Evaluation of hydrologic indices for forecasting Western U.S. seasonal water supply

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ABSTRACT
Forecasting seasonal runoff is an important challenge in the Western U.S. because the timing and volume of summer (dry season) streamflows play a critical role in managing water supply and delivery systems. Beginning in mid-December of each year, observations of the snow pack throughout the west begin to provide invaluable information on the amount of runoff expected in late spring and summer. The skill of such water supply forecasts also benefits, in some locations, from the consideration of synoptic climate indices – e.g., using sea surface temperature anomalies to characterize ENSO or PDO state, which have been shown to have predictable teleconnections to land surface hydrology months in advance. These two sources of forecast information complement each other, with climate/SST state information providing predictability at long lead times (3-6 months), and observed snow and other moisture states of local catchments providing skill at shorter lead times (1-4 months). However, since similar SST anomalies can produce widely different future hydrology outcomes, information at intermediate lead times describing how a particular teleconnection or climate pattern is evolving on a macro-scale level (especially regarding precipitation anomalies) may provide additional insight into future spring and summer runoff. In this study, we explore the use of a long-term land surface hydrology data set to define hydrologic indices with potential predictive value, and to assess where these might enhance predictability already achievable using local observations and climate indices. We find one candidate index with potential value in the Pacific Northwest, but little improvements in the southwestern U.S. relative to existing climate and observation-based indices.

BACKGROUND and STUDY RATIONALE
Currently two sources of hydrologic predictability are commonly used in monthly to seasonal streamflow forecasts: remote (ocean temperature- or SST-based) and local (observation-based).

1) Remote SST-based indices exhibit predictive skill for hydrology in the Western United States, and the predictability of the SST indices themselves is relatively high. Uncertainty in the manifestation of any SST anomaly event (e.g., El Nino), however, creates uncertainty in the event’s future hydrologic impacts. Since these indices describe drivers of large-scale climate patterns, their value is generally highest at longer lead times up to 9 months.

2) Local ground-based, point observations of snow water equivalent and accumulated water year precipitation are central to the operational long lead forecasts of summer streamflow. These predictors are local to the streams they are used to predict. They have little accuracy in the first few months of the water year, hence official water supply forecasts (produced by the NRCs NWCC and NWS RFCs) are not released until mid-December and January 1. These indices have their peak predictive value late in the runoff season in April and May.

A third category of predictive information that may be useful for summer runoff prediction can be termed a synoptic scale hydrologic index.

Recent work (Wood and Lettenmaier, 2006) provides a real-time estimation of the evolution of continental-scale patterns of land surface moisture. The information is derived from snow water equivalent and soil moisture as simulated by a water and energy balance model that is driven by real-time ground observations of temperature and precipitation. Predictors derived from this dataset appear to show potential for providing seasonal forecast information at lead times between those that are optimal for the remote SST- and local ground-based data sources.

DEVELOPING CANDIDATE LAND-OCEAN PREDICTORS

The exploration for a suitable land-based index requires certain characteristics:
- Objective characterization – reproducible by others
- Capture large-scale evolution of integrated climate effects on the land surface
- High correlation with streamflow or other hydrologic characteristics

1. Exploratory Data Analysis

Using the archive of retrospective forecasts of snow water equivalent (SWE) and soil moisture (SM) over the Continental U.S., we performed a principal components (PC) analysis on both the SWE and SM data from the major and minor north-south (N-S) dipoles, a common expression of western U.S. climate anomalies. The Nino3.4 time series and the predictability of the SST indices themselves is relatively high. Uncertainty in the manifestation of any SST anomaly event (e.g., El Nino), however, creates uncertainty in the event’s future hydrologic impacts. Since these indices describe drivers of large-scale climate patterns, their value is generally highest at longer lead times up to 9 months.

2. Predictor Development

With the goal of forecasting summer streamflow in major western U.S. rivers, we are evaluating two types of predictors for use in a regression framework by calculating their correlation with summer river flow:

- NS-diff = NW - SW
- NS-sum = NW + SW

We compared these against predictors provided by:
- Local drainage-basin averaged SWE+SM
- The Nino3.4 time series

REFERENCES