Czech Bioclimatological Society
Czech Hydrometeorological Institute
J. E. Purkinje University Ústí nad Labem
Czech University of Life Sciences Prague
Slovak Bioclimatological Society

BIOCLIMATE 2012
"Bioclimatology of Ecosystems"

International Scientific Conference

August 29th-31st 2012
Ústí nad Labem
Czech Republic

CONFERENCE PROCEEDINGS

Editors:
Věra Kožnarová
Soňa Sulovská
Lenka Hájková

Czech Bioclimatological Society (CBcS)
Czech Hydrometeorological Institute – Regional Branch in Ústí nad Labem
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Faculty of Science – J. E. Purkinje University Ústí nad Labem

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Contents

Ladies and gentlemen,

the collection of scientific texts that you are beginning to read contains contributions from the conference BIOCLIMATE 2012 - BIOCLIMATOLOGY OF ECOSYSTEMS, which is a further continuation of international conferences organized alternately by the Czech Bioclimatological Association and the Slovak Bioclimatological Association in collaboration with other organizations.

The topic of bioclimatology (biometeorology) is a common subject of our conferences, each of which has its narrower focus, similarly as in this collection of contributions, where you will find articles containing the current knowledge on the links between the atmospheric environment and organisms in different time periods. The articles focus on four main topics of the conference, namely agricultural and forestry climatology, as well as agroecology and climate change, aerobiology and phenology, human bioclimatology, zoobioclimatology, and finally a separate topic of urban climate variability.

We do not always realize that only the knowledge of mutual influence between organisms and their environment, allows us to carry out the necessary and appropriate action. Much required development of human society was and still is often treated as a procedure for the use of natural resources, regardless of the laws of nature, and thus the demands and needs of different ecosystems. Use of science and technology begins to gradually change from a sole attempt to reach economic development to nature-friendly and nature-like advancement, which means conditions of sustainable development should be appropriate also for human beings who are still bound to nature. This relationship is far more complex than just increasing the amount of crop yields, higher production of wood, etc. It is a negative phenomenon accompanying this form of science and technology that has led to the fact that we are trying to recognize linkage from microclimate to macroclimate so that we can design procedures to ensure needs of society while protecting nature.

Bioclimatology therefore addresses the extensive issue of possible climate change, its nature, impacts and possible measures. Inclusion of the urban climate variability into this topic may seem surprising to some of the readers. However, as evidenced by the recent bioclimatological research, the knowledge of urban climate is doubtlessly vital, taking into consideration that the global growth of urban areas and increase in urban population in at the expense of rural areas is an unquestionable fact. The topic does not include just the issue of urban pollution, their heat island, etc., but also the possibility of prevention of the extreme manifestations of urban meso- and microclimate.

We dare to hope that each of you found not only interesting findings in this collection of contributions, but also answers for questions from the field of bioclimatology, as well as ideas and inspiration for your next activity. We are looking forward to meeting you at the next scholarly and scientific events.

Jaroslav Rožnovský
On behalf of the organizers of the event

PHENOLOGICAL TRENDS REGARDING THE WILD TREES IN THE CZECH REPUBLIC

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Abstract. We have analyzed the results of phenological observations of wild trees in the Czech Republic in the years 1941–2011. Our results showed that the statistically significant warming trend since 1941 resulted in an earlier onset of the first flowering and beginning of leaf colouring of wild trees. The strongest trend to early arrival in spring was measured for the first flowering of the rowan for the period between 1941 and 2011 with over 16 days. Birch leaves have also changed colour somewhat earlier over the past 70 years.

Introduction

Phenological observations of plants have received increasing attention as a part of the research on climate change. For spring plant phenology in temperate zones that are not water limited, temperature is the predominant driving force for leafing, flowering and ripening phenology. Not only this, but it would also seem that the temperatures of the immediately preceding months are the important ones. An average earlier onset of plant phases of 3.8 days per 1 °C increase over the last decades has been observed for Europe, with negative shifts for spring and summer phases and positive shifts for fall phases.

Perennial cropping systems and trees are very vulnerable to climate change due slower rate of adaptation compared to the field crops. The problem of phenological observations is the use of new crop varieties and different time of sowing. Farmers can change cultivars from year to year, while perennial crops like fruit trees are often cultivated for decades and forest trees for even longer periods.

The present study, carried out by the Czech Hydrometeorological Institute, the Mendel University in Brno and the Czech University of Life Sciences, sought to chart phenological trends in response to climate in the Czech Republic in the period 1941–2011.

Material and methods

The Czech Republic is located in the central Europe and is characterized by a moderate, humid climate with the year divided into four distinct seasons. Corresponding phenological data have been taken from the PHENODATA database of the Czech Hydrometeorological Institute (CHMI) which contains systematic phenological observations from several dozens sites across the Czech Republic. Observations of phenophase dates (the beginning of flowering of *Corylus avellana*, *Betula pendula*, *Sorbus aucuparia* and *Tilia cordata*, beginning of leaf colouring of *Betula pendula*) for the Czech Republic were ascertained for the 1941–2011 period. In total, 32,124 phenophase dates from 80 sites were collected. The obtained temperature data underwent strict control and homogenization using AnClim software. For each year were calculated mean dates of phenophases for the Czech Republic using data from all available stations.

The average annual temperatures of the Czech Republic were taken from the Czech Hydrometeorological Institute CLIDATA database.

Results and discussion

Mean annual and mean monthly temperatures averaged over all phenology sites showed a positive linear trend for the period 1941–2011 with the largest increase in January (0.37 °C per decade) and the smallest increase in October (0.01 °C per decade) and December (0.01 °C per decade). Temperature increase during the spring (March-May) was 0.18 °C per decade while mean annual temperature increased by 0.11 °C per decade (Table 1). Trends were statistically significant ($P < 0.05$) for mean annual temperature, for the mean temperature in the period March to August, March to May, June to August and for the mean temperatures of the months January and May (Table 1).

Table 1. *Mean values Tmean (°C) and linear trends (°C per decade) of annual, seasonal (March-May, June-August, March-September) and monthly air temperatures of the Czech Republic during the period 1941–2011. Trends in bold are statistically significant (P < 0.05 and P < 0.1).*

	Tmean	**Trends**
JANUARY	-2.6	**0.37** (P < 0.05)
FEBRUARY	-1.3	**0.25** (P < 0.1)
MARCH	2.4	**0.20** (P < 0.1)
APRIL	7.5	**0.14** (P < 0.1)
MAY	12.5	**0.19** (P < 0.05)
JUNE	15.7	**0.11** (P < 0.1)
JULY	17.3	**0.12** (P < 0.1)
AUGUST	16.8	**0.12** (P < 0.1)
SEPTEMBER	12.9	**0.10** (P < 0.1)
OCTOBER	7.9	0.03
NOVEMBER	2.9	0.07
DECEMBER	-0.9	0.01
MAR-MAY	7.5	**0.18** (P < 0.05)
JUN-AUG	16.6	**0.12** (P < 0.05)
MAR-SEP	12.2	**0.11** (P < 0.05)
JAN-DEC	7.6	**0.13** (P < 0.05)

Temperature increases were associated with an earlier onset of wild trees phenological phases; not just the beginning but also the interval between successive phenological phases was shorter.

The statistical significance of the earlier first flowering of wild trees (*Corylus avellana*, 0.157 days/year, $P < 0.01$; *Betula pendula*, 0.124 days/year, $P < 0.01$; *Sorbus aucuparia*, 0.223 days/year, $P < 0.01$; *Tilia cordata*, 0.156 days/year, $P < 0.01$) and the earlier beginning of leaf colouring (*Betula pendula*, 0.124 days/year, $P < 0.01$) are evident in the period between 1941 and 2011 (Figure 1).

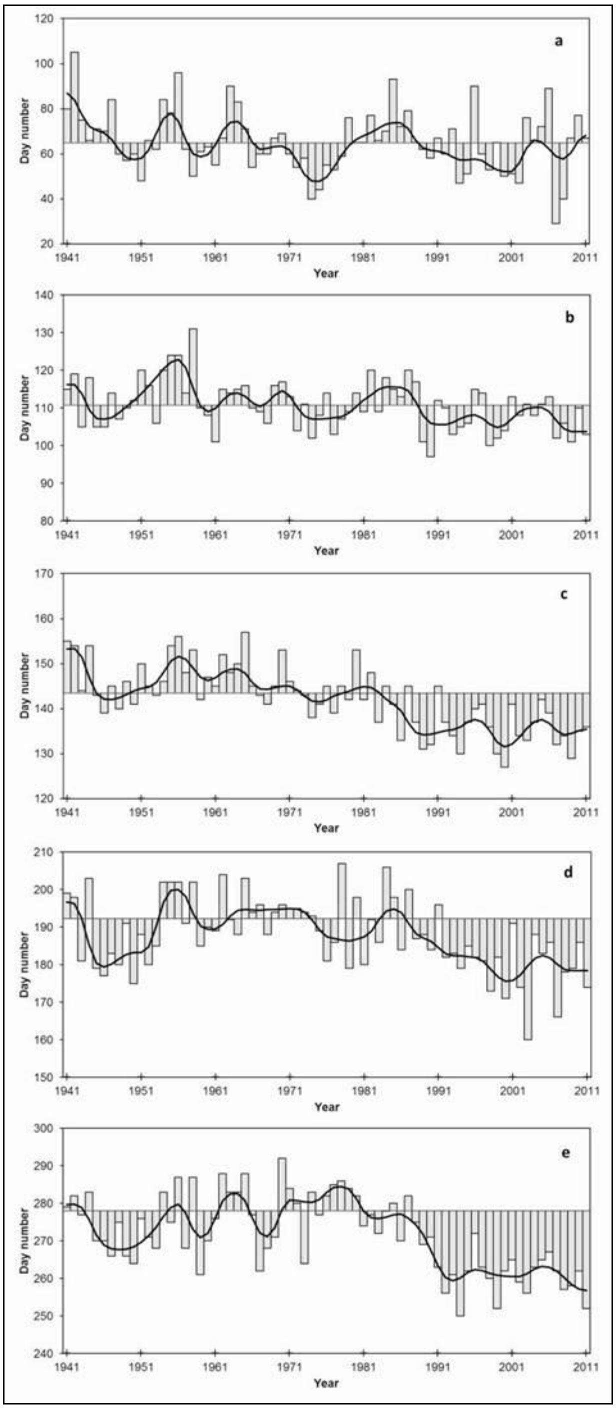

Figure 1. *The beginning of flowering of Corylus avellana (a), beginning of flowering of Betula pendula (b), beginning of flowering of Sorbus aucuparia (c), beginning of flowering of Tilia cordata (d), beginning of leaf colouring of Betula pendula (e) in the Czech Republic in the 1941–2011 period. Bars indicate deviations from the average value and 4253H filter has been used to show the underlying trend.*

In 19 of the past 20 years flowering (*Sorbus aucuparia*, *Tilia cordata*) were earlier than average. Similar trends in the natural flood plain forests have been recorded at other sites of the Czech Republic (e.g. Bauer *et al*., 2010; Možný and Nekovář, 2008) and Europe (Chmielewski and Rötzer, 2001).

The start of the earlier first flowering of wild trees depends on the weather patterns of the preceding months. The start dates for the earlier flowering were found to depend significantly on mean March-May temperatures (*Betula pendula*, R^2=0.72, $P < 0.01$; *Sorbus aucuparia*, R^2=0.63, $P < 0.01$; *Tilia cordata*, R^2=0.71, $P < 0.01$) and on mean January-February (*Corylus avellana*, R^2=0.79, $P < 0.01$) in the 1941–2011 period. The start date for the earlier beginning of leaf colouring of *Betula pendula* was found to depend significantly on mean March-September temperatures (R^2=0.53, $P < 0.01$).

Conclusions

We found a statistically significant negative relationship of the first flowering of wild trees with temperature. Increasing temperatures result in the earlier onset of the first flowering trees.

Over the past 70 years was reported in the Czech Republic an earlier onset of first flowering by 9 to 16 days.

The results reported here confirm the responsiveness of wild tree phenology, particulary of the first flowering, to temperatures. These facts help to confirm the value of tree phenology as a climate indicator.

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COMPARATIVE ANALYSIS OF PROJECTED DROUGHT INDEX TENDENCIES FOR CENTRAL/EASTERN EUROPE

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Abstract. Experiments of regional climate model PRECIS are used to evaluate the projected changes of several drought indices considering different emission scenarios (SRES B2, A1B, and A2). The results suggest drying trends for the 21st century in the region, especially, in summer.

Introduction

Regional climate models (RCMs) nested in global climate models (GCMs) can be applied to assess future trends of climatic conditions on national and regional scales. In this study, model PRECIS developed at the UK Met Office Hadley Centre is used for Central/Eastern Europe. The main focus is on the analysis of drought-related climatic conditions. For this purpose different types of drought indices (summarized in Dunkel, 2009) are used, namely, precipitation index (PI), standardized precipitation anomaly index (SAI), De Martonne aridity index (MAI), Thornthwaite index (TI), Lang's rainfall index (LRI), Ped's drought index (PDI), and Foley's anomaly index (FAI). In order to calculate the time series of these indices, monthly temperature and precipitation datasets of PRECIS simulations (Bartholy *et al*., 2009) were used. Simulations for the periods 1961–1990 (as the reference period), 1951–2100 (using the SRES A1B emission scenario), and 2071–2100 (using the SRES A2 and B2 emission scenario) are analyzed.

Material and methods

The RCM PRECIS is a high resolution limited area model with both atmospheric and land surface modules. The model was developed at the Hadley Climate Centre of the UK Met Office (Wilson *et al*., 2010), and it was adapted at the Department of Meteorology, Eötvös Loránd University (Budapest, Hungary). PRECIS is based on the atmospheric component of HadCM3 (Gordon *et al*., 2000) with substantial modifications to the model physics (Jones *et al*., 2004). The atmospheric component of PRECIS is a hydrostatic version of the full primitive equations, and it applies a regular latitude-longitude grid in the horizontal and a hybrid vertical coordinate. The horizontal resolution can be set to 0.44° × 0.44° or 0.22° × 0.22°, which gives a resolution of ~50 km or ~25 km, respectively, at the equator of the rotated grid (Jones *et al*., 2004). In our studies, we used 25 km horizontal resolution for modeling the Central European climate. Hence, the target region contains 123×96 grid points. There are 19 vertical levels in the model, the lowest at ~50 m and the highest at 0.5 hPa (Cullen, 1993) with terrain-following σ-coordinates (σ = pressure/surface pressure) used for the bottom four levels, pressure coordinates used for the top three levels, and a combination in between (Simmons and Burridge, 1981). The model equations are solved in spherical polar coordinates and the latitude-longitude grid is rotated so that the equator lies inside the region of interest in order to obtain quasi-uniform grid box area throughout the region. An Arakawa B grid (Arakawa and Lamb, 1977) is used for horizontal discretization to improve the accuracy of the split-explicit finite difference scheme. Due to its fine resolution, the model requires a time step of 5 minutes to maintain numerical stability (Jones *et al*., 2004).

The initial and the lateral boundary conditions of PRECIS are provided by the HadCM3 ocean-atmosphere coupled GCM. PRECIS is able to sufficiently reconstruct the climate of the reference period in Central/Eastern Europe (Bartholy *et al*., 2009). Temperature and precipitation bias fields of the PRECIS simulations can be considered acceptable if compared to other European RCM simulations (Jacob *et al*., 2007, Bartholy *et al*., 2007). Therefore, model PRECIS can be used to estimate future climatic change of the Central/Eastern European region. For the future (2071–2100), three experiments have been completed so far, namely, considering SRES A2, B2, and A1B global emission scenarios (Nakicenovic and Swart, 2000). A2 scenario is the least optimistic and B2 is the most optimistic, which is indicated by the CO_2 concentration level projected for 2100 (856 ppm and 621 ppm, respectively).

Results and discussion

Due to page limit, only one drought index is analyzed here, namely, Thornthwaite (1948) Index, which is an often used agrometeorological index type. Besides precipitation (*P*), it considers an important agricultural effect, the evaporation determined from temperature (*T*). Index value (*TI*) for a given *i* month can be calculated as follows:

$$TI_i = 1.65 \cdot \left(\frac{P_i}{T_i + 12.2} \right)^{\frac{10}{9}}.$$

Due to the definition, this formula may result in spurious values in winter (when the monthly mean temperature is less than -12.2 °C). Different climatic conditions can be categorized on the basis of TI as shown in Table 1.

Table 1. *Climatic conditions represented by Thornthwaite Index.*

Interval (mm/°C)	Climatic condition
6.4 < TI	Wet
3.2 < TI < 6.4	Semi-arid
1.6 < TI < 3.2	Dry
TI < 1.6	Very dry

In general, the index values are projected to decrease in all seasons for the entire region, which implies drier climatic conditions in the future compared to the reference period. The largest decrease (i.e., the largest drying trend) is likely to occur in summer, for which the spatial pattern of simulated changes are shown in Figure 1. Larger decrease is projected for the higher elevated mountainous regions of the target domain than for the lowlands. Considering the scenarios, the patterns are similar but the largest changes are projected in case of A2.

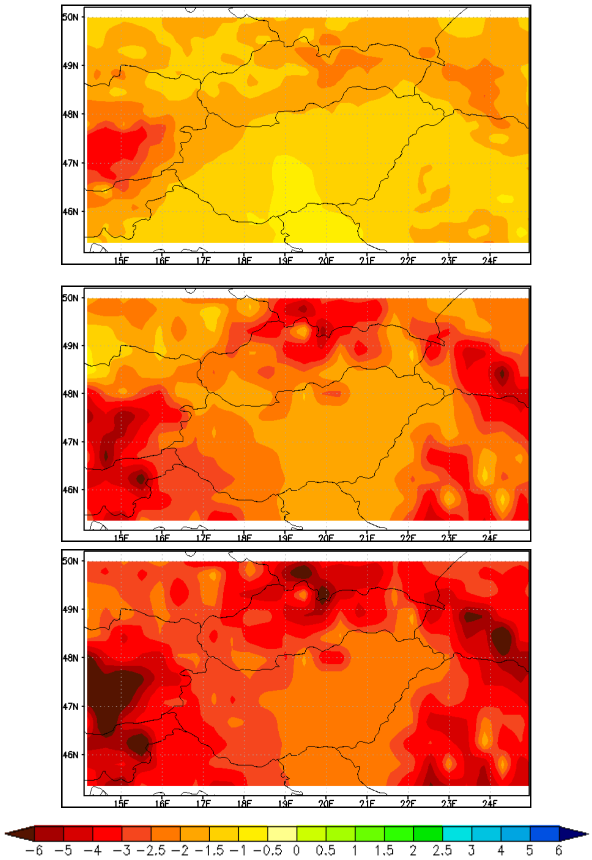

Figure 1. *Spatial structure of the projected summer change (mm/°C) of the Thornthwaite index for the three scenarios (A1B: top, B2: middle, A2: bottom) by 2071–2100 relative to 1961–1990 reference period.*

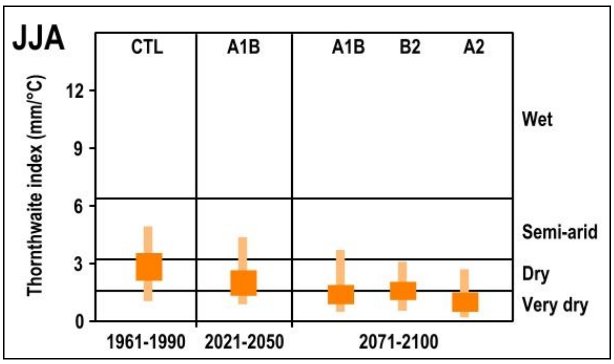

Figure 2. *Simulated Thornthwaite index values for Hungary in summer. The box indicates the upper and lower quartiles of the spatial average values; the line is drawn from the minimum to the maximum values.*

Among the simulated seasonal time series of the Thornthwaite index summer is shown in Figure 2 as being the most important part of the year from the agricultural and drought points of view. The Box-Whisker plot diagram is drawn on the basis of the spatial average values for the 229 grid points located within Hungary. The drying trend can be clearly recognized, as well, as the decreasing interannual variability (which is represented by the entire interval calculated from the minimum and maximum index values). The climatic conditions were mostly dry in the reference period, whilst they are likely to shift into very dry category by the end of the 21st century.

Conclusions

In this paper the main focus was on the analysis of drought-related climatic conditions (represented by various drought indices) using the results from experiments of the RCM PRECIS. The results suggest that the summer climate of Central/Eastern Europe is projected to become remarkably drier during the 21st century.

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THE RESPONSES OF TWO RESIDENT AND ONE LONG-DISTANCE MIGRANT BIRD SPECIES TO WEATHER CONDITIONS IN THE CZECH REPUBLIC

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Abstract. This analysis includes three bird species: *Sitta europaea* L., *Parus major* L., and *Ficedula albicollis* T. The data were available for the period from 1961 to 2008 from 3 locations in Czech Republic (centered on 48°48' N, 16°46' E). *S. europaea* and *P. major* are residents, *F. albicollis* is long-distance migrant species and their phenological development (terms of laying eggs) passed over the different time periods during spring. Phenological phases of birds´ populations were analyzed and the shifts in the phenophases and also response to climate conditions differed among the bird species.

Introduction

It is evident that the temperature across Europe is changing. Rosenzweig *et al*. (2008) mentioned that 90–94 percent of significant changes are consistent with warming in physical and biological systems (e.g., migration and the timing of the reproduction of various bird species) across Europe. Many studies have investigated the relationships among weather-related variables and the influence of climate change on bird populations (e. g. Crick *et al*. 1997). Indeed, several papers studied different response of migrants and residents and most of them have shown that long-distance migrants have advanced their phenology less than short-distance migrants or residents in recent decades (e. g. Rubolini *et al*., 2010; Goodenough *et al*., 2011). Equally there are some papers which published that long-distance migrants significantly shifted their time of eggs laying while residents did not significantly change their timing of eggs laying (Rubolini *et al*., 2007). So there can be little doubt that migrants and also resident´s responses to a warming climate specifically (Jenkins and Sparks, 2010). So we assumed that the phenological development of migrants and residents differ among each other. Therefore our main goal was to evaluate if there is any differences between timing of phenophases among residents and migrant. Next goal was to determine the relationship among timing of phenophases and meteorological parameters at experimental sites.

Material and methods

The observation of the phenology of the resident species *Sitta europaea* and *Parus major* and the migrant species *Ficedula albicollis* took place at three experimental sites in southern Moravia: Lanžhot, Lednice and Vranovice. All of these sites included fully grown, multi-aged canopies. Additionally, they were characterized by similar meteorological conditions and exhibited low variability in precipitation. The observations were carried out from 1961 to 2008 and two phenological phases (for *S. europaea*, *P. major* and *F. albicollis*) were chosen and evaluated. 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 in a given year. The MLD phenophases were calculated to obtain more robust datasets for the entire population at each site, and the value of the MLD in each year at a given site was determined for 3 to 9 pairs of *S. europaea*, 15 to 18 nesting pairs of *P. major* and 13 to 15 pairs of *F. albicollis*. Because none of the experimental sites included its own meteorological station (the closest were 4–15 km away), daily meteorological data were interpolated using the ProClimDB software package. The interpolation procedure employed a detailed digital terrain model in combination with meteorological data from 130 weather stations in the Czech Republic and 25 stations in adjacent regions of Austria. The daily data from each station were quality controlled, homogenized and interpolated using the method of regionally weighted regression. The significance of the observed trends for both the climatological and the phenological parameters was assessed using a t-test. The correlation between the phenological stages of each bird species and also between phenological stages and temperature series was assessed using Spearman correlation coefficients, which were calculated for 20-year subsamples (e.g., determining the correlation between the phenological phases in 1951–1970 and a particular weather parameter in 1951–1970 and then finding the same correlation for the years 1952–1971, the years 1953–1972, etc.). Thus it was possible to evaluate the correlations that existed during the entire period.

Results and discussion

At all of the experimental sites the values showed an increase in the mean, maximum and minimum temperatures in the first half of the year. The mean annual air temperature showed a significant increase of 0.19–0.22 °C per decade for a period of 48 observational years at all three experimental sites. Nearly identical warming trends in the mean temperature were recorded during March and April. Overall, very similar temperature increases were also confirmed during March, April and throughout the year for the maximum and minimum temperatures.

Based on the observed terms of the FLD and MLD phenophases from 1961 to 2008, reproductive activity was first observed for the population of *S. europaea* (the average dates of the FLD and MLD were between days 94 and 119, respectively), then for the *Parus major* population (with values between days 101 and 120, respectively) and finally for the *Ficedula albicollis* population (with values between days 108 and 138, respectively). There were distinct long-term differences between the earlier- and later-reproducing species with respect to statistical significant shifts in the MLD phenophases. The onset of the *F. albicollis* phenophases, which shifted by 1.9 days per decade on average, advanced more than that of the *P. major* and *S. europaea* phenophases, which shifted by 1.5 days and 1.6 days per decade on average. There were no long-term trend toward earlier breeding for *S. europaea* (Wesołowski and Cholewa, 2009), while *P. major* showed significant acceleration in its breeding season (e.g. Visser *et al*., 2003) and also *F. albicollis* exhibited earlier start dates for nesting (e.g. Both *et al*., 2004). Anyway some papers mentioned no shifts in phenology of *P. major* and *F. albicollis* (e.g. Both and Visser, 2001; Ahola *et al*., 2004). Some papers dealt with response of migrants and resident and more papers agreed on the fact that residents and also short-distance migrants reacted to the warming strongly and shifted in phenology significantly that long-distance migrants (e.g. Rubolini *et al*., 2010; Palm *et al*., 2009). What is contra to our results; anyway some studies showed similar trend in shifting as our results (Rubolini *et al*. 2007).

Different rate of shifting in phenology in our study also confirmed different values of correlation coefficients between pairs of phenophases of each bird species in 20-year subsamples (e.g. correlation between MLD phenophases among *S. europaea* and *P. major* in 1961–1980, 1962–1981 etc.) (Figure 1).

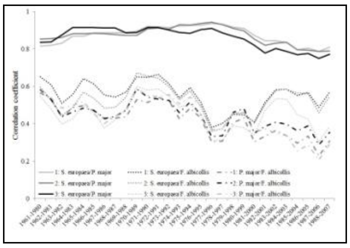

Figure 1*. Spearman correlation coefficient values for moving 20-year windows for pairs of the MLD phenophases among Sitta europaea, Parus major and Ficedula albicollis.*

Strong and consistent correlation between phenophases of two species was calculated for MLD phenophases of *S. europaea* and *P. major*. Weaker correlation was assessed for pairs of *P. major* and *F. albicollis* and also *S. europaea* and *F. albicollis*. Moreover, the correlation between each pairs of bird species is getting lower since the eighties. The coefficients showed weaker correlation between pairs of residents with long-distance migrant and so the different response and timing among bird species in our study.

The terms of phenophases were correlated with meteorological parameters. The highest values of coefficients were calculated (for all three bird species) for average temperature during time period of two months – March and April – MA in 20-year subsamples (Figure 2). Correlation for *S. europaea* and *P. major* with temperature in MA period developed in almost same rate; by contrast *F. albicollis* correlated with average temperature in MA period differently and also with higher variability. This could be explained by the fact that the migrants may be unable to respond to climate conditions at their breeding grounds in the same way as residents because they do not experience local environmental conditions until migration has been completed, or because of limited plasticity in response to environmental variation (Rubolini *et al*., 2010).

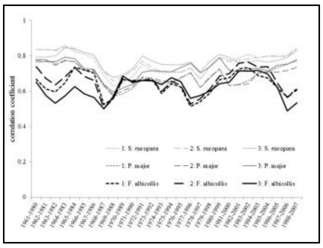

Figure 2. *Spearman correlation coefficient values for moving 20-year windows for pairs of the mean daily air temperature during the March and April (MA) period and the MLD phenophases of the Sitta europaea, Parus major and Ficedula albicollis.*

Conclusions

Our hypothesis about different response of migrant and residents to warming climate was confirmed. Not only the shifting in phenology but also the reaction to local temperature conditions differed among the three studied bird species.

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THE ONSET AND DURATION OF VEGETATIVE PHENOLOGICAL STAGES IN A SPRUCE MONOCULTURE

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Abstract. Vegetative phenological stages were evaluated in spruce monoculture of the third age class in the region of the Drahanská vrchovina Upland. Evaluation of the 21-year period shows that onsets of phenological stages in particular years differed markedly. The onset and duration of phenological stages differed in particular years, depending on the course of weather. The start of budbreak and foliation is affected by air and soil temperatures, which also proved by statistical evaluations. High dependence between the onset of budbreak and air temperatures is confirmed by statistically significant correlation coefficient. Results show that in recent years, the earlier onset of spring phenological stages occurs at higher sum of effective temperatures. The length of their duration shortens.

Introduction

The phenology of forest tree species can be used at the evaluation of the effect of actual conditions of the environment on the development of plant communities and thus, to contribute to the discussed problem of climatic changes, their impacts on the species composition and health conditions of forest ecosystems. Due to warming, changes in the development of forest tree species and herbs can also occur. Therefore, plants can be considered to be bioindicators of climatic changes (Škvareninová, 2009; Bednářová and Merklová, 2011). Thus, effects of climatic changes on forest stands are a long – term phenomenon requiring continuous phenological monitoring. Phenological data are a certain expression of the climate character of a given region. Developmental stages of a biota occur every year but in various terms and with a different intensity because they characterise time-variable conditions of the environment, particularly the course of weather in particular years. The beginning and course of particular phenological stages are substantially affected by meteorological factors, namely air temperature, because through its effects the growth and development of plants can be accelerated or slowed down. In addition to the air temperature also the temperature and moisture of soil are considerably important.

Material and methods

Phenological stages of a pure spruce stand (the 3rd age class) were monitored on a research area of the Department of Forest Ecology (Mendel University in Brno) for a period of 21 years (1991–2011). The research area is determined by 16°41'30" E longitude and 49°26'31" N latitude coordinates in the geographical unit of the Drahanská vrchovina Upland. The air temperature in a stand was monitored by means of Datalloger Minikin T sensor placed at the lower margin of crowns. To measure soil temperatures a Micro-Log SP sensor was used at a depth of 20 cm. To each of the phenological stages, sums of mean daily air temperatures were calculated at a threshold value of 0 °C and 5 °C and sums of the soil temperature at a threshold value of 1 °C.

Results and discussion

Evaluation of temperature sums showed that in the region of the Drahanská vrchovina Upland, it was most suitable to use the sum of air temperatures > 5 °C and at soil temperatures values > 1 °C. Air and soil temperatures were measured just in the monitored spruce stand.

The long-term monitoring of particular phenological stages showed that the beginning of the Norway spruce (*Picea abies*/L./Karst.) budbreak occurred in the studied region on average the 124th day from the calendar year beginning. The most frequent beginning of budbreak was noted the 118th day and latest the 133rd day. The beginning of foliation from 10 % was on average the 129th day. It was most frequent the 121st day and latest the 137th day. A stage of the beginning of foliation from 50 % was on average the 133rd day within the 21-year period. This stage was noted first the 124th day and latest the 142nd day. The beginning of foliation from 100 % occurred on average the 137thday. This stage occurred first the 129th day and at the latest the 146th day, A phenological stage of the fully unfolded leaf area occurred on average the 164th day from the year beginning. This stage showed, however, the longest time span in the monitored period. First, it was detected the 138th day and at the latest the 175th day.

The beginning and duration of monitored phenological states differ in particular years depending on the course of weather. The beginning of flushing and foliation are affected by the air and soil temperature, which was also proved by statistical evaluations. A high dependence between the beginning of budbreak and air temperature is confirmed by statistically significant coefficients R^2 = 0.854. Also Luknárová (2001), Braslavská and Kamenský (1999), Bednářová and Kučera (2002) mention high correlation between the onset of the stage of budbreak at Norway spruce and air temperatures. The dependence of the beginning of budbreak on the temperature of soil is confirmed by a correlation coefficient R^2 = 0.658. The dependence of the beginning of foliation on air temperature results from a correlation coefficient R^2 = 0.687. The foliation of Norway spruce was also dependent on the soil temperature R^2 = 0.650.

Results obtained show that also the temperature of soil considerably affects the budbreak and the onset of foliation of spruce. Lawander *et al*. (1973), Timmis and Worral (1974) came to the same conclusion. The rate of variability between the air temperature and soil temperature was depending on R^2 = 0.864.

Conclusions

The beginning and duration of phenological stages change according to the characters of weather in particular years. Results obtained show that in addition to genetic factors, the onset and duration of particular phenological stages are particularly affected by air and soil temperatures before the onset of a respective phenological stage. The onset and duration of spring phenological stages on the monitored area are particularly dependent on air and soil temperature because this area is not endangered by the critical lack of precipitation in the spring season. These decisive stages cannot be separated from each other and it is necessary to evaluate them as a whole. The long-term monitoring of vegetative phenological stages in a spruce monoculture in the Drahanská vrchovina Upland shows that recently, the onset of spring phonological stages occurs at higher sums of effective temperatures and shortening their duration. Phenology of forest tree species can be used at the evaluation of the effect of topical environmental conditions on the development of plant communities and thus to contribute to the discussed question of climatic changes and their impacts on the species composition and health conditions of forest ecosystems.

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ATMOSPHERIC PRECIPITATION IN THE HIGH TATRA MTS., SLOVAKIA (1961–2011)

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Abstract. Homogenised precipitation data (1961–2011) measured at selected rain gauge stations was used for investigation of long-term variability and spatial-temporal characteristics of precipitation in the High Tatra Mts. Daily precipitation totals usually fluctuated around mean values of 4–7 mm and achieved maxima between 80–150 mm in dependency on position and elevation of stations. Seasonal course showed high rainfall totals around 550 mm at sites Skalnaté Pleso (1,778 m a.s.l.) and Tatranská Javorina (1,013 m a.s.l.) in the middle altitude zone during summer months (JJA) while dominant seasonal totals about 300–400 mm at high altitude station Lomnický štít (2,735 m a.s.l.) were recorded during remaining parts of the year. Regression analysis indicated statistically significant correlation and increase in course of mean annual totals for 4 from 6 sites. Slightly enhance was noticed for stations situated in elevation zone from 1,000–1,800 m a.s.l. (Tatranská Javorina, Skalnaté Pleso, Štrbské Pleso). On the other hand, evidence of increasing tendency at Lomnický štít suggests relevant precipitation addition in zone above atmospheric boundary layer during last two decades. Gradually growth of precipitation with altitude described by obtained relations may be useful for regional spatial interpolation analysis. Comparison of two periods including interval before (1961–2004) and after (2005–2011) devastative windstorm in 2004 show higher mean annual precipitation totals about 8–39 % for interval covering after windstorm period.

Introduction

Long-term series of precipitation data obtained in mountain regions are relevant source for study of climate variability in different vertical zones of lower troposphere. Vertical climatic zones in the Polish western Carpathians studied Hess (1965) and then Konček *et al.* (1974) in frame of study focused on the High Tatras climate. Existing network of precipitation stations in the Slovak part of the High Tatra Mts. includes sites situated in elevation profile from 700 to 2,635 m a.s.l. In this profile, climatic data series covering period 1961–2011 are available for selected representative locations.

The aim of this paper is to describe long-term precipitation characteristics and tendency of mean annual precipitation totals at representative climatological stations in region of the High Tatra Mts. Furthermore, precipitation changes after extraordinary windstorm event in 2004 that devastated large forested area is also included in this work.

Material and methods

Data of daily precipitation totals (> 0.1mm) measured at selected sites in the High Tatras region (Table 1) by standard rain gauge (collecting area of 500 cm^2) was used for evaluation of precipitation characteristics covering period 1961–2011. Statistical tools of Statgraphics package were applied for processing of data. Summary statistics related to daily, monthly, seasonal and annual courses were calculated for each station. Data quality control and test of homogeneity ProcClimDB (Štepánek *et al.*, 2009) showed a significant discontinuity for peak station Lomnický štít in the year 1991, which was solved by adjusting the relatively low values in the years 1961–1990.

Table 1. *Rain gauges position.*

Measurement sites		Latitude N	Longitude E	Altitude [m a.s.l.]
LS	Lomnický štít	49°11' 43"	20°12' 54"	2,635
SkP	Skal. Pleso	49°11' 22"	20°14' 04"	1,778
TL	T. Lomnica	49°09' 52"	20°17' 17"	827
PP	Poprad	49°04' 08"	20°14' 44"	694
StP	Štrbské Pleso	49°07' 10"	20°03' 48"	1,322
TJ	T. Javorina	49°15' 47"	20°08' 37"	1,013

Results and discussion

Table of summary statistics and Box-and-Whisker Plots (minimum, quartile, median, upper quartile, maximum) describe variability of precipitation totals (PT) related to daily (Table 2, Figure 1), seasonal (Table 3, Figure 2) and annual (Table 4, Figure 3) values.

Table 2. *Daily PT summary statistics 1961–2011: increase of mean values from basin (PP 3.9 mm) to high altitude (LS 7.0 mm) positions; high variation of data for all sites (coefficients of variation CV >1); nearly similar maxima (>140 mm) at station SkP and TJ in the middle altitude zone.*

PT [mm]	LS	SkP	TL	PP	StP	TJ
Count	10,954	10,468	8,537	7,827	10,588	9,598
Average	7.0	6.6	4.7	3.9	4.9	6.9
St.Dev	8.5	9.4	6.6	5.9	6.8	9.9
CV	1.22	1.44	1.40	1.52	1.38	1.43
Maximum	91.8	144.5	83.2	79.3	100.8	147.1

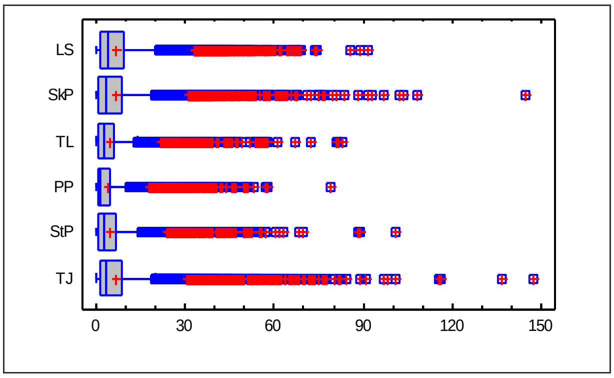

Figure 1. *Daily PT measurements 1961-2011: median (50th percentile, line inside rectangle) under 5 mm; upper quartile (75th percentile, right side of rectangle) under 10 mm; rarely occurrence over value of 70 mm (PP), 80 mm (TL), 90 mm (LS, StP) and 140 mm (SkP, TJ).*

Table 3. Seasonal PT averages 1961–2011: winter minima from 76 mm (PP) to 206 mm (StP) and summer maxima from 244 mm (PP) to 559 mm (SkP) except for LS; relatively small interseasonal ratio (1.22) at high altitude position (LS).

PT [mm]	LS	SkP	TL	PP	StP	TJ
Winter (DJF)	361	197	108	76	206	181
Spring (MAM)	379	302	187	146	244	307
Summer (JJA)	442	559	325	244	350	545
Fall (SON)	312	287	174	130	222	265
Summer/Winter	1.22	2.83	3.01	3.21	1.70	3.01

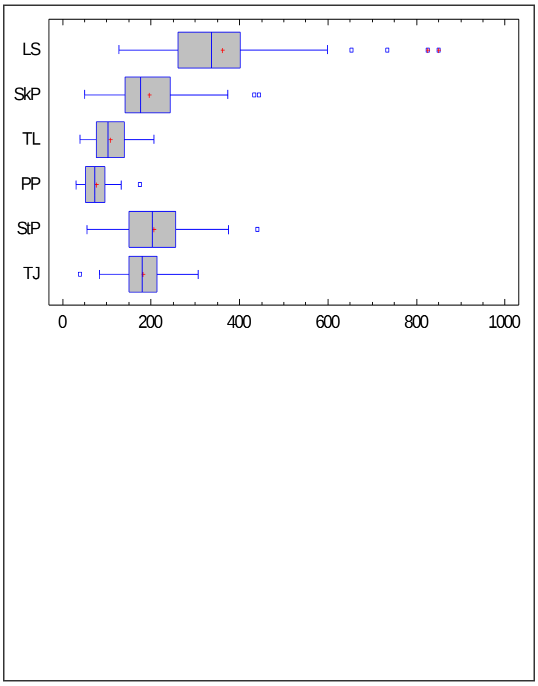

***Figure 2.** Seasonal PT characteristics 1961–2011: precipitation scarcity in winter and abundance in summer; substantially shift forward in case of upper quartile (75th percentile, right side of rectangle) and maxima in zone of atmospheric boundary layer (SkP, TJ) in comparison with high altitude zone (LS).*

Table 4. Annual PT summary statistics 1961–2011: long-term annual means > 1,000 mm at sites with altitude over 1,000 m a.s.l. (StP, TJ, SkP, LS) around 2 times higher than for basin (PP) and foothill (TL) sites; similar dispersion of the variable corresponding to coefficients of variation (CV=0.16) for foothill (TL) and uphill sites (SkP, StP, TJ); range of annual minima from 414 to 924 mm; scale of annual maxima between 997 and 2,400 mm; positive correlation coefficients suggest slightly increase tendency of annual totals during considered period; statistically significant linear regressions for stations situated above 1,000 m a.s.l. (LS, SkP, StP, TJ), especially for LS.

PT [mm]	LS	SkP	TL	PP	StP	TJ
Annual mean	1,494	1,346	794	597	1,022	1,299
St.Dev	380	217	129	109	168	208
CV	0.25	0.16	0.16	0.18	0.16	0.16
Minimum	893	924	558	414	691	908
Maximum	2,400	1,955	1,103	997	1,449	1,839
Correlations	0.682	0.396	0.162	0.200	0.365	0.430
P-value	0.000	0.004	0.257	0.159	0.009	0.002

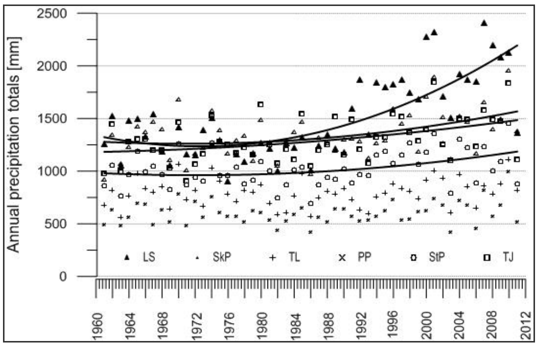

***Figure 3.** Annual PT (points) covering period 1961–2011: polynomial lines illustrate statistically significant increase of annual PT (P-value <0.05 in Table 4), markedly for high altitude site LS.*

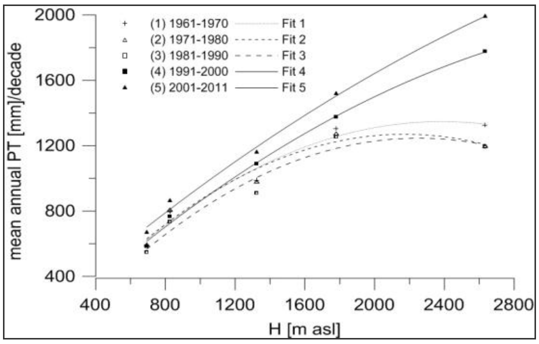

***Figure 4.** Vertical profile of mean annual PT (points) covering selected decades of period 1961–2011: polynomial lines illustrate markedly shift for zone above 1,800 m a.s.l.*

Table 5. Comparison of mean annual PT covering periods before (B) and after (A) windstorm in 2004 with damage effect on forest: 7.9 % increase for directly affected site (TL); 10–14 % increase for other sites under 1800 m a.s.l.; markedly 40 % growth in high altitude zone (LS) influenced by global atmospheric circulation more than by local conditions.

PT [mm]	LS	SkP	TL	PP	StP	TJ
B: 1961–2004	1,417	1,320	786	585	1,009	1,274
A: 2005–2011	1,975	1,504	848	668	1,108	1,456
A/B [%]	39.4	13.9	7.9	14.1	9.8	14.3

Conclusions

Presented results based on measurement of precipitation in the High Tatra Mts. region (1961–2011) suggest high abundance of precipitable water in the high altitude zone (above 2,000 m a.s.l.) of the lower troposphere in central part of Europe during last two decades. Complex study of climate zones requires cooperation and data from both Slovak and Poland part of the High Tatras.

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METHODOLOGY OF CLIMATE CHANGE ADAPTATION IN THE CZECH REPUBLIC

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Abstract. Climate change in one way or another affects every sector of our society. Only those companies in history, which are adapted to ongoing changes, had a chance to succeed. It is impossible to generalize impacts of climate change in different areas and take some universal solution. Our goal is to help users of landscape with searching for appropriate and available measures that would help them to adapt to up going changes. The measures must be simple and designed with the specifics of each location. Therefore, we use models of climate characteristics, along with knowledge of local farmers.

Introduction

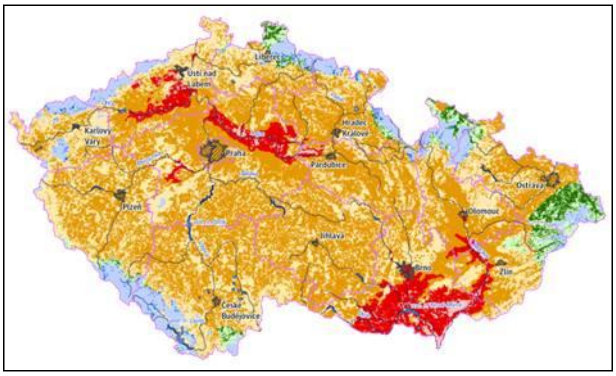
Our society gradually adapts on climate change. If twenty years ago climate change was an interesting theory, ten years ago it aroused doubts and concern of politicians and others. Today we take it as fact and we are trying to get more information so we can prepare for the consequences of climate changes. Speaking about future development, we mean the future for 10 to 50 years. For the closer future is not generally possible to implement the described measures in time. However, for the far future are the predictions and models still too inaccurate. Even today there is a refinement of estimates of future climate development. Therefore, we consider a time horizon of 2025, 2055 and as the most distant year we predict the 2085.

The aim of the described project is to create an Adaptation guidebook of climate change that would help the end users (mayors, farmers and other users of landscape) to identify appropriate adaptation measures. These measures would help to reduce negative effects of climate change. Positive impacts could be used more efficiently. It is clear that, whatever the consequences of climate change may be, it is better to be prepared!

Material and methods

The objective and originality of our solution is the solution from below. It shows that the general solutions in specific cases not always work and is not expected interventions of central power (ministries, EU...). Therefore we propose most of the measures with a local effect, which can be carried out quickly, flexibly and at lower cost. Such measures may establish and finance their own end-users of landscape and farmers.

Even within the relatively small country, like the Czech Republic are significant regional differences. There will be different impacts of climate change in mountain and foothill areas, or in the lowlands, the agricultural regions, large rivers in the basin. Other impacts are seeing in the urbanized landscape, in other areas with a large proportion of biodiversity and natural ecosystems. Therefore we try to divide the territory of the Czech Republic to several regions, where the impacts of climate change should be similar. This division was established on the basis of climatic regions according to climatic atlas of the Czech Republic (Tolasz *et al.*, 2007) and the extent of human impact (land use). As the following map show, we have divided Czech Republic into eight regions (Bolom *et al.*, 2011).



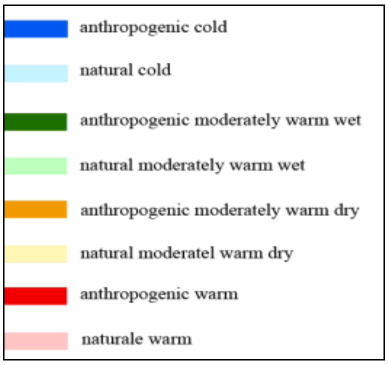


Figure 1. *Division of Czech Republic into eight regions.*

The main input data for the process are field research (information from mayors, farmers and other users of the farming area), measured data from climate stations on catchment areas and also modeled climate data. These are the values of temperature, precipitation and runoff in the required time frames.

Based on these inputs is always specified a catalog of possible (expected) impacts of climate change on the solution area.

For these effects will be designed appropriate adaptation arrangements from catalog of measures which will mitigate impacts of future climate for a specific catchment. Then, these measures will be implemented and realized by end-users of river basin.

Impacts of climate change on river basins are collected in several ways.

On the basis of measured values of temperature, rainfall and rate of flow at closure profile, time series were created showing a trend in progress of these measured values in the area. These data can also show a quantity of extreme climatic events. By modeling of these measured values according to the probable development scenarios we can obtain data for the future. As an input data we used data from SRES A1B scenario.

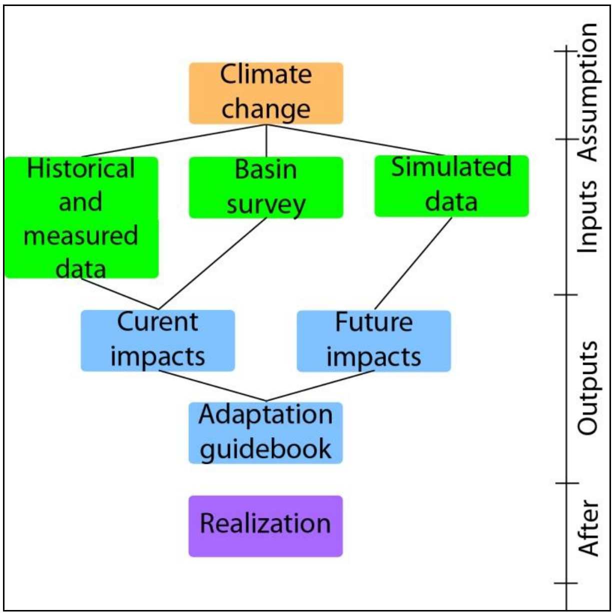


Figure 2. *Diagram of the project.*

Field surveys were conducted on each basin. At this point we focused on morphology, finding problematic locations and existing adaptation measures. We also consulted with end users, what changes or problems they observe.

Potential adaptation arrangements will serve in the future. It was necessary to simulate a future date to find out what requirements will be placed on adaptation arrangements.

For modeling data was used Bilan, the water balance model (Horáček *et al.*, 2009) which works with the river basin as a closed unit. Bilan models data in monthly or daily steps. After modeling, we have data for reference years 1975, 2025, 2055 and 2085.

Results and discussion

In a present time a particular pilot watershed are solved. These watersheds represent each types of climate region of Czech Republic. Impacts of climate change were observed in every visited catchment. This proves that this project is actual and necessary. It also proves that the impacts are within catchments very similar, demonstrations of climate development are typical for these locations, and it is possible to assume similar affects also on other catchments with character a like observed ones.

On individual watersheds were observed impacts of climate change, which were expected, such as divergence of weather, frequent occurrence of floods, increasing occurrence of ticks on higher altitude, frequent dry period and increasing requirements of irrigation. By a field observation were found some problems that weren't expected from modeling or character of catchment itself such as drying of wetland areas known for accumulation of water (Lipták, 2011).

Our aim is to increase the number of explored pilot catchments, ideally, by 2–3 pieces for each climatic region. This will help to create more complex catalog of possible impacts of climate change which is necessary for proper adaptation arrangements project. This also means a detailed field surveys on 24 catchments (about 100 km^2) and ensuring of necessary climatic data for all those catchments and its modeling and evaluation.

The result is a design of suitable arrangements for concrete areas. These arrangements should be suggested as a simple with a local impact, for example revitalization arrangements of water bodies within complex land adjustments, arrangements against erosion and also arrangements and changes in favour of higher ecological stability of a landscape.

Conclusions

An Adaptation guidebook of climate change should serve as a tool for mitigation of its negative affection. We have to plan for climate change in future and it will be our advantage if we know about them and if we get ourselves ready for them! This Guidebook should ease decision making about timely acceptance of protection measures with a final land users, for example mayors, water managers, farmers, etc. This project is focused on Czech Republic but its principle of a detection of input data and a suggestion of protection measures is applicable in other countries, which would consider an adaptation, as well. A local protection measures are usually very effective and practicable unlike global suggestions of mitigate solutions even in their partial measure. This is the biggest advantage of local protection measures and their application.

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ASSESSING THE REGCM3 PERFORMANCE IN SIMULATING WINTER AND SUMMER TEMPERATURE AND PRECIPITATION OVER THE REPUBLIC OF MOLDOVA

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Abstract. In this paper we present a validation analysis of the recent past climate simulation over the Republic of Moldova with the Abdus Salam International Centre for Theoretical Physics (ICTP) regional climatic model RegCM3, one of the CECILIA (Central and Eastern Europe Climate Change Impact and Vulnerability Assessment) high resolution RegCMs. The analysis refers to the ability of the RegCM3 to simulate winter and summer temperature and precipitation over the Republic of Moldova for the period 1960–1997.

Introduction

The Republic of Moldova is one of the Eastern Europe countries affected by the climate change. It is likely to experience a diverse range of impacts on various socio-economic sectors due to temperature increases accompanied by extreme precipitation (dry and wet events). Moldova´s climate is moderately continental. The winters are relatively mild and dry, with temperatures ranging from -3.0 °C in the north and -1.4 °C in the south and winter total precipitation averaging 104 mm. The summers are warm and long, with temperatures averaging about 20.0 °C and total precipitation ranging from 230 mm in the north and 182 mm in the south, respectively.

Studies with different greenhouse gas emission scenarios show that Europe is one of the Earth's most sensitive regions to global warming (Giorgi, 1993) and the Romania and Moldova are located in a transition region of the precipitation change pattern.

High resolution climate model simulations are thus needed to provide accurate climate change scenarios accounting for this complex spatial and temporal modulation of the climate change signal.

The project CECILIA (Halenka, 2010) was thus developed to produce higher resolution simulations over different sub-regions of Central and Eastern Europe, including Romania and Republic of Moldova. Different RCMs were run for this purpose at a grid resolution of 10 km which represents the limits of application of the current generation of hydrostatic RCMs such as the one used here.

In this paper we validate the ability of the regional climatic model RegCM3 to simulate winter and summer temperature means and precipitation totals over the Republic of Moldova. The RegCM3 simulations were conducted at a horizontal resolution of 10 km in the framework of EU-FP6 project – CECILIA. The model simulations forced by ERA40 were compared with the observations from CRU TS2.1 dataset and stations.

Material and methods

Model description

The RegCM3 version used here was originally developed by Giorgi *et al*. (1993) and later modified and improved (Pal *et al*., 2007). It is a hydrostatic and terrain following sigma vertical coordinate model whose dynamical core is essentially the same as that of the hydrostatic version of the National Center for Atmospheric Research (NCAR) and the Pennsylvania State University mesoscale model MM5 (Grell *et al*., 1994). The Biosphere-Atmosphere Transfer Scheme BATS (Dickinson *et al*., 1993) is used to represent surface processes while boundary layer physics is described via the non-local vertical diffusion scheme of Holtslag *et al*. (1990).

Experiment design and observation data sets

The integration domain (41.016º N–50.175° N; 14.095º E–36.192 ºE) was centered over Romania at 46ºN, 25ºE. The lateral meteorological boundary conditions needed to run the model were obtained from the 25 km RegCM simulation run driven with ERA40 reanalysis of observations. For this study we have selected a smaller domain (45.01° N–49.01° N; 26.52º E–30.48º E) including only the Republic of Moldova.

The RegCM temperature and precipitation simulations were compared with the CRU TS2.10 land observation data set which has a horizontal resolution of 0.5º lat x 0.5º lon. The monthly temperature and precipitation simulations have also been compared with the observations recorded at 15 meteorological stations of Moldova's State Hydrometeorological Service. The distribution of the stations and the model domain and topography are represented in Figure 1.

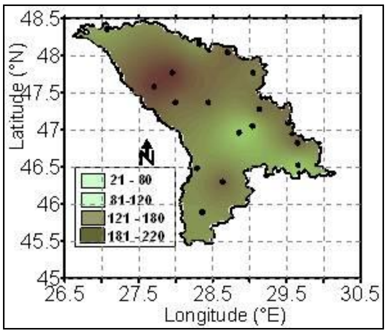

Figure 1. *Location of the 15 meteorological stations and their elevation (m a.s.l.) and the RegCM-Moldova domain (26.5°–30.5° E; 45°– 49°N).*

Results and discussion

The model validation has been achieved both at station and domain levels for the period 1960–1997. In this respect, the gridded data of temperature and precipitation totals (RegCM simulations, forced by ERA40 data and CRU observation data) have been downscaled to station coordinates. For these series seasonal means were calculated and compared. Comparison between the simulated and observed seasonal temperature shows that the model skillfully captures the temperature characteristics during summer over Moldova but overestimates the winter temperature mean. The model overestimates the winter precipitation at all stations and only small differences are observed during summer. The spatial distributions of winter temperature means and precipitation totals over Moldova domain as represented in RegCM simulation, CRU TS2.1 data set and at station level are presented in Figure 2. The lowest winter temperatures are simulated (observed) in the north and the highest in the south; the highest winter precipitation totals are simulated (observed) in the centre of the country.

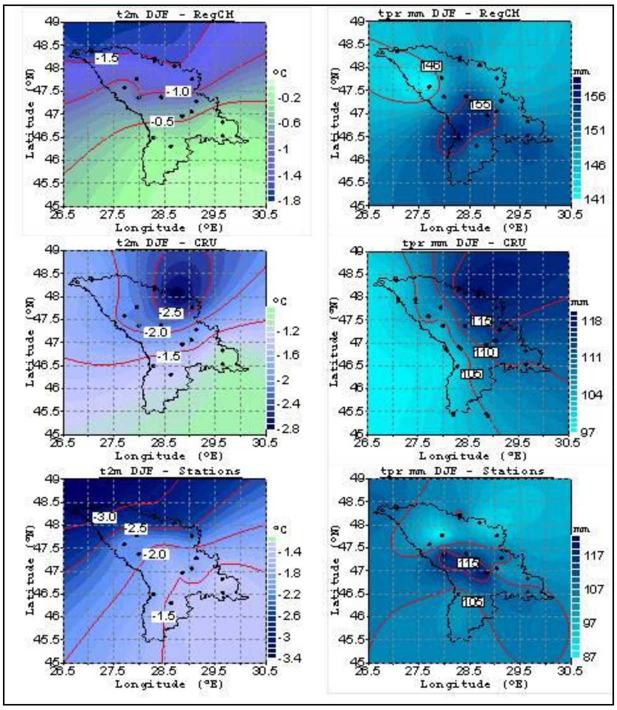

***Figure 2**. The maps of mean winter (DJF) air temperature and precipitation for simulation (RegCM3), CRU TS2.1 data (0.5°lat x 0.5°lon) and station observations.*

Similarly, Figure 3 represents the spatial distributions of summer temperature means and precipitation totals over Moldova domain. Higher temperatures are simulated (observed) in the southern part of the country. Highest summer precipitation totals are simulated and observed at station level in the northern half of the country while in the CRU data the highest precipitation totals are observed in the centre of the country.

Then, the series of monthly temperature means of RegCM simulations, CRU observations in each grid point and station observations were spatially averaged and compared. The model does well in representing the annual cycle of temperature but slightly overestimates the winter (DJF) temperatures and slightly underestimates autumn (SON) temperatures. Monthly precipitation totals are systematically overestimated by the model compared to stations and CRU data. The largest precipitation errors are observed in winter (DJF) and early spring (AM).

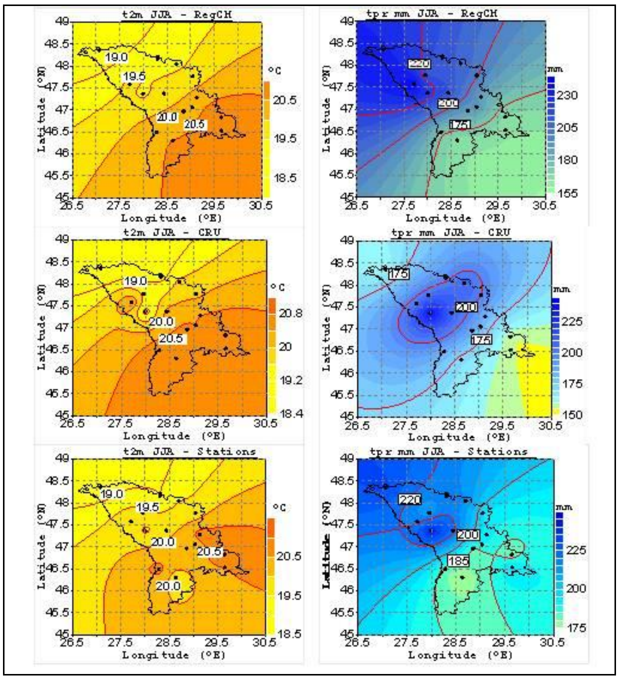

***Figure 3**. The maps of mean summer (JJA) air temperature and precipitation for simulation (RegCM3), CRU TS2.1 data (0.5°lat x 0.5°lon) and station observations.*

Conclusions

RegCM simulations forced by ERA40 data were compared with station observations and CRU data downscaled at station coordinates. The results show that the model does quite well in representing the annual cycle of temperature but precipitation totals are systematically overestimated compared both to stations and CRU data.

Acknowledgements: The RegCM simulations have been produced in the NMA-Romania in the framework of CECILIA–EU-FP6 Project, Contract 037005 GOCE/2006 (http://www.cecilia-eu.org). This study was supported by S grant of MSMT CR and project 6046070901.

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PHENOLOGICAL PHASES OF BEECH FORESTS DERIVED FROM SATELLITE DATA – RESULTS FROM THE YEAR 2011

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Abstract. In this study satellite data MODIS were used to derive phenological phases in beech stands. Normalized difference vegetation index (NDVI) was considered as a suitable indicator of changing phenological phases, because of its sensibility to increasing or decreasing amount of greenness in forest ecosystems. The course of NDVI was modeled in program Phenological profile using the logistic sigmoid function (Fisher, 2006). This program also calculated the local extremes of this function. These local extremes were used to identify the phenological phases. Differences between satellite derived and visual observed phenophases were find out. Also NDVI values were assigned to each phenophase.

Introduction

Phenology is the study of the timing of recurrent biological events, the causes of their timing with regard to biotic and abiotic forces, and the interrelation among phases of the same or different species (Lieth, 1974). In recent years, the plant phenology achieved a new status in global climate changes investigating, with increasing popularity and availability of remote sensing data. Satellite derived phenology usually use vegetation indices (such as NDVI), because these are related with amount of green leaf biomass (Ahl, 2006).

The aim of this study was to assign the suitable phenological phase to local extremes of phenological function and find out the differences between satellite derived and visually monitored phenological phases.

Material and methods

<u>Study sites</u>

In this study, five beech stands on localities Turová and Bukovina in Kremnica mountains, belonging to The University Forest Enterprise (VšLP) of Technical University in Zvolen, were monitored. Area of one stand was 6.25 ha, which corresponds to the area of one pixel MODIS with spatial resolution of 250 m.

Figure 1. *Internal structure of forest stand no. 514.*

These stands are characterized with dominant incidence of beech (*Fagus sylvatica*, L.) and minimum incidence of evergreen conifers. In these stands, there is a typical vertical heterogeneity with beech in undergrowth (Figure 1).

<u>Visual phenology observation</u>

The method by SHMU (1984) was used for phenology observations. 10 trees in each stand were selected to monitor phenological phases. Following spring phenological phases were observed on selected tree groups: buds bursting (BB), leaf unfolding (LU) and leaf onset (LO). In autumn, these phenophases were observed: leaf colouring (LC) and leaf fall (LF). Each phenophase has three basic states: beginning - 10% onset, general - 50% onset, and full - 100% onset.

<u>Satellite derived phenology</u>

MODIS product selection as well as the procedure of satellite data obtaining, processing, and derivation of NDVI were described by Bucha and Koreň (2009). NDVI values are derived from spectral reflectance in red (*RED*: 620–670 nm) and infrared (*IRED*: 841–876 nm) channel using the function [1]:

$$NDVI = (IRED-RED) / (IRED+RED) \qquad [1]$$

The growing season in our climate and nature conditions can be modeled by sigmoid logistic function [2] (Fisher, 2006), which capture one increasing (spring) and one decreasing (autumn) term:

$$v(t) = v_{min} + v_{amp}[(1/ 1+e^{m_1 - n_1 t}) - (1/1+ e^{m_2 - n_2 t})] \qquad [2]$$

where $v(t)$ - NDVI value; v_{min} - minimum NDVI value; v_{amp} - total NDVI amplitude; m_1, m_2, n_1, n_2 - fitting parameters controlling phase and slope for both greenup (m_1, n_1) and senescence/abscission (m_2, n_2). Software Phenological profile was used to determine the course of the phenology. This software models the phenology with function [2] proposed by Fisher (2006). Input data were the NDVI time series of the year 2011.

Results and discussion

Phenological function was modeled for each stand. Local extremes of 1. and 2. derivative of this function [2] were used to determine the onset days of phenological phases as follows:

1. in ascendenting period:

– BB 10 % was assigned to local maximum of 2. derivative,
– BS 100 % was assigned to local maximum of 1. derivative,
– LO 100 % was assigned to local minimum of 2. derivative,

2. in descencenting period:

– LC 10 % was assigned to local minimum of 2. derivative,
– LC 100 % was assigned to local minimum of 1. derivative,
– LF 100 % was assigned to local maximum of 2. derivative.

On Figure 2 is shown how visually observed phenophases were assigned to the local extremes. Average differences discovered between visual observed and satellite derived phenological phases are noted in Table 1. Also NDVI values relating with these phenophases were find out.

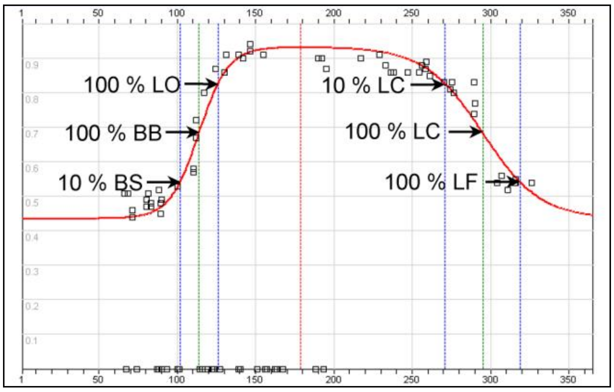

Figure 2. *Identification of phenological phases using local extremes of function [2]. On x axis: day of year, on y axis: NDVI values.*

Table 1. *Average differences between visual observed and satellite derived phenophases, the corresponding average NDVI values and their standard deviations.*

Phenological phase	Avg. D.[1) (days)]	NDVI	
		$x^{2)}$	$s_x^{3)}$
BB 10%	3.4	0.55	0.03
BS 100%	2.0	0.66	0.02
LO 100%	4.6	0.78	0.03
LC 10%	3.8	0.82	0.01
LC 100%	8.8	0.62	0.03
LF 100%	3.6	0.53	0.02

Note: [1)]average difference, [2)]average, [3)]standard deviation

In comparison with results achieved using other phenological methodology for validating satellite derived phenological phases - methodology made for Monitoring of Slovak Forests (MSF) used in Brandýsová (2010), methodology used in this study (SHMU, 1984) is more suitable for validation, because the differences between satellite derived and visual observed phenophases are smaller. Also assigning the phenological phases observed using these two methodologies to local extremes was different (Table 2).

Table 2. *Assigning local extremes according to methodology for Monitoring of Slovak Forests (MSF) and Slovak Hydrometeorological Institute (SHMU, 1984).*

Local extreme	MSF		SHMU (1984)	
	PP[3)]	Avg.D.[4)]	PP	Avg.D.
max 2. deriv. in AP[1)]	-	-	10 % BB	3.4
max 1. deriv. in AP	10% BS	3.0	100% BS	2.0
min 2. deriv. in AP	50% LO	5.9	100% LO	4.6
min 2. deriv. in DP[2)]	10% LC	6.0	10% LC	3.8
min 1. deriv. in DP	100% LF	8.3	100% LC	8.8
max 2. deriv. in DP	-	-	100% LF	3.6

Note: [1)]ascendenting period, [2)]descendenting period, [3)]phenological phase, [4)]average difference

Similar results like ours were publicated by Liang (2011). They compared phenological phase *FBB* (full bud burst analogy with our 100% BB) from visual observations with SOS (start of season) derived from EVI (Enhanced Vegetation Index) and NDVI time series of deciduous stands. They find out maximum difference between *EVI SOS* and *FBB* 2 days, and between *NDVI SOS* and *FBB* 15 days (in one year only 4 days). Soudani (2008) compared visually observed onset of greenness (*OG10%* and *OG90%*, analogy with our BS) in beech and oak stands with satellite derived inflection point of NDVI values (*dinfNDVI*) and average onset of greenness (*OGI+OGM/2*). In beech stands, there was average difference between *OG* and *dinfNDVI* 2–7 days and between *OG* and *OGI+OGM/2* 3.5–9.5 days.

Conclusions

In this paper, the methodology how the phenological phases were derived from satellite data was presented and compared with previous results. Sigmoid logistic curve and its local extremes were used to identify phenological phases from satellite data. We find out average differences between visual observed and satellite derived phenological phases in monitored beech stands in the year 2011 in range from 2.0 to 8.8 days. NDVI values were assigned to each phenological phase. Now we continue with validating phenological phases in the year 2012. In the future, we are going to examine the effect of biometeorological factors on phenophases onset days in regional scale.

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SEVERE WINDS IN POLAND AND THEIR EFFECTS

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Abstract. The aim of this study was to present the characteristics of strong winds in Poland in 2000–2010 and their effects. During this period, were analyzed 495 cases of severe winds and even 280 cases of tornadoes. It was shown, that in recent years there has been much more strong winds, than at the beginning of the decade. Mainly, this is related to more and more excellent methods of the monitoring of the atmosphere and with the better flow of information. Most often, these phenomena occur in July and August. Most of them are created in the afternoon.

Introduction

Strong winds created over the Poland, are associated with many meteorological situations. We can distinguish three groups:
- winds associated with cyclonic activity,
- winds associated with orographic barrier (fen winds),
- winds associated with the phenomena supporting the storms.

To the last group belongs the winds created in frames of vortices: *tornado*, *gustnado* and straight-line winds: *bow echo*, *derecho*, *gust front*, *downburst*, *microbust* (Żurański, Gaczek, Fiszer, 2009).
Tornadoes occurring at the Polish areas, are associated mainly with zones of squall fronts or supercell, in which growns the mezocyclone (Lorenc, 2012).
The intensity of the winds is defined by measuring their speed at meteorological stations. In the case of tornadoes, because of their relatively small spatial size, the probability of measuring the wind speed is low. Therefore, not all the strong winds are recorded by the devices belonging to the Polish observation network (IMGW). In the absence of absolute measurements, the strength of severe winds is usually determined on the basis of the damage they cause. An example of classification includes Table 1.

Material and methods

Data for this study come from the website ESWD – European Severe Weather Database, Version 4.0.1, 02. 01. 2012 (*http://www.essl.org/cgi-bin/eswd/eswd.cgi*). For analysis were chosen all cases of severe winds and tornadoes from 01.01.2000 to 31.12.2010. Due to the lack of data, the work does not include cases gustnadoes.
Based on information about the date of the appearance of each of phenomena, their long-term and annual course was drawn up. Moreover, using details about the hour of passing these phenomena, their daily progress was presented. Location of the appearance of a particular phenomenon in the database (geographic coordinates, and place) allowed determine the administrative area over which there were strong winds (region, district, and commune). Thanks to the ArcGis program, presented in the spatial way occurrence of severe winds and tornadoes on Polish territory in 2000–2010.

Table 1. *Maximum wind speeds in Poland and their effects (based on: Lorenc H., Maximum wind speeds in Poland, pp. 16–17, IMGW, Warsaw, 2012).*

No. of class	Wind speed (m/s) (km/h)	Character of the wind	Model effects
I	≥11–16 (40–59)	gusty wind	Wind is chaotic in the flow; with gusts moving large branches of trees; it is difficult to use an umbrella and walking into the wind; during snow blizzards cause;
II	≥17–20 (60–73)	stormy wind	Wind breaks branches, damaging marquise and tents; turns wooden fences, billboards, road signs; raises clouds of dust; break a single roof tiles; walking against the wind is very difficult; hinders the work of lifts and threatens their operators; going cars are sensing the wind speed;
III	≥21–24 (74–86)	gale	Wind causes substantial damage to buildings - break roof tiles; breaks large branches of trees; floats in the air lighter objects, unsecured building structures;
IV	≥25–28 (87–103)	strong gale	Wind causes significant damage to buildings, towers and chimneys; breaking and pulling trees with shallow root; makes it difficult to drive cars; High-excursion sways power lines and railroad, and during the rime or glazed frost –it breaks due to overload;
V	≥29–32 (104–117)	hurricane winds	Wind causes the destruction of entire buildings and halls with flat roofs; severs sections of power lines and breaking their supporting structures; makes it difficult to drive trucks; snatches the tree from the roots and destroys the larger tracts of forest - in the mountains so called windfalls;
VI-1	≥33–49 (≥118–178)	hurricane tornado I degree	Wind breaks all the roofs; turns and moves campers; pulls out big trees with their roots or breaking them in larger spaces; breaks the power lines and railroad; destroys the power building structures; blows from the road going cars; turns lighter building lifts over; levitation of the destroyed objects (roofs, doors, windows); equipment turning into flying missiles
VI-2	≥50–69 (≥179–250)	hurricane tornado II degree	Wind causes general destruction and devastation; uprooted a large and healthy trees; breaks roofs of houses and moves them from a distance; collapses buildings with reinforced construction; destroy entire swaths of forests and orchards; damages the structures of bridges; levitation of cars and other objects, which change into flying missiles; wreaks havoc

Results and discussion

In the last years the severe winds have increased. In the studied decade, most phenomena of this kind occurred in 2009 (154 cases). In 2006 above Poland the most tornados were formed (52 cases). Least of cases reported in 2000. Increase the frequency of the phenomena is associated with improvement of methods for monitoring the atmosphere and a better flow of information (Figure 1.).

