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A real-time evaluation and demonstration of strategies for 'Over-The-Loop' ensemble streamflow forecasting in US watersheds

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Many if not most national operational streamflow prediction systems rely on a forecaster-in-the-loop approach that require the hands-on-effort of an experienced human forecaster. This approach evolved from the need to correct for long-standing deficiencies in the models and datasets used in forecasting, and the practice often leads to skillful flow predictions despite the use of relatively simple, conceptual models. Yet the 'in-the-loop' forecast process is not reproducible, which limits opportunities to assess and incorporate new techniques systematically, and the effort required to make forecasts in this way is an obstacle to expanding forecast services – e.g., though adding new forecast locations or more frequent forecast updates, running more complex models, or producing forecast and hindcasts that can support verification. In the last decade, the hydrologic forecasting community has begun develop more centralized, 'over-the-loop' systems. The quality of these new forecast products will depend on their ability to leverage research in areas including earth system modeling, parameter estimation, data assimilation, statistical post-processing, weather and climate prediction, verification, and uncertainty estimation through the use of ensembles.

Currently, many national operational streamflow forecasting and water management communities have little experience with the strengths and weaknesses of over-the-loop approaches, even as such systems are beginning to be deployed operationally in centers such as ECMWF. There is thus a need both to evaluate these forecasting advances and to demonstrate their potential in a public arena, raising awareness in forecast user communities and development programs alike. To address this need, the US National Center for Atmospheric Research is collaborating with the University of Washington, the Bureau of Reclamation and the US Army Corps of Engineers, using the NCAR 'System for Hydromet Analysis Research and Prediction Applications' (SHARP) to implement, assess and demonstrate real-time over-the-loop ensemble flow forecasts in a range of US watersheds. The system relies on fully ensemble techniques, including: an 100-member ensemble of meteorological model forcings and an ensemble particle filter data assimilation for initializing watershed states; analog/regression-based downscaling of ensemble weather forecasts from GEFS; and statistical post-processing of ensemble forecast outputs, all of which run in real-time within a workflow managed by ECWMF's ecFlow libraries over large US regional domains. We describe SHARP and present early hindcast and verification results for short to seasonal range streamflow forecasts in a number of US case study watersheds.