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HAIL HITS IN EASTERN GEORGIA

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Abstract

Hail is a hazardous weather phenomena, which inflict enormous damage to the economy, especially agriculture, since often completely demolishes or considerably damages crops, plants, gardens, vineyards, extirpates live-stock, destroys buildings and various constructions.

Georgia was one of the first countries worldwide, where as early as from 60's of the last century has been arranged a specialized service for combating with hail, which protected about 200 thousands hectares of territory

Hail-suppression works have been interrupted after the collapse of Soviet Union but in last year, as a result of catastrophic hail hits, which inflict considerable material damage, the Georgian government has raised a question of renewal of hail-suppression works. Institutes of Hydrometeorology and geophysics have been assigned with solution of this problem. All this placed on the agenda a question of necessity of study of space structure of number of hail days, its periodicity, intensity, duration and areas of hail hit on the basis of advanced materials, and that was namely the goal of this article.

Number of hail days, periods of hailfall, intensity, duration, number and area of hail hits have been studied according the materials of observations made by 30 meteorological stations of Eastern Georgia as of from 1961 to 2012. Obtained results will be used in case of renewal of hail-suppression works.

Key words: *hail, number of days with hail, duration of hail-hits, amount of precipitation.*

Hail is the hazardous weather phenomena, which inflict enormous damage to the economy, especially agriculture, since often completely demolishes or considerably damages crops, plants, gardens, vineyards, extirpates live-stock, destroys buildings and various constructions. Infrequently hail can be the reason of loss of life. Hailfall is a big problem for a lot of countries worldwide – Italy, France, USA, Russia, Moldova, Australia, Hungary, Poland, China, Argentina, countries of Transcaucasus and Middle Asia etc.

Hail is the hazardous weather phenomena for Georgia [4]. That's why namely Georgia was one of the first countries of the world, where as early as in 60's of the last century has been arranged a specialized service for combating with hail, which protected about 200 thousands hectares of territory.

Hail-suppression works have been interrupted after the collapse of Soviet Union but in last years, as a result of catastrophic hail hits, which inflict considerable material damage, the Georgian government has raised a question of renewal of hail-suppression works. This fact placed on the agenda a question of necessity of study of space structure of number of hail days, its periodicity, intensity, duration, variability and areas of hail hit on the basis of advanced materials, and that was the goal of this article.

Data of observations made by 30 meteorological stations of Eastern Georgia as of from 1961 to 2012 have been used as the starting material.

Distribution of number of days with hail on the territory of Georgia considerably depends on physical-geographic conditions. Highlands and mountains have a massive impact, since in air-ground interface of submontane and mountainous areas takes place strengthening of turbulence in front of obstructions, and convective clouds increase. This has an impact on the nature of distribution of number of days with hail (Table 1).

As is seen from table 1, number of days with hail in Kakheti equals to 2-3, at Southern-Georgian upland – 7-10, while in central part of Greater Caucasus – more than 6. The biggest number of days with hail at Southern-Georgian upland and in central part of Big Caucasus exceeds 20 in the course of the year.

Terrain elevation has a considerable impact on the distribution of number of days with hail. As is seen from table 1, the number of days with hail increases with altitude, the nature of change of number of hail days with altitude depends on specific region, its climatic features, slope exposure and other factors.

Table 1. Number of days with hail and hailfall period (months).

region	post	elevation	average number of days per year	the greatest number of days per year	period of hailfall (months)
Kakheti	Telavi	568	2.8	7	III-XI
	Sagarejo	802	2.6	5	III-X
South Georgian Highland	Akhalkalaki	1716	7	16	III-XI
	Bakuriani	1665	9.5	23	III-XI
	Tskhratskaro	2466	8	11	IV-XI
Central part of the Greater Caucasus	Gudauri	2194	9	21	II-XI
	Cross Pass	2395	6	13	IV-X

