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Calibration of data-driven models using Monte-Carlo simulation: the case of Bayesian networks

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Data-driven methods are computationally more flexible and more efficient than complex physically-based models for real-time use. However, their application to flood forecasting is limited because basins with long data sets for calibration or validation of this type of models are relatively scarce. Furthermore, its is not easy to include the modeller's expert judgement or the local knowledge about the basin in data-driven models, since model structure and parameters are usually based exclusively on numerical data. In this paper, a mixed approach based on the combination of deterministic physically-based models and probabilistic data-driven models is presented. The approach uses a Bayesian network built upon the results of a deterministic rainfall-runoff model for real-time decision support. The data set for the calibration and validation of the Bayesian model is obtained through a Monte-Carlo simulation technique, combining a stochastic rainfall generator and a deterministic rainfall-runoff model. The methodology allows to make probabilistic discharge forecasts in real time using an uncertain quantitative precipitation forecast. The validation experiments made show that the data-driven model can approximate the probability distribution of future discharges that would be obtained with the physically-based model applying ensemble prediction techniques, but in a much shorter time. The approach is specially useful to make predictions in complex basins with short response times, where the ensemble prediction technique is computationally unfeasible, due to the large number of combinations that need to be simulated. The computational structure of the Bayesian network also allows for an efficient user interface for real-time decision support.