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Towards an Improved Postprocessing of Hydrological Forecast Ensembles using Copula

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Postprocessing of hydrological forecasts regardless of the inherent dependencies among model forecasts and real-time observations is subject to several errors that may even degrade the original forecasts. This study addresses the major drawbacks of the frequently applied bias correction method, the so called Quantile Mapping (QM) in adjusting hydrological forecasts, and then introduces an auxiliary index (failure ratio) to identify the capability of QM in improving forecasts prior stepping into the forecast period. Failure ratio reflects the frequency of incorrect adjustment moves from the original forecast trajectories for an analysis period before the forecast date. Thereafter, to establish a model between hydrological forecasts and real-time observations, a set of multivariate distribution functions (i.e. copula functions) are employed to characterize the joint behavior of forecasts and simulations as dependent hydrological variables. While copula functions have been recently applied in different hydrologic disciplines, this is the first application of copulas in hydrological forecast postprocessing. Owing to complex hydrological processes and complicated relations among hydrologic variables, it is difficult to establish a conditional distribution of observed variables given model forecasts if the raw variables are used directly. Copula functions, however, combine the variables via their marginal distributions instead of the direct raw variables and this is the main advantage of copulas in postprocessing the forecasts. Both QM and copula-based methods are primarily tested on a set of 2500 hypothetical case studies with parametric marginal distributions for the observed and forecast variables followed by a real-case study of the streamflow forecast of the Sprague River Basin located in southern Oregon, US. Results show that the failure ratio is a controlling factor on the performance of QM method while the copula-based method does not show a specific sensitivity to the failure ratio and it is found as the preferred method in general contesting with QM. The point-wise verification metrics illustrate the definite superiority of copula-based approach in adjusting forecasts especially in cases with large values of failure ratio and the probabilistic verification metrics recognize them as rather competitive approaches in most of the metrics. Comparing the results of both postprocessors, however, demonstrates the remarkable ability of the multivariate postprocessor in bias correction of hydrologic forecasts comparing to the QM approach.