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Thunderstorm and Hail Processes over Georgian Territory Against Global Climate Change Background

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ABSTRACT

Hail and thunderstorm processes are very often phenomena over Globe. But the mechanism of their origin isn't completely understood yet. According NASA information their frequency and intensity has been increased for last period. Caucasus region is distinguished by mentioned phenomena. Hail and thunderstorm processes have been investigated based on 1960-2014 year period meteorological observation data for Georgian territory in presented article. The conducted statistical analysis revealed that those processes have increasing tendency over Georgian territory. Constructed GIS maps revealed that these processes cover whole territory. Especially there exist some local areas in west, east and south part where they are especially intensified.

Key words: Thunderstorm and hail processes, statistical analysis, geoinformation mapping.

Introduction

Georgian relief may be characterized by three sharply expressed orographic elements: in north Caucasus, in south – Georgian south uplands and lowland located between those two risings or intermountain depression (Fig. 1). This begins from the Black Sea shore by triangular Kolkheti Lowland and spreads up to eastern Georgia like narrow strip. Between those two uplands small scaled orographic elements can be allocated. Such complicated relief has definite influence on air masses movement in atmosphere lower layers. Mainly west and eastern atmospheric processes prevailed over Georgian territory**.**

Fig.1. Climatic zones of Caucasus region

Due to complex orographic conditions and influence of the Black Sea Georgia is one of most problematic country by natural disasters. 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. Current geodynamics and orographic properties of Georgia play an important role in occurrence of geological (earthquake), geomorphologic (landslide, mudflow, snow avalanche), hydro (flashflood) and meteorological (drought, hurricane, lightning, hail, fog, frost, ice) hazards.

There are old traditions of a study of the thunderstorm and hail processes in Georgia. The regular observation period on hail process covers 100 year [1,2].

During this period quantitative measurements, hail climatology research have been carried and also physical parameters of hailstones (density, structure, radios, etc) were studied. Also radiolocation parameters of convective clouds were studied and on this base radiolocation criteria of hail hazard have been identified in east and west parts of Georgia. Together with those investigations thunderstorm data have been processed.

Studies of thunderstorm electricity, thunderstorm and hail processes in the recent three decades within the framework of the study of climate change in Georgia were even more activated [3-7]. To the indicated studies the works on the study of the influence of the anthropogenic pollution of the atmosphere and works on the weather modification on these processes were added [8,9].

Statistical structure and spatial-temporary characteristics of the number of days with the thunderstorm and hail [10-18], the connection of duration of thunderstorms with the number of days with the thunderstorms [19-21], the special feature of the long-term dynamics of the intensity of hail processes on the territory of Georgia are studied [10,13,14,22,23].

The special features of thunderstorm activity in Kakheti, connection of the electrical and radar parameters of thunderstorm clouds are investigated. Taking into account of these connections and data about the radar parameters of convective clouds the map of the distribution of ground-based lightning discharges for Kakheti is built [24-26].

A study of changes in atmospheric precipitations, thunderstorm and hail processes in the conditions of eastern Georgia and their connections with the anthropogenic pollution of the atmosphere is carried out. The statistical models of the connection of thunderstorm activity with the aerosol pollution of atmosphere are developed. In particular it is obtained that the intensity of thunderstorm and hail processes depends substantially on the aerosol pollution of the atmosphere (including radioactive), although this dependence has fairly complicated nature. As a whole an increase in the nonradioactive aerosol pollution of the atmosphere led to the intensification of the intensity of hail damages and respectively to the decrease of the effectiveness of the action of anti-hail works [8, 27-32].

In recent years, before the renewal of works on the weather modification, special attention was given to detailed studies of damage from the dangerous weather phenomena and to questions of the prevention of natural catastrophes in the conditions of Georgia [9,22,23,33,34].

Study area and Methods

The main hail character is hailstone size. For most cases small intensive hail (70%), middle (20-30mm) and large (>30mm) is typical for Caucasus region. Hail repeatability is 25-30%. In most cases hail diameter doesn't exceeds 20mm. Hailstone with 50-70 mm diamter is rare phenomena [17,22]. Hail duration changes from minutes to several hours. Damaged area covers 20-50 km^2. The main negative hail impact is mainly connected with agriculture, construction,communication damages and human losses.

