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Climate Change As A Possible Influence On Genetic Diversity Of Plants And Animals.

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ABSTRACT

The article examines the issues of climate change on the territory of the Republic of Tatarstan in the 1977–2017 timeframe. The tendency to an increase in the average annual air temperature, water vapor pressure, the number of days with precipitation greater than 1 mm, the total amounts of adjusted liquid, mixed and solid precipitation, the average annual snow depth and the tendency to a decrease in atmospheric pressure at the level of weather stations was established. A very high correlation relationship was found between the number of days with precipitation greater than 1 mm and the total amount of adjusted precipitation (r=0.95); a high relationship between the average annual air temperature and the water vapor pressure, the number of days with precipitation greater than 1 mm and the total amount of adjusted liquid precipitation, the total amount of adjusted precipitation and the total amount of adjusted liquid precipitation (r=0.75, r=0.83 and r=0.88, respectively); a noticeable relationship between the water vapor pressure and the number of days with precipitation greater than 1 mm, as well as the total amount of adjusted liquid precipitation (r=0.50 and r=0.52, respectively), between the average annual snow depth and the total amount of adjusted precipitation and the total amount of adjusted solid precipitation (r=0.51 and r=0.58, respectively), between the total amount of adjusted precipitation and the total amount of adjusted solid precipitation (r=0.56). A noticeable negative relationship was identified between the average annual atmospheric pressure at the station level and the number of days with precipitation greater than 1 mm and (r = -0.61) and the total amount of adjusted precipitation (r = -0.57). This research was supported by FASO Russia project AAAA-A18-118031390148-1.

Keywords: weather stations, climate, changes, correlation

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INTRODUCTION

It is now established that the global climate of the Earth over the past 500 thousand years included a combination of the main cycle lasting 100 thousand years, which included periods of ice ages, with shorter interglacial periods lasting about 10 thousand years [1].

In general, climate change is formed under the influence of many factors, some of which are determined by the global dependence of the state of the atmosphere on the Earth's seasonal position relative to the main source of energy – the Sun. In addition, climate change is influenced by the state of the energy balance between the Earth and the World ocean, the state of the energy balance between short-wave radiation coming from the Sun and long-wave radiation emitted by the Earth. A significant role in climate change is assigned to the processes occurring in the depths of the Earth and at the bottom of the oceans, as well as to the little studied effects of interplanetary interactions and fluctuations in the positions of the magnetic and geographical poles of the Earth [2].

Most scientists (N.K. Kononova, L.M. Aksimov, T.N. Zadorozhnaya et al.) believe that global warming will continue in the foreseeable future, primarily due to the influence of anthropogenic factors [3].

The processes of global warming at the Earth's surface occurring in the climate system have a significant impact on various sectors of the economy and on many spheres of social life. A comprehensive study of large-scale changes in all components of the climate system of the atmosphere and the Earth's surface is necessary to correctly represent the climate change trend. The technogenic load on the components of the biosphere leads to noticeable changes in the parameters that make up the entire climate [4].

In response to global warming, many plant and animal organisms have significantly changed important aspects of their lives, such as blossoming and reproduction [5, 6, 7].

The ambient temperature has a direct impact on the phenological phases of plant development throughout the vegetation period. However, the mechanisms by which this influence is exercised are not fully understood, despite a long history of observations. In general, climate change can affect the genetic diversity of plants and animals [8, 9, 10].

Analysing various scientific results of research, it should be noted that during the historical era there has been no climate change towards a progressive decrease in the amount of precipitation. It has been established that the climate has either remained constant for all time, or even some tendency is noted towards greater humidity [11].

Climate change in the Russian Federation has both negative and positive socio-economic consequences. Negative consequences include the destruction and reduction of the reliability of the infrastructure built in the permafrost zone, distribution of new infectious diseases, agricultural pests and parasites towards the North, excessive loads on ecosystems. Positive effects include a favourable impact on the yield of some crops, improving the situation with water resources, lengthening the navigation season in the Northern Sea Route. The observed downward trend in the heating season increases the thermal efficiency of existing buildings and creates conditions for reducing energy consumption, although additional energy resources may be required for air conditioning. Regional differences are very large, especially with regard to dangerous weather events [12].

MATERIALS AND METHODS

For the analysis, data arrays of average monthly air temperature [13], average monthly water vapor partial pressure [14], average monthly air pressure [15], number of days with precipitation greater than 1 mm [16], monthly precipitation totals [17] and snow cover characteristics [18] at weather stations of the Republic of Tatarstan were used: No. 27595, No. 28506, No. 28704 (Fig. 1).

The coordinates of the weather station No. 27595: 55.80 North latitude, 49.30 East longitude; the coordinates of the weather station № 28506: 55.80 North latitude, 52.10 East longitude; the coordinates of the weather station No. 28704: 54.50 North latitude, 50.40 East longitude.

