ИЗМЕНЕНИЯ И КОЛЕБАНИЯ КЛИМАТА, ДЕНДРОХРОНОЛОГИЯ, ДЕНДРОКЛИМАТОЛОГИЯ

DOI:10/58168/FECC2025_229-233
UDC 551.583.2

CLIMATE DYNAMICS IN ARMENIA FROM 1938 TO 2023

A.M. Karapetyan[1], A.S. Stepanyan[1], Zh.A. Fafuryan[1], Y.A. Yanbaev[2]
[1]Institute of Botany after A.L. Takhtajyan National Academy of Sciences of the Republic of Armenia, Yerevan, Armenia, e-mail: AregMKarapetyan@gmail.com
[2]Bashkir State Agrarian University, Ufa, Russia, e-mail: yanbaev_ua@mail.ru

Abstract. This study examines long-term climate patterns in Armenia through the analysis of data obtained from two meteorological stations located at different elevations above sea level. Information on precipitation, air temperature, and relative humidity over an 85-year period (1938–2023) was analyzed from October, marking the end of the tree growth period, to September of the next vegetation season. The results are useful for dendrochronological research.

Keywords. Long-term climate dynamics, precipitation, air temperature, relative humidity.

ДИНАМИКА КЛИМАТА В АРМЕНИИ В 1938-2023 ГГ.

А.М. Карапетян[1], А.С. Степанян[1], Ж.А. Фафурян[1], Ю.А. Янбаев[2]
[1]Институт ботаники им. А.Л. Тахтаджяна Национальной академии наук Республики Армения, г. Ереван, Армения, AregMKarapetyan@gmail.com
[2]Башкирский государственный университет, г. Уфа, Россия, yanbaev_ua@mail.ru

Аннотация. В работе рассматриваются долгосрочные климатические изменения в Армении на основе анализа данных с двух разновысотных метеорологических станций. Данные об осадках, температуре и относительной влажности воздуха за 85-летний период (1938-2023 гг.) были рассмотрены в порядке с октября, месяца окончания прироста древесных, по сентябрь следующего вегетационного сезона. Результаты полезны для дендрохронологических исследований.

Ключевые слова. Долговременная динамика климата, осадки, температура воздуха, относительная влажность.

Armenia, a mountainous country where about 85% of the territory lies above 1,000 meters and 51% above 2,000 meters, has an average elevation of 1,800 meters. The entire territory is vulnerable to global climate change, and Armenia ranks among the most climate-sensitive countries in Europe and Central Asia [2]. While a general decline in precipitation is expected, accurate projections remain uncertain due to the complexity of influencing factors. Armenia's significant variation in temperature and precipitation is shaped by its geographic position, complex topography, and the combined effects of global and regional climate systems, including latitude, mountains, and nearby oceanic and continental influences [1, 3]. Unfortunately, using calendar year data has limitations in dendrochronology, as the annual growth of woody plants is influenced not only by the climate during the current growing season, but also by conditions in the preceding autumn and winter [4].

This study aims to analyze the dynamics of temperature, precipitation, and relative humidity from October to September in the two driest forest growth regions of the Republic of Armenia, assessing changes from 1938 to 2023 with a focus on identifying annual climate trends relevant to the growth periods of woody plants.

The climatic records were obtained from the Hydrometeorology and Monitoring Center, a State Non-Commercial Organization. For the analyzes, we used the climate data obtained for two meteorological stations for the period 1938-2023), each representing distinct geographical contexts and elevations. Amberd is located at a higher elevation (approximately 2,071 m) on the southern slopes of Mount Aragats in central Armenia, while Kapan station is situated much lower (705 m) in Syunik Province, southeastern Armenia, on the northern slopes of Mount Khustup. This substantial elevation difference between the stations (over 1,000 m) offers an opportunity to examine how elevation influences climate parameters in Armenia’s mountainous regions. Based on this database, new variation series were formed, incorporating data from October of the previous year to the following September — the period corresponding to the end of the growing season under Armenian conditions. Calculations were conducted to determine the average monthly values for the year (air temperature, relative air humidity) and the annual total precipitation in these months. For descriptive and correlation analyses, as well as for figures creation, STATISTICA 13.3 software was used. Due to the non-binomial patterns of most distributions, parameters (including both arithmetic means and medians) and nonparametric statistical procedures were used. The Spearman coefficient was applied to evaluate the correlation in the dynamics of climatic parameters. The Shapiro-Wilk test was applied to verify the normality of data distributions. Statistical significance of differences was determined using the χ^2 test with the Kruskal-Wallis method, which is used to test equality of medians.