Thunderstors are dangerous natural phenomena and created on the result of such atmospheric processes that lead the formation of strong convective clouds. Lighting falls off the Earth 8-10^6 time per day, the covered area varies from $40{\cdot}10^4$ km^2 at 4 o'clock till $110{\cdot}10^4$ km^2 at 14-20 o'clock [18,33].

Georgia is considered as one of most dangeous thunderable region, as mean annual thunderstorm day number (N) reaches 35-90. Such a large diapason is explained by Georgian climate variability, conditioned by its complex mountinous relief. Especially Surami and Arsiani Ridges are important, as they are perpendicular to west wet air masses.

To identify mean annual thunderstorm day number temporal-spatial distribution in west and east Georgian regions 1960-2012 meteostation data have been used. The following statistical parameters were calculated: observation period, max., min., and mean values, standard deviations, modal values, asimetry, excess and variation members. Thunderstorm mean day number maximum comose 53 day, mean-32, modal-25 for west Geogia and for east those values are as following: N-61, aver.-39, mod-38. The distribution has normal characted as assymetry and excess values don't exceed 1 for all observation station. Variation members are vithin 30% range. Statistical provision has been checked by their correlation with standard deviationas for thunderstorm as for hail day number. Determining members are $R_l^2 = 0{,}5977$ $R_{el}^2 = 0{,}4177$

respectively. Consequently for Georgia thundersorm minimal observation period is 10-15 years. To identify thundersorm duration in western regions emphiric-statistical equation has been used, that became in good converged with observation data.

Between thunderstorm day number and duration there exists high correlation. For investigation 33 (12 in west and 21 in east regions) meteostation 50 year period thundersorm day number data have been used.

Thundersorm mean annual duration has been calculated using the following equation:

$$D = 3.3 \cdot (N - 10) \quad (1)$$

for stations where N < 40.

$$D = 0.14 \cdot N^{1.7} \quad (2)$$

for stations where N > 40.

where N - mean annual thunderstorm day number, D mean annual duration (hr.). Obtained results are presented in table 1.

Table1

Thunderstorm multiyear mean duration (D), thunderstorm day number (N), station elevation (H), thunderstorm process mean duration (K)

	№	Meteostation	H (m)	N	D (hr)	K=D/N
West Georgia	1	Anaklia	3	25	50	2
	2	Batumi	10	41	102	2.5
	3	Lanchkhuti	20	28	59	2.1
	4	Chaqvi	30	51	112	2.2
	5	Kutaisi	114	37	89	2.4
	6	Zugdidi	117	41	102	2.5
	7	Qeda	256	20	33	1.7
	8	Tsageri	474	39	96	2.5
	9	Ambrolauri	544	41	102	2.5
	10	Sairme	910	25	50	2
	11	Shovi	1507	40	99	2.5
	12	Bakhmaro	1926	28	59	2.1
		average			79	2.3

East Georgia	13	Lagodekhi	362	44	87	2
	14	Gurjaani	410	37	65	1.8
	15	Khvareli	443	40	74	1.9
	16	Tbilisi	490	36	62	1.7
	17	Bolnisi	534	49	105	2.1
	18	Mukhrani	550	46	94	2
	19	Telavi	568	48	101	2.1
	20	KhaSuri	690	45	90	2
	21	Dedoflistskaro	800	35	82	2.3
	22	Dusheti	922	44	87	2
	23	Axaltsixe	982	55	127	2.3
	24	Pasanauri	1070	43	84	2
	25	Aspinza	1098	46	94	2
	26	Tetritskaro	1140	54	123	2.3
	27	Manglisi	1194	56	131	2.4
	28	Abastumani	1265	51	112	2.2
	29	Bakuriani	1665	52	116	2.2
	30	Akhalqalaqi	1716	54	123	2.3
	31	Stepantsminda	1744	22	40	1.9
	32	Paravani	2100	55	127	2.3
	33	Gudauri	2194	49	105	2.1
		average			97	2.1

Results

Hail mean anual and warm period (IV-IX months) distribution are presented on geoinformation maps (Fig. 1,2), based on 1962-2014 year period observation data. As it is obvious from mean annual map hail processes cover Georgian whole territory.

