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Marek Nowosad

AN ATTEMPT TO DETERMINE THE CHANGES OF THE CIRCULATION SEASONS PRESENTED UPON THE EXAMPLE OF THE UPPER VISTULA RIVER BASIN

Abstract: On the basis of the calendar of atmospheric circulation types, drawn up by T. Niedźwiedź, the year has been divided into circulation seasons. The division has been done for the long-term period 1874-1990, as well as separately for its parts: 1874-1910, 1911-1950, 1951-1990. Distinguishing circulation seasons for the period 1951-1990, together with a detailed description of the method, was published earlier (Nowosad 1998a). For individual long-term periods circulation seasons have been obtained, differing clearly by their opening and closing dates as well as their duration.

Key words: atmospheric circulation, circulation types, circulation seasons, Vistula river basin, Wrocław dendrite method.

1. Introduction

Atmospheric circulation is characterised by seasonality in its annual course (Kaszewski 1992; Niedźwiedź 1981; Osuchowska-Klein 1973). The present study analyses the frequency of occurrence of the types of atmospheric circulation over the upper Vistula river basin. The analysis uses the calendar of occurrence of particular circulation types since 1874, prepared by T. Niedźwiedź. Part of the calendar has been published (Niedźwiedź 1988, 1992)[1].

The data, being the published part of the calendar and covering the period 1951-1990, were the source material for distinguishing the circulation seasons in the upper Vistula river basin (Nowosad 1998a, 1998b). In comparing circulation seasons in 20-year periods, 1951-1990 and 1971-1990, distinctly different dates of occurrence of the seasons were obtained (Nowosad 1999). The present study is an attempt to

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[1] The unpublished part of the calendar was made available to me by Professor T. Niedźwiedź, for which I extend to him my sincere thanks.

determine the differentiation of those dates for a possibly long period. Circulation seasons were distinguished (apart from the ones distinguished for the 40-year-long period 1951-1990) for the 40-year period (1911-1950) and the 37-year period (1874-1910), as well as for the whole period analysed (1874-1990) jointly.

2. Method

Distinguishing circulation seasons for particular 40-year periods, as well as for the whole period analysed jointly, was carried out by the same method. Its successive steps included:

1. Determining the mean long-term frequency of occurrence of particular types of atmospheric circulation (according to Niedźwiedź's classification) on successive days of the year.

2. Applying a 15-element symmetrical triangular filter in order to eliminate short-term fluctuations of the mean.

3. Calculating the indices of occurrence of circulation types. The indices were defined in order to reduce the role of the variability of the frequency of occurrence of those circulation types which represent relatively similar circulation conditions. In order to determine the indices, for the type representing air advection from a particular direction, similar, different and decidedly different types were defined. Similar types represent the same character of the air pressure system and a contiguous direction of advection. Different types represent either the same character of the air pressure system and the direction of advection differing by the angle of 90°, or the same direction of advection and a different character of their air pressure system. All the remaining types (15 in number) have been defined as decidedly different. Then, by modifying slightly the method applied earlier (Nowosad 1985), indices of the frequency of individual types were defined. In the case of the types representing air advection from a particular direction, while defining frequency indices with weight 3, the frequency of a given type was added. For indices with weight 2, the frequencies of similar types were added. Lastly, for indices with weight 1, the frequencies of different types were added. For example:

frequency index $N_a = 1/10\ (3\ N_a + 2\ NW_a + 2\ NE_a + W_a + E_a + N_c)$

frequency index $N_c = 1/10\ (3\ N_c + 2\ NW_c + 2\ NE_c + W_c + E_c + N_a)$

In types C_a, K_a, C_c and B_c the frequency indices were defined as follows:

frequency index $C_a = 1/3\ (2\ C_a + K_a)$

frequency index $K_a = 1/3\ (2\ K_a + C_a)$

frequency index $C_c = 1/3\ (2\ C_c + B_c)$

frequency index $B_c = 1/3\ (2\ B_c + C_c)$

The frequency index of a given type cannot be applied in characterisation, but may be used as a taxonomic tool.

These steps were ended by arranging the results in the form of a 365 x 21 matrix (365 days in the year, 21 circulation types).

4. Determining the distance between particular days of the year in a 21 dimensional space, defined by means of the Manhattan metric.

