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Special Features of Changeability of Daily Sum of Precipitation in Tbilisi in 1957-2006

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Abstract

Wide-ranging studies of contemporary climate change in Georgia were begun in 1996 and they continue on the present time. First of all the inventory of greenhouse gases in Georgia was carried out, spatial-temporary variations in the fields of temperature, precipitation, cloudiness, aerosol air pollution, surface cover and other climate-forming parameters were studied. Later there have been begun works on forecasting of air temperature and precipitation change in some region of Georgia.

In particular results of detailed statistical analysis of the average semi-annual and annual values of precipitation in Tbilisi for the period 1957-2006 are presented earlier. In the indicated period of time the weak positive trend of precipitation in the cold period of year was observed. A trend of precipitation for warm half-year periods was not observed. For a year the weak tendency of an increase of the precipitation was observed.

In this work, which presents the continuation of the foregoing studies, some results of the standard statistical analysis of observational data of the Hydrometeorological department of Georgia of daily sum of precipitation (DSP) in Tbilisi in 1957-2006 are represented.

Thus, the statistical structure of atmospheric precipitation with daily intensity of 0.1-2, 2.1-5, 5.1-15, 15.1-30 and >30 mm and annual quantity of days without and with precipitation for the ten five-year time intervals from 1957-1961, 1962-1966,…, to 2002-2006 is studied.

The weak positive and positive trend of DSP respectively for the ranges of 5.1-15 and 15.1-30 mm was observed. The negative and weak negative trend of DSP respectively for the ranges of 0.1-2 and 2.1-5 mm was observed. The trend of DSP with an intensity of >30 mm was not observed.

***Key words**:* Climate change, urban climate, precipitation.

Introduction

Researching intensity and distribution of precipitations has always been the most actual problem among well-known atmospheric events. It became even more important on the background of the ongoing process of climate change. Precipitation is a basic source for moistening earth's surface. It belongs to those meteorological elements, which play an active role in water-water vapor circulation. Therefore in Georgia, as in other countries, to studies of atmospheric precipitations was always given special attention. For example, study of the precipitation climatology, their statistical structure and distribution on the territory of Georgia

in the works [1-4] were carried out. The detailed data about the climatology of precipitation in Tbilisi in the book [5] are represented.

In the work [6] for the specially selected region of Eastern Georgia with 18 meteorological stations the analyses of statistical structure of spring-summer precipitation were carried out. The correlations between data from every single station are established, corresponding correlative matrix is built, and relevant analysis (including dividing the region) is done.

And some works the influence of the anthropogenic pollution of the atmosphere of the regime of precipitation was studied [7, 8]. In particular it is obtained that in the Kakheti region of Georgia during the week days a values of solid and liquid precipitations is higher than into the holydays.

The important stage of an investigation of precipitation with wide-ranging studies of contemporary climate change in Georgia was connected. These studies in 1996 were begun and they continue on the present time. First of all the inventory of greenhouse gases in Georgia was carried out, spatial-temporary variations in the fields of temperature, precipitation, cloudiness, aerosol air pollution, surface cover and other climate-forming parameters were studied. In particular it was obtained that in different regions of Georgia trends of annual sum of precipitation can be as constant, so positive and negative [9]. Later there have been begun works on forecasting of air temperature and precipitation change in some region of Georgia [10].

In particular results of detailed statistical analysis of the average semi-annual and annual values of precipitation in Tbilisi for the period 1957-2006 are presented in [10]. In the indicated period of time the weak positive trend of precipitation in the cold period of year was observed. Trend of precipitation in warm half-year periods are not observed. Clearly expressed trend of precipitation for a year are not observed also. It is observed the weak tendency of an increase in the precipitation with the little significant level of linear correlation coefficient.

Information about atmospheric precipitations for the development of the bioclimatic characteristics of territories has great importance. For example, during the calculation of the most widely known and applied tourism climate index proposed by Mieczkowski [11] data about atmospheric precipitations are necessary. This index is combination of seven factors and parameters with max value 100. In this case the share of the role of precipitation in the values of tourism climate index can reach to 20 %.

