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Extreme values of selected event thermal phenomena
in the Lublin Region in the years 1982–2006

Ekstremalne wartości wybranych charakterystyk termicznych
na Lubelszczyźnie w latach 1982–2006

ABSTRACT

This paper presents the frequency of occurrence and distribution of extreme values of selected thermal phenomena in the Lublin Region in the years 1982–2006. There used data coming from 9 stations of the Institute of Meteorology and Water Management, and from the Meteorological Observatory of Maria Curie-Skłodowska University (UMCS), located in the centre of the city of Lublin. The stations have a uniform observation sequence for the 25 years studied. The extreme thermal phenomena were analysed: very hot days – $T_{\max} \geq 35^{\circ}\text{C}$, “tropical nights” – $T_{\min} \geq 20^{\circ}\text{C}$, very cold days – $T_{\min} \leq -30^{\circ}\text{C}$, days with frost in May – $T_{\min} 200 \text{ cm a.g.l.} \leq -2.0^{\circ}\text{C}$, days with frost ($T_{\min} 200 \text{ cm a.g.l.} \leq 0.0^{\circ}\text{C}$) in summer months (VI–VIII), significant day-to-day changes of more than 10°C of mean daily air temperature.

Key words: air temperature extremes, Lublin Region

INTRODUCTION

During the last several years, the climate at various spatial and temporal scales has been subject to increased interest. This may be related to the observed relatively fast changes in climatic conditions in various areas of the globe, according to a widespread opinion mainly induced by human activity. Particularly close attention is paid to extreme phenomena, the frequency of which is expected to increase in the future (Miętus 2005). The evidence of high interest in those phenomena at varied temporal and spatial scales are numerous conferences on

the subject and related monographs. Information on extreme phenomena also appears more and more frequently in climatic atlases covering various areas (e.g. Ustrnul, Czekierda 2009). The calendar of extreme meteorological and hydrological events, prepared by 26 scientific entities from all over Poland, is supplemented on a current basis. It is available at www.ekstrema-polskie.pl.

The forecast of such events, important also for practical reasons, must be preceded by a detailed analysis of their frequency and rate of occurrence. Contemporary climatic models do not allow for a detailed determination of local climatic extremes, among others due to a very scarce network of reference points. Therefore, data obtained directly from meteorological stations are of high significance (Kundzewicz 2002).

Thermal extremes are probably the most popular subject of papers analysing extreme weather events. The occurrence of heat at the European scale in selected years was studied among others by R. Twardosz (2009). The distribution of extreme values of various thermal phenomena in Poland was presented in the following papers: Kuchcik (2006), Cebulak, Limanówka (2007); Kejna et al. (2009), Ustrnul et al. (2010), and Ustrnul and Wypych (2011). A number of papers discuss thermal extremes in selected regions of Poland (Grabowska et al. 2007; Bielec-Bąkowska, Łupikasza 2009, Sobik, Błaś, 2010), and at selected stations (Owczarek 2005; Piotrowicz 2005, 2007; Kaszewski et al. 2007; Michniewski 2007; Żarski et al. 2007; Kossowska-Cezak 2010).

OBJECTIVE, MATERIAL, METHODS

The objective of this paper was to determine the frequency of occurrence and distribution of extreme values of selected thermal phenomena in the Lublin Region in the years 1982–2006. The data come from 9 stations of the Institute of Meteorology and Water Management, and from the Meteorological Observatory of UMCS, located in the centre of the city of Lublin (Tab. 1). The stations have a uniform observation sequence for the 25 years studied.

