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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

[*]Amiranashvili A., [*]Chelidze T., [*]Svanadze D., [**]Tsamalashvili T., [***]Tvauri G.

[*]M. Nodia Institute of Geophysics, Iv. Javakhishvili Tbilisi State University, Tbilisi, Tbilisi, Georgia
[**]A. Janelidze Geological Institute of I. Javakhishvili Tbilisi State University, Tbilisi, Georgia
[***]E. Andronikashvili Institute of Physics of I. Javakhishvili Tbilisi State University, Tbilisi, Georgia
e-mail: datosvani@gmail.com

Abstract: *The data of ground-based (Prec_MS) and satellite (Prec_Sat) measurements of the monthly sum of atmospheric precipitation are compared using the example of Tbilisi in 2001-2020. In particular, the following results are obtained. In general, for all observational data (240 months), Prec_MS values vary from 0 to 267.3 mm, and Prec_Sat - from 3.0 to 184.0 mm. Their average values are 43.6 and 64.8 mm, respectively. Monthly mean values of Prec_MS vary from 16.7 mm (January) to 93.2 mm (May) and Prec_Sat values – from 32.5 mm (December) to 114.4 mm (May). Ground-based measurements are lower than satellite data for all months of the year. The difference between the average values of Prec_MS and Prec_Sat over 20 years varies from -8.8 mm (November) to -33.4 mm (March). Ratio between the average values of Prec_MS and Prec_Sat varies from 40.6 % (January) to 81.5 % (May). There is a direct linear correlation between the studied parameters. For all observational data (240 months) coefficient of correlation is 0.86 (high correlation), for separate month changes from 0.65 (July, moderate correlation) to 0.94 (April, very high correlation). Coefficient of correlation between average values of the studied parameters is 0.97 (very high correlation).*
Key Words: *Atmospheric precipitation, ground-based and satellite measurements.*

Introduction

Researchers need accurate and timely precipitation information to better understand and model where and when severe floods [1], droughts [2], landslides [3-7] can occur. GPM Global Satellite Precipitation Data helps you better prepare for and respond to a wide range of natural disasters [http://svs.gsfc.nasa.gov/goto?11091]. However, the use of satellite precipitation data requires comparison with ground-based measurements. Similar comparisons for monthly precipitation data, in particular, are given in [8,9]. This paper compares the data of ground-based and satellite measurements of the monthly total of atmospheric precipitation using the example of Tbilisi in 2001-2020.

Study area, material and methods

Study area – Tbilisi. The data of Georgian National Environmental Agency and GPM Global Satellite Precipitation Data [http://svs.gsfc.nasa.gov/goto?11091] about the monthly sum of atmospheric precipitation for Tbilisi from January 2001 to December 2020 (240 months) are used.
In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods [10]. The following designations will be used below: Mean – average values; Max - maximal values; Min – minimal values; St Dev - standard deviation; C_v – coefficient of variation = 100·St Dev/Mean, %; R – coefficient of linear correlation; α - the level of significance; the level of significance of the difference between the two mean values was determined using Student's t-test; ground-based data – meteorological station of Tbilisi - Prec_MS; satellite data - Prec_Sat.

The degree of correlation was determined in accordance with [10]: very high correlation ($0.9 \leq R \leq 1.0$); high correlation ($0.7 \leq R < 0.9$); moderate correlation ($0.5 \leq R < 0.7$); low correlation ($0.3 \leq R < 0.5$); negligible correlation ($0 \leq R < 0.3$).

Table 1 provides information on the distance from the Tbilisi weather station, within which the data of this weather station on monthly precipitation are applicable with a high degree of representativeness. The calculations were carried out in accordance with [11] using data 2001-2020.

Table 1. Distance from meteorological station Tbilisi (L, km), within which the data of this station on the monthly precipitation amounts are applicable with a high level of representativeness.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	32	24	77	19	41	31	52	35	126	64	37

As follows from Table 1, distance L varies from 19 km (May) to 126 km (October). The resolution of satellite measurements of precipitation is 10x10 km. Therefore, the comparison of series of observations of monthly precipitation lasting 20 years or more is quite justified.

Results and discussion

Results in Fig. 1-3 and table 2,3 are presented.

In Fig. 1 time-series of Prec_MS and Prec_Sat data from January 2001 to December 2020 are presented.

