Journal of the Georgian Geophysical Society, ISSN: 1512-1127
Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 24(1), 2021, pp. 25-36

Modeling the Distribution of Hailstones by Mean Max Sizes on the Territory of Kakheti (Georgia) using Data of the Freezing Level in the Atmosphere and Radar Measurements

[1]Avtandil G. Amiranashvili, [2]Nana R. Bolashvili, [2]Zaza M. Gulashvili, [1]Nino K. Jamrishvili, [2]Nikoloz E. Suknidze, [1]Khatia Z. Tavidashvili

M. Nodia Institute of Geophysics of Iv. Javakhishvili Tbilisi State University, 1 M Alexsidze Str 0160, Tbilisi, Georgia, avtandilamiranashvili@gmail.com

Vakhushti Bagrationi Institute of Geography of Iv. Javakhishvili Tbilisi State University, Tbilisi, Georgia

ABSTRACT

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.

***Key words*:** *Hail, map of hail distribution by size.*

Introduction

Hail phenomena occur in many regions of the world [1-3], including Georgia [4-7]. Annual global losses of agricultural products from hail damage range from 4 to 18% of the harvest, and in monetary terms, they exceed 11 billion US dollars [https://www.meteorf.ru/activity/activ/antigrad/obs-info/]. At the same time, with regard to damage from hail, Georgia is one of the most hail-hazardous countries in the world. Therefore, the problem of hail in this country is devoted to numerous works covering a wide range of studies, such as climatology of hail [5,8-15], radar observation on hail processes [16-19], theoretical and experimental studies of the mechanisms of hail formation [20-22], methods of impact on hail processes [18,23,24], analysis of impact results [25-28], etc.

To solve various problems of scientific or applied significance (the impact of climate change on hail processes, comparison of experimental data on hailstorms with theoretical models of hail processes, assessment of the expected damage from hailstorms, planning of work on active impacts on hail processes, etc.), detailed information on the spatial-temporary characteristics of hail distributions and its sizes on different locations is necessary. Corresponding ground-based network studies (the number of days with hail per year, determination of the size of hail, their structure, kinetic energy, etc.) have been widely carried out and are being carried out both in different countries of the world [2,3,29-34] and in Georgia [1,4,5-15].

To construct of spatial-temporary maps of the distribution of hail processes, data from radar observations of convective clouds are also used [3,16,19,22,25,35-37]. In particular, in the paper [19] 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. 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).

This work is a continuation of the study [19]. Results of modeling of the distribution of hailstones by mean max sizes on the territory of Kakheti (Georgia) using data of the freezing level in the atmosphere and radar measurements of hail sizes in clouds are presented below.

Study area, material and methods

Study area – Kakheti region of Georgia. 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) [38] - are used.

Period of observation: April-September, 2016-2019. The area of shielded from the hail territory - 11 309.5 km^2.

The expected diameter of hailstones falling out to the earth's surface according to the Zimenkov-Ivanov model of hail melting in the atmosphere [1,39-41] by taking into account the radar data about their max diameter in the clouds and freezing level in atmosphere was calculated [42, 43].

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 was 0.11 ÷ 3.84 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.

The initial dimensions of hailstones in clouds from April to September in Table 1 are presented.

Table 1. The statistical characteristics of hailstones in the clouds above Kakheti territory by mean max diameter from April to September 2016-2019 (cm).

Parameter	April	May	June	July	August	September
Mean	1.17	1.69	1.97	1.97	1.27	1.79
Min	0.16	0.09	0.09	0.29	0.09	0.20
Max	2.55	4.30	4.83	3.58	4.05	3.58
Range	2.40	4.21	4.74	3.29	3.96	3.38
St Dev	0.65	0.90	0.96	0.82	0.94	0.87
σ_m	0.10	0.06	0.07	0.09	0.22	0.11
99%_Low	0.91	1.53	1.79	1.73	0.70	1.49
99%_Upp	1.42	1.84	2.16	2.21	1.84	2.08

GIS technologies to construct maps of the distribution of hailstones by size near the surface of the earth in the territory of Kakheti were used.

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; Range - Max – Min; St Dev - standard deviation; σ_m - standard error; %; 99% _Low and 99%_Upp – 99% of lower and upper levels of the mean accordingly.

Results

Results in Fig. 1-12 and Table 2,3 are presented.

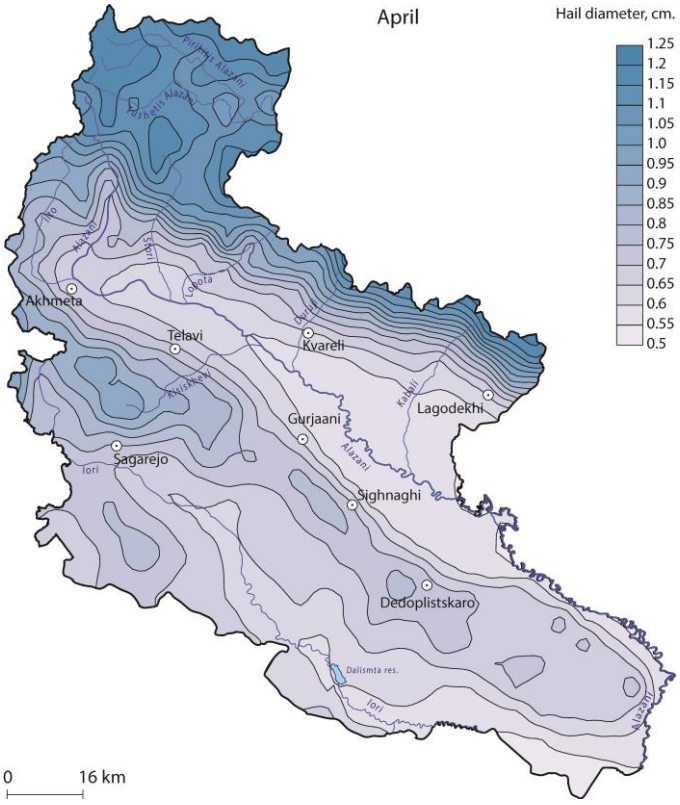

Fig. 1. Distribution of hailstones by mean max diameter on the territory of Kakheti in April.

