

Drought Amelioration and the Current California Drought

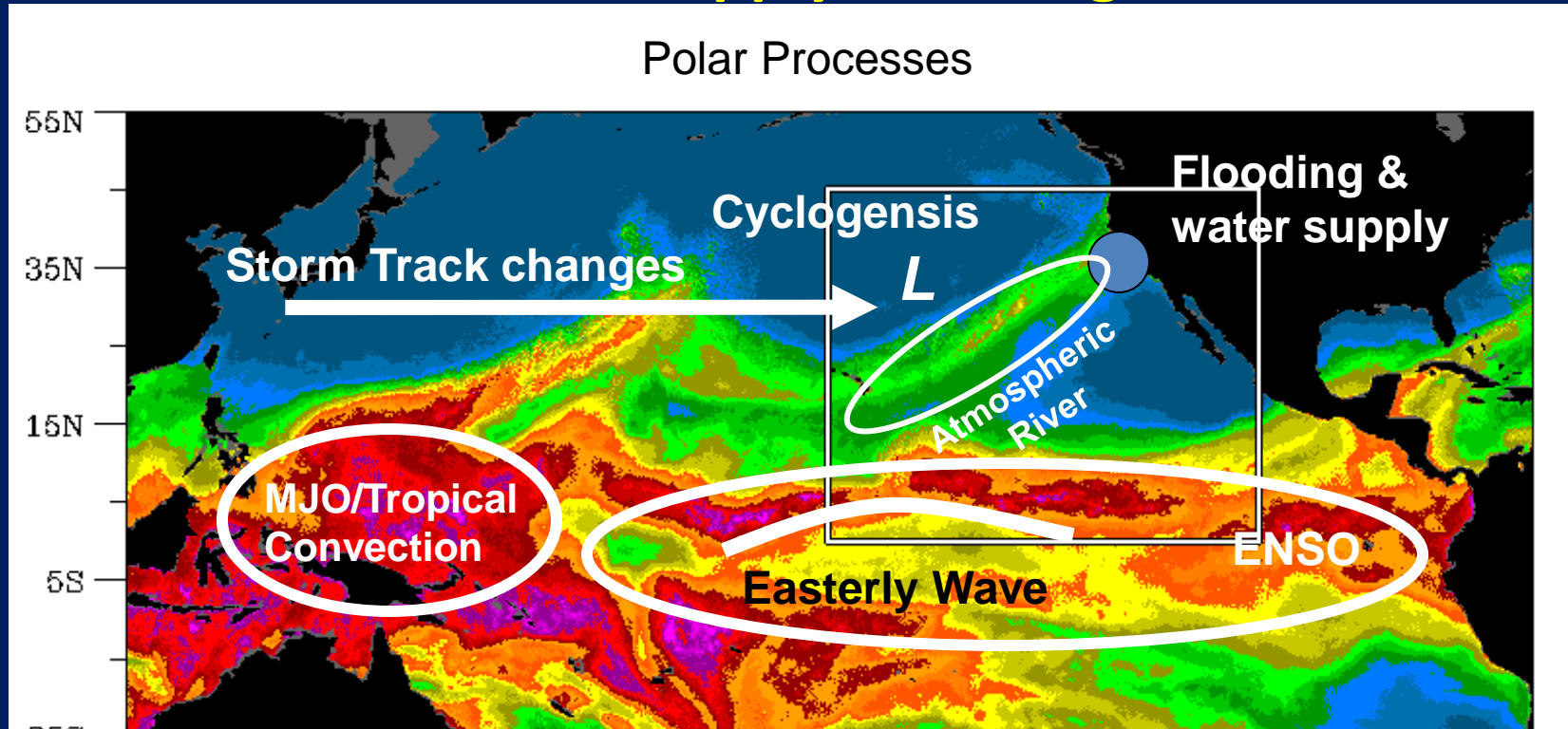
Michael Anderson, State Climatologist
California Department of Water Resources

California's topography affects our weather and climate



Key Phenomena Affecting California

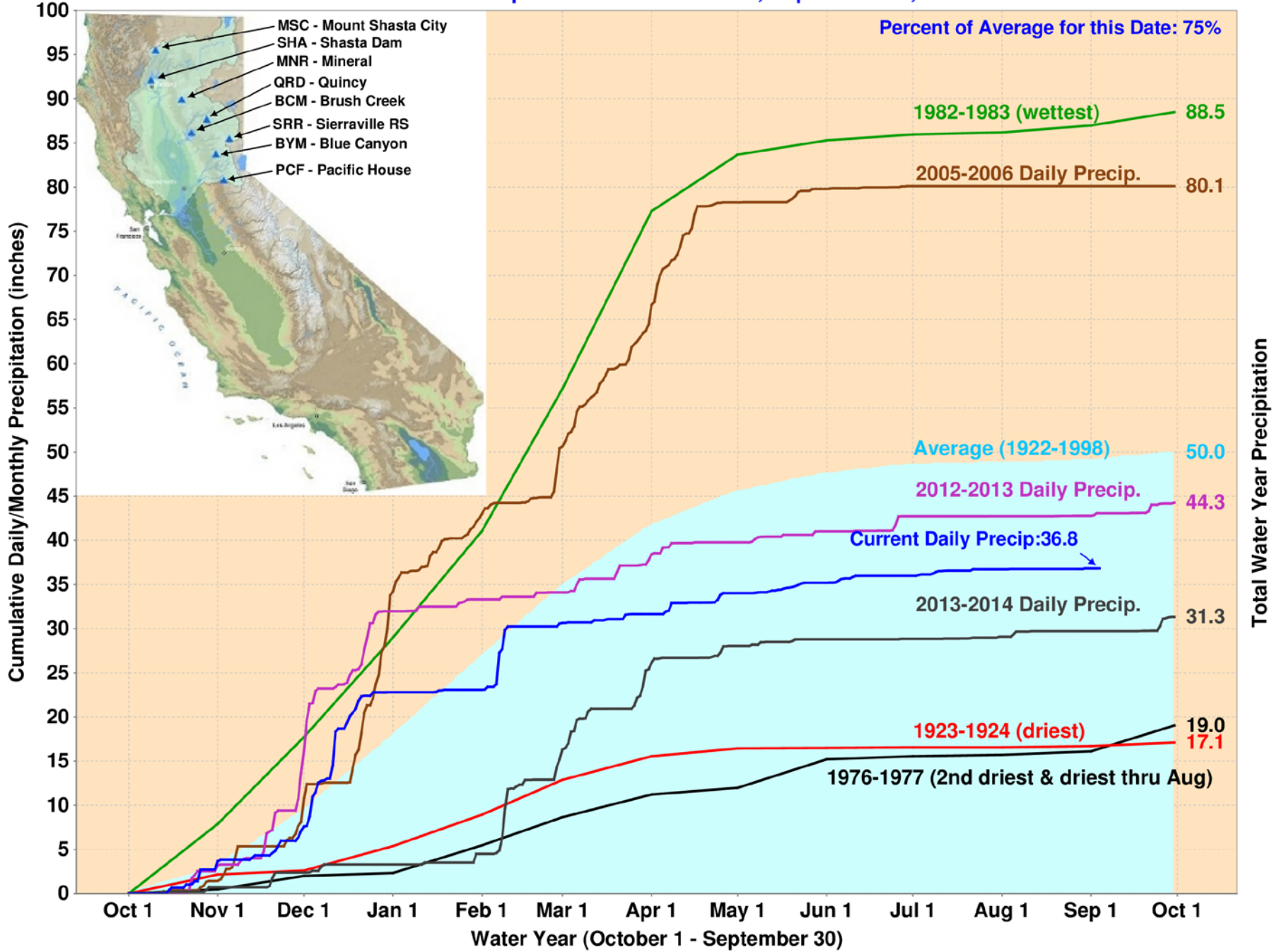
Water Supply/Flooding:



The size and number of atmospheric river events (ARs) result from the alignment of key processes

