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Milan Lapin, Ingrid Damborská, Pavel Faško, Marián Melo, Pavel Štastný

SCENARIOS OF CLIMATIC EXTREMES FOR SLOVAKIA

Abstract: Review of climatic extremes in Slovakia, more detailed elaboration of daily precipitation maxima and designed climate change scenarios for Slovakia are presented in the paper. Annual maxima of daily precipitation totals were elaborated on the basis of 557 stations in Slovakia in 1950-1999. Climatic scenarios have been prepared as baseline for 1901-1990 and scenarios of climate change for 2001-2100 (2090). Scenarios of variability and extremes change are considered as the most complex problem in this field.

Key words: precipitation, specific humidity, areal variability.

1. Introduction

Besides scenarios of the long-term climatic means for the selected time frames in the 21st century, the scenarios of possible change of climatic extremes are also of high priority at the users. Some natural and socio-economic systems are primarily influenced by the extremes and the change of long-term means have only secondary importance there. Slovakia is a country with no very significant occurrence of weather extremes compared to the other parts of Europe. In spite of this the every year damages due to the exceptional weather events are very high there. As an example, the basic extremes of air temperature, precipitation and specific humidity in comparison with long-term means are presented. The statistical elaboration of extremes is considered as necessary step prior to the General Circulation Models (GCMs) output downscaling. Overview of climatic scenarios prepared in Slovakia, together with philosophy of the extreme weather scenarios design, are included.

In the lowlands of south-western Slovakia, January and February temperature means are about -2 and –1°C, but the absolute minimum was about –35°C there on February 11, 1929. In the hollows of central and northern Slovakia January and February means vary about –5°C and absolute minimum was –41°C in Víglaš on

February 11, 1929. In the Slovak high mountains (above 1,500 m a.s.l.) the absolute minimum temperature only exceptionally falls below –30°C and during severe frosts in lowlands and hollows only about –20°C temperatures have occurred there. Absolute minimum temperatures are above 0°C in the majority of Slovakia from June 1st to August 20th, in the lowlands and at some slope localities this period is prolonged from May 15th to September 10th. On the other hand the absolute maximum of temperatures can reach nearly 40°C at the southern border of Slovakia and higher than 37°C temperatures occurred exceptionally in the majority of the country in July and August. Temperature means for July and August vary from 17 to 21°C in the localities below 300 m a.s.l. The winter (December-February) absolute maximum temperatures are above 10°C and can be nearly 20°C in the south-western Slovakia and in some föhn localities.

From the point of view of scenarios the temporal and areal distribution of monthly values is also important. The lowest monthly means of temperature occurred in the lowlands were about –11°C in January and February and the highest 24-26°C in July and August. Standard deviation of monthly temperatures is about 3°C in January and February and about 1.2°C from June to August.

The problem of absolute maximum precipitation totals can be divided into several topics. Firstly the extreme short-term precipitation intensities are very important. In Slovakia the pluviographs are installed at about 170 precipitation stations. Measurements are provided only in the non frosty period of the year and less than 30 stations have enough long series of measurements to elaborate the statistical values. The highest 15-minute and 60-minute intensities ever measured in Slovakia were 48 mm (3.2 mm/min) and 86 mm (1.4 mm/min) without significant areal dependence. Maximum daily precipitation totals have also a great importance, because the all year round measurements at more than 700 stations exist in Slovakia. Extremes measured at more than 600 such stations in 1950-1999 have been analysed recently. Absolute maximum daily precipitation total, 231.6 mm, was measured at Salka, south Slovakia, on July 12, 1957 (Tab. 1). This topic will be discussed later in the text. The hydrologists and some other users need for their applications daily, monthly, seasonal and several days precipitation extremes. The highest monthly totals exceeded 350 mm in Slovak lowlands and 500 mm in the mountains in summer, while long-term means are only 60-100 mm and 100-150 mm, respectively in the June-August season. The monthly maximum of areal precipitation totals in Slovakia was only 198 mm in October 1974 and 94 mm in February 1977 what is significantly less than at selected stations in the surrounding of mountains (Tab. 6).

