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Study of the Mean and Extreme Values, Intensity and Recurrence Variability of Meteorological Elements Based on the 1956-2015 Observation Data

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ABSTRACT

Based on the data of the last 60 years (1956-2015) of 39 stations of the Georgian Meteorological Network, the nature of the change in the intensity and recurrence of the mean and extreme values of the meteorological elements was studied. The mentioned 39 stations were selected in order to optimally take into account the climatic features of the territory of Georgia. The trends of temperature and precipitation were evaluated. For the indices (35 indices) the change trends according to the average annual value were studied. The R-based software package ClimPact2 was used to calculate the sector climate indexes. The R-based software RHtestV4 and RHtests_dlyPrcp4 were used to check the homogeneity of the discussed time series.

Key Words: *Mean and extreme value, average annual value, climatic indices, homogeneity check, warming and cooling centers.*

Introduction

Georgian relief may be characterized by three sharply expressed orographic elements: in north Caucasus, in south – Georgian south uplands and lowland or intermountain depression located between those two risings. This one begins from The Black Sea shore by triangular Colchis Lowland and spreads up to eastern Georgia like narrow strip. Between those two uplands small scaled orographic elements are allocated. Such complicated relief has definite influence on air masses motion in atmosphere lower layers. Mainly west and eastern atmospheric processes prevailed over Georgian territory. Due to complex orographic conditions and influence of the black Sea in Georgia exist most of Earths climatic types, from marine wet subtropical climate in west Georgia and steppe continental climate in east Georgia up to eternal snow and glaciers in high mountain zone of Great Caucasus, and 40% of existed landscapes [1]. Thus those climatic zones uphold the formation of different dangerous hydrometeorological phenomena, namely: hailstone, heavy showers, flooding, thunderstorm, draughts, sea storms. The economical losses and casualties caused by those catastrophic events are impressive [2].

Here exist most of Earths climatic types, from marine wet subtropical climate of west Georgia and steppe continental climate of east Georgia up to eternal snow and glaciers of high mountain zone of Great Caucasus, and also approximately 40% of observed landscapes. The complexity of the orographic structure of Georgian territory, along with other physical -geographical factors is the cause of wide variety of climates and landscapes. There are almost all types of climates observed on the Globe, from the climate of eternal snows of high mountains and glaciers to steppe continental climate of eastern Georgia and humid climate of the Black Sea coast subtropical

Current geodynamics and orographic properties of Georgia play an important role in the formation of various weather patterns. Such complex relief conditions the formation and evolution of various scaled circulation systems and heterogeneous spatial distribution of meteorological elements. This is verified by the fact, that precipitation annual distribution has diverse type, with sharply expressed spatial inhomogeneities.

The local circulation systems developed on the background of synoptical processes play significant role in the spatial-temporal distribution of weather determining parameters. The study of all those phenomena needs the processing of long-term observation series of those climatic parameters.

Data and methods

Based on the 39 stations data of the Georgian Meteorological Network of last 60 years (1956-2015), the change nature of the intensity and recurrence of the mean and extreme values of the meteorological elements was studied. These 39 stations were selected in order to optimally take into account the climatic characteristics of the territory of Georgia; the temperature and precipitation change trends, as well as wind speed was assessed.

Extreme values of climate parameters are more sensitive to climate change than their mean values, however, medium values often make it impossible to assess socio-economic impacts on different sectors of climate change. In addition to the mean values of climate parameters, various types of climate characteristics / indices (such as heat waves, extremely rainy / rainless periods, etc.) are calculated to assess climate change., the calculation methodology of which is developed according to the recommendations of the IPCC and by which the change regularities of the magnitude, frequency and intensity of extreme climate parameters are determined.

In order to increase the reliability of the obtained results, these parameters were evaluated by two methods: for each parameter to detect change trends in 1956-2015 and to assess the statistical reliability of these trends (Mann-Kendall method) and for two 30-year periods (1956-1985 & 1986-2015) the comparison of mean / extreme values.

The R-based software package ClimPact2, developed by the IMO Climate Commission's Sector Climate Index Expert Group (https://github.com/ARCCSS-extremes/climpact2), was used to calculate sectoral climate indices [3].

R-based software RHtestV4 and RHtests_dlyPrcp4 (http://etccdi.pacificclimate.org/software.shtml) were used to test the homogeneity of the time series under consideration [4].

