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Some Characteristics of Hail Processes in Kakheti (Georgia) According to Radar Observations into 2016-2019

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ABSTRACT

The paper presents the results of a statistical analysis of such parameters of hail processes for separate municipalities of Kakheti in the period from 2016 to 2019, as: the maximum height of hail clouds, the maximum diameter of hailstone in clouds, the number of hail clouds of various categories, repetition of hail clouds of various categories, the mean hail hazard relative ratio G. In particular, it was found that during the study period , the greatest hail hazard was observed in the Gurjaani municipality (G = 1.74), and the smallest in the Dedoplistskaro municipality (G = 0.39).

Key words: *hail clouds, hailstone, hail clouds category, hail hazard relative ratio.*

Introduction

Georgia is a small mountainous country where almost all types of natural disasters occur, including hydrometeorological [1]. Among natural disasters in Georgia, hail processes occupy one of the leading places, especially in Kakheti [1-3].

From 1967 to 1989, production works were carried out in this region of Georgia to protect agricultural crops from hail using rocket technologies [4- 6]. These works were renewed in 2015 [7,8].

The anti-hail service is equipped with a modern meteorological radar "METEOR 735 CDP 10 - Doppler Weather Radar", which allows to control many processes in the atmosphere associated with cloud formations [9-12]. In addition to using the radar in operational work, the analysis of radar observation data for various atmospheric processes is carried out.

For example, in recent five years in a number of works were represented the preliminary results of radar studies of hail processes [13-18], rainfall [19-22] and dust formation migration [23, 24] in Eastern Georgia and its neighboring countries (Azerbaijan, Armenia).

In particular, in our last work [25], according to the data of radar observations in Kakheti in 2016-2019, the following characteristics of hail clouds were established for this region: repetition of category of hail clouds, mean max diameter of hailstones in the clouds of different category, dependence of mean values of max diameter of hailstones in the clouds on mean values of max altitude of the radio echo of clouds.

This work is a continuation of the study [25]. Results of the analysis of radar observation of data about number of hail clouds of different category, the max diameter of hailstones, the max height of the radio echo of hail clouds and mean hail hazard relative ratio for separate municipalities of Kakheti in 2016-2019, are presented below.

Study area, material and methods

Study area – separate municipalities of Kakheti region of Georgia (Akhmeta, Gurjaani, Dedoplistskaro, Telavi, Lagodekhi, Sagarejo, Signagi, Kvareli). Data of meteorological radar "METEOR 735 CDP 10 - Doppler Weather Radar" of Anti-hail service of Georgia about the max diameter of hailstones

D_o (mm) and the max height of the radio echo of hail clouds H_m (km) - radar products HAILSZ (Size) and MAX (dBZ) [11,12] - are used.

Period of observation: April-October, 2016-2019. The area of shielded from the hail territory - 800000 hectares. The categories of clouds (objects of action, four categories) in the correspondence with [2] were determined. The hail hazard relative ratio G in Kakheti municipal educations were calculated with use the data about numbers of clouds in each category, to the correspondence with [2] also.

$$G = (0.1 \cdot n_1 + 0.3 \cdot n_2 + 1.0 \cdot n_3 + 5.0 \cdot n_4)/(0.1 \cdot N_1 + 0.3 \cdot N_2 + 1.0 \cdot N_3 + 5.0 \cdot N_4)$$

Where: n_1 …. n_4 - the number of clouds by category in separate municipalities of Kakheti, N_1…. N_4 - the number of clouds by category on the whole in Kakheti.

Thus, the value of G is the ratio of the hail hazard of separate municipalities of Kakheti to the hail hazard of Kakheti as a whole.

For the data analysis the standard statistical methods are used. The following designations of statistical information are used below: Mean – average values; Min – minimal values; Max - maximal values; St Dev - standard deviation; σm - standard error; Cv = 100·St Dev/Mean – coefficient of variation, %; Count - number of cases; 99% _Low and 99%_Upp – 99% of lower and upper levels of the mean accordingly.

Results

Results in table 1 and fig. 1-5 are presented.