So, under the more-less similar thermal conditions of the atmosphere the decisive role in the values of tourism climate index (TCI) have the value of precipitation. For example, because of the increased values of precipitation in Batumi (capital of the Adjarian Autonomous Republic, Georgia) [12], values of tourism climate index here are lower than in Tbilisi and Anaklia (Georgia) [13-15]. Besides Batumi atmospheric precipitations substantially influence on values of TCI also in other localities of Adjara (Kobuleti, Khulo, Goderdzi) [16].

In Baku (Azerbaijan), Erevan (Armenia) and many cities of Iran (Mahabad, Jolfa, Marageh, etc,) the value of precipitation is lower than in Tbilisi, Batumi and Anaklia. Accordingly in Tbilisi, Batumi and Anaklia value of tourism climate index is lower than in the indicated cities in Azerbaijan, Armenia and Iran [17]. Thus the data about the precipitation find wide application with the certification of the health resort and tourist resources of territories in the aspect of their bioclimatic conditions [15, 18].

Excess precipitation contributes to the appearance of floods. The critical values of precipitation per 12 hours, that cause disastrous water flows, flooding in rivers and in dry ravines are: in seaside regions of Western Georgia – 130 mm and more, in the central and western part of Colchis lowland and adjoining mountains slopes – 100 mm and more, on the

remaining part of Western Georgia, on the Southern slopes of Larger Caucasus – 80 mm and more, on the remaining part of Eastern Georgia – 60 mm. Using these critical values, the recurrence rates of disastrous heavy rains are calculated and corresponding flash flood hazard maps are compiled [19-21].

As it follows from the brief of literature revue, in Georgia there are sufficiently many works on a study of precipitation, including in Tbilisi. However, there is a certain deficiency in the studies of the changeability of atmospheric precipitations in different ranges of their intensity.

In this work, which presents the continuation of the foregoing studies, some results of the standard statistical analysis of observational data of the Hydrometeorological department of Georgia about daily sum of precipitation in different ranges of their intensity in Tbilisi in 1957-2006 are represented.

Study area and methods

Study area is Tbilisi city. Data of the Hydrometeorological department of Georgia about daily sum of precipitation in different ranges of their intensity in Tbilisi in 1957-2006 are used.

The statistical structure of atmospheric precipitation with a daily intensity of 0.1-2, 2.1-5, 5.1-15, 15.1-30 and >30 mm and annual quantity of days without and with precipitation for the ten five-year time intervals from 1957-1961, 1962-1966,…, to 2002-2006 is studied.

The following designations will be used below: Min – minimal values; Max - maximal values; Stdev - standard deviation; C_v - coefficient of variation (%); R - coefficient of linear correlation; α – the two-sided level of significance; α(R) - level of significance of R; K = 100·{Value(2002-2006)/Value(1957-1961) – 1} – value of relative changeability in the last five-year period of time in comparison with the first, calculated according to the equation of the regression of trend (%). The dimensionality of the precipitation (mm) in the text in the majority of the cases is omitted.

Results and discussion

Results in table 1-3 and fig. 1-5 are presented.

Table 1

Statistical characteristics of annual sum of atmospheric precipitation for the ten five-year time intervals from 1957 to 2006 in Tbilisi

Parameter	Total sum of precipitation	Daily intensity of atmospheric precipitation				
		0.1-2	2.1-5	5.1-15	15.1-30	>30
Min	445.7	36.6	67.1	154.0	95.3	37.9
Max	601.8	49.1	92.2	236.9	148.5	119.8
Mean	493.2	41.0	79.3	186.0	122.9	64.0
Stdev	52.5	4.2	8.3	25.3	19.3	23.6
C_v,%	10.6	10.1	10.4	13.6	15.7	36.8
R	0.21	-0.39	-0.25	0.22	0.44	0.03
α(R)	0.27	0.12	0.25	0.25	0.07	no sign
	Coefficients of the linear regression equation Y = a·X + b					
a	3.71	-0.54	-0.70	1.80	2.81	-
b	472.8	44.0	83.1	176.0	107.4	-
K,%	7.0	-11.1	-7.6	9.1	22.9	-

