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RAINFALL CHARACTERISTICS IN SOUTHERN POLAND DURING THE SEVERE FLOODING EVENT OF JULY 1997

INTRODUCTION

Intensive precipitation on 4–9 July 1997, caused a catastrophic flood over the large territory of Southern Poland and the Czech Republic. The flood in the Odra basin was a cataclysm which has not been observed on such a scale this century. Rainfall totals as well as water level values in the upper Vistula basin were similar to those of July 1934 and 1970. Three rainfall periods were observed in July 1997 (Niedźwiedź and Czekierda 1998):
— the main period from 4–9 July, responsible for catastrophic flooding across the Odra river and upper part of the Vistula river and its Carpathian tributaries;
— 18–20 July — the second phase of flooding;
— the third period of rainfall from 25–26 July, mainly in the south-eastern part of Poland (San basin) and on the central part of the Bug river (eastern Poland).

Analysis of synoptic maps (IMGW 1997a) and satellite picture images were undertaken in order to explain the causes for such a great rainfall. The spatial and temporal distribution of daily precipitation totals were based on data of the dense precipitation network of the Institute of Meteorology and Water Management (IMGW 1997b). Data from the Czech Republic were partly published by V. Kveton et al. (1997).

The intense rainfall of July 1997 was compared with other such extreme events in the 20th century and with normal precipitation levels. Long-term fluctuations in July rainfall levels were also presented for selected stations.

SYNOPTIC CHARACTERISTICS OF THE JULY 1997 FLOODING EVENT

The synoptic conditions that initiated the first phase of large rainfall during 4–9 July 1997 were quite typical for such an extreme event during the summer in southern Poland. A relatively stationary weak cyclone developed over the south-eastern part of Poland and western Ukraine. During this five-day period, winds aloft and at the surface came from the north, bringing cool and moist air directly into the slopes of the Western Carpathians and the Sudety Mountains. The main stream of these airflows was directed into the Moravian Gate between the two orographic systems. It produced a thick layer of orographic rain-clouds with the largest rainfalls on the slopes of Silesian Beskidy Mountains in the Western Carpathians and the Hruby Jesenik Massive on the eastern side of Sudety Mountains.

Similar synoptic situations were associated with previous flooding occurrences (Cebulak 1987, 1992b; Lapin and Niedźwiedź 1984; Milata 1955; Morawska-Horawska 1971, 1979; Niedźwiedź 1972, 1980, 1981, 1983). In southern Poland a rather large thermal contrast existed between the western and eastern parts of the Carpathians (with warm air in the eastern part). On the western side of this cyclone, strong cool and humid air advection from the northern sector could be seen over the course of the few days. This influenced the continuous and almost permanent heavy rainfalls during the 3–5 day period. The apogee of this phenomenon was observed between 5 and 8 July and was the first important factor of such huge precipitation totals.

The second factor was connected with the orographic barrier, which forced the condensation of the water vapour. A quite different meteorological situation took place on the eastern side of the low. During the general airflow from the south and south-east, there were some periods with fair weather or short showers and thunderstorms.

According to the slow movement of the low centre, the highest precipitation, first took place in the eastern Sudety Mountains (the Hruby Jesenik Massive) and in the Silesian Beskid range in the Western Carpathians (5–7 July). The most intense rainfalls were observed on 6 July, with daily totals reaching 234 mm at the Lysa Hora summit (Table 1, Fig. 1). On 8 July orographic rains occurred mainly in the Beskid Żywiecki range and the Tatra Mountains, where on the northern slope daily totals exceeded 200 mm (Table 2, Fig. 2). On 9 July, at the end of the flooding period, the low-pressure system was shifting to the East and precipitation disappeared in the Sudety and the Silesian Beskid in the Western Carpathian Mountains. However, in the same day in the middle part of the Dunajec basin a huge convection cell was created; it contained vertically risen *Cumulonimbus* clouds. This produced very heavy torrential rainfalls and a kind of cloudburst, with extremely high intensity (about 150 mm during 2 hours).

After 8 days, from 18–20 July, the next low-pressure system occurred over southern Poland. Although the structure of the synoptic situation was very

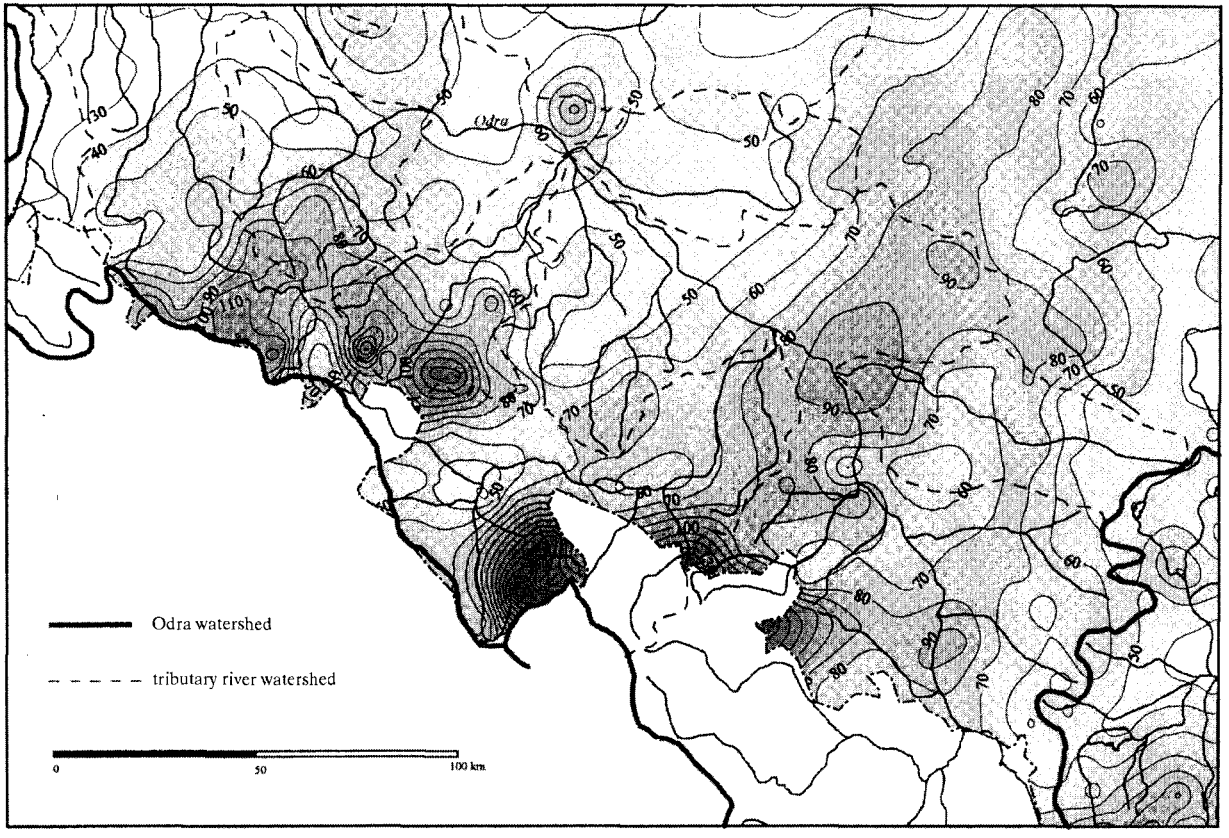

Fig. 1. Maximum daily rainfalls in the upper Odra river basin in July 1997

Table 1

Maximum rainfall of 1–5 days duration and monthly totals of July 1997 in the upper Odra river basin