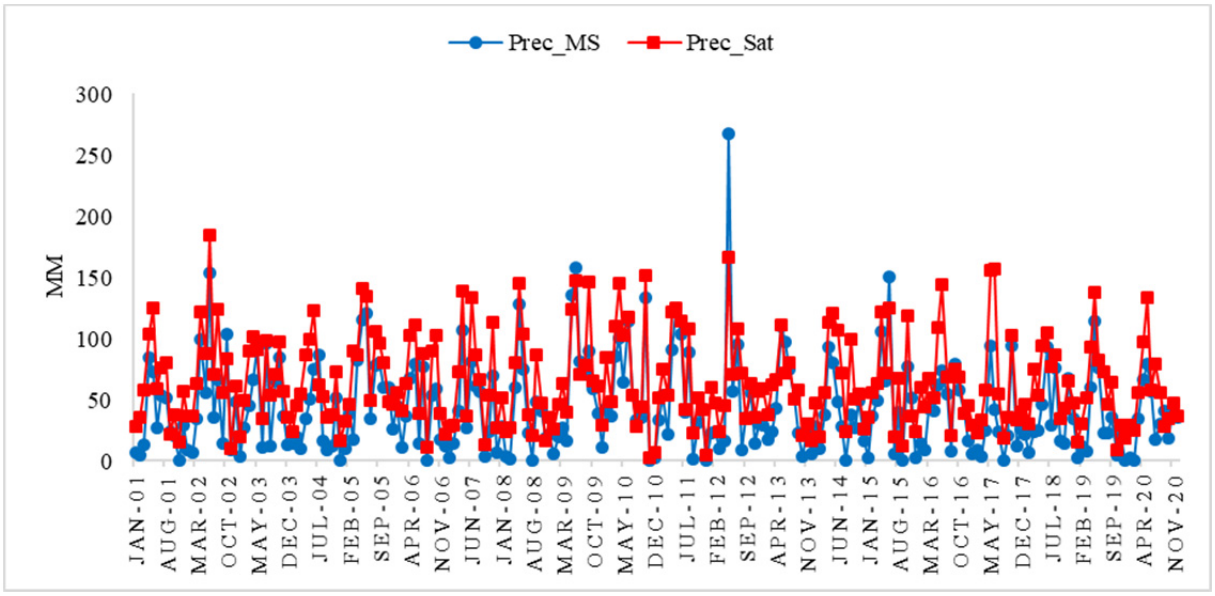

Fig. 1. Time-series of monthly sum of atmosperic precipitation in Tbilisi according to ground-based and satellite measurements from January 2001 to December 2020.

In Table 2 statistical characteristics of Prec_MS and Prec_Sat data from January 2001 to December 2020 are presented. In Fig 2 for clarity the intraannual distribution of mean monthly sum of atmosperic precipitation in Tbilisi according to ground-based and satellite measurements are presented.

As follows from Fig. 1 and 2 the synchronism of the time course of both parameters is visually well traced. At the same time, in general, the excess of the values of satellite measurements over ground ones is noticeable.

Table 2 and Fig. 1,2 show that in general, for all observational data (240 months), Prec_MS values vary from 0 to 267.3 mm, and Prec_Sat - from 3.0 to 184.0 mm. Their average values are 43.6 and 64.8 mm, respectively. Monthly mean values of Prec_MS vary from 16.7 mm (January) to 93.2 mm (May) and Prec_Sat values – from 32.5 mm (December) to 114.4 mm (May).

Table 2. Statistical characteristics of monthly sum of atmosperic precipitation in Tbilisi according to ground-based and satellite measurements in 2001 - 2020.

