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Global climate change and its regional impacts in Azerbaijan

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ABSTRACT

The article provides a research analysis of climate change in Azerbaijan based on scientific-historical and real hydrometeorological data. All the analyses made based on real data and uses stationary observations on meteorological network of Azerbaijan. The meteorological network covers all mountain areas, with various attitudes. Climate change impacts on a river flow were assess making statistical analyses. The real results obtained based on long-term observations and scientific facts have theoretical and practical significance and can be used in developing mitigation and adaptation measures.

KEYWORDS

Temperature; Precipitation; Climate change; River flow trend; Hydrometeorological observations orography; Oceans; Seas.

INTRODUCTION

Currently, global climate change and its regional impacts continue to shape the sustainable development worldwide. Irregular atmospheric processes caused by climate change leads to shiftes in hydro-meteorological patterns and the cause natural hazards including including floods, hurricanes, droughts, high winds, heavy rains, forest fires.

At present, the effects of climate change are causing great damage not only to individual countries but to the world economy as a whole. Over the past few decades, the number of natural disasters caused by hydrometeorological processes in different regions of the planet, the amount of damage they cause to the economy of individual countries is constantly increasing. According to the World Meteorological Organization, 80-85% of natural disasters in the world are caused by hydrometeorological processes[10].

Global climate change and its damage to the population, biodiversity, agriculture, infrastructure, and natural disasters are some of the biggest challenges facing humanity. Modern climate change has to be addressed by the world community, causing ocean and sea-level fluctuations, desertification, increasing forest fires, changing surface and groundwater regimes, declining world snow and ice, freshwater resources, and people's lifestyle and health problems. puts issues.

The World Health Organization estimates that climate change accounts for 10% of all deaths among older people in Europe each year. The results of more than 50 studies in Western Europe show that the highest mortality during the hot summer is among the elderly suffering from chronic diseases of the cardiovascular system, respiratory system, diabetes, people living on the upper floors of buildings and in cities. For example,

according to various estimates, between 27,000 and 40,000 people died in Western and Central Europe in the summer of 2003, and about 15,000 in Paris. The hot August of 2019 killed an additional 6,000 people in Spain and up to 1,300 in Lisbon

From this point of view, it is not accidental that the problems related to climate change have a special place on the agenda at any high-level international event. Along with numerous examples of this, with the participation of world governments and heads of state, international organizations, scientists, and experts, in recent years only in Paris (in 2015, the 21st International Conference on Climate Change in Paris with 196 countries participating) the Paris Protocol is adopted to commit to the use of alternative energy sources to keep it at a low level) and the international events held in Madrid in 2020. All this shows that if there are two natural problems in the world today that need to be addressed in the face of civilization, one is climate change and the other is the problem of freshwater supply. In general, the problem of modern climate change must be solved in a system of facts, causes, possible scenarios, and forecasts.

GLOBAL CLIMATE CHANGE - CHRONICLE, CAUSES, CONSEQUENCES

It is known that changes in the Earth's climate system are of both natural and anthropogenic origin. Even in the absence of human civilization on Earth, periodic changes took place in the Earth's climate 2426-2460 million years ago. As a result, periods of glaciation and warming in the history of the Earth have always replaced each other. 17,000 years ago, due to changes in the Earth's axis and rotation around the Sun, as well as the influence of physical processes on the Sun, the ice age stopped, ocean temperatures rose to 120 m, ocean currents changed and the famous Holfstream current was restored. At the end of the glacial period 10,000 years ago, a period of flooding occurred on land, changing the map of the world's land and water areas, creating several seas (Baltic), bays (Hudson), lakes (North America), the formation of flora and fauna in what is now the Sahara. has been[6,7].

Subsequent warming of the Earth's atmosphere due to natural factors has increased the process of desertification on Earth. Several civilizations around the Mediterranean were destroyed by climate change in 1200 BC. In the 1940s, volcanic eruptions increased around the world and the amount of precipitation decreased. During this period, the level of major rivers declined sharply, and even the decline of the Nile River in Egypt led to famine and migration in Egyptian civilization.

In general, climate change has led to the destruction or formation of historical civilizations (for example, the Roman Empire, the Egyptian civilization). Paleoclimatologists have shown in the 6th century AD (530-540 AD) that strong climate change on the planet, especially the decrease in average annual temperatures, reduced productivity, and the underdevelopment of forest cover. explained by the sharp increase in the number of aerosols in the atmosphere as a result of the eruption[10].

