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Use of Structured Data to Evaluate Natural Hydrometeorological Events in Vulnerable Regions of Georgia

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Summary. The location and orographic conditions of Georgia lead to the formation of a variety of climatic and landscape types. These factors are favorable for formation of natural hydrometeorological phenomena (flooding, landslide, hurricane, etc.) of different intensity and frequency. The study of all those phenomena needs the processing of long-term observation series of climatic parameters. The purpose of the presented research is to study the spatial-temporal regularities of basic climatic parameters in the mountain regions of Georgia. The following statistical parameters and climatic indices were calculated: standard deviation, mean absolute error, temperature extremes, extreme precipitation day number, repeatability of strong windy days. Between two 30-year periods, the average annual temperature has been increased almost everywhere, up to 1 degree; the average increase is 0,5˚C. It has been established that for second period there is a significant increase in the average max air temperature from 0,3˚C to 1,2˚C. The precipitation regime changes are unstable in time and are spatially heterogeneous, although they are characterized by some regularity. In particular, the annual rainfall in western Georgia is mainly increased, while in some eastern regions – decreased. The average wind speed change trends seem to be decreased, however maximal velocities are increased. The results may be used in early warning systems.

Keywords: Climate Change, Early Warning, Natural Hazards, Statistical Analysis Structural Data

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 [1]. 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 [2]. 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 too notable [2].

Data and Methods. Based on the1961-2021 period data of Georgian hydrometeorological observation net the research for mountainous regions of Georgia (Bakhmaro, Bakuriani, Borjomi, Goderdzi, Gudauri, Khaishi, Khulo, Lentekhi, Mestia, Pasanauri, Shovi, Stepantsminda, Tianeti) was conducted to reveal the variable nature of the intensity and recurrence of the mean and extreme values of the meteorological parameters [3].
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.

Results. According to the preliminary analysis for whole Georgian territory the precipitation changing regime is unstable in time and also spatially heterogeneous, although it may be 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 according to the comparison of two 30 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 and other locations too [2].

Discussion. The mean annual, half year and monthly min and max air temperature (Tmax) data are calculated and range of variability of the mean values of Tmax for the indicated stations is as follows: Mean Year - from 6.6 °C (Goderdzi) to 16.4 °C (Borjomi); Mean Cold - from 0.0 °C (Goderdzi) to 9.7 °C (Khulo); Mean Warm - from 13.3 °C

(Goderdzi) to 23.9 °C (Khaishi); Min - from -11.8 °C (Goderdzi) to -0.5 °C (Borjomi); Max - from 23.4 °C (Goderdzi) to 35.0 °C (Borjomi) [3].

Table 1. The mean min, monthly mean, max and mean seasonal values of Tmax (°C) in thirteen locations of Georgia in 1961-2021

Station	Mean Year	Mean Cold	Mean Warm	Min	Max
Bakhmaro	8.6	3.0	14.2	-8.2	24.2
Bakuriani	11.3	5.1	17.5	-5.7	27.7
Borjomi	16.4	9.4	23.5	-0.5	35.0
Goderdzi	6.6	0.0	13.3	-11.8	23.4
Gudauri	7.8	2.0	13.7	-8.8	25.4
Khaishi	16.3	8.7	23.9	-1.3	33.7
Khulo	15.8	9.7	22.0	-1.6	31.4
Lentekhi	15.8	7.9	23.7	-1.9	34.5
Mestia	13.4	5.9	20.9	-6.4	30.2
Pasanauri	14.5	7.4	21.6	-2.9	33.0
Shovi	12.6	5.7	19.5	-5.5	30.8
Stepantsminda	10.6	4.5	16.7	-5.7	27.4
Tianeti	14.4	7.6	21.2	-1.7	31.6

The mean monthly annual, half year and monthly min and max P values are presented in Table 2.

Table 2. Monthly min, monthly max and mean monthly seasonal P (mm) values in selected locations of Georgia during 1961-2021

Station	Mean Year	Mean Cold	Mean Warm	Min	Max
Bakhmaro	130	154	107	9.8	554
Bakuriani	70	59	82	0.5	283
Borjomi	55	48	62	1.5	181
Goderdzi	110	115	104	7.7	361
Gudauri	128	106	151	0	536
Khaishi	102	108	96	1.0	670
Khulo	117	149	84	0.5	628
Lentekhi	107	110	104	1.3	556
Mestia	82	76	88	1.0	284
Pasanauri	82	59	105	0	353
Shovi	98	85	111	3.4	444
Stepantsminda	62	34	89	0	252
Tianeti	64	42	85	0	277

