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Variability of climatic norms during instrumental observations in the Kuzbass Botanical Garden

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Abstract. In the work, based on a number of observations at station 29645 Kemerovo for the period from 1955 to 2023, the long-term variability of air temperature was investigated. For the first time for the Kuzbass Botanical Garden, climatic norms for the period 1991-2020 were estimated, using linear trend analysis, the rates of change in climatic indicators were estimated. It has been established that climatic indicator on the territory of the Kuzbass Botanical Garden for the period from 1955 to 2023. have an upward trend. However, the temperature growth rates are slightly higher than those noted for Western Siberia. It has been shown that the climatic standards of air temperature in the modern period differ significantly from the base period of 1961-1990 proposed by WMO.

1 Introduction

Climate change is one of the most important international issues of the 21st century, which goes beyond scientific discussions and is a comprehensive interdisciplinary field of knowledge covering the environmental, economic and social aspects of sustainable development. Climate changes are diverse and manifest themselves, in particular, in changes in the level of the oceans, the areas of distribution of glaciers and permafrost, the flow regime of rivers, the increase in uneven precipitation, and changes in the frequency and intensity of extreme weather events [5, 6, 7, 8].

Expected climate changes will inevitably affect people's lives, wildlife and flora in all regions of the planet, and in some of them will become a tangible threat to human well-being and sustainable development [3].

With climate change, there is also an increasing need for reliable information on climate change at the global, national, regional and subregional levels, its analysis, activities, recommendations and assessment of risks to the natural environment and socio-economic spheres. The current trend of global climate warming is becoming a significant environmental factor, the impact of which has unpredictable consequences on both natural and economic facilities. The global climate is seen as a system of local climates, which are a major cause of the diversity of natural conditions and landscapes.

One of the main complex indicators of the state of the climate is the long-term air temperature regime, which significantly affects biota and all aspects of human activity. To study it, it is necessary to have long time series of atmospheric parameters at its various

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levels, in which case the most acceptable information for forecasting meteorological elements for long periods is climatic indicators of air temperature obtained by processing a set of data for a certain period of time and studying their internal structure.

The purpose of this study is to identify and study the regional features of changes in norms, including those newly calculated for the period 1991-2020, the main climatic parameters at station 29645 Kemerovo in recent decades.

The following tasks were set:

1. identify open sources of meteorological data, create a temporary database of meteorological parameters for the Kuzbass Botanical Garden;

2. analyze the dynamics of meteorological parameters.

The object of the study is the thermal regime on the territory of the Kuzbass Botanical Garden in the surface layer of the atmosphere.

The subject of the study is climatic indicators of the temperature regime (average annual temperatures).

According to the modern definition, "climate" is a generalization of weather changes, which is represented by a set of parameters characteristic of a certain territory at a given time interval. The following statistical characteristics are used to characterize the climate: averages, extremes, indicators of variability and the frequency of events over a period of at least 30 years. On the recommendation of the WMO, the period from 1961 to 1990 (climate norm) is recommended as the standard 30th anniversary for assessing the variability of the modern climate.

For the purposes of climate monitoring and operational assessment of current weather anomalies, it is recommended to use climatological standard norms, which should be updated every ten years [9, 10, 11]. At VNIIGMI-MCD, on the instructions of Roshydromet, the norms of the main climatic parameters (air temperature, precipitation, water vapor elasticity, atmospheric pressure at sea level, etc.) in Russia were calculated over three 30-year periods with a step of 10 years: 1961-1990, 1971-2000 and 1981-2010.

The seventeenth World Meteorological Congress (Kg-17) in 2015, in resolution 16 (Kg-17), "Report of the sixteenth session of the Commission on Climate Science," decided to improve the definition of the climatological standard norm. The climatological standard norm is now designated as the last 30-year period, which ends with a year ending with zero (1981-2010, 1991-2020, etc.) [9,10].

The study analyzed data from long-term observations at the meteorological station 29645 Kemerovo, agro (New Building) in the period 1955-2023. In addition, data from the daily resolution from the VNIIGMI-MCD archive were used [4].

2 Material and methods

In this work, based on a long series of observations, the long-term variability of air temperature was studied, the average climatic values of the main meteorological indicators for 30 years from the beginning of observations to the present with an overlap of 10 years were calculated and the corresponding trend lines were built.

To analyze the temporal variability of climatic quantities, their basic characteristics were calculated using the Excel software package: average (climatic norms).

Regional climate change in the region was estimated using trend analysis and correlation analysis. The linear trend equation is:

$$ym=am+b \quad (1)$$

where ym is the averaged value of the value over time (from 20 to 30 years), am is the slope of the trend line (KNLT), which characterizes the rate of change of the value, b is the free term (the initial value of the trend line). A positive value of the coefficient am indicating an increase (increase) of the value, a negative value indicates its decrease (decrease). The

value of the coefficient of determination R2 was used to estimate the contribution of the linear trend to the overall variability of the indicator. The trend in the 68-year period was considered statistically significant at the 95% confidence level if the R2 value is > 0.08 [1].

