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EXTREME PRECIPITATION EVENTS IN THE WESTERN CARPATHIANS

Abstract: More than 500 precipitation stations in the Upper Vistula Basin in the southern part of Poland and more than 700 precipitation stations in Slovakia have been in the operation each year since 1949. This was the main reason for the analysis of all measured daily precipitation totals ≥100 mm. The majority of these days and events were connected with the synoptic situation trough (B, Bp, Bc) or cyclone (C, Cv, Nc) in Central Europe. The analysis showed that the years without daily maximum total ≥100 mm have occurred only eight times in Poland and nine times in Slovakia (from 50).

Key words: the Western Carpathians, spatial distribution of extreme daily totals, dynamic-climatological analysis.

1. Data and Method

The paper presents an analysis of daily precipitation ≥100 mm/day in the Upper Vistula Basin (Poland) and in the territory of Slovakia, taking the area of the Carpathians into particular consideration. More than 500 in the upper Vistula basin and more than 700 precipitation station in Slovakia have been in the operation each year since 1949. About half of the territory of Upper Vistula basin takes up the Carpathians. Slovakia is a hilly country, about one third of its territory is considered as mountainous area. This is probably enough number of stations to observe the majority of exceptional precipitation events. In case of very intense precipitation connected with thunderstorms this density of stations is insufficient and only about one third of such events can be observed by this network. The core (the most intense) precipitation area in the strongest thunderstorms is about 1-3 km in diameter and it is moving several km (usually no more than 25 km) in accordance with the progression of thunderstorm. Because of about 8 km mean distance of precipitation stations in Slovakia it is probable that only one third of such core precipitation belts have hit

some of the stations and another two third cases have not been registered directly. In Poland mean distance of precipitation stations is greater than in Slovakia. In spite of this the presented analysis can show the principal distribution of the most extreme precipitation events in the second half of 20th century. From the point of statistical analysis we need to stress that the elaboration of extreme precipitation events was done without consideration (testing) of temporal homogeneity and completion of series. Our basic aim was to register as many observed ≥100 mm daily precipitation totals as possible.

2. Results

In Poland in the 1949-1999 period 547 events with ≥100 mm daily precipitation were recorded in Upper Vistula Basin. This number of events occurred in 104 days and at 242 stations. The majority of events -360 (in 23 days) were recorded in the northern cyclonic situation (Nc) according to Niedźwiedź calendar (Niedźwiedź 2000).The slope exposition influences significantly the spatial differentiation of this precipitation, when the air masses advection over the Carpathians takes place.149 events have been registered in one day – 18 July 1970 in this situation. The wide-ranged precipitation has been noted not only in the Carpathians but on the greater area of the upper Vistula basin as well. Similar genetic types of precipitation had the rainfalls in days -29 June 1958 (43 stations), 21 August 1972 (32 stations), 30 June 1973 (34 stations), 8 July 1997 (22 stations). The majority of the days (25) but only 38 events precipitation ≥100 mm were connected with the synoptic situation trough (Bc). Heavy rainfalls with storms in this situation often had a local range and appeared separately. The spatial differentiation of the number of ≥100 mm daily precipitation cases illustrates a map (Fig. 1). Most of all, i.e. over 6 cases of such rainfall were recorded in Polish part of the Carpathians, on the area of the Silesian Beskid (10 Ustroń Równica Wieś) exposed to the northern-west and Tatra Mts (14 events Hala Gąsienicowa) on the slopes exposed to the north. Generally, in Upper Vistula Basin, the heavy precipitation is recorded in the western part of the Carpathians, and to the east the Dunajec river basin the decay of the rainfall exceeding 100 mm per day is observed.

In Slovakia in the 1949-1999 period altogether 214 events with ≥100 mm daily precipitation total have been registered. This number of events occurred in 82 days (1 day with 36 events – 29 June 1958, C (CS) and Nc (PL) synoptic situation; 1 day with 19 events – 18 July 1970, B and Nc synoptic situation; 1 day with 15 events – 1 July 1954, B and Ea synoptic situation, 2 days with 8 events; 1 day with 7, 6 and 5 events; 3 days with 4 events; 5 days with 3 events; 17 days with 2 events and 49 days with one event of ≥100 mm daily precipitation total). Events with ≥100 mm daily precipitation occurred at 153 stations. Extremely daily precipitation totals occurred more times at one station in the mountains part of Slovakia (Low and High Tatras).The spatial distribution of the number of such events is described in Figure 2. It is shown clearly there that only some of mountainous areas are loaded with 2 and more such events and great majority of Slovakia was without any ≥100 mm daily precipitation