The absence of AR activity is important to drought

Northern Sierra Precipitation: 8-Station Index, September 04, 2015

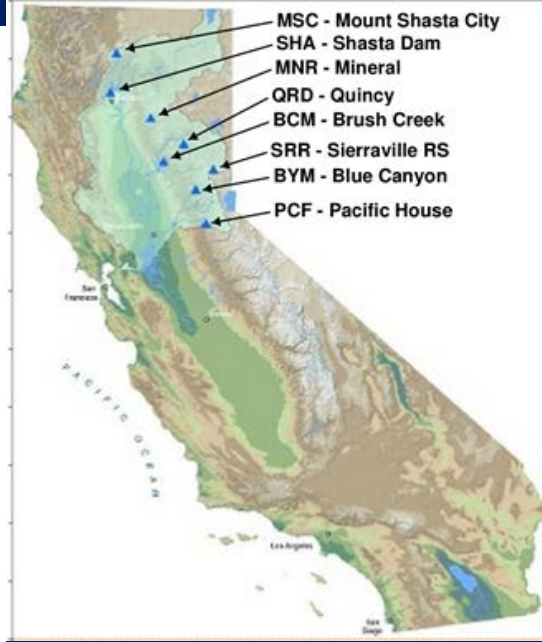
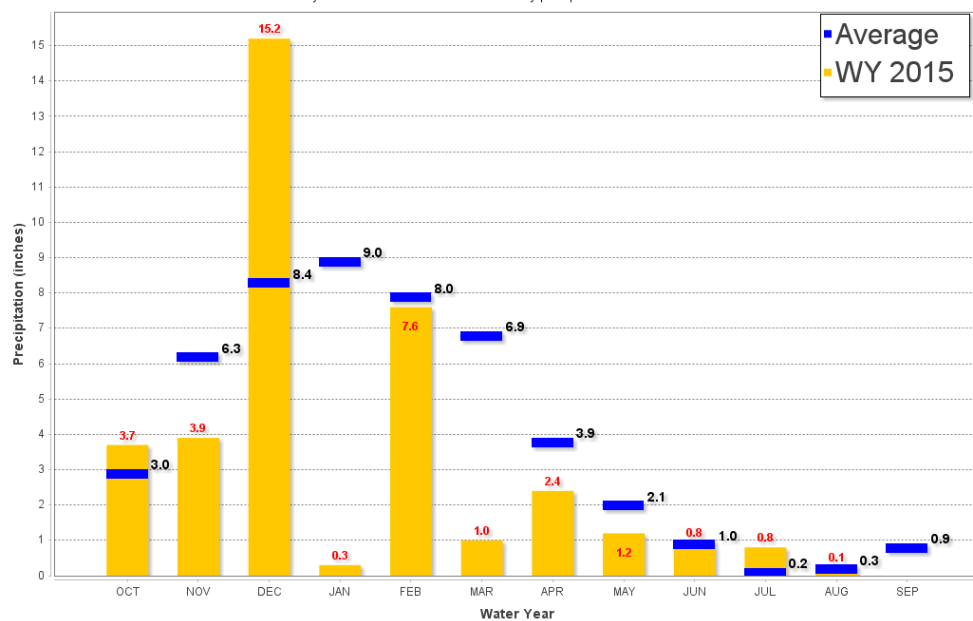




Northern Sierra 8-Station

Precipitation Index for Water Year 2015 - Updated on September 4, 2015 08:45 AM

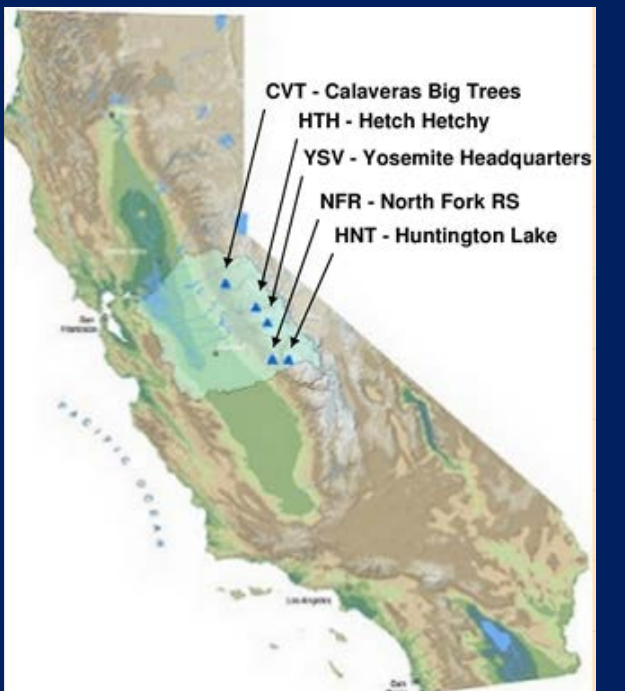
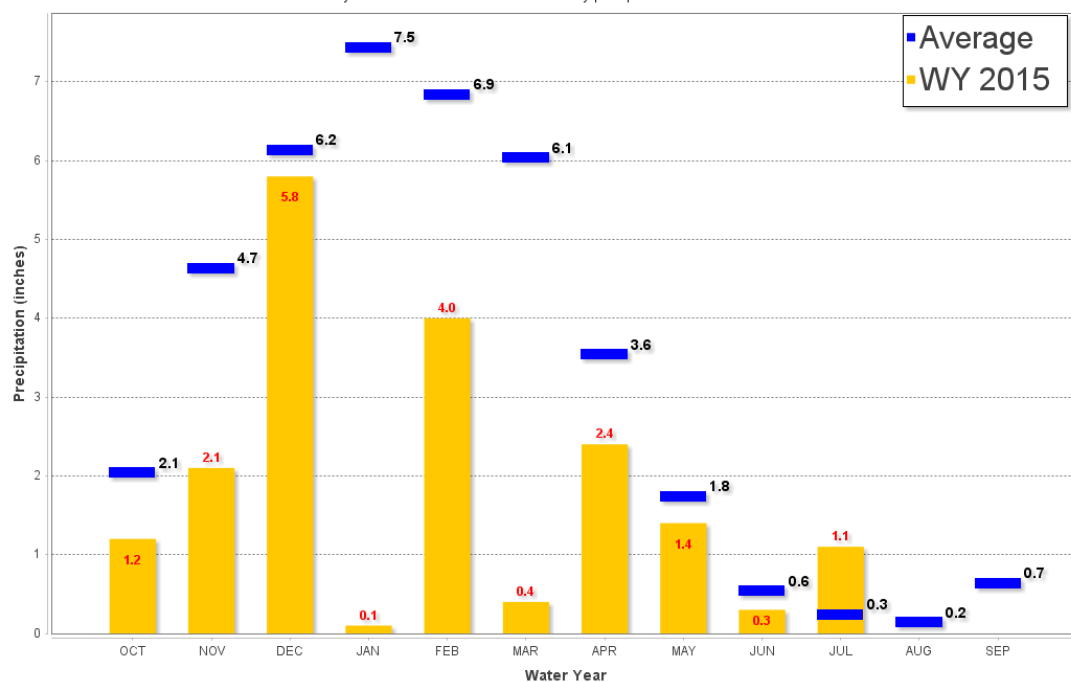
Note: Monthly totals may not add up to seasonal total because of rounding
Water Year Monthly totals are calculated based on Daily precipitation data from 12am to 12am PST



