SHORT-TERM CHANGES OF AIR TEMPERATURE IN POLAND

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ABSTRACT. - Short-term changes of air temperature in Poland. The paper presents an analysis of short-term changes in maximum air temperature values, understood as interdiurnal (T_2-T_1) temperature changes in Poland. It was calculated as the differences of the daily maximum air temperature from the multi-year period (1961- 2010), from 8 stations (Leba, Suwałki, Szczecin, Poznan, Warsaw, Włodawa, Wrocław and Krakow), which are representative of Polish regions. In most cases, these changes amount were no more than 2.0-3.0°C. However It was found that in extreme cases, day-to-day changes may have exceeded even 20.0°C. Accordingly in this paper, special attention was paid to the number of days with the abrupt increases and decreases in temperature, understood as the differences greater than or equal 8.0 °C.

Keywords: short-term changes of air temperature, interdiurnal temperature variability, maximum temperature

1. INTRODUCTION

Many studies published since the mid-20th century have focused on air temperature and its interdiurnal variation (Kostrzewski 1961; Kossowski 1970; Hoffman 1971; Kossowska-Cezak 1988, 1993; Krysiak 1990, Moberg et al. 2000, Robetez 2001, Fortuniak et al. 2004, Panfil 2007). However, the phenomenon was first mentioned in papers authored as far back as in the late 19th and in the early 20th century by researchers such as Merecki (1899), Romer (1912) and Gorczyński (1915). European climatologists were not the only ones to have a keen interest in the problem, though. The worldwide literature also discussed research conducted in Canada and in the USA, focusing on short-term temperature changes and their multiannual trends in various climate zones, ranging from subpolar and moderate to tropical (Tam, Gough et al. 2012, DeGaetano 1998).

The most characteristic feature of moderate climate is the high dynamics of weather changes, which may occur overnight and even on an hourly basis (Olejniczak 2003). Without doubt, atmospheric circulation is the principal factor influencing changes in air temperature in this climate zone. However, besides the weather situation and the advection of various air masses, the scale of short-term temperature changes is influenced by local factors, such as relief and land cover (Szwejkowski et al. 2006).

Significant short-term temperature changes are interesting for research purposes, but they do also have a practical dimension. Abrupt increases or

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decreases in air temperature, especially in the intermediate seasons (spring and autumn), may have an impact on various sectors of the economy, as well as on human health and well-being. Significant temperature drops in late autumn may cause the formation of sleet and lead to plant winterkill in spring, while warmer spells occurring when snow cover persists increase the risk of flooding (Fortuniak et al. 2004). Short-term temperature changes are also a strong thermal stimulus for the human body (Mąkosza, Nidzgorska-Lencewicz 2011). The temperature swings which are most strongly felt by the human body – not prepared to rapidly adapt to them - are mainly those occurring in winter and spring as a result of the advection of thermally different air masses (Kosowska-Cezak 1987).

This study explores the patterns of short-term changes in maximum air temperature values, understood as interdiurnal temperature changes in Poland between 1961 and 2010. In particular, the authors have accounted for abrupt increases and decreases in temperature, understood as changes greater than or equal to 8.0°C.

2. DATA AND METHODS

The study looks at the maximum values of air temperature recorded every day from 1961 to 2010 in order to trace its short-term changes over that period. The data was collected at 8 weather stations: Łeba, Suwałki, Szczecin, Poznań, Warsaw, Włodawa, Wrocław, and Krakow, which are uniformly spaced across Poland and make part of the IMGW-PIB (Institute of Meteorology and Water Management - National Research Institute) weather observation network (Figure 1). Differences in maximum temperature values on consecutive days have been calculated as T_2-T_1. Since small changes of around 2-3°C (Fortuniak et al. 2004, Kosowska 1987) are quite common during the year, this paper pays special attention to cases where maximum temperature values on consecutive days dropped or rose by 8.0°C or more. This is a threshold value beyond which interdiurnal temperature changes can be considered abrupt (Tam, Gough et al. 2012).

3. RESULTS

An analysis of mean annual interdiurnal air temperature variation at eight selected sites in Poland has revealed minor differences between the stations located in the Polish Lowlands (in Poznan, Warsaw, Wrocław and Włodawa) and a stark thermal contrast between the coastal stations (in Łeba and Szczecin) and the one in Krakow, which can be considered representative of the Carpathian Foothills area. In the analysed multiannual period (1961-2010), the greatest values of mean annual air temperature changes were recorded in Krakow (2.6°C), while the lowest values were reported for Łeba and Szczecin. For comparison, the mean annual temperature change at both of these stations only amounted to 2.1°C (Table 1).