Station	1 day	2 days	3 days	4 days	5 days	monthly total
Sance	230	329	**537**	**602**	**617**	805
Lysa Hora	**234**	339	510	571	586	**812**
Rejviz	214	359	441	477	511	722
Międzygórze	200	**365**	431	445	454	677
Kamienica	180	334	456	472	482	702
Praded	139	250	356	444	455	661
Karpacz	121	182	199	208	213	501
Głuchołazy	150	234	272	295	306	476
Jarnołtówek	131	230	269	296	314	482
Głubczyce	112	165	212	237	240	359
Racibórz	93	160	204	234	244	352
Opole	96	121	137	155	166	270
Wrocław	33	60	66	80	86	238

similar to the first one, the precipitation intensity was not so high and the duration of events was much shorter. Maximum daily precipitation occurred in the central part of the Sudety Mountains (over 100 mm).

After 21 July, the low moved over to Ukraine. However, local convection cells were appearing in the humid air for a few days, causing local downpours. For example, on 22 July in Krakow, 40 mm of precipitation occurred within 45 minutes. On 25 and 26 July, large rainfalls also occurred in south-eastern Poland and in the middle part of Bug river basin in the frontal zone.

THE MAIN RAINFALL PERIOD (4–9 JULY 1997)

Precipitation started on July 4. Its distribution was very dispersed, because the most of the rainfall was of the thunderstorm origin. Daily totals generally did not exceed 20 mm and did not yet have any influence on river water levels. In the Sudety Mountains precipitation reached 50 mm in Jagniątków (Bóbr catchment) and 28–38 mm between Kłodzko and Bardo. In the Carpathians and their foreland in the Raba catchment in Stróża, the daily total amounted to 36.6 mm and, during thunderstorm in Kolbuszowa, 35 mm. The central part of the Vistula river basin remained dry.

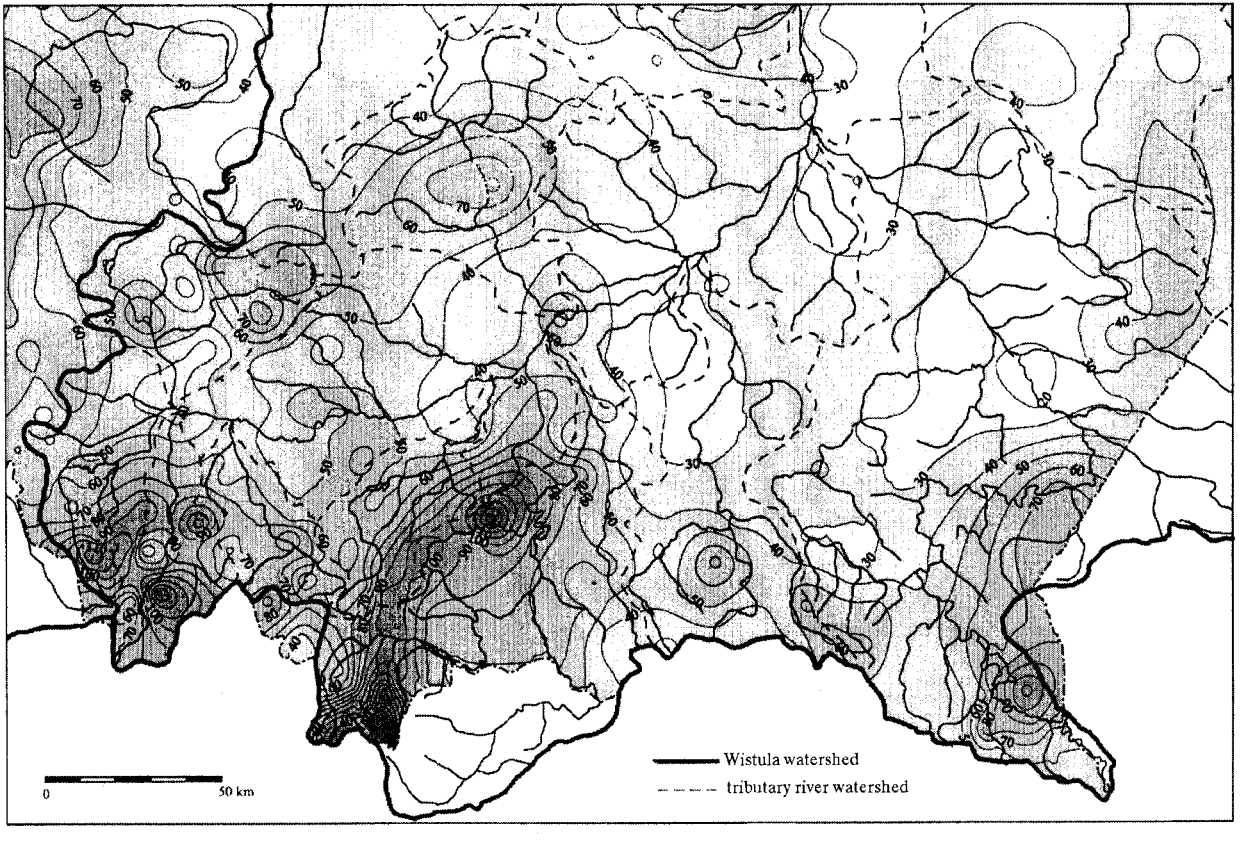

Fig. 2. Maximum daily rainfalls in the upper Vistula river basin in July 1997

Table 2

Maximum rainfall of 1–5 days duration and monthly totals of July 1997 in the upper Vistula (Wisła) river basin

Station	1 day	2 days	3 days	4 days	5 days	monthly total
Brenna-Leśnica	133	224	336	397	424	602
Równica-Wieś	112	196	302	343	380	648
Szczyrk	110	182	289	332	364	540
Wisła	113	163	275	318	343	482
Wisła Malinka	109	178	286	328	350	501
Straconka	103	175	272	311	340	469
Kocierz Moszczanicki	119	170	239	287	306	424
Żabnica	145	206	255	292	304	436
Istebna Kubalonka	89	151	238	275	300	438
Skrzyczne	100	176	260	297	304	499
Wisła Głębce	88	135	223	266	289	398
Brenna	80	140	206	244	265	438
Bielsko/Aleksandrowice	83	126	192	223	246	362
Międzybrodzie	78	117	166	220	234	341
Korbielów	93	143	182	206	222	362
Koszarawa	63	120	178	198	214	396
Maków Podhalański	90	123	169	192	202	338
Wadowice	62	112	140	198	209	155
Hala Gąsienicowa	224	253	280	328	355	560
Dolina Pięciu Stawów	208	245	283	313	328	613
Kasprowy Wierch	166	192	232	257	281	461
Polana Chochołowska	131	154	170	209	233	384
Hala Ornak	163	189	229	247	265	420
Zakopane	104	136	166	193	207	365
Poronin	156	183	207	231	248	386
Rozdziele	120	165	210	227	240	374
Limanowa	86	166	189	204	216	332
Olewin/Olkusz	92	130	164	204	210	422
Pilica	76	101	167	235	240	405
Ryczów	80	106	172	230	237	424
Wolbrom	76	109	174	195	205	344

