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ANNUAL AMPLITUDE REGIME OF GROUND SURFACE TEMPERATURE IN GEORGIA

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Abstract

The present paper deals with the regime of annual amplitude of temperature applying the annual empirical data of the ground surface temperature of the territory of Georgia. In particular, we have determined the amplitude distribution according to the values and obtained within-year change regularity. We have also determined the change of amplitude values according to years and determined the connection of ground surface amplitude to the height of location from the sea level and constructed the annual distribution schematic map of the ground surface temperature for the territory of Georgia.

Keywords: temperature amplitude, within-year change, change according to years, connection to height, territorial distribution

Introduction

The main factors in the formation of the climate are the solar radiation energy and the shape of the earth. But, during the formation of regional climate, other processes also take place. For example, the proximity of the region to the ocean or sea has a great influence upon the formation of the regional climate of the continent. The oceans and the seas have a relatively long retention capacity of the radiation energy, or the inertia, and thus affect the climate. The closer the region is to the ocean or the sea coast, the stronger is the influence. This process determines the so-called "Continentality" of the climate and the minimum temperature of winter and maximum temperatures of summer of the ground temperature during a year are most clearly dependent on it, specifically, the ground surface temperature amplitude which is determined by the difference between the maximum and the minimum temperatures (Elsnen and Tsonis, 1996).

Having used the data of 120 years of the 30 observation points of the Russian Federation, the work by Sedov (2015) deals with the regime structure of the average annual amplitude of the ground surface temperature and its modification in conditions of modern global warming. The author notes that one of the main parameters of the climate system is the average annual amplitude, which basically determines the climate "continentality". The paper shows that the minimum volume of amplitude mode of the ground surface temperature in the European territory of the Russian Federation is observed in Socha and its surroundings and it is equal to 16.7 °C and the maximum is in Volgograd and equals to 33.2°C. The eastern part the amplitude is 30 inches high and reaches the maximum in Verkhoyansk where it is equal to 64.7°C. Today, on the entire territory of the Russian Federation, the annual amplitude of the surface temperature is growing and the authors think that the growth process will last until 2030.

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The change of annual amplitude of ground surface temperature is described on the territory of Belarus (Davidenko, 2014). The author concludes that the amplitude has been decreased to about 1°C and unevenly in the territory of Belarus in the background of global warming, namely, less than 1°C in the West, and 1.5°C in the east. The reason for this is the rise of urbanization in the East.

It is noteworthy that the work Polevoi (2014) discusses the regime structure of transiting to 0, 5, 10 and 15°c surface temperatures on the territory of Ukraine, it is stated here that the spring transition date is in the early period and in autumn it occurs on the contrary - the date of transition is later. i.e. the ground surface temperature amplitude gradually increases.

