTRIBUTION FUNCTION	DIFFERENCE BETWEEN FUNCTIONS
(t)	$F_n(t)$	F(t)	$F(t) - F_n(t)$
10	0. 0105	0. 0033	0. 0072
20	0. 0433	0. 0191	0. 0243
30	0. 0785	0. 0529	0. 0256
40	0. 1161	0. 1074	0. 0087
50	0. 1863	0. 1823	0. 0040
60	0. 2639	0. 2746	0. 0107
70	0. 3759	0. 3791	0. 0032
80	0. 4690	0. 4888	0. 0198
90	0. 5715	0. 5964	0. 0249
100	0. 6460	0. 6953	0. 0493
110	0. 7263	0. 7807	0. 0544
120	0. 8239	0. 8499	0. 0259
130	0. 8969	0. 9025	0. 0056
140	0. 9659	0. 9401	0. 0258
150	1. 0000	0. 9652	0. 0348
c =	0. 000009	$[F_n(t) - F(t)]_{max}$ =	0. 0544
γ =	2. 562112	$D_n(\alpha)$ =	0. 1942
n =	46. 6599 km^2		

However, the application of its fitted counterpart F(t) enables to decrease the variability of expected destruction and thus the risk insurance premiums, as well.

The probabilities of destruction in a common year p(t) were calculated as presented by Holecy and Hanewinkel (2006) by using the number of assumed age classes of a beech forest (k), the differences $\Delta F(t) = F(t) - F(t-1)$ and the estimated mentioned population proportion (f) as follows:

$$p(t) = k \,.\, \Delta F(t) \,.\, f \qquad (1)$$

The right-tailed interval estimations of p(t) then served as the essential inputs of the proposed insurance model itself.

Formulation of the risk insurance model

The proposed insurance model is based on the paradigm of the economic vulnerability of forest (Holecy, 2009) and estimating the vulnerable value of forest VFV(t) was done according to Eq. (2):

$$VFV(t) = FEV(t) - SV(t) + RPSEV(u) \qquad (2)$$

Here, FEV(t) denotes the forest expectation value of a (t) years old forest stand, SV(t) its salvage value and RPSEV(u) the risk premium on the soil expectation value SEV(u) at the (u = 150) years lasting rotation. The economic analysis of the underlying beech stand management project necessary to determine the capital value of forest property was carried out by using the single-tree growth simulator SIBYLA constructed by Fabrika and Ďurský (2005).

Based on this, the gross insurance premiums $G_m(t)_{1-\alpha}$ at the scale of (m) insured hectares were modeled in economic terms as follows:

$$G_m(t)_{1-\alpha} = N(t) + R_m(t)_{1-\alpha} \quad (3)$$

where N(t) represents the net insurance premiums and $R_m(t)_{1-\alpha}$ risk premiums concerning the risk of an insurer himself.

Results and disscussion

The results of reckoning the net insurance premiums N(t) informing also about risk concerning a forest owner are presented in Tab. 2. The development of respective gross insurance premiums is displayed in Fig. 1. The level of confidence necessary for the needs of an insurer was selected at ($\alpha = 0.05$).

Table 2. The net insurance premiums calculated for the vulnerable value of a beech forest stands VFV(t) according to their age.

AGE (years)	VULNERABLE FOREST VALUE	DESTRUCTION PROBABILITY (per 1 year)	NET INSURANCE PREMIUMS (per 1 year)
(t)	VFV(t)	p_n(t)	N(t)
	(€ . ha^{-1})		(€ . ha^{-1})
0	1 643	0. 000237	0. 39
10	5 567	0. 000237	1. 32
20	7 400	0. 000744	5. 50
30	9 452	0. 000797	7. 53
40	11 696	0. 000851	9. 95
50	14 148	0. 001589	22. 48
60	16 161	0. 001758	28. 41
70	14 847	0. 002536	37. 66
80	11 612	0. 002107	24. 47
90	9 641	0. 002323	22. 39
100	8 370	0. 001687	14. 12
110	7 745	0. 001817	14. 07
120	6 240	0. 002210	13. 80
130	8 233	0. 001652	13. 60
140	8 530	0. 001563	13. 33
150	9 906	0. 000772	7. 65

Although it deserves a more detailed explanation, among the greatest advantages of the proposed integrated risk insurance model can be regarded a fact, that at this approach to a forest property insurance are the gross insurance premiums lower than in the case of insuring forest property against the each kind of a forest management risk separately.

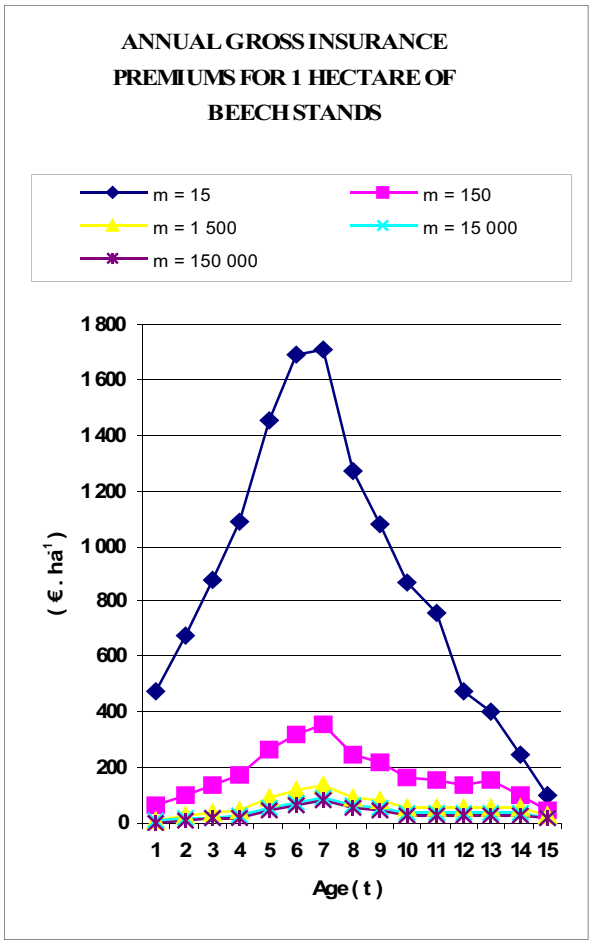

Figure 1. The development of annual gross insurance premiums $G_m(t)_{1-\alpha}$ in relation to the age of insured beech forest stands.

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Estimation of groundwater recharge, water balance of small catchments in the High Tatra Mountains in hydrological year 2008

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Abstract. The work presented in this paper had two objectives: 1) estimation of groundwater recharge in the subcatchments of the upper Poprad river catchment and 2) comparison of water balance and hydrological reactions of nested catchments in the High Tatra Mountains in hydrological year 2008. Groundwater recharge was estimated from hydrograph separation by means of the bflow filter. Long-term mean annual recharge varies between 121 and 536 mm. Annual water balance data in hydrological year of 2008 did not indicate significant differences within nested catchments with exception of the Poprad-Svit catchment. However, daily and hourly runoff data revealed different behavior of headwater areas compared to the whole catchments. Time delays between peakflows during high runoff events in July 2008 varied from 4 to 6 hours.

Introduction

Recent research in the High Tatra Mountains indicated that the knowledge of groundwater recharge might help to better understand nutrients leaching from the soils after the windfall in November 2004 (Bischoff et al., 2008). Numerous approaches exist in hydrology, soil science and hydrogeology to estimate the groundwater recharge. They range from the data demanding mathematical modeling, pumping or tracer tests, water balance calculations to simpler statistical runoff data processing or hydrograph separations. Each approach has its drawbacks and advantages and the estimated groundwater recharge has always uncertainties. Given the data which were available for our study, we have used hydrograph separation to estimate the long-term groundwater recharge at catchment scale. Hydrograph separation is a traditional approach used in hydrology. It was first used to separate direct and indirect components of streamflow to aid with flood simulation. Later it was frequently used to estimate so called baseflow as one of the flow components. Although the universally accepted definition of baseflow does not exist, it is generally agreed that it represents contribution of groundwater to the rivers and creeks. Thus, the long-term values of baseflow should be numerically equal to mean recharge of groundwaters feeding the rivers. The true value of the baseflow is mostly unknown no mater which separation method is used. The first objective of this study was to estimate the long-term mean values of groundwater recharge based on hydrograph separation.

Previous analyses did not indicate dramatic change of water balance and runoff characteristics (minima, maxima, thresholds, number of events, selected characteristics of the events, runoff coefficients and flashiness indices) in the subcatchments of the upper Poprad river basin affected by the windfall in November 2004. Detailed description of analyses including possible reasons why the deforestations was not manifested in measured catchment data are given by Holko et al., (2009). However, the measurements in the headwater areas (Veľký Šum, Slavkovský creek-fire, Jazierkový creek, Škaredý creek) of small catchments which started in the year of 2007 revealed interesting runoff regimes. The above headwater areas/catchments are nested within the catchments of the Poprad river at Svit, Slavkovský creek and Skalnatý creek where the gauges of the standard network of Slovak Hydrometeorological Institute operate on the long-term basis (Fig. 1). The nested catchments approach allows comparison of hydrological responses of different parts of the catchments. The second objective of this study was calculation of water balance for the first year of measurements in the headwater areas (i.e. hydrological year of 2008) and comparison of hydrological response during rainy end of July 2008.

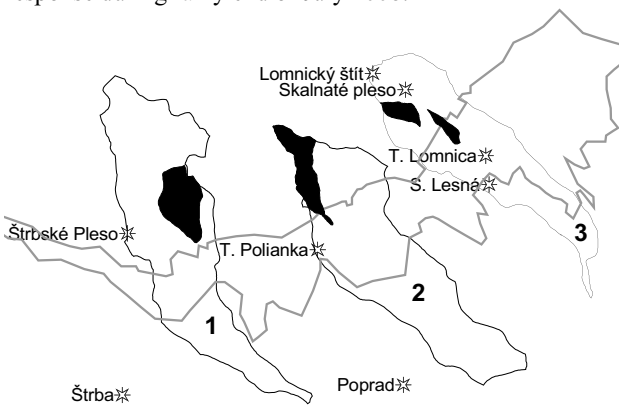

Figure 1. Nested catchments; 1-Poprad-Svit and Veĺký Šum (black), 2-Slavkovský creek and Slavkovský creek-fire (black), 3-Skalnatý creek and Škaredý and Jazierkový creeks (both black); stars and names show precipitation stations; grey line represents the area deforested by windfall.

Methodology

Graphic filter bflow (Arnold and Allen, 1999) was used to separate baseflow for the Poprad at Svit, Slavkovský creek, Velický creek and Poprad at Matejovce catchments. The separation was performed with two datasets. The long-term data (daily runoff in hydrological years 1967-2008) were used to estimate mean annual groundwater recharge. Mean values for periods 1967-1976, 1977-1986, 1987-1996 and 1997-2008 were also compared to see the decadal variability. Daily data from hydrological years 2001-2008 split into two periods (2001-2004, 2005-2008) were used compare the values before and after the windfall.

Water balance of the nested catchments was determined from measured discharges and calculated catchment precipitation. Catchment precipitation was calculated by means of the altitude gradient using data from 8 precipitation stations (Fig. 1). Except the main water

balance data (precipitation, runoff, runoff coefficients) also the time variability in hydrological year 2008 and time shifts in peakflows during rainy end of July 2008 were compared for the nested catchments shown in Fig. 1.

Results and discussion

The highest mean annual groundwater recharge (536 mm) in period 1967-2008 was calculated for the Poprad-Svit catchment. Mean annual groundwater recharges for other catchments were much smaller, i.e. 121 mm for Mlynica, 293 mm for Velický creek, 230 mm for Slavkovský creek and 257 mm for Poprad at Matejovce. Mean annual baseflow index BFI (ratio of baseflow to total runoff) was similar in all catchments. BFI varies from 0.56 in Mlynica to 0.67 in Slavkovský creek. Seasonal (monthly) variability of BFI in the catchments was similar, too. Seasonal distributions in periods 2001-2004 and 2005-2008 differed, but the differences seem to be caused rather by climate than by windfall.

Table 1. Selected characteristics of the nested catchments; A-area, H-mean elevation (from DEM with resolution 25 m), P-annual precipitation in hydrological year 2008, R_c-runoff coefficient (ratio of runoff to precipitation) for hydrological year 2008; catchments written in italics are nested within the larger catchments written in normal letters.

Catchment	A [km^2]	H [m a.s.l.]	P [mm]	R_c [mm]
Veľký Šum	4.59	1592	1277	0.49
Poprad-Svit	45.63	1396	1132	0.87
Slavkovský creek-fire	3.69	1759	1400	0.40
Slavkovský c.	43.22	1001	841	0.44
Škaredý c.	1.14	1564	1256	0.79
Jazierkový c.	0.67	1041	870	0.51
Skalnatý c.	33.70	1074	894	0.70

Basic water balance data for the nested catchments in hydrological year 2008 are shown in Tab. 1. Runoff coefficients for the headwater areas are similar to those for the whole catchments. It applies also for the Jazierkový creek catchment which was almost completely deforested by the windfall and has flashy hydrological response. There is one exception, namely a very high runoff coefficient for the Poprad-Svit catchment. Considering catchment elevation, the runoff in the Poprad-Svit catchment seems to be too high. However, runoff is generally the most precisely measured water balance component. If it is true also for the Poprad-Svit catchment, then the only possible explanation of high runoff coefficient is connected with incorrect calculation of catchment precipitation.

While annual runoff coefficients did not reveal significant differences within the nested catchments, short time (daily, hourly) runoff data did. Fig. 2 indicates that there might be problems with runoff measurements in the Poprad-Svit catchment. Runoff depth in the large Poprad-Svit catchment is higher than that in the smaller and higher located Veľký Šum catchment. It is unusual as catchment runoff depth should decrease downstream. Hydrological response of the Veľký Šum catchment is more damped than that of the Poprad-Svit catchment. Runoff events which were measured downstream between December and February did not appear in the upstream Veľký Šum catchment. Similar phenomenon indicating snowmelt in the foothill parts of the larger catchments is shown also in Figs. 3 and 4.

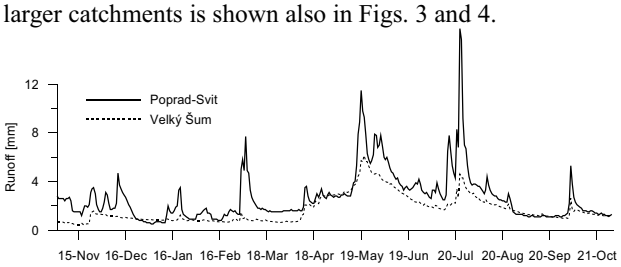

Figure 2. Daily runoff in the Poprad-Svit and Veĺký Šum nested catchments in hydrological year 2008.

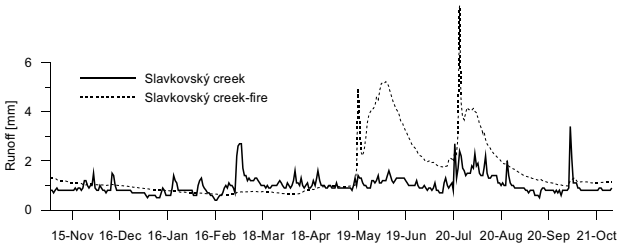

Figure 3. Daily runoff in the Slavkovský creek nested catchments in hydrological year 2008.

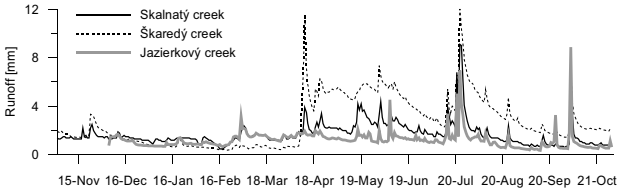

Figure 4. Daily runoff in the Skalnatý creek nested catchments in hydrological year 2008.

High rainfall in July 2008 that caused flood in the northern part of the High Tatra Mountains did not have such an effect in the southern part of the mountains where the rainfall was smaller. However, even there it resulted in maximum annual runoff in most of the studied catchments (Figs. 2-4). The delay between the occurrence of peak flows in headwaters and at catchment outlets varied from 4 to 6 hours.

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Diurnal circumference changes of a subalpine Norway spruce stems: their linkage to atmospheric vapour pressure deficit

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Abstract. Diurnal changes in the stem circumference of a subalpine mature Norway spruce (*Picea abies*,(L.)) individuals were measured simultaneously with basic meteorological variables in 2007. After the preliminary screening we found, that the dynamics of daily stem shrinkage was closely related mainly to the daily amplitude in atmospheric vapour pressure deficit (VPD) as well as to its daily average.

Introduction

Transpiring surfaces of plants do not use only the water absorbed by the roots but temporarily also that stored in the plant tissues. This is important for plants if they need to respond rapidly to changes in their transpiratory demands (Kozlowski et. al., 1991). The parts of trees from which the water is withdrawn may fluctuate in size. Zweifel and Häsler (2001) reported that mature spruce stems lost daily between 0.2 and 0.5 % of their volume as the result of bark dehydration, corresponding to about 2 to 5 l of water. This water contributed directly to transpiration. Offenthaller et al. (2001) reported that also water stored in xylem contributed to transpiration. The phenomenon of diurnal stem shrinkage and subsequent swelling has been well documented in the observations of the daily diameter dynamics.

The objective of this contribution is to present the sensitivity of spruce diurnal stem circumference changes to evaporative demands represented by atmospheric vapour pressure deficit.

Data and methods

The examined experimental material was acquired from the research site located on the Predná Poľana Mts (PP) (48°37' N, 19°27' E, 1360 m a.s.l.) during the growing season 2007. The site is a part of the Poľana Biospheric Reserve and the Zadná Poľana Nature Reserve. The research plot is situated near the top of a south-west oriented slope with an inclination of 5-25°. The parent rock material is volcanic (andesite), the soil type has been classified as a Dystric Cambisol.

The studied forest stand belongs to the seventh forest altitudinal vegetation zone, the group of forest types *Sorbeto – Piceetum*, *Acereto – Piceetum*. The dominant tree species is spruce (*Picea abies*,(L.)) (93 %) mixed with beech (*Fagus sylvatica*, (L.)) (4%) and European rowan (*Sorbus aucuparia*, (L.)). It is an uneven-aged primeval forest with spruce stands aged up to 150-190 years and reaching an average height of 25 m. The stand structure is highly differentiated in thickness and height, the stocking value is about 0.6. We measured the stem circumference in three spruce individuals. The selected spruce trees were 17.0-21.5 m high and 26-39 cm in dbh (1.3 m above ground). Their age was estimated (wood cores) between 85-100 years.

The climate ranks this area to mountain, cold ones, with a mean annual temperature ranging from 3.5 – 4.0 °C and mean annual precipitation total reaching 900 – 1100 mm over the last decade (Matejka et al., 2009).

The values of meteorological variables were measured at a meteorological station situated at an altitude of 1260 m a.s.l, by the mountain hotel Poľana, at about a 660 m distance from the studied forest stand. The data from period May 16 - September 28 are presented in this contribution.

Parallel digital measurements of temperature and relative air humidity, intensity of global radiation and daily precipitation totals were done. The scanning ran continually, at 10 min. intervals. The data were stored into the memory of a digital MINICUBE 32 datalogger (EMS Brno, Cz). Soil temperature and soil water potential (gypsum blocs) were measured at a depth of 0.3 m, and the values were stored into the memory of a MICROLOG datalogger (EMS Brno, Cz) in the studied forest stand.

The changes in stem circumference were measured with an automatic band dendrometer - DR 22 (EMS Brno, Cz). The dendrometers were installed at 2.5 m above ground. The measured circumference data were stored at 10 min. intervals into the data-loggers. For our analysis, we used hourly average circumference values and climatic data.

For calculation of the daily shrinkage of trees' stems we used the difference between the morning (1-12 h) maximum and afternoon (13-24 h) minimum. The first principal component values, which represented 98 % of whole variability, were used as a common shrinkage representative.

Based on preliminary screening of the influence of individual weather variables on the shrinkage of stems we used the calculated vapour pressure deficit (VPD) as an independent (explanatory) variable presented in this paper. VPD is the difference (deficit) between the amount of water vapour in the air and the amount of water vapour the air can hold when it is saturated. Unlike relative humidity, vapor pressure deficit has a simple, nearly linear relationship to the rate of evapotranspiration.

The daily amplitude of VPD was calculated as a difference between the afternoon maximum (13-24 h) and morning (1-12 h) minimum.

Results and disscussion

Figs. 1 and 2 illustrate the relation between the shrinkage pattern over the day and VPD as well as between shrinkage and VPD amplitude. The two relations are rather close, with the daily amplitude of VPD manifesting a closer relation compared to the average VPD. The stepwise regression unveiled the VPD amplitude as the governing explanatory variable – explaining 70.6 % of the total variance. Both regression coefficients were statistically significant with $p = 0.000$.

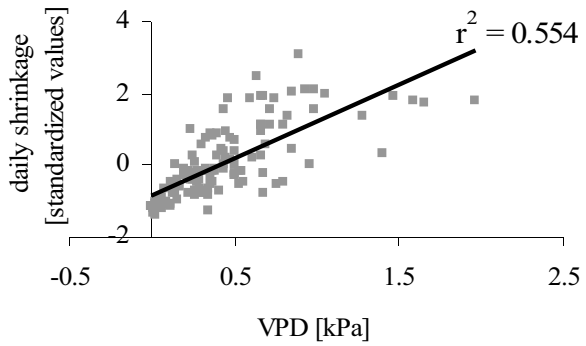

Figure 1. Relationship between the first principal component values of daily shrinkage and average daily vapour pressure deficit (VPD).

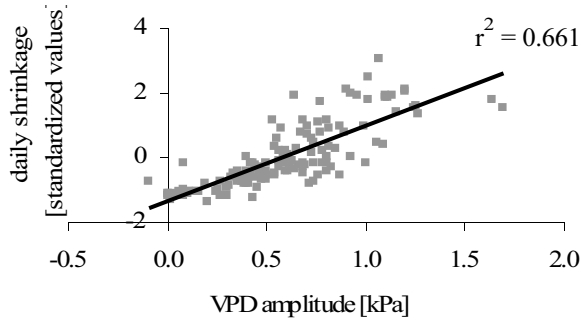

Figure 2. Relationship between the first principal component values of daily shrinkage and average daily vapour pressure deficit amplitude.

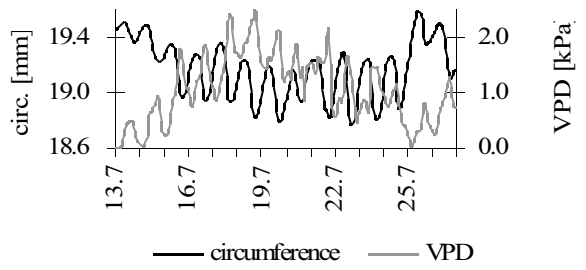

Figure 3. Diurnal courses of the stem circumference of spruce and vapour pressure deficit (VPD) during July 13-26, 2007.

The Fig. 3 shows the diurnal shrinkage patterns of circumference and VPD (hourly average values) in the period of extremely hot weather in July 2007, when the growth was already minimal and the daily amplitude of circumference changes was big. During the day, the stem circumference decreased with increasing VPD. At night, the stem re-expanded but did not always reach the dimension of the previous day – despite of the montane site location. A recovery of the previous circumference occured after an espressive rise in humidity and fall in temperature along with VPD in July 25. These results correspond well with the results of e. g. Herzog et. al. (1995), Offenthaler et. al. (2001), Zweifel et al. (2001) declaring that the course of water content in stem tissues and sap flow are closely coupled to fluctuations in the stem dimensions.

Conclusions

The changes in stem circumference (diameter) not only respond to the growth processes occurring in creation of a new annual ring; they also reflect the water content in the stem tissues and the associated stem flow. In the mountain environment of the Predná Poľana in year 2007, we recorded a close correlation between the stem shrinkage course over the day and the vapour pressure deficit. A more detailed recognition of these relations should enable us to make estimations about transpiration flow or about stress load due to physiological drought.

Acknowledgements „This work was supported by the Slovak Research and Development Agency under the contract No. APVV-0022-07“

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Analysis of ozone concentrations and climatic variables in environment of a submountain beech forest stand (Western Carpathians Mts.)

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Abstract: Research, carried out at the Beech Ecological Experimental Site in the Kremnické vrchy Mts. (410-570 m a. s. l.), was used to determine differences in ground level ozone concentrations and values of selected climatic variables between a former clear-cut which was the result from a cutting performed in 1989 and also a beech forest stand not subjected to the intervention. Differences in ozone concentrations were pronounced mainly in summer (July, August) when the values on the former clear-cut were much higher than those measured in the forest stand. In August 2004, a value of 118 µg m^{-3} was recorded on the former clear-cut. The increase in air temperature in the region was up to 15.4 °C, compared to the former long term mean value 14.8 °C from years 1961–1990 which was reported from Sliač, this is unequivocal.

Introduction

Forests covering 40 % of Slovak territory are subjected to significant changes, including changes to the local climate – initiated due to both anthropogenic and natural influence. Over the past decades, many various changes were characteristic for the whole of Central Europe (Alewell et al., 2000). These changes were mainly connected with conversion and innovation of industry, and with measures accepted in legislation. The positive turn over in trends in emmissions and airborne pollutants was mainly thanks to a considerable decrease in pollutants of domestic origin (Spišáková et al., 2003). The present pollution is caused by particular matter and by ozone (Váňa & Smrčková, 2000; SHMÚ, 2006). This development shows a positive trend, nevertheless the decrease in NO_x – one of ozone precursors was not as steep as that of the SO_2 emissions (Fleischer et. al., 2005). Periods of dry warm weather represent unfavourable climatic conditions promoting an increase in the amount of ground level ozone consequently, creating an advers effect on public health, vegetation and whole ecosystems (Bičárová et al., 2005; Godzik & Grodzinska, 2002; Šec et. al., 2007). Ozone is a photo-chemical pollutant arising from the presence of precursors: nitrogen oxides and VOC, coupled with the presence of favourable photo-chemically favourable conditions. This substance initiates changes to plant assimilatory organs which slows down photosynthesis and influences synthesis of chlorophyll. In spite of the ecological measures applied, the ozone concentrations reach beyond the limit values (Šach & Černohous, 2005; Zapletal & Chroust, 2007). Based on the measurements made by the EMEP network stations, Slovakia has been classified as a country with a medium ozone load. The most severely loaded are industrial European areas such as: Germany, France, and Mediterranean area: Italy, Spain (Elvingson & Årgen, 2004). At present, the influence of ozone load is higher in the countryside and mountainous areas rather than urban areas. For this reason, our research was focussed on pollution of the ground layer of atmosphere in an area of forest type which was sufficiently more remote from urban and local pollution sources. Amounts and characteristicts of pollutants at local and regional levels are determined by a range of factors – acting in synergy – the origin of which can be meteorological, organic or caused by precursors. Recognition of causes and regularities in performance of individual climatic factors should help to maintain the necessary equilibrium between all components of ecosystems, humans not omitted.

Data and methods

The purpose of our research was to determine differences in ground level ozone concentrations and values of selected climatic variables between the ones entering a forest stand and those entering a plot which was subjected in 1989 as clear cutting – this resulted in a stocking density of 0.0. At the moment of cutting intervention, the stand age was 80–90 years. The stand without intervention is dominated by beech, covering 94.7 % of the stand area. The research subjects are situated in Central Slovakia, in the SE part of the Kremnické vrchy Mts. (Western Carpathians Mts., φ = 48°38´ N, λ = 19° 04´ E), at an altitude of 470–510 m. The slope is exposed on the west, with an inclination of 30 %–36 %. For measuring the long-term influence of immission load to forest ecosystems a suitable method to determine the ground level ozone (O_3) concentrations would by provided with the sorption-accumulation method (Werner, 1991). The values of ground level ozone concentration, air and soil temperature and precipitation amounts were recorded at regular intervals covering the whole growing seasons. Illumination intensity was measured at the time without leaves and at the time of leaves fully developed.

Results and discussion

The values of ozone (O_3) concentrations obtained by passive sampling were analysed. The research started 10 years after the cutting. The stand left without intervention has maintained its original characteristics – without understorey. The dynamical regeneration running on the former clear-cut has resulted in the current 16-year-old young growth with dominant beech. The description of the two different plots together with mean ozone concentration values and other important parameters are outlined in Tab. 1. In spring, in the absence of sufficient foliage with an air temperature reaching minima on both plots, the values of ozone concentrations were very similar. The differences in ozone concentrations between the plots were especially marked in summer (July, August) – reaching on the former clear-cut much higher values than in the forest stand: Figs 1 A and B. Such big differences could mainly follow from extremely high ozone concentrations: in August 2004 we recorded on the former clear-cut a value of 118 µg m^{-3}. The mean ozone concentration of 40 µg m^{-3} obtained in

years 1999-2003 increased in the following years 2004–2006 to 55 µg m^{-3}. The mean temperature value in 1999-2003 on both 15.35°C, in the following years 2004-2006 it was 15.45 °C. Comparing these values with the long term mean from Sliač – representing 14.8°C for years 1961-1990, the increase in air temperature in this region is undisputable.

Table 1. BEES Kremmnické vrchy Mts. (Western Carpathians Mts.). Dynamics of natural and artificial regeneration of a small-sized clear-cut, history of stocking density in a beech stand, mean air temperature, precipitation, illumination intensity and mean values of ground level ozone during vegetation periods.

Research plots	CC Clear cut	FS Forest stand without intervention
1989 cutting intervention	0.0	0.9
1999 10 years after cutting	young growth	0.9
2004 15 years after cutting	small pole	1.0
1999-2006 mean temperature	15.6°C	15.3°C
1999-2006 precipitation	678mm	511mm
1999-2006 mean O_3 concentration	49 µg m^{-3}	46 µg m^{-3}
Illumination intensity		
before foliage 1990	36 klx	15.7 klx
before foliage 2001	6.7 klx	6.7 klx
under foliage 1990	40.9 klx	2.5 klx
under foliage 2001	0.6 klx	1.2 klx

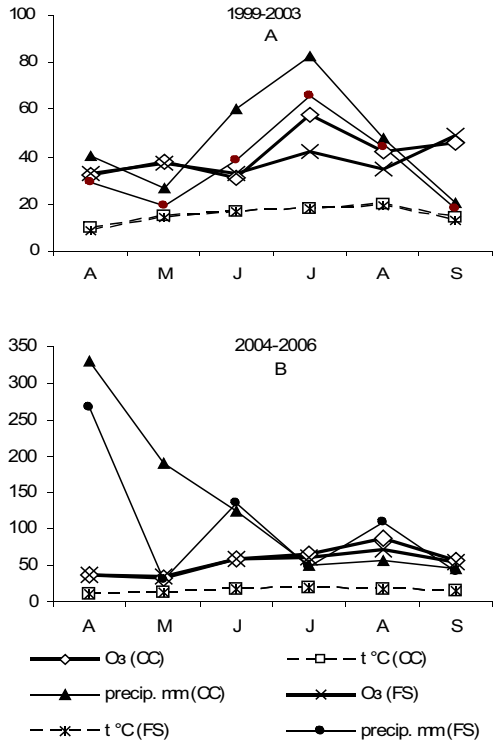

Figure 1. History of air temperature, illumination intensity and ozone concentrations (warm half-of-year) on a former clear-cut and in a forest stand not subjected to cutting intervention situated at the Beech Ecological Experimental Site Kremnické vrchy Mts.: A - 10 years after cutting, B - 15 years after cutting (O_3 concentration: µg m^{-3}).

Conclusions

In terms of ecological stability, the area of the Kremnické vrchy Mts. has previously been considered as only slightly polluted. In spite of this classification, also in this area occur episodes with high ozone concentrations (118 µg m^{-3}). Increasing air temperature and ozone concentrations seem to be risk factors in this sub-mountain area, in spite of the fact that they do not reach extreme values reported from other regions of Slovakia. Conditions necessary for ozone creation are dependent on developing meteorological situations and the maintainance of extensive areas during anticyclones.

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Drought stress simulated in adult spruce trees

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Abstract Material from selected adult spruce trees was sampled to determine parameters of the fast phase of chlorophyll *a* fluorescence, concentration of chlorophylls and needle water potential. The research ran in the year 2007, on spruce trees growing at forest edge and inside the stand. Root systems of certain trees were covered with impermeable foil, and the results obtained for these trees were compared with the control ones. This works summarizes the obtained data and evaluates differences between the groups.

Introduction

Ecological and static stability of non-native spruce monocultures is generally considered to be unsatisfactory. Functional resistance of forest stands is extremely important in case when ecological variables (temperature, water supply) manifest considerable daily and seasonal fluctuations. The current climate changes, especially changes in precipitation, cause that the issue of response of spruce stands to the reduced amount of accessible water becomes topical.

Drought stress has been recognised as a key factor participating in dieback of forest stands, especially spruce monocultures. In many cases, this factor reduces the plant's resistance against secondary harmful agents (primarily bark beetles and fungi). Most of works were focussed on assessment of how physiological processes in young spruce trees reflect the drought. This work studies simulated drought in adult spruce trees.

Data and methods

The research ran in the Kysucké Beskydy Mts, in a spruce stand situated at an altitude of 950 m a.s.l. in 2007. Physiological response to drought in adult spruce trees growing under different conditions were observed. There were selected 9 sample trees at the stand edge and other 9 inside the stand. The root systems of three sample trees at the stand edge and other three ones inside the stand (3+3) were covered with impermeable foils (Fig. 1). The response of these trees was compared with the response of trees non-shaded against precipitation, growing at the stand age and inside the stand (6+6). The study material consisted of branches sampled from these trees three times: in May, July and October. The assimilatory organs were collected manually, from the upper thirds of illuminated crown parts, according the international methods ICP Forests. Two branches from each adult sample tree were used for measuring the parameters of fast kinetics of chlorophyll *a* fluorescence. After a period of 30-minute darkness adjustment, each sample was irradiated with a saturated impulse. Following fluorescence parameters were measured in one-year-old spruce needles: F_0 (initial fluorescence – all reaction centres are open), F_M (maximum fluorescence – all reaction centres are closed), $F_V/F_M = (F_M–F_0)/F_M$ (maximum quantum yield of photochemical reactions). A fluorimeter *Plant Efficience* (PEA, Hansatech, Kings Lynn, UK) was used. In the same needles, the assimilatory pigments´ concentrations were also determined using methods suggested by Lichtenhaler (1987). The needle samples were homogenised; and the pigments were extracted in 80% water solution of acetone. The absorbance values were measured spectroscopically (equipment Cintra 6.5, GBS, Australia). Selected spruce trees were examined, once in summer and once in autumn, to measure water potential of the needles. We used the measuring equipment PSY PRO (WESCOR, USA).

The software STATISTICA was used for evaluation of significance of differences between the groups. The different letters in figures mean statistically significant differences between the variants.



Fig. 1. Drought stress simulation in adult spruce trees

Results and discussion

The ratio of F_V/F_M is the most-frequently-used index for assessment of plant vitality. It is also used in early „*in situ*" diagnosis of stress in plants (Meinander *et al*., 1996). Our experiments on young spruce trees also confirmed a relatively high sensitiveness of F_M/F_0 to drought stress (Kurjak *et al*., 2008).

The values measured in May had not been influenced yet by the root system cover that was applied around the first measurement. On the other hand, there were identified significant differences in the studied parameters between the locations. The value of each of them was found less favourable in trees at the stand edge. It was evidently caused by stronger irradiation and by pronounced negative influence of low temperatures in winter and in spring.

In July, all the values were found balanced, without statistically significant differences. In October, we observed a considerable general decrease in the measured values.

Similar to May, more marked decrease in trees at the stand edge were recorded; however, surprisingly, the lowest mean values were obtained for trees with their root systems uncovered.

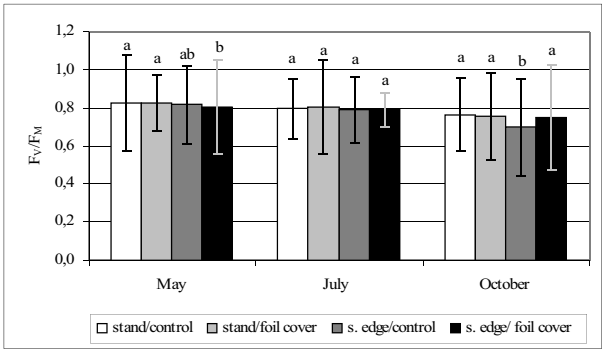

Figure 2. F_V/F_M: mean values and standard deviations.

Kmeť *et al*. (2007), carrying measurements towards the end of the vegetation period, also report lower values for the trees growing at the stand edge.

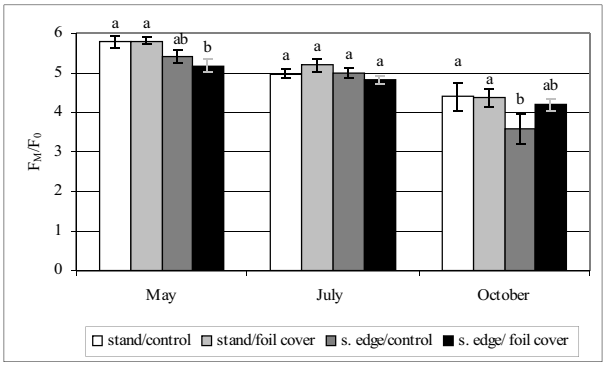

Figure 3. F_M/F_0: mean values and standard deviations.

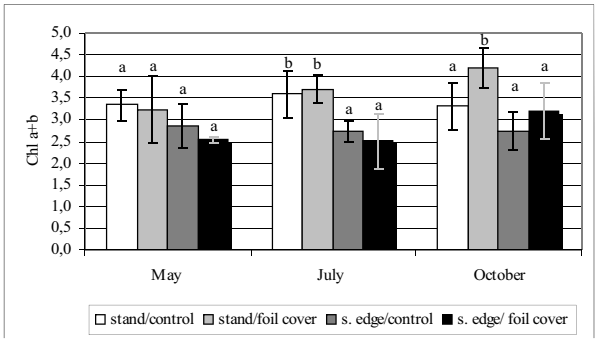

Figure 4. Concentrations of chlorophylls *a+b* (μmol m^{-2} s^{-1}): mean values and standard deviations.

The lowest mean value of needle water potential (Tab. 1) was recorded in October: in trees with root systems uncovered, growing at the stand edge (-0.5 MPa). The measured values showed that the water potential was lower in trees with uncovered root systems (except of one case); the values, however, were not very low. Neither the differences were pronounced. It could be caused by the fact that the flow direction preference in soil water was under-estimated and also by the fact that the root system cover limited also evaporation.

Comparison between the chlorophylls concentration values resulted in identification of considerable differences, especially between the trees growing at the stand edge and the ones growing inside the stand. The most pronounced were these differences during July (significant differences). Under stress, the chlorophyll concentration decreases – causing that the rate of chlorophyll synthesis is lower and the degradation runs faster. In our experiment, the differences in water potential were only slight; therefore, it is no surprise that there were not found significant differences between the trees with covered root systems and the control trees.

Table 1. Values of needle water potential (MPa).

Variant	July	October
Stand: control	-0.15	-0.14
Stand: foil cover	-0.23	-0.33
Stand edge: control	-0.31	-0.50
Stand edge: foil cover	-0.41	-0.24

Conclusions

Today, the field or „*in situ*" research (especially in case of adult woody plants) has lost its primary importance. The main shortcomings of this approach are: difficulties with accessibility of experimental material, woody plants´ longevity, frequently occurring delayed response of adult trees to environmental changes, problems connected with quantification of the measure of influence in case when several factors act synergically, making measurements outside laboratory, etc. In spite of a wide range of complications, it is necessary to proceed with working on improved methods for study of influence of harmful factors on forest woody plants. The results of simulated experiments and experiments carried out in controlled conditions are not possible to be used automatically for forest woody plants growing in their natural environment. However, the mosaic of phenomena, relations and processes in nature is highly complex, and our results promise to be a supplementing fragment. They also should provide a sound base for the next study.

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The Influence of Environmental Characteristics on Stem Circumference Changes in Clone Spruce Trees

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Abstract. This contribution presents the results of the analysis of influence of environmental conditions (selected meteorological and soil characteristics) on stem circumference changes of the Norway spruce (*Picea abies* L. Karst). The research runs on the level of young forest from car-vegetative reproduction. Research plot Predmier I (500 m asl.) is located in CHKO Kysuce – The West Beskydy. The circumference changes were measured on spruce sample trees. Simultaneously the microclimate elements near research plot (global radiation, air temperature, air humidity) and the soil characteristics (soil water potential, soil moisture) were measured also. Daily precipitation levels were obtained from nearest hydrometeorological station – Turzovka (465 m asl.). The diameter increment of sample trees started in the first week of May. It is possible to observe the acceleration of increments from the middle of May and decrease during August and at the beginning of September. Measured data showed a relationship between the diameter increment and monitored meteorological factors. The stem circumference growth was always observed after precipitation and by contrast in the period without precipitation, the circumference of stems decreased.

Introduction

The problem of climate change is a burning topic throughout the world. Relatively long drought periods and abnormal precipitation in short time periods are expected due to the increase of air temperatures and assumed changes in the distribution of precipitation.

Essentially, water stress limits physiological and growth activity of plants. The impact of precipitation deficiency on plants largely depends on the effect of the duration and the intensity of the stress factor and the genetically determined capacity of species. Even though it depends on meteorological conditions, mostly size, it is linked with the properties of tolerance and resistance of plants toward drought. The daily variability in stem diameter can be considered as direct response to the quantity of water in tissues, following that actual knowledge and results of several authors is assumed (e.g. Sevanto, 2003; Tardif *et al,*. 2001). The tree responds with a decreased level of daily growth up to the stem diameter, which is a decrease in comparison to a sufficiently water supplied tree in the deficient water supply (Baláž *et al,*. 2005).

This paper is aimed at evaluating climatic and soil factors impact on growth and increment of Norway spruce clone trees.

Data and methods

The research plot (0.54 ha) was based through the autovegetative reproduction in 1989, in stand 1741 c, in threat zone C (categorisation in LHP). The reasearch plot is situated in high altitude-500 m a.s.l., in the 5th forest vegetation stage, with a gentle slope with eastern exposure and a slope gradient of 10 %. The research plot is typologicaly classified to forest type group *Fageto – Abietum* nst. Geological background form predominant flysch units with variable contributions of sandstones, claystones and marlites. From the climatic aspect, the area falls into the mild warm zone, with the average annual air temperature 6.7°C, and average annual precipitation 875 mm. The research plot was chosen and 15 individuals were marked (3 clone x 5 individuals; marked: a1-5, b1-5, c1-5.). Changes of stem circumference were measured through the use of a dendrometer, DRL26, in growing season 2008. Simultaneously the microclimate elements were measured also: air temperature [°C], global radiation [kWh.m^{-2}] and air humidity [%]. Daily precipitation was obtained from SHMUstation – Turzovka (465 a.s.l.). Soil characteristics (soil water potential [bar] and soil moisture [%]) were measured at two depths 10-15 cm and 25-30 cm. To measure the soil water potential Microlog SP with gypsum blocks was applied.. Measuring instruments used during the data collection were from the manufacturer EMS Brno with automatized assessment of data. The soil moisture was measured by gravimetric method.

Results and disscussion

Several extreme situations in monthly precipitation were doscovered. The month of July showed as above-normal in precipitation when precipitation achieved 137 % of long-term average (LTA). By contrast, April and August showed as subnormal in precipitation (precipitation in April achieved 50 % from LTA, and in the month of August, 69 % from LTA). Concerning average monthly air temperatures, above-normal temperatures were only recorded for June. Other months were normal in comparison, with long-term average temperatures. The increase in the 2008 season was normal in comparison to the long-term average precipitation and temperature also.

Stem diameter increment is strongly influenced by climatic factors such as precipitation and air temperature. (Orwig & Abrams, 1997; Ježík et al., 2007). Wenk & Fiedler (in: Šmelko et al., 1992) reported, that the inititation of growth underlies that temperatures in spring were in contrast to the end of growth, which is influenced by the length of day, because the majority of species stop their diameter growth independently on weather in the late of August or early in September (Šmelko et al., 1992). Temperatures in April determine the growth beginning and influence the intensity of increment rate in May.

The influence of temperature and precipitation balances in June, however the influence of temperature is minimal in July and in August. Precipitation is especially important in August. These facts were confirmed by our investigation also. The diameter increase of monitored individuals began in the early May. It was discovered, that the weather had a

strong influence on the diameter increase of monitored individuals of Norway spruce. Stem circumference changes and precipitation during growing season 2008 is showed in Fig. 1. The increment value as a function of precipitation and relative air humidity during growing season 2008 is presented in Fig. 2.

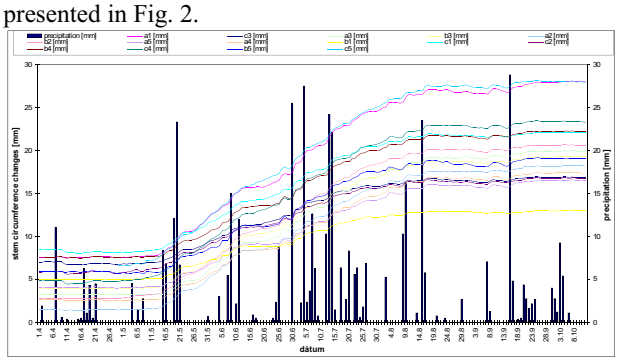

Figure 1. The course of stem circumference changes of sample trees of Norway spruce and precipitation during growing season 2008.

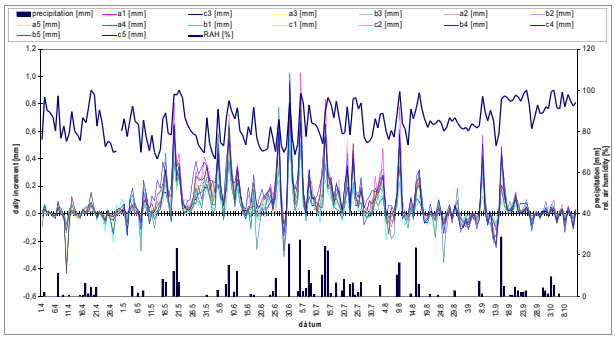

Figure 2. Daily increment values as a function of precipitation and relative air humidity during growing season 2008.

Our results confirmed that intensity and increase in circumference is strongly influenced by precipitation. Increase of precipitation and relative air humidity during monitored growing season increased the increment.

On the contrary, the intensity of the diameter increment decreased in the period without precipitation. The highest values of diameter increment were recorded in June (31.1 % from the yearly increment (YI)) and July (32.4 % from the YI). The highest precipitation was recorded in July, with the value 152 mm. The highest increment was recorded on monitored individuals in this month. The drought period from the latter half of August to the first half of September incurred stagnancy diameter growth (August 9.7 % from the YI; September 3.4 % from the YI).

Soil characteristics such as the soil weight, moisture and soil water potential were monitored. The highest soil moistures in depths 10-15 cm and 25-30 cm were recorded in April, despite the lowest precipitation in this month. The high soil moisture was caused by snow precipitation supply from the past wintertime and by their consistent unlocking in April. The average moisture in the depth of 25-30 cm and 10-15 cm achieved the value 28 %. An increase of increment was recorded in the period when soil water potential approximated to zero. By contrast it was discovered that with a decrease of water potential, a decrease of increment also occurred.

On the basis of variance analysis we did not find out statistically significant differences in stem circumference changes among clones. Within monitored trees, higher individual differences in the intensity of the increment were discovered. The regression analysis was used for the evaluation of the influence of precipitation, air humidity and soil water potential on the increment (Tab. 1). It was found a 42_% dependency of intensity of increment on precipitation, 11 % dependency on air humidity (RAH)and 12 % dependency on soil water potential (SWP).

Table 1. Results of regression analysis.

Dep. variable	**increment**	**increment**	**increment**
Indep. variable	**precipit.**	**RAH**	**SWP**
Regr. koef.	0.65	0.34	0.34
Koef. determ.	0.42	0.11	0.12
p	0.0001	0.0001	0.0001
F	14.211	24.711	26.481

Conclusions

This contribution includes results of the influence of environment conditions (precipitation, air humudity, soil moisture and soil water potential) on stem circumference changes and the diameter increment of Norway spruce clones spruce (*Picea abies* L. Karst). From the climatic aspect, it can be stated, that growing season 2008 was normal in comparison to long-term average precipitation, and also temperature. The diameter increment of monitored individuals began in the first half of May. The stem circumference increase was observed always after precipitation and on the contrary in the period without precipitation, the circumference of stems decreased. The highest values of diameter increment were recorded in June. The drought period from the latter half of August to first half of September incurred stagnancy diameter growth.

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Optimization of biotic parameters of some Slovak mountain streams for modeling by the IFIM method

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Abstract. In 2008, research on the relationship between the quantitative parameters of ichthyofauna as a bioindicator and the ratio of habitat suitability was implemented. According to the Instream Flow Incremental Methodology (IFIM) this relationship is defined as a weighted usable area (WUA). The WUA was assessed according to the River Habitat Simulation System (RHABSIM) for characteristic fish species. Special attention was paid to the assessment of habitat availability, which is represented by suitability curves. The analysis resulted in an optimal proposal for processing habitat suitability curves, which have a major influence on the determination of minimum flows. Basic results from the streams in the catchments of the Topľa and Torysa streams located in eastern Slovakia are given in the paper. The methodology for the assessment of habitat quality, including the determination of minimum flows, was verified for these streams.

Introduction

In recent water management practice, the determination of minimum flows (MQ) as a one-dimensional parameter appears antiquated. MQ have to set the favourable life conditions for fish, zoobenthos and fytobenthos and sustain an ecological balance. The paper is aimed at assessing the quality of the biotic part of a stream as represented by the ichthyofauna. The ichthyofauna is characterized by habitat suitability curves, which are essential in the process of MQ determination via bioindication. The suitability curve is a graphical expression of habitat preference by fish. The habitat availability is a presence of cells with highly preferred microhabitat within the reach habitat suitability - knowledge about the conditions that provide favorable habitat for a species, and those that do not (Bovee, 1986). The RHABSIM model (Payne, 1998) was used for modeling the minimum flow. Biotic parameters in the model are represented by fish as the most important element resting on the top of the food chain of the aquatic biota. Fish are the best bioindicators that most sensitively indicate the quality of a stream microhabitat. Further information on the simulation system can be found in the literature (Bovee, 1986; Gard, 2009).

Data and methods

The habitat suitability curves of particular fish species are determined for the two most important abiotic characteristics – flow velocity and water depth. This procedure is time-consuming. However, the quality of suitability curves determines the reliability of the MQ assessment; therefore, this article pays special attention to the technique by which the suitability curves are determined. The method was verified on four mountain streams located in eastern Slovakia:

- The Torysa stream near the village of Pečovská Nová Ves
- The Šibská voda stream under the confluence of the Rychvaldský potok
- The Topľa steram near the village of Tarnov
- The Topľa stream near the village of Gerlachov

Basic data on the ichthyofauna and abiotic parameters of the reaches are given in the Tab.1.

Table 1. Basic data on the ichtyofauna and abiotic parameters of the investigated areas. The italicized data represents low numbers within certain species of fish, where suitability curves evaluation wouldn´t be representative; *d, t* and *v* are water depth, temperature and flow velocity, respectively.

Stream	Torysa	Šibská voda	Topľa Tarnov	Topľa Gerlachov	
Altitude [m n.m.]	330	292	321	370	
Date	11.7.2008	7.7.2008	7.7.2008	7.7.2008	
Q [m^3/s]	1.110	0.060	0.722	0.211	
d_{min} [m]	0.12	0.11	0.16	0.08	
d_{max} [m]	0.76	0.50	0.90	0.56	
v_{min} [m/s]	0.03	0.03	0.03	0.03	
v_{max} [m/s]	1.05	1.14	0.95	1.36	
t [°C]	21.0	19.0	20.6	14.6	
O_2 [mg/l]	10.40	9.63	8.43	9.21	
O_2 [%]	121.70	107.70	98.10	95.40	
pH	8.40	8.00	8.13	7.92	
Latin name of fish	Number of pieces caught during the research				Total
Phoxinus phoxinus	-	24	*13*	73	**110**
Leuciscus cephalus	18	21	*11*	*7*	**57**
Barbus carpathicus	140	92	45	-	**277**
Albumoides bipunctatus	31	*1*	61	*6*	**99**
Salmo trutta m.fario	*2*	118	*4*	28	**152**
Barbatula barbatula	36	-	11	44	**91**

Results and disscussion

Habitat suitability curves

The normalization of the frequency polygon of the fish - histogram analysis is the simplest assessment of habitat suitability curves. This method is sensitive to the choice of histogram interval. This fact is obvious in Figs. 1 and 2, where various interval dimensions are presented (the range varies from 10 cm to 40 cm). Although the choice of larger increments leads to the creation of smoother frequency polygons, it may be at the expense of a less accurate histogram. The main sources of the deformation of

suitability curves are uneven distribution of the field data, schooling of fish and irregular distribution of the microhabitat. From the analysis of suitability curves it follows that considering the habitat availability is very important for the objectiveness of the curves. The results are shown in Tab. 2 and Fig. 3.

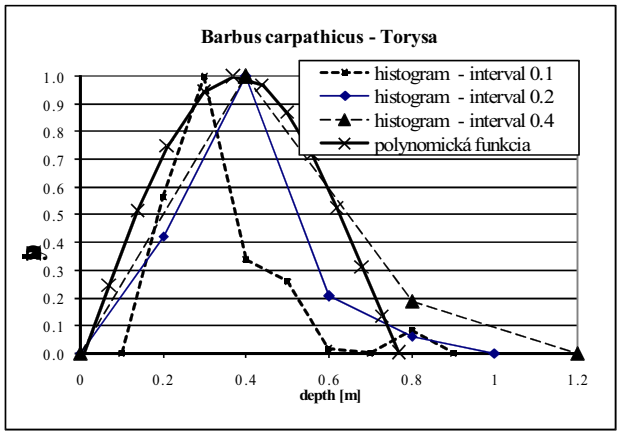

Figure 1. The shape of the frequency polygon of the depth utilization for Barble (*Barbus carpathicus*) in Torysa near Pečovská Nová Ves as a function of various water depth increments. The curve's smoothing according to the polynomial function is also presented.

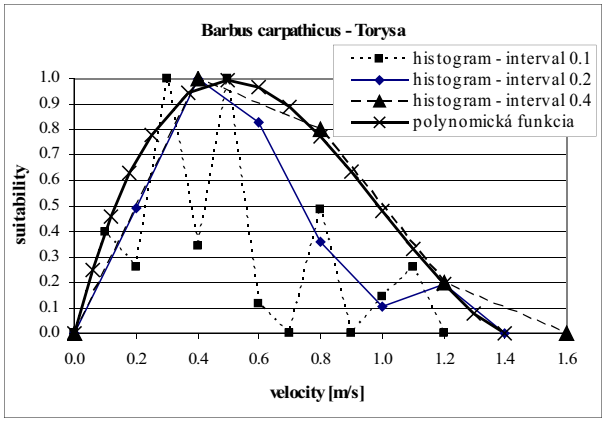

Figure 2. The curves of the microhabitat utilization, availability and normalized preference derived from the histogram analysis for Barbel (*Barbus carpathicus*) in Torysa near Pečovská Nová Ves. The preference curve is smoothed according to the polynomial function.

Table 2. Example of the computation and normalization of the preference from the progress of the habitat utilization and availability (Barbel in Torysa near Pečovská Nová Ves).

depth [m]	habitat utilization (relative frequency)	habitat availability (relative frequency)	preference	normalized preference
0.00	0.000	0.000	0.000	0.000
0.10	0.000	0.000	0.000	0.000
0.20	0.250	0.320	0.781	0.255
0.30	0.443	0.347	1.277	0.416
0.40	0.150	0.170	0.882	0.288
0.50	0.114	0.037	3.081	1.000
0.60	0.007	0.036	0.194	0.065
0.70	0.000	0.091	0.000	0.000

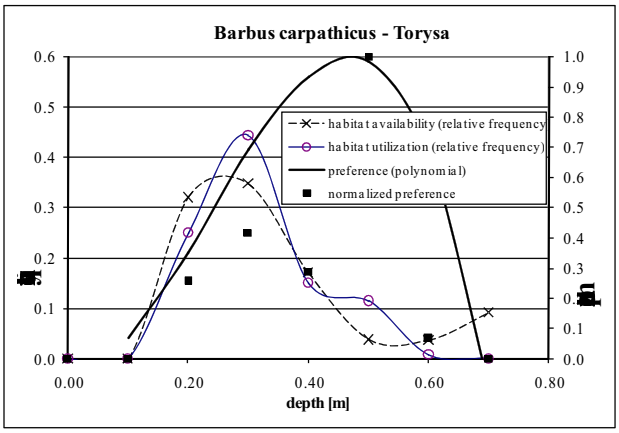

Figure 3. The weighted usable area (WUA) presented in Torysa, Šibská voda and Topľa.

The MQ determination

The MQ was determined from the outcomes of the calibrated RHABSIM model, particularly:

- The suitability ratio for the velocity and depth
- Combined suitability ratio
- Weighted usable area

Conclusions

From our research, which was aimed at an analysis of preference of particular abiotic parameters, it follows that the dominant parameter during the low-flow period is the water depth. Flow velocity is not the limiting factor during low flows.

The field work in the Slovak mountain streams which is realized since 1995 indicates gradual decrease of the fish abundance. This is also the reason of lower number of the fish indicating the habitat quality. From the analysis of the habitat suitability curves it follows that the fish loss can be partially offset by appropriate techniques that bring more objective results even in the case of optimal fish count.

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Climate and treeline dynamics in the Ukrainian Carpathians

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Abstract. In this paper climate change and treeline dynamics of the Ukrainian Carpathians during the 20th century was examined. Changes in atmospheric circulation responsible for warmer summer and winter temperatures are investigated. Comparison of treeline positions in 1930-s and 2000 reveals a decrease of area above the treeline and a general rise of treeline elevation, mostly in places where the treeline is formed by coniferous species. However, at locations with predominantly deciduous species there is little or no change. The magnitude of change is spatially heterogeneous. Warmer temperatures were considered, among other relevant factors, to have impacted the observed treeline changes.

Introduction

On a global scale, climate determines vegetation zonality, including montane vertical vegetation belts. Climate warming has been observed to raise the world's temperature by 0.6±0.2 ºC in the XX ct. Atmospheric circulation is an important agent in determining global and regional climates, as well as causing extreme weather events. Temporal assessment of the variability of large-scale atmospheric circulation and its weather types for climate change analysis is a traditional task of synoptic climatology and is studied by different methods: statistical methods, classification of synoptic patterns, by Empirical Orthogonal Functions, by method of analogs, cluster analysis, Canonical Correlation Analysis, and Principal Component Analysis.

Climate change, associated with rising temperatures, has been reported to raise the treeline elevation in many places of the world; moreover, paleoclimatic investigations indicate a higher treeline position in previous warm epochs. At local scales, however, the modern treeline in Europe is influenced by other factors, both natural and anthropogenic; the latter include grazing, tourism and logging (Gehrig-Fasel et al., 2007). The treeline of the Ukrainian Carpathians is mainly coniferous (main species – spruce *Picea abies*), but at some parts it is formed by beech (*Fagus silvatica*). Its average altitude is 1200-1300 m, lowering to 1000 m in regions with intense grazing and close proximity to settlements. The altitude rises from west to east, indicating an influence of continentality. Overall, the position of the modern treeline is a result of a sum of relevant factors. Evaluation of treeline dynamics provides insight on how coupled human-induced and natural processes impact the environment.

Data and methods

Mean monthly fields of Sea Level Pressure (SLP) and geopotential fields over the North Hemisphere archive from World Data Center, Obninsk Russia (1961-2000) and database of Ukrainian Hydrometeorological Institute (1990-2005) are used (both 5x5° regular grid) for analysis of the large-scale atmospheric circulation. Historical data was taken from (Lamb, 1961). Change of the large-scale atmospheric circulation is studied from decade to decade during the 20th century

Objective classification of synoptic processes in this research was made on the basis of method of analogs (Martazinova, 2005). Etalons of SLP fields were chosen. An etalon for each class of synoptic situations is a SLP field selected among others which has the greatest similarity with all the other fields in its class. SLP etalons of the most probable class characterize the pattern of atmospheric circulation which forms predominant weather conditions for every month of the XX ct.

For assessment of treeline dynamics of the Ukrainian Carpathians (47°40'-49°32' N, 22°40'-24°50' E) WIG historical maps issued by the Polish Military Institute circa in 1930 (1:100 000) and renewed Czech maps based on the Third Military Survey of the Austro-Hungarian issued circa in 1925 (1:75 000) were compared with Landsat ETM images (2000-2002) and contemporary topographic maps (1:100 000, 2006) in ArcInfo software produced by ESRI. A Digital Elevation Model (DEM) from contour heights of 1:200 000 topographic maps. 71 mountain ridges were selected with elevation above 1000 m. Two vector layers were created by manually delineating the forest-free area above the treeline – the first, "historical" one from Polish and Austrian maps (S_1), and the second, "contemporary" one from the Landsat images (S_2). The difference $\Delta S=S_1-S_2$ was calculated. To spatially compare the measure of treeline dynamics a treeline advance coefficient k was introduced: $k=\Delta S/L$, where L is the length of each mountain ridge (measured based on the highest points contained by the S_1 polygons). The average treeline altitude for each mountain ridge was calculated based on DEM values. Based on a geobotanic map (Golubets et al, 1968) and satellite vegetation spectral features - one of four categories (coniferous, deciduous, mixed – mainly coniferous, mixed – mainly deciduous) was assigned to each ridge.

Results and discussion

Transformation of atmospheric circulation in the Atlantic-European sector during the recent decades

Over the North hemisphere the maximum warming since the end of the 1970s took place in continental areas between 40º N and 70º N in winter and spring. The winter planetary atmospheric circulation of the North hemisphere in the middle level of the troposphere between 40º and 70º N is a system consisting of three high-pressure areas (North Atlantic, Siberian and Canadian). Three low pressure systems are placed between them (European, Aleutian, and Icelandic). For winter weather of the Ukrainian Carpathians, an important role is played by the state of the European minimum and Siberian maximums of pressure. In this paper prevailing pressure fields are shown for winter and summer of the three decades of the period 1974-2005 (Fig. 1).

The area of high pressure was predominating in winter over the Ukrainian Carpathians during 1974-1983; however, cyclones are also well developed in the area of Icelandic minimum and in East Europe, causing colder and snowy winters in Ukraine. Summer of 1974-1983 is characterized by less intensive SLP gradients with moderately warm weather. In subsequent decades (1986-1995 and 1996-2005) in winter the high pressure moves eastward and occupied almost all Europe including Ukraine. Such position of high pressure creates anomalously warm

winters with little or no snow. From the East, the contraction of Siberian maximum significantly reduces the opportunity for cold air to inflow to the East Europe and Ukraine.

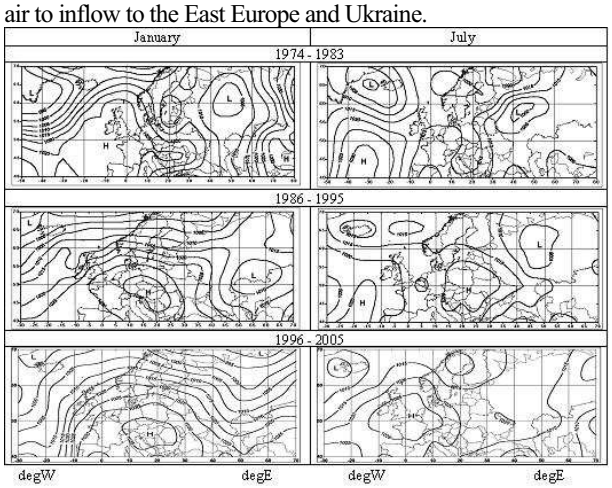

Figure1. Etalon SLP fields in the Atlantic-European sector in winter and summer, 1974-1983, 1985-1995, 1996-2005.

In following decades in summer high pressure is intensified over Central Europe creating mainly hot and dry weather in Europe, including its eastern part. High temporal stability is another distinctive feature of the most probable MSLP field during the recent decade that sometimes resulted in heat waves and droughty conditions in Europe.

Comparison of treeline positions (1930s to 2000).

During the study period the total mountain meadow area had decreased by 15380.8 ha, which is 24% of the initial area S_1. The largest decrease was observed on ridges with coniferous species at the treeline (42%, k=305.3). On the contrary, ridges with deciduous forest have demonstrated slightly decreasing meadow area (-6%, k= -18.1). Ridges with mainly coniferous forests have experienced decrease of meadow area, but the magnitude is less than in the 1st group (24%, k=178.7), while the rate of meadow decrease on ridges with mainly deciduous species is quite less (32%, k=69.8). This 4th group has experienced a 100% decrease in meadow area in some situations, which biased the high ΔS value (Tab. 1).

Table 1. Changes in mountain meadow area during extent of study period. S_1 – meadow area on historical map; S_2 – meadow area on modern map; $\Delta S=S_1-S_2$; k – coefficient of treeline advance.

Categories of mountain ridges	S_1, ha	S_2, ha	ΔS, ha	$\Delta S/S_1$, %	k
All categories	62971.4	47590.6	15380.8	24	147.8
1.Coniferous forest	20575.9	12017.3	8558.6	42	305.3
2.Deciduous forest	11103.4	11736.7	-633.3	-6	-18.1
3.Mixed forest – mainly coniferous	30150.4	23057.9	7092.5	24	178.7
4.Mixed forest – mainly deciduous	1141.3	778.7	362.5	32	69.8

At some locations, such as the Svidovets ridge from the Polonina system, the treeline from the northern slope is constituted by coniferous trees, while from the southern slope it is formed by beech. At this location coniferous species have demonstrated a noticeable rise in altitude while the beech treeline has remained stable.

At ridges from the Beskids with predominant deciduous trees at treeline colonization of meadow area by coniferous species is observed. In many places the presence of sheepholds obviously lowers the treeline position. Treeline advance coefficients were positively correlated with altitude, which reflects more difficult access to elevated mountaintops and thus better conditions for tree establishment.

Overall, treeline dynamics in the Ukrainian Carpathians demonstrate regional peculiarities (Fig. 2). The largest treeline advance coefficients are located in the Gorgan, Chornogora, and Marmarosh area, followed by minimal positive values in the Beskids and negative values in the Polonina region. The changes in average treeline height for these regions are described in Tab. 2.

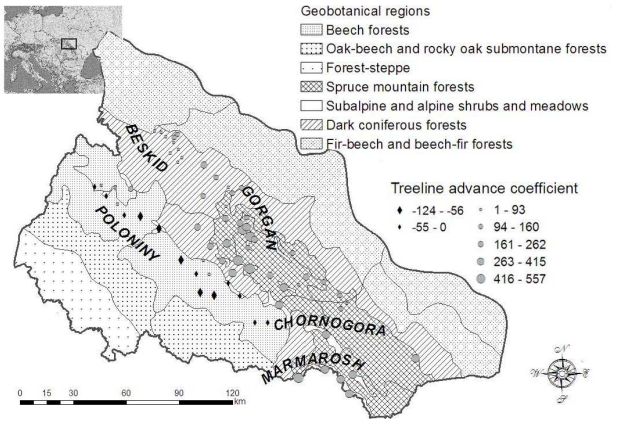

Figure 2. Spatial distribution of treeline advance coefficients over geobotanical regions.

Table 2. Changes in average treeline elevation. h_1, h_2 – average treeline elevation on satellite images and historic maps, respectively. $\Delta h= h1 – h2$.

Region	Average h_1, m	Average h_2, m	Δh, m
Beskid	1105	1096	9
Gorgan	1393	1347	46
Poloniny	1169	1183	-14
Chornogora	1370	1345	25
Marmarosh	1448	1413	35
All	1306	1293	13

Conclusions

Climate change has resulted in warmer summer temperatures over the Carpathians, which are especially favorable for trees at upper elevations. A decrease of mountain meadow area and rise of treeline elevation has been observed from the early decades to the end of the 20th ct., mostly by coniferous species at upper elevations. The observed heterogeneity of treeline changes makes assessment of other treeline-forming factors necessary for understanding the interaction of climate and treeline dynamics in the Carpathian region.

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The dependence of soil respiration on soil temperature on the windfall area in Tatra National Park

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Abstract. Soil respiration is one of the largest and most important fluxes of carbon in terrestrial ecosystems. There are many factors that influencing on the soil respiration. One of the most dominant factors affecting the soil respiration rate are soil temperature and soil moisture.

Introduction

After photosynthesis, soil respiration is the second largest flux of carbon in most ecosystems. Soil carbon dioxide (CO_2) efflux derives from respiration of decomposers of soil organic mater (heterotrophic respiration) and respiration of plant rhyzosphere (autotrophic respiration). Soil respiration, which includes both root and microbial respiration, has been estimated to be 60 – 90% of total ecosystem respiration (Goulden et al., 1996).

Potential factors that have been cited as influencing the spatial variability of soil CO_2 efflux are: topography (Hanson et al., 1993; Rayment and Jarvis, 2000); root density or biomass (Fang et al., 1998; Janssens et al., 1998); quantity and quality of soil organic mater (Rayment and Jarvis, 2000; Scott -Denton et al., 2003); microbial biomass (Scott- Denton et al., 2003); vegetation characteristics (Law et al., 2001); distance from trees and leaf litter amount (Fang et al., 1998; Law et al., 2001; Scott – Denton et al., 2003). Natural disturbances (e.g., fire, windthrow) or anthropogenic land – use changes (e.g., logging, afforestation) often alter the soil profile, thereby changing not only carbon stocks, but maybe also carbon fluxes.

Soil respiration, temperature and moisture are strongly correlated, particularly in temperate ecosystems where root phenology and aboveground productivity are also linked with temperature and moisture. In this paper we refer on the relation of soil respiration and the soil temperature.

Data and Methods

The study was conducted at four sites with different disturbance and management regime on the windfall area in the Hight Tatra Mts. The intact forest site (REF, Vyšné Hágy) was chosen as reference site without damage by the windfall event. At the extracted l site (EXT, Danielov Dom) the dead wood has been removed shortly after the windfall event. At the non-exracted site site (NEX, Jamy) the trees have not been removed. Later, after a large fire which hit the windfall area, fire site (FIR, Tatranské Zruby) was established. The general characteristics of the research sites is in the Tab. 1.

At all sites soil respiration was measured every 7 – 12 days from July to November 2008 using a portable closed dynamic system with Vasisala CARBOCAP hand- held carbon dioxide meter GM70. The soil chamber was placed on fixed collars (each covering 0.075 m^2) with 5 – 10 cm inserted 5/10 cm into the soil. At all sites soil respiration was measured at 10 sampling points. Near the sampling points soil temperature was also measured, at the depth of 8 cm by portable thermometer. Soil respiration values were directly corrected by temperature and atmospheric pressure (this parameters are entered to the instrument of Vaisala CARBOCAP GM70).

Table 1. General characteristics of the research sites (Fleischer, 2008).

Research site Chracteristic	REF	EXT	FIR	NEX
Size (ha)	110	95	90	115
Altitudinal span (m a.s.l.)	1100 -1250	1040 - 1260	1000 - 1200	1050 – 1150
Slope %	10 - 20	10	5 – 10	5 – 10
Orientation	SE	S	SE	SE – S
Soil	Cambisoil podzolic	Cambisoil podzolic	Cambisoil podzolic	Cambisoil podzolic
Forest community	*Lariceto-Piceetum*	*Lariceto-Piceetum*	*Lariceto-Piceetum*	*Lariceto-Piceetum*
Tree sp share (%) before windfall	Spruce 80 Larch 20	Spruce 90 Larch 10	Spruce 70 Larch 30	Spruce 70 Larch 20 Pine 10
Stand age before windfall	120/25	80	80	125/60/25

Result and Discussion

Buchman (2000) states that about 80% of the variance in the soil CO_2 fluxes was explained by changes in soil temperature. At all our sites was observed soil respiration dependence on the soil temperature, as it is displayed on the Fig. 1. Coefficient of determination at respective sites REF, EXT, FIR, NEX was r^2=0.765; r^2=0.581; r^2=0.468; and r^2=0.722). Generaly, soil temperature alone is sufficient to explain seasonal variation of soil respiration (Buchmann, 2000; Hanson, 1993). However, under certain conditions, soil respiration could also be constrained by precipitation or soil moisture (Buchmann, 2000). There are also other factors that are highly variable at a microscale such as litter quality or water availability, microbial biomass. Vegetation characteristics might be responsible for large within-site variations during summer months. This factors will be the topics for future observations.