Extreme events of specific air humidity (q) are connected usually with extreme temperatures. The lowest values are nearly q = 0 g/kg at temperatures below –20°C. The possible highest short-term values can reach nearly 26 g/kg on the lowlands in summer at the conditions of very warm and very humid air coming from the Mediterranean to Central Europe. All values of specific humidity decrease with the altitude, the highest value measured in Gánovce at the 850 hPa level in 1961-1990 was only about 11 g/kg on July 24, 1988. The possible highest specific humidity can be 14 g/kg there (in Cb clouds). The highest monthly mean of specific humidity measured at Hurbanovo (115 m a.s.l., south Slovakia, 1961-1990) was 11.3 g/kg in June 1964 and July 1972 and 11.0 g/kg in August 1974. At the 850 hPa level in Gánovce it was about 7.5 g/kg in July 1987. Long-term mean for July at Gánovce and 850 hPa level is about 7 g/kg and for Hurbanovo at ground level (115 m a.s.l., 1000 hPa) it is 9.8 g/kg. The 850 hPa level is usually the height of the greatest amount of condensation products (water contents) in Cumulonimbus (Cb) cloud during thunderstorms and in Nimbostratus (Ns) cloud during heavy rains.

2. Annual Maximum of Daily Precipitation Totals

Because of limited space, only daily precipitation extremes are discussed in the paper. The highest daily totals may occur at the conditions of summer thunderstorms or at cyclonic weather with continuous heavy rains lasting one or more days. We elaborated annual maximum of daily precipitation totals for all precipitation stations having been to disposal in Slovakia since 1950. The number of stations varied about 700 each year. Some stations had interrupted series and needed to be completed. So the series of 607 stations have been prepared for the period 1950-1999. Then we excluded the stations with gaps of more than 10 years and 557 stations left. Statistical elaboration showed interesting temporal and areal distribution of daily precipitation extremes. Have a look at the Figure 1 first. There can be seen the course of maximum,

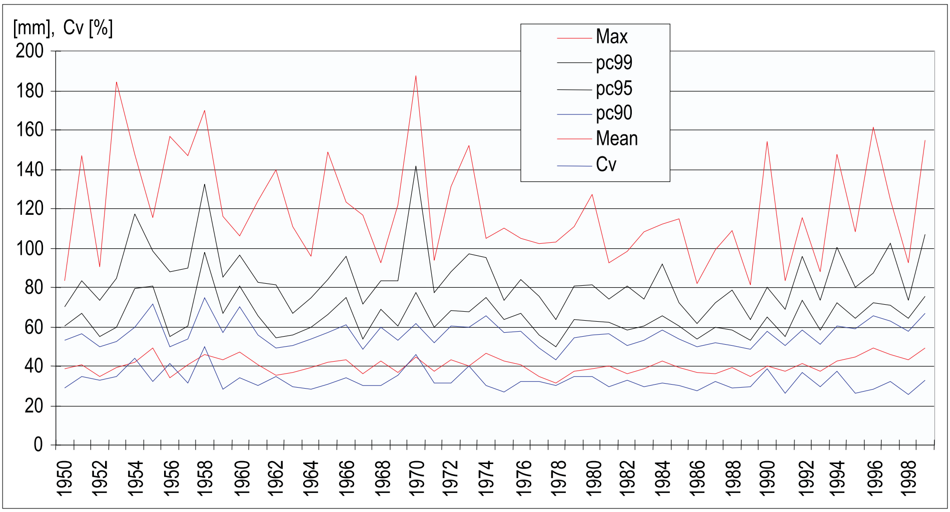

Fig. 1. Statistical characteristics of annual maximum of daily precipitation totals at 557 stations in Slovakia in 1950-1999 (Max - absolute maxima for each year at 557 stations; pc99, pc95, pc90 - 99%, 95%, 90% percentiles; mean - average of maxima for each year at 557 stations; Cv - variation coefficient of maxima for each year at 557 stations).

Tab. 1. The highest daily precipitation totals measured in Slovakia from 1901 to 1998 (334 stations, some with interrupted series, have been analysed; lowlands' stations are bold) [3].

Station, altitude [m]	[mm]	Date	Station, altitude [m]	[mm]	Date
Salka, 111	**231.9**	**12.7. 57**	Zbojnícka ch., 1958	169.0	29.6. 58
Zverovka, 1027	220.0	16.7. 34	Zuberec, 764	168.5	16.7. 34
Stará Bystrica, 484	193.0	17.6. 29	Hrebienok, 1267	165.0	29.6. 58
Novot, 752	187.6	18.8. 70	Velké Pole, 556	164.0	19.8. 66
Zdiar, 910	180.5	16.7. 34	Oravská Lesná, 779	163.2	18.7. 70
Zboj, 354	176.1	21.3. 31	**Trnava, 146**	**162.8**	**3.6. 51**
Skal. Pleso, 1778	170.0	29.6. 58			

99%, 90% percentiles and all Slovakia means. The mean is conservative characteristic (about 40.4 mm) with slight variability (C_v = 32.2%). The variability of other characteristics is much higher (C_v = 68.6% at maximum, 59.6% at 99% percentile and 45.8% at 90% percentile). No significant trends can be seen, but the relatively colder 1974-1989 period in summer had lower maxima and 99% percentiles. More about this issue is presented in the poster (Faško et al. 2000a).