On 5 July the rainfall became more intense. The largest daily totals covered the eastern part of Sudety Mountains, mainly inside the Nysa Kłodzka (Kamienica 122.5 mm, Bielice 108 mm) and the Biała of Głuchołazy (Bila near Praded 101.6 mm, Ramzova 93.1 mm) catchments. In the upper part of the Odra river basin in the Czech Republic precipitation exceeded 80 mm in the Opava catchment and 60 mm in the Ostravica river catchment. Showers connected with thunderstorms were concentrated mainly on the left side of the Vistula river basin, where the daily amount of rains exceeded 50 mm. The highest rainfalls were observed on the western side of the Kraków Upland (Olewin near Olkusz 92 mm), the Silesian Upland (Czeladź 69.6 mm) and the central part of the Nida Basin (Kliszów 83.4 mm, Skroniów 72.8 mm). In the Carpathians only the Silesian and Small Beskid received more than 40 mm of precipitation. After this day the water level in the rivers markedly increased.

Exceptionally heavy rains occurred during the whole day of 6 July (Table 1, Fig. 1). These rains associated with main stream of humid air flowing from the North directly to the Moravian Gate between the Sudety and Carpathian Mountains, creating a strong orographic effect on the slopes. The highest rainfall covered the upper Odra river basin in the Czech Republic. On the Lysa Hora summit in Silesian Beskid rainfall levels reached 234 mm (Kveton et al. 1997). Large daily totals of 214 mm were also observed in the Hruby Jesenik mountain group at station Rejviz (Kveton et al. 1997; Malinowska-Małek 1997). In the Kłodzko Basin at the Międzygórze station daily precipitation exceeded 200 mm. Even at the Sudety foreland (Głuchołazy 150 mm) the precipitation was exceptionally high. On the northern slopes of the Karkonosze mountain range daily rainfalls were greater than 100 mm (Karpacz 121.4 mm).

A zone of intense but even precipitation also covered the western part of the upper Vistula river basin. The highest amount of water fell on the northern slopes of the Carpathian Mountains, west of from the Raba catchment (Brenna-Leśnica 133.2 mm, Wisła 112.8 mm, Równica 112.1 mm). The Soła catchment (Fig. 3) also received relatively high precipitation although it is partly located in the shadow of the rain (Szczyrk 107.2 mm, Kocierz Moszczanicki 68.9 mm, Koszarawa 63.1 mm). In the eastern part of the Carpathian Mountains on the day of analysis, precipitation did not exceed 10 mm.

July, the 7th was the second day with continued strong precipitation. An exceptionally large amount of rainfall was observed in the Kłodzko Basin (Międzygórze 164.5 mm, Lądek-Zdrój 159.4 mm, Kamienica 154.0 mm). A similar situation occurred in the Czech Republic in the Biała Głuchołaska river basin (Jesenik 167.0 mm, Zlate Hory 145.0 mm), the Opava basin (Vidly 149.6 mm, Rejviz 144.6 mm, Praded 139.0 mm) and the Ostravica catchment (Lysa Hora 105.2 mm, Sance 99.2 mm). Even in the lower localities precipitation was near the 100 mm level (Racibórz 92.9 mm, Adamowice 95.3 mm).

Large orographic precipitation continued over the western part of the upper Vistula river basin west of Kraków, mainly on the northern slopes of the Silesian

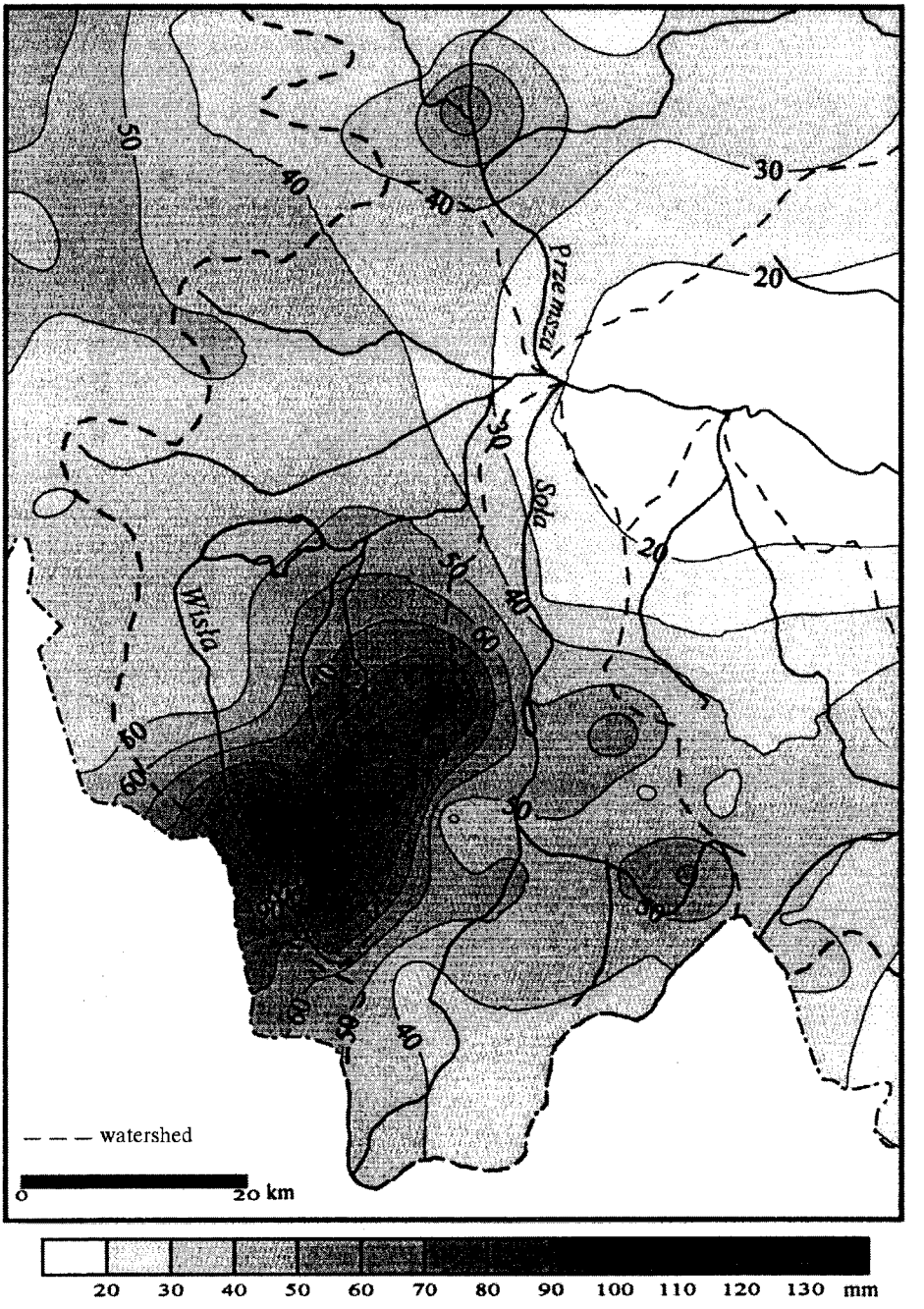

Fig. 3. Daily totals of precipitation in Soła and small Vistula river basins on 6 July 1997