The results are presented in Tables 1 and 2, as well as Figures 1-3. They demonstrate significant differences in precipitation, air temperature and relative humidity patterns between the two stations. Amberd received considerably higher average annual precipitation compared to Kapan. The precipitation range during the study period was also more extensive at Amberd, compared to Kapan. Notably, precipitation showed the highest variability among all climate parameters examined, with coefficients of variation higher in Amberd, compared to Kapan (Table 1). This indicates that at higher elevation, Amberd received more annual precipitation and has more variation than Kapan. Mean annual temperatures differed substantially between the two stations, reflecting the elevation gradient. According to data from Table 1, Kapan is warmer, but this suggests greater temperature variability at higher elevations. These findings align with the data from [3], indicating that the most mountain regions experience moderate to high temperature changes, while precipitation changes vary significantly across different mountainous areas, including in Armenia. Relative humidity was notably higher at Kapan compared to Amberd. The coefficients of variation for humidity were relatively low compared to other parameters indicating more stable humidity conditions over time, with Kapan being more humid and having stable humidity level.

Table 1 - Climate of Armenia according to data from the Kapan and Amber weather stations for 1938-2023

Parameters	Stations	Averages	Median	Minimum	Maximum	C
Relative air humidity	Kapan	73,07±0,40	72,50	64,67	85,99	5,06
	Amberd	63,05±0,46	63,27	51,92	72,78	6,79
Air temperature	Kapan	5,71±0,09	5,65	3,59	7,73	14,71
	Amberd	12,31+0,09	12,33	10,61	14,57	6,78
Precipitation	Kapan	549,21±11,52	547,15	322,10	907,4	19,45
	Amberd	692,91+20,00	689,10	375,90	1241,44	26,77

C - coefficient of variation, %

Table 2 - Spearman's correlation matrix between climatic variables in Armenia according to data of the Kapan and Amber weather stations 1938-2023

Parameters	Stations	Humidity	Temperature		Precipitation	
		Amberd	Kapan	Amberd	Kapan	Amberd
Humidity	Kapan	0,43***	0,02	0,30**	-0,13	-0,38***
	Amberd		-0,08	-0,16	0,09	0,12
Temperature	Kapan			0,67***	-0,30**	-0,28**
	Amberd				-0,58***	-0,55***
Precipitation	Kapan					0,36***

The symbols ** and *** show a correlation at the significance levels $p<0.01$ and $p<0.001$, respectively.

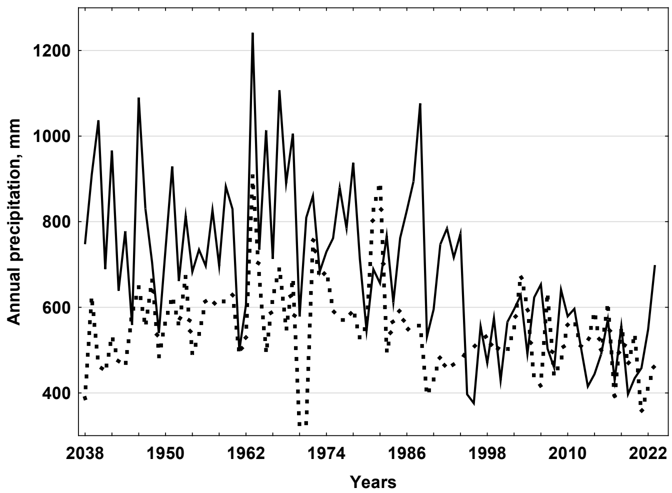

Figure 1 - Precipitation dynamics in Armenia in 1938-2023 according to Amberd (solid line) and Kapan (dashed) meteorological stations

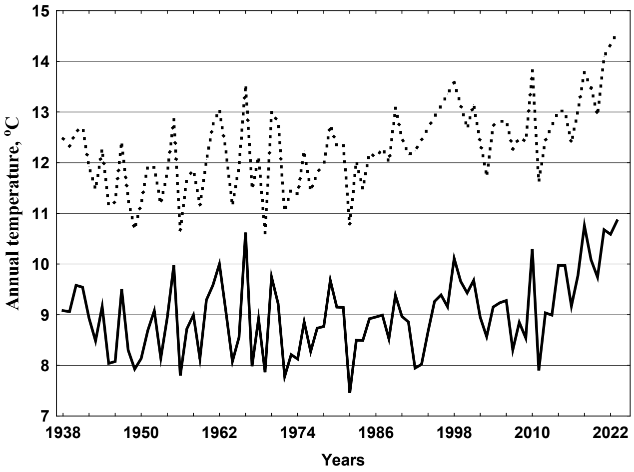

Figure 2 - Temperature dynamics in Armenia in 1938-2023 according to Amberd (solid line) and Kapan (dashed) meteorological stations