Conclusions

One of the most dominant factors affecting soil respiration rate is soil temperature. It alone is sufficient to explain seasonal variation of soil respiration.

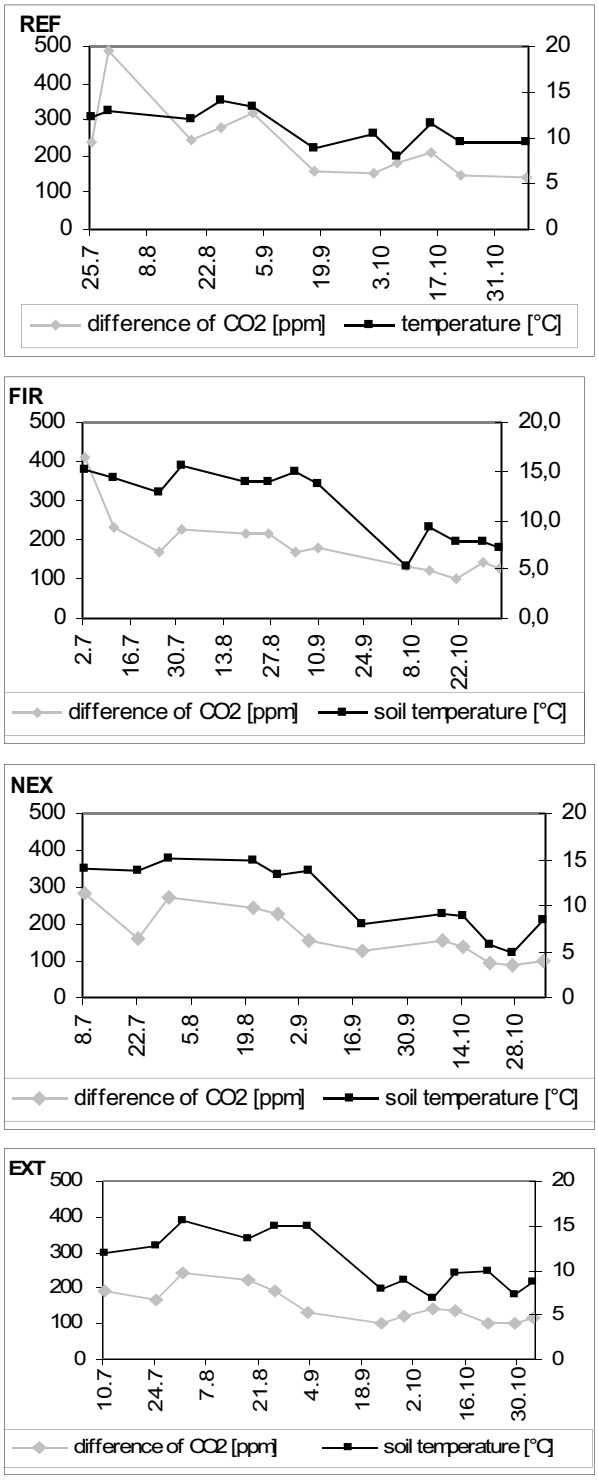

Figure 1. Dependence of soil respiration on the soil temperature at the sites REF, EXT, FIR, NEX.

AcknowledgementsThe study was supported by research grants VEGA No. 1/0515/08, 1/4393/07, 1/3283/06, from the Slovak Grant Agency for Science.

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Relationship between crown status and radial increment of Norway spruce forest stands under stress impacts in the Silesian Beskids Mts.

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Abstract. In the last years, Norway spruce forest stands in the Slezské Beskydy Mts. (forest enterprise Jablunkov) have been exposed by increased environmental stress impact, resulting in the decrease of tree vitality. It has been manifested by increased defoliation and extensive needle yellowing, following by bark beetle outbreak. These phenomena have been observed also in neighbouring areas in Slovakia and Poland. The aim of the contribution is to inform about the found relationship between the stress response history of the crown structure and dendroclimatological analysis of trees. In comparison with other mountain areas with similar defoliation rate, Norway spruce forest stands in the Silesian Beskids Mts. had lower percentage of secondary shoots. It indicates relatively short time and quick course of the forest decline process. Some consequence between tree resistance and resilience and radial increment rate was revealed and discussed.

Introduction

Synergistic action of climatic change, including extreme climatic events, and long-term natural and man-made acidification result in the vitality decrease all over the forest stands in the Middle Europe (Schulze et al., 1989). The retrospective method of detection of crown structure transformation enables to reconstruct the historical and current Norway spruce response to accelerated defoliation, caused by above mentioned stress factors (Cudlín et al., 2001; Polák et al., 2007). Together with the results of dendroclimatological study and data about historical incidental fellings it is possible to describe stress response history, present status and regeneration potential of given Norway spruce forest ecosystem. The relationship between tree health status and radial increment in the same study area was investigated rexently by Šrámek et al. (2008).

Material and methods

The crown structure transformation method, based on ground observation using binoculars, was elaborated (Cudlín et al., 2001), using the principles of the tree health status observation published in ICP Forest (2007), Lesinsky and Landman (1988) and Gruber (1994). The crown was divided for upper - juvenile, middle - production and bottom - saturation parts. Juvenile part was characterized mostly by its shape, production part by total defoliation, defoliation of primary structure, percentage of secondary shoots and defoliation types; according these parameters the trees were classified into 4 stress response categories – resistant trees, resilient trees, damaged trees with slightly regenerated crown and damaged trees with heavily regenerated crown (Polák et al., 2007). In 6 forest districts (Nýdek, Písek, Rovina, Mosty u Jablunkova, Dolní a Horní Lomná), situated in the territory of forest administration Jablunkov, 18 research plots in maturity age were established with the aim to cover both the widest spectrum of site conditions and various stage of forest decline. Regarding to the most frequent forest vegetation degree 5 (fir-beech), research plots were selected predominantly in forest types 5S, 5F, 5N and 5K.

Dendroclimatological analysis was performed in 270 trees on 9 research plots, crown structure evaluation in 318 trees on 18 plots. Sampling and elaboration of increment cores were carried out according to the standard method of Cook and Kairiukstis (1990), elimination of the age trend of increment curves according to Holmes et al. (1986). Climatic series of temperature and precipitation for the area of the Silesian Beskids Mts.were constructed as a space average from data from meteorological station Jablunkov. Correlation of the dependence of radial increment on climatic characteristics was counted from May of previous year to August of current year (16 months) using the software DendroClim (Biondi &Waikul, 2004).

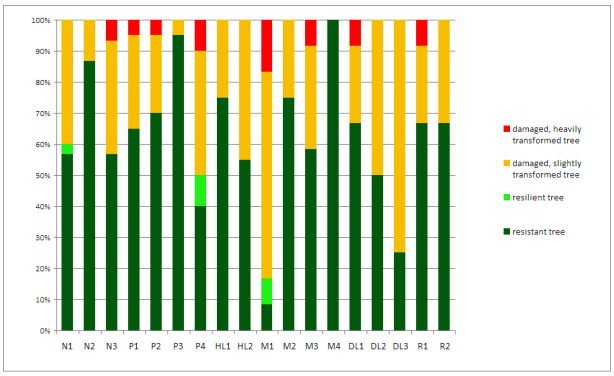
Results and discussion

Main studied parameters of the crown status (total defoliation, defoliation of primary structure, percentage of secondary shoots) fluctuated considerably between research plots; the lowest variability was observed by total defoliation. Mean total defoliation varied from 28.25% on the plot Písek 3 to 44.58% on the plot Mosty 1, defoliation of primary structure moved between 41.25 % (Písek 3) and 65.83% (Mosty 1). The most distinct fluctuation was ascertained by percentage of secondary shoots (from 13.00 % on the plot Horní Lomná 2 to 40.75% (on the plot Písek 1). Yellowing of needles were relatively small (maximal value 6.75%) and non-regular; highest values were observed on the plots Písek 1, 2, 3) and plot Horní Lomná 2.

Representation of stress response categories is illustrated on the Fig. 1. The most frequent category (62.04%) was the category of resistant trees (trees with defoliation up to 35% and 50% of secondary shoots), the second significant category (32.96 %) was the category of damaged trees (trees with defoliation higher than 35% and up to 50% of secondary shoots). Remaining two categories of trees with higher than 50% of secondary shoots were not considerable represented.

Dendroclimatological analysis proved a continual decrease of radial increment from the beginning of 70ties to the end of the first half of 90ties. In the second half of 90ties, gradual increase of radial increment, interrupted in 2000 and subsequently in 2003 and 2006, probably by drought events, succeeded (Fig. 2).

In the forest districts Nýdek and Písek following forest status types occurred: a) relatively resistent forest stands (Nýdek 2, Písek 3, Písek 2); b) forest stands slightly damaged since 70ties with low regeneration; these trees have had the lowest radial increment since the beginning of studied period in 1969 (Nýdek 3, Písek 4); c) stands able to maintain their defoliation up to 35%, using regeneration processes; these trees have had since the second half of 90ties the highest radial increment (Nýdek 1, Písek 1).
Both plots in the forest district Horní Lomná had mean defoliation fluctuating on the border of damaged stand (35% - 40%) but the lowest percentage of secondary shoots (14%). The lowest radial increment on the both plots can be also explained by their highest altitude.



Explanation: N-Nýdek, P-Písek,HL-Horní Lesná, M-Mosty, DL-Dolní Lesná, R-Rovina (forest districts)

Figure 1. Representation of stress response categories of Norway spruce for 336 trees on 18 research plots in the Slezské Beskydy in 2008.

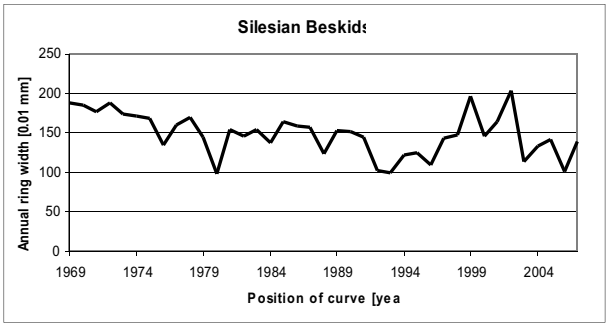


Figure 2. Ring width average curve for 240 trees on 10 research plots in the Slezské Beskydy in 2008.

Conclusions

In comparison with other mountain areas with similar defoliation rate, Norway spruce forest stands in the Slezské Beskydy Mts. had lower percentage of secondary shoots (e.g. Orlické hory 44.39%, Silesian Beskids 26.82 %); total defoliation values did not differ significantly. It shows the relatively short time and quick course of the forest decline process. Similar forest stand status was observed on the research plots in the Kysuce Mts. (Slovakia).
Forest stands slightly damaged since 70ties with low regeneration have proved the lowest radial increment since the beginning of studied period (1969). Stands, which have been able to maintain their defoliation up to 35% using regeneration processes, have had the highest radial increment since the second half of 90ties.

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Infiltration of water into stony soil: To what extent is infiltration affected by stoniness?

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Abstract. Soils containing rock fragments are widely distributed mainly in mountaineous areas. However, literature describing water fluxes in such soils is scarce. In this paper the Green–Ampt equation is used to evaluate the influence of stones (as a part of stony soil) on the infiltration process. The key parameter, saturated hydraulic conductivity K_e, was estimated by numerical experiments, simulating steady flow through representative volume of stony soils. A two dimensional simulation model, HYDRUS – 2D, was used for K_e evaluation. Using evaluated K_e as a function of the relative stone content (R_v), a one-dimensional simulation model HYDRUS –ET, with appropriate K_e values was used to simulate infiltration. It was demonstrated that infiltration rate decreases with the increasing value of stoniness (R_v).

Introduction

Infiltration of water into porous media (soil) was studied from the very beginning of the soil research. The importance of this phenomenon is clear: infiltration is the process by which subsurface water is recharged, which then enables the hydration of rivers, soil and groundwater .

Soil water is the source of water for biomass, which is the first part of the food chain. The interest was first focused on agricultural soils, thus studies were performed mainly on fine earth fraction of soil (i.e. soil particles less than 2 mm in diameter) without stony parts. Even in modern books dedicated to Soil Hydrology (Kutílek&Nielsen, 1994), information regarding water movement in stony soils cannot be found.

Stony soils containing solid particles bigger than 2 mm are spread mainly in mountainous areas. According to Poesen & Lavéé (1994), 30% of Western Europe soils and nearly 60% of soils in the Mediterranean are stony soils. Across the territory of Slovakia, the majority of forest soils contains stones, strongly influencing the soil hydraulic properties; they have a lower conductivity for water and their water retention capacity is significantly decreased in comparison to fine earth. Stones in such soils are able to influence water transport due to their content, size, shape and their positioning.

The moraine soils in the High Tatras are of particular interest. The majority of the area affected by the 2004 windthrow is covered by moraine soils (Gömöryová, et al., 2008), in which stones of nearly spherical shape are (1 – 30 cm in diameter) with the average diameter approximately 10 cm. Those stones are dispersed in loamy sand with high hydraulic conductivity.

The aim of this paper is to demonstrate the influence of stone content in soils (stoniness) on the infiltration rate taking into account their shape, size and layout in the soil.

Theory

Probably the first equation describing ponded, stationary infiltration rate of water into homogeneous soil –which is still in use – is the Green and Ampt's equation, which can be written in the following form:

$$v_i = -K\left(\frac{z_o - h_f + z_f}{z_f}\right) \qquad (1)$$

v_i is the infiltration rate LT^{-1}, K is the saturated hydraulic conductivity LT^{-1}, z_o is the thickness of the water layer on the soil surface. If the negative pressure (tension infiltrometer), is applied on the surface, then z_o is the negative value of pressure height L, h_f is the effective pressure head at the infiltration front (negative value) L, and z_f is a depth of infiltration front below the soil surface L.

The above equation is basically Darcy´s law rewritten for ponding infiltration. The equation is valid for steady infiltration of water into homogeneous soil, hydraulic conductivity of which is expressed by K.

But, how is one able to apply this equation to the soil containing stones and is it possible indeed ? In principle, such a soil is non-homogeneous. The soil in equation (1) is characterized solely by the value of hydraulic conductivity, i.e. if the hydraulic conductivity is known, some „effective" K, can be deduced accounting for the influence of stones on soil conductivity. Application the Green-Ampt equation to stony soil is strongly dependent on the representation of K. The representative (or effective) conductivity, K_e, must not be the conductivity of fine earth fraction (K_{fe}), but it must be the integral value of the dispersion system, containing both: fine earth and stones. It must be „representative". To fulfil this condition, K_e should be measured on a sufficiently „big" so called „representative" volume of soil. A sufficient volume ensures that its increase cannot influence the measured K_e, but its decrease will change (usually decrease) soil hydraulic conductivity. Measurement of hydraulic conductivity of stony soils, with stones up to 30 cm in diameter, or conversely in a laboratory using soil samples is a difficult task; but only then it can be applied to the equation (1). The final criteria that need to be applied to the sample to enable the use the equation (1), is that the hydraulic conductivity and retention capacity of stones should to be close to zero.

Results and discussion

To overcome the difficulties related to the direct K_e measurements, the hydraulic conductivities of soil with stones were estimated by the numerical experiments with a virtual soil sample, of volume 1 m^3. This fulfilled the criteria, related to the sample dimensions mentioned previously. The relative stone contents, for which K_e were evaluated, were R_v = 0, 0.1, 0.2, 0.3, 0.4. The chosen stone diameter was 10 cm and these were regularly dispersed in the sample.

Assuming a constant water layer height on the soil surface (z_o) during ponding, stones were uniformly distributed in the

soil. Because of the uniform initial soil water content in the virtual sample, pressure height at the infiltration front, h_f, was constant. Thus, infiltration rate depends on K_e only. The solution of the problem is reduced on the relationship between K_e and the properties of the stones (stone relative content, size, shape). In addition, their layout in the line earth is a further consideration.

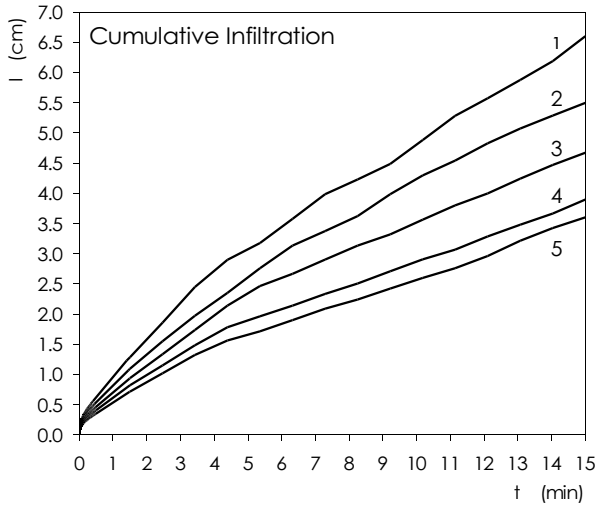

Figure 1. Cumulative water infiltration into stony soil with different stones content: R_v = 0, (1); R_v = 0.1, (2); R_v = 0.2, (3); R_v = 0.3, (4); R_v = 0.4,(5). Loamy sand, FIRE site, High Tatras, Slovakia.

It can be further assumed that the stones have a zero conductivity for water. Presence of non- conductive stones in the fine earth decreases the effective (conductive) cross section of soil and thus decreases the hydraulic conductivity of soil and infiltration rate. This is valid for stones dispersed in the fine earth without lacunar pores; i.e. along the boundaries between stone surface and fine earth are not macropores due to shrinking of fine earth or improper soil consolidation. In the literature there can be found cases in which infiltration rate can be increased with stoniness (Fiés at al., 2002), but the reason should be one of the above mentioned effects, especially, if the „stony" soil is prepared in the laboratory from stones and fine earth in some kind of arrangement. Then preferential ways for water may have been created.

Kinetics of infiltration into stony soil was simulated by the one dimensional model HYDRUS -ET (Šimůnek et al., 1997). The courses of cumulative infiltration for different stonines at the same soil are presented in Fig. 1. Hydraulic conductivities of stony soil K_e were estimated by numerical experiments on virtual soil samples too.

Conclusion

The results of simulation indicate the hampering of infiltration by stones; the higher the level of stoniness, the lower the rate of infiltration. This is, because the hydraulic conductivity of the soil decreases with increasing stoniness. Fine earth of forest stony soils are usually highly conductive, because it contains coarse sand, as the basic constituent. As a result, the infiltration rate of such stony soil is usually relatively high, and surface runoff is rarely observed. However, the retention capacity of stony soils significantly decreased such that the retention capacity of stones is assumed (and it really is) close to zero.

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The *Montado* agroforestry system microclimatic specificity in the context of global change

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Abstract. The effects of oak trees on microclimatic parameters in *Quercus rotundifolia* Lam. woodland in the Alentejo, Southern Portugal, are reported. Results show that oak tree create a marked differentiation in the grass matrix, between open and undercanopy areas. Compared to open areas, it presents lower soil moisture beneath the oak canopy, lower soil temperatures and lower photosynthetically active radiation (PAR). Soil temperatures outside trees canopy were generally higher than undercanopy areas, reaching twice its values during the winter. The decrease of soil water content is more rapidly in areas outside the trees canopy action, but the replenishment starts early and is faster in those areas. PAR intercepted by tree canopy is greater than 60%, and affects dramatically herbaceous production.
Different climatic conditions due to the presence of the tree, associated with greater variability in chemistry environment undercanopy, if combined with the IPCC forecasts for Mediterranean region, pose new challenges in the management of the *montado* areas.

Introduction

The main agroforestry system of Southern Portugal is an open *Quercus* woodland, called *montado*, which corresponds to a savanna like formation (Joffre and Rambal, 1993). The interactions between the trees and the under layer environment may have an important role in the management of these systems in a multiple use perspective. Although the study of these interactions is of utmost importance, some uncertainty subsist in Southern Portugal regarding the role of trees on microclimatic and soil characteristics, specially on soil water content, and on chemical characteristics and nutrient availability. The great economic and ecological importance of *montado* silvopastoral multi purposes system and the considerable concern about their long-term sustainability raised the relevance of studying the functioning of those oak woodlands ecosystems, and their influence on nutrient cycling in a way to understand how management practices affect his long-term sustainability.

Data and methods

The study was carried out in Southern Portugal at the Centro de Estudos e Experimentação da Mitra (CEEM), experimental *campus* of the University of Évora (38º32'N, 8º01'W, 243 m), during 2001-2002. The local climate is Mediterranean-type (Csa according to Köppen), characterized by winter-wet and summer-dry pattern. Mean annual rainfall is 665 mm, most of wich falling from autumn to early spring (90%) in less than 75 days of rain per year (INMG, 1991). Mean annual air temperature is about 15.4°C, ranging from 8.6ºC in January to 23.1ºC in August. Air relative humidity is about 70%. The dry period is up to 5 months.
The landscape is gently undulating and the slope, at the study site, ranges from 5 from 3 to 8%. The geological substratum consists of granites and gneisses (Carvalhosa *et al.*, 1969). Soils are mostly Eutric Leptosols developed on gneiss (WRB, 2006), with a maximum soil depth of about 1 m. Soil texture is sandy to sandy loamy.
The vegetation consists of open pasture with scattered trees of *Q. suber* L and *Q. rotundifolia* Lam.. The oak stocking ranges from 35-45 trees ha^{-1} with an average canopy coverage of 21%. The herbaceous layer, with forbs and grasses, was invaded by shrubs, mainly *Cistus salviifolius* L..
Microclimatic parameters (photosynthetically active radiation, soil temperature and soil moisture), were monitored under the tree canopies and without their influence. Photosynthetically active radiation (PAR) was recorded by PAR sensors, placed at 0.30 m above soil surface, the upper limit of herbaceous layer. Average hourly soil temperature under trees canopy was recorded continuously using copper-constantan thermocouples of Delta-t, placed on soil organic surface layers, between surface organic horizon and mineral profile (0 cm), 2.5 cm, 5 cm, 10 cm, 15 cm and 20 cm. In the open, average hourly soil temperature was also recorded continuously with thermocouples placed at 2.5 cm, 5 cm, 10 cm, 15 cm and 20 cm. Soil moisture was monitored by 20 ThetaProbe sensors (ML2x, Delta-T Devices, Cambridge, UK). Ten sensors were installed in the soil under an isolated *Q. rotundifolia* tree (crown radius was 7.2 m) used for precipitation interception studies, and ten sensors were installed beyond the crown projection limits. In both cases half of the sensors were installed at 0.06 m depth, and the other half at 0.25m. Soil volumetric water content was averaged and stored at half-hourly intervals. All sensors were connected to a $DL2_e$ data-logger (Delta-T Devices, Cambridge, UK).

Results and discussion

Photosynthetically active radiation (PAR) was higher at the areas without the tree canopies than at those under their influence (Fig. 1).
The PAR interception by the tree and shrub layers attained 95%. The pattern determined for the radiation decrease is in accordance with that found by other authors (Belsky *et al.*, 1993) in savanna formations.
Temperatures obtained during December 2001 and March 2002 at 2.5 cm and 10 cm depth were always higher in the areas without the canopies influence (Fig. 2). However, the differences found between the soil at these areas and at

those under the canopies were still more accentuated during the summer months. A similar pattern was found by Rorison (1991), who compared north and south slopes and by Belsky *et al*. (1993) in its studies with *Acacia tortilis* and *Adansonia digitata*.

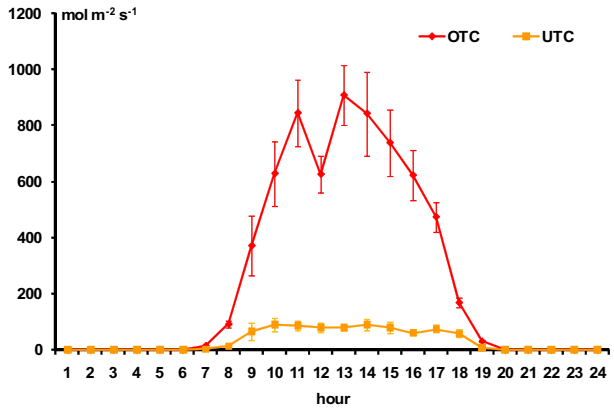

Figure 1. Average time course of photosynthetically active radiation (PAR, µmol m^{-2} s^{-1}), under tree canopy (UTC) and outside tree canopy (OTC), during March 2002.

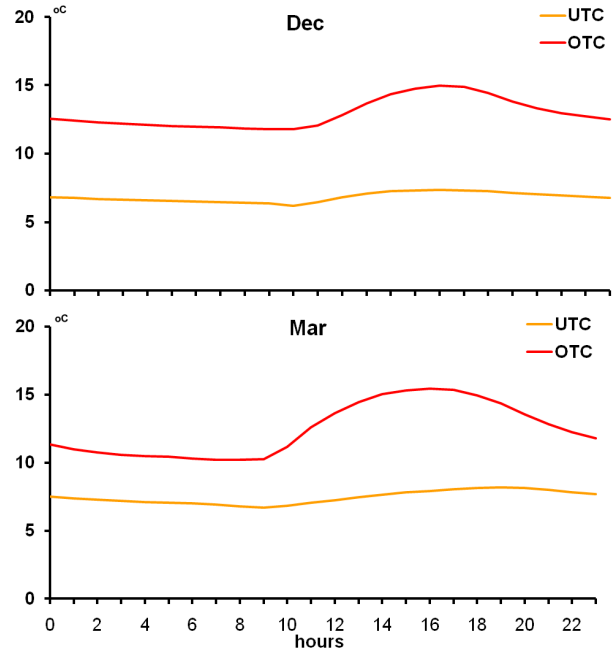

Figure 2. Average time course of soil temperature (°C) at 2.5 cm depth, under tree canopy (UTC) and outside tree canopy (OTC), during December 2001 and March 2002.

The pattern of soil moisture variation during the dry period was similar for both areas, although the highest values were always obtained for open areas (Fig. 3). The same behavior was observed as result of the first rains after summer drought. As result of this moistening both areas present the same soil water content at surface. There were no statistical significant differences in soil moistures values, between undercanopy and open areas, for all the measured periods.

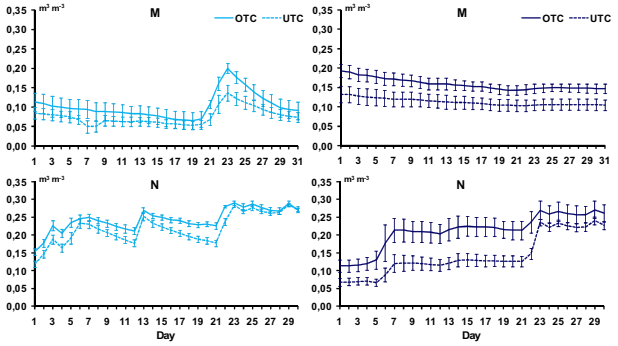

Figure 3. Average soil water contents undercanopy of *Q. rotundifolia* tree (UTC) and outside tree canopy (OTC) at 6 cm (——) and 25 cm (——), in March and November 2002.

Given the scenarios of wide variation in the distribution of precipitation and temperature, referred to the regions of Mediterranean climate (IPCC, 2007), the behavior of this mosaic ecosystem may be strongly changed. The differentiation between undercanopy and open areas, in soil carbon and nitrogen cycles, and in herbage production, will probably be exacerbated, questioning the sustainability of the *montado* ecosystem. The animal support capacity may decrease, and tree susceptibility to deseases may increase.

Conclusions

Quercus rotundifolia trees canopy changes dramatically the microclimatic environment of the under layer, namely PAR, soil temperature and soil moisture. This differentiation has as result, differences in herbaceous production, nitrogen mineralization and carbon storage, between undercanopy and open areas. The expected climatic change for Mediterranean region can tear down the present equilibrium of the *montado* ecosystem, questioning its sustainability

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Secondary succession of vegetation on the permanent monitoring plots in the High Tatra Mts.

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Abstract. The paper deals with the evaluation of data obtained from the permanent monitoring plots and research plots located on the windthrow areas in the High Tatras Mts. A development of vegetation on research plots with different management was traded off: REF (area wasn´t attacked from windthrow), EXT (extracted area), FIRE (area after fire), NEX (nonextracted area), WTR1 (area with hydrological management). Phytosociological records, obtained during 2005- 2008, has been assessed. The data submitted was carried out using the principles of BRAUN – BLANQUET approach. The results from statistical analyses were processed in CANOCO software for Windows. The PCA analysis implied a relationship among vegetation species, environmental factors and differential management.

Introduction

Many authors express interest about windfall development of vegetation in forest ecosystems. For example Fischer *et al.* (2002) presents the results from research plots which were established on areas after disturbance in 1988 in the Bavarian forest. Näuhaslová¸ Wild (2001) description of communities with dominant species *Clamagrostis villosa,* which today is the most representative of the clearing of vegetation. Šoltés *et al.* (2008) this research describe after windthrow in the High Tatras Mts. Previous articles describing vegetation dynamic outline the significance of vegetation abundance as bioindicators for a middle or long term change in the ecosystem (Križová, 1996).

Data and methods

The first phytosociological relevés from years 2005-2006 have been obtained from the Research Station of TANAP. During years 2007-2008 we recorded relevés on permanent monitoring plots (TMP) with their cooperation. TMP area about 20x20 m^2 are on territories with different management as: REF, EXT, FIRE, NEX, WTR1. Each year classical phytosociological records have been recorded and analyzed according to methods of botanists of Research station of TANAP (Šoltés *et al*., 2008). For visualisation variation among communities PCA analysis improvement were used, Ellenberg´s ecological numbers (Eellenberg *et al.,* 1992).

Results and disscussion

Different trends of development of vegetation on stands with different management were analysed between years 2005-2008. We evaluated the relationship between vegetation species, environmental factors and different management by PCA analysis. For interpretation of ecological factors we applied average Ellenberg´s numbers (Tab. 2). As we describe on the plot "REF" typical forest species (herb, moos and tree) are all a regular occurrence. The "NEX" plot is also very similar. These species relate to wetter, shadier, colder and more acid stands. Another tendency within the plots WTR1, EXT a FIRE illustrate. In these plots the species indicate stands which are light and warm, with high values of nutritive substances. A higher volume of nitrogen plays a very important role on the plot FIRE. Conditions such as these require species to conform to the following characteristics light-demanding, nitrophilous, clearing species, ruderal plants and a pioneer trees. *Calamagrostis villosa* is moisture-demanding and a typical species for forest communities. It is also light - demander, that´s why on plots EXT and WTR1 it is described as very expansive species (Fig. 1). Through ecological analysis following the average values of environmental factors we indicate a feature of environment (Tab. 2). According to average values of environmental factors we can submit, species on representative plots in the year 2008 on indicated stands: **REF** – stand is shade to half-shade, acid, poor to half-wealthy on nutrients, fresh moist to moist, cold to mild warm, **NEX** – stand is half-shade, cold to mild warm, soil is moist, acid and poor on the nutrients, **WTR1** – stand is half-shade to half-light, acid, poor on the nutrients, fresh moist to moist, cold to mild warm, **EXT** – stand is half-shade to half-light, acid, poor to half-wealthy on the nutrients, fresh moist to moist, cold to mild warm, **FIRE** – stand is half-light, mild warm, soil is fresh moist, mild acid and full on the nutrients.

The detailed research on these plots were made by botanists of the Research Station of TANAP. They also recorded the most significant changes on the plot FIRE. There was destruction of understory and top humus where only the mosaic was destroyed. During following years they are going to expect a recession of *Chamaerion angustifolium* and a raise in nitrophilous vegetation *Sambucus racemosa* and *Rubus idaeus.* Our researchers admit an increasing abundances of species on others plots (Šoltés *et al*., 2008). Similar research with similar conclusions was made in the Czech Republic. They observed the clearing communities dominated by *Clamagrostis villosa* at levels of climax spruce and spruce-beech forests (Näuhaslová¸ Wild, 2001). In the association of *Junco effusi-Clamagrostietum villosae* they recorded a field layer, which is divided into two sub-layers.

The higher sub-layer is dominated by *Clamagrostis villosa*, sometimes with an a mixture of ferns and tall herbs (*Chamaerion angustifolium, Senecio hercynicus, S. ovatus*), half-shrubs (*Vaccinium myrtillus, Rubus idaeus*) or *Juncus* species. In the lower sub-layer *Avenella flexuosa* prevails. In some places, *Oxalis acetosella, Trientalis europaea* plays an important role. Younger stands (usually up to five years) contain some elements of the synanthropic vegetation which disappear in the further succession.

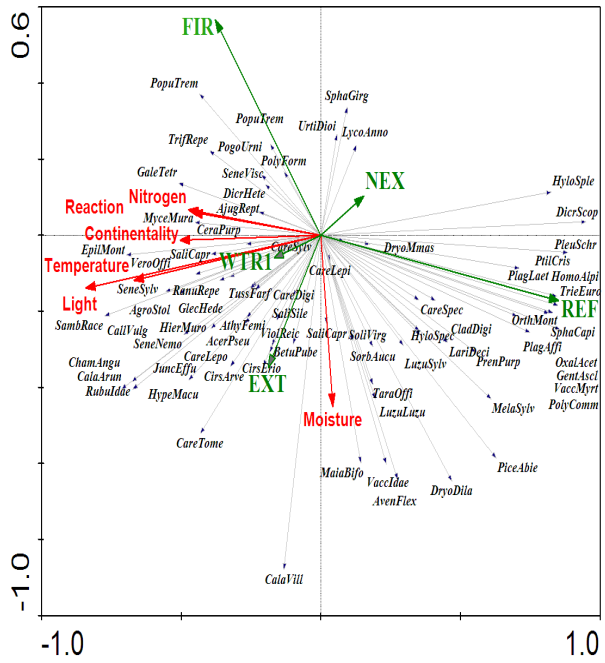

Figure 1. The PCA analysis describing relationship among vegetation species, environmental factors and different management.

Table 2. The average values of environmental factors on the compared monitoring plots 2005-2008.

Plots	year	L	T	C	M	R	N
REF	**2005**	4.16	4.15	3.68	5.59	3.24	3.82
REF	**2006**	4.86	4.09	3.63	5.88	2.95	3.35
REF	**2007**	5.30	4.06	3.59	6.13	2.73	3.2
REF	**2008**	4.26	4.06	3.08	5.54	2.98	4.02
NEXT	**2005**	5.17	4.00	3.00	5.75	2.35	2.91
NEXT	**2006**	5.74	4.00	3.61	6.65	2.24	2.72
NEXT	**2007**	5.90	4.09	3.21	6.61	2.21	2.68
NEXT	**2008**	5.8	4.04	3.42	6.68	2.17	2.71
WTR1	**2005**	4.60	4.00	4.50	5.75	2.40	2.60
WTR1	**2006**	5.81	4.18	3.54	6.15	2.47	2.98
WTR1	**2007**	6.18	4.24	3.92	6.34	3.02	3.39
WTR1	**2008**	6.42	4.37	4.08	6.05	3.33	4.19
EXT	**2005**	5.33	4.11	3.93	5.93	2.73	3.36
EXT	**2006**	5.76	4.08	3.64	6.43	2.52	3.14
EXT	**2007**	6.33	4.40	3.98	5.91	3.34	4.29
EXT	**2008**	6.42	4.28	4.05	6.01	3.24	4.15
FIRE	**2005**	5.50	4.33	3.00	5.67	3.00	3.50
FIRE	**2006**	6.41	4.20	3.88	5.67	3.76	4.93
FIRE	**2007**	7.36	4.39	4.65	5.19	4.63	6.94
FIRE	**2008**	7.34	4.61	4.65	5.11	4.57	6.87

Conclusions

From these results, we can submit, that area FIRE was colonized by light-demanding, nitrophilous, clearing species, for example: *Chamaerion angustifolium, Veronica officinalis, Rubus idaeus, Taraxacum officinale, Urtica dioica, Senecio viscosus, Senecio nemorensis agg., Senecio sylvaticus* and others. However, the areas EXT, WTR1 were colonized by light-demanding, moisture-demanding species *Calamagrostis villosa* and other as: *Calamagrostis arundinacea*, *Calluna vulgaris, Ajuga reptans, Galeopsis tetrahit, Trifolium repens, Epilobium montanum, Cirsium eriophorum, Cirsium arvense* and pioneer tree species as *Sambucus racemosa, Salix caprea, Populus tremula*. Area NEX was the most similar as area REF. Here we don´t observe an increases in abundance of nitrophilous vegetation we do however record original species as *Picea abies, Vaccinium myrtillus, Avenella flexuosa, Calamagrostis villosa, Maianthemum bifolium, Luzula luzuloides, Oxalis acetosella, Dryopteris dilatata.* On all monitoring plots we observed the natural regeneration of trees: *Populus tremula, Sambucus racemosa, Salix caprea.* These species tend to prefer light and soil enriched by nitrogen, however *Betula pubescens* favour moisture stands. *Picea abies, Sorbus aucuparia* didn´t regenerate in stands of *Chamaerion angustifolium*. We observed growth of moisture-demanding vegetation on plot WTR1 as: *Juncus effusus, Carex tomentosa, Luzula multiflora*.

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Forests and environmental interactions – overview of results of ecological monitoring

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Abstract. Systematic forest condition assessment started in Slovakia in 1987 within the international co-operative programme on assessment and monitoring of air pollution effect on forests (ICP Forests). At present, the monitoring activities are being executed on 112 plots of large-scale forest monitoring (level I monitoring) and 8 intensive monitoring plots (level II monitoring). Results show changes in antropogenic and natural stress factors (air quality, climatic and weather conditions etc.) and indicators of forest and tree condition (defoliation, increment etc.).

Introduction

In the 1980s, forests of Slovakia were rather strongly affected by different types of air pollution and forest decline was observed not only on local or regional level. Forest condition assessment started on permanent monitoring plots on a 16x16 km grid in 1987. In 1995 the first three intensive monitoring plots were established under the pan-European programme. Main results are published in annual reports and also within the Environmental Information System of the Slovak Republic.

The national forest monitoring system comprises all activities defined in the ICP Forests programme: crown condition (defoliation, discoloration) and tree damage inventory, increment measurements, chemical foliar analyses, air quality monitoring, meteorological monitoring, atmospheric deposition monitoring, soil condition survey, soil solution monitoring, visible ozone injury assessment, ground vegetation survey, phenological observations, litterfall assessment. Other surveys were involved in National Programs Forest Focus (2003-2006) in relation to forest biodiversity indicators.

The monitoring system, beside national forests inventory and other forest surveys, is considered very important source of information about forest condition for decision makers, for scientists and also for public.

Data and methods

All data from long-term monitoring of forests are stored in the database of forest condition. However, time series for individual plots and different surveys are not the same.

Crown condition discoloration) and tree damage inventory on level I plots and level II plots is carried out annually (end of July, beginning of August).

Interval for sampling or assessment for different surveys on level II plots differs: from continuous measurement (air quality, meteorology) and sampling every two weeks (atmospheric deposition, soil solution, phenology, increment) to one or more years (foilar analyses) (Pavlenda et al., 2008).

Methods used for monitoring of forests and environmental interactions are harmonised in the frame of the program ICP Forests (and following programmes: Forest Focus and FutMon). Manuals for sampling and measurements for individual surveys and assessments are available on webapage of the programme (www.icp-forests.org).

Results and discussion

Relatively simple indicator of tree condition (though still discussed) is defoliation. Trees are annually assessed according to defoliation (in %) and class of defoliation (0, 1, 2, 3, 4). For evaluation of deterioration or improvement of the health condition of forests the proportion of trees in defoliation classes 2-4 (moderately and severely defoliated trees and dead trees) is crucial. The year 1989 can be considered the most critical when almost 49% of trees (all species together) were classified into the defoliation classes 2-4. Two years later, in 1991 an apparent improvement occurred (only 28% of trees were in defoliation class 2-4). Since that year the health condition of forests gradually deteriorated until 1994 and 1995. Years 1996-2000 and 2005 are the years with the best health condition of tree species. In 2008 the percentage of trees in defoliation classes 2-4 was 29 % (21 % of broadleaved tree species and 41 for conifers).

Values of average defoliation of all tree species together ranged in the period of years 1987-1996 in interval 25 - 30%. We can state that the health condition of the forests in Slovakia is stabilized in last years. The fluctuations in some years are caused mainly by climatic and meteorological factors. Hornbeam and European beech are the tree species damaged the least by defoliation while fir and spruce are tree species with the highest values of defoliation.

The diameter (or radial) increment is the most important mensurational parameters as it is basic and easily detectable component of volume increment. Fig.1 illustrates an example: average defoliation of Norway spruce and development of radial increment (ir) calculated as average value of all individuals of respective tree species.

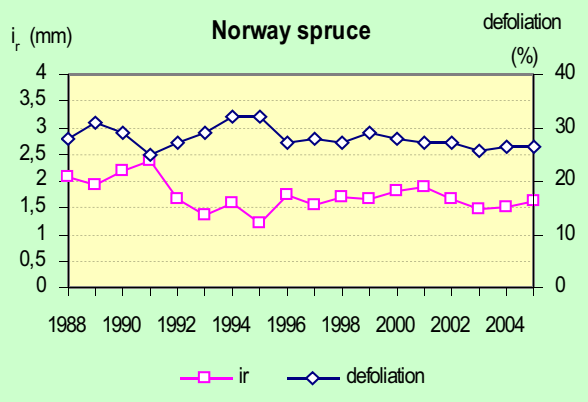

Figure 1. Relation between defoliation and radial increment *ir*.

Defoliation increase reflects in the same year usually in increment decrease. In 2003 the average radial increment dropped for all tree species when compared with 2002. It

was caused first of all by precipitation deficit in vegetation period.

Deposition is sampled and measured on all 8 intensive monitoring plots. Here we present evaluation for 2 typical forests with different trees species composition and geographical localization: Čiféare (Turkey oak stand, altitude 225 m, southern Slovakia) and Grónik (spruce stand, altitude 875 m, north-western Slovakia).

The sulphates and nitrates represent the main acidic components in forest ecosystems. The changes of weighted means for sulphates and nitrates concentrations in throughfall are documented in Figs. 2 and 3. Concentrations on sulphates show the decreasing trend on all monitoring plots, when the mean annual concentrations decreased from the level 4-5 $mg.l^{-1}$ (1997) to the level lower than 2 $mg.l^{-1}$ (2007). On the other hand the nitrates concentrations do not show any positive significant trend and concentrations of NH_4 are increasing. Similarly also the concentrations of calcium and magnesium do not show any significant trend, but we can detect the influence of the dry periods connected with higher level of terrestrial dust (2000, 2002 and 2003).

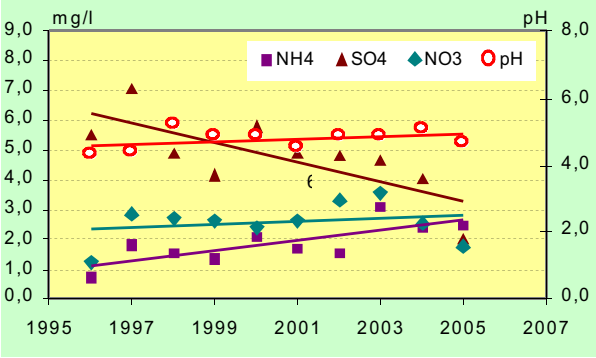

Figure 2. Trends in deposition quality on monitoring plot Čiféare.

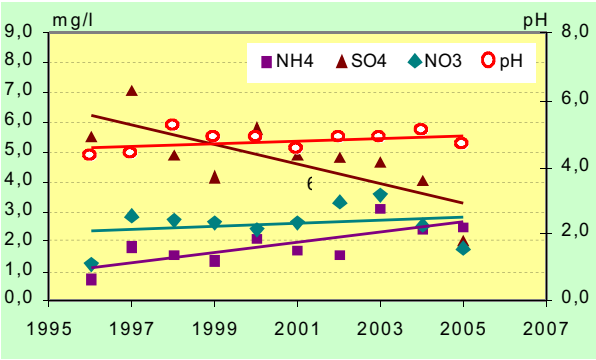

Figure 3. Trends in deposition quality on monitoring plot Grónik.

The total annual sulphur deposition in the year 2007 was about 5-11 kg per hectare, total annual nitrogen depositions ($N\text{-}NO_3$ and $N\text{-}NH_4$) were at the level of about 5-13 kg of nitrogen per hectare. The highest values for both sulphur and nitrogen deposition have been detected on the plot Grónik (Beskydy Mts.). The throughfall nitrogen depositions show the important influence of canopy due to uptake and leaching from and to assimilatory organs. Therefore in some cases we can find a situation when the throughfall nitrogen deposition is lower than the bulk nitrogen deposition (open field). Such situations are mainly connected with occurrence of broadleaved trees. For Norway spruce forest (Grónik plot) the throughfall deposition is higher than bulk nitrogen deposition all years. In that case the effect of nitrogen leaching from the canopy is more important.

Ozone concentrations showed typical annual pattern with double maximum (late spring - April, May and late summer - August), and winter minimum. The value of annual mean level depends on the altitude and photochemical conditions in concrete year. AOT40 (accumulated ozone exposure over a threshold of 40 ppb) is calculated for daylight hours during vegetation season (April – September). The critical level 10,000 ppb is regularly exceeded in all stands, in photochemicaly favourable years even at the beginning of the vegetation season. On the other hand , critical level of 100 ppb for 1-hour mean is exceeded only rarely.

Drought has become very important factor infuencing tree viatlity. Very clear impact of water supply on tree increment is demontrated on the example of plot Čiféare, year 2003 (Fig. 4).

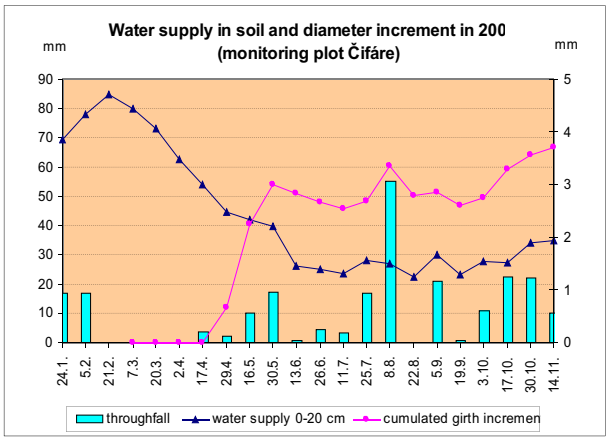

Figure 4 Relation between precipitation, soil water supply and increment of trees.

Conclusions

The long-tem monitoring of forests has brought many important results, knowledge and information for policy makers both at national and European level. The existing monitoring system is a unique basis for harmonised data collection and analyses producing information in forestry including broader environmental aspects of forests.

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Evaluation of Ozone Effects on ICP Forests Intesive Monitoring Plots in Slovakia

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Abstract Ozone concentrations from four ICP Forests (Internationl Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests) intensive monitoring plots in Slovakia from vegetation period in 2008 obtained by using of passive sampling method are evaluated in this paper. Simultaneously, assessment of ozone visible symptoms on vegetation within closed forest edge was carried out on these plots. The symptomatic plant species were recorded on all of assessed plots. The number of symptomatic species ranged from 1 to 3 per plot. Beside ozone concentration, it was affected by site conditions and species diversity of particular plots.

Introduction

Ground ozone is considered as the most important air pollutant for forest ecosystems in Europe and North America. Critical levels of ozone set for protection of vegetation are broadly exceeded. Ozone can cause adverse effects on vegetation, including visible foliar injury, growth and yield reduction, enhanced sensitivity to abiotic and biotic stress.

Monitoring of ozone and assessment of ozone visible injury at intensive monitoring plots within ICP Forests program has been carried out since 2001 in Europe. Passive methods are broadly used for ozone monitoring due to their simplicity and relatively low costs. The main advantage of this method is independence on the electric power and measuring devices, which are neccessary for continual monitoring. Small size and low weight of passive samplers (tubes, filters, etc.) made this method suitable for application in complex terrain and vertical profiles of forest stand. The disadvantage of this method is its robust approach and impossibility of direct calculation of critical levels exceedance.

The ozone visible injury was assessed only in one intensive monitoring plot Poľana – Hukavský grúň during previous years in Slovakia, where the continual ozone monitoring data were available. In 2008, passive samplers were used for monitoring of ozone concentrations at selected intensive monitoring plots. Consequently, assessment of ozone visible symptoms on vegetation within closed forest edge was done at the end of the vegetation season on these plots.

Data and methods

Study sites

Ozone monitoring was organized at selected ICP Forests intensive monitoring plots with different altitude, tree species composition and site conditions. The basic description of study plots is given in Tab. 1.

Monitoring of ozone concentrations

The passive samplers from Gradko Ltd. were used for monitoring of ozone concentration. The ozone tubes were exposed during vegetation period (April – September) with two week exposure interval in an open plot near monitoring plot, except of Hukavský grúň, where ozone measurements were carried out at the top of the meteorological tower. At Hukavský grúň, passive samplers were collocated with active ozone monitor API 400 as well. Selected meteorological parameters were measured in parallel with ozone measurements, to evaluate effect of meteorological conditions to ozone uptake by pasive samplers.

After exposure, the tubes were stored in refrigerator and sent back to Gradko Ltd. for analysis.

Table 1. Basic description of intensive monitoring plots with ozone measurements in 2008

Intensive monitoring plot	Ladzany (Štiavnické vrchy)	Grónik (Moravsko-Sliezske Beskydy)	Hukavský grúň (Poľana)	Lomnistá dolina (Nízke Tatry)
Latitude	48°17´41´´	49°29´54´´	48°38´34´´	48°55´31´´
Longitude	18°51´07´´	18°34´04´´	19°32´22´´	19°29´15´´
Altitude	532 m	820 m	850 m	1250 m
Aspect	WSW	SSW	NE	SE
Slope	5 – 15 %	60 %	5 – 15 %	35 %
Age of forest stand	130, 2	90	90 - 120	57
Edapho-trophic order	B	A	B	B/C
Forest type group	Querceto-Fagetum	Fagetum abietino -pic. nst.	Abieto-Fagetum	Fageto-Aceretum vst.
Tree species composition (%)	oak-80, beech-15, hornbeam-5	spruce-100	beech-70, spruce-20, fir, maple, ash-10	spruce-95, beech, maple, rowan-5

Visible ozone injury

Assessment of ozone visible injury was done according to UN-ECE/ICP Forests Manual (2004), part X.B. The occurence of ozone symptoms was searched within LESS plot (Light Exposed Sampling Site), which was established in the sun exposed forest edge in the vicinity of the open plot with ozone measurements. Natural vegetation was surveyed for ozone syptoms at the given number of subplots (mini-LESS), which were temporary established within the LESS plot, according to the manual. All study sites differ in lenght of LESS plot and number of mini-LESS.

Results and disscussion

Monitoring of ozone concentration was carried out during vegetation period, exposure interval for passive samplers was two weeks. Average ozone concentrations for exposure intervals are given in Fig. 1.

Ozone concentrations during vegetation period showed typical seasonal pattern for all plots. Two maxima were reached, the first in the beginning of May, the second in the

beginning of July, however, high ozone concentrations lasted till the end of August. Average ozone concentrations during whole vegetation period at monitoring plots reached following values: 52.0 ppb (Lomnistá dolina), 54.2 ppb (Ladzany), 56.7 ppb (Grónik) and 63.8 ppb (Hukavský grúň).

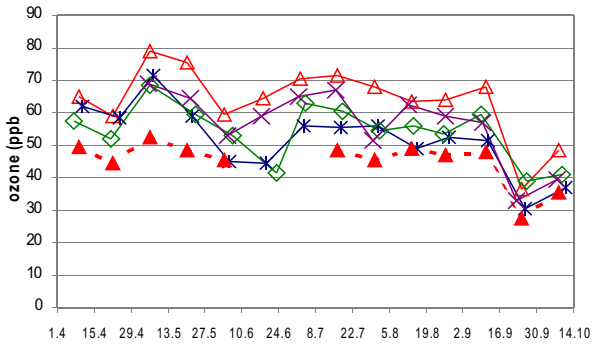

Figure 1. Average ozone concentrations for exposure intervals during vegetation period in 2008 (Hukavský grúň △, Lomnistá ✳, Ladzany ◇, Grónik ×, Hukavský grúň - analyzer ▲).

To test the accuracy of passive assessment of ozone concentration, comparisons with values obtained from automatic analyzer calibrated to national ozone standard were used. Ozone concentrations obtained from passive sampling and automatic analyzer showed relatively high correlation (r^2=0.87), however, values obtained from passive sampling was systematically overestimated for 39.6 % in average. Afterwards, all concentrations were corrected by the coefficient of 0.71. Corrected ozone concentration reached values in range 37.3 – 45.7 ppb.

During processing of monitoring data, the effect of selected meteorological parameters to average ozone concentration was evaluated. From set of evaluated meteorological parameters (air temperature and humidity, wind speed, global radiation), only air temperature showed correlation with ozone. During spring, till reaching of spring ozone maximum, ozone concentrations and air temperature showed independent pattern. During summer, in the hot period, ozone average concentrations showed relatively high correlation with average air temperature at all evaluated plots (r^2 = 0.70 – 0.86).

Assessment of ozone visible injury was carried out in the beginning of September, when there is assumption, that ozone symptoms on sensitive species may occur. All trees, shrubs and herbs within mini-LESS were assessed (except of monocotyledone). Total number of species per plot, average number of species per subplot, abundance of species, number of symptomatic species and percentage of plots with symptom occurence were evaluated.

LESS plots at Hukavský grúň, Ladzany and Lomnistá have the highest species diversity, the last one has the highest average number of species per subplot. All of these plots are situated in mezonitrophilic or mezotrophic edapho-trophic order. LESS plot Grónik, situated in oligotrophic order, has the lowest total number of species and average number of species per plot as well.

Generally, 9 symptomatic species were found in all plots in 2008. Equal number of symptomatic species of 3 was found at Hukavský grúň and Ladzany , 2 in at Lomnistá and 1 in at Grónik. Considering total number of species per plot, the highest relative number of symptomatic species has LESS plot Grónik, the lowest LESS plot Lomnistá. Lomnistá has the lowest percentage of subplots with symptoms occurrence - 16 % only, then follows Grónik, Poľana and the highes percentage of subplots with symptoms occurence reached Ladzany (48 %).

Assessed visible ozone injury only partially corresponds to measured ozone concentrations. The lowest ozone concentrations during vegetation period 2008 showed monitoring plot Lomnistá, which had the lowest percentage of symptomatic species and the lowest percentage of subplots with ozone symptoms. The highest ozone concentrations were measured at locality Hukavský grúň, however, this one had only average percentage of both symptomatic species and subplots with symptoms occurrence. At locality Ladzany, which had the highest percentage of symptomatic species and subplots with symptoms, the values of ozone concentrations were lower than the average.

The aim of this assessment is not comparison of forest sites within relatively small region, with differences not only in ozone levels, but also in site conditions influencing ozone uptake and with different sensitivity of present species. Assessment of ozone visible injury in Slovakia is important as a part of survey monitoring across the whole Europe. In this large-scale survey, there is potencial for comparison of sites with similar species composition and site conditions. However, the main goal of this survey is spatial and temporal mapping of ozone symptoms incidence.

Conclusions

Monitoring of ambient ozone using passive sampling seems to be suitable method for spatial evaluation of ozone stress to forest ecosystems.

Assessment of ozone visible injury was carried out simultaneously with monitoring of ozone concentrations. The presented study contributes to the European spatial survey. The result of this monitoring is ozone injury distribution across Europe. Considering site conditions that affect ozone uptake, the presence of ozone injury seems to be good marker of ozone stress to forest ecosystems.

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Fluxes of total mercury (THg) in forested ecosystems in the Kremnické vrchy Mts.

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Abstract. Mercury (Hg) is a global pollutant, but little information is available on rates of atmospheric input, outputs and distribution in forests ecosystems and soils in Slovakia. The objectives of this study were to investigate input and output fluxes of total mercury (THg) in two forest ecosystems with a different anthropogenic load in Kremnické vrchy Mts. The first monitored site was located in an area with a strong mining activity in the past (14th- 18th century). The controlled site was located in a remote area near protected area called „Badínsky prales". Bulk precipitation, throughfall, litterfall and drainage water leaching from soil layer (two dephts - 10 and 20 cm) were collected biweekly from April 2008 to May 2009. The results pointed out high levels of mercury wet deposition at both monitored plots (MP1: 51 g.km^{-2} y^{-1}, MP2: 37 g.km^{-2} y^{-1}) and high levels of mercury deposition via througfall (MP1: 74 g.km^{-2} y^{-1}, MP2: 51 g.km^{-2} y^{-1}). Fluxes of THg via litterfall have less importance in mercury cycling in the studied areas. Forest ecosystem has ability to capture atmospheric Hg, so it is forming a source of the new Hg inputs (througfall, litterfall) in the forest floor.

Introduction

Due to its physicochemical properties mercury (Hg) is a naturally widespread element on the global scale. It is released into the environment by both, natural sources and human activities in three dominant forms: elemental mercury Hg^0, divalent mercury Hg^{2+} and particulate mercury Hg(p) (Schroeder&Munthe, 1998). Natural transformations and environmental pathways of mercury are very complex and are greatly affected by local conditions.

Forest ecosystems are link between atmospheric mercury and aquatic ecosystems (Schwesig&Matzner, 2000). The most important fluxes of THg to the forest floor are wet deposition, dry deposition and litterfall and the important outputs are vaporization of mercury from forest soil and canopy, leaching of mercury from soil layer and runoff (Grigal, 2002, Friedli *et al.,* 2003). In spite of the importance of the forests ecosystems in the global biogeochemical cycle of mercury, there is little information on size of these fluxes in the forest. The aim of this study was thus to determine fluxes of total mercury (THg) in two forests with different anthropogenic load in the past in Kremnické vrchy Mts. (Slovakia).

Data and methods

The plots MP1 and MP2 are situated in the Kremnické vrchy Mts. (Slovakia). The plot MP1 (19° 02' 51" E; 48° 42' 59" N) dominated by *Fagus sylvatica* L., *Picea abies* (L.) Karst. and *Pinus nigra* L. is located in a historic mining area of cinnabar (14th-18th century) near village Malachov. The elevation ranges from 715 to 730 m above sea level (a.s.l.). The MP2 plot (19° 03' 34" E; 48° 41' 35" N) dominated by *Fagus sylvatica* L., *Picea abies* (L.) Karst and *Abies alba* L. is located near a protected area "Badínsky prales". The elevation ranges from 725 to 740 m a.s.l.

Samplers for throughfall, bulk precipitation and drainage water leaching from soil were self-constructed according to Schwesig&Matzner (2000, 2001). For throughfall sampling, in each field three samplers were installed. Bulk deposition was collected by one sampler at an open site in each field. Samplers for soil drainage water were installed in two dephts (10 and 20 cm) in the forest and in the open field at each area. For litterfall sampling, three high-density polyethylene funnels (80 cm diameter) were installed 1 m above the ground in each field. Bulk deposition, throughfall, litterfall and soil drainage water were sampled biweekly from April 2008 to May 2009.

All liquid samples were filtered (glassfibre 1mm) and kept in cold. The samples of litterfall were dried at laboratory temperature and then they were homogenized.

Analysis of total Hg (THg) in the samples was performed by Advanced Mercury Analyser AMA 254 (the single-purpose absorption spectrophotometry) with the detection limit of 0.01 ng Hg. Every sample was analysed three times at least.

Throughfall, bulk deposition and litterfall fluxes of THg were calculated by multiplying the measured volume in the samplers by the determined concentration biweekly. In this same way was calculated the leaching from two soil depths (10 and 20 cm).

Results and disscussion

Direct wet deposition of THg.

Concentrations of THg at the plot MP1 ranged between 0.01 – 0.21 μg.l^{-1} and at the plot MP2 ranged between 0.01 – 0.16 μg.l^{-1}. Fluxes of THg in direct wet deposition were 51 g.km^{-2} yr^{-1} (MP1) and 37 g.km^{-2} yr^{-1} (MP2). Direct wet depositions of THg in our condition are higher than in Scandinavia (10 g.km^{-2} yr^{-1} – Lee *et al.,* 2000) or North America (8.7 g.km^{-2} yr^{-1} – Rea *et al.,* 2002), but comparable with data from Germany (35 g.km^{-2} yr^{-1} – Schwesig&Matzner, 2000).

Throughfall fluxes of THg.

Mean concentrations of THg in throughfall collected at the plot MP1 under spruce/beech/ pine forests ranged between 0.03 – 0.36 μg .l^{-1} and at the plot MP2 under spruce/beech/fir forests ranged between 0.03 – 0.29 μg.l^{-1}. Fluxes of THg in throughfall at the MP1 plot during the monitored period were 74 g.km^{-2} yr^{-1} and at the MP2 plot 51 g.km^{-2} yr^{-1}.

Concentrations of THg in net throughfall (concentrations THg in throughfall minus concentrations THg measured in direct wet deposition) were not significantly correlated with concentrations in wet deposition measured in the open.field Same explanation introduced St. Louis *et al.* (2001).

Fluxes of THg via througfall were higher than those in direct wet deposition, suggesting that dry deposition of mercury at both monitored sites is relatively high. Lindberg *et al.* (1994) have suggested that net throughfall is a good estimate of dry deposition of mercury to ecosystems.

Litterfall fluxes of Hg.

Concentrations of THg were at the plot MP1 between 0.036 – 0.589 $\mu g.g^{-1}$ and between 0.035 – 0.129 $\mu g.g^{-1}$ at the plot MP2. Flux of THg in litterfall at the MP1 plot during the monitored period was 27.0 $g.km^{-2}\ yr^{-1}$ and at the MP2 plot was slightly lower (22.9 $g.km^{-2}\ yr^{-1}$). These results are comparable with data from remote areas in Scandinavia (23 $g.km^{-2}\ yr^{-1}$ – Munthe *et al.,* 1998) or Gemany (16-32 $g.km^{-2}\ yr^{-1}$ – Schwesig& Matzner, 2000). Some authors (e.g. Lee *et al.,* 2000; Schwesig&Matzner, 2000; Grigal, 2002) consider that litterfall is the most important input of mercury to the forests floor.

Total flux of THg under the forest canopy.

Our data clearly show that the forest canopy provides (via litterfall and throughfall) an important additional flux of THg to forest ecosystems. At both monitored sites total flux of THg under a forest canopy was 2 times higher as the flux of THg in wet deposition in the open field (Figs. 1, 2).

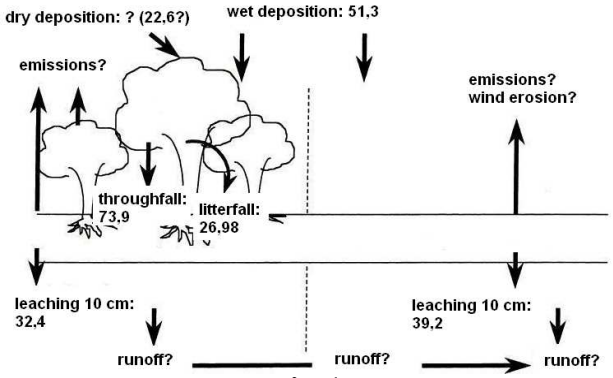

Figure 1. Fluxes of THg ($\mu g.m^{-2}.\ yr^{-1}$) at the plot MP1.

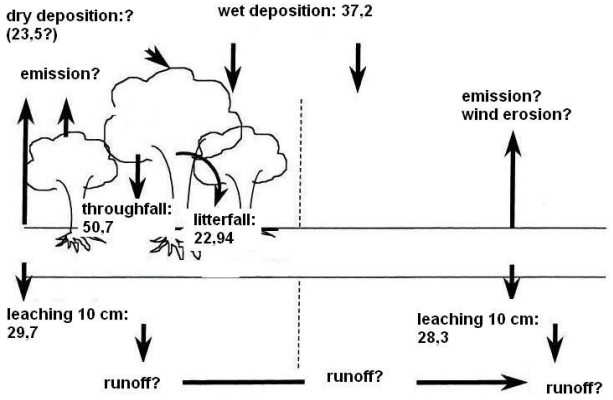

Figure 2. Fluxes of THg ($\mu g.m^{-2}.\ yr^{-1}$) at the plot MP2.

Ouput fluxes of THg via leaching from soil.

THg concentrations in soil drainage water in the forest at the MP1 plot were higher (0.09 – 0.33 μg $THg.l^{-1}$) than the concentrations at tha MP2 (0.05 – 0.22 $\mu g.l^{-1}$). Similar results are in the open field (MP1: 0.02 – 0.25 $\mu g.l^{-1}$, MP2: 0.02 – 0.18 $\mu g.l^{-1}$). Output fluxes of THg of leaching from soil layer (10 cm) at both monitored sites are shown in Fig. 1 and in Fig. 2.

On the basis of these results we can see potential accumulation of THg in forest floor. Total mercury in forest floor could be under methylation prosesses or under vaporization. These fluxes we are not able to monitor under our conditions.

Conclusions

Deposition rates of THg from open field precipitation and througfall in forests ecosystems in the Kremnické vrchy Mts. (Slovakia) were found higher as compared to remote areas in Scandinavia and in North America, but they were only slightly higher than fluxes in Germany. The THg fluxes by net throughfall and even higher fluxes of this compound by litterfall indicate Hg deposition processes to the foliage, since significant root uptake seems improbable. At our monitored sites, litterfall was not as dominating for the soil input of THg as it was found in other studies. Determination of THg fluxes via litterfall and throughfall is important in calculations of critical mercury load for forests soil.

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Soil microscopic fungi composition at monitored localities in the Vysoké Tatry Mts.

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Abstract. Genera and species composition of soil microscopic fungi including heat-resistant ones is presented. Species *Talaromyces striatus, Trichoderma koningii, T. viride*, *Zygorhynchus moelleri* and *Z. heterogamus* belong to the most frequent occurring in all studied soil samples. Four new species of soil microscopic fungi for Slovakia were identified: *Eupenicillium lapidosum, E. abidjanum*, *Myceliophtora thermophila* and *Talaromyces ohiensis.*

Introduction

The changes of plant community structure affect not only the soil, reserves of water in it, but the other pedochemical charcteristics and the entire ecosystem, including its zoological and the microbial parts. The changes of soil microbiocoenoses could be evident in biodiversity of soil microorganisms, in extension of physiological groups of microorganisms as bacteria and microscopic fungi, in their activity and activity of biological processes running in the soil.

Material and methods

Soil sampling was realised at four international monitored research plots of about 30 m x 30 m in Vysoké Tatry Mts.: EXT - Danielov dom, GPS - N49°07'11.9''; E20°09'47.6''. Plot NEX - Tatranská Lomnica - Jamy, GPS - N49°09'36.3''; E20°15'08.8''. Plot REF - Vyšné Hágy, GPS - N49°07'17.5''; E20°06'16.4''. Plot FIR - Tatranské Zruby, GPS - N49°07'49.7''; E20°11'57.3''.

Soil samples from the A horizon upto the depth of 15 cm were taken from five sampling points during the vegetation period at each monitored plot in 2007-2008. Average soil sample comprised the mixture of soil from all five points at each plot. The soil was siewed through 2 mm siewe being resulted at the fine soil. Genera and species composition of soil micromycoflora including heat-resistant species were studied. The amount of 10 g of the fine soil was used to isolate microscopic fungi. CDY, PDA and MEA (Himedia, Bombay, India) according to Domsch et al. (2007) were used as cultivation media. The heat-resistant microscopic fungi were isolated from the amount of 100 g of fine soil in SAB medium with Rose Begal (Himedia, Bombay, India) after heating at 75 °C for 30 min. and cultivated at 25 °C according to Samson et al. (1996). SAB agar was used for the pure cultures' isolation. The species were identified according to De Hoog&Guarro (1995), Domsch et al. (2007) and Pitt (1979). Pure cultures are deponed on the SAB agars at the Department of Soil Science, Faculty of Natural Sciences, Comenius University and in the Certificated Lab of Indoor Mycology, Slovak Medical University in Bratislava.

Results and discussion

At the plots EXT, REF and NEX, there are Dystric Cambisols and Eutric Cambisol at the plot FIR. The soils range from extreme acid to very strongly acid (Mičuda et all., 2006). Monitoring of changes of pedochemical (% C_{ox}, % N_{tot}, C/N, % of humus, NH_4-N mg/kg) and microbiological parameters (C_{bio} mg C.100g/kg dry soil, CO_2 kg soil/24h.) is given by Hanajík et al. (2009). Cambisols belog to the group of the most widespread forest soils in Slovakia with occurrence of 55.4 % (Šály, 1996). The soils are very heterogenous with a low amount of organic matter (1.77 % C_{ox}), (Bielek, 1999).

Table 1. Soil microscopic fungi identified at the monitored plots (E - EXT, R - REF, N - NEX, F - FIR).

Genera/species	Plot			
	E	R	N	F
Absidia sp.	+	-	-	-
Achaetomium sp.	-	-	+	+
Acremonium murorum	+	-	-	
Alternaria alternata	+	+	-	+
Aspergillus fischerianus	-	+	-	-
Botryotrichum piluliferum	-	-	+	-
Cladosporium sp.	-	+	+	-
Eupenicillium lapidosum	-	-	-	+
E. abidjanum	-	-	-	+
Mucor sp.	-	+	+	+
Mortierella bainieri	+	+	+	-
Myceliophtora thermophila	+	-	+	-
Neosartorya fischeri	+	-	-	+
Gliocladium sp.	-	-	+	-
Paecilomyces sp.	-	+	-	+
Penicillium sp.	+	+	+	+
P. expansum	-	-	-	+
P. glabrum	+	-	+	+
P. janthinellum	+	-	-	-
P. raistrickii	+	-	-	-
Piptocephalis sp.	-	-	-	+
Rhizopus stolonifer var. *stolonifer*	-	+	-	-
Talaromyces flavus	+	+	-	+
T. ohiensis	+	-	-	-
T. striatus	+	+	+	+
T. wortmanii	-	-	-	+
Trichoderma harzianum	-	-	+	+
T. koningii	+	+	+	+
T. viride	+	+	+	+
Verticillium lecani	+	-	-	-
Zygorhynchus heterogamus	+	+	+	+
Z. moelleri	+	+	+	+
Sum: 31	18	14	15	19
%	58.1	45.2	48.4	61.3

In the studied soil samples, there were 31 genera and species of soil microscopic fungi identified (Tab. 1). The species of *Talaromyces striatus, Trichoderma koningii, T. viride, Zygorhynchus moelleri* and *Z. heterogamus* occurred in all soil samples. At the contrary, the species of genera

Absidia, Gliocladium and *Piptocephalis* and the species *Acremonium murorum*, *Aspergillus fischerianus*, *Botryotrichum piluliferum, Eupenicillium lapidosum, E. abidjanum, Penicillium expansum, P. janthinellum, P. raistrickii, Rhizopus stolonifer* var. *stolonifer, Talaromyces ohiensis, T. wortmanii* and *Verticillium lecani* were isolated only once. Four new species of microscopic fungi, *Eupenicillium lapidosum, E. abidjanum*, *Myceliophtora thermophila* and *Talaromyces ohiensis* for Slovakia were found in the analysed soil samples. These species are not listed in the Checklist of non-vascular and vascular plants of Slovakia (Lizoň & Bacigálová, 1998).

The occurrence of microscopic fungi in the soils of the Vysoké Tatry Mts. was studied only marginally until now (Bernát, 1958, 1976; Šimonovičová, 1989, 1992a, b, 1993). Therefore, we can't pronounce if the found fungal species are common, less common, scarce or rare. To study species which formed only sterile mycelium without generative structures (mycelia sterilia) seems to be very important.

