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Correcting the Mathematical Structure of a Hydrological Model via Bayesian Data Assimilation

Hoshin Gupta (1) and Nataliya Bulygina (2)

(1) University of Arizona, Hydrology and Water Resources, Tucson, USA (hoshin.gupta@hwr.arizona.edu), (2) Imperial College, Civil and Environmental Engineering, London, United Kingdom (n.bulygina@imperial.ac.uk)

The goal of model identification is to improve our understanding of the structure and behaviour of a system so the model can be used to help and/or to make inferences about its input-state-output response. The conventional way to do this is to preselect (assume) some model form and then evaluate its "suitability" against historical observed data. If deemed unsuitable, the modeller must find ways to "correct" and re-evaluate the model through some intuitive process. In this work, we discuss a way in which the historical data can be used to diagnose what might be wrong with the presumed mathematical structure of the model, and to provide guidance towards fixing the problem, via a process of Bayesian data assimilation.

In previous work we showed how, given a suitable conceptual model for the system, the method of Bayesian Estimation of Structure (BESt) can be used to estimate the stochastic form for the structural equations of a model that are most consistent with historical observations at the spatio-temporal scale of the data, while providing explicit estimates of model structural contributions to prediction uncertainty. However, it is often the case that a prior assumption regarding the form of the equations (an existing model) is available. In work we extend the BESt method to show how the mathematical form of those prior model equations can be corrected/improved to be more consistent with the available data, while remaining consistent with the presumed physics of the system. The potential of the extended BESt approach is demonstrated in the context of basin-scale hydrological modelling, by correcting the equations of the HyMod model applied to the Leaf River catchment and thereby significantly improving its representation of system input-state-output response.