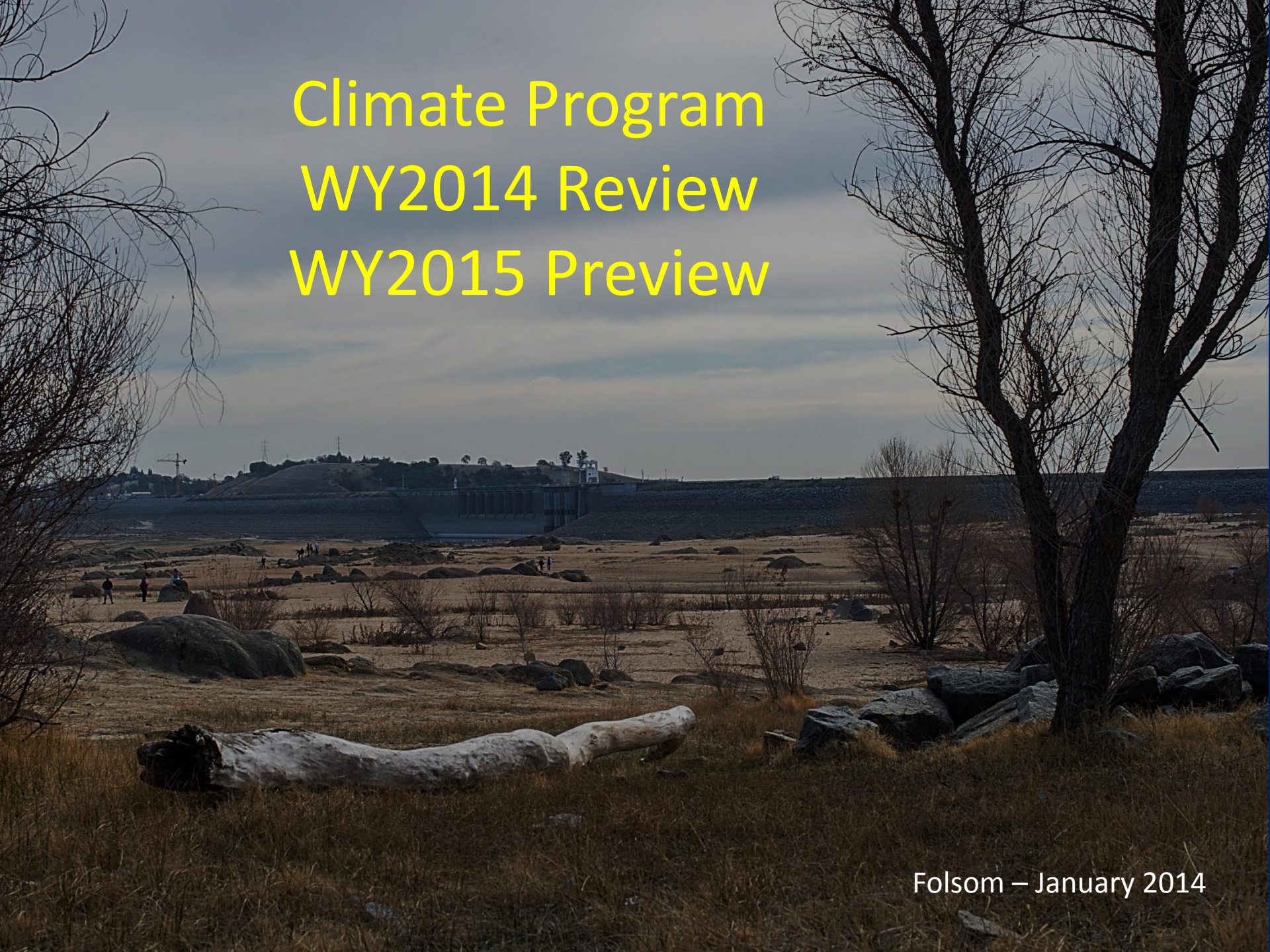
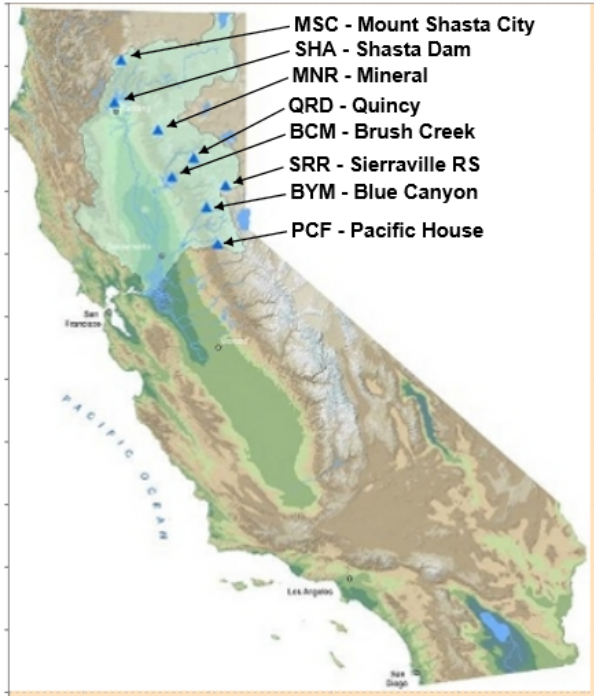

Climate Program
WY2014 Review
WY2015 Preview
Folsom – January 2014

Overview

- WY2014 in Review
- Drought Perspectives and Program Activities
- El Nino and Looking ahead to WY2015

Northern Sierra Precipitation: 8-Station Index, September 30, 2014



Percent of Average for this Date: 63%

1982-1983 (wettest) 88.5

2005-2006 Daily Precip. 80.1

Average (1922-1998) 50.0

2012-2013 Daily Precip. 44.3

Current Daily Precip: 31.3

1923-1924 (driest) 17.1

1976-1977 (2nd driest & driest thru Aug) 19.0

Cumulative Daily/Monthly Precipitation (inches)

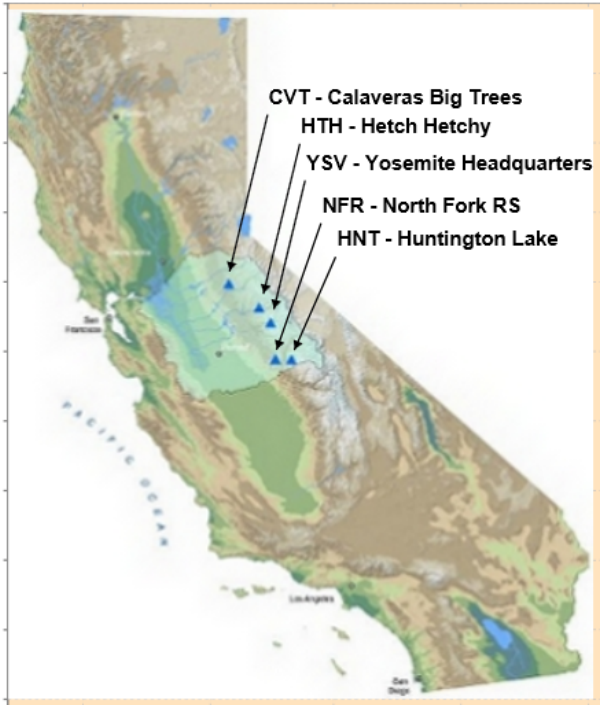
Total Water Year Precipitation

Water Year (October 1 - September 30)

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

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

San Joaquin Precipitation: 5-Station Index, September 30, 2014



Percent of Average for this Date: 50%

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: 20.4

1976-1977 15.4

1923-1924 (driest) 14.8

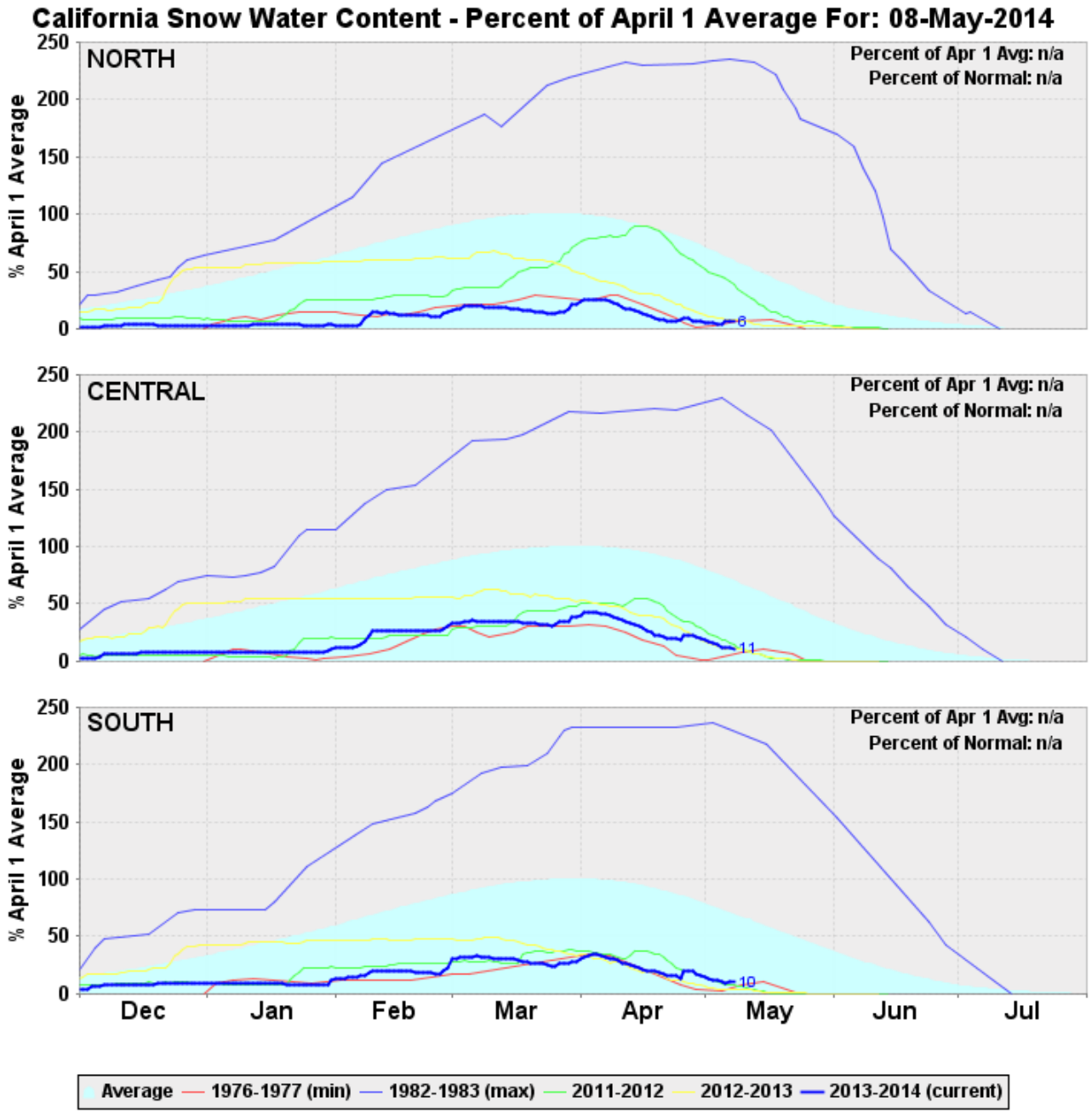
Cumulative Daily/Monthly Precipitation (inches)

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

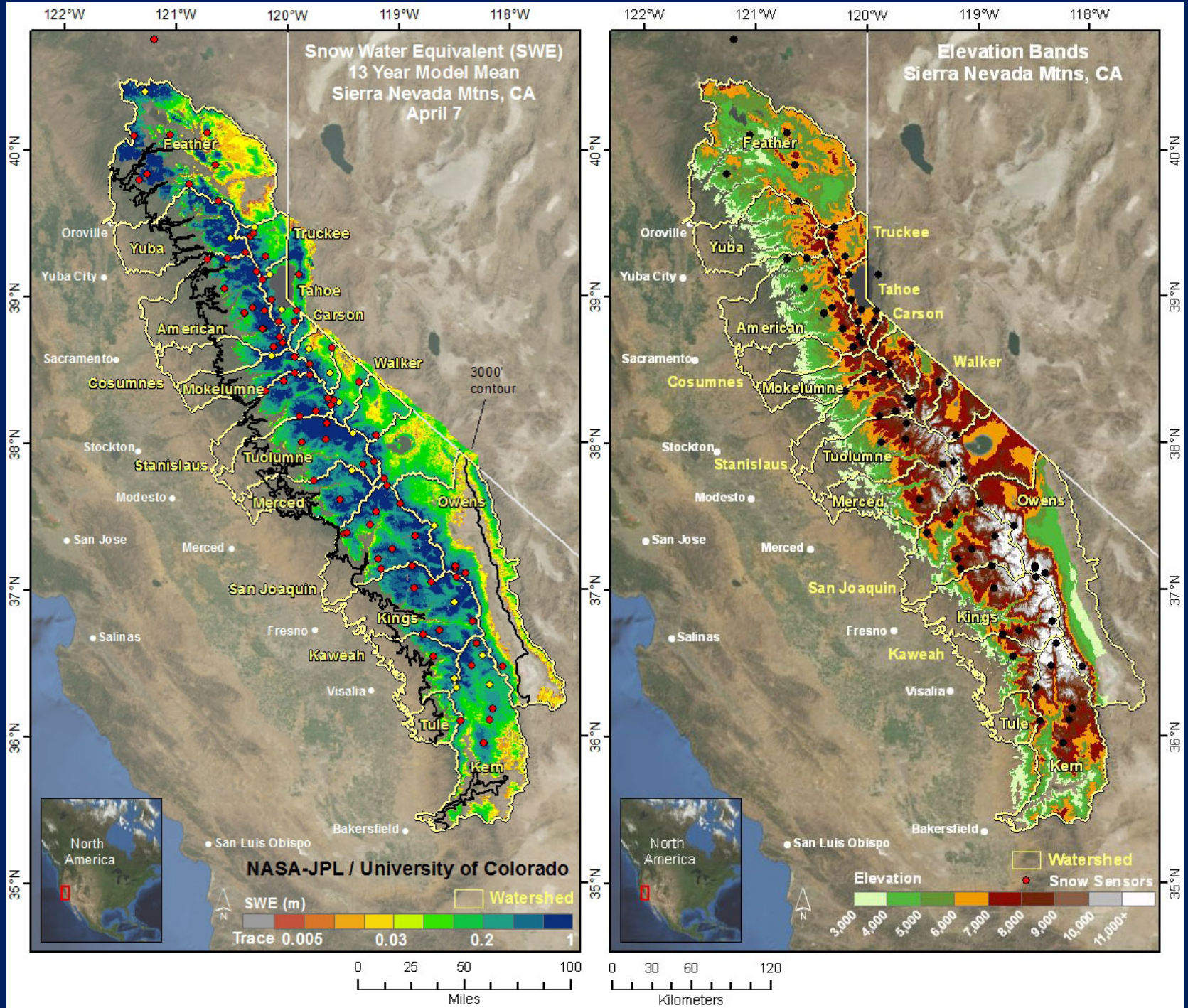
Oct 1 Nov 1 Dec 1 Jan 1 Feb 1 Mar 1 Apr 1 May 1 Jun 1 Jul 1 Aug 1 Sep 1 Oct 1

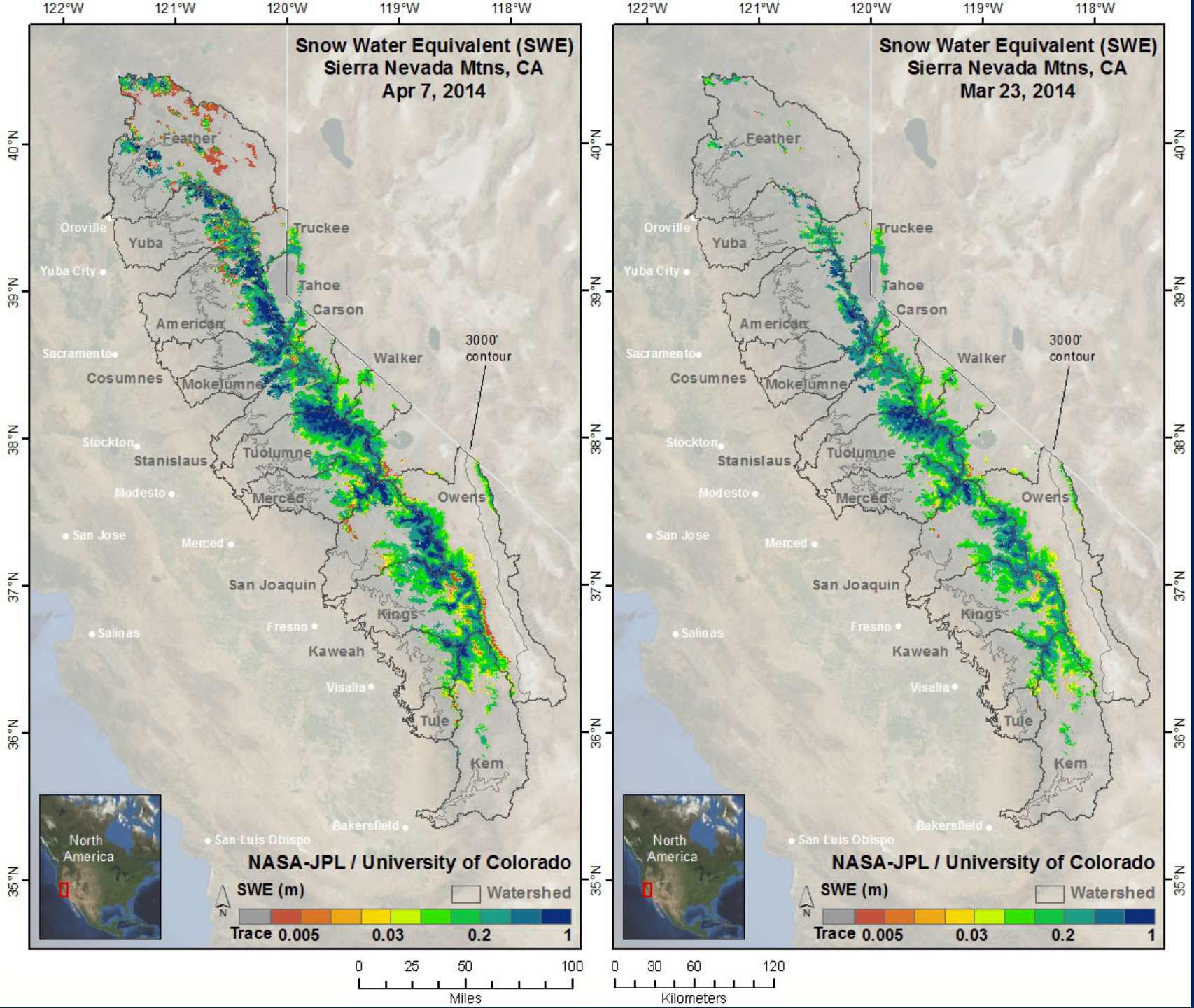
Water Year (October 1 - September 30)

