VARIABILITY OF THE AVERAGE ANNUAL AIR TEMPERATURE IN TBILISI AGAINST THE BACKGROUND OF GLOBAL WARMING IN 1880-2021

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Abstract

Some results of a study of the variability of the average annual air temperature in Tbilisi against the background of global warming in 1880-2021 are presented.

For the analysis, data of the National Environment Agency of Georgia (http://www.pogodaiklimat.ru/) and the NASA Goddard Institute for Space Studies (https://data.giss.nasa.gov/gistemp/) are used.

A comparison of data on the variability of the anomalies of the average annual air temperature in Tbilisi in relation to the average temperature in 1951-1980 (T:TB) with similar anomalies of the global air temperature over land and ocean (T:GL), air temperature in the northern hemisphere (T:NH), and zonal air temperature in the northern hemisphere in different latitude ranges (T:24°N-44°N, T:24°N-64°N, T:44°N-64°N and T:64°N-90°N) are conducted.

In particular, the following results are obtained.

Mean value of T:TB in 1880-2021 is 0.05°C and best match to mean value of T:GL (0.06°C). Max value of T:TB is 2.26 °C and best match to max value of T:44°N-64°N (1.82 °C). Min value of T:TB is -1.70 °C and best match to min value of T:64°N-90°N (-1.76 °C).

Coefficient of linear correlation of T:TB with others investigation parameters change from 0.51 (with T:64°N-90°N) to 0.67 (with T:24°N-44°N).

Difference between mean values T:TB in 1992÷2021 and 1880÷1909 is 1.2 °C and exactly coincides with the analogous difference for T:24°N-64°N.

The trends of all studied parameters are satisfactorily described by a fourth power polynomial. For Tbilisi, a linear approximation is also acceptable.

Keywords: Climate Change, Air Temperature, Global Warming

Introduction

The problem of climate change is well known in the World [1]. This problem is of great importance for Georgia due to the diversity of climatic regions on their territory [2, 3].

In our recent studies, using various statistical methods, we studied the variability of air temperature and its expected changes in the coming decades for some regions of Georgia (including Tbilisi) [4-8], as well as St. Petersburg [9-11], Kislovodsk [12].

In this paper some results of a study of the variability of the average annual air temperature in Tbilisi against the background of global warming in 1880-2021 are presented.

Study Regions, Materials and Methods

A comparison of data on the variability of the anomalies of the average annual air temperature in Tbilisi in relation to the average temperature in 1951-1980 (T:TB) with similar anomalies of the global air temperature over land and ocean (T:GL), air temperature in the northern hemisphere (T:NH), and zonal air temperature in the northern hemisphere in different latitude ranges (T:24°N-44°N, T:24°N-64°N, T:44°N-64°N and T:64°N-90°N) are conducted. Note that the degree sign is omitted in the text below (T:24N-44N, T:24N-64N, etc.).

For the analysis, data of the National Environment Agency of Georgia [13] and the NASA Goddard Institute for Space Studies [14] are used.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods of random events and methods of mathematical statistics for the non-accidental time-series of observations [15,16].

The following designations will be used below: Mean – average values; Min – minimal values; Max - maximal values; Range – Max-Min; St Dev - standard deviation; σ_m- standard error; R^2 – coefficient of determination; R – coefficient of linear correlation; K_{DW} – Durbin-Watson statistic; α - the level of significance. Difference between average annual air temperature anomalies over different locations of World and in Tbilisi in 1992-2021 and 1880-1909 was produced with the use of Student's criterion with the level of significance α not worse than 0.01. The statistical programs Data Fit 7 and Excel 16 were used for calculations.

The curve of trend is equation of the regression of the connection of the investigated parameter with the time at the significant value of the determination coefficient and such values of K_{DW}, where the residual values are accidental. If the residual values are not accidental the connection of the investigated parameter with the time we will consider as simply regression.

Results and Discussions

Results in **Diagram 1-4** and **Table 1-2** are presented.

