===

doi.org/10.36073/1512-0902-2025-136-54-63
UDC: 551.506.3

General Statistical Analysis of Long-Term Changes in the Number of Days with Hail in the Background of Climate Change in Eastern Georgia

Mikheil Pipia[1,2], Nazibrola Beglarashvili [1,3], Tsitsino Diasamidze[1], Nino Jamrishvili[2]
[1]Inssitute of Hydrometeorology of Georgian Technical University
[2]Mikheil Nodia Institute of Geophysic of Ivane Javakhishvili State University
[3]Samtskhe-Javakheti State University
m.pipia@gtu.ge

Abstract. Modern climate changes can affect the microphysical and electrical properties of clouds, such as the conditions that cause intense hail and lightning. At the same time, the effect of the impact largely depends on the physical-geographical conditions and the ecological situation. It should be noted that global warming that has occurred in recent decades has a significant impact on the dynamics of hail processes.
For the statistical analysis of the number of hail days against the background of modern climate change, the average number of hail days at the stations according to decades was used, which allows to weaken short-term fluctuations and reveal long-term changes. In order to determine the dynamics of hail days in Eastern Georgia, the observation data of some meteorological stations from 1961-2000 and 2014-2020 were analyzed.
In total, the data of 17 meteorological stations of Eastern Georgia about hail for the period of 1961-2020 have been processed.

Key words: *Climate; Hail; Natural hazards*

Introduction. It is established that in the last decades, against the background of global climate change, there is a noticeable increase in the frequency and intensity of natural hydrometeorological events.
Hail is precipitation of particles of ice (hailstones). These can be either transparent, or partially or completely opaque. They are usually spheroidal, conical or irregular in shape, and generally 5-50 mm in diameter. The particles may fall from a cloud either separately or agglomerated in irregular lumps. They are generally observed during heavy thunderstorms. Hailstones are particles of ice which can be either transparent, or partly or completely opaque. They are usually spheroidal, conical or irregular in form [1].

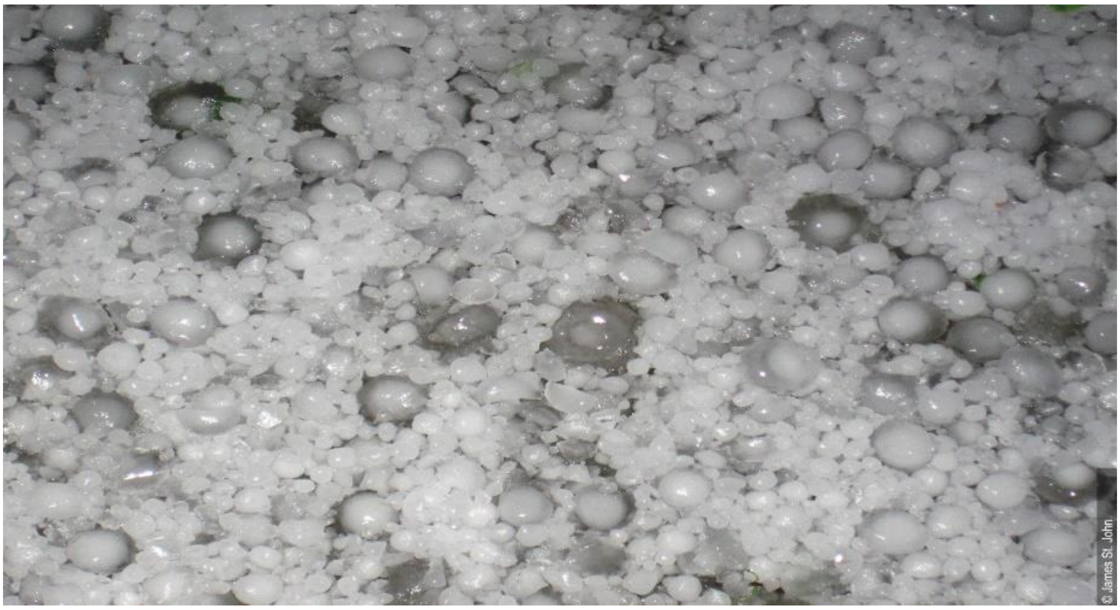

Fig. 1 Hailstones [1].

Consists of a nucleus surrounded by alternating layers of opaque and transparent ice. There are usually not more than five layers, except in very large hailstones, which have been found to have 20 or more layers. Some other hailstones do not have any layers, and consist of transparent or opaque ice only.
Hailstones typically have a density between 0.85 g/cm3 and 0.92 g/cm3, but may have a lower density if they have large cavities filled with air. Some hailstones are partly composed of spongy ice, which is a mixture of ice, water and air [1].

Area under study. In terms of hail damage, Eastern Georgia is the most hail-prone part in thecountry. Therefore, as before in recent years many works are devoted to the problem of hail in our country, among them in eastern Georgia, covering a wide range of studies - from hail climatology [2-5].

Eastern Georgian relief may be characterized by three sharply expressed orographic elements: in north Caucasus, in south – Georgian south uplands and lowland located between those two risings or intermountain depression. It is geographically defined by the watershed of the Mtkvari and Rioni bassins (disposing to the Black or the Caspian Sea) [6].

