SNOW COVER CHANGES IN THE LITTLE CARPATHIANS IN SLOVAKIA

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Abstract: The Little Carpathians represent relatively isolated 80 km long mountains in south-western Slovakia with mean altitude of their ridge about 600 m and steep slopes. Observations from 20 stations have been utilized for areal and temporal snow cover analysis (3 of them with complete observations since 1921 and 6 since 1951, all other stations have shorter periods of observations, insignificantly interrupted series, or they have already closed their operation). After analysis of selected series we came into conclusion to reconstruct daily snow cover time series from October 1950 to April 1990 and from October 1990 to April 2004 (without and with influence of supposed climate change). The results showed that in spite of significant increase in temperature means and some decrease in precipitation totals in the November to March season no remarkable decrease in snow cover conditions occurred after 1990. Only selected results are presented in this extended abstract.

Keywords: *climate change, variability, snow cover*

1. INTRODUCTION

The Little Carpathians represent relatively isolated 80 km long mountains in south-western Slovakia (Fig. 1 left) with mean altitude of their ridge about 600 m a.s.l. and steep slopes. This mountain is surrounded by flat lowlands in the North-west and South-east with altitudes from 130 to 200 m a.s.l. The city of Bratislava lies at the southwestern edge of mountains. Also other parts of its surroundings are densely populated (more than one mil. inhabitants). That is why the Little Carpathians are very frequently visited by tourists, mainly in winter. The snow conditions are influenced there by relatively high winter precipitation totals and by temperatures near the freezing point. For example precipitation total at the Modra station (SE foot, 168 m a.s.l.) is 243 mm in the November to March season and 250 mm from May to August, while annual mean total is 696 mm for the 1901–1990 period. Mean January temperature is about -1.5°C at the southern foot of mountains and about -4.0°C in the 600 m altitude. Mean snow cover depth in 600 m altitude is about 35 cm with about 80% probability of occurrence in top winter (end of January to end of February), while near the Bratislava city it is only about 12 cm with 55% probability of occurrence by the end of January. Absolute snow cover depth maximum is about 100 cm at the ridge (measured maximum – 119 cm in February 1931) and about 50 cm at the foot of mountains (all from previous snow conditions elaboration (see references))

2. METHOD AND RESULTS

Observations from 20 stations have been utilized (Tab. 1). After analysis of selected series we came into conclusion to reconstruct temporal and areal changes in snow cover conditions for the periods from winter 1921/22 to 1949/50 (6 stations), from 1950/51 to 1989/90 (19 stations) and from 1990/91 to 2003/04 (16 stations), supposing that only the last one was significantly influenced by supposed climate change, IPCC, TAR (2001). Significant trends in air temperature means can be seen in Fig. 1 right (about 1.5°C increase in the November–March season since 1951 – this season was selected for snow conditions analysis, because of insignificant snow cover in October and April – Fig. 3 left).

Table 1. List of utilized stations and elaborated snow cover characteristics (Sum – mean sum of daily snow cover depths in the winter season, M SC – mean winter snow cover depth calculated from days with snow cover ≥1 cm, Max – maximum of daily snow cover depth in the whole selected period and the datum of maximum occurrence), * - selected period was insignificantly completed using data from other stations or there was extrapolated shorter series of observation (see comments at the foot), SE and NW – the station lies to the southeast or to the northwest from the ridge of the Little Carpathians.