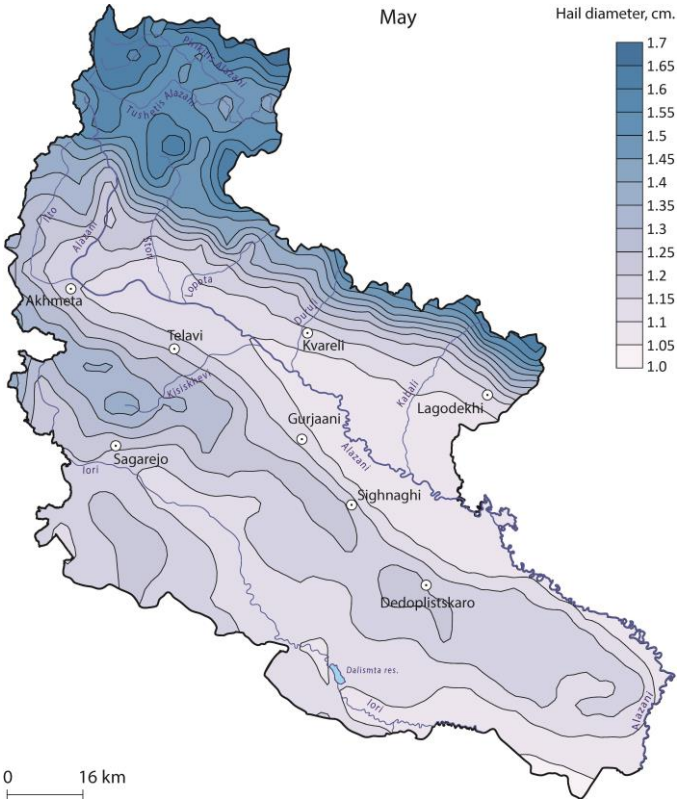

Fig. 2. Distribution of hailstones by mean max diameter on the territory of Kakheti in May.

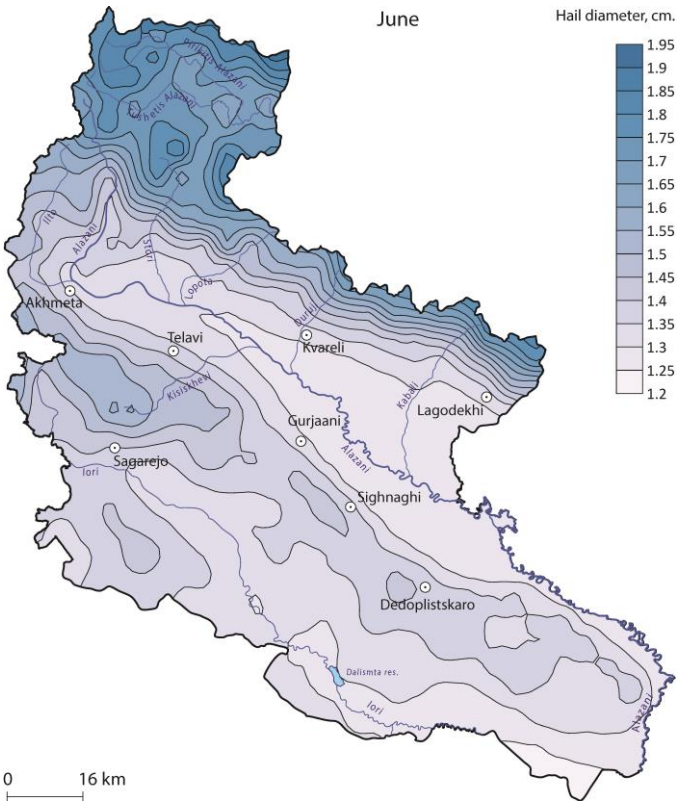

Fig. 3. Distribution of hailstones by mean max diameter on the territory of Kakheti in June.

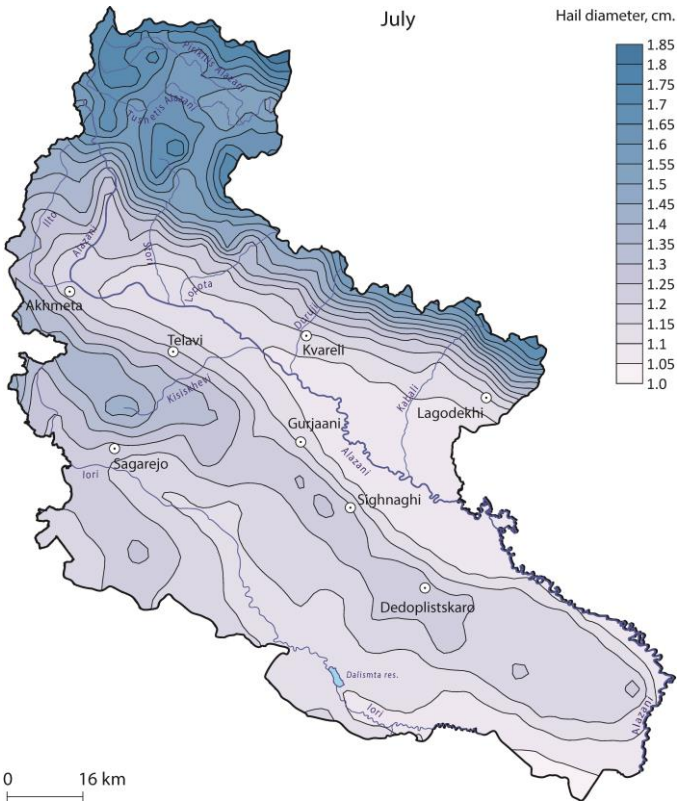

Fig. 4. Distribution of hailstones by mean max diameter on the territory of Kakheti in July.

