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THE FREQUENCY OF OCCURRENCE OF THUNDERSTORMS IN POLAND

The purpose of the present report is to determine the frequency of occurrence of thunderstorms in Poland, with special emphasis on the annual cycle and the year-to-year variation, as well as association of appearance of storms with the circulation types. The source materials from the Institute of Meteorology and Water Economy, concerning the numbers of days with storms, encompass the period of 40 years, between 1951 and 1990, and come from 20 weather stations.

The spatial distribution of thunderstorms in Poland is characterised by the gradual increase of their frequency in the direction from the North towards the South (Table 1). The average number of days with a storm is the smallest at the seacoast — in Gdańsk (15.4 days) and Kołobrzeg (19.0). Within the belt of the lowlands this number remains below 25 days — like in Poznań (21.0) or Białystok (24.2), an exception being constituted by the area of the Masovian Plain (Warsaw — 26.1), where the average number of stormy days is similar to the numbers characteristic for the upland areas (Kielce — 25.8, Cracow — 26.9, and Zamość — 29.4). In the Carpathian Mts., and the Carpathian Foothills, the average numbers of days with storms exceed 30 — like on Kasprowy Wierch Mt. (34.4) or in Przemyśl (31.1).

During spring and summer, Baltic Sea has a cooling influence on the moving air masses at the seacoast, contributing to the decrease of stormy activity over these areas. The increased number of days with storms in the mountains and on the uplands is largely due to the differentiated relief, and therefore a variable, unstable weather, in opposition to the lowlands, where weather is shaped by the different moving air masses.

The maximum numbers of days with thunderstorms in a year fluctuated in Poland between 26 in Gdańsk and as many as 55 on Kasprowy Wierch. It takes the values exceeding 35 days in central, eastern and south-western Poland. The maximum number of days with thunderstorms informs us on the intensity of threat from these phenomena in particular regions of the country. The least advantageous with this respect are the mountain areas (especially the Carpathians), while the safest — the areas around the Szczecin Bay (Szczecin — 30 days) and the Gulf of Gdańsk (Gdańsk — 26 days). A lower threat from thunderstorms exists also on the Greater Polish Lakeland

Table 1.

Average numbers of days with thunderstorms on the basis of data from the years 1951–1990

Weather station	Minimum		Maximum		Average
	number	year	number	year	
Białystok	11	1953	37	1984	24.2
Chojnice	11	1952	38	1967	21.1
Gdańsk	6	1977	**26**	**1963**	**15.4**
Kasprowy Wierch	21	1984	**55**	**1963**	**34.4**
Kielce	16	1958, 1965	39	1989	25.8
Kołobrzeg	6	1976	33	1967	19.0
Cracow	17	1965	38	1968, 1975	26.9
Olsztyn	5	1951	36	1985	19.4
Poznań	13	1951, 1952	31	1967, 1987	21.0
Przemyśl	**23**	**1955**	42	1975	31.1
Suwałki	11	1953	37	1963	22.5
Szczecin	9	1989	30	1962	19.4
Śnieżka	18	1984, 1990	40	1963	27.4
Terespol	**2**	**1954**	36	1972	21.4
Toruń	13	1982	35	1961, 1968	22.7
Warsaw	12	1987	38	1955	26.1
Wieluń	15	1952	40	1971	24.7
Wrocław	7	1961	31	1968, 1987	20.2
Zamość	19	1952	41	1979	29.4
Zielona Góra	13	1976	40	1955	24.5

(Poznań — 31 days) and in the eastern part of the Silesian Lowland (Wrocław — 31 days), that is — in western Poland, characterised by the greater influence from the oceanic climate.

In terms of differentiation in time the highest intensity of thunderstorm activity took place, within the entire period here considered, in the years 1955–1968 in the majority of the selected geographical regions, except for the seven areas located in southern and eastern Poland.

