Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127
Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 29(1), 2026, pp. 50 - 59

Retrospective Analysis of Landslides Processes in Akhaldaba (A Suburb of Tbilisi, Georgia) on June 13-14, 2015

[1]Avtandil G. Amiranashvili, [1]Tamaz L. Chelidze, [1]Tengiz V. Kiria, [1] David T. Svanadze, [3] Tamar N. Tsamalashvili, [1] Nodar D. Varamashvili

[1]M. Nodia Institute of Geophysics of I. Javakhishvili Tbilisi State University, Tbilisi, Georgia
[2]A. Janelidze Geological Institute of I. Javakhishvili Tbilisi State University, Tbilisi, Georgia
avtandilamiranashvili@gmail.com

ABSTRACT

The article presents the results of an analysis of radar measurements of precipitation intensity preceding a series of small landslides in the Akhaldaba region (a suburb of Tbilisi, Georgia) on June 13-14, 2015. Specifically, the following results were obtained. The time course of the cumulative precipitation in the zone of maximum cloud radar reflectivity from 20:49 hour to 23:58 hour on June 13, 2015, has the form of a fifth-degree polynomial. The cumulative precipitation by 23:58 hour was 402.8 mm. The time course of the cumulative number of small landslides from 22:30 hour on June 13, 2015, to 01:00 hour on June 14, 2015, has the form of a third-degree polynomial. The number of landslides by 01:00 hour was 98.
The dependence of the cumulative landslide sum on the cumulative precipitation with a one-hour lead time is obtained, which has the form of a third-degree polynomial. A rapid increase in the number of landslides is observed with increasing accumulated precipitation (with a one-hour lead time).
This study once again demonstrates that radar measurements of precipitation intensity can be an effective tool for studying the role of precipitation in landslide occurrence, as well as for short-term forecasting of their activation, especially in areas where ground-based precipitation measurements are unavailable.

Key words: *atmospheric precipitation, radar observations, landslides.*

Introduction

The activation of landslide and mudflow processes is often associated with precipitation patterns on various time scales (from minutes to several years) [1,2]. In Georgia, a modern database of these processes [3-5], as well as precipitation data, has been created and is being improved based on ground-based [6-18], satellite [19-21], and radar [22-25] observations.

Using these databases, the relationships between landslides and mudflows and precipitation on various time scales (from hours to climate scales) and territories (landslide location, regions of Georgia, territory of Georgia [10,11,14-18,20,23-25]) have been studied in recent years, including using machine learning methods [26].

In particular, in the works [23,24] data on the radar characteristics of a rain cloud that caused a landslide in Akhaldaba and a catastrophic flood in Tbilisi on June 13-14, 2015 are presented. The temporal variability of the maximum radar reflectivity of the cloud, precipitation intensity, etc. was studied. It is noteworthy that the cloud did not move much and was over the zone where the landslide descended for more than 5 hours. The consequences of this landslide are well known - the closure of the Vere River, the accumulation of water, the breaking of an artificial dam and the catastrophic flood in Tbilisi.

In the next work [25] results of the analysis of radar measurements of precipitation intensity preceding the landslide in the vicinity of Akhaldaba (a suburb of Tbilisi, Georgia) on June 13, 2015 from 21.00 to 23.97 h are presented. In particular, the following results are obtained. Time-series of precipitation intensity under zone with the maximum radar reflectivity of the cloud has the form of a fifth power of polynomial. Time series of areas of precipitation of different intensity under the cloud were obtained and their statistical characteristics were studied. Dependence of the average intensity of precipitation under the cloud on the effective radius from the zone with the maximum radar reflectivity is obtained.

Statistical characteristics of precipitation intensity over the center of the landslide top is presented. Sum of precipitation under zone with the maximum radar reflectivity of the cloud and over the center of the landslide top on 13 June 2015 from 21.00 to 23.97 h and before landslide from 21.00 to 22.45 h is assessed.

This work is a continuation of previous studies [23-25]. Below the results of a more detailed analysis of the relationship between intense rainfall and the formation of landslides in Akhaldaba on June 13-14, 2015 are presented.

Study Area, Materials and Methods

Study Area – landslide (LS) zone in Akhaldaba (a suburb of Tbilisi, Georgia, Fig. 1).

