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SPECIFIC CHANGES IN MAIN CLIMATIC CHARACTERISTICS OF THE DEBED RIVER BASIN (ARMENIA)

В. Г. Маргарян, В. Г. Клименко, Н. І. Черкашина. ОСОБЛИВОСТІ ЗМІН ОСНОВНИХ КЛІМАТИЧНИХ ХАРАКТЕРСИТИК У БАСЕЙНІ РІКИ ДЕБЕД (ВІРМЕНІЯ). *В роботі розглядається зміна основних кліматичних характеристик басейну Дебед (Вірменія). В даний момент - це одна з актуальних проблем, так як багато вчених вважають, що кінець 20 і початок 21 століття, є періодами змін основних кліматичних характеристик. Так середня річна температура приземного шару повітря зростає, а кількість опадів зменшується. В якості вихідного матеріалу в роботі були використані середні місячні дані фактичних спостережень за температурою приземного шару повітря і кількістю опадів «Центру гідрометеорології і моніторингу» ГНКО Міністерства навколишнього середовища Республіки Вірменія басейну Дебед. Дослідження проводилися на 6 метеорологічних станціях басейну р. Дебед (Баграташен, Ташир, Одзун, Степанаван, Пушкінський перевал, Ванадзор) за період спостережень з середини 1930-х рр. по 2018 р. В результаті досліджень було встановлено, що на території, що вивчається розподіл температури повітря і опадів нерівномірний. Так з висотою місцевості знижується температура повітря і збільшується кількість опадів. Вертикальний градієнт відповідно становить 0,54 ℃ / 100 м і -20 мм / 100 м. Середньорічна температура повітря коливається в межах від 3,74 ℃ до 12,3 ℃, а річна кількість опадів - від 462 мм до 770 мм. Дослідження показали також повсюдну тенденцію до підвищення середньорічної температури повітря і зменшення річної кількості опадів (за винятком деяких метеорологічних станцій). Було встановлено, що в середньому по басейну Дебед з 1964 р. по 1992 р. температура повітря за рік підвищилася на 0,68 °C, з 1993 по 2018 р. - на 1,01 °C, а з 1964 по 2018 р. - на 1,65 °C. В середньому по басейну Дебед відбувається зменшення річної суми опадів, так з 1964 р. по 2001 р. на 126 мм, з 2002 по 2018 р. - на 105 мм. На окремих метеостанціях (Степанаван) спостерігається також тенденція незначного збільшення кількості опадів, особливо значно - після 2002 року.*

Ключові слова: *басейн р. Дебед, річна температура повітря, річна кількість атмосферних опадів, розподіл лінії тренду, багаторічні зміни.*

В. Г. Маргарян, В. Г. Клименко, Н. И. Черкашина. ОСОБЕННОСТИ ИЗМЕНЕНИЙ ОСНОВНЫХ КЛИМАТИЧЕСКИХ ХАРАКТЕРИСТИК В БАССЕЙНЕ РЕКИ ДЕБЕД (АРМЕНИЯ). *В работе рассматривается изменение основных климатических характеристик бассейна Дебед (Армения). В данный момент – это одна из актуальных проблем, так как многие ученые считают, что конец 20 и начало 21 века, являются периодами изменений основных климатических характеристик. Так средняя годовая температура приземного слоя воздуха возрастает, а количество осадков уменьшается. В качестве исходного материала в работе были использованы средние месячные данные фактических наблюдений за температурой приземного слоя воздуха и количеством осадков «Центра гидрометеорологии и мониторинга» ГНКО Министерства окружающей среды Республики Армения бассейна Дебед. Исследования проводились на 6 метеорологических станциях бассейна р. Дебед (Баграташен, Ташир, Одзун, Степанаван, Пушкинский перевал, Ванадзор) за период наблюдений с середины 1930-х гг. по 2018 г. В результате исследований было установлено, что на изучаемой территории распределение температуры воздуха и осадков неравномерное. Так с высотой местности понижается температура воздуха и увеличивается количество осадков. Вертикальный градиент соответственно составляет 0,54 ℃ / 100 м и -20 мм / 100 м. Среднегодовая температура воздуха колеблется в пределах от 3,74 ℃ до 12,3 ℃, а годовое количество осадков – от 462 мм до 770 мм. Исследования показали также повсеместную тенденцию к повышению среднегодовой температуры воздуха и уменьшения годового количества осадков (за исключением некоторых метеорологических станций). Было установлено, что в среднем по бассейну Дебед с 1964 г. по 1992 г. температура воздуха за год повысилась на 0,68 °C, с 1993 по 2018 г. – на 1,01 °C, а с 1964 по 2018 г. – на 1,65 °C. В среднем по бассейну Дебед происходит уменьшение годовой суммы осадков, так с 1964 г. по 2001 г. на 126 мм, с 2002 по 2018 г. – на 105 мм. На отдельных метеостанциях (Степанаван) наблюдается также тенденция незначительного увеличения количества осадков, особенно значительно – после 2002 года.*

Ключевые слова: *бассейн р. Дебед, годовая температура воздуха, годовое количество атмосферных осадков, распределение линии тренда, многолетние изменения.*

Introduction. For the past several decades the planet's climate has been rapidly changing due to global warming. The problem of assessing the macroeconomic consequences of climate change in a given territory arose at its background in a given territory [15]. Moreover, the problem of global climate change has gone beyond the scope of scientific research in this area. It has become the subject of discussion for officials and politicians at various international scientific and political forums. This has led to formulation of solutions on adaptation to climate change and mitigation of their consequences

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[11]. Armenia also did not stay away from the problems of global climate change. According to the 4th national meeting [18] on climate change in the Republic of Armenia in the period from 1929-1996 the average annual temperature increased by 0.4 ºC, from 1929 to 2007 - by 0.85 ºC, from 1929-2012 - by 1.03 ºC. From 1929 to 2016 it increased by 1.23 ºC, and the average annual precipitation decreased by 6% over the period from 1935-1996 and about 9% - for 1935-2016.

Numerous scientific works consider standard climatic characteristics, such as average annual and average monthly air temperatures, the amount of precipitation for the year and in individual months [6, 11, 19-20]. G.A. Aleksandryan [2], A.B. Bagdasaryan [4], V.G. Margaryan [12-13, 21-22], G. Nersesyan [14], G. G. Surenyan [16] et.al made a great contribution to the study of the main climatic characteristics of Armenia. The issue of climate change in the Republic of Armenia was discussed at the fourth national meeting [18]. A number of climate reference books contain the data on air temperature and precipitation in Armenia [7-8]. This work evaluates the change in the main climatic characteristics in the Debed river basin, using a long series of instrumental observation data (1930–2018).

Research methods and initial data. To solve the set tasks, the authors used corresponding research and published works as a theoretical basis in their work. As a starting material in the work, we used the daily factual data of the "Center for Hydrometeorology and Monitoring" of the SNCO, the Ministry of Environment of the Republic of Armenia for more than 80 years (1930–2018) at six meteorological stations.