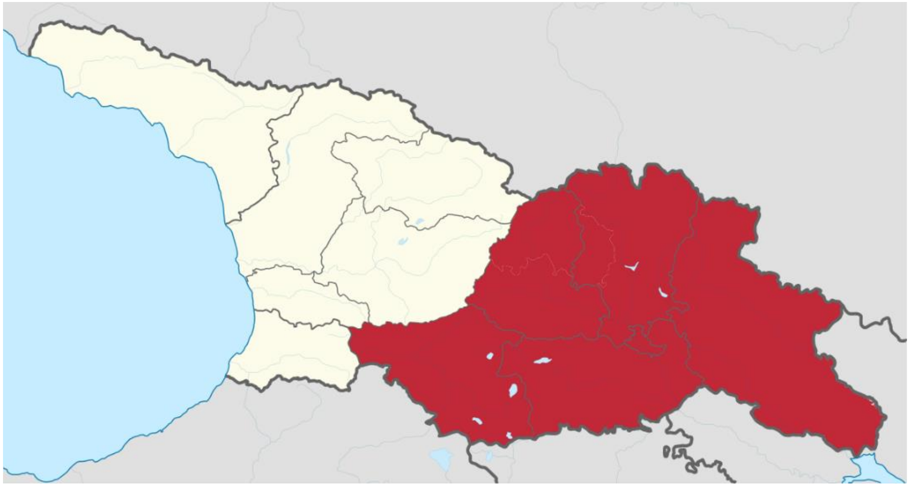

Fig. 2. Eastern Georgia (Georgia) [6].

These conditions determine the climate of Eastern Georgia and the diversity of its characteristics, which determines the number and quality of natural disasters in the country.

Eastern Georgia includes the following regions: Shida Kartli, Kvemo Kartli, Kakheti, Samtskhe-Javakheti, Mtskheta-Mtianeti, Tbilisi administrative unit.

Materials and Methods. The detection of hail in Eastern Georgia was based on the exiting materials of many years of field studies, the databases of the National Environment Agency and Georgian Technical University/Institute of Hydrometeorology, information and publications published literary sources.

The research is carried out using the methods of mathematical statistics and probability theory widely used in climatology.

Results. Based on the data processing (National Environment Agency), we selected those stations that had perfect data from the weather stations in Eastern Georgia. 17 such meteorological stations were found in Eastern Georgia. The research years include 1961-2020. We processed the data according to decades (6 decades in total). In each decade, the average number of hail days for each station is given (Table 1).

Table 1. The dynamics of changes in the number of days with hail according to the regions of Eastern Georgia (1961-2020)

Region	Observation area	Years of observation					
		I	II	III	IV	V	VI
		1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020
		Number of hail days (April-October)					
Shida Kartli	Khashuri	1	0,4	1	-	0,9	1,9
	Gori	2,6	1,3	1,2	-	1,8	1,2
Kvemo Kartli	Tsalka	3,3	3,9	2,7	1,5	1,7	2,0
	Bolnisi	1,9	0,8	0,8	1,8	1,1	2,0
	GArdabani	1,8	0,7	0,9	0,6	0,5	0,1
Samtskhe-Javakheti	Akhaltsikhe	3,3	1	0,5	-	2,8	3,8
	Faravani	8,4	6,4	3,1	-	0,3	0,1
Mtskheta-Mtianeti	Stefantsminda	0,8	1,1	0,4	-	1	0,1
	Fasanauri	2,7	1,4	1,8	-	0,3	1,0
	Tianeti	4,3	2,2	2,2	1,5	2,0	2,0

Tbilisi administrative unit	Kojori	2,3	2,1	1,6	1,0	0,6	0,1
	Tbilisi	0,8	1,3	1,0	2,0	1,5	1,0
Kakheti	Telavi	2,7	1,2	1,2	-	0,6	2,0
	Sagarejo	3,0	1,3	1,6	-	0,1	1,0
	Lagodekhi	1,6	0,9	0,4	-	2,4	0,9
	Kvareli	2,4	1,1	1,3	-	0,3	0,1
	Dedoflistskaro	1,7	1,2	1,1	0,9	0,4	0,4

As shown in Table 1, the data for the 4th decade is not complete. The reason for this is the current situation in the country for this period. Since the 90s of the last century, due to the difficult economic and political situation in Georgia, the hydrometeorological observation network has been significantly reduced.

As a result of processing the obtained data, we created graphic diagrams for the average number of days with hail according to the decades of 1961-2020, for 17 observation points in Eastern Georgia. The graphs presented in Figures 3-19.

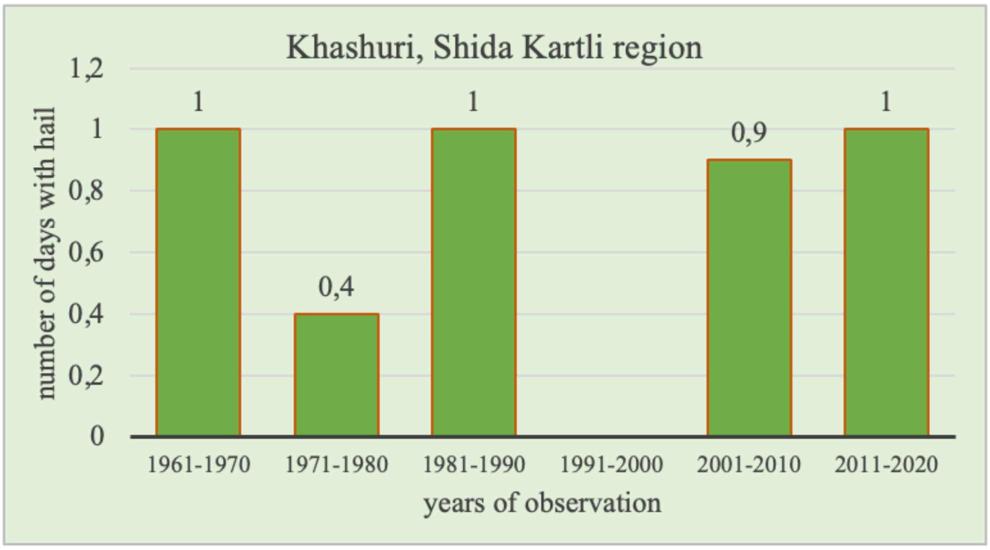

Fig. 3. Average number for hail according to the decades of 1961-2020, Kahashuri, Shida Kartli region.

