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

Some Characteristics of Hail Process in Georgia and Azerbaijan on May 28, 2019

[1]Avtandil G. Amiranashvili, [1]Teimuraz G. Bliadze, [1]Nino K. Jamrishvili, [1,2]Eliso N. Kekenadze, [1]Khatia Z.Tavidashvili, [1,2]Mikheil N. Mitin

[1]M. Nodia Institute of Geophysics of I. Javakhishvili Tbilisi State University,
e-mail:avtandilamiranashvili@gmail.com
[2]Military Scientific-Technical Center "DELTA"

ABSTRACT

The detailed information about such characteristics of hail process in Georgia and Azerbaijan on 28 May, 2019 as: the maximum diameter of hail stones in the cloud and on the earth's surface, trajectory and velocity of the migration of convective cells with the maximum size of hail stones, the rate of growth in the maximum size of hail stones in cloud, etc. is presented.

In particular, the connections of the speed of migration of convective cells and maximum size of hail stones with the height of area relief are established. The comparison of the data about the rate of growth in the hail stones in the actual conditions with previously obtained analogous data under laboratory conditions for the uncharged cloud medium, they showed the satisfactory agreement between them.

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

Introduction

Among the enumeration of natural catastrophes in Georgia, hail processes occupy one of the leading positions [1-3]. Hail will regularly do serious material damage to agriculture, buildings, infrastructure, truck transport, etc. [1-8]. Therefore, taking into account the importance of problem, to studies of hail processes in Georgia was always paid special attention, including in recent years [1-9]. What is more, 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 [2, 10]. These works continued until 1989 and were renewed using newest technologies in Kakheti region of Georgia in 2015 [10-14]. The anti-hail service is equipped with a modern meteorological radar "METEOR 735 CDP 10 - Doppler Weather Radar" [15-17], which in the future, in addition to anti-hail activities, is planned to be used for operational monitoring of different dangerous hydro-meteorological processes in eastern Georgia and adjacent territories [13, 14].

Thus, in recent years in a number of works were represented the preliminary results of radar studies of hail processes [18-21], rainfall [22-25] and dust formation migration [26, 27] in Eastern Georgia and its neighboring countries (Azerbaijan, Armenia). In particular, in the work [21] preliminary data about the hail process in Tbilisi and Kakheti on May 28, 2019 from 16 hour 34 min to 17 hour 04 min was presented. More detailed data on this process, which, besides Georgia, has spread to the territory of Azerbaijan, is presented below.

Material and methods, study regions

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 [12-14]. The products of radar are sufficiently varied [15-17]. 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 some parts of the territories of Armenia and Azerbaijan). In this work two radar products are presented, MAX (dBZ) and HAILSZ (Size) [16, 17]. 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 [28-31] by taking into account the radar data about their diameter in the clouds and freezing level in atmosphere [32-34].

Study regions: Georgia – areas of Tbilisi and Rustavi, Kakheti (municipalities of Sagarejo and Kvareli); Azerbaijan – areas east of Agstafa and Tovuz. Date and time of the study: May 28, 2019 from 15 hour 23 min to 20 hour 37 min (below - 15:23, etc.). Discreteness of radar measurements - every three minutes.

Accordingly, every three minutes, the following characteristics of hail clouds were determined: the maximum hailstones diameter D_o (mm), coordinates of the convective cells with the maximum size of hailstones, air temperature at the level of this cells T (°C), height of the relief under this cells H (km), horizontal speed of migration of the cells with the maximum diameter of hailstones V (m/sec), maximum hail diameter at the ground level D (mm), speed of growth of maximum hailstones diameter in hail clouds $\check{D}_o$ (mm/min).

The vertical distribution of air temperature, wind speed and direction in the atmosphere over the studied region using data of the worldwide network of the aerological observations [http://ready.arl.noaa.gov/READYcmet.php] was determined.

The following designations of statistical information are used below:

Min – minimal values; Max - maximal values; St Dev - standard deviation; $C_V = 100 \cdot St\ Dev/\ Mean$ – coefficient of variation, %; R^2 – coefficient of determination.

In Fig. 1 and 2 data about vertical distribution of wind direction and wind speed about the investigated territory are presented.

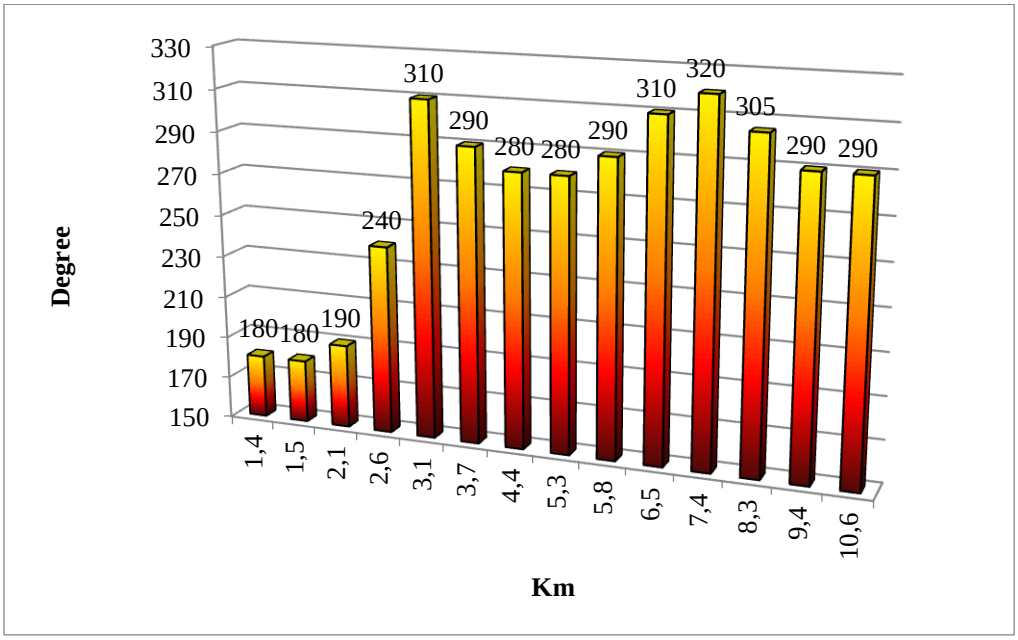

Fig.1. Vertical distribution of wind direction about the investigated territory

As follows from these figures in the layer of the atmosphere from 1.4 to 10.6 km wind direction changed from 180 to 320 degrees, and wind speed - from 1 to 17 m/sec. Speed of the main flow - 7 m/sec, direction - 280 degrees**.**

