Estimation of hydrological extremes with rainfall-runoff stochastic simulation. Application to the Loire catchment in current climate.

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Abstract

We present a method aiming at estimating hydrological extremes, based on the stochastic generation of rain and temperature fields as input of a distributed hydrological model. The method is built around two stochastic generators of rain and temperature field (RAINSIM and TEMPSIM), based on weather pattern sub-sampling and meta-gaussian models (Ayar et al., 2020). Observed data at stations are sub-sampled into subsets by seasons and weather types on which most of the statistical models (e.g. point distribution, space-time covariance etc.) are parametrized.

The simulated fields are processed by the MORDOR-TS hydrological model (Rouhier et al., 2017), a distributed conceptual model representing all the hydrological processes including snow accumulation and melt for mountainous catchments.

Simulations are performed continuously at a daily time step over periods spanning several decades, resulting in tens of thousands of years of synthetic daily discharge data at the outlets of various sub-catchments. These outlets correspond either to the boundary conditions of the hydraulic model for the site's river water levels or to the main branches of a reservoir system. Daily hydrographs of annual floods are disaggregated at a hourly time step to provide input for the hydraulic model. Following hydraulic simulations, extreme quantiles of peak water level or discharge are estimated where required.

The method is intended for application at **EDF** in safety studies of French riverine nuclear sites and large hydrological domains regulated by dams (up to several tens of thousands of square kilometres).

The presentation is illustrated with a complete application for the Loire at Gien catchment (35 000 km2) up to the estimation of hydrological extremes in current climate. The modelling explicitly incorporates temporal trends in air temperature. A fully non-stationary version-currently under development-will also be discussed. In this version, non-stationary point rainfall distributions are driven by large-scale climate covariates (e.g., sea surface temperature), enabling the estimation of hydrological extremes under projected climate scenarios.

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