A powerful Caldera volcano in Indonesia in 1257 caused the atmosphere to cool by increasing aerosols in the atmosphere, causing a sharp decline in world productivity and famine in England and Europe. This is most evident in the burnt coal of the forests, in the identity of the chemical materials in the mountain and continental glaciers. It should be noted that in 1883, the Krakatau volcano erupted again, lowering the average annual temperature in the atmosphere by 2-30C, destroying 30,000 people and 295 villages and settlements.

However, there is ample scientific evidence that volcanic eruptions, the polarization of the Earth's poles, the Earth's imaginary axis, and periodic changes in motion around the Sun cause periodic changes in the Earth's climate system as natural factors. At present, modern climate change is synthesized by anthropogenic factors in addition to natural ones. As a result of such effects, heat exchange and heat-energy balance in the atmosphere-ocean system change. This, in turn, leads to strong hurricanes over the Atlantic Ocean, which have a greater impact on North and Central America, and events such as EL-Ninyo and LA-Ninya, which are characterized by positive and negative temperature anomalies in the Pacific Ocean.

As a result, there are changes in the direction of hot and cold currents in the oceans and seas (for example, the recent changes in the flow of the Gulfstream current,

which plays a special role in shaping the European climate[2]). Rising temperatures on the ocean surface were greater than thousands of years ago and led to an increase in hurricanes during the same period. So today, rising temperatures on the ocean and sea surfaces will lead to an increase in such hurricanes. This, in turn, can lead to abnormal atmospheric processes in any region of the world, including strong hurricanes, floods, desertification, forest fires, extreme temperatures, and so on. causes such phenomena as[12].

Global warming is leading to a sharp decline in the snow and ice cover of the continental and land areas, which is considered the white cover of the world, which in turn leads to overheating of the land surface and a decrease in soil moisture and temperature. Thus, the reduction of the white cover reduces the reflection of incident direct solar radiation, converting it from the returning beam to the absorbed beam. Rising temperatures and declining humidity in the earth's crust affect the overall productivity of forest cover and plants by increasing their need for water. Research by scientists shows that rising temperatures in the world's oceans and seas reduce the amount of oxygen there, which affects the living world of the oceans and seas. NASA scientists have compiled maps showing the depletion of oxygen in the world's oceans and seas.

According to the World Meteorological Organization (WMO), the 20th century is the hottest in history, the first and second decades of the 21st century are the hottest in history, and the last 4 years (2015-2019) have been the hottest. 20 of the last 22 years in the world were the hottest years, and the hottest period in the last 1500 years was 2016-2018. In the history of Antarctica, a record maximum temperature (+18.3 ^{0}C) was observed on February 6, 2020. Extreme temperatures around the world, historical highs and lows are updated almost every year. All this once again reflects the reality of climate change on our planet.

CLIMATE CHANGES IN AZERBAIJAN

Climate changes cause negative effects in various sectors of the economy of Azerbaijan[2] due to natural hazards caused by climatic patterns[2]. In Azerbaijanthe maximum, minimum, average daily, monthly, seasonal, etc. recorded during the periods of historical instrumental meteorological observation. new records are observed in temperature indicators. In 2018, which is considered one of the hottest years in the world, the historical maximum temperature of + 43^{0}C in the country was renewed and amounted to + 46.2^{0}C.

The average daily maximum temperature in Baku in 1991-2019 was +0.8 ^{0}C higher than in 1961-1990, and the number of days when the maximum air temperature was above 35^{0}C was 81 days (1961-1990) and 260 days (1991-2019) in Baku. The number of days when temperatures below zero degrees were observed in Khinalig in 1992 was 140 days, while in 2010, one of the hottest years, it was only 38 days. Similar anomalies are observed in other temperature indicators.

To conduct a comprehensive analysis of climate change in Azerbaijan, data from 95 hydrological stations of 57 meteorological stations located in different regions and at different heights of the country (30 of which are automatic meteorological stations) were used, and comparative, statistical methods were used in the study. It should be noted that the temperature and precipitation data, which are the main meteorological parameters and better characterize climate change, are based on a comparative statistical analysis of the period after 1991, with the cyclical base recommended by the World Meteorological Organization (1961-1990)[10]. To determine the trend of change of temperature and precipitation indicators in Azerbaijan, their analysis was carried out in the range of different heights and different territorial units. All of these are given in TABLES 1, 2, and 3, respectively.