Table 1. List of meteorological stations analysed in the paper

Station	Latitude	Longitude	Altitude a.s.l. [m]
1	2	3	4
Jarczew	51°49'	21°59'	182
Lublin – Plac Litewski	51°15'	22°34'	216
Lublin – Radawiec	51°14'	22°34'	238
Sandomierz	50°42'	21°43'	217
Siedlce	52°11'	22°16'	146
Sobieszyn	51°36'	22°10'	158

1	2	3	4
Terespol	52°05'	23°37'	133
Tomaszów Lubelski	50°27'	23°24'	270
Włodawa	51°33'	23°33'	175
Wysokie	50°55'	22°40'	240

The analysis applied the criteria of distinguishing extreme phenomena developed for the purposes of grant PBZ KBN 086/P04/2003 by a team managed by Prof. T. Niedźwiedź, and other descriptions of extreme phenomena.

The following thermal phenomena were analysed:

- very hot days – $T_{\max} \geq 35^{\circ}\text{C}$,
- “tropical nights” – $T_{\min} \geq 20^{\circ}\text{C}$,
- very cold days – $T_{\min} \leq -30^{\circ}\text{C}$,
- days with frost in May – T_{\min} 200 cm a.g.l. $\leq -2.0^{\circ}\text{C}$,
- days with frost (T_{\min} 200 cm a.g.l. $\leq 0.0^{\circ}\text{C}$) in summer months (VI–VIII),
- significant day-to-day changes of over 10°C of mean daily air temperature.

RESULTS

At the ten meteorological stations and posts of the Lublin Region subject to the study, 281 cases of extreme thermal phenomena were determined. The extremes were recorded on 114 days, which constituted 1.2% of all days.

The highest number of such cases (52) was recorded in 1987. This was mainly related to substantial day-to-day changes in mean daily air temperature, and occurrence of extremely cold days in January. The year 1992 was the second in terms of the frequency of occurrence of thermal extremes. It was dominated by extreme values of phenomena related to high temperatures in August. No cases of such phenomena occurred in 1983, 1990, or 1993.

At the annual scale, the highest number of cases occurred in January, and somewhat less in July and August. No case of extreme values of the phenomena analysed occurred in March.

Such an annual course is related to the method of distinguishing the extremes selected for analysis. Only one of the phenomena selected, i.e. significant day-to-day changes in mean daily air temperature, can theoretically occur in each season of the year.

Very hot days ($T_{\max} \geq 35^{\circ}\text{C}$)

In the years 1982–2006, 23 cases of occurrence of very hot days were recorded in the Lublin Region (Tab. 2). The phenomenon occurred on only 10 days in 1992 and 1994. Those were individual days in two cases, and two sequences of 3 and 5 days. The individual cases were mainly related to the advection of hot tropical

air from the southern sector in warm sectors of lows from the centre in West or North Europe. The several-day-long sequences were also related to the inflow of tropical air directed by high systems from the centre in Central or Eastern Europe. Similar conclusions were drawn by Z. Ustrnul and D. Czekierda (2009), as well as Z. Ustrnul and A. Wypych (2011), analysing the highest values of maximum temperature in Poland.

The highest number of very hot days (7) was recorded in Włodawa. No such days occurred at two stations: Tomaszów Lubelski and Sandomierz (Tab. 2).

In one case, on 29th August 1992, a very hot day occurred at 7 stations, and on 31st July 1994 – in 5 stations.

At the annual scale, the occurrence of very hot days is limited to two months: July and August (Tab. 2).

Table 2. The annual course of the number of very hot days at selected stations of the Lublin Region (1982–2006)

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Włodawa							1	6					7
Lublin – Plac Litewski								1					1
Tomaszów Lubelski													-
Terespol							1	2					3
Radawiec								1					1
Jarczew								1					1
Sobieszyn							3	1					4
Siedlce							1						1
Sandomierz													-
Wysokie							1	4					5
Total							7	16					23

The highest air temperature value (36.0°C) was recorded in Włodawa on 29th August 1992 and 31st July 1994. During those days, Poland was located in the warm sector of lows from the centre in the area of the Norwegian Sea. Hot tropical air flowed into the Lublin Region from the southern sector (Fig. 1).

The highest maximum air temperature in the area analysed (37.1°C) was observed in Sandomierz on 15th August 1952 (Ustrnul, Czekierda 2009).

