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How to estimate extreme values when the studied events are too rare?

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The statistical extreme value theory is commonly applied to estimate extreme events, like rare return levels of observed time series. However, this theory is based on the asymptotical convergence of the distributions of the highest values of a sample, when the sample size tends to infinity. This is never the case in practice, but when the number of observations is large, the assumption can be admitted. However there are situations for which this assumption is not verified. This is typically the case for example when dealing with snow events or very cold episodes in some places in France or in Europe. These types of event may occur one to three times in a winter, and may not be observed for a non negligible number of winter seasons during an observation period. Thus, neither the number of events per season, in a block maxima approach, nor the total number of events over the observation period can reasonably be assumed as tending to infinity. In such a situation, one proposed solution for very cold episodes for instance is to use a stochastic temperature generator in order to simulate a large number of temperature time series similar to the observed one. This then allows inferring the statistics of these rare events from a much larger sample than observed. The stochastic model used will be briefly described and an example of use to estimate return levels of cold events will be presented.