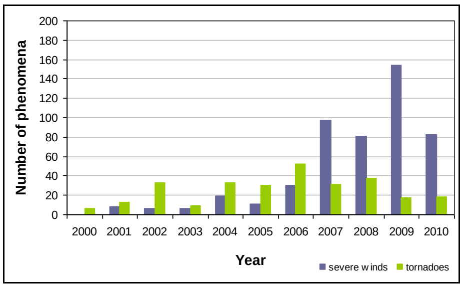

Figure 1. *Long-term course of severe winds and tornadoes in Poland (period 2000–2010).*

In the period 2000–2010, most of severe winds occurred in July (133 cases). Also in this month, the most tornadoes are formed (72 cases). It is possible to suppose, these occurrences largely were connected with stormy formations. Several dozen cases were reported from May to August. In January, strong winds also occurred frequently (72 cases), but their genesis is associated with more cyclonic activity in the cold season (Lorenc 2012) (Figure 2).

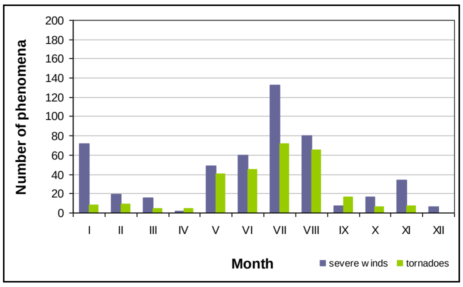

Figure 2. *Annual course of severe winds and tornadoes in Poland (period 2000–2010).*

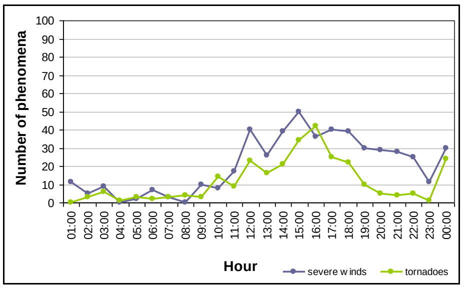

Figure 3. *24h course of severe winds and tornadoes in Poland (period 2000–2010).*

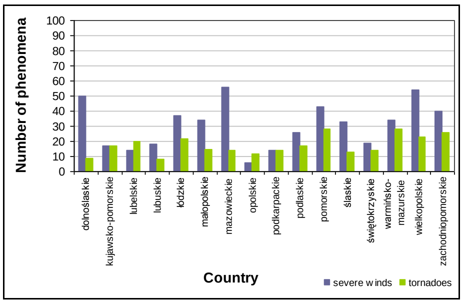

Figure 4. *Severe winds and tornadoes in Poland by voivodeship (period 2000–2010).*

Most of these phenomena were created in the afternoon. Most severe winds were noted between 12^{00} and 18^{00} (50 cases of 15^{00}), and tornadoes occured most often between 15^{00} and 16^{00} (according to 34 and 42 cases) (Figure 3).

Most winds occurred in the following voivodships: Mazowieckie (56 cases), Wielkopolskie (54 cases) and in Dolnośląskie (50 cases). For 28 tornadoes formed in the provinces of Warmińsko-Mazurskie and Pomorskie. In Zachodniopomorskie there were 26 events of this type (Figure 4).

Based on the spatial arrangement of severe winds and tornadoes in Poland (years 2000-2010) can not clearly identify the areas most frequently haunted by these phenomena. However, we can distinguish two zones with increased activity of strong winds (south-western and southern Poland). In the case of tornadoes, you can set a narrow coastal lane and the area south of the country (Figure 5).

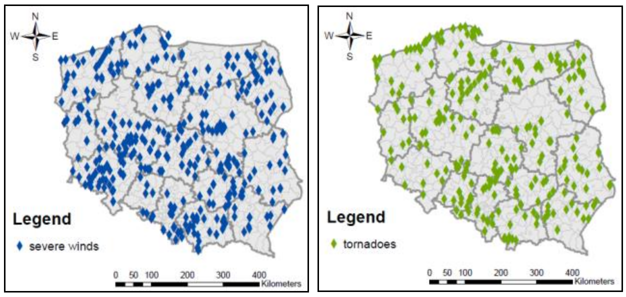

Figure 5. *Spatial arrangement of severe winds and tornadoes in Poland (period 2000–2010).*

Conclusions

Strong winds pose a serious threat to the achievements, health, and sometimes even people's lives. This type of phenomenon is caused by pressure gradient. Rapid changes in this element also influence mood. For the human, it constitutes the mechanical strong incentive.

Strong winds in Poland occur usually on days with variable weather types associated with the movement of weather fronts and rapid changes in pressure. It is therefore important to identify areas exposed to frequent occurrence according to the three genetically different reasons for their occurrence (cyclonic activity, orographic barrier and storms). The fact is that strong winds characterize mountain areas. At the time of occurrence of fen winds has been observed in susceptible persons, so called *fen disease*. It is characterized by such cardiovascular disorders, the nervous system imbalance, or excessive physical and mental excitability.

The effects of these phenomena are also its social and economic dimension. Human is not able to prevent this type of disaster - he can only minimize its effects. Therefore, should carry out the research about design and durability of buildings exposed to high velocity winds and flying debris.

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PRECIPITATION EXTREMES IN THE BRNO REGION IN THE PERIOD 1961─2010

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Abstract. Presented paper focuses on the analysis of precipitation extremes in the period 1961─2010 in the city of Brno and its urban area which is the second largest in the Czech Republic (approx. 400 ths. inhab., 230 km^2). Analysis of maximum daily precipitation amounts and their return periods is included as well as synoptic-climatological analysis of precipitation events with amounts exceeding limit values based on 99th percentile computed from the reference period 1961─1990. Attention is paid also to the occurrence of dry spells which are described with the help of selected extremity indices. These indices are analysed for trend by means of non- parametric methods and the results are compared with the trends of precipitation totals.

Introduction

Precipitation extremes have important impacts on human life in the urban areas. The occurrence of high precipitation amounts resulting from rainstorms can paralyse life in the cities considering mainly transportation, sewer systems etc. On the other hand, the occurrence of periods with precipitation deficiency (dry spells) is unfavourable for human health, especially when it is combined with high air temperature. The absence of precipitation can also obstruct natural wash out of pollutants and thus it can influence the quality of urban air in a fundamental way (Hosiokangas, *et al*., 2004).

Urban areas itself are able to modify the regime of precipitation and to generate the occurrence of extreme precipitation amounts accompanied by dangerous meteorological phenomena. This was well described for densely populated cities in the United States of America (Huff, *et al*., 1973). In Brno, precipitation has been measured since the beginning of the 19th century and potential urban influence has been studied since the 1950s. From an extensive research done in the 1970s, it was clear that the influence of Brno urban area on precipitation is expressed more weakly in comparison with Prague and Ostrava, nevertheless some influence there probably exists (Brázdil, 1979).

The extremes based on low precipitation are connected with the change of climate predicted for the whole Central European region in IPCC's Fourth Assessment Report.

Material and methods

Presented work deals with precipitation in the Brno region including Brno cadastral area and its surroundings. Studied area (see Figure 1) was set asymmetrically in relation to the city centre because of the complex topography of the region that is assumed to have influence on spatial variability of potential urban effect on precipitation in the Brno region. Precipitation measurement in Brno started in 1803 and the highest density of precipitation monitoring network was reached in the period 1931─1960 (13 stations within Brno cadastral area). In spite of lower density after the reduction of monitoring network in 1961, in this work the period 1961─2010 was analysed because of data quality and availability. Annual, seasonal and daily precipitation sums from 13 meteorological stations belonging to the Czech Hydrometeorological Institute (CHMI) monitoring network were used. Daily precipitation totals were quality controlled, tested for homogeneity with the help of various tests, homogenized and missing values were completed and thus the data has the character of technical series.

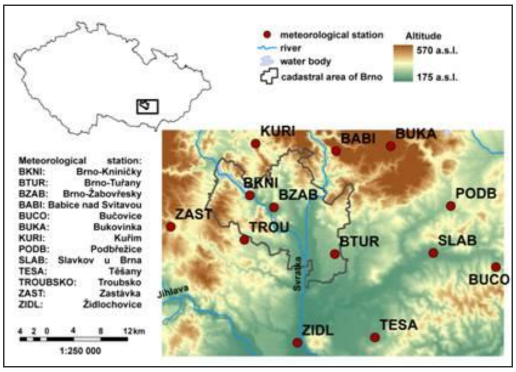

Figure 1. *Study area and meteorological stations used in this study.*

Annual values of maximum daily precipitation totals were modelled by 3-parametric GEV distribution and the values corresponding to several return periods were evaluated. The extremity of precipitation was described with the help of three extremity indices defined in Table 1. These indices were tested for trend by non-parametric Mann-Kendall test and the trend size was estimated by Sen's method (Sen, 1968). The trend analysis was performed in a dynamical way, i.e. for 30-year periods with a 1-year shift. Annual and seasonal precipitation totals were fitted by linear trend.

Table 1. *Extremity indices used in this study.*

Index	Abb.	Definition	Unit
Precipitation due to extremely wet days	PD 95	Percentage of total amount in days with prec. > 95th perc., 95th perc. estimated from period 1961─1990.	%
Average length of dry spell	DS AVG	Dry spells = periods with at least 2 consecutive days with prec. amount < 1mm.	days
Maximum length of dry spell	DS MAX	─	days

Results

Maximum daily precipitation amount in the Brno region in the period 1961─2010 varies typically between 70 and 80 mm and with the exception of Brno-Tuřany and Zastávka station it did not occur before 1985. The maximum for Zastávka that was recorded on 21/08/1977 and represents at the same time the absolute maximum of all stations used here (97.4 mm). The lowest value of maximum daily amount occurred in Bučovice (48.5 mm) on 04/06/2008. Stations in the northern part of the studied area (BABI, KURI, BZAB) reached their maxima on 07/08/2006 when weather was influenced by extensive air pressure low centered above Poland during the northeastern cyclonic situation (NEc) according to CHMI classification. In the eastern part (PODB, SLAB), the absolute maximum occurred on 02/09/1988 at the end of 3-day period with western cyclonic situation (Wc) while in the south of the studied area (TESA, ZIDL) it was on 27/08/1989 at the beginning of 5-day period with "Wc" synoptic situation.

Extreme daily precipitation amount corresponding to 99th percentile computed from empirical values in the reference period 1961─1990 varies between 20 mm and 22 mm. During the study period, the total number of days when this limit value was exceeded at the majority of stations was 68. They occurred mainly in the autumn months (28 cases) or summer months (26 cases) during the synoptic situation with low air pressure trough over Central Europe (B), trough advancing across Central Europe (Bp) or cyclone over Central Europe (C) (23, 15 and 10 cases).

Daily precipitation totals corresponding to 5, 10, 20, 50 and 100-year return period vary in the ranges from 37 to 48 mm, 40 to 56 mm, 44 to 65 mm, 48 to 82 mm and 50 to 96 mm. Regarding spatial distribution, the lowest values for all return periods can be seen in the eastern part (BUCO, PODB) while the highest values appear in the west and northwest (BZAB, BKNI, ZAST) and also in Těšany.

Annual and seasonal precipitation totals show mainly positive but statistically insignificant trend. The only exception is for Bučovice, where the trend of annual values is significant as well as the trend in all seasons except the winter. Statistically significant positive trend for annual values was found also in Podbřežice (see Figure 2).

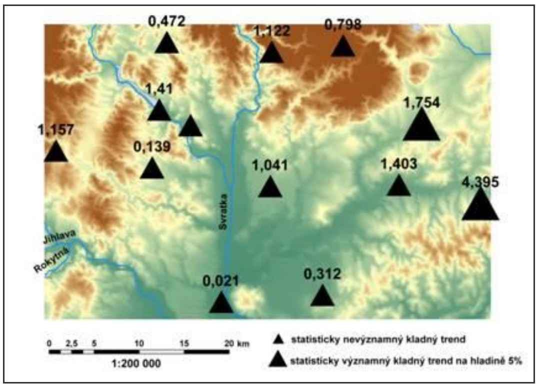

__Figure 2.__ Linear trend of annual precipitation sums in the Brno region in the period 1961─2010.

The trend of PD 95 is mainly positive in case of annual, summer and autumn values. From the beginning of the 1960s the values of linear coefficient were increasing to the maximum between 1968 and 1973 that was significant at some stations. Then the trend started to decrease to be near to zero by the end of the studied period. In winter and spring, linear coefficient shows "U" shaped course with positive values in the periods beginning in the first half of the 1960s or second half of the 1970s and negative values in between. In case of DS AVG and DS MAX, positive trend of summer values persisted during the whole studied period and it was well pronounced especially between 1965 and 1975 (Figure 3). On contrary, in spring this time span represents a period with the prevalence of negative trend sign and the values of linear coefficient form "U" shape. In autumn, the trend was predominantly negative with the peak in 1975 but in case of DS MAX, strong negative trend persisted to the end of the studied period. Trend of annual and winter values was mainly positive with a tendency to weaken since 1978 and to become negative in last two or three 30-year periods.

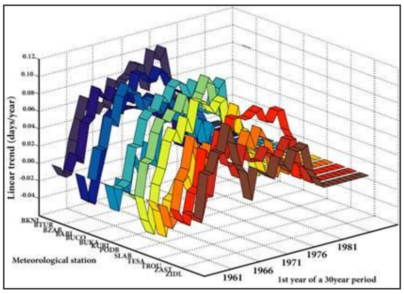

__Figure 3.__ Linear trend of summer values of DS AVG for moving 30-year periods in the Brno region.

Conclusions

Precipitation extremes including high and low precipitation amounts in the Brno region during the period 1961−2010 were examined. Extremely high daily amounts occur the most frequently in summer or autumn months and they are connected mainly with the synoptic situations with low air pressure trough over Central Europe, trough advancing across Central Europe or cyclone over Central Europe. Daily amounts corresponding to various return periods reach the highest values in the NW part of Brno and in the W part of the studied area while the lowest values were in all cases found in the E part of the interest area. Regarding the low extremes, there is no downward tendency of annual or seasonal precipitation totals apparent at any station that is confirmed by the predominance of insignificant positive trend in the period 1961−2010. However, the shift towards drier climate manifests itself through characteristics based on dry spells. When analyzed this in a dynamical way, annual values of average and maximum length of dry spells shows predominantly positive trend caused especially by the summer events. Increasing extremity of precipitation regime is confirmed also by the results for PD 95 which shows an increasing proportion of precipitation from extreme events to total amount in summer and autumn.

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GOAT ETHOLOGY DURING REGULATED PASTURE IN A PROTECTED LANDSCAPE AREA

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Abstract. The objective was to summarize knowledge on the controlled grazing of goats in the protected landscape area (PLA) of Czech Karst (Český kras). A total of 26 goats of diverse ages and breeds (White Short-haired, Brown Short-haired, Boer, Cameroon and Cashmere goats along with crossbreeds of these) as well as four sheep (Suffolk x Merino and Suffolk x Charolais crossbreeds) were observed during the study. Research was performed by means of direct observation, this occurring seven times during the grazing season from 16 May to 3 October 2010 on a daily basis, from 8 a.m. to 7 p.m. It was confirmed that the percentage of forms of individual behaviour throughout the day and the percentage of forms of active and passive behaviour depended especially on weather patterns and the condition of the pasture.

Introduction

The importance of grazing small ruminants in protected areas is on the rise. Therefore, the authors focused particular attention on the ethology of goats grazing on selected sites at Czech Karst PLA. Goats tolerate both heat and cold very well. They dislike rain and strong winds, seeking shelter from an approaching storm in a stable or in vegetation. They avoid walking in watery and muddy areas and shun any dwellings in damp locations. In the heat of midday, they seek shade. When grazing with sheep, goats roam and scatter around the pasture, the range of such movement being greater than for the sheep. However, their behaviour is more social than that evident when grazed separately (Fantová et al., 2010).

Material and methods

For determining the numbers of animals, results from the activity of monitored grazing in previous years were taken into account. In fact, the number of animals per herd varied during the grazing season. Initially, monitoring efforts pertained to 14 adult goats and five kids as well as three adult sheep and one lamb, whilst two adult goats and five kids were also incorporated at the end of the grazing period. According to preliminary theoretical calculations as regards the burden on pastures, the area grazed should have amounted to 14.48 hectares, although it only totalled 8.47 ha. Ethological observations were conducted from 8 a.m. to 7 p.m. on the site, this being performed by direct observation using photography, with a total of seven monitoring actions being carried out during the grazing season in the period from 16 May to 3 October 2010.

The ethology survey comprised a total of five categories of behaviour: grazing, standing, moving and lying down, as well as comfort, playful and maternal behaviour.

The following characteristics were selected to assess weather conditions: maximum, average and minimum daily air temperature, dew point temperature and precipitation conditions, so as to assess air humidity; these were expressed using daily totals; as for wind, this was described using three characteristics: average wind speed, maximum wind speed and maximum gust speed. The weather situation during the days monitored was described by typing of synoptic situation used to the territory of the Czech Republic. The data acquired were subsequently processed using Excel.

Results and discussion

A summary of the most common distribution of behaviour displayed during the day is shown in Table 1. The percentage of these activities was primarily based on the following factors as recorded: weather patterns, air temperature, and the quantity of available forage.

***Table 1** Most common form of behaviour displayed during the day*

Time	Activity	Time	Activity
8.00	Grazing	**14.00**	Grazing
9.00	Grazing	**15.00**	Lying down
10.00	Lying down	**16.00**	Lying down
11.00	Lying down	**17.00**	Lying down
12.00	Grazing	**18.00**	Grazing
13.00	Grazing	**19.00**	Grazing

The representation of grazing and lying activities was thus variable, and generalizations applicable to the grazing behaviour of goats shall require further study. Surprisingly, the proportion of grazing during all the activities proved rather low, and much greater representation had been expected in accordance with the results of Mládek et al. (2006) and Fantová et al. (2010). This finding, however, was primarily influenced by the research occurring during a limited time through the day and not at all at night.

The percentage of physical activity increased whenever the animals were moved onto another pasture, this happening in two observation sessions. Any other relatively high proportion of physical activity was recorded during observation session #1 in mid-August, when male goats displayed sexual behaviour although the female goats still did not show signs of oestrus, thus running away from the males. Comfort, playful and maternal behaviour was relatively balanced, the highest percentage being recorded during session 5 in August. There were no influences confirmed that would affect the percentage of behaviour under the category of “standing” (e.g. defence against troublesome insects). The lowest representation of displays of active behaviour was recorded in the summer, whilst the highest representation, with grazing accounting for the greatest percentage, was typical for the end of the grazing season, by which time vegetation had become meagre and the animals had to spend more time and effort to find suitable food.

Table 2 *Frequency of each behavioural category (%).*

	Grazing	Standing	Moving	Comfort behaviour	Lying down	Active behaviour	Passive behaviour
16. V	36	10	3	7	44	56	44
28. V	30	11	3	4	52	48	52
19. VI	24	14	10	6	46	54	46
15. VII	15	10	1	5	70	30	70
15. VIII	32	16	5	8	39	61	39
19. IX	46	5	2	2	45	55	45
3. X	68	6	10	4	12	88	12

Summaries of the proportion of the frequency of each behavioural category for all observation periods are given in Table 2 and Figure 1, the latter giving an example of the daily physical activity curve as recorded during the observation session of 15 August 2010.

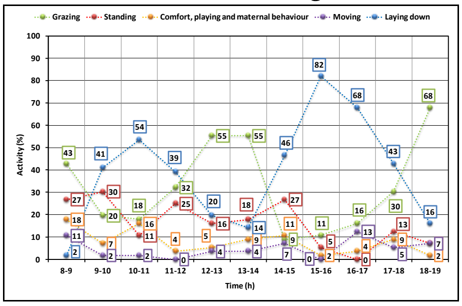

Figure 1. *Representation of each vital sign.*

The proportion of forms of behaviour displayed corresponds particularly with two basic factors, i.e. the season and weather conditions, plus it relates to the quality and quantity of the pasture vegetation available to the animals.

Weather patterns throughout the grazing period and on each date of ethological observation are documented through Figures 2, 3 and 4.

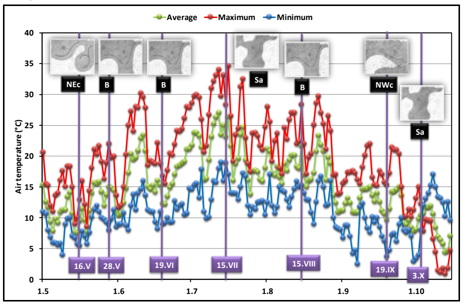

Figure 2. *Variability of air temperature.*

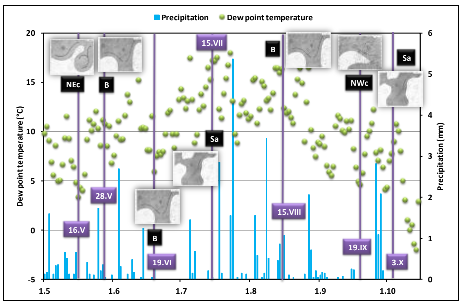

Figure 3. *Daily totals of precipitation and air humidity.*

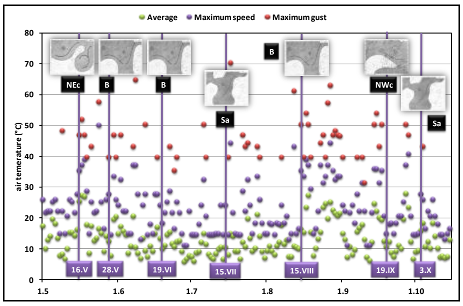

Figure 4. *Wind conditions.*

Weather circulation is described by the schema into graph (NEC - Northeast cyclonic situation, B - stationary trough over central Europe, Sa - South anticyclonic situation, NWc -Northwest cyclonic situation).The influence of the weather on displays of passive and active behaviour is expressed through Figure 5.

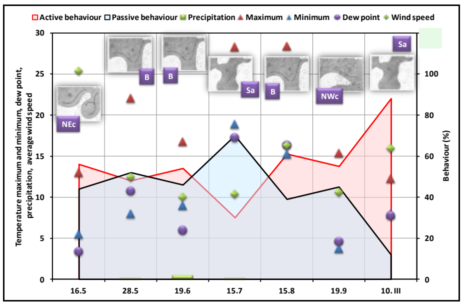

Figure 5. *Weather conditions on each date of observation.*

High temperatures negatively influence the activity of animals (15 July, 15 August), with cooling through air flow playing a considerable role in this (15 August). The greatest activity was discerned on 3 October during a southern anticyclone, when warm air was flowing from the south into the country.

Conclusion

The report evaluates the behaviour of small ruminants, specifically goats, grazing on sites of Czech Karst PLA, where protected flora species are present; this occurring in the period from 16 May to 3 October 2010.

The main trends as regards the daily sequence of behaviour and representation of individual categories of behaviour were identified as follows:

- the distribution of three daily peaks of grazing (morning, midday, evening) and two peaks of lying at rest (morning and afternoon) were recorded as the most common distribution of activities during the day;
- the distribution of activities during the day as well as the percentage of these was mainly influenced by weather patterns, air temperature and the quantity of available forage.

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UNCERTAINTY RANGES OF CLIMATE PROJECTIONS FOR THE SAXON-CZECH BORDER REGION

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Abstract. Global and regional climate projections build a crucial fundament for climate impact research and climate adaptation. However, the information obtained from climate model results is bound to uncertainties arising from both a number of methodical aspects of climate modeling and emission scenarios. An appropriate interpretation of subsequent climate impact research results and eventually adaptation measures have to take regard to these uncertainties. This article focuses on the uncertainties arising from the choice and combination of global (GCM) and regional climate models (RCM). Uncertainties in the model representation of projected seasonal temperature and precipitation change signals are outlined for the Saxon-Bohemian border region.

Introduction

In the federal state of Saxony (Germany), commonly different regional climate models are considered to assess uncertainties originating from different modeling approaches. In particular, these are the dynamical RCMs CLM and REMO as well as the statistical methods WEREX IV and WETTREG (Bernhofer *et al*., 2011). The analysis and interpretation of these projection approaches (hereinafter denoted as REGKLAM dataset) provides an insight into the regional performance of the models and thus helps to assess the uncertainties of projected future climates. However, the RCMs are relying on input information derived from the forcing GCM ECHAM5-MPI-OM and consequently only represent a limited range of potential climate change.

Within the ENSEMBLES project (Van der Linden *et al*., 2009) a systematic multimodel ensemble of climate projections has been developed by performing simulations for a large number of different of GCM x RCM combinations. These multimodel results can add valuable information for a more comprehensive assessment of climate change in the Saxon-Bohemian border region.

Material and methods

The ENSEMBLES dataset is available in a spatial resolution of 25km (CRU-grid) and for the period of 1951–2050 or 2100, respectively. This analysis includes combinations of 7 GCMs and 14 RCMs while the projections consistently assume the underlying global emission scenario A1B.

The study area is rectangularly shaped (latitude 50.4°– 51.7° north and longitude 12.7°–14.9° east) and ranges from the southern part of the federal state of Brandenburg, throughout Saxony and the Ore Mountains to the northern part of Czech Republic.

For the ENSEMBLES dataset, data conversion and spatial-temporal aggregation was performed applying *Climate Data Operators* (Schulzweida *et al*., 2010). Climatology characteristics were calculated for the spatial mean of 9 x 5 RCM grid cells and on a temporal resolution of months and meteorological seasons. Respective climate change signals were obtained by comparing the mean values of the time periods 2021–2050 and 2071–2100 against the reference period 1961–1990.

The REGKLAM RCM-dataset derives from the REGKLAM climate database (Bernhofer *et al*., 2011) and here includes one model run of CLM, REMO, WEREX and WETTREG. In contrary to the ENSEMBLES dataset, aggregation and calculation of spatial mean values was conducted in the original model resolution. In this context, obtaining spatial means for station-based datasets (WEREX and WETTREG) required spatial interpolation performed with IDP (Kreienkamp and Spekat, 2007).

Results and discussion

The REGKLAM dataset consists of four RCMs, each driven by the GCM ECHAM5-MPI/OM run 1, while the ENSEMBLES dataset encompasses 18 (2021–2050) or 11 (2071–2100) different GCM x RCM combinations, respectively. The relevance of model selection becomes obvious by regarding the low increase of projected spring temperature in the REGKLAM dataset compared to the ENSEMBLES dataset. Thus, a consideration of several GCM x RCM chains can prevent a misinterpretation of climate variability as a climate change induced signal.

Both datasets however show an increasing warming signal towards the end of the 21st century (Figure 1).

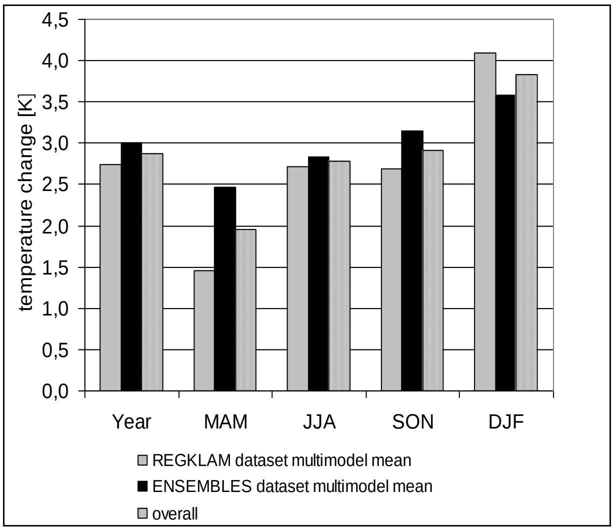

Figure 1. *Seasonal temperature change signals for the multimodel datasets REGKLAM and ENSEMBLES.*

For 2021–2050 the warming signal of the REGKLAM projections (+0.9 K) is remarkably lower than the ENSEMBLES signal (+1.4 K). Both datasets however converge towards the end of the century (REGKLAM: +2.7 K, ENSEMBLES: +3.0 K). The span of all individual multimodel members ranges from a temperature increase from +0.6 to +2.1 K for 2021–2050 and from +2.1 to +4.1 K for the period 2071–2100. The data suggests a tendency to strongest warming signals during winter season and lowest warming rates in spring, albeit not by all individual multimodel members.

The remarkable difference of projected annual temperature change during the time period 2021–2050 obviously arises from the choice of the RCM model type, as the statistical models WEREX and WETTREG produce lower warming signals.

Regarding projected precipitation, the signal range stays rather indifferent for the time period 2021–2050. The results from the statistical models WEREX and WETTREG depict a decrease of summer precipitation in 2021–2050 while this signal is not clearly detectable in the dynamical projections. In the time period 2071–2100 however, there also is an indication for decreasing summer precipitation from the majority of the dynamical models (Figure 2). During spring and winter season most models show a precipitation increase or respectively do not show any significant decrease. Thus, there exists no pronounced change of annual precipitation, as already suggested from the analysis of a number of GCMs for the area of central Germany (Feske, 2009).

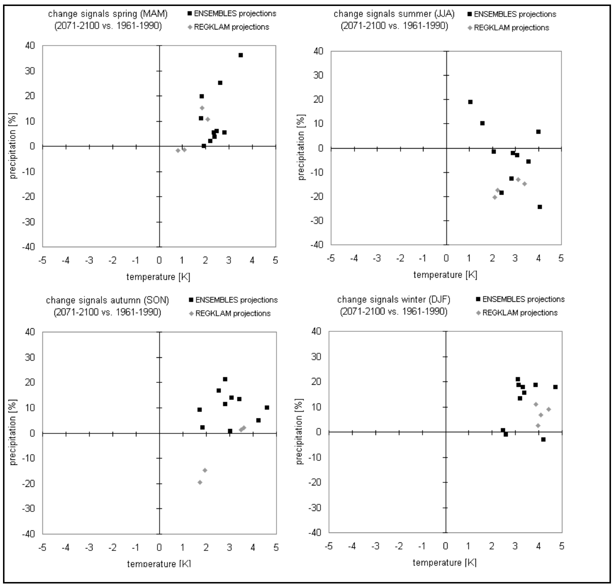

Figure 2. *Combined seasonal change signal (2071–2100 vs. 1961–1990) of temperature and precipitation for the individual multimodel members, grouped by REGKLAM and ENSEMBLES.*

The consistency of projection signals is relevant for climate adaptation measures and leads to the conclusion, that the consideration of different model methodologies (statistical and dynamical) significantly enhances a comprehensive assessment of climate projection induced uncertainties. However, there are methodological aspects that have to be taken into account for an appropriate interpretation of the results. Differences in spatial resolutions and parametrisation are naturally associated with different model results.

Furthermore, there is a systematic difference between station based data (statistical models) and grid based dynamical models. Both, the spatial resolution and the underlying elevation model of dynamical RCMs influence the regional representativeness of the results. Particularly, with regard to this analysis, the results represent spatial mean values over a large region which is naturally characterized by complex terrain, including both lowlands and mountain ranges.

The numerous effects on the sub-regional and local climate scale can not be addressed here and require a more intensive investigation of the data. Moreover, an additional analysis of climate observations as well as the involvement of circulation pattern induced effects can deliver crucial information on specific sub-regional climate effects and consequently provide information to assess the regional representativeness of regional climate projections.

Conclusions

A comprehensive synopsis of different RCM results and methods reduces the risk of misinterpretation and inappropriate conclusions. A substantiated extension of multimodel datasets with additional members and methods can help to confirm or disprove assumptions based on a limited number of climate projections and lastly, prevent insufficient or unsuitable adaptation measures.

Acknowledgements: The ENSEMBLES data used in this work was funded by the EU FP6 Integrated Project ENSEMBLES (Contract number 505539) whose support is gratefully acknowledged.

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THUNDERSTORM DAYS DURING PERIODS WITH HOT AND HEAT WEATHER IN WARSAW, PRAGUE AND NAPLES (1986–2011)

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Abstract. Thundertorms in the days and nights of warm and hot weather in Warsaw, Prague and Naples are characterized in the paper. Data on thunderstorm days and maximum and minimum air temperatures comes from the years 1986–2011. Most thunderstorms occur in Warsaw and Prague in July, in Naples - in November; dominated by thunderstorms on the hot and warm nights. In Naples and Warsaw were a few thunderstorms in tropical days, in Prague they were not present.

Introduction

The high air temperature a huge is strain on the human body. Many climatologists have drawn attention to the increasingly frequent occurrence of hot and heat days and nights, tropical days, and especially heat waves in Europe (Twardosz 2009; Kossowska-Cezak 2010, 2010a, 2011). It seems that the incentives will be even stronger weather if, in these days there are also thunderstorms.

The tourists trips 1 or 2 weekly, connected with change of climate zone, especially in the warm half, are not good for us because of the short period of acclimatization. Popular with tourists is the Mediterranean Sea Basin at the same time an area of high thunderstorm activity (Grabowska, 2010). Among many localities, Naples has a very large number of thunderstorms (average of 37.8 thunderstorm days of the year).

Also visited by tourists city of Prague (an average of 28.5 thunderstorm days of the year) and Warsaw (average 26.9 thunderstorm days of the year) located in the cooler warm temperate, are subject to hot and heat weather, during which there are thunderstorms.

The aim of the study is to determine the frequency of thunderstorm days during the hot and heat days and nights in Warsaw, Prague and Naples in the years 1986–2011.

Material and methods

Data on the number of thunderstorm days and daily values of maximum and minimum air temperatures are derived from archival database OGIMET and TUTIEMPO.

Heat and hot weather is characterized by the corresponding ranges of values of maximum and minimum temperatures. The hot weather is represented by: hot day, warm night and very warm night. The heat weather is represented by: heat day, very heat day, super heat day and hot night and very hot night. The most difficult thermal conditions prevail during the tropical day (Table 1).

In determining the days and nights of hot, heat and tropical days in Naples (transitional subtropical climate) used a classification of the selected thermal characteristic days (Kossowska-Cezak, 2007) expanded with respect to Warsaw and Prague (transitional warm temperate climate) with a super heat days (Tmax > 37 ^{o}C) and very hot nights (Tmin > 23 ^{o}C) (Table 1).

Table 1. *Selected thermal characteristic days (as amended by: Kossowska-Cezak 2007, 2010a and Kossowska-Cezak, Skrzypczuk 2011).*

Thermal characteristic days	Maximum temperature (Tmax) [^{o}C]	Minimum temperature (Tmin) [^{o}C]
Hot day	25.1–30.0	
Heat day	30.1–35.0	
Very heat day	35.1–37.0	
Super heat day	> 37.0	
Warm night		15.1–18.0
Very warm night		18.1–20.0
Hot night		20.1–23.0
Very hot night		> 23.0
Tropical day	> 30.0	> 20.0

Results

Thunderstorms in the surveyed cities can occur throughout the year, but mostly this phenomenon is observed in Warsaw and Prague in the summer (July – 6.6 thunderstorm days on average a month), and Naples in the autumn (November – 5.0 thunderstorm days on average a month).

In Warsaw, the thunderstorm season begins during the hot days in April and ends in September (last 6 months). Thunderstorms during the warm nights begin in May and ends in August (4 months). In Prague, the thunderstorm season during hot days is one month less (May-September) and during the warm nights, as long as in Warsaw, but it starts later (June-September). In Naples thunderstorms during the hot days and warm nights are longest, for 7 months, from May to November (Figure 1).

Most thunderstorms occurred during the hot days (on average a year: Warsaw – 19.7, Prague – 17.8, Naples – 16.6) and warm nights (on average a year: Warsaw – 13.0, Prague – 9.9, Naples – 14.7). The thunderstorms do not appear during the super heat days, and in Warsaw during the very hot nights, in Prague during the hot nights and very hot nights. A small number of them was accompanied by only a very hot nights in Naples (on average a year – 0.2) (Table 2).

Most likely to thunderstorm it was during the very hot days of the Warsaw (100 % in June) and Prague (66.7 % in August). The highest probability of a thunderstorm was during the hot nights in Warsaw (100 % in August and 50 % in July). Most thunderstorms were during the tropical days in Warsaw (50 % in July) (Table 3).

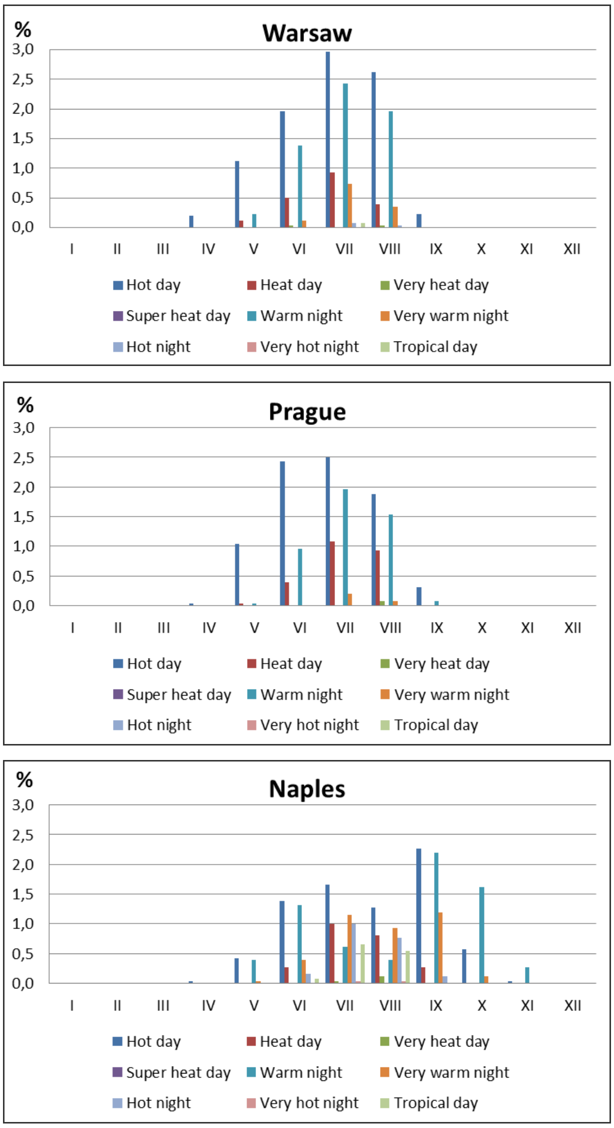

__Figure 1.__ Annual course of thunderstorm days during days (hot, heat, very heat and super heat) and night (warm, very warm, hot and very hot) and tropical days in Warsaw, Prague and Naples (1986–2011).

__Table 2.__ Average annual number of days (hot, heat, very heat and super heat) and night (warm, very warm, hot and very hot) and tropical days in total and with storms in Warsaw (W), Prague (P) and Naples (N) (1986–2011).

Thermal characteristic days	Annual average of total			Annual average of storms		
	W	**P**	**N**	**W**	**P**	**N**
Hot day	75.1	67.8	171.4	19.7	17.8	16.6
Heat day	14.3	14.7	98.5	4.2	5.3	5.1
Very heat day	0.9	0.5	6.0	0.2	0.2	0.3
Super heat day	0.0	0.0	1.2	0.0	0.0	0.0
Warm night	36.0	23.0	107.7	13.0	9.9	14.7
Very warm night	6.1	1.0	78.1	2.6	0.6	8.3
Hot night	0.4	0.0	78.4	0.3	0.0	4.4
Very hot night	0.0	0.0	5.8	0.0	0.0	0.2
Tropical day	0.3	0.0	62.6	0.2	0.0	2.8

__Table 3.__ Relative frequency (%) of appearance of thunderstorm days in selected thermal characteristics days in Warsaw (W), Prague (P) and Naples (N) (1986–2011).

Thunderstorms in thermal characteristic days	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year	City
Hot day	0,0	0,0	0,0	21,7	29,3	27,6	27,4	25,2	14,0	0,0	0,0	0,0	26,2	W
	0,0	0,0	0,0	14,3	32,9	37,5	29,4	18,4	12,1	0,0	0,0	0,0	26,2	P
	0,0	0,0	0,0	4,8	4,1	8,4	12,1	12,0	11,9	7,7	16,7	0,0	9,7	N
Heat day	0,0	0,0	0,0	0,0	42,9	40,6	27,3	23,3	0,0	0,0	0,0	0,0	29,2	W
	0,0	0,0	0,0	0,0	33,3	35,7	35,9	36,4	0,0	0,0	0,0	0,0	35,8	P
	0,0	0,0	0,0	0,0	0,0	4,1	6,3	4,4	7,7	0,0	0,0	0,0	5,2	N
Very heat day	0,0	0,0	0,0	0,0	0,0	100,0	0,0	20,0	0,0	0,0	0,0	0,0	18,2	W
	0,0	0,0	0,0	0,0	0,0	0,0	0,0	66,7	0,0	0,0	0,0	0,0	33,3	P
	0,0	0,0	0,0	0,0	0,0	0,0	4,2	8,1	0,0	0,0	0,0	0,0	5,6	N
Super heat day	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	W
	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	P
	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	N
Warm night	0,0	0,0	0,0	0,0	46,2	42,9	34,8	34,2	0,0	0,0	0,0	0,0	36,1	W
	0,0	0,0	0,0	0,0	50,0	54,3	43,2	40,4	22,2	0,0	0,0	0,0	43,1	P
	0,0	0,0	0,0	0,0	4,7	11,3	13,0	10,8	16,3	23,5	28,0	0,0	13,6	N
Very warm night	0,0	0,0	0,0	0,0	0,0	33,3	40,4	52,9	0,0	0,0	0,0	0,0	42,5	W
	0,0	0,0	0,0	0,0	0,0	0,0	71,4	50,0	0,0	0,0	0,0	0,0	58,3	P
	0,0	0,0	0,0	0,0	3,4	5,2	10,4	10,0	19,1	13,6	0,0	0,0	10,6	N
Hot night	0,0	0,0	0,0	0,0	0,0	0,0	50,0	100,0	0,0	0,0	0,0	0,0	60,0	W
	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	P
	0,0	0,0	0,0	0,0	0,0	3,7	7,3	4,8	5,5	0,0	0,0	0,0	5,6	N
Very hot night	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	W
	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	P
	0,0	0,0	0,0	0,0	0,0	0,0	3,7	2,9	0,0	0,0	0,0	0,0	2,9	N
Tropical day	0,0	0,0	0,0	0,0	0,0	0,0	50,0	0,0	0,0	0,0	0,0	0,0	50,0	W
	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	P
	0,0	0,0	0,0	0,0	0,0	2,5	6,2	3,7	0,0	0,0	0,0	0,0	4,4	N

Conclusions

Thunderstorms in all cities are popping up throughout the year. In Naples, usually in autumn, when it is still warm and the humidity is higher than in summer. For this reason (high maximum, minimum air temperature and less humidity) thunderstorms occur less frequently during the hot and heat weather – 25 % and even 17 % of the total thunderstorms.

In Warsaw and Prague, most thunderstorms occur in summer, which is more humid than in Naples. In Warsaw and Prague in the summer there are more frontal thunderstorms.

The thunderstorms were relatively rare in the days under consideration of the thermal characteristics. The greatest chance of popping up is during the warm and very warm nights and hot days. At the same time those selected nights and days had the highest attendance during the year.

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50 YEARS OF METEOROLOGICAL OBSERVATIONS AT THE METEOROLOGICAL STATION IN ÚSTÍ NAD LABEM

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Abstract. In this paper were analyzed climatological conditions of Ústí nad Labem (this city is located in the Czech Republic in the North Bohemia region) from the results of the meteorological station with the 50-years' continuous period. Basic meteorological elements as precipitation and air temperature were evaluated. The average annual precipitation total is 545.2 mm; the average annual air temperature is 9.5 °C. The maximum amount of annual precipitation total was measured in 2010 (974.5 mm), the minimum amount of annual precipitation total was in 1976 (296 mm). The maximum amount of daily precipitation total was observed on the 7th August 2010 (75.2 mm). The warmest year occurred in 2000 (11.1 °C), the coldest year appeared in 1965 (8.1 °C).

Introduction

Ústí nad Labem is the city of the Czech Republic, in the Ústí nad Labem region. The city is the 7th most populous in the country. Ústí nad Labem is situated in a mountainous district at the confluence of the Bílina and the Labe Rivers. The first meteorological station in Ústí nad Labem was established on the 1st January 1936 and the station was situated in the downtown. The station has moved several times during the whole observation period. At present, it is located in the suburb called Vaňov (the station was installed there on the 1st April 2003). According to the Quitt's classification the city Ústí nad Labem falls into the warm region W2 (Květoň and Voženílek, 2011) with subsequent climatological characteristics: number of summer days (50–60), number of days with mean temperature 10 °C and more (160–170), number of days with frost (100–110), number of ice days (30–40), mean January temperature (from -2 to -3 °C), mean July temperature (18–19 °C), mean April temperature (8–9 °C), mean October temperature (7–9 °C), mean number of days with precipitation equal to 1 mm and more (90–100), sum of precipitation in the vegetation period (350–400 mm), sum of precipitation in the winter period (200–300 mm), number of days with snow cover (40–50), number of cloudy days (120–140) and number of cloudless days (40–50).

Material and methods

Meteorological data (air temperature and precipitation) were processed in the 50-years' period (1961–2010) in a similar way like meteorological data from the meteorological station in Tušimice (Hájková and Kožnarová, 2012). CHMI meteorological data are stored in Clidata-Oracle database since as long as the 1st January 1961. As it was mentioned above, the station has been moving within the territory of the city several times during the observed period, the geographical coordinates are at present as follows: 150 m a.s.l., 50°37'32" N, 14°03'30" E.

Daily and monthly data were exported from the database Clidata from the 1st January 1961 to 31st December 2010. These data were processed (statistically and graphically) in the environment of the Excel and basic statistical characteristics (average, median, maximum, minimum, upper and lower quartile, standard deviation) were calculated. The limits of intervals used in the thermopluviogram are shown in Table 1 (according to the World Meteorological Organization recommendation).

Table 1. *The limits of intervals (Kožnarová et al., 1997).*

Terms		Percentile
Extraordinary cold year	**extraordinary dry year**	< 2.0 %
Very cold year	**very dry year**	2.0 to 9.9 %
Cold year	**dry year**	10.0 to 24.9 %
Normal year	**normal year**	25.0 to 75.0 %
Warm year	**wet year**	75.1 to 90.0 %
Very warm year	**very wet year**	90.1 to 98.0 %
Extraordinary warm year	**extraordinary wet year**	> 98.0 %

Results and discussion

Basic monthly precipitation and air temperature characteristics (e.g. average, average daily maximum, average daily minimum and absolute daily maximum) are shown in Figures 1-4.

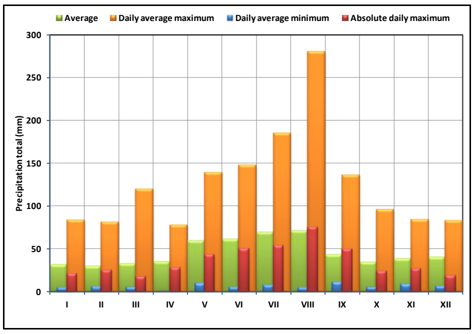


Figure 1. *Precipitation characteristics.*

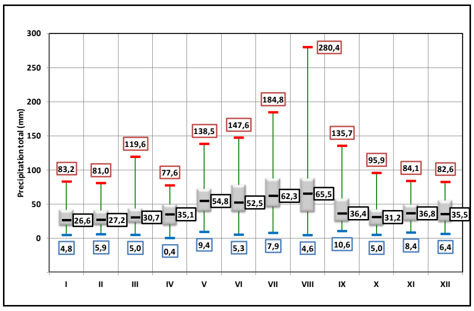


Figure 2. *Mean monthly precipitation.*

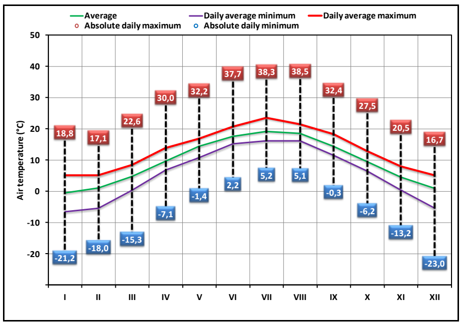


Figure 3. *Air temperature characteristics.*

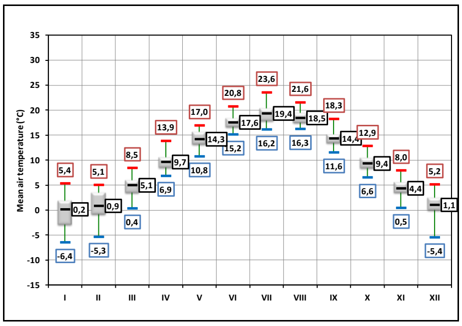


Figure 4. *Monthly mean of air temperature.*

Differences between averages calculated from period 10, 20, 30 (standard climatological normal), 40 and 50 years are presented in Figure 5 (precipitation totals of months) and in Figure 6 (monthly mean of air temperature).

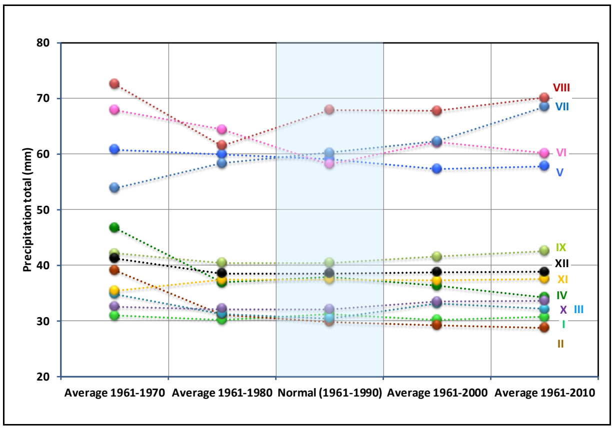


Figure 5. *Different calculated average of monthly precipitation totals.*

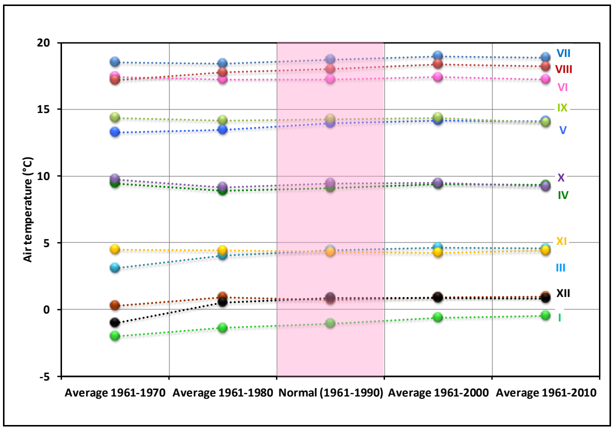
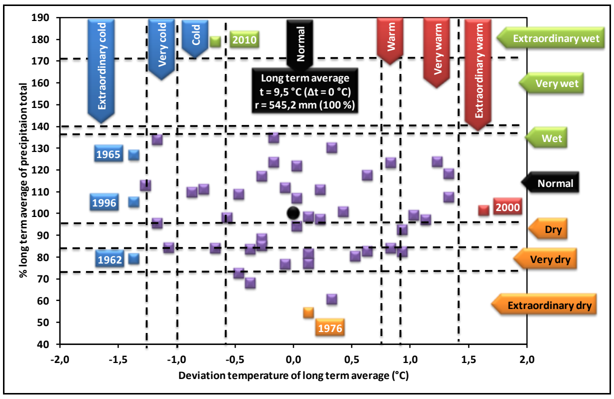


Figure 6. *Different calculated average of monthly mean air temperature.*

The lowest and the highest average temperature and precipitation characteristics in the whole observed period (1961–2010) were evaluated for thermopluviogram according to the limits mentioned in Table 1. The thermopluviogram (see Figure 7) expresses variability of average annual air temperature and average annual precipitation total by the deviation of these characteristics.



Conclusions

The average annual precipitation total is 545.2 mm in the period 1961–2010 (e.g. the average annual precipitation total is 522 mm within the normal period 1961–1990). The maximum annual precipitation total is 974.5 mm (2010); the minimum annual precipitation total is 296 mm (1976). The mean annual air temperature is 9.5 °C within the 50-years' period (e.g. the mean annual temperature was 9.1 °C in the normal period 1961–1990). The maximum daily precipitation total was recorded on the 7th August 2010 (75.2 mm). The mean daily minimum air temperature is 5.3 °C and the mean daily maximum air temperature is 14.0 °C. The absolute minimum air temperature was measured on the 29th December 1996 (-23.0 °C); the absolute maximum air temperature was observed on the 1st August 1994 (38.5 °C) in this 50-years' period.

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DROUGHT IN EASTERN SLOVAKIA IN 2011 COMPARED WITH THE PREVIOUS PERIOD

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Abstract. Geographic position of Eastern Slovakia creates preconditions for existence of the temporary precipitation deficit periods resulting in drought mainly during transition seasons (spring and autumn) as well as summer. Not only precipitation deficit but also precipitation surplus represents a trouble that cause increasingly more significant and widespread damages. The long-term time series of daily precipitation totals available from the year 1961 to present period have made us possible to analyze the incidence of the precipitation deficit period in Eastern Slovakia. In the paper we deal with the frequency analysis as well as with the annual regime and regional extent analysis of the precipitation deficit periods incidence at selected meteorological station in Eastern Slovakia.

Introduction

The drought may not be solely the period without rainfalls, but can also be taken of the other meteorological elements such as wind, temperature and humidity, cloudiness, and others, which affecting evaporation and thus the drought. In this paper we evaluate the long time series of daily precipitation totals for the period 1961 to 2011 nine selected meteorological stations Košice and Prešov region (Table 1). In addressing this issue, we have focused on trends and frequency of periods with a precipitation deficit and the annual mode.

Table 1. *Geographical location of selected meteorological stations.*

Station	Altitude (m a.s.l.)	Coordinates (GPS)	
Kamenica n/C	176	48.9347	21.9942
Košice letisko	229	48.6706	21.2386
Medzilaborce	304	49.2531	21.9119
Milhostov	102	48.6631	21.7219
Plaveč n/P	485	49.2603	20.8428
Poprad	693	49.0681	20.2494
Rožňava	311	48.6522	20.5353
Somotor	97	48.4214	21.8183
Švedlár	472	48.8106	20.7089

Material and Methods

To determine the period with precipitation deficit in the past established a number of criteria. We used the criteria by which the drought evaluated frequently and they are based on the duration of the period with a precipitation deficit and the precipitation, which can be achieved in the period.
1. criterion, if the precipitation deficit lasted at least 15 days during which fell less than 1 mm of precipitation
2. criterion, if the precipitation deficit last at least 20 days, and fell less than 2.5 mm of rainfall
3. criterion, if the precipitation deficit lasted at least 30 days and fell less than 5 mm of rainfall

The first criterion is usually satisfied and therefore we have not given this criterion, we focused on other criteria. If a drought period occurs continuously over several months to identify the month in which the drought lasted several days, if the rainfall is lower. The precipitation deficit during the growing season in 2011 was compared with evaporation from free water level at selected meteorological stations, where evaporation during the growing season is observed.

Results and discussion

Summary of drought periods in Košice and Prešov region in the period 1961–2011 shows Table 2, where the annual regime of drought periods has two maxima and two minima. The first is the maximum in autumn (October) and the second is in the spring (February and March). The first minimum in summer (June–July), tend to be more frequent incursions of marine air from the Atlantic and also the types with anticyclonic weather situation, they are sometimes quite abundant summer storms that cause the periods without rainfall may not develop for a longer period. The second minimum is at the end of autumn (November–December).

Table 2 shows that the longest period of drought was at the station Košice airport, lasted 74 days. At the stations Poprad and Plaveč nad Popradom the drought period was less than 60 days.

Table 2. *Summary of the longest drought periods and the largest number of drought periods observed at the stations.*

	The longest drought period	Largest number of drought periods
	Number of days/date	year(number)/month
Kamenica n/C	69 days 11.2. –19.4.1974	 October
Košice letisko	74 days 10.2. –24.4.1974	1991,2011 (2) March
Medzilaborce	68 days 11.2. –19.4.1974	 February
Milhostov	69 days 16.2. –25.4.1974	2011 (4) March
Plaveč n/P	59 days 20.2. –19.4.1974	 October
Poprad	58 days 21.2.–19.4.1974	2011 (3) October
Rožňava	65 days 31.1.–4.4.1998	2011 (2) February
Somotor	70 days 10.2. –19.4.1974	 September
Švedlár	60 days 20.2.–20.4.1974	2011 (2) January a October

The longest drought in the monitored stations occurred in 1974, only at the station Rožňava it was in 1998. In the second column of the table we see year in which it occurred most periods of drought, with the exact number of periods given in brackets as well as the month in which period of drought usually occurred at the station.

A detailed review of drought periods during each month gives us the Figure 1, which shows the occurrence of drought after month's summary for all the stations monitored during the 1961–2011 period.

In Figure 1 we see that during 2011 were recorded 4 periods of drought. The drought in February and in November we have underpinned by the soil water deficit, but the drought periods in August and September are corresponding to the soil water deficit.

Evaporation of free water level in the network SHI measured from April to September, and therefore precipitation deficit in February and November can not be compared with the soil water deficit. Table 3 shows the evaporation of free water level for the IV–X/2011 period of 7 stations Košice and Prešov region. The highest the soil water deficit from April to October was recorded at stations Košice - Airport (-230 mm), Milhostov (-186 mm), Somotor (-139 mm) and Tisinec (-107 mm).

Table 3. *Evaporation from free water level and the soil water deficit (-) for the period IV–X/2011 in Eastern Slovakia.*

		IV	V	VI	VII	VIII	IX	X	Σ
Kamenica n/C	V	47	74	81	57	83	59	33	434
	Z	23	44	95	204	35	38	38	477
	Z-V	-23	-30	14	147	-48	-21	5	44
Somotor	V	57	78	91	72	75	66	32	469
	Z	21	28	92	115	9	49	18	331
	Z-V	-36	-50	1	43	-65	-17	-14	-139
Tisinec	V	48	80	85	68	85	73	40	479
	Z	24	52	47	167	34	11	37	372
	Z-V	-25	-29	-37	99	-51	-62	-3	-107
Milhostov	V	67	100	104	85	110	86	39	590
	Z	14	46	112	166	11	41	14	404
	Z-V	-53	-54	8	82	-99	-45	-25	-186
Košice letisko	V	75	101	108	91	99	95	53	623
	Z	8	68	100	150	31	15	21	393
	Z-V	-67	-33	-8	59	-68	-80	-32	-230
Rožňava	V	57	77	75	63	80	64	35	452
	Z	13	78	130	116	49	5	37	429
	Z-V	-43	1	55	53	-31	-59	2	-23
Spišské Vlachy	V	43	71	70	62	75	64	31	415
	Z	17	89	72	152	19	19	45	412
	Z-V	-27	18	2	90	-55	-44	13	-3

Conclusions

The problem of precipitation deficit is only one part of the phenomenon of drought. The drought and the associated precipitation deficit are becoming the dominant danger of mankind. On the territory of Eastern Slovakia we are register the signs of disturbance annual course of precipitation, as well as other meteorological elements, such as lack of moisture, so the soil water deficit, and not least the extreme temperatures during the year.

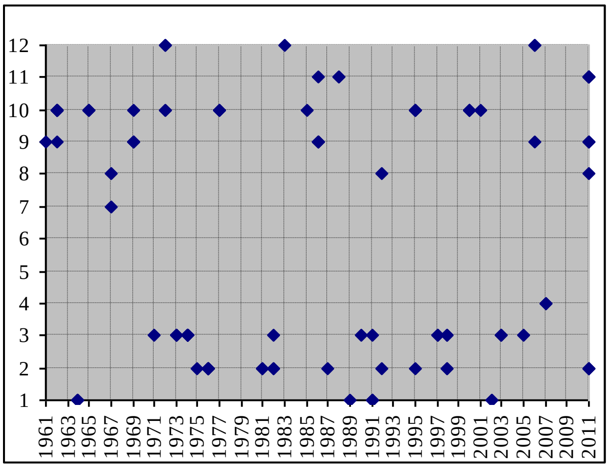

Figure 1. *The drought occurrence by months during the period 1961–2011 a summary of all the monitored stations.*

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USING REMOTELY SENSED NDVI FOR DROUGHT IMPACT ASSESSMENT WITHIN SELECTED CROPS

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Abstract. The relationship between Normalized Difference Vegetation Index (NDVI) and selected agrometeorological parameters (yields of selected crops, water balance) was investigated. The source for NDVI was Spectroradiometer MODIS within satellite Terra and it was available for grids in resolution 500 x 500 m from 2000 to 2010. The analysis was conducted within 12 grids spread through Southern and Central Moravian region. The information about cultivated crops (including spring barley, winter wheat and maize for grains, sugar beet and winter rape) were collected from the farmers and water balance simulated using SoilClim model.

Introduction

The Normalized Difference Vegetation Index (NDVI) is one of the frequently used vegetation indices which could be obtained through remote sensing. If the measurements are conducted from the satellite then the dynamics of the vegetation development could be analyzed in time or spatially through large regions. By this way the stress factors for the plants could be detected and classified. The main aim of submitted study was to analyze the ability of NDVI to explain the yields of selected agricultural crops (i.e. spring barley, winter wheat, maize for grains, sugar beet and winter rape) and also investigate its relationship with water balance to test possible applicability of NDVI for drought impact assessment within agriculture.

Material and methods

For the purpose of submitted study the information about NDVI, soil properties, meteorological parameters and data about cultivated crops was obtained for 12 locations through Southern and Central Moravian region. Each location was represented by the crop field where it was possible to identified square 500 x 500 m with the same position as grids for which NDVI was available. The used NDVI was observed from satellite Terra by MODIS (Moderate Resolution Imaging Spectroradiometer) and these values are freely available (from the link https://lpdaac.usgs.gov/get_ data) in 16 days time step from the spring of the year 2000. The Terra fly over each location once per one or two days and consequently only highest observations from the 16 days period is published and called composite value. This principle is used (besides other) to avoid some disturbance within the measurements e.g. due to the clouds appearance.
The information about cultivated crops (yields, date of sowing and harvest, term and amount of nitrogen fertilizers) for selected grids was obtained from local farmers. Due to the personal contact detail description of exceptional events such as floods, hails or lodging was available as well. The meteorological parameters (global solar radiation, maximum and minimum temperature, vapor pressure, precipitation and wind speed in daily time step) were interpolated for each of included grids from the near stations of Czech Hydrometeorological Institute. The information about maximum soil water holding capacity (in mm of water column up to the 1 meter) comes from Research Institute for Soil and Water Conservation, v.v.i.
The reference evapotranspiration (ETo) of standard grass surface (e.g. Allen *et al*., 1998) and actual evapotranspiration (ETa) of investigated crops was derived using SoilClim model (Hlavinka *et al*., 2011).
Consequently cumulative NDVI above certain level was used for the vegetation state assessment within conducted study. During the analyses the best combination of base NDVI level (above which values were included into cumulative NDVI) and the duration of period for accumulation were investigated for each crop separately. Coefficient of determination R^2 was used as statistical indicator.

Results and discussion

Suitable level above which cumulated NDVI gave best results varied from 0.35 (for Maize) to 0.45 (Sugar beet). The optimal duration of the period for NDVI accumulation significantly varied according to the specific crop and is described within Table 1.

Table 1. *Overview of included crops, number of analyzed seasons through included grids (n), (Start) and (End) of period for NDVI accumulation in julian days and the level of NDVI above which it was accumulated ($NDVI_b$).*

Crop	n	Start (JD)	End (JD)	$NDVI_b$
Maize	14	128	256	0.35
Spring barley	22	112	176	0.40
Winter wheat	48	80	208	0.40
Sugar beet	19	128	256	0.45
Winter rape	6	112	160	0.40

Cumulative NDVI was able to explain up to 70 % of maize yields variability and for spring barley, sugar beet and winter rape the R^2 varied from 0.36 to 0.45. For winter wheat R^2 near to zero was achieved (see Table 2). However when this analysis with winter wheat was conducted for each grid separately, seasons with lower accumulated NDVI have general tendency to yields decrease.

Table 2. *Overview of achieved coefficient of determination (R^2) for cumulative NDVI versus crop yields, difference between precipitation and ETo, precipitation and ETa and ratio between ETa and ETo. The last two regressions are not available for Sugar beet and Winter wheat crop (NA).*

Crop	NDVI vs. Yields	NDVI vs. "Prec-ETo"	NDVI vs. "Prec-ETa"	NDVI vs. "ETa/ETo"
Maize	0.70	0.48	0.52	0.46
Spring barley	0.45	0.37	0.29	0.43
Winter wheat	0.06	0.13	0.06	0.12
Sugar beet	0.43	0.07	NA	NA
Winter rape	0.36	0.81	NA	NA

The general trend of maize yield to decrease for season with lower cumulated NDVI is apparent from Figure 1. At the same time the seasons with low NDVI are connected with highest water deficit (described as difference between sum of precipitation and ETa) of assessed period (see Figure 2).

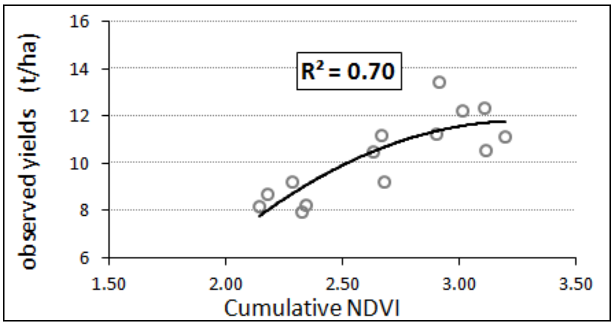

Figure 1. *The relationship between cumulative NDVI (accumulated above the value 0.35 and between 128th and 256th day of the year) and yields of maize for grain within included grids.*

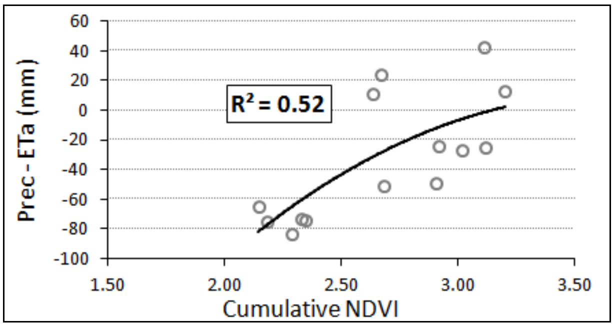

Figure 2. *The relationship between cumulative NDVI (accumulated above the value 0.35 and between 128th and 256th day of the year) and water balance for the same period expressed as difference between sum of precipitation and ETa.*

Similar behaviour was observed in case of spring barley when R^2 for NDVI vs. yields was 0.45 and when only Southern Moravian grids were analysed R^2 was 0.87 (in this case only six seasons were included). In case of sugar beet the R^2 for Southern Moravian grids was 0.68 (with 7 included seasons).

Conclusions

It was proved that cumulative NDVI might be used for identification of stress within growth of agricultural crops such as maize for grain, spring barley, sugar beet or winter rape which were included within submitted study. As this preliminary results show the lower NDVI is associated with yield reduction. Simultaneously it was indicated that one of the possible reasons for yield decrease is associated with lower water availability or even drought which was in general captured also by cumulated NDVI per crucial parts of growing periods. These results seem to be promising for future using NDVI within drought monitoring and assessment and this could be supported by the fact that NDVI data from satellite Terra covers large areas (even at continental scale), has fine spatial and temporal resolution and are freely available.
On the other hand there was not proved the generally valid relationship between NDVI and observed yields of winter wheat and is also difficult to say something more specific about this relationship for crops which were not included within submitted study. Moreover some complications for practical using could be connected also with crop specific length of proper period for NDVI accumulation. Consequently, we don't know (based on satellite NDVI observations) if there is some stress (e.g. due to the drought) or lower NDVI is due to the later sowing date. Moreover the situations for grids represented by several fields with different crops should be investigated, as they are most common cases in real agricultural landscape.

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SOIL MOISTURE IN HODONÍN AND STRÁŽNICE IN YEARS 2009–2011

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Abstract. Soil moisture can be determined by measuring equipment or calculated using models. The results of measurements of soil moisture using VIRRIB equipment were compared with results from AVISO and FAO Crop Evapotranspiration models. The comparison was based on data from the area of light soils in Hodonín-Pánov and data from heavier soils in Strážnice from period 2009–2011. The measured and model data in wetter years 2009 and 2010 brought very similar results, while in drier year 2011, both models underestimated the measured values of soil moisture.

Introduction

Water accessible by plants is limited by soil hydrolimit of wilting point, which determines soil moisture, time when plants are constantly insufficiently supplied with soil water, when water absorption by their root system is substantially lower than the intensity of transpiration, as a result of which these plants wilt (Kutilek, 1966). The second important hydrolimit of soil proves to be water-holding capacity (field capacity), which indicates the maximum amount of suspended water that soil is able to hold (Kutilek, 1966). Soil moisture can be measured by measuring equipment or calculated using various models. Our contribution compares results of measurements and models of soil moisture in Hodonín and Strážnice in 2009–2011.

Material and methods

A variety of agro-meteorological measurements took place in Hodonín-Pánov area of grassland on light sandy soils in 2009–2011 within the grant "A model project of prevention of biological soil degradation in arid climate conditions". One of the agro-meteorological measurements took place in the form of measurement of soil moisture using VIRRIB equipment produced by Amet company from Velké Bílovice (Litschmann, 1991). Soil moisture was recorded at several levels, however, in this paper we work only with average values of soil moisture in the layer of 0–60 cm. Data on soil moisture in the layer of 60–100 cm were not measured as this contribution did not aim at this layer. Soil moisture was measured at a number of habitats with specific characteristics within the locality mentioned (Hora, 2011); however, this paper analyzes only the data from habitats presence of solely natural soils. Due to meteorological measurements, soil moisture was modeled in the layer of 0–100 cm using FAO methodology (Allen *et.al*., 1998) and using AVISO model (Vitoslavský and Kohut, 1999). In addition to special-purpose measurements in Hodonín, we also present the results of measurements of soil moisture from the regular network of CHMI in Strážnice. Soil moisture was recorded using VIRRIB device which made it possible to record data of soil moisture up to the depth of 90 cm.

In order to analyze soil moisture, it is important to determine selected soil hydrolimits. Repeated pedological measurements in Hodonín-Pánov brought inconsistent information, which, however, always indicated that the value of retention water capacity is significantly higher than the actually measured values of soil moisture (not only measured by VIRRIB device, but also occasional gravimetric measurement), respectively higher than the value that should theoretically correspond to the area of soils occurring in this locality. Values of soil hydrolimits were therefore obtained for the purposes of our own measurements of soil moisture during the whole period analyzed.

Soil water-holding capacity at Hodonín-Pánov locality was enumerated by this method at 12 %, wilting point to 6 %. For climatological station in Strážnice, these hydrolimits were estimated to 26 % (water-holding capacity of soil) and 15 % (wilting point).

Results and discussion

Comparison of measured and model data on soil moisture in Hodonín-Pánov is presented in Figure 1. The graph also includes amount of precipitation, in a scale compatible with the models of soil moisture. As stated above, measurements of soil moisture in Hodonin were applied only for the 0-60 cm layer, so the comparison with the models of soil moisture is not completely accurate. AVISO model can simulate soil moisture only in the range of hydrolimits of water-holding capacity and wilting point (the usable water capacity of soil), which relates to the identification of this model. In contrast, FAO model is intended to work with the states when the soil moisture rises above the hydrolimit of water-holding capacity. Under natural conditions, however, short-term fluctuations below the wilting point are possible.

Comparing the measured and model values of soil moisture, we can see very good accordance between 2009 and 2010. In the second half of 2011, greater difference was observed between the model and measured values of soil moisture, the model values were significantly lower in case of both models.

In addition to data quality issues, in case of both - soil moisture and the data used as input into the model, there are several theoretical explanations of mutual inhomogeneities between the individual models and measurements. In addition to the above mentioned, the problem in non-uniform depth of the layer used to calculate or measure soil moisture can be a major problem in modeling of vegetation development. In a period of sufficient water supply, modeling of the conditions of plants is very satisfactory, but in the event of prolonged dry period, wilting of plants occurs in natural conditions. During subsequent precipitation, it appears that both models underestimate the evapotranspiration of drought-affected crop, and thereby underestimate the real conditions of soil moisture.

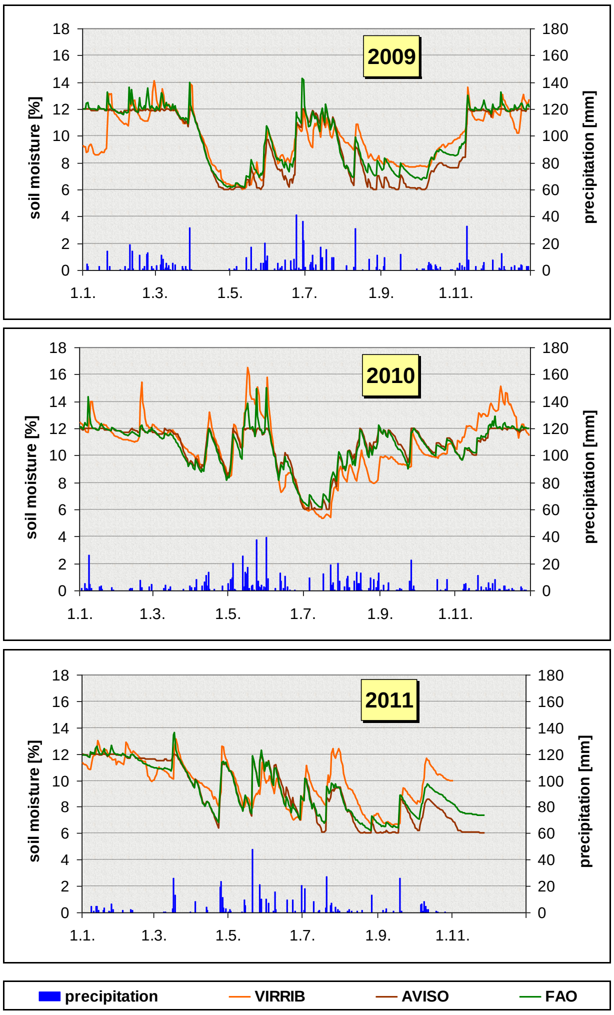

Figure 1. *Measured and model soil moisture and precipitation in Hodonín-Pánov in the period of 2009–2011.*

All three data series point out several facts in the dynamics of soil moisture. Light soils with low water-holding capacity dry up very quickly. In case of further rains, however, the soil moisture gets relatively close to the values of water-holding capacity in a relatively short time. Years 2009 and 2010 were above the regular values of precipitation in Hodonin, in 2011, however, precipitation was normal. In 2011 there were frequent alternations of periods of low and high soil moisture, while the most significant period of low soil moisture occurred in August and September.

