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## Comparing different versions of the continuous ranked probability score to account for forecast or observation uncertainty

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Recent studies have shown that probabilistic forecasts are superior to deterministic forecasts in terms of quality, reliability, and representing the uncertainty of future states. One of the most well-known and widely used tools for assessing the performance of (probabilistic) forecast systems is the continuous ranked probability score (CRPS). This metric is employed to evaluate the forecasting system when only forecast uncertainty is considered. In addition to multiple sources of uncertainty in a forecasting system (such as initial conditions, model structure and parameters, and boundary conditions), the uncertainty can also originate from observations (e.g., streamflow). However, this uncertainty, which has rarely been explored in previous research, should also be regarded in evaluating the forecasting system. A version of the CRPS is redefined and analyzed to overcome this important flaw, considering the observation's uncertainty. To estimate the uncertainty associated with streamflow observations, the Bayesian Rating curve method (BaRatin) is utilized. This study focuses on comparing the different versions of the CRPS in considering the uncertainties of forecasts and observations. Three types of streamflow forecasting systems are used in this study: deterministic forecasts, raw ensemble forecasts (applying meteorological ensemble forecasts as inputs to the hydrological model), and post-processed ensemble forecasts (postprocessing of hydrological model outputs using weighted ensemble dressing method). The assessment is performed for short-term forecasts (lead times of 1 to 5 days) for the Au Saumon watershed in southern central Quebec, Canada. It is found that considering observation uncertainty has a significant effect on the values of CRPS compared to when only forecast uncertainty is considered. In addition, CRPS changes in probabilistic forecasts are more than deterministic ones. Our results also point out that using the modified version of the CRPS can help end-users better understand and evaluate their forecasting system.