# COMPARISON OF SATELLITE AND GROUND-BASED DATA ON SEMI-ANNUAL AND ANNUAL SUM OF ATMOSPHERIC PRECIPITATION FOR 26 POINTS IN GEORGIA IN 2001-2020

***Amiranashvili A., *Chelidze T., *Svanadze D., **Tsamalashvili T., *Varamashvili N.**

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

***Abstract.*** *The paper compares satellite ($P_S$) and ground-based ($P_M$) data on semi-annual and annual precipitation for 26 points in Georgia for 2001-2020. In particular, it was found that the relationship between $P_S$ and $P_M$ is satisfactorily described by a linear equation.*

***Key Words:*** *atmospheric precipitation, ground-based and satellite measurements.*

## Introduction

In scientific research, accurate and timely precipitation information is often needed to better understand and model severe floods [1,2], droughts [3], water resources [4], landslides and mudflows [5-13]. Global satellite precipitation data (GPM) help to better prepare for and respond to a wide range of natural disasters [https://gpm.nasa.gov].

At the same time, the use of satellite precipitation data requires comparison with ground-based measurements. Such comparisons for monthly and annual precipitation data, in particular, are given in [4, 14-16]. This article compares ground-based and satellite measurements of semi-annual and annual precipitation amounts for 26 points in Georgia in 2001-2020.

## Study area, material and methods

Study area – 26 meteorological stations in Georgia (Akhalkalaki, Akhaltsikhe, Ambrolauri, Bakuriani, Bolnisi, Borjomi, Chokhatauri, Dedoplistskaro, Gori, Khashuri, Khulo, Lagodekhi, Mta-Sabueti, Pasanauri, Poti, Kobuleti, Kutaisi, Sachkhere, Sagarejo, Shovi, Tbilisi, Telavi, Tianeti, Tsalka, Zestafoni, Zugdidi). Information on the coordinates and altitudes of these stations is presented in [17].

The data of Georgian National Environmental Agency and GPM Global Satellite Precipitation Data [https://neo.gsfc.nasa.gov/view.php?datasetId=GPM_3IMERGM] about the monthly sum of atmospheric precipitation for these points from January 2001 to December 2020 (240 months to station) are used.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods [18]. The following designations will be used below: satellite ($P_S$) and ground-based ($P_M$) data on mean sum of atmospheric precipitation; Cold Period: October-March; Warm Period: April-September; R – coefficient of linear correlation; α – the level of significance.

The degree of correlation was determined in accordance with [18]: very high correlation ($0.9 \le R \le 1.0$); high correlation ($0.7 \le R < 0.9$); moderate correlation ($0.5 \le R < 0.7$); low correlation ($0.3 \le R < 0.5$); negligible correlation ($0 \le R < 0.3$).

## Results

Results in Table 1 and 2 are presented.

In Table 1 information on satellite and ground-based data on mean sum of atmospheric precipitation in the three periods of year for 26 points in Georgia in 2001-2020 is presented.

**Table 1. Information on satellite ($P_S$) and ground-based ($P_M$) data on mean sum of atmospheric precipitation in the three periods of year for 26 points in Georgia in 2001-2020.**

