საერთაშორისო სამეცნიერო კონფერენცია „ეკოლოგიის თანამედროვე პრობლემები“
შრომები, ISSN 1512-1976, ტ. 6, ქუთაისი, საქართველო, 21-22 სექტემბერი, 2018
International Scientific Conference „Modern Problems of Ecology“
Proceedings, ISSN 1512-1976, v. 6, Kutaisi, Georgia, 21-22 September, 2018
Международная научная конференция „Современные проблемы экологии“
Труды, ISSN 1512-1976, т. 6, Кутаиси, Грузия, 21-22 сентября, 2018

ESTIMATION OF THE DIAMETER OF FALLEN TO THE EARTH'S SURFACE HAIL STONES TAKING INTO ACCOUNT THEIR SIZE IN THE CLOUD AND THE HEIGHTS OF ZERO ISOTHERM UNDER THE CONDITIONS OF KAKHETI REGION OF GEORGIA

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Summary: *The Zimenkov - Ivanov model about the hailstones thawing in the atmosphere and the contemporary data about the freezing level in Kakheti (Georgia) during calculations of diameter of falling out to the earth's surface of hailstones in the condition of this region were used. Data about the diameter of the falling out to the earth's surface of hailstones from April through October, for all decade periods of the indicated months are acquired. At the initial size of the hail from 1,0 to 5,0 cm and the height of earth's surface from 300 to 700, the finite size of hailstones are changes from 0 to 4,88 cm.*

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

Introduction

Kakheti region of Georgia is one of the hail-dangerous regions of world [1]. In the period from 1967 through 1989 here was conducted production work on the fight with the hail [2]. The works on the weather modification in this region of the Georgia was restored in 2015 (first of all - fight with the hail) [3-5]. The Anti-hail service is equipped with contemporary C-band, dual polarized Doppler meteorological radar "**METEOR 735 CDP 10 - Doppler Weather Radar"**, with which it is possible to determine the size of hail in the clouds [6].

In connection with this appears the task of evaluating the sizes of the falling out to the earth's surface hailstones, taking into account their sizes in the clouds. Similar evaluations are important both for the estimation of the effectiveness of anti-hail protection and for the optimization of the warning system of population about the dangerous weather phenomena (previously it is possible to warn in what place and of what size of hail will fall out). One more of the important the aspect of this task - simulation of the danger from hail of territories taking into account the dimensions of hail in the clouds, the freezing level and height of area relief.

This work is the first stage of similar studies for different regions of the Georgia. Results of estimations the sizes of falling out to the earth's surface of hailstones under the conditions of Kakheti for all ten-days periods of hail season (April - October) are represented below.

Material and methods

The Zimenkov - Ivanov model about the hailstones thawing in the atmosphere [7,8] and the contemporary data about the freezing level in Kakheti [9] during calculations of diameter of falling out to the earth's surface of hailstones in the condition of this region were used. Taking into account that agricultural land in Kakheti in essence are arranged on the heights to 700 m above sea level, calculations for the heights of area relief 300, 500, and 700 m are carried out.

The following designations will be used below:

H - heights of area relief, meter; D_o - hail diameter in cloud, cm; D – hail diameter at the ground level, cm;

Min – minimal values, Max - maximal values, Range - variational scope, St Dev - standard deviation, Cv = 100ʾ St Dev/Average– coefficient of variation, %. D_o = 1,0; 1,5; 2,0; 2,5; 3,0; 3,5; 4,0; 4,5; 5,0 cm.

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.

Results and discussion

The results of calculations in the table and in figures are presented.

