Non-stationarity in dispersion and skewness of extreme floods

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Hydrological design under changing climate, land use, and socio-economic conditions demands methods for detecting (and adequately accounting for) non-stationarity in extreme rainfalls and floods. However, the vast majority of methods for considering non-stationarity in extreme-value analysis account for possible variations in time in the sample average, disregarding possible trends in dispersion and skewness. Indeed there is no plausible reason why higher-order sample moments (or L-moments) should not be affected by change dynamics. The rationale behind disregarding these variations should therefore be ascribed to (i) the lack of a simple framework for detecting non-stationarity in dispersion and skewness, (ii) the perception that non-stationarities will not be detectable in higher order moments due to increased sample variability, and (iii) the difficulty to translate a detected non-stationarity into a corresponding revised design value without inflating estimation uncertainty.

In a nutshell, there is a relevant knowledge and perception gap tentatively addressed in this work. First, we extend the standard tools for trend detection and estimation to higher-order L-moments and L-coefficients. Second, we demonstrate that significant trends are indeed observed in dispersion and skewness of annual maxima floods on a vast database of 191 time series from Northern Italy with, for example, 30% of increasing trends (at a 10% significance level) in L-CV of longer time series (>30 years). Third, we set up a framework to extend the reasoning to regional frequency analysis, so as to deflate the estimation uncertainty trading space for time. Fourth and last, we reframe the design-flood exercise within a linearized cost-benefit context in order to properly account for the observed non-stationarities and the resulting estimation uncertainty.