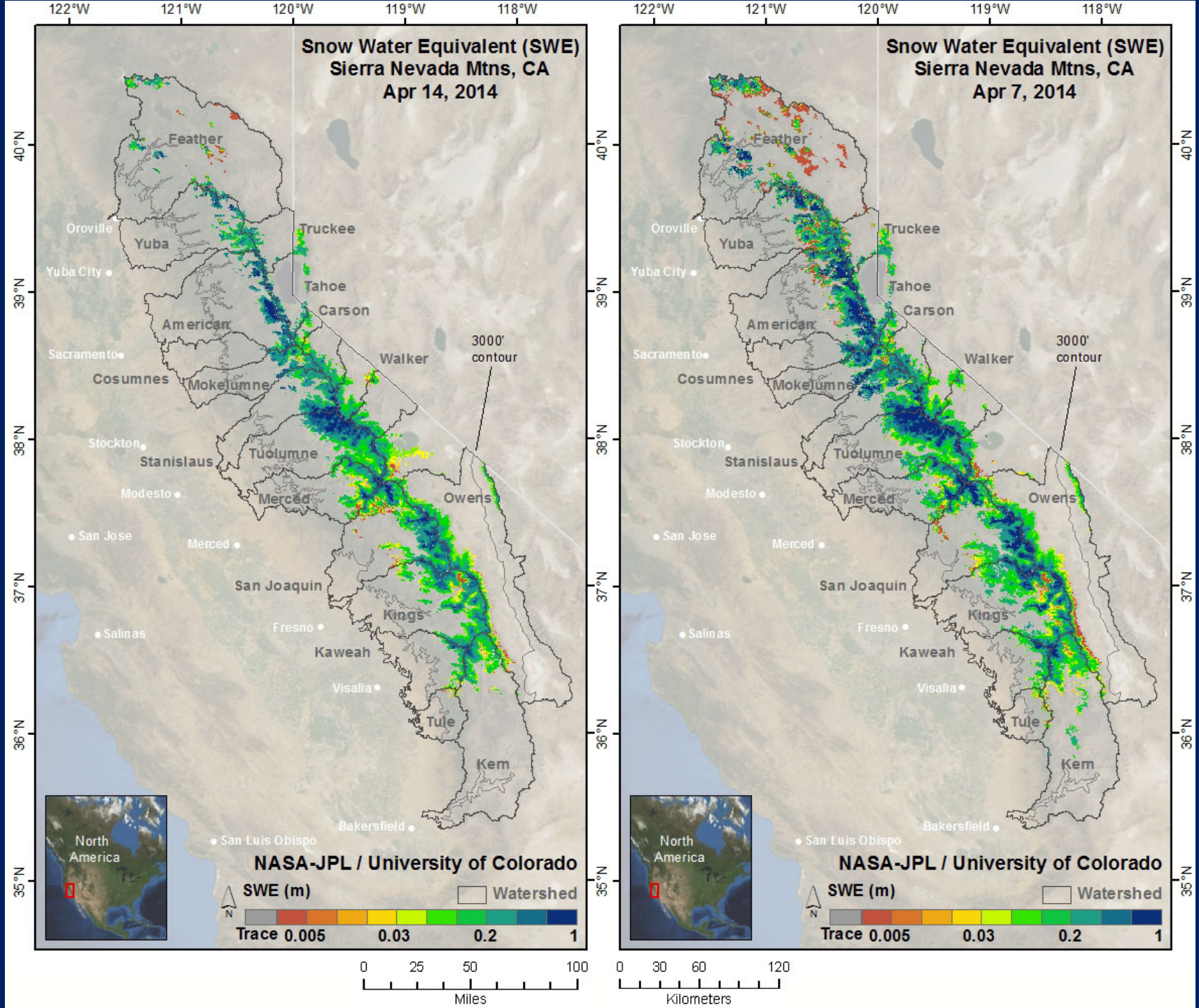
Total Water Year Precipitation

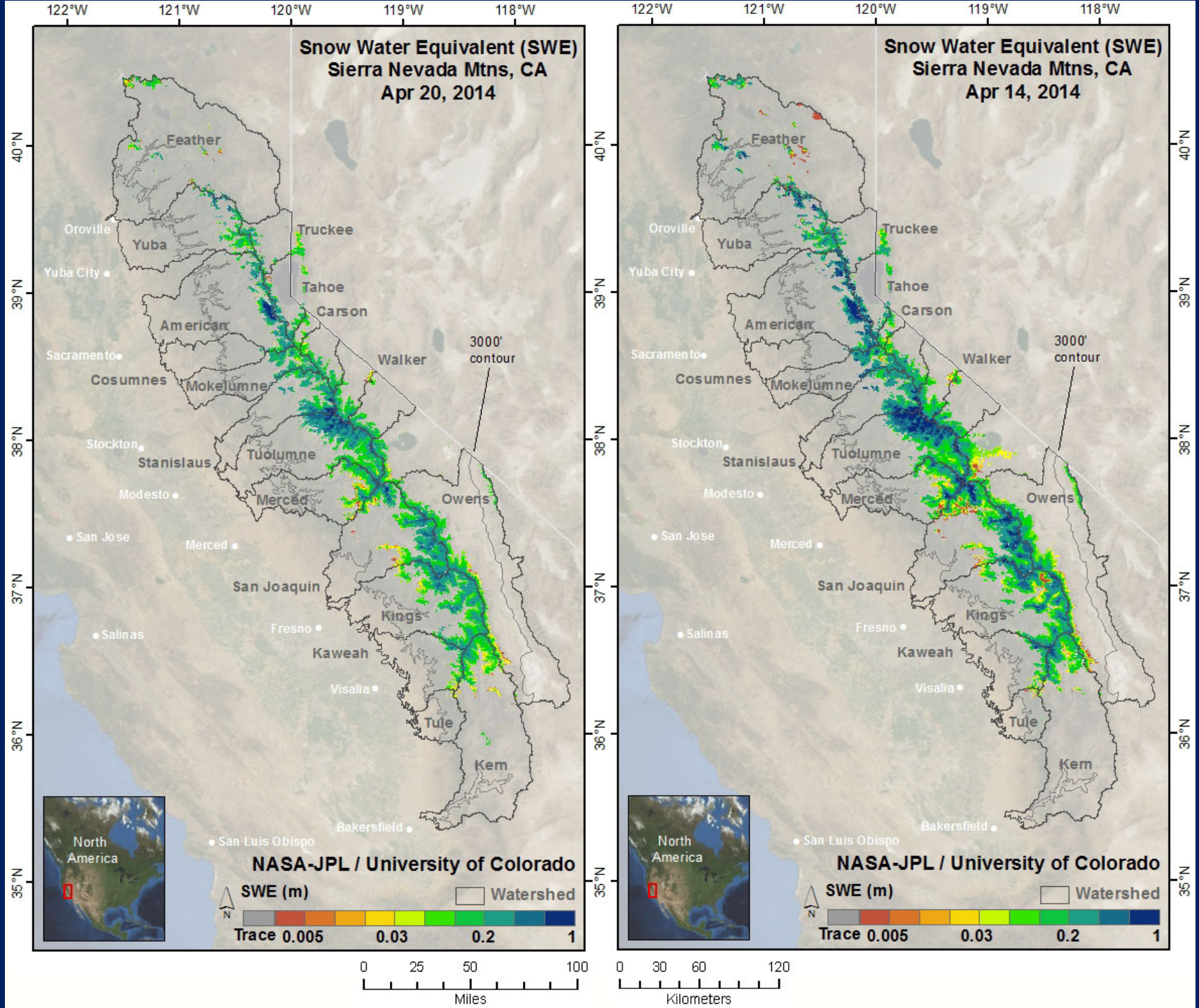


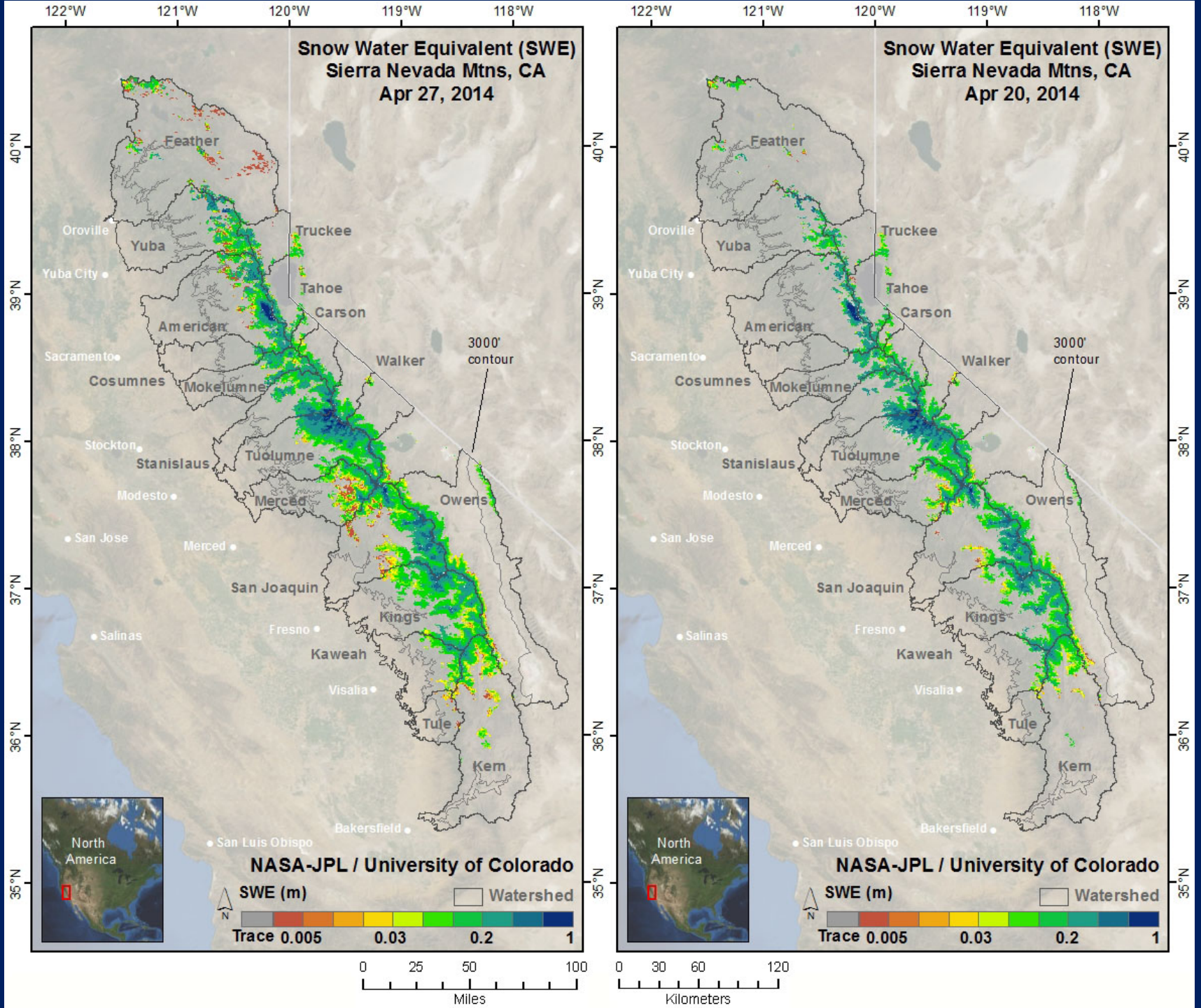
AJ Runoff
Sacramento
2012 5.5MAF
2013 3.0 MAF
2014 2.6 MAF
Avg: 6MAF

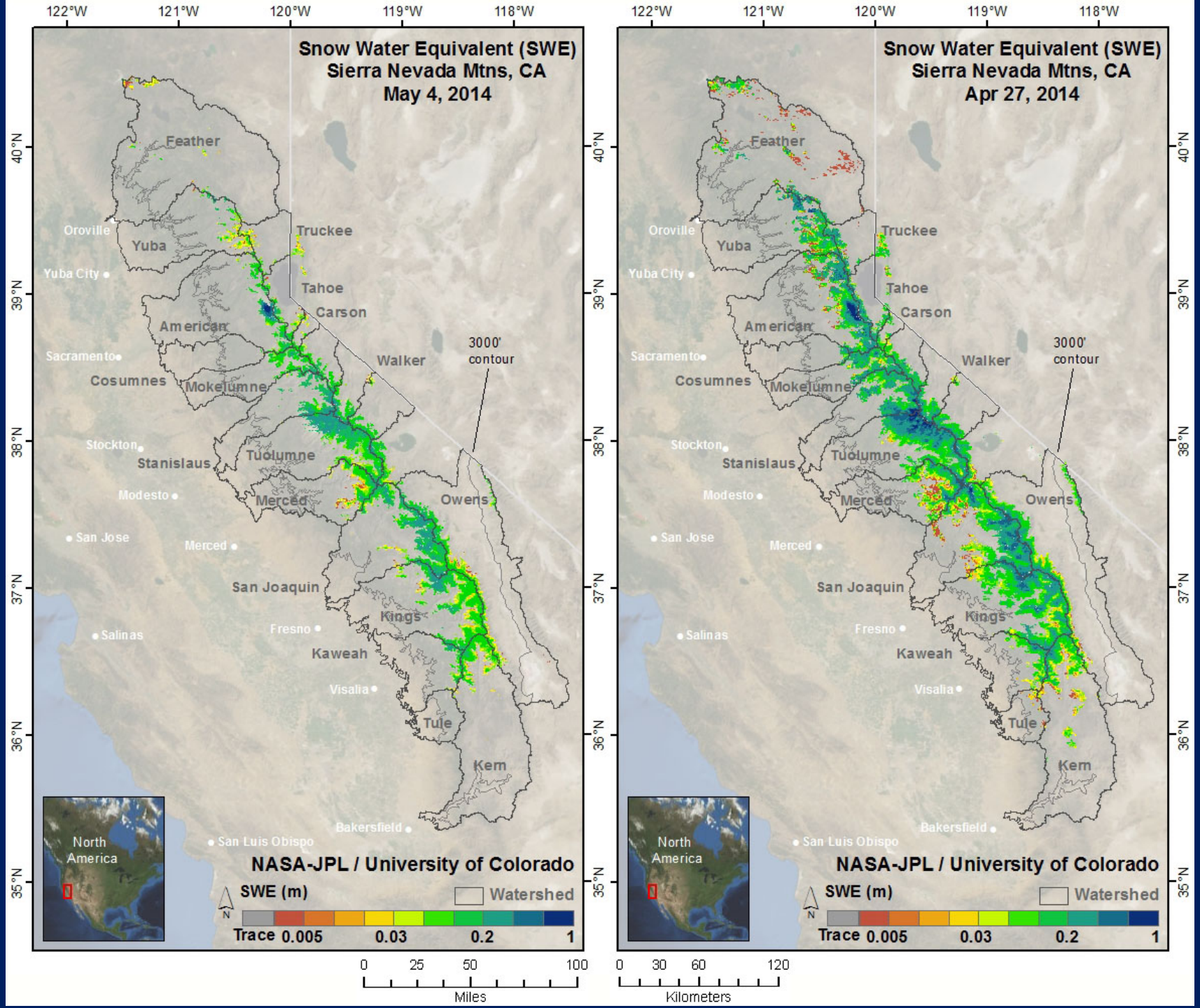

Snow Water Equivalent (SWE)
13 Year Model Mean
Sierra Nevada Mtns, CA
April 7
Elevation Bands
Sierra Nevada Mtns, CA
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Walker
Cosumnes
Mokelumne
3000' contour
Stockton
Stanislaus
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
Elevation
Snow Sensors
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000+
0
25
50
100
Miles
0
30
60
120
Kilometers

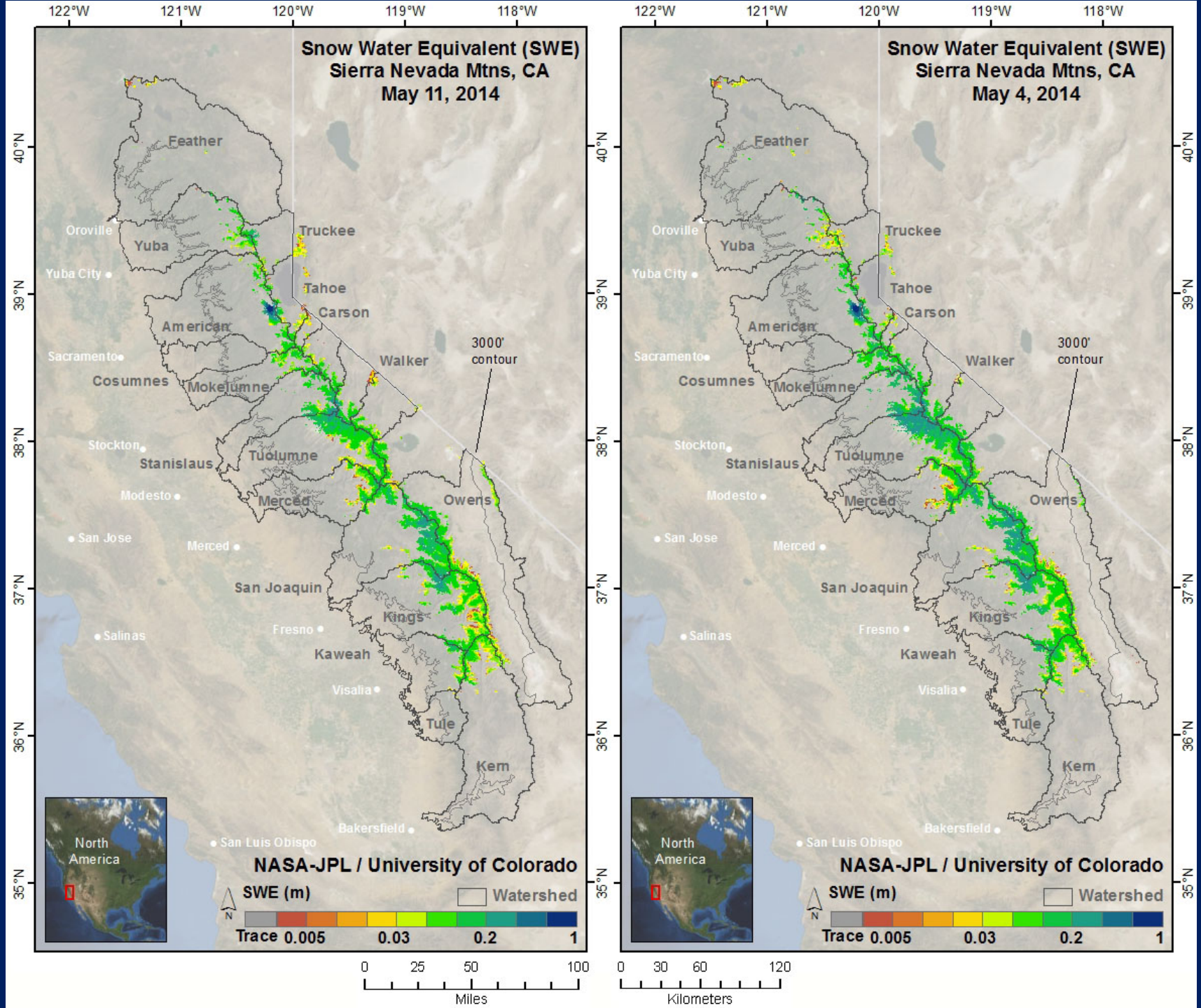

Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
Apr 7, 2014
Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
Mar 23, 2014
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Walker
3000' contour
Cosumnes
Mokelumne
Stockton
Stanislaus
Tuolumne
Modesto
Merced
Owens
San Jose
Merced
San Joaquin
Kings
Fresno
Salinas
Kaweah
Visalia
Tule
Kern
Bakersfield
San Luis Obispo
North America
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

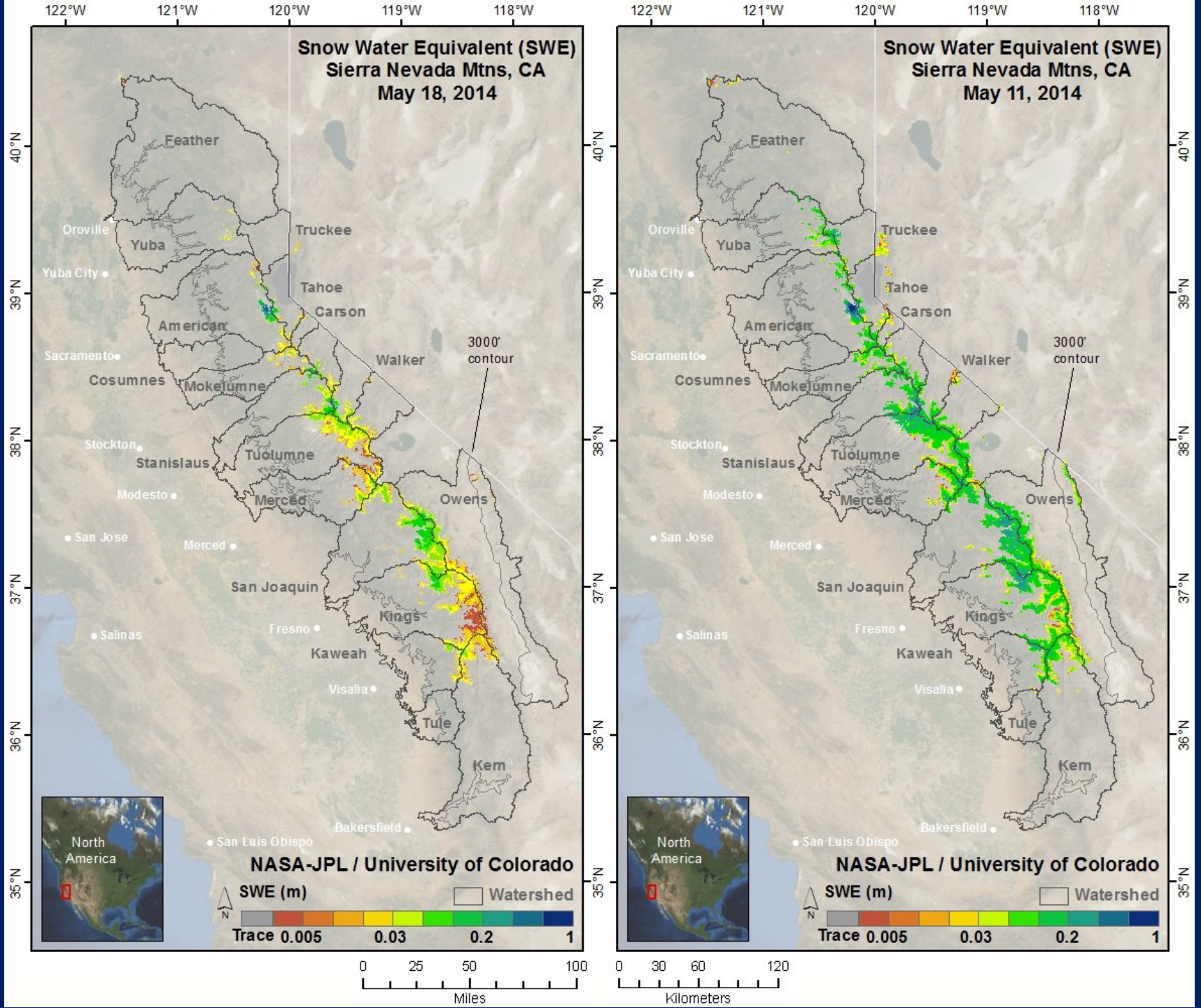

Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
Apr 14, 2014
Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
Apr 7, 2014
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Cosumnes
Mokelumne
Walker
3000' contour
Stockton
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

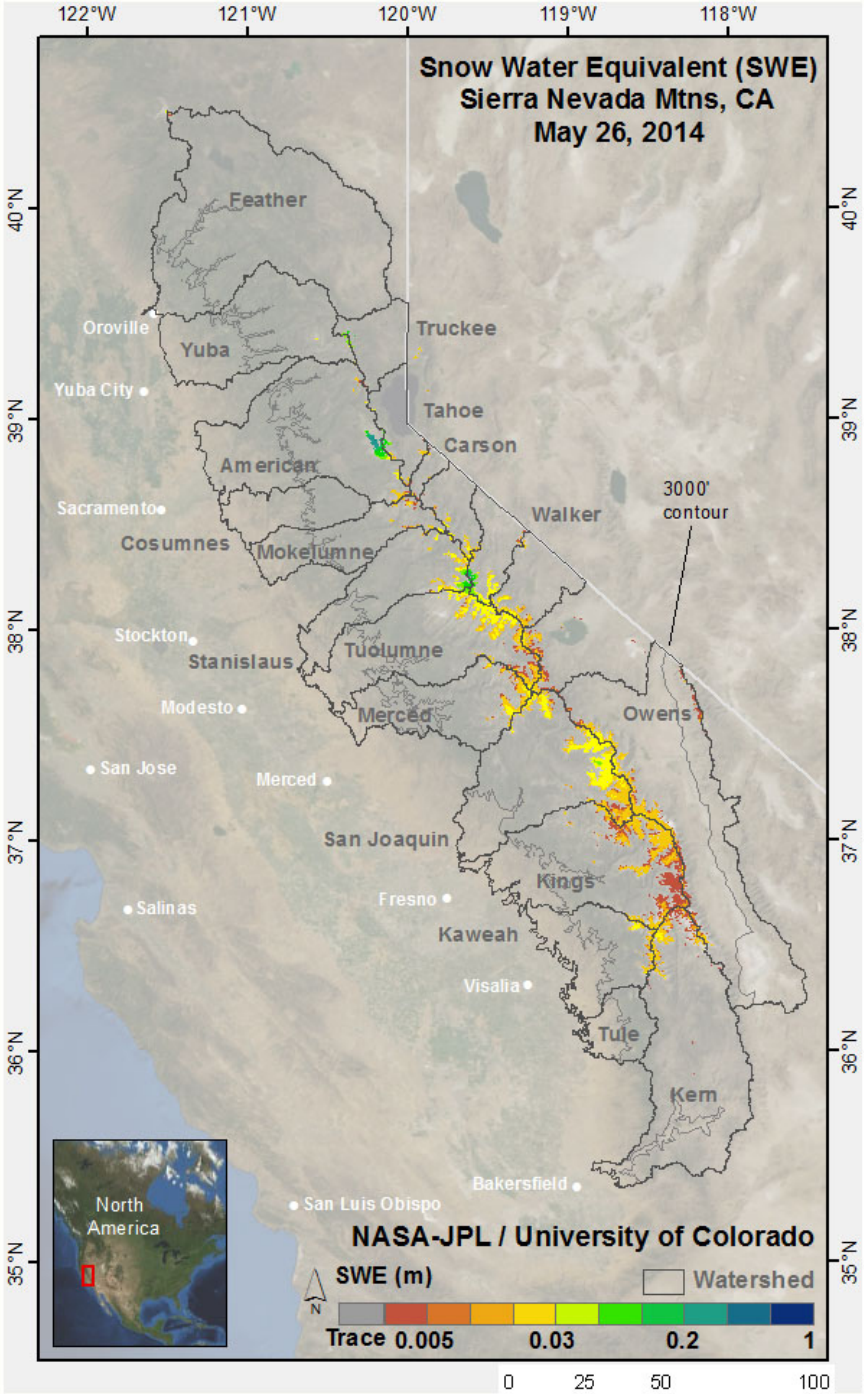

Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
Apr 20, 2014
Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
Apr 14, 2014
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Walker
3000' contour
Cosumnes
Mokelumne
Stockton
Stanislaus
Tuolumne
Modesto
Merced
Owens
San Jose
Merced
San Joaquin
Kings
Fresno
Salinas
Kaweah
Visalia
Tule
Kern
Bakersfield
San Luis Obispo
North America
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

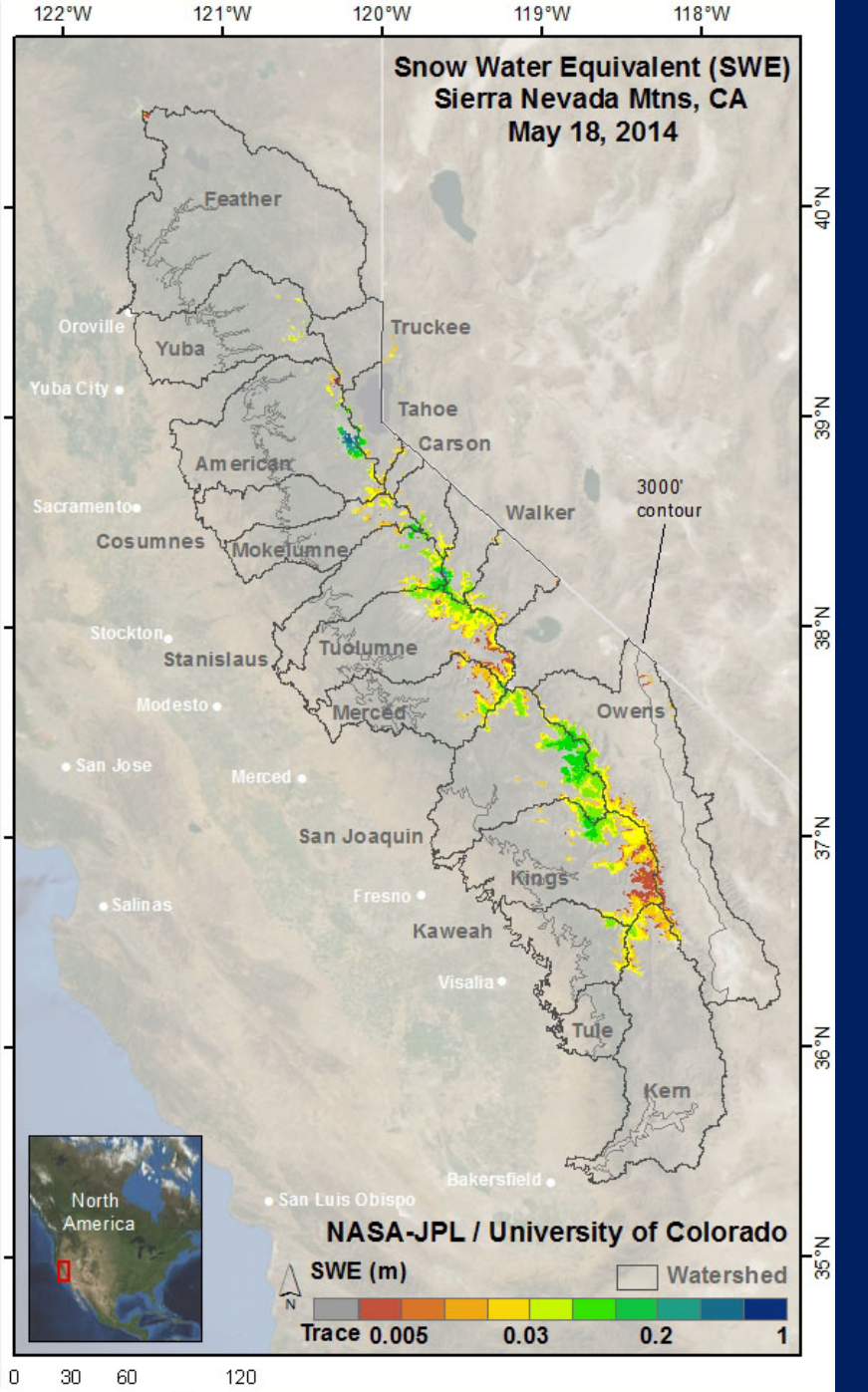

Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
Apr 27, 2014
Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
Apr 20, 2014
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Cosumnes
Mokelumne
Walker
3000' contour
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

