Climate, Drought, and Change

Delta Science Program

August 25, 2014

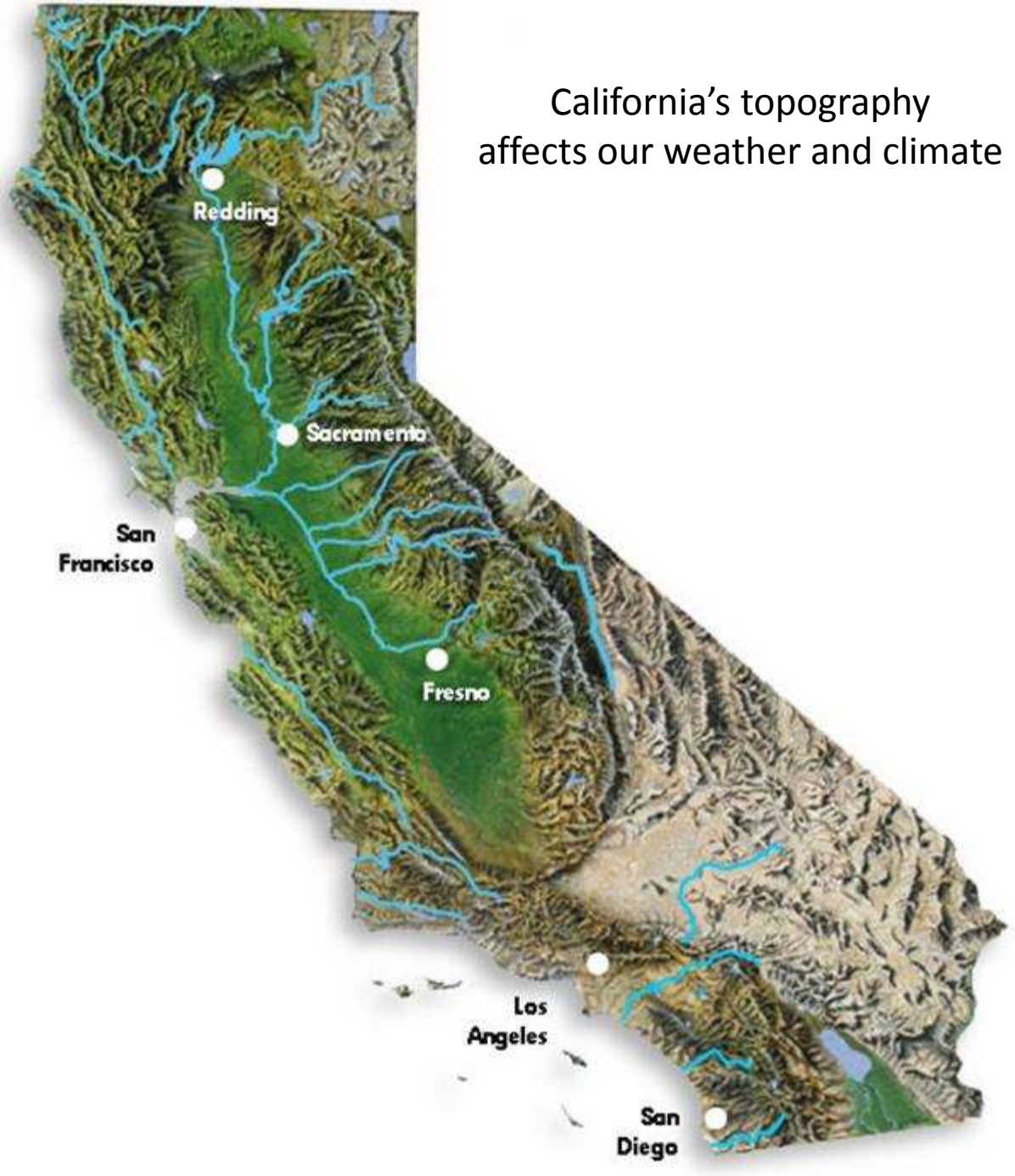
Oroville Reservoir January 2009

Presentation Overview

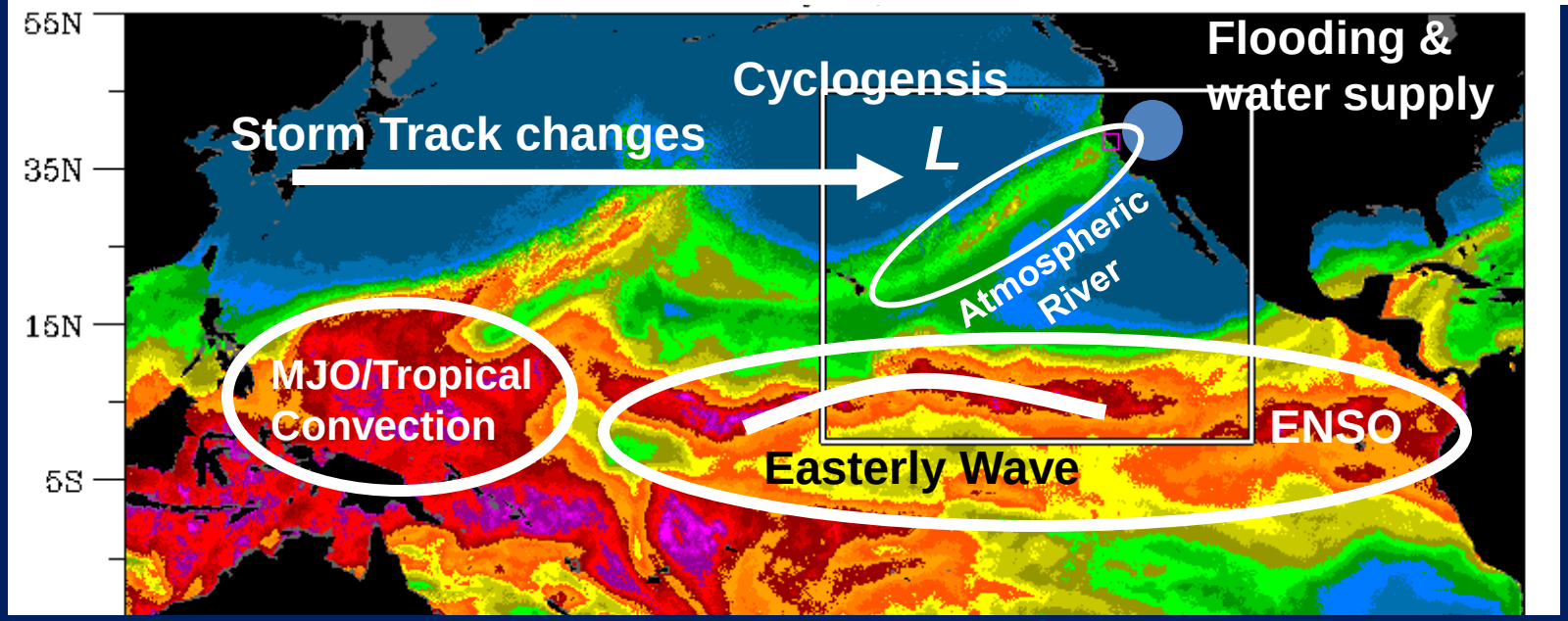
- Current Drought Conditions
- Relation to 20th Century Droughts
- Decadal Scale Variability
- Signs of Change

Folsom Reservoir January 2014

California's topography
affects our weather and climate

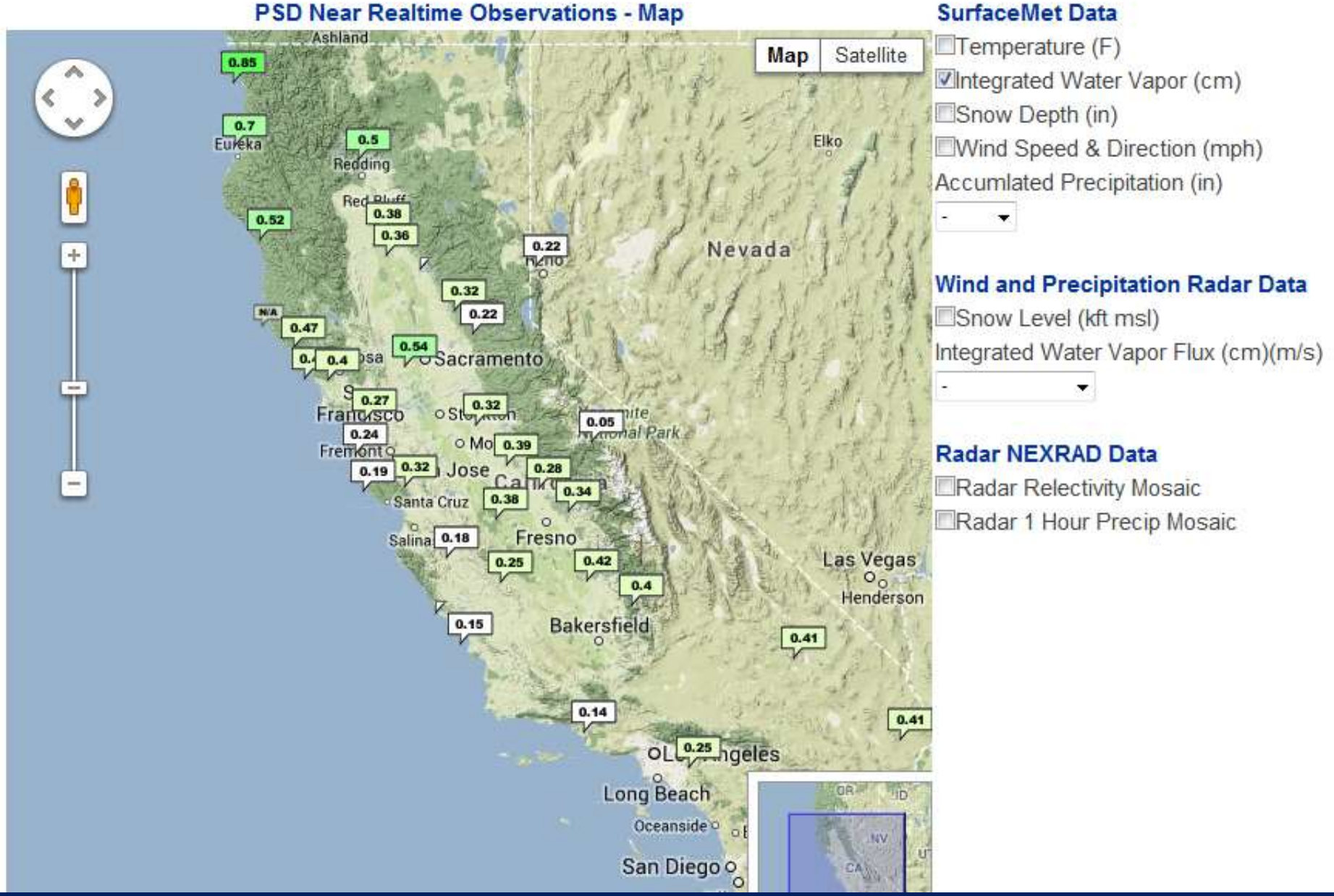


Key Phenomena Affecting California Water Supply/Flooding:

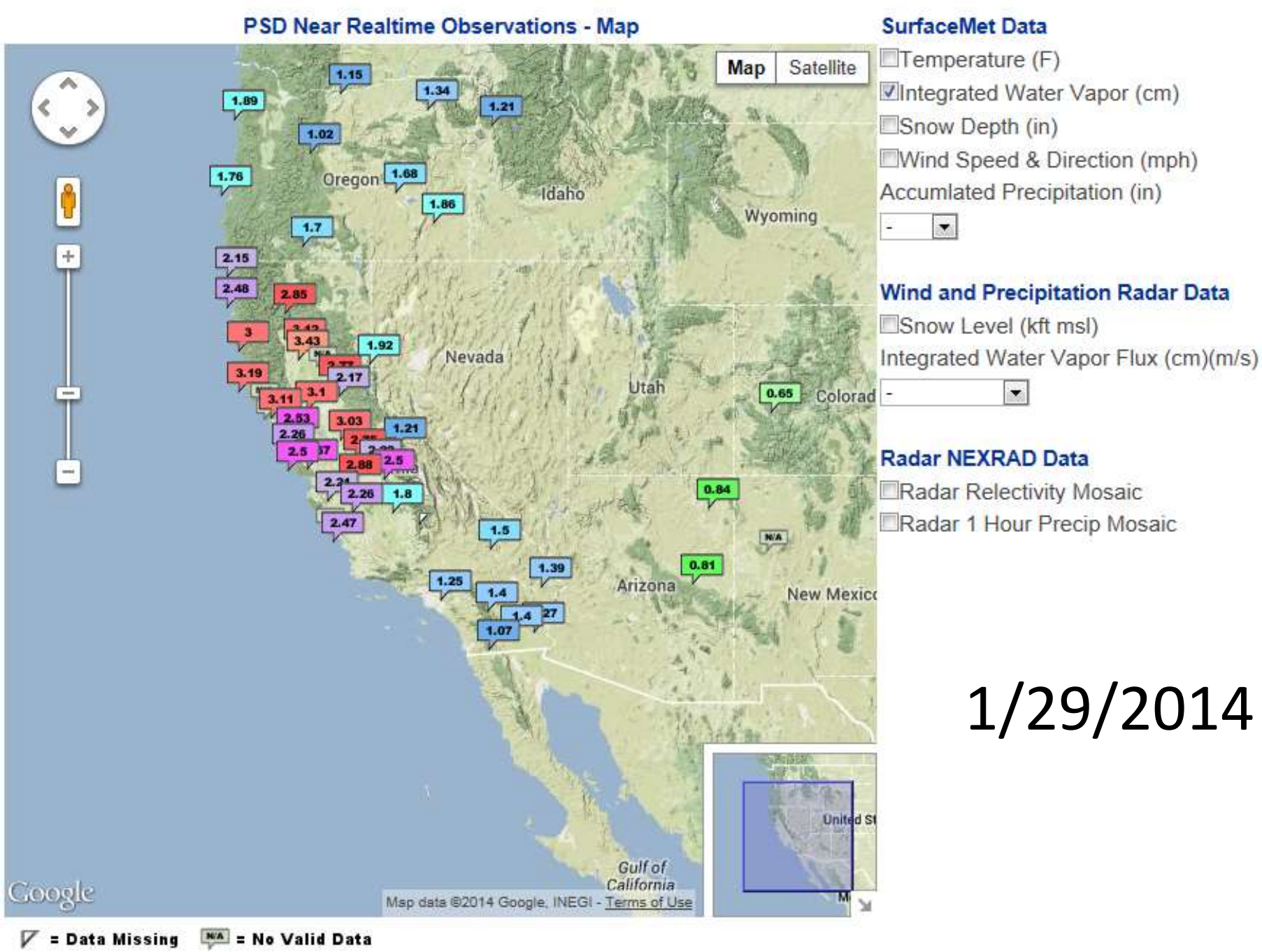


The size of the AR results from the alignment of key processes

The absence of AR activity important to drought


PSD Near Realtime Observations - Map
Map
Satellite
SurfaceMet Data
Temperature (F)
Integrated Water Vapor (cm)
Snow Depth (in)
Wind Speed & Direction (mph)
Accumlated Precipitation (in)
Wind and Precipitation Radar Data
Snow Level (kft msl)
Integrated Water Vapor Flux (cm)(m/s)
Radar NEXRAD Data
Radar Relectivity Mosaic
Radar 1 Hour Precip Mosaic
Ashland
Eureka
Redding
Elko
Nevada
Sacramento
Fresno
Bakersfield
Las Vegas
Henderson
Long Beach
Oceanside
San Diego
0.85
0.7
0.5
0.52
0.38
0.36
0.22
0.32
0.47
0.54
0.4
0.27
0.24
0.19
0.39
0.28
0.34
0.18
0.25
0.42
0.15
0.41
0.14
0.05