Table

The statistical characteristics of the ten-days average hail size at the ground level in Kakheti taking into account the dimensions of hail in the clouds from April to October

H, m	D_o, Cloud, cm	D, hail size at the ground level					
		Average	Min	Max	Range	St dev	Cv,%
300	5,0	4,73	4,62	4,86	0,24	0,08	1,7
500		4,75	4,64	4,87	0,24	0,08	1,6
700		4,77	4,65	4,88	0,23	0,08	1,6
300	4,5	4,21	4,08	4,34	0,26	0,09	2,0
500		4,23	4,10	4,36	0,26	0,08	2,0
700		4,25	4,12	4,37	0,25	0,08	1,9
300	4,0	3,68	3,54	3,83	0,29	0,10	2,6
500		3,70	3,56	3,85	0,28	0,09	2,5
700		3,72	3,59	3,86	0,28	0,09	2,4
300	3,5	3,14	2,98	3,31	0,33	0,11	3,4
500		3,17	3,01	3,33	0,32	0,10	3,3
700		3,19	3,04	3,35	0,31	0,10	3,2
300	3,0	2,59	2,41	2,79	0,38	0,12	4,8
500		2,62	2,44	2,81	0,37	0,12	4,6
700		2,65	2,47	2,83	0,36	0,12	4,4
300	2,5	2,02	1,80	2,25	0,46	0,15	7,4
500		2,05	1,84	2,28	0,44	0,14	7,0
700		2,08	1,87	2,30	0,43	0,14	6,7
300	2,0	1,40	1,10	1,70	0,60	0,20	14,0
500		1,45	1,16	1,73	0,58	0,19	13,0
700		1,49	1,21	1,76	0,55	0,18	12,1
300	1,5	0,60	0,00	1,11	1,11	0,39	65,3
500		0,68	0,00	1,15	1,15	0,36	53,4
700		0,76	0,21	1,19	0,99	0,31	40,6
300	1,0	0,04	0,00	0,37	0,37	0,11	241
500		0,07	0,00	0,45	0,45	0,15	217
700		0,10	0,00	0,53	0,53	0,18	192

As follows from table and figures the hailstones with diameter 4,5÷5,0 cm in the clouds weakly melt in the atmosphere and fall to the earth's surface with dimensions 4,08÷4,88 cm (the corresponding damage is stated above).

