U.S. Department of the Interior
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Exploring the Use of Temperature to Understand Recent Drought and Project Future Conditions in the Colorado River Basin

Research Bulletin
S&T Project 19264

Mission Issue

Improving performance in projections of Colorado River flow at time scales between 2 and 10 years into the future and downscaling for use in planning models.

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Problem

The Colorado River Basin (CRB) is a critical resource for over 40 million people in the Southwestern U.S. and Northern Mexico but exhibits highly variable streamflow year to year and is susceptible to multiyear and even multidecadal droughts. In river basins with storage capacities that can hold multiple years' worth of average flow, like the CRB, flow projections past a 12-month lead time are important for planning as they can potentially be used to inform current year operations. While many good forecasts for Colorado River flow exist at seasonal time scales, projections beyond one year into the future perform little better than simply using a long-term average. Improving so-called "decadal" projections, or forecasts spanning 2 to 10 years into the future, can help water managers better plan under increasing pressures from population growth and climate change.

Solution

We investigate whether the skill found in climate model-based temperature projections can be transferred to decadal streamflow forecasts in the CRB. This critical need combined with the knowledge that (a) global climate models have good skill and agreement in projecting decadal temperatures and (b) the documented sensitivity of CRB flows to temperature, motivates the present study with this research question—can skill in decadal temperature projections be translated to operationally skillful flow projections and consequently, water resources management?

We used temperature projections from the Community Earth System Model-Decadal Prediction Large Ensemble (CESM-DPLE) along with past basin runoff efficiency as covariates in a Random Forest (RF) machine learning model to project ensembles of multiyear mean flow at the key aggregate gauge of Lees Ferry, Arizona. The projections were disaggregated to monthly and subbasin scales to drive the Colorado River Mid-term Modeling System (CRMMS) to generate ensembles of water management variables. Of key interest were pool elevations at Lakes Mead and Powell, the two largest U.S. reservoirs that are critical for water resources management in the basin.

"The translation of skillful multi-year temperature projections to streamflows in the Colorado River network offers bright prospects for sustainable water resources management in the basin."

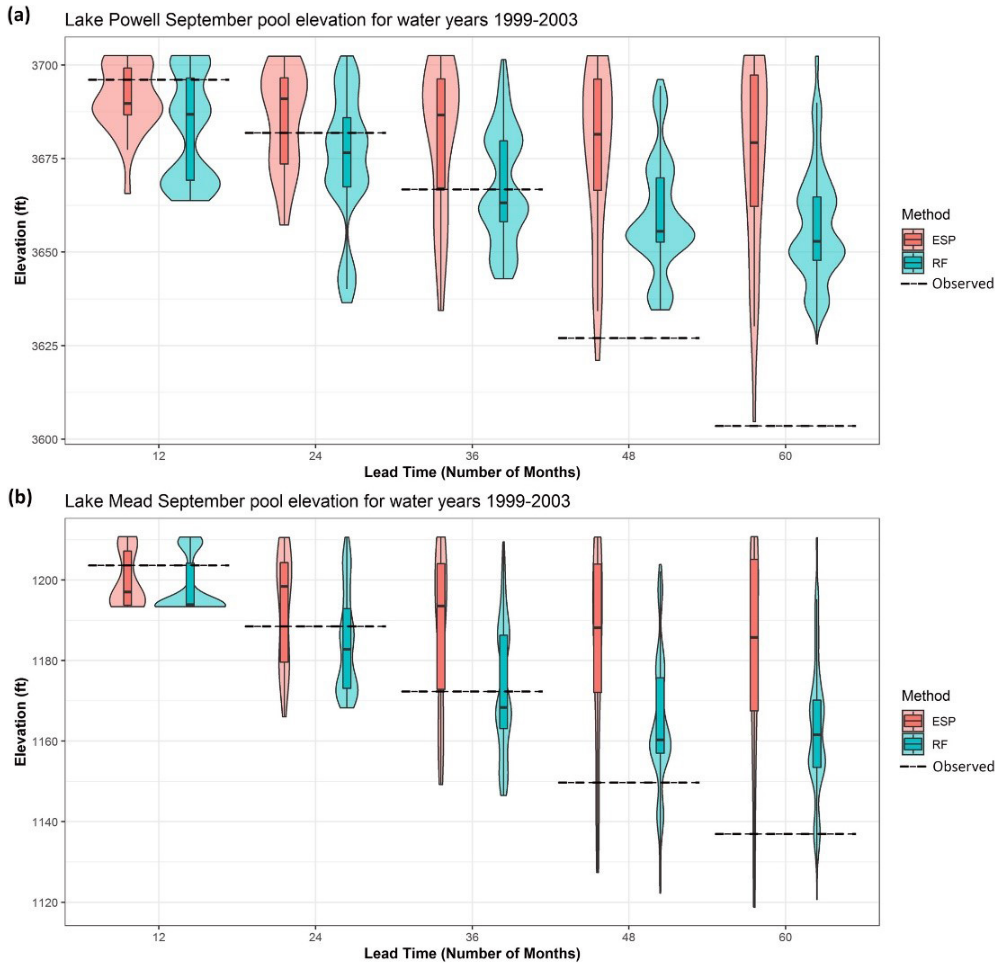
Dr. Balaji Rajagopalan
Professor & Associate Chair
Civil, Environmental, and Architectural Engineering,
University of Colorado, Boulder

More Information

https://www.usbr.gov/research/projects/detail.cfm?id=19264

Application and Results

When used as hydrologic flow forcings in the CRMMS operational simulation model of the CRB, RF projections generally outperformed ESP in predicting pool elevations at Lakes Powell and Mead for lead times of 36 months or greater. The RF forecasts were found to reduce the hindcast median root mean square error by up to 20% and 30% at lead times of 48 and 60 months, respectively, relative to projections generated from ESP.



CRMMS-simulated pool elevation at Lake Powell (a) and Lake Mead (b) from ESP and 5-year mean RF flow forecasts as well as a historical simulation.

Future Plans

Future work might investigate methods to improve skill of the RF approach and the covariates used. Of particular importance is improving the skill for precipitation and pre-1980 temperature simulations, upon which the performance of any derivative flow projection is heavily dependent. Additionally, the model training data set might be further expanded through inclusion of paleo-reconstructed flow and overlapping simulated hydroclimate data.