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THERMIC WEATHER TYPES IN HEL AND ATMOSPHERIC CIRCULATION TYPES

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Abstract

The main purpose of the article is the analysis of the relations between thermic weather types in Hel and types of circulation from Osuchowska-Klein's classification (1978). Thermic types have been constructed on the basis of A. Woś's classification of weather types (1993). As a result, in the study eleven thermic types have been distinguished and grouped into three categories of weather: warm, transitory and frosty. Detailed analysis has revealed that the frequency of thermic weather types in particular types of circulation is determined by the character of circulation (cyclonic/anticyclonic) as well as by its direction. The most numerous types of circulation over Poland: E (north-eastern anticyclonic) and CB (north-western cyclonic) most often are accompanied by warm and transitory weather. In Hel the warm weather group is conditioned mainly by the circulation types associated with the advection of the air from the West or South; transitory and frosty groups are related to the types of circulation conditioning the airflow from the northern or eastern sector.

Key words: types of circulation, thermic weather types, atmospheric circulation over Poland

INTRODUCTION

Atmospheric circulation is one of the most important factors determining the variety and course of weather processes in the moderate zone. Intense cyclonic activity, the formation, development and movement of low and high-pressure atmospheric disturbances, are the main reasons of a very high variability of weather conditions in Europe (especially in winter). The location of Poland within reach of the atmosphere's main centers of activity in Europe (the Icelandic Low and Azores High) plays a key role in shaping the features of the air temperature field in the country. The pressure fluctuation between these centers is the main factor conditioning the intensity and the character of circulation in Europe. Lower (than average) pressure values within the Icelandic Low and higher in the Azores High usually result in higher frequency of circulation types associated with the inflow of the air masses

from the western sector over Poland. Humid and relatively warm air moving at that time from the Atlantic Ocean most often brings a significant increase in temperatures during the winter months (X-II), while during the periods of weaker zonal circulation, marked by the prevalence of continental air over Poland, freezing winters are usually noted (Baranowski 2008, Kożuchowski 1989, Niedźwiedź 1981).
The most important features of atmospheric circulation can be defined according to indices or types of circulation. The circulation indices are most often used during comprehensive, component analyses of circulation factors (e.g. Barnston and Livezey 1987, Thompson and Wallace 1998, Wibig 1999), while classifications of circulation types are generally used in studies on circulation conditions for particular countries or regions (e.g. Péczely 1957, Muller 1977, Niedźwiedź 1983). Some of them, however, may be based on circulation types over large territories and even over the whole hemisphere (Vangengeim 1952, Girs 1971, Lamb 1972, Dmitriev 2000). In this paper, due to the local character of the conducted analyses, the following study makes use of B. Osuchowska-Klein's classification of circulation types (1978), which is characterized (like other visual classifications) by a high elasticity in the process of weather types cataloguing, which in turn facilitates the generalization of factors that influence atmospheric circulation.

AIM AND SCOPE OF THE PAPER

The main purpose of the study is to define the frequency of thermal weather types in Hel (in 1976-1995 period) in dependence on the type of atmospheric circulation (according to Osuchowska-Klein classification 1978).

Table 1

Thermic weather types

Type:		
warm $t_{min} \geq 0°C$	transitory $t_{min} < 0°C$, $t_{max} \geq 0°C$	frosty $t_{max} < 0°C$
• hot weather (type 0) $t_{avg} > 25°C$ • considerably warm weather (type 1) $15°C < t_{avg} \leq 25°C$ • moderately warm weather (type 2) $5°C < t_{avg} \leq 15°C$ • cool weather (type 3) $0°C < t_{avg} \leq 5°C$	• moderately cool transitory weather (type 4) $t_{avg} > 5°C$ • very cool transitory weather (type 5) $0°C < t_{avg} \leq 5°C$ • moderately cold transitory weather (type 6) $-5°C < t_{avg} \leq 0°C$ • very cold transitory weather (type 7) $t_{avg} \leq -5°C$	• moderately harsh weather (type 8) $-5°C < t_{avg} \leq 0°C$ • rather harsh weather (type 9) $-15°C < t_{avg} \leq -5°C$ • very harsh weather (type 10) $t_{avg} \leq -15°C$

