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DISTRIBUTION OF HAIL BY MEAN MAX SIZE ON THE TERRITORIES OF MUNICIPALITIES OF THE KAKHETI REGION OF GEORGIA

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Summary: *Results of modeling of the distribution of hailstones by mean max diameter (D) on the territories of municipalities of the Kakheti region of Georgia using data of the freezing level in the atmosphere and radar measurements of hail max sizes in clouds are presented. Data about D on the territories of municipalities of the Kakheti region for individual months, from April to September, are presented. The vertical distribution of D on the indicated territories was studied.*
Key words**:** *Hail, hail distribution by size.*

Introduction

The problem of hail in Georgia is devoted to numerous works covering a wide range of studies, such as climatology of hail [1-3], theoretical and experimental studies of the mechanisms of hail formation [4, 5], radar observation on hail processes [6, 7], methods of impact on hail processes [8], analysis of impact results [9, 10], etc.

To solve various problems of scientific or applied significance detailed information on the spatial-temporary characteristics of hail distributions and its sizes on different locations is necessary. The results of such studies for Georgia, in particular, are presented in works [1-3, 6, 7, 11].

To construct of spatial-temporary maps of the distribution of hail processes, data from radar observations of convective clouds are also used [6, 7, 11]. In particular, in the paper [11] results of modeling of the distribution of hailstones by mean max diameter (D) on the territory of Kakheti (Georgia) using data of the freezing level in the atmosphere and radar measurements of hail max sizes in clouds are presented. Maps of the distribution of hail by the average maximum diameter in the territory of Kakheti for individual months, from April to September, have been built. The vertical distribution of D on the indicated territory in the range of heights from 0.11 to 3.84 km was studied.

This work is a continuation of the study [11]. Results of modeling of the distribution of hailstones by mean max diameter (D) on the territories of municipalities of the Kakheti region of Georgia using data of the freezing level in the atmosphere and radar measurements of hail max sizes in clouds are presented below.

Study area, material and methods

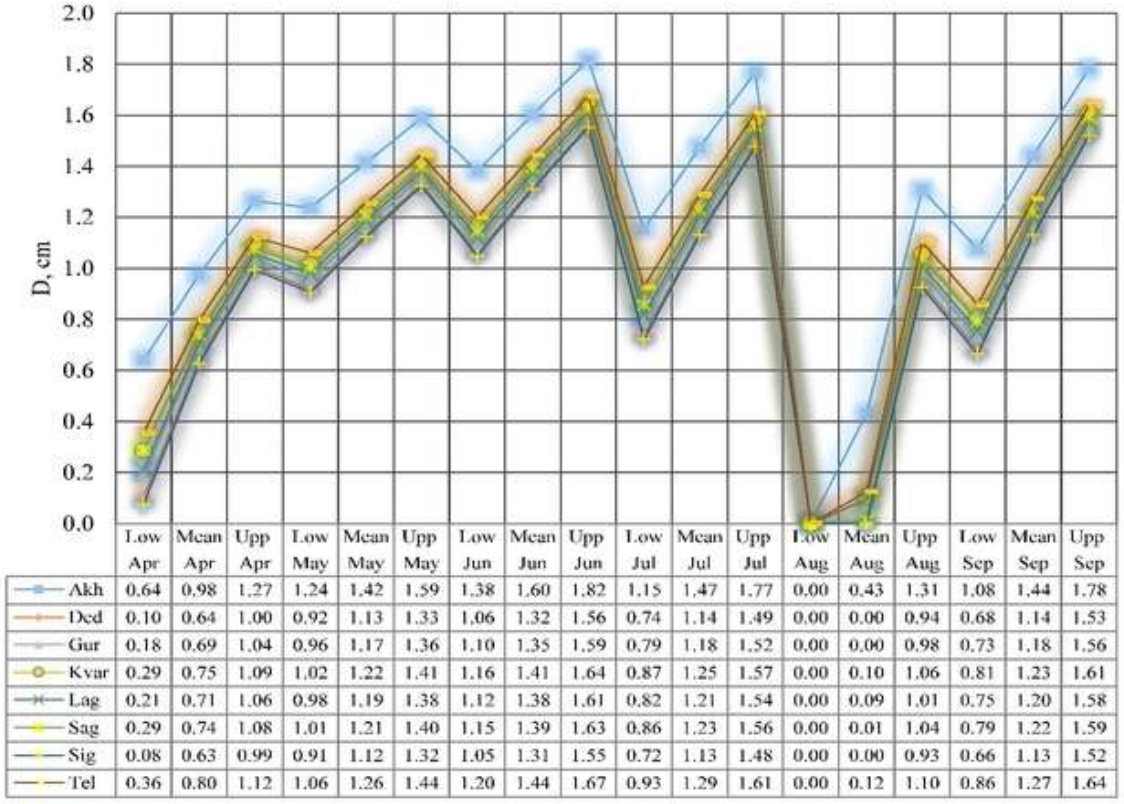
Study area – eight municipalities of Kakheti region of Georgia (Akhmeta, Dedoplistskaro, Gurjaani, Kvareli, Lagodekhi, Sagarejo, Signagi, Telavi). Data of meteorological radar “METEOR 735 CDP 10 - Doppler Weather Radar” of Anti-hail service of Georgia about the max diameter of hailstones in the clouds (cm) - radar products HAILSZ (Size) [7, 8] - are used. Period of observation: April-September, 2016-2019.