Conclusions

The comparative plot REF is a stabile forest ecosystem with any extreme differences of basic pedochemical characteristics including the abundance and occurrence of soil microscopic fungi. It can be supposed, the noticed differences between the monitored plots EXT, NEX and FIR will change during the following years. The plot influenced by the fire (FIR) represents the independent ecosystem in which the ash layer positively influences the soil mycobiocoenoses. At the plot with extracted wood mass (EXT), the increased solar radiation can be considered as a very important factor which is closely related to the changes of the soil temperature and moisture. On the other hand, at the plot with non-extracted wood mass (NEX) the influence of fallen trees is evident. They help to stabilize the soil moisture and affect the soil temperature as well.

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Seasonal dynamics of the selected water balance compounds in the Norway spruce, beech and oak forest stands in Slovakia: Experimental study in mesoscale basins

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Abstract. This study is focused on an evaluation of preliminary findings from water regime research in the selected spruce, oak and beech forest stands in Slovakia. The experimental results related to the years 2007 and 2008 are presented. The spatial hydrological models developed for two target mesoscale basins were validated by the measured and calibrated data of volumetric soil water content (SWC%). In the paper also the seasonal development of SWC% in the forest soils of different properties in relation to the daily precipitation amount is discussed. In the measurements as well as in models the upper (15 cm) soil layer seems to be more sensitive and fluctuating than the deeper one. Based on our findings we can conclude that correctly parametrised spatial models are useful tools for hydrological analysis in mesoscale basins. Nevertheless before interpretation of results the models should be validated and so enhanced by experimental data obtained directly in the field.

Introduction

Water supply is often one of the key factors affecting growth and health forest stands. In order to gain a better understanding of seasonal dynamics of main water balance components (soil moisture, precipitation under canopy, evapotranspiration) the long term and continuously recorded experimental data from the different forest sites are highly required. The experimental data are also essential for parametrisation or validation of hydrological and water budget models. On the other hand, the large spatial and temporal microvariability of the forest soil properties makes the precise soil moisture measurement hardly achivable. Therefore a sensors calibration to the specific soil condition at a given site is one of basic prerequisites to obtain data of acceptable quality. The paper consider some ecohydrological aspects of complicated water cycle in the forest stands and try to analyse this problem at different levels (basins, forest stands, soil profiles, horizons).

Data and methods

Two mesoscale basins in the middle-western (Bebrava basin) and northern (Kysuca basin) part of Slovakia were selected as the model areas (Fig. 1). Eight research plots have been established in forest stands of each basin. Locations of field measurements were based upon the most occured combination of forest and soil types across the basins. The Kysuca basin covers area of 1016 km^{-2} with 52% of total forest coverage dominated by man-made pure Norway spruce stands with locall admixture of beech, fir and other tree-species. The Bebrava basin is of rather small area (420 km^{-2}) with the total forest coverage about 58%. The forest stands are dominated by beech (40%) and oak with a few more important admixed species: Scotch pine, Black pine and Norway spruce.

The volumetric soil water content (SWC%) was measured at each research plot at three measuring points in two soil depths (15, 45cm). The Frequency Domain Reflectometry method was applied for measuring of the volumetric water content. The Soil Moisture Sensors EC–10 of company Decagon Device, Inc. (2006) were calibrated to the soil specific condition according to approach published in Kodešová *et al.* (2008). SWC data were recorded at hourly interval. Meteorological parameters such as precipitation, air temperature, humidity and global radiation were measured by standard methods in the open area located near the research plot. In this study we compared also the measured SWC data with the results of two hydrological models: SWIM (Krysanova *et al.,* 1998) and FRIER (Horvát, 2008).

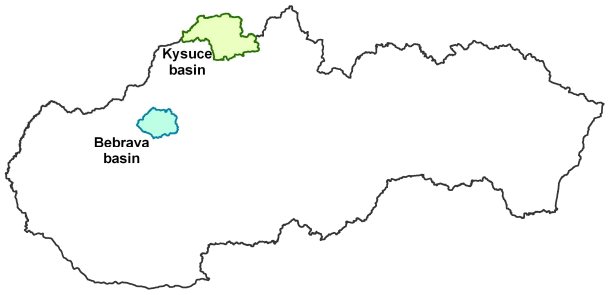

Figure 1. Location of study regions (Bebrava and Kysuca river basins) in Slovakia

Results and disscussion

The experimental findings based on field measurements of some water balance components can be analysed from several points of view. On the one hand is the variability within the research plots that shows a diversification not only in the one soil profile but also between the measurement points. On the other hand, there is also the aspect of an evaluation of the seasonal dynamic of soil water content and its comparison between forest stand within basin and between the basins as well.

The measured values show the soil water content response to the actual precipitation events (Fig. 2) and they also reflect the soil physical properties (rendzinas in beech stand A and luvisols in oak stand B).

Beside the assessment of the moisture behavior during the growing seasons 2007 and 2008 also the comparison of simulated and observed data was achieved. As the results from measurement locality Olešna in the Kysuca basin show (Fig. 3), the comparison suggests fairly well correspondence between the modeled and observed seasonal trends of SWC%.

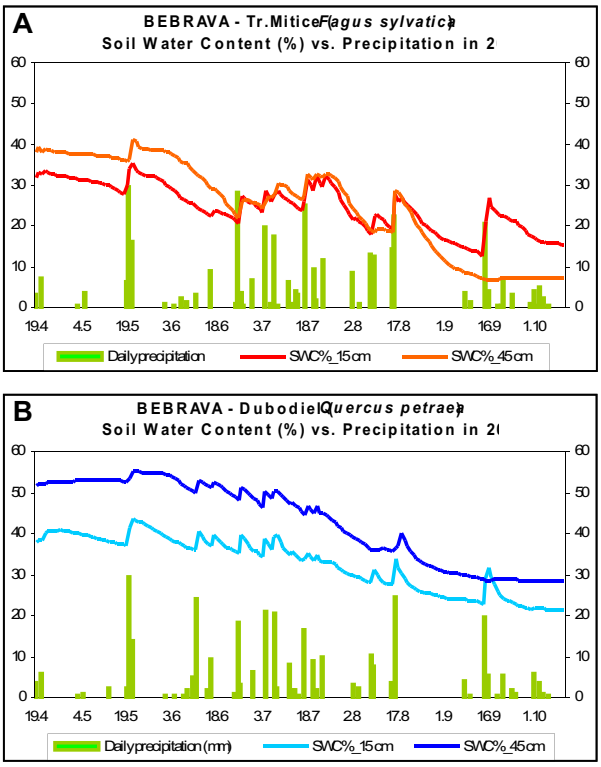

Figure 2. Development of daily precipitation (mm) and soil water content (%) observed in beech (A) and oak (B) forest stands during the growing season of year 2008.

The remaining discrepancies pointed out the need of further model parameterizations in the interactions with given soil physical properties and climatic seasonal variation.

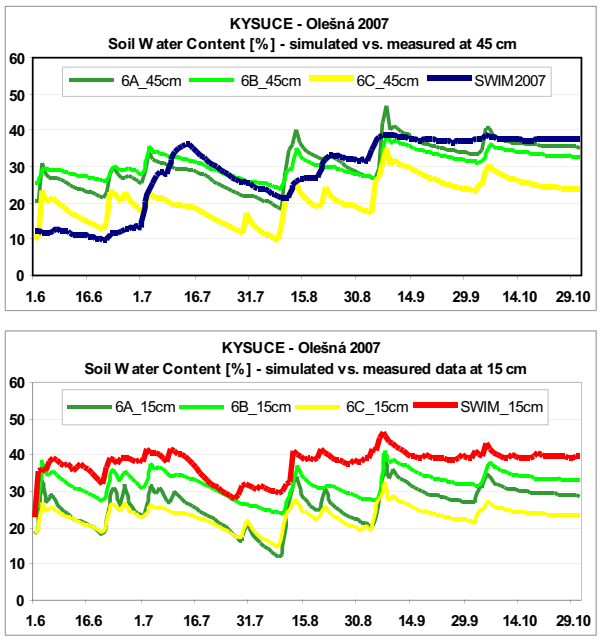

Figure 3. Measured and modeled data of SWC% at two soil depths (15 cm and 45 cm) during the growing season 2007. An example of typical adult Norway spruce monoculture with podzol cambisols is shown.

From seasonal variation of measurements as well as from model values is also evident that the upper layer (15 cm) responds much more sensitive to changes of meteorological variations than the deeper horizon (45 cm), what appeared by smaller but more frequent fluctuation of SWC values. Better agreement between modeled and observed soil water content dynamic in the upper soil layer also significant R square 0.65 at depth 15 cm confirms.

Conclusions

However, both, the soil and the trees are interconnected elements of forest ecosystems; the seasonal dynamic of soil moisture reflects more the hydrophysical properties of soil than the properties of the vegetation (forest) cover.

The other outcomes of this study indicate that the SWIM and FRIER models are good modeling tools for spatial analysis of hydrological conditions in the mesoscale basins because besides they include the huge range of input data provide also benefits of simulation in various time and spatial step. Moreover all hydrological processes produced by above mentioned models can be easily visualized using different GIS software.

Finnaly, this paper emphasizes the need of further improvement of spatial hydrological models (mainly better considering of actual landuse categories and specific soil properties) on the one hand and gain the quality and long-term measurements of main water balance compounds (soil moisture, precipitation under canopy, transpiration) on the other hand.

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The analysis of selected phenological stages of Norway spruce (*Picea abies* (L.) Karst.) from Slovakia

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Abstract. The paper presents evaluated results of observations concerning the selected vegetative (bud burst, the first May shoots), generative (male flowers lasting) and general flowering phenological stages of Norway spruce (*Picea abies* (L.) Karst.). There were 38 phenological stations in Slovakia observed during the period of 1996-2008. Stations situated in the altitudinal range 100-940 m a.s.l. were divided in 3 altitudinal groups. The average start of bud burst was observed from the 21st April till the 6th May, the first May shoots occurred from the 2nd May till the 18th May. The average time of male flowers was lasting from the 12th May till the 19th May and the general flowering occurred from the 17th till the 24th May. The time shifts of vegetative phenological stages among the mentioned altitudinal groups were 2 – 5 days. The trends of occurrence concerning the all phenological stages pointed out a shift to a sooner time period.

Introduction

Norway spruce (*Picea abies* (L.) Karst.) belongs to the most spread out tree-species in Slovakia and its artificial growing as pure forest stands has brought many problems. That is the reason why it is necessary to pay the greater attention to its original populations, but also to its reactions to changed conditions within the new area of their occurrence. Phenological observations have proven to be the important bio-indicators of changed environmental conditions. They can be applied to recognition of mutual relationships between the revealed phenological trends and the development of a climate (Balut & Sabor, 2002; Skvareninova, 2008), as well as to the modeling of phenological stages of tree-species at the possible impact of climate change and the forecast of their further spreading out and vitality.

Data and methods

Data about the vegetative (bud burst - ZP, the first May shoots - PMV) and generative (male flowers lasting - KSK and general flowering – KV) phenological stages of Norway spruce (*Picea abies* (L.) Karst.) were collected by using the phenological network of the Slovak Hydro-meteorological Institute (SHMI). There were observed 38 localities from Slovakia within the altitudes from 100 m up to 940 m a.s.l. These phenological observations were carried out according to the methodological guidelines of the SHMI (Braslavská & Kamenský, 1996). These localities have been divided into 3 altitudinal groups with the approximately same altitudinal intervals and the number of stations. These statistical data were processed by using the spreadsheet Microsoft Excel.

Results and discussion

The average starts of phenological stages, as well as the next statistical characteristics are presented in Tab. 1.

Table 1. The statistical characteristics of phenological stages in particular altitudinal groups (Ø – the mean beginning of a stage, min – the soonest start, max – the latest start, s_x% - the coefficient of variation).

Altitudinal groups	**1** (100–300 m a.s.l.) n= 11			
Phenostages	Ø	min	max	s_x%
ZP	21.4.	24.3.	5.5.	8.42
PMV	2.5.	11.4.	25.5.	6.36
KSK	12.5.	11.4.	16.6.	7.8
KV	17.5.	17.4.	21.6.	7.47
Altitudinal groups	**2** (310–500 m a.s.l.) n= 14			
Phenostages	Ø	min	max	s_x%
ZP	28.4.	20.3.	19.5.	8.26
PMV	9.5.	20.4.	28.5.	7.57
KSK	14.5.	21.4.	15.6.	6.89
KV	19.5.	2.5.	20.6.	6.66
Altitudinal groups	**3** (510–940 m a.s.l..) n= 13			
Phenostages	Ø	min	max	s_x%
ZP	6.5.	10.4.	26.5.	6.26
PMV	18.5.	28.4.	18.6.	6.4
KSK	19.5.	25.4.	26.6.	9.55
KV	24.5.	10.5.	23.6.	8.61

The phenological stage of bud bursting was observed from the 21st April till the 6th May, the first May shoots occurred from the 2nd May till the 18th May. The time shifts of a ZP stage among the investigated altitudinal groups have approached 7 – 8 days. The soonest start of a phenostage was recorded on March 20, 2007 at the station of Ratkova situated in the altitude of 330 m a.s.l., its latest start occurred on May 26, 1997 at the locality of Liptovska Teplicka (940 m a.s.l.). The soonest PMV have been recorded at Banovce nad Ondavou (105 m a.s.l.) on 17. 04. 2000, its latest occurrence at Vysny Slavkov (770 m a.s.l.) on June 18, 2006. Time shifts among observed altitudinal groups lasted 7-9 days.

The average generative phenostage of KSK was lasting from the 12th till the 19th May with observed shifts among particular altitudinal groups approaching 2 – 5 days. The soonest has started at Trencin (210 m a.s.l.) on the 11th April 2007, the latest has occurred at Vysny Slavkov on the 19th June 2008. The average KV stage lasted from the 17th till the 24th May with the time shifts among observed groups

approaching 2 – 5 days. Its soonest occurrence was recorded at the station of Trencin on the 17th April 2007 and its latest occurrence was observed at Vysny Slavkov on the 23rd June 2008 and at Liptovska Teplicka on the 23rd June 1997.

The obtained results correspond with the results presented by other authors (Luknarova, 2000; Kurpelova, 1972) concerning periods of 1931-1960 and 1961-1985. The evaluation of trends observed at vegetative phenostages (Fig. 1) points out the sooner shifts of both stages by 3 days.

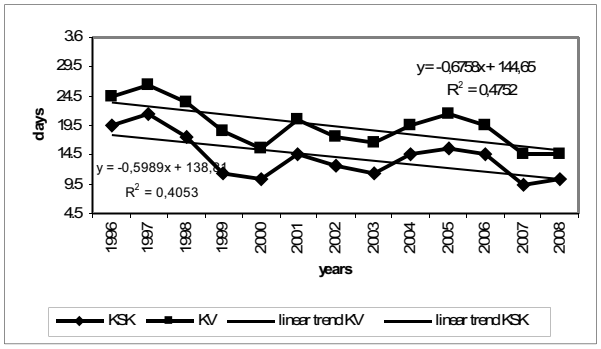

Figure 1. The average starts of vegetative phenostages in particular years and their trends of development during the period of 1996-2008.

The correlation coefficients detect a low degree of dependence. Both generative phenostages (Fig. 2), the blossoming of male flowers and the general flowering show their decreasing trends, as well, and also inform about their sooner starts by 7-8 days. Correlation coefficients reveal more significant relationships than in the case of vegetative phenostages.

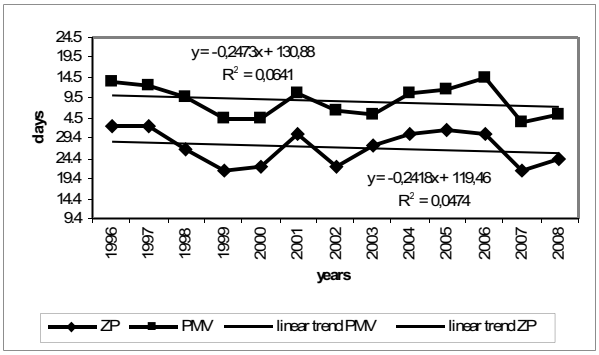

Figure 2. The average starts of generative phenostages in particular years and trends of their development during the period of 1996-2008.

Conclusions

The observations of 38 stations of a forest phenology situated within the altitudinal range of 100-940 m a.s.l. showed that the average bud bursting had been lasting from the 21st April till the 6th May, the first May shoots had occurred from the 2nd till the 18th May. The time shifts of vegetative phenostages among particular altitudinal groups approached 7-8 days. The average blossoming of male flowers was lasting from the 12th till the 19th May and the general flowering from the 17th till the 24th May. The delay of starts of observed phenological stages among particular altitudinal groups have approached 2-5 days. The analyses of time series pointed out the shifts at all phenological stages towards sooner time periods. Vegetative phenostages point out the shift by 3 days, the generative ones by 7-8 days.

Acknowledgement The authors gratefully thank to the Slovak Ministry of Education, Project VEGA No. 1/4393/07, 1/0515/08 for funding the opportunity to carry out this kind of Research.

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Phenological phases and transpiration of spruce and larch trees in the Tatra National Park

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Abstract. The transpiration of spruce (*Picea abies*) and larch (*Larix deciduas)* sample trees were measured over a 2 year period at the locality Smrekovec near Vyšné Hágy, located in the Tatra National Park at an altitude of 1250 m asl. The results showed that the transpiration of larch is affected by the starting of phenological phases in spring and the beginning of the vegetation period. Temperature is considered the most important factor for timing the instigation of physiological processes and growth. The sap flow continually dropped with the decreasing air temperature, and with the commencement of the autumn phenophases in the latter half of October.

Introduction

The vegetative period starts with the development of the first leaves in spring (Braslavská & Kamenský, 1999). Phenological phases and the annual development of the vegetative organs (buds, leaves, needles) of trees are influenced by meterological patrameters, mainly air temperature and humidity, and also temperature and soil moisture. Phenological changes are influenced by the annual climatic course in the year (Škvareninová, 2009).

The condition of the foliage determines the process of water evaporation in the system: soil – plant – atmosphere by transpiration through assimilatory organs. The amount of water evaporated from woody species is, except for the state of foliage, directly influenced by the levels of water storage in the soil and trees, and by the state of the atmospheric environment especially by the intensity of solar radiation, temperature and humidity of the boundary layer. Woody species transpire maximally during the phenophase of the physiologically mature leaf (Střelcová et al., 2008).

The aim of this paper is to evaluate the introduction of the spring phenological phases of the spruce and larch trees in 2007, and in addition the end of autumn phenological phases in 2008. Finally we have evaluated the influence of the phenophases and meteorological characteristics upon the sap flow of the sample larch and spruce trees.

Data and methods

The data used in this study was obtained during the period of May – October in the years 2007 and 2008 at a spruce primeval forest in the locality Smrekovec near Vyšné Hágy, located in the Tatra National Park, at an altitude of 1250 m asl. The mixed 121 year old forest is situated in the 7th forest vegetation rank. The stand was composed of Norway spruce (*Picea abies* (L.) 80 % of the stand basal area) and Larch (*Larix decidua* (MILL.) 20 % of the stand basal area). Sap flow was measured continually on four sample trees of spruce and four sample trees of larch during the vegetation season in 2007 and 2008. Measurements of the air temperature, humidity, and global radiation were recorded on the meterological tower, which is 30 m above the forest stand. All sensors were sampled at intervals of 10 and 30 minutes and averages were computed and stored on the data logger Campbell 10x.

Sap flow of spruce and larch sample trees were measured by direct non-destructive and continuous measurements by tree-trunk heat balance method (THB) with internal heating of xylem tissues and sensing of temperature, using a modificated system with constant power. The measuring point was heated by the electrical current passing the wet xylem tissues between three stainless plate electrodes inserted into the wood. The electronic feedback units control the heating power by measuring points at certain levels (0.63 W) and the temperature difference of the heated volume was recorded for the sap flow rate calculation. The reference temperature (related to the non-heated part of the stem) is measured also along the electrode, which is inserted 100 mm below the heated electrodes. This measuring method is nearly independent of the radial sap velocity profile; the output value is calculated per cm of circumference using the affective width of heating space. The final tree sap flow is calculated using the stem diameter of trees at breast height (Kučera, 2003).

Phenological monitoring provides valuable information regarding the spring start and the autumn end-point of the physiological processes . Particular phenophases of larch and spruce were evaluated according to the scale compiled by the Slovak Hydrometeorological Institute (in Střelcová et al., 2008). Description of particular phenophases of vegetative organs is given in Tab. 1 below.

Table 1. Phenological phases of vegetative organs of spruce and larch species.

Larch	
Spring phenophases	*Autumn phenophases*
1. Growing bud	4. The start of yellowing leaf
2. The first leaf	5. Yellowing leaf
3. Green (physiologically mature) leaf	6. The start of leaf fall
Spruce	
Spring phenophase – The first May sprouts	

Results and disscussion

Bioklimatic characteristics in the time of the experiment are presented in Tab. 2.

Table 2. Bioklimatic characteristics in May 2007 and October 2008.

May 2007		**October 2008**	
ø air temperature [°C]	10.2	ø air temperature [°C]	4.9
ø air humidity [%]	75.4	ø air humidity [%]	91.8
ø soil temperature [°C]	7.9	ø soil temperature [°C]	4.2
ø soil moisture [%]	11.3	ø soil moisture [%]	9.4
global radiation [W/m^2]	5390	global radiation [W/m^2]	619
precipitation [mm]	163.2	precipitation [mm]	121.8

The coldest day was 1st May 2007 when the measured temperature was 0.3°C, and the warmest day was the 25th May 2007 with the temperature reaching 17°C. The highest temperature of October 2008 was 10.4°C and the lowest temperature was 0.4 °C.

The course of spring phenophases is determined by the character of finishing winter and the start of warm spring periods (Tab. 3). The weather in the spring period can be extremely variable, with contrasting warm and cold periods (Střelcová et al., 2008). Due to this, decisive meteorological characteristics that influenced the start of bud growth can by considered, as the average daily air temperatures were in the interval of 0 - 5°C.

Table 3. Temperature sums for days with averagetemperaturehigher than 0, 5, 10 °C in 2007 until the start of the phenophase 1 (0-1) and during the phenophase 1-3.

2007	TS 0	TS 5	TS 10
Phenophase 0-1	139.4	21.0	0.0
Phenophase 1-3	180.6	41.9	2.5

In 2007 the sap flow was measured from May 8th, when the larch bud growing started. The phenophase "green leaf" was observed on May 17th. The third spruce phenological phase was noted on June 6th (the first and the second spruce phenophase was not observed).

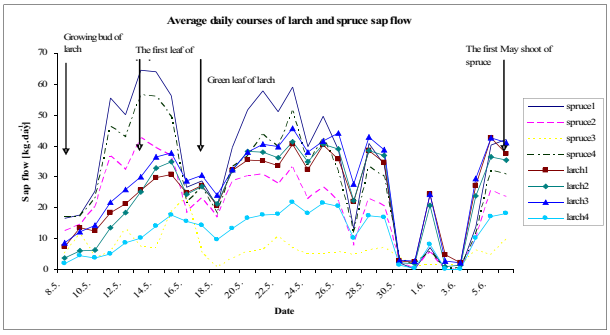

Figure 1. Daily totals of the sap flow of larch and spruce sample trees in 2007, and the start of the spring phenophases.

The values of measured sap flow are presented in Fig. 1. The sap flow increased gradually, except in the middle and at the end of May when we observed a decrease of average day temperatures, and the sums of global radiation. The comparison of average larch and spruce trees sap flow (Tab. 4) shows that the total larch sap flow in the period up to May 17th is lower than the averege spruce sap flow. We can assume therefore the start of the spring phenologoical phases of larch can affect the transpirated water amount in the spring.

Table 4. The average sap flow of spruce and larch trees before the green leaf phenophase and after the starting green leaf phenophase.

2007	8.5. - 17.5.	18.5. - 6.6.
ø **spruce** [kg.day $^{-1}$]	260.40	352.18
ø **larch** [kg.day $^{-1}$]	187.33	488.48

Škvareninová (2009) stated that the start phenophase "the first May sprouts" in the Arboretum Borová hora from the provenience of spruce, at an altitude of 1200 m asl was on May 12th 2007. This is, compared to our results, 25 days ahead of the estimated start phenophase. This is likely a result of the region and its individual temperature conditions.

The start of the autumn phenophase, especially the yellowing leaves of larch, is accompanied by a reduction of chlorophyll in leaves, and with the physiological changes closely before the littering of the assimilatory organs (Střelcová et al., 2008). The start of the larch autumn phenophases and sap flow are presented in Fig. 2 below.

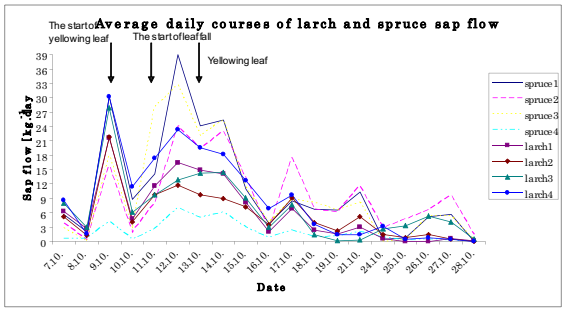

Figure 2. Daily totals of the sap flow of larch and spruce sample trees in 2008 and the start of the larch autumn phenophases.

In the monitored year 2008, the yellowing phenophase of trees started at the beginning of October, when the sap flow of larch decrease started. In Table 5 the average sap flow of the spruce and larch sample trees before and after the leaves start to fall are compared. The sap flow of larch sample trees decreased from 72.94 kg.day $^{-1}$ to 48.58 kg.day $^{-1}$ when the phenophases "leaf fall" started. It is a significant decrease of sap flow in the fully leaved stage of larch trees.

Table 5. The average sap flow of spruce and larch trees during vegetation period and after starting the leaves fall.

2008	7.10. - 13.10.	14.10. - 28.10.
ø **spruce** [kg.day $^{-1}$]	81.02	72.94
ø **larch** [kg.day $^{-1}$]	83.84	48.58

Conclusions

The presented results showed that the vegetative period of mixed larch and spruce forest, at an altitude of 1250 m above see level, starts at the beginning of May and ends roughly around the middle of October. With the increasing air temperatures in May, and with the development of the leaf area, consequently the sap flow was rising gradually.. In the latter weeks of October the sap flow rate values continually dropped with the decreasing air temperatures and with the beginning of autumn phenophases. The differences between spruce and larch trees were observed in sap flow rates in spring and autumn due to the phenological stage of needles in the broad-leaf species, larch. The phenological state of the needles of the larch trees is important for timing of the physiological processes – transpiration and growth.

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Agricultural climatology

Influence of climatic factors of year and foliar nutrition on production parameters of sugar beet

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Abstract The field polyfactorial experiment was established on experimental locality Dolná Malanta in 2005 – 2007. Four varieties (Takt, Terano, Radek, Federica) and three variants of fertilization (V1 - NPK + FM control, V2 - NPK + FM + Atonik, V3 - NPK + FM + Campofort Fortestim beta) were monitored. Influence of weather conditions of monitored period and influence of foliar application of preparations or their active substances on root yield, digestion and raffinate yield of concrete varieties of sugar beet was evaluated. Applied preparations had positive influence on root yield, digestion value and raffinate yield. Growth stimulator the best influenced root yield (61.84 t.ha^{-1}) and the highest digestion value was achieved after leaf fertiliser application (16.57 °S). Influence of both preparations on raffinate yield was positive. The highest raffinate yield was achieved after application of leaf fertiliser (8.35 t.ha^{-1}). Results of experiment confirmed important influence of weather conditions of year on all monitored parameters of sugar beet. The best values of root yield (63.13 t.ha^{-1}) and digestion (17.14 °S) were achieved in 2006. Weather conditions of year 2005 were the most suitable for raffinate yield (8.85 t.ha^{-1}). Unsuitable rainfall distribution during vegetation period in 2007 resulted in the lowest values of root yield (59 t.ha^{-1}), digestion (14.99 °S) and raffinate yield (7.24 t.ha^{-1}).

Introduction

Trend of climatic changes during last 100 years signalizes permanent decrease in sum of annual atmospheric water rainfall. Average annual air temperatures increase and evapotranspirate water requests accumulate too. Drought periods have been lengthened, consequently plants suffer from water deficiency and it limits growth and productivity of plants (Masarovičová et al., 2002). It is necessary to apply supporting substances as growth biostimulators and liquid fertilisers in order to reduce the negative impact of these unfavourable climatic changes on sugar beet production. These preparations contain micronutriments with antitranspirate influence, which help plants faster overcome stress (Bajči et al., 1997).

Data and methods

The field polyfactorial experiment was established on experimental locality Dolná Malanta in 2005 – 2007. The area is situated in altitude 175 – 180 m a.s.l.; it belongs to maize production area, to warm and mild arid climatic region. Average annual rainfalls are 532.5 mm, average annual temperature is 9.8 ºC and average relative humidity is 74 %.

Experiment was established by method of vertically divided segments (Ehrenbergerová, 1995). Degrees of factors were situated in casual ordering. The size of the experimental area was of 32.4 x 70 m and sides of experimental parcel were of 5.4 x 6.0 m. Experiment was realized in three repeats.

Four varieties of sugar beet were included in experiment. Takt (triploid, normal type, tolerant to rhizomania and Cercospora beticola), Terano (triploid, normal type, tolerant to rhizomania and Cercospora beticola), Radek (triploid, normal-sugary type, tolerant to rhizomania and Cercospora beticola), Federica (normal-sugary type).

Leaf fertilizers of Campofort kind contain basic macro elements and microelements and stimulation substances. These fertilizers have biostimulative and antistress effect, they increase yield gain and improve its qualitative characteristics.

Atonik is plant stimulator which contents mixture of three aromatic nitro compounds on the bases of nitrophenolate sodium (2-nitrophenolate sodium, 4-nitrophenolate sodium and nitroguaiakolate sodium). Atonik favourably influences root yield, raffinate yield and technological quality of sugar beet. It helps plant overcome stress conditions (e.g. continual drought and high temperatures).

Sugar beet was grown by technology with sowing at final distance, in spacing of 0.16 x 0.45 m and its fore crop was winter wheat.

Experiment was made with three variants of fertilization including control which wasn't fertilized: V1 - control variant (NPK + FM, amount of nutrients calculated upon soil analysis for yield of 50 t.ha^{-1}); V2 - NPK + FM + Atonik: 0.6 l.ha^{-1} in phase 4. - 6. leaves, 0.6 l.ha^{-1} before the final growth phase; V3 - NPK + FM + Campofort Fortestim beta: 7 l.ha^{-1} in phase 4. - 6. leaves, 10 l.ha^{-1} in phase 9. - 10. leaves and 10 l.ha^{-1} two weeks after plant-emerging.

The aim of this experiment was to review the influence of climatic conditions of year and influence of foliar application of preparations or their active substances on root yield, digestion and raffinate yield of concrete varieties of sugar beet.

Results of experiment were evaluated in statistical program Statgraphics Plus by Multifactor Analysis of Variance.

Results and discussion

Average root yield achieved in experiment was 61.09 t.ha^{-1}.

Within particular years, the highest average root yield was achieved in 2006 (63.13 t.ha^{-1}) and the lowest in 2007 (59 t.ha^{-1}). It was caused by rainfall deficiency in July and early in August (Fig. 1.)

According to Švihra et al. (2001), mentioned period is critical for sugar beet, when it needs rainfall sufficiency for root yield production.

As result from Tab. 1, average values of root yield achieved after preparation application. Higher increase of root yield was after application of growth stimulator (about 1.45 t.ha^{-1} compared to control). It corresponds with results of Černý et al. (2001).

Average digestion value of whole experiment was 16.39 °S. The highest digestion value was achieved in 2006 (17.14 °S) and the lowest in 2007 (14.99 °S). It was caused by abnormal rainfall at the end of vegetation period (Fig. 1).
Average values of digestion increased after preparation application. Higher increase of digestion was after application of leaf fertiliser (about 0.28 °S compared to control). Results of sugar beet research in 1962 – 2002 confirm this fact, where application of leaf fertiliser increased digestion about 0.5 – 0.8 % (Zahradníček et al., 2004).

Table 1. Average root yield and digestion of sugar beet varietes in dependence on variant of fertilisation in 2005-2007.

Indicator	Variety	Variants of fertilisation		
		V_1	V_2	V_3
Root yield (t.ha $^{-1}$)	Takt	60.86	64.28	65.29
	Terano	59.00	62.39	61.75
	Radek	63.69	63.43	59.99
	Federica	58.01	57.26	57.17
	x	**60.39**	**61.84**	**61.05**
Digestion (°S)	Takt	16.32	16.25	16.68
	Terano	16.20	16.36	16.22
	Radek	15.80	15.88	16.11
	Federica	16.84	16.77	17.28
	x	**16.29**	**16.32**	**16.57**
Raffinate yield (t.ha $^{-1}$)	Takt	8.01	8.66	8.85
	Terano	7.84	8.34	8.22
	Radek	8.17	8.23	7.89
	Federica	8.31	8.03	8.42
	x	**8.08**	**8.32**	**8.35**

Average raffinate yield in experiment was 8.25 t.ha^{-1}.
The highest raffinate yield was achieved in 2005 (8.85 t.ha^{-1}) and the lowest raffinate yield was determined in 2007 (7.24 t.ha^{-1}) (Fig. 2).

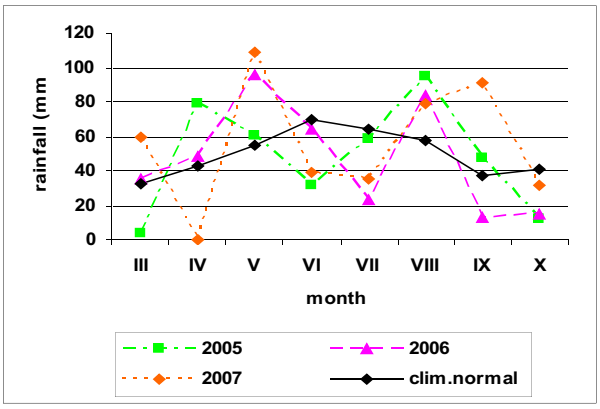

Figure 1. Average rainfall values in 2005-2007.

Preparations application increased average raffinate yield. The highest increase of raffinate yield was determined after application of leaf fertiliser (about 0.27 t.ha^{-1} compared to control) whereby growth stimulator increased raffinate yield about 0.24 t.ha^{-1} compared to control.

Conclusions

Results confirmed significant influence of weather conditions of year on root yield, digestion and raffinate yield of sugar beet. In term of rainfall and temperature conditions, year 2006 showed optimal for root yield (63.13 t.ha^{-1}) and digestion (17.14 °S). Weather conditions of year 2005 the best matched raffinate yield (8.85 t.ha^{-1}). But unsuitable rainfall distribution during vegetation period in 2007 resulted in the lowest values of root yield (59 t.ha^{-1}), digestion (14.99 °S) and raffinate yield (7.24 t.ha^{-1}). Influence of applied preparation on monitored parameters was positive. Application of growth stimulator the most significantly contributed to root yield (61.84 t.ha^{-1}). Application of leaf fertiliser had the most significant influence on digestion value (16.57 °S). Influence of both preparations on raffinate yield was positive (Atonik – increase about 0.24 t.ha^{-1}; Campofort – increase about 0.27 t.ha^{-1} compared to control).

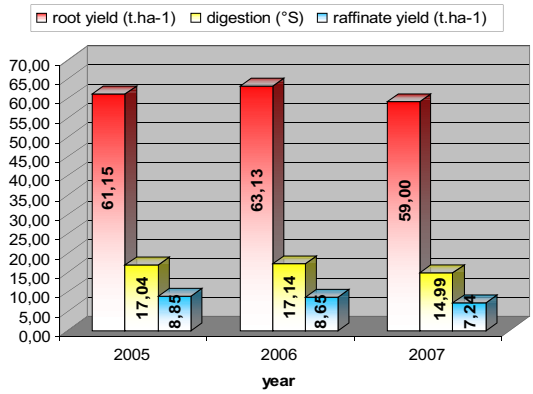

Figure 2. Root yield, digestion and raffinate yield in dependence on year.

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Mulching and soil tillage influence on the thermal behaviour of a Luvisol surface layer

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Abstract. Important energy exchanges at soil surface regulate the thermal environment within top soil layer and the boundary layer above it. By this reason, the application of mulches or the modelling of micro relief by soil tillage are common practises to modify the thermal regime of a soil. The aim of this study is to compare the effect on thermal behaviour of a Luvisol resulting of soil tillage and the application of stubble mulch and, different amounts of straw mulch. For this purpose, experiments were performed from January to May 2007 in a field sowed with winter wheat. Temperatures were measured with copper-constantan (Type T) thermocouples placed over straw and over stubble, at soil surface and at 2, 4 and 8 cm depth. Temperatures above canopy were also recorded.

Daily mean temperatures and temperature amplitudes in the top soil layer covered by straw mulch were smaller than those verified either by stubble mulch or with soil tillage. Daily minimum temperatures in mobilized plots or covered by stubble mulch were smaller than those verified in plots covered by straw mulch, therefore being the former treatments more susceptible to frost than the later ones. Thermal differences between the four plots decreased significantly with wheat growth. Implications of these techniques of soil temperature control for crop growth are also discussed.

Introduction

Crop establishment is a major factor determining crop productivity in the field which is strongly controlled by soil temperature (Abreu, 1987). Important energy exchanges at soil surface regulate the thermal environment within top soil layer and the boundary layer above it (Arya, 1988). Therefore both the application of mulches and the modelling of micro relief by soil tillage are common practises to modify the soil thermal regime. All these practises affect the soil thermal regime by changes on surface net radiation and heat transfer by evaporation (De Vries, 1975). Thus, investigation into the influence of surface treatments on soil thermal regime is useful to evaluate differences of performance on crop growth.

The aim of this study is to compare the effect on thermal behaviour of a Haplic Luvisol (WRB, 2006) under different types of soil surface management: soil tillage, stubble mulch and different amounts of straw mulch.

Data and methods

Field experiments were performed at Herdade da Revilheira, Reguengos de Monsaraz (lat.: 38º28'N; long.: 7º28'W), from January to May 2007, in a field sowed with winter wheat (*Triticum aestivum* L.) in preceding December. The local climate is Csa, according to Köppen. According to climatic data recorded at the nearest station (Évora, about 40 Km away from the site) the mean annual temperature averages 15.6ºC, ranging from a monthly mean of 9.3ºC in January to 23.0ºC in August. Mean annual rainfall is 642.6 mm, 77% of which falls between October and March. The soil is a Haplic Luvisol (WRB, 2006) and its profile was Ah-AB-Bt-C. The clay-loamy Ah (0-8 cm) and AB (8-24 cm) horizons had a bulk density of 1.51±0.12 Mg m^{-3} and 1.58±0.07 Mg m^{-3}, respectively while the clayey Bt (24 - 53 cm) horizon had a bulk density of 1.63±0.04 Mg m^{-3}.

Soil temperatures were measured in four profiles with copper-constantan thermocouples connected to a data-logger (*data Taker* 600). One profile was subject to a surface soil tillage only (modality A), another was covered by stubble mulch (mod B) and the remainder were covered by different amounts of straws mulch (mod C - 2500 Kg ha^{-1} and mod D - 5000 Kg ha^{-1}). Thermocouples were placed in each profile at its surface, 2, 4 and 8 cm depth and over straw and stubble mulches. Hourly averaged temperatures were recorded anyway.

Effects on soil thermal regime were evaluated by daily mean temperatures and daily minimum temperatures at 2 cm depth as well as by thermal amplitudes at 2 cm, at 4 cm depth and at the surface of the mulch.

Results and discussion

Daily mean temperatures at 2 cm depth ranged from about 3-4ºC (end of January) to 23-28ºC (middle of May), following the annual course of net radiation at a soil surface in areas of Mediterranean climates (Fig. 1). From January to March, no significant differences were found between daily mean temperatures recorded in the four plots; in April and May, the plots covered by straw presented mean temperatures significantly lower than those covered by stubble mulch or subject to surface tillage. This means that

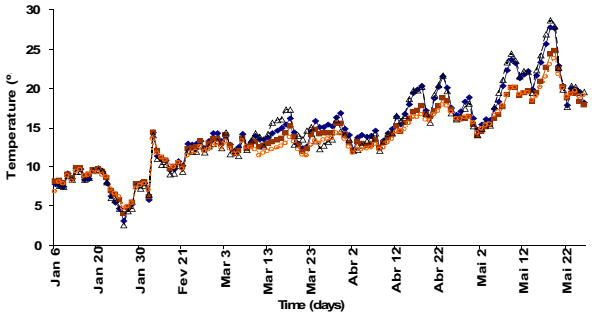

Figure 1. Daily mean temperatures recorded at 2 cm depth from Jan 6 to May 26: mod A (—♦—), mod B (---△---), mod C (—■—) and mod D (---o---).

the application of straw mulch can influence more the establishment of summer crops than that of winter crops. In April and May, the increase of mean temperatures in soil profiles covered by straw (mod C and mod D) follows, with same delay, the increase verified in the other profiles (mod A and B), probably due to the higher water holding capacity

presented by straw mulch. Maintenance of stubble mulch over soil surface did not seem to benefit crop establishment when compared with tilled soil.

Daily minimum temperatures recorded at 2 cm depth were lower in profiles covered by stubble or subject to a surface tillage than in profiles covered by straw mulches, irrespective of their densities (Fig. 2). Differences between minimum temperatures recorded in modalities B (stubble mulch) and D (straw mulch – 5000 Kg ha^{-1}) were about 2ºC, reaching to about 4ºC on some days of January and April. Differences between minimum temperatures in modalities C and D were generally lower than 0.5ºC, meaning that frost prevention does not seem to depend on densities of straw mulch.

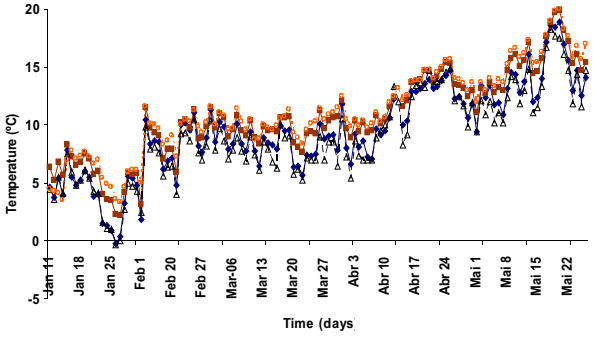

Figure 2. Daily minimum temperatures recorded at 2 cm depth: mod A (–♦–), mod B (---△---), mod C (–■–) and mod D (---o---).

Damping of thermal wave down to 4 cm depth was significantly higher with straw mulch (mod D) than with other modalities; in addition, the damping was the lowest when modality B is applied (Fig. 3). Ratio between

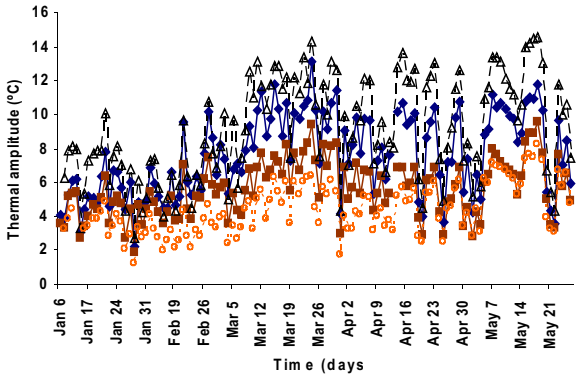

Figure 3. Temperature amplitudes at 4 cm depth recorded from Jan 6 to May 26: mod A (–♦–), mod B (---△---), mod C (–■–) and mod D (---o---).

thermal amplitudes verified at 4 cm depth in tilled soil and those verified in profile covered by stubble mulch (ΔT_{modA}/ ΔT_{modB}) varied from 0.90 to 0.71 (0.81±0.04), while that verified in covered profiles by straw (ΔT_{modD}/ ΔT_{modC}) ranged from 1.05 to 0.72 (0.77±0.13). Thermal amplitudes at 2 cm depth were 44±7% and 23±4% of those observed at the top of straw mulch layer, respectively in modalities C and D; on the contrary, stubble mulch damped the thermal wave in about 21 per cent only, i.e., the amplitudes at 2 cm depth are 79±10% of those observed at the surface (Fig.4). Relationship between amplitudes recorded in different modalities didn't seem to be affected by crop growth.

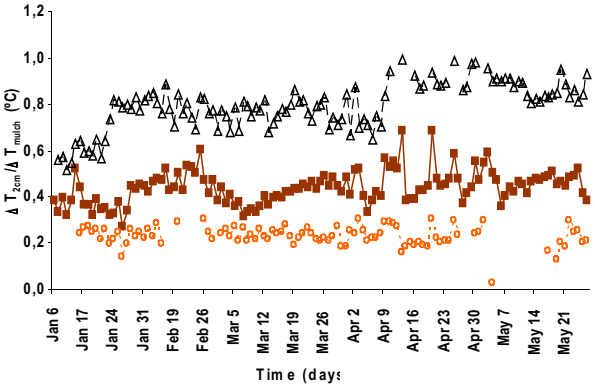

Figure 4. Ratio thermal amplitudes at 2 cm depth/ Thermal amplitudes over mulch: mod B (---△---), mod C (–■–) and mod D (---o---).

Conclusions

The more evident is the soil warming that reflects the annual course of net radiation, the more evident is the cooling resulting of the application of straw. The application of straw mulch at soil surface increases daily minimum temperatures in top soil layer by about 2ºC, avoiding often the occurrence of frost and consequent crop damages. In spite of no significant influence of the amount of straw mulch on daily mean and minimum temperatures, it affects significantly the damping of thermal wave into top soil layer. To keep the stubble mulch at soil surface is not an efficient practice on the thermal moderation in top soil layer or to prevent frosts.

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Comparative estimates of N_2O cumulative fluxes from agricultural soils in Slovakia and Russia using the DNDC model

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Abstract. The DNDC model was used to predict seasonal N_2O cumulative fluxes from light-textured agricultural soils in Danubian Lowland of Slovakia and in northwestern region of Russia. Validation of modeled against observed data demonstrated that the DNDC model being sensitive to soil water-filled pore space and rates of N fertilizers adequately predicted the N_2O fluxes from soils in Russia. A comparison of the modeled N_2O cumulative fluxes showed that the DNDC model could be applied for the prediction of their seasonal dynamics in the selected agricultural regions.

Introduction

Nitrous oxide (N_2O) emissions from agriculture reach approximately 70% of annual global N_2O emissions (Mosier, 2001). Among the environmental and anthropogenic pressures, which account for the increased N_2O emissions from agriculture, it is necessary to distinguish precipitation, temperature, fertilisers, soil compaction, animal grazing and erosion processes. In recent years scientists have undertaken successful attempts to estimate the N_2O emissions from agricultural soils and to establish a validate basis for national agricultural policy on a reasonable application of mineral and organic fertilisers.

Process-based models of C and N biogeochemical cycling are powerful tools in agro-ecosystem studies. Among such models, the DNDC (Denitrification-Decomposition) model showed a distinguished capacity of predicting soil organic C dynamics and N_2O, NO, NH_3, CO_2 and CH_4 emissions from soils (Li, 2000). In Slovakia and Russia the DNDC model is being now used to assess the environmental and anthropogenic impacts on N_2O emissions from agricultural soils. The DNDC model can simulate the trace gas emissions from agriculture at a site level and at a regional level. At the site level, the model predicts the N_2O emissions from selected locations and, therefore, can be validated against measured N_2O emissions from a cropping system in an agricultural region. Using the validation records, the DNDC model's sensitivity and capacity of predicting trace gas emissions can be assessed for other similar cropping systems in regions with similar climatic conditions. The objectives of the present studies were to: (1) validate the modelled against measured N_2O fluxes from agricultural soil in Russia, (2) compare the modelled N_2O fluxes from soils on selected agricultural sites in Slovakia and Russia.

Data and methods

Agricultural sites with different crop types (spring barley, winter wheat, sugar beet, potato) and nutrient conditions (levels of SOC and mineral N) were included into our studies. The candidate sites were located on a loamy sand soil in northwestern region of Russia (near St. Petersburg) and on a sandy loam soil in the Danubian Lowland of Slovakia (near Nitra). The two sites represent typical agro-ecosystems in these regions of Russia and Slovakia.

In the Danubian Lowland, rates of N fertilizers were: 37.5 kg N ha^{-1} (for spring barley and sugar beet) and 230 kg N ha^{-1} (for winter wheat). Other records on soil properties, weather conditions and soil management in the Danubian Lowland have been well documented by Horak and Siska (2006).

In the northwestern region of Russia, the rates of N fertilizers were: 0, 65 and 110 kg N ha^{-1} for spring barley and 120 kg N ha^{-1} for potato in 2004. In our field studies, direct N_2O fluxes from soils are being measured by a closed chamber method 2-3 times a week through the growing season from April to September (Buchkina et al., 2006). 4-6 flux PVC chambers were used for each treatment with the selected crops. Gas samples were withdrawn by syringes from a headspace of the hermetically closed PVC chambers pushed into a surface layer of soil. N_2O concentrations in the gas samples, placed into hermetically closed glass vials, were measured with a gas chromatograph fitted with an electron capture detector. Soil temperature and moisture content was simultaneously determined at each gas sampling. Measurements of soil bulk density, pH, content of soil organic C, mineral N (NO_3^-, NH_4^+) and water, were regularly made during the growing period. Air temperature and precipitation was measured daily. Soil analyses were conducted using routine methods in three replicates. The DNDC model (version 9.1) was used in our studies.

Results and discussion

There were two key factors affecting direct N_2O fluxes from the loamy sand soil in the Northwestern Russia during the growing season of the crops. The first factor was a rate of N fertilizers. The N_2O fluxes from the soil with spring barley increased with increasing rate of N fertilizers (Fig. 1).

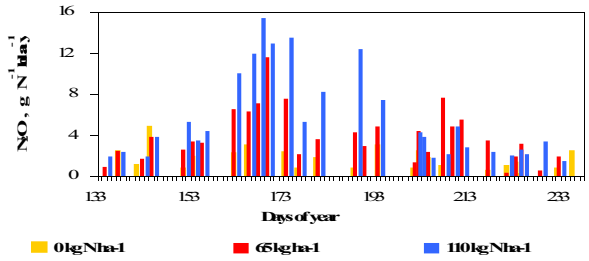

Figure 1. Dynamics of N_2O emission from a loamy sand soil at 0, 65 and 110 kg N ha^{-1} during the growing season of spring barley.

The second factor was a water-filled pore space (WFPS). N_2O fluxes from soil drastically increased if WFPS became higher than 60% after rainfall events. The total amount of precipitation reached 690.0 mm and 769.3 mm during the growing season of spring barley and potato. Heavy precipitation could result in a formation of anaerobic soil conditions, which were favourable for microbial process of

denitrification responsible for the increased production of N_2O. Strong positive correlations were observed between N_2O emission and WFPS in the soil with spring barley without N fertilizers (r = 0.71) and with the rates of N fertilizers of 65 kg N ha^{-1} (r = 0.81) and 110 kg N ha^{-1} (r = 0.78). On the plots with potato, there were weak correlations between N_2O emission (0.4-27.0 g N ha^{-1} day^{-1}) and WFPS in ridges (r = 0.28) as aerobic conditions dominated in this zone of soil. In furrows of potato plots, anaerobic conditions were dominant especially after rainfall events. Hence, correlations between N_2O emission (0.6-92.2 g N ha^{-1} day^{-1}) and WFPS were stronger in the furrows (r = 0.59) than in the ridges as WFPS played a greater role in contribution to higher denitrification (r = -0.81).

The results of validation tests showed a satisfactory agreement between the modeled and measured N_2O cumulative fluxes from the loamy sand soil with spring barley and potato (Figure 2). Differences (y, %) between the modelled (mod) and measured (meas) N_2O cumulative fluxes (F) were calculated according to a formulae: y = (Fmod – Fmeas)/Fmeas*100.

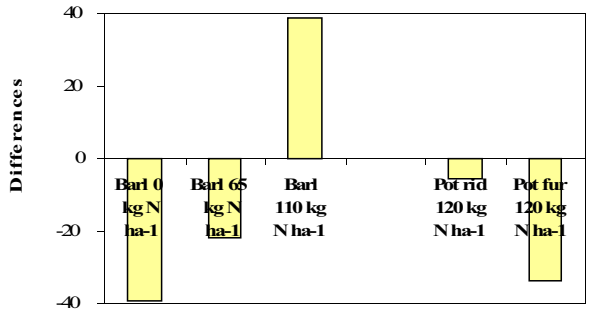

Figure2. Differences between the modeled and measured N_2O cumulative fluxes from a loamy sand soil with spring barley (Barl) and potato in ridges (Pot rid) and furrows (Pot fur).

These results demonstrated that the differences between the modelled and measured N_2O cumulative fluxes, in terms of their final absolute values, changed from negative (at the rate of 0 and 65 kg N ha^{-1}) to positive ones (at the rate of 110 kg N ha^{-1}). In the case of potato, the discrepancies between the modelled and measured records were higher for furrows than for ridges. The DNDC model was not able to adequately distinguish the above-mentioned anaerobic conditions in the furrows. However, strong correlations between the modelled and measured N_2O cumulative fluxes from the soil with spring barley (r = 0.73-0.80, at 65 and 110 kg N ha^{-1}) and potato (r = 0.65, in ridges) supported a distinguished capacity of the DNDC model to predict their seasonal dynamics in the north-western region of Russia.

There were high negative differences between the modeled N_2O cumulative fluxes if we compared the Slovak and Russian soils with spring barley (78-94%) and those with sugar beet and potato (78-84%). The differences in precipitation and soil moisture content could result in the observed discrepancies in the modeled data for the selected sites in both countries. Total amount of precipitation in the Danubian Lowland was several times less than that in the Northwestern Russia, and was equal to: 132.4 mm (spring barley in 2001), 130.6 mm (winter wheat in 2003) and 266.5 mm (sugar beet in 2000). Therefore, the DNDC model was likely able to adequately predict the lesser N_2O cumulative fluxes, induced by lower amount of precipitation and soil water, from the soils in the Danubian Lowland.

Huge positive differences (>400%) were observed between the modeled N_2O cumulative fluxes from soils with winter wheat (Slovakia) and spring barley (Russia). These discrepancies could by explained by huge differences in the rates of N fertilizers for winter wheat (230 kg N ha^{-1}) and spring barley (65-110 kg N ha^{-1}). However, the differences between the modeled N_2O cumulative fluxes from two soils decreased with increasing rate of N fertilizers for spring barley. These results also supported that the DNDC model could adequately predict the increased N_2O fluxes from soils after application of increasing rates of N fertilizers.

Strong correlations between the simulated predictions for the soils with spring barley amended with N fertilizers (r = 0.66-0.80), and with sugar beet and potato (r = 0.77-0.79, in ridges and furrows), in contrast to winter wheat (r = 0.44-0.70), better reflected the capacity of the DNDC model in predicting the seasonal dynamics of N_2O fluxes.

Conclusions

The results of validation of the DNDC model against field observations demonstrated its distinguished capacity to predict the N_2O fluxes from the loamy sand soil in the northwestern region of Russia. The data on comparison tests of the modeled N_2O cumulative fluxes showed a reliability of the DNDC model in the prediction of their seasonal dynamics in the selected agricultural sites of Slovakia and Russia.

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The effects of crop residues on nitrous oxide emission from a loamy sand Spodosol in northwestern region of Russia

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Abstract Crop residues incorporated in soils are significantly important source of nitrous oxide (N_2O) and are poorly quantified in agriculture of Russian Federation. N_2O emission from loamy sand Spodosol amended with four types of crop residues was studied in a 60-day laboratory experiment. N_2O emission from soil amended with white cabbage leaves (C/N ratio =12), red clover (C/N =18), cereal grasses (C/N =41) and spring wheat C/N = 68) was: (1) significantly different from control (without crop residues), (2) equal to 0.34 to 2.6 % of an amount of N added with crop residue, and (3) higher in soil a greater content of organic carbon. Accurate quantification of N_2O emission from soils amended with these crop residues will be required to develop the rational management practices for mitigating unfavourable N gaseous losses from Russian agricultural soils.

Introduction

N_2O is a greenhouse gas which emission needs to be quantified by countries according to the Kyoto protocol. Emission of this gas from agricultural soils is regulated by several key properties such as soil moisture, temperature, mineral nitrogen (N), available soil organic carbon (SOC) and pH, and is notoriously variable in space and time (Dobbie et al., 1999). N_2O is produced microbially through nitrification and denitrification. Addition of N with mineral fertilizers and manure increases the N_2O emission from soils (Smith et al., 1998; Buchkina et al., 2006). Crop residues may also enhance N_2O emission upon return to soils (Velthof et al., 2001), but this source of N is poorly quantified. The global N_2O emission from crop residues has been estimated at 0.4 Tg per year using the IPCC methodology (Moisier et al, 1998). The C/N ratio of crop residues affects the rate of N mineralization, denitrification and N_2O emission. An easily mineralisable N from crop residues with low C/N ratio may be transformed into mineral N, whereas easily minerasible organic C may enhance activity of denitrification and, hence, N_2O emission from soil. The content of easily mineralisable organic C differs significantly between crop residues and generally higher in fresh green materials than in straw.

N_2O emission originated from such sources as crop residues is not comprehensively studied in Russian Federation. To improve our knowledge in the field of interest, a 60-day laboratory incubation study was conducted with the objective to quantify the N_2O emission from soil amended with four types of crop residues differing in C/N ratio. The effects of SOC, mineral N and soil water content were also assessed because these factors may significantly contribute to N_2O emission from soil.

Data and methods

The experiment was carried out with a loamy sand Spodosol differing in fertility (Tab. 1). Experimental plots were located at the Experimental Agricultural station of the Agrophysical Research Institute in St. Petersburg region of Russia (59º34'N, 30º08'E). Soil samples were collected in autumn of 2007 from a depth of 0-30 cm on plots after harvesting of carrot.

Table 1. Properties of a loamy sand Spodosol with different fertility.

Soil fertility	pH (H_2O)	SOC, g C kg^{-1} soil	Mineral N, mg N kg^{-1} soil
poor	6.2	18.5	10.5
rich	6.4	23.5	47.7

Soil samples were air-dried and sieved through a sieve with a diameter of openings of 8 mm. 2 kg of the soil samples moistened to field capacity were placed into PVC chambers equipped with lids and septum caps to retard evaporation of water and to regularly collect air samples from a headspace.

Experimental pattern included control and four treatments with crop residues: straw of spring wheat, hay of cereal grasses and red clover, and raw leaves of white cabbage. All crops residues were chopped to pieces (<2 cm) and homogeneously mixed with soil at a rate of crop residues (6-15 g kg^{-1} soil), usually left after harvesting in a topsoil layer, to simulate the crop residue incorporation into a plough horizon of plots.

N_2O fluxes were measured by closed chamber method 2-3 times a week through 60 days of the experiment. Air samples were withdrawn by syringes from a headspace of the hermetically closed PVC chambers. N_2O concentrations in the air samples, placed into hermetically closed glass vials, were measured with a gas chromatograph fitted with an electron-capture detector. Soil temperature and moisture content was simultaneously determined at each air sampling. Soil analyses were conducted two times per month using routine methods in three replicates.

Both soils were set up as a randomized block design with four replicates.

Results and discussion

The N_2O-production process in soils can be controlled by the supply of raw and dry organic materials. The mineralization of organic N bound in crop residues provides inorganic N for nitrification and denitrification. Nitrification requires NH_4^+ and O_2, whereas denitrification demands available organic carbon and NO_3^- (Lemke, 1999). As both these processes may take place simultaneously in the soil, it is difficult to distinguish the N_2O production from each

process. In our study, the crop residue application resulted in an increase of mineral N content both in the poor and rich soil. The maximum increase in NO_3^- content was observed after clover residue application: from 10.5 to 64.3 mg N-NO_3 kg^{-1} of poor soil and from 47.7 to 202.0 mg N-NO_3 kg^{-1} of rich soil. Application of white cabbage leaves contributed to an increase in soil mineral N to 71.0 and 49.0 mg N-NO_3 kg^{-1} soil, while incorporation of cereal grasses and spring wheat straw resulted in an increase in soil mineral N to 27.5 and 53.0 mg N-NO_3 kg^{-1} soil for poor and rich soils, respectively. Most of the mineral N in all treatments was in a form of NO_3^--N, while an amount of NH_4^+-N was 10 times less than that of NO_3^--N.

Measurements of N_2O emission from the soil showed that its highest values were occurring within first 15 days after crop residue application (Fig. 1). In two weeks after the beginning of the experiment N_2O fluxes were becoming lower and almost negligible by the end of the experiment.

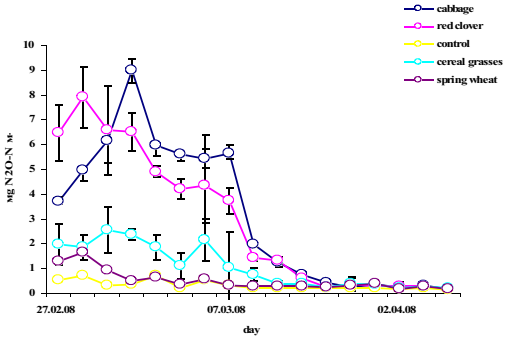

Figure 1. Everyday N_2O fluxes from a loamy sand Spodosol with poor fertility after amendment with crop residues.

Maximum cumulative N_2O fluxes (60.8 and 56.3 mg N_2O-N m^{-2}) were observed from the poor soil amended with white cabbage leaves and red clover residues (Fig. 2).

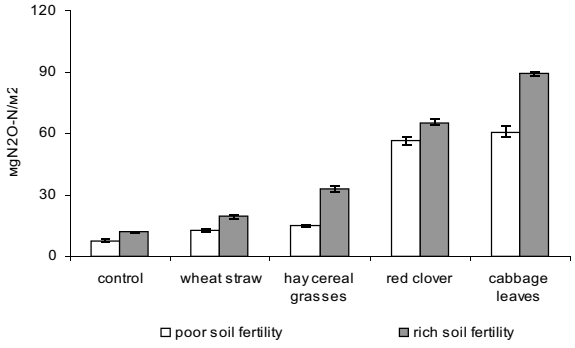

Figure 2. Cumulative N_2O fluxes from a loamy sand Spodosol with different fertility after amendment with crop residues.

The poor soil with residues of spring wheat straw and cereal grasses produced 12.0 and 15.0 mg N_2O-N m^{-2}, respectively, and that was about twice more than for the soil with no crop residues. The rich soil produced more N_2O than the poor soil in all the crop residue treatments - 1.5 times more for cabbage leaves, 1.2 times more for clover and 1.7 more for spring wheat straw and cereal grasses, presumably, as a result of a higher initial SOC and mineral N content. Velthof et al. (2001) earlier also reported that the N_2O emission from soils was small for the crop residues with high C/N ratio (>60) and high for those with low C/N ratio (<20).

The N_2O emission factor was derived during the 60-day soil incubation in which no N leaching and plant N uptake from the soil could occur. Therefore, N_2O emission may have been overestimated in our laboratory experiment compared to field conditions.

The N_2O emission factor derived in this study substantially differed from its default critical value of 1.25% (Mosier et al., 2001). We observed that for two of the four crop residues the N_2O emission factor was equal 2.6% for white cabbage leaves and 3.0% for red clover. Decomposition of crop residues with high C/N ratio (spring wheat and cereal grasses) did not result in the N_2O emission factor exceeding its default critical value. These results supported data of the above-mentioned scientists that the incorporation of red clover and white cabbage leaves into soils with poor or rich fertility could result in unfavourable gaseous N losses from the crop residues.

Conclusions

Incorporation of crop residues into loamy sand Spodosol led to an increase of N_2O emission. The extent of N_2O emission depended from the type of crop residues with different C/N ratios. The crop residues (red clover and white cabbage leaves) with low C/N ratio stronger affected the rate of N mineralization and N_2O emission than those (cereal grasses and spring wheat straw) with high C/N ratio. The cumulative N_2O flux from the loamy sand Spodosol with rich fertility was significantly higher than that from the soil with poor fertility.

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Influence of climatic factors and foliar application of growth stimulator Atonik on production parameters of sunflower.

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Abstract. The field polyfactorial experiment was established on farms Co-op Nitrianska Blatnica in 2007-2008. Four sunflower hybrids (NK Brio, NK Armoni, NK Country, NK Ferti), two variants of fertilization (V1 – control variant, V2 – growth stimulator Atonik) and two forms of growth organization (56 000 and 65 000 plants per hectare) were monitored in the experiment. Influence of weather conditions of monitored period, growth organization and foliar application of growth stimulator Atonik on achenes yield of sunflower was evaluated. Results confirmed significant influence of wether conditions of monitored period on achenes yield. The highest achenes yield was achieved in 2007 (3.82 t.ha^{-1}) but the lowest achenes yield was found in temperature-unbalanced year 2008 (3.72 t.ha^{-1}). Growth stimulator Atonik had positive influence on achenes yield. Average yield of whole experiment was increased about 0.11 t.ha^{-1} compared to control after Atonik application. All hybrids of sunflower responded to Atonik application also positive. The highest achenes yield was observed by hybrid NK Brio (increase about 0.19 t.ha^{-1} compared to control). Within growth organization, higher achenes yield was achieved by 65 000 plants per hectare.

Introduction

Naturally high variability of Slovak agrecological conditions claim to pay continual attention to choice of optimal growing locality, forecrop and suitable technological growing system of sunflower, especially to choice of suitable hybrid. Mentioned trend (the choice of optimal hybrid) have very important function mainly in sugar-beet production area, because growing conditions of maize production area (soil and climatic) enable utilization of genetic material of all types hybrids (Fábry, 1990; Maďar, 1996).

In connection with soil-climatic conditions of environment, the possibilities of new factors application, which have positive influence on yield and quality, are looking for in sunflower growing system. To the alternatives of achenes production increase we can include preparations on the base of biological active substances, concrete Atonik, which is applied foliar in tank-mix with leaf fertilizers or with pesticide substances (Černý, 2004).

Data and methods

The field polyfactorial experiment was established in warm maize production area, in farms Co-op Nitrianska Blatnica in 2007-2008.

Experiment was realized by block method with experimental units ordered casually, with three repeats (Ehrenbergerová, 1995).

Four sunflower hybrids (NK Brio, NK Armoni, NK Country, NK Ferti), two variants of fertilization (V1 – control variant, V2 – growth stimulator Atonik: 0.6 l.ha^{-1}in phase of 6-10 leaves and 0.6 l.ha^{-1} in growth phase of butonisation) and two forms of growth organization (56 000 and 65 000 plants per hectare) were monitored in the experiment.

Atonik is plant stimulator which contents mixture of three aromatic nitro compounds on the bases of nitrophenolate sodium (2-nitrophenolate sodium, 4-nitrophenolate sodium and nitroguaiakolate sodium). It influences physiological and biochemical processes not only in sunflower plant but also in other plants. Atonik helps plant overcome stress conditions (e.g. continual drought and high temperatures).

Technological growing system of sunflower (*Helianthus annuus L.*) was conventional. It means optimal forecrop (winter wheat), two-plough system of soil cultivation, balanced nutrition and fertilization, reliable pre-sowing soil preparation, sowing in agrotechnical date, preventive and system protection against harmful factors and harvest realized in standard humidity and technological conditions.

Meteorological characteristics of experimental locality were obtained from Agrometeorological station ÚKSUP Bratislava, station Veľké Ripňany.

Average values of rainfall and temperatures in vegetation period of sunflower are illustrated in Figs. 1 and 2.

The aim of this article was to evaluate influence of weather conditions of monitored period, growth organization and foliar application of growth stimulator Atonik on achenes yield of sunflower.

Results and discussion

Average achenes yield of sunflower was 3.81 t.ha^{-1} in monitored period of years 2007-2008. Within particular years, higher achenes yield was achieved in 2007 (3.82 t.ha^{-1}) (Fig. 3). Unsuitable weather conditions in 2008, mainly cold September, resulted in lower achenes yield (3.72 t.ha^{-1}). We observed increase of average achenes yield after Atonik application in both monitored years. Results of several authors (Štrojtlová et al., 1994; Pulkrábek et al., 2007; Gulluoglu et al., 2006) sustain this fact.

Higher achenes yields were achieved by growth organization of 65 000 plants per hectare (Tab.1.). Within particular hybrids differences in achenes yield compared to control were follow: NK Brio +0.28 t.ha^{-1}; NK Armoni -0.08 t.ha^{-1}; NK Country 0.00 t.ha^{-1} a NK Ferti -0.04 t.ha^{-1}.

Increase of achenes yield about 0.11 t.ha^{-1} compared to control was recorded. Results of Štrojtlová et al. (1994) sustain this fact. She achieved increase of sunflower yield about 20% after Atonik application. Within particular hybrids of sunflower, variances in achenes yield after Atonik application were follow: NK Brio +0.19 t.ha^{-1}; NK Armoni +0.09 t.ha^{-1}; NK Country +0.15 t.ha^{-1} a NK Ferti +0.02 t.ha^{-1}.

Achieved results sustained dependency of cultural plants yield, which is formations by influence of genetic specialization of particular biological materials and application of biological active substances from weather conditions of year (Pechová et al., 1999).

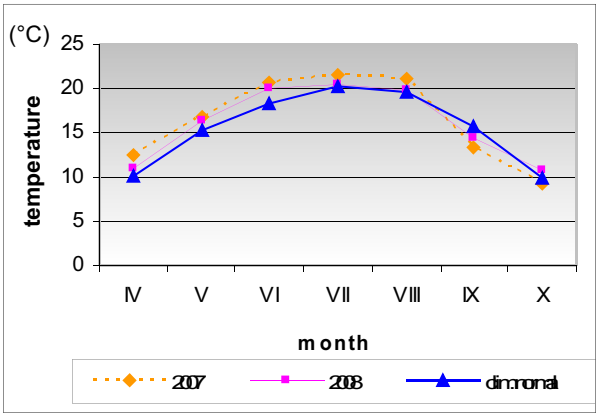

Figure 1. Average values of temperatures in 2007-2008.

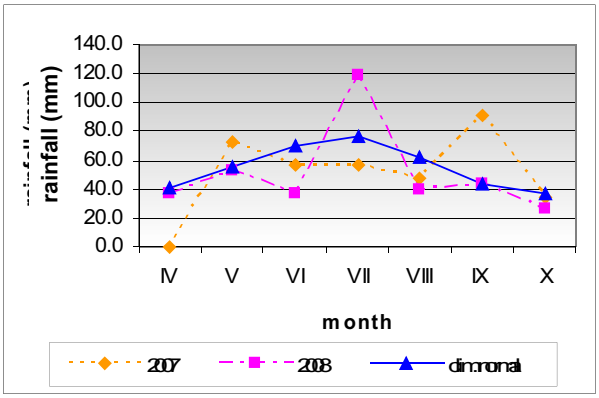

Figure 2. Average values of rainfall in 2007-2008.

Table 1. Achenes yield of sunflower in dependence on growth organization and Atonik application.