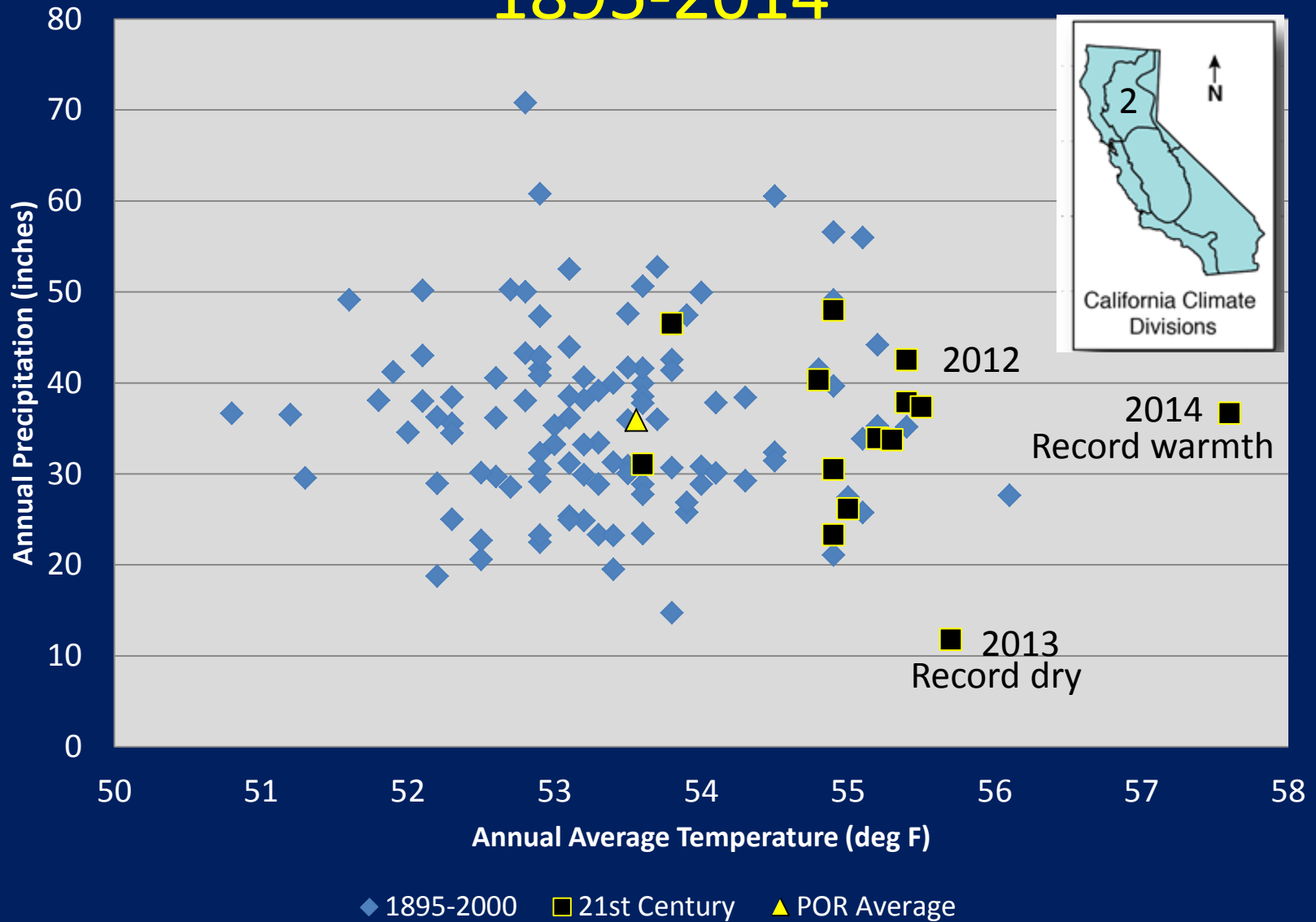
San Joaquin 5-Station

Precipitation Index for Water Year 2015 - Updated on September 4, 2015 08:45 AM

Note: Monthly totals may not add up to seasonal total because of rounding
Water Year Monthly totals are calculated based on Daily precipitation data from 12am to 12am PST

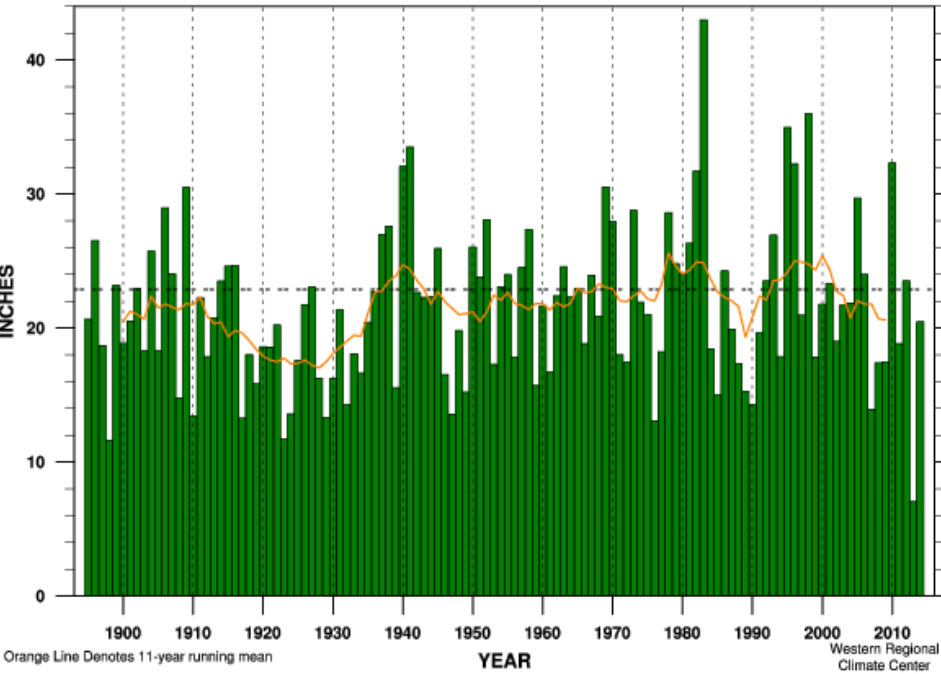


NOAA Climate Division 2 Calendar Year Data 1895-2014



Calendar Year Precipitation

California Statewide Precipitation Jan-Dec

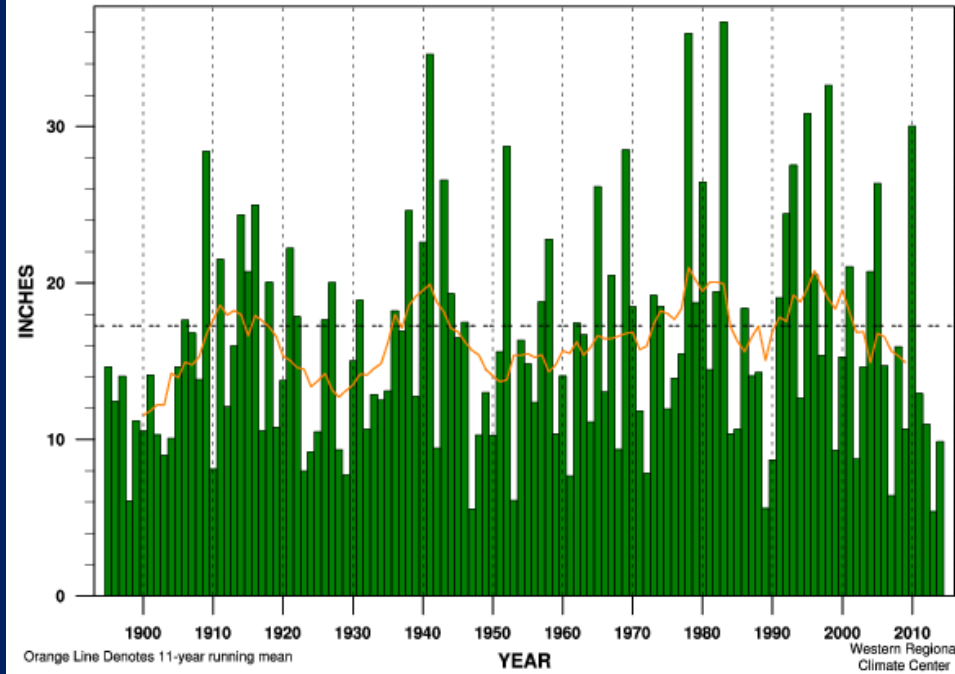


Orange Line Denotes 11-year running mean

Western Regional
Climate Center

| | | | |
|---------------------------|--------------------|-------------------------|----------------|
| Linear Trend 1895-present | + 2.41 ± 2.98 in. | (+ 10 ± 13%) per 100 yr | |
| Linear Trend 1949-present | - 1.20 ± 7.92 in. | (- 5 ± 34%) per 100 yr | |
| Linear Trend 1975-present | - 7.84 ± 19.70 in. | (- 34 ± 86%) per 100 yr | |
| Wettest Year | 43.00 in. (187%) | in 1983 | MEAN 22.88 in. |
| Driest Year | 7.04 in. (30%) | in 2013 | STDEV 5.87 in. |
| Jan-Dec | 2014 | 20.46 in. (89%) | RANK 54 of 120 |

