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VARIABILITY OF THE MEAN MAX ANNUAL AIR TEMPERATURE IN 39 LOCATIONS OF GEORGIA IN 1956-2015

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Abstract: The research results of the variability of the mean max annual air temperature at 39 locations in Georgia against the background of global climate change in 1956-2015 are presented. The statistical characteristics of the mean max annual air temperature in the period 1956-2015 (T), 1956-1985 (T_1) and 1986-2015 (T_2) for each point were studied. It has been established that in the second period compared to the first, there is a significant increase in the average max air temperature at the 29 stations from 0.3 °C (Stepantsminda) to 1.2 °C (Bakuriani); for Shovi this difference is 1.1 °C. It is shown that between the T_1, T_2 values and the terrain height there has been observed the high inverse linear correlation and regression relationship there. At the same time, the lines of the regression equations are parallel with the increasing in the second period compared to the first by 0.6 °C.

It is shown, that a significant value of $(T_2 - T_1)/T$ changes from 2.0 % (Chokhatauri) to 11.0% (Bakuriani); for Shovi this indicator is 8.4 %. The significant value $(T_2 - T_1)/T$ increases with terrain height in accordance with a second power polynomial.

Key words: *Mean max annual air temperature, climate change, significant value, second power polynomial.*

Introduction

Currently, the problem of climate change is very relevant in the world [1]. This problem is of significant importance for Georgia, especially with the wide variety of climatic regions on its territory [2].

Our recent studies examined the variability of average and average max air temperatures in some regions of Georgia [3-6], as well as in Kislovodsk [7]. In addition the assessment was carried out using various methods expected changes in air temperature in the coming decades for some regions of Georgia (including Tbilisi), as well as St. Petersburg [8-12].

This article presents some results of a study of the mean max annual air temperature variability in 39 locations in Georgia against the background of global warming in 1956-2015. Besides other facts, the need to detailly conduct such studies is also preconditioned by the intensification of glacier melting in landslides and mudflows prone areas. The latest example is the disaster in Shovi on August 3, 2023, as a result of which more than 30 people died due to a mudflow caused by the melting of a glacier.

Study area, material and methods

Study area – 39 locations of Georgia (Table 1). In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods.

The following designations will be used below: Mean – average values; Min – minimal values; Max - maximal values; St Dev - standard deviation; Cv – coefficient of variations (Cv = 100· St Dev/ Mean, %); R^2 – coefficient of determination; H - height of the meteorological station above sea level, meter; T, T_1 and T_2 - mean max annual air temperature in 1956-2015, 1956-1985 and 1986-2015 accordingly; $(T_2 - T_1)/T$ – relative difference of mean max annual air temperature, %; difference between *mean max annual air temperature* $(T_2 - T_1)$ was produced with the use of Student's criterion with the level of significance not worse than 0.15.

Results and discussion

Results on Table 1 and Fig. 1-4 are presented. Table 1 shows the statistical characteristics of the mean annual max air temperatire in 39 locations of Georgia in 1956-2015, 1956-1985 and 1986-2015.

Table 1. Statistical characteristics of mean max annual air temperatire in 39 locations of Georgia.

