CNAP
California-Nevada Climate Applications Program
— A NOAA RISA —

PRECIPITATION WATER YEAR 2017

SEPT 2017

CW3E

AN EXCEPTIONALLY WET YEAR & ATMOSPHERIC RIVERS

CA/NV PRECIPITATION RAN KINGS

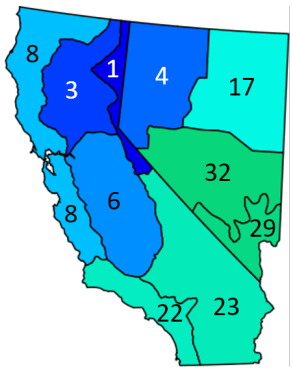

Figure 1. The ranking, based on 122 years of record, of the water year to-date (Oct 2016-Aug 2017) precipitation for CA/NV climate divisions.

Water Year (WY) 2017 (Oct. 2016 through Sept. 2017) was California's (CA) 2nd wettest and Nevada's (NV) 7th wettest in a 122-year record. Measured by climate division precipitation aggregates, northern CA and northern NV experienced some of their wettest WYs while the southern parts of both states experienced nearer-to-normal precipitation amounts (Fig.1). This extraordinarily wet year followed the modestly wet 2016 (ranked 51st and 28th wettest WYs in CA and NV respectively), and followed the remarkably dry four years 2012-2015 (driest and 29th driest 4-year period in CA and NV respectively). While nearly all areas in CA and NV experienced drought recovery this year, southern California, particularly Santa Barbara and Ventura counties, continue to face drought impacts and remain classified as moderate drought by the US Drought Monitor. These regions identified by the US Drought Monitor do not fully map onto the counties that remained in drought emergency under the CA Governor Brown's excutive order (see back), highlighting how different agencies determine drought based on different information.

A major driver of the overall wetness in WY 2017 was the unprecedented number of atmospheric rivers (ARs), narrow bands of high water vapor transport, that made landfall along the West Coast. ARs deliver large amounts of precipitation, especially in mountainous regions where terrain lifts the moist air they carry, producing enhanced precipitation. During WY 2017, 53 ARs delivered some amount of precipitation to CA (Fig. 2). An unusually large number of these ARs also traversed the Sierra and produced abundant precipitation in northwest Nevada as well (Fig. 1). The number of ARs in 2017 greatly exceeded that in previous years, which averaged 34% higher compared to average from 1949-2017[1]. The total water vapor transport (a measurement of AR strength) delivered to the West Coast by WY 2017 ARs was estimated to be 2.4 times more than average (more than 3 standard deviations above average) during Jan. through Mar[1]. True to form for CA and NV a relatively few wettest days of 2017 were the dominant source of the annual total precipitation. For example, at the Lake Tahoe Basin, this year the 12 wettest days contributed 50% of the total precipitation for Oct. through March (the wettest months of the water year; Fig. 3), which is close to the 1981-2016 average. These 12 wettest days were all associated with ARs.

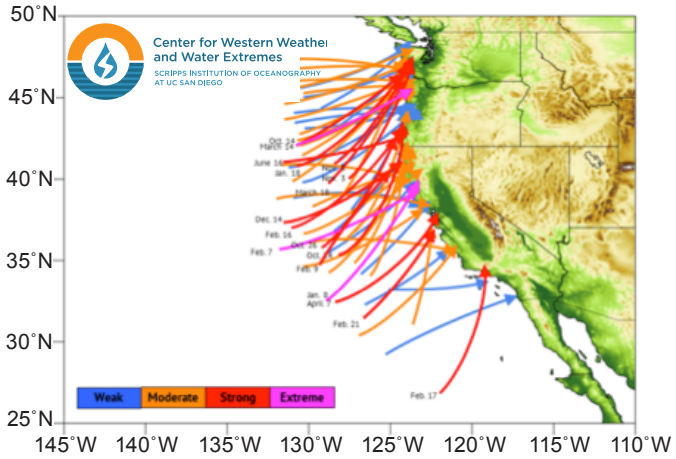

Figure 2. Trajectories of ARs making landfall on the US West Coast in WY 2017. Arrows represent the core of the moisture transport of each AR when it was making its strongest landfall and color indicates the strength of each AR at its maximum intensity. Map courtesy of the Center for Western Weather and Water Extremes (cw3e.ucsd.edu).