Source: A. Woś 1993

The classification is based on visual comparison of pressure fields (on synoptic maps) with the model pattern given for the particular type of circulation. Each type corresponds to a defined distribution of atmospheric pressure at sea level and results from the position of the main pressure centers in Europe and North Atlantic Ocean, which determine the direction of air advection over Poland in cyclonic or anticyclonic circulation. The typical baric situations marked with letters (by the catalogue's author) A, CB, E_0, F, B, D have been designated as cyclonic and C_2D, E_2C, E, E_1, D_2C, G as anticyclonic types. Furthermore, the catalogue distinguishes type BE – of a transitional nature between cyclonic and anticyclonic circulation and so-called indeterminate situations (X). The most important argument for using Osuchowska-Klein's classification in the following study is a low number of types distinguished, as well as the existence of the catalogue of circulation types for the years 1976-1995 (Osuchowska-Klein 1991, Baranowski and Ewert 1997).
Thermic weather types have been distinguished on the basis of the modified classification system proposed by A. Woś (1993) – established on twenty-four hours weather conditions. In this case, the main criteria for grouping weather in classes were daily temperature values (average, minimum and maximum), cloudiness and precipitation. In this paper, taking into consideration only extreme temperature values (t_{max}, t_{min}) during the day, three basic weather groups have been distinguished (warm, transitory and frosty) which, depending on the mean daily temperature (t_{avg}), have been subdivided into eleven thermic weather types (Tab. 1).

FREQUENCY OF THERMIC WEATHER TYPES

In Hel the most frequently represented weather type is moderately warm weather (type 2), which in the analysed period 1976-1995 constitutes more than 40% of classified days (Tab. 2) On an annual course, type 2 appears most often during late

Table 2

Average annual number of thermic weather types in Hel (1976-1995)

Type	Jan.	Feb.	Mar.	Apr.	June	July	Aug.	Sept.	Oct.	Nov.	Nov.	Dec.	Sum
0	-	-	-	-	-	-	0.1	-	-	-	-	-	0.1
1	-	-	-	0.1	3.2	11.8	25.6	25.9	7.4	0.4	-	-	74.4
2	2.6	1.1	5	14.5	26.1	18.3	5.4	5.1	22.4	27.7	14.7	3.9	146.8
3	10.4	7.5	12.3	8.3	1.1	-	-	-	-	2.4	9.5	13.2	64.7
4	0.2	-	0.2	0.9	0.4	-	-	0.1	-	0.2	0.1	-	2.1
5	3.8	4.6	7.5	6.0	0.2	-	-	-	0.1	0.3	3.0	5.1	30.6
6	4.8	5.6	3.9	0.1	-	-	-	-	-	-	1.7	3.8	19.9
7	0.1	-	0.3	-	-	-	-	-	-	-	-	-	0.4
8	5.8	6.3	1.3	0.1	-	-	-	-	-	-	1	3.7	18.2
9	3.2	3.0	0.6	-	-	-	-	-	-	-	-	1.3	8.1
10	-	-	-	-	-	-	-	-	-	-	-	-	-

spring and autumn (with a maximum in October) and least frequently in February. High frequency types also include: considerably warm weather (type 1) – noted mostly in the period May-September, as well as cool weather (type 3) – occurring from October to May. Very cool transitory weather (type 5), moderately cold transitory weather (type 6) and moderately harsh weather (type 8) are also distinguished by high frequency – especially in the cold half-year (Oct.-Mar.). The remaining types constitute a total of 2.9% of classified days.

