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Interactive Comment

Interactive comment on "Hydrological model parameter dimensionality is a weak measure of prediction uncertainty" *by* S. Pande et al.

S. Pande et al.

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We thank the referee for her critical review of our manuscript. Please find in the below our attempt to adequately respond to her comments.

Comment: The manuscript is not finished with a lot of little errors and sometimes poor grammar.

Response: We will improve the grammar in the revised manuscript.

Comment: It is not self contained - quite a number of concepts are not sufficiently explained.

Response: The will incorporate the details that this referee has raised in the following.

Comment: It seems that "complex hydrological model" (as generally used in the hydrological community) and "model complexity" h (which originates from statistical learning) are two very different concepts that are hard to distinguish in the manuscript. This makes the manuscirpt very difficult to read.

Response: We have presented hydrologic model complexity in context of prediction uncertainty. We have also provided relevant hydrologic literature that have explored the subject in Bayesian context, including Arkesteijn and Pande (2013) who have explored the issue in great detail. We perceive hydrological processes can be represented by certain differential equations. The solutions to such equations that provide time series of variables of interest such as storage and fluxes lie in a certain class of functions. The concept of model complexity that we have proposed here applies to any class of functions, hence covering possible hydrological response functions (hydrological models). The concept of model complexity is introduced within a framework that connects it to prediction uncertainty. Hence, in context of predictive uncertainty presented in this paper, complex hydrological models and model complexity are exactly the same. Both belong to notions derived from mathematical statistics.

Comment: The manuscirpt leaves it open why the model complexity h should be related to the number of paramters. Without giving strong support to this hypothesis, the remaining analysis is useless. I would expect this to happen in section 2.1.

Response: We thank the referee for pointing this out. We hypothesize that prediction uncertainty increases with (a notion of) model complexity. The latter may depend on the number of parameters. In particular we consider an upper bound on prediction uncertainty (that incorporates model complexity) that depends on the number of parameters. Our manuscript extends the argument to suggest that it may not depend only on the number of parameters. It may also depend on the magnitude of the parameters. For the latter, we selectively define parameter ranges for a given model structure, sample parameters from those ranges, quantify model complexity corresponding to those ranges and compare corresponding distribution of model complexities in order to demonstrate

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the effect of parameter magnitudes on model complexity and prediction uncertainty.

Hence our theory is about the connection between model complexity as introduced in the paper (that may or may not depend on the number of parameters) and prediction uncertainty. We will provide details on the same in the methodology section of the manuscript.

Comment: It is not easily understandable where the contribution relates to hydrology of real catchments.

Response: We respect the opinion of the referee. In our opinion, the paper advances our understanding of what hydrological model complexity is in context of prediction uncertainty. We will clearly state the contribution of the paper.

Comment: What happens to water stored in the catchment when data is permuted as described in algorithm 1? How does this relate to storage processes in the hydrological model? The authors should discuss how this relates to one of their conclusions that complexity depends on the range of the recession parameters.

Response: Please note that observations corresponding to variables of prediction interest are not used in the algorithm. Strength of the presented theory is that model complexity can be quantified independently of variables of prediction interest. It solely depends on the permutations of input forcing since it attempts to quantify the complexity of a given model structure. Since the model structure is fixed, the storage processes remain fixed. The storage changes in accordance with permuted input forcings and sampled parameters. For a given input forcing, higher values of recession parameters result in quicker flow responses and models that have quicker flow response are deemed more complex. This has been analytically shown to hold for a class of linear reservoir models (Pande et al, 2012).

We will provide an extended discussion of the above conclusion in our revised manuscript.

References:

Pande, S., Bastidas, L. A., Bhulai, S., McKee, M. (2012). Parameter dependent convergence bounds and complexity measure for a class of conceptual hydrological models, Journal of Hydroinformatics, Vol 14, No 2 pp 443–463.

Arkesteijn, L., and Pande S. (2013), On hydrological model complexity, its geometrical interpretations and prediction uncertainty, Water Resour. Res., 49, 7048–7063, doi:10.1002/wrcr.20529.

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