The analysis was carried out for the period from 1977 to 2017. The analysis of the data arrays and construction of diagrams, the calculation of the correlation coefficients were performed using Microsoft Excel. Research performed at the Tatar Scientific Research Institute of Agriculture, FRC Kazan Scientific Center, Russian Academy of Sciences.

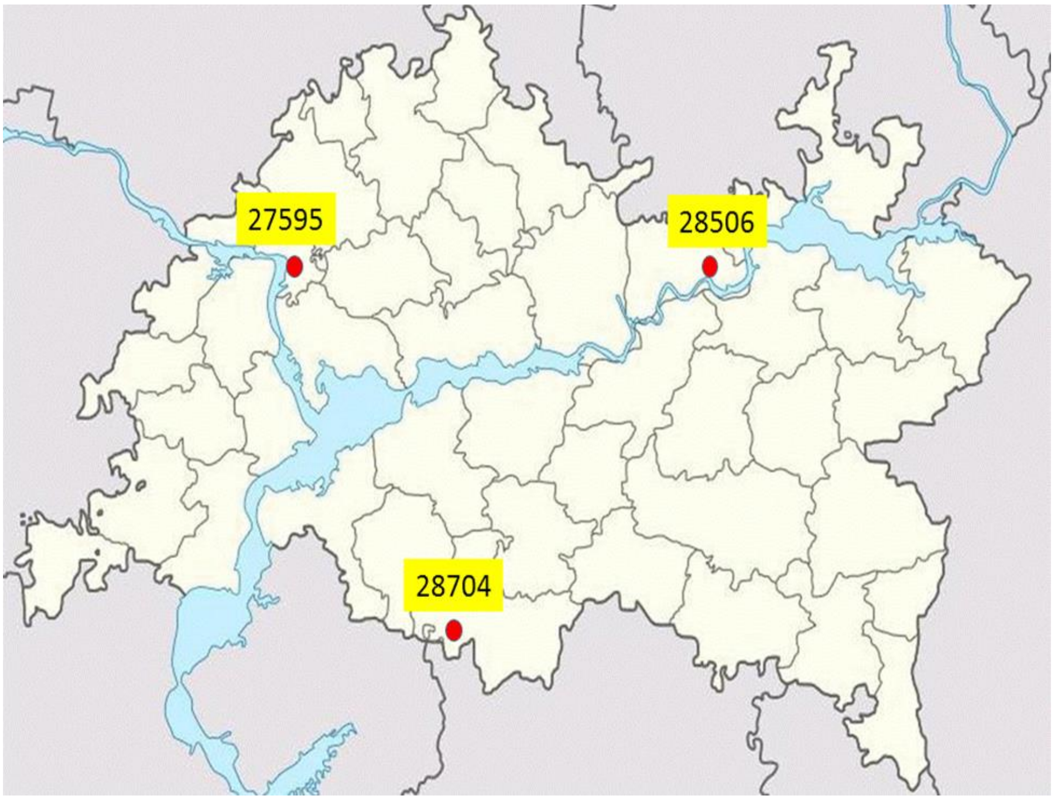

Fig 1: Geographical location of meteorological stations

RESULTS AND DISCUSSION

It was found that the average annual air temperature for the study period was 4.2 °C (Fig. 2). In general, the tendency to increase the average annual air temperature was identified. The maximum value of the average annual air temperature was observed in 1995 and amounted to 6.0 °C, and the minimum value in 1986 was 0.8 °C. For the analyzed period, 24 years were revealed, when the average annual air temperature exceeded the long-term annual average, and 17 years, when the average annual air temperature was below it.

In the period from 1977 to 2017, the trend of the water vapor pressure tended to increase (Fig. 3). The average value of this indicator was 7.67 mm Hg. For the observation period, 20 years were revealed, when the values of water vapor pressure exceeded the average value indicated above, and 21 years, when its value was below the long-term annual average. The highest annual average value of water vapor pressure was observed in 2007 – 8.34 mm Hg, and the lowest – in 1980 (6.41 mm Hg).

The long-term annual average of atmospheric pressure at the level of weather stations for the study period was 755.7 mm Hg. (Fig. 4). The tendency of insignificant decrease of this indicator was identified. 22 years were revealed, when the atmospheric pressure at the level of weather stations was below the long-term annual average and 19 years, when the atmospheric pressure at the level of meteorological stations was higher than the long-term annual average. The maximum average atmospheric pressure was recorded in 1996 and amounted to 759.6 mm Hg, and the minimum – in 1983 (752.5 mm Hg).

