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Hydrological Modeling Uncertainty Analysis with the Bayesian Model Averaging method

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Bayesian Model Averaging (BMA) method is a tool to infer the statistical distribution of a quantity to be predicted as the mixture of a set of individual prediction distributions, with each individual prediction distribution constructed on the basis of the performance of each different model. In the BMA, there should be a number of models used to construct the model ensemble, and the mixture coefficient, or the weight of each individual model, is traditionally determined by the Expectation-Maximization (EM) algorithm. Since the BMA is a method that can combine the forecasts of different models together to generate a new forecast expected to be better than any individual model's forecast, it has been widely used in hydrology for ensemble hydrologic prediction. Previous studies of the BMA mostly focused on the comparison of the expected BMA prediction with the prediction of each individual model. As the BMA has the ability to provide a statistical distribution of the quantity to be forecasted, the research focus in this study is shifted onto the comparison of the prediction interval generated by the BMA with that of each individual model, in order to see if the BMA can improve the prediction reliability. Three hydrological models are employed in the investigation of two BMA schemes. The first BMA scheme is to calibrate each of the three models under the same Nash-Sutcliffe efficiency objective function, thus providing three different forecasts for the BMA combination. In the second BMA scheme, three different objective functions other than Nash-Sutcliffe efficiency are adopted, each of which is targeted for simulating different parts of flows, i.e. low flow, medium flow, and high flow. All three models are respectively calibrated for each of three objective functions to obtain the optimized parameter sets. As the same model with the different optimized parameter sets will give rise to different forecasts, thus in the second BMA scheme, there are nine different forecasts used for the BMA combination. For each of individual member model as well as both BMA combination schemes, the Monte Carlo method is used to infer the probability distribution of the quantity to be forecasted and determine prediction intervals. Then, the model efficiency and uncertainty of each member model and two BMA combination schemes are assessed and compared.