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# PRELIMINARY RESULTS OF A STUDY OF THE RELATIONSHIP BETWEEN THE VARIABILITY OF THE MEAN ANNUAL SUM OF ATMOSPHERIC PRECIPITATION AND LANDSLIDE PROCESSES IN GEORGIA

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

*[*]M. Nodia Institute of Geophysics of I. Javakhishvili Tbilisi State University*
*[**]I. Javakhishvili Tbilisi State University*
*e-mail: avtandilamiranashvili@gmail.com*

**Summary:** Preliminary results of the study of the relationship between the variability of the mean annual sum of atmospheric precipitation and landslide processes in Georgia for 32 years are presented. In particular, it was found that with an increase in the annual sum of atmospheric precipitation, the tendency of increase in the number of landslides is observed in accordance with a second power of polynomial.

**Key words:** Landslide, atmospheric precipitations.

## Introduction

Landslides occupy an important place among the list of natural disasters. The danger of landslide processes is manifested not only in the damage they cause, but also in their almost ubiquitous distribution [1]. Landslides are often accompanied by human casualties [2]. This problem is very topical for Georgia as well. Despite the small territory of the country, the number of landslides included in the cadaster reaches 7000 here [3]. In connection with the above, the study of landslide processes in Georgia has always been and is receiving special attention [4-8].

Landslide phenomena depend on many processes, one of which is atmospheric precipitation [3,9,10]. At the same time, the time scale of the effect of atmospheric precipitation on provoking landslides has a wide range - from several tens of minutes to several days, months, and years (climatic time scale). This paper presents the preliminary results of a study of the relationship between the variability of the mean annual sum of atmospheric precipitation and landslide processes in Georgia for 32 years.

## 1. Study area, material and methods

Study area – territory of Georgia.

The data of Georgian National Environmental Agency about the mean annual sum of atmospheric precipitations for 39 meteorological stations and number of landslides are used. Period of observation: 1966-1968, 1971-1991, 1995-1998, 2001-2004 (32 years). The locations of meteorological stations and their names are shown in fig. 1 and 3.

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

The following designations will be used below: Mean – average values; Min – minimal values; Max - maximal values; Range – Max-Min; St Dev - standard deviation; $C_v$ – coefficient of variation, %; $\sigma_m$ – standard error; 95%(+/-), 95% confidence interval of average; $R^2$ – coefficient of determination; R – coefficient of linear correlation; $R_K$ - Kendall rank correlation coefficient; $R_S$ - Spearman rank correlation coefficient; $\alpha$ - the level of significance.

## Results and discussion

Results in table 1,2 and fig. 1-4 are presented.

In table 1 the statistical characteristics of mean annual sum of atmospheric precipitation for 39 meteorological station of Georgia in investigation period are presented. For clarity, fig. 1 shows the location of these stations on the study area and the values of the mean annual sum of atmospheric precipitation at each of them.

Table 1. Statistical characteristics of mean annual sum of atmospheric precipitation for 39 meteorological station in investigation period.

| Mean | Min | Max | Range | Median | St Dev | σm | Cv (%) | 95%(+/-) |
|---|---|---|---|---|---|---|---|---|
| 1085 | 402 | 2531 | 2129 | 984 | 509 | 83 | 47 | 162 |

