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Space-time stochastic rainfall models and the Monte Carlo evaluation of flood hydrographs

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This paper focuses on the application of tools developed for the integration of spatial and temporal stochastic rainfall models with geomorphic models of the hydrologic response. Answering the need of reliable tools for water resources management and flood mitigation we develop and apply an approach to generate space-time rainfall fields reproducing the relevant characters of observed rainfall events, with specific applications to catchments located in Northern Italy. We then use the stochastic rainfall generator developed to force hydrological models and study the influence and consequences of the space-time structure of rainfall fields on the hydrologic response and their use for water resources management objectives. The stochastic rainfall model relies on the Bartlett-Lewis formulation for the reproduction of the temporal variability of rainfall whereas it adopts a convective cells formulation (based on Cox and Isham, 1987) to describe the spatial variability and the correlation structure of rainfall fields. The proposed applications consist of the stochastic model calibration on different catchments in Northern Italy, with variable size and rainfall regimes, and of Monte Carlo experiments to generate a sequence of floods at different outlets by means of a geomorphologic model of the hydrologic response. We show that the generated rainfall fields are respectful of the statistical characters of the observed rainfall both in space and time and allow for the reproduction of extreme events which are coherent with observed ones for the relatively low return periods accessible through existing time series. Coupling rainfall and hydrologic models allows the computation of 'synthetic' flood hydrographs, which, in turn, allow studying the return period associated with different properties (e.g. peak flow, total hydrograph volume, etc.), which is of particular interest in the design of hydraulic works aimed at flood mitigation.

Keywords: Flood mitigation, Stochastic rainfall models, Monte Carlo simulations, geomorphic model