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STATISTICAL ANALYSIS OF THE NUMBER OF DAYS WITH HAIL IN GEORGIA ACCORDING TO METEOROLOGICAL STATIONS DATA IN 2006-2021

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Abstract: *A statistical analysis of data on number of days with hail (annual and for period from April to October) in 43 locations of Georgia in 2006-2021 are presented. In particular, the following results are obtained. The max average annual number of days with hail in Akhaltsikhe is observed (3.4). The max annual number of days with hail in Mirveti is observed (16). The max average number of days with hail in warm period in Akhaltsikhe also is observed (3.3). The max number of days with hail in warm period in Khashuri is observed (9). The climate change influence on the number of days with hail during the warm period has been studied. Comparison of the number of days with hail for 30 meteorological stations in 2006-2021 and 1941-1990 showed that in the second period of time, compared to the first period, the number of days with hail at the 18 stations decreased, at the 10 stations - did not change, and increased at only one station (Keda). The data of this work will be used to compile a Natural Hazards Catalog in Georgia.*
Key Words: *Number of days with hail, climate change.*

Introduction

Hail processes occur in many countries of the world [1], including Georgia [2-11]. Every year, the total loss of agricultural products due to hail damage ranges from 4 to 18% of the crop (more than 11 billion US dollars [https://www.meteorf.ru/activity/activ/antigrad/obs-info /]). In terms of hail damage, Georgia is one of the most hail-prone countries in the world. Therefore, as before in recent years many works are devoted to the problem of hail in our country, covering a wide range of studies - from hail climatology [2-9], modeling the distribution of hailstones by mean max sizes on the territory of Kakheti (Georgia) [10] to the development of ways to influence on hail processes [11].

Study area, material and methods

Study area – Georgia.

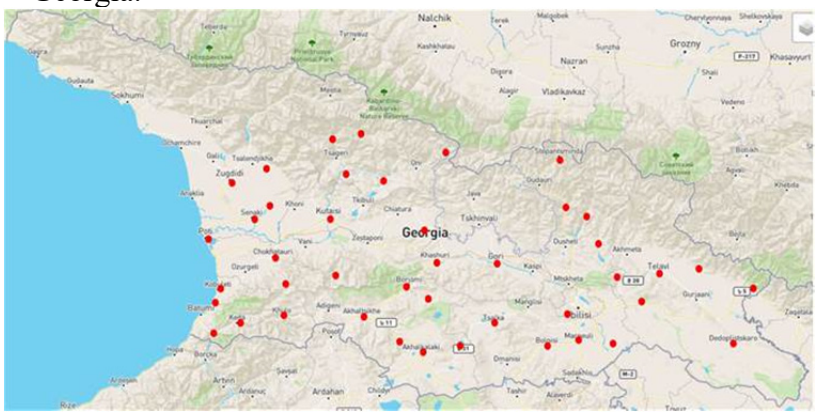

Fig. 1. Location of 43 meteorological stations on the territory of Georgia.

The data of Georgian National Environmental Agency on number of days with hail for 43 locations of Georgia (Fig. 1) in 2006-2021 are used. In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods. The following designations will be used below: Mean – average values; Max - maximal values; Min – minimal values; St Dev - standard deviation; α - the level of significance; the level of significance of the difference between the two mean values was determined using Student's t-test. The number of days with hail is considered for two periods of the year: January-December (annual) and April-October (warm half-year for hail processes).

Results and discussion

Results in Table 1,2 and Fig. 2,3 are presented.

In Table 1 statistical characteristics of annual number of days with hail in 43 locations of Georgia from 2006 to 2021 are presented.

Table 1. Statistical characteristics of annual number of days with hail in 43 locations of Georgia in 2006-2021. In the 25 points of Georgia (marked in light blue) during the cold period of the year (November-March) hail processes were not observed.

Season	Year			Season	Year		
Location	Max	Mean	St Dev	Location	Max	Mean	St Dev
Akhalkalaki	5	2.4	1.3	Lentekhi	1	0.1	0.3
Akhaltsikhe	8	3.4	1.9	Luji	4	1.3	1.6
Alpana	2	0.6	0.9	Magharoskari	1	0.2	0.4
Ambrolauri	1	0.1	0.3	Marneuli	1	0.1	0.3
Bakhmaro	4	0.8	1.3	Mirveti	16	3.3	4.9
Bakuriani	8	2.9	2.2	Mta-Sabueti	1	0.1	0.3
Bolnisi	5	1.7	1.5	Nokalakevi	2	0.4	0.8
Borjomi	6	2.3	1.6	Paravani	1	0.1	0.3
Chakvi	6	0.4	1.5	Pasanauri	3	0.4	0.8
Chokhatauri	8	3.2	2.5	Poti	2	0.1	0.5
Dedoplistskaro	2	0.4	0.7	Sagarejo	3	0.7	1.1
Gardabani	1	0.1	0.3	Sairme	5	0.6	1.5
Gori	4	1.4	1.0	Senaki	1	0.1	0.3
Keda	8	1.8	2.7	Shovi	5	1.5	1.6
Khashuri	9	1.5	2.1	Stapantsminda	3	0.4	0.8
Khertvisi	1	0.13	0.3	Tbilisi	4	1.2	1.4
Khulo	1	0.2	0.4	Telavi	8	1.8	2.2
Kobuleti	4	0.4	1.0	Tianeti	5	2.0	1.4
Kojori	3	0.2	0.8	Tsalka	5	2.1	1.6
Kutaisi	1	0.1	0.3	Zugdidi	3	0.5	0.9
Kvareli	1	0.1	0.3	Min	1	0.1	0.3
Lagodekhi	9	1.7	3.0	Max	16	3.4	4.9
Legakhare	2	0.2	0.5	Mean	4.0	1.0	1.0