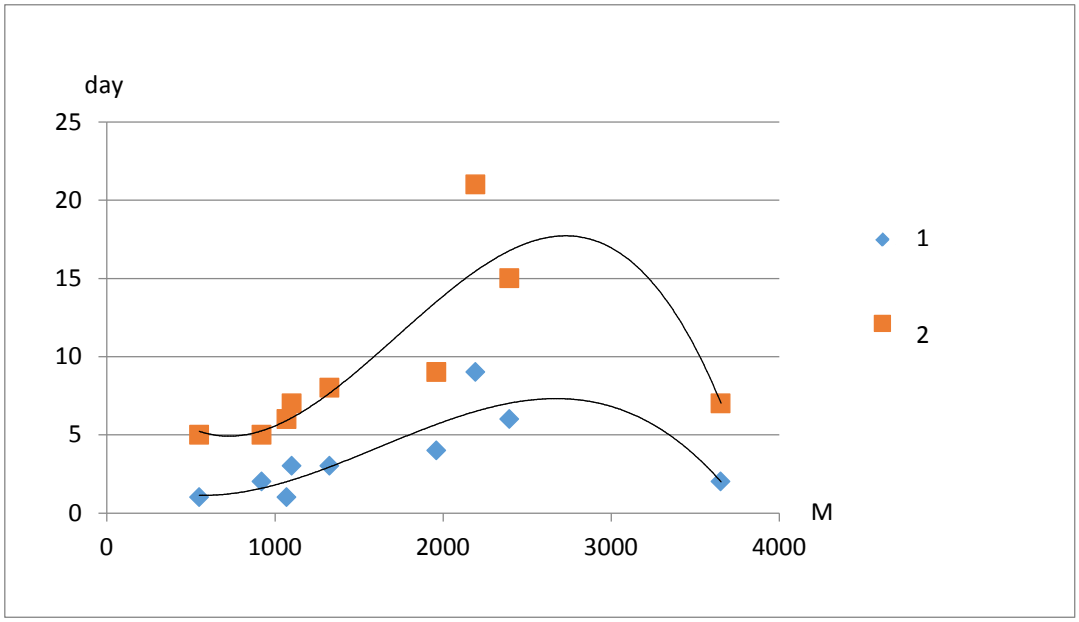


Fig. 1. Change in annual number of hail days with the altitude in the central part of Southern slope of Greater Caucasus: 1 – average number of days; 2 – maximal number of days

Change in number of hail days with the terrain elevation for the central part of Southern slope of Greater Caucasus is represented on Fig. 1. It follows from Fig. 1 that increase in number of hailhits continues up to 2500-2800 m altitude, while further it starts to decrease that is in good compliance with G.K. Sualakvelidze's studies of Northern Caucasus [3].

Change in number of hail days with the altitude is adequately described by third degree polynomial. Equations of regression for average and maximal number of days with hail are of following form, respectively:

$$y=-0.9x^3-0.6x^2-0.006x+2.756,$$

$$y=-0.9x^3-0.5x^2-0.018x+11.17,$$

where y – number of days with hail, and x – terrain elevation above sea level. Correlation ratios in both cases are considerable and are equal to $R^2=0.776$ and R2=0.759, respectively.