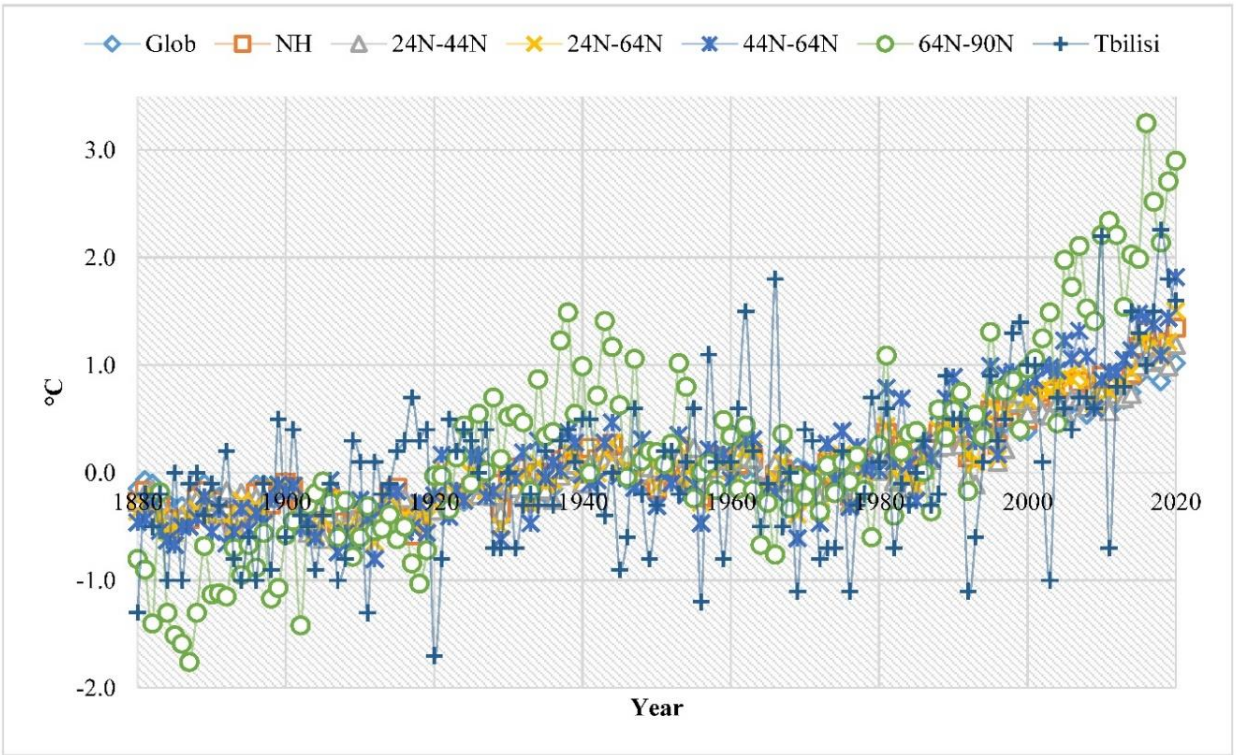

Diagram 1. Changeability of average annual air temperature anomalies over different locations of World and in Tbilisi in 1880-2021 (real data).

In Diagram 1 data on changeability of average annual air temperature anomalies over different locations of World and in Tbilisi from 1880 to 2021 are presented. Table 1. presents the statistical characteristics of the data shown in Diagram 1.

Table 1.

Statistical characteristics of the anomalies of the average annual air temperature over different locations of World and in Tbilisi in 1880-2021.