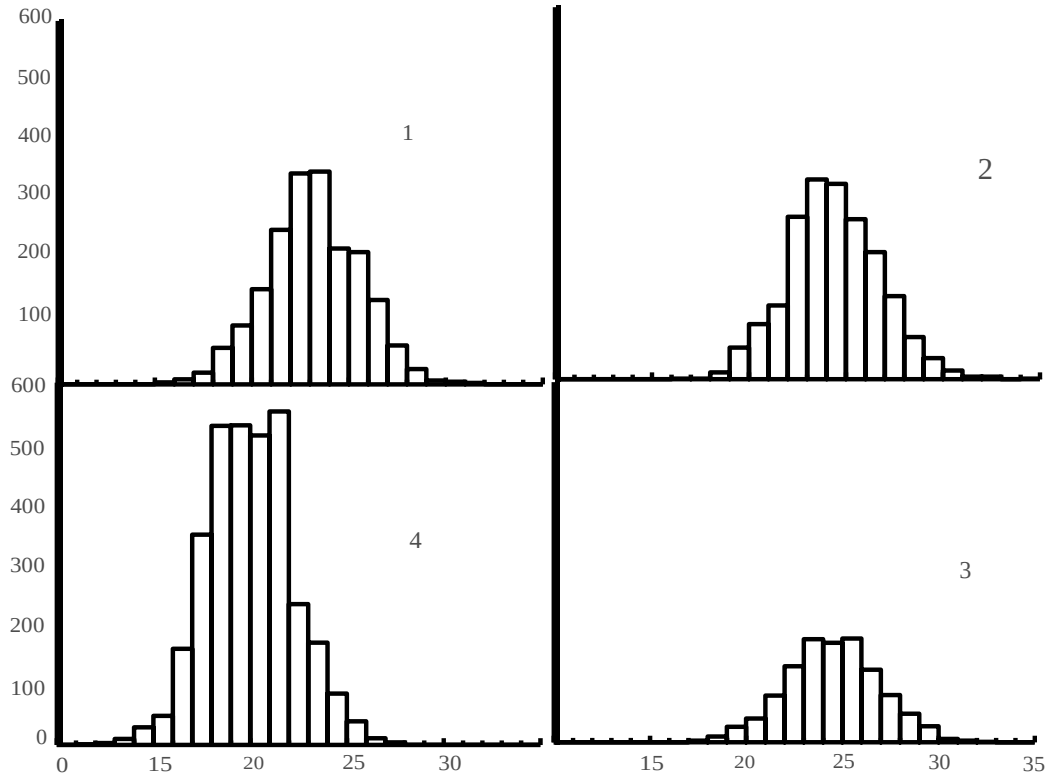

Fig. 1. *Distribution of ground surface temperature amplitude of Georgia in the highlands of the southern slopes of the Caucasus (1), on the plains of eastern Georgia (2) on the Meskheti-Javakheti uplands (3) and in the foothills of western Georgia (4).*

In the work Andreizhuk and Mongush (2009), the continentality of the climate is analytically connected to the ground surface temperature amplitude and the geographical longitude of the location. Having been introduced the so-called "Continentality Index", it is gradually increased for the Tuvi mountainous system, along with the global growth of temperature. The surface temperature amplitude for the territory of Georgia is less studied. The main determinant of the annual amplitude change of the ground surface for the earth is the distance from the equator; it is minimal on the equator and the maximum value is reached at the poles. Using the data on the ground surface temperature of 90 years (1906-1995) of the 89 points of observation in the territory of Georgia

(Tavartkiladze et al. 1994, 2012), the aim of this work is to study the regime structure of the temperature amplitude on the territory of Georgia and the influence of the climate change on it.

Methods

Annual amplitude of ground surface temperature for all points of observation was determined by two different ways in order to reduce the marginal consequences of the results. In particular, during the study of amendments according to the within-year regimes and years the amplitude for each point of observation is represented as a difference between the maximum and minimum values of the average monthly temperatures of each year. And while studying the connection of the location with the height and determining the territorial distribution, the amplitude represents the average monthly maximum and minimum temperatures between the values of the 90-year period of the observation point.

Results

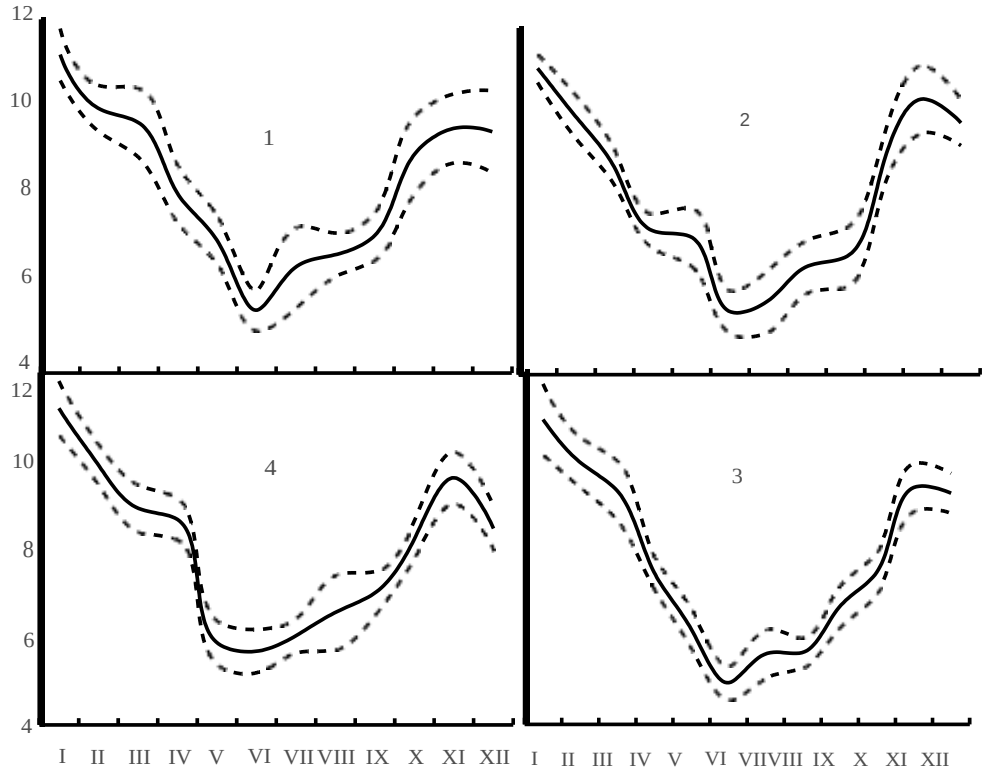

Fig.2. Within-year distribution of the ground surface temperature amplitude in Georgia (Definition of the values of numbers is given on Fig. 1).

