

COMPARATIVE ANALYSIS OF THE VARIABILITY OF MONTHLY AND SEASONAL AIR TEMPERATURE IN TBILISI AND KISLOVODSK IN 1931-2020

*Amiranashvili A., **Povolotskaya N., ***Senik I.

*Mikheil Nodia Institute of Geophysics of Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia
avtandilamiranashvili@gmail.com

**Pyatigorsk Research Institute of Resort Study of the Federal Medico-Biological Agency, Russia
***A.M. Obukhov Institute of Atmospheric Physics of Russian Academy of Sciences

Summary: A statistical analysis of data on monthly and seasonal values of air temperature in Tbilisi and Kislovodsk from 1931 to 2020 was carried out. Comparison of monthly and seasonal mean values of air temperature in three thirty years of time (1931-1960, 1961-1990 and 1991-2020) was carried out. In particular, it was found that in Tbilisi, the effect of climate warming is more pronounced than in Kislovodsk.

Key Words: Climate change, air temperature.

Introduction

In recent decades the problem of observed and expected climate change on our planet acquired special urgency [1]. This problem is of great importance for Georgia and Russia 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), as well as St. Petersburg [4-10].

This paper presents the results of a comparative analysis of the variability of monthly and seasonal air temperature in Tbilisi (large city with a population of over a million people) and Kislovodsk (resort town with a population around 130 thousand people) in 1931-2020.

Material and methods

Data of the Hydrometeorological department of Georgia and [<http://www.pogodaiklimat.ru/history/37123.htm>] about monthly mean air temperature in Tbilisi and Kislovodsk in the period from 1931 to 2020 are used.

The standard statistical methods are used. The following designations will be used below: Mean – average values; Min – minimal values; Max - maximal values; T - air temperature, °C; Cold – cold season from October to March; Warm – warm season from April to September .

Missing observational data using standard methods were recovered. Comparison of mean values of air temperature in three thirty years of time (I - 1931÷1960, II - 1961÷1990 and III - 1991÷2020) was produced with the use of Student's criterion with the level of significance α not worse than 0.15.

Results and discussion

Results in table 1, 2 and Fig. 1-4 are presented.

In table 1 and 2 statistical characteristics of monthly mean and seasonal values of air temperature in Tbilisi and Kislovodsk are presented.

As follows from table 1 monthly mean values of air temperature in Tbilisi in 1931-2020 changes from 1.9 °C (January) to 24.8 °C (July). Range of changeability of (Max – Min) monthly values of air temperature

composes 32.3 °C (-3.5 °C in January and 28.8 °C in August). The same data for three thirty-year time periods are as follows.

Table 1. Statistical characteristics of monthly and seasonal values of air temperature in Tbilisi in 1931-2020.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Cold	Warm
Year	1931-2020 (Full period)														
Max	6.3	7.3	11.9	16.8	20.3	25.5	28.1	28.8	23.5	17.1	10.9	9.2	15.3	9.1	21.9
Min	-3.5	-2.1	2.8	9.4	15.0	18.8	21.9	22.1	15.4	10.1	0.4	-1.1	11.8	4.1	18.5
Mean	1.9	3.2	7.0	12.6	17.6	21.7	24.8	24.5	19.9	13.9	7.9	3.5	13.2	6.3	20.2
Year	1931-1960 (I period)														
Max	5.2	6.8	10.5	15.2	19.6	23.1	26.4	27.0	22.9	17.0	9.7	5.8	14.1	7.3	21.5
Min	-3.0	0.5	2.8	9.7	15.1	18.8	22.6	22.3	17.0	10.1	4.2	0.2	11.8	4.6	19.0
Mean	1.3	3.1	6.0	12.1	17.5	21.5	24.6	24.4	19.8	13.7	7.8	2.9	12.9	5.8	20.0
Year	1961-1990 (II period)														
Max	6.3	7.3	9.9	16.3	20.0	23.6	26.7	25.9	22.3	16.0	10.4	6.2	14.8	9.1	21.4
Min	-3.5	-2.1	4.4	9.4	15.0	19.1	21.9	22.1	17.5	10.3	5.4	1.0	11.9	4.1	18.5
Mean	1.8	2.8	6.9	12.8	17.4	21.2	24.4	23.7	19.6	13.4	8.1	3.8	13.0	6.2	19.9
Year	1991-2020 (III period)														
Max	5.6	7.0	11.9	16.8	20.3	25.5	28.1	28.8	23.5	17.1	10.9	9.2	15.3	8.6	21.9
Min	-1.5	0.1	2.9	9.5	15.6	20.0	22.3	23.1	15.4	12.6	0.4	-1.1	11.9	4.6	18.7
Mean	2.8	3.8	7.9	12.9	17.8	22.4	25.2	25.5	20.4	14.7	7.7	3.8	13.7	6.8	20.7