In the table 1 statistical characteristics of annual sum of atmospheric precipitation and annual sum of precipitation with a daily intensity of 0.1-2, 2.1-5, 5.1-15, 15.1-30 and >30 mm for the ten five-year time intervals from 1957 to 2006 in Tbilisi are presented. The coefficients of the equation of the regression of trend $\mathbf{Y = a \cdot X + b}$ here are also given, where **Y** is mean annual amount of precipitation for the five-year interval of time, **X** - number of the interval of time from 1 to10 (1957-1961…2002-2006).

In the fig. 1-2 the graphs of trends of annual total sum of atmospheric precipitation and annual sum of precipitation in the different ranges of their intensity for the ten five-year time intervals from 1957 to 2006 in Tbilisi are given.

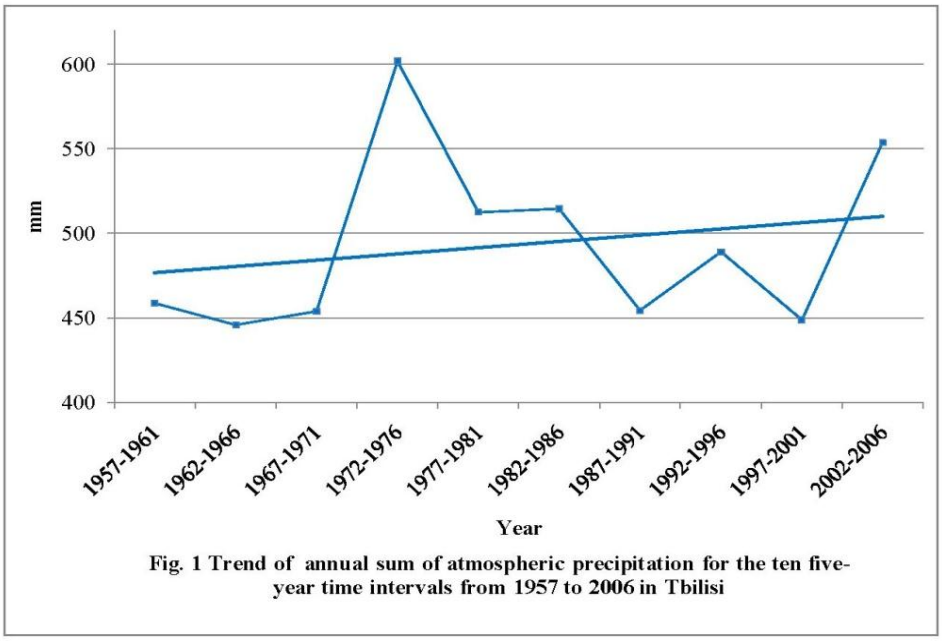

Fig. 1 Trend of annual sum of atmospheric precipitation for the ten five-year time intervals from 1957 to 2006 in Tbilisi