TABLE 1: Compared to the multi-year norm (1961-1990) of temperatures at different altitudes in the territory of Azerbaijan in 2007-2019 change ^{0}C

Periods	Elevation intervals, m					On the territory of the republic
	≤ 0	1 - 200	201-500	501-1000	>1000	
Perennial norm	14.6	14.3	13.3	11.9	7.8	12.3
Medium multiplicity 2007-2019	15.4	15.4	14.5	12.7	9.1	13.3
Growth relative to the perennial norm	+0.8	+1.1	+1.2	+0.8	+1.3	+1.0

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TABLE 2: Temperature changes in different regions of Azerbaijan in 2007-2019 compared to 1961-1990 ^{0}C

Periods	Regionlar						On the Republic
	Absheron-Gobustan	Lankaran-Astara	Greater Caucasus	Lesser Caucasus	Kura-Araz	Nakhchivan AR	
Norma 1961 -1990	14.5	12.9	10.7	9.2	14.3	12.4	12.3
Average perennial 2007- 2019	15.3	13.8	11.4	10.4	15.5	13.5	13.3
Growth relative to the perennial norm	+0.8	+0.9	+0.7	+1.2	+1.2	+1.1	+1.0

As can be seen from TABLE 1, the temperature increase in the country compared to the multi-year norm in the period 2007-2019 is +1.0 ^{0}C. The highest increase in elevation intervals falls to altitudes over> 1000 m (+ 1.3^{0}C). However, the highest annual temperature increase for the period 2007-2019 was in 2010 (+ 1.3^{0}C), 2012 (+ 1.3^{0}C), 2014 (+ 1.3^{0}C), 2015 (+ 1.5^{0}C), It fell to 2018 (+ 1.8^{0}C) and 2019 (+ 1.5^{0}C). In general, 2018 has gone down in history as the hottest year in the world during the entire observation period, and this has manifested itself in Azerbaijan as well. In other words, the highest annual temperature increase in the country (+ 1.8^{0}C) and the historical maximum temperature (+ 46.2^{0}C) was observed in 2018. In 2007-2019, only in 2011, there was no increase in temperature in the country compared to the perennial norm ((0^{0}C).

As can be seen from TABLE 2, the highest temperature rise in the regions is in the Kura-Araz and the Lesser Caucasus (+ 1.20C), and the lowest in the Greater Caucasus + 0.7^{0}C. In 2018, a sharp temperature rise was observed in all regions. Thus, + 1.4^{0}C in Absheron-Gobustan, + 1.7^{0}C in Lankaran-Astara, + 1.1^{0}C in the Greater Caucasus, + 1.6^{0}C in the Lesser Caucasus, 16.2^{0}C in the Kura-Araz, + 2.8^{0}C in Nakhchivan AR, and + 1.8^{0}C in the republic has been. This increase in the regions reflects its regularity for the multi-year period (2007-2019), respectively. In the Nakhchivan region, which is characterized by its hot continental climate, a record temperature increase of + 2.8^{0}C was observed compared to the perennial norm. Figure 1 shows the trend of the average annual temperature in the country for 2007-2019 and its difference from the multi-year norm (1961-1990).

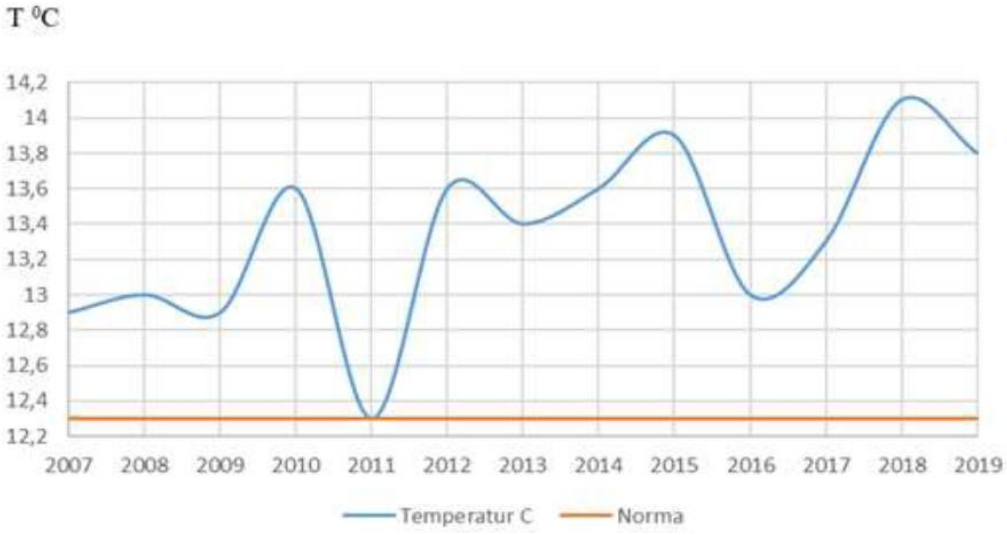

Figure 1: Multiple courses of average annual temperatures and norm (1961-1990) in Azerbaijan.

