PRACE GEOGRAFICZNE, zeszyt 108

Instytut Geografii UJ
Kraków 2000

Pavel Faško, Milan Lapin, Pavel Šťastný, Jozef Vivoda

MAXIMUM DAILY SUMS OF PRECIPITATION IN SLOVAKIA IN THE SECOND HALF OF THE 20TH CENTURY

Abstract: Increasing number of natural disasters caused by heavy rains and exceptional rain intensities occurred in Slovakia initiated the analysis of maximum daily precipitation totals. About 600 precipitation stations in Slovakia have sufficiently reliable time series of maximum daily precipitation totals in the 1950-1999 period.

Key words: annual maximum of daily precipitation, maps of maximum precipitation probability.

1. Data and Method

About 700 precipitation stations is in the operation each year in Slovakia since 1950. According to detail analysis 607 stations have sufficiently reliable time series of annual maximum of daily precipitation totals in the 1950-1999 period. This is probably enough database for obtaining new knowledge predominantly in areal analysis of heavy daily precipitation events. It is known, that individual Slovak regions are differently loaded by heavy rains and flash floods. They can occur exceptionally also in generally dry lowland localities. Some stations from mentioned 607 had interrupted series and needed to be completed. After the reliability analysis we excluded the stations with gaps of more than 10 years and 557 relatively better stations left for detail statistical analysis. For each station the annual maximum of daily precipitation totals series are to disposal (607 or 557 series of 50 maximum daily totals).

All 607 stations were used for calculation of maximum daily totals occurrence probability with returning period of 100, 50, 20, 10, 5 and 1 year by use of Gumbel theoretical data distribution. The calculations were carried out for each station separately. The final results have been elaborated in the form of tables and maps (Fig. 1 and 2, complete series of maps is presented as a poster).

Data from more reliable 557 stations were elaborated as follows: We divided Slovakia roughly into 4 regions according to the river basins, different topography

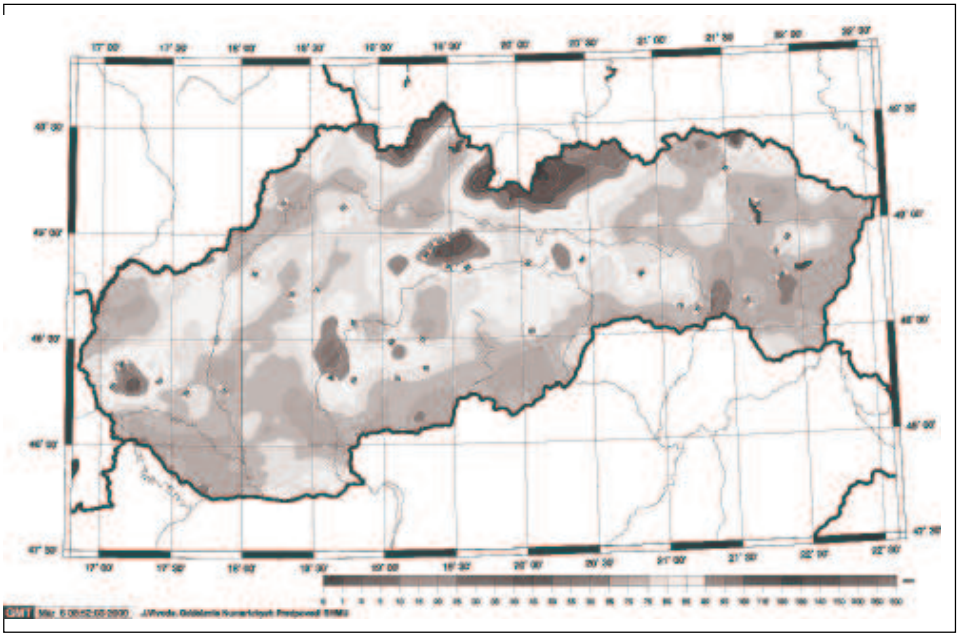

Fig. 1. Maximum daily precipitation totals in Slovakia with probability p = 0.02 (50-year returning period; data from 607 stations and 1950-1999 period have been elaborated).

