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ESTIMATION OF THE CRITICAL SIZE OF HAILSTONES IN CLOUDS NON PREJUDICED TO AGRICULTURE IN KAKHETI

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Summary: *Using the Zimenkov-Ivanov model of hail melting in the atmosphere and modern data on the level of zero isotherm in Kakheti (Georgia), the critical size of hailstones in clouds that are not harmful to crops in the conditions of this region was estimated (almost complete melting of hailstones near the earth's surface at altitudes 250, 500, 750 and 1000 m). The calculations were performed for the average ten-day values of the heights of the zero isotherm from April to October. In particular, it was found that the critical size of hailstones in clouds, almost completely melting near the surface of the earth at an altitude of 1000 m and 250 m, respectively, varies from 0.73 to 0.92 cm for the first decade of April and from 1.43 to 1.60 cm for the second decade of August.*

Key Words: *Hail storm, zero izotherm, hailstones thawing, hail size.*

Introduction

Kakheti (region of Georgia) is one of the most hail-dangerous regions of the world [1,2]. In the last century, until 1989, anti-hail works were carried out here [3]. These works were restored in 2015 [4-6]. The anti-hail service is equipped with the modern "METEOR 735 CDP 10 – Doppler Weather Radar", meteorological radar, with which it is possible to determine the size of the hail in the clouds [7]. Therefore, the problem arises of estimating the size of hail falling on the earth's surface, taking into account their size in the clouds. These estimates are important not only for assessing the effectiveness of the anti-hail service, but also for optimizing the system of warning the public about dangerous weather events (it was possible to warn in advance in what place and at what size the hail would fall). Another important aspect of this task is modeling the danger from the hail of territories taking into account the size of the hail in the clouds, the level of freezing and the height of the terrain.

Such estimates were first made in [8], in which the Zimenkov – Ivanov model on hail melting in the atmosphere [9, 10] and modern data on the level of zero isotherm in Kakheti [11] were used. Data were obtained on the diameter of hail falling on the earth's surface from April to October for all ten-day periods of the indicated months. With the initial size of the hail from 1.0 to 5.0 cm and the height of the earth's surface from 300 to 700, the final size of the hail varies from 0 to 4.88 cm.

This work is a continuation of the previous study. Results of calculations of the critical size of the hail in the clouds, which do not harm agriculture in the conditions of Kakheti are presented below.

Material and methods

The Zimenkov – Ivanov model about the hailstones thawing in the atmosphere [9,10] and the contemporary data about the freezing level in Kakheti during calculations of diameter of falling out to the earth's surface of hailstones in the condition of this region were used (Fig. 1). Calculations for the heights of area relief 250, 500, 750 and 1000 m are carried out.