| Period | Cold Period | | | Warm Period | | | Year | | |
|---|---|---|---|---|---|---|---|---|---|
| Location | $P_S$, mm | $P_M$, mm | $P_S/P_M$ | $P_S$, mm | $P_M$,mm | $P_S/P_M$ | $P_S$, mm | $P_M$,mm | $P_S/P_M$ |
| Akhalkalaki | 337 | 193 | 1.75 | 471 | 378 | 1.24 | 807 | 571 | 1.41 |
| Akhaltsikhe | 540 | 182 | 2.97 | 551 | 376 | 1.46 | 1091 | 558 | 1.95 |
| Ambrolauri | 746 | 526 | 1.42 | 651 | 532 | 1.22 | 1397 | 1058 | 1.32 |
| Bakuriani | 412 | 345 | 1.20 | 510 | 491 | 1.04 | 923 | 836 | 1.10 |
| Bolnisi | 244 | 188 | 1.30 | 458 | 346 | 1.32 | 701 | 534 | 1.31 |
| Borjomi | 464 | 284 | 1.63 | 521 | 354 | 1.47 | 984 | 638 | 1.54 |
| Chokhatauri | 895 | 1019 | 0.88 | 755 | 677 | 1.11 | 1650 | 1696 | 0.97 |
| Dedoplistskaro | 270 | 212 | 1.28 | 431 | 366 | 1.18 | 701 | 578 | 1.21 |
| Gori | 382 | 217 | 1.76 | 528 | 304 | 1.74 | 911 | 522 | 1.75 |
| Khashuri | 497 | 282 | 1.76 | 528 | 305 | 1.73 | 1025 | 587 | 1.75 |
| Khulo | 776 | 921 | 0.84 | 648 | 579 | 1.12 | 1424 | 1499 | 0.95 |
| Lagodekhi | 293 | 496 | 0.59 | 486 | 809 | 0.60 | 780 | 1306 | 0.60 |
| Mta-Sabueti | 523 | 741 | 0.71 | 535 | 456 | 1.17 | 1058 | 1196 | 0.88 |
| Pasanauri | 384 | 353 | 1.09 | 567 | 611 | 0.93 | 951 | 964 | 0.99 |
| Poti | 1046 | 993 | 1.05 | 884 | 1150 | 0.77 | 1930 | 2143 | 0.90 |
| Kobuleti | 1096 | 1482 | 0.74 | 831 | 1125 | 0.74 | 1927 | 2607 | 0.74 |
| Kutaisi | 828 | 797 | 1.04 | 706 | 566 | 1.25 | 1534 | 1363 | 1.13 |
| Sachkhere | 625 | 506 | 1.24 | 568 | 488 | 1.16 | 1193 | 994 | 1.20 |
| Sagarejo | 258 | 264 | 0.98 | 441 | 469 | 0.94 | 699 | 733 | 0.95 |
| Shovi | 595 | 515 | 1.15 | 574 | 644 | 0.89 | 1169 | 1159 | 1.01 |
| Tbilisi | 283 | 163 | 1.74 | 495 | 360 | 1.37 | 778 | 523 | 1.49 |
| Telavi | 271 | 238 | 1.14 | 470 | 537 | 0.87 | 741 | 775 | 0.96 |
| Tianeti | 331 | 218 | 1.51 | 523 | 399 | 1.31 | 854 | 618 | 1.38 |
| Tsalka | 303 | 171 | 1.77 | 488 | 474 | 1.03 | 791 | 645 | 1.23 |
| Zestafoni | 672 | 775 | 0.87 | 614 | 478 | 1.28 | 1286 | 1253 | 1.03 |
| Zugdidi | 983 | 929 | 1.06 | 877 | 928 | 0.94 | 1860 | 1857 | 1.00 |
| Mean | 541 | 500 | 1.29 | 581 | 546 | 1.15 | 1122 | 1047 | 1.18 |
| Min | 244 | 163 | 0.59 | 431 | 304 | 0.60 | 699 | 522 | 0.60 |
| Max | 1096 | 1482 | 2.97 | 884 | 1150 | 1.74 | 1930 | 2607 | 1.95 |

As follows from Table 1, the variability of the average values of the studied parameters is as follows.

Cold Period: 244 mm (Bolnisi) ≤ $P_S$ ≤ 1096 mm (Kobuleti); 163 mm (Tbilisi) ≤ $P_M$ ≤ 1482 mm (Kobuleti); 0.59 (Lagodekhi) ≤ $P_S/P_M$ ≤ 2.97 (Akhaltsikhe).

Warm Period: 431 mm (Dedoplistskaro) ≤ $P_S$ ≤ 884 mm (Poti); 304 mm (Gori) ≤ $P_M$ ≤ 1150 mm (Poti); 0.60 (Lagodekhi) ≤ $P_S/P_M$ ≤ 1.74 (Gori).

Year: 699 mm (Sagarejo) ≤ $P_S$ ≤ 1930 mm (Poti); 522 mm (Gori) ≤ $P_M$ ≤ 2607 mm (Kobuleti); 0.60 (Lagodekhi) ≤ $P_S/P_M$ ≤ 1.95 (Akhaltsikhe).

On average, per weather station, the excess of satellite precipitation data over ground-based data is as follows: Cold Period – on 29 %, Warm Period – on 15 %, Year – on 18 %.

In Table 2 information on parameters of linear correlations and regression between satellite and ground-based data on sum of atmospheric precipitation in the three periods of year for 26 points in Georgia in 2001-2020 is presented.

As follows from Table 2, the variability of the R values of the studied parameters is as follows.

Cold Period: 0.53 (Zestafoni, moderate correlation) ≤ R ≤ 0.92 (Bolnisi, very high correlation); Warm Period: 0.47 (Kobuleti, low correlation) ≤ R ≤ 0.94 (Zugdidi, very high correlation); Year: 0.34 (Mta-Sabueti, low correlation) ≤ R ≤ 0.90 (Zugdidi, high correlation). On average, per weather station, mean value of R change from 0.70 to 0.76 (high correlation).