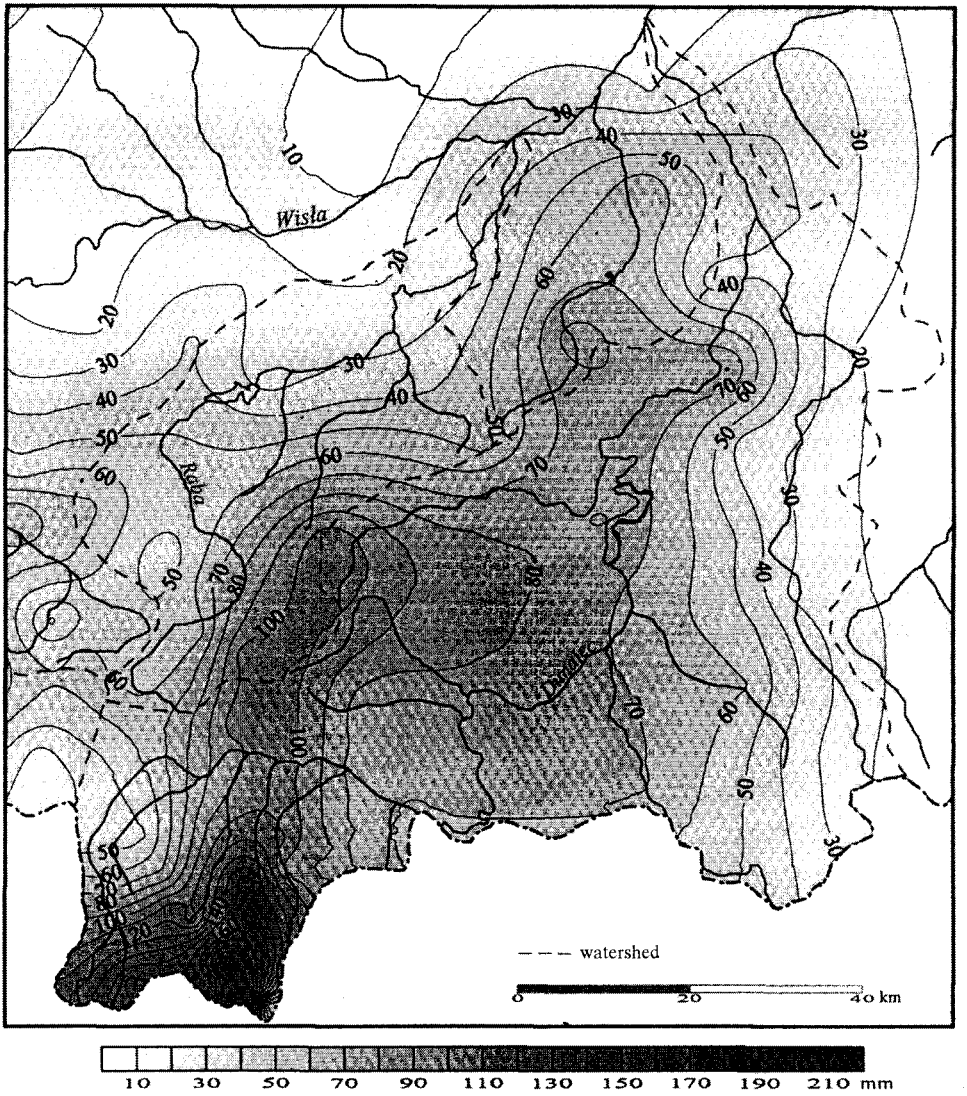

Fig. 4. Daily totals of precipitation in Dunajec and Raba river basins on 8 July 1997

Beskid and the Pilsko and Babia Góra mountains groups, and also on the Kraków–Częstochowa and Silesian Uplands. In the Little Vistula daily catchment totals of rain were less than 100 mm (Brenna-Leśnica 91.0 mm, Równica 84.3 mm, Straconka 72.2 mm). Similar amounts were noticed on the Soła river (Szczyrk 72.0 mm, Żabnica 60.8 mm) and Skawa river (Roztoki 73.1 mm). In the northern part of the uplands the strongest precipitation was connected with thunderstorms (Wolbrom 76.2 mm, Pilica 65.8 mm). A similar situation was observed in the middle part of the Dunajec and Biała river basins (Grybów 67.3 mm).

On 8 July the rains stopped above the largest part of the Odra river basin. Precipitation continued only in the territory of the Czech Republic (Sance 207.3 mm, Lysa Hora 170.7 mm, Moravka 135.0 mm, Praded 110.0 mm).

The main zone of the strongest precipitation moved eastwards from the Odra to the Vistula river basin (Table 2, Fig. 2), enveloped the Silesian, Żywiec Beskids, and Tatra Mountains (Fig. 4), where precipitation exceeded 200 mm (Hala Gąsienicowa 223.5 mm, Dolina Pięciu Stawów 207.9 mm), with maximum intensity exceeding 40 mm during one hour. Large damages and strong geomorphologic processes such as debris-flow, sheet slides and strong water erosion were observed in several streams with water level 3.0–3.5 m above the average (Kotarba 1998). Precipitation exceeding 100 mm and covered the Podhale Basin and Gorce Mountains (Zakopane 104.0 mm, Poronin 156.1 mm, Białka 112.0 mm, Szaflary 103.2 mm, Łopuszna 104.6 mm).

In the Soła river basin the highest daily totals (144.9 m) were measured in Żabnica. High values of precipitation also occurred in Kocierz Moszczanicki (118.7 mm) and Szczyrk (109.5 mm). In the Small Vistula catchment second-day rainfall totals once again exceeded 100 mm (Brenna-Leśnica 112.3 mm, Wisła 112.0 mm, Wisła-Malinka 109.1 mm, Równica 106.0 mm, Straconka 103.2 mm). In the Skawa river basin, the largest amount of rainfall occurred in the middle part (Maków Podhalański 90.0 mm), but was probably higher on the slopes of Leskowiec Mount, where meteorological station was closed. Daily rainfall in the upper part of the Raba Basin also exceeded 100 mm (Jasionów 104.1 mm). Relatively high precipitation was observed on the eastern border of the Kraków–Częstochowa Upland (Pilica 67.5 mm, Lelów 48.9 mm). The great amount of precipitation on the slopes of the Carpathian mountains terminated suddenly on the eastern part of Dunajec river, according to a change in airflow direction from north to south.

On 9 July the rain stopped completely in the Odra river basin, and in the western part of the Carpathian Mountains daily precipitation totals did not exceed 20 mm. However, the synoptic situation described in the previous section caused an exceptional flash flood in the middle part of the Dunajec river basin (Łososina and Uszwica catchments — Fig. 5). Gigantic *Cumulonimbus* clouds produced showers with an intensity of at least 150 mm during one hour in the late afternoon (about 16 GMT). The nearest rain-gauge station at Rozdziele measured 120.2 mm of precipitation. The consequences of this cloudburst were especially severe, because it occurred in a region where previous rains saturated the soil cover. Strong river erosion, landslides on the slopes, and even mud flows devastated several villages in the region (German 1997).