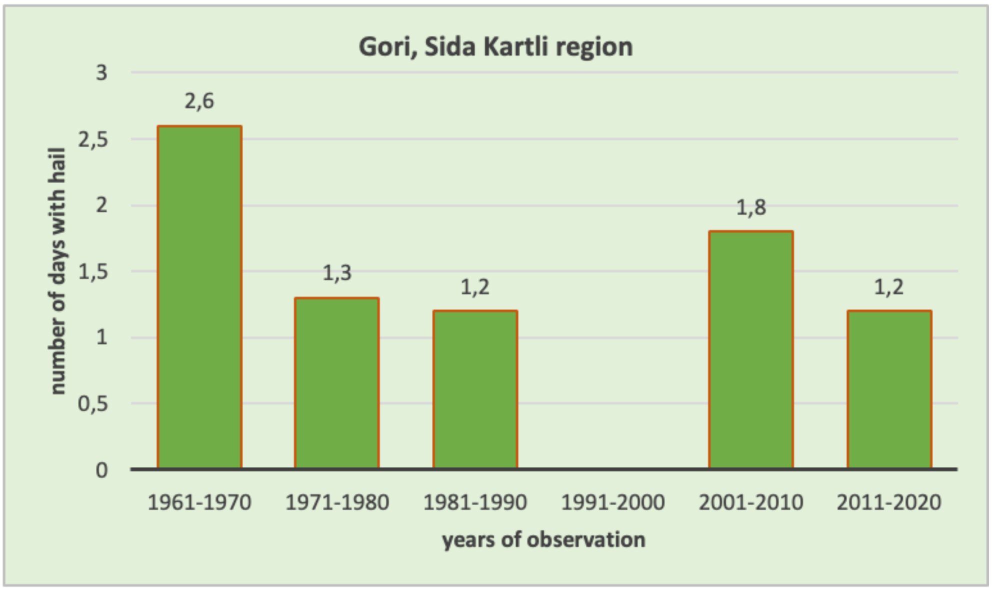

Fig. 4. Average number for hail according to the decades of 1961-2020, Gori, Shida Kartli region.

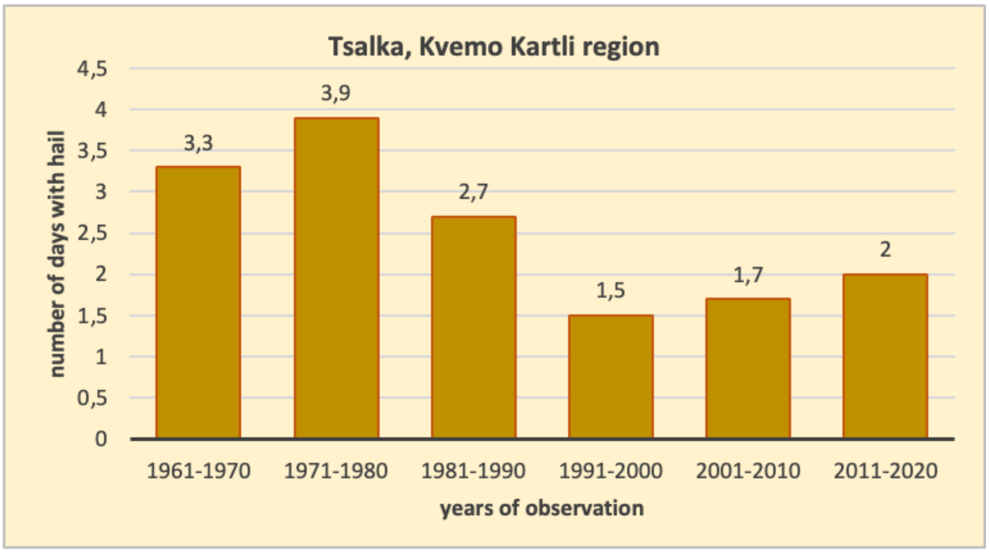

Fig. 5. Average number for hail according to the decades of 1961-2020, Tsalka, Kvemo Kartli region

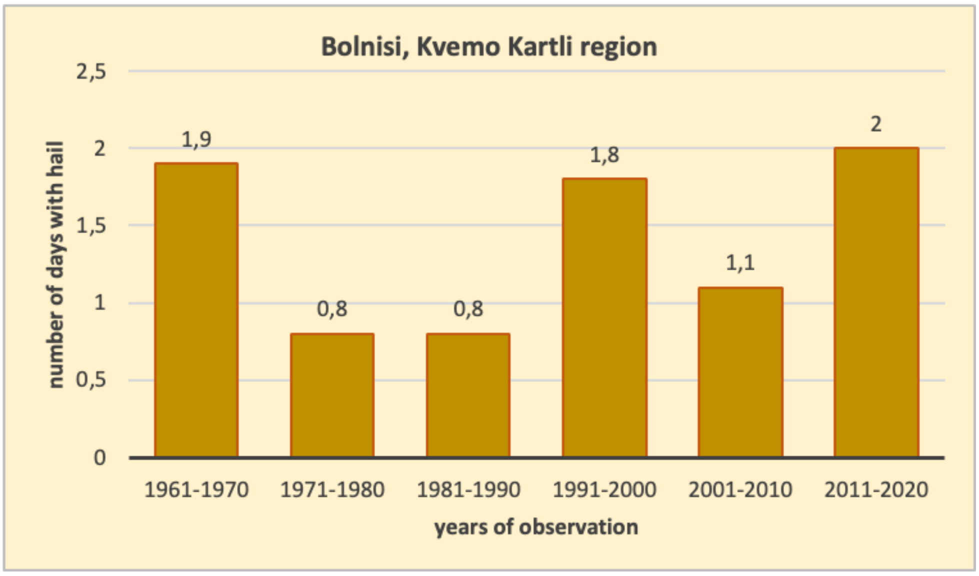

Fig. 6. Average number for hail according to the decades of 1961-2020, Bolnisi, Kvemo Kartli region.