The authors used the mathematical and statistical, extrapolation, analysis, analogy, correlation, cartographic methods in their research.

To identify climate changes over a significant period, two types of non-stationary mean models were used: a linear trend and stepwise changes in relation to the basic stationary model. In [9, 11]. We have found that the model of stepwise changes in the mean value is more effective than the linear trend model. At the same time, even a preliminary visual analysis indicates that the model of stepwise changes in mean values is more consistent with the structure of the series than the trend model, although it can also be statistically significant [10].

The aim of this work is to analyze and assess the features of the territorial distribution of the main climatic indicators in the Debed river basin, their changes over the past 80–90 years in different conditions of Armenia.

Physical and geographical characteristics of the river Debed basin.

River Debed (Fig. 1) basin is located in the north of the Republic of Armenia. It occupies an area of 3790 km2 within the republic (4080 km^2 outside). The lowest point (375 m) of the territory of Armenia is located in the lower reaches of the Debed River. The basin is distinguished by a rugged relief, there are canyons reaching 300 meters in depth (the canyon of the Debed River), as well as separate massifs, reaching more than 2500 meters in height. The difference in altitude exceeds 2800 m.

On the territory of the river Debed there are mountain ranges, valleys with different slopes and exposures, which create a variety of air temperature and precipitation distribution in both vertical and horizontal directions. In the west from the Shirak marz, it is separated by the Javakhk ridge, on the south side it is bounded by the Pambak ridge. The eastern border goes along the divide line between the right tributaries of the Debet and Aghstev rivers. From the west and south-west towards the east and northeast it gradually decreases towards the valley of the Kura river. Lori highland plain, with an average height of 1500 m, is located between the Virahayotsky (Somkheti) and Bazum ridges, Pambak depression is between the Bazum and Pambak ridges [4, 22].

The basin is distinguished by significant moderation: the average annual air temperature amplitudes reach 20.0–22.0 ºC. Winters are mild, a particularly large percentage is thawed weather (40-60%).

In the Debed river basin you can trace the mountain-forest, mountain-steppe and alpine climatic zones.A temperate climate of dry steppes forms only in the deep gorges of the extreme northeastern part of the basin. The plain parts of the basin are covered with chernozems with different steppe vegetation, and the mountain slopes are covered with brown-greyish and brown-wooded podzolized soils with deciduous forests. A significant part of the slopes of these ridges is covered with forests [4].

Research results. The study area is characterized by an uneven distribution of air temperature and precipitation due mainly to the geographical latitude of the area, general and local circulation of the atmosphere, nature of the active surface, radiation energy and orographic features.

The average annual temperature is positive on the river Debed territory at heights from 451 m to 2066 m, according to actual observations (Table 1). Long-term average annual air temperatures for the period from the 60s of the 20th century to 2018 on average vary from 3.7 ºC (Pushkin pass) to 12.3 ºC (Bagratashen). Of the 6 meteorological stations, the lowest values of the average monthly temperature (-6.4 ºC) are in January at the Pushkin Pass, and the highest values (23.7-24.0 ºC) are in Bagratashen in

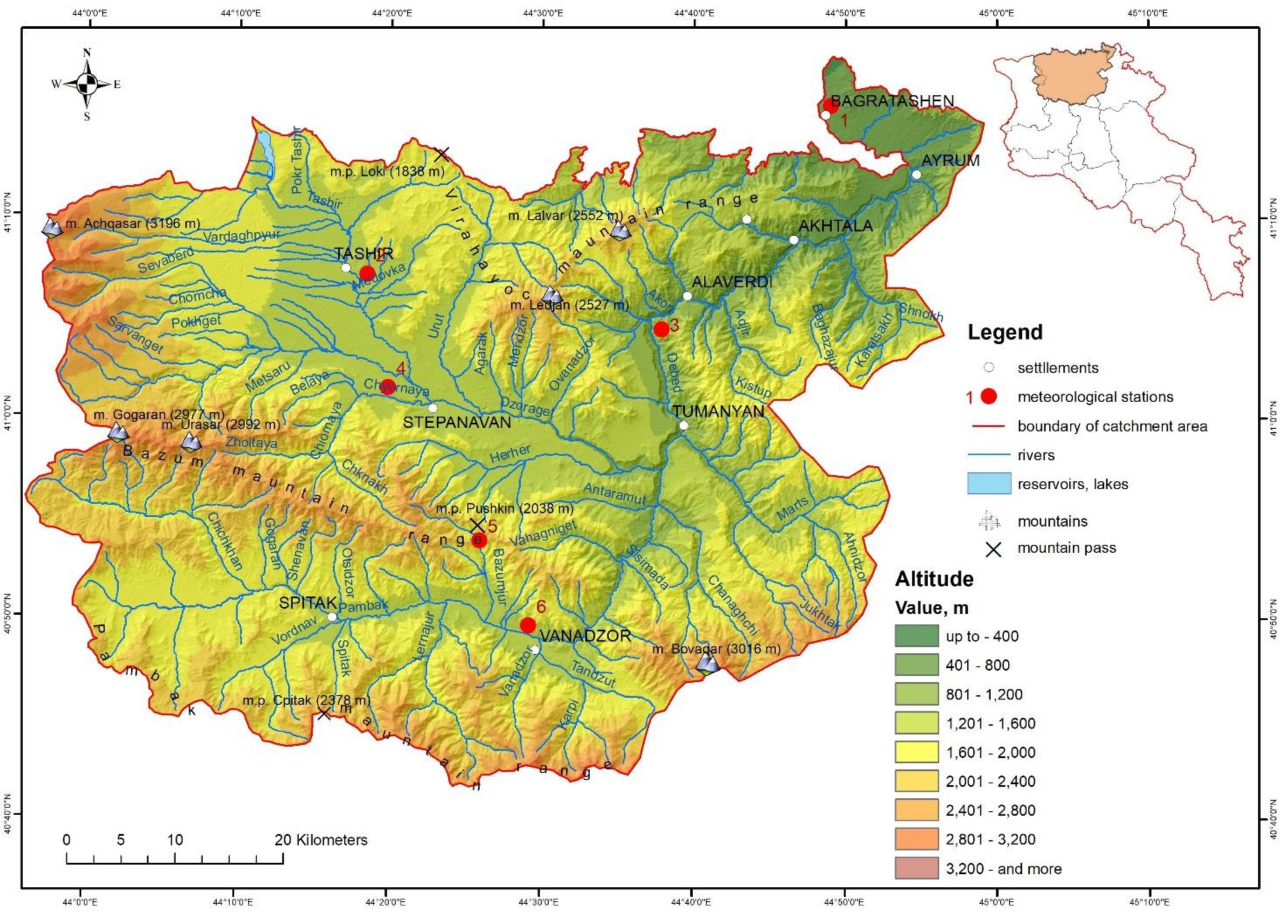

Fig. 1. The network of meteorological stations in the Debed river basin.
1 - settlements; 2 - border of the Debed river basin; 3 - rivers; 4 - lake; 5 - passes;
6 - *theorological stations:* 1 - Bagratashen, 2 - Tashir, 3 - Odzun, 4 - Stepanavan,
5 - Pushkin Pass, 6 - Vanadzor; 7 - *meteorological posts*

Table 1

Values of average and extreme annual air temperatures at meteorological stations for the period 1964-2018

№	Meteorological stations	Height, m	Air temperature, °C	Atmospheric precipitation, mm
1	Bagratashen	451	12,3	462
2	Tashir	1507	6,2	731
3	Odzun	1105	9,5	547
4	Stepanavan	1397	7,3	668
5	Pushkin pass	2066	3,7	770
6	Vanadzor	1376	8,3	566

July-August. In March-April, the average monthly temperature becomes positive when snowmelt and floods occur in the rivers of the basin.