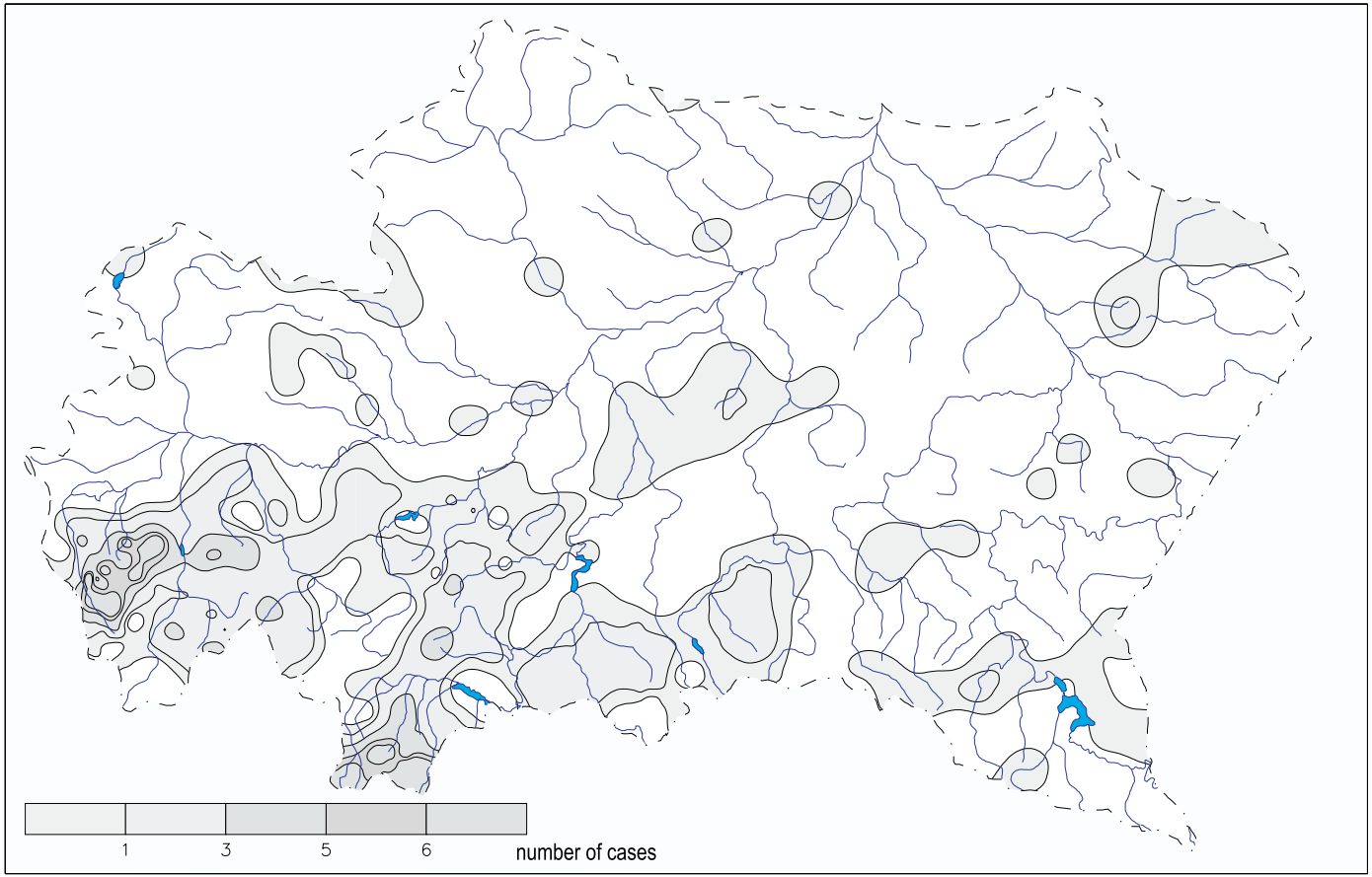

Fig.1. Frequency of the daily precipitation ≥100 mm in the Upper Vistula Basin (number of cases).