As follows from Table 1 the max average annual number of days with hail in Akhaltsikhe is observed (3.4). The max annual number of days with hail in Mirveti is observed (16). It should be noted that in the 25 points of Georgia (marked in light blue) during the cold period of the year (November-March) hail processes were not observed.

In Table 2 statistical characteristics of number of days with hail during the warm period (April-October) in 18 locations of Georgia in 2006-2021 are presented.

Table 2. Statistical characteristics of number of days with hail during the warm period in 18 locations of Georgia in 2006-2021. For the remaining 25 points of Georgia relevant data are given in Table 1 (marked in light blue).

Season	Warm (April-October)			Season	Warm (April-October)		
Location	Max	Mean	St Dev	Location	Max	Mean	St Dev
Akhaltsikhe	8	3.3	1.9	Magharoskari	1	0.1	0.3
Bakhmaro	4	0.7	1.3	Marneuli	0	0.0	0.0
Borjomi	4	2.2	1.4	Mirveti	4	0.6	1.3
Chakvi	1	0.1	0.3	Nokalakevi	2	0.3	0.7
Chokhatauri	6	1.4	1.5	Senaki	0	0.0	0.0
Gori	4	1.3	0.9	Shovi	5	1.4	1.7
Keda	4	0.8	1.2	Zugdidi	1	0.2	0.4
Khertvisi	1	0.06	0.3				
Kobuleti	1	0.1	0.3	Min	0	0.0	0.0
Lagodekhi	7	0.8	1.9	Max	9	3.3	2.2
Legakhare	0	0.0	0.0	Mean	3.2	0.8	0.9

Table 2 show, that the max average number of days with hail in warm period in Akhaltsikhe also is observed (3.3). The max number of days with hail in warm period in Khashuri is observed (9).

The climate change influence on the number of days with hail during the warm period has been studied.

