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Improving the conditional performance of medium-range ensemble streamflow forecasts

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Medium range ensemble streamflow forecasts can inform a wide variety of applications, including emergency responses to flooding, delivery of urban and irrigation water and management of environmental flow releases. To support these applications in Australia, an approach to generating ensemble streamflow forecasts has been established that (1) post-processes numerical weather predictions of catchment precipitation to reduce bias and reliably quantify forecast uncertainty; (2) simulates the conversion of precipitation to streamflow using a semi-distributed hydrological model; and (3) reduces hydrological simulation errors and represents the remaining prediction uncertainty using a hydrological error model. In real time, hourly ensemble streamflow forecasts are generated for lead times of up to 10 days by forcing the initialized hydrological model with ensemble precipitation forecasts and updating the resulting streamflow forecasts with the staged error model.

Reliable quantification of uncertainty is a crucial property of useable ensemble streamflow forecasts. In addition, many forecast applications (e.g. reservoir operations) require complete hydrographs rather than predictions at isolated lead times, which means that uncertainty must be correctly propagated along the hydrograph through all lead times. This presentation focusses on the need of the hydrological error model to ensure that uncertainty estimates of hourly ensemble streamflow forecasts are reliable. We show that at the hourly time steps, the statistical characteristics of errors for the receding limb of the forecast hydrograph are different to those for the rising limb. These differences can be related to physical processes. Forecasts of the rising limb of the hydrograph are prone to large errors, because they require the accurate estimation of the timing and magnitude of rain storms together with the response of runoff to these storms. Forecasts of hydrograph recessions are generally more accurate because these rely largely on simulating the drainage of catchment moisture stores. To account for these differences, we propose a hydrological error model that allows the residual distribution to vary according to whether the forecast hydrograph is rising or falling. We use a technique termed ‘stochastic updating’ to propagate uncertainty along the forecast hydrograph. We show that the error model improves forecast reliability overall and conditionally, leading to more useable streamflow forecasts. We conclude by discussing how the conditional characteristics of ensemble forecasts can influence management strategies to manage operational risks.