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Thermal conditions in Bydgoszcz Region in growing seasons of 2011–2050 in view of expected climate change

Bogdan BĄK [ABCDEF], Leszek ŁABĘDZKI [CDE]

Institute of Technology and Life Sciences, Kujawsko-Pomorski Research Centre in Bydgoszcz, ul. Glinki 60, 85-174 Bydgoszcz, Poland; tel. +48 52 375-01-07, e-mail: b.bak@itp.edu.pl

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Abstract

The paper presents an analyse of the scenario of expected changes in monthly mean air temperature of months in the growing season (April–September) and growing seasons of 2011–2050 in Bydgoszcz Region. Prediction of thermal conditions is made using regional climate model RM5.1 with boundary values taken from global model ARPEGE. When compared with the reference period 1971–2000, an increase of mean air temperature should be expected in most months and growing seasons of the years 2011–2050. The biggest positive change in the mean monthly temperature is predicted for July (1.5°C) and August (1.2°C). In 2011–2050 significant increase trends of air temperature change can be expected in April, June and August. According to the thermal classification proposed by Lorenc, normal, slightly warm and slightly cool months and growing periods will dominate. The frequency of normal and slightly cool growing periods will decrease and the frequency of slightly warm growing periods will increase.

Key words: *air temperature, climate change, thermal classification*

INTRODUCTION

Air temperature is one of the most important meteorological elements which determines distinct natural periods associated with annual cycle of heat input to the Earth's surface [LIMANÓWKA 2010]. Studies on climate change in Poland carried out by ŻMUDZKA [2009] showed that significant warming observed in the years 1951–2000 occurred in spring and was caused by substantial increase of the sum of total irradiation and by an increase of insolation. Positive and statistically significant trends of changes in air temperature occurred in March and May. The last two decades of the 20th century and the beginning of the 21st century when the rate of warming gathered momentum deserve special attention. This was observed not only in winter and spring (January–May) but also in warm seasons. Till the year 2006 the rate of change in the mean annual air temperature increased from 0.018 to 0.020°C per year. Mean air temperatures after the year 1987 (with the exception of 1996) were higher than the long-term mean and most of them, especially in the 1990s, belonged to the highest since the middle of the 20th century.

Average territorial annual temperature in Poland exceeded 9°C four times: in 2000 (9.5°C), 1989 (9.2°C) and in 1990 and 2002 (9.1°C) [ŻMUDZKA 2009]. These were the highest means since the beginning of the 20th century. Studies by SZYMCZAK [2005] on the river outflow in the years 1966–2000 in small lowland catchments of Masovian Province showed decreasing trends of maximum unit outflows in years and in winter half-years. The author showed that observed changes were a result of climate warming, particularly in the wintertime, and of decreasing annual sums of atmospheric precipitation.

In the second half of the 20th century, especially in the 1980s and 1990s, positive temperature trends were also observed in other European countries [CHAOUCHE *et al.* 2010; ESPADAFOR *et al.* 2011; IPCC 2007; KLEIN THANK 2002; MLADENOVA, VARLEV 2007; VERGINI, TODISCO 2011; ZEBISCH *et al.* 2005]. They were particularly visible in the growing season. PRZYBYLAK and MASZEWSKI [2009] are of the opinion that the increased frequency of cyclone circulation in cold seasons (0.6 day·decade^{-1}) and anticyclone circulation in warm seasons are responsible for current climate warming in Poland.

Thermal conditions in Bydgoszcz Region were analysed e.g. by ŁASZYCA and KUŚMIEREK-TOMASZEWSKA [2013]. The authors studied variability of air temperature in the period 1951–2010 in various time intervals based on daily means of air temperature. They found a statistically significant increase of mean annual temperature (0.17°C·decade^{-1}). They also found an increase of mean annual air temperature in the years 1981–2010 compared with the years 1951–1980. An increase of temperature from 8.0 to 8.4°C was an effect of a series of warmer years between 1989 and 2009, particularly of the warmest year 2000 with the mean temperature of 9.9°C. In 1989–2009 mean air temperature was 9.4°C being by 1.2°C higher than the mean 8.2°C from the years 1951–2010. Similar study was performed by ŻARSKI *et al*. [2010], who analysed series of measurements of air temperature from the years 1949–2008. According to these authors, hypotheses on climate warming near Bydgoszcz should be treated with caution due to different equations of linear trends with the domination of insignificant equations and to nonexistent intensification of non-normal or extreme thermal conditions during the last fifteen years of their study.