Figure 2 compares the measured and model soil moisture in Strážnice. Since data from 2011 seem to be problematic in terms of quality, we present only the situation in 2009 and 2010 in our contribution. At first sight it is evident that the dynamics of changes in soil moisture for soils with higher available water capacity is slower than that of light soils.

Conclusions

The aim of the paper was evaluation and, in particular, comparison of measured and calculated (model) values of soil moisture in Hodonín-Pánov and in Strážnice in the period of 2009–2011. Basic assumptions were confirmed, that the lighter soils in the area of Hodonín are characterized by frequent alternation of high and low status of soil moisture, while the heavier soils in Strážnice area are characterized by slower fluctuation of hydrolimits of soil moisture of water retention capacity and wilting point. VIRRIB equipment and both models are used, namely AVISO and FAO brought comparable results, especially in wetter years of 2009 and 2010. In drier year of 2011, both models underestimated values of soil moisture compared to the values measured in Hodonín-Pánov.

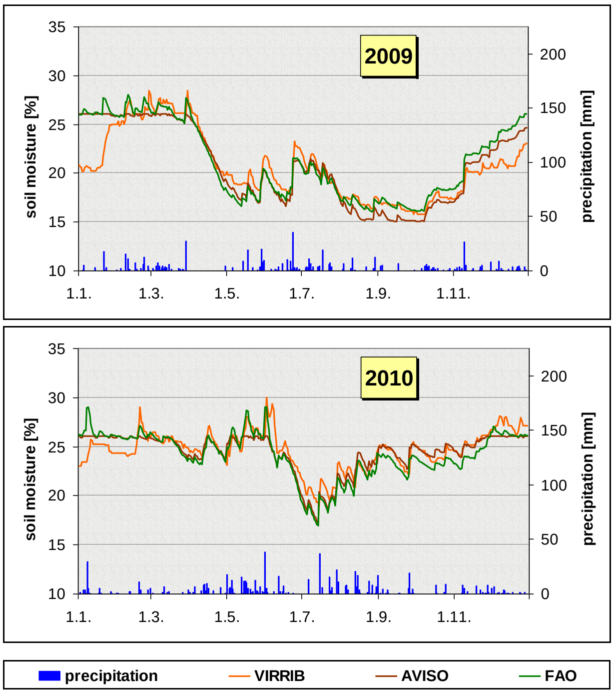

Figure 2. *Measured and model soil moisture and precipitation in Strážnice in the period of 2009–2011.*

Acknowledgements: This paper presented came into being as a part of project of the Ministry of Education, Youth and Sports of the Czech Republic No. 2B08020 called "Model project of prevention of biological soil degradation in conditions of arid climate."

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BEGINNING OF FLOWERING OF COMMON HAZEL (*Corylus avellana* L.) IN THE CZECH AND SLOVAK REPUBLIC IN THE PERIOD 1991–2010

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Abstract. Common Hazel (*Corylus avellana* L.) was analyzed in the phenological phase beginning of flowering (10%) in the Czech and Slovak Republic within the period 1991–2010. The results were processed from 61 phenological stations at different altitudes from 158 to 870 m a.s.l. The phenological data were evaluated also in the geographic information systems. The beginning of hazel flowering occurred between 22nd February and 29th March in the Czech Republic and between 24th February and 5th April in the Slovak Republic. The latest (1996) and earliest (2007) phenophase onset within the twenty year period appeared in both countries in the same year.

Introduction

Common Hazel (*Corylus avellana* L.) as a main pollen allergen is observed in the phenological network of the Czech and Slovak Hydrometeorological Institute in the vegetative and generative phenological stages. For the indication of the pollen release is important the phenological stage the beginning of flowering. The production of pollen is plentiful, if species does not grow in the shrub layer and is overshadowed (Rybníček *et al.*, 1997) and the pollen grains of Common Hazel contain at least allergen Cor a 1 (Špičák and Panzner *et al*., 2004).

The timing of beginning of flowering in the Czech and Slovak Republic was presented in some related papers within the different periods (Bissolli *et al*., 2005; Braslavská *et al*., 2004; Hájková and Nekovář, 2008; Remišová and Vinceová, 2007).

Detailed relations between the phenophase onset and the climatological element can be given in the phenotermopluviogram (Kožnarová *et al*., 2012). The time of beginning of flowering is influenced by weather conditions in the current year. Hájková *et al*. (2012) evaluated the onset of other phenological stages of Common Hazel in the Czech Republic for the same period.

Material and methods

The phenological stage beginning of flowering of Common Hazel was observed in the Czech and Slovak Republic in the period 1991–2010. The detailed phenophase description represent the methodology instruction number 10 of the Czech Hydrometeorological Institute (2009), Phenological atlas (Coufal *et al*., 2004) and Methodology of the Slovak Hydrometeorological Institute (1996).

Beginning of flowering of Common Hazel was observed at 33 phenological stations from 158 to 830 m a.s.l. in the Czech Republic and at 28 phenological stations from 180 to 870 m a.s.l. in the Slovak Republic.

The phenological data were processed in the environment of Excel and the maps were evaluated with using geographic information systems (Application Clidata-GIS and Grass GIS). As the input data, were used the mean dates of phenophase onset from the period 1991–2010. The maps use horizontal resolution of 500 meters with reference to altitude (method of local linear regression between the measured value and the digital relief model).

Results and discussion

The mean date of beginning of flowering of Common Hazel in the period from 1991 to 2010 was 9th March in the Czech Republic and 14th March in the Slovak Republic. The mean earliest date was 7th February (2007) in the Czech Republic and 19th February (2007) in the Slovak Republic. On contrary, the mean latest date was 4th April (1996) and 6th April (1996) in the Czech and Slovak Republic.

In comparison with other periods, e.g. in the period 1987–2006, the mean date for the beginning of hazel flowering in the Slovak Republic was 15th March. The mean earliest onset was 24th February in 1998, the mean latest date was 7th April in 1987 (Remišová and Vinceová, 2007).

In Figure 1 are the deviations from average value, the highest positive value was 29 in the Czech Republic and 23 days in the Slovak Republic and the highest negative value was 28 days in Czech Republic and 23 days in Slovak Republic.

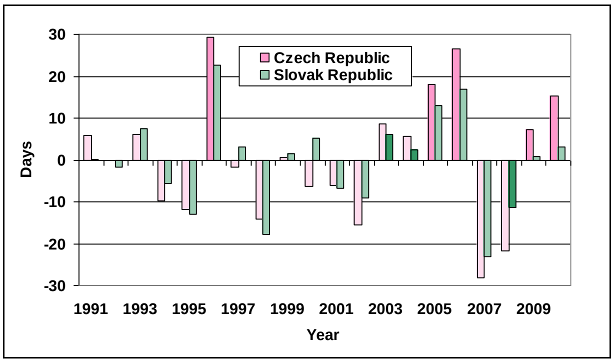

Figure 1. *Deviations of beginning of flowering from average value in the Czech and Slovak Republic, Corylus avellana L.*

Due to inconsistent methodology in the Czech and Slovak Republic it is not possible to compare the length of flowering in both countries (the phenological stage end of flowering is observed in the Slovak Republic until the year 1996). In the Czech Republic lasts the time of flowering, so the duration of pollen season was 22–23 days on average.

Spatial variability of the beginning of hazel flowering

(BBCH 61) in both countries is presented in Figure 2, 3. The average onset of beginning of flowering in the Czech and Slovak Republic was between 22nd February and 5th April. Hazel generally began to flower from lowlands up to the foothills; some differences could cause the natural conditions of the territory.

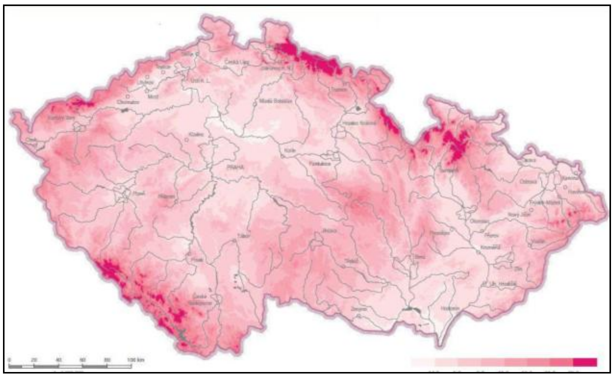

Figure 2. *Average date of beginning of flowering (BBCH 61) in the Czech Republic in the period 1991–2010, Corylus avellana L.*

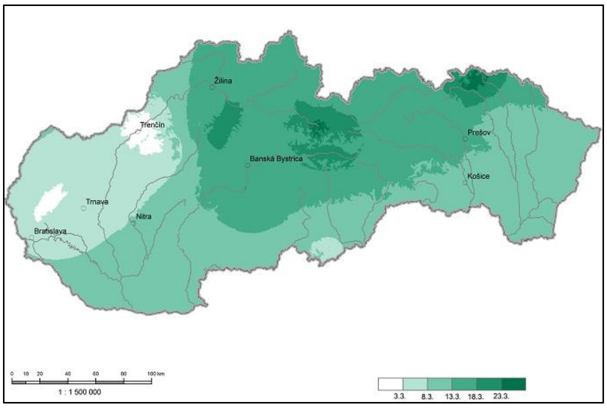

Figure 3. *Average date of beginning of flowering (BBCH 61) in the Slovak Republic in the period 1991–2010, Corylus avellana L.*

Conclusions

The mean date of the beginning of flowering of Common Hazel in the period from 1991 to 2010 was 5 days earlier in the Czech Republic (9th March) than in the Slovak Republic (14th March). The latest and earliest phenophase onset occurred in the same year in both countries (1996, 2007) in the processed period. The average deviation from the mean date (1991–2010) was higher in the Czech Republic (in 3 days) than in the Slovak Republic. From the spatial variability of the beginning of hazel flowering resulted that the main onset of the phenological stage was in the same term in the most of the territory in these two countries.

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SEARCHING FOR THE BEST INDEX CHARACTERIZING HUMAN THERMAL CONDITIONS IN LITHUANIA

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Abstract. The UTCI is one of the best characterizing human thermal conditions and it is still not analyzed in Lithuania. The data from coastal (Klaipėda) and inland (Kaunas) meteorological stations covering 19 years period was used for the analysis. The UTCI values were computed using *BioKlima ver. 2.6* software. The Index variations throughout the year and the day were analyzed. The mean monthly differences between air temperature and UTCI were obtained. Also 3 variants of input data for mean radiant temperature calculations were proved. The research proved that half of the year human thermal conditions are under cold stress and thermal comfort is felt only 1/3 of the days in the year. The best results calculating mean radiant temperature is achieved using global solar radiation data.

Introduction

There are lot different biometeorological indices characterizing human thermal conditions in the world. Unfortunately, the usage of indices is limited by temporal, spatial, thermal etc. differences of the environments and human physiology features (Epstein and Moran, 2006). Some thermal conditions indices are already widely used: PMV (Fanger, 1970), SET (Gonzalez *et al*., 1974) etc. Also special indices are very useful for extreme thermal conditions evaluation: WCT (Bluestein and Zecher, 1999), HUMIDEX (Masterton and Richardson, 1999). Presently, a lot of effort made finding new complex indices: PET (Höppe, 1999) and UTCI (Jendritzky *et al*., 2002). Meanwhile, the finding of "the perfect one" is still an issue and adaptation to climate change impacts on human thermal environments brings new challenges (Burton *et al*., 2009).
The WMO already have outlined indices for biometeorological forecasts (Kusch *et al*., 2004). Since 2008 the Lithuanian Hydrometeorological Service has produced HUMIDEX forecasts for warm and WCT – for cold season (Nariūnaitė and Liukaitytė, 2009). Also scientific research on HUMIDEX (Liukaitytė and Rimkus, 2008), PET (Nariūnaitė and Liukaitytė, 2009; Liukaitytė, 2011) and WCT (Liukaitytė, 2011) have already been performed in Lithuania.
The UTCI is thermophysiologically significant in whole range of heat exchange and valid in all climates, seasons, and scales (Jendritzky *et al*., 2002). The UTCI still have not been analyzed in Lithuania. This research focuses on application of the UTCI for climate variability and for the characterization of human thermal conditions research under Lithuanian weather conditions.

Material and methods

The data from Kaunas (inland) and Klaipėda (coastal) meteorological stations situated in Lithuania and covering period from 1993 to 2011 were used for the research. The measurements of air temperature (°C), humidity (%), wind speed ($m.s^{-2}$) and cloudiness (cover in %) were made every 3 hours (UTC time). For additional calculations, data of global sun radiation (Wm^{-2}) and visibility (m) in 2009 were used. The UTCI and the mean radiant temperature (Mrt), which is essential parameter for UTCI calculations, values for every 3 hours were computed using *BioKlima ver. 2.6* software. Also daily, monthly, yearly averages were structured for the further analysis.
The UTCI average and 11-day moving average of maximum, mean and minimum values variation were calculated with the respect to thermal stress categories (Table 1). The stress categories recurrence throughout the year was constructed. The mean differences between air temperature and UTCI maximum, mean and minimum values were calculated for every month. The daily cycles of the UTCI values in January and in June were composed.

Table 1. *UTCI Assessment Scale: UTCI categorized in terms of thermal stress (www.utci.org).*

UTCI (°C) range	Stress Category
above +46	extreme heat stress
+38 to +46	very strong heat stress
+32 to +38	strong heat stress
+26 to +32	moderate heat stress
+9 to +26	no thermal stress
+9 to 0	slight cold stress
0 to -13	moderate cold stress
-13 to -27	strong cold stress
-27 to -40	very strong cold stress
below -40	extreme cold stress

Also the UTCI index was calculated using 3 different Mrt values, using data of: global solar radiation (S), cloudiness (C) and visibility (V). The mean differences between 3 methods were obtained for January, April, July & October; and for day, night & 24 hrs in Kaunas and Klaipėda.

Results and discussion

The most comfortable human thermal conditions compound 32 % throughout the year in Klaipėda (coastal station). The comfortable period starts in the end of June and lasts till the end of August (Figure 1). Through moderate and strong heat stress are possible from the middle of May till the middle of September (37 % days in the year). Averagely moderate cold stress is possible from the third decade of October till the middle of April. Meanwhile, very strong cold stress could assert in 1/3 days of the year (Figure 1). Also, the same distributions are typical for Kaunas (inland station) with small alterations to more extreme vales.

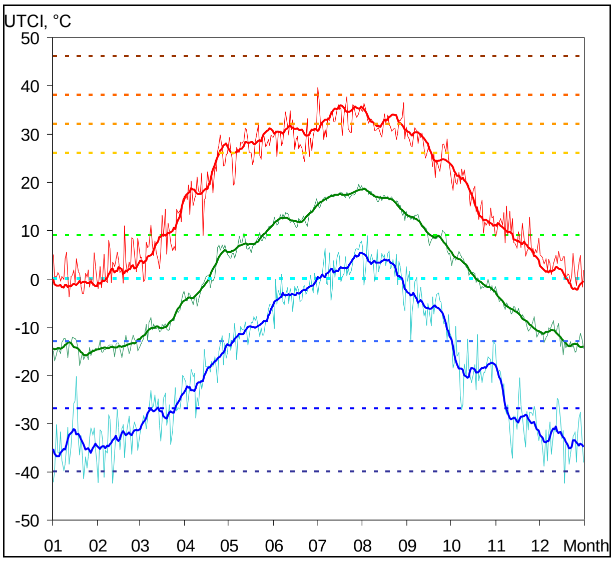

Figure 1. *The UTCI variation throughout the year in Klaipėda in 1993–2011: daily average (thin line) and moving 11-day average (thick line) maximum (red), mean (green), minimum (blue) values. The dotted lines represent UTCI categories (Table 1).*

Averagely, humans felt thermal comfort during the whole day in July in Klaipėda (Figure 2). Though moderate cold stress could be possible (minimum UTCI values) throughout the day and strong heat stress (max UTCI values) could last from 6 a.m. till 10 p.m. While the strong cold stress prevailed throughout the day in January (Figure 2) with the lowest UTCI, minimum values from midnight till 8 a.m.

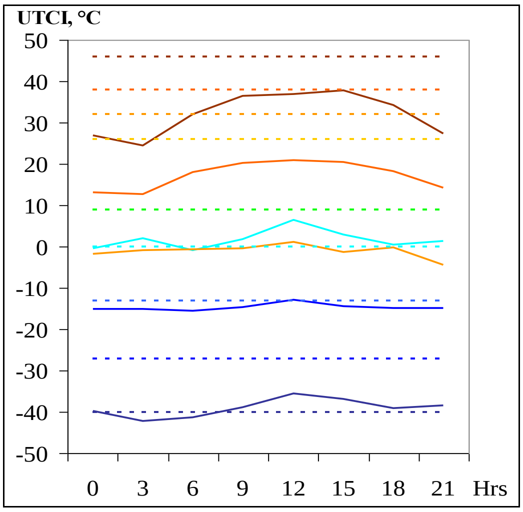

Figure 2. *The UTCI maximum, mean and minimum values daily cycle in January (solid lines, blue tones) and in July (solid lines, orange tones) in Klaipėda in 1993–2011. The dotted lines represent UTCI categories (Table 1).*

The highest differences between monthly mean air temperature and UTCI values recorded in winter. The reason of these distributions is wind chill effect and low Mrt values. Meanwhile, the highest differences between maximum values in summer associated with humidity and high Mrt.

It is obvious that differences between S-V is greater than S-C (Table 2). The mean differences are greater in April and July compare to October and January, because of intensive convection and air clearness changes in warm period.

Table 2. *The mean differences between UTCI (°C) computed using "Global solar radiation - Cloudiness" (S-C) and "Global solar radiation - Visibility" (S-V) data in Kaunas and Klaipėda.*

	Global solar radiation - Cloudiness (S-C)				**Global solar radiation - Visibility (S-V)**			
Kaunas	**JAN**	**APR**	**JUL**	**OCT**	**JAN**	**APR**	**JUL**	**OCT**
Night	0.6	0.4	0.6	0.4	1.6	2.3	1.7	1.6
Day	0.1	-0.4	-0.1	0.0	0.6	-1.9	-0.2	1.0
24 hr	0.4	-0.1	0.2	0.2	1.2	-0.3	0.4	1.4
Klaipėda	**JAN**	**APR**	**JUL**	**OCT**	**JAN**	**APR**	**JUL**	**OCT**
Night	-1.1	-1.1	-0.9	-1.1	1.4	1.6	1.3	1.4
Day	-0.3	4.2	2.5	-0.5	0.7	-3.6	-1.7	0.8
24 hrs	-0.8	2.3	1.6	-0.9	1.1	-1.7	-0.9	1.2

Conclusions

The UTCI is suitable for the evaluation of the human thermal conditions in Lithuania. It perfectly performs under heat stress conditions and a little overestimates cold stress impact on humans. The half of the year human thermal conditions are under cold stress and thermal comfort is felt only 1/3 of the days in the year.

Acknowledgements: An author is grateful to the Hydrometeorological Service of Lithuania under the Ministry of Environment for providing archive data and to the student of the Department of Hydrology and climatology (Vilnius University) A. Štramaitytė for the help in calculations.

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METEOROLOGICAL CONDITIONS AND PM_{10} CONCENTRATION IN BRNO IN 2011

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Abstract.The thesis deals with an analysis of concentration of suspended particles in Brno in 2011. The aim of the study is a comparison of running the concentration of suspended particles in the centre and at the outskirts of the city and a determination of the effect of the meteorological situation on pollution in different local conditions. Cases with the largest differences of PM_{10} concentrations at monitored stations were subject to the analysis. To explain the causes of differences in PM_{10} concentrations in both locations, an analysis of meteorological conditions was carried out on selected days.

Introduction

The field of concentration of suspended particles depends on the position of pollution emission sources, and also on meteorological conditions. The largest source of suspended particles in Brno is traffic (Skeřil, Elfenbein, Rožnovský, 2009) and, therefore, the highest PM_{10} concentrations usually occur in the city centre. In addition, there are worse spreading conditions caused by limited ventilation in the city centre. Nevertheless, under special weather conditions the PM_{10} concentration may be higher at the outskirts (pollution background), which shows significance of the natural sources of particle emissions.

Material and methods

The elaboration was based on the measurement of PM_{10} concentration at 13 emission monitoring stations and meteorological observations from three climatic stations in Brno and its closest surroundings. It includes data measured at daily steps. For a detailed analysis, two stations of emission monitoring were selected – the traffic urban station Brno-střed situated in the centre of Brno and the background suburban station Brno-Tuřany situated at the south-eastern outskirts of the city. The Brno-střed station is loaded with a numerous pollution sources, mainly traffic, and it can be stated that the emission of suspended particles is continuous in this place even if it has a cyclical daily run, while in Brno-Tuřany, apart from the urban pollution of Brno and the effect of local fire places in surrounding villages in winter, natural sources such as re-emissions or occasional fires of grasslands also play a substantial role.

Results and discussion

The year 2011 at the climatological station Brno-Tuřany appeared to be very warm and dry. The deviation of the mean annual temperature of 10.3 °C from standard (1961–1990) was +1.5°C and the annual precipitation total of 392.7 mm was 80 % of standard. The months April, June, August, September and December were very warm. February was very dry, August was dry and November was extremely dry, while March and July were considered wet. The weather development considerably affected the concentrations of suspended particles in 2011, which took effect in their atypical annual run. The maximum average monthly PM_{10} concentration appeared at all Brno stations in November and the secondary maximum was in February. The PM_{10} concentration was lower in January than in March and the PM_{10} concentration was lower in December than in October. As expected, the minimum average monthly PM_{10} concentration was in July, but the PM_{10} concentration in August was slightly higher than in September and at the Brno-Líšeň and Brno-Tuřany stations it was even higher than in December. The run of the average monthly PM_{10} concentration at the Brno-střed and Brno-Tuřany stations and also the temperature and precipitation in Brno-Tuřany are presented in Figure 1.

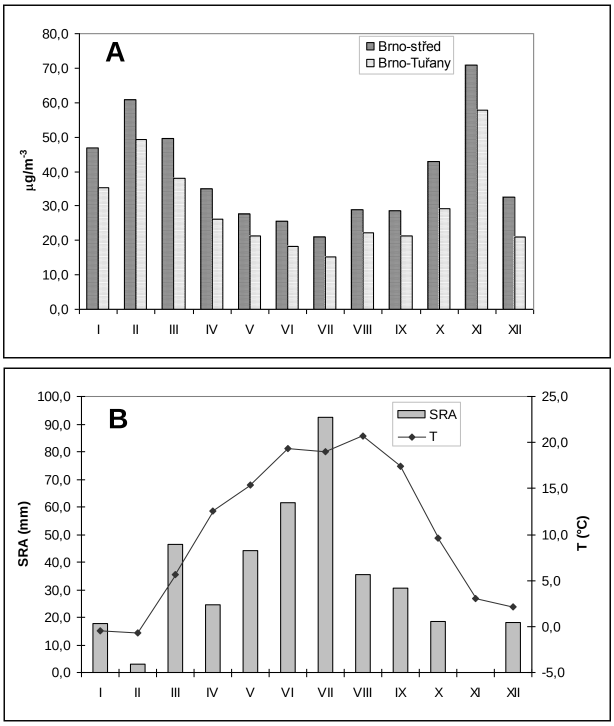

Figure 1. *Mean monthly PM_{10} concentration at the Brno-střed and Brno-Tuřany stations (A) and monthly precipitation totals and mean air temperature and in Brno-Tuřany station (B) in 2011.*

The two compared stations are 10 km far from each other. The comparison of the PM_{10} concentration at the Brno-střed and Brno-Tuřany stations shows that, as expected, a higher pollution by suspended particles is in the city centre and larger differences between both stations are in winter months and smaller in summer months, from April to September. In the daily PM_{10} concentration run there is a strong correlation between pollutions in both locations of 0.95. Ten cases of the largest differences in the PM_{10} concentration at the monitored stations were subject to a detailed analysis, as well as 10 cases when the pollution was higher at the suburban station (Table 1).

Table 1. *Extreme differences in the PM_{10} concentration between the Brno-střed and Brno-Tuřany stations.*

PM_{10} in Brno-střed > PM_{10} in Brno-Tuřany		**PM_{10} in Brno-Tuřany > PM_{10} in Brno-střed**	
Date	**Difference [μg/m³]**	**Date**	**Difference [μg/m³]**
17. 1. 2011	28.8	10. 1. 2011	4.3
31. 1. 2011	35.6	28. 1. 2011	0.4
10. 2. 2011	31.4	29. 1. 2011	0.1
9. 3. 2011	27.7	16. 3. 2011	2.4
21. 10. 2011	31.4	17. 3. 2011	2.8
23. 10. 2011	31.0	5. 6. 2011	0.1
30. 10. 2011	27.7	9. 7. 2011	3.4
31. 10. 2011	41.0	2. 8. 2011	2.4
1. 11. 2011	53.3	2. 11. 2011	3.4
31. 12. 2011	39.2	22. 12. 2011	1.2

The average difference in the PM_{10} concentration in 2011 between Brno-střed and Brno-Tuřany stations is 9.7 μg/m³ and the highest difference was 53.3 μg/m³. However, the most frequent differences were from 1 to 13 μg/m³. To explain the causes of the differences in the PM_{10} concentrations at both locations, an analysis of meteorological conditions on selected days was carried out, specifically air temperature, wind velocity and direction, occurrences of precipitation and temperature inversion at the aerological station in Prostějov, about 50 km far from Brno. Cases when the daily PM_{10} concentration at the Brno-střed station was considerably higher than in Tuřany occurred in winter season. With one exception, there were days with an inversion type of weather.

The most probable cause of the higher concentration of suspended particles at the urban position was local traffic emissions (exhaust gases, tyre abrasions, re-emission of dust from the road surface). At temperature inversion, the mixing layer thickness is small and all pollutants emitted in the ground layer accumulate in it. Such situation occurred on the last days of October when, after cooling, sources related to the heating of residential spaces were activated. During the period without precipitation and with temperature inversion in November, there was an extreme increase in the PM_{10} concentration and in the days from 3 to 7 November and from 15 to 21 November, smog warnings were announced (Ostatnická, 2012). On all monitored days, the mean wind velocity did not exceed 4 m/s, which prevented transfer of particles in horizontal direction and only on a single day, 9 March, the wind gust was 11.2 m/s.

The second group of analyzed cases includes days when the PM_{10} concentration at the suburban station Brno-Tuřany was higher than in the city centre. Only 4 of such situations occurred in winter months: in January and December. It must be highlighted that the predominance of suburban pollution is not large. The difference in the PM_{10} concentration in such situations was 4 μg/m³ at the most. In most cases, the cause of higher pollution in Brno-Tuřany was the eastern wind direction which brought pollution from the nearby town of Šlapanice. In addition, the substantial source of particles are the surrounding fields from which re-emission occurs under suitable conditions (dry surface and moderate to fresh wind), especially intensive in spring and autumn when the fields are not covered with vegetation. Also the field work in the harvest period may be the cause of increased dust formation at the background station. Another source of particles in this place is grass fires, relatively frequent in dry periods. In 2011, fire brigades around Brno-Tuřany recorded the most of this type of events in March. The most significant were repeated grassland fires in the natural park Výhon near Židlochovice (12 fire brigade interventions in March 2011) situated about 10 km to the south of Brno-Tuřany, which caused a growth in the PM_{10} concentration in Brno particularly in the period without precipitation between 11 and 15 March, when suspended particles at south wind transferred above the area of Brno and on 15 March, the daily PM_{10} concentration limit was exceeded – the mean PM_{10} concentration of all stations was 83 μg/m³.

Conclusions

In 2011, the concentration of suspended particles in the centre of Brno was higher than at the outskirts by 9.7 μg/m³ on average. The largest differences occurred in winter during the inversion type of weather. Situations when the concentration of particulate matter was lower in the city centre occurred on 10 days in all seasons of the year. The cause of the increased PM_{10} concentration in the suburban position was mainly transfer of urban pollution from Brno, the effect of local fire places in surrounding villages in winter, but the substantial role was played also by natural sources such as re-emissions of particles from soil and grassland fires.

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EVALUATION OF EVAPORATION OF WATER LEVEL MEASURED BY GGI-3000 DEVICE IN SOUTHERN AND CENTRAL MORAVIA

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Abstract. The paper deals with evaluation of evaporation of water level measured by GGI-300 device within the nework of CHMI measuring points in the area of Southern Moravian region and region of Zlín town. In the period of 1968–2011, there were 9 stations measuring evaporation in the area of southern and central Moravia. Five of these stations dispose of longer lines of evaporation measurement suitable for climatological evaluation. This paper presents the results of statistical data of monthly and seasonal totals of evaporation from water level for each decade from 1971 to 2010.

Introduction

Evaporation is a physical process in which liquid water or solid ice changes into the gaseous state of water - vapor. The extend of evaporation is affected by the physical properties of the surface, balance of solar radiation, humidity and air flow, vegetation cover, etc. It is due to the complexity of the process of evaporation, unlike other meteorological elements, why measuring evaporation is still problematic. The simplest evaporative process is evaporation of water. The Czech Hydrometeorological Institute conducted measurements of water evaporation (further referred to as WE) with several devices. A manual evaporimeter GGI-3000 used to be used as the standard equipment for this measurement, but has been deprecated and in recent years gradually withdrawn or replaced by a modern automatic device EWM.

The aim of this work is to evaluate climatological monthly totals of WE including trends of changes in season (May-September) in areas of southern and central Moravia, one of the driest areas in the Czech Republic (Kohut, Rožnovský, Chuchma, 2009) where device GGI-3000 is still used even nowadays.

Material and methods

Periodic measurement of WE was launched in the Czech Republic in 1968. There were nine stations measuring evaporation in southern and central Moravia in the period of 1968–2011 (Figure 1), however some of them were in operation for only a short time. Overview of commencement and completion of routine observations in each location is recorded in Table 1. For purposes of this paper we selected 5 stations with the longest series of observations. Measurement of WE took place only in frost-free period that usually begins in mid-April and ends in the second half of October or the first days of November.

For uniform evaluation, period of 1st May to 30th September was chosen. Daily totals of WE measured by GGI-3000 were compared between the individual climatologic stations and compared with the calculation implemented by AVISO (Kohut, 2005). Missing and unreliable data were then reconstructed on the basis of regression relationship between measured and calculated values. Based on complete series of daily estimates of water evaporation, monthly and seasonal totals were calculated which were subjected to statistical analysis for each decade of period 1971–2010.

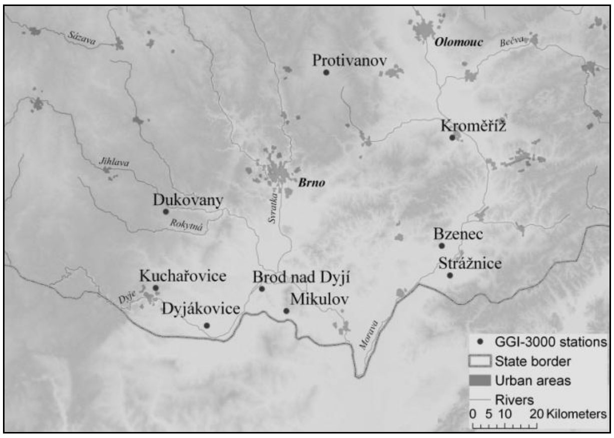

Figure 1. *Climatological stations of CHMI measuring water evaporation using GGI-3000 in southern and central Moravia (1968–2011).*

Table 1. *Period of water evaporation measurement using GGI-3000 in southern and central Moravia.*

Station	Beginning	End	No. of years
Brod nad Dyjí	1. 5. 1982	In operation (2012)	30
Bzenec	1. 5. 1974	In operation (2012)	38
Dukovany	1. 8. 1987	31. 10. 2000	14
Dyjákovice	1. 4. 1976	In operation (2012)	36
Kroměříž	25. 5. 1968	In operation (2012)	43
Kuchařovice	1. 6. 1968	6. 6. 2006	39
Mikulov	23. 6. 1968	1. 10. 1969	2
Protivanov	1. 6. 1972	20. 9. 1973	2
Strážnice	1. 7. 1971	30. 6. 1973	3

Results and discussion

WE can be considered as potential evaporation, i.e. maximum possible, whose intensity is dependent on atmospheric conditions and is not limited by water shortages. All monitored sites are, according to Quitt's classification, located in warm area W2. Temperature conditions of the region have impact on the fact that WE measured here reaches high values. Average total of WE of season from May to September of the whole period of measurements varies from 427.7 mm in Dyjákovice to 478.0 mm in Kuchařovice. Monthly totals of WE increase during the warm season to peak in July and decrease in the second half of the summer period.

Described annual course is visible in all the observed decades (Figure 2).

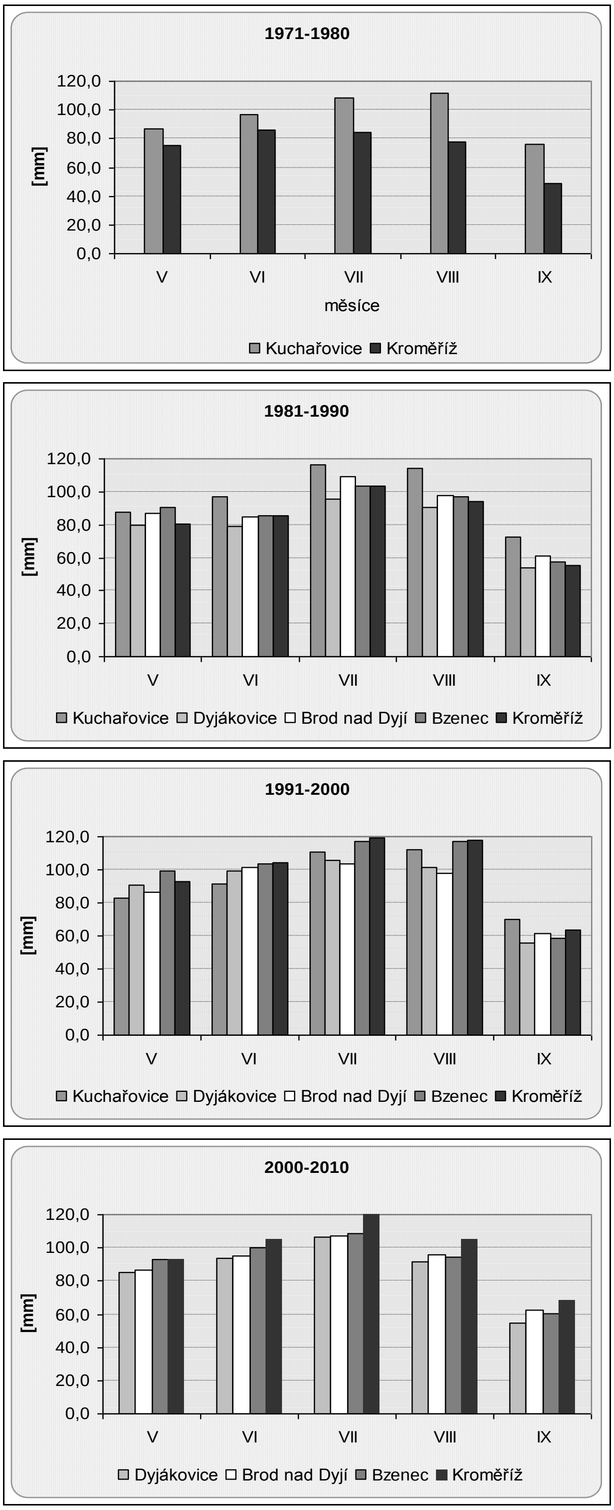

Figure 2. Monthly totals of water evaporation in southern and central Moravia in different decades of the period of 1971–2010.

In the first period of 1971–1980, only measurements from two stations (Kuchařovice and Kroměříž) were available. Throughout the whole season, WE in Kucharovice was significantly higher. In the following period of 1981–1990, WE of all five stations (Kuchařovice, Dyjákovice, Brod nad Dyjí, Bzenec and Kroměříž) was compared. The highest monthly totals occurred in Kuchařovice again. The situation changed in the next decade of 1991–2000. The total recorded in the months from July to August was measured in Kroměříž. It should be noted that WE measured in this decade of 1991–2000 has reached the highest totals at all stations. All-season totals of WE in 1992 reached the maximum in the whole period of measurement stations in Kuchařovice, Bzenec and Kroměříž, while in Brod nad Dyjí the maximum occurred in 1994 and in Dyjákovice already in 1990. In the period 2000–2010 measurements of WE were terminated in Kuchařovice (GGI-3000 was replaced by an automatic device EWM). The total recorded in the months from June to September was the highest in Kroměříž.

Table 2. *Time trends of changes in estimates of water evaporation measured by GGI-3000 in the period.*

Period	Station	Regression equation	R^2
1971–2000	Kuchařovice	y = -1.4329x + 500.19	0.0296
1981–2010	Brod nad Dyjí	y = 0.1172x + 442.64	0.0002
	Bzenec	y = 0.5584x + 448.02	0.0054
	Dyjákovice	y = 1.5648x + 387.81	0.0574
1971–2010	Kroměříž	y = 3.882x + 365.58	0.3516

The described changes in the monthly totals of WE are also reflected in changes in estimates for the entire season from May to September, expressed in regression equations (Table 2). There is a significant increasing trend of seasonal totals of WE in Kroměříž. The other three stations also show increase in the value of WE, although not statistically significant. Change in the seasonal totals of WE in Kuchařovice seems to be minor as well but it should be noted that the regression equation indicates a decrease of WE in South Moravia.

Conclusions

Analysis of changes in monthly and seasonal totals of WE in southern and central Moravia brought interesting results. It was found that during 1971–2010 there was a visible change not only in the amount of the overall totals of WE, but also in its spatial distribution. In north-eastern and south-western parts of the monitored area there are different trends of changes of WE. The totals of WE in Kroměříž are demonstrably increasing, while in Kuchařvice we observed rather a decrease of WE totals.

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SELECTED AGROCLIMATIC CHARACTERISTICS OF CLIMATIC REGIONS OF THE CZECH REPUBLIC

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Abstract. The current division of the Czech Republic into climatic regions (Mašát *et al*., 1974) was carried out according to basic criteria which meet the assumption of similar conditions for growth and development of agricultural crops. Ten climatic regions in the Czech Republic were labeled with numbers 0 (VT, very hot) to 9 (CH, cold). In this paper we have utilized selected agroclimatic characteristics for these climatic regions, which were not considered in the original classification. Evaluation was performed according to the daily interval of agro-meteorological model AVISO with the use of technical series of meteorological elements of a regular network of 789 grid points (10x10km) for the period of 1961–2010.

Introduction

In the years of 1973–1980, definition of the economic performance of potential soil units (BPEJ) was carried out as the logical outcome of a completed project "Comprehensive survey of soils in the CR". Following the purpose and conditions of the realization of the survey, parameters defining the achievable accuracy of BPEJ were determined, which were later included in the second edition of the methodology, 1974 (Mašát *et al*., 1974). In conclusion of the evaluation, ten climatic regions were defined in the Czech Republic, based on selected criteria (sum of average daily air temperatures > = 10 °C, average annual air temperature during the growing period, the average rainfall per year, consumptive water security and the likelihood of occurrence of dry vegetation periods). Processing of the data was performed for the period of 1901–1950. The overview of selected criteria implies that for the purposes of the classification of the climatic regions of the Czech Republic only selected climatic elements were used and factors such as evaporation and evapotranspiration were therefore omitted especially in regards to moisture conditions in the landscape environment with the emphasis on the upper soil horizon, which would be very important particularly in relation to agriculture.

Material a methods

This paper presents processing of evapotranspiration potential of graminaceous areas (hereinafter referred to as PEVA_TP) and (basic) potential water balance of soil of grassland (hereinafter referred to as POTVLBI_TP) for the period of 1961–2010 with the regard to the current climate regions in the country. By characteristic of POTVLBI_TP we understand simple difference of precipitation and PEVA_TP. Complete processing in daily interval was performed based on the technical series of basic meteorological elements for a set of 789 grid points of a regular network 10x10km (Štěpánek *et al*., 2009; Štěpánek *et al*., 2011). For the purposes of the entire calculation, AVISO ("Agrometeorological Computing and Information System"), was used, which was operated in an operational regime by CHMI, branch Brno (Vitoslavský and Kohut, 1999; Kohut, 2007). AVISO is basically analogous to the English system MORECS („The **M**eteorological **O**ffice for **R**ainfall and **E**vaporation **C**alculation **S**ystem"), see Hough *et al*., 1997, Thompson *et al*., 1981. Both models are based on the combined Penman-Montei's equation for calculation of evapotranspiration in a modified manner. The input meteorological data are "penmannic" variables (temperature and humidity in the form of water vapor, sunshine duration, wind speed and precipitation).

Grid points are further divided according to current classification of climatic regions. We are aware of some irregularities, dwelling in different frequency of grid points respective to the climatic regions. All graphs clearly document the differences between climatic regions. As opposed to the original classification, we useshortcuts KR_0, KR_1 ... KR_8, KR_9 for the individual climatic regions.

Results and discussion

Potential evapotranspiration of grassland was determined as the first agrometeorological characteristics. Figure 1 shows its long-term average values for a year, summer season and growing season (1961–2010) in the climatic regions. The graph shows the expected trend of significant decrease in PEVA_TP with increasing altitude. Values varied at intervals from 487.8 to 713.6 mm (year), from 400.0 to 576.9 mm (growing season) and from 239.5 to 334.7 mm (summer season).

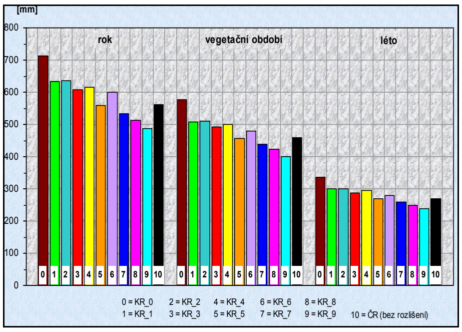

Figure 1. *Climatic regions in the CR, long-term potential evapotranspiration of grassland (1961–2010).*

Figure 2 compares the long-term monthly PEVA_TP of the warmest (KR_0, VT) and coldest (KR_9, Ch) climatic region with long-term totals calculated for the whole territory of the Czech Republic. PEVA_TP distribution is very similar with the highest totals in the summer months (especially July) and lowest in winter.

Potential (basic) soil moisture balance in grassland was determined as the second agrometeorological characteristics. Figure 3 shows the long-term average values of

POTVLBI_TP for individual climatic regions for a year, summer season and growing season (1961–2010). The graph below shows the expected trend of increasing moisture conditions in the landscape environment with increasing altitude. The lowest long-term values were observed in the very hot and dry region KR_0 (VT), while the highest values were measured in the cold region KR_9 (Ch). The values varied in range of -201.6 to 480.3 mm (year), -250.4 to 136.7 mm (growing season) and -143.9 to 75.5 mm (summer).

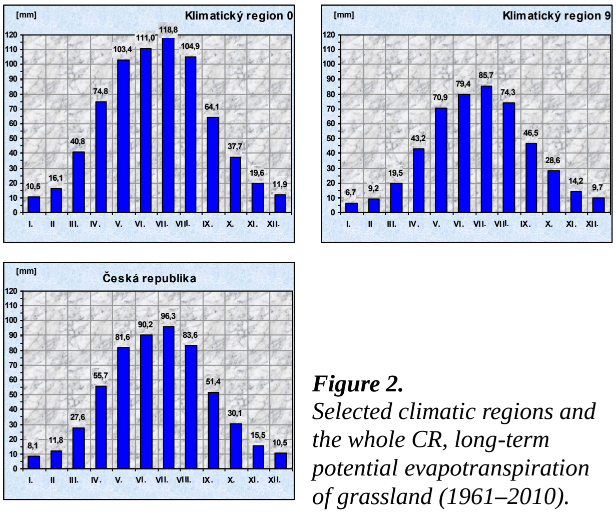

Figure 2. *Selected climatic regions and the whole CR, long-term potential evapotranspiration of grassland (1961–2010).*

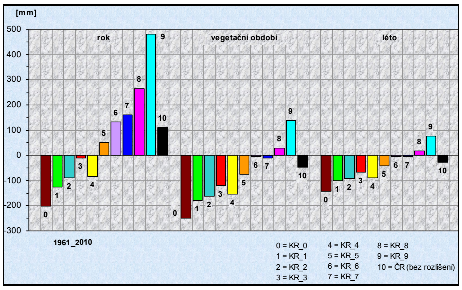

Figure 3. *Climatic regions in the CR, long-term potential soil moisture balance in grassland (1961-2010).*

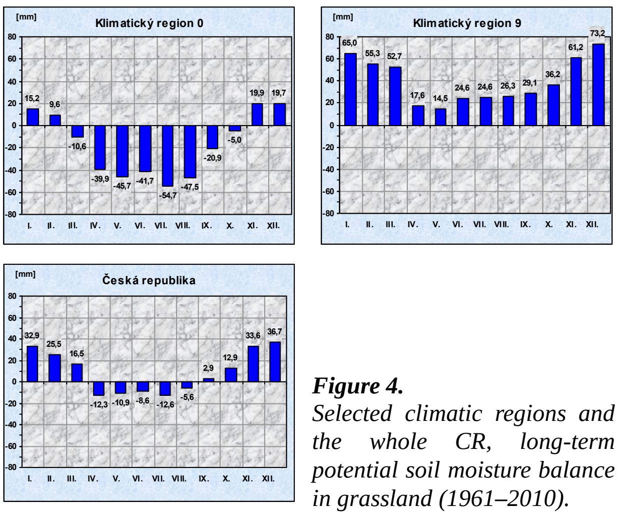

Figure 4. *Selected climatic regions and the whole CR, long-term potential soil moisture balance in grassland (1961–2010).*

Figure 4 compares the long-term monthly totals of POTVLBI_TP of the warmest (KR_0, VT) and coldest (KR_9, Ch) climatic region with the long-term totals calculated for the whole territory of the Czech Republic. Distribution of POTVLBI_TP in terms of one year in various climatic regions depends on the altitude significantly. Warm regions with mostly dry precipitation and lower altitude are generally characterized by a negative water balance during the summer months (especially July and August), eventually also in spring and autumn months. Colder regions with richer precipitation located in higher altitudes are characterized by predominantly positive water balance.

Conclusion

In this contribution we aimed to evaluate selected agroclimatic characteristics (PEVA_TP and POTVLBI_TP) in connection with the current division of the Czech Republic into climatic regions. Both characteristics presented were processed with the use of AVISO model in daily intervals for the period of 1961–2010, through the use of technical series of basic meteorological elements in a regular grid network 10x10km. Each climatic region is represented by the average value calculated from the respective grid points for the selected time period (year, growing seasons, summer season, individual months). Based on the results calculated, there was observed, demonstrated and quantified decline of PEVA_TP with increasing altitude and vice versa, POTVLBI_TP increase, which improves the humidity conditions in the region.

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THE TRANSPIRATION INTENSITY OF MODEL SPRUCE STANDS IN DROUGHT CONDITIONS

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Abstract. The actual transpiration of model even-aged and fully dense stands in the period June to September 2009 and 2010 was calculated from data of transpiration intensity measured in sample trees. In order to investigate the impact of drought on the physiological characteristics of spruce six out of twelve sample trees in each plot were left in conditions of drought and other six sample trees were irrigated due to generation of appropriate conditions for physiological and growth processes. In 2010 trees were not irrigated due to optimal moisture conditions. Transpiration intensity was measured by use of tree-trunk heat balance method. The amount of water transpired by trees of nonirrigated variant in June–September 2009 was 40 % lower in comparison with "irrigated" in the case of pole stage and 34 % lower in the case of maturing stand.

Introduction

Norway spruce is one of the most significant European tree species which suffers from various health and growth problems appearing in the last decades due to climate change. The main problem in Slovakia nowadays is large-scale dieback of spruce forests. Drought is one of the factors, which influences spruce stands in sites, which are lower than ecological optimum of spruce. Transpiration is an important physiological characteristic, which responds to drought very sensitively. The works of many authors confirm a direct connection between drought and transpiration. The lack of soil water in periods of extreme drought is a dominant factor which causes reduction in transpiration (Matejka *et al.*, 2009). If a tree is optimally supplied with water, then internal water deficit is not influenced by soil water deficit. It is primarily influenced by evaporative demands of the atmosphere (Masarovičová *et al*., 1989).

A role of precipitation is more than just the accumulation of water in the soil and its availability for trees. Precipitations are also retained by the trees canopies as interception. According to Fabrika *et al*. (2009) the limit 1 mm of precipitations per day represents a statistically significant difference in level of tree transpiration.

The aim of the presented contribution was a definition of stand transpiration in conditions of drought ("nonirrigated" in 2009) in comparison with transpiration in optimal moisture conditions ("irrigated" in 2009, all trees in 2010) and with potential evapotranspiration.

Material and methods

Experimental plots Hriňová (pole stage) and Iviny (maturing stand) were established in homogeneous spruce stands, out of the original distribution of spruce in our area in the centre of Slovakia in Biosphere Reserve Poľana. In order to investigate the impact of drought on the physiological characteristics of spruce six out of twelve sample trees in each plot were left in conditions of drought and other six sample trees were irrigated due to generation of appropriate conditions for physiological and growth processes. In the "pole stage" trees of variant "irrigated" were watered by 23 m^3 (divided into 19 applications) in period 16 July–28 August 2009, in "maturing stand" 18 m^3 (in 6 applications) during 28 July–27 August 2009.

Measurement of transpiration intensity (ITR) in experimental plots was managed by using the THB method (EMS Brno), specifically by 'Sap Flow System EMS 51 for large stems operating with constant dT'. Values of sap flow were recorded in 20 minutes intervals [l·hod^{-1}·cm^{-1}]. Continual record of global radiation intensity [W·m^{-2}], air temperature [°C], relative air humidity [%] was set by Minikin TH (EMS Brno, CZ). Precipitation total was measured by using MetOne 370 (Oregon, USA). Transpiration intensity of trees [l·day^{-1}] was finally re-counted for hectare of stand [mm] by using the variable-density yield tables (Halaj and Petráš 1998). Potential evapotranspiration was calculated from measured meteorological parameters by use of the Penman-Monteith method (Monteith and Unsworth, 2008).

Results and discussion

We dealt with the evaluation of transpiration of model even-aged fully dense spruce stand in two different growth stages – "pole stage" and "maturing stand".

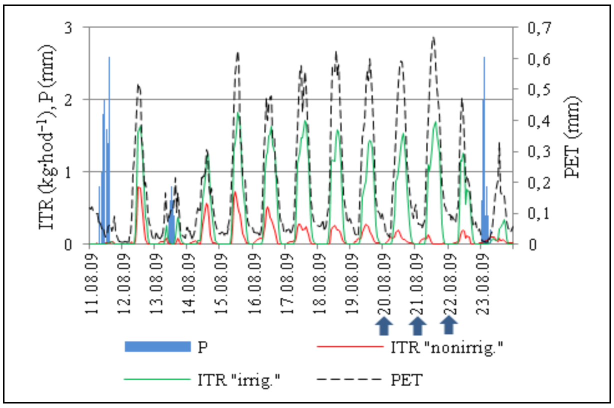

Figure 1. Daily course of transpiration intensity (ITR), potential evapotranspiration (PET) and precipitation (P) in "pole stage" (Hriňová). Blue arrow means irrigation – 2 m^3 of water.

Matejka *et al.* (1999) pointed out the importance of transpiration from the water balance point of view. They dealt with the structure of evapotranspiration of 20-year-old top spruce monoculture. Transpiration shared in evapotranspiration in June–October from 72.7 % (in cloudy days) to 88.6 % (in sunny days). Čermák and Prax (2009) found that the value of transpiration was higher than 80 % of the potential evapotranspiration in conditions of optimal supply of soil water. Cienciala *et al*. (1997) investigated transpiration of 50-year-old and 100-year-old pine-spruce stands in May–October. In younger stand pine transpired 70 mm, spruce 86 mm, in older one pine transpired 38 mm and spruce 80 mm. It means that pine transpired 19 and 53 % less than spruce.

In the monitored period (June 14–July 14) 190-year-old spruce stand transpired 138 mm of water while there was only 81 mm of precipitation. It is clear, that water accumulated in the soil during the spring was used for transpiration (Střelcová and Kučera, 2005). Čermák and Kučera (1987) determined transpiration of spruce stand by extrapolation in the period June–September by use of the results from THB-measurements. The value of transpiration was 136.7 mm, it means 43 % (30–47 % for separate months) of calculated PET (320.4 mm). According to our results the value of the transpiration of the model spruce pole stage represented 46 % of PET in the case of "irrigated" and only 28 % of PET in the case of "nonirrigated" in 2009. In 2010 the transpiration total of stand was 59–69 % of PET. The value of the transpiration of the model spruce maturing stand represented 40 % of PET in the case of "irrigated" and only 27 % of PET in the case of "nonirrigated" in 2009. In 2010 the transpiration total of stand was 39–45 % of PET.

Table 1. *Input values for calculation of spruce stand transpiration intensity in pole stage and maturing stand and potential evapotranspiration in course of June–September 2009 and 2010.*

	Variant	Year	SF (kg)		n	SF/ha (mm)	PET (mm)
				m_x			
PS	irrigated trees	2009	1056	307	2258	238	516
		2010	1220	353	2258	276	398
	nonirrigated trees	2009	631	109	2258	142	516
		2010	1047	138	2258	237	398
MS	irrigated trees	2009	3673	625	521	191	474
		2010	3601	834	521	188	416
	nonirrigated trees	2009	2430	250	521	127	474
		2010	3152	328	521	164	416

n – number of trees per hectar, PS – pole stage, MS – maturing stand

Conclusions

In presented contribution we observed transpiration intensity of stand in two growth stages. We compared ITR of model spruce stand in conditions of natural drought with ITR of stand in optimal moisture conditions.

Pole stage

Amount of water transpired by trees of irrigated variant in June–September 2009 was 13 % lower (38 mm·ha^{-1}) in comparison with the same period in 2010, when trees of irrigated variant were not irrigated due to favourable moisture conditions.

Amount of water transpired by trees of nonirrigated variant in June–September 2009 was 40 % (96 mm·ha^{-1}) lower in comparison with "irrigated" one. In favourable moisture conditions of 2010 the amount of water transpired by "nonirrigated" was 40 % higher (94 mm·ha^{-1}).

Maturing stand

Amount of the water transpired by trees of irrigated variant in June–September 2009 was comparable with amount of water transpired in the same period of 2010, when trees of irrigated variant were not irrigated due to favourable moisture conditions (table. 1). In comparison with 2010 the amount of transpired water was 2 % (3 mm·ha^{-1}) lower.

The amount of water transpired by trees of nonirrigated variant in June–September 2009 was 34 % (65 mm·ha^{-1}) lower in comparison with "irrigated". In favourable moisture conditions of 2010 the amount of water transpired by "nonirrigated" was 23 % higher (94 mm·ha^{-1}).

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INFLUENCE OF CLIMATE CHANGE ON WIND EROSION

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Abstract: Database of climatological factors (such as wind velocity, precipitation and air temperature) of the period of 1961–2010 was made from measured meteorological values of 15 meteorological stations of Southern Moravia, Czech Republic. The climatological data was then evaluated for the periods of 1961–2010, 1961–1990 and 1991–2000. Climatic-erosion factor, which explains potential erodibility of soil by wind, was determined through the analyses of factors influencing the wind erosion. Subsequently, climate change scenarios were created through the sensitivity analysis on the basis of available data. The assessment of changes in data sets and the comparative analysis of the outputs of the scenarios with measured data from the normal period of 1961–1990 were done. The climatic-erosion factor was also determined from the altered data of the scenarios. Afterwards, the influence of climate change on the wind erosion in the area of Southern Moravia was evaluated.

Introduction

Wind erosion is significantly influenced by climatic factors. Thus it is evident, that climate change will influence also wind erosion. Considering the fact, that the area of Southern Moravia is the most threatened territory of the Czech Republic, it is necessary to focus on this region when studying the mentioned phenomenon.

Material and methods

Data concerning the wind velocity, amount of precipitation, and air temperature – all for the period of 1961–2010 – were necessary for the evaluation of the influence of climate conditions on the intensity of wind erosion.

The influence of climate conditions on wind erosion is represented by the equation which Chepil *et al*. (1962) has called the erosion-climatic factor C (1). It depends on the wind velocity and effective soil surface humidity:

$$C = \frac{v^3}{(I_T + 60)^2} \times \frac{100}{1{,}9} \qquad (1)$$

where: C = erosion-climatic factor, v = average annual wind velocity in the high of 10 m above the ground (mile per hour) and I_T = Thornthwaite's humidity index.

The changes of the erosion-climatic factor influenced by the variability of meteorological factors that come from were monitored on the data coming from 15 meteorological stations of Southern Moravia.

Scenarios of climate change were made on the basis of available meteorological data through sensitivity analysis. Analysis was made using incremental scenarios. When designing the incremental scenarios, the results of available studies occupying stated problems were used as a source for determination of limit values (e.g. Dufková 2004; IPCC 2007; Žalud 2009). Following limit values were chosen for the climate changes till the year of 2050 (Table 1):

– for air temperature – +2 °C, +2.5 °C and +3 °C,
– for precipitation – first option +10 % in cool half-year and –10 % in warm half-year; second option +15 % in cool half-year and –20 % in warm half-year (cool half-year means October to March, warm half-year April to September),
– wind velocity – 0, +10 % and –10 %.

Table 1. *Values of designed scenarios of climate change till 2050*

Scenario	Air temperature change [°C]	Precipitation change (%)		Wind velocity change [%]
		cool half-year	warm half-year	
S1	+2.0	+10	–10	0
S2	+2.0	+10	–10	+10
S3	+2.0	+10	–10	–10
S4	+2.0	+15	–20	0
S5	+2.0	+15	–20	+10
S6	+2.0	+15	–20	–10
S7	+2.5	+10	–10	0
S8	+2.5	+10	–10	+10
S9	+2.5	+10	–10	–10
S10	+2.5	+15	–20	0
S11	+2.5	+15	–20	+10
S12	+2.5	+15	–20	–10
S13	+3.5	+10	–10	0
S14	+3.0	+10	–10	+10
S15	+3.0	+10	–10	–10
S16	+3.0	+15	–20	0
S17	+3.0	+15	–20	+10
S18	+3.0	+15	–20	–10

Thus 18 possible scenarios of climate change were created by approximation and they are able to cover most of alternatives in several following decades.

Proposed climate change scenarios were applied on the data from 15 selected meteorological stations and the results were compared with month averages of the standard climatological period 1961–1990. Obtained results were analysed with respect to the differences between measured data and individual scenarios for the evaluated climatological factors of the measured period. Subsequently, the erosion-climatic factor was calculated as from the data of present climate, as from the data of changed one (through climate scenarios).

Results and discussion

Maximum wind velocity of the most analysed areas is observed since February till April, when the arable soil is not protected by vegetation. However, the wind velocity linear trend is not evidential in the area of the Czech Republic, despite the fact that statistically significant trends could be found in the time series of wind velocity of almost all the stations during all the studied periods. From the total evaluation it is possible to expect that the wind velocity will not change and when the other factors influencing the wind erosion stay at the same level – which is improbable – the erodibility should not increase.

According to the climate change scenarios, the annual sum of precipitation will decrease a few or it will stay at the same level as at the present time. Observed or by the scenarios predicted changes in the annual course of precipitation are important. And just these changes could have the substantial negative impacts on the threat of soils by wind erosion in the spring time especially.

The air temperature is the only climatic factor from the three analysed that gives clear idea about its trend in the future. All the climatic scenarios give the increase in the average air temperature during all the months. The increase confirms also the increasing linear trend of the average month air temperature for the monitored period 1961–2010 at all the analysed climatological stations. The air temperature influences the evapotranspiration and hereby also the soil humidity. Generally, it can be stated that the lower the soil humidity is, the larger the threat by wind erosion exists. It is evident that impact of expected climate change will appear in the significant spreading of soils threatened by wind erosion.

Table 2. *Average values of erosion-climatic factor that were changed by climate scenarios till the year of 2050*

Station	636	667	685	686	687	698	716	723	724	725	749	754	755	774	777
1961 –1990	8.7	2.3	17.8	3.4	2.5	24.1	8.7	14.0	1.4	3.0	1.5	9.4	7.2	2.5	0.5
S1	11.8	3.6	24.2	4.3	2.9	32.3	11.0	20.2	1.9	4.3	2.0	12.4	9.6	4.0	0.6
S2	15.8	4.7	34.0	5.9	4.2	45.0	14.9	31.1	2.7	5.8	2.7	17.1	13.3	5.3	0.8
S3	8.0	2.3	16.8	3.0	2.2	20.9	7.9	14.1	1.5	3.1	1.4	9.0	6.7	2.6	0.4
S4	14.0	4.6	28.7	4.9	3.4	45.5	12.9	28.2	2.5	5.8	2.6	16.8	11.2	4.9	0.7
S5	18.8	6.2	40.6	6.8	4.9	64.7	17.5	44.2	3.7	7.9	3.6	23.3	15.6	6.6	0.9
S6	9.4	2.9	19.9	3.5	2.6	28.9	9.2	19.4	2.0	4.2	1.8	12.0	7.8	3.2	0.5
S7	12.6	3.8	25.6	4.5	3.1	35.7	11.5	22.3	2.0	4.7	2.1	13.5	10.3	4.3	0.7
S8	16.9	5.1	36.1	6.2	4.4	50.0	15.7	34.5	3.0	6.4	2.9	18.7	14.4	5.7	0.8
S9	8.5	2.4	17.8	3.2	2.3	23.0	8.3	15.5	1.6	3.4	1.5	9.7	7.2	2.7	0.5
S10	15.0	5.1	30.6	5.2	3.6	51.3	13.6	31.7	2.8	6.5	2.8	18.6	12.2	5.3	0.8
S11	20.2	6.7	43.3	7.2	5.2	73.6	18.6	50.0	4.2	8.8	3.9	25.8	17.0	7.2	0.9
S12	10.1	3.2	21.2	3.7	2.7	32.3	9.8	21.6	2.3	4.7	2.0	13.3	8.4	3.4	0.5
S13	13.4	4.2	27.2	4.8	3.3	39.8	12.2	24.7	2.2	5.2	2.3	14.8	11.2	4.6	0.7
S14	18.0	5.5	38.3	6.6	4.7	56.0	16.6	38.5	3.3	7.1	3.1	20.4	15.6	6.2	0.8
S15	9.1	2.6	18.9	3.4	2.5	25.4	8.7	17.1	1.8	3.8	1.6	10.6	7.8	2.9	0.5
S16	16.1	5.5	32.7	5.6	3.9	58.4	14.4	35.8	3.2	7.2	3.1	20.6	13.3	5.8	0.8
S17	21.7	7.3	46.3	7.7	5.6	84.4	19.7	57.0	4.7	9.9	4.3	28.7	18.6	7.8	1.0
S18	10.8	3.5	22.6	3.9	2.9	36.4	10.3	24.3	2.5	5.2	2.2	14.7	9.1	3.7	0.6

The values of erosion-climatic factor grow up during the studied period of 1961–2010 what theoretically means the increasing of potential threat of soil by wind erosion. The increasing trend is the most evident at the stations of warm and dry areas. Also climate change scenarios predict the increase in values of erosion climatic factor (Table 2). Its values increased from 1.1 to 2.9 times in average in comparison with the period of 1961–1990, which means the increasing of potential threat of soil by wind erosion.

Conclusions

During evaluation of individual climate change scenarios it is not possible decidedly determine which change of climate factor has the most important impact on soil erosion susceptibility. The highest showing values were achieved always through individual combinations.

Climate conditions have substantial influence on the intensity and spreading of wind erosion especially in the dry areas of Southern Moravia. Thus, negative impacts of climate change will appear at first in these areas. Therefore at least from the beginning the humid areas with higher elevation will be spare from the negative impacts of warming. In the future it must be taken into account that threat of soil by wind erosion will extend into the areas up to now not threatened by wind erosion. The wind erosion is dependent also on the soil type. And if it is impossible to influence the climate process, then it should try to prevent the soil degradation and change of its structure state.

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EFFECTIVE SUNSHINE DEFICIENCY IN THE COLD HALF-YEAR IN POLAND

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Abstract. This paper deals with the effective sunshine deficiency in the cold half-year in Poland. The study is based on daily and decadal sunshine duration from 48 meteorological stations in the period 1976–2000. Data were processed according to formula proposed by Gumiński (1948) formula. The western and southern parts of the country showed a negative, highly significant trend in the length of the period with daily sunshine < 2 h. The least favourable conditions of effective sunshine prevailed in the Pomerian and Masurian Lake Districts, followed by the Silesian-Cracow conurbation.

Introduction

In the cold half-year, atmospheric pollution is usually two to three times as high as that in the warm half-year. Coupled with a large deficiency of effective sunshine and wide changes in atmospheric pressure, it leads to a substantial discomfort for humans (Kozłowska-Szczęsna *et al.*, 2004; Koźmiński and Michalska 2005). Daily sunshine duration in large cities and industrial centres, such as Warsaw, Łódź, Wrocław, and Cracow as well as Upper Silesia is, compared to adjacent areas, have periods of days with daily sunshine of > 2, > 3, and > 6 hours shorter by an average of 5-10 days, and in some years even by 20 days (Koźmiński 2012). This study was aimed to assess the duration of and trends in periods with daily sunshine < 4, < 2, and 1 h.

Material and methods

The study is based on data on daily and decadal sunshine duration spanning the period of 1976-2000 at 48 meteorological stations. The formula proposed by Gumiński (1948) was used to determine the onset, termination, and duration of periods with daily sunshine < 4, < 2, and < 1 h in the cold half-year (October–March). Trends of variability in periods with sunshine duration < 4, < 2, and < 1 h in 1971–2000 were extracted for some stations representing different regions of Poland.

Results and discussion

In 1971–2000, a negative, highly significant trend was observed in the length of periods with daily sunshine of < 2 h in the western and southern parts of Poland. In the remaining part of the country, the trends tended to be negative (Figure 1). The period with daily effective sunshine < 4 h was the longest (exceeding, on the average, 200 days) in the Upper Silesian conurbation from Racibórz to Rybnik, Katowice, and Cracow to Tarnów, followed by a period exceeding, on the average, 190 days a year in higher parts of the Pomeranian Lake District and around Suwałki (Figure 2, 3 and 4). At the Polish Baltic coast and in Legnica, Wroclaw, and Wieluń as well as on the Lublin Upland, the average duration was less than 170 days.

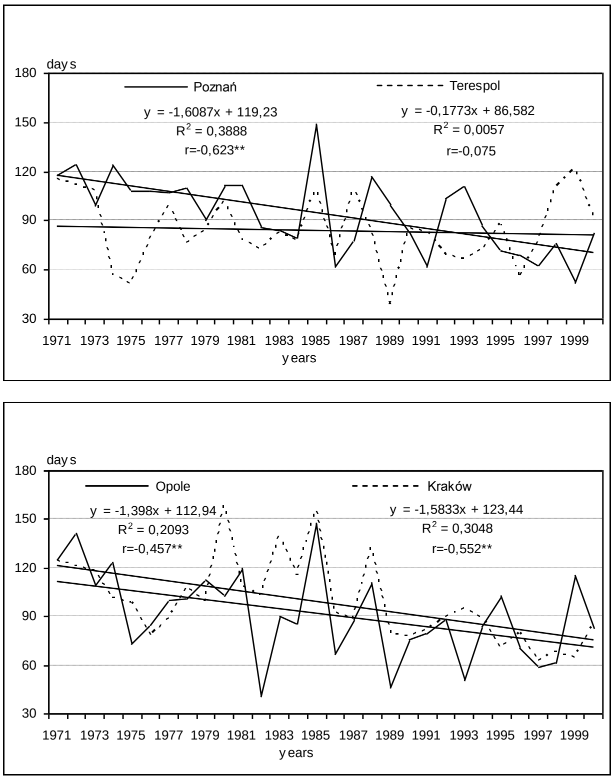

Figure 1. Lengths of periods with daily effective sunshine < 2 h, and the corresponding trend line.

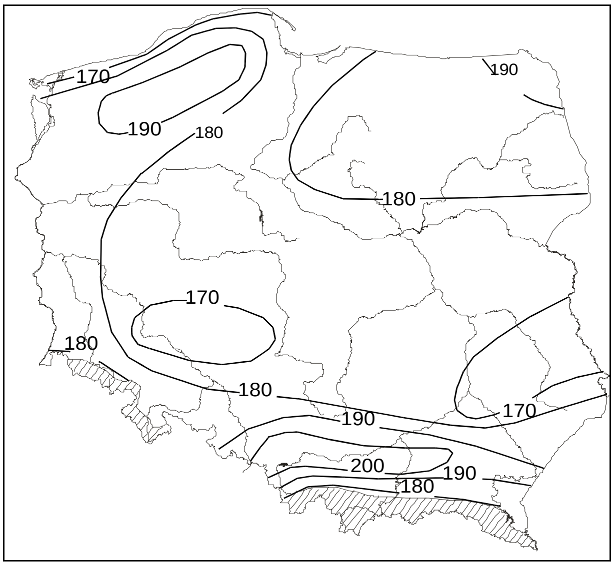

Figure 2. Mean lengths of periods in the years 1976-2000 with daily effective sunshine < 4 h.

The period with daily sunshine < 2 h (vs. the required minimum of 4 h) was about half that long (less than 75 days) in the Carpathians and Sudety Mountains to more than 95 days in the Pomeranian and Masurian Lake Districts and around Cracow. A pronounced spatial variability was typical of the period with daily sunshine < 1 h, from less than 10 days in Lower Silesia and in the south-eastern part of the country to more than 40 days in both lake districts; around Szczecinek and Suwałki, the period in question exceeded 50 days. Noteworthy is the high variability of the duration of this period (20–40 days) in the northern part of Poland.

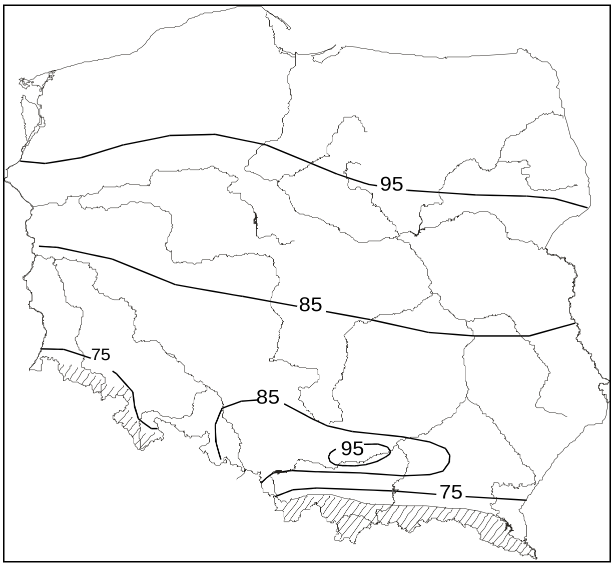

Figure 3. *Mean lengths of periods in the years 1976-2000 with daily effective sunshine < 2 h.*

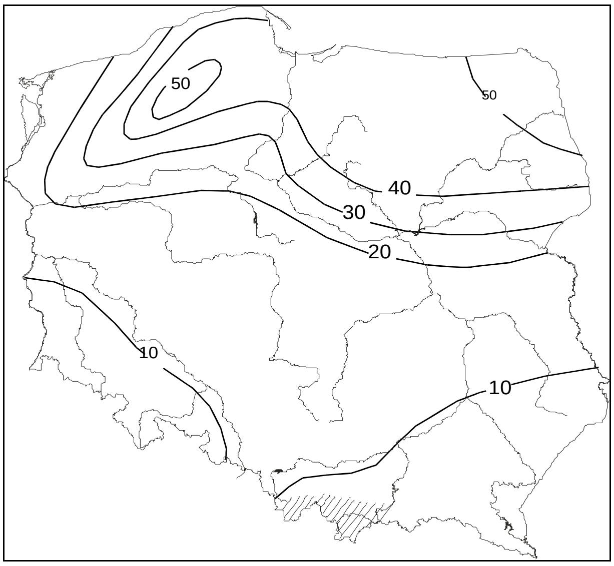

Figure 4. *Mean lengths of periods in the years 1976-2000 with daily effective sunshine < 1h.*

Conclusion

In the 30-year-long period analysed, the western and southern parts of the country showed a negative, highly significant trend in the length of the period with daily sunshine <2 h; the period was being reduced at a rate of 12–15 days per 10 years.

In the cold half-year, the least favourable conditions of effective sunshine prevailed in the Pomeranian and Masurian Lake Districts, followed by the Silesian-Cracow conurbation. In the latter area, periods with effective sunshine deficiency increased in duration from 10 to 15 days, compared with the adjacent areas.

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URBAN HEAT ISLAND IN PRAGUE

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Abstract. The aim of this paper was to analyse the heat conditions in Prague during the summer represented by data of July between 1973 and 2011 and evaluate the influence of the urban heat island. For this purpose we have created databases: daily maximum of air temperature at Klementinum and Ruzyně stations and synoptic situations. The results were compiled into graphs and inscribed with basic statistical characteristics. The reciprocal relationship between the temperature characteristics in the centre and peripheries is described with equations.

Introduction

The urban heat island (UHI) is a microclimatic phenomenon of metropolitan areas. Its intensity grows proportionally to the size and population of the urban area; consequently, it is doomed to become more severe in the coming years due to the constantly growing number of people living in urban areas. In addition, UHI effects are directly related to (and worsened by) climate change phenomena, where it is expected that an increase of the average temperature has a considerable and immediate effect on health of people living in cities, particularly for already handicapped persons (Fallmann, Suppan, Emeis, 2012).