South Coast Region Precipitation Jan-Dec



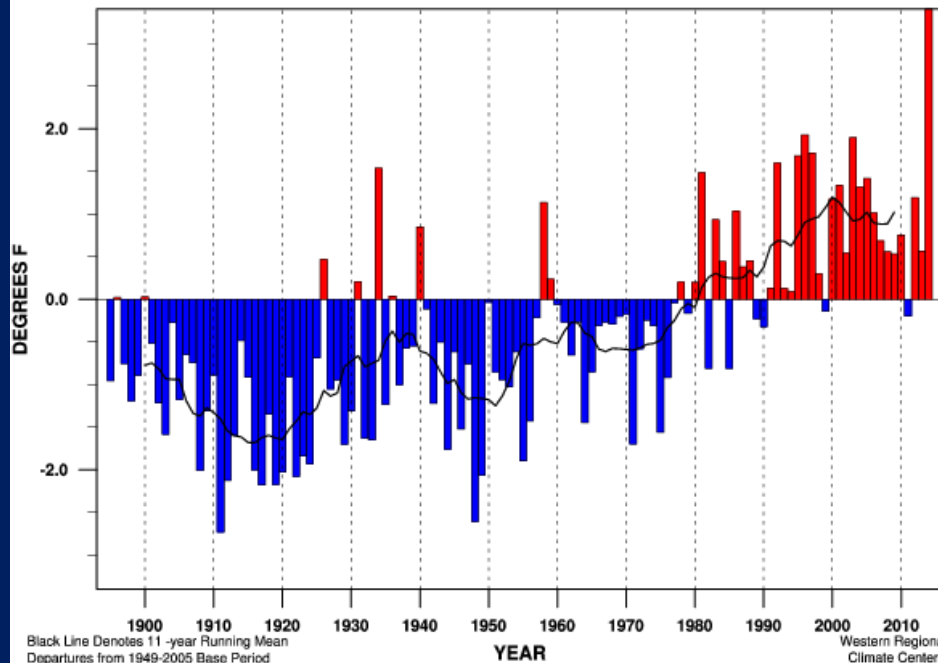
Orange Line Denotes 11-year running mean

Western Regional
Climate Center

| | | | |
|---------------------------|--------------------|--------------------------|----------------|
| Linear Trend 1895-present | + 2.44 ± 3.57 in. | (+ 14 ± 20%) per 100 yr | |
| Linear Trend 1949-present | + 0.55 ± 9.70 in. | (+ 3 ± 56%) per 100 yr | |
| Linear Trend 1975-present | -14.83 ± 22.58 in. | (- 85 ± 130%) per 100 yr | |
| Wettest Year | 36.68 in. (212%) | in 1983 | MEAN 17.26 in. |
| Driest Year | 5.39 in. (31%) | in 2013 | STDEV 7.39 in. |
| Jan-Dec | 2014 | 9.87 in. (57%) | RANK 20 of 120 |

Calendar Year Minimum Temperatures

California Statewide
Minimum Temperature Departure Jan-Dec

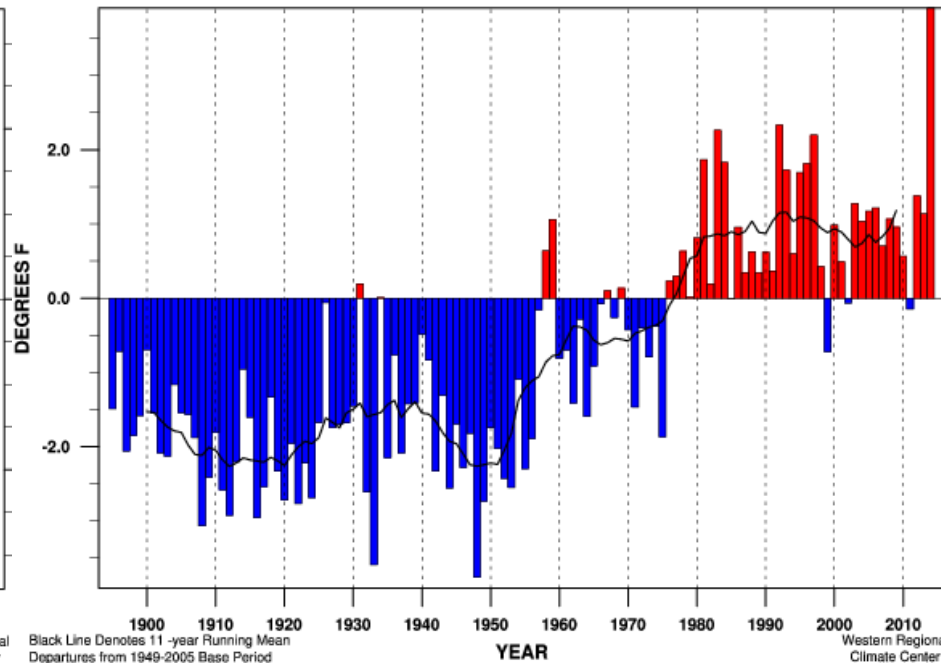


Black Line Denotes 11-year Running Mean
Departures from 1949-2005 Base Period

Western Regional
Climate Center

| | | | |
|---------------------------|----------------------------|-------|------------|
| Linear Trend 1895-present | + 2.09 ± 0.44 °F/100yr | | |
| Linear Trend 1949-present | + 3.63 ± 0.98 °F/100yr | | |
| Linear Trend 1975-present | + 4.18 ± 2.24 °F/100yr | | |
| Warmest Year | 46.5 °F (+ 3.4 °F) in 2014 | MEAN | 43.1 °F |
| Coldest Year | 40.4 °F (- 2.7 °F) in 1911 | STDEV | 0.98 °F |
| Jan-Dec | 2014 | RANK | 120 of 120 |

South Coast Region
Minimum Temperature Departure Jan-Dec



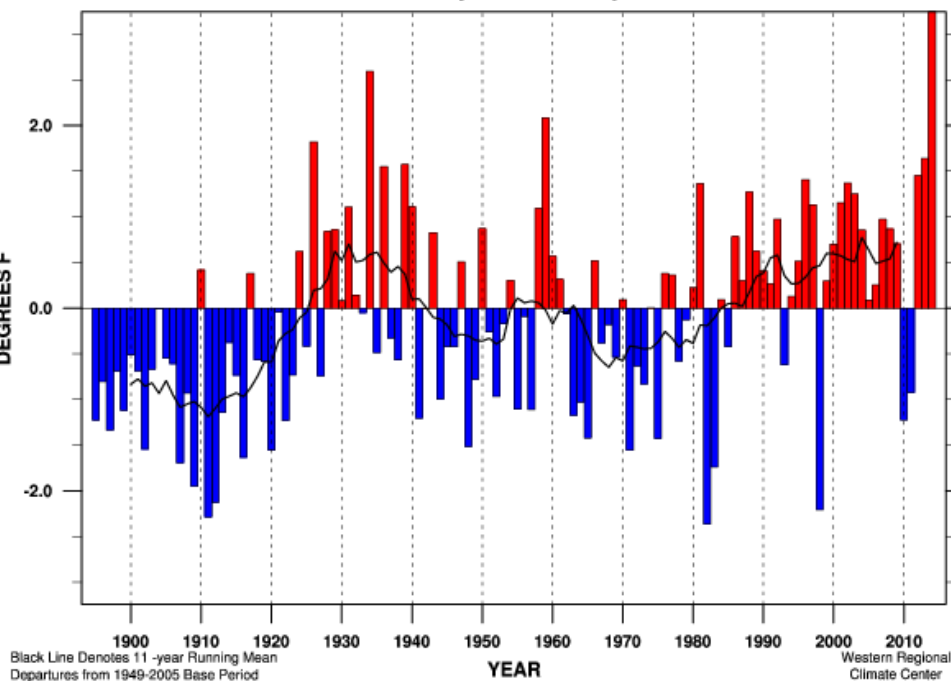
Black Line Denotes 11-year Running Mean
Departures from 1949-2005 Base Period