Most climatic scenarios assume further increase of air temperature in Poland in the next periods of the 21st century [ICM 2013; IMGW 2012; IPCC 2013; LISZEWSKA 2000; 2013; LISZEWSKA *et al.* 2012; SOLOMON *et al*. 2007]. They depend on the assumptions on greenhouse gas emissions, which in turn are related to the socio-economic, demographic and technological development. Predicted increase of temperature will vary globally from 1.5 to 4.5°C and from 2.0 to 6.3°C in Europe from 1990 to 2100 [ZEBISCH *et al.* 2005]. European Union policy on mitigation the effects of global warming predicts undertaking such actions that the increase of temperature would not exceed 2.0°C till the end of 2050.

There is no single proven scenario, you always need to consider a bundle of potential implementations. Despite the constant modification of models and increasingly better parameterization of physical phenomenon, models do not fully describe the climate system and its change. Not accurate knowledge of the physical processes causes that the predictability of climate is still limited, as evidenced by, for example, a significant discrepancy between climate simulation models for different fixed emission scenario [BŁAŻEJCZYK, ŻMUDZKA 2013].

Climate scenarios are made with global climate models (GCM – Global Climate Model/General Circulation Model) or still more often with regional climate models (RCM – Regional Climate Mode*l*). Climate simulations are usually made in spatial resolution of 50 km (climate and air quality) and 25 km [JUDA-REZLER, REIZER 2013].

The effect of predicted climate changes on agrometeorological and soil-water conditions in selected Polish regions, including Bydgoszcz Region, for the years 2021–2050 and 2071–2100 were the subject of studies by ŁABĘDZKI *et al*. [2012; 2013]. According to these authors climate change in the years 2021–2050 will result in diverse changes of agro-meteorological and soil-water conditions. Both conditions will worsen in Bydgoszcz, will improve in Wrocław and in Olsztyn, in Warsaw and Cracow the changes will be insignificant. More unfavourable changes in agrometeorological conditions are expected to come in the years 2071–2100.

ZIERNICKA-WOJTASZEK [2009] is of the opinion that agricultural-climatic regionalization of Poland will be verified in view of current climate changes. Simulations of the increase of air temperature by 1°C in the 21st century compared with the years 1971–2000 indicate a decrease of moderately cool regions from 37% to 3%, an increase of moderately warm regions from 62% to 75% and the appearance of warm regions covering 22% of Poland's area. In the scenario that assumes temperature increase by 2^{o}C the latter would cover 94% of the country area.

The increase of temperature is forecast to be followed by more uneven distribution of atmospheric precipitation, increase of extreme weather phenomena and more frequent sets of rain-free days [ŁABĘDZKI 2009]. One of favourable effects of temperature rising will be the elongation of growing period of crop plants in Poland. According to DRAGAŃSKA *et al.* [2008] the simulated growing period in Wielkopolska in 2050 will start on 4 March and will end on 20 November. It will last 261 days i.e. by 31 days longer than that in the period 1991–2005. The authors predict that the terms of sowing and harvesting and the duration of particular phenological phases of maize grown for grain will change. The increase of temperature will shorten all growth phases of maize with the exception of full maturity interphase which will prolong by 20 days on average. Prospected mean term of sowing was estimated on 1 April and that of harvesting – between 5 and 8 August. The growing period of early varieties of maize will shorten from 149 to 126 days, of medium-early varieties – from 154 to 128 days and of medium-late varieties – from 160 to 129 days on average.

Development of pests and diseases that cause larger and larger crop losses may be another negative effect of temperature increase. In the global scale, these losses are estimated at 10–16%. Scientists estimate the rate of spreading of pests such as insects, viruses, bacteria and viroids in the north and south direction at about 2.7 km·y^{-1} [BEBBER *et al*. 2013].

Most climate change scenarios assume further increase of air temperature in Poland in the next decades of the 21st century. This paper was aimed at analysing thermal change scenario for Bydgoszcz Region and the growing period (April–September) in the years 2011–2050 based on adopted scenarios for climate change in Poland.

