Generation of Mid-Range Precipitation Ensemble Forecast from GFS Ensemble Mean at Basin Scale

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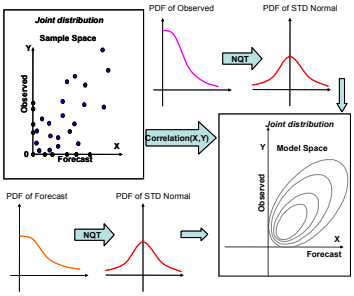
Introduction

The Office of Hydrologic Development at the National Weather Service and its partners have been developing an experimental system for Hydrologic Ensemble Forecast Service (HEFS), with the goal of operationally producing reliable and skillful streamflow ensemble forecasts with about a year of lead time using forcings from short, medium, and long range numerical weather prediction models. A key component of the system is a preprocessor that extracts information from single-valued, as well as ensemble, precipitation and temperature forecasts produced by a number of U.S. weather and climate forecast centers. The extracted forecast information is then turned into debiased forcing ensembles for the HEFS system at the basin scale. In this presentation, we describe the methodology employed in the preprocessor and demonstrate its performance in generating forcing precipitation ensembles using the source ensembles from the 1998 frozen version of the Global Forecast System (GFS), a medium range system developed by the National Center for Environmental Prediction. It is widely recognized that the raw ensemble forecasts produced by numerical weather prediction models tend to be biased (Hamill *et al.,* 2007). Several recent studies show that the predictive skill of the raw ensemble forecasts can often be captured by the ensemble mean. Therefore, one may use the GFS ensemble mean values as the singe-valued forecasts to derive reliable ensemble forecasts from the historical relationship of the observed and the ensemble mean (Kelly and Krzysztofowicz, 1997; Schaake *et al*., 2006), provided that the relationship is representative of the future. We use the GFS ensemble reforecasts, which are available for over 20 years, in calibrating the preprocessor. We present dependent validation results for a selected test river basin in California.

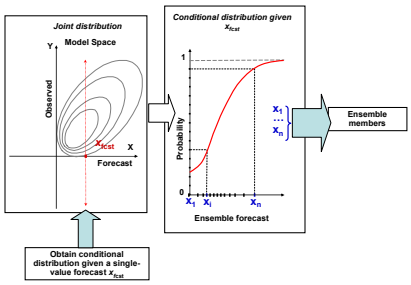
Methodology

- Use various temporal scales (12 hours to several days) to capture forecast skill for different forecast lead times (canonical events).
- Use Meta-Gaussian model for the joint probability distribution between the single-valued forecast and the corresponding observed mean areal precipitation from historical data for a given canonical event. Use normal quantile transform (NQT) for marginal distribution mapping.
- Sample the conditional probability distribution given the single-valued forecast.
- Apply Schaake Shuffle (Clark *et al.,* 2004) to the sample to obtain a forecast ensemble that behaves similarly to the historical ensemble in space-time variability.

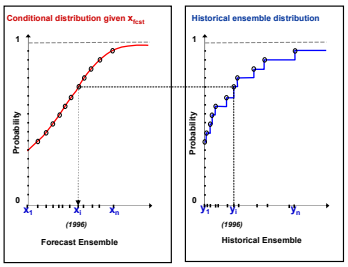
Meta-Gaussian model



Ensemble Generation



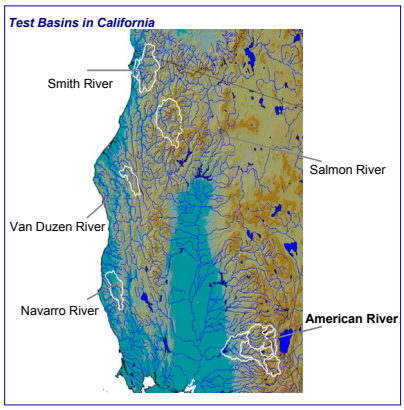
Schaake Shuffle



Dependent Validation

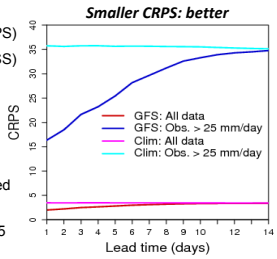
Results for a study basin selected from the service area of California-Nevada River Forecast Center

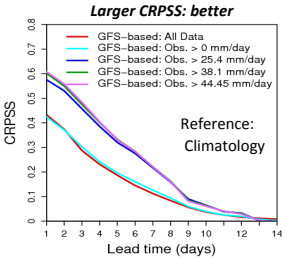
- Study basin (NFDC1): North Fork of the American River (875 km2) near Sacramento, California
- Calibration period: 1979-2005
- Validation period: July 1, 2003 – June 30, 2008



Validation metrics

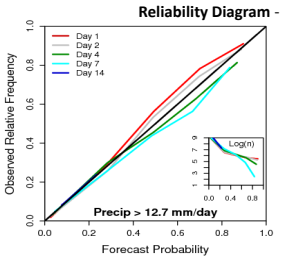
- Mean Continuous Ranked Probability Score (CRPS)
- Continuous Ranked Probability Skill Score (CRPSS)
- Reliability diagram
- Relative Operating Characteristic (ROC) score

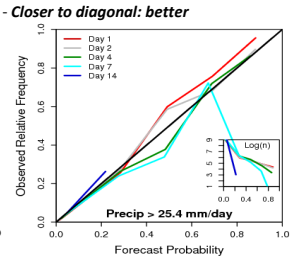


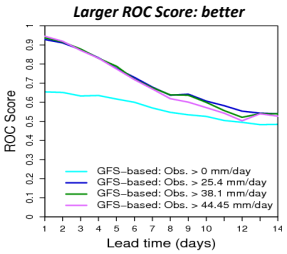


Findings

- The Mean CRPS plot shows that these GFS-based ensembles possess significant skill relative to climatology, especially for the larger threshold (> 25 mm/day).
- The CRPSS plot reinforces this observation, showing that the ensembles, relative to climatology, possess substantial skill for the first several lead days, and some marginal skill until about lead day 9, for all thresholds.
- The reliability diagrams show that the ensembles are generally reliable for the two large thresholds for all lead times.
- The ROC score plot shows good discriminatory skill for all thresholds, with the prediction of precipitation events of (> 0 mm/day) being the least skillful.







Summary

The model is capable of generating reliable ensembles from the GFS ensemble mean values at the basin scale. The ensembles possess varying degrees of skill up to about day 9, and the skill for the first several days is substantial.

Future work

- Carry out large-sample independent validation using the GFS reforecast data set to assess sensitivity of performance to the size of historical data.
- Evaluate ensemble performance using additional forecast sources (e.g., HPC/RFC single-valued forecasts, GEFS ensembles, CFS forecasts).
- Carry out comparative evaluation with post-processed operational GEFS forecasts (in collaboration with Middle Atlantic River forecast Center and NCEP).
- Evaluate the performance on multiple temporal scales (from 12-hr to 14 days).

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