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Experimental hydrologic ensemble forecast service in the U.S. National Weather Service

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Quantifying the predictive uncertainty in hydrologic forecasts is one of the most pressing needs in operational hydrologic forecasting in order to support risk-based decision making for a wide range of applications, including flood forecasting, water supply management, streamflow regulation, recreation safety, and ecosystem management. To address this, the National Weather Service (NWS) has been actively developing an experimental capability for a Hydrologic Ensemble Forecast Service (HEFS) to produce hydrologic forecasts at multiple spatio-temporal scales while better quantifying and reducing the uncertainties associated with the major sources of error in hydrologic forecasting. The HEFS aims to provide for all forecast horizons uncertainty-quantified forecast and verification products that can be tailored to users' needs. Testing and experimental operation of the HEFS components began in late 2009.

The current HEFS capability allows modeling of different sources of uncertainty separately via three major components: 1) the atmospheric ensemble pre-processor (EPP) that accounts for the input uncertainty to produce reliable and skillful atmospheric ensemble forcings for the hydrologic models at the required space and time scales; 2) the ensemble streamflow prediction (ESP) component that propagates the input uncertainty through a suite of hydrologic models to generate streamflow ensembles using current hydrologic conditions; 3) the hydrologic ensemble post-processor (EnsPost) that accounts for the hydrologic uncertainty and corrects for remaining systematic bias in the streamflow ensembles. To evaluate the performance of these components and identify key factors responsible for model error and skill, hindcasting is performed to retroactively produce large samples of EPP-ESP-EnsPost streamflow ensembles.

In this presentation, we report verification results for dependent validation of streamflow ensembles for selected test basins in Central and Western U.S. Streamflow ensembles were produced for over 20 years by ESP-EnsPost from the EPP-generated precipitation and temperature ensembles, which were based on the 14-day ensemble means of the 1998 frozen version of the NWS National Centers for Environmental Prediction's Global Forecast System (GFS). These streamflow ensembles are evaluated against ESP-generated ensembles from climatology-based precipitation and temperature ensembles. Results from a variety of ensemble verification metrics (e.g., Continuous Ranked Probability Skill Score, reliability component of the Continuous Ranked Probability Score, Relative Operating Characteristic score) show that EPP and, to a lesser extent, EnsPost improve the skill, the reliability, and the event discrimination of the ensembles across all forecast horizons; the gain in skill is more significant for larger events. We also discuss planned enhancements and challenges for providing operational hydrologic ensemble prediction services, such as the on-going evaluation of other post-processing and data assimilation techniques on a wider set of basins, and the collaborations with forecasters to determine how forecast uncertainty and verification information could be effectively communicated to diverse user groups.