MATERIAL AND METHODS

Monthly mean air temperature coming from the A1B climate scenario in the growing periods (April–September) were used in this paper. This scenario for Poland was based on simulations performed for emission scenario SRES (Special Report on Emissions Scenarios) [ŁABĘDZKI *et al.* 2013]. Emission scenario A1B belongs to a family of scenarios A1 and takes into account the equilibrium among various energy sources. Simulations performed for A1B scenario reflect mean changes with respect to extreme scenarios A2 and B1.

Analysis was made based on calculations performed in the Interdisciplinary Centre of Mathematical and Computer Modelling, Warsaw University [ICM 2013] with the use of regional model of climate change for Poland RM5.1 and boundary conditions from the global circulation model ARPEGE. According to LISZEWSKA *et al*. [2012] analysis of changes in temperature can be done for a percentile of 10%, 50% and 90%. 10% percentile indicates the value below which 10% of temperature values fall, 50% percentile is the middle value (median), which divides all possible values for the half, while the 90% percentile cut off 10% of the largest value of the temperature in the period. In this paper adopted for the analysis values of temperature have been computed for the percentile 50%. Reference data for the prediction period were grid values of mean air temperature in months of growing periods (April–September) in the years 1971–2000 while scenario simulations were made for the years 2011–2050. Data pertaining to Bydgoszcz Region were acquired from the network of points of a resolution 0.25° (about 25 km).

Thermal classification of particular months and the whole growing period was elaborated according to classification proposed by LORENC [2000] (Tab. 1). Lorenc's classification was based on multiple standard deviation from the long-term mean air temperature in analysed period. This classification is currently used to assess Warsaw thermal conditions at the Institute of Meteorology and Water Management [IMGW 2013]. The frequency of occurrence of normal, warm and cool months and periods for the years 1971–2010 and 2011–2050 was determined in the study.

There is also a classification elaborated by Miętus [CZERNECKI, MIĘTUS 2011; MIĘTUS *et al*. 2002] in the literature. The authors found that Lorenc's classification has some flaws, especially when distribution of studied characteristics deviate from the normal. They proposed classification based on percentiles of distribution (5, 10, 20, 30, 40, 60, 70, 80, 90 and 95) which belong to the group of positional characteristics. As did Lorenc, they distinguished 11 thermal categories (classes). This classification was used e.g. to assess thermal conditions in the Arctic [PRZYBYLAK, MASZEWSKI 2007], to assess thermal and precipitation conditions near Toruń [USCKA-KOWALKOWSKA, KEJNA 2009] and to assess nephology conditions in Poland in the second half of the 20th century [ŻMUDZKA 2007].

Table. 1. Thermal classification of months, seasons and years

Month, period, year	Criteria
Extremely warm	$T > T_{śr} + 2.5\delta$
Abnormally warm	$T_{śr} + 2.0\delta < T \leq T_{śr} + 2.5\delta$
Very warm	$T_{śr} + 1.5\delta < T \leq T_{śr} + 2\delta$
Warm	$T_{śr} + \delta < T \leq T_{śr} + 1.5\delta$
Slightly warm	$T_{śr} + 0.5\delta < T \leq T_{śr} + \delta$
Normal	$T_{śr} - 0.5\delta < T \leq T_{śr} + 0.5\delta$
Slightly cool	$T_{śr} - \delta < T \leq T_{śr} - 0.5\delta$
Cool	$T_{śr} - 0.5\delta < T \leq T_{śr} - \delta$
Very cool	$T_{śr} - \delta < T \leq T_{śr} - 1.5\delta$
Abnormally cool	$T_{śr} - 1.5\delta < T \leq T_{śr} - 2\delta$
Extremely cool	$T \leq T_{śr} - 2.5\delta$

Explanations: T – air temperature in a given period, $T_{śr}$ – long-term mean temperature in a given period, δ – standard deviation of air temperature in a given period.
Source: elaborated acc. to LORENC [2000].

