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STATISTICAL CHARACTERISTICS OF FLASH FLOOD IN GEORGIA

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ABSTRACT: results are presented from the analysis of observations data on flash flood in Georgia over a period of 45 years, from 1961 to 2005, provided of the of Hydro-meteorology Service of Georgia.The following parameters of flash flood were studied: the number of cases with the flood (F) in different area of Georgia, the maximum water flow (M) and area subjected to each flood (Q) , the number of cases with the flood per year (N) and total area subjected to flood per year (S) in Georgia. Correlation analysis of the time-series of N and S are carried out (linear correlation, the rank correlation of Kendall and Spearmen, autocorrelation). Time-series of N and S is random, non autocorrelate and without trend. For example, values of the N and S changes within the following limits: N from 0 to 24 (mean value – 5.2, median – 5.0, 95% confidence interval – 1.4, 99% confidence interval – 1.9), S from 0 to 1049 km^2 (mean value – 211.3 km^2, median – 151 km^2, 95% confidence interval – 61.8 km^2, 99% confidence interval – 81.2 km^2). Linear correlation and regression analysis between the values N and S, and M and Q are carried out. The map of the distribution of F on the territory of Georgia is obtained. Other statistical characteristics of F, M, Q, N and S are also represented (distribution functions, periodicity etc.). Data are also provided on the economic damage and the fatalities due to the flash floods.

KEY WORDS: flash flood, hazard zones, statistical analysis.

NOTATION

F – distribution function, K_{dw} – Durbin-Watson criteria, M – max water flow (m^3/s), N - number of cases with the flood per year, P - damaged area to one flash flood per year (km^2), Q - area subjected to each flood (km^2) , R – coefficient of linear correlation, R^2 - coefficient of determination, R_a - coefficient of autocorrelation with lag = 1 year, R_k -

Kendall's rank correlation coefficient, R_s - Spearmen's rank correlation coefficient, S - total area subjected to flood per year (km^2), T - flash flood frequency in different area (year), α - level of significance.

INTRODUCTION

Special attention was always paid to studies of floods in Georgia [1-5]. In this work some results of the analysis of data of observations on flash flood in Georgia have been presented. An observation period makes 45 years, from 1961 to 2005. Data of the service of hydrometeorology of Georgia are used.

THE STANDARD STATISTICAL ANALYSIS OF THE SEPARATE FLASH FLOODS PARAMETERS

The results of the statistical analysis of such separate flash floods parameters as M and Q are represented in tables 1-2 and in figure 1-3.

Table 1

The statistical characteristics of the separate flash floods parameters in Georgia in 1961-2005

Parameter	M (m^3/s)	Q (km^2)
Mean	660,6	40,8
Min	28	5
Max	4850	165
Range	4822	160
Median	400	40
Mode	160	40
Standard Deviation	852,5	24,0
Standard Error	56,0	1,6
Coefficient of variation (%)	129,1	58,8
Coefficient of skewness	2,8	2,1
Coefficient of kurtosis	7,9	7,2
Count	233	233
95%(+/-) confidence interval	109,7	3,1

As it follows from table 1 the mean value of M is equal 660.6 and varied from 28 to 4850. The value of Q varied from 5 to 165. The mean value of Q is equal 40.8. Thus, the values of the indicated parameters change over a wide range. Therefore for constructing the distribution functions of these parameters and analysis of the connections between them to more conveniently use the logarithm of their values. The distribution functions of the studied parameters are represented in table 2 and fig. 1-2. The connection between values Lg M and Lg Q is represented in fig. 3.

Table 2

Distribution function of M and Q

$F(LgM) = 1/(a+b(LgM)+c(LgM)^2)$			$F(LgQ) = 1/(a+b(LgQ)+c(LgQ)^2)$		
Coefficient	Value	68% (+/-) confidence interval	Coefficient	Value	68% (+/-) confidence interval
a	1,232209	0,159194	a	2,102083	0,310972
b	-0,92953	0,123987	b	-2,64248	0,401318
c	0,18014	0,024153	c	0,839338	0,129144
R^2	0,984		R^2	0,99	