The expected diameter of hailstones falling out to the earth's surface according to the Zimenkov-Ivanov model of hail melting in the atmosphere [11, 12] by taking into account the radar data about their max diameter in the clouds and freezing level in atmosphere was calculated [11].

To calculate the mean max diameter of hailstones (D) on the surface of the earth, the territory of Kakheti was divided into 465 squares, the range of heights ΔH was 0.11 ÷ 3.84 km (Akhmeta: 95 squares, ΔH = 0.43 ÷ 3.84 km; Dedoplistskaro: 102 squares, ΔH = 0.11 ÷ 0.87 km; Gurjaani: 35 squares, ΔH = 0.23 ÷ 1.10 km; Kvareli: 36 squares, ΔH = 0.26 ÷ 2.61 km; Lagodekhi: 37 squares, ΔH = 0.21 ÷ 2.84 km; Sagarejo: 66 squares, ΔH = 0.43 ÷ 1.63 km; Signagi: 51 squares, ΔH = 0.19 ÷ 0.97 km; Telavi: 43 squares, ΔH = 0.36 ÷ 2.94 km). The monthly average values of the max sizes of hailstones and their 99% values of the lower and upper levels of the average were calculated.

For the data analysis the standard statistical methods are used. The following designations of statistical information are used below: Mean – average values; 99% _Low and 99%_Upp – 99% of lower and upper levels of the mean accordingly.

Results. Results in fig. 1 and 2 are presented.



	Low Apr	Mean Apr	Upp Apr	Low May	Mean May	Upp May	Low Jun	Mean Jun	Upp Jun	Low Jul	Mean Jul	Upp Jul	Low Aug	Mean Aug	Upp Aug	Low Sep	Mean Sep	Upp Sep
Akh	0.64	0.98	1.27	1.24	1.42	1.59	1.38	1.60	1.82	1.15	1.47	1.77	0.00	0.43	1.31	1.08	1.44	1.78
Ded	0.10	0.64	1.00	0.92	1.13	1.33	1.06	1.32	1.56	0.74	1.14	1.49	0.00	0.00	0.94	0.68	1.14	1.53
Gur	0.18	0.69	1.04	0.96	1.17	1.36	1.10	1.35	1.59	0.79	1.18	1.52	0.00	0.00	0.98	0.73	1.18	1.56
Kvar	0.29	0.75	1.09	1.02	1.22	1.41	1.16	1.41	1.64	0.87	1.25	1.57	0.00	0.10	1.06	0.81	1.23	1.61
Lag	0.21	0.71	1.06	0.98	1.19	1.38	1.12	1.38	1.61	0.82	1.21	1.54	0.00	0.09	1.01	0.75	1.20	1.58
Sag	0.29	0.74	1.08	1.01	1.21	1.40	1.15	1.39	1.63	0.86	1.23	1.56	0.00	0.01	1.04	0.79	1.22	1.59
Sig	0.08	0.63	0.99	0.91	1.12	1.32	1.05	1.31	1.55	0.72	1.13	1.48	0.00	0.00	0.93	0.66	1.13	1.52
Tel	0.36	0.80	1.12	1.06	1.26	1.44	1.20	1.44	1.67	0.93	1.29	1.61	0.00	0.12	1.10	0.86	1.27	1.64