12/27/2013


PSD Near Realtime Observations - Map
Map
Satellite
SurfaceMet Data
Temperature (F)
Integrated Water Vapor (cm)
Snow Depth (in)
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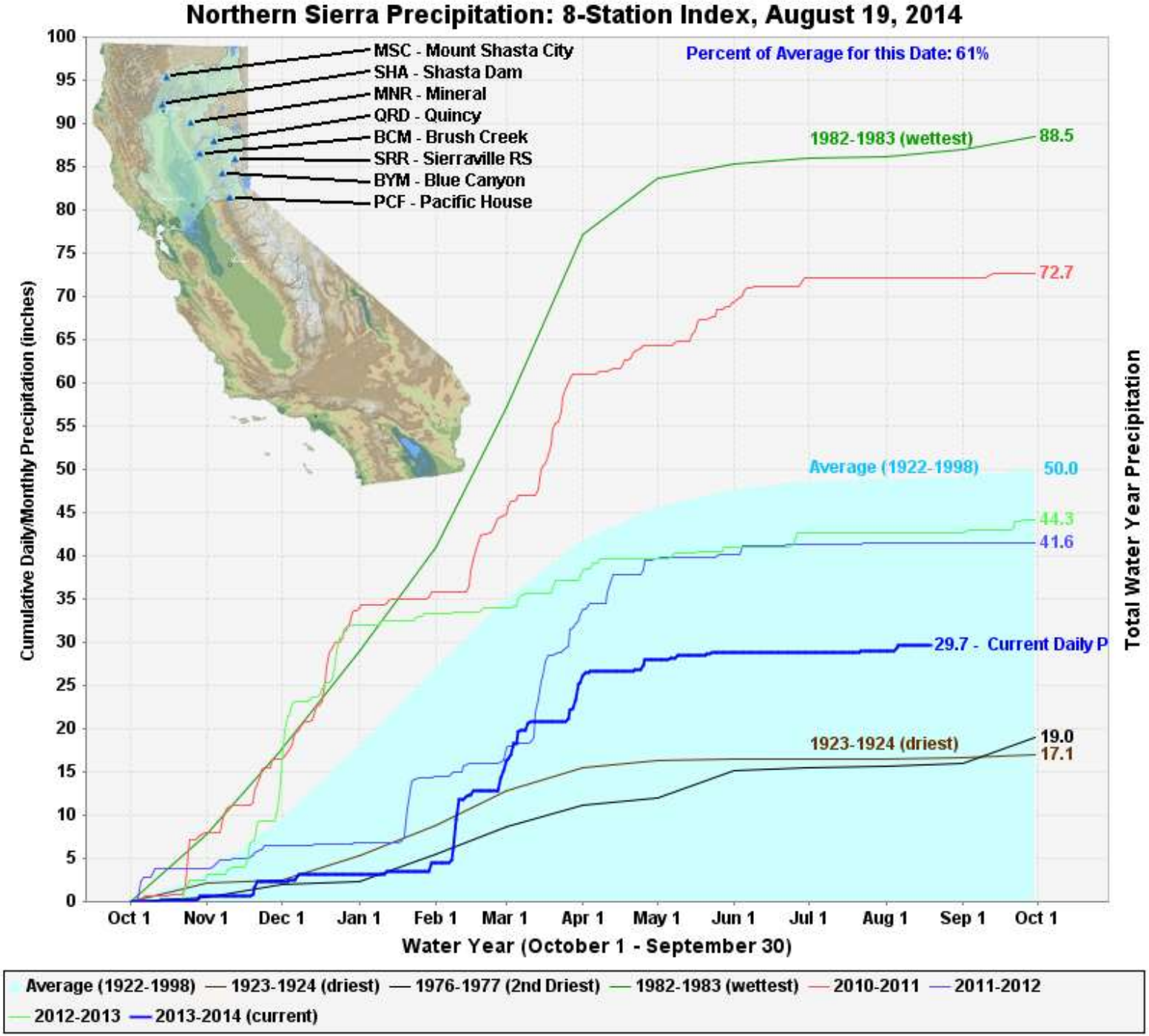
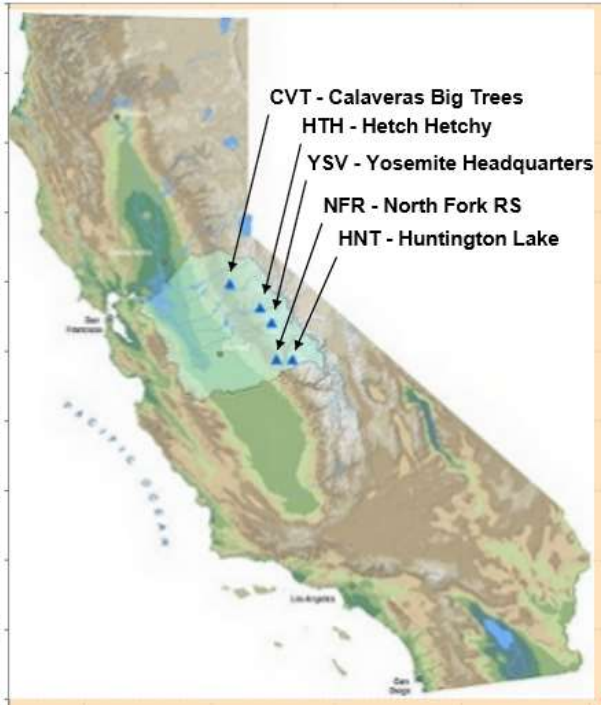
Snow Level (kft msl)
Integrated Water Vapor Flux (cm)(m/s)
Radar NEXRAD Data
Radar Relectivity Mosaic
Radar 1 Hour Precip Mosaic
Oregon
Idaho
Wyoming
Nevada
Utah
Colorad
Arizona
New Mexic
Gulf of California
Google
Msp data ©2014 Google, INEGI - Terms of Use
= Data Missing
= No Valid Data

1/29/2014


Northern Sierra Precipitation: 8-Station Index, August 19, 2014
MSC - Mount Shasta City
SHA - Shasta Dam
MNR - Mineral
QRD - Quincy
BCM - Brush Creek
SRR - Sierraville RS
BYM - Blue Canyon
PCF - Pacific House
Percent of Average for this Date: 61%
1982-1983 (wettest)
88.5
72.7
Average (1922-1998)
50.0
44.3
41.6
29.7 - Current Daily P
1923-1924 (driest)
19.0
17.1
Cumulative Daily/Monthly Precipitation (inches)
Total Water Year Precipitation
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
May 1
Jun 1
Jul 1
Aug 1
Sep 1
Oct 1
Water Year (October 1 - September 30)
Average (1922-1998)
1923-1924 (driest)
1976-1977 (2nd Driest)
1982-1983 (wettest)
2010-2011
2011-2012
2012-2013
2013-2014 (current)

San Joaquin Precipitation: 5-Station Index, August 25, 2014



Percent of Average for this Date: 49%

1982-1983 (wettest) 77.4

2005-2006 Daily Precip. 56.3

Average (1956-2005) 40.8

2012-2013 Daily Precip. 26.5

Current Daily Precip: 19.6

1976-1977 15.4

1923-1924 (driest) 14.8

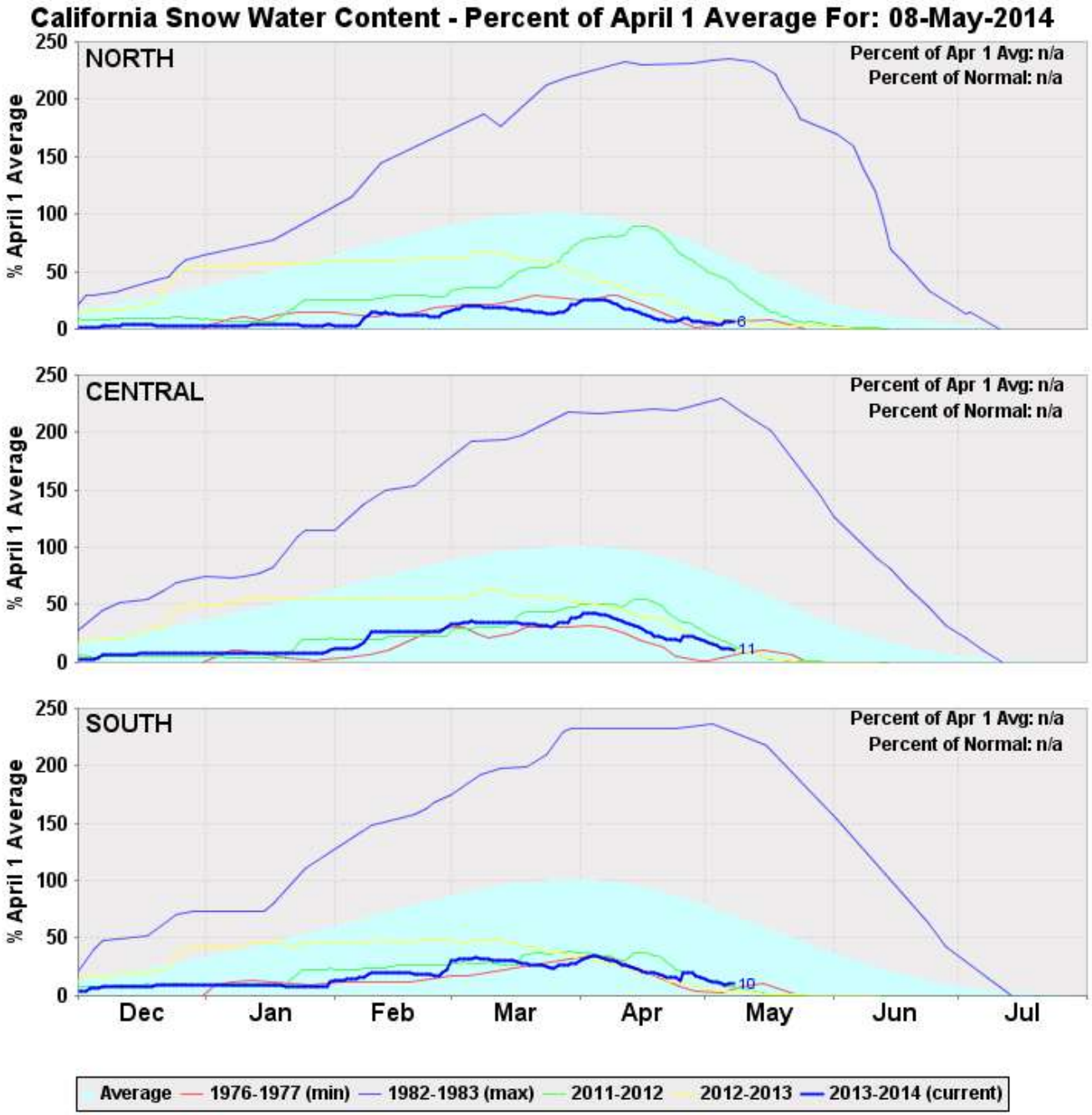
Cumulative Daily/Monthly Precipitation (inches)

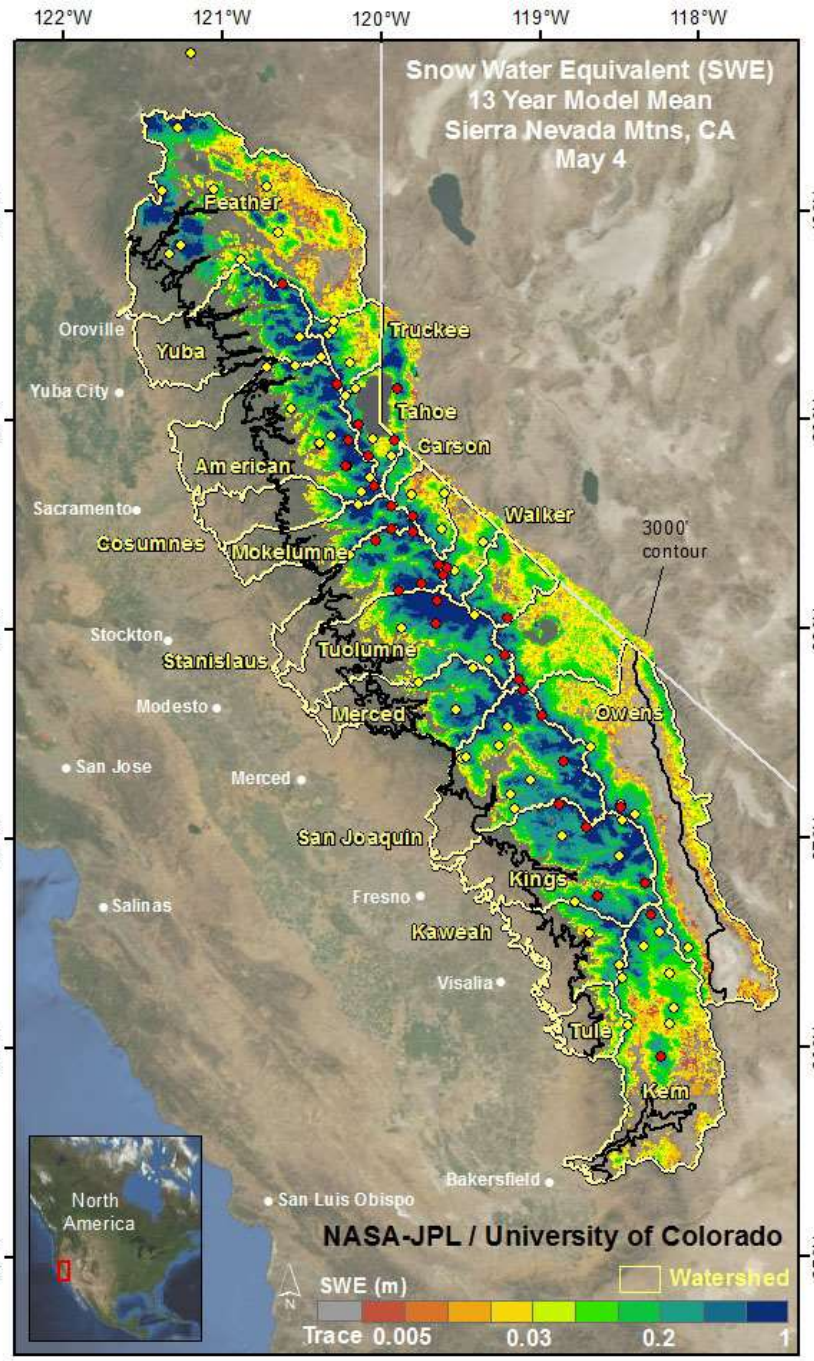
Total Water Year Precipitation

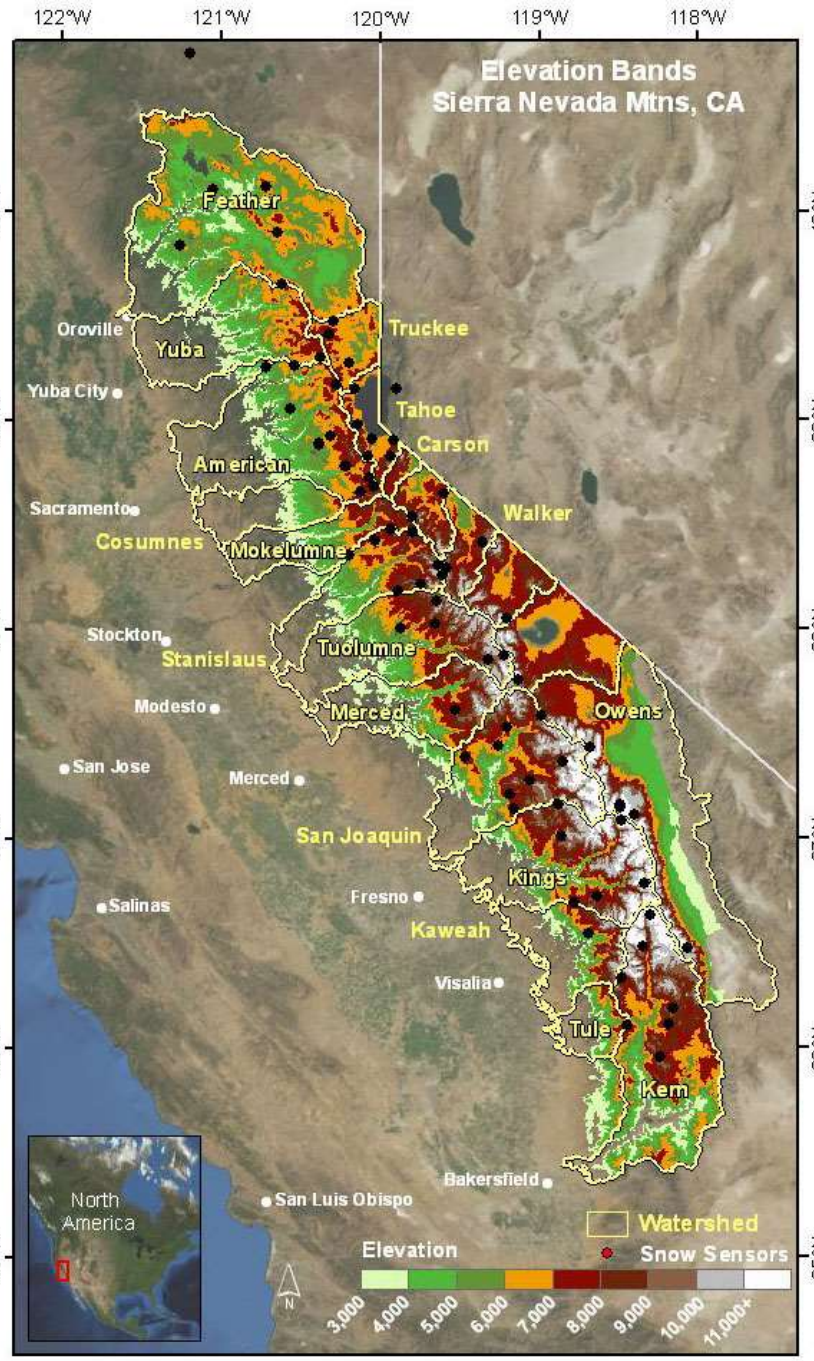
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90

