

CALIFORNIA PRECIPITATION

Seasonality of Precipitation

Precipitation in California is highly variable year-to-year and understanding this variability is critical to water resource management and policy. California has a Mediterranean climate – cool, wet winters and warm, dry summers. This means that the bulk of California’s precipitation falls in the cool season months from October through April. It is highly variable across the state with the southeast deserts receiving less than 5 inches in a year to the north coast which can get over 100 inches per year. One way to visualize the temporal distribution of California precipitation is using the Northern California 8-station precipitation index from the California Department of Water Resources. The index, which averages 50 inches per year, gives a sense of how much precipitation the Sacramento River watershed – a key area for the state’s water supply - has received. A map of the location of the stations is shown in Figure 1 along with the average monthly distribution of precipitation. As can be seen in Figure 1, about half the annual precipitation total arrives in the three-month period from December through February and 90% of the annual precipitation falls between October 1 and April 30.

During this time period, winter storms come off the Pacific Ocean delivering rain and snow to California. Some of these storms include moisture from atmospheric rivers – narrow bands of high concentration water vapor that extend from the tropics – and deliver heavy precipitation to the state which can lead to flooding (Ralph et al., 2006; Fig. 2). On average 5-7 larger storms contribute most of the precipitation that falls during the wet months (Dettinger et al., 2011). When more storms arrive, conditions are wetter; when fewer storms arrive, conditions are drier.

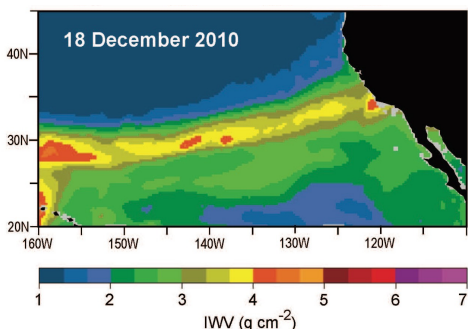


Figure 2. Image of an atmospheric river making landfall in California (Ralph and Dettinger, 2012)

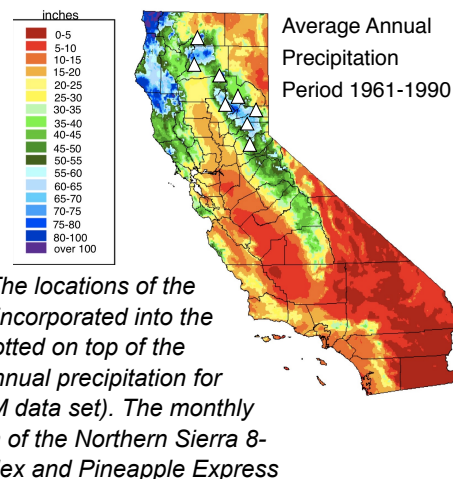
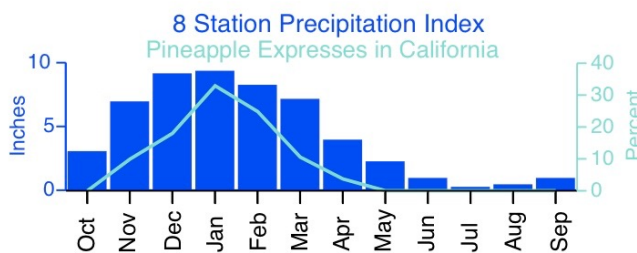


Figure 1. The locations of the 8 stations incorporated into the index is plotted on top of the average annual precipitation for CA (PRISM data set). The monthly distribution of the Northern Sierra 8-Station Index and Pineapple Express



Climate Change

As climate changes, there is no clear signal how precipitation accumulations may change for California. Although precipitation changes are uncertain, climate models agree that California will become warmer. The increased temperatures will mean more of the precipitation will fall as rain instead of snow which will change the timing of river flows in the state. Efforts are underway to develop a metric to track the rain versus snow percentages and identify regions that are vulnerable to this transition that is already beginning.

Ralph, F. M., et al., 2006, Geophys. Res. Lett., 33, L13801.
 Ralph F. M. and Dettinger, M.D., 2012, Bull. Amer. Meteor. Soc., 93, 783–790.
 Dettinger, M. D., et al., 2011, Water, 3, 455-478.
 Dettinger, M.D. and Cayan, D.R., 2014, San Francisco Estuary and Watershed Science, 12(2).

