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On the two steps threshold selection for over-threshold modelling of extreme events

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The estimation of the probability of occurrence of extreme events is traditionally achieved by fitting a probability distribution on a sample of extreme observations. In particular, the extreme value theory (EVT) states that values exceeding a given threshold converge through a Generalized Pareto Distribution (GPD) if the original sample is composed of independent and identically distributed values.

However, the temporal series of sea and ocean variables usually show strong temporal autocorrelation. Traditionally, in order to select independent events for the following statistical analysis, the concept of a physical threshold is introduced: events that excess that threshold are defined as "extreme events". This is the so-called "Peak Over a Threshold (POT)" sampling, widely spread in the literature and currently used for engineering applications among many others.

In the past, the threshold for the statistical sampling of extreme values asymptotically convergent toward GPD and the threshold for the physical selection of independent extreme events were confused, as the same threshold was used for both sampling data and to meet the hypothesis of extreme value convergence, leading to some incoherencies. In particular, if the two steps are performed simultaneously, the number of peaks over the threshold can increase but also decrease when the threshold decreases. This is logic in a physical point of view, since the definition of the sample of "extreme events" changes, but is not coherent with the statistical theory.

We introduce a two-steps threshold selection for over-threshold modelling, aiming to discriminate (i) a physical threshold for the selection of extreme and independent events, and (ii) a statistical threshold for the optimization of the coherence with the hypothesis of the EVT. The former is a physical events identification procedure (also called "declustering") aiming at selecting independent extreme events. The latter is a purely statistical optimization aiming at choosing the best fit extreme value distribution, based on the EVT.

This approach is general and can be applied to different environmental processes. Thus, a list of physical criteria traditionally used for the selection of the "extreme events" sample is given and discussed. Two applications are made: one on extreme surge analysis and the other on extreme wave heights analysis.