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SPATIAL TEMPORAL VARIABILITY OF MAXIMUM FLOW IN SLĂNIC, TELEAJEN AND PRAHOVA RIVER BASINS

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Key words: maximum flow, river basins, defence levels, flood

Abstract. The present study analyzes the spatial temporal variation of maximum flow in Slănic Teleajen and Prahova river basins (upper basin). Maximum flow rates were analyzed in relation to the threshold values corresponding to the Defence Levels respectively the maximum flow which determines exceeding Warning and Flooding Levels. The series of major floods events, selected on the basis of the threshold values mentioned above, were then statistically analyzed to determine trends (Mann-Kendall test) and the variations in the level of frequency, analysis which was applied seasonally and annually. The analysis made revealed that trends in terms of maximum flow rates in the Prahova upper basin were generally negative (decreasing), statistically significant for the February, May, July, August and the annual average, while in Slanic river basin, the trend was mostly positive, statistically significant for October.

Introduction

The topics related to variability in rivers water flow has been approached in studies, both at national level (Hristova Nelly, 2015; Peter et al., 1989; Diaconu et al., 1994; Stanescu et al., 2002) and international level (Milly et al., 2005; Redmond et al., 1991; Dettinger et al., 2000).

Evolution of practical engineering needs of water use, in general, and the defense against dangerous hydrological phenomena, in particular, required knowledge of maximum water flow, with a major interest in the activity of hydrological forecasting and also, very important, to establish measures to protect against flood (Diaconu, 1988).

Because, in recent decades, because of climate change, especially after 1970 (Wijkman, Rockström, 2013), there were significant changes in river flow regime

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in many parts of the Globe. The global warming trend, is evidenced by means of statistical tests (eg. Mann-Kendall test) (Haidu, 2006), rivers flow being influenced by changes of the amount of precipitation.

In Romania, following the researches done in the last 50 years, it was found that trends of watercourses were generally decreasing trends during spring and summer and increasing in autumn and winter, mainly due to the climate change in the country (Bîrsan et al., 2013).

Thus, because the floods have affected increasingly more of analyzed basins, in this paper it is highlighted the variability of spatial and temporal maximum water flow, trying at the same time to establish a trend in the evolution of the hydrological regime, using the Mann-Kendall test (MAKESENS).

Of the total series of analyzed years, 2005 stands out with most events of floods with the highest intensity.

General geographical features of the Prahova river basin

The hydrographical basins of Slanic, Teleajen and Prahova river fit in the middle and upper basin of Prahova river with an area of 429 km^2 (Fig. 1).

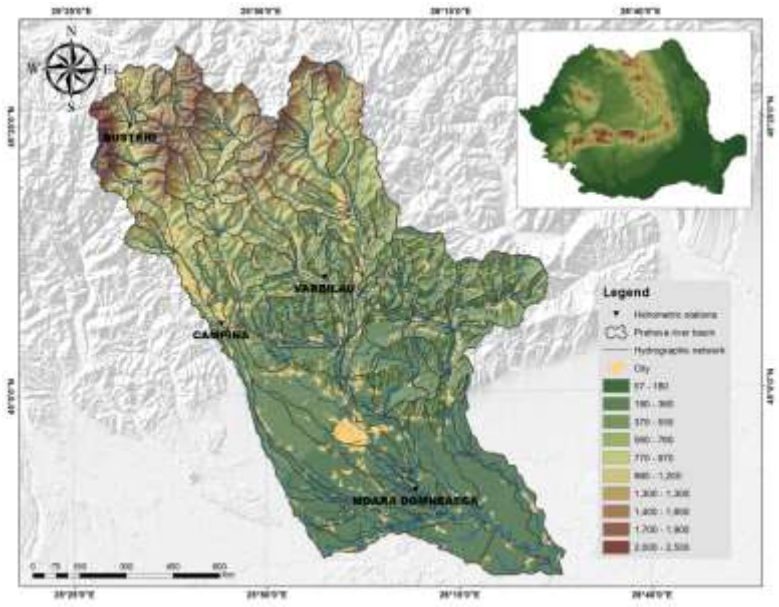


Fig. 1 – The location of analyzed hydrometrical stations in Prahova river basin

Prahova River springs from Bucegi, at about 1110 m altitude and flows at Adâncata into Ialomița river (Nedelcu, 2010).

