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THE INFLUENCE OF CIRCULAR PROCESSES ON CHANGES IN PRECIPITATION IN THE SCOPE OF CLIMATE CHANGE

*Lamzira Lagidze[1], Lia Matchavariani[1] and Nino Paichadze[1]

[1]Faculty of Exact and Natural Sciences, Ivane Javakhishvili Tbilisi State University, Georgia

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ABSTRACT: Global climate change is one of the main problems in the world along with terrorism and poverty. Samtskhe-javakheti region, located in the south of Georgia, is very different from other regions of the country in terms of climate conditionings which is mainly due to local circular processes. Absolute altitude of Samtskhe-Javakheti varies in the 900-3300 m range. It is surrounded by high ridges. Meridian disposition of mentioned ridges weakens the impact of large-scale atmospheric circulation processes developed in the territory of the South Caucasus and significantly strengthens the influence of local complex orographic factors (tablelands, plateaus, basins) that has considerable effect on the cloud regime. Data used in the study is mainly based on observations on atmospheric precipitation (key indicators of precipitation, their monthly and annual amounts), obtained from the following (formerly existing and currently acting in Samtskhe-Javakheti) meteorological stations and weather shelters, namely: Akhalkalaki (1967-2006), Akhaltsikhe (1971-2010) and Paravani (1967-2006). Statistical, climatological and graphical analyses of multi-year (40 year period) meteorological data is used for research. Based on analyses of data, obtained for Samtskhe-Javakheti region, observed for the 10 year periods, a sharp change of monthly and annual amounts (the increase, as well as a reduction in precipitations), was observed.

Keywords: Samtskhe-Javakheti, Orography, Circulation Processes, Climate Change, Precipitations.

1. INTRODUCTION

According to data of the International Panel on Climate Change (IPCC), in the course of 100 years (1906-2005) average air temperature has increased by 0,74°C [1], while in 1961-2005 average global temperature has raised by 0,44°C [2], [3].

The problem of mankind's impact on the environment from the viewpoint of effect on climate formation, is the most important at the modern stage. In the future it may become the reason of further progress or degradation [4]. Georgia with its complex physical-geographical conditions (the altitude of the country above sea level is 0-5068 m), is considered a classical example of a mountainous country with diversified climatic conditions. In this respect, Samtskhe-Javakheti, one of the most important regions of Georgia, is outstanding and characterized by the diversified climatic conditions (fig. 1). It is located to the southward of the country and climate here is sharply distinguished from climate conditions of other regions of Georgia (that is caused by effect of local factors).

Absolute altitude of Samtskhe-Javakheti varies in the 900-3300 m range. It is surrounded by high ridges. Meridian disposition of mentioned ridges weakens the impact of large-scale atmospheric circulation processes developed in the territory of the Transcaucasus and significantly strengthens the influence of local complex orographic factors (tablelands, plateaus, basins) that has considerable effect on the cloud regime [5].

Fig. 1 Location of study area (Samtskhe-Javakheti region), Georgia

Both climate and natural conditions markedly differ from each other according to regions of Samtskhe-Javakheti. Even climate and natural conditions of Samtskhe and Javakheti are different. Javakheti is characterized by a very continental climate, according to the nature of hypsometric development and vegetative cover. The situation is comparatively different in settlements located in gorges and on Akhalkalaki plateau, where due to terrace system are developed different sectors of economy and agriculture [6].

Agriculture is the leading branch of the regional economy. As is known the climate is one

of the most important natural components of agriculture, that's why an assessment of precipitation amount in the region is of special significance in order to rationally use climate conditions of the region [7], [8].

Region of Samtskhe-Javakheti is also distinguished from the recreational viewpoint. Different kinds of resorts are located there: mountain ski resort (Bakuriani), health-related (Likani), mineral waters (Borjomi). That's why the study of this region against the background of climate changes is especially important for sustainable development of economy, power engineering, agriculture, etc.

