Modeling simultaneous flooding in river networks with precipitation covariates using Hüsler–Reiss graphical models

Rita Maatouk*[1], Thomas Opitz[2], and Mike Pereira

[1]École Nationale Supérieure des Mines de Paris [Fontainebleau] – Mines Paris - PSL (École nationale supérieure des mines de Paris) – France

[2]Biostatistique et Processus Spatiaux (BioSP) – Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement – Site Agroparc Domaine St Paul 84914 Avignon cedex 9, France

Abstract

This study focuses on the risk of simultaneous flooding in river networks. The objective is to develop a graphical model that integrates climate variables as covariates in order to estimate extreme river flow values under specific climatic conditions. To capture the dependence structure of extremes across multiple sites and basins, we employ the Hüsler–Reiss graphical model for multivariate extremes which identifies conditional dependencies between rivers and covariates. First, we investigate the spatial relationships between extremes of precipitation and river flows within a watershed using the Hüsler–Reiss graphical model. This allows us to characterize dependencies between river flow stations, between precipitation locations, and between precipitation and river flows. Building on this framework, we propose a novel semi-imposed approach: part of the graphical structure is pre-specified based on hydrological knowledge, while the remaining edges and the model parameters are learned from the data. This balance aims to achieve a model that is both interpretable and computationally efficient.

Keywords: Graphical model, Multivariate extreme events, Hüsler–Reiss distribution, Flood risk, Climate covariates

*Speaker