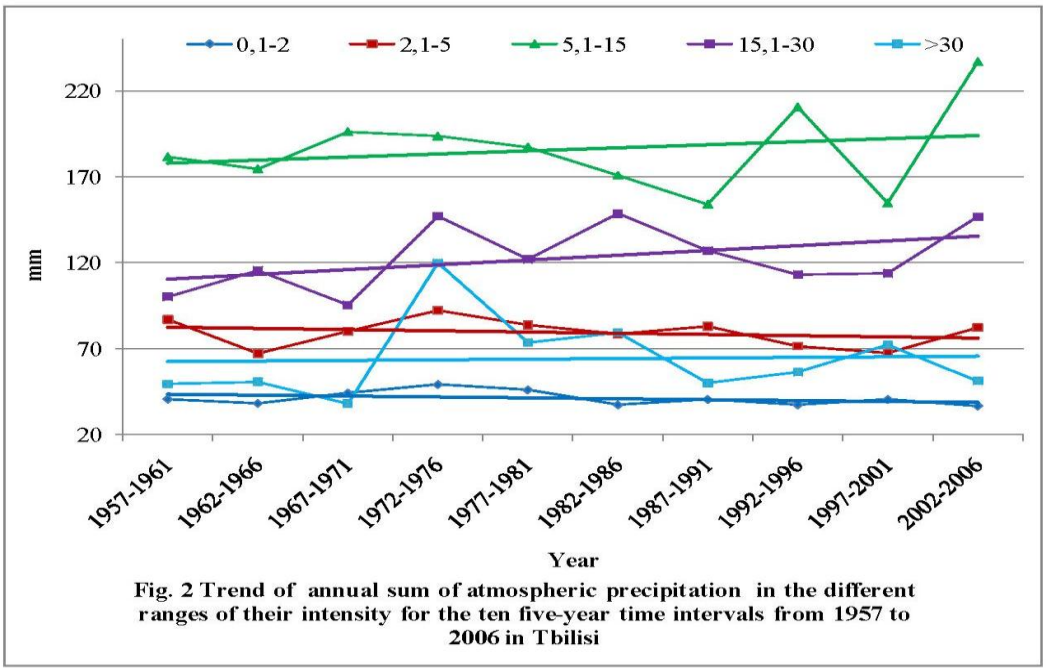

Fig. 2 Trend of annual sum of atmospheric precipitation in the different ranges of their intensity for the ten five-year time intervals from 1957 to 2006 in Tbilisi

In particular, as follows from table 1 and fig. 1-2, positive linear trends for the total sum of precipitation and precipitation in the range of their daily intensity of 5.1-15 and 15.1-

30 are observed. Trends the precipitation in the range of their daily intensity of 0.1-2 and 2.1-5 are negative. Not observed trend for precipitation with daily intensity >30.

The greatest increase in the precipitation in the last five-year period of time in comparison with the first for range 15.1-30 is noted (22.9%), the greatest decrease - for range 0.1-2 (-11.1%). An increase in the total sum of precipitation composes 7.0%.

In the table 2 statistical characteristics of the share of atmospheric precipitations in the different ranges of their intensity from the total sum of precipitation (below- the share of atmospheric precipitation) for the ten five-year time intervals from 1957 to 2006 in Tbilisi.

Table 2

Statistical characteristics of the share of atmospheric precipitations in the different ranges of their intensity from the total sum of precipitation for the ten five-year time intervals from 1957 to 2006 in Tbilisi (%)

Parameter	**Daily intensity of atmospheric precipitation**				
	0.1-2	**2.1-5**	**5.1-15**	**15.1-30**	**>30**
Min	6.6	14.6	32.2	21.0	8.4
Max	9.7	19.0	43.2	28.9	19.9
Mean	8.4	16.1	37.8	24.9	12.8
Stdev	1.0	1.6	4.3	2.5	3.6
C_v,%	11.3	9.8	11.4	10.2	27.8
R	-0.52	-0.51	-0.01	0.47	0.04
α(R)	0.05	0.05	no sign	0.07	no sign
	Coefficients of the linear regression equation Y = a·X + b				
a	-0.16	-0.27	-	0.39	-
b	9.3	17.6	-	22.7	-
K,%	-16.1	-13.9	-	15.2	-

In the fig. 3 the graphs of trends of the share of atmospheric precipitations in the different ranges of their intensity from the total sum of precipitation for the ten five-year time intervals from 1957 to 2006 in Tbilisi are given.