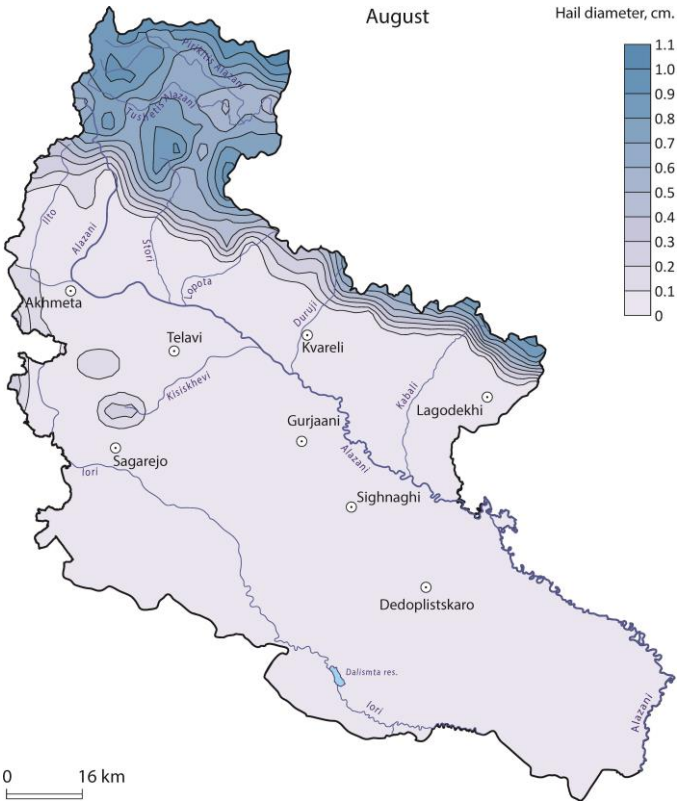

Fig. 5. Distribution of hailstones by mean max diameter on the territory of Kakheti in August.

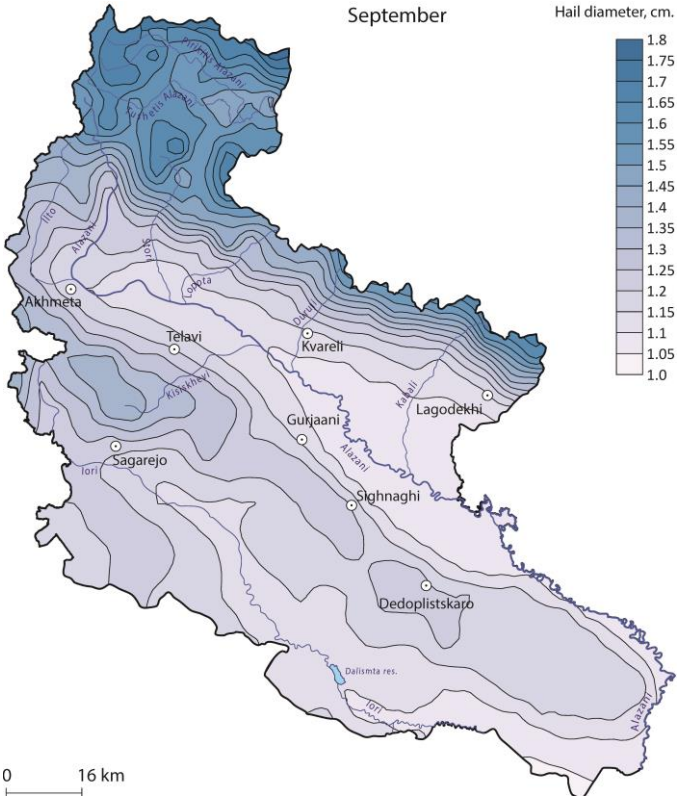

Fig. 6. Distribution of hailstones by mean max diameter on the territory of Kakheti in September.

Fig. 1-6 clearly demonstrated distribution of hailstones by mean max diameter on the territory of Kakheti from April to September.

The statistical characteristics of hailstones by mean max diameter on the earth surface in Kakheti from April to September in Table 2 and 3 are presented. In particular, as follows from Table 2,3 mean values of D to full Kakheti territory change from 0.12 cm (August) to 1.41 cm (June), mean values of D_99%_Low change from 0 cm (August) to 1.17 cm (June) and mean values of D_99%_Upp – from 1.06 cm (August) to 1.65 cm (June).

Table 2. The statistical characteristics of hailstones by mean max diameter on the earth surface in Kakheti from April to June.

Month	April			May			June		
Parameter	99%_Low	Mean	99%_Upp	99%_Low	Mean	99%_Upp	99%_Low	Mean	99%_Upp
Mean	0.29	0.75	1.09	1.02	1.23	1.42	1.17	1.41	1.65
Min	0.00	0.52	0.92	0.82	1.05	1.26	0.96	1.24	1.49
Max	0.91	1.17	1.42	1.53	1.69	1.84	1.75	1.94	2.12
Range	0.91	0.65	0.50	0.72	0.65	0.58	0.79	0.70	0.64
St Dev	0.29	0.18	0.14	0.17	0.15	0.14	0.17	0.15	0.14
σm	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
99%_Low	0.25	0.73	1.07	1.00	1.21	1.40	1.15	1.39	1.63
99%_Upp	0.32	0.78	1.11	1.04	1.24	1.43	1.19	1.43	1.66

Table 3. The statistical characteristics of hailstones by mean max diameter on the earth surface in Kakheti from July to September.