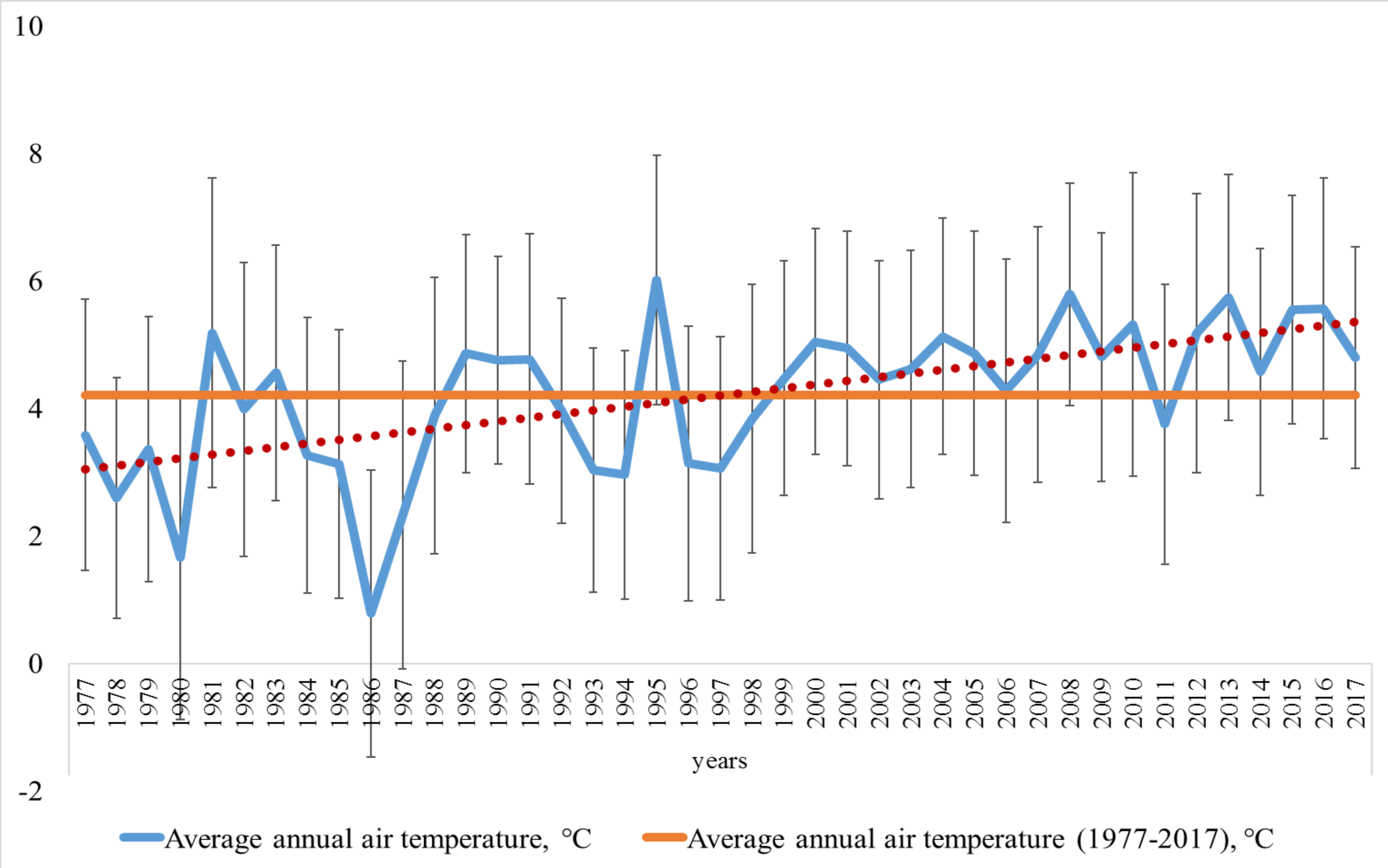

Fig 2: Average annual air temperature

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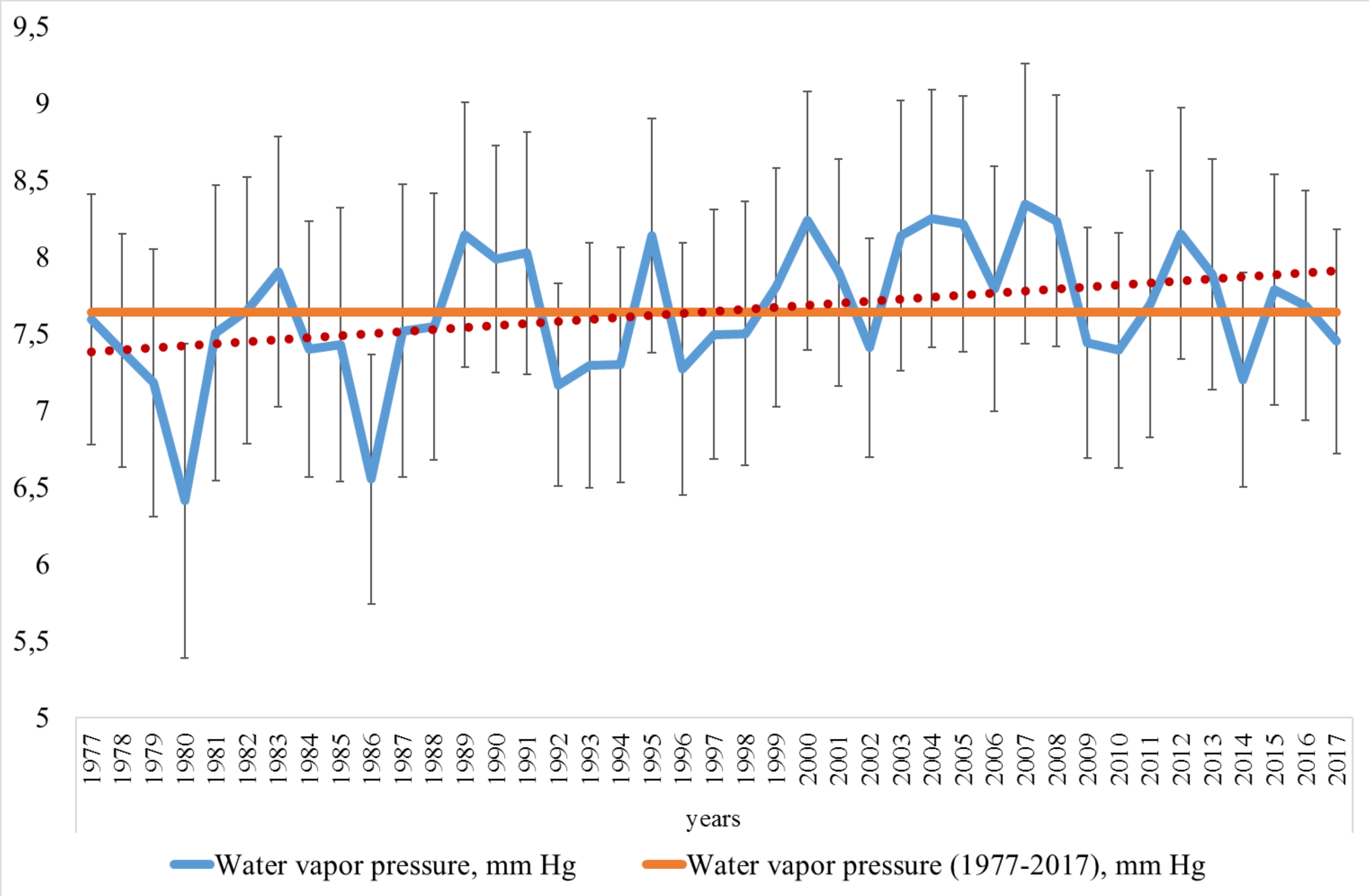