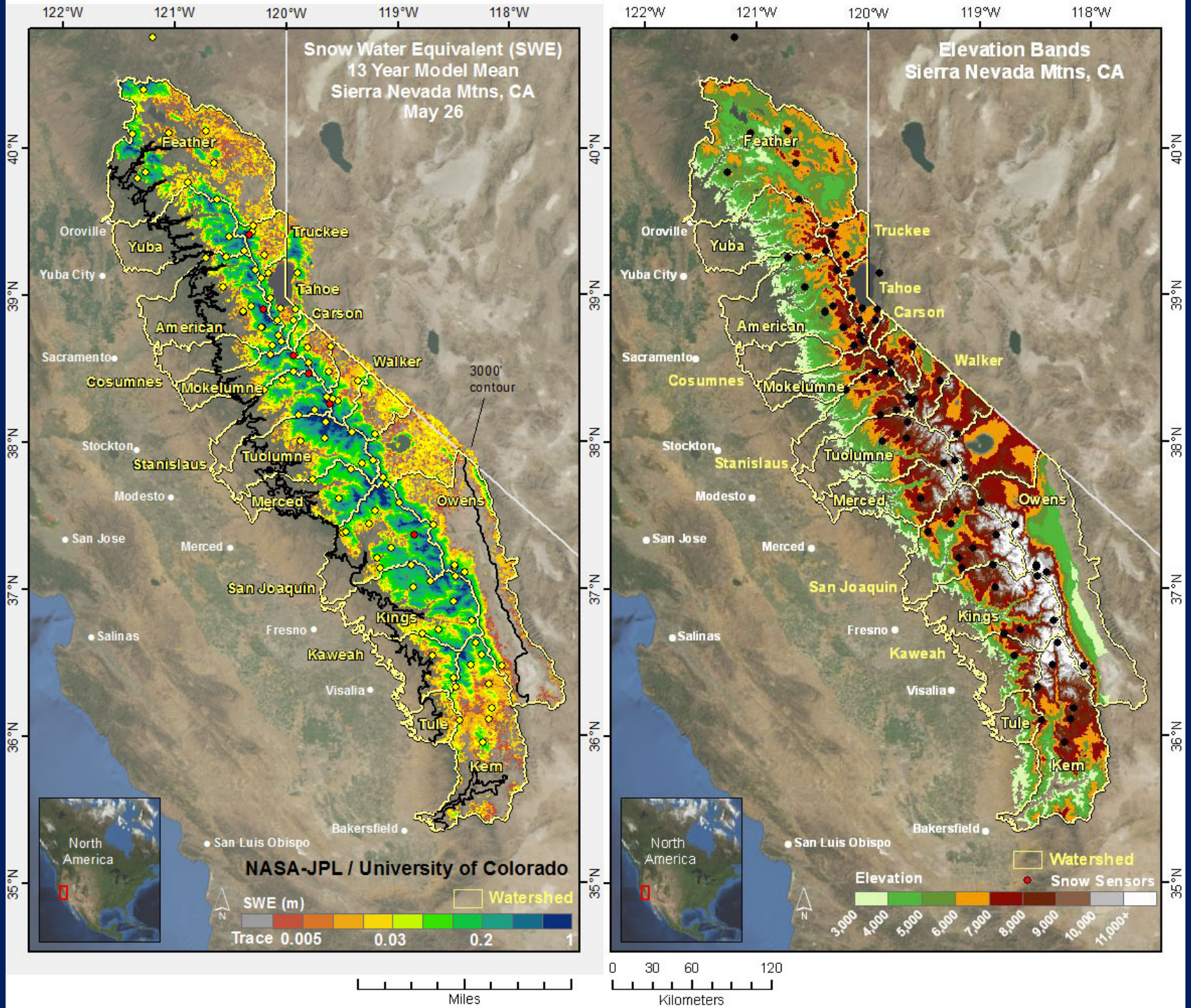

Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
May 4, 2014
Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
Apr 27, 2014
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Walker
3000' contour
Cosumnes
Mokelumne
Stockton
Stanislaus
Tuolumne
Modesto
Merced
Owens
San Jose
Merced
San Joaquin
Kings
Fresno
Salinas
Kaweah
Visalia
Tule
Kern
Bakersfield
San Luis Obispo
North America
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


Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
May 11, 2014
Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
May 4, 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
Walker
3000' contour
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
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

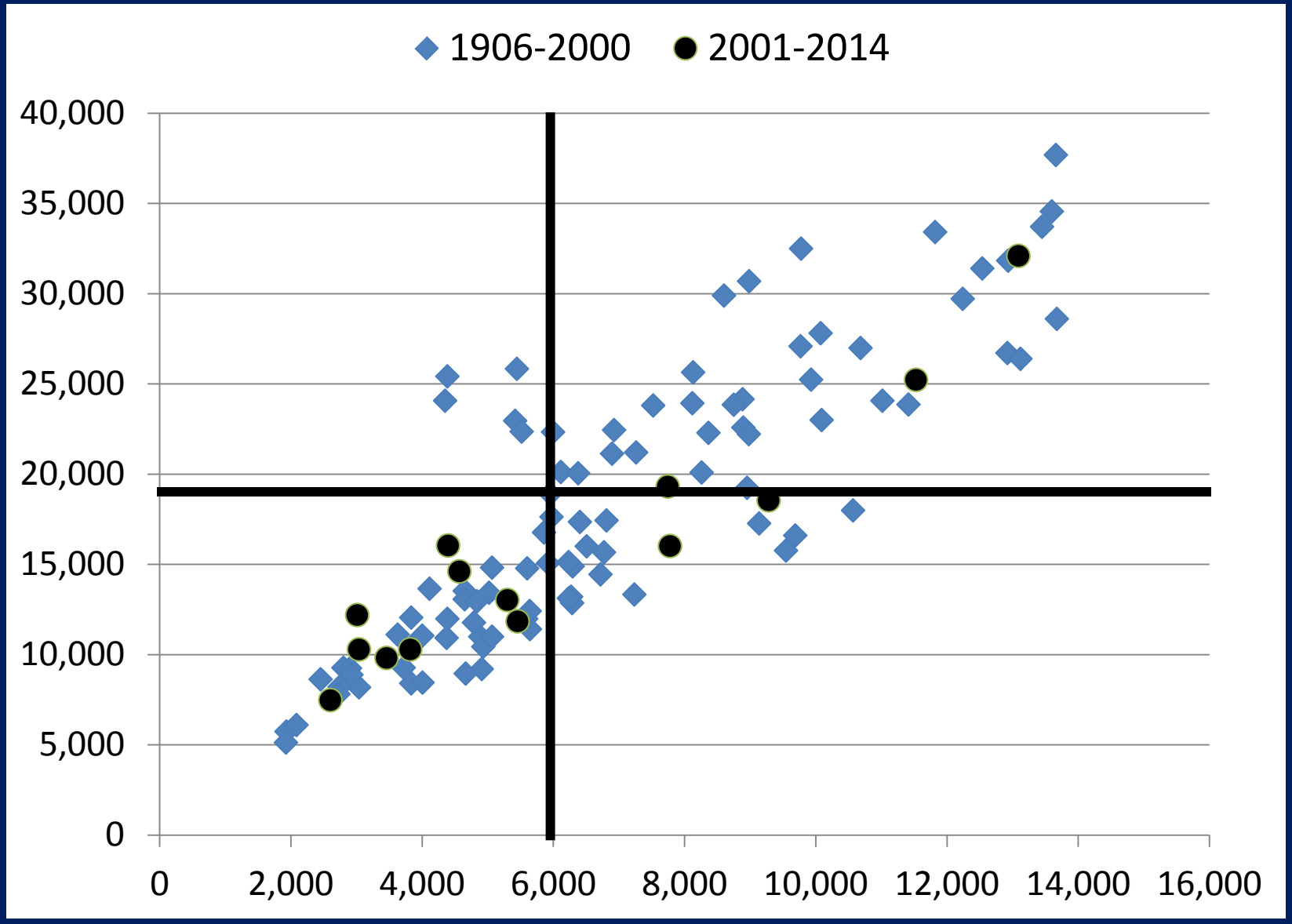

Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
May 18, 2014
Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
May 11, 2014
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Walker
3000' contour
Cosumnes
Mokelumne
Stockton
Stanislaus
Tuolumne
Modesto
Merced
Owens
San Jose
Merced
San Joaquin
Kings
Fresno
Salinas
Kaweah
Visalia
Tule
Kern
Bakersfield
San Luis Obispo
North America
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


Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
May 26, 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
Walker
3000' contour
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
NASA-JPL / University of Colorado
SWE (m)
Watershed
Trace
0.005
0.03
0.2
1
0
25
50
100
Miles

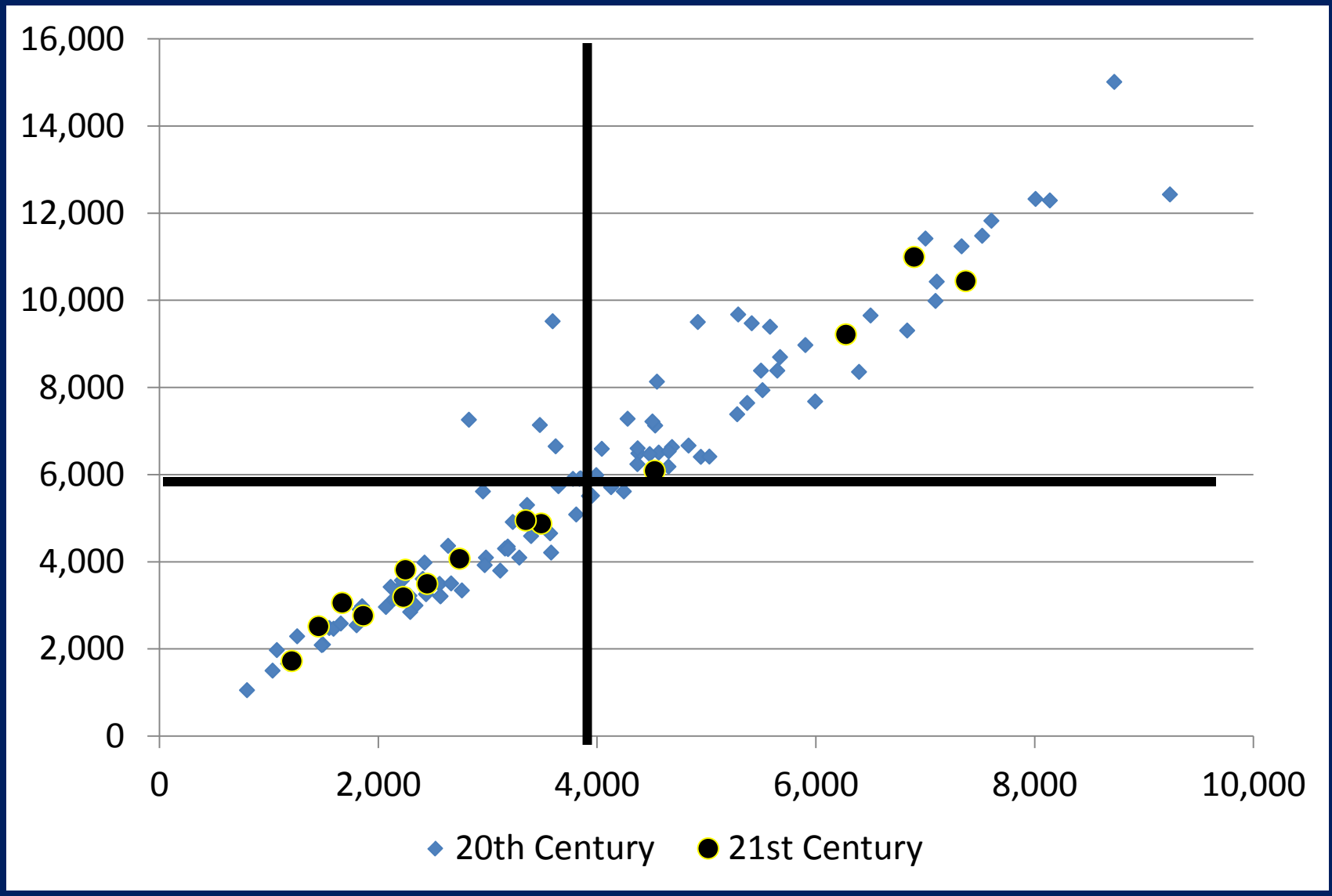

Snow Water Equivalent (SWE)
Sierra Nevada Mtns, CA
May 18, 2014
122°W
121°W
120°W
119°W
118°W
40°N
39°N
38°N
37°N
36°N
35°N
Feather
Oroville
Yuba
Yuba City
Truckee
Tahoe
Carson
American
Sacramento
Walker
3000' contour
Cosumnes
Mokelumne
Stockton
Stanislaus
Tuolumne
Modesto
Merced
Owens
San Jose
Merced
San Joaquin
Kings
Fresno
Salinas
Kaweah
Visalia
Tule
Kern
Bakersfield
San Luis Obispo
North America
NASA-JPL / University of Colorado
SWE (m)
Watershed
Trace
0.005
0.03
0.2
1
0
30
60
120
Kilometers


Snow Water Equivalent (SWE)
13 Year Model Mean
Sierra Nevada Mtns, CA
May 26
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
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
Elevation
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000+
Snow Sensors
0
30
60
120
Miles
Kilometers

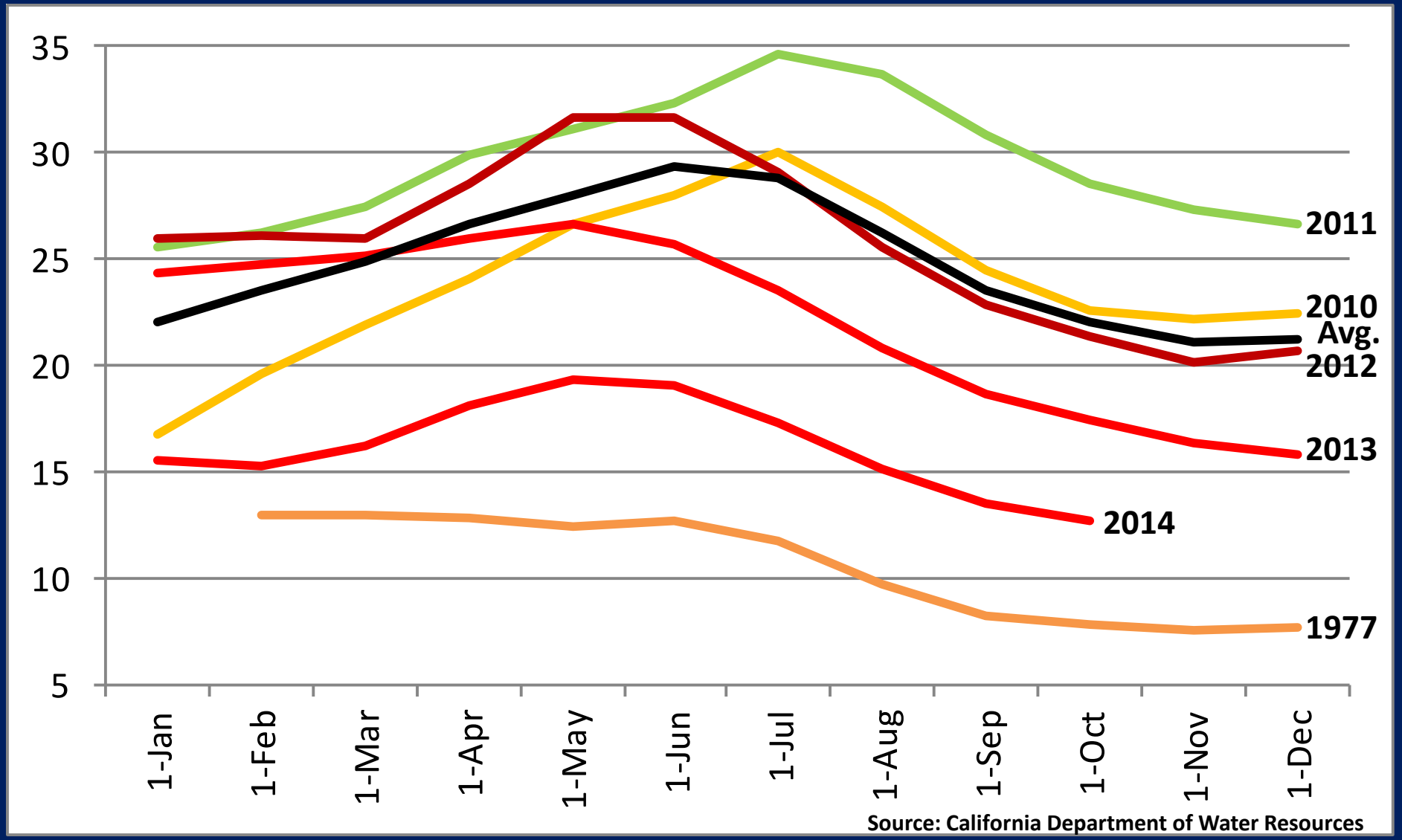
Sacramento River AJ versus WY Runoff Volumes



San Joaquin River AJ versus WY Runoff Volumes



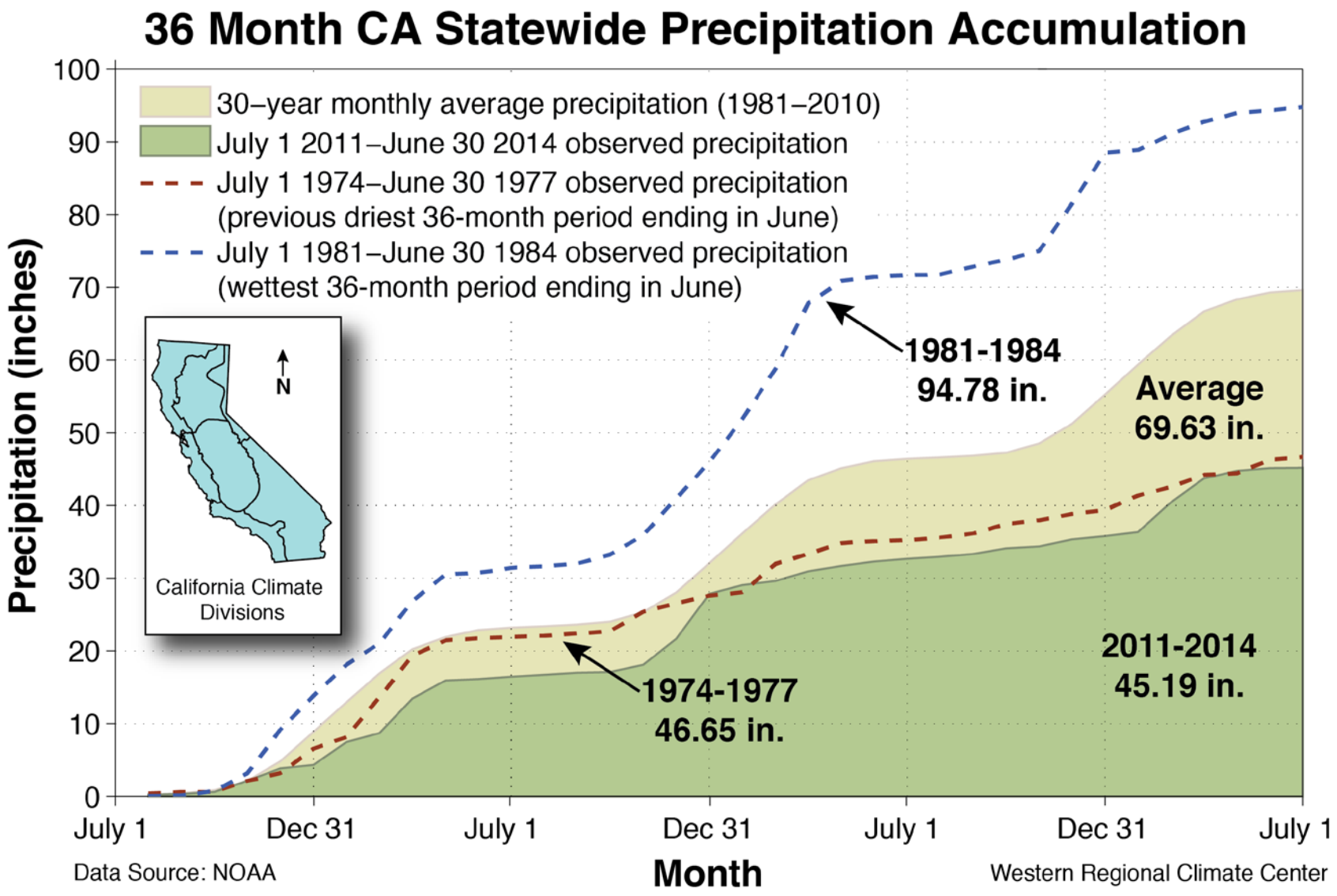
California Reservoir Storage, Million Acre-Feet, 1977 and 2010-14

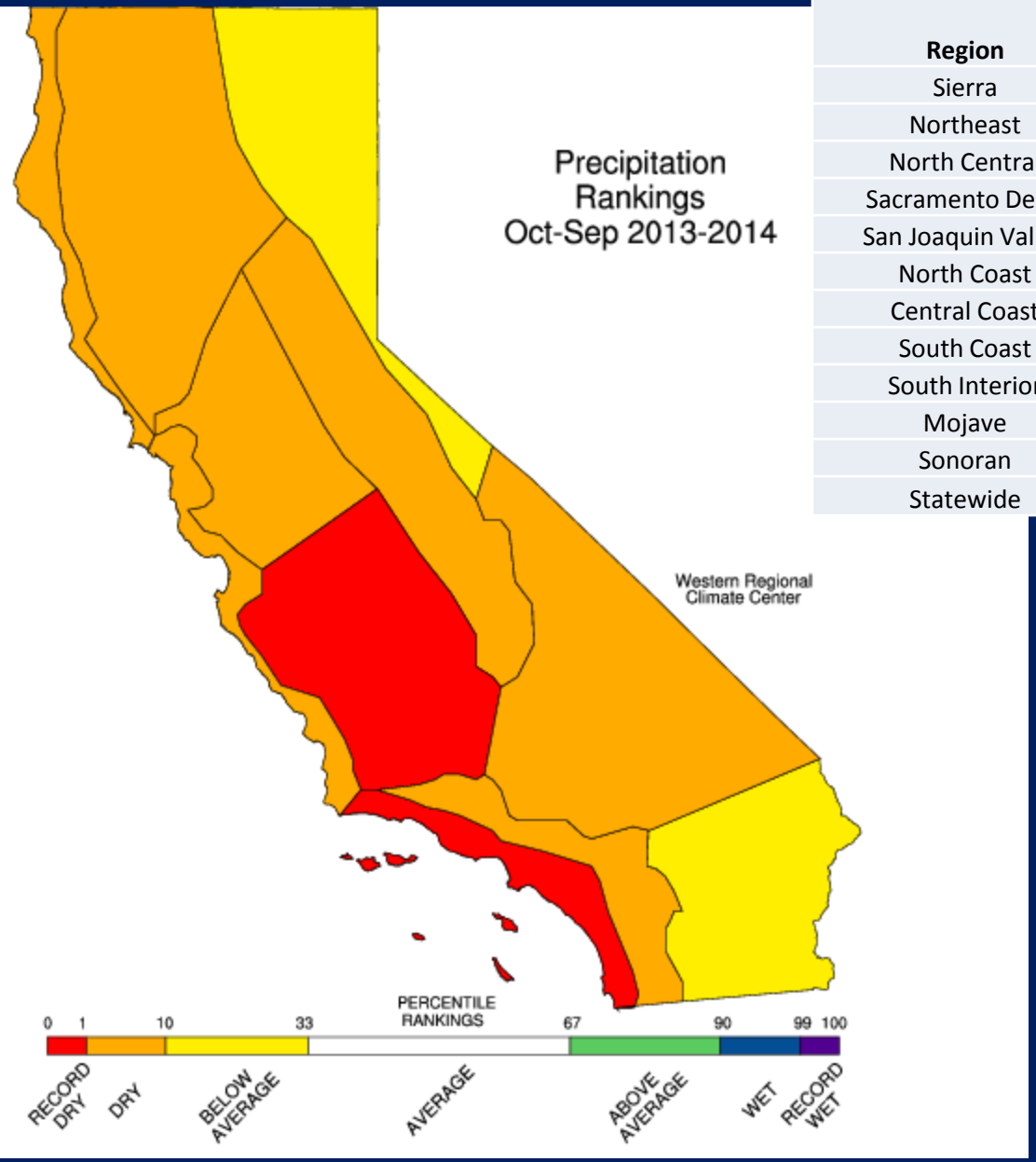


Source: California Department of Water Resources

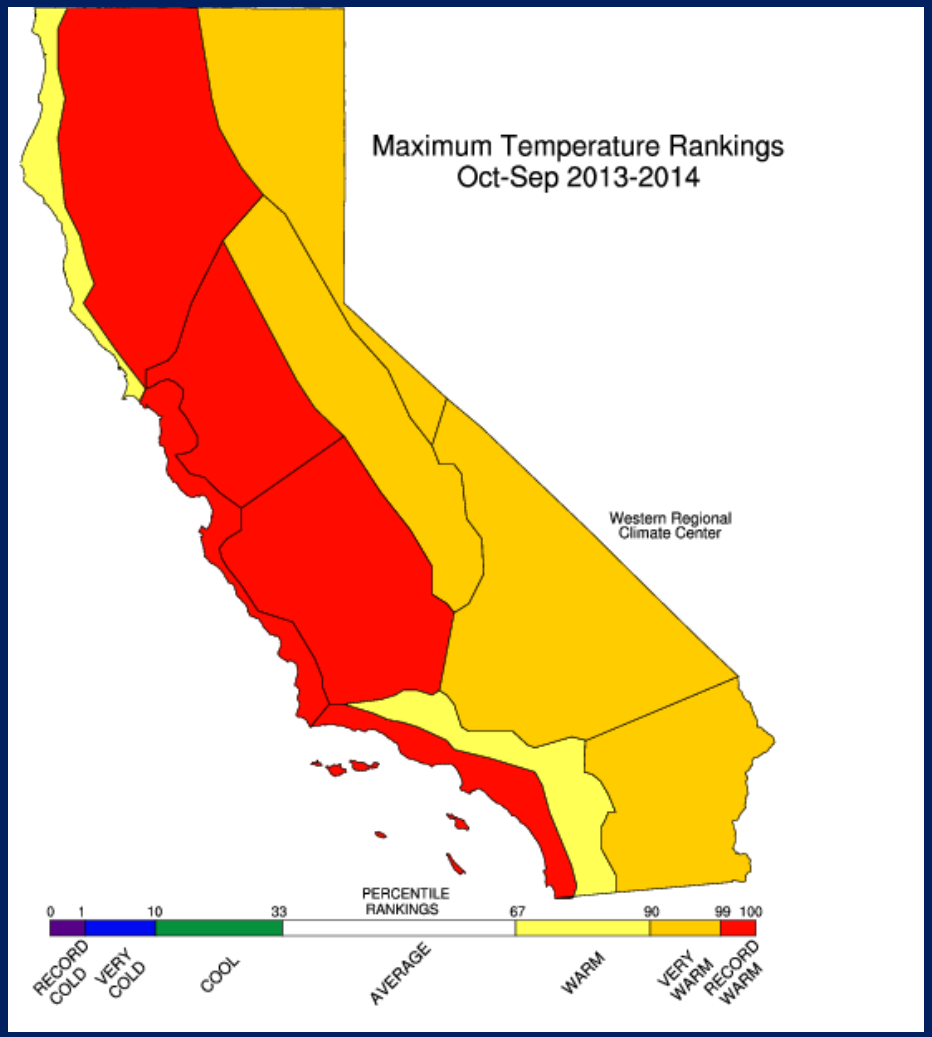
Note: One acre-foot is equal to 325,851 gallons, or the amount of water it takes to cover one acre to a depth of one foot.