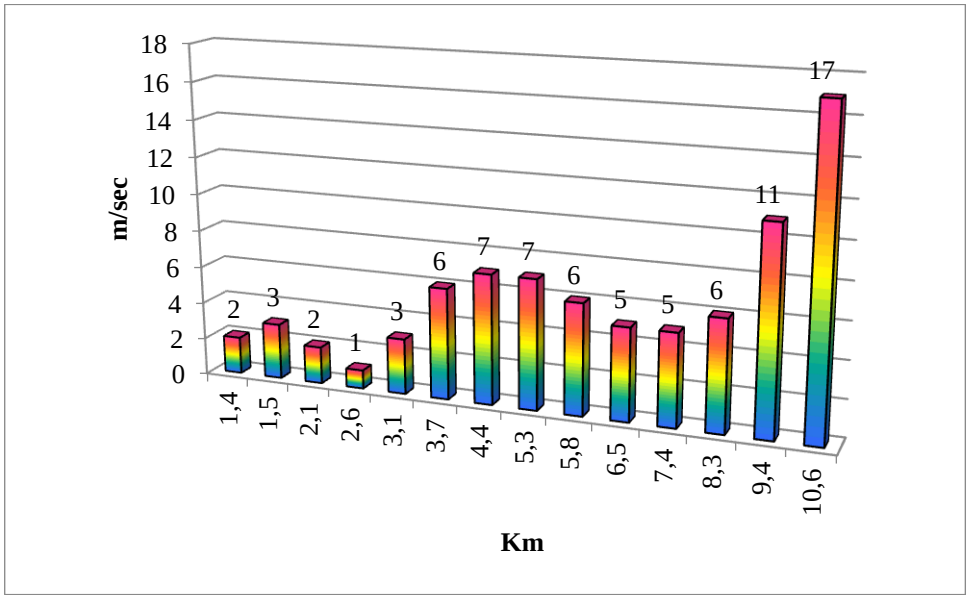

Fig.2. Vertical distribution of wind speed about the investigated territory

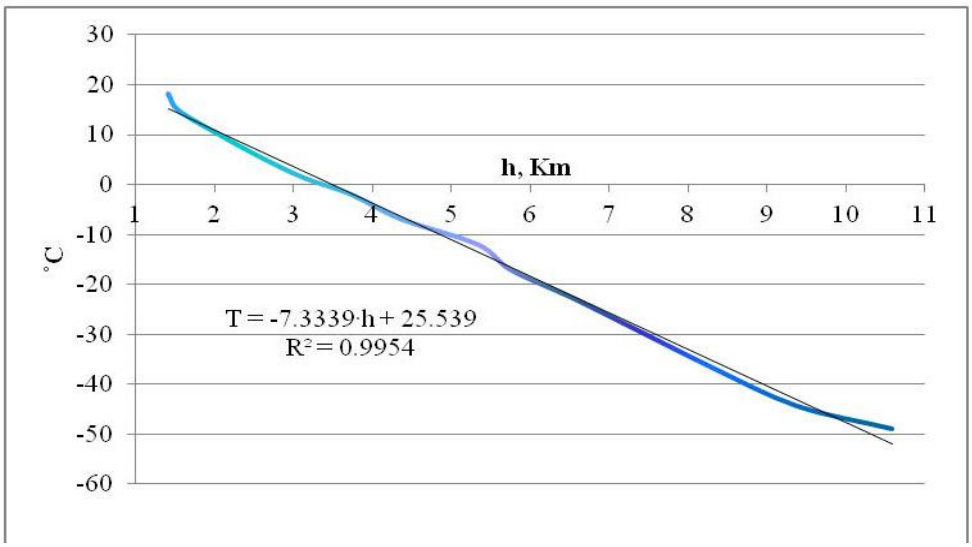

Fig. 3.Vertical distribution of air temperature about the investigated territory

Data about vertical distribution of air temperature about the investigated territory in Fig.3 is presented. The air temperature changed from 18.1 °C at the height of 1.4 km to -49 °C at the height of 10.6 km with the gradient of -7.33 degree/km. Height of zero isotherm was 3.38 km

On 28 May 2019 above the investigated territory northwestern synoptic process with the wave perturbations was observed.

Examples of radar picture of the movement of hail process above the investigated territory on May 28, 2019 in different times on Fig.4 are present. On this day, for a number of reasons, there were no active impacts on the hail processes in Kakheti.

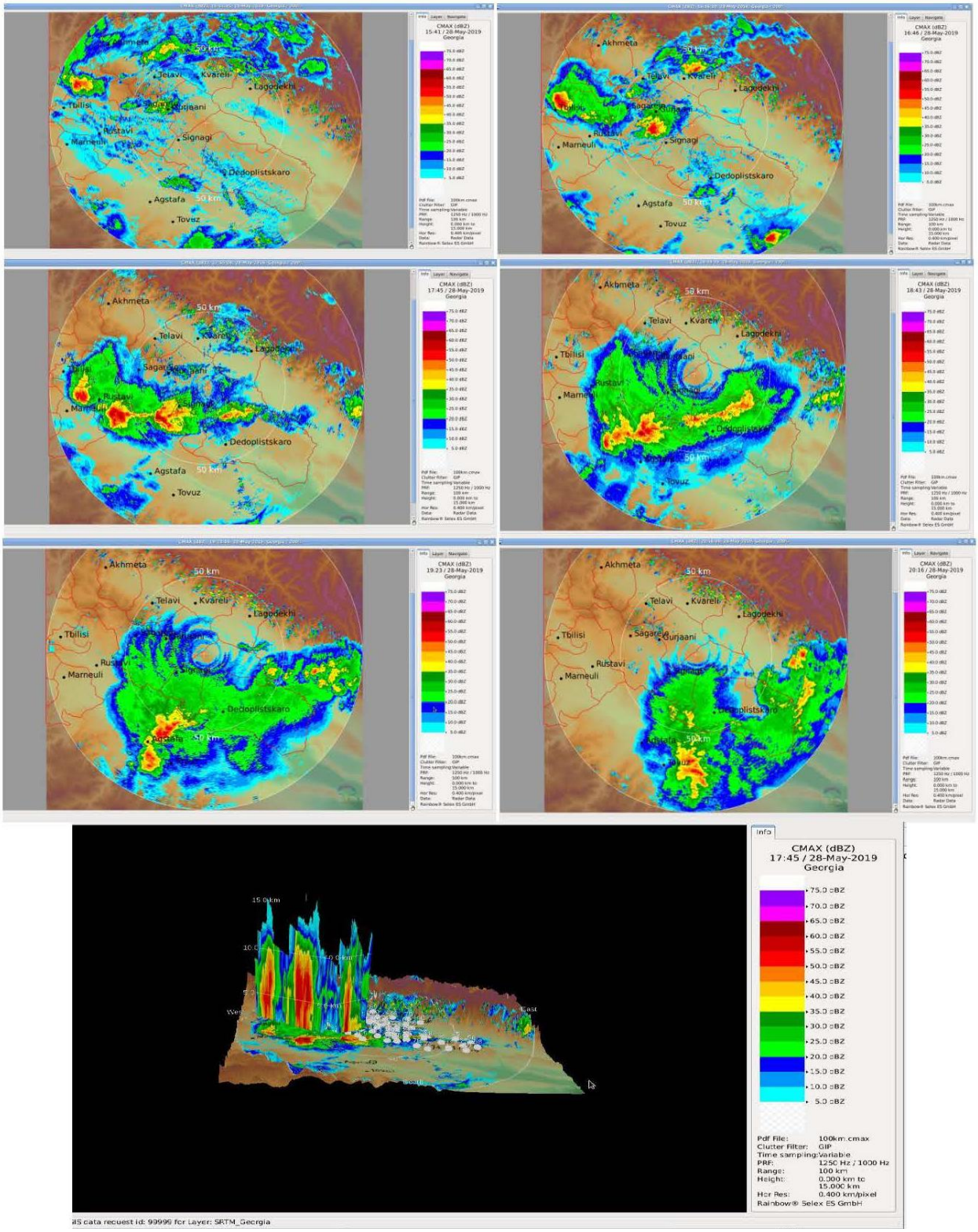

Fig.4. Radar picture of the movement of hail process above the investigated territory on 15:41, 16:46, 17:45, 18:43, 19:23 and 20:16. Below - 3D the picture of hail process on 17:45

Results

The results in Fig. 5-15 and Table 1,2 are represented.