We divided Slovakia roughly into 4 regions according to the river basins and different topography. Region 1 (north-western Slovakia, 101 stations, mostly mountains) is predominantly influenced by western to northern atmospheric currents, Region 2 (south-western Slovakia, 188 stations, mostly lowlands) is the warmest and driest part of the country, Region 3 (southern part of Central Slovakia, 119 stations, mostly southerly oriented slopes of mountains) is influenced mostly by southern to south-eastern atmospheric currents and Region 4 (eastern Slovakia, 149 stations, complex topography, frequent lee effects) has usually different precipitation conditions compared to the other regions. In the Table 2 we can see the correlation of 50-year series of areal values of maximum daily precipitation totals among the Regions. The greatest differences are between the Regions 1 and 2 (maxima and Cv, not at minima and low percentiles) and between the Regions 2 and 4 (all, including minima, probably due to the greatest distance). It is interesting that at the Regions 1 and 3 the correlation is very close, except the absolute maxima, but at the Regions 2 and 3 is correlation in general very close. It seems, the Region 1 is the most exceptional in Slovakia (the greatest variability, extremes and means). Some of the stations listed in the Table 1 had significantly interrupted series of maximum daily precipitation and were not included among 557 stations elaborated in the paper and shown in Figure 1 and Table 2.

In 1949-1999 altogether 82 days and 214 events with ≥100 mm of daily precipitation totals were identified in Slovakia (about 700 precipitation stations have been analysed each year). The greatest number of such events occurred on June 29, 1958 (36). Dynamic-climatological analysis showed that the greatest number of such cases occurred at the trough synoptic situations - B (15 days and 56 events) and at

Tab. 2. Correlation of time series of statistical characteristics of daily totals annual maxima for selected Regions in Slovakia (Region 1 - north-western Slovakia, 101 stations; Region 2 - south-western Slovakia, 188 stations; Region 3 - southern part of Central Slovakia, 119 stations and Region 4 - eastern Slovakia, 149 stations; other explanations see in Figure 1).

Correlations	1 & 3	2 & 4	1 & 4	3 & 4	2 & 3	1 & 2
Mean	0.444	0.206	0.391	0.395	0.442	0.352
StDev	0.247	0.089	0.536	0.519	0.283	-0.074
Cv	0.044	0.146	0.322	0.462	0.264	-0.083
Maximum	-0.009	0.139	0.270	0.190	0.244	-0.100
pc95%	0.361	0.063	0.607	0.478	0.323	0.129
pc90%	0.418	0.051	0.519	0.569	0.345	0.176
pc75%	0.411	0.137	0.316	0.434	0.425	0.380
pc25%	0.378	0.311	0.222	0.344	0.429	0.407
pc10%	0.400	0.196	0.191	0.257	0.430	0.431
Minimum	0.253	0.129	0.029	0.399	0.391	0.523

Tab. 3. Scenarios of mean monthly air temperature change for Slovakia.

Frame	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
CCCM 1995 (compared to 1951-1980)												
2010	1.2	1.4	1.4	1.0	0.9	0.9	1.1	1.0	1.1	1.1	0.9	0.9
2030	2.0	2.4	2.3	1.7	1.5	1.6	1.8	1.7	1.9	1.8	1.4	1.5
2075	3.7	4.5	4.3	3.2	2.9	3.0	3.3	3.2	3.6	3.4	2.7	2.8
CCCMprep 1999 (compared to 1951-1980)												
2010	0.5	0.7	0.9	0.7	0.4	0.6	0.9	1.0	1.0	0.9	0.6	0.4
2030	0.9	1.2	1.4	1.1	0.8	1.1	1.4	1.5	1.6	1.2	0.7	0.7
2075	2.2	2.9	2.8	2.3	2.3	2.9	3.4	3.6	3.6	3.0	2.0	1.8

central cyclonic ones - C (11 and 55). According to Polish classification (Niedźwiedź 1981), at Nc (North cyclonic synoptic situation) 7 such days and 73 events occurred, but at central cyclone and trough the sum was only 22 days and 30 events in 1949-96 (Faško et al. 2000a,b).