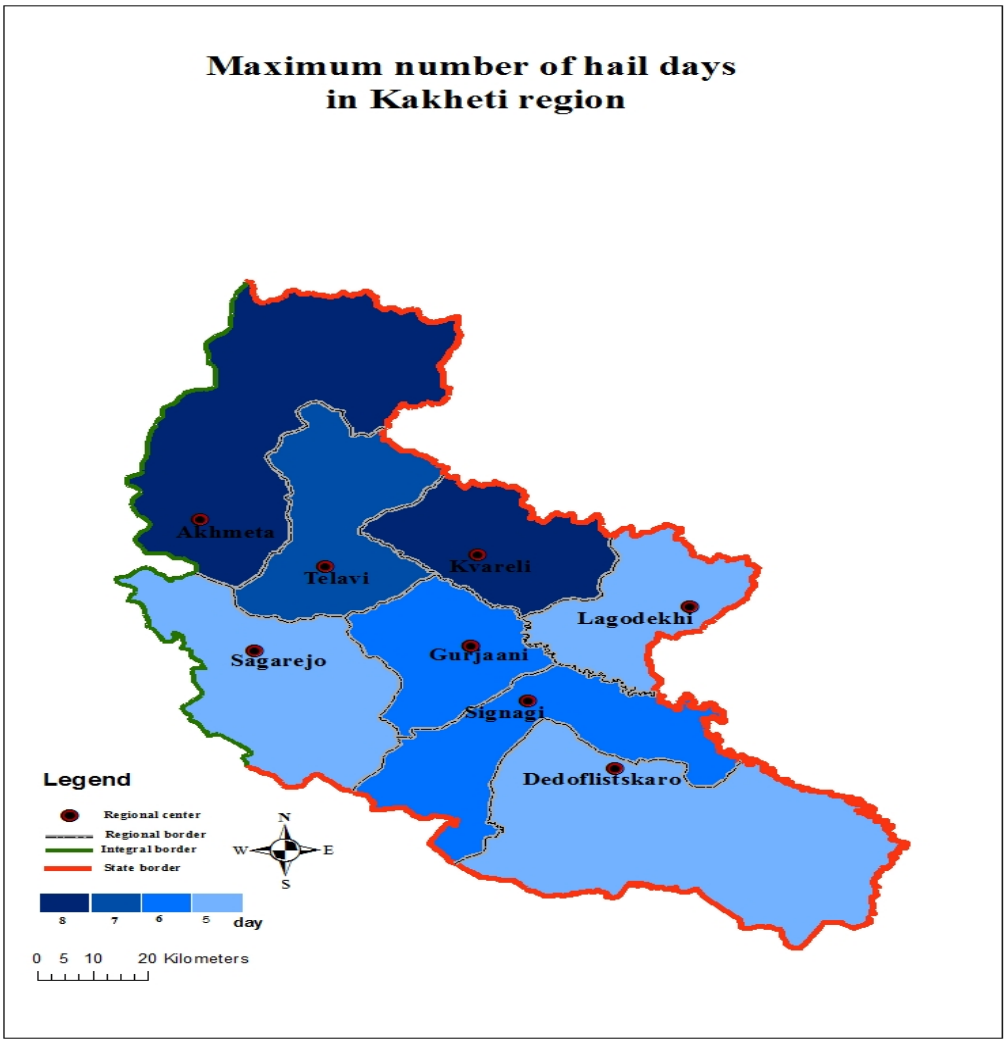


Fig. 2. Maximal annual number of hail days at the territory of Kakheti

Geoinformation map of distribution of maximal number of hail days at the territory of Kakheti is represented on Fig. 2. It follows from Fig. 2 that maximal number of hail days is observed in Akhmeta and Kvareli districts and is equal to 8 and more. The maximal number of hail days for Telavi district is 7 days, for Gurjaani and Signagi districts – 6 days, for Lagodekhi, Sagarejo and Dedoplistskaro districts the maximal number of hail days doesn't exceed 5.

Most frequently a hail emerges during cold fronts passage (1, 2, 3 etc.), however local orographic conditions as a result of heavy thermal overload of underlying surface, as well as instability of air mass stratification can strengthen the convection process in the atmosphere. According to V.M. Gigineishvili's data [1], the probability of hailfall at the territory of Georgia during cold front passage is 44%, during wave disturbance at the South equals to 24%, while during air-mass convection processes is equal to 17%. In first two cases hail process usually covers big areas, while in third case, which is associated with convection processes, hailfall area is relatively small.

Fallen hail forms hail path on the earth surface. Histogram of repeatability of various areas of hailhits damaged by 100 percent is represented on Fig. 3.

