

## RADAR MONITORING OF HAIL PROCESSES IN EASTERN GEORGIA AND ITS NEIGHBORING COUNTRIES (AZERBAIJAN, ARMENIA)

<sup>\*\*</sup>Gvasalia G., <sup>\*</sup>Kekenadze E., <sup>\*\*\*</sup>Mekoshkishvili N., <sup>\*\*\*\*</sup>Mitin M.

<sup>\*</sup>State Military Scientific-Technical Center “DELTA”, Tbilisi, Georgia

<sup>\*\*</sup>National Environmental Agency of Georgia, Tbilisi, Georgia

<sup>\*\*\*</sup>Agricultural and Rural Development Agency, of Georgia, Tbilisi, Georgia

<sup>\*\*\*\*</sup>Mikheil Nodia Institute of Geophysics of Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia  
[wolkalak@gmail.com](mailto:wolkalak@gmail.com)

**Summary:** Examples of radar monitoring of hail processes in eastern Georgia and its neighboring countries (Azerbaijan, Armenia) are presented. Monitoring was carried out using the METEOR 735CDP10 weather radar. In the case of relevant interstate agreements, it is possible to organize an international service for short-term warning of the population and emergency structures about the possibility of dangerous meteorological phenomena.

**Key Words:** Radar monitoring, dangerous meteorological processes, hail, precipitation.

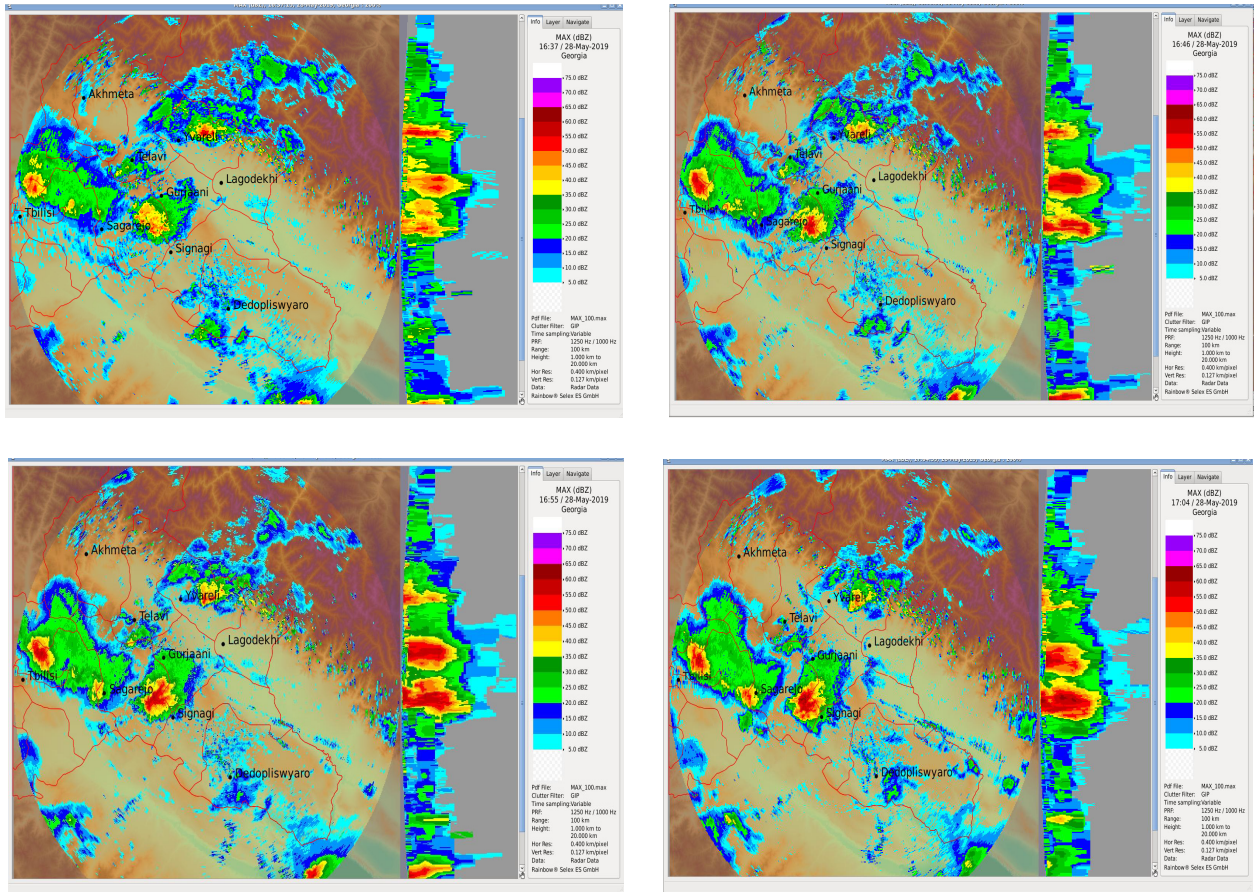
**Introduction.** Georgia is one of the most hail-dangerous countries of world [1, 2]. Taking into account the significant economic damage, brought by hail damages, in Georgia in the beginning of the fifties of past century began works on the fight with the hail [3, 4]. These works continued until 1989 and were renewed using newest technologies in Kakheti region of Georgia in 2015 [5-7]. The anti-hail service is equipped with a modern meteorological radar, which in the future, in addition to anti-hail activities, is planned to be used for operational monitoring of dangerous hydro-meteorological processes in eastern Georgia and adjacent territories [8-11]. Below are an examples of such use of radar outside the hail-protected territory in the case of the hail process in Tbilisi and Kakheti on May 28, 2019, Belaken (Azerbaijan) on May 10, 2019 and Ijevan (Armenia) on May 20, 2019.