The sequences of days were identified within the period considered, during which thunderstorms occurred on each consecutive day (the so-called thunderstorm day series). The shortest of these sequences lasted, of course, two days, and were observed at all the weather stations accounted for. The longest one had 11 days, and was observed in Tatra Mts., on Kasprowy Wierch (31 May — 10 June, 1960).

At all the stations considered the sequences of at least five days of length were observed. The longest sequences occurred at the Polish Seacoast (Szczecin, Kołobrzeg, Gdańsk), on the Greater Polish Lakeland (Poznań), on the Silesian Lowland (Wrocław) and on Masovian Lowland (Warsaw), as well as close to the eastern border of Poland (Terespol). The longest sequences of

the days with thunderstorms constituted between 0.6% and 3.3% of all the days with thunderstorms, which were observed in each of the regions considered.

The shortest storm sequences occurred most frequently. The single days with thunderstorms constituted the largest share of the stormy days (more than 50% of the total — except for Kasprowy Wierch: 37.3%, Przemyśl: 49.2%, and Zamość: 48.4%). In Gdańsk, Kołobrzeg, Olsztyn, Poznań, Szczecin and Wrocław, however, the single days with storms amounted to more than 60% of the respective totals. At all the stations the two-day sequences accounted for 20–30% of the total number of stormy days.

The changes of thunderstorm activity depending upon the types of atmospheric circulation in Poland were analysed as well. This study concerned the two months with the highest number of thunderstorms: June and July.

The classification of the types of atmospheric circulation selected for this purpose was the one after B. Osuchowska-Klein (1978 and 1991). The catalogue used was established on the basis of the qualitative "visual" method. It consists in the direct classification of the weather situations from the synoptic maps with respect to the 13 patterns called circulation types.

The circulation type is understood as the image of atmospheric circulation, corresponding to a given pressure distribution at the sea level, representing the locations of the primary pressure settings over Europe and North Atlantic. The thus understood circulation type conditions a definite direction of inflow of the air masses over Poland, given the concrete situation of the cyclonal or anti-cyclonal circulation.

During the 40-year period considered, in June and July, at all the stations studied, occurrence of thunderstorms was primarily associated with the types of cyclonal circulation: north-eastern and eastern (E_0) and north-western (CB), of anti-cyclonal circulation: north-eastern (E) and western (C_2D), and with the undefined circulation type X (see Tables 2 and 3).

The highest number of the days with thunderstorms occurred in June in the Tatra Mts., on Kasprowy Wierch, during the north-eastern anticyclonal situation (E) — 88 altogether (30.9%), the western anticyclonal situation (C_2D) — 48 (29.1%), and the undefined (X) type — 47 (38.8%). Equally frequently, in the situation of the north-eastern and eastern circulation (E_0) the days with thunderstorms occurred in south-eastern Poland — in Zamość — 55 days (31.6%). In this part of Poland a very high probability (reaching 62.1%) of occurrence of days with thunderstorms is associated with the south-eastern cyclonal (F) circulation. This type of circulation appears less frequently over Poland, but brings with it a high number of storms.

In July the highest thunderstorm activity was noted in Przemyśl under the north-western circulation (CB) — 79 (28.9%), and the north-eastern anticyclonal circulation (E) — 68 (28.2%). Then, on Kasprowy Wierch Mt., side by side with the ones already mentioned, thunderstorms were associated with the western anticyclonal situation (C2D) — 62 (25%) and the undefined conditions (X) — 33 (41.3%). In conditions of the cyclonal north-eastern and

Table 2.

