ANALYSIS OF TEMPERATURE, SNOW, AND PRECIPITATION REGIMES IN THE REPUBLIC OF AZERBAIJAN (for the multi-year period 2017-2023)

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Abstract

The analysis of multi-year observations shows that the average annual temperatures in the Republic of Azerbaijan, as well as the Greater and Lesser Caucasus regions are increasing both compared to the norm and to previous years. The average annual temperature increased the most in the Greater and Lesser Caucasus in 2021. A decrease in snow and rain is observed across the Republic over the years. Multi-year observations show that in years when snow decreases, rain increases, and in years when rain decreases, more snow falls in that same area. In the Republic of Azerbaijan, snow started falling in October 2021. In 2021, precipitation (rainfall) in the country was 134 mm below the norm. Compared to the 2020-2023 period, the most snow fell in 2022, primarily in January. In 2022, precipitation was 144.3 mm below the norm. In the years 2022-2023, snow fell even in May and April. In May 2023, more snow fell than in November of the same year. Although snow fell in the Republic in April and May of 2023, it decreased compared to the January, February, March, and December months of previous years. Conversely, rainfall increased and was approximately equal to the norm. The average annual temperature was 2.0°C above the norm in 2022 and 2.2°C above the norm in 2023.

1. Introduction

According to the 1961-1991 norm, the global average annual temperature has increased by 0.5°C. Overall, since 1993, the Earth's climate has warmed by close to +1.0°C compared to the multi-year average. In some regions, the temperature increase is even higher. These occurrences have begun to manifest clearly in recent decades through the frequent repetition of events such as landslides, floods, flash floods, powerful hurricanes, droughts in various countries, the expansion of forest fire areas, and so on. The results of numerous studies show that 65% of the damage to the global economy resulting from adverse weather conditions falls to the share of agriculture [1; 4; 5; 6].

All of this proves that climate change is a real threat to humanity and compels the world community, scientists, and politicians to approach this issue seriously. It is no coincidence that today there is no high-level assembly of world states where issues related to climate change and the natural disasters it causes are not included on the agenda [10].

In 2024, under the slogan "Let's unite for a Green World," the 29th session of the Conference of the Parties (COP29) to the UN Framework Convention on Climate Change was held in Azerbaijan. During this conference, decisions and commitments were adopted to keep the Earth's temperature increase within 1.5°C [1; 2; 11].

The climate of Azerbaijan's territory is also an integral part of the global climate system. The processes occurring within this system impact the country's climatic conditions with varying intensity and over different time periods. Therefore, the study of climate change, the investigation of its impact on various sectors of the economy, and the research into the adaptation capabilities of the economic system have become crucial issues for Azerbaijan's territory and its economy [5; 6].

In the presented work, temperature, precipitation, and snow observation data for the Republic of Azerbaijan and its regions were analyzed com-

paratively, and the impact of climate change on these meteorological parameters was studied.

2. Research Methodology

The presented work utilized observation data from automatic and traditional meteorological stations operating under the National Hydrometeorological Service (MHX), mathematical statistical methods, and the temperature and precipitation norm from the 1961-1990 period [7].

3. Analysis and discussion

Dynamics of changes in the meteorological conditions of the Greater Caucasus region of Azerbaijan for the 2017-2023 period. The snow cover, average, maximum, and minimum temperatures, and precipitation regime of the Saribash (1680m), Altiaghaj (1099m), and Khaltan (1063m) regions in the Greater Caucasus were analyzed.

In Saribash (1680 m), a decrease in snow cover height is observed over the years for the months of January, February, and November, with the exception of December 2020 (335 cm), while an increase is observed in March and April. Overall, more snow fell in February (1618 cm) and March (165 cm) compared to January. A gradual decrease in snow cover over the years is observed in November, while an increase is observed in April. More snow fell in April compared to November. The first snow in Saribash began to fall in October 2018.

It can be seen from Figure 1 that the most snow in Sarıbaş over the seven-year period fell in March 2022.