In the Odra river basin the period of precipitation lasted five days (4–8 July). The amount of rainfall for such a short period was comparable with normal annual totals (Table 1, Fig. 6). In the Czech Republic (Kveton

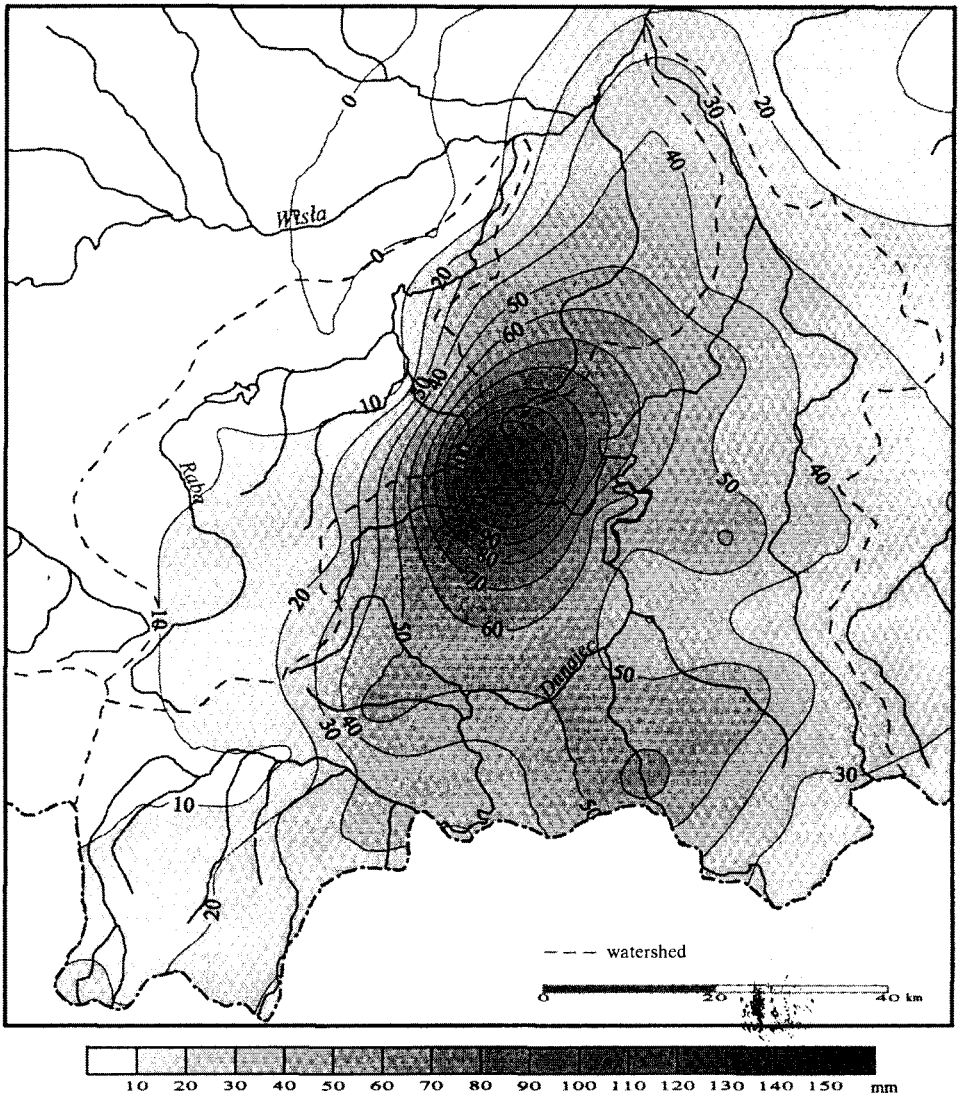

Fig. 5. Daily totals of precipitation in Dunajec and Raba river basins on 9 July 1997

et al. 1997) the highest five-day rains were observed in Sance (617 mm) and Lysa Hora (586 mm) in the Ostravica catchment area, and also in the Hruby Jesenik mountain group (Rejviz 511 mm, Zlate Hory 513 mm, Jesenik 512 mm). On the Polish side of the Sudety Mountains (Malinowska-Małek 1997), the most intense precipitation was concentrated in the Kłodzko Basin (Kamienica 482 mm, Międzygórze 454 mm).

In the western part of the Vistula river basin intense precipitation lasted until 9 July. Still, the 5–6 day totals were much less than in the Odra catchment