The annual amount of atmospheric precipitation changes dramatically. Long-term average annual precipitation values for the period 1964-2018 are in the range from 462 mm (Bagratashen) to 770 mm (Pushkin pass). Relatively high rainfall is in the Lori Basin. Here, in Tashir, at an altitude of 1507 m, the annual precipitation is 731 mm, and in Stepanavan at an altitude of 1397 - 668 mm. There is comparatively less precipitation in the lower reaches of the Debed River (Bagratashen) and in the valley of the Pambak River, in the Spitak Basin (Spitak, 439 mm). A significant part of precipitation falls in April-June (35-45% of the annual amount), minimum amount is in the second half of summer and winter. Moreover, the amount of precipitation in the summer months exceeds the amount of precipitation in the winter months.

As a rule, along with the absolute height of the area, the annual air temperature naturally decreases (Fig. 2-a) and the annual amount of precipitation increases (Fig. 2-b). Annual air temperature decreases on average by 0.5 ºC with an altitude of every 100 m and the annual precipitation increases by 20 mm. Based on this connection, it is possible to study the air temperature regime and the amount of precipitation in unexplored and poorly studied areas and to build a map of the territorial distribution of the latter.

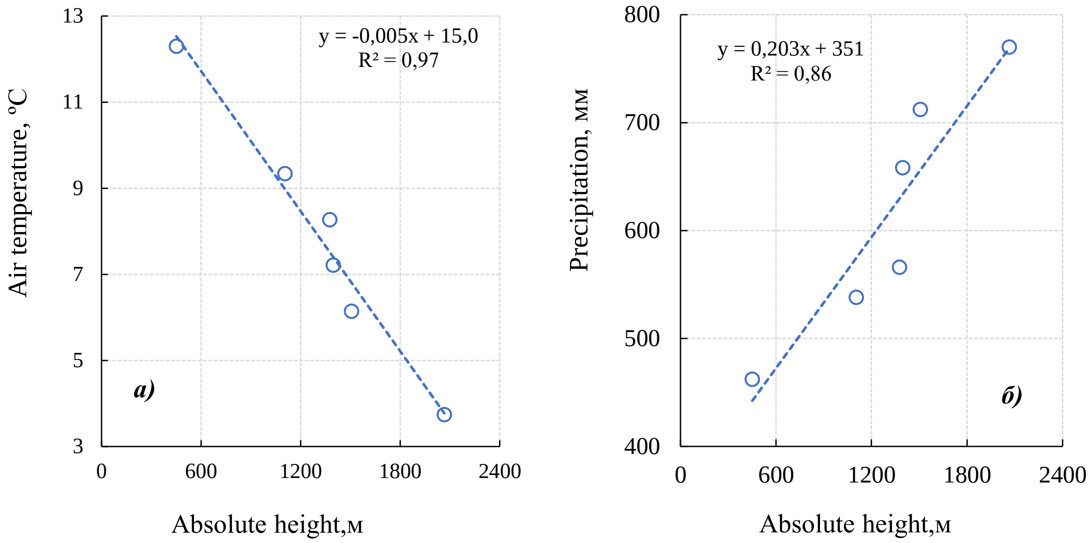

Fig. 2. Dependence of air temperature (a) and atmospheric precipitation (b) onan absolute height in the Debed river basin

Annual precipitation increases with altitude from 450–550 mm below heights of 1000–1100 m to 750 mm above 2000 m. The air temperature, on the contrary, decreases with altitude: at heights up to 1000–1100 m, it changes from 12.0–12 .5 to 9.0–1.0 ° C, and at altitudes of 2000 m and more, it reaches almost 4.0–4.5 ° C (Fig. 2).

Fig. 3 shows the intra-annual distribution of air temperature, atmospheric precipitation at Stepanavan meteorological station and river runoff on the example of Stepanavan water measuring station of the Dzoraget River. As we can see from the figure, the river runoff depends on air temperature and precipitation.

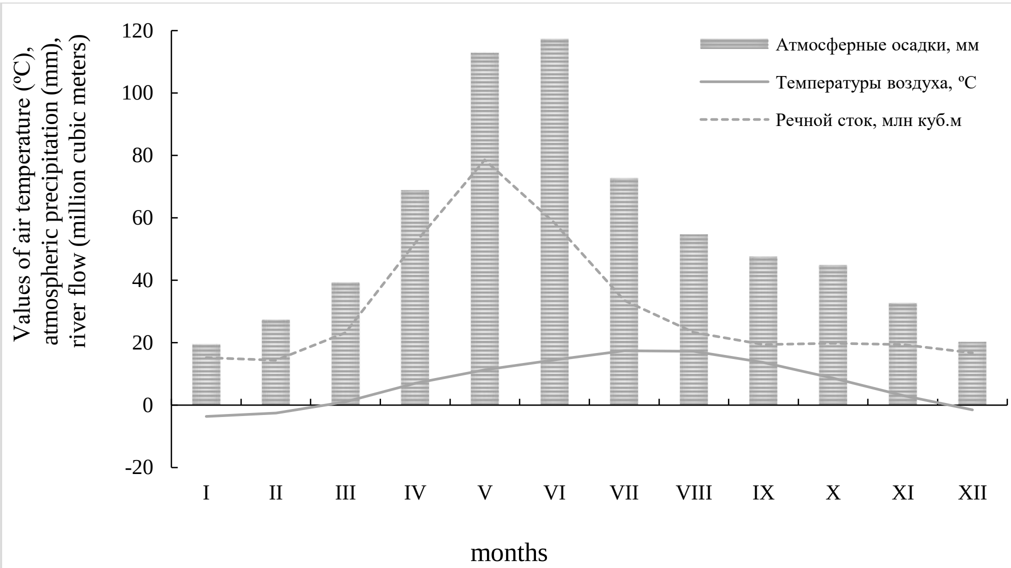

Fig. 3. Annual variation of air temperature and atmospheric precipitation at the weather station Stepanavan, the Dzoraget river flow (Stepanavan village)

The river runoff rises with an increase in atmospheric precipitation, and with an increase in air temperature, on the contrary, it decreases. However, in spring, a steady transition of temperature over 0 ºC leads to an increase in river runoff due to snow melting. Thus, the formation of the river runoff, as well as its intra-annual distribution, is closely related to the climatic conditions of a given territory, in particular, to the spatial and temporal features of air temperature and precipitation. Therefore, to identify the intra-annual distribution of the river flow in any territory, it is necessary to study in detail distribution of air temperature and precipitation in this territory in time and space.