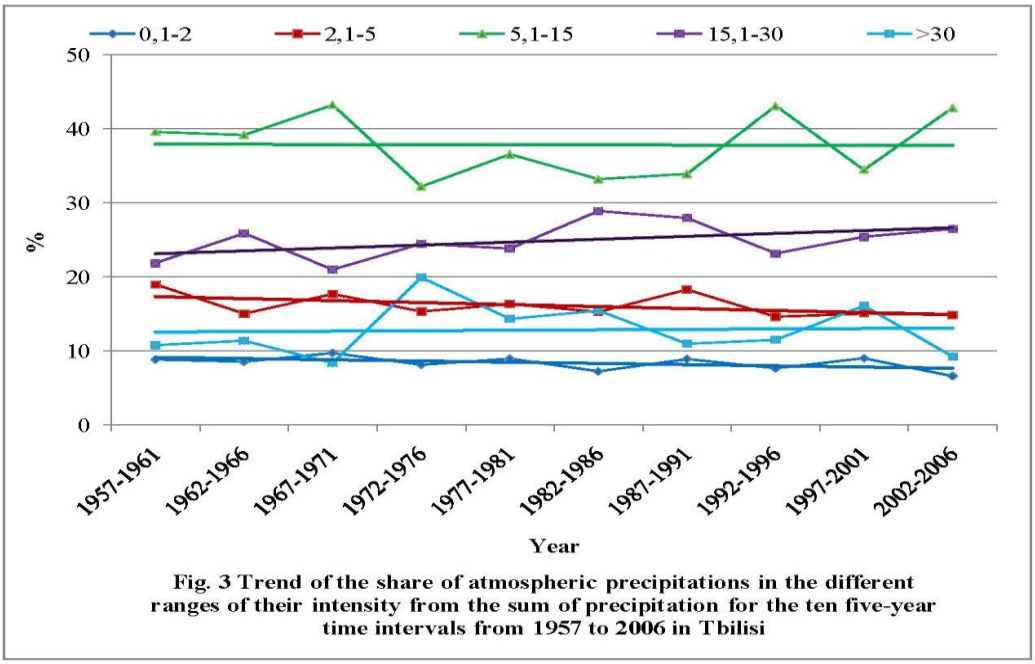

Fig. 3 Trend of the share of atmospheric precipitations in the different ranges of their intensity from the sum of precipitation for the ten five-year time intervals from 1957 to 2006 in Tbilisi

As follows from table 2 and fig. 3, the greatest contribution to the total sum of precipitation the precipitation with a day intensity of 5.1-15 is made (37.8%), smallest - with a day intensity of 0.1-2 (8.4%). Positive linear trends for the share of precipitation in the range of daily intensity 15.1-30 is observed only. Trends the share of precipitation in the range of their daily intensity of 0.1-2 and 2.1-5 are negative. Trends the share of precipitation with daily intensity 5.1-15 and >30 are not observed.

The greatest increase in the share of precipitation in the last five-year period of time in comparison with the first for range 15.1-30 is noted (15.2%), the greatest decrease - for range 0.1-2 (-16.1%).

Table 3

Statistical characteristics of annual quantity of days without and with precipitation for the ten five-year time intervals from 1957 to 2006 in Tbilisi

Parameter	Without precip.	With precip.	Daily intensity of atmospheric precipitation				
			0.1-2	2.1-5	5.1-15	15.1-30	>30
Min	249.6	87.2	35	20	17.8	4.4	1
Max	278	115.8	54.4	28.8	27.2	7.4	2.2
Mean	266.4	98.86	46.1	23.88	21.52	5.96	1.4
Stdev	8.3	8.3	6.7	2.6	2.7	1.0	0.4
C_v,%	3.1	8.4	14.6	10.9	12.6	17.0	26.1
R	0.68	-0.68	-0.89	-0.26	0.21	0.49	0.01
α(R)	0.005	0.005	0.001	0.22	0.27	0.05	no sign
	Coefficients of the linear regression equation Y = a·X + b						
a	1.9	-1.9	-1.99	-0.23	0.19	0.16	-
b	256	109.1	57.04	25.13	20.49	5.05	-
K,%	6.5	-15.7	-32.5	-8.2	8.1	28.3	-

In table 3 statistical characteristics of annual quantity of days without and with precipitation for the ten five-year time intervals from 1957 to 2006 in Tbilisi are given

