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[Poster]

Assessment of Long-Term River Discharge Variability and Precipitation Coherence: The South Morava River, Serbia

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Abstract: Long-term hydrological records provide an important basis for understanding how climate variability is reflected in river discharge. This study examines the relationship between precipitation variability and river discharge cycles in the South Morava River Basin (Serbia), over a 100-year period (1924–2023). Mean and maximum annual discharges at the downstream Mojsinje hydrological station were analysed in relation to annual total precipitation and maximum daily precipitation recorded at five representative meteorological stations across the basin. Cross-spectral analysis was applied to identify common periodic components and their coherence. For that purpose, statistical method of cross-spectral analysis was performed. The results reveal pronounced spatial differences in precipitation–discharge system. Stronger and more consistent coherence was identified between mean annual values, whereas relationship between maximum values were weaker and more spatially heterogenous. The findings can provide a basis for broader research on the relationship between climate variability, climate change and river discharge, while also offering useful insights for future water-resource management.

Keywords: river discharge, climate variability, cycles, South Morava River

Introduction

Climate change and direct human impacts affect hydrological cycle and the availability of both groundwater and surface water resources. Hydrological variations and river regimes are primarily influenced by variations in temperature and precipitation, as well as by frequency and magnitude of extreme events (Blöschl et al., 2019; Bărbulescu et al., 2025). Consequently, understanding long-term river discharge variability and its characteristics has become increasingly important for human activities, integrated water management, environmental protection and natural hazard assessment.

Long hydrological records are particularly valuable because they enable short-term fluctuations to be distinguished from multi-decadal variability and provide an opportunity to investigate whether recurrent patterns in river discharge are associated with corresponding climatic oscillations (Melnik et al., 2025). Previous studies have demonstrated that long-term discharge series may contain multi-year and multi-decadal cycles, although their periodicity vary considerably among catchments (Pekarova et al., 2021).

The South Morava River Basin represents an appropriate case study due to the availability of an almost century-long hydrological record and its spatially heterogeneous climatic conditions. A previous comprehensive analysis identified significant differences in discharge trends and cyclicity along the river course (Langović et al., 2023). Building on these findings, the present contribution focuses specifically on precipitation–discharge relationship. The main objective is to examine relationship between precipitation variability and river-discharge cycles on the example of the South Morava River, Serbia, using a 100-year period (1924–2023).

Methods and data

Hydrological data included mean annual discharge (Q_{mean}) and maximum annual discharge (Q_{max}) at the Mojsinje hydrological

station for the period 1924-2023. Discharge data were obtained from the Hydrological yearbooks of the RHSS.

Meteorological data were obtained from stations distributed across the South Morava River Basin. Five representative stations - Niš, Leskovac, Vranje, Kuršumljia, and Vlasina – were selected for detailed analysis.

Cross-spectral analysis was applied to investigate common periodic components and the strength coherence between hydrological and precipitation time series in the frequency domain (Wang and Worman, 2019). The climate – hydrology relationship was analyzed using multiple correlation. This approach enabled the identification and comparison of dominant precipitation–discharge periodicities at different temporal scales. The statistical analysis was performed in the JASP/R environment.

Results and discussion

The obtained results revealed pronounced differences in precipitation-discharge coherence among the analyzed meteorological stations. Mean annual discharge and annual precipitation showed a stronger and consistent relationship, with statistically significant cross-spectral coherence identified at all five stations. A common cycle of approximately 17-20 years was particularly evident at four stations (Vranje, Leskovac, Niš and Kuršumljia). Other significant periodicities varied spatially, including approximately 8–12 years at Vranje, 5 years at Vlasina and Kuršumljia, and 7–8 years at Niš. These differences indicate considerable spatial heterogeneity in precipitation–discharge coupling within the South Morava River Basin.

In contrast, maximum annual discharge and maximum daily precipitation generally showed weaker and less consistent cross-sectoral relationship. The most pronounced exception was Leskovac, where significant coherence was identified at approximately 8-year and 17-20-year periods. At the other stations, significant components were either absent, as in the case of Vranje, or concentrated mainly

withing short 2-3-year periods, which does not necessarily mean repeatability of the time series..

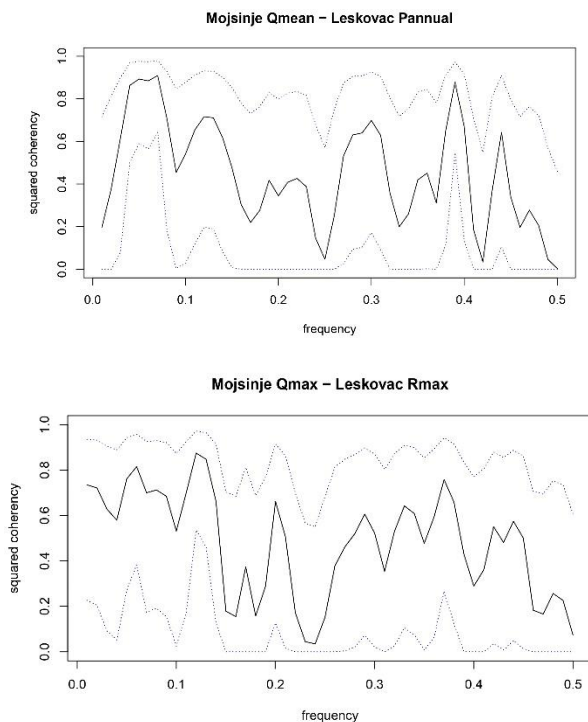


Figure 1 – Cross-spectral coherence between discharge at HS Mojsinje and precipitation at MS Leskovac: (a) $Q_{\text{mean}} - R$, and (b) $Q_{\text{max}} - R_{\text{max}}$

Overall, the results confirm the importance of precipitation as a major factor controlling long-term discharge variability, while indicating a clearer relationship with mean then with maximum annual discharge. Mean discharge represents an integrated response of the basin to precipitation over longer periods. On the contrary, maximum annual discharge reflects individual events that occur once or more times a year without the regularity of their occurrence. Likewise, the direct influence on discharge depend also on external factors such as the current bankfull discharge and water level, height of snow cover in the basin, anthropogenic endangerment of the riverbed, etc.

Furthermore, the maximum daily precipitation registered at an individual station does not necessarily correspond spatially or temporally to the event responsible for the annual maximum discharge at HS Mojsinje. This difference may partly explain the weaker and more spatially heterogeneous coherence observed for maximum values.

Conclusion

The main objective of this study was to examine the statistical relationship between mean and maximum annual discharge of the South Morava River and precipitation characteristics obtained from five meteorological stations within the basin. The results showed significant and relatively consistent cross-spectral coherence between mean annual discharge and annual precipitation, including a 17–20-year cycle identified at most analysed stations. At the same time, secondary periodicities differed considerably between stations, indicating pronounced spatial variability.

In contrast, maximum annual discharge and maximum daily precipitation showed weaker and less consistent periodic relationships. This suggests that hydrological extremes are controlled by a more complex combination of meteorological and basin conditions and therefore exhibit lower temporal regularity.

Future research should extend the analysis to additional hydrological stations within the South Morava River Basin and include seasonal discharge and precipitation variability, as well as the potential influence of large-scale atmospheric circulation patterns.

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