Geophysical Research Abstracts,
Vol. 11, EGU2009-9489, 2009
EGU General Assembly 2009

Uncertainty assessment through a precipitation dependent HUP: an application to a small Southern Italy catchment

D. Biondi, P. Versace, and B. Sirangelo
Universita della Calabria, Dipartimento Difesa del Suolo, Arcavacata di Rende (CS), Italy (dbiondi@dds.unical.it, 0039 0984 496619)

The present study focuses on the application of a precipitation dependent HUP (Hydrologic Uncertainty Processor) to assess the predictive uncertainty on water discharge predictions for a small headwater catchment located in Calabria (South Italy) through a complete example of the estimation procedure, modelling assumptions and results.

The applied HUP was proposed by Krzysztofowicz in 1999, and is a component of the Bayesian forecasting system (BFS) which provides a general methodology for probabilistic forecasting via any deterministic hydrologic model. Within the BFS framework, the task of the HUP is to quantify the effects of various uncertainty sources on the forecasts, e.g. of river discharges, under the hypothesis that there is no precipitation uncertainty.

According to the principle of Bayesian revision of a probability distribution, the general formulation of the HUP supplies the hydrologic uncertainty in terms of a family,g$\phi(\cdot|s,h_0)$, of posterior densities of discharge H, for every possible realization s of the model river discharge process S and observation $H_0 = h_0$ of river discharge up to the forecast time.

This result is obtained through the revision of a prior distribution g of the predictand, which exists before the preparation of a forecast, on the basis of a likelihood function f estimated from past evidence on model performance against observations.

The implemented HUP rests on the following assumptions:

1. precipitation dependent structure;
2. nonstationarity of both actual river stage and model river stage process with lead time n;
3. meta-gaussian formulation for all the conditional distributions.

The study watershed is the test site of the Turbolo Creek catchment (29 km^2), a tributary of the Crati River, located in Southern Italy. The hydro-meteorological database used within this study comprises rainfall, temperature, and discharge values sampled with a 20 minutes temporal resolution.

The hydrologic response in the HUP is simulated by the RISE (Runoff by Infiltration and Saturation Excess) rainfall-runoff model which is a process-oriented one, conceived for applications to small and medium size catchments. It considers both conceptual and physically-based schemes to represent the primary processes of the hydrological cycle, and has been designed through a stepwise approach, with the aim of a realistic description of the mechanisms that are assumed to be dominant in controlling storm runoff production and saturated area space-temporal dynamics.

An almost continuous five-year period starting at the 2000 and ending at 2005 was examined. Furthermore we assumed that:

1. precipitation forecasts are produced hourly, so that each hour marks the beginning of a separate realization of the precipitation event and the model actual river discharge process;

2. the processor has three branches and each distribution of the HUP is conditioned on the indicator of precipitation V according to the basin average forecasted precipitation amount R with: $V = 0 \leftrightarrow R = 0$; $V = 1 \leftrightarrow 0 < R < 2$ mm and $V = 2 \leftrightarrow R \geq 2$ mm.

3. the hydrologic model outputs a time series of river discharges at 20 minutes steps, but probabilistic forecasts of river discharge are prepared in 1-h steps for times $t_1, \ldots, t_N$, with N=3 (the time to peak of the unit hydrograph is about 2 hours).

The HUP processor was specified by deriving parametric expressions for the family of the prior density and the family of the likelihood functions through a detailed statistical analysis of available observed and simulated data following the steps laid out in Krzysztofowicz & Herr (2001) and Maranzano & Krzysztofowicz (2004), in order to reduce the conditioning of the likelihood functions and the prior distributions in the transformed space to the smallest dimension that is necessary to capture the dependence structures between the model output and the actual process.

The end result of the estimation procedure, is the evaluation of the dependence parameters of the posterior distributions. A first order Markov process for the prior densities and a conditional Markov process of order 1 for the likelihood function were assumed respectively.

The analysis of the obtained posterior distributions showed that under each hypothesis about the precipitation event, the hydrologic uncertainty increases with lead time n as one would expect. Furthermore, hydrologic uncertainty increases with the forecasted discharge and it's higher when precipitation occurs, confirming the merit of assuming a precipitation dependent HUP.

A real time simulation of 4 storm events was performed: within this application observed discharges were compared with the median value of the 1 hour ahead prior and posterior distributions: the prior mostly underestimates the actual discharge while forecasted discharges are closer to the bisector and more symmetrically distributed in the posterior distribution. Results also highlight a partial inadequacy of the linear model as a dependence structure between observed and simulated discharge for high values and prove the deterioration of the processor performance with increasing lead times which is mainly due to the zero precipitation fed into the hydrologic model beyond the forecast period.