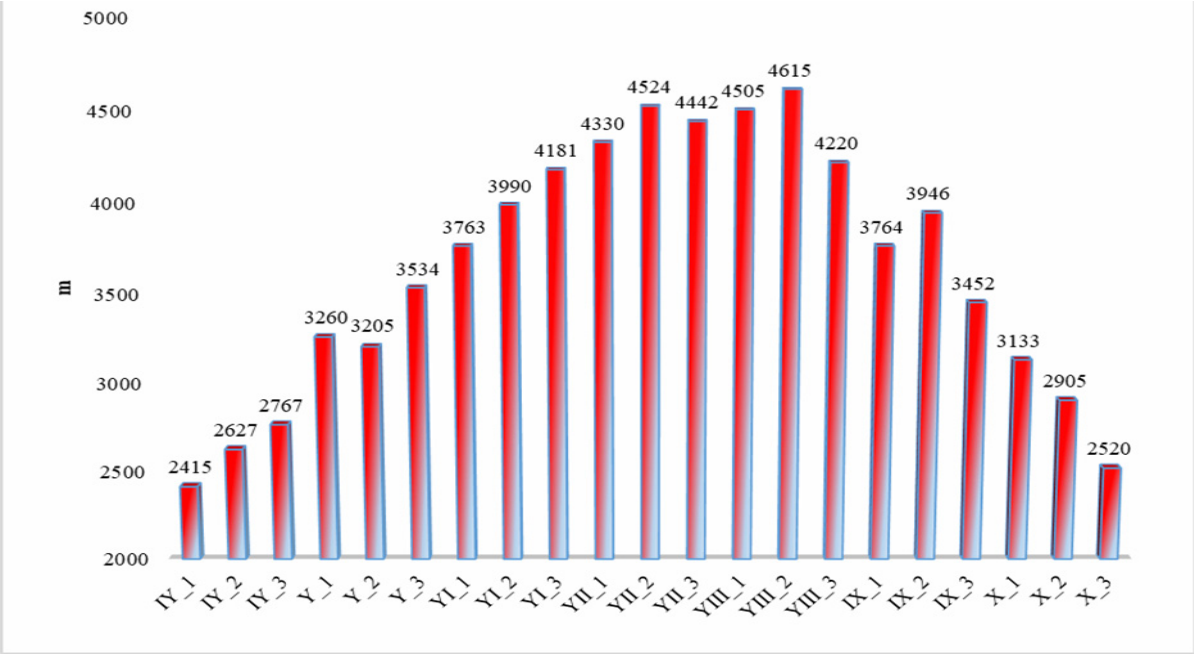


Fig. 1. Ten-Day Period Distribution of Freezing Level over Kakheti from April to October [11].

The following designations will be used below:

H – heights of area relief, meter; D_o_Cr – critical hail diameter in cloud, cm; Min – minimal values; Max – maximal values; St Dev – standard deviation; Cv = 100·St Dev/Average – coefficient of variation, %; σ_m – standard error; 99%(+/-) – 99% confidence interval of mean.

According to the TORRO Hailstorm Intensity Scale (http://www.torro.org.uk/hscale.php) hailstones with the following diameters lead to the subsequent consequences: ≤0.5 cm – no damage; 0.5÷1.5 cm – slight general damage to plants, crops; 1.0÷2.0 cm – significant damage to fruit, crops, vegetation; 2.0÷3.0 cm – severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored; 2.5÷4.0 cm – widespread glass damage, vehicle bodywork damage; 3.0÷5.0 cm – wholesale destruction of glass, damage to tiled roofs, significant risk of injuries; 4.0÷6.0 cm – bodywork of grounded aircraft dented, brick walls pitted, etc.

In our calculations, the critical size of hailstones in the clouds corresponded to the hailstone diameter at the earth surface ≤0.1 cm (small graupel or complete melting).

Results and discussion

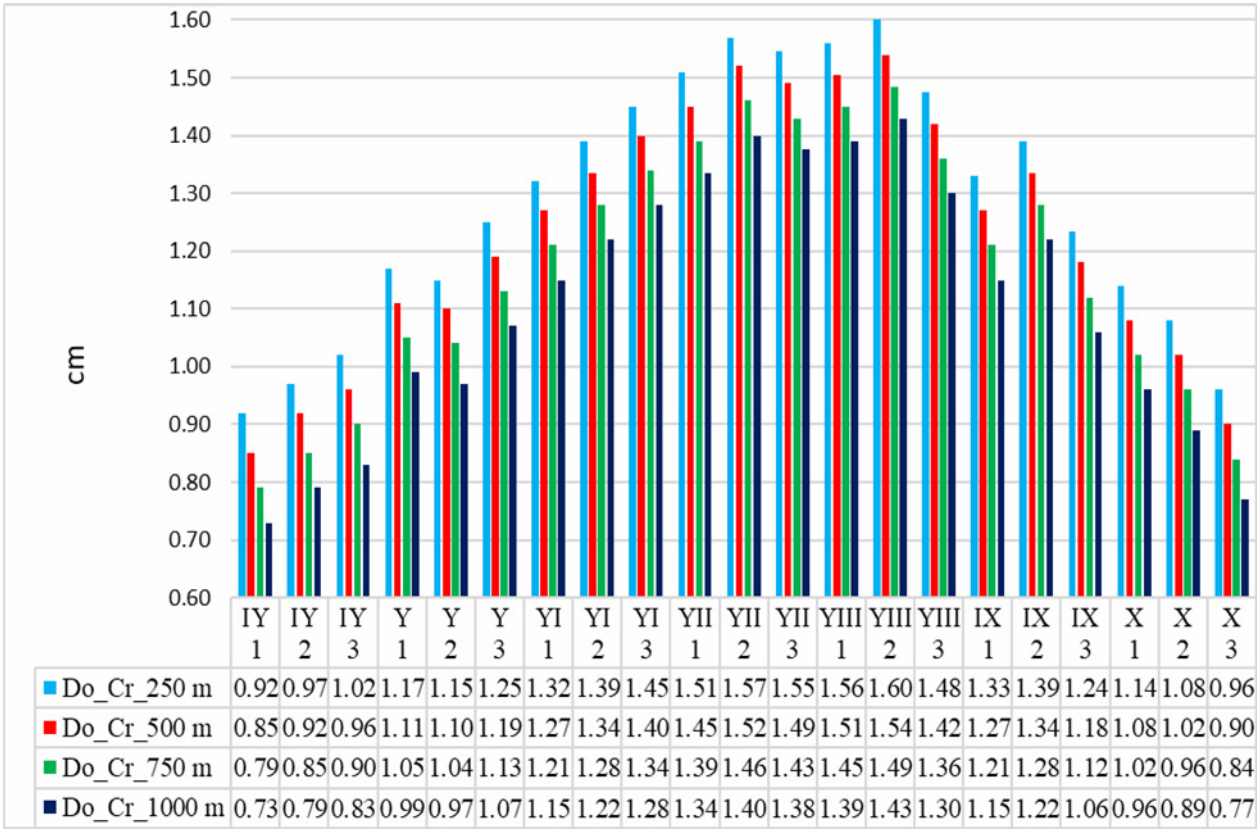
The results of calculations in the Table and in Fig. 2 are presented.