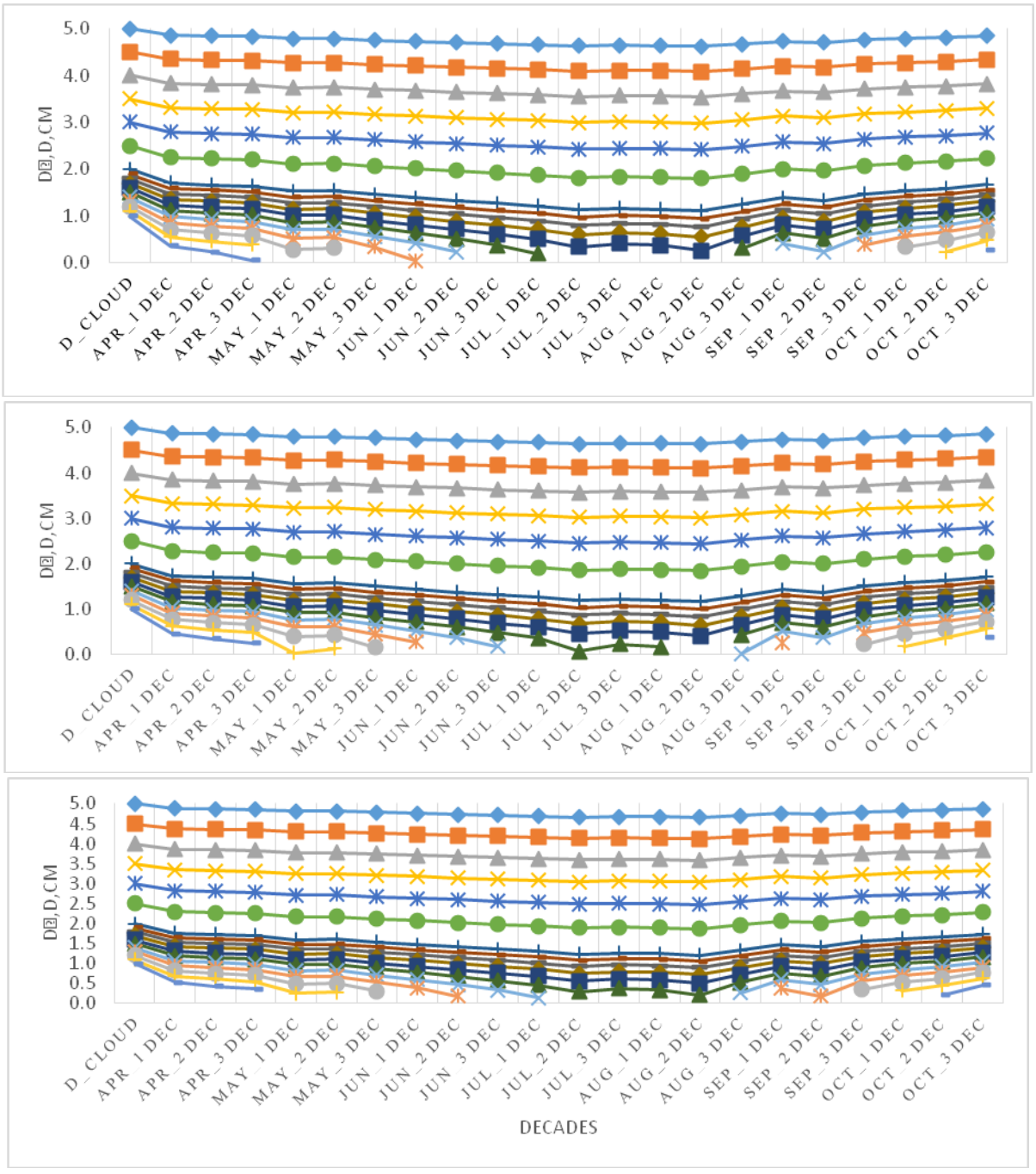

Fig. The ten-days average hail size at the ground level with altitude 300 m (upper chart), 500 m (middle chart) and 700 m (lower chart) in Kakheti taking into account the dimensions of hail in the clouds.

The hailstones with diameter 3,5÷4,0 cm in the clouds fall to the earth's surface with sizes 2,98÷3,86 cm; the hailstones with initial diameter 2,5÷3,0 cm fall to the earth's surface with sizes 1,80÷2,83 cm and the hailstones with initial diameter 1,5÷2,0 cm fall to the earth's surface with sizes 0,0÷1,76 cm (the corresponding expected damage is stated above). The hailstones with diameter 1,0 cm in the clouds practically melt in the atmosphere during a fall on the earth's surface.

The size of falling hailstones depending on the height of the terrain (height difference - 400 m) in the spring-autumn and summer decades of the month decreases as follows: for D_o = 4,5÷5,0 cm on 0.27÷0.29 cm, D_o = 3,5÷4,0 cm on 0,32÷0,36 cm, D_o = 2,5÷3,0 cm on 0,42÷0,50 cm, D_o = 1,5÷2,0 cm on 0,66÷1,19 cm.

Finally, we note that in the TORRO Hailstorm Intensity Scale, certain ranges of hailstone sizes overlap each other, which makes it difficult to this uses to build hail hazard maps. In the future, it is planned to improve somewhat this scale by correcting the ranges of hailstones that exclude their overlapping.

Conclusion

In the near future is planned the making of the detailed maps of the hail danger of Kakheti territory for different seasons of year taking into account the results, obtained in this work (the dimensions of hail, the degree of the damage of different agricultural cultures according to improved TORRO Hailstorm Intensity Scale). Over the long term is planned performing analogous work, also, for other regions of Georgia.

Acknowledgement

The authors are grateful to the chief of the atmospheric physics department of M. Nodia Institute Geophysics A. Amiranashvili for assistance in the fulfillment of this work.

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