and different precipitation regime. Region 1 (north-western Slovakia, upper Váh river basin up to Trencín, 101 stations, mostly mountains) is predominantly influenced by western to northern atmospheric circulation. 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, upper Hron river basin up to Brehy, the river basins of Ipel, Slaná and Bodva, 119 stations, mostly southerly oriented slopes of mountains) is influenced mostly by southern to south-eastern atmospheric circulation and Region 4 (eastern Slovakia, the river basins of Bodrog, Hornád and Poprad, 149 stations, complex topography, frequent lee effects) has usually different precipitation conditions compared to the other regions. Within the Region 1 we selected sub-Region 1a, upper Váh river basin up to Zilina with 81 stations, frequently considered as a model river basin in Slovakia.

The statistical analysis of data divided into several regions in Slovakia was concentrated mostly on comparisons of means, variation coefficients (Cv), maximum and minimum (Max, Min) and percentiles (pc10, pc25 (q1), pc75 (q3), pc90 (d9) and pc95) between the regions and stations. These statistical characteristics were calculated as values of empirical series for individual stations and years in the selected regions and for all 1950-1999 period (Tab. 1-2, Fig. 3-7).

Not any special methods for the data reliability testing have been used. The completion of 50-year series was adopted as only criterion for 557 station selection.

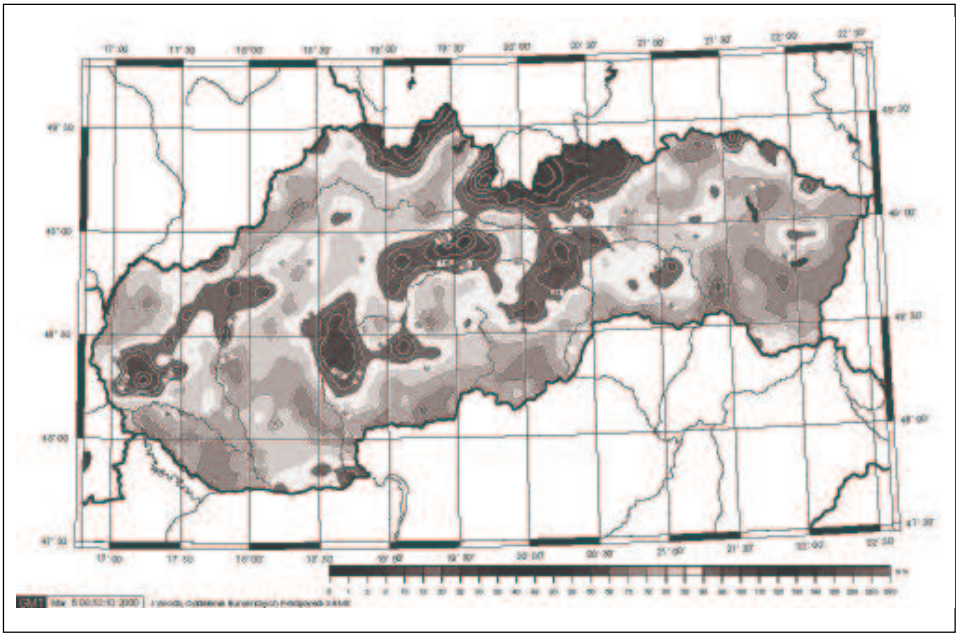

Fig. 2. Maximum daily precipitation totals in Slovakia with probability p = 0.01 (100-year returning period; data from 607 stations and 1950-1999 period have been elaborated).

Series with more than 10 year consecutive gaps in data and more than 15 year total gaps have been excluded from the detailed analysis. The gaps in the series have been filled by the method of surrounding stations comparison in maps. The filled maxima have been expressed in 5 mm steps (75, 80, 85 mm…). Less than 200 stations are without any gaps in the series.

