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ESTIMATION OF THE METHODS OF THE EXTREME WINTERS CLASSIFICATION

Abstract: This study contains a verification of the methods for setting the dates of the beginnings and the endings of winters, and a methodological proposal for analysing winter temperatures. It was stated that limiting the definition of winter to just three months (December–February) does not reflect its true character, as it often happens that very low temperatures that have an impact on the conditions of the entire winter occur in November or in March, which are rarely recognised as winter months. Also the assessment of winter severity only on the basis of one criterion does not seem sufficient to the author, while the criteria employed in this study are complementary, as they define the quantitative intensity of the cold in various ways.

Key words: winters, extreme winters, air temperature, methods of classification.

1. Introduction, Aim of Study

According to many climatologists, extreme meteorological phenomena point to the changes of the climate, and their intensification within the recent years is related to observed global warming. In Kosiba's (1956) opinion, the most visible changes in climate are the thermal oscillations of winters, which have been very strong in the temperate climate. The deviation from the average long-term values observed for the features like: dates of beginning and end, time period and mean temperatures, is the highest for the winter season. The author stresses, however, that classification of winters is a complex issue requiring possibly the most objective methods. Although there is literature referring to the thermal conditions of winters, there are no universal methods and criteria for their characteristics, typology or classification.

The aim of this study is to define the extreme winters, taking into consideration various criteria for setting the dates of beginnings and ends of this season, which have most frequently been enlisted in literature. The methods described were tested, and selected according to the comparable results achieved, with the simultaneous assessment of the usefulness of the thermal criteria for classification of winters.

2. Source Materials and Methods

The analysis employed the daily values of air temperature from Prague-Klementinum (1775/76-1995/96) and Cracow (1811/12-1995/96). The stations are representative for the Central European region up to 300 m above sea level.

The research on climate increasingly more frequently touches upon extreme phenomena, which definitely include cold and mild winters. In order to select these, one must decide what value of the standard deviation (σ) from the average would be the best to define the anomaly. This issue was broadly commented upon in Warakomski's (1994) study. According to that author, a severe criterion for anomalies is the standard deviation by $\pm 2.5\ \sigma$, while a moderate deviation would be $\pm 2\ \sigma$. Another method would be to select the cases where the values of the adopted criterion are higher than the upper decile and lower than the lower decile. As Crowe (1971) states, 10% of all cases from the top and bottom of the scale defined in this way make "mean extremal values" and those are usually the values showing "natural capriciousness", and these include mainly abnormal values. This study applies this method, as well as a moderate anomaly criterion equal to $\pm 2.0\ \sigma$ deviation from the average for particular criteria.

3. Beginnings and Ends of Winters

Most frequently, winter is regarded as the period of three months, from December, 1st to February, 28th or 29th. Some climatologists define the season in much broader limits, from four to six months (Liliequist 1943; Hesse 1953; Kosiba 1954). Therefore winter months may fall in various "combinations": December-March, November-February, November-March, November-April. Paczos (1982) has verified several "versions of winter" presented here. In his opinion, the most appropriate period for the thermal conditions prevailing on the entire territory of Poland is the period between December and February or December and March. The adoption of three months of winter (Dec.-Feb.) is the easiest way to select them, which allows for comparing the average values of the particular features calculated for many stations employed in the analysis. There is, however, a hazard that by limiting ourselves to these three months we may not account for the appropriate character of the season discussed.

Winter in Central Europe is not limited only to the period December–February. The conditions characteristic for this season may also occur in November and March. The mean monthly air temperature below freezing point during these two months was observed in Cracow with the frequency of 8.4 and 17.2% respectively; while in Prague – 1.0 and 3.6% (Tab. 1). These values show that March doubled November as to the temperature below zero. Thus the assumption of Mitosek (1961) and Paczos (1982) concerning the inclusion of March to winter months is grounded. But should we be limited only to including only March?

Tab. 1. Frequency (%) of mean monthly temperature values and winter (Dec.-Feb.) in particular sections in Cracow and Prague.

Temperature	Cracow (1811/12-1995/96)						Prague (1775/76-1995/96)					
	Nov.	Dec.	Jan.	Feb.	March	Dec.-Feb.	Nov.	Dec.	Jan.	Feb.	March	Dec.-Feb.
≥0	91.6	38.2	21.6	39.4	82.8	25.0	99.0	68.3	42.6	64.2	96.4	56.5
<0	8.4	61.8	78.4	60.6	17.2	75.0	1.0	31.7	57.4	35.8	3.6	43.5

Tab. 2. Frequency (%) of the lowest mean monthly temperature values in Cracow and Prague.

Stations	Nov.	Dec.	Jan.	Feb.	March	Nov.-March
Cracow (1811-1995)	2.4	19.6	51.0	25.5	1.5	100.0
Prague (1775-1995)	1.4	19.9	51.1	24.9	2.7	100.0

Climatological literature most frequently states that the coldest month of the year in Central Europe is January. Actually, it was so only in about half of the periods analysed (Tab. 2). The lowest monthly mean of air temperature may occur in any of the other four months. It's worth considering that in Cracow, more frequently November (2.4%) was the coldest month rather than March (1.5%), while in Prague the reverse was true (1.4% and 2.7%) (Tab. 2). Therefore, when analysing thermal conditions of winters, one should additionally consider March and November, especially that recently we have had very mild winters, where the coldest month was November, e.g. in winter 1988/89. However, if we include the period from November, 1st to March, 31st into analysis of winters, we may find that the mean air temperatures calculated for these five months would be too high.