THERMIC WEATHER TYPES AND ATMOSPHERIC CIRCULATION TYPES

The study analyzes the frequency of thermic weather types depending on the type of circulation on an annual scale (Tab. 3), as well as according to a division into cold (Oct.-Mar.) and warm (Apr.-Sept.) half-years (respectively Tab. 4 and 5). The calculations conducted show that the most frequently represented in the 1976-1995 period moderately warm weather (type 2) is most often accompanied by the circulation

Table 3

Average annual number of thermic weather types in Hel depending on the type of circulation (1976-1995)

Circulation type	Thermic weather type											Sum
	0	1	2	3	4	5	6	7	8	9	10	
A	-	3.6	11.0	5.9	0.2	1.0	0.1	-	0.1	0.1	-	22.0
CB	-	9.0	24.8	13.6	0.1	4.6	2.9	-	1.5	0.2	-	56.7
D	-	4.7	12.0	5.8	0.2	2.5	0.7	-	0.7	0.1	-	26.7
B	-	2.9	8.7	4.5	0.1	1.7	0.7	-	0.5	0.2	-	19.3
F	-	2.9	6.7	2.5	0.1	1.5	1.4	0.1	1.2	0.5	-	16.9
C_2D	-	10.0	13.3	5.3	0.3	2.4	1.2	-	0.6	-	-	33.5
D_2C	-	3.3	7.6	2.6	0.1	1.4	0.5	-	0.3	-	-	15.8
G	-	4.6	6.8	2.1	0.2	1.9	1.2	-	1.6	0.6	-	19.0
E_2C	-	2.4	7.2	1.9	0.1	1.8	0.9	-	0.6	0.2	-	15.1
E_0	-	7.9	15.6	6.0	0.1	2.7	3.3	0.1	2.4	1.7	-	39.8
E	0.1	16.0	21.3	7.3	0.5	5.1	3.0	0.1	2.7	2.2	-	58.5
E_1	-	5.3	8.4	5.0	0.1	3.3	3.4	0.1	5.4	2.2	-	33.2
BE	-	0.8	2.9	2.1	-	0.5	0.5	-	0.5	0.1	-	7.4
X	-	0.4	0.5	0.1	-	0.2	0.1	-	0.1	-	-	1.4
Sum	0.1	74.0	147.0	64.7	2.1	30.6	19.9	0.4	18.2	8.1	-	365.3

Table 4
Average number of thermic weather types in Hel in the cold half-year (Oct.-Mar.) depending on the type of circulation (1976-1995)

Circulation type	Thermic weather type											Sum
	0	1	2	3	4	5	6	7	8	9	10	
A	-	0.1	6.6	5.8	0.2	0.9	0.1	-	0.1	0.1	-	13.9
CB	-	-	8.2	11.5	-	3.8	2.9	-	1.5	0.2	-	28.1
D	-	0.1	7.7	5.7	0.1	2.3	0.7	-	0.7	0.1	-	17.4
B	-	0.1	3.3	4.0	-	1.5	0.7	-	0.5	0.2	-	10.3
F	-	-	1.7	1.9	-	1.0	1.4	0.1	1.2	0.5	-	7.8
C_2D	-	-	5.9	5.0	0.1	1.6	1.2	-	0.6	-	-	14.4
D_2C	-	0.2	5.3	2.5		1.4	0.5	-	0.3	-	-	10.2
G	-	-	2.9	2.0	0.2	1.4	1.2	-	1.6	0.6	-	9.9
E_2C	-	-	2.1	1.7	-	1.4	0.9	-	0.6	0.2	-	6.9
E_0	-	-	1.5	3.7	-	1.6	3.2	0.1	2.3	1.7	-	14.1
E	-	-	3.3	5.1	-	3.4	3.0	0.1	2.7	2.2	-	19.8
E_1	-	0.1	4.7	4.8	-	3.1	3.4	0.1	5.4	2.2	-	23.8
BE	-	-	2.0	1.6	-	0.5	0.5	-	0.5	0.1	-	5.2
X	-	-	0.2	-	-	0.1	0.1	-	0.1	-	-	0.5
Sum	-	0.6	55.4	55.3	0.6	24.0	19.8	0.4	18.1	8.1	-	182.3

types with airflow from the northern sector: CB, E and E_0. Considerably warm weather (type 1) is usually noted (more than 35% days with this weather) within the range of influence of anticyclonic types: the north-western E and the western C_2D. Furthermore, in Hel the south-western and southern anticyclonic circulation C_2D, the north-eastern and eastern cyclonic circulation E_0 and the central anticyclonic circulation G are distinguished by a high degree of warm weather.