Month	July			August			September		
Parameter	99%_Low	Mean	99%_Upp	99%_Low	Mean	99%_Upp	99%_Low	Mean	99%_Upp
Mean	0.88	1.25	1.58	0.00	0.12	1.06	0.81	1.24	1.61
Min	0.59	1.04	1.40	0.00	0.00	0.82	0.54	1.05	1.46
Max	1.60	1.86	2.11	0.42	1.11	1.72	1.49	1.79	2.09
Range	1.01	0.82	0.71	0.42	1.11	0.90	0.95	0.75	0.63
St Dev	0.22	0.18	0.15	0.02	0.26	0.20	0.21	0.16	0.14
σm	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01
99%_Low	0.85	1.23	1.56	0.00	0.09	1.04	0.79	1.22	1.60
99%_Upp	0.90	1.27	1.60	0.00	0.15	1.08	0.84	1.26	1.63

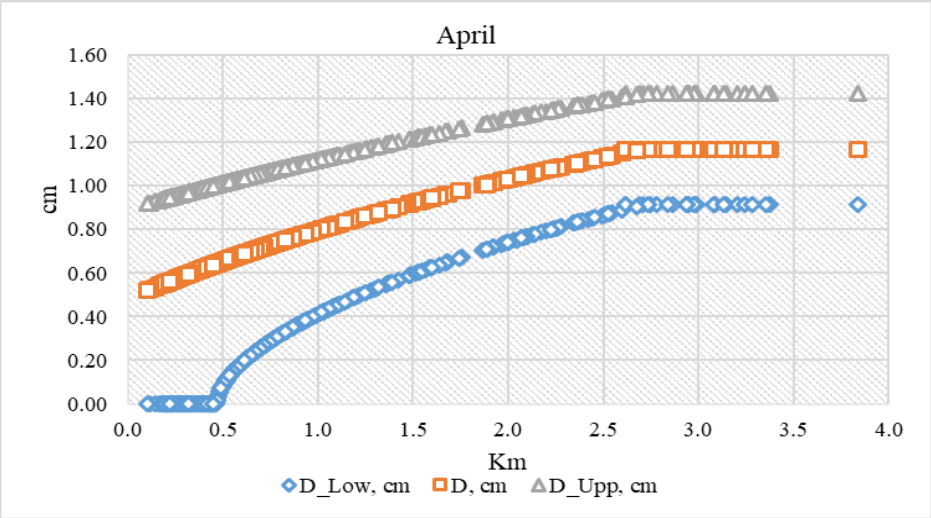

Fig. 7. Vertical distribution of mean max diameter of hailstones and their 99% lower and upper levels in Kakheti in April.

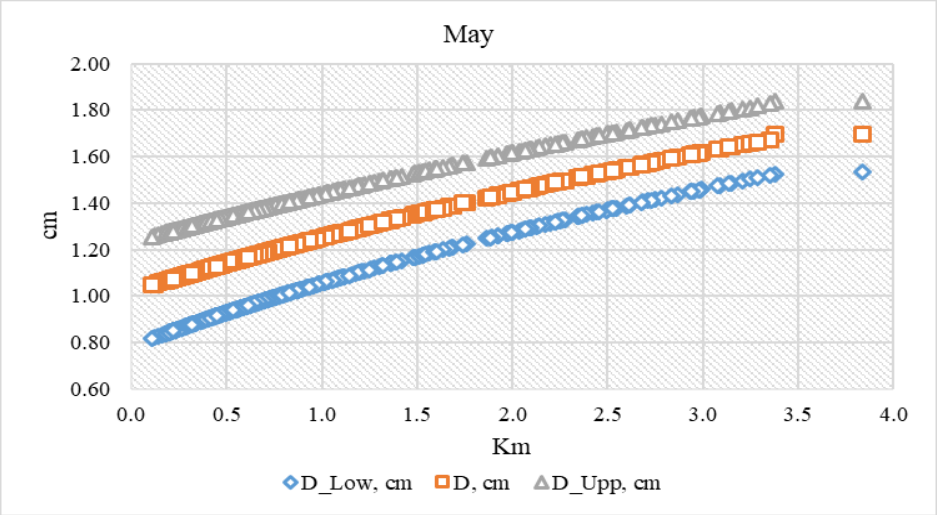

Fig. 8. Vertical distribution of mean max diameter of hailstones and their 99% lower and upper levels in Kakheti in May.

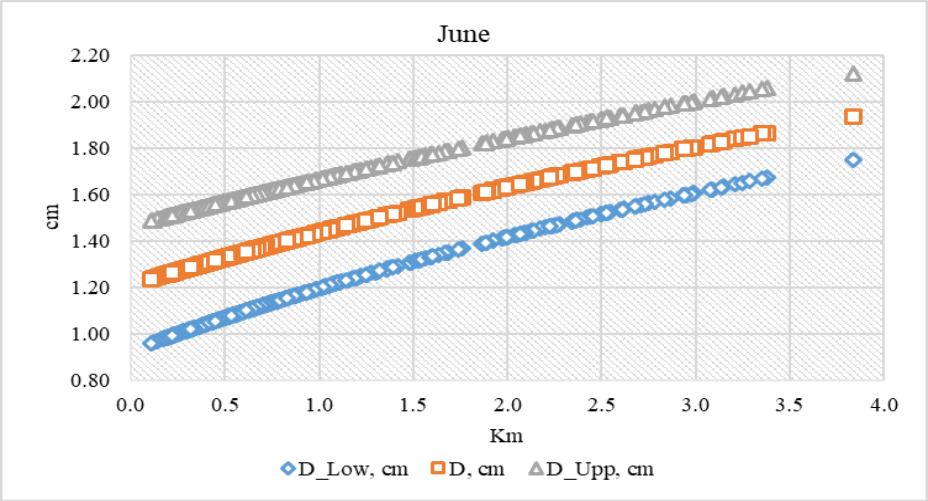

Fig. 9. Vertical distribution of mean max diameter of hailstones and their 99% lower and upper levels in Kakheti in June.