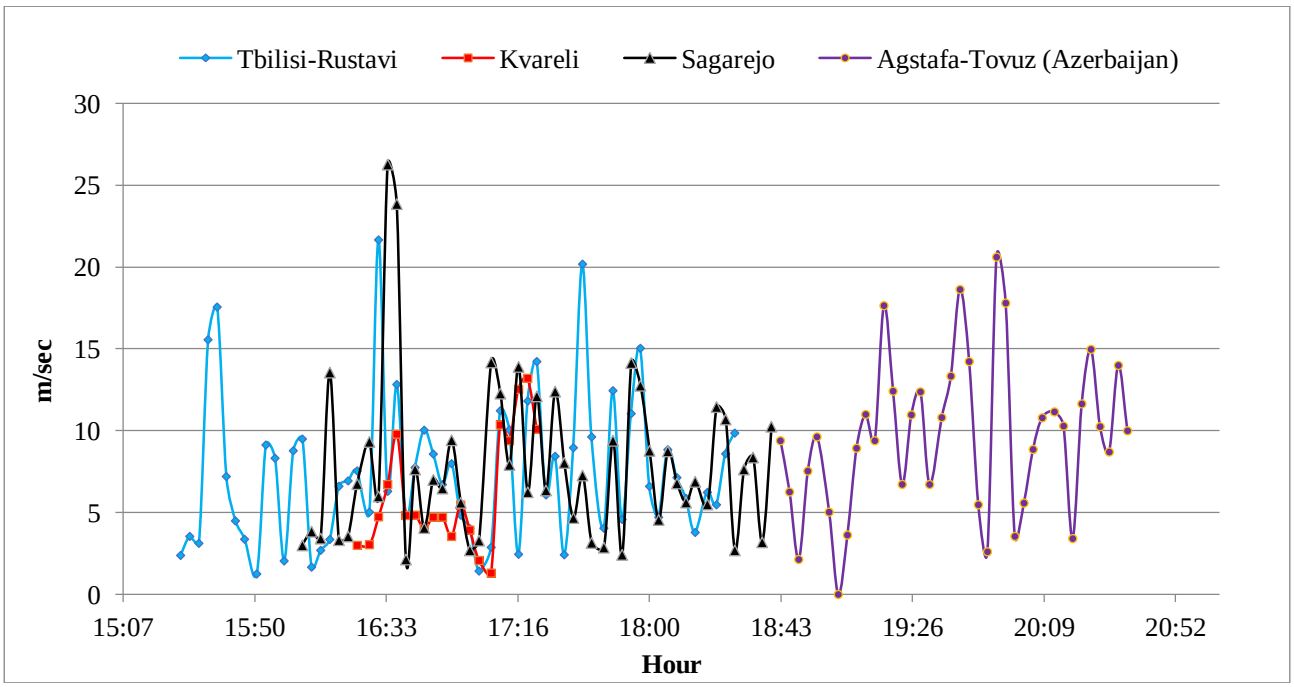

Fig.5. Changeability in the time of the speed of migration of convective cells with the maximum diameter of hailstones

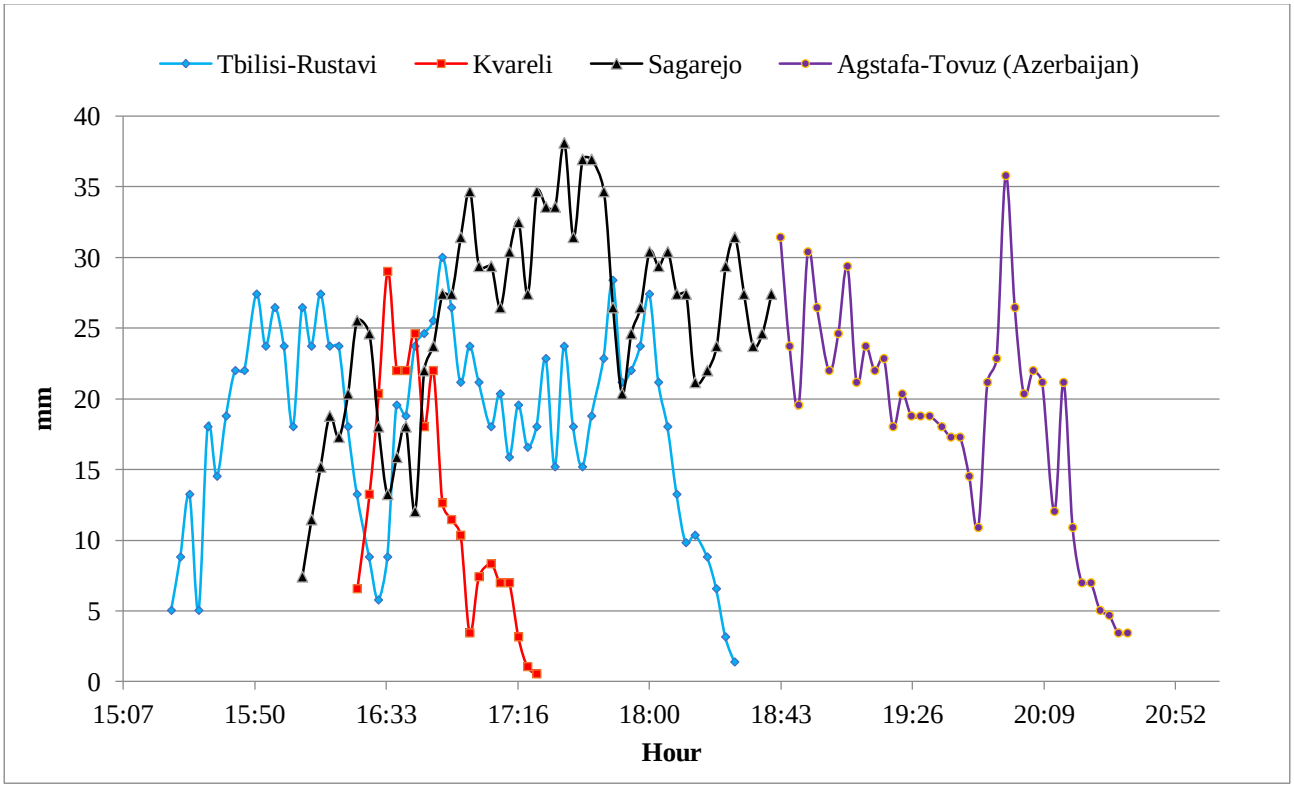

Fig.6. Changeability in the time of the maximum diameter of hailstones in the clouds from 15:23 to 20:37

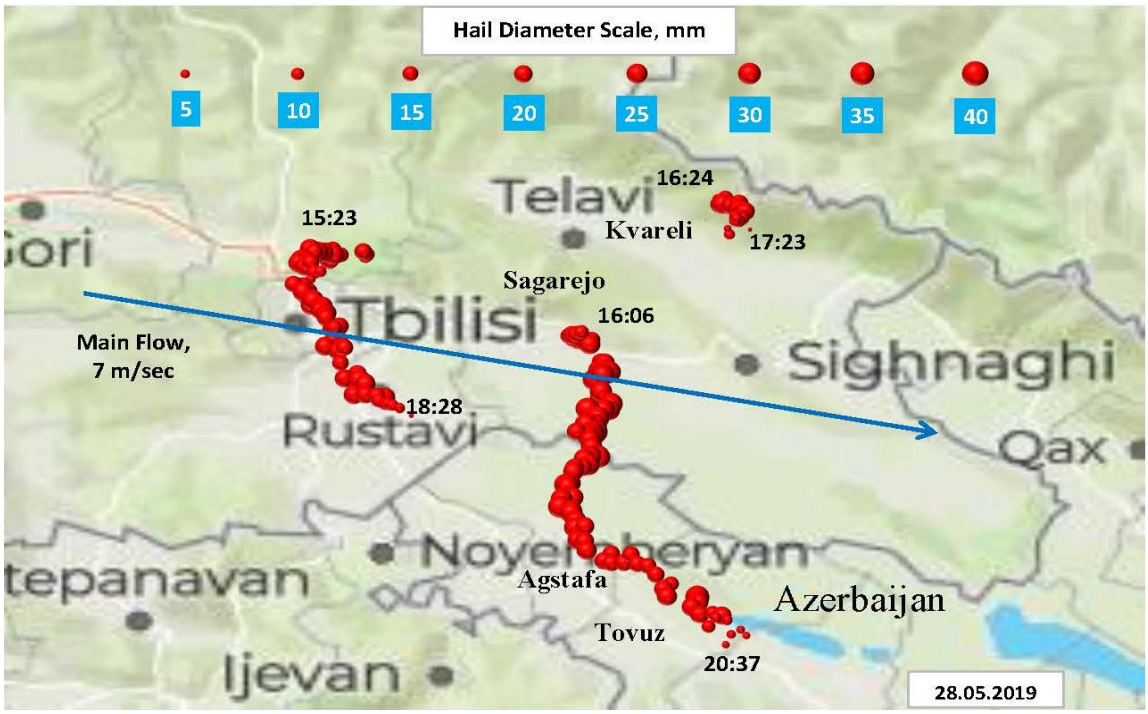

Fig.7. Convective cells with the maximum diameter of hailstones trajectory about the investigated territory from 15:23 to 20:37