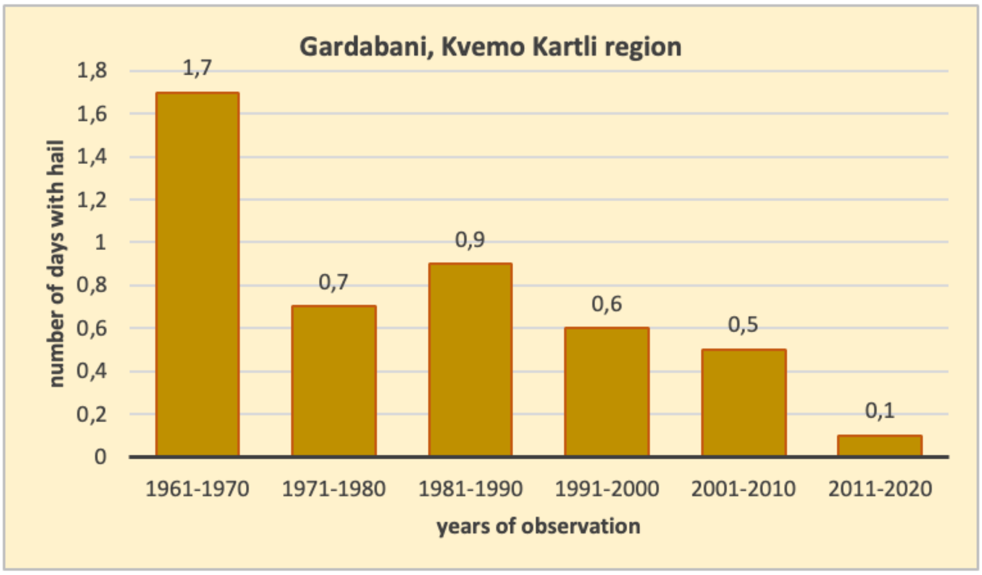

Fig. 7. Average number for hail according to the decades of 1961-2020, Gardabani, Kvemo Kartli region.

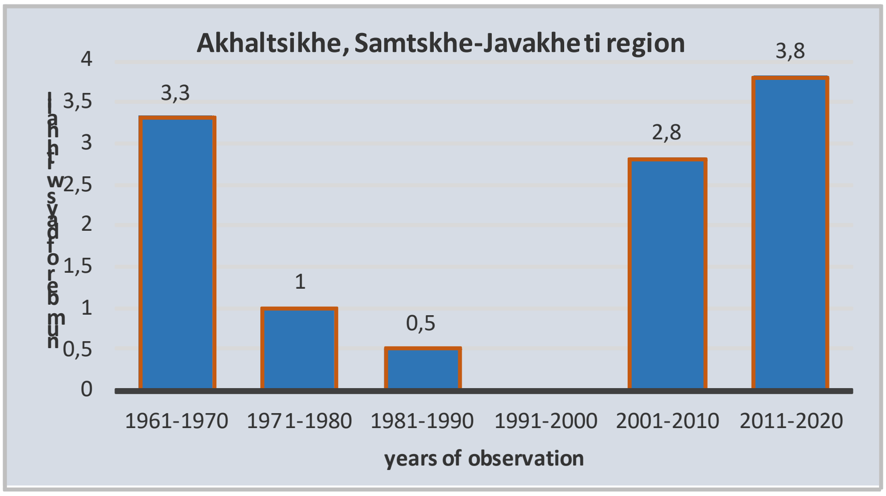

Fig. 8. Average number for hail according to the decades of 1961-2020, Akhaltsikhe, Samtskhe-Javakheti region.

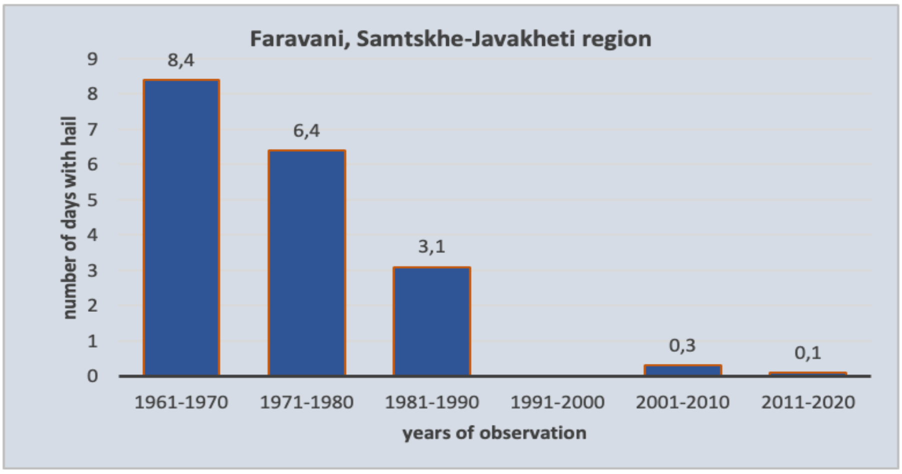

Fig. 9. Average number for hail according to the decades of 1961-2020, Faravani, Samtskhe-Javakheti region.

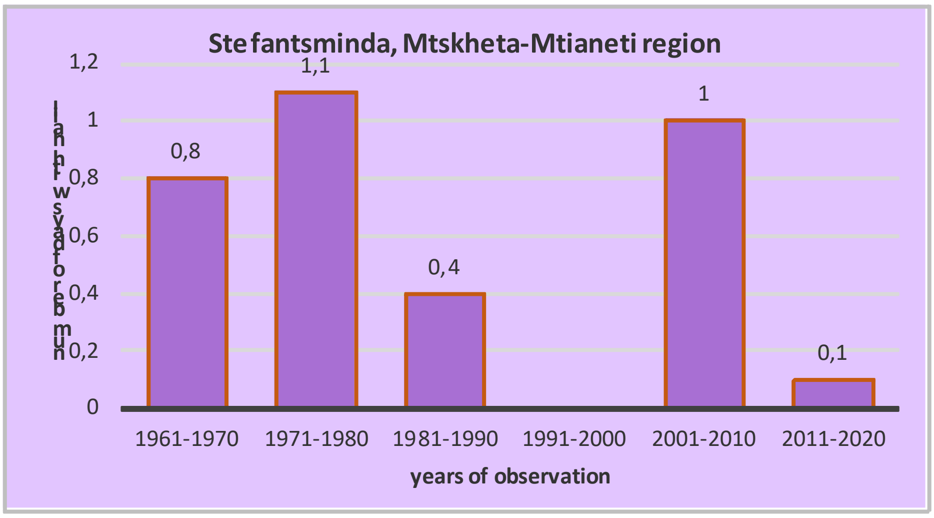

Fig. 10. Average number for hail according to the decades of 1961-2020, Stefantsminda, Mtskheta-Mtianeti region.

