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Probabilistic simulation and data assimilation with deterministic rainfall-runoff models

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The availability of high-performance computing offers new opportunities for operational hydrometeorological forecasting. In this paper, a real-time framework for probabilistic flash flood forecasting and data assimilation in the Besós basin (northeast Spain) is presented. The framework uses the deterministic RIBS (Real-time Interactive Basin Simulator) model in a probabilistic way through Monte Carlo simulation in real time. The Besós river catchment has an area of 1020 km2. It is located in Barcelona area, and it is a typical example of Mediterranean complex catchment. The river basin is now instrumented by several telemetric rain and streamflow gauges, and the area is also well covered by the National Weather Service radar system. Radar data, with 15-minute temporal resolution, are used to feed the distributed hydrological model RIBS, which is calibrated by means of a probabilistic multiple-objective global optimization methodology. The result of the calibration is a set of probability distribution functions for relevant model parameters. A Monte Carlo simulation approach allows for the probabilistic simulation of an ensemble of basin states and response hydrographs at every step of the operational loop. After measured rainfall and discharge data are received, the ensemble of basin states is propagated in time, and then reduced selecting those states which better represent observed discharges. The reduced set of basin states is then expanded through conditional sampling from the probability distributions of model parameters, and used to generate probabilistic forecasts with several alternatives of future rainfall, which are generated through radar image extrapolation and blending. When new rainfall and discharge observations are received, a new operational loop is started. The process is computationally intensive, because it requires to simulate many replicas of the ensemble using a distributed rainfall-runoff model, and it is therefore well suited to test the applicability of the potential of the Grid technology to hydrometeorological research.