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Uncertainty quantification by a probabilistic hydrological forecast

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Hydrological forecasts have many associated uncertainties, ranging from precipitation measurement to accuracy of discharge forecasts. All these uncertainties are propagated to the final forecast output and its quantification is essential to improve decisions in a real time flood event. One important uncertainty source in a hydrological forecast is the rainfall-runoff process, because different basin states would produce different hydrographs for the same precipitation event.

A procedure to quantify the uncertainty of a hydrological forecast based on the RIBS distributed rainfall-runoff model is presented. RIBS is a topography-based, rainfall-runoff model which can be used for real-time flood forecasting in midsize and large basins. Basin representation adopts the rectangular grid of the DEM, and other soil properties, input data and state variables are also represented as data layers using the same scheme. The basic objective is to map the topographically-driven evolution of saturated areas as the storm progresses. Two modes of runoff generation are simulated: infiltration excess runoff and return flow. RIBS applies a kinematic model of infiltration to evaluate local runoff generation in grid elements, and also accounts for lateral moisture flow between elements in a simplified manner. Flow propagation to the basin outlet is computed through distributed convolution, using as instantaneous response function for each element a Dirac delta function, with a delay equal to the time of travel from the location of the element to the basin outlet.

Feasible temporal and spatial distributions of rain events in the basin have been simulated by a stochastic rainfall generator, calibrated from recorded rainfall events. The ensemble of basin behaviours in the basin has been identified through probabilistic calibration of the RIBS model. This probabilistic calibration gives probability distributions for the most influential model parameters. A feasible set of hydrographs has been generated by taking the spatially distributed rain events as input and running RIBS model with its probabilistic parameters in a Monte Carlo simulation exercise.

Probabilistic distributions of outlet discharge, that take into account all these uncertainties, have been quantified by Bayesian networks. Bayesian networks have been widely and successfully applied in different scientific fields and can easily make a representation of a system from causality relations between the system variables. The model is validated with a different set of synthetic events, evaluating different measures of probabilistic forecast skill.