It is worth emphasising that on 9 in 10 days, very hot days were accompanied by tropical nights.

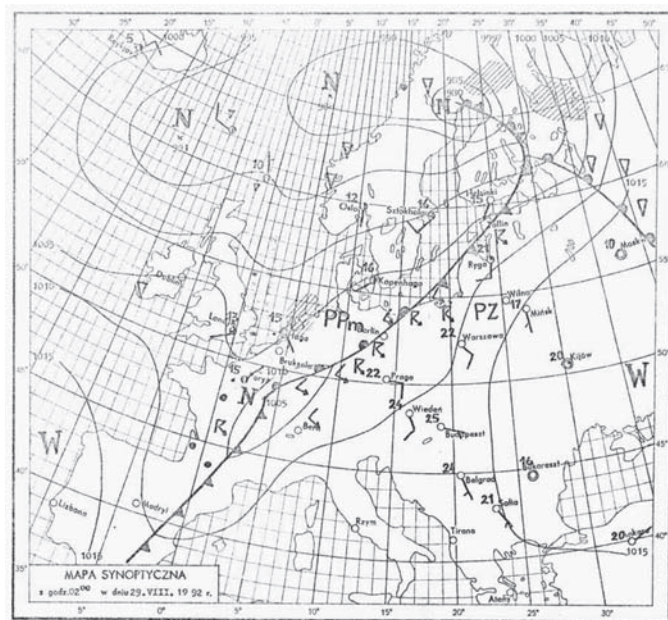


Fig. 1. Synoptic map of 29th August 1992 (source: Codzienny Biuletyn Meteorologiczny IMGW)

Tropical nights ($T_{\min} > 20^{\circ}\text{C}$)

In the years 1982–2006 in the Lublin Region, 100 cases of occurrence of tropical nights were recorded (Tab. 3). The phenomenon occurred in 17 out of 25 years analysed. The highest number of such days (9) was recorded in 1994. The spatial distribution of the cases is diversified. The highest number of tropical nights was observed in Lublin (40) and Wysokie (21). In Tomaszów Lubelski, only one such case occurred, and in Radawiec – two. Such a high number of tropical nights recorded in Lublin is related to the location of the station in the city centre, and the occurrence of the so-called urban heat island.

Tropical nights usually occurred at one station (33 cases). On 16 July 2001, a tropical night was observed at 7 stations (except for: Tomaszów, Radawiec, and Wysokie). On that day, the Lublin Region was located in an area with increased atmospheric pressure (with weakly developed barometric field), favouring advection from the southern sector (Fig. 2). Moreover, three cases of tropical nights at 5 stations were recorded: on 11th August 1992 (Terespol, Radawiec, Lublin, Sobieszyn, and Wysokie), 29th August 1992 (Lublin, Jarczew, and Siedlce. Sandomierz, and Wysokie), and 31st July 2005 (Włodawa, Radawiec, Lublin, Sandomierz, and Wysokie). Tropical nights mainly occurred in July and August (93 cases in total). The earliest tropical night occurred on 29th May 2005 in Jarczew, and the latest on 3rd September 1994 in Wysokie.

The occurrence of tropical nights is related to the inflow of tropical air from the southern sector in the scope of high pressure system (Ustrnul and Czekierda 2009). Somewhat more seldom (in approx. 40% of cases), tropical nights in the Lublin Region also occur in tropical air inflowing within a warm sector of low.

The highest minimum temperature (24.9°C) occurred in Wysokie on 10th July 1995.

