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Bootstrap-Based Confidence Intervals for Return Level Estimation from Autocorrelated Processes

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The magnitude of extreme events can be expressed in an m-year return level. Such return levels are important for, e.g., hydrological engineering. They can be estimated by means of peak-over-threshold or block maxima approaches and a corresponding parametric models for the extremes. Under the assumption of independent observations confidence intervals can frequently be derived from the asymptotic distribution of an estimator for the model parameters, for example, a maximum-likelihood estimator. As soon as observations are considered to be dependent, these confidence intervals might not be a meaningful representation of the uncertainty anymore.

We compare four bootstrap approaches for a more adequate representation of the uncertainty of return level estimates. These approaches involve classical bootstrap resampling procedures, Fourier based surrogate methods and linear stochastic models. In a simulation study with a known long-range dependent process [1] one of these methods yields adequate results. This approach is then investigated in more detail for a varying ensemble size.

We exemplify it with a case study: an extreme value analysis for a run-off record from a catchment in southern Germany. With the bootstrap approach and under the assumption of a long-range dependent underlying process, we find the upper 95%-confidence limit being about 20% larger than the corresponding asymptotic confidence limit derived under the assumption of an uncorrelated process. This is certainly a dimension worth considering in practical applications.

[1] A process is called long-range dependent if its autocorrelation function is decaying algebraically for lags $\tau \to \infty$.