Crucial role in the formation of a climate of Samtskhe-Javakheti is assigned to atmospheric precipitation.

2. INITIAL MATERIAL

Use at most three levels of headings that correspond to chapters, sections and subsections. The first level headings for chapter titles should be in 10pt, bold, justified, and upper case font. Leave one-blank line before and after the first level headings, respectively.

2.1 Basic Circulation Processes – Conditioning Factors of Precipitation

Western processes, which cause cloudy and rainy weather in the western part of the region, play a significant role in weather formation in Samtskhe-Javakheti, that's why the major part of the fallout down throughout a year is related to these processes [9].

The role of air masses intrusion from the East in the formation of weather and climate of Samtskhe-Javakheti is relatively lesser. Its impact is important in Akhaltsikhe hollow and Akhalkalaki plateau.

Eastern processes are more intense in spring, since during these processes takes place increase of instability of air masses and temperature of underlayer surface that promotes the development of convectional processes [10].

Peculiar synoptic processes and characteristic weather conditions are developed due to wave perturbations formed southward of the South Caucasus, which are mainly bilateral or develop after completion of air masses intrusion from the west. Among total atmospheric precipitation falling out throughout a year up to 150 mm of precipitation falls on southern processes. Sometimes they are distinguished by high intensity and continue for several days. Process duration depends on the intensity of air masses intrusion [5].

Climate peculiarities of Samtskhe-Javakheti, especially its moisture regime (humidity conditions), are mainly conditioned by convectional processes (due to south location of the region), which have great influence on the total amount of precipitation and their annual distribution. Abundant precipitation for a short time and of local character are characteristic for mentioned processes. Usually they don't cover large territories, but about 30-40% of precipitation falling out in summer fall on these processes.

As it turned out from analysis of atmospheric circulation processes, their action and intensity in the region varies according to seasons that causes seasonal peculiarities of climate conditions here.

Orographic barriers also are significant precondition of climate peculiarities of the area. The Greater Caucasus mountains are important for the formation of regional climate, since they impede intrusion of cold air masses from the north to the Southern Caucasus and, in particular, to the territory of Samtskhe-Javakheti. Arsiani and Adjara-Imereti ridges, which impede diffusion of humid air masses coming from the west, also represent an important orographic barrier for Samtskhe-Javakheti. That's why their windward slopes are characterized by abundant precipitation, while leeward slopes, adjacent gorges and basins are distinguished by less precipitation. All this creates very important climate contrast here [10].

Observation data from meteorological stations, in particular basic characteristics of precipitation, their monthly and annual amounts, were used for establishment of atmospheric precipitation dynamics in Samtskhe-Javakheti (fig. 2).

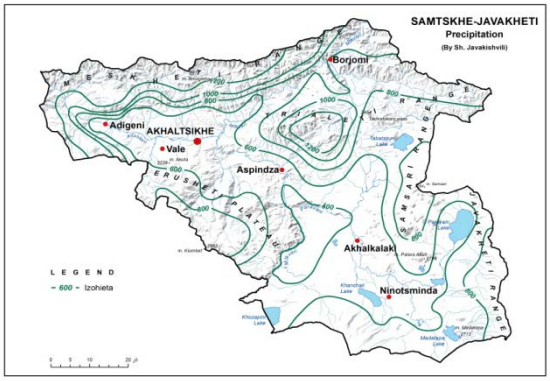

Fig.2 Total precipitation in Samtskhe-Javakheti region, Georgia (1903-1967)

Data of observation over atmospheric precipitation obtained from the following (formerly existing and currently acting in Samtskhe-Javakheti) meteorological stations and weather shelters are used for the study, namely: Akhalkalaki (1967-2006), Akhaltsikhe (1971-2010) and Paravani (1967-2006). Statistical, climatological and graphical analyses of multi-year meteorological data is used for research.

