VERIFICATION OF WATER SUPPLY FORECAST TOOLS IN THE COLORADO RIVER BASIN:

Ensemble Prediction (ESP) and Hydrologic Ensemble Forecast System (HEFS)

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Introduction

Water supply forecasting has a lengthy history in the semi arid western United States where water is valuable and central to many aspects of the economy, the landscape, and life. As water demands increase and supply decreases, the demand for optimizing water management has increased the need for improved forecast services.

Historically, forecast agencies have largely relied on two forecast approaches: statistical models relating snow measurements and other predictor variables to runoff and simulation models, such as the National Weather Service River Forecast System (NWSRFS:NWS 2005),that account for physical processes and weather forecasts. Additional forecast approaches, such as the hydrologic ensemble forecast system (HEFS), are in development to address the need for improved forecasts.

Objective: Compare the skill and reliability of four probabilistic forecast tools (two currently used and two in development) for seasonal water supply volumes in basins in the upper Colorado River and Eastern Great Basins to leverage new forecast capabilities.

Methods

Study Area

The upper Colorado River Basin above Lake Powell and the Eastern Great Basin in Utah were chosen as the study areas (Fig 1).

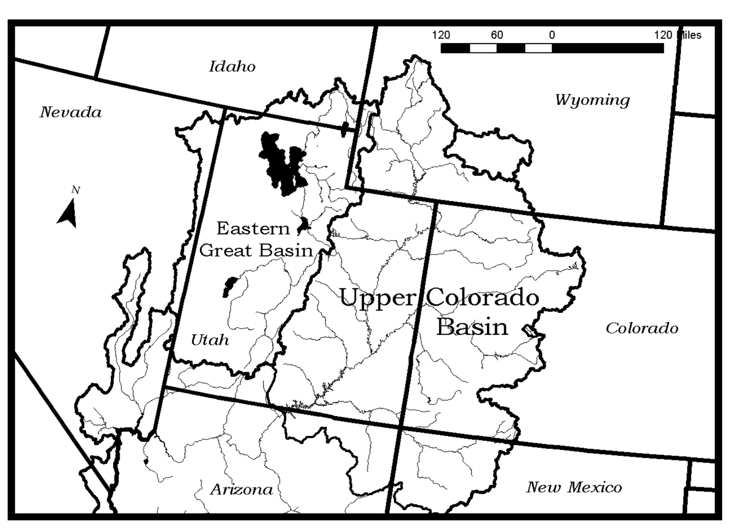

Figure 1. Study area map

The hydrology of the area is dominated by snowmelt and large seasonal and inter-annual variability flows. We analyzed verification statistics for ~130 points forecast points for three of the tools and 10 points for all forecast tools.

Forecasts/Observations

A reforecast approach was employed to overcome the lack of a large sample set of archived forecasts. Reforecasts were generated as described in Werner et al (2005) for the first of month from January-June for all four forecast tools: statistical water supply (SWS), ensemble streamflow prediction (ESP), ESP with Schaake post adjustment (ESP-POST), and HEFS. Forecasts from all tools were aggregated to an April-July period and compared to April-July observations.

Metrics

We assess forecast performance via two measures: skill and reliability.

Skill

To measure skill, we computed the improvement in the mean absolute error of the reforecasts over the mean absolute error of observed volumes from 1985-2010.

$$SS = 1 - \frac{MAE(forecasts)}{MAE(observations)}$$

Reliability

Reliability was computed using the four categories defined by the three probability thresholds : 10%, 50%, and 90%. To quantitatively compare the forecast reliability, we calculated a reliability metric as follows (Fig 2):

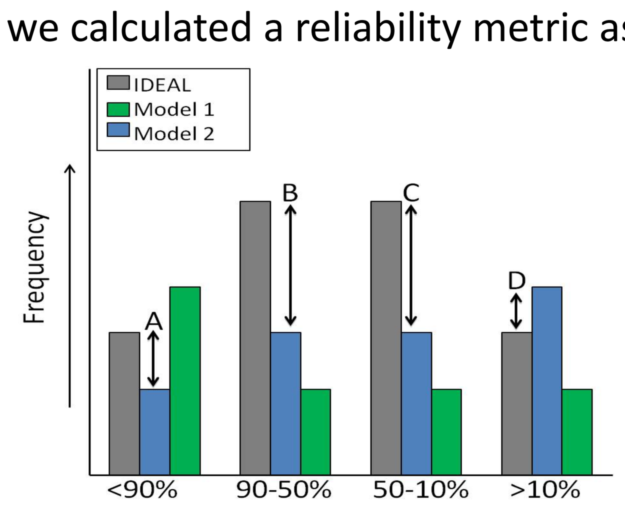

Figure 2. Reliability metric

Results

All Models: Single Headwater Location: Little Cottonwood Creek , Utah

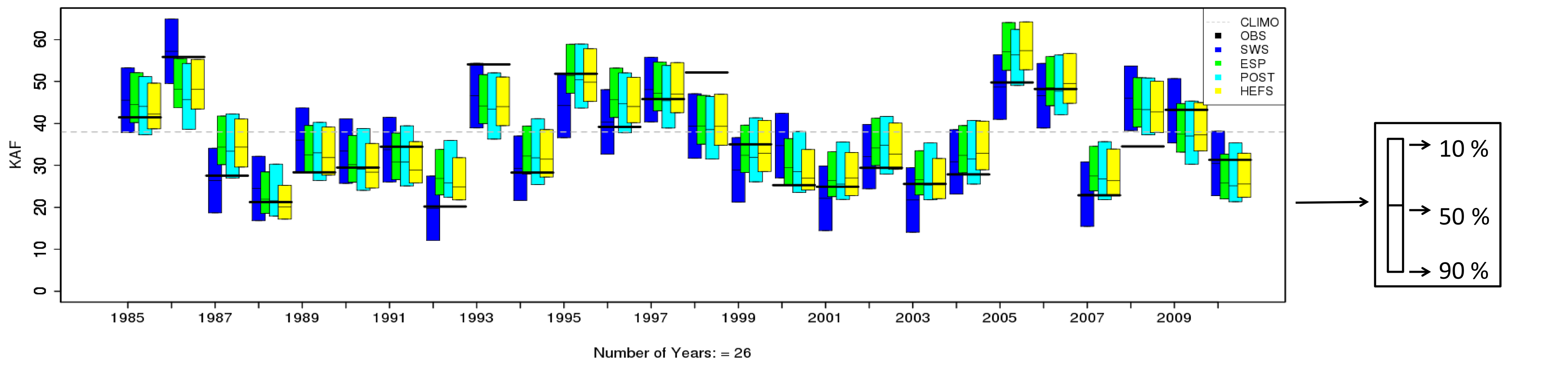

Figure 3. April 1st forecasts and corresponding observations for April-July volumes at Little Cottonwood Creek, Utah. Climatology or average April-July volume is represented by the gray dashed line.

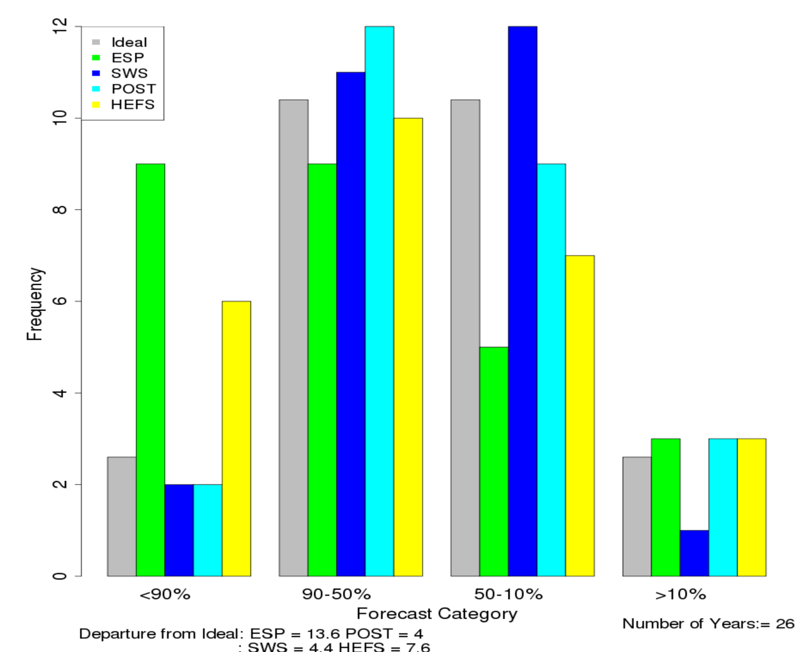

Figure 4. Number of observations falling within four categories defined by forecasts for April 1st forecasts at Little Cottonwood Creek, Utah. Departure from ideal represents the reliability metric.

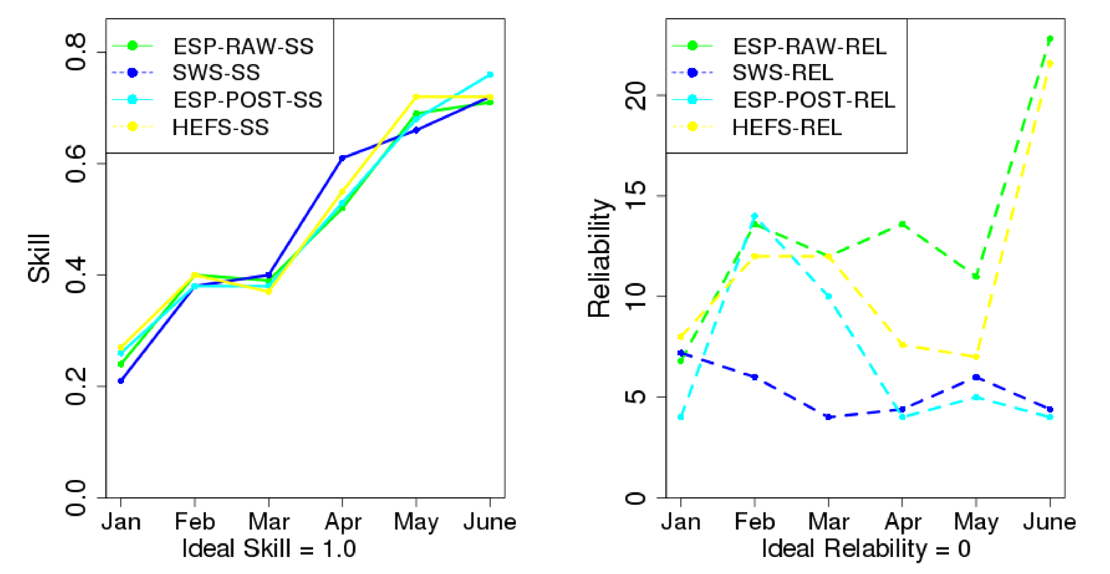

Figure 5. Forecast skill (left) and reliability (right) as a function of forecast lead time for Little Cottonwood Creek, Utah.

SWS+ ESP+ESP-POST: All Forecast Points: Upper Colorado River and Eastern Great Basins

Skill

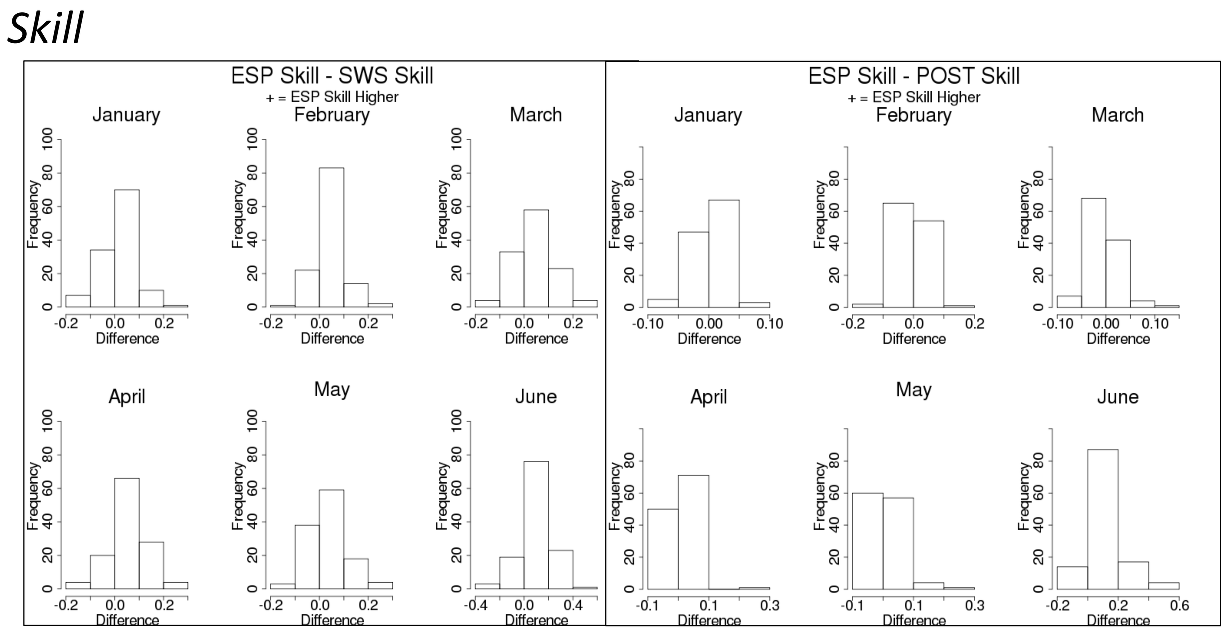

Figure 6. Frequency of skill differences for January-June issuance of all forecast points. Values greater than zero indicate ESP is more skillful than SWS (left) or ESP-POST (right).

Reliability

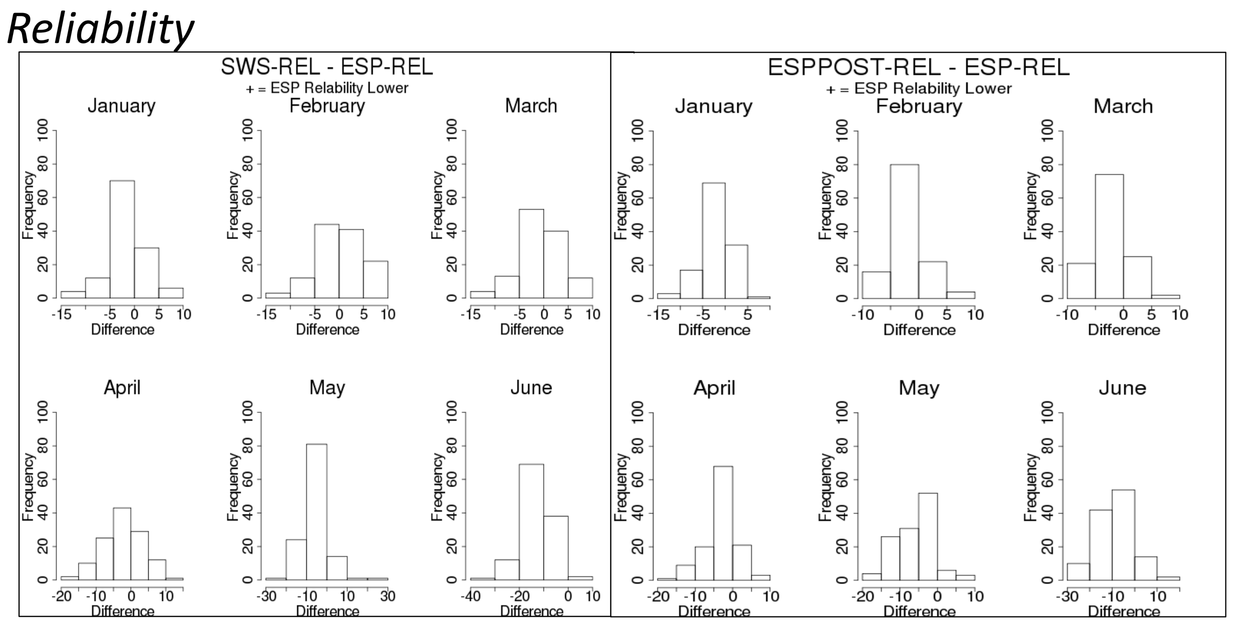

Figure 7. Frequency of reliability differences for January-June issuance of all forecast points. Values greater than zero indicate ESP is more reliable than SWS (left) or ESP-POST (right).

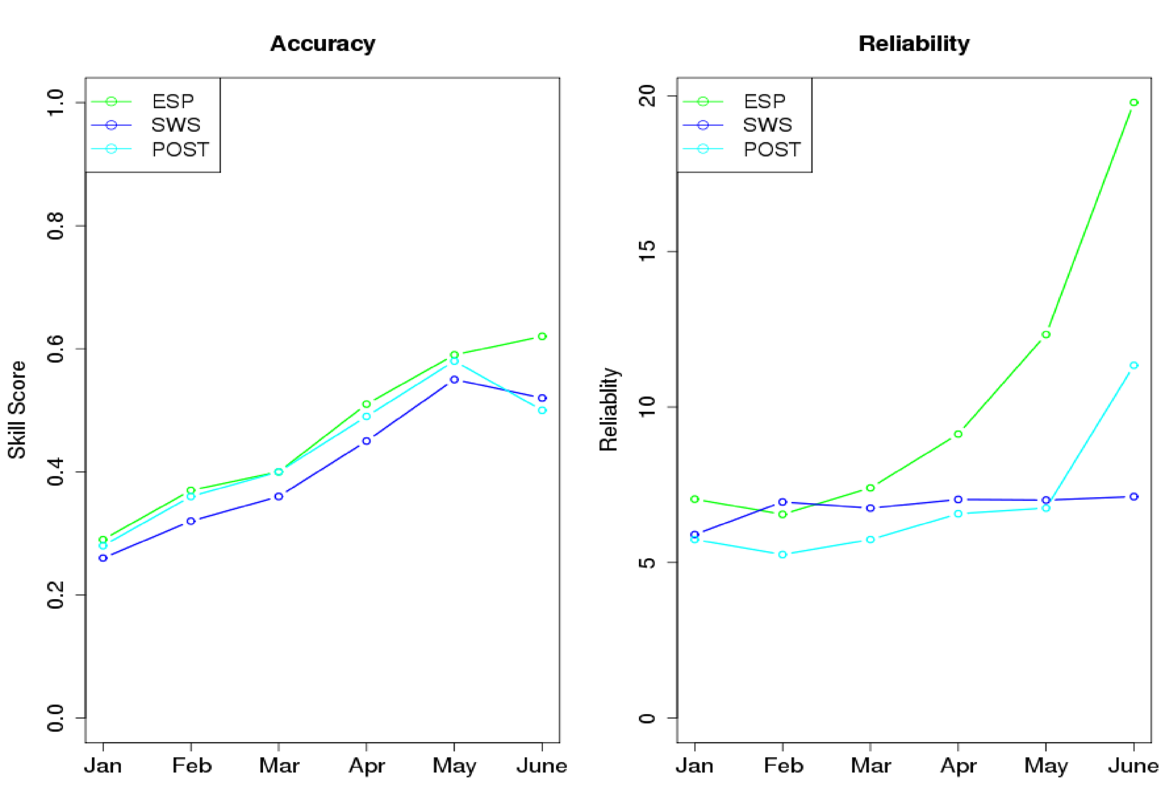

Figure 8. Mean skill (left) and reliability (right) for January-June issuances of all forecast points in the Upper Colorado River and Eastern Great Basins.

Discussion/Conclusions

All Models: Single Headwater Location: Little Cottonwood Creek , Utah

- Reliability is similar for SWS, ESP-POST, and HEFS models for April 1st forecasts
- Similar skill across all lead times for all models
- SWS more reliable at all lead times; ESP-POST similar to SWS from April-June
- ESP and HEFS dispersion issues in May and June

SWS+ ESP+ POST: All Forecast Points

- ESP and SWS have comparable skill for all lead times
- ESP and ESP-POST have comparable skill except in June where ESP is more skillful
- ESP and SWS have comparable reliability January-April. ESP underdispersive May-June
- ESP-POST more reliable than ESP at all lead times
- **All results vary based on forecast point and basin characteristics**

Limitations

- Small sample size
- No weather forecasts (ESP/SWS/ESP-POST)
- No model state modifications (ESP/ESP-POST/HEFS)
- Each reforecast year included in analysis (may bias stats)

Next Steps

- Study validates focus on ESP tools rather than SWS
- Add ESP-POST to operational water supply tools to improve spread issues with ESP
- Additional verification studies of HEFS
- Additional verification studies of different forecast periods (e.g monthly, weekly, and daily)

References

National Weather Service (NWS), 2005: National Weather Service River Forecast System (NWSRFS) User Manual Documentation. National Weather Service documentation, Silver Spring, Maryland, USA [Available online at: www.nws.noaa.gov/oh/hrl/nwsrfs/users_manual/htm/xrfsdocpdf.php]

Werner, K., Brandon, D., Clark, M., & Gangopadhyay, S. (2005). Incorporating medium-range numerical weather model output into the ensemble streamflow prediction system of the National Weather Service. Journal of Hydrometeorology, 6(2), 101-114.

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