Table 1. ***Average annual changes in the day-to-day maximum temperature (T_2-T_1) in a multi-year period (1961-2010)***

Station	φ [N]	λ [E]	H [m a.s l]	T_2-T_1 [°C]
Łeba	54°45'	17°32'	2	2.1
Suwałki	54°07'	22°56'	184	2.2
Szczecin	53°23'	14°37'	1	2.1
Poznań	52°25'	16°50'	83	2.3
Warszawa	52°09'	20°57'	106	2.3
Włodawa	51°33'	23°31'	177	2.3
Wrocław	51°06'	16°54'	120	2.4
Kraków	50°04'	19°48'	237	2.6

As regards the frequency of the changes, rather than their size, considerable disproportions between individual stations can also be seen in terms of positive and negative changes. At five stations, cases of interdiurnal maximum air temperature increases were somewhat more numerous than cases of decreasing temperature values (Table 2). The greatest predominance of increases over decreases was recorded in Włodawa (2.5%). In turn, at the stations in Łeba, Poznan and Szczecin, temperature drops were more frequent than rises, with the greatest prevalence in Łeba (48.6%). Cases of no interdiurnal temperature changes within the margin of measurement error (0.1≤ΔT≤-0.1°C) were most frequently observed in Northern Poland (Łeba, Szczecin and Suwałki). At the Łeba weather station, such days accounted for 5.1% of all cases in the entire study period (Table 2).

Table 2. ***The frequency of occurrence [%] increases (ΔT>0.1), decreases (ΔT< -0.1) and no changes (0.1≤ΔT≤-0.1) of the day-to-day maximum air temperature (T_2-T_1) in a multi-year period (1961-2010) in Poland***

Station	Łeba	Suwałki	Szczecin	Poznań	Warsza-wa	Włodawa	Wrocław	Kraków
ΔT>0.1	46.3	48.5	47.4	48.1	48.7	49.2	49.0	49.0
σ [°C]	2.1	1.8	1.8	1.9	1.8	1.8	1.9	2.0
ΔT< -0.1	48.6	47.2	48.3	48.2	47.3	46.7	47.7	48.1
σ [°C]	1.9	1.9	1.8	1.9	1.9	2.0	2.0	2.1
0.1≤ΔT≤ -0.1	5.1	4.3	4.3	3.7	4.0	4.1	3.3	2.9

An analysis of day-to-day changes in temperature values in particular months has revealed that the greatest share of all changes occurred in May. It is in May that the maximum air temperature changed overnight almost every day at all of the stations - ranging from 97% in Łeba, Szczecin and Wrocław, to 98% at the other stations.

An analysis of the extreme values of short-term maximum temperature changes in Poland has revealed that in extreme cases they even exceeded 20.0°C, January and April being the months of the greatest extremes. The greatest day-to-day increase in temperature was recorded in Łeba (19.2°C), while extreme drops were reported at weather stations in Central and Southern Poland (-20.3°C in Poznan and Krakow) (Fig. 1).

In the period 1961-2010, a clear difference was noticed in terms of the number of days with abrupt temperature changes of ΔT≥8.0°C. They were most numerous in Łeba and in Krakow (373 and 355 cases in the entire long-term period). In Łeba there were more temperature increases than decreases, while the opposite was the case in Krakow. The changes were most common in spring months, mainly in April and May. The lowest frequency of day-to-day temperature changes of ΔT≥8.0°C was recorded in Szczecin (185 days) (Fig. 2). At the other five stations, the number of cases of abrupt overnight temperature changes ranged between 240 and 277 days, accounting for a little over 1% of the cases.

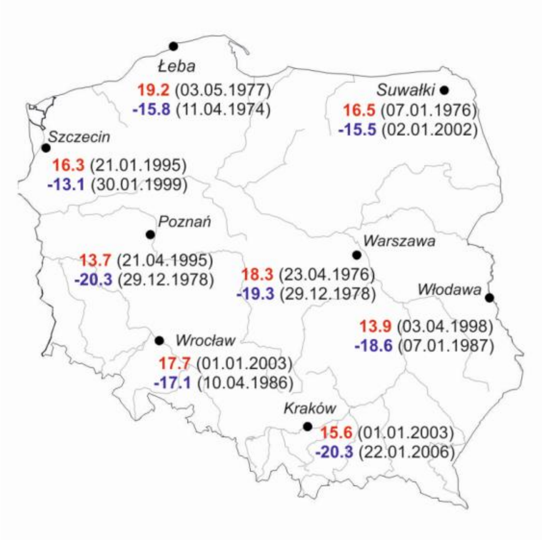

Fig. 1. ***Extreme values of the day-to-day maximum air temperature* [°C] *increases and decreases in a period 1961-2010***

An analysis of the total abrupt temperature changes (including both increases and decreases) in the 50 year-long period has revealed that they were more frequent in the first 25 years than later. The clearest tendency was observed at the station in Krakow.

Between 1961 and 1985 there were 5% more increases and 7% more decreases in temperature values as compared to the subsequent 25 year-long period (Fig. 2).