Hybrid		Achenes yield (t.ha^{-1})			
		56 000	65 000	control	Atonik
NK Brio	2007	3.70	3.95	3.88	3.97
	2008	3.69	3.98	3.59	3.89
	X	**3.69**	**3.97**	**3.74**	**3.93**
NK Armoni	2007	3.87	3.74	3.85	4.03
	2008	3.81	3.82	3.70	3.69
	X	**3.84**	**3.76**	**3.77**	**3.86**
NK Country	2007	3.87	3.74	3.74	3.99
	2008	3.76	3.88	3.73	3.77
	X	**3.81**	**3.81**	**3.73**	**3.88**
NK Ferti	2007	3.87	3.74	3.81	3.97
	2008	3.79	3.84	3.84	3.70
	X	**3.83**	**3.79**	**3.82**	**3.84**
average		**3.79**	**3.83**	**3.76**	**3.87**

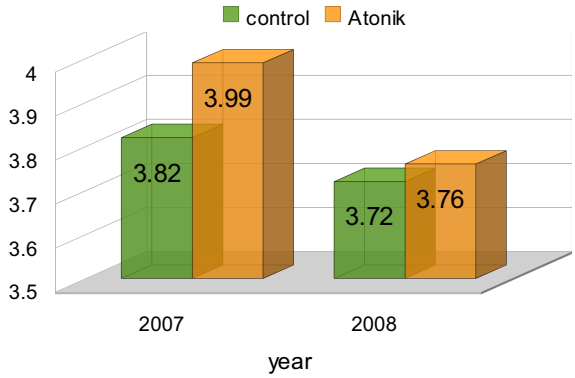

Figure 3. Achenes yield of sunflower in dependence on year and Atonik application

Conclusions

From facts mentioned above result, that weather conditions of monitored period had significant influence on achenes yield. The year 2007 showed more suitable for achenes yield (3.82 t.ha^{-1}) in term of rainfall and temperature conditions. But unsuitable temperature distribution in 2008 resulted in lower values of achenes yield (3.72 t.ha^{-1}).

Within the growth organization, variant with 65 000 plants per hectare showed more suitable for achenes yield (3.83 t.ha^{-1}).

Increase of achenes yield about 0.11 t.ha^{-1} compared to control was observed after application of growth stimulator Atonik. Within particular hybrids, these all reacted positive to Atonik application. We observed the highest increase of yield by hybrid NK Brio (increase about 0.19 t.ha^{-1} compared to control).

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The Agro Climatic Analysis Phytomass Production of Salix (Salix Vilimalis)

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Abstract. This contribution deals with the creation of agrometeorological models of phytomass production, which can be used for benchmark foreboding of phytomass harvests by the occurrence of selected temperatures and rainfall. It showed that the harvests of phytomass, which were estimated by agrometeorological model showed an average probability of 86%. In the approximately 40% of years, probability of appearance amount of harvest phytomass was provided with an accuracy of 96%. Finally, it can be concluded that the simple mathematical - statistical model provides a good ability for prediction of salix phytomass.

Introduction

Autotrophic plants are characterized by a unique capability - create in the process of photosynthesis bioproduction, i.e. phytomass harvest. However, the amount of harvest is a resultant interaction of genetic potential of plants and external environmental factors, especially agro climatic factors. In highly productive variety of the plant species, an energy and water balance of ecosystem is a limiting factor in the creation of organic matter. Any divergency from optimal energy and water conditions of plants at any stage of its growth has a negative effect on its further growth and development and thus affects the overall yield. In the presented work the relationship between phytomass production of salix (Salix vilimalis) and energy and water balance is analyzed by mathematical - statistically methods. Water and energy balance is expressed by the average air temperature and total atmospheric rainfall for the months of major growing season (MGS) limited by entering and leaving the average daily air temperature $T \geq 5.0$ ºC. For the determination of this relationship is also used the methodology for modeling plant crops developed by Šalitovom (1975). In our conditions eg. Kurpelová (1982), Zachar (1982), Špánik et al. (1992) and others devoted similar issue.

Data and methods

Data about the crops were obtained from polyfactors field experiments with salix which were made by Otepka and Habán (2006). Experiment was stablished in the years 1996-2003 on an experimental basis of SPU – Malanta by Department of sustainable agriculture and herbology. Experimental base lies at an altitude of 173 m, latitude 48 º 19` and longitude 18 º 07`. Analysis included 3 varieties of salix (Salix vilimalis ULV, RAPP, ORM) at 2 options according to clip sowing. In the 8 year experimental period 48 strong set of biological data was created, i.e. phytomass harvests in $kg.m^{-2}$ for the analysis. Agrometeorological characteristics: air temperature (T °C) and atmospheric rainfall (R in mm) were measured on the agro climatic station KBH, FZKI, SPU in Nitra, which is situated in the area of experimental bases. Agro climatic analysis is applicable to the growing production of phytomass, i.e. calendar vegetation period, bounded from april to september. Effect of temperature and rainfall on yield was analyzed:

1. For the winter half-year of the growing season (10. - 3.) according to non-linear correlations. Selection of appropriate test functions of the reporting relationship (parabola quadratic and cubic, and polynomial function exponential) was the coefficient of determination (R^2). Demonstrativeness margin for $N = n - 2 = 48 - 2 = 46$ for $\alpha = 0.05$ when $R^2 = 0.28644$. For more comprehensive analysis of the impact of temperature and precipitation for the production of phytomass, according to the highest values of R^2 4 + 8 temperature and precipitation characteristics were set.
2. Intractive relationship between crop phytomass and agro climatic characteristics of the growing season with the highest R^2 values was modeled by the linear regression.

Results and disscussion

The temperature and the production process

Temperature as a basic condition of life affects the nutrient intakes, transpiration, photosynthesis, breathing, and other environmental operations of plants that are directly or indirectly involved in the production of crops.

Statistical analysis of the above-average yields creation observed in the growing and pre-term growing intervals of optimal air temperatures is listed in Tab. 1. The tightness of the relationship betwen temperature and the harvest in selected periods of vegetation season and during pre-vegetation period is expressed as a coefficient of determination (R^2). The analysis shows most optimal average air temperature during the $4^{th} – 9^{th}$ month ranging from 17.5 to 18.5 ºC ($R^2 = 0.060$). Significatly important seems the temperature in the third quarter of year i.e. during the 7th – 9th month ranging from 18.0 to 20.00 ºC ($R^2 = 0.41$). Analysis shows generally theconversion of thermal energy to the energy of chemical bonds in the production process of willow. This relationship confirms direct dependence of the harvest on air temperature.

Table 1. Interval of optimal average air temperature (T ºC) and total atmospheric precipitation (R in mm) for the creation of phytomass (Y_{Fa} in $kg.m^{-2}$) according to the non-linear correlations.

Time period	Interval of optimal characteristics			
	T (ºC)	R^2	R (mm)	R^2
10. - 3.	3.5 – 5.5	0.17	200 – 250	0.33
4. - 9.	17.5 – 18.5	0.6	185 – 360	0.35
4. - 6.	14.5 – 17.0	0.15	50 – 190	0.33
7. - 9.	18.0 – 20.0	0.41	130 – 190	0.12
4	10.0 – 13.0	0.11	20 – 65	0.44
5	17.0 – 19.0	0.21	25 – 85	0.34
6	19.5 – 21.0	0.03	5 – 75	0.05
7	20.5 – 22.5	0.2	50 – 85	0.17
8	21.0 – 23.0	0.32	50 – 85	0.0001
9	15.0 – 18.0	0.29	5 – 85	0.01

Rainfall and production process

Water forms dispersive environment for colloidal plasma in plant cells, where biochemical processes of metabolism are in progress and new organic matter (the new harvest) is produced. In order to carry out these processes optimally, plant cells must be sufficiently saturated with water - hydrated. Every water deficit leads to decline in intensity of biochemical production processes and thus yields.

Mathematical - statistical analysis listed in Tab. 1 shows close direct relationship (R^2 = 0.33) between rainfall and phytomass harvest in the winter half-year (10. – 3. month). In winter period, the stock moisture is kept in the soil profile, what is needed for the spring beginning of vegetation period. But also a progressive water supply is important for plants in other parts of vegetation season. The highest yields of phytomass were found by the most accumulated atmospheric precipitation in the range of 200 - 250 mm. In the summer half-year (4. - 9.) the best conditions for production process with , in the range 180 - 360 mm were recorded. However, the anaysis also showed that in the summer half-year ~~of~~ the production process has been limited primarily by the temperature and not by moisture. This results from a low coefficient of determination and outstanding and mainly indirect dependence of harvest on rainfall.

Table 1. Parameters of agro climatic analysis of salix phytomass production under the linear regression (Nitra, 1996 - 2003).

Year	$R_{10.-3.}$	$T_{4.-9.}$	$T_{8.}$	Y_{Fa}	Y_{Fm}	ΔU	Probability of appearance
	(mm)	(ºC)		(kg.m^{-2})			(%)
1996	166	16.0	19.4	2.43	3.03	0.60	80
1997	138	16.2	20.8	3.02	2.99	-0.03	99
1998	178	17.3	20.9	3.19	4.16	0.97	77
1999	184	17.3	19.0	4.24	4.05	-0.19	96
2000	235	17.6	22.1	5.92	4.91	-1.02	83
2001	255	17.7	23.1	5.33	5.21	-0.12	98
2002	134	17.5	20.8	5.17	3.87	-1.30	75
2003	194	18.4	22.7	4.12	5.20	1.08	79
Average	185	17.2	21.1	4.18	4.18		86

Multiple correlation analysis

Using the multi-correlation analysis of the production process of salix, several combinations of agro climatic characteristics were assigned according to the coeficient of determination values (R^2). Three most important relationships were found between the salix yealds and following temperature/precipitation characteristics :

- rainfall for the winter semester ($R_{10.-3.}$ in mm),
- average air temperature in the growing season ($T_{4.-9.}$ in º C),
- average air temperature in August (T_{8} ºC).

According to the multiple correlation analysis following equation modeling phytomass production of the calculation (in kg.m^{-1} Um) was compiled:

$Ym = - 11.217 + 0.0085\ R_{10.-3.} + 0.7084\ T_{4.-9.} + 0.07597\ T_{8.}$

$R = 0.71395$

The above equation expresses the proportion of the impact of temperature and precipitation characteristics in the creation of willow phytomass. Thus the equation can be regarded as a simple mathematical - statistical agrometeorological model of the salix tree phytomass creation. Comparison of actual yields (Y_{Fa}) and the modelled yields (Y_{Fm}) are listed in Tab. 2 and Fig. 3. It showed that the crop phytomass which was calculated by model, occured with an average probability of 86%. In the approximately 40% of years, probability of modeled harvest phytomass occurence was of 96%. This model can be used for a good estimation of crop production of the salix tree phytomass under the rainfall in the winter.

Generally, therefore we can conclude that the simple mathematical - statistical model provides a good posibility for modeling of crop conditions under the most often used agrometeorological characteristics, i.e. the average air temperature and atmospheric precipitation.

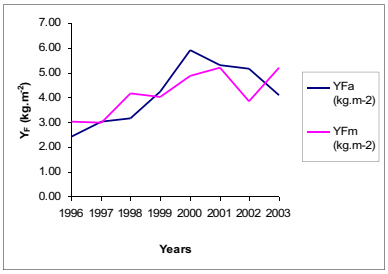

Figure 3. Measured YFa and modeled ($T_{4.-9.}$, $T_{8.}$, $R_{10.-3}$) YFm salix phytomass harvest in kg.m^{-2} at Nitra in 1996 – 2003.

Conclusions

Relationship between phytomass production of salix and energetical (temperature T in °C) and water characteristic (from rainfall in mm) was analyzed using the non-linear correlation and linear regression. In the framework of the analysis, simple agrometeorological model of phytomass production of salix was designed, which can be used for benchmark estimation of phytomass harvests by some temperatures and rainfall in the pre-growing and crop-growing period of salix.

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Long-term trends in spring phenological phases in Slovenia between 1955 and 2008

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Abstract The long-term phytophenological and meteorological data set for the 1955-2008 period was analysed to assess the impact of increased winter and spring temperatures on the plant development in Slovenia. The 54-year series of the leaf unfolding and flowering were studied for 11 plants (herbaceous plants, shrubs and trees) at eight selected observation points. The mean linear trends in phenophases appearance were negative, ranging from one day per decade for leaf unfolding, two days per decade for late-spring flowering, and three days per decade for early-spring flowering. This resulted in earlier leaf unfolding of 6 days and earlier flowering of 10-14 days for the discussed period. A 10-day shift to an earlier spring in Slovenia corresponded well with changes in early-spring temperatures from February to April.

Introduction

Phytophenology deals with the recurring growth and development phenomena of plants in their annual rhythm. The occurrence times of characteristic vegetation stages (phenophases) are in close relation to the climate of the observation site and current weather. Inter-annual changes in spring plant phenology may be the most sensitive and observable indicators of the plant response to climate change (Beaubien and Freeland, 2000). Earlier spring development is occurring in different parts of Europe (Menzel et al., 2006; Defila and Clot, 2001). The earliest flowering species in the growing season show more variability in bloom time over the years than later-flowering species (Bergant et al., 2002). Phenological data of the International Phenological gardens for the period 1969-1998 showed that the average beginning of growing season across Europe advanced by 8 days (Chmielewski and Rötzer, 2002). The investigation showed (Chmielewski and Rötzer, 2001) that a warming in the early spring (February-April) by 1°C causes an advance in the beginning of growing season of 7 days. This study analyses long-term phenological time series to assess the impact of air temperature changes on selected plants in Slovenia.

Data and methods

For the long-term phenological analyses only the best quality phenological data, that over at least 30 years, were selected. The study is based on eleven common plants at eight different observation points (Tab. 1). These phenological data-series were extracted from the historical phenological data set of the Environment Agency of Slovenia. Spring phenophases (leaf unfolding, flowering) were selected for study as the effect of climate change is more pronounced in early spring in Slovenia and owing to the availability of quality data set. First, logical and critical control of the data was performed including plotting of all phenological data. No data were added or corrected because filling in the gaps could change the trends of complete records. For this study, the phenological dates of eleven species were combined in an annual leaf unfolding index, early-spring flowering index and late-spring flowering index to determine the changes at the beginning of the growing season in Slovenia for the 1955-2008 period (Tab. 1). Combining species phenophases to derive an index value has the advantage of summarizing plant responses to weather conditions over extended period or region (Beaubien and Freeland, 2000) and obtain a common but more reliable data (Schaber, 2002). For the study of phenological and mean monthly air temperature time series, the linear trend analysis was used. For statistical analysis, the STATGRAPHICS Plus 4.0 and EXCEL 2002 standard modules were applied. Correlations were calculated between phenological data and mean monthly air temperatures for 54 years (1955-2008).

Table 1. Phenological data: phenophases, indicator plants, phenological indexes and locations.

PHENOPHASES **- First leaf unfolding date, Flowering date**
INDICATOR PLANTS -beech (*Fagus sylvatica* L.) -black locust (*Robinia pseudacacia* L.) -common elder (*Sambucus nigra* L.) -common lilac (*Syringa vulgaris* L.) -common silver birch (*Betula pendula* Roth.) -dandelion (*Taraxacum officinale)* -goat willow (*Salix caprea* L.) -hazel (*Corylus avellana* L.) -horse-chestnut (*Aesculus hippocastanum* L.) -large-leaved lime (*Tilia platyphyllos* Scop.) **-snowdrop (*Galanthus nivalis* L.)**
PHENOLOGICAL INDEXES Phenological data set was used to calculate four phenological indexes: **Leaf unfolding index (LI)** Leaf unfolding index is determined as the annual mean of the leaf unfolding dates for beech, common silver birch, large-leaved lime and horse-chestnut. **Early-spring flowering index (F_1I)** Spring-flowering index is determined as the annual mean of the flowering dates for common silver birch, dandelion, goat willow, hazel and snowdrop. **Late-spring flowering index (F_2I)** Late-spring flowering index is determined as the annual mean of the flowering dates for black locust, common elder, common lilac and large-leaved lime. **Growing season index (GSI)** **Growing season index is the mean value of the three phenological indexes (LI, F_1I, F_2I) for eleven species at eight locations: GSI = (LI + F_1I + F_2I)/3**

LOCATIONS
-Celje (46°15'N, 15°15'E, 242 m a.s.l.)
-Ilirska Bistrica (45°34'N, 14°15'E, 414 m a.s.l.)
-Lesce (46°22'N, 14°11'E, 515 m a.s.l.)
-Ljubljana (46°04'N, 14°31'E, 299 m a.s.l.)
-Maribor (46°32'N, 15°39'E, 275 m a.s.l.)
-Murska Sobota (46°39'N, 15°12'E, 190 m a.s.l.)
- Novo mesto (45°48'N, 15°11'E, 220 m a.s.l.)
- Rateče (46°30'N, 13°43'E, 864 m a.s.l.)

Results and discussion

As a long-term average (1955-2008), the beginning of growing season (defined as growing season index-GSI) in Slovenia starts in the *third decade* of April. Standard deviation of growing season index is about 7 days and variation interval 30 days. The greater part of earliest springs was noticed after year 1987. The majority of spring phenological trends were significantly negative (90%), 10% were not significant. Negative trends indicate an earlier onset of leaf unfolding and flowering during the past decades. The mean linear trends (days/decade) ranged from one day for leaf unfolding, two days for late-spring flowering, and three days for early-spring flowering. This means a movement forward by 6 days in the timing of leafing and of 10-14 days in the timing of flowering. The growing season index showed a significant negative trend of two days per decade, corresponding to 10 days earlier beginning of growing season over the last six decades. There are differences among the spring trends of different phenophases observed, the higher trends being found for early-spring flowering of *Coryllus*, *Salix* and *Galanthus*, indicating that changes of events occurring in the early spring are more distinct and related to considerable change in late-winter and early-spring temperatures. Changes are more distinct for phenophases of flowering, indicating that these phenophases are more sensitive to air temperatures (Rosenzweig et al., 2007).

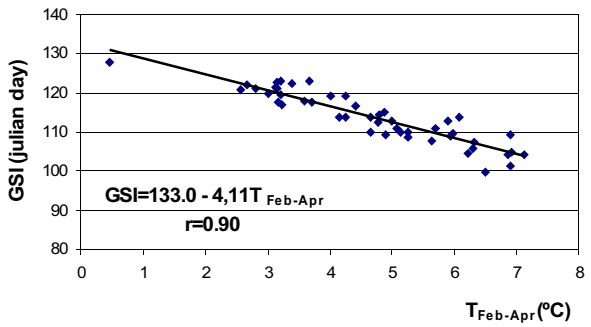

Figure 1. Relationship between mean spring temperature $T_{Feb-Apr}$ (February to April) and growing season index (GSI). A warming of 1ºC in $T_{Feb-Apr}$ means approximately 4 days earlier beginning of growing season in Slovenia.

The annual timing of spring phenophases is largely a esponse to temperature and reflects thermal conditions of the current year and location. From February to April, significant negative correlation coefficients between GSI and temperature were found, meaning that higher temperatures in early spring promote earlier flowering and leaf unfolding. Annual monthly temperatures for eight locations for February, March and April were averaged for each year. These temperatures and GSI correlated at high significant correlation coefficient (r = -0.90). A comparison with the simpler relationship with the one-month temperatures confirmed that relationships were tighter when the temperatures of many months were dealt with together. The later beginning of growing season was associated well with lower than average temperatures. According to the regression equation, a warming of 1°C promotes beginning of growing season by four days in Slovenia.

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Climatic Wine Growing Potential under Future Climate Scenarios in Austria

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Abstract. A significant warming trend is expected in Austria, as in many Central European regions during the next decades, leading to a large shift of agroclimatic zones. These shifts will change land use in agriculture over large regions in the long term. Wine is known as a crop which climatic demands are relatively well known for several climatic parameters. According to these climatic growing limitations, the borderline of wine growing climate will significantly shift due to climate warming in Austria due to the significant climatic gradients. In this study, based on the EU-project ADAGIO, the change of wine growing potential areas in Austria is analysed under several climate scenarios using agroclimatic indices such as the HUGLIN index. According to the results a doubling of potential wine growing areas is expected till the 2050s for several regions in Austria.

Introduction

Grapewine is known as a good climatic indicator because of his long life cycle. Wine harvesting dates, for example, are used in historical climatology to detect and describe historical climatic changes and variability as these data were recorded well over the past centuries in Europe because of the economic importance of wine. According to Harlfinger et al. (2002) wine growing in Austria is limited by several climatic limitations such as temperature sum during the vegetation period, sunshine hours, minimum temperatures in winter or annual precipitation. In Austria and over Europe the HUGLIN index (or Heliothermal index), which is based on temperature sums during summer can represent relatively well the current wine growing areas at the larger regional scale. However, for a small scale assessment, considering local climatic phenomena in complex terrain, additional limitations have to be applied, such as terrain characteristics or small scale variations in temperature extremes (Eitzinger et al., 2009).

Data and methods

Long term daily weather data from the period 1971-2000 were used as reference period to calculate the HUGLIN index (e.g. Tonietto and Carbonneau, 2004) for Austria. The Huglin index, a temperature sum based index for the growing period, is as follows:

$$HUGLIN = ((Tmax - 10) + (Tmean - 10) * K) / 2$$

where T is daily temperature from April till September in °C and K is a coefficient for latitude (1.02-1.08 vs. 40°-50°).

Climatic scenarios of daily weather data for the period of 2041-2050 (HadCM3, SRES A2) were applied for future climate to calculate the index over Austria in a resolution of 10x10km in order to assess the potential wine growing areas based on this index (Eitzinger et al., 2009).

In order to create a higher spatial resolution of the temperature and precipitation field over Austria, a monthly climatic data base at 1x1km resolution was used for further analyses. Based on this high resolution temperature map, the HUGLIN index results and information on historical archieved wine growing regions in parts of Austria the limitations from annual temperature and precipitation were extracted. Finally the relative changes in temperatures of the climate scenarios were applied on that high resolution scale. A further limitation of potential wine growing locations was applied using GIS implemented algorithms to detect the preferred climatic locations for vineyards, namely slopes and the slope aspect from south to eastern directions, as it is also the observed prevailing terrain condition in current wine growing regions of Austria.

Results and disscussion

The results for the region of Upper Austria, where currently no significant wine growing areas exist are shown in the following. For this region the historical wine growing region of the warm period of the middle age was used to assess the annual temperature and precipitation limitation. The temperature limitation for the annual temperature was set at 9.5 °C as also pointed out be Harlfinger et al. (2002). The annual precipitation limit, which is closely correlated to annual sunshine hours, was set to 1100mm.

In Fig. 1 the change of the HUGLIN index during the past decades at 3 different regions in Austria (represented by meteorological stations Vienna, Graz and Kremsmünster) is shown.

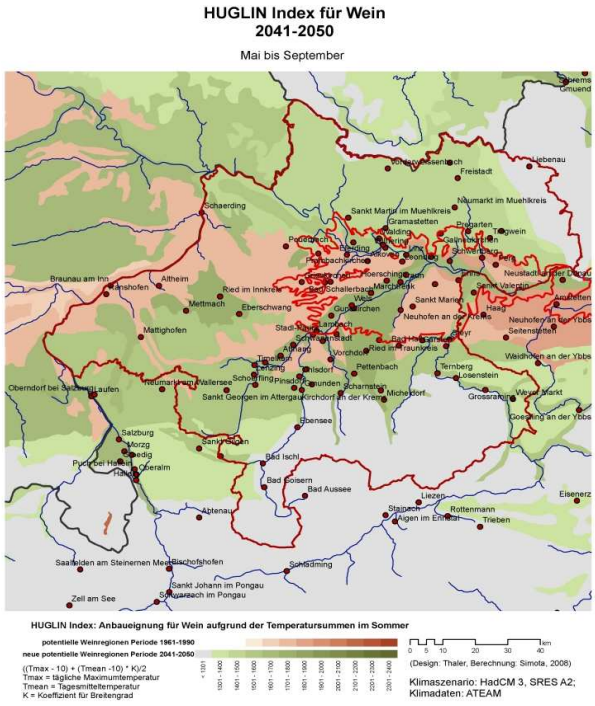

Figure 1. Trend of the HUGLIN index at 3 different sites in Austria, representing southern (Graz), eastern (Vienna) and northern (Kremsmünster) parts of Austria.

Fig. 1 shows a significant increase of the index at all 3 stations as caused by the warming trend. It indicates also that optimum growing conditions of cultivars will change (indicated at the right axis). Fig. 2 shows the potential wine growing areas, based on the HUGLIN index only for the region of Upper Austria.

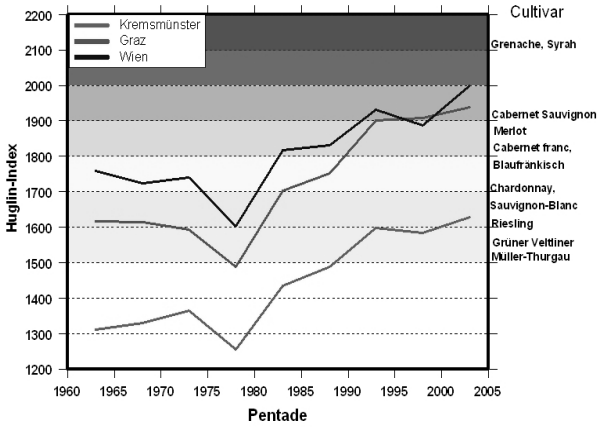

Figure 2. Assessment of large scale potential of wine growing areas for the region of Upper Austria for current conditions (in red) and climate scenario of 2050s (in green). The red line represents the historical wine growing area (approx. 1000-1600).

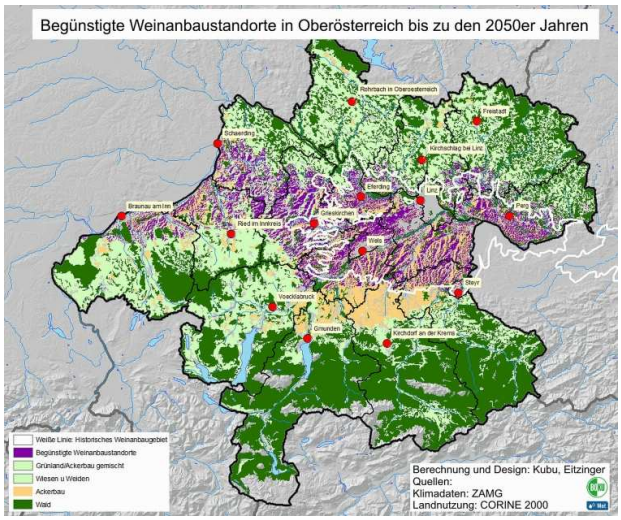

Figure 3. High spatial scale resolution of best potential wine growing areas in Upper Austria in the 2050s by application of additional limitations as in Fig. 2 (annual precipitation and terrain characteristics (in purple).

As it can be seen in Fig. 2, part of the region of Upper Austria is already again (see the historical documented wine growing areas) suitable for wine growing. This trend will continue showing almost all of the region suitable for wine growing till the 2050s. In Fig. 3 the map shows the wine growing areas considering additionally annual precipiatation and terrain characteristics, which obviously reduces the potential areas as assessed by the HUGLIN Index only. However, for the region of Upper Austria it covers still approximately 100 000 ha of potential growing areas, with a further doubling by the end of the century (not shown).

Conclusions

Due to climate warming, as indicated by climate scenarios, a significant shift of agroclimatological zones is expected in Austria. On the example of potential wine growing areas it is shown that a considerable increase of these areas is possible in the future indicating dramatic shifts in agricultural land use. Similarly, the expansion of crops with higher temperature demand is expected such us late ripening maize cultivars, sunflower or soybean. The areas of currently grown crops adapted to temperate climate such as permanent grassland, some cereals (e.g. oat) or potatoes is expected to decrease in the future. Especially for permanent grassland in many areas with low precipitation sums (e.g. below 800mm annual precipitation) a reduced production potential due to increasing summer drought is expected. In these areas adaptation to fodder crops is possible if the soil and terrain is suitable for arable farming. In complex terrain, however, such as in many current grassland regions of Austria (e.g. regions north of the Danube) terrain does not allow arable farming by technical, environmental or economic reasons. In some of these regions wineyards could be therefore an alternative for farmers as shown in this study.

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Landscape structures (hedgerows) as adaptation measure to climate change in semi-arid regions

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Abstract. Climate change associated with limited natural water supply hampers agriculture. Without adequate adaptation measures agriculture may partially become impossible in the North-East of Austria that is characterized by semi-arid climate. Landscape structures, such as windbreak hedges, can change microclimate as they improve water use efficiency of crops by slowing down wind speed, promoting dew formation and reducing evapotranspiration. Furthermore they reduce wind erosion. In semi-arid regions the impact of landscape structures on evapotranspiration is crucial and can have a significant effect on crop water balance, drought damage and crop yields. A landscape that is structured with hedgerows could have an average windbreak function of about 10 to 15 times the height of the hedge. This effect may increase yield considerable and means an economic benefit for the farm. The assessment of the economic opportunities and limitations of a landscape structure showed that there are not necessarily very high yield increases needed to get an economic benefit out of a structured landscape.

Introduction

Hedgerows play an important role for agricultural production as their impacts on field crops are manifold (Mayus et al., 1999). One of the important effects is the modification of the microclimate of neighbouring fields, especially caused by the well known function of wind speed reduction.

Since water is already today one of the limiting factors of agricultural production in the eastern part of Austria the efficient use of this limited and in future scarce resource by adaptation measures gets an important role in relation to the conservation of agricultural production.

A possible adaptation measure to face climate change in agricultural regions could be the implementation of landscape structures (e.g. hedgerows) whith the aim to influence the microclimate and thereby significantly improve the water use efficiency of their neighbouring fields.

Data and methods

Downscaled climate scenarios (Dubrovski et al., 2005) for the eastern part of Austria show a raise in temperature and about similar amounts in annual sums of precipitation. Compared to the period 1961-1990 the mean temperature will increase by about 1,9 °C for the period 2015-2035 and by about 2.5 °C for the period 2040-2060. Higher temperatures result in an increase of potential evapo-transpiration of 18% (2015-2035) and 25% (2040-2060) respectively (Eitzinger et al., 2005). As far as precipitation is concerned at least the annual distribution is expected to change. This means less rainfall during the summer months and more precipitation (but less snowfall) during winter.

Since 2003 field studies and special measurements campaigns (transect measurements) were carried out within the framework of the interdisciplinary monitoring project MUBIL (www.mubil.at) to define the total sphere of influence of a hedgerow in the semi-arid NE of Austria. Some relevant results are presented later. Additional literature research completes the state of our knowledge. First economic assessments at farm level concerning the increased demand of crop yield in a landscape structured with hedgerows were undertaken within a recently finshed national project.

Results and discussion

Based on literature analysis, a wind protecting effect can be assumed on a width of 10 to 20 times of the height of the landscape structures (see, e.g. Mazek-Fialla, 1967). Hence a 5-meter-high hedge causes a potential windbreak function up to 100 m and thus has a positive influence on water supply of this arable land. Literature research also shows that landscape structures should have a minimum width of 6 meters, so that a significant climate impact and thus a positive influence on the water and soil erosion can take place (DVL, 2006; Meyerhoff, 2006).

An overview of effects of a hedgerow on micro-climate is given in Fig. 1. The analysed effect depends on the regarded parameter and on the structure of the hedge, which means height, width, wind permeability and orientation. For the sake of completeness it should be mentioned that there are also other factors such as abiotic site conditions (soil and subsoil of rock, water and nutrient budget) and the cultivated crop itself which influence yield.

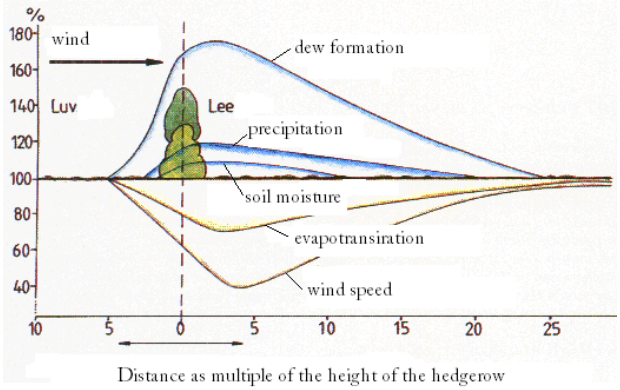

Figure 1. Effects on microclimate. Distances as multiple of the height of a hedgerow (Frielinghaus et al., 1997, modified by Gerersdorfer).

Based on field measurement campaigns during the above named monitoring project MUBIL the total sphere of influence of the hedgerow was investigated. Parameters like precipitation, wind speed, potential evapotranspiration and others were measured in orthogonal transects at different distances.

Snow banks directly at the hedgerow and snow cover thickness play an important role for the soil water budget.



Figure 2. Snow banks near the hedge in March 2005, left and middle: leeward, right: windward.

The melting water equivalent of these snow banks (Fig. 2) of about 158 mm represents more than 30% of the average annual precipitation in this region. A simulation of the conditions in March 2005 showed a positiv influence on soil water content for about 2 months nearby the hedgerow. Additionally, these snow banks affected crop yield in 2005. Crop yield is decreasing with increasing distance from the hedgerow as shown for winter wheat in Fig. 3.

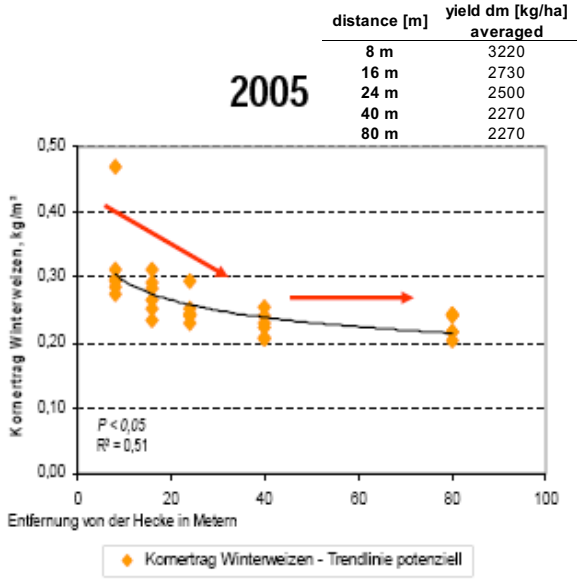

Figure 3. Inventory of yield. Manually and multiple yield measurements in a transect at different distances from the hedgerow (Surböck et al, 2009).

For our first economic assessments local field crop rotation in conventional farming in the eastern part of Austria, its crop yield, price forecasts and the maintenance of income were assumed, despite unfavourable climate conditions. The economic limitations and opportunities of a structured landscape in terms of direct economic impact and effects were estimated.

Model scenarios for a landscape structure with 5 m height and 6 m in width and the assumed windbreak function of 50m (10 times the height of the structure) show an increase the yield by about 10 % (in relation to the crop harvest), which is already an economic advantage for the farm. If the average wind protection is 20 times the height of the hedge, an increase of approximately 5 % of the natural yield causes a positive effect of the landscape component on the farm account.

Conclusions

Landscape structures change the microclimate. They improve water use efficiency of crops by increasing dew formation and reducing wind speed, evaporation and furthermore wind erosion. Dislocation of snow (snow banks) near the hedge has a high impact on soil water budget in spring. Under climatic conditions of today, this leads to an increase of crop yield. Considering climate change adaptation measures are increasingly important. One possible adaptation is the use of landscape structures such as hedgerows.

A landscape structured with hedgerows could have an average windbreak function up to 20 times of the height of this structure. It may increase yields by about 10 % which means an economic benefit for the farm. First assessments of economic opportunities and limitations of a landscape structure showed that there are not necessarily very high yield increases needed to get an economic benefit out of a structured landscape.

Structuring the agriculturally used landscape with hedgerows provides a meaningful adaptation measure - microclimatological and economically to the changing climate in the eastern part of Austria.

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Pollen season duration of winter rape (Brassica napus L.) in Czech and Slovak Republic

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Abstract. *Brassica napus L.*, belongs to family Brassicaceae, is very important oil plant grown in Czech and Slovak Republic mainly in recent years for biooil and bioethanol production. *Brassica napus L.* is also allergology important plant. CHMI and SHMI observe winter rape at phenological network with subsequent phenophases: sowing, emergence, first leaves, stem elongation, beginning of flowering, full flowering, end of flowering, yellow ripeness and harvest. In this contribution is evaluated the onset of beginning and end of flowering of winter rape and their interphase interval in the period from 1996 to 2008 from phenological stations with the most complete temporal rows. The basic statistics and trend analysis were computed. The mean date of onset of beginning of flowering is from April 26th to May 8th in Czechia and from April 23rd to May 5th in Slovakia. From the trend analysis of the mean beginning and end of flowering resulted declining trend-it means the shift of phenological onsets towards to earlier date. The onset of beginning of flowering is shifted for 9.4 days in Czech Republic and for 9.3 days in Slovak Republic. The interphase interval proceeds from 21 to 30 in Czechia and from 22 to 27 days in Slovakia.

Introduction

Winter rape originate from Central Europe, species from genus Brassica were used as vegetable. Later on in Middle Ages become more important for its seeds for oil and soap production. Winter rape is widespread on the present for biooil and bioethanol production. Winter rape can be winter or spring status (in Czechia and Slovakia are mainly winter form), it is annual or biennial 60-120 cm high plant. The plant creates earthbound foliar rosace and elongates in spring. It has very good frostproof (-12°C). Inflorescence makes thin bunch with up to 30 flowers. Single flowers are yellow, 1 cm length. Pollen grains are coated with adhesive lipoid substances and stick together. There is a typical odour during flowering-organic substance run out into air.

The air temperature has the high influence on beginning of flowering-start of pollen season (Remišová and Vinceová, 2006). Results of analysis of weather effect on start of phenological phases at winter rape show that, winter rape production depends on start and duration of individual growing stages. Partition of precipitations is important during vegetation period (Šrojthová and Tóth, 2006). There are more other factors affected the beginning of flowering, but primarily it is the weather in early spring and spring.

Data and methods

We have analyzed the onset of beginning and end of flowering of winter rape and interphase interval for the period 1996-2008 in both countries (Czech and Slovak Republic). There were chosen phenological stations with the most complete rows from the special field crops stations at elevation from 104 to 624 m a.s.l. The results are given in form of the number of the year, stations were analyzed also separately. There were done the statistical and trend analysis of onsets of evaluated phenological phases. The phenological data were observed according to the accepted methodology of the Czech and Slovak Hydrometeorological Institute.

Results and disscussion

There is a part of statistical results in Tab. 1 and trend analysis in Fig. 1 from phenological stations in Czech and Slovak Republic. The date of beginning of flowering in the period 1996-2008 at separately stations is from 96 (Somotor station, 2007) to 145 (Chrastava station, 1996), the date of end of flowering is from 119 (Kroměříž station, 2007) to 174 (Chrastava station, 1996). Differences between average and median are very small.

The beginning and end of flowering of winter rape have a tendency to shift to the earlier date, on the other side the interval between these two phenological phases have a tendency to prolong.

The average value of interphase interval of beginning of flowering-end of flowering is 25 days in Czech Republic and 24 days in Slovak Republic. Course of deviations of beginning of flowering from average value 1996-2008 are similar in both countries (Fig. 2).

Table 1. Statistical results of beginning and end of flowering of *Brassica napus L.* and interphase interval in the period 1996-2008.

	Beginning of flowering		End of flowering		Interphase interval	
	CR	SR	CR	SR	CR	SR
Average	122	119	147	143	25	24
Median	123	120	148	143	24	25
Upper q.	118	115	142	138	21	21
Lower q.	126	124	152	148	28	28
STD	7.6	7.4	8.8	7.2	5.3	4.8
MIN	101	96	119	126	12	13
MAX	145	135	174	161	42	36
Relative variation coeff.	6.2	6.2	5.9	5.0	21.1	19.6

Conclusions

The results show the shift of phenophase onsets to earlier dates. Comparison between Czech and Slovak Republic shows similar results. The onset of both phenophases starts on average earlier in Slovakia, relative variation coefficients are the same by phenophase beginning of flowering in both countries, by phenophase of end of flowering are very close.

On the other side the relative variation coefficients by interphase interval is too high.

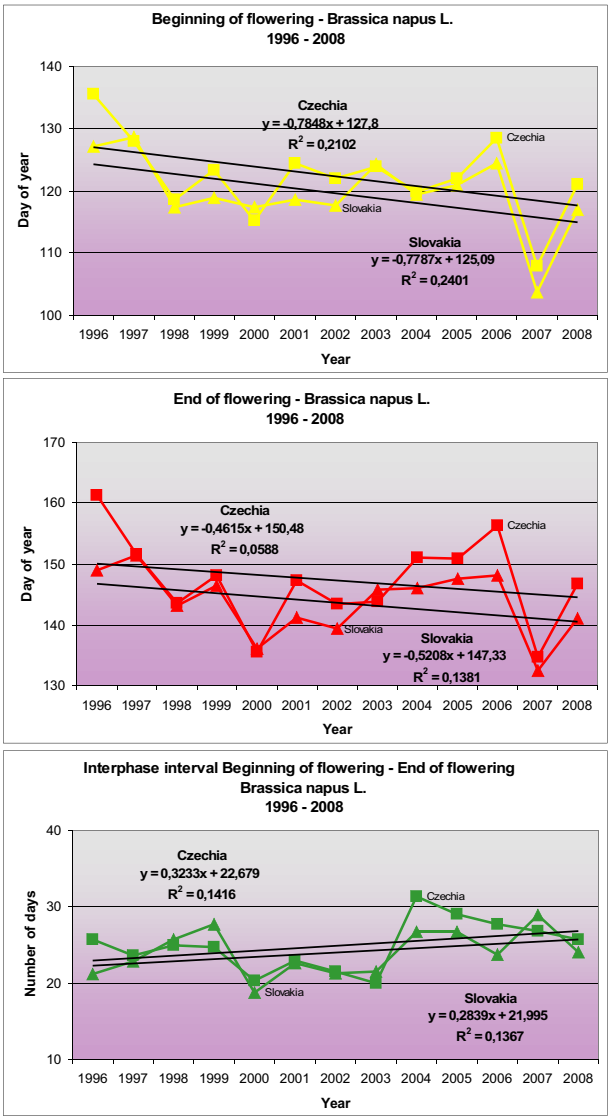

Figure 1. Onset and trend of beginning and end of flowering of *Brassica napus L.* and their interphase interval in the period 1996-2008.

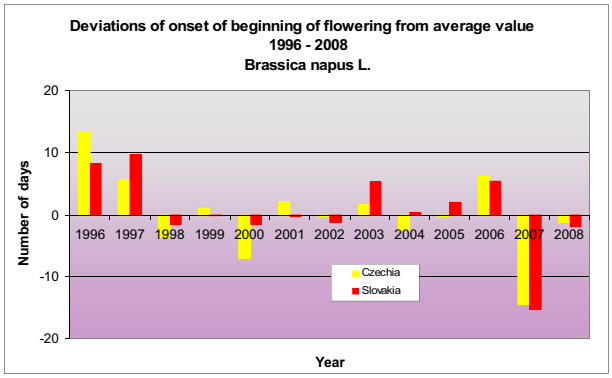

Figure 2. Deviations of onset of beginning of flowering from average value 1996-2008, *Brassica napus L.*

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Determination of period with prevailing temperatures

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Abstract. The objective of this paper is comparison of method of a determination of a period with prevailing defined average daily temperatures.

Introduction

One of the ways how to assess agroclimatical condition of landscape is a determination of a period with prevailing defined average daily temperatures. By this way can determined, for example, the big vegetative period as a period with prevailing average temperatures $t \geq 5°C$ and main (small) vegetative period with prevailing average temperatures $t \geq 10°C$. Of course, this way of determination vegetative period depends only on air temperature and it is possible that this doesn't have to be compatible with the stadium of vegetation. The issue is more difficult, because every plant has its own temperature requirements, thus the vegetation period of particular plants starts and ends in different time. Anyway, determination of a period with prevailing average daily temperatures $t \geq 5$ °C and $t \geq 10$ °C is a useful characteristic.

Using long-term average of daily temperatures is easy way how to determine the datum of the beginning and end of the period with given temperatures. If one wants to do it in particular year, the situation is much more difficult. It's because the temperature often fluctuates and there can be a few warm and cold waves. There exist many methods concerning this subject.

Data and methods

This paper describes and compares two basic methods of determination the period with particular prevailing average daily temperatures which work only with daily values. This means that there are not used any longer-term averages which can help make the course of the temperatures smoother. The smoother temperature annual course helps the determination of the period, but using the average can cause that the beginning of the period can be on the day when the temperature is low.

Pokladníková, et al. (2008) described the method which was used in frame of research project CECILIA (EC 6th Framework Programme). The beginning of the period starts with the first interval of at least 6 days with daily mean temperature above defined level. The end of the period comes with first interval of 6 days with daily mean temperature below defined level. The important rule is that the beginning of the period must be in the first half of the year and the end of the period in the second half of the year. This method is very easy for computation but has some problems. The beginning of the period can be in early days of the year, if the temperatures are high, but in next days the temperatures can be low for a long time. In praxis this trouble is often reduced in that the first two moths of the year are omitted and the beginning of the period can be in March at first. However this solution is rather controversial, because there's nothing wrong with the fact that the vegetation period in some years and locations begins early and sometimes and somewhere later. The similar problem is the end of the period that can be found very early when the temperatures temporarily drop. The last trouble is that using not 6 but for example 5 consecutive days could give different results, so this method seems to be very subjective.

The other method was used in Climate Atlas of Czechia (2007). This method is more sophisticated than the previous one. There are examined not only days with the given temperatures but also the particular values of the temperature. The beginning of the period can be determined by an interval of only one day with the temperature above particular level. There are computed temperature sums in the warm and cold period (the periods with the temperatures above or below the given value). The beginning of the period is calculated, so that the sum of temperature differences from a given limit during the cold wave within the duration of the period is smaller than the sum from the beginning of the period. It's similar for the end of the period.

This paper presents the results of determination periods with a prevailing average daily temperature $t \geq 5$ °C and $t \geq 10$ °C in 1961 - 2000 period. There were used data from 21 climatological stations of south Moravia in period from 1961 to 2000 (some data were not complete, so the missing ones were computed using statistical methods). For every year there were calculated beginning and end of the period with prevailing temperatures.

Results and discussion

The differences between Cecilia and Climate Atlas method of determination of a period with daily temperatures of 5 °C and higher are presented in Fig.1. Data of all the stations are used to construct this graph. The both methods give the same result approximately in 50 % of events. The beginning and also the end of the period are determined by Cecilia method later in 1/3 of the events. The opposite situation has smaller probability. However, there are, mainly according to the beginning of the period, the cases when Cecilia method gives much earlier data of beginning of the period. These are the cases, when there are a few (at least 6) warm days in early months of the year following by the longer period of low temperatures.

In average, the difference between Cecilia and Climate Atlas method of determination of a beginning of a period with prevailing average daily temperatures exceeding 5 °C (mean absolute error) is 9 days. However, sometimes earlier beginning dates are given by one method and sometimes by the second, the average datum of beginning of the period with $t \geq 5$ °C in years 1961 - 2000 (mean error, bias) is determined by Cecilia method only 2 days earlier then by Climate Atlas method. This is, however, the average of all the stations. The data of particular stations differs more. At Protivanov, according Cecilia method, the beginning of the

period is 11 days earlier, at Velké Meziříčí 3 days later than by Climate Atlas method.

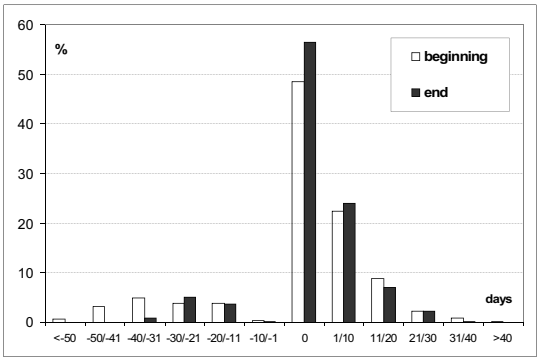

Figure 1. Probability distribution of differences (in days) between Cecilia and Climate Atlas method of determination of a period with prevailing temperatures t≥ 5 °C calculated for all stations and the whole 1961 - 2000 period.

The maximum difference in beginning of the period with t≥5°C between Cecilia and Climate Atlas method was 91 days. This situation happened in 1993 in Bystřice pod Hostýnem. The 10th of the January was the first day of the period of 6 days with the daily average temperatures t≥5 °C. After this period, colder days came. Warmer days came much later and the Clime Atlas method gave the beginning of the period on the 12th of the April. Slightly different event was also in Bystřice in 1997. The Cecilia method gives the beginning of the period on the February 21st, the Climate Atlas on the 23rd of the April. In Nedvězí in 1972, the beginning of the period was on the 16th of the March according Cecilia method and on the 30th of the April according Climate Atlas method.The most significant event when Cecilia method gave the datum of the beginning of the period later than Climate Atlas method was at Velké Meziříčí in 1994 when the difference was 44 days. Climate Atlas method determinates the datum of the beginning of the period on the March 8th. The first 6 following days with temperatures t≥5 °C did not occur until the April 21st.

The data of the end of the period using both methods differ rather less. In average the difference in determination of end of a period with prevailing average daily temperatures t≥5 °C (mean absolute error) between the Cecilia and Climate Atlas method is 5 days. The average date of the end of the period with t≥5 °C (mean error) is determined by Cecilia method only 1 day later than by Climate Atlas method. At Protivanov station, according to Cecilia method, the end of the period is 3 days earlier, in Brno-Tuřany 4 days later than by Climate Atlas method.

Data in particular years at particular stations differs more. In extremes, according to Cecilia method, the end of the period with t≥5 °C was 39 days earlier and 32 days later than by Climate Atlas method.

The differences between Cecilia and Climate Atlas method of determination of a period with prevailing average daily temperatures 10 °C or more are presented in Fig.2.

The differences between beginnings and ends are smaller than it was in case of temperature 5 °C. In average, the difference between Cecilia and Climate Atlas method of determination of a beginning as well as an end of a period with prevailing average daily temperatures t≥10 °C (mean absolute error) is 6 days.

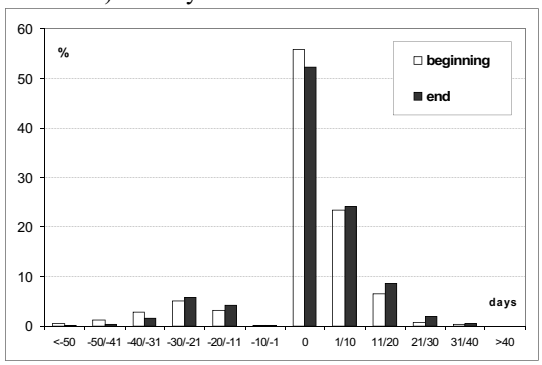

Figure 2. Probability distribution of differences (in days) between Cecilia and Climate Atlas method of determination of a period with prevailing temperatures t≥ 10 °C calculated for all stations and the whole 1961 - 2000 period.

The average date of beginning of the period with t≥10 °C (mean error) determined by Cecilia method is only 1 day earlier than by Climate Atlas method. Concerning the end of the period, both methods give the same date in average. The dates for particular stations differ more. In Kuchařovice, according to Cecilia method, the beginning of the period was 4 days earlier than by Climate atlas method, in many stations the beginning was 1 day later. In Nedvězí, according to Cecilia method, the end of the period was 3 days earlier, at Velké Meziříčí the end was 4 days later in comparison to the Climate Atlas method.

In extremes, according Cecilia method, the beginning of the period was 53 days earlier and 34 days later than by Climate Atlas method, the end of the period was 53 days earlier and 35 days later.

Conclusions

Different methods of determination of a period with prevailing defined average daily temperatures gave different results. In years with big temperature fluctuation there can be large differences. In the period of few decades the average results are more similar, but this is “the statistics” and it can’t be read that one method of determination of a period with prevailing defined average daily temperatures can be easily replaced by the other method.

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Influence of spatial differences in soil organic carbon content (Cox) in agricultural regions on nitrous oxide (N_2O) emissions

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Abstract. Carbon (C) and nitrogen (N) move through agroecosystem in coupled biogeochemical cycles and increasing C stocks in soils and vegetation has an influence on the N cycle. This paper reports how the soil organic carbon (Cox) affects nitrous oxide (N_2O) emissions from arable soils in agricultural regions of Slovakia. A process-based model DNDC (denitrification-decomposition model) was used in this study to quantify N_2O emissions under the diverse climate, soil, and crop rotation conditions across the four agroregions in Slovakia. Soil organic carbon content differs in this agroregions. The highest average Cox content is in mountainous agricultural region then in potato agroregion, maize agroregion and the lowest is in sugar beet agricultural region. Simulated N_2O emissions correlated with the Cox content in these agroregions with the highest N_2O emissions in Mountainous agricultural region and the lowest in Sugar beet agricultural region.

Introduction

Soil organic carbon (Cox) is one of the most important pools for C storage. Microbial production of N_2O in soils is tightly linked to Cox content. Increase in Cox storage in cropland soils benefits soil productivity and environmental health. Decreasing Cox causes environmental problems which include soil degradation, soil erosion and desertification. On the other hand soils with higher Cox generally have higher N_2O fluxes (Bouwman et al., 2002).
Positive correlation between Cox and N_2O flux is due to coupled biogeochemical cycles of C and N. According to Thematic strategy of soil protection is critical value 1,2 % from the point of Cox content. Soils below this value are considered to have lower potential for securing their functions in the nature and society. And the soils below 1 % Cox are considered to be in pre-desertification state. Soil organic carbon content differs spatially in 4 agroregions of Slovakia. The highest average Cox content is in Mountainous agricultural region (2,4 % Cox) then in Potato agroregion (1,6 % Cox), Maize agroregion (1,4 % Cox) and the lowest is in Sugar beet agricultural region (1,1 % Cox).
The most promising alternative management practices for sequestration of soil organic carbon is incorporating more crop residue in the soils and resuming traditional manure fertilizer.

Data and methods

We used the DNDC agroecosystem biogeochemistry model to evaluate the impact of spatial differences in Cox content in agroregions of Slovakia on N_2O emissions. The model consists of two components. The first component, consisting of the soil climate, crop growth and decomposition sub-models, predicts soil temperature, moisture, pH, redox potential (Eh) and substrate concentration profiles driven by ecological driver (e.g., climate, soil, vegetation and anthropogenic activity). The second component, consisting of the nitrification, denitrification and fermentation sub-models, predicts NO, N_2O, N_2, CH_4 and NH_3 fluxes based on the modeled soil environmental factors. During the past decade, DNDC has been tested by many researchers worldwide with promising results (Brown, 1995; Smith et al., 1997; Kesik et al., 2005).

Agricultural regions of Slovakia

Agricultural regions of Slovakia are divided into 4 agroregions according to influence of chosen physical-geographic factors as altitude, average annual air temperature and precipitation. Except these main factors agroregions are also divided and named according to crops which are most suitable for them in terms of agroclimatic conditions of growing field crops in Slovakia (Špánik et al., 2008). Required input data were obtained or recalculated according to this classification. We divided Maize agricultural region into two climatic subregions Maize_1 and Maize_2 where each was represented with one climatic station. Sugar beet agricultural region was divided into 3 subregions. Potato and Mountainous agricultural regions were represented with one climatic station each (Fig. 1).

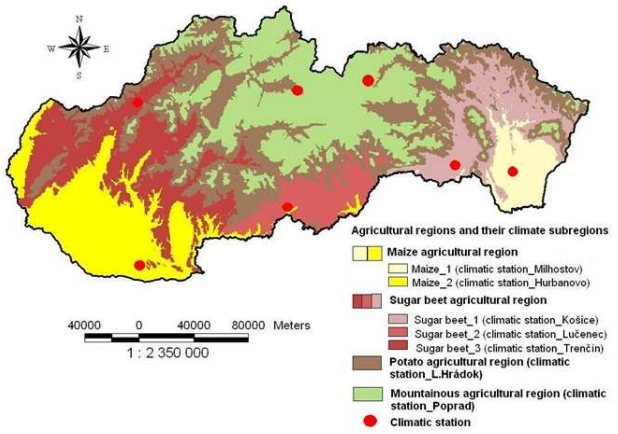

Figure 1. Agricultural regions of Slovakia and classification of subregions for this study.

To estimate N_2O emissions, it is necessary to know spatial database of inputs about soils, climate, grown crops and agricultural management in each agroregion.

Inputs:

Climate

Daily data of maximum and minimum air temperature as well as precipitation were obtained from the Slovak Hydrometeorological Institute (SHMI). Climatic stations were chosen according to representation of climatic condition in agricultural regions and subregions (Fig. 1).

Soil

Soil data were obtained from GIS database of Soil Science and Conservation Research Institute (SSCRI). N_2O emissions were simulated from arable soils. Soil texture

classes according to BPEJ are divided into 5 categories (light soils, medium heavy soils-lighter, medium heavy soils, heavy soils, very heavy soils). There were calculated average soil input values of bulk density, pH, Cox for each soil texture class for each agricultural region or subregion according to classification listed in Fig. 1.

Farming management

Inputs representing agricultural practices in each agroregion were obtained from Central Agricultural Supervisory and Testing Institute (CASTI). There were created specific crop rotations for each agricultural region. Into these crop rotations were included crops which have the biggest sowing areas according to the statistical yearbooks (Tab. 1).

Table 1. Specific crop rotations in agricultural regions and evaluated time period according number of crops in rotation.

Agroregions	Crop rotation [*]	Time period
Maize	A, WW, S, WW, RS, C, C	2000-2007
Sugar beet	A, WW, RS, C, WW, S, C, C	1998-2007
Potato	A, WW, RS, WW, C, B	2002-2007
Mountainous	A, A, WW, RS, WW, C, R	2000-2007

[*] Crops in crop rotation: A-alfalfa, WW-winter wheat, S-sunflower, RS-rapeseed, C-corn, B-barley, R-rye

N_2O emissions were simulated with all these input parameters with a different climate condition, on each soil texture class with its soil properties (Cox, Bulk density, pH etc.), and with created specific crop rotations. We received huge amount of values of N_2O emissions from each soil texture class for a time period listed in Table 1 for the subregion and agroregion according to classification listed in Fig. 1 (Maize_1, Maize_2, Sugar beet_1, Sugar beet_2, Sugar beet_3, Potato agroregion and Mountainous agroregion). After that, an average values of N_2O emissions were calculated for the whole agroregion and also for the whole time period of years which was set up according to number of crops in rotations. So we received one value of N_2O emissions for each agricultural region, which we compared with the average of Cox content in each agroregion.

Results and discussion

Simulated N_2O emissions had high spatial differences according to DNDC model outputs. The highest N_2O emissions were in Mountainous agricultural region then in Maize and Potato agricultural region and the lowest were in Sugar beet agricultural region (Fig. 2).

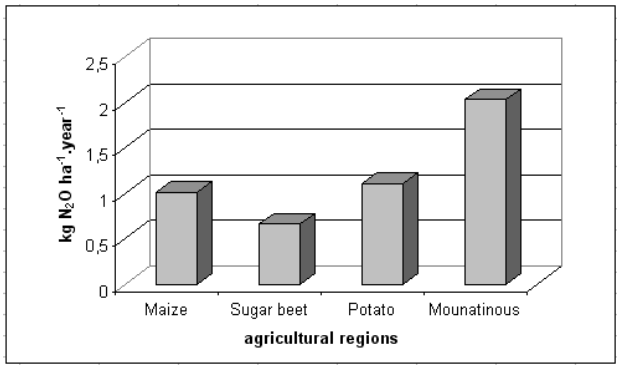

Figure 2. Average N_2O emissions from arable soils of agricultural regions of Slovakia.

There was found very close correlation between average N_2O emissions and average soil organic carbon content in agricultural regions. The highest soil organic carbon (Cox) was in Mountainous agroregion and the lowest in Sugar beet agricultural region. So N_2O emission is higher with higher soil organic carbon content and lower with lower soil organic carbon according to DNDC model (Fig. 3).

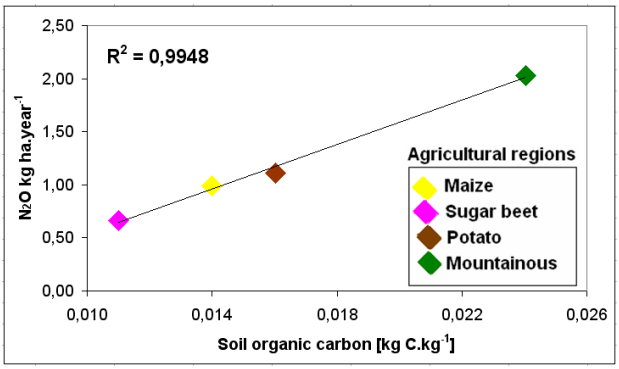

Figure 3. The average N_2O emissions as a function of the average soil organic carbon content (Cox) in agricultural regions of Slovakia.

Conclusions

The lack of organic matter incorporated into the soils cause the decrease in Cox content in agricultural regions of Slovakia. Cox content in Sugar beet region is 1.1 % This means that this soils are considered to have lower potential for securing their functions in the nature and society. This knowledge should lead to the farming management practices which will increase Cox content in this agricultural region. This will help to improve the soil structure and fertility.

However, the study reported in this paper indicated that higher Cox content also means higher N_2O emissions according to DNDC model.

As a solution for the dilemma, best farming management practices should be developed to increase soil organic carbon content with taking into account mitigations strategies of N_2O emissions. The process-based models such as DNDC could make unique contributions to the solution of this dilemma.

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Present trends of changes of climate conditions for plant production in central-west Poland

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Abstract. Climate change observed in the last two decades has caused substantial losses in agricultural production. Mitigation and adaptation to new climate conditions need an estimate of possible future changes. Study of trends of climate water balance and its components, i.e. precipitation and evaporation, is reported here. Using the method of linear regression the data from central-west Poland from 1966-2005 was analyzed. Results show a stable decreasing trend of climatic water balance (and its components), which leads to the conclusion that conditions for agricultural production will continue to worsen in the future.

Introduction

All economic sectors are vulnerable to some degree to changeable natural conditions, especially climate conditions but none is as dependent on climate conditions as agriculture. Changes of climate that have been observed for the last two decades have caused substantial loses in agricultural production and natural environment. This fact indicates the need to investigate the occurring climate changes and the need to estimate the possible future changes. Conclusions of such analyses will help to develop instructions on how to mitigate the negative effects of the climate change and to find possible adaptation solutions. This topic is also the subject of COST Action 734 "Impacts of Climate Change and Variability on European Agriculture - CLIVAGRI" within which some of the analyses, whose results are presented here, were conducted.

The paper presents the analysis of selected agroclimatic indices from the central-western Poland (Wielkopolska region). Compared to the other regions of Poland, agriculture in Wielkopolska is very well developed. It is characterized, among others, by high agral culture, high yields, and advanced equipment. Wielkopolska region is, however, an area of limited water resources with recurring droughts causing substantial output losses. If these adverse conditions continue to develop, it will necessary to adapt to changed climatic conditions of agricultural production.

Data and methods

Analysis included those elements that have a significant impact on plant production in Wielkopolska region i.e. climatic water balance and its components: precipitation and evaporation. Data from 5 meteorological stations located in Wielkopolska and 9 neighboring sites was used. This allowed to determine spatial distribution variability of the analyzed elements. The analysis is based on precipitation totals, evaporation rate and climatic water balance for the

period of 1966 - 2005. In Poland, the presently observed warming process became visibly evident in the late 1970's and early 1980's. The 1966-2005 period was therefore divided into two two-decade subperiods: 1966 – 1985 and 1986 – 2005. Since the focus of this work was the changes in values of climate elements, the differences between the two subperiods were analyzed on the assumption that they will indicate the direction of the observed changes.

As mentioned before, the research included an analysis of changes of climatic water balance and its elements. If the values of climatic water balance are negative it is referred to as climatic water deficit. Climatic water balance (CWB) is calculated using the following equation:

$$CWB = P - E,$$

where:
CWB – climatic water balance [mm],
P – registered precipitation [mm],
E – evaporation [mm].
Monthly totals of precipitation and monthly evaporation totals calculated as indicative evaporation were used.

Results and disscussion

Differences in precipitation values between the two analyzed subperiods oscillated between +20 mm and -20 mm. During vegetative period (Apr – Sept) a small increase of precipitation totals (up to 20 mm) in central and north parts of the region was noted, while the rest of the region noted a decrease of up to - 40 mm. During the cold season (Oct – March) the differences in precipitation totals oscillated between – 10 mm and +10 mm.

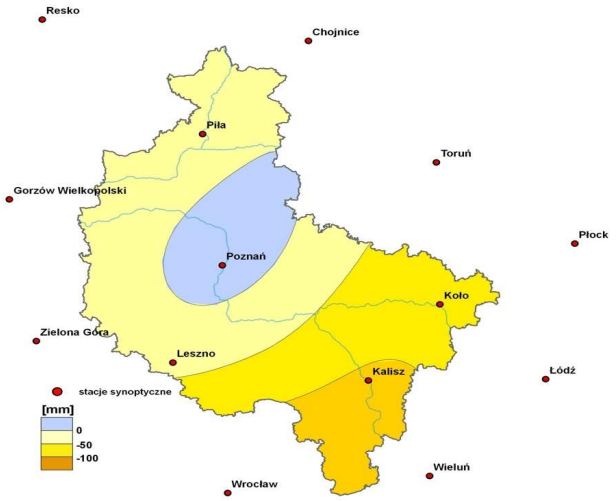

Figure 1. Differences in mean annual climatic water balance totals [mm] betwen two-decade periods 1986-2005 and 1966-1985.

Precipitation decreased only in the south fringes of the region by over 20 mm. A substantial increase of mean evaporation totals was registered in subperiod 1986 – 2005. During the second subperiod, the lowest increases of annual evaporation totals (<40 mm) occurred in the entire central and north-west parts of the area, while the highest increase - over 60 mm - was noted in the south part of the region. Mean evaporation totals during vegetative period increased in the entire area compared to the earlier subperiod by up to 30 mm in the central andnorth-west parts, and in the south

they increased to over 50 mm. Distribution of the mean evaporation totals during cold season was less differentiated – relatively small increase (5 mm - 10 mm) in the entire area. Analysis of climatic water balance indicates a relatively small increase of its values in the central and north-east parts of the region during the last two decades (ca. 15 mm). The remaining area experienced a decrease, highest in south – over 100 mm locally (Fig. 1).

During vegetative period values of the analyzed parameter decreased in almost whole area with most visible drop in the east and south-east (by over 80 mm locally). During cold seasons of the 1986 - 2005 subperiod, the mean values of climatic water balance showed a slight increase (central and north-east parts), while the remaining area showed a decrease, most visible in the south part of the region - by over 30 mm. Small increases of climatic water balance in the central part of the region are probably caused by periodicrecipitation oscillations (in this case – an increase) and, therefore, may not be a permanent feature. In general, the results show that water resources, available for agricultural production, were diminishing in a considerable majority of the analyzed area in 1986 - 2005.

Conclusions

As mentioned in the introduction, climatic water balance is a value that allows to estimate the relative shortages of water in any given area. In case of the Wielkopolska region, the highest shortages of water occur in central and central-east parts of the region. The climatic water balance of this region is among the lowest in Poland. Presented here generally adverse changes of mean values of climatic water balance are a result of adverse changes of its two components, i.e. precipitation and evaporation. There is considerable evidence that allows to expect that the direction of main changes shown here (evaporation increase, overall decrease of climatic water balance) may be relatively stable and will have an impact on agriculture in the future.

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Winter calculation-based air temperatures and their variability in the Czech Republic

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Abstract. The presented study discusses evaluation of the winter period in relation to comfort and discomfort of animals bred in stable and shed buildings. Calculation-based temperature that was determined as the average temperature of the coldest pentad from November to March, in winters 1921/22 - 2007/2008, was used as the fundamental characteristic. The database was created using data from Praha – Karlov station. The results clearly show that the coldest pentad can occur at any time, although the number of the so called severe winters has been declining in the most recent decade.

Introduction

Optimization of the thermal regime of animal breeding building interiors ranks among the most complex constructional design tasks of applied biometeorology and bioclimatology. Complications and difficulties arise from the broad scale of kinds and categories of the bred animals and their demands on thermal comfort on one hand, and from the high weather variability and differences in climate in individual European regions, on the other hand.

A large amount of the so called temperature characteristics are used in quantitative description and evaluation of temperature conditions, ranging from simple to complicated multiple factor indexes.

The calculation-based temperature characteristic is used in the field of constructional zoning and thermal dimensioning of stables and sheds (ČSN 06-0210, 1993; ČSN 73 0543-1, 1998), taking into account the weather and climate of the given locality (sometimes also contemplated temperature). It is defined as arithmetic average of air temperature from the coldest, five consecutive days occurring during winter, irrespective of their dates; it is thus the average air temperature of the coldest pentad. In some cases, the three-day calculation-based temperature is determined, as well. It is used either as a highly variable temperature characteristic of a specific winter or as a less variable climate characteristic that represents the given locality. (The highest summer calculation-based temperature is used in the study of thermal-accumulation properties of buildings. It is a useful thermal characteristic in the calculation of the cooling power of the designed air-conditioning system and in evaluation of the attenuating effect of buildings on the daily temperature amplitude.)

The presented study pays detailed attention to the most widely used and presumably the most important calculation-based, winter pentad temperature of the air.

Data and Methods

Historical summary of the coldest pentads in the course of the past 90 years was created using the measurement database of Praha – Karlov observatory, starting from winter 1921/22 and continued to 2007/2008 winter. First, daily air temperature measurements stored in the CHMI archive were used; later data was obtained from weather reviews based on data of this station (CHMI, 1921-2007). For the time period considered, the data for the cold six months were investigated (from the beginning of November until the end of March of next year) with aim to find the coldest pentad of the given period (irrespective its particular date).

The results obtained were set up in the graphic form providing a good and integrated view on the complex issues of the studied subject in the changing climate of Central Europe.

Results and Discussion

The results are presented in the graph (Fig. 1) that shows chronological average air temperature values of the coldest winter pentad. The aggregate graphic output is completed with an abbreviated Table 1 that shows the succession of the coldest and thus also most risky five-day episodes. The Table 1 also includes the date of the given pentad found.

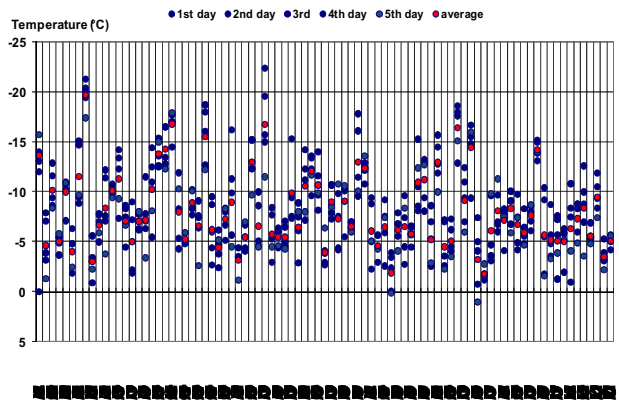

Figure 1. Average temperature of the coldest pentad in the winter periods 1921/1922 - 2007/2008.

Considerable variability in calculated average air temperatures and their high time variability of possible incidence are apparent from both results.

Generally, it can be noted that the coldest pentad can occur in Central Europe at any time from the end of November to the middle of March. We consider this finding to be of special importance for climatic regionalization of construction and dimensioning of objects for commercial as well as hobby animal breeding. Special interest can also be devoted to exotic animal breeds in zoological gardens where the time alternation and distribution of cold and hot periods can represent a significant factor in bioclimatology of the breeding animals.

