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EXTENDED ABSTRACT ONLY

Progress towards generating accurate and reliable 7-day ensemble streamflow forecasts for Australia

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Abstract: Streamflow forecasts for lead times of up to 10 days are valuable for a wide variety of applications. Forecasts of potential flood conditions enable emergency services and water managers to plan mitigation and community responses. Forecasts of within-bank streamflow allow water managers to optimize water distribution and environmental benefits in regulated streams. Streamflow forecasts are generated by initializing a calibrated hydrological model using observed precipitation and evapotranspiration, then forcing the hydrological model with weather forecasts derived from numerical weather prediction (NWP) models. There are many potential sources of error in streamflow forecasts. Hydrological and NWP models are simplified representations of real-world processes and therefore result in prediction errors. Imperfect observational data introduce errors into model parameterizations and the initial conditions of the models used to generate forecasts. These errors mean that streamflow forecasts are fundamentally uncertain. Ensemble methods that combine statistical techniques and process-based models provide a robust approach for characterizing forecast uncertainties. International experience suggests that formal estimates of forecast uncertainty can lead to better and more robust decision making.

For ensemble forecasts to be valuable to users, they need to be as accurate as possible and the ensemble spread should reliably quantify remaining uncertainty (i.e. to ensure the spread is not too wide or too narrow), which is a formidably difficult task. CSIRO, in partnership with the Bureau of Meteorology, have been working to overcome barriers to the development of an ensemble 7-day streamflow forecasting service for Australia. This presentation describes progress towards generating accurate and reliable ensemble streamflow forecasts for lead times of up to 10 days, to support emergency and water resources management applications. Advanced methods are used to estimate historical and real-time sub-catchment rainfall from rain gauge records. These interpolation methods allow for incomplete gauge records, explicitly characterize the effects of covariates, such as elevation, and quantify the uncertainty of rainfall estimates. Statistical post-processing is used to obtain sub-catchment precipitation forecasts from NWP model output, and in the process reduce biases and generate reliable estimates of forecast uncertainty. Semi-distributed hydrological modelling is implemented in computationally efficient software designed for ensemble forecasting. Residual errors in hydrological predictions are reduced and represented using a staged hydrological error model. At each stage the error model reduces uncertainty of hydrological predictions by removing a systematic component of residual errors. The final stage of the error model is used to refine the distribution of residual errors to ensure uncertainty estimates are reliable. Each component of the forecasting system that quantifies forecast uncertainty is able to handle data heteroscedasticity with data transformation, and treats the mixed discrete-continuous distribution of precipitation and streamflow in intermittent streams using continuous distributions and data censoring. We show that the accuracy of streamflow forecasts generated using the integrated system is dependent on catchment area and hydrological characteristics, and that the ensemble forecasts are statistically reliable. We conclude the presentation by highlighting opportunities to further improve forecast accuracy and to support the use of these forecasts to improve operational water management in Australia.

Keywords: *Ensemble forecasts, forecast reliability, hydrological prediction, uncertainty, forecast verification*