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Expected change of average semi-annual and annual values of air temperature and precipitation in Tbilisi

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Abstract

Results of statistical analysis of the average semi-annual and annual values of air temperature and precipitation in Tbilisi for the period 1957-2006 are presented. The analysis of accident of time-series data, them autocorrelate, periodicity, presence of trends is carried out. For an estimation of expected changes of air temperature and precipitation the classical method of forecasting of curves growth of the specified parameters and their confidential intervals has been used. In 2036 in comparison with 2006 it is expected: growth of average air temperature in cold half-year and for a year - on 0.2 ºC, in warm half-year - on 0.4 ºC; growth of precipitation in cold half-year on 21 mm. Trends of precipitation for a year and warm half-year periods are not observed.

1. Introduction

Wide-ranging studies of contemporary climate change in Georgia were begun in 1996 and they continue on the present time [1]. 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 [2-6]. Later there have been begun works on forecasting of air temperature and precipitation change in some region of Georgia [7-8]. The given work is continuation of the previous researches.

2. Method

In the work were used the data of the Hydrometeorological department of Georgia about the average semi-annual and annual values of air temperature and precipitation in Tbilisi for the period 1957-2006. The analysis of data was conducted with the aid of the methods of the correlation and regression analysis of stationary and non stationary series of observations [9-12].

The following designations will be used below: T, T_w, T_c - average air temperature for a year, warm half-year and cold half-year periods (ºC); P, P_w, P_c – sum of precipitation for a year, warm half-year and cold half-year periods (mm); Min – minimal values; Max - maximal values; Range - variational scope; σ - standard deviation; σ_m - standard error (68% - confidence interval of mean values); C_v - coefficient of variation (%); A - coefficient of skewness; K - coefficient of kurtosis; R - coefficient of linear correlation; R^2 – coefficient of determination; R_s – Spearman's rank correlation coefficient; R_k – Kendall's rank correlation coefficient; R_a - autocorrelation coefficient with a Lag = 1 year; K_{DW} - Durbin-Watson statistic; 95%(+/-) CONF - ±95% confidential interval; α - the level of significance; X – number of years: from 1957 to 2006 (real data), from 2007 to 2036 - extrapolation (X = 1,…50, 51 . . . 80).

3. Results

The results of the statistical analysis of the average semi-annual and annual values of air temperature and precipitation in Tbilisi are represented in the table and in figure 1-2.

Table. The statistical characteristics of mean six month and yearly values of air temperature and precipitation in Tbilisi in 1957-2006.

Parameter	Air temperature			Precipitation		
	Year	Warm season	Cold season	Year	Warm season	Cold season
	Standard statistics					
Mean	13.1	20.0	6.2	493	331	163
Min	11.9	18.5	4.1	240	131	75
Max	14.8	21.8	9.1	813	690	247
Range	2.9	3.3	5.0	573	559	172
Median	13.1	19.9	6.2	487	308	152
σ	0.69	0.77	0.91	107	100	48
σ_m	0.10	0.11	0.13	15	14	7
C_v(%)	5.3	3.8	14.6	21.7	30.3	29.6
A	0.08	0.40	0.22	0.82	1.32	0.13
K	-0.26	-0.34	1.23	1.47	3.06	-1.14
95%(+/-) Conf	0.19	0.22	0.25	30	28	13
	Correlation matrix					
Year	1	0.78	0.86	1	0.89	0.36
Warm season	0.78	1	0.35	0.89	1	-0.10
Cold season	0.86	0.35	1	0.36	-0.10	1
	The characteristic of time - series					
R with year	0.16	0.20	0.08	0.07	-0.02	0.21
(α) R	0.15	0.14	-	-	-	0.13
R_k	0.16	0.14	0.12	0.04	-0.02	0.15
(α) R_k	0.12	0.14	0.21	-	-	0.12
R_s	0.22	0.23	0.17	0.08	-0.04	0.22
(α) R_s	0.12	0.11	0.24	-	-	0.12
R_a , Lag = 1	0.18	-0.01	0.16	-0.12	-0.05	0.09
(α) R_a	0.19	-	0.25	-	-	-
95%(+/-) Conf	0.23	0.21	0.30	27	27	15
K_{DW}	1.62	1.97	1.67	No trend	No trend	1.87
(α) K_{DW}	0,05	0,05	0,05	No trend	No trend	0,05
	Periodicity (year)					
Peak	5		2.2	25	25	2.1
Large peak	2.1	2.3	4.2	3.3	5	3.1
		5.0				16.7
Local min	2.8	3.8	6.3		2.1	2.2
	6.3	16.7			3.6	25
Large min	2	2.5	3.1	2.4	2	4.2
				7,1		
	Trend (Y = a·X + b)					
a	0.0074	0.0104	0.0050	No trend	No trend	0.68
b	12.92	19.73	6.09	No trend	No trend	145
	Extrapolation 95%(+/-) Conf					
2006	11.8≤ 13.3 ≤ 14.7	18.7≤ 20.2 ≤21.8	4.4≤ 6.3 ≤8.3	No trend	No trend	80≤179 ≤279
2036	11.9≤13.5 ≤15.1	18.8≤20.6 ≤22.3	4.4≤ 6.5 ≤8.6	No trend	No trend	91≤200 ≤309
2036 - 2006	0.2	0.4	0.2	No trend	No trend	21