Fig 3: Water vapor pressure

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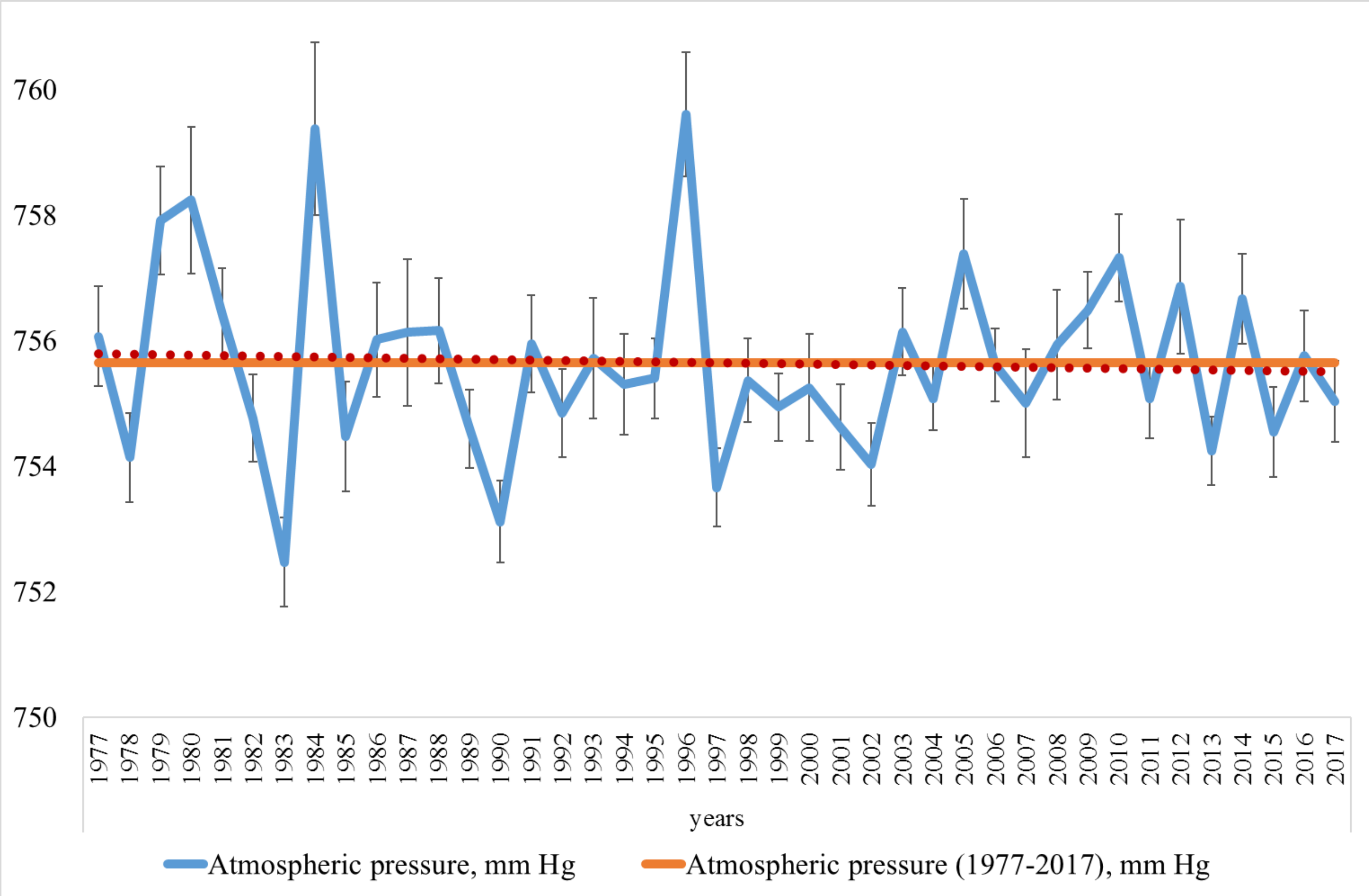