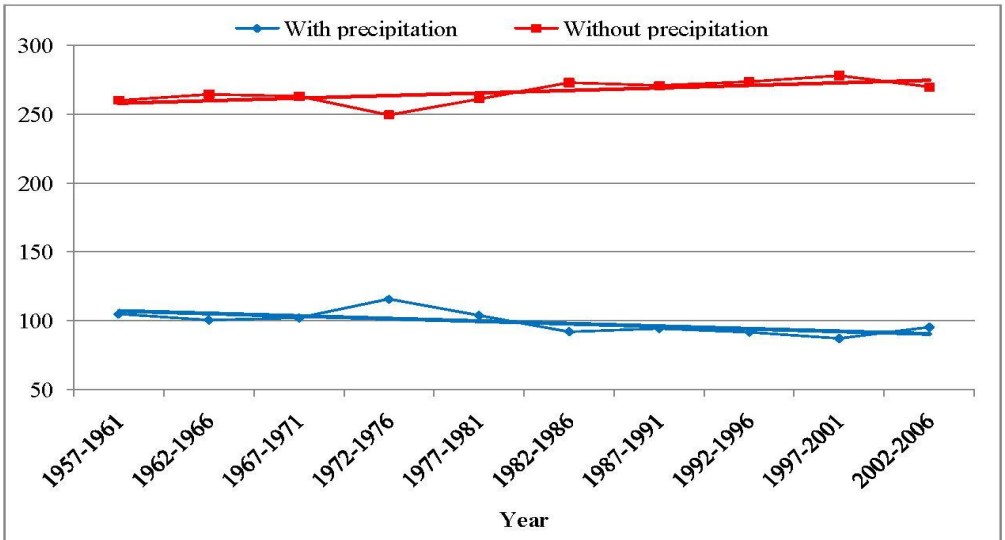

Fig. 4 Trend of annual quantity of days without and with precipitation for the ten five-year time intervals from 1957 to 2006 in Tbilisi

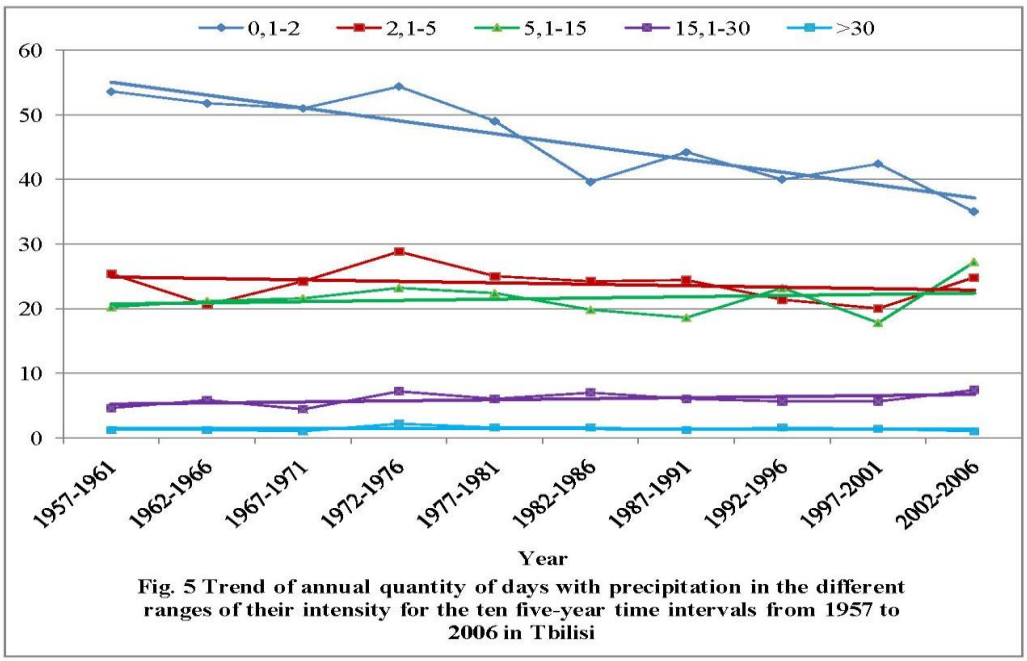

Fig. 5 Trend of annual quantity of days with precipitation in the different ranges of their intensity for the ten five-year time intervals from 1957 to 2006 in Tbilisi

In the fig. 4-5 the graphs of trends of the annual quantity of days without and with precipitation and days with precipitation in the different ranges of their intensity for the ten five-year time intervals from 1957 to 2006 in Tbilisi are given.