Western Regional
Climate Center

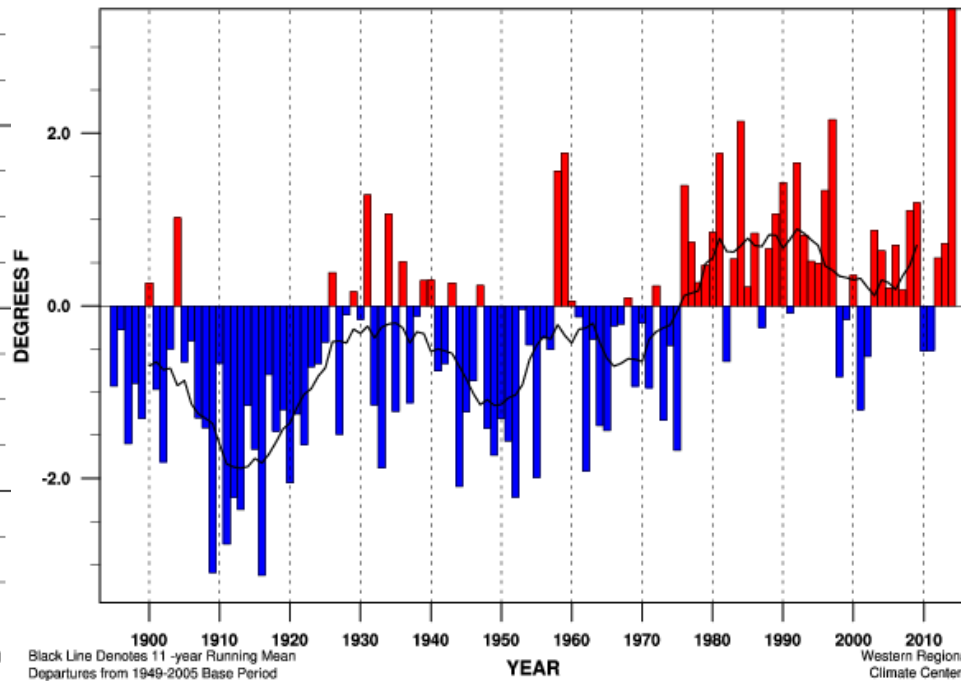
| | | | |
|---------------------------|----------------------------|-------|------------|
| Linear Trend 1895-present | + 3.27 ± 0.51 °F/100yr | | |
| Linear Trend 1949-present | + 4.94 ± 1.22 °F/100yr | | |
| Linear Trend 1975-present | + 2.42 ± 2.58 °F/100yr | | |
| Warmest Year | 53.3 °F (+ 3.9 °F) in 2014 | MEAN | 49.4 °F |
| Coldest Year | 45.6 °F (- 3.8 °F) in 1948 | STDEV | 1.29 °F |
| Jan-Dec | 2014 | RANK | 120 of 120 |

Calendar Year Maximum Temperatures

California Statewide
Maximum Temperature Departure Jan-Dec



South Coast Region
Maximum Temperature Departure Jan-Dec



Linear Trend 1895-present + 1.17 ± 0.51°F/100yr

Linear Trend 1949-present + 1.94 ± 1.26°F/100yr

Linear Trend 1975-present + 3.63 ± 2.85°F/100yr

Warmest Year 72.2°F (+ 3.2°F) in 2014

Coldest Year 66.6°F (- 2.4°F) in 1982

Jan-Dec 2014 72.2°F (+ 3.2°F)

MEAN 69.0°F

STDEV 0.95°F

RANK 120 of 120

Linear Trend 1895-present + 1.82 ± 0.51°F/100yr

Linear Trend 1949-present + 2.82 ± 1.28°F/100yr

Linear Trend 1975-present + 0.40 ± 2.71°F/100yr

Warmest Year 76.7°F (+ 3.4°F) in 2014

Coldest Year 70.2°F (- 3.1°F) in 1916

Jan-Dec 2014 76.7°F (+ 3.4°F)