Variable	Prec_MS	Prec_Sat	Prec_MS	Prec_Sat	Prec_MS	Prec_Sat	Prec_MS	Prec_Sat	Prec_MS	Prec_Sat	Prec_MS	Prec_Sat
Month	Jan		Feb		Mar		Apr		May		Jun	
Min	2.5	15.6	0.0	19.6	1.3	24.0	16.6	40.1	26.6	37.2	10.6	34.7
Max	45.0	84.4	53.2	75.2	85.3	110.5	107.3	145.4	267.3	166.0	157.6	184.0
Mean	16.7	41.1	17.9	39.4	28.3	61.7	64.2	91.5	93.2	114.4	81.4	105.7
St Dev	13.9	17.5	14.1	13.3	19.8	20.6	30.8	31.2	50.7	30.1	43.5	40.6
Cv,%	83.4	42.5	78.6	33.7	69.8	33.3	47.9	34.1	54.4	26.3	53.4	38.4
Month	Jul		Aug		Sep		Oct		Nov		Dec	
Min	5.5	20.0	0.0	11.2	0.3	12.2	4.0	8.7	0.0	3.0	0.0	5.0
Max	96.1	107.7	89.3	124.2	89.9	146.6	133.1	151.7	69.9	113.6	48.0	61.1
Mean	49.8	68.2	35.7	58.5	35.8	56.3	49.0	65.8	33.6	42.4	17.1	32.5
St Dev	27.9	21.0	29.9	32.4	27.0	34.8	35.7	35.3	21.6	24.9	13.9	16.2
Cv,%	56.0	30.8	83.9	55.4	75.4	61.9	72.8	53.6	64.3	58.8	81.2	49.9
Month	Jan – Dec (240 months)											
Variable	Prec_MS						Prec_Sat					
Min	0.0						3.0					
Max	267.3						184.0					
Mean	43.6						64.8					
St Dev	37.6						37.2					
Cv,%	86.4						57.4					

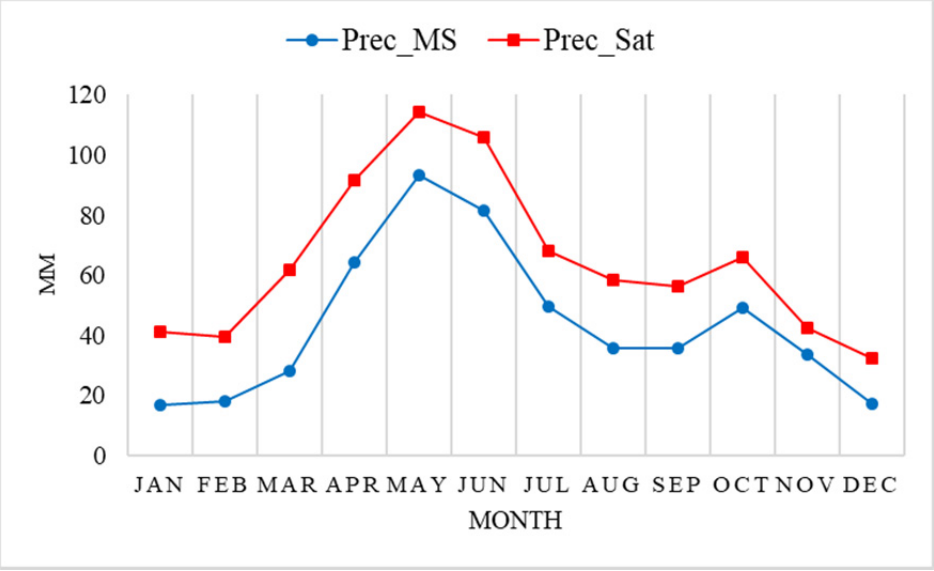

Fig. 2. Intraannual distribution of mean monthly sum of atmosperic precipitation in Tbilisi according to ground-based and satellite measurements from January 2001 to December 2020.

Ground-based precipitation measurements are subject to higher fluctuations than satellite measurements. Values of Cv for mean monthly data of Prec_MS varied from 47.9% (April) to 83.9 % (August), and for mean monthly data of Prec_Sat - from 26.3 % (May) to 61.9 % (September). In general, according to all observational data (240 months), the Cv values are 86.4% and 57.4%, respectively (Table 2).