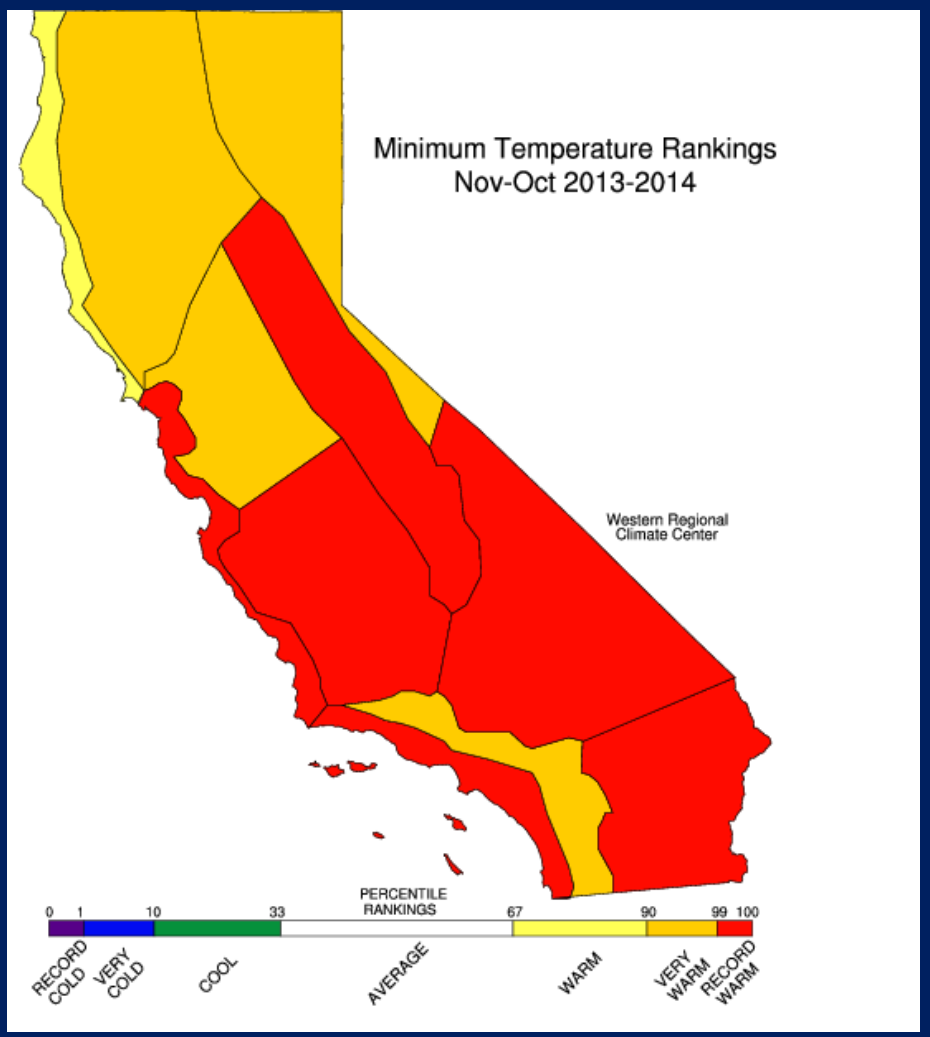
From B. Rippey, USDA


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)
N
California Climate Divisions
1981-1984
94.78 in.
Average
69.63 in.
1974-1977
46.65 in.
2011-2014
45.19 in.
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

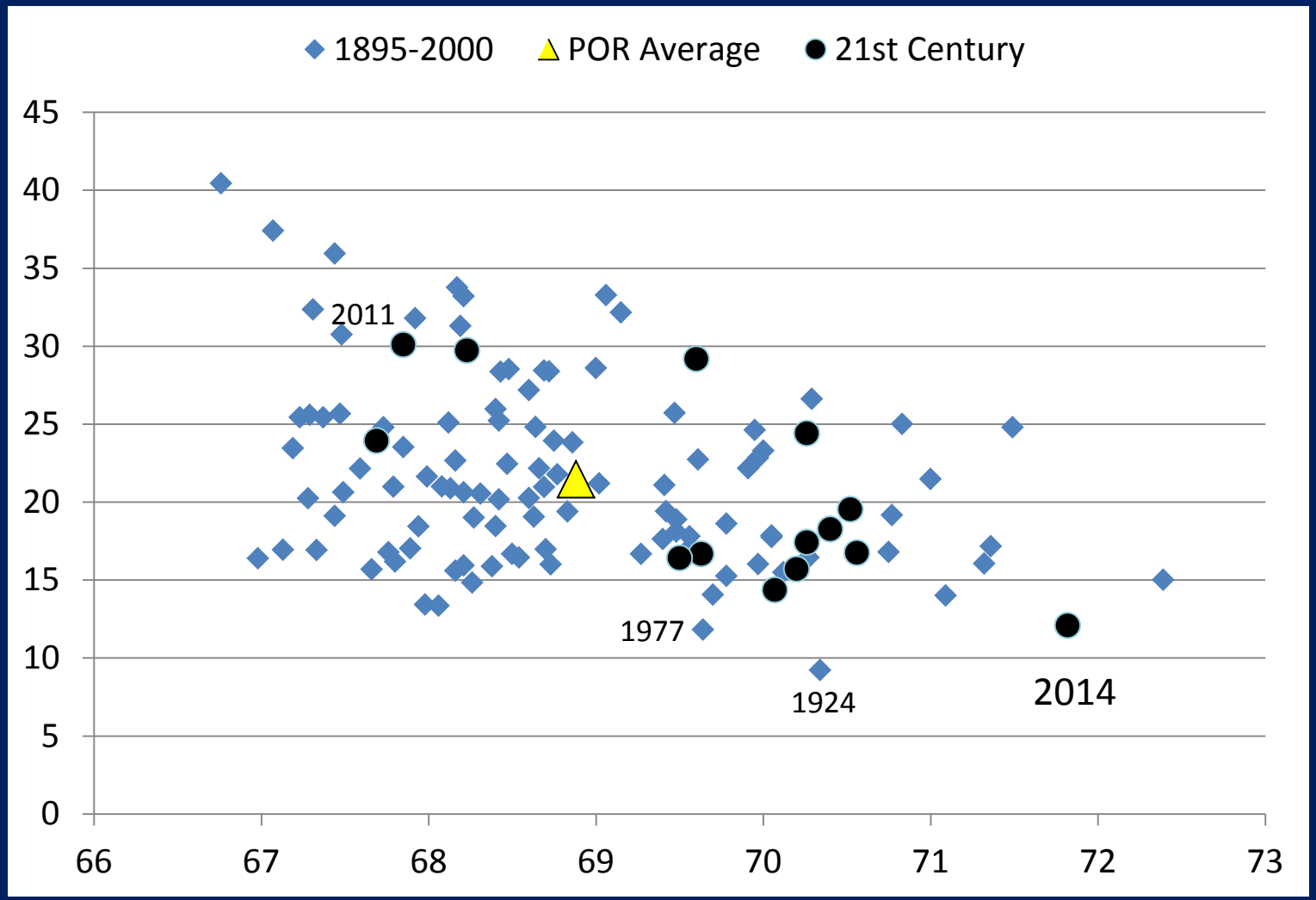


Region	WY2014 Value (inches)	% of Average	Rank
Sierra	20.76	53%	3
Northeast	15.21	63%	15
North Central	28.87	56%	6
Sacramento Delta	10.68	54%	8
San Joaquin Valley	4.81	38%	1
North Coast	33.48	51%	3
Central Coast	11.94	47%	2
South Coast	5.63	32%	1
South Interior	9.04	50%	5
Mojave	2.9	39%	2
Sonoran	2.41	54%	21
Statewide	12.08	52%	3


Maximum Temperature Rankings
Oct-Sep 2013-2014
Western Regional
Climate Center
PERCENTILE
RANKINGS
0 1 10 33 67 90 99 100
RECORD COLD
VERY COLD
COOL
AVERAGE
WARM
VERY WARM
RECORD WARM

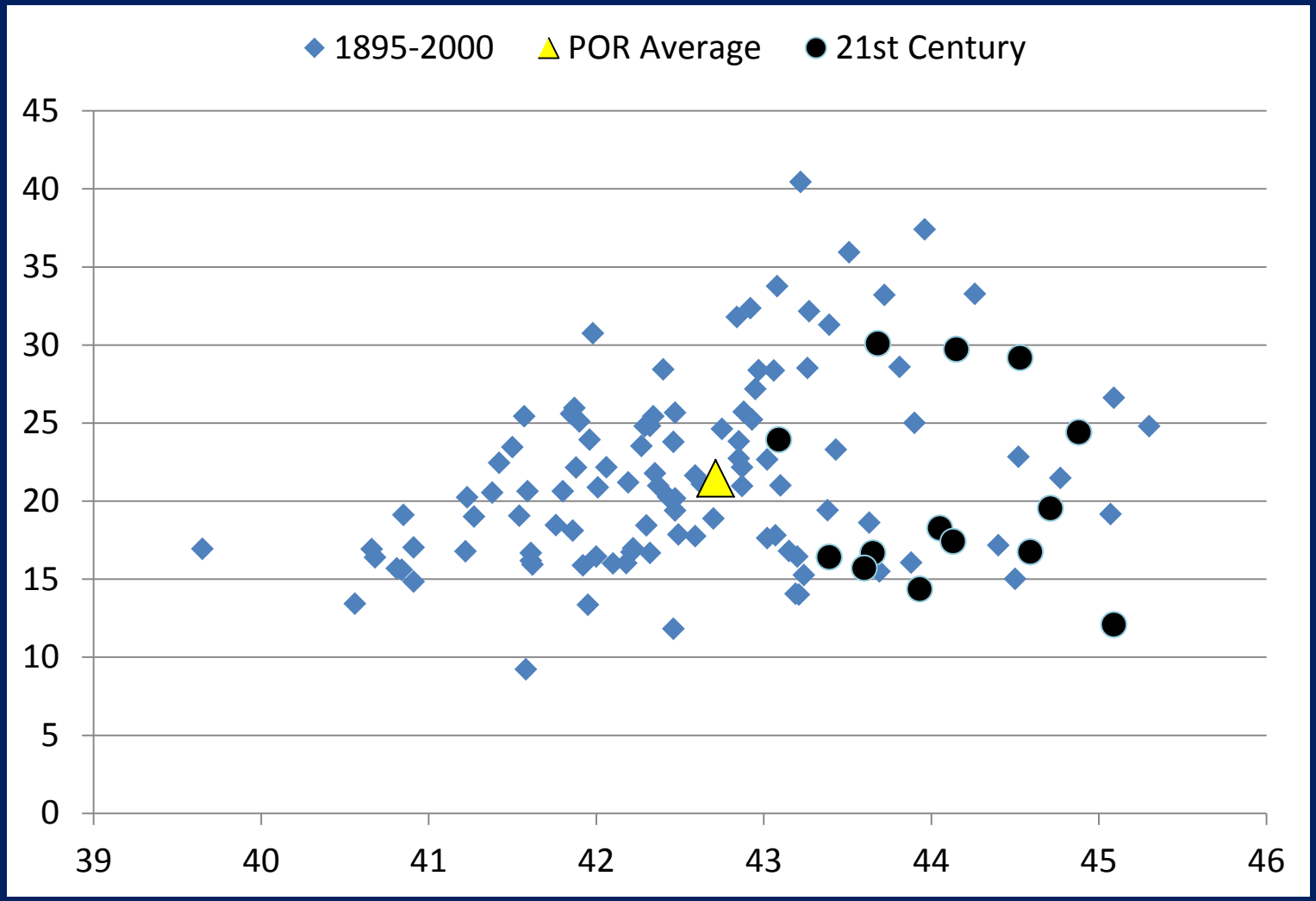

Minimum Temperature Rankings
Nov-Oct 2013-2014
Western Regional
Climate Center
PERCENTILE
RANKINGS
0 1 10 33 67 90 99 100
RECORD COLD
VERY COLD
COOL
AVERAGE
WARM
VERY WARM
RECORD WARM

Statewide WY Precipitation/Max Temperature 1895-2014



Data from WRCC CA Climate Tracker

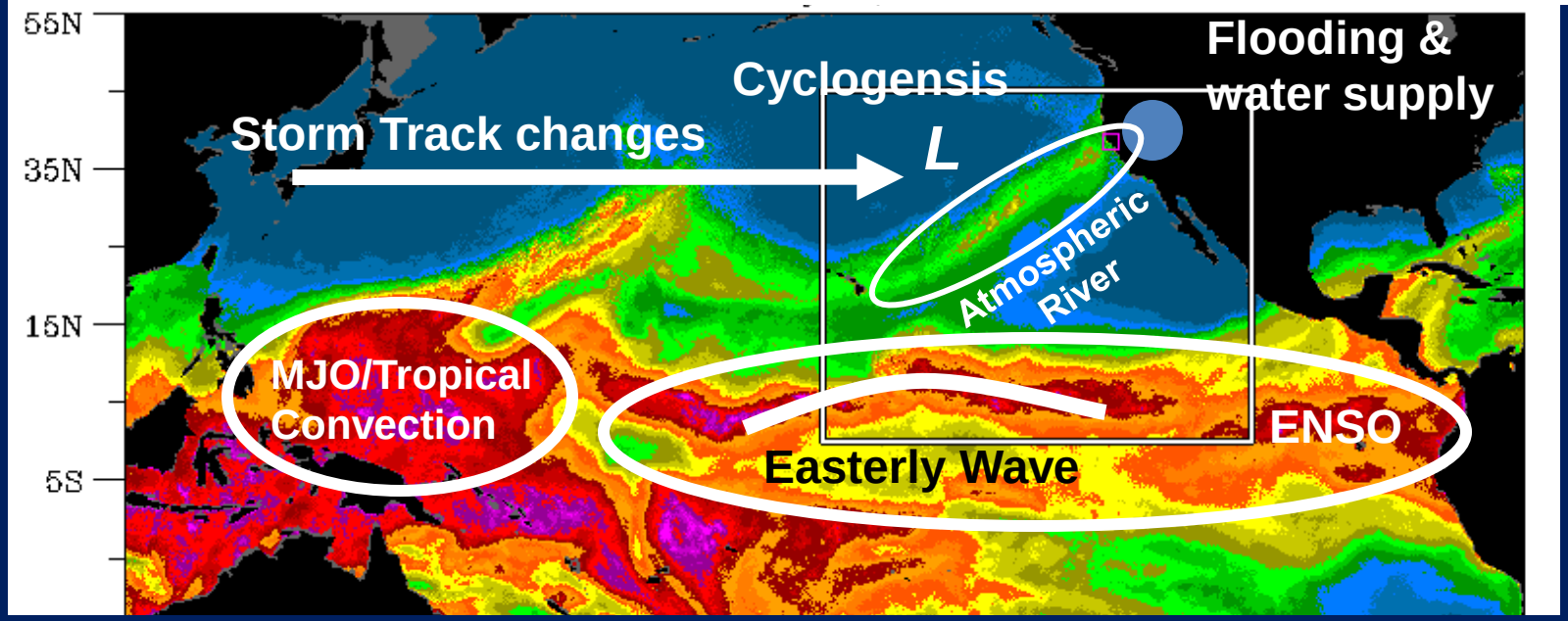
Statewide WY Precipitation/Min Temperature 1895-2014



Data from WRCC CA Climate Tracker

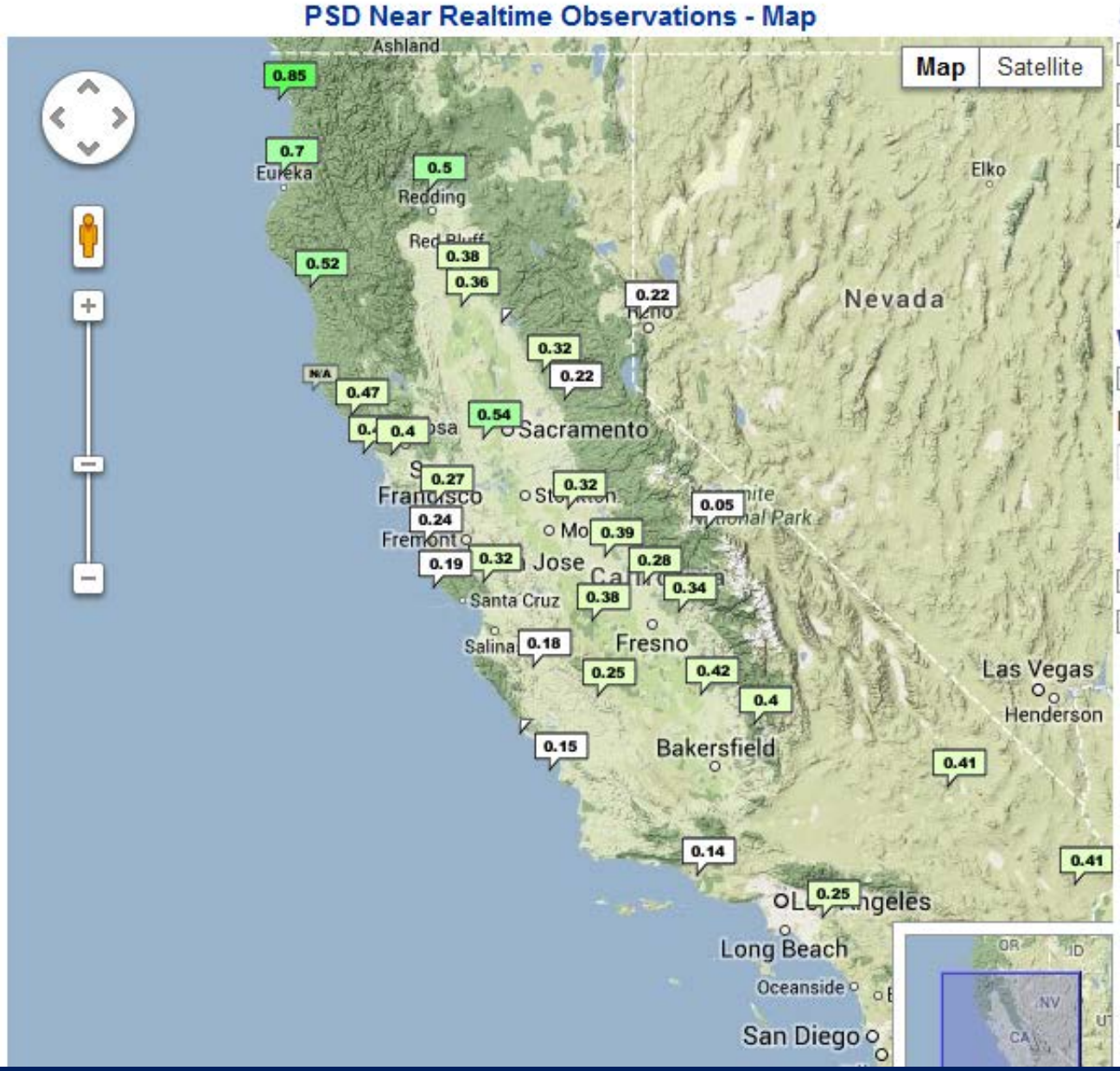
Climate Program Activities

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



SurfaceMet Data

- [ ] Temperature (F)
- [x] Integrated Water Vapor (cm)
- [ ] Snow Depth (in)
- [ ] Wind Speed & Direction (mph)

Accumlated Precipitation (in)

-

Wind and Precipitation Radar Data

- [ ] Snow Level (kft msl)

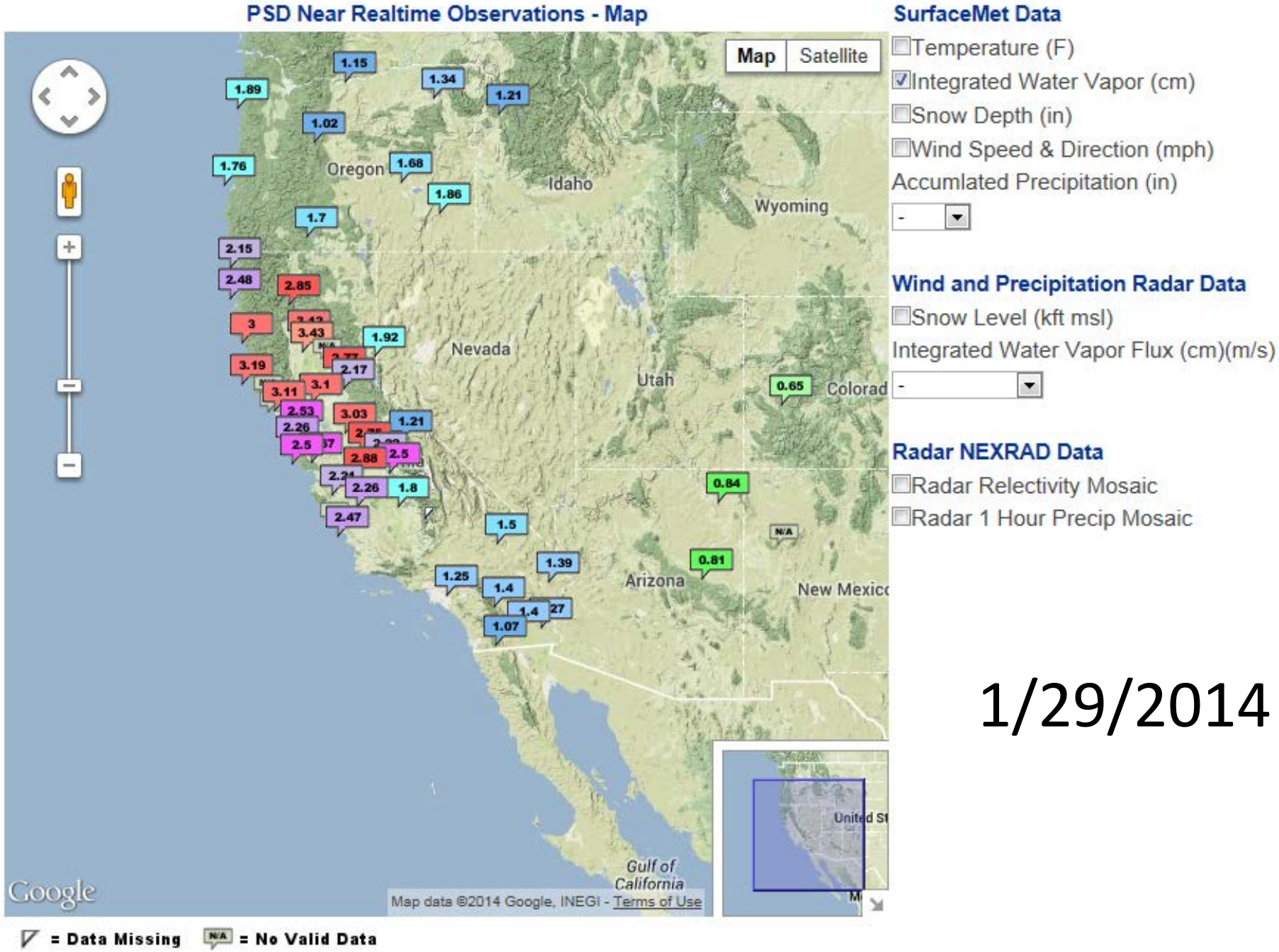
Integrated Water Vapor Flux (cm)(m/s)