Between the two 30-year periods (1956-1985 & 1986-2015), the average annual atmosphere surface layer temperature in the country has risen almost everywhere, within 1 degree, with an average increase of 0.5^0C in the territory.

The warming process is relatively intense in Samegrelo-Zemo Svaneti, Kakheti and Samtskhe-Javakheti. The most significant warming was revealed in Dedoplistskaro district.

Discussion

The precipitation regime changes are unstable in time and are also spatially heterogeneous, although they are still characterized by some regularity. In particular, the annual rainfall in western Georgia is mainly increased, while in some eastern regions - decreased, although the nature of the change in annual rainfall is mostly unreliable and there are no obvious trends. Trends were revealed only on a number of curves. Trends in the change in the average annual rainfall in the West are almost everywhere positive, with the largest deviation between the two periods (up to 15%) and, consequently, the most stable growth trend was observed in Poti and Khulo (60-75 mm / 10 years). The only exceptions are significant tendencies of precipitation decrease (60-120 mm / 10 years) in Guria and high mountains of Adjara (Goderdzi Pass). In the east, the annual growth is maximal and the corresponding trends are significant in Lagodekhi (17%, 75 mm / 10 years), while the decrease in precipitation is most intense in Tianeti (-18%, 39 mm / 10 years).

The average wind speed change tends seems to be decreased for almost all study stations. The average wind speed between the two 30-year periods decreases by an average of 1-2 m / s. Exceptions in this regard are Kobuleti and Bakhmaro, where the wind speed is unstable, but increases with each passing season. It should be noted, however, that these trends are based solely on observations prior to 2010. Most of the trends in average wind speed change across the country are reliable for both annual values and seasonal average speeds. Only at Tbilisi station the trend is not stable in any season of the year, in Zugdidi - in autumn (September-October) and in Kutaisi - in summer. The picture of the most intense decrease in average wind speed in the whole area was revealed in Mta-Sabueti and Poti, where the average annual speeds decrease by 0.5 m / s every 10 years, and in the east - in Shida Kartli (Gori). Such a decrease in wind speeds is due to the intense decline detected in the spring of this parameter, most notably in April.

The number of strong windy days (maximum wind speed ≥15 m / s, ≥25 m / s) was selected to characterize the maximum wind speed regime. Since maximum speed wind data are available only from 1970, the change trends were built on 1970-2015. For the period, while the comparison of the numbers of strong winds was carried out in 1971-1985, 1986-2000 and 2001-2015for 15-year periods.
Tendencies to decrease the number of strong winds (≥15 m / s) are predominant in the West, while in Eastern Georgia, their frequency will be observed. It is noteworthy that the number of such days is decreasing in western Georgia - Kutaisi and especially on the western slopes of the Likhi Range (Mta-Sabueti), where trends were revealed in the summer-autumn seasons, and in the east, in the Mtkvari gorge, a significant increase is observed. Frequency of strong winds in Gori will be observed in all seasons, while in Tbilisi their annual number increases mainly at the expense of March. The trend changes maximum in Mta-. Sabueti and Gori and are 1.7 days / 10 years. The frequency of extremely strong winds (≥25 m / s) changes with a similar regularity. In particular, a significant decrease in such days was observed in Kutaisi and Mta-Sabueti, while the steady increase is observed in Gori, as well as in Poti.

Conclusion

The following may be stated based on the analysis of observation data:

- The average annual temperature has risen everywhere, up to 1 degree.
- Warming is taking place in June-October (0.7-1.3 degrees), especially in August (0.9-1.8 degrees).
- Spring-winter warming is unreliable.
- Cooling trends are also predominant in some months (May, November-December).
- In western Georgia it is mainly conditioned by the increase of night temperatures, and in the east - by daytime temperatures.
- Annual precipitation is mainly increased in western Georgia, while it is reduced in some eastern regions.
- The increase in the West is mainly observed in January, in the East - in October-November, while the decrease is everywhere at the expense of July-September.