3. RESULTS AND DISCUSSION

The dynamics of the total amount of precipitation according to seasons and 10-year periods is determined for 40-year period with the use of the basic characteristics of precipitation – their monthly and annual amounts. Materials of observations over the annual precipitation amount according to periods are represented in the form of diagrams (Fig. 3-11).

Akhalkalaki – for determination of precipitation changes we used 1967-2006 observation materials, which were divided into four 10-year periods: 1967-1976, 1977-1986, 1987-1996, 1997-2006.

Study analysis shows, that under the influence of global climate changes in Akhalkalaki, from 1967 to 2006 (40-year period) total amount of precipitation (according to 10-year periods) experiences the following changes: during the period precipitation amount varies from 190 to 1004 (Fig. 3).

In period I (during 1967-1976), total amount of precipitation changes from 245 mm to 1004 mm. In winter – from 245 mm to 274 mm, in spring – from 275 mm to 859 mm, in summer – from 516 mm to 1004 mm, in autumn period – from 349 mm to 419 mm. The total amount of precipitation of the mentioned period equals to 5633 mm.

In period II (1977-1986), in the course of nine years, the total amount of precipitation changes from 190 mm to 865 mm. The minimum is registered in January, while the maximum – in May. In the winter period, total amount of precipitation changes from 190 mm to 274 mm, in spring – from 301 mm to 865 mm, in summer – from 501 mm to 846 mm, in autumn – from 315 mm to 429 mm. Annual precipitation amounts of this period equals to 5360 mm.

In period III (1987-1996), the total amount of precipitation varies from 265 mm to 920 mm. The maximum is registered in June, while the minimum – in March. In the winter period, annual precipitation amount changes from 303 mm to 371 mm, in spring – from 265 mm to 689 mm, in summer – from 441 mm to 920 mm, and in autumn – from 326 mm to 428 mm. Precipitation amount of this period (1987-1996) equals to 5421 mm.

In period IV (1997-2006), the annual precipitation amount varies from 310 mm to 901 mm. The maximum is registered in May, while the minimum – in November. In the winter period, annual precipitation amount changes from 354 mm to 388 mm, in spring – from 555 mm to 901 mm, in summer – from 541 mm to 845 mm, and amount of the IV period is 6528 mm.

Comparison of 10-year periods in Akhalkalaki (1967-2006) has shown that during winter period, minimum precipitation amount is observed in the II period – 190 mm, while the maximum is in the IV period – 388 mm (fig. 3). In spring, we have a minimum annual precipitation amount in the III period – 265 mm, while the maximum – in the IV period – 901 mm. Minimum value in summer is registered in the III period – 441 mm, while the maximum is registered in the I period – 1004 mm. Minimum value in autumn is observed in the IV period – 310 mm, and the maximum is in the IV period – 512 mm.

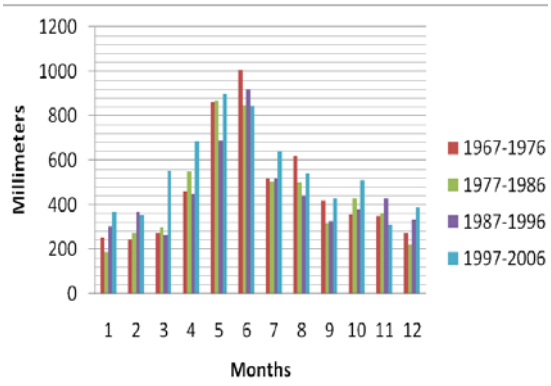

Fig.3 Precipitation change according to months in 10-years period – 1967-2006 (Akhalkalaki)

In the mentioned period, according to data on precipitation (1967-2006) during four 10-year periods is observed the change of precipitation amount according to periods (from I to IV period). During periods I and II, the total amount of precipitation decreased by 273 mm, from II to III period, it increased by 61 mm, also from III to IV period precipitation amount increased by 1107 mm. So, during 40 years, the increase in precipitation is registered equal to 895 mm (Fig. 4).

