Geophysical Research Abstracts
Vol. 13, EGU2011-2153, 2011
EGU General Assembly 2011

Joint consideration of timing and amplitude uncertainties in hydrological simulation and forecasting

Simon Seibert (1) and Uwe Ehret (2)

(1) Technische Universität München, Germany (s.seibert@bv.tum.de), (2) Technische Universität München, Germany (u.ehret@bv.tum.de)

Quantification of uncertainty associated with simulations or forecasts of hydrological models is subject of intense and ongoing research.

The related sources of uncertainty are manifold, ranging from the input (uncertain forecasts, uncertain measurements, uncertainties associated with aggregation/disaggregation/interpolation) and the hydrological model (imperfect model structures, uncertain parameter sets) to the output (uncertainties of the reference observations due to measurement errors, disagreement of scale etc.).

Depending on the dominant source of uncertainty, data availability and the intended use of a model, many approaches to describe and quantify uncertainty associated with the output of hydrological models have been developed: Direct combination of (known) input and model uncertainty, statistical analysis of model output errors by comparison with related observations (Krzysztofowicz 2002, Montanari and Grossi 2008), approaches based on generalized formulations of Likelihood (Beven and Binley 1992, Beven 2006) and non-probabilistic methods. Especially in hydrological forecasting, in recent years Ensemble Weather Predictions have been used to generate ensembles of discharge forecasts, whose spread is used as approximation of the forecast uncertainty (Cloke and Pappenberger 2009).

However, despite the many ways used to consider the source and nature (additive, multiplicative, normally distributed etc.) of the error(s) causing uncertainty, the metric to quantify it is in most cases amplitude-based (Nash, Root Mean Square Error, etc.), i.e. the error is calculated between two values at the same point in time (an exception is the Multicomponent Mapping approach proposed by Pappenberger and Beven (2004)). Using a purely amplitude–based metric may lead to unduly high uncertainties associated with the model predictions (or, if used in a GLUE approach, unduly low Likelihoods associated with the model/parameter set). For example, if the output of a model perfectly matches the corresponding observations, except that it is offset in time, a merely amplitude-based measure will indicate poor performance, especially in small catchments with short and steep rising hydrograph limbs. The model deficit (the poor timing) is then inadequately represented by an amplitude error.

We therefore suggest an approach for the statistical analysis of model errors (based on the new distance metric 'Series Distance' proposed by Ehret and Zehe (2010, submitted)) which jointly but separately evaluates errors in amplitude and timing, resulting in a bivariate distribution of errors. The point pairs to compare are not identified by equality in time, but by matching position in matching segments (rising and falling limbs) of matching events in the observed and simulated hydrograph. Thus calculating the discrepancy between 'hydrologically matching' elements of the hydrographs and consideration of timing/amplitude errors with corresponding timing/amplitude metrics significantly reduces the overall uncertainty. We will present the theory of Series Distance as an uncertainty measure, how it is used to determine error distributions and how they can be applied to new simulations/forecasts.

Beven, K. and A. Binley (1992): The future of distributed models - model calibration and uncertainty prediction. Hydrological Processes 6 (3), 279-298.

Beven, K. (2006): A manifesto for the equifinality thesis. Journal of Hydrology 320 (1-2), 18-36, 10.1016/j.jhydrol.2005.07.007.

Cloke, H. L. and F. Pappenberger (2009): Ensemble flood forecasting: A review. Journal of Hydrology 375 (3-4), 613-626, 10.1016/j.jhydrol.2009.06.005.

Ehret, U. and E. Zehe (2010): Series distance – an intuitive metric for hydrograph comparison. Hydrol.

Earth Syst. Sci. Discuss. 7 (5), 8387-8425, 10.5194/hessd-7-8387-2010.

Krzysztofowicz, R. (2002): Bayesian system for probabilistic river stage forecasting. Journal of Hydrology 268 (1-4), 16-40.

Montanari, A. and G. Grossi (2008): Estimating the uncertainty of hydrological forecasts: A statistical approach. Water Resources Research 44, 9, W00b0810.1029/2008wr006897.

Pappenberger, F. and K. Beven (2004): Functional classification and evaluation of hydrographs based on Multicomponent Mapping. Intl. J. River Basin Management 2 (2), 89-100.