According to FILIPIUK [2011], when climate elements have probability distribution close to normal, both methods are not mutually exclusive but may complement each other as it happens in classical and position measures in descriptive statistics. Characteristics used in the Lorenc's method (arithmetic mean and standard deviation) are classic measures while percentiles used by MIĘTUS *et al*. [2002] belong to position measures. The authors do not exclude application of the Lorenc's method in classifying thermal conditions, they only say that „…application of the method proposed by the author needs to take precautions and first of all to check the agreement of temperature distribution at a given station with normal distribution in every case".

Statistical significance of linear trends of air temperature in months and growing periods was checked with Student *t*-test at $\alpha = 0.05$.

RESULTS

Statistics of the distribution of mean air temperature in particular months and growing period in the reference period 1971–2000 and in forecasted period 2011–2050 are presented in Table 2.

Results of climate modelling indicate that in Bydgoszcz Region one should expect an increase of the mean air temperature in most months and growing

Table 2. Statistics of the mean air temperatures (°C) in the years 1971–2000 and 2011–2050

Parameter	April	May	June	July	August	September	April–September
1971–2000							
Mean	7.6	13.0	18.2	19.3	19.7	16.5	15.7
Minimum	3.5	9.7	13.7	16.9	15.8	13.8	14.2
Maximum	14.5	17.9	21.9	21.5	23.8	19.5	17.6
Median	7.0	12.9	17.8	19.5	19.8	16.4	15.7
SD	2.5	2.0	2.0	1.2	1.6	1.6	0.8
VC, %	33	15	11	6	8	10	5
2011–2050							
Mean	7.4	13.3	17.2	20.8	20.9	16.8	16.1
Minimum	3.6	8.7	13.5	16.8	17.1	14.1	13.8
Maximum	13.8	19.2	21.5	23.8	24.9	19.3	18.8
Median	7.9	13.0	17.5	20.7	21.3	16.6	16.2
SD	2.2	2.6	2.1	1.7	1.8	1.5	1.2
VC, %	29	20	12	8	8	9	7

Explanations: *SD* – standard deviation, *VC* – variability coefficient.
Source: own study.

periods of the years 2011–2050 compared with the reference period 1971–2000. The highest positive changes of monthly mean temperatures are forecasted for July (1.5°C) and August (1.2°C). In April, mean monthly temperature will be lower by 0.2°C, and in June the cooling will be more remarkable (by 1.0°C) in relation to the last three decades of the 20th century. In summer months (July–September) temperature variability measured with the variability coefficient will not exceed 10% and in spring months (April–May) it will be two to three times higher.

Predicted course of mean temperature in particular months and growing periods of the years 2011–2050 is presented in Figure 1 and trend equations are set up in Table 3. Statistically significant increasing trend of air temperature in April, June, August and in the whole growing period was found. They are equal to 0.5–0.7°C·decade^{-1} in these months and 0.3°C·decade^{-1} in the whole growing season.

Table 3. Equations of the trend of mean air temperature in 2011–2050

Month, period	Trend equation	R^2	Tendency of temperature °C·decade^{-1}
April	$Y = 0.0667x + 6.073$*	0.127	0.7
May	$Y = 0.0098x + 13.129$	0.002	0.0
June	$Y = 0.0536x + 16.086$*	0.092	0.5
June	$Y = –0.004x + 20.863$	0.001	0.0
August	$Y = 0.0685x + 19.519$*	0.193	0.7
September	$Y = -0.0043x + 16.908$	0.001	0.0
April–September	$Y = 0.0317x + 15.430$	0.099	0.3

Explanations: R^2 – determination coefficient, * – statistical significance at $\alpha = 0.05$.
Source: own study.

Predicted distribution of months and growing periods in the year 2011–2050 determined from data forecasted based on thermal classification adopted from LORENC [2000] is presented in Table 4. Distribution of the frequency of particular thermal classes of months and growing periods in the reference and forecasted years is presented in Figure 2.