**Material and methods.** The Anti-hail service is equipped with contemporary C-band, dual polarized Doppler meteorological radar “METEOR 735 CDP 10 – Doppler Weather Radar”, which is installed in the village Chotori (1090 m height from sea level) of the Signagi municipality of the Kakheti region of Georgia. The products of radar are sufficiently varied. For the anti-hail works the optimal radius of action of radar is 100-120 km, (distance, which practically covers the territory of Kakheti and the some parts of the territories of Armenia and Azerbaijan). In this work two radar products are presented, MAX(dBZ) and HAILSZ (Size) [12, 13]. The expected size of hailstones falling out to the earth's surface was calculated according to the Zimenkov-Ivanov model of hail melting in the atmosphere by taking into account the radar data about their diameter in the clouds [14]. The mass media information about the hail damages is also used to show the full picture.

The following designations will be used below:  $D_0$  – maximum hail diameter in cloud, cm;  $D$  – maximum hail diameter at the ground level, cm; time designation, for example, 14 hour 33 min – 14:33 h., etc. In Fig. 3 minutes are given in fractions of an hour.

**Results.** The results in Fig. 1-10 and Table are represented.

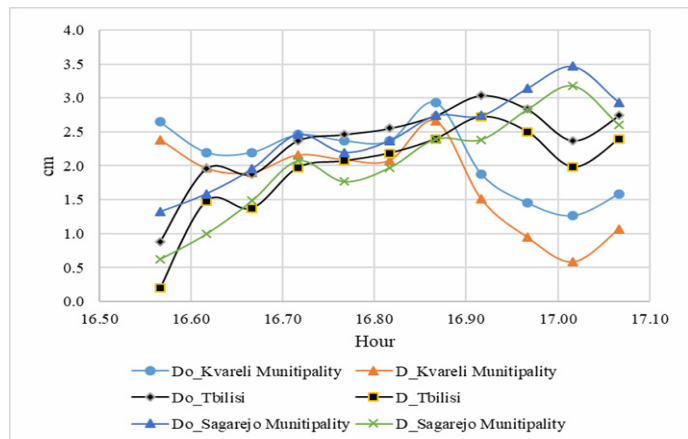
Fig. 1 presents the fragments of the radar product MAX(dBZ) about the hail process in eastern Georgia in 16:37, 16:46, 16:55 and 17:04 hour. As it follows from this Fig. and Fig. 2 hail clouds in the indicated time simultaneously they were observed above Tbilisi and two locations of Kakheti (municipalities Sagarejo and Kvareli). The diameter of hail stones in the clouds was changing from 0.9 (Tbilisi) to 3.5 (municipalitie Sagarejo) cm. The diameter of hail stones on the earth's surface was changing from 0.2 (Tbilisi) to 3.2 (municipalities Sagarejo) cm (Fig. 3, Table).