TABLE 3: Distribution of precipitation in the territory of the Republic of Azerbaijan on the interval of different heights about the multi-year norm, in mm

Years	Elevations, m					On the territory of the republic
	≤ 0	1 - 200	201-500	501-1000	>1000	
Norma 1961- 1990	334	327	478	534	639	476
Average perennial 2007-2019	364	332	404	631	630	466
Change relative to the perennial norm	+30	+5	- 74	+97	-9	-10

As can be seen from TABLE 3, there is no significant difference in the increase or decrease of precipitation in the country compared to the multi-year norm. In 2007-2019, precipitation decreased by only 10 mm compared to the long-term norm.

In the height intervals, the highest precipitation increase is observed in the range of 501-1000 m (97 mm), and the decrease is observed in the range of 201-500 m. The highest increase in precipitation (110 mm) in the country compared to the long-term norm was observed in 2016, and the largest decrease was observed in 2017 (101 mm). It is noteworthy that in all altitude intervals for 2007-2019, precipitation increased or decreased compared to the norm in some years, while in the 201-500 m altitude range, only a decrease was observed in all years.

During the entire observation period, the maximum decrease in precipitation compared to the norm in 2013 (186 mm) and 2017 (260 mm) falls on this height range (201-500). Maximum precipitation increases were recorded in 2011 in areas below <0 m (178 mm) and in the same year in the height range of 501-1000 m (288 mm). In 2011, as noted, no increase in temperature was recorded in the country. It is this regularity that has shown itself in the largest increase in precipitation in 2011. In other words, the low temperatures in 2011 and the corresponding heavy rainfall are regular. Figure 2 shows the multi-year precipitation trend and multi-year norm (1961-1990) in the territory of Azerbaijan for 2007-2019.

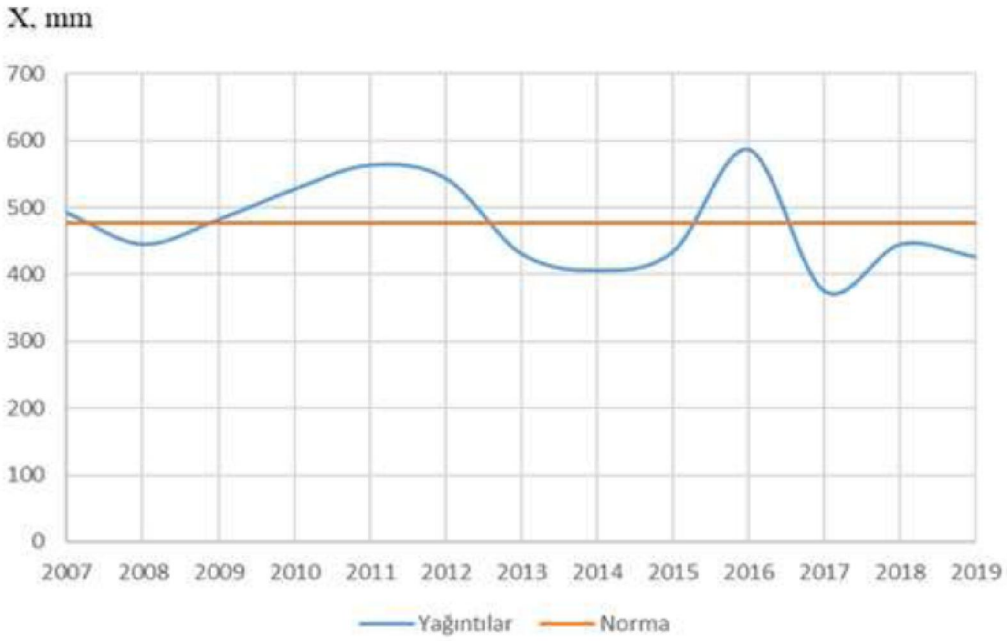

Figure 2: Multiple courses of average annual precipitation and norm (1961-1990) in Azerbaijan.