Table 4. Mean temperature of months and vegetation periods and their thermal classification in 2011–2050

Year	Temperature in month, period: April	May	June	June	August	September	April–September
2011	7.0	11.2	14.6	21.9	19.7	16.9	15.2
2012	4.8	10.5	14.4	21.5	20.0	16.2	14.6
2013	6.7	14.5	18.5	19.8	20.7	17.7	16.3
2014	8.4	12.8	16.1	19.3	17.8	15.2	14.9
2015	4.9	16.9	16.6	21.4	22.3	18.5	16.8
2016	4.8	10.8	17.8	23.6	19.7	16.0	15.4
2017	8.9	15.8	15.2	20.4	22.2	15.9	16.4
2018	6.5	18.7	17.8	21.3	21.0	20.0	17.6
2019	3.2	13.9	18.3	19.7	18.6	17.7	15.2
2020	7.6	12.1	14.6	20.9	17.3	13.1	14.3
2021	5.5	9.3	13.7	17.8	19.6	17.0	13.8
2022	4.9	10.1	15.4	18.4	17.1	18.1	14.0
2023	9.8	14.0	17.7	20.7	21.4	15.6	16.5
2024	10.4	15.6	20.3	22.1	21.8	18.3	18.1
2025	8.6	17.2	16.7	23.0	22.2	16.6	17.4
2026	4.2	12.0	16.2	22.2	22.5	19.1	16.0
2027	9.5	14.3	16.7	20.2	21.8	18.3	16.8
2028	8.5	10.3	16.7	22.9	20.6	15.8	15.8
2029	6.6	15.5	16.2	20.8	21.1	15.3	15.9
2030	8.1	11.6	20.4	19.9	20.7	18.2	16.5
2031	7.8	8.7	13.5	20.2	20.1	15.5	14.3
2032	3.6	13.0	15.5	21.1	20.6	16.5	15.1
2033	13.8	10.8	14.2	19.6	18.3	14.5	15.2
2034	5.8	12.7	21.5	20.7	21.9	18.8	16.9
2035	6.6	14.8	18.8	22.0	20.1	18.9	16.9
2036	5.4	19.2	19.6	23.8	21.8	18.5	18.1
2037	5.9	13.6	21.1	19.3	20.2	17.4	16.3
2038	7.4	12.9	20.0	20.2	20.6	17.0	16.4
2039	8.7	11.9	16.5	19.6	18.8	14.1	14.9
2040	8.8	14.2	19.2	19.8	21.7	15.8	16.6
2041	7.3	16.2	17.4	18.5	24.6	15.9	16.6
2042	8.3	11.2	15.1	22.4	23.4	15.3	16.0
2043	8.9	10.4	17.8	21.1	20.0	15.6	15.6
2044	7.6	10.1	16.5	19.0	22.3	16.5	15.3
2045	7.3	16.8	18.1	21.0	22.6	16.7	17.1
2046	8.0	11.1	18.2	20.4	21.8	16.1	15.9
2047	8.3	15.8	17.5	16.8	19.6	15.1	15.5
2048	12.3	16.0	19.1	23.0	24.4	17.7	18.8
2049	7.7	15.1	18.7	23.7	24.9	19.3	18.2
2050	9.5	11.6	15.3	21.1	21.1	18.2	16.1

extremely warm
abnormally warm
very warm
warm
slightly warm
normal
slightly cool
cool
very cool
abnormally cool
extremely cool

Source: own study.