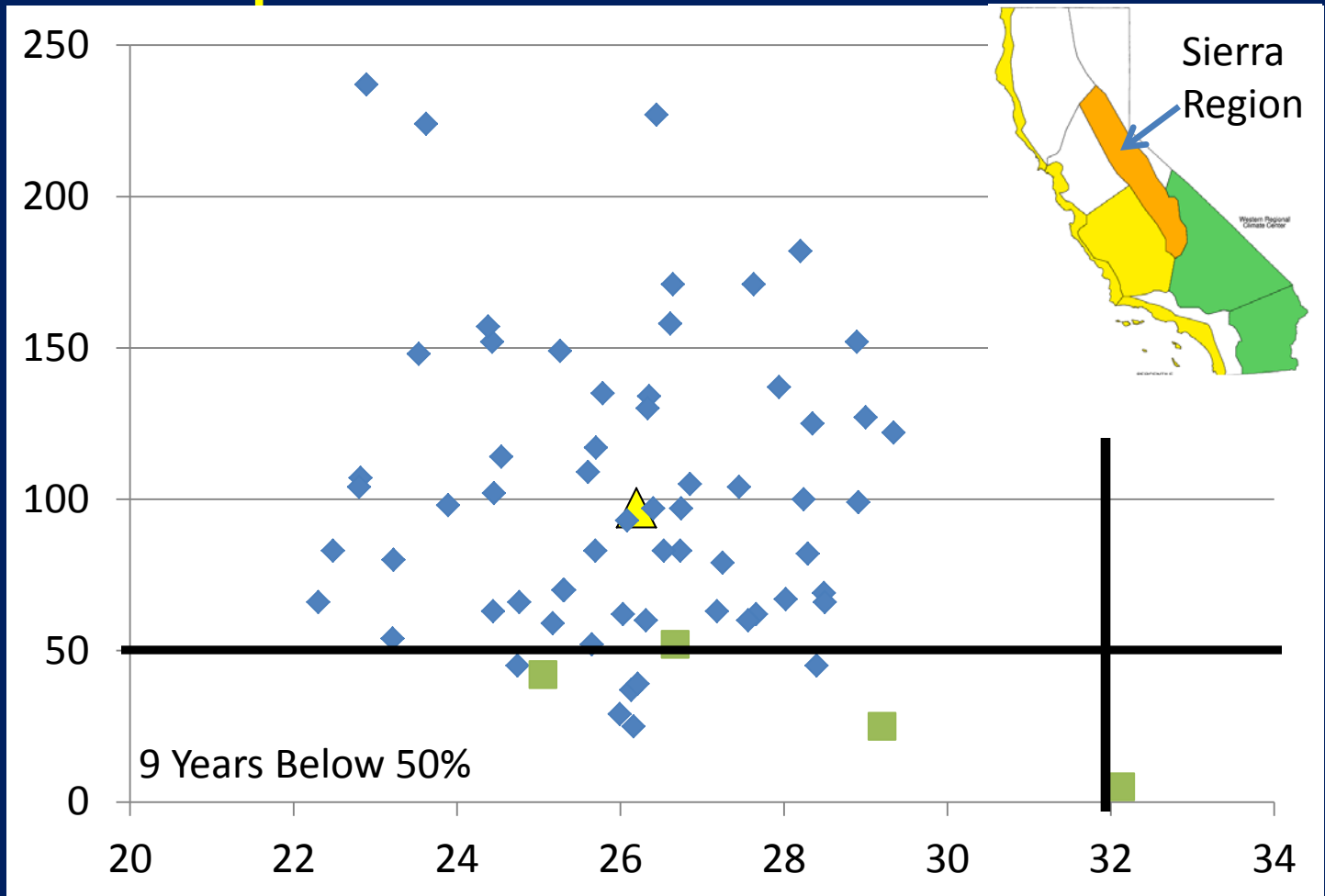
MEAN 73.3°F

STDEV 1.09°F

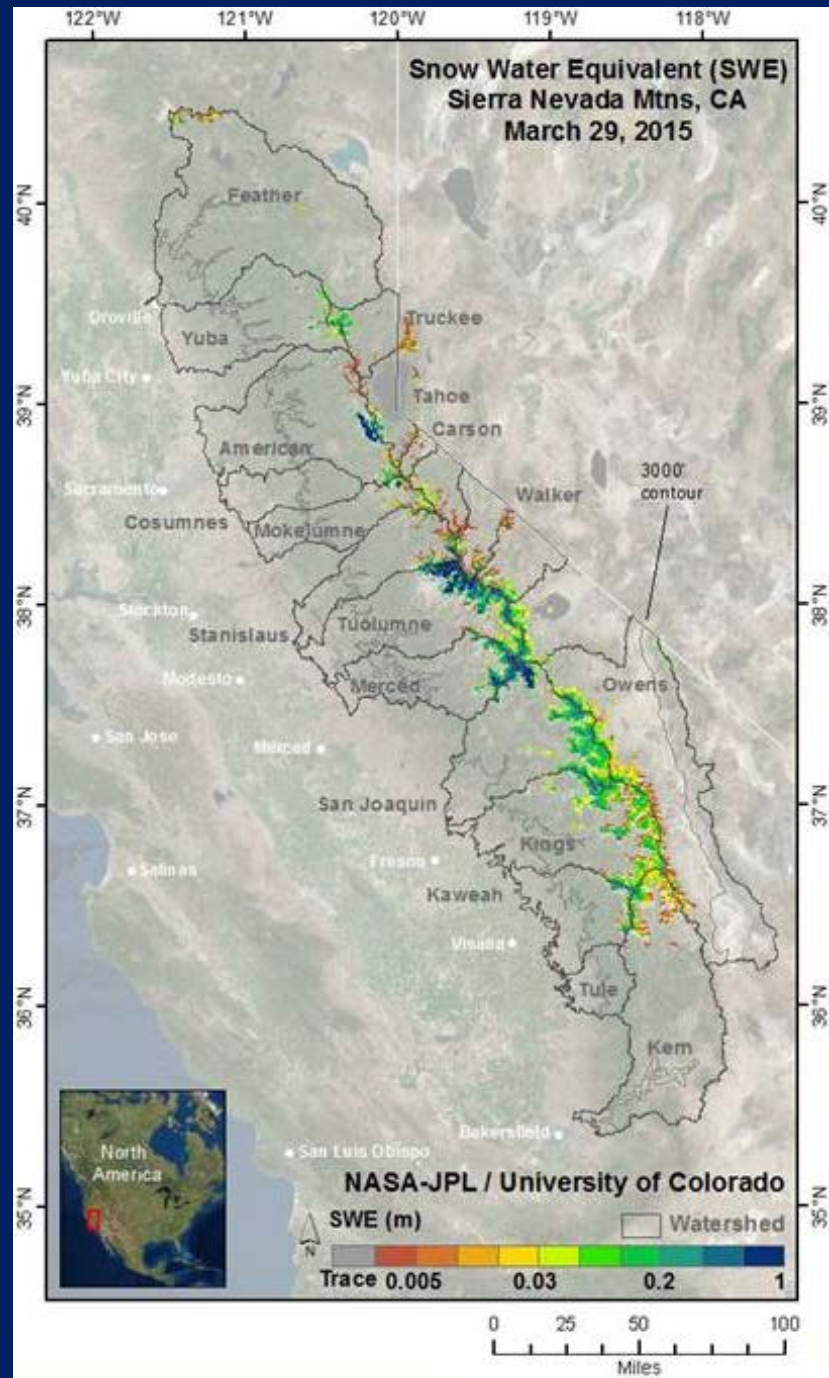
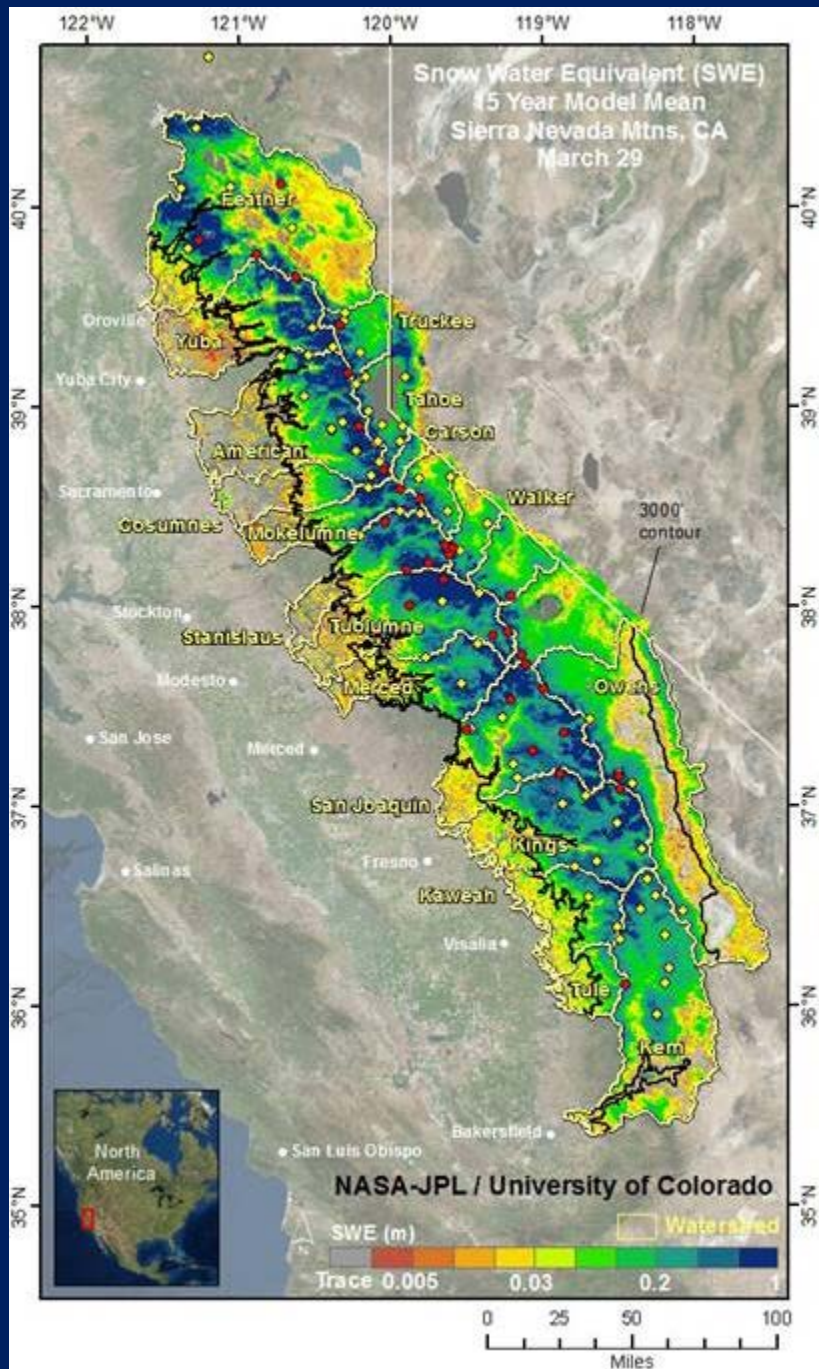
RANK 120 of 120

Sierra Snowpack vs Winter Temperature 1950-2015

April 1 Snowpack Percent of Average
From California Cooperative Snow Surveys



Sierra Winter (DJF) Average Minimum Temperature (degrees Fahrenheit)
Temperature Data from California Climate Tracker, WRCC