Urbanization, or replacing natural land covered with buildings and impervious surface, is omnipresent due to urban population growth. Thermal and radiative properties of urban materials, building conditions, size, type and locations of windows, canyon geometry, anthropogenic heat fluxes and most importantly the combination of these factors in different weather conditions affect urban heat transfer (Yaghoobian, Kleissl, 2011).

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 of synoptic classifications allows interpretation of surface environmental processes and patterns in the synergistic effects of atmospheric characteristics.

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 (Křivancová and Vavruška, 1997), 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.

Material and methods

For evaluation of the variability of air temperature in urban heat island of Prague was necessary to create database of daily maximum temperature with sufficient long and continual series of measuring (Sulovská, Kožnarová, Klabzuba, 2010). We choose Klementinum station (50°04' N, 14°25' E, 191 m), which is located in a historical centre of Prague 1. Thermometer is placed in the meteorological box on the first floor on the north side of south part of main courtyard; in 197 m above sea-level. Ruzyně station (50°06' N, 14°25' E, 365 m), which is placed in the northwest periphery of Prague 6 was chosen for comparison.

In this article has been for the presentation chosen one month - July - in interval 1973–2011. Daily data were lined-up according to a size and for the next processing were used 5 highest and 5 lowest values of July in each year for both stations. Data were set up to couples and put through another analyse. Synoptic situation were fined out to the days with 5 highest and lowest temperature values. Synoptic situations according to the calendar are based on the classification of weather types used in the Czech Republic (Table1). These situations are published by the Czech Hydrometeorological Institute every year (http://synopinfo. wz.cz/ typizace).

Table 1. *Synoptic situation.*

A	Stationary anticyclone over central Europe
Ap	Anticyclone travelling
B	Stationary trough over central Europe
Bp	East travelling trough
C	Cyclone over central Europe
Cv	Upper-air cyclone
Ea	East anticyclonic situation
Ec	East cyclonic situation
Nc	North cyclonic situation
NEa	Northeast anticyclonic situation
NEc	Northeast cyclonic situation
NWa	Northwest anticyclonic situation
NWc	Northwest cyclonic situation
Sa	South anticyclonic situation
SEa	Southeast anticyclonic situation
SEc	Southeast cyclonic situation
SWa	Southwest anticyclonic situation
SWc1	Southwest cyclonic situation moving north to north-eastwards
SWc2	SW cyclonic situation moving northeast to eastwards
SWc3	SW cyclonic sit. with frontal zone shifted southwards
Vfz	Frontal zone entrance
Wa	West anticyclonic situation
Wal	West anticyclonic situation of a summer type
Wc	West cyclonic situation
Wcs	West cyclonic situation with southern track of cyclones

Results and discussion

The results are presented especially in the graphic form. Statistical characteristics of daily maximum temperature interpreted by box plots graph (Figure 1 and 2) indicate variability during years in analyzed interval 1973–2011 and differences between stations Klementinum and Ruzyně. The figures reveal substantially higher daily maxima of temperature on Klementinum station, e.g. between urban and suburban areas. Table 2 has shown summary of statistic characteristics, where "max" is the highest and "min" is the lowest value of statistic characteristic.

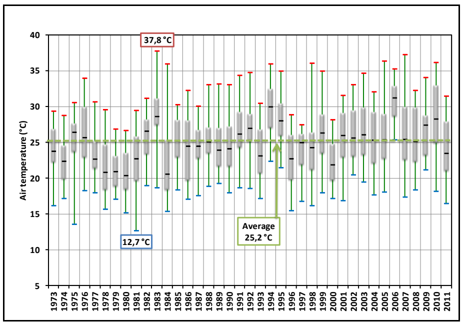

Figure 1. *Daily maximum of air temperature at Klementinum station.*

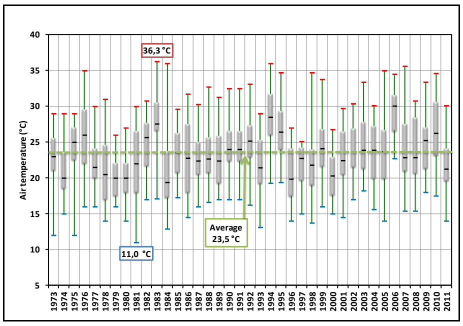

Figure 2. *Daily maximum of air temperature at Ruzyně station.*

Table 2*. Statistical characteristics*

	Klementinum		Ruzyně		Differences Klem-Ruz	
	max	**min**	**max**	**min**	**max**	**min**
Minimum	25.4	12.7	22.7	11.0	2.7	1.7
Lower quartile	28.7	18.5	26.6	17.0	2.0	1.5
Median	31.3	20.4	30.1	19.4	1.2	1.0
Upper quartile	32.9	23.0	31.6	22.0	1.3	1.0
Maximum	37.8	26.7	36.3	25.1	1.5	1.6

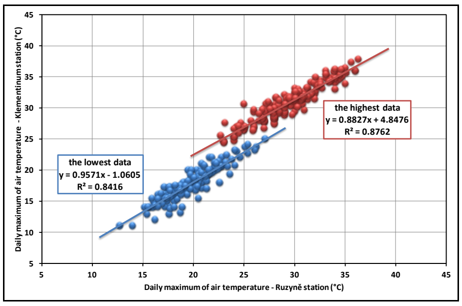

Figure 3. *Relations between stations.*

Graphs in Figure 3 are constructed of couple data (Klementinum x Ruzyně) from interval 1973–2011, respectively from 5 the highest (red colour) and lowest (blue) daily maximum temperature in July. Relations between stations are described by regression equation. For all couple data were fined synoptic situations. Frequency of these situations is presented in Figure 4.

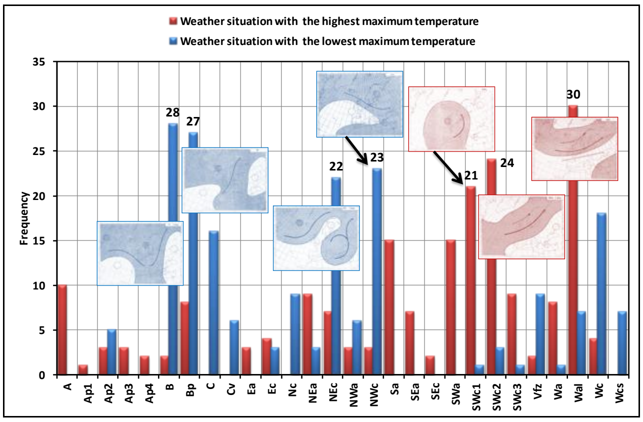

Figure 4. *Frequency of synoptic situation.*

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. Daily maximum of air temperature was chosen as a characteristic that describes weather variability and as the factor determined built-up area in July during 1973–2011.
3. The reciprocal relationship between the temperature characteristics in the centre and peripheries is described with equations. For the highest values of daily maximum temperature y=0.8827 x+4.8476, for lowest values y=0.9571 x-1.0605.
4. The highest values of daily maximum temperature are closely bound to Wal - West anticyclonic situation of a summer type, SWc2 - Southwest cyclonic situation moving northeast to eastwards, SWc1 - Southwest cyclonic situation moving north to northeast wards.
5. The lowest values of daily maximum temperature can be seen under weather types Bp - East travelling trough, B - Stationary trough over central Europe, NWc - Northwest cyclonic situation and NEc - Northeast cyclonic situation characterized by low atmospheric pressure.

Acknowledgements This report was produced with the support of the *S Grant* of the Ministry for Education - Specific Research and by the grant SVV-2011-263 202.

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RELIABILITY OF MATHEMATICAL MODEL OF RELATIONSHIP BETWEEN ALPHA ACID CONTENT IN HOPS AND WEATHER

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Abstract. Mathematical model of the relationship between alpha acid contents in hop and weather parameters was worked out for Saaz variety and locality Brozany (Ausha growing region; altitude 158 m). Model was worked out using analytical data covering the period 1981–2006. Meteorological data were provided with Czech Hydrometeorological Institute, observatory Doksany located appr. 2 km from the farm. Model was proposed as multilinear comprising 10 parameters. It showed that alpha acid content is influenced by weather conditions in a relatively short time period June-August, i.e. stage of flowering, cone forming and ripening. Average air temperature and humidity in June, July and August, average daily sunshine in July and August and accumulated precipitation in August were found as key input variables of the model. Correlation coefficient between true and model alpha acid resulting from 25 years data files is 0.914. Subsequent period 2007–2011 reliability of the model was tested in 2 localities: Brozany and Kněževes. Second locality is located at Saaz growing region 70 km far west from Brozany. Relative differences between true and model alpha acid contents in the course of testing period were in the interval of [– 17.3 to + 7 % rel.] in Brozany and [–17.8 to +11.5 % rel.] in Kněževes. More than 80% reliability of the model is well acceptable.

Introduction

Alpha acid content in hop cones is the most important quality parameter of hops. Significant effect of weather conditions on alpha acid contents in hop cones is generally accepted. Long-term monitoring of alpha acid content in hops cultivated in the region of central Europe shows notable year to year variations. In a study of hops grown in the Hallertau region of Germany over a period of 35 years (1926–1961) Zattler and Jehl (1962) concluded that high alpha was associated with a moist summer and below average temperatures but with an average amount of sunshine. Thompson and Neve (1972) concluded that seasonal fluctuations in alpha acid level are associated with variations in air temperature in the 40/60 days period before harvest and thus not under the grower´s control. Smith (1969) suggested that there was an optimum temperature in the period July-August for each cultivar with respect to alpha acid content in hops. The optimum temperature appeared to be between 16.0 to 17.0 °C. Adverse influence of high temperatures on hop resins formation in the period of hop maturation confirmed Ljašenko (1985) and Magadan (1999). Not only high temperatures but also low temperatures (below 12 °C) during hop cones ripening adversely influence alpha acid contents in hops as reported Hautke (1979). High positive correlation between alpha acid content and rainfalls and negative correlation between alpha acids and max. daily temperatures found Hacin (1987) in Slovenian hops in the period 1972–1983. Multilinear mathematical model of the relationship between alpha acid content in hops and meteorological variables worked out Park (1988) for variety Hallertauer grown in South Korea. This paper describes mathematical model for prediction of alpha acid contents from meteorologi-cal data for Saaz aroma variety grown in Czech Republic. Reliability of the model was tested in two growing localities with different site characteristics.

Material and methods

Mathematical model of the relationship between alpha acid contents and meteorological parameters was worked out for Saaz aroma variety on the basis of data analyses in the period of 1981–2006 in the locality Brozany. Brozany is a traditional hop growing locality in the central part of Auscha growing region (altitude 158 m; GPS 50°27'10.97" N 14°08'42.44" E). Alpha acid content was measured by lead conductance method according to EBC 7.4 in individual lots of raw hops. The same analytical method was used in the course of the whole investigated period. This way at least 20 individual alpha acid values were obtained from each crop harvest. Average value for model application was counted as arithmetic mean of individuals. Meteorological data were provided by Czech Hydrometeorological Institute, observatory Doksany located in 2 km distance from the farm. Average day temperatures, air humidity, daily sunshine duration and daily precipitation were used as input variables of the model. The strategy of data analysis was based on the influence of weather conditions in different parts of the season on the alpha acid production. Therefore, the importance of different variables in months relevant to plant growth and ripening was investigated. Twenty five years long time series of all available variables in daily resolution were mixed to one file for fast data processing by Mini32 software (Environmental Measuring Systems, Brno, CZ, www.emsbrno.cz). Each variable was split into next eight variables containing just one-month values (January to August). Then, the file containing thirty three monthly averages of meteorological variables as well as alpha acid percentage in twenty five years was created for the next processing. By using ordinary linear regression analysis the most important variables were pre-selected fore next step of processing. The following multi-regression analysis calculated the parameters of linear equation describing the alpha acid percentage as a function of weather conditions in certain months of the whole 25-years period. In this way, the variables with a significant influence to the alpha acid estimation were selected with respect to coefficient of determinacy and well balanced standard error of estimation of individual parameters. Subsequent period 2007–2011 reliability of the model was tested in 2 localities: Brozany (Ausha growing region) and Kněževes. Second locality is located at Saaz growing region 70 km far west from Brozany (altitude 364 m; GPS 50°8'44.99"N 13°38'2.75"E). Another site with different altitude and location was chosen with the aim of verification of general model applicability.

Results and discussion

On the basis of assessment of individual meteorological elements effect on alpha acid content in Saaz aroma hops, ten-parameter multi linear mathematical model has been outlined. The assessment of weather elements showed that only June, July and August meteorological parameters have effect on alpha acid content in Saaz aroma variety. True and predicted alpha acid contents in Saaz aroma variety in Brozany in the period 1981–2006 are shown on Figure 1. Correlation coefficient between true and model alpha acid resulting from 25 years data files is 0.914.

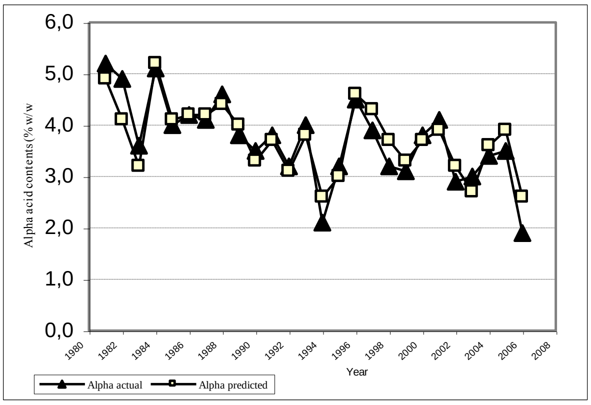

Figure 1. *True and predicted alpha acid contents in Saaz aroma variety in Brozany in the period 1981–2006.*

Partial negative correlation of July temperatures and alpha acids significantly expressed itself into regression model (r_5 = -0.236). It is interesting that precipitation are included only marginally in August (r_{10} = -0.004) and indirectly in air humidity and temperature. In some years it happens that intensive rains in the course of August, which come after water stress period, promote the growth of hop cones size but biosynthesis of hop resins falls behind. It results in ”dilution” of alpha acids in cones. Thus, negative correlation coefficient $\underline{r_{10}}$ between alpha acid contents and August precipitations confirms empiric experience. Global climatic changes cause increase of the average temperatures, deficit of the rainfalls during the vegetation period and occurrence of extreme weather phenomena (hailstorm, strong winds, long-term dry spells, floody rainfalls). All these factors significantly affect annual hop crop and alpha acid production in many countries. In the region of central Europe the years 1994 and 2006 were typical for long term hot period during July and August. In both years the historically lowest alpha acid contents in Saaz aroma hops were recorded. The accuracy of the model in such extreme years is worse. Predicted content of alpha acids is higher by 24 % and 37 % respectively compared to true ones. It can be caused by non-linearity of any of weather parameters or by other factors which were not included into the model. One of such possible effects can be hydrological and other parameters of the soil. Relative differences between true and model alpha acid contents in the course of testing period 2007–2011were in the interval of [– 17.3 to + 7 % rel.] in Brozany and [–17.8 to +11.5 % rel.] in Kněževes (Figure 2).

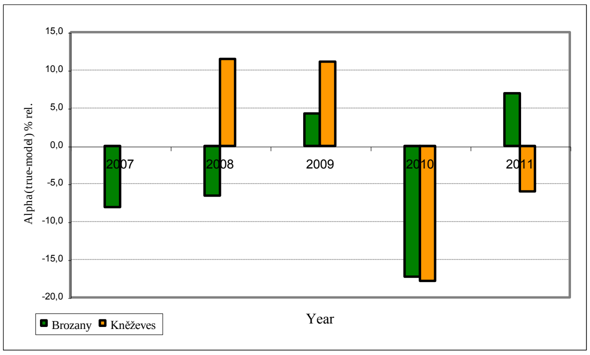

Figure 2. *Relative differences of true and model alpha acid contents in the period 2007–2011 in Brozany and Kněževes.*

Conclusions

Mathematical model for prediction of alpha acid contents from meteorological data showed that alpha acid contents in Saaz aroma hops was influenced by weather conditions in a relatively short period June-August, i.e. stage of flo-wering, cone forming and ripening. July temperatures are the most significant weather parameter (r_i = -0.24) effec-ting alpha acid contents in Saaz hops, which confirming empiric experience. The quality of modeling in terms of coefficient of determinancy within investigated period since 1981 till 2006 reaches the value R^2=0.83. Soil moisture values and non-linear fit could be used for increasing for the accuracy of modeling. More than 80 % reliability of the model in the course of testing period 2007–2011 is well acceptable.

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THERMAL SENSITIVITY ASSESSMENT OF SETTLEMENT AREAS

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Abstract. Urban thermal stress is an issue with increasing importance for urban dwellers, and, accordingly, for urban development and planning authorities due to global warming and effects of climate change. Considering an ageing society and the urban sprawl, urban planning has to deal with bio-climatology because of the growing amount of the older population which is especially sensitive to thermal stress in terms of well-being and health.

We introduce a method for the identification of settlement areas which are particularly affected by thermal stress regarding their urban and demographic structures. The methodology incorporates the Physiological Equivalent Temperature (PET), urban structure types (UST), and demographic structures and is based on the employment of several input datasets like thermal remote sensing data as well as the application of bioclimatic models.

The calculation of the settlement heat sensitivity index (SHSI) enables the assessment of the bio-climate sensitivity of residential areas which are subject to planning activities in order to mitigate the potential of thermal stress. As a result, a series of sensitivity maps for the city of Dresden has been derived. We found out that high-dense settlement areas with impervious surface coverage and a high contingent of sensitive urban dwellers with an age over 75 years cause the highest surface and consequently the highest SHSI-values. The opposed manner were achieved with an increasing percentage of both vegetation and unsealing and a heterogeneous age-based arrangement of urban dwellers.

Introduction

Thermal stress within dense urban structures is one of the main issues of the urban heat island (UHI) which keeps the increased temperatures of inner city over hours after sun set due to the high rates of impervious surfaces and their thermal characteristics. Sleep deprivation, reduced physical and mental heat resistance may occur as a result since nocturnal temperatures do not cool down enough to ensure recreation effects for urban dwellers (Matzarakis *et al*., 2009). Moreover the vulnerability and mortality of urban residents rises with the duration of heat periods as the 2003 European heat wave has indicated (IPCC 2007, Kosatsky, 2005). Especially infants, seniors and invalids had been affected due to their high vulnerability and sensitivity against heat loads (IPCC 2007). As a result of the global warming, thermal stress situations are expected to occur more often and with higher intensity than nowadays (IPCC 2007, Bernhofer *et al*., 2009). Therefore, it is eminent to assess the current state of urban climate issues in order to take measures for climate mitigation. Thus, spatial knowledge about thermal properties of urban settlement areas during summer heat periods is of high importance (Kosatsky, 2005; Matzarakis *et al*., 2009).

The research area of Dresden is the 11th largest city in Germany with slightly more than 520,000 inhabitants. Dresden covers an area of approximately 328 km² (rank 4 in Germany) of which 25 percent are covered by forest and 21 percent are made up of residential urban structures, industrial and commercial sites not included (IOER Monitor 2012). The climate is characterized as Cfb – temperate humid climate – according to the Köppen classification (Matzarakis *et al*., 2009).

Material and methods

Physiological Equivalent Temperature PET

The PET is based on the human energy balance and is therefore well-suitable to estimate impacts of outdoor thermal environment on human beings (Höppe, 1999). For this study PET values are classified into six thermal perception classes ranging from cold stress to heat stress according to Matzarakis and Amelung (2008). PET values are calculated by a regression of Landsat remote sensing land surface temperatures (LST) using the RayMan model (Matzarakis *et al*., 2007).

Urban structure type UST

The UST is based on the potential of heating up of the different land uses (20 different UST were identified) (Arlt *et al*., 2003) linked with their bioclimatic relevance. It is well-known that surfaces in built-up urban environments heat up more than natural areas overgrown with vegetation (Dimoudi and Nikolopoulou, 2003). Sealed and built surfaces have lower reflectivity values, higher factors of heat conductivity and heat storage capacity than natural surfaces; accordingly, they have a higher potential of warming up (Oke, 1987). Each UST can be associated with a LST, at which forest and water surfaces causes the lowest LST. High density urban structure causes the highest LST values. In general it can be said that the surface temperature gradually increases with the amount of impervious surface coverage. Moreover each structure type class had to be assigned to four-level scale in order to evaluate its bioclimatic stress relevance (*RELbioclim*).

For example Settlement and infrastructure areas characterized by residence and long-term stayings of human beings are assigned to the highest value of 4 (very high). Green and free spaces within cities also have high bioclimatic relevance (value 3: high), as they are used by many people for recreation and leisure time activities during summer.

Settlement Heat Sensitivity Index SHSI

Based on different weighting factors; thermal information (PET maps), land use data (UST) and socio-demographic data, the resulting SHSI indicates the sensitivity of settlement areas (Figure 1). Following the example of Matzarakis and Mayer (1996) we define a classification of six values expressing the degree of thermal sensitivity of urban areas.

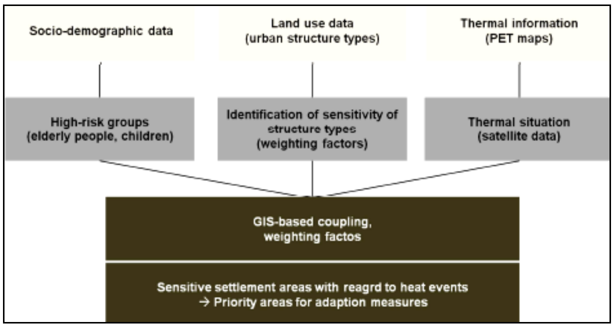

Figure 1. *Modelling approach for the identification of heat sensitive settlement areas (Hoechstetter et al., 2010; changed).*

Results and discussion

The results gained from the SHSI calculations and illustrations give information on thermally sensitive areas in the city of Dresden. The high-resolution localization of sensitive areas provides the development of specific recommendations for urban planning and adaption measures. High SHSI values are relatively scarce and arise only in few street blocks where dense population coincides with highly sealed and less vegetated urban structures (Figure 2). However, values from the most severe of the SHSI-classes (SHSI > 5) are not reached at all in Dresden. The orange and red colors indicate areas where the combined assessment of potential thermal stress, receptor density (consisting of cohorts or the whole of the population), and urban structure parameters indicates an elevated value of thermal sensitivity.

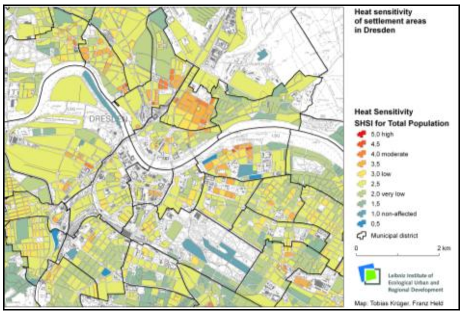

Figure 2. *Heat sensitivity map - SHSI for total population in inner-city of Dresden.*

Based on the infrastructural arrangement the old town city centre of Dresden is susceptible for overheating, yet the relatively low population density in this area is the cause that SHSI values here do not raise over the low level. Since the city centre is a touristic and economic spot of Dresden it is evident that much more human beings are actually affected by heat during daytime than actually residing here. Therefore, the inclusion of visitor's and employee's statistics would be useful to increase the meaningfulness of the index.

Conclusions

In this paper we suggest a method for identification and localization of bioclimatic heat-sensitive spots of urban areas. The calculation of SHSI incorporates the use of high resolution thermal satellite data as well as spatial and statistical datasets of the demographic and urban structures and is based on in-situ measurements of meteorological parameters carried out on hot days. The SHSI can be used for vulnerability and sensitivity analyses for different risk groups (elderly people, infants and invalids) to support the development of mitigation and adaption strategies.

At the current state the methodology has some limitations concerning the adaption to other cities because it has been developed on partly Dresden-specific datasets (especially remote sensing datasets and UST). The advancement and continuance of the SHSI will be threatened in a graduate thesis. Today the methodology can be adapted for any municipality if the data basis of Figure 1 is available:

Outlook**:** One main topic for ongoing studies is to develop methods to assess the thermal sensitivity of urban areas not only for resident population but for the general public which would also include traffic participants, employees and tourists. Moreover the modelling of nocturnal situation is important to assess the heat stress of urban dwellers at night.

Acknowledgements: The SHSI has been developed within the framework of a research project for the development of adaptation strategies to climate change in climatological, economic and social manner in Dresden, Germany (REGKLAM 2012).

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INFLUENCE OF GLOBAL WARMING AND DROUGHT ON CARBON SEQUESTRATION AND BIODIVERSITY OF *Sphagnum* peatlands – PRESENT, PAST AND FUTURE PERSPECTIVES (CLIMPEAT PROJECT)

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Abstract. Northern peatlands represent a globally significant pool of carbon and are subject to the highest rates of climate warming. However, it is unclear how rapidly peatlands respond present changes in temperature and surface moisture. In the recent decade more and more projects are focused in this topic. One of them is the CLIMPEAT project brings together scientists from Poland and Switzerland. Our goal is to assess the past and present vulnerability to climate change of *Sphagnum* peatland plant and microbial communities, peat organic matter transformations and carbon sequestration using a combination of field and mesocosm experiments simulating warming and water table changes and palaeoecological studies. Warming will be achieved using ITEX-type "Open-Top Chambers". The field studies are conducted in Poland, at the limit between oceanic and continental climates, and are part of a network of projects also including field experiments in the French Jura (suboceanic) and in Siberia (continental).

Introduction

Peatlands are recognized as valuable pools of sequestered C and their response to predicting potential feedbacks on the global C cycle becomes crucial (Yu, 2006). The key to Caccumulation in peatlands is not high net primary production (NPP) but low decomposition. Indeed, highest C sequestration is in ombrotrophic bogs, which have low NPP. Therefore, high research priority should be given to how the constraints to decomposition in these environments are sensitive to climate (Bragazza *et al*., 2009). One scenario is the accelerated decomposition of organic matter and the resulting increase of greenhouse gases (CO_2 and CH_4) in the atmosphere. *Sphagnum*-dominated peatlands are primarily situated in Boreal and Subarctic areas and are expected to experience large climate changes in the coming century, making the identification and quantification of potential feedbacks from these high-latitude ecosystems essential for future climate projections (IPCC reports). Peatlands are currently exposed to indirect human impact such as climate change and atmospheric deposition of nitrogen, which will affect their structure and functioning and possibly invalidate previous findings under steady state climate setting. Indeed, those peatlands that are currently recovering from past damage may fail to recover fully. As shifts in vegetation are slow and even the presence of keystone species such as *Sphagnum* sp. do not necessarily indicate the full recovery of a C-sequestering function (Francez, 2000), other indicators such as testate amoebae (Protists) are being considered as early indicators of ecosystem dynamics and functioning (Buttler *et al*., 1996; Laggoun-Défarge *et al*., 2008). Relationships between peatlands and climate are presently tested experimentally in several parts of the World. It is still not clear how fast peatlands respond to changes in temperature and droughts in continental climate setting and, since continental regions account for a significant proportion of all northern hemisphere peatlands (e.g. much of Russia and North America), consequently how this will affect global C cycling. These questions can therefore be considered as research priorities to strengthen the value of peatlands as indicators of past, present and future global change and to better understand peatland ecosystem/biodiversity response to climate warming. Among the approaches to be used, some are entirely new for this part of Europe:

- Contrary to the former projects, in the experiment we will manipulate not only temperature but also drought. Therefore we will simulate long lasting heat waves.
- The experimental heating system "Open-Top Chambers" based on a standardized ITEX protocol will be used for the first time in a Polish peatland ecosystems.
- High-tech equipment is going to be used to constantly monitor climate and greenhouse gas emission. Linje site will become a reference point in this part of Europe for the monitoring of carbon budget in peatlands.
- We will look at the past changes and relate it to the future perspective.

Material a methods

<u>Aim of the project</u>

Experimental/monitoring site - Linje mire - is located in northern Poland near Bydgoszcz city (Figure 1). The mire covers 5.95 ha. In a homogenous (with respect to plant species assemblage and water table depth) area of lawn vegetation in the poor fen we will use a manipulative approach with treatments of temperature (OTC vs ambient as control) and water table depth (high, intermediate as control, low). Plots of 100x100 cm will be prepared by excavating the top layer up to a depth of 20 cm, 30 and 40 cm. These holes will be refilled with intact monoliths sampled nearby in a similar area. These monoliths will be circled with a PVC frame and placed on a PVC board introduced from the side of the trench. These monoliths with their living vegetation will be transplanted (four pieces) in the prepared plots. A PVC frame 15cm depth will be inserted around the plot with its four transplanted cores. This procedure will allow for three water table levels: +10 (lower transplantation), -10 (highest transplantation) an +0 (control, transplantation at the same height).

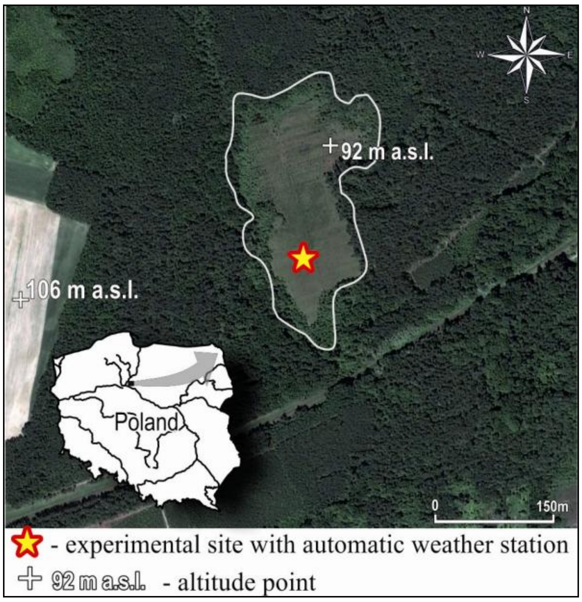

Figure 1. *Map showing the location of Linje mire.*

For the warming treatment, ITEX open-top hexagonal chambers (diameter 2.5 m at the bottom, 50 cm height) will be installed on a series of plots. In selected plots micrometeorological and hydrological measurements will be done. In order to avoid soil trampling, a wood board will be permanently installed for accessing the plots. All the measurements will be carried out from a mobile platform installed above the plots at 70 cm.

Each plot will comprise four subplots for different measurements. One subplot will be used for the vegetation relevés, one will be used for destructive soil sampling, one will be used for gas exchange measurements and one will be used for the water chemistry sampling with selective piezometers, for water level monitoring, for sampling individual mosses and for plant productivity and chemistry.

Results and discussion

Hypotheses

- Higher temperature in combination with dryness will induce a shift from a Sphagnum-dominated system to a vascular plant-dominated system.
- A rise in temperature in combination with drought changes the interaction between plants and microbes for the N and P acquisition in favour of nutrient acquisition by vascular plants.
- A rise in temperature in combination with drought induces changes in primary net plant production and soil respiration, thus resulting in a modification of the carbon balance.
- A change in soil temperature and/or humidity will change microbial community structure, diversity and biomass, but responses will vary among the taxonomic and functional groups.
- The responses in community structure, biodiversity and OM composition can be used, alone or in combination, as 1) indicators of temperature-induced changes in the functioning of the ecosystem, 2) to reconstruct climatic changes during the last 2000 years and 3) to predict future effects of climate changes.
- There was a gradual decrease in carbon accumulation rate during the last millennium. Hydrological instability started in Little Ice Age and continued until today reinforced by mire dehydration ca 50 years ago.

Conclusions

Summarising:

a) We plan to apply a new scientific approach to study how the climate affects peatland carbon stock.

b) We will apply this new approach in an area of Poland that would be a bridge between western and eastern study sites and therefore fill a gap in the climate gradient to be studied if one wants to have a better picture of the sensitivity of peatlands to climate change in Europe.

c) We will connect different groups of scientists to obtain integrated research on the functioning of peatlands

d) We will become actors in a network of European scientists addressing the impact of climate change on peatlands.

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NEW COMBINED CLIMATE CHANGE SCENARIOS FOR SLOVAKIA BASED ON GCMS AND RCMS

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Abstract. General Circulation Models (GCMs) and Regional Circulation Models (RCMs) provide daily climatic data in gridpoint scale with about 300x300 km to 25x25 km resolution. Statistical downscaling method enables to prepare data as scenarios for selected station with good statistical congruity (means, extremes, variability) with measured data in the control period (1961–1990). Physical relations among variables offer good possibilities for calculation of derived climatic variables like saturation deficit, potential evapotranspiration, snow cover etc.

Introduction

Several generations of climate change scenarios have been prepared in Slovakia since 1993 (Lapin and Melo, 2004). Most of them indicated mean annual air temperature rise by 2–4 °C, no significant mean annual precipitation total change but notable modification of seasonal precipitation regime until 2100 (increase in winter, mainly in the North and decrease in summer, mainly in the South). Evaluation of 1991–2011 climatic characteristics proofed good congruity of scenarios and measured data in whole Slovakia. In 2011 new generation of GCMs and RCMs was tested and selection of 2 GCMs (CGCM3.1, ECHAM5) and 2 RCMs (KNMI and MPI) for further elaboration was made. Applying 3 IPCC SRES emission scenarios (A2, B1 and A1B, IPCC, 2007) seven different scenarios as 1951-2100 timeseries of daily data were obtained (mean, maximum and minimum air temperature, mean relative air humidity, precipitation totals, wind speed and global radiation flux).

Material and methods

Applied models (Lapin *et al*., 2012) belong to the newest category of so called coupled atmosphere-ocean models with more than 10 atmospheric levels and more than 20 oceanic depths of model equations and variables integration in the network of grid points. The regional GCMs (shortly RCMs) KNMI and MPI represent more detail integration of atmospheric and oceanic dynamic equations with grid points resolution 25x25 km, while the boundary conditions are taken from the ECHAM5 GCM. The KNMI and MPI RCMs have 19x10 grid points (190) in Slovakia and its neighborhood with detailed topography and appropriate expression of all topographic elements larger than 25 km. The process of climatic data and characteristics elaboration as time series for 1951–2100 can be divided into several steps according to the methodology developed in the DCM and published by Lapin *et al*. (2004). In 2011 some modifications of published method have been carried out.

As a first step the selection of suitable models for downscaling can be considered. This selection was based on comparisons of GCMs and RCMs outputs with observed climate in the control periods 1961–1990 and 1991–2010. As observed control climate the measurements at 15 Slovak Hydrometeorological Institute (SHMI) stations have been used. The first period (1961–1990) was finally applied as reference for calculations of downscaling coefficients and the second one (1991–2010) as a control period for evaluation of downscaling reliability (15 RCMs and 5 GCMs have been analyzed).

As the second step the selection of emission scenarios has been done. In accordance with our previous studies and the Intergovernmental Panel of Climate Change (IPCC, 2007) recommendations the SRES A2 as pessimistic scenario and the SRES B1 as the optimistic one have been selected. The RCMs use the medium pessimistic scenario SRES A1B that places output data between the SRES A2 and B1 values in 2001-2040. All outputs of models (for all SRES scenarios) lie in relatively narrow interval until the year 2040. The A1B is medium pessimistic scenario with global warming by 2.9 °C, A2 with warming by 3.8 °C and B1 by 2.0 °C until 2100 compared to 1961-1990.

Calculation of interpolated values of daily model output from the nearest four grid points into selected meteorological stations with reliable measurements in 1961–1990 was the next step. At daily precipitation totals the values from one nearest grid point with similar topography have been taken only. Interpolation from four nearest grid points would result in smoothing and therefore worsening of daily totals temporal variability. Modeled precipitation totals are usually higher than measured, the reason is in simplified topography on one side and systematic errors of measured totals (up to 50 % in winter months) on the other (Lapin *et al*., 2012).

In the third step the core calculations of statistical downscaling have been done. More detail description of this procedure is presented in Lapin *et al*., 2012. Because of measured data availability and standard normal 1961–1990 recommendation by the WMO, this period has been accepted as reference (control period). The correction was calculated using moving average values around the given day of comparison (11- or 21-day moving average from 30-year mean values for the given day). Recommended procedure of statistical downscaling is based on three preconditions: 1) Not any or least disturbance of physical plausibility among variables in the model outputs; 2) Modifying of model outputs averages in some longer period have to be closer to the same means of measured data; 3) Modifying of model outputs distribution (variability) in some longer period have to be closer to the same distribution (variability) of measured data. Variation coefficient (standard deviation in case of temperature) was used at variability modification. Final result is that the modified model outputs have similar climatic characteristics in the reference period 1961–1990 as the measured ones. The corrections were generally low at the RCMs and acceptable at the GCMs, both in case of averages and variability.

Results and discussion - combined scenarios

Combined climate change scenarios can be designed using modified outputs from GCMs and RCMs for selected stations and some physical (statistical) relations among those modified outputs and other variables not available in GCMs and RCMs outputs. Because of limited area air humidity and potential evapotranspiration scenarios are presented as a sample, another possibility is snow cover, soil moisture, etc. The air humidity characteristics play very important role in all impact models. For practical use more convenient are elements: relative air humidity (***RH*** in %), water vapor pressure (***e*** in hPa) and saturation deficit (***D*** in hPa). That is why we prepared scenarios of these there three air humidity elements. The results showed no significant changes in ***RH*** (some decrease only at RCMs), but increase in ***e*** and ***D*** averages and extremes, because of expected increase of air temperature.

Table 1. *Scenarios (deviations) of monthly and annual water vapor pressure means change (in hPa) in 2051–2100 from the 1961–1990 reference by 6 different RCMs and GCMs models for Hurbanovo after statistical modification using 4 grid point averages, H 1961–1990 − mean measured values at Hurbanovo in hPa.*

Scenarios	Jan.	Apr.	Jul.	Oct.	Year
H 1961-1990	**4.6**	**8.3**	**15.6**	**9.5**	**9.8**
KNMI A1B	1.24	0.88	2.13	2.16	1.61
MPI A1B	1.01	1.10	2.34	2.25	1.66
CGCM3.1 A2	1.67	3.27	2.91	2.12	2.34
CGCM3.1 B1	1.14	2.08	1.81	1.66	1.51
ECHAM5 A2	1.18	0.96	2.28	1.90	1.52
ECHAM5 B1	1.10	0.56	1.83	1.49	1.15

Table 2. *Scenarios (deviations) of monthly and annual saturation deficit means change (in hPa) in 2051–2100 from the 1961–1990 reference by 6 different RCMs and GCMs models for Hurbanovo after statistical modification using 4 grid point averages, H 1961–1990 − mean measured values at Hurbanovo in hPa.*

Scenarios	Jan.	Apr.	Jul.	Oct.	Year
H 1961-1990	**0.95**	**4.76**	**8.48**	**3.05**	**4.13**
KNMI A1B	0.29	0.94	3.48	0.54	1.23
MPI A1B	0.69	0.56	1.81	0.83	1.12
CGCM3.1 A2	0.05	2.05	1.02	1.22	1.11
CGCM3.1 B1	0.02	1.32	-0.20	0.63	0.51
ECHAM5 A2	0.62	1.98	5.78	2.04	2.40
ECHAM5 B1	0.47	1.45	3.43	1.39	1.63

Potential evapotranspiration (E_o) is a complex meteorological, hydrologic and climatic variable depending on temperature (radiation balance), wind speed (turbulence conditions), saturation deficit and active Earth surface properties (including vegetation type) at well saturated upper soil layer and unchanged meteorological conditions. Preparing of climate change scenarios for such complex element is complicated task. Up to present several methods were introduced in Slovakia at E_o calculation. Quite simple formula was applied here, $E_o = k_i D$, where only saturation deficit ***D*** is necessary. The semi-empiric Zubenok (1976) formula can be calculated separately for each month during the year and for specific geobotanic areas (like desert, semidesert, steppe, forest-steppe, deciduous forest, conifer forest and tundra) – different k_i coefficient is for each month. Forest-steppe region was adopted at Hurbanovo.

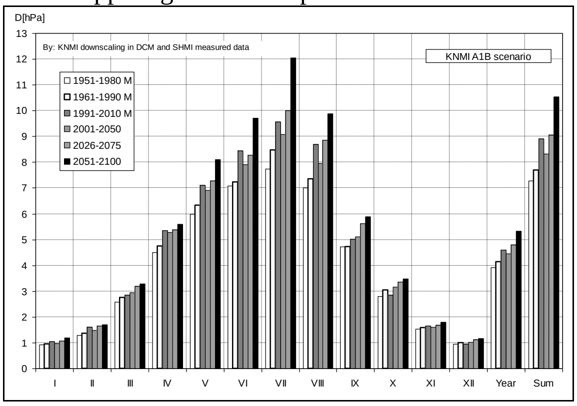

Figure 1. *Example of modeled (modified KNMI RCM outputs) and measured (M) monthly (I - Jan. to XII - Dec.), annual (Year) and summer (Sum) saturation deficit means (D) for the Hurbanovo station in 2001–2100 (KNMI) and 1951–2010 (measured).*

Table 3. *Scenarios of monthly and annual sums of potential evapotranspiration E_o (in mm) in 2011–2040 (2025 time frame) and in 2071–2100 (2085 time frame) by 4 different RCMs and GCMs models for Hurbanovo, H 1961–1990 − calculated according to measured values, all by Zubenok method.*

Scenarios	Jan.	Apr.	Jul.	Oct.	Year
H 1961-1990	**11.7**	**84.3**	**133.7**	**46.8**	**808.9**
KNMI A1B 2025	12.5	92.2	141.0	49.6	859.4
KNMI A1B 2085	14.7	93.7	156.6	52.7	926.7
MPI A1B 2025	14.3	91.4	136.7	52.6	859.0
MPI A1B 2085	19.1	90.3	148.0	56.2	929.6
CGCM3.1A2 2025	12.7	91.4	136.0	52.6	857.5
CGCM3.1A2 2085	12.4	103.7	143.0	57.8	926.6
CGCM3.1B1 2025	12.3	90.0	135.5	50.4	845.3
CGCM3.1B1 2085	11.8	95.9	136.7	53.3	865.1

Conclusion

Climate change scenarios have been widely used in Slovakia since 1993, at the beginning only as changes in selected time frames, later as time series of monthly and daily data and recently also as extreme weather events and complex climatic characteristics (Lapin *et al.*, 2004). This paper shows briefly the last possibility of climatic scenarios.

Acknowledgements: SHMI measured data, outputs of GCMs and RCMs from three modeling centers, data from EU FP6 Integrated Project ENSEMBLES, and the results of projects COST Action ES0905, VEGA 1/0063/10 and 1/0992/12 were used.

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ANALYSIS OF FLOWERING ONSET TIME SERIES FROM THE 19th CENTURY USING LONG TERM TRANSYLVANIAN PHENOLOGICAL OBSERVATIONS

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Abstract. In the present study we have investigated the first flowering response of numerous plant species to interannual fluctuation of local seasonal temperatures (i.e., heat sensitivity of the phenophase), also the rate of these species-specific sensitivities in order to test their applicability as proxy. From the few available data sources recorded in the Carpathian Basin during the 19th century, the relatively long flowering onset data sets of 16 plant species and time series of monthly mean temperature (site: Hermannstadt; period: 1851–1891) were selected for the analyses.

Introduction

Several evidences are gathered from the past half-century for spatial and temporal shifts of plant phenophases associated to global warming trends (e.g., Fitter *et al*., 1995; Sparks, 2000; Menzel, 2003; Parmesan and Yohe, 2003). In order to understand and predict the impact of current climatic changes on plant phenophases, it is necessary to analyse also phenological time series from the period, which are not influenced by the recent anthropogenic warming trends. Studies about the responses of the ecosystem components to climate in the Carpathian Basin are crucial because there are numerous endemic and climatic-endangered species in the Pannon Biogeographical Region. The protection of these important species and their environments under climatic changes is substantial. Unfortunately, the most of phyto-phenological data series in the 19th century have gaps and scattered both in time and space (Szalai, 2008). Studies on different phenological data have started in the second half of 20th century, which period is already influenced by the warming spring conditions (e.g., Walkovszky, 1998; Badeck, 2004; Szabó *et al*., 2009). In this study we analysed the flowering onsets of 16 plants and temperature series recorded near Hermannstadt.

Our aims were as follows:

(i) to find the effective temperatures (T_{eff}) for flowering onset (FO) of each studied species;
(ii) to analyse the temporal shifts of first flowering as a response to T_{eff};
(iii) to rank the plant species by their heat sensitivity of the flowering phenophase;
(iv) to test the accuracy of proxy estimations from flowering onset to temperature.

Material and methods

The analyses were accomplished using flowering onset data sets of 16 wild plant species (Figure 1) recorded in the second half of 19th century and the time series of monthly mean temperatures. The observations were carried out near Hermannstadt [45°48' N, 24°09' E, today a Romanian locality] in the period 1851–1891. We have also involved data from Mediasch [46°10' N, 24°21' E, today Mediaș], from the period 1854–1865, to test the proxy accuracy. Trend analysis, cross-correlation function (CCF), and regression analysis were used as statistical methods. The effective temperature periods were found by 'moving window' technique: bi-, tri-, and tetra-monthly temperatures were calculated from the monthly means by shifting one month step (Figure 2). Then, we determined the most effective temperature (T_{eff}) period for the phenophase of each species using serial CCF (Figure 2). T_{eff} was selected by the highest absolute value of the CCF at 0 lag. The temporal shifts of first flowering as a response to T_{eff} and the heat sensitivity were determined by the slope of the regression equations between the flowering and temperature time series. For the relative response of flowerings to relative changes in T_{eff}, both data series were transformed to percents (Lehoczky *et al*., 2012).

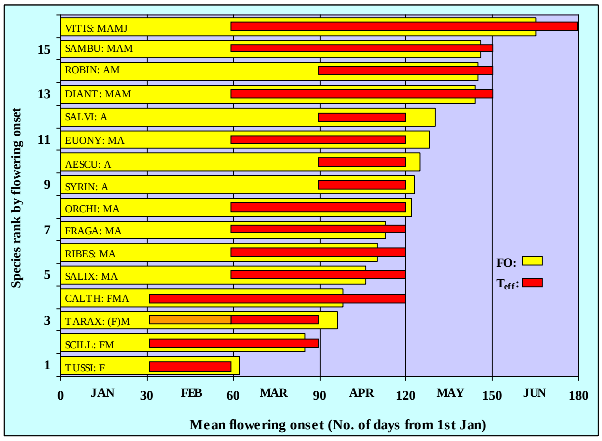

Figure 1. *Timing of mean flowering onsets (FO) and the period of effective temperatures (T_{eff}). The plant species studied:*
1: Tussilago farfara L., 2: Scilla bifolia L., 3: Taraxacum officinale Weber, 4: Caltha palustris L., 5: Salix fragilis L., 6: Ribes rubrum L., 7: Fragaria vesca L., 8: Orchis morio L., 9: Syringa vulgaris L., 10: Aesculus hippocastanum L., 11: Euonymus europaeus L., 12: Salvia pratensis L., 13: Dianthus carthusianorum L., 14: Robinia pseudoacacia L., 15: Sambucus nigra L., 16: Vitis vinifera L.

Results and discussion

Characteristics of the time series

Herbaceous and wooden plants were selected from the late winter to early summer flowering species (Figure 1). The flowering onset dates of different plants were significantly synchronously fluctuated and temporal trends were not detected in any of the time series. Standard deviations of the first flowerings were increased towards early FOs caused by the higher variability of temperatures in cooler months.

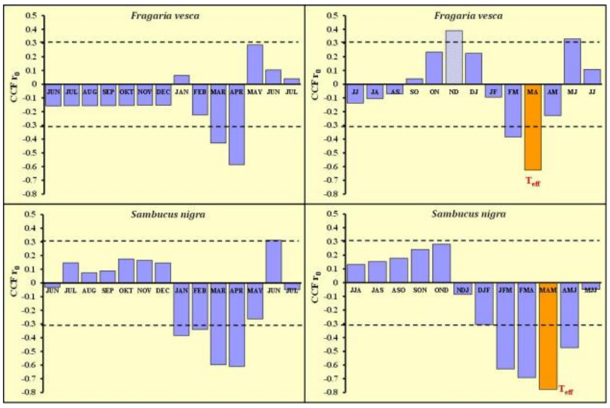

Figure 2. *Two examples for the finding of effective temperature (T_{eff}) of flowering onset using moving windows with different number (1, 2, 3 and 4) of months and serial cross-correlation functions. (Scattered lines on the graphs indicate the threshold of significant [$p < 0.05$] correlation coefficient values).*

<u>Heat sensitivity and the accuracy of the proxy</u>

The effect of mean monthly, bi-monthly, tri-monthly, tetra-monthly temperatures on flowering onsets and from the obtained response surfaces each species-specific effective temperature value (T_{eff}) was estimated. Flowering sensitivities to the effective temperatures were different. On the base of this characteristic the plant species were ranked by (i) the correlation coefficients between first flowering dates and T_{eff}, (ii) the temporal shifts of first flowering as a response to a unit change in T_{eff}, (iii) the relative response of first flowering to a relative change in T_{eff}. We illustrated in different ways the regression slope assessment of sensitivity using relative monthly temperature and flowering changes. To mean temperatures with various time periods 7 plants expressed the strongest response as 'thermal indicators' (Figure 3).

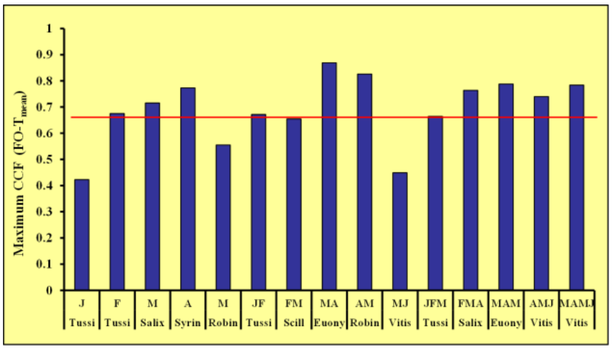

Figure 3. *The greatest significant CCF (r_0, $p < 0.05$) values found by the 'moving window' method between flowering onset (FO) and mean temperature (T_{mean}) for different periods. The 7 indicator species with the highest correlation coefficients are: Tussilago, Scilla, Salix, Syringa, Euonymus, Robinia and Vitis.*

The phenophase onset was tested as a temperature proxy using data sets from Mediasch. The accuracy of estimation was between 1.0–1.5 °C. The heat sensitivity was increased if mean flowering date was later in the season and significant relationships can be detected between them.

Conclusions

The main conclusions of the present study are as follows.

(i) The time series of flowering onsets and effective temperatures significantly synchronously fluctuated and temporal trends were not detected in them.

(ii) According to the species-specific responses to T_{eff} and heat sensitivities, the studied plants were ranked using different statistical characteristics.

(iii) The beginning of flowering phenophases was tested as 'thermometers' and the accuracy of proxy was between 1.0 °C and 1.5 °C.

Due to the calculated accuracy values of the flowering onset as a proxy are not satisfactory in a climatological aspect, it is necessary to refine the results by further methods, such as using annual degree days.

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ANALYSIS OF HUMIDITY CONDITIONS IN SELECTED FOREST ALTITUDINAL ZONES OF THE ZVOLENSKÁ VALLEY AND ITS SURROUNDING DURING THE YEARS 2009–2011

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Abstract. The paper analyses the climatic characteristics measured at regional meteorological stations TUZVO, which are situated in sub-montane and montane regions of the Zvolenská valley at various elevations representing different forest altitudinal zones. The analysis used the meteorological data from the three stations: Arborétum Borová hora (2nd forest altitudinal zone), Kráľová nad Zvolenom (4th forest altitudinal zone) and Predná Poľana (7th forest altitudinal zone). We thoroughly addressed the meteorological situation in three growing periods of the years 2009, 2010 and 2011, which were markedly different with regard to climate. Humidity conditions were analysed using the values of potential evapotranspiration and climatic indicator of irrigation.

Introduction

Global climate changes cause changes in spatial and temporal distribution of precipitation at a global as well as at a regional scale (Dore, 2005). Due to the overall higher atmosphere warming, the air at the ground layer absorbs more water vapour based on which it is assumed that the totals of extreme precipitation events will raise by 50 % until 2010 (Pecho *et al*, 2009). An opposite meteorological phenomenon to extreme precipitation events is a significant decrease of precipitation totals in the last 20 years (Lapin and Szemesová, 2009) and more frequent occurrence of rainless periods, particularly in growing periods (Fisher *et al.*, 2007).Precipitation conditions vary between individual years, while the precipitation totals are significantly correlated with elevation. In addition, significant differences between the windward and leeward slopes occur at same elevations, while the precipitation distribution is also influenced by local orographic conditions. The increasing frequency and intensity of climate extremes is obvious from the increasing damages recorded on forest ecosystems. The knowledge about the meteorological conditions contributes to the clarification and better interpretation of various physiological and growth processes ongoing in forest stands or in individual trees. The goal of the work was to analyse the development of the meteorological conditions with the focus on humidity conditions in the selected forest altitudinal zones in the region of the Zvolenská valley during the three climatically different growing periods.

Material and methods

The measurement of meteorological elements is performed in regional meteorological stations which are situated at different altitudes in forested regions of the Zvolenská valley. For the measurement, a digitial meteorological station produced by EMS Brno (www.emsbrno.cz) with automated data storing and on-line transmission to TUZVO web site (www.tuzvo.sk). The measured meteorological data were processed to obtain climatic characteristics that were compared with long-term averages of the period from 1961 to 1990. For the assessment of humidity conditions we used the values of potential evapotranspiration calculated according to Penman-Monteith, and a climate indicator of irrigation calculated as a difference between the potential evapotranspiration and precipitation (K=Eo–P). The results were analysed for the warm half-years of 2009, 2010 and 2011. Table 1 presents the descriptive characteristics of the meteorological stations.

Table 1. *Characteristics of regional climatic stations TUZVO.*

	Borová hora	Kráľová	Predná Poľana
Elevation	350 m a.s.l.	785 m a.s.l.	1,264 m a.s.l.
Aspect	South-west	North	South
AT_{year}	8.2 °C	6.5 °C	3.7 °C
$AT_{SD\ (IV.–IX.)}$	14.7 °C	12.9 °C	9.6 °C
P_{year}	757 mm	786 mm	1,069 mm
$P_{SD\ (IV.–IX.)}$	428 mm	459 mm	609 mm
Clim. region	warm, slightly moist	warm, slightly oist	cool – mountainous
For. alt. zone	2nd beech-oak	4th beech	7th spruce

Results and discussion

The results of air temperature measurements suggest that in the growing periods of 2009 to 2011 the temperature increased when compared with long-term normal from the period 1961–1990. In all months except September 2010 we recorded positive differences of air temperature from the long-term average (Figure 1). Hence, the analysed warm half-years can be characterised as extremely above-normal in all three stations (Figure 1). However, when comparing individual years 2009, 2010, and 2011, more significant differences were detected in case of humidity conditions than for temperature, which was also proven by a statistical test of the differences between the measured daily values (Table 2). From the point of humidity conditions, the years 2009 and 2011 were very similar and significantly differed from the values measured in 2010. Considering precipitation, the analysed half-year of 2009 can be characterised as extremely below-normal or even dry with the predominance of the months with the values below the long-term average (Figure 1). On the contrary, the half-year of 2010 was extremely above-normal in precipitation. At the beginning of August the precipitation totals already reached the average precipitation totals. The warm half-year of 2011 was markedly differentiated in precipitation. Spring and particularly autumn months were extremely below-normal in precipitation, while summer months July and August were extremely above-normal. Although the precipitation in the year 2010 was above-normal, it was also warmer than other rainy years.

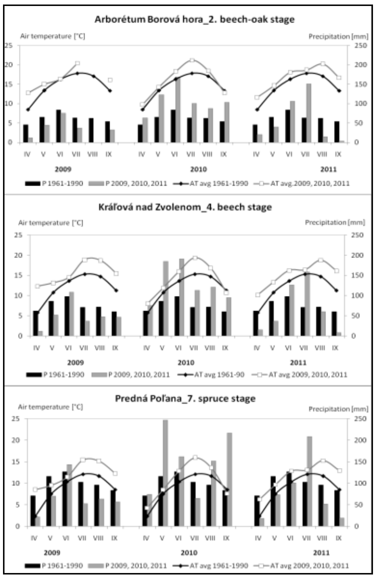

Figure 1. *Comparison of air temperature and precipitation in the years 2009–2011 with long-term average of 1961–1990 period for the stations Borová hora, Kráľová nad Zvolenom and Predná Poľana.*

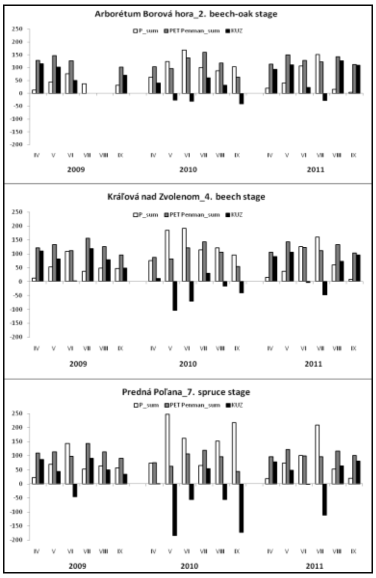

Figure 2. *Monthly precipitation totals, potential evapotranspiration and climatic indicator of irrigation at the meteorological stations Borová hora, Kráľová nad Zvolenom and Predná Poľana in the years 2009–2011.*

Table 2. *Test of differences of meteorological parameters between the years 2009 to 2011 on Arborétum Borová hora station (t - test characteristics, p – significance level, sv – degrees of freedom).*

year	**2009 vs. 2010**		**2009 vs. 2011**		**2010 vs. 2011**	
N=183/sv=182	**t**	**p**	**t**	**p**	**t**	**p**
AT	1.079	0.281	-0.815	0.416	-1.793	0.074
RAH	-8.049	0.000	-0.537	0.001	5.408	0.000
P	-3.548	0.000	-0.841	0.401	2.470	0.014
VPD	6.648	0.000	2.377	0.018	-4.709	0.000
PET	3.755	0.000	1.287	0.199	-2.815	0.005

p > 0.05 – difference is not significant at 5 % significance level,
p > 0.01 - difference is significant at 5 % significance level,
p > 0.001 - difference is not significant at 1 % significance level.

The next goal was to assign the climate in individual forest altitudinal zones to arid or humid climate. In earlier works, the regions with high precipitation totals were considered humid regardless of their water balance sinks.

Nowadays, we use several criteria to assess aridity (humidity): the difference between the actual and the potential evapotranspiration (Tomlain, 1997), comparison of energy from radiation balance and precipitation totals (radiation index of drought) (Tomlain, 2000), or the difference between the potential evapotranspiration and precipitation totals (Kurpelová *et al*., 1975) etc. Špánik *et al*. (1998) considers the climate arid if potential evapotranspiration exceeds precipitation..

In Figure 2 we can see significant differences between the values of the climatic indicator of irrigation in the individual growing periods. In the growing season of 2010 we recorded mostly negative values, while in the growing seasons of 2009 and 2011 we observed only positive values except July 2011, when the sum of precipitation exceeded the value of potential evapotranspiration.

We can also see the increase of precipitation totals and the decrease of radiation balance with increasing elevation. Due to this, the values of the climatic indicator of irrigation decrease (Figure 2).

Conclusions

In addition to seasonal trends in the annual precipitation regime, there is an increasing tendency towards imbalance between the periods with precipitation deficiency and with precipitation surplus. The presumed higher occurrence of extreme events in the last years was proven, and may also be expected in the next years.

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PERCEPTION OF BIOMETEOROLOGICAL CONDITIONS BY TOURISTS AND RESIDENTS AT THE OLD TOWN OF WARSAW

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Abstract. This paper presents some findings of human perception investigations carried out at the Old Town of Warsaw among tourists and residents of the city. The results confirm strong relationship between biometeorological conditions and thermal sensation of people staying in open spaces in urban environment. There is also strong evidence for adaptation taking place, both physically by adjusting clothing and behaviour, as well as psychologically.

Introduction

Perception of the weather is very complex phenomenon. Air temperature, humidity, solar radiation and wind have great impact on human organism. It is an autonomous thermoregulatory system, with some help of behavioural adaptations, that controls heat budget and helps maintain proper core temperature. In theory every healthy person should react more or less similarly to particular biometeorological conditions, but due to some physical and psychological factors there are great variances in thermal perception. In the same weather different people usually have different sensations, and what is more, they tend to be more tolerant to extreme temperature than it is expected.

Therefore human assessment of sensible climate appear worthy of further investigation. In this kind of research weather perception questionnaires are commonly used. Until now few surveys were conducted all over the world, mainly on urban climate (Spagnolo and de Dear, 2003; Nikolopoulou and Lykoudis, 2006; Eliasson *et al*., 2007; Oliveira and Andrade, 2007; Bröde, 2012).

Material and methods

Field studies were focused on the most popular tourist area in Warsaw - the Old Town. Microclimatic measurements and questionnaire surveys were conducted at the Old Town Market Place, which is a rectangle square (90 x 73 m), surrounded by three or four-storey historic buildings. During field studies microclimatic measurements and thermal perception questionnaire surveys were simultaneously carried out. The measurements were done over couple of days in each season of the year: in July 2010 as well as in February, April and October 2011. During the chosen days weather conditions typical for seasons and for central districts of Warsaw prevailed. The exception was July 2010 when heat wave occurred. Independently on the year season, throughout all measurements low wind speed (< 1 m/s) was registered, due to the limitations in air flow among dense downtown buildings. Measurements and surveys lasted from 11 a.m. to 4 p.m. (local time), when the most tourists visited this area and the whole place was well insolated.

In order to characterise thermal environment during experiment, basic meteorological parameters (air temperature, relative humidity, wind speed and global solar radiation) were measured using HOBO® weather micro station (Figure 1). Then meteorological data was used to calculate 5-minutes means of biometeorological index *PET* (Physiological Equivalent Temperature) (Höppe, 1999).

Figure 1. *HOBO® weather micro station used to measure weather parameters at the Old Town of Warsaw.*

Subjective assessment of the weather was investigated by weather perception questionnaire, adapted from Spagnolo and de Dear (2003) research. First part of the survey concerned thermal perception of the interviewees, as well as their preferences in relation to the weather parameters. Questioned people assessed their thermal perception using 7-grade scale, from -3 - "cold" to +3 - "hot". Second part of the survey was addressed to personal characteristics of interviewees, like gender, age, state of health, place of residence, time of stay in Warsaw, time of being outdoors, the purpose of being in that specific place, clothing worn at the moment and recent physical activity. The questionnaires used in different seasons were almost identical, the only differences regarded list of clothing items.

In total 818 questionnaires were collected, however 790 were used for further analysis. Excluded were interviewees that were of age younger than 15 and older than 65 (in order to avoid the possible impact of age on thermal perception).

Results and discussion

It was expected that human thermal sensations would change adequately to changes in thermal environment. Figure 2 presents distribution of human thermal sensation votes in particular *PET* thermal sensation ranges. In general the higher values reached *PET*, the more frequently people used to declare feeling slightly warm, warm and hot. However, the majority of the people, regardless of the weather, usually reported feeling close to thermal neutrality (+/- 1 thermal sensation vote). This observation cannot be explained only by efficiency of thermoregulatory system in human body. It is also evidence that other physical and psychological adaptation processes take important part in forming thermal sensations.

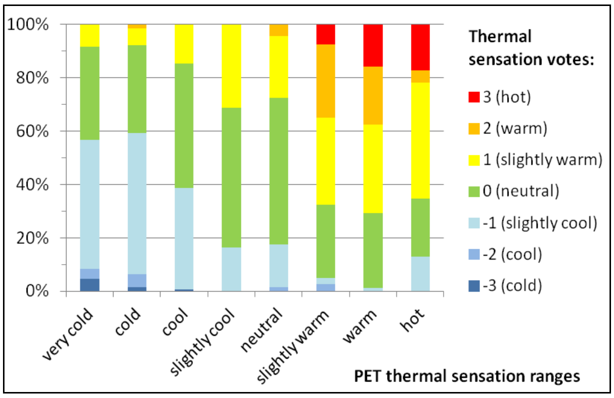

Figure 2. *Frequency of thermal sensation votes in particular ranges of Physiological Equivalent Temperature (PET).*

In transitional seasons under the same biothermal conditions defined by *PET* index, different thermal sensations were reported (Figure 3). In spring *PET* values around 10 °C were usually treated as neutral, while in autumn they were perceived generally as slightly cool. These differences in sensation between seasons according to Spagnolo and de Dear (2003) may be explained by psychological mechanism called *alliesthesia*. Human perception of the previous season is being desensitised by their perception of their short-term thermal history. That is why in spring, after cold winter people usually assess better the same thermal conditions then after hot summer, in autumn.

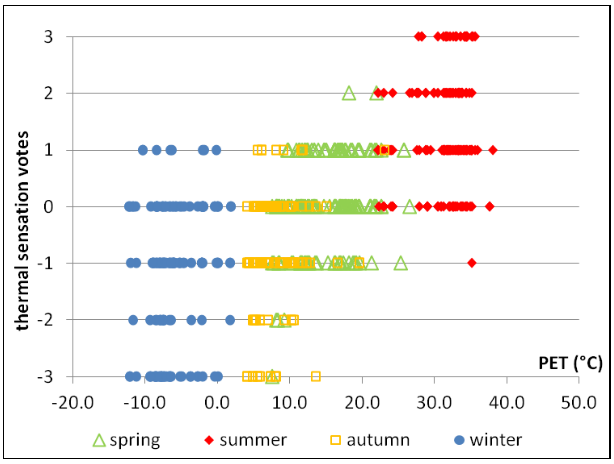

Figure 3. *Seasonal distribution of thermal sensation votes versus Physiological Equivalent Temperature (PET) value.*

Not only expectations and past experiences of the weather may influence the thermal perception in man. Other psychological factors, like personal choice to expose oneself to particular biothermal conditions have sometimes great impact on thermal sensation votes given by people (Nikolopoulou and Lykoudis, 2006). In present studies people who were staying outdoors for tourism reason usually assessed thermal conditions in less extreme manner than the others (Figure 4). On average tourists' thermal sensation votes were a little closer to the thermoneutral sensations than responses obtained from residents just passing the Old Town. This observation has confirmed that voluntary nature of tourism results in higher tolerance and more positive attitude towards certain weather conditions.

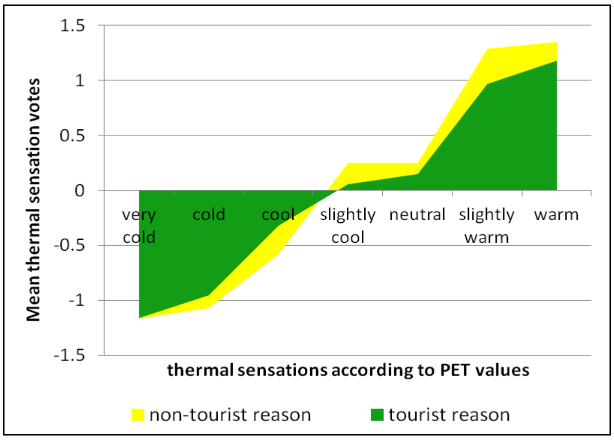

Figure 4. *Mean votes of thermal sensation given by respondents staying at the Old Town for tourist and non-tourist reasons juxtaposed to PET thermal sensation ranges.*

It was also revealed that tourists have specific preferences towards thermal environment. They obviously enjoy warm conditions and display increased tolerance for annoying states of weather. Preference for more intensive sunshine and clear sky was observed as well.

Conclusions

There are great differences in weather perception among people. In general they reveal great acceptance for not diverging from standard biometeorological conditions and only in extreme states of heat or cold they report feeling very uncomfortable (hot or cold). It was also pointed out that human thermal sensations are strongly affected not only by thermoregulatory processes. Psychological factors such as recent experiences or the cause of staying outdoors and voluntarily exposing oneself on particular weather conditions can play important role as well.

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A PROPOSAL TO ENHANCE URBAN CLIMATE MAPS WITH THE ASSESSMENT OF THE WIND POWER POTENTIAL - THE CASE OF CASCAIS MUNICIPALITY (PORTUGAL)

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Abstract. Urban climatic analysis and planning guidelines are fundamental tools in urban planning. Climate potentialities, such as the wind, can be integrated in the evaluation process, but it is not a well explored issue at the present. In this paper we propose a mesoscale methodology to assess the peri-urban areas more suitable for the installation of small wind turbines in Cascais/Portugal (urban canyons are excluded). The information can be used by the local government to motivate communities to implant facilities that can produce energy for their own use from renewable resources.

Introduction

Urban Climatic Maps (UCM) are fundamental tools to integrate urban climate information into town planning process. UCM has typically two main components (Scherer *et al.*, 1999; Ren *et al.*, 2010): *i*) the Urban Climatic Analysis Map and; *ii*) the Planning Recommendation Map. In Lisbon, Portugal, the Master Plan revision process required several urban climate studies that resulted in climatic guidelines to mitigate the negative impacts of the UHI and ameliorate the urban ventilation (Alcoforado *et al*., 2009). At the present, the excessive energy consumption of our society requires new approaches to the problem of urban planning. One of the renewable resources that can be used with advantage is definitely the wind and its potential to create electric power. However, from a mesoscale point of view, the wind speed in urban areas is reduced about 20/30%, or even more, with the densification of buildings (Lopes *et al*., 2011). This fact can hindered the wind power use in such areas, but many cities possess open periurban spaces that can be utilized to install Small Wind Turbines (SWT). However, in the micrometeorological scale, urban canyons can accelerate the wind and at some points this can be used to implant SWT. If the wind potential is good, the installation of such turbines can be useful, for example, to support an electro-mobility network and help to reduce CO_2 emissions and mitigate climate change. According to the Canadian Wind Energy Association (CWEA, 2006) “small wind” can be defined as a wind energy conversion system which has a rated capacity less than 300 kW, intended to provide electrical power for use on-site. However, to the IEC (International Standard 61400-2/) a small turbine must have a rotor swept area less than 200 m^2, which corresponds to a power less than 50 kW (Wood, 2011). In Portugal, for all renewable energies, a micro production (depending on the type of compensation regime), is typically <15 kW and a mini production is a unit with a maximum power of 250 kW. This research is primarily oriented to micro production.

This work presents a new step in this research: to create a new level of information (potentialities of the local climate for energy efficiency) in UCM. The aim is to create a third component of UCM and make this information useful for urban planning, by assessing the areas where wind potential can be useful. Cascais municipality is located on the western part of Lisbon Metropolitan Area, near the ocean. To the north, the *Serra de Sintra*, a small mountain with a maximum altitude of ±520 m, creates a barrier effect to the prevailing north wind. According to Lopes *et al.* (2010), the region has a good wind power potential (inside the municipal area the average wind power is about 100 Wm^{-2}), with a maximum of about 400/500 Wm^{-2} in the northern hills and on the west coast (Figure 1). The principal aim of this research is to present a methodological approach to assess wind power near the urban areas in a mesoscale perspective (excluding urban canyons that should be address to CFD computation).

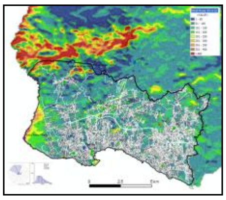

Figure 1. *Wind power density (Wm^{-2}) of the Cascais Region, estimated with WAsP v.10 (color). Urban areas are light grey*

Material and methods

Beside the interior of the urban fabric, several restricted areas (Tires aerodrome, Estoril raceway and forests) are present and were not taken into account in the final assessment. WAsP v.10 software (DTU Wind Energy, Risø, Technical University of Denmark) was used to assess the wind power density. A near five year (June 2004- April 2009) hourly data from the Tires/Aerodrome meteorological station was used. Classes of the municipal master plan (urban, green areas and parks, open fields, industrial areas, etc.) were used to determine the roughness length (z0) classes. Contour lines (with an equidistance of 10 m) were also used in the model. In the first stage of the work, Climatopes (morphological climate response units, not showed in this paper), were delimited according to Alcoforado *et al*. (2009). A discussion with municipal architects and other technicians was fundamental to define climate guidelines. In the second stage, the annual wind power density information was added to the GIS database which contains the Climatopes and several other features (like urban areas, forests and restricted areas). To know effectively the amount of wind energy that can be used, it is advisable to be acquainted with the viability for a specific small wind turbine. This necessity is due to the range of wind speed that a turbine can use to transform in electric power. Depending on the type or turbine there is a cut-in wind speed (the minimum speed at which the wind turbine at hub height will generate usable power), a rated wind speed that corresponds to the speed at which the wind turbine will generate its designated rated power and a cut-out speed at which a wind turbine ceases to generate electricity. The Cascais Municipality installed several 16 m high Skystream3.7 turbines near the coast line (Ponta do Sal), with a rated capacity of 2.4 kW. The cut-in and the rated speed are respectively 3.5 and 13 m/s (in the studied area these values correspond approximately to 50 and 500 Wm^{-2}). The methodology to assess the areas with suitability to locate SWT, was based, primarily, on the cut-in value of 3.5 m/s (the generalized minimum wind speed needed to generate power) following classes of 1 m/s of interval. In the Cascais region, these wind classes are translated in the corresponding wind power density shown in the Figure 2 and Table 1.

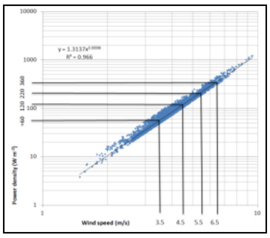

Figure 2. *Relation between wind power density (Wm-2) and wind speed in Cascais Region. Classes of potential are marked on the left.*

Table 1. *Annual average wind speed (all directions) and suitability to produce energy form wind power density at 15 m high, in Cascais.*

Wind power classification		
Power class	**Wind speed [m/s]**	**Wind power density [Wm^{-2}]**
Without potential	< 3.5	< 60
Fair	3.5–4.4	61–119
Good	4.5–5.4	120–219
Very good	5.5–6.5	220–360
Excellent	> 6.5	> 360

Results and discussion

The suitability to certain area to produce energy from the wind depends, not only, on the potential wind power but also on other several issues, namely economic, social, legal and even political factors. The economic factors depend, generally, on fixed costs, namely the turbine cost, the installation (including cables and connections to the electricity network) and maintenance. The installation of SWT very close to urban areas involves other problems such as the acceptance by the population (NIMBY "syndrome"), noise, visual impacts, safety, etc. The methodological aspect of zoning the areas more suitable to install small turbines near urban areas brings up two questions: *i*) how far should the facility be apart from the houses and; *ii*) how far the turbine can be installed taking in account the fixed costs. In European countries, regarding the distances, there are no recommendation guidelines to the installation of small turbines (only noise regulations should be taken into account. Based on a survey, the Canadian Association of Wind Energy (CAWE, 2006) recommends a setback distance range from 6-9 m from the property line and from two-thirds of the tower height, for mini turbines, to 1.5 times the height for larger ones. For the scale used on this research the setback distance is irrelevant. According to some installation experts (personal communications), the maximum distance depends more on fixed costs (especially the price of the cable) and should not be more than 150m from the electric network point of access. Based on these two criteria (wind power density and maximum distance from the urban areas) the suitability classes were set up in the GIS. The wind power suitability in Cascais region is presented in the Fig. 3.