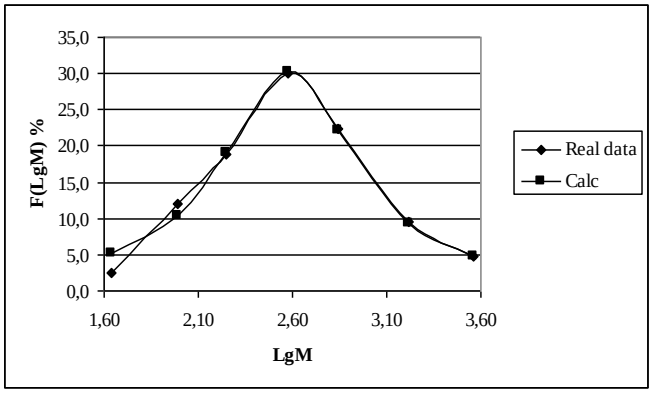

Fig. 1
Distribution function of LgM

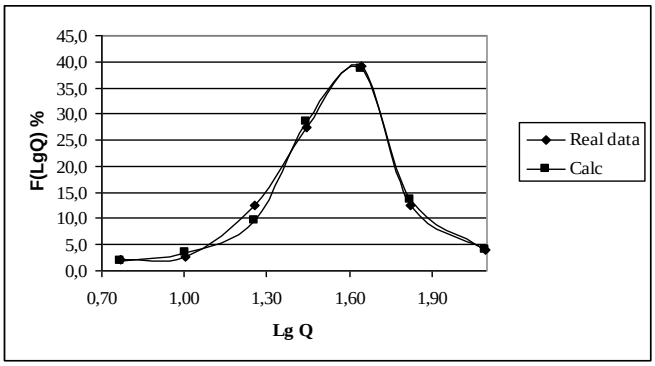

Fig. 2
Distribution function of LgQ

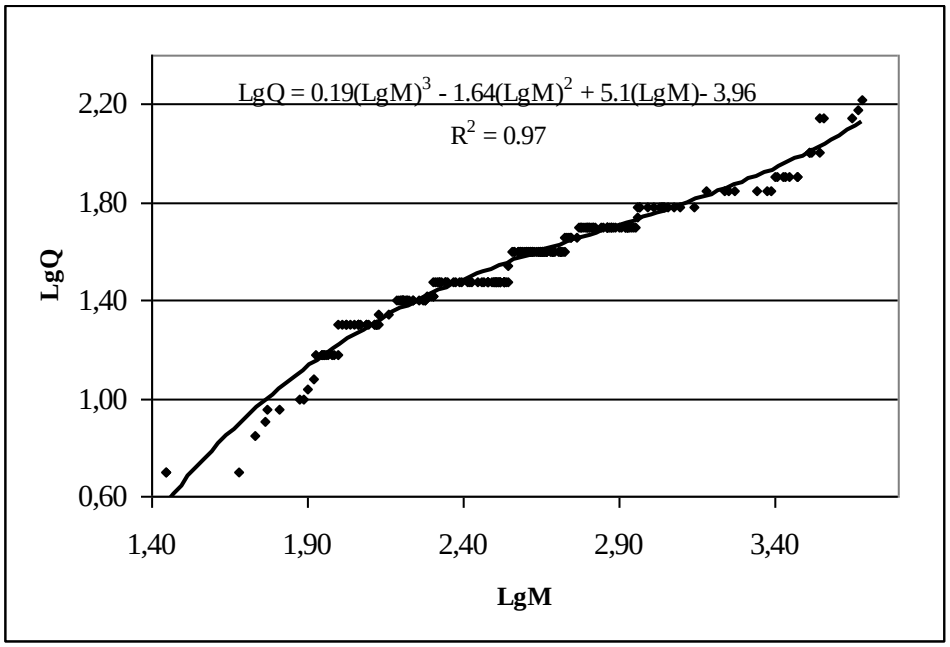

Fig. 3
Connection between the values LgM and LgQ

THE STATISTICAL ANALYSIS OF THE TIME-SERIES OF SOME FLASH FLOODS PARAMETERS

The results of the statistical analysis of the time-series parameters N, S and P are represented in tables 3-4 and in figure 4.
As it follows from table 3 time-series of N and S is random, non autocorrelate and without trend (coefficients of R, R_k, R_s, R_a and K_{dw} have the appropriate values). For example, values of the N and S changes within the following limits: N from 0 to 24 (mean value – 5.2, median – 5.0, standard deviation – 4.8, standard error – 0.7, coefficient of variation – 93.1%, coefficient of skewness – 1.8, 95% confidence interval – 1.4); S from 0 to 1049 km^2 (mean value – 211.3 km^2, median – 151 km^2, standard deviation – 209.1, standard error – 31.5, coefficient of variation – 98.9%, coefficient of skewness – 1.9, 95% confidence interval – 61.8 km^2).