2. Results

Maximum daily precipitation totals can be caused by two characteristic types of synoptic situations (weather conditions): 1. By very intense thunderstorms, sometimes with the series of such thunderstorms, 2. By the continuous heavy rains in the area of local cyclone. At the first type of high totals the precipitation event duration is usually one to several hours, but at the second type the precipitation event duration can be even several days. The firstly mentioned events cause local flash floods only, but the second ones, the regional longer lasting floods. This problematic was studied by Šamaj et al. (1985), analysing the 334 most reliable stations in Slovakia in 1901-1980 (some series were not complete, the gaps in the series were not filled there).

The Figures 1 and 2 can be considered as presentation of main results of the elaboration. The probabilities p = 0.01 and 0.02 (100-year and 50-year returning periods)

are very frequently used in climatological and hydrological studies. At p = 0.01 less than 20% of stations in Slovakia have more than ≥100 mm precipitation maximum (the High Tatras, the Low Tatras, north-western Slovakia, the Little Carpathians and some small areas in central and western Slovakia). It is surprising, that eastern Slovakia have mostly significantly lower totals at p = 0.01 than 100 mm (locality Vyšný Caj, near Košice, only 59.3 mm, what is the lowest value in Slovakia). The highest values for p = 0.01 have stations in the Tatras (Skalnaté Pleso - 164.1 mm, Zverovka - 163.4 mm, Jasná - 159.7 mm, Podspády - 153 mm). For p = 0.02 the absolute maximum is at Skalnaté Pleso - 147.6 mm and the absolute minimum 55.1 mm in eastern Slovakia.

In the Figures 3-6 the statistical characteristics for individual years and selected regions are shown. There can be seen differences between the regions and their temporal trends. It seems that the Region 1 is significantly more loaded by extreme daily precipitation totals than the other ones, but in many years the situation is completely different and all parts of Slovakia can have the country maximum of daily heavy rains in the individual years. For the most extreme Region 1a (81 stations in the upper Váh river basin) the selection of stations into two groups A and B was realised. The A stations lie in the open valleys not affected directly by upwind and other mountainous effects, but some lee effects are possible there. The B stations lie in the mountains, or at the foot of mountains with upwind effects. Figure 7 and Table 2 show some differences between the A and B groups of stations. All statistical

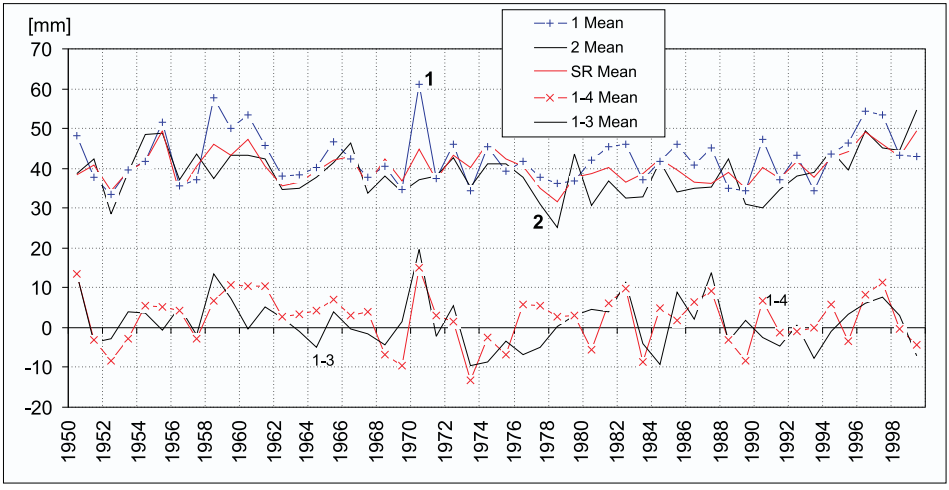

Fig. 3. Yearly values of average from the annual maxima of daily precipitation totals for the stations in the selected regions (1, 2 and all SR) in Slovakia in 1950-1999 (1-4 - difference between the Region 1 and Region 4, see the text).