3. Climate Change Scenarios

In 1994-1997 Slovakia participated in the U.S. Country Studies Program. Climate change scenarios were presented in the Slovak National Climate Program and Country Study publications. New generation of General circulation models (GCMs) has been issued since 1996. Outputs of the Canadian Climate Centre 1st generation atmosphere-ocean coupled model (CCCMprep here) have been adopted for Slovakia (CO_2 rise by 1% per year, doubling of CO_2 in 1980-2050, negative aerosol forcing, model outputs for the 1901-2100 period). Temperature, precipitation, specific air humidity and solar radiation monthly data enable to calculate/generate time series of monthly means comparable to original measured ones (comparable averages, distribution, variability) for selected sites/grids in Slovakia. The regional modification of CCCMprep scenarios for the mean air temperature and precipitation changes in the 2010, 2030 and 2075 time frames are comparable with those prepared for the CCCM outputs in 1995. Precipitation scenarios have been constructed separately for the northern and southern Slovakia in 1995 and separately for each station in 1999 (Lapin et al. 1995, 1999; Tab. 3 and 4). The main problem at GCMs output downscaling is based on the necessity to remain physical plausibility and statistical structure of the series (temporal and areal, cross-series relations) of all climatological elements in the future time periods comparable with the control period (1901-1990). This is possible to do by the dynamic-

Tab. 4. Scenarios (quotients) of mean precipitation totals change for Hurbanovo.

Frame	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
CCCM 1995 (compared to 1951-1980)												
2010	1.09	1.01	1.05	1.01	0.95	0.95	0.93	1.01	0.97	1.03	1.05	1.07
2030	1.15	1.01	1.08	1.02	0.92	0.91	0.89	1.02	0.95	1.06	1.08	1.12
2075	1.29	1.02	1.15	1.04	0.85	0.83	0.79	1.03	0.91	1.11	1.16	1.22
CCCMprep 1999 (compared to 1951-1980)												
2010	1.06	1.00	1.21	1.02	1.13	0.91	0.91	0.92	0.97	1.15	1.02	1.14
2030	1.09	1.03	1.25	1.07	1.17	0.92	0.92	0.94	0.98	1.17	1.06	1.17
2075	1.25	1.15	1.29	1.04	1.11	0.83	0.87	0.95	0.97	1.16	1.11	1.31

statistical methods only. Any statistical method or stochastic weather generator can hardly ensure that the scenarios of several elements will fulfil the physical theory in the area and time considered.

Let us to pay attention to monthly precipitation totals, including extreme events, downscaled from the GCMs output for some Slovak stations. During the 1901-1990 period (control period for CCCMprep model outputs), the maximum monthly precipitation totals varied about 250 mm at most of stations (less in some lowland and hollows localities). The downscaled CCCMprep monthly totals are basically in accordance with the measurements (both means and distribution curves). Extreme high monthly totals are slightly different for individual months in the year and did not exceed the characteristic values in measured series. This enables a consideration on acceptable reliability of monthly precipitation time series as scenarios for 2001-2100. Examples of the 1st modification of CCCMprep outputs for selected stations are shown in (Lapin, Melo 1999). There can be seen some increase of monthly maximum precipitation compared to the 1901-1990 totals for all Slovakia. Precipitation time series are mainly used in the hydrological and agricultural modelling (Marecková et.al. 1997; Szolgay et al. 1997). In this case not only temporal but also the areal variability is important. Table 5 presents the correlation coefficients between precipitation time series at selected pairs of stations (with different distances). Natural areal variability is described by the 1901-1990 series and it is very high also at small distance of stations (correlation coefficients lower than 0.7). The same correlation coefficients for air temperature series are usually higher than 0.85 for all territory of Slovakia.