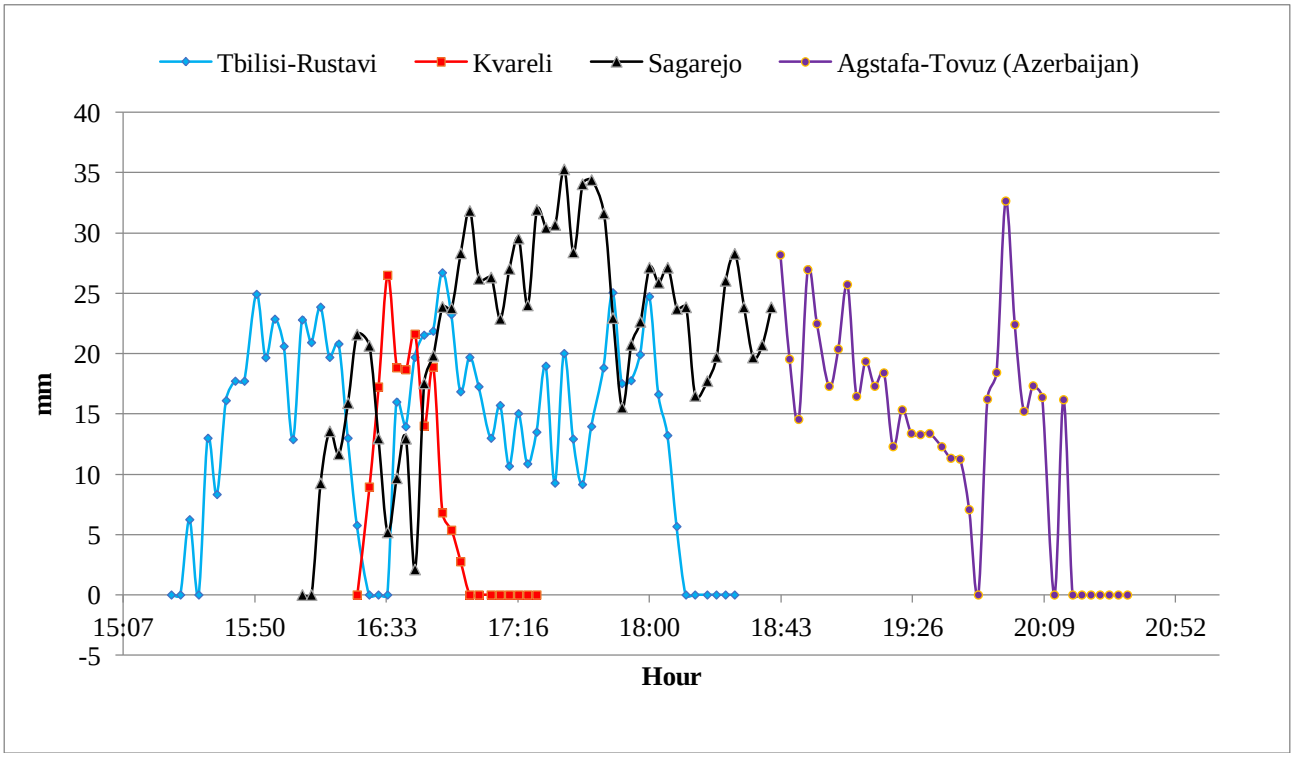

Fig.8. Changeability in time of the maximum diameter of hailstones falling on the earth surface from 15:23 to 20:37

Table 1

Statistical characteristics of hail process in Georgia and Azerbaijan on May 28, 2019

Parameter	Beginning - End of Process, Hour	Duration of Process, Minute	H, relief, km	T, °C	Do, mm	D, mm	V m/sec
Location	**Tbilisi - Rustavi**						
Min	15:23	0	0.345	-32.2	1.4	0	1.3
Max	18:28	185	1.720	-1.4	30.0	26.7	21.7
Mean			0.651	-15.5	18.4	13.5	7.5
St Dev			0.291	9.4	7.0	8.3	4.5
Cv, %			44.7	60.3	38.1	61.0	60.0
Location	**Kvareli Municipality**						
Min	16:24	0	0.543	-24.1	0.5	0	1.3
Max	17:23	59	1.476	-2.1	29.0	26.5	13.2
Mean			1.057	-9.9	12.5	8.0	6.1
St Dev			0.249	6.7	8.5	9.2	3.5
Cv, %			23.5	68.0	67.9	115.4	57.3
Location	**Sagarejo Municipality**						
Min	16:06	0	0.307	-35.1	7.4	0	2.1
Max	18:40	154	0.676	-0.7	38.1	35.3	26.3
Mean			0.437	-10.8	25.7	21.6	7.9
St Dev			0.102	8.1	7.1	8.6	5.0
Cv, %			23.2	75.4	27.5	40.0	62.9
Location	**Agstafa - Tovuz regions**						
Min	18:43	0	0.142	-25.6	3.4	0	0
Max	20:37	114	0.377	-0.7	35.8	32.6	20.6
Mean			0.226	-5.0	18.8	13.4	9.6
St Dev			0.056	5.7	7.9	9.0	4.8
Cv, %			24.8	113.7	42.1	67.1	49.5

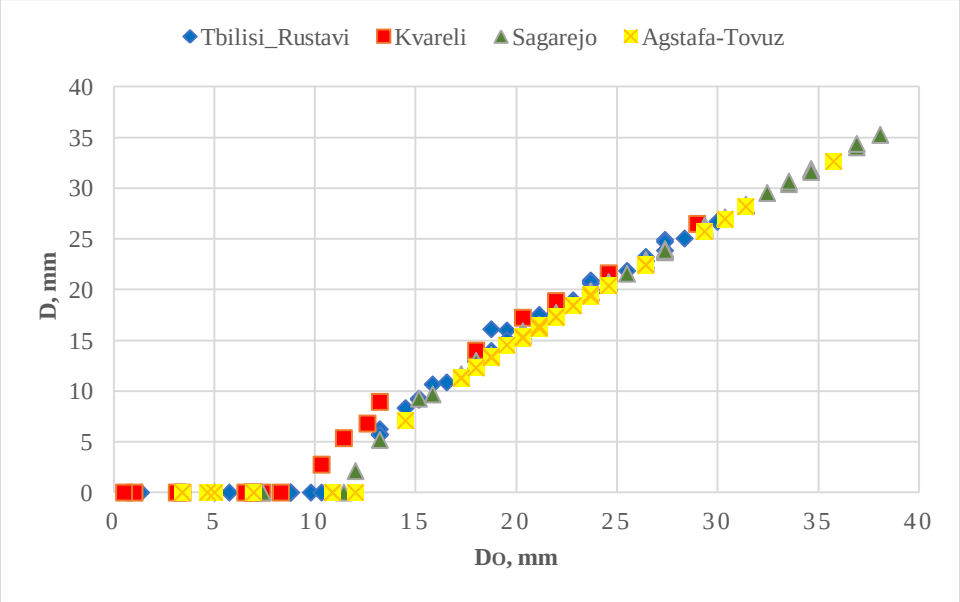

Fig.9. The ratio between values of Do and D in the study region from 15:23 to 20:37