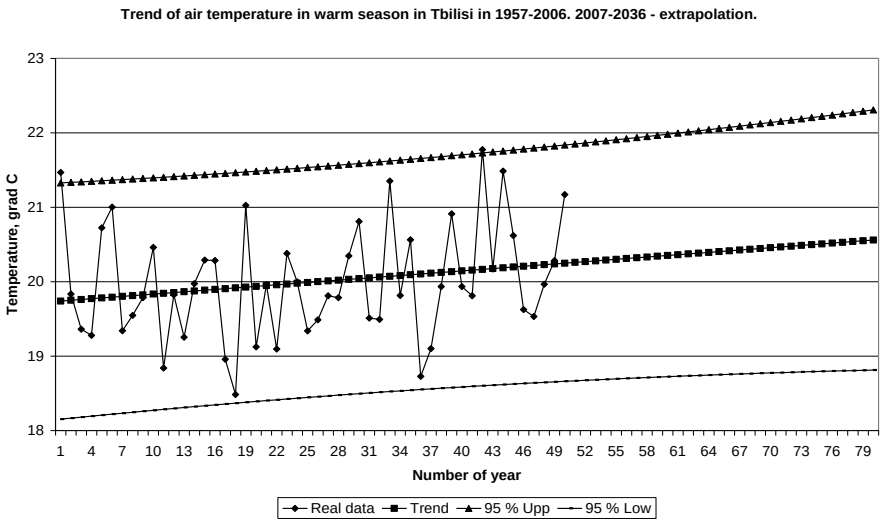

Fig. 1

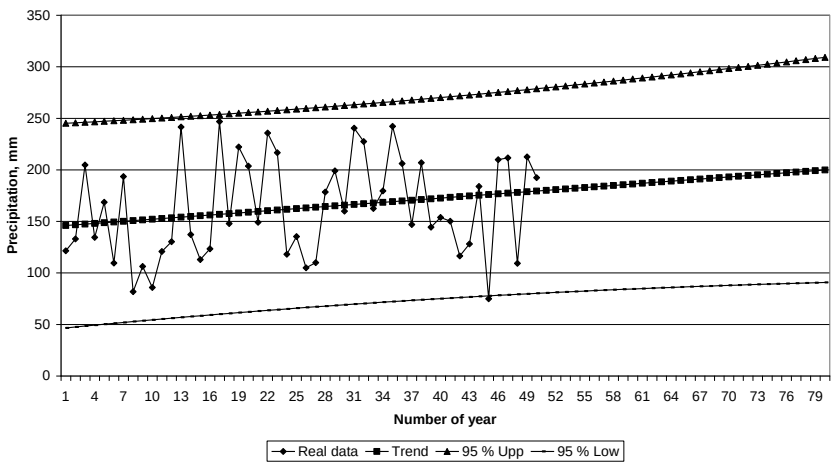

Fig. 2

T**he standard statistical analysis.**

Values of the indicated parameters change within the following limits (table upper part): T from 11.9 to 14.8 (mean value – 13.1, median – 13.1); T_w from 18.5 to 21.8 (mean value – 20.0 median – 19.9); T_c from 4.1 to 9.1 (mean value – 6.2, median – 6.2); P from 240 to 813 (mean value – 493, median – 487); P_w from 131 to 690 (mean value – 331 median - 308); P_c from 75 to 247 (mean value – 163 median - 152). The greatest variations for the time-series of P_w is observed (C_v = 30.3 %), the smallest – for T_w (C_v = 3.8 %). The relative range (Range/Mean) changes from 16.5 % (for T_w) to 168.9 % (for P_w). The distribution functions of the T, T_w, T_c, P and P_c in the general population are close to the normal (the corresponding ratios between values of mean and median; A not more than 1, and K not more than 2). The distribution functions of the P_w has right-hand asymmetry.The coefficient of linear correlation between the values T, T_w and T_c changes from 0.35 (for pair T_w - T_c) to 0.86 (for pair T - T_c). The coefficient of linear correlation between the values P, P_w and P_c changes from -0.10 (for pair P_w - P_c) to 0.89 (for pair P - P_w).

The characteristic of time – series of indicate parameters in the middle and low part of the table and in fig. 1-2 are presented.

