USING OBSERVATIONS TO BETTER ASSESS CLIMATE CHANGE IMPACTS ON STREAMFLOW IN THE WESTERN U.S.

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The sensitivity of streamflow (Q) to temperature (T) and precipitation (P) changes is an important part of the hydrological response to climate change, and of particular interest to water managers, the agricultural sector, and ecosystems. A large number of studies have examined this sensitivity using hydrological models with T and P changes taken from global climate models. However, hydrological models can have biases, leading to a desire to use of historical observations of Q, T, and P in a basin to validate the models.

We use historical data over the period 1915-2002 to estimate the effect of T and P on runoff efficiency (Q/P) in three societally important basins in the western U.S.: the Columbia, Northern Sierra, and Colorado basins. Unlike previous work, we focus on runoff efficiency because it isolates the part of streamflow changes that are due to precipitation changes with no alteration in land surface processes, and changes in streamflow that are due to a different disposition of moisture once it reaches the surface.

The water-year averaged runoff efficiency varies widely across the three study basins, from 16% (Colorado) to 42% (Columbia). Similarly, the interannual variability in runoff efficiency varies from a range of 10-25% (Colorado) to 30-50% (Columbia). A regression between runoff efficiency and T, P captures 24, 35, and 54% of the bi-annual variance in runoff efficiency in the Columbia, N. Sierra, and Colorado basins, respectively. This equates to capturing 66, 77, and 79% of the variance in streamflow in the three basins.

The coefficients of the fit yield the observed sensitivity of runoff efficiency (and streamflow) to T and P variations, a key parameter for climate change impact studies. The sensitivities of streamflow to temperature are −5, 0, and −10% per degree C in the Columbia, N. Sierra, and Colorado, respectively. With an expected warming of 3-5 C in the region, these sensitivities could have an appreciable impact on water supplies. The sensitivities of streamflow to precipitation are 1.25, 1.6, and 1.9 %/% in the same basins. The sensitivities are only weakly dependent on the time scale (from 2-9 years), except for the temperature sensitivity in the Columbia basin, which grows at longer timescales.

We compared the observed sensitivities to those found in 5 widely used hydrological models: Catchment, CLM, Noah, Sacramento, and VIC. In general, the models do a worse job capturing the sensitivity to precipitation than to temperature, although this is mainly due to the wide uncertainty bands in the temperature sensitivity given the period of record available. The model errors were almost universally in the direction of overestimating the sensitivity of runoff to precipitation changes.