The occurrence of transitory weather types in Hel is most often associated with the types of circulation conditioning airflow from the eastern or northern sector (E, CB, E, E_0). Moreover, the western anticyclonic circulation C_2D, the south-western cyclonic D and the central anticyclonic circulation G are distinguished by a high degree of transitional weather.

The greatest frequency of frosty weather was noted during airflow from the eastern sector both in anticyclonic (E_1, E) and cyclonic types (E_0, F) and within a range of influence of the central anticyclonic circulation G.

In the cold half-year (Tab. 4) the most frequently represented are types 3 and 2 (occurring most often during westerly airflow in circulation types: A, CB, D and C_2D), as well as types 5 and 6 (usually accompanied by the types of circulation that bring

Table 5

Average number of thermic weather types in Hel in the warm half-year (Apr.-Sept.) depending on the type of circulation (1976-1995)

Circulation type	Thermic weather type											Sum
	0	1	2	3	4	5	6	7	8	9	10	
A	-	3.5	4.4	0.1	-	0.1	-	-	-	-	-	8.1
CB	-	9.0	16.6	2.1	0.1	0.8	-	-	-	-	-	28.6
D	-	4.6	4.3	0.1	0.1	0.2	-	-	-	-	-	9.3
B	-	2.8	5.4	0.5	0.1	0.2	-	-	-	-	-	9.0
F	-	2.9	5.0	0.6	0.1	0.5	-	-	-	-	-	9.1
C_2D	-	10.0	7.4	0.3	0.2	0.8	-	-	-	-	-	19.1
D_2C	-	3.1	2.3	0.1	0.1	-	-	-	-	-	-	5.6
G	-	4.6	3.9	0.1	-	0.5	-	-	-	-	-	9.1
E_2C	-	2.4	5.1	0.2	0.1	0.4	-	-	-	-	-	8.2
E_0	-	7.9	14.1	2.3	0.1	1.1	0.1	-	0.1	-	-	25.7
E	0.1	16.0	18.0	2.2	0.5	1.7	-	-	-	-	-	38.7
E_1	-	5.2	3.7	0.2	0.1	0.2	-	-	-	-	-	9.4
BE	-	0.8	0.9	0.5	-	-	-	-	-	-	-	2.2
X	-	0.4	0.3	0.1	-	0.1	-	-	-	-	-	0.9
Sum	0.1	74.0	91.4	9.4	1.5	6.6	0.1	-	0.1	-	-	183.0

to Poland air from the eastern and northern sector: E_1, E, CB). In Hel no extreme weather types in the cold half-year were noted (the warmest type 0 and the coldest – type 10). From October to March the group of frosty weathers is distinguished by the highest degree of moderately harsh weather (type 8). The mean share of type 8 in the cold half-year exceeds 9.9% of classified days.

In the warm half-year (Apr.-Sept.) the warm weather group predominates, among which type 2 (moderately warm weather) and 1 (considerably warm weather) are most frequently represented. Their mean frequency in the years 1976-1995 amounts to 91.4 and 74.0 respectively (Tab. 5). Moderately warm weather (type 2) usually occurs during circulation types associated with the advection of the air from the northern sector: E, CB and E_0; considerably warm weather (type 1) is most often noted during the north-eastern anticyclonic circulation E and the western anticyclonic one C_2D. From April to September the frosty weather types in Hel appear rarely (less than 0.1% classified days), while moderately cold and very cold transitory weather (type 7) from the transitory weather group do not occur.

The comparative analysis of frequency of thermic weather types in Hel in dependence on the type of atmospheric circulation indicates a higher degree of variability

during the cold half-year (Tab. 4 and 5). In the period from October to March, the share of six weather types exceeds more than 4% of classified days, with only three such types during the warm half-year.