At the same time, since the relatively small area of Georgia is characterized by a variety of climatic regimes, the regime structure has been studied by four different regions. These regions are: mountainous southern slopes of the Caucasus Mountains; plain of the East Georgia; Meskheti-Javakheti highland and foothills of western Georgia.

Certain picture on the applied empirical data is given by their distinction according to the values of amplitude for specific regions. It is represented on the fig 1.

In the vertical and horizontal sides of the figure, the number of cases and the values of amplitudes are consequently measured in °C. The largest amplitude is observed on the Meskheti-Javakheti upland and the plain of eastern Georgia. Therefore, their average perennial amplitudes are 23.55 °C and 23.42 °C. The standard drawbacks of these values are 2.43 °C and 2.38 °C, and the number of cases - 1080 and 1890.

In the highlands of the southern slopes of the Caucasus Mountains, the value of the ground surface temperature is 22.19 °C and the corresponding standard drawback and the number of cases is 2.38 °C and 1980. The foothills of western Georgia are characterized by significantly small amplitude. Here it is equal to 18.92 °C, and the standard drawback is 2.26 °C and 3060.

The horizontal and vertical axes of the drawing are adjusted for months and amplitude values. Continuous curves determine the values of the average amplitude of the month, and the intermittent curves show the boundaries of standard drawbacks. As seen from the drawing, the ground surface temperature amplitude experiences significant seasonal changes. During moving from the warm season to the cold season, the amplitude gradually increases. From the warm season to the cold season, the amplitude gradually increases, which is almost similar to the entire area and varies within about 6°C.

Changing the average monthly value of ground surface amplitude on the territory of Georgia (within-year distribution), allocated for four regions is not significantly different from each other (Fig. 2).

Regardless of the sharply fragmented surface, the regional differences seem to have less impact on the change of ground surface temperatures. Therefore, we have represented the amplitude changes according to the years and the impact of the change in the atmosphere of the whole territory of Georgia without regional divisions. In order to be compatible with all the data of the observations, we have carried out all the standardization of the observation data, and we took the values of the average perennial amplitude of each observation point. Thus, the change of average annual amplitude of ground surface temperature in 1905-1995 for the entire territory of Georgia is presented on Fig. 3.

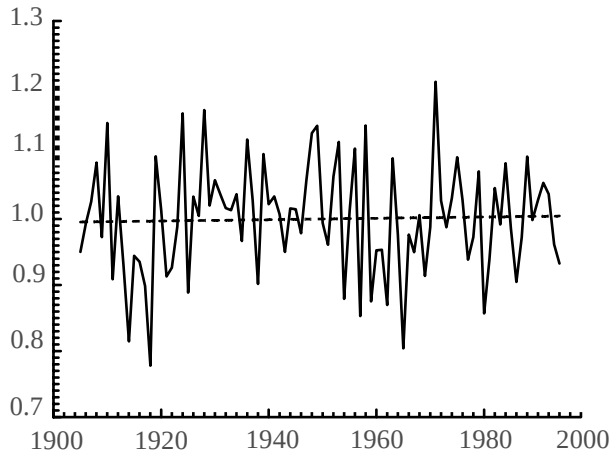

Fig. 3. Average annual amplitude changes of normalized ground surface temperature in Georgia and its linear approximation (intermittent line).

As mentioned above, the volume of the ground surface temperature amplitude is influenced by the distance from the equator, as well as from the shoreline of the oceans and seas. For such a distinctly fragmented area, like Georgia it is particularly interesting whether it is influenced by the change of the altitude of the location from sea level or not. In order to determine this, on the Fig.4 is given the values of annual anomalies in the ground surface temperature according to the heights of the location above the sea level (the height above the sea level in km and the amplitude values have been measured on the axes of coordinates).