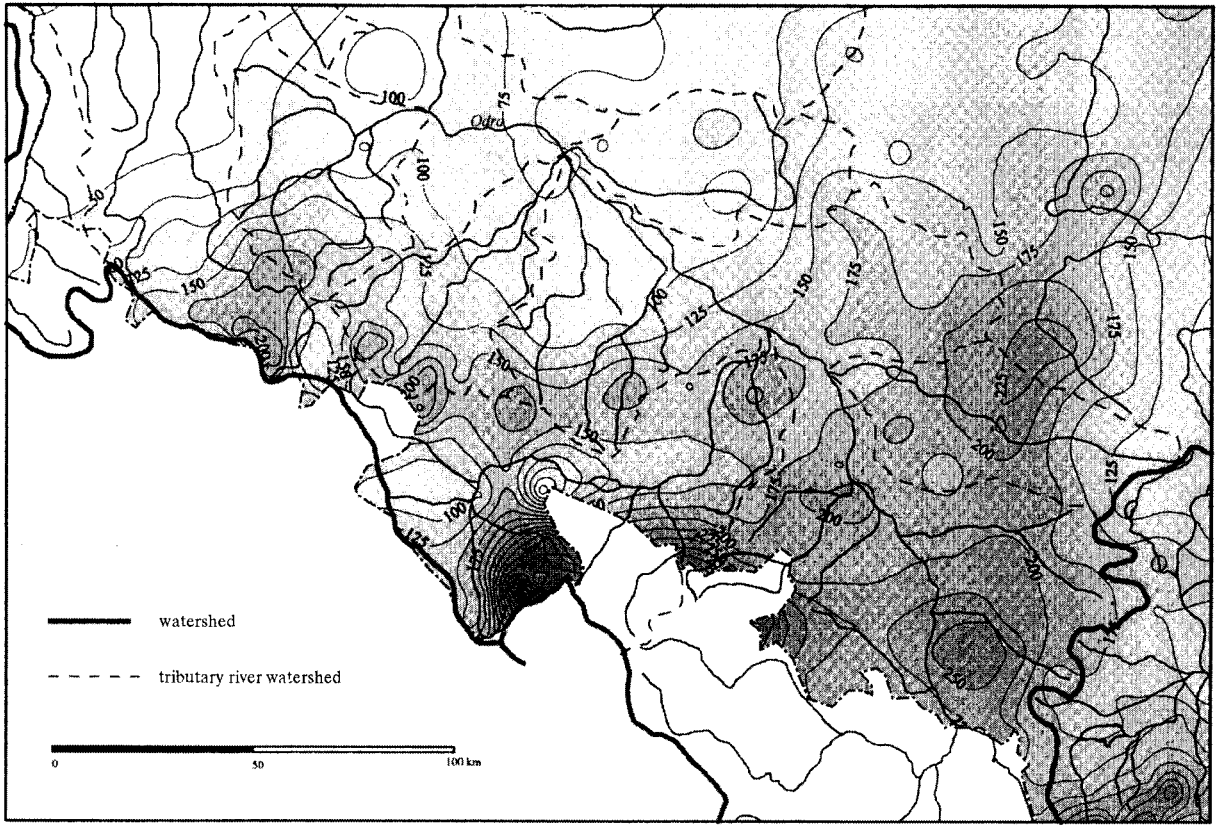

Fig. 6. Total rainfalls in the upper Odra river basin on 4–9 July 1997

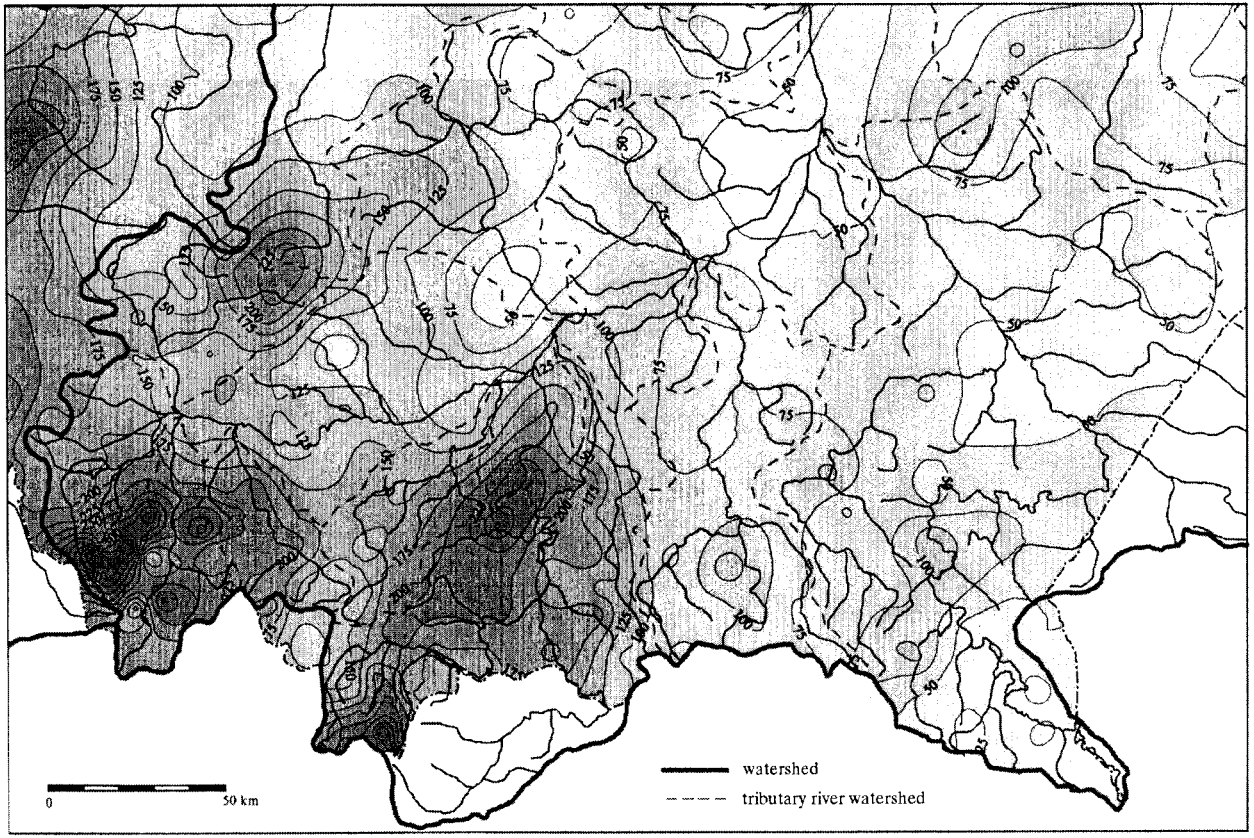

Fig. 7. Total rainfalls in the upper Vistula river basin on 4–9 July 1997

(Table 2, Fig. 7). The highest amount of precipitation mainly covered the Silesian Beskid (Brenna-Leśnica 424 mm, Równica 380 mm, Szczyrk 364 mm, Wisła 343 mm, Skrzyczne 334 mm). The region with the second highest rainfall was the Tatra Mountains (Hala Gąsienicowa 360 mm, Kasprowy Wierch 286 mm, Zakopane 220 mm). The third area in Carpathian Mountains with relatively high precipitation was the central part of the Dunajec river basin (Rozdziele 244 mm, Limanowa 230 mm). Kraków–Częstochowa Upland also received more than 200 mm of precipitation. Other places had smaller rainfall totals: 166 mm in Katowice, 157 mm in Kraków, 150 mm in Nowy Sącz, 97 mm in Tarnów and 69 mm in Kielce. The eastern part of the Carpathian Mountains east of the Dunajec and Biała rivers were not affected by the heavy precipitation.

THE SECOND RAINFALL PERIOD (18–22 JULY 1997)

After the first phase of catastrophic rainfall from 10–17 June, southern Poland was under the influence of an anticyclone. The weather was quite clear. From 18–20 July, however, a new cyclone was formed above Central Europe which caused a second phase of continuous precipitation. The rainfall intensity level was less than during the previous period. The highest daily precipitation enveloped the central part of the Sudety Mountains (Malinowska-Małek, 1997). In the Bystrzyca catchment on 18 July daily precipitation totals exceeded 100 mm (Rościszów 136 mm, Walim 134 mm, Wałbrzych 101 mm). A similar situation also occurred in the upper part of the Bóbr river drainage area (Przesieka 116 mm, Śnieżka 108 mm, Jakuszyce 100 mm). In the last region a maximum amount of rainfall was noticed in Boguszów (149 mm) on 19 July (Table 3).

In the upper Vistula river basin orographic precipitation was observed mainly above the Saint Cross Mountains and the Silesian and Żywiec Beskid Mountains. Above the south-eastern part of Poland showers with thunderstorms were observed. On 18 July the highest amount of precipitation exceeded 40 mm (Wieliczka 56.3 mm, Sadków 49.4 mm), and in part of the Tatra Mountains up to 60 mm (Morskie Oko 62.4 mm). On 19 July above the western part of the Carpathians precipitation exceeded 50 mm (Brenna 50 mm, Ślemień 75 mm). Heavy showers with thunderstorms were observed above Tarnów. Within 57 minutes 43 mm of rain fell, and the daily total reached 53.7 mm. On 20 July a wide zone of precipitation above 30 mm was observed with local maximum levels mainly in the Silesian Beskid (Równica 56.6 mm), the Silesian and Kraków Upland (Ryczów 40.5 mm), the Holy Cross Mountains (Święty Krzyż 45.8 mm) and the Lublin Upland (Werbkowice 45.7 mm).

