



How model selection and averaging strategies help us improve hydrological models

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Statistical model selection and averaging techniques have become popular tools in hydrological modelling. These techniques promise objective guidance in (1) identifying relevant physical processes, (2) diagnosing model structural deficits, (3) weighting model predictions to obtain robust ensemble estimates, and (4) performing sensitivity analyses with respect to available and potential future observation data. Such tools are therefore highly valuable for increasing process understanding and predictive skill of models. However, within the last two decades, many different flavours of multi-model techniques have emerged which complicate an easy access to and a thorough understanding of the underlying principles. With the many approaches and applications, a variety of terms has been defined which easily leads to misunderstandings and confusion among the community.

To counteract this development, we offer a structured overview of model selection and averaging approaches, including BMS (Bayesian model selection), cross-validation-type model selection (e.g., AIC), forecast-based model combination, three versions of pdf-based model averaging (Hoeting-BMA, MLBMA, Raftery-BMA), and what we call BCMA (Bayesian combined model averaging). We point out theoretical foundations, similarities and disparities, and implications of implementation choices. With simple synthetic examples, we illustrate the philosophy behind the different approaches. These considerations finally clarify what to expect from which statistical method and how to interpret its results.

With this contribution, we offer guidance to identify the suitable model selection or averaging approach for a specific situation and hope to further strengthen the utility of such methods for hydrological model building.