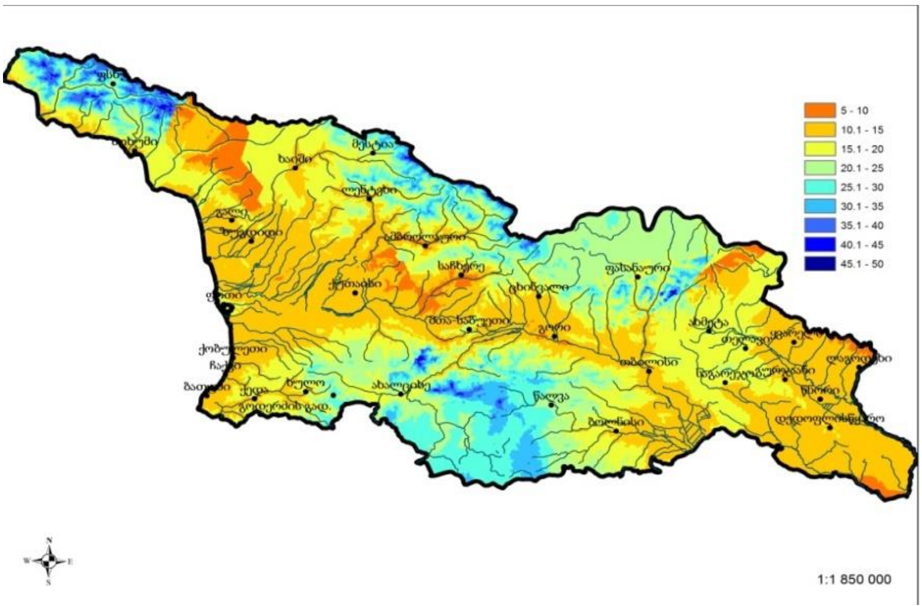

Fig.2. Hail annual distriburion over Georgian territory for 1962-2014 year period

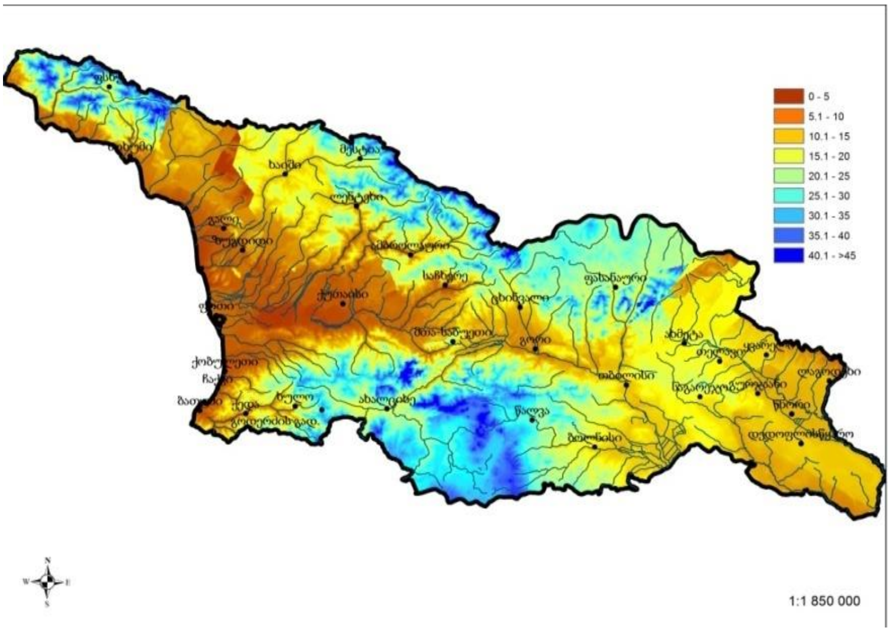

Fig.3. Hail l distriburion for warm period (IV-IX months) over Georgian territory for 1962-2014 year period.

Main hail centres are Kvemo Kartli, Kakheti, Svaneti, Dusheti regions. Hail processes are intensive in subtropical zones too, but they are dangerous for Kakheti region especially for vineyards and grape harvest, as this area is known as vinery region [21].