In terms of altitude, the height ranges from 2505 m (Omu Peak) to 383 m, near the Ploiesti Plain. The watershed covers an area of oblong shape, NW-SE direction, with a length of 75 km.

In terms of geomorphology, the study area overlaps two major relief levels: the mountain area is crossed on an area of 329 km^2 and the Carpathian foothills area (Curvature Subcarpathians) covers an area of 100 km^2 (Ujvari, 1972).

Data and methods

For the study were used maximum monthly flow data recorded at selected hydrometric stations (Vărbilău, Moara Domnească, Bușteni and Câmpina) since their establishment till 2014.

Maximum flows were analyzed according to Defence Levels corresponding threshold values, and maximum flow that determines overcoming of the Warning and Flood Levels. To establish the proper Warning and Flood Levels flows, the actual rating curve was used (Tab. 1).

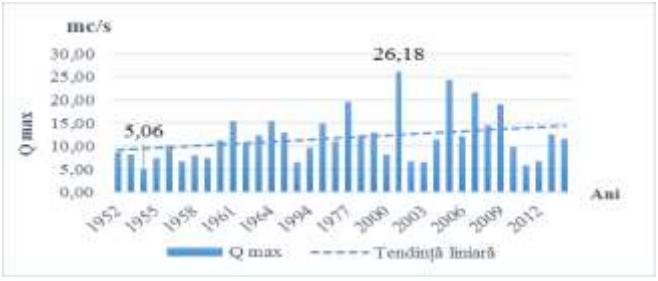
The series of major floods events, selected on the basis of the threshold values mentioned above, were then statistically analyzed to determine trends (Mann-Kendall test) and the variations in the level of frequency, analysis which was applied seasonally and annually.

Tab. 1 Defence Levels for the selected hydrometric stations and the corresponding flows

River	Hidrome-tric station	Warn-ing Level (cm)	Warn-ing Flow (m^3/s)	Flow (m^3/s)	Flood-ing Level (cm)	Food-ing flow (m^3/s)	Flow (m^3/s)
Slănic	Vărbilău	140	23.8	23.8	200	53.2	53.2
Teleajen	Moara Domnească	350	91.8	91.8	450	262	262
Prahova	Bușteni	100	38.2	38.2	150	89.7	89.7
Prahova	Câmpina	250	188	188	320	286	286

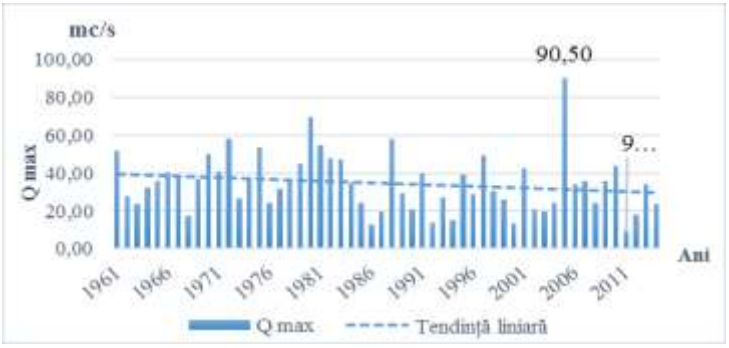
Data source: I.N.H.G.A.

Results



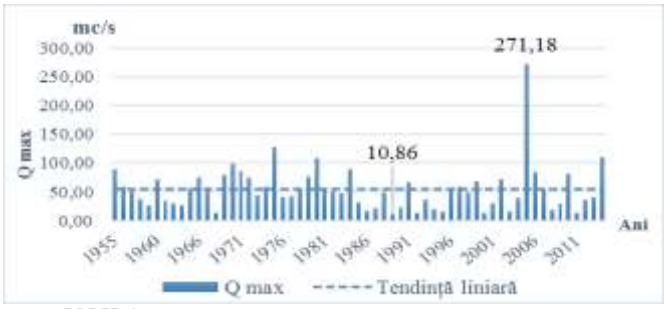
Data source: I.N.H.G.A.