Fig. 1. Mean max diameter of hailstones and their 99% lower and upper levels in Kakheti munitipalities from April to September.

Fig. 1 demonstrated distribution of hailstones by mean max diameter and their 99% lower and upper levels on the territories of munitipalities of Kakheti from April to September. As follows from fig. 1 mean values of D change from 0 cm (August – Dedoplistskaro, Gurjaani and Signagi munitipalities) to 1.60 cm (June – Akhmeta munitipality). Values of 99% _Low of the D change from 0 cm (August – all munitipalities) to 1.38 cm (June, Akhmeta munitipality). Values of 99% _Upp of the D change from 0.93 cm (August – Signagi munitipality) to 1.82 cm (June, Akhmeta munitipality).

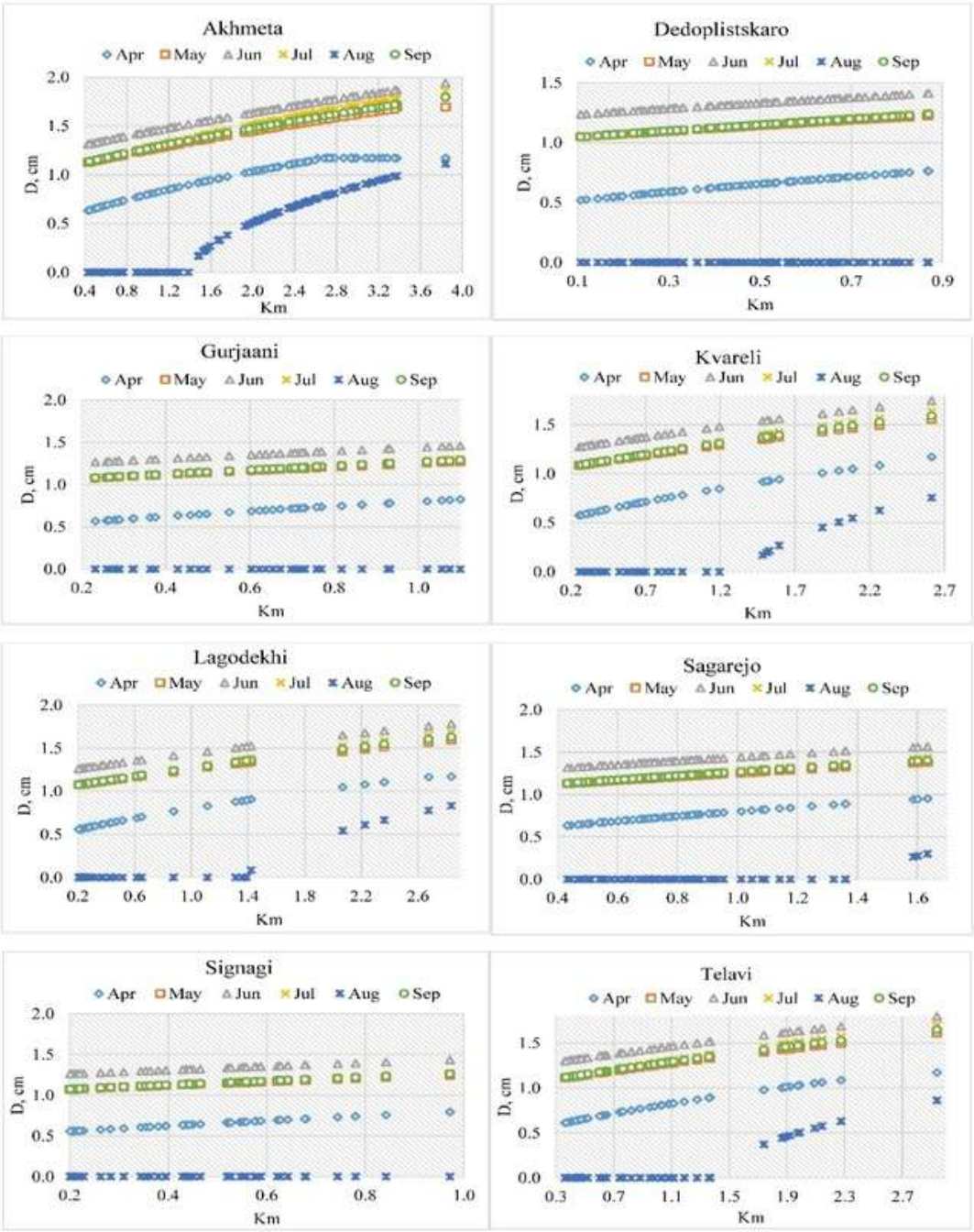


Fig. 2. Vertical distribution of mean max diameter of hailstones in different municipalities of Kakheti from April to September.

In fig. 2 vertical distribution of mean max diameter of hailstones in eight munitipalities of Kakheti from April to September are presented. In particilar, fig. 2 shows, that the variability of the mean maximum hail diameter on the territories of munitipalities of Kakheti in is as follows:

- Akhmeta**.** April: 0.63÷1.17 cm; May: 1.12÷1.69 cm; June: 1.31÷1.94 cm; July: 1.13÷1.86 cm; August: 0÷1.11 cm; September: 1.13÷1.79 cm; April-September: 1.32 cm.