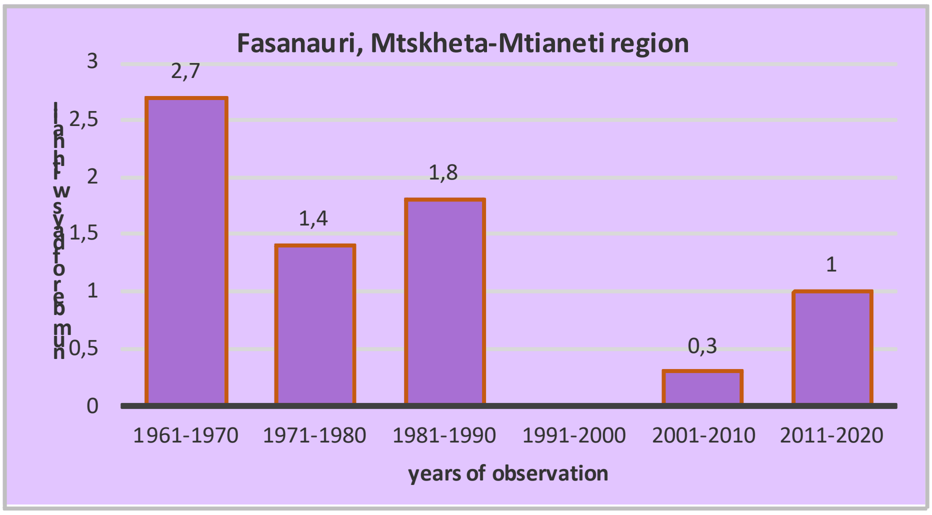

Fig. 11. Average number for hail according to the decades of 1961-2020, Fasanauri, Mtskheta-Mtianeti region.

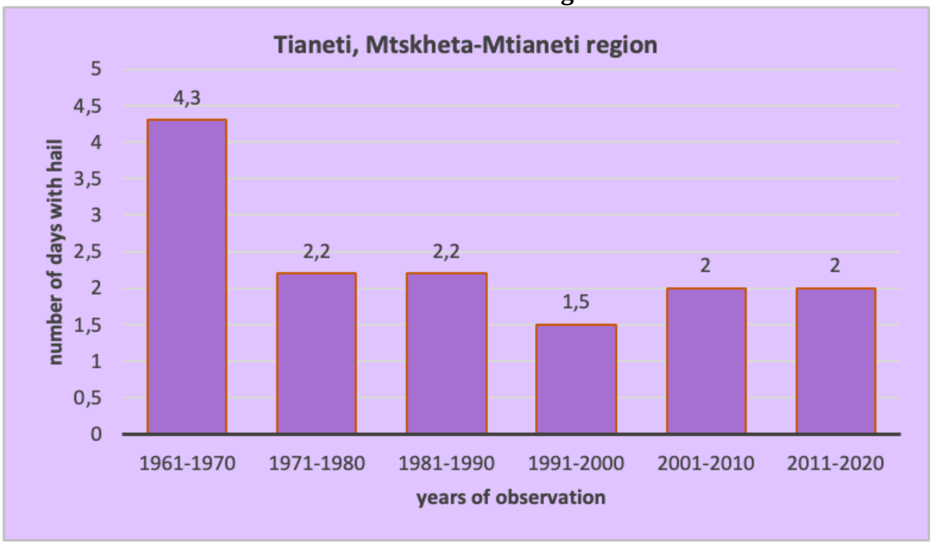

Fig. 12. Average number for hail according to the decades of 1961-2020, Tianeti, Mtskheta-Mtianeti region.

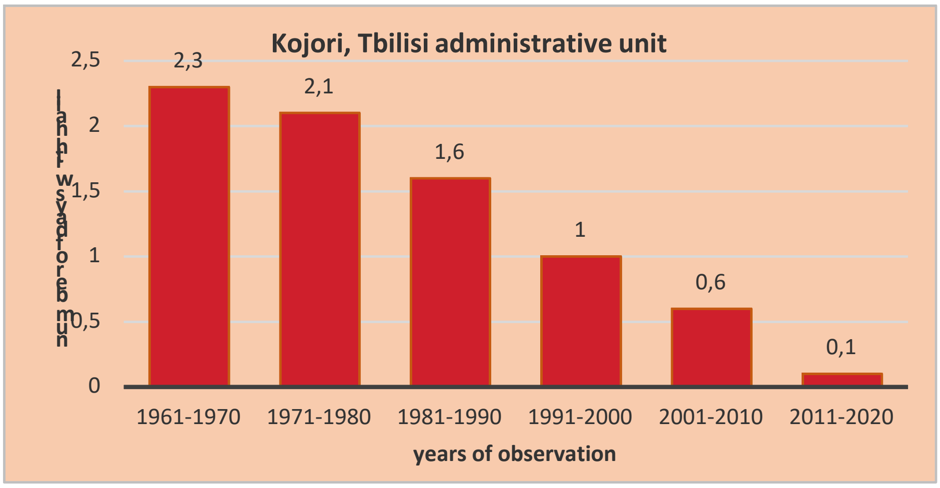

Fig. 13. Average number for hail according to the decades of 1961-2020, Kojori, Tbilisi administrative unit.