- 1931-1960: T mean changes from 1.3 °C (January) to 24.6 °C (July), range of changeability of T is 30.0 °C (-3.0 °C in January and 27.0 °C in August).
- 1961-1990: T mean changes from 1.8 °C (January) to 24.4 °C (July), range of changeability of T is 30.2 °C (-3.5 °C in January and 26.7 °C in July).
- 1991-2020: T mean changes from 2.8 °C (January) to 25.5 °C (August), range of changeability of T is 30.3 °C (-1.5 °C in January and 28.8 °C in August).

Table 2. Statistical characteristics of monthly and seasonal values of air temperature in Kislovodsk in 1931-2020.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Cold	Warm
Year	1931-2020 (Full period)														
Max	2.0	3.6	7.0	12.7	15.8	19.4	21.5	22.7	18.0	13.1	8.7	5.5	10.3	4.8	16.8
Min	-9.8	-8.7	-3.5	4.4	10.1	13.7	15.4	14.9	10.4	3.5	-4.7	-7.0	6.3	-0.7	13.0
Mean	-2.6	-1.9	1.6	8.0	13.0	16.3	18.8	18.4	14.0	8.6	3.2	-0.7	8.1	1.4	14.8
Year	1931-1960 (I period)														
Max	1.9	3.6	7.0	12.7	15.3	18.4	21.5	21.1	17.8	12.6	6.3	4.1	9.1	3.3	16.8
Min	-9.8	-8.7	-3.5	4.8	10.4	14.6	16.9	15.6	10.6	3.5	-3.6	-5.1	6.6	-0.6	13.8
Mean	-2.9	-2.2	0.8	7.8	13.2	16.6	19.2	18.8	14.0	8.7	2.7	-1.2	8.0	1.0	15.0
Year	1961-1990 (II period)														
Max	2.0	3.2	6.3	12.7	15.0	18.1	20.2	21.0	16.4	13.1	7.1	3.5	9.9	4.8	16.3
Min	-9.8	-7.6	-1.7	4.4	10.2	13.7	15.4	14.9	11.0	4.4	-0.2	-5.4	6.5	-0.6	13.0
Mean	-2.9	-2.2	1.5	8.2	12.7	15.8	18.2	17.6	13.6	8.0	3.7	-0.4	7.8	1.3	14.4
Year	1991-2020 (III period)														
Max	0.7	3.6	7.0	12.0	15.8	19.4	21.4	22.7	18.0	12.9	8.7	5.5	10.3	3.9	16.7
Min	-6.5	-6.5	-1.3	4.9	10.1	14.3	16.6	16.0	10.4	6.4	-4.7	-7.0	6.3	-0.7	13.1
Mean	-2.2	-1.4	2.6	7.9	12.9	16.6	19.1	18.9	14.5	9.3	3.2	-0.6	8.4	1.8	15.0

As follows from table 2 monthly mean values of air temperature in Kislovodsk in 1931-2020 changes from -2.6 °C (January) to 18.8 °C (July). Range of changeability (Max – Min) of monthly values of air temperature composes 32.5 °C (-9.8 °C in January and 22.7 °C in August). The same data for three thirty-year time periods are as follows.

- 1931-1960: T mean changes from -2.9 °C (January) to 19.2 °C (July), range of changeability of T is 31.3 °C (-9.8 °C in January and 21.5 °C in July).
- 1961-1990: T mean changes from -2.9 °C (January) to 18.2 °C (July), range of changeability of T is 30.8 °C (-9.8 °C in January and 21.0 °C in July).
- 1991-2020: T mean changes from -2.2 °C (January) to 19.1 °C (July), range of changeability of T is 29.2 °C (-6.5 °C in January and 22.7 °C in August).

In fig. 1 data about difference between air temperature ΔT in Tbilisi and Kislovodsk in 1991-2020 and 1931-1960, 1991-2020 and 1961-1990, 1961-1990 and 1931-1960 are presented.