During this three-day period above the Sudety Mountains the highest totals of precipitation exceeded 200 mm (Walim — 266 mm). In the western part of the Vistula river basin precipitation was higher than 100 mm, with a maximum in Równica of 155.3 mm (Table 3).

Table 3

Precipitation [mm] during the period of 18–20 July 1997

Station	River basin	18 July	19 July	20 July	18–20 July
Walim	Bystrzyca	133.5	121.0	11.5	266.0
Rościszów	Bystrzyca	135.8	80.0	18.1	233.9
Boguszów	Bóbr	75.4	149.4	8.6	233.4
Jakuszyce	Bóbr	100.4	98.9	15.2	214.5
Wałbrzych	Bystrzyca	100.6	98.6	14.1	213.3
Równica Wieś	Wisła	31.5	67.2	56.6	155.3
Ślemień	Soła	14.1	75.3	35.1	124.5
Siepraw	Wisła	41.1	35.4	45.3	121.8
Sadków	Czarna	49.4	21.9	48.1	119.4
Wieliczka	Wisła	56.3	25.2	33.1	114.6
Ryczów	Przemsza	35.0	34.9	40.5	110.4
Dolina Pięciu Stawów	Dunajec	62.7	11.0	36.0	109.7
Oblęgór	Nida	47.2	22.6	39.6	109.4
Święty Krzyż	Kamienna	37.8	21.2	45.8	104.8
Stopnica	Czarna	38.5	29.3	36.5	104.3
Cisów	Czarna	49.3	19.5	34.0	102.8

THE THIRD RAINFALL PERIOD (25–26 JULY 1997)

After 21 July the low-pressure system moved to Ukraine. The rain generally stopped, but during a few days convection cells with thunderstorms and showers developed locally in the moist air-mass. On 22 July 40 mm of rain fell within a period of 45 minutes. More precipitation developed on 25 and 26 July in the south-eastern part of Poland. On the first day four thunderstorm cells were noticed above the Małopolska Upland: 70.3 mm in Olewin near Olkusz, 48.0 mm in Rycz, 54.8 mm in Książ Wielki and 48.1 mm in Mętków.

On the second day heavy rainfalls connected with the frontal zone were observed in the upper parts of the drainage basins of the San and Wisłok rivers (Polana 115.2 mm, Dwernik 91.7 mm, Kalnica 89.0 mm, Przemyśl 75.4 mm, Wisłok Wielki 62.2 mm). In some places the two-day totals exceeded 100 mm (Table 4).

Table 4

Precipitation [mm] during the period of 25–26 July 1997

Station	River basin	25 July	26 July	25–26 July
Polana	San	6.4	115.2	121.6
Kalnica	San	26.2	89.0	115.2
Dwernik	San	11.4	91.7	103.1
Puławy Dolne	Wisłok	44.7	55.5	100.2
Lutowiska	San	10.8	86.6	97.4
Stuposiany	San	25.2	66.6	91.8
Sakowczyk	San	9.8	77.2	87.0
Żubracze	San	38.2	47.4	85.6
Wisłoczek	Wisłok	28.9	56.7	85.6
Wetlina	San	21.4	61.1	82.5
Wisłok Wielki	Wisłok	18.0	62.2	80.2
Rybotycze	San	4.4	75.3	79.7
Nowosielce	Wisłok	36.7	42.3	79.0
Lubatowa	Wisłok	15.1	63.0	78.1
Nowotaniec	Wisłok	25.5	52.0	77.5
Przemyśl	San	0.9	75.4	76.3
Cisna	San	29.1	47.1	76.2
Jaśliska	Wisłok	13.2	62.7	75.9
Dolina Pięciu Stawów	Dunajec	5.5	67.3	72.8
Solina-Jawor	San	1.8	70.8	72.6
Olewin/Olkusz	Przemsza	70.3	2.1	72.4
Terka	San	18.2	53.6	71.8
Brzegi Dolne	Strwiąż	0.6	70.8	71.4
Teleśnica Oszwarowa	San	0.0	70.1	70.1

THE JULY 1997 PRECIPITATION AGAINST THE BACKGROUND OF THE LONG-TERM PERIOD

Circulation conditions in southern Poland in July 1997 were quite different from the averages (Niedźwiedź 1981). The typically western (20.1%) and north-western (14.0%) airflow direction prevailed in July. A situation with stagnant air or with variable airflow covered 30% of the cases. In July 1997 the latter situation was about 21% more frequent, due to the presence of

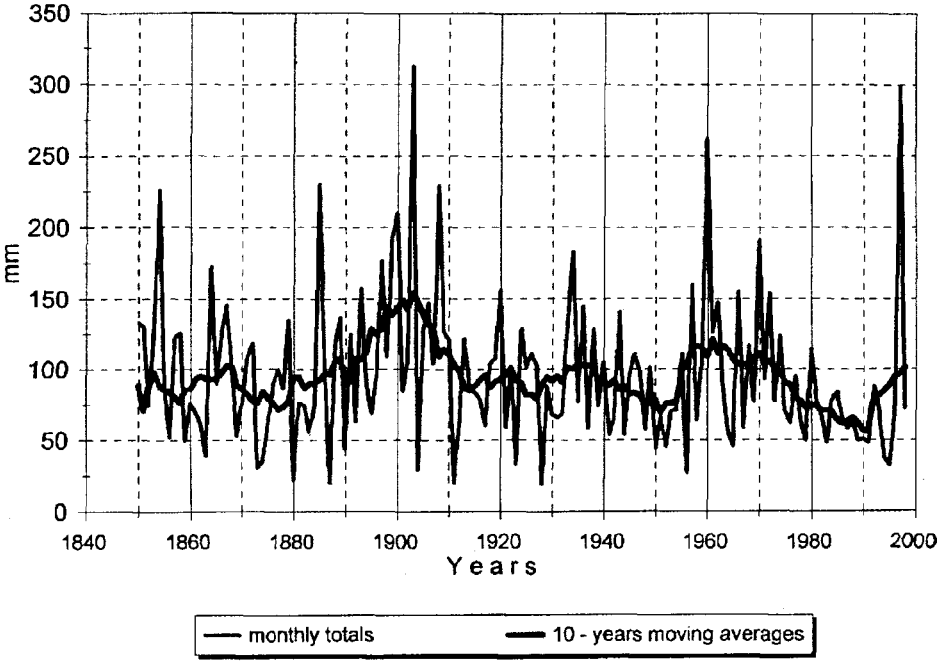

Fig. 8. July precipitation variability in Kraków in 1850–1998

a stationary low pressure system above Central Europe. Western airflow was completely reduced. Instead, airflow from the northern sector was observed during 45% of the days (direction N — 16.1%, NE — 19.4% and NW — 9.7%).

Such a large anomaly in the atmospheric circulation influenced the precipitation totals. In Kraków (Fig. 8), it was the second wettest July (299 mm) after July 1903 (302 mm). But in a large part of the Odra river the rainfall of July 1997 was exceptional. In the Lysa Hora station in the Czech Republic the monthly rainfall total reached 812 mm — 412% of the monthly norm, and at the Praded station 661 mm — 421% of the norm (Kveton et al. 1997). In Poland the highest monthly rainfall (702 mm) was observed in the Kłodzko Basin at the Kamienica station. On the left side of the Odra river basin near Głubczyce such precipitation as occurred during July 1997 was never before observed. On the Vistula river basin the situation was not so extreme.