Fig. 1 illustrates the current state of the main landslide in Akhaldaba with the reconstructed road. It should be noted that following flash floods in the region on June 14, 2014, a landslide on the Vera River near the village of Akhaldaba damaged several sections of roads in the area. The area directly affected by the landslide was approximately 537065 square meters, with 1110 meters of roadway buried or damaged by the landslide [25].

According to data of the Georgian Environment Agency in addition to the largest landslide (Fig. 1), up to 98 small landslides were recorded in the Akhaldaba zone.

Fig. 1. Largest LS Center below the road (after road reconstruction), Lat 41.676421° N, Lon 44.677314° E.

Fig. 2-4 provide information on the number and location of small landslides at different time intervals.

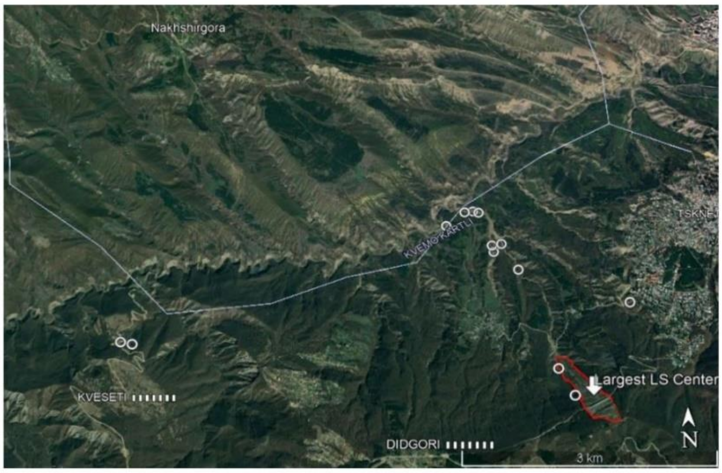

Fig. 2. LS 13.06.2015, 22:30 hour (13 LS locations).

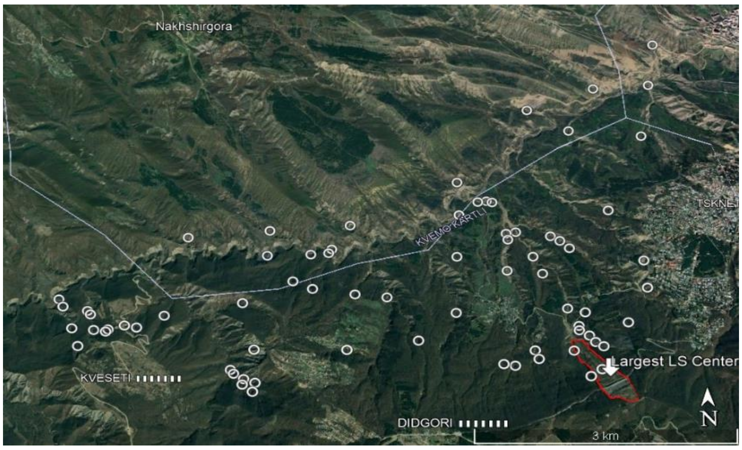

Fig. 3. LS 13.06.2015, 23:00-23:45 hour (73 LS locations).

