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The impact of climate change on the temperature regime of the Kelbajar and Lachin regions of the Republic of Azerbaijan

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Abstract

In an article based on reanalysis data MERRA-2 (Modern-Era Retrospective Analysis for Research and Applications, Version 2) for the period 1980-2022 the general trends in the temperature regime of the Kalbajar and Lachin regions, which are part of the modern East Zangezur economic region, were studied. It has been determined that during the period under review there is a tendency to increase average annual and seasonal temperatures. Temperature trends for all seasons and annual periods were statistically significant at the 5% confidence level. Calculations showed that the average annual air temperature in the period 2001-2022. increased by 0.9 °C compared to the period 1980-2000, which is consistent with the results obtained in other regions of the republic. The largest increase in average monthly temperature was recorded in February (1.7 °C), March (1.8 °C) and October (1.3 °C). The largest increase in the maximum average temperature was observed in March (2.7 °C) and December (1.9 °C), and the minimum average temperature in October (3.5 °C). A decrease of 0.6°C in the minimum average temperature in January was recorded.

1. Introduction

The territory of Kalbajar and Lachin regions belonging to Eastern Zangazur economic region is mainly mountainous. According to the 1961-1990 period data of the Istisu hydrometeorological station located at an altitude of 2257 m above sea level in Kalbajar region, the average annual air temperature is 4,0 ^{0}C. The coldest month is January (-5.2 ^{0}C), and the warmest month is July (13.5 ^{0}C). The average annual precipitation amounts to 506 mm, most of which occurs during the warm half of the year (Khalilov and Safarov, 2001).

According to the data of the Lachin hydrometeorological station for the period 1961-1990, the average annual air temperature is 10 ^{0}C. The coldest month is recorded in January (0 ^{0}C), and the warmest month is July (21.0 ^{0}C). The average annual precipitation is 506 mm, most of which occurs in the warm half of the year. The average annual precipitation is 587 mm, most of which occurs in the warm half of the year (Khalilov and Safarov, 2001). Thunderstorms and fog are very frequent in both areas, continuous snow cover, mountain-valley winds prevail (Климат Азербария, 1968; Museyibov, 1998).

Since the territory was occupied by the Armenian armed forces in 1993-2020, there are no observational materials for those years. For this reason, it is appropriate to use alternative data sources and research methods, including satellite and reanalysis data, to determine the effect of global warming on the temperature regime of the area in recent years.

Thus, the main goal of the research is to determine the changes in the temperature regime in Kalbajar and Lachin regions of East Zangazur economic region in recent years (1991-2022 period).

2. Method

The monthly reanalysis data of MERRA-2 (Modern-Era Retrospective analysis for Research and Applications, Version 2) with a resolution of 0.5º for the period of 1980-2022 was used in the research (https://giovanni.gsfc.nasa.gov). Due to the relatively low resolution, the temperature data was obtained by averaging over the entire area, not individual observation stations. For this purpose, the considered area was marked on the map located on the relevant electronic portal (Giovanni) and with the help of relevant procedures, the time series of the average values of the air temperature in that area for the months of each year

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were obtained. With the help of the obtained series, the trends of temperature change in years and seasons were determined based on the corresponding trend curves. The statistical significance of the trends is determined according to the Equation 1:

$$R/\sigma_R \geq s \quad (1)$$

where R *is* the correlation coefficient and σ_R is the random mean squared error (Sikan, 2017). The random mean squared error is calculated by Equation 2:

$$\sigma_R = (1 - R^2)/\sqrt{(n-1)} \quad (2)$$

where n is the number of terms of the time series. s=2.02 at 5%-significance level and n=40.

3. Results and Discussion

Let's consider temperature changes in Kalbajar-Lachin area. As can be seen from Table 1, compared to the period of 1980-2000, the average annual temperature in the period of 2001-2022 has increased by 0.9 ^{0}C. An increase in average temperature was recorded in all months except April. Larger increases were observed in February, March, June, August, September and October. In April, there was no change in temperature, and in July, November, and December, there were no significant changes.

An increase in the maximum average temperature was recorded in all months, but the highest increases occurred in March and December, and the lowest in February, April and May.

In January and April, the minimum average temperature decreased, while in October it increased sharply (3.5 ^{0}C).

Figure 1 also shows the increasing trend of the annual average temperature in the area during the considered period. According to the formulas (1) and (2), the linear

trend showing an increasing trend, as can be seen from the figure, is statistically significant and amounts to 0.4 °C/10 years. The lowest value of the temperature was recorded in 1992, and the highest value was recorded in 2010, which corresponds to the indicators observed in other regions of Azerbaijan. (Safarov et al., 2018; Safarov et al., 2018).

In addition, the temperature series was divided into 2 equal periods and the corresponding temperature anomalies were calculated.