Materials of observations over the annual precipitation amount in the course of years (1967-2006) are presented in Fig. 5, where clearly shows the rapid change of total precipitation during last period.

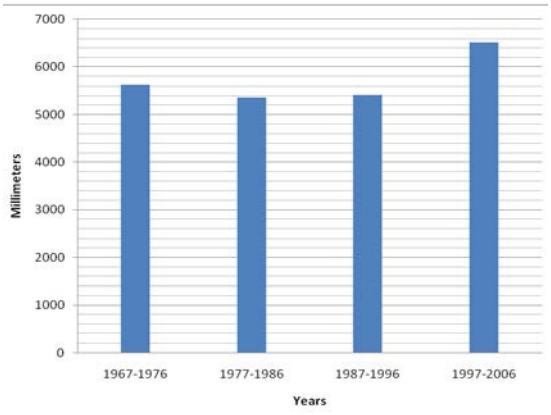

Fig.4 Total precipitation change in 10-years period – 1967-2006 (Akhalkalaki)

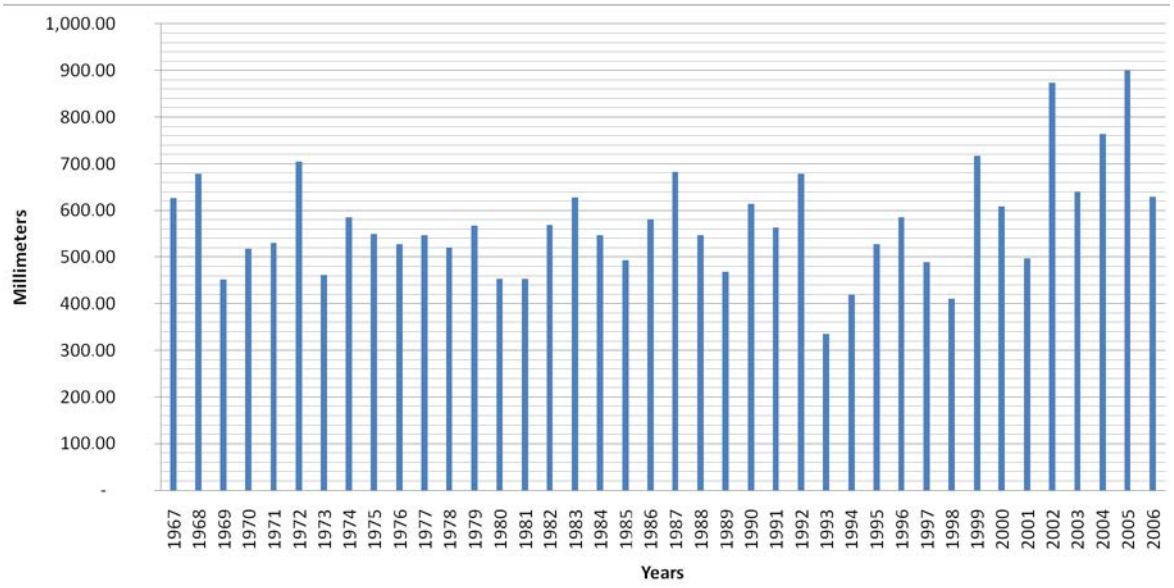

Fig.5 Annual variations of total precipitation in 1967-2006 (Akhalkalaki)

Akhaltsikhe – for determination of precipitation changes we used 1971-2010 observation materials, which were divided into four 10-year periods: 1971-1980, 1981-1990, 1991-2000, 2001-2010.

Materials of observations over the annual precipitation amount according to periods are represented in the form of diagrams (Fig. 6-7).

Study analysis shows that under the influence of global climate changes in Akhaltsikhe, from 1971 to 2010 (40-year period) total amount of precipitation (according to 10-year periods) experiences the following changes: during the period total precipitation vary from 183 mm to 880 mm (December-June) (fig. 6).