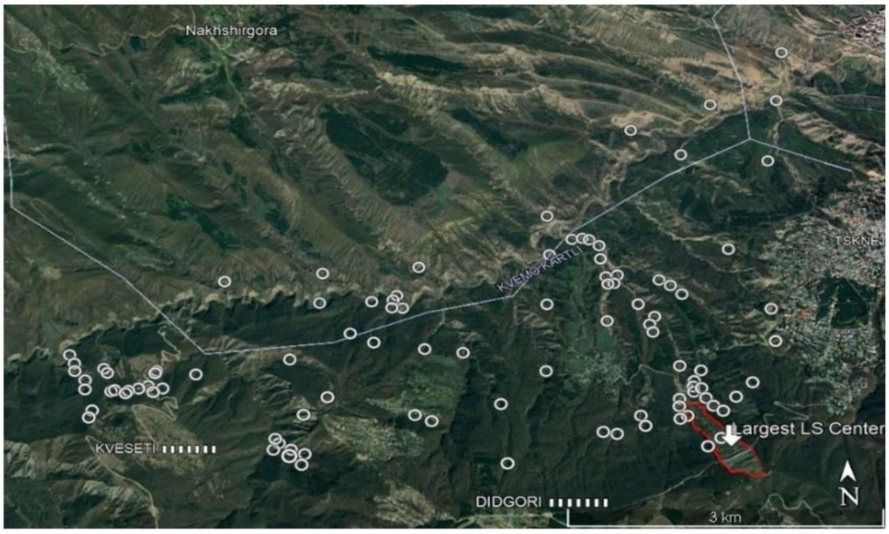

Fig. 4. LS 14.06.2015, 00:30-01:00 hour (98 LS locations).

Precipitation intensity was measured using meteorological radar “METEOR 735 CDP 10 - Doppler Weather Radar”. Radar is established in the village Chotori of the Signagi municipality of Kakheti region of Georgia [35,36]. In this work radar product MPPI (dBz) is used [27-29]. Example of this radar product on Fig. 5 is presented.

