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Rainfall frequency analysis from short data records: state-of-the-art automatic procedures for at-site applications

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Rainfall frequency analysis is crucial for hydrological design and flood risk management and relies on long records of rain gauge measurements. The recent developments in remote sensing of precipitation, as well as the deployment of new rain gauge networks in previously ungauged regions, provide rainfall information with unprecedented detail, calling for new methods able to exploit these short records for frequency analysis. Objective of this study is to assess the potential of different state-of-the-art methodologies for at-site rainfall frequency analyses based on short data records.

We implement automatic procedures based on (i) annual maxima series (AMS) and (ii) peaks over threshold (PoT), i.e. the classic extreme value theory, and on the newly-proposed (iii) meta-statistical extreme value framework (MEV). The procedures comprise separation of independent events based on the temporal autocorrelation and PoT threshold selection based on goodness of fit tests, allowing to adopt all these approaches in a non-supervised manner. We use a quality-controlled database of long-recording hourly rain gauges available for the United States (>200 gauges, >60-year record) and focus on long recurrence intervals. Assuming these records provide information on 100-year hourly intensities, we define the reference return levels from the full data series, quantifying the uncertainty via bootstrapping. We create synthetic short records randomly sampling 5–30 years from the full series and quantify errors (bias and standard error) and uncertainties (bootstrapping) related to the use of the three methods to estimate such return levels from short records.

The classic AMS and PoT approaches show similar dispersion of the 100-year return levels around the reference but, decreasing the record length, important over-estimations emerge (>25%, up to 100%). The MEV framework shows a consistent under-estimation (generally ∼20–30%, up to ∼50% for 5-year records), but no severe overestimation emerges when considering short records (<20%). The MEV framework proves highly robust to the use of short records (e.g., standard error <44% even for 5-year records), becoming preferable for records of 10 years or shorter. Results from this study are relevant for situations in which the quantification of long recurrence intervals from short records is sought, such as the case of remote sensing precipitation products and recently deployed rain gauge networks.