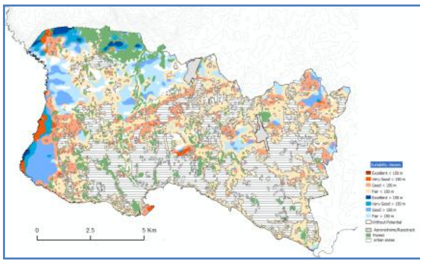

Figure 3. *Suitability to install SWT. This information will be included as a layer in the UCM.*

The double classification of suitability classes in the map (<150m from the buildings, and >150m), has two advantages: a) the first, presents the areas that are more suitable to locate SWT at the present; b) the second (>150m), shows the potential areas where new neighbourhoods can benefit from this renewable resource.

Two research lines should be continued in the future: the first is related to the efficiency of the power generated in areas of great wind speed variability. The monthly regimes and the possible number of productive hours should be assessed. This would help the investors and local government to decide if the installation of SWT is cost-effective. The second one is how to include this new layer of information in the Climate Guidelines and Planning Recommendations maps. This lead to an old issue: how to maintain scientific accuracy without losing the simplicity in communication to the public that is non climate/engineering expert.

Conclusions

Small wind power assessment can be useful to help local governments to decide which areas are more suitable to implement autonomous energy projects. This can lead to attain the goal to create new sustainable and carbon free local communities. This research proposes a new resource component of UCM (at the same level of "Climatic Analysis Map"), that will help to create new climatic guidelines oriented not only to mitigate thermal stress, but also to take advantage of local climate factors such as the wind and the solar irradiation among others.

A lot of work to engage citizens in this process is needed: in the first place to disseminate the knowledge related to the new technology and its relation with the reduction of the effect of climate change and its mitigation, and secondly to know, through inquiring, the degree of commitment that local communities have to this problem.

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The list of **references** is available from the authors.

INFLUENCE OF RAINFALL FACTOR R ON CALCULATION OF AVERAGE ANNUAL SOIL LOSS

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Abstract. The aim of this paper is to find out how the different values of rainfall factor influence the average annual soil loss on selected land area Lukáčovce, region Nitra and also how these values influence classification of erosion threat of agricultural soils in selected area. The rainfall factor was calculated according adjusted Wischmeier- Smith (1978) methodology. The calculated values were substituted into universal soil loss equation and then with using GIS devices were created maps. The second calculation of average annual soil loss was done with value of rainfall factor which was calculated by Soil Science and Conservation Research Institute (SSCRI) and then was also created maps with GIS device. It was find out than annual soil loss calculated with using our values of rainfall factor is 2-times higher than the annual soil loss calculated with R-factor of SSCRI and therefore is the erosion threat of agricultural soils more significant. These conclusions result to question if are anti-erosion measurement applied on this area adequate, because we consider our calculated values of rainfall factor for correct.

Introduction

Soil water erosion consider serious problem in the Europe Union. Almost 12.0 % of all areas in Europe are endangered by water erosion and of course in Slovak republic is endangered as many as 43.3 % of agricultural soils. These alarming numbers incite detailed research of water erosion factors. One of these factors is the rain factor R or rain erosivity. The value of rain factor which is used in calculation of annual soil loss significant influence with the resultant values on selected area and therefore it was made this kind of research.

Material and methods

As model area was chosen plot i.e. concrete productive block LPIS in cadastral area Lukáčovce (region Nitra). Area size almost 7 ha is agricultural used by local agricultural company. It is situated in height interval from 157 to 217 m a.s.l. with average sloping 7 %.

Figure 1. *View on the examined area Lukáčovce (district Nitra).*

For purpose of determination of erosive soiltransport were determinate each erosive factors by following method. Rainfall factor R was determined by following process (the rainfall factor was calculated on Department of Biometeorology and Hydrology, Slovak Agriculture University in Nitra by Maderková and Antal):

Slovak Hydrometeorological Institute in Bratislava provided data about one minute precipitation for chosen meteorological stations situated in area of south-western Slovakia. Totally were processed data from 5 meteorological stations for different time period. We used the methodology of Wischmeier-Smith (1978) which considers the erosive effective rainfall, those rainfalls, which are higher than 12.5 mm and with intensity higher than 24.00 mm.h^{-1} in one rain division. The main different in this work is that each minute of rain was consider for individual rain division. The following equations were used for calculation of rainfall factor:

$$R = E * I_{30} \quad [\mathrm{MJ.ha^{-1}.cm.h^{-1}}]$$

where:

R – rainfall factor [MJ.ha^{-1}.cm.h^{-1}],

E – rainfall kinetic energy [J.m^{-2}.mm^{-1}],

I_{30} – maximal 30-minutes rain intensity [cm .h^{-1}].

$$KE = (11,87 + 8,73 * \log_{10} I) * H_z \quad [\mathrm{J.m^{-2}.mm^{-1}}]$$

where:

KE – kinetic energy of rain [J.m^{-2}.mm^{-1}],

H_z – precipitation height [mm].

The rainfall factor (R) in this case represent value 42 MJ.ha^{-1}.cm.h^{-1} for comparison and for expression its influence also SSCRI (Ilavská, Jambor, Lazúr, 2005) defined the rainfall factor and it reaches value 24.62 MJ.ha^{-1}.cm.h^{-1}.

Soil erodibility factor (K) was determined as function of main soil unit (classified soil-ecological unit), whereby it does not represent constant factor in examined area, but nearly there are represent 3 factors, namely: 0.40; 0.51 and 0.72 t.MJ^{-1}.

Length and steepness of slope factor (LS) was determined with using contour line basic map of Slovak Republic in scale 1: 10 000. With using interpolation method Topo to Raster was created digital model of terrain, from which were derived other relief characteristics as slope in % and slope length in m. Consequently were calculated values of LS factor with using of raster (map) calculator:

$$LS = \sqrt{s} * (0,0138 + 0,0097 * s + 0,00138 * s^2)$$

where:

s – slope length [m].

Cropping and management factor (C) was determined according cultivated crops on examined plot, which was

Swedish turnip after root crop with value 0.22.
Conservation practices factor (P) was deprived i.e. P=1.

Results and discussion

Reciprocal multiplication of each erosion factor were obtained spatial presentation of erosive soiltransport on example of two rainfall factor which were determined by different methods (Figure 2).

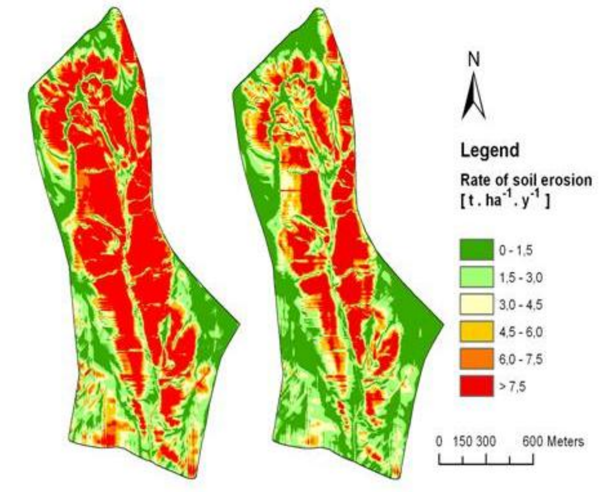

Figure 2. *Rate of soil erosion with using two different values of rainfall factor.*

Classification of erosion treatment of agricultural soil was taken from Czech Republic (Collective, 1999).
Abundance of each erosive soiltransport categories and threat on examined area are represented in following table.

Table 1. *Abundance of each erosive soil transport categories.*

Rate of erosion [t.ha^{-1}.y^{-1}]	Soil endange-red	Soil erosion *		Soil erosion **	
		[m^2]	[%]	[m^2]	[%]
0–1.5	**Very small**	14, 006	20.16	22,081	31.78
1.5–3.0	**Small**	10, 950	15.76	13, 388	19.27
3.0–4.5	**Medium**	7, 921	11.40	8, 902	12.81
4.5–6.0	**Heavy**	5, 819	8.37	6, 749	9.71
6.0–7.5	**Very heavy**	5, 104	7.35	4, 653	6.70
> 7.5	**Extremely**	25, 685	36.96	13, 712	19.73
Σ		**69, 485**	**100.00**	**69, 485**	**100.0**

**R=42 MJ.ha^{-1}, **R=24.62 MJ.ha^{-1}*

From the maps and also from the table expression of erosive soiltransport follows significant influence of rainfall factor on resultant value of soiltransport. Hereby it is necessary to mention that, while with using rainfall factor which was determined by Soil science and Conservation research Institute is erosion soiltransport in interval from 0 to 42 t.ha^{-1} (weighted average 4.6), the rainfall factor which was determined by Department of Biometeorology and Hydrology is in interval from 0 to 71 t.ha^{-1} (weighted average 7.8).

Conclusions

Rainfall factor is one of the important components of universal soil loss equation designed by Wischmeir-Smith. Its value has significant influence on annual average soil loss and also on classification of area to the erosive soiltransport categories. As can be seen from created maps and also from the table, the rate of soil erosion on examined area is significant higher with using of rainfall factor calculated on Department of Biometeorology and Hydrology. Concretely the rate of soil erosion is two times higher than the rate of soil erosion calculated with using of values designed by Soil Science and Conservation Research Institute. These significant differences invoke question, if are applied anti-erosion measurement sufficient because the rate of soil erosion is higher and the calculated and used values of rainfall factor designed by Maderková and Antal are considered for correct.

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NEW RESULTS ON TEMPERATURE TRENDS AND EXTREME EVENTS

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Abstract. Statistical analyses of meteorological time series in the period 1961–2010 provide prove of changes in temperature and precipitation in the border region of the Czech Republic and Saxony. Since 2000 occurred previously unobserved extremes of seasonal temperatures. Seasonal rainfall totals of the last decade show an increasing number of extreme values.

Introduction

Climate Change has altered the intensity, frequency, and geographic extent of some types of extreme events and it is expected to continue to increase in the future. At present, we see a regional variation in temperature changes; increases are higher over land and in the northern hemisphere. It is only through the careful study of the pattern of events over years or decades that we can begin now to attribute the changing pattern of our weather and the weather extremes to climate change. For the time being, until humanity brings its greenhouse gas emissions under control, we can expect each decade to be warmer than the preceding one.

Material and methods

Meteorological time series for temperature and precipitation from the stations Nová Ves v Horách (CZ) and Fichtelberg (D) in the Ore mountain are used for the seasonal trend analysis in the period 1961–2010. To classify the regional temperature trend in the global temperature trend data and maps supported by the Goddard Institute are used.

Results and discussion

The four seasons shows a different temperature trend in the regional scale, represented by the station Nová Ves v Horách. In the global scale there are no significant differences to be seen. At the regional scale, in the period 1961–2010 changes in the frequency of circulation patterns has the trend of the increasing temperature strong amplified in winter and strong weakened in autumn.

Table 1. *Linear temperature trend in [K/50a] in the period 1961–2010 at the station Nová Ves v Horách and in the global temperature.*

Season	Nová Ves v Horách	Global temperature	Ratio
Spring	2.18	0.70	3.1 : 1
Summer	1.63	0.64	2.5 : 1
Autumn	0.56	0.69	0.8 : 1
Winter	2.49	0.71	3.5 : 1
Year	1.71	0.69	2.5 : 1

Even in the presence of the existing warming trend, natural climate variability can lead to more or fewer cold outbreaks in a given season and region. Coupling of natural climate modes can change the climate state for years including prolonged warming and cooling. Unfortunately, it is common for the public opinion to take the most recent local temperature anomaly as indicative of long-term climate trends.

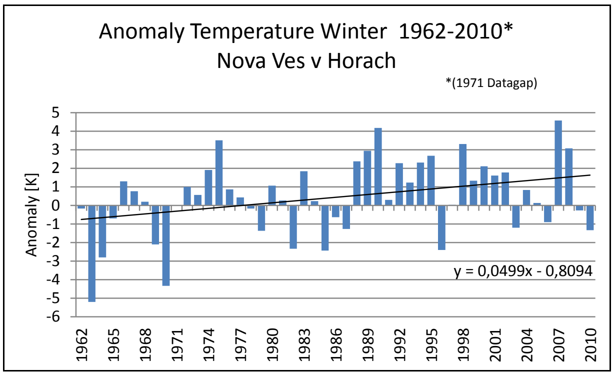

Figure 1. *Winter temperature anomaly in [K] and the linear trend in the period 1961–2010 at the station Nová Ves v Horách (Ore Mountain).*

The extent of extreme warm anomalies increases disproportionately as average temperature rises. Examples are autumn 2006 and July 2006. They demonstrate the new quality of some temperature extreme events (new temperature records for month, season and year after the millennium) not at least because of "Warming-Background" and the coupling of changing circulation patterns. So, in summer 2003 and July 2006 Western Europa and July 2010 Eastern Europa (Russia), respectively, suffered unusual extreme heat waves and dry spells. Heat waves in particular show a high probability of worsening over the most land areas in upcoming years due to rising global air temperature.

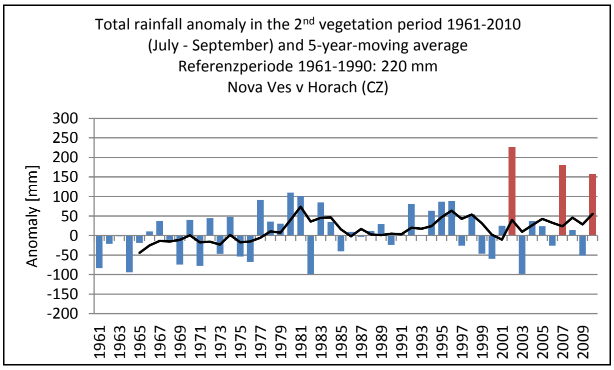

Figure 2. *Rainfall anomaly in the 2nd vegetation period in [mm] and the 5-year-moving average in the period 1961–2010 at the station Nová Ves v Horách (Ore Mountain).*

Future trends in cyclone activity and tornadoes were more difficult to assess due to limitations in monitoring records and climate forecasting models. Moreover, global warming is projected to intensify the hydrological cycle and increase the magnitude and frequency of intense precipitation and river flood events in many parts of the world. First significant changes in this direction are already clearly to be seen and should be discussed for the Ore mountain region.

Conclusions

Regional trends in the period 1961–2010 and previously unobserved extremes for month and seasons in recent years are related to global warming.
Due to the observed signals a regional climate monitoring in terms of a comprehensive and constantly being updated analysis are necessary in order to adapt to future climate change.

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MONITORING PHENOLOGY BY USE OF DIGITAL PHOTOGRAPHY

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Abstract. In this study we tested the application of inexpensive digital cameras in monitoring phenology. The digital repeat photography provides reliable information on canopy greenness with a high temporal resolution and can be considered as a useful and relatively low-cost tool for monitoring canopy developments and phenological observations. The use of cameras can standardize measurement protocol across sites and reduction of bias due to observer variation in identifying the date of phenological stages, which is typical of traditional monitoring.

Introduction

Traditional plant phenological observations, made by direct observations, record specific phenophases, such as leaves unfolded or flowering. They are typically made on a limited number of individual, across a limited geographic area or a specific site. On the other hand, satellite remote sensing, used to quantify the seasonal patterns of development and senescence of vegetation (land surface phenology), operates at coarse spatial and temporal resolution, and at a regional or larger scale (White and Nemani, 2006; Normets, 2009).

More recently new technologies with intermediate features between these two types of monitoring methods are becoming more common: the so-called "near-surface" remote sensing method, which can focus observations on single individual or on the whole ecosystem canopy. In particular, the use of inexpensive visible spectrum digital cameras for proximal remotely monitoring of phenological events has become more common, repeated photography allows obtaining samples at very high temporal resolutions for monitoring vegetation phenology. Mounting these systems on towers or other platforms provides also data at an intermediate scale of observation, allowing a contrast between field-based observations and satellite-derived measures (Richardson, 2007).

The aim of this paper is to show the possibility of using standard, commercially available cameras for phenological observations. The future use of cameras may reduce labor costs of phenological observations.

Material and methods

In September 2006, a year-long project of distance monitoring of phenological phases of forest-tree species was launched at the Doksany observatory. The Doksany observatory is located at 50°27'31" N and 14°10'14" E at 158 m a.s.l., 45 km northwest of Prague. A project of Geographical Institute at university in Bern served as an inspiration. The camera Canon PowerShot S3 is located on a piece of land, where there is an International Phenological Garden Doksany, and is connected via ethernet cable to a computer inside the observatory. Features of Canon: 12x optical zoom lens with Canon's Optical Image Stabilizer technology, 6.0 MP CCD, extensive movie functions, ISO 800, widescreen recording, 2.0" vari-angle LCD, 20 Shooting modes and My Colours. In intervals given in advance a set of defined points is photographed and the images are saved to a computer in the building. 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. In September 2009, continuous monitoring has been expanded to 10 megapixel digital single-lens reflex camera Olympus E-410 and a year later to 5 megapixel ip camera Basler BIP2-2500C.

The images obtained were analysed using the Sigma Scan software (Figure 1). We used the relative brightness of the green channel (GF: the ratio of the mean raw green value to the sum of the mean raw red, green and blue values).

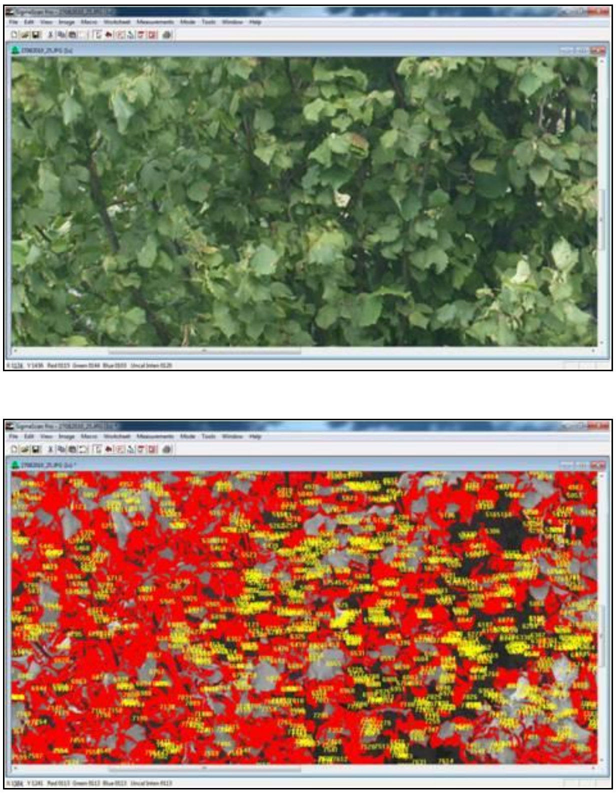

Figure 1. *Image processing using software SigmaScan.*

CO_2, water and energy fluxes between vegetation and atmosphere were measured using the eddy covariance (EC) technique. Canopy spectral properties were measured with the Skye 2 and 4 channels sensors.

Results and discussion

The median phenophases difference in wild trees (*Betula pubescens*, *Populus tremula*, *Sorbus aucuparia*, *Tilia cordata*, *Salix aurita*, *Corylus avellana*) between the traditional monitoring (TM) and the camera systems (CS) for the comparative period 2009–2011 was positive for the beginning of leaf-unfolding (M = 1.78 day, standard deviation SD = 0.4 day), the beginning of flowering (M = 2.26 day, SD = 0.9 day), the general flowering (M = 2.14 day, SD = 0.8 day), the autumn colouring (M = 1.52 day, SD = 0.3 day) and the leaf fall (M = 2.11 day, SD = 0.7 day).

We found that the use of commercially available cameras offers the possibility of monitoring phenology with high temporal and spatial accuracy with respect to the phenological phenophases of individual deciduous trees. Our study clearly showed that changing illumination conditions and weather conditions introduce a moderate uncertainty in phenological estimates. By choosing pictures taken at a particular hour every day to monitor vegetation development, this uncertainty can be minimized.

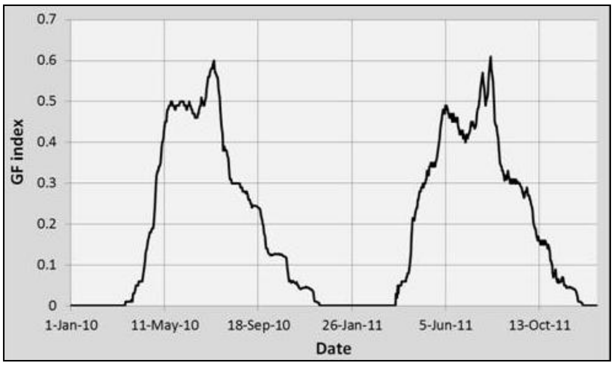

Figure 2. *Variation of the mean GF index (the ratio of the mean raw green value to the sum of the mean raw red, green and blue values) at IPG Doksany in the period from January 2010 to December 2011.*

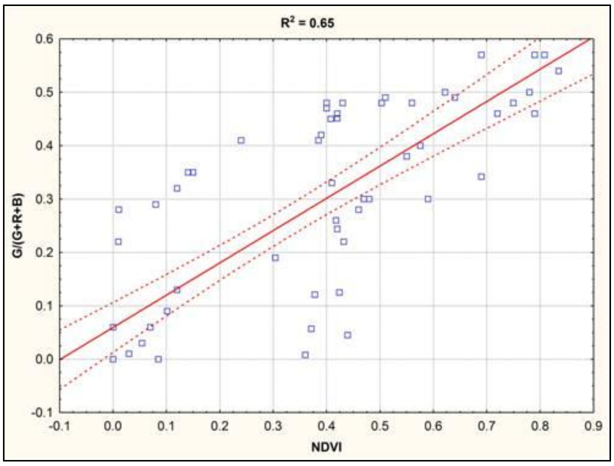

Figure 3. *Relationships between mean GF index (the ratio of the mean raw green value to the sum of the mean raw red, green and blue values) and NDVI index at IPG Doksany in the period from January 2010 to December 2011.*

Most digital cameras have a native capture system in the red (R) − green (G) − blue (B) colour space. An effective way to synthesize RGB colour information from digital photographs is through color indices such as the GF index (Mozny *et al*., 2011), which was shown to be a good indicator of canopy development.Figure 2 shows the GF curves and GF - derived leaf emergence dates for 2010 and 2011. The GF showed a characteristic curve shape, similar to the spring leaf emergence phenology, and could therefore be used as a surrogate index for phenological phases. Maximum GF values represent vegetation cover fraction and maximum canopy closure.

Within the period from the 21st January 2010 to the 30th September 2011 a statistically significant relationship was found (Figure 3) between the GF index and the NDVI index (R^2=0.65, $P < 0.01$).

Conclusions

Digital cameras can be used in the phenological observations for their high accuracy and low labor costs. Data from the cameras can be easily systematically recorded and permanently stored.

We tested the relationships between Green Index (GF) tracking canopy greenness extracted from repeated digital images against Normalized Difference Vegetation Index (NDVI) computed from spectroradiometric measurements and concentration of atmospheric carbon dioxide (CO_2) at IPG Doksany. A strong relationship was found between daily GF and daily mean NDVI, daily GF and daily average CO_2 concentration.

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HOW THE POSSIBLE LIVING TERRITORIES OF THE EUROPEAN TERRESTRIAL WILD MAMMALS ARE PROJECTED TO CHANGE DUE TO GLOBAL WARMING?

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Abstract. In this research we aim to estimate the regional impacts of climate change to the European terrestrial mammals. Results suggest that rapid change and significant decline in habitats redraw the wild animals' living territory and make them migrate northward. Simultaneous analysis of climate simulations and animal range datasets enables us to evaluate the vulnerability of the European terrestrial mammal species to regional climate change.

Introduction

Global climate change affects humans and the urban environment, and furthermore, the living conditions of wild animals (Bartholy *et al*., 2012). Animals tend to occupy geographical regions with climatic conditions, which are optimal to the specific needs of the given species. Due to the projected global warming and climate change the wild animals' living territory may be reshaped in the future. The analysis of phenological, geographical, and genetic impacts of climate change to wildlife is an increasingly popular research topic (e.g., Thomas *et al*., 2004, Chen *et al*., 2011), however, the projections of future conditions are rarely investigated due to the lack of proper methodology. Results so far suggest clearly strong relationship between global warming and the response of wildlife. Climate is one of the abiotic factors, which controls primarily the range areas of the wildlife. If the climate significantly changes in a particular region, it may disturb the ecosystem, and increase the risk of extinction. Based on previous studies (e.g., Williams *et al*., 2007) accomplished in case of the A2 scenario (Nakicenovic and Swart, 2000), 12–39 % of the Earth's terrestrial surface is very likely to experience significantly different climate conditions from the current climate.

The above mentioned studies all highlight the importance of this global issue and the need of further research to understand the mechanisms of climate stress to ecosystems. Such detailed analysis may help to minimize these negative impacts of global warming to the wildlife and ecosystems before it would be irreversible.

Material and methods

The aim of our research was to make a comparative case study for the projection of the European terrestrial mammals' vulnerability to future climate change. The Atlas of European Mammals (available from Societas Europaea Mammalogica) was used for the range area of species. This database was compiled in 1999 (Mitchell-Jones *et al*., 1999) and has been widely used as reference dataset. It separately contains data for the pre-1970 and post-1970 presence of mammal species in Europe. Figure 1 shows an example for *Mustela erminea*. For past and present climate information we used the E-OBS gridded datasets, which was compiled on the basis of observed daily temperature and precipitation (Haylock *et al*., 2008). Finally, for the 21st century climate projections, we used bias corrected RACMO simulation outputs (van Meijgaard *et al*., 2008), which was accomplished by KNMI in the frame of ENSEMBLES project (van der Linden and Mitchell, 2009). Bias correction was completed using monthly quantile matching technique (Formayer and Haas, 2009).

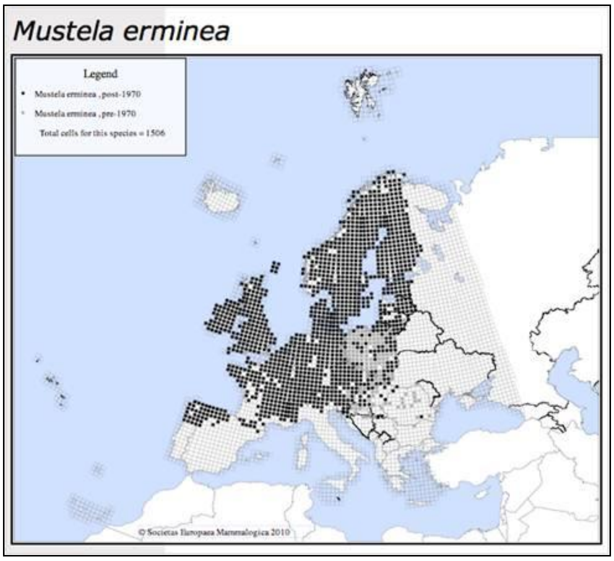

Figure 1. *The range map of Mustela erminea on the base of the Atlas of European Mammals.*

To characterize the climate indicators of the animals, we used the annual means of the four climatic parameters (daily mean temperature, daily minimum temperature, daily maximum temperature, daily precipitation sum) based on the gridded E-OBS dataset. Then, we estimated specific percentiles of the frequency distribution of the climatic parameters, and made three symmetric confidence intervals around the average (optimum) of the histograms. These specific climatic intervals have been presented on maps for the past (1961–1990), and also, for the middle (2021–2050) and the end (2071–2100) of the 21st century using the RACMO regional climate model bias corrected simulations. The applied confidence intervals are as follows:

- 10 % - 40th–60th percentiles, the closest to optimum
- 25 % - 25th–75th percentiles (lower and upper quartiles)
- 40 % - 10th–90th percentiles (lower and upper deciles)

Results and discussion

The mapped information based on the observed annual sum of precipitation explains the current eastern boundaries of the European *Mustela erminea* (Figure 2). Similar map for the observed annual mean temperature implies the boundaries of the north-south spread of *Mustela erminea* (Figure 3). Thus, analyzing the maps of all the four variables provide an estimate of the animal's current spread (Figure 1) within Europe. The model simulations for the periods 2021–2050 and 2071–2100 indicate a clear northward shift of the optimal climatic conditions of all European terrestrial mammals, which is evidently due to global warming. According to our estimations 48 % of the species will probably suffer habitat decrease, 46 % are likely to experience habitat increase and 1 % shows no change by the end of the 21st century.

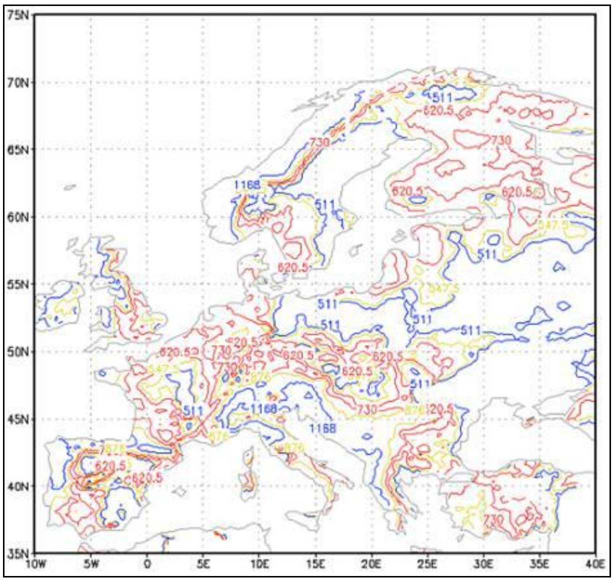

Figure 2. *The map of Mustela Erminea's climate indicators, based on the observed annual sum of precipitation, 1961–1990.*

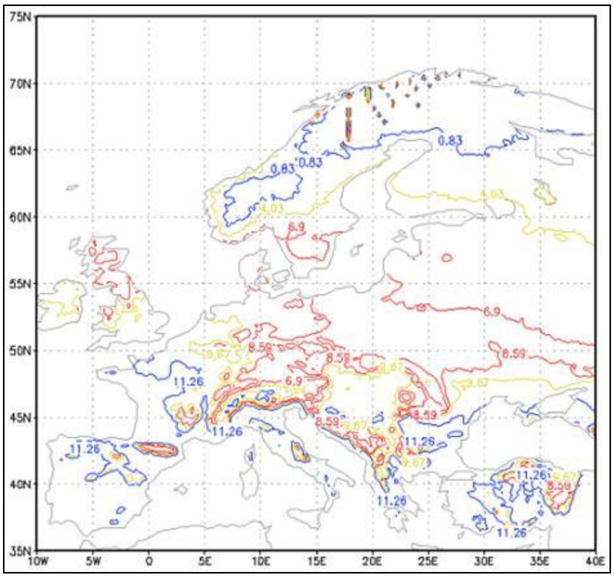

Figure 3. *The map of Mustela Erminea's climate indicators, based on the observed annual mean temperature, 1961–1990.*

Conclusions

The purpose of this study was to analyze the possible regional impacts of global warming to the living territory and conditions of the wild European terrestrial mammals. Our results based on the climate profile indicator technique suggest a remarkable change in the habitats of wild animals and their northward migration in order to find their optimal conditions. The northward shift of the daily mean temperature climate indicator may imply a significant change in habitats. In the meanwhile, the projected precipitation change is not likely to effect the possible migration of terrestrial mammal species in Europe. As a result habitat conditions are likely to decrease in continental climate regions during the 21st century.

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TREE-RING BASED TEMPERATURE RECONSTRUCTION FOR THE UPPER SILESIA, SOUTHERN POLAND, SINCE A.D. 1572

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Abstract. In this paper, tree-ring width chronology of Scots pine (*Pinus sylvestris*), combining the recent and historical pine wood from Upper Silesia, southern Poland, was constructed. The results of growth-climate responses show that winter temperature and summer precipitation are the limiting factors affecting radial growth of pine trees in the study area. According to previous polish dendroclimatic research, temperature from February to March seems to be one of the most stable climatic factors which influenced pine growth in Poland. After successful calibration/verification procedure, utilizing the 126 years of instrumental data (1885–2012), the 440-year pine chronology was used as a base for paleoclimatic reconstruction of February-March air temperature. Comparison with documentary archives provided an independent verification of this reconstruction. Applying 11-year and 35-year moving averages allowed for identification of two warm periods and two cold periods. The duration of well-known climate fluctuations, like: the Little Ice Age with the Maunder and Dalton Minimums, and the Modern Warming was also determined.

Introduction

Knowledge about past climatic conditions is becoming increasingly important in terms of global changes. A key aspect of the debate on future climate changes focuses on identifying the size, frequency and causes of natural climate variability at different spatial scales. The tree rings, as a continuously and annually resolved proxy, have been widely used to reconstruct past climate all over the world. Also the information stored in the annual rings of relict wood can serve as an invaluable archive of past climatic variations (e.g., Brázdil *et al*., 2002**;** Büntgen *et al*., 2011; Szychowska- Krąpiec, 2010).

Although knowledge of the past climate in Poland has increased in last decades, long term dendroclimatological reconstructions exists only for some regions of Poland (e.g., Niedźwiedź 2004, 2010; Przybylak *et al*., 2005, Krąpiec *et al.*, 2009; Szychowska-Krąpiec, 2010; Koprowski *et al*., 2012). Upper Silesia is the area with very few historical climate studies, despite conducting meteorological observations from the early 19th century and the existence of potential sources of historical tree-ring data. Longer records from tree rings can extend existing climate information back in time.

The objective of this study was to obtain long temperature record for this region, based on composite tree-ring chronology and early instrumental measurements.

Material and methods

Despite the study area is characterized by a significant transformation of the natural environment, the oldest and semi-natural forest stands are covered by reserve protection, as they are considered to be the remnants of the Silesian Primeval Forest. The samples were taken from living trees in such locations (Figure 1). The historical wood was mainly sampled in the open-air museum in Opole, collecting the oldest wooden buildings from the region. A relict wood also come from wooden poles. A total of 305 samples were analyzed. The cores were prepared using standard dendrochronological procedures (Speer, 2010) and ring widths were measured to the nearest 0.01 mm. The measured ring-width sequences were then visually and statistically crossdated in TSAP. The crossmatching and quality-checking were carried out using COFECHA. Next, the sequences were standardized to remove biological growth trends and other potentially non-climatically conditioned fluctuations, using the ARSTAN. The two-step detrending method was applied (a negative exponential curve followed by a cubic smoothing spline, with 67 % of the length of the series criterion - Cook and Kairiukstis, 1990).

Monthly resolved temperature and precipitation data from four stations (Katowice, Opole, Racibórz and Wrocław) were selected to develop a regional temperature series for calibration purposes (1885–2012). The data were verified for homogeneity problems. Part of the instrumental series before 1885 (not included into calibration) were reconstructed based on the early instrumental data from two stations only: Głubczyce and Wrocław (1792–1884).

In order to investigate climate / growth relationships, the response function and correlation analyses were calculated in DendroCLIM 2002. The predictor variables were monthly mean values starting from April of the previous year to September of the year of ring formation (according to vegetation period of pine in Poland). Reconstructed values were calculated using linear regression and scaling. In order to analyze long-term changes in winter temperature, the 11-year and 35 year Gausian filter was applied.

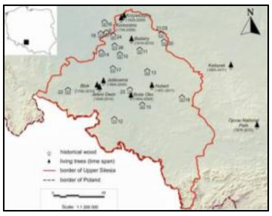

Figure 1.
Study area with sampling sites.

Results and discussion

The time span of created TRW chronology is 1572–2010 (after truncation <5 series) (Figure 2). EPS (>0.85) and RBAR (>0.4) statistics are above critical values in whole analyzed period. In some sequences strong growth depressions occurred, most pronounced in the years

1960–1980. These curves with disturbed course were excluded from further analysis as observed depressions are conditioned by atmospheric pollution, as shown by previous dendro-ecological studies from this area (e.g., Malik *et al*., 2009).

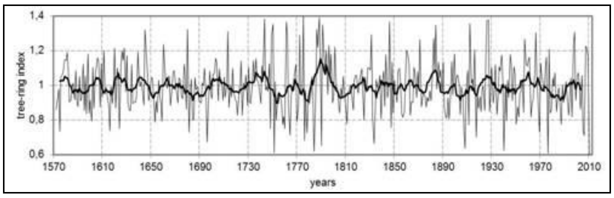

Figure 2. *Regional tree-ring chronology of Pinus sylvestris.*

Ring width shows significantly ($p < 0.001$) positive correlations with the temperature in current February and March (0.41), and also with summer precipitation (0.4). The results obtained for the temperature are consistent with other reports on the climatic drivers of pine growth in the lowland areas of Poland (e.g., Zielski, 1997; Wilczyński, 1999; Krąpiec *et al*., 2009).

After cross calibration/verification procedure based on sub-periods: 1885–1948 and 1948–2010, the final reconstruction was calculated by solving the regression equation for mean value of F-M temperature using:

$$T_{(F\text{-}M)t} = -3{,}9 + 5{,}3I_t + 0{,}5E_t$$

where $T_{F\text{-}Mt}$ is reconstructed air temperature in year t, I_t is the indexed tree ring width in a year t, and E_t is the extreme year index in a year t.

A comparison of the reconstructed and observed February-March temperature reveals a statistically significant correlation coefficient ($p<0.001$) equal to 0.45 for years 1885–2010. The analysis of reconstructed indexed values of temperature after smoothing with 11-year and 35-year Gaussian moving averages allows the coldest and warmest periods to be determined. The cold phases occurred in the years: 1583–1700, 1795–1890 and the warm ones in the years: 1701–1794, 1891–2012. Comparison with historical data, concerning the occurrence of particularly cold or warm winters allowed for validation of dendroclimatic reconstruction (Figure 3). This data are consistent especially during Maunder and Dalton Minimum. In the light of presented reconstruction, the Little Ice Age period in the Upper Silesia lasts from 1583 to 1890.

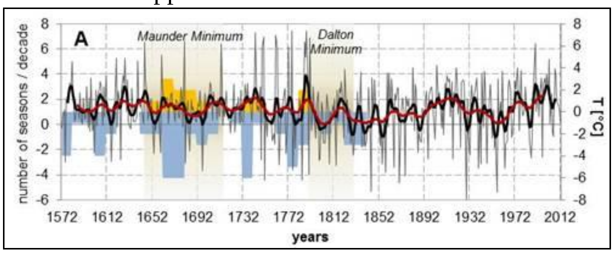

Figure 3. *Reconstruction of winter temperature compared with historical data (yellow bars-warm winters, blue bars-cold winters).*

Conclusions

Tree-ring based reconstruction of the climatic conditions of areas where there is more than one factor limiting growth is possible, although with slightly less accuracy than for extreme environments. In Upper Silesia, the temperature of the second half of winter can be reconstructed the most precisely, as this are growth limiting factors of *Pinus sylvestris* in the study area. The beginning of presented, reconstruction, falling in the second half of the sixteenth century, is a particularly interesting period, because many researchers date for these years the begging of the Little Ice Age. Although this newly created reconstruction does not extend further than 1572, in the light of the literature the first cold phase (1583–1700) can be regarded as the beginning of LIA in the Upper Silesia.

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IMPACT OF HIGH AMBIENT TEMPERATURE ON HUMAN MORTALITY DURING HOT SUMMER 2007 IN THE REPUBLIC OF MOLDOVA

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Abstract. The statistical and epidemiological analysis of the impact of hot temperatures of summer 2007 on the mortality rate in Moldova was carried out. The most sensitive to heat are women, urban population, elderly, and people with cardiovascular diseases. Raising the minimum temperature has the greatest effect on increasing mortality.

Introduction

In recent decades many scientific studies focused on the study of climate extremes, including heat waves, because of their impact on ecosystems and human society. One of the reasons for such interest is a concern that the frequency and the severity of these phenomena have recently increased, especially in Europe, and that this trend will continue due to global warming (IPCC, 2007b). Moreover, the unusually hot summers in recent years, more and more often observed in various regions of the world, saying that such a future not too far away. The extremely hot summer of 2003 in Western Europe claimed thousands of lives (44,000 excess deaths in 12 European countries) and caused great damage to the economy of many countries (EuroHeat, 2009). Summer heat in 2007 affected a number of countries in South-Eastern Europe, including Greece, Hungary, Romania, Bulgaria and others. This year was one of the warmest in the history of instrumental observations in Moldova, when long-term temperature records were broken during the winter, spring and especially in the summer (Cazac, 2007). Given the hot summer climate of the country, the continuation of this trend can lead to very negative consequences for all biological systems, primarily affecting the most vulnerable components – agriculture and human health. The hot weather of summer 2007 has led to both direct and indirect impacts on human health, reflected in the increase in ambulance calls and in the increase in total mortality, particularly from cardiovascular diseases among the elderly. As it was shown in study of Corobov and Opopol (Corobov, 2010), the direct effect of heat in the summer of 2007 in Chisinau has resulted in 200 excess deaths. The purpose of this paper is statistical and epidemiological analysis of the impact of hot temperatures of summer 2007 on the mortality rate in Moldova.

Material and methods

Important concepts in the study of relationships "temperature-mortality" is death associated with the heat, and death from all causes. Death associated with heat, defined as death, when exposure to high ambient temperatures either caused death or contributed to it. The main cause of death used in epidemiological studies is sufficient to characterize the relationship between temperature and mortality, although the associated cause of death can also be used (Basu, 2009).

The object of our study was the data on daily mortality in Chisinau and in 3 regions of North (Falesti), Center (Anenii Noi) and South (Cahul) of the country, disaggregated by area (urban, rural), gender (males, females), age (0–17, 18–39, 40–59 and over 60 years) and the main causes of death according to the International Classification of Diseases – endocrine diseases (E00–E99), diseases of the cardiovascular (I00-I99), respiratory (J00–J99) and digestive (K00–K93) systems. Data on daily mortality were obtained from death certificates archived at the National Center for Health Management. Total population in four studied regions is 1 mln 085 thou 400 people (1/3 of the total population).

Meteorological data (mean, maximum and minimum daily air temperature) on Chisinau weather station (φ=46°58'03" N, λ=28°51'23" E, h=173 m) were provided by the State Hydrometeorological Service. There are no missing values in the datasets over the studied period.

The impact of temperature was studied in Chisinau during June-July-August for the period 2001–2010. Additional mortality (excess deaths) was estimated as the difference between deaths in 2007 from the average mortality of reference period (2001–2010, excluding 2007 as abnormal). Because of the small size of Moldova (33,846 km^2), the relatively homogeneous terrain, and the location of Chisinau near its geographic centre, the research results of "temperature-mortality" linkage could be considered as representative for the whole country. In addition, the overwhelming (73 %) proportion of the population used in this study is the Chisinau population, and others three areas are similar to the capital by their relative height (up to 100 m above sea level). So, using the Chisinau data series is justified and the obtained results could be interpreted countrywide.

Statistical computations were performed, using the StatGraphics Centurion Data Analysis and Statistical Software.

Results and discussion

A long time persistent high air temperature causes increased morbidity and short-term peaks of mortality, especially in persons with chronic diseases and the elderly. Increased frequency and severity of heat waves lead to the health deterioration of these groups.

Relative (%) estimate of the number of excess deaths compared to the reference period for gender and area has shown that during the summer additional deaths in the urban area exceed that in the rural in 1.5 times, and the excess mortality of women relative to men is more than 3 times. Only in July the excess female deaths reached 35 %! Therefore, during the heat of summer 2007 additional deaths have been registered mainly due to the urban female population – more than 12 % (Figure 1).

Comparative analysis of excess deaths by age revealed the sensitivity of population of different ages to the heat. First of all the elderly people have reacted. Already in May, the percentage of excess deaths in this age group was positive and reached in July (peak of the heat) about 34 %.

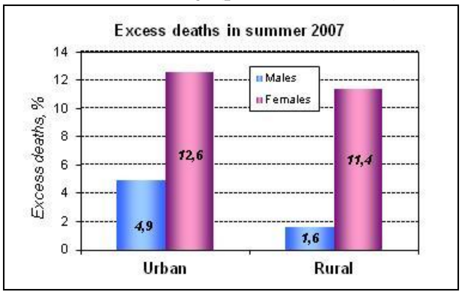

***Figure 1**. Excess deaths (%) by area and gender during summer (JJA) 2007 in the Republic of Moldova.*

In the structure of excess deaths by causes the overwhelming percentage belongs to cardiovascular diseases (77 %), an order smaller – digestive diseases (10 %) and endocrine, nutritional and metabolic (7 %) diseases.

However, the greatest interest for the study is the determination of mortality of various categories depending on air temperature. Many studies are based on the average daily air temperature for the identification of exposure (Kim, 2006; Barnett, 2007); others use the maximum and minimum temperatures for the coverage of day and night temperatures, which play an important role in heat-related mortality (Baccini, 2008; Armstrong, 2010).

In the present study the statistical analysis of excess mortality of different categories due to mean; maximum and minimum daily air temperature was carried out. Parameters of simple linear regression are presented in the Table 1, characterizing the power of connection (correlation coefficient – *r*), its significance (p-value) and value (regression coefficient – *b*).

***Table 1**. Parameters of the linear dependence of excess mortality on daily air temperature in summer of 2007.*

Category	Mean T		Max T		Min T	
	r	*b*	*r*	*b*	*r*	*b*
Urban	0.331^{***}	0.428	0.299^{**}	0.319	0.366^{***}	0.574
Rural	-	-	-	-	-	-
Males	0.287^{***}	0.252	0.227^{**}	0.165	0.346^{***}	0.369
Females	0.248^{*}	0.237	0.285^{***}	0.225	0.259^{**}	0.301
0–17 y.o.	-	-	-	-	-	-
18–39 y.o.	-	-	-	-	0.227^{*}	0.090
40–59 y.o.	-	-	-	-	-	-
60+ y.o.	0.345^{***}	0.395	0.354^{***}	0.335	0.357^{***}	0.496
E00–E99	-	-	-	-	-	-
I00–I99	0.292^{**}	0.303	0.345^{***}	0.296	0.339^{***}	0.427
J00–J99	-	-	-	-	0.204^{*}	0.056
K00–K93	0.199^{*}	0.071	-	-	-	-

The statistical significance - * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

The urban population is more sensitive to high ambient temperatures due to the significantly pronounced heat storage by urban buildings and large areas of asphalt, creating a "heat island". In Moldova this relationship is confirmed by a low but statistically significant correlation coefficient for mean and minimum temperatures with the largest increase in excess mortality in the urban area depending on the minimum (or night) temperature (regression coefficient 0.574).

The regression analysis of the causes of death showed the prevalence of cardiovascular disease, but at the same time did not reveal any links to high temperatures with mortality from endocrine and respiratory diseases. It should be noted that the minimum air temperature also has a higher regression coefficient.

The resulting regression equation can quantify the degree of dependence of growth of population mortality on the temperature conditions of summer. The model provides a satisfactory quantitative prediction of daily mortality during episodes of extreme heat, which is especially important in today's global warming and the increasing risks to public health.

Conclusions

The attempt to quantify the impact of high temperatures on mortality in Moldova in an abnormally hot summer of 2007 has allowed the following conclusions:

- identified relationships are more pronounced for the urban population, women and elderly people, i.e. these categories are the most sensitive to the high ambient temperature;
- resistance of the human body to heat decreases with age, the most sensitive to heat are elderly people;
- an overwhelming percentage of excess deaths due to the cardiovascular diseases;
- raising the minimum (night) temperature has the greatest effect on increasing mortality.

The study of the effects of heat waves contributes to our understanding of pathophysiological mechanisms of heat effects on the human organism, serving as a basis for argumentation of advanced adaptation measures in public health structures.

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METEOROLOGICAL FACTORS INFLUENCING ONSET OF PHENOLOGICAL PHASES OF THE TURKEY OAK (*Quercus cerris* L.) IN NATURAL NATURE RESERVE BOKY IN SLOVAKIA

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Abstract The thesis deals with the influence of meteorological factors on the timing of phenological phases of Quercus cerris L. in Kremnica Mountains in central part of Slovakia. Phenological observations and meteorological measurements were carried out at site Boky (northernmost occurrence of Turkey oak in Slovakia) during the period of years 2007–2011. For spring phenophases we found its highest correlation (p<0.05) with air temperature, soil temperature, global radiation and number of ice and frost days. For autumn phenophases we found no statistically significant dependence.

Introduction

Plant growth requires enough light, water, oxygen, mineral nutrients and appropriate temperatures. These apparently simple requirements are influenced by different environmental factors and physiological processes such as meteorological factors (temperature, precipitation, humidity, wind etc.), soil factors (topography, slope, exposure, soil properties etc.), biotic factors (pests, diseases) and the internal periodicity of plants or its genetic properties (Menzel 2002, Štefančík 1995, Priwitzer *et al.*, 2009).

While spring phenological phases are quite well interpreted in relation to spring temperatures, the influence of factors on autumn phenological phases is less clearly explained and fewer authors have dealt with it (Walther *et al.*, 2002), perhaps because of the less pronounced changes in onsets of autumn phenophases and their more heterogeneous structure (Menzel, 2002). There are less scientific papers dealing with leaf coloring and leaf fall than bud burst or leafing (Štefančík, 1995, Donnelly *et al.*, 2006). Onsets of autumn phenophases are formed by more complex processes, which are aroused by a lack of light, chilling, air flow etc. not just shortly before their onsets, but during the process of creating of leaves (Chalupa ex Štefančík 1995, Škvareninová *et al.*, 2007).

The better we understand the seasonality of flora and fauna, the better we understand the world around us and it will help us to adapt to climate change and better manage our natural resources.

Material and methods

In the period 2007–2011, we carried out phenological observations of Turkey oak (*Quercus cerris* L.) in the central part of Slovakia on the site Boky which is located in the southern part of the Kremnica Hills. The research area is located at an altitude of 530 meters a.s.l. on a slope with the southern exposition (Table 1).

Phenological observations were made according to methodology (Kolektív, 1984) prepared by the Slovak Hydrometeorological Institute in Bratislava. This is usually used for monitoring of forest tree species in Slovakia. For each tree species we monitored 10 individuals. We recorded the beginning and the end of each phenological phase which mean that at least 10 % and 100 % of monitored trees reached the phenophase. For statistical analysis of the onset of phenological phases in different years we used the absolute number of days in the year (the Julian date).

Table 1. *Characteristics of the observed sites Zvolen and Boky in the years 1987–2011.*

Latitude Longitude	Altitude [m a.s.l.]	Exposure slope	Tempera-ture [°C]	Rainfall [mm]
48°34'02" N 19°01'15" E	530	S, 25°	7.5	720

We also worked with meteorological data which were downloaded from the nearby meteorological station. They were obtained in 10 minutes intervals and were processed by the program MINI32. Statistical analyses were carried out using Statistica7.

Results and discussion

Statistically, the most important factors influencing spring phenological phases of Turkey oak were air temperature, soil temperature and global radiation in the previous months. The onset of bud swelling 10 % correlated the best with mean air temperature in February (increase by 1°C means an earlier onset of phenophase for almost 2 days) and also related soil temperature and number of ice and frost days in February ($p<0.05$). The phenophase of leafing 10 % was the most influenced by amounts of global radiation in January and April. This variable had with the mean air temperature in April a significant impact on the phenophase of blossom fall 10% ($p<0.05; p<0.1$) (Table 2).

Strong relationship between spring temperature and leafing was recorded in the whole Europe (Cannell *et al.*, 1999). Vitasse *et al.*, (2009) found for oak the greatest sensitivity to changes in spring temperatures, which responds to shifts of bud swelling by 7.5 days with the increase in temperature by 1 °C. Chmielewskι and Rötzer (2001) found shift by 8 days with the increase in temperature by 1.5 °C. Askayev (2005) found different data. Increase in mean spring temperature by 1°C mean advance in spring phenophases by 2.8 days. He also found that leafing is the most negatively correlated with the March and April temperatures. According to Sparks and Carey (1995) leafing depends mainly on March, April, February and August (previous year) temperatures (R^2%=73 %), respectively. Harper (2007) also found a significant negative dependence of leafing and mean air temperatures in February, March and April.

According to model, whereby the winter temperature will increase by 3.5 °C and spring and autumn temperature by

3 °C, Sparks and Carey (1995) determined a possible advance of leafing up to 22 days to the year 2100.

For autumn phenophases we found statistically significant dependence ($p<0.1$) of leaf coloring 10% and number of summer and tropical days in July and leaf fall 10 % correlated with mean air temperature in October, however this dependence was not statistically significant.

Zhu and Sun (2006) found that the sooner leaves of the oak begin to colour, the longer it takes until all of them fall down. However they found no significant relationship between leafing in spring and coloring of leaves in autumn. According to Askyev *et al.* (2005) autumn phenophases respond to the general conditions in summer more than to average meteorological data in previous months. Vitasse *et al.* (2010) described that for the correlation of autumn senescence of leaves and average air temperature is better to use hyperbolic function. He also said that thanks to the oak resistance to drought is its influence on timing of autumn phenophases very small.

Table 2. *Regression analysis of phenological phases and thme most statistically significant meteorological and other factors of the Quercus cerris L. ($p^* = p<0.05$; $p^{**} = p<0.1$; n – number of cases, b_1 indicates average annual change observed during monitoring period).*

Dependent variable	Independent variable	n	R^2	p	b_1
BS 10%	ø AT (I.–II.)	5	0.87	*p***	–1.8
	ø AT (I.)	5	0.66	0.19	–1.6
	ø AT (II.)	5	**0.96**	***p****	**–1.7**
	ø ST (I.)	5	0.69	0.17	4.3
	ø ST (II.)	5	**0.97**	***p****	**–2.4**
	ø ST (I.–II.)	5	**0.98**	***p****	**–7.9**
	TS5 from 1. January	4	0,88	*p***	0.1
	Σ ice+frost days (II.)	5	**0.98**	***p****	**0.4**
	Σ ice+frost days (XII.–II.)	4	0.77	0.12	0.4
L 10%	ø AT (III.)	5	0.50	0.18	–1.8
	ø GR (IV.)	4	**0.97**	***p****	**–0.2**
	ø ST (I.)	5	0.59	0.13	–2.8
BF 10%	ø AT (IV.)	5	0.75	*p***	–1.5
	ø GR (I.)	4	**0.93**	***p****	**–0.7**
	ø GR (IV.)	4	**0.90**	***p****	**–0.2**
LC 10%	Σ trop.+sum. days (VII.)	5	0.70	*p***	1.2
LF 10%	ø AT (X.)	5	0.78	0.15	–8.0

BS - bud swelling, L - leafing, BF – blossom fall, LC - leaf coloring, LF - leaf fall; AT - air temperature, ST - soil temperature, GR - global radiation, TS5 - sums of temperatures above 5 °C

Conclusions

We found out, that timing of phenological phases is a very simple tool for identifying possible changes of climate on the Earth, because its onsets are very sensible especially to changes in temperature. We also found their high dependence on global radiation and numbers of days with defined temperatures. However our main aim in future should not be just evaluation of the timing of phenophases. We have to focus on the impact of the earlier onsets of phenophases on production (in agriculture, horticulture, viticulture and forestry), human health (flowering of allergenic plants, insect infestation) and on species distributions, their interspecific relationships and life cycles of organisms which are influenced by the predicted global warming. Changes in phenology effect not only wild plants and animals, but they can have serious economic and social impacts.

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INFLUENCE OF ATMOSPHERIC AND SOIL FACTORS ON STEM DIAMETER INCREMENT OF PROVENANCES OF NORWAY SPRUCE ORIGINATED FROM VOLOVSKÉ VRCHY

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Abstract. This contribution presents the results of the measurements the stem diameter changes during two different years 2010 and 2011. The measurements were performed on three provenances of Norway spruce in Borová hora Arboretum of Technical University in Zvolen during the growing seasons. Stem diameter was monitored with digital dendrometers DRL 26 (EMS Brno, CZ) at 1 hour intervals. The largest increment was monitored in June 2010 and 2011. Whereas in September 2010 the trees were still growing in September 2011 the contraction of stems already occurred. The increment in 2011 by-more than 50 % smaller than in 2010.

Introduction

In central Europe summer droughts occur on average every 4-5 years, and every 10-11 years they are extremely severe (Schmidt-Vogt, 1989). Increasing temperatures stimulate the growth of Norway spruce as long as there is enough water available (Schmidt-Vogt, 1977). Norway spruce finds its growth optimum at an altitud of about 600 m a.s.l. Below this zone its growth correlates with precipitation - while above with temperature during the growing season (Modrzyński and Eriksson, 2002). Short-term (during day) fluctuation of stem diameter of trees is strongly affected by water balance of trees. Thus, the changes of stem diameter are not only the result of xylem activity, but they are also often caused by water balance of a tree. Therefore these changes reflect the current contraction or swelling of stems due to water - inflow and outflow.

The aim of the study was to evaluate monthly increment of stems diameter of Norway spruce and the dynamics of increment during two different growing seasons (April–October) 2010 and 2011 in terms of humidity.

Material and methods

Stem diameter increment was observed during 2010 and 2011 growing seasons in Arboretum Borová hora in Zvolen. The experimental plot is situated at 350 m a.s.l., northwestern aspect and 15 % slope. For our experiment we used 3 provenance, each represented by 6 trees (in 2011 only 4 trees) of Norway spruce (*Picea abies* (L.) Karst), all 35 years old, originated from different altitudes of theVolovské vrchy mountains:

1. Provenance – 500 m a.s.l.
2. Provenance – 750 m a.s.l.
3. Provenance – 1,100 m a.s.l.

On each sampled tree a dendrometer DRL 26 (EMS Brno, CZ) with built-in datalogger for long-term recording of data was instaled. The changes of stem diameter were recorded continuously in one hour intervals. Near sampled Norway spruce trees meteorological parameters (global radiation [$W.m^{-2}$], air temperature [°C], relative air humidity [%], precipitation [mm]) and soil temperature [°C] were measured. Air temperature and humidity were measured 2 m above ground and soil temperature 10 cm below ground. Data was recorded in datalogger every 10 minutes. Obtained dendrometric and meteorological data was processed by Mini32 software (EMS Brno, CZ) and Microsoft Excel. Because the values of meteorological parameters and stem diameter were recorded in different intervals, the meteorological parameters were recalculated to hourly values.

Results and discussion

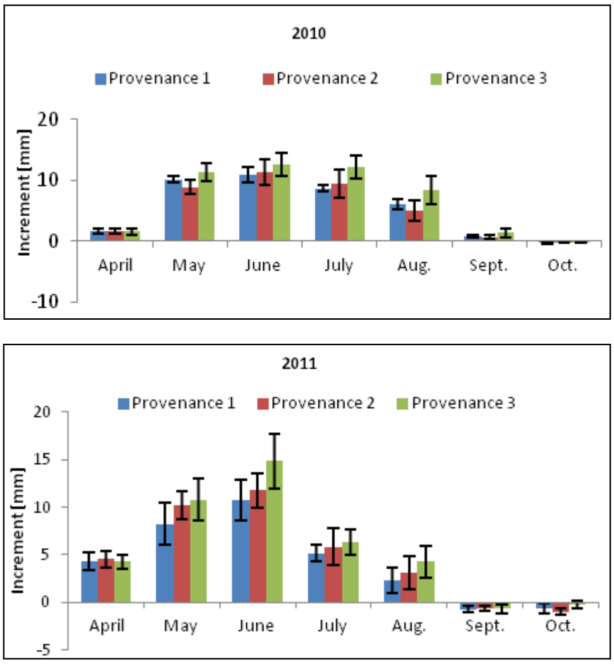

Figure 1*. Increment of three provenances of Norway spruce in growing seasons 2010 and 2011.*

Figure 2 and 3 we can see that the increment in year 2011 was more than 50 % smaller than in 2010. In both years incremental curves culminated in June. The highest values of increment of stem diameter were recorded in June (-2010 – 29 % and 2011 – 35 % of total increment in the same year – average of three provenances).

In terms of precipitation the year 2010 was wet and 2011 was dry (Figure 2). The beginning of growth in spring depends on air temperature whereas the end of growth is related to day-length, because independently of weather most trees stop their diameter growth at the end of August or at the beginning of September. Air temperature in April is of decisive importance for the beginning of growth, while air temperature in May influences the magnitude of increment. The influence of air temperature and precipitation in June is balanced, but in July and August the influence of air temperature is minimal (Leštianska, 2011).

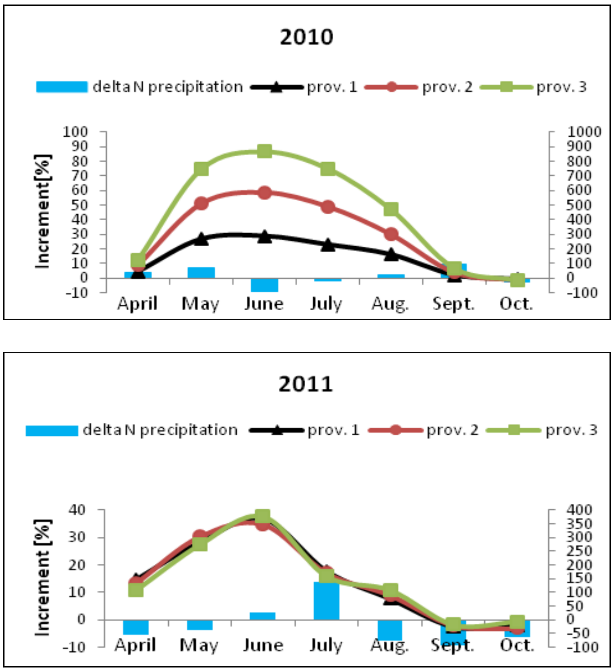

Figure 2. *Relative incremental curves of provenances of Norway spruce in growing seasons 2010 and 2011 compared with the deviations of precipitation totals from long-term average 1961–1990.*

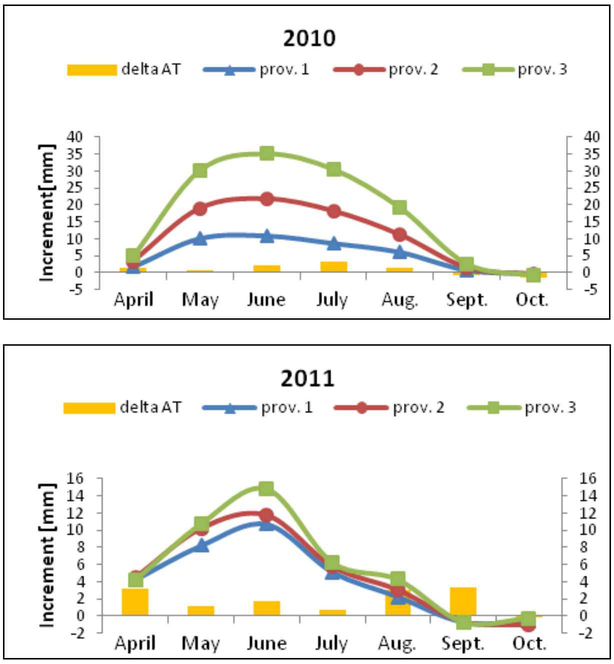

Figure 3. *Relative incremental curves of provenances of Norway spruce in growing seasons 2010 and 2011 compared with the deviations of air temperature from long-term average 1961–1990.*

Due to the lack of precipitation and above average air temperatures in June and July 2010 the decline of increment occurred. At the end of August and at the beginning of September the increment ceases as a consequence of the end of growing season. In the year 2011 negative influence of high air temperatures and deficit of precipitation was visible in all months, what was reflected in a smaller increment than in 2010 and in the cessation of the diameter growth already at the beginning of September. In contrast, in 2010 the diameter growth stopped only at the beginning of October. The analysis of the error bars did not reveal any statistically significant differences of stem diameter increments among the three compared provenances (Figure 1).

Conclusion

In conclusion, the third provenance seems to be the best growing provenance which can be used in the future, when considering - global warming.

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ESTIMATION OF AOT40 FROM PASSIVE SAMPLER MEASUREMENT OF OZONE CONCENTRATIONS

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Abstract. The study deals with estimation of AOT40 from passive sampler measurement of ground level ozone. The calculation of AOT40 is based on estimation of hourly ozone concentration. Estimation according Loibl et al. 1994 was adjusted by measurement of 37 EMEP Central European monitoring stations. Possibilities of using hourly ozone concentration estimated from passive sampler measurements for ozone flux calculation are discussed here.

Introduction

Ground ozone is considered 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.

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 necessary 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.

Material and methods

Study sites

Ozone monitoring was organized at ICP Forests intensive monitoring plots with different altitude, tree species composition and site conditions. The basic description of study plots is given in Table 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 weeks exposure interval in an open plot near monitoring plot. Ozone measurements at Hukavský grúň in 2009 were carried out only at the top of the meteorological tower, in 2010 and 2011 simultaneously at open plot and meteorological tower. At this plot, passive samplers were collocated with active ozone monitor as well (API 400, Thermo 49i). 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.

Estimation of AOT40

The estimation of AOT40 (Accummulated Exposure Over a Threshold of 40 ppb) is based on the estimation of hourly ozone concentration from passive sampler measurements. The two methods were used; i) according Loibl *et al*. (1994), where ozone concentration for relative altitude h_r (real altitude minus the lowest altitude within 5 km radius) was calculated following logarithmic function

$$O_3(h_r(x, y)) = a \ln ((h_r(x, y)/100) + b)$$

(parameters a and b were calculated for every hour according method described at Loibl *et al*. (1994)) and ii) adjusted logarithmic function calculated from 10 years of EMEP data (vegetation period) from continental Central Europe, where relative ozone concentration was calculated following function

$$O_{3rel}(h_r(x, y)) = a \ln (h_r(x, y) + b)$$

(parameters a and b were calculated for every hour of day from altitude-concentration relationship; not published yet).

Table 1. *Basic description of intensive monitoring plots with ozone measurements in 2009–2011.*

Intensive monitoring plot	Latitude	Longitude	Altitude [m a.s.l.]
Čifáre	48°12'45"	18°23'16"	225
Žibritov	48°23'22"	19°00'42"	520
Svetlice	49°11'4"	22°05'41"	570
Turová	48°37'58"	19°02'49"	575
Grónik II.	49°29'54"	18°34'04"	820
Poľana	48°38'34"	19°32'22"	850
Železnô	48°57'17"	19°23'20"	1010
Lomnistá dolina	48°55'31"	19°29'15"	1250

Results and discussion

Monitoring of ozone concentration was carried out during vegetation period; exposure interval for passive samplers was two weeks. Average ozone concentrations for vegetation period from 2009 to 2011 are given in Figure 1.

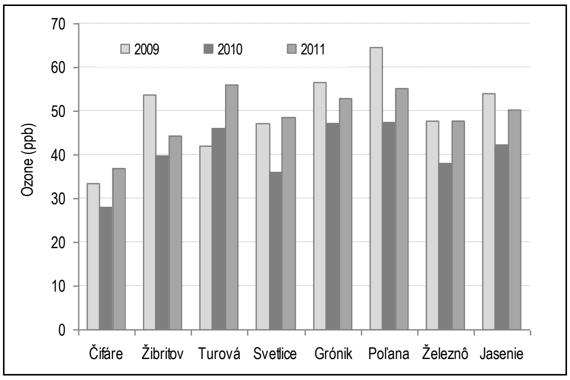

Figure 1. *Average ozone concentrations during vegetation period 2009–2011.*

Ozone concentrations during vegetation period showed typical seasonal pattern, usually with two maxima, for all plots. Average ozone concentrations during whole vegetation period at monitoring plots reached lowest values in 2010 and highest in 2009 and 2011. Ozone concentration during study period were partially altitude dependent, however, the correlation with altitude was weak.

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=0.68–0.87), however, values obtained from passive sampling were systematically overestimated.

The hourly ozone concentrations were estimated for all hours during vegetation season with average ozone concentration from passive sampling available. The performance of both logarithmic functions was tested at ozone data from continuous measurement at Poľana-Hukavský grúň for selected periods (e.g. Figure 2). The EMEP function fitted better then the Loibl function, values of AOT40 estimated from passive sampler measurement was higher than values simulated from ozone analyzer data for the same period.

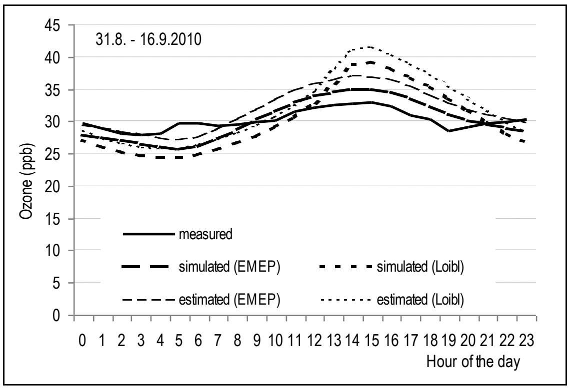

Figure 2. *Comparison of measured, simulated and estimated daily ozone course from period August 31, 2010 – September 16, 2010.*

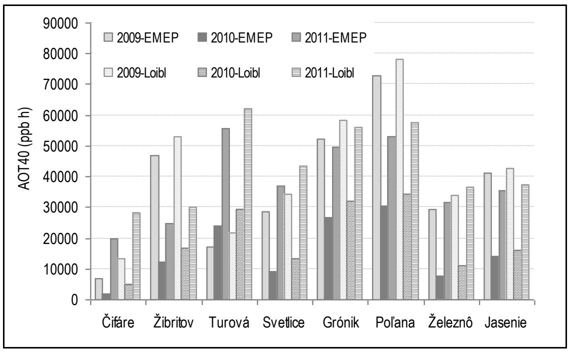

Figure 3. *AOT40 in 2009–2011 estimated from passive sampler measurements according methods of Loibl et al. (1994) and logarithmic function derived from EMEP data.*

AOT40 estimated from passive sampler measurement in ICP Forests intensive monitoring plots in Slovakia during years 2009–2011 reached values from 1734 to 72986 ppb h according to EMEP function and 5033 to 78239 ppb h according to Loibl function (Figure 3).

As for the ozone concentration data, the highes values of AOT40 occured in 2009 and 2011 and the lowest in 2010. The critical level of AOT40 set for forest protection 5000 ppb h was exceeded in all cases using both methods, except of locality Čifáre in 2010 (only EMEP function). Monitoring plots with the highest exceedance of CL (Turová, Grónik, Poľana and Jasenie) are the plots with occurence of visible ozone injury at the end of vegetation season (e.g. Pavlenda, Pajtík *et al*., 2010).

Comparing Loibl and EMEP logarithmic function in estimation of AOT40, the EMEP function performed better than the Loibl function. Both functions underestimated AOT40 values in lower relative altitudes and overestimated them in high altitudes; the EMEP function has higher underestimation in low altitudes and the Loibl function has considerably higher overestimation in high altitudes.

The estimation of hourly ozone concentrations from passive sampling with meteorological and site specific data available could be used for calculation of flux based critical levels for ozone as POD_Y (Phytotoxic ozone dose over a threshlod of Y nmol m^{-3} PLA s^{-1}), however it should be tested and simulated at more research sites. We still have to find a proper way how to consider overestimation of passive sampling data.

Conclusions

Monitoring of ambient ozone using passive sampling seems to be suitable method for spatial evaluation of ozone stress to forest ecosystems.

Hourly values of ozone concentrations estimated from passive samplers measurements can be used for calculation of ozone critical levels like AOT40 and POD_Y as well.

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MONITORING OF THE VARIABILITY OF SELECTED MICROCLIMATE FACTORS NEAR ECOTONES

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Abstract. This work is focused on the variability monitoring of the chosen microclimate factors in the ecotone's neighbourhoods. The main aim was to measure the air temperature, wind speed and air humidity in the eight demarcated transects which go through an ecotone. Ecotones are transitional zones between two or among more different ecosystems. In the case of this measurement, the ecotones create a boundary between a forest and grassland. The measurements were carried out in the ecotones nearby two municipalities: Kobylí and Ždánice, in Trkmanka's basin.

Introduction

At present time which enables the use of modern equipment for precise measurements of microclimatic factors it is possible to advance to the issue of quantifying the changes of microclimate which are caused by the presence of an ecotone. We can ask certain questions connected with this fact, for example: how does the wind speed change while passing through an ecotone? And what changes are apparent in temperature and humidity characteristics? Do the ratios change during the year? Does an ecotone resemble a forest community or a grass community in terms of microclimate? The term ecotone means a transition between two or more different communities (ecosystems). Ecotone communities usually comprise a number of species estimated for adjacent ecosystems and also species specific for the ecotones. The ecotones mostly have ecological, cultural and production purpose. The width of an ecotone is significant in terms of space attributes. An ecotone is commonly defined by a rather wide stretch with a characteristic gradient of ecological characteristics, i.e. a slow transition of one ecosystem into another. Another significant characteristic is the time variability of ecotone communities (Sklenička, 2003).

A microclimate may be defined as the climate of very small areas whose space limitations vary from 1 cm to 100 m. A microclimate is often most considerably formed by an active surface (bare land, water surface, forest, microreliefs, etc.).