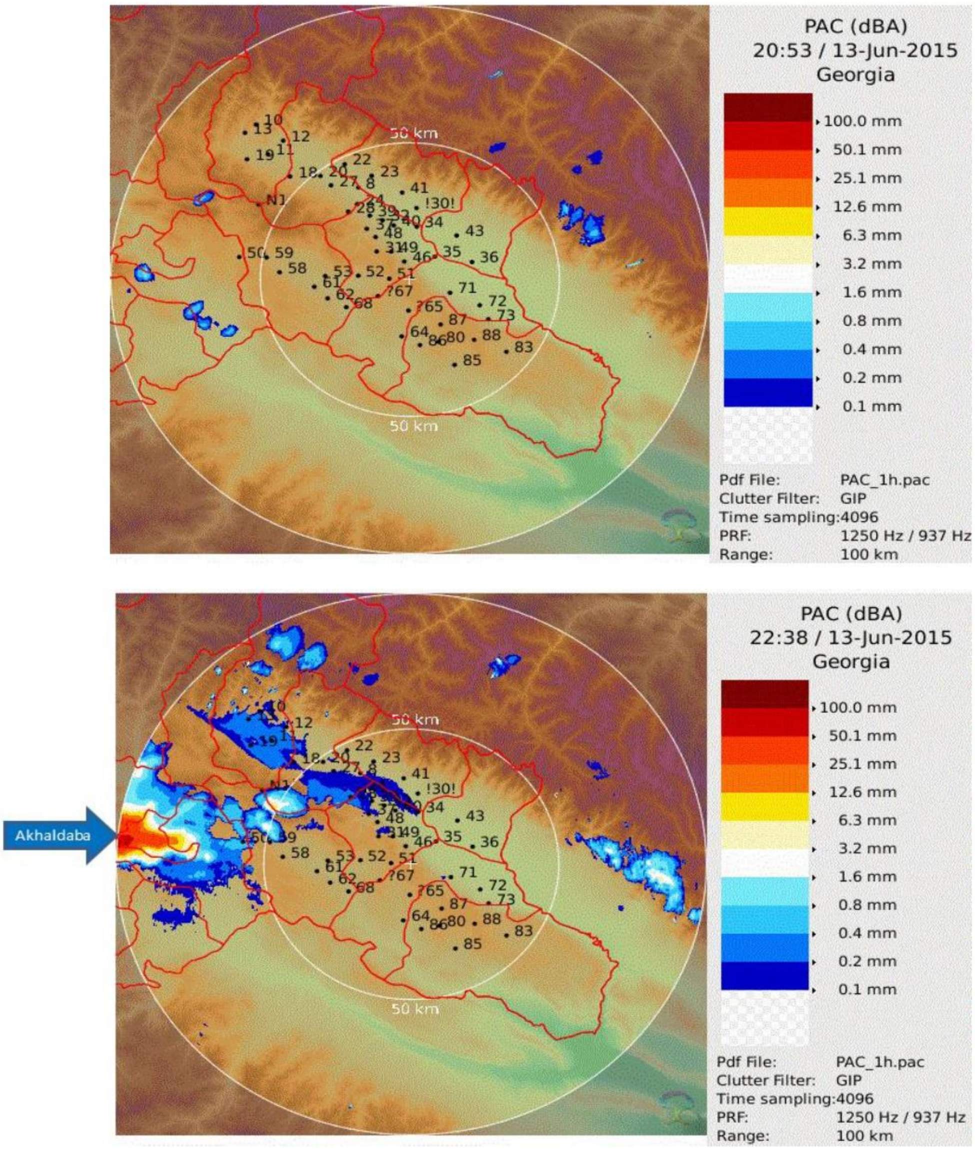

Fig. 5. Radar images of hourly precipitation sums in eastern Georgia in 20.53 and 22.38 hours on June 13, 2015.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods [30].

Results

Results in Fig. 6-8 are presented.

In Fig. 6 time course of the cumulative max precipitation sums in the zone of max cloud radar reflectivity from 20:49 to 23:58 hour on June 13, 2015, having the form of a fifth-degree polynomial, is presented. Accumulated max precipitation sum to 23:58 hour on June 13, 2015 was 402.8 mm.

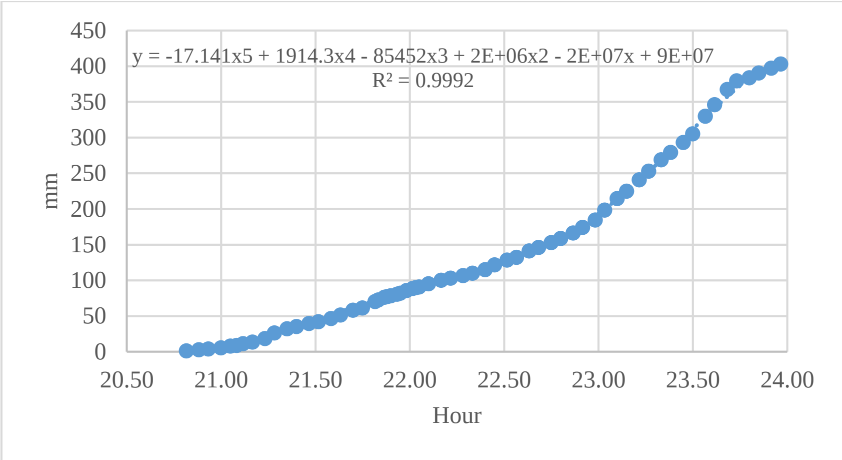

Fig. 6. Time course of the cumulative maximum precipitation sums from 20:49 to 23:58 hour on June 13, 2015.

In Fig. 7 time course of the cumulative number of landslides from 22:30 hour on June 13 to 01:00 hour on June 14, 2015, having the form of a third-degree polynomial, is presented. Accumulated number of landslides to 01:00 hour on June 14, 2015 was 98.

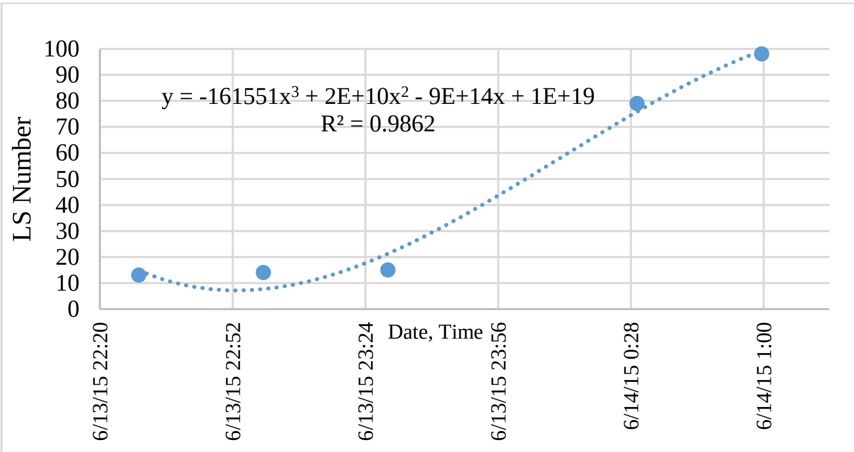

Fig. 7. Time course of the cumulative number of landslides from 22:30 hour on June 13 to 01:00 hour on June 14, 2015.

