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AIR TEMPERATURE VARIABILITY ON THE SILESIAN LOWLANDS IN THE YEARS 1957-2014

Stanisław Włodek[1], Jakub Sikora[2], Katarzyna Pawęska[3], Andrzej Biskupski[1], Zygmunt Owsiak[3], Juraj Maga[4]

[1]Institute of Soil Science and Plant Cultivation,[2]University of Agriculture in Krakow,
[3]Wrocław University of Environmental and Life Sciences ,[4]Slovak University of Agriculture in Nitra

Abstract

Results of air temperature measurements in the 1957-2014 multi-annual period were analysed in the paper. The data originated from Jelcz-Laskowice locality situated in the south-western part of Poland, at the flat part of the Lower Silesia, on Silesian Lowlands. Average annual and monthly air temperatures and the number of days of thermal seasons duration were analysed. Trends of changes were set and extreme values of average monthly air temperatures were analysed. Mean annual air temperatures in the studied multi-annual period revealed a tendency to increase. Average monthly extreme values of the analysed factor revealed a similar direction of changes; however, more apparent changes occurred for the maximum values. Over the analysed period, average monthly air temperatures revealed a tendency to increase. The most serious changes occurred in July, slightly lesser in August, May and April. The number of days in the years 1957-2014 in the interval limited by the air temperature threshold values: 0°C, 5°C and 15°C was greatly diversified. Analysed results had a clear growing tendency for the summer, slightly lower for the spring, but evidently declining for the autumn.

Keywords: average annual, average monthly air temperatures, number of days, Silesian Lowlands

INTRODUCTION

The weather has a major impact on many areas of economy, including agriculture, particularly crop production. Among the weather elements which characterize atmospheric conditions, the air temperature is of particular importance. The amount of heat reaching the earth surface has a definite influence on the dynamics of biochemical processes, as well as the rate of plant growth and development. A change of climate, in the first place global warming, is apparent not only in the increase in temperature, but it also impacts all elements of coupled systems of climate and water, physical, biological and human resources (Kundzewicz 2011).

METHODS

The paper used the database containing average daily air temperatures for the 1957-2014 multi-annual period from Laskowice Oławskie (51°02'N, 17°20'E, 134 m a.s.l.), from 1976 known as Jelcz-Laskowice (after obtaining municipal rights), which is situated in the flat part of the Lower Silesia region, on Wrocław Lowlands, on the border of Oleśnica Plain and Wrocław Proglacial Stream Valley. The observational material was accumulated for the calendar years using the results of observations conducted in compliance with the methodology obligatory for all IMWM units (Janiszewski 1988). The database provided a basis for graphic presentation of the analysis of changes of average annual, maximum and minimum air temperatures. For individual years of the analysed period (1957-2014), the number of days per year with temperatures within the intervals determined by the threshold temperatures characterizing the seasons of the year were computed. A division of the year into 6 seasons, suggested by E. Romer (1938) for the area of Poland, was applied in the paper: early spring $0°C < t \leq 5°C$, spring $5°C < t \leq 15°C$, summer $t > 15°C$, autumn $5°C < t \leq 15°C$, early winter $0°C < t \leq 5°C$ and winter $t \leq 0°C$. The division was based on the threshold values of mean daily air temperatures: 0 °C, 5 °C, 10 °C and 15°C. The presented temperature threshold values have an influence on plant vegetation. The thermal threshold of 5°C means the start and finish of the vegetation, the next threshold 10°C determines the period of intensive growth, while the subsequent threshold value15°C means the beginning of ripening period. The number of days with average daily air temperature < 0°C was counted separately for the first and second half-year.

A linear trend of changes, its equation and R^2 value were determined for the analysed values of air temperature and the number of days.

RESULTS

Average annual air temperatures in the years 1957-2014 were clearly diversified (Fig. 1). The lowest average value 7.1°C was noted in 1996, whereas the highest 10.1°C was registered thrice, in the years 2000, 2007 and 2014. Presented graphic data revealed a significant, on the 0.05 level, upward linear trend of average annual air temperatures with an increase of 0.178°C per 10 years. A similar direction of changes of average annual air temperatures occurred in the other regions of Poland, as evidenced by the results of meteorological data analysis for the Mazurian Lake District for the period of 1951-1995 (Szwejowski *et al*. 2002), but also results from Dziwnów for the 1956-2009 period (Tylkowski 2013).