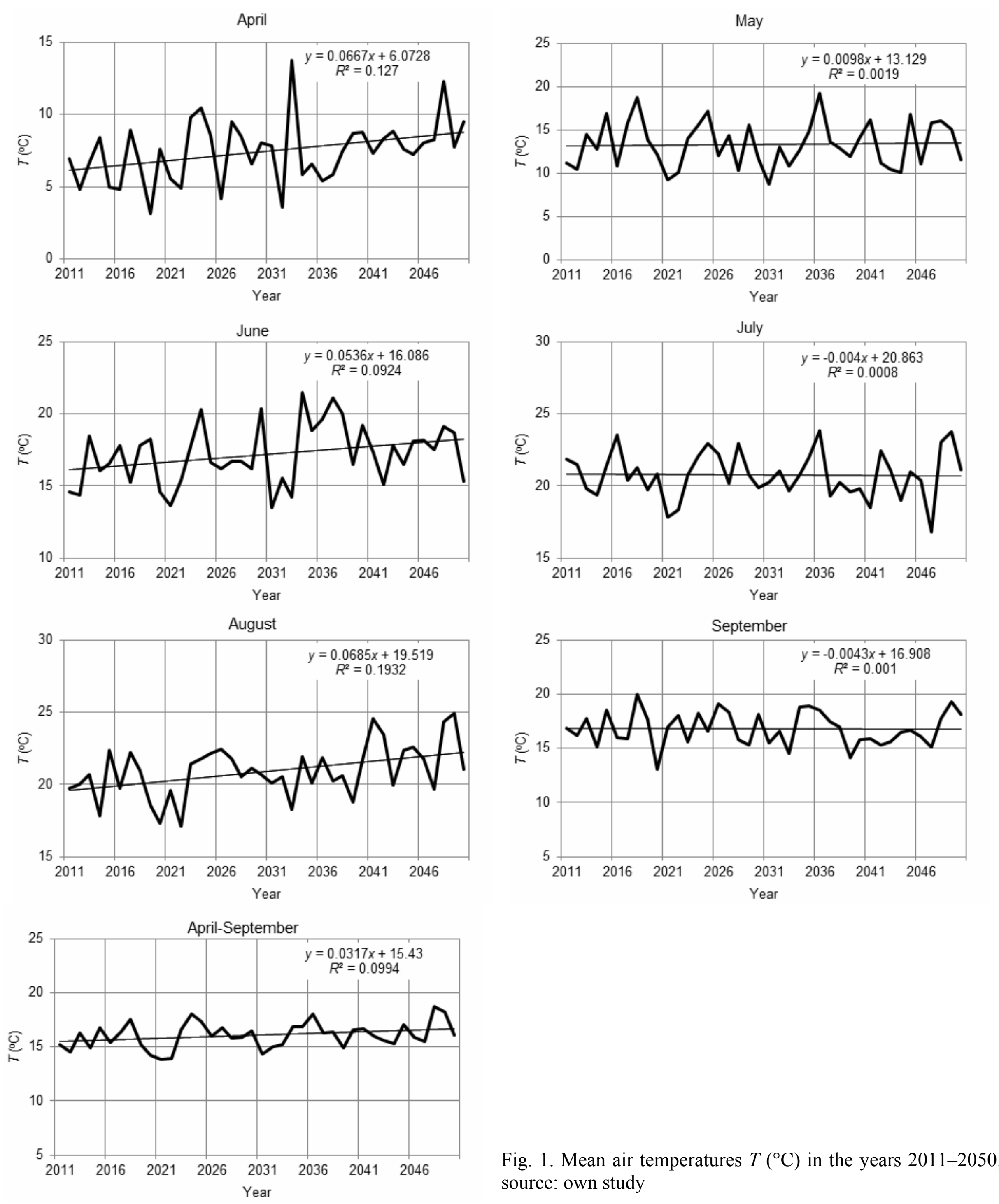

Fig. 1. Mean air temperatures *T* (°C) in the years 2011–2050; source: own study

Normal months will dominate (about 37% of all) in the years 2011–2050. These months will be only by 1% fewer than in the reference period 1971–2000. Next frequent will be slightly cool (18%) and slightly warm (16%) months. The share of both will increase by a little compared with the reference period. Further increase or decrease of temperature in relation to the long-term mean will decrease the share of subsequent thermal periods. According to the forecast, one may expect only one extremely warm month and a lack of extremely cool months.

A decrease is expected in the frequency of growing periods with normal conditions from 33% noted in the years 1971–2000 to 20% in the years 2011–2050. The share of slightly warm periods will increased markedly from 13% to 40% and the frequency of slightly cool periods will decrease from 23% to 5%.

Warmest months in the years 2011–2050 will be: August 2049 (24.9°C) and August 2041 (24.6°C). In the first case the forecast temperature will be by 4°C higher and in the second – by 3.5°C higher than the mean monthly temperature from the years 2011–2050 (20.9°C).