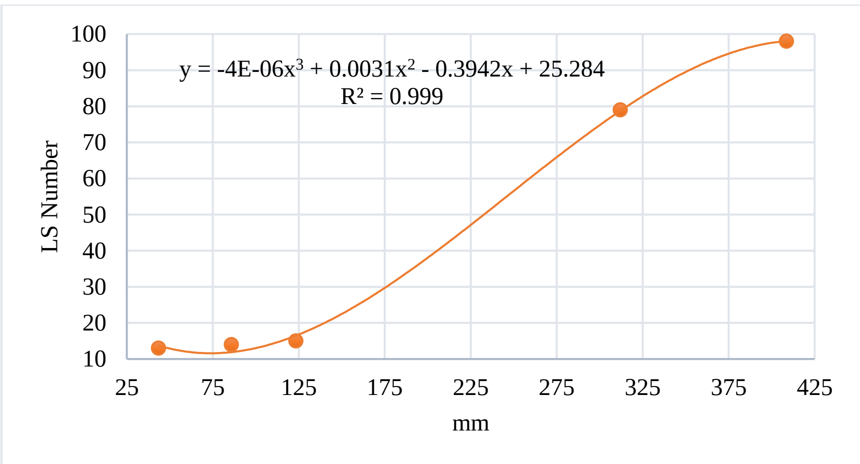

Fig. 8. The relationship between the cumulative number of landslides and the cumulative maximum precipitation amount with a one-hour lead time on June 13-14, 2015.

Finally, Fig. 8 present the relationship between the cumulative number of landslides and the cumulative maximum precipitation amount with a one-hour lead time on June 13-14, 2015. This relationship has the form of a third-degree polynomial. Fig. 8 clearly demonstrates the rapid increase in the number of landslides as the accumulated amount of precipitation increases with the indicated lead time (one hour).

Conclusion

This study further demonstrated that radar measurements of rainfall intensity can be an effective tool for studying the role of rainfall in landslide occurrence and for short-term prediction of landslide activation, especially in areas where ground-based rainfall measurements are not available.

In the future, we plan to further explore this area (comparison of ground-based, radar, and satellite precipitation data, the use of machine learning methods for integrated short-term landslide prediction based on these data, etc.).

Acknowledgments

This work was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG), Grant number FR-23-5466, “Machine Learning Approach to the Landslide Activation Prediction in Georgia”.

References

[1] Segoni S., Piciullo L., Gariano S.L. A Review of the Recent Literature on Rainfall Thresholds for Landslide Occurrence. Landslides, vol. 15, pp. 1483–1501, 2018. DOI 10.1007/s10346-018-0966-4.

[2] Gonzalez F.C.G., Cavacanti M.D.C.R., Nahas Ribeiro W., Mendonça M.B., Haddad A.N. A systematic review on rainfall thresholds for landslides occurrence. Heliyon, 10, 2024, https://doi.org/10.1016/j.heliyon.2023.e23247

[3] Fourth National Communication of Georgia Under the United Nations Framework Convention on Climate Change. Chapter 4.9 Geological Hazards in Georgia, Tbilisi, 2021, pp. 278-286.

[4] Varazanashvili O., Gaprindashvili G., Elizbarashvili E., Basilashvili, Ts., Amiranashvili A., Fuchs S. The First Natural Hazard Event Database for the Republic of Georgia (GeNHs). Catalog, 2023, 270 p. https://openscience.ge/server/api/core/bitstreams/12d32a4e-11dc-4b5c-8878-7c1bf091039d/content; DOI: 10.13140/RG.2.2.12474.57286

[5] Geological bulletins. 2015-2025, (in Georgian). https://nea.gov.ge/c/Departments/Geology

[6] Amiranashvili A.G. Special Features of Changeability of Daily Sum of Precipitation in Tbilisi in 1957-2006. Journal of the Georgian Geophysical Society, Issue B. Physics of Atmosphere, Ocean and Space Plasma, v.18B, Tbilisi, 2015, pp.81-91.

[7] Sakartvelos sametsniero-gamoqenebiti klimaturi tsnobari. Gamomtsemloba "Universali", ISBN 978-9941-26-798-7, Tbilisi, 2020, 307 gv.