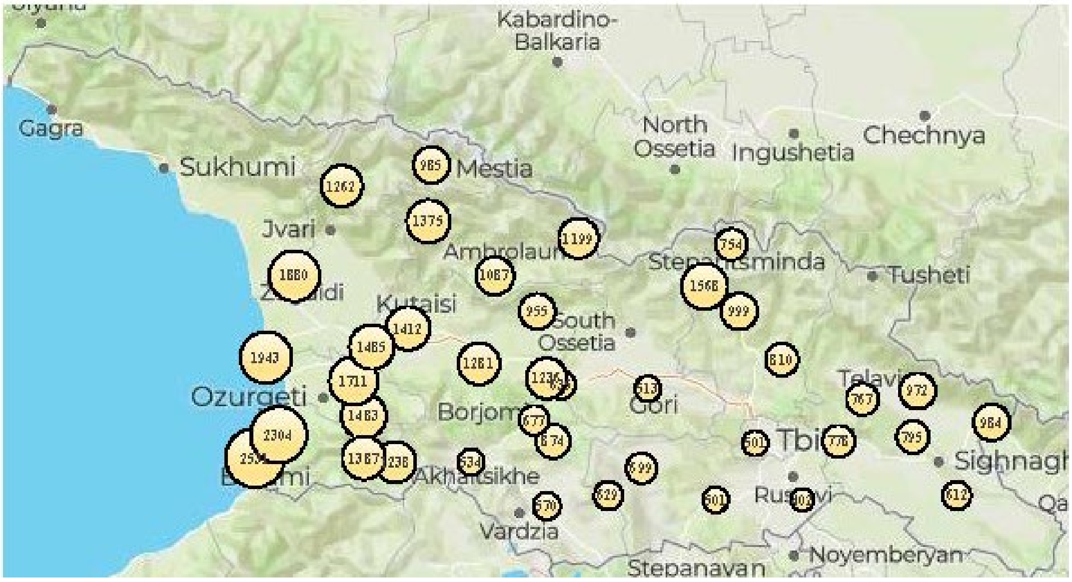


Fig. 1. Map of mean annual sum of atmospheric precipitation in Georgia in investigation period.

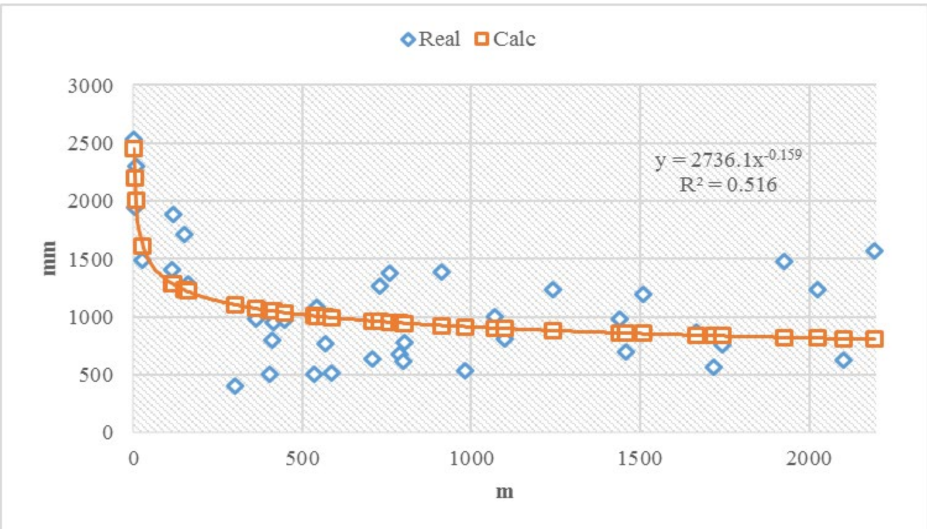


Fig. 2. Vertical distribution of mean annual sum of atmospheric precipitation in Georgia (($\alpha(R^2) < 0.005$).

As follows from table 1 and fig. 1, the distribution of the mean annual sum of atmospheric precipitation in Georgia is extremely uneven and varies from 402 mm (Gardabani) to 2531 mm (Batumi). The median value is 984 mm, coefficient of variation - 47%.

The vertical distribution of mean annual sum of atmospheric precipitation in Georgia has the form of power function on the height of locality (fig. 2). It should be noted that in the altitude range of 300–2200 m at most stations, the mean annual sum of atmospheric precipitation varies practically within the median value without a tendency to increase or decrease (fig. 2). Accordingly, the data averaged over all stations on the mean annual sum of atmospheric precipitation should adequately characterize their regime for the territory of Georgia as a whole.