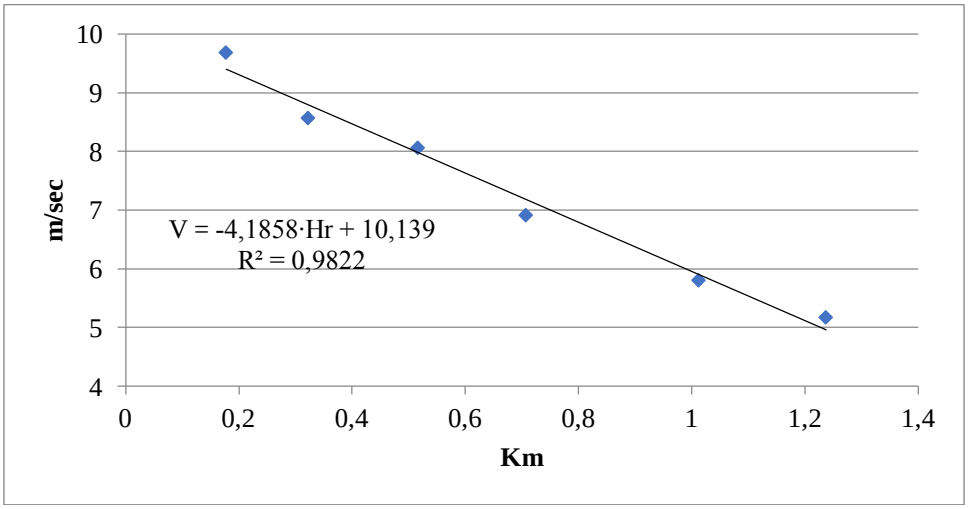

Fig.10. Dependence of the mean speed of migration of convective cells with the maximum diameter of hailstones on the height of locality

In Fig. 5-8 and Table 1 presents data on the various characteristics of the hail process on May 28, 2019.

The results of the analysis of these data are given below.

Changeability in the time of the speed of migration of convective cells with the maximum diameter of hailstones (Fig 5, Table 1).

Tbilisi – Rustavi: Values of V changes from 1.3 to 21.7 m/sec (mean value – 7.5 m/sec);

Kvareli Municipality: Values of V changes from 1.3 to 13.2 m/sec (mean value – 6.1 m/sec);

Sagarejo Municipality: Values of V changes from 2.1 to 26.3 m/sec (mean value – 7.9 m/sec);

Agstafa - Tovuz regions: Values of V changes from 0 to 20.6 m/sec (mean value – 9.6 m/sec).

It should be noted that speed of migration of convective cells with the maximum diameter of hailstones above the three investigation locations (excluding Kvareli Municipality) in some moments of time is higher, that max wind speed (Fig.2).

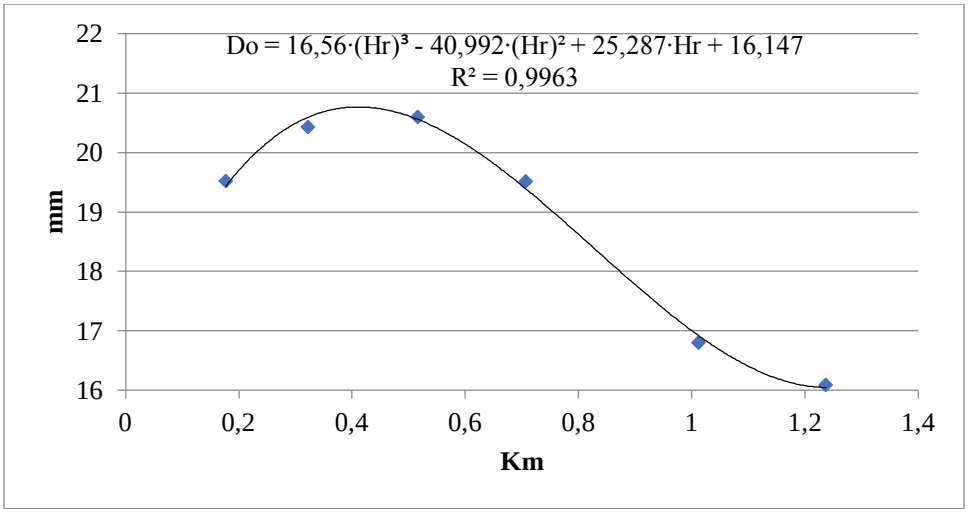

Fig.11. Dependence of the mean values of D_o in hail clouds on the height of locality

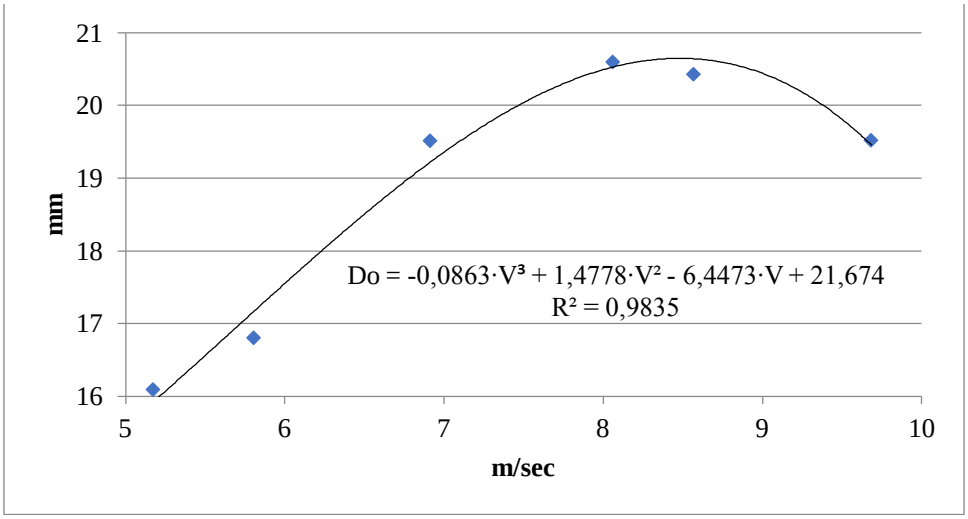

Fig.12. Dependence of the mean values of Do in hail clouds from the mean speed of their migration

Changeability in the time of the maximum diameter of hailstones in the clouds (Fig 6-7, Table 1).

Tbilisi – Rustavi: Values of Do changes from 1.4 to 30.0 mm (mean diameter – 18.4 mm);

Kvareli Municipality: Values of Do changes from 0.5 to 29.0 mm (mean diameter – 12.5 mm);

Sagarejo Municipality: Values of Do changes from 7.4 to 38.1 mm (mean diameter – 25.7 mm);

Agstafa - Tovuz regions: Values of Do changes from 3.4 to 35.8 mm (mean diameter – 18.8 mm).

Changeability in time of the maximum diameter of hailstones falling on the earth surface (Fig 8, Table 1).

Tbilisi – Rustavi: Values of Do changes from 0 to 26.7 mm (mean diameter – 13.5 mm);

Kvareli Municipality: Values of Do changes from 0 to 26.5mm (mean diameter – 8.0 mm);

Sagarejo Municipality: Values of Do changes from 0 to 35.3 mm (mean diameter – 21.6 mm);

Agstafa - Tovuz regions: Values of Do changes from 0 to 20.6 mm (mean diameter – 9.6 mm).

The ratio between values of Do and D in the all study regions on Fig. 9 is presented.

