PEAK MAXIMUMS ON THE RIVERS OF THE PRUT AND SIRET BASINS (WITHIN UKRAINE)

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Introduction

The maximum river runoff is one of the important extreme regime characteristics of river water runoff. It causes various manifestations of catastrophic situations (flooding of territories, settlements, destruction of bridges, buildings, hydraulic structures, etc.). The maximums on the rivers are characterized by the daily mean maximum discharge of water runoff (defined as an average over the periods daily measurement) or peak discharge of water runoff (the absolute maximum of the day). On small rivers, there could be significant differences in values between these maximum, but the larger the river, the smaller these differences. Especially, such differences can be traced in mountainous regions, where, flowing from mountains with large slopes, rivers pass into the foothills and then go to the plain or lowland

Prut and Siret are the rivers in southeastern Europe (Fig. 1). They belong to the Danube river basin and they are its left tributaries. The heights of the terrain in these basins are distributed as follows: 55% of the study area is within the heights of 200-400 m a.s.l, 16% - 400-800 m a.s.l and 29% - above 800 m a.s.l.

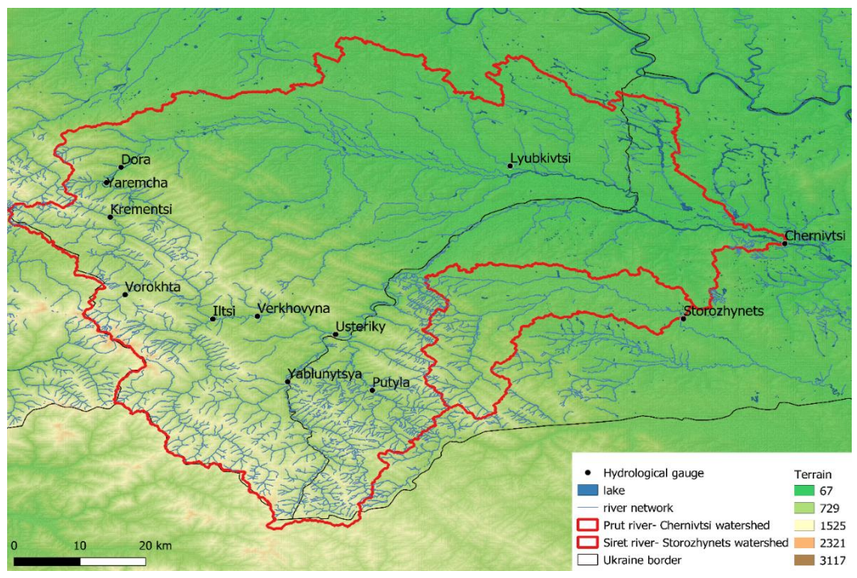

Fig. 1. Area of investigation

Results and discussion

The overwhelming majority of the variation coefficients of the maximum water runoff on the rivers of the Prut and Siret river basins vary in the range of 0.8-1.0; the asymmetry coefficients have positive values and, in general, are in the range of 1.8-2.5. The observation series for the maximum water flow in the studied rivers are representative.

Checking the equality of mean values by Student's test (statistics t) and equality of variance by Fisher's test (statistics F) showed that the hypothesis of homogeneity of samples of the maximum annual water runoff for all rivers of the Prut and Siret basins is accepted. The result is the same for Wilcoxon's test (statistics of the number of inversions U).

Maximum peak annual water runoff in small river (from catchment areas of 100-200 km^2) has little effect on the value of the average annual, only 15-20 %. For rivers with catchment areas of 500-2000 km^2, the formation of the average annual runoff by 30-50% determines the values of maximum peak. For hydrological gauge on the Prut river that is located near the city of Chernivtsi (Prut river- Chernivtsi) with the largest catchment area of 6890 km^2 the degree of such impact increases to 60 % (Fig. 2).

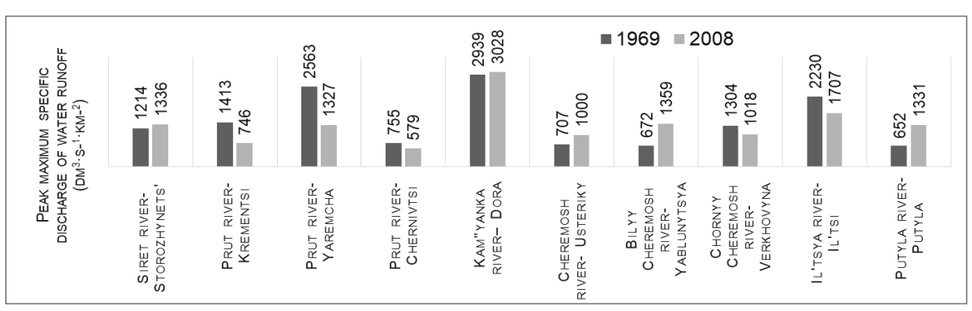

Fig. 4. Comparison of maximum peak specific discharge on the rivers of the Prut and Siret basins. 1969-2008.

