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A climate-informed model for frequency analysis of seasonal streamflow extremes in Europe

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The study of extreme streamflow is a key question for infrastructure design and for the reinsurance industry. During the last decades many studies examined possible links between large-scale atmospheric circulation and streamflow. However, a study investigating the effect of large-scale circulation modes on the frequency of seasonal extremes on the European scale is missing. Here we fit the classical Generalised Extreme Value distribution (GEV) to more than 600 records in Europe for each of the standard seasons, i.e. to winter, spring, summer and autumn maxima. The study covers the period 1950 to present and the gauges examined span a period of at least 50 years. We compare the classical GEV with a climate-informed model where the location parameter is a linear function of a large-scale atmospheric index. Mean indices of the same season as streamflow extremes are investigated. Five indices with known influence on the European climate are examined independently as covariates, namely the North Atlantic Oscillation (NAO), the East Atlantic pattern (EA), the East Atlantic / Western Russia pattern (EA/WR), the Scandinavia pattern (SCA) and the Polar-Eurasia pattern (POL).
For the fitting of the distribution we use a Bayesian methodology with non-informative priors and a no-pooling (local) model. We assess the performance of the climate-informed models with a two-step methodology: first we examine the statistical significance of the slope of the location parameter and secondly we compare the classical and climate-informed approaches by means of the Deviance Information Criterion (DIC). For many of the seasons and covariates investigated, the climate-informed distribution is preferred to the classical one for a high percentage of stations, with NAO having the largest influence during the winter season (preferred to the standard GEV for about 40% of the stations). The climate-informed fits are characterised by spatial coherence, forming patterns that resemble relations between the climatic indices and seasonal precipitation.