Variable	Glob	NH	24N-44N	24N-64N	44N-64N	64N-90N	Tbilisi
Max	1.02	1.35	1.26	1.51	1.82	3.25	2.26
Min	-0.48	-0.58	-0.62	-0.65	-0.80	-1.76	-1.70
Range	1.50	1.93	1.88	2.16	2.62	5.01	3.96
Mean	0.06	0.08	0.03	0.08	0.12	0.23	0.05
St Dev	0.36	0.44	0.40	0.48	0.58	0.99	0.75
σm	0.03	0.04	0.03	0.04	0.05	0.08	0.06

As follows from Diagram 1. and Table 1. mean value of T:TB in 1880-2021 is 0.05°C and best match to mean value of T:GL (0.06°C). Max value of T:TB is 2.26 °C and best match to max value of T:44N-64N (1.82 °C). Min value of T:TB is -1.70 °C and best match to min value of T:64N-90N (-1.76 °C). Range of T:TB is 3.96 °C and best match to range of T:64N-90N (5.01 °C).

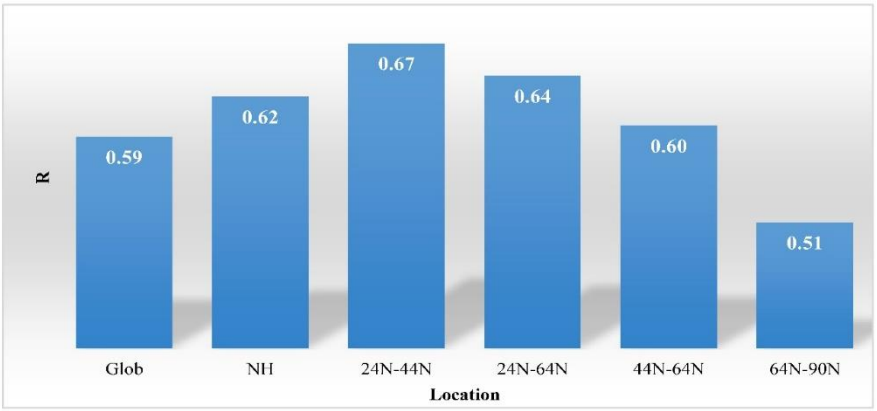

Diagram 2. Linear correlation between average annual air temperature anomalies in Tbilisi and over different locations of World in 1880-2021 (α<0.005).

Coefficient of linear correlation of T:TB with others investigation parameters (**Diagram 2.**) change from 0.51 (with T:64°N-90°N) to 0.67 (with T:24°N-44°N). The degrees of all values of R are moderate [16].

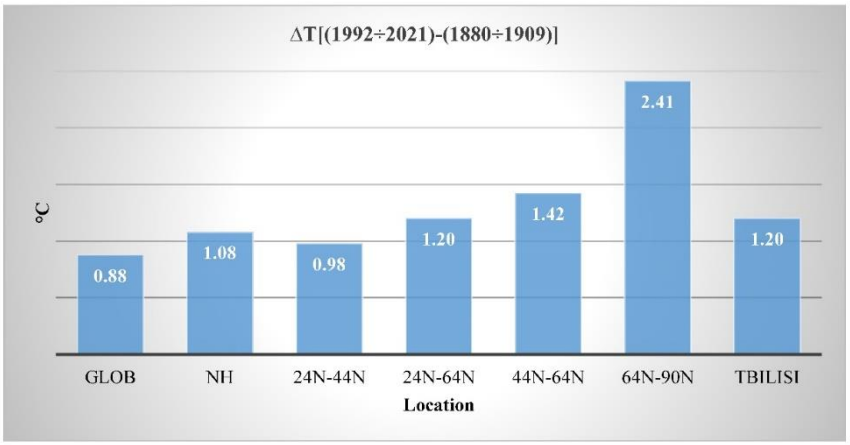

Diagram 3. Difference between average annual air temperature over different locations of World and in Tbilisi in 1992-2021 and 1880-1909.

Difference between mean values of T:TB in 1992÷2021 and 1880÷1909 is 1.2 °C and exactly coincides with the analogous difference for T:24°N-64°N (**Diagram 3.**).

In **Table 2** two types of regression equation (Linear and fourth order polynomial) of average annual air temperature anomalies over different locations of World and in Tbilisi in 1880-2021 are presented. As follows from Table 2, in general, a fourth-degree polynomial describes the study process better than linear regression (corresponding R^2 values). For Tbilisi, a linear regression is also acceptable. Note that a further increase in the degree of the polynomial does not significantly increase the value of R^2.