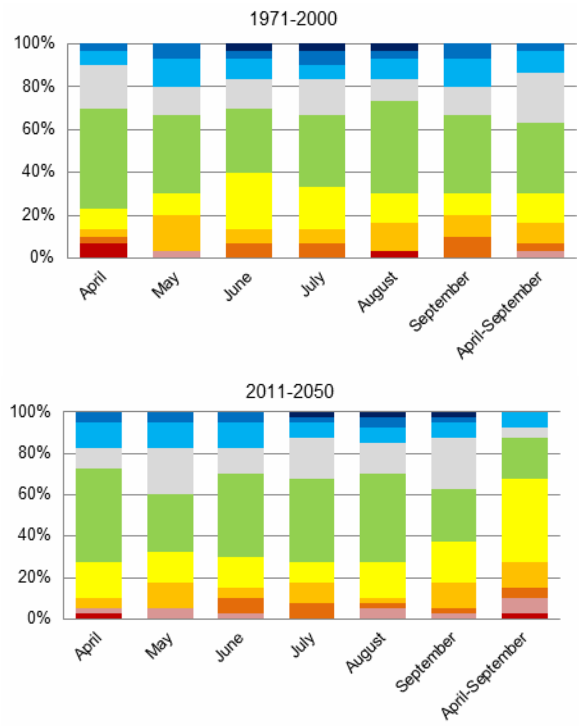

Fig. 2. Frequency of thermal periods in 1971–2000 and 2011–2050; explanations as in Table 4; source: own study

The forecast envisions that April will be the coolest month in the long-term period. In 2019 the predicted mean monthly temperature will be 3.2°C i.e. will be lower by 4.2°C than the long-term mean of 7.4°C. In April 2032 predicted temperature will be 3.6°C.

The longest series of cool weather including cool, very cool, abnormally cool and extremely cool months are predicted for the years: 2014 (June–September), 2021 and 2022 (April–August), 2033 (May–September). The longest and only series of warm months (very warm, abnormally warm and extremely warm) is predicted for the year 2049 (July and September). As for the whole growing periods, a four-year long cooling period is predicted for the years 2019–2022, three-year long one in 2031–2033 seasons and a two-year long period of warming in the years 2048–2049.

Analyses of the course of mean air temperature in months and growing periods divided into 5-year time intervals did not show any regularities in the distribution of cooling and warming periods. In general, one may expect a greater density of coolest 5-year long periods in the years 2011–2020 and warmest periods – after 2025 (Tab. 5).

Table 5. Mean air temperature in 5-year periods

Multi-year period	Temperature (°C) in						
	April	May	June	June	August	Septem-ber	April–Septem-ber
2011–2015	6.4	13.2	16.0	20.8	20.1	16.9	15.6
2016–2020	6.2	14.3	16.7	21.2	19.8	16.5	15.8
2021–2025	7.8	13.2	16.7	20.4	20.4	17.1	16.0
2026–2030	7.4	12.8	17.3	21.2	21.3	17.3	16.2
2031–2035	7.5	12.0	16.7	20.7	20.2	16.9	15.7
2036–2040	7.2	14.4	19.3	20.6	20.6	16.6	16.4
2041–2045	7.9	13.0	17.0	20.4	22.6	16.0	16.1
2046–2050	9.2	13.9	17.8	21.0	22.3	17.3	16.9

Source: own study.

Threshold values of mean air temperature in months and growing periods for particular classes acc. to adopted classification were determined for the reference and forecasted periods. Predicted threshold values for the years 2011–2050 and their changes in comparison with the years 1971–2000 are set up in Table 6. Decrease is marked with ↓ and increase – with ↑. In 21 months the threshold value of thermal class will decrease, in 38 cases it will increase and in 1 month it will not change. Six growing periods will show higher temperature, three – lower temperature and one period will show no changes.

Table 6. Forecasted threshold values of average air temperature (°C) in the years 2011–2050

Thermal classification	Threshold values in period						
	April	May	June	June	August	September	April–September
Extremely warm	≥12.9 ↓	≥19.9 ↑	≥22.3 ↓	≥24.8 ↑	≥25.5 ↑	≥20.7 ↑	≥19.0 ↑
Abnormally warm	11.8 ↓	18.6 ↑	21.3 ↓	24.0 ↑	24.6 ↑	19.9 ↑	18.4 ↑
Very warm	10.7 ↓	17.3 ↑	20.3 ↓	23.2 ↑	23.7 ↑	19.2 ↓	17.8 ↑
Warm	9.6 ↓	16.0 ↑	19.2 ↓	22.4 ↑	22.7 ↑	18.4 ↑	17.3 ↑
Slightly warm	8.5 ↓	14.7 ↑	18.2 ↓	21.6 ↑	21.8 ↑	17.6 ↑	16.7 ↑
Normal	6.3 ↓	12.0	16.2 ↓	20.0 ↑	20.0 ↑	16.0 ↑	15.5 ↑
Slightly cool	5.3 ↑	10.7 ↓	15.1 ↓	19.2 ↑	19.1 ↑	15.3 ↓	14.9
Cool	4.2 ↑	9.4 ↓	14.1 ↓	18.4 ↑	18.2 ↑	14.5 ↑	14.3 ↓
Very cool	3.1 ↑	8.0 ↓	13.1 ↓	17.5 ↑	17.3 ↑	13.7 ↑	13.7 ↓
Abnormally cool	2.0 ↑	6.7 ↓	12.0 ↓	16.7 ↑	16.4 ↓	12.9 ↑	13.1 ↓
Extremely cool	≤2.0	≤6.7	≤12.0	≤16.7	≤16.4	≤12.9	≤13.1