Fig. 2 – Annual maximum flow at Bușteni hidrometric station (1952-2014)



Data source: I.N.H.G.A.

Fig. 3 – Annual maximum flow at Câmpina hydrometric station (1961-2014)



Data source: I.N.H.G.A.

Fig. 4 – Annual maximum flow at Moara Domnească hydrometric station (1955-2014)

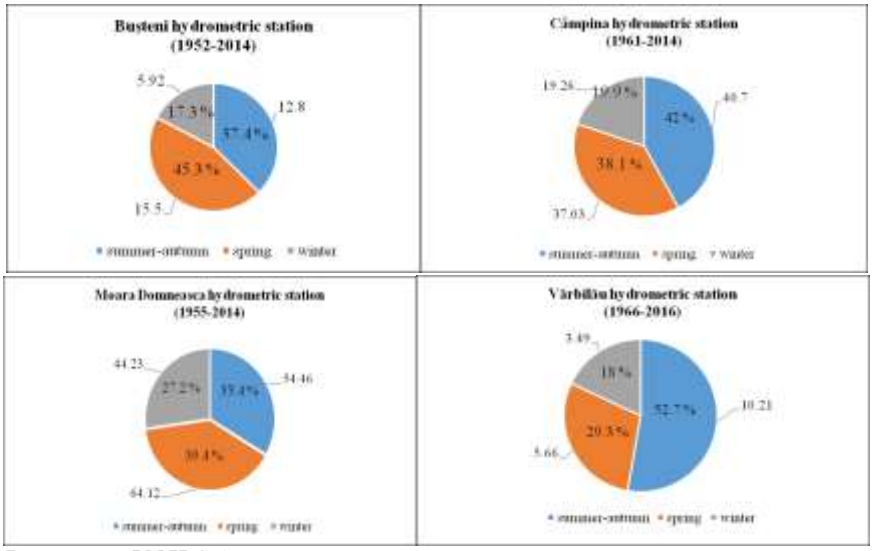
Data source: I.N.H.G.A.

Fig. 5 – Annual maximum flow at Vărbilau hydrometric station (1966-2014)

Based on the previous charts can be observed the succesion of years with high flow rates. Analyzing the annual maximum flows recorded of the four hydrometric

stations, Moara Domnească stand out, with a maximum flow of 271,18 sm/s (2005) but showing a stationary trend. The lowest maximum annual flow was recorded at Văbirlău hydrometric station in 1989 – 0,3 sm/s.

Regarding the evolution of the maximum annual flows, no significant trend is observed, but in the annalyzed period the year 2005 stands out with the highest number of events and the biggest floods, followed by 2001, 2007 and 2010.

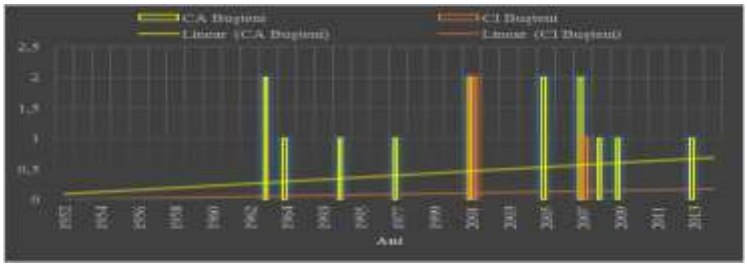


Data source: I.N.H.G.A.

Fig. 6 – Flood frequency with higher maximum flows than the selected threshold values, at seasonal level

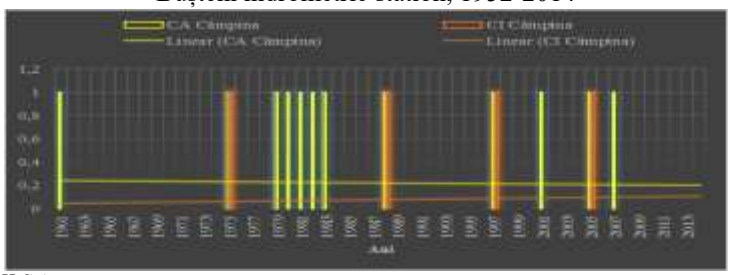
From the seasonal analysis made it results that most flood events with significant flows are recorded in the spring-summer season (in the Prahova and Teleajen river basin) and summer-autumn (in Slănic river basin).

