

WARMER PERIODS IN THE SLOVAK MOUNTAINS ACCORDING TO ANALOGUE METHOD AND COUPLED GCM

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Abstract: In this paper the temperature time series of three Slovak mountain stations and one Slovak lowland station are analyzed from the point of view of their warmer periods. These warmer periods are analysed by an analogue method. Selected periods (warmer summer and warmer winter seasons) are characterized by air temperature as well as by precipitation, humidity and some other variables. In the second part of this paper the behaviour of the Canadian climate model outputs are studied from the point of view of their ability to catch similar warmer periods for this Central European region in the model control periods (1900-2004). Finally the results obtained by the analogue method and by climate model outputs are compared. Obtained results are in good coincidence between both used methods. Past warmer periods can be considered as some analogue of future climate events under enhanced greenhouse conditions.

Keywords – warmer periods, analogue method, climate models

1. INTRODUCTION

Global climate has become warmer in the last years. Likewise warming continues up to the present days in the Central Europe (Fig.1, Fig.2). Our effort was aimed on analysis of long observation records at some stations in the Central Europe. We attempted to find warmer periods in this long time series and to analyse these periods by an analogue method. According to IPCC (2001) temporal analogues make use of climatic information from the past as an analogue for possible future climate. Periods of observed global scale warmth during the historical periods have also been used as analogues of a greenhouse gas induced warmer world. The advantage of the analogue approach is that the changes in climate were actually observed and so, by definition, are internally consistent and physically plausible (IPCC 2001). The analogue scenarios are much more important if they are used as a combination of several climatic elements (Lapin, Melo, 2004). Warmer periods in the past were usually connected with significant decrease of snow in winter months, especially in the lowlands, with decrease of precipitation and relative air humidity from spring to autumn (Lapin et al., 1994, Melo, 2001). Temporal analogues results presented in this paper have been completed by results obtained from the climate model outputs. The climate models are the most important source of information about behaviour of climatic system under changed conditions. At present the most highly developed climate models are coupled atmospheric and oceanic general circulation models (GCMs). Utilization of climate models is the most physically plausible method for preparation of regional climate change scenarios (Lapin et al., 2001, Lapin, Melo, 2004).

2. METHODS

Data from the stations Liptovský Hrádok (1881-2004), Skalnaté Pleso (1961-2004) and Lomnický štít (1951-2004) have been utilized. Liptovský Hrádok lies at the SW foot of the High Tatras Mts. (640 m a.s.l.), Skalnaté Pleso lies approximately in the centre of the High Tatras (1778 m a.s.l.) and Lomnický štít is the 3rd highest peak there (2635 m a.s.l.). Further the Hurbanovo Observatory as a reference station has been utilized. Hurbanovo (115 m a.s.l.) is representative station for the Danubian lowland in Slovakia and it ranks among the best meteorological stations in the Central Europe with sufficiently long and good-quality observations (1871-2004). Selected warmer summer and warmer winter periods are characterized by air temperature as well as by atmospheric precipitation, air humidity (water vapour pressure, relative

humidity) air pressure, sunshine duration and some other variables. We use mean monthly values of selected climatic elements. Summer season creates June, July and August, winter season December of the previous year, January and February. The aim is to find warmer periods in the existing time series and to characterise their climatic patterns. The problem is solved by two different methods. In the first case we go out from the warmer seasons, where this warmer period continual exists at least five years and average season temperature is in all years higher than 1951-1980 normal. This normal period was chosen as insignificantly influenced by climate change, because of the IPCC recommendation. If any singular year (or years) occurs in this continual series which is not suitable for our requirement we can take account it only in this case, if instead it this requirement is fulfilled by its 5-years simple weighting moving average for this concrete year. In the second case warmer season periods are selected from every individual year. All individual years, which have higher (lower) values of air temperature in season than the 1951–1980 normal, we included into the warmer (colder) season period. For these chosen season periods the seasonal means and totals of several climatological elements (air temperature, precipitation totals, relative air humidity means, sunshine duration,...) have been calculated.

In the second part of this paper the behaviour of the Canadian coupled GCM output from the point of view its ability to catch similar warmer season periods for this locality in the model control periods (1900-2004) has been studied. We utilized model data from the Canadian Centre for Climate Modelling and Analysis in Victoria, B.C. (CCCM 2000 model with IPCC"IS92a" forcing scenario). CCCM 2000 model is the second generation coupled global climate model (CGCM2) of this centre (Flato, Boer, 2001). We take into account model outputs from six gridpoints near to Slovakia. Interpolation from these gridpoints to the Hurbanovo locality (the weights with respect to the distance from Hurbanovo) is used. For estimate of warmer season periods in model simulation with consecutive characteristic the same method than in case of the analogue method is used. Next model characteristics take into account: air temperature, precipitation, specific humidity and air pressure. Finally the results achieved by climate model outputs and the results achieved by analogue method are compared.

3. RESULTS

In 1871–2004 we have achieved moderate air temperature increase (annual mean) at Hurbanovo (according to linear trend by about 1.4 °C in this period), in case of Liptovský Hrádok it is by about 1.4 C in 1881-2004, at Skalnaté Pleso by about 1.0 C in 1961-2004 and at Lomnický štít by about 0.6°C in 1951–2004. Some higher increases were achieved according to linear trend in the case of summer and winter temperatures in all results. Summer temperature increase in case of Hurbanovo is by about 1.2 C in 1871-2004, at Liptovský Hrádok by about 1.4°C in 1881-2004, at Skalnaté Pleso by about 1.5 C in 1961–2004 and at Lomnický štít by about 0.7 C in 1951–2004. Winter temperature increase is for Hurbanovo by about 1.9°C in 1871–2004, for Liptovský Hrádok by about 1.9 C in 1882–2004, for Skalnaté Pleso by about 2.0 C in 1962–2004 and for Lomnický štít by about 1.4 C in 1952–2004 (Fig.1, Fig.2).