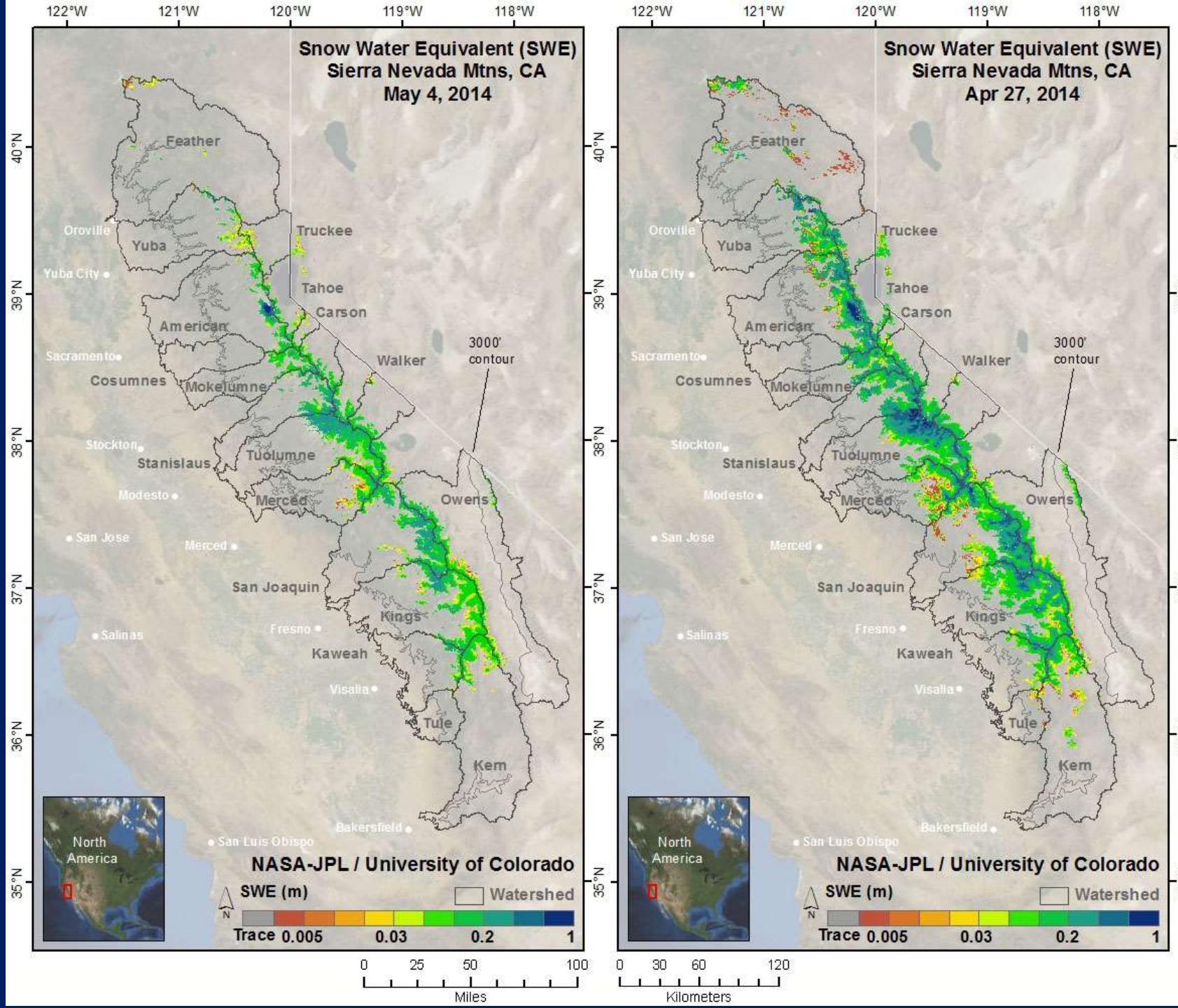
Oct 1 Nov 1 Dec 1 Jan 1 Feb 1 Mar 1 Apr 1 May 1 Jun 1 Jul 1 Aug 1 Sep 1 Oct 1

Water Year (October 1 - September 30)

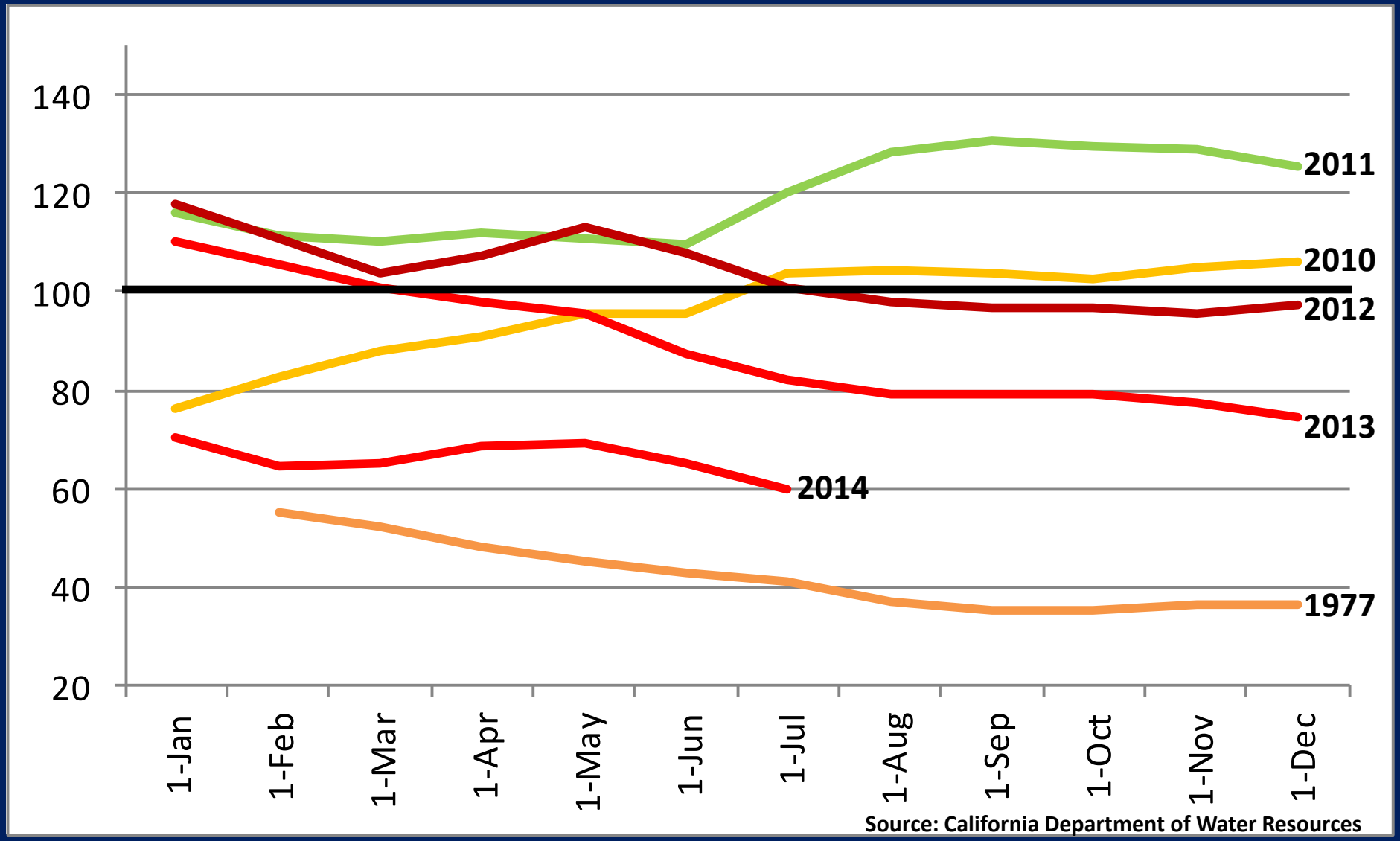

California Snow Water Content - Percent of April 1 Average For: 08-May-2014
NORTH
Percent of Apr 1 Avg: n/a
Percent of Normal: n/a
% April 1 Average
250
200
150
100
50
0
6
CENTRAL
Percent of Apr 1 Avg: n/a
Percent of Normal: n/a
% April 1 Average
11
SOUTH
Percent of Apr 1 Avg: n/a
Percent of Normal: n/a
% April 1 Average
10
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Average
1976-1977 (min)
1982-1983 (max)
2011-2012
2012-2013
2013-2014 (current)


Snow Water Equivalent (SWE)
13 Year Model Mean
Sierra Nevada Mtns, CA
May 4
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Walker
Cosumnes
Mokelumne
3000' contour
Stockton
Stanislaus
Tuolumne
Modesto
Merced
Owens
San Jose
Merced
San Joaquin
Kings
Fresno
Salinas
Kaweah
Visalia
Tule
Kern
Bakersfield
San Luis Obispo
North America
NASA-JPL / University of Colorado
SWE (m)
Trace
0.005
0.03
0.2
1
Watershed
0
25
50
100
Miles


Elevation Bands
Sierra Nevada Mtns, CA
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Walker
Cosumnes
Mokelumne
Stockton
Stanislaus
Tuolumne
Modesto
Merced
Owens
San Jose
Merced
San Joaquin
Kings
Fresno
Salinas
Kaweah
Visalia
Tule
Kern
Bakersfield
San Luis Obispo
North America
Watershed
Snow Sensors
Elevation
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000+
0
30
60
120
Kilometers


Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
May 4, 2014
Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
Apr 27, 2014
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Cosumnes
Mokelumne
Walker
3000' contour
Stockton
Stanislaus
Tuolumne
Modesto
Merced
Owens
San Jose
Merced
San Joaquin
Kings
Fresno
Salinas
Kaweah
Visalia
Tule
Kern
Bakersfield
San Luis Obispo
North America
NASA-JPL / University of Colorado
SWE (m)
Watershed
Trace
0.005
0.03
0.2
1
0
25
50
100
Miles
0
30
60
120
Kilometers

California Reservoir Storage, Percent of Normal, 1977 and 2010-14

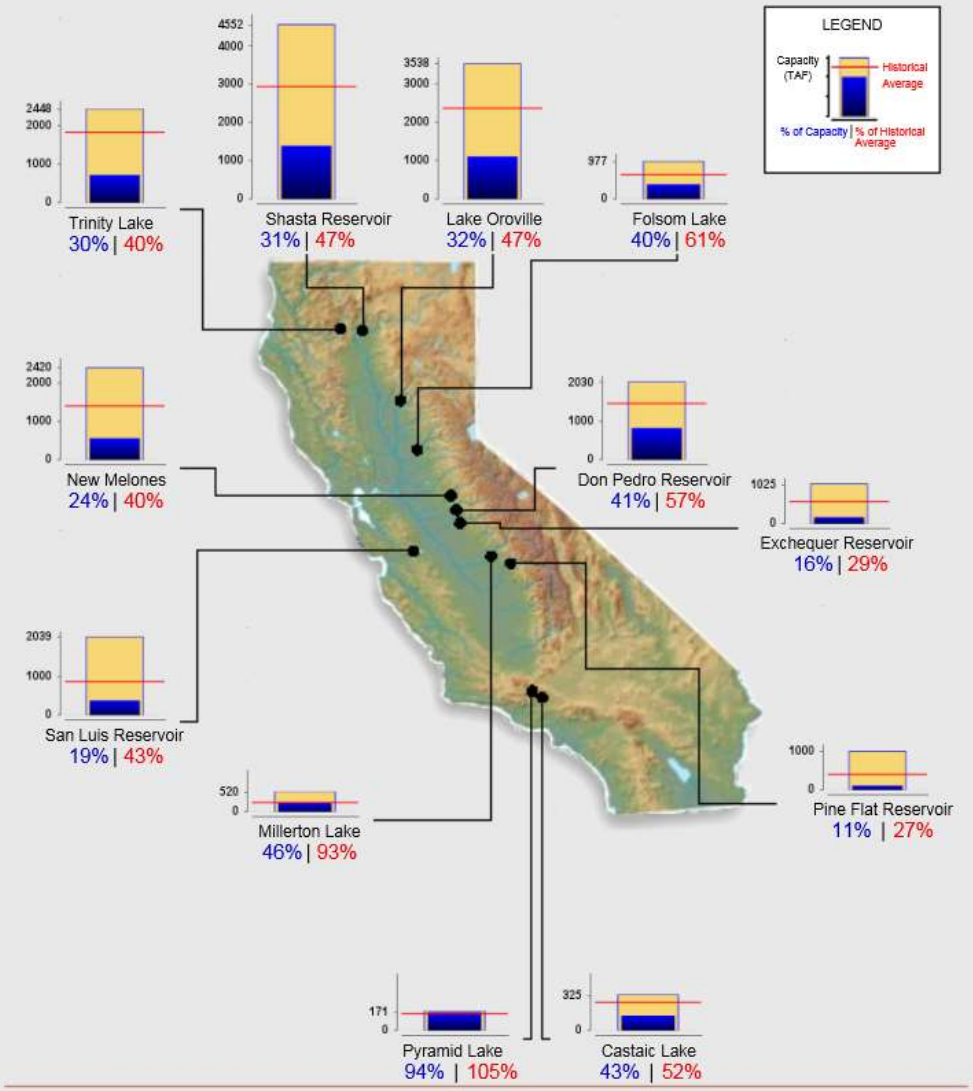


Credit: Brad Rippey, USDA

Reservoir Conditions

Ending At Midnight - August 24, 2014

CURRENT RESERVOIR CONDITIONS

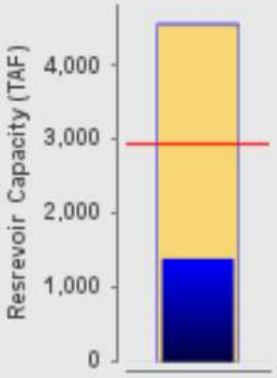


Graph Updated 08/25/2014 08:45 AM

Reservoir Conditions - Shasta Reservoir

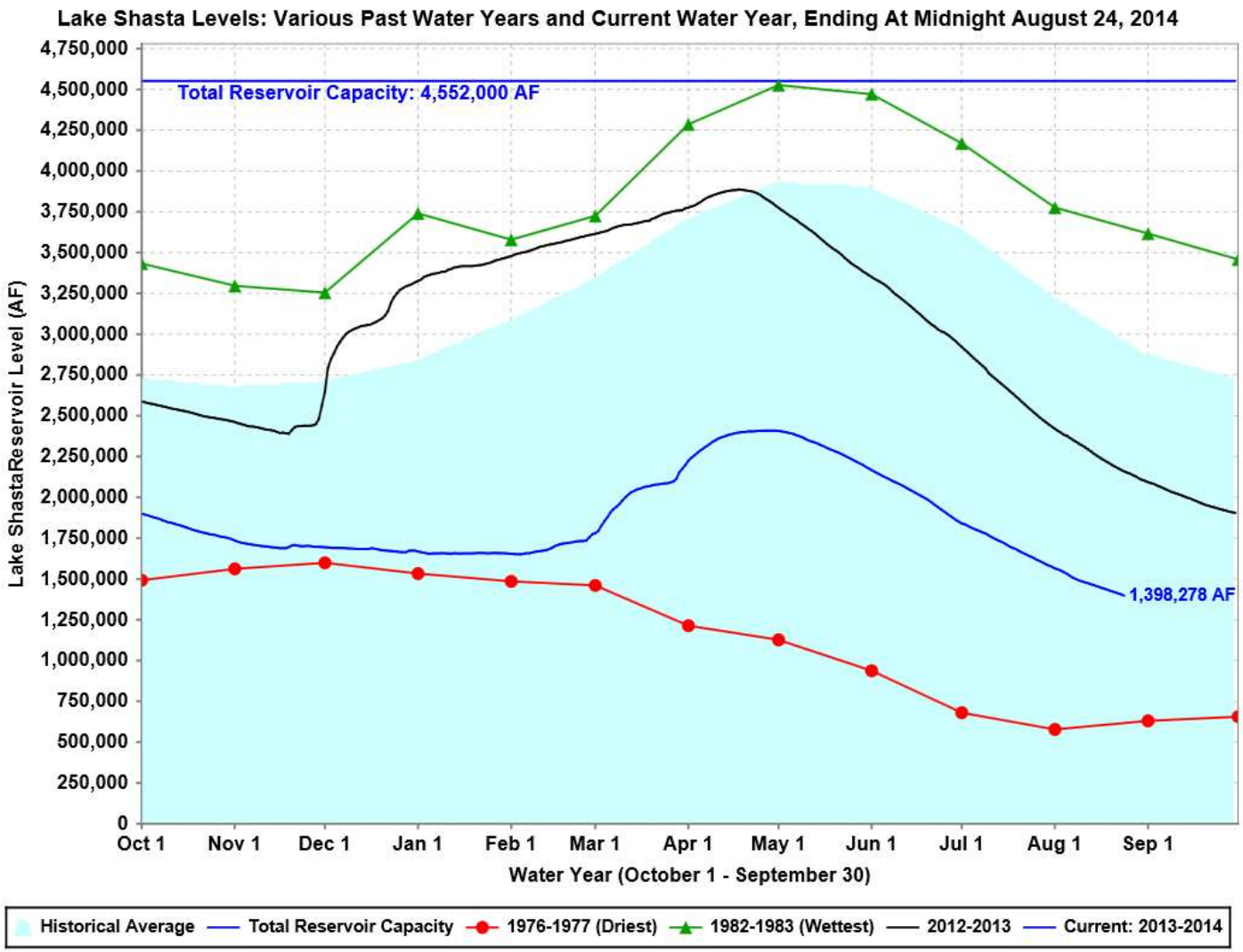
Lake Shasta Conditions

(as of Midnight - August 24, 2014)



Current Level: 1,398,278 AF

31% (Total Capacity) | 47% (Historical Avg.)