Table 3. The annual course of the number of tropical nights at selected stations of the Lublin Region (1982–2006)

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Włodawa							3	1					4
Lublin – Plac Litewski						4	22	14					40
Tomaszów Lubelski								1					1
Terespól							4	1					5
Radawiec							1	1					2
Jarczew					1		2	6					9
Sobieszyn							2	2					4
Siedlce							3	2					5
Sandomierz							7	2					9
Wysokie						1	8	11	1				21
Total					1	5	52	41	1				100

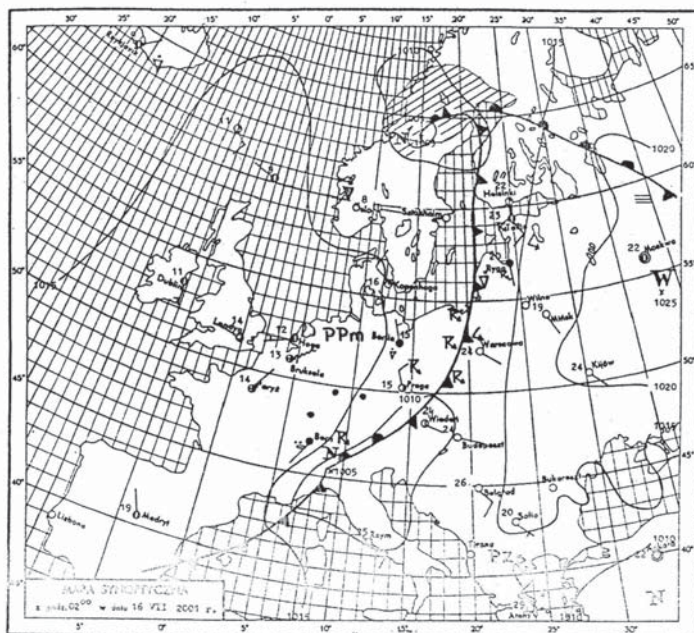


Fig. 2. Synoptic map of 16th July 2001 (source: Codzienny Biuletyn Meteorologiczny IMGW)

Very cold days ($T_{\min} \leq -30^{\circ}\text{C}$)

During the period analysed in the Lublin Region, 20 cases of occurrence of very cold days were recorded (Tab. 4). They only occurred in two years: 1987 and 2006. The highest number of such cases (4) was observed in Jarczew. No such days were recorded at two stations: Lublin (Plac Litewski) and Sandomierz.

Table 4. The annual course of the number of very cold days ($T_{\min} \leq -30^{\circ}\text{C}$) at selected stations of the Lublin Region (1982–2006)

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Włodawa	2												2
Lublin – Plac Litewski													
Tomaszów Lubelski	3												3
Terespol	3												3
Radawiec	1												1
Jarczew	4												4
Sobieszyn	3												3
Siedlce	3												3
Sandomierz													
Wysokie	1												1
Total	20												20

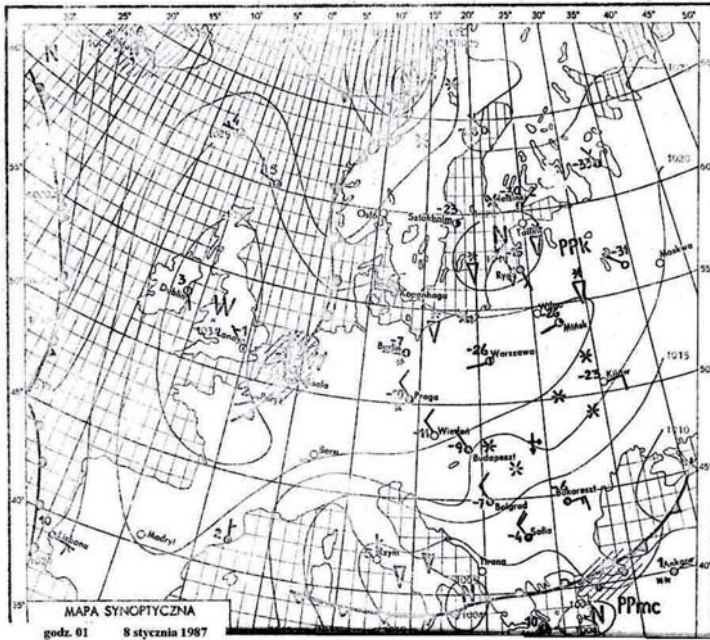


Fig. 3. Synoptic map of 8th January 1987 (source: Codzienny Biuletyn Meteorologiczny IMGW)

On 8 January 1987, a very cold day occurred at 8 stations, when cold air from the northern sector flowed into the Lublin Region. In the conditions of cloudless sky, the air was additionally cooled as a result of emanation from the earth surface (Fig. 3).