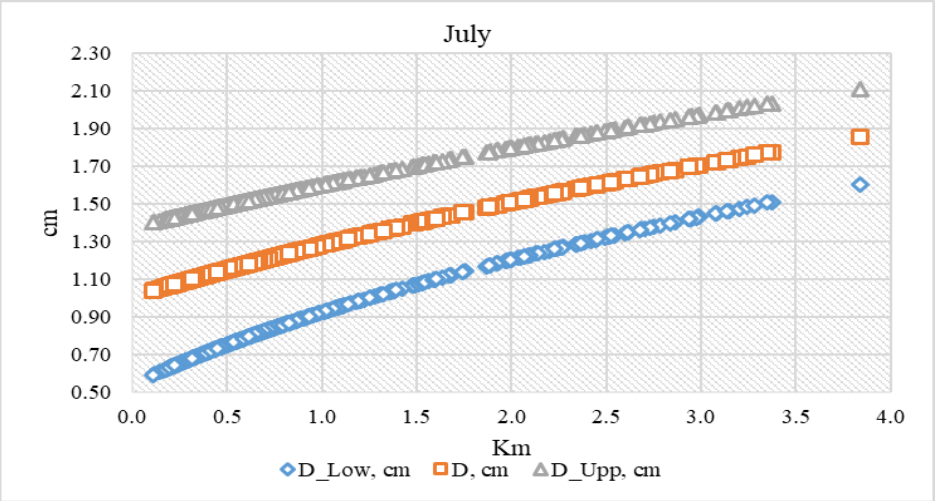

Fig. 10. Vertical distribution of mean max diameter of hailstones and their 99% lower and upper levels in Kakheti in July.

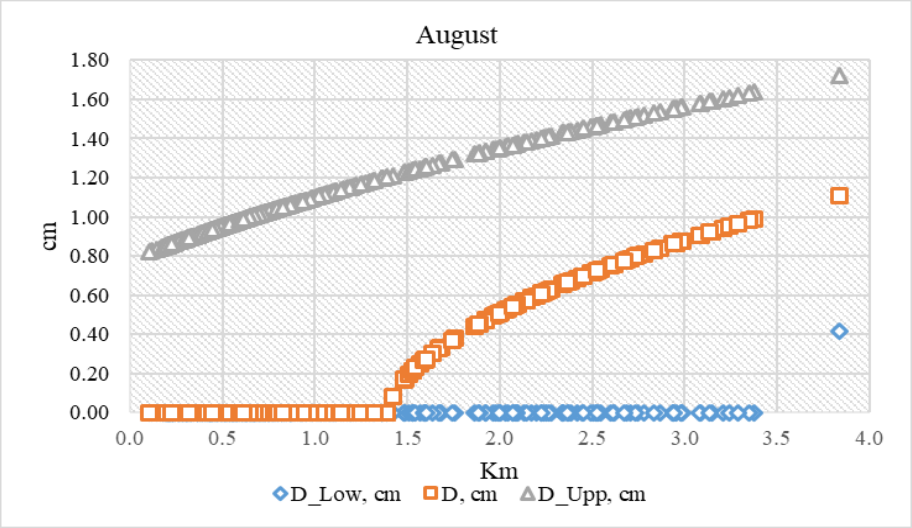

Fig. 11. Vertical distribution of mean max diameter of hailstones and their 99% lower and upper levels in Kakheti in August.

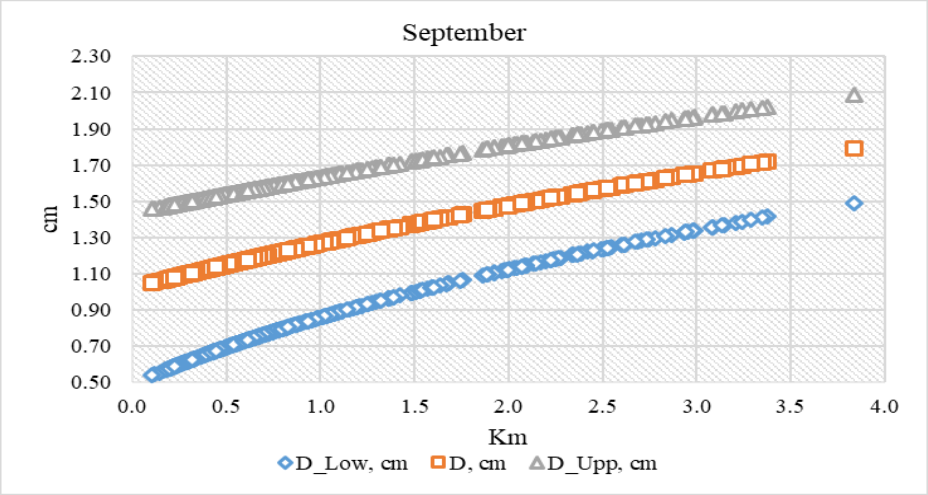

Fig. 12. Vertical distribution of mean max diameter of hailstones and their 99% lower and upper levels in Kakheti in September.

In Fig. 7-12 vertical distribution of mean max diameter of hailstones and their 99% lower and upper levels in Kakheti from April to September are presented. In particilar, Fig. 5-12 and Table 2, 3 shows, that the variability of the mean maximum hail diameter on the territory of Kakheti in the range of heights from 0.11 to 3.84 km is as follows:

- **D_99%_Low.** April: 0÷0.91 cm; May: 0.82÷1.53 cm; June: 0.96÷1.75 cm; July: 0.59÷1.60 cm; August: 0÷0.42 cm; September: 0.54÷1.49 cm.
- **D.** April: 0.52÷1.17 cm; May: 1.05÷1.69 cm; June: 1.24÷1.94 cm; July: 1.04÷1.86 cm; August: 0÷1.11 cm; September: 1.05÷1.79 cm.
- **D_99%_Upp.** April: 0.92÷1.42 cm; May: 1.26÷1.84 cm; June: 1.49÷2.12 cm; July: 1.40÷2.11 cm; August: 0.82÷1.72 cm; September: 1.46÷2.09 cm.