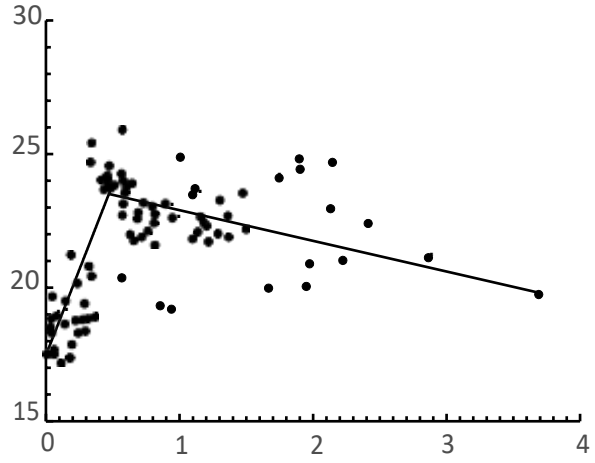

Fig 4. Change of average annual amplitude of ground surface temperature according to height.

As shown from the drawing, the average value of the amplitude for the whole territory is almost unchanged, but according to individual territories the boundary of change is within ±20%. It is noteworthy that the changes in the ground surface temperature in Georgia during this period were characterized by both, warming and cooling. The temperature amplitude is like that, despite the invariability for the entire area, there is an increase in temperature amplitude and reduction in certain areas. Thus, linear approximation of the amendment presented in the drawing, for the whole territory of Georgia, gives us the following image of the annual amplitude (Ta) change of the normalized ground surface temperature:

$Ta = 0.995 + 0.0001\,\mathrm{n}$ [1]

Where n is the years recounted since 1900. i.e. the change for one hundred years (0.01 °C/100 years) is practically zero. The amplitude changes for the four regions allocated by us for 100 years are characterized by the following values: North - positive 0.036°C, East - negative 0.014°C, South - zero and West - positive 0.012°C. All the values are within boundaries of the calculation drawbacks and we can conclude that there is no change in the temperature amplitude for any region. Today it is very difficult to determine what causes the opposite directions of change in such a small area. But such a misunderstanding also occurs during the modern global warming, when some cooling centers emerge in some of the world's enclosed areas on the background of warming.

It should be noted that from the 89 observation points, the amplitude is reduced on the 37th. The maximum reduction in annual amplitude of ground surface temperature takes place in Tbilisi (-0.0050°C/ 100 years) and in nearby Karsani (0.0057°C/100 years).

While the largest amplitude is observed in western Georgia, on the Mtsvane Kontskhi territory and it is equal to 0.0081°C/100 years.

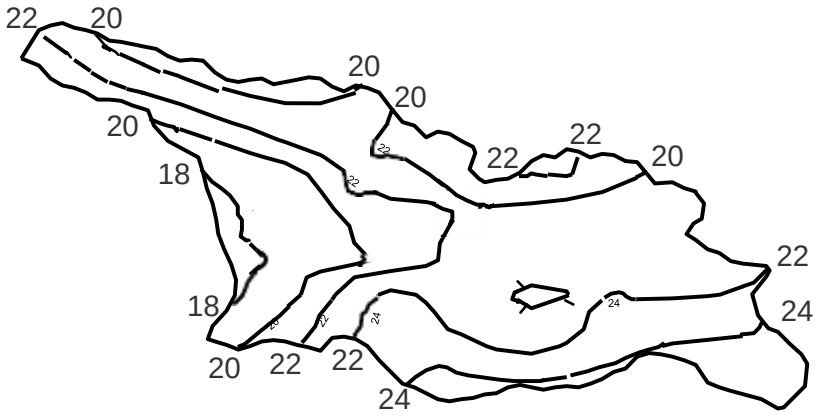

Fig. 5. Distribution of average annual amplitude of ground surface temperature in the territory of Georgia.

As seen from the drawing, the change of annual amplitude of temperature does not show a sharp expression according to height (zo). Its estimated approximation can be presented as follows:

$$Ta = \begin{cases} 17.5 + 12.80\ zo & \text{when } zo < 0.5\ km \\ 24.4 - 1.24\ zo & \text{when } zo \geq 0.5\ km \end{cases} \quad [2]$$

Conclusion

According to the height the approximate change of the amplitude can be given as following: the amplitude of about 500 meters above the sea level increases sharply, and during the further growth of height it is gradually reduced.

As a result of the survey, a schematic map of the yearly amplitude distribution of the ground surface temperature is constructed for the territory of Georgia and it is given in Fig. 5.

At great heights above the sea level, the fact of annual amplitude reduction of the ground surface temperature, which is shown by the 4th drawing, has been partially shown on the map. But it seems that the main reason for amplitude change is the factor of separation from the sea for Georgian territory.

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