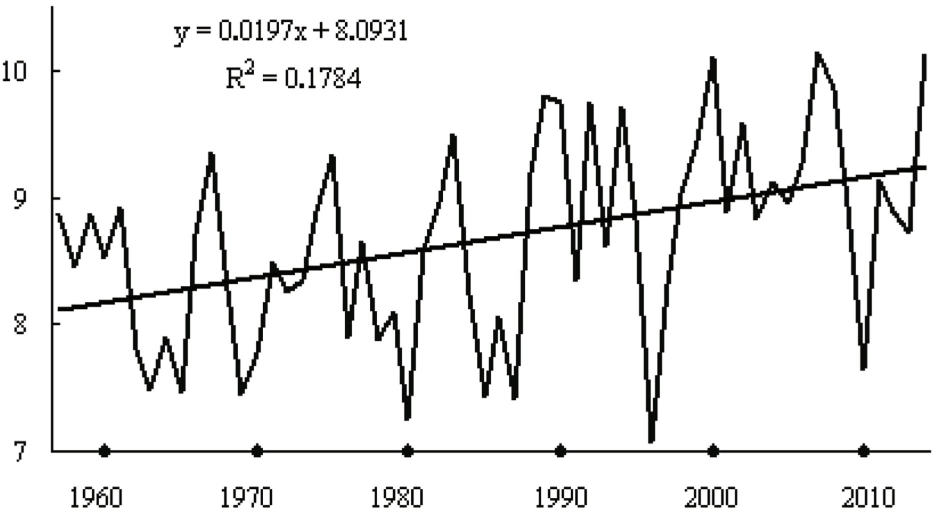

Figure 1. Average annual air temperature (°C) in the years 1957-2014

According to the Intergovernmental Panel on Climate Change (IPCC) (Solomon *et al*. 2007), warming measured by a linear trend over the period of 50 years (from 1956 to 2005) was 0.128°C per decade.

A compilation of the year's lowest monthly averages of the analysed weather element revealed considerable fluctuations (Fig. 2). Limit temperature values fell within the interval from – 9.7°C in the years 1963 and 1987 to 1.9°C in 1989. In these years minimum average monthly temperatures occurred in January. At such vast range an upward trend of changes became visible with a slope of a straight line, approximate to the trend of annual averages change, but it was not significant.

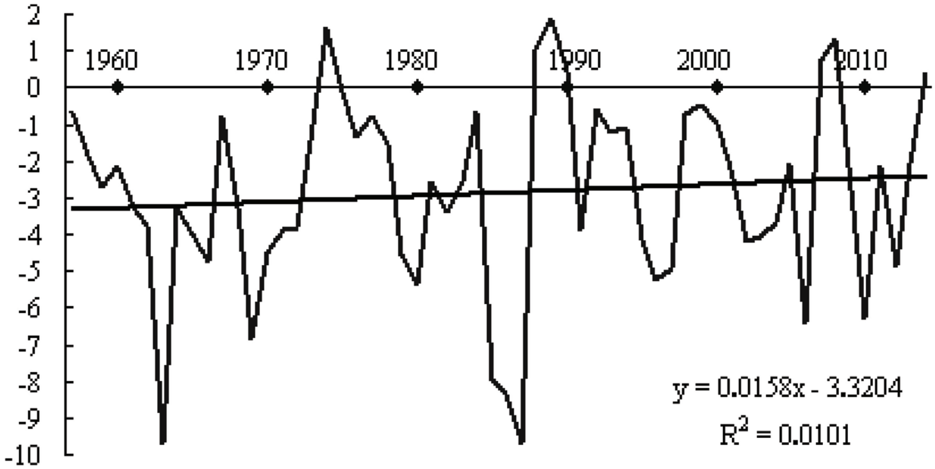

Figure 2. The year's lowest average monthly air temperatures (°C) in the years 1957-2014