Fig 4: Atmospheric pressure

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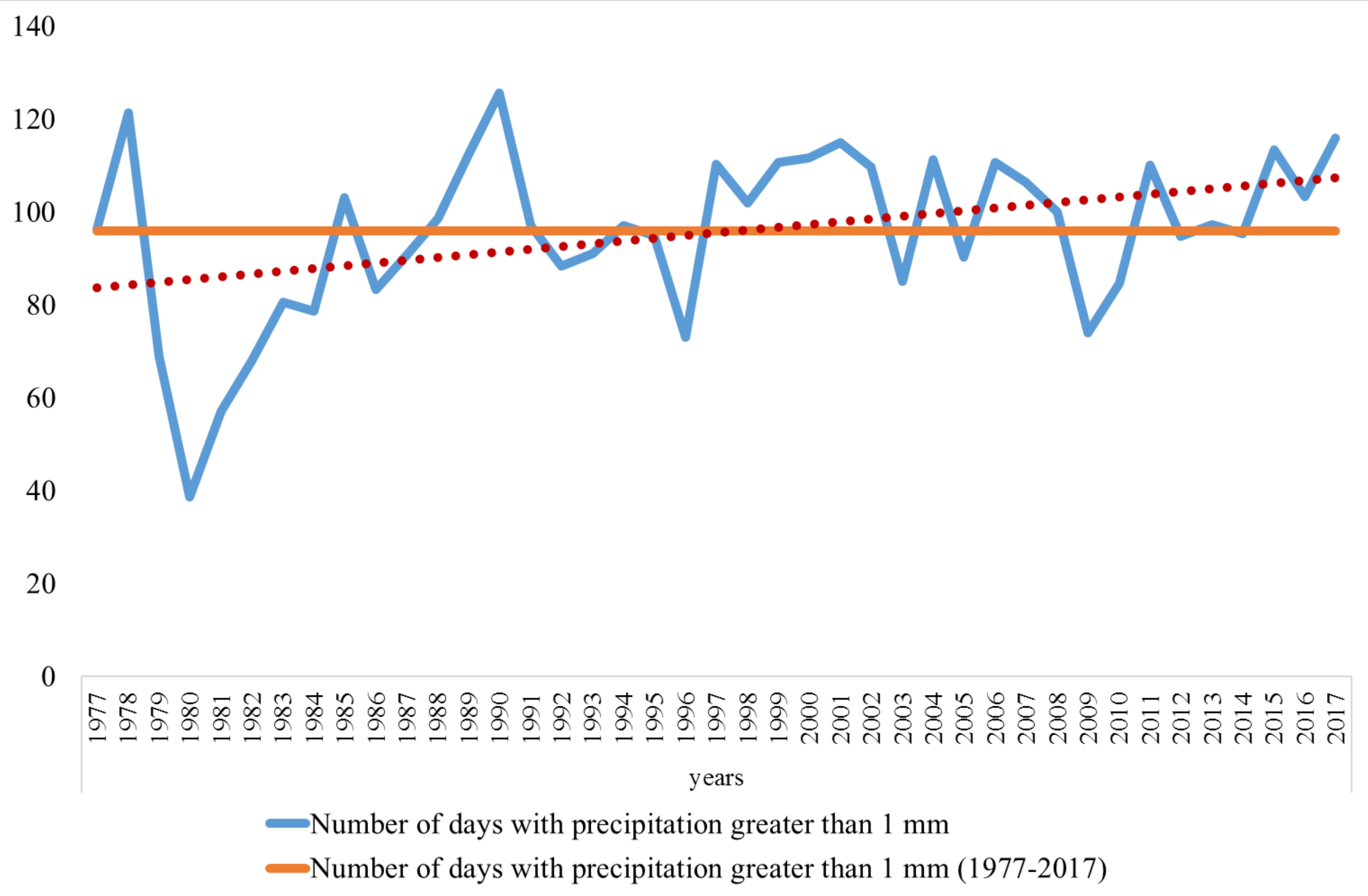

