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A Bayesian Joint Probability Post-Processing Tool for Quantifying Uncertainty in Predictions from a Deterministic Water Balance Model

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It has been widely known that a model is a simplified representation of a system and therefore always contains errors and thus uncertainty in their predictions. The model prediction uncertainty can be due to a combination of input, parameter and structural uncertainty. Despite the acknowledgment of presence of uncertainty in model predictions, many research and practical applications in hydrology continues to be deterministic. The current study provides a simple and reliable approach to quantifying uncertainties in model predictions.
The method, based on the Bayesian Joint Probability (BJP) modelling approach proposed by Wang et al (2009), assumes that the predictor (in this case deterministic model simulation) and predictand (observed streamflow) follow a multivariate normal distribution in a transformed space. It then uses Bayesian inference scheme to "learn" from the error distribution of the deterministic prediction and quantify the total (input, parameter and model) uncertainty associated with the model prediction. In addition, model prediction is updated from using real-time observations, which helps in the reduction of bias in the prediction.
The approach was applied to post-process model simulation results from a Water Partition and Balance (WAPABA) model, a deterministic monthly water balance model. The model was first calibrated using five years data, and the simulated flow in the validation period was then used as a predictor in the BJP post-processing. Applied to 19 catchments in Eastern and South-eastern Australia, the approach resulted in significant reduction in median prediction errors for most of the catchments. A comparison of the prediction probability distributions with the observed flows showed that the probabilistic uncertainty quantification was reasonable in most cases.

Reference:
Wang, Q. J., D. E. Robertson, and F. H. S. Chiew (2009), A Bayesian joint probability modeling approach for seasonal forecasting of streamflows at multiple sites, Water Resour. Res., 45, W05407, doi:10.1029/2008WR007355