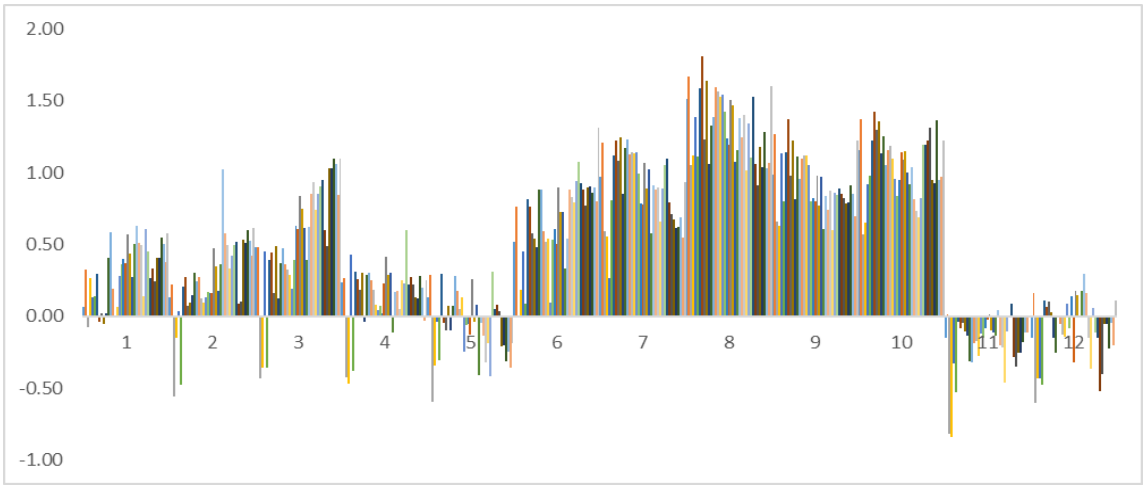

Fig.1. The monthly mean temperature change based on the1956-2015 observation data.

The conducted research gives possibility to conclude regarding precipitation change:

- Annual precipitation is mostly increased in western Georgia, while it is reduced in a number of eastern regions.
- The increase in the West is mainly observed in January, in the East - in October-November, while the decrease is everywhere mainly due to July-September.

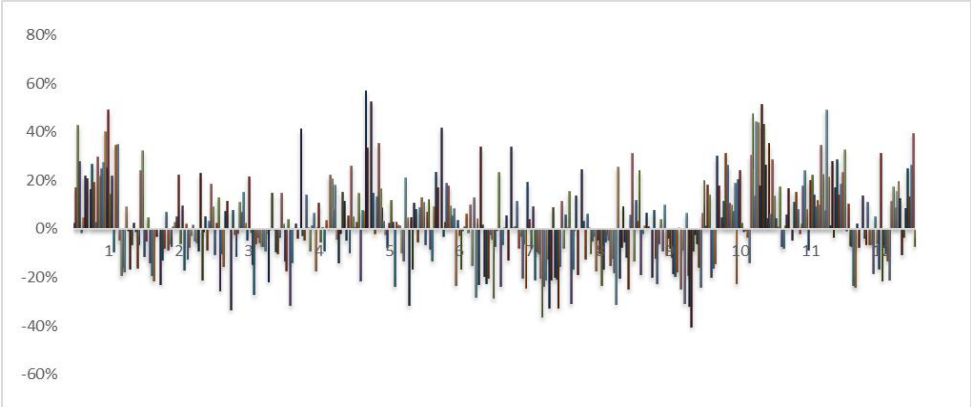

Fig.2. Precipitation change based on the1956-2015 observation data.

The linear trends for Poti and Tianeti stations are presented below.

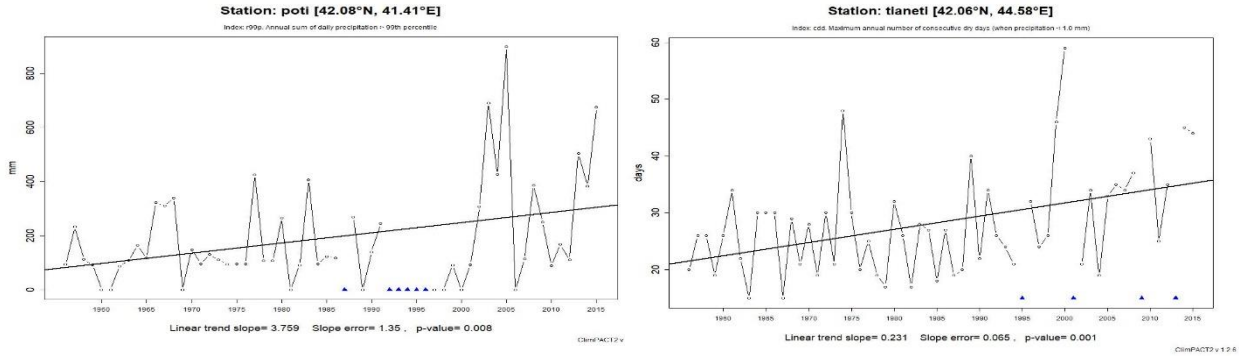

Fig.3. Precipitation linear trends for Poti and Tianeti.