Thermal seasons are set on the basis of crossing the thermal point (0°C for winter). A simplified method is applied, where mean monthly temperatures from a long-term period are used, and a graphical or calculation method. It is assumed that mean monthly temperature is close to the daily average of the 15th day of a month, each month is 30 days long, while the increase and decrease of temperature can be connected with a straight line. The methods may be recommended for setting the averages for the long-term dates of beginnings and ends of winters for at least 10-year periods in Cracow, and at least 30-year long periods in Prague. Otherwise one may come across long-term mean temperatures which did not fall below 0°C, thus where winter did not occur. In Cracow such a case was for the mean temperatures from the period of 1991-1995, and in Prague for the 30-year period between 1961 and 1990. Wasn't there any winter in Prague between 1961-1990? It is hard to accept such a statement without an attempt to set the winter period separately for each year.

In climatological literature one may find several ways of setting the dates of beginnings and ends of particular winters (Piotrowicz 1996). It seems that the best,

Tab. 3. Extreme winters concerning their beginning and end in Cracow (1811/12-1995/96) and Prague (1775/76-1995/96).

Extreme winters	Cracow	Prague
Very early coming winters	1908/10 (19.10)	1908/10 (20.10)
Very late coming winters	1970/71 (18.12), 1929/30 (18.12), 1992/93 (16.12), 1898/99 (16.12), 1944/45 (14.12), 1972/73 (13.12), 1949/50 (13.12), 1872/73 (13.12)	1982/83 (20.01), 1825/26 (5.01), 1824/25 (5.01), 1806/07 (5.01), 1949/50 (31.12), 1841/42 (31.12), 1979/80 (26.12)
Very early ending winters	1989/90 (14.01), 1988/89 (29.01), 1896/97 (16.02)	1973/74 (11.12), 1989/90 (9.01), 1816/17 (13.01), 1994/95 (21.01), 1793/94 (22.01), 1867/68 (26.01), 1814/15 (28.01), 1944/45 (30.01)
Very late ending winters	1816/17 (26.04), 1876/77 (22.04)	-

although not faultless method is the one defining the "potential winter period", i.e. exactly the first and the last day of winter (t_{mean}<0°C). The extreme winters in Cracow and Prague according to this criterion have been presented in the Table 3.

4. Thermal Conditions in Winters

When preparing a thermal characteristics of winters, apart from setting the dates of beginning and end, it is important to define thermal conditions, if possible for the entire group. In the author's opinion, preparation of winter characteristics on the basis on one criterion is not sufficient. The characteristics applied should be complementary, account for variability of thermal conditions of winter in a region, and in various ways define the intensity of cold. The classification of winters on the basis of mean season temperature, could be complemented by additional calculation of the value of the sum of frost, i.e. the sum of mean daily air temperatures below 0°C (Σt_{mean}<0°C), which was used by Hesse (1953) and Paczos (1982).

Kosiba (1956) enumerates 49 winter features. The author is of the opinion that there shouldn't be too many features, as they might make the analysis and the later synthesis more difficult. Therefore, she has decided to employ four criteria: the number of winter days (t_{mean}<0°C), cold days (t_{max}<0°C), very cold days (t_{max}<-10°C), and the sum of frost (Σt_{mean}<0°C). The analysis of the particular features did not result in a clear assessment of the degree of winter severity. It seems more efficient to analyse them not only in parallel manner, but also simultaneously. Thus only the winters where simultaneously the values of winter days, cold days, very cold days and sum of frost exceeded the limits adopted may be considered abnormal. On the basis of standard deviation, neither in Cracow nor in Prague was it possible to differentiate extreme winters where the particular thermal criteria exceeded the value of $\pm 2.0\,\sigma$. It seems therefore that the application of the extremes value is a better method here.

5. Conclusions

The verification of the methods for defining the extreme winters showed that in many cases it was not sufficient to analyse the temperatures of the three winter months in order to conduct the analysis of the season. It often happens that low temperatures occur in November (8.4% winters in Cracow in the years 1811-1996), or in March (17.2%), which are not considered to be winter months. Various "combinations" of the winter season were analysed. The best solution seems to focus on three months of winter, and in particular years where low temperatures occurred already in November or still prevailed in March, to additionally take them to account.

The methods of setting dates of beginnings and ends of winters on the basis of long-term monthly and daily mean temperatures bring similar results. These methods may be, however, recommended for analyses of the mean temperatures of at least 10-year period in Cracow, and not shorter than 30-year periods in Prague. A good method for setting the dates of beginnings and ends of winters and their features is to adopt a framework for the season as the first and the last day with $t_{mean}<0^{o}C$ and consideration of winter days ($t_{mean}<0^{o}C$), cold days ($t_{max}<0^{o}C$), very cold days ($t_{max}<-10^{o}C$) and sum of frost ($\Sigma t_{mean}<0^{o}C$). In order to define the extreme winters, one may try to use both the values of the standard deviation (σ) and the extremes, but the earlier does not always provide satisfactory results.

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