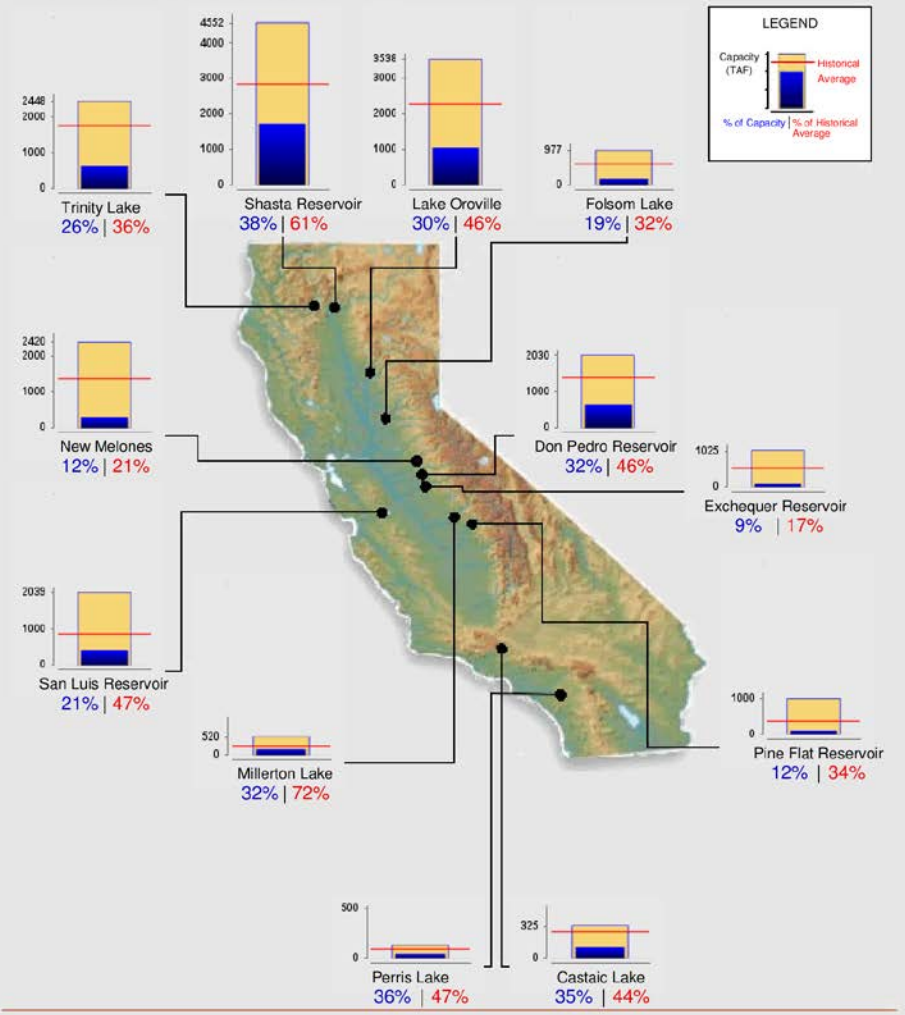


Reservoir Conditions - Lake Oroville

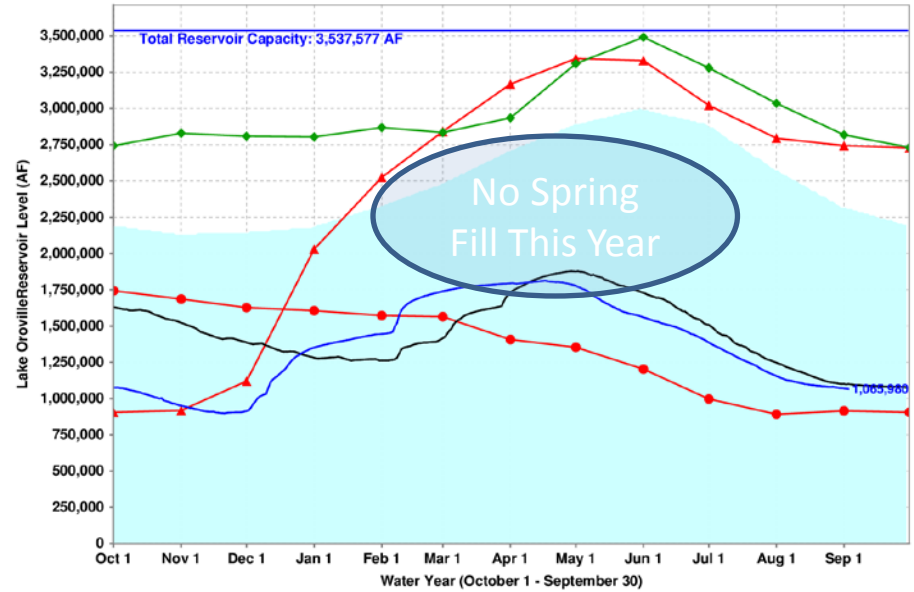
Reservoir Conditions

Ending At Midnight - September 8, 2015

CURRENT RESERVOIR CONDITIONS



Lake Oroville Levels: Various Past Water Years and Current Water Year, Ending At Midnight September 3, 2015



■ Historical Average
 — Total Reservoir Capacity
 ● 1976-1977 (Driest)
 ▲ 1977-1978
 ▲ 1982-1983 (Wettest)
 — 2013-2014
 — Current: 2014-2015

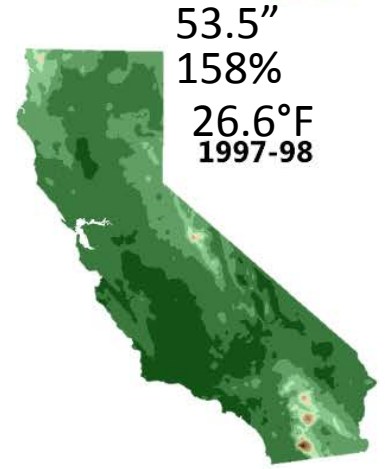
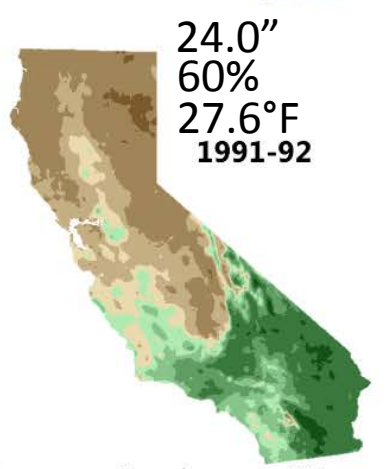
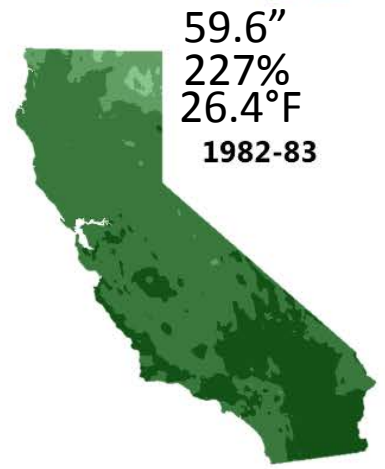
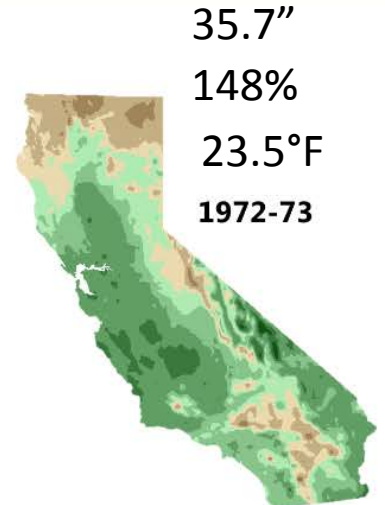
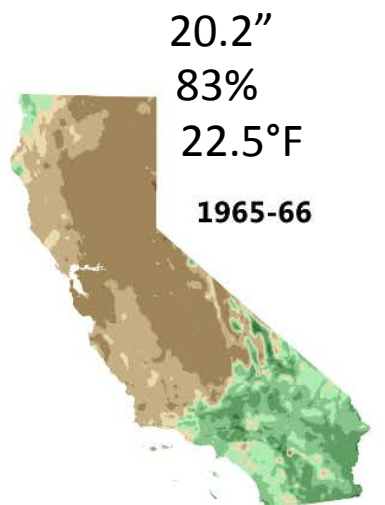
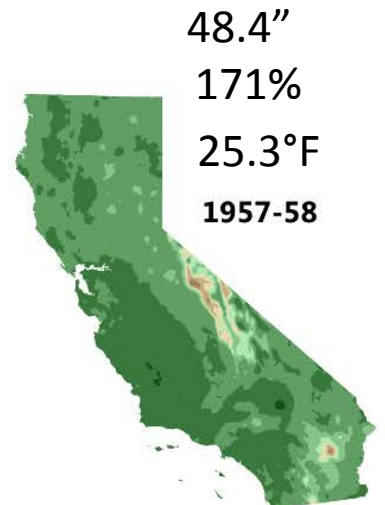
Drought Amelioration

- Impacts Reduction:
 - Winter Runoff to Refill Storage Deficits in Surface Reservoirs
 - Abundant Snowpack for
 - Cold Pool Supply
 - Summer Anthropogenic Supply
 - Mountain Block Recharge
 - Recharge Opportunities for Groundwater Recovery (takes more than 1 year)
- Locally Specific

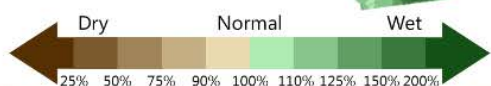
Oroville Reservoir Example

- Oroville Storage Recovery (1.5 MAF deficit)
 - Spread over ~650,000 acres (below average snow line) results in 45.7 inches of effective rainfall needed
 - Additional precipitation needed to address soil moisture deficits (~3-5 inches)
 - Time between storms enables soil moisture deficits to re-form
 - 8 Station Index averages 29.3 inches (Dec-Mar)