Time-series of P is autocorrelate (R_a = 0.29), without trend (coefficients of R, R_k, R_s, and K_{dw} have the appropriate values). Values of the P changes from 0 to 100 (mean value – 37.1, median – 39.3, standard deviation – 16.7, standard error – 2.5, coefficient of variation –

44.9%, 95% confidence interval without taking into account R_a – 4.9, coefficient of skewness – 0.4, 95% confidence interval with taking into account R_a – 6.6).

Table 3

The statistical characteristics of the time-series of flash floods parameters in Georgia in 1961-2005

Parameter	N	S (km^2)	P (km^2)
Mean	5,2	211,3	37,1
Min	0	0	0
Max	24	1049	100
Range	24	1049	100
Median	5	151	39,3
Standard Deviation	4,8	209,1	16,7
Standard Error	0,7	31,5	2,5
Coefficient of variation (%)	93,1	98,9	44,9
Coefficient of skewness	1,8	1,9	0,4
Coefficient of kurtosis	4,7	5,0	4,9
95% (+/-) confidence interval	1,4	61,8	4,9
R	0,037	0,05	0,02
(α) R	-	-	-
R_k	-0,055	-0,028	0,09
(α) R_k	0,59	0,78	0,41
R_s	-0,073	-0,051	0,2
(α) R_s	0,63	0,73	0,19
R_a	0	0	0,29
95% (+/-) confidence interval with taking into account R_a	1,4	61,8	6,6
K_{dw}	1,89	1,85	1,41
(α) K_{dw}	0,05	0,05	0,025

Table 4

Periodicity of the flash floods characteristics in Georgia - years (parameters of periodogram)

N	S	P
14.7 (large min)	14.7 (local min)	22 (large peak)
4.9 (large peak)	4.9 (large peak)	8.8 (local min)
2.6 (large min)	4.4 (local min)	2.75 (large min)
	2.6 (large min)	2.6 (large peak)
	2.1 (peak)	

Data of periodicity of the flash floods characteristics in Georgia are represented in table 4. For N the periodicity are 14.7, 4.9 and 2.6 years; for S -14.7, 4.9, 4.4, 2.6 and 2.1 years; for P – 22, 8.8, 2.75 and 2.6 years.

Connection between values N and S is represented in fig. 4. As follows from this figure, the indicated connection is linear.

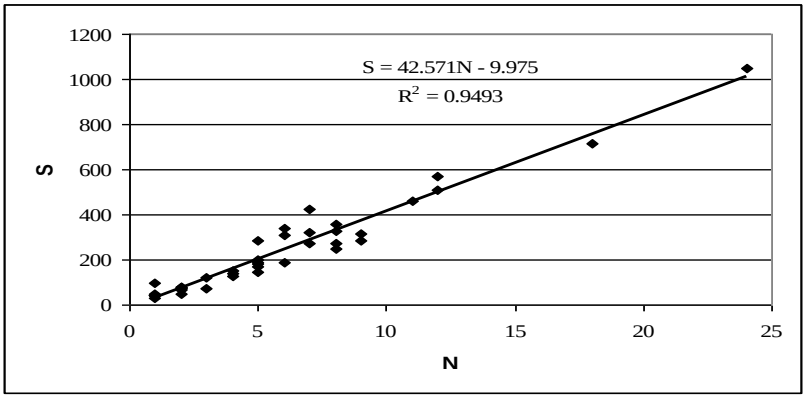

Fig. 4
Connection between values N and S

DISTRIBUTION OF FLASH FLOOD FREQUENCY AND HAZARD ZONES ON THE TERRITORY OF GEORGIA. ECONOMIC DAMAGE AND VICTIM.

The flash flood frequency T distribution on the territory of Georgia is represented in the fig. 5.