Station * calculated	Altitude/ Location	Measurements From	 To	Winters N	Days N	Sum [cm]	M SC [cm]	Max [cm]	Datum
Vývrat	365 / NW	XI.1921	IV.1950	29	64.3	959.2	14.9	88	7.2.1931
Vývrat*	365 / NW	X.1950	IV.1990	40	56.0	748.3	13.4	71	21.2.1956
Kuchyna	252 / NW	XI.1921	IV.1950	29	52.1	640.7	12.3	66	12.1.1945
Kuchyna	252 / NW	X.1950	II.1990	40	46.1	432.6	9.4	70	19.2.1952
Kuchyna	236 / NW	X.1990	III.2004	14	34.6	290.1	8.4	35	28.12.1993 10.3.2004
Kosariská*	380 / NW	X.1950	VI.1990	40	70.6	1223.2	17.3	75	18-20.2.1952
Borinka*	230 / NW	XII.1950	II.1990	40	57.0	590.9	10.4	65	18-19.2.1952
Borinka	226 / NW	X.1990	III.2004	14	44.1	649.4	14.7	60	26.2.1993
Kacín*	297/ NW	X.1950	IV.1990	40	61.9	1067.5	17.2	77	7.3.1970
Devín. N.V.	154 / NW	XII.1950	II.1990	40	33.0	293.1	8.9	79	16.2.1952
Devín. N.V.	140 / NW	X.1990	III.2004	14	27.1	186.0	6.9	40	14.2.1999
Br., Devín	169 / NW	XII.1950	II.1990	40	37.7	339.8	9.0	73	18.2.1952
Br., Devín	156 / NW	X.1990	III.2004	14	32.6	252.4	7.7	34	28.2.1993
Br., Kamzík	410 / SE	X.1950	III.1990	40	74.7	1260.1	16.9	83	4.2.1963
Br., Kamzík	403 / SE	X.1990	III.2004	14	53.1	847.0	16.0	65	20-21.2.1996
Mlyn. Dolina*	182 / NW	X.1950	IV.1990	40	47.2	563.7	12.0	44	16.1.1987
Mlyn. Dolina	182 / NW	X.1990	III.2004	14	40.6	349.6	8.6	30	28.12.1993
Mudronova	246 / SE	X.1950	II.1990	40	44.5	486.0	10.9	55	15.1.1987
Mudronova	246 / SE	X.1990	III.2004	14	42.2	477.9	11.3	35	28-29.1.1996
BR, Koliba	286 / SE	I.1951	III.1990	40	53.9	639.2	11.9	71	24.1.1987
BR, Koliba	286 / SE	X.1990	III.2004	14	56.2	634.6	11.3	38	29.3.1993 28.12.1993
BR, Airport	131 / SE	I.1951	II.1990	40	30.3	268.5	8.9	58	22.2.1956
BR, Airport	131 / SE	X.1990	III.2004	14	35.4	356.5	10.1	36	29-30.1.1996 14.2.1996
Limbach 1	315 / SE	XI.1921	III.1950	29	76.9	1625.6	21.1	83	9.2.1931
Limbach 1	315 / SE	X.1950	II.1990	40	60.2	851.7	14.1	87	21-22.2.1956
Limbach 1*	315 / SE	X.1990	IV.2004	14	52.4	809.1	15.4	80	14.2.1996
Limbach 2*	181 / SE	X.1990	IV.2004	14	37.2	371.1	10.0	29	14.2.1996
M. Javorník*	586 / SE	X.1950	IV.1990	40	83.5	1227.3	14.7	81	27.1.1987
M. Javorník	586 / SE	X.1990	IV.2004	14	79.1	1484.6	18.8	99	14-15.3.1996
Biely Kríz*	495 / SE	X.1950	IV.1990	40	66.2	1099.5	16.6	75	27.1.1987
Mod. Piesky*	533/ SE	X.1950	IV.1990	40	99.1	1696.1	17.1	90	27.1.1987
Mod. Piesky*	533/ SE	X.1990	IV.2004	14	89.2	1611.3	18.1	94	14.3.1996
Panský D.*	479/ SE	X.1921	IV.1950	29	93.3	3007.8	32.2	119	16-17.2.1931
Panský D.*	479/ SE	X.1950	IV.1990	40	77.7	1769.3	22.8	80	27.1.1987
Modra	190/ SE	XI.1921	III.1950	29	55.2	683.6	12.4	64	16.2.1940
Modra	206 / SE	III.1950	III.1990	40	42.7	395.3	9.3	56	23.2.1956
Modra	168 / SE	X.1990	III.2004	14	34.4	279.2	8.1	28	28.1.1996
Buková	336/ SE	X.1990	III.2004	14	42.1	429.4	10.2	77	29.12.1996
Smolenice	241 / SE	XI.1921	III.1950	29	56.8	619.3	10.9	46	25.2.1946
Smolenice	241 / SE	X.1950	II.1990	40	49.3	478.4	9.7	60	4.3.1970
Smolenice	228 / SE	X.1990	III.2004	14	43.4	478.1	11.0	42	20.2.1996

