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Принос към изясняване на режима на движение на водите и на водния баланс на трансграничната река Ерма

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The Jerma is a transboundary river shared by Serbia and Bulgaria. It originates on the Vlasina Plateau in Serbia, near Lake Vlasina, and flows in the northwesterly direction towards Bulgaria. It leaves Serbia and enters Bulgaria near the village of Strazimirovci, flows through Bulgaria and re-enters Serbia near the village of Petačinci (Dimitrovgrad Municipality). The Jerma rises at the junction of the Vučja and the Grubina near the village of Klisura, but because the former is the longer stream, the source of the Vučja is considered the source of the Jerma as well. The Jerma empties into the Nišava River. Its source-to-mouth length is 73.9 km, of which 46.5 km falls within Serbia and the remainder in Bulgaria (Đokić, 2015). The catchment size is 820.19 km^2, of which 389.72 km^2 (47.5%) is in Serbia and 430.47 km^2 (52.5%) in Bulgaria (Ristić Vakanjac et al., 2019). From its source to the Bulgarian border, the Jerma receives the following tributaries: the Kostreševska (right) and the Drajinska and the Crvena (left). The Jerma enters Bulgaria (where it is the Erma) near Strazimirovci and widens in the Znepole Valley. There is receives the Yarlovachka (left) and the Lishkovitsa and the Glogovshtitsa further downstream. Downstream from Znepole Valley, the Erma has cut Transko Zhdrelo (Gorge of Tran) in limestones. It re-enters Serbia near the village of Petachinci (Petačinci). In this area, it receives the Yablanitsa, its largest (right) tributary. Further downstream, it is joined by the Poganovska (right tributary) the Zvonačka and the Kusovranska (major left tributaries).

Given that the flow regime of the Jerma is not uniform and that this river is prone to flash flooding, the paper will focus on the pluviographic and flow regimes. The study period was from 1961 to 2019, or from the time, the National Hydrometeorological Service of Serbia (RHMZ) established a river stage and discharge gauging station on the Jerma. The pluviographic regime was analyzed based on monthly totals from rain gauges near or within the Serbian part of the Jerma's catchment. These included the Klisura Station (alt. 800 m), the Vlasi Station (485 m) and the Sukovo Station (475 m) in the Jerma catchment, as well as the Stojković Mahala Station (1280 m) located near the source, on the very water divide of the Jerma, and the Okruglica Station (1160 m) and the Kalna Vlasotinačka Station (950 m) in the immediate vicinity of the Jerma catchment. Data from the Dimitrovgrad Weather Station was also taken into account, even though it is not located in the Jerma catchment but was the only station that could provide daily precipitation totals and snow cover data in the extended area. Mean annual precipitation ranged from 638 mm (at Sukovo) to 868 mm (at Stojković Mahala). The highest monthly precipitation levels were recorded in June and the lowest in August, on average. Precipitation clearly increased with altitude. A regression analysis showed an increase of 28 mm with every 100 m, on average.

In Serbia, the discharge of the Jerma is gauged on two locations: the Strazimirovci Station monitors 95 km^2 of the catchment area and is located immediately upstream from the point where the Jerma enters Bulgaria, and the Trnski Odorovci Station, situated slightly downstream from the place where the Jerma re-enters Serbia (covering 557 km^2, of which 77.5% is in Bulgaria). Both of these gauging stations were set up by RHMZ in 1961. For insight into annual rainfall-runoff (Figs. 1a, b), show the correlations between annual precipitation totals (at Stojkovic Mahala), calculated for calendar and hydrological years, and the mean annual discharges calculated for both the gauging stations. The weather station at Stojković Mahala was selected because it yielded the best results. The reason for this was certainly its altitude (1280 m). It best reflects the pluviographic regime of the catchment, particularly in the source area of the Jerma (or the part of the catchment monitored by the gauging station at Strazimirovci). The regression correlations in both cases for the calendar year and the hydrologic year were similar, but there was some data scatter in the case of the hydrologic year and thus the correlation coefficients were higher. The hydrological year coefficient of correlation between total rainfall and mean annual runoff at Strazimirovci was 0.577 and at Trnski Odorovci – 0.468. The slightly lower latter value is certainly due to the hypsometric curve of the catchment. The upper part of the catchment is at higher elevations, where a snow cover forms in winter (November–March) and snowmelt occurs in early spring, when air temperatures rise above freezing.