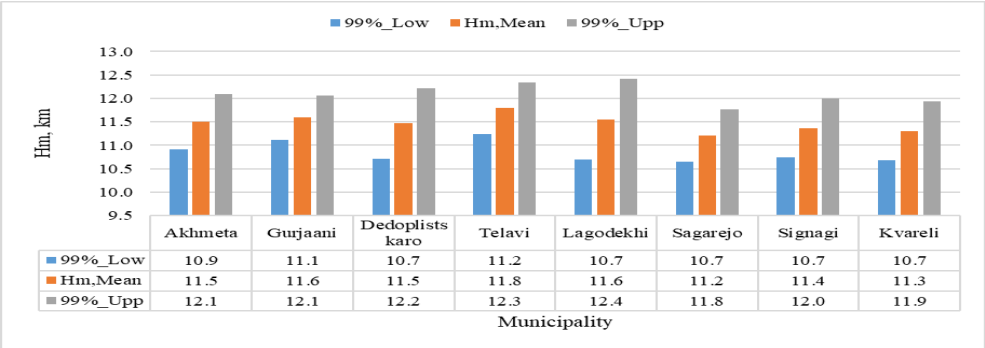
In table 1 and fig. 1,2 the statistical characteristics of Hm and Do of hail clouds in separate municipality of Kakheti are presented. As follows from table 1 and fig. 1,2 mean values of Hm changes slightly, from 11.2 km (Sagarejo) to 11.8 km (Telavi). Mean values of Do changes substantially, from 16.0 mm (Dedoplistskaro) to 21.5 mm (Gurjaani).

Hail clouds with a maximum height of 18.0 km were observed in the municipalities of Lagodekhi and Sighnagi. Hailstones with a maximum diameter of 63.1 mm were observed in the Lagodekhi municipality.

Table 1. Statistical characteristics of Hm and Do of hail clouds in separate municipality of Kakheti

Municipality	Akhmeta		Gurjaani		Dedoplistskaro		Telavi	
Parameter	Hm, km	Do, mm	Hm, km	Do, mm	Hm, km	Do, mm	Hm, km	Do, mm
Mean	11.5	16.2	11.6	21.5	11.5	16.0	11.8	18.3
Min	7.0	0.9	6.8	0.9	7.0	0.9	6.0	0.9
Max	16.0	48.3	17.0	53.9	16.0	35.8	17.0	43.0
St Dev	2.2	9.6	1.9	9.9	2.1	8.9	2.1	9.9
σm	0.2	1.0	0.2	0.9	0.3	1.3	0.2	1.0
Cv (%)	18.9	59.6	16.5	46.1	17.9	55.6	17.7	53.8
Count	92	92	110	110	51	51	96	96
Municipality	Lagodekhi		Sagarejo		Signagi		Kvareli	
Mean	11.6	19.4	11.2	17.3	11.4	19.0	11.3	17.4
Min	7.0	2.9	5.0	2.9	7.0	0.9	7.0	0.9
Max	18.0	63.1	16.0	48.3	18.0	43.0	16.0	35.8
St Dev	2.2	10.5	2.1	10.2	2.4	9.9	1.9	8.8
σm	0.3	1.6	0.2	1.1	0.2	1.0	0.2	1.1
Cv (%)	19.0	54.4	18.7	59.0	20.7	52.3	16.5	50.4
Count	44	44	95	95	95	95	60	60