**Table 2. Information on parameters of linear correlations and regression between satellite and ground-based data on sum of atmospheric precipitation in the three periods of year for 26 points in Georgia in 2001-2020.**
**$P_S = a \cdot P_M + b$, ($R_{min}$ = 0.34, α = 0.15)**

| Period | Cold Period | | | Warm Period | | | Year | | |
|---|---|---|---|---|---|---|---|---|---|
| Location | R | a | b | R | a | b | R | a | b |
| Akhalkalaki | 0.76 | 0.83 | 175.6 | 0.82 | 0.54 | 265.3 | 0.81 | 0.62 | 452.5 |
| Akhaltsikhe | 0.62 | 1.34 | 295.3 | 0.69 | 0.68 | 295.7 | 0.62 | 1.07 | 492.2 |
| Ambrolauri | 0.65 | 0.74 | 355.8 | 0.64 | 0.59 | 336.6 | 0.59 | 0.60 | 757.7 |
| Bakuriani | 0.65 | 0.64 | 190.9 | 0.82 | 0.68 | 174.7 | 0.78 | 0.64 | 386.6 |
| Bolnisi | 0.92 | 1.06 | 45.1 | 0.79 | 0.83 | 169.5 | 0.83 | 1.07 | 129.8 |
| Borjomi | 0.75 | 1.15 | 135.6 | 0.78 | 0.65 | 290.4 | 0.74 | 0.90 | 412.1 |
| Chokhatauri | 0.73 | 0.64 | 239.9 | 0.85 | 0.61 | 341.0 | 0.79 | 0.70 | 467.9 |
| Dedoplistskaro | 0.81 | 0.66 | 129.3 | 0.70 | 0.51 | 245.7 | 0.68 | 0.45 | 440.8 |
| Gori | 0.69 | 1.01 | 163.4 | 0.75 | 0.83 | 276.6 | 0.78 | 1.03 | 374.3 |
| Khashuri | 0.78 | 0.90 | 242.4 | 0.67 | 0.77 | 294.2 | 0.76 | 0.92 | 482.4 |
| Khulo | 0.90 | 0.86 | -15.1 | 0.84 | 0.62 | 291.3 | 0.89 | 0.79 | 244.6 |
| Lagodekhi | 0.66 | 0.27 | 159.0 | 0.70 | 0.29 | 250.4 | 0.61 | 0.24 | 470.6 |
| Mta-Sabueti | 0.54 | 0.35 | 267.1 | 0.59 | 0.42 | 343.6 | 0.34 | 0.26 | 747.0 |
| Pasanauri | 0.87 | 0.55 | 190.7 | 0.73 | 0.36 | 346.4 | 0.71 | 0.38 | 582.4 |
| Poti | 0.74 | 0.65 | 404.7 | 0.79 | 0.32 | 513.6 | 0.64 | 0.38 | 1115.5 |
| Kobuleti | 0.83 | 0.63 | 168.3 | 0.47 | 0.20 | 601.4 | 0.64 | 0.46 | 738.1 |
| Kutaisi | 0.79 | 0.94 | 76.4 | 0.83 | 0.81 | 246.7 | 0.76 | 0.94 | 251.0 |
| Sachkhere | 0.64 | 0.77 | 235.1 | 0.49 | 0.39 | 378.0 | 0.36 | 0.36 | 836.1 |
| Sagarejo | 0.88 | 0.62 | 95.3 | 0.65 | 0.48 | 216.5 | 0.74 | 0.48 | 350.9 |
| Shovi | 0.73 | 0.57 | 302.2 | 0.63 | 0.58 | 198.4 | 0.63 | 0.52 | 561.2 |
| Tbilisi | 0.91 | 0.95 | 129.1 | 0.64 | 0.45 | 333.4 | 0.82 | 0.62 | 455.0 |
| Telavi | 0.90 | 0.79 | 82.7 | 0.70 | 0.50 | 199.2 | 0.77 | 0.61 | 269.1 |
| Tianeti | 0.84 | 0.65 | 187.9 | 0.69 | 0.37 | 374.5 | 0.73 | 0.41 | 601.5 |
| Tsalka | 0.88 | 1.02 | 128.3 | 0.82 | 0.59 | 206.0 | 0.86 | 0.76 | 303.7 |
| Zestafoni | 0.53 | 0.36 | 391.0 | 0.52 | 0.42 | 413.9 | 0.42 | 0.31 | 902.2 |
| Zugdidi | 0.80 | 0.86 | 182.9 | 0.94 | 0.72 | 204.8 | 0.90 | 0.90 | 177.7 |
| Mean | 0.76 | | | 0.71 | | | 0.70 | | |
| Min | 0.53 | | | 0.47 | | | 0.34 | | |
| Max | 0.92 | | | 0.94 | | | 0.90 | | |

## Conclusion

In the future, it is planned to continue these studies for monthly and daily sum of atmospheric precipitation.