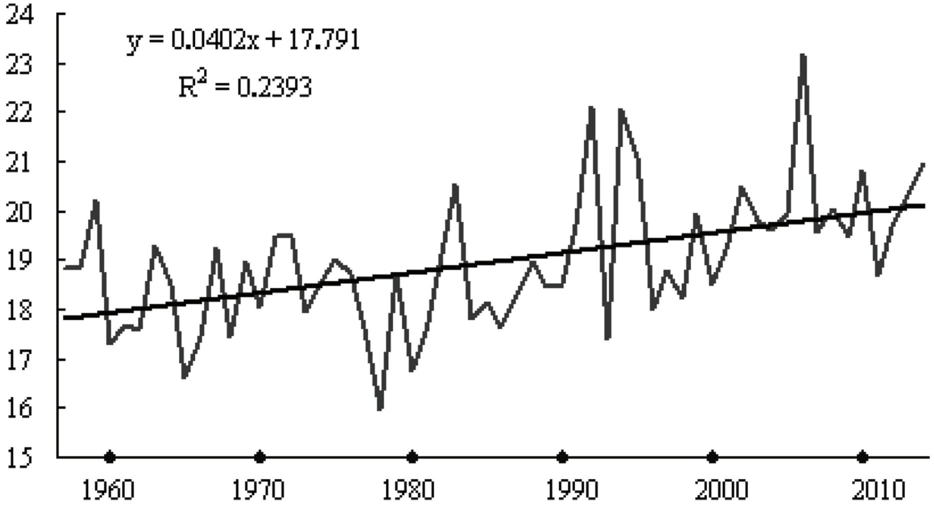

Figure 3. The year's highest average monthly air temperatures (°C) in the years 1957-2014

The year's maximum average monthly temperature values oscillated within a narrower range than the minimum values (Fig. 3). The lowest observed temperature was 16.0°C and was noted in 1978, whereas the highest reached 23.2°C in 2006. In both cases the extreme values occurred in July. Despite a lesser diversification the results formed a significant upward trend. The increase value was twice higher for the annual averages, i.e. 0,402°C in 10 years.

Hansen *et al*. (2010) from GISS NASA also pointed out that the temperature variability in Europe is very strong in the winter months, much stronger than in summer.

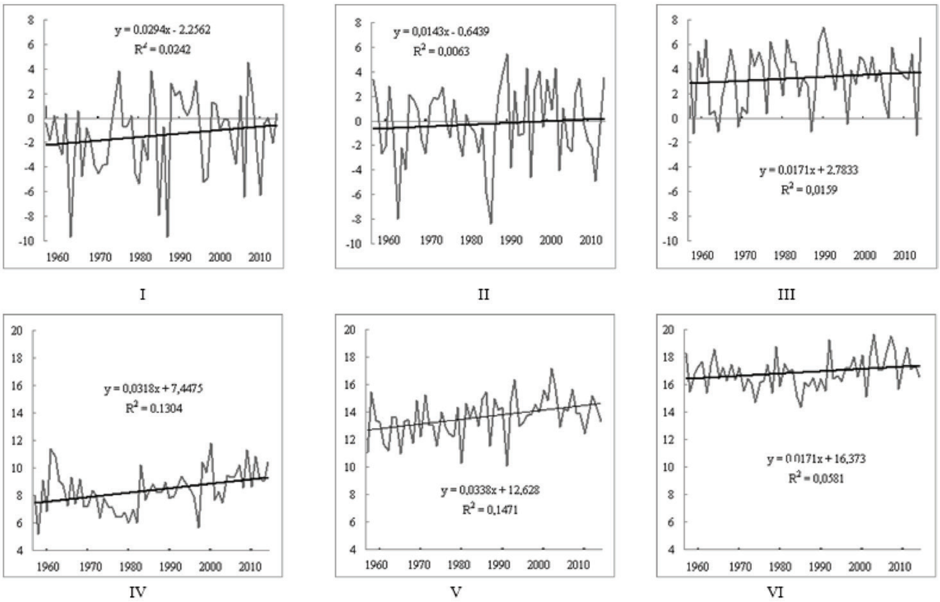

Figure 4. Average monthly air temperatures (°C) from January to June over the years 1957-2014

Regarding the profiles of extreme temperatures, a gradual increase in their values was observed also in the Mazurian Lake District. In this region, however, it was more apparent for the minimum than maximum temperatures (Szwejkowski *et al*. 2002), which is the opposite observation to the one for the Lower Silesia Lowlands. The increase in the air temperature might have been caused by a greater amount of surface waters in the Lake District. At high temperatures water accumulates heat, which lowers the ambient temperature, whereas, while freezing, it returns the heat, therefore contributing to the increase in the air temperature.