CCCMprep grid outputs represent some areal averages (grid distance is about 300 km). This makes not any troubles at air temperature scenarios, but downscaled precipitation totals into grids or stations with higher resolution correlate very closely with unrealistic low areal variability (Tab. 5 for the 1st modification of CCCMprep outputs). At the 1st modification only averages and variance coefficients Cv have been changed in accordance with the statistical values of baseline series for individual stations (Lapin et al. 1999). This is why some noise was statistically included into time series prepared by the 1st modification. We tested the areal variability of measured totals in the control period and a consideration on similar areal variability for the 2001-2090 period was adopted. The time series prepared at 1st modification have not changed significantly (Fig. 2), but correlation coefficients changed dramatically and became very close to those naturally occurred in measured time series (2nd modification in Table 5). Table 6 shows only insignificant change of extreme high monthly totals after the 2nd modification of precipitation time series. Correlation of increase and decrease in CCCMprep mean monthly precipitation totals and change of monthly maximum precipitation up to end of the next century is not very clear (but at areal precipitation for Slovakia and 1901-1990 vs. 2001-2090 periods it is r=0.77). Solution of this problem is at the beginning only. The very serious question is if these modifications of CCCMprep model outputs influenced the physical relations among variables (physical plausibility). This could be sufficiently tested only by use of dynamic regional climatic model. Our aim was to do as little changes in the time series calculated by the GCMs as possible and we modified only averages and variability in accordance with the statistics in measured series (control period).

Simple dynamic and regression models have been designed for extreme precipitation scenarios preparing. The philosophy of models and the first results of scenarios are presented there only. Firstly the scenarios of possible change of specific humidity (s) have been designed. Based on the CCCMprep outputs downscaling, the s scenarios quotients are presented in Table 5 for 50-year time frames (2075 is for 2051-2100). In Slovakia the data of s at 850 hPa level are to disposal since 1951, so the time series of monthly s averages can be designed for the 1951-2100 period. Significant rise (6-11%) of s is supposed according to CCCMprep up to 2045, then even more intense continual rise of means and variability can be expected. Let us suppose that the internal s variability remains so as at present up to 2045, than the maxima of s at exceptional precipitation events will be greater by the same quotients as the long-term averages (Tab. 5).

Tab. 5. Correlation coefficients of monthly precipitation totals between stations in Slovakia (SP - Štrbské Pleso, 1360 m; VYB - Vyšná Boca, 930 m; Liptovská Teplička, 903 m; Liptovský Hrádok, 640 m; Liptovský Mikuláš, 570 m; Hurbanovo 115 m; and Habura, 372 m; A - the 1st modification of CCCMprep outputs, 2001-2090; B - the 2nd modification of CCCMprep outputs in 2001-2090; C - measured totals, 1901-1990; SP-VYB - 29 km, across the valley; LTE-VBO - 24 km, the same mountain slope; LHR-LMI - 11 km, valley bottom; HU-HAB - 340 km).

Stations		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Mean
SP-VYB	A	0.983	0.984	0.969	0.988	0.989	0.991	0.992	0.991	0.988	0.980	0.981	0.982	**0.985**
LTE-VYB	A	0.999	0.997	0.984	0.999	0.999	0.999	0.999	0.999	0.999	0.994	0.998	0.998	**0.997**
LHR-LMI	A	0.977	0.977	0.985	0.997	0.997	0.996	0.999	0.999	0.996	0.996	0.990	0.986	**0.991**
HU-HAB	A	0.857	0.864	0.836	0.902	0.904	0.907	0.926	0.911	0.888	0.853	0.853	0.857	**0.880**
SP-VYB	**B**	**0.627**	**0.727**	**0.657**	**0.701**	**0.700**	**0.647**	**0.759**	**0.767**	**0.837**	**0.752**	**0.522**	**0.600**	0.691
LTE-VYB	**B**	**0.757**	**0.627**	**0.686**	**0.735**	**0.770**	**0.614**	**0.678**	**0.648**	**0.722**	**0.816**	**0.558**	**0.776**	0.699
LHR-LMI	**B**	**0.916**	**0.845**	**0.822**	**0.843**	**0.840**	**0.855**	**0.908**	**0.834**	**0.829**	**0.911**	**0.867**	**0.872**	0.862
HU-HAB	**B**	**0.481**	**0.335**	**0.314**	**0.415**	**0.288**	**0.456**	**0.476**	**0.471**	**0.312**	**0.635**	**0.412**	**0.449**	0.420
SP-VYB	C	0.656	0.622	0.690	0.658	0.661	0.497	0.676	0.720	0.827	0.871	0.728	0.592	**0.683**
LTE-VYB	C	0.804	0.698	0.793	0.693	0.709	0.521	0.665	0.554	0.796	0.868	0.747	0.724	**0.714**
LHR-LMI	C	0.936	0.918	0.887	0.845	0.818	0.864	0.890	0.879	0.916	0.949	0.907	0.894	**0.892**
HU-HAB	C	0.409	0.277	0.532	0.343	0.428	0.250	0.347	0.347	0.411	0.711	0.470	0.271	**0.400**

Tab. 6. Comparison of absolute maximum in measured monthly precipitation totals (1901-1990, C) and in the series of the 1st and 2nd modifications (A, B) of CCCMprep outputs for some stations in Slovakia and in all Slovakia areal totals in 2001-2090.