In the same year, several days later (on 14th January), a very cold day was recorded at five stations (all except for Tomaszów Lubelski and Wysokie). At the annual scale, such days only occurred in January.

The lowest minimum temperature (-34.3°C) was observed on 30th January 1987 in Terespol.

Days with frost in May ($T_{\min} \leq -2.0^{\circ}\text{C}$)

In the years 1982–2006 in the Lublin Region, 15 cases of occurrence of days with frost in May at 200 cm a.g.l. were recorded (Tab. 5). The phenomenon occurred in five years: 1984, 1994, 1995, 1999, and 2000. The highest number of such cases was recorded in Siedlce (5) and Tomaszów Lubelski (4). No such days occurred at four stations: Włodawa, Lublin, Sandomierz, and Wysokie. The occurrence of frost is related not only to the atmospheric circulation, but also to local factors. On 3 May 1995, strong frost occurred at 5 stations simultaneously. In the course of the month, such frost occurred in the period from 3rd to 13th May.

Table 5. The course of the number of days with strong frost (T_{\min} at 200 cm a.g.l. $\leq -2.0^{\circ}\text{C}$) in May at selected stations of the Lublin Region (1982–2006)

Station	May													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Włodawa														-
Lublin – Plac Litewski														-
Tomaszów Lubelski			1	1	1		1							4
Terespol			1											1
Radawiec			2											2
Jarczew			1											1
Sobieszyn			1							1				2
Siedlce			2		1		1						1	5
Sandomierz														
Wysokie														
Total			8	1	2		2			1			1	15

The lowest minimum temperature (-3.9°C) was recorded in Siedlce on 3rd May 1995. On that day, the Lublin Region was the centre of high pressure with a mass of arctic air (Fig. 4). An additional factor causing a decrease in the temperature was high emanation during a cloudless night.

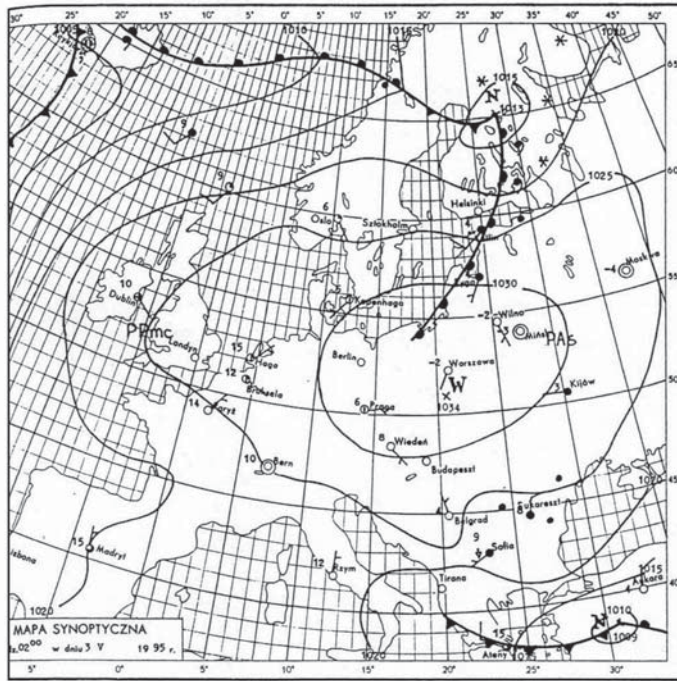


Fig. 4. Synoptic map of 3rd May 1995 (source: Codzienny Biuletyn Meteorologiczny IMGW)

It is worth emphasising that in summer months (VI–VIII), frost (T_{\min} at 200 cm a.g.l. $\leq 0.0^{\circ}\text{C}$) did not occur at any of the stations analysed.