[8] Amiranashvili A., Chelidze T., Svanadze D., Tsamalashvili T., Tvauri G. On the Representativeness of Data from Meteorological Stations in Georgia for Annual and Semi-Annual Sum of Atmospheric Precipitation Around of These Stations. International Scientific Conference „Natural Disasters in the 21st Century: Monitoring, Prevention, Mitigation“. Proceedings, ISBN 978-9941-491-52-8, Tbilisi, Georgia, December 20-22, 2021. Publish House of Iv. Javakhishvili Tbilisi State University, Tbilisi, 2021, pp. 79 - 83. http://openlibrary.ge/bitstream/123456789/9566/1/20_Conf_ND_2021.pdf

[9] Kartvelishvili L., Tatishvili M., Amiranashvili A.,Megrelidze L., Kutaladze N. Weather, Climate and their Change Regularities for the Conditions of Georgia. Monograph, Publishing House “UNIVERSAL”, Tbilisi 2023, 406 p., https://doi.org/10.52340/mng.9789941334658
[10] Amiranashvili A., Chelidze T., Svanadze D., Tsamalashvili T., Tvauri G. Study of the Relationship Between the Mean Annual Sum of Atmospheric Precipitation and Re-Activated and New Mudflow Cases in Georgia. Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 26(1), 2023, pp. 19–29.
[11] Amiranashvili A., Brocca L., Chelidze T., Svanadze D., Tsamalashvili T., Varamashvili N. Analysis of the precipitation regime that triggered the landslide in Nergeeti (Imereti, Georgia) on February 7, 2024. Int. Sc. Conf. “Complex Geophysical Monitoring in Georgia: History, Modern Problems, Promoting Sustainable Development of the Country”, Proceedings, ISBN 978-9941-36-272-9, Publish house of Iv. Javakhishvili Tbilisi State University, Tbilisi, Georgia, October 17-19, 2024, pp. 155 – 158. http://dspace.gela.org.ge/bitstream/123456789/10619/1/39_MM-180.pdf
[12] Amiranashvili A., Chelidze T., Svanadze D., Tsamalashvili T., Varamashvili N. About the Representativeness of Data from Meteorological Stations in Georgia for Monthly Sum of Atmospheric Precipitation Around of These Stations. Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 27(1), 2024, pp. 52–57. https://ggs.openjournals.ge/index.php/GGS/article/view/7983
[13] Amiranashvili A.G., Brocca L., Chelidze T.L., Svanadze D.T., Tsamalashvili T.N., Varamashvili N.D. Statistical Analysis of Annual and Semi-Annual Sum of Atmospheric Precipitation Data for 59 Municipalities (11 Regions) of Georgia with Landslide Hazard Zones from 2015 to 2024. Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127 Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v.28(1), 2025, pp. 50 - 63. https://ggs.openjournals.ge/index.php/GGS/article/view/9249
[14] Amiranashvili A., Brocca L., Chelidze T., Kiria T., Svanadze D., Tsamalashvili T., Varamashvili N. Statistical Analysis of the Relationship Between Monthly and Cumulative Multi-Month Sums of Precipitation with the Number of Landslides in the Regions of Georgia. Transactions of Mikheil Nodia Institute of Geophysics, ISSN 1512-1135, vol. LXXVIII, Publish House of Ivane Javakhishvili Tbilisi State University, Tbilisi, 2025, pp. 49-66. http://dspace.gela.org.ge/bitstream/123456789/10809/1/7_Tr_IG_78_2025.pdf
[15] Amiranashvili A., Brocca L., Chelidze T., Svanadze D., Tsamalashvili T., Varamashvili N. Statistical Analysis of the Number of Damaging Landslides in Municipalities and Regions of Georgia and their Relationship with Atmospheric Precipitation in 2015-2024. Reliability: Theory and Applications, ISSN 1932-2321, Volume 20, Special Issue No. 9 (87), November 2025, pp. 255-264. https://doi.org/10.24412/1932-2321-2025-987-255-264
[16] Amiranashvili A., Brocca L., Chelidze T., Kiria T., Svanadze D., Tsamalashvili T., Varamashvili N. Intra-Annual Distribution of Landslide Recurrence in Georgia and its Relationship with Monthly and Cumulative Multi-Month Sums of Precipitation. Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v.28(2), 2025, pp. 25-30. https://ggs.openjournals.ge/index.php/GGS/article/view/10453
[17] Amiranashvili A., Brocca L., Chelidze T., Kiria T., Svanadze D., Tsamalashvili T., Varamashvili N. Assessment of the Relationship Between Daily and Total Multi-Day Precipitation Sums and Landslide Activation in the Regions of Georgia. Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v.29(1), 2026, pp. 27-49.
[18] Amiranashvili A., Brocca L., Chelidze T., Kiria T., Svanadze D., Tsamalashvili T., Varamashvili N. Peculiarities of Intra-Annual Distribution of Landslide Recurrence in Adjara and Guria Regions (Western Georgia) and in Eastern Georgia and their Relationship with Monthly Sums of Precipitation. Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v.29(1), 2026, pp. 60-68.