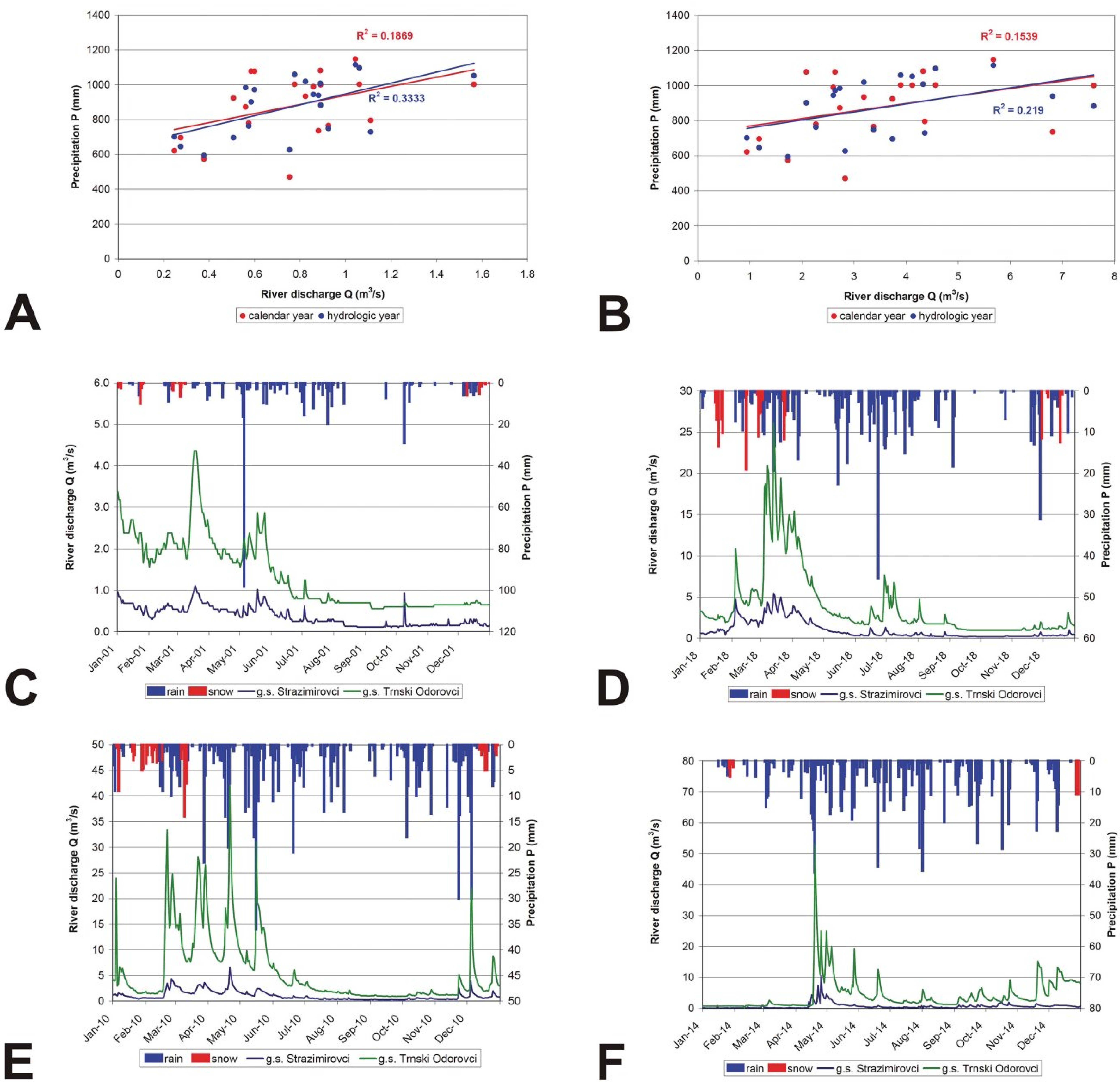

Fig. 1. Precipitation vs. runoff in the Jerma catchment: *a*, correlation between mean annual discharge of the Jerma at Strazimirovci and annual precipitation at the met station of Stojković Mahala; *b*, correlation between mean annual discharge of the Jerma at Trnski Odorovci and annual precipitation at Stojković Mahala; *c–f*, hydrographs of the Jerma at Strazimirovci and Trnski Odorovci and pluviograph at the met station of Dimitrovgrad for the 4 selected characteristic years

Table 1. Characteristic water balance parameters of the Jerma River at the studied gauging stations

Gauging station	F	P	E	h	Qav	q	W	φ
	km^2	mm	mm	mm	m^3/s	$l/s/km^2$	10^6 m^3	
Strazimirovci	95	865.9	633	233	0.701	7.379	22.11	0.27
Trnski Odorovci	557	865.9	667	199	3.518	6.316	110.94	0.23

In this regard, precipitation in the form of snow recorded in November and December contributes to runoff in the next calendar year. For a catchment such is that of the Jerma, it is important to use the hydrological year that begins on 1 October and ends on 30 September of the following calendar year.