Significant day-to-day changes of mean daily air temperature (exceeding 10°C)

In the period analysed (1982–2006) in the Lublin Region, 123 cases of occurrence of significant (exceeding 10°C) day-to-day changes in mean daily air temperature occurred (Tab. 6–8). The changes mainly constituted decreases (74 cases).

Such changes occurred in 19 out of 25 years analysed. The highest number of such days (7) was recorded in 1987. Their high spatial differentiation was observed. The highest number of such cases was recorded in Terespol (22), less in Włodawa and Siedlce (16 each), and the least in Sandomierz (only 6).

Such significant changes in the temperature usually occurred at only one station. In two cases, such changes (decreases) were recorded at all stations: from 6th to 7th January 1982 and from 6th to 7th January 1987. Once, such changes were observed at 9 stations (all except for Tomaszów Lubelski), involving a decrease from 2nd to 3rd January 2002, and once at 8 stations (all except for Sandomierz and Lublin), involving an increase from 17th to 18th December 2001. The most sub-

stantial increase in mean daily air temperature (15.3°C) was observed in Jarczew from 30th to 31th January 1987. The most significant decrease (19.3°C) occurred at the same station from 6th to 7th January 1987.

Table 6. The course of the number of days with significant day-to-day changes in mean daily air temperature (exceeding 10°C)

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Włodawa	5	1							1		1	7	16
Lublin – Plac Litewski	7	1		1	2	1							12
Tomaszów Lubelski	5	2										4	11
Terespol	7	5			1				1		2	6	22
Radawiec	8	1										3	12
Jarczew	6	1										2	9
Sobieszyn	5	2								1		2	10
Siedlce	6	3			1						2	4	16
Sandomierz	4			1								1	6
Wysokie	6			1								2	9
Total	60	16		3	4	1			2	1	5	31	123

In January, significant day-to-day changes in air temperature occurred at all of the stations. In December, they did not occur in Lublin, and in February, in Sandomierz and Wysokie. In March, July, and August, no significant temperature changes were recorded at any of the stations.

The principal cause of significant changes in mean daily air temperature are circulation conditions related to the passing of atmospheric fronts.

Table 7. The course of the number of days with significant day-to-day decreases in mean daily air temperature (exceeding 10°C)

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Włodawa	5	1							1			2	9
Lublin – Plac Litewski	5			1	2	1							9
Tomaszów Lubelski	5	2											7
Terespol	5	3			1				1			2	12
Radawiec	6											1	7
Jarczew	5												5
Sobieszyn	4												4
Siedlce	5	1			1							2	9
Sandomierz	4			1									5
Wysokie	5			1								1	7
Total	49	7		3	4	1			2			8	74

Table 8. The annual course of the number of days with significant day-to-day increases in mean daily air temperature (exceeding 10°C)

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Włodawa	1										1	5	7
Lublin – Plac Litewski	2	1											3
Tomaszów Lubelski												4	4
Terespol	2	2									2	4	10
Radawiec	2	1										2	5
Jarczew	1	1										2	4
Sobieszyn	1	2								1		2	6
Siedlce	1	2									2	2	7
Sandomierz												1	1
Wysokie	1											1	2
Total	11	9								1	5	23	49

RESULTS

In the period analysed (1982–2006) at 10 meteorological stations and posts of the Lublin Region, 281 cases of extreme thermal phenomena occurred within 114 days, which constituted 1.2% of days. The highest number of such cases (52) was recorded in 1987. In 1983, 1990, and 1993, no cases of such phenomena occurred.

In the annual course, most of such cases occurred in January. In March, no cases of occurrence of extreme values of the phenomena analysed were observed.

Among the five extreme thermal phenomena discussed, the highest number of cases concerned significant changes in mean daily air temperature (exceeding 10°C), and the least number of cases involved the occurrence of frost in May ($T_{\min} \leq -2.0^\circ\text{C}$).