CONCLUSIONS

1. The character of circulation over Poland in the analyzed period 1976-1995 is predominantly determined by two types: the north-western cyclonic CB and the north-eastern anticyclonic E (occurring with a mean annual frequency of 56.7 and 58.5 days respectively). Types characterized by an average frequency include: the north-eastern and eastern cyclonic circulation E_0 (39.8 days a year), the western anticyclonic circulation C_2D (33.5 days) and the south-eastern and eastern anticyclonic one E_1 (33.2 days). The mean annual frequency of the remaining types does not exceed 27 days.
2. Atmospheric circulation to a large extent determines the frequency of different thermic weather types in Hel, although the role of the advection of air masses direction is greater than the character (cyclonic/anticyclonic) of the baric systems.
3. The most frequent weather type is moderately warm weather (type 2). On an annual scale this weather type most often occurs in late spring and autumn (with its maximum in October) with the lowest frequency in February. Considerably warm weather (type 1 – noted from April to October) and cool weather (type 3 – which occurs during Oct.-May period) are commonly represented too.
4. A greater frequency of circulation types characterized by airflow from the southern or western sector is conducive to warm weather. Types of circulation that bring air to Poland from the North or East most often are accompanied by transitional and frosty weather during the studied 20-year period.
5. In the cold half-year (Oct.-Mar.) the most frequently represented are types 3 and 2 (occurring most often during western airflow in cyclonic types of circulation: A, CB, D and C_2D), as well as types 5 and 6 (the most strongly associated with the types of circulation that bring to Poland air from the eastern and northern sector: E_1, E, CB). The frosty weather group frequently occurs during circulation types associated with advection of the air from the eastern sector: E, E_1, E_0 or within a high pressure area over Poland (type G).
6. From April to September (warm half-year) the warm weather group predominates, among which types: 2 (moderately warm weather) and 1 (considerably warm weather) are most frequently represented. Moderately warm weather usually accompanies circulation types associated with the advection of the air from the northern sector: CB, E_0 and E. The highest frequency of considerably warm weather is noted during the north-eastern anticyclonic circulation E and the western anticyclonic one C_2D.
7. In the cold half-year variability of thermic weather types within reach of particular types of atmospheric circulation is higher then in the warm half-year.

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TERMICZNE TYPY POGODY W HELU A TYPY CYRKULACJI ATMOSFERYCZNEJ

Streszczenie

Zasadniczym celem pracy było określenie częstości występowania w Helu termicznych typów pogody (w latach 1976-1995), w zależności od typu cyrkulacji atmosferycznej (według klasyfikacji B. Osuchowskiej-Klein 1978). Termiczne typy pogody wyróżniono na podstawie klasyfikacji zaproponowanej przez A.Wosia (1993), opartej na dobowych warunkach pogodowych. W niniejszym opracowaniu jedynym kryterium grupowania pogody w klasy były charakterystyki termiczne z tej klasyfikacji. Biorąc pod uwagę dobowe wartości temperatur ekstremalnych (t_{max}, t_{min}), wyróżniono trzy podstawowe grupy pogód: ciepłe, przejściowe oraz mroźne, które w zależności od wartości średniej dobowej temperatury powietrza podzielono na 11 termicznych typów pogody.

W opracowaniu, w pierwszej kolejności określono typy decydujące o charakterze cyrkulacji nad obszarem Polski, a następnie przeanalizowano towarzyszące im termiczne typy pogody w półroczu chłodnym (X-III), ciepłym (IV-IX) oraz w skali roku. Uzyskane wyniki pozwalają na wysnucie następujących wniosków. Cyrkulacja atmosferyczna w dużej mierze determinuje częstość występowania termicznych typów pogody w Helu, przy czym rola kierunku adwekcji mas powietrza jest większa niż charakter (cyklonalny/antycyklonalny) układu barycznego. Występowaniu pogód ciepłych sprzyja większa frekwencja typów cyrkulacji charakteryzujących się napływem powietrza z sektora południowego i zachodniego. Pogody przejściowe i mroźne towarzyszą najczęściej typom cyrkulacji sprowadzającym do Polski powietrze z północy lub ze wschodu. Najliczniej reprezentowanym typem pogody jest pogoda umiarkowanie ciepła, która pojawia się najczęściej późną wiosną i jesienią (z maksimum w październiku) przy najmniejszej częstości w lutym. Do grupy typów o dużej frekwencji należy ponadto: pogoda bardzo ciepła – notowana wyłącznie od kwietnia do października oraz pogoda chłodna – występująca od października do maja. W półroczu chłodnym występuje większe zróżnicowanie termicznych typów pogody w zależności od typu cyrkulacji atmosferycznej.