Table 1. Succession of the coldest pentads in the period of winter 1921/22 to 2007/2008 and their dates.

average pentade temperature (°C)	cold half-year	date of begin	average pentade temperature (°C)	cold half-year	date of begin	average pentade temperature (°C)	cold half-year	date of begin
-19,7	1928/29	10.II	-9,0	1965/66	15.I	-6,0	1994/95	4.I
-16,8	1941/42	20.I	-9,0	1950/51	28.XII	-5,8	1977/78	17.II
-16,8	1955/56	9.II	-8,9	1944/45	23.XII	-5,8	1956/57	20.I
-16,4	1984/85	6.I	-8,4	1931/32	9.II	-5,7	1997/98	30.I
-15,5	1946/47	4.I	-8,4	2003/04	22.I	-5,6	2004/05	27.II
-14,5	1986/87	10.I	-8,4	1992/93	30.I	-5,5	1952/53	6.XII
-14,3	1940/41	16.XII	-8,2	1990/91	2.II	-5,5	1957/58	23.I
-14,2	1996/97	28.XII	-8,0	1942/43	8.I	-5,5	1958/59	11.II
-13,8	1939/40	17.I	-7,7	1995/96	6.II	-5,3	1943/44	17.II
-13,1	1921/22	5.II	-7,4	2002/03	7.I	-5,3	1980/81	6.I
-13,0	1969/70	19.XII	-7,3	1966/57	6.I	-5,2	1998/99	8.XII
-13,0	1953/54	30.I	-7,3	1949/50	27.I	-5,1	1999/00	22.I
-13,0	1981/82	13.I	-7,2	1937/38	2.I	-5,1	1983/84	2.XII
-12,4	1970/71	3.I	-7,2	1991/92	9.XII	-5,1	2007/08	19.XII
-12,1	1962/63	11.I	-7,1	1934/35	7.II	-5,1	1924/25	23.XII
-11,6	1927/28	18.XII	-7,1	1936/37	25.I	-5,1	1935/36	8.II
-11,3	1933/34	13.XII	-6,8	1993/94	13.II	-5,0	2000/01	12.I
-11,3	1979/80	11.I	-6,7	1930/31	9.I	-4,7	1922/23	17.II
-11,0	1978/79	1.I	-6,6	1945/46	7.XII	-4,6	1972/73	21.XII
-10,7	1963/64	17.I	-6,6	1954/55	3.I	-4,5	1982/83	14.II
-10,6	1961/62	23.XII	-6,6	1968/69	14.II	-4,5	1948/49	3.III
-10,3	1938/39	16.I	-6,5	1976/77	27.XII	-4,1	1926/27	18.II
-10,2	1923/24	27.XII	-6,5	1973/74	29.XI	-4,0	1964/65	4.III
-10,2	1932/33	23.I	-6,5	1960/61	24.I	-3,6	2006/07	23.I
-10,0	1925/26	5.XII	-6,4	2001/02	2.I	-3,3	1987/88	7.XII
-9,9	1959/60	12.I	-6,3	1947/48	17.II	-3,2	1951/52	13.II
-9,5	2005/06	22.I	-6,2	1975/76	28.I	-3,1	1929/30	19.XII
-9,2	1985/86	8.II	-6,2	1989/90	4.I	-1,9	1974/75	21.II
-9,1	1967/68	9.I	-6,1	1971/72	28.I	-1,8	1988/89	24.I

Conclusions

- This paper confirms the known experience that the microclimate of enclosed objects used for breeding various species and age categories of animals causes no significant problems in Central Europe during the spring and autumn periods.
- Risky periods occur especially in the winter, as longer lasting severe frosts may occur, having an adverse effect on the bred animals, technological facilities and power demands. Significant problems can also be caused by prolonged periods with high air temperature in the hot summer period, especially considering to insufficient ventilation of the objects and animal discomfort.
- This study was focused on the incidence of the coldest periods choosing the five-day minimum calculation-based temperature of the air as a particular thermal characteristic. Attention was paid both to the values and to the time variability of the characteristic mentioned above. Considerable variability of both observed parameters was noted, making climatic regionalization as well designing of the mentioned projects more difficult.
- The study is based on the data of Praha – Karlov observatory, i.e. from a locality that ranks among the "warmest" ones in the Czech Republic (thus the situation is likely to be worse for other localities). Obvious decrease of the incidence of the so called severe winters during the most recent decades is apparent from the result.
- In further study of this subject, it would be purposeful to focus on the indisputable connection with the synoptic situation where the effect of other meteorological factors (air mass properties, air flow velocity and direction and so on) shall be involved in a more complex range, as well.

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The long-term soil moisture reserve variability in the Czech Republic based on the AVISO model

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Abstract. Knowledge of the soil moisture conditions is crucial not only for the development of agricultural crops but also for the assessment of soil fertility. At the Brno branch of the Czech Hydrometeorological Institute (thereinafter only CHMU) soil moisture is included in agro-meteorological evaluations. The data base of soil moisture for the period of 1961-2000 was obtained as the output of the **AVISO** model ("**A**grometeorologická **V**ýpočetní a **I**nformační **SO**ustava" – "Agro-meteorological Computer and Information System) which is exercised at the Department of Agro-meteorology and Phenology in an operative and regime manner. In our present assignment the evaporating surface was grassland. We computed three groups of soil types specified on the basis of the values of utilisable water capacity (roughly concerning light, medium-heavy and heavy soil). Evaluation of the soil moisture content was based on calculations of the actual deficit expressed in mm and the present paper also specifies the differences in long-term soil moisture reserves on a vertical scale.

Introduction

In presented report the long-term soil moisture reserve is briefly analysed in Czech Republic in period 1961 - 2000. The AVISO model which is exercised at the Department of Agro-meteorology and Phenology in an operative and regime manner was used for komplex evaluation. The actual deficit of soil water expressed in mm, specifying the amount of water in the soil which the field moisture capacity is short of, is one of the basic outputs of the model. Derived charakteristic is soil water reserve expressed in mm or in percentage of utilisable water capacity.

Data and methods

Evaluation of particular years in period 1961 - 2000 was proceeding in regular daily intervals. As an input data was used the air temperature, vapor pressure, duration of sunshine, wind speed and precipitation. Evaporation surface was set as grassland while a fenology data was not required. All calculations were applied for an irregularly distributed network of 155 climatology CHMU stations. Logically, missing values in applied data have been controled, filled and verified by means of statistic methods.

The problem analysis is very difficult, because the applied model primarily needs as input values of hydrolimits (available moisture capacity, field moisture capacity, wilting point) in the surrounding of each station. It would be necessary for expression of concrete soil moisture condition. Accordingly we computed 3 groups of soil types, namely roughly concerning light soil with available moisture capacity (thereinafter only AWC) = 70 mm, medium-heavy soil with AWC = 170 mm and heavy soil with AWC = 120 mm. The passing between particular years was the other problem regarding the soil moisture, because it is unreal to know actual soil misture capacity at the beginning of the year. Hence we simplified the calculation, calculation of bilance starts with soil moisture caspacity equal to the value of field moisture capacity. For evaluation of loss of water from upper horizon by evaporation, the full Penman-Monteith equation with temperature of evaporating surface correction and with evaluation air humidity by means of vapor pressure was used. As method for determination of soil moisture deficit we used the simplified two-layered model of soil water movement with its constant drainage in active profile. On principle of above-mentioned terms the actual soil water deficit and reserve in mm and in percentage of UWC was computed for each day in period 1961-2000. With data gained by means of this manner we could evaluate long-term soil-moisture charakteristics for every day of the year. The whole area of Czech Republic was processed in two parts. In the first part, 155 climatology stations were sorted into groops in accordance with elevation with 100 m interval. The second part of areal analysis was made for chosen areas, whose stations have the lowest elevation. That ones include agriculturaly used land units. This method was used, because distribution accordance with elevation can take in some imperfections, when some specific characteristics of some areas take no effects in evaluation.

Results and discussion

Model processing of long-term soil moisture reserve was made in two steps. Firstly areal processing for vertical scale and for chosen areas was organized and consecutively maps were created. Both of them was then used for calculation of values for characteristic days such as begginig and finish of the year, summer and vegetation period and also for change of soil moisture reserve during growing season and summer, which periods are most affected in case of absence of precipitation.

Table 1. The long-term soil moisture reserve (mm, 1961-2000) in chosen areas of CR for groups of soil types and chosen days and year periods.

Areas of CR / AWC [mm]	1.4. begin. veget.	30.9. end period	31.12. end of year	1.6. begin. summer	31.8. end of summer	veget. period 1.4.-30.9.	summer 1.6.-31.8.
s. Morava: *70 mm*	56.5	20.5	57.1	19.1	16.6	-36	-2.6
120 mm	105.2	28.8	77.6	52	25.1	-76.4	-26.9
170 mm	154.5	41.8	92.9	96.7	40.9	-112.7	-55.9
c. Morava: *70 mm*	59	30.7	63.3	29	25.9	-28.2	-3.1
120 mm	107.9	50.9	98.6	69	46.4	-57	-22.6
170 mm	157.5	81.2	132.9	116.2	79.1	-76.3	-37.2
Polabí: *70 mm*	60.9	30.2	61.4	31.2	26.4	-30.7	-4.7
120 mm	110.3	51.7	92.3	71.1	47.5	-58.6	-23.7
170 mm	160	81.7	124.1	118.4	79.7	-78.3	-38.7
Poohří: *70 mm*	60.4	25	54.9	25.5	19.8	-35.4	-5.7
120 mm	109.4	40.1	75.8	63.8	35.5	-69.3	-28.3
170 mm	158.8	65.7	101.7	110.5	63.3	-93.1	-47.2

Table 2. The long-term soil moisture reserve (in mm, 1961-2000) on vertical scales for groups of soil types and chosen days and year periods.

elevation [m a.s.l.] / AWC [mm]	1.4. begin. veget.	30.9. end period	31.12. end of year	1.6. begin. summer	31.8. end of summer	veget. period 1.4.-30.9.	summer 1.6.-31.8.
< 200: *70 mm*	59.4	28.5	60.1	29.3	24.1	-30.9	-5.2
120 mm	108.6	47.1	88.9	68.3	43.4	-61.5	-24.9
170 mm	158.2	74.4	118.2	115.2	73.1	-83.9	-42.2
201-300: *70 mm*	60.7	32.5	62.1	31.9	27.4	-28.2	-4.5
120 mm	109.9	55.4	95.5	72.7	49.9	-54.5	-22.8
170 mm	159.5	86.7	129.5	120.1	82.9	-72.8	-37.1
301-400: *70 mm*	63.4	38.2	65.4	37.7	33.8	-25.1	-3.9
120 mm	112.8	68.4	105.6	82	63.3	-44.4	-18.7
170 mm	162.5	106	146.6	130.5	102.3	-56.1	-28.2
401-500: *70mm*	64.9	41.5	67.3	41.6	37.1	-23.4	-4.6
120 mm	114.4	76.2	110.3	88.2	72.1	-38.1	-16.2
170 mm	164.1	119	154.7	137.4	115.4	-45.3	-22
501-600: *70 mm*	65.4	41.4	67.8	42.3	36.2	-23.9	-6
120 mm	114.7	75.8	112.2	88.1	70.6	-39	-17.5
170 mm	164.4	117	156.5	137	113.1	-47.2	-23.9
601-700: *70 mm*	66.7	50.3	69.3	47.3	45.3	-16.4	-2
120 mm	116.2	92.2	117.4	95.1	86.6	-24	-8.5
170 mm	166	138	165.5	144.4	133.1	-27.6	-11.3
701-800: *70 mm*	66.6	50.3	69.3	48.1	45.6	-16.3	-2.5
120 mm	116.1	91.3	117.4	95.3	85.6	-24.8	-9.7
170 mm	165.8	136	164.7	144.4	130.6	-29.9	-13.9
nad 800: *70 mm*	67.5	53.9	68.6	53.9	50.4	-13.6	-3.5
120 mm	117	96.7	115.4	101.9	92.8	-20.2	-9.1
170 mm	166.7	142	162.2	151.1	138.4	-24.4	-12.7
SUM: *70 mm*	63.7	39.7	65.6	39.3	35.1	-24	-4.2
120 mm	113	71	106	83.7	66.1	-42	-17.6
170 mm	162.7	110	146.9	132.2	105.7	-53.2	-26.5

The results for chosen areas or vertical scale are presented in Tables 1 and 2. The data were calculated as a simple average from climatologic stations. Graphs in Figs. 1 and 2 illustrate the state of soil moisure reserve for medium-heavy soil in chosen areas and on vertical scale.

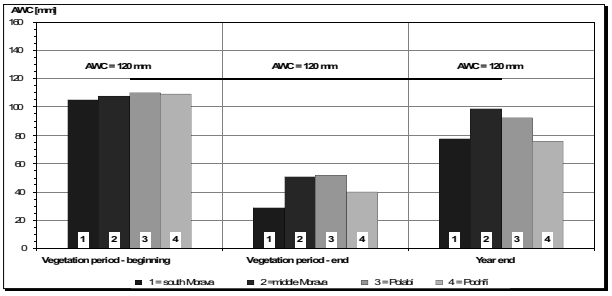

Figure 1. The long-term soil moisture reserve (mm, 1961-2000) in chosen areas of Czech Republic.

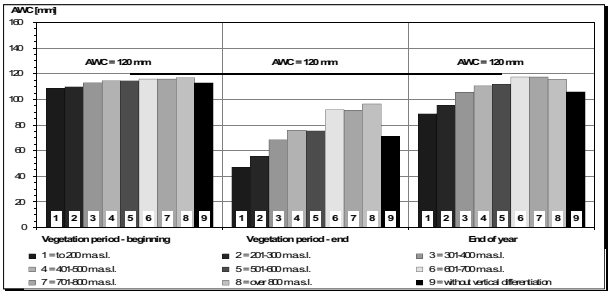

Figure 2. The long-term soil moisture reserve (in mm, 1961-2000) on vertical scale in Czech Republic.

Conclusions

From gained results we can make these conclusions. The minimal differences of long-term moisture conditions among vertical zones are for all groups of soil types at beginning of vegetation period as a result of predominance of precipitation over evapotranspiration and small rate of variability by comparison of vegetation periods.

The maximum of long-term actual deficit of soil moisture we can see at the end of vegetation period, when it is the most marked in lowlands and partially in middle parts too. In the highest parts it is not so evidential. The evapotranspiration in vegetation period has negative influence on soil moisture condition. With increasing elevation the soil moisture conditions of areas are improved, by thus the soil moisture reserve increases for all groups of soil types. Within the vegetation period the most unfavourable conditoins are in vertical zone below 200 m a.s.l., whereas we can observe the most conspicuous increases of soil moisture reserve in the highest parts over 800 m a.s.l.. The similar situation was proved in summer.

The lowest differences of long-term moisture conditions among the chosen agricultural areas of Czech Republic are for all groups of soil types at beginning of growing season, as a result of distinct predominance of precipitation over evapotranspiration. The highest values of actual deficit of soil moisture we can observe at the end of vegetation period and year, as a result of high rate of evapotranspiration in summer, when evapotranspiration is in most cases higher then sum of precipitation. Among the chosen areas the differences are very apparent. The most unfavourable condition of soil moisture is especially in south Morava and also in Poohří, the better condition is in Polabí and mainly in central Morava. Logically, the rate of saturation of soil by moisture is in chosen areas lower than in the vertical profile.

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Possible Uses of Weather Types for Microclimatic Studies of Radiation Conditions of the Vegetation

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Abstract. The paper discusses the analysis of radiation conditions under various circulation patterns characterized by synoptic situations. Daily sums of solar radiation were processed for this purpose from the National Radiation Centre in Hradec Králové, obtained during summer months (June, July, August) form 1984 to 2008. Situations with the highest and the lowest monthly values were detected and frequency of their occurrences under investigated synoptic weather patterns was determined. Average values of global radiation were calculated for microclimatological studies under various weather types for every summer month.

Introduction

The large-scale circulation of the atmosphere is one of the principal components determining the regional variation in the climate, including wind, temperature and precipitation. The increasing interest in the development synoptic classifications allows interpretation of surface environmental processes and patterns in the synergistic effects of atmospheric characteristics (Bower et al., 2007). Synoptic weather classification or sorting of weather pattern into categories, continues to be popular, and numerous methods have been developed over the last century. The recent increased interest in the classification procedure is attributed to its utility in solving a wide array of applied climatological problems. Concern over the impacts of weather, especially for the purpose of understanding possible implications of climate change, has driven the search for more, and better, weather-classification schemes. Yarnal (1993) notes several different subdivisions of synoptic classification; among these is the distinction of manual versus automated classification schemes. Manual procedures involve the subjective classification of circulation patterns or weather types from visual analyses of individual synoptic maps. The computer revolution of recent decades has resulted in the development of many automated synoptic classification methods. Traditional manual subjective methods such as those proposed by Lamb (1972) for British Islands, or Hess and Brezowsky (1977) for Europe, are today replaced by or combined with objective or semi-automated techniques permitting the analysis of large amounts of data using less time and effort.

Until 1956, Hess – Brezowsky classification was applied predominantly in the former Czechoslovakia. Although this classification assumes validity for all of the Central Europe, it showed to be fully representative only for western Germany. Numerous principal differences in circulation led to the processing of weather types classification for the lands of Bohemia and Slovakia (Brádka et al., 1961; Czech Hydrometeorological Institute [CHMI], 1969; Křivancová and Vavruška, 1992). The classifications were created for varied purposes, and they differ in the concepts, manifested in the differing spatial and time scale of arrangement of the categories. CHMI classification, set up for short-term and medium-term regional forecasts, enables to include an integrated circulation process in its categories, which occurs over a large part of Central Europe; it is thus more generous from the systematic point of view, and also uniform for Bohemia and Slovakia .

The presented study is aimed at analysis of weather types and their impact on solar radiation for possible use in microclimatic studies and models. Under natural conditions, solar radiation that reaches the Earth's surface is a fundamental factor, together with other weather elements as temperature and humidity, having an influence on the vegetation (Klabzuba and Kožnarová, 1986).

Data and Methods

Daily sums of global radiation were chosen for the study, in kJ/m^2 or MJ/m^2, measured during summer months in 1984 – 2008 in Hradec Králové observatory, which plays the role of the National Radiation Centre. Synoptic situations according to the calendar based on classification of weather types used in the Czech Republic, were assigned to the daily sums of global radiation. Graphic outputs and fundamental statistical methods were applied in evaluation of the global radiation daily sums, which were subsequently used to calculate average daily sums of global radiation for individual synoptic situations and for every investigated month (June, July, August).

Results and Discussion

The results are presented especially in the graphic form. Monthly sums (Fig. 1) in June indicate gradual increase in monthly sums of global radiation; substantially higher variability is manifested in July, while August has shown lower values in recent years, which also corresponds to the more frequent incidence of situations with cloudiness and precipitation activity (Figs. 2 and 3).

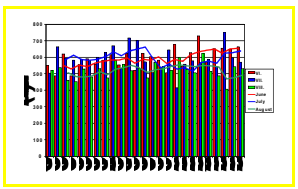

Figure 1. Monthly sums of global radiation in MJ/m^2 (columns) smoothed by moving averages (solid lines) in 1984 – 2008 in Hradec Králové .

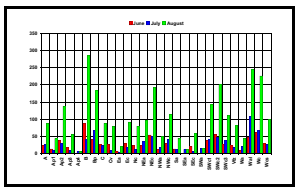

Figure 2. Histogram of frequencies of all weather types in 1984 – 2008.

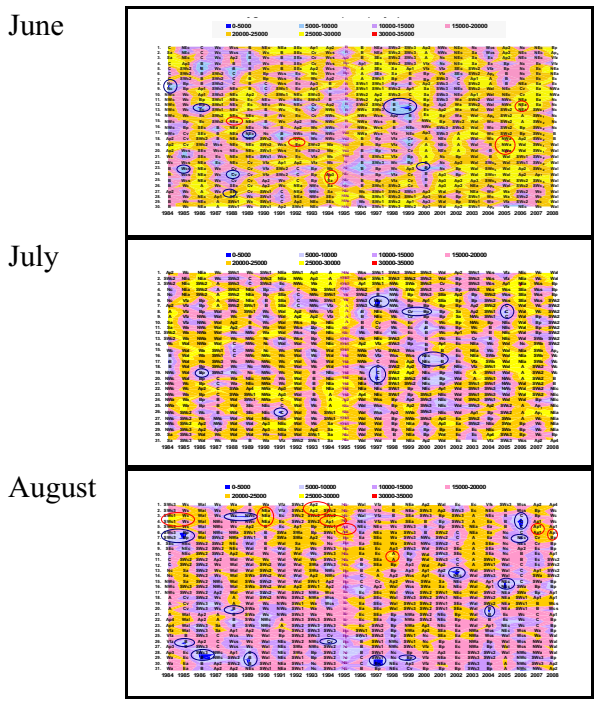

Figure 3. Isolines of daily sums of global radiation in (add UNITS) in relation to circulation types. Maximum (red) and minimum (blue) monthly values are designed by circles.

The situations were analyzed based on the graphic interpretation. Data with the highest and the lowest values of global radiation daily sums were selected for every month. The appropriate weather pattern was found for determined dates of monthly maxima and minima of global radiation. The frequencies of monthly maxima and minima of global radiation were subjected to every investigated weather pattern category (Fig. 4) in 1984 – 2008 period .

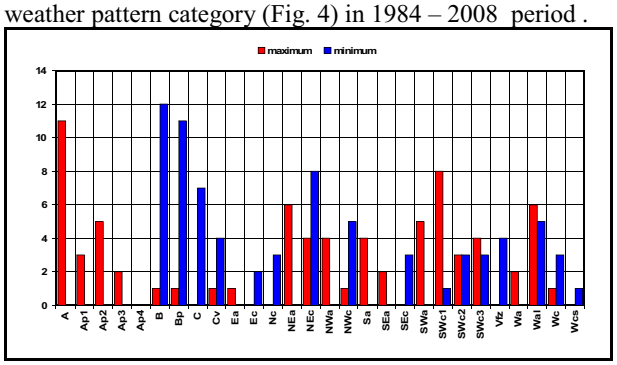

Figure 4. Frequencies of monthly maxima and minima of global radiation daily sums for investigated weather pattern categories at Hradec Kralove in 1984-2008.

Furthermore, average values of daily sums of global radiation were calculated under individual weather types during summer months (Tab. 1).

Table 1. Calculated average daily sums of global radiation under individual weather types (MJ/m^2).

	June	July	August		June	July	August		June	July	August		June	July	August
A	27.42	26.40	21.77	C	15.11	11.89	12.08	NWa	26.83	23.48	18.22	SWc2	21.24	19.26	17.75
Ap1	24.61	23.76	22.02	Cv	18.40	14.37	14.46	NWc	17.24	14.20	11.57	SWc3	18.09	18.02	14.90
Ap2	23.82	22.42	19.95	Ea	27.81	22.94	19.39	Sa	27.03	26.12	22.80	Vfz	18.34	17.18	16.30
Ap3	24.58	26.16	19.17	Ec	19.78	16.31	16.68	SEa	-	27.81	20.75	Wa	23.61	22.99	19.99
AP4	-	25.51	21.06	Nc	15.04	16.32	13.71	SEc	20.57	20.05	17.35	Wal	22.89	21.40	18.28
B	15.37	13.69	13.60	NEa	24.93	25.67	21.03	SWa	-	24.75	21.01	Wc	17.96	16.17	15.36
Bp	17.16	15.30	13.78	NEc	18.43	16.19	13.74	SWc1	23.60	20.87	18.80	Wcs	15.65	17.20	14.63

Conclusions

Results of the presented study can be summarized under several points:

1. Detailed analysis of frequencies of synoptic situations during the summer period was performed within the realm of investigation the given problem.
2. Global radiation was chosen as a characteristic that describes weather variability.
3. Daily sums of global radiation show considerable variability in every month, closely related to the weather type.
4. The monthly maximum values are closely bound to anticyclonal weather patterns–The highest number of weather patterns A, Ap2, NEa, Wal situations fall on August.
5. The monthly minimum values of global radiation can be seen under weather types B, Bp, C, Cv, NEc situations, characterized by low atmospheric pressure. Their highest incidence can be seen in August, as well.
6. Average values of daily sums of global radiation for individual summer months (June to August) were calculated from the time series 1984 – 2008 and from incidence frequencies of individual weather types; the calculated average values can be used as a basis for growth models and microclimatic studies.

Acknowledgements This research was supported by Research Project No. 604607901 and QH 72275.

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Estimation the Characterization of the Erosive Effective Rainfall for the Slovak Republic

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Abstract. The aim of this paper is to compare the value of R-factor, which were published in the Methodology for inputting of research results into agricultural practice (1992) and publication published by Soil Science and Conservation Institute – SSCI (2005) with the values that were calculated on the basis of relations Zachar, Holý and Šabata. For the calculation were used data from selected rain-gauge stations for the period of 50-years. The values calculated by the three authors on all selected stations were several times higher than those indicated in the Methodology for implementation of research results into agricultural practice and in the publication of SSCI. These significant differences are likely cause of the use of different methods of calculation.

Introduction

The pedogenic process is extremely slow process, so the land can be considered essentially as an unrestored resource. According to the World Soil Charter between the main, for human available sources include land, which consists of soil, water and tied them to the plants and animals. The use of these resources can not cause the impairment (degradation) or destruction (the destruction), because of maintaining of their continuing depends the existence of mankind.

The main manifestation of physical soil degradation includes water erosion of soils, which is showed by transport of soil particles from the soil surface. In the Slovak Republic is dominated water erosion and potentially is vulnerable to 43.3% of agricultural land. In Europe it is estimated that up to 115 million ha respectively, to 12% of all land in Europe are affected by water erosion and 42 million ha are affected by wind erosion (State of Environment Report Slovak republic, 2007 and Thematic Strategy for Soil Protection [SEC(2006)620], 2006).

In regard of these alarming numbers, not only in the Slovak Republic, but also throughout the European Union is increasing the need for detailed research factors that influence not only the intensity of water erosion. These factors include rain factor R - rainfall erosivity factor, which is defined as the conjunction of rainfall kinetic energy and the largest 30-minute intensity.

Currently, for the territory of the Slovak Republic is used values of R-factor, which poorly reflected the data such as rainfall erosion force during the year and there are no lines of probability of exceedance of annual average values of factor R for each rain-gauge stations.

Data and methods

In solution the issues we used meteorological data from rain-gauge stations Hurbanovo, Kosice, Nitra, Oravská Lesná, Poprad, Rimavská Sobota and Telgárt for the period of 50-years. For station Nitra it is the period 1959 - 2008 and for the other station is referred to the period from 1951 to 2000. In our calculations of the R-factor, we worked with total annual precipitation. On estimation of rain factor we used three relationships, which take into account the deficiency of the characteristic of erosive effective rainfall, namely:

1)According to Zachar et al. (1981):

$R = 0.068 * Hz, r$ [MJ.ha^{-1}.cm.h^{-1}] (1)

where:

Hz, r - average annual rainfall precipitation [mm]

2)According to Holý (1978):

$R = 0.0679 * Hz, r + 4.2793$ [MJ.ha^{-1}.cm.h^{-1}] (2)

3)According to Šabata (1978):

$R = 0.058 * H_z r + 10.5$ [MJ.ha^{-1}.cm.h^{-1}] (3)

The calculated values, we then compared with the values of the rain factors listed in the Methodology for inputting of research results into agricultural practice (1992) and publication of SSCI (2005). Both of these publications use the research results of Malíšek who used the methodology by Wischmeier-Smith to determining the R-factor. This methodology calculates the R-factor only for selected rainfall, particularly for rainfall, when the precipitation is higher than 12.5 mm and rainfall intensity is higher than 24.0 mm.hod-1, which is separated from the previous rain by 6 hour break.

Furthermore, from provided data for each station we developed empirical and theoretical lines exceeded of rain factor calculated by the authors on the basis of relations (1), (2) and (3).

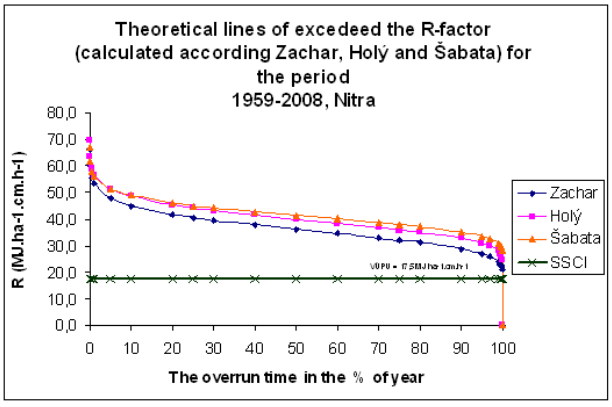

Figure 1. Example of theoretical lines exceeded the R-factor (calculated according to Zachar, Holý and Šabata) for the meteorological station Nitra, for the period 1959-2008.

Empirical and theoretical lines (Fig. 1) were constructed by the method of moments. From the constructed theoretical lines of rain factor we can retrench the value of R-factor, which will occur once per 100, 50, 20, 10, 5 and 1 year.

According SSCI publications based on the calculations of Malíšek, it corresponds to the calculated value of R-factor probability of appearance of 100%, which corresponds to the time of recurrence 1 year. This means that if the equation Zachar, Holý and Šabata, at least approximately correct, then erosion control measures proposed by R-Factor SSCI protect land for the rains, which occur at least one time in one year.

Results and discussion

On the basis of the relations we have calculated the value of R-factor average for the 50-years period and these results, we compared with the results from introduced publications.

Table 1. Comparison of R-factor calculated according to different authors with the data in introduced publications

Locality	R_{aver} Zachar	R_{aver} Holý	R_{aver} Šabata	M[1]	SSCI	P[2] %
Hurbanovo	50.6	54.8	53.6	x	8.75	100
Košice	41.6	45.8	45.9	27.8	20.0	100
Nitra	36.6	40.8	41.7	24.6	17.5	100
Oravská Lesná	74.8	78.9	74.3	18.72	20.0	100
Poprad	39.5	43.7	44.2	19.8	20.0	100
Rimavská Sobota	41.1	45.2	45.5	X	17.5	100
Telgárt	57.2	64.1	59.3	X	15.0	100

[1] Methodology for inputting of research results into agricultural practice (1992)

[2] Periodicity of appearance

As we can see in Tab. 1 and in Fig. 2 the average values calculated from the relationship of Zachar, Holý and Šabata are on each meteorological station several times higher than those that are published in Methodology for inputting of research results into agricultural practice (1992) and publication of SSCI (2005). These significant differences are likely cause of the used calculation methods.

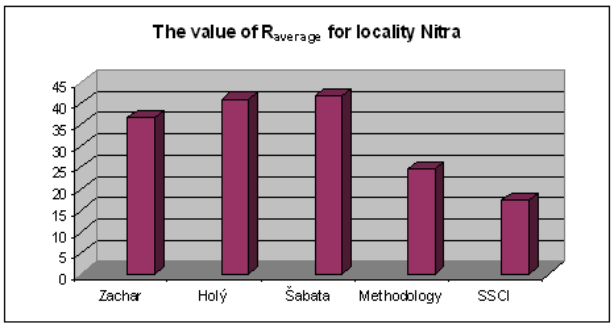

Figure 2. Value R_{aver} calculated by various authors for the locality Nitra for the period 1959 – 2008.

Publications, with which we compared our calculated value of rain factor, used Malíšek results which were determined in accordance with the methodology of Wischmeier-Smith. Since this methodology selects the torrential rains in total more than 12.5 mm and intensity higher than 24 $mm.h^{-1}$ may be differences in the comparison of the value of a rain factor just due to this fact. Relations by Zachar, Holý and Šabata calculate with a total annual precipitation, this means that these relations do not take into account the deduction of a certain height and intensity. According to the Methodology for inputting of research results into agricultural practice, which also indicate redistribution of a rain factor for individual months shows that nearly 90% so called erosive effective rainfall occurs during the growing season. Rain factor values provided by Malíšek (1992) listed in the Methodology for implementation of research results into agricultural practice are calculated for a shorter period than our values. For example, on the Nitra meteorological station A.Malíšek options only with 33 ranks of years and in our calculations we used the 50 strong ranks of years. This could bring on differences in the values of R-factor for each station, as well.

Conclusions

Calculation of R-factor by various authors points to significant differences in the calculated values, which may be caused by different factors such as the calculation methodology and data used for different time periods. According to Fulajtár and Jánsky (2001) soil erosion caused by rain is almost exclusively caused with the so-called high-intensity. Torrential rains (rainfall, flash downpour, torrential rain), it is necessary for calculating the rain factor to take into account the following types of rain. Malíšek also recommended for the calculation of R-factor using at least 50-year data series. In that data about the R-factor, which are used for the conditions of Slovakia are deficient particularly as regards the definition of their frequency of occurrence and distribution during the year. The next step should therefore be the creation of theoretical and empirical lines exceeded the average annual values of R and its distribution during the year.

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Validation of DAISY Model for Silage Maize in Climatic Conditions of Nitra Region

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Abstract. The aim of this paper is validation of DAISY model for silage maize in climatic conditions of Nitra region. Simulations were realised during years 2004 – 2007 and the results were compared with real yields measured in Kolíňany locality. Yield simulations match with real yields (varieties Domingo; Queen). Model is suitable for modelling of silage maize yields in climatic conditions of Danubian lowland after parameterization.

Introduction

The amount of published models (Eitzinger et al., 2008) shows that it is easier to develop a new model than verifying or validating existing computer codes. After developing a model it is usually applied to a limited number of simulation periods or simulation sites, often the same sites on which the model was developed. Therefore it can be expected that model calibration and validation is successful (Diekkrüger et al., 1995).

There were several models for some crops tested in climatic conditions of Nitra in the past. DAISY model is new one in this region (Takáč and Šiška, 2009). Parameterization, validation and crop simulations for corn maize in climatic conditions of Nitra were done by CERES model in the past (Samuhel and Šiška, 2007). Validation of DAISY model for silage maize in the same climatic conditions is new.

Data and methods

Parameterization of the model for agro climatic conditions of Nitra region was made according to the experimental data from field trials in Kolíňany. The experimental locality (160 – 180 m above sea level) is situated about 11 km far from Nitra town. The annual mean air temperature is 9.8 °C, the mean annual precipitation is 539 mm (Špánik et al., 1995), soil type is fluvisoil, the level of groundwater is 10 m under the surface (Chlpík and Pospíšil, 2004).

DAISY is Danish model of agroecosystem, which simulates crop growth, water and heat regime, organic matter balance and nitrogen dynamics in agricultural soils according to the management and meteorological data (Hansen et al., 1990; Abrahamsen and Hansen, 2000). The model was described in many publications (e. g. Abrahamsen and Hansen, 2000; Hansen et al., 1990; Abrahamsen, 2007 etc.).

Meteorological data

Meteorological data were recorded on agrometeorological station of Department of Biometeorology and Hydrology (Šiška and Čimo, 2006), consequently daily reference evapotranspiration was calculated according to Penman – Monteith equation and FAO methodology (Allen et al., 1998).

Soil data

Soil characteristics come from the field experiments of Department of Biometeorology and Hydrology and from available literature (Chlpík and Pospíšil, 2004). Input soil files contain information about physical and chemical soil characteristics in each soil horizon, e.g. dry bulk density, soil texture (according to the USDA classification), organic matter content, C : N ratio, water retention curve characteristics according to van Genuchten and water conductivity on saturated soil K_s.

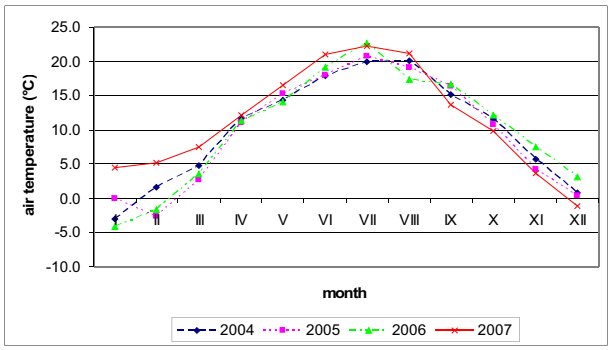

Figure 1. Mean air temperature course in Kolíňany during field experiments.

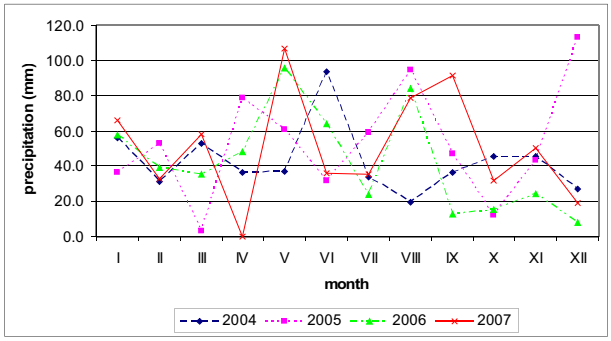

Figure 2. Precipitation in Kolíňany during field experiments.

Fertilizers data

Input file containing fertilizers data can be found in DAISY library (Abrahamsen and Hansen, 2000) under the name „fertilizer.dai“. Fertilizers used by the simulations were: “cattle manure”, “AmmoniumNitrate” and “NPK02”. Cattle manure 25 t. ha^{-1} was applied on the field before planting.

Tillage operations data

Different tillage operations are defined as activities in „tillage.dai“ file, including stubble cultivation, plowing and seed bed preparation, which were used in simulations.

Crops

DAISY library (parameterization for Danish conditions) offers different kinds of crops with defined growth parameters. Parameterization of silage maize according to field trials data in situ is required for better response to real yields. Emergence temperature sum was reduced from 300 °C to 200 °C (“EmrTSum”), while the development rate in the reproductive stage was changed from 0.021 to 0.018, what prolonged this stage. Specific leaf weight (“SpLAI”) was raised from 0.010 to 0.030. Fraction of shoot assimilate that goes to the leaves (“Leaf”) was

changed into following values (where the first number means the development stage: 0.0 – emergence, 1.0 – flowering, 2.0 – ripeness): (0.00 0.70) (0.35 0.70) (0.65 0.50) (1.00 0.15) (1.20 0.10) (1.35 0.05) (1.85 0.05) (2.00 0.05). Fraction of shoot assimilate that goes to the stem ("Stem") was changed into these values: (0.00 0.30) (0.35 0.30) (0.65 0.50) (1.00 0.85) (1.20 0.30) (1.35 0.30) (2.00 0.10). Upper limit for N – concentration in leaves ("PtLeafCnc") was modified into: (0.000 0.038) (0.500 0.038) (1.000 0.030) (1.500 0.018) (1.800 0.015) (2.000 0.013) and critical limit for N – concentration in leaves ("CrLeafCnc") was changed into: (0.000 0.010) (0.367 0.010) (0.500 0.009) (1.000 0.008) (2.000 0.008).

Validation of the model for silage maize was realized according to the yields of silage maize during years 2004 – 2007 in Kolíňany. Real yields were compared with simulated yields of parameterized silage maize and silage maize with original Danish parameters.

Results and discussion

Yields of silage maize in 2004 – 2007 (measured) had similar tendency like simulated yields (NR), while those from original Danish library (DK) had worse results in comparison with real yields (Fig. 3).

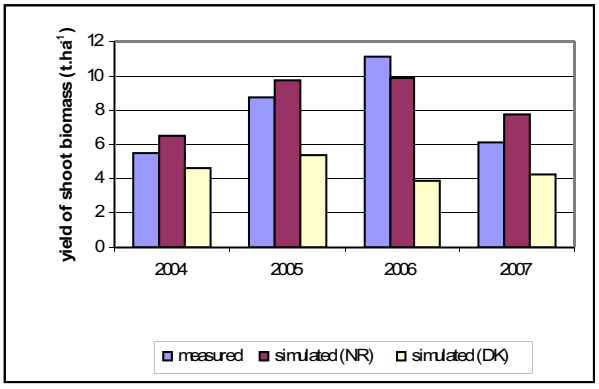

Figure 3. Real silage maize yields (measured) compared with simulated yields (NR, DK).

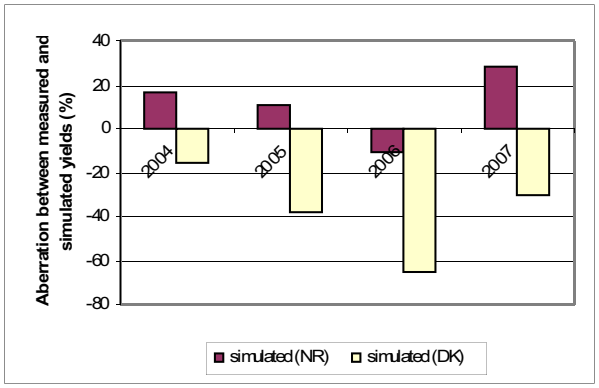

Figure 4. Aberration between measured and simulated yields of parameterised silage maize (NR) and yields with original Danish parameters (DK).

The highest percentual difference between real and simulated yields is visible in 2006 (- 65 %, DK), then 2005 (- 38 %, DK) and in 2007 (- 29.8 %, DK) (Fig. 4). Silage maize with original Danish parameters is therefore not suitable for yields modelling in conditions of Nitra region.

Conclusions

Parameterization of silage maize in Kolíňany is appropriate for modelling in climatic conditions of Nitra region as well as in conditions of Danubian lowland. Validation of model shows that the results of yield simulations have similar trend like real yields of silage maize in Kolíňany locality.

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Cereal harvest dates as a proxy for Czech Republic March to June temperature reconstructions back to A.D. 1701

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Abstract. In order to be able to compare data about harvest cereals, we performed a transformation of different types of cereals to winter wheat and uniform altitude. We created a continuous series of the beginning of a winter wheat harvest over the past 308 years, well representing the conditions of the Czech Republic. This series was used to reconstruct temperatures for March to June in the years 1701-2008. Temperature increases were associated with an earlier onset of phenological phases; not just the beginning of the growing season but also the interval between successive phenological phases was shorter. The earliest ever harvest in the last 300 years has been recorded in the last 25 years. For verification of reconstructed temperatures were measured using temperatures in the period 1775 - 2008 from Prague - Klementinum. Winter wheat harvest dates explain 74 % of March – June mean temperature variance in the verification period. It acquired a series of average temperatures for March to June corresponds well with a series of temperatures for April-August reconstructed from the grape harvest dates in France and Switzerland.

Introduction

Continual instrumental measurements of air temperature have been available in Central Europe only since the second half of the 18th century. For older times, only biological and geophysical proxy data, such as tree rings, pollens, stalagmites and phenological data are available. Of in this manner gained proxy data reliability and accuracy is, of course lower, than of instrumental measurements (Mann et al., 2007). So far, spring and autumn temperature variations in the past have not been investigated neither at hemispheric nor continental scale due to limited information in climate proxies for these seasons (Jones and Mann, 2004; Brázdil et al., 2005). Luterbacher et al. (2004) and Xoplaki et al. (2005) used multi-sourced proxy data evaluation in attempt to reconstruct air temperatures in Europe in the last 500 years. From the phenological proxy data, most useful would be observations of wild plants, which are not influenced by human activity. Unfortunately, such continual observations are with few exceptions (Terhivuo et al., 2009) available only for the last 120 years (Možný and Nekovář, 2007; Nejedlík and Szalai, 2009). On the contrary, the most available data are connected with cultivated plants. The best known phenological proxy data are grape harvest dates. A number of authors have used grape harvest dates for spring-summer season temperature reconstruction (Chuine et al., 2004; Meier et al, 2007; Rutishauser et al., 2007). The most available historical phenological observations in the Czech Republic are records of the start of cereal crop harvests (Možný and Nekovář, 2008). The topic of this paper is use of the proxy data of cereal crop harvest for the reconstruction of temperature anomalies since 1701.

Materials and methods

Meteorological and phenological values have been taken from the Czech Hydrometeorological Institute's CLIDATA and PHENODATA databases. The PHENODATA database contains phenological observations from several hundred weather stations in the Czech Republic. Historical data, gained from chronicles, farming calendars, personal diaries, farming records and reports, are gradually added to the database (Nekovář et al., 2007). A lot of historical data were gathered at the Doksany observatory and branch offices of CHMI. In total, 26164 dates from 330 sites in the Czech Republic were collected. The most observations were available after 1921. The data does not have any temporal gaps; for each year, at least one entry was found. The data were transformed to a standard elevation above sea level (a.s.l.) of 250 m and to winter wheat with the use of linear regression. The temperature measurements come from the Klementinum station (50°05´27″, 14°25´09″, 191 m a.s.l.) in Prague, where continuous measuring of air temperatures has taken place since 1775. The series were homogenized by AnClim software (Štěpánek, 2007).

Results and discussion

In the environmental conditions of the Czech Republic, in most cases of cereal crops winter rye is harvested first and oats last. Through linear regression relationships, dates of the harvest of particular cereal crops from various stations were converted to winter wheat and a standard elevation of 250 meters a.s.l. We found a statistically significant correlation between the start of harvesting winter wheat and winter rye (R^2 = 0,69, $p < 0.01$), winter wheat and spring barley (R^2 = 0,64, $p < 0.01$), winter wheat and rye (R^2 = 0,60, $p < 0.01$), winter wheat and elevation (R^2 = 0,79, $p < 0.01$). Long-term series of harvested winter wheat (Fig. 1) shows a statistically significant downward trend (0,036 days/year, R^2 = 0,22, $p < 0.05$).

Date of harvesting winter wheat affects the weather, especially temperature. The statistically significant relationship between winter wheat harvest starts and March–June's temperatures over the 1901–2008 in the Czech Republic ($R2 = 0.67$, $p < 0.01$). Validation of the model was performed on data from the Klementinum station in the period 1775–2008. Winter wheat harvest starts explain 74 % of March-June average temperature variance in the verification period. Fig. 2 shows long-term fluctuations of average air temperature for the March-June period, expressed as a deviation from the average value in the period 1701-2008. In the given period, irregular variation of warmer and colder periods occurred. Gained series of March-June average temperature corresponds well to the series of temperatures of the April-August period, which has been reconstructed from the grape harvest dates

from France and Switzerland (Chuine et al., 2004; Meier et al., 2007).

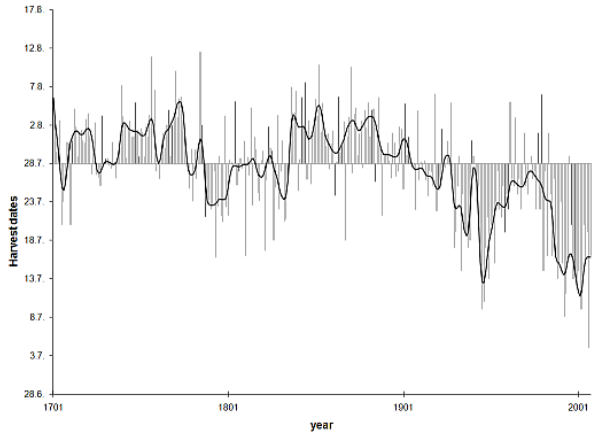

Figure 1. The beginning of the winter wheat harvest in the Czech Republic in the period 1701-2008. Bars indicate deviations from the average value and 4253H filter has been used to show the underlying trend.

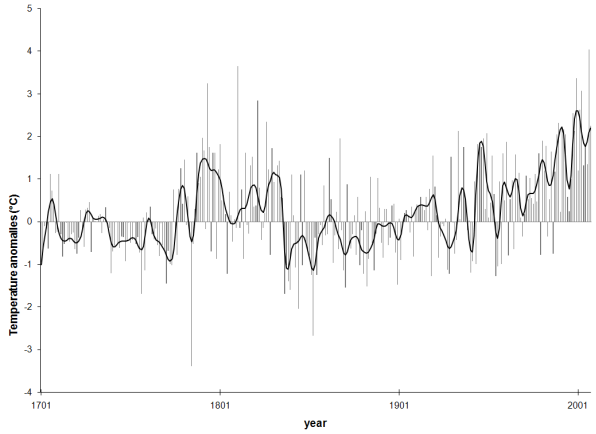

Figure 2. Long-term fluctuations of reconstructed temperature anomalies for March-June in the period 1701-2008. Bars indicate deviations from the average value and 4253H filter has been used to show the underlying trend.

Conclusions

Data on the harvest of cereals are still a slightly unjustly neglected source of regional climate proxy data. Our results showed a dependence on the temperature of the cereal harvest. We created a continuous series of the beginning of a winter wheat harvest over since 1701, well representing the conditions of the Czech Republic. This series was used to reconstruct temperatures for March to June in the years 1701-2008. Thanks to information from historical chronicles, we can obtain information about the time before instrumental meteorological measurements started.

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Estimating the dormancy of some fruit trees by chilling units

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Abstract. The aim of the study is to estimate possible effect of chilling on starting of vegetation of some trees. Chilling units were calculated at selected low positioned localities in Slovakia in order to investigate their possible influence on the start of vegetation season by recognizing the first phenological phase of bud burst. 45ºF and Under as well as Utah model were used for the calculation. It appeared that the chilling requirements in temperate zone were met in all twelve years of calculation (1996-2007). During a common winter these requirements are usually met already in early winter. It looks the accumulated chilling units could influence the start of the vegetation in the spring but other environmental factors have to be taken into account as well.

Introduction

Many studies indicate that air temperature is the most important environmental factor regulating the timing of leaf and flower bud burst. While the winter may look like a time of inactivity many things are actually going on with the trees and also some shrubs particularly with the regard to the development of buds and flowers for the coming season. Once buds have entered dormancy, they will be tolerant to temperatures much below freezing and will not grow in response to mid-winter warm spells. These buds remain dormant until they have accumulated sufficient chilling units (CU) of cold weather. Prevailing theory explains that the air temperature regulates the timing of bud burst in two ways. After growth cessation in late summer or early autumn, the buds are in a state of rest, i.e., their ontogenetic development toward bud burst stops or is slowed by the physiological conditions in the bud. It occurs after the physiological development of buds is overcome by prolonged exposure to chilling (Fig. 1). There are two major hypotheses on how the chilling requirement is connected to the onset of bud development. So called sequential approach says the chilling requirement must be fully met before bud development is enabled. In the parallel approach accumulated chilling affects the amount of forcing required for bud burst or the rate at which forcing accumulates at a given temperature, and the chilling and forcing phases may overlap. The coldness of the winter has a strong influence on many wild trees (Sarvas, 1974) and horticultural crops regarding quantity and quality of buds and flowers (Linsley-Nokes et al., 1995; Niederholzer, 2009), as well as the timing of flowering. Winter chilling is the term used to refer to how effective the cold of winter has been. The insufficient number of CU may lead to the delayed foliation and in fruit trees also to reduced fruit set and increased buttoning and reduced quality of fruits (Sheard, 2002).

Data and methods

Vegetation season is usually defined as the period with the daily mean temperature below 5ºC. This does not correspond with the rest time of trees. A number of methods have been developed for measuring the effectiveness of winter chilling. We shall present two simple models which we used to calculate chilling units.

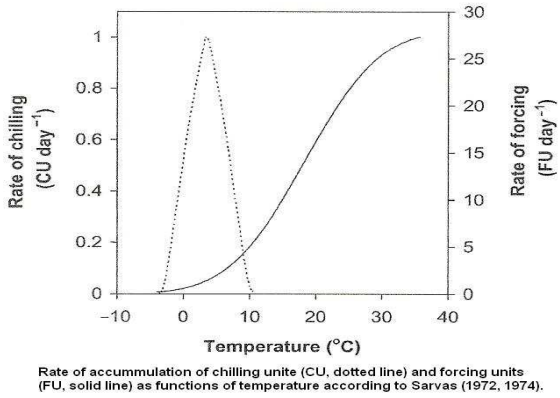

Figure 1. The rate of chilling and rate of forcing (detailed description is in Figure) as a function of temperature.

Chilling units are most meaningfully described and measured using an hourly time scale. Chill hours below a threshold are one of the most common methods for calculating chill. A base temperature is chosen, usually at 7ºC. If the temperature is above this base then it is too warm for the plant to accumulate chilling. If the temperature is below 7ºC then the plant is affected by the cold temperatures, with colder temperatures producing bigger effects. As soon as temperature drops below the base temperature for one hour, one Chill Unit is accumulated. This type of calculation is usually called 45ºF and Under model. More complicated Utah model considers 6ºC as the best temperature for the completion of tree rest.

In Utah model the CUs are calculated in categories according to their deviation from this temperature. This model refers mostly to the needs and behavior of different stone and pome fruit trees.

Results

Using these criteria chilling units were calculated at selected localities. As the temperature reaches chilling units range during September at most of lowlands and low basins in Slovakia, September 15 was selected as the starting date for the calculation of CU and the calculation continued until April 15 if not being interrupted by start of the first phenological phase of the particular tree. This calculation was done over the winter periods 1995/1996 to 2006/2007. As the Utah model does not count the hours with temperature bellow 1.4 ºC as a CU the results of both methods bring big differences in the number of CU. Further to that the tendencies in the particular year also differ. Simple calculation showed high number of chilling units at different localities. Twelve-year averages reached more than 3000 CU with 45ºF and Under Model and more than 1000 CU with Utah model. This is far over the general limits 150-

600 CU listed for stone fruit and up to 800 CU for pome fruit in the literature for different varieties of plums, apples and peaches grown in the investigated area. The same concerns the time distribution when the sufficient amount of chilling units was usually accumulated during autumn and early winter.

An illustrative set of chilling units from Sliač shows the accumulation of chilling units at this locality (Fig. 2).

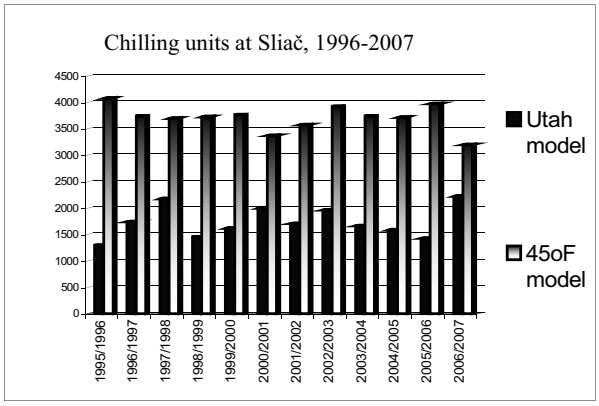

Figure 2. The chilling units calculated by 45°F model and Utah model for Sliač in 1996-2007.

The accumulating chilling units do not fully correspond with the severity of the winter season.

The comparison of the number of accumulated chilling units with the onset of the first phenological phase in spring did not show any close correlation. The latest start of the bud burst in many localities happened mostly in the years with quite low number of chilling units. Nevertheless, other factors could play role in bringing the favorable condition for the trees to start the vegetation.

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Testing the possibility of using improved phenological data in the national yield forecasting system in Slovakia

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Abstract. In the article, the preliminary results of the National System for Crop Monitoring and Crop Yield Forecasting (SK_CGMS) sensitivity analyse to the phenological data are presented. Grain maize phenological data available for Slovakia and recorded in 1996 and 2000 were used to prepare three different alternatives of the phenological data spatial representation. Grain maize development was simulated in 1996 and 2000 years for the agricultural land of Slovakia by the SK_CGMS system. Vegetation indicator Water Limited Dry Weight of Storage Organs (WLDS) was used to evaluate the SK-CGMS sensitivity to phenological data via i) assesment of spatial pattern of the simulated values for the each alternative, ii) cross-comparison of the values obtained for the alternatives, and iii) as ii, but using NUTS5 level spatially aggregated data. The weather impact in 1996 and 2000 years was also taken into account in interpetation of obtained results. The results confirmed impact of the alternative crop calendars on the simulation results of SK_CGMS system.

Introduction

Slovak System for Crop Monitoring and Crop Yield Forecasting (SK_CGMS) is national system for agrometeorological modeling. SK_CGMS was developed on the basis on the EC Joint Research Centre methodology (http://mars.jrc.it/mars/About-us/AGRI4CAST).

The WOFOST model (Supit et al., 1994) and national geographical data infrastructure (soil data, weather data) is used as the crop growth and crop development simulation tool in the SK_CGMS.

Data on crop phenology are also important input for the WOFOST model. Collection of the accurate phenological data is therefore the key task for obtaining good modeling results.

In the paper we present the results of the SK_CGMS system sensitivity analysis to the various spatial detail pheneological data. Sensitivity analysis is demonstrated on the example of grain maize planted in two vegetation seasons 1996 and 2000 years differing in the observed weather conditions.

Data and methods

Phenological data (sowing, emergence and harvest dates for grain maize in 1996 and 2000 years) and the 1996 and 2000 years daily weather data on maximum, minimum and mean temperature (°C), sunshine (hours.d^{-1}), mean vapour pressure (hPa), wind speed (m.s^{-1}), and rainfall (mm d^{-1}) were obtained from the observation network datasets of the Slovak Hydrometeorological Institute. Data from totally 70 weather stations and 31 (1996) or 27 (2000) phenological stations were used in the subsequent analyses. Soil-ecological regions (Džatko, 2002) and agroclimatic crop production regions (Benda et al., 1963) data were used for spatial representation of the phenological data.

Interpolation of daily weather data in to 10km resolution geographical grid was done using SK_CGMS system (more details in Nováková (2007)). Based on interpolated data the weather conditions for the 1996 and 2000 years were interpreted.

Three alternatives of grain maize sowing, emergence and harvest dates for both 1996 and 2000 years: i) national average ii) soil-ecological regions specific average, and iii) agroclimatic crop production regions average were interpreted from the collected phenological data and displayed geographically via 10 km resolution geographical grid.

Simulations of grain maize production in 1996 and 2000 years and crop calendar alterntives were performed using SK_CGMS system. Simulation conditions setting was as follows: i) simulation of water – limited production; ii) water balance initialization on 1-st of January; iii) with influence of ground water table.

Simulated parameter Water Limited Dry Weight of Storage Organs, kg.ha^{-1} (WLDS) was selected as vegetation indicator. Visualisation of WLDS values in 24th decade of 1996 and 2000 years was done and relative diferences between WLDS values simulated for the alternatives were statistically evaluated. Moreover, statistical evaluation of the crop calendar alternatives influence on the spatially aggregated WLSD data (county level, NUTS5) was done.

Results and disscussion

The analyse of the spatial distribution of the graine maize phenological data in 1996 and 2000 (Fig. 1) confirmed relatively significant differences between the dates of main crop phenological phases interpreted for the different regions (Tab. 1).

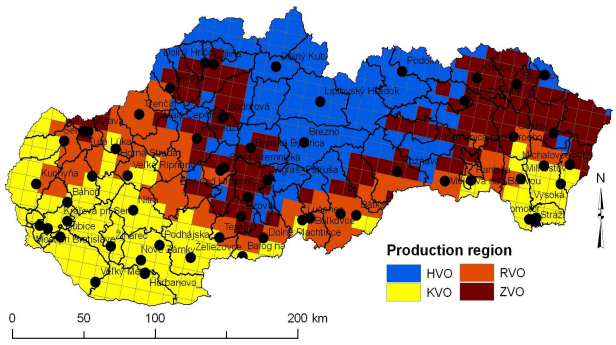

Figure 1. Phenological stations location in individual agroclimate crop production regions of Slovakia.

Weather conditions during the analysed vegetation seasons were notable different. The season in 1996 is characterized as a normal or humid practically for all territory of Slovakia (even as very or extremely humid in south-west regions) with approximately regular rainfall distribution during individual months (from April to September), whereas the

season in 2000 is characterized as normal in east and central regions but the south and west regions of Slovakia are dry, very or extremely dry, with dry conditions especially in May, June and August.

Table 1. The differences between national and agroclimate crop production regions averages of the phenological dates in 1996 (SW – date of sowing, EM- date of emergence; HW – date of harvest).

Graine maize in 1996				
alternative	**region**	**SW**	**EM**	**HW**
Uniform	SK	April, 25th	May, 12nd	October, 10th
Prod. regions	KVO	May, 1st	May, 12nd	October, 2nd
	RVO	April, 24th	May, 8th	September, 29th
	ZMO	May, 9th	May, 20th	October, 10th
	HVO	May, 3rd	May, 14th	October, 4th

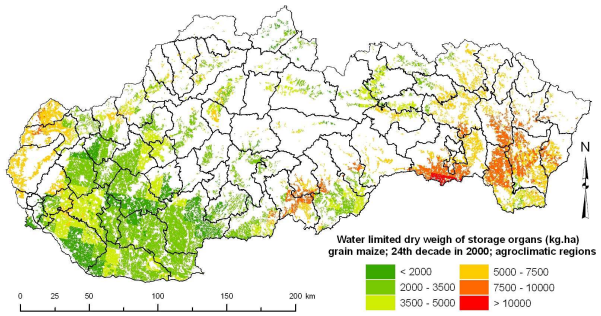

Figure 2. Graine maize WLDS value in 24th decade of 2000 simulated under crop calendar interpreted for agroclimatic regions.

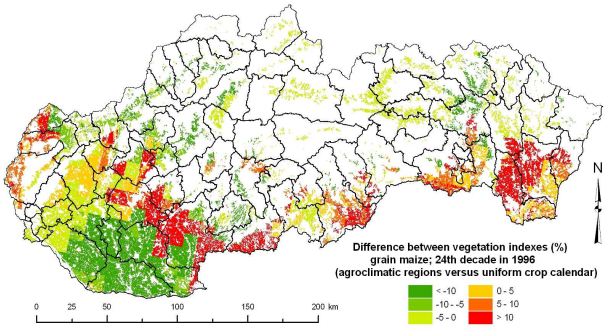

Figure 3. The difference between graine WLDS simulated in 24th decade of 1996 under crop calendar for agroclimatic regions and uniform one.

The analyses of simulated vegetation indexes point out the following: i) observed spatial pattern of WLDS values (Fig. 2) is similar for all crop calendar alternatives in individual years and the differnce is only in the absolute WLDS values, the highest differences between the absolute WLDS values occured in 2000; *ii)* relative differences (%) in WLDS values obtained for the national and regional crop calendars in the individual years (Fig. 3) show up the similar trend; the alternatives differ each to other only in the level of spatial disintegration; the highest differences in WLDS relative values occured in humid year 1996;

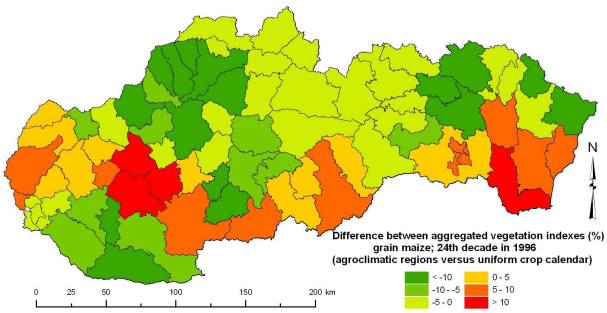

Figure 4. The difference between graine maize aggregated WLDS values simulated in 24th decade of 1996 under crop calendar for agroclimatic regions and uniform one.

iii) relative differences (%) in spatially aggregated WLDS values obtained for the national and regional crop calendars in individual years (Fig. 4) show up significant impact of spatially detailed phenological data; lower differences between ranges of aggregated relative indexes were observed in year 2000.

Conclusions

The results confirmed our anticipations that there is impact of the alternative crop calendars with different spatial resolutions on the simulation results of SK_CGMS system. It can be further conclude that weather conditions in the evaluated seasons (1996 and 2000) have had also some influence on the obtained simulatuion results.

Methodology presented in the paper is only very first attempt and not all possibilities of the phenological data interpretation were taken into account here, as well as more precize statisitcal evaluation have to be done in order to get the most appropriate input phenological data for the SK-CGMS system.

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Soil types and their influence on winter wheat yield in expected climate conditions - spatial analysis for the Czech Republic

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Abstract. The contribution concentrates on the influence of soil type in the study of climate change impact on the yield of winter wheat. For the years 2020 and 2050 compared to the present climate, 21 soil types were analysed in the experiments using three global circulation models (GCM), two versions of emission scenarios and CERES-Wheat growth model. For most of the tested variations and soil types the growth of the average yields can be stated.

Introduction

The singularity of winter wheat (*Triticum aestivum* L.) consists in its position in the structure of cereals and crops grown on the arable land where it is on the first place both worldwide and in the Czech Republic (CR). It has a direct influence on the economy of most of the agricultural companies due to the extent of its areas. In the CR wheat makes about 38 % of cereal sowing, wheat acreage makes 30 % of the arable land with total size varying about 800 000 hectares. Wheat growing is considerably influenced by spatio-temporal variability of meteorological elements which has a direct connection with climate change. Climatic influences were evaluated by means of medium-term experiments with wheat in selected stations of the Central Institute for Supervising and Testing in Agriculture (ÚKZÚZ), by calibration of CERES-Wheat model (Trnka et al., 2004), the processing of climate change scenarios based on GCM, the choice of two emission scenarios (A2 and B1) and the use of selected modules of Geographical Information Systems (GIS) enabling the realization of spatial visualization and analysis of the results for the present and expected climatic conditions in the CR. The yield study comprising the territory of the CR has to take into account not only the present and future climatic aspects but also the differences in siol qualities. For this reason, the spatial study was performed in the way which considers climate change impact on the individual soil types. Thus the work is linked to the evaluation of climate change impact on the yield of winter wheat on the level of all districts in the CR (Semerádová et al., 2008b) and complex evaluation of the CR territory for arable land (Semerádová et al., 2008a).

Data and methods

The basic data layer for the evaluation of climate change impact on the yield of winter wheat is the conversion of all necessary data into the grid vector format with 500 x 500 m resolution for the whole territory of the CR. Each cell in the grid network was assigned altitude as the first step, consequently the layer of soil types (Tomášek, 1995; Czech Geological Service, 2000) containing information not only about soil type, subtype and variety but also about soil class, basic hydrolimits, etc. (Fig. 1). For the simulation of winter wheat yield by CERES-Wheat model, climatological data in daily step are necessary (maximum and minimum air temperature, daily precipitation amount, and global radiation). These data were processed for the period of 1961 – 2000 and went from 125 stations of Czech Hydrometeorological Institute (ČHMÚ). For each station 99 files (years) were prepared by stochastic generator of meteorological data Met&Roll (Dubrovský, 1997) for the sake of satistically correct estimate of the probability of real development and, above all, regarding the comparability of simulation results and changed climate simulations. The generator parameters were derived from the above-mentioned observed 40-year series.

With regard to the uncertainty in future climate projections, a set of climate change scenarios was used for spatial analysis combining standardized scenarios from three GCM models (model HadCM version 3, model ECHAM version 5, and model NCAR - DOE-PCM). "Low" estimate is based on the presumption of optimistic emission scenario SRES - B1 and low climatic sensitivity (i.e. balanced global temperature change while doubling CO_2 concentration) expressed by low value 1.5 °C. „Upper" estimate results from the presumption of pessimistic emission scenario SRES - A2 and high climatic sensitivity (expressed by high value 4.5 °C) for 2020 and 2050 time horizons. The determination of the growth and development for the present climate and the evaluation of climate change impact is based on the method developed by Semenov and Porter (1995) and adjusted for the conditions of the CR by Žalud and Dubrovský (2002). Multiple simulations were preformed with climatic files from 125 stations of ČHMÚ (99 years were generated for each station by synthetic meteorological data, generator parameters for the present climate were derived from the measured data on these stations for the period of 1961 – 2000, for the changed climate they were modified according to the respective climate change scenario) in the combination with 394 soil files. The simulation is performed as the combination of 125 climatic and 394 soil files (x 99 years). Then the selected outputs are bound back to the positional attributes by an appropriate interpolation method and presented graphically. Basically each climatological station gains 394 soil attributes by means of this technique. The applied interpolation method assesses each grid of the vector network, identifies its assignment to a soil type and one of the 394 soil probes and selects climatological stations in the radius of 100 m in combination with this soil type (or the results of simulation processes for these stations and soil files). The value of the selected output parameter is estimated for the grid by the method of inverse distance. All the yield analyses were evaluated for the most significant soil types of the CR.

Results

Grids containing the identical soil type were examined regardless whether they are found in the same region, altitude or production area. On the basis of data sources from the Czech Geological Service, 21 soil types were analysed and for these the impacts of climate change were processed concerning the yields of winter wheat.

The analysis of the average yields for the present climate (1961-2000) shows that yield values in clear majority of soil types move around in logical numbers. However, there are soil types where it is necessary to consider the additional calibration and parameterization of soil files in CERES-Wheat model, like gleyic phaeozem (soil type 4 in Fig. 2), pararendzinas (9) or gleysols (21). The greatest yields are simulated on phaeozem, chernozem, fluvisol and haplic luvisol (20>1>19>2>5), the lowest on strongly acid cambisol, podzol, luvisol and rusty soils with podzols (16>18>6>17). The spatial pattern of the applied soil database shows a considerable influence on yield distribution in the present conditions. The climate change impacts on the yield of winter wheat for the individual soil types embody a similarity (for ECHAM and NCAR models) and correspond with the present situation – unsteady level of the total yield value in the framework of the individual soil types and, on the contrary, a relatively balanced change of yields in all soil types. The ECHAM 2050 SRES – A2 scenario (Fig.2) and to a lesser extent SRES – B1 as well show slightly above-average yield increase on the more fertile soils and a decrease or minimum increase on less favourable types.

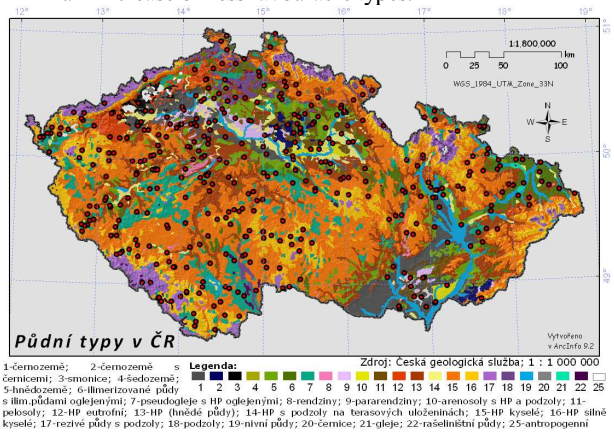

Figure 1. A survey of soil types in the CR used in spatial analysis (source Czech Geological Service).

On the other hand, HadCM model shows the lowest increase of yields (SRES – A2 2050) or a decrease for soil types with the simulation of the greatest yield in the present conditions. It is influenced by the warmer and drier character of HadCM model at the time of making the yield-forming elements which lower the yield even on soils of high quality lying mainly in low-altitude regions. Likewise, yield decrease or minimum increase is simulated for podzols (18) and pararendzinas (9). By contrast, HadCM shows a significant yield increase on the soil types of rusty soil with podzols and illimerized soil. Thus the variability of total yield level is lowered according to soil types. In the B1 scenario with low climatic sensitivity the soil structure pattern is more outstanding in map visualization, in A2 scenario with high climatic sensitivity the pattern recedes in favour of the spatial distribution of climatological data.

Conclusions

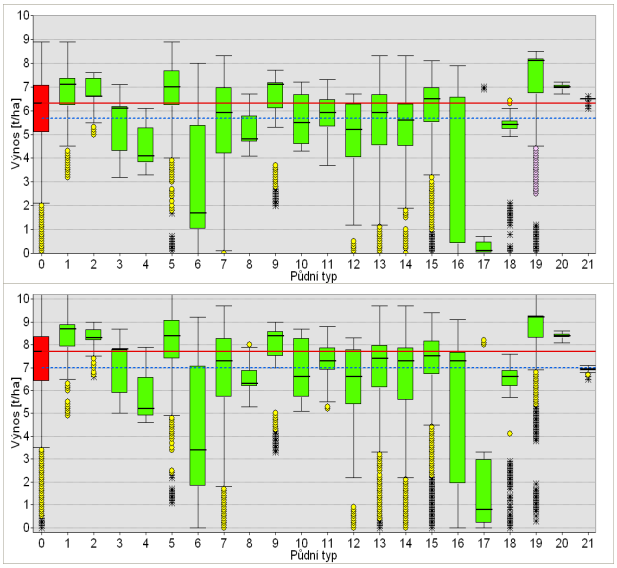

Figure 2. The analysis of winter wheat yield for 21 soil types in the CR. Present climate at the top, ECHAM A2 2050 scenario at the bottom.

Acknowledgements We gratefully acknowledge the support of the project NAZV QG60051 "Climate change impacts on selected field crops" and Research Plan No. MSM6215648905, "Biological and technological aspects of sustainability of controlled ecosystems and their adaptability to climate change".

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Systems of microclimate creation and provision in animal breeding under conditions of changing climate

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Abstract. The paper analyzes basic principles and trends of microclimate creation in animal production under the conditions of changing microclimate, decisive aspects like outdoor climate and its changes, breeding technical and construction design of buildings. It defines ventilation systems and their modification function, in particular the air movement. At present there have been introduced new requirements on the reduction of heat stress, elimination methods and their technical provision to prevent decrease in performance, reproduction and death of animals.