The variability range of the P mean values for the indicated stations is as follows: Mean Year - from 55 mm (Borjomi) to 130 mm (Bakhmaro); Mean Cold - from 34 mm (Stepantsminda) to 154 mm (Bakhmaro); Mean Warm - from 62 mm (Borjomi) to 151 mm (Gudauri); Min - from 0 mm (Gudauri, Pasanauri, Stepantsminda and Tianeti) to 9.8 mm (Bakhmaro); Max - from 181 mm (Borjomi) to 670 mm (Khaishi). The P smallest values for Stepantsminda are observed (24 mm) during January and the P greatest values for Gudauri (185 mm) are observed in May. The variability of the atmospheric precipitation monthly mean sum is observed for all study stations (except Bakhmaro, and Bakuriani) in 25 cases (including for 12 cases - an increase and for 13 cases - a decrease of ΔP values) [4].

The range of variability of the V mean values for the indicated stations is as follows: Mean Year - from 0.3 m/sec (Lentekhi) to 4.8 m/sec (Goderdzi); Mean Cold - from 0.2 m/sec (Lentekhi) to 5.4 m/sec (Goderdzi); Mean Warm - from 0.4 m/sec (Lentekhi) to 4.2 m/sec (Goderdzi); Min - 0 m/sec (for all stations); Max - from 2.1 m/sec (Lentekhi) to 10.7 m/sec (Goderdzi).

The smallest V values for all points during January and December are observed (0.1 m/sec, Lentekhi). The greatest values of V for Goderdzi (6.1 m/sec) in January are also detected.

Table 3. The monthly mean min, monthly mean max and mean seasonal V (m/s) values in thirteen locations of Georgia in 1961-2021

Station	Mean Year	Mean Cold	Mean Warm	Max
Bakhmaro	1.7	2.2	1.3	5.7
Bakuriani	1.3	1.1	1.5	5.2
Borjomi	0.7	0.5	0.8	2.2
Goderdzi	4.8	5.4	4.2	10.7
Gudauri	1.2	1.1	1.2	3.4
Khaishi	0.9	0.7	1.2	3.7

Khulo	1.9	2.0	1.7	4.0
Lentekhi	0.3	0.2	0.4	2.1
Mestia	0.5	0.3	0.7	2.2
Pasanauri	1.1	1.1	1.2	2.9
Shovi	1.1	1.0	1.1	2.9
Stepantsminda	1.7	1.8	1.6	6.1
Tianeti	1.2	1.2	1.2	4.6

Conclusions. The following may be deduced based on the on the conducted research: The variations of the ΔT_{max} values in the separate points are the following: Bakhmaro - increase of the values of ΔT_{max} (July, August), decrease (-1.1 °C, December); Bakuriani - increase (February, March, May-October, mean annual, cold and warm seasons mean); Borjomi - increase (February-April, June-October, mean annual and warm season mean); Goderdzi - increase (August), decrease (-1.0 °C, November); Gudauri - increase (March, June-October, mean annual and warm season mean); Khaishi - increase (March, July-October, warm season mean); Khulo increase (July-September); Lentekhi - increase (July-September, warm season mean), decrease (-1.3 °C, November); Mestia - increase (April-September, warm season mean); Pasanauri - increase (March, June-October, warm season mean); Shovi - increase (April-October, mean annual and warm season mean); Stepantsminda - increase (June-September, warm season mean); Tianeti - increase (March, June-October, warm season mean).

Totally, the ΔT_{max} values change from -1.3°C (Khulo, November) to 2.6 °C (Bakuriani, August), amplitude - 3.9 °C.

The changeability of the ΔP values in the separate points is the following: Bakhmaro and Bakuriani (no changes); Borjomi - decrease (June and December); Goderdzi - decrease (March, April mean annual and warm season mean); Gudauri - increase (August, October and cold season mean), decrease (September); Khaishi - increase (April and May); Khulo - increase (January, September, mean annual, cold and warm seasons mean); Lentekhi - increase (May and June), decrease (September); Mestia – increase (mean annual and cold season mean); Pasanauri - increase (August, October and cold season mean); Shovi - increase (October); Stepantsminda - decrease (July, September), increase (October); Tianeti - decrease (March, May-July, September, mean annual and warm seasons mean).

The changeability of the ΔV values in the separate points is the following: Bakhmaro – increase (January, March, May and June); all another station, except Shovi – decrease (all months, mean annual, cold and warm seasons mean); Shovi - decrease (all months, except April, June and October, mean annual, cold and warm seasons mean).

