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Identification of accurate nonlinear rainfall-runoff models with unique parameters

G. Schoups (1), J.A. Vrugt (2), F. Fenicia (1), and N. van de Giesen (1)

(1) Delft University of Technology, Water Management, Delft, Netherlands (g.h.w.schoups@tudelft.nl), (2) Center for Nonlinear Studies, Los Alamos National Laboratory, USA

We propose a strategy to identify models with unique parameters that yield accurate streamflow predictions, given a time-series of rainfall inputs. The procedure consists of five general steps. First, an a priori range of model structures is specified based on prior general and site-specific hydrologic knowledge. To this end, we rely on a flexible model code that allows a specification of a wide range of model structures, from simple to complex. Second, using global optimization each model structure is calibrated to a record of rainfall-runoff data, yielding optimal parameter values for each model structure. Third, accuracy of each model structure is determined by estimating model prediction errors using independent validation and statistical theory. Fourth, parameter identifiability of each calibrated model structure is estimated by means of Monte Carlo Markov Chain simulation. Finally, an assessment is made about each model structure in terms of its accuracy of mimicking rainfall-runoff processes (step 3), and the uniqueness of its parameters (step 4). The procedure results in the identification of the most complex and accurate model supported by the data, without causing parameter equifinality. As such, it provides insight into the information content of the data for identifying nonlinear rainfall-runoff models. We illustrate the method using rainfall-runoff data records from several MOPEX basins in the US.