The authors assessed changes in the mean annual air temperature and atmospheric precipitation both for the entire territory of the Debed basin (Fig. 4), and for each of the currently operating meteorological stations separately (Fig. 5). We found a stable positive trend in the average annual air temperature and a stable negative trend in the annual amount of atmospheric precipitation in the river Debed basin as a whole. Since meteorological stations began their activity at different times (for example, the Pushkin Pass meteorological station has been operating since 1963), the average air temperature for the year and the annual amount of precipitation for the entire territory have been calculated since 1964.

As follows from Fig. 4 (a, b), the air temperature trend lines are positive. This pattern also characterises other regions of our planet, including the South Caucasus [19], Eastern Georgia [17], on the territory of the high-mountain landscapes of the North-East Caucasus [1], the Russian Federation [6], the territories of all CIS states [5], Ulyanovsk region [15], landscapes of the North Caucasus [3]. Since the 1960s, there has been a clear change in annual temperatures, especially in the mid-1990s. Changes in the air temperature trend are represented by two trend lines: for the period 1964–1992 and 1993–2018, which are positive. However, for the period 1964-1992 the rate of annual warming (+0.227 ºC / 10 years) is less than the rate of annual warming (+0.389 ºC / 10 years) for the period 1993–2018. A significant increase in annual temperatures is observed especially over the period 1993–2018. (Table 2). On average, from 1964 to 1992, the air temperature over the year increased by 0.68 ° C, from 1993 to 2018 - by 1.01 ° C, and from 1964 to 2018 - by 1.65 ° C in the Debed basin.

The trend lines of the annual amount of atmospheric precipitation are negative (Fig. 4-c, d). As a result of the research,we identified two changes in trend lines: for the period 1964-2001 and 2002–2018. The rate of change in the annual amount of atmospheric precipitation for the period 1964–2001 is -33.2 mm / 10 years, and for the period 2002–2018 is 61.7 mm / 10 years. As for the entire period 1964-2018, the rate of precipitation change is insignificant - 1.02 mm / 10 years (Fig. 4-c). On average, in the Debed basin, the decrease in the annual amount of precipitation was 126 mm from 1964 to 2001, by 105 mm - from 2002 to 2018 (Table 2).

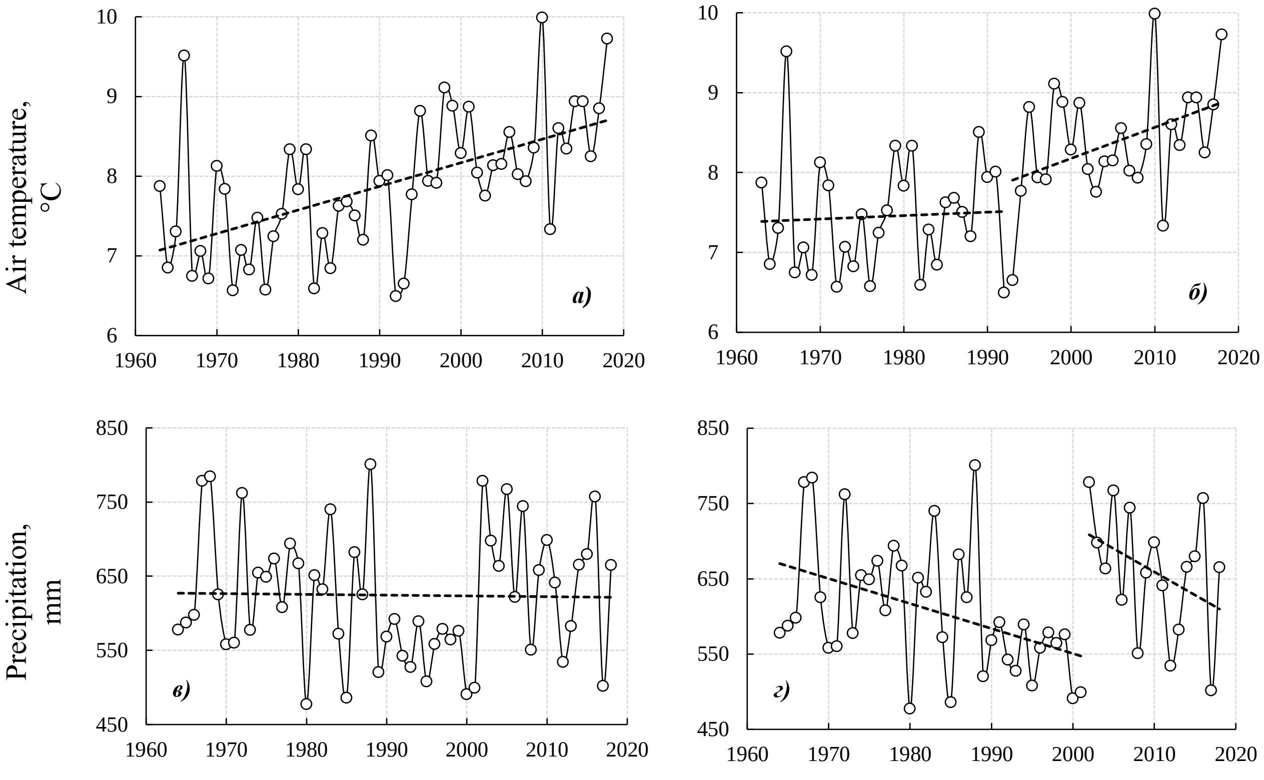

Fig. 4. Long-term changes in the average air temperature (a, b) and the amount of precipitation (c, d) per year in the basin of the river Debed

Table 2

Statistical characteristics of the average annual air temperature and precipitation

Name	Periods	Statistical characteristics			
		rate of change in temperature (ºC / 10 years) and the amount of precipitation (mm / 10 years)	changes in temperature (ºC) and the amount of precipitation (mm)	root mean square error	coefficient variations
Air temperatures, ºC					
At all stations	1964-1992	+0,227	0,68	1,64	0,51
	1993-2018	+0,389	1,01	1,69	0,81
Annual precipitation, mm					
At all stations	1964–2001	-33,2	126	0,14	15,9
	2002–2018	-61,7	105	0,14	18,0

In the Debed basin, as a whole ,we noticed relatively low annual temperatures (less than 6.5–6.6 ºC) over the past 60 years - 1972, 1976, 1982, 1992. Since 1993, there has been a sharp rise in temperature. Comparatively high annual temperatures (over 9.5 ºC) were in 1966, 2010 and 2018. The warmest were 1966 and 2010 on the territory of alpine landscapes of the North-Eastern Caucasus [1]. A small annual amount of precipitation (less than 500 mm) was recorded in 1980, 1985, 2000, 2016, a large amount of precipitation (more than 750 mm) - in 1967, 1968, 1972, 1988, 2001, 2004, 2015.