## Acknowledgments

This work is 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] Amiranashvili A., Basilashvili Ts., Elizbarashvili E., Varazanashvili O. Catastrophic Floods in the Vicinity of Tbilisi. Transactions IHM, GTU, ISSN: 1512-0902, vol.133, 2023, pp. 56-61, (in Georgian), doi.org/10.36073/1512-0902-2023-133-56-61; http://openlibrary.ge/bitstream/123456789/10337/1/133-11.pdf; doi.org/10.36073/1512-0902-2023-133-56-61

[2] Beglarashvili N., Jamrishvili N., Janelidze I., Pipia M., Tavidashvili Kh. Analysis of Strong Precipitation in Tbilisi on August 29, 2023. Int. Sc. Conf. "Geophysical Processes in the Earth and its Envelopes". Proceedings, ISBN 978-9941-36-147-0, Publish House of Iv. Javakhishvili Tbilisi State University, November 16-17, 2023, pp. 143-146. http://www.dspace.gela.org.ge/handle/123456789/10421

[3] 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”, ISBN: 978-9941-33-465-8, Tbilisi 2023, 406 p., https://doi.org/10.52340/mng.9789941334658

[4] Tsitelashvili N., Biggs T., Ye Mu, Trapaidze V. Regional precipitation regimes and evaluation of national precipitation datasets against satellite-based precipitation estimates, Republic of Georgia. // Journal of Hydrometheorology, Volume 25: Issue 4, 2024, pp. 591–600. https://doi.org/10.1175/JHM-D-23-0116.1

[5] Amiranashvili A., Chelidze T., Dalakishvili L., Svanadze D., Tsamalashvili T., Tvauri G. Preliminary Results of a Study of the Relationship Between the Monthly Mean Sum of Atmospheric Precipitation and Landslide Cases in Georgia. // Journal of the Georgian Geophysical Society, ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 23(2), 2020, pp. 37 – 41. DOI: https://doi.org/10.48614/ggs2320202726

[6] Amiranashvili A., Chelidze T., Dalakishvili L., Svanadze D., Tsamalashvili T., Tvauri G. Preliminary Results of a Study of the Relationship Between the Variability of the Mean Annual Sum of Atmospheric Precipitation and Landslide Processes in Georgia. // Int. Sc. Conf. „Modern Problems of Ecology“, Proc., ISSN 1512-1976, v. 7, Tbilisi-Telavi, Georgia, 26-28 September, 2020, pp. 202-206.
http://www.dspace.gela.org.ge/bitstream/123456789/8809/1/Eco_2020_3.33.pdf

[7] Stankevich S.A., Titarenko O.V, Svideniuk M.O. Landslide susceptibility mapping using GIS-based weight-of-evidence modelling in central Georgian regions. // Int. Sc. Conf. „Natural Disasters in Georgia: Monitoring, Prevention, Mitigation“, Proceedings, Tbilisi, Georgia, December 12-14, 2019, pp. 187-190.

[8] Amiranashvili A., Chelidze T., Svanadze D., Tsamalashvili T., Tvauri G. Some Results of a Study of the Relationship Between the Mean Annual Sum of Atmospheric Precipitation and Re-Activated and New Landslide Cases in Georgia Taking into Account of Climate Change. // Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 25(2), 2022, pp. 38–48. https://openjournals.ge/index.php/GGS/article/view/5959, DOI: https://doi.org/10.48614/ggs2520225959

[9] 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

[10] 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.

[11] 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.
https://ggs.openjournals.ge/index.php/GGS/article/view/6958; DOI: https://doi.org/10.48614/ggs2620236958

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

[13] Kirschbaum D., Stanley T. Satellite-Based Assessment of Rainfall-Triggered Landslide Hazard for Situational Awareness. // Earth's Future, 6, 2018, pp.505-523, https:// doi.org/10.1002/, 2017EF000715

[14] Retalis A., Katsanos D., Tymvios F., Michaelides S. Comparison of GPM IMERG and TRMM 3B43 Products over Cyprus. // Remote Sens. 12, 3212, 2020, 18 p., doi:10.3390/rs12193212

[15] Akinyemi D.F., Ayanlade O.S., Nwaezeigwe J.O., Ayanlade A. A Comparison of the Accuracy of Multi-satellite Precipitation Estimation and Ground Meteorological Records Over Southwestern Nigeria. // Remote Sens. 12, 3964, 2020, 22 p., doi:10.3390/rs12233964

[16] 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

[17] 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. // Int. Sc. Conf. „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.

[18] 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.