In period I (1971-1980) in the course of years, the total amount of precipitation changes from 187 mm to 810 mm (January-May), in winter – from 187 mm to 360 mm, in spring – from 325 mm to 810 mm, in summer – from 436 mm to 794 mm, in autumn period from 318 mm to 367 mm. The total amount of precipitation of mentioned period is 5273 mm.

In period II (1981-1990) in the course of the years, the total amount of precipitation changes from 259 mm to 880 mm, minimum is in December, the maximum – in June. In the winter period, the total amount of precipitation changes from 259 mm to 291 mm, in spring amount changes from 277 mm to 742 mm, in summer – from 475 mm to 880 mm, in autumn from 274 mm to 376 mm. The total amount of precipitation of this period is 5389 mm.

In period III (1991-2000), the total annual precipitation amount changes from 207 mm to 758 mm, maximum precipitation is registered in June, minimum – in February. In winter period precipitation change from 207 mm to 326 mm, in spring - from 363 mm to 636 mm, in summer – from 434 mm to 758 mm, in autumn from 323 mm to 350 mm. The total amount of precipitation of this period (1991-2000) is 4867 mm.

In period IV (2001-2010), the total amount of precipitation, changes from 183 mm to 726 mm, maximum is registered in June, minimum – in December. In the winter period, precipitation amount changes from 183 mm to 292 mm, in spring – 435-660 mm, in summer –372-726 mm, in autumn – from 293 mm to 480 mm. The total amount of precipitation of the IV period equals to 5440 mm.

Comparison of a 10-year periods in Akhaltsikhe (1971-2010) shows that during a winter period minimum precipitation amount is observed in the IV period – 183 mm, while the maximum is in I period – 360 mm. In spring we have a minimum amount in the II period – 277 mm, while the maximum – in the IV period – 810 mm (fig. 5). Minimum value in summer is registered in the III period – 434 mm, while the maximum is registered in the II period – 880 mm. Minimum value in autumn is observed in the II period – 274 mm, and the maximum is in the IV period – 480 mm.

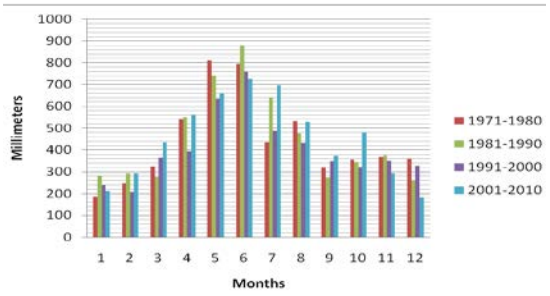

Fig.6 Precipitation change according to months in 10-years period – 1971-2010 (Akhaltsikhe)

In the mentioned period, according to data on precipitation (1971-2010) during four 10-year periods is observed the change of precipitation amount according to periods (I-IV periods). During 40 years, is registered the increase in precipitation, which equals to 167 mm/40 years (fig. 7).

Materials of observations over the annual precipitation amount in the course of years (1971-2010) are represented in figure 8, where have observed the changes (decrease-increase) of total annual precipitation during last period.

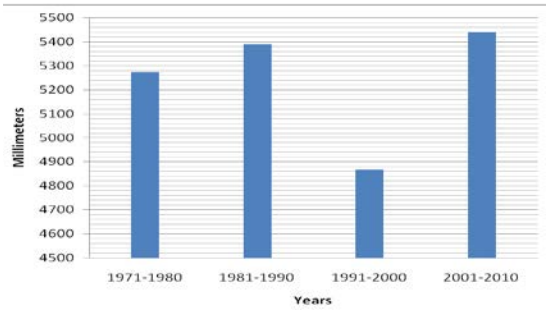

Fig.7 Total precipitation change in 10-years period – 1971-2010 (Akhaltsikhe)