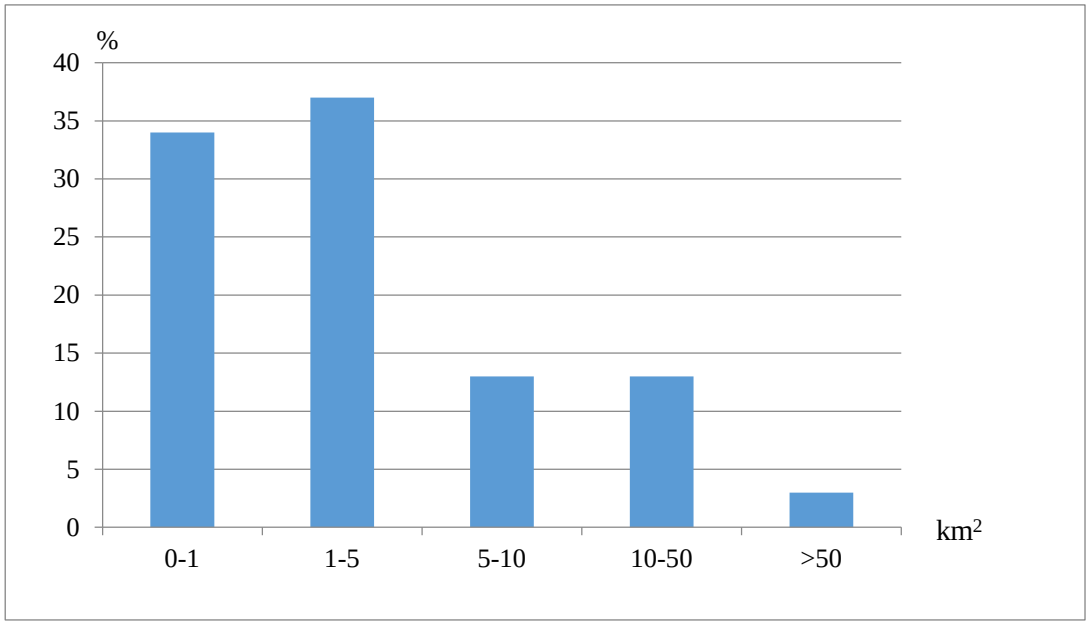


Fig. 3. Repeatability of various areas of hailhits damaged by 100 percent

It follows from fig. 3 that most frequently the hail damages territory of 1-5 sq. km in area, and also less than 1 sq. km (37 and 34 percents, respectively). Territories of more than 5 sq. km in area are completely (100 percent) damaged in less than 30% of cases. In 26% of cases takes place complete damage of territories of 5-50 sq.km in area. However, on rare occasions hailhit damages more considerable territories, e.g. territory with more than 50 sq. km in area is damaged by 100 percents in 3% of cases of hailhits.

As it follows from Table 2, where are represented the data about territories damaged by 100 percents and corresponding damage during some hailhits in Georgia, most frequently hailhit takes place at large territories in Kakheti, basically in Alazani Valley and Tsiv-Gombori ridge. At that it inflicts considerable damage which is estimated at several dozens millions of USA dollars. That's why as early as in 60's of the last century the first hail-suppression service had been put into operation namely at this territory. Renewal of hail-suppression works at the present time is also scheduled here.

Table 2. Territories damaged by100% and corresponding damage during some hail hits

year	month	number	area km^2	detriment (mln USD)	region (centre of greatest intensity)
1978	May	28	129	21.552	Kakheti (Sighnaghi)
1982	May	20	34	7.370	Kakheti (Gurjaani, dedoplistskaro)
1982	July	5	72	9.360	South Georgian Highland (Akhalkalaki)
1986	May	21	30	5.840	Kakheti (Ruispiri, Gurjaani)
1987	May	9	121	26.0	Kakheti (Udabno, Nukriani)
1987	May	12	42	9.130	Kakheti (Napareuli)
1987	June	4	18	3.810	Kakheti (Gavazi)
2012	June	19	35	30.150	Kaheti (Telavi)

Histogram of repeatability for different duration of hail hit is represented on Fig. 4. As is seen from fig. 4, in about 60% of cases the hail duration is less than 5 minutes, in 80% of cases it is less than 10 minutes. Repeatability of more than half-hour hail duration equals only to 3%, while repeatability of more than hour duration of hail is less than 1%. Proceeding from these data, average duration of hail hit is equal to 9-10 minutes.