Introduction

Optimization of microclimate creation in animal production is influenced by the impact of the continental climate with changing parameters of microclimate in various periods and regions, with their geographical differences and related weather influences. With the view of this it would be reasonable to design technological and building plans, construction of new buildings or modernization of the existing ones, which probably prevails. The final construction and technological design does not often meet the requirements of different kinds and categories of animals. Complex analysis of breeding conditions from the viewpoint of physiological and production influences at defined changeability of microclimate parameters according to production objective and demands on efficiency of herd help to make the whole process more precise. This analysis significantly determines the process of intensification of animal breeding, which should take into consideration requirements on the reduction of increased heat stress, reduction of heat stress of bred animals.

Basic conditions of microclimate creation

The process of microclimate creation in animal breeding is heavily influenced by the continental climate with a high changeability of the different meteorological elements and microclimate parameters in different regions. In differently shaped regions with the relevant weather influences during the year they have various occurrence and course. The decisive element is the temperature and air flow, as well as relative the air humidity.

Outer parameters of climate– extreme states of weather

In our climatic conditions the continental climate has its specifics, which at present in the process of general intensification and demanding economic situation in animal breeding create a new view on definition of criteria for optimization in farm animal breeding, i.e. of microclimatic parameters. Arisen situation states due to non-standard course of weather, mainly when extreme conditions occur, cannot be compensated by up to now used standard methods – by ventilation technique only. The situation is complicated by considerably different temperature conditions in summer and in winter; up to 50-60 K, i.e. at temperatures -20 (-25) ^{o} C in winter and 30+35° C in summer (max 40° C). These are the conditions which must be taken into consideration when thinking about possible states of the outer air. For the given and extreme air states the balance of accounts must be granted to ensure compensation and modification equally in summer as well as in winter. Summer course of temperature extremes – if efficient measures for their reduction are not taken, generate production and reproduction losses, physiological and health problems which often end up in mass loss-rate of animals, broiler chicken – usually before the feeding period is finished. There also are other specific situations which are known. If modifications for summer conditions are neglected, there are huge losses in milk production and in pig breeding they discovered lower reproduction and high loss-rate, (Šottník, 2008)

Technological and construction design of farms

Construction design, technical provision of thermal and isolation qualities is the basis for low energy buildings and their stable temperature and humidity regime both in summer and in winter.

According to current information the basic defined parameter is the temperature resistance and its extreme limits are determined separately for roof and perimeter constructions and according to required parameters of the building, where there are heated and non-heated rooms.

Building – stable, hall and their temperature and isolation qualities are as passive elements, shading of yards – shading of feeding points, the basic modification aspects of optimization of microclimate creation, (Šottník, 2004)

Breeding systems – analysis of their influence on microclimate creation in buildings

Common result of the applied breeding systems determines technological and production influences which directly and visibly determine the final state of microclimate in the building and its impact on animals, elimination of production losses, reproduction parameters, negative influences on the animals state of health and mortality.

As a consequence there is a need to update the data about the influence of breeding technology, technical and construction design, manure treatment in breeding systems in relation to ventilation systems and draining of detrimental gasses as well as smelling and dust elements. It is vital to start the process of testing the technology with low emission in farm animal breeding, (Šottník, 2005).

Function of ventilation system

The basic method of microclimate modification in buildings for animal breeding is intensive ventilation. The function of the ventilation system is determined by the principles for definition and running of highly varied ventilation efficiency, with the highest efficiency differentiation in summer and the lowest in winter, with thecontinuity regulation, or at least degree regulation. From this point of view it is vital to ensure at least minimum ventilation in winter and increase it in spring and autumn. Technically

ensured minimal ventilation, ventilation efficiency, should have continual increase of the air temperature according to the course of its regulation course.Ventilation systems must take into consideration all the specifics connected with different conditions of animal breeding. Their principal task is to drain off the redundant heat, air humidity and detrimental gasses produced in the building. Their dimension is determined on the basis of ventilation efficiency requirements and the mass of ventilation air. The next important task is compensation, when the temperature rises by means of faster movement, however, following the calculation principles, criteria for different breeds of animals as well as the most recent knowledge in the relevant field – compensation of the high temperature load by means of its increased flow speed.(Defra study, 2005; Chiappini and Christiaens, 1992; Šottník, 2002).

Air flow

Air flow is the fundamental aspect of ventilation system under the appropriate circulation conditions of the air flow. Then, when determining the second function of the air flow within the ventilated room, technological room limit, as e. g. in a cage. The task of the air flow in the room is to drain the redundant heat off. The heat and the material load have to be moved without any draught. The typical feature of the draught is that the air speed in the room is higher than the optimal range of standard recommended for the determined temperature. That is why it is important to pay attention to the air flow speed in the place of stay as well as to the direction of the air flow towards the identified parts of body (Šottník, 2002).

Reduction of heat stress in buildings

Reduction of heat stress in buildings for housing of animals is a current programme in farm animal breeding under conditions of continental climate. The whole process is often speeded up by variations in weather to extreme temperature conditions that cannot be currently anticipated and predict their time course. The process has important economic consequences that depend on the rate of decline of production parameters and influence of climate change on reproduction traits and health of bred animals. In contrast to it are costs connected with improvement of technological and construction parameters as well as operation parameters. Complex of costs for modification of technologies condition the requisite standard of parameters expressed by microclimate elements temperature and relative air humidity, air movement speed, its cooling values. Increased demands for microclimatic elements – in principle it is not possible achieve microclimate only with hitherto used ventilation technique. These techniques respect classical principles of ventilation and broadly used processes for clean air in stable and standard modification of outer climate, air exchange, and they respect basic demands for microclimate. With modern techniques are demands made on decrease of heat stress, prevention of heat stress and its consequences. For the mentioned processes it is necessary to respect the new drawn up criteria for temperature and humidity parameters, air movement, ventilation capacity, functional balance of the given element in the breeding room, its sections. Specific problems are with requirements for double environment, and it is hard to realize the present reduction criteria. It is necessary to propose economically available techniques of heat reduction together with construction-technical parameters for the selected farm animal categories and for the given microclimatic zone, parameters of outer climate and for summer and winter periods (Chiappini and Christiaens, 1992; Defra study, 2005; Šottník, 2008)

Conclusions

To create microclimate under the conditions of changing climate, it is necessary to use new technical and building procedures with respect to newly defined criteria and parameters for different kinds and categories of animals. The decisive climate parameters are the outer ones for which it is typical to have all the time bigger difference in summer standard and extreme course of temperatures, where max. temperatures are up to 35°C (40°C). Under these conditions it is unavoidable to use efficient building and technical measures to reduce heat stress by means of newly designed ventilation systems with the ability not only to air the given room efficiently but also to limit building and animal heat stress by means of the increased air flow speed in the area where the animals are. At high temperatures it is necessary to decrease them in the breeding area by means of the available techniques of aerosol evaporating cooling. The importance of the efficiency and application of reduction techniques is nowadays sufficiently documented. Currently it is not possible to design new, modern buildings for animal breeding without facilities which enable reduction procedures, decrease of the impact of the high temperature of the air.

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New software package for agroclimatological utilisation

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Abstract. The aim of the contribution is to present available software packals for evaluation of agroclimatological conditions, which can be applied both at local scale as well as in large scale studies. Four tools are introduced (SoilClim, AgriClim, FenoClim, snowMAUS) and some case studies and result examples are shown within the agriculture landscape.

Introduction

The basic assumption for successful agricultural output (production) is better understanding of meteorological and climatological elements of growth and development on field crops. Newly developed specialized software allows easily assess tens of agroclimatological parameters, indices or generally conditions and that not only in short-term (week, month) but also in long-term (year, decades) aspect. Software picks up on generally accepted work in the field of evapotranspiration, modeling of soil moisture (water) content, levels and water volume of snow etc. The output should be applied in science, research, consultancy but also in common agricultural working experience. The basic components are four separate parts called AgriClim, SoilClim, FenoClim and snowMAUS.

Data and methods

In order estimate soil moisture and temperature regime at a given site, or within a selected region, a software SoilClim was developed, tested, and applied in two markedly different regions of the Northern Hemisphere (Hlavinka et al., 2009). SoilClim is based on an enhanced daily water balance model that incorporates interactions between the soil and atmosphere through a dynamic module of vegetation cover. In addition, a snow cover effect on the water balance (through freezing and thawing), as well as on the soil temperatures, is taken into account through the incorporation of a snow cover simulator.

AgriClim (Trnka et al., 2008) is a tool including set of agroclimatological indices capturing drought and other extreme events (e.g. late or early frost) with special relevance for agriculture. It also includes range of dynamic models representing e.g. snow cover, soil water balance, phenology and crop growth that are aimed to assess the overall suitability and agroclimatic limiting factors in a given site/region/area. The tool was develop with a special focus on the speed and flexibility over time and spatial domains.

FenoClim was developed for detail analysis of phenological data in combination with climate predictors. Minimum, maximum and average temperatures, precipitation sum and solar radiation, compose a minimum dataset together with observed phenological dates. The software allows easy determination of meteorological drivers of particular phenophases and finding the optimum combination of thresholds (or e.g. degree day sums) through repetitive iterations. FenoClim then provides user with complete range of statistical parameters allowing for easy final pick of the most suitable parameters to be used in subsequent phenological modeling.

The core algorithm used in the snow cover model for agrometeorological use (snowMAUS) was proposed by Running and Coughlan (1988). The algorithm was modified and tested in Central Europe by Trnka *et al.,* (2009). It relies on daily maximum and minimum air temperature (T_{max}, T_{min}) and precipitation (*Precip*) values as predictors of snow cover. We chose to modify this very simple formulation as the basis of our snowpack model in order to maintain its independence from the radiation and humidity data. Radiation and humidity are two variables that are usually included in more sophisticated snowpack models. Similarly, modeling techniques are rarely based on hourly data or on multiple temperature observations per day, due to the poor availability of data. The present version of snowMAUS operates with a daily time step, with seven key parameters governing snow accumulation and melting.

Results

The whole system (four tools) was programmed within Delphi and the user interface is user friendly and is designed to operate with large quantites of data in automated regime (e.g. outputs from RCM model runs). Examples of one of the presented softares tools (SoilClim) its modul structure, interface and easy validation experiment for reference evapotranspiration at Žabčice experiment location are shown in Figs.1 – 3.

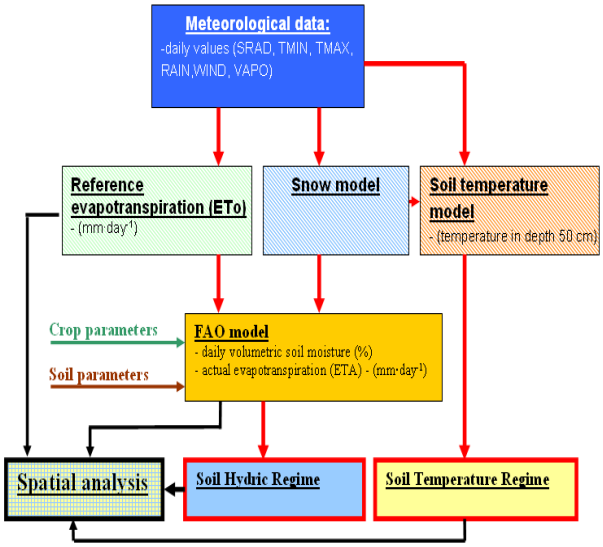

Figure 1. Scheme of SoilClim software tool.

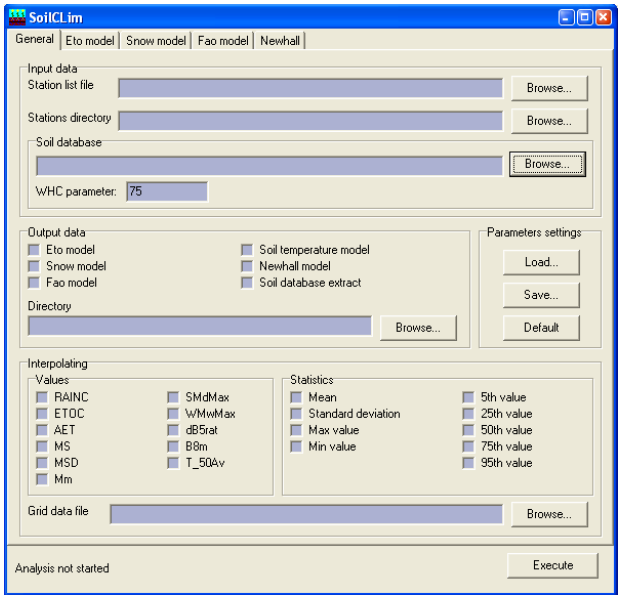

Figure 2. Structure of SoilClim software interface.

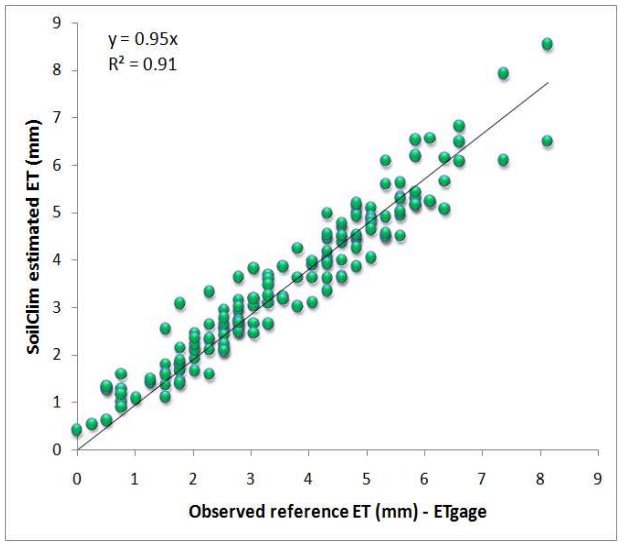

Figure 3. Reference evapotranspiration - Example of SoilClim validation vs. ETgage measurement

Acknowledgements We gratefully acknowledge the support of the project NAZV QI91C054 "Atlas of soil climate of the Czech Republic" and Research Plan No. MSM6215648905, "Biological and technological aspects of sustainability of controlled ecosystems and their adaptability to climate change.

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The temporal dynamics of the grapevine phenophases and their prediction for future

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Abstract. Grapevine *(Vitis vinifera L.)* cultivation is influenced by the weather. The study try to explain connection between selected phenophases and meteorological characteristics with the focus on their temporal dynamics. Phenological observations in the Czech Lands have a long tradition, but choice of a suitable station is not simple. Finally were selected station Velké Pavlovice, this station have meteorological elements observation. The guideline for observers was set up in 1956 and has included the subsequent observed variables for the vine *Vitis vinifera L.*. This was replaced by the new CHMI methodology instruction number 3 in 1984. This case study researched available period 1984-2007. The quality control of meteorological characteristics were executed and then data were checked for relative homogenity by Standard Normal Homogeneity Test and then adjusted with respect to the inhomogeneity year. Grapevine phenophases best respond with high correlation coefficient with average and maximum temperature. In the last time the temperature significantly increase and it is hyphothesis this phenomen will be continued. Grapevine react on this climatic change yet in the present time. Beginning of the phenophases is earlier about 8 to 20 days before 20 years and in the future could be starting of the phenophases faster. The study work with time scale 2021-2050 and 2071-2100.

Introduction

Viticulture in the Czech Republic is strongly influenced by the fact that cultivation of the vine *Vinis vinifera*, which originally came from latitudes 25–40º N with only secondary extension to the south and north, is at the northernmost extent of its range in Europe. In such conditions, its dependence on weather patterns increases enormously. The nature of the impact of the weather is closely bound to the times of year in which weather affects vine growth and fruiting. Predominantly abundant sunshine and higher air temperatures, together with sufficient precipitation, are factors positively influencing yield and quality of grapes. On the other hand, cold and rainy weather in the period of maturation, extreme winter frosts, late spring and early autumn frosts and hailstorms appear as negative factors. The occurrence of various vine diseases and pests also depends to some extent upon meteorological patterns (Brázdil, 2008). The study try to find the relationship between meteorological characteristic and grapevine phenophases. Generally from the 80th years of the 20th century the temperature significantly increase and it have impact on the wide spectrum of the natural component and also on the human activity. The essay pose the question, if thanks to recent climatic change come to the significantly difference in the start of the grapevine phenophases. This study work with hypothesis that increase of the temperature will be continued. For two time scale 2021-2050 and 2071-2100 will be calculate start of the grapevine phenophases.

Data and methods

Phenological observations in the Czech Lands began in the 1780s, the work of Director Antonín Strnad at the Prague-Klementinum observatory, and have continued since. Phenological yearbooks started to be published from 1923 (under the auspices of the Agriculture Research Institute of Brno), and from 1938 under the Central Meteorological Institute (later Hydrometeorological Institute) in Prague, but without vine observations. However, in the archives of the Czech Hydrometeorological Institute, viticultural data appear in original handwritten observations preserved from individual phenological stations. The guideline for observers was set up in 1956 and has included the subsequent observed variables for the vine *Vitis vinifera L.*. This was replaced by the new CHMI methodology instruction number 3 in 1984. This case study researched available period 1984-2007.

For this study was select Velké Pavlovice, where is situate the phenological and climatological station belong to the CHMI network. In the first step the quality control of meterological characterics were executed and all incorrect measurement were from input data removed and replaced by new calculate value. In the second step the data were checked for relative homogenity by Standard Normal Homogeneity Test and then adjusted with respect to the inhomogeneity year (Štěpánek, 2009). Within the CECILIA project, the regional climate model ALADIN Climate/CZ is driven by GCM ARPEGE with the IPCC A1B emission scenario and the experiments are performed for two time slices, 2021-2050 and 2071-2100. For the territory of the Czech Republic was create the new gridded dataset with spatial resolution 10*10 km based on records stored in the CHMI climatological database. Before time slice 2021-2050 and 2071-2100 analysis, the model data were corrected according to validation results carried out for the period 1961-1990 (Štěpánek, 2008). For prediction grapevine phenophases in the future was necessery take temperature from the gridded dataset. The nearest grid point from the Velké Pavlovice is 6139 (2,5 km distanc and similar altitude). The correlation between these two point is 0.999 ($p = 0.05$). The increase of the temperature for grid point 6139 is statistical significant for all months and season. Linear trend for the annual value is 0.29°C/10y. for the period 1961-2100 (Fig. 1).

For future prediction of the trend grapevine phenophase used the knowledge their relationship with temperature in the present time. We used two methods. First method is linear regression model of the temperature, which have highest correlation with phenophase. Second method is the model of the active sum of the temperature higher than 10°C. In the reference period 1984-2007 was calculate for each year the sum of the temperature, which achieved in the day of the starting phenophase and this value used for prediction.

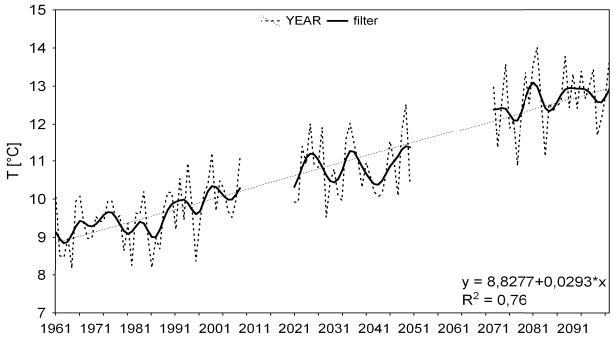

Figure 1. Annual temperature for the grid point 6139 in the period 1961-2100.

Results and discussion

Because in this article is not lot of space, the results will be present on the example phenophase beginning of flowering (BBCH 60). Average start of the phenophase is 10th June. Median is 4 day later. 80 % of the all value is between 31st May to 18th June. In the year 2007 was earliest beginning of flowering (21st May). The latest start of the phenophasy was in the year 1989 (28th June).

Table 1. Correlation between the beginning of flowering of the variety Frankovka and meteorological characteristics for the period 1984-2007 at the station Velké Pavlovice (in italics statistically unimportant, p = 0.05).

	IV	V	VI	IV-V	V-VI	IV-VI
T	**-0.53**	**-0.73**	**-0.63**	**-0.80**	**-0.79**	**-0.85**
ΣT >5°C	**-0.53**	**-0.72**	**-0.63**	**-0.79**	**-0.79**	**-0.84**
ΣT >10°C	**-0.49**	**-0.73**	**-0.62**	**-0.78**	**-0.79**	**-0.80**
TMA	**-0.59**	**-0.79**	**-0.67**	**-0.84**	**-0.83**	**-0.87**
TMA MAX	*-0.40*	**-0.47**	**-0.60**	**-0.61**	**-0.67**	**-0.74**
ΣTMA >5°C	**-0.58**	**-0.79**	**-0.67**	**-0.84**	**-0.83**	**-0.87**
ΣTMA >10°C	**-0.60**	**-0.78**	**-0.67**	**-0.83**	**-0.83**	**-0.83**
TMI	*-0.24*	**-0.49**	**-0.5**	**-0.53**	**-0.63**	**-0.67**
SSV	**-0.64**	**-0.51**	**-0.58**	**-0.77**	**-0.68**	**-0.78**
E	*-0.18*	*-0.30*	*-0.19*	*-0.39*	*-0.31*	*-0.38*
SRA	*0.40*	**0.42**	*0.04*	**0.53**	*0.27*	**0.48**
SRA > 0.1 mm	**0.66**	*0.02*	*0.31*	**0.54**	*0.24*	**0.57**
SRA > 1 mm	**0.49**	*0.34*	*0.33*	**0.57**	*0.40*	**0.62**
SRA > 5 mm	**0.42**	*0.26*	*0.16*	**0.46**	*0.29*	**0.51**
PEVA	**-0.71**	**-0.70**	**-0.59**	**-0.80**	**-0.71**	**-0.78**

Beginning of flowering is most influence by temperature conditions (Tab. 1) of the previous period April-June. From the single month is close relationship with the May. The strongest correlation was show with the maximum temperature. Correlation between beginning of flowering and average. maximum temperature. active sum of the temperature higher then 5 a 10°C is very high and it is mean the temperature is very significant factor for evolution of the grapevine. From the other meteorological elements is begging of flowering influence by sunshine duration. mainly in the month April and in the period April-June. Precipitation and number of the precipitation´s days have positive correlation relationship (Tab. 1) with this phenophase. Less precipitation mean earlier start of flowering. This result could be affect by temperature. because generally speaking. rainy weather is colder and vice versa. Strong correlation is with potencial evapotranspiration too.

In the period 1984-2007 temperature increase about 0.5°C per 10 year in the Velké Pavlovice and beginning of flowering is still earlier. In the 80th years was about 8 days late. The linear trend is 4.5 days per 10 years. Precondition is this trend will be continued in the future. First model for prediction future phenology use the equation of the linear regression with April-June temperature (y = 251.5-6.1t. r^2 = 0.72). Phenophasy in the period 2021-2050 will be about 2 days earlier than average in the present. but 7 day earlier than median. Standart deviation is lower. Second prediction model use activ sum of the temperature. Median value for beginning of flowering (Fig. 2) in the period 1984-2007 is 902°C. Second model calculate the similar results for the period 2021-2050. The phenophase start about 2 day earlier. than result of the first model. Another situation is for second time scale. The different between these two models is higher. Beginning of flowering calculate by linear regression will be about 10 days earlier than average in the present and 12 days earlier than median. But by second method will be flowering 20 days earlier than in reference period 1984-2007.

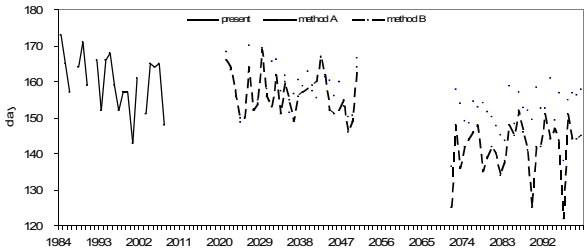

Figure 2. Beginning of flowering at the station Velké Pavlovice for the time scale 1984-2100 (method A – linear regression. method B – active sum of the temperatures).

Conclusions

These analysis were calculated for all grapevine phenophases. The results are similar. For evolution grapevine are most important maximum and average temperature. mostly is first part of the vegetation time ("summer" phenophase). The correlation for "summer" phenophase is higher than phenophase. which have start in the spring. High correlation is with sunshine duration and evapotranspiration too. All phenophase have fall trend. In the present is about 8-10 days earlier before 20 years. Hanging up of the grape is earlier about 1 month. For the future is prediction with this fall trend. The phenophases will be about 5-10 days earlier in the time scale 2021-2050 and about 20-25 days earlier in the period 2071-2100.

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Urban climate and human bioclimatology

Dust fall measurements in road tunnels

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Abstract. Particulate matters (PM) are an actual part of research not only due to increasing concentrations in the ambient air but primarily because of their negative effects on human health (respiratory and cardiovascular diseases). Especially in the large cities PM can be a problem due to the road transport that is an important source of these particles. This study was focused on PM production due to mechanical abrasion of tyres and road surface. Results of the dust fall measurements in two road tunnels that are the components of town circuit in Prague are presented in this paper.

Introduction

Transport becomes significant factor in society development both in positive (passenger transport, transport of goods, products, information) and negative (traffic injuries, emissions) sense. Air pollution is the most discussed issue at present however the share of traffic on pollution of other environmental matrices such as ground and surface water, soil and organisms is also inconsiderable. Increasing number of gases and solid pollutants emitted to the atmosphere demonstrably has adverse effects on human health and environmental ecosystems. Combustion processes are the reason of exhaust gasses emissions that contain hundreds of chemical compounds in different concentrations contributing to green house effect and often with toxic, carcinogenic or mutagenic effects. However pollutants emissions especially PM could be also related to non combustion processes such as particles mechanical separation during interaction between tyres and road pavement. So one of the approaches how to decrease PM air pollution is road pavements construction that are more resistant against abrasion. PM are considered a mixture of chemical components originated from a variety of sources with specific physical parameters (such as shape, diameter, electric charge, solubility, surface of the particles) and chemical composition (organic and inorganic compounds).

Data and methods

Dust fall measurements in road tunnels with different pavements were done to determine the pavement abrasion contribution to overall PM emissions. It is assumed that contribution of PM from non traffic sources is insignificant comparing with emissions from traffic in this environment. PM emissions from transport include emissions of exhaust gasses, wear of break shoe lining, tyres and road pavement. Inorganic particles originate purely because of abrasion of cement concrete pavement (Snilsberg et al., 2007).

Special sampling devices for dust fall measurements were developed. These devices were placed near the tunnel centre during sampling campaigns, 4 sedimentation glasses in each tunnel tube with the neck diameter of 75 mm and high 200 mm filled with the mixture of 250 ml distilled water and 25 ml isopropanol (see Fig. 1). Sampling interval in both campaigns was 28 days. Captured sample of dust fall was for determination of overall content of inorganic compounds burned in 710°C (Snilsberg et al., 2006). Partial pressure of CO_2 above $CaCO_3$ is in this temperature approximately 4 kPa and $CaCO_3$ is not significantly decomposed in this temperature. Chemical composition of burned residuum thus represents aggregates used in wear road pavement. Subsequent chemical analyses have proceeded to determine the content of selected metals (ICP/MS, Agilent 7500ce) and to find out the differences in composition of PM (dust) originated due to vehicles operation on roads with different pavements. Also polyaromatic hydrocarbons (PAHs) content in the dust fall samples was determined (Shimadzu QP2010).



Figure 1. Dust fall sampling device.

Results and discussion

The results of dust fall measurements are summarized in Tab. 1. Higher production of dust fall was determined in tunnel with cement concrete pavement that indicates more intensive abrasion of this type of pavement. This is in accordance with the previous results from PM measurements next to the roads with different pavement types.

However, higher amount of dust was measured in downward-sloping tube of both tunnels. The share of inorganic content in dust fall in downward sloping tube is about 84 % whereas in the upward sloping tube of the tunnels it is about 60 % of dust fall. Also the share of PAH on organic dust fall is smaller. The reason could be higher PM production because of break shoe lining wear during more intensive braking or lower loading of vehicle engines when going downward sloping tube.

Selected metals contents were also determined in dust fall in both tunnels. There was found no statistically significant correlation between tunnels or more precisely between pavement types (see Figs. 2 and 3).

The only correlation was determined for the content of Ba between decreasing and increasing tubes of both tunnels namely its concentration was higher in downward sloping tube. This element is mostly originated due to break lining

abrasion (Valius et al., 2005) so the interpretation of this fact could be more intensive vehicles breaking.

Table 1. Dust fall measurements in one of the campaigns.

Tunnel		Strahovský		Mrázovka	
Pavement		cement concrete (CC)		asphalt (A)	
Slope		decrease	increase	decrease	increase
inorganic share	g.m^{-2}	1449.9	247.6	946.6	91.2
organic share		261.5	74.1	188.5	39.7
total		1711.4	321.7	1135.2	130.9
PAH sum		6.69	0.91	5.88	1.26
organic share	%	15.3	23	16.6	30.3
PAH in organic share		2.56	1.23	3.12	3.17

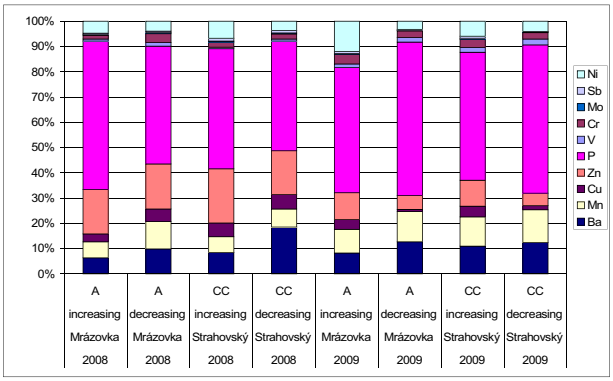

Figure 2. Comparison of micro element concentrations.

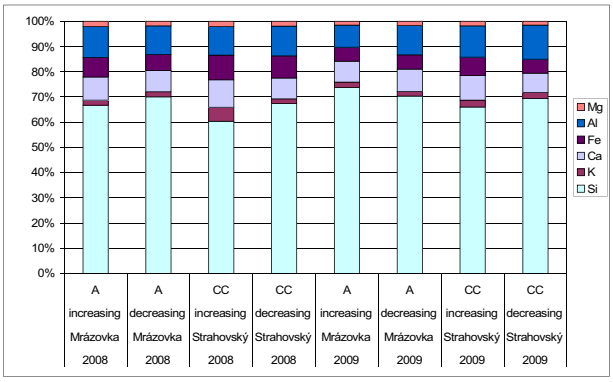

Figure 3. Comparison of lithophile element concentrations.

Conclusions

Higher amount of dust was measured in the tunnel with cement concrete pavement. Also the share of inorganic ontent in dust fall was higher in this tunnel. Obtained results indicate that cement concrete pavement is less resistant to abrasion and produces more particulate matter.

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Climatic Spas in Slovakia

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Abstract. Climatic treatment has been well known not only in Europe, but also in Slovakia since the 20th century. The biggest expansion in Slovakia was noticed about 100 years ago. The areas of Slovakia with their diversity and the altitude difference of the land provide opportunities for the existence of natural curative spas focused on the climatic treatment. Their position depends on different indicators, which characterize the climate, the purity of the air, the elevation above the sea level, etc. Natural curative spas in Slovakia focused on the climatic treatment are positioned in the height range of 800 to 1200 meters above the sea level.

Introduction

There are about 1800 spa towns with thousands of spa clinics, hotels and pensions in Europe now that are mostly focused on the spa client. In general, there are three regions that we can talk about. In the first one there are countries that are not enriched for the natural curative sources like Sweden, Norway, Finland, Denmark, Netherlands, Great Britain and Ireland. They are under the effect of American short stays at the relax center. In the treatment the whole region of the middle and southern Europe is oriented on the usage of thermal and mineral waters and climate where the long-lasting tradition of their usage is (Zalesakova, 2008).

Climatic treatment

Human bioclimatology has been studying the effects of the weather and the climate to healthy and ill human organism in Slovakia for more than 100 years. It determines the actual state of the air, its changes, negative and positive impact of the air to the human health, working activity and stability, adapting ability of the human. According to the results, it defines the areas of several meteorological elements and their usage for the improvement of the health state of the population and also it determines the influences of the atmospheric changes on different diseases and the sickness absence in general (Kolesar, 1989).

Under the term of climatotherapy can be understand a therapeutic stay in a place where the climate has extremely pleasing or healing effects. It uses a complex of climatic elements that influence the reactivity of the sick and through this it helps to settle up with the disease, and helps to mobilize its own back up.

It is predicted, that the beginnings of the climatotherapy in Europe are known from Davos, where in the winter season of 1866-1867 Dr. Alexander Spengler accepted first 15 patients with their sick lungs and breathing system to the small boarding house. Later in 1875, Dr. Mikulas Szontagh established a new first private sanatorium in Novy Smokovec. Since this, the history of climatic treatment in the Tatras began. Along the activity of the sanatoriom he used experience, which he gained on his visit in the sanatorium in the Alps. Gradually, there had been several places which can be considered as spa.

The therapeutic procedures in the Tatras are based mostly on the irretrievable effects of the clear air and climate in general. The places changed into the spa and professional curative constitutes. The biggest progress of climatotherapy in the world had been in the 20th century that is considered to be the golden age. The human bioclimatology has been developed as an autonomous science field since 1910.

The Earth can be divided into basic climate types according to the geographical position: tropical, oceanic, desert, polar, and moderate. This categorization is based on geographical latitude, but the important factor of the climate is also the height above the sea level. The spa can be divided in following group with respect to altitude in Slovakia:

- The places of lowlands (up to 350 m a.s.l. – T. Teplice, Piešťany, Bardejov,…)
- The places under mountains (from 350 to 800 m a.s.l.– Sliač)
- The mountainous places (from 800 to 1200 m a.s.l – they have low pressure of the air, lower average temperatures, intensive UV radiance, they lay in the places that are guarded with sharp wind and big difference of temperatures. The places that lay above the clouds and have usually dry and sunny weather are especially valuable, like places in the High Tatras – Smokovce, Tatranská Polianka, Tatranské Matliare, the region of Lučivná)
- The places of high mountains (1200 meters and more). There is only one spa place and it is Štrbské Pleso with the height of 1351 m a.s.l.

The users of climatic conditions for the treatment are obliged to get the observation according to the providing of the health care in the natural curative spa according to the law no. 538/2005 (later on spa law). Also the results of the measured data have to be given to the Ministry of Health of the Slovak Republic – the Inspectorate of spas and springs (MZ SR). There is a temporary act defined in § 50 section 18 of the mentioned law for the measured data from 2006. The followed limits for the climatic data from the year 2006 are pronounced according to the notice of MZ SR no. 116/1996 Z.z.:

1. the relative time of sunshine duration, that in long lasting year average overcomes 40 % and the annual time of the sunshine duration is more than 1650 hours,
2. the temperature variability – daily amplitude of the air temperature, that is not overcoming 13°C in long lasting month average,
3. the relative humidity of air, that is not overcoming 87% in long lasting monthly average,
4. the equivalent temperature of air, that in not overcoming in more that 25 days per year 50°C in the long lasting annual average.

The keepers of the natural curative spas where the climatic treatment is indicated have to control climatic conditions

according to the notice of MZ SR no. 87/2006 Z.z. now, which had cancelled the Notice no. 116/1996 Z.z.

The natural curative spas

According to the spa law, the natural curative spas and the spa therapeutic houses can be kept on the places where are the natural curative sources or the areas with the good climatic conditions for the healing process. Climatic conditions that are considered to be good according to the notice no. 87/2006 Z.z. have to be approved by the States committee of spa that is formed on MZ SR. The area where the spa is located is pronounced to be the spa area. Spa region is a determined space in a spa area whose area is defined according to the status of the spa area. The protection of the spa regime is *determined* in the spa region.
The indicated list for the spa treatment is a part of the law no. 577/2004 Z.z. and its amendment, the law no. 661/2007 Z.z., where was the payment from the public insurance edited to the category A – a full paid and B – partially paid from the insurance. In the supplement no. 6 is a table of Indicated list for the spa care: adults I. – XII. and children (up to 18 years) XX. – XXX.
The natural curative spa and therapeutic houses can be kept only according to the allowance that will be given good position, suitable natural condition and well health from the State spa committee in the region with the suitable climatic conditions.
MZ SR records the valid concessions for keeping these natural curative spas where the indication for the spa care no. V. or XXV. is being cured – Non tuberculosis diseases of the respiratory system:

- Kúpele Horný Smokovec, s.r.o. (only XXV.)
- Kúpele Lučivná, a.s. (only XXV.)
- Kúpele Nový Smokovec,a.s.
- Sanatórium Dr. Guhra n.o., Tatranská Polianka
- Sanatórium Tatranská Kotlina, n.o.
- TATRASAN, s.r.o., Nový Smokovec
- VZZ, a.s., Tatranské Matliare
- KRU MV SR Bystrá Liptovský Ján
- Kúpele Štós, a.s.

The spa treatment has gone through a lot of changes since 2004 mostly because of the financing from the public insurance. This change has brought the decreasing number of the patients that get the spa treatment. Now is the period of slowly increasing number of people interested in the spa treatment, although the amount of the short lasting stays of the adults is still overcomes the classical spa stay – 21 or 28 days.

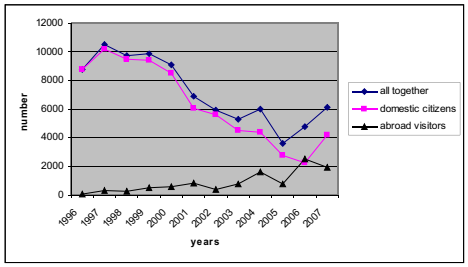

Figure 1. The number of cured adult patients wiyh the V. Indication.

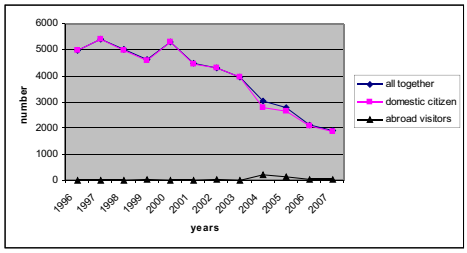

Figure 2. The number of cured children to the indication XXV.

Conclusions

The clientele of the spas has been rapidly changed in these days of complicated progress of the society. There are only 40% of patients coming from the health insurance companies; almost 40% of clients are from abroad. The other clients are the citizens paying on their own that are mostly interested in short stays. The diseases of the respiratory system (several allergies etc.) have been noticed more frequently. It is inportant for these patients especially for children to have the opportunity to stay in the natural curative spas that have all of the good predictions to obtain the successful climatic treatment in the framework of their global therapy.

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Zákon č. 538/2005 Z. z. o prírodných liečivých vodách, prírodných liečebných kúpeľoch, kúpeľných miestach a prírodných minerálnych vodách a o zmene a doplnení niektorých zákonov v znení neskorších predpisov

Zákon č. 577/2004 Z. z. o rozsahu zdravotnej starostlivosti uhrádzanej na základe verejného zdravotného poistenia a o úhradách za služby súvisiace s poskytovaním zdravotnej starostlivosti v znení neskorších predpisov a o zmene a doplnení niektorých zákonov

Zákon č. 661/2007 Z. z. ktorým sa mení a dopĺňa zákon č. 577/2004 Z.z.

Vyhláška MZ SR č. 116/1996 Z. z. o parametroch, pri ktorých možno vyhlásiť klimatické podmienky za priaznivé na liečenie a o spôsobe ich vyhlasovania

Vyhláška MZ SR č. 87/2006 Z.z. o požiadavkách na klimatické podmienky vhodné na liečenie a o rozsahu a podmienkach ich monitorovania.

The evaluation of bioclimate conditions in Torquay (Great Britain)

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Abstract The hereby paper presents the results of researches conducted in Torquay on the south coast of Devon in Great Britain. The aim of the work is determination and evaluation of Torquay bioclimatic values from the point of view of recreation. Torquay climatic conditions were presented basing upon series of meteorological data and supplemented with results of survey researches. The aim of the survey was the verification of hypothesis: *how climate of Torquay influences on human beings*? Incentivity of Torquay bioclimate as well as its influence on human health and well-being were determined. The conducted researches proved the primal asumptions of sunny and mild climate of south coast of Devon. They also allowed to state that the town of Torquay, thanks to its specific localization and unique climatic values, possesses advantageous conditions for development of specific forms of sport recreation.

Introduction

It is assumed that Torquay possesses bioclimatic conditions which are capable of offering good recreation and enhancing people. An important role here is played by beach resting, which is one of the most popular forms of recreation on the coast (deFreitas, 2001). However, a question arises: why do the local climate and weather act lesseningly and perturbatively on some people and their opinions about this matter are negative? When considering this problem, one shall ask the question: what forms of recreation are supported by Torquay climate, who shall take advantage of them and in which season of the year?

Data and methods

Meteorological data from the station in Torquay (50°27'3" N; 03°30'8" W) from the period of four years (2003-2006) were used in the work. The analysis was conducted in relation to the long-term series of data from the years 1971-2000 and was found representative. Detailed analysis of bioclimatic conditions of the town of Torquay was conducted. For that aim, meteorological elements of the strongest influence on human organism were considered: actual sunshine duration, atmospheric pressure, maximal and minimal air temperature, average daily air temperature, relative air humidity, sum of daily precipitation as well as wind direction and speed. Basing upon the chosen treshold values, characteristic days were determined, followed by atmospheric incentives: radiation, thermo-humidity and mechanical ones. Radiation incentives were determined by the number of days with sunshine duration below 1 hour, above 4 hours (Kozłowska-Szczęsna et. al., 1997) and above 8 hours per day (www.weather2travel.com). The total annual number of sunny hours was also determined. To determine the thermo-humidity incentives, the criteria of Lamb (1964) and Błażejczyk (2004) were applied. Among the discomfortable days, they counted the freezy ($t_{max} \leq 0.0°C$) and scorching ones ($t_{max} \geq 25.0°C$), days with daily temperature's change ≥6.0°C, days with amplitude (t_{max}-t_{min}) ≥12.0°C and thermo-normal days (19.3–22.3°C) (Kozłowska-Szczęsna et. al., 2002). Air humidity, presence of foggy days and frequency of days with precipitation establish the hygric criterion for evaluation of Torquay climate. The treshold value of relative humidity for dry air makes ≤55% and ≥85% for very humid air (Kozłowska-Szczęsna et. al., 1997). Numbers of days with precipitation per year (daily precipitation ≥0.1 mm) and with high precipitation (≥10.0 mm) were determined (Lamb, 1964). The dynamic criterion for evaluation of bioclimatic conditions of Torquay is the number of days with mild wind (0-1 m/s), days with strong wind (>8 m/s) as well as days with big daily changes of atmospheric pressure (>8 hPa) (Kozłowska-Szczęsna et. al., 1997). Basing upon the abovelisted criteria, it was possible to determine comfortable and discomfortable days, evaluate bioclimatic conditions and distinguish the seasons of the biggest importance for recreation. In addition, the survey researches conducted in Torquay allowed to assess the subjective thermal senses of people staying in the researched resort.

Results and discussion

The result of the work is the bioclimatic information which presents the bioclimatic conditions of Torquay as well as the possibilities of their optimal usage for various forms of recreation in different tourist seasons. There were observed 42 days with sunshine duration below 1hour, mostly during the winter season (Fig. 1). There were also 217 days with sunshine duration above 4 hours, minimum 7 per month. 92 days with over 8 hours were also observed.

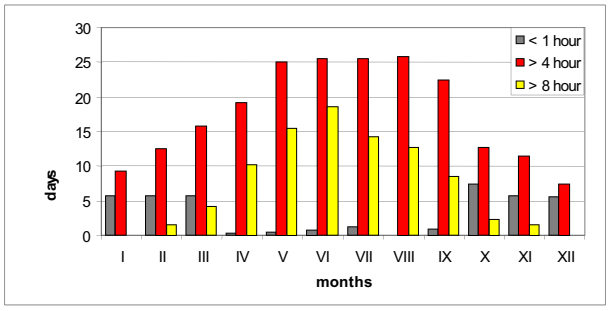

Figure 1. Average number of days with sunshine duration <1, >4 and >8 hours in various months in Torquay.

In Torquay, the annaul sunshine duration value exceeds 1900 hours and is much higher than in Central-European resorts (1350 h) and spas (1500 h) (Kozłowska-Szczęsna et. al., 2002). A characteristic feature of Torquay sunshine duration is also its high value in winter comparing to the whole year. It allows to perform various forms of sport activity during the whole year. Freezy days ($t_{max} \leq 0.0°C$) are very rare there. There are only 5 during the whole year, similarly as scorching ones ($t_{max} \geq 25.0°C$), in the number of 7. Torquay is free from severe scorches ($t_{max} \geq 30.0°C$) and

very freezy days ($t_{max} \leq$ -10.0°C). This proves the mild climate of south Devon. There are observed 34 days with thermo-neutral optimum on average, all in the summer season. The prevailing number of days during the year (254) represent neutral intencives (comfortable days). The biggest share (28) is present in October. Days with severe intencives (discomfortable days) happen 5 times a year, in average – in December and, randomly, in the period between March and July. Humid days are prevailing in Torquay (71-85% relative humidity). Altogether, 84 very humid days were observed, while only 16 dry days, during the year. Number of days with precipitation (≥0.1 mm) in Torquay does not exceed a half-year (165 days). Altogether, there are 18 days with high precipitations observed per year. The visibility in Torquay is extraordinarily good, as the air is clean and non-polluted. An additional advantage is the extremily rare presence of fogs. Thanks to the terrain relief, fogs do not appear above the land (Radclyffe, 1857). Days with high pressure changes are observed 75 times a year, in average. Discomfortable days are prevailing in winter, with their maximum in December (11 days in average) and January (10 days). They are much less present in the summer – 3 days in average in July. Silent days represent 11% of the days per year, while the ones with strong wind – only 8%. Distribution of days with strong wind is very differentiated during the year. Upon the survey researches, it was stated that the biggest group of people resting there were Britons (66%), including the citizens of Torquay (26%). Over one half of the people resting were men (54%). From the age point of view, young people, below 34 years (65%) prevails. People of over 65 years make 10%. The majority of the respondents assess the climate positively: *warm, sunny and mild*. Positive opinions were prevailing in the summer (Fig. 2).

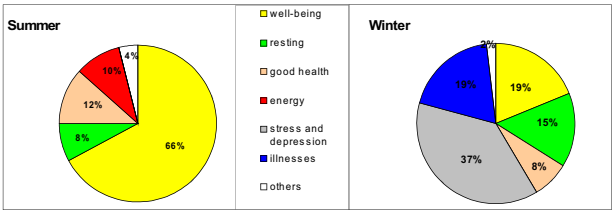

Figure 2. Opinions of respondents (2007) on the influence of Torquay climate on peoples' health and well-being in summer and winter.

On the other hand, negative opinions were present mostly in the winter: *windy, cold and humid*, mostly among visitors. The Britons usually describe the climate of Torquay positively. The disonanse in perception of the climate by the Britons and people of other nationalities is the result of their adaptation to living in the specific climatic conditions (Dubaniewicz et. al., 1988). The Britons are characterized by higher immunity and organism's hardiness. Such fatures are shaped already in the childhood years, what can be observed in the clothing.

Conclusions

The research shows that, comparing to the Great Britain, Torquay climate is more sunny and warm as well as has got good influence on people's health and wellbeing. Severe intencives and rapid temperature changes appear rarely, what is particularly important for children, elderly as well as ill people. Torquay possesses a set of bioclimatic values as well as both the features of intencing and saving climate which can be fully applied in climatotherapy (e.g. aerotherapy), kinetic-therapy as well as thalasotherapy. Low frequency of days with severe thermal conditions allows for staying in open area for most of the day during the year. This provides good conditions for recreation not only for citizens of Great Britain, but also for visitors. It was prooved, however, that people of sensitive thermo-regulative system or suffering of health problems shall perform activities in the open area in a moderate mode and mostly in the summer season. Winter season in Torquay is characterized by intensive mechanic intencives. This allows mostly the Britons and people of hardened organisms to stay in open area. In the summer season, on the other hand, the intencivity of the climate is lower, which allows for taking advantage of its values by most of the persons staying there, irrespectively of their age, health and places they come from. People from abroad, however, require adaptation to the new bioclimatic conditions, both in winter and summer. The knowledge about the influence of the climate on people's health allows for optimal application of values of the surrounding environment, properly prepare to atmospheric conditions and enjoying the leisure safely.

Acknowledgements The Author would like to thank Steve Jebson and Matthew Perry (The *Met Office*, Exeter), for providing data and information.

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Selected bioclimatic characteristics in area Tatranské Zruby

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Abstract. In the presented work the climatic and bioclimatic characteristics (air temperature, relative humidity, water vapour pressure, sunshine duration, clouds, precipitation, wind speed and direction, equivalent temperature, etc.) of the Tatra location – Tatranské Zruby have been assessed. The study has been elaborated with regard to the conditions necessary for the acknowledgement of the healing effects of the given climatic conditions on the human body in coincidence with the Decree 87 of the Ministry of Health of the Slovak Republic from 6 February 2006 on the requirements of the climatic conditions appropriate for healing (Decree 87 MZSR, 2006). The results of the assessment showed that the Tatranské Zruby location with its own considerably stimulation climate and further favourable climate and bioclimatic features fulfils all the prerequisites for the acknowledgement of this location as convenient one for healing and recreational purposes. We give attention to five-year period from 2003 to 2006 included wind calamity in 2004. This gale disaster cause a lot of damage to stands in this locality too and it is assumed that it is able to influence course of some climatic indicators. We mention state of living environment specifically on concentration of selection pollutant in atmosphere. Only characteristics that are takes into the account in the Decree 87 MZSR (2006) about request for climatic qualification desirable to therapeutics.

Introduction

Daily course of temperature primarily its expression trough use of daily maximum and minimum (in monthly average) and daily amplitude This characteristic is able to attend concerning thermal load for declaration climatic conditions for locality favourable, if thermal load (difference of extremes temperature) is less as 13°C in monthly average in 24 hours.

Data and methods

The data from meteorological stations of Slovak Hydrometeorological Institute in the High Tatra were used (Tab. 1).

Processing of the long-term observation of individual climatological components from period 1931 – 1960 and daily measure out data from the database of SHMI in period 2003 till 2007 were the basis of bioclimatological expertise.

Daily course of temperature was expressed trough use of daily maximum and minimum (in monthly average) and daily amplitude. This characteristic is able to attend concerning temperature load for declaration climatic conditions for locality favourable, if temperature load (difference of temperature) is less as 13° C in monthly average in 24 hours.

Table 1. List of used meteorological stations .

Station	Latitude (N)			Longitude (E)			Altitude [m a.s.l.]
Stará Lesná	49°	09′	10′′	20°	17′	28′′	808
Tatranská Lomnica	49°	09′	52′′	20°	17′	17′′	827
Tatranská Polianka	49°	07′	19′′	20°	11′	15′′	975
Starý Smokovec	49°	08′	23′′	20°	13′	23′′	1018
Vyšné Hágy	49°	07′	20′′	20°	06′	30′′	1140
Štrbské Pleso	49°	07′	26′′	20°	04′	09′′	1354
Lomnický Štít	49°	11′	43′′	20°	12′	54′′	2635

Results and discussions

The observational data from Starý Smokovec exhibit that in examined locality is not executed qualification of thermal load (13° C) in all month of year. This is very favourable sign of climatic condition for recondition of locality as suitable for climatic therapy.

Present locality - Tatranské Zruby satisfy other important request for thermal load according to that is not equivalent air temperature overrun value 50° C in forward yearly average in more than 25 days in year.

Tab. 2 shows characteristics of equivalent temperature in term of occurrence of thermal comfort and discomfort (Čabajová, 1990). In term of existence of thermal comfort and discomfort valuation locality has much beneficial condition and after wind calamity in 2004 oneself is able to occurrence thermal comfort increase, concerning assumed hike lengths sunshine.

Certain survey of air pollutant concentration leads Tab. 3 during period 2003 – 2005.

Table 2. Relative frequency of occurrence in single class of thermal comfort and discomfort in % expressed by means of equivalent temperature and wind speed.

		Term			Average
		7:00 AM	2:00 PM	9:00 PM	
Spring	cold discomfort	72.2	42.0	56.7	57.0
	comfort	27.8	56.7	43.3	42.6
	warm discomfort	-	1.3	-	1.3
Summer	cold discomfort	0.6	-	0.2	0.4
	comfort	93.3	83.3	95.9	90.8
	warm discomfort	6.2	16.7	3.9	8.9
Autumn	cold discomfort	47.7	28.8	42.0	39.5
	comfort	52.3	70.5	58.0	60.3
	warm discomfort	-	0.7	-	0.7
Winter	cold discomfort	98.4	96.4	33.0	76.1
	comfort	1.6	3.6	33.3	12.8
	warm discomfort	-	-	33.3	33.3
Year	cold discomfort	56.7	44	33.1	44.6
	comfort	42.0	52	50.2	48
	warm discomfort	1.4	4.0	16.7	7.4

Table 3. Annual averages of gaseous and particulate components in ambient air, 2005 – 2007 (SHMI, http://www.shmu.sk).

Station	Year	SO_2 (S) µg/m³	SO_4^{2-} (S) µg/m³	NO_x (N) µg/m³	NO_3^- (N) µg/m³	HNO_3 (N) µg/m³
Stará Lesná	2003	0.87	0.92	1.41	0.26	0.07
	2004	0.66	1.17	2.15	0.24	0.04
	2005	0.64	0.85	1.64	0.26	0.03

Station	Year	O_3 µg/m³	PM_{10} µg/m³	Pb ng/m³	Mn ng/m³	Zn ng/m³	Cd ng/m³
Stará Lesná	2003	66	15.8	9.91	4.5	20.29	0.31
	2004	62	13.8	8.46	4.03	16.44	0.25
	2005	70	14.7	8.14	4.75	12.83	0.25

The processing data of air pollution at Stará Lesná indicated that pollution in Tatranské Zruby does not over allowable attributes dusty fallout.

Conclusions

Results ratings demonstrate that locality Tatranské Zruby with his considerably simulative climate and other favourable bioclimatic characteristics lull moon all assumes for recognition locality how favourable for therapeutic purposes.

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Climate change and its economic effects

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Abstract. My study concerns economic aspects of climate change. I am interested in climate change problematic because it is very often the topical subject of many publications with controversial information on human role in this phenomenon. Postulated in some publications that only people are responsible for climate change, I disagree with such opinions. From the available publications, I conclude that humankind contributes to global warming and have made the warming process faster, but the human activities are not the only phenomenon affecting the observed global increase in temperature.

Introduction

The Earth's climate has been developing for a long time and this process is permanent. Several large climatic changes have occurred in the past, and many animal species, which were not able to adapt, extinct. Mankind is happy to live in such a stable and relatively cool period called the Holocene. For example, the water in the ocean was approximately 12°C warmer about 50 million years ago[2]. However, the Earth started to cool, and Antarctica became covered by ice for the first time. 35 million years ago, it was 2°C warmer than it is today. Global warming could be compared to a virus which gradually makes you ill. Climate change will attack every sector of economies. Worst of all, it is not possible to estimate losses accurately, because climatic changes have regional character and they do not have the same influence everywhere. Insurance, tourism, agriculture, fisheries, and forest industry seem to be the most effected economic areas. It is expected that by the end of the next century the deficiency in agriculture will reach 40 million dollars per year[3]. Other parts of economies might be badly influenced by catastrophes as well. In my compilation study, I am trying to prove that changes in our climate are no longer a fact hidden behind observations. I think they are a real threat, which may have disastrous consequences if people do not organize effective activities for adaptation to the global warming.

Climatic changes and tourism

Tourism will become another sector of economy, which will be seriously influenced by climatic changes. Some of ski resorts, which are low-lying, may remain without snow in the following 15 years[2]. In many ski centres in the Alps the temperature has increased about 1°C in recent ten years[2]. Consequently the snow line has moved 150m higher and in the next 15 years it may move another 1200 – 1800m higher[2]. As a result of global warming, most of the continental glaciers may disappear. The tourist centres in Switzerland, and also in other countries, will be forced to put more and more investments in technical equipment for an artificial snow production. However, such effort is often ineffective when the air temperature is above the freezing point. It causes the ski services more expensive. On the other hand, while the snow will disappear forever in low-lying ski resorts, the more elevated ski resorts may have even more snow. According to the observations, the ski season has lengthened here to spring time, and there is more fresh snow at the end of the ski season in the past few years[2]. Some of our mountain ski resorts (e.g. in the High Tatras) has struggled with a similar problem.

Climatic changes and insurance industry

Insurance companies are the most endangered economic branch. On the other hand, it is one of the richest sectors of economy. Yet, they have already experienced the consequences of climatic changes. From 1990 to 1995 the insurance companies all over the world paid compensations of 57 milliard-dollars for catastrophes caused by weather fluctuations[4]. They paid 40 milliard dollars more than during the whole decade of 1980-ties. Only the hurricane Andrew caused the bankruptcy of seven American insurance companies, which were not able to pay the compensations[5]. The dilemma of insurance companies' representatives is that it is very difficult to determine a yearly level of the insurance. It is based on the average of the climatic damages throughout several past years with assumption that the weather conditions will remain similar. However, the weather conditions have changed radically. So the climatic change may cause that the applied method will turn into useless in the future. Consequently nowadays, many insurance companies decrease their liabilities and tend to reduce the possession insurance on sea shores, islands and the places where there is a high probability of storms, floods or fires. Such policy means that if private insurance companies are not willing to insure the endangered areas, state will be forced to bear potential risk. But the damage increases up to 10% per year, which is greatly above the increase of GDP[6] (gross domestic product). Such losses will lead to damage of global economy.

Climatic changes and agriculture

American scientists suppose that agricultural production may decrease in many countries of the tropical and subtropical zones due to climatic changes[7], also some increase in agricultural production is projected in mid latitudes. Nowadays up to 800 million people suffer from hunger[8]. Due to permanent population increase, food demand might be twice or three times greater in the next

[2] Svět, 4/2008, pp. 15, 16, Zbyněk Hrkal: „'Histeorie' klimatických změn"

[3] http://www.seps.sk/zp/fond/klima02/60.htm

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three or four centuries. In relation to the analyses, worldwide food production should not be influenced if the global temperature rises less than 2ºC[9]. Nevertheless, the production will rapidly fall in case of steeper temperature increase. It is assumed that if the atmosphere warms up even in 1ºC, the land for agriculture use will be moved 150-200 m polewards[8].Along with this, greater draughts in summer may decrease harvest in mild climate areas from 10 to 30%, including a possibility that today's most productive areas such as Midwest of the USA may face draughts and hot weather conditions even more than nowadays[8].

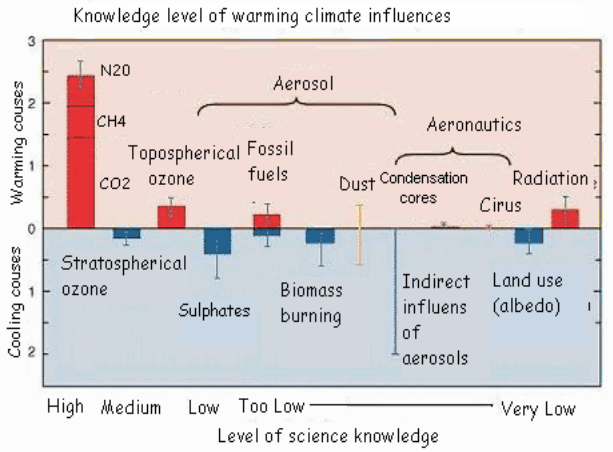

Figure 1. The chart shows the knowledge level on factors, which support (red columns) and mitigate (blue columns) global warming process[10].

Discussion

In the period when many people live in air-conditioned homes and eat fresh food grown in remote places, which are thousands kilometres far away, it is easy to ignore dependency on climate. People living in the developed industrial areas, which are close to the sufficient water sources, do not even think on the risk of their shortage. It is similar with the foodstuffs. Our needs are fulfilled by agriculture crops or fishery, which are however, dependent on certain climate condition - temperature, rainfall, and humidity. People are able to manage consequences of regional draughts, storms and even floods but nowadays expansive catastrophes which happen probably due to global warming affects the sustainable development in many regions and affects the global economy (e.g. Catrina hurricane).

It is difficult to estimate real impact of such changes since global climate is a very complicated phenomenon. If some key factor changes little, e.g. average air temperature, other factors will be changed as well. For instance, atmospheric conditions and rainfall may be modified; sea level will possibly rise and endanger islands and low-lying countries. In the world which has already been undergoing various difficulties, such climatic changes may evoke even other conflicts between the nations.

Conclusions

The aim of this study was to discuss mainly economic consequences of the climatic change. My hypothesis is that the climatic changes also have an impact on human civilization, e.g. some areas have become uninhabitable because of the warming climate and the habitable border has been gradually moving. As a result of such movement, nation migration may begin which might initiate war conflicts.

The consequences of the global warming are not only negative but also positive. The continental glaciers are melting – it will lead to changes in density of the sea water. However, it does not only mean that the sea level will rise. The salt concentration in the sea water will decrease and it will be possible to drink it. That might solve the problem of drinking water shortage.

It is up to humans how the global warming phenomenon will be managed to minimize the undesirable consequences and to avail benefits associated with this global problem.

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Monitoring the Effects of Pavement on Composition of Particulate Matter

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Abstract. According to current research, particulate matter (PM) has a negative impact primarily on citizens (respiratory and cardiovascular diseases). Based on EU studies, deaths of 347,900 Europeans are attributable to air pollution. Formation of particulate matter from road transport has been a concern for big cities in particular.

Introduction

Considering the predominant use of combustion engines, exhaust gases contain high amount of both gaseous and solid contaminants. They include high quantities of the finest fractions that can stay in the air for a long time; they can easily enter the respiratory tract and be harmful to human health.

The Faculty of Civil Engineering and the Transport Research Centre (Centrum dopravního výzkumu, v.v.i) in Brno have participated in the international project "SPENS Sustainable Pavements for European New Member States" focusing on sustainable transport.

The aim of this part of the work to be presented is to compare development of particulate matter and its composition along roads depending on surface type of the road.

Data and Methods

Sites representing both non-urban and urban roads with various traffic volumes and various surfaces were selected to monitor concentrations of specific fractions of the particulate matter at locations with different traffic volume.

Air samples were taken using medium-volume LECKEL MVS6 sampling pumps. This device is intended for outdoor use at high or low temperatures. The flow of the air to be taken is controlled and basic physical parameters are maintained by means of a thermally compensated slot. PM capturing filters are inserted between Teflon holders into a sampling head forming an integral part of the device. Filters from silicone and nitrocellulose fibres were used to capture PM.

Measurements were done in compliance with the European standards EN 12341:1998 and EN14907:2005, in which this methodology is used as a reference method.

Particle concentrations were determined gravimetrically from every exposed filter. Traffic volume was recorded continuously using an automatic traffic detector SIERZEGA SR4.

Multiple measurements were done at four sites from April 2008 until May 2009. Most measurements focused on PM_{10} monitoring. Representation of different particles was monitored at two sites in July and October 2008, taking samples to monitor chemical composition of PM. First site was at the D1 highway in Predmier with traffic volume of 20,000 vehicles per 24 h, and the second site was urban through-road of the I/18 road in Žilina – Mostná street (Fig. 1) with traffic volume of 25,000 vehicles per 24 h.



Figure 1. Žilina – sampling.

Results and Discussion

Samples taken were analysed further to determine volume of selected metals (ICP/MS, Agilent 7500ce) and PAH – polyaromatic carbohydrates (GS/MS, Shimadzu QP2010) and to identify differences in PM composition due to vehicles operated on roads with different surfaces.

It is assumed that inorganic particles are formed only by abrasion of cement-concrete pavements. These particles therefore represent 90% of the particles resulting from abrasion of asphalt-concrete pavements (Snilsberg et al., 2007) and they consist mostly of coarse fraction PM.

The share of this coarse fraction on total PM_{10} concentrations was higher at sites with asphalt concrete (AC) surface at the city ring (approximately 480) than its share in stone matrix asphalt (SMA) – 35 to 40%. This has been confirmed during both collection campaigns (Fig. 2), although the $PM_{1.0}$ fraction was generally predominant in both campaigns at both sites. These results indicate a higher production of coarse fraction PM due to abrasion of asphalt concrete.

Contents of selected metals, representing sources related to mechanical abrasion of particles, such as Zn, Sb, Cu, Ba and other, have been identified in both fine and coarse PM fractions. Contents of selected metals in both PM fractions were higher at sites with asphalt-concrete pavement at both collection campaigns, except K and Pb in the second collection period in the autumn (see Figs. 3 and 4).

The $PM_{2.5}$ fraction with the content of polyaromatic carbohydrates related to the amount of particulate matter was evaluated separately (Fig. 5). Less volatile PAH were determined according to the US EPA list of significance, starting with Fluoranthene, including Benzo[a]pyrene and Dibenz[a,h]anthracene as the most harmful components, and Coronene. Higher PAH concentration was identified during the autumn sampling campaign at both sites; the PAH concentrations were higher in both campaigns also at sites with asphalt-cement pavement. The lower PAH quantity during the summer campaign is likely to result

from PAH occurrence mostly in its gaseous form due to higher temperatures, or from PAH degradation due to sunshine.

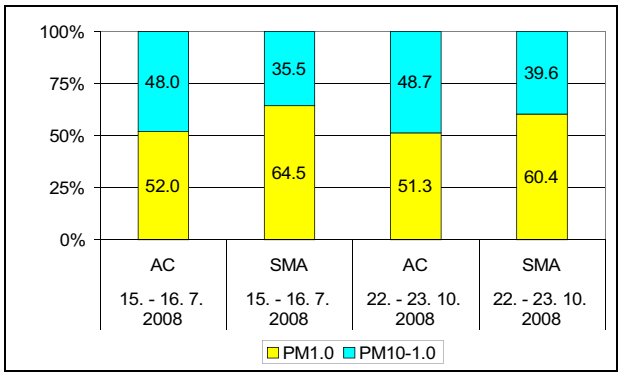

Figure 2. Representation of fine fractions in PM_{10} – summer campaign.

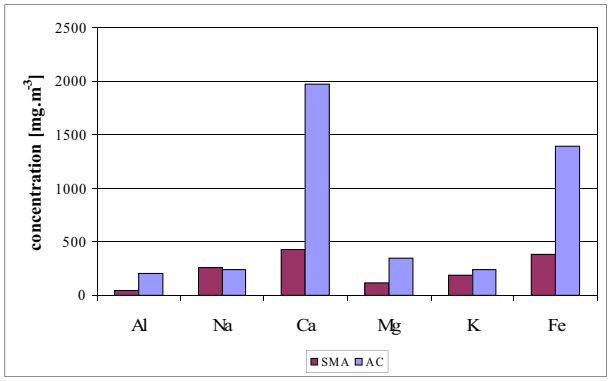

Figure 3. Content of selected macro particle substances in PM_{10} fraction – summer campaign.

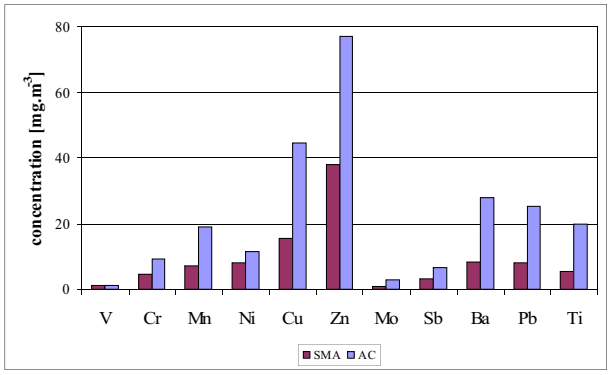

Figure 4. Content of other selected trace substances in PM_{10} fraction – summer campaign.

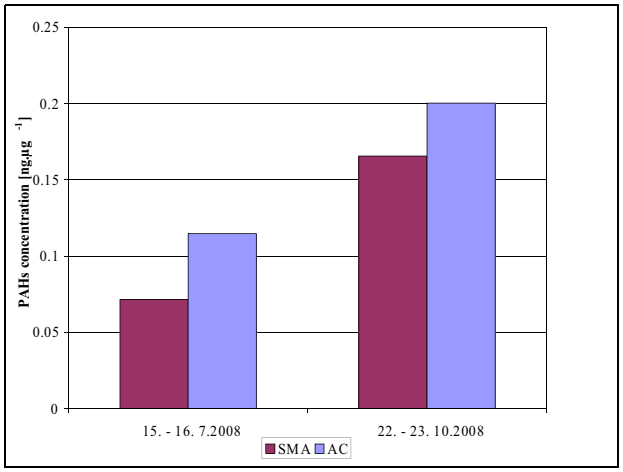

Figure 5. PAH content bound to $PM_{2.5}$ fraction.

Conclusions

Discussed results indicate higher production of coarse PM fraction due to abrasion of AC pavement with higher content of selected elements. Higher PAHs concentration was determined during the autumn sampling campaign on both localities but there was found no significant difference between localities.

Acknowledgements This paper was worked out in terms of the scientific research task VEGA 1/0673/08 Impact of Roadway Serviceability on Road Traffic Immissions, and the international project 6. RP EU SPENS Sustainable Pavements for European New Member States.

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Long-term changes of some meteorological elements and characteristics in Bratislava for the period 1983-2007

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Abstract. The paper deals with the long-term changes of air temperature and humidity, cloudiness, sunshine duration, number of days with fog and number of days with minimum relative air humidity equal to or less than 40% at station Bratislava, Mlynská dolina for the period 1983-2007. Data from this station are analysed together with the data from meteorological stations at the airport and at Koliba in Bratislava. The long-term course of annual values above mentioned characteristics is completed with their linear trend. Annual course of studied elements at station Bratislava, Mlynská dolina is presented in a form of table. Intensity of the heat island for Bratislava, Mlynská dolina station is evaluated.

Introduction

In the last years a great attention is paid to the problem of long-term change and variability of the basic climatic elements. This change can be marked in Bratislava where air pollution was diminished in the nineties of the last century and the concentration of aerosols in the atmosphere began to sink (Závodský, 2007).

Data and methods

The data from 3 meteorological stations – at Koliba (φ = 48°10′, λ = 17°07′, H = 286 m a.s.l.), Mlynská dolina (φ = 48°09′, λ = 17°04′, H = 182 m a.s.l.) and the airport (φ = 48°10′, λ = 17°12′, H = 131 m a.s.l.) in Bratislava were used. The method of regression analysis was applied to computation of linear trend equations.

Results and discussions

Figs. 1-4 and 6 show the long-term course of annual values: of number of days with fog (Fig. 1), sums of sunshine duration (Fig. 2), cloudiness (Fig. 3), relative air humidity (Fig. 4) and air temperature (Fig. 6). We can see the decreasing tendency in linear trend of relative air humidity and number of days with fog at stations Bratislava, Mlynská dolina and Koliba. On the contrary, the annual sums of sunshine duration and air temperature tend to increase. Trend of cloudiness is statistically insignificant – mean annual value changed according to long-term normal for the period 1951-1980 by 0.1 tenth – Table 1.

This table gives departures of monthly and annual values for the period 1983-2007 in view of their long-term ave-rage 1951-1980. The increase of mean annual air temperature reached 0.7°C. From the mean air temperature vertical gradient (0.6 °C/100 m) we can determine the mean annual heat island intensity for Mlynská dolina about 0.3°C. Because of nearness of the river Danube the mean annual relative air humidity is not less than that at airport station in the outskirts of Bratislava. Number of days with the minimum air relative humidity 40% and less tend to increase in April and June (Fig. 5).