Characterization of the area of interest

The area of interest is the basin of the Trkmanka which enters the Dyje as a left-hand side tributary. This area is in the south-east part of the Czech Republic in the South-Moravian region and on the borderline of the Hodonín, Břeclav and Vyškov districts; the largest part belongs to the Hodonín district. The area of the basin is approximately 380 km^2. According to Quitt (1971), most of the area belongs to warm climate; only a narrow stretch in the north of the basin overlaps with a moderately warm climate area. The main water current in the area of interest is the Trkmanka which springs north-west of Ždánice in the altitude of 300 m. The river flows approximately in the north-south direction and enters the Dyje south-west of Podivín in the altitude of 158 m. The river stretches on 42.3 km from the spring to the mouth of the river (Vlček, 1984). The most widespread soils in the area of interest are the loam soils which are created mainly on loess substrates in lowlands and downs (Kilianová, 2009). Four phytogeographic units occur in the studied area – meadows and alders, hornbeam groves, sub-xerophilic oak woods, oak woods and rocky forest-steppes (Vachek, 1997). Smaller model areas were further determined in the Trkmanka basin wherein ecotones were selected and transects were defined in which the microclimate characteristics were measured. These model areas were selected in such a manner so that they could represent the character of the landscape of the entire basin. The first model area is in the vicinity of Ždánice, the second area is in the vicinity of Kobylí. Three transects were delimited in the model area near Ždánice (T5, T6 and T8) and five transects in the model area near Kobylí (T1, T3, T4, T9 and T10). These transects cross perpendicularly the ecotone and penetrate the two following ecosystems. The length of the transects differs depending on the character (type) of the ecotone.

Figure 1. *The Trkmanka basin.*

Material and methods

Long-term microclimatic characteristics were processed to evaluate the Trkmanka basin. The data from weather stations, which are in the area of interest, namely in the Klobouky u Brna, Velké Pavlovice and Ždánice, were used. The work contains individually characterised temperature, precipitation, snowfall, humidity, pressure and airflow rates. Then the characteristics of solar radiation, sunshine and clouds follow.

The main part of the work dealt with measurements of selected microclimate factors and monitoring their changeability caused by the existence of an ecotone. The measurements were carried out in two selected model areas. Three or possibly four factors were selected to monitor the changeability of the microclimate; they are vital for the character of the microclimate. The Testo 410-2 and the similar 410-1 instruments were used to collect the data of the individual meteorological variables (microclimatic factors). The monitored meteorological variables were the wind speed, the temperature and the perceived temperature, and the relative humidity. The measurements were carried out in each transect once per month during one year. The measurements were accomplished in three stations simultaneously to assess the influence of an ecotone on the development of the monitored climatic characteristics. Each measurement in a station was accomplished in two different levels: 15 cm and 2 m above ground. The 15 cm measurement was carried out in order to ascertain the influence of ground vegetation on the monitored meteorological variables. Furthermore, measurements in two levels were carried out in 4 directions so that the airflow was caught from eight cardinal points. Each measurement took 2 minutes. The temperature, airflow and humidity data measured in the field were tested using the basic statistical analysis: the arithmetic mean, median, standard deviation, maximum and minimum values, and variation range which indicates the difference between the maximum and minimum were calculated. The measured data were visualised in synoptic tables and graphs. The data were then depicted in maps.

Results and discussion

It is apparent from the analysis of temperatures which compares average values achieved in the forest part of a transect, in an ecotone, and on permanent grassland that the top changeability is usually achieved on the days when radiation weather prevails and the solar radiation is intense. In the course of a year, most transects showed higher average temperature in stations with permanent grassland. And at least one winter measurement showed higher temperature in a forest. The temperatures in different parts of a transect were more balanced outside the growing season. In the monitoring, the airflow represented the most variable factor of a microclimate. The wind speed and direction were mainly influenced by the terrain configuration and the present vegetation, the forest and shrubby vegetation which retarded the wind speed or changed its direction. We can hypothesise on the basis of the carried out analysis which compared the wind speed in each part of a transect separately that in most cases the top speed was recorded in the part from which the wind blew. An ecotone role differed in dependence on whether the direction of the flow was obstructed by an obstacle (e.g. a tree or shrub). In those transects where the vegetation on the border of a forest was dense, the ecotone usually had the character of the 59 barrier. If the wind blew in the direction of a transect without shrubbery, the ecotone functioned as a through zone or a corridor in several cases. As concerns humidity of most transects, it can be concluded that higher relative humidity occurs in forests or near forests. The top relative humidity values were recorded in winter, the lowest values on a summer or sunny day. The course of relative humidity was significantly influenced by the course of temperature. On the basis of the 15 cm and 2 m measurements we can establish that the ground vegetation (the active surface) had a greater influence on the airflow speed where the higher values were usually recorded in 2 m above ground. On the other hand, higher temperature and relative humidity were mostly recorded in 15 cm above ground.

Conclusion

This work dealt with the changeability of temperature, airflow and humidity characteristics of a microclimate, which were monitored in the vicinity of ecotones. The measurements were carried out in 87 marked transects passing through an ecotone which were around the villages Ždánice and Kobylí. The monitored microclimate factors were measured using three manual Testo anemometers type 410-1 and 410-2 from April 2008 to April 2009. The acquired data were analysed statistically and visualised using graphs, tables and maps. The resultant character of an ecotone microclimate was ascertained mostly on the basis of its type and the involvement of vegetation. Hypothetically, the ecotones whose centre (the centre of a transect) was on the border of a forest, under the marginal trees or behind a dense shrubbery are the ecotones which resemble forests because of their microclimate (Machar, Pechanec, 2011). On the other hand, an ecotone resembled permanent grassland in the case where the centre of the ecotone was in a wide shadow-free shrubbery bordering a forest.

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AIR TEMPERATURE AND HUMIDITY IN VERTICAL PROFILE OF WINTER RAPE STAND

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Abstract. Temperature and relative air humidity was monitored in rape canopy in Žabčice during the main growth season in 2010 and 2011. Automatic sensors were positioned at three levels (on the ground, at the effective height and at 2 meters above the ground) in order to cover the whole vertical profile. Temperature and air humidity in vertical profile of canopy differed significantly in dependence on year, rape developmental stage and time of day. The differences in vertical stratification of air humidity were pronounced especially during the light part of the day. In this time the temperature was lower and humidity significantly higher in ground part of rape canopy.

Introduction

The plant diseases are result of interrelationships between host plant, pathogen and environment, especially weather conditions and soil. The appropriate temperature and humidity are inevitable for development of several pathogens stages. E.g., important pathogen, *Sclerotinia sclerotiorum,* which causes *Sclerotinia* stem rot of rape, develops sexual ascospores in fruiting bodies apothecia which are formed on firm bodies of fungi mycelium, called sclerocia. Carpogenic germination of sclerocia (apothecia formation) occurs from 10 to 25 °C with optimum 20 °C. The high air or soil humidity is necessary for this process, also (Clarkson *et al*., 2007; Mila et Yang, 2008; Foster *et al*., 2011). The ascospore dispersal is influenced by changing of temperatures and air humidity during the day (Qandah et del Rio Mendoza, 2011). The optimal conditions of rape stems infection by these ascospores are from 16 to 22 °C (Koch *et al*., 2007). The range of these parameters is used for prediction models of pathogen occurrence. The data from climatological stations measured in 2m are usually used in these models.

A significant amount of heat and water vapor enters the atmosphere as a result of the process of substance and energy exchange between the active surface and the lowest layers of atmosphere. As a result, a change of air temperature and humidity inside a canopy and immediately above it occurs. The correlation between microclimate measuring at climatological stations and canopies microclimate measuring strongly depends on the canopy structure as well as on the height at which the measurement sensors are positioned (Chelle *et al*., 2009). The microclimate can differ in dependence on development stage of plant stands. For these reason it is necessary to know the course of air temperature and humidity in winter rape stand during stages important for infection by fungi pathogens.

Material and methods

Experimental site, plant stand

The microclimatic data were obtained at the field trial station of the Mendel university in Brno in Žabčice municipality (GPS - Loc: 49°1'18.658"N, 16°36'56.003"E) in the canopy of winter rape cv. Petrol.

Air temperature and humidity measurement

Data recording for each crop was conducted by means of a mobile meteo station equipped by digital temperature sensors (Dallas semiconductor, DS18B20 type) and air humidity sensors (analog sensor Honeywell HIH 4000) placed in the screen. The recorders were positioned at three levels (on the ground, at the effective height and at 2 meters above the ground) in order to cover the whole vertical profile. Sensors positioned at the effective height were moved up as the crop was growing. The effective canopy height is the height corresponding to approximately 70 % of the actual canopy height.

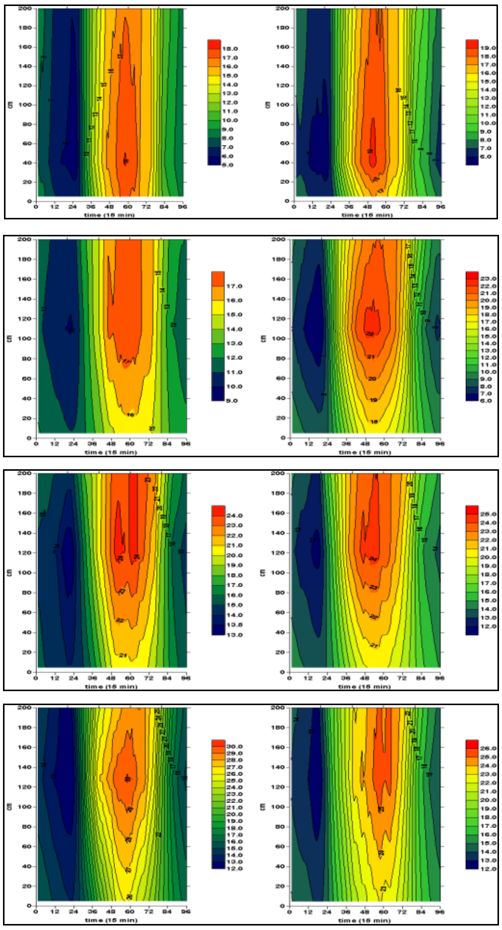
Data analysis

The spring vegetation period of winter rape was divided in four stages: I - from spring regeneration to inflorescence emergence; II – flowering; III – development of fruits; IV – ripening. Values from the above the ground vertical profiles were evaluated by the method of triangulation with linear interpolation and graphically displayed in the form of temperature isotherms and humidity isolines' (isohumids) by the Surfer ver. 8.03 (Golden Software, Inc.) program.

Results and discussion

The highest temperatures were recorded in rape effective height during the light part of the day, usually. The air temperature in this level was by 1 to 2°C higher in all rape developmental stages in comparison with temperature measured 2m above the ground. On the contrary, temperature was by 1 to 2 °C lower in this level during the dark part of day. The air temperature between ground level and 2m differed significantly in dependence on year, rape developmental stage and part of the day. There were not recorded differences between the ground level and 2m during the dark part of day. As for the light part of day, temperatures in the ground level were lower by 1 to 2 °C from spring regeneration to inflorescence emergence (Figure 1a, b). The differences were 2 °C in the cold period of 2010 and 5 °C in warm period in 2011 during the stage of flowering (Figure 1c,d). Similar differences were recorded also in the development of fruits (Figure 1e,f) and ripening (Figure 1g,h) stages. Air humidity in vertical profile of canopy differed significantly in dependence on year, rape developmental stage and time of day, also. The differences in vertical stratification of air humidity were pronounced especially during the light part of the day. There were no differences stage from spring regeneration to inflorescence emergence during the wet period of 2010, but air humidity was higher by 16 % in the ground level in comparison with

2m in dry period in 2011 (Figure 2a,b). During the flowering the differences by 18 and 36 % were recorded in 2010 and 2011 (Figure 2c,d), respectively. The air humidity was by 20 % higher in the ground level in 2010 and by 28 % in 2011 in the stage of development of fruits (Figure 2e,f). During the last stage (ripening) these differences reached 16 and 14 % (Figure 2g, h).



a - 2010
b - 2011

c - 2010
d - 2011

e - 2010
,f - 2011

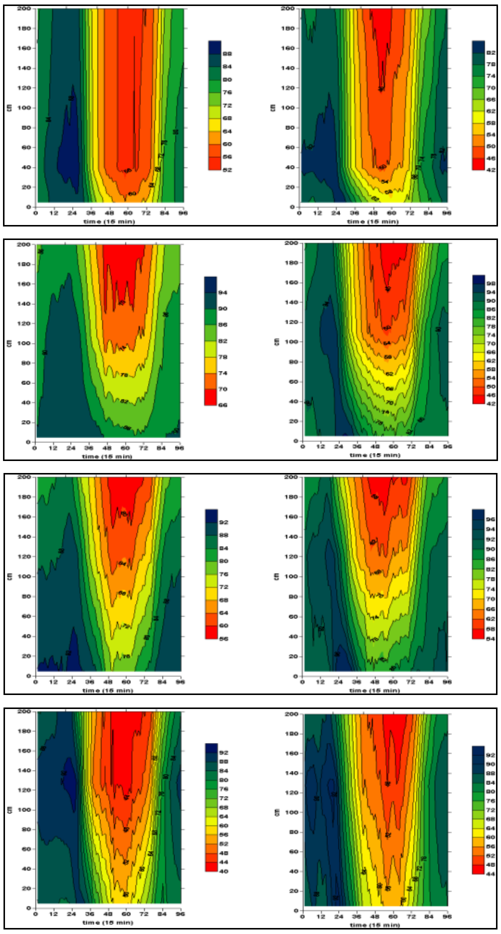
g – 2010
h - 2011

Figure 1. *Mean values of air temperature in vertical profile of winter rape stand: stage I. – a. b; stage II. – c, d; stage III. – e, f; stage IV – g, h.*

The knowledge of microclimate in different crops can be very useful for making more accurate prediction models of pathogens and pest occurrence in crop stand. Jurke and Fernando (2006) found out, that with an increase of seeding rate the incidence of sclerotinia stem rot caused by pathogen *Sclerotinia sclerotiorum* was significantly increased. They suppose it was because of changes in rape microclimate in dense stands. Plants are infected by particular pathogen species in particular developmental stages. E.g. flowering developmental stage is crucial for rape infection by above mentioned pathogen (Koch *et al*., 2007). We have recorded, that during this stage the air temperature and humidity can differ very significantly.

Conclusions

The air temperatures and humidity differed significantly in vertical profile of winter rape stand during spring vegetation periods. These differences were dependent on the year, rape developmental stage and time of day. These findings can be used in making more accurate prediction models of pathogens and pest occurrence on winter rape.



a - 2010
b - 2011

c - 2010
d - 2011

e - 2010
,f - 2011

g – 2010
h - 2011

Figure 2. *Mean values of air humidity in vertical profile of winter rape stand: stage I. – a. b; stage II. – c, d; stage III. – e, f; stage IV – g, h.*

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WHAT ARE THE PROJECTED TRENDS OF PRECIPITATION-RELATED AGROCLIMATOLOGICAL INDICES IN CENTRAL/EASTERN EUROPE USING BIAS-CORRECTED ENSEMBLES-SIMULATIONS?

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Abstract. In addition to the evaluation of projected precipitation changes in six Central/Eastern European countries (i.e., Austria, Czech Republic, Hungary, Romania, Slovakia, Slovenia), bias corrected precipitation outputs of regional climate models were used to calculate climate index time series for 1951–2100. The entire study includes the number of wet days using several threshold values defining extremes, the maximum number of consecutive dry days, the highest 1-day precipitation amount, the greatest 5-day rainfall total, etc.

Introduction

In order to build regional adaptation and mitigation strategies, global climate model (GCM) simulation results must be downscaled for local analysis, which can better serve agriculture-related end-users' needs. This is especially important in case of precipitation due to the large temporal and spatial variability. Furthermore, both the high potential risks of drought events on agricultural production, and the possible flood events sometimes resulting in inland water covered areas for longer or shorter periods, also highlight the importance of this issue.

Recently, the most often used technique for downscaling GCM outputs involves regional climate model (RCM) experiments driven by a GCM. For Europe, in the frame of project ENSEMBLES several RCM runs were accomplished for the period 1951–2100 (Van der Linden and Mitchell, 2009). All the RCM experiments used 25 km horizontal resolution, and considered the SRES A1B scenario (Nakicenovic and Swart, 2000) for the future. According to this scenario the total world population is estimated to increase to 9 billion by 2050, and then, during the second part of the 21st century it is projected to decrease, the estimated total population by 2100 is 7 billion again. The scenario contains a balance use between the different energy sources (nuclear, renewable, fossil fuel), and it provides a mid-line scenario for carbon dioxide. The estimated CO_2 level is 532 ppm and 717 ppm for 2050 and 2100, respectively.

Material and methods

In the present analysis, monthly precipitation sums calculated from 1951–2100 RCM simulation outputs of the ENSEMBLES project was used. The selected 11 RCMs, their driving GCMs (which provide initial and lateral boundary conditions for the regional scale models), and the institutes accomplished the 150 year long RCM experiment are summarized in Table 1. From the RCM output database covering the entire European continent, our selected domain contains 150-year-long precipitation data sets from the region between 43-51° N latitude and 9-30° E longitude. In our analysis, the selected countries are represented by the gridpoints within their borders, thus Austria contains 160 gridpoints, the Czech Republic 162, Hungary 227, Romania 422, Slovakia 103, and Slovenia 41.

Table 1. *List of selected RCMs, their driving GCMs, and the responsible institute.*

RCM	Driving GCM	Institute
HadRM3Q0	HadCM3Q	HC, UK
RCA3	HadCM3Q	C4I, Ireland
CLM	HadCM3Q	ETHZ, Switzerland
RCA	HadCM3Q	SMHI, Sweden
RCA	ECHAM5	SMHI, Sweden
RACMO	ECHAM5	KNMI, Netherlands
REMO	ECHAM5	MPI, Germany
RegCM	ECHAM5	ICTP, Italy
HIRHAM5	ECHAM5	DMI, Denmark
HIRHAM	ARPEGE	DMI, Denmark
ALADIN	ARPEGE	CNRM, France

In order to estimate the bias of the different RCM simulations, outputs from 1951–2000 were compared to the E-OBS datasets (Haylock *et al*., 2008) containing gridded daily precipitation values. The validation results suggest that the simulated values usually significantly overestimate the observations, except in summer when mostly underestimations were found (Pongracz *et al*., 2011). These biases of the raw RCM outputs are corrected using the monthly empirical distribution functions (Formayer and Haas, 2009). Then, time series of precipitation-related climate index (e.g., the number of wet days using several threshold values defining extremes, the maximum number of consecutive dry days – CDD, the highest 1-day precipitation amount – RX1, the greatest 5-day rainfall total – RX5, etc.) are calculated from the corrected precipitation data sets for each grid point. Projected seasonal changes by 2021–2050 and 2071–2100 are determined relative to the 1961–1990 reference period. In this paper, due to page limits only one of them is shown, and only for Hungary.

Results and discussion

For the evaluation of seasonal changes, the 30-year-long average amounts calculated for the RCM-runs of the reference (1961–1990) and the future periods (2021–2050, 2071–2100) are compared for all the gridpoints within the selected domain. For each RCM, the four seasonal precipitation changes are determined, and then, weighted composite mean values are calculated for each season. The applied weighting factors depend on the total numbers of ensemble members driven by the same GCM. Thus, in case of the RCM experiments driven by HadCM3Q, ECHAM5, and ARPEGE, the weighting factor is 1/12, 1/15, and 1/6, respectively (since these GCMs provide initial and lateral boundary conditions for 4, 5, and 2 RCM experiments). Figure 1 shows the seasonal spatial structure of composite projected precipitation change by 2071–2100 for the largest regional increase (in winter) and decrease (in summer). On the base of the composite maps, the estimated changes for the late-century are larger than for the mid-century.

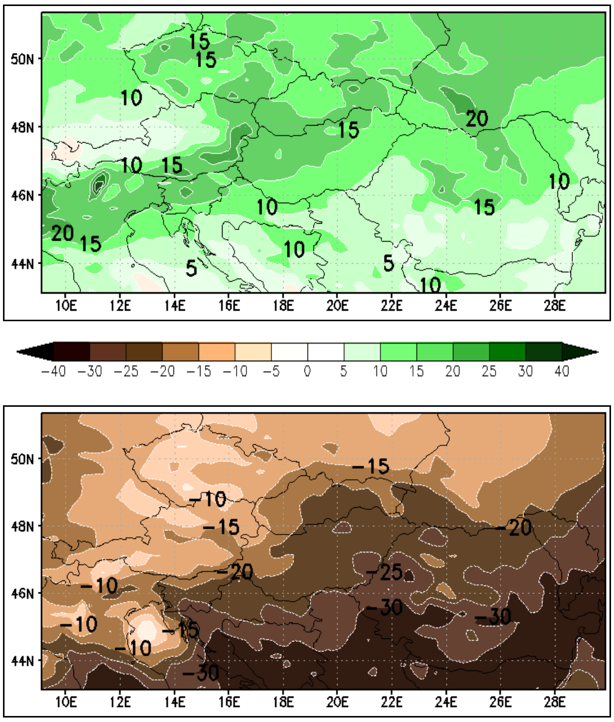

Figure 1. *Composite maps of the weighted projected winter (top) and summer (bottom) mean precipitation change (%) by 2071–2100 relative to the 1961–1990 reference period.*

In most of the southern regions, the projected summer changes by 2071–2100 exceed 20 % (including Slovenia, Hungary and Romania). The largest precipitation decrease (by 20–40 %) in summer is estimated in case of Romania; consequently, summer drought is especially likely to hit this country. In case of winter precipitation the estimated increase by the last three decades of the 21st century exceeds 20 % in Slovenia, southern Austria, northwestern part of Hungary, moreover, in several regions of the Czech Republic, Slovakia, and northern Romania.

Trend analysis of consecutive dry days (CDD) provides useful information for agriculture on the critical dry periods. Annual and seasonal CDD index values are defined as the longest period in a year or a given season with daily precipitation less than 1 mm. For the selected target region, composite maps of projected seasonal change in CDD are generated using the bias corrected RCM outputs for the periods of 1961–1990 (as the reference period), 2021–2050, and 2071–2100. Here, results of seasonal CDD trend analysis for Hungary are shown in Figure 2. The largest change by 2071–2100 is projected for summer: 9 simulations out of 11 RCM experiments project significant increase of CDD in Hungary, the projected change is 25–75 % relative to the 1961–1990 reference period. The projected increase is larger in the southern part of the country than the northern regions.

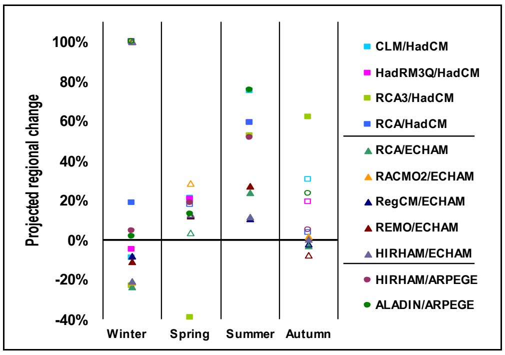

Figure 2. *Projected seasonal change in CDD by 2071–2100 calculated for Hungary, reference period: 1961–1990.*

Conclusions

Projected precipitation changes for Austria, Czech Republic, Hungary, Romania, Slovakia, and Slovenia were analyzed for the 21st century using several RCM simulation outputs available from the ENSEMBLES database. Our results can be summarized as follows: (1) Future summers in the region are projected to become drier compared to the past few decades. The opposite is estimated for winters. (2) The largest summer precipitation decrease by 2071–2100 is projected for Romania, which is likely to exceed 20–40 %. (3) Consecutive dry periods are likely to lengthen in the future, especially in summer.

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ANALYSIS AND COMPARISON OF THE URBAN HEAT ISLAND EFFECT USING REMOTELY SENSED AND IN-SITU OBSERVATIONS

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Abstract. Urban heat island (UHI) is defined as the positive temperature anomaly occurring between built-in areas and their surroundings. For detailed analysis of UHI in a particular area, different approaches can be used. Here, two different techniques (using remotely sensed and in-situ observations) are applied to the Budapest agglomeration area and the results are compared. Monthly, seasonal, and annual mean temperature values are calculated and analyzed for 2001–2010.

Introduction

Human settlements, especially, the large urban agglomerations significantly modify the environment. For instance, atmospheric composition is highly affected mainly due to industrial activity and road traffic. Urban smog events are common characteristics of large, populated cities. Furthermore, artificial covers and their emitted energy substantially modify the energy budget of urban regions (Landsberg, 1985), and hence, local climatic conditions. As a result, urban heat island (UHI) effect occurs, which is the positive temperature anomaly detected between built-in areas and their surroundings (Oke, 1982). Several possible methods are used to measure temperature from which UHI intensity can be calculated. The often applied method is to observe air temperature at fixed weather stations or by sensors mounted on a moving vehicle. Another possibility is to use remotely sensed technique (Pongrácz *et al*., 2006), e.g., a multispectral radiation sensor called MODIS (Moderate Resolution Imaging Spectroradiometer). Seven infrared channels of MODIS (Barnes *et al*., 1998) can be applied to calculate surface temperature (Wan and Snyder, 1999). The purpose of this study is to compare temperature values observed by ground-based and satellite-based instruments between 2001 and 2010.

Material and methods

In the current analysis we used temperature datasets (i) measured in six weather stations operated by the Hungarian Meteorological Service (HMS) in Budapest and its vicinity (Table 1); and (ii) calculated from MODIS radiation measurements (NASA, 1999). HMS stations 2 and 3 are located in the downtown of Budapest, stations 1 and 4 can be found in the suburbs. Stations 5 and 6 are both in the rural region around Budapest, to the northeast and to the southeast from the city, respectively. Air temperature observations from the standard 2 meter height are available from 2001. At the weather stations real-time automated sensors are operated, which record the meteorological parameters at every hour. However, the relatively small number of available weather stations in and around Budapest is not suitable for detailed analysis of UHI spatial analysis; moreover, the future installation of further weather stations in the region is not realistic due to the high costs.

Table 1. *Geographical coordinates and elevation above the sea level for the selected weather stations used in this paper.*

Station number/ Name	Latitude (°N)	Longitude (°E)	Altitude (m)
1/ Ujpest	47.57	19.07	100
2/ Kitaibel Pal st.	47.51	19.03	120
3/ Lagymanyos	47.48	19.06	105
4/ Pestszentlorinc	47.43	19.18	130
5/ Penc	47.79	19.28	240
6/ Kakucs	47.25	19.36	120

The remotely sensed MODIS data are available from satellites Terra and Aqua starting in 2001 and 2003, respectively. Both satellites are on polar orbit (at about 700 km height) as part of the NASA’s Earth Observing System. The surface temperature is calculated using seven infrared channel radiation with 1 km^2 spatial resolution. Although Terra provides two images per day (at around 09-10 UTC and 20-21 UTC), as well, as Aqua (at around 02-03 UTC and 12-13 UTC), only those measurements can be used for urban studies when the surface radiation is observed (i.e., in case of clear conditions without clouds). The nearest MODIS grid point to each weather station is selected for the comparison. In case of the satellite-measured data pixels are classified as urban or rural using the MODIS Land Cover Product categories (Strahler *et al*., 1999), satellite images of the Google Earth, distance from the city centre, and the GTOPO30 global digital elevation model (USGS, 1996). Urban pixels are defined as the built-in area within the city border, excluding the areas where the GTOPO30-based elevation is 50 m higher or lower than the mean elevation of Budapest. Rural pixels can be found around the urban pixels, excluding the built-in and water regions and the pixels exceeding 100 m difference from the mean elevation of the city (Dezső *et al*., 2005). The averages of the surface temperature values in urban and rural pixels are defined as urban mean, and rural mean, respectively. Detailed analysis of these average time series can be found in Pongrácz *et al*. (2010).

Results and discussion

First, ground-based air temperature and satellite-based surface temperature time series are compared for every station. Figure 1 illustrates the results of the frequency distribution of temperature differences for station 3 (Lágymányos) for winter and summer. The average night-time difference is the largest in winter and spring (-1.7 °C and -1.8 °C, respectively), and the smallest in summer (-1.1 °C). During day-time, the largest average difference occurred in summer (6.6 °C), and the smallest in winter (1.1 °C). The difference between the day-time and night-time temperature differences is the largest in spring and summer (exceeding 7.5 °C) when the incoming solar radiation is also larger than in the other seasons. The seasonal distributions clearly show that the day-time surface temperature is generally larger than the air temperature (especially, in summer and spring), and the night-time surface temperature is smaller than the air temperature. This can be explained by the radiation transfer, namely, both day-time warming and night-time cooling of the boundary layer of the atmosphere proceeds from the surface.

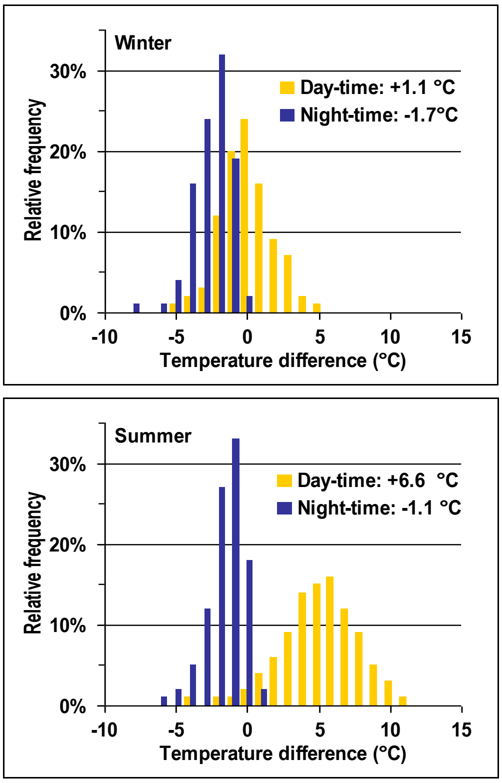

Figure 1. *Seasonal relative frequency of the difference between satellite-based and ground-based temperature values at Lágymányos. The average temperature difference values are indicated in the legends.*

The average satellite-based temperature of Kakucs and Penc can be considered as an appropriate, good estimate for the rural mean temperature (T_{rural}), the correlation coefficient of the remotely sensed time series anomalies is 0.995, and the average monthly difference is less than 0.4 °C. Hence, UHI intensity can be defined as the difference between the average temperature of the four weather stations of Budapest and the average temperature of the two rural weather stations (i.e., T_{rural}). The day-time UHI intensity is between 0 °C and 2 °C when using the ground-based temperature values, the average for 2001–2010 is 0.6 °C. The largest intensities occurred in winter and summer.

When using the satellite-based measurements, the variability of the day-time monthly UHI intensity is larger, in summer the UHI intensity exceeded 3–4 °C, whereas the average throughout the whole studied period is 1.6 °C. The smallest UHI intensity occurred in spring and autumn. During night-time the UHI intensity values determined using the satellite-based or the ground-based temperature observations differ much less than during day-time. The correlation coefficients of the intensity time series are 0.7 and 0.5 for night-time and for day-time, respectively. The average UHI intensities throughout the whole 2001–2010 period are 3.2 °C based on the satellite-based surface temperature, and 3.4 °C, based on the ground-based air temperature. This means that in general the UHI intensity is slightly weaker when using the satellite-based observations than the ground-based measurements.

Conclusions

Satellite-based and ground-based temperature observations (2001–2010) were compared here for the Budapest agglomeration area. The results can be summarized as follows. (1) Satellite-based surface temperature is higher (lower) than ground-based air temperature during day-time (night-time), which is due to the fact that both day-time warming and night-time cooling of the boundary layer of the atmosphere proceeds from the surface. (2) The difference between the satellite-based and the ground-based temperature values are the largest in summer and spring. (3) The largest variability of the UHI intensity can be identified in case of day-time satellite-based surface temperature.

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EFFECT OF MOISTURE CONDITIONS AT VARIOUS LAGS ON FOREST GROWTH IN THE MOST BASIN COAL FOREST RECLAMATION AREAS IN THE CZECH REPUBLIC

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Abstract. This study evaluated the effect of moisture conditions at various lags on the nine tree species (*Robinia pseudoacacia, Pinus strobus, Betula pendula, Quercus rubra, Quercus robur, Fraxinus excelsior, Tilia cordata, Larix decidua* and *Juglans nigra*) dominated in the Most Basin coal forest reclamation areas located in the driest areas of the Czech Republic. The standardized precipitation evapotranspiration index (SPEI) was used to quantify the moisture conditions for each month of the year and 24 accumulated lags during the period 1961–2010. To enhance and extract the climate signal in the tree-ring data, standardization was performed. The response of tree growth to drought largest varied among species, being the maximum growth-drought correlation strong for *J. nigra*, *B. pendula* and *Q. rubra* (r=0.8), medium for *Q. robur* and *R. pseudoacacia* (r=0.6) and weak *L. decidua* (r=0.3). The minimum association between growth and drought was detected for *T. cordata*.

Introduction

In a region where the growth of forests is water-limited, variation in moisture conditions can be markedly influence forest changes. Thus, Breshears *et al*. (2005) and Adams *et al*. (2009) were introduced a new concept of "global-change-type drought" to describe droughts related to precipitation shortages and warmer conditions. Adams *et al*. (2009) separated the effect of temperature from other climate variables and biotic agents and showed that the effect of warmer temperature in conjunction with drought can be substantial. They established that with warmer temperatures, droughts of shorter duration, which occur more frequently, would be sufficient to cause a widespread die-off in *Pinus edulis*. Generally, there are lacks of studies analyzing the response of radial tree growth to various time scales of moisture conditions (wet/dry). The majority scientific research in forestry reclamations deal only with the importance of ameliorating for individual species, their initial survival rate of seedlings and/or the impact of various measures on their well-being. The primary criterion for selection of tree species assortment of reclamation was the resistance in the first year after planting. Further, for afforestation tree species priorities were used a large ecological spectrum and also takes into account the tolerance to high air pollution load. However, the very little information can be found in the literature regarding to long-term development and growth dynamics of individual species in these habitats. Thereby, in this study was investigated the response of tree growth to different lags of drought, quantified by means of the SPEI, in the Most Basin coal forest reclamation areas in the north-western of the Czech Republic. This approach could improve the knowledge of the long-term responses of tree growth to water availability better than using precipitation data itself.

Material and methods

This study integrated the long-term experimental dendrochronological data and monthly meteorological dataset recorded in the network of the Czech Hydrometeorological Institute. It was selected the oldest forestry reclaimed area in the Most Basin, to evaluate the growth dynamics of individual species in the four dump sites. For each tree species, the mean annual incremental curve was computed and detrended (standardized) using quadratic regression function with the aim to remove non-climatic signals. The SPEI was used to quantify the moisture conditions for each month of the year and 24 accumulated lags during the period 1961–2010. The steps followed for the SPEI calculation were: i) the parameterization of potential evapotranspiration (*PET*) based on monthly minimum (*Tmin*) and maximum air temperature (*Tmax*) and extraterrestrial radiation; ii) a simple monthly water balance, calculated as the difference between monthly precipitation (*P*) and potential evapotranspiration (*PET*) and iii) normalisation of the water balance into a log-logistic probability distribution to obtain the SPEI series from Kopisty station located in study area (Figure 1). Effect of drought on dynamics of growth was determined on standardized anomalies of annual increment series of nine tree species. Since we cannot know in advance the growth responses to drought at various lags, the SPEI series at timescales between 1 to 24 months was correlated with the standardized increment of trees (SIT) series (Figure 2). A negative drought effect on dynamics of trees growth was detected when the SIT values was ≤-1. While a drought episode was defined as a period longer or equal to 1 month when the SPEI value was ≤ -1.

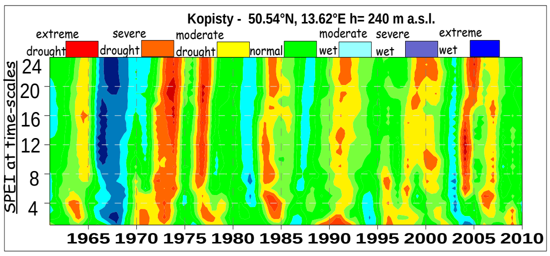

Figure 1. *Temporal evolution of SPEI at time scales from 1 to 24 months for the period 1961–2010.*

Results and discussion

Summarized our results, we can state that a stressed tree may take a year (12 month lag) or two (24 month lag) recover from a drought period, this problem can be dealt with more complex modeling and/or e.g. the SPEI at different lags.

We found delayed response of trees growth to drought. The negative effect of extreme drought of 2003 on the increment of trees for the majority of species appeared to the next year.

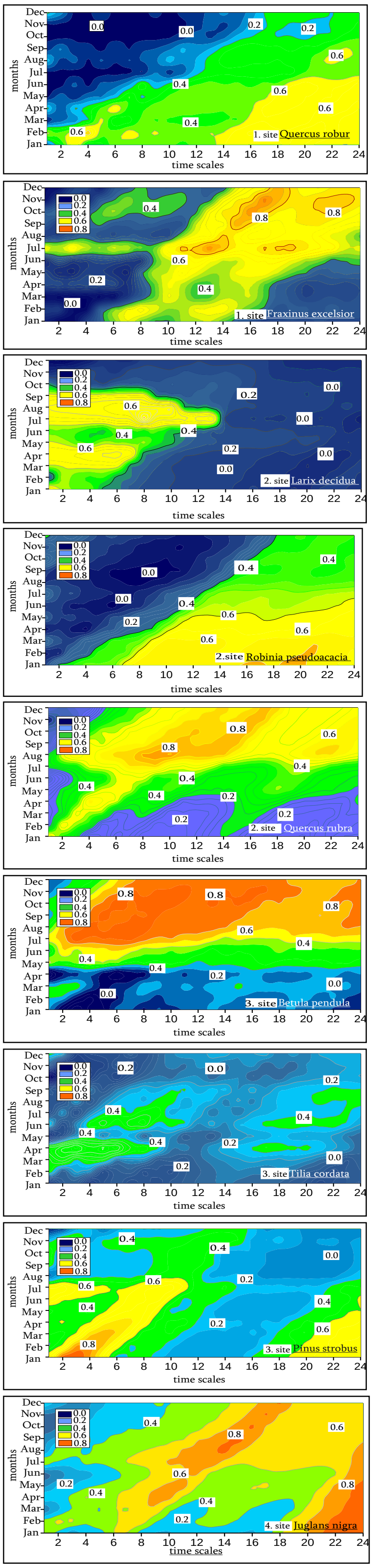

Figure 2. Mean correlation coefficients between monthly SPEI series at 1 to 24 month lag and annual SIT of dominants species growing in four sites: 1- Šmeral; 2- Čepirohy-Bylany; 3- Větrák; 4- Užin.

To summarize the correlation analyses and compare to drought effect among species, we found differences in the responses of tree growth to different lags of the SPEI (Figure 2). Tree species growing in coal forest reclamation areas showed relative high relationship (r>0.66) with SPEI≤-1 drought series at longer time scales, which it shows that cumulative water deficit during one year affect tree growth. Nevertheless, for *L. decidua* significant correlations only appeared in April-May and July-October (*r*=0.3-0.6) at short- to mid-term droughts, the period when growth rates are usually maximum and when water deficit in dry years is markedly (Figure 2). High correlation were found between the SPEI and the SIT of *J. nigra*, *B. pendula* and *Q. rubra* (maximum *r*=0.8), while for *T. cordata* did not show significant correlation (less than 0.4). A moderate growth response (*r*=0.6) to drought was obtained for *Q. robur* and *R. pseudoacacia* since they showed significant correlation at lags up to 14 month, mostly during early-spring months. High level dependence of water availability of *P. strobus* was only reported in short time scales.

Conclusions

High growth-SPEI correlation can be explained as follows: (i) forest reclamation area is situated in the driest region; (ii) due to unfavourable properties of soil substrate (with low water holding capacity) leads to shallower rooting near all trees and (iii) unavailability of groundwater level for the active part of the root system.

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TEMPORAL EVOLUTION OF DRY AND WET CONDITIONS IN THE CZECH REPUBLIC DURING THE GROWING SEASON

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Abstract. In the present study, the Standardized Precipitation Evapotranspiration Index (SPEI) was adopted to assess temporal evolution of wet and dry months during growing season (April to September) in the Czech Republic based on a dense network of 184 climatological stations for the period 1961–2010. The SPEI were calculated with various lags, 1, 3, 6, 12 and 24 months because the drought at these time scales is relevant for agricultural, hydrological and socio-economic impact, respectively. To assess the temporal evolution of dry and wet conditions during the growing season, first, the monthly time series of the SPEI for the months April to September were averaged at each station for each SPEI accumulation period (1, 3, 6, 12 and 24 months, respectively). Then, these SPEI time series were averaged over all 184 stations to get a time series of drought index at country level. The temporal evolution of the SPEI with one month lag represents the year by year moisture characteristic of the current growing season. In this respect, at country level, during the second half of the 20th century and the first decade of 21st century, the hierarchy of the driest years during the growing season was 2003, followed by 1992, 2000, 1983, 1982, 1976, 2009 and 1999. On the other hand, the wettest years during the growing seasons were 1965, 2010, 1977, 1996, 1966, 2001, 1972, 1980 and 1995.

Introduction

The consequences of climate changes for the modern agriculture will depend on three main factors. First is the nature of climate change itself. The second key factor is the response of cropping systems to changes in climate and atmospheric constituents. The third factor will be the response of the agriculture to changes in cropping systems throughout the word (Lobell and Burke, 2008). Patterns of rainfall distribution across a target region as well as between seasons are unpredictable and their variance is expected to increase as climate changes. At global scales, the recent drought study of Dai (2011) suggested that the increasing drying trends over many land areas are mainly due to the increasing temperature (via evapotranspiration processes) since middle 1980s. Also, global warming leads to increased risk of heat waves in association with drought; because once the soil moisture is depleted, all of the heating goes toward raising temperatures and wilting plants. At the European scale during the last two decades, droughts, floods, frosts and heat waves in the central Europe have increased public awareness on the severity of extreme meteorological events and their environmental and social-economic impacts. At the country scale, over the last two decades, extreme meteorological events have been the greatest threat for farmers cultivating field crops in the lowland regions of the Czech Republic. The present study aims at the analysis of the temporal evolution of the SPEI at various time scales during growing season over the Czech Republic.

Material and methods

For calculation the SPEI, the algorithm developed by Vicente-Serrano *et al*. (2010) was used. We used the documentation and executable files which are freely available at http://digital.csic.es/handle/10261/10002. A batch script was created and used for optimizing the calculation of the SPEI for the 184 stations and five accumulated periods: 1, 3, 6, 12 and 24 months. The selected stations represent different climate conditions in both lowland and highland regions and reflect differences between the maritime and continental weather regimes which manifest across the Czech Republic (Figure 1).

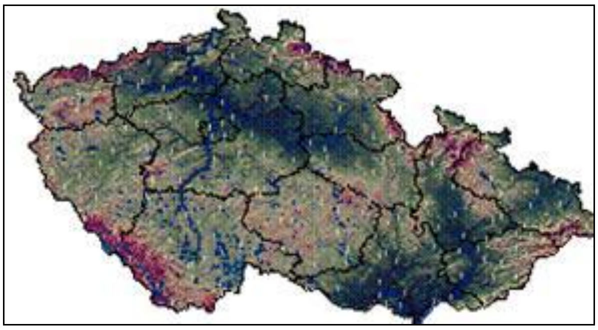

Figure 1. *Location of stations used for the calculation of the SPEI drought index in the Czech Republic.*

The SPEI was calculated based on observed monthly data of mean temperature and precipitation totals for the period 1961–2010. Monthly series of temperature and precipitation were selected from the Czech Hydrometeorological Institute CLIDATA database. The SPEI was calculated for each month of the year but for this study only the months of the growing season (April to September) were selected for analysis (Potop *et al*., 2012). A drought episode was defined as a period longer or equal to 1 month during the growing season (April to September) when the SPEI value was ≤ -1. The monthly SPEI values > -0.99 or < 0.99 were considered as normal conditions. Drought categories according to the SPEI are presented in Table 1.

The characteristics of drought were analyzed in terms of temporal evolution of the SPEI and duration of drought at country level. The following analysis were carried out to assess the drought characteristics over the Czech Republic: (i) Numerical values of the SPEI at five accumulated periods (1, 3, 6, 12 and 24 months) calculated for each station, which then allowed to evaluate the drought conditions for entire territory of the Czech Republic. (ii) Averaged number of drought episodes during growing season at various lags for two SPEI series: (1) at each station and (2) at the entire country territory. (iii) Averaged number of drought episodes counted during the growing season at various SPEI time scales at country level.

Table 1. *The 7 classes of SPEI category according to its value.*

SPEI	Drought category	Probability
≥ 2.0	Extreme wet	0.02
1.50 – 1.99	Severe wet	0.06
1.49 - 1.00	Moderate wet	0.10
0.99 - -0.99	Normal	0.65
-1.00 – -1.49	Moderate drought	0.10
-1.50 - -1.99	Severe drought	0.05
≤ -2.00	Extreme drought	0.02

Results and discussion

The averaged SPEI for the growing season at 1 month lag shows 14 (13) dry (wet) years, at 3 month lag 16 (17) dry (wet) years, at 6 month lag 19 (16) dry (wet) years, at 12 month lag 18 (20) dry (wet) years and at 24 month lag 17 (17) dry (wet) years, respectively. The differences in these numbers for different SPEI lag may appear due to the memory of moisture conditions in the previous months.

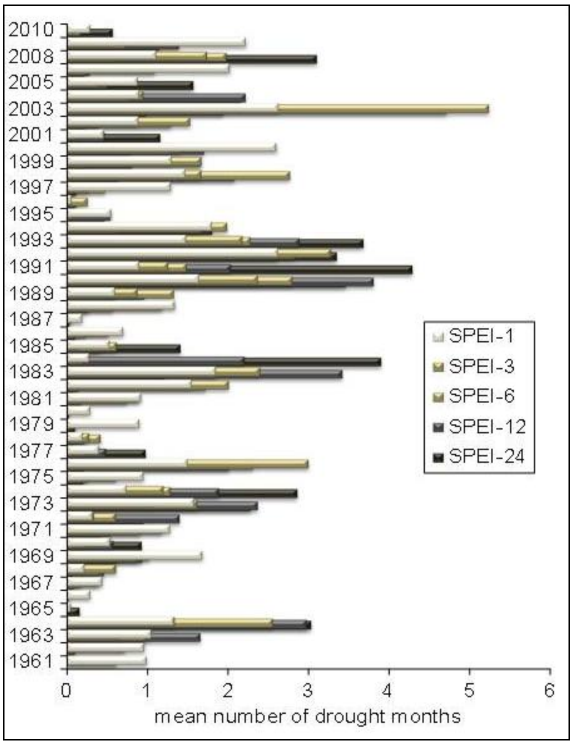

Figure 2. *The mean number of dry months at various lags (1, 3, 6, 12 and 24 months) at the level country during the growing season (1961–2010).*

The hierarchy of the driest years during the growing season was 2003, followed by 1992, 2000, 1983, 1982, 1976, 2009 and 1999. On the other hand, the wettest years during the growing seasons were 1965, 2010, 1977, 1996, 1966, 2001, 1972, 1980 and 1995.

In order to give more insight on the expansion of drought during the growing season, the dry months (SPEI≤ -1) have been counted for the SPEI series with various lags at each station, every year. Then these time series with the number of dry months during the growing season at each station have been averaged for the entire territory of the country. Figure 2 represents the evolution of the mean number of dry months at the level country during the growing season. This graph also reflects the transition of meteorological drought (SPEI-1) to agricultural drought (SPEI-3 and SPEI-6) and hydrological drought (SPEI-12 and SPEI-24). For the entire territory of the country, the largest number of dry months (meteorological and agricultural drought) during the growing season was recorded, chronologically, in the following years: 1964, 1976, 1983, 1990, 1992, 1994, 1998, 2000, 2003 and 2007. The most persistent hydrological drought during the growing season was recorded in 1990 when on average 3.8 dry months during the growing season were reported at country level. The most persistent agricultural drought during the growing season was in 2003 when on average 5.2 dry months were recorded. It terms of persistence it was followed by the years 1992 (3.3 months) and 1976 (3.0 months).

Conclusions

The various lags that might be considered for the SPEI calculation can be related to different drought types in a region. Short time scale lags show a strong relationship with variations of soil moisture which determines water availability for vegetation and agriculture, while water resources in reservoirs are related to longer time scales.

Acknowledgements: This study was supported by S grant of MSMT CR and project 6046070901.

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RELATIONSHIP BETWEEN LOCAL CLIMATE CONDITIONS AND THE GROWTH CHARACTERISTICS OF SELECTED WEEDS

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Abstract. The presented paper introduces an analysis of growth characteristics of selected weeds species in dependence on local climate conditions. The study has connected daily data recorded by the network of the weather stations of the Czech Hydrometeorological Institute and experimental data describing growth characteristics of weed species with different photosynthesis type (C3: *Chenopodium album*, *Avena fatua*; C4: *Echinochloa crus-galli*, *Amaranthus retroflexus*). The influence of selected meteorological characteristics on growth of weeds with different photosynthesis within the ecological gradient from Central Lowland (Central Bohemia) to Central Highland (Vysočina) was statistically determined. Correlation analysis confirmed that the daily minimum temperature (R^2~80 %) is one of the factors hindering the further expansion of C4 weeds, whereas for weeds C3 it is the daily minimum and maximum air temperature (R^2~86 %).

Introduction

A lot of current studies deal with the influence of ongoing and anticipated climate change on distribution and harmfulness of weeds and consequently also with the impact on weed control systems (e.g., Žalud, 2009). Increased CO_2, changes in temperature and precipitation patterns can affects C3 and C4 weeds differently. It is unclear whether C3 or C4 species will be influenced more in their area of occurrence. There is hypothesis that C3 weeds may become less competitive than C4 weeds, which express more efficient water use and higher photosynthetic efficiency at higher temperatures (Monfreda et al., 2008).

In this study, species with different photosynthesis type was monitored in natural condition. Fat-hen (CHEAL) is a dicotyledonous C3 photosynthetic type and growing in all the spring crops and is abundant throughout the Czech Republic from the lowlands to the foothills areas. Spring wild-oats (AVEFA) is a monocotyledonous C3 photosynthetic species occurring mainly in the warmer areas of the Czech Republic. Cockspur (ECHCG) is the monocotyledonous C4 type photosynthetic species and it spreads to the middle altitude in recent years. Common amarant (AMARE) is a dicotyledonous C4 plant of photosynthetic type. In the warmer lowland areas, AMARE ranks among the most harmful weed in root crops and due to a gradual expansion of the cultivation of sugar beet and maize, it penetrates into the arable highlands (Jursík *et al.*, 2011).

The weeds-climate research should provide information on potential changes in competitive ability of important arable weeds and composition of weed communities under changing climate. Over past 20 years the average number of tropical days in the summer season has increased in more than 1.5 times in Central lowlands region in the Czech Republic. Spring and summer drought episodes also gained in persistence during the last 20 years, with a greater number and duration occurring in the period of 1991–2000. The drought during this period was associated with high temperatures anomalies (i.e., more than 2.5 °C) (Potop *et al.*, 2012).

Material and methods

Field experiment was started in 2009 with collection of the weed seeds at the South Moravia. The seeds were then used in experiments during 2010. The seeds were sown at four locations with different altitude (Table 1). The experimental plots were chosen at field of maize in all cases. Each weed species were sown on an area of 1m^2 at four duplications. Throughout experiment time, those plots as well as the surroundings were consistently maintained in weed-free condition. At the same time, the number of monitored plants was gradually reduced to avoid mutual competition between individuals. Monitoring and collecting data took place once every 14 days. In this period, plant height was measured. The experiment was terminated at the time of physiological maturity.

In order to evaluate the impact of the climate conditions on the growth characteristics of weeds during different developmental stages, we have used the following approach: (i) multiple regression analysis to assess the occurrences of weeds depending on daily temperature and precipitation characteristics and (ii) examination of the daily patterns of the Spearman correlation coefficient (r) between extreme temperatures (Tmax and Tmin), precipitation and the height of C3 and C4 weeds.

Table 1. *List of experimental sites with mean annual temperature, precipitation and sunshine data from 1961–1990.*

Localities	**Longitude N Latitude E**		**Altitude [m a. s. l.]**	**Tempe-rature [°C]**	**Precipi-tation [mm]**
Brežany I	15° 04'	50° 02'	240	8.5	616.8
Prague	14° 22'	50° 07'	285	7.9	525.9
Hořice	15° 12'	49° 35'	468	6.6	675.3
Dobrá Voda	15° 01'	49° 23'	624	5.7	761.5

Results and discussion

Using Spearman Spearman correlation coefficient (r), we estimated dependence of the growth of selected C3 and C4 weeds on variability of daily temperature and precipitation. We found weak and medium (and/or missing) correlation between the height of the weeds and the daily rainfall. However, the estimate impact of rainfall on height of weeds was not statistical significant (p>0.066). A negative correlations were found between the weeds height and the daily minimum temperature in May and July, in both regions at Central Bohemia (r =-0.30 to -0.83) and Vysočina (r =-0.36 to -0.77). A positive correlation was found in June as well as in the daily minimum and daily maximum for both regions (r =0.67 to 0.88). Very strong positive correlation between the height of the weed species as AMARE, AVEFA, CHEAL and daily maximum air temperature in June at Vysočina region was found. Regarding the summaries of statistical analysis of the weeds height at four sites, we can conclude that the weeds of the C4 type (Common amaranth and Cockspur) reached the maximal height in locations with lower altitude (I Březany, Prague-Suchdol). This can be attributed to the higher temperatures in these areas. We can say that the higher temperature and lower altitude conditions are suitable for these weeds species. Moreover, their growth potential asserts more than for the weeds from the group C3 (Fat-hen, Spring wild-oat). Low height of Cockspur on the experimental site Brežany I was due to “flash drought” during the growing period. Flash drought occurred in Central Bohemia region during July 2010 as the result of a synoptic meteorological pattern in which the potential evapotranspiration greatly exceeds the level of precipitation and daily maximal temperature exceeds 30 °C. Weeds of the group C3 (Fat-hen, Spring wild-oat) achieved higher growth in colder locations, such as Spring wild-oats at the experimental site Dobrá Voda (643 m). However, Fat-hen recorded the highest growth in the hottest experimental site. The effect of the temperature-precipitation ratios on growth and development for each type of weed was assessed by means of the multiple regression analysis. The resulting regression equations might be used to predict the variability of height of weeds depending on a value of the maximum and minimum temperature, whereas the resulting coefficient of determination (R2) indicates to what extent the model as fitted explains how extreme weather events reduced height of weeds during the growing season (Table 2).

Table 2. *Statistical model of impact of meteorological parameters on height of weeds.*

$Y= a_0 + b_1T + b_2T + b_3T + b_4T$	R^2	p
Central Bohemian region		
AMARE=64.2–6.9*$_{Tmin5}$+8.8*$_{Tmin6}$ – 3.1*$_{Tmin7}$	70.4	0.02
AVEFA=252.4 – 11.3*T_{min5} – 3.6*T_{max7}	75.9	0.05
CHEAL=47.9+3.1*T_{max6}+9.7*T_{min6}– .5*T_{min7}	94.8	0.00
ECHCG=50.2–2.4*T_{min5}+2.4*T_{min6}–2.3*T_{min7}	93.4	0.00
Vysočina region		
AMARE=34.8–3.9*T_{min5}+6.5*T_{min6}–3.0*T_{min7}	83.8	0.00
AVEFA = 381.3 – 14.1*T_{min5} – 7.9*T_{max7}	74.1	0.05
CHEAL = 45.6+5.9*T_{max6}+4.3*T_{min6} – 3.9*T_{min7}	97.3	0.00
ECHCG=47.3+0.18*T_{min5}+6.8*T_{min6}– 7.2*T_{min7}	83.6	0.05

Furthermore, non-significant variables were excluded from the model using the stepwise regression (Forward Selection) leaving only the most informative combination. Finally, only those variables whose influence on the depended variable is significant remain in the multiple regression equations (Table 2). As can be seen from Table 2, even for weed from the C3 type low daily minimum temperatures in May also has negative effect on growth weed. The statistical model is only validated for the annual normal temperature regime (-0.3 °C deviation from long-term normal 1961–1990) and a wet year 2010 (127 % of the long-term normal precipitation).

The numerical values of dry biomass of C4 weed are relatively greater than C3 weed type. Therefore, year with high temporal variability of temperature-rainfall patterns, C4 weeds type are ably to accumulate drier biomass than C3 weeds type.

Analyzing the published research in the last decades, we found that temperature increase or drought in combination with elevated CO_2 was less studied (Tang *et al*., 2009) and more research has been done manipulating CO_2 concentrations alone. However, looking at the photosynthesis and CO_2 alone might be insufficient.

Conclusions

The results describe correlation between the climate characteristics and the growth characteristics of selected weeds and they might be used for a model selecting suitable areas for growing of the weeds and predicting the weeds incidence. Correlation analysis confirmed that the daily minimum temperature is one of the factors hindering the further expansion of C4 weeds, whereas for weeds C3 it is the daily minimum and maximum air temperature. Although regression models suggest that extreme temperature characteristics have very strong statistically significant effect (95% confidence level), but in the most cases other factors have a significant influence too. Those may be mainly the soil temperature, soil moisture and the global radiation. Effectiveness of the statistical model can be achieved only through the interaction of complex meteorological factors and growing characteristic of weeds. Plants of the groups C3 and C4 are able to grow at the selected altitudes.

The results suggest that the C4 weed species respond positively to higher temperatures at lower altitudes. Thereby, the maximum dry weed biomass was recorded in the site with the lower altitude, whereas the minimum in the site with the higher altitude was found.

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DIRECT ATTRIBUTION OF THE ANTHROPOGENIC CLIMATE SIGNAL TO PHENOLOGICAL OBSERVATIONS - DATAPHEN

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Abstract. Via a one-step or direct attribution study the human influence on the climate system has been quantitatively linked with phenological entry dates via an end-to-end modelling system in Central Europe. Based on piControl runs representing the internal variability of the climate system, observed temperature and phenological trends throughout the past 60 years appear unusual to exceptional and for most cases trends of historical runs (all forcings) are more consistent with observed trends than trends from historicalNat (natural forcings only) runs.

Introduction

Warming of the climate system has been widely observed during the last decades. Attribution analyses suggest that the global pattern of warming during the past half century is very likely caused by human-induced greenhouse gas forcing. There is a dearth on direct attribution studies, which quantitatively link the human influence on the climate system with observed impacts for instance on the biosphere. This work intends to apply the direct attribution method via an end-to-end modelling system to quantitatively link anthropogenic forcing with the observed shift of phenological entry dates.

Material and methods

Objective

On basis of an end-to-end modelling system the effects of various external climate forcing factors on phenological entry dates in Central Europe are to be compared. It is to be seen, if the additional anthropogenic forcing during the last decades is able to explain the observed temperature and phenological trends via a consistency analysis.

Data sets

The following data sets were compiled for this study:

Table 1 Data sets abd sources

Data sets	**Data sources**
Observed phenological entry dates	PEP725
Observed 2 m daily mean temperatures, stations	ECSN (European Climate Support Network, KNMI)
Observed 2 m daily mean temperature, grid	HadCRUT3 (Hadley Centre and Climate Research Unit of the University of East Anglia)
Modelled monthly and daily mean temperature (tas): 27 “historicalNat” (natural forcings only) runs 36 “historical” (all forcings) runs 2“piControl” (pre-industrial) runs	CMIP5 (Climate Model Intercomparison Project 5) and the DKRZ (Deutsches Klimarechenzentrum)

Analysis procedure

A phenological Temperature Sum Model (TSM) has been deduced at the ECSN (European Climate Support Network) stations on basis of the PEP725 phenological data base. 18 phenological phases have been selected for consistency analysis. Near surface temperature data of each of the 65 model runs were interpolated to the ECSN stations. Each of the 18 phases was modelled at each ECSN stations for each model run, then a European mean calculated from all stations resulting in a data set of more than 1,170 modelled phenological time series ready for analysis

Results

Even when restricting the region of analysis to Europe (0–30 deg E and 45–60 deg N), a clear difference between the historical (all forcings) and historicalNat (natural forcings only) runs becomes evident throughout all seasons (Figure 1). The observed time series and time series of the historical runs appear consistent, both show an increasing trend, whereas there is much less consistency between the observed time series and the time series of the historicalNat runs. This supports the attribution of the recent temperature trend to the human influence on the atmospheric trace gas composition.

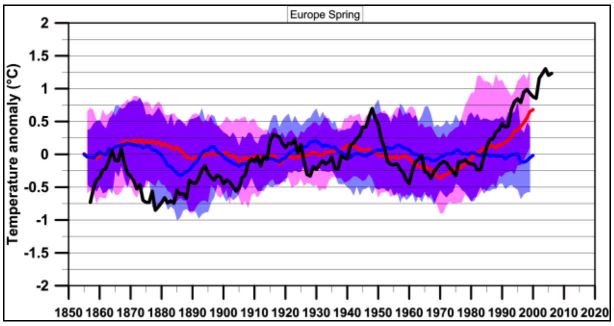

***Figure 1**. Anomaly time series of the mean spring temperature (March, April and May, 11 year moving average) from 1850 to 2011 related to the time period 1901 to 2000 over Central Europa (0–25 deg E and 45–55 deg N). Observed (black), historicalNat model runs (mean over all model runs blue, the area between the 5% and 95% quantiles blue) and historical model runs (mean over all model runs red, the area between the 5% and 95% quantiles pink).*

Assuming the 1,000 year piControl run to represent internal variability of the climate system, the observed 50 year spring and summer trends ending between 2000 and 2011 appear to be at least unusual if not exceptional (Figure 2, detection). The 50 year spring and summer trends of the piControl run appear to be consistent with those of the historicalNat runs, which means that both kinds of runs display a similar variability in this frequency range. The spring and summer trends of the observations appear more consistent with the historical runs than with the trends of the historicalNat cases.

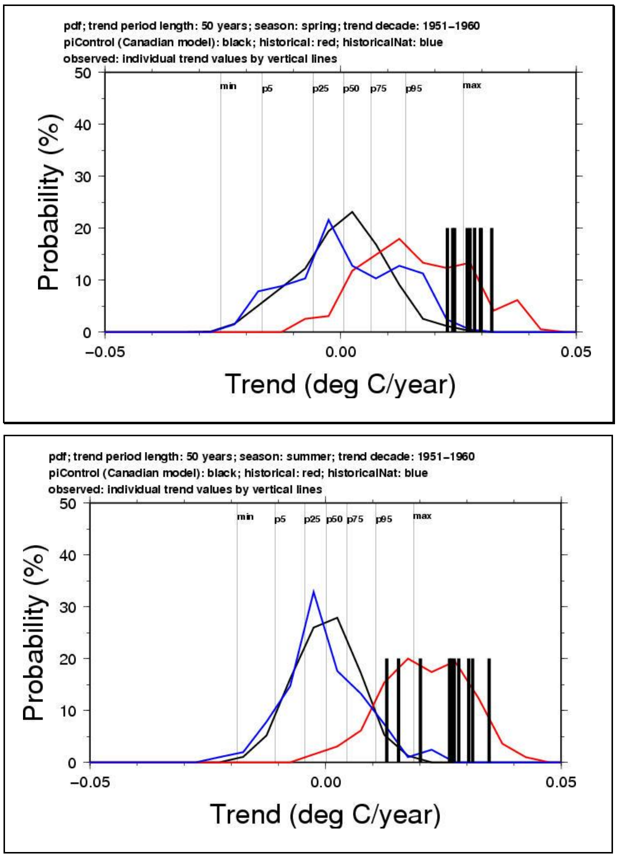

Figure 2. *Histograms of the temperature trend values over all 50 year periods starting in the decade 1951–1960 (1951– 2000, 1952–2001, etc.) in case of the ensemble of 36 historical runs (red), 27 historicalNat runs (blue) and black bars refer to the observations. The black curve represents the histogram of all 50 year trends within the total piControl time period of about 1000 model years with thin grey vertical bars for the various quantiles, the minimum and maximum trend values. Spring (top) and summer (bottom).*

For demonstration purposes the results of the phenological phase "*Aesculus hippocastanum* (Horse chestnut) beginning of leaf unfolding" and "*Alnus glutinosa* (Black alder) beginning of leaf unfolding" have been plotted in a similar way (Figure 3). The results are quite comparable to that of temperature. Only the sign of the trends are inverted, earlier entry dates are associated with increasing temperatures.

Conclusions

Detection. Through the end-to-end modeling system various external climate forcings can be directly modeled right through to phenological entry dates. Observed temperature and phenological trends of the last 60 years appear unusual (1,000 year piControl trends 95% < observed trends < 1,000 year piControl maximum trends) to exceptional (> 1,000 year piControl maximum trends).

Attribution. For most cases trends of historical runs are more consistent with observed trends than those from historicalNat runs.

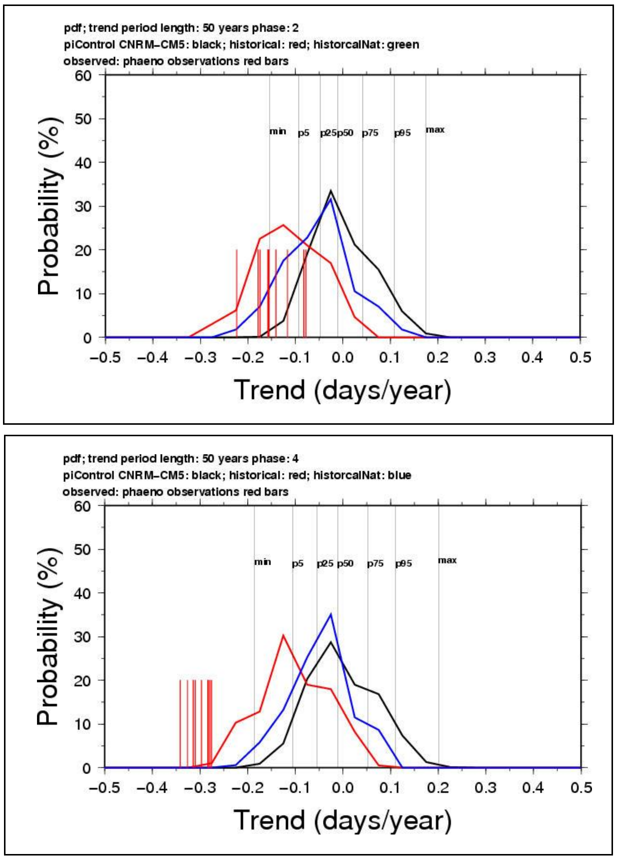

Figure 3*. Histograms of the phenological trend values over all 50 year periods from the period 1951–2009 of the ensemble of 35 historical runs (red), 27 historicalNat runs (blue) and red bars of observations. The black curve represents the histogram of all 50 year trends within the total piControl time period of about 1,000 model years with thin grey vertical bars for the various quantiles, the minimum and maximum trend values. Aesculus hippocastanum (Horse chestnut) beginning of leaf unfolding (top) and Alnus glutinosa (Black alder) beginning of leaf unfolding (bottom).*

Acknowledgements: The following data providers are acknowledged: the CRU (Climate Research Unit of University of East Anglia), the climate modeling groups contributing to CMIP5 (Climate Model Intercomparison Project 5) and the DKRZ (Deutsches Klimarechenzentrum). DATAPHEN was supported by the ACRP (Austrian Climate Research Programme, application number A963777).

SPRING PHENOLOGICAL PHASES OF EUROPEAN BEECH IN 2011 AND 2012 WITH REGARD TO DIVERSE STAND MICROCLIMATE

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Abstract. In this paper I process observations of spring phenological phases of European beech (*Fagus sylvatica* L.) in 2011 and 2012. Observation takes place in two areas differing in altitude and stand mixing. The course of phenophases has a periodic character, however, to alarge extent it is dependent on climate of the specific location and by a long-term observation and comparison we can characterize subtle changes of climate related with global warming.

Introduction

Recently, global warming and possible climate changes become ones of the most serious environmental problems. Observation and evaluation of phenological phases in relation to climatic factors and stand microclimate may contribute to the detection of emerging climate changes, since the beginning and duration of phenological phases can serve as their bioindicator. Phenology of forest-tree species can be used in evaluating the impact of current environmental conditions on the development of plant communities and thus contribute to the discussed issue of presumed climate changes and their impact on species composition and health of forest ecosystems.

Microclimate of broad-leaved deciduous stands and evergreen coniferous stands with dense canopy is completely different. Most noticeable is the difference between beech and spruce stands. Microclimate of mixed stands depends on mixing of the specific stand. The crucial properties of the climate are determined by the prevailing woody species. Admixture of deciduous species into coniferous stands strongly corrupts the marine influence of shady coniferous stand and brings elements of continental climate into it. On the contrary, the evergreen species in deciduous species stands reduces the differences between spring and summer in stand climate and brings elements of ocean climate into it (Petrík *et al*., 1986).

By comparing two different altitudes (vegetation zones) it might be possible to answer the question of how will plants, in this case forest tree species and respond to climate change. Whether it is possible, that their area moves in both the latitude and altitude.

Material and methods

Both areas intended for phenological observations are located in young mixed stands. The area in Drahany Highlands is located in a stand, in which European spruce, beech and larch are represented. The area is situated at an altitude of 625 meters.

Another observed area is located in Bílovice nad Svitavou in a stand, in which oaks, European hornbeam, beech and larch are represented. The area is situated at an altitude of 320 meters. Altitude difference of the two areas of interest thus amounts to 305 meters. Literary sources imply that the accession shift of spring phenological phases is 4–7 days for 100 meters of altitude.

Ten individuals constituting a representative sample of each species were selected in both stands. The individuals are not located on the edge of the stand, where they would absorb more solar radiation. They are selected not to be extremely dominant and vice versa, not to be suppressed into subordination. Accession of the phenophase is recorded for each individual (the date in which more than 50 % of the observed individuals reached phenological phase is considered as the beginning of the specific phase) and then the average value is determined. Spring phenophases are observed three times a week. For better comparison, each phenophase is assigned a serial number of the day of the year.

Temperature requirements for the accession and duration of phenological phases for each species are best expressed as the sum of effective temperatures; therefore the sum of affective temperatures is calculated for each phenological phase.

The basic operating method is visual observation using binocular telescope and then capturing the phenological phases using a digital camera with optical zoom. Phenological phases are evaluated under revised methodology, based on the methodology of Czech Hydrometeorological Institute.

The values obtained in individual areas are then compared among themselves.

Results and discussion

In the years of observation, the shift of phenological phases is noticeable; however it is much smaller than the expected shift.

In 2011, beech began to sprout in the area in Bílovice on April 19, which is day 109 and in the Drahany Highlands area on April 23, day 113. The shift of the first spring phenological phase was thus only 4 days. The beginning of 10 % foliage was recorded in Bílovice on day 111 and in the second observed area on day 120. The shift was 9 days in this phase. The beginning of 50 % foliage was recorded in the Bílovice area as early as in 2 days, which is day 113. In the Drahany Highlands the phenophase was recorded on day 123 and the shift in this phenophase thus counted up to 10 days. The beginning of 100 % foliage occurred in Bílovice on April 25, which is day 115. In the Drahany Highlands, the phenophase was recorded with a shift of 11 days, on day 126. The last spring phenophase, full foliage, was recorded in Bílovice on day 120 and in the Drahany Highlands on day 132. This shift in this phenophase was 12 days between these areas (Figure 1).

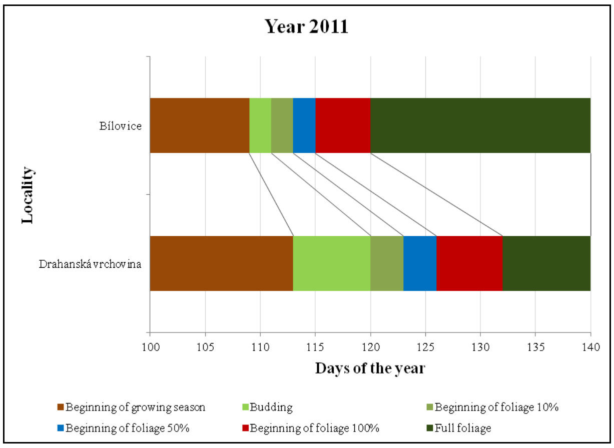

Figure 1. *Comparison of observed areas in 2011.*

In 2012, the sprouting phenophase in Bílovice was recorded on April 22, day 113. With the shift of 5 days this phase was recorded in the Drahany Highlands area. The beginning of 10% foliage was recorded in Bílovice on day 116 and in the Drahany Highlands on day 119. The shift of accession of this phenophase was only 3 days. The beginning of 50% foliage started in the areas with 2 day interval, in Bílovice on day 118 and in the Drahany Highlands on day 120. At the beginning of the phenological phase of 100% foliage there was only one day shift. In the Bílovice area the phase was recorded on day 121 and in the Drahany Highlands on day 122. At the last spring phenophase, full foliage, there was a shift of 3 days. In the Bílovice area it occurred on May 6, day 127 and in the Drahany Highlands it was recorded on May 9, day 130 (Figure 2).

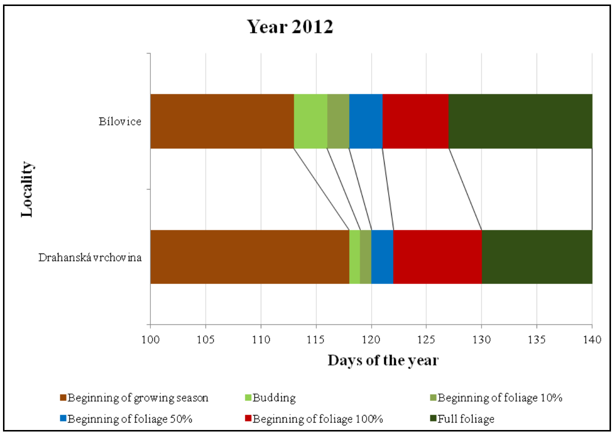

Figure 2. *Comparison of observed areas in 2012.*

Conclusions

Long-term observations are crucial for phenological observations. As for this project, the specific areas brought different data. The Drahany Highlands area offered results of long-term observations, while from the Bílovice forest district, which was founded in 2011 as an area extending phenological observations at the Institute of Forest Ecology, we have complete results only from 2011 and partial results from this year.