-

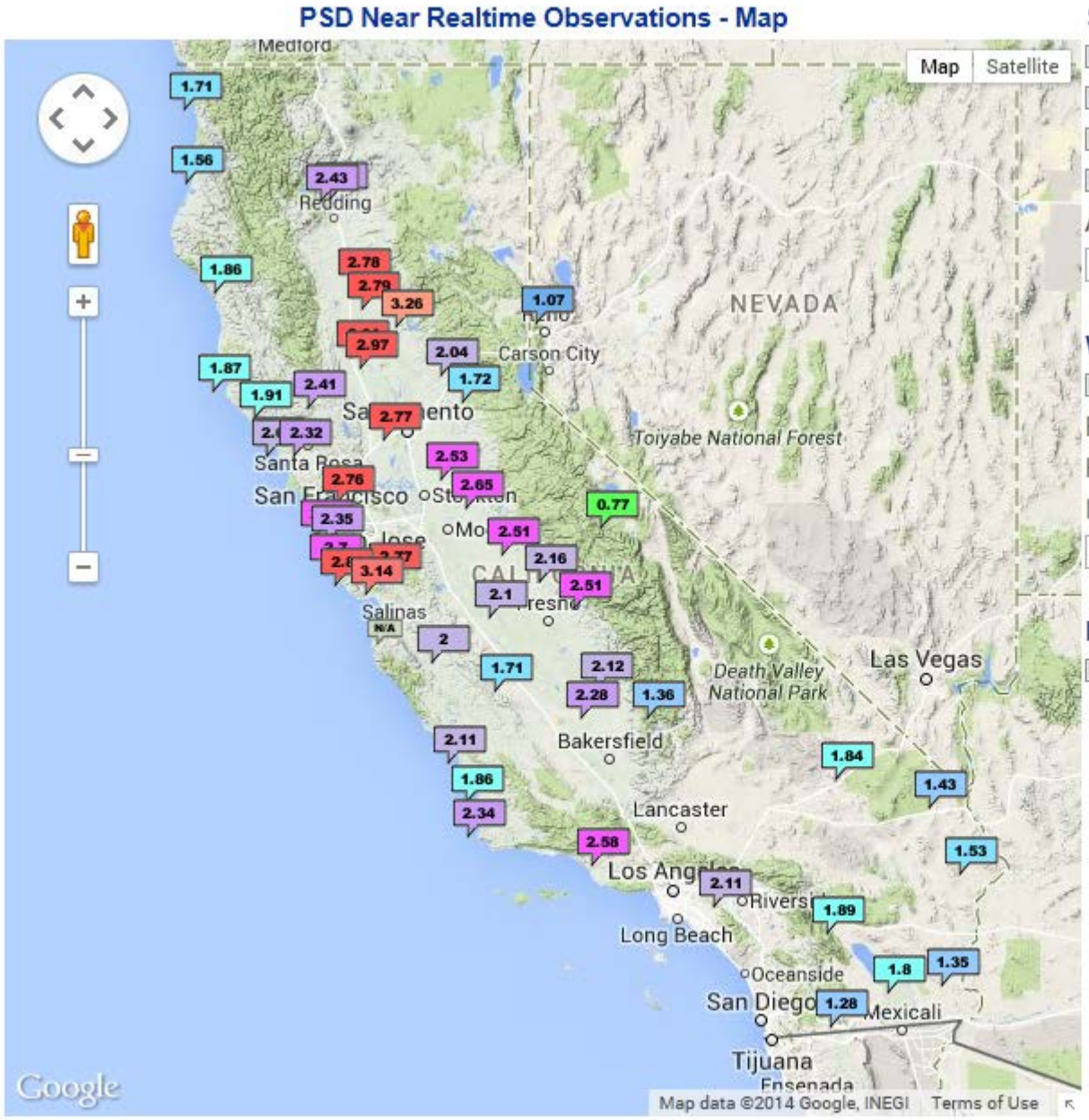
Radar NEXRAD Data

- [ ] Radar Relectivity Mosaic
- [ ] Radar 1 Hour Precip Mosaic

12/27/2013


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
Oregon
Idaho
Wyoming
Nevada
Utah
Colorad
Arizona
New Mexic
Gulf of California
Google
Map data ©2014 Google, INEGI - Terms of Use
= Data Missing
= No Valid Data

1/29/2014



SurfaceMet Data

- [ ] Temperature (F)
- [x] Integrated Water Vapor (cm)
- [ ] Snow Depth (in)
- [ ] Wind Speed & Direction (mph)

Accumlated Precipitation (in)

-

Wind and Precipitation Radar Data

- [ ] Snow Level (kft msl)

Profiler Wind Speed And Direction (mph)

Height (m msl): -

Integrated Water Vapor Flux (cm)(m/s)

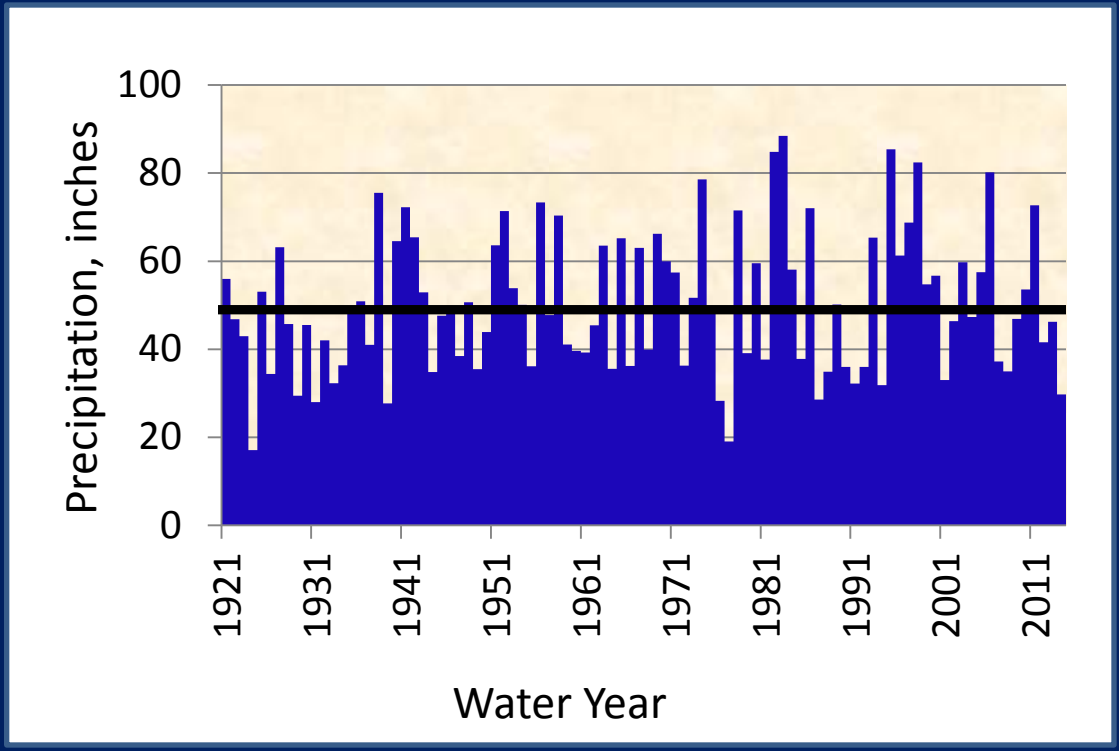
-

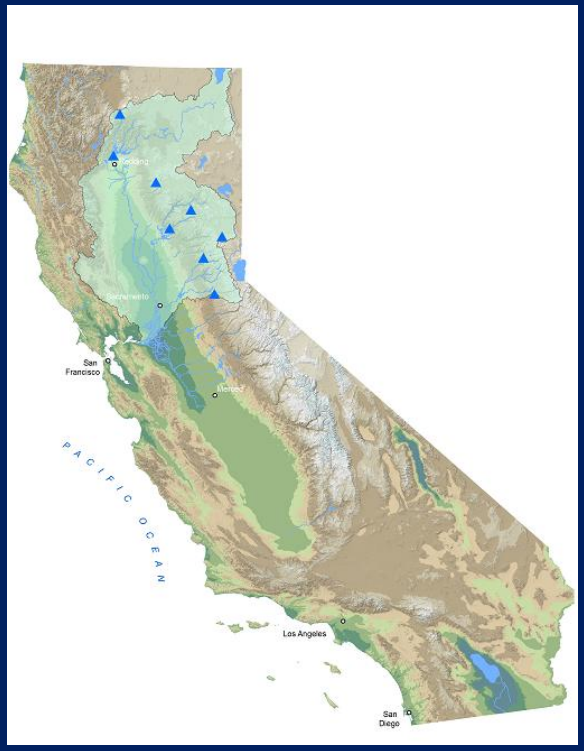
NEXRAD Data

- [ ] Radar Relectivity Mosaic

10/31/2014

Northern Sierra 8 Station Index





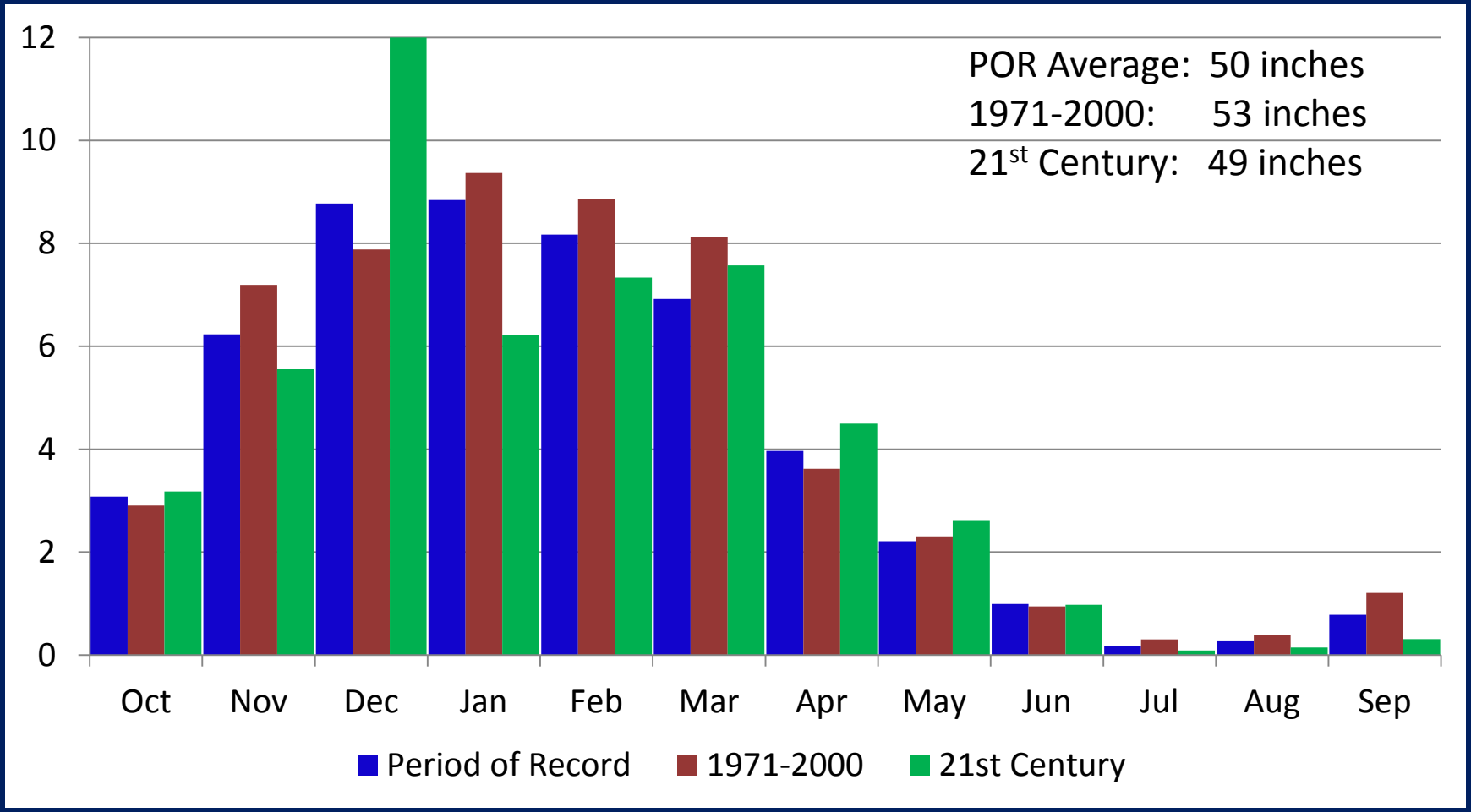
Annual Average: 50 inches
Maximum Year (1983): 88.5 inches
Minimum Year (1924): 17.1 inches
Period of Record 1921- Present

9 of 14 years of 21st Century below average

Average of:

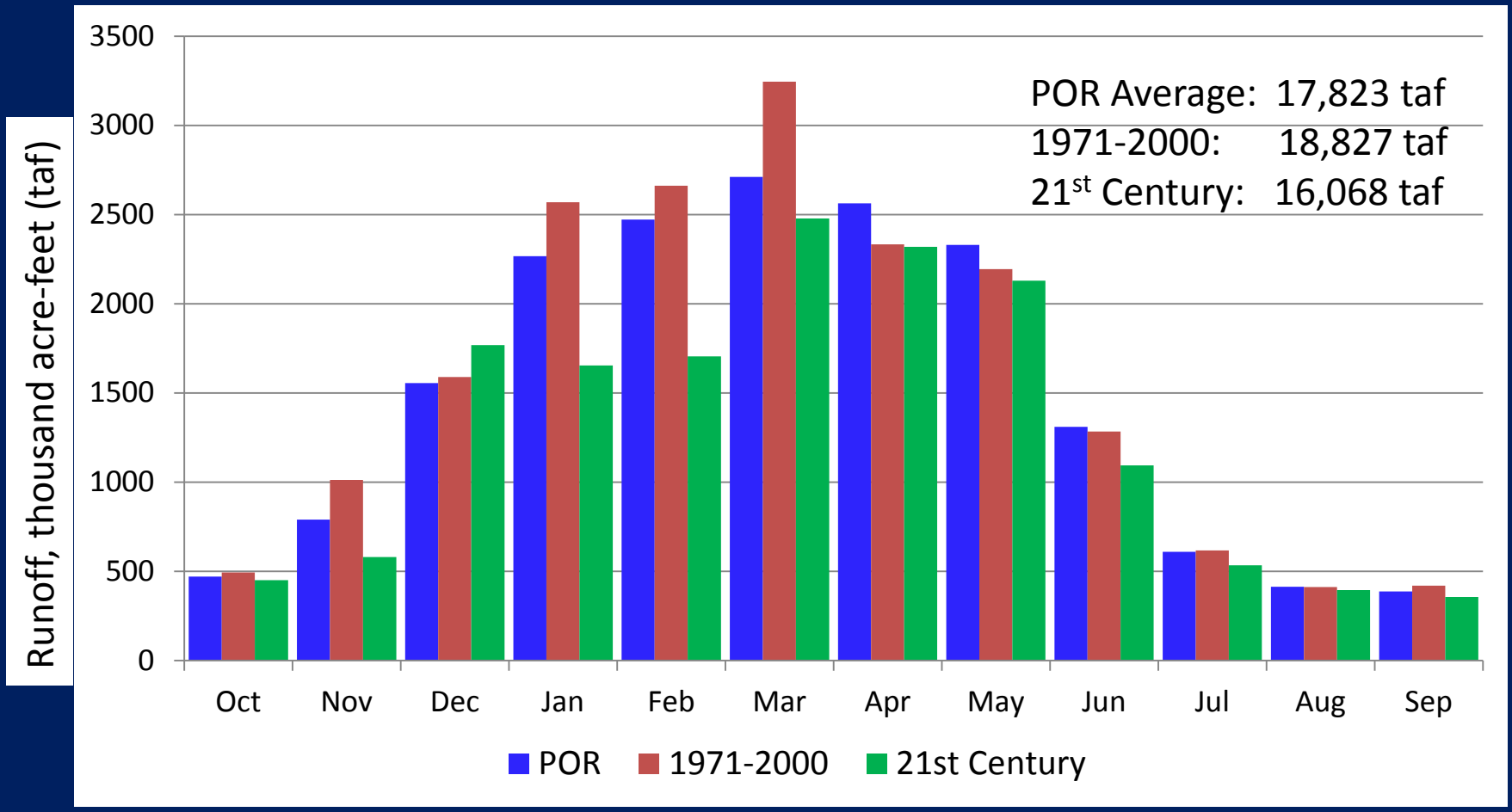
Mt. Shasta City	Quincy
Shasta Dam	Sierraville RS
Mineral	Pacific House
Brush Creek RS	Blue Canyon

21st Century Breakdown So Far – 8 Station Index

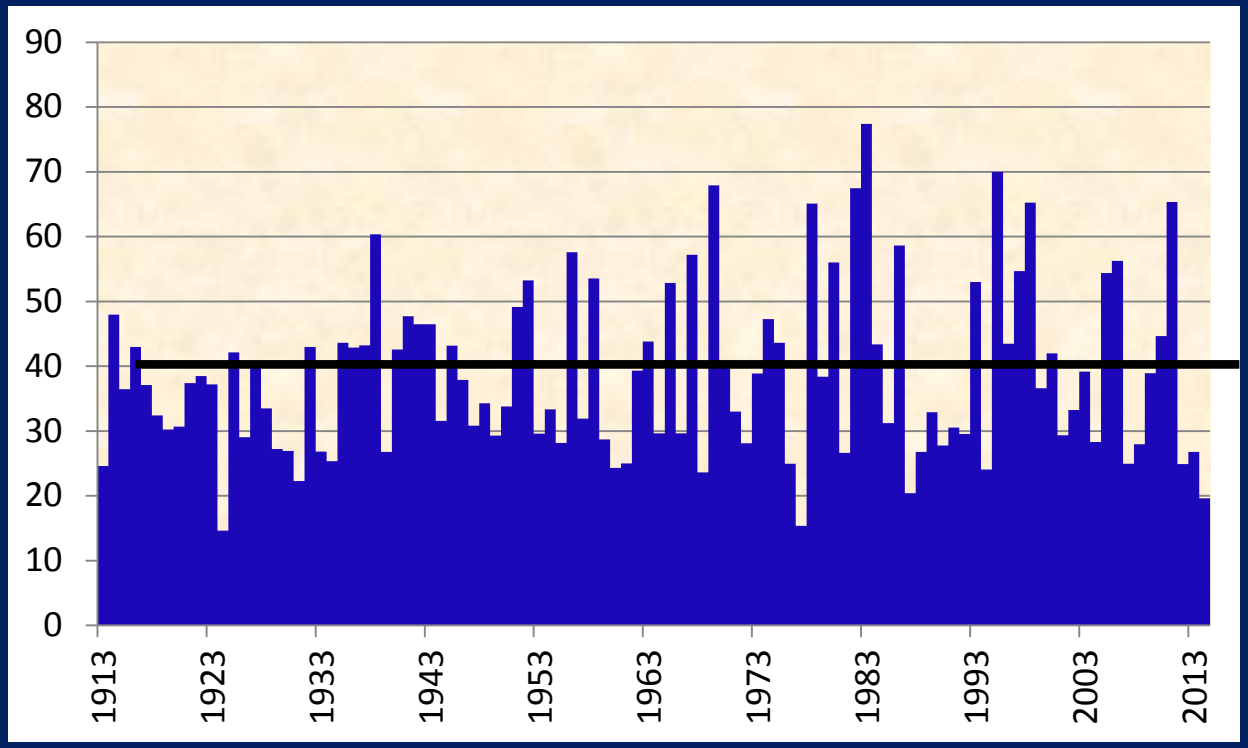


Note WY2012 was 3rd driest December (0.34”) and WY2014 was 4th driest (0.80”)

Sacramento River Runoff Distributions (Thousand Acre-Feet)



San Joaquin 5-Station Index

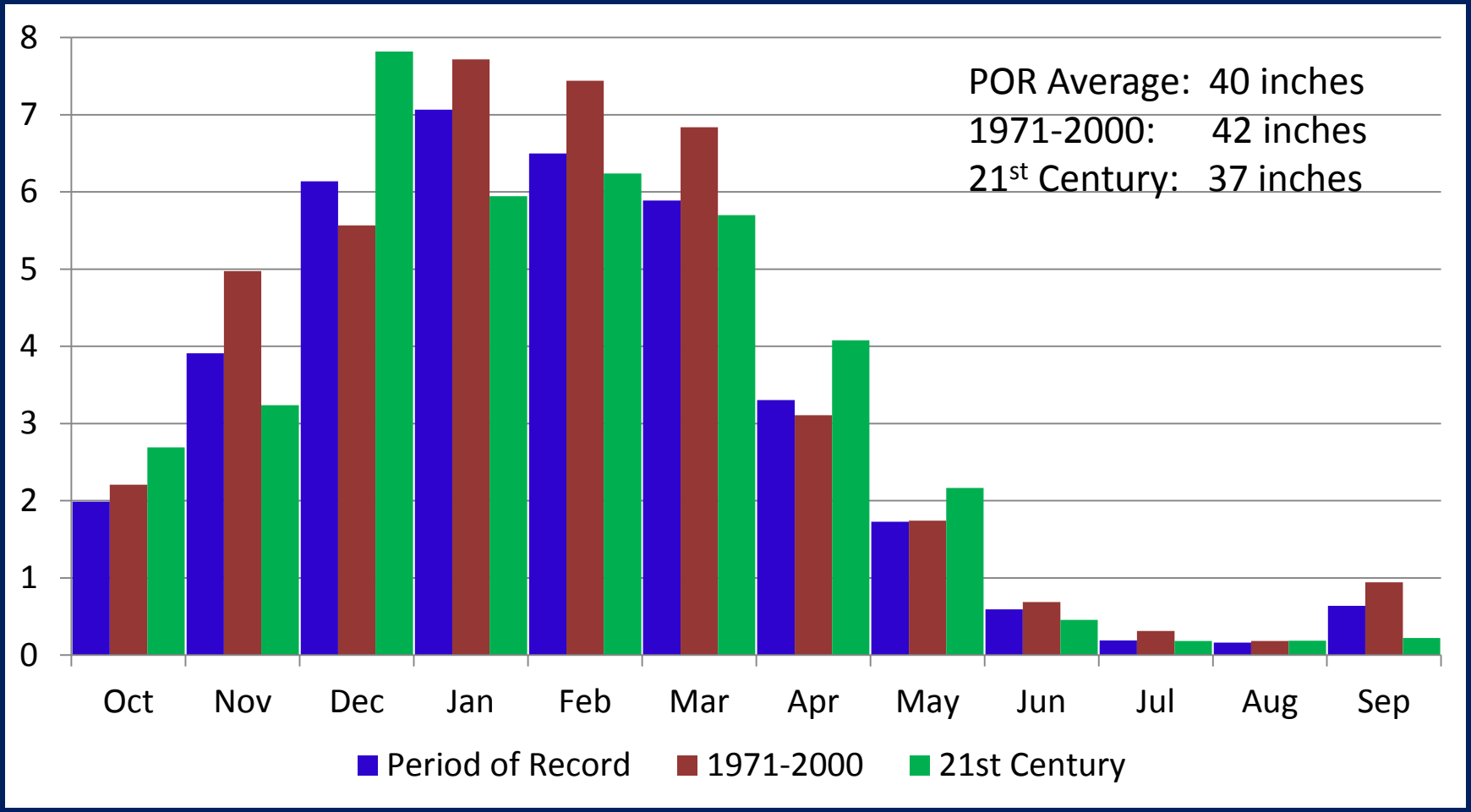


Annual Average: 40 inches
Maximum Year (1983) 77.4 inches
Minimum Year (1924) 14.8 inches
Period of Record 1913 - Present