**Fig. 1. Data of radar product MAX(dBZ) about hail process in Tbilisi and Kakheti on May 28, 2019 in 16:37, 16:46, 16:55 and 17:04 h.**



**Fig.2. Hail Processes Trajectory in Tbilisi and Kakheti 28.05.2019 from 16:34 to 17:04 h.**



**Fig. 3. Hail Size Changeability in Clouds and at the Ground Level in Tbilisi and Kakheti on May 28, 2019**

<https://imedinews.ge/ge/saqartvelo/107002/dzlierma-tsvimam-da-setkvam-tbilisshi-problemebi-sheqmna-poto>



Statistical Characteristics of Hail Size in Clouds and at the Ground Level in Tbilisi and Kakheti on May 28, 2019

Location	Do_Tbilisi	D_Tbilisi	Do_Sagarejo Municipality	D_Sagarejo Municipality	Do_Kvareli Municipality	D_Kvareli Municipality
Min	0.9	0.2	1.3	0.6	1.3	0.6
Max	3.0	2.7	3.5	3.2	2.9	2.7
Mean	2.3	1.9	2.4	2.0	2.1	1.8

In the municipality Sagarejo to 100% about 600 hectare of agricultural land was damaged. In this day the anti-hail service conked out because of the ban on the action by the organs of aviation.



Fig. 4. Hail in Tbilisi. Photo left by I. Tbeli, right – M. Bokolishvili

<https://imedinevs.ge/ge/saqartvelo/107002/dzlierma-tsvimam-da-setkvam-tbilisshi-problemebi-sheqmna-poto>  
<https://imedinevs.ge/ge/saqartvelo/107002/dzlierma-tsvimam-da-setkvam-tbilisshi-problemebi-sheqmna-poto>

In Tbilisi from the hail especially suffered the regions of Gldani, Digomi, Vazisubani, Varketili and Sanzona (Fig. 2, 4).

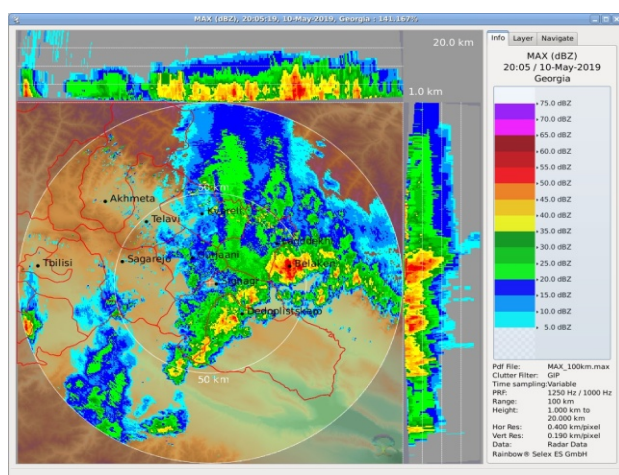


Fig. 5. Data of Radar Product MAX(dBZ) About the Hail Cloud on 10 May 2019 in Belaken in 20:05