In particular, as follows from table 3 and fig. 4-5, positive linear trends for the annual quantity of total days without precipitation and days with of their daily intensity of 5.1-15 and 15.1-30 are observed. Trends of the annual quantity of total days with precipitation and days with of their daily intensity of 0.1-2 and 2.1-5 are negative. Trend for the annual quantity of days with precipitation with daily intensity >30 are not observed.

The greatest increase in annual quantity of days with precipitation in the last five-year period of time in comparison with the first for range of their daily intensity of 15.1-30 is noted (28.3%), the greatest decrease - for range 0.1-2 (-32.5%). An increase in the total annual quantity of days without precipitation composes 6.5%, an decrease in the total annual quantity of days with precipitation composes 15.7%.

Thus, in the investigated period of time a certain increase of total sum of precipitation was observed. At the same time in different ranges of their daily intensity the tendency of the changeability of precipitation was both the constant and positive and negative. The same relates to such investigated parameters, as the share of atmospheric precipitations in the different ranges of their intensity from the total sum of precipitation and the annual quantity of days without and with precipitation and days with precipitation in the different ranges of their intensity.

Conclusions

Investigation of climate changes and reasons for these is one of the most important problems of the present. Precipitation is a basic source for moistening earth's surface, and, correspondingly, one of the most important factors of support to life on our planet. Besides climate changes many of other factors with the changeability of atmospheric precipitations can be connected. For example, in the industrial regions this can be the heat islands, air pollution, the local special features of the dynamics of air masses, etc.

In different regions of Georgia long-term tendency of changeability of annual sum of precipitation has a complex nature: they can be as constant, so positive or negative. As in

other countries air pollution has an effect on the precipitation regime in some regions of Georgia. In particular in the Kakheti region of Georgia air pollution influence on increase of the precipitations.

Tbilisi is megalopolis with all characteristic for such cities indicated special features. Therefore, climate variation in this city, and in particular the precipitation regime, has special interest for us. This investigation showed that long-term variations of the precipitations regime in Tbilisi have complex nature.

In the investigated period of time (1957-2006) a certain increase of total sum of precipitation was observed. At the same time in different ranges of their daily intensity the tendency of the changeability of precipitation was both the constant and positive and negative. The same relates to such investigated parameters, as the share of atmospheric precipitations in the different ranges of their intensity from the total sum of precipitation and the annual quantity of days without and with precipitation and days with precipitation in the different ranges of their intensity.

In the future the analysis of the possible reasons of the indicated special features of variations of the precipitation regime in Tbilisi will be carried out. In addition to this, the continuation of these studies on the more extensive material is provided.

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თბილისში დღიური ჯამური ნალექების ცვალებადობის თავისებურებანი 1957-2006 წლებში