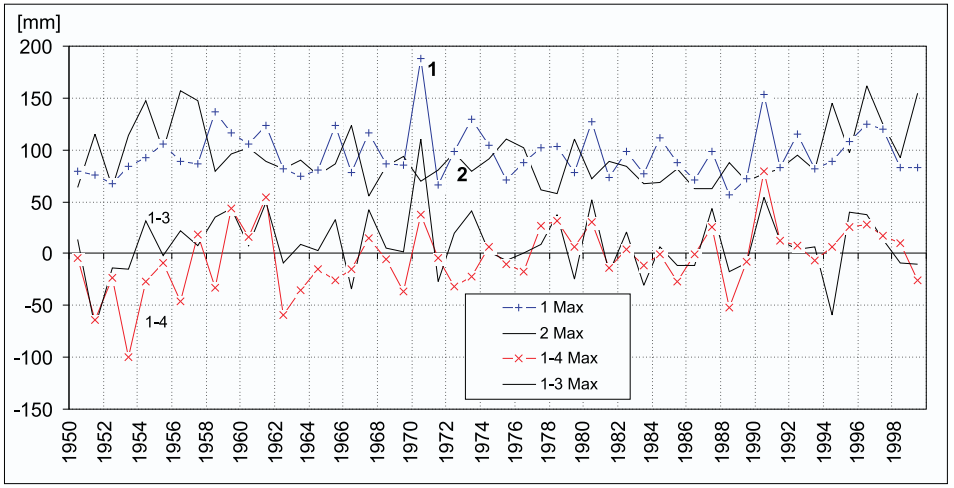

Fig. 4. Yearly values of absolute maximum from the annual maxima of daily precipitation totals for the stations in the selected regions (1 and 2) in Slovakia in 1950-1999 (1-4 - difference between the Region 1 and Region 4, see the text).

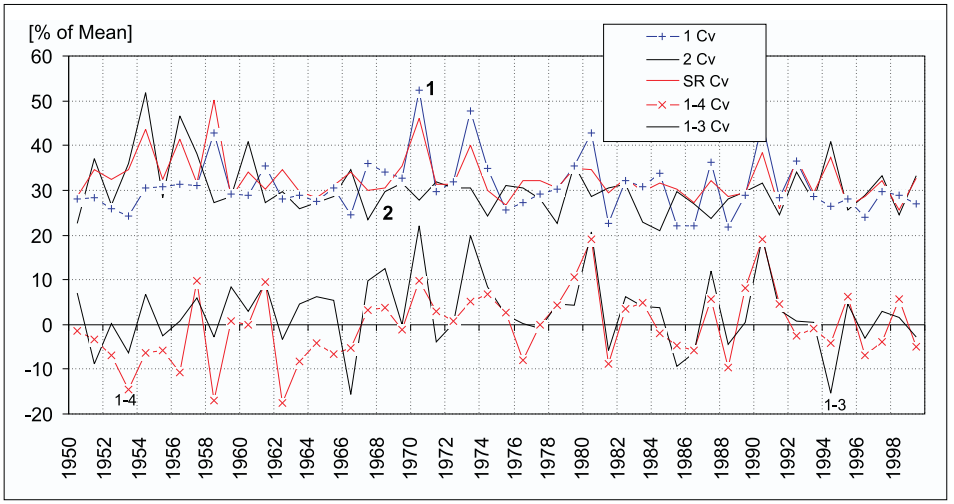

Fig. 5. Yearly values of variation coefficient from the annual maxima of daily precipitation totals for the stations in the selected regions (1, 2 and all SR) in Slovakia in 1950-1999 (1-4 - difference between the Region 1 and Region 4, see the text).

