Risk measures based on time series

Catastrophic climate events like floods, wildfires, heatwaves are often the result of the simultaneous extreme behavior of several interacting processes. The combination of processes leading to a significant impact is referred to as a compound event. Traditionally, climate science research has though focused on single drivers or univariate dangers, reducing the complexity of climate dynamics and possible consequences. However, compound risk reflects the chance of many interacting climate causes or hazards, and hence these should be considered simultaneously in statistical analyses. Since in compound events several factors are jointly extreme it is for a proper understanding of them crucial to develop extreme value methods in a multivariate context, and this is the major aim of this PhD. In particular, we will study extensions of univariate risk measures to the multivariate context, without assuming unrealistic assumptions for applications in climate science, such as independence of the observations.

The most well-known example of a multivariate risk measure is the Marginal Expected Shortfall (MES), defined by

$$E(X|Y>Q(\alpha)),\ \alpha \in (0, 1),$$

where (X, Y) represents a pair of risks and $Q(\alpha)$ is the α-quantile associated with risk Y. This tool is important for measuring the systemic risk of financial institutions. Cai et al. (2015) proposed an estimator of the MES when the variables of interest follow Pareto-type distributions and recently Goegebeur et al. (2021, 2023) considered the estimation of the MES when the random variables of interest are observed together with a random covariate. Unfortunately, these works are not directly applicable in climate science, where data are often collected over time (temperature, precipitation, ozone…) and therefore exhibit time dependence, thus violating the usual assumption of independent observations.

Our objective in this thesis will therefore be to estimate risk measures based on time series, in particular those of the MES type. The presence of a temporal dependence will clearly constitute the mathematical challenge to be grasped in the theoretical study of estimators and will have to be done in the context of time series with regular variations (Basrak and Segers, 2009).

Note that this PhD may be preceded by a Master 2 thesis over the period February - July 2024 (dates to be defined) allowing the candidates to familiarize themselves with the subject.

References:

Basrak, B. & Segers, J. (2009). Regularly varying multivariate time series. Stochastic Processes and their Applications, 119, 1055-1080.

Cai, J.J., Einmahl, J.H.J., de Haan, L. & Zhou, C. (2015). Estimation of the marginal expected shortfall: the mean when a related variable is extreme. Journal of the Royal Statistical Society Series B, 77, 417-442.

Goegebeur, Y., Guillou, A., Ho, N.K.L. & Qin, J. (2021). Conditional marginal expected shortfall, Extremes, 24, 797-847.

Goegebeur, Y., Guillou, A., Ho, N.K.L. & Qin, J. (2023). A Weissman-type estimator of the conditional marginal expected shortfall, Econometrics & Statistics, 27, 173-196.

Starting date: October 1st, 2024.

Application deadline: From now until May 1st, 2024.

Place of work: Institut de Recherche Mathématique Avancée, UMR 7501, Université de Strasbourg.

Skills: solid background on statistics and probability, particularly in stochastic processes, and a taste for applications. Good programming skills (R and if possible a programming language).

Instructions for applying: Applications must contain: CV + letter of motivation + master and bachelor notes + the names and emails of two references. All these documents should be addressed to Armelle Guillou (armelle.guillou@math.unistra.fr).