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Multi-catchment rainfall-runoff simulation for extreme flood estimation

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The SCHADEX method (Paquet et al., 2013) is a reference method in France for the estimation of extreme flood for dam design. The method is based on a semi-continuous rainfall–runoff simulation process: hundreds of different rainy events, randomly drawn up to extreme values, are simulated independently in the hydrological conditions of each day when a rainy event has been actually observed. This allows generating an exhaustive set of crossings between precipitation and soil saturation hazards, and to build a complete distribution of flood discharges up to extreme quantiles.

The hydrological model used within SCHADEX, the MORDOR model (Garçon, 1996), is a lumped model, which implies that hydrological processes, e.g. rainfall and soil saturation, are supposed to be homogeneous throughout the catchment. Snow processes are nevertheless represented in relation with altitude. This hypothesis of homogeneity is questionable especially as the size of the catchment increases, or in areas of highly contrasted climatology (like mountainous areas). Conversely, modeling the catchment with a fully distributed approach would cause different problems, in particular distributing the rainfall-runoff model parameters trough space, and within the SCHADEX stochastic framework, generating extreme rain fields with credible spatio-temporal features.

An intermediate solution is presented here. It provides a better representation of the hydro-climatic diversity of the studied catchment (especially regarding flood processes) while keeping the SCHADEX simulation framework. It consists in dividing the catchment in several, more homogeneous sub-catchments. Rainfall-runoff models are parameterized individually for each of them, using local discharge data if available. A first SCHADEX simulation is done at the global scale, which allows assigning a probability to each simulated event, mainly based on the global areal rainfall drawn for the event (see Paquet el al., 2013 for details). Then the rainfall of each event is distributed through the different sub-catchments using the spatial patterns calculated in the SPAZM precipitation reanalysis (Gottardi et al., 2012) for comparable situations of the 1948-2005 period. Corresponding runoffs are calculated with the hydrological models and aggregated to compute the discharge at the outlet of the main catchment. A complete distribution of flood discharges is finally computed.

This method is illustrated with the example of the Durance at Serre-Ponçon catchment (south of French Alps, 3600 km^2) which has been divided in four sub-catchements. The proposed approach is compared with the "classical" SCHADEX approach applied on the whole catchment.

References:
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