Variability of climatic norms of annual precipitation in the Kuzbass botanical garden

Rashit Sheremetov*

Department "Kuzbass Botanical Garden", Federal State Budget Scientific Institution «The Federal Research Center of Coal and Coal Chemistry of Siberian Branch of the Russian Academy of Sciences», 650065, Leningradsky av., 10, Kemerovo, Russia

Abstract. In the work, based on a number of observations at station 29645 Kemerovo for the period from 1951 to 2023, the long-term variability of air temperature and precipitation 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 1951-2023. have an upward trend. However, the temperature growth rates are slightly lower than those noted for Western Siberia. Annual precipitation is characterized by stable growth throughout the study period. However, there is some instability of this trend. It has been shown that the climatic standards of air temperature and precipitation in the modern period differ significantly from the base period of 1961-1990 proposed by the 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

*Corresponding author: rashit-sheremetov@rambler.ru .

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.

Comprehensive indicators of the state of the climate are long-term regimes of the main climatic indicators: air temperature and precipitation, which significantly affect biota and all aspects of human activity. To study them, it is necessary to have long time series of atmospheric parameters at its various levels, in which case the most acceptable information for predicting meteorological elements for long periods of time is climatic indicators of air temperature and precipitation obtained by processing many 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 annual precipitation amounts for the Kuzbass Botanical Garden;
2. analyze the dynamics of annual precipitation amounts.

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 object of the study is the long-term course of annual amounts of atmospheric precipitation on the territory of the Kuzbass Botanical Garden in the surface layer of the atmosphere.

2 Material and methods

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 WMO, it is recommended to use the period from 1961 to 1990 (climate norm) as a camp of the - dart 30th anniversary to assess the variability of the modern climate.

The climatic norm is understood as one or another characteristic of the climate, statistically obtained from a long-term series, most often the average long-term value. According to the WMO regulations (Guidelines..., 2017), the averaging period for obtaining norms should be 30 years, although objective data omissions of up to 20% are ¬ allowed. By decision of the 16th Session of the Commission on Climate Science, WMO was recommended to use the period 1961-1990. as a stable base period for WMO, and for these purposes, the norms are recalculated for non-overlapping 30-year periods.

For the purposes of climate monitoring and operational assessment of anomalies of current weather, it is recommended to use climatological standard norms, which should be updated every ten years (Commission for Climatology..., 2014). 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].

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:

$$y_m = a_m + b \quad (1)$$

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].

3 Results and discussion

Analysis of the dynamics of annual precipitation over 30 years and the construction of a trend line (Fig.1) indicate, in general, an increase in the annual precipitation at station 29645 Kemerovo. However, it should be noted some instability of this trend, characterized by a consistent alternation of climatic norms of precipitation from one 30th anniversary to another.

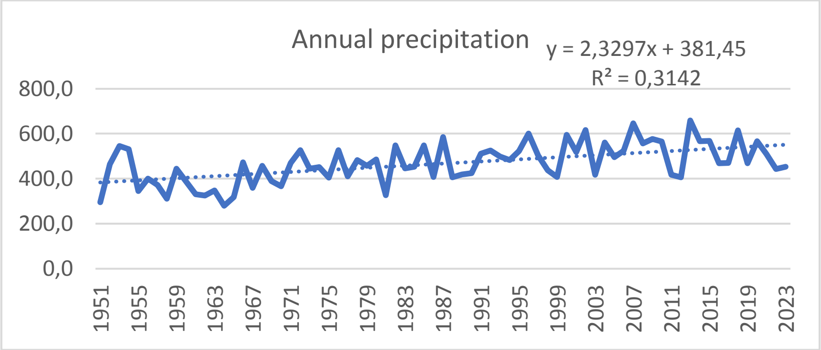

Fig. 1. Dynamics of the annual rainfall at station 29645 Kemerovo.

When analyzing precipitation dynamics data (Fig. 1 and Table 1), it should be taken into account that for the period 1951–1965. the databases contain direct observation data, and since 1966 – observation data, taking into account wetting corrections [1].

Table 1. Estimates of the linear trend of average annual surface air temperature and annual precipitation

Time period	Annual precipitation, mm	% of 1991-2020 norm	Equation parameters, indicators		
			b, mm/10 years	to, mm	R^2
1951-1980	372	73	26	372	0.09
1961-1990	360	71	44	360	0.26
1971-2000	449	88	18	449	0.06
1981-2010	438	86	43	438	0.24
1991-2020	510	100	10	510	0.02
2001-2023	552	108	-22	552	0.04
1951-2023	468	92	23	381	0.31

It is known that from 1936 to 1949 the amount of annual precipitation (at neighboring stations) was unstable and ranged from 431 mm (1943) to 667 mm (1949). This is followed by a marked decline until 1964, after which a steady increase in annual precipitation amounts until 2013 begins, and then a new decline that continues to date.

The variability of annual precipitation for the period from 1951 to 2023 was reflected in the value of precipitation rates (Table 1). This can partially explain the higher values before 1966, in the period 1964-2000. there is a slow increase in precipitation, however, within periods, due to significant differences in individual years, the growth rate (coefficient b) varies from 10 to 44 mm/10 years, and at the beginning of the twentieth century - up to -85 mm/10 years, which does not coincide with the corresponding data for the Siberian region (Report on climate features., 2023).

4 Conclusion

Thus, in the course of the work performed for various time periods (1951–1980, 1961–1990, 1971–2000, 1981–2010, 1991–2020 and 2001–2023), the values of the amount of annual precipitation for the territory of the Kuzbass Botanical Garden at meteorological station 29645 Kemerovo were determined.

For the first time for the Kuzbass Botanical Garden, climatic standards for the period 1991-2020 were estimated, which are currently: 510 mm; using a linear trend analysis, the rates of change in cli mathematical indicators were estimated: annual precipitation amounts - at a rate of 10 mm/10 years.

It has been established that the climatic indicators of the Kuzbass Botanical Garden for the period 1951-2023. have an upward trend and correspond to those for Russia and, in particular, Western Siberia (Report on climate features., 2023). However, the temperature growth rates are slightly lower than the 0.43 ° C/10 years noted for Western Siberia.

In general, the variability of the annual rainfall at station 29645 Kemerovo for the period from 1951 to 2023 is characterized by an increase in the annual rainfall. However, it should be noted some instability of this trend from one 30th anniversary to another. In the last decade (2013–2023), there has been a noticeable decrease in annual precipitation at a rate of 136.11 mm per decade, which must be taken into account when conducting an introduction experiment, since changes in the long-term course of precipitation inevitably affect the ecological regime of moisture in the Kuzbass Botanical Garden.

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