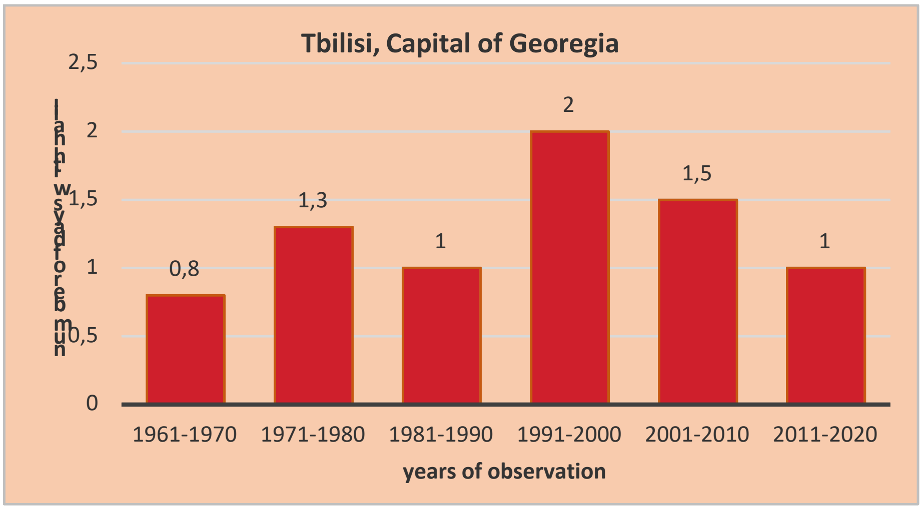

Fig. 14. Average number for hail according to the decades of 1961-2020, Tbilisi, capital of Georgia.

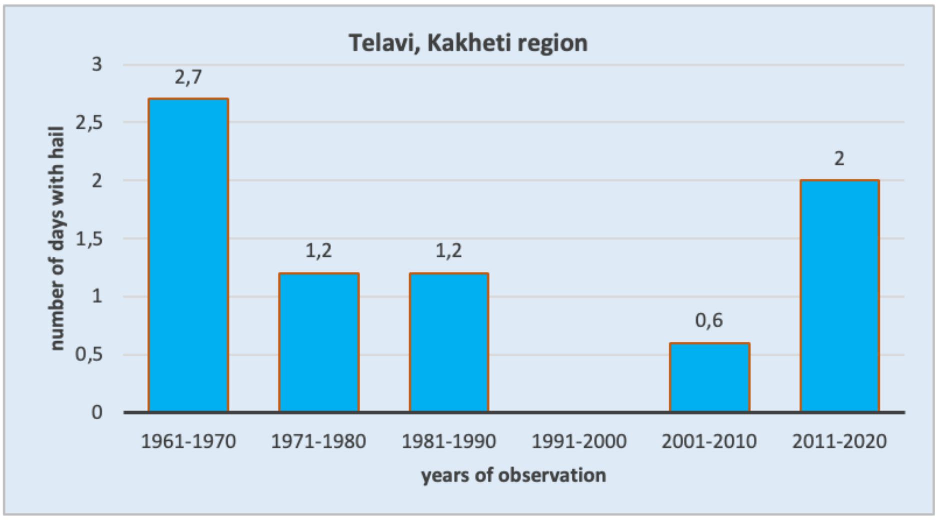

Fig. 15. Average number for hail according to the decades of 1961-2020, Telavi, Kakheti region.

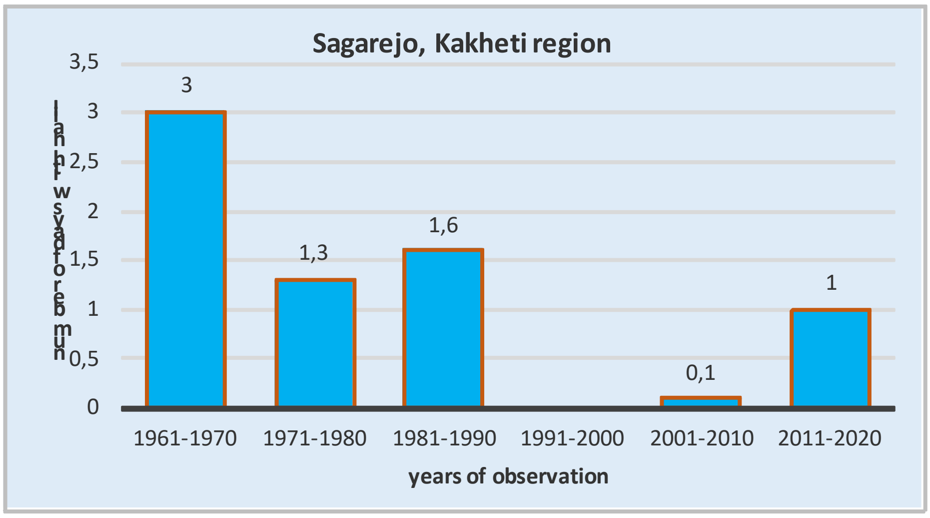

Fig. 16. Average number for hail according to the decades of 1961-2020, Sagarejo, Kakheti region

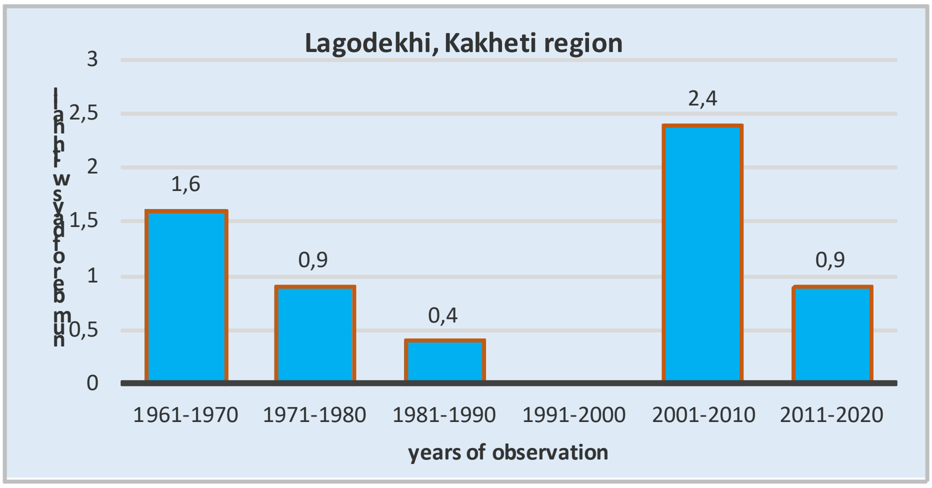

Fig. 17. Average number for hail according to the decades of 1961-2020, Lagodekhi, Kakheti region.