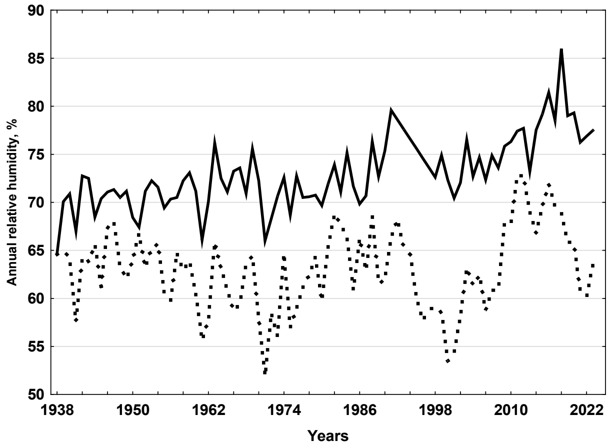

Figure 3 – Relative humidity dynamics in Armenia in 1938-2023 according to Amberd (solid line) and Kapan (dashed) meteorological stations

As shown in Table 2, Spearman correlation analysis revealed significant associations between climate indicators, including a strong positive correlation in temperature trends between the two stations and a notable negative correlation between temperature and precipitation in Amberd, reflecting complex climate dynamics across regions.

High-elevation environments are affected by the temperature gradient in the atmosphere, which refers to the variation in temperature with changes in elevation, commonly called as the "temperature lapse rate ". The observed differences between Kapan and Amberd clearly demonstrate the influence of elevation on climate parameters in Armenia's mountainous terrain. The temperature differential of approximately 6.6°C between stations aligns with the expected lapse rate of about 0.6°C per 100m of elevation gain, given their elevation difference of roughly 1,000 m.

The higher precipitation variability at Amberd indicates that precipitation patterns at high elevations could be more vulnerable to shifts in atmospheric circulation patterns.

Among the examined three climate parameters, precipitation showed the highest variability at both stations, while humidity demonstrated the most stability over the study period. The greater temperature variability at Amberd compared to Kapan suggests that higher-elevation environments in Armenia may experience more pronounced temperature fluctuations, potentially making them more sensitive to climate change impacts.

The long-term data from these two stations provide valuable insights into Armenia's climate patterns. The significant variations observed between stations separated by just over 1,000m in elevation highlight the importance of maintaining weather-monitoring stations across different elevation zones in mountainous regions to accurately characterize climate conditions. This analysis of over 85 years of climate data (1936-2023) from Amberd and Kapan meteorological stations reveals notable differences in precipitation, temperature, and relative humidity patterns between these locations in Armenia. The influence of elevation on climate parameters is evident, with higher-elevation areas experiencing increased precipitation, lower temperatures, and reduced humidity compared to those at lower elevations. The climate parameters show different degrees of temporal stability, with precipitation demonstrating the highest variability and humidity showing the greatest stability over the study period. These patterns of variability may have important implications for understanding the climate change patterns in Armenia.

The analytical approach used in this study is crucial for dendrochronological studies, as October to September time frame typically demonstrates a complete biological growth year, including both: dormancy and active growth phases.

The authors thank Eva Danielyan and Artur Gevorgyan for providing the climate data and valuable suggestions.

Our study was supported by the Higher Education and Science Committee of the Republic of Armenia, project 23RL-1F017, "Current trends of forest tree species adaptation in the face of climate change in Armenia ".

References

1. Distribution of biodiversity of wild beet species (Genus *Beta* L.) in Armenia under ongoing climate change conditions / A. Avetisyan, T. Aloyan, A. Iskandaryan, M. Harutyunyan, L. Jaakola, A. Melikyan // Plants. – 2022. – Vol. 11, No. 19. doi: 10.3390/plants11192502.

2. Galstyan, H. Long term variability of annual temperature in Armenia in the context of changing climate / H. Galstyan, L. Sfîcă, P. Ichim // World Academy of Science, Engineering and Technology. International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering. – 2016. – Vol. 10. doi:10.15551/SCIGEO.V60I2.331

3. Gevorgyan, A. Surface and tropospheric temperature trends in Armenia / A. Gevorgyan // International Journal of Climatology. – 2014. – Vol. 34, No. 13. – P. 3559–3573. DOI:10.1002/joc.3928.

4. Climate responses of tree-ring width and $\delta^{13}C$ signatures of sessile oak *(Quercus petraea* Liebl.*)* on soils with contrasting water supply / W. Haerdtle, T. Niemeyer, T. Assmann et al. // Plant Ecology. – 2013. – Vol. 214. – P. 1147-1156.