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Effects of inter-annual climate variability on water storage in the Colorado River Basin

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The Colorado River Basin (CRB), located in the Southwestern United States, is largely semi-arid. 70% of streamflow originates from the high-elevation snowpack, and precipitation is generally concentrated in the North-American Monsoon period (summer). Recently, the CRB experienced a severe multi-year drought, and the population in the area is growing fast, increasing the pressure on water resources. Understanding the long-term (inter-annual to decadal) variability of water availability, therefore, is paramount for water resources management. Here, we analyze monthly time series of simulated terrestrial water storage components, observed precipitation and discharge spanning 74 years in the Colorado River Basin and statistically relate them to monthly climate indices that describe variability of sea surface temperature and sea level pressure in the tropical and extra-tropical Pacific. ENSO indices in winter (JFM) are related to winter precipitation, as well as to soil moisture and discharge in the Lower Colorado. The low-frequency mode of the Pacific Decadal Oscillation (PDO) appears to be strongly correlated with saturated water storage (groundwater). During the negative PDO phase, saturated storage anomalies tend to be negative, and the "amplitudes" (mean absolute anomalies) of soil moisture, snow and discharge are lower compared with periods having positive PDO phases. Predicting inter-annual variability, therefore, strongly depends on the capability of predicting PDO regime shifts. If indeed a shift to a cool PDO phase occurred in the mid-nineties, as data suggest, the current dry conditions in the Colorado basin may persist.