The other important hail processes parameter is its repeatability. To represent repeatability in the course of time 1962-2014 year data were used (Fig.3).

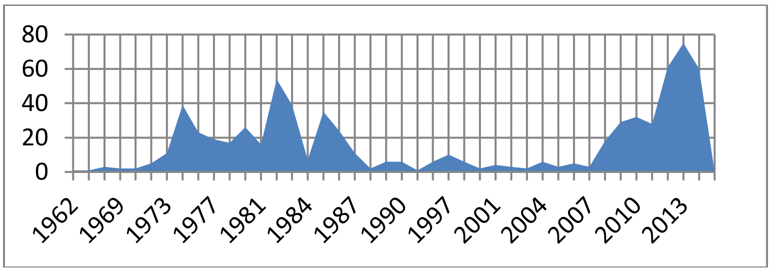

Fig.4. Hail repeatability over Georgian territory for 1962-2014 year period.
As it is revealed hail repeatability has been increased in last years.

As it reveals from table in west Georgia thunderstorm duration is less than in east part. The dependence of thunderstorm duration on elevation is presented on Fig. 5,6.

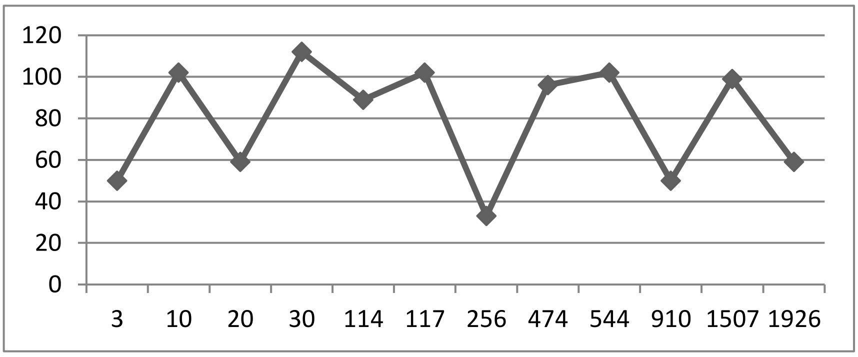

Fig.5. Dependence of thunderstorm duration (hr) on elevation (m) in west Georgia

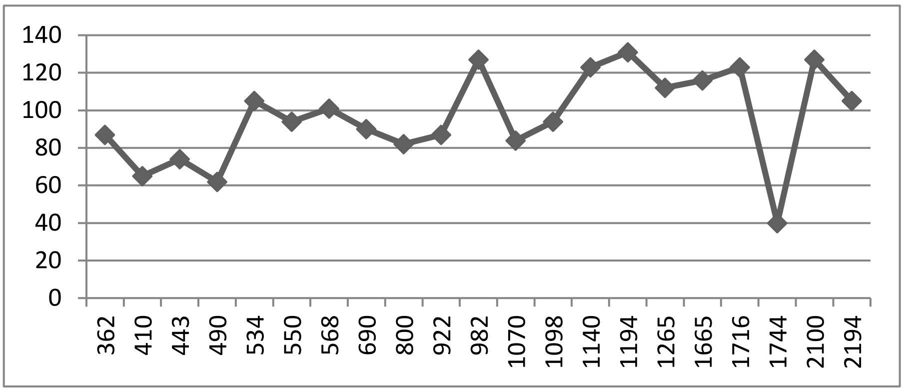

Fig.6. Dependence of thunderstorm duration (hr) on elevation (m) in east Georgia

As it is clear from charts the dependence has heterogeneous character. As for K member that represents duration of single thunderstorm process, in west Georgia it is higher. This confirms the fact that in western Georgian territory frontal thunderstorms prevails and in eastern part thunderstorms are mainly inner-massive.

The thunderstorm mean annual distribution is presented on geoinformation map, and it reveals thunderstorm intensive propagation centers.