In Samegrelo and Adjara-Guria precipitation tendency has increased character, which is due to the frequency of heavy rainfall (R95pTOT, R99pTOT r95p, r99p, r30mm, r50mm). In addition, a significant increase in the maximum daily precipitation (Rx1D, Rx5D) was observed in these areas.

In the south and east of the country, precipitation indices for most stations (especially in Kakheti and Mtskheta-Mtianeti) indicate precipitation decrease due to the prolonged precipitation periods (CDD). At the same time, there are increased tendencies in Tbilisi, Telavi and Lagodekhi, as well as the increasing number of cases of extreme rainfall.

Therefore, it is likely that droughts, floods and natural geological processes will increase in frequency.

References

[1] Climate and climatic resources of Georgia, 1971.

[2]Tatishvili M., Elizbarashvili E., Meskhia R., Elizbarashvili Sh. Natural hydrometeorological disasters, their causes and prevention measures. The Macrotheme Review. A multidisciplinary journal of global macro trends, 148-154, A Macrotheme Capital Management, LLC Academic Publication, Volume 2, Issue 1, Winter 2013 (January). ISSN 1848-4735, France

[3] https://github.com/ARCCSS-extremes/climpact2

[4] http://etccdi.pacificclimate.org/software.shtml

მეტეოროლოგიური ელემენტების საშუალო და ექსტრემალური მნიშვნელობების, ინტენსივობისა და განმეორებადობის ცვალებადობის შესწავლა ბოლო 60-წლიანი პერიოდის (1956-2015 წ.წ.) დაკვირვებათა მონაცემების საფუძველზე

მ. ტატიშვილი, ლ.მეგრელიძე, ა.ფალავანდიშვილი

რეზიუმე

საქართველოს მეტეოროლოგიური ქსელის 39 სადგურის უკანასკნელი 60-წლიანი პერიოდის (1956-2015 წ.წ.) მონაცემებზე დაყრდნობით შესწავლილი იქნა მეტეოროლოგიური ელემენტების საშუალო და ექსტრემალური მნიშვნელობების ინტენსივობისა და განმეორებადობის ცვლილების ხასიათი. აღნიშნული 39 სადგური შერჩეული იქნა საქართველოს ტერიტორიის კლიმატური თავისებურებების ოპტიმალურად გათვალისწინების მიზნით. შეფასებული იქნა, როგორც ტემპერატურისა და ნალექების, ცვლილების ტენდენციები. სექტორული კლიმატური ინდექსების გაანგარიშებისთვის გამოყენებული იქნა **R**-დაფუძნებული პროგრამული პაკეტი ClimPact2.განსახილველი დროითი სერიების ჰომოგენურობის შემოწმების მიზნით გამოყენებული იქნა **R**-დაფუძნებული პროგრამული უზრუნველყოფები RHtestV4 და RHtests_dlyPrcp4

Изучение средних и экстремальных значений, интенсивности и повторяемости метеорологических элементов на основе данных наблюдений за 1956-2015 гг.

М.Р. Татишвили, Л.Д. Мегрелидзе, А. М. Палавандишвили

Резюме

По данным 39 станций Грузинской метеорологической сети за последние 60 лет (1956-2015 гг.) изучен характер изменения интенсивности и повторяемости средних и экстремальных значений метеорологических элементов. Указанные 39 станций выбраны с целью оптимального учета климатических особенностей территории Грузии. Были оценены тенденции изменения температуры и осадков. Для расчета климатических индексов использовался программный пакет ClimPact2 на базе R. Программное обеспечение на основе R RHtestV4 и RHtests_dlyPrcp4 использовалось для проверки однородности рассматриваемого временного ряда.