As follows from Table, on the whole the critical diameter of hailstones in clouds non prejudiced to agriculture at the ground level with height 250 m varied from 0.92 to 1.6 cm, and 1000 m – from 0.73 to 1.43 cm. Mean values of D_o_Cr varied from 1.11 cm (for H=1000 m) to 1.29 cm (for H=250 m).

Table

Statistical Characteristics of Critical Size of Hailstones in Clouds non Prejudiced to Agriculture on the Various Elevations in Kakheti in Different Ten-Day Period from April to October

Elevation, (H)	250 m	500 m	750 m	1000 m
Min	0.92	0.85	0.79	0.73
Max	1.60	1.54	1.49	1.43
Mean	1.29	1.23	1.17	1.11
St Dev	0.22	0.22	0.22	0.23
Cv,%	17.1	18.0	19.1	20.4
σm	0.05	0.05	0.05	0.05
99%(+/-)	0.13	0.13	0.13	0.13



	IY 1	IY 2	IY 3	Y 1	Y 2	Y 3	YI 1	YI 2	YI 3	YII 1	YII 2	YII 3	YIII 1	YIII 2	YIII 3	IX 1	IX 2	IX 3	X 1	X 2	X 3
Do_Cr_250 m	0.92	0.97	1.02	1.17	1.15	1.25	1.32	1.39	1.45	1.51	1.57	1.55	1.56	1.60	1.48	1.33	1.39	1.24	1.14	1.08	0.96
Do_Cr_500 m	0.85	0.92	0.96	1.11	1.10	1.19	1.27	1.34	1.40	1.45	1.52	1.49	1.51	1.54	1.42	1.27	1.34	1.18	1.08	1.02	0.90
Do_Cr_750 m	0.79	0.85	0.90	1.05	1.04	1.13	1.21	1.28	1.34	1.39	1.46	1.43	1.45	1.49	1.36	1.21	1.28	1.12	1.02	0.96	0.84
Do_Cr_1000 m	0.73	0.79	0.83	0.99	0.97	1.07	1.15	1.22	1.28	1.34	1.40	1.38	1.39	1.43	1.30	1.15	1.22	1.06	0.96	0.89	0.77

Fig. 2. The Critical Size of Hailstones in Clouds Non Prejudiced to Agriculture on the Various Elevations in Kakheti in Different Ten-Day Period from April to O

Fig. 2 provided detailed information on the Do_Cr values for various ten-day period from April to October. In particular, these data can be used to compile detailed hail hazard maps on the territory of Kakheti for different seasons.

Conclusion

Over the long term is planned performing analogous work, also, for other regions of Georgia.

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