DAILY CONTRIBUTION TO PRECIPITATION TAHOE BASIN, OCT-MAR

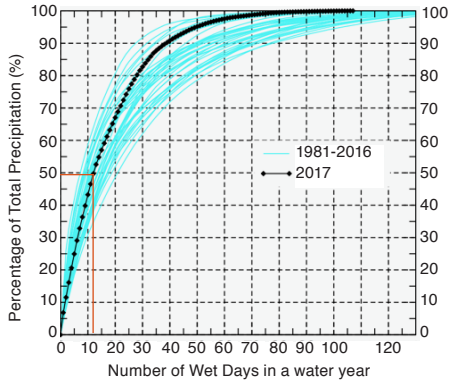

Figure 3. The bottom axis indicates the number of the wet days that together contributed a given percentage of the water year precipitation, shown on the vertical axis. Half of WY 2017's precipitation occurred in 12 wet days, about the historical average for contributions by daily precipitation events. The same is plotted for each WY from 1981-2016 shown by the thin cyan curves.

1. Gershunov et al., 2017, *Geophysical Research Letters*.
2. Hatchett et al., in review, *Geophysical Research Letters*.

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ENSO FORECASTS & EXTREMES

Seasonal, 3-month, forecast issued in November for winter (December, January, and February) by various sources, including Climate Prediction Center and North American Multi-Model Ensemble, showed a greater chance of drier than normal precipitation for the southern half of CA and NV. These forecasts were in part influenced by the weak La Niña that occurred during winter of 2017. Although La Niña has historically been linked to drier conditions in Southern CA and NV, the largest historical stream flows in many parts of central to northern CA and NV have occurred during weak La Niña events (Fig. 3). This indicates a historical precedent for extreme precipitation events or series of extreme events, along with major flooding, during weak La Niña events.

Improving monthly to seasonal forecast has long been requested of decision makers in all sectors. The large contributions of the unusually large number of landfalling ARs in 2017 (Fig. 2) highlights how improving capabilities of monthly to seasonal prediction of ARs and extreme events is important to forecasting if a month or season will be wet or dry.

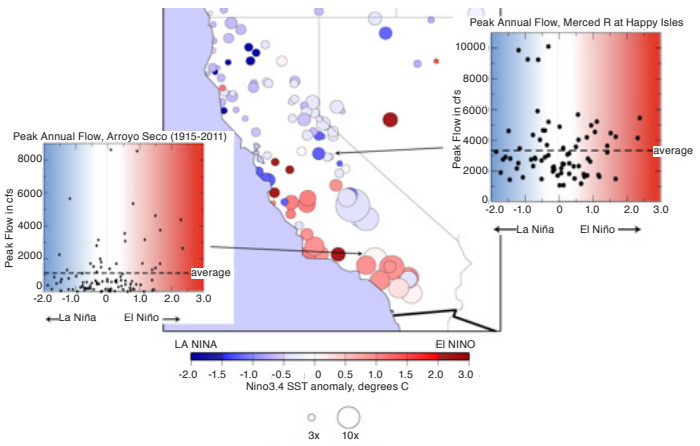
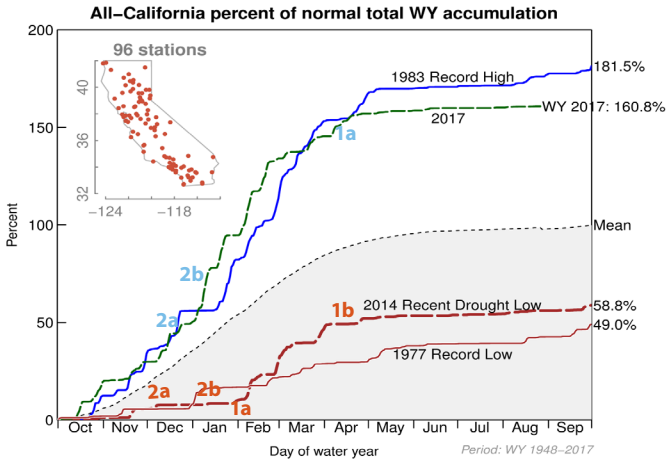