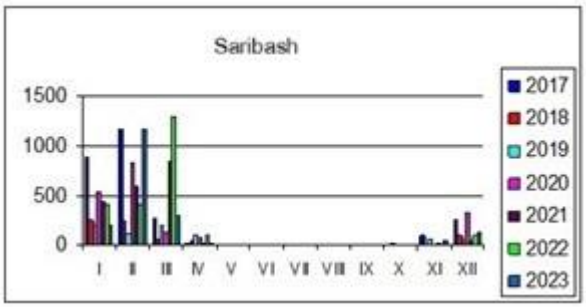

Figure 1. Dynamics of changes in total snow by month for 2017-2023

In Saribash, the average monthly temperatures increased more significantly in all months except June, July, and August, with a particularly notable increase in November. A gradual increase in the maximum daily temperatures over the years is observed, especially during the winter and autumn seasons. The minimum daily temperatures decreased, particularly in the winter season. With the exception of December 2021 (-12.7°C), they decreased by approximately 2.1°C in January and by 1.2°C in December. In the autumn season, the minimum daily temperatures also decreased in September and November. In October, they remained almost constant, with the exception of the year 2021. Precipitation during the month decreased in January, February, and October, but increased during the spring and summer seasons.

In Altıaghaj (1099 m), the total snow cover gradually increased in January and March, with the exception of January 2019. It even reached 540 cm in March 2022, which is 44 cm more than the snow that fell in December 2020 (496 cm) during the multi-year period. However, it began to gradually decrease in February. Snow also fell in Altıağac in April. The highest snow cover here was recorded in 2018 and increased in the following years compared to 2017. As a result of the year-over-year increase in snow in March during the multi-year period, the total snow that fell in this month became approximately equal to the total snow that fell in January.

The average annual temperatures decreased in January, May, and September of 2020 and 2023, but increased in other months, particularly in October and November. The maximum daily temperatures increased in November, December, and January. The minimum daily temperatures, however, decreased in all months, especially in April and November. Precipitation was higher than the norm in 2020 but decreased in other years. On March 21st, 52 cm of snow fell.

In Khaltan (1063 m), during the multi-year period, starting from 2018, less snow gradually began to fall in the cold months, with the exception of March 2017 (1393 cm) and December 2017 (113 cm). This decrease was more pronounced in 2018 and 2019. More snow fell in April compared to November. On March 19, 2022, the maximum snow depth was 47 cm.

In Khaltan, the average annual temperatures decreased in January, May, and June but increased in other months. The maximum daily temperatures increased. The minimum daily temperatures increased in January 2023 (-22.9°C) and October 2021, but a decrease over the years was observed in other months. Precipitation increased in February, April, May, July, August, and November, but decreased more significantly in January and December.

The total snow that fell over the last seven years in the Saribash, Altiaghaj, and Khaltan regions of the Greater Caucasus is shown in Figure 2.

It can be seen from Figure 2 that more snow fell in Saribash compared to the other regions. Furthermore, as the altitude decreases, more snow

fell in March in Khaltan compared to Altiaghaj (Figure 3).

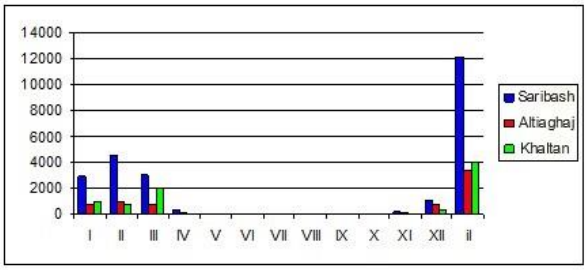

Figure 2. Dynamics of changes in total snow by month over seven years (2017-2023) in the Greater Caucasus

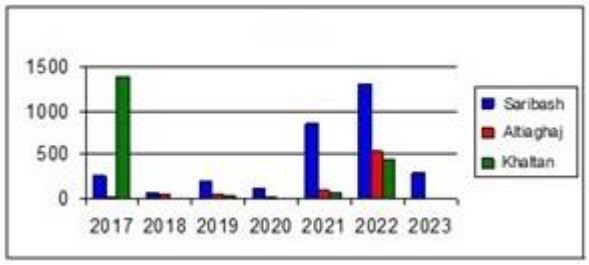

Figure 3. Dynamics of changes in snowfall in March in the Greater Caucasus over the years

Figure 3 shows that the increased snowfall in March over the last three years in Saribash, which is located at a higher altitude than Altiaghaj and Khaltan, compared to previous years, can be considered a result of rising temperatures across altitudes and seasonal changes.