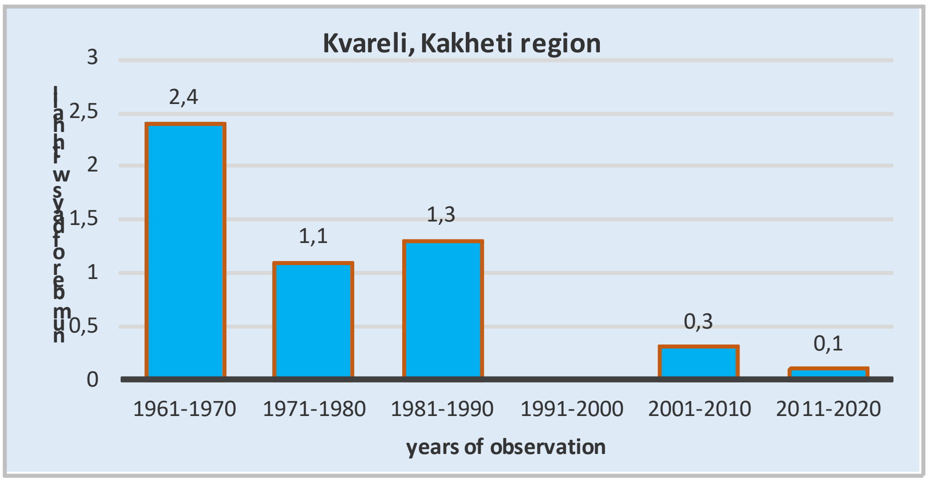

Fig. 18. Average number for hail according to the decades of 1961-2020, Kvareli, Kakheti region.

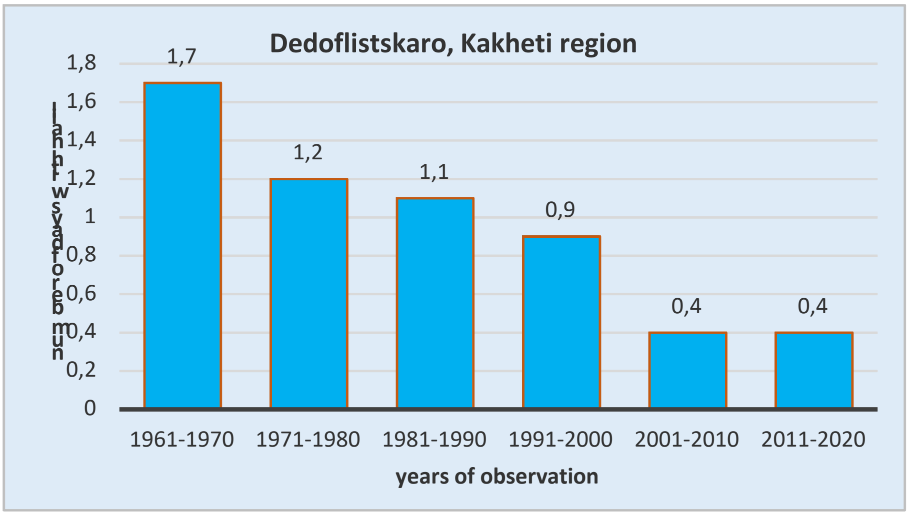

Fig. 19. Average number for hail according to the decades of 1961-2020, Dedoflistslaro, Kakheti region.

Discussion. The data obtained after the processing of the material showed that there is a significant decreasing trend at the observation points of Shida Kartli region in the second decade.

In the Kvemo Kartli region, based on the data of Bolnisi and Tsalki weather stations, there is a tendency to decrease at the beginning of the research period, and to increase in the last two decades. And, the analysis of Gardabani data shows that the number of hail days in the research period is characterized by a decreasing trend.

According to the data of Akhaltsikhe of the Samtskhe-Javakheti region, the highest data from the 6 decades of the study is recorded in the last decade. And according to the data of Faravni weather station, there is a decreasing trend throughout the research period.

Based on the data of Mtskhet-Mtianeti weather stations, there is no significant decrease or increase in the number of hail days in the region (for example, Tianeti).

Tbilisi administrative unit - Kojori is characterized by a consistent decreasing trend throughout the entire research period. And the capital, according to the average number of days with hail, is characterized by inconsistent data in the first three decades, and in the last three decades it has a significant decreasing trend.

Kakheti is the most interesting region among the research regions. Kakheti is one of the hail-dangerous regions of Georgia [7-11]. In 1967-1989 here was conducted the production work on the protection from the hail [12-13]. In the post-Soviet period, the operation of this service was stopped, which were renewed in 2015 [14-15]. Based on the data of all five meteorological stations in the Kakheti region, the number of hail days in the first two decades is characterized by a significant decreasing trend, and it is logical that this decrease is related to the work of the anti-hail service. In the 1990s, the data are unstable and incomplete (as in the whole of Georgia).

And as for the last two decades, the trend of the number of days with hail is decreasing and in some cases it is characterized by changing dynamics.

Conclusions. Based on the data processing as a result of conducted researches works, against the backdrop of modern climate change, the indicators of the number of days with hail in Eastern Georgia show a changing trend, which is mainly expressed as a decrease in the number of days with hail.

An increase in the number of days with hail is observed only in two municipalities (Bolnisi municipality in the Kvemo Kartli region, Akhaltsikhe municipality in the Samtskhe-Javakheti region).