5. Dividing the year into seasons by using the Wrocław dendrite method. The longest segments of a dendrite divide the year into periods differing the most by the structure of the frequency of occurrence of particular types of atmospheric circulation. Among other applications, the Wrocław dendrite method was earlier used in differentiating climatic seasons (Woś 1977, 1996). An assumption was made that a circulation season must last at least 5 days. The number of circulation seasons the year is divided into is a separate problem for discussion. Due to compatibility with an earlier-presented division, covering the period 1951-1990 (Nowosad 1998a), the present study opts for a division of the year into 8 circulation seasons.

A detailed description of the method of distinguishing circulation seasons was published earlier (Nowosad 1998a).

3. Results

The lengths of the segments forming dendrites for particular long-term periods are shown in Fig. 1. Table 1, on the other hand, shows the longest segments forming particular dendrites (in the order of diminishing size). Those segments determine the boundaries between particular circulation seasons. The dates and durations of the seasons formed in this way are contained in Tab. 2.

In the 117-year-long period (1874-1990) the boundaries determining the greatest differentiation of the structure of occurrence of atmospheric circulation types were found to be the dates 22/23 June and 6/7 June (Tab. 1, Fig. 1a). In the 1951-1990 period analysed earlier (Nowosad 1998a, 1998b) the date 22/23 June did not stand out as a boundary between circulation seasons. On the other hand, the boundary in this period was the date 9/10 June. This is 3 days later than the boundary of 6/7 June, outstanding in the entire 117-year period. Attention is drawn to the similarity of those dates to the 5/6 June boundary, standing out in the period 1874-1910 (Tab. 1, Fig. 1b).

Season-boundary dates approximating each other were observed in single cases between the periods 1911-1950 and 1951-1990 (10/11 and 12/13 November). A difference of 4 days was also noted between season boundaries within the periods

Tab. 1. The longest segments forming a dendrite (after introducing the criterion that a season must last at least 5 days).

	Date (day – month)							
Nr	Period 1874 - 1990		Period 1874 - 1910		Period 1911-1950		Period 1951-1990	
1	22-06	23-06	5-06	6-06	22-10	23-10	6-05	7-05
2	6-06	7-06	4-07	5-07	10-11	11-11	26-07	27-07
3	22-11	23-11	24-01	25-01	27-05	28-05	12-02	13-02
4	28-05	29-05	23-06	24-06	30-06	1-07	7-03	8-03
5	15-04	16-04	24-04	25-04	6-12	7-12	9-06	10-06
6	7-05	8-05	2-05	3-05	16-07	17-07	15-03	16-03
7	3-10	4-10	15-04	16-04	5-11	6-11	2-04	3-04
8	13-02	14-02	3-08	4-08	24-09	25-09	12-11	13-11

