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Multivariate Analysis of Extreme Natural Hazards Combination: Basics and Examples.

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Some combination of external hazards might cause damage to nuclear power plants which have been designed to withstand alone hazards including margins. Thus there is a need to better quantify the likelihood of such combination of extreme hazards, in order to take a decision regarding their modelisation: according to their impact on the safety of the nuclear power plant and their likelihood, the extreme combination will be taken into account in the safety demonstration studies or not.

In our studies, we focus on extreme natural hazards such as flooding, high winds, high air temperatures, for which we have a certain amount of simultaneous measures, observed for the last decades. We use the theory of extreme multivariate statistics to estimate the probability of some extreme combinations: in addition to classical univariate extreme value analysis performed for each extreme hazard that leads to estimate a Generalized Pareto Distribution (GPD) or a Generalized Extreme Value distribution (GEV: Weibull, Frechet or Gumbel), we need to study and model the tail dependence between the hazards, which can take various forms: dependence, exact independence, or asymptotical independence with positive or negative association.

In the paper, we briefly recall the main results of the theory of extreme multivariate statistics. We also explain different strategies to statistically infer on multivariate observations, which needs a certain number of choices from the analyst.

Then, we illustrate the different cases of extreme dependence and some possible statistical results such as the probability and the annual frequency of joint occurrence of extreme hazards on several data set related to hydrology and meteorology: conjunction of high wind and high flow, of two rivers discharges, conjunction of low air temperatures and low river flow. We also draw cartographies of joint probability or annual frequency of joint extreme hazards defined by their return period.