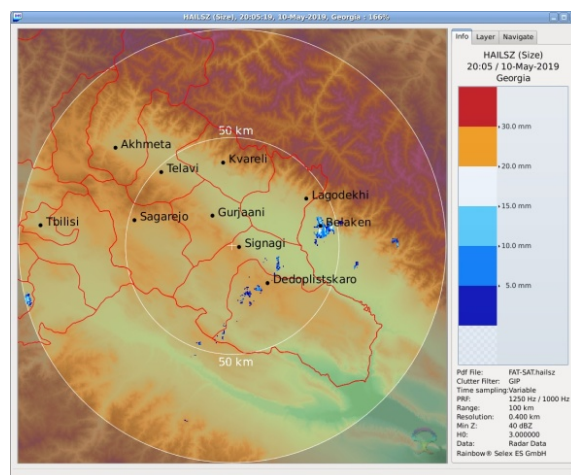
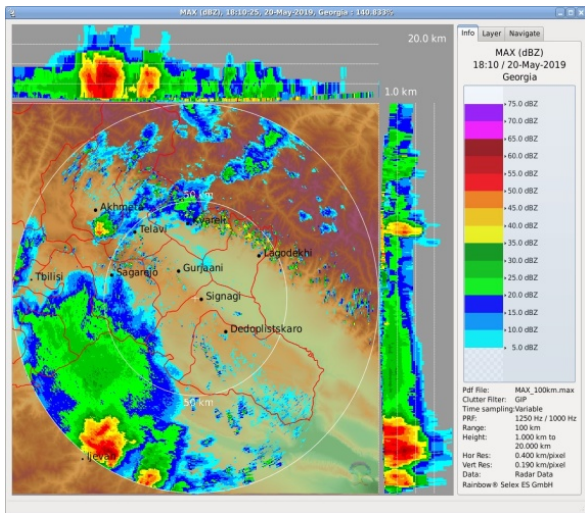
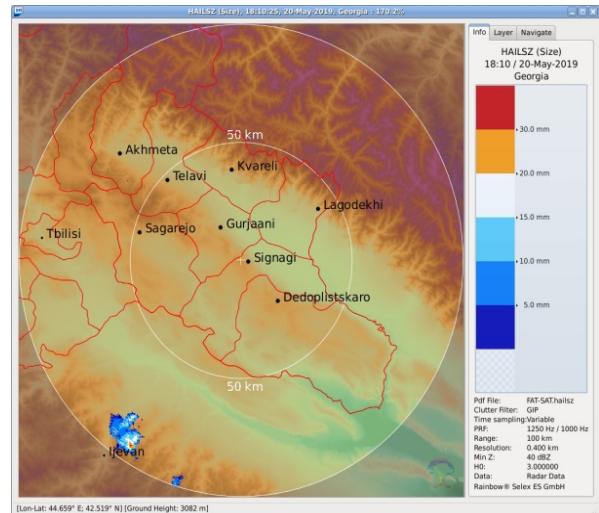


Fig. 6. Data of Radar Product HAILSZ About the Hail Cloud on 10 May 2019 in Belaken in 20:05 h. (D<sub>0</sub> = 15-20 mm).



**Fig. 7. Data of Radar Product MAX(dBZ) About the Hail Cloud on 20 May 2019 in Ijevan in 18:10 h.**



**Fig. 8. Data of Radar Product HAILSZ About the Hail Cloud on 20 May 2019 in Ijevan in 18:10 h. ( $D_0 = 30\text{-}35$  mm).**

Fig. 5-8 presents the fragments of the radar products MAX(dBZ) and HAILSZ about the hail process in Belaken environments (10 May 2019, 20:05 h.) and Ijevan environments (20 May 2019, 18:10 h.).



**Fig. 9. Hail in the Belaken Environments on 10.05.2019.**



**Fig. 10. Hail in the Ijevan Environments on 20.05.2019.**

In the environments of Belaken fell out the hail (Fig.9, <https://aviton-press.ru/v-azerbaidjane-vypal-grad.html>). Hail damage caused significant loss to agricultural crops in several communities of Ijevan region (Fig. 10, <https://www.panorama.am/ru/news/2019/05/21/Град-Армения/2117870>).

**Conclusion.** At present, the anti-hail service carries out continuous radar monitoring of weather in eastern Georgia and adjacent territories of neighboring countries. The radar information is transmitted in parallel to the National Environmental Agency of Georgia. In the near future, it is planned to further improve the system of operative warning of the population about dangerous hydro-meteorological phenomena.

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

## References

1. 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, 2021-2056, 2012, DOI: 10.1007/s11069-012-0374-3, <http://www.springerlink.com/content/9311p18582143662/fulltext.pdf>.