Fig 5: Number of days with precipitation greater than 1 mm

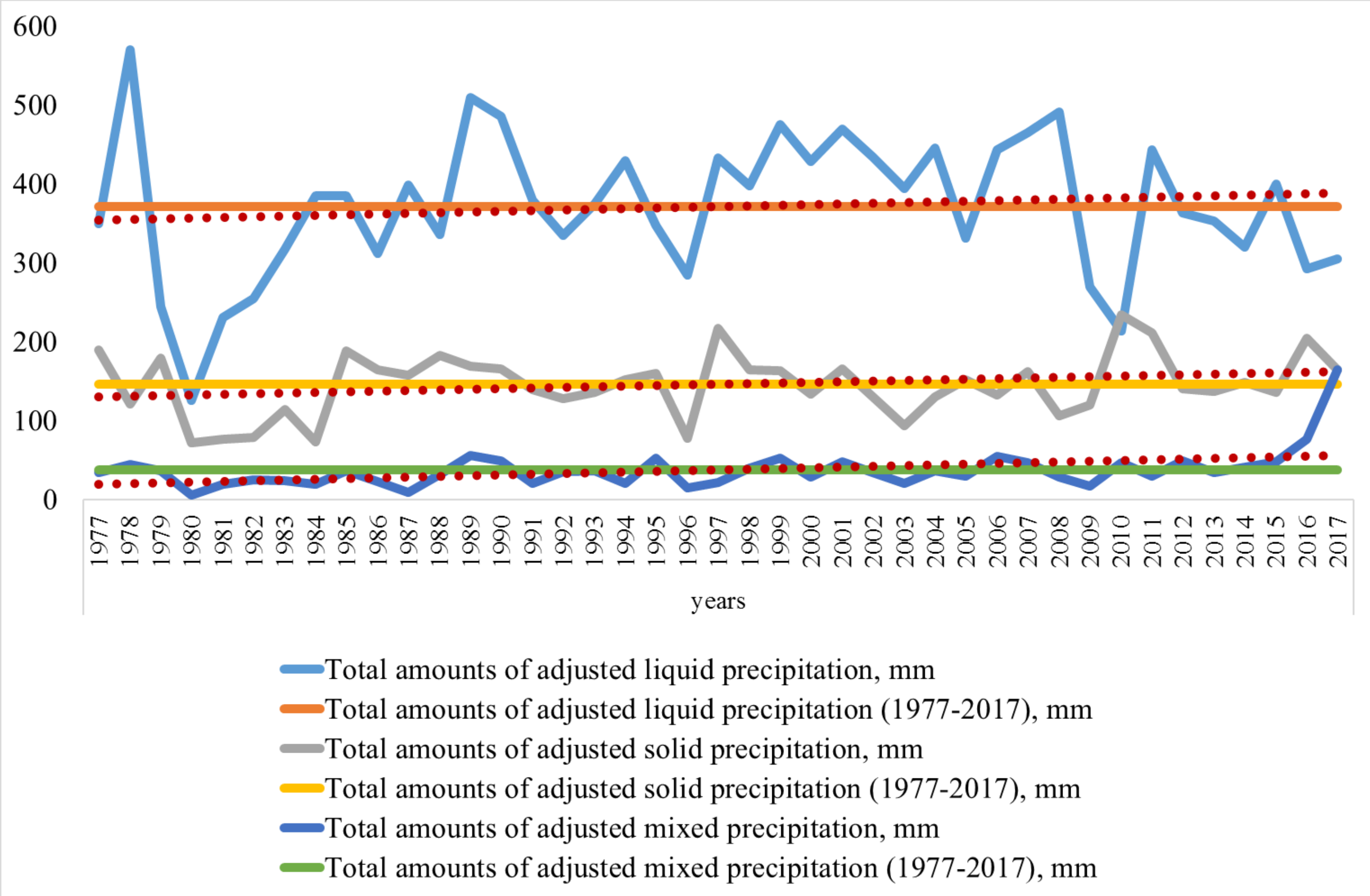

Fig 6: Total amounts of adjusted