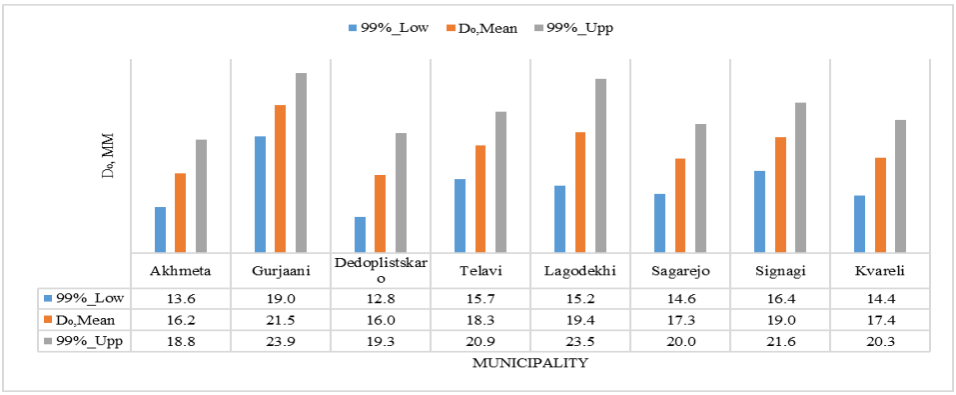
Variations in Hm values are insignificant: the coefficient of variation varies from 16.5% (Gurjaani and Kvareli municipalities) to 20.7% (Signagi municipality). Variations in Do values compared to variations in Hm values are significantly higher: the coefficient of variation changes from 46.1% (Gurjaani municipality) to 59.6% (Akhmeta municipality).



	Akhmeta	Gurjaani	Dedoplistskaro	Telavi	Lagodekhi	Sagarejo	Signagi	Kvareli
99%_Low	10.9	11.1	10.7	11.2	10.7	10.7	10.7	10.7
Hm,Mean	11.5	11.6	11.5	11.8	11.6	11.2	11.4	11.3
99%_Upp	12.1	12.1	12.2	12.3	12.4	11.8	12.0	11.9

Fig. 1. Mean maximum height of hail clouds in Kakheti by municipal educations.

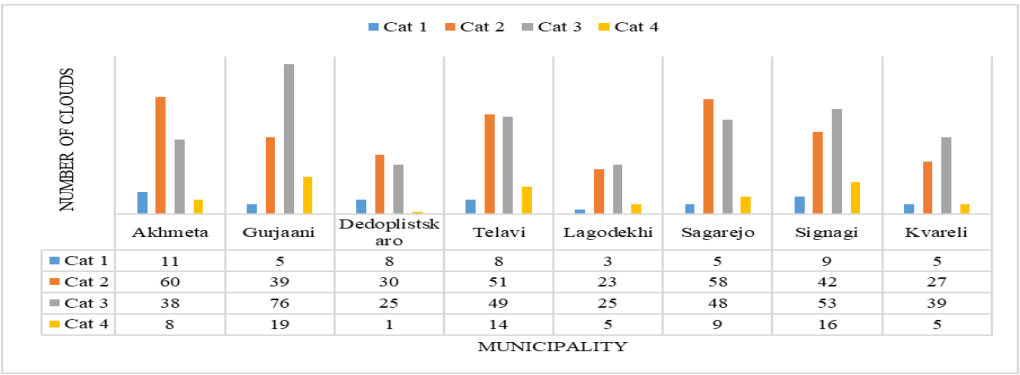
Fig. 1 shows that the range of variation from the lower to the upper 99% levels of the confidence interval of the mean for the Hm values is as follows: from 10.7 km (all municipalities except Akhmeta, Gurjaani and Telavi) to 12.4 km (Lagodekhi municipality).



	Akhmeta	Gurjaani	Dedoplistskaro	Telavi	Lagodekhi	Sagarejo	Signagi	Kvareli
99%_Low	13.6	19.0	12.8	15.7	15.2	14.6	16.4	14.4
Do,Mean	16.2	21.5	16.0	18.3	19.4	17.3	19.0	17.4
99%_Upp	18.8	23.9	19.3	20.9	23.5	20.0	21.6	20.3

Fig. 2. Mean maximum diameter of hailstone in clouds in Kakheti by municipal educations.

Fig. 2 shows that the range of change from the lower to the upper 99% levels of the confidence interval of the mean for Do values is as follows: from 12.8 mm (Dedoplistskaro municipality) to 23.9 mm (Gurjaani municipality).