TABLE 4: Shows the maximum temperatures observed in recent months (2017, 2018, 2019) due to the impact of regional climate change in the territory of Azerbaijan in 2017, 2018 and 2019.

a) 2017												
Temperature indicators	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
T_{max}, ^0C	20	22	26	30	36	40	42	43	41	31	23	20
Average monthly temperature change relative to the perennial norm	±	-	+	+	+	+	+	+	+	±	±	+
b) 2018												
Temperature indicators	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
T_{max}, ^0C	16	20	28	29	37	42	46	42	37	35	24	19
Average monthly temperature change relative to the perennial norm	+	+	+	±	+	+	+	+	+	+	±	+

(Continue TABLE 4)

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c) 2019												
Temperature indicators	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
T_{max}, ^0C	20	18	25	31	37	42	42	42	37	32	24	21
Average monthly temperature change relative to the perennial norm	+	+	+	±	+	+	+	-	+	+	±	+

Note: + increase in temperature relative to the perennial climate norm; ± increase in temperatures in some regions relative to the perennial climate norm, in some there is a decrease; - decrease in temperatures relative to the perennial climate norm.

As can be seen from TABLE 4, due to the regional effects of climate change in Azerbaijan, an increase in average monthly temperatures is observed in most months.

In 2017, only in February there was a decrease in average monthly temperatures, in January, October and November there was an increase in some regions and a decrease in others.

As the hottest year in 2018, there was an increase in temperature in all months, only in April and December, along with an increase, a decrease was observed in some regions.

In 2019, a decrease in average monthly temperatures was observed only in August, and an increase and decrease in April and December.

Regional climate change has also affected the country's river and water resources, regime, and annual flow. Thus, a decrease in the maximum water consumption (Qmax) was observed in the annual flow of rivers (Clay) in most countries.

There is an increase mainly in the minimum currents (Qmin) of the winter solstice. This is mainly due to the increase in mid-season temperatures in the winter months, which increase the melting of snow and water resources during the winter months, as well as increase the flow of the dry season[4.8]. An example of this is the trend charts showing all three processes at the Kur-Giragkesemen border checkpoint, the largest river in the area (Figure 3)