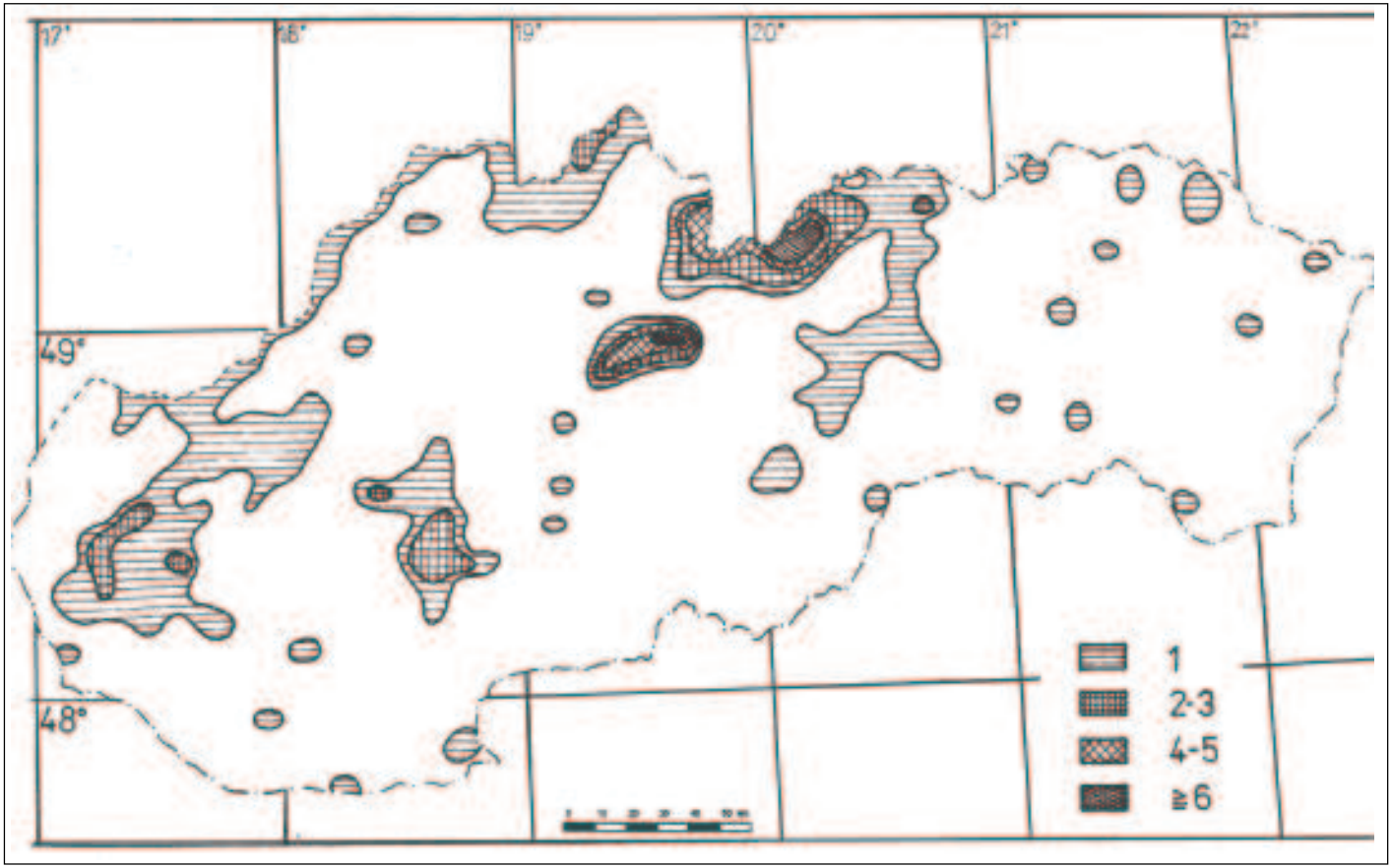

Fig. 2. Frequency of the daily precipitation ≥100 mm in Slovakia (number of cases).

total in 1949-1999. From the lowlands (<300 m a.s.l.) only 7 stations had 2 days with ł100 mm total (all in south-western Slovakia), but only one of them (Trnava) lies far from the mountains. The synoptic analysis was done by use of the Czecho-Slovak and Polish classifications (Tab. 1). It showed expected results that such events are

Tab. 1. Number of days with ≥100 mm precipitation (at least at one station from about 700 in Slovakia) in 1949-1999 (at Polish classification in 1949-1996); CS - Czecho-Slovak and PL - Polish synoptic classification.