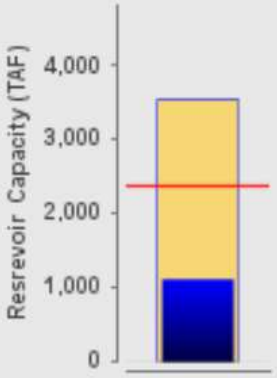


Data Updated 08/25/2014 08:45 AM

Reservoir Conditions - Lake Oroville

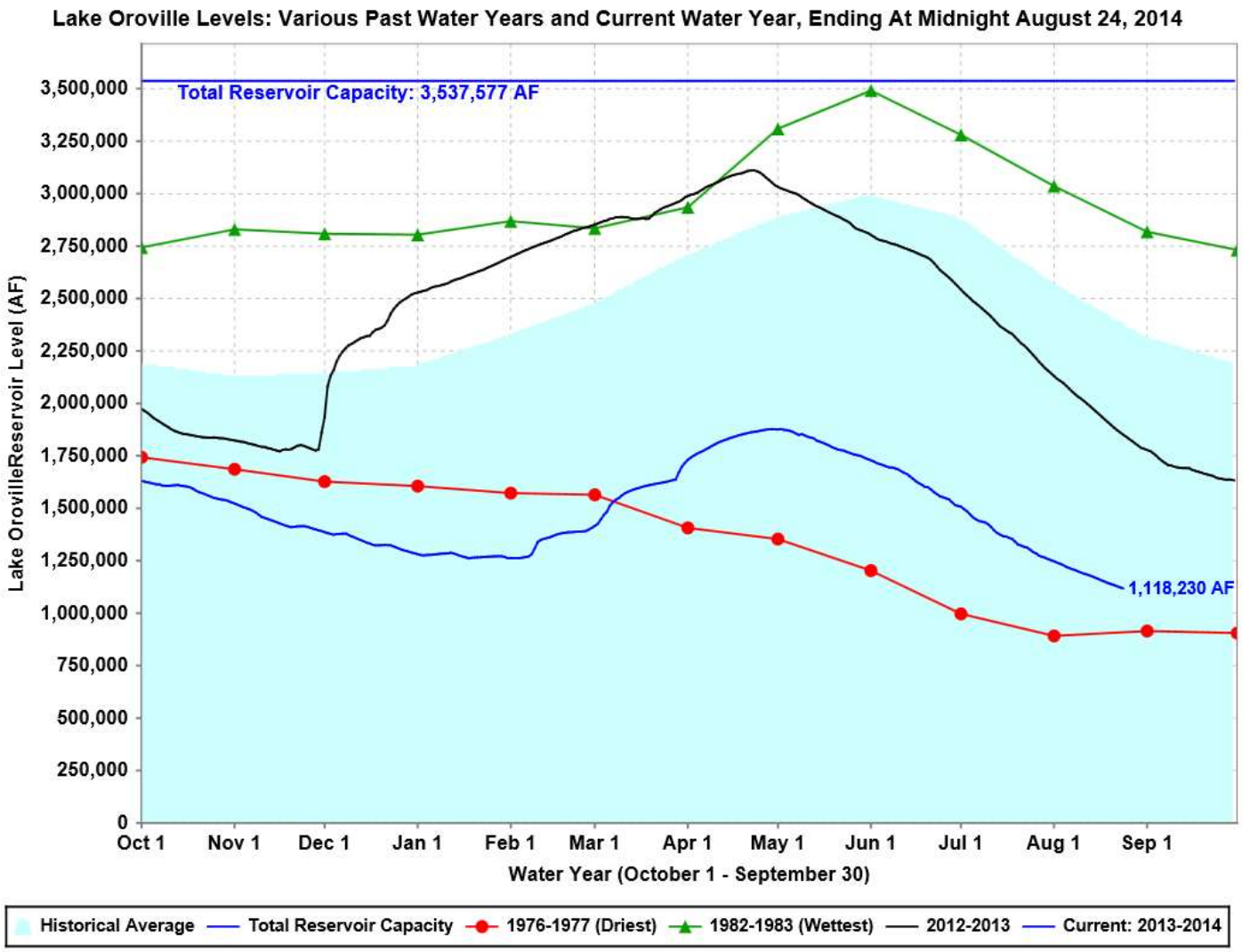
Lake Oroville Conditions

(as of Midnight - August 24, 2014)



Current Level: 1,118,230 AF

32% (Total Capacity) | 47% (Historical Avg.)

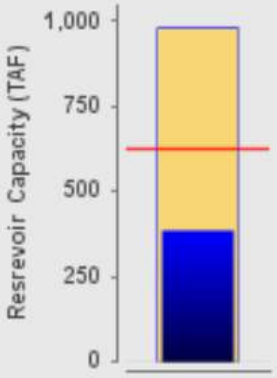


Data Updated 08/25/2014 08:45 AM

Reservoir Conditions - Folsom Lake

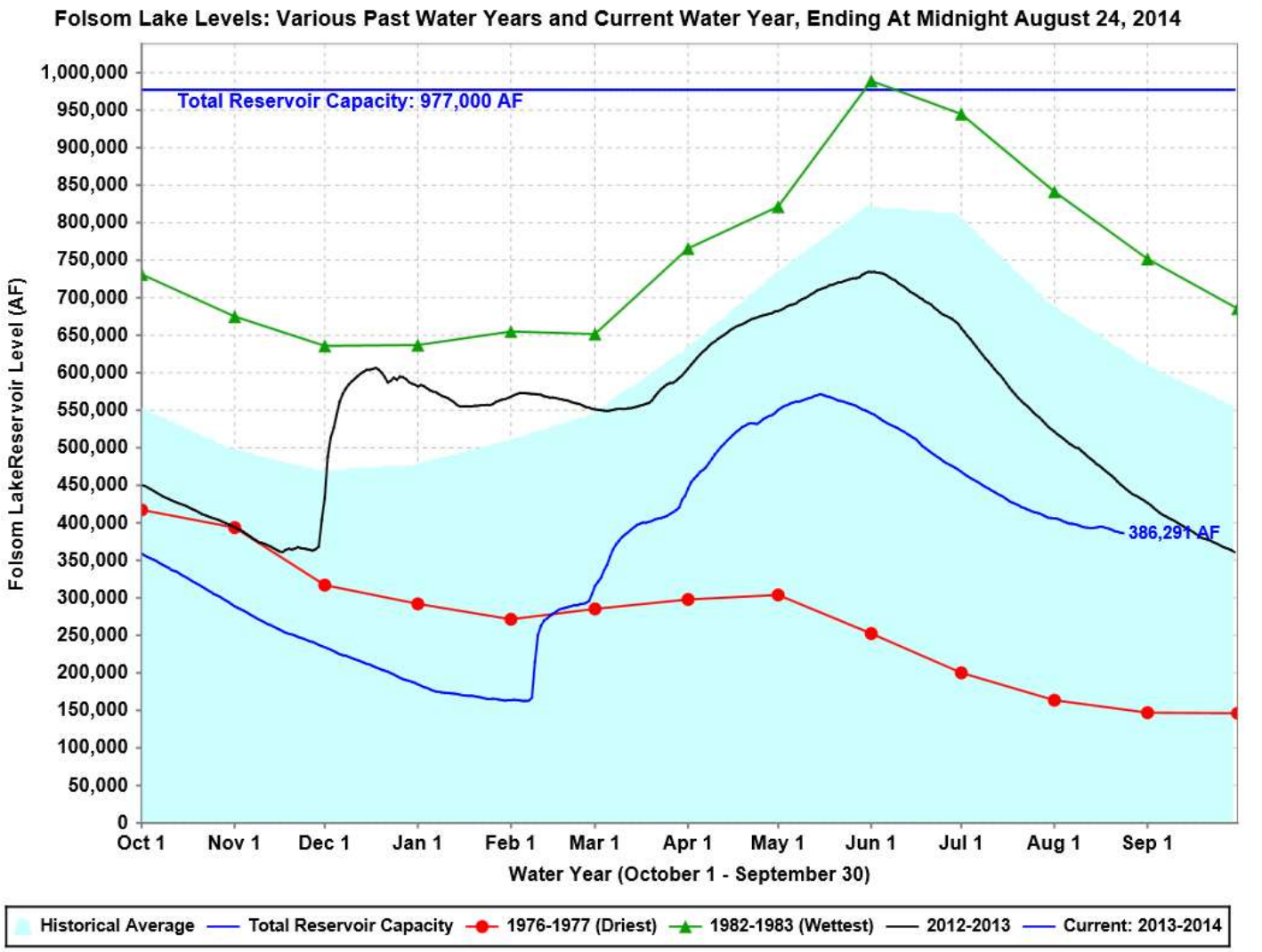
Folsom Lake Conditions

(as of Midnight - August 24, 2014)



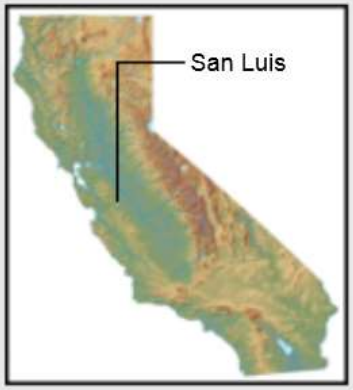
Current Level: 386,291 AF

40% (Total Capacity) | 61% (Historical Avg.)



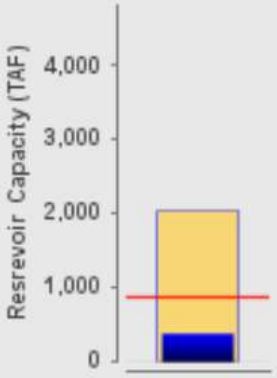
Data Updated 08/25/2014 08:45 AM

Reservoir Conditions - San Luis



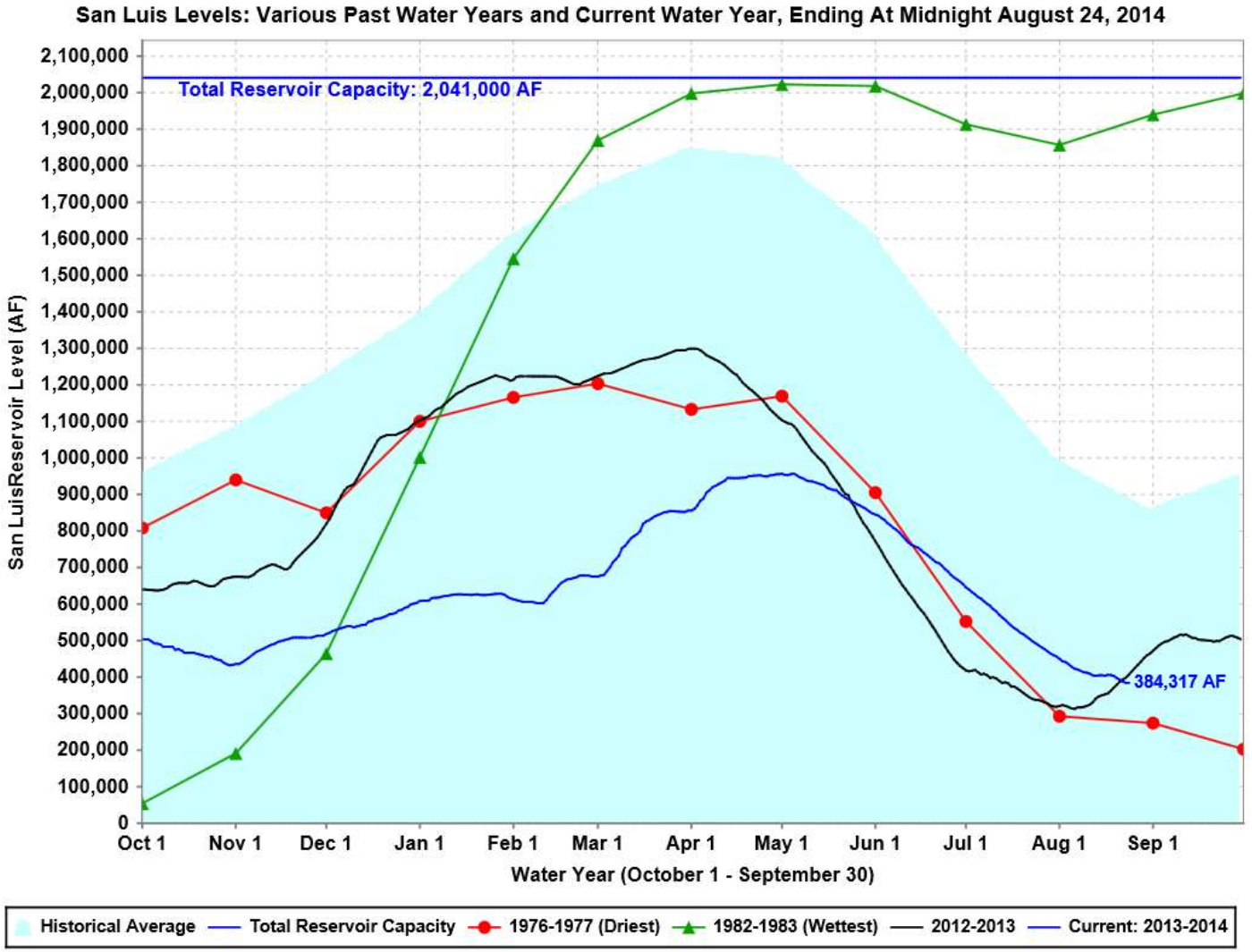
San Luis Conditions

(as of Midnight - August 24, 2014)



Current Level: 384,317 AF

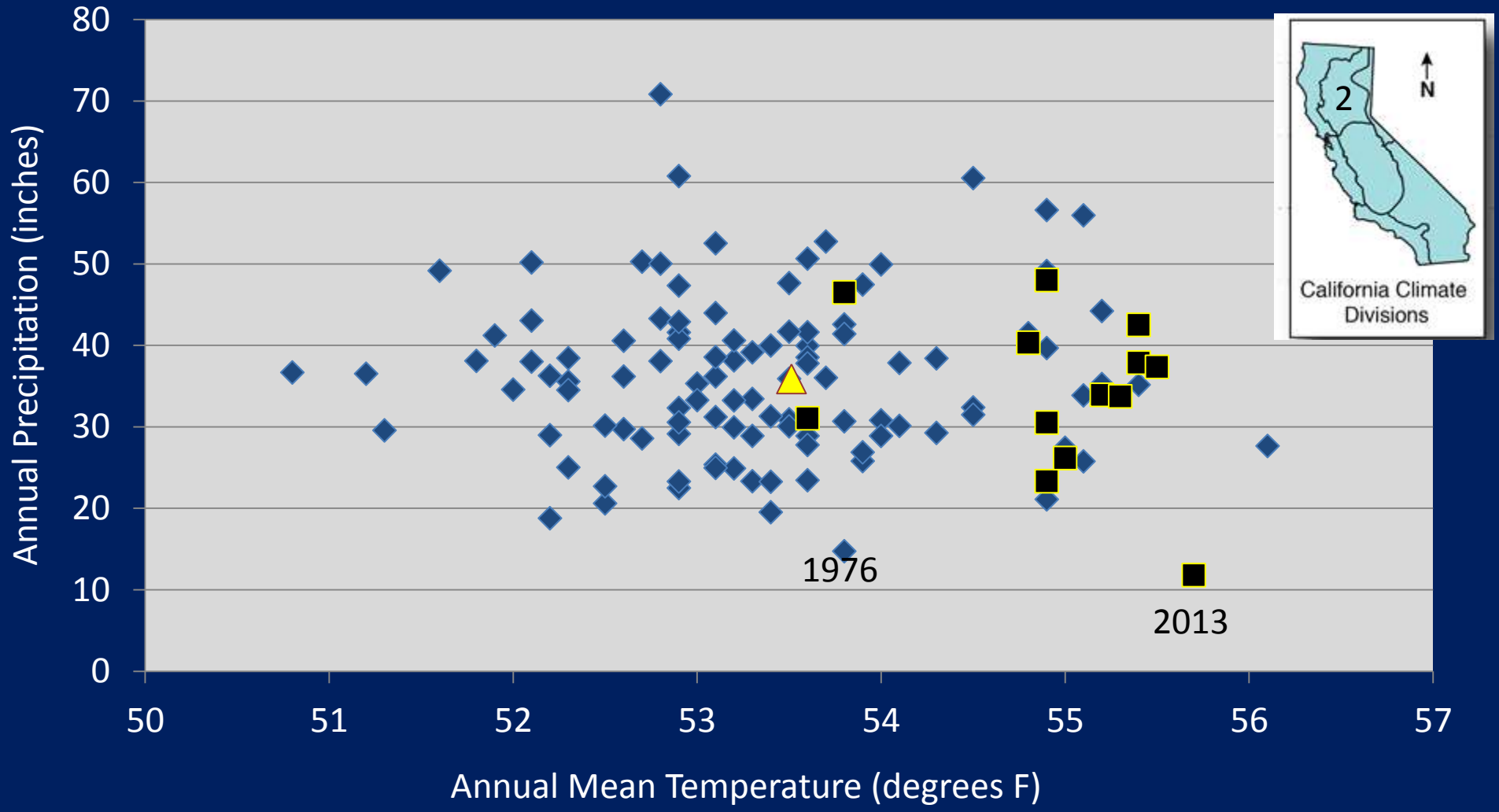
19% (Total Capacity) | 43% (Historical Avg.)