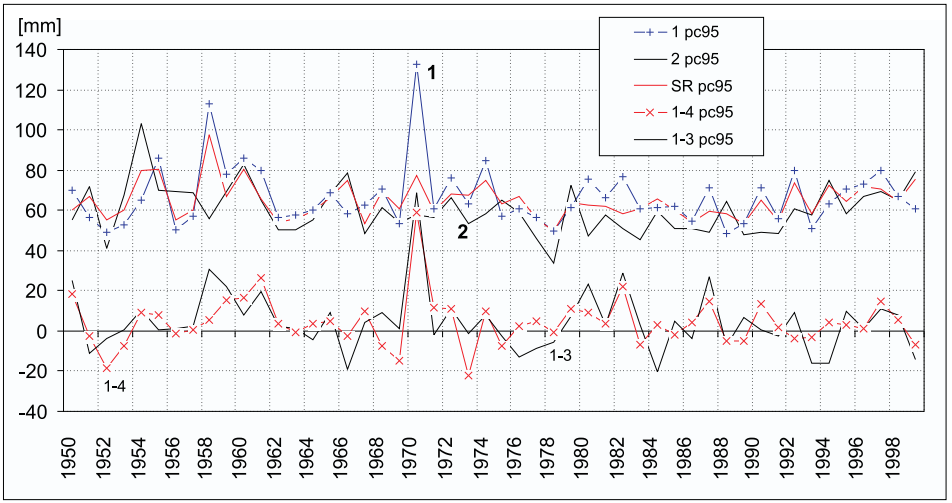

Fig. 6. Yearly values of 95% percentile from the annual maxima of daily precipitation totals for the stations in the selected regions (1, 2 and all SR) in Slovakia in 1950-1999 (20-year returning period, 1-4 - difference between the Region 1 and Region 4, see the text).

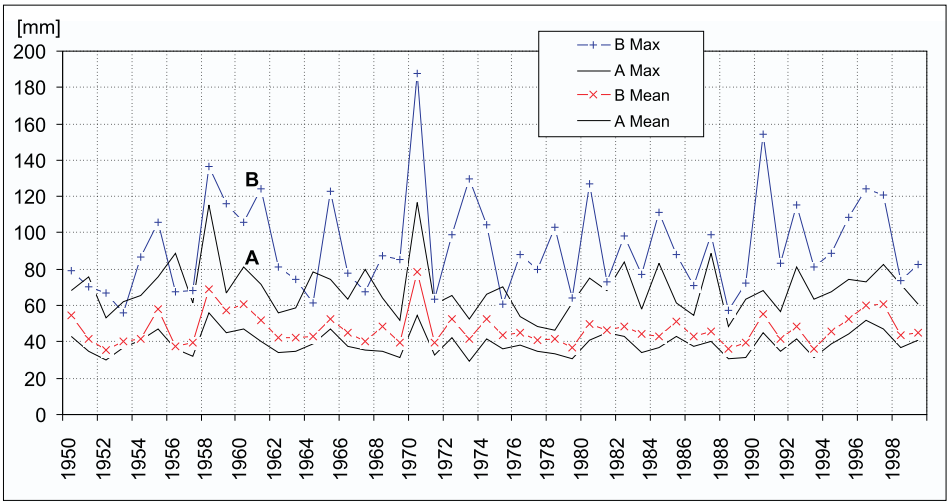

Fig. 7. Yearly values of absolute maximum and average from the annual maxima of daily precipitation totals for the stations in the mountainous part (B) and open valley part (A) of the Region 1a in northern Slovakia in 1950-1999 (Region 1a - 81 stations, A part - 42 stations, B part - 39 stations, see the text).

characteristics are significantly higher in the B group of stations (the mean is by 8.0 mm higher in average).

In Table 1 we can see the correlation of 50-year series of maximum daily precipitation total areal values among the regions. The greatest differences are between the Regions 1 and 2 (maximum and Cv, not at minimum and low percentiles) and between the Regions 2 and 4 (all, including minimum, probably due to the greatest distance). It is interesting that at the Regions 1 and 3 (northern and southern Slovakia) the correlation is very close, except the absolute maximum, but at the Regions 2 and 3 (south-western and southern SR) the correlation is in general very close. It seems, the Region 1 is the most exceptional in Slovakia (the greatest variability, extremes and means).

Tab. 1. Correlation coefficients for the statistical characteristics of annual maximum of daily precipitation totals between the Regions 1a, 1, 2, 3, 4 and Slovakia (SR) in 1950-1999 (see text).

