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Contrasting projected changes in European streamflow extremes across global warming levels

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Our study analyses streamflow characteristics across the European domain, focusing on changes in the frequency, magnitude, and duration of low and high streamflow events and their interactions. We use the percentile of the Standardized Runoff Index distribution (SRI-P) as a metric to characterize these hydrological events (dry using SRI-P < 0.2 and wet SRI-P > 0.8). The monthly gridded discharge time series are obtained from the multiscale Hydrological Model (mHM), which was forced by meteorologic data from the ISIMIP3b archive, which has been bias-corrected and downscaled using the latest E-OBS observational dataset. We first perform a historical evaluation (1960-2024) to evaluate the model's ability to capture observed streamflow characteristics against observation-based E-OBS meteorological characteristics. The projections are then analyzed according to different Global Warming Levels (GWLs) to identify non-linear responses in streamflow extremes to warming levels. Increasing global warming from 1.5°C to 3°C (with respect to the 1980-2010 GCM specific baseline) essentially intensify European streamflow toward severe and more extended drought conditions. While Northern Europe is projected strong high-flow events, these extremes lose their strength in the south. Instead, the focus shifts to low-flow extremes, which are growing more severe and frequent. This leaves the Mediterranean in a state of pronounced drying, while Central Europe sits in the middle, highlighting its vulnerability to hydrological risk as wet extremes weaken and droughts intensify, elevating pressure from both ends.