Year	H, meter	T_(1956-2015)					T_1_(1956-1985)	T_2_(1986-2015)
Location	Variable	Mean	Min	Max	St Dev	Cv (%)	Mean	Mean
Akhalkalaki	1716	11.8	9.6	15.2	1.1	9.2	11.4	12.2
Akhaltsikhe	982	16.6	14.5	19.1	1.1	6.3	16.3	17.0
Ambrolauri	544	18.2	15.8	20.6	0.9	4.9	17.9	18.5
Bakhmaro	1926	8.6	6.5	11.1	1.0	11.4	8.6	8.6
Bakuriani	1665	11.3	9.3	14.6	1.2	10.2	10.7	11.9
Batumi	2	18.7	16.8	21.5	0.9	4.7	18.6	18.8
Bolnisi	534	18.2	16.3	20.4	0.9	5.1	17.9	18.5
Borjomi	789	15.8	6.6	20.2	2.3	14.5	15.8	15.8
Chokhatauri	150	19.6	17.6	22.0	0.9	4.5	19.4	19.8
Dedoplistskaro	800	16.5	14.1	18.9	1.1	6.7	15.9	17.0
Gardabani	300	19.5	15.7	21.2	1.0	5.1	19.3	19.7
Goderdzi	2025	6.6	3.8	9.6	1.0	15.8	6.7	6.6
Gori	588	17.0	15.2	19.3	0.9	5.3	16.7	17.3
Gudauri	2194	7.8	5.9	10.6	1.0	12.2	7.4	8.3
Gurjaani	410	18.4	16.5	20.3	0.9	4.7	18.1	18.7
Khaishi	730	16.3	14.4	18.6	0.9	5.3	16.0	16.6
Khashuri	709	16.0	13.9	18.8	1.1	6.7	15.7	16.3
Khulo	914	15.8	13.0	18.1	1.0	6.3	15.9	15.8
Kobuleti	7	18.7	16.9	21.1	0.9	4.6	18.3	19.0
Kutaisi	114	19.9	17.5	22.6	0.9	4.7	19.8	20.0
Kvareli	449	18.7	16.5	21.0	1.0	5.2	18.3	19.1
Lagodekhi	362	18.7	16.8	21.1	1.0	5.4	18.5	19.0
Lentekhi	760	15.8	13.4	18.5	1.0	6.1	15.7	15.9
Mestia	1441	13.4	11.0	15.8	1.0	7.8	13.2	13.7
Mta-sabueti	1242	11.1	9.1	13.5	0.9	8.1	10.9	11.3
Paravani	2100	7.9	6.0	10.2	0.9	11.2	7.7	8.2
Pasanauri	1070	14.5	12.3	17.2	0.9	6.3	14.1	14.9
Poti	4	19.1	17.5	21.6	1.0	5.2	18.7	19.6
Sachkhere	415	18.6	16.2	21.1	1.0	5.6	18.5	18.7
Sagarejo	802	17.0	15.5	19.0	0.9	5.1	16.9	17.2
Samtredia	28	20.3	17.9	23.0	1.0	4.9	20.0	20.6
Shovi	1507	12.6	10.0	17.6	1.5	11.6	12.1	13.1
Stepantsminda	1744	10.6	8.6	13.5	1.0	9.3	10.4	10.8
Tbilisi	403	18.9	17.1	20.5	0.9	4.6	18.7	19.1
Telavi	568	17.7	15.8	19.7	0.9	5.3	17.3	18.1
Tianeti	1099	14.4	12.4	16.7	0.9	6.3	14.1	14.7
Tsalka	1457	12.2	10.2	14.5	0.9	7.6	11.8	12.6
Zestafoni	160	20.3	17.9	22.5	0.9	4.5	20.2	20.3
Zugdidi	117	19.9	17.7	22.5	1.0	4.9	19.5	20.2

The data of Table 1 was used to analyze the variability features in the mean max air temperature in Georgia (Fig. 1-4).

On the Fig. 1 the difference between mean annual max air temperatire in Georgia in 1986-2015 (T_2) and 1956-1985 (T_1) are presented.