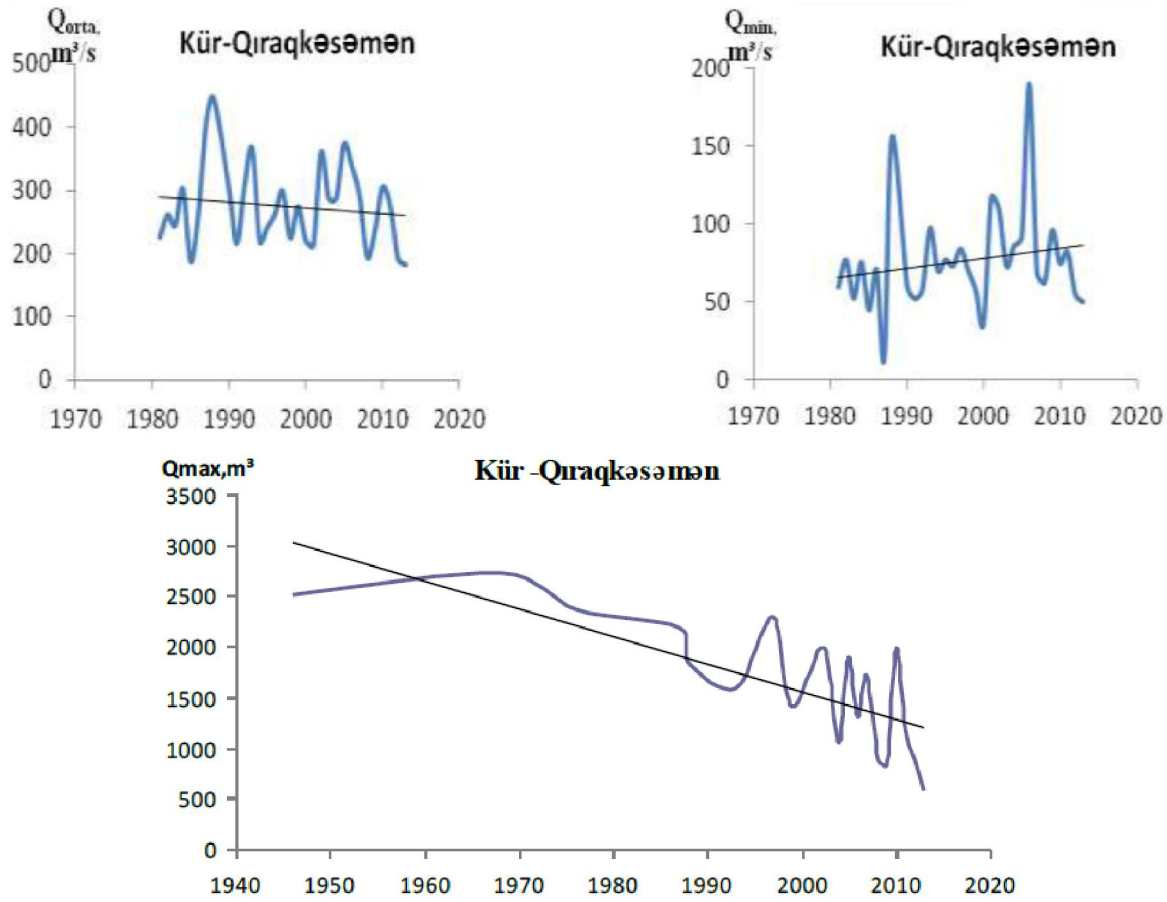

Figure 3: Dynamics of change of average, minimum, maximum water consumption of rivers

Global climate change is having a greater impact on the cryosphere, primarily on the world's snow cover, leading to serious disruptions in their morphological structure and a decrease in glacial masses. This process, which takes place in the glaciers of the world, is also observed in the main glaciers of Azerbaijan. This is clear from both satellite photography and the results of expedition research. In 1986-2016, the Shahdag glacier area of Azerbaijan decreased by 0.17 km2, and the Bazarduzu and Tufandag glacier areas decreased by 0.04 km^2.

RESULTS AND DISCUSSIONS

1. The average multi-year temperature increase in the territory of Azerbaijan for the period 2007-2019 is + 1^0C relative to the multi-year norm;
2. The maximum temperature increase occurs at altitudes above> 1000 m (+ 1.3^0C) and the lowest at □0 m (+ 0.8^0C);
3. The highest temperature increase in the country was observed in 2018 (+ 1.8^0C). During the entire observation period, the historical maximum temperature (+ 46.2^0C) was recorded in 2018. In the same year, the temperature rise at an altitude of> 1000 m was + 2.30C;
4. Seasonal changes in temperatures increase in most seasons except spring;
5. The highest temperature increase by regions is observed in Nakhchivan and Kura-Araz;
6. Although no significant change in the distribution of precipitation was observed (there was only a 10 mm decrease compared to the multi-year norm), both increase and decrease were observed in all altitude intervals for the period 2007-2019. The maximum average increase is 97 mm in the height range of 501-1000 m, and the maximum decrease is 74 mm at the height of 201-500 m. However, in the 201-500 m elevation range, only a decrease in precipitation is observed during 2007-2019;
7. In 1961-1990, the number of days exceeded 35^0C in Baku was only 92 days, while in 1991-2019 the number of such hot days was more than 3 times 280 days;
8. There is a decrease in the maximum and annual flow of rivers during the turbulent and flood periods. Rivers with an average basin height of more than> 1000 m have an opposite increase in the winter flow period, which is due to the increase in the average winter temperatures and the corresponding role of snowmelt water;
9. Due to the regional effects of global climate change, the area of Shahdag glacier, one of the high mountain glaciers of Azerbaijan, decreased by 0.17 km^2, and Bazarduzu and Tufandag glaciers decreased by 0.0.4 km^2.

CONCLUSION

If in the world at the present time there are two natural problems of one of which are climate change on local and global scales, and other water problems that annually increase the needs of the population. It is known that the last few decades in different corners of the planet, the impact of climatic changes contributes to the increase in the repetition of anomalous hydrometeorological processes and natural disasters. And this inevitably affects the population, the economy, as separate states, and on a global scale.

The article teaches scientific-historical and modern hydrometeorological observations, examines the chronicle of the problems of climatic changes in the world and their current regional aspects of influence in Azerbaijan. For this purpose, using the multi-year data of all existing hydrometeorological stations and posts in Azerbaijan, the dynamics of changes in the regional climate and its impact on river flow have been studied. Climatic changes were assessed in separate high intervals and in separate territorial units by methods of comparison and statistics.

We hope that the obtained real results, based on long-term meteorological data and real scientific analysis, will have a theoretical and practical scientific value.

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