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Understanding seasonal variability of uncertainty in hydrological prediction

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Understanding uncertainty in hydrological prediction can be highly valuable for improving the reliability of streamflow prediction. In this study, a monthly water balance model, WAPABA, in a Bayesian joint probability with error models are presented to investigate the seasonal dependency of prediction error structure. A seasonal invariant error model, analogous to traditional time series analysis, uses constant parameters for model error and account for no seasonal variations. In contrast, a seasonal variant error model uses a different set of parameters for bias, variance and autocorrelation for each individual calendar month. Potential connection amongst model parameters from similar months is not considered within the seasonal variant model and could result in over-fitting and over-parameterization. A hierarchical error model further applies some distributional restrictions on model parameters within a Bayesian hierarchical framework. An iterative algorithm is implemented to expedite the maximum a posterior (MAP) estimation of a hierarchical error model. Three error models are applied to forecasting streamflow at a catchment in southeast Australia in a cross-validation analysis. This study also presents a number of statistical measures and graphical tools to compare the predictive skills of different error models. From probability integral transform histograms and other diagnostic graphs, the hierarchical error model conforms better to reliability when compared to the seasonal invariant error model. The hierarchical error model also generally provides the most accurate mean prediction in terms of the Nash–Sutcliffe model efficiency coefficient and the best probabilistic prediction in terms of the continuous ranked probability score (CRPS). The model parameters of the seasonal variant error model are very sensitive to each cross validation, while the hierarchical error model produces much more robust and reliable model parameters. Furthermore, the result of the hierarchical error model shows that most of model parameters are not seasonal variant except for error bias. The seasonal variant error model is likely to use more parameters than necessary to maximize the posterior likelihood. The model flexibility and robustness indicates that the hierarchical error model has great potential for future streamflow predictions.