Growth and development processes are conditioned by internal factors of plants, however, to a considerable degree they are influenced by external factors such as air temperature, soil temperature, radiation, soil conditions and precipitation activity. The beginning and duration of spring phenological phases are influenced to the largest extent by air and soil temperature and as for the autumn phenological phases, the amount of precipitation is influential in a large degree as well. The course of phenophases can therefore be very different in the same species (individuals) in different years (Figure 3 and 4).

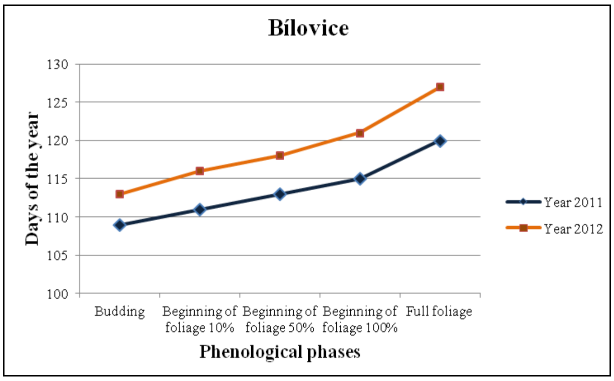

Figure 3. *Comparison of phenophase course of European beech in the Bílovice area.*

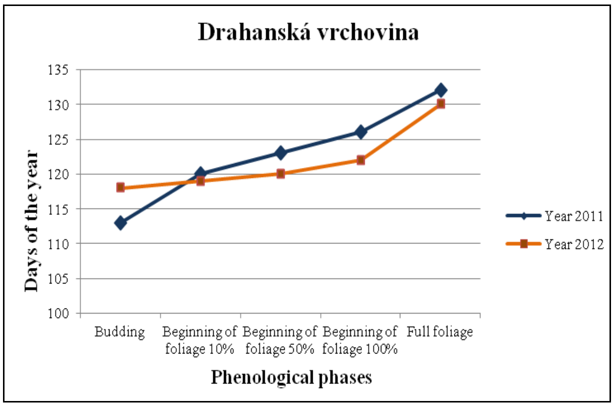

Figure 4. *Comparison of phenophase course of European beech in the Drahany Highlands area.*

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MICROCLIMATIC CONDITIONS OF *Sphagnum* PEATLAND IN NORTHERN POLAND AND THEIR POSSIBLE CHANGES IN 21ST CENTURY

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Abstract. Peatlands are carbon-accumulating ecosystems. Increase of air temperature at relatively stable totals of annual precipitation may cause rise in evapotranspiration rate and thus changes in water balance. This turn may cause increase in CO_2 emission from the peat surface. The paper presents analysis of changes of air temperature, vapour pressure and precipitation in XXI century on Linje mire located in northern Poland. The simulations base on MPI-M-REMO regional climate model with spatial resolution of 25x25 km. Simulations applied boundary conditions used in GCM ECHAMP5 for climate scenario A1B. According to adopted scenario of climate change air temperature can rise ca 2.11 °C and *VP* ca 1.4 hPa on Linje mire from the present day by the end of the century.

Introduction

Functioning of ombrotrogenic peatlands is entirely dependent on climate variables that control water balance (Charman, 2002). Our former study showed that air temperature and precipitation are key-factors influencing hydrology of *Sphagnum* Linje peatland (Słowińska *et al*., 2010).

Due to IPCC reports global climate will change meaningful in XXI century. These changes and resultant local hydrological fluctuations will influence on carbon storage, greenhouse gas flux and biodiversity in peatland ecosystems (Parish *et al.*, 2008). Therefore, there is urgent need to study how climate will influence peatland in the continental setting. One of the method to get the answer in a quite short time is experimental treatments, where there is possibility to manipulate the temperature and water level. This is also used in CLIMPEAT project (Lamentowicz *et al*., 2012 – this volume). However, long-term microclimatic, gas flux and ecological monitoring is essential to predict future changes.

The aim of this publication is to discuss future changes in the XXI century of essential climate variables which influence functioning of *Sphagnum* Linje peatland in northern Poland. Results can be regarded as a reference for the other peatland areas in this part of Europe.

Material and methods

Linje peatland is a nature reserve located in northern Poland near Bydgoszcz city (53°11'15" N, 18°18'37" E). The area of the reserve is 12.7 ha and the mire covers 5.95 ha.

In the present studies we have used two data sets. The first one is experimental data collected within the period of 1 Dec 2007 to 30 Apr 2012. The HOBO Pro sensor of air temperature and humidity was placed in the central part of the mire at 30 cm height above surface, so it represents microclimatic conditions for this ecosystem. Daily precipitation was measured by Hellmann's rain gauge as well.

The second data set consist of simulations of selected climate elements (air temperature, vapour pressure, precipitation, global solar radiation) for the period 1970–2100 prepared in the frame of SPA project in the Interdisciplinary Centre for Mathematical and Computational Modelling (ICM) of the University of Warsaw by Dr. M. Liszewska's team. The simulations were based on MPI-M-REMO regional climate model with spatial resolution of 25x25 km. Simulations applied boundary conditions used in GCM ECHAMP5 for climate scenario A1B. The data consist of daily values of studied climate variables.

The simulated data obtained for the raster represented Linje peatland were downscaling basing on daily observations of air temperature and air vapour pressure carried out at Linje peatland. Downscaled values of temperature and vapour pressure were used in the analysis of possible climate changes in Linje mire. In this purpose mean values of air temperature (*Tmean*) and air vapour pressure (*VP*) were calculated both, as annual means and means of vegetation period (April-September).

Results and discussion

The average (for the period 2006–2010) annual air temperature in the studied area of Linje peatland is 7.5–8.0 °C, and average annual precipitation totals ranges from 500 mm to 550 mm (Słowińska *et al*., 2010).

Due to applied model *Tmean* showed statistically significant increasing trend within the period of 1971–2100 ($P < 0.05$). The rate of change in annual *Tmean* is about 0.24 °C per 10 years and 0.20 °C per 10 years for vegetation period (Figure 1). Comparing seasonal trends in *Tmean* we observed a larger warming in winter months than in summer what is consistent with IPCC prediction for the Northern Europe (Christien *et al*., 2007).

A significant increase of *VP* occurred as well. A decadal change of *VP* is about 0.16 hPa for mean annual and 0.19 hPa for mean vegetation period (Figure 2).

Regarding possible changes in precipitation and global solar radiation we noted very small increasing trend. However, for both variables the trends are statistically insignificant at significance level is 0.10.

Thus, according to adopted A1B scenario of climate change annual *Tmean* will increase from the present day to the end of 21st century of ca 2.11 °C and *VP* – of ca 1.41 hPa. Vegetation period will be characterized by lower rate of *Tmean* increase (ca 1.76 °C) but greater rise in *VP* (ca 1.67 hPa) then the whole year.

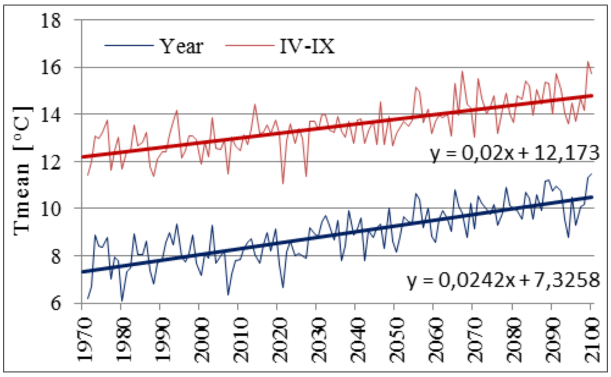

Figure 1. *Mean values of air temperature (Tmean) for the whole year and for vegetation period in years 1971–2100 with a trend line in Linje peatland.*

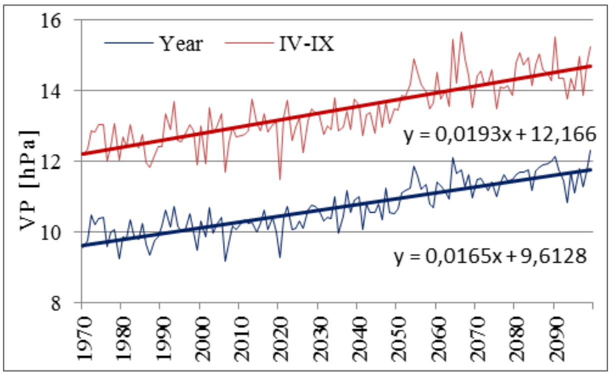

Figure 2. *Mean values of vapour pressure (VP) for the whole year and for vegetation period in years 1971–2100 with a trend line in Linje peatland.*

Conclusions

The studies show possible significant changes in climate variables in 21st century. Increase in air temperature at relatively stable annual totals of precipitation for this region may cause rise in evapotranspiration rate and modification in water balance on Linje peatland.

However, the process of evapotranspiration depends also on many other meteorological factors (e.g. net radiation, wind speed) and vegetation characteristics (Łabędzki *et al*., 2011) which was not taken into consideration in the present paper. The studies will be continued to collect more data from, including net radiation and wind speed. Additionally, evapotranspiration characteristics of vegetation covering the mire will be also included in further research. Long-term results can be regarded as a reference for the other peatland areas in this part of Europe.

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VARIABILITY OF FLOWERING OF COMMON HAZEL (*Corylus avellana* L.) IN SLOVAKIA

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Abstract. This paper presents the results of flowering of Common hazel (*Corylus avellana* L.) on 52 stations in Slovakia during period of years 1987–2011 in seven altitudinal groups. Mean onset of flowering in Slovakia was set on 18th March. The earliest mean beginning was set in 2007 and the latest in 1987. We found high variability of flowering in all altitudinal groups with coefficients of variation between 2.7–38.9 %. Altitudinal phenological gradient for flowering was set on 2 days/100 meters in average. General trend was shifted by 6 days in advance, but it has shown to be insignificant.

Introduction

Common hazel (*Corylus avellana* L.) is one of the first tree species which starts its phenological activity in early spring. It is a species which causes often allergic reactions because of its pollen. For this reason it is important to know dates of its flowering. That is why so many authors, not only in Slovakia, but also in other world increased attention about hazel´s flowering (Kasprzyk, 2003; Remišová and Vinceová 2007; Črepinšek *et al.*, 2011). The main reason is knowledge of relationships between fluctuations in weather on possible climate change and flowering of tree species. The main aim to the future should be possibility to predict beginning of flowering (Hájková *et al.*, 2011). It is also very important to know how the onsets of phenophases shift during the years and between different regions of Slovakia.

Material and methods

Dates of onsets of flowering were provided by Slovak Hydro-meteorological Institute from 52 phenological stations all around Slovakia for the period of years 1987–2011. Stations were located in altitudes 110–1,265 meters a.s.l. We divided them into seven altitudinal groups while each of them was in 100 meters intervals. Phenological observations were done according to methodology by Slovak Hydrometeorological Institute. Date of flowering occurred, when at least one half of the observed male flowers started flowering (shedding pollen).

Results and discussion

During the observed period, we evaluated mean onsets of flowering on hazel in Slovakia. As we can see on Figure 1 there was high variability of data between years. Values of variation coefficients in each altitudinal groups were between 2.7–38.9 %, and it was caused by strong temperature fluctuations at the end of winter and in the early spring. We set its mean date of flowering on 18th March during the years 1987–2011. In comparison with the same period but shorter for 5 years (Remišová and Vinceová, 2007) we found that the phenophases were delayed for about 3 days. Difference was caused by bigger amount of phenological stations (24 stations more), and 5 of them were in the altitude above 800 meters a.s.l. The earliest mean beginning during the years was set on 21st February 2007 and the latest on 8th April 1987. The absolutely earliest minimums (14th and 15th January 2007) were recorded on different stations in 1st and 3rd altitudinal group. The absolutely latest onset (maximum) was recorded on 5th May 1987 in 4th altitudinal group.

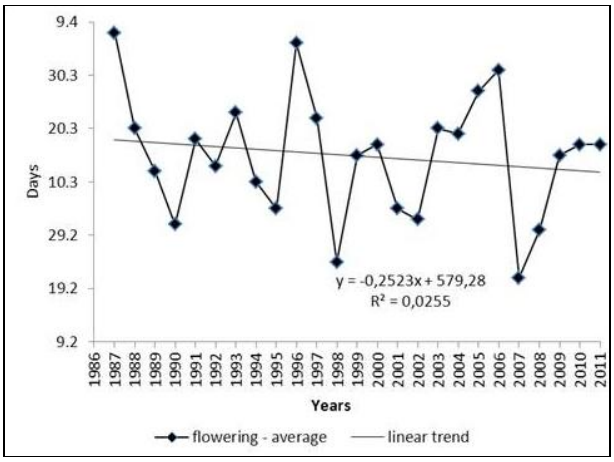

Figure 1. *Mean onset of flowering of Common Hazel in Slovakia in the period 1987–2011.*

We also evaluated flowering of hazel by the altitudinal groups. Results are summarized in Table 1. It is clear that mean onset of flowering delayed with altitude irregularly. Shift between altitudinal groups was 2–14 days. There were also some cases when mean onset of flowering started in higher altitude sooner than in lower altitude. It was caused by exposure of stations. Phenological gradient, which mean difference of mean dates of flowering between the highest and the lowest stations converted to 100 meters interval was calculated on 2 days/100 meters. Locations of stations and weather variability in years and altitudinal groups caused relatively high variability. Values of coefficients of variations are shown in Table 1. For example, in 6th altitudinal group the variation coefficient was 10.7 % on average. Similar results were found by Bednářová, Merklová (2006). They found variation coefficient 15.8 % in altitude of 625 meters in the period of years 1991–2006. Different trends in dependence on altitudinal groups are shown in Table 1. There are visible relatively high trends (9–20 dates) in the groups with high altitude. They are all negative which means advance of flowering. General trend for the years 1987–2011 was shifted by 6 days in advance, but it has shown to be insignificant (Figure 1). Our results coincide with the work of Remišová andVinceová (2007), which had shown the same trend although they worked with different number of stations in different areas in Slovakia.

Table 1. *Flowering of hazel in Slovakia during the years 1987–2011 according to altitudinal groups (Ø – the mean beginning, min – the earliest beginning, max – the latest beginning, s_x% – the coefficient of variation).*

Altitudinal group [m a.s.l.]	**Ø**	**Ø min**	**Ø max**	**R**	**Sx%**	**Trend**
1 100–199	70	50	96	46	4.1–26.3	-6
2 200–299	72	40	96	56	5.6–23.1	0
3 300–399	74	48	97	49	6.9–38.9	-7.5
4 400–499	74	52	108	56	9.4–28.4	-6,5
5 500–599	73	43	100	57	3.2–28.8	-5
6 600–699	88	68	109	41	2.7–24.0	-20
7 > 800	85	72	106	34	2.6–32.3	-9

Conclusions

We evaluated phenophases flowering of Common hazel on 52 stations in Slovakia during period of years 1987–2011. Stations which were located in the altitudes of 110–1,265 meters a.s.l. were divided into seven altitudinal groups by 100 meters. Mean onset of flowering in Slovakia was set on 18th March. The earliest mean beginning during the years was set on 21st February 2007 and the latest on 8th April 1987. High variability of flowering in different altitudinal groups was caused by exposure and variability of weather in each year. With increasing altitude we found unequal delay of flowering for 2–14 days. We set altitudinal phenological gradient for flowering on 2 days/100 meters on average. We found the highest advance of trends of flowering for the highest altitudes by 9–20 days for whole period. General trend was shifted by 6 days in advance, but it has shown to be insignificant.

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CLIMATIC REGION CHARACTERISTICS IN CONTEXT OF CLIMATE DEVELOPMENT

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Abstract. The first position in a five-digit EPEU code occupies climatic region (CR). CR takes into account a sum of daily average air temperature equal to or above 10 °C, annual average air temperature and average air temperatures during the growing period, annual average precipitation total and drought event probability in % and moisture certainty. The values of CRs were determined and compared for both periods 1961–1990 and 1961–2010. The estimation was carried out on a daily interval for complete set of 789 simulated 10 km grid points in the Czech Republic. Based on the existing methodology can be classified only 17 % of the Czech Republic area - for the period of 1961–2010. Another option is to redefine a range of individual climatic characteristics of each region according to areas identified in the original map. It would mean a substantial change of the intervals defining individual CRs.

Introduction

Estimated pedilogical-ecological unit (EPEU) is used especially for the valuation of agricultural land. The first position in a five-digit EPEU code occupies climatic region (CR). CR is defined in the methodology by Mašát *et al*. (1974, 2002) for the period 1901–1950. A similar system is used also in the Slovak Republic. The Slovak BPEJ code is a seven-digit and CR (00 to 10) occupies the first two positions.

CR includes areas with approximately the same conditions for growth and development of agricultural crops. The current EPEU system is based on condition of the socialist way of farming and in the same time (by time-scale) involving a change in natural conditions, on which are the primal criteria established. It is mainly a shift that occurred in climatic conditions accompanied by further soil degradation.

In recent decades an increase of temperature and precipitation extremes with negative effects on crop production is registered. Climate scenarios predict the continued trend of extreme temperatures occurrence and changes in rainfall distribution during the year. Crop production depends on current weather conditions as well as on long-term climate variability.

Definition of CR takes into account the following characteristics: sum of daily average air temperature equal to or above 10 °C, annual average air temperature and average air temperatures during the growing period, annual average precipitation total, the drought event probability in % and moisture certainty.

Ten CR codes numbered 0–9 (very warm, warm, moderate warm, moderate cool and cold) and moisture (dry, moderate dry, moderate humid and humid) were defined.

The issue of CR has been solving by Vopravil *et al*. (2011), Středa *et al*. (2011), Středová *et al*. (2010 and 2011). The combination of the CR and soil characteristics help identify areas of wind erosion risk i.e. sandy soils in dry and warm regions (Podhrázská and Novotný, 2007).

Changing climatic conditions along with the development of measurement and evaluation techniques are the main causes of CR definition update. Changes in climate conditions towards increasing air temperature and different distribution of precipitation during the year till the end of the 21st century Mužíková *et al*. (2011).

Material and methods

Original CRs were determined for the period 1901–1950. Digitized and homogeneous climatological data are available since 1961. For reclassification of CR was thus used analogous period of 50 years (1961–2010). The estimation of selected climate elements was carried out on a daily interval for complete set of 789 simulated grid points in the Czech Republic.

Model data correction based on validation, it means technical data series of 10 km grid and model results comparison, was realized before analysis itself. The validation period was 1961–1990. The model results are fully compatible with observed (directly measured) data after this correction. The grid data creation and all data processing including further climate analyses were worked up by ProClimDB software.

Results and discussion

Figure 1 shows an existing CR distribution in the Czech Republic based on climatic data of 1901–1950. Comparison of maps in Figure 1, 2 and 3 showed the impossibility of mere application of existing methodology for defining climate regions (Mašát *et al*., 1974, 2002) to the current (and future) period. Based on this methodology can recently clearly be classified only 17 % of the area (Figure 2). Figure 2 show reclassified CR for the period of 1961–2010. A substantial part of the territory can not be classified into any defined CR code, because the sub-intervals of individual CR parameters do not overlap.

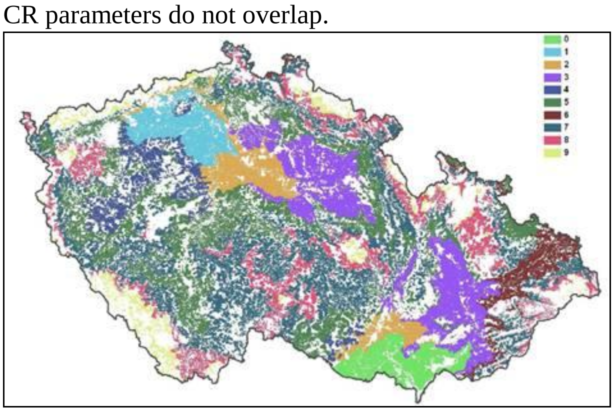

Figure 1. *Map of climate regions according to the methodology by Mašát et al. (1974, 2002) for the period 1901–1950.*

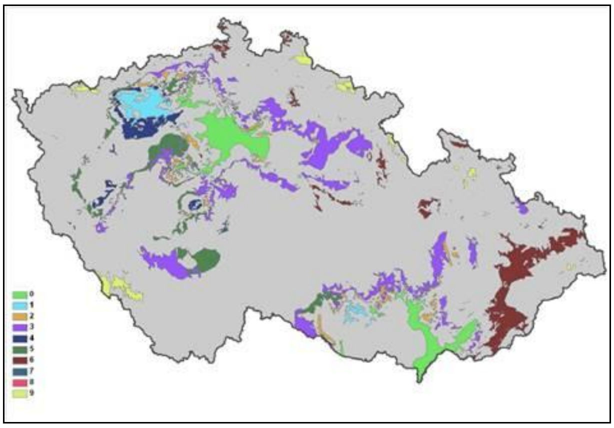

Figure 2. *Map of climate regions according to the methodology by Mašát et al. (1974, 2002) for the period 1961–2010.*

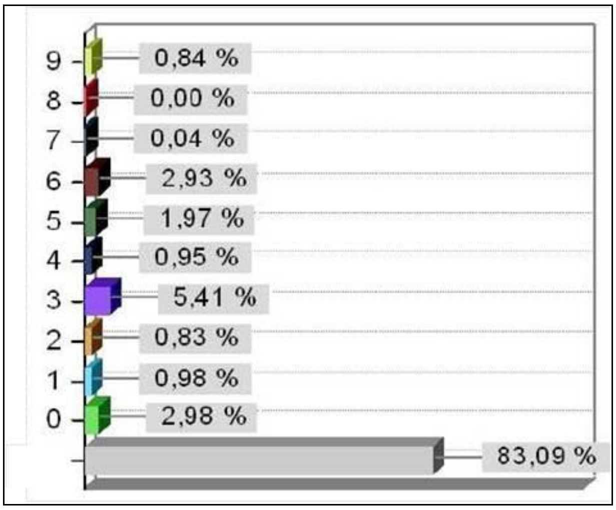

Figure 3. *Percentage rate of individual climatic region classified for the period 1961–2010 (grey column means "unclassified" area).*

According to methodology by Mašát *et al*. (1974, 2002) some areas in the period 1961–2010 has to be classified as CR "very warm, moderately dry" or "very warm, moderately humid" Those CRs did not occur in the period 1901–1950 and thus are not defined by Mašát *et al*. (1974, 2002). The reason for these differences is an increasing air temperature and practically unchanged annual precipitation totals.

Conclusions

Detailed evaluation of CRs in fifty-year period 1961–2010 was based on digitized and homogeneous meteorological data in a regular grid network of 10 km. When evaluate the period of 1961–2010 by this methodology only 17 % of the Czech Republic can be clearly classified.

Středová *et al*. (2011) compared CR characteristics for two period 1901–1950 and 1960–2010 and found out significant increase of temperature sum above 10 °C and average annual temperature. An average annual precipitation total did not differ significantly during the both periods. Moisture certainty analyses proved an increase of the driest areas. Drought event probability increased in the second period.

Another option is to redefine a range of individual climatic characteristics of each region according to areas identified in the original map. Application of this procedure would mean a substantial change of the intervals defining individual CRs. Precise graphical output was created by the GIS tools. It should be emphasized that the current methods of measurement and processing partial cause differences in reclassified CRs compared to the original methodology.

Analysis from 1961 clearly proved that the CR cannot be longer defined in accordance with criteria specified in the original methodology. The reason is mainly rising temperatures and almost unchanged precipitation totals regime. Since CRs are determined on the basis of temperature and precipitation it is clear that intervals defining individual CR must be changed.

The obtained results proved the need for an update of methodology defining CR regarding to climate change and variability.

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SIMULATION OF WIND FIELD INFLUENCED BY WINDBREAKS

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Abstract. The paper summarizes the results of wind speed measuring at different distances from selected windbreak in combination with optical porosity (OP) determination in different periods. Wind speed at 2 m above the soil surface had been measured since 2006. Thirty images of different phenological stages from 2006 to 2010 were analyzed. The highest correlation was found out when use the wind speed measurement at 50 m on the leeward side. The dependence decreases with increasing distance. Full foliage reduces a wind speed about 60 % at 50 m and about 30 % at 150 m on the leeward. These values for non-foliaged windbreaks decrease on 80 and 90 %. Maximum distance of windbreak effect on wind speed reduction was found out by the extrapolation of the curves constructed using the regression equation of wind speed reduction in dependence on OP and different distances from the windbreak. Regardless OP the reduction effect disappears at a distance of 250 m. The quietest zone of evaluated windbreak with an average height of 15–18 m was detected in the area about four times the height.

Introduction

Aerodynamics and erosion control parameters of windbreaks are variable regarding to wood species, density and rows number. Height and porosity of windbreaks are two major controls on these airflows and both are amenable to design and management (Forman, 1995). Significantly variable aerodynamic properties of deciduous trees during the year must be taken into account. On the basis of windbreak efficiency testing subsequently mentioned conclusions were found out: evenly distributed porosity of stem and canopy results in the longest protected area; dense lower parts are more efficient than more porous lower parts; an erosion is almost not observed in the case of a barrier with evenly distributed porosity; the absence of a dense lower part results in an excessive zone of erosion behind the barrier (Cornelis *et al.*, 2000). Actual shape of wind speed curve depends mainly on windbreak height and porosity and additionally on other important characteristics of airflow × windbreak system (Vigiak, 2003). The aerodynamic porosity of the windbreak determines the ratio between airflow that passes through the barrier pores ("through–flow") and airflow that diverges over the barrier ("diverged–flow").

The impact of individual windbreaks on air flow in its vicinity can be described by methods that allow simply expression of windbreak aerodynamic properties during the year. An analysis of windbreak OP allows assessing its effect in different phenological phases. The method is based on computer analysis of digital windbreaks images. OP is defined as the ratio between the gaps in windbreaks to its total area (Guan *et al*., 2003). OP is expressed as a remainder to value 1 or in percents as a remainder to 100 percent.).

The most papers referring to OP method do not contain its exact description. According to Sudmeyer and Scott (2002) the OP is a ratio of the windbreak area trough which the sky is visible in frontal view to the total windbreak area. The main disadvantage of this method is a conversion and reduction of 3-D space to 2-D space (Loeffler *et al*., 1992). Procedure for OP determination applicable in our conditions is published by Litschmann and Rožnovský (2005). They described the detailed assessments of OP for each vertical layer of windbreaks to define OP changes with height.

Wan-Meng *et al*. (2005) found out a significant correlation between windbreak porosity, number of rows and row spacing. Forman (1995) presents that highly porous windbreak decreases wind speed only minimally, but it has the advantage of turbulence minimizing. Furthermore a highly porous windbreak provides a relatively long distance of reduced airflow downwind. Low-porosity windbreak produces a short downwind zone of highly diminished wind speed and high levels of turbulence. Medium-porous windbreak reduced the wind speed almost as the impenetrable barrier. Grant and Nickling (1998) evaluated a vegetation drag coefficient to optimal management of windbreak and its function modeling. They found out the highest vegetation drag coefficient when optical porosity about 20 % and volume porosity about 50 %. Several wind tunnel trials indicate that the optimal extent of shelter is provided by windbreaks with 20 % porosity (Burke, 1998). According to Ian *et al*. (2009) a windbreak with 30 % porosity reduces wind speed to 70 % of the open-field speed. The paper summarizes the results of wind velocity measuring in different distance from windbreak in combination with OP determination in different periods. The procedure is suitable for relatively rapid assessment of the windbreak efficiency. It can be applied in erosion control measures realization in frame of land adjustment or for windbreaks revitalizing.

Material and methods

Experimental windbreaks: four windbreaks in southern Moravia - municipalities of Micmanice (MC), Suchá Loz (SL), Dolní Dunajovice (DD) and Blatnice pod Svatým Antonínkem (BS). Windbreaks height varies from 12 to 25 meters, width from 12 to 20 m. Main woods are *Populus ×euroamericana* and *Fraxinus excelsior* L. Additional trees are mostly *Tilia cordata* Mill. and *Acer negundo* L.

Measurement of wind speed: wind speed at 2 m above the surface had been provided since 2006 by anemometers type W1 and W2. Six anemometer sets measured at the distances of 150 and 50 meters on the windward side and at 50, 100, 150 and 200 m on the leeward side. Measurements were carried out before and after the main crop growing season or during the growing season to a maximum plant height of 10 cm. The individual measurement lasted 2 hours with 5 recording step.

Optical porosity: thirty images of different phenological stages of selected windbreaks from 2006 to 2010 (taken from a distance of 30 m) were analyzed. The images were converted into black and white spectrum, divided into 9 to 11 vertical columns and 7 to 9 horizontal lines. The precision of OP determination increases with the number of squares. OP of each square was assessed by ImageTool analyses. The resulting OP for each image was then determined as the arithmetic average of all squares.

Results and discussion

The highest values of OP are logically achieved in non-vegetation period. Almost full foliage of windbreaks occurs approximately 10 days in the spring. The OP is changing analogically. Autumn leaf fall and gradual change of OP lasts longer. Although two values of OP (vegetation and non-vegetation) for each windbreak can be considered. The combination of wind speed reduction and OP for all measurements is shown by Figure 1.

The wind speed reduction on the leeward side relatively strongly correlated with OP. The highest correlation was found out when use the wind speed measurement at 50 m on the leeward side. Full foliage in summer (10% OP) reduces a wind speed about 60 % at 50 m and about 30 % at 150 m on the leeward side in comparison with speed at 150 m on the windward side. These values for non-foliaged windbreaks decrease on 80 and 90 %.

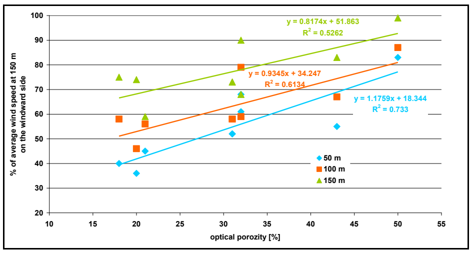

Figure 1. *Influence of OP on wind speed on the leeward side.*

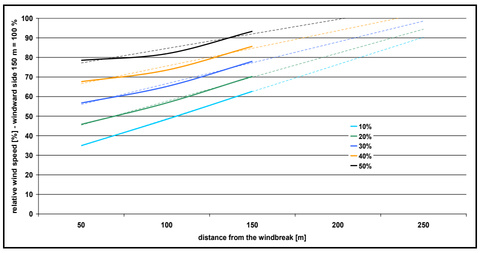

Figure 2. *Wind speed reduction at different distances on the leeward side depending on OP.*

The curves in Figure 2 were constructed using the regression equation of wind speed reduction in dependence on OP and different distances from the windbreaks. The wind speed reduction on the leeward side for individual OP values can be derived from the curves. Maximum distance of windbreak effect on wind speed reduction was determined by the curves extrapolation. Regardless OP value the reduction effect disappears at a distance of 250 m.

Conclusions

The paper evaluates the wind speed reduction by windbreak on the basis of OP assessment. The method allows quantify the influence of windbreaks of different structures in different phenological stages without the need of direct terrain measurements. The described method is applicable just for the line windbreaks (up to tens meters wide) and requires high-resolution images. Aerodynamic porosity of windbreaks wide 12 to 20 meters can be still be successfully evaluated by the optical porosity method. The relationship between OP and the wind speed reduction is the strongest at the distance of the first measurement (i.e. at 50 m). The relationship is reduced with increasing distance due to other factors. The relationship between OP and wind speed reduction at different distances on the leeward side proved the full foliage windbreak influence even at a distance of 200 to 250 m. For the bare windbreaks this distance is only about 50 m. When increasing the number of rows a positive effect could only be observed close to the windbreak.

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THE INCREASE OF THE AIR TEMPERATURES OBSERVED IN DIFFERENT EUROPEAN LOCALITIES DURING 1951–2010

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Abstract. Uninterrupted series of annual mean temperatures from 72 European observatories have been processed. The temperature at these stations increased in general more than global temperature, but with considerable fluctuations. The increase at the individual stations is very different – it moves between zero and 2.5 °C. It depends very slightly on the geographic longitude. Stations where lower temperature increase has been observed are located mainly at the Atlantic coast, those with higher increase being mainly in inland. There are, however, many exceptions from this rule, but the gross character of the distribution of stations with different temperature increase seems to be clear.

Introduction

The climatic change – global warming – is for many decades a subject of the intensive investigation. Indeed, the observed temperature increase started more than one century ago and in the last decades it becomes more and more rapid. It is supposed that the main cause of this increase is the increasing concentration of greenhouse gases in the atmosphere due to the human activity (Smith, 1993). This process is irreversible and due to this fact, the increase of global temperature will continue in future (Hansen and Sato, 2004). Besides, there are some natural long-term temperature fluctuations (Pfister, 1992). These may contribute to some corrections of the supposed increase.

The temperature increase is different in different regions. In general, in the North Hemisphere the temperature increases more than in the South Hemisphere. Especially, compared with the tropic region (between 30° N and 30° S), the increase is more pronounced outside to the North and less pronounced outside to the South (Brohan *et al.*, 2006). Moreover, some preliminary studies suggest that also over the European territory the temperature increase is not the same throughout.

In this paper, data from a net of European stations will be processed and the increase at each station will be determined. The differences among the individual stations will be judged in order to find possible dependence of this increase on the position of the station.

Material and methods

The global and regional annual temperature series have been calculated by Met Office Hadley Centre in collaboration with the Climatic Research Unit of the University of East Anglia (Brohan *et al.*, 2006) and are available on http://www.metoffice.gov.uk/hadobs/hadcrut3. Here global, NH and SH temperatures and regional temperatures for tropic region (between 30° N and 30° S) and NH and SH regions without tropics (over 30° N or 30° S) can be found for each month. Only the data from the time interval from 1951 to 2010 have been selected for further processing. Data from thousands worldwide observatories are available on web pages of National Climatic Data Center ftp://ftp.ncdc.noaa.gov/pub/datasets/climatedataold. They are presented in a compressed form and their extraction is a little complicated. Moreover, in many series considerable gaps occur. Prior to 1950, the amount of gaps rapidly increases. Therefore, the time interval 1951–2010 has been selected and only uninterrupted data series from this interval have been used. There are 70 stations, which fulfill these conditions. Using the data from these stations, a mean European temperature has been calculated for each year.

The course of the annual temperature for each station can be approximated by a regression line. Its parameters give the approximated temperatures in 1950 and in 2010 so that the increase during 60 years can be given numerically. Correlations of the found temperature increases with the latitudes, longitudes and altitudes of the stations have been calculated as well.

Results and discussion

The course of the mean European annual temperatures is shown in Figure 1 together with the course of the global temperature during the same time interval. All data have been normalized in such way that the mean value for the whole interval is zero. It is clear that the increase of the European temperature is more pronounced than that of the global temperature. Regression lines determine the increase being 1.26 °C for European temperatures whereas for global temperatures, the increase is only 0.70 °C and for the NH region outside the tropics (over 30° N) it is 0.89 °C.

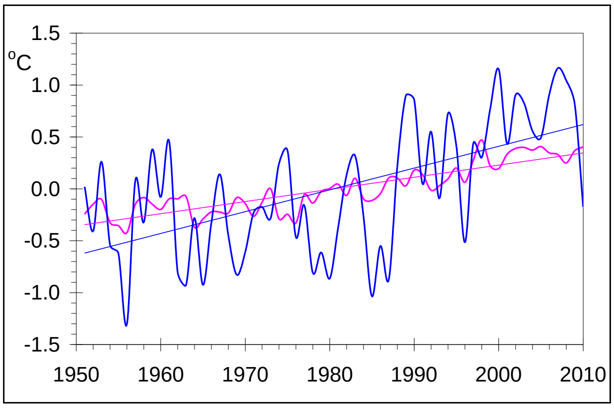

Figure 1. *The course of the mean annual temperature for all selected European stations (blue) and for global temperature (red) with regression lines.*

Moreover, there are many fluctuations, which are quite different for both series. Their amplitude for the European data is considerable, the temperature jumps sometimes up or down by about 1 degree during a few years.

The increase in the individual stations differs considerably from the mean increase. Its values move between zero and 2.5 °C. They depend slightly on the geographical longitude, from 0.95 at 30° W to 1.55 at 50° E. However, the correlation coefficient is only 0.2 and it is not significant. The dependence of the temperature increase on the altitude of the station is a little lower; the dependence on the geographic latitude is practically negligible.

All 70 stations have been subdivided into two groups: the first, where the temperature increase did not reach 1.25 °C (34 stations), and the second, where this increase exceeds 1.25 °C (36 stations). Their distribution on the European territory is presented in Figure 2 by circles with different colors.

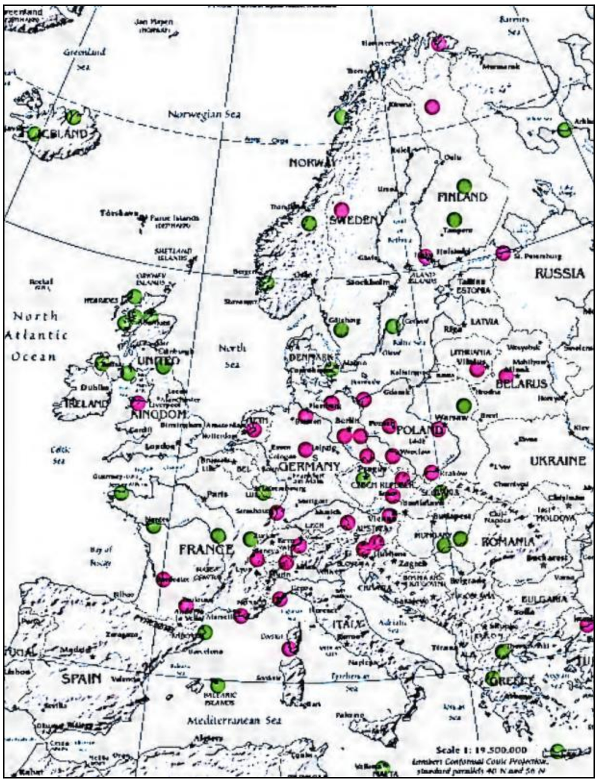

Figure 2. *The distribution of stations with different temperature increase over the European territory. Stations are marked by circles: green – stations with the increase less than 1.25°C, red – stations with the increase more than 1.25 °C.*

One can see that the distribution is not accidental. Stations where only a low increase has been observed are located predominantly at the Atlantic coast (British Isles, Island) and partly at the coast of Mediterranean and Baltic Sea. Stations where a high increase has been observed are located preferably in Central and East Europe, some of them in inland of Scandinavians and in West Europe. It suggests that the temperature increase is lower at the Atlantic coast or near a larger sea and becomes higher when going more to the inland, so that a very slow dependence on the geographic longitude and partly on the altitude could take place. The amount of stations located at the coast and in inland with respect to the observed temperature increase is given in Table 1.

Table 1. *Distribution of station, where low and high temperature increase has been observed, with respect to their position at the coast or in the inland.*

Increase	Amount		Percentage	
	Coastal	Inland	Coastal	Inland
< 1.25 °C	23	11	68	32
> 1.25 °C	11	25	31	69

However, there are many exceptions from this rule and therefore the correlations are very low. Nevertheless, for some exceptions an explanation can be found. For example, most stations far from the Atlantic coast where low temperature increase has been observed (green circles in Figure 2) are located in lowland (Hungary, Finland, Belarus). Stations at the coast where high temperature increase has been observed (red circles in Figure 2) are usually (but not always) located far from the Atlantic ocean itself (St. Petersburg, Turku), or in such position that more land than water is in the vicinity of stations (St. Petersburg, Hamburg, Bordeaux, Istanbul). Nevertheless, some exceptions remain (e.g. high increase in Wales or low increase in the Czech basin or in Slovakia) and they will require a more detailed evaluation of local conditions.

Finally, shorter intervals 1960–2010 and 1970–2010 have been investigated too in the same way. Results from these studies are practically the same as those using 1950–2010 interval – the distribution of stations marked by red and green circles does not differ from that shown in Figure 2.

Conclusions

The above presented results show that there is a clear difference between the temperature increase at stations located near the Atlantic coast or inside the European continent, the increase being stronger inside the continent. Regression lines do not suggest any change in the last decade, as it is the case for global temperatures, and therefore the continuation of the described trend is expected. However, some problems remain to be solved: how the difference looks for summer or winter temperatures, for maximal and minimal temperatures, whether similar differences have been observed also at other continents etc. In any case, scenarios for global (and regional) warming should take the differences between coastal and continental regions into account.

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PRELIMINARY STUDY ABOUT THE POSSIBLE HYDROECOLOGICAL CONSEQUENCES OF CLIMATE CHANGE IN THE SEDIMENT OF LAKE FERTŐ/NEUSIEDLER SEE

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Abstract. Lake Fertő/Neusiedler See (309 km^2) is situated on the Hungarian-Austrian border. It is the westernmost steppe lake in Eurasia. The Hungarian part of the lake is 75 km^2 and 86 % of it is covered by reed stands. The typical water bodies of the Hungarian part of the lake are open waters, reed stands, and open water areas enclosed by reed, the so-called inner ponds. The temperature measurements of every cm of sediment of different water bodies took place between 1987 and 1992. The sediment temperature of the various areas reached its maximum in August. There was nearly 10 °C difference between sediment temperatures taken in summer and in autumn. During the year, sediment warmed slowly and to different degrees, reached its maximum at every depth in August, and afterwards cooling of the sediment in the subsequent part of the year was faster than its warming.

Introduction

The deep lakes of the temperate zone become thermally stratified in the summer with a thermocline (Wetzel, 2001). Below this, water and sediment is permanently about 4 °C. However, in shallow lakes sediment temperature changes seasonally. In lake ecosystems sediment is the main site of degradation (Wetzel, 2001, Hakanson and Jansson, 1983). The intensity of degradation completed mainly by bacteria and also by fungi and sediment dwelling invertebrates is significantly influenced by temperature (Ágoston-Szabó and Dinka, 2008).

As opposed to deep lake sediments' 4 °C environment for degradation, in shallow lakes this process is subject to seasonal temperature change, although changes are slighter than those of the water above it. This is important considering the amount of degraded organic matter (mineralized material is crucial for assimilation processes) and also influences the state of dissolved oxygen in the bottom water, as increasing intensity of degradation decreases the amount of dissolved oxygen in the water (Berczik, 1983a, b; Ágoston-Szabó and Dinka, 2004, 2008). In accordance with the above mentioned: if temperature conditions are affected by permanent changes or stronger and more frequent extreme phenomena than previously, then this has temporary or even permanent consequences concerning the whole lake's material flow. These changing life conditions (i.e., the changes in hydroecological circumstances) change the species structure and quantitative characteristics of assemblies and the rhythm of their vital processes with either positive or negative consequences.

Our hypothesis is that in the extremely shallow Lake Fertő/Neusiedler See sediment temperature changes are different horizontally, vertically, and also seasonally.

Material and methods

Lake Fertő/Neusiedler See situated on the Hungarian-Austrian border (47º42' N, 16º 46' E), is the westernmost and largest steppe lake in Eurasia, declared as a biosphere reserve by UNESCO in 1977 and 1979. It has a surface area of 309 km^2 (Hungarian part 75 km^2), with a mean depth of 1.1 m and 54 % of the whole lake, 85 % of the Hungarian part is covered by reed (*Phragmites australis* Cav. Trin. Ex Steud.). Within the reed belt, there are numerous reedles ponds of variable size (Márkus, 1983). According to the characteristical ionic ratios the water of Lake Fertő/Neusiedler See can be categorized as hydrogencarbonate-sulphate and sodium-magnesite mixed water type with conductivity of 1,300–3,500 μS cm^{-1}, a pH of 7.9–9.5, and a sulphate concentration of 300–500 mg l^{-1}. The sediments of the lake are characterised by autochthonously formed minerals, protodolomit and Mg-calcite (Jungwirth, 1979). The mass and level of water in the lake fluctuate significantly. Life conditions are highly influenced by the stirring effects of the primarily N and NW winds.

Table 1. *Sampling sites and dates*

year	1987			1989					1990					1991					1992		
month	06	07	10	06	06	08	08	10	03	06	07	07	07	05	05	07	07	09	02	08	11
site\day	05	07	23	12	13	24	25	20	27	14	11	12	14	13	14	1	2	11	21	11	4
11	X	X	X																		
13																			X		X
22		X							X												
23								X				X								X	
25		X			X	X		X				X									
26								X													
41		X	X				X	X							X						
42											X					X		X			
44		X								X			X		X		X	X			
45				X						X				X							
47		X						X		X							X			X	

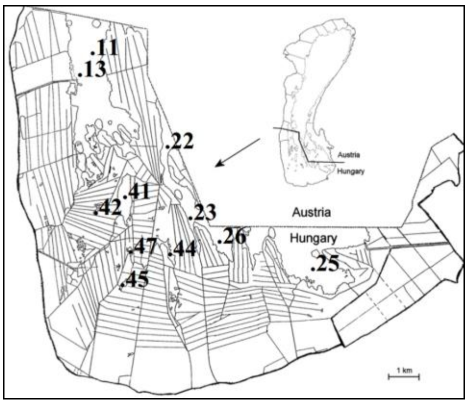

Figure 1. *Sampling sites at the Hungarian part of Lake Fertő/Neusiedler see.*

Sampling was carried out with a 5 cm diameter plexiglass tube, with 1.5 mm diameter holes every cm. Temperature was taken with an Ultrakust-Thermistor-thermometer from the freshly picked samples, every cm from 10 to 37 cm depth, with 0.1°C accuracy, between February and November. Sampling points and dates are shown in Figure 1. and Table 1. In case of open water: 11, 13, 22, 23, 25, 26, in case of inner lakes: 41, 42, 44, 45, 47.

Results and discussion

Sediment temperatures were taken on 11 sampling sites on 21 dates. From these we selected the datasets registered on site 25 (open water), site 41 (largest inner lake), and site 47 (southernmost inner lake) on 7 July 1987 and 20 October 1989. These datasets demonstrate well the development of temperature by depth in the sediment of different types of water bodies.

There is nearly 10 °C difference between sediment temperature in spring and autumn. On both dates, sediment temperature of the southernmost inner lake (47) is the highest, followed by the largest inner lake (41), and open water body (25). At summer sampling, temperature of the water right above the sediment and surface water is higher than sediment temperature, and temperature curves are more variable (Figure 2). In autumn, sediment temperature change depends less on depth, and water temperature is lower than sediment temperature.

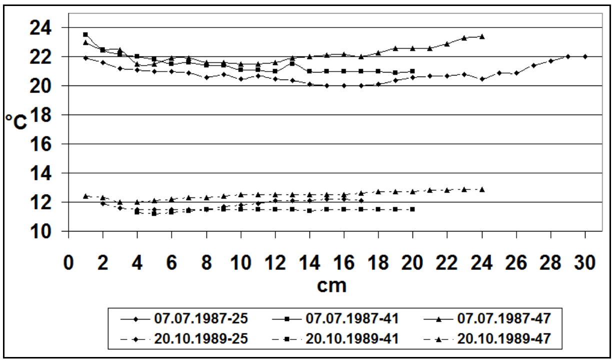

Figure 2. *Sediment temperature at Lake Fertő in July 1987 and October 1989 (sampling site: 25, 41,47).*

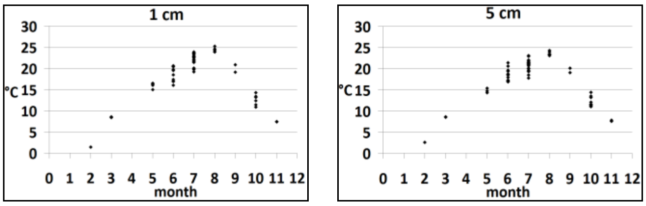

Figure 3. *The temperature of the upper 1st cm and 5th cm of the sediment.*

Sediment temperature changes from month to month during the year. To confirm this, we analysed the temperature data taken in different months from the upper 1st and 5th cm of the sediment (Figure 3). On all sampling sites at all two depths sediment temperature is the highest in August. Temperature increase in the sediment in spring and summer is slower and more gradual, while decrease of temperatures in autumn and early winter is much faster. In February and March sediment temperature increases with depth, while in summer months it is highest in the upper 1 cm of the sediment.

Conclusions

We have very little information about temperature conditions of the sediment of Hungarian shallow lakes (especially about their vertical pattern). Data analysed here provide reliable, basic information on seasonal, horizontal, and vertical temperature changes of Lake Fertő's sediment and confirm the need of spreading the analysis of the possible effects of climate change on Lake Fertő/ Neusiedler See to the patterns of sediment temperature as well, as it concerns the whole of this shallow lake's material flow.

During the year temperature in the upper 5 cm layer of sediment changes between 2.5–3.0 °C and 22.0–24.0 °C.

We explored the spatial and vertical distribution of the changes of sediment temperature of the Lake Fertő/ Neusiedler See in the large open water bodies and water bodies enclosed by reed. On the grounds of these, the effects of the temperature development of climate change, which is characteristically different from earlier patterns, on the measure and durability of the changes in sediment temperature can be assessed. Consequences are particularly considerable in changes of the intensity of biological (microbiological) processes.

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BIODIVERSITY CHANGES OF BEETLES (*Coleoptera*) IN OAK-HORNBEAM FOREST OF NATIONAL NATURE RESERVATION BÁB FOREST NEAR NITRA IN CONDITIONS OF CHANGING CLIMATE

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Abstract. Changes of beetle biodiversity in National Nature Reservation Veľký Báb near Nitra are evaluated comparing results of field researches in two periods of years 1968–1970 and 2002–2004. Results were related to changing parameters of climate on the research area. As the most frequent species were found ground beetles (Carabidae, Staphylinidae) lady beetles (Coccinelidae), leaf beetles (Chrysomelidae) and weevils (Curculionidae). Specimens of these families created 71 % of total amount of recorded beetles. 78 hygrophilous species recorded at the end of 60th last century absent in new records. Almost all new records of beetles belong to termophilous species.

Introduction

Climatic conditions become the most important factor influencing stability of ecosystems in Slovakia today. These facts influence significantly composition and richness both phytocenoses and zoocenoses including beetle cenoses. High mobility of insects as well as its short lifetime cycles depending on outside temperature and humidity of environment is good assumption to use this group as the model grouped for studies of climate change impact on its biodiversity.

In the frame of International Biosphere Program (Man and Biosphere) during years 1968–1970 held in oak-hornbeam forest of National Nature Reservation Báb forest near Nitra there were also evaluated records of different groups of arthropods including beetles. Beetles (*Coleoptera*) were evaluated separately for different etages (Drdul, 1970, 1972, 1974, Korbel, 1973, Kleinert, 1980).

The aim of this paper is to compare biodiversity of beetles recorded in oak-hornbeam forest of National Nature Reservation Báb forest near Nitra in two periods 1968–1970 and 2002–2004.

Material and methods

The research area is located on the northward oriented slope in altitude 150–205 above sea level. Trees composition of the area is classified as the oak-hornbeam forest. The area is the rest of original lowland forest in agricultural landscape on the northern edge of Danubian lowland. National Nature Reservation Báb Forest near Nitra was established in 1966 with acreage 30.66 ha.

Databases for identification of biodiversity changes were created both from literature sources (results published in the frame of International Biosphere Program held in Bab near Nitra during years 1968–1970) and field research that was repeated after more than 30 years during 2002–2004 by authors.

Beetles were collected by the same methods in both time slices. There were used methods of pit fall traps, beating and sweeping. Records from reference period of years 1968–1970 were compared with those from years 2002–2004.

Time frequency of collecting trips was twice a month. Beetles were determined on species level and classified according to Systematic Check List of Czechoslovak Insects (Jelínek, 1993).

Figure 1. *Location of the research area (light blue square) in National Nature Reservation Báb forest near Nitra.*

New records as well as lost species in time slice 2002–2004 as compared with reference time slices of years 1968–1970 were analyzed from the point of view of their needs on environmental conditions.

Results and discussion

Air mean temperature on Danubian lowland increased during 20th century by 1.1 °C (Lapin *et al*., 2001). Dramatic increase was recorded especially in the second half of this period. On the base of climate monitoring of the research area there was recorded increase of air mean temperature from 9.3 to 10.7 °C during evaluated period. According to the last results this area becomes also more sensitive to drought occurrence as compared with former climatic conditions (Šiška and Takáč, 2009).

Increase of temperatures evoke lengthening of vegetation season and consequently allow more life cycles of herbivorous insects as well as occurrence of new beetle species on the habitat.

There were recorded all together 398 species belonging to 47 beetle families on the research area during years 1968–1970 (Drdul, 1970, 1972, 1974; Korbel, 1973; Kleinert, 1980).

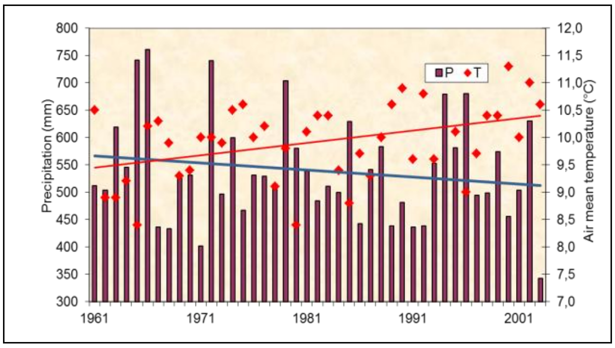

Figure 2. *Air mean temperatures (T) and precipitations (P) in Báb near Nitra during years 1951–2005.*

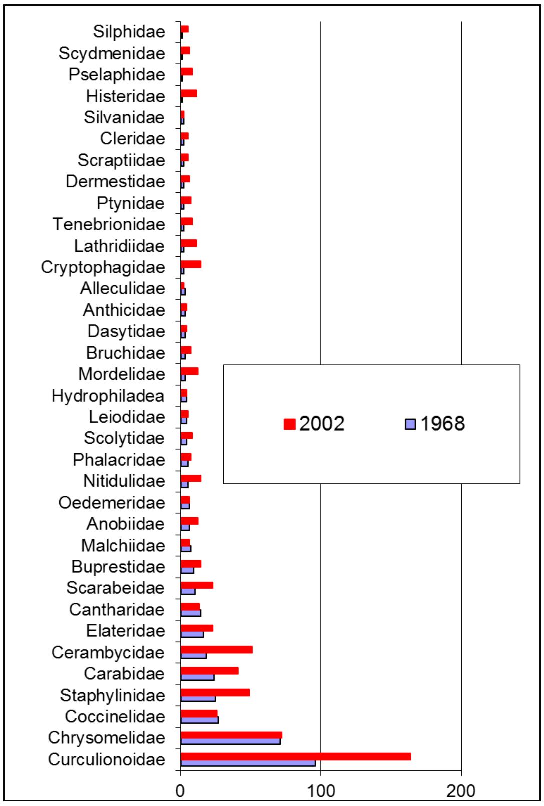

Figure 3. *Species richness according to beetle families in recorded in period of years 1968–1970 (1968) and 2002–2004 (2002).*

After 30 years significant increase of new species was recorded on the habitat. There were found 717 species belonging to 64 beetle families. As the most frequent species were found ground beetles (*Carabidae*, *Staphylinidae*) lady beetles (*Coccinelidae*), leaf beetles (*Chrysomelidae*) and weevils (*Curculionidae*). Specimens of these families created 71 % of total amount of recorded beetles. Almost all new records are related to termophilous species (e.g. *Claviger testaceus*, *Bothrideres contractus*, *Phytoecia nigricornis*, *Lucanus cervus*, *Liocola lugubris*, *Cetonischema aeruginosa*, *Potosia cuprea obscura*, *Anisarthron barbipe*, *Smaragdina aurita Nanophyes nitidulus)*. Remarkable founding is that there was also recorded in the habitat some species that are considered as vulnerable in condition of Slovak republic (Holecová and Franc, 2001).

On the other hand there was not confirmed occurrence of 78 species recorded in years 1968–1970. Especially hygrophilous beetles absent in present records (*Notiophilus biguttatus*, *Asaphidion flavipes*, *Agonum sexpunctatum*, *Ophonus puncticollis*, *Lebia humeralis*, *Helophorus granularis*, *Phyllobius chloropus*, *Phyllobius arborator*, *Gymnetron beccabungae)*.

Conclusions

Climate change can enrich biodiversity of beetles, but on the other hand some species can disappear in future climatic conditions.

After 30 years significant increase of new species was recorded on the habitat. There were found 717 species belonging to 64 beetle families.

Ground beetles (*Carabidae*, *Staphylinidae*) lady beetles (*Coccinelidae*), leaf beetles (*Chrysomelidae*) and weevils (*Curculionidae*) was the most frequent beetles creating 71 % of total amount of records in both evaluated time slices.

Remarkable founding is that occurrence of some beetles considered today as vulnerable can be more frequently occurred in future climatic conditions.

Acknowledgements: This study was made with the help of grant project VEGA 1/1220/12. I would like to express my cardial thanks for help with determination of beetles to next specialists and also my friends (in alphabetic order): S. Benedikt, P. Hlaváč, E. Jendek, P. Průdek, I. Rychlík, T. Jászay, and M. Zúber.

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IMPACT OF HEAT WAVES ON PHENOLOGICAL ORDERING OF TREE-SPECIES

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Abstract. The work presents the results of the impact of heat waves on phenological phase colouring of the leaves of European beech (*Fagus sylvatica* L.) and English oak (*Quercus robur* L.) in Central Slovakia. In the period 1987–2011 we found heat waves in 5 years. Advance of colouring of leaves appeared just in the years 2000 and 2007 for beech. For oak we found no significant influence of heat waves on its leaves colouring. There was observed no advance in colouring of leaves in the following years with heat waves (1994, 2010 and 2011) because of higher rainfalls before its (heat waves) onsets. In the last 5 years there were significant increase of heat waves and it may signal possible climate change in our conditions.

Introduction

The climate on Earth is constantly changing and developing. The changes are mainly visible in temperature and rainfall regime of a land during the year. In recent decades we can see more frequent extreme events characterized by prolonged drought periods with high temperatures or periods with huge amounts of rainfalls in short time.

One of accompanying phenomena of climate change and global warming is also an appearance of heat waves. In a literature it is not possible to find a single definition for "hot wave". Quantitative determination of boundaries of heat waves is affected by breaking the threshold of maximum daily air temperature and its duration in a specified geographical area as well as specified conditions of each locality.

Heat waves negatively influence forest ecosystems. Phenology as a bioindicator of environmental changes could be a great tool for obtaining answers to questions relating to climate change in our country.

Material and methods

Heat waves were defined for Central Europe (Sobíšek 1993, Kyselý 1994, Kyselý and Pecho, 2012) by three conditions:

- mean daily air temperature reaches ≥ 30 °C for at least 3 or more days,
- every day maximum temperature reaches at least 25 °C,
- mean maximum daily temperature for whole period is ≥ 30 °C.

For the determination of the impact of heat waves on colouring of the leaves we had selected two native tree species growing in the forest ecosystems of Central Slovakia. European beech (*Fagus sylvatica* L.) is shade tolerant deciduous tree of oceanic climate, sensitive to drought. English oak (*Quercus robur* L.) is light tolerant species easy to soil moisture. The site is located in Zvolen basin in altitude of 290 meters asl. In the period of years 1987–2011 we monitored the beginning of leaf colouring. It was a date, when at least 10% of the observed trees started to colour their leaves. Phenological observations were done according to methodology by Slovak Hydrometeorological Institute in Bratislava (Kolektív, 1984). The occurrence of heat waves was defined by temperature data from close meteorological station.

However, the mean maximum daily temperature for whole period has never achieved 30 °C threshold, we had modified this condition by the conditions of the site. We studied the period when the *mean maximum daily temperature for whole period was ≥ 25 °C.* We evaluated amount of rainfall one month before the onsets of heat waves as well.

Results and discussion

Each year (except 1996) during the observed period we determined some tropical days with different duration of their appearance when daily mean temperature reached more than 30 °C (Figure 1).

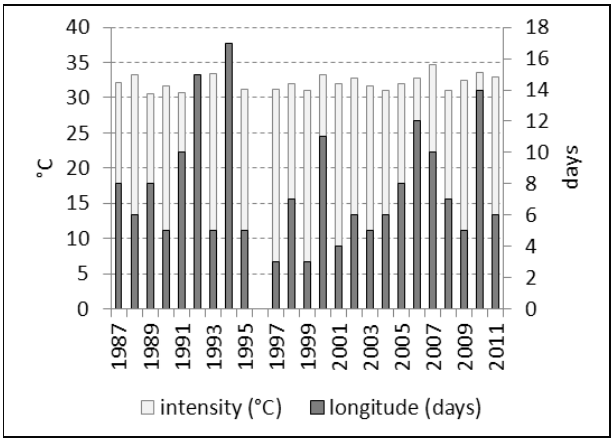

Figure 1. *Occurrence of tropical days and its duration in 1987–2011.*

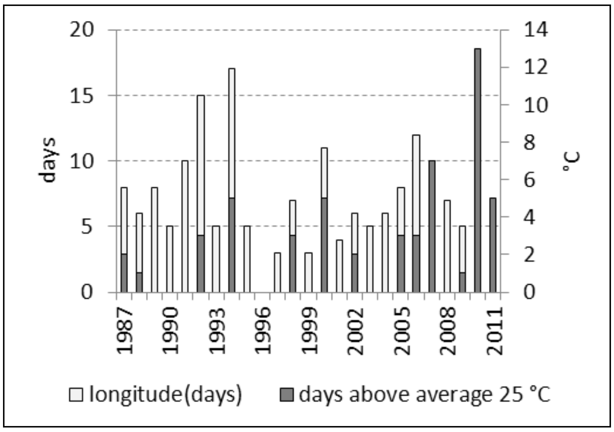

Figure 2. *Occurrence of heat waves in Zvolen basin in 1987–2011 according to established criteria.*

Just in 5 years of these (Figure 2) there were also heat waves occurrence with defined criteria (1994, 2000, 2007, 2010 and 2011). The occurrence of heat waves between 1994 and 2010 in Slovakia coincided with heat waves in whole Europe (Kyselý and Pecho, 2012). Other differences in years could result from the partial modification of the conditions as well as because of specific types of atmospheric circulation. Maximal duration of heat wave was recorded in 1994 and it was 17 days. The data corresponded with the results of Středa et al. (2011), where is written about the same year and its highest duration of heat waves (16–19 days) on different sites.

During the observed period we noted the beginning of leaves coloring of European beech and English oak. The onset of this phenophases was on 16th and 17th September on average for both species. The course of this phenological phase in each year is shown in Figure 3. According to long-term mean onsets of phenophases on our site (25 years), we found different shifts in timing in each year.

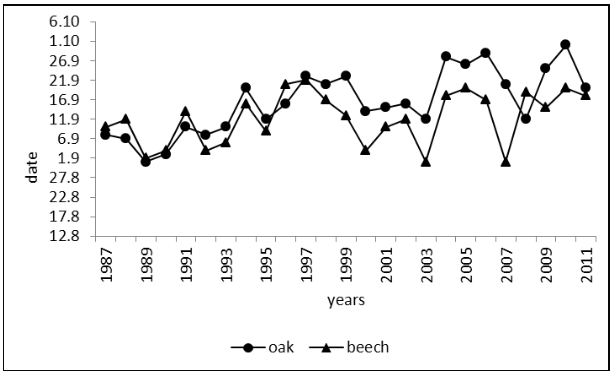

Figure 3. *Colouring of leaves of English oak and European beech in Zvolen basin in 1987–2011.*

We found earlier onset of leaf colouring phenophases because of heat waves just for a beech in the years 2000 and 2007. That was the reason, why we took into account other criteria – mean monthly rainfalls before heat waves as well as higher daily precipitations at this time. Observed data are given in Table 1.

Table 1. *Mean monthly amounts of rainfall, the highest day maximums and shifts of leaves colouring during heat wave (+ advance, - delay).*

Years	**Mean monthly rainfall (mm)**	**Day max (mm) / number of dates**	**Shifts (days)**	
			English oak	**Europ. beech**
1994	7.1	26.7 / 1	-4	+1
2000	2.8	11.8 / 1	-2	+13
2007	3.4	16.0 / 0	-5	+16
2010	8.2	37.6 / 3	-15	-3
2011	5.5	55.0 / 2	-4	-1

From Table 1 it is clear that amounts of precipitations before heat waves influenced earlier coloring of leaves only for a beech which as a shade tolerant species requires higher soil moisture. On the contrary oak as a light requiring species shall bear more extreme periods of hot and dry weather. Earlier colouring of leaves even did not occur in 1994 despite the prolonged heat waves (17 days) when maximum daily temperatures reached over 25 °C in at least 5 days. Some years (2010 and 2011) were characterized by relatively high amounts of precipitation (25–55 mm) during June and July. It could lead to mitigation of heat waves which did not affect advance of phenophases to earlier periods in those years.

Conclusions

In this paper we examined whether there was some influence of heat waves on colouring of the leaves of English oak and European beech in Zvolen basin in 1987–2011. We found out significant advance of this phenophases during the year 2000 and 2007 for beech because of heat waves. For oak we found no statistically significant influence of heat waves on its onset of leaves colouring in Zvolen basin. In 1994 and 2010 despite prolonged heat waves (14–17 days), when the maximum temperatures reached more than 25 °C during at least 5 days, we found no advance in leaf colouring. The small or no effect of heat waves was caused by higher amounts of rainfalls during previous months.

The results of 25-year long research have shown that there is climate change, as is confirmed by the increased incidence of heat waves in the last five days. Longer time series of phenological observations will show, whether this extreme events will affect the further development of native ecosystems.

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CLIMATE CHANGE IN THE AREA OF THE CZECH REPUBLIC ACCORDING TO VARIOUS MODEL SIMULATIONS

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Abstract. In recent years, simulations from various regional climate models became available for the area of the Czech Republic, thank to several national or international projects (e.g. the EC FP6 projects CECILIA, ENSEMBLES or VaV). The simulations of the all models were performed according to the IPCC A1B emission scenario with various spatial resolutions. Since models suffer from biases, the model outputs were statistically corrected using the quantile approach of M. Déqué. After correction, RCM outputs were statistically processed and analyzed. In this paper, the differences between models outputs, as well as corrected and uncorrected results, are presented.

Introduction

Regional climate models (RCM) are the state of the art tools employed for downscaling information from the coarse resolution global circulation models (GCMs) to a local scale. The regional climate model ALADIN - Climate/CZ is an adaptation of the Aladin numerical weather prediction model, version CY28T3 (its description can be found e.g. in Farda *et al.*, 2007 or Farda, 2008). Within the EU FP6 project CECILIA, it was coupled with GCM ARPEGE to provide a projection of future climate in two time slices, 2021–2050 and 2071–2100. Within the national project VaV SP/1a6/108/07, other model simulations of ALADIN-CLIMATE/CZ in the resolution of 25 km are available for the continuous period up to 2100 (here, research focused on three time horizons of thirty years: 2010–2039, 2040–2069 and 2070–2099). Further simulations in 10 km resolution are available for RegCM driven by a transient run of ECHAM5 (Halenka *et al.*, 2006), future projections were again given in two time slices: 2021–2050 and 2071–2100. All the future runs are based on the IPCC A1B emission scenario. For analysis, we selected the following elements/characteristics: mean, maximum and minimum temperature, precipitation, wind speed, humidity and global radiation.

Material and methods

Before the analysis of the future climate, the model data were corrected according to validation results carried out for the period of 1961–1990. For this purpose (comparison with the truth), the so-called the technical series were recalculated from station data in the positions of grid points of the model (ALADIN-Climate/CZ grid at 10 km horizontal resolution, for details about the method, see e.g. Štěpánek *et al.*, 2011). All input station observations were quality controlled, homogenized in daily scale and gaps in data were filled (for more information about the pre-processing of station data, please refer to Štěpánek *et al.*, 2009).

According to the relationship between the RCM outputs and the re-calculated station data (technical series for the grid points), outputs of the A1B scenario integrations of the future climate were corrected applying an approach of Déqué (2007) that is based on a variable correction. The model outputs are then fully compatible with the station (measured) data. For the VaV project model outputs, the 25 km resolution is too coarse for some impacts studies (especially those using precipitation). For this reason, model outputs were re-calculated into station locations and corrected in these positions (in the case of precipitation, the model outputs are re-calculated into the locations of the rain-gauge station network which corresponds to a 10 km regular grid density).

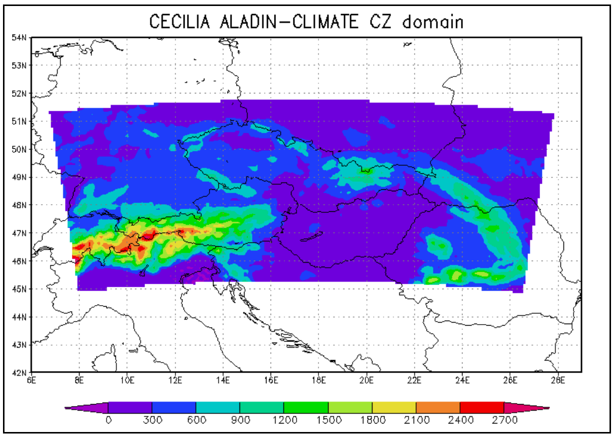

Figure 1. *Integration area and orography details of the ALADIN-Climate/CZ model, as used in the EC FP6 CECILIA project.*

The average series for the Czech Republic were calculated (from all the grid points/stations) from both corrected and uncorrected model outputs and the results were compared.

All data processing was performed by ProClimDB database software for the processing of climatology datasets (free download is possible from www.climahom.eu).

Results and discussion

The mean annual temperature in the area of the Czech Republic calculated from the technical series is 7.3 °C in the period 1961–1990. Results from model simulations for this period are dependent on whether a corrected or uncorrected version is used (Table 1). The largest differences are found in the case of the VaV project simulations (Figure 2). The corrected model produced a temperature near the reality, but the values simulated by the uncorrected model are significantly lower. In spring, the simulated values of the VaV model are lower on average by 2.1°C than the real data. Linear trends differ from 0.28 to 0.54 °C /10 years in the case of annual values in the period 1961–2100. The highest linear trend is found in summer (0.33–0.66 °C/10 years).

The linear trends of the corrected models are higher. The highest increase in temperature is produced by the ALADIN-CLIMATE/CZ model.

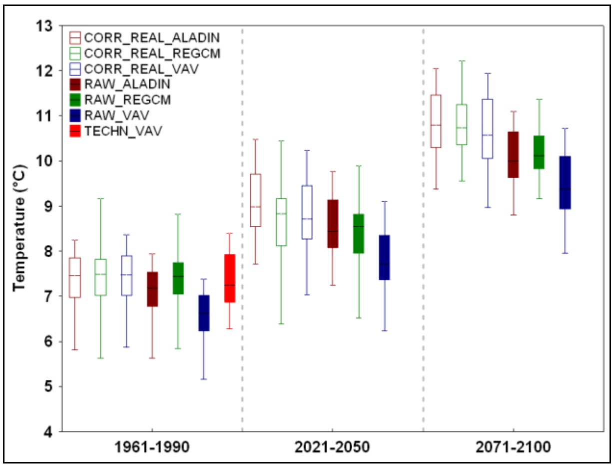

Figure 2. *Annual temperature produced by various model simulations for corrected and uncorrected version in three time periods, 1961–1990, 2021–2050 and 2071–2100.*

Table 1. *Change in annual temperature produced by various models in the period 1961–2100.*

Model	Type	Year		
		1960-90 [°C]	2021-50 [°C]	2071-100 [°C]
ALADIN	corrected	7.4	+1.7	+3.5
	uncorrected	7.1	+1.4	+3.0
RegCM	corrected	7.5	+1.2	+3.4
	uncorrected	7.4	+1.0	+2.8
VaV	corrected	7.4	+1.4	+3.3
	uncorrected	6.6	+1.2	+2.9
Real		***7.3***		

The mean annual sum of precipitation in the area of the Czech Republic is 681.8 mm in the period 1961–1990 (Table 2).

Table 2. *Change in annual precipitation sums produced by various models in the period 1961–2100.*

Model	Type	Year		
		1960-90 [mm]	2021-50 [%]	2071-100 [%]
ALADIN	corrected	657.7	105.0	99.3
	uncorrected	891.1	102.5	97.5
RegCM	corrected	674.4	106.4	113.6
	uncorrected	1240.4	102.3	106.8
VaV	corrected	658.5	107.8	100.5
	uncorrected	787.7	104.5	98.7
Real		***681.8***		

The uncorrected models significantly overestimate the amount of precipitation (Figure 3). For example, the uncorrected version of RegCM gives nearly double the amount. After correction, the difference is only 6 mm. In the case of precipitation, most of the trends are non-significant. Annual and significant trends are produced by uncorrected ALADIN - CLIMATE/CZ model simulations (3 mm/10 years) and by corrected VaV project simulations (1.7 mm/10 years).

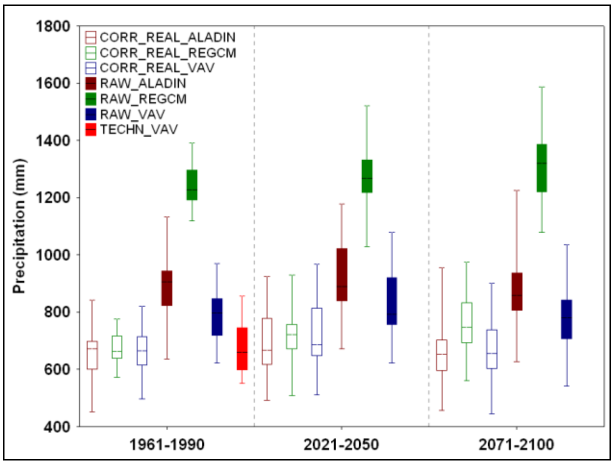

Figure 3. *Annual precipitation sums produced by various model simulations for the corrected and uncorrected version in three time periods, 1961-1990, 2021-2050 and 2071-2100.*

Conclusions

Various model simulations were analyzed for air temperature and precipitation in the area of the Czech Republic. Corrected and uncorrected model outputs were compared. In the case of precipitation, it is especially necessary to correct the model data, because model outputs are given with large biases (e.g. RegCM doubled the amounts).

From the comparison of corrected future climate simulations for the period 1961–1990, we can expect temperatures of 1.2–1.7 °C higher in the near future and about 3.3–3.5 °C higher in the period 2071–2100. Increases in temperature are especially expected in winter and summer and less so in spring and autumn. For precipitation, we find most of the trends statistically non-significant (p=0.05).

