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Toward a Systematic Framework for Model Evaluation in Catchment Hydrology

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In recent years, a strong debate has emerged in the hydrologic literature regarding what constitutes an appropriate framework for model evaluation and uncertainty estimation. Particularly, there is strong disagreement whether an uncertainty framework should have its roots within a proper statistical (Bayesian) context, or whether such a framework should be based on a different philosophy and implement informal measures and weaker inference to summarize parameter and predictive distributions. Here, I compare a formal Bayesian approach using Markov Chain Monte Carlo (MCMC) sampling with Generalized Likelihood Uncertainty Estimation (GLUE) for assessing uncertainty in conceptual watershed modeling. Our formal Bayesian approach is implemented using the recently developed DiffeRential Evolution Adaptive Metropolis (DREAM) MCMC scheme with a likelihood function that explicitly considers model structural, input and parameter uncertainty. Our results demonstrate that DREAM and GLUE can generate very similar estimates of total streamflow uncertainty. This suggests that formal and informal Bayesian approaches have more common ground than the hydrologic literature and ongoing debate might suggest. The main advantage of formal approaches is, however, that they attempt to disentangle the effect of forcing, parameter and model structural error on total predictive uncertainty. This is key to improving hydrologic theory and to better understand and predict the flow of water through catchments.