Conclusion

In the near future, we plan to study the statistical characteristics of the mean max size of hailstones for the municipalities of Kakheti as well as modeling the damage from hail to vineyards, wheat and corn in the agricultural regions of Kakheti.

References

[1] Sulakvelidze G.K. Livnevyye osadki i grad. L., Gidrometeoizdat, 1967, 412 s., (in Russian).

[2] Dessens J., Frale R. Haistone Size Distributions in Southwestern France. Atmospheric Research, 33, 1994, pp. 57-73.

[3] Abshaev A.M., Abshaev M.T., Barekova M.V., Malkarova A.M. Rukovodstvo po organizacii i provedeniu protivogradovih rabot. ISBN 978-5-905770-54-8, Nalchik, Pechatni dvor, 2014, 508 s, (in Russian).

[4] Elizbarashvili E.Sh., Elizbarashvili M. E. Extreme Weather Events over the Territory of Georgia, 2012, Tbilisi (in Russian).

[5] Varazanashvili O., Tsereteli N., Amiranashvili A., Tsereteli E., Elizbarashvili E., Dolidze J., Qaldani L., Saluqvadze M., Adamia Sh., Arevadze N., Gventcadze A. Vulnerability, Hazards and Multiple Risk Assessment for Georgia, Natural Hazards, Vol. 64, Number 3 (2012), 2021-2056, DOI: 10.1007/s11069-012-0374-3, http://www.springerlink.com/content/9311p18582143662/fulltext.pdf.

[6] Amiranashvili A., Varazanashvili O., Pipia M., Tsereteli N., Elizbarashvili M., Elizbarashvili E. Some Data About Hail Damages in Eastern Georgia and Economic Losses from Them. Int. Conf. "Advanced Problems in Geophysics". Reports, presented on the Scientific Conference "80 years of the M. Nodia Institute of Geophysics". Tb., 2014, pp. 145-150, (in Russian).

[7] Elizbarashvili E. Sh., Amiranashvili A. G., Varazanashvili O. Sh., Tsereteli N. S., Elizbarashvili M. E., Elizbarashvili Sh. E., Pipia M. G. Hailstorms in the Territory of Georgia. European Geographical Studies, ISSN: 2312-0029, vol.2, № 2, 2014, pp. 55-69, DOI: 10.13187/egs.2014.2.55, www.ejournal9.com, (in Russian).

[8] Gigineishvili V.M. Gradobitia v vostochnoi Gruzii. Leninhrad, Gidrometeoizdat,1960,123 s.

[9] Amiranashvili A.G., Nodia A.G., Toronjadze A.F., Khurodze T.V. Some Statistical Characteristics of the Number of Days with Hail into the Warm Half-Year in Georgia in 1941-1990. Trans. of Institute of Geophysics of Acad. of Sc. of Georgia, ISSN 1512-1135, v. 58, 2004, pp. 133-141, (in Russian).

[10] Amiranashvili A., Varazanashvili O., Nodia A., Tsereteli N., Khurodze T. Statistical Characteristics of the Number of Days with Hail Per Annum in Georgia. Trans. of the Institute of Hydrometeorology, ISSN 1512-0902, vol. 115, Tb., 2008, pp. 427 – 433, (in Russian).

[11] Amiranashvili A.G., Nodia A.G., Toronjadze A.F., Khurodze T.V. The Changeability of the Number of Days with the Hail in Georgia in 1941-1990. Trans. of Institute of Geophysics of Acad. of Sc. of Georgia, ISSN 1512-1135, v. 58, 2004, pp. 127-132, (in Russian).

[12] Amiranashvili A.G., Amiranashvili V.A., Nodia A.G., Khurodze T.V., Toronjadze A.F., Bibilashvili T.N. Spatial-Temporary Characteristics of Number of Days with a Hails in the Warm Period of Year in Georgia, Proc. 14thInternational Conference on Clouds and Precipitation, Bologna, Italy,18-23 July 2004, 2_2_215.1-2_2_215.2.

[13] Amiranashvili A.G., Bliadze T.G., Jamrishvili N.K., Khurodze T.V., Pipia M.G., Tavidashvili Kh.Z. Comparative Analysis of the Distribution of Number of Days with Hail Per Annum on the Territory of Kakheti According to the Data of the Meteorological Stations and State Insurance Service of Georgia. Journal of the Georgian Geophysical Society, Issue A. Physics of Solid Earth, v.20A, 2017, pp. 44 - 56.