As follows from Fig. 10 the mean speed of migration of convective cells with the maximum diameter of hailstones linearly decreases with increasing of relief altitude.

Dependence of the mean values of Do in hail clouds on the height of locality has the form of a third power polynomial (Fig. 11).

Dependence of the mean values of Do in hail clouds from the mean speed of their migration has the form of a third power polynomial also (Fig. 12).

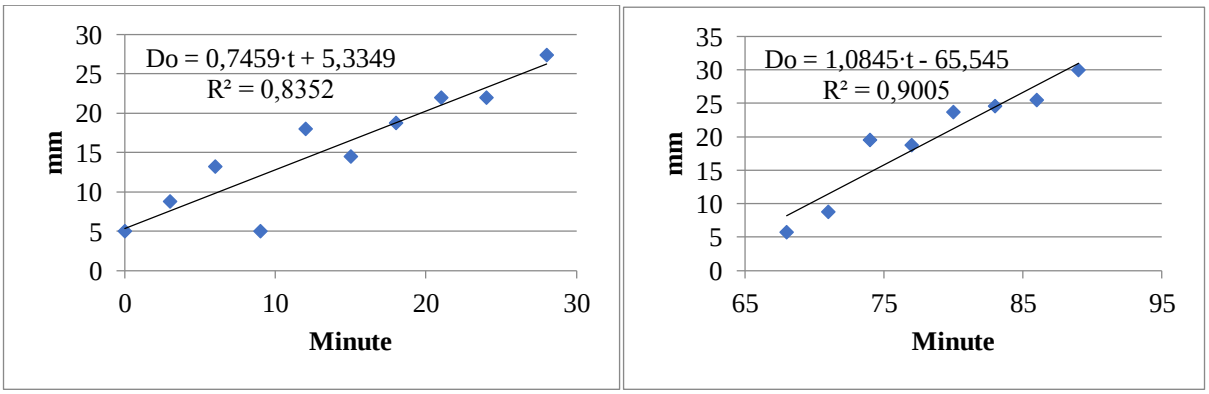

Fig.13a. Increase of value of Do in hail cloud from 15:23 to 15:51 (to the left) and from 16:31 to 16:52 (to the right), Tbilisi-Rustavi

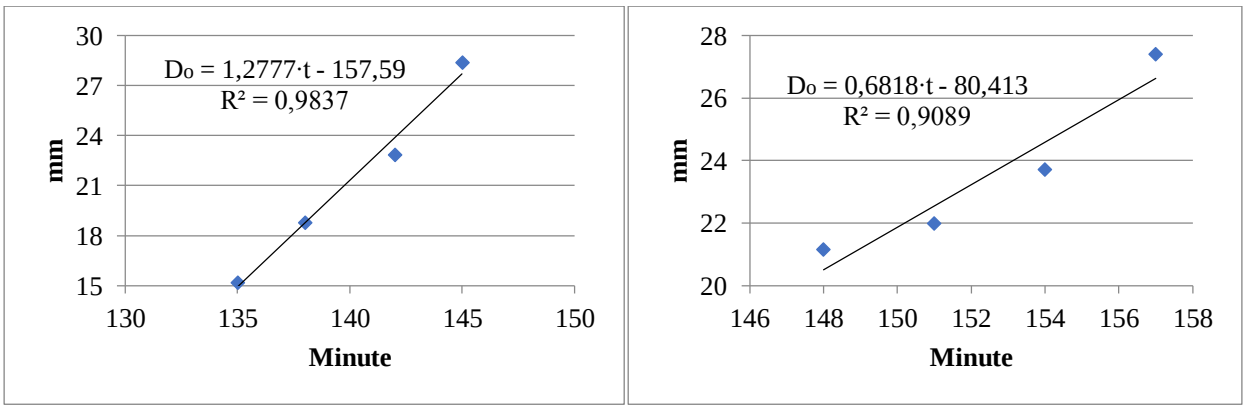

Fig.13b. Increase of value of Do in hail cloud from 17:38 to 17:48 (to the left) and from 17:51 to 18:00 (to the right), Tbilisi-Rustavi

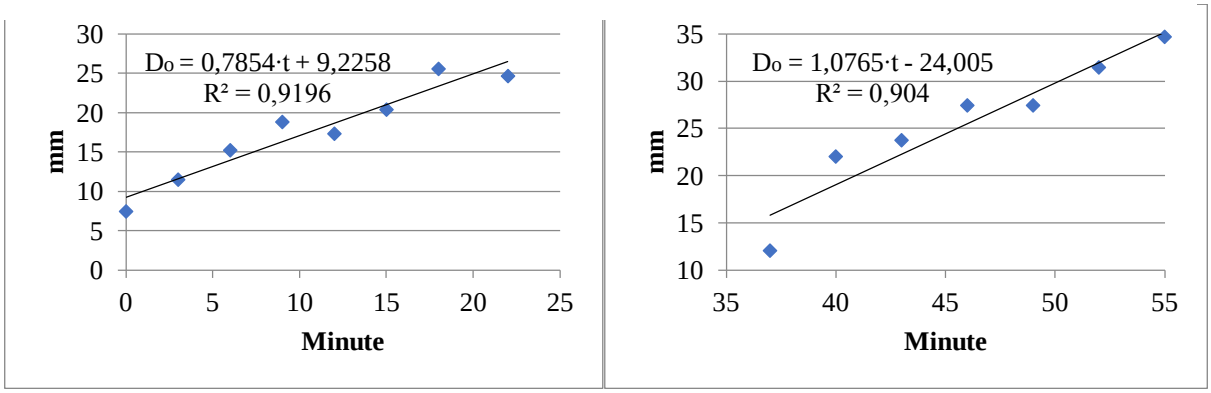

Fig.14a. Increase of value of Do in hail cloud from 16:06 to 16:28 (to the left) and from 16:43 to 17:01 (to the right), Sagarejo Municipality

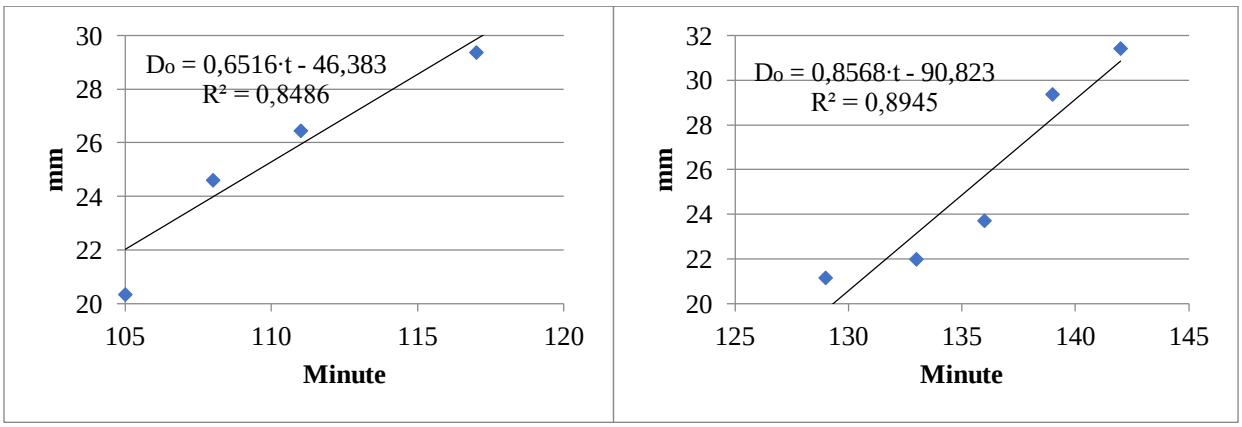

Fig.14b. Increase of value of Do in hail cloud from 17:51 to 18:06 (to the left) and from 18:15 to 14:28 (to the right), Sagarejo Municipality

