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On better monitoring and forecasting of freshwater availability at catchment scales: literature review and a first attempt using a mechanistic/deterministic approach

Lin, P.[1], Yang, Z.-L.[1], Anderson R.[2]
prlin@utexas.edu
1. Jackson School of Geosciences, The University of Texas at Austin, Austin, TX
2. Water Services, Lower Colorado River Authority

In the context of global warming-induced acceleration of the hydrological cycle, where extreme events such as droughts tend to occur more frequently and intensively, there is an urgent need for research on better monitoring and forecasting of freshwater availability at catchment scales. Streamflow forecast with seasonal lead times is, within this context, the most important one for reservoir operations and water management. Previous studies have been seeing significant progress in understanding how the following factors are affecting local water availability: 1) large-scale oceanic patterns in Pacific and Atlantic, known as "teleconnections"; 2) soil moisture and groundwater, considered as local "memories"; and 3) changes in CO_2 and aerosol levels, driven by anthropogenic altering. A volume of studies use both observational and modeling datasets in quantifying impacts of El Nino-Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO) and Atlantic Multidecadal Oscillation (AMO) over various basins, among which ENSO and PDO are generally concluded as the most related ones for Texas hydrology.

Currently, the water supply forecasts model of the Highland Lakes catchment (in Texas) applied by Lower Colorado River Authority (LCRA) is a stochastic model. Except for the hydrologic persistence, the model also incorporates knowledge on ENSO impacts, thus providing a robust mechanistic but stochastic tool for predicting. The model has some advantages over deterministic but empirical models derived from statistical regressions, especially in short-term predictions. However, it still has deficiencies because of its 1) high dependence on historical data; 2) inaccurate assumption on stationarity of flows; and 3) inability in forecasting regions where gauging data are lacking.

The River Application for Parallel computatIon of Discharge (RAPID), on the other hand, is developed based on the best available knowledge on land surface processes and river routing, thus is a mechanistic and deterministic approach as compared with above approaches. Based on "blue-lines", and given runoff estimates from North American Land Data Assimilation System (NLDAS2) or other Land Surface Models (LSMs), it can compute stream flow and volume in each river reach in every river basin on land. Thus, as a first attempt, this study will use RAPID computed streamflow in Highland Lakes for lake level monitoring (hindcast) based on simple mass balance relations. This initial attempt will also potentially open possibilities for future research in applying NCEP Coupled Forecast System model (CFS) in more accurate hydrologic prediction at catchment scales.

Keywords: the hydrological cycle; streamflow monitoring/forecasting; ENSO; LCRA; stochastic model; RAPID; NLDAS2; mechanistic/deterministic model