[14] Janelidze I., Pipia M. Hail storms in Georgia in 2016-2018. Int. Sc. Conf. "Natural Disasters in Georgia: Monitoring, Prevention, Mitigation". Proc., ISBN 978-9941-13-899-7, Publish House of Iv. Javakhishvili Tbilisi State University, December 12-14, Tbilisi, 2019, pp. 144 -146.
[15] Beglarashvili N., Janelidze I., Pipia M., Varamashvili N. Hail Storms in Kakheti (Georgia) in 2014-2018. Int. Sc. Conf. „Modern Problems of Ecology", Proc., ISSN 1512-1976, v. 7, Tbilisi-Telavi, Georgia, 26-28 September, 2020, pp. 176-179.
[16] Amiranashvili A., Amiranashvili V., Doreuli R., Khurodze T., Kolesnikov Yu. Some Characteristics of Hail Processes in the Kakheti Region of Georgia, Proc.13th Int. Conf. on Clouds and Precipitation, Reno, Nevada, USA, August 14-18, vol.2, 2000, 1085-1087.
[17] Abaiadze O., Avlokhashvili Kh., Amiranashvili A., Dzodzuashvili U., Kiria J., Lomtadze J., Osepashvili A., Sauri I., Telia Sh., Khetashvili A., Tskhvediashvili G., Chikhladze V. Radar Providing of Anti-Hail Service in Kakheti. Trans. of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, vol. 66, Tb., 2016, pp. 28-38, (in Russian).
[18] Amiranashvili A., Chikhladze V., Dzodzuashvili U., Ghlonti N., Sauri I., Telia Sh., Tsintsadze T. Weather Modification in Georgia: Past, Present, Prospects for Development. International Scientific Conference "Natural Disasters in Georgia: Monitoring, Prevention, Mitigation". Proceedings, ISBN 978-9941-13-899-7, Publish House of Iv. Javakhishvili Tbilisi State University, December 12-14, Tbilisi, 2019, pp. 216-222.
[19] Amiranashvili A., Chikhladze V., Kveselava N., Kvilitaia N., Sauri I., Shavlakadze Sh. Some Characteristics of Hail Processes in Kakheti (Georgia) According to Radar Observations into 2016-2019. Journal of the Georgian Geophysical Society, ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 23(2), 2020, pp. 50 – 56.
[20] Bartishvili I. T., Nadibaidze G.A., Begalishvili N.A., Gudushauri Sh. L. K fizicheskim osnovam metoda ZakNIGMI. Tr. ZakNIGMI, vip. 67(73), 1978, s. 73-82, (in Russian).
[21] Amiranashvili A., Gzirishvili T. Aerosols and Ice Crystals in the Atmosphere. Tbilisi, Metsniereba, 1991, 113 p., (in Russian).
[22] Amiranashvili A., Bliadze T., Jamrishvili N., Kekenadze E., Tavidashvili Kh., Mitin M. Some Characteristics of Hail Process in Georgia and Azerbaijan on May 28, 2019. Journal of the Georgian Geophysical Society, ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 22(2), 2019, pp. 40–54.
[23] Amiranashvili A., Bakgsoliani B., Begalishvili N., Beritashvili B., Rekhviashvili R., Tsintsadze T., Chitanava R. On the Necessity of Resumption of Atmospheric Processes Modification Activities in Georgia. Trans. of the Institute of Hydrometeorology, Georgian Technical University, 2013, v. 119, pp.144-152, (in Russian).
[24] Amiranashvili A., Burnadze A., Dvalishvili K., Gelovani G., Ghlonti N., Dzodzuashvili U., Kaishauri M., Kveselava N., Lomtadze J., Osepashvili A., Sauri I., Telia Sh., Chargazia Kh., Chikhladze V. Renewal Works of Anti-Hail Service in Kakheti. Trans. of Mikheil Nodia institute of Geophysics, ISSN 1512-1135, vol. 66, Tb., 2016, pp. 14 – 27, (in Russian).
[25] Amiranashvili A., Dzodzuashvili U., Lomtadze J., Sauri I., Chikhladze V. Some Characteristics of Hail Processes in Kakheti. Trans. of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, vol. 65, Tb., 2015, pp. 77 – 100, (in Russian).
[26] Amiranashvili A., Nodia A., Khurodze T., Kartvelishvili L., Chumburidze Z., Mkurnalidze I., Chikhradze N. Variability of Number of Hail and Thunderstorm Days in the Regions of Georgia with Active Influence on Atmospheric Processes, Bull. of the Georgian Acad. of Sciences, 172, N3, 2005, 484-486.
[27] Amiranashvili A., Chikhladze V., Kveselava N., Sauri I. Some Results of Anti-Hail Works in Kakheti into 2016-2019. Int. Sc. Conf. „Modern Problems of Ecology", Proc., ISSN 1512-1976, v. 7, Tbilisi-Telavi, Georgia, 26-28 September, 2020, pp. 153-156.

