Geophysical Research Abstracts,
Vol. 10, EGU2008-A-05750, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-05750
EGU General Assembly 2008

Improving conceptual rainfall-runoff models using Bayesian total error analysis

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Incorporating additional components into conceptual hydrological models is an iterative procedure of formulating and testing hypotheses about the dominant hydrological processes and their mathematical description. However, model-based hypothesis testing in hydrology is challenging because of uncertainties in the forcing and response data and the structural errors in the existing model components. It is therefore difficult to determine whether incorporating a new hydrologic process gives a better description of catchment dynamics, either in the scientific sense or in the applied context of making predictions.

Recent progress in Bayesian model estimation offers the potential to quantify data and model structural errors separately. This is a prerequisite for testing whether adding a new hydrologic process decreases the structural error of the model and therefore offers new perspectives for hypothesis testing. In the present study, we use the Bayesian total error analysis (BATEA) methodology to analyze the effects of including interception in a conceptual rainfall-runoff model (here, the HBV model). Neglecting interception introduces errors in the rainfall-runoff model input as the amount of rainfall participating in runoff formation is overestimated at every time step (ie, this error can be viewed either as structural error of the overall model, or as input error in the rainfall-runoff model). We compare several approaches for dealing with it, including BATEA calibration with and without the interception store, as well as a standard least squares calibration that ignores input uncertainty.