Dynamics of changes in the meteorological conditions of the Lesser Caucasus for the 2017-2023 period. The snow cover, average, maximum, and minimum temperatures, and precipitation regime of the Dashkasan (1637m), Gadabay (1414m), and Goygol (1584m) regions in the Lesser Caucasus were analyzed.

In Dashkasan (1637 m), a decrease in snow over the years is observed, with the exception of February 2017 and the January-February months of 2021. An increase is observed in the months of March and December. The most snow within a year fell in March 2021 and March 2022, with 266 cm and 253 cm, respectively. Over the last seven years, more snow fell in Dashkasan in December, February, and March compared to January.

The average monthly temperature increased in all months, with the exception of January 2023 and the September and October months of 2021. The increase was particularly notable in November and December. The maximum temperatures during the month increased most significantly in November and December. The minimum temperature decreased the most in January and November.

An increase in precipitation over the years is observed during the months of December, April, and May. A decrease is observed in other months, particularly in January.

In Goygol (1584 m), a decrease in snow over the years is observed in January and February (with the exception of 2021), while an increase is observed in March and December. During this multi-year period, more snow fell in March 2019 and March 2022 compared to the January, February, and December months of those years. An increase in snowfall in April compared to previous years is also observed. Over the multi-year period, 158 cm more snow fell in March than in January, and 206 cm more than in December.

In Goygol, the average monthly temperatures increased primarily in November and December, but decreased in January. An increase in maximum daily temperatures was most observed in September, October, November, December, January, February, and March. The average monthly precipitation increased in June and December but decreased in other months.

In Gadabay (1414 m), snow in January decreased over the years during the multi-year period, with the exception of 2021 (105 cm). The least snow in February during this period fell in 2022 (14 cm). Snow in February decreased from 2017 to 2020, increased in 2021 (186 cm), sharply decreased in 2022, and increased again in 2023 (122 cm). In 2022, less snow fell in February, while more fell in March (194 cm). Snowfall in December has increased over the years. Overall, during this period, more snow fell in February and March than in January.

The average monthly temperature increased in all months, particularly in November. The maximum daily temperatures increased more during the winter and autumn seasons, while the minimum temperatures decreased, with the exception of December. The average monthly precipitation increased in October and November but decreased in other months.

The total snow that fell over the last seven years in the Dashkasan, Goygol, and Gadabay regions of the Lesser Caucasus is shown in Figure 4.

It can be seen from Figure 4 that snow fell in approximately equal amounts in all three regions in January. More snow fell in Dashkasan in February, March, and December. In Gadabay, which is located at a lower altitude than Goygol, more snow fell in March compared to January. In the analyzed regions of the Lesser Caucasus, a gradual decrease in snow over the last 7 years is

observed in January and December, while an increase is observed in February and March (Figure 5).

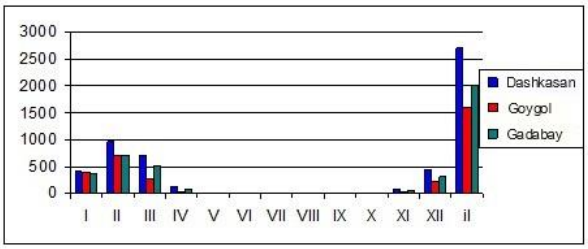

Figure 4. Dynamics of changes in total snow by month (2017-2023) across the Lesser Caucasus

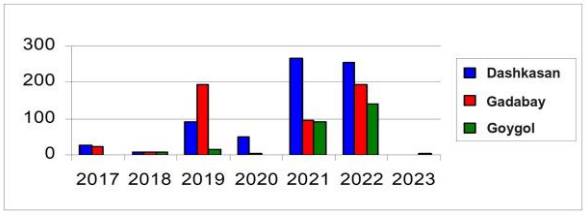

Figure 5. Dynamics of year-to-year changes in total snow fallen during the month of March in the Lesser Caucasus.