Stations		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Max
Štrbské Pl.	A	199	168	190	160	204	260	319	228	175	194	206	182	**319**
Štrbské Pl.	B	199	168	188	160	202	254	292	220	167	180	199	182	**292**
Štrbské Pl.	C	**190**	**187**	**172**	**162**	**215**	**241**	**290**	**264**	**197**	**228**	**175**	**161**	290
Hurbanovo	A	110	108	131	124	159	164	166	177	114	117	167	135	**177**
Hurbanovo	B	106	109	131	119	142	161	122	161	109	107	167	135	**167**
Hurbanovo	C	**95**	**107**	**138**	**128**	**152**	**169**	**166**	**153**	**147**	**151**	**157**	**102**	169
Slovakia	C	***111***	***94***	***137***	***108***	***165***	***187***	***192***	***176***	***152***	***198***	***148***	***110***	*198*

Water content in the atmosphere is the most important for intense precipitation. The general equation for water vapour content V ($s = \rho_w / \rho$ is specific humidity, ρ_w ρ and ρ ρ are water vapour and air density) in the column of atmosphere from the height $z = 0$ to the top of the atmosphere $z = \infty$ is (Zikmunda 1966):

$$V = \int_o^\infty \rho . s . dz .$$

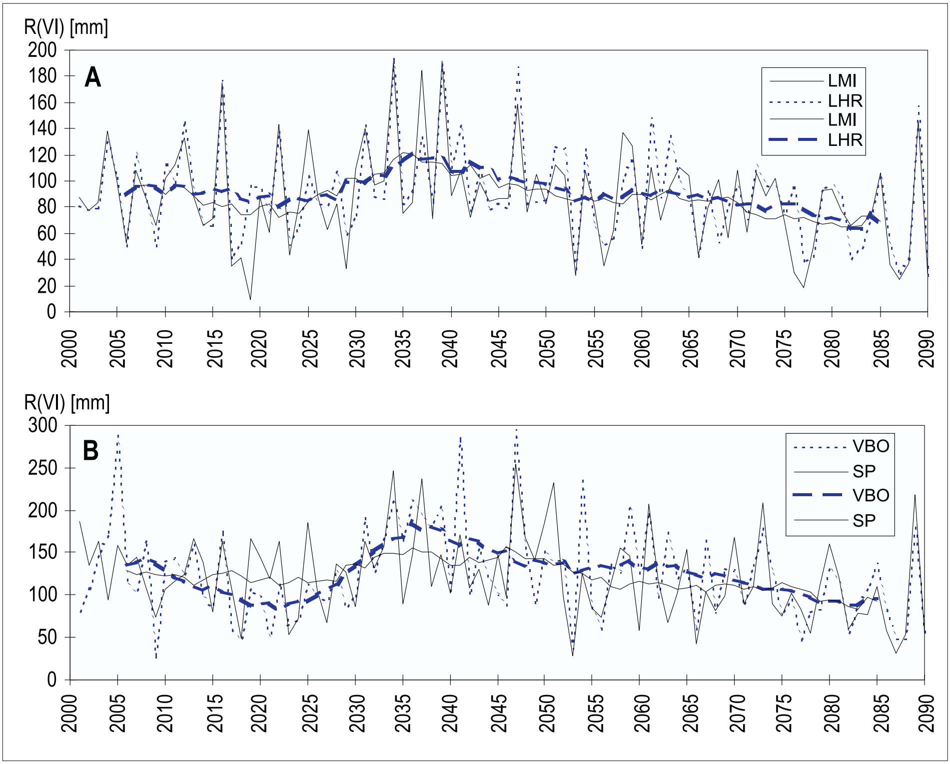

Fig. 2. Downscaled CCCMprep monthly precipitation totals into the stations in the upper Váh river basin and 11-year moving averages (June 2001-2090; description of stations is in Table 5; the 2nd modification of model outputs are presented; the 1st modifications of model outputs are nearly identical at all stations - see correlation in Table 5).