10 of 14 years of 21st Century below average

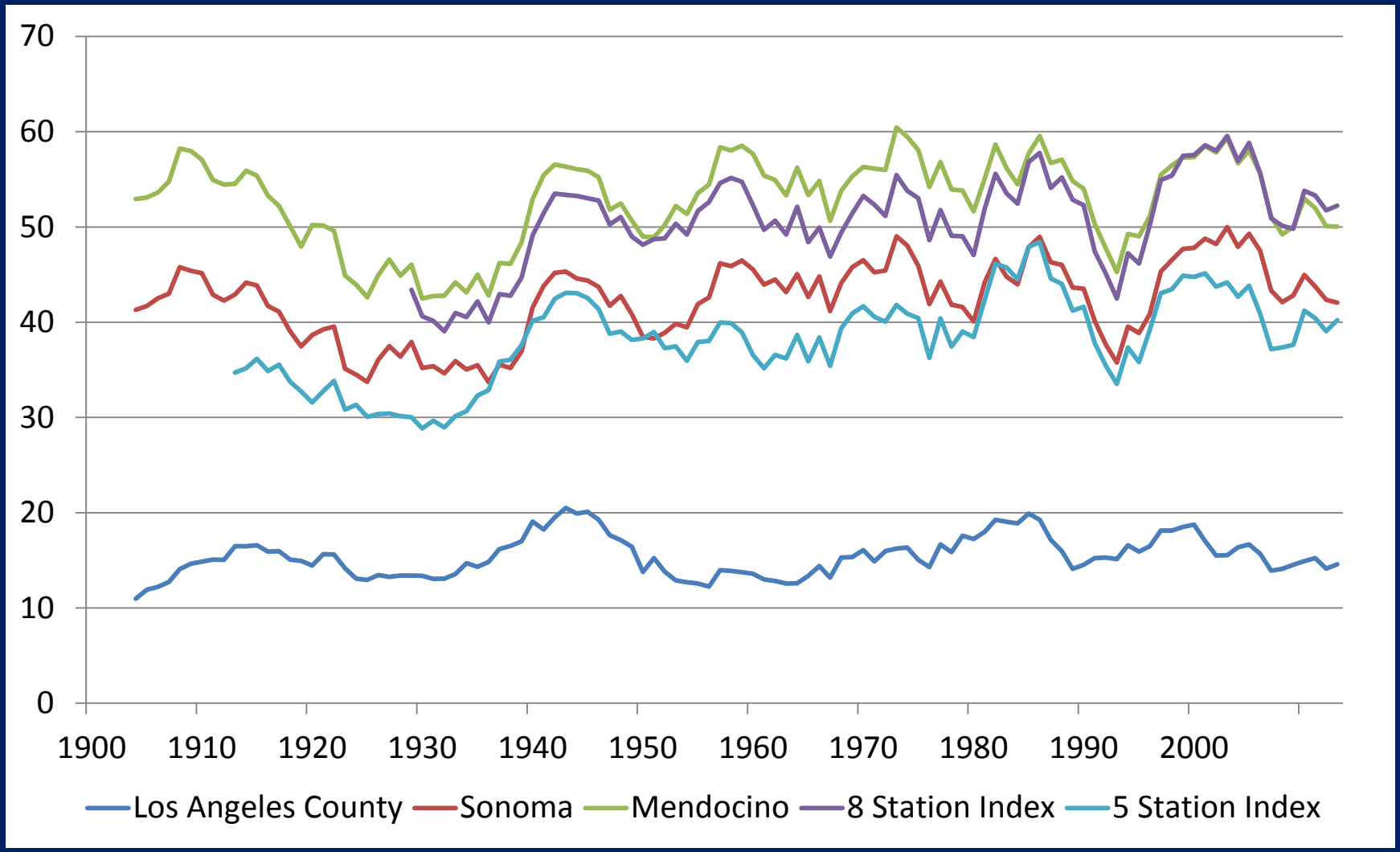
Average of:
Calaveras Big Trees
Hetch Hetchy
Yosemite HQ
North Fork Ranger Station
Huntington Lake

21st Century Breakdown So Far – 5 Station Index



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

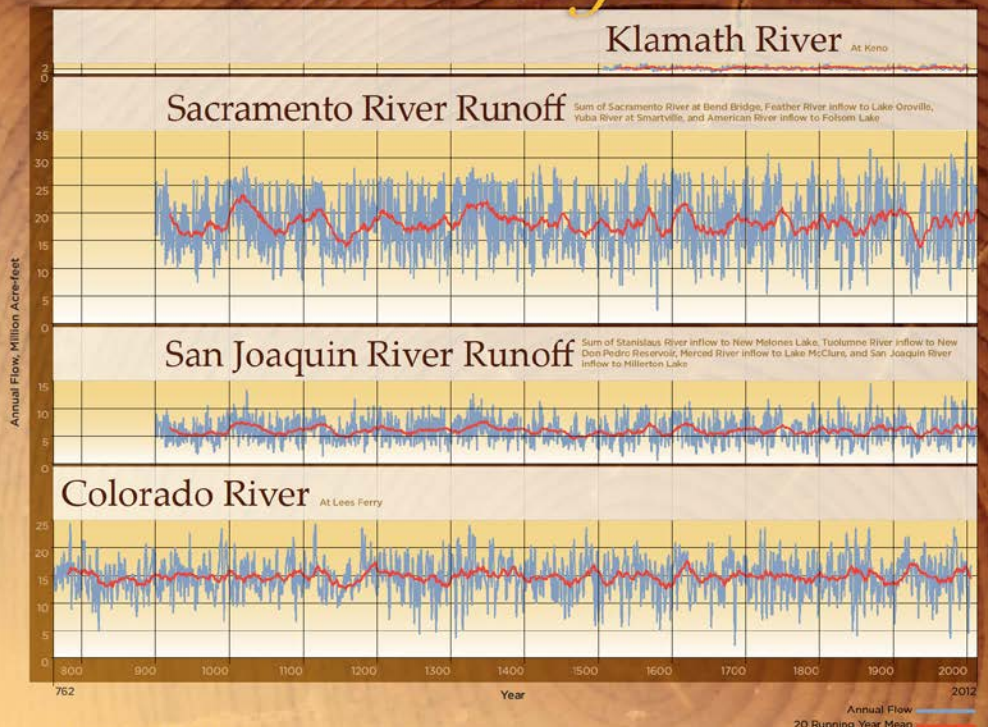
Decadal Scale Variability



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

A tree-ring reconstruction is a set of tree-ring width data that have been calibrated with an instrumental or gaged record of a hydrologic or climatic variable such as annual streamflow or precipitation. The reconstruction, based on a statistical model that describes the relationship between tree growth and the gage record, extends that record back hundreds of years into the past.

Tree growth in dry climates is limited by water availability. Trees that provide the best information about hydroclimatic variability are those particularly sensitive to variations in moisture. These include species such as blue oak, ponderosa pine, Douglas fir, and western juniper, usually growing at lower elevations in sparse stands on dry and rocky sites where soil moisture storage is minimal.

Tree-ring reconstructions of hydroclimatic variables are developed from tree-ring chronologies. A tree-ring chronology is a time-series of annual values derived from the ring-width measurements of 10 or more trees of the same species at a single site. To create a tree-ring chronology, cores from the sampled trees at each site are cross-dated (i.e., patterns of narrow and wide rings are matched from tree to tree) to account for missing or false rings, so that every annual ring is absolutely dated to the correct year. Then all rings are measured to the nearest thousandth of a millimeter using a computer-assisted measuring device. After growth-related trends unrelated to climate are statistically removed, the ring width values from all sampled trees for each year are averaged to create a time series of annual ring width indices. The complete series of ring width indices from a site is called a tree-ring chronology.

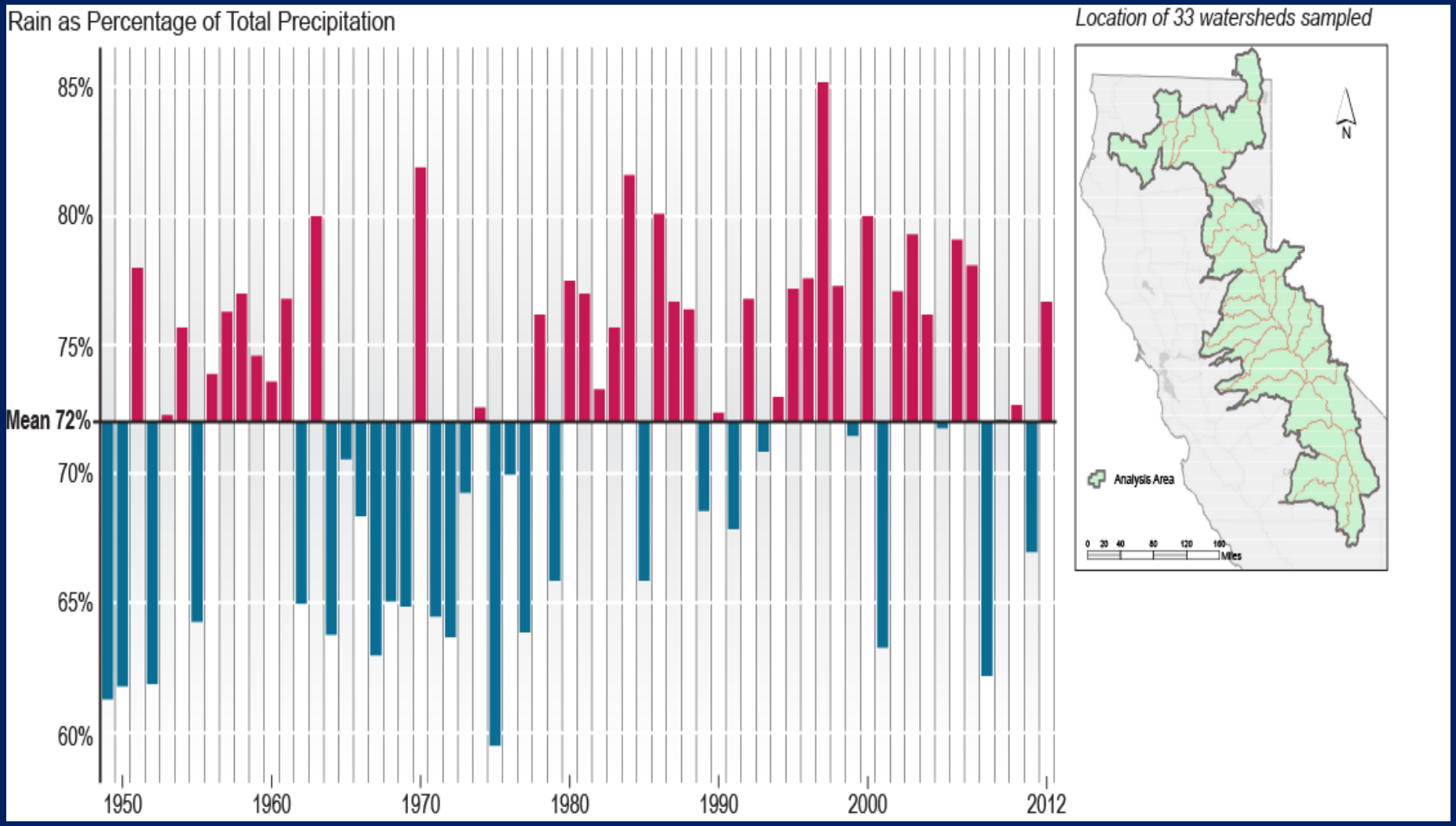
Once a gaged record of interest is selected for reconstruction, a set of tree-ring chronologies from the region near the gage is calibrated with the gage record to form a reconstruction model. A statistical technique called multiple linear regression is commonly used. The reconstruction is evaluated by comparing the observed gage values with the reconstructed values by assessing the amount of variance in the gage record that is explained by the reconstruction.

DROUGHTS PRIOR TO THE HISTORICAL RECORD

The period of reliably measured streamflows for rivers throughout the West seldom reaches beyond 100 years, which represents only a fraction of climatologically modern time. As these streamflow reconstructions show, there have been droughts prior to the historical period that were more severe – particularly in duration – than those in the measured record. The reconstructed record captures a broader range of hydrologic variability than does the historical record, making reconstructions useful for drought preparedness planning. Of particular interest from a scientific perspective is the Medieval Climate Anomaly, a time during which sustained severe drought gripped much of the western United States, as exemplified illustrated in the Sacramento, San Joaquin, and Colorado River reconstructions.

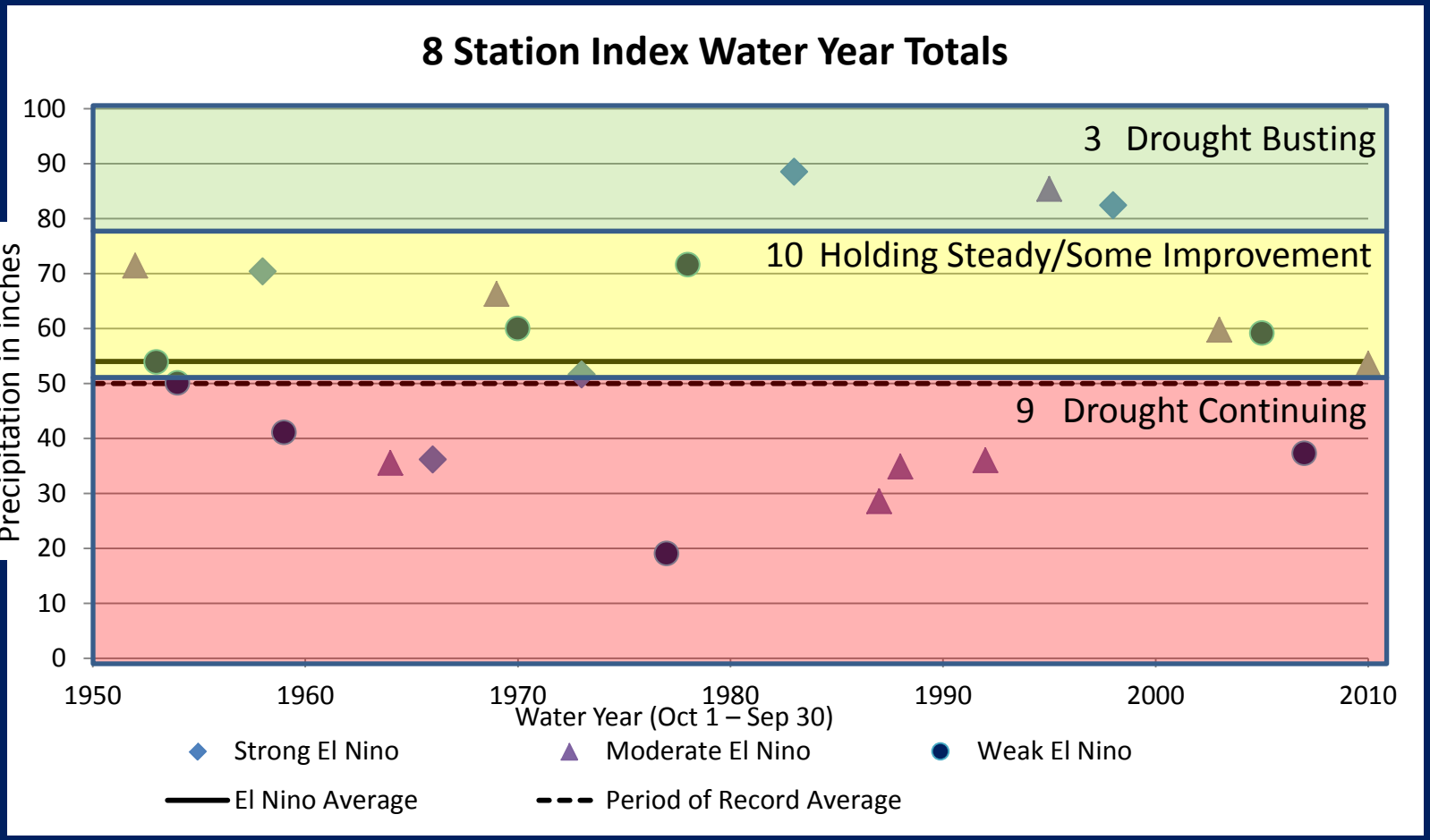
Data source: Work performed by the University of Arizona under contract to the California Department of Water Resources. CDWR Agreements 4600003682 (David Meko, 2005) and 4600006950 (David Meko, Connie Woodhouse, Ramzi Touchan, 2014)

New Rain/Snow Metric for DWR



Credit: Aaron Cuthbertson, Elissa Lynn DWR
Kelly Redmond WRCC

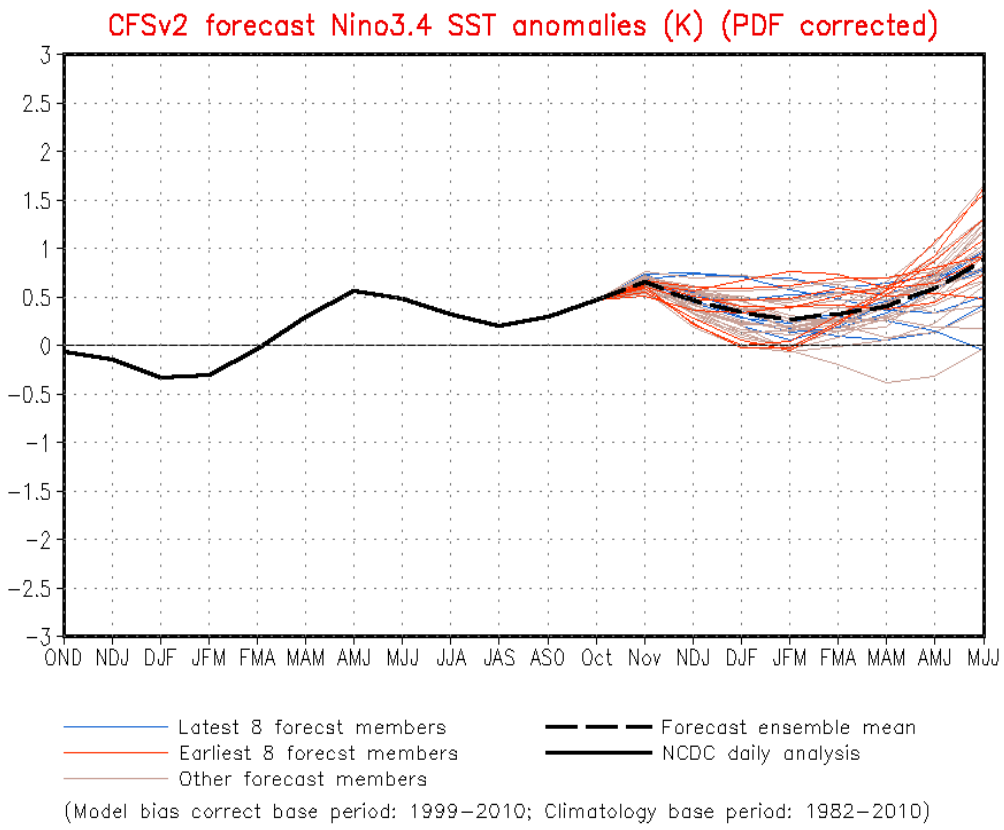

Looking Ahead to 2015
Forecast of Weak El Nino

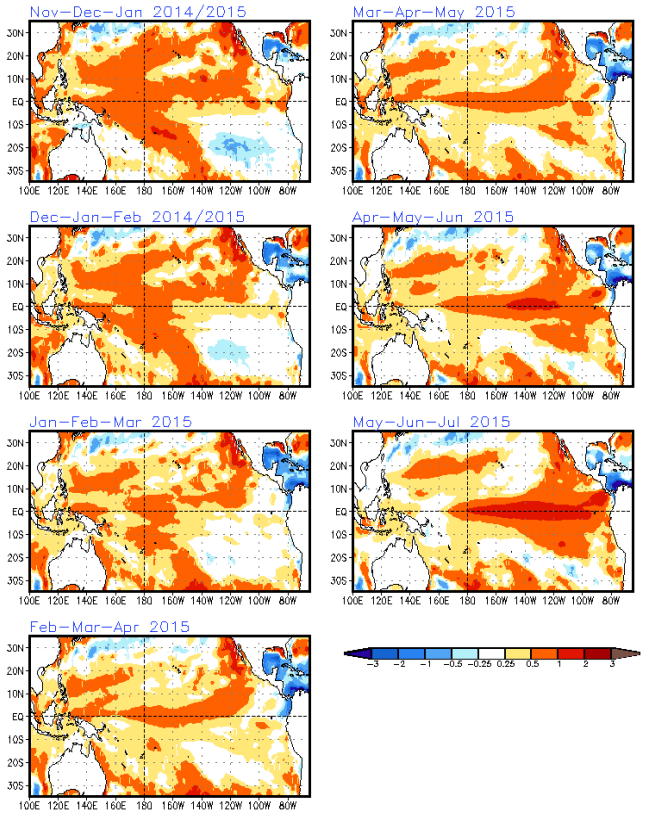

8 Station Index Water Year Totals
Precipitation in inches
100
90
80
70
60
50
40
30
20
10
0
1950
1960
1970
1980
1990
2000
2010
Water Year (Oct 1 – Sep 30)
3 Drought Busting
10 Holding Steady/Some Improvement
9 Drought Continuing
Strong El Nino
Moderate El Nino
Weak El Nino
El Nino Average
Period of Record Average

SST Outlook: NCEP CFS.v2 Forecast (PDF corrected)

Issued: 3 November 2014

The CFS.v2 ensemble mean (black dashed line) predicts warm-neutral conditions into early 2015.



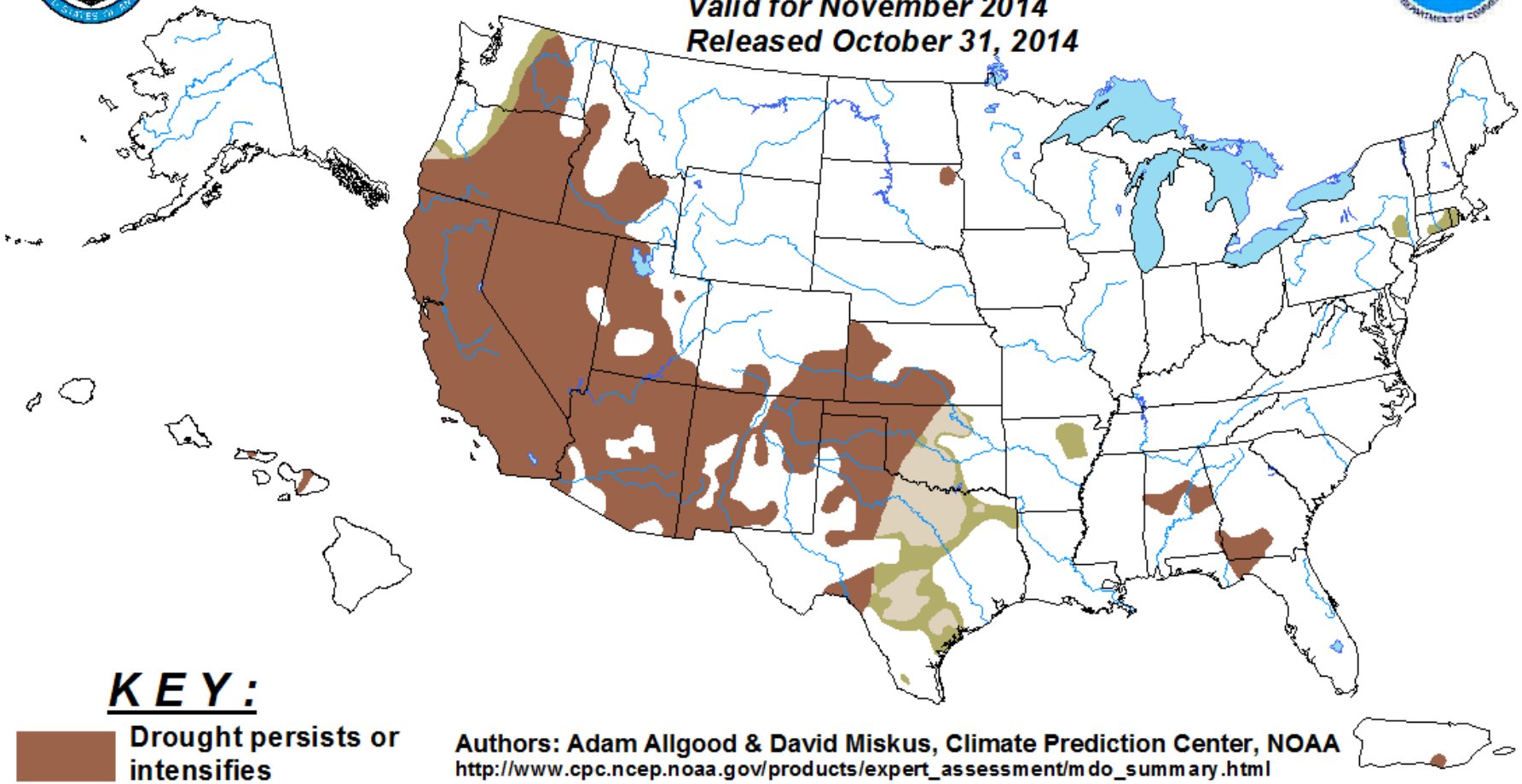


U.S. Monthly Drought Outlook

Drought Tendency During the Valid Period

Valid for November 2014

Released October 31, 2014



K E Y :

- **Drought persists or intensifies**
- **Drought remains but improves**
- **Drought removal likely**
- **Drought development likely**

Authors: Adam Allgood & David Miskus, Climate Prediction Center, NOAA
http://www.cpc.ncep.noaa.gov/products/expert_assessment/mdo_summary.html

Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Short-term events -- such as individual storms -- cannot be accurately forecast more than a few days in advance. Use caution for applications -- such as crops -- that can be affected by such events. "Ongoing" drought areas are approximated from the Drought Monitor (D1 to D4 intensity). For weekly drought updates, see the latest U.S. Drought Monitor.