ა.ამირანაშვილი

რეზიუმე

საქართველოს კლიმატის თანამედროვე ცვლილებების ფართომასშტაბური შესწავლა დაიწყო 1996 წელს და გრძელდება დღემდე. უპირველეს ყოვლისა ჩატარდა საქართველოში სათბური გაზების ინვენტარიზაცია, გამოკვლეულ იქნა ჰაერის ტემპერატურის, ნალექების, ღრუბლიანობის, ატმოსფერული ჰაერის აეროზოლური დაბინძურების, ზედაპირული საფარის და სხვა კლიმატწარმომქმნელი ფაქტორების ველების სივრცულ-დროითი ვარიაციები. მოგვიანებით დაიწყო სამუშაოები საქართველოს სხვადასხვა რაიონში ჰაერის ტემპერატურისა და ნალექების ცვლილებების პროგნოზირებისათვის. კერძოდ, თბილისში 1957-2006 წლების პერიოდში ჯამური ნალექების საშუალო ნახევარწლიური და წლიური მნიშვნელობების დეტალური სტატისტიკური ანალიზის შედეგები იყო წარმოდგენილი ადრეულ ნაშრომებში. დროის აღნიშნულ პერიოდში დაიკვირვებოდა ნალექების სუსტი დადებითი ტრენდი წლის ცივ პერიოდში. ნალექების ცვალებადობა წლის თბილ პერიოდში არ შეიმჩნეოდა. წლიური მონაცემებით შეიმჩნეოდა ნალექების მატების სუსტი ტენდენცია. მოცემულ ნაშრომში, რომელიც წარმოადგენს ადრინდელი გამოკვლევების გაგრძელებას, მოცემულია საქართველოს ჰიდრომეტეოროლოგიური დეპარტამენტის თბილისში დღიურ ჯამურ ნალექებზე დაკვირვებათა მონაცემების სტანდარტული სტატისტიკური ანალიზის ზოგიერთი შედეგი 1957-2006 წლებისათვის. კერძოდ, შესწავლილია ატმოსფერული ნალექების სტატისტიკური სტრუქტურა 0.1-2, 2.1-5, 5.1-15, 15.1-30 და >30 მმ დღიური ინტენსივობით და ნალექიანი და უნალექო დღეების წლიური რაოდენობა ათი ხუთწლიანი დროითი ინტერვალისათვის 1957-1961, 1962-1966, ...2002-2006 წლებამდე. დღიური ჯამური ნალექების სუსტი ზრდა და დადებითი ტრენდი დაიკვირვებოდა 5.1-15 და 15.1-30 დიაპაზონებისათვის შესაბამისად.სუსტი შემცირება და უარყოფითი ტრენდი დაიკვირვებოდა, შესაბამისად 0.1-2 და 2.1-5 დიაპაზონებისათვის. დღიური ჯამური ნალექების ცვალებადობა დროში ინტენსივობით >30 არ დაიკვირვებოდა.

Особенности изменчивости суточных суммы осадков в Тбилиси в 1957-2006 гг.

А.Г. Амиранашвили

Резюме

Широкомасштабные исследования современного изменения климата Грузии были начаты 1996 году и продолжаются в настоящее время. Прежде всего была проведена инвентаризации парниковых газов в Грузии, исследованы пространственно-временные вариации полей температуры воздуха, осадков, облачности, аэрозольного загрязнения атмосферного воздуха, поверхностного покрова и других климатообразующих факторов. Позже были начаты работы по прогнозированию температуры воздуха и изменения осадков в некоторых районах Грузии.

В частности, результаты детального статистического анализа средних полугодовых и годовых значений суммы осадков в Тбилиси в период 1957-2006 гг были представлены в ранних работах. В указанный период времени наблюдался слабый положительный тренд осадков в холодный период года. Изменчивость осадков в теплый период года не наблюдалась. По годовым данным наблюдалась слабая тенденция к увеличению осадков.

В данной работе, которая представляет продолжение предыдущих исследований, представлены некоторые результаты стандартного статистического анализа данных наблюдений гидрометеорологического департамента Грузии за суточной суммой осадков (DSP) в Тбилиси в 1957-2006.

В частности, изучена статистическая структура атмосферных осадков с суточной интенсивностью 0.1-2, 2.1-5, 5.1-15, 15.1-30 и >30 мм и годового количества дней с осадками и без осадков для десяти пятилетних временных интервалов с 1957 -1961, 1962-1966, ..., до 2002-2006 гг.

Слабый рост и положительный тренд DSP наблюдались для диапазонов 5.1-15 и 15.1-30 мм соответственно. Слабое уменьшение отрицательный тренд DSP наблюдались, соответственно, для диапазонов 0.1-2 и 2.1-5 мм. Изменчивости во времени DSP с интенсивностью >30 мм не наблюдалось.