	1&SR	2&SR	3&SR	4&SR	1&3	2&4	1&4	3&4	2&3	1&2	1a&1	1a&2	1a&3
Mean	0.71	0.77	0.76	0.66	0.44	0.21	0.39	0.40	0.44	0.35	0.98	0.25	0.45
Cv	0.61	0.49	0.52	0.72	0.04	0.15	0.32	0.46	0.26	-0.08	0.96	-0.07	0.34
Max	0.54	0.50	0.24	0.69	-0.01	0.14	0.27	0.19	0.24	-0.10	0.96	-0.09	0.26
Min	0.49	0.70	0.58	0.54	0.25	0.13	0.03	0.40	0.39	0.52	0.88	0.43	0.14
q3	0.67	0.69	0.80	0.66	0.41	0.14	0.32	0.43	0.43	0.38	0.97	0.26	0.39
q1	0.62	0.86	0.68	0.62	0.38	0.31	0.22	0.34	0.43	0.41	0.97	0.34	0.26
d9	0.67	0.59	0.81	0.72	0.42	0.05	0.52	0.57	0.34	0.18	0.97	0.12	0.56
d1	0.62	0.88	0.63	0.51	0.40	0.20	0.19	0.26	0.43	0.43	0.94	0.31	0.30
pc95	0.71	0.59	0.70	0.73	0.36	0.06	0.61	0.48	0.32	0.13	0.98	0.07	0.59

Tab. 2. Differences between the statistical characteristics of annual maximum of daily precipitation totals in the Region 1a (upper Váh river basin up to Zilina), B - 39 stations in the mountains, A - 42 stations in the open valleys, the 1st column - statistical values for the 1950-1999 means, 2nd column - for the 1950-1999 variation coefficients…).

Characteristic	Mean	Cv	MAX	MIN	Q3	q1	d9
Mean (B) - Mean (A)	8.0	3.4	27.8	3.2	8.9	5.7	12.5
Cv (B) - Cv (A)	9.2	5.5	11.5	3.3	10.3	6.0	11.3
Max (B) - Max (A)	25.9	10.5	71.0	5.1	35.0	17.2	42.9
Min (B) - Min (A)	5.6	-1.4	11.6	0.3	3.6	5.0	7.0
q3 (B) - q3 (A)	7.2	6.3	44.3	3.3	8.1	5.8	12.8
q1 (B) - q1 (A)	5.0	1.6	12.3	2.7	5.8	3.9	7.4
d9 (B) - d9 (A)	14.4	7.6	57.1	5.1	13.8	9.1	25.1

3. Conclusion

The series of completed annual maximum of daily precipitation totals for nearly all precipitation stations in Slovakia since 1950 is a base for many applications in climatology and hydrology. Only limited amount of selected characteristics are presented in the paper. This database will be widened for the monthly maximum of daily precipitation totals in the next years. The prolongation of series behind 1950 is problematic because of many serious gaps and unreliability in the observed precipitation data. Our aim is to complete as many stations as possible and to do some areal evaluation of obtained statistical characteristics.

References

Faško P., Lapin M., Štastný P., 1999, *Statistics of Heavy Precipitation Totals in Slovakia,* [in:] *Proceedings of the Swiss-Slovak Workshop on Meteorology and Climatology*, Bratislava, Zurich (in print).

Šamaj F., Valovic Š., Brázdil R., 1985, *Denné úhrny zrázok s mimoriadnou výdatnostou v CSSR v období 1901-1980 (Daily Precipitation Totals with Extraordinary Intensities in Czechoslovakia in the Period 1901-1980)*, Zb. prác SHMÚ, 24, ALFA, Bratislava, 9-112 (in Slovak).

Šamaj F., Valovic Š., 1973, *Intenzity krátkodobých dazdov na Slovensku (Intensities of Short-term Rains in Slovakia)*, Zb. prác HMÚ, 5, HMÚ, Bratislava, (in Slovak).

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