Relative frequency (in %) of appearance of the days with thunderstorms in June under various types of atmospheric circulation, observed in the years 1951–1990

Weather stations	E_0	F	B	D	A	CB	E	E_1	D_2C	C_2D	E_2C	G	BE	X
Białystok	20.1	44.8	29.0	13.3	21.4	22.9	14.0	8.8	20.8	10.9	5.0	11.5	–	27.3
Chojnice	14.9	41.4	16.1	24.4	14.3	18.4	14.0	26.5	25.0	12.7	5.0	11.5	–	24.8
Gdańsk	7.5	24.1	12.9	15.6	16.7	12.8	5.6	32.4	16.7	9.1	–	7.7	–	19.0
Kasprowy	28.2	58.6	32.3	40.0	26.2	20.7	30.9	26.5	16.7	29.1	22.5	11.5	–	38.8
Kielce	20.1	44.8	29.0	26.7	31.0	20.7	15.4	11.8	12.5	17.0	12.5	15.4	–	24.0
Kołobrzeg	6.9	24.1	9.7	26.7	16.7	14.5	6.3	23.5	12.5	10.3	5.0	23.1	–	17.4
Kraków	23.0	48.3	38.7	22.2	23.8	19.0	19.6	5.9	4.2	18.8	22.5	11.5	–	26.4
Olsztyn	18.4	24.1	19.4	17.8	23.8	13.4	8.8	8.8	25.0	12.1	2.5	7.7	33.3	18.2
Poznań	16.1	34.5	9.7	20.0	14.3	14.0	12.6	29.4	29.2	11.5	12.5	15.4	–	24.8
Przemyśl	27.6	58.6	19.4	33.3	26.2	24.6	23.5	23.5	20.8	22.4	27.5	15.4	–	30.6
Suwałki	24.7	51.7	25.8	28.9	33.3	22.3	14.4	20.6	12.5	12.1	5.0	11.5	–	23.1
Szczecin	11.5	34.5	12.9	24.4	14.3	11.2	9.5	20.6	8.3	10.9	10.0	7.7	–	26.4
Śnieżka	23.6	31.0	12.9	20.0	21.4	19.6	22.8	41.2	25.0	17.6	25.0	23.1	33.3	27.3
Terespol	19.5	48.3	25.8	26.7	16.7	19.0	13.7	5.9	20.8	15.2	12.5	3.8	–	23.1
Toruń	20.1	44.8	25.8	13.3	19.0	20.7	10.9	26.5	25.0	13.9	7.5	7.7	–	28.1
Warszawa	21.8	44.8	25.8	17.8	28.6	20.7	13.7	8.8	12.5	19.4	5.0	15.4	–	26.4
Wieluń	19.0	41.4	32.3	17.8	19.0	20.7	15.8	14.7	8.3	15.8	7.5	7.7	–	28.9
Wrocław	20.7	34.5	12.9	15.6	11.9	16.2	15.4	17.6	33.3	10.9	15.0	11.5	33.3	21.5
Zamość	31.6	62.1	38.7	24.4	19.0	24.6	19.6	17.6	12.5	15.8	15.0	15.4	–	24.8
Zielona G.	16.7	24.1	9.7	31.1	19.0	16.2	14.7	23.5	29.2	12.1	12.5	23.1	–	28.1

Table 3.

Relative frequency (in %) of appearance of the days with thunderstorms in July under various types of atmospheric circulation, observed in the years 1951–1990