Comments: Complete observations: Vývrat – 1921-1980, Košariská – 1950-1970, Kacín – 1950-1980, BR Mlynská Dolina – 1982-2004, Limbach – 1921-2003 (moved in 1990), Biely Kríz – 1958-1973 (near Malý Javorník), Modra Piesky – 1988-2004, Panský Dom – 1926-1936, Buková – 1986-2004.

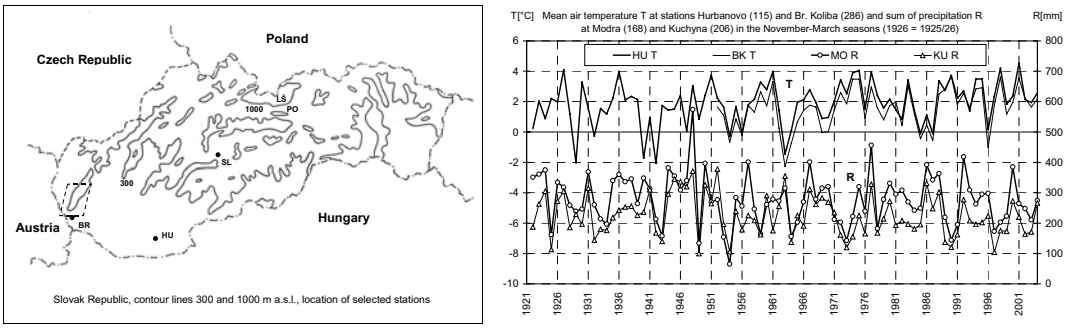

Figure 1. Left - map of Slovakia with contour lines 300 and 1000 m altitude, and selected stations HU (Hurbanovo), BR (Bratislava), and marked rectangle of analyzed area in the Little Carpathians; Right – November – March air temperature means T[°C] and at the stations HU in 1920/21-2003/04 and BR Koliba in 1951/52-2003/04, and precipitation totals at the stations Kuchyna (NW foot) and Modra (SE foot) in 1920/21-2003/04.

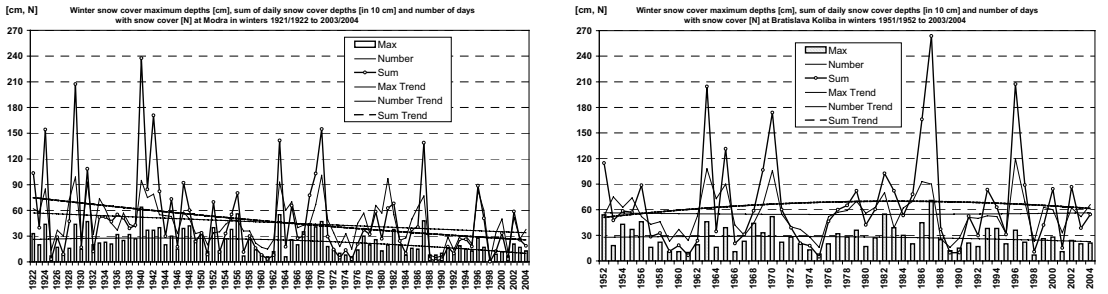

Figure 2. Snow cover maximum (columns [cm]), number of snow cover days (simple line) and sum of daily snow cover depths (top lines, [10 cm]) at the stations Modra (left) in 1921/22-2003/04 winters and BR Koliba (right) in 1951/52-2003/04 winters, including power trends.