Table 2 illustrates characteristics of changes in air temperature and precipitation in the basin of the Debed river. As we see, the standard deviation of air temperature is greater than that of precipitation, and the coefficient of variation of air temperature, on the contrary, is less. On the territory under consideration, as a whole, the standard deviations for air temperature vary within 1.64–1.69 for the period from 1964–1992 to 1993–2018. The coefficient of variation is 0.51–0.81, and for precipitation, respectively 0.14 and 15.9-18.0. For air temperature, with an increase in standard deviations, the coefficient of variation also increases. Moreover, the standard deviations have smaller values than the coefficient of variation.

Fig. 5 and Fig. 6 shows the long-term changes in the average annual air temperature and the annual amount of precipitation in the Debed river basin for meteorological stations at different heights: Stepanavan - 1397 m, Odzun - 1105 m. In the Debed basin, according to the data of all operating meteorological stations, we observed a tendency towards an increase in the average annual air temperature, what cannot be said about precipitation.

Changes in the air temperature trend for the Stepanavan and Odzun meteorological stations are also represented by two positive trend lines (Fig. 5 - b, d). Changes in the air temperature trend for the Stepanavan meteorological station are presented for the period 1932–1992 and 1993–2018, and for the Odzun meteorological stations - for the period 1940–1992 and 1993–2018. The rate of annual warming is higher and amounts to +0.397 ºC / 10 years - for the Stepanavan meteorological stations and +0.383 ºC / 10 years - for the Odzun meteorological stations for the period 1993–2018. For the period 1993–2018 there is a significant increase in annual temperatures. So, for the Stepanavan meteorological station, the air temperature over the year, respectively, increased by 1.03 ° C and 1.00 ° C from 1993 to 2018.

The trend lines of the annual amount of atmospheric precipitation are both positive (Fig. 6 - a) and negative (Fig. 6 - c). The rate of change in the annual amount of atmospheric precipitation at the Stepanavan meteorological stations for the period 1932-2001 is +2,328 mm / 10 years, and at the Odzun meteorological stations for the period 1940–1992 is 4.817 mm / 10 years.

As a result of the research,we identified two changes in trend lines for the period 1932–2001 and 2002–2018 - at the Stepanavan meteorological stations (Fig. 6 - b); for the period 1940–2001 and 2002–2018 - at the Odzun meteorological station (Fig. 6 - d). The rate of change for the Stepanavan meteorological station in the annual amount of atmospheric precipitation is +1.28 mm / 10 years for the period 1932–2001 and -79.056 mm / 10 years - for the period 2002–2018. (Fig. 6 b). At the Odzun meteorological stations, the rate of change in the annual amount of atmospheric precipitation is -13.45 mm / 10 years for the period 1940–2001 and

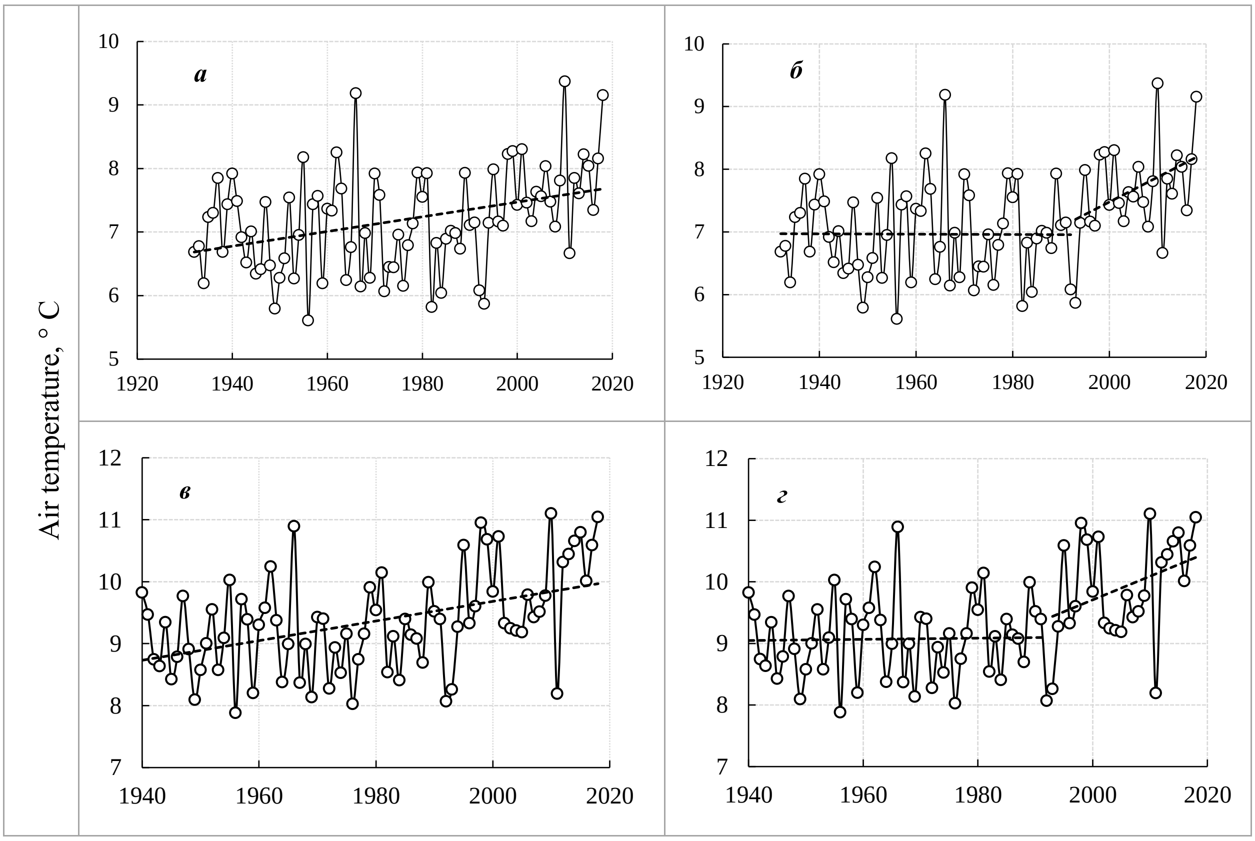

Fig. 5. Long-term changes in the average annual air temperature in the basin of the river Debed for meteorological stations at different heights: Stepanavan - 1397 m (a, b), Odzun - 1105 m (c, d)