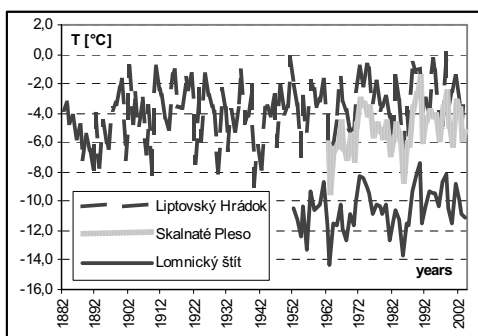


Figure 1. Mean summer air temperature course in Tatra

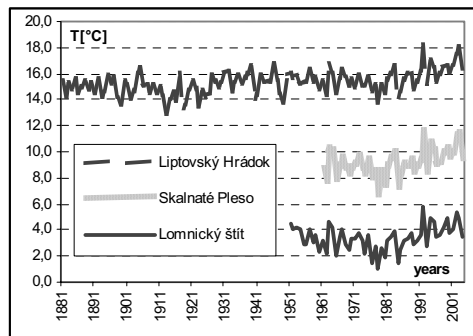


Figure 2. Mean winter air temperature course in Tatra

Analyzing the temperature records from Hurbanovo we found several periods with relatively stable warmer summer and winter periods longer than 5 years and without any significant sequence of colder months. The 1988–2004 summer and 1988–2002 winter periods were the warmest in the Danubian lowland in Slovakia. The warmest summer periods in the High Tatras Mts. are in the reality very similar (at Liptovský Hrádok in 1981–2004, at Skalnaté Pleso in 1981–2004 and at Lomnický štít in 1986–2004). The warmest winter periods in this region were achieved in different terms (in case of Liptovský Hrádok it is in 1971–1980, at Skalnaté Pleso in 1988–2004 and at Lomnický štít in 1988–2002). Warmer season periods in the High Tatras Mts. were characterised by drier conditions during the summer (with exception of Lomnický štít), wetter conditions during the winter (with exception of Skalnaté Pleso), by higher values of water vapour pressure in both season periods, by no significant change, or by moderate decrease of relative humidity in both season periods, by higher values of air pressure both in summer and winter and by higher values of sunshine duration during the summer (all in comparison with the mean of longer time-scale period). Only winter sunshine duration is different at each station. The example of climate pattern in warmer (including the warmest period), normal and colder summer periods for Lomnický štít in 1951–2004 is given in Table 1 and the example of climate pattern in warmer (including the warmest period), normal and colder winter periods for Lomnický štít in 1952–2004 is given in Table 2. In case of Hurbanovo this characteristic is similar. Results are different only in one case. Winter values of air pressure are lower in the lowlands in warmer seasons. Frequent air temperature inversions in the mountain hollows during the winter period caused this different air pressure pattern.

Table 1. Characteristic of warmer (including the warmest period), colder and normal summer periods at Lomnický štít in 1951–2004 by air temperature [T], atmospheric precipitation [R], air pressure [P], water vapour pressure [WP], relative humidity [U] and sunshine duration [S]

Summer period	T [°C]	R [mm]	P [hPa]	WP [hPa]	U [%]	S [h]
Warmer	3.9	444	741.224	7.0	85	492
Colder	2.3	437	739.696	6.6	89	413
1951–2004 normal	3.4	442	740.772	6.9	86	469
1986–2004	4.0	449	741.305	6.9	84	502

Table 2. Characteristic of warmer (including the warmest period), colder and normal winter periods at Lomnický štít in 1952–2004 by air temperature [T], atmospheric precipitation [R], air pressure [P], water vapour pressure [WP], relative humidity [U] and sunshine duration [S]:

Winter period	T [°C]	R [mm]	P [hPa]	WP [hPa]	U [%]	S [h]
Warmer	-9.6	365	730.089	2.3	74	361
Colder	-11.8	332	727.217	2.0	76	361
1952–2004 normal	-10.6	351	728.843	2.2	75	361
1988–2002	-9.5	383	731.183	2.2	70	378

In the model control period 1900–2004 (CCCM 2000 model) we can find three continual warmer summer periods and six warmer winter periods in Central Europe (locality of Hurbanovo). The 1977–2004 summer and 1977–1981 winter periods were the warmest in the Danubian lowland according to these model results. Model warmer periods are characterized by drier conditions during the summer, wetter conditions during the winter, by higher values of the specific humidity in both season periods, by higher values of air pressure in the summer and lower values in the winter. This climate pattern of warmer season periods by model is in coincidence with the reality. Finally we can state the agreement in results according to both used methods.

4. CONCLUSION

Past warmer periods have been applied as the analogue of warmer climate (e.g. future climate events under enhanced greenhouse conditions). Selected warmer periods are advisable for analysis of interrelations among climatic elements as well. We can state that results achieved by Canadian climate model are very similar to the results achieved by analogue method in the summer and winter periods for Central European region.

At present GCM scenarios are not very reliable for some important climatic elements (evaporation, soil moisture, relative humidity, runoff, snow cover, wind speed, extreme weather events...). For the regional climate study and its following impact study in Slovakia is advisable to utilise a combination of several methods, usually based on GCMs outputs (mean annual/monthly warming and mean annual/monthly change in precipitation totals) and on temporal analogue (more in Lapin, Melo, 2004).

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