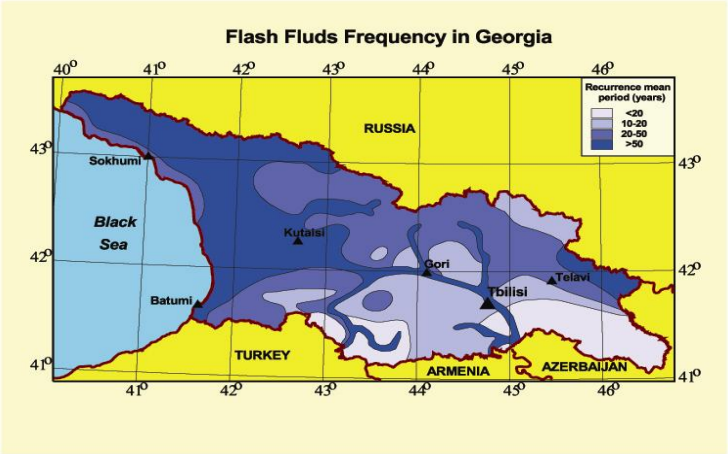

Fig. 5

The flash flood hazard zones in Georgia is represented in the fig. 6.

Fig. 6

In the table 5 is represented the flash floods intensity scale and in the table 6 some data about economic damage and victim from flash floods is represented.

Table 5

Scale of the flash floods intensity

Intensity (amount)	The max water discharge repetition (year)	Effect	Possible destruction and damage
1	5-10	No hazard	Relatively weak damage. Insignificant part of the coastal zone of river under water. Less than 10 % the area of agricultural land is flooded.
2	20-25	Low	Sensitive material damage. Sufficiently large area of the river basin under water. 10 - 15 % the area of agricultural land are flooded.
3	50-100	Medium	Large material damage. 50 - 70 % the area of agricultural land and some populated areas are flooded. Need for the evacuation of people from the flooded areas.
4	Larger 100	High	Greatest material damage, victims. Entire territory of the basin of one or several rivers under water. Many populated areas, engineering and industrial communications are flooded. Need for the mass evacuation of people.

Table 6

Economic damage and victim from flash floods

Year	Month	Day	Killed	Damage US$ (1000's)	Location	River
1967	06	04		10000	Nokalakevi	Tekhuri
1967	08	06		5000	Pasanauri	Tetri Aragvi
1968	04	18		50000	Tbilisi	Mtkvari
1977	08	11		2000	Rtskhmeluri	Tskhenistskali
1978	04	10		7700	Chaladidi	Rioni
1979	12	03		400	Tseva	Dzirula
1982	04	01		25000	Zestafoni	Kvirila
1982	04	02		500	Chaladidi	Rioni
1983	07	19		200	Khaishi	Inguri
1986	06	18		2000	Zestafoni	Kvirila
1987	02	01	3	60000	Chaladidi	Rioni
1987	06	09		4000	Namokhvani	Rioni
1987	06	11		1000	Kekhvi	Didi Liakhvi
1988	06	25		2000	Chaladidi	Rioni
1989	08	01		60000	Rtskhmeluri	Tskhenistskali
1989	08	15		37000	Namokhvani	Rioni
1989	11	28	1	10500	Chaladidi	Rioni
1991	07	07		200	Natanebi	Natanebi
1996	06	04		2100	Magaroskari	Pshavis Aragvi
1996	12	25	1	2500	Zestafoni	Kvirila
1997	01	03		1500	Zestafoni	Kvirila
1997	01	03		1000	Chokhatauri	Supsa
1997	04	28		8000	Likani	Mtkvari
1997	04	28		1200	Magaroskari	Pshavis Aragvi
1997	07	03		29200	Nokalakevi	Tekhuri
2001	04	02		1500	Oni	Rioni
2001	05	21		2000	Khobi	Legakhare
2002	04	30		36000	Tbilisi	Mtkvari
2003	08	05		2200	Rtskhmeluri	Tskhenistskali
2005	04	25		2000	Namokhvani	Rioni
2005	27	04		3000	Tbilisi	Mtkvari
2005	27	04	1	8000	Pasanauri	Tetri Aragvi
2005	06	06		3000	Shesartavi	Shavi Aragvi

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