Table 2.

Types of regression equation of average annual air temperature anomalies over different locations of World and in Tbilisi in 1880-2021.

Regression equation	Linear		Autocorrelation of residuals	Fourth order polynomial		Autocorrelation of residuals
Location	R^2, α<0.005	Kdw, α =0.01		R^2, α<0.005	Kdw, α =0.01	
Glob	0.756	0.38	Positive autocorrelation	0.908	1.01	Positive autocorrelation
NH	0.729	0.41		0.889	1.00	
24N-44N	0.690	0.40		0.873	0.97	
24N-64N	0.728	0.69		0.863	1.35	
44N-64N	0.699	1.15		0.802	1.75	Absent
64N-90N	0.594	0.77		0.789	1.45	Positive autocorrelation
Tbilisi	0.264	1.66	Absent	0.386	1.99	Absent

It should also be noted that in the classical sense [15] for the study parameters, the trend stands out (lack of autocorrelation of residuals) only for Tbilisi (both types of regression) and T:44N-64N (fourth order polynomial). That is, calling the regression a trend for these cases, one should keep in mind the presence of autocorrelation of the residuals.

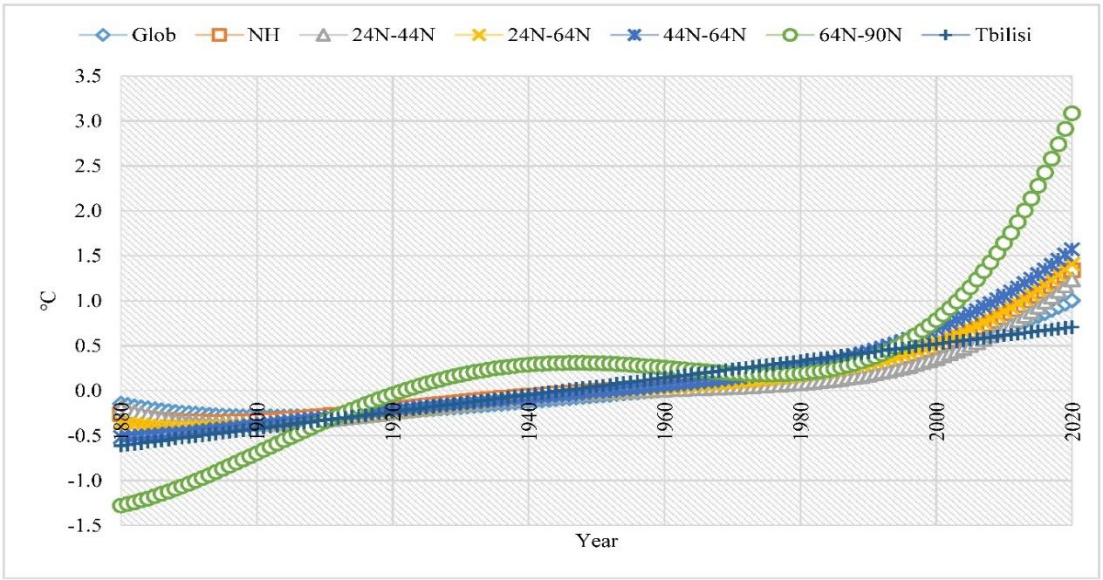

Diagram 4. Example of calculated curves of cangeability of average annual air temperature anomalies over different locations of World and in Tbilisi in 1880-2021 (Tbilisi – linear regression, another locations - fourth order polynomial).

In **Diagram 4**. example of calculated curves of cangeability of average annual air temperature anomalies over different locations of World and in Tbilisi in 1880-2021 are presented (Tbilisi – linear regression, another locations - fourth order polynomial).

Conclusions

In the future, it is planned to continue these studies, including forecasting changes of air temperature in various regions of Georgia for several decades.

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