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Sources of uncertainty and probability bands for flood forecasts: an upland catchment case study

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The sources of uncertainty associated with a flood forecast for an upland catchment are first examined in a pragmatic way. Forecasts are obtained operationally using a lumped rainfall-runoff model with catchment-average rainfall estimates as the primary input. One source of uncertainty is associated with the method used to estimate catchment-average rainfall from observations from a raingauge network. Different methods are used to quantify the spread of estimates arising from choice of method. Uncertainty in the raingauge values themselves is explored using a simple random observation model in a Monte Carlo framework. Ensembles of rainfall forecasts from STEPS are used to quantify the effect of rainfall forecast uncertainty on the spread of possible flood forecasts. Uncertainty arising from model parameter estimation is assessed by comparing the forecasts obtained by models calibrated by two different model development teams. Uncertainty in the river flow observations themselves is quantified through the spread of values given by two stage-discharge relationships developed for operational use, one employing current meter readings and the other ultrasonic flow measurements.

Following these exploratory studies on the sources of uncertainty, two direct methods for estimating probability bands on flood forecasts are investigated. The first method employs a standard parametric ARMA approach for calculating probability uncertainty bands on a forecast, which itself is constructed from the sum of a rainfall-runoff model simulation and a prediction of its error. A proportional error model is invoked to address the normality assumptions of the approach. The method is compared with the use of quantile regression as an estimator of probability bands and found to give similar performance. Both methods are implemented assuming perfect foreknowledge of rainfall observations. The parametric ARMA approach is then applied using ensemble rainfall forecasts from STEPS as input to the rainfall-runoff model for future times, emulating the real-time forecasting situation. The probability bands of model uncertainty for ensemble forecast percentiles are calculated. This allows model uncertainty and rainfall forecast uncertainty to be jointly assessed.