The **main purpose** of the study is to identify how the daily mean maximum and peak maximum of water runoff of the day on the rivers in the Prut and Siret basins are related. This is an influential issue in assessing and forecasting the hazard of the hydrological situation on rivers.

Material and methods

To accomplish the tasks set, statistical methods for processing hydrometeorological information were used (determining the numerical characteristics of random variables, testing statistical hypotheses for the homogeneity of data series, statistical analysis of dependencies between variables, etc.).

A database has been created for a long-term period - the daily mean maximum water discharge and the maximum peak water discharge corresponding them on the rivers of the Prut and Siret river basins. There are 12 gauging stations in the study area, which monitor the flow of water in rivers. Eleven of them are located in the Prut basin and 1 gauging station is in the Siret basin.

River -Hydrological gauge	Observation period (number of years)	Fall of the river, ‰		River basin				
		average	Weighted average	Area, km^2	Average height, m (a.s.l.)	Average fall,%	Waterlogged, n/	Wooded, %
Siret river- Storozhynets'	1953-2016 (64)	9.3	4.7	672	590	144	<1	51
Prut river - Vorokhta	1978-2016 (39)	-	-	48.3	-	-	-	-
Prut river- Krementsi	1959-2016 (57)	27.5	11.9	366	1000	285	0	85
Prut river- Yaremcha	1950-2016 (67)	21.8	9.6	597	990	281	0	87
Prut river- Chernivtsi	1895-1911, 1920-1924, 1926-1935, 1945-2016 (109)	7.8	3.6	6890	450	-	<1	42
Kam"yanka river– Dora	1946-2016 (71)	111	66.4	18.1	870	446	0	76
Chornyava river- Lyubkivtsi	1984-2016 (32)	-	-	333	-	-	-	-
Cheremosh river- Usteriky	1957-2016 (59)	9.8	9.0	1500	1100	-	0	51
Bilyy Cheremosh river- Yablunytsya	1958-2016 (59)	19.0	10.2	552	1200	334	0	56
Chornyy Cheremosh river-Verkhovyna	1958-2016 (59)	16.7	11.4	657	1200	321	0	57
Il'tsya river- Il'tsi	1959-2016 (58)	40.2	30.5	86.1	1100	303	0	52
Putyla river- Putyla	1963-2016 (54)	24.2	15.8	181	960	325	0	50

Table 1. Hydrographic characteristics of rivers and their catchments of the Prut and Siret river basins

At 83% of hydrological stations on the rivers of the Prut and Siret basins have an observation periods for water runoff of 54 ÷ 72 years, only 2 stations have an observation period less than 40 years.

Greatest ratio between the peak maximum and daily mean maximum of water discharge is observed in small mountain watersheds with average heights of 1000-1200 m. a.s.l. where, the peak maximums typically exceed in 1.8-2.0 times the daily ones. From catchments with average heights of 400 m a.s.l. such ratios decrease to 1.1-1.3 with increasing catchment area (Fig.3).