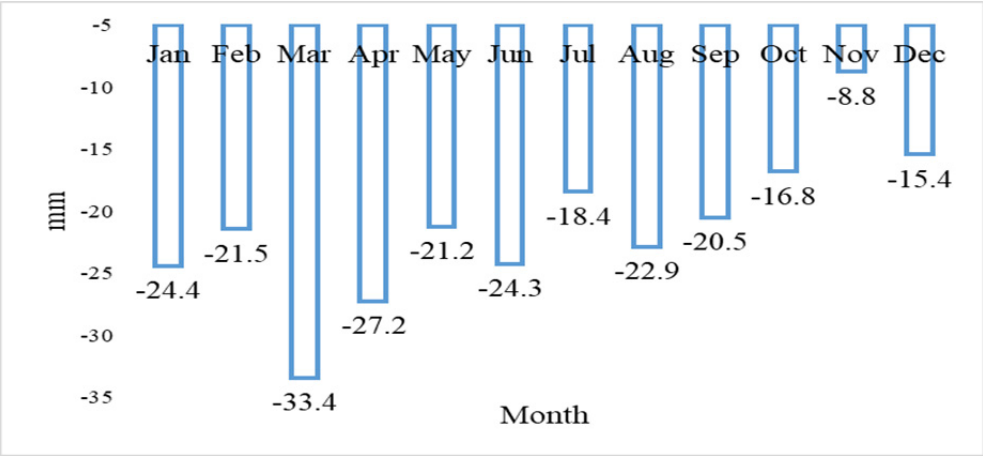

Fig. 3. Difference between mean montly sum of atmospheric precipitation at meteorological station and satellite data in Tbilisi in 2001 – 2020, ($\alpha \leq 0.23$).

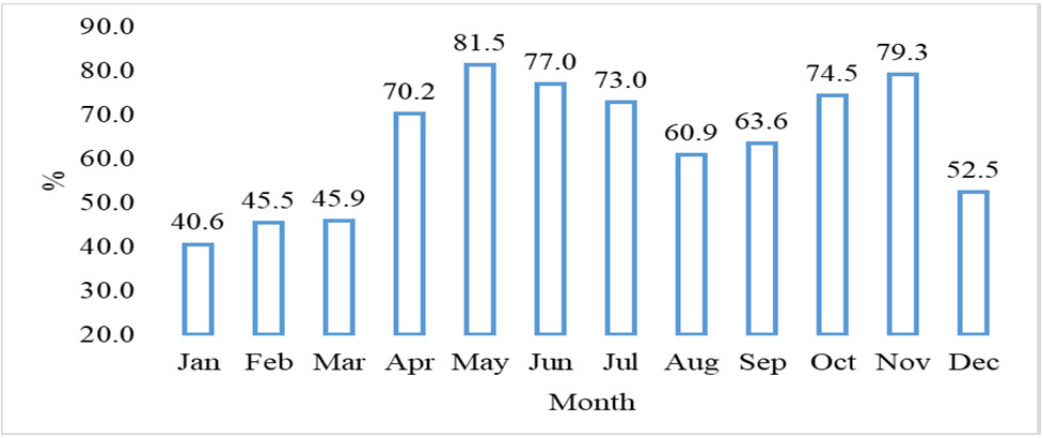

Fig. 4. Ratio between mean montly sum of atmospheric precipitation at meteorological station and satellite data in Tbilisi in 2001 – 2020.

As noted above ground-based measurements are lower than satellite data for all months of the year. The difference between the average values of Prec_MS and Prec_Sat over 20 years (Fig. 3) varies from -8.8 mm (November) to -33.4 mm (March). Ratio between the average values of Prec_MS and Prec_Sat (Fig. 4) varies from 40.6 % (January) to 81.5 % (May).

There is a direct linear correlation and regression between the studied parameters (Table 3).

Table 3. The values of the coefficients of the linear regression equation (a and b) and the correlation coefficient (R) between montly (Jan-Dec), all 240 months and mean monthly (Aver.) sum of atmospheric precipitation at meteorological station and satellite data in Tbilisi in 2001 – 2020. α (R) < 0.005.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan-Dec	Aver.
a	1.05	0.80	0.79	0.95	0.43	0.64	0.49	0.92	1.06	0.91	0.95	1.03	0.85	1.03
b	23.6	25.0	39.4	30.4	74.8	53.3	43.9	25.7	18.3	21.2	10.4	14.8	27.7	20.0
R	0.83	0.86	0.76	0.94	0.72	0.69	0.65	0.85	0.82	0.92	0.83	0.88	0.86	0.97

Table 3 show that for separate month coefficient of correlation changes from 0.65 (July, moderate correlation) to 0.94 (April, very high correlation), for all observational data (Jan-Dec, 240 months) coefficient of correlation is 0.86 (high correlation). Coefficient of correlation between average values of the studied parameters is 0.97 (very high correlation).

Conclusion

Similar comparisons will be made for other meteorological stations in Georgia in the near future.

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