The most important factor determining the occurrence of extreme thermal values in the Lublin Region (and in the entire Poland) is atmospheric circulation, and particularly the occurrence of certain relatively rarely recorded synoptic situations. It is especially evident in the occurrence of very hot and very cold days (they only occurred in two years during the period analysed: in 1992 and 1994, as well as in 1987 and 2006, respectively) and strong frost in May (they only occurred in five years).

The main factors determining the differentiation of the frequency of occurrence of extreme thermal values in the Lublin Region are the location of a given meteorological station or post, and the character of its direct vicinity. It is evident in the case of differences in the frequency of occurrence of tropical nights between the centre of Lublin and station Lublin-Radawiec, located outside the city, as well as lack of occurrence of very cold days in Lublin and Sandomierz.

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STRESZCZENIE

Celem pracy jest określenie częstości występowania i rozkładu ekstremalnych wartości wybranych charakterystyk termicznych na Lubelszczyźnie w latach 1982–2006. Dane pochodzą z 9 stacji Instytutu Meteorologii i Gospodarki Wodnej oraz z Obserwatorium Meteorologicznego UMCS, położonego w centrum Lublina. Posiadają one jednorodny ciąg obserwacyjny dla badanego 25-letnia. Spośród charakterystyk termicznych przeanalizowano:

- dni bardzo upalne – $T_{\max} \geq 35^{\circ}\text{C}$,
- „noce tropikalne” – $T_{\min} \geq 20^{\circ}\text{C}$,
- dni extramroźne – $T_{\min} \leq -30^{\circ}\text{C}$,
- dni z przymrozkiem w maju – $T_{\min} \text{ 200 cm n.p.g} \leq -2,0^{\circ}\text{C}$,
- dni z przymrozkiem ($T_{\min} \text{ 200 cm n.p.g} \leq 0,0^{\circ}\text{C}$) w miesiącach letnich (VI–VIII),
- duże zmiany z dnia na dzień, powyżej 10°C , średniej dobowej temperatury powietrza.

W analizowanym okresie (1982–2006) w 10 stacjach i posterunkach meteorologicznych Lubelszczyzny wystąpiło 281 przypadków ekstremalnych charakterystyk termicznych w 114 dniach, co stanowiło 1,2% dni. Najwięcej takich przypadków (52) zanotowano w roku 1987, natomiast w latach 1983, 1990 i 1993 przypadki takich charakterystyk nie wystąpiły. W przebiegu rocznym najczęściej przypadków wystąpiło w styczniu; w marcu nie zanotowano przypadku wystąpienia ekstremalnej wartości analizowanych charakterystyk. Spośród wziętych pod uwagę pięciu ekstremalnych charakterystyk termicznych najczęściej przypadków dotyczyło dużych zmian średniej dobowej temperatury powietrza (powyżej 10°C), najmniej zaś przypadków wystąpienia przymrozków w maju ($T_{\min} \leq -2,0^{\circ}\text{C}$). Najważniejszym czynnikiem warunkującym występowanie ekstremalnych wartości termicznych na Lubelszczyźnie jest cyrkulacja atmosferyczna warunkująca występowanie pewnych stosunkowo rzadko notowanych sytuacji synoptycznych. Widać to szczególnie w przypadku pojawiania się dni bardzo upalnych i bardzo mroźnych (wystąpiły tylko w dwóch latach analizowanego okresu: odpowiednio w 1992 i 1994 oraz w 1987 i 2006) i silnych przymrozków w maju (wystąpiły tylko w pięciu latach).

Głównymi czynnikami różnicującymi częstość wystąpienia ekstremalnych wartości termicznych na terenie Lubelszczyzny jest lokalizacja stacji lub posterunku meteorologicznego oraz charakter bezpośredniego otoczenia stacji.

Słowa kluczowe: ekstrema temperatury powietrza, Lubelszczyzna