Table 1. The main statistical temperature indicators of the air temperature in the Kalbajar-Lachin area during the years 1980-2000 and 2001-2022, ^{0}C

	Months												
	1	2	3	4	5	6	7	8	9	10	11	12	Annual
	1980-2000												
Average	-5.7	-5.2	-1.0	5.8	10.0	14.6	17.7	17.0	13.2	6.9	1.0	-3.4	5.9
Max.	-2.6	-1.7	2.0	8.6	1.5	17.0	20.2	19.8	15.3	9.0	3.6	-0.3	7.1
Min.	-8.8	-8.7	-4.2	3.2	7.3	12.1	16.1	14.9	11,1	2.5	-4.2	-7.1	4.2
	2001-2022												
Average	-5.0	-3.4	0.8	5.8	10.7	15.5	17.9	17.9	14.2	8.2	1.6	-3.1	6.8
Max.	-2.0	-1.3	4.8	9.0	12.9	18.0	20.7	20.9	16.4	10.1	4.7	1.6	8.2
Min.	-9.5	-7.9	-3.9	3.0	8.2	13.3	16.6	15.0	11.3	6.0	-3.8	-7.1	5.4
	Temperature anomalies												
Average	0.7	1.7	1.8	0.0	0.7	1.0	0.2	0.9	1.0	1.3	0.5	0.4	0.9
Max.	0.6	0.4	2.7	0.4	0.4	1.0	0.5	1.0	1.1	1.1	1.1	1.9	1.0
Min.	-0,6	0.8	0.2	-0.2	0.9	1.2	0.5	0.1	0,3	3.5	0,4	0.0	1.2

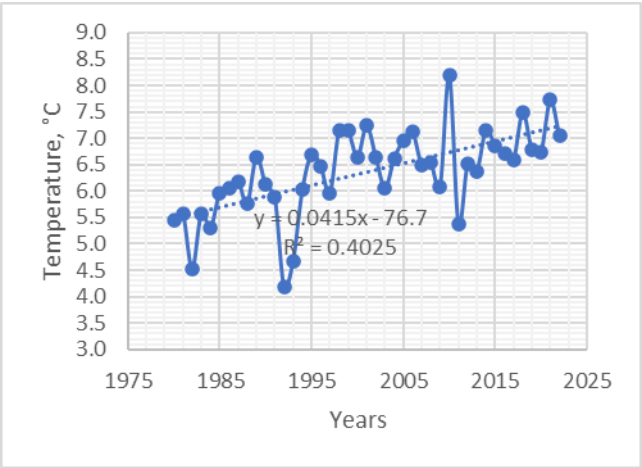

Figure 1. Time course of average annual air temperature in Kalbajar-Lachin area in 1980-2022.

The study of changes in the temperature regime of individual seasons is also of great interest. Figure 2 shows the time course of average temperatures for different seasons. As can be seen from the figure, temperature changes in all seasons have an increasing trend and are statistically significant at the 5% assurance level based on the formulas of the corresponding linear trends (1) and (2).

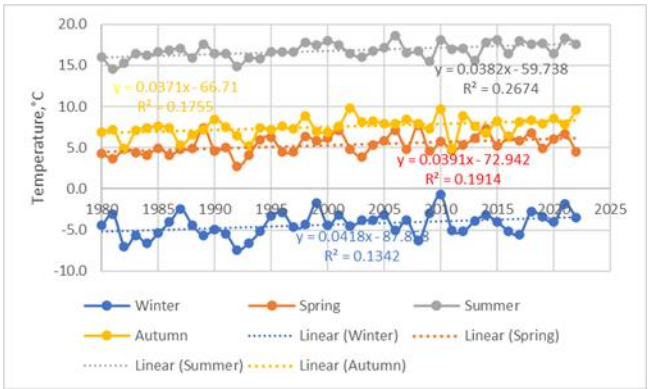

Figure 2. Time course of the average air temperature for separate seasons in the period 1980-2022

Table 2. The difference between the average temperatures of the periods 2001-2022 and 1980-2000 for separate seasons, ^{0}C

(2001-2022)-(1980-2000)	Winter	Spring	Summer	Autumn
Average	0.9	0.8	0.7	1.0
Maximum	2.7	2.7	1.0	1.1
Minimum	-0.6	-0.2	0.1	0.3

Table 2 shows the average, maximum, and minimum temperature differences in the period 2001-2022 and 1980-2000 for separate seasons. As can be seen from the table, the differences in average temperatures mostly coincided with the cold periods of the year (0.9-1.0 ^{0}C). The greatest increases are recorded in maximum average temperatures. In winter and spring, this increase is greater (2.7^{0}C). Changes in minimum average temperatures are not significant.

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