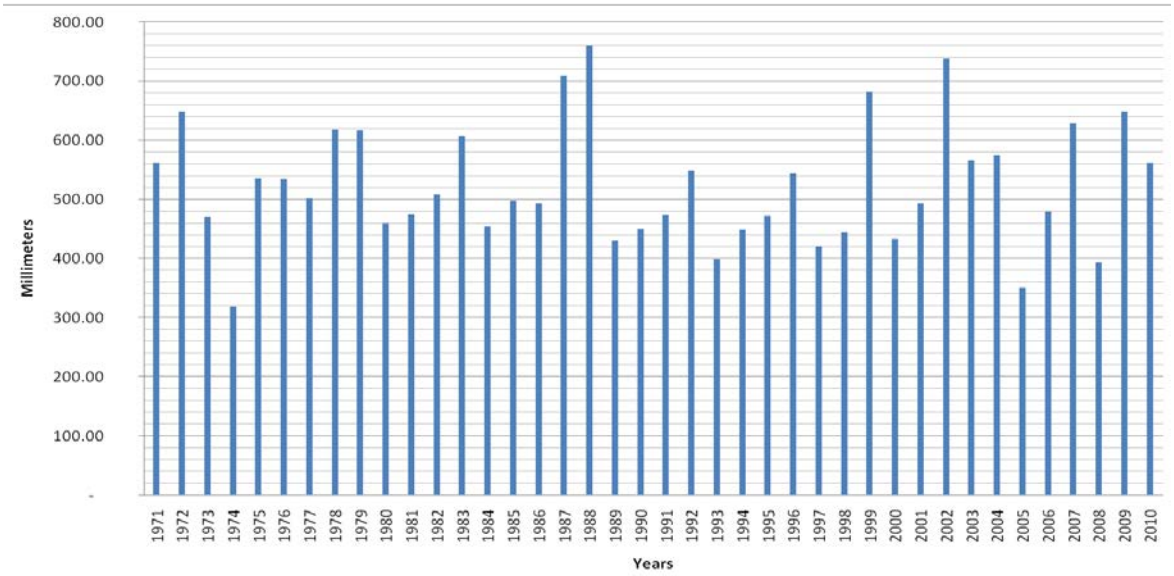

Fig. 8 Annual variations of total precipitation in 1971-2010 (Akhaltsikhe)

Paravani. 1967-2006 observation materials were used for determination of Paravani precipitation change. They were divided into 4 periods: 1967-1976, 1977-1986, 1987-1996, 1997-2006.

Materials of observation over the total amount of precipitation according to periods are represented in the form of table and diagrams (fig. 9-11).

Study analysis shows that under influence of global climate changes in Paravani, from 1967 to 2006 total amount of precipitation (according to 10-years period) experiences the following changes: throughout a year total precipitation vary from 198 mm to 996 mm (January-May) (fig. 9).

In the I period (during 1967-1976) total amount of precipitation changes from 360 mm to 996 mm, in winter – from 425 mm to 570 mm, in spring – from 541 mm to 996 mm, in summer – from 497 mm to 929 mm, in autumn period – from 360 mm to 482 mm. The total amount of precipitation of this period equals to 6936 mm.

In the II period (1977-1986) total amount of precipitation in the course of years varies from 369 mm to 977 mm, it is minimal in November, while is maximal in May. In winter period, the total amount of precipitation changes from 387 mm to 455 mm, in spring – from 406 mm to 977 mm, in summer – from 487 mm to 935 mm, in autumn - from 369 mm to 453 mm. The total amount of precipitation of this period equals to 6490 mm.

In the III period (1987-1996) total amount of precipitation varies from 224 mm to 876 mm. The maximum amount is registered in June, the minimum – in September. In the winter period, total amount of precipitation changes from 281 mm to 380 mm, in spring – from 255 mm to 628 mm, in summer – from 355 mm to 876 mm, in autumn – from 224 mm to 389 mm. The total amount of precipitation of this period (1987-1996) equals to 4810 mm.