[19] Amiranashvili A., Chelidze T., Svanadze D., Tsamalashvili T., Tvauri G. Comparison of Data from Ground-Based and Satellite Measurements of the Monthly Sum of Atmospheric Precipitation on the Example of Tbilisi City in 2001-2020. Int. Conf. of Young Scientists "Modern Problems of Earth Sciences". Proceedings, ISBN 978-9941-36-044-2, Publish House of Iv. Javakhishvili Tbilisi State University, Tbilisi, November 21-22, 2022, pp. 154-158. http://openlibrary.ge/bitstream/123456789/10251/1/37_YSC_2022.pdf

[20] Chelidze T., Amiranashvili A., Svanadze D., Tsamalashvili T., Tvauri G. Terrestrial and Satellite-Based Assessment of Rainfall Triggered Landslides Activity in Georgia, Caucasus. Bull. Georg. Nat. Acad. Sci., vol. 17, no. 2, 71-77, 2023, http://science.org.ge/bnas/vol-17-2.html

[21] Amiranashvili A., Chelidze T., Svanadze D., Tsamalashvili T., Varamashvili N. Comparison of Satellite and Ground-Based Data on Semi-Annual and Annual Sum of Atmospheric Precipitation for 26 Points in Georgia in 2001-2020. Int. Sc. Conf. "Complex Geophysical Monitoring in Georgia: History, Modern Problems, Promoting Sustainable Development of the Country", Proceedings, ISBN 978-9941-36-272-9, Publish House of Iv. Javakhishvili Tbilisi State University, Tbilisi, Georgia, October 17-19, 2024, pp. 159 – 163. http://www.openlibrary.ge/bitstream/123456789/10618/1/40_MM-180.pdf

[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, v. 66, Tbilisi, 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, v. 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. Int. Sc. Conf. „Natural Disasters in Georgia: Monitoring, Prevention, Mitigation", Proc., ISBN 978-9941-13-899-7, pp. 167-171, Tbilisi, Georgia, December 12-14, 2019

[25] Amiranashvili A., Chelidze T., Svanadze D., Tsamalashvili T., Tvauri G. Abnormal Precipitation before the Landslide in Akhaldaba (A Suburb of Tbilisi, Georgia) on June 13, 2015 according to Radar Measurements. Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 26(1), 2023, pp. 30–41.

[26] Chelidze T., Kiria T., Amiranashvili A., Svanadze D., Tsamalashvili T., Varamashvili N. Landslide Hazard Maps of Georgia Using Machine Learning Approach. Bulletin of the National Academy of Sciences of Georgia, ISSN: 0132 - 1447, vol. 20(194), no. 2, 2026, pp. 23-29. http://science.org.ge/bnas/t20-n2/03_Chelidze_Geophysics.pdf

[27] 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, http://dspace.gela.org.ge/handle/123456789/8613

[28] Selex ES GmbH · Gematronik Weather Radar Systems. Rainbow®5 User Guide, 464 p., www. gematronik.com

[29] 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, Tb., 2016, vol. 66, pp. 60-65, (in Russian).

[30] Hinkle D. E., Wiersma W., Jurs S. G. Applied Statistics for the Behavioral Sciences. Boston, MA, Houghton Mifflin Company, ISBN: 0618124055; 9780618124053, 2003, 756 p.