	Akhmeta	Gurjaani	Dedoplistskaro	Telavi	Lagodekhi	Sagarejo	Signagi	Kvareli
Cat 1	11	5	8	8	3	5	9	5
Cat 2	60	39	30	51	23	58	42	27
Cat 3	38	76	25	49	25	48	53	39
Cat 4	8	19	1	14	5	9	16	5

Fig. 3. The number of hail clouds of various categories in Kakheti by municipal educations.

As follows from fig. 3, the smallest number of hail clouds of the second category is observed in the municipality of Lagodekhi (23), the third category - in the municipalities of Dedoplistskaro and Lagodekhi (25 each), the fourth category - in the municipality of Dedoplistskaro (1)

The highest number of hail clouds of the second category is observed in the Akhmeta municipality (60), the third category - in the Signagi municipality (53), the fourth category - in the Gurjaani municipality (19).

Fig. 4. Repetition of hail clouds of various categories in Kakheti by municipal educations, %. On top – 1 category; on the right - 2 category; below - 3 category; on the left - 4 category.

Fig. 5. Mean hail hazard relative ratio G in Kakheti by municipal educations (G for Kakheti = 1).

From fig. 4 follows, that the smallest repetition of hail clouds of the second category is observed in the municipality of Gurjaani (28.2%), the third category - in the municipality of Akhmeta (32.6%), the fourth category - in the municipality of Dedoplistskaro (2.0%)

The highest repetition of hail clouds of the second category is observed in the Akhmeta municipality (51.1%), the third category - in the Gurjaani municipality (54.5%), the fourth category - in the Signagi municipality (13.7%).

Finally, as follows from Fig. 5, during the study period the greatest hail hazard was observed in the Gurjaani municipality (G = 1.74), and the smallest in the Dedoplistskaro municipality (G = 0.39).

Conclusion

In the near future, it is planned to continue the studies presented in this article. In particular, the monthly distribution of the maximum height of hail clouds, the maximum diameter of hailstone in clouds, the number of hail clouds of various categories, repetition of hail clouds of various categories, etc. will be studied.

It should be noted that the time-series of observations of the specified parameters of hail clouds is only five years. Therefore, in the future, as new data are received, the results of their statistical analysis will be refined.

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კახეთში (საქართველო) სეტყვის პროცესების ზოგიერთი მახასიათებელი რადარის დაკვირვების მიხედვით 2016-2019 წწ.

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რეზიუმე

ნაშრომში მოყვანილია 2016 -2019 წწ. კახეთის ცალკეული მუნიციპალიტეტებისთვის სეტყვის პროცესების ისეთი პარამეტრების სტატისტიკური ანალიზის შედეგები, როგორიცაა: სეტყვის ღრუბლების მაქსიმალური სიმაღლე, სეტყვის მარცვლების მაქსიმალური დიამეტრი ღრუბელში, სხვადასხვა კატეგორიის სეტყვის ღრუბლების რაოდენობა, სხვადასხვა კატეგორიის სეტყვის ღრუბლების განმეორადობა, საშუალო ფარდობითი სეტყვასაშიშროების კოეფიციენტი G. კერძოდ, მიღებულია, რომ აღნიშნულ პერიოდში სეტყვის ყველაზე დიდი საშიშროება დაფიქსირდა გურჯაანის მუნიციპალიტეტში (G = 1.74), ყველაზე დაბალი - დედოფლისწყაროს მუნიციპალიტეტში (G = 0.39).

Некоторые характеристики градовых процессов в Кахетии (Грузия) по данным радиолокационных наблюдений в 2016-2019 гг.

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Резюме

В работе представлены результата статистического анализа таких параметров градовых процессов для отдельных муниципалитетов Кахетии в период с 2016 по 2019 гг., как: максимальная высота градовых облаков, максимальный диаметр градин в облаках, количество градовых облаков различных категорий, повторяемость градовых облаков различных категорий, средний относительный коэффициент градовой опасности G. В частности, получено, что в исследуемый период времени наибольшая градовая опасность наблюдалась в муниципалитете Гурджаани (G=1.74), наименьшая - в муниципалитете Дедоплисцкаро (G=0.39).