The total amount of precipitation of the IV period (1997-2006) varies from 198 mm to 706 mm, a maximum amount is registered in June, minimum – in January. In the winter period, total amount of precipitation changes from 198 mm to 330 mm, in spring – from 316 mm to 693 mm, in summer – from 469 mm to 706 mm, in autumn – from 255 mm to 416 mm. The total amount of precipitation of the IV period is 5128 mm.

Comparison of 10-year periods in Paravani (1967-2006) shows that during a winter period minimum precipitation amount is observed in the IV period – 198 mm, while the maximum is in the I period – 996 mm (fig. 9). In winter the minimum amount is in the IV period – 198 mm, while the maximum – in the I period – 570 mm. In spring we have a minimum precipitation amount in the III period – 255 mm, while the maximum is in the I period – 996 mm. Minimum value in summer is in the III period – 355 mm, while the maximum is registered in the II period – 935 mm. Minimum value in autumn is observed in the III period – 224 mm, and the maximum is in the I period – 482 mm.

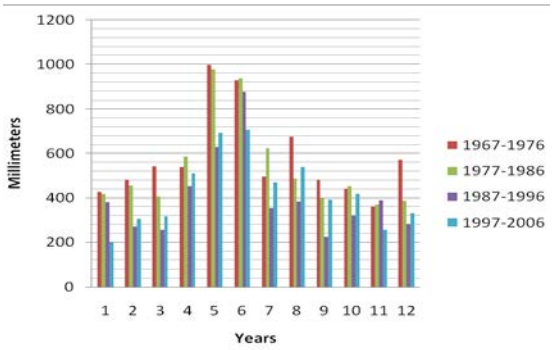

Fig. 9 Total precipitation change according to months in 10-year periods – 1967-2006 (Paravani)

In the mentioned period, according to data on precipitation (1967-2006) during four 10-year is observed the change of the total amount of precipitation according to periods (from I to IV period) (fig. 10). During I and II periods, the total amount of precipitation decreased by 446 mm, from II to III period, it decreased by 1680 mm, and from III to IV period precipitation amount increased by 318 mm. So, during 40 years, is registered the decrease in precipitation.

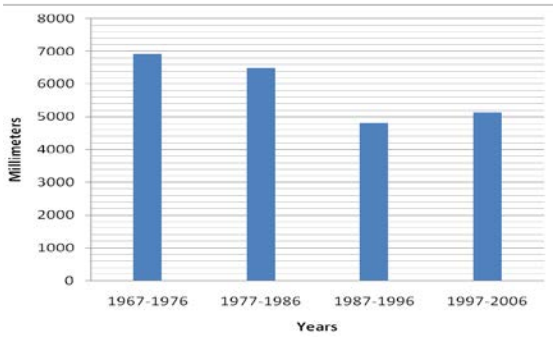

Fig. 10 Total precipitation change in 10-years periods – 1967-2006 (Paravani)

Material of observations over annual precipitation amount is represented in figure 11, where is observed the rapid changes of precipitation amount during mentioned years.

