

# About the features of the time course of the average annual air temperature in the territory of the Debed river basin (Armenia)

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**Abstract.** The article examines the features of the time course of the average annual air temperature in the Debed river basin in Armenia. As a starting material, we used daily data of actual observations of the temperature of the surface air layer for a year in the Debed river basin. The study was carried out at 6 meteorological stations in the Debed river basin based on long-term observation data series from 1930 to the present (2018). Analysis of the trend lines of temporal changes in air temperatures shows that at all meteorological stations currently operating on the territory of the basin, there is mainly a tendency for an increase in temperatures of annual values.

## 1 Introduction

Air temperature is characteristics of situation on of links of climatic system (atmosphere). The air temperature has a main role in the forming of atmosphere circulation, evaporation and moisture regime of territory. Clarifying and estimation of regularities of temporal distribution of air temperature has importance, especially for more accurate definition of thermal balance, for productive using of thermal resources. That is why the air temperature study is an important task and caught our attention.

The purpose of this study is to solve the following tasks: to identify, analyze and evaluate the features of the territorial distribution of the mean annual air temperature, to estimate their time course over the past 80-90 years in different conditions of the Debed river basin.

## 2 Study areas, Data and Methods

To solve the set tasks, the corresponding studies and published works [3, 8-9] served 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 Republic of Armenia for a period of 80 years and more (1930–2018) 6 meteorological stations.

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The Debed river basin is located in the north of the Republic of Armenia, occupying an area within the republic of 3790 sq.km (4080 km<sup>2</sup> – outside of it). Here, in the lowest point (375m) of the territory of the Republic of Armenia. The basin is distinguished by a rugged relief, there are canyons reaching 300m depth (the Debed river canyon), and separate massifs reaching more than 2500m in the height. The difference in altitude exceeds 2800m. In the basin, one can trace the mountain-forest, mountain-steppe and alpine climatic zones, only in the deep gorges of the extreme northeastern part of the basin a moderately warm climate of dry steppes is formed.

The following methods were used in the work: mathematical-statistical, correlation, extrapolation, interpolation, analysis, synthesis, analogy.

### 3 Results and discussion

The study area is characterized by an uneven distribution of air temperature (table 1), which is mainly due to the geographical latitude of the area, general and local circulation of the atmosphere, the nature of the active surface, radiation energy and orographic features. On the territory of the Debed river basin, from an altitude of 451 to 2066 m, according to actual observations, the average annual temperature is positive. Long-term average annual values of air temperature for the period from the 30th of the XX century to 2018 on average ranges from 3,74 °C (Pushkin pass) to 12,3 °C (Bagratashen).

**Table 1.** Values of average annual air temperature at meteorological stations for the entire period of their operation

Meteorological stations	Bagratashen	Tashir	Odzun	Stepanavan	Pushkin pass	Vanadzor
Height, m	451	1507	1105	1397	2066	1376
Air temperature, °C	12,3	6,14	9,34	7,21	3,74	8,27

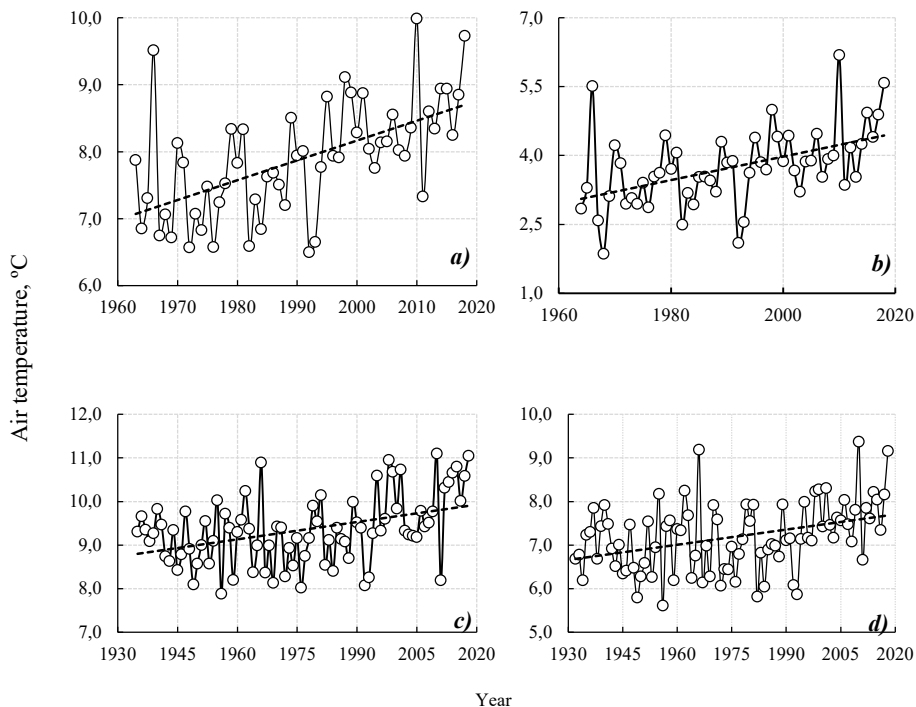
As a rule, with the absolute height of the area, the annual air temperature naturally decreases (table 2). It turned out that in the study area with an altitude of every 100m, the annual air temperature decreases on average by 0,54 °C. On the basis of this connection, it is possible to study the regime of air temperature and precipitation in unexplored and poorly studied areas of the discussed territory, as well as to build a map of their territorial distribution.