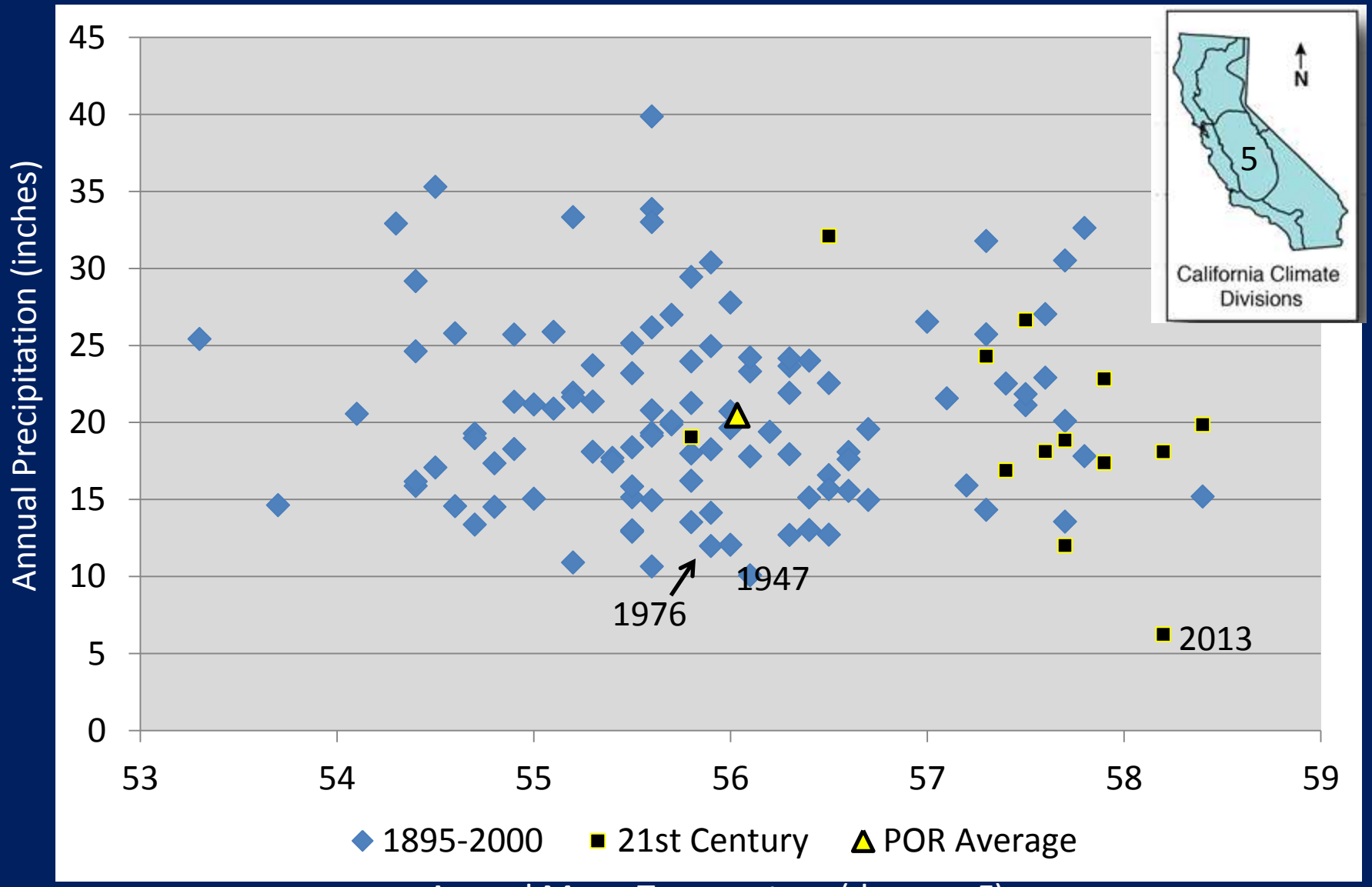
Data Updated 08/25/2014 08:45 AM

Lake Oroville 2014, DWR Photo

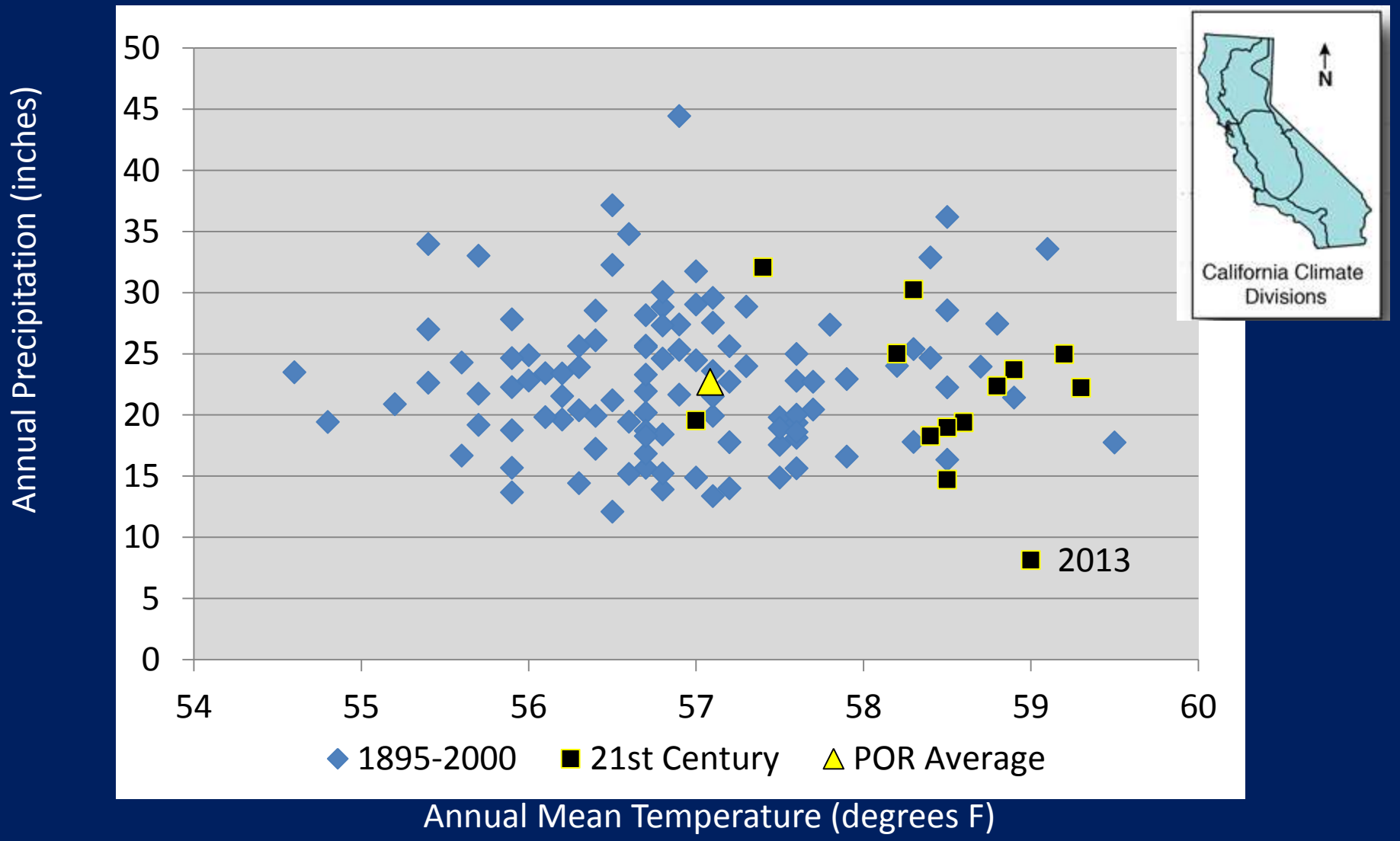
NOAA Climate Division 2 Calendar Year Data 1895-2013

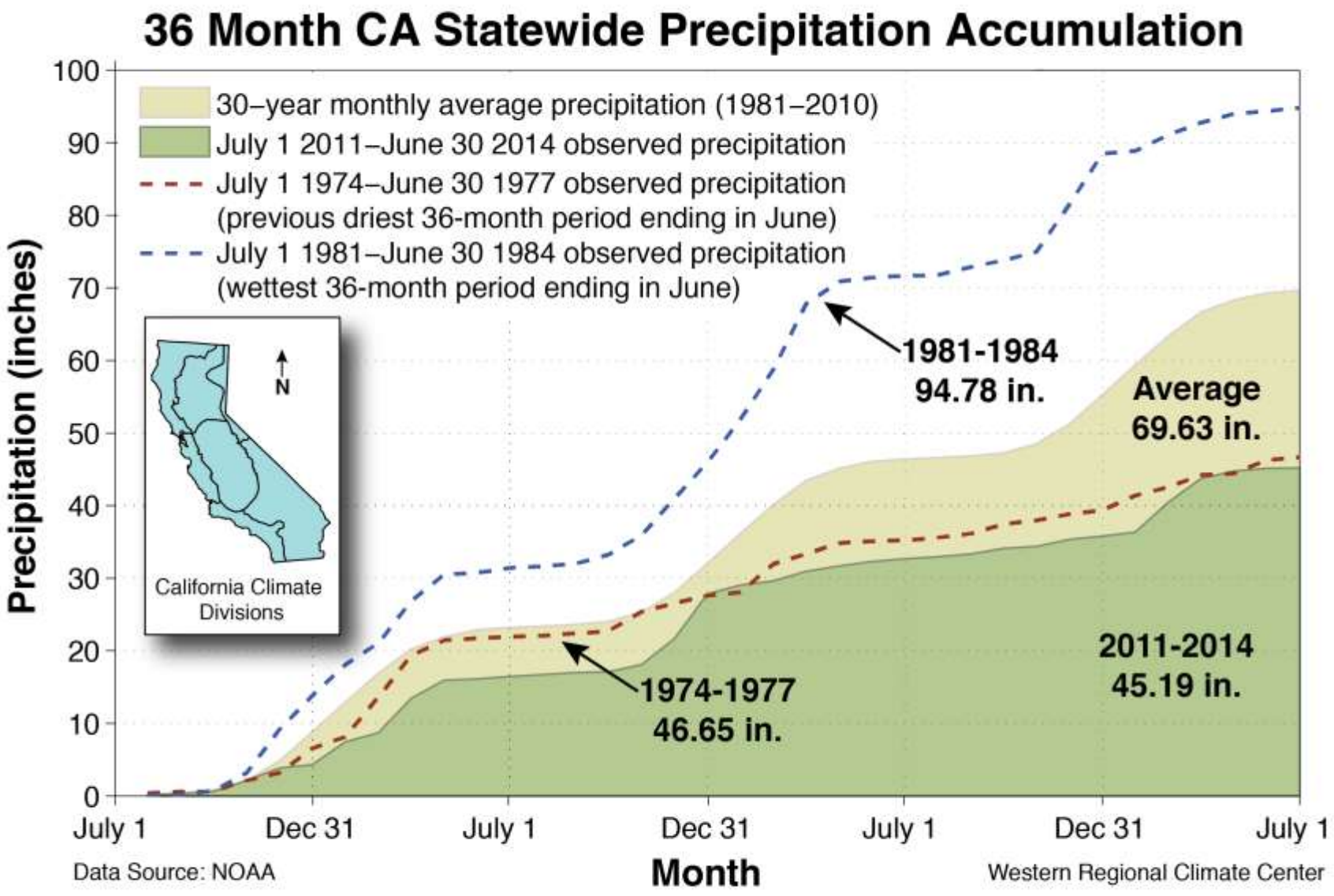


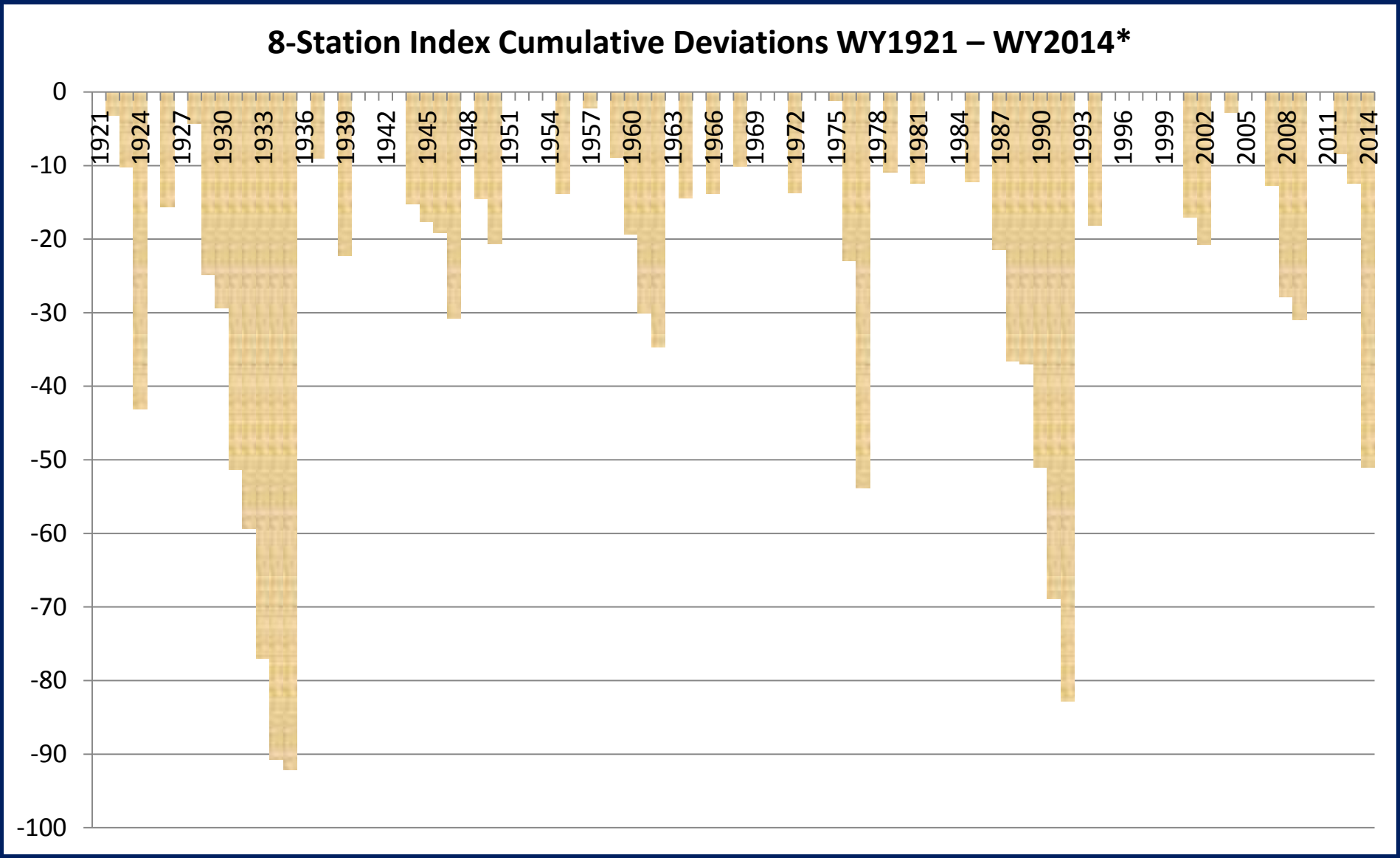
NOAA Climate Division 5 Calendar Year Data 1895-2013



Westmap Statewide Calendar Year Data 1895-2013




36 Month CA Statewide Precipitation Accumulation
30–year monthly average precipitation (1981–2010)
July 1 2011–June 30 2014 observed precipitation
July 1 1974–June 30 1977 observed precipitation
(previous driest 36-month period ending in June)
July 1 1981–June 30 1984 observed precipitation
(wettest 36-month period ending in June)
1981-1984
94.78 in.
Average
69.63 in.
2011-2014
45.19 in.
1974-1977
46.65 in.
N
California Climate Divisions
Precipitation (inches)
100
90
80
70
60
50
40
30
20
10
0
July 1
Dec 31
July 1
Dec 31
July 1
Dec 31
July 1
Month
Data Source: NOAA
Western Regional Climate Center



*WY2014 assumes no further precipitation this year

Other Rankings

- 8 Station Precipitation Index 8th driest water year
- 5 Station Precipitation Index 3rd driest water year
- 8 River Index 4th driest single year
  and 3rd driest 3-year
- California Climate Tracker warmest winter, second warmest water year to date for Sierra region

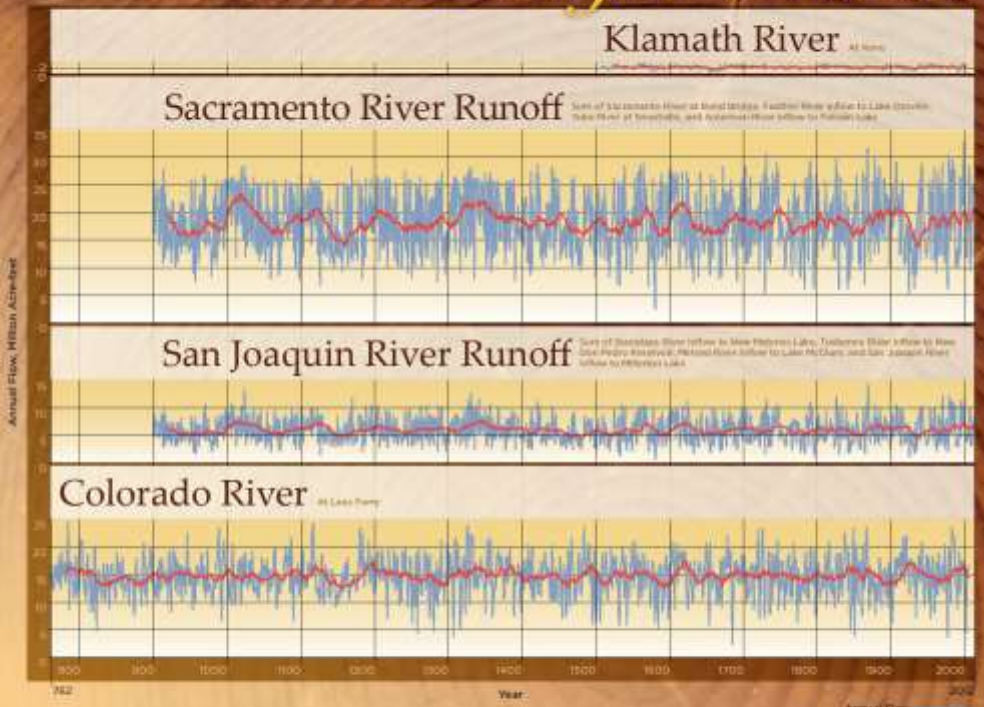
Multi-Year Sequencing

- 20th Century shows 2, 3, 4, and 6 year droughts
- Multi-decadal dry period 1910-1940 in observed record for 8 Station Index & Sacramento Basin Runoff
- Paleorecord shows multiple 10+ year droughts as well as 2 century-long dry periods (climate shifts)