Let us consider only upward motion of air mass, not taking into account turbulence and heat exchange, and all condensation product above the condensation level p_c will immediately fall as precipitation on the ground. Simple equation for precipitation total (R) calculation can be then considered as follows:

$$R = g^{-1} \int_{to}^{t} \int_{pc}^{0} \omega \frac{ds}{dp} .dp .dt$$

where $g \approx 10$ m.s^{-2}, $\omega = dp/dt = -\rho.g.v_z$ – generalized vertical velocity, v_z – upward vertical component of the velocity vector, p – air pressure, t – time, ρ – air density. In case of s increase by 25% at the p_c level (≈850 hPa) it can be calculated from the above simple equation the increase of extreme precipitation total R at least by 25% as well. At higher s the upward v_z will increase in average, it depends on vertical temperature gradient and on energy of temperature vertical instability. If we take into account also the turbulence exchange of specific humidity and energy, the increase of precipitation can be even about 50% in this case. The up to present measured maximum of intense precipitation totals in Slovakia is about 100 mm/h and 232 mm/day. Presented simple consideration lead to the solution of about 125-150 mm/h and 290-350 mm/day precipitation intensity by the end of the next century. This problem can be solved also by use of regression model designed by comparisons of extreme precipitation events and the initial meteorological conditions (temperature and humidity at the ground and the 850 hPa levels) in the control period 1951-1990. More detail analysis of physical conditions at precipitation in the warmer and more humid atmosphere and description of regression model will be published in the separate paper.

Tab. 7. Scenarios (quotients) of specific humidity change at 850hPa level (a) and at ground level (b) for Slovakia (smoothed values; the ground level is considered in altitude of about 450 m a.s.l.).

Frame	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
CCCMprep 2000 (compared to 1951-1980)												
2010a	1.04	1.06	1.07	1.04	1.03	1.06	1.08	1.07	1.06	1.08	1.09	1.07
2030a	1.08	1.09	1.10	1.07	1.06	1.10	1.11	1.10	1.10	1.10	1.10	1.09
2075a	1.21	1.21	1.18	1.14	1.16	1.22	1.25	1.25	1.25	1.24	1.23	1.22
2010b	1.04	1.05	1.07	1.05	1.03	1.06	1.07	1.07	1.07	1.09	1.10	1.07
2030b	1.07	1.08	1.10	1.08	1.06	1.09	1.11	1.10	1.10	1.11	1.11	1.10
2075b	1.18	1.20	1.20	1.17	1.17	1.21	1.23	1.23	1.23	1.23	1.21	1.18

Tab. 8. Long-term means of the CCCMprep specific humidity at 850hPa level (a) and at ground level (b) for central Slovakia (Max - maximum monthly means for July).

Period	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Max
CCCMprep 2000 (model outputs are not modified according to measured series of specific humidity)													
1951-1980a	3.6	3.4	3.6	4.6	6.5	8.1	9.5	9.0	7.0	5.3	4.3	3.9	**10.6**
2051-2100a	4.3	4.2	4.3	5.1	7.5	10.0	11.9	11.2	8.9	6.4	5.4	4.7	**14.3**
1951-1980b	4.3	4.4	5.0	6.8	9.3	11.5	13.3	12.7	10.0	7.2	5.4	4.6	**14.6**
2051-2100b	5.1	5.3	6.1	7.8	10.8	14.2	16.4	15.4	12.4	8.8	6.6	5.4	**19.6**

4. Conclusion

Designing of extreme precipitation scenarios for the next century is a very complex problem. The outputs of GCMs represent some areal averages and can not be used as values for individual stations directly. This is why some downscaling procedure, taking into account measured values in the control period, has to be used. The solution of the topic is at the beginning and some preliminary results are presented there only. The preparing as many data as possible for the control period and selection of the most convenient GCMs outputs are the most important steps at present. The further step is oriented for designing two GCMs output modification at least. Besides CCCM coupled model, the GISS coupled model outputs are planned to be modified for Slovakia.

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Milan Lapin, Pavel Faško, Pavel Štastný
Slovak Hydrometeorological Institute
Bratislava
Slovak Republic

Milan Lapin, Ingrid Damborská, Marián Melo
Department of Meteorology and Climatology
MFF, Comenius University
Bratislava
Slovak Republic