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Estimating Best Achievable Performance Using an Information Theoretic Approach

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[Abstract]:
This study discusses hydrologic model uncertainty from a different aspect. Other than the well-known and intensively studied Bayesian based inverse problem solvers, we focus on an alternative methodology based on information theory to estimate the best achievable performance of a model with given data. As a model structure independent approach, it can offer a benchmark of model structure adequacy. In particular, we (a) discuss how to compute the information content of multivariate hydrological dataset; (b) estimate best achievable model performance with mutual information given by data; (c) define two kinds of uncertainty: Epistemic Uncertainty that can potentially be reduced by improving model structure, Aleatory Uncertainty that can't be identified by a deterministic model (and may be resolvable only up to its density by ensemble models); (d) with an ideal numerical experiment, we identify that the uncertainty of rainfall-runoff processes is not only caused by observation error but by the propagation of rainfall error in the model. On building two conceptual models, HyMod and SAC-SMA, on Leaf River and Chunky River, our analysis shows that the aleatory uncertainty is relatively small comparing to epistemic uncertainty. Though SAC-SMA is better than HyMod, both of them have a considerable room of improvement. Restraining error propagation by data assimilation may be the most preferred way to reduce epistemic uncertainty.
[Keywords]: Information Theory, Model Structure Adequacy, Mutual Information, Data Assimilation.