Bayesian mixture models for heterogeneous extremes

Viviana Carcaiso*[1], Miguel De Carvalho[2], Ilaria Prosdocimi[3], and Isadora Antoniano-Villalobos[3]

[1]institut national de recherche sur l'agriculture, l'alimentation et l'environnement – INRAE – France
[2]University of Edinburgh – United Kingdom
[3]Université de Venise Ca' Foscari — Università Ca' Foscari di Venezia – Italy

Abstract

The conventional use of the Generalized Extreme Value (GEV) distribution to model block maxima may be inappropriate when
extremes are actually structured into multiple heterogeneous groups. This can result in inaccurate risk estimation of extreme events based on return levels and in inaccurate generation of maxima based on unrealistic models. In this work, we propose a novel approach for describing the behavior of extreme values in the presence of such heterogeneity. Rather than defaulting to the GEV distribution simply because it arises as a theoretical limit, we show that alternative block-maxima-based models can also align with the extremal types theorem while providing improved robustness and flexibility in practice. Our formulation leads us to a mixture model that has a Bayesian nonparametric interpretation as a Dirichlet process mixture of GEV distributions. The use of an infinite number of components enables the characterization of every possible block behavior, while at the same time defining similarities between observations based on their extremal behavior. By employing a Dirichlet process prior on the mixing measure, we can capture the complex structure of the data without the need to pre-specify the number of mixture components. The posterior distribution can also be used to generate climate maxima that reflect the heterogeneity observed in real data. The application of the proposed model is illustrated using both simulated and real-world climate data.

Keywords: Bayesian nonparametrics, Dirichlet process mixture, Extreme value theory, Heterogeneity

*Speaker