Following the seasonal distribution of the maximum flow in the analysed river basins, can be observed that the months that produce the highest flows are in the summer-autumn season (about 41%), followed by spring season (about 38%), months in which beacause of the snowmelt and havy rainfalls, lead to the formation of floods, while in winter, due to climatic conditions, determine the low water level period (about 21%).



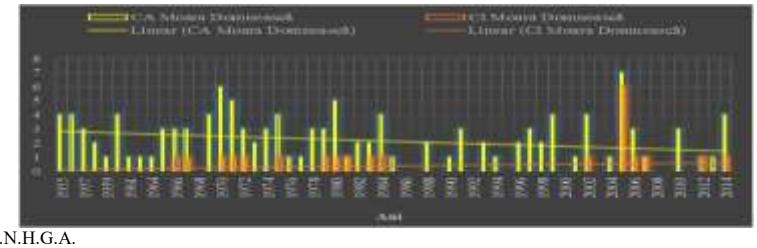
Data source: I.N.H.G.A.

Fig. 7 – The numer of annual events of overcoming the Warning and Flood Levels at Bușteni hidrometric station, 1952-2014



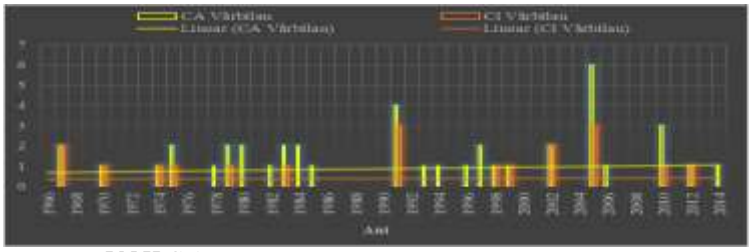
Data source: I.N.H.G.A.

Fig. 8 – The numer of annual events of overcoming the Warning and Flood Levels at Câmpina hidrometric station, 1961-2014



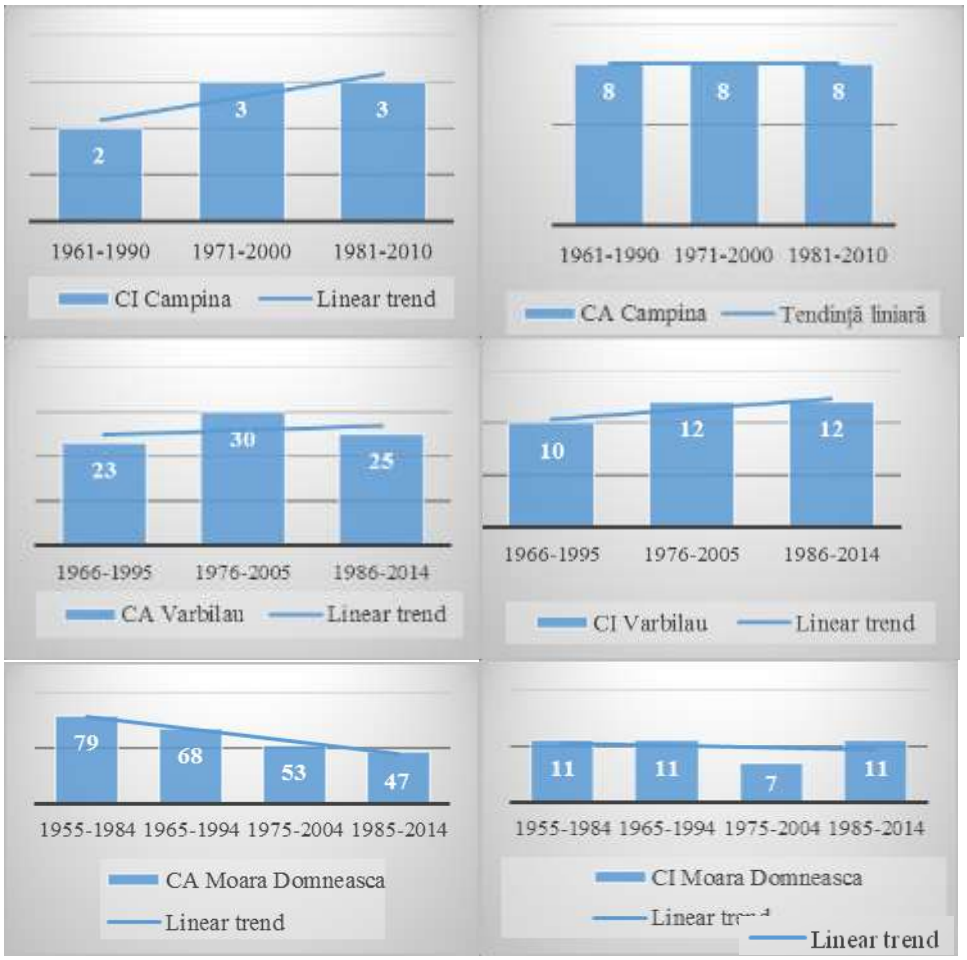
Data source: I.N.H.G.A.