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სტრუქტურირებული მონაცემების გამოყენება საქართველოს დაუცველ რეგიონებში ბუნებრივი ჰიდრომეტეოროლოგიური მოვლენების შესაფასებლად/ მარიკა ტატიშვილი, ინგა სამხარაძე,ანა ფალავანდიშვილი, ნანა ნებიერიძე, ხათუნა ელბაქიძე-ჩარგაზია/სტუ-ის ჰმი-ის შრომათა კრებული-2025.-ტ.136.-გვ. 105-108. -ქართ., რეზ. ქართ., ინგლ., რუს.

საქართველოს მდებარეობა და ოროგრაფიული პირობები განაპირობებს კლიმატური და ლანდშაფტური ტიპების მრავალფეროვნების ფორმირებას. ეს ფაქტორები ხელს უწყობს სხვადასხვა ინტენსივობისა და სიხშირის ბუნებრივი ჰიდრომეტეოროლოგიური მოვლენების (წყალდიდობა, მეწყერი, ქარიშხალი და ა.შ.) ფორმირებას. ყველა ამ ფენომენის შესწავლა მოითხოვს კლიმატური პარამეტრების გრძელვადიანი დაკვირვების სერიების დამუშავებას. წარმოდგენილი კვლევის მიზანია საქართველოს მთიან რეგიონებში ძირითადი კლიმატური პარამეტრების სივრცით-დროითი კანონზომიერებების

შესწავლა. გამოთვლილია შემდეგი სტატისტიკური პარამეტრები და კლიმატური ინდექსები: სტანდარტული გადახრა, საშუალო აბსოლუტური შეცდომა, ტემპერატურის ექსტრემალური მაჩვენებლები, ექსტრემალური ნალექიანობის დღეების რაოდენობა, ძლიერი ქარიანი დღეების განმეორებადობა. ორ 30-წლიან პერიოდს შორის საშუალო წლიური ტემპერატურა თითქმის ყველგან გაიზარდა 1 გრადუსამდე; საშუალო მატება 0,5˚C-ია. დადგინდა, რომ მეორე პერიოდში ჰაერის საშუალო მაქსიმალური ტემპერატურა მნიშვნელოვნად იზრდება 0,3˚C-დან 1,2˚C-მდე. ნალექების რეჟიმის ცვლილებები დროში არასტაბილურია და სივრცით ჰეტეროგენულია, თუმცა გარკვეული კანონზომიერებით ხასიათდება. კერძოდ, დასავლეთ საქართველოში წლიური ნალექების რაოდენობა ძირითადად გაზრდილია, ხოლო აღმოსავლეთის ზოგიერთ რეგიონში - შემცირებული. ქარის საშუალო სიჩქარის ცვლილების ტენდენციები, როგორც ჩანს, შემცირებულია, თუმცა მაქსიმალური სიჩქარეები გაზრდილია. შედეგები შეიძლება გამოყენებულ იქნას ადრეული შეტყობინების სისტემებში.

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Использование структурированных данных для оценки природных гидрометеорологических явлений в уязвимых регионах Грузии /Марика Татишвили, Инга Самхарадзе, Ана Палавандишвили, Нана Небиеридзе, Хатуна Элбакидзе-Чаргазия/Сб. Трудов ИГМ ГТУ. - 2025. – том 136. - с. 105-108. - Груз.; Рез: Груз., Англ., Рус.

Местоположение и орографические условия Грузии обуславливают формирование разнообразных климатических и ландшафтных типов. Эти факторы благоприятны для формирования стихийных гидрометеорологических явлений (наводнения, оползни, ураганы и т. д.) различной интенсивности и частоты. Изучение всех этих явлений требует обработки многолетних рядов наблюдений за климатическими параметрами. Целью представленного исследования является изучение пространственно-временных закономерностей основных климатических параметров в горных регионах Грузии. Рассчитаны следующие статистические параметры и климатические индексы: стандартное отклонение, средняя абсолютная ошибка, экстремумы температур, число экстремальных дней с осадками, повторяемость дней с сильным ветреным воздухом. Между двумя 30-летними периодами среднегодовая температура повысилась почти повсеместно, до 1 градуса; среднее повышение составляет 0,5˚C. Установлено, что за второй период наблюдается существенное повышение средней максимальной температуры воздуха от 0,3˚C до 1,2˚C. Изменения режима осадков нестабильны во времени и пространственно неоднородны, хотя и характеризуются некоторой закономерностью. В частности, годовое количество осадков в западной Грузии в основном увеличивается, а в некоторых восточных регионах – уменьшается. Тенденции изменения средней скорости ветра, по-видимому, уменьшаются, однако максимальные скорости увеличиваются. Результаты могут быть использованы в системах раннего оповещения.