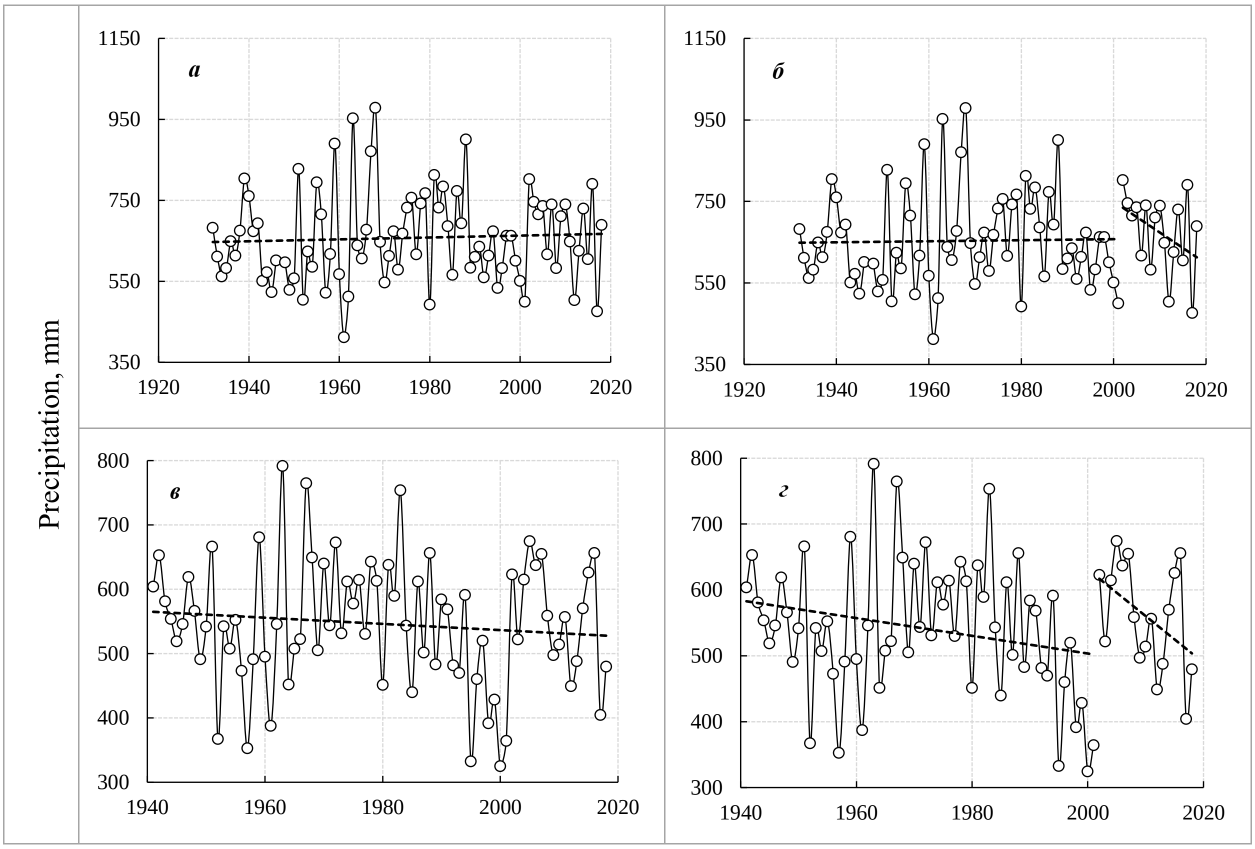

Fig. 6. Long-term changes in the annual amount of precipitation in the basin of the river Debed for meteorological stations at different heights: Stepanavan - 1397 m (a, b), Odzun - 1105 m (c, d)

-70.85 mm / 10 years - for the period 2002–2018. (Fig. 6 d)

Thus, over the entire observation period, the rate of change in precipitation is insignificant - +2.328 mm / 10 years (Stepanavan) and - 4.817 mm / 10 years (Odzun). Significant changes in the annual amount of atmospheric precipitation occur more over the period 2002–2018 - from -79.056 mm / 10 years (Stepanavan) to -70.85 mm / 10 years (Odzun). On average, the decrease in the annual amount of precipitation ranges from 120 mm (Odzun) to 129 mm (Stepanavan) and this occured from 2002 to 2018.

In the study area, we observe a tendency towards a decrease in the annual amount of precipitation, especially since 2002. At the Stepanavan meteorological station, there is a tendency for a slight increase in the amount of precipitation for the period 1932–2018 (Fig. 6 - a) and for the period 1932-2001 (Fig. 6 - b). The revealed tendencies of changes in the amount of precipitation in comparison with the tendencies of changes in air temperature have a lower statistical significance and are less stable. A weak tendency to an increase in the amount of precipitation is observed in other regions [15].

Conclusions. As a result of the research, we came to the following conclusions:

- distribution of air temperature and precipitation in the study area is uneven. The air temperature decreases and the amount of precipitation increases with the height. The vertical gradient is 0.54 ºC / 100 m and -20 mm / 100 m, respectively. The average annual air temperature ranges from 3.74 ºC to 12.3 ºC, and the annual precipitation ranges from 462 mm to 770 mm;

- long-term fluctuations of the average air temperature for the year are characterized by positive trends in all places. On average, from 1964 to 2018 the air temperature in the basin of the Debed river increased by 1.65 ° C. A significant increase in annual temperatures has been observed after the 1990s, when the rate of annual warming was +0.389 ºC / 10 years (for the period 1993–2018). The warmest years were 1966, 2010 and 2018;

- the tendency to decrease the annual amount of precipitation predominantly prevails. The most significant amount of precipitation decreased after 2002. The rate of change in the annual amount of atmospheric precipitation for the period 2002–2018 was -61.7 mm / 10 years, for the entire period 1964-2018 - 1.02 mm / 10 years. On average,there was a 126 mm decrease in annual precipitation in the basin of the Debed river from 1964 to 2001, by 105 mm - from 2002 to 2018. At the Stepanavan meteorological station, there is a tendency for a slight increase in the amount of precipitation;

- the rate of change in precipitation in the basin of the Debed river is insignificant for the entire observation period for meteorological stations at different heights. So, at the Stepanavan meteorological station, the rate of precipitation change is +2.328 mm / 10 years from 1932 to 1992, and at the Odzun meteorological station - 4.817 mm / 10 years from 1940 to 1992;

- the rate of change in the annual amount of atmospheric precipitation was greater from 2002 to 2018 - from -79.056 mm / 10 years (Stepanavan) to -70.85 mm / 10 years (Odzun). For the period 2002-2018 the decrease in the annual amount of precipitation was in the range from 120 mm (Odzun) to 129 (Stepanavan);

- it is necessary to develop strategic programs to adapt the consequences of changes in the main climatic characteristics. This will serve as a stimulus for the long-term development of the region's economy.