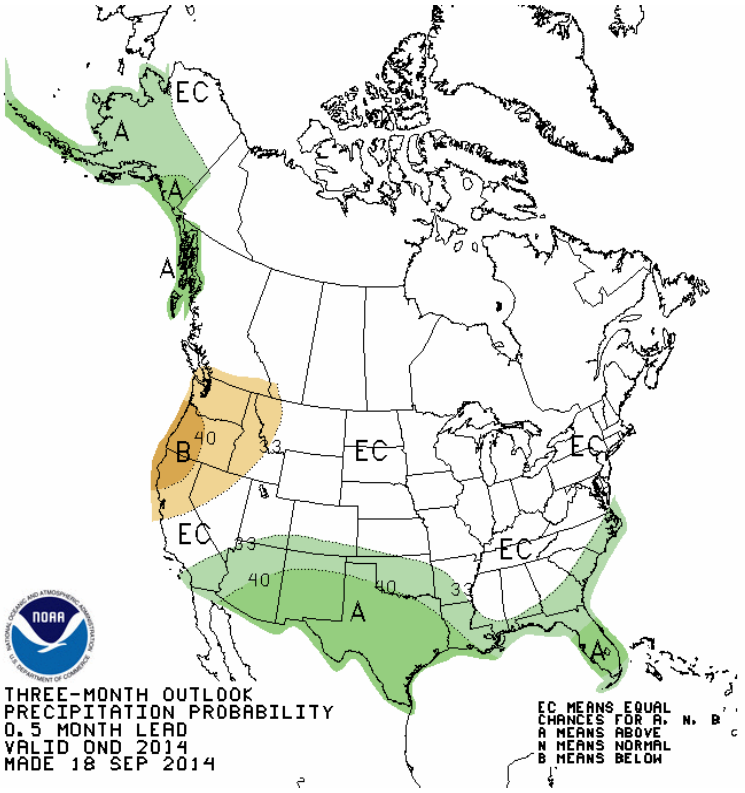
NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period although drought will remain. The green areas imply drought removal by the end of the period (D0 or none)

U. S. Seasonal Outlooks

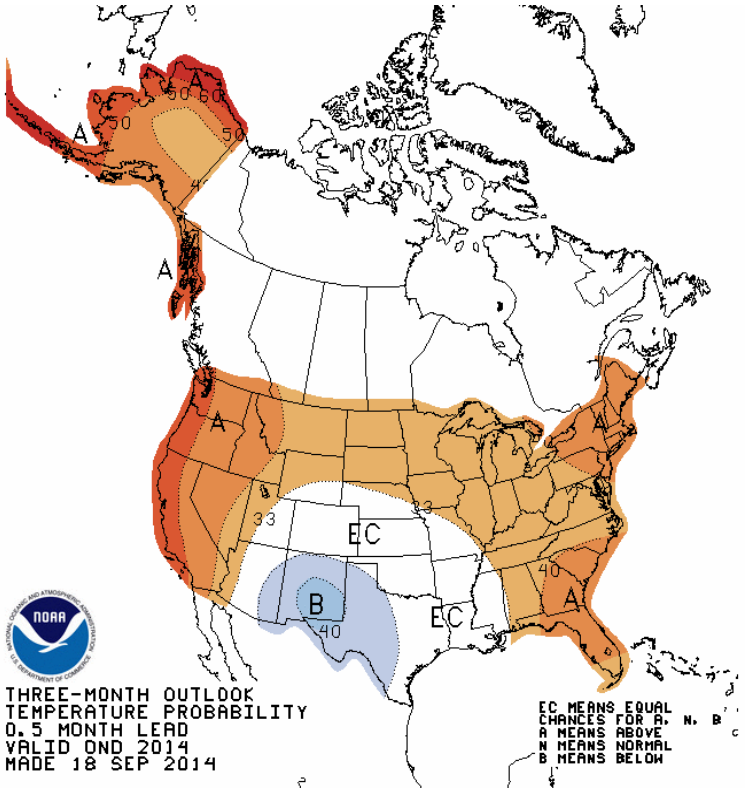
October - December 2014

The seasonal outlooks combine the effects of long-term trends, soil moisture, and, when appropriate, ENSO.

Precipitation



Temperature



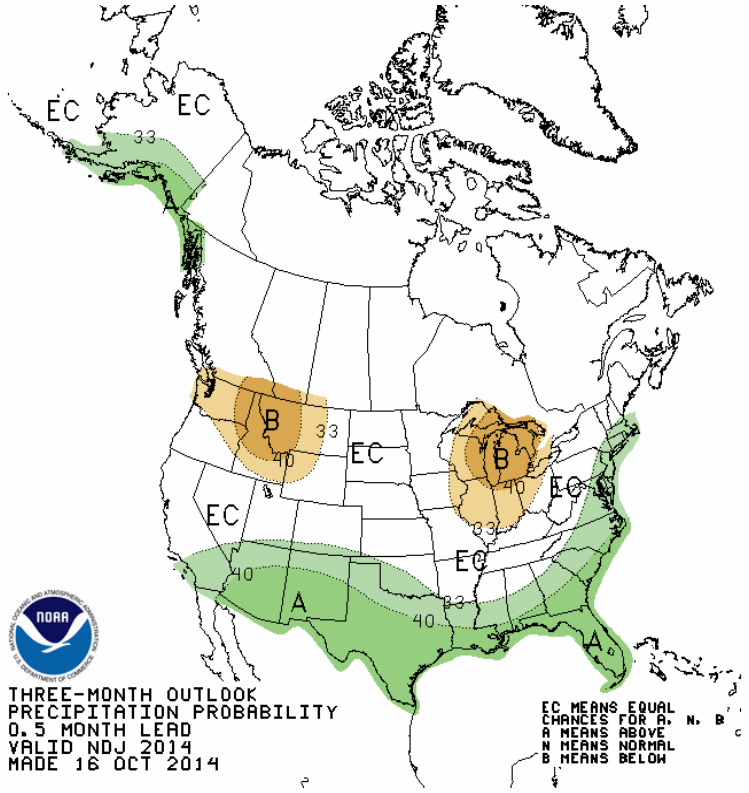
CPC Slide

U. S. Seasonal Outlooks

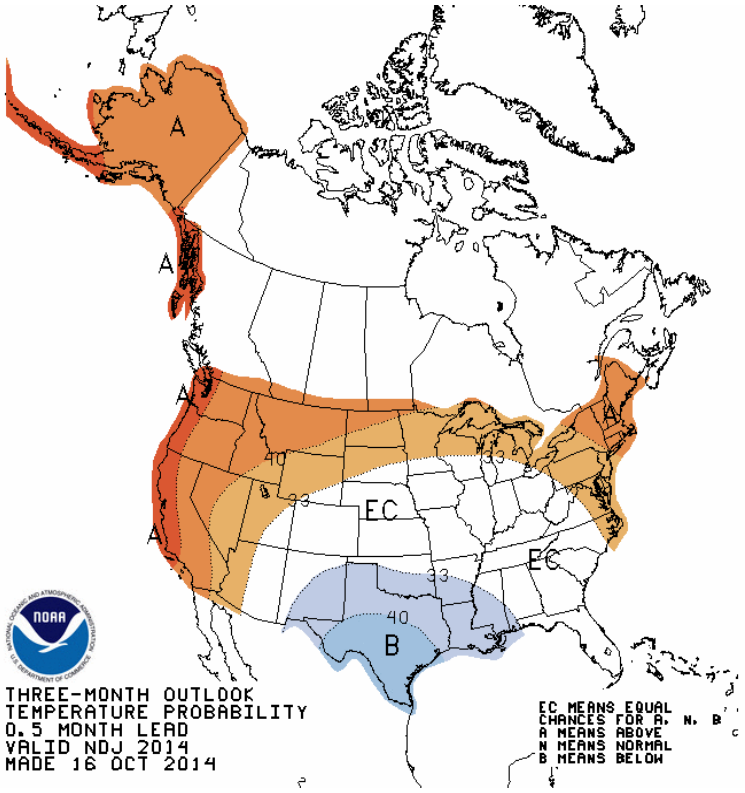
November 2014 – January 2015

The seasonal outlooks combine the effects of long-term trends, soil moisture, and, when appropriate, ENSO.

Precipitation

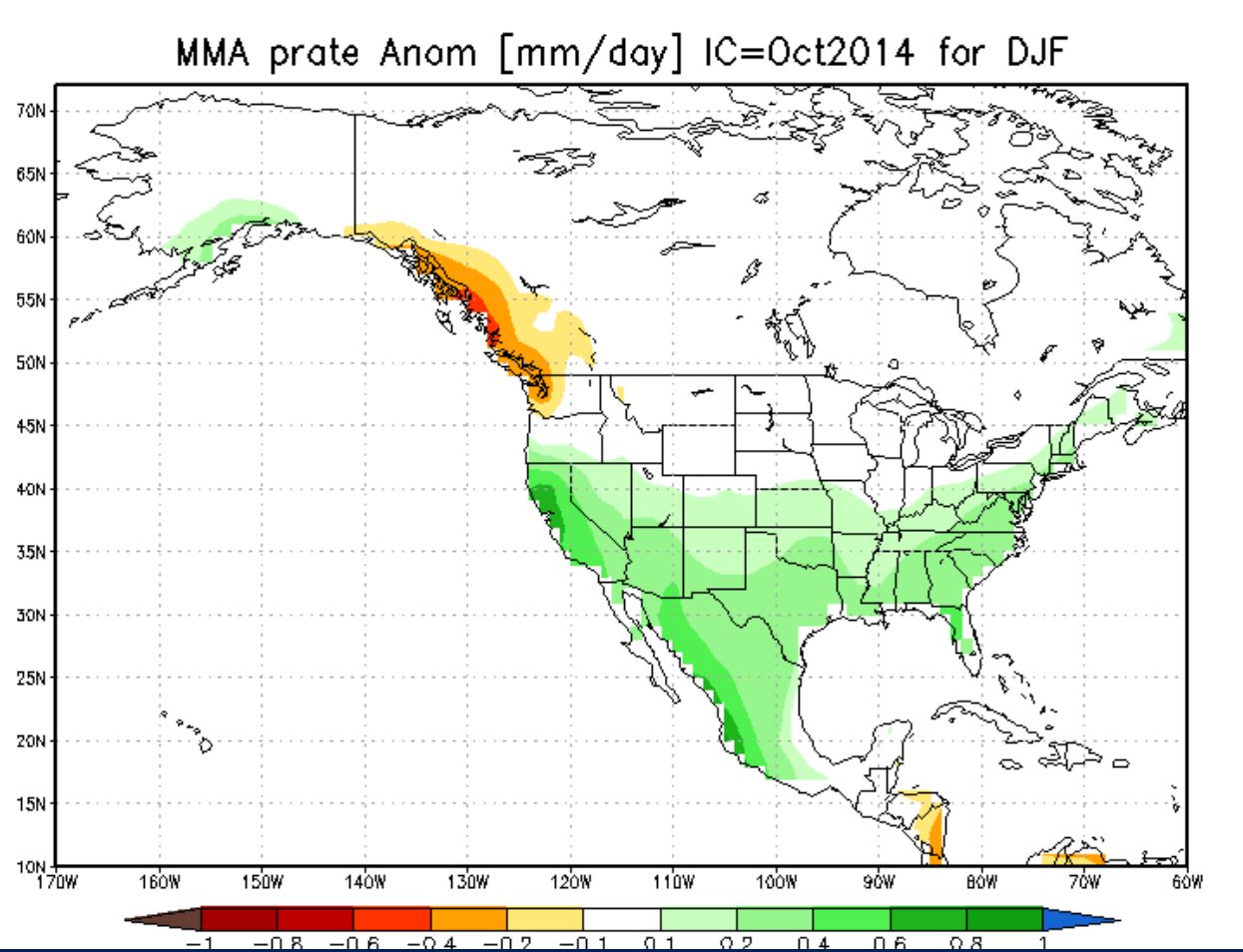


Temperature

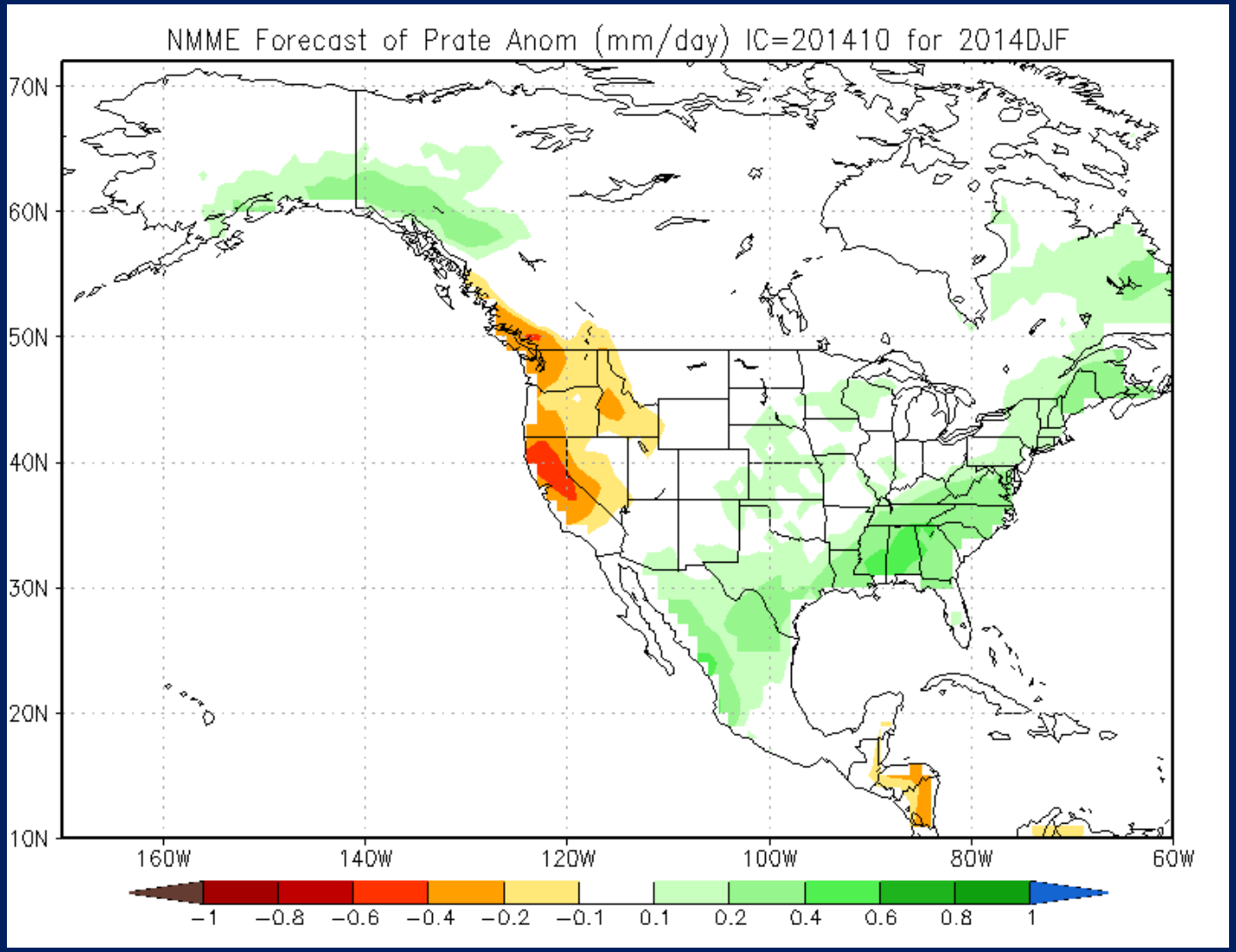


CPC Slide

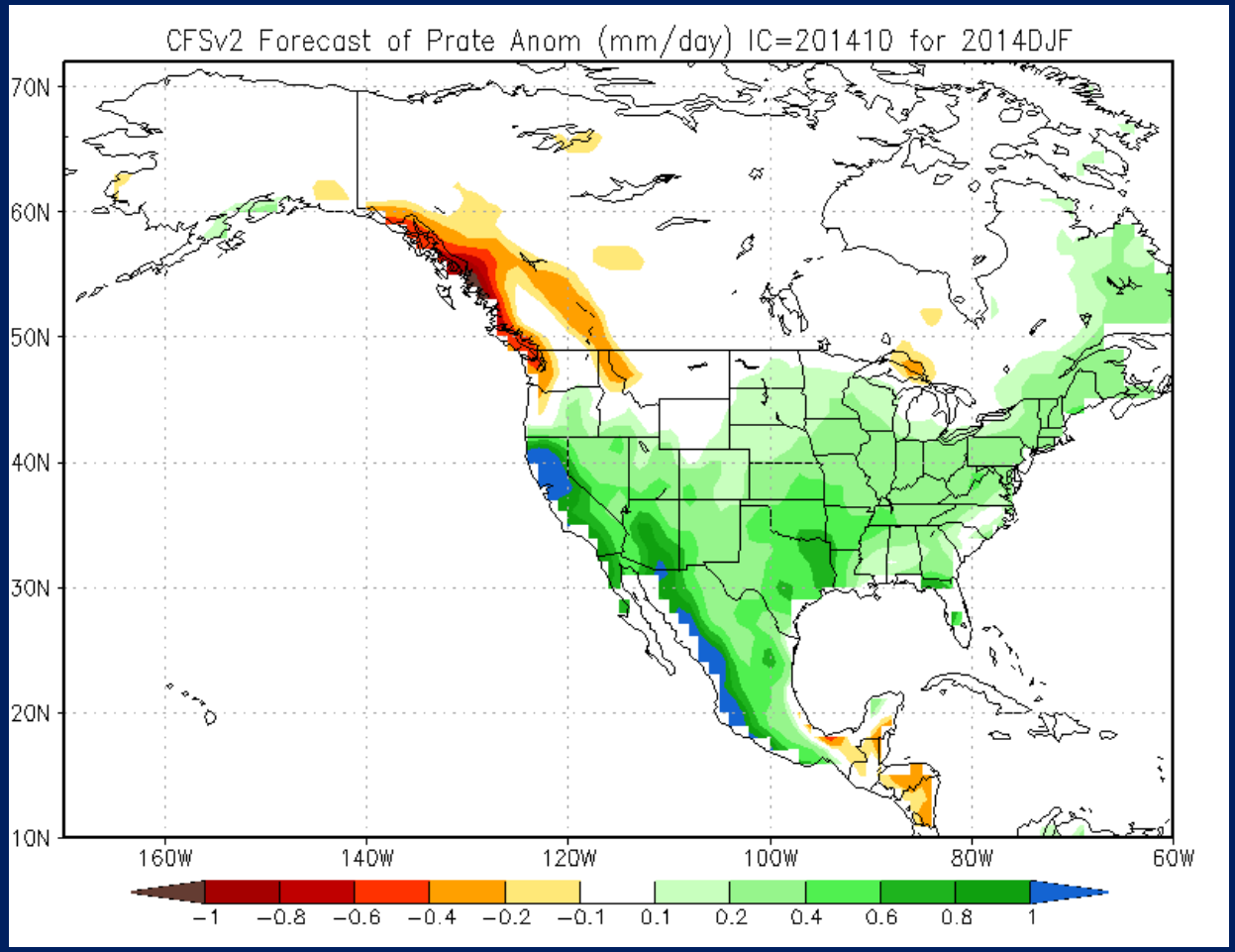
International Multi-Model Ensemble



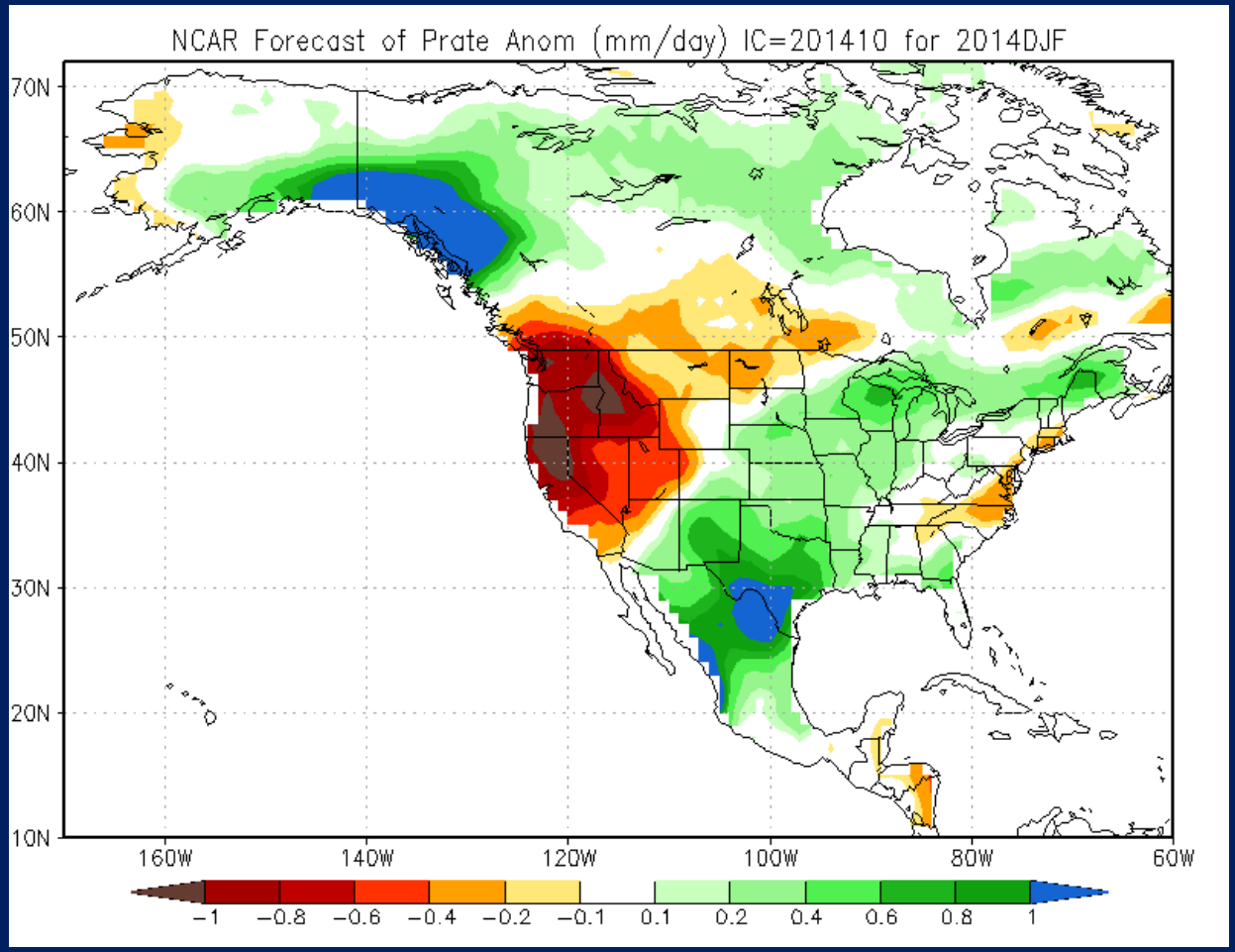
North American Multi-Model Ensemble



CFSv2 – only model with wet outcome

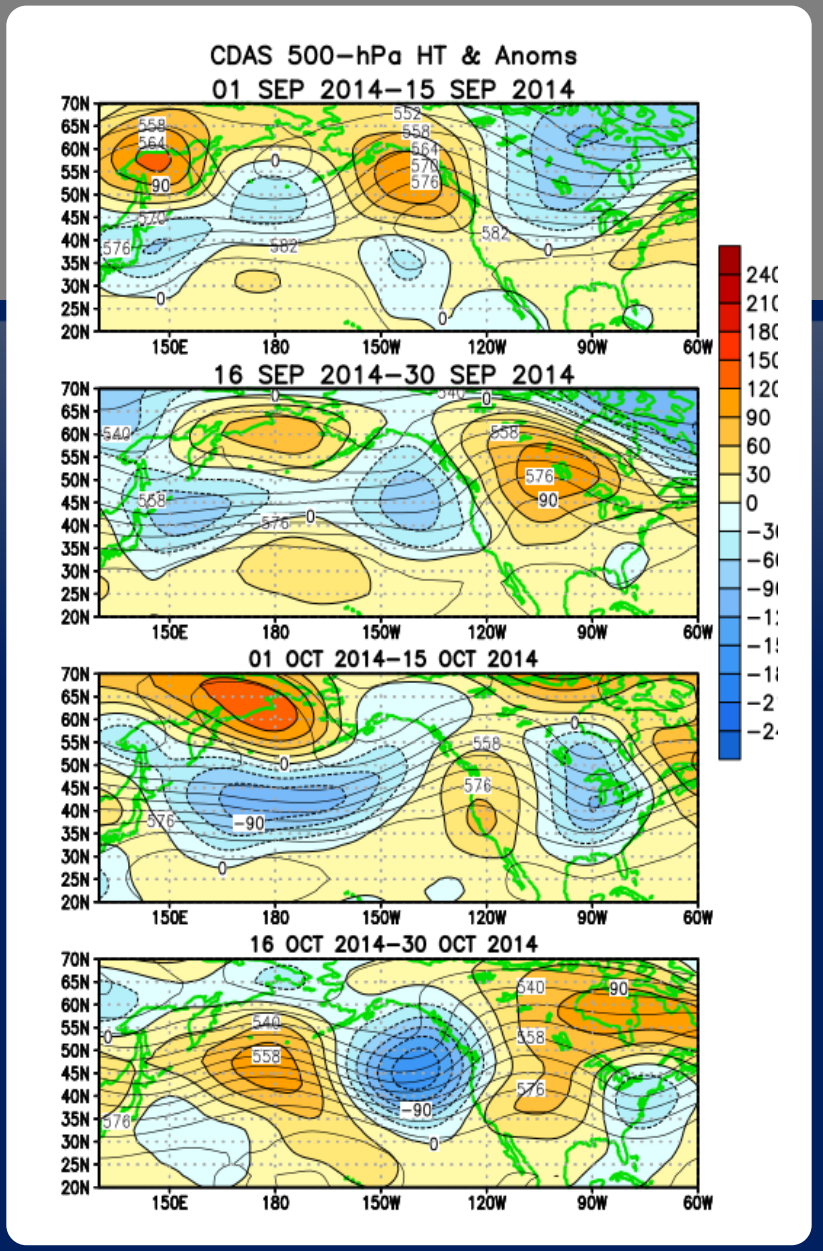


NCAR – most extreme dry outcome



Atmospheric anomalies over the North Pacific and North America During the Last 60 Days

During early September-late October, the pattern generally featured an anomalous ridge over the western N. America and an anomalous trough over the eastern N. America. This pattern often led to abvoe-average temperatures in the West and below average temperatures in the East.



