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Detection, attribution and frequency analysis of non-stationary flood peaks in 32 big rivers worldwide

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Due to climate variability and reservoir regulation worldwide, it is fundamentally challenging to implement holistic assessments of detection, attribution and frequency analysis on non-stationary flood peaks. In this study, we proposed an integrated approach that combines the prewhitening Mann-Kendall test technique, Partial Mutual Information-Partial Weights (PMI-PW) method and Generalized Additive Models for Location, Scale and Shape parameters (GAMLSS) method to achieve reliable non-stationary flood frequency analysis. Firstly, the prewhitening Mann-Kendall test was employed to detect the trend change of flood peaks. Secondly, the PMI-PW was employed to attribute the contribution of climate change and reservoir regulation to non-stationarity of flood peaks. Lastly, the GAMLSS method was employed to quantify the change in flood risks under the non-stationary condition. The applicability of the proposed approach was investigated by long-term (1931-2017) flood series collected from 32 big river catchments globally. The results suggested that global flood trends varied from increasing +19.3%/decade to decreasing -31.6%/decade. Taking the stationary flood frequency analysis as the benchmark, the comparative results revealed that the flood risk in 5 rivers under the non-stationary condition in response to warming climate significantly increased over the historical period whereas the flood risk in 7 rivers in response to increasing reservoir storage largely reduced. Despite the spatiotemporal heterogeneity of observations, the changes in flood peaks evaluated here were explicitly associated with the changing climate and reservoir storage, supporting the demand for considering the non-stationarity of flood peaks in the best interest of social sustainability.

Keywords: Flood peaks; Large catchments; Non-stationarity; Frequency analysis

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