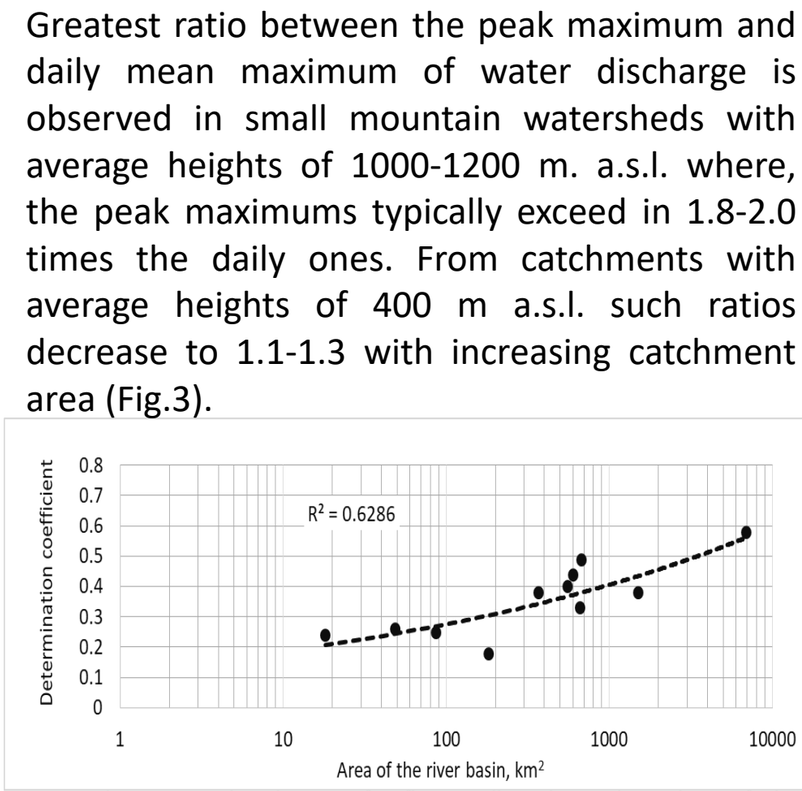

Fig. 2. Changes in the degree of influence (based on the values of the determination coefficients R^2) of the peak runoff on the average annual runoff of the rivers of the Prut and Siret basins, depending on the areas of their basins

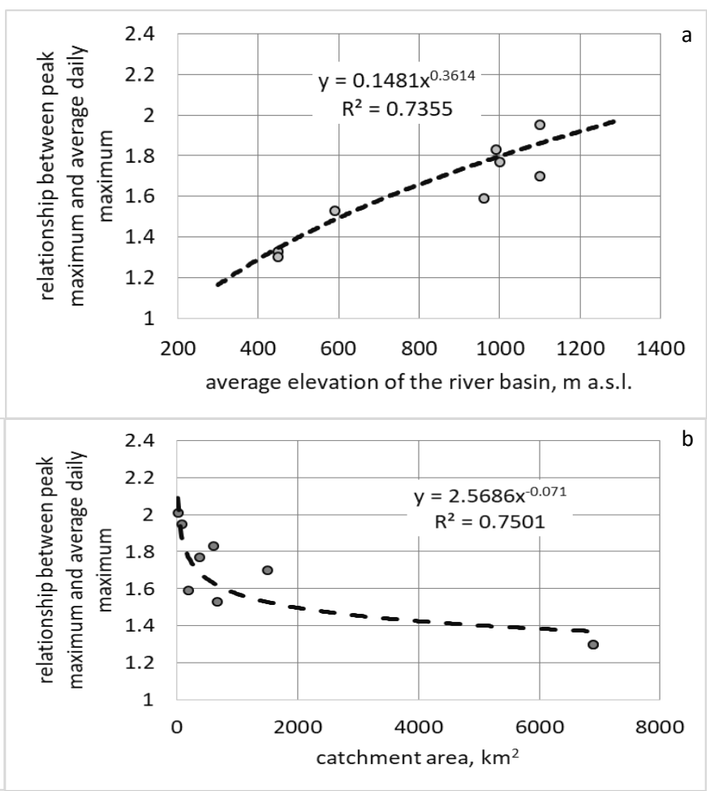

Fig. 3. Dependencies of ratios between peak maximum and average daily maximum to: (a) average elevations, (b) catchment area in the rivers of the Prut and Siret basins

Conclusion

The physical and geographical conditions of the Prut and Siret river basins (first of all, climatic and orographic) contribute to the formation of significant maxima on the rivers. The study area has elements of mountain and foothill orography. The water regime of rivers is characterized by spring freshets, but rain floods in the warm period of the year predominate, and snow-rain floods of the cold period are not inherent in these catchments. It is in the warm period we observe the greatest maximum peaks over the year, which have a rather intensive development during their formation. The time interval between the onset of the precipitation core and the maximum flood for the catchment area of 1000-1200 km^2 does not exceed 6-10 hours. Therefore, between the peak maximum and daily mean maximum on the rivers of Prut and Siret basins are observed significant differences in values. In mountain watersheds with average heights of 1000-1200 m. a.s.l, the peak maximums typically exceed in 1.8-2.0 times the daily ones. From catchments with average heights of 400 m a.s.l. such ratios decrease to 1.1-1.3.

The highest maximum peaks of water runoff on the rivers in the Prut and Siret basins during the observation period were recorded in 1969 and 2008 (Fig.4). The highest maximum peak specific discharge can reach 3000-3500 dm^3·s^{-1}·km^{-2} on small mountain rivers with small-scale catchment areas.