

# Explaining Climate Extremes

## An Assessment of the 2017-18 Upper Colorado Drought

### Decision Making Context

A recently noted feature of the mostly snow-fed Colorado River basin—which has a long fall-to-spring snow accumulation season followed by summer melt—are the increased temperatures accompanied by sometimes lower summer flow volumes than expected from April 1 snowpack. The decision context for science is to assess how, and by how much, predictability of the runoff into Lake Powell has changed. In particular, is early spring snowpack no longer the gold standard for Colorado River forecasting? Is the relation between water resources and snowpack changing in a significant and detectable manner? Here are some clues to those pressing issues from a preliminary assessment of Colorado River Basin snowpack evolution during 2017–2018.

**60% deficit for Lake Powell inflow in April–July 2018.**

### Indications from Meteorological Observations

The 2017–2018 season witnessed unusually high temperatures (Figure 1a), and low precipitation (Figure 1b) that led to the development of drought conditions last witnessed during the peak of the 2012 drought (and last exceeded in 2003<sup>1</sup>). The former—2nd warmest on record since 1895—both in spatial scale and magnitude is linked to a sustained warming trend since about 1970, shared with much of the West and synchronous with the rise in global temperatures overall. The latter—5th lowest October–May precipitation on record since 1895, is not a trend feature—indeed, there is little trend (within observational uncertainty) during the last half century over the basin. The low precipitation is instead symptomatic of the basin’s moderate precipitation variability on seasonal to decadal time-

**Near-record high temperatures not yet contributing much to precipitation-driven deficit.**

scales. Various sub-basin features of the 2017–18 precipitation (e.g., driest in the south, wettest in the north, and greater percentage deficits in valleys than mountains) are consistent with the naturally occurring cold eastern equatorial Pacific Ocean in 2017–18 (La Niña), and known historical effects of La Niña.

### Snowpack and Runoff

April 1 snowpack was 74% of the 1981–2010 median<sup>2</sup>—consistent with SNOTEL (snow telemetry) sites’ precipitation of 76% of normal through March 2018. This year’s near-record warmth has apparently had minimal impact on snowpack values, at least at SNOTEL elevations mostly above 9K where much

<sup>1</sup> USDM: <http://droughtmonitor.unl.edu/Data/Timeseries.aspx>

<sup>2</sup> NRCS: [https://www.wcc.nrcs.usda.gov/webmap\\_beta/index.html](https://www.wcc.nrcs.usda.gov/webmap_beta/index.html)

of the Colorado River runoff originates. Consistent with the low water equivalent, the latest estimate for April-July inflow into Lake Powell is 40% of the 1981–2010 median (Figure 2). This year's deficit of 60% for the Colorado River runoff is about twice the basin precipitation deficit, consistent with a long known two-fold amplification in the percentage variations of annual flow compared to annual precipitation.

### Takeaway from 2017-18

The 2017–18 drought on the Colorado River, though among the warmest droughts on record owing to a long-term warming trend, did not see its water resources greatly diminished by these temperatures. Near-record precipitation deficits, partly predictable a season in advance, appear to be mainly of natural causes. The resulting low snowpack as early as January 1, confirmed on April 1, has provided for a skillful forecast of the very low runoff into Lake Powell this summer.

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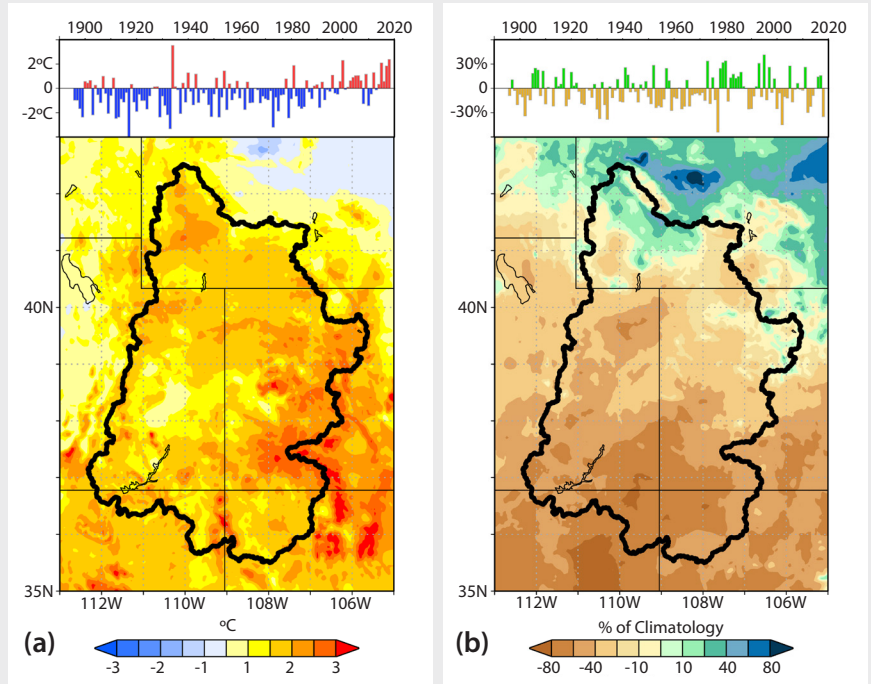
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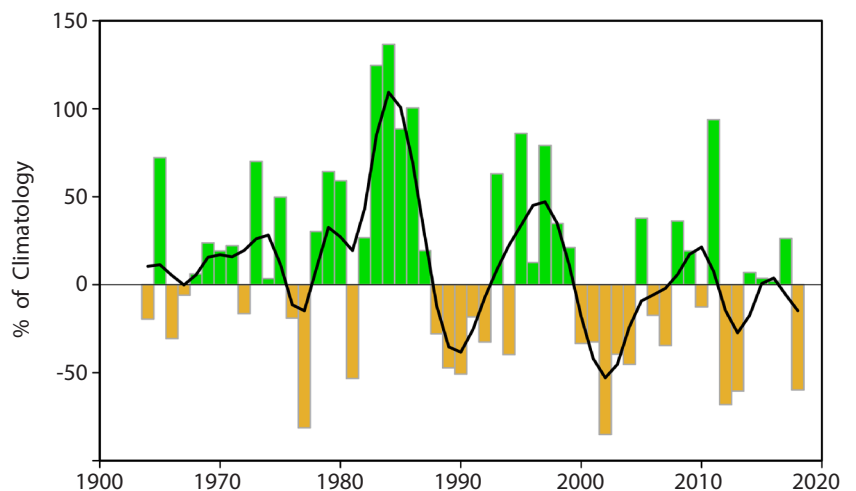


## October to May Temperature & Precipitation Anomalies Compared to 1981–2010 Normals



**Figure 1:** (a) Temperature (2017–18: +1.8°C) and (b) Precipitation (2017–18: -34%) based on PRISM data (Source: <http://prism.nacse.org>).

## Runoff into Lake Powell April–July 2018



**Figure 2:** 2018 value estimated at 2.6 million acre-feet (MAF) compared to a normal of 6.5 MAF (Source: <https://www.cbrfc.noaa.gov/>).