Average monthly air temperatures were greatly diversified in the analysed years, particularly in January and February (Fig. 4). In the first month the lowest value was – 9.7°C in 1963 and 1987, whereas the highest 4.5°C in 2007. Slightly lower disproportions occurred in February, when the lowest average was – 8.3°C in 1986 and the highest 5.4°C in 1990. In June the range of changes of average temperatures was from 14.4°C in 1985 to 19.7 in 2003 and was the lowest in the whole year. In all months of the first half-year a growing tendency for changes of monthly averages was marked but only in April and May the increases (0.318 and 0.338°C over 10 years, respectively) were significant on the significance level 0.05.

In months of the second half of the year in the analysed 1957-2014 period, a significantly growing linear trend of average monthly air temperatures occurred in July and August, the increase per decade was 0.428°C and 0.365 (Fig. 5). In the other months no unmistakable tendency of changes occurred. The greatest differences of the analysed results were registered in December: in 1969 the average monthly air temperature was – 6.9°C, while in 1974 it was 3.9°C.

During the year, changes of average daily air temperatures did not always occur in one direction. Usually, threshold values were exceeded several times, which made it difficult to explicitly determinate beginning and end dates of a season of the year. Therefore, the number of days was computed in individual temperature ranges characteristic for an individual season of the year. In case of the temperatures below zero, noted at the turn of calendar years, the computations and analyses were conducted separately for the first and second half-year.

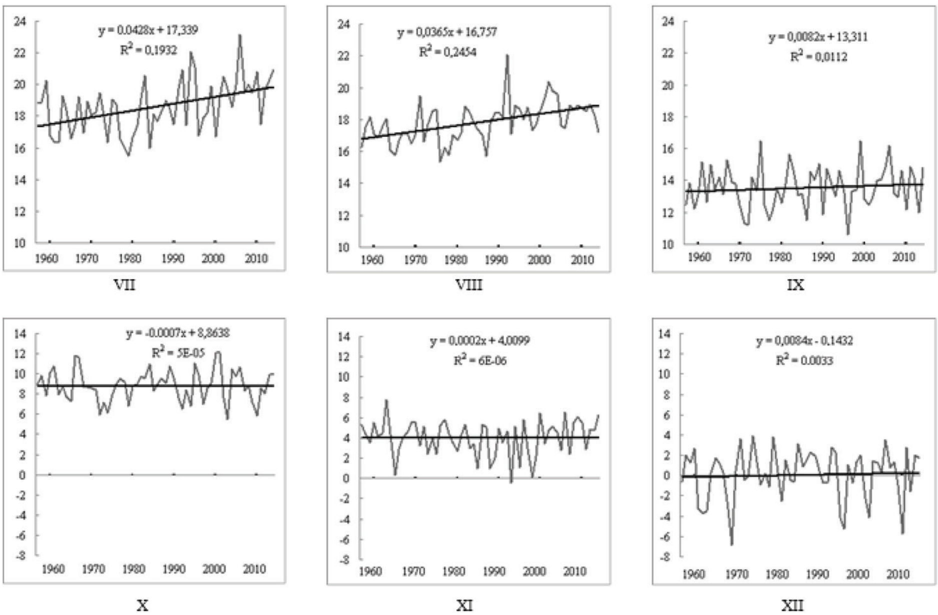

Figure 5. Average monthly air temperatures (°C) from July to December in the years 1957-2014

Concerning the analysed period 1957-2014, the number of days in individual intervals of threshold temperatures was greatly diversified (Fig. 4 and Fig. 5). The greatest disproportions occurred in the number of the thermal winter days in the first half-year of the calendar year. In 1990 only during 8 days the average daily air temperature did not exceed 0°C – the upper limit for the wintertime. The highest number of days with an average daily air temperature not exceeding 0°C was registered in the years 1963 and 2006 – 70 and 71, respectively.

A downward trend of changes in the number of days with average daily air temperature below 0°C became apparent. Samborski and Bednarczuk (2009) observed a similar direction of changes. Slightly lesser differences in the number of days concerning the characteristic temperatures were observed for the spring and autumn. For spring temperatures within the range from 5.1 to 15°C extreme values were registered in 2003 – 41 days and in 1990 – 96 days. The number of days with temperatures within the range of > 15°C, characteristic for the summertime ranged from 60 in 1978 to 126 in 2002. The lowest number of autumn days with air temperature from 5.1 to 15°C was noted in 1975 – only 43, whereas the highest number in 1978 – 104 days. In the air temperatures interval from 0.1 to 5°C, 9 days were noted in 1969, 46 in 1974, 3 days in 2006 and 39 in 1995.