liquid, mixed and solid precipitation

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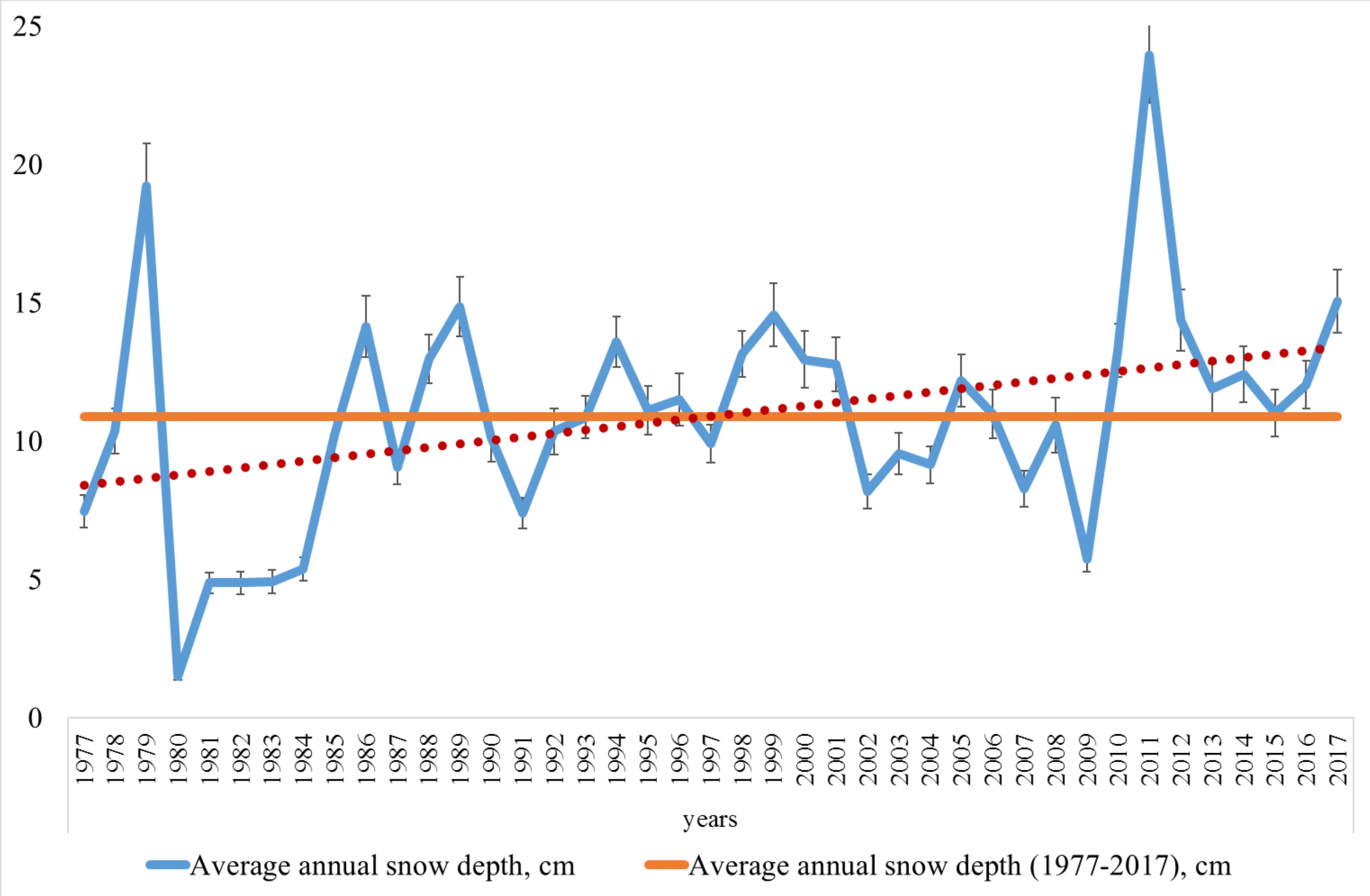