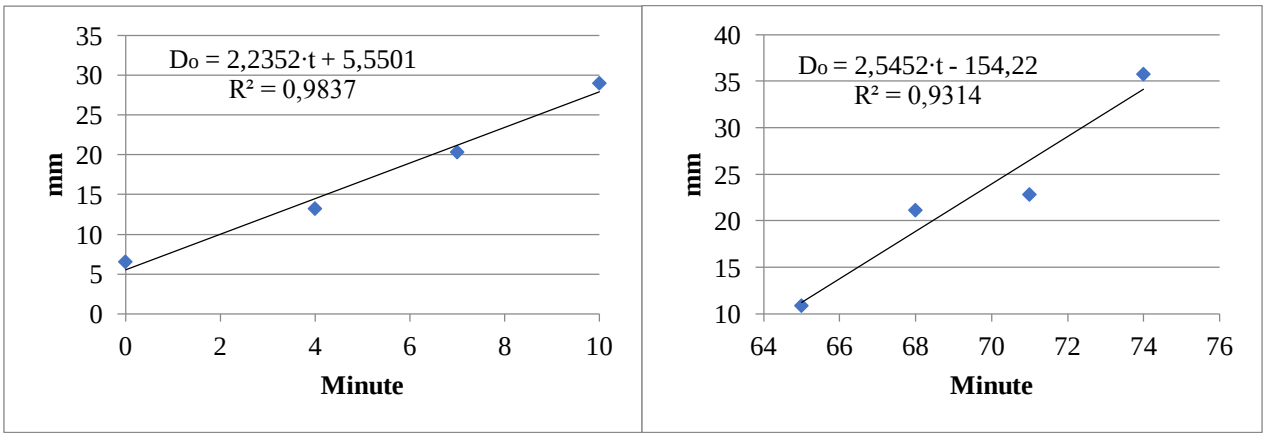

Fig.15. Increase of value of Do in hail cloud from 16:24 to 16:34 (to the left, Kvareli Municipality) and from 19:48 to 19:57 (to the right, Agstafa-Tovuz)

Table 2

Speed of growth of Do in hail clouds on May 28, 2019

Location	Tbilisi-Rustavi	Sagarejo	Kvareli	Agstafa - Tovuz
Hour	15:23 - 15:51	16:06 - 16:28	16:24 - 16:34	19:48 - 19:57
Speed of growth of Do, mm/min	0.75	0.79	2.24	2.55
T, °C	-29.3÷-7.3 (-14.2)	-19.0÷-8.7 (-16.7)	-24.1÷-12.4 (-16.2)	-4.3÷-0.7 (-2.9)
Hour	16:31 - 16:52	16:43 - 17:01		
Speed of growth of Do, mm/min	1.08	1.08		
T, °C	-32.2÷-5.1 (-22.6)	-22.7÷-4.3 (-12.0)		
Hour	17:38 - 17:48	17:51 - 18:06		
Speed of growth of Do, mm/min	1.28	0.65		
T, °C	-25.6÷-22.7 (-24.5)	-35.1÷-0.7 (-11.5)		
Hour	17:51 - 18:00	18:15 - 18:28		
Speed of growth of Do, mm/min	0.68	0.86		
T, °C	-22.7÷-5.8 (-10.9)	-18.3÷-3.6 (-8.0)		

In Fig. 13-15 and Table 2 data about speed of growth of Do in hail clouds are presented. Above the four investigation locations speed of growth of Do is following:

Tbilisi – Rustavi: 0.68÷1.28 mm/min (4 cases, cloud medium temperature range: -32.2÷-5.8 °C); **Sagarejo Municipality:** 0.65÷1.08 mm/min (4 cases, cloud medium temperature range: -35.1÷-0.7 °C); **Kvareli Municipality:** 2.24 mm/min (1 case, cloud medium temperature range: -24.1÷-12.4 °C); **Agstafa - Tovuz regions:** 2.55 mm/min (1 case, cloud medium temperature range: -4.3÷-0.7 °C). Average growth rate of Do for all 10 cases: 1.20 ± 0.57 mm/min (confidence interval - 99%).

Table 3

Statistical characteristics of the parameters of uncharged cloud medium and mean rate of growth of the diameter of hailstones for the conditions for a dry and wet increase in the hail (data of laboratory experiments [35])

Regime	**Dry growth**			**Wet growth**		
Parameter	**Cloud water content, g/m^3**	**T, °C**	**Speed of growth of D_o, mm/min**	**Cloud water content, g/m^3**	**T, °C**	**Speed of growth of D_o, mm/min**
Mean	2.6	-14.0	0.74	3.4	-5.4	0.82
Min	1.2	-19.3	0.35	0.9	-9.7	0.13
Max	4.3	-6.8	1.14	4.8	-1.2	1.4
St Dev	0.77	3.77	0.24	1.18	2.64	0.36
Count	35			17		

In Table 3 for comparison data of laboratory experiments [35] about rate of growth of the diameter of hailstones for the conditions for a dry and wet increase in the hail in uncharged cloud medium are presented. As follows from this Table, speed of growth of Do change from 0.35÷1.14 mm/min (dry growth, mean value - 0.74 mm/min) to 0.13÷1.4 mm/min (wet growth, mean value - 0.82 mm/min).

As follows from Tables 2 and 3, the agreement between field and laboratory data on the growth rate of Do is generally satisfactory (coincidence - 80%, excluding hail processes over Kvareli Municipality and Agstafa - Tovuz regions).

Conclusions

In the near future, a similar analysis is planned for hail processes in Kakheti during the days of the works of anti-hail service in order to assess the physical effectiveness of these works. In addition to this, the analysis of the temporary changeability of the parameters of hail processes with the use of methods of mathematical statistics for investigating the non stationary time series of observations (autocorrelation, periodicity, etc.) will be carried out.

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] 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, 500 s, (in Russian).

[3] Amiranashvili A.G. Increasing Public Awareness of Different Types of Geophysical Catastrophes, Possibilities of Their Initiation as a Result of Terrorist Activity, Methods of Protection and Fight With Their Negative Consequences. Engaging the Public to Fight Consequences of Terrorism and Disasters. NATO Science for Peace and Security Series E: Human and Societal Dynamics, vol. 120. IOS Press,

Amsterdam•Berlin•Tokyo•Washington, DC, ISSN 1874-6276, 2015, pp. 155-164. http://www.nato.int/science; http://www.springer.com; http://www.iospress.nl
[4] 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).
[5] Pipia M. G., Beglarashvili N. G. Hail Hits in Eastern Georgia. Journal of International Scientific Publications: Ecology and Safety, Volume 8, 2014, Burgas, pp. 567-573.
[6] Elizbarashvili E., Amiranashvili A., Varazanashvili O., Tsereteli N., Elizbarashvili M., Elizbarashvili Sh., Pipia M. Hailstorms in the Territory of Georgia. European Geographical Studies, Vol. 2, No. 2, 2014.
[7] 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).
[8] 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, vol. 20A, 2017, pp. 44 - 56.
[9] Janelidze I., Pipia M. Hail Storms in Georgia in 2016-2018. International Scientific Conference „Natural Disasters in Georgia: Monitoring, Prevention, Mitigation", Proceedings, Tbilisi, Georgia, December 12-14, 2019, pp. 112-114.
[10] 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.
[11] Amiranashvili A., Ghlonti N., Dzodzuashvili U., Lomtadze J., Chikhladze V. On the renewal of anti-hail works in Georgia. Int. Conf. "Advanced Problems in Geophysics". Reports, presented on the Scientific Conference "80 years of the M. Nodia Institute of Geophysics". Tb., 2014, pp. 208-212, (in Russian).
[12] 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, ISSN: 1512-1127, Issue B. Physics of Atmosphere, Ocean and Space Plasma, vol. 18B, Tb., 2015, pp. 92-106.
[13] 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).
[14] 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, Tbilisi, Georgia, December 12-14, 2019, pp. 213-219.
[15] 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, Tbilisi, 2016, pp. 28-38, (in Russian).
[16] Selex ES GmbH · Gematronik Weather Radar Systems. Rainbow®5 User Guide, 2015, 464 p., www.gematronik.com
[17] Avlokhashvili Kh., Banetashvili V., Gelovani G., Javakhishvili N., Kaishauri M., Mitin M., Samkharadze I., Tskhvediashvili G., Chargazia Kh., Khurtsidze G. Products of Meteorological Radar «METEOR 735CDP10». Trans. of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, vol. 66, Tb., 2016, pp. 60-65, (in Russian).
[18] Banetashvili V., Grebentsova A., Javakhishvili N., Jamrishvili 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, vol. 66, Tb., 2016, pp. 66-74, (in Russian).

