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Intercomparison of the performances of lumped rainfall runoff models for flash flood forecasting.

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A large body of scientific literature has been devoted the development and the evaluation of various types of rainfall-runoff (RR) models for flood forecasting. Nevertheless, such models are still rarely used in practice by operational flood forecasting services. The main reason for this seems to be that the inaccuracy of the forecasts based on RR simulations is considered as too high by the hydrologic forecasters who are more familiar with deterministic and accurate forecasts on large rivers.

To assess the possibilities and the limits of RR models when used for flash flood forecasting, a complete calibration and validation study has been conducted using the rich operational rainfall and runoff data set available on the upper Loire river catchment (France), an area frequently affected by severe flash floods.

A large variety of models were tested including autoregressive models with external data (ARX), six lumped conceptual models as well as artificial neural networks (ANN). They were all calibrated and validated using the same standard split sample test approach on eleven catchments with areas ranging from 20 km^2 to 3200 km^2. The performances of the models were rated using the widely used Nash and Sutcliffe efficiency criterion, but using also a series of other criteria specifically adapted to the evaluation of forecasting models (persistence criteria, criteria based on the discharge variations or evolution tendencies, detection discharge threshold exceedence). The large operational data set used, the number of considered models and the diversity

of the evaluation criteria is the originality of the present work if compared to previous studies on the same topic.

The major conclusions that can be drawn from this detailed analysis of the forecasting performances of the rainfall-runoff models on the upper Loire area are the following:

- ANNs are difficult tools to use. The risk of over-fitting or over-parameterization limits the complexity (number of hidden neurons) of the models that can be calibrated on the existing data set and limits thereby the usefulness of ANN. Their efficiency appears to be highly variable from one case study to the other and it can hardly been anticipated in which case they will be efficient. Furthermore, ANNs, like the linear model, appear to be essentially interpolation models that do not take real advantage of the rainfall information. For all these reasons, conceptual RR models, specifically developed to simulate the rainfall-runoff process, appear to be better suited flood forecasting tools provided that they are coupled with a data assimilation procedure.
- Overall, the performance of the forecasting models is relatively modest. Only 20 to 30% of the discharge trend variance is explained by the models even after a large calibration and validation effort. This explains why, despite the fact that conceptual RR models have been developed for 40 years, they still are seldom used by operational flood forecasting services. This relatively disappointing result may be due to the limits of the models but also to the various sources of uncertainties and particularly the uncertainties on the actual rainfall amounts as illustrated by another study conducted on the same data set.