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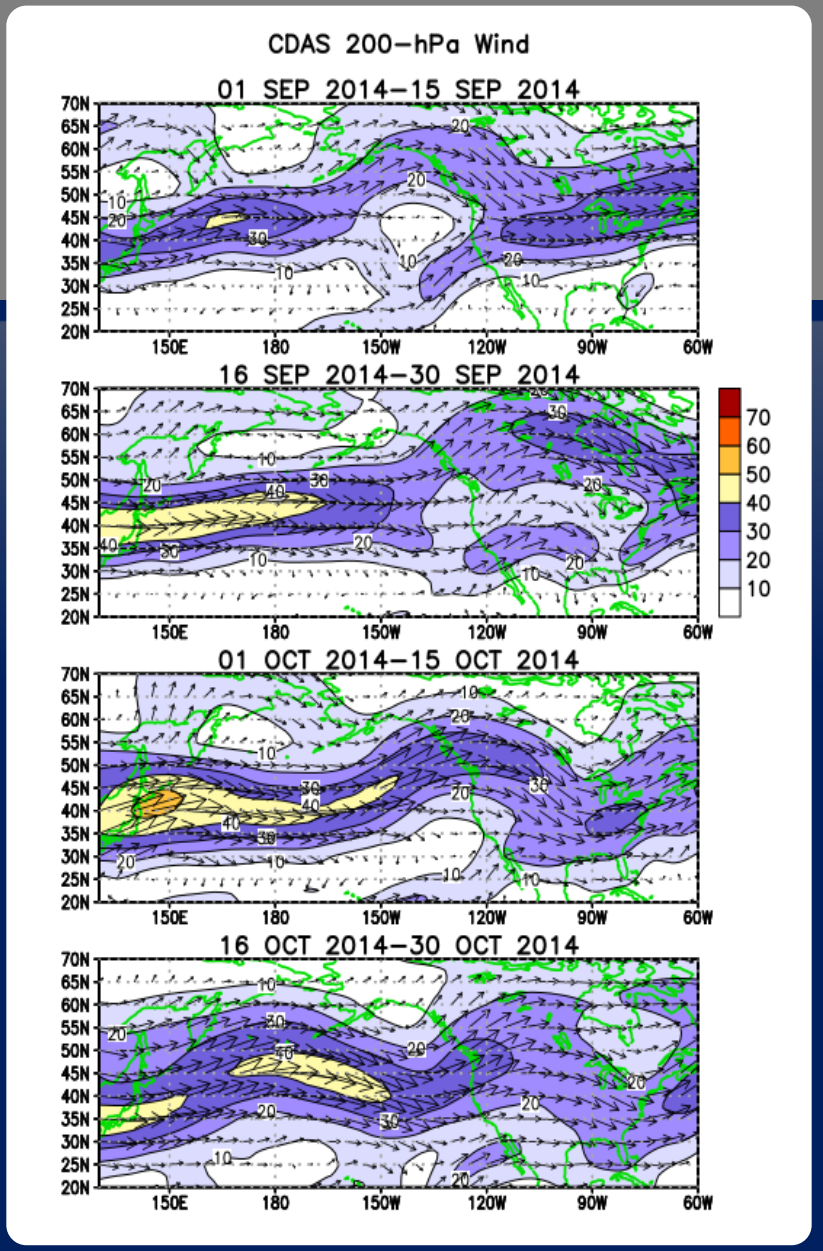
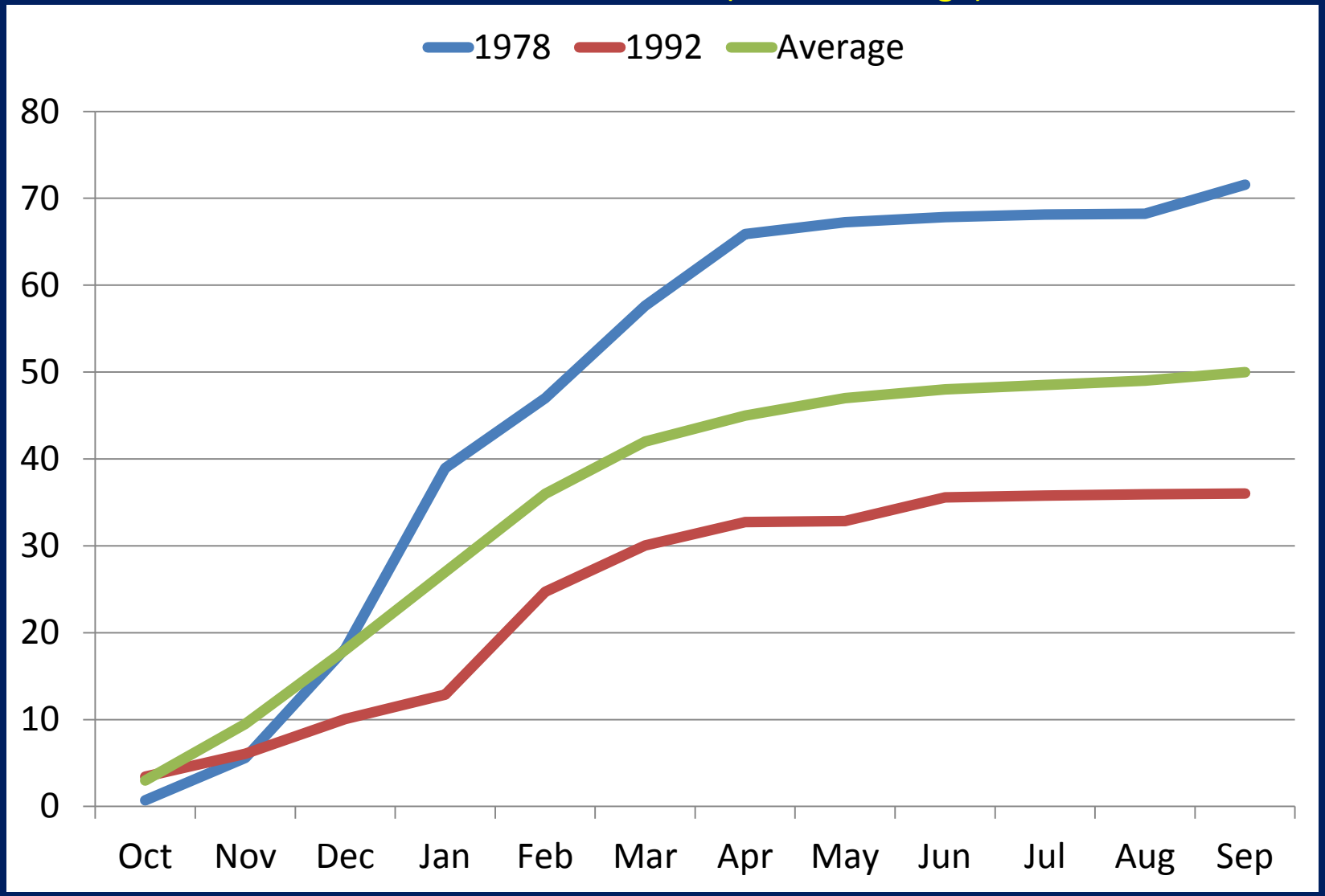


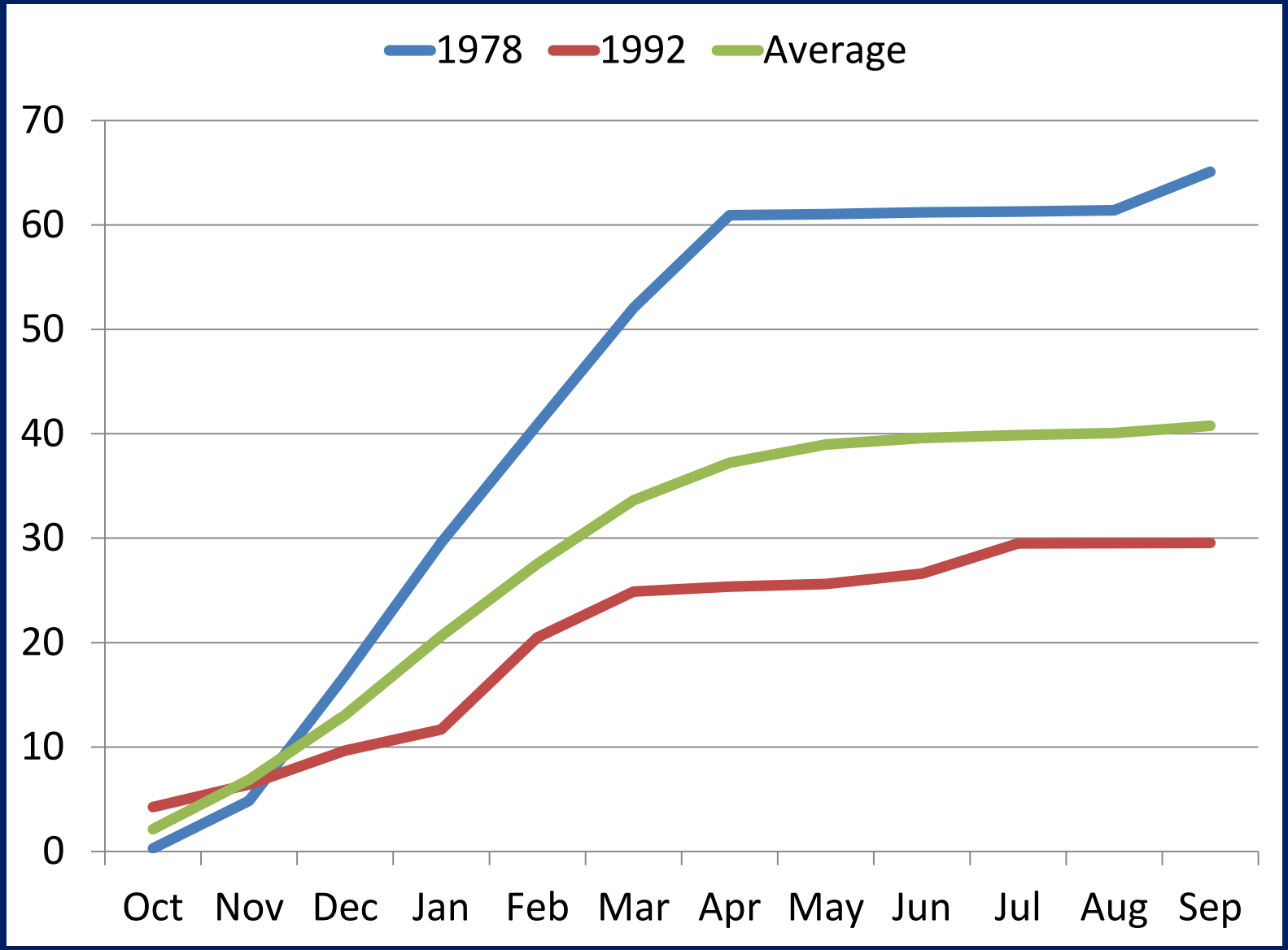
8-Station Index

Oct 2014: 2.7 inches (90% of average)

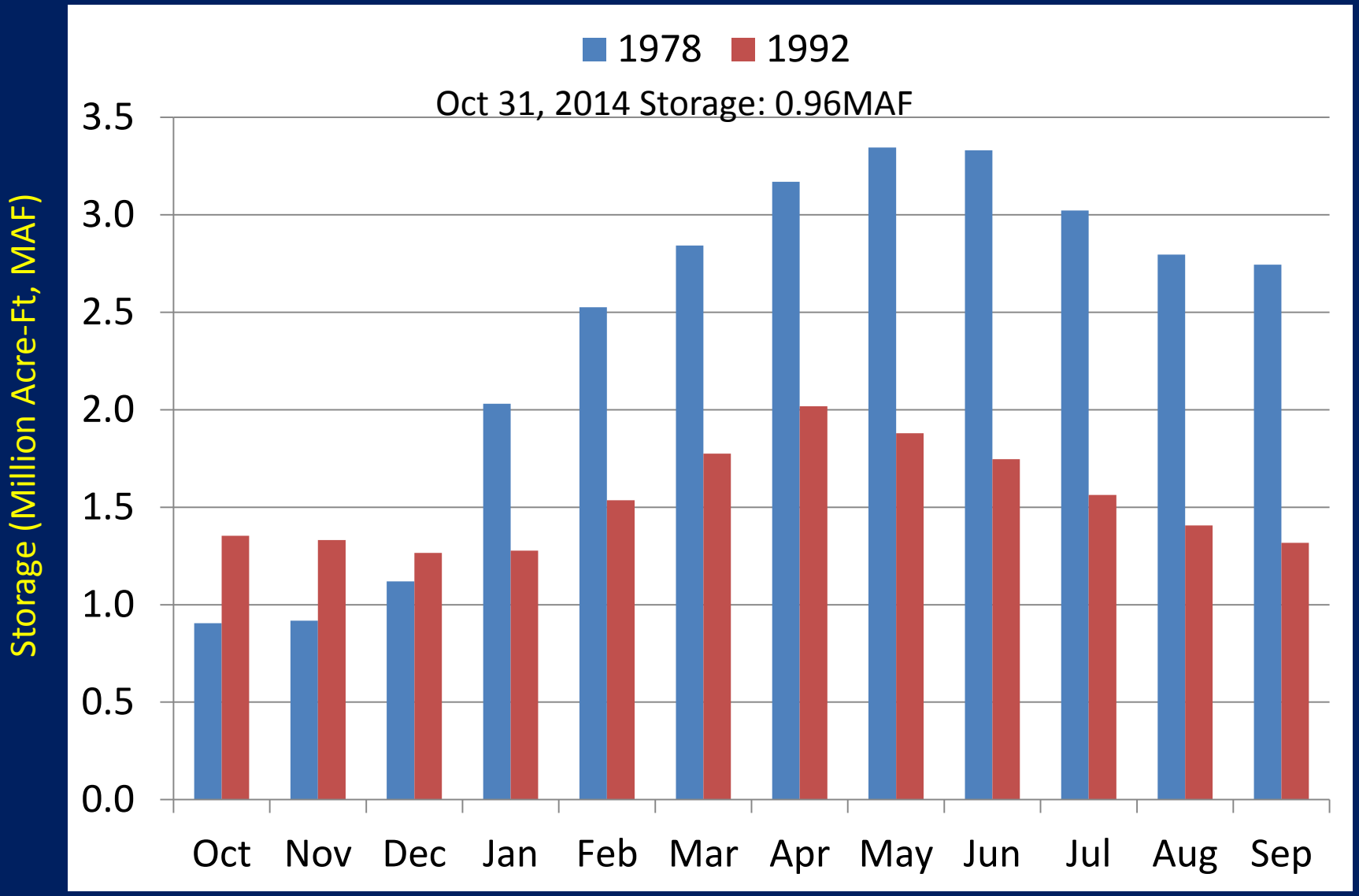


5-Station Index

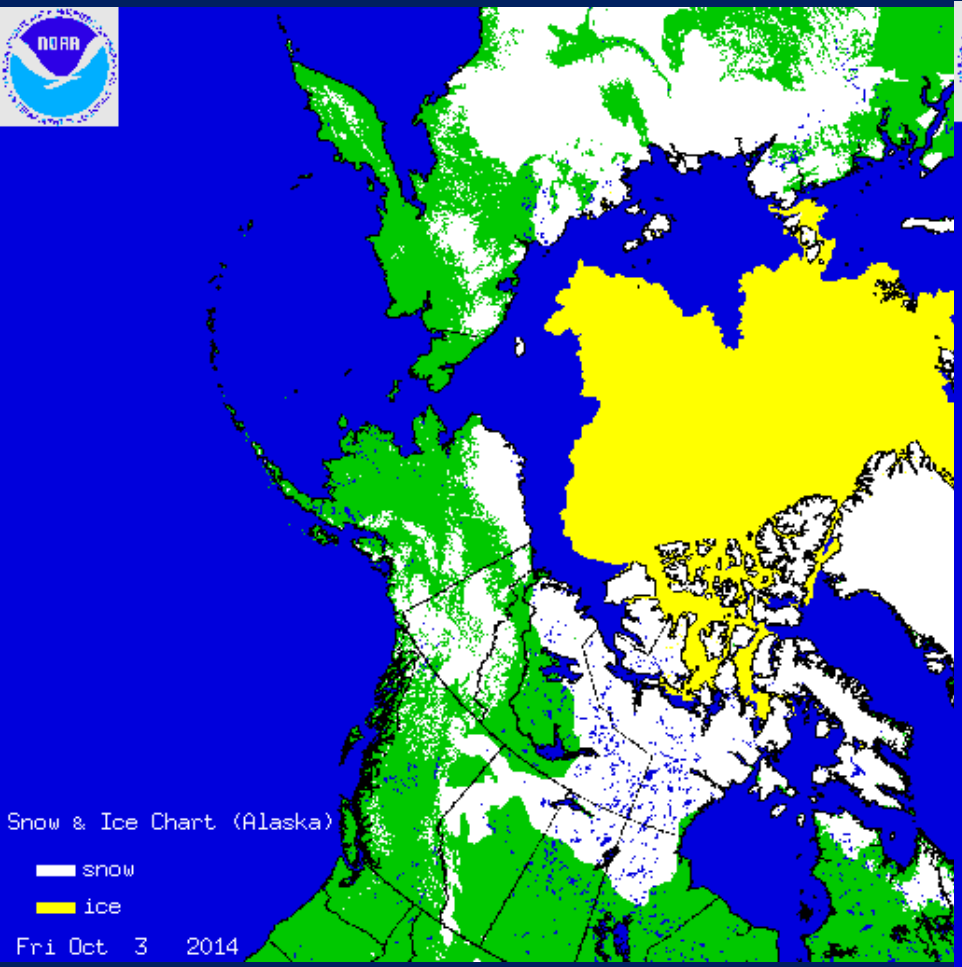
Oct 2014: 0.1 inches (5% of average)

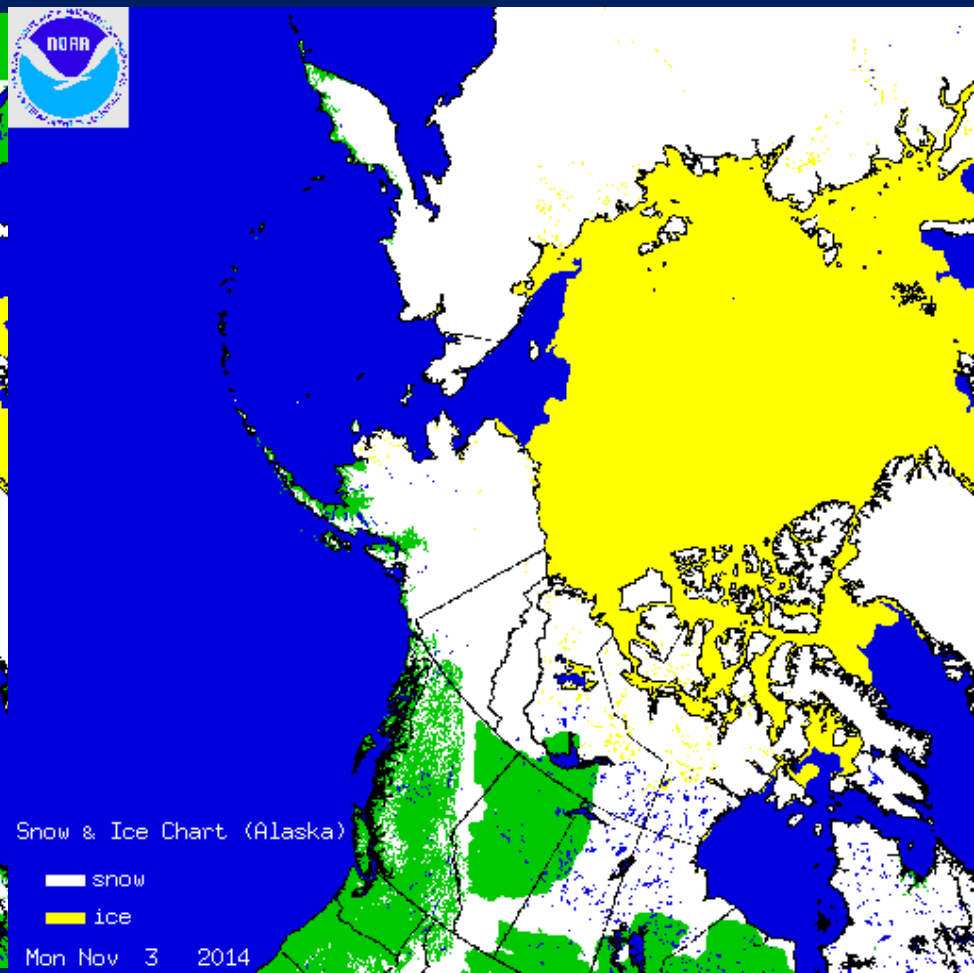


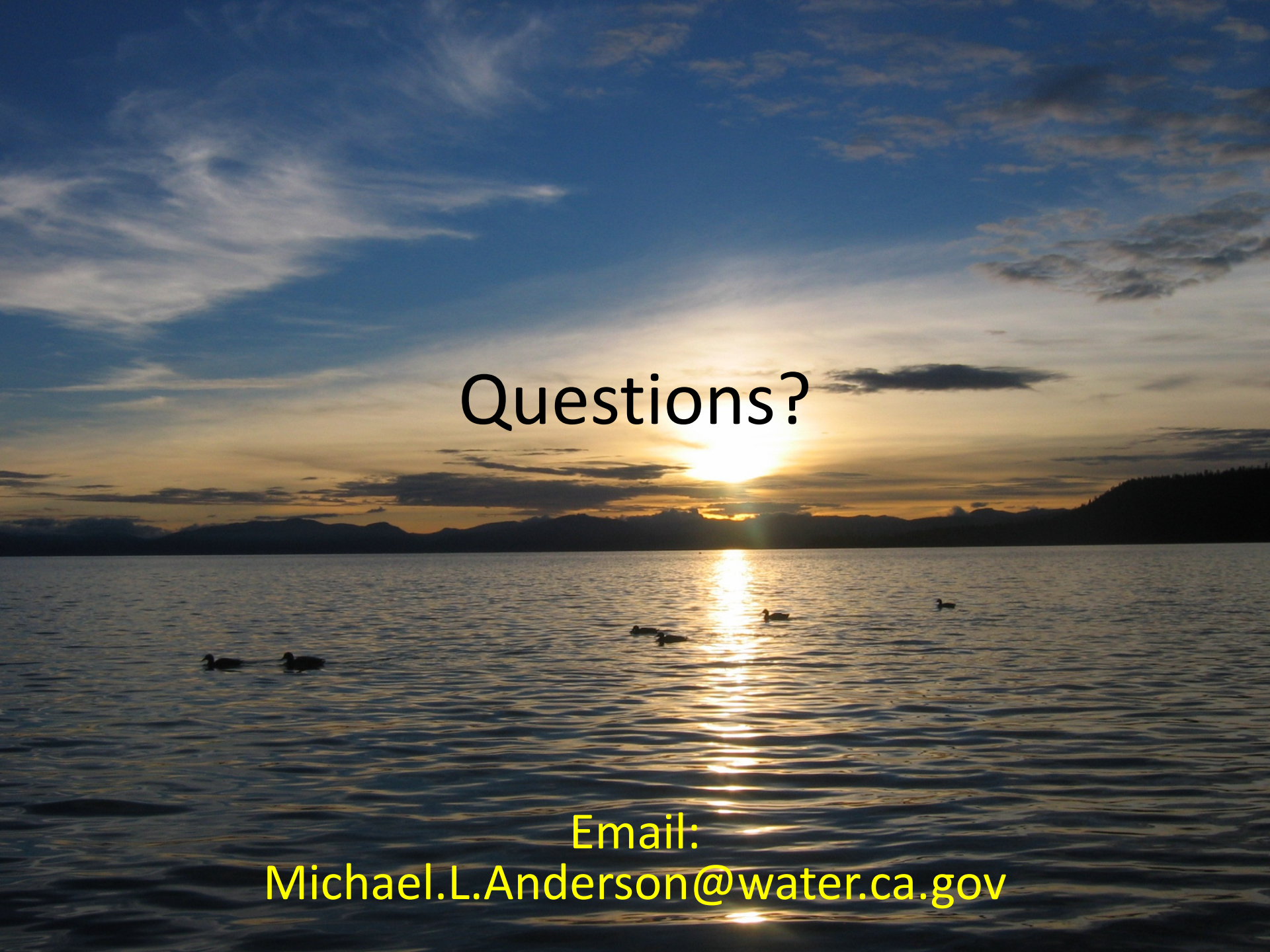
Oroville Storage



Arctic Snow/Ice Cover 2014






Questions?
Email:
Michael.L.Anderson@water.ca.gov