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Estimating flood-frequency curves with scarce data: a physically-based analytic approach

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Predicting magnitude and frequency of floods is a key issue for hazard assessment and mitigation. While observations and statistical methods provide good estimates when long data series are available, their performances deteriorate with limited data. Moreover, the outcome of varying hydroclimatic drivers can hardly be evaluated by these methods. Physically-based approaches embodying mechanics of streamflow generation provide a valuable alternative that may improve purely statistical estimates and cope with human-induced alteration of climate and landscape.

In this work, a novel analytic approach is proposed to derive seasonal flood-frequency curves, and to estimate the recurrence intervals of seasonal maxima. The method builds on a stochastic description of daily streamflows, arising from rainfall and soil moisture dynamics in the catchment. The limited number of parameters involved in the formulation embody climate and landscape attributes of the contributing catchment, and can be specified based on daily rainfall and streamflow data.

The application to two case studies suggests the model ability to provide reliable estimates of seasonal flood-frequency curves in different climatic settings, and to mimic shapes of flood-frequency curves emerging in persistent and erratic flow regimes. The method is especially valuable when only short data series are available (e.g. newly or temporarily gauged catchments, modified climatic or landscape features). Indeed, estimates provided by the model for high flow events characterized by recurrence times greater than the available sample size do not deteriorate significantly, as compared to performance of purely statistical methods.

The proposed physically-based analytic approach represent a first step toward a probabilistic characterization of extremes based on climate and landscape attributes, which may be especially valuable to assess flooding hazard in data scarce regions and support the development of reliable mitigation strategies.