DWR Paleohydrology Study

- Extend existing record for Sacramento, San Joaquin and Klamath Basins
- Conducted by University of Arizona Laboratory for Tree Ring Research (Dave Meko, Connie Woodhouse, and Ramzi Touchan)
- Data and report available at: http://water.ca.gov/waterconditions/waterconditions.cfm

Reconstructed Streamflows & Drought Periods

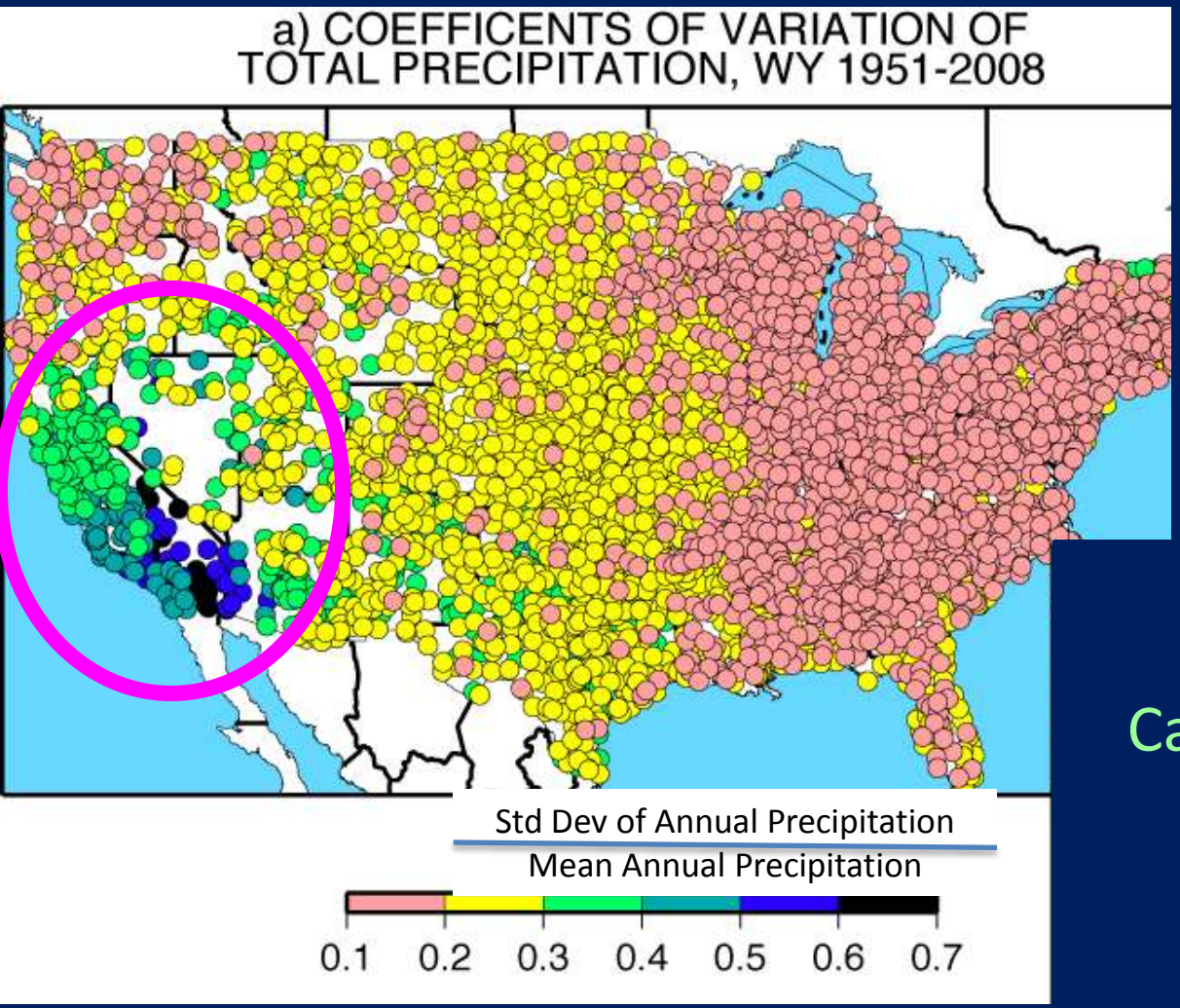


USING TREE-RINGS TO RECONSTRUCT STREAMFLOW

DROUGHTS PRIOR TO THE HISTORICAL RECORD


Temporal Variability
San Luis Reservoir 2014, DWR Photo

Year to Year Precipitation Variability

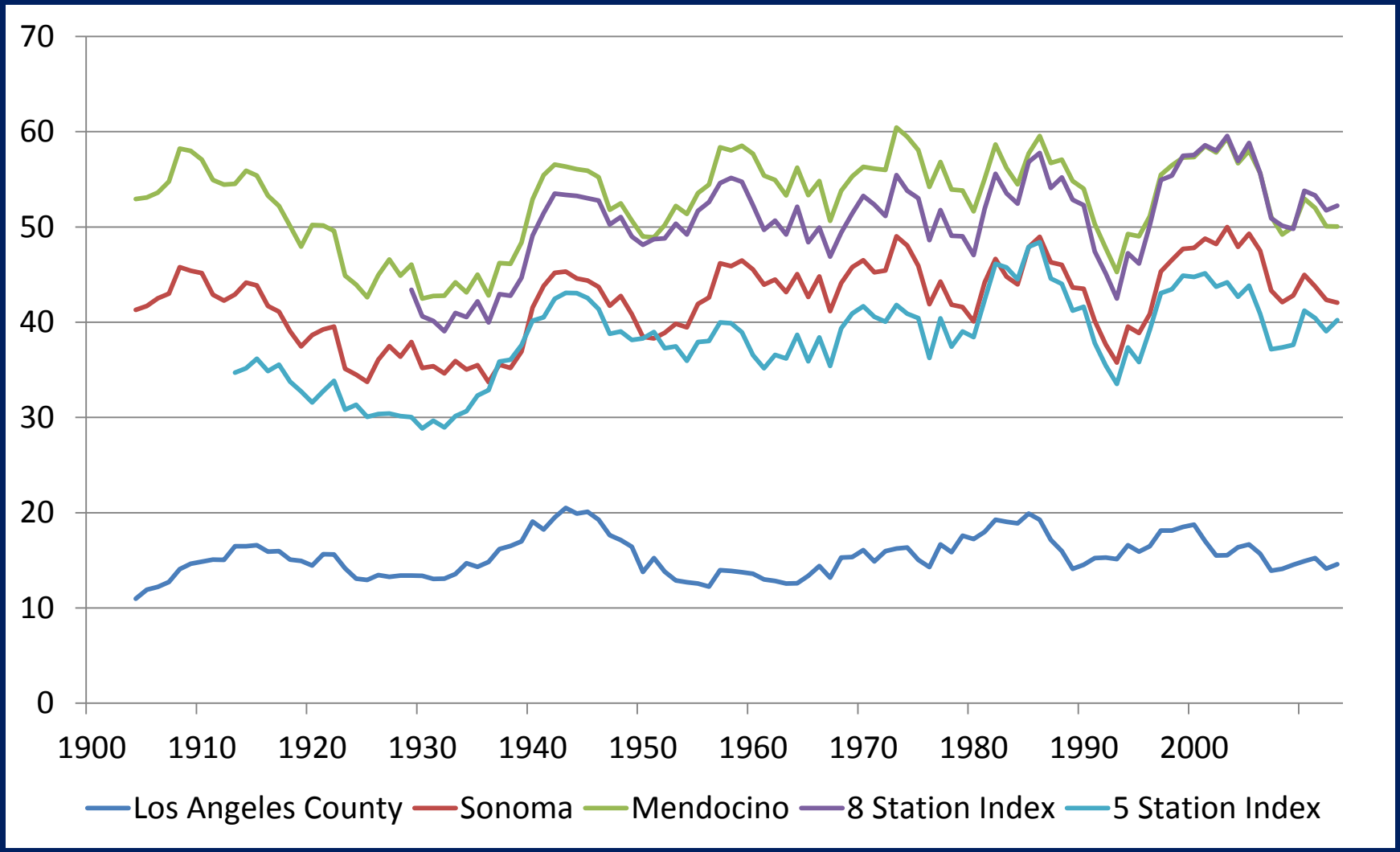


Higher values are higher variability

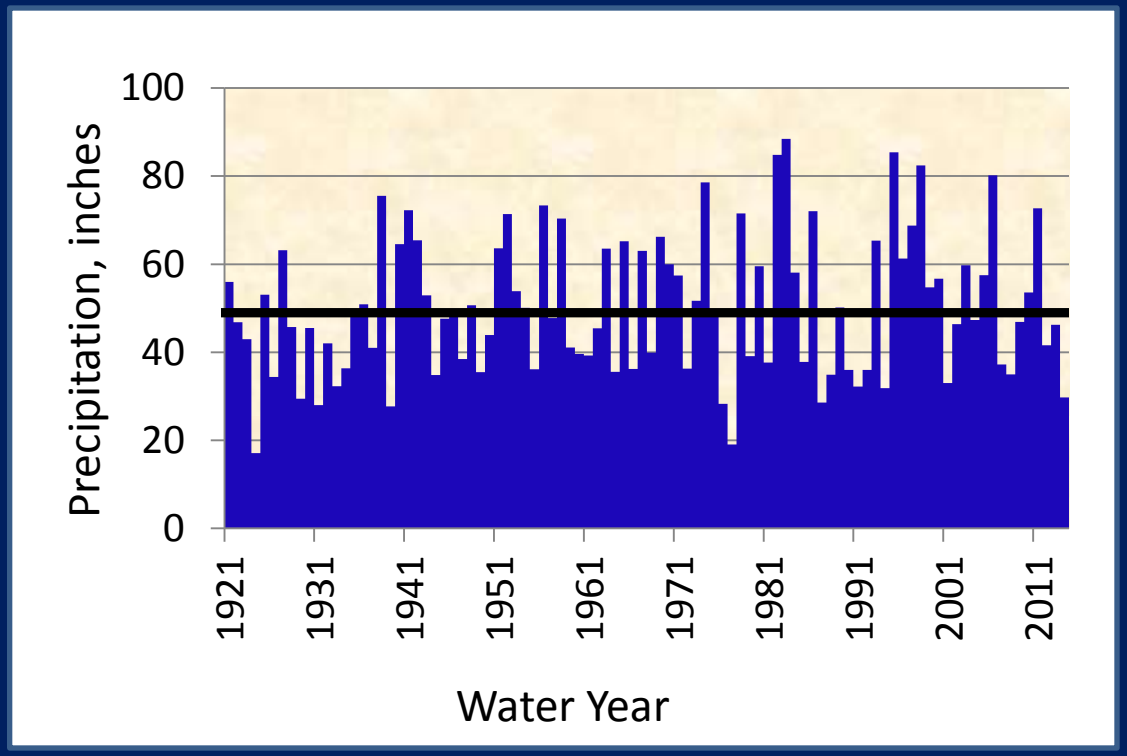
California precipitation is uniquely variable

Dettinger et al, 2011

Decadal Scale Variability



Northern Sierra 8 Station Index



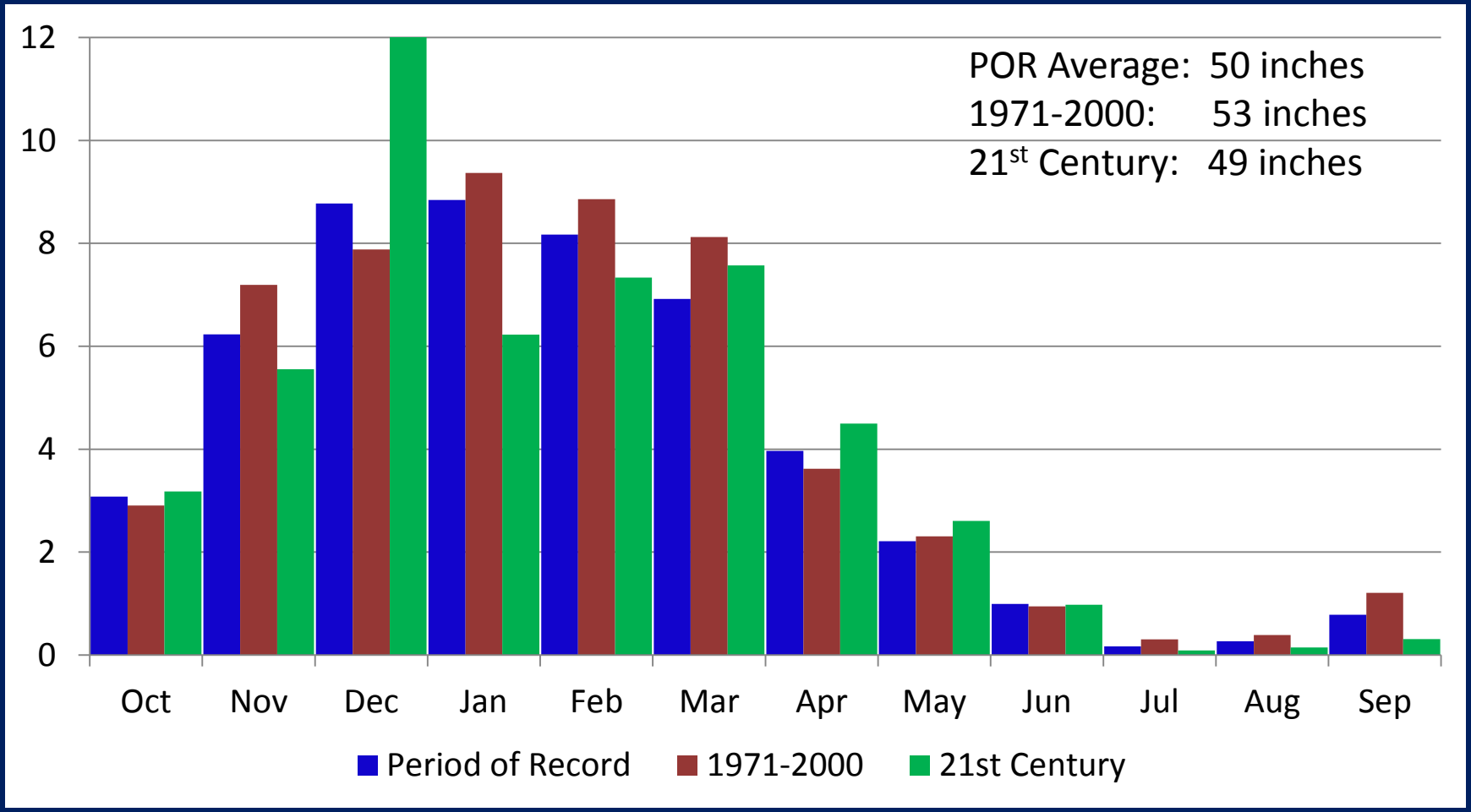
Annual Average: 50 inches
Maximum Year (1983): 88.5 inches
Minimum Year (1924): 17.1 inches
Period of Record 1921- Present

9 of 14 years of 21st Century below average

Average of:

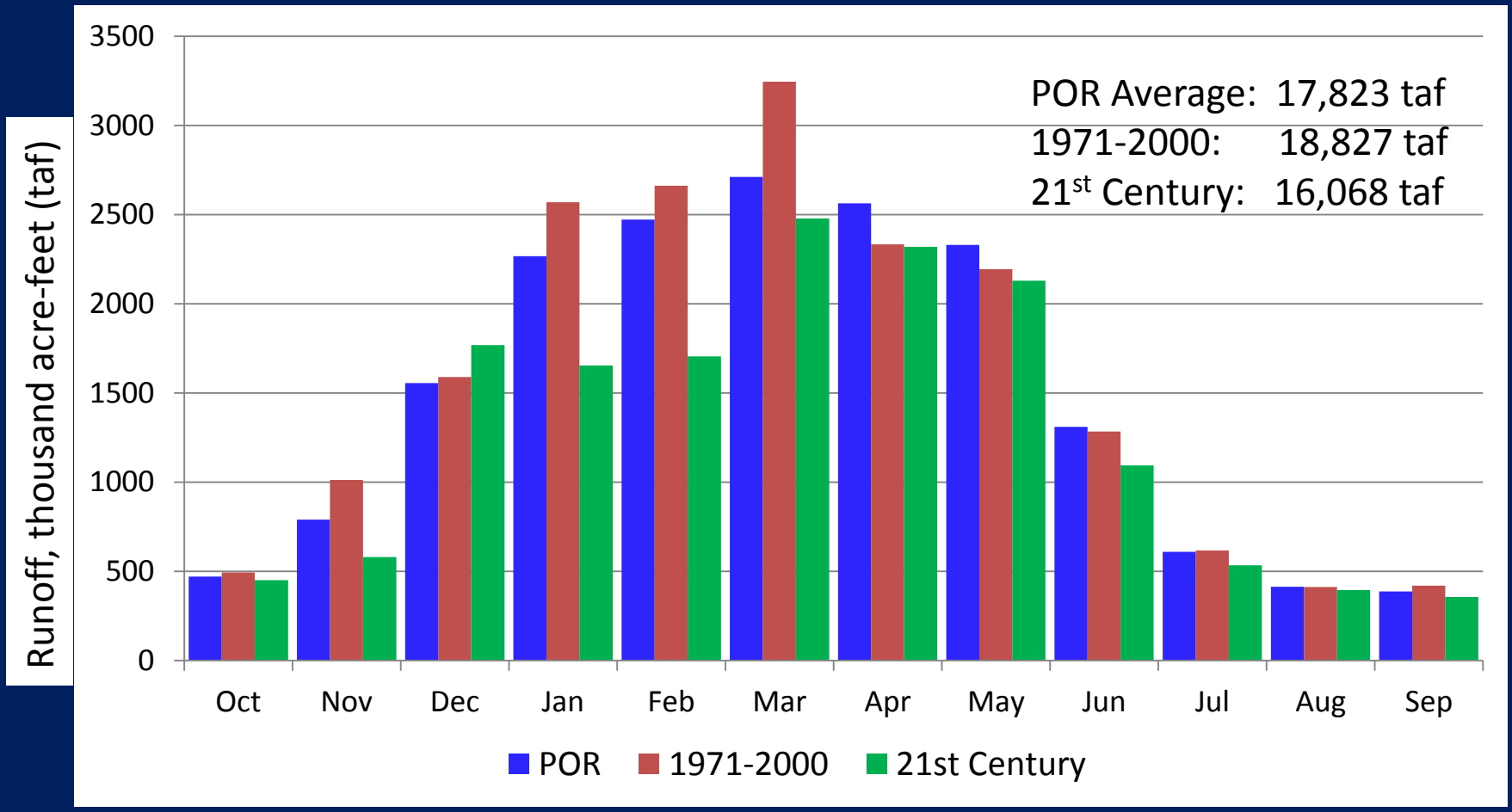
Mt. Shasta City	Quincy
Shasta Dam	Sierraville RS
Mineral	Pacific House
Brush Creek RS	Blue Canyon

21st Century Breakdown So Far – 8 Station Index

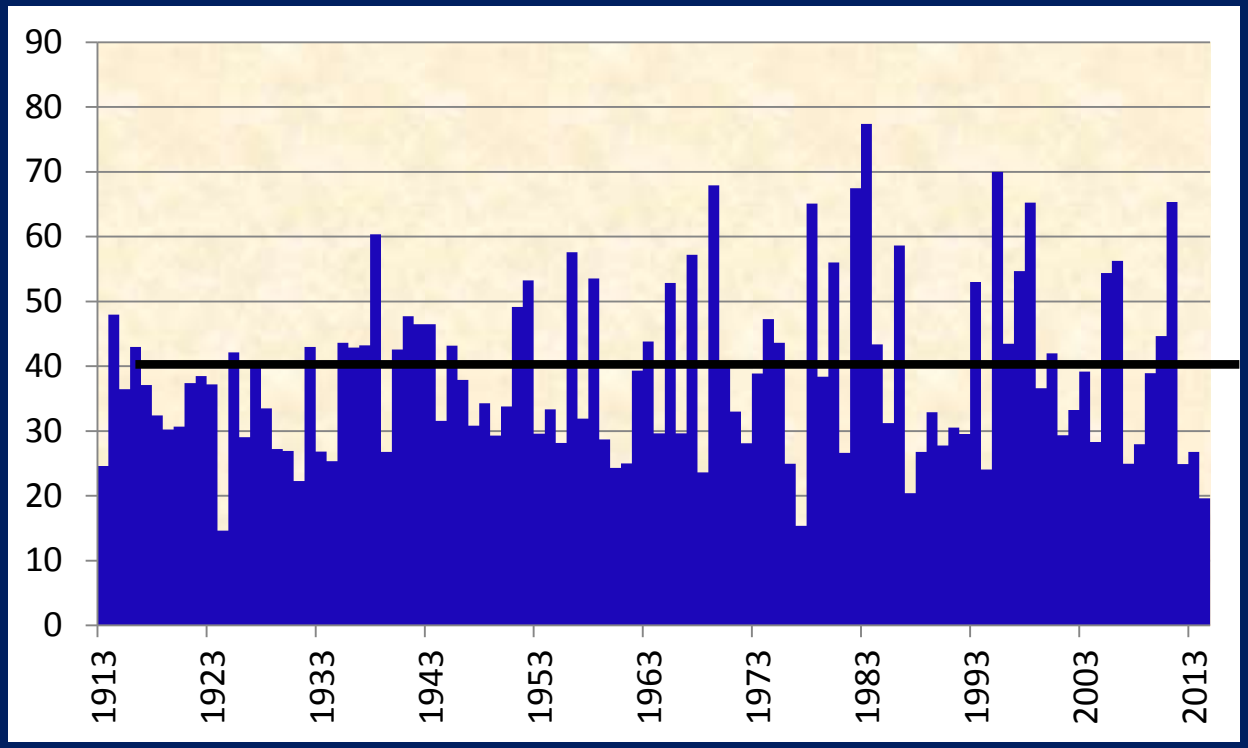


Note WY2012 was 3rd driest December (0.34”) and WY2014 was 4th driest (0.80”)

Sacramento River Runoff Distributions (Thousand Acre-Feet)



San Joaquin 5-Station Index

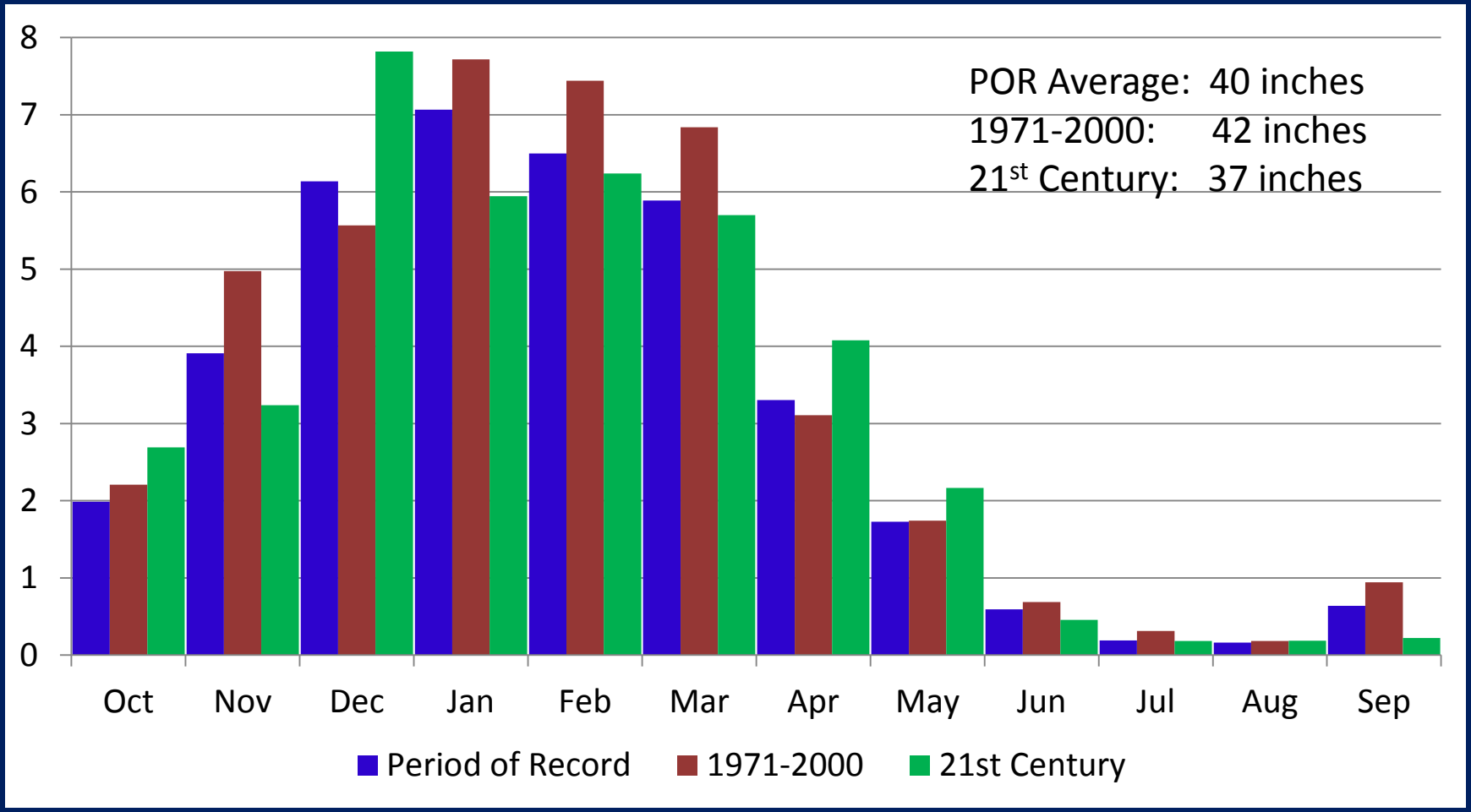


Annual Average: 40 inches
Maximum Year (1983) 77.4 inches
Minimum Year (1924) 14.8 inches
Period of Record 1913 - Present

10 of 14 years of 21st Century below average

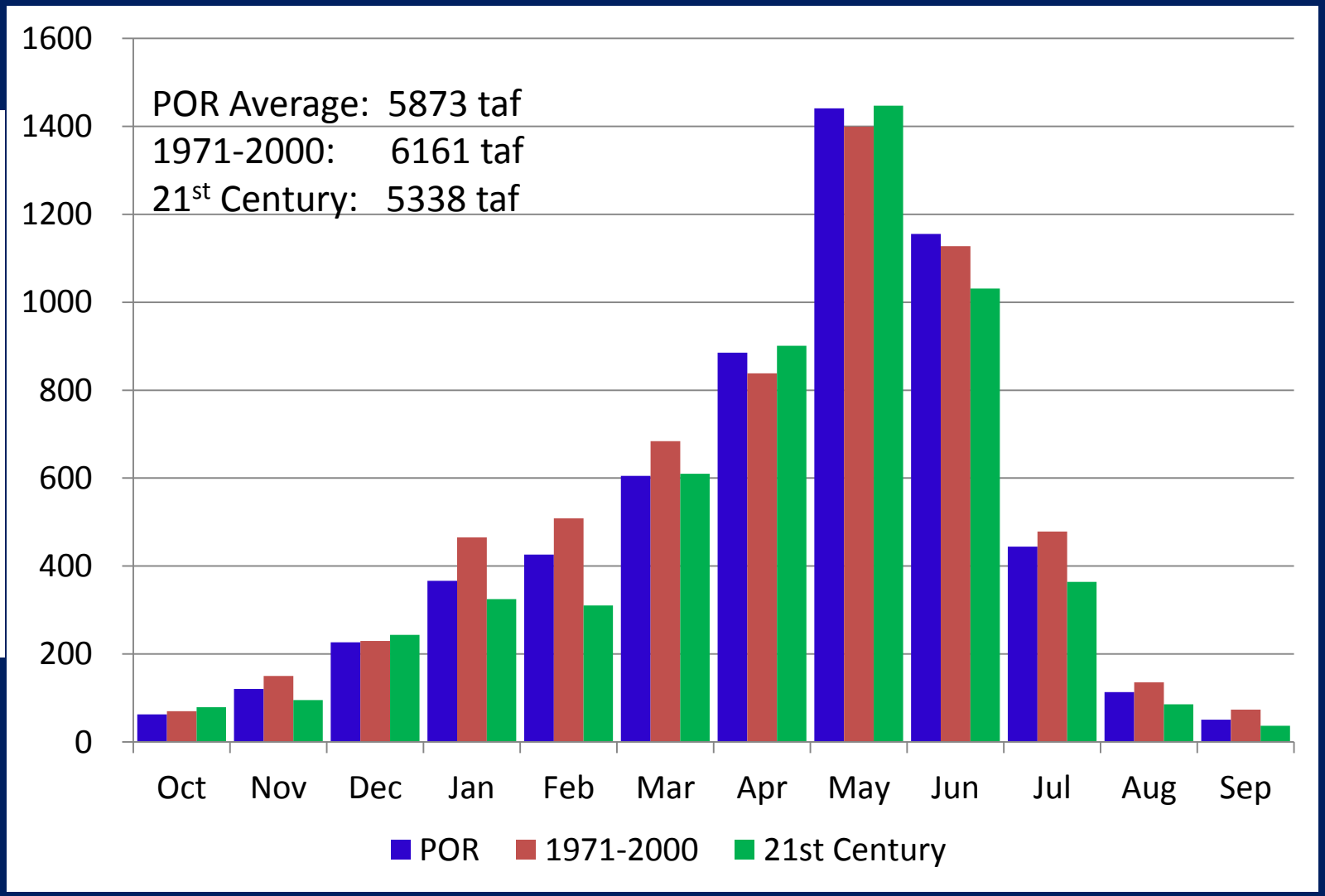
Average of:
Calaveras Big Trees
Hetch Hetchy
Yosemite HQ
North Fork Ranger Station
Huntington Lake

21st Century Breakdown So Far – 5 Station Index



Note WY2012 driest Dec (0”) and WY2014 10th driest (1.10”)

San Joaquin River Runoff Distributions (Thousand Acre-Feet (taf))



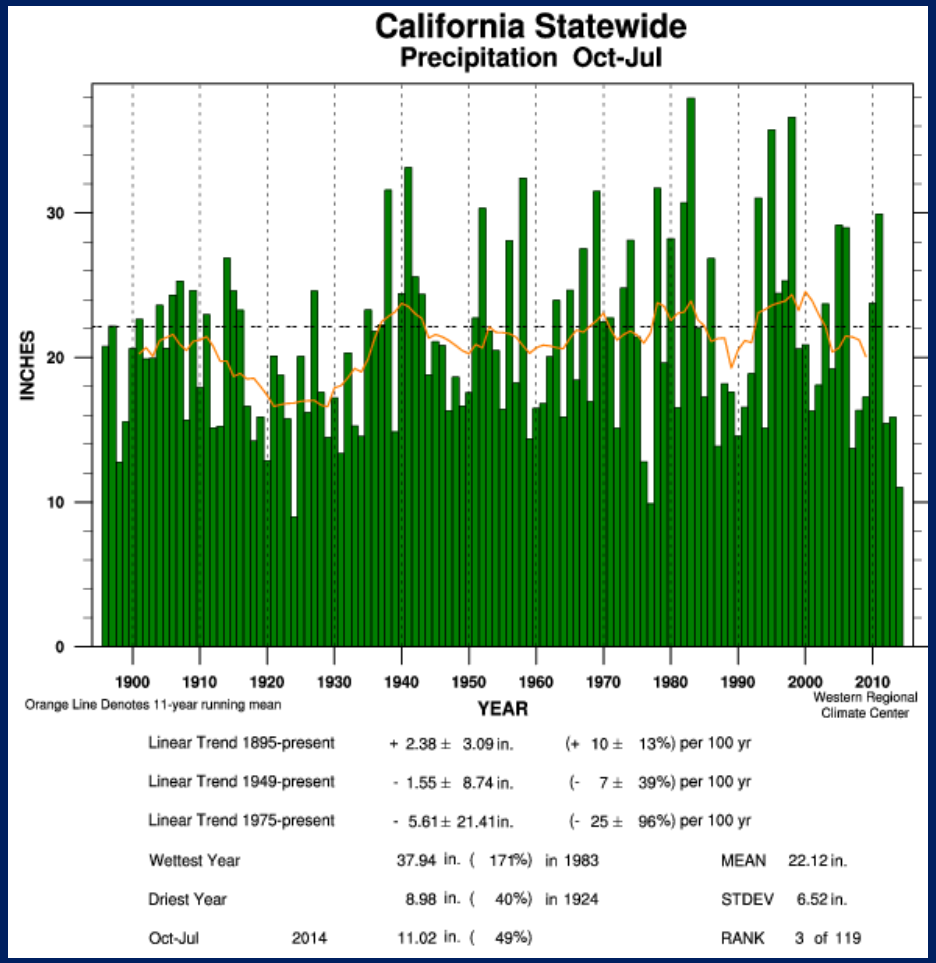

Climate Change
Tenaya Lake

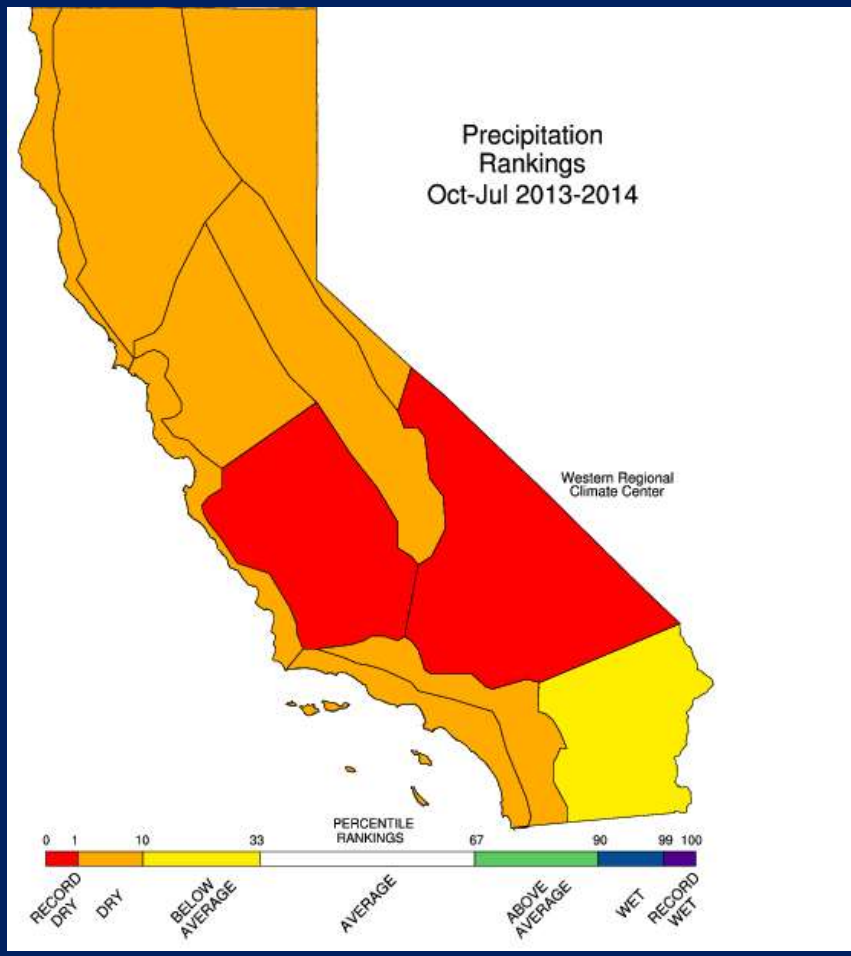
Climate Change Expectations

- Smaller Snowpack/More Rain Less Snow
- Earlier Snowmelt Onset
- More Variability
- More Extremes

