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Consistent Parameter and Transfer Function Estimation using Context Free Grammars

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This contribution presents a method for the inference of transfer functions for rainfall-runoff models. Here, transfer functions are defined as parametrized (functional) relationships between a set of spatial predictors (e.g. elevation, slope or soil texture) and model parameters. They are ultimately used for estimation of consistent, spatially distributed model parameters from a limited amount of lumped global parameters. Additionally, they provide a straightforward method for parameter extrapolation from one set of basins to another and can even be used to derive parameterizations for multi-scale models [see: Samaniego et al., 2010]. Yet, currently an actual knowledge of the transfer functions is often implicitly assumed. As a matter of fact, for most cases these hypothesized transfer functions can rarely be measured and often remain unknown. Therefore, this contribution presents a general method for the concurrent estimation of the structure of transfer functions and their respective (global) parameters. Note, that by consequence an estimation of the distributed parameters of the rainfall-runoff model is also undertaken. The method combines two steps to achieve this. The first generates different possible transfer functions. The second then estimates the respective global transfer function parameters.

The structural estimation of the transfer functions is based on the context free grammar concept. Chomsky first introduced context free grammars in linguistics [Chomsky, 1956]. Since then, they have been widely applied in computer science. But, to the knowledge of the authors, they have so far not been used in hydrology. Therefore, the contribution gives an introduction to context free grammars and shows how they can be constructed and used for the structural inference of transfer functions. This is enabled by new methods from evolutionary computation, such as grammatical evolution [O'Neill, 2001], which make it possible to exploit the constructed grammar as a search space for equations. The parametrization of the transfer functions is then achieved through a second optimization routine.

The contribution explores different aspects of the described procedure through a set of experiments. These experiments can be divided into three categories: (1) The inference of transfer functions from directly measurable parameters; (2) The estimation of global parameters for given transfer functions from runoff data; and (3) The estimation of sets of completely unknown transfer functions from runoff data. The conducted tests reveal different potentials and limits of the procedure. In concrete it is shown that example (1) and (2) work remarkably well. Example (3) is much more dependent on the setup. In general, it can be said that in that case much more data is needed to derive transfer function estimations, even for simple models and setups.

References:

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