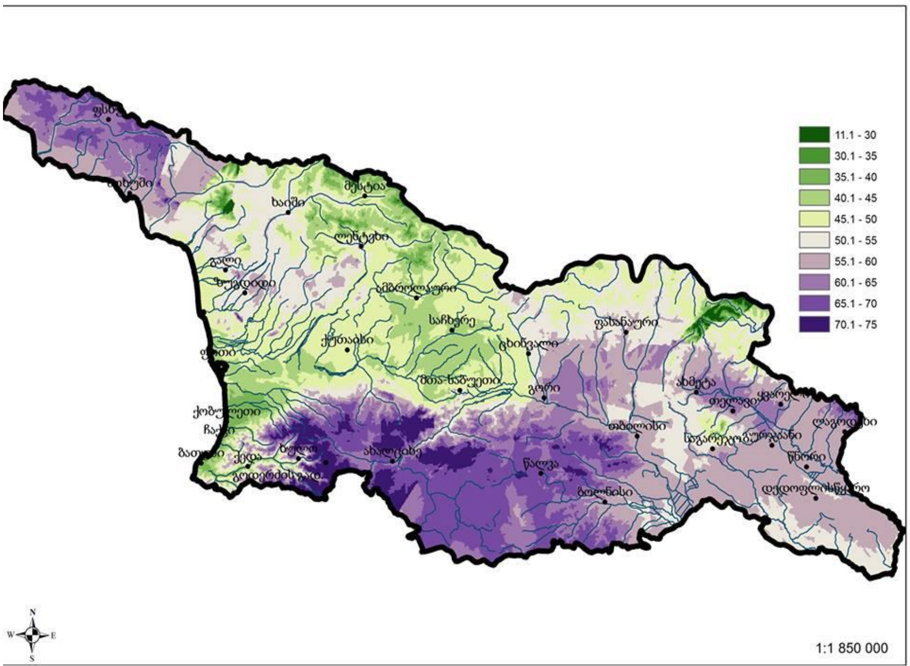

Fig.7. Thundersorm annual distribution over Georgian territory for 1960-2012 year period.

The obtained results may be used in different weather and climate models and also in lighting protecting measues. As it is known that if durable process is the higher is the probability of induced potential penetreats building communication, that may cause various damages.

Let us note in conclusion, that the intensity of hail processes have been increased over various regions of the Globe as in Georgia too. This investigation will be useful for planning of the expansion of works on the weather modification in Georgia [35,36].

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სეტყვისა და ელჭექური პროცესები საქართველოს ტერიტორიაზე კლიმატის გლობალური ცვლილების ფონზე

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რეზიუმე

სეტყვის და ელჭექის პროცესები გავრცელებული მოვლენაა მთელს დედამიწაზე. თუმცა მათი წაარმოქმნის მექანიზმი სრულად გარკვეული ჯერ კიდევ არარის. *NASA* ინფორმაციის მიხეევით ამ პროცესების სიხშირე და ინტენსივობა ბოლო პერიოდში გაზრდილია. ამ მოვლენით გამორჩეულია კავკასიის რეგიონი. წარმოდგენილ ნაშრომში ეს პროცესები გამოკვლეულია 1960-2014 წლების მეტეოროლოგიური დაკვირვების მონაცემების გამოყენებით. ჩატარებულმა სტატისტიკურმა ანალიზმმა აჩვენა, რომ საქართველოს ტერიტორიაზე ამ პროცესებს აქვს ზრდის ტენდენცია. გეოსაინფორმაციო რუკებიდან ცხადად ჩანს, რომ ისინი ფარავენ მთელს ტერიტორიას. არსებობს ლოკალური ცენტრები სამხრეთ, დასავლეთ და აღმოსავლეთ ნაწილებში, სადაც ეს პროცესები განსაკუთრებით ინტენსიურია.

Градо-грозовые процессы на территории Грузии на фоне глобального изменения климата

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Резюме

Градо-грозовые процессы частые явления на Земле. Но механизмы их возникновения еще не полностью изучены. По информации *NASA* их частота и интенсивность возросла за последний период. Кавказский регион отличается упомянутыми явлениями. В представленной статье на территории Грузии градо-грозовые процессы были исследованы на основе данных метеорологических наблюдений 1960-2014 г.г. Проведенный статистический анализ показал, что эти процессы имеют возрастающую тенденцию на территории Грузии. Построенные карты ГИС показали, что эти процессы охватывают всю территорию. Существуют некоторые локальные районы в западной, восточной и южной части, где они особенно активизировались.