No	CS		PL		No	CS		PL		No	CS	
1	A	2	Na	2	**11**	Ec	5	Nc	9	**22**	SWc2	4
2	Ap1	0	NEa	2	**12**	Nc	3	NEc	4	**23**	SWc3	3
3	Ap2	1	Ea	5	**13**	NEa	0	Ec	3	**24**	VFZ	3
4	Ap3	0	SEa	1	**14**	NEc	10	SEc	6	**25**	Wa	0
5	Ap4	0	Sa	1	**15**	NWa	0	Sc	4	**26**	WaL	5
6	B	15	SWa	1	**16**	NWc	0	SWc	3	**27**	Wc	2
7	Bp	3	Wa	2	**17**	Sa	0	Wc	5	**28**	WcS	3
8	C	11	NWa	1	**18**	SEa	1	NWc	1			
9	Cv	3	Ca	2	**19**	SEc	2	Cc	5			
10	Ea	0	Ka	6	**20**	SWa	0	B	19			
					21	SWc1	6	UX	0			

mostly connected with cyclonic situations B, Bp, C, C_v (32 days), SWc, Wc, WcS (18 days) and NEc, Ec, SEc (17 days) when Slovakia is usually influenced by relatively warm and moist air masses from the southern directions. From all 214 events 56 occurred at B synoptic situation and 55 at C situation.

The annual course of such days and events is shown in Figure 3. This result is also in accordance with the expectancy in Slovakia and it confirms that 189 events

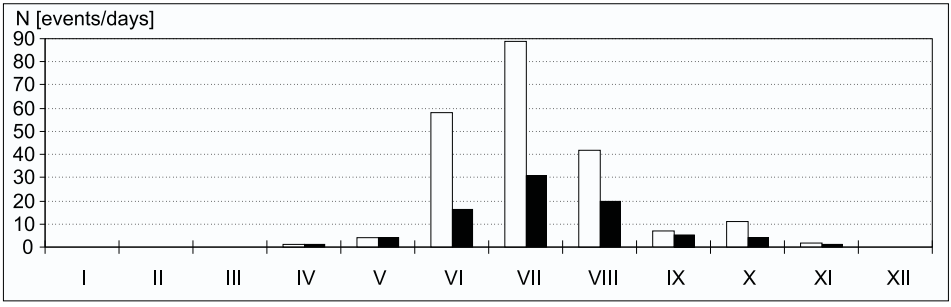

Fig. 3 Number of events (white) and days (black) with daily precipitation total ≥100 mm at about 700 stations in Slovakia in 1949-1999 (annual distribution of 214 events and 82 days).

(from 214) and 67 days (from 82) occurred in the June-August season. Extreme precipitation events in Poland were observed in the warm half of year. In summer (June –August) occurred 504 events (from 547) of heavy precipitation in 82 days (from 104). Most of them were observed in July (42 days, 302 events) – Figure 4. But sometimes the occurrence of exceptional precipitation events in the cold half of year was recorded. It was in days: 19 January 1974, 13 March 1951, 22 April 1974, 8 October

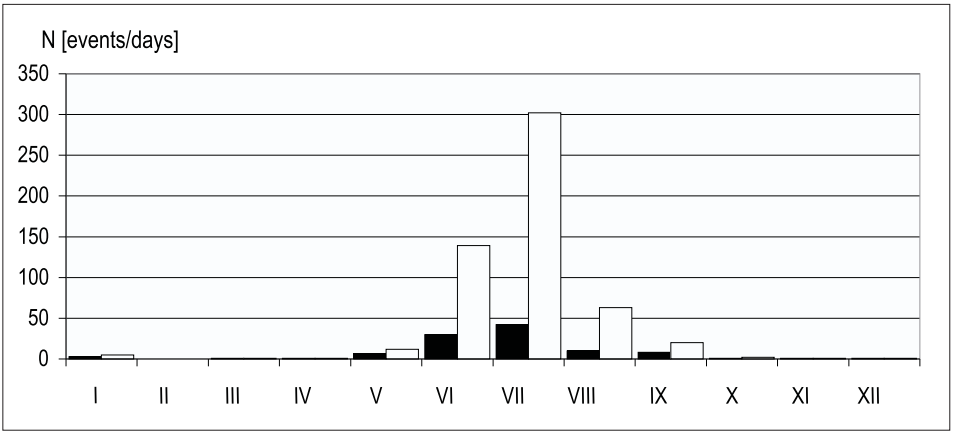

Fig.4. Number of events (white) and days (black) with daily precipitation total ≥100 mm at about 500 stations in Poland in 1949-1999 (annual distribution of 547 events and 104 days).