ახალდაბაში (თბილისის გარეუბანი, საქართველო) მეწყრული პროცესების რეტროსპექტული ანალიზი, 2015 წლის 13-14 ივნისი

ა. ამირანაშვილი, თ. ჭელიძე, თ. ქირია,
$\boxed{\text{დ. სვანაძე}}$, თ. წამალაშვილი, ნ. ვარამაშვილი

რეზიუმე

სტატიაში წარმოდგენილია 2015 წლის 13-14 ივნისს ახალდაბის რაიონში (თბილისის გარეუბანი, საქართველო) მომხდარი მცირე მეწყერების სერიამდე ნალექების ინტენსივობის რადიოლოკაციური გაზომვების ანალიზის შედეგები. კერძოდ, მიღებული იქნა შემდეგი შედეგები. 2015 წლის 13 ივნისის 20:49 საათიდან 23:58 საათამდე ღრუბლის მაქსიმალური რადიოლოკაციური არეკვლის ზონაში კუმულაციური ნალექების დროითი სვლა მეხუთე ხარისხის პოლინომის ფორმას ატარებს. 23:58 საათისთვის კუმულაციური ნალექების რაოდენობა 402.8 მმ-ს შეადგენდა. მცირე მეწყერების დაგროვილი რაოდენობის დროითი სვლა 2015 წლის 13 ივნისის 22:30 საათიდან 2015 წლის 14 ივნისის 01:00 საათამდე მესამე ხარისხის პოლინომის ფორმას ატარებს. 1:00 საათისთვის მეწყერების რაოდენობა 98 იყო.
მიღებულია მეწყერების დაგროვილი ჯამის დამოკიდებულება დაგროვილი ნალექების რაოდენობაზე ერთსაათიანი წინსწრები დროით, რომელსაც მესამე ხარისხის პოლინომის ფორმა აქვს. მეწყერების რაოდენობის სწრაფი ზრდა შეინიშნება დაგროვილი ნალექების ზრდასთან ერთად (ერთსაათიანი წინსწრები დროით).
ეს კვლევა კიდევ ერთხელ აჩვენებს, რომ ნალექების ინტენსივობის რადიოლოკაციური გაზომვები შეიძლება ეფექტური ინსტრუმენტი იყოს მეწყერების წარმოქმნაში ნალექების როლის შესასწავლად, ასევე მათი გააქტიურების მოკლევადიანი პროგნოზირებისთვის, განსაკუთრებით იმ ადგილებში, სადაც მიწისზედა ნალექების გაზომვები არ არის ხელმისაწვდომი.

საკვანძო სიტყვები: ატმოსფერული ნალექები, რადიოლოკაციური დაკვირვებები, მეწყერები.

Ретроспективный анализ оползневых процессов в Ахалдабе (пригород Тбилиси, Грузия) 13-14 июня 2015 года

А. Амиранашвили, Т. Челидзе, Т. Кириа,
$\boxed{\text{Д. Сванадзе}}$, Т. Цамалашвили, Н. Варамашвили

Резюме

Представлены результаты анализа радиолокационных измерений интенсивности осадков, предшествующих серии небольших оползней в районе Ахалдаба (пригород Тбилиси, Грузия) 13-14 июня 2015 г. В частности, получены следующие результаты. Временной ход накопленной суммы осадков в зоне максимальной радиолокационной отражаемости облака с 20:49 по 23:58

час 13 июня 2015 имеет вид полинома пятой степени. Накопленная сумма осадков к 23:58 час состаляла 402.8 мм. Временной ход накопленной суммы количества небольших оползней с 22:30 час 13 июня 2015 по 01:00 час 14 июня 2015 имеет вид полинома третьей степени. Количество оползней к 01:00 час час состаляло 98.

Получена зависимость накопленной суммы оползней от накопленной суммы осадков с опережением в один час, имеющий вид полинома третьей степени. Отмечается быстрое увеличение количества оползней с ростом накопленной суммы осадков (с опережением в один час).

Данное исследование еще раз продемонстрировало, что радиолокационные измерения интенсивности осадков могут быть эффективным инструментом для изучения роли осадков в возникновении оползней, а также для краткосрочного прогнозирования их активиации, особенно в районах, где наземные измерения осадков недоступны.

Ключевые слова: атмосферные осадки, радиолокационные наблюдения, оползни.