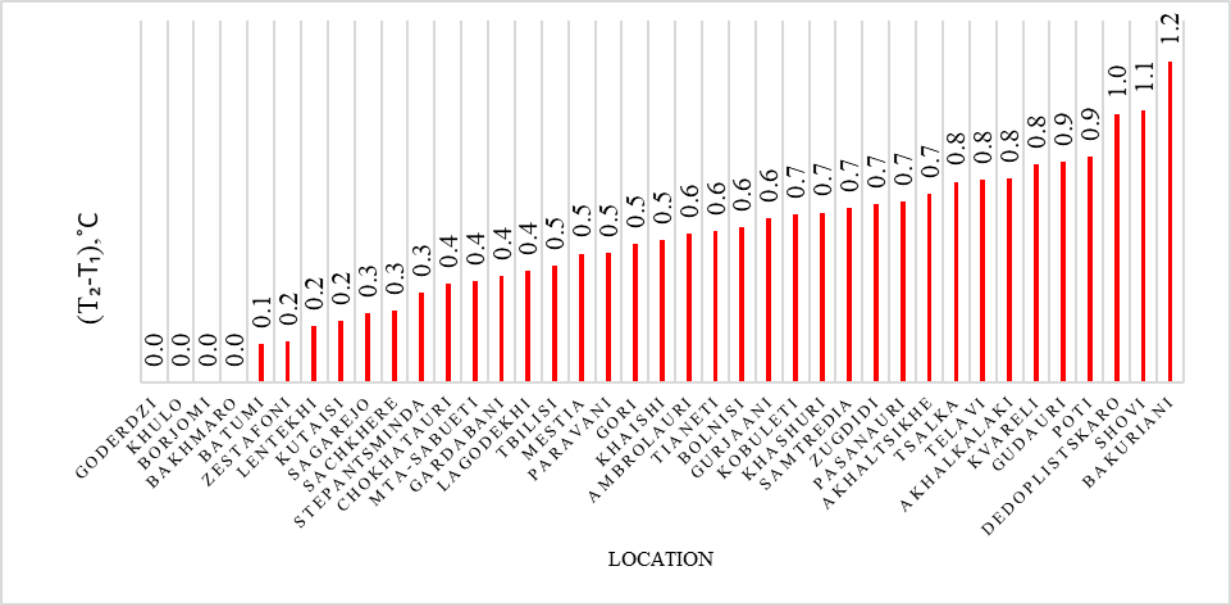

Fig. 1. Difference between mean max annual air temperatire in Georgia in 1986-2015 (T_2) and 1956-1985 (T_1).

In particular, as follows from Fig. 1, in the second period compared to the first, there is a significant increase in the average maximum air temperature at the 29 stations from 0.3˚C (Stepantsminda) to 1.2˚C (Bakuriani); for Shovi, where on August 3, 2023 due to a mudflow that killed more than 30 people, this difference is 1.1˚C.

It is important that the insignificant increase in the mean max air temperature in the second period compared to the first is observed in Goderdzi, Khulo, Bakhmaro, Borjomi, Zestafoni, Batumi, Kutaisi, Lentekhi, Sachkhere and Sagarejo.

On Fig. 2 vertical distribution of mean annual max air temperatire in Georgia in 1956-1985 (T_1) and 1986-2015 (T_2) are presented.

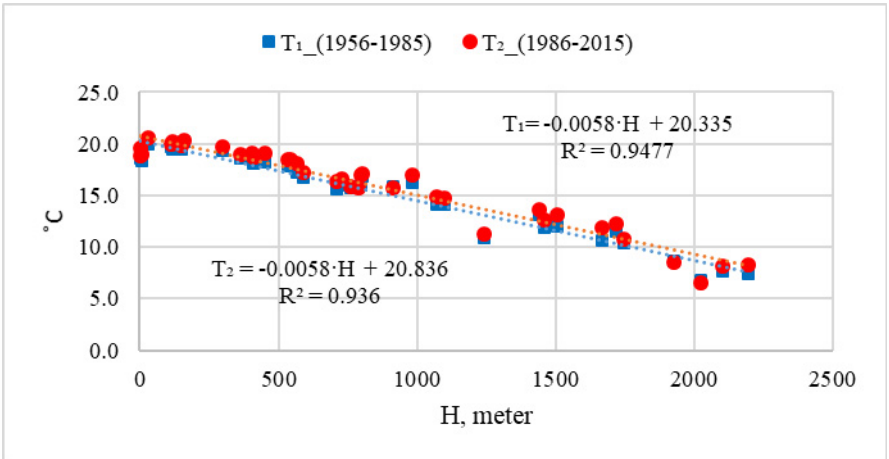

Fig. 2. Vertical distribution of mean max annual air temperatire in Georgia in 1956-1985 (T_1) and 1986-2015 (T_2).

As it follows from Fig. 2 the high inverse linear correlation and regression relationship is observed between the mean max air temperature and area height in both periods. At the same time, the lines of the regression equations are parallel with an increase in the second period compared to the first by 0.6 ˚C.

On Fig. 3 the map of the relative difference distribution of mean max annual air temperature in Georgia is presented.

