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A software environment for stochastic spatio-temporal modelling

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Distributed process-based models are frequently used in the earth sciences, and are valuable in management, planning, and risk assessment. For model development, the use of appropriate software tools is essential. An optimal tool should make it simple to build even complex models without the need of specialist programming knowledge. Furthermore, a single tool, or an integrated software environment, should support all steps in the model development cycle, in particular the programming of the model itself, the visualisation of the model data, and calibration or data assimilation techniques. We have built such an environment following these principles (Karssenberg et al. 2005a,b, 2007). In this presentation we will explain the software architecture and present an example to illustrate the concepts.

The tool includes a set of building blocks for model construction. These building blocks are operations on 2D and 3D data entities. The tool is particularly strong in operations for hydrological modelling; it incorporates for instance operations for kinematic and dynamic wave routing. The modeller constructs a model by combining these operations in a standard script that provides control flow for iterations over time steps, over realizations of the model, and over periods of time. Although the operations included allow a wide range of models to be built, it is sometimes required to link to external models. Currently, a standard link is available between the model environment and MODFLOW for groundwater flow modelling.

In addition, the tool supports the construction of stochastic models and error propagation modelling. This is done by using the control flow of the standard script to

iterate over realizations of the model, representing a Monte Carlo framework. Functions to calculate sample statistics (e.g., percentiles) of stochastic spatio-temporal data generated by the model are included. Outputs can be displayed by an interactive visualisation program that supports visualisation of stochastic spatio-temporal data.

The same software environment allows optimisation of static and dynamic parameters or variables of models using built-in genetic algorithms. In addition, the particle filter data assimilation technique is included in the framework. The genetic algorithm and the particle filter algorithms use the control flow provided by the script for iterations over realizations and over periods of time.

References

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