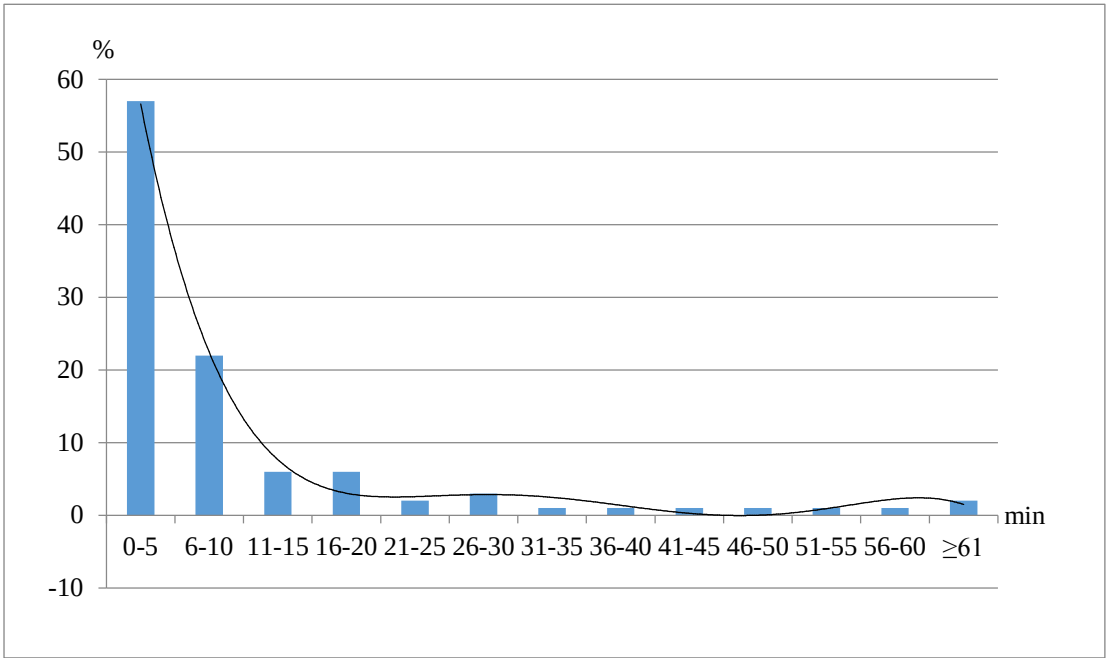


Fig. 4. Repeatability of different durations of hail hit and corresponding equation of regression

Represented histogram is well described with fifth degree polynomial:

$$y=-0.005x5+0.212x4-3.325x3+24.84x2-88.39x+123.3,$$

where y – repeatability, and x – duration. Correlation ratio is quite high and equals to $R^2=0.994$. It is possible to calculate the probability of any duration of hail hit according this polynomial.

During hailhit, along with hail takes place fallout of liquid precipitations, moreover hailhits are often accompanied by intensive showers and squalls. In such cases total amount of fallen out precipitation according to our calculation varies in wide range from several millimeters to 10 centimeters and more. In average, this value 3-4 times exceeds average daily amount of precipitation fallen out in precipitation days during warm period of year. In particular, average total daily precipitation during warm period of year in Georgia varies within the range of 3-6 mm, while average amount of fallen out precipitations in hailfall days is 14-20 mm.

Histogram of repeatability of different amount of precipitation during hailhits at the territory of Kakheti is represented on Fig. 5.

It follows from Fig. 5 that the most frequent amount of precipitation is 11-30 mm. Repeatability of fallout of such amount of precipitation equals to 36%. In 31% of cases amount of precipitation varies within the range of 6-10 mm, in 26% of cases total precipitation doesn't exceed 5 mm. Seldom, in 2% of cases, amount of precipitation during hailhits can exceed 100 mm. Such cases have been observed in Tbilisi (11.05.1940; 14.08.1957; 29.05.1972), in Tetri Tskaro (13.06.1973) etc.

Multiyear variation of number of days with hail in Telavi is represented on Fig. 6.