The coefficient of linear correlation between the values T, T_w and T_c and years changes from 0.08 (for T_c) to 0.20 (for T_w). The values of the Kendall rank correlation coefficient changes from 0.12 (for T_c) to

0.16 (for T). The values of the Spearmen rank correlation coefficient changes from 0.17 (for T_c) to 0.23 (for T_w). The values of autocorrelation coefficient with the Lag = 1 year for T and T_c are positive and respectively comprise 0.18 and 0.16. It is not autocorrelation in the time – series of T_w . Thus, as a whole, the time-series of T and T_c are autocorrelate and non accidental, the time-series of T_w is non autocorrelate and non accidental.

The coefficient of linear correlation, the Kendall and Spearmen rank correlation coefficients between P, P_w and years are no significations. Indicate correlation coefficients between P_c and years are significations. The value of R_a for time-series of P, P_w and P_c are no significations. Thus, the time-series of P and P_w are random, time-series of P_c is non autocorrelate and non accidental.

The periodicity (large peak and large min respectively) are: for T - 2.1 and 2 years; for T_w - 2.3 (5.0) and 2.5 years; for T_c – 4.2 and 3.1 years; for P - 3.3 and 2.4 (7.1) years; for P_w - 5 and 2 years; for P_c – 3.1 (16.7) and 4.2 years.

Trends T, T_w, T_c and P_c are linear positive (the values of Durbin-Watson statistic changes from 1.62 to 1.97). Settlement values of a trend in 2006 and 2036 accordingly equal: for T – 11.8≤ 13.3≤ 14.7 and 11.9≤13.5≤15.1; for T_w - 18.7≤ 20.2≤21.8 and 18.8≤20.6≤22.3; for T_c – 4.4≤ 6.3≤8.3 and 4.4≤ 6.5≤8.6; for P_c – 80≤179≤279 and 91≤200≤309. Thus, in 2036 in comparison with 2006 it is expected: growth of average air temperature in cold half-year and for a year - on 0.2 ºC, in warm half-year - on 0.4 ºC; growth of precipitation in cold half-year on 21 mm.

4. Conclusion

The detailed statistical structure of the time-series of observations of air temperature and precipitation (semi-annual and annual values) in Tbilisi is presented. The standard methods of statistical analysis and the methods of the analysis of non accidental time-series of observations were used. The characteristics trend of time-series of air temperature and precipitation are studied. The estimation of change of air temperature and precipitation till 2036 is spent.

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Ожидаемое изменений средних полугодовых и годовых значений температуры воздуха и осадков в Тбилиси

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Резюме

В работе представлены некоторые результаты статистического анализа данных наблюдений за средними полугодовыми и годовыми значениями температуры воздуха и осадков в Тбилиси в период с 1957 по 2006 гг. Проведен анализ случайности рядов наблюдений, их автокоррелированности, периодичности, наличия трендов. Для оценки ожидаемых изменений температуры воздуха и осадков был использован классический метод прогнозирования кривых роста указанных параметров и их доверительных интервалов. В 2036 году по сравнению с 2006 годом ожидается: рост средней температуры воздуха в холодное полугодие и за год – на 0.2 ºС, в теплое полугодие - на 0.4 ºС ; рост количества осадков в холодное полугодие на 21 мм. Тренда количества осадков за год и в теплое полугодие не наблюдается.

ქალაქ თბილისში ჰაერის ტემპერატურის და ნალექების საშუალო ნახევარწლიური და წლიური მნიშვნელობების მოსალოდნელი ცვლილება

ავთანდილ გ. ამირანაშვილი, ვიქტორ ა. ჩიხლაძე, ლიანა გ. ქართველიშვილი

რეზიუმე

ნაშრომში წარმოდგენილია 1957-დან 2006 წლების პერიოდში ქალაქ თბილისში ჰაერის ტემპერატურის და ნალექების საშუალო ნახევარწლიური და წლიური მნიშვნელობების დაკვირვების მონაცემების სტატისტიკური ანალიზის ზოგიერთი შედეგები. ჩატარდა დაკვირვების რიგების შემთხვევითობის, მათი ავტოკორელირულობის, პერიოდულობის და ტრენდების არსებობის ანალიზი. ჰაერის ტემპერატურის და ნალექების მოსალოდნელი ცვლილების შესაფასებლად ზემოდ ხსენებული პარამეტრების ზრდის მრუდეების და მათი სანდოობის ინტერვალების პროგნოზირების კლასიკური მეთოდი იქნა გამოყენებული. 2006 წელთან შედარებით, 2036 წელს მოსალოდნელია ჰაერის საშუალო ტემპერატურის ცივ ნახევარწელში და წელიწადში 0,2 °C, ხოლო თბილ ნახევარწელში 0,4 °C ზრდა, ცივ ნახევარწელში ნალექების რაოდენობის 21 მმ ზრდა. ნალექების რაოდენობის ტრენდი წლიურად და თბილ ნახევარწელში არ დაიკვირვება.