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Dynamic Model Emulation: A New Tool in Data-Based Mechanistic Modelling

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The paper discusses a new approach to large computer model 'emulation' that is now part of the Data-Based Mechanistic (DBM) modelling strategy. At the initial stages of DBM modelling, it is likely that data will be scarce, so that modelling from real data will not be possible. Moreover, existing models of the system based on physical modelling principles may well be in the form of a large and complex computer models that are not ideal for tasks such as uncertainty analysis, forecasting or control system design. In this situation the Dynamic Emulation (DE) model provides a way of overcoming these difficulties and, subsequently, building a bridge between the large model and parsimonious DBM models obtained from the analysis of real data. In DE model synthesis, DBM modelling methods are applied to data obtained from planned experiments on the large computer simulation model (in the present context, a hydrological or hydraulic model). For any given selection of the large model parameters, this will normally yield a parsimonious, 'dominant mode' DBM model that explains the experimental data from the large model almost perfectly. Based on a random selection of the large model parameters, over a user-specified range, multiple parsimonious models of this kind are generated and these provide the information necessary to map the relationship between the large model parameters and the associated DBM model parameters using State-Dependent Parameter (SDP) estimation. This mapping, together with the DBM model, constitutes the DE model, which can be used to mimic the large computer model for any specified parameter combination within the user-specified range, not just the parameter combinations used in the original DE model synthesis. The utility of DE modelling will be illustrated by two examples: first a 'toy' example, in which a fifteenth order Nash Cascade model is emulated by a fourth order DBM model; and second, by initial results obtained from the emulation of the large, distributed HEC-RAS flow routing model.