2. 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).
3. 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, ISSN 1512-0902, 2013, vol. 119, pp.144-152, (in Russian).
4. Amiranashvili A.G. History of Active Effects on Atmospheric Processes in Georgia. // In the book: Essays of the History of Weather Modification in the USSR and the Post-Soviet Territory, ISBN 978-5-86813-450-0, St. Petersburg, RSHMU, 2017, 352 pp., ill., pp. 234-254, (in Russian), <http://mig-journal.ru/toauthor?id=4644>.
5. Amiranashvili A.G., Chikhladze V.A., Dzodzuashvili U.V., Ghlonti N.Ya., Sauri I.P. Reconstruction of Anti-Hail System in Kakheti (Georgia). //Journal of the Georgian Geophysical Society, Issue B. Physics of Atmosphere, Ocean and Space Plasma, Tbilisi, 2015, vol.18B, pp. 92-106.
6. 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, Tbilisi, 2016, vol. 66, pp. 14 – 27, (in Russian).
7. Amiranashvili A.G., Dzodzuashvili U.V., Ghlonti N.Ya., Kaishauri M.N., Sauri I.P., Chargazia Kh.Z., Chikhladze V.A. Obnovlennaya Sluzhba Bor'by s Gradom v Kakhetii i perspektivy razvitiya rabot po modifykatsii pogody v Gruzii. //Doklady Vserossiyskoy konferentsii po fizike oblakov i aktivnym vozdeystviyam na gidrometeorologicheskiye protsessy, 23-27 oktyabrya 2017 g., chast' 2, FGBU «Vysokogornyy Geofizicheskiy Institut», Nal'chik, ISBN 978-5-00109-257-5 ch.2; ISBN 978-5-00109-258-2, 2017, s. 135-162, (in Russian), [http://dspace.gela.org.ge/bitstream/123456789/6498/1/Амиранашвили...Конф\\_ВГИ\\_2017\\_Часть\\_2\\_с.\\_155-162.pdf](http://dspace.gela.org.ge/bitstream/123456789/6498/1/Амиранашвили...Конф_ВГИ_2017_Часть_2_с._155-162.pdf)
8. Abiaidze O., Avlokhashvili Kh., Amiranashvili A., Dzodzuashvili U., Kiria J., Lomtadze J., Osepashvili A., Sauri I., Telia Sh., Khetashvili A., Tskhvediasvili G., Chikhladze V. Radar Providing of Anti-Hail Service in Kakheti. //Trans. of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, Tbilisi, 2016, vol. 66, pp. 28-38, (in Russian).
9. Banetashvili V., Grebentsova A., Javakhishvili N., Jamrlishvili N., Kaishauri M., Mitin M., Saginashvili N., Khurtsidze G., Tsereteli A., Chargazia Kh., Chkhaidze B. Some examples of hail processes in Kakheti according to the data of radar surveillance in 2015. //Trans. of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, Tb., 2016, pp. vol. 66, 66-74, (in Russian).
10. Jamrlishvili N. K., Javakhishvili N.R., Sauri I. P., Tavidashvili Kh.Z., Telia Sh. O. Comparison of the Radar and Ground-Level Characteristics of the Hail Process On 10 June 2017 In Tbilisi. // Int. Sc. Conf. „Modern Problems of Ecology“ Proc., ISSN 1512-1976, v. 6, Kutaisi, Georgia, 21-22 September, 2018, pp. 134-137.
11. Javakhishvili N.R. Radar Characteristics of the Hail Process on 10 June 2017 in Rustavi Municipality (Georgia). // Journal of the Georgian Geophysical Society, ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 21(1), 2018, pp. 41 -47.
12. Selex ES GmbH · Gematronik Weather Radar Systems. Rainbow®5 User Guide, 2015, 464 p., [www.gematronik.com](http://www.gematronik.com)
13. Avlokhashvili Kh., Banetashvili V., Gelovani G., Javakhishvili N., Kaishauri M., Mitin M., Samkharadze I., Tskhvediasvili G., Chargazia Kh., Khurtsidze G. Products of Meteorological Radar «METEOR 735CDP10». // Trans. of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, Tb., 2016, vol. 66, pp. 60-65, (in Russian).
14. Jamrlishvili 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. // International Scientific Conference „Modern Problems of Ecology“, Kutaisi, Georgia, 21-22 September, 2018.