Acknowledgement

This work was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG), Grant number - FR-22-2882.

Note: The report on the mentioned study entitled “Impact of modern climate change on hail processes in Eastern Georgia” was made at an international scientific conference held in 2024 in Istanbul (Turkey). - International Conference On Natural Science And Environment (ICONSE-24)

ლიტერატურა - References – Литература

[1]. Hail. World meteorological organization (Section 3.2.1.2.9). https://cloudatlas.wmo.int/en/hail.html

[2]. 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.pd

[3]. 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, Tbilisi, pp.44 -56.

[4]. 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.

[5]. Amiranashvili A., Basilashvili Ts., Elizbarashvili E., Gaprindashvili G., Varazanashvili O. STATISTICAL ANALYSIS OF THE NUMBER OF DAYS WITH HAIL IN GEORGIA ACCORDING TO METEOROLOGICAL STATIONS DATA IN 2006-2021. International Conference of Young Scientists "Modern Problems of Earth Sciences" Proceedings, ISBN 978-9941-36-044-2, Tbilisi, Georgia, November 21-22, 2022. pp. 164-168.

[6]. Wikimedia commons. Eastern Georgia https://commons.m.wikimedia.org/wiki/File:Eastern_Georgia.svg

[7]. Amiranashvili A., Chikhladze V., Kveselava N., Sauri I. „SOME RESULTS OF ANTI-HAIL WORKS IN KAKHETI INTO 2016-2019“. International Scientific Conference „Modern Problems of Ecology“ Proceedings, ISSN 1512-1976. Vol. 7, 26-28 September, 2020. pp. 153-156.

[8]. 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, DOI: 10.1007/s11069-012-0374-3, Vol. 64, Number 3 (2012), pp. 2021-2056,

[9]. 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”. Reports, presented on the Scientific Conference “80 years of M. Nodia Institute of Geophysics”. Tbilisi, 2014, pp. 145-150.

[10]. Abshaev A.M., Abshaev M.T., Barekova M.V., Malkarova A.M. “Rukovodstvo po organizacii i provedeniu pro-tivogradovih rabot”. Nalchik, Pechatni dvor, ISBN 978-5-905770-54-8, 2014/

[11]. 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, 2015, pp. 77 – 100.

[12]. Amiranashvili A.G. “History of Active Effects on Atmospheric Processes in Georgia”. 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, pp. 234-254.

[13]. Amiranashvili A., Bakhsoliani 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.

[14]. 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, vol.18B, 2015, pp. 92-106.

[15]. 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.

უაკ:551.506.3

სეტყვიან დღეთა რიცხვის მრავალწლიური ცვლილების ზოგადი სტატისტიკური ანალიზი კლიმატის ცვლილების ფონზე აღმოსავლეთ საქართველოში / მიხეილ ფიფია, ნაზიბროლა ბეგლარაშვილი, ციცინო დიასამიძე, ნინო ჯამრიშვილი/ სტუ-ის ჰმი-ის შრომათა კრებული-2025.-ტ.136.-გვ. 54-63. -ქართ., რეზ. ქართ., ინგლ., რუს.

თანამედროვე კლიმატის ცვლილებამ შეიძლება გავლენა მოახდინოს ღრუბლების მიკროფიზიკურ და ელექტრულ თვისებებზე, როგორიცაა ძლიერი სეტყვა და ელვის გამომწვევი პირობები. ამასთან, ზემოქმედების ეფექტი დიდწილად დამოკიდებულია ფიზიკურ-გეოგრაფიულ პირობებზე და ეკოლოგიურ მდგომარეობაზე. აღსანიშნავია, რომ ბოლო ათწლეულების განმავლობაში მომხდარი გლობალური დათბობა მნიშვნელოვან გავლენას ახდენს სეტყვის პროცესების დინამიკაზე.

თანამედროვე კლიმატის ცვლილების ფონზე სეტყვის დღეების რაოდენობის სტატისტიკური ანალიზისთვის გამოყენებული იქნა სადგურებში სეტყვის დღეების საშუალო რაოდენობა ათწლეულების მიხედვით, რაც საშუალებას იძლევა შეასუსტოს მოკლევადიანი რყევები და გამოავლინოს გრძელვადიანი ცვლილებები. აღმოსავლეთ საქართველოში სეტყვის დღეების დინამიკის დასადგენად გაანალიზდა ზოგიერთი მეტეოროლოგიური სადგურის 1961-2000 და 2014-2020 წლების დაკვირვების მონაცემები.

ჯამში დამუშავებულია აღმოსავლეთ საქართველოს 17 მეტეოროლოგიური სადგურის მონაცემები სეტყვის შესახებ 1961-2020 წლების პერიოდისთვის.

УДК: 551.506.3

Общий статистический анализ многолетних изменений числа дней с градом на фоне изменения климата в Восточной Грузии / Михаил Пипия, Назиброла Бегларашвили, Цицино Диасамидзе, Нино Джамришвили/ Сб. Трудов ИГМ ГТУ. - 2025. – том 136. - с. 54-63. - Груз.; Рез: Груз., Англ., Рус.

Современные изменения климата могут влиять на микрофизические и электрические свойства облаков, например, на условия, вызывающие интенсивный град и молнии. При этом эффект воздействия во многом зависит от физико-географических условий и экологической обстановки. Следует отметить, что глобальное потепление, произошедшее в последние десятилетия, оказывает существенное влияние на динамику градовых процессов.

Для статистического анализа количества градовых дней на фоне современных изменений климата использовалось среднее количество градовых дней на станциях по десятилетиям, что позволяет ослабить краткосрочные колебания и выявить долгосрочные изменения. Для определения динамики градовых дней в Восточной Грузии были проанализированы данные наблюдений некоторых метеорологических станций за 1961-2000 и 2014-2020 годы.

Всего обработаны данные 17 метеорологических станций Восточной Грузии о граде за период 1961-2020 годы.