Table 1. Annual course of air temperature and humidity at Mlynská dolina and at the airport in Bratislava and the departures of the mean air temperature – dT (°C), relative humidity – dRH (%), cloudiness – dN (tenth), duration of sunshine – dS (%) and precipitation – dP in (%) at Koliba for the period 1983-2007 according to the long-term average for the period 1951-1980

	Koliba					Mlyn. dol.		Airport	
Month	dT	dRH	dN	dS	dP	T	RH	T	RH
1	1.4	-3	-0.4	12	-7	0.1	81	0.0	81
2	0.9	-5	-0.7	34	11	1.5	76	1.2	76
3	0.7	-4	0.0	10	8	5.5	70	5.4	71
4	0.9	-4	0.2	5	-20	11.0	64	11.0	64
5	1.4	-3	-0.1	10	1	16.0	66	16.1	65
6	0.5	-5	0.0	8	-19	18.7	69	19.1	65
7	1.3	-6	-0.3	14	-14	20.9	66	21.3	62
8	1.4	-5	-0.1	11	-1	20.6	67	20.8	64
9	0.1	0	0.5	1	73	15.7	73	15.7	72
10	0.4	-1	0.3	2	-8	10.8	77	10.4	77
11	-0.1	-1	-0.2	9	-1	4.8	82	4.7	82
12	0.0	-2	-0.2	1	1	0.7	84	0.7	84
Year	0.7	-3	-0.1	9	-1	10.5	73	10.5	72

Conclusions

The processing of basic climatic elements confirmed their marked changes in annual course as well as in long-term course of annual values.

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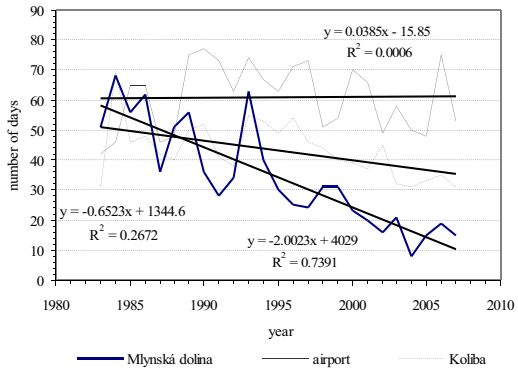

Figure 1. Long-term course of annual number of days with fog at Bratislava stations Mlynská dolina, airport and Koliba for the period 1983-2007 with linear trend.

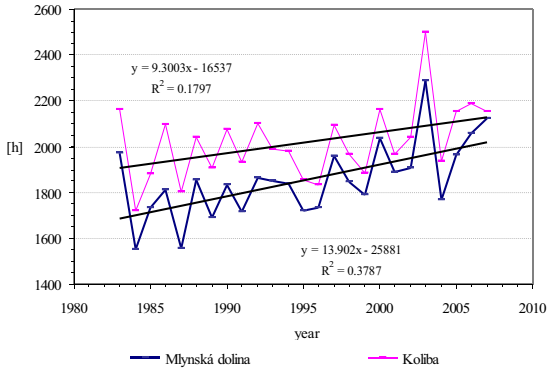

Figure 2. Long-term course of annual sunshine duration in hours at Bratislava stations Mlynská dolina and Koliba for the period 1983-2007 with linear trend.

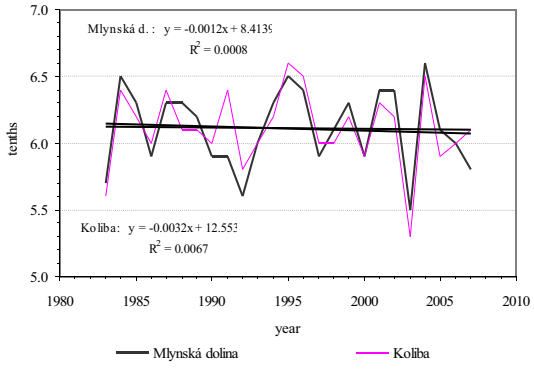

Figure 3. Long-term course of mean annual cloudiness in tenths at Bratislava stations Mlynská dolina and Koliba for the period 1983-2007 with linear trend .

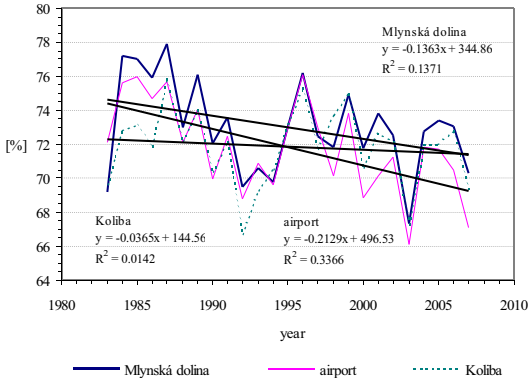

Figure 4. Long-term course of mean annual relative air humidity at Bratislava stations Mlynská dolina, airport and Koliba for the period 1983-2007 with linear trend.

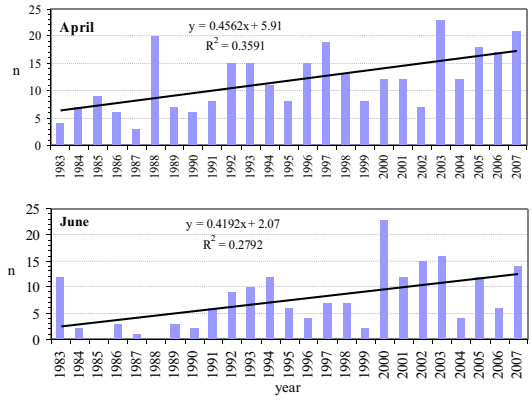

Figure 5. Long-term course of number of days with minimum relative air humidity 40% and less (n) at station Bratislava, Mlynská dolina in April and June for the period 1983-2007.

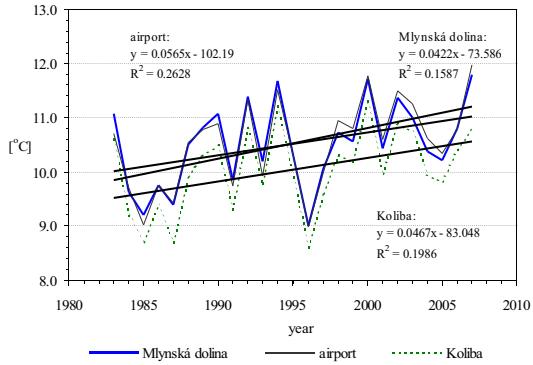

Figure 6. Long-term course of mean annual air temperature at Bratislava stations Mlynská dolina, airport and Koliba for the period 1983-2007 with linear trend.

Fire danger trend of the period 1983-2007 in the Bratislava wildland-urban interface area

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Abstract. Assessment of possible fire danger in wildland-urban Interface area is complicated due to many influencing factors. One of them is meteorological condition important for the fire ignition and spread. This paper brings the trend of fire danger development on the base of occurrence of fire prone days assessed by the meteorological situations suitable for the fire occurrence and by the meteorological fire indices (Baumgartner index, Angstrőm index). The trend of 25 years (1983-2007) is showing increase in number of days during fire season with suitable meteorological conditions for fire occurrence.

Introduction

The Wildland-Urban Interface (W-UI) can be considered to be a zone where the probability of fire occurrence (ignition and propagation) is by definition higher than in other zones, such as plain rural zones or remote areas of poor accessibility (Cohen, 1999). There are several factors influenced the fire risk potential. The major one is the people activity. The presence of agglomerations of people, that frequently are tourists or house and cottages holders, do represent a potential risk itself in the probability of fire occurrence. Thus, urban areas are frequently sources of new wildland fires (Alcazar et al., 1998). The other factor is country pattern of vegetation, urban areas, routs and paths distribution. The frequency of wildland fire occurrence and area burned is also limited by the meteorological conditions important for the fire ignition and propagation. By the fact of recent growing demand for wildlands as places where to live or to spend pleasant vacation periods, that is more evident in the nearby of large urban agglomerations and cities (Caballero, 2004), we can also fallow the present climate change that is enhancing the meteorological potential for the forest fire occurrence in many parts of the world (e.g. Pausas, 2004; FAO, 2007).

In our model area Bratislava county II, III, IV and V (Fig. 1 left) (Area of 358 km^2, 385672 citizens in 2007) was through the last 10 years (1999-2008) recorded more than 1600 fires of the country (land or forest) with total burned area of 352 ha and the damage cost of 10 630 000 Sk (€ 352 851) (PTEU - Ministry of Interior of SR).

Knowledge of the factors that made forest, agriculture and also man made structures vulnerable in W-UI areas is a key for planning the management and taking preventive steps to protect these areas (Holécy et al., 2008).

The advanced paper is aimed to show the trend of climate change development and its influence on wildland fire danger potential change in the W-UI area of Bratislava.

Data and methods

Basic restricting factor of fire occurrence and propagation in the central Europe region is fuel moisture that depends on presence of precipitation, air temperature and relative humidity through the year (Stolina et al., 1985). Therefore a number of days in fire season (May-September) with suitable meteorological condition for fire occurrence were assessed firstly. Following meteorological situations were investigated:

1. number of tropical days,
2. number of tropical days with low relative air humidity (40 % and lower),
3. number of tropical days without rain and with low relative air humidity (40 % and lower).

Meteorological data from Bratislava-Mlynská dolina meteorological station (182 m a.s.l.) was used in this step.

Secondly, meteorological data was used to calculate meteorological fire indices. Baumgartner index (BI) is based on meteorological water balance counting from air temperature, relative humidity and precipitation. Angstrőm index (AI) is calculated from relative humidity and air temperature. Five different fire danger classes are used depending on the value of the index:

- no fire risk,
- low risk,
- medium risk,
- high risk,
- extremely high risk.

Number of days with fire danger equal tree or higher was analyzed over the investigated period. Data from Bratislava-Koliba meteorological station (286 m a.s.l.) was used in this step. Fig. 1 right shows location of meteorological stations. Thereafter, trend of fire danger potential was expressed graphically.

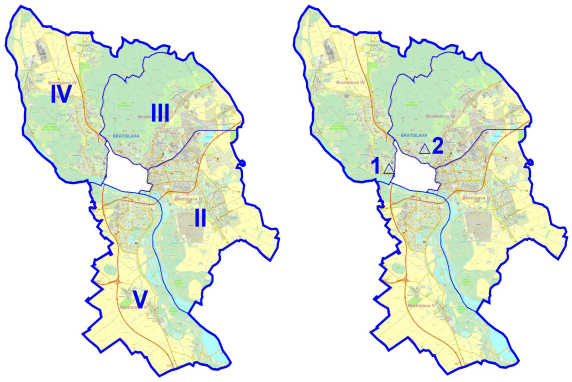

Figure 1. Maps of Bratislava model area with county II, III, IV, and V (left) and places with meteorological stations (right) highlighted. Number 1 represents Bratislava-Mlynská dolina and number 2 Bratislava-Koliba meteorological stations.

Results and discussion

As one can see in the Figs. 2, 3 and 4, the 25 year trend (1983-2007) is showing increase of the days with suitable meteorological situations for fire occurrence. In the cases of combination of meteorological conditions (situation two and three) (Figs. 3, 4) one can see decrease in number of suitable days compared to meteorological situation one (Fig. 2).

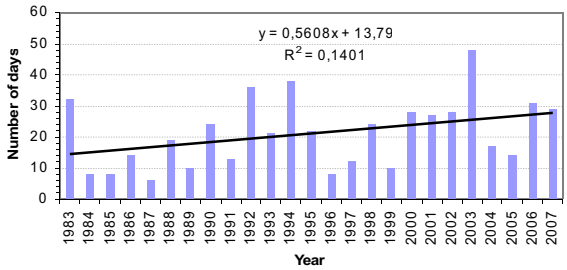

Figure 2. Long-term development of tropical days number at Bratislava-Mlynská dolina meteorological station for the fire season (April-September) of the years 1983-2007.

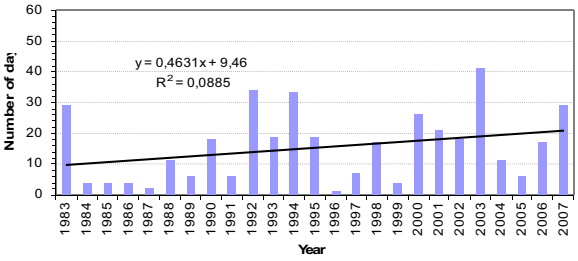

Figure 3. Long-term development of number of tropical days with relative humidity lower than 40 % at Bratislava-Mlynská dolina meteorological station for the fire season (April-September) of the years 1983-2007.

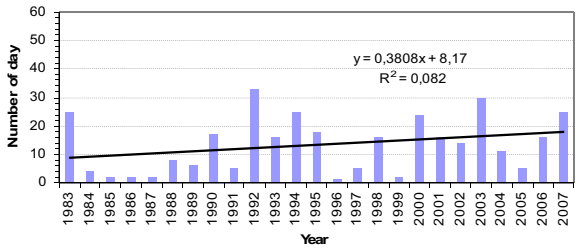

Figure 4. Long-term development of number of tropical days with relative humidity lower than 40 % and without rain at Bratislava-Mlynská dolina meteorological station for the fire season (April-September) of the years 1983-2007.

Similar mounted up trend for the whole period was recorded also for fire risk days assessed on the base of meteorological fire indices (Fig. 5). This phenomenon is described also in paper of Groisman et al. (2007) for northern Eurasia or by Szczygiel et al. (2007) for Poland.

The assessment of 25 years growing trend of fire risk days for individual months of fire season showed substantial differences. Fire season is split in two parts. The increase of the fire prone days was detected in the first part of the season (April to June) while second part (July to September) showed minimal increase or even slight decrease (in case of fire indices assessment for July) of number of fire prone days. This phenomenon will need more complex research approach in the future to evaluate its causes. Assessment of the number of fire risk days on the base of meteorological fire indices shows higher sensitivity that resulted into higher number of these days in average for the BI as well as for the AI (Fig. 5).

Conclusions

To assess the possible fire danger in W-UI areas is a complicated due to many influencing factors.

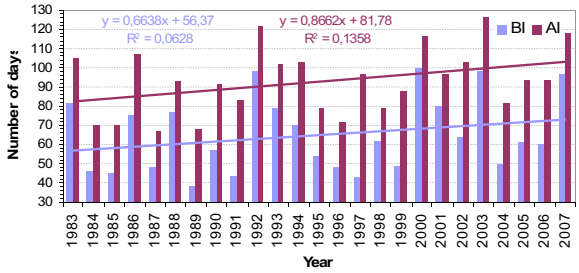

Figure 5. Long-term development of days reached 3, 4 or 5 values of Baumgartner (BI) and Angstrőm (AI) index at Bratislava-Koliba meteorological station for the fire season (April-September) of the years 1983-2007.

But, their study is important for planning a suitable management of human activities, property and nature protection. In this paper, a long-term fire danger development is assessed, based on meteorological situations dangerous for ignition and propagation of fire. The increase of fire prone days as a possible consequence of present climate change is evident from the elaboration of meteorological data of fire season.

Further deeper study of growing danger could by helpful for sustainable development of W-UI areas of Slovakia.

Acknowledgements The study was supported by research grants No. 1/0515/08, 1/4393/07, 1/3528/06 from the Slovak Grant Agency for Science and project No. 0022-07 from the Slovak Research and Development Agency.

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Assessing meteorological conditions accompanying smog episodes in selected cities in the Czech Republic

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Abstract. The objective of this paper is to assess meteorological characteristics such as wind speed, air temperature and humidity – as well as meteorological phenomena accompanying SO_2 and PM_{10} smog episodes – in three areas of the Czech Republic most affected by winter smog in the period from 1992 to 2007.

Introduction

Winter smog is a label denoting a mixture of urban and industrial emissions and fog, typically occurring in winter conditions, especially in connection to considerable near-ground temperature inversions. Depending on industrial pollution, smog is primarily composed of sulphur dioxide (SO_2) and a number of highly oxidizing substances. In addition to SO_2 smog episodes and with respect to the proven negative impact of high concentrations of suspended particles on human health, attention is also devoted to PM_{10} smog episodes.

The objective of this study is the statistical assessment of meteorological characteristics accompanying smog episodes in the period from 1992 to 2007 in three areas of the Czech Republic most affected by winter smog.

Data and methods

Hourly data on SO_2 air pollution from 1992–2007 and PM_{10} air pollution from 1995–2007 retrieved from a total of eighteen Automated Imission Monitoring stations constituting the basis for research. Two stations are located in Ústí nad Labem, seven in Prague and nine in the Ostrava region.

Identification of smog episodes caused by high SO_2 concentration was facilitated by adhering to criteria set out in the air protection regulation. Situations where three consecutive mean hourly SO_2 concentration readings exceed 250 $\mu g.m^{-3}$ (according to the 2002 regulation) are considered to constitute SO_2 smog. Smog episodes caused by PM_{10} have been assessed according to a criterion used in the Upper Silesian industrial area in Poland (Ośródka et al., 1998). A smog situation is defined as a situation where the three consecutive mean hourly PM_{10} concentration exceeds 230 $\mu g.m^{-3}$. Such smog episodes have been subjected to a minute statistical analysis (Knozová et al., 2009).

The authors of this study focus on an analysis of weather conditions recorded at weather stations representative of the areas in question as registered on days with smog episodes. An assessment of meteorological conditions accompanying SO_2 smog situations was carried out based on data from two stations: Ústí nad Labem – Kočkov and Prague – Libuš from period 1992-2008. In the years 1999-2007 only station Ústí nad Labem recorded one three-hour-long smog episode which, however, is not included in this analysis. Data from Ostrava region had not been included due to the small number of cases – only 24 occurrences were registered. PM_{10} smog episodes were assessed using data from stations in Ústí nad Labem – Kočkov, Prague – Libuš and Ostrava – Poruba.

Table 1. Days with SO_2 and PM_{10} smog episodes in selected areas of the Czech Republic.

Region	number of days with SO_2 smog situation 1992-1998	number of days with PM_{10} smog situation 1995-2007
Ústí nad Labem	67	51
Prague	173	292
Ostrava region	24	371

Results and discussion

Smog episodes occurring in three monitored areas of the Czech Republic were each accompanied by distinct meteorological conditions. For example, mean wind speed recorded at the Prague – Libuš weather station during SO_2 smog episode periods was only 1.2 m/s lower than overall recorded mean wind speed, while in Ústí nad Labem lists a difference of 1.9 m/s. Average daytime wind speed changes also display marked differences (Fig. 1). Differences in humidity are relatively insignificant (Fig. 2).

Distinct differences are also in mean hourly air temperatures during PM_{10} smog episodes and mean overall temperatures between Prague and Ostrava region. This is due to the fact that high PM_{10} concentrations occurring in Prague are not a result of combustion processes – the primary source of PM_{10} pollution in the Ostrava region. Smog episodes in the capital city are predominantly a result of heavy traffic; this is also the reason for greater smog incidence in spring and summer months. Since temperature is naturally connected to humidity, this indicator also displays differences between Prague, Ústí nad Labem and the Ostrava region.

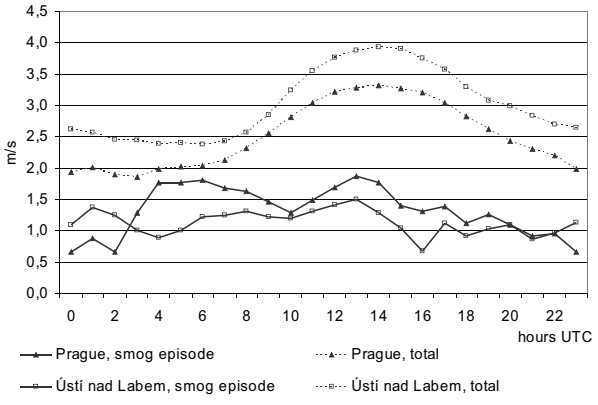

Figure 1. Mean hourly wind speed during SO_2 smog episodes and mean overall wind speed (1992–1998).

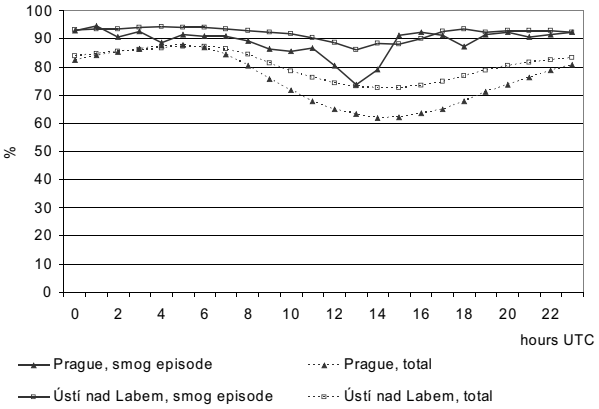

Figure 2. Mean hourly air relative humidity during SO2 smog episodes and mean overall humidity (1992–1998).

Table 2. Probability (in %) of SO_2 smog episode incidence in selected areas of the Czech Republic during particular meteorological conditions. F – wind speed, H – relative humidity, T – air temperature, phenom. – selected atmospheric phenomena.

Prague		Ústí nad Labem	
F<=1.7	10.2	F<=1.3	7.3
H>=80	10.1	H>=92	10.4
T<=1.8	17.1	T<=-3.0	16.3
phenom.	16.2	phenom.	7.7
complex	31.1	complex	63.6

Table 3. Probability (in %) of PM_{10} smog episode incidence in selected areas of the Czech Republic during particular meteorological conditions. F – wind speed, H – relative humidity, T – air temperature, phenom. – selected atmospheric phenomena.

Prague		Ústí nad Labem		Ostrava region	
F<=2.0	7.3	F<=1.7	3.4	F<=1.3	11.4
H>=68	4.6	H>=78	1.2	H>=80	9.7
T<=7.4	7.5	T<=1.1	2.6	T<=-0.5	28.1
phenom.	11.2	phenom.	3.1	phenom.	23.2
complex	34.9	complex	8.5	complex	62.8

One of the methods for detection to what extent the extremely high concentrations of the two pollutants in question depend on meteorological factors is calculating incidence probability under a particular set of conditions. The mean daily values of individual factors recorded during the relevant period were used as a criterion for assessment of meteorological conditions. These included: wind speed, relative humidity and air temperature. In addition to this, on analyzing their incidence, a number of atmospheric phenomena relevant to radiation processes in the near-ground air layer were also selected: fog, freezing fog, ground fog, hard and soft rime, and ice prisms. Smog episode probability was subsequently calculated with respect to individual phenomena as well as taking into account the full set of conditions. However, conditions in the assessed areas are not comparable due to the above mentioned pollution diversity of individual areas.

Conclusions

The study specifies which meteorological conditions tend to accompany smog episodes most often. The best results were reached in the case of SO_2 smog in Ústí nad Labem and PM_{10} smog in the Ostrava region, where smog incidence probability has been established at 64 % and 63 % respectively. Although such assessments must always be considered an approximation, the fact that the above mentioned weather conditions – save wind speed – have accompanied the occurrence of a SO_2 smog episode in Ústí nad Labem almost ten years later is evidence of their validity.

Acknowledgements This study was supported by a grant from Academy of Sciences of the Czech Republic KJB307530701.

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Smog Episode Occurrence in Urban and Suburban Areas in the Czech Republic

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Abstract This paper presents selected parameters of smog episodes caused by sulphur dioxide (SO_2) and particulate matter (PM_{10}) in twenty two air pollution monitoring stations in the Czech Republic. The aim of this study is the description of smog episode frequency and duration in the period of 1992–2007 as well as a comparison of characteristics between urban and suburban locations.

Introduction

Cities throughout the Czech Republic have experienced a marked improvement in air quality in recent decades. Dangerously high concentrations of SO_2, the driving force behind smog episodes, hardly ever occur anymore. However, the concentration of suspended particles (PM_{10}) has not decreased in recent years and still presents a health hazard to the general population. The study presents a characteristic of smog episodes caused by high SO_2 and PM_{10} concentrations in four agglomerations in the Czech Republic. Due to the fact that urban environments tend to be extremely varied in terms of emission sources as well as geographic and – perhaps most importantly – climate conditions, the localities in question have been divided into urban and suburban. The paper focuses on analysing and comprising the occurrence and progress of both smog episode types: SO_2 episodes and PM_{10} episodes.

Data and Methods

Hourly data on SO_2 air pollution from 1992–2007 and PM_{10} air pollution from 2004–2007 retrieved from a total of twenty two Automated Imission Monitoring stations constitute the basis for research. Four stations are based in Ústí nad Labem, seven in Prague, two in Brno, and nine in the Ostrava and Karviná region.

Identification of smog episodes caused by high SO_2 concentration was facilitated by adhering to criteria set out in the air protection regulation. Situations where three consecutive mean hourly SO_2 concentration readings exceed 250 $\mu g.m^{-3}$ (according to the 2002 regulation) are considered to constitute SO_2 smog. Smog episodes caused by PM_{10} have been assessed according to a criterion used in the Upper Silesian industrial area in Poland (Ośródka et al., 1998). A smog situation is defined as a situation where the three consecutive mean hourly PM_{10} concentration exceeds 230 $\mu g.m^{-3}$.

Results and Discussion

The greatest number of days with SO_2 smog situations in the 1992–2007 period in the selected urban locations were recorded in 1993. Since then, they have been on an irregular decline and only sporadic occurrences are currently being registered.

Table 1. Basic smog episode characteristics in the four processed areas in the Czech Republic.

Station type	Episode count	Mean episode duration [h]	Max. episode duration [h]
SO_2 (1992-2007)			
Urban	382	7.5	125
Suburban	104	10.9	124
All	486	8.7	125
PM_{10} (2004-2007)			
Urban	260	6.9	72
Suburban	142	6.5	43
All	402	6.8	72

SO_2 smog situations are three times as frequent in urban than in suburban environments (Tab. 1). Although most of them last 3 hours, their maximum duration in the areas in question varies from 9 to 125 hours. The average episode lasts 8.7 hours. The fact that they generally last longer in suburban areas – 3.4 hours longer on average – may be considered rather interesting. The phenomenon is a result of daily pollution concentration developments and the daily near-ground air thermal stratification cycle. Urban stations recorded maximum smog incidence as occurring at 11 AM and the secondary at 8 PM; on the other hand, smog situations are relatively infrequent at 1 AM and at 3 PM (Fig. 1).

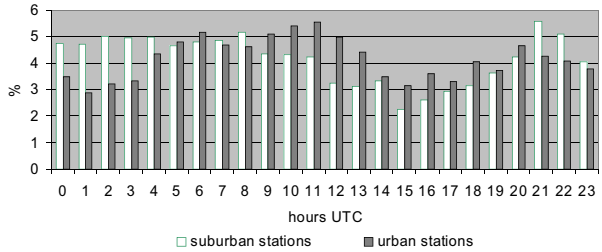

Figure 1. Average daily development of SO_2 smog in four areas in the Czech Republic.

SO_2 smog develops differently in suburban areas: the greatest concentration occurs at 9 PM, i.e. the time when – in case of a clear sky – temperature inversion and radiation fog have already formed. In such cases, air pollution is trapped in braking layers and, as a consequence, the number of smog episodes in suburban areas – where fog tends to remain overnight – only experiences a slight drop. However, it will grow again during the night and morning, especially due to more intense thermal inversion and fog. When radiation-connected phenomena fade away at around 8 AM, SO_2 again disperses and the smog episode count starts falling, eventually reaching a minimum at 3 PM. Smog situations in the urban environment do not last all night due to a different course of radiation process development; this is caused by a different type and structure of the active surface and fog incidence.

Smog incidence throughout the year also depends on meteorological conditions. SO_2 smog is typical of winter: while non-existent in the warm months (i.e. from May to August), it is more and more frequent in the autumn, reaching an apex in January and then again decreasing in frequency. Differences in smog situation incidence between urban and suburban locations are not as prominent. However, it should be noted that there are more suburban than urban smog situations in September and January and February; again, this is connected to higher fog occurrence. Urban smog episodes are prevalent in the remaining months.

The highest number of PM_{10} smog situations in the period 2004-2007 occurred in 2006. In most years, suburban smog situations were more frequent; however, only in 2004 urban smog episodes prevailed. The number of days with smog rose from 2004 to 2005 and declined from 2006 to 2007. It should be noted that the number of days with smog in urban and suburban areas has been levelling out in recent years. The greatest number of PM_{10} smog episodes – a total of 57 – has been registered in Bohumín.

In comparison with SO_2 smog situations, high-concentration PM_{10} smog episodes have shorter duration: they only last an average 6.8 hours. Differences in episode duration between the two locality types are relatively minor, smog episodes in urban areas last just under a half hour longer than they do in a suburban environment. The maximum duration of a smog episode as registered at individual stations varies from 4 hours, recorded at a suburban station in Ústí nad Labem – Kočkov, to 72 hours in urban station Karviná.

The average daily development of PM_{10} smog is linked to dust particle emission; PM_{10} smog development also takes place in a very different way to SO_2 smog development. Incidence is lowest at noon (Fig. 2) while the number of smog episodes grows during the afternoon and culminate in the evening hours.

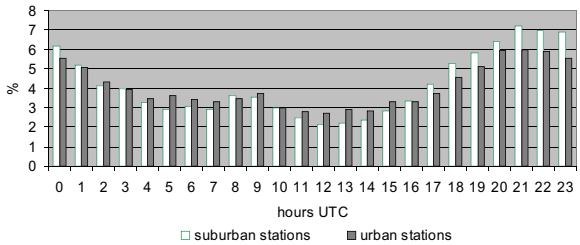

Figure 2. Average daily development of PM_{10} smog in four areas in the Czech Republic.

Differences between urban and suburban areas are quite distinct. While most urban situations occur during the daytime, suburban smog episodes are more common at night. One of the causes – as in the case of SO_2 smog – is pollution trapped in inversion layer, which are naturally more frequent in a suburban setting. Pollution sources also differ: heavy daytime traffic is generally concentrated in cities while individually heated suburban and country houses constitute a prime influence during the night time – and especially so in winter (city houses on the other hand generally have central heating).

A distinct yearly cycle culminating in January is as typical of PM_{10} smog as it is of SO_2 smog. However, unlike SO_2 smog, PM_{10} smog also tends to occur in warmer months, especially in urban areas. Once again, this difference is connected to the disparate origins of each pollutant: a larger number of relatively small pollution sources are to be found in suburban areas, hence the higher incidence of suburban smog situations in winter months. The above mentioned meteorological conditions also play a significant role, affecting the suspended particles in ways similar to the ways such conditions affect gases.

Conclusions

This paper indicates that in spite of a decrease in most emission pollutants during recent decades (especially in the 1990s), cities throughout the Czech Republic may still encounter hazards connected to smog of the winter type. Occurrences of smog caused by high SO_2 concentration are limited, but SO_2 smog may still form due to unfavourable meteorological conditions. Suspended particulate matter (PM_{10}) poses a far greater threat: it is the cause of smog situations on an average of 22 days per year. Potential conditions facilitating smog development depend on a given locality and especially on local climate.

Acknowledgements This study was supported by a grant from Academy of Sciences of the Czech Republic KJB307530701.

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The relationship between weather fronts and daily emergency room admissions in mountainous areas, on the example of the northern Tatra foothills.

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Abstract. This article concerns the influence of passages of atmospheric fronts upon the number of emergency room visits to Zakopane's County hospital during 2005-2008. Seasonal influences of different kinds of fronts and days without fronts upon circulatory, respiratory and nervous system diseases along with psychological disorders are presented.

Introduction

Regionally, one of the main outcomes of global climate changes is greater daily weather variation, something that is closely connected with a more dynamic course of specific meteorological elements that directly affect human health (IPCC, 2007). The significant influence of extreme climatic variables upon morbidity is widely reported in a number of studies. A large body of research exists which shows connections between extreme air temperature values and circulatory system diseases (e.g. Morabito et al., 2005; Inglis et al., 2008), respiratory system ailments (McGregor et al., 1999; Panagiotis and Matzarakis, 2006), nervous system and psychological disorders (Przybyła, 1992; Hessmann-Kosaris, 1998).

This paper aims to answer the question: how does the passage of fronts, bringing short-term weather variations, influence people's health in mountainous areas. Nevertheless, some previous research consistently shows increased morbidity during prolonged periods of extreme meteorological occurrences. On the example of the Polish Tatra foothills, an attempt is made to determine whether factors of weather variation or the duration of extreme events is more prevalent a cause of increased emergency room admissions.

Data and methods

Data sources. The research needed to answer the above question was conducted using two sets of data for the 2005-2008 period. The meteorological data used was taken from the Calendar of Synoptic Situations in the Upper Vistula River Basin as assembled by Professor T. Niedźwiedź (Niedźwiedź, 2006-2009) of Climatology at Jagiellonian University in Cracow.

The hospital data utilized was extracted from a running record of the Section of Patients Register, Medical Statistics and Clearing of the County Hospital in Zakopane.

Data organization. The following division of the days with fronts was used and organized as showed below:

Days with a warm front (fc), days with a cold front (fz), days with an occluded front (fo), days with a stationary front (fs) and days with various fronts (rf). Additionally, days between two fronts and days without the passage of a front were also selected for analysis.

All of the patients were divided into three groups: age, place of residence and type of reported disease as defined by the International Classification of Diseases (ICD-10).

Methods. The influence of weather upon public morbidity can be easily evaluated using the incident frequency (per day) index for a particular weather type. For this study, the index was modified by comparing the frequency of incidents during days with (or without) fronts to a theoretical "even distribution" for each season. The ideal situation would exist when, for example, 10% of the total people admitted to the hospital emergency room in a season were so during 10% of the days with a particular weather front. The following equation was applied to measure the skewness from the "ideal" distribution during different weather fronts:

$$F_{s,\mathrm{mod}} = \left(\frac{\%\,Pe_s}{\%\,d_s} \times 100\%\right) - 100\%$$

The $F_{s,mod}$ of 0% denotes that in the examined season, the share of patients Pe_s (in %) is equal to the share of days with a particular frontal weather type d_s (also in %).

Results and Discussion

A very important finding of the research carried out is the significant influence of passages of atmospheric fronts upon a rise in the number of patients admitted to the hospital emergency room in the area of the Tatra foothills. The majority of emergency room visits took place during days with fronts. Thomson (1979) reported a similar result, stating that human susceptibility to weather changes is considerably higher during the passages of fronts.

Though fronts do adversely affect human morbidity, the results of this study indicate that different kinds of fronts do not have an equal force in determining morbidity. This is also reported by other studies, e.g. Tromp (1964), who found that the passages of cold fronts have the greatest negative influence upon people's health.

Though there is a lack of scientific research exploring the meteotropic influence of stationary fronts upon public health, the results of this study indicate that this kind of front is connected with a sizeable increase in emergency room visits. This can be seen during all of the seasons of the investigated time period, but chiefly during the winter and spring. It is suggested that this effect is caused by a substantial variation of weather conditions and a relatively longer time of negative impacts of atmospheric factors over a particular area, the latter being triggered by the slow front movement.

In addition to the aforementioned results, this study provides confirmation of the influence of some types of fronts upon particular groups of diseases (Fig. 3.). Kveton (1991) and Kriszbacher et al. (2008) both suggest that there is an exacerbation of circulatory system diseases during the

passage of cold fronts. Generally, in the research area, this influence of cold fronts is observed in the winter, spring and summer seasons, whereas during the fall a large increase in the number of patients at the emergency room is noticeable in days with a warm front.

Foehn weather was found to have a similarly unfavorable affect upon nervous system diseases and psychological disorders in the Zakopane region during the fall and winter seasons. An analogous outcome is reported by Moos (1964), who points out an increase in pathologic nervous system reactions in the vicinity of the Alps during days with a foehn wind, leading to increased accidents and injuries during this time. Additionally, in the Tatra foothills, respiratory system diseases tend to multiply during passages of cold and stationary fronts.

Conclusions

This research draws attention to the influence of atmospheric front passages' upon public health in mountainous areas. Apart from atmospheric front impacts of many kinds upon morbidity, a prominent influence of weather variation on days both with fronts (increased weather variation) and without fronts (with more extreme weather elements variables) can be observed. Some of the issues presented in this study reveal a sizeable research field that should be intensively explored in the future.

The atmospheric situations favorable for biometeorological research include short-term weather variation and extreme meteorological variables, both of which should be considered while examining relationships between weather and health. Additionally, the duration of unfavorable weather situations should be taken into account, as this research shows the duration causes increased morbidity outcomes during the passage of stationary fronts.

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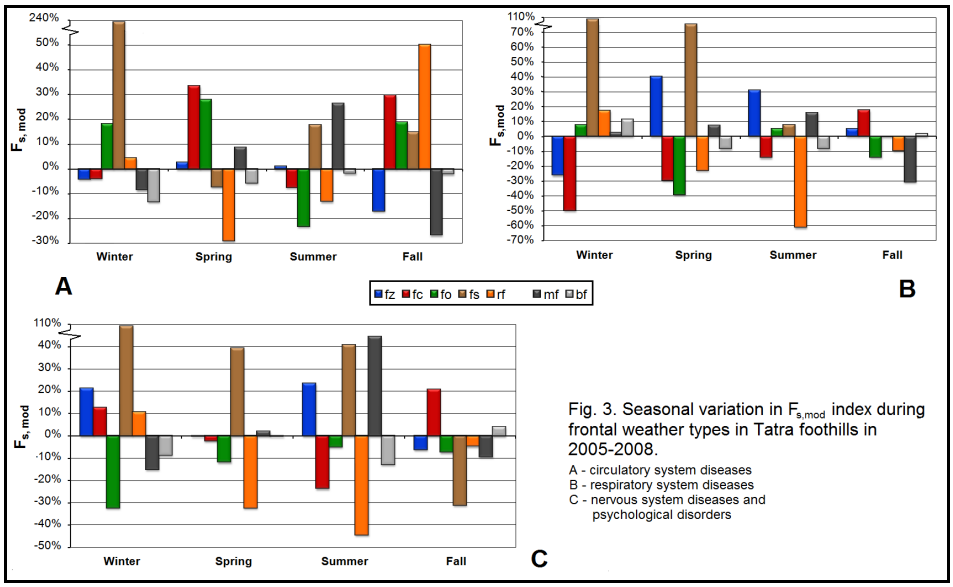

Fig. 3. Seasonal variation in $F_{s,mod}$ index during frontal weather types in Tatra foothills in 2005-2008.
A - circulatory system diseases
B - respiratory system diseases
C - nervous system diseases and psychological disorders

The incidence of heat index levels in urban areas of Brno

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Abstract. Urban climate is increasingly becoming the aim of study not only for climatologists. Building bigger cities changes radiation and energetic balance as well as values and trends of individual meteorological elements. The "urban heat island" becomes a familiar concept. The climate evaluation of Brno with the help of temperature indexes was done while using the database of meteorological elements in the years 2006 to 2008. The calculations of temperature-humidity index, temperature index and Humidex were performed. The achieved results indicate that the situation from the category "extreme caution" appear in Brno as opposed to Brno surroundings. Also a relatively high number of days with temperature discomfort appear here. Temperature load can cause degradation of organism with hazardous groups of inhabitants.

Introduction

The city climate problem and its influence on man becomes frequently a theme of scientific works. Also specialized conferences focused exclusively on this problem are held. A lot of issues are investigated, such as the definition of Urban Heat Island (UHI) in the individual parts of territory, measurement and modeling of microclimate in individual typical urban areas, bioclimatic studies about the influence on inhabitants, suggestions for the reduction of the negative climate effect on inhabitants. A series of indexes to characterize bioclimatology properties of urban atmosphere is used in the world. These indexes take into consideration various number of meteorological elements.

Čabajová (in: Kolektiv, 1979) used equivalent temperature to characterize differences between individual urban parts from the point of view of climatology.

Air temperature and humidity enters the calculation in the case of equivalent temperature. Similarly, a series of indexes is constructed while the most commonly used indexes are THI (Temperature Humidity Index), HI (Heat Index), HUMIDEX and others.

Temperature-Humidity Index THI

THI was used for the determination of temperature comfort in the works by Toya et al. (2007). Yilmaz et al. (2007) used THI for quantification of temperature comfort over various vegetation and artificial surfaces. The THI calculation as used by Unger (1999) follows:

$THI\ (^oC) = T-(0.55-0.0055RH)*(T-14.5)$

where T – air temperature (°C)

RH – relative air humidity (%)

Optimum temperature conditions for human organism are within the range of 15 to 20 °C.

Heat Index HI

HI index expresses felt temperature as combination of air temperature and humidity. HI index was defined by R.G. Steadman in 1979 and is used mostly in the U.S. It is also called Apparent Temperature (AT). The following equation is used for HI calculation:

$$HI(^oF) = -42.38 + 2.049*T + 10.143*rh - 0.2248*T*RH - .0068378*T^2 - .05482*RH^2 + .001229*T^2* RH + .0008529*T* RH^2 - .00000199*T^2* RH^2,$$

where T – air temperature (°F)

RH – relative air humidity (%)

The HI index is calculated only for temperatures above 20 °C (68 °F). The calculated value expresses the degree of health hazard for hazardous groups of inhabitants.

Humidex

The Humidex index was used for the first time in 1965 in Canada and has been used there till now. The following equation is used for Humidex calculation:

$$humidex = T + (0.5555)*(e - 10.0),$$

where T – air temperature (°C)

e – actual vapor pressure (kPa).

This equation is similar to that for calculation of equivalent temperature as used by Čabajová (in: Kolektiv, 1979):

$$T_e = T + 15e,$$

where T – air temperature (°C)

e – actual vapor pressure (kPa).

Material and methods

The data from four measurement places were processed in order to study time and space variability of bioclimatology indicators in Brno. These data comprise the summer season (April – September) in the years from 2006 to 2008. Two of the places, Tuřany and Žabovřesky, are part of station network of ČHMÚ. Another two places, namely Jundrov and Mendlovo Square are part of the network built for the purpose of climate study in Brno. All stations are automatic, with measurement period of 15 minutes. Two categories of Heat Index, "caution" and "extreme caution" were used.

Results and discussion

As expected, the frequency of high values of all indices is the highest at Mendlovo Square. The frequency of high values becomes lower in the direction towards the city boundaries and the lowest values were measured in the reference station in Tuřany. The values of indexes in the "caution" category are increased by 44 to 61% in Mendlovo Square in comparison with the values measured in Tuřany.

The differences in the frequency of high values in the category "extreme caution" are even bigger (Fig. 1). The value of index in this category was measured only once in Tuřany every year from 2006 and 2008 while values of 260 and 79 were measured in the city centre. The year of 2007 was the warmest year of the three measured years and a significant increase of values in this category was observed in the stations placed out of the city centre and in Tuřany. This fact suggests that small changes of the average

temperature can lead to a dramatic growth of days with a high temperature load on inhabitants, even in the places where the frequency of such values of indexes was negligible in the past.

The highest frequency of values in both categories during daytime was registered around 1 to 2 p.m. The highest frequency was measured again in Mendlovo Square while the values become lower in the order of mention in the stations in Žabovřesky, Jundrov, with the lowest frequency being measured in Tuřany.

Continuous periods are more important than absolute numbers of frequency of HI in the individual categories from the point of view of the temperature load on inhabitants. The organism has no chance to relax temporarily at lower temperatures. Thus, we have created the database of all continuous periods with the occurrence of "caution" or the higher index category, period length at least 2 hours and maximum gap of 30 minutes.

At first glance it can be seen that longer periods appear more frequently in the city center than in the city boundaries. These periods appear in less than 12% of all days in the summer season in Tuřany station. The trends of individual stations are close to each other if the period extends. The period length of individual stations is similar if the period occurrence is less probable. The longest period takes 14 hours, thus all periods are broken at least at night.

Further, it has been found that there is no proportion between the period length in the city and in Tuřany for periods with "caution" and a higher category. This relation cannot be expressed by any simple proportional coefficient as in principle there are three types of days with various relation between period lengths:

1. Period length in Tuřany is significantly shorter than the period length of a station in the city
2. Period length in Tuřany is similar to that of a station in the city
3. All other cases between the two above-mentioned situations

Conclusions

The present paper has shown a survey of indices most frequently used for the determination of human temperature comfort or discomfort in relation to the air temperature and humidity. HI index calculated from four measuring stations and quarter-hour samples in the years from 2006 to 2008 indicates that "caution" category appears more in the station placed in the city centre than in the station placed out of city build-up area. The difference is 44 to 61%.

Also the second index category "extreme caution" can be expected more frequently in the city than outside the city limits. However, the increasing temperature discomfort on inhabitants related to the increasing average air temperature can be found also outside of the city boundaries. This is valid especially for hazardous groups of inhabitants.

But, although the qualification scales of most indexes are focused on the quantification of the increased temperature load, it can be concluded that the danger of organism degradation due to temperature load appears more frequently in the city, but at the same time the "pleasant" period becomes longer, namely in spring and autumn months and in morning and afternoon hours in summer.

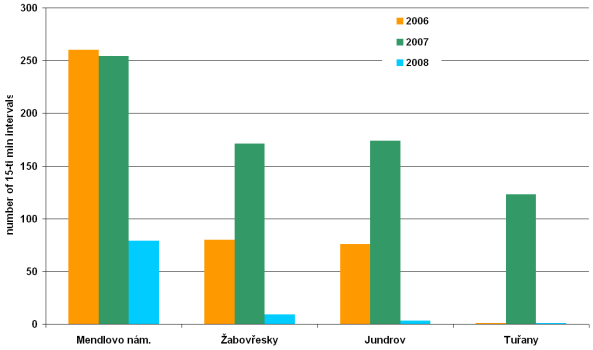

Figure 1. Frequency of category "extreme caution" of the Heat index in various years.

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Variability of diurnal amplitude of temperature in Cracow on the background of global warming effect

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Abstract. This paper analyses long term course of diurnal amplitude of temperature (DAT) in Cracow. Diurnal values of maximal and minimal temperature, diurnal cloud cover observations (%), cloud genera observations and values of relative sunshine duration covering years 1958 – 2007 were used to the analysis. Long term variability of DAT equalled 2ºC. The main factor of DAT variability is atmosphere circulation specified by cloud cover amount and cloud genera.

Introduction

The increase of air temperature in recent years is a fact. It is not easy, though, to indicate the reasons of the increase. Diurnal amplitude of temperature (DAT) is a synthetic index of atmospheric state. DAT is also an index of physical processes in the atmosphere (Kejna, 2005). Therefore, it is very important to recognize the reasons for DAT variability. Finding these reasons can help to explain the causes of global warming effect.

The main aim of this paper is to estimate the variability in diurnal amplitude of temperature DAT in Cracow and to specify the causes of the variability.

Data and methods

In this paper the original data from the Research Station of the Department of Climatology, Institute of Geography and Spatial Management in Jagiellonian University in Cracow (1958 – 2007) were used. These were diurnal values of maximal air temperature and minimal air temperature. Diurnal amplitude of temperature was calculated as the difference between extreme temperatures. In the analysis the data of cloud cover observations (%), cloud genera observations and values of relative sunshine duration were used. Basic statistical methods to research of DAT variability were used.

The Research Station of the Department of Climatology, Institute of Geography and Spatial Management in Jagiellonian University is situated about 2 km from Cracow Centre, in the Botanical Garden.

Results and discussion

Analysis of DAT variability in Cracow (1958 – 2007) showed relatively little variability (Fig. 1). The variability equals about 2ºC (7.9 -9.8ºC). The main cause of such course in DAT was a parallel increase of maximal and minimal air temperature (Fig. 2). Global warming effect connected with the increase in course of extreme temperatures was not a cause of decrease in the course of DAT. The faster tendency of increase in course of maximal air temperature (Tmax) than minimal one (Tmin) caused the increase of the course in DAT. The variability of extreme DAT values amounts to over 24ºC. On the background of statistically little variability of annual mean DAT, some days occurred with DAT equalling even 25ºC and days with DAT below 1ºC. Therefore, the fact of occurrence of such high and such low DAT values is a sign of transitional climate. The increasing trend in the annual range of DAT and variability during a year (Fig. 3) points to the impact of global warming effect.

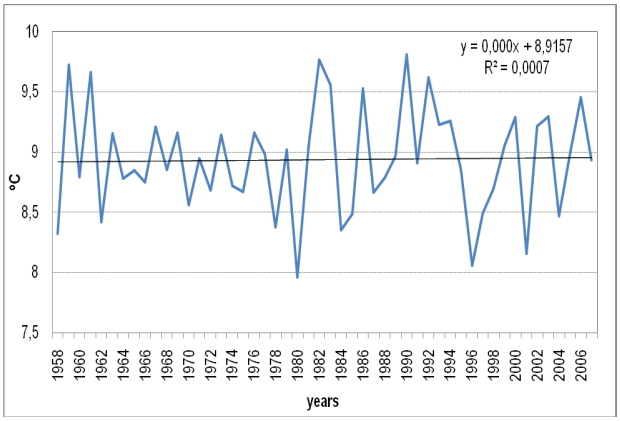

Figure 1. Mean annual diurnal amplitude of temperature DAT in Cracow (1958 – 2007).

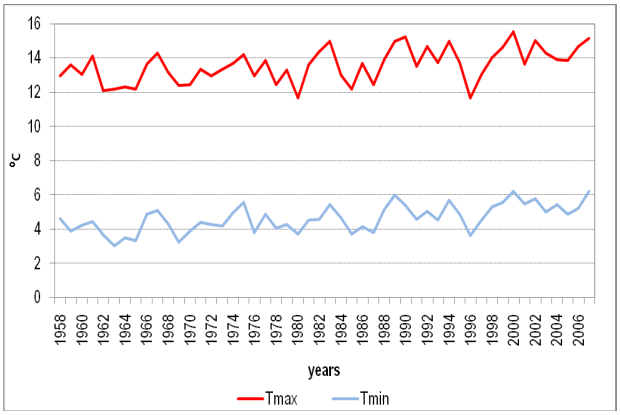

Figure 2. Mean annual maximal temperature Tmax and minimal temperature Tmin in Cracow (1958 – 2007).

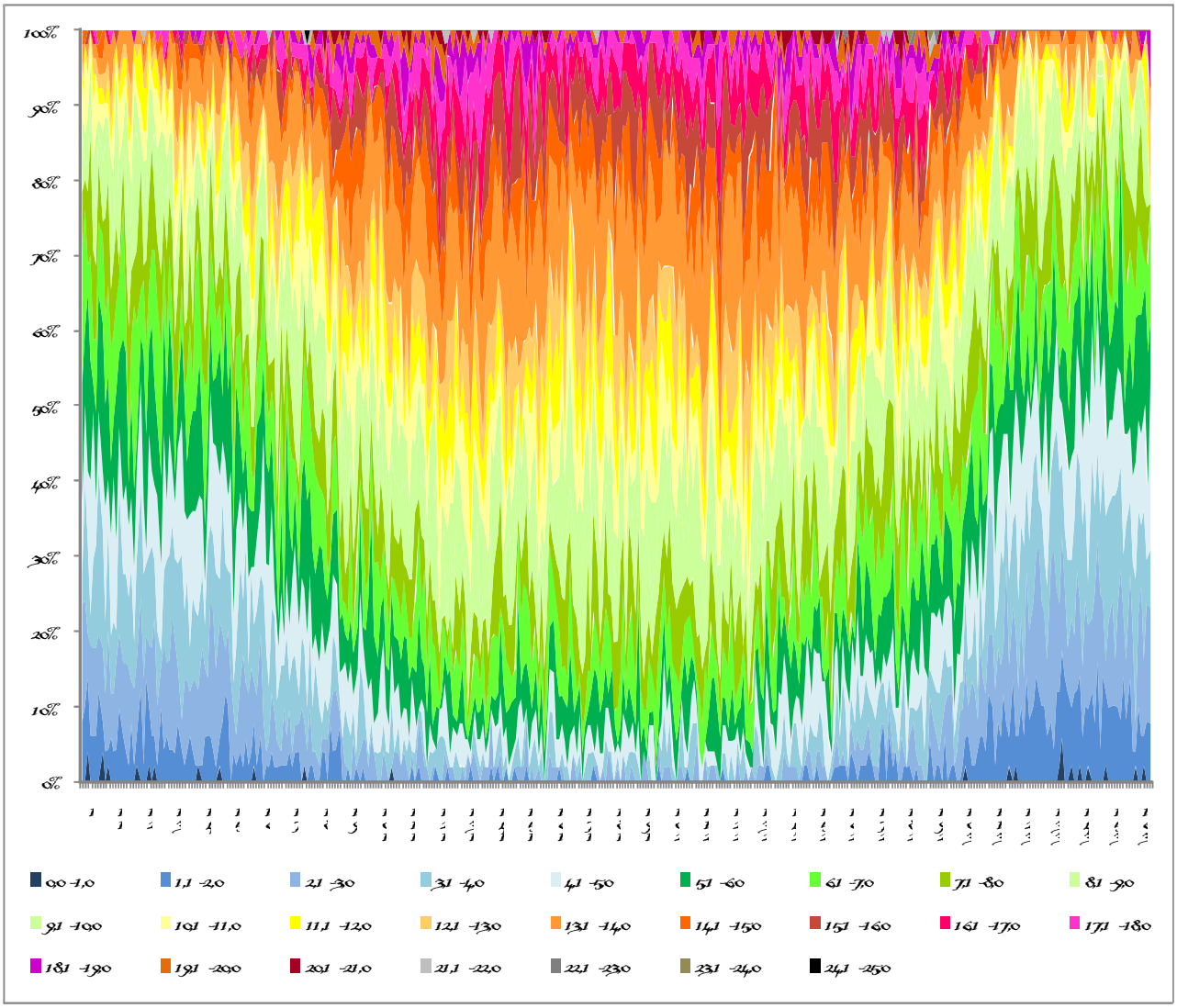

Figure.3. Diurnal amplitude of temperature during a year in Cracow (1958 – 2007).

The long term variability of DAT showed its decrease in values during climatic autumn and winter and the increase of DAT values during spring and summer. Occurrence of maximal annual DAT changed a date of appearance from 19th June for 6th June and from middle September to middle August in a long term course. Minimal annual DAT changed the date of occurrence from 11th December for 28th November (Skublicka, 2006). The changes in the dates of occurrence of extreme DAT are a sign of transformation of thermal conditions in Cracow (1958 – 2007).

Conclusions

The research of the causes in DAT variability in urban climate conditions allowed to establish that the main factor of DAT variability is atmosphere circulation. Synoptic situation decided of cloudiness (Matuszko, 2000). Cloudiness determinates solar radiation coming to the surface and nocturnal radiation. Cloud cover is not a sufficient information to determine an impact of cloudiness on DAT. There are events when the sky is completely covered by high clouds and the impact of solar radiation during such days is higher than on days with partial cloudiness of low layer clouds. The difference in diurnal range of cloud genera explains the difference of DAT values during cold and warm season and also in a long term course.

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Relationships between subjective sensations of patients with selected psychiatric diagnosis and weather

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Abstract. In cooperation between the Regional branch of the Czech Hydrometeorological Institute in Ústí nad Labem and Well-being Centre Blue Lagoon was proceeded a pilot project (Novák et al., 2008). Some relations between subjective sensations of selected patients from Blue Lagoon Well-being Centre and actual weather and its progress were searched. These relations were observed during two cold seasons – 2007/2008 and 2008/2009.

Introduction

Psychiatry observes various physical effects influence on an organism for a longer period. Influence of light quantum on depression and fatigue development is entirely unquestioned, some circulation patterns generate anxiety, excitation and/or aggressiveness. Because of significant growth of meteorosensitivity in recent years, we decided to observe this effects by the help of volunteers. They heal for disorders caused by supraliminal load and stress (sleep disorders, headaches, fatigue, apathy, concentration disorders and so on).

Data and methods

Depressions diagnosis and whole sphere of neurosis were selected from all patients of Well-being Centre Blue Lagoon (diagnosis F40 – F48 and F22 groups from International Statistical Classification of Diseases and Related Health Problems, Tenth Revision).

Table 1. Table of patients' basic data.

Age	*Sex*	*DG*	*DG description*
	Season		
57	M	F45.3	Somatoform autonomic dysfunction
	07/08		
41	F	F40.0	Agoraphobia
	07/08-08/09		
51	F	F22.0	Delusional disorder
	07/08-08/09		
69	F	F45.4	Persistent somatoform pain disorder
	07/08-08/09		
62	F	F41.2	Mixed anxiety and depressive disorder
	07/08		

A medical data gathering was carried out by long-term voluntary questionnaire action. Personal data of patients was used by their attending physician, the basic data only was utilized for research (Tab. 1). The filling of forms was fully voluntary. The questionnaire was targeted on large spectra of subjective weighted dispositions (in a scale „--“ = very bad, „-“ = bad, „0“ = neutral, „+“ = good, and „++“ = very good, for nausea only „yes“ or „no“). Following categories were incorporated to research: headache, pains of spine and joints, fitness, mental condition, predominant state of mind, sleep quality, capacity of concentration, cardiac function, respiration and nausea (rows in Fig. 1, columns are days of week). The second page of the form was marked off for patients' notes to each day in the week.



Figure 1. First page of the questionnaire for patients.

There were more than 20 patients in the research beginning. But only data from 5 patients had sufficient quality after first winter season (2007/08) of this research, and from 3 patients only for both seasons (2007/08 and 2008/09).

Gained medical data had to be standardized before statistical comparison. Subjective data character restricts its direct utilization only for single relationships searching. It is necessary to determinate „normal value“ of patient's sensations for every patient separately and to evaluate daily deviations from this individual „normal value“ for associated elaboration.

The data from meteorological station Praha – Ruzyně (364 m a.s.l.) was assigned to files with patients‘ subjective sensations and selected diagnosis. The meteorological database is consisted of temperature indicators (maximum and minimum air temperature values, daily air temperature amplitude, average daily air temperature), air pressure values (sum of positive and negative 3-hours pressure trends and daily air pressure amplitude). Sunshine was described by two characteristics – daily sunshine duration and the ratio of measured sunshine duration to maximal sunshine duration in a particular day. In addition, these data were completed by notes on the selected atmospheric phenomena

occurrence – thunderstorms, precipitation and wind gusts above 15 m/s.

Results and discussion

It is necessary to realize, before itself interpretation of gained statistical characteristic, that the main aim of this case-study is to get preliminary imagination about planned future project with similar target but with wider range. Current statistical file is too small, as well as the length of monitored period, and it does not allow to evaluate all possible large-scale weather situations.

It wasn't possible to use a robust statistical method, because a range our medical data file is very small, it is not sufficient for statistical computing. After first winter season, the research was concerned upon reactions of respondents on the strong extra-tropical storm on Saturday 1st March 2008 (known as „Emma“ in the Europe). Synchronous reaction of all 5 patients was reported for headaches only, but this reaction is very strong (Fig. 2).

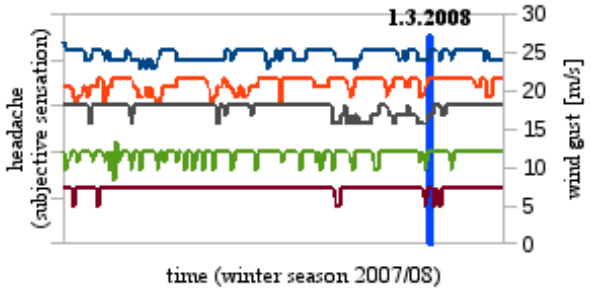

Figure 2. Subjective sense of headache in 2007/08 winter season. The wind gust accompanying the extra-tropical storm “Emma” (March 1, 2008) is marked by the blue column; patients’ subjective sensations of the headache are marked by coloured lines.

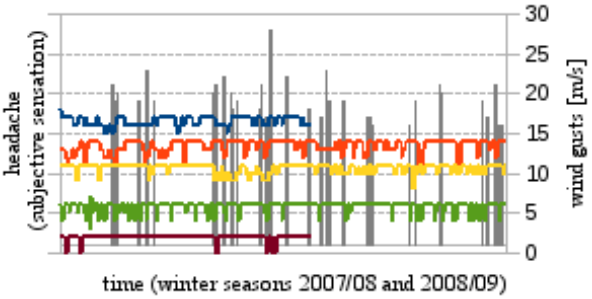

Figure 3. Relations between headache and wind gusts (>15 ms^{-1}) .for winter seasons 2007/08 and 2008/09. Wind gusts are marked by grey columns, patients’ subjective sensations of the headache are marked by coloured lines.

Long-term perspective (whole winter season 2007/08) is plotted in the Fig. 2. A divergent progression of headaches of all patients is evident in this period, but their reaction is the same in the time shortly before Emma. Therefore, a patients headache sensations were compared during episodes with wind gusts over 15 ms^{-1}. Result of this comparison is in Fig. 3.

The reactions of patients on wind gusts were not as strong as during the Emma cyclonic system case, but they were more pronounced than in days without significant wind gusts evidently. It is a pity that the medical file is very small. A regular statistical verification of this phenomena could not be realized. However, these results of our yearlong work are an inspiration for next researches.

Conclusions

Unfortunately, the results of our research are not satisfactory. Relevant statistical characteristics could not be computed, because medical file is very small. The restricted range of this file (five, respective three patients only) is caused by following factors. The first one is a selection of a method. To fill the questionnaire is very difficult task, it is not suitable for long-term action. The respondents take no patience for regular fillings of the form. It would be better to simplify the categories in the questionnaire. The second one is a deficiency of motivation. The usage of the full voluntariness for a long-term work was not good approach; the respondents need some reward for the cooperation. It is necessary to include the questionnaire in the therapy procedures.

Presented research brings an inspiration for next scientific work. Similar relations should be investigated in cooperation with larger medical communities with higher number of patients.

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Differences in the spreading of pollution in urban and non urban environment

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Abstract Despite reduction in emissions continues, many cities and surrounding areas struggles with high concentration of harmful air pollution, which is currently still very actual and persistent problem. Calculation of immission pollution from various sources through the models is an important tool for assessing the state of air pollution in the urban and non- urban environment. The material conditions of work are models designed for the pollution source located in urban area environment, and the same pollution source located in the non- urban area. In the harsh urban area environment, turbulences are created, which contributes to the intensive mixture of polluted air and therefore a lower concentration are achieved but the impact of the source of pollution is greater. In the non-urban conditions is the surface smooth and „laminar flow" is achieving (particularly characteristic for coastal areas) which has higher concentration and the impact is decreasing, except the direction of prevailing winds.

Introduction

Despite reductions in emissions continues, many cities and surrounding areas are struggling with high concentrations of harmful air pollution, which is currently still very actual and persistent problem. With increasing frequency of traffic and large industrial companies concentrated in urban areas is also increasing local and regional impact on air pollution. As the most air pollution impacts is considered the impact on human health and environmental impact. In terms of impact on human health are now considered two most important substances: fine particles and ground-level ozone. Long-term exposure to these substances, as well as exposure during peak hours can lead to various health complications in range from minor problems with the respiratory tract to premature death. Air pollution is also responsible for damage to the environment because it causes such as: acidification - from the 90`s and more from 80`s significantly reduces the amount of sensitive ecosystem areas exposed to excessive deposition of acidity and until 2010 this surface will be exposed above the critical acidification limit still exceeds 10% of the natural ecosystems of countries, eutrophication - the reduction of eutrophication has been made with lesser progress, more than 40% sensitive ecosystem areas are exposed to nitrogen deposition over the critical threshold, damage to crops - the most of agricultural crops are exposed to increased ozone concentrations that exceed the long-term policy objectives to protect vegetation from ozone damage.

Data and methods

The material conditions of work are models designed for the pollution source located in urban environment, and the same source located in the non-urban area. Methodological part consists of evaluating the impact of air pollution by using a model calculation in urban and non- urban area for the source of pollution.

Characteristics of a mathematical model for calculating the concentrations of *NOx* and SO_2

Choice of suitable model substantially affects the type and size of the pollution source, character of the terrain model, the requirements of the input meteorological data and the accuracy of output data from the used model. There is also an inconsiderable factor of the price of the program itself, which processes the calculation.

In accordance to the mentioned factors was chosen the model MODIM (modeling of air pollution) - CPI (Szabo et al., 2002).

MODIM - calculates with the forecast for the distance from local to close regional distances to 30 km. Over a distance of 30 km, we have introduced sector calculation. Calculations of concentrations of pollutants on complex terrain are carried out in accordance with the methodology of ISC. The methodology includes the correction factor for the decrease in concentration with altitude based on measured values from background stations. The model was modified for the calculation of air pollution from linear sources in accordance with the methodology recommended by the U.S. EPA - CALINE. Model calculations of the linear sources includes algorithms, which takes into account the effects of density and structure of build-up area (surface roughness) on the dispersion of pollutants in urban agglomerations. The model does not contain a module to calculate the concentrations of chemically reactive substances. In the presence we are considering only the calculation of nitrogen oxides (NOx), nitrogen dioxide (NO2), carbon monoxide (CO) and sulfur dioxide (SO2).

Input data for calculating the concentrations of NOx and SO2 in the atmosphere can be found in Tab. 1.

Table 1. Input data for calculating the concentrations of SO_2 in the air.

emissions	SO_2
Stack height (m)	150
average (m)	5.87
Average emissions ($g.s^{-1}$)	15.8
temperature combustion gas discharged (°C)	140
speed ($m.s^{-1}$)	8
atmospheric stability class	C, D, E[1]
wind speed (according to the degree of stability atmosphere) ($m.s^{-1}$)	2-4, 4-6, 6-8, 8-10, nad 10

[1]- C slightly vulnerable, D neutral, E slightly stable

The modeling was created network of points in two dimensions with coordinate system x, y (each point, which has recorded concentration, is defined by two coordinates x, y) which includes:

- 21 points (receptors) in the distance from 0 m to 10,000 m, distance between the points is 500 m
- 8 points in the distance from 0 m to 3500 m from the source in the direction of axis x and 13 points in the

distance from 4,000 m to 10,000 m from the source in the same direction
- 10 points in the a distance from 0 m to 4,500 m from the source in the axis of y and 11 points in the distance from 5,000 m to 10,000 m from the source in the same direction.

Results and disscussion

Output from the model is in graphic and text form. In the modeling of air pollution concentrations were calculated SO_2 in the urban and non-urban environment, in Tables 2 and 3 are shown the maximum concentrations in the designated distance from the source. Tables contain specific classes of atmospheric stability in the wind speed.

Table 2. Currently, the data calculating the maximum concentrations of SO_2 in the extra-urban environment of atmospheric stability classes

atmospheric stability class	maximum concentration SO_2 ($\mu g.m^{-3}$)						
	the distance from the source of pollution (m)						
	500	1000	1500	2500	3000	4000	5000
C2*	0.0	0.3	0.9	2.4	3.0	3.4	3.2
C3	0.0	0.2	1.0	3.2	3.7	3.6	2.8
C4	0.0	0.5	1.8	3.8	3.9	3.5	2.5
C5	0.0	0.7	2.3	3.8	3.7	3.0	2.4
C6	0.1	1.1	2.1	3.5	3.6	2.9	2.1
D2	0.0	0.0	0.0	0.1	0.1	0.2	0.4
D3	0.0	0.0	0.1	0.3	0.4	0.6	0.8
D4	0.0	0.0	0.1	0.3	0.5	0.8	1.2
D5	0.0	0.1	0.3	0.7	0.9	1.3	1.4
D6	0.0	0.1	0.2	0.6	0.9	1.2	1.3
E2	0.0	0.0	0.0	0.0	0.1	0.1	0.2
E3	0.0	0.0	0.0	0.1	0.1	0.1	0.2
E4	0.0	0.0	0.0	0.0	0.1	0.1	0.2
E5	0.0	0.0	0.0	0.1	0.1	0.1	0.2
E6	0.0	0.0	0.0	0.0	0.1	0.1	0.2

* 2 - wind speed 2-4 ($m.s^{-1}$), 3- wind speed 4-6 ($m.s^{-1}$), 4 - wind speed 6-8 ($m.s^{-1}$), 5 - wind speed 8-10 ($m.s^{-1}$), 6 - wind speed over 10 ($m.s^{-1}$)

Table 2 depicts the output of a mathematical model MODIM, where are the maximum concentrations in the distance from the source. For each class of atmospheric stability and wind speed was confirmed that the non-urban area are higher concentrations of pollution, depending on the distance from the source.
Table 3 confirms the that if the environment is harsher then the concentration of more pollution from sources of pollution are higher, except atmospheric stability class E - slightly stable, when the concentration of pollution began to increase gradually and then decreased from 5,000 m from the source of pollution, as in other cases it was much earlier.

Table 3. Currently, the data calculating the maximum concentrations of SO_2 in the urban environment by atmospheric stability classes

atmospheric stability class	maximum concentration SO_2 ($\mu g.m^{-3}$) urbar in the environment						
	the distance from the source of pollution (m)						
	500	1000	1500	2500	3000	4000	5000
C2*	2.3	6.8	6.0	3.6	2.5	2.0	1.4
C3	5.1	6.5	4.6	2.4	1.8	1.2	0.5
C4	5.9	5.5	3.6	1.8	1.1	0.7	0.3
C5	4.8	5.9	4.6	2.0	1.4	0.8	0.2
C6	4.6	5.4	3.7	1.5	0.8	0.5	0.2
D2	0.2	3.7	5.6	5.3	4.8	3.7	1.9
D3	1.1	5.4	5.8	4.2	3.0	2.3	1.2
D4	2.0	5.6	5.1	3.3	2.3	1.7	0.9
D5	4.3	5.1	4.2	2.7	1.8	1.4	0.7
D6	4.1	4.4	3.5	2.1	1.4	1.0	0.5
E2	0.1	0.4	1.2	2.5	3.4	3.8	3.2
E3	0.1	0.5	1.2	2.2	2.7	2.9	2.5
E4	0.2	0.6	1.1	1.9	2.2	2.3	2.0
E5	0.2	0.5	1.0	1.7	1.9	1.9	1.7
E6	0.1	0.5	0.9	1.4	1.6	1.5	1.3

* 2 - wind speed 2-4 ($m.s^{-1}$), 3- wind speed 4-6 ($m.s^{-1}$), 4 - wind speed 6-8 ($m.s^{-1}$), 5 - wind speed 8-10 ($m.s^{-1}$), 6 - wind speed over 10 ($m.s^{-1}$)

Conclusions

In the harsh urban environment occurs turbulences, which contributes to the more intense mixing of air with pollutants and therefore lower concentrations but greater impact of action of the source of pollution is achieved. In non-urban conditions is the smooth surface and "Laminar flow" (particularly characteristic of coastal areas) is presented, when the concentrations are higher and the impact is decreasing, except the direction of prevailing winds.
Immission and emmision calculation of pollution from various sources through the models is an important tool for assessing the state of air pollution in urban and non-urban environment. These models take particular significance in that cases, where direct measurements of air pollution cannot be done, or where is a new source of pollution.

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Comparison of the impacts of temperature extremes on mortality in Prague and other regions of the Czech Republic

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Abstract. The study examines and compares association between positive and negative temperature anomalies (hot and cold spells) and mortality in the population of Prague and the whole Czech Republic. We focus on differences in mortality impacts in individual seasons, several groups of population (younger/older, men/women), and in mortality due to cardiovascular diseases and other causes of deaths. The main differences in the mortality response in Prague and in the other regions of the Czech Republic are that the population of Prague is more vulnerable to high temperatures in summer, whereas it is less impacted by low temperatures in winter.

Introduction

Extreme temperature events influence human society in many ways, including impacts on morbidity and mortality. While the effects of hot summer periods are relatively direct in mid-latitudinal regions (the heat-related mortality; Gosling et al., 2009), much less is known and little consensus has been achieved about possible consequences of both positive and negative temperature extremes in the other parts of year. Relatively little is known also about differences in the magnitude of the mortality response in provincial regions and in cities, where the impacts may be exacerbated by air pollution effects and/or heat island.

This study examines links between hot and cold temperature anomalies and daily mortality due to cardiovascular diseases and other causes of deaths in the population of the Czech Republic and separately in the city of Prague. The impacts are studied in individual seasons (DJF, MAM, JJA, SON) over the period 1992-2004.

Data and methods

Daily data on mortality due to cardiovascular diseases (CVD) and other causes of deaths (TOT-CVD) in the Czech Republic (population of about 10 million) and in Prague (about 1.2 million) were obtained from the Institute of Health Information and Statistics. The relative deviations of mortality were calculated as ratios of the excess mortality to the expected number of deaths, expressed in percent above/below the baseline (which takes into account effects of long-term changes in mortality and the annual cycle; Kyselý and Kříž, 2008). Excess mortality was calculated separately for the CVD mortality (which represents about 54% of all deaths), TOT-CVD, and all-cause mortality for persons younger than 70 years (70- yrs) and persons aged 70 years and more (70+ yrs), respectively. Periods when mortality is affected by influenza and acute respiratory infection outbreaks (Kynčl et al., 2005) have been excluded from the datasets before the analysis (all these periods occurred between December and March).