**Table 2.** Values of the average annual air temperature in altitude zonation

Altitudinal zones, m	600	800	1000	1200	1400	1600	1800	2000	2200	2400
Air temperature, °C	11,7	10,7	9,6	8,5	7,4	6,3	5,3	4,2	3,1	2,0

Changes in the average annual air temperature were also estimated for the entire territory of the Debed basin (fig. a, fig. 1), and for each of the currently operating meteorological stations separately (fig. b,c,d fig. 4). Since the meteorological stations began their activities 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. In the Debed river basin as a whole, a stable positive trend of the average annual air temperature was revealed. For the period from 1964–2018 the rate of annual warming will be +0.296 °C/10 years. A significant increase in annual temperatures is observed especially over the period 1993–2018. On

average, the air temperature in the Debed basin from 1964 to 2018 increased by 1,65 °C over the year.



**Fig. 1.** Values of the average air temperature for the year in the Debed river basin as a whole (a) and for meteorological station at different heights : Pushkin pass – 2066m (b), Odzun – 1105m (c), Stepanavan – 1397m (d).

In the Debed river basin as a whole, over the past 60 years, 1972, 1976, 1982, 1992 are distinguished by relatively low annual temperatures (less than 6,5–6,6 °C). Since 1993, there has been a sharp rise in temperature. Comparatively high annual temperatures (more than 9,5 °C) stand out in 1966, 2010 and 2018. The warmest years were also in 1966 and 2010 on the territory of the high mountain landscapes of the northeastern Caucasus [1].

This pattern is typical both for other regions [11–13], and for the whole territory of Armenia [3, 10], other regions of our planet, including the South Caucasus [6], Eastern Georgia [2], the territory of high-mountainous landscapes of the north-eastern Caucasus [1], the Russian Federation [7], the territory of all CIS countries [5], the Ulyanovsk region [14], the landscape of the North Caucasus [4]. According to Armenia’s fourth national communication on climate change [2], in hate Republic of Armenia over the period of 1929–1996, the annual mean temperature increased by 0,4 °C, during 1929–2007 – by 0,85 °C, during 1929–2012 – by 1,03 °C, and during 1929–2016 – by 1,23 °C. According to the METRAS model and RCP8.5 scenario in the territory of Armenia expected the annual mean temperature increased by 1,6 °C during 2011–2040, by 3,3 °C during 2041–2070, by 4,7 °C during 2071–2100.

Table 3. The projected values of average annual air temperature (°C) in the territory of Armenia by different altitudinal zones (m), according to the METRAS model and RCP8.5 scenario [3]

Altitudinal Zones, m	1961–1990	2011–2040	2041–2070	2071–2100
< 800	11,2	12,8	14,5	15,9
800–1000	10,8	12,4	14,1	15,5
1000–1500	8,4	10,0	11,7	13,1
1500–2000	5,5	7,1	8,8	10,2
2000–2500	3,3	4,9	6,6	8,0
2500–3000	1,6	3,2	4,9	6,3
> 3000	-0,7	0,9	2,6	4,0
Armenia	5,5	7,1	8,8	10,2

The change of air temperature will its inevitable consequence on change of components of hydrothermal balance study area, on a violation of the ecological balance of natural ecosystems, as well as the social, environmental and economic development of study area. Therefore, to adapt to changing temperature needs an ecosystem approach, for mitigation – implementation of complex measures for adaptation.

#### 4. Conclusions

As a result of the research came to the following conclusions:

- The distribution of air temperature in the studying area is uneven: the average annual air temperature ranges from 3,74 to 12,3 °C. The air temperature decreases with the terrain height: the vertical gradient is 0,54 °C/100m.

- Long-term fluctuations in the average air temperature for the year are everywhere characterized by positive trends. On average, in the Debed river basin from 1964 to 2018, the air temperature increased by 1,65 °C over the year. The warmest years were observed in 1966, 2010 and 2018.

- It is necessary to develop strategy programs for adapting the consequences of changes in the average annual air temperature, which will serve as a stimulus for the long-term development of the region's economy.

- The results obtained can be used in planning the development of the economy on the territory of the Debed river basin, in providing climatic services to the branches of the national economy, in adjusting building standards.

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