Bibliography

1. *Абдулжалимов А.А. Современные климатические изменения высокогорных ландшафтов Северо–Восточного Кавказа [Текст] / А.А. Абдулжалимов, З.В. Атаев, В.В. Братков // Известия Дагестанского государственного педагогического университета. Естественные и точные науки. – 2015. – № 2. – С. 86–94.*
2. *Александрян Г.А. Атмосферные осадки в Армянской ССР [Текст] / Г.А. Александрян. – Ереван: изд-во АН АрмССР. – 1971. – 180 с.*
3. *Атаев З.В. Реакция ландшафтов Северного Кавказа на современные климатические изменения [Текст] / З.В. Атаев, В.В. Братков // Юг России: экология, развитие. – 2014. – №1. – С. 141–157.*
4. *Багдасарян А. Б. Климат Армянской ССР / А. Б. Багдасарян. – Ереван: изд-во АН АрмССР. – 1958. – 151 с.*
5. *Бардин М. Ю. Особенности наблюдаемых изменений климата на территории Северной Евразии по данным регулярного мониторинга и возможные их факторы [Текст] / М. Ю. Бардин, Т. В. Платова, О.Ф. Самохина // Труды ФГБУ. – М.: Гидрометцентр России. – 2015. – Вып. 358. – С. 13–35.*
6. *Груза Г.В. Наблюдаемые и ожидаемые изменения климата России: температура воздуха [Текст] / Г.В. Груза, Э.Я. Ранькова. – Обнинск: ФГБУ «ВНИИГМИ–МЦД». – 2012. – 194 с.*
7. *Климатический справочник [Текст]. Ч. I. Температура воздуха и почвы. – Ереван, 2011. – 150 с. (на армянском яз.).*
8. *Климатический справочник [Текст]. Часть II. Влажность воздуха, атмосферные осадки и снежный покров. – Ереван, 2012. – 172 с. (на армянском языке).*

9. *Кириллина К. С. Оценка современных климатических изменений температуры воздуха на территории республики Саха (Якутия) [Текст] / К. С. Кириллина, В. А. Лобанов // Ученые записки РГГМУ. – 2015. – № 38. – С. 137–151.*
10. *Лобанов В. А. Оценка климатических изменений температуры воздуха и их устойчивости на территории центральной Азии [Текст] / В. А. Лобанов, С. А. Мамедов // Ученые записки РГГМУ. –2018. –№ 51. – С. 22–36.*
11. *Лобанов В. А. Применение эмпирико-статистических методов для моделирования и анализа климатических изменений [Текст] / В. А. Лобанов, А.Е. Шадурский // Ученые записки РГГМУ. – 2010. – № 14. – С. 73–88.*
12. *Маргарян В.Г. Закономерности пространственно-временных изменений атмосферного увлажнения в РА [Текст]: автореф. дис. ученой степени канд. геогр. наук / В.Г. Маргарян. – Ереван, 2009. – 169 с. (на армянском яз.).*
13. *Маргарян В.Г. Закономерности пространственно-временного изменения экстремальных температур приземного слоя атмосферы и их воздействие на ландшафтную структуру Араратской котловины [Текст] / В.Г. Маргарян, Н.И. Самвелян // Вестник ВГУ, серия: география, геоэкология. – 2019. – №4. – С. 15–22.* https://doi.org/10.17308/geo.2019.4/2707
14. *Нерсесян А. Г. Климат Армении [Текст] / А. Г. Нерсесян. – Ереван. – 1964. – С. 304.*
15. *Переведенцев Ю.П. Изменение основных климатических показателей на территории Ульяновской области [Текст] / Ю.П. Переведенцев, Р.Б Шарипова // Вестник Удмуртского университета. Серия «Биология. Науки о Земле». – 2012. – Вып. 1. – С.136–144.*
16. *Суренян Г. Г. Синоптический анализ барических полей, формирующих погодно–климатические условия Республики Армения [Текст]: дис. канд. геогр. наук / Г. Г. Суренян. – Ереван, 2010. – 145 с. (на армянском яз.).*
17. *Amiranashvili A. Climate Change in Georgia; statistical and nonlinear dynamics predictions / A. Amiranashvili, T. Matcharashvili, T. Chelidze // Journal of Georgian Geophysical Society, Issue (A), Physics of Solid Earth. – V. 15a, 2011-2012. – Pp. 67–87.*
18. *Armenia's fourth national communication on climate change, 2014. – 213 p.*
19. *Building Resilience to Climate Change in South Caucasus Agriculture / Nicolas Ahouissoussi, James E. Neumann, and Jitendra P. Srivastava, Editors. International Bank for Reconstruction and Development, 2014. – 167 p.* https://doi.org/10.1596/978-1-4648-0214-0
20. *IPCC (Intergovernmental Panel on Climate Change: Climate Change). The physical science basis. In Contribution of Working Group I to the Firth Assessment Report of the Intergovernmental Panel on Climate Change / Thomas F. Stocker, Dahe Qin, Gian–Kasper Plattner, Melinda M.B. Tignor, Simon K. Allen, Judith Boschung, Alexander Nauels, Yu Xia, Vincent Bex, Pauline M. Midgley (eds). Cambridge: Cambridge University Press, 2013. – 1552 p.*
21. *Margaryan V.G. Assessment of climatic trend of air temperature at the earth surface in the context of stable development (case of Gyumri city) / V.G. Margaryan // Visnyk of V.N. Karazin Kharkiv National University, series "Geology. Geography. Ecology". – No. 50. – Pp. 125–135.* https://doi.org/10.26565/2410-7360-2019-50-09
22. *Margaryan V. About the features of the time course of the average annual air temperature in the territory of the Debed river basin (Armenia) / V. Margaryan, G. Tsibulskii, K. Raevich // E3S Web of Conferences, 2020. – Vol. 223, id. 03009. Regional Problems of Earth Remote Sensing (RPERS 2020).*

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SPECIFIC CHANGES IN MAIN CLIMATIC CHARACTERISTICS OF THE DEBED RIVER BASIN (ARMENIA)

Formulation of the problem. The article discusses changes in the main climatic characteristics in the Debed river basin (Armenia) at six meteorological stations.

The aim of the work is to analyze and assess peculiar territorial distribution of the main climatic indicators in the Debed river basin, their changes over the past 80-90 years in different conditions of Armenia.

Methods. To solve the set tasks, the authors used corresponding research and published works as a theoretical basis in the work. As a starting material, the work used the daily factual data of the "Center for Hydrometeorology and Monitoring" of the SNCO, Ministry of Environment of the Republic of Armenia for the period from 1930 to 2018 at six meteorological stations.

The authors applied the following research methods in the article: mathematical and statistical, extrapolation, analysis, analogy, correlation, cartographic.

Results. Climate of the earth has been changing rapidly over the past decades, leading to global warming. As a result, we are facing the problem of assessing the macroeconomic consequences of climate change in this territory. Armenia did not remain aloof from the problems of global climate change.