[28] Amiranashvili A., Kveselava N., Kvilitaia N., Sauri I., Shavlakadze Sh., Chikhladze V. Some Results of Anti-Hail Works in Kakheti into 2016-2020. Trans. of M. Nodia Institute of Geophisics, ISSN 1512-1135, vol. LXXII, Tbilisi, 2020, pp. 123-128. (in Georgian).
[29] Tlisov M.I., Khuchunayev B.M. Issledovaniye prostranstvennogo raspredeleniya zarodyshey grada. Tr. Vses. semin. "Aktivnyye vozdeystviya na gradovyye protsessy i perspektivy usovershenstvovaniya l'doobrazuyushchikh reagentov dlya praktiki aktivnykh vozdeystviy", Nal'chik, 16-21 oktyabrya 1989. M., MO Gidrometeoizdata. 1991. C. 61-74.
[30] Tlisov M.I., Zagidulin A.A., Khuchunayev B.M., Fedchenko L.M. Apparatura, metodika i rezul'taty nazemnykh issledovaniy fizicheskikh kharakteristik grada. Tr. Vses.konf. "Aktivn. vozd. na gidromet. protsessy". Nal'chik, 22-25 oktyabrya 1991. Sankt-Peterburg. Gidrometeoizdat, kniga 2. 1995. c. 24-30. 29.
[31] Fraile R., Sa´nchez J.L., de la Madrid J.L., Castro A., Marcos J.L. Some Results from the Hailpad Network in Leo´n (Spain): Noteworthy Correlations among Hailfall Parameters. Theor. Appl. Climatol., 64, 1999, pp. 105–117.
[32] Sánchez J.L., Gil-Robles B., Dessens J., Martin E., Lopez L.,.Marcos J.L, Berthet C., Fernández J.T., García-Ortega E. Characterization of Hailstone Size Spectra in Hailpad Networks in France, Spain, and Argentina. Atmospheric Researchm Vol. 93, Iss. 1-3, 2009, DOI: 10.1016/j.atmosres.2008.09.033
[33] Hermida L., Merino A., Sánchez J.L., Berthet G., Dessens J., López L., Fernández-González S., Gascón E., García-Ortega E. Spatial Variability of Hailfalls in France: An Analysis of Air Mass Retro-Trajectories. Conference: European Geosciences Union (EGU) General Assembly, 2014, DOI:10.13140/RG.2.1.2647.3843
[34] Tsitouridis K. The Greek Hailpad Network 2008 to 2019: Analysis of the Hailpad Data - The Equivalent Hail Diameter. International Journal of Engineering Science Invention (IJESI) ISSN (Online): 2319-6734, ISSN (Print): 2319-6726, Vol. 10, Iss. 9, Series II, 2021, pp. 18-32, DOI: 10.35629/6734-1009021832
[35] Montopoli M, Picciotti E, Baldini L., Fabio S.Di., Marzano F.S., Vulpiani G. Gazing Inside a Giant-Hail-Bearing Mediterranean Supercell by Dual-Polarization Doppler Weather Radar. Atmospheric Research, Vol. 264, 2021, https://doi.org/10.1016/j.atmosres.2021.105852
[36] Barekova M.V., Gazayeva Z.A., Makitov V.S. Kharakternyye trayektorii superyacheykovykh gradovykh protsessov na Severnom Kavkaze. Tr. VGI, Vyp. 90, 1999, S.80-95, (in Russian).
[37] Gazayeva Z.A., Makitov V.S. Raspredeleniye trayektoriy peremeshcheniya mnogoyacheykovykh gradovykh protsessov na Severnom Kavkaze. Tr. VGI, Vyp. 80, 1991, S.93-99, (in Russian).
[38] Selex ES GmbH · Gematronik Weather Radar Systems. Rainbow®5 User Guide, 2015, 464 p., www. gematronik.com
[39] Zimenkov V.A., Ivanov V.V. Raschet tayaniya gradin v estestvennykh protsessakh. Tr. VGI, 1966, vyp. 3(5).
[40] Jamrishvili N. K., Tavidashvili Kh. Z. 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. Int. Sc. Conf. „Modern Problems of Ecology" Proc., ISSN 1512-1976, v. 6, Kutaisi, Georgia, 21-22 September, 2018, pp. 130-133.
[41] Jamrishvili N., Tavidashvili Kh. Estimation of the Critical Size of Hailstones in Clouds non Prejudiced to Agriculture in Kakheti. International Scientific Conference "Natural Disasters in Georgia: Monitoring, Prevention, Mitigation". Proceedings, ISBN 978-9941-13-899-7, Publish House of Iv. Javakhishvili Tbilisi State University, December 12-14, Tbilisi, 2019, pp. 126-129.
[42] Amiranashvili A.G., Berianidze N.T., Jamrishvili N.K., Tavidashvili Kh.Z. Statistical Characteristics of the Monthly Average Values of the Air Temperature in the Layer of Atmosphere 0.54-27 km above the Kakheti Territory (Georgia) in 2012-2016. Journal of the Georgian Geophysical Society, Issue B. Physics of Atmosphere, Ocean and Space Plasma, v. 20B, 2017, pp.24 –42.

[43] Jamrishvili N. Monthly and Ten-Day Average Values of Freezing Level in the Atmosphere above Kakheti Territory (Georgia) from April to October. Journal of the Georgian Geophysical Society, ISSN: 1512-1127, Iss. A, Physics of Solid Earth, Tb., 2017, vol. 20A, pp. 57-64.

კახეთის ტერიტორიაზე საშუალი მაქსიმალური ზომების მიხედვით სეტყვის განაწილების მოდელირება ატმოსფეროში გაყინვის დონისა და რადარის გაზომვების მონაცემების გამოყენებით

ა. ამირანაშვილი, ნ. ბოლაშვილი, ზ. გულაშვილი,
ნ. ჯამრიშვილი, ნ. სუქნიძე, ხ. თავიდაშვილი

რეზიუმე

წარმოდგენილია სეტყვის განაწილების მოდელირების შედეგები საშუალო მაქსიმალური ზომების მიხედვით კახეთის ტერიტორიისათვის ატმოსფეროში გაყინვის დონისა და ღრუბლებში სეტყვის მაქსიმალური ზომების შესახებ რადიოლოკაციური გაზომვების მონაცემების გამოყენებით.

შედგენილია სეტყვის განაწილების რუკები საშუალო მაქსიმალური ზომების მიხედვით კახეთის ტერიტორიისთვის ცალკეულ თვეებში აპრილიდან სექტემბრამდე. შესწავლილია D - ს ვერტიკალური განაწილება აღნიშნული ტერიტორიისთვის 0.11 - დან 3.84 - კმ- მდე სიმაღლეების დიაპაზონში.

Моделирование распределения по средним максимальных размерам града на территории Кахетии (Грузия) с использованием данных об уровне замерзания в атмосфере и радиолокационных измерений

**А.Г. Амиранашвили, Н. Р. Болашвили, З.М. Гулашвили,
Н. К. Джамришвили, Н. Э. Сукнидзе, Х. З. Тавидашвили**

Резюме

Представлены результаты моделирования распределения градин по средним максимальным размерам на территории Кахетии (Грузия) с использованием данных об уровне промерзания в атмосфере и радиолокационных измерений максимальных размеров града в облаках.

Построены карты распределения града по средним максимальным размерам на территории Кахетии для отдельных месяцев, с апреля по сентябрь. Изучено вертикальное распределение D на указанной территории в диапазоне высот от 0.11 до 3.84 км