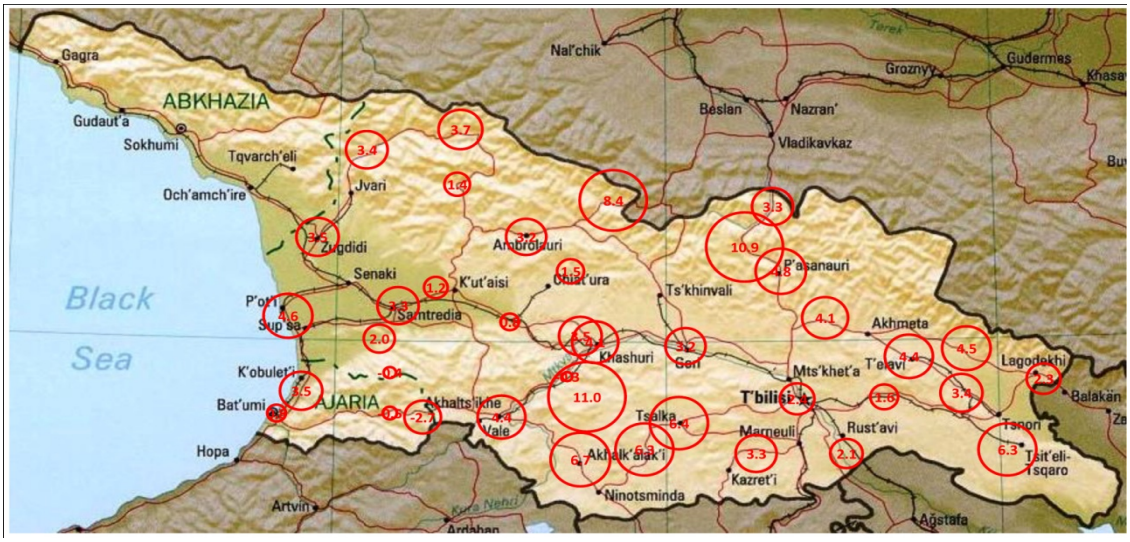

Fig. 3. Map of the difference distribution between the mean max annual air temperature in Georgia in 1986-2015 (T_2) and 1956-1985 (T_1) relative to air temperature in 1956-2015 (T), %.

As follows from this map the significant value of $(T_2 - T_1)/T$ changes from 2.0 % (Chokhatauri) to 11.0% (Bakuriani). For Shovi this indicator is 8.4 %.

And finally on Fig. 4 vertical distribution of the significant values of $(T_2 - T_1)/T$ in Georgia is presented.

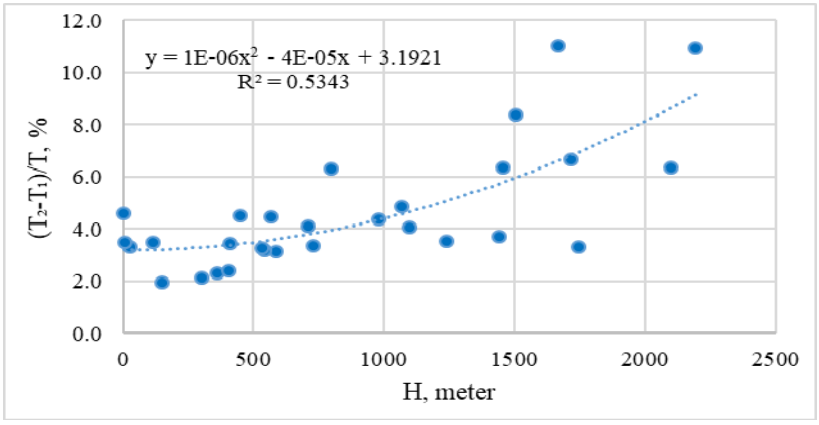

Fig. 4. Vertical distribution of the difference between the mean max annual air temperature in Georgia in 1986-2015 (T_2) and 1956-1985 (T_1) relative to air temperature in 1956-2015 (T).

As it follows from Fig. 4 in general, the significant value $(T_2 - T_1)/T$ increases with terrain height in accordance with a second power polynomial. Thus, with the increasing of area height there is mainly the intensification of the increase in air temperature as a result of climate change.

Conclusion

In the future, we envisage even greater expansion of work on studying the impact of climate change on its various elements, including air temperature, as well as forecasting these changes in Georgia.

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