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Complete time-series frequency analysis: return period estimation for time-dependent processes

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Risk analysis relies on finding the probability of failure of a given hydraulic structure/system, usually expressed in terms of return period, as a consequence of the occurrence of extreme hydrological events. In order to quantify risk conditions or design mitigation strategies, a probability distribution function is inferred after a series of observations of the random variable of interest. Frequency analysis is performed under the hypotheses of stationarity and independence of the observations, that are typically assumed as necessary conditions for return period equation (i.e. the inverse of exceedance probability). Specifically, to allow the assumption of the statistical independence of the observations, it is common practice in hydrological applications to implement some techniques for data selection, such as annual maxima or peak over threshold; this implies that some observations are a-priori discarded before the analysis. However, it was recently demonstrated that, under the stationarity assumption, the independence condition is not necessary in order to apply the classical equation of return period. Here, we illustrate and discuss how return period can be directly estimated from data records of time-dependent processes without applying any data selection strategy, i.e. potentially exploiting all the information provided by observations.