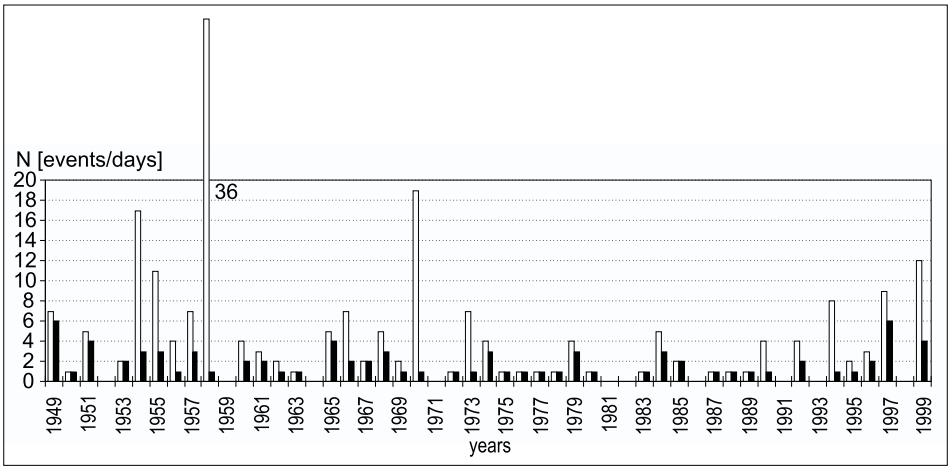

Fig.5. Number of events (white) and days (black) with daily precipitation total ≥100 mm at about 700 stations in Slovakia in 1949-1999 (annual distribution of 214 events and 82 days).

1980, 8 November 1952, 28 December 1954. February was the only month without daily precipitation ≥100 mm. In Figure 5 we can see the temporal trend of such days and events. In Slovakia significantly higher number was observed in the first half of the considered period, with maximum from 1954 to 1970. Then only small number of such events occurred then up to 1993 and some increase was registered in 1994-1999. In Poland (Fig. 6) the largest daily rainfall events and days were grouped in the period 1954-1973 (catastrophic floods in the Carpathians: June 1958, July 1960, July 1970, August 1972, June 1973). After relatively long period of rather poor rainfalls in the years 1981-1995 more humid phase in rainfall course started in 1996 (Cebulak 1998).

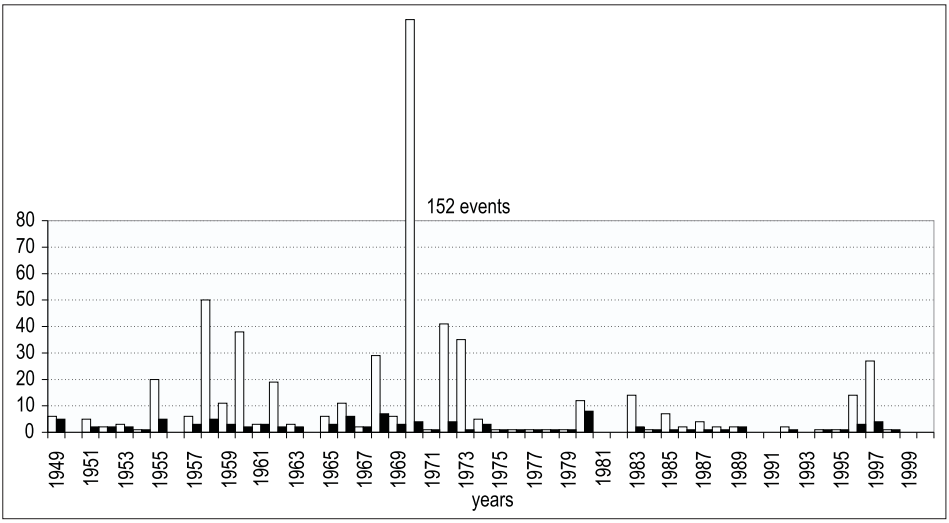

Fig. 6. Number of events (white) and days (black) with daily precipitation total ≥100 mm at about 500 stations in Poland in 1949-1999 (annual distribution of 547 events and 104 days).

3. Conclusion

An analysis of the events of the daily precipitation totals ≥100 mm proved, that the majority of the heaviest, most frequent and wide-ranged rainfalls have been noted on the northern slopes of the Carpathians due to the northern cyclonic situation with the advection of air masses from North and the accumulation of the air masses over the Carpathians. In Slovakia daily precipitation totals ≥100 mm dominated when the country was usually influenced by relatively warm and moist masses from southern directions. The majority of the days with ≥100 mm in the whole area were connected with trough of low pressure.

The results presented in this paper are considered as the first step of the extreme precipitation totals analysis only. The further elaboration should be done by use of more detail analysis of meteorological conditions at each event.

Acknowledgements

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