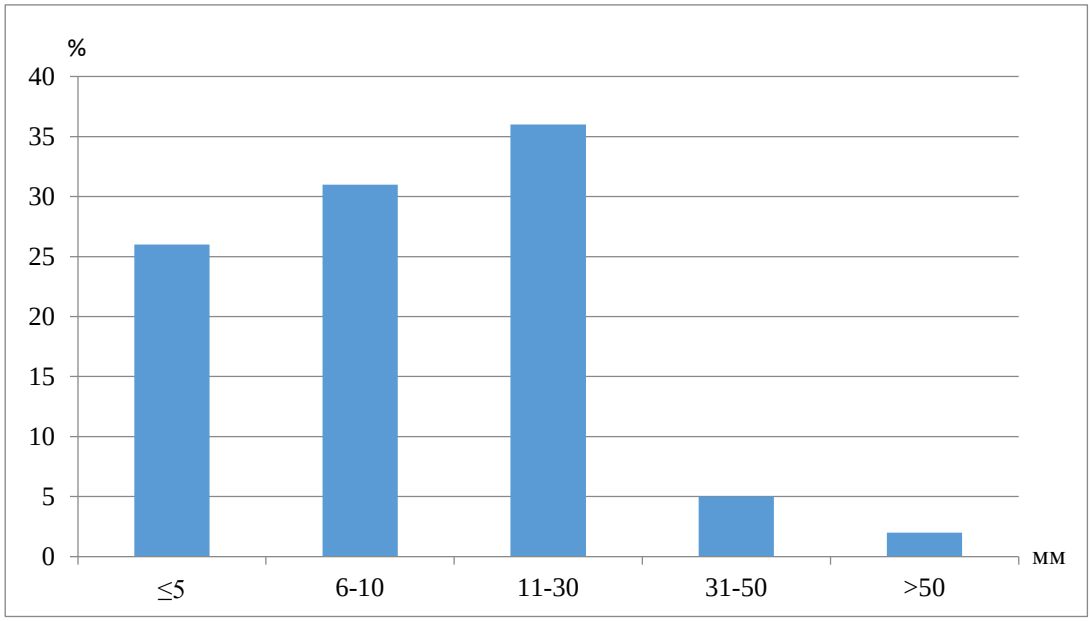


Fig. 5. Repeatability of different amount of precipitation during hailhits at the territory of Kakheti

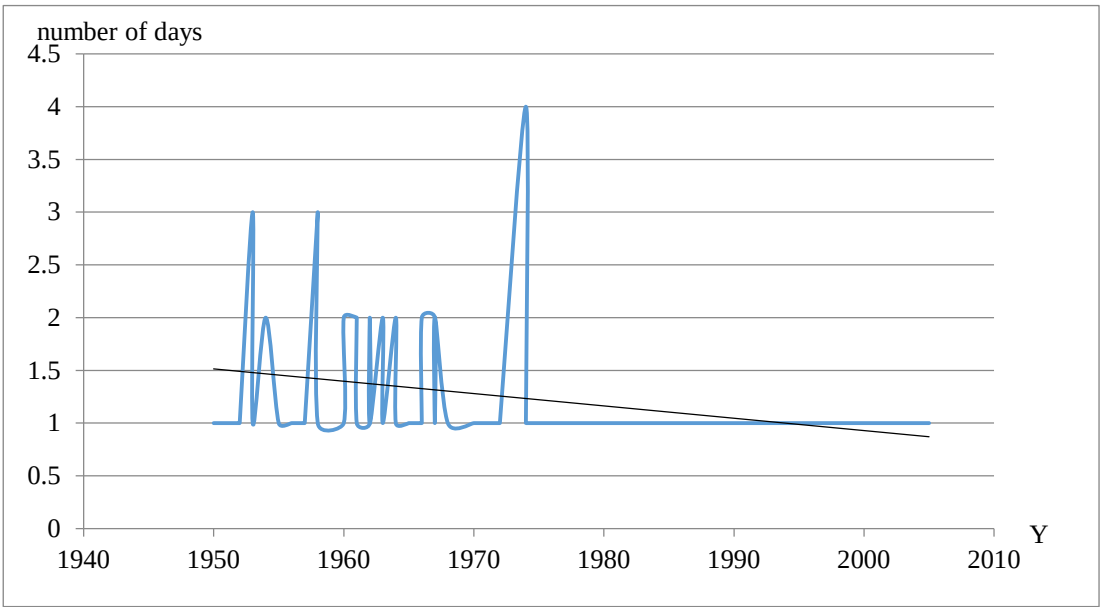


Fig. 6. Multiyear variation of number of days with hail in Telavi

It follows from Fig. 6 that over a 1950-2005 period there is an general tendency of decrease in number of days with hail. Equation of regression is as follows:

$$y = -0.011x + 24.3,$$

where y – number of days with hail, while x are years. Correlation coefficient equals to 0,75 in this case.

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