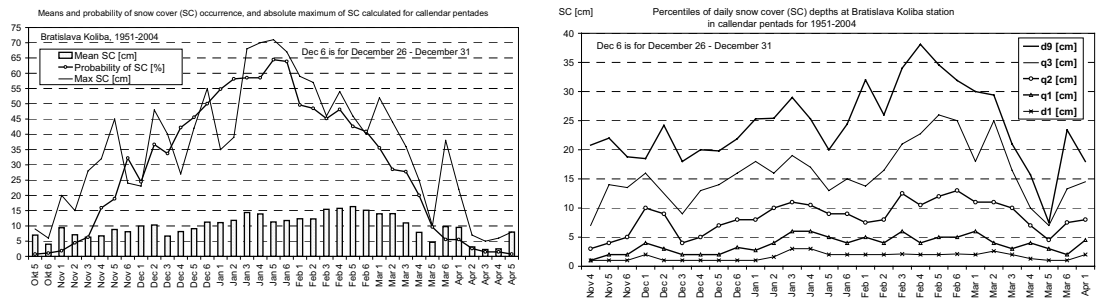

Figure 3. Bratislava Koliba station: Left –winter course of mean snow cover depths SC[cm] calculated from the days with SC ≥1 cm for calendar pentads, absolute maximum of daily SC depths and mean probability of SC occurrence in the calendar pentads from the end of October to the end of April; Right - at the stations HU, PO and LŠ, and at 850 hPa level* (2 h. p.m.) in 1951-2004 (; 71-2004)*; Right – percentiles of daily snow cover depths (upper decile, upper quartile, median, lower quartile, lover decile) calculated for calendar pentads from the middle of November to the beginning of April (the calendar pentad in October: 1 – from Oct. 1st to 5th, 2 – from Oct. 6th to 10th, … 6 – from Oct. 26th to 31st, etc).

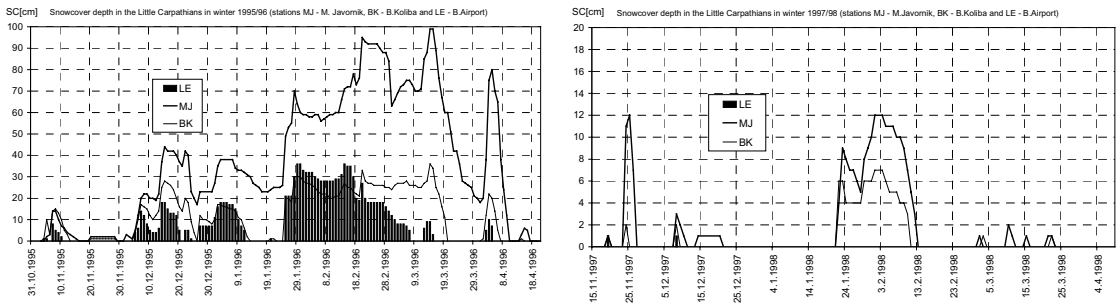

Figure 4. Bratislava Airport (columns, LE), Malý Javorník (top line, MJ) and Bratislava Koliba (BK) – daily snow cover depths in winter 1995/96 (left, one of the highest since 1950) and in winter 1997/98 (right, one of the lowest since 1950).

From the presented snow characteristics in Table 1 it can be seen that except the stations Bratislava Koliba and Bratislava Airport (Borinka and Malý Javorník at sum of daily snow cover depths) all stations show decrease of snow cover after 1990. The most significant decrease occurred in the north western and northern part of the Little Carpathians (even more than by 30%). Increase of snow cover in the south eastern part of Bratislava since 1990 needs to be analyzed more in details. Figures 1 right and 2 show that one of the possible reason could be change in atmospheric circulation, because precipitation in the Little Carpathians is very sensitive to direction of atmospheric currents. Complete study on snow conditions in the Little Carpathians will be published in 2005.

3. CONCLUSION

Presented paper shows only a brief study on climate change detection in Slovakia using snow cover data from as much dense stations network as possible. Winter weather conditions occurred in the 1991–2004 period were in Slovakia very unusual with several exceptional events also at snow cover. We will try to compare obtained results with characteristics from other Slovak regions (regular snow cover observations are to disposal from about 180 stations since 1921, about 400 stations since 1951 and more than 600 stations since 1961).

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