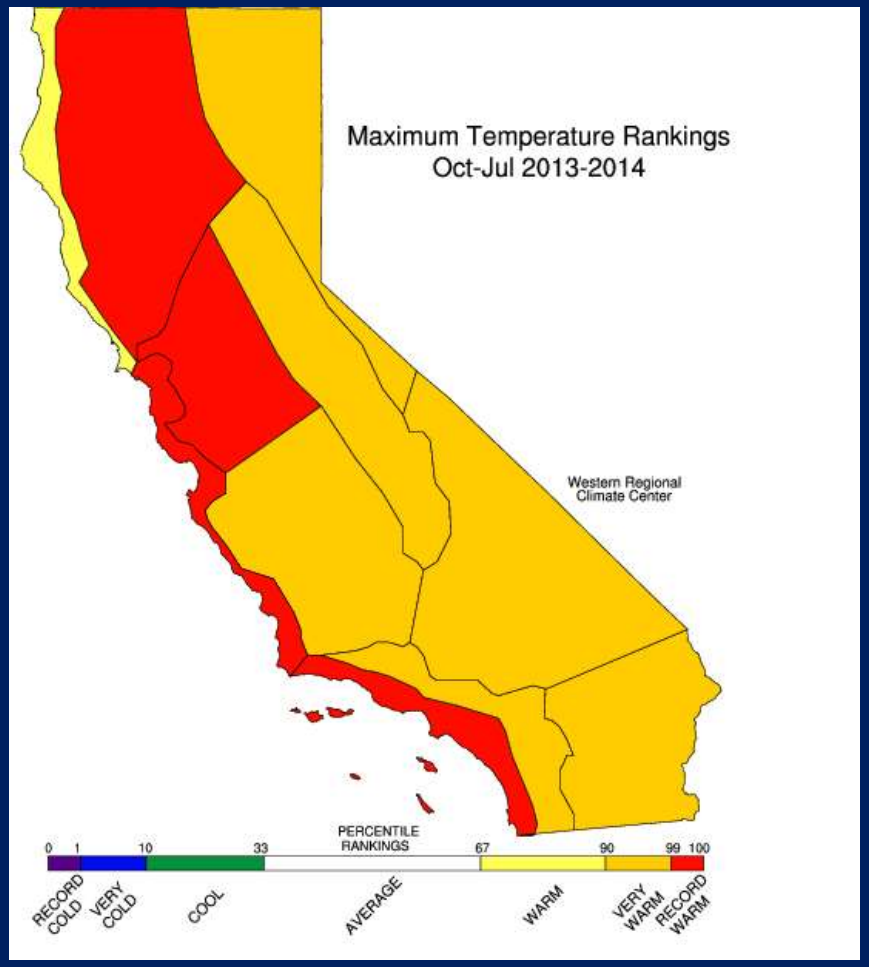
Are we seeing these already?

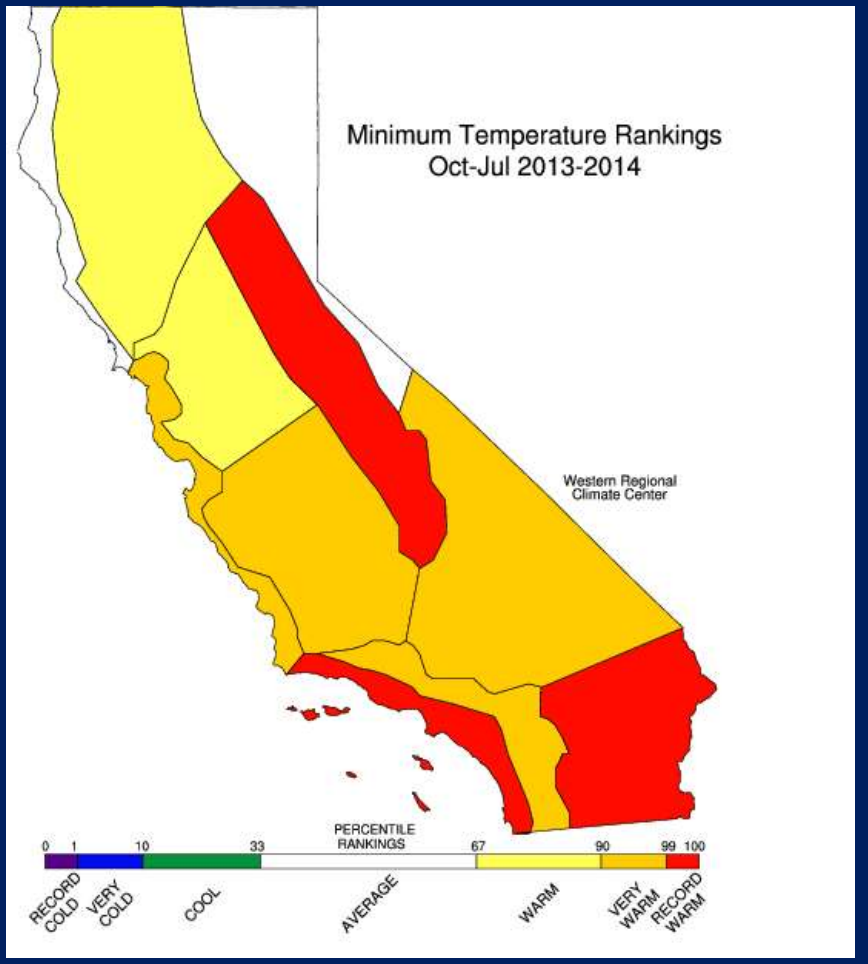
California Climate Tracker - WRCC



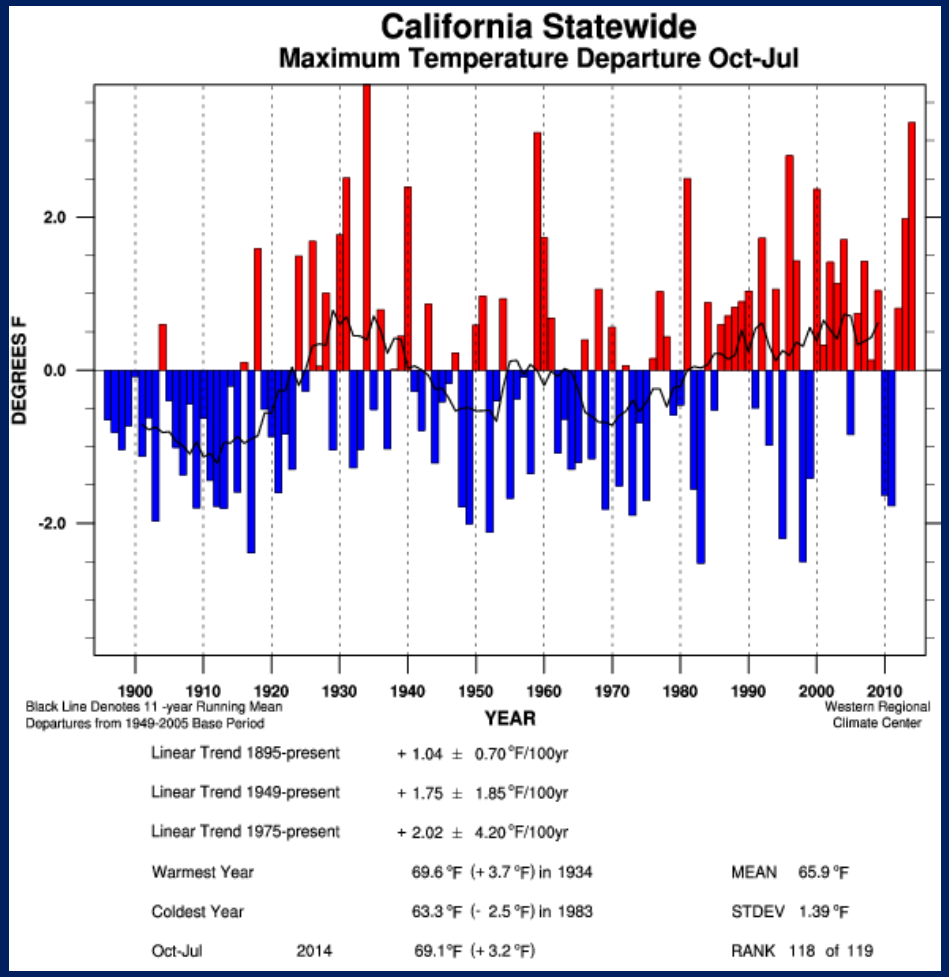


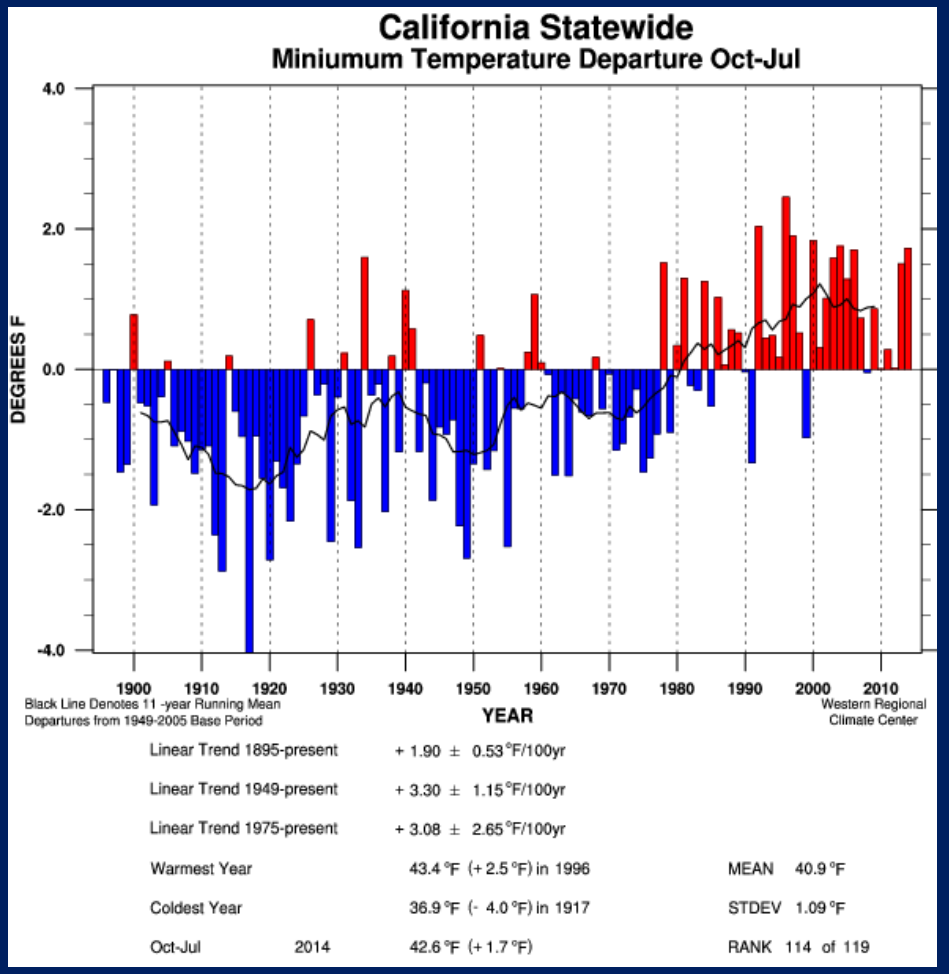
California Climate Tracker - WRCC



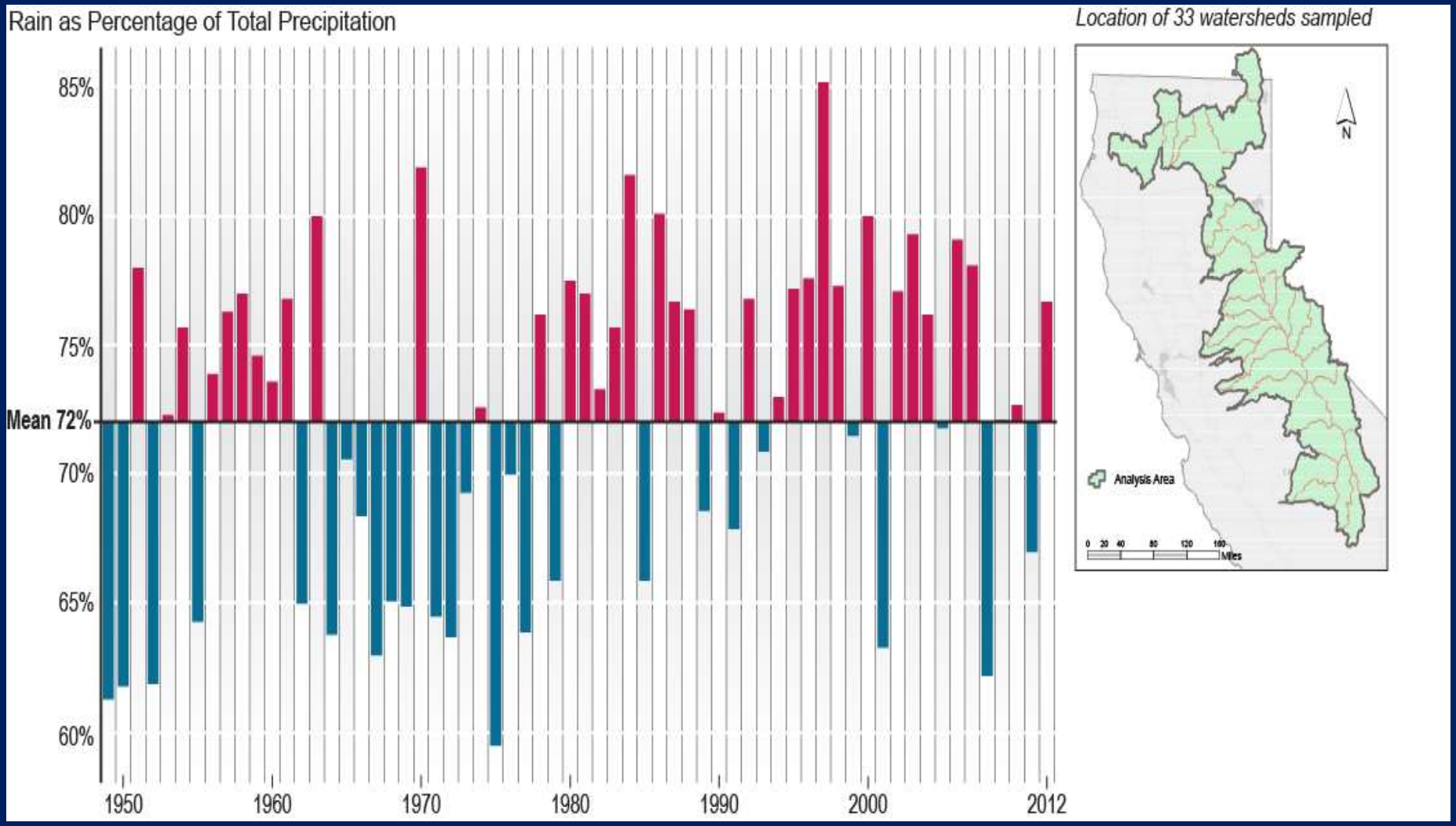


California Climate Tracker - WRCC





New Rain/Snow Metric for DWR



Credit: Aaron Cuthbertson, Elissa Lynn DWR
Kelly Redmond WRCC

Summarizing Thoughts

- Current drought along with 21st century droughts have shown record setting characteristics and are warmer than 20th century counterparts

- Atmospheric river events provide significant inputs into annual precipitation totals – fewer such events in drought years

Conclusions

- The expectation of increased variability means new extremes and extreme transitions with WY 2013 serving as an example.

- Planning for future droughts can take advantage of information in the historical record including paleo reconstructions. The trick will be to increase our understanding of causal mechanisms and watershed condition/response.


Questions?
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