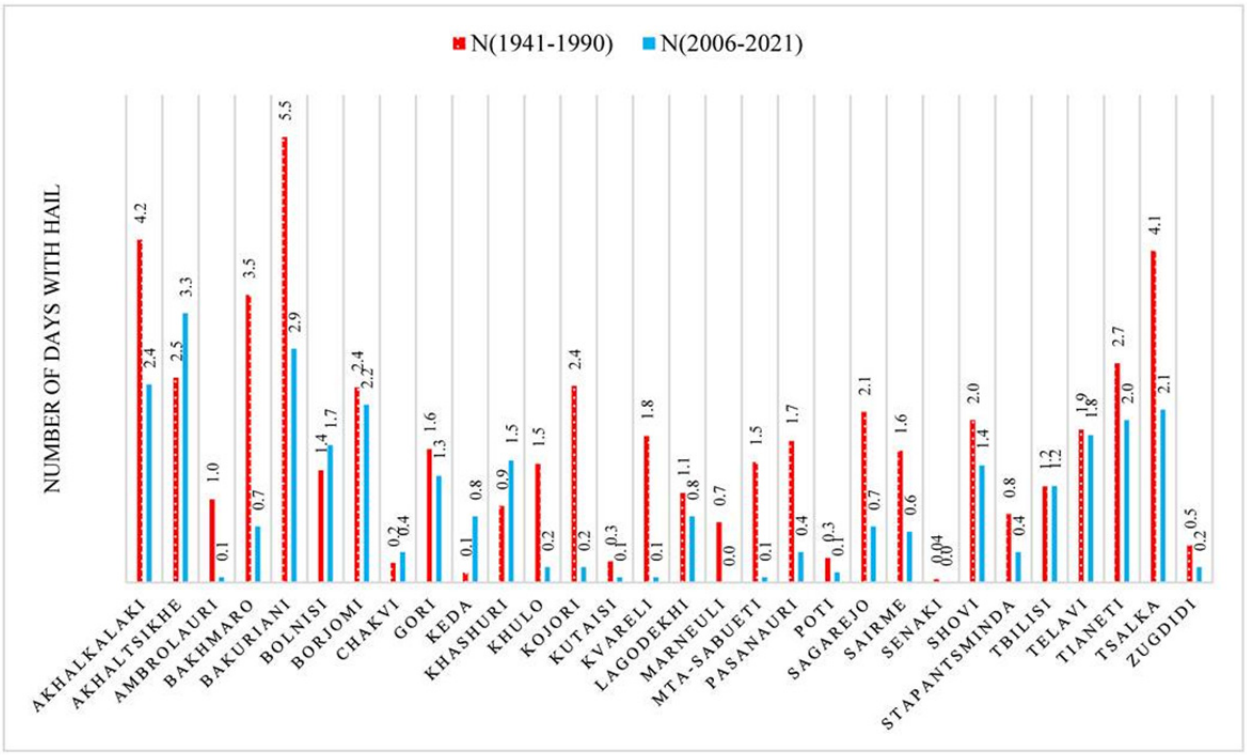

Fig. 2. Number of days with hail during the warm half year in 30 locations of Georgia in 1941-1990 and 2006-2021.

In Fig. 2 number of days with hail during the warm half year in 30 locations of Georgia in 1941-1990 [2] and 2006-2021 are presented.

In Fig. 3. difference between number of days with hail during the warm half year in 2006-2021 and 1941-1991 in 30 locations of Georgia are presented.

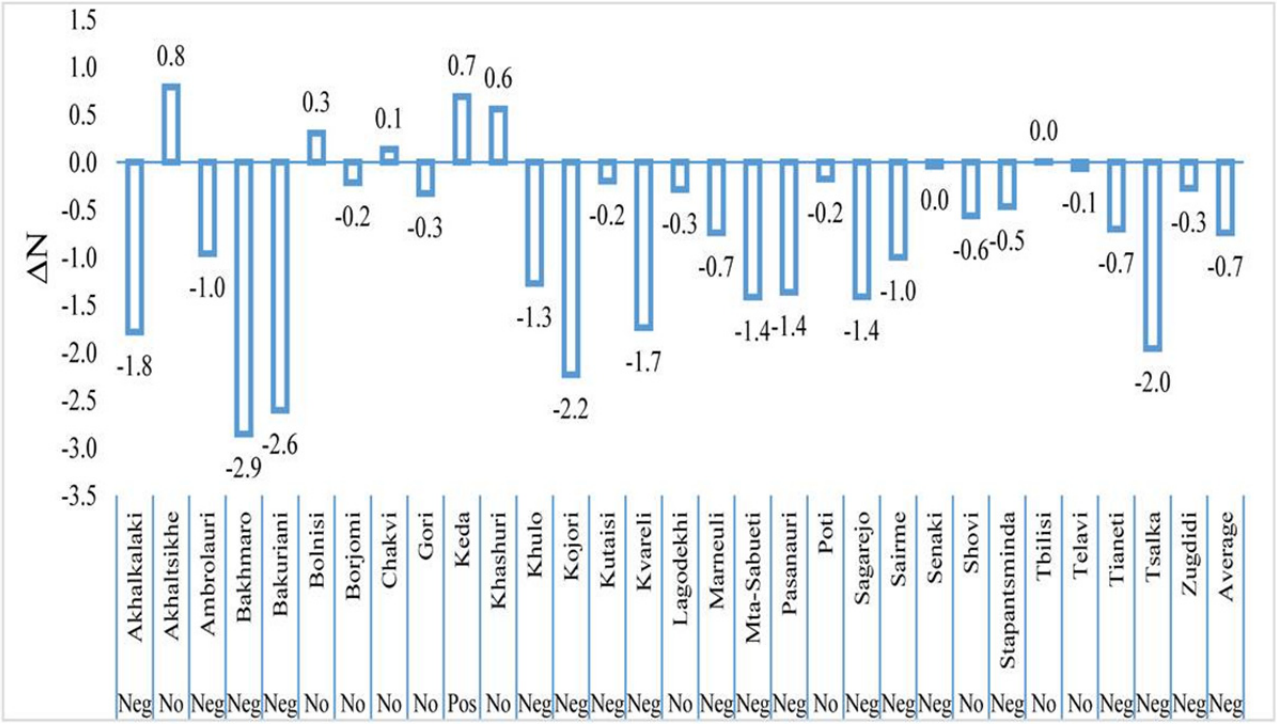

Fig. 3. Difference between number of days with hail during the warm half year in 2006-2021 and 1941-1991 (ΔN) in 30 locations of Georgia, ($\alpha \leq 0.15$).

Comparison of the number of days with hail for 30 meteorological stations in 2006-2021 and 1941-1990 (Fig. 3) showed that in the second period of time, compared to the first period, the number of days with hail at the 18 stations decreased (Neg), at the 10 stations - did not change (No), and increased (Pos) at only one station (Keda).

Conclusion

The data of this work will be used to compile a Natural Hazards Catalog in Georgia [12].

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