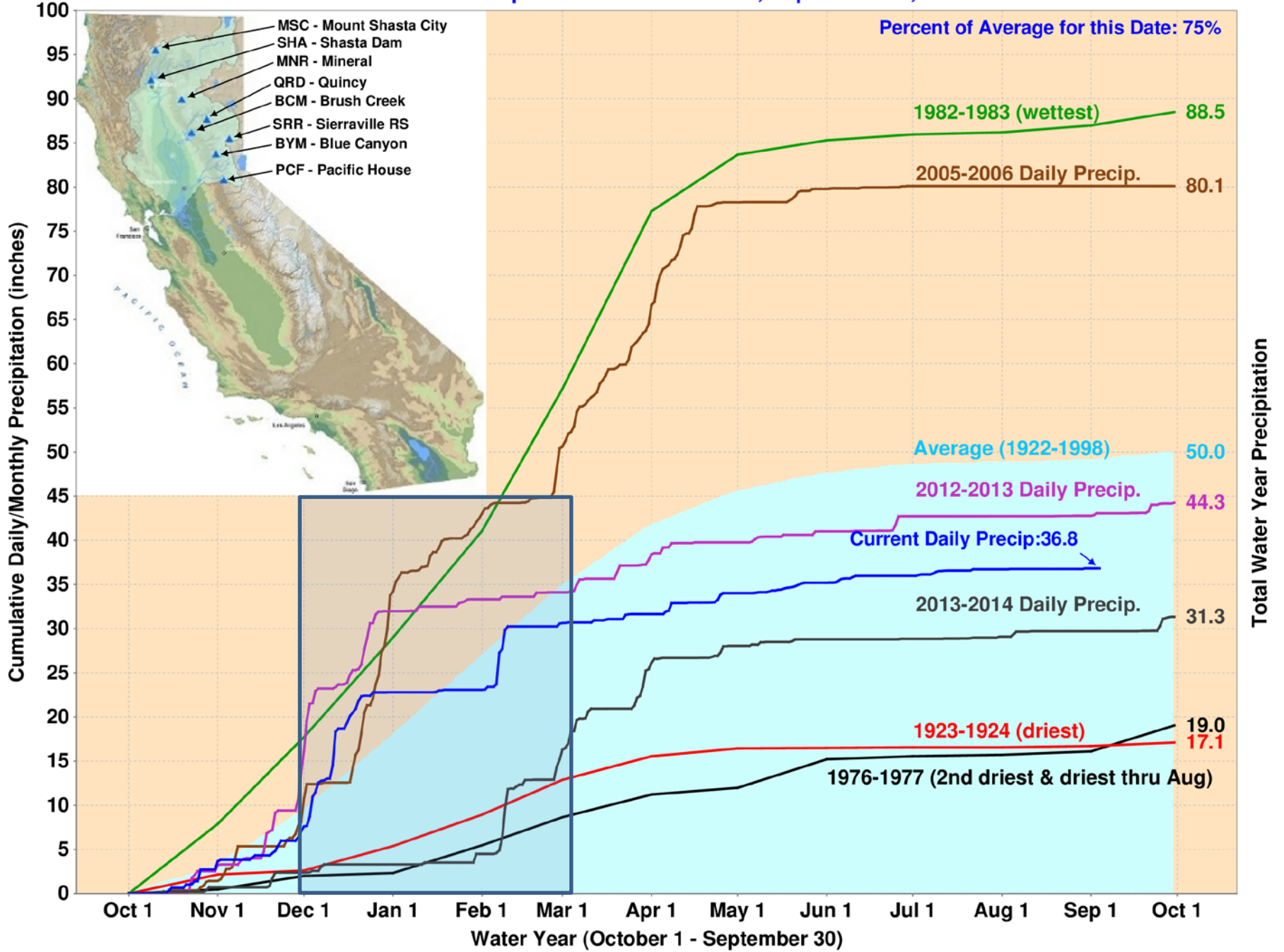
Historical Strong El Nino Precipitation Outcomes



2015
24.1"
5%
32.1°F

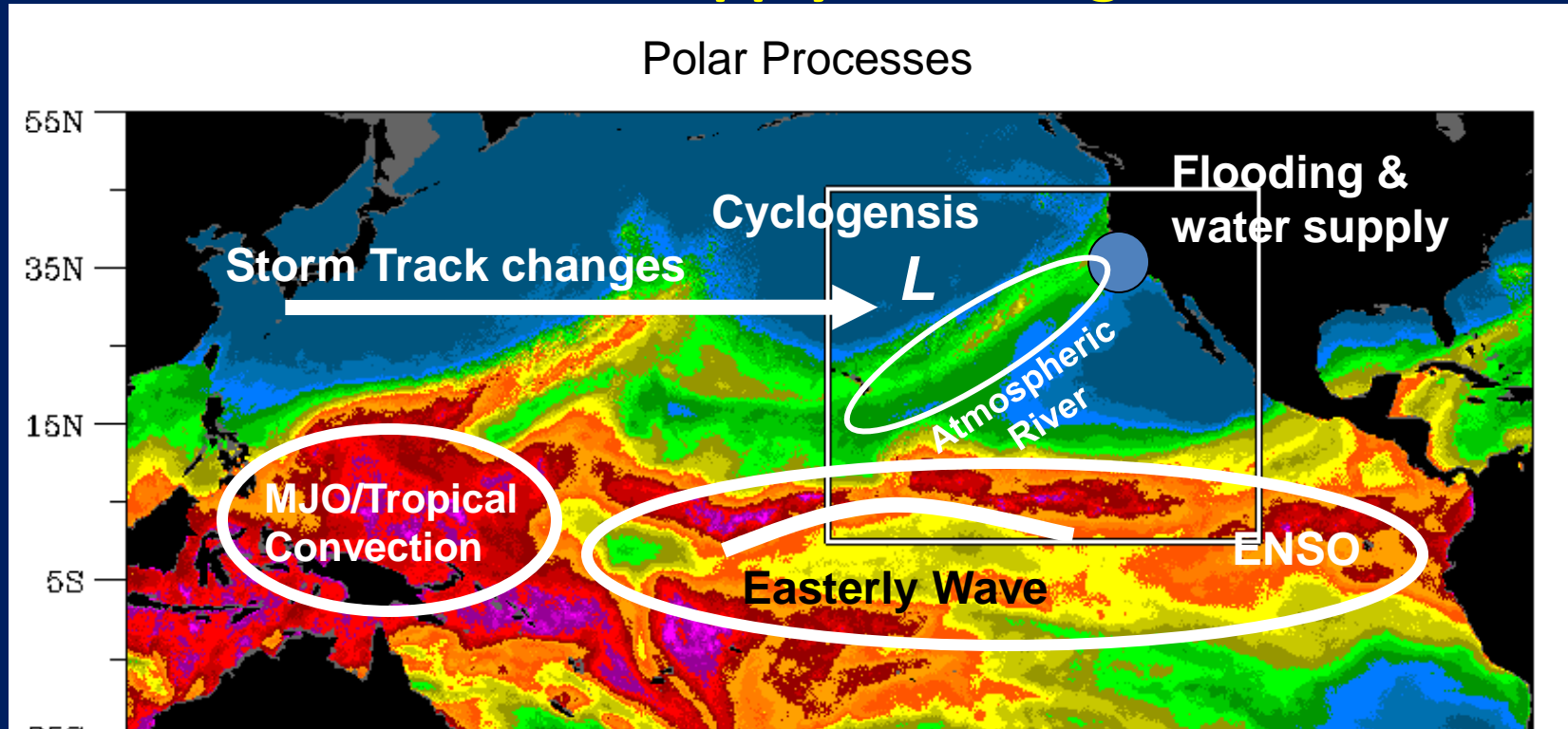


Northern Sierra Precipitation: 8-Station Index, September 04, 2015



Key Phenomena Affecting California

Water Supply/Flooding:



The size and number of atmospheric river events (ARs) result from the alignment of key processes

The absence of AR activity is important to drought

Closing Thoughts

- Drought amelioration happens one storm at a time
- Each storm's characteristics (moisture, wind, freezing height) important to the process (snowpack, runoff, recharge)
- Location and intensity are important (strong storms can cause damage without relieving drought impacts)