Figure 3. The map shows the tropical El Niño-La Niña condition (color) and historically largest daily flows at stream gages. The size of the circle indicates the maximum flow compared to the average of all annual-peak daily flows at the gage and color indicates the ENSO state; warm colors indicate El Niño and cool colors indicate La Niña. The two figures on the left and right illustrate all the peak annual flows at Arroyo Seco (Southern CA) and the Merced River (Central CA) as a function of El Niño-La Niña state. Many of the peak daily flows in Northern CA and NV occurred during weak La Niña phases; most in southern CA occurred during El Niño phases.

PRECIP. & POLICY DECISIONS

The extremely dry 2014 and extremely wet 2017 have been occasions and motivations for many policy and decisions to be made regarding drought, flood and water management in CA. Some of the significant decisions are listed below.



WY 2014

1.For the first time in the 54-year history, DWR announced a zero State Water Project (SWP) allocation to all 29 public water agencies that buy from the SWP, Jan. 31, 2014 (1a) SWP allocations were 5%, Apr. 18,2014 (1b).

2. Governor Brown creates an interagency Drought Task Force on Dec. 17, 2013 (2a). A month later, Governor Brown declares a drought state of emergency on Jan. 17th, 2014, mobilizing resources and cooperation between groups and levels of government (2b).

3. Federal and state governments provide aid in order to provide relief.

WY 2017

1. SWP allocations were 85% on Apr. 14, 2017 (1a).

2. Flood Responses: Governor Brown issued 2 emergency proclamations on Jan. 23, 2017 (2a); Brown requested presidential major disaster declaration on Feb. 10, 2017 (2b).

3. State drought emergency is declared officially over on Apr. 7, 2017, except for Fresno, Kings, Tulare, and Tuolumne counties. The State Water Resources Control Board maintained urban water use reporting requirements and prohibitions on wasteful practices such as watering during or after rainfall and hosing off sidewalks.

SNOW LEVELS

Historically, one of CA and NV's wettest years was WY1983, ranked wettest in CA and third wettest in NV. Both 1983 and 2017 had extraordinary amounts of precipitation but WY2017 did not produce as much snow pack as accumulated in 1983. Looking at the observations, the differences in the WY 2017 snow pack relative to WY 1983 were mostly the lesser snowpack in 2017 at elevations below 2500 meters (8200 ft) (Fig. 4). This difference follows a trend toward rising snow levels in recent years during which median snow levels in the northern Sierra Nevada have increased by approximately 500 m since 2008[2]. Higher snow levels can be attributed to relatively warm storms and storm interludes this last winter--as a whole. winter 2016-17 was +0.3˚F above 1949-2005 long term average.

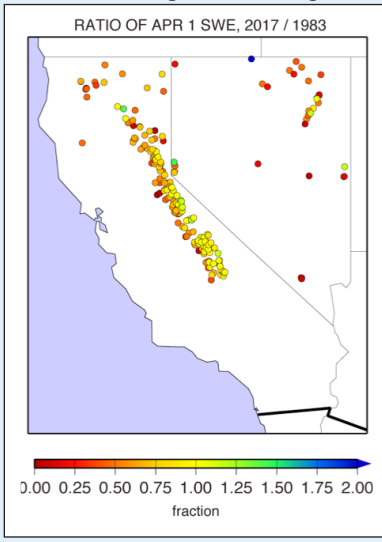


Figure 4. (Left) Storage of water in April 1st snowpacks (snow water equivalent = SWE) in 2017 relative to 1983. Values less than 1 (warm colors) are the 189 of 206 (87%) measurement locations where 2017 had less SWE than 1983. SWE at most locations below 2000m (6560 ft) was less than 75% of 1983.