Fig. 9 – The numer of annual events of overcoming the Warning and Flood Levels at Moara Domnească hidrometric station, 1955-2014



Data source: I.N.H.G.A.

Fig. 10 – The numer of annual events of overcoming the Warning and Flood Levels at Văbirlău hidrometric station, 1966-2014



Data source: I.N.H.G.A.

Fig. 11 – Analiza frecvenţei de producere a viiturilor cu debite maxime peste valorile prag selectate pentru perioadele glisante de 30 ani

According to the charts that resulted from the analysis, Mora Domnească hidrometric station stands out with the highest number of annual events of overcoming the Warning Level (over 100 records) as well as the Flood Level (aver 20 records), followed by Văbirlău hidrometric station (Fig. 7,8,9,10).

Regarding the number of calculated events for the 30 years period, the hidrometric station which stand out with the most events is Moara Domnească,

with a declining trend, while Câmpina hidrometric station has the fewest overcomings of the Warning Level, currently with a growing trend.

TREND STATISTICS

Q max Campina

				Mann-Kendall trend			Sen's slope estimate									
Time series	First year	Last Year	n	Test S	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B	Bmin99	Bmax99	Bmin95	Bmax95
I	1966	2014	49		-0.88		-0.049	-0.238	0.107	-0.183	0.068	7.93	14.05	5.11	13.00	5.72
II	1966	2014	49		-1.97	*	-0.182	-0.584	0.065	-0.428	-0.003	15.63	25.64	7.28	23.78	8.12
III	1966	2014	49		-0.03		-0.003	-0.324	0.372	-0.245	0.249	15.38	24.79	8.74	21.86	11.00
IV	1966	2014	49		0.48		0.120	-0.376	0.589	-0.276	0.415	28.51	35.53	16.77	32.74	21.12
V	1966	2014	49		-1.98	*	-0.518	-1.198	0.166	-1.023	-0.014	44.47	61.76	33.91	56.27	34.54
VI	1966	2014	49		-1.21		-0.406	-1.474	0.490	-1.171	0.236	63.15	77.91	39.86	72.44	46.49
VII	1966	2014	49		-1.99	*	-0.802	-2.229	0.202	-1.697	-0.011	56.79	100.99	36.37	84.51	39.57
VIII	1966	2014	49		-2.71	**	-0.531	-1.414	-0.020	-1.202	-0.128	17.44	66.13	21.62	62.05	25.02
IX	1966	2014	49		-0.30		-0.043	-0.434	0.425	-0.310	0.270	16.75	26.87	8.80	23.79	11.14
X	1966	2014	49		1.49		0.164	-0.103	0.571	-0.046	0.457	7.60	16.14	1.14468	14.518	2.74806
XI	1966	2014	49		-0.71		-0.079	-0.577	0.218	-0.425	0.124	15.069	30.9801	9.07865	25.039	10.6773
XII	1966	2014	49		-0.07		-0.009	-0.305	0.307	-0.225	0.194	9.8154	17.7002	3.57	15.8	4.65172
An	1966	2014	49		-1.90	+	-0.338	-0.728	0.099	-0.611	0.005	40.615	51.6605	32.5851	47.797	36.3455
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TREND STATISTICS