- Dedoplistskaro April: 0.52÷0.76 cm; May: 1.05÷1.22 cm; June: 1.24÷1.41 cm; July: 1.04÷1.25 cm; August: 0÷0 cm; September: 1.05÷1.24 cm; April-September: 0.84 cm.
- Gurjaani**.** April: 0.57÷0.82 cm; May: 1.08÷1.27 cm; June: 1.27÷1.46 cm; July: 1.08÷1.31 cm; August: 0÷0 cm; September: 1.08÷1.29 cm; April-September: 0.88 cm.

- Kvareli. April: 0.57÷1.17 cm; May: 1.08÷1.55 cm; June: 1.27÷1.74 cm; July: 1.08÷1.63 cm; August: 0÷0.76 cm; September: 1.09÷1.59 cm; April-September: 0.98 cm.
- Lagodekhi. April: 0.56÷1.17 cm; May: 1.07÷1.59 cm; June: 1.26÷1.78 cm; July: 1.07÷1.68 cm; August: 0÷0.83 cm; September: 1.07÷1.63 cm; April-September: 0.93 cm.
- Sagarejo. April: 0.63÷0.95 cm; May: 1.13÷1.38 cm; June: 1.31÷1.57 cm; July: 1.13÷1.43 cm; August: 0÷0.30 cm; September: 1.13÷1.40 cm; April-September: 0.94 cm.
- Signagi. April: 0.55÷0.79 cm; May: 1.07÷1.25 cm; June: 1.26÷1.43 cm; July: 1.06÷1.28 cm; August: 0÷0 cm; September: 1.07÷1.26 cm; April-September: 0.82 cm.
- Telavi. April: 0.61÷1.17 cm; May: 1.11÷1.61 cm; June: 1.30÷1.80 cm; July: 1.11÷1.70 cm; August: 0÷0.86 cm; September: 1.11÷1.65 cm; April-September: 1.03 cm.

Conclusion. In the near future, we plan to modeling the damage from hail to vineyards, wheat and corn in the agricultural regions of Kakheti.

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