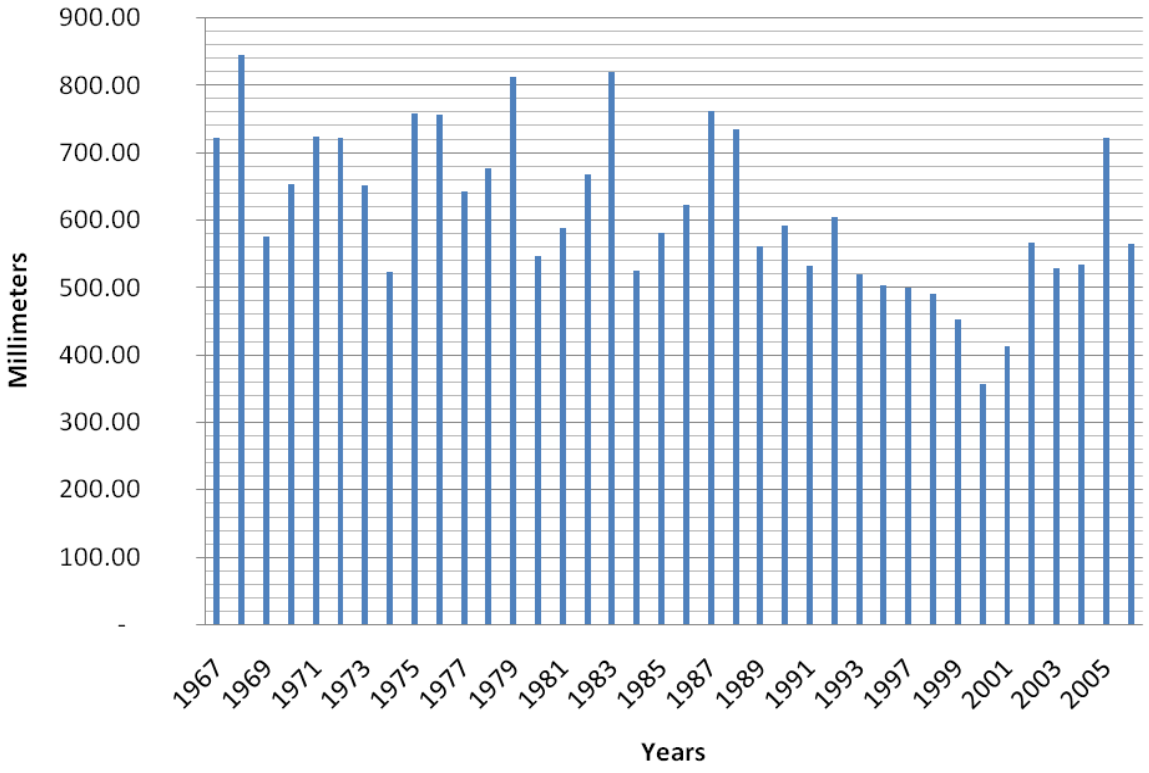

Fig. 11 Annual variations of total precipitation in 1967-2006 (Paravani)

As seen from analysis of studies carried out for assessment of global climate change, in Samtskhe-Javakheti, the diverse picture of precipitation changes was observed. These was based on a 10-year period of meteorological observation data available at each meteorological station but in some cases a study was carried out in different years (due to unavailability of materials). As a result of analysis on 10-year average values of precipitation amounts (40-year periods) we obtained the following results:

- in Akhalkalaki during I-IV periods (1967-2006) total amount of precipitation increased by 895 mm. In I-II periods was registered the decrease by 273 mm, in II-III periods, it increased by 61 mm, while in III-IV periods it was increased again by 1107 mm.
- in Akhaltsikhe during I-IV periods (1971-2010) total amount of precipitation in the whole time range increased by 167 mm. From here in I-II periods, it increased by 116 mm, in II-III periods were registered a decrease by 522 mm, while in III-IV periods it was increased again by 573 mm.
- in Paravani during I-IV periods (1967-2006) total amount of precipitation in the whole time range decreased by 1808 mm. From here in I-II periods, it decreased by 446 mm, in II-III periods were registered a decrease by 1680 mm, while in III-IV periods it was increased by 318 mm.

4. CONCLUSION

On the background of global warming, the change of the regional climate in Samtskhe-Javakheti has special peculiarities, which are important in the regions, located in a warming or cooling border area. The boundary between these opposite processes must be found on the territory of Georgia. The main cause of regional climate change, besides of Global climate change, is due to the region's climate and orographic distinctiveness.

Results of study of meteorological observation materials in Samtskhe-Javakheti allow us to make the conclusion that against the background of climate changes takes place rapid variation of total precipitation: in 1967-2006 in Akhalkalaki was observed increase in annual total precipitation by 895 mm, and in Paravani – decrease by 1808 mm. In Akhaltsikhe (1971-2010) total amount of precipitation was increased by 167 mm.

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