# Tracking California's hydroclimatology and markers of drought

## (EDUCATIONAL USE ONLY)

**Glen M. MacDonald,**
**Department of Geography, University of California at Los Angeles**

UCLA Geography
John Muir Memorial Chair

Southwest Climate Science Center

# CURRENT WATER/DROUGHT RELATED INDICATORS OF CLIMATE CHANGE IN CALIFORNIA

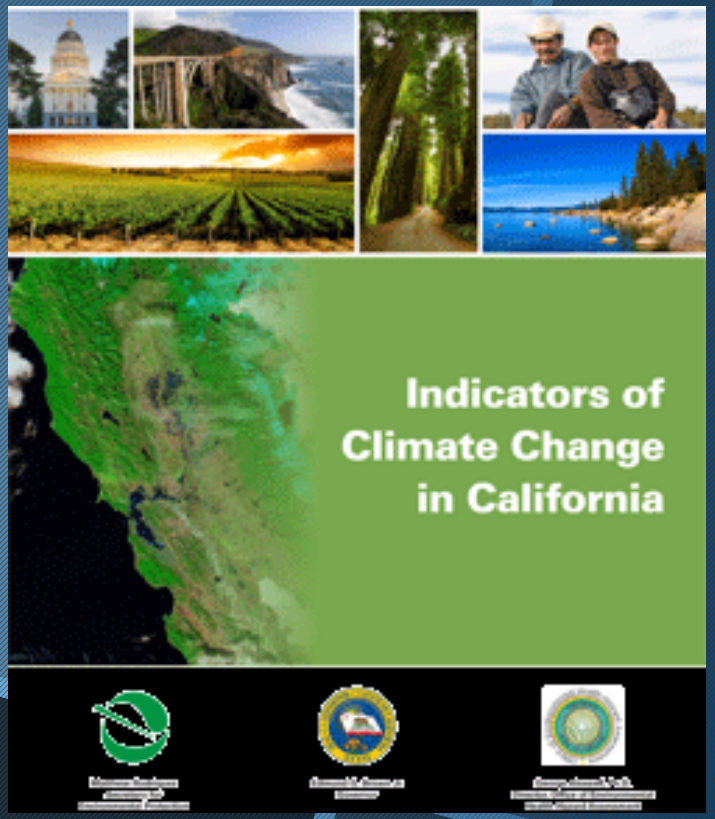
## CHANGES IN CLIMATE

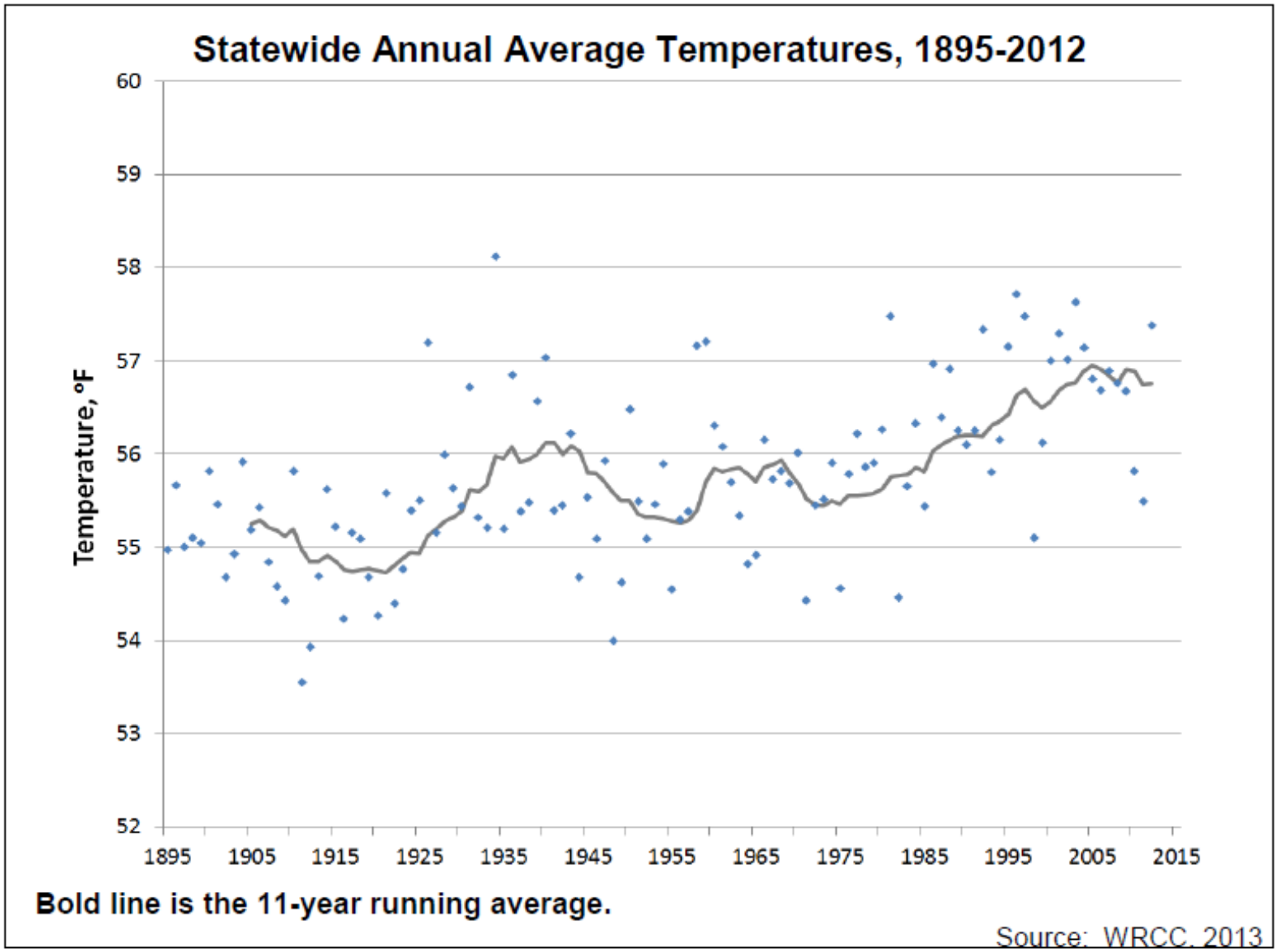
.Annual air temperature (updated)
.Annual precipitation (updated)

## IMPACTS OF CLIMATE CHANGE

### On physical systems