Four characteristic years were selected to portray the analysis of daily discharges of the Jerma: (i) 2001, a typical dry year in which both stations recorded low discharges (Fig 1c); (ii) 2018, during which the discharges were of the order of mean annual values at both stations (Fig. 1d); (iii) 2010, a year of high discharges at both stations (Fig. 1e); and (iv) 2014, a year during which high discharges were recorded at Trnski Odorovci and discharges close to the multiyear average at Strazimirovci (Fig. 1f). Daily precipitation totals from the weather station at Dimitrovgrad were used to define their effect on the discharge of the Jerma, given that only that station could provide data at the time of the study. The coefficients of correlation between the discharges recorded by the two gauging stations were in the range from r=0.95 for the dry year (2001), r=0.94 for the wet year (2010) to 0.93 for discharges roughly equal to the multiyear average (2018). In the year 2014, during which the mean annual discharge at Strazimirovci was average and at Trnski Odorovci above average (wet year), the coefficient of correlation was only r=0.6. In 2014, the tributaries that join the Jerma downstream from Strazimirovci contributed to the formation of the flood waves registered at Trnski Odorovci, so that the flood waves were actually formed in Bulgaria. It is apparent from Figures 1c–f that hydrograph peaks are associated with spring months, due to snowmelt and/or heavy rainfall. In summer and autumn, the lower peaks were caused by heavy rainfall.

Since precipitation levels vary to a large extent over both space and time, there were certainly rainfall episodes in the central part of the Jerma catchment, which were registered at Trnski Odorovci (hydrograph rise) but not at Stazimirovci. For example, in addition to 2018, high mean annual discharges were recorded at Trnski Odorovci in 2005, whereas the discharges at Strazimirovci were around the multiyear average. By contrast, the latter station recorded high mean annual discharges in 1999, which had no affect on the discharges at Trnski Odorovci. The station at Trnski Odorovci registered discharges that reflected an average wet year. As such, the tributaries of the Jerma between Strazimirovci and Trnski Odorovci have a considerable effect on its flow regime. The monthly distribution is similar; it indicates high discharges at Strazimirovci in April and at Trnski Odorovci in March, due to snowmelt. The Strazimirovci Station is at a higher elevation and the air temperatures are lower, so snowmelt is delayed. The water balance of the Jerma during the study period (1961–2019) was estimated based on available measured data and observations in the catchment area covered by the gauging stations at Strazimirovci and Trnski Odorovci. The results are shown in Table 1, where F is the catchment area, P is the multiyear average precipitation (rain gauge at Stojković Mahala), E is the evaporation, h is the runoff depth, Qav is the multiyear average discharge, q is the specific runoff, W is the runoff volume, and j is the runoff coefficient.

The gauging station at Strazimirovci covers a catchment area of 95 km^2, which is entirely in Serbia. The multiyear average discharge in this part of the Jerma catchment is 0.701 m^3/s. The gauging station at Trnski Odorovci covers a catchment area of 557 km^2, of which 77.3% is in Bulgaria, and the gauging station at Strazimirovci covers 17.1%. The remainder (5.6%) is the part of the Jerma's catchment from the point of re-entry into Serbia to the gauging station at Trnski Odorovci. The study shows that due to the spatial and temporal non-uniformity of precipitation, flood waves can rise near the source of the Jerma, or in Bulgaria, or along the lower river course. A more detailed study of the flow and pluviographic regimes of the Jerma would require monitoring of the catchment to collect better data for subsequent analyses or simulation models that would yield better results.

References

Đokić, M. 2015. *Nišava – potamološka studija*. Doktorska disertacija, Prirodno-matematički fakultet, Univerzitet u Nišu, 342 p. (in Serbian).

Ristić Vakanjac, V., M. Čokorilo Ilić, D. Polomčić, D. Bajić., B. Vakanjac, P. Kostić. 2019. Režim pogranične reke Jerme. – In: *2nd Intern. Sci. Conference "Regional Development and Cross-border Cooperation"*, 731–741 (in Serbian).