

## ***Interactive comment on “HESS Opinions “The art of hydrology”<sup>1</sup>” by H. H. G. Savenije***

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I thank Keith Beven for his useful comments. They provide an excellent opportunity to elaborate on the important issues that he raised. The first point Beven makes, is that I misinterpreted the meaning of the term 'model of everywhere' which he used in his paper 'Towards integrated environmental models of everywhere' (Beven, 2007). In this paper, Keith Beven advocated that modelling should be treated more explicitly as a learning process, not about how model parameters vary from place to place, but about how different catchments behave differently due to different model structures. Of course we fully agree on this. In the opinion paper, however, I used the term 'model of everywhere' to mean something else. With this term I meant 'a model that is applicable everywhere': a model which has a fixed structure that is applicable in all situations and

<sup>1</sup>Invited contribution by H. H. G. Savenije, the EGU Henry Darcy Medallist 2008 for outstanding contributions to Hydrology and Water Resources Management.

in a wide variety of catchments. Most models have been set-up like that, as if they represent a universal truth. To avoid misunderstanding I shall use the term 'one-size-fits-all' for a model with a fixed model structure, as opposed to flexible models that can be tailor-made for a particular catchment.

It is important to underline that different catchments require different model representations (different model structures). One could say that this is already being done (e.g. Beven's paper on Uniqueness of place: Beven, 2000). But in reality it isn't. There are very few examples of researchers using a flexible or adjustable model structure (as is for instance done by Fenicia et al., 2008). I believe that the need for a flexible modelling approach needs to be continuously stressed, as in current practice one-size-fits-all modelling is the rule rather than the exception.

It may be hard to accept, but if catchments are unique we have to depart from the 'one-size-fits-all' models such as HBV, Mike SHE, VIC, or TopModel, in favour of an approach that uses a flexible model structure or a flexible 'model architecture' that can be tailored to the catchment under study. So the paradigm should be tailor-made instead of one-size-fits-all. The pitfall of a tailor-made model is, of course, that modellers may be inclined to make the tailor-made structure too complicated, i.e. allowing too many degrees of freedom and too many parameters. The art is to design a model that reflects the dominant mechanisms while remaining at the same time parsimonious in the number of parameters. The architecture should limit itself to the rainfall-runoff characteristics of the dominant mechanisms.

This brings us to the second point Beven made, which focuses on the problem of how to evaluate models, and in particular on how to judge if a model adjustment indeed results in a better model.

The issue is how to identify the appropriate model structure, while several structures may be equally acceptable. Is there an objective methodology that allows one to find the appropriate architecture. The decision on which model structure to use depends

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on data availability (the more information is available on different aspects of the system, the more detail is warranted) and on performance assessment criteria (what is the required accuracy? what is the allowable predictive uncertainty?). We are presently working on an approach where different model architectures are generated as hypotheses, which are subsequently tested in a multi-criteria framework where complexity is weighed against accuracy. Model structures that provide a good trade-off between complexity and accuracy are preferred. As a result one can identify typical model structures that belong to a certain catchment classification, where classification depends on geology, topography, climate and land use. It is our intention that this methodology can help to make predictions in ungauged basins.

## References:

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