Meteorological data were provided by the Czech Hydrometeorological Institute. Mean series for the Czech Republic was calculated from data at 46 stations covering the area; in the analysis for Prague, data from the Prague-Ruzyně station were examined. Hot/cold days were defined in terms of anomalies of average daily temperature from the mean annual cycle above/below the 95%/5% quantile of their empirical distribution in a given part of year. Three groups of selected events were defined: hot (cold) spells of at least 2 successive days of extreme temperature anomaly (d2+); isolated 1-day extremes (d1); and all spells and singular days together (d1+).

Relative deviations of mortality for days D-3 (3 days before the beginning of a temperature extreme) up to D+16 (16 days after) were averaged over the selected events. Statistical significance of this mean relative deviation was represented by comparison with the 2.5%, 5%, 95% and 97.5% quantiles (plotted in Figures) of a distribution calculated using the Monte Carlo method: the same numbers of 20-day sequences (D-3 to D+16) as the counts of the selected events (given in Figures) was 10 000-times randomly drawn from the data over 1992-2004 in a given season.

Results

The largest effects of either hot or cold spells are observed for hot spells in JJA, with a 17% increase in mortality for the 1-day (3-day) lag for 70+ yrs (CVD) in the population of the Czech Republic; upper row in Figure 1. The mean relative deviation of mortality is significantly positive on 4 successive days (D+1 to D+4). The effect is greater for women than men (cf. Kyselý and Kříž, 2008), which is related to the demographic and social structure of European populations, with larger percentage of women in the older age groups and among those living alone. A decrease of mortality due to harvesting effect (Gosling et al., 2009) occurs on days following a temperature drop, particularly for mortality due to CVD and in age group 70+ yrs.

In Prague (lower row in Fig. 1), the effect of hot days is more pronounced with different attributes: (i) it starts sooner: mortality is significantly enhanced already on day D+0, and (ii) it is larger: deviations reach up to 25%. There is remarkable difference in the age group 70- yrs in Prague: in contrast to mortality in this age group for the whole country and also to the age group 70+ yrs in Prague, the excess mortality reaches its maximum (21%) already on day D+0. In the city, it could be more difficult for persons working outdoors (in the age group 70- yrs) to refresh during hot days. (This increase on day D+0 is noticeable for both d2+ and d1+.)

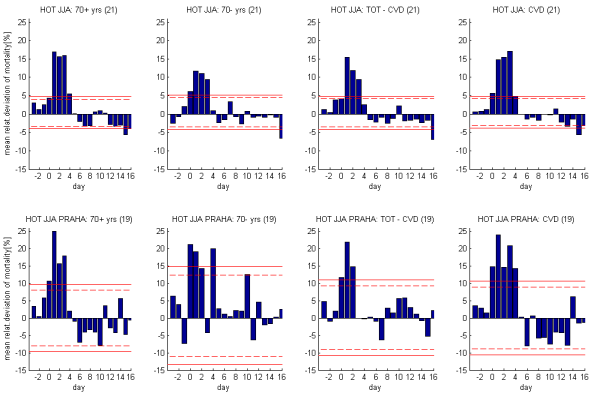

Figure 1. Association between mortality and hot spells (d2+) in JJA; upper row for the Czech Republic, lower row for Prague; the dashed line represents the 5% (95%) quantile and the solid line the 2.5% (97.5%) quantile of deviations, estimated by means of the Monte Carlo method.

Much smaller but still significant increases in mortality are associated with hot spells in MAM and SON. The effects are generally less (or not at all) pronounced in Prague when compared to the country as a whole, except for the age group 70- yrs in SON, in which case the mortality is significantly increased on day D+0 in Prague (the pattern is similar as in JJA).

No effect on mortality was detected during hot spells in DJF neither in the country nor in Prague; mortality during these periods is generally reduced.

Cold spells are associated with excess mortality in the population of the Czech Republic in DJF (Fig. 2, upper row) and to lesser extent in SON and MAM. Most of the excess deaths are due to CVD. The lag with the largest impacts in DJF is longer in the older age group (around 11 days) than younger population (4 days), which may point to different prevailing physiological effects (cf. Kyselý et al., 2009); the same pattern of longer lags in the elderly is preserved in SON and MAM, too.

A strong difference between the response to cold temperature in winter in the country as a whole and in Prague is shown in Fig. 2. Probably because of a different life-style (lower necessity to spend time in the open air) and socio-economic background (such as better developed public transportation) in the city, urban population is less affected by extremely low temperatures.

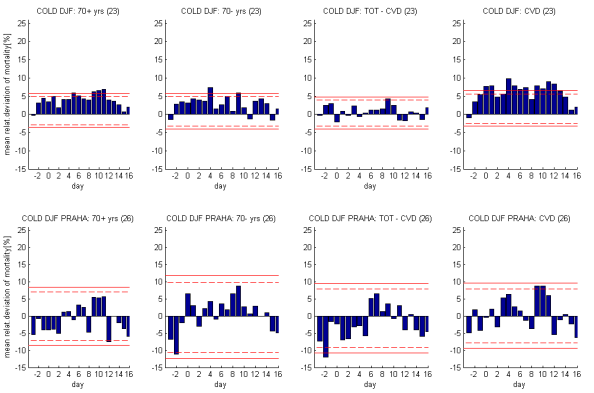

Figure 2. Same as in Figure 2 but for cold spells (d1+) in DJF.

Largest mortality deficits occur during and after cold spells in JJA. In the population of the whole area they are much more pronounced in the older than younger age groups, whereas in the population of Prague, the lowest relative deviation of mortality is for the age group 70- yrs.

Conclusions

Temperature extremes are associated with typical variations in daily mortality in the examined population of the Czech Republic that depend on season, and mean excess/deficit mortality is significant on many days around the spells. Significant increases in mortality were found during and after hot spells in summer and spring, and after cold spells in winter. In Prague, the effects of temperature anomalies on mortality are less pronounced in transition seasons when compared to the country as a whole. However, the population of Prague is more vulnerable to hot spells in summer whereas it is less affected by extremely low temperatures in winter; the cause of the latter is probably a different life-style and socio-economic background in large cities.

The vulnerability to extreme temperatures is usually larger for the older age group (70+ yrs). The more pronounced deviations of mortality in this population group relate to smaller ability of thermoregulation, large prevalence of chronic diseases, and reduced adaptability to oppressive weather in general, which is in agreement with results of other studies investigating mortality due to heat stress (e.g. Huynen et al., 2001) and cold stress (Ballester et al., 1997).

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The role of the climate in complex treatment of respiratory disease

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Abstract. The climatotherapy associated with favourable environmental conditions is important factor of improvement of human health. In this paper, results from selected studies carried out at the Srobar´s institute for tuberculosis and respiratory dieseases (SITRS) Dolný Smokovec in the High Tatras are presented. SITRS is specialised health care institution providing complete hospital and private outpatients medical and preventive care for children of 0 - 18 years of age. Cooperation with Pediatric clinic St Andrea hospital of Universita La sapienza in Roma performed in 2002 showed interesting results. It was found–out that children suffered respiratory allergy and asthma had lower level of values of MEF25 (middle forced respiratory flow on the level of 25% of peak respiratory flow) at the first day of hospitalization in opposite to the values after one-week treatment. On the other hand, the level of eNO concentration (expired nitrogen monoxide) was significantly lower after one-week treatment. For children without chronic allergy and asthma, values of MEF 25 and eNO were unchanged.

Introduction

The role of climatic and environmental conditions in the treatment of different diseases is known more than 8000 years. Document "Air, waters and places" written by Hippocrates is considered as the first scientific document about bioclimatology. Latter Celsius and mainly Galenos had used spa Castellamare under the Vezuv for the tuberculosis (tb) treatment. Another famous physician Avicena recommended his patients suffered tb to the Kreta forests. Ever green coniferous forest considered as appropriate medicine for tb treatment. Evaluation of bioclimatic conditions has been continued during 17th century due to development of new devices for measurement of meteorological parameters. The meteorological laboratory prepared by Domo in 1905 can be regarded as the first step to helio and climatotherapy development. The climatotherapy in Slovakia had been advanced during the first decades of 20th century due to endavour physicians as Stibor, Matoušek, Barcal, Hensel, Kolesár and others.

Climatotherapy

Laznička (2004) defined climatotherapy as tool for improving of the human health using good environmental conditions. Ponikowska (2004) declared air temperature, wind velocity, air humidity and solar radiation (effect on synthesis of vitamin D in human body) as main meteorological factors of climatotherapy.

Climatotherapy is considered as a part of complex therapy of the respiratory disorders in many European countries including Slovakia. Despite of this, there is not enough experiences and scientific information about the influence of environmental and climatic conditions on the human health.

Effect of climate on human health

Brimkulov (1991) presented results of treatment of 132 patient group in North Thien Shane at the altitude of 3200m a.s.l. He showed very good results associated with the steroidogenesis and the pulmonary surfactant production. Schuh (1993) declared that successful climathoterapy is based on the several weeks therapy stay in appropriate environmental conditions. Engst and Vock (2000) confirmed positive effect of forest climate (at altitude above 1560 m a.s.l.) comparable with see areas on the treatment of the allergic dermatoses, psoriasis, T-bb lymphomas and bronchial asthma. McVernon et al. (2004) investigated influence of the climate on the H.influenze type B during repeated respiratory disorders. They postulated that longer surviving in cold indoor conditions during autumn and winter seasons is cause of repeated infections. Marco de et al. (2002) observed influence of NO_2 pollutant from the roads and traffic on the prevalence of the bronchial asthma and allergic rhinitis in Italia. Obtained results confirmed that prevalence of bronchial asthma is arising during increasing NO_2 concentration. NO_2 is transformed into O_3 pollution in atmospheric boundary layer. Emissions from road transport and industry can be effective throuht secondary air pollution (O_3) not only in urban areas but also in rural and mountain environment (Fleischer et al., 2009).

Climate treatment in the High Tatras

The respected physician Dr. Szontag is considered as a establisher of climatotherapy in High Tatras. After his arrival from the Switzerland at the end of the 19th century he began to offer climatic and therapeutic procedures for the hotel guests in the High Tatras. Hotels had been transformed to the sanatories continuously. Sanatories used moderate High Tatras climate characterized by cold and dry air as well as intensive solar radiation as a treayment. Selected climate characteristics for different sites of High Tatras are declared in Tab. 1.

Table 1. Selected climate characteristics for different altitude sites in the High Tatras.

Sites	Rglob W m^{-2}	Wind >10m s^{-1} a	Wind >10m s^{-1} b	Foggy days
Poprad, 672 m a.s.l.	877	1.1	109	33
SkalnatéPleso,1778m a.s.l.	1013	1.3	189	203
Lomnický štít 2634 m a.s.l.	1058	2.1	203	269
Rglob/Solar radiation – mean noon values of global radiation (Smolen and Ostrožlík in Vološčuk et al., 1994)				
Wind speed a/Relative frequency of days (%) with mean daily wind speed above 10m.s^{-1} (Konček and Orlicz in Konček et al., 1977)				

Wind speed b/Mean number of days with strong blast of wind above 10m.s^{-1} (Konček and Orlicz in Konček et al., 1977)
Foggy day/Mean annual number of foggy days during period 1941-1960 (Orliczowa and Peterka in Konček et al., 1974)

Medical research of respiratory diseases in the High Tatras

SITRS is sanatorium with long time tradition in the treatment of chidren respiratory disorders and in research of these diseases. Sanatorium is situated on altitute of 860 - 1010 meters a.s.l. on the southeast down hills of the High Tatras. Research focused on observation of complex treatment (pharmacotherapy, respiratory physiotherapy, excercisse activity, dietotherapy, elimination from the home environment) influence on the clinical situation of the children patients was carried out during years 1986-1988. The results of study confirmed that nearly 2 months complex therapy supported by appropriate climatic conditions had positive effect on health management of the sick children. Experiences based on cooperation of the SITRS researchers with prof. Zapletal from Motol hospital Prague showed the worsening of functional status of children coming back to their home environment (Prague). These experiences accent importance of repeated climatotherapy. MEF25 and PEF (characterize value of the level of maximal expiration during maximal forced expirium) and AEX (area under the line of PEF) were recognized as relevant parameters for classification of the functional status of the children respiratory airways.

Influence of repeated climatotherapy on the eNO concentration in respiratory system

Investigation of climatotherapeutic effects on asthmatic children was carried out according to cooperation between SITRS and Pediatric clinic of St. Andrea hospital, Universita La sapienza Roma headed by prof Roncheti in 2002. Group of 33 children (mean age 10.6 +/-2.4, sexual ratio b/g: 16/17) had been included in the study. 17 children suffered from asthma (AB) and atopy, 8 of them had been treating ICS (inhalatory corticosteroids) and 9 had not been treating. Additional 16 children had not confirmed asthma. All children were separated in the 2 groups:

I group – the first procedures were done inmediatelly after admission to hospital

II group - the first procedures were done after one week hospitalization.

For the evaluation of functionality of the respiratory system, parameter eNO (concentration of the expired nitric oxide) measured by Sieves analysator NOA 280TM and spirometer (Spirolab II MIR) was used. The results confirmed that level of eNO ussually increased by the patients who were not sufficiently treated for their allergic asthma symptoms.

Reasults of the study showed that (Tab. 2):

- for non-allergic children, the levels of the spirometric parameters and eNO concentration were comparable for both I and II group of the patients
- allergic children suffering from asthma bronchiale in II group had significantly lower level of the MEF(FEF) 25 at the begining in comparison with children in group I; in case of parameter eNO, signinficantly lower level after one week therapy was achieved .

Table 2. Results of measurements of parameters for classification of functional status of the children respiratory airways.

Non asthmatic children	I group I (n=8)			II group II (n=8)		
	1st day	7thday	p	1st day	7thday	p
eNO 58mL/s	6.3	6.6	n. s	6.4	8.7	n. s
FVC (%)	97.9	102.9	n. s	104.0	102.0	n. s
FEV_1 (%)	100.6	101.5	n. s	102.9	98.7	n. s
FEF_{25-75} (%)	99.9	100.1	n. s	100.1	92.8	n. s
Asthmatic children	I group (n=10)			II group (n=7)		
	1stday	7thday	p	1st day	7thday	p
eNO 58mL/s	9.4	9.7	n. s	8.7	5.1	0.018
FVC (%)	97.9	102.9	n. s	100.1	100.2	n. s
FEV_1 (%)	100.6	101.5	n. s	91.9	94.6	n. s
FEF_{25-75} (%)	99.9	100.1	n. s	68.3*	75.9	n. s

*p=0.019 between I and II group

Conclusions

Climate is an important factor of human health. If humans will be able better recognize the climatic conditions they can prepare more possibilities for better health care about the patients suffered from chronic respiratory disseases. More scientific information focused on influence of climate parameters on health status of patients should be useful for new treatment methods convenient to individual needs of patients. Application of advanced climatotherapy procedures can improve quality of patients life and to achieve effectiveness and cost benefit of the therapy.

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Specifics of temperature extremes in the conditions of the urban climate

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Abstract. Urban climate causes intensive physical stress with negative impacts on health. One of the main risk factors is incidence of long-term period of high temperatures during the summer months, so-called heat waves. In the paper the heat waves incidence and their dynamics are defined in the long-term monitoring in the cadastral of Brno. To determine of the urban heat island impact on observed characteristics the temperature data series directly affected the urban environment and temperature data series of non-urban area were evaluated.

Introduction

Recently increased attention is paid to study of climate extremes not only for their own hazard (casualties, material damage), but also in relation to the threat of their prominence in the climate change. The negative consequences of possible climate change are rather caused by changes in variability and occurrence of extreme events than changes in average temperature. Among extreme events the so-called heat waves are included (Kyselý and Kalvová, 1998). Heat wave is defined as a different long episode of extremely hot weather. Meteorological dictionary (Sobíšek et al., 1993) defines the heat wave as more days lasting period of summer heat during which the maximum daily air temperatures reaching 30 °C or more. In Central Europe a heat waves are caused by flow of tropical air above the land or intensive radiative heating of polar air continuing above overheating land in the anticyclone area. Much attention is worldwide focused of research of extreme temperature events. Kukel et al. (1996) studied the intense heat wave, which hit Chicago in July 1995. In the Czech Republic conditions the incidence of heat waves in South Moravia was analyzed by Kyselý and Kalvová (1998), temporal variability of heat waves described Kyselý (2003) and analysis of mortality related to heat stress were worked up by Kyselý and Huth (2004).

The term "heat wave" is relative due to climatic conditions of specific location. Temperatures, which are for humans and other organisms in warmer areas considered as normal, in colder areas are concidered as abnormal. Therefore WMO recommends heat wave to define as the period during which the maximum daily air temperature in five consecutive days was at least 5 °C higher than the normal daily mean maximum for a given period (Heat Wave Duration Index HWDI) (Frich et al., 2002). Kyselý and Kalvová (1998) defined heat wave as the period that simultaneously fulfills the following three conditions: (1) at least 3 days with daily maximum temperature ≥ 30 ° C, (2) daily mean maximum temperature for the entire period ≥ 30 ° C, (3) daily maximum temperature in all days ≥ 25 ° C. Netherlands Royal Meteorological Institute defines heat wave as a period of at least 5 days with daily maximum temperature of 25 ° C and higher, which includes at least 3 days with maximum temperature 30 °C and higher (Huynen et al., 2001). For the purposes of mortality analysis in heat waves Kyselý and Huth (2004) defined heatt wave as a continuous at least three days period during which the maximum air temperature is 30 °C and higher.

For the analysis of the heat waves, the sites, which lie in the potentially comparable climatic conditions but with significantly different environmental conditions, were selected. One site is located in the city center, the second lies on the outskirts (out of the reach of the urban environment). Urban area shows significantly higher temperature than the surroundings. These temperature differences are greater at night than during the day and in winter than in summer and most significant are during low wind or calm. The main reason is the overlap of the original natural surface by infrastructure and buildings. Unlike higher plants asphalt and concrete surfaces do not have the ability to utilize the incident solar radiation and convert it to a chemical or other energy. Dark color of these surfaces also causes greater absorption of light and heat radiation. In winter the thermal energy supplied to individual houses and flats participates on the temperature increase in the cities. According to meteorological dictionary (Sobíšek et al., 1993) the area of increased air temperature in the ground layer of atmosphere above the city compared with rural surroundings is defined as the heat island. In connection with the occurrence of temperature extremes the certain population groups (particularly the elderly and long-term sick) are most affected. Increased incidence of hot periods due to city heat island is investigated in the urban environment of Brno in this study.

Data and methods

For the purposes of the study two climatological stations of Czech Hydrometeorological Institute (CHMI) were selected. Urban climate is represented by Brno-Žabovřesky station and sub-urban climate by Brno-Tuřany station. Results are presented for the possible longest period i.e. since 1987 (when measurements in Žabovřesky began) till 2008 (22 years). Brno-Žabovřesky station is located in the vicinity of the CHMI Brno branch in the Žabovřesky. Brno-Tuřany station is located close to Brno airport on the outskirts of Brno.

For the evaluation homogenized data of the daily maximum air temperature were used. The basis of the data was obtained by measurement at CHMI station network. The data were controlled for the presence of errors (by comparing the difference with the surrounding stations, by comparison with the expected value calculated by geostatistical methods etc.) and then tested for the presence of inhomogeneities (using statistical tests and the reference series with a subsequent correction of inhomogeneities). Missing values were completed by using IDW method (Štěpánek and Zahradníček, 2008). The heat wave calculation was realized in software ProClim. As a heat wave a period of at least 3 consecutive days with daily maximum air temperature ≥ 30 ° C was considered.

Results and disscussion

The highest number of heat waves station was found in Brno-Žabovřesky in 1992 and in 1998 and at the Brno-Tuřany station in 2003 (Fig. 2). The results show that the values of monitored characteristics were significantly higher on the Brno-Žabovřesky station (representative of the urban environment) than at the Brno-Tuřany station (sub-urban environment).

Maximum number of days in the heat waves was reached in 1994 (Brno-Žabovřesky -32 days and Brno-Tuřany - 24 days) (Fig. 1). The average length of the heat wave in Žabovřesky was 8 days and in Tuřany 7. The maximum length of heat wave occurs in 1994 - 19 days in Žabovřesky and 17 days in Tuřany. Maximum number of heat waves per year was detected in 1992 and 1998 at the Žabovřesky station and in 2003 at the Tuřany station.

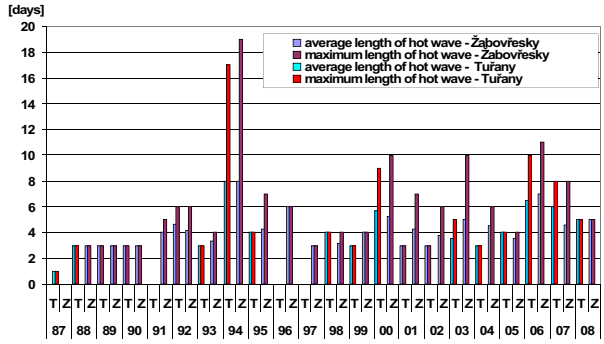

Figure 1. Average and maximum length of heat waves at Žabovřesky (Z) and Tuřany (T).

For detail presentation of heat waves occurrence, two extreme years 1994 and 2003 were selected. The first heat wave at the Žabovřesky station was detected from 26.6. to 29.6. 1994. In Tuřany the first heat wave occurred from 27.6. to 29.6. In July 1994, two heat waves were detected in Tuřany, 14.-17.7. and from 22.7. - 7.8. (17 days). Even longer heat wave than that in Tuřany was established in 1994 in Žabovřesky which lasted from 21.7. to 8.8. (19 days). In June 2003, the beginning of the first heat wave at the Žabovřesky station was recorded 4.6, the wave lasted until 8.6. At the Tuřany station the first heat wave started 11.6. and lasted until 13.6. At that time the second heat wave of this year which lasted from 10. to 13.6 was already recorded at the Žabovřesky station. In July 2003 heat wave occurred only 20.-22.7. in Žabovřesky. In Tuřany there was no wave in July.

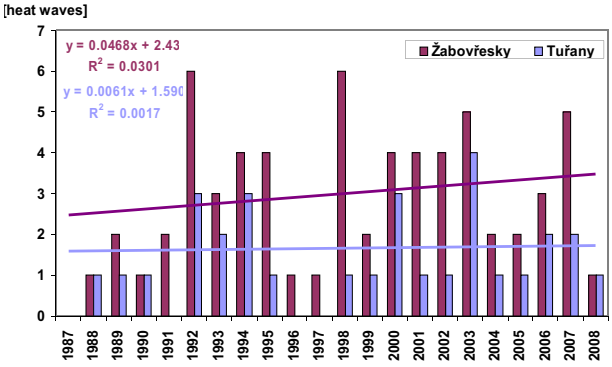

Figure 2. The number of heat waves per year.

August 2003 was the most extreme of this viewpoint. Already at the beginning of the month a very long heat wave that lasted from 1. to 10.8. was recorded in Žabovřesky and two shorter in Tuřany: 1.-5.8. and 8.-10.8. At both stations one heat wave lasting 3 days from 12. to 14.8. was found. The highest daily maximum air temperature was measured 13.8. (Žabovřesky 37.8 °C and Tuřany 37.1 °C). The longest average length of the heat wave was recorded in 1994 (Žabovřesky and Tuřany 8 days). The longest maximum length of the heat wave was recorded in 1994 (Žabovřesky - 19 days, Tuřany - 17 days). The maximum number of heat waves per year has been detected at the Brno-Žabovřesky station (6) and Brno-Tuřany (4) (1992, 1998 - Žabovřesky and 2003 – Tuřany.

Conclusions

At Brno-Žabovřesky station (urban environment) more and longer heat waves occurred than at the Brno-Tuřany station (sub-urban environment).

- The longest average length of the heat wave was recorded in 1994 (Žabovřesky and Tuřany 8 days).
- The longest maximum length of the heat wave was recorded in 1994 (Žabovřesky 19 days, Tuřany 17 days).
- The maximum number of heat waves per year was 6 at the Brno-Žabovřesky station and 4 at Brno-Tuřany station (1992, 1998 - Žabovřesky and 2003 - Tuřany).

The results showed a significant specific phenomenon of urban climate (more frequent and longer heat wave occurrence) compared with sub-urban areas.

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Regular variations of air pollution on selected stations during 2003–2007

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Abstract. The variations of concentration of five most important pollutants on the station in Praha-Libuš and of two pollutants (sulphur dioxide SO_2 and nitrogen oxides NO_X) on ten stations in the Czech Republic have been investigated. A high correlation appears between concentrations of different pollutants on the same station. The correlation between the concentration of the same pollutant on different stations decreases rapidly with the distance between these stations. The concentration of all pollutants displays an expressive maximum in winter. This maximum for the SO_2 concentration is narrower on all stations than that for the NO_X concentrations. The concentration of the ground-level ozone O_3 displays negative correlation with concentrations of all other pollutants and an opposite annual variation.

Introduction

Much effort has been devoted to the investigation of the influence of different meteorological parameters on the biosphere, e.g. on the morbidity or mortality. Air pollution, however, was not taken into account in many of such works though this parameter has a significant influence on the biosphere. In this paper, we attempt to give an overview, from the point of view of the user, which air pollution data are available and which regular variations of them should be taken into account.

There are about twenty pollutants which may be present in the atmosphere and the concentration of which is being measured regularly on many stations in the Czech Republic. But most of stations restrict themselves only on some most important pollutants, the other are measured only on a small number of stations, located mostly in the industrial region of Ústí nad Labem. In clean regions, air pollution is measured on less number of stations.

Data

Data of air pollution measured on all stations in the Czech Republic since 1997 are available in the form of tables and graphs on www pages of the Czech Hydrometeorological Institute http://www.chmi.cz/uoco/isko/tab_roc/tab_roc.html. These tables and graphs are oriented mostly on information where and when the concentration of pollutants exceeded the set limit values. Moreover, there are many shorter and sometimes longer periods when some stations were not working, some stations stopped their activity during the years and new stations were introduced, especially before 2003. Therefore, it is not so easy to find a suitable net of stations where the air pollution was measured continuously during five years with only small gaps.

Variations of pollution on Praha-Libuš station

The station in Praha-Libuš is the only station where nearly all pollutants have been regularly measured. In this chapter, the values of five most important pollutants during 2003-2007 were used for investigation: the sulphur dioxide SO_2, nitrogen oxides NO_X, carbon monoxide CO, ground-level ozone O_3 and suspended particles PM_{10} fraction. Tab. 1 presents mean and maximal concentrations of these pollutants. Maximal values are much higher than mean ones and this fact suggests that there are very big differences between concentrations in the individual days. Moreover, the high values occur only rarely.

Table 1. Average and maximal concentration of pollutants on the station Praha-Libuš in µg/m^3.

	SO_2	NO_X	CO	O_3	PM_{10}
Average	5.48	35.6	504	51.9	30.0
Maximum	44.0	315.5	3486	131.0	199.3

The concentration of all pollutants depends on the season significantly. Annual course for all five pollutants is shown in Fig. 1. The concentration for all pollutants displays very similar course during the year, only the difference between summer and winter may differ. A significant maximum occurs in winter. The reason is higher production of pollutants (especially SO_2 due to higher consumption of coal for heating) and mainly worse conditions for the dispersion. The exception is the ground-level ozone O_3. The production of the ozone depends on solar UV radiation and this is the highest in spring months. Together with the length of day, the maximum of the ozone concentration results between April and June. All these regularities agree well with those found by other authors in different regions (e.g. Katsoulis and Pnevmatikos, 2009; Teixeira et al., 2009; Esen et al., 2005)).

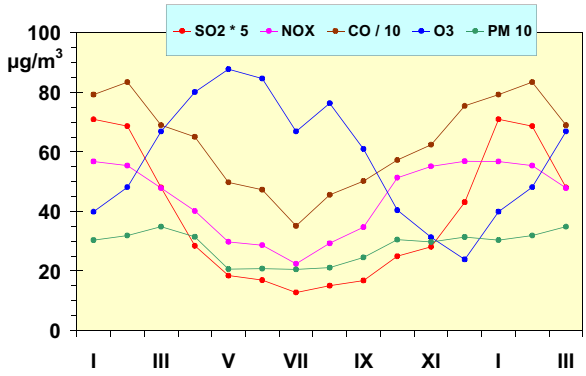

Figure 1. Annual variation of the concentration of some pollutants on the station Praha-Libuš during 2003-2007.

There are significant correlations between concentrations of the individual pollutants in the same day. It means that when the concentration of one pollutant is high in a selected day, the concentration of other pollutants will be probably also high. This fact is given by the conditions of dispersion. The values of coefficients of correlation move between 0.5 – 0.6, the highest one being 0.63 for NO_X with PM_{10}). The exception is the concentration of ozone, it displays negative

correlation with the concentrations of all other pollutants (the highest is -0.51 for O_3 with NO_X).

Variations of SO_2 and NO_x on selected stations

For further investigation two most important pollutants were selected – the sulphur dioxide SO_2 and nitrogen oxides NO_X. Daily values of the concentration of these pollutants were taken from ten selected stations, most of them in towns or industrial regions, one (Hojná voda) in a clean region for comparison. Their list with mean and maximal values is given in Tab. 2.

Table 2. Mean and maximal concentration of SO_2 and NO_X on selected stations during 2003-2007 in $\mu g/m^3$.

	Praha Libuš	Praha R. sady	Praha Vršovice	Praha Mlynářka	Hojná voda
Mean SO_2	5.48	6.03	6.27	5.73	2.21
Max. SO_2	44.0	43.7	43.7	42.4	23.8
Mean NO_X	35.6	47.4	69.5	81.8	7.44
Max. NO_X	316	298	455	518	42.6

	Brno Kroftova	Brno Tuřany	Kladno město	Ústí n.L. Kočkov	Ostrava Přívoz
Mean SO_2	2.58	5.98	8.82	13.6	
Max. SO_2	48.6	72.8	69.9	171	
Mean NO_X		29.8	31.6	21.0	43.5
Max. NO_X		273	232	213	246

The values given in Tab. 2 demonstrate some important regularities concerning the production and dispersion of the pollutants, and some differences between SO_2 and NO_X. The source of the SO_2 is mostly combustion of the coal; therefore, it comes to the atmosphere from chimneys, usually high above the ground, and is being distributed into a broad area. For example, in Prague is the SO_2 concentration nearly the same in the all town, in parks as well as in industrial suburbs. A part of the SO_2 in industrial regions (Ústí n.L., Ostrava, Kladno) comes from industrial sources on the ground (e.g. chemical and metallurgical industry). The main source of the NO_X is car traffic. It lies on the ground and therefore the NO_X concentration rapidly decreases with the distance from busy roads. The highest NO_X concentration was observed in Prague, it was lower in other towns even in those with a big industry. Very low concentrations of both pollutants appeared in Hojná voda, far from the industry and busy car traffic.

The conditions for production, transport and dispersion of pollutants are nearly the same in all regions. Nevertheless, they may differ somehow in the individual days. The correlation between concentrations of pollutants on two stations depends on the distance between them – it reaches 0.9 for pairs of stations in Prague and falls down to 0.4 for stations in Moravia correlated with Ústí n. L. or Kladno. The industrial sources of the SO_2 concentration in some regions contribute to lower correlation between these regions and those without industry.

Concentration of both pollutants depends considerably on the season. A significant maximum occurs always in winter. Mean annual course of the concentration of the SO_2 is presented in Fig. 2, that of the NO_X in Fig. 3. In both figures, also the mean course for all stations was added. The course is nearly the same for all stations. It is very well seen that the curve for some station lies higher than for the others in accordance with the data in Tab. 2.

The annual amplitude of the SO_2 concentration is higher than that for the NO_X one and is restricted only on January and February. For the NO_X concentration a very big difference among stations can be observed, e.g. in Prague is the concentration ten times higher than in Hojná voda, whereas for the SO_2 concentration it is only five times. The highest SO_2 concentration appears in industrial regions, whereas the highest NO_X concentration appears in Prague.

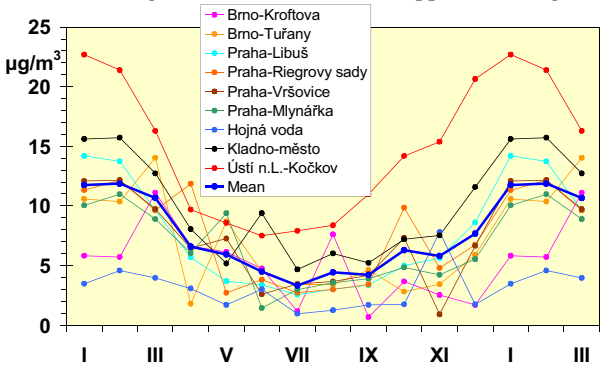

Figure 2. Annual variation of the SO_2 concentration on selected stations during 2003-2007.

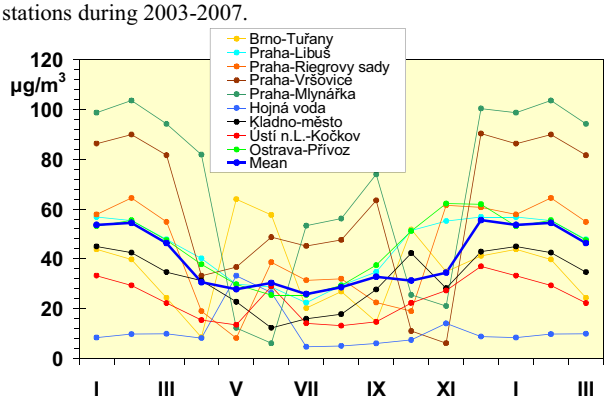

Figure 3. Annual variation of the NO_X concentration on selected stations during 2003-2007.

Conclusions

The concentration of pollutants is being used for the biometeorological prediction together with other meteorological factors. Therefore, in winter, due to higher concentration of pollutants, higher degrees of discomfort (2 or 3) appear more often than in summer. However, high concentration of pollutants needs not occur automatically in all regions, though often it does take place. This fact may be one of the reasons why the correlation between the predicted degree of discomfort and the actual incidence of heart attacks appeared to be very low. This point supports the necessity to present the biometeorological prediction for the individual regions separately.

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National Inventory System for GHG Emissions of the Slovak Republic

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Abstract. Climate change, caused by increasing anthropogenic emission of greenhouse gases, represents the most serious environmental issue in the history of humankind. The most important anthropogenic greenhouse gases are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Other greenhouse gases included in GHGs inventory are halogenated hydrocarbons (PFCs, HFCs) and SF6, which are not controlled by the Montreal Protocol. Slovak Hydrometeorological Institute, Department of Emission is the organization authorized by the Ministry of the Environment as a chief coordinator of the National Inventory System under the Kyoto Protocol to monitor and report all activities as related to the annual inventory of GHG emissions, sinks and projections.

Introduction

In accordance with Article 5.1 of the Kyoto Protocol each Party included in Annex I to the UN Framework Convention on Climate Change shall have in place, no later than one year prior to the start of the first commitment period (i.e. since 1 January 2007), a national system for the estimation of anthropogenic emissions (NIS) by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. In accordance with 19/CMP.1 decision the NIS has to be proposed and controlled to enable a transparent, consistent, comparable, complete and precise inventory of greenhouse gases. At the same time the NIS has to meet the requirements for quality through the planning, preparation and management of activities related to inventory, including assessment of uncertainties in estimation of emissions and a plan to assure and control quality (QA/QC). Characteristics, general and specific functions and principles are defined in detail in decisions 20/CP.7 and 19/CMP.1. The National Inventory System for GHG emissions of the Slovak Republic (www.ghg-inventory.gov.sk) has been established and officially announced by the Decision of Minister of the Environment of the Slovak Republic on 1st January 2007 in the official bulletin: Vestnik, Ministry of Environment, XV, 3, 2007, page 19 (http://www.enviro.gov.sk/ servlets/files/16715).

International Situation

The unfavourable development and balance of GHG emission generation since 1992 have created a demand to adopt an additional and effective instrument that would involve the participation of developing countries. In 1997, the parties of the Convention agreed to endorse the Kyoto Protocol (KP) that defines reduction objectives and instruments to achieve them for countries of the Annex I to the Convention. Developed countries defined in Annex B of the KP should reduce individually or together emissions of six GHG (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) on average by 5.2% from the level of the year 1990 during the first commitment period 2008–2012. The Slovak Republic, as a member states of the EU committed to an 8% reduction of emissions compared to the base year 1990. The Slovak Republic and the EU countries ratified the Kyoto Protocol on May 31, 2002.[11]

EU-27 greenhouse gas emissions are decreasing. This overall trend is projected to continue until 2020 but further emission reductions will be needed to meet of a 20% reduction by 2020 compared to 1990. Total GHG emissions without LULUCF in the EU-27 were 7.7% below the base year in 2007. The largest absolute reductions took place in Germany, the United Kingdom and in the most EU-12 Member States, while the largest absolute increases were observed in southern EU-15 Member States (Spain, Portugal, Greece and Italy). The new member states (EU-12) reduced together the GHG emissions in average about 28% in the 1990–2007 period without LULUCF. The main reason for this important emission reduction is above all the strong although temporary decreasing of the economy activities, following restructuring of the economy joined with the implementation of new, more effective low carbon technologies, reducing the share of the intensive energy industry and increasing the share of services in the GDP generation. The important exception is transport (mostly road transport), with the emissions´ increasing. The continuous pressure is made in formulation of the effective strategy and policy for the further reduction of the emissions.

National Circumstances

The current situation in the emission balance of the Slovak Republic is influenced by economic development of the country and complexity of other important indicators. The GHG per GDP in 2006 was 1 097.2 t CO_2/Euro (current prices) and was the 6th highest in the EU-27. Transition from a centrally planned economy to a modern and market oriented type was difficult, connected with a significant economic recession accompanied with high unemployment rate, high inflation, low incomes and significant changes in life standards. Energy intensity of the Slovak economy has gradually decreasing (Tab. 1) but, it is still almost twice time higher than the EU average. Currently, the Slovak Republic is a high-income economy with one of the fastest growth in the EU and OECD. Growth acceleration from 2003 (Tab.1) was and is still caused namely by the dynamics of auto-mobile production, development of electrical engineering, cement and lime production and booming of construction sector. Combination of measures and timing, as far as political, economical, technological and environmental changes, were dynamic and occurred in very short time. Positive indirect impact of Air Protection Act on decrease in GHG emissions is undoubted to achieve and keep emission control due to fact that it covers significant part of domestic emission sources. Occurred changes led to final consumption of brown coal in 2006 was only 31% from this in 1990, light fuel oil consumption in

[11] Kyoto Protocol came into force on February 14, 2005

2006 decreased by 95% and heavy fuel oil by 70% compared to 1990.

Overview of Source and Sink

The GHG emissions presented in the Slovak National Inventory Report 2009 were updated and converted using the newest available methods, national conditions and data published by the Slovak Statistical Office. Total GHG emissions were 46 950.67 Gg in 2007 (without LULUCF). This represents a reduction by 35.9% in comparison with the reference year 1990. Total GHG emissions in the SR are stable or slightly increasing due to recovery of economic activities, increase in transport and expected increase in actual emissions of F–gases (mainly HFCs and SF_6). The Fig. 1 shows the current trend in GHG emissions with the estimated projections based on three scenarios: without the measures, with measures and with additional measures up to 2020.

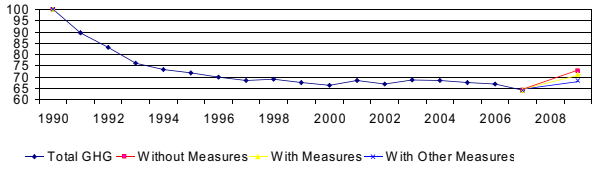

Figure 1: The GHG emission trends compared with the Kyoto target (%) in the Slovak Republic.

Table 1: The total anthropogenic greenhouse gas emissions in Tg of CO_2 eq in Slovakia.

Pollutant	CO_2 *	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total*	Total
Year									
1990	61.96	59.56	4.79	6.23	0.00	0.27	0.00	**73.26**	**70.87**
1991	55.65	52.14	4.64	5.04	0.00	0.27	0.00	**65.60**	**62.10**
1992	52.06	47.91	4.38	4.22	0.00	0.25	0.00	**60.91**	**56.77**
1993	47.82	43.53	4.09	3.58	0.00	0.16	0.00	**55.64**	**51.37**
1994	45.56	42.25	4.07	3.92	0.00	0.13	0.01	**53.70**	**50.39**
1995	44.04	41.34	4.25	4.16	0.02	0.11	0.01	**52.59**	**49.91**
1996	40.07	40.07	4.21	4.29	0.04	0.03	0.01	**51.07**	**48.66**
1997	41.42	40.01	4.24	4.18	0.06	0.03	0.01	**49.94**	**48.55**
1998	42.10	40.16	4.50	3.78	0.04	0.03	0.01	**50.46**	**48.53**
1999	41.35	39.72	4.70	3.32	0.07	0.01	0.01	**49.47**	**47.85**
2000	40.32	37.92	4.42	3.58	0.08	0.01	0.01	**48.42**	**46.04**
2001	41.74	36.52	4.47	3.77	0.08	0.02	0.01	**50.09**	**44.88**
2002	40.05	34.80	5.08	3.73	0.10	0.01	0.01	**48.99**	**43.76**
2003	41.42	36.59	4.84	3.76	0.13	0.02	0.02	**50.19**	**45.38**
2004	41.11	36.86	4.82	3.86	0.15	0.02	0.02	**49.98**	**45.75**
2005	40.74	39.86	4.58	3.85	0.17	0.02	0.02	**49.37**	**48.53**
2006	39.98	36.93	4.63	4.07	0.20	0.04	0.02	**48.94**	**45.91**
2007	38.14	34.92	4.53	4.01	0.23	0.02	0.02	**46.95**	**43.75**

**Total aggregated GHGs emission without LULUCF*

Transport Sector

Emissions from road transport continued to grow in most countries as well as in the Slovak Republic. The total aggregated emissions from road transportation reached 6 580 Gg of CO_2 equivalents in 2007, the increase in comparison to the previous year 2006 is more than 14%, but in comparison to the base year 1990, the increase is even more significant (43%). The major share belongs to the duty vehicles and passenger cars (Fig. 2).

Land Use Change and Forestry Sector (LULUCF)

No other sector has such mitigation potential as LULUCF. By land use change measures is possible to change carbon flow significantly. LULUCF experts are developing new methods in order to properly account carbon sinks or emissions from several environmental sources. Most effort is currently focused right on accounting methods but one question still remains for next commitment periods – how should be the GHG emissions calculated with respect to heterogeneity of ecosystems and to understanding of the local GHG cycle components.

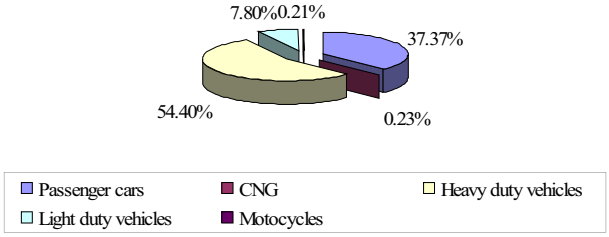

Figure 2. The share of GHG emissions from road transport in 2007 in Slovakia.

There are three accounting options assessed for forest management. The total net emissions/removals of carbon dioxide represent -3219.35 Gg due to forest land (-3266.30 Gg), cropland (1.998 Gg), grassland (-439.45 Gg) and other land (484.40 Gg). Total amount of methane emission from LULUCF sector represents 0.906 Gg and total amount of N_2O emissions was of 0.0125 Gg in 2007. The situation in Slovakia is summarized in Fig.3.

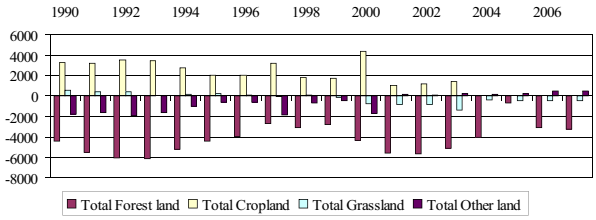

Figure 3: The CO_2 emissions balance in sector LULUCF (Gg) in the Slovak Republic.

Conclusion

Concerning the actual and proposed dynamics of GDP growth in the Slovak Republic, there exist legitimate assumption that GHG emissions will increase in line with it. Due to this scenario there is necessary to prepare investment strategies and programs that allow us to achieve permanent distribution of GDP growth and emissions growth with the regards to the further post-Kyoto reduction goals. The first EU proposals includes 20% reduction the GHG emissions after 2020 against 1990. For the Slovak Republic, the strategic target within this connection is to apply low-energy effective technologies for the energy production (for the new sources), emission trading, restructuring of industry and agriculture, development of service sector and the improvement of the industry and public awareness in the environmental issues.

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The evaluation of winter severity on the basis of daily minimum air temperature in Prague for the period of 1978 – 2009

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Abstract. This paper evaluates the winter season on the basis of daily minimum air temperature at the station Prague Karlov for the period of 1978 - 2009. December, January and February have been set as the winter season consecutive months. Using the standard deviation, the threshold for the interval scale significance phenomenon have been set. The coldest winter over this period was in 1984/1985. In the same year the absolute minimum for this period -22.6°C was measured in 9.1.1985. The coldest consecutive winter seasons were these ones in 1984/1985, 1985/1986 and 1986/1987 with the number of 19, 15 and 13 extreme cold and severe cold days. The mildest, without the occurrence of extremely cold and very cold days, were winters in 1988/1989, 2006/2007 and 2007/2008. Since 1978, it has been evident a significant decrease in the number of severe cold days and extreme cold days.

Introduction

About half of the world population lives in cities, in developed countries even more than 70%. Such concentration of people in confined space leaves marks on the environment. In the context of the still debated global climate change, the increasing number of people in the cities most likely appears at the so-called heat island town. Climatic conditions are significantly affected by the urban structure of these urban settlements, and also by the anthropogenic activities of man. These have resulted in the accumulation of heat in the materials (concrete, asphalt, brick buildings) and the release of heat due to heat buildings and fuel combustion. In summer we can say that the city heat island is rather negative in nature, but in winter this can be vice versa as a result of mitigation of low temperatures. Prague City is situated in the Prague Basin. It is the nature of the valley that has resulted in a lack of exchange of air as a result of blowing winds and frequent run-off the winter cold air into the valley and the creation of temperature inversion. The paper deals with the analysis of daily minimum air temperatures of urban Prague Karlov station in the period of 1978 - 2009.

Data and methods

In this study was analyzed the data series of Prague Karlov station for the period of 1978 - 2009. Winter months of a calendar year were not evaluated, but winter season was defined by consecutive months of December, January and February. These were divided into ten days period and within framework ten days was analyzed daily minimum air temperature. We adopted criteria to define the threshold of intervals of negative temperatures calculated by the standard deviation δ and the arithmetic mean μ. The interval of winter severity criteria was determined by:

moderate cold day $\mu - 1{,}5\delta \leq t_{min} < \mu - \delta$
severe cold day $\mu - 2\delta \leq t_{min} < \mu - 1{,}5\delta$
extreme cold day $t_{min} < \mu - 2\delta$

In the ten days of every month, days estimated as severe and extreme cold ones were selected and further processed.

Results and disscussion

Absolute minimum air temperature over the past 31 winter times was measured in Prague Karlov in 9.1.1985 (-22.6°C). This year assesses Štěpánek (2004) as the last period of low extreme levels since 1961. Střeštík (2004) indicates that low temperatures below -25.0°C in Prague Klementinum occurred only a few times in the end of the 18th and in the beginning of the 19th and in the 20th century. It the end of the 70's and the beginning of the 80's of the last century, Prague had the biggest winter times in the past 31 years old according to the temperature extremes. The coldest consecutive winter seasons were those ones in 1984/1985, 1985/1986 and 1986/1987 with the number of extreme cold and severe cold days 19, 15 and 13, respectively. Also the winters in 1980/1981 and 1981/1982 with the number of 14 and 18 extreme cold and severe cold days were observed. The moderate winters were found in the beginning of the 21st century, except for winters 2002/2003 and 2005/2006. The moderate, without the occurrence of extreme cold and severe cold days, were winters in 1988/1989, 2006/2007 and 2007/2008 (Fig.1).

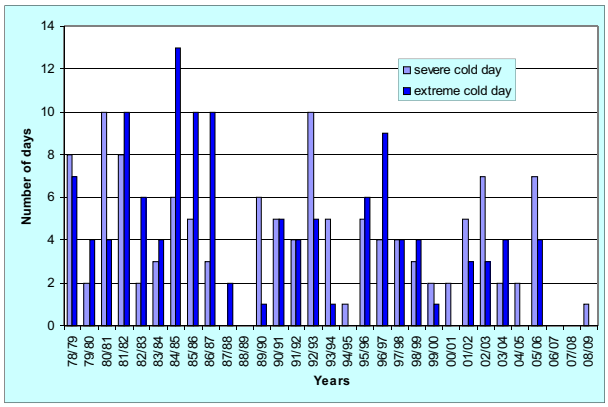

Figure 2. Number of severe and extreme cold days in the winter season (Prague Karlov 1978 – 2009).

Střeštík (2004) noted in the analysis of temperature minimum in Prague Klementinum (1775 - 2000) a significant decrease of number of ice and arctic days during the 20th century. The most frequent occurence of these days was identified during January and less of them during February and December.

The detailed assessment of individual periods showed the second ten days in January as the coldest period with a total of 18 extreme cold days. On the other hand, the lowest

number of extreme cold days (10) was found during the first ten days of January (Tab. 2).

Table 1. Frequency of extreme cold and severe cold days in Prague station Karlov on the period 1978 – 2009, month December.

t_{min} PRAHA KARLOV 1978 - 2009 December												
first 10-days				second 10-days				third 10-days				
extreme cold		severe cold		extreme cold		severe cold		extreme cold		severe cold		
date	°C	date	°C	date	°C	date	°C	date	°C	date	°C	
5.12.78	-10.0	8.12.78	-7.4	17.12.81	-9.2	19.12.78	-8.8	21.12.81	-14.6	27.12.92	-11.0	
6.12.78	-12.4	1.12.80	-9.0	**18.12.81**	**-11.4**	14.12.81	-7.5	28.12.95	-11.5	29.12.92	-11.0	
7.12.78	-11.1	3.12.80	-7.0	20.12.81	-10.4	16.12.81	-7.1	29.12.95	-12.8	30.12.92	-9.0	
2.12.80	-12.8	4.12.80	-7.7	13.12.83	-11.3	12.12.83	-8.4	30.12.95	-11.8	21.12.96	-10.6	
8.12.80	-11.5	5.12.80	-8.0	15.12.83	-9.4	11.12.91	-8.0	22.12.96	-14.8	26.12.96	-10.2	
9.12.80	-9.4	7.12.80	-8.8	11.12.89	-11.0	14.12.91	-7.4	23.12.96	-13.9	23.12.99	-10.2	
3.12.83	-11.2	5.12.83	-8.8	12.12.91	-10.5	16.12.91	-8.7	24.12.96	-11.4	23.12.00	-10.0	
4.12.83	-11.0	1.12.89	-8.5	13.12.91	-10.7	17.12.91	-7.0	25.12.96	-14.7	23.12.01	-10.7	
6.12.83	-9.1	2.12.89	-8.9	16.12.97	-10.2	15.12.97	-7.4	27.12.96	-16.3	24.12.01	-10.5	
9.12.87	-10.1	3.12.89	-8.1	17.12.97	-10.3	15.12.01	-8.7	28.12.96	-18.4	24.12.03	-11.2	
10.12.87	-11.3	4.12.89	-8.7	11.12.98	-10.0	20.12.02	-8.5	**29.12.96**	**-21.4**	25.12.03	-10.8	
7.12.90	-9.2	10.12.89	-7.6	12.12.98	-10.8			30.12.96	-15.2	31.12.05	-9.6	
8.12.90	-10.4	1.12.93	-8.3	13.12.01	-11.0			31.12.96	-18.8			
9.12.91	-9.5	9.12.98	-7.8	14.12.01	-10.7							
10.12.91	**-13.2**	8.12.02	-7.0	11.12.02	-9.9							
10.12.98	-9.8	9.12.02	-8.7	12.12.02	-9.2							
10.12.02	-10.2											
n = 17		n = 16		n = 16		n = 11		n = 13		n = 12		
n = 33				n = 27				n = 25				
t_{min} = -13.2 °C				t_{min} = -11.4 °C				t_{min} = -21.4 °C				

The most consecutive extreme cold days were in 1996 during the third ten days of December (Tab. 1).
Next long period with extreme cold days was during the coldest winter (1984/1985) in the first ten days of January and for the second coldest winter (1981/1982) in the second ten days of January (Tab. 2).

Table 2. Frequency of extreme cold and severe cold days in Prague station Karlov on the period 1978 – 2009, month January.

t_{min} PRAHA KARLOV 1978 - 2009 January												
first 10-days				second 10-days				third 10-days				
extreme cold		severe cold		extreme cold		severe cold		extreme cold		severe cold		
date	°C	date	°C	date	°C	date	°C	date	°C	date	°C	
1.1.79	-18.2	2.1.79	-14.1	19.1.79	-15.0	20.1.79	-11.4	28.1.80	-12.2	24.1.81	-12.0	
5.1.79	-15.6	3.1.79	-12.4	13.1.80	-15.4	12.1.80	-11.8	23.1.81	-13.0	27.1.81	-10.9	
7.1.79	-16.6	4.1.79	-12.0	14.1.80	-16.5	16.1.80	-14.0	30.1.87	-17.2	29.1.81	-11.6	
6.1.85	-17.1	6.1.79	-14.5	15.1.80	-16.6	12.1.82	-12.0	**31.1.87**	**-19.4**	30.1.81	-11.4	
7.1.85	-19.9	9.1.81	-13.5	11.1.82	-18.9	17.1.82	-13.2	31.1.93	-14.9	22.1.87	-10.9	
8.1.85	-22.3	10.1.82	-14.2	13.1.82	-14.4	19.1.82	-12.2	31.1.99	-13.6	28.1.87	-11.0	
9.1.85	**-22.6**	4.1.85	-13.7	14.1.82	-18.0	20.1.82	-11.6	24.1.00	-12.5	29.1.87	-10.2	
10.1.85	-20.1	8.1.90	-13.5	**15.1.82**	**-21.8**	12.1.03	-11.6	23.1.04	-14.4	31.1.91	-10.5	
4.1.02	-15.0	2.1.93	-13.1	16.1.82	-17.4	12.1.09	-11.6	24.1.04	-17.2	30.1.93	-10.8	
6.1.04	-16.5	3.1.93	-14.5	18.1.82	-14.3			25.1.04	-13.9	25.1.96	-11.4	
		4.1.93	-12.8	11.1.85	-15.3			22.1.06	-12.5	26.1.96	-10.4	
		5.1.95	-13.4	14.1.85	-14.8			23.1.06	-14.9	31.1.96	-10.3	
		1.1.97	-13.8	19.1.85	-14.4			24.1.06	-14.6	27.1.98	-10.0	
		5.1.02	-13.7	11.1.87	-17.9			29.1.06	-12.7	28.1.98	-10.6	
		6.1.02	-12.4	12.1.87	-18.9					25.1.00	-10.5	
				13.1.87	-17.0					25.1.06	-11.8	
				14.1.87	-20.5					27.1.06	-10.3	
				15.1.87	-15.2					28.1.06	-12.1	
										30.1.06	-11.6	
n = 10		n = 15		n = 18		n = 9		n = 14		n = 19		
n = 25				n = 27				n = 33				
t_{min} = -22.6 °C				t_{min} = -21.8 °C				t_{min} = -19.4 °C				

February in Prague Karlov has the most extreme cold days in its first ten days (16). The most consecutive extreme cold days in February were identified during the winter 1985/1986 in the third ten days (Tab. 3).

Table 3. Frequency of extreme cold and severe cold days in Prague station Karlov on the period 1978 – 2009, month February.

t_{min} PRAHA KARLOV 1978 - 2009 February												
first 10-days				second 10-days				third 10-days				
extreme cold		severe cold		extreme cold		severe cold		extreme cold		severe cold		
date	°C	date	°C	date	°C	date	°C	date	°C	date	°C	
9.2.86	-14.0	7.2.79	-10.0	19.2.78	-12.6	13.2.78	-10.3	21.2.78	-14.0	21.2.82	-8.6	
10.2.86	-12.9	10.2.85	-11.9	16.2.83	-16.8	16.2.78	-10.6	23.2.83	-13.6	25.2.83	-10.5	
1.2.87	**-18.7**	7.2.86	-10.8	17.2.84	-12.8	18.2.78	-11.2	24.2.83	-11.6	20.2.85	-10.3	
2.2.87	-17.4	8.2.86	-12.5	18.2.84	-12.4	15.2.83	-11.6	21.2.86	-11.0	23.2.85	-9.5	
3.2.87	-16.8	1.2.91	-12.5	11.2.85	-15.6	16.2.84	-9.7	22.2.86	-13.1	20.2.86	-10.0	
3.2.91	-12.6	2.2.91	-12.2	**12.2.85**	**-21.0**	16.2.85	-12.0	24.2.86	-16.4	23.2.86	-9.8	
4.2.91	-13.5	5.2.91	-12.2	13.2.85	-20.6	18.2.85	-10.2	25.2.86	-15.4	28.2.93	-8.7	
6.2.91	-15.6	7.2.91	-10.2	14.2.85	-18.3	11.2.86	-9.8	26.2.86	-17.1	20.2.94	-9.8	
1.2.93	-16.1	4.2.93	-11.9	15.2.85	-12.4	13.2.94	-10.5	**27.2.86**	**-17.4**	25.2.01	-10.2	
2.2.93	-16.0	5.2.93	-10.6	12.2.86	-14.7	14.2.94	-12.1	28.2.86	-13.0	24.2.05	-9.5	
3.2.93	-13.6	1.2.96	-11.5	18.2.94	-12.7	19.2.94	-9.9	27.2.93	-11.6			
7.2.96	-12.8	2.2.96	-10.2			11.2.99	-10.0					
9.2.96	-12.8	3.2.97	-10.2			13.2.03	-10.3					
10.2.96	-14.9	3.2.98	-10.0			14.2.03	-10.7					
1.2.98	-15.2	1.2.99	-10.7			18.2.03	-11.5					
2.2.98	-13.5	8.2.05	-10.3									
		5.2.06	-11.2									
		6.2.06	-11.2									
n = 16		n = 18		n = 11		n = 15		n = 11		n = 10		
n = 34				n = 26				n = 21				
t_{min} = -18.7 °C				t_{min} = -21.0 °C				t_{min} = -17.4 °C				

Conclusions

The coldest of the period 1978-2009 was winter 1984/1985 in Prague Karlov. In the same period, the absolute minimum (1978 - 2009) -22.6°C was also measured. The coldest consecutive winter seasons were in the years 1984/1985, 1985/1986 and 1986/1987. The higher number of severe cold and extreme cold days was found in the 70's and 80's of the 20th century. The frequency of these days in the investigated period has decreasing character. The moderate winters without the occurrence of severe and extreme cold days were these of 1988/1989, 2006/2007 and 2007/2008. The coldest period of winter time was the third ten days of January, whereas the moderate period was the third ten days of February in Prague Karlov. The longest period of consecutive extreme cold days was the third ten days of December in 1996 and the third ten days of February in 1986.

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Abstracts

Changes in Atmospheric Circulation and Drought Events in Central Eastern Germany

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Abstract.

Recent studies on drought characteristics in Central Eastern Germany (e.g., Hänsel 2009) demonstrated that short and severe meteorological dry periods as well as long term drought events show a similar timing over the entire study area, suggesting some larger scale triggers of drought occurrence. This contribution analyses the connection between the occurrence and duration of long term drought events and the frequency and character of observed weather patterns. The focus is on atmospheric circulation patterns that are connected with the onset and termination of drought conditions and their changes within 1900—2005. Analysis is done using the subjective classification system of atmospheric circulation pattern by Hess-Brezowsky called *Grosswetterlagen* (GWL; Hess & Brezowsky 1977, Gerstengarbe & Werner 2005). Additionally, the ten driest and wettest months, seasons, half years and years are identified for the period 1951—2005. Times of precipitation conditions far above or far below average are explained by the statistical analysis of GWL. Dry conditions have thus occurred more frequently connected with anticyclonal circulation pattern, while extremely wet conditions predominantly occurred with cyclonal atmospheric circulation. Combinations of temperature and precipitation extremes were analysed to evaluate the influence of associated temperature extremes on the statistics of GWL occurrence, connected with dry and wet extremes. The GWL characteristics of dry/cold, dry/warm, wet/cold and wet/warm extremes were assessed.

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Comparison of regional approaches to modelling probabilities of heavy precipitation in the Czech Republic

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Abstract. Extreme precipitation events are associated with large negative consequences for human society, mainly as they may trigger floods and landslides. The recent flash flood in the Odra river basin in the Nový Jičín district in late evening of June 24, 2009, leaving 10 people dead and causing extensive damage to buildings and infrastructure, may serve an example. Estimates of growth curves and design values (corresponding e.g. to 50-yr and 100-yr return periods) of precipitation amounts and their uncertainty are important in hydrological modelling, design of hydraulic structures, urban and landscape planning, etc. The interest in high quantiles of precipitation distributions is also related to possible climate change effects, as climate model simulations – although not capable of reproducing some important features of observed patterns, which reduces their credibility – tend to project increased severity of precipitation extremes over central Europe in a warmer climate.

The present study compares several up-to-date methods to modelling probabilities of precipitation extremes that make use of regional approaches. Unlike a single-site analysis, which estimates distributions from observations at individual locations separately, a regional method makes inference by taking into account data in a 'region' (termed also 'pooling group'), in which one may assume that the frequency distributions of extremes at different sites are identical apart from a site-specific scaling factor (the condition is referred to as 'regional homogeneity'). In other words, all data in a region – often weighted in some way – are taken into account when estimating the probability distribution of extremes at a given site. The advantage is that sampling variations in the estimates of model parameters and high quantiles are to a large extent reduced compared to the single-site analysis.

The region-of-influence (ROI) method, originating in hydrology, is one of the variants of the regional methods: it identifies unique pooling groups (which form the database for the estimation) for each site under study. The similarity of sites is evaluated in terms of a set of site attributes that are supposed to be linked to the distributions of extremes. The key issue of the pooling methodologies is to decide on the number of 'similar' sites that should form the pooling group of the target site, i.e. where (and how) to draw the imaginary borderline between sites belonging and not belonging to a given pooling group. It is often useful to link this issue with a built-in test on 'regional homogeneity' of data, i.e. whether the distributions of extremes may be considered identical after scaling by the at-site mean. Once a pooling group is delineated, weights based on a dissimilarity measure are assigned to individual sites involved in a pooling group, and all (weighted) data are employed in the estimation of model parameters and high quantiles at a given site.

Another regional frequency analysis method, the Hosking-Wallis (HW) approach, is based on delineating fixed regions (instead of flexible pooling groups) and assigning unit weights to all sites in a given region. In this approach, the area of the Czech Republic was originally divided into 4 homogeneous regions; this regionalization has been revised after data from a dense network of rain-gauges became available, since some of the original regions were found heterogeneous with more data involved in the tests. The present analysis recognizes 9 homogeneous regions (Fig. 1).

Based on data on annual maxima of 1-day and 5-day precipitation amounts at 209 stations covering the Czech Republic, with altitudes ranging from 150 to 1490 m a.s.l., we compare the performance of the individual regional models (several variants of the ROI method that differ mainly in site attributes used to measure the similarity of sites, and the HW analysis) in terms of Monte Carlo simulation experiments, and conclude that the ROI methodology is superior to the HW analysis, particularly for very high quantiles (100-yr return values). Another advantage of the ROI approach is that subjective decisions – unavoidable when fixed regions in the HW analysis are formed – may efficiently be suppressed, and almost all settings of the ROI method may be justified by results of the simulation experiments. The differences between (any) regional method and single-site analysis are very pronounced and suggest that the at-site estimation is highly unreliable.

The ROI method is then applied to estimate high quantiles of 1-day and 5-day precipitation amounts, corresponding to 50-yr and 100-yr return values, at individual sites. The estimates and their uncertainty are compared with those based on a single-site analysis. We focus on the region of northeast Moravia and Silesia with complex orography (mountain ranges of the Jeseníky Mts. and Beskydy Mts.) and a particularly pronounced role of Mediterranean cyclones in producing precipitation extremes. The design values are compared with precipitation amounts recorded during the recent heavy precipitation events, including the one related to the flash flood on June 24, 2009.

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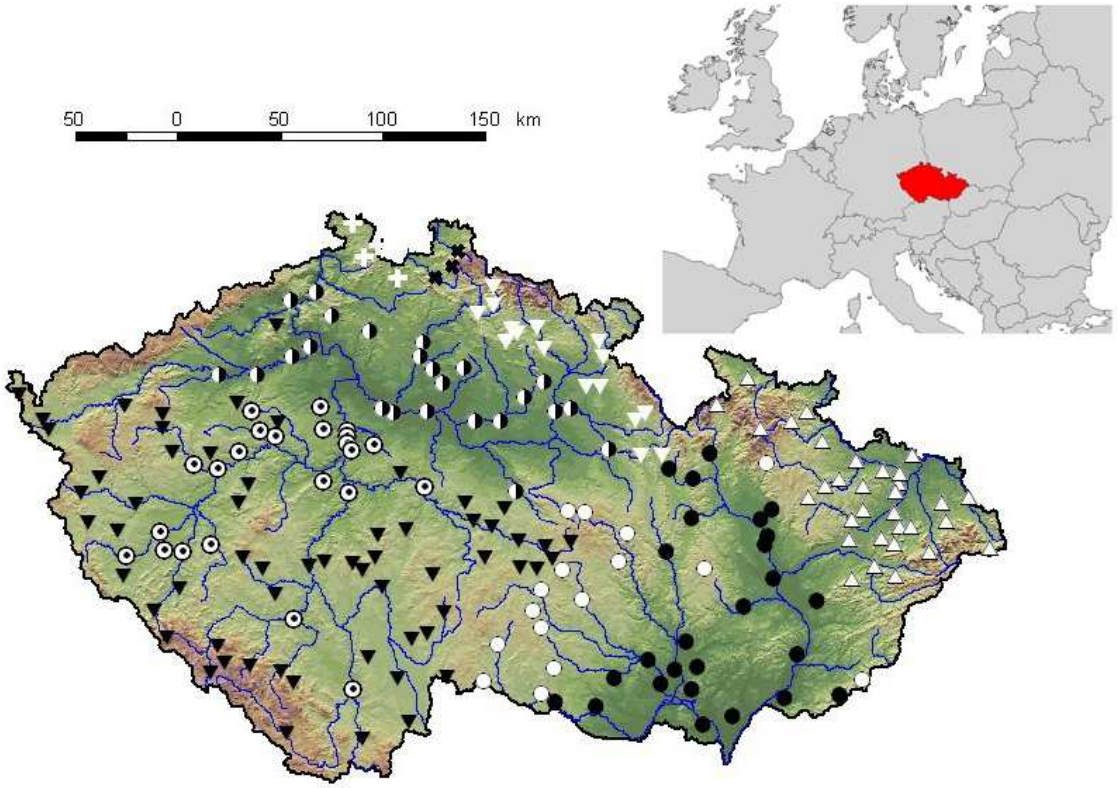

Figure 1. 209 stations in 9 homogeneous regions involved in a regional frequency analysis of heavy precipitation.

Interacting Environmental Interfaces: Source of Uncertainties in Calculating the Surface Temperature in Land-Surface Schemes for Use over Urban Areas

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Abstract. The field of environmental sciences is abundant with various interfaces and it is the right place for application of new fundamental approaches leading towards better understanding of environmental phenomena. For example, following definition of environmental interface, such interface can be placed between natural or artificially built surfaces and atmosphere. This situation is typical over urban areas where the model grid-cell consists from different patches of underlying surfaces. Calculation of surface temperature of such grid cell is a difficult task. In the numerical modeling communities this is usually done by solving the energy balance equation. However, use of this method can be a source of many uncertainties particularly in surface schemes coupled with urban models. We will analyze these uncertainties using methods of nonlinear dynamics.

Since all the energy transfer processes occurs in the finite time interval the energy balance equation for environmental interface can be written in terms of finite differences of ground and air temperatures and then, under some conditions, further transformed into the logistic equation. In the case of the two interacting environmental interfaces, we have a higher-dimensional complex system. The chaos in a higher dimensional system is one of the focal subjects of physics today. One way, in studying this complex system, naturally leads to the model of coupled logistic maps with different logistic parameters. In this study, we report the results of numerical investigation on the system of two logistic maps, representing energy exchange on environmental interfaces in the grid-cell in urban models, with different logistic parameters. The analysis is supported by calculating the Lyapunov coefficient, for a broad region of the coupling parameter, which points out on the region where the chaotic fluctuations of surface temperature occur.

The vision of a long-term development of the Slovak society and the global cirisis

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Abstract. The long-term development of the Slovak society up to the year 2030 we understand not only as a future concept involving a single generation, but as a part of a future development within the great post-industrial transformation of the human civilisation. It is a deeply controversial process of its progress towards a higher level, which began in the middle of the last century and will continue even after the year 2030.

An analytical insight into the history of forming opinions of the future in the world and in Slovakia has allowed us to choose as our basic methodological approach for forming the vision a matching application of the concept of path dependency and the concept of path shaping. The first enables us to show how the past determines ongoing changes in the present and the bases of the future. The second expresses a possibility to project changes and co-create the future development orientation within specific limits.

A critical comparative generalisation of recent approaches toward defining determining megatrends of civilisation development has shown that at the beginning of the third millennium Slovakia is still within the industrial civilisation range, yet at the same time it is already being sucked into the whirl of the great post-industrial transformation, which represents a deeply controversial process of its progress towards a higher level of civilisation. In these terms, it is possible to identify two main lines of megatrends which will crucially influence the forming of humanity´s future in the next decades and also determine the claims in the adaptation of the Slovak society. The first is the general megatrend of the forming of a knowledge-based economy and society, the existential megatrend of quality and sustainability of life and other associated supporting megatrends.

The methodological approach applied in the Vision allows for the overcoming of the superficial and simplified understanding of the basis and causes of the processes addressed as the financial and economic crisis. In the context of the Vision and its findings, it is a case of a qualitatively new, unprecedented phenomenon – a global crisis. Its root causes and associations lie in an extremely uneven and controversial process of the forming of the knowledge-based economy and globalisation, with a primary influence of two most important differences: between the economy and the human, or the society and between the economy and nature, or the environment. The controversy economy – man is visible in the disproportion between the growing production of wealth and the deepening inequality of its division. The controversy economy – nature or environment is threatening with an apocalyptical denouncement. The turning point occurred at the turn of the 1980s and 1990s. The ecological footprint per capita started to exceed Earth´s biocapacity, global production and consumption exceeds by 25 % the reproductive capacity of our planet, with only 1/5 of the population consuming 90 % of natural resources.

An outstandingly explosive area was to become the one of the financial markets, with the globalisation´s recent appearance taking place most dynamically there and where it dangerously exceeds the limits of sustainable development. The combination of deregulation, liberalisation, ICT and an innovative diversification of financial products outstandingly accelerated the extreme asymmetrical expansion of financial markets.

The global financial and economic crisis represents an unprecedented qualitatively new phenomenon, in which civilisation antagonisms have exceeded a critical rate. Recent trends have already started clashing on absolute barriers of extreme deformation of demand and consumption. They are not merely an ethical problem but are becoming economically unsustainable. The crisis in full nudity displays the economic and moral perversity of various key aspects of the currently functioning form of the globalised world economy. The separation of economic processes from the controlling, regulating surveillance of states and the absence of forming adequate global institutions has opened up space for incorrect misleading behaviour of top management of corporations, banks, investment companies, audit and rating agencies, grey and black economy, tax havens and finally far-reaching deformations of market, demand and consumption functioning.

It seems that the unavoidable healing process, as a basis and overcoming of the global crisis demand that what the Roman club representatives visionarilly called the first global revolution in which the complexity and interconditionality of global problems calls for a globally coordinated activity.

Notices: