HARNESSING THE SEASONAL PREDICTABILITY OF STREAMFLOW

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EXTENDED ABSTRACT

In the western United States, most operational forecasts of seasonal streamflow either use: (i) regression equations based on *in situ* observations (e.g., snow water equivalent, rainfall) or (ii) hydrologic model simulations that employ current hydrologic conditions and historically observed weather sequences to generate an ensemble of possible futures (e.g., Ensemble Streamflow Prediction, ESP) (Day, 1985; Wood and Lettenmaier, 2006; Pagano et al, 2014;). In this project, we are developing a framework that includes benchmark forecasts and new techniques which include additional predictive information. More specifically, the framework currently generates forecasts for a range of techniques (statistical, dynamical, and hybrid methods) that leverage predictability from both the land surface and climate (Figure 1). This framework provides a platform for systematic intercomparison of techniques,

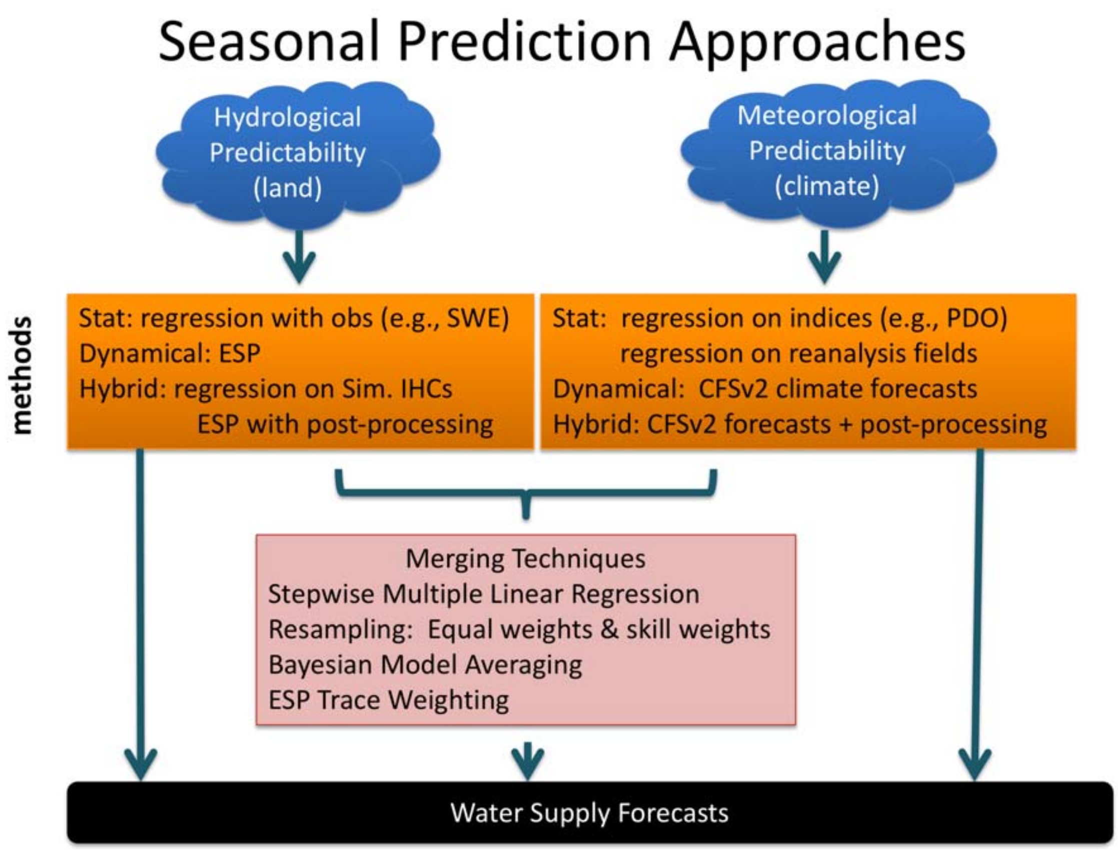

Figure 1. Schematic of predictability-based approaches. Current methods used in operation include only statistical (Stat) and dynamical approaches capturing hydrological predictability (the top left corner of the schematic). The framework being developed allows for these methods to be compared to a range of additional methods that also incorporate meteorological predictability and a variety of blending techniques.

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enabling a structured way to assess whether a new technique increases predictability relative to current benchmarks. The project also explores the concept that an automated forecasting workflow is viable, which opens the door to potential scientific and technical advances in forecasting, including the use of higher complexity modeling, statistical post-processing, data assimilation, and forecast verification. An automated system would also provide a foundation for exploring future streamflow predictability under climate change.

Techniques under development in the research community currently span a range of data requirements and complexity (Rosenberg et al., 2011), and it is hard to assess potential benefits (and costs) of more complex methods. The framework is currently set up to compare across thirteen methods, including dynamical approaches based on conceptual hydrological modeling and ESP (1-2 in Figure 2); statistical regression using initial hydrologic conditions (IHC) and/or climate information (3-7 in Figure 2); and several hierarchical combinations of dynamical and statistical forecasts (8-13 in Figure 2). In all cases, prediction methods are fully cross-validated so that their hindcast skill is an accurate measure of their skill in real-time operations. In addition, the study avoids the use of any predictors that are not available in real-time, so that all methods are suitable for operations.

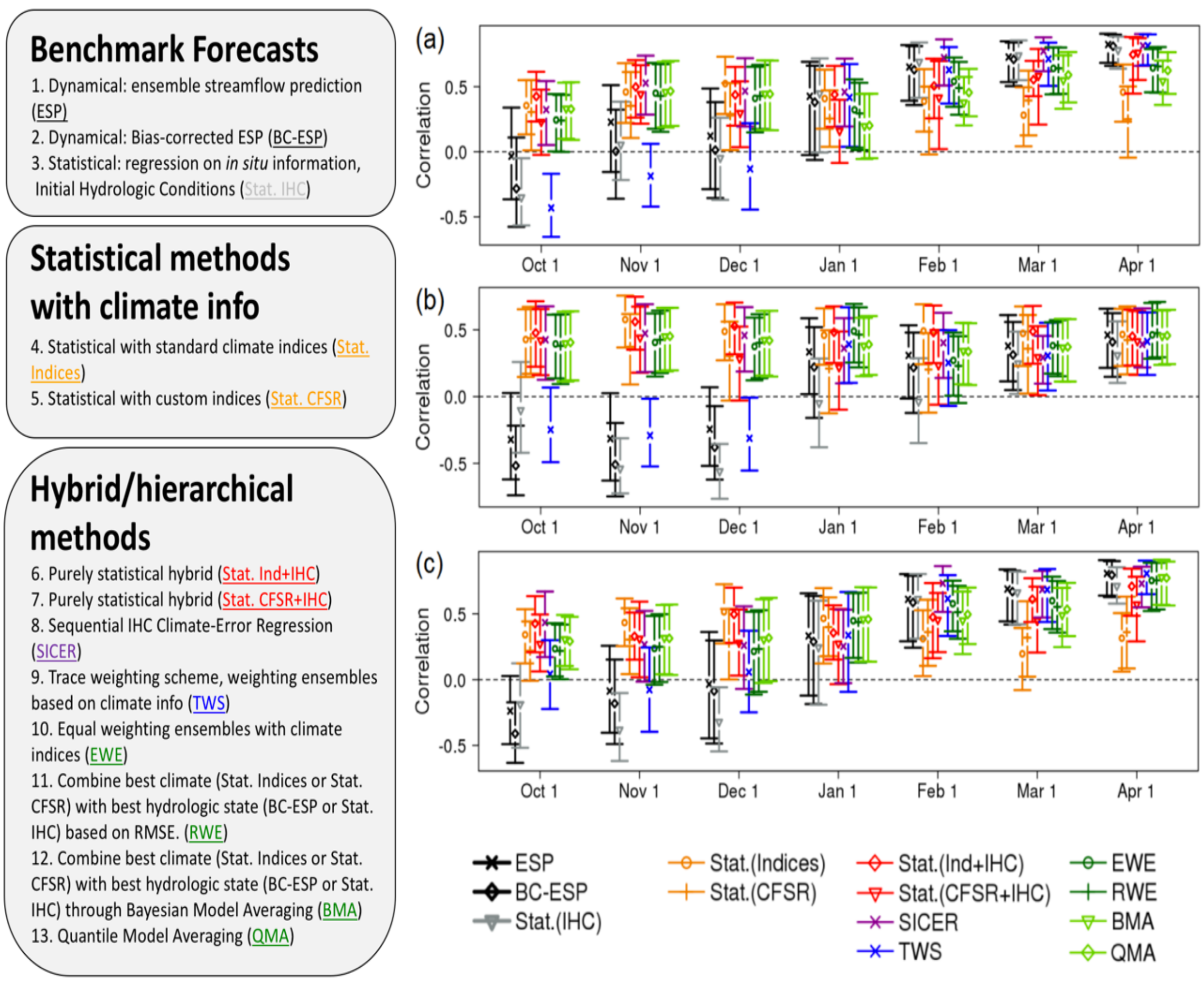

Figure 2. Seasonal streamflow forecasting methods included in the intercomparison framework. Panels on the left are the methods compared which coincide (in both order and color) with the bars on the right. Bar graphs are correlation coefficients of ensemble median forecasts versus observations obtained from all methods at different initialization times. The error bars define 95% confidence limits obtained through Monte Carlo resampling. Higher correlation values indicate better skill. Locations include inflows to (a) Dworshak Reservoir (ID), (b) Howard Hanson reservoir (WA), and (c) Hungry Horse reservoir (MT).

Preliminary results at several test basins in the Pacific Northwest suggest that including climate information in seasonal forecasts improves forecast skill (Figure 2). For example, for forecasts made before January 1, techniques that include climate information do better than benchmarks. More generally, however, these results illustrate the idea that there are a family of viable, automated techniques, which allow for hindcasting and verification to reveal strengths and weaknesses – i.e., which can be ruled out, especially at certain times of year, versus those that may lead to improved forecasts.

Additionally, this framework provides a powerful tool that can help the community better understand different sources of predictability at different times of year. This project has benefited from interactions with the Boise Office of the U.S. Bureau of Reclamation in helping shape products, and continues to seek interested partners from the water management community. (KEYWORDS: predictability, streamflow, water management, Pacific Northwest)

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