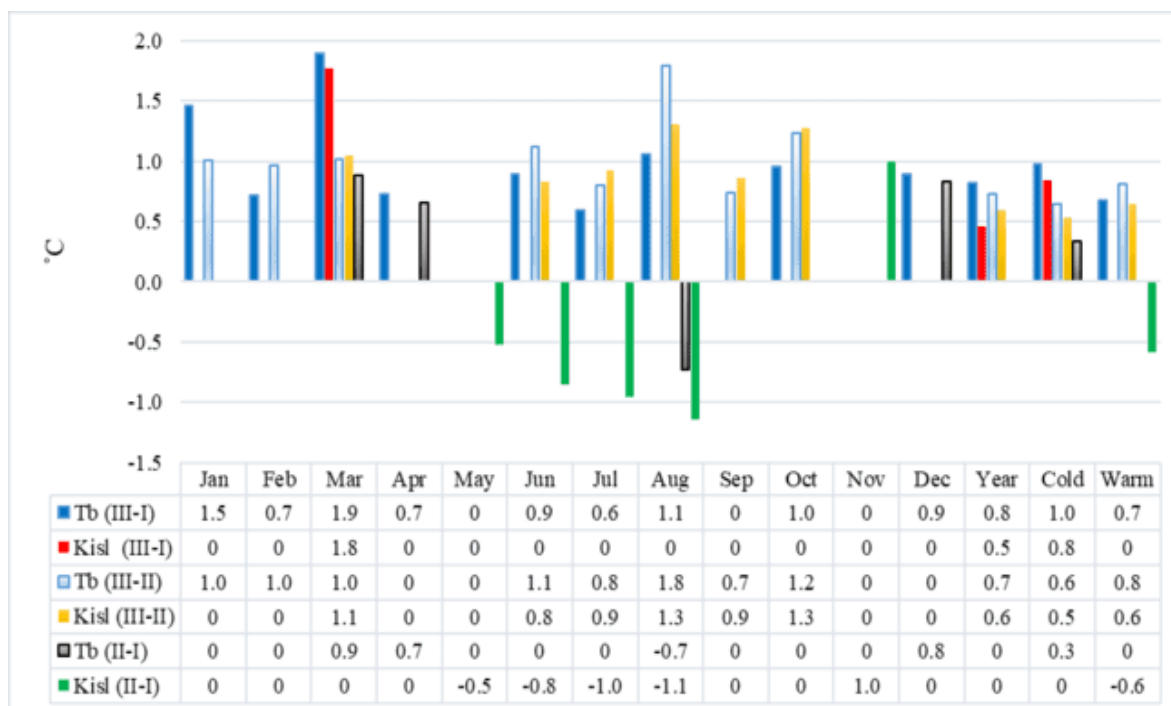


Fig. 1. Difference between mean monthly and seasonal values of air temperature in Tbilisi and Kislovodsk in 1991-2020 and 1931-1960, 1991-2020 and 1961-1990, 1961-1990 and 1931-1960.

In the indicated periods of time a significance changes of air temperature for indicated towns are as follows.

ΔT (III-I): Tbilisi - increase of the air temperature in third thirty-year period of time in comparison with the first period is observed during all months and seasons, excluding May, September and November. The greatest increase of the ΔT in March is observed (+1.9 °C). Kislovodsk - increase of the ΔT only in March (+1.8 °C), year and cold period is observed.

ΔT (III-II): Tbilisi - increase of the air temperature in third thirty-year period of time in comparison with the second period is observed during all months and seasons, excluding April, November and December. The greatest increase of the ΔT in August is observed (+1.8 °C). Kislovodsk - increase of the ΔT in March, from June to October and all seasons is observed. The greatest increase of the ΔT in Kislovodsk in August and October is observed (+1.3 °C).

ΔT (II-I): Tbilisi - increase of the air temperature in second thirty-year period of time in comparison with the first period is observed only in March (Max ΔT = +0.9 °C), April, December and cold season. In August decrease of ΔT is observed (-0.7 °C). Kislovodsk - increase of the ΔT only in November is observed (+1.0 °C). From May to August and warm season decrease of ΔT is observed. The greatest decrease of the ΔT in Kislovodsk in August is observed (-1.1 °C).

So in Tbilisi, the effect of climate warming is more pronounced than in Kislovodsk.

Conclusion

In the near future, it is planned to analyze these data using statistical methods for non-stationary observation series, as well as to carry out a comparative assessment of the expected changes of air temperature in Tbilisi and Kislovodsk for several decades.

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