Figure 5 also shows that snow fell in all three regions in March every year. Less snow fell in Dashkasan and Gadabay in March of 2017 and 2018. In 2019, it increased significantly in Gadabay. In 2020, less snow fell in Gadabay, while more fell in Dashkasan. In 2021 and 2022, a lot of snow fell in all three regions, particularly in Dashkasan. An increase in snow in March over this multi-year period is observed in Dashkasan, as well as in Gadabay and Goygol. In 2023, snow decreased; conversely, precipitation (rain) was higher.

4. Conclusion

1. It was observed that in March, a large amount of snow fell in Khaltan in 2017, which decreased in subsequent years. Conversely, in Altiaghaj, an increase over the years was observed.

2. In Saribash, which is located at a higher altitude than Altiaghaj and Khaltan, more snow fell in March during the last three years compared to previous years.

3. In Saribash, Altiaghaj, and Khaltan, the average monthly temperatures increased primarily in October and November, while precipitation decreased more significantly in January and December.

4. In Dashkasan, a decrease in snow over the years is observed, with the exception of February 2017 and the January-February months of 2021. An increase is observed in March and December.

5. In Dashkasan, the average monthly temperature increased in all months, particularly in November and December. A gradual increase in precipitation was observed in December, while a decrease was observed in February and other months, especially January.

6. In Goygol, more snow fell in February and March compared to January and December. An increase in snow in April compared to previous years was also observed.

7. In Goygol, the average monthly temperatures increased primarily in November and December but decreased in January. The average monthly precipitation increased in June and December but decreased in other months.

8. In Gadabay, more snow fell in February and March than in January. The average monthly temperature increased in all months, particularly in November. The average monthly precipitation increased in October and November but decreased in other months.

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AZƏRBAYCAN RESPUBLİKASINDA TEMPERATUR, QAR, YAĞINTI REJİMİNİN (2017-2023 çoxillik dövrü üzrə) TƏHLİLİ

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Xülasə. Çoxillik müşahidələrin təhlili göstərir ki, Azərbaycan Repsublikası daxilində, Böyük Qafqaz və Kiçik Qafqazda orta illik temperaturlar həm norma ilə, həm də özündən əvvəlki illərlə müqayisədə artır. Orta illik temperatur Böyük və Kiçik Qafqazda 2021-ci ildə daha çox artmışdır. Respublika üzrə qar və yağışın illər üzrə azalması müşahidə edilir. Çoxillik müşahidələr göstərir ki, qarın azaldığı illərdə yağış artır, yağışın azaldığı illərdə həmən əraziyə qar çox düşür. 2021-ci ildə respublikaya qar oktyabr ayından yağmışdır. 2021-ci ildə respublikaya yağış normadan -134 mm az düşmüşdür. 2020-2023-cü illərlə müqayisədə ən çox qar 2022-ci ildə yağmış, və əsasən yanvar ayına daha çox düşmüşdür. 2022-ci ildə yağış normadan -144.3 mm az olmuşdur. 2022-2023-cü illərdə qar may, hətta aprel ayında da yağmışdır. 2023-cü ilin may ayına noyabr ayından daha çox qar yağmışdır. 2023-cü ildə qar respublikaya may, aprel aylarında da yağsada əvvəlki illərin yanvar, fevral, mart, dekabr ayları ilə müqayisdə azalmış, əksinə yağış artmış və təxminən normaya bərabər olmuşdur. Orta illik temperatur normadan 2022-ci ildə 2^0C, 2023-cü ildə isə 2.2 ^{0}C çox olmuşdur.

Açar sözlər: Böyük Qafqaz, Kiçik Qafqaz, orta illik temperatur, meteoroloji elementlər, qar, yağış, müşahidə məlumatları.