The exceptional precipitation of July 1997 appeared after a relatively long period of rather poor rainfall in the years from 1981–1995 (Cebulak 1994; Cebulak et al. 1996). The moister phase in rainfall began in 1996 (large precipitation in September). The last period of large precipitation was noticed in Poland during the years 1958–1980 (Cebulak 1998).

Extreme monthly precipitation in the upper Vistula river basin during the 20th century was observed mainly in July. The highest monthly total occurred at the Hala Gąsienicowa station (on the northern slopes of the Tatra Mountains)

Table 5

Maximum daily precipitation >200 mm observed in the upper Vistula basin in the 20th century (after Cebulak 1998)

Station	Drainage area	Altitude [m]	Date	Rainfall [mm]
Hala Gąsienicowa	Dunajec	1520	30 VI 1973	300.0
Witów	Dunajec	795	16 VII 1934	285.0
Leskowiec	Skawa	870	18 VII 1970	275.1
Hala Kondratowa	Dunajec	1333	30 VI 1973	269.4
Hala Gąsienicowa	Dunajec	1520	16 VII 1934	255.2
Stańcowa	Czarna Orawa	850	18 VII 1970	234.4
Kasprowy Wierch	Dunajec	1991	30 VI 1973	232.0
Magurka	Wisła	910	18 VII 1970	229.3
Zubrzyca Górna	Czarna Orawa	700	18 VII 1970	226.0
Szczyrk	Soła	520	18 VII 1970	224.0
Hala Gąsienicowa	Dunajec	1520	**8 VII 1997**	223.5
Zalesie	Dunajec	631	16 VII 1934	223.4
Pilsko	Soła	1270	18 VII 1970	223.1
Sienno	Kamienna		19 V 1941	218.5
Wapienica Zapora	Wisła	480	21 VIII 1972	215.5
Lipowa	Soła	640	18 VII 1970	213.0
Istebna Młoda Góra	Olza	840	18 VII 1970	210.5
Bieńkówka	Skawa	475	18 VII 1970	209.1
Dolina Pięciu Stawów	Dunajec	1670	**8 VII 1997**	207.9
Hala Ornak	Dunajec	1110	30 VI 1973	205.3
Ustroń Równica Wieś	Wisła	640	21 VIII 1972	204.5
Kotówka	Dunajec	680	17 VII 1934	202.7

in July 1934 (684 mm). The second highest monthly total occurred at the Równica station in Silesian Beskid, where the monthly rainfall in July 1997 reached 648 mm.

The highest observed daily totals of precipitation in the upper Vistula river basin varied on a large scale, from 60 mm in the Nida Basin to 300 mm in

the Tatra Mountains (Cebulak 1992a, 1992b). A rainfall level of 300 mm, which was reached on 30 June 1973 at the Hala Gąsienicowa station, was the highest level for the entire country. During the 20th century there have been 22 instances of daily rainfall above 200 mm (Table 5). They occurred in the years 1934, 1941, 1970, 1972, 1973 and 1997.

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STRESZCZENIE

T. Niedźwiedź

OPADY ATMOSFERYCZNE W POLSCE POŁUDNIOWEJ W CZASIE KATASTROFALNEJ POWODZI W LIPCU 1997 ROKU

W lipcu 1997 r. znaczny obszar Europy Środkowej został dotknięty klęską powodzi o rozmiarach od dawna niespotykanych. Szczególnie intensywne opady wystąpiły w dorzeczu górnej Odry, głównie w Beskidzie Śląskim i w Sudetach, a także w dorzeczu górnej Wisły w Karpatach Zachodnich, na zachód od doliny Dunajca.

W dniach 4–9 lipca 1997 Polska południowa znajdowała się pod wpływem stacjonarnego niżu, którego centrum znajdowało się na wschód od Krakowa. Układ ten powodował występowanie długotrwałych opadów zwłaszcza w zachodniej części, gdzie przeważał spływ powietrza z kierunków północnych. Prowadziło to do zwiększonego natężenia opadów wskutek efektu orograficznego na stokach Karpat i Sudetów eksponowanych ku północy.

W pierwszych dniach największe opady koncentrowały się w dorzeczu górnej Odry, gdzie sumy dobowe w dniu 7 lipca przekraczały 200 mm (Lysa Hora 233,8 mm, Sance 230,2 mm, Frenstat 205,7 mm, Zlate Hory 214,0 mm, Międzygórze 200,1 mm). W dorzeczu górnej Wisły opady dobowe powyżej 100 mm wystąpiły w dniu 6 lipca (Wisła — 113 mm, Szczyrk — 107 mm). W dniu 8 lipca maksimum opadów przeniosło się nad Tatry i Beskid Żywiecki. Rekordowy opad 223,5 mm zanotowano wtedy w Tatrach na Hali Gąsienicowej. W dorzeczu Soły najwyższy opad tego dnia wystąpił w Żabnicy osiągając 145 mm. W ostatnim dniu tego okresu tj. 9 lipca, kiedy opady na większości obszaru zmniejszyły swoje natężenie, niezwykle intensywny kilkugodzinny opad spowodował spustoszenia we wschodniej części Beskidu Wyspowego (gminy: Żegocina, Lipnica Murowana, Laskowa oraz okolice Limanowej). Na posterunku opadowym w Rozdzielu zmierzono wtedy 122 mm opadu. Jednak w centrum ulewy, która prawdopodobnie znajdowało się w okolicach Laskowej opad musiał być większy.

Łącznie w ciągu 5 dni największe opady wystąpiły w dorzeczu górnej Odry na stokach Beskidu Śląskiego (Sance 617 mm i Lysa Hora 586 mm w zlewni Ostravicy) i w masywie Hrubego Jesenika (Rejviz w zlewni Opavy 511 mm i Zlate Hory w dorzeczu Białej Głuchołazkiej — 513 mm, Jesenik — 512 mm) oraz w Kotlinie Kłodzkiej (Kamienica 482 mm, Międzygórze 454 mm). Znacznie mniejsze opady objęły karpacką część dorzecza górnej Wisły. W ciągu omawianego pięciodniowego okresu najwięcej deszczu spadło w Beskidzie Śląskim (Brenna-Leśnica 424 mm, Równica 380 mm, Szczyrk 364 mm, Wisła 343 mm, Skrzyczne 334 mm). Drugim obszarem o najwyższych opadach były Tatry (Hala Gąsienicowa 360 mm, Kasprowy Wierch 286 mm, Zakopane 220 mm). Trzecim obszarem dużych opadów była wschodnia część Beskidu Wyspowego (Rozdziele 244 mm, Limanowa 230 mm). W tym okresie w Krakowie — Woli Justowskiej opad wynosił 157 mm, w Nowym Sączu 150 mm, w Katowicach 166 mm, w Bielsku-Białej 251 mm, w Tarnowie 97 mm i w Kielcach 69 mm. W zasadzie duże opady wystąpiły w zachodniej części Karpat położonej na zachód od dorzecza Białej Dunajcowej.