Fig 7: Average annual snow depth

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Table 1: Correlation between some climate parameters

Indicators	Average annual air temperature, °C	Water vapor pressure, mm Hg	Number of days with precipitation greater than 1 mm	Average annual snow depth, cm	Total amounts of adjusted precipitation, mm	Total amounts of adjusted liquid precipitation, mm	Total amounts of adjusted mixed precipitation, mm	Total amounts of adjusted solid precipitation, mm	Atmospheric pressure, mm Hg
Average annual air temperature, °C	1	0,75	0,31	0,06	0,20	0,13	0,35	-0,04	-0,22
Water vapor pressure, mm Hg		1	0,50	0,09	0,48	0,52	0,12	0,06	-0,33
Number of days with precipitation greater than 1 mm			1	0,44	0,95	0,83	0,38	0,46	-0,61
Average annual snow depth, cm				1	0,51	0,27	0,28	0,58	-0,03
Total amounts of adjusted precipitation, mm					1	0,88	0,31	0,56	-0,57
Total amounts of adjusted liquid precipitation, mm						1	-0,007	0,27	-0,52
Total amounts of adjusted mixed precipitation, mm							1	-0,001	-0,16
Total amounts of adjusted solid precipitation, mm								1	-0,28
Atmospheric pressure, mm Hg									1

During the analysed period, the number of days with precipitation greater than 1 mm increased (Fig.5). The long-term annual average number of days with precipitation greater than 1 mm was 96 days per year. At the same time, 23 years were revealed, when the number of days with precipitation exceeded the average value for the entire study period, and 18 years when the number of these days was below the long-term annual average. The maximum and minimum values of this indicator were 126 and 39 days in 1990 and 1986, respectively.

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It was found that the total amount of the adjusted liquid, mixed and solid precipitation tended to increase over the meteorological observation period (Fig. 6). So, if the long-term annual average amount of liquid precipitation was 371 mm, then the total amount of solid and mixed precipitation was 146 and 38 mm, respectively. The maximum value of the amount of liquid precipitation was revealed in 1978 and amounted to 570 mm, and solid and mixed precipitation – 234 and 164 mm in 2010 and 2017, respectively. The smallest amount of liquid, solid and mixed precipitation was characteristic for 1980 – 126, 72 and 6 mm, respectively. At the same time, the number of years when the total amount of liquid and solid precipitations exceeded the long-term annual average was 22 and 21 years, respectively, and 19 and 20 years when it was below this value. The amounts of mixed precipitation were mainly below the long-term annual average (26 years).

The long-term annual average value of the average annual snow depth over the study period was 10.9 cm (Fig.7). There was a tendency to increase the value of this indicator. The smallest average annual snow depth was typical for 1980 and amounted to 1.5 cm, and the largest – for 2011 (23.4 cm). 20 years were revealed when the values of this indicator were below the long-term annual average and 21 years when the values of this indicator were above the long-term annual average.

A very high correlation relationship was found (Table 1) between the number of days with precipitation greater than 1 mm and the total amount of adjusted precipitation (r = 0.95). The relationship between average annual air temperature and water vapor pressure, the number of days with precipitation greater than 1 mm and the total amount of adjusted liquid precipitation, as well as between the total amount of adjusted precipitation and the total amount of adjusted liquid precipitation was high (r = 0.75, r = 0.83 and r = 0.88, respectively). The relationship between the water vapor pressure and the number of days with precipitation greater than 1 mm and the total amount of adjusted liquid precipitation was noticeable (r=0.50 and r=0.52, respectively). A similar relationship was found between the average annual snow depth and the total amount of adjusted precipitation and the total amount of adjusted solid precipitation (r = 0.51 and r = 0.58, respectively). There was also a noticeable relationship between the total amount of adjusted precipitation and the total amount of adjusted solid precipitation (r=0.56). A noticeable negative relationship was identified between the average annual atmospheric pressure at the station level and the number of days with precipitation greater than 1 mm and (r = -0.61) and the total amount of adjusted precipitation (r = -0.57). The relationship between the other indicators was moderate or weak.

CONCLUSION

The analysis of meteorological data from 1977 to 2017 showed that in the Republic of Tatarstan, there is a tendency to increase in average annual air temperature, water vapor pressure, the number of days with precipitation greater than 1 mm, the total amount of adjusted liquid, mixed and solid precipitation, the average annual snow depth and a tendency to decrease in atmospheric pressure at the level of weather stations. Very high, high and noticeable correlations between some indicators have been found. These changes need to be considered when developing tactics for the management of various branches of agriculture (crop production, feed production, livestock farming), especially with regard to the development of optimal technologies for obtaining biologically valuable food products with maximum safety for human health and the environment.

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