[19] 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, vol. 21(1), 2018, pp. 41 -47.
[20] Jamrishvili 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, vol. 6, Kutaisi, Georgia, 21-22 September, 2018, pp. 134-137.
[21] Gvasalia G., Kekenadze E., Mekoshkishvili N., Mitin M. Radar Monitoring of Hail Processes in Eastern Georgia And its Neighboring Countries (Azerbaijan, Armenia). International Scientific Conference „Natural Disasters in Georgia: Monitoring, Prevention, Mitigation", Proceedings, Tbilisi, Georgia, December 12-14, 2019, pp. 170-174.
[22] Banetashvili V., Gelovani G., Grebentsova A., Javakhishvili N., Iobadze K., Mitin M., Saginashvili N., Samkharadze I., Khurtsidze G., Tsereteli A., Tskhvediashvili G., Chkhaidze B. Some Examples of Strong Precipitation in Eastern Georgia According to the Data of Radar Surveillance of 2015. Trans.of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, vol. 66, Tb., 2016, pp. 75-83, (in Russian).
[23] Amiranashvili A., Kereselidze Z., Mitin M., Khvedelidze I., Chikhladze V. Alarming Factors of the Microclimate of the Vere River Valley and their Influence on the Floods Intensity. Trans. of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, vol. 69, Tbilisi, 2018, pp. 204-218, (in Georgian).
[24] Mitin M., Khvedelidze I. Radar Characteristics of Rain Cloud wich Caused Landslide into Akhaldaba and Catastrophic Flood in Tbilisi on June 13-14, 2015. International Scientific Conference „Natural Disasters in Georgia: Monitoring, Prevention, Mitigation", Proceedings, Tbilisi, Georgia, December 12-14, 2019, pp. 165-169.
[25] Javakhishvili N., Janelidze I. On the Prediction of Floods Caused by Rainfall in the Area of Action of the Meteorological Radar "Meteor 735CDP10". International Scientific Conference „Natural Disasters in Georgia: Monitoring, Prevention, Mitigation", Proceedings, Tbilisi, Georgia, December 12-14, 2019, pp. 175– 179.
[26] Amiranashvili A.G., Berianidze N.T., Chikhladze V.A., Mitin M.N., Mtchedlishvili A.A. Preliminary Results of the Analysis of Radar and Ground-Based Monitoring of Dust Formation in Atmosphere Above the Territory of Eastern Georgia on 27 July 2018. Journal of the Georgian Geophysical Society, ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, vol. 21(2), 2018, pp. 61 – 69.
[27] Berianidze N., Javakhishvili N. Mtchedlishvili A. About the Possibility of Using the "Meteor 735CDP10" Radar for Monitoring Volcanic Formations, Dust Storms and Smoke from Large Fires in Atmosphere in South Caucasus. International Scientific Conference „Natural Disasters in Georgia: Monitoring, Prevention, Mitigation", Proceedings, Tbilisi, Georgia, December 12-14, 2019, pp. 180-184.
[28] Sulakvelidze G.K. Livnevyye osadki i grad. L., Gidrometeoizdat, 1967, 412 s., (in Russian).
[29] Zimenkov V.A., Ivanov V.V. Raschet tayaniya gradin v estestvennykh protsessakh. Tr. VGI, 1966, vyp. 3(5).
[30] 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. International Scientific Conference „Modern Problems of Ecology", Kutaisi, Georgia, 21-22 September, 2018.
[31] 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, Tbilisi, Georgia, December 12-14, 2019, pp. 124-127.
[32] Bliadze T., Jamrishvili N., Iobadze K., Tavidashvili Kh. Changeability of Height of Zero Isotherm in Kakheti into the Season of the Anti-Hail Works of 2015. Transactions of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, vol. 66, Tb., 2016, pp. 90-95, (in Russian).
[33] Jamrishvili N. K., Tavidashvili Kh. Z. Vertical Distribution of the Monthly Mean Values of the Air Temperature Above the Territory of Kakheti (Georgia) in the Central Months of the Year 2012-2016. Journal of the Georgian Geophysical Society, ISSN: 1512-1127, Issue B. Physics of Atmosphere, Ocean and Space Plasma, vol. 19B, Tb., 2016, pp. 66-72.
[34] Jamrishvili N.K. 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, Issue A. Physics of Solid Earth, ISSN 1512-1127, vol. 20A, 2017, pp. 57 – 64.

[35] Bliadze T. Connection of the Rate of Growth in Sizes and Mass of Hailstones with Temperature and Water Content of the Modeling Cloud Medium. Trans. of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, vol. 64, Tbilisi, 2013, pp. 178-185, (in Russian).

სეტყვის პროცესის ზოგიერთი მახასიათებლები საქართველოში და აზერბაიჯანში 2019 წლის 28 მაისს

ა.ამირანაშვილი, თ. ბლიაძე, ნ. ჯამრიშვილი, ე. კეკენაძე,
ხ. თავიდაშვილი, მ. მიტინი

რეზიუმე

განხილულია სეტყვის პროცესი საქართველოს და აზერბაიჯანის ტერიტორიაზე 2019 წლის 28 მაისს. სეტყვის მარცვლის მაქსიმალური დიამეტრი ღრუბელში და დედამიწის ზედაპირზე, სეტყვის მარცვლის მაქსიმალური ზომით კონვექტიური უჯრედის გადაადგილების ტრაექტორია და სიჩქარე, სეტყვის მარცვლის ზრდის სიჩქარე ღრუბელში და სხვ. დადგენილია კავშირი კონვექტიური უჯრედის გადააადგილებასა და აგრეთვე, სეტყვის მარცვლის ზრდის სიჩქარეს, ზღვის დონიდან რელიეფის სიმაღლესთან. სეტყვის მარცლის ზრდის სიჩქარის შედარებამ რეალურ პირობებში და ადრე მიღებულ ანალოგიურ მონაცემებთან, ლაბორატორიულ, დაუმუხტავი ხელოვნური ღრუბლის პირობებში აჩვენა დამაკმაყოფილებელი თანხვედრა.

Некоторые характеристики градового процесса в Грузии и Азербайджане 28 мая 2019 г.

А.Г. Амиранашвили, Т.Г. Блиадзе, Н.К. Джамришвили, Э.Н. Кекенадзе, Х.З. Тавидашвили, М.Н. Митин

Резюме

Приводится подробная информация о таких характеристиках градового процесса в Грузии и Азербайджане 28 мая 2019 года, как: максимальный диаметр градин в облаке и у поверхности земли, траектории и скорости миграции ячеек с максимальным размером градин, скорость роста максимального размера градин в облаке и др. В частности, установлены связи скорости миграции конвективных ячеек и максимального размера градин с высотой рельефа местности. Сравнение данных о скорости роста градин в реальных условиях с ранее полученными аналогичными данными в лабораторных условиях для незаряженной облачной среды, показали удовлетворительное согласие между ними.