The most important component for understanding the modern global climate is the study of regional changes in air temperature. Fig. 1 shows the long-term course of the average annual air temperature.

Place the figure as close as possible after the point where it is first referenced in the text. If there is a large number of figures and tables, it might be necessary to place some before their text citation.

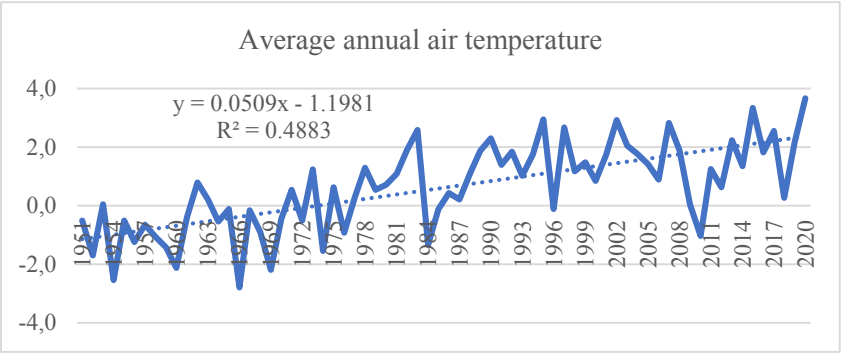

Fig. 1. Dynamics of the average annual air temperature at station 29645 Kemerovo.

To characterize the intensity of changes in average air temperatures using linear trend analysis, linear trend coefficients were calculated, b (° C/10 years) for different periods (Table The periods are "rolling" 30-year periods relative to the period 1961-1990, adopted by the World Meteorological Organization as the basis for calculating "climatological norms" [8, 9].

3 Results and discussion

The average annual temperature growth rate for the period 1976-2023. according to weather station 29645 Kemerovo is 0.32 ° C/10 years, which is slightly lower than the temperature growth rate for Western Siberia of 0.43 ° C/10 years [2].

The dynamics of climatic norms of the average annual air temperature presented in the figure and table shows that they also consistently grow throughout the entire period under study and reach their greatest values in the first decades of the 21st century. Positive values of the norm are reached only in 1961-1990, and the average long-term air temperature for the period under review is positive and amounts to 0.50°C.

The new standard annual air temperature norm exceeded the previous ones and amounted to 1.6 ° C, which is 0.2 ° C lower compared to the long-term average 2001-2023 and 1.4 ° C higher than the standard annual air temperature norm for the standard 30th anniversary of 1961-1990. It should be noted that during the entire period under review there is a gradual increase in the annual air temperature. However, the growth rate for the individual periods is not the same. The highest rates of temperature growth are characteristic of the period from 1951 to 2000, which reached 0.72-0.56 ° C/10 years. In the last decades of the twentieth century, in the dynamics of annual air temperature, there was a distinct slowdown in growth rates, which began to increase again, although not so significantly in the first decades of the

21st century (Table), the average annual air temperatures were the highest during this period and further growth rates decreased, and in 2001-2023. again, increased to 0.30 ° C/10 years.

In general, the variability of annual air temperature norms is characterized by steady growth with unstable speeds in certain segments of the study period.

Table 1. Linear trend estimates of average annual surface air temperature.

Time period	Average annual surface air temperature		Equation parameters, indicators		
	Average annual temperature for the period, ° C	% of the norm 1991-2020	b, °C/10 years	t_o	R^2
1951-1980	-0.5	31	0.56	-1.4	0.21
1961-1990	0.2	12	0.72	-0.9	0.26
1971-2000	0.9	57	0.6	0	0.22
1981-2010	1.3	82	0.11	1.1	0.01
1991-2020	1.6	100	0.13	1.4	0.01
2001-2023	1.8	109	0.3	1.4	0.03
1951-2023	0.7	42	0.5	-1.2	0.51

4 Conclusion

Thus, in the course of the work performed for various time periods (1951-1980, 1961-1990, 1971-2000, 1981-2010, 1991-2020, 2001-2023 and 1951-2023), the values of the average annual air temperatures for the territory of the Kuzbass Botanical Garden were determined.

For the Kuzbass Botanical Garden, climatic standards for the period 1991-2020 were estimated, which are currently: 1.6 ° C; using linear trend analysis, the rate of change in climatic indicators was estimated: the annual temperature changes at a rate of 0.13 ° C/10 years. It should be noted that over the past two decades, the average annual temperature has increased by 0.20 ° C, and its rate of change has increased significantly and reached 0.30 ° C/10 years, which indicates a continuing increase in the rate of climate warming at the Kuzbass Botanical Garden.

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