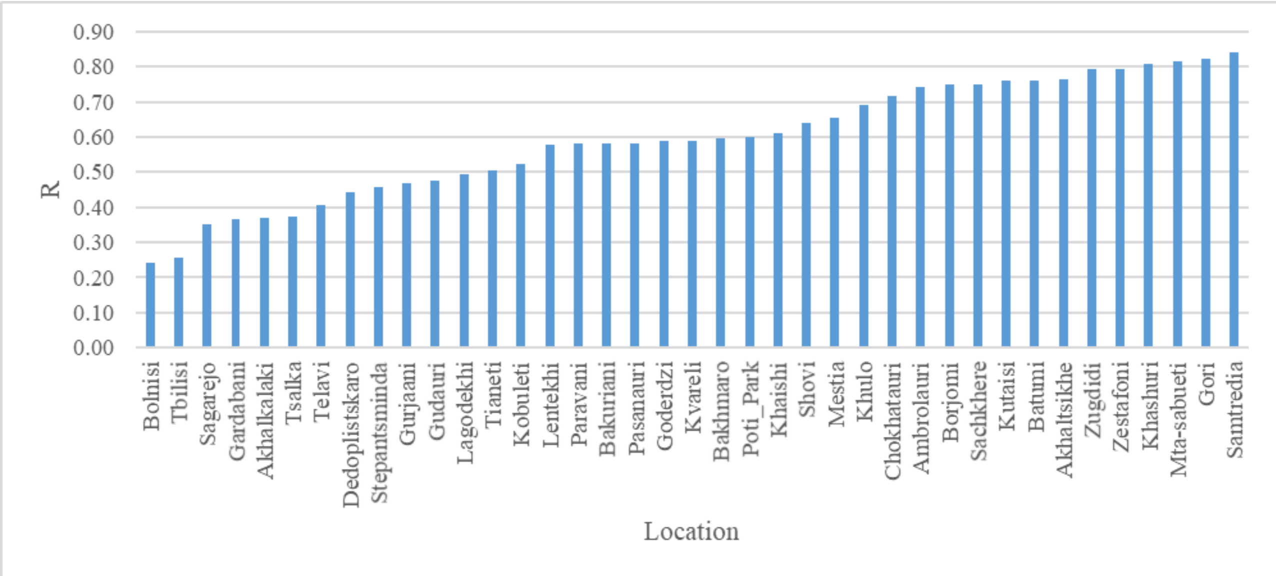


Fig.3. Linear correlation between mean annual values of atmospheric precipitations on each meteorological station with mean annual values of atmospheric precipitations, averaging on all stations.

This is confirmed by fig. 3, which shows data on the linear correlation between the annual amounts of atmospheric precipitation at each of the meteorological stations with averaged data for all stations. As follows from this figure, the R values vary from 0.24 ($\alpha = 0.1$, Bolnisi) to 0.84 ($\alpha < 0.005$, Samtredia).

Table 2. Statistical characteristics of mean annual sum of atmospheric precipitation, averaging on all stations, and number of landslides in Georgia in investigation period.

| Parameter | Mean | Min | Max | Range | Median | St Dev | $\sigma_m$ | Cv (%) | 95%(+/-) |
|---|---|---|---|---|---|---|---|---|---|
| Precipitations | 1085 | 885 | 1331 | 447 | 1076 | 112 | 20 | 10.3 | 39 |
| Landslides | 28 | 1 | 161 | 160 | 20 | 33 | 6 | 118 | 12 |

In table 2 the statistical characteristics of mean annual sum of atmospheric precipitation, averaging on all stations, and number of landslides in Georgia in investigation period are presentedAs follows from this table, the variations in the number of days with landslides are significantly higher than the variations in the mean annual sum of atmospheric precipitation for the territory of Georgia (Cv = 118 and 10.3%, respectively). Therefore, the relationship between these parameters should be more qualitative than quantitative.