Explanations: ↓– decrease, ↑ – increase compared with the reference period 1971–2000.
Source: own study.

SUMMARY

In most months and growing periods of the years 2011–2050 one should expect higher mean air temperatures than in the reference period 1971–2000. The highest increase will occur in July (by 1.5°C) and in August (by 1.2°C). Significant increasing trends of temperature changes in the forecasted period will take place in April, June and August. The highest increase of temperature is estimated at 0.7°C·decade^{-1} (in April and August). For other months the trends are insignificant and usually equal zero. Insignificant rising trend of 0.3°C·decade^{-1} is predicted for growing periods.

In total, normal, slightly warm and slightly cool months will constitute 73% of all months in the study period. Extremely warm and abnormally cool months and growing periods will be least frequent. Extremely cool months and growing periods are not expected. One may expect a greater concentration of coolest years in the period 2011–2020 and the warmest ones – after 2025.

Estimating further trends in a perspective of few decades is of key importance for the creation of programmes adapting various sectors of economy and public life to climate changes [BĄK *et al*. 2012; NIERÓBCA *et al*. 2009]. In agriculture, the adaptation may consist in increasing available water resources and their rational use, applying soil cultivation technologies to increase water retention or introducing plant varieties more resistant to water deficits. Obtained results may also serve as a support for the long-term development strategy of Kujawsko-Pomorskie Province [Strategia… 2013]. The forecast may be an indication for relevant services to be prepared for periodical unfavourable thermal conditions, excess or deficit of atmospheric precipitation and associated problems for regional economy and human welfare.

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Warunki termiczne w rejonie Bydgoszczy w okresie wegetacyjnym w latach 2011–2050 w świetle przewidywanej zmiany klimatu

STRESZCZENIE

Słowa kluczowe: *klasyfikacja termiczna temperatury, temperatura powietrza, zmiana klimatu*

W pracy przedstawiono analizę scenariusza prognozowanych zmian średniej temperatury powietrza w rejonie Bydgoszczy w miesiącach okresu wegetacyjnego (kwiecień–wrzesień) i okresów wegetacyjnych w wieloleciu 2011–2050. Prognozę wykonano na podstawie wyników obliczeń przeprowadzonych z użyciem regionalnego modelu zmian klimatu dla Polski RM5.1 z warunkami brzegowymi z modelu globalnego

ARPEGE. Danymi referencyjnymi w stosunku do okresu prognozowanego były gridowane wartości średniej temperatury powietrza w miesiącach okresu wegetacyjnego w wieloleciu 1971–2000. W wieloleciu 2011–2050 należy oczekiwać wzrostu średniej temperatury powietrza w większości miesięcy i w okresach wegetacyjnych w stosunku do wielolecia referencyjnego 1971–2000. Największe dodatnie zmiany średniej miesięcznej temperatury prognozowane są w lipcu (1,5°C) i sierpniu (1,2°C). W prognozowanym wieloleciu 2011–2050 istotne wzrostowe trendy zmian temperatury wystąpią w kwietniu, czerwcu oraz w sierpniu. Według klasyfikacji termicznej Lorenc, w prognozowanym wieloleciu będą dominować miesiące i okresy wegetacyjne określane jako normalne oraz okresy lekko ciepłe i lekko chłodne. Zmniejszy się częstotliwość okresów wegetacyjnych z warunkami normalnymi i lekko chłodnych, a zwiększy się znacząco udział okresów lekko ciepłych.