Q max Varbilau

				Mann-Kendall trend			Sen's slope estimate									
Time series	First year	Last Year	n	Test S	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95	B	Bmin99	Bmax99	Bmin95	Bmax95
I	1966	2014	49		0.27		0.001	-0.019	0.021	-0.013	0.017	0.66	1.11	0.23	0.93	0.30
II	1966	2014	49		-1.51		-0.020	-0.073	0.010	-0.055	0.004	1.68	3.30	0.90	2.67	1.14
III	1966	2014	49		-0.08		-0.001	-0.032	0.052	-0.021	0.031	0.85	1.57	0.22	1.29	0.43
IV	1966	2014	49		0.20		0.003	-0.038	0.078	-0.022	0.048	1.44	2.71	0.34	2.11	0.75
V	1966	2014	49		0.57		0.013	-0.063	0.230	-0.038	0.147	1.86	3.95	-0.38	3.23	0.13
VI	1966	2014	49		1.11		0.068	-0.155	0.295	-0.064	0.221	4.34	11.69	0.04	7.67	1.24
VII	1966	2014	49		0.84		0.037	-0.080	0.209	-0.045	0.141	2.56	5.92	-0.18	4.51	0.56
VIII	1966	2014	49		-0.55		-0.012	-0.122	0.082	-0.088	0.053	2.67	5.74	0.01	4.30	1.14
IX	1966	2014	49		0.64		0.003	-0.014	0.024	-0.008	0.018	0.46	1.02	0.02	0.82	0.11
X	1966	2014	49		2.66	**	0.010	0.000	0.036	0.002	0.026	0.10	0.29	-0.2673	0.2196	-0.1426
XI	1966	2014	49		0.38		0.003	-0.021	0.024	-0.012	0.015	0.6079	1.09829	0.07491	0.8298	0.13619
XII	1966	2014	49		1.28		0.007	-0.017	0.070	-0.005	0.049	0.919	1.14939	-0.21717	0.938	-0.0431
An	1966	2014	49		0.73		0.033	-0.092	0.169	-0.060	0.135	3.989	7.22423	1.55673	6.6891	2.18662
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Data source: I.N.H.G.A.

Fig. 12 – Mann-Kendall statistical test

The analysis revealed that trends in maximum flow in the Prahova upper basin were generally negative (decreasing), statistically significant for February, May, July, August and the mutiannual mean, while for Slănic river basin the trend was mostly positive, statistically significant for October.

Conclusions

The maximum flow is the result of high supply resulting form snowmelt and heavy rainfall. This is influenced by the climatic factors, the surface and the river basin form, the moisturing level, soil temperature and permeability, vegetation etc..

The analyzed region, where the four hidrometric stations are located, presents a nivo-pluvial hydrologic regime, characterized by high waters in late spring and low waters in winter.

Regarding the evolution of the annual maximum flow no significant trend can be observed, but from the analyzed period the year 2005 can be observed it has the largest number of events and the biggest floods, followed by 2001, 2007 and 2010 (Fig. 2,3,4,5). Maximum annual flows were recorded in Teleajen river basin (at Moara Domnească hidrometric station), having the largest area of all analyzed river basins (Fig. 4).

From the seasonal analysis results that the most foold events with significant flows are recorded in the spring-summer season (in Prahova and Teleajen river basin) and summer-autumn (in Slănic river basin) (Fig. 6).

Regarding the number of calculated events for the 30 years period, the hidrometric station which stand out with the most events is Moara Domnească, with a declining trend, while Câmpina hidrometric station has the fewest overcomings of the Warning Level, currently with a growing trend (Fig. 11).

The analysis revealed that trends in maximum flow in the Prahova upper basin were generally negative (decreasing), statistically significant for February, May, July, August and the mutiannual mean, while for Slănic river basin the trend was mostly positive, statistically significant for October (Fig.12).

The next step is intended to analyze the potential impact of climate change on the hydrological regime af the maximum flow in the analyzed basins.

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******* Studii la staţiile hidrometrice. Arhiva I.N.H.G.A.