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Quantification of devastating climate events under climate change through novel multivariate bias correction methods

Some of the most devastating climate events of recent decades involve the combination of several climate variables on fairly large scales and over a period of time. Sometimes combinations of elementary climate events which are not necessarily devastating when isolated can have devastating effects when they occur simultaneously or successively within a short period. These extreme climate events, called compound events (EC, Zscheischler et al., 2020) correspond to particular combinations of climatic variables presenting patterns of spatio-temporal dependencies and inter-variables dependencies.

To better understand their evolution in a climate change context, climate models, such as those involved in the "Coupled Model Intercomparison Project Phase 6" (CMIP6, Eyring et al., 2016), are used to get simulated data of a future climate. Due to numerical issues (discretization effects, low spatial resolution) or physical issues (parametrizations), climate models exhibit various biases in their marginal, spatial and inter-variable properties, which necessarily affect the representativeness of compound events. The outputs of the climate models need to be bias corrected with statistical methods (François et al., 2020).

The objective of this thesis project is to establish a statistical relationship between high-impact catastrophic compound events and the large-scale structures that are their triggers, first on reanalysis data in the near past, and then to project this relationship in the future to assess the evolution of these catastrophic events in terms of frequency and location. Considering the shortcomings of current bias corrections, several multivariate bias correction methods will be tested and compared in the near past (as well as compared to univariate correction, as a benchmark) and the best correction method will be selected for projection.

The first results show a massive statistical improvement of the return periods of the selected events after the use of a univariate bias correction method. The next steps of the PhD work will consist in implementing multivariate bias correction methods to improve the statistical properties of the bivariate return period. More results are needed to conclude on the frequency evolution of precipitation events, as climate models do not give a common tendency in future precipitation.

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