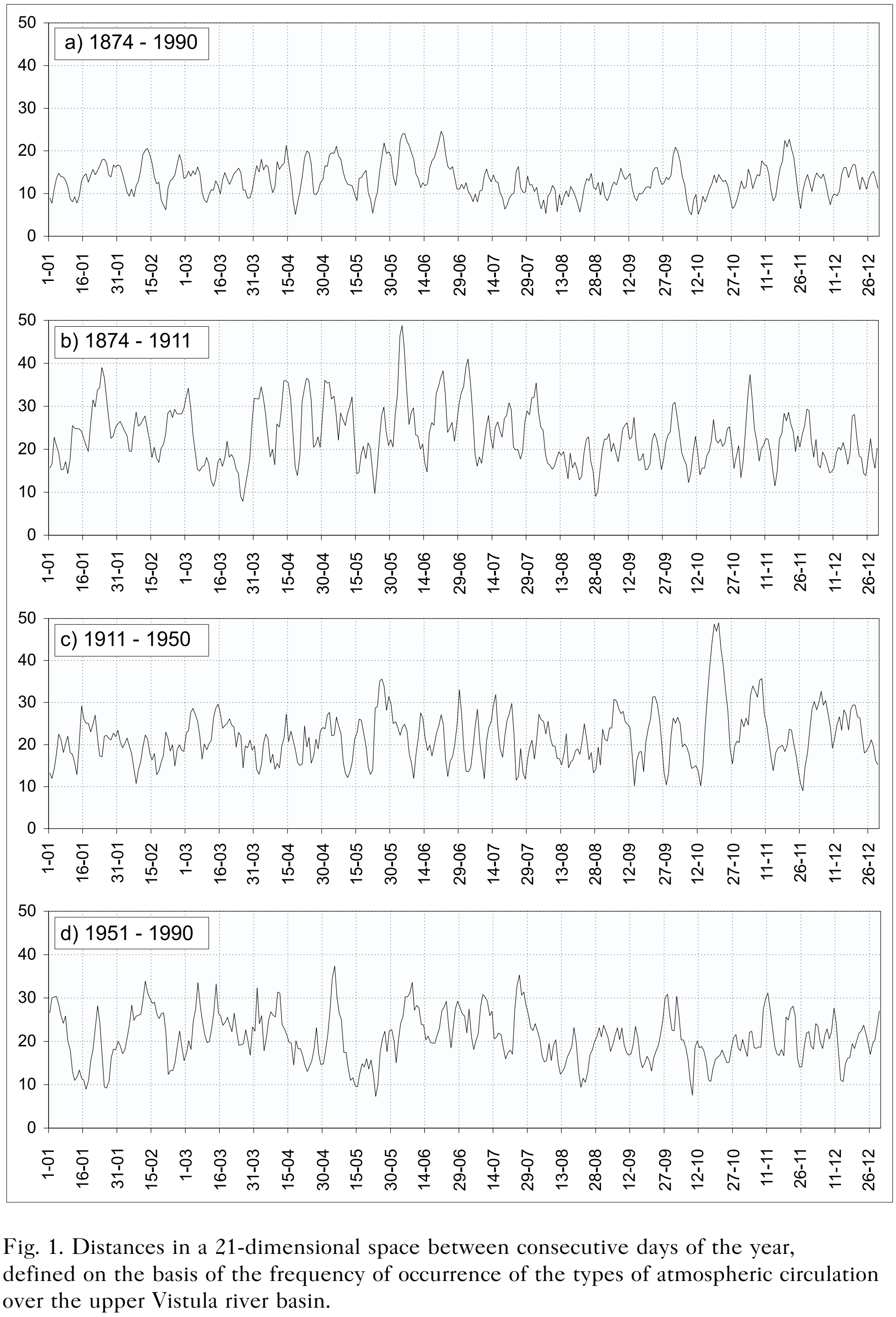

Fig. 1. Distances in a 21-dimensional space between consecutive days of the year, defined on the basis of the frequency of occurrence of the types of atmospheric circulation over the upper Vistula river basin.

Tab. 2. Circulation seasons in the upper Vistula river basin.

	Dates of the beginning end the end (day – month) / the duration							
Nr	Period 1874 - 1990		Period 1874 - 1910		Period 1911-1950		Period 1951-1990	
1	23-11	13-02	4-08	24-01	7-12	27-05	13-11	12-02
	82 days		173 days		172 (173) days		92 days	
2	14-02	15-04	25-01	15-04	28-05	30-06	13-02	7-03
	62 (63) days		82 (83) days		34 days		23 (24) days	
3	16-04	7-05	16-04	24-04	1-07	16-07	8-03	15-03
	22 days		9 days		16 days		8 days	
4	8-05	28-05	25-04	2-05	17-07	24-09	16-03	2-04
	21 days		8 days		70 days		18 days	
5	29-05	6-06	3-05	5-06	25-09	22-10	3-04	6-05
	9 days		34 days		28 days		34 days	
6	7-06	22-06	6-06	23-06	23-10	5-11	7-05	9-06
	16 days		18 days		14 days		34 days	
7	23-06	3-10	24-06	4-07	6-11	10-11	10-06	26-07
	103 days		11 days		5 days		47 days	
8	4-10	22-11	5-07	3-08	11-11	6-12	27-07	12-11
	50 days		30 days		26 days		109 days	

1874-1910 and 1951-1990 (2/3 and 6/7 May). There are a number of cases where the boundary dates approximate each other if one compares the entire 117-year period with the sub-periods analysed.

Essentially, however, each of the 3 parts the entire long-term period was divided into, is characterised by distinctly different dates of occurrence of circulation seasons. The seasons also differ in their duration. The duration of particular seasons ranges from 5 to 173 days.

Considering the period 1874-1910, the already-mentioned boundary of 5/6 June could be pointed out as more distinct than other boundaries in this period (Fig. 1b). In the period 1911- 1950, on the other hand, considerable differentiation of the structure of circulation types can be seen between the 2nd and 3rd decade of October (Fig. 1c).

4. Conclusions

On the basis of the above attempt to divide the year into circulation seasons it can be seen that the duration of circulation seasons is clearly influenced by the selection of the long-term period analysed. This conclusion is compatible with earlier results (Nowosad 1999). It seems that the outcome of the present attempt testifies to a relatively large differentiation of the structure of the types of atmospheric circulation in particular parts of the year and from one long-term period to the next.

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Marek Nowosad
Department of Meteorology and Climatology
Maria Skłodowska Curie University
Lublin
Poland