Despite such big disproportions only within two temperature ranges, the linear trend of changes of the number of days was significant on the significance level 0.05. In the range of temperatures over 15°C corresponding to the summertime the trend was upward, whereas for the temperature interval from 5.1 to 15°C, characteristic for the autumn, the trend was downward. In the first half-year a decreasing tendency was observed for the duration of wintertime and early spring, with a growing tendency for the springtime and summertime. In the second half-year, the growing trend of the number of days exceeding the threshold value for summer 15°C changed more apparently than in the first half-year, concurrently a downward trend with a similar slope manifested itself for the number of autumntime days. The number of early winter and winter days, despite a considerable fluctuation over the analysed period, did not reveal any clear direction of changes, as evidenced by a low value of the slope of a straight line.

Nowosad and Filipiuk (1998) obtained approximate results evidencing changes of the duration time of thermal seasons of the year while analysing the data for 1951-1995 characterizing thermal conditions in Lublin, Skower and Kopeć (2008) for the south-eastern regions of Poland, Bartoszek and Cichoń (2008) for the region of Czesławice, and Szyga-Pluta (2011) for the environs of Poznan.

Quite considerable variability of thermal seasons of the year is one of the features of the climate in Poland resulting from combining the maritime and continental climates. The impacts are visible in the changes of beginning and end dates of thermal periods and associated number of days for individual seasons of the year. Observed long-lasting variability may indicate the occurrence of climatic changes.

CONCLUSIONS

Average annual air temperatures in the years 1957-2014 fell within the range from 7.2°C in 1996 to 10.1°C in 2000, 2007 and 2014. The changes revealed a significant growing tendency, the linear trend revealed increase of 0.2°C per 10 years.

The year's lowest average monthly air temperatures fluctuated within a wide range from 9.7°C in 1963 and 1989 to 1.9°C in 1989 and also had a growing tendency, the linear trend was not significant, however.

The year's highest average monthly air temperatures oscillated in a narrower range, from 16.0°C in 1978 to 23.3°C in 2006 and revealed a significant growing tendency. The linear trend was characterized by an increment of 0.4°C per 10 years.

Average monthly air temperatures over the analysed period revealed a growing tendency, for April and May, the linear trend was significant on the significance level 0.05 and the increase was about 0.4°C over 10 years, like for July and August, at the increase about 0.4°C per 10 years.

A significant upward trend became apparent over the analysed 1957-2014 period for the number of days with an average daily air temperature > 15°C, characteristic for the summertime and significantly downward trend for the temperature range from 5.1 to 15°C, characteristic for autumn.

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Corresponding author: Eng. Stanisław Włodek, PhD
Andrzej Biskupski, PhD
Institute of Soil Science and Plant Cultivation,
Department of Tillage Techniques and Fertilisation
ul. Orzechowa 61. 50-540 Wrocław
Phone. (071) 318 15 78 w.13 fax: (071) 318 15 40
e-mail: s.wlodek@iung.wroclaw.pl

Eng. Jakub Sikora, PhD
University of Agriculture in Krakow
Faculty of Production and Power Engineering
Institute of Agricultural Engineering and Computer Science
ul. Balicka 116 b, 30-149 Kraków
phone: +48 12 662 46 60
e-mail: Jakub.Sikora@ur.krakow.pl

Eng. Katarzyna Pawęska, PhD
Wrocław University of Environmental and Life Sciences
Faculty of Environmental Engineering and Geodesy,
Institute of Environmental Engineering,
pl. Grunwaldzki 24, 50-363 Wrocław.

Zygmunt Owsiak
Wrocław University of Environmental and Life Sciences
Faculty of Przyrodniczo-Technologiczny, Instytut Inżynierii Rolniczej,
ul. J. Chełmońskiego 37/41. 51-630 Wrocław

doc. Eng. Juraj Maga, PhD
Slovak University of Agriculture in Nitra
Department of Machines and Production Systems (TF)
e-mail: Juraj.Maga@uniag.sc
phone: 421 37 641 4362

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