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ANALYSIS OF RAINFALL INTENSITY IN THE AREA OF BRNO

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Abstract. The measurements of 18 stations in the area of Brno, in the Czech Republic, were established for the purpose of better management of the city sewerage system. The background for the measurements was to propose optimizations for the sewerage network for occasions of extremely intense precipitation. The automatic precipitation stations (instrument type SR 02) were installed with respect to the prevailing wind direction (inflow), and at least four stations were situated along the main sewerage routes (Prax *et al*., 2010). These measurements were combined with the measurements of CHMI. Before evaluation of the measurements, quality control was executed on the daily sums and 15-minute precipitations and all suspicious data were compared with radar measurements and erroneous input data were removed. From this quality-controlled data, the maxima of precipitation sums for durations of 5, 10, 15 and 60 minutes were calculated for the given time frames (months, seasons and years) and were spatially analyzed.

Introduction

High precipitation often has dramatic impacts on human society, e.g. through material damage or loss of lives. Depending on its amount and duration, the rainfall can result in river flooding (e.g. Moravia, July 1997; Moravia, May 2010; Bohemia, August 2010) or flash floods (North Moravia, July 2009). Spatial variability of the precipitation is usually very high. The Czech Hydrometeorological Institute (CHMI) operates a relatively dense rain gauge network in the Czech Republic (about 800 stations with a mean minimum distance of about 8 km) but the majority of these are only manually operated, thus providing only daily sums. Therefore, the spatial analysis of short-time rainfall is rather complicated. For the requirements of the city sewerage management, measurements of 18 stations (VAK company) over the area of Brno, Czech Republic, have been established in 2003 (see Figure 1). The reason for the measurements was to propose optimizations for the sewerage network for cases of extremely intense precipitation. For our analysis, these measurements were combined with rain gauges operated by the CHMI – represented by two stations in Brno. From the quality controlled data, maxima of precipitation sums for durations of 5, 10, 15, 20, 30 and 60 minutes were calculated for the given time frames (months, seasons and years) and were spatially analyzed. The measurements of VAK stations were also compared with other sources of data: with the automated CHMI stations and with the digitized ombrograms from the period 1948–2000.

Material and methods

Before processing the analysis of the measurements, quality control was carried out on the data of daily and 15-minute rainfall amounts and all suspicious values were compared with radar measurements and subsequently removed from the input data. We used our own approach of data quality control, which combines several methods (ŠTĚPÁNEK *et al*., 2009): (i) the analysis of differences between tested and reference series, (ii) by applying limits derived from interquartile ranges (applied either to individual series, i.e. absolutely or, better, to difference series between candidate and reference series, i.e. relatively and (iii) by comparing tested series values with “expected” values − technical series created by means of statistical methods for spatial data (e.g. kriging). The data was checked with the aid of ProClimDB software (Petr Štěpánek, www.climahom.eu). Data quality control showed that the values from BWSSA stations are reliable. Finally, 32 values were replaced (20 daily sums and 12 15-minute sums).

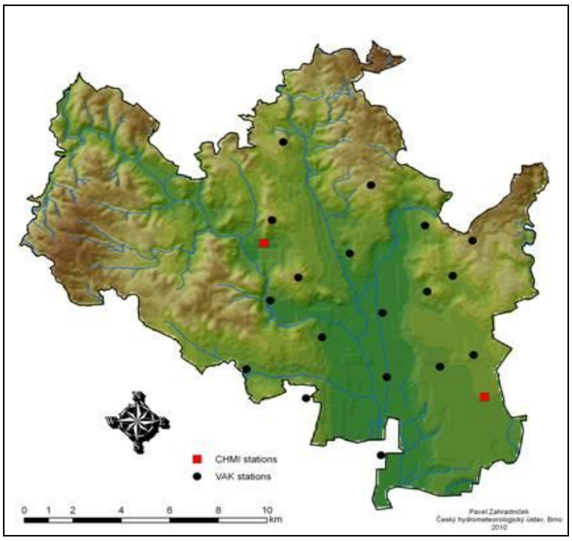

Figure 1. *The location of the dense network of automated rain gauges operated by CHMI and the Water Supply and Sewerage Authority of Brno City.*

Results and discussion

From the 1-minute precipitations, daily sums have been aggregated and coefficients of correlation have been calculated between all stations in the network. As anticipated, the coefficient of correlation decreases with distance and also with altitude. The similarity of daily sums is lowest in the summer months and highest in the autumn. The mean correlation coefficient for May is 0.762; for July, 0.732; for October, 0.874 and the value for the whole period of March–October is 0.817 (see Figure 2).

Precipitation amounts for durations of 5, 10, 15, 20, 30, and 60 minutes were also calculated from 1-minute records. The results were sorted according to the type of station: either VAK (purpose network) or that of CHMI. Furthermore, these values were compared with the ombrograph measurements from the Brno-Tuřany station during the years 1948–2000. The annual distribution of maximum sums for the various rainfall durations is of similar character: the highest sums occur in the summer months (June, July and August). This is mainly due to convective storms. Maximum precipitation sums logically increase with the length of duration. The average maximum annual value for a 5-minute rain on VAK stations during the years 2003–2009 is 8 mm and 7 mm on CHMI stations. The ombrograph (1948–2000) recorded an average value of 7.3 mm. The average maximum intensity of 15-minute rainfall differs from 13.2 to 15.3 mm. This value is slightly lower (12.7 mm) from the ombrograms. The maximum intensity of a 15-minute rainfall during the period of 2003–2009 was 28.8 mm (see Table 1). The differences between the types of stations increase with longer durations. VAK stations indicated approximately 12 % higher intensities during 2003–2009 than CHMI stations and 18 % higher than the ombrograph in the period of 1948–2000. This may be due to the number of stations that were included in the calculation (VAK-18 stations, ČHMI-2 stations). If we analyze the maximum precipitation sums of various durations by individual months, then the differences between the types of stations are much less significant.

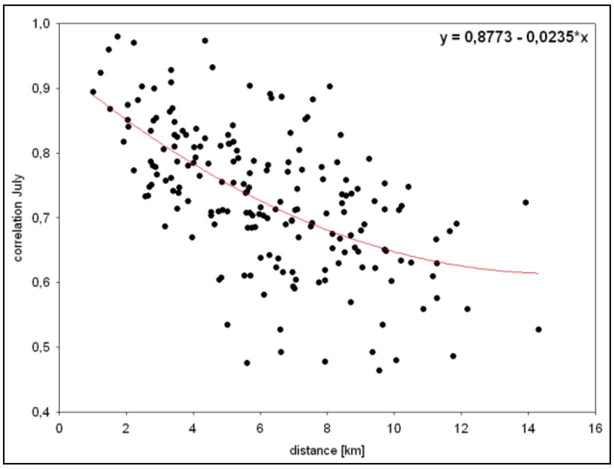

Figure 2. *Spatial correlation for daily precipitation sums in the area of Brno in July in the period of 2003–2009.*

Table 1. *Average (AVG) and maximum (MAX) precipitation sums for durations of 5, 10, 15, 20, 30, and 60 minutes in the area of Brno city according to type of station (VAK – purpose network; ČHMI – official network; both for the period of 2003–2009, and OMBRO –measured by ombrograph between 1948–2000).*

	Station type	5 min [mm]	10 min [mm]	15 min [mm]	20 min [mm]	30 min [mm]	60 min [mm]
AVG	VAK	8.0	12.3	15.3	17.4	19.7	23.2
	CHMI	7.0	10.7	13.2	15.1	17.6	20.4
	OMBRO	7.3	10.5	12.7	14.3	16.6	20.1
MAX	VAK	14.2	22.4	28.8	35.0	44.0	52.0
	CHMI	14.6	20.1	25.5	30.3	37.8	42.7
	OMBRO	15.9	24.4	31.7	34.4	37.6	41.0

The spatial patterns are similar for all the investigated rainfall durations (5, 10, 15, 20, 30, and 60 minutes). The highest annual precipitation sums occur in the southeast part of Brno (see Figure 3). The second area with high annual sums is located in the eastern part of the city of Brno. Conversely, lower values occur in the western part. Differences in the mean maximum intensity for 10-minute rains in the study area can be greater than 3 mm and, for 20-minute rains, greater than 5 mm. Even if we analyze a relatively small area, the difference in monthly sums of individual stations can be quite high. The total precipitation sum was calculated for the period of March to October. The spatial variability can be greater than 70 mm.

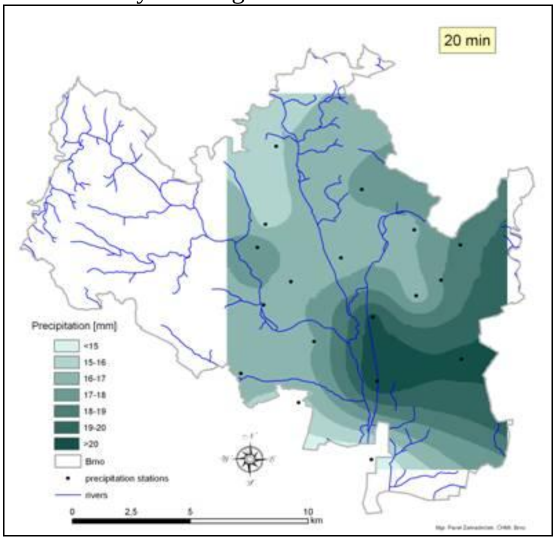

Figure 3. *Average annual maximum precipitation sums in the area of the city of Brno for durations of 20 minutes.*

Conclusions

Based on the VAK purpose rain-gauge network, and complemented by two stations managed by CHMI, it was possible to perform thorough data quality control and spatial analysis of maximum precipitation sums of various durations for the area of the city of Brno. For rainfall durations of 5, 10, 15, 20, 30 and 60 minutes, maximum values for the period of 2003–2009 were calculated. The typical annual cycle of rainfall, with the maximum in the summer months, was presented. Correlation coefficients decrease with increasing distance and differences in altitude. The maximum annual values of rainfall intensity for various durations are higher at VAK stations, however, in the monthly sums, we do not find this feature.

Acknowledgements: The present work was supported by the CzechGlobe project - Centre for Global Climate Change Impact Studies, Reg. No. Cz 1.05/1.1.00/02.0073 and by project support from the Grant agency of the Czech Republic No. 205/09/1297.

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NUMERICAL MODELLING OF AIR FLOW OVER COMPLEX TERRAIN AT ALTITUDE OF 1.2 METER

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Abstract. The speed and direction of wind is affected by many different factors such as: terrain features, surface roughness, convection developing and atmosphere equilibrium state. In this paper we present preliminary results on possibility of mapping the wind field at altitude of 1.2 meter using GIS techniques. Simulations concerning Mazury Lake District were based on digital terrain model (Triangular Irregular Network TIN) which includes different types of terrain coverage, soils, geology, aerodynamic roughness (z_0), and speed and direction of wind measured by Institute of meteorology and water management (IMGW) meteorological stations at altitude of 10 meters above the ground. For different kinds of terrain we used corresponding wind speed change index (Kω) (Romanova, 1977). Obtained hypothetical air flow models allow mapping the wind field at 1.2 meter altitude from the data measured by meteorological stations. Concerned altitude is important for bioclimatic investigations and it corresponds to mean trunk height.

Introduction

In the literature exist many relationships which are used to describe the vertical distribution of horizontal mean wind speeds within the lowest portion of the planetary boundary layer. Although many of them are complex and take into account many parameters in practise for engineering purposes the influence of surface roughness and atmospheric stability are often ignored (Flaga, 2008). Usually, for simplicity terrain rough index equal “0” is substituted in equations in spite of fact that its value corresponds closest to flat water surface. This is because information about both terrain surface roughness and convection of air in a specific local area are not always available and without additional research values of these parameters are not precise. Even in studies of wind flow around city buildings, in which aerodynamic wind tunnels are used, scientists assume some random distributions of structures and though the obtained results do not describe correctly every situation (Sosnowski and Gnatowska, 2010). In the recent years, with development of wind power engineering new papers were published concerning wind flow at the height of wind turbine operational level (80–150 m). Some researchers are using the GIS software (Geographic Information System) together with CFD (Computational Fluid Dynamics) to e.g. study the spread of air pollutions in urban areas) (Chu *et al*., 2005). However not many research papers were dedicated to understanding the wind flow in varied terrain of lake districts, especially at human body level. The presented in the literature models collapse in this nearest to the ground air layer. Some of the papers regarding this problem were published in Soviet Union in 70's and 80's but they were connected with the preliminary investigations on generalized characteristics of dependencies between wind speed and land cover and topography. To our knowledge, no systematic research exists in which scientists are trying to combine GIS techniques with measured empirical data in order to predict the noticeable wind speed.

The goal of presented work is to combine GIS software (ArcGIS 10) with known methods of assessing the wind speed at the altitude of 1.2 meter in order to automatically predict the wind speed in a specific area. The demonstrated analysis was performed for Mazury Plain and Mrągowo Lake District.

Material and methods

The research area is characterised by a large number of varied terrain features and many different types of land cover. Based on the digital terrain model (TIN) and topographic maps we created in ArcGIS software elevation and land cover models. We also added layers with surface roughness, soil humidity and forests. Meteorological data from the years 2001-2010 (speed and wind direction, pressure, temperature) were obtained from meteorological IMGW stations located near by the research area that is in Mława, Olsztyn and Mikołajki (Figure 1).

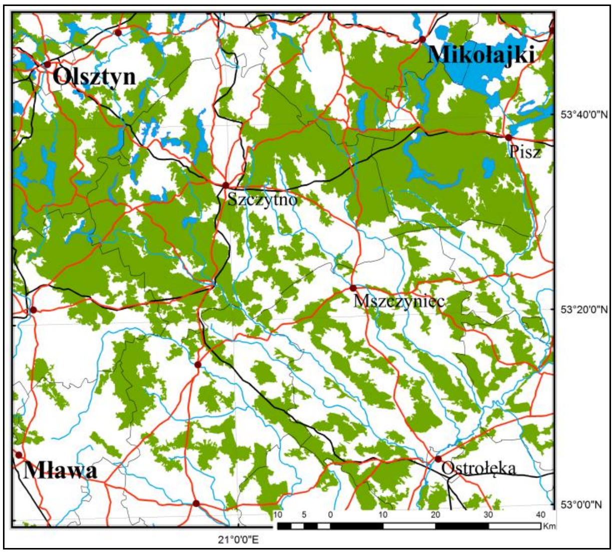

Figure 1. *Research area (own work based on the BDO data).*

Firstly, using the exponential equation (1) we reduced the wind speed measured by wind vane (V_x) to the altitude of 1.2 m (z) [2]:

(1)

$$V_{1,2} = V_x \left(\frac{z_{1,2}}{z_x}\right)^{\alpha}$$

For each terrain roughness index (K) we assigned value of the exponential coefficient α (Table 1), obtained for a ten-minute averaged time series (Żmuda, 1986). Presented terrain roughness index are taken from work of Lorenc.

Table 1. *Terrain roughness index and exponential coefficient α (Lorenc, 1996, Żmuda, 1986 , Tarnowska, 2010).*

K	**α**	**Description of the terrain**
0	0.130	open flat terrain with 0.5 m high obstacles
1	0.140	slightly undulating, open area, with a few groups of trees
2	0.155	slightly undulating, open area, with loose groups of trees
3	0.170	a small forest, village, suburb
4	0.200	area with many obstacles and close to each other barrier; The measuring point is located at least 300 m away from the nearest terrain feature.
5	0.245	regular large obstacle coverage areas (cities, forest)

K - terrain roughness index;
α - exponential coefficient for a ten-minutes averaged time serie.

Secondly, the influence of terrain shape on the change of wind speed has been developed on the basis of publications of Romanova (1977). According to her article the value of wind speed change index ($K\omega$) for the exposed, flat terrain is 1.0. She also enumerated indices for:

- exposed hill ($K\omega$ – 1.3-1.5);
- slope inclination > 3° ($K\omega$ – 0.7-1.3);
- flat slope ($K\omega$ – 0.7-1.4);
- valleys and gorges ($K\omega$ - < 0.6-1.3).

However, presented coefficients refer only to wind speed at altitude of 2 meters above the ground and they are valid only in the situation when equilibrium of the atmosphere is either stale or labile. Wind speed change maps were drawn for the two prevailing wind directions.

Thirdly, in this study we also take into account the impact of forests on the wind speed (Kozłowska-Szczęsna, 1997). Index is describing the wind attenuation inside deep forest areas speed (θ) in the different forest communities, ranges from 0.00725 (sparse fir forests without undergrowth and lower forest floor) up to 0.02890 (mixed or deciduous forests with height of trees up to 8.5 m). Wind speed (V_1) in different forest communities is determined by the relation (2):

$$V_1 = V \cdot \exp(-\theta \cdot x) \qquad (2)$$

where:
V – wind speed on the windward side of the forest [m/s]
x – distance from the edge of the forest to its interior [m].

Results and discussion

The results of this study are in the form of potential wind speed maps. Performed calculations take into account dependences between wind speed and such parameters as terrain roughness index, shape of the terrain and forest cover. Wind speed profiles obtained for the located below the measurement altitude (z < 10) surface boundary air layer depend significantly from the surface roughness index and the distance to the ground (Figure 2). The higher the value of surface roughness the larger is the influence of terrain features on average wind speed. This effect is stronger with the decrease of the altitude. Above the measurement altitude (z > 10) the larger is the surface roughness and the higher is the altitude the faster is the increase in the wind speed.

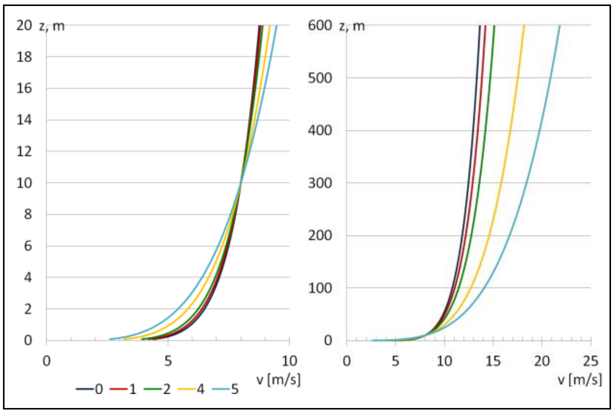

Figure 2. *Wind speed as a function of altitude, terrain roughness index and exponential coefficient α. The presented graphs are based on Table 1 and wind profile equation (1).*

Conclusions

Real scale experimental studies are seldom performed in aerodynamic tunnels. Largely predominant methods used to characterize the wind flow at altitude of 1.2 meter above the ground are measurements on gradient masts. However, the obtained results refer only to situation when the masts are located in flat areas of aerodynamic roughness "0". Present in the literature equations which are used to take into account different terrain shapes are driven from the fluid mechanics, and often there are not enough precise to describe the realistic state of the air boundary layer. Thanks to the dynamic development of GIS techniques we propose usage of automated computational methods in order to determine direction and speed of wind in specific area and air conditions. This problem is important in bioclimatological science, forestry and wind-power industry.

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EVALUATION OF SOIL TEMPERATURES IN HURBANOVO

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Abstract. In our paper, we are presented the evaluation of soil temperatures at climatological station Hurbanovo during the period 1966–2010. There are analyzed results of manual measurements of soil temperatures at the depth of 2, 5, 10, 20, 50 and 100 cm for standard climatological daily terms. Monthly and annual average and extreme characteristics of soil temperatures were used daily averages for its evalution. The average of monthly soil temperatures in the respective month has been compared with long-term average soil temperature of 1966–2010 for classification of single months. The months were devided into seven categories, from extraordinary warm months to extraordinary cold months, according to average monthly soil temperature and its standard deviation.

Introduction

The soil temperature as a result of heat transfer between the atmosphere and the pedosphere is an important feature of the soil thermal regime. The estimate long-term characteristics and the trends of soil temperatures could be to help to further elucidate several ecosystem processes and also may provide more information for design works in technical fields, e.g. in construction.

The soil temperatures at the climatological station Hurbanovo (φ = 47°52', λ = 18°12', H = 115 m a.s.l.) were manually measured in daily climatological terms sporadically since 1893, but place and methods of observation until 1966 were changed several times. Since *2002* the soil temperatures are measured in Hurbanovo also automatically. The average annual air temperature in Hurbanovo is 10.5 and average annual precipitation total is 536.8 mm for the period 1966 to 2010.

The mechanical composition of soil (soil texture) has great influence on the soil temperatures. The mechanical analyze of soil in Hurbanovo was made by Petrovič, according to Novak classification (Petrovič, 1960), that takes into account only the clayey particles, are at depths of 5, 10, 20 and 50 cm clayey soil (medium), while soil depth of 40 cm and 100 cm falls under classification of the heavy clay loam. Thus soil temperatures were measured to a depth of 1 m the soil profile, which contains medium to heavy soils. Basically, it is kind of difficult soil that conducts heat better, it is accumulated at the base, and less is heated during the day and less cooled at night. The soil thermometers at depths of 100 are often in levels of the ground water. The water level occasionally creeps up to 10 cm, which affects the characteristics of soil temperatures in Hurbanovo, because increasing of soil moisture increases its thermal conductivity.

Material and methods

The daily, monthly and annual climatological characteristics of soil temperatures were analyzed for the climatological station Hurbanovo during the period 1966 to 2010. This period was chosen because in this period were made continuous climatological standard manually measurements of soil temperature at all evaluated depths (of 2, 5, 10, 20, 50 and 100 cm) below the grass surface in three climatological terms (7, 14 and 21 local mean time) except of the depth of 100 cm, which is it sufficient to measure the temperature once a day at 14 local mean time. There are used objectively controlled data from the database SHMI in Bratislava for to solve the problems. The average and extremes of monthly temperatures TSM (°C) are computed on the basis of average daily values TSD (°C) of three manually measurements in the standard daily climatological terms. The thermal characteristics of the average monthly temperatures of the specified soil layers were evaluated by comparing of differences ΔTS between the values of the average soil temperature of the given month of the selected year and the average soil temperature in the same month of the entire assessment period (1966 – 2010) with value of standard deviation σX. The average monthly temperatures of soil temperature and their relation to the standard deviation of the long-term series of average monthly soil temperature were tested according to the dispersion analysis and then they were classified and ranked into seven categories, so as stated Table 1.

Table 1. *The thermal classification of monthly characteristics of soil layers, where ΔT is difference between average monthly soil temperature in the selected year and the long-term average, σX is standard monthly deviation for the long-term period.*

Criterion	**Thermal classification of soil layers**
$\Delta TS_M \leq \pm\sigma_X$	Month temperature normal (N)
$\Delta TS_M \leq 1.5\,\sigma_X$	Warm month (W)
$\Delta TS_M \leq 2.0\,\sigma_X$	Very warm month (Vw)
$\Delta TS_M > 2.0\,\sigma_X$	Extraordinary warm month (Ew)
$\Delta TS_M \geq -1.5\,\sigma_X$	Cold month (C)
$\Delta TS_M \geq -2.0\,\sigma_X$	Very cold month (Vc)
$\Delta TS_M < -2.0\,\sigma_X$	Extraordinary cold month (Ec)

The temperature categories were assessed for every depths and every month of the period 1966 to 2010.

Results and discussion

The long-term annual averages of soil temperature are changed from 11.3 °C (20 cm) to 11.6 °C (5 and 100 cm). The warmest months according to average soil temperatures are July (2, 5, 10, 20 cm) and August (50 and 100 cm), the coldest months are January (2, 5, 10, 20, 50 cm) and February (50 and 100 cm) - (Table 1). The average annual amplitude decreases with depth from 2.9 °C (2 cm) to 12.6 °C (100 cm) - (Table 1). Extraordinary warm months were occurred 35 times, warm months were occurred 96 times, very cold months were occurred 76 times and extraordinary cold months were occurred 19 throughout the depth profile. Total 540 months was evaluated in 6 different layers. In our paper presents detailed results of the temperature classification of months throughout the test soil profile – Table 2. The warmest year was occurred 2007 with absolute extremes in January and February when the soil temperature were evaluating extraordinary warm in all tested depths, except for the month September, when the layer 2 cm was evaluated as a cold. The normal monthly temperatures were only from October to December in all tested depths. The other month in 2007 were evaluating warmer than normal.

Table 2. *The extremely and average characteristics of soil temperatures in Hurbanovo during the period 1966–2010.*

Dep.	Character.		Jan	Feb	July	Aug	Year
2 cm	Avg	[°C]	**0.0**	1.2	**22.9**	22.1	11.5
	Max	[°C]	3.6	5.3	26.1	26.1	13.1
		Year	2007	2007	1967	2003	2007
	Min	°C	-2.5	-1.5	20.3	19.4	10.1
		Year	1969	1991	1978	1987	1980
5 cm	Avg	[°C]	**0.2**	1.3	**22.7**	22.1	11.6
	Max	[°C]	3.7	5.3	25.7	25.0	13.1
		Year	2007	2007	1967	2003	2007
	Min	[°C]	-2,3	-1.5	20.4	19.3	10.2
		Year	1969	1991	1984	1987	1980
10 cm	Avg	[°C]	**0.2**	1.3	**22.7**	22.1	11.6
	Max	[°C]	3.9	5.3	25.0	24,6	13.0
		Year	2007	2007	1967	2003	2007
	Min	[°C]	-2.2	-1.2	20.0	19.2	10.0
		Year	1979	1991	1984	1987	1980
20 cm	Avg	[°C]	**0.2**	1.3	**22.7**	22.1	11.3
	Max	[°C]	4,1	5.4	24.3	23.6	12.9
		Year	2007	2007	1967	2003	2007
	Min	[°C]	-1.3	-1.3	19.3	18.6	9.9
		Year	1969	1991	1984	1987	1980
50 cm	Avg	[°C]	**3.1**	**3.1**	19.7	**20.1**	11.6
	Max	[°C]	5.7	6.3	21.6	21.8	13.0
		Year	2007	2007	2010	2003	2007
	Min	[°C]	1.0	0.8	17.8	18.1	10.4
		Year	1969	1981	1984	1987	1980
100 cm	Avg	[°C]	**5.6**	4.9	17.2	**18.2**	11.6
	Max	[°C]	8.0	7.7	19.1	19.8	13.2
		Year	2007	2007	2010	2007	2007
	Min	[°C]	4.3	3.2	15.7	16.7	10.4
		Year	1973	1981	1980	1987	1980

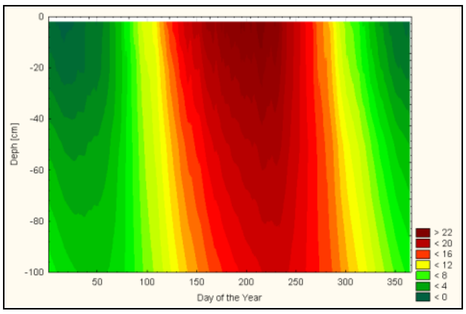

Figure 1. *The soil variations with time and depth in Hurbanovo (1966–2010).*

Table 3. *The frequency of monthly temperature characteristics at the depth of 20 cm in Hurbanovo in the period 1966–2010.*

	E	V	W	N	C	Vc	Ec	ST	σ_X
I	3	2	2	30	7	1	0	0.8	1.29
II	1	3	5	27	8	1	0	1.5	1.64
III	0	2	6	27	7	3	0	5.2	1.65
IV	1	2	2	37	1	1	1	10.8	1.05
V	0	0	6	33	4	1	1	16.4	1.11
VI	0	4	0	36	4	1	0	19.9	1.04
VII	0	1	2	37	4	1	0	21.6	1.11
VIII	0	0	3	38	3	1	0	21.3	1.11
IX	0	0	3	41	0	1	0	17.2	1.08
X	0	0	4	39	1	1	0	12.0	1.26
XI	0	0	4	37	4	0	0	6.5	1.40
XII	0	0	3	38	4	0	0	2.5	1.33
Year	5	14	40	42	47	12	2	11.3	0.62

The coldest years was occurred 1980. In the year 1980 it had been the minimal annual average of soil temperatures in all tested depths. There in the tested depths were 7 months with more cold soil temperatures than normal, however was never once occurred an extraordinary cold. From the point of view of thermally evaluated months there is the interesting the year 1987, when were the soil to the depth of 20 cm evaluated as extraordinary cold in two months – March and May. There are the coldest days are 18th to 21st January and the warmest day is 2nd August in the long-term averages of daily soil temperatures (Figure 1). The results of linear trend analyze show that trend of annual average of soil temperatures in all tested layers to show an upward trend (Figure 2).

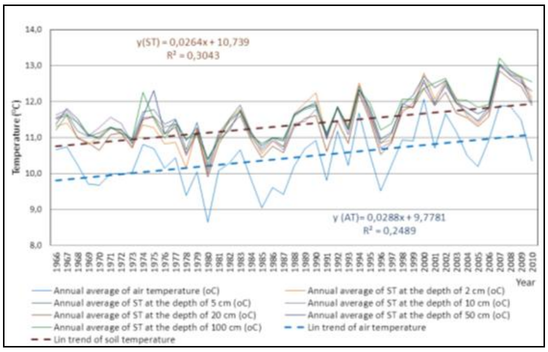

Figure 2. *The long-term series of annual averages of soil temperatures and of air temperature in Hurbanovo (1966–2010).*

Conclusions

The performed analysis is a contribution to the agroclimatological analysis with applications mainly in agriculture and construction.

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RECONSTRUCTION OF LONG-TERM SERIES OF SOIL TEMPERATURE IN HURBANOVO

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Abstract. The paper deals with investigating of the reconstruction of long-term series of soil temperature measurements according to the long-term series of measuring air temperature at climatological station Hurbanovo during the period 1901–2011. The evaluated monthly and annualy series of soil temperature consist of the manually measured data in the period since at least 1951 to 2011, and supplemented with the data until 1901. The manually gained values of soil temperature were measured at the depths of 2, 5, 10, 20 and 50 cm in standard climatological observation terms at 7:00, 14:00 and 21:00 local mean time, in the depth of 100 cm at 14:00 local mean time. The supplemented data in the reconstructed long-term series are calculated by the method of modeling causality.

Introduction

Soil temperature and its variation at various depths are unique parameters that are useful in understanding both the surface energy process and regional environmental and climatic conditions. Soil temperature is very important in regulating ecosystem processes, yet it often difficult and costly to measuring.

One of the possible reconstructions of soil temperature series is using a known series of air temperature in the same region, because it has a direct effect on heat transfer in the soil. Therefore, we were looking for suitable mathematical and statistical methods that allow us to supplement the shorter or interruption series of measurements of the soil temperature.

Material and methods

The soil temperatures were chosen from the climatological station Hurbanovo, which has the longest series of climatological and agrometeorological observations in Slovakia for the complementarity of the data. Monthly and annual characteristics of the manually measured soil temperatures are calculated from the average daily temperatures determined as the arithmetic mean of soil temperatures at the depths of 2, 5, 10, 20 and 50 cm in the three climatological terms characterized by value of temperature at 14:00 local mean time.

Table 1. *Overview of available data about soil temperatures at standard assessment of depths under grass surface in Hurbanovo from the database SHMI in Bratislava.*

Depths	Evaluated manually measured data
2 cm	1966 – 2011
5 cm	1950 – 2011
10 cm	1951 – 2011
20 cm	1950 – 2011
50 cm	1954 – 2011
100 cm	1954 – 2011

The values of soil temperatures measured in standard climatological terms in local mean time are objectively validated data from the climatological database SHMI in Bratislava for the period 1950–2011(Table 1).

The average daily soil temperature at the depth of 100 cm during the day is virtually unchanged and it is The average values of monthly soil temperatures TS_M (°C) and annual soil temperatures TS_A (°C) are computed from three manually measurements in standard daily climatological terms on the basis of average daily values of soil temperature TS_D according to the arithmetic mean method, e.g. $TS_D = (TS_7 + TS_{14} + TS_{21})/3$.

The reconstruction long-term series of average monthly and annual soil temperature data for the period 1901 to 2011 according to air temperature data is designed using the method of modeling causality.

The estimate of long-term trends of soil temperatures are calculated by regresion analyze.

Results and discussion

The result is the design and verification methodology for supplementing and extending long-term series of average annual and monthly values of soil temperatures, with average annual and monthly air temperatures. The basis of the applied methodology is to determine the coefficients of the linear regression equation B0 and B1 expressing the relationship of the average values of air temperature and soil temperature and are the basis for estimating missing values of long-range average values (Table 2 and 3).

The correlation between long-term series of average air temperature and long-term series of soil temperatures at specified depths is sufficiently high. The correlation coefficients for the series of the annual average temperature values are exceeding value 0.9 (Table 2). The correlations decrease from 20 cm depth, because increasing the phase shift of annual extreme temperature operation is due to the heat distribution patterns in the soil (Figure 1).

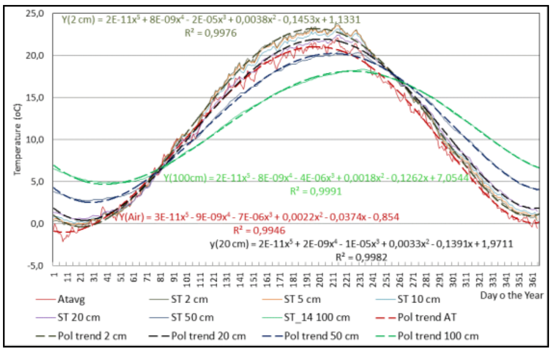

Figure 1. *Annual variation of average daily values of air temperature and soil temperatures at depths of 2, 5, 10, 20, 50 and 100 cm in Hurbanovo during the period 1966 to 2011.*

Table 2. *The results of determining the parameters of the reconstructed series of annual average of soil temperature at the site Hurbanovo and the comparisons to the accuracy of the estimated long-term series (PEst and VEst) for the results of manual measurements (Petrovič, 1960 - Petr, Valuš 1968 - Val).*

Depth of soil [cm]	Regression coefficients		Corr. coeffi-cients	Comparisons of annual averages of soil temperatures at selected depths [°C]			
	B1	B0		Petr	PEst	Val	VEst
2	0.844	2.666	0.951	x	x	x	x
5	0.853	2.642	0.954	10.7	10.8	11.1	11.1
10	0.822	2.919	0.946	10.8	10.8	11.1	11.0
20	0.810	2.883	0.959	10.7	10.8	10.9	10.9
50	0.763	3.619	0.933	10.9	10.7	11.1	11.2
100	0.760	3.66	0.906	x	x	11.3	11.1

Lower, but statistically significant correlation dependence to the monthly average temperature of the air and the various soil layers. This correlation does not decrease dependence below value 0.746 at the depth of 20 cm. The annual course of correlation coefficients at the depth of 20 cm has the highest correlation dependence monthly values in the transitional seasons, peaking in March, September and October and lowest during the winter months of December and January (Table 3). This fluctuation is caused by changes in the difference of the absolute values of air temperature and soil temperature in the layer of 20 cm and mainly due to the phase shift of annual extremes of temperature. Climatic factors have significant influence to reduce the correlation of monthly values. It is the influence of rainfall, site conditions, and especially seasonal coverage of the soil surface with snow cover.

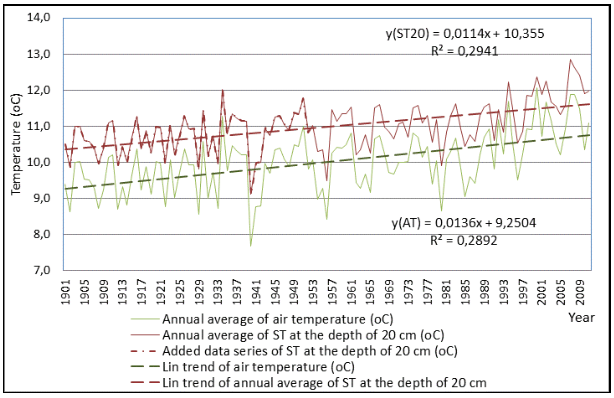

Figure 2. *Annual long-term series of soil temperature (ST) at the depths of 20 cm and air temperature (AT) in Hurbanovo for the period 1901–2011 with their linear trends.*

The results of the reconstructed long-term series of average annual values of soil temperature at a depth of 20 cm and its trend analyze are visualized at the Figure 2.

The results of long-term reconstruction series were verified by comparing the corresponding average values of soil temperature for manual measurement values Petr by Petrovič (1921–1937 and 1940–1944) and Val by Valovič (1931–1960) and series of estimated values PEst and supplemented series VEst calculated for the same periods - Table 2 and 3. The compared long-term series of average values of soil temperatures show good agreement and confirm the correctness of the method of reconstruction of long-term soil temperature ranges.

Table 3. *The results of determining the parameters of the reconstructed series of monthly average of soil temperature at the 20 cm of the depth at the site Hurbanovo and the comparisons to the accuracy of the estimated long-term series (PEst and VEst) for the results of manual measurements (Petrovič, 1960 - Petr, Valuš 1968 - Val).*

Depth of soil [cm]	Regression coefficients		Corr. coeffi-cients	Comparisons of annual averages of soil temperatures at selected depths [°C]			
	B1	B0		Petr	PEst	Val	VEst
I	0.410	1.186	0.788	0.5	0.4	0.7	0.5
II	0.441	0.897	0.835	0.5	0.7	0.6	0.9
III	0.817	0.439	0.907	4.2	4.1	4.4	4.2
IV	0.609	4.080	0.879	15.6	15.6	15.6	15.8
V	0.673	5.345	0.905	18.9	18.9	19.3	19.2
VI	0.686	6.601	0.844	20.9	21.1	21.3	21.2
VII	0.680	7.294	0.856	20.4	20.7	20.8	20.7
VIII	0.670	7.729	0.869	20.4	20.7	20.8	20.7
IX	0.644	7.111	0.911	16.9	17.1	17.3	17.2
X	0.721	4.410	0.921	11.5	11.8	11.4	11.5
XI	0.624	3.456	0.892	6.4	6.5	6.4	6.6
XII	0.510	2.189	0.746	2.1	2.1	2.6	2.5
Year	0.810	2.883	0.959	10.7	10.8	10.9	10.9

Conclusions

With the proposed methodology there has been restored long-term average annual series of soil temperatures at depths of 2, 5, 10, 20, 50 and 100 cm in Hurbanovo locality with an estimated since 1901. The presented results and discussion show the possibility of application of the presented methods for refill and addition of long-term average annual temperature series of land through long-term series of air temperature in a certain area, resp. an analogous region to the stratification and quality of soil and climate characteristics of the region.

The presented method of reconstruction long-term series of monthly (annual) average soil temperatures would be appropriate to incorporate the effect of precipitation conditions on soil surface in the future.

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CHANGES IN WEATHER-SPRING BARLEY YIELD RELATIONSHIPS BETWEEN 1869–1913 AND 1961–2007

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Abstract. This study focuses on the changes in the yield stability of spring barley over the past 140 years and changes in the weather-yield relationships. There was a considerable increase in the inter-annual variability of the absolute yields over Czech Republic territory. The study also found that the sensitivity to inter-seasonal temperature increase was much more pronounced during 1961–2007 than at the end of the 19th century and that an increase of the mean temperature by 1°C led to yield decreases of up to 10 % for spring barley in three tested districts. In contrast, the same temperature increase during the 1869–1913 period would have caused yield decreases of up to 5 %. The negative effects of increasing temperature and drought on grain yield were most pronounced in the warmest and driest region.

Introduction

Barley (*Hordeum vulgare* L.) yields are limited in northern Europe by cool temperatures (Holmer, 2008) and in southern Europe by high temperatures and low rainfall (Reidsma and Ewert, 2008); therefore, the response to warming within these regions is likely to differ.

This study uses previously unavailable yield and climatic data within a small but relatively diverse region of Central Europe. These data provide a new source of information about annual yields and climatic conditions on a district level (an administrative unit of approximately 1,000 km^2) for two periods (1869–1913 and 1961–2007).

Material and methods

The study area is located in the southeastern part of the Czech Republic (eastern Central Europe) between 48°37'–49°30' N and 15°29'–17°55' E. The region includes three districts (Brno-venkov – total area 1,109 km^2, arable land 47 %, Břeclav 1,173 km^2, 53 % Třebíč 1,516 km^2 and 56 %) for which yield data were collected between 1869–1913 and 1961–2007.

The monthly mean and maximum air temperatures, precipitation totals and drought severity expressed in terms of the Palmer Z-index (Palmer, 1965) were used as the climatic predictors of the yield and its variability. A more detailed description of the Palmer Z-index and the drought climatology of the region can be found in Trnka *et al*. (2009a, b). The monthly climatic data for each district were based on observations from up to 28 climatological stations within the district itself and its vicinity. The data layers of the interpolated monthly data were then aggregated only for the area of arable land, and the spatial means for each climatic variable and each district were calculated. To ensure comparability of both periods in terms of station density, approximately the same number (and location) of climatological stations was used in both periods. The mean temperature and precipitation totals (and consequently the Palmer Z–index) were available from the first half of the 19th century onwards and covered both periods well. The systematic measurements of maximum temperature started only in the late 1870s, and therefore only the period of 1879–1913 could be analyzed for this particular variable. For the 1869–1913 period, the arable land distribution was based on The Third Austrian Military Survey, which took place between 1876 and 1878, whereas for the period of 1961–2007, the Corine land cover database CLC2000–9/2007 at a 100-m resolution was used.

To evaluate the relationship between the yield series and climate, we applied multiple linear regressions with the first differences in yield (ΔYield) as the response variable and the first differences in mean temperature (ΔTmean), maximum temperature (ΔTmax), and Palmer Z-index (ΔZindex) as predictors. The method is in detailed described by Trnka *et al*. (2012).

Results and discussion

Table 1*. The sensitivity of the barley crop yields to a 1°C increase in the mean (T_{mean}) and maximum temperatures (T_{max}) and the change of Palmer Z-index (Z_{index}) by "–1", which corresponds to increased dryness. The yield trends in* ***bold italic*** *are significant at the 0.01 significance level, whereas those in* ***bold*** *are significant at the 0.05 level.*

Change of the yield predictor	Time period	Change of the Yield (%) in the district		
		Brno venkov	Břeclav	Třebíč
T_{max}	1869–1913	–0.7	–1.1	–2.6
	1961–2007	***–8.1***	***–10.2***	–2.2
T_{mean}	1869–1913	**–5.0**	**–4.4**	–2.5
	1961–2007	***–7.5***	***–9.9***	–2.2
Z_{index}	1869–1913	2.2	3.1	1.9
	1961–2007	***–9.2***	***–6.9***	**–4.3**

Figure 1 gives examples of the Tmean–yield and Zindex–yield relationships for three districts representing the temperature gradient of the studied area and shows that the first period examined (1869–1913) had climate-yield relationships different from those of the second one (1961–2007). The sensitivity to temperature increase was much more pronounced during the 1961–2007 period than it was during the 1869–1913 period. The 1961–2007 period was notably warmer for all regions than the 1869–1913

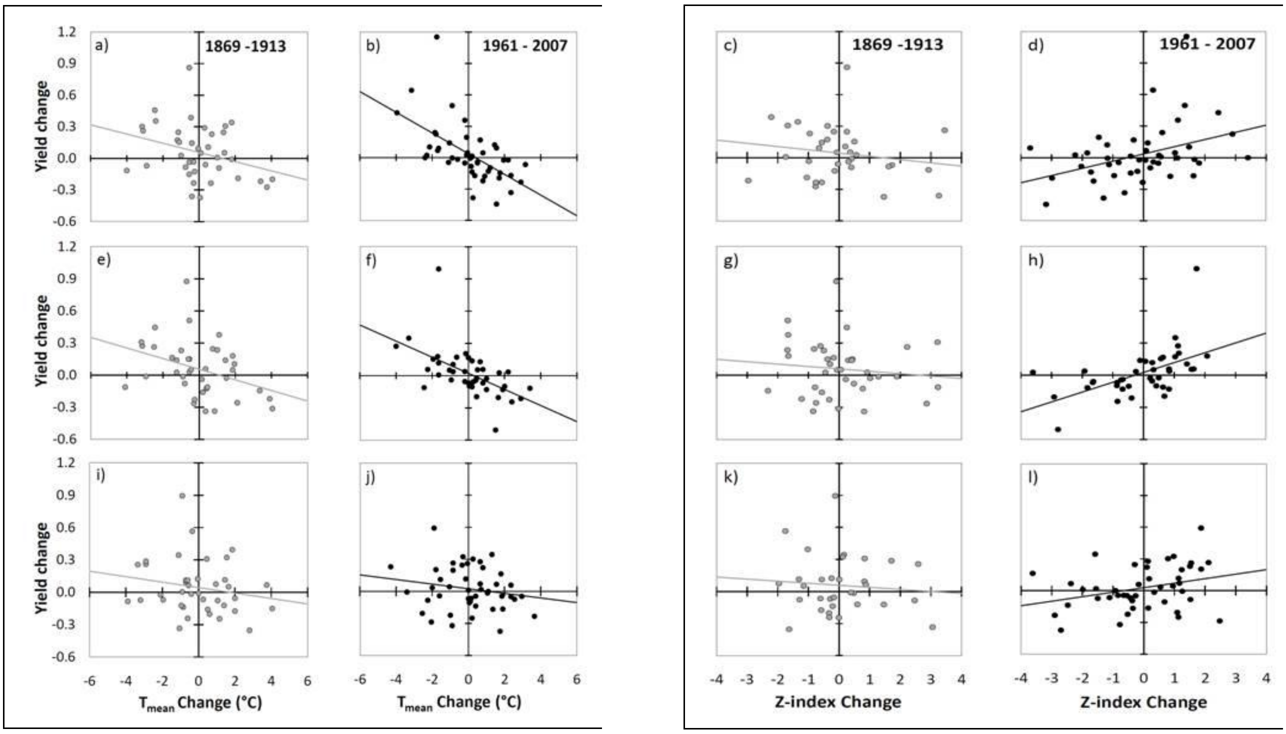

Figure 1. *Relationships among the annual differences in mean temperature (Tmean) during the May–June period (a, b, e, f, i, j) and Z-index (c, d, g, h, k, l) and the annual deviations of barley yield during 1869–1913 and 1961–2007) at districts Břeclav (a-d), Brno venkov (e-h) and Třebíč (i-l).*

period, and an increase of 1 °C in the mean temperature led to yield decreases between 2.2 and 9.9 % for spring barley. In contrast, the same temperature increase during the 1869–1913 period would have caused a yield decrease between 2.5 and 5.0 % (Table 1).

Conclusions

Although the geographical extent of the study is limited, the significant changes that occurred between 1869 and 2007 and the role of increasing temperature and dryness can be found in many parts of Europe. The yields for spring barley have increased in the region studied by factor of 2–3 since the late 19^{th} century and there has been a considerable increase in the inter-annual variability of absolute yields. When the variability was evaluated in relative terms (i.e., compared with the yield level), it showed no change or insignificant increases in the warmest and driest regions. It should be stressed that the temperature and precipitation showed trends toward warmer and drier conditions. In the same time period, the largest reductions in grain yield from increased temperatures and droughts generally occurred in the districts having the highest temperatures and driest conditions. The sensitivity to inter-seasonal temperature increase was much more pronounced during 1961–2007 than during 1869–1913. The yields have also become much more sensitive to drought during May and June. These findings indicate that the warming that occurred within the region during the 20^{th} century affected the climate–crop yield relationship.

The increasing vulnerability of barley production to increasing temperatures over time should be urgently addressed by plant breeders, as there are relatively few adaptation options available to farmers except switching to other crops.

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MICROCLIMATIC CONDITIONS OF VENTAROLS IN BOREČ HILL

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Abstract. In the period from November 29, 2011 to March 28, 2012 microclimatic conditions of fissures in phonolite massive were monitored. Fissures form a phenomenon known as ventarols. High accumulation capacity of the rock causes exhalations of warm and moist air in winter. The highest temperature of outflowing air was recorded in the period from 11/29/2011 to 03/28/2012 and it was 15.5 °C. The total temperature drop for the observation period was 4.8 °C, or 4.1 °C as the case may be. The largest difference in average temperature of inflowing and outflowing air was 26.6 °C and it was recorded during the very frosty weather of February 12, 2012. Microclimatic regime of the system creates favorable conditions for *Targionia hypophylla* L., whose developmental stages are closely tied to specific features of the airflow in the fissures.

Introduction

Temperature conditions in the Czech Central Mountains are significantly influenced by the topography of the landscape. Their closed position from the north and the opened position to the south create a specific temperature conditions for the occurrence of thermophilous vegetation. Boreč hill (446 m above sea level) belongs to the Milešovská part of the Czech Central Mountains and to Lovoš Highlands. On the nothern side, the slopes of Boreč are mainly covered with scree formed in frost erosion. The hill body is penetrated with network of fissures created by tension when the phonolite rock was cooling down. Thermal regime of the scree slopes is mainly dependent on the specific microclimate of the scree. The temperature of the surface fluctuates, but conditions inside the scree are humid and have a balanced temperature, which leads to airflow and exhalations (Kubát, 1971). Besides its geological aspect, Boreč's fauna and flora are also interesting. There is a number of protected plant species; particularly rare *Targionia hypophylla* L. Kubát (1974) describes few locations outside the Czech Central Mountains with ventarols – Kotelní jáma valley in the Giant Mountains, Malý šišák, Malá Čertova zahrádka etc. Outside the Czech Republic, ventarols are abundant and often described mainly from the geological point of view.

Material and methods

The research focused on the evaluation of thermal conditions and airflow in the fissure systems of the Boreč hill (N50 30.851 E13 59.322). Temperature sensors PT100 were placed in selected locations and the temperature of flowing air in the fissures was measured at hourly intervals in the period from November 29, 2011. At the same time, the ambient air temperature was measured 2 m above the ground. Speed and direction of airflow in the fissures was measured manually using anemometer Stoppani. Particular locations were chosen with regard to winter exhalations and relief of the hill. The locations included places with winter outflow (1, 2 and 3) and winter inflow with various strengths of the flow. On Location No. 1, a sensor was damaged on January 9, 2012. The locations of sensors were targeted by a GPS navigation system and their positions marked in the map.

Results and discussion

The present experimental results have proved the high thermal storage capacity of the fissure system. In the period from 11/29/2011 to 03/28/2012, the temperature of expelled air was fluctuating at Location No. 2 between 15.5 °C and 8.9 °C, and No. 3 between 15.5 °C and 9.3 °C. The lowest temperature of exhaled air was not recorded at the end of the experiment on March 28, 2012, but on January 12, 2012 at Location No. 2, and March 24, 2012 at No. 3. The temperature of exhaled air was influenced by the then weather situation and the season of year. During the winter, the hill was cooling down and the temperature of outflow at No. 3 dropped from the beginning to the end of experiment by 4.1 °C; the drop at No.2 was by 4.8 °C. There are also visible correlations between the ambient and the exhaled air temperature, which became evident with a mild delay. Delay, frequency and severity of correlations depend on the structure and length of the route that the air has to pass through the fissures. Váně (1992) assumes that the ingenous mass of Boreč extends to the depth of 200 to 300 m, and he estimates the cubature of fissures to be hundreds of m^3.

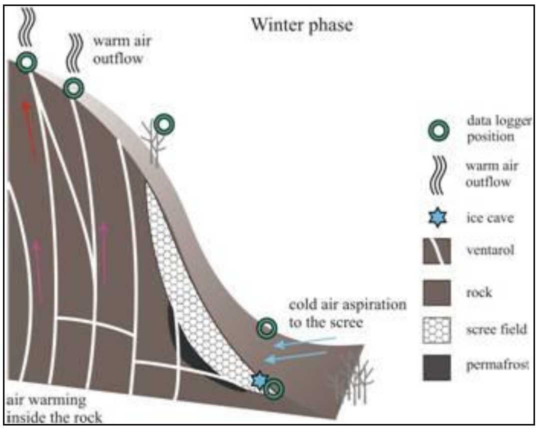

Figure 1. *Scheme of the principle of winter airflow in the fissures.*

Because of the stability and power of the outflowing air, we can conclude that the inflowing air does not flow through the massive in the shortest way (which is only about 61 m), but it drops to the depth of the hill, where it slowly warms up and rises through a complex of fissures to the place of exhalation. Therefore, the connection of a particular inflow and outflow location can not be proved.
According to the mean temperature of inflowing air and outflowing air, the greatest temperature difference of 26.6 °C was recorded during heavy frosts on February 12, 2012. In such periods, water vapor forms hoarfrost on objects nearby ventarols (Figure 2).

Figure 3 shows three different modes of the observed ventilation:

– *Period A*, the temperature of exhaled vapor slowly decreases due to cooling of the rock; time series No. 2 correlates with the ambient air – with the reduction of temperature difference, the flow ceases, and the temperature inside the ventarol influences the cooler ambient air.

– *Period B*, the largest difference between temperatures inside and outside of the system occurs during heavy frost season – the upward flow is stable and exhalations are strong.

– *Period C*, the outside air temperature is equalized with the temperature inside the hill – the flow direction is influenced by slight variations in atmospheric temperature (turning point around 14 to 16 °C), the system also fluctuates under influence of particular weather conditions (Váně 1992).

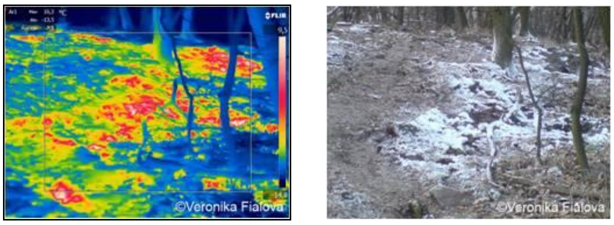

Figure 2. *Temperature scheme of winter outflow on the hill of Boreč in the IR and VIS spectre.*

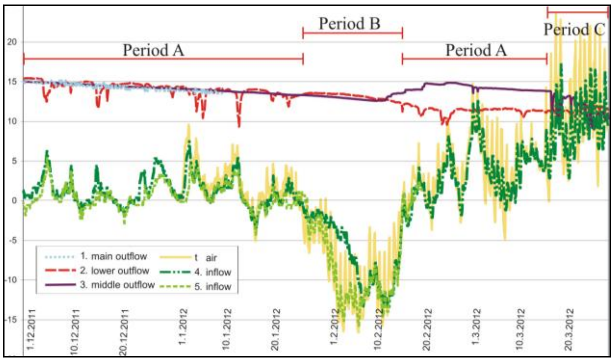

***Figure 3**. Air temperature [°C] in the fissures of the hill of Boreč.*

Airflow velocity in fissures depends mainly on the inside and outside temperature gradient in the system. The exhaled air velocity in the biggest and strongest ventarole No.1 was 3.6 m.s^{-1} during manual measurement on 9 January, 2012 at 11:00. The air temperature outside the ventarol was 2.4 °C. During further measurements, the velocity of outflow decreased with increasing ambient air temperature; and during observations on 03/28/2012 at 11:00, the opposite direction of air flow occurred. The velocity of airflow was 0.8 m.s^{-1}. The variations in airflow regime can be caused by reasons described below:

– Balch effect, the influence of gravity on airflow according to its specific weight – cold air is heavier than warm air and it flows out at the bottom of the scree (Balch, 1990).

– Chimney effect, air in the fissure system warms up and rises; it is replaced by cold air sucked in from the surrounding debris (Wakonigg, 1996). A similar mode was observed in dynamic caves.

– The influence of latent heat, when the phase of water changes (evaporation, melting and sublimation), latent heat is consumed and it can cause cooling of environment (Wakonigg, 1996).

– Interaction with the atmosphere, changes in flow may occur due to the current weather situation (Harris, 1998).

Occurrence and development of *Targionia hypophylla* L. is closely tied to the thermal regime of the fissure system. Changes in flow represent increase or decrease in relative humidity and air temperature to which Targionia responds very quickly. During the dry and warm weather, the thallus is shrivelled and black (Figure 4b). Targionia starts to grow again at the time when the warm and humid air is exhaled, which happens out of the growing season of the vast majority of plant species (Figure 4a).

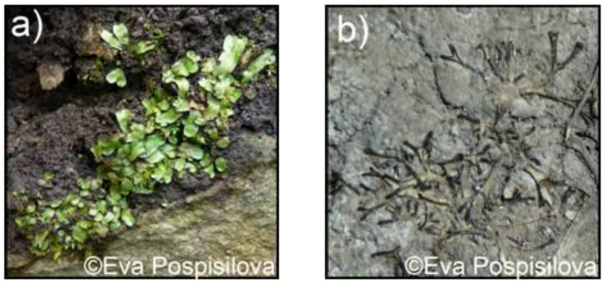

Figure 4. *Vegetation periods of Targionia hypophylla L.*

Conclusions

– High thermal storage capacity of the fissure system has been proved.

– The highest recorded temperature of exhaled air in the period from 29/11/2011 to 28/03/2012 was 15.5 °C.

– The overall decrease in exhaled air temperature during the reported period was by 4.1°C at the location No. 3, and by 4.8 °C at location No. 2.

– The largest difference in temperature average of inflowing and outflowing air was 26.6 °C and it was recorded during the heavy frosts on February 12, 2012.

– Velocity and direction of flow is dependent on the temperature gradient inside and outside the system.

– Developmental stages of *Targionia hypophylla* L. are dependent on temperature and humidity of exhaled air.

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CHANGES IN NOCTURNAL MELATONIN SECRETION AS A RESULT OF TOURISM ACTIVITIES IN A DIFFERENT LIGHTING ZONE

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Abstract. Melatonin (MEL) is a hormone produced by the pineal gland. It is mainly is responsible for the functioning of the sleep-awake diurnal cycle. MEL production occurred mainly in a nocturnal hours. A previous studies shows that daylight generates changes in MEL cycle. Making tourism activities (even within the same time zone) involves changes of the environmental-lighting stimuli which acting on the body. Field experiment was conducted to investigate the changes of the daily melatonin production observed as a result of tourism in different lighting zone. The experiment was performed in a period of polar day in Norway on volunteers from moderate lighting zone.

Introduction

Solar radiation has a great impact on the functioning of the human body, particularly on the processes of thermoregulation (Blazejczyk *et al*., 2000) and hormonal secretion (Zawilska and Nowak, 2002). A significant correlation between lighting conditions and pineal gland hormone – melatonin (MEL) is observed as well (Karasek, 1997). Maximum of MEL production is observed during the night. Melatonin is mainly responsible for awake-sleep diurnal cycle. Increased levels of MEL inform human brain and other organs (synchronized by endogenous biological clock) of the beginning of dark phase period and it stimulates the initiation of sleep process (Skwarlo-Sonta, and Piesiewicz, 2010). A photic history (radiation for which subjects were exposed during day time) and exposure to light during night affect changes in MEL rhythm. Occurrence of light pulses in the first period of night will result in a delay of MEL cycle and maximum secretion will be shifted for a morning period, when the normal situation should be a time of awakening. (Canton *et al*., 2009). This problem is common at shift-workers and people traveling with the change of time zones (jet-lag). Previous studies conducted on populations of Poles, Japanese and Vietnamese have shown that due to changes in lighting cycle during the year seasonal diversity of melatonin production is also observed (Morita *et al*., 2002; Blazejczyk *et al*, 2005). These results may suggest that after moving to another lighting zone with longer/shorter photoperiod and increased/decreased distribution of solar radiation some changes in MEL rhythm should be expected. Thus an interesting issue is whether and how journey to a different geographical lighting area within the same time zone (traveling along the meridian) affect the rhythm of MEL secretion and how long an adaptation process will take?

The purpose of the paper is to present changes of melatonin (MEL) concentrations observed at Polish volunteers during their tourism activity in northern Norway at polar day period.

Material and methods

In the experiment eight Polish volunteers (age 23–26, both sexes) were involved. Whole experiment session lasts 21 days, first 5 days subjects spent in their place of habitual residence in Warsaw. At 6th day they were transferred to Tromso (70°N, Norway) and they stayed there for 7 days. At 14th day volunteers returned to Warsaw and last 7 days of the experiment they spent in at home place. Three types of measurements were carried out during experiment. Meteorological parameters (intensity of global 0.4–3.0 μm and visible 0.4–0.76 μm solar radiation, wind speed as well as air temperature and humidity) were registered every 1 minute by HOBO Micro Station. Additionally spectral characteristics of solar light (irradiation, CCT, peak wave length, light intensity) were recorded several times a day with the use of LightSpex, (GretagMacbeth). Activity level of each participant and light intensity in their surroundings were reordered with the use of ActiWatch (Mini Mitter Comp., Inc). Spectral characteristics of visible radiation doses the subject was exposed were controlled in 7 spectral ranges by HandyLight (Biotex). Saliva samples were collected at 4h intervals, beginning at 11:00 with subsequent sampling times at 15:00, 19:00, 23:00 and 03:00, 07:00. Samples were collected into Salivette (Sardstedt) collection tubes and then were analyzed by using RIA (*Radio Immuno Assay*). Melatonin Peak (MP), which is the maximum value of hormone noted during a night, and the Time of its occurrence (MPT) were found by using Spline software, based on Gauss interpolation.

Results and discussion

Clinical studies have shown that the circadian MEL rhythm in individual subject in typical conditions is relatively stable. Thus at the beginning of experiment control measurement of MEL concentrations was made in the place of their residence. Changes in MEL rhythm during stay at tourism destination (Tromso) has been analysed in relation to the value of the control test (25 May 2011) in Warsaw. After one day stay in polar day conditions significant differences of MEL rhythm were observed. Mean melatonin concentrations at 11 pm on 28th May 2011 in Tromso were about 6 pg/ml lower than this occurred in the same time at control day in Warsaw. MEL concentrations at 3 a.m. were lower of 3.5 pg/ml and at 7 a.m. about 1.2 pg/ml. Depending on a person it decreased: of 23–69 % at 11 p. m. (at each subject), of 7–45 % at 3 a.m. (at 7 persons) and of 13–65 % at 7 a.m. (at 5 subjects).

In almost each subject (except subject P1) MP value on 28 May (1st day of stay in Tromso) was significantly lower than control as well as MPT was delayed (except subject P6).

Experiment confirms the hypothesis that during stay in polar day conditions a phase shift (delay) will be expected. This delay is a consequence of exposition to bright light during evening hours. Totals of solar radiation for the period 7–11 p.m. in analyzed day in Tromso were 1306 kJ/m^2, when in Warsaw it was only 126 kJ/m^2. Frequency of extra bright light pulses (> 1,000 lux) during whole period of volunteers activity (7 a.m. – 11 p.m.) at compared days were about 2–5 times higher in Tromso.

Table 1. *Maximum melatonin concentration (MEL Peak) value and time of its occurrence in each participant. W – Warsaw control, T – Tromso 1st day.*

	P1	P2	P3	P4	P5	P6	P7	P8
MP - Melatonin Peak Value (pg/ml)								
W	16.0	15.0	27.0	10.0	31.0	14.0	11.0	13.0
T	18.2	7.9	20.4	8.3	19.9	11.5	7.5	11.0
MPT - Melatonin Peak Time (h:mm)								
W	1:00	0:23	1:47	2:28	0:28	4:02	4:44	0:18
T	1:15	0:58	3:14	2:58	1:19	3:45	5:50	2:53

Experiment has shown that MPT represents large individual variation. Participants in examined group are characterized by two MPT patterns. First group: participants P1, P2, P4, P5 with MPT at the beginning of night, between 11 p.m. and 3 a.m. Second group: participants P3, P6, P7 and P8 with MPT occurred between 3–6 a.m. (Figure 1). On the control day the same patterns were observed. This demonstrates the existence of individual determinants of the period of maximum of MEL production and lighting factors can probably involve only a slight shift of MPT period in a given person. MPT patterns represent two chronotypes described as a lark and an owl, well known in biological sciences.

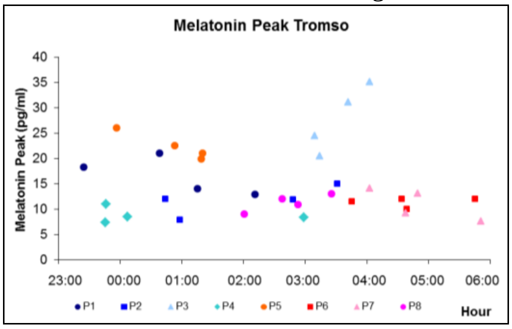

Figure 1. *Interindividual variation of Melatonin Peak during stay at polar day lighting conditions in Tromso.*

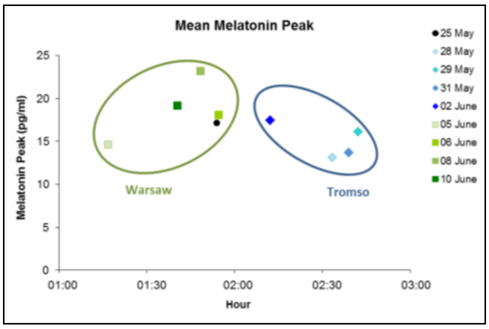

Figure 2. *Mean Melatonin Peak (P1-P8) during stay in Tromso and after return to habitual residence in Warsaw.*

In general, mean changes in Melatonin Peak (MP) value and occurrence time (MPT) are presented at Figure 2. As was expected exposition of subjects in Tromso to lighting conditions of polar day (lower irradiation in the morning and during day time, but much higher during evening and at night time) makes the changes in MEL rhythm which have already appeared on the first night of stay. The greatest changes have taken place on the first day. MP was reduced by 17–43 % (only at subject P1 it was higher by 13 %). On next days observed MP were still delayed but MEL concentration raised slightly.

Conclusions

Tourism activities taken in a different lighting zone affect the rhythm of MEL secretion. In addition to the changes of lighting conditions tourists often changes their behavior. During undertaken activities tourists usually spend more hours in the open areas, with direct exposure to solar radiation. The greatest changes in MEL rhythm were observed on first day in Tromso, which may be described as a "light shock". Diurnal cycles at next days of stay were modified by local lighting conditions and an "adaptive" factor. It seems that adaptation processes of MEL production last about a week. A greater diversity of MP and MPT were observed after returning to the place of habitual residence. Due to the greater variability and instability of observed circadian rhythms compared to control measurement it is probably that this process of adaptation will takes longer after return.

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EFFECT OF FREEZE OUT OF WINTER WHEAT ON WEED INFESTATION OF A SUBSTITUTE CROP

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Abstract. Evaluation of weed infestation was carried out on a field experiment plot at Ivančice na Hané (the Czech Republic). In February 2012 winter wheat froze out and spring wheat was sown as a substitute crop. Results of the weed infestation in spring wheat were compared with results of winter wheat infestation in years 2010 and 2011. The highest infestation was found out in the substitute crop, the mean number of weed plants was 20.77 pcs.m^{-2}. Species belonging to the group of summer weeds were the most frequent and *Chenopodium album* was the most numerous.

Introduction

Course of weather in winter is crucial for overwintering of winter crops. Very low temperatures, black frosts or drastic changes of low temperatures with thaw can cause freeze out of winter crops. Similar situation happened this year and number of stands froze out. A question arises what to do with a destroyed or seriously damaged stand in this case? The most frequent solution is to plant a substitute stand of spring form of the cultivated crop. Course of weather mentioned above and a substitute stand have a distinctive effect not only on full-grown weed plants but also on dormant fruits and seeds in soil.

Material and methods

A field experiment was established on the Field Experimental Station at Ivanovice na Hané (belonging to the Crop Research Institute in Prague-Ruzyně) in 1989. The station is situated in 230 m a. s. l., in the beet production area and it is classified to the warm and moderately dry climate region. Long term mean sum of year precipitations is 564 mm, long term mean temperature is 8.6 °C (data from the meteorological station at Ivanovice na Hané). Chernozem loamy soil type occurs on the experimental plot. Three types of crop rotation are applied with a different proportion of cereals.

The first rotation of crops has 33 % of cereals. Crops are grown in following order: alfalfa the first and the second year, winter wheat, maize for silage, sugar beet and spring barley.

The second rotation of crops has 50 % of cereals and crops are grown as follows: pea, maize for silage, winter wheat, winter wheat, sugar beet and spring barley.

The third rotation of crops has 66.6 % of cereals. Crops are grown in this order: winter wheat, pea, winter wheat, sugar beet, spring barley.

In 2012 stands of winter wheat froze out. Spring wheat was sown as the substitute crop. Weed infestation was assessed in stands of winter wheat in years 2010 and 2011. Next year 2012 weed infestation was assessed in spring wheat. Assessments were carried out in spring before herbicides application. Number of individuals was counted on 144 plots 1-m^2 every year. The botanical nomenclature follows Kubát (2002).

Abundance data were processed by means of Redundancy Analysis (RDA) because of rather short data gradient (Program Canoco 4.0, Ter Braak 1998). Significance of results was calculated by the Monte-Carlo test with 499 permutations. Variants of crop rotations were used as covariables so that differences between weeds in winter wheat sown in 2010 and 2011 and weeds in the substitute crop spring wheat could be revealed.

Results and discussion

During three years of observations, 29 weed species were found. The highest weed infestation was found out in spring wheat, 2012. Mean abundances of all species are in Table1. Relations between weed species and variants of the experiment were visualized in the Figure 1.

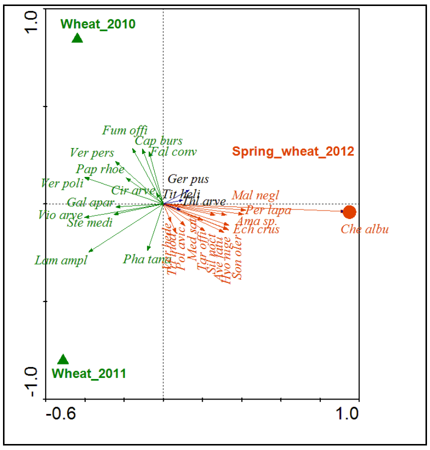

Figure 1. *RDA ordination diagram with occurrence of weeds in crops under study.*

Explanations: Wheat_2010 – winter wheat in 2010, Wheat_2011 – winter wheat in 2011, Spring-wheat_2012 – substitute crop (spring wheat) 2012. *Ama* sp. *– Amaranthus sp., Ave fatu – Avena fatua, Cap burs – Capsella bursa-pastoris, Cir arve – Cirsium arvense, Ech crus – Echinochloa crus-galli, Fal conv – Fallopia convolvulus, Fum offi – Fumaria officinalis, Gal apar – Galium aparine, Ger pus – Geranium pusillum, Hyo nige – Hyoscyomus niger, Che albu – Chenopodium album, Lam ampl – Lamium amplexicaule, Mal negl – Malva neglecta, Med sati – Medicago sativa, Pap rhoe – Papaver rhoeas, Per lapa – Persicaria lapathifolia, Pha tana – Phacelia tanacetifolia, Pol avic – Polygonum aviculare, Sil noct – Silene noctiflora, Son olera – Sonchus oleraceus, Ste medi – Stellaria media, Tar office – Taraxacum officinale, Thl arve – Thlaspi arvense, Tit heli – Tithymalus helioscopia, Tri inod – Tripleurospermum inodorum, Ver hede – Veronica hederifolia, Ver pers – Veronica persica, Ver poli – Veronica polita, Vio arve – Viola arvensis.*

The weed infestation of different variants of crop rotations is highly significant at α = 0.002. Species in the ordination diagram can be divided into several groups. More frequent weed species occurring in winter wheats are as follows: *Lamium amplexicaule, Galium aparine, Veronica polita, Viola arvensis* and *Veronica persica*. They belong to the group of winter weeds.

On the opposite *Chenopodium album, Malva neglecta, Persicaria lapathifolia, Amaranthus sp. and Echinochloa crus-galli*, i.e. late spring weeds, occurred more frequently in substitute crop *(spring wheat).*

Chenopodium album is the most numerous species. Its pronounced occurrence can be influenced by low temperatures which caused the wheat freeze out. Similar situation noted Winkler (2008), i.e. spring occurrence of *Chenopodium album* after strong winter. This species can achieve high abundance even in densely sown crops and can be also objectionable for next crops due to its ability of high seed production.

Table 1. *Weed infestation of spring wheat in 2012 and in winter wheat in 2011 and 2010 (mean numbers of species and individuals).*

Weed species	**Crop, year, pcs.per 1 m^2**		
	Spring wheat	**Winter weat**	
	2012	**2011**	**2010**
Chenopodium album	11.81	0.00	0.01
Lamium amplexicaule	1.38	4.84	2.43
Galium aparine	2.09	1.78	1.78
Veronica polita	0.36	0.97	1.63
Medicago sativa	1.79	0.85	0.28
Viola arvensis	0.01	1.54	1.19
Fallopia convolvulus	0.38	0.10	1.35
Malva neglecta	1.26	0.00	0.00
Veronica persica	0.01	0.25	0.92
Stellaria media	0.01	0.49	0.67
Fumaria officinalis	0.20	0.24	0.54
Papaver rhoeas	0.00	0.22	0.57
Cirsium arvense	0.12	0.12	0.32
Thlaspi arvense	0.28	0.04	0.14
Capsella bursa-pastoris	0.00	0.01	0.40
Persicaria lapathifolia	0.40	0.00	0.00
Amaranthus sp.	0.28	0.00	0.00
Polygonum aviculare	0.10	0.07	0.01
Echinochloa crus-galli	0.16	0.00	0.00
Geranium pusillum	0.06	0.00	0.08
Phacelia tanacetifolia	0.00	0.13	0.00
Veronica hederifolia	0.00	0.08	0.01
Tithymalus helioscopia	0.03	0.00	0.02
Tripleurospermum inodorum	0.01	0.03	0.00
Avena fatua	0.04	0.00	0.00
Silene noctiflora	0.01	0.01	0.00
Hyoscyomus niger	0.01	0.00	0.00
Sonchus oleraceus	0.01	0.00	0.00
Taraxacum officinale	0.00	0.01	0.00
Mean number of species	3.91	3.87	4.24
Mean number of individuals	20.77	11.79	12.38

Conclusions

Results suggest that the freeze out of winter wheat sets up good conditions for summer weed species, for *Chenopodium album* in particular. We can suppose that low temperatures in winter season are more favourable for higher weed infestation by late spring weeds in spring.

Occurrence of very low temperatures in winter can influence dormancy of fruits and seeds in soil significantly. It can be expressed by their more intensive emergence in substitute crops and cause higher weed infestation.

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