Hydrological Regime Shifts in the Carpathian Basin: Assessing Decreasing Minimum Discharges During the Warm Season

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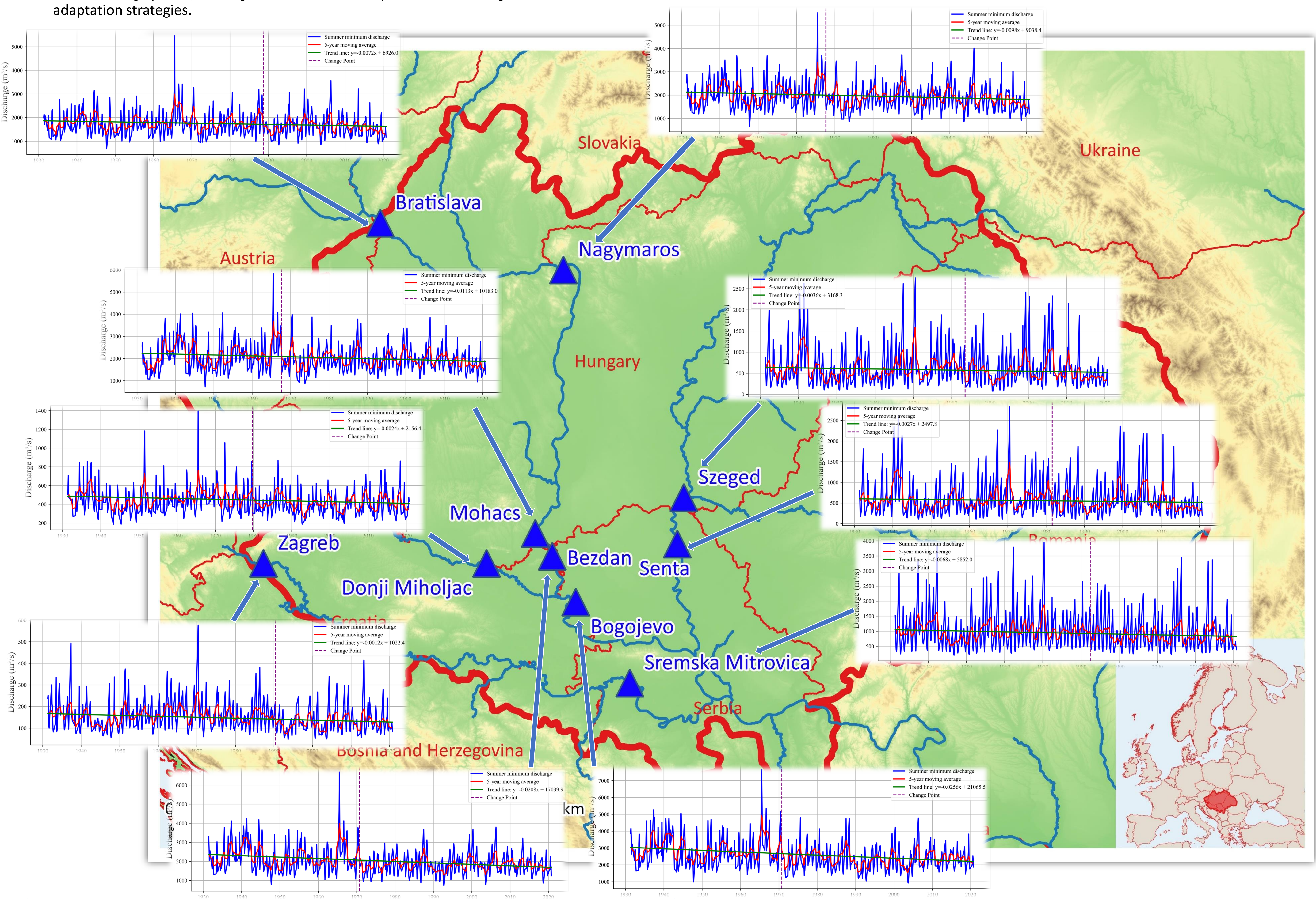
Introduction

- River discharge plays a crucial role in shaping natural and human environments, influencing floods, droughts, water availability, and ecosystem sustainability.
- Climate projections indicate significant hydrological changes in southern Europe and the Carpathian Basin, with reduced river flows and increased frequency of extreme water events.
- tudies show declining river flows in southern and eastern Europe, while northern Europe experiences increasing discharge, highlighting spatial variability in hydrological responses.
- Winter discharges have increased, while summer flows show a declining trend, particularly in regions with low groundwater reserves, increasing the risk of summer droughts.
- Existing studies often rely on short-term datasets or focus on extreme events, lacking comprehensive long-term trend analyses, especially in southern and southeastern Europe.
- This study analyzes long-term summer minimum discharges in the Carpathian Basin, identifying trends, change points, and regional variations to improve water management and climate adaptation strategies.

Methods

- The study utilizes a 90-year (1931–2020) daily discharge dataset from 10 stations within the Carpathian Basin
- The dataset focuses on minimum monthly streamflow during the hydrological summer (April–October).
- Homogeneity checks were conducted using the Mann–Kendall (MK) and Pettitt tests to identify trends and potential change points.
- Mann–Kendall (MK) Test: A non-parametric method used to detect monotonic trends in river discharge.
- Pettitt Test for Change Points: A statistical method used to detect abrupt shifts in time series data.



Results

- Spatial Trends in Minimum Discharges
  - Downstream stations along the Danube, Tisza, and Sava Rivers show an increase in minimum discharge values due to tributary inflows and reduced extractions.
  - Significant discharge increases occur at key locations, such as between Bezdan and Bogojevo on the Danube and between Szolnok and Senta on the Tisza, indicating hydrological shifts.
- Temporal Variability of Summer Low Flows
  - Upstream sections exhibit greater variability in minimum summer discharges compared to downstream stations, where flow regulation and groundwater exchanges attenuate fluctuations.
  - The Drava River (Donji Miholjac) shows pronounced interannual variability, emphasizing strong climatic influences on low-flow conditions.
- Declining Trends in Summer Minimum Discharges
  - Mann-Kendall test results reveal a **statistically significant long-term decline in summer low flows** across the Danube, Tisza, Sava, and Drava Rivers.
  - Pettitt test identifies change points in discharge regimes occurring primarily between the late 1960s and 1980s, with earlier shifts in upstream sections.

Conclusion

- A 90-year dataset analysis reveals significant declines in summer minimum discharges across the Danube, Tisza, Sava, and Drava Rivers, with the **most pronounced reductions** in downstream Danube stations.
- Change points in river discharge patterns occurred **between the late 1960s and early 1990s**, indicating the combined impact of climate change and human activities on regional hydrology.
- Reduced summer flows highlight the **growing risk of prolonged droughts and water shortages**, posing challenges for water resource management, ecosystems, and socio-economic activities.
- Future strategies should integrate climate projections and hydrological models to **develop sustainable water management policies** that mitigate the impacts of changing flow regimes.
- Declining summer flows correspond to major hydrological changes, potentially driven by climatic variability, increased temperatures, and human interventions (dams, water extraction).
- The observed shifts align with broader regional hydrological changes, reinforcing the need for adaptive water management strategies in response to evolving flow patterns.

DroughtThruTime

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