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Multivariate Discrete Generalized Pareto distributions: Theory, likelihood-free inference, and applications to drought risk assessment

Understanding extreme environmental phenomena is crucial for risk management in a changing climate. In particular, dry spells, defined as consecutive days without precipitation, play a key role in drought dynamics, with direct impacts on agriculture, water resources, and insurance systems. Dry spell lengths are inherently discrete and often exhibit complex dependence structures across locations. Classical extreme value models, designed for continuous data, are therefore not well suited to such settings.

We introduce the multivariate discrete generalized Pareto distribution (MDGPD), a probabilistic framework tailored to model multivariate exceedances with integer-valued support. This model extends extreme value theory to discrete settings while preserving key tail properties. Inference for MDGPD models is challenging due to the intractability of the likelihood. To address this, we develop likelihood-free inference procedures combining neural Bayes estimation with Wasserstein-based discrepancies.
We illustrate the methodology on multivariate dry spell lengths derived from daily precipitation records in Switzerland, highlighting its relevance for environmental risk modeling.

Special/ Invited session

Data science and environment

Classification

Both methodology and application

Keywords

Extreme Value Theory, Discrete extremes, Simulation-based Inference

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