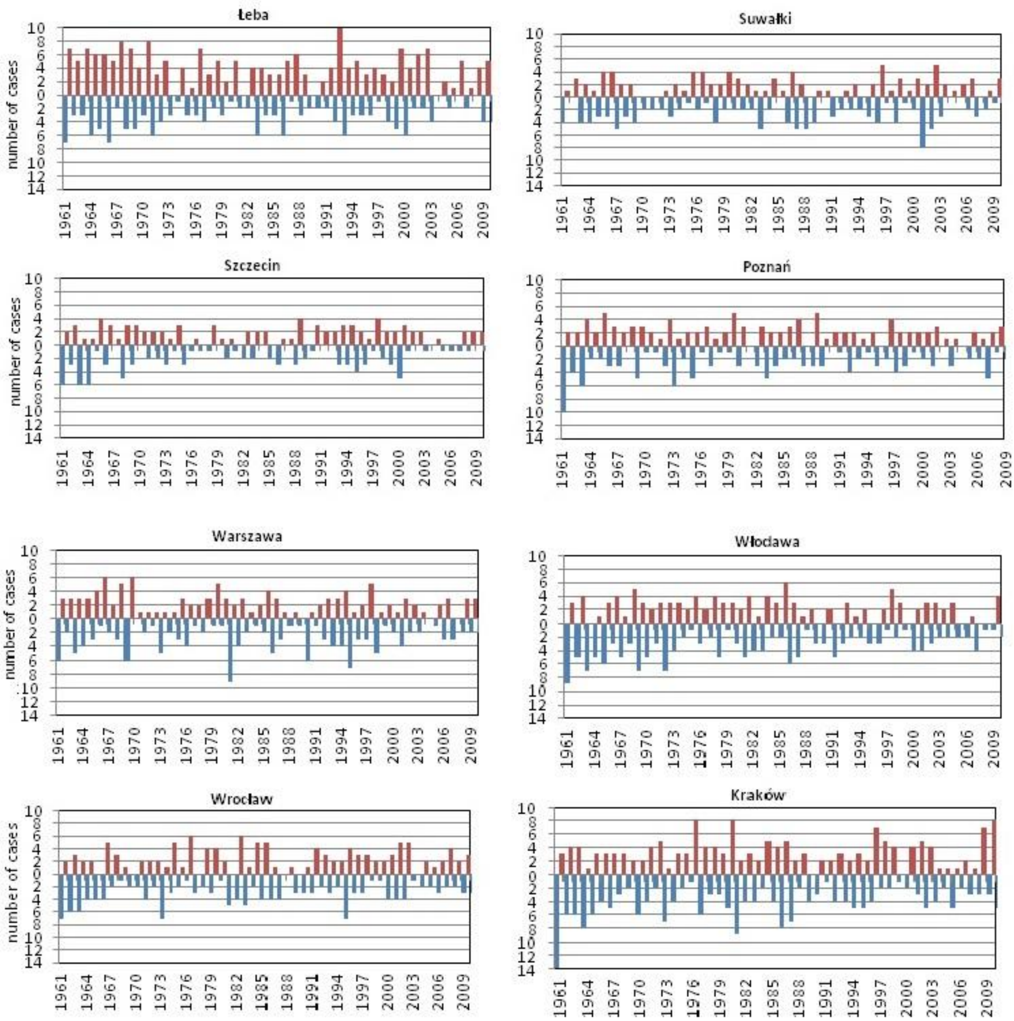

Fig. 2. ***The number of days with rapid change of the maximum air temperature increases ($T_2-T_1 \geq 8.0°C$) and decreases ($T_2-T_1 \leq -8.0°C$) at selected stations in Poland***

4. DISCUSSIONS AND CONCLUSIONS

An analysis of interdiurnal changes in maximum air temperature values indicates their spatial diversity. Poland, with its total surface area of 311,888 km^2, is located in a warm temperate climate zone of a transitional nature. The climate is therefore shaped by air masses originating from various directions, with seasonally-conditioned frequencies. In areas with limited topographic diversity, i.e. in most of the Polish territory, abrupt temperature changes are caused directly by the advection of much cooler air masses (from northerly and easterly directions in winter and spring and from northerly and westerly directions in summer) or warmer ones (from westerly and southerly directions in winter and from southerly and easterly ones in summer) (Kossowska-Cezak 1982). Along the Baltic Sea coast, changes in circulation directions may trigger abrupt temperature swings as a result of air moving in from over warm land or cool sea (or the other way around). Such patterns are mostly typical of late spring and early summer.

An analysis of abrupt interdiurnal changes in maximum temperature (ΔT≥8.0°C) has revealed significant seasonal and spatial differences and confirmed the occurrence of specific patterns. Most day-to-day changes, as well as most abrupt ones (ΔT≥8.0°C), were recorded in spring (April-May). In addition, the greatest frequency of occurrence of abrupt increases and decreases in temperature was observed at the coastal weather station in Łeba. Increases and decreases of |ΔT≥8.0°C| between April and May at this station accounted for one third of all abrupt day-to-day changes during the year.

The extreme values of air temperature increases and decreases in Poland should also be highlighted. They oscillate between 13.7 and 18.3°C, at times also exceeding 20.0°C. The extreme temperature differences were most frequently observed in January and April. In such cases, a significant increase in air temperature may lead to the premature onset of the vegetative period, while another abrupt temperature drop may result in winterkill. This may cause significant losses to farmers and have an impact on the human body.

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