# Clearing up confusion on future of Colorado River flows

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This is Lake Powell and Glen Canyon Dam in July 2004, when the high-water mark was about 120 feet above the water's surface. This year, Lake Powell and Lake Mead are heading toward their lowest levels since 1968. Credit: Bradley Udall, Univ. of Colorado

The Colorado River provides water for more than 30 million people, including those in the fast-growing cities of Las Vegas, Phoenix and Los

Angeles. Increasing demand for that water combined with reduced flow and the looming threat of climate change have prompted concern about how to manage the basin's water in coming decades.

In the past five years, scientific studies estimated declines of future flows ranging from 6 percent to 45 percent by 2050. A paper by University of Washington researchers and co-authors at eight institutions across the West aims to explain this wide range, and provide policymakers and the public with a framework for comparison. The study is published this week in the *Bulletin of the American Meteorological Society*.

"The different estimates have led to a lot of frustration," said lead author Julie Vano, who recently earned a UW doctorate in civil and environmental engineering. "This paper puts all the studies in a single framework and identifies how they are connected."

Besides analyzing the uncertainty, the authors establish what is known about the river's future. Warmer temperatures will lead to more evaporation and thus less flow. Changes to precipitation are less certain, since the headwaters are at the northern edge of a band of projected drying, but climate change will likely decrease the rain and snow that drains into the Colorado basin.

It also turns out that the early 20th century, which is the basis for water allocation in the basin, was a period of unusually high flow. The tree ring record suggests that the Colorado has experienced severe droughts in the past and will do so again, even without any human-caused climate change.

"The Colorado River is kind of ground zero for drying in the southwestern U.S.," said co-author Dennis Lettenmaier, a UW professor of civil and environmental engineering. "We hope this paper sheds some light on how to interpret results from the new generation of climate models, and why there's an expectation that there will be a range of values, even when analyzing output from the same models."

The authors include leaders in Western water issues, ranging from specialists in atmospheric sciences to hydrology to paleoclimate. Other co-authors are Bradley Udall at the University of Colorado in Boulder; Daniel Cayan, Tapash Das and Hugo Hidalgo at the University of California, San Diego; Jonathan Overpeck, Holly Hartmann and Kiyomi Morino at the University of Arizona in Tucson; Levi Brekke at the federal Bureau of Reclamation; Gregory McCabe at the U.S. Geological Survey in Denver; Robert Webb and Martin Hoerling at the National Oceanographic and Atmospheric Administration in Boulder; and Kevin Werner at the National Weather Service in Salt Lake City.

The authors compared the array of flow projections for the Colorado River and came up with four main reasons for the differences. In decreasing order of importance, predictions of future flows vary because of:

- Which climate models and future emissions scenarios were used to generate the estimates.

- The models' spatial resolution, which is important for capturing topography and its effect on the distribution of snow in the Colorado River's mountainous headwaters.

- Representation of land surface hydrology, which determines how precipitation and temperature changes will affect the land's ability to absorb, evaporate or transport water.

- Methods used to downscale from the roughly 200-kilometer resolution used by global climate models to the 10- to

20-kilometer resolution used by regional hydrology models.

While the paper does not determine a new estimate for future flows, it provides context for evaluating the current numbers. The 6 percent reduction estimate, for example, did not include some of the fourth-generation climate model runs that tend to predict a dryer West. And the 45 percent decrease estimate relied on models with a coarse spatial resolution that could not capture the effects of topography in the headwater regions. The analysis thus supports more moderate estimates of changes in future flows.

"Drought and climate change are a one-two punch for our water supply," said Overpeck, a professor of geosciences and of atmospheric sciences at the University of Arizona.

The new paper is intended to be used by scientists, policymakers and stakeholders to judge future estimates.

"I hope people will be able to look at this paper and say, 'OK, here's the context in which this new study is claiming these new results,'" Vano said.

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