Comparison of 32 years of series of observations of the mean annual sum of atmospheric precipitation for Georgia and the number of days with landslides showed that there is a direct correlation between these parameters: $R = 0.33$ ($\alpha = 0.05$), $R_K = 0.20$ ($\alpha = 0.12$), $R_S = 0.28$ ($\alpha = 0.11$). The values of these correlation coefficients, although low, are significant. That is, at least it can be argued that with the annual scale of data averaging, is fixed a tendency for the number of days with landslides to increase with an increase in the annual sum of atmospheric precipitation.

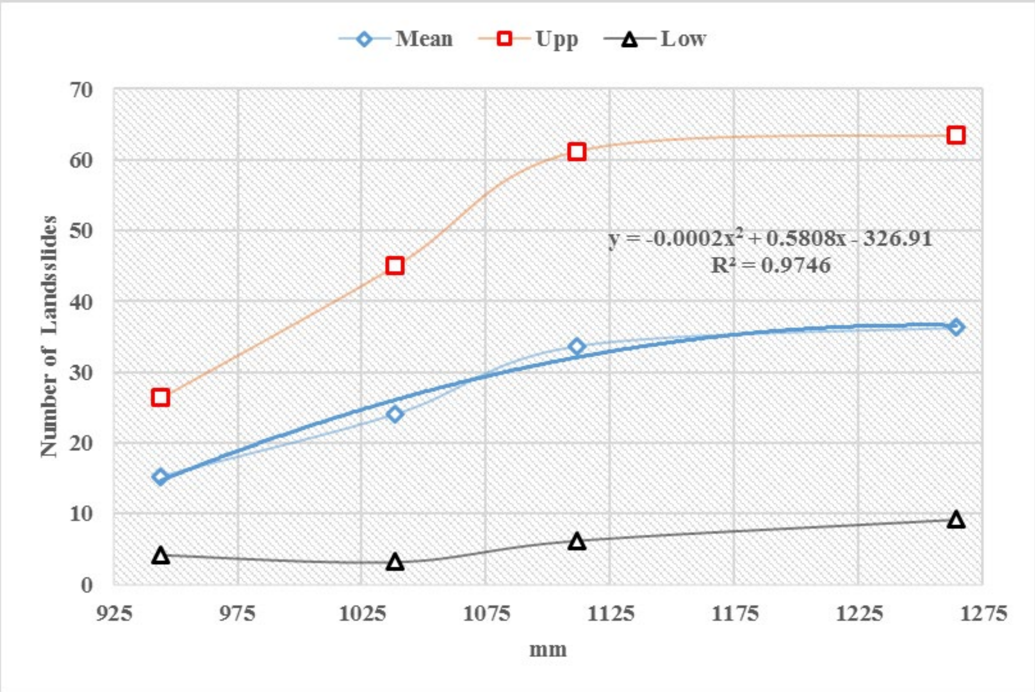


Fig.4. Connection of number of lanslides in Georgia with mean annual values of atmospheric precipitations, averaging on all meteorological stations (($\alpha(R^2)$ = 0.01).

In fig. 4 dependency cyrves of number of lanslides in Georgia with mean annual values of atmospheric precipitations, averaging on all meteorological stations, are presented. Landslide number data were averaged for four ranges of annual sum of atmospheric precipitation for the territory of Georgia: 885-1012 mm (7 years), 1018-1073 mm (8 years), 1075-1200 mm (11 years), 1242-1331 mm (6 years ). As follows from this figure with an increase in the annual sum of atmospheric precipitation, the tendency of increase in the number of landslides is observed in accordance with a second power of polynomial. At the same time, there is a fairly wide range of the upper and lower levels of the confidence interval for the average values of the number of days with landslides.

**Conclusion**

It is shown that even with the annual scale of averaging data on the sum of atmospheric precipitation and the amount of landslides in Georgia, a tendency towards an increase in the activation of landslide processes with an increase in precipitation is noticeable.

In the future, these studies will be continued with a variety of scales of averaging ground-based and satellite observations in accordance with the Shota Rustaveli National Science Foundation of Georgia project FR-19-8190 “Assessment of landslide and mudflow hazards for Georgia using stationary and satellite rainfall data”

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