Weather stations	E_0	F	B	D	A	CB	E	E_1	D_2C	C_2D	E_2C	G	BE	X
Białystok	30.3	18.2	35.7	26.9	17.2	18.7	12.9	32.0	3.4	16.1	–	–	–	26.3
Chojnice	15.4	22.7	14.3	42.3	10.3	14.7	15.8	36.0	20.7	9.3	16.7	21.1	–	32.5
Gdańsk	9.1	13.6	21.4	30.8	6.9	13.2	8.3	36.0	13.8	8.9	10.0	21.1	–	27.5
Kasprowy	23.4	13.6	42.9	26.9	20.7	21.6	27.8	60.0	3.4	25.0	26.7	5.3	–	41.3
Kielce	20.0	40.9	50.0	23.1	24.1	18.7	17.8	32.0	3.4	15.7	13.3	5.3	–	27.5
Kołobrzeg	8.6	18.2	14.3	42.3	15.5	13.9	9.5	28.0	20.7	12.5	10.0	5.3	–	26.3
Kraków	21.1	22.7	50.0	23.1	27.6	20.5	17.0	16.0	3.4	13.7	26.7	5.3	–	28.8
Olsztyn	17.7	13.6	21.4	30.8	13.8	16.5	10.0	24.0	3.4	11.7	13.3	21.1	–	25.0
Poznań	14.9	31.8	35.7	42.3	12.1	14.7	14.1	20.0	20.7	9.3	10.0	21.1	–	22.5
Przemyśl	28.6	22.7	42.9	23.1	19.0	28.9	28.2	32.0	6.9	14.5	20.0	5.3	–	26.3
Suwałki	21.7	13.6	57.1	34.6	8.6	19.4	13.7	36.0	13.8	13.3	16.7	5.3	–	27.5
Szczecin	12.6	22.7	14.3	34.6	8.6	14.7	13.7	28.0	17.2	14.5	13.3	21.1	–	27.5
Śnieżka	13.1	22.7	28.6	34.6	13.8	17.2	18.3	44.0	20.7	20.2	20.0	15.8	–	32.5
Terespol	23.4	18.2	28.6	7.7	17.2	15.0	14.5	28.0	3.4	13.7	10.0	–	–	26.3
Toruń	18.3	36.4	28.6	42.3	22.4	16.8	13.3	32.0	6.9	10.9	20.0	21.1	–	21.3
Warszawa	22.9	22.7	42.9	26.9	19.0	22.7	17.4	28.0	6.9	12.1	13.3	15.8	–	27.5
Wieluń	21.7	31.8	42.9	26.9	17.2	18.3	15.8	20.0	3.4	12.5	13.3	21.1	–	25.0
Wrocław	10.3	31.8	21.4	26.9	20.7	17.2	13.7	24.0	13.8	10.5	6.7	21.1	–	23.8
Zamość	29.1	18.2	35.7	23.1	25.9	25.6	21.2	28.0	6.9	19.4	20.0	5.3	–	28.8
Zielona G.	17.1	40.9	21.4	34.6	17.2	16.1	18.3	24.0	24.1	13.3	23.3	26.3	–	22.5

eastern circulation type (E0) the highest number of days with thunderstorms occurred in Białystok — 53 (30.3%).

The anticyclonal types — southern and south-western (D_2C), north-western (E_2C), and the centre of high pressure over Poland (G), as well as the very rarely appearing southern intermediate type between the cyclonal and anticyclonal (BE), were all decidedly not advantageous for the occurrence of thunderstorms in June and July.

Thunderstorms appeared most frequently (roughly 25% of cases) during the undefined synoptic situation (X).

CONCLUSIONS

— The increase of frequency of occurrence of the days with thunderstorms from the North towards the South of Poland is associated with the increase of altitude above the sea level. Besides, the bigger the latitude (lower air temperature and humidity), the less the weather circumstances are conducive to the appearance of thunderstorms.

— The longer sequences of days with thunderstorms (5–11 days) take place very rarely (only a couple or so times during 40 years). This means that the weather conditions conducive to the appearance of this phenomenon do not persist for a long time, ending after just one or two days. Thereby, the high dynamics of changes in atmospheric circulation at moderate latitudes and the intermediate character of Poland's climate, are confirmed.

— The biggest number of days with thunderstorms were caused by the synoptic conditions, having appeared under the influence of the north-eastern and eastern cyclonal circulation (type E_0) and the north-western cyclonal circulation (type CB), in which the frequency of occurrence of the days with thunderstorms was associated with the passage of the cool front (frontal storms) during the movement of the low pressure area over the central or northern Europe. Thermal thunderstorms occurred during this character of atmospheric circulation rather rarely. On the other hand, when the air masses moved under the influence of the north-eastern anticyclonal circulation (type E), the intra-mass (thermal) thunderstorms occur, taking place frequently in the central, southern, and eastern regions of Poland, remaining under the stronger influence of the continental climate.

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