Large Storms Control California's Annual Precipitation Variability

Variability in precipitation is tied to the number of large storms, also known as atmospheric river events (Dettinger and Cayan, 2014). A depiction of the variability is shown in Figure 3. The top figure in Figure 3 shows the annual precipitation accumulations with a five-year averaged time series illustrated by the heavy black line. The red line shows the contribution to the annual precipitation made by the top 5% of rainy days while the green line shows the contribution from the other 95%. Note the red line follows the five-year line quite closely. This implies that the decadal scale variability is tied to the number of extreme events. This conclusion is further illustrated in the bottom figure which shows a count of the number of strongest atmospheric river events, often called pineapple express storms, that hit California.

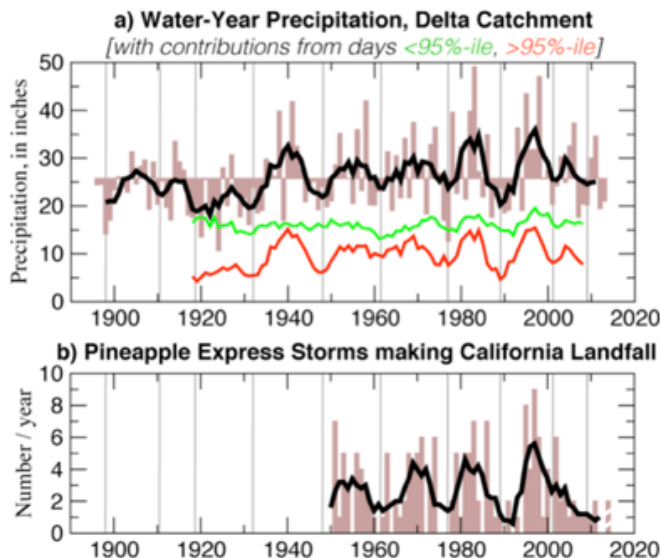


Figure 3. Water-year precipitation and associated contributions from the top 5% of wet days versus the other 95% and association with pineapple express storms.

In addition to the decadal scale fluctuations in precipitation associated with the number of large events, there is year-to-year variability in precipitation accumulation. Figure 4 shows an estimate of the year-to-year variability in precipitation for the Continental United States (Dettinger et al., 2011). Note that California has the largest year-to-year variability depicted by the green and blue circles indicating yearly variability on the order of half the annual average. It is also a unique

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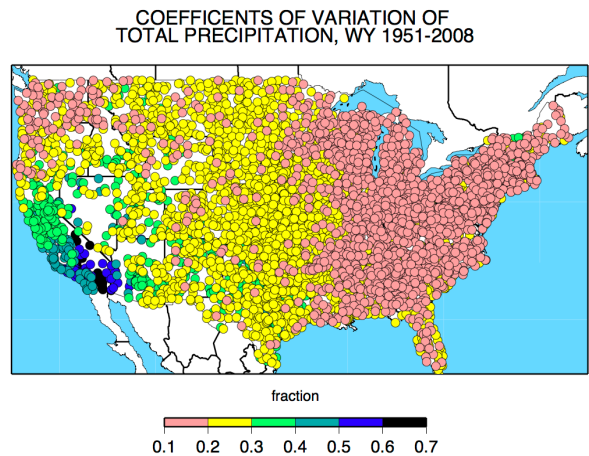


Figure 4. Coefficient of variation (the standard deviation divided by the average) of total precipitation based on water year data from 1951-2008.

phenomenon to California as shown in Figure 5, which shows the percent of year to year variance in total precipitation due to the wettest 0.2% of days based on data from 1950-1999 (Dettinger and Cayan, 2014). As floods, drought and water availability are all related to a few large storms every year that occur in a limited time frame, understanding and forecasting these extreme precipitation events are critical to improving California's water management resilience now and in the future with warmer temperatures and declining snowpacks.

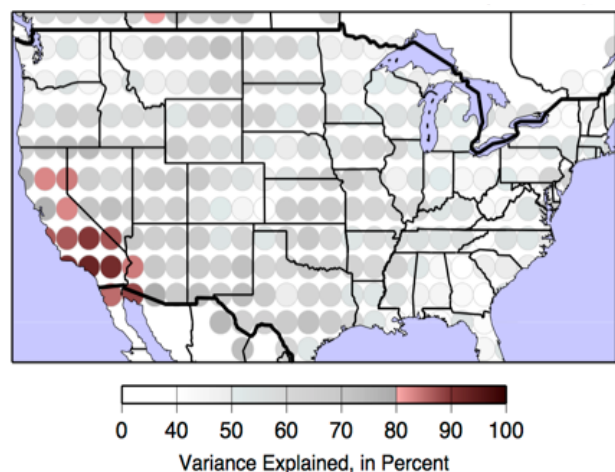


Figure 5. Percent variance of water-year precipitation from wettest 0.2% of days using water year data from 1951-1999.