On the territory of the river Debed's basin air temperature distribution and precipitation is uneven, due to the geographical latitude of the area, general and local circulation of the atmosphere, radiation energy and orographic features. We notice a decrease in air temperature and an increase in precipitation with the height of the terrain and the vertical gradient, respectively, is 0.54 ºC / 100 m and -20 mm / 100 m. The average annual air temperature ranges from 3.74 ºC to 12.3 ºC, and the annual precipitation is from 462 mm to 770 mm.

Studies have also shown that long-term fluctuations in average air temperature over the year are generally characterized by positive trends. Air temperature in the basin of the river Debed increased by 1.65 °C on average over the year from 1964 to 2018. A particularly significant increase in annual temperatures has been observed after the 1990s, when the rate of annual warming reached +0.389 ºC / 10 years (for the period 1993-2018). The warmest years were 1966, 2010 and 2018.

The tendency towards a decrease in the annual amount of precipitation prevails in the area. The most significant amount of precipitation decreased in the basin of the river Debed after 2002. The rate of changes in the annual amount of atmospheric precipitation for the period 2002–2018 reached -61.7 mm / 10 years, and for the entire period 1964-2018 - 1.02 mm / 10 years. On average a decrease in annual precipitation was 126 mm from 1964 to 2001, 105 mm - from 2002 to 2018 in the basin of the river Debed. There is a tendency for a slight increase in the amount of precipitation at the Stepanavan weather station.

Keywords: river Debed basin, annual air temperature, annual precipitation, trend line distribution, long-term changes.

Reference

1. *Abdulzhalimov A.A., Ataev Z.V., Bratkov V.V. (2015). Modern climate changes of high-mountain landscapes of the North-Eastern Caucasus. Izvestiya Dagestanskogo gosudarstvennogo pedagogicheskogo universiteta. Journal Dagestan State Pedagogical University. Natural and Exact Sciences. 2, 86-94 [In Russian].*
2. *Aleksandryan G.A. (1971). Atmospheric precipitation in Armenian SSR. Yerevan. Science of Academy of ASSR, 180 [In Russian].*
3. *Atayev Z.V., Bratkov V.V. (2014). Reaction of landscapes of the North Caucasus on the current climatic changes // The South of Russia: ecology, development. 1, 141-157 [In Russian].*

4. *Bardin M.Yu., Platova T.V., Samokhina O.F.(2015). Features of observed climate changes on the territory of Northern Eurasia according to regular monitoring data and their possible factors // Proceedings of the FSBI «Hydrometeorological Center of Russia». 358, 13-35 [In Russian].*
5. *Gruza G.V., Rankova E.Ya. (2012). Observed and expected climate changes over Russia: surface air temperature. Obninsk: «VNIIGMI-MTSD», 194 [In Russian].*
6. *Baghdasaryan A.B. Klimat Armyanskoj SSR. (1958). The climate of Armenian SSR. Yerevan: Publishing House of the Armenian SSR Academy of Sciences, 151 [In Russian].*
7. *Climatic handbook. Part 1. Air and soil temperature (2011). Yerevan, 150 [In Armenian].*
8. *Climatic handbook. Part 2. Air humidity, precipitation and snow cover (2012). Yerevan, 172 [In Armenian].*
9. *Kirillina K.S., Lobanov V.A. (2015). Assessment of modern climatic changes of air temperature in the territory of the Republic of Sakha (Yakutia). Proceedings of the Russian State Hydrometeorological University (RSHU). 38, 137–151 [In Russian].*
10. *Lobanov V.A., Mammedov S.A. (2018). Assessment of climatic changes in air temperature and their stability in Central Asia. Proceedings of the Russian State Hydrometeorological University (RSHU). 51, 22–36. [In Russian].*
11. *Lobanov V.A., Shadursky A.E. (2010). Application of empiric-statistical methods for modeling and analysis of climatic changes. Proceedings of the Russian State Hydrometeorological University (RSHU). 14, 73–88. [In Russian].*
12. *Margaryan V.G. (2009). Regularities of atmospheric humidification spatial-temporal distribution in the Republic of Armenia. Thesis for the degree of candidate of geographical sciences. Yerevan, 169 [In Armenian].*
13. *Margaryan V.G., Samvelyan N.I. (2019). The regularities of spatial and temporal change of extremal temperatures of earth layer of atmosphere and its influence on the environment Ararat valley hollow. Vestnik Voronezskogo gosudarstvennogo universiteta. Seria Geografia. Geoekologia. 4, 15-22 [in Russian] https://doi.org/10.17308/geo.2019.4/2707*
14. *Nersesyan A.G. (1964). Klimat Armenii [Climate of Armenia]. Yerevan, 304 [in Armenian]*
15. *Perevedentsev Yu.P., Sharipova R.B. (2012).Change of the basic climate indicators in the territory of the Ulyanovsk region. Bulletin of the Udmurt University. Series «Biology. Earth Sciences». 1, 136–144 [In Russian].*
16. *Surenyan G.G. (2010). Synoptic analysis of baric fields forming the climatic conditions of the Republic of Armenia. Thesis for the degree of cand. geogr. sciences. Yerevan. 145 [In Armenian].*
17. *Amiranashvili A., Matcharashvili T., Chelidze T. (2012). Climate Change in Georgia; statistical and nonlinear dynamics predictions. Journal of Georgian Geophysical Society, Issue (A), Physics of Solid Earth, 15a, 2011-2012, 67-87.*
18. *Armenia's fourth national communication on climate change (2014). 213.*
19. *Building Resilience to Climate Change in South Caucasus Agriculture (2014). Nicolas Ahouissoussi, James E. Neumann, and Jitendra P. Srivastava, Editors. International Bank for Reconstruction and Development. 167. https://doi.org/10.1596/978-1-4648-0214-0*
20. *IPCC (Intergovernmental Panel on Climate Change: Climate Change) (2013). The physical science basis. In Contribution of Working Group I to the Firth Assessment Report of the Intergovernmental Panel on Climate Change, Thomas F. Stocker, Dahe Qin, Gian-Kasper Plattner, Melinda M.B. Tignor, Simon K. Allen, Judith Boschung, Alexander Nauels, Yu Xia, Vincent Bex, Pauline M. Midgley (eds). Cambridge: Cambridge University Press. 1552.*
21. *Margaryan V.G. (2019). Assessment of climatic trend of air temperature at the earth surface in the context of stable development (case of Gyumri city). Visnyk of V.N. Karazin Kharkiv National University, series «Geology. Geography. Ecology». 50, 125-135. https://doi.org/10.26565/2410-7360-2019-50-09*
22. *Margaryan V., Tsibulskii G., Raevich K. (2020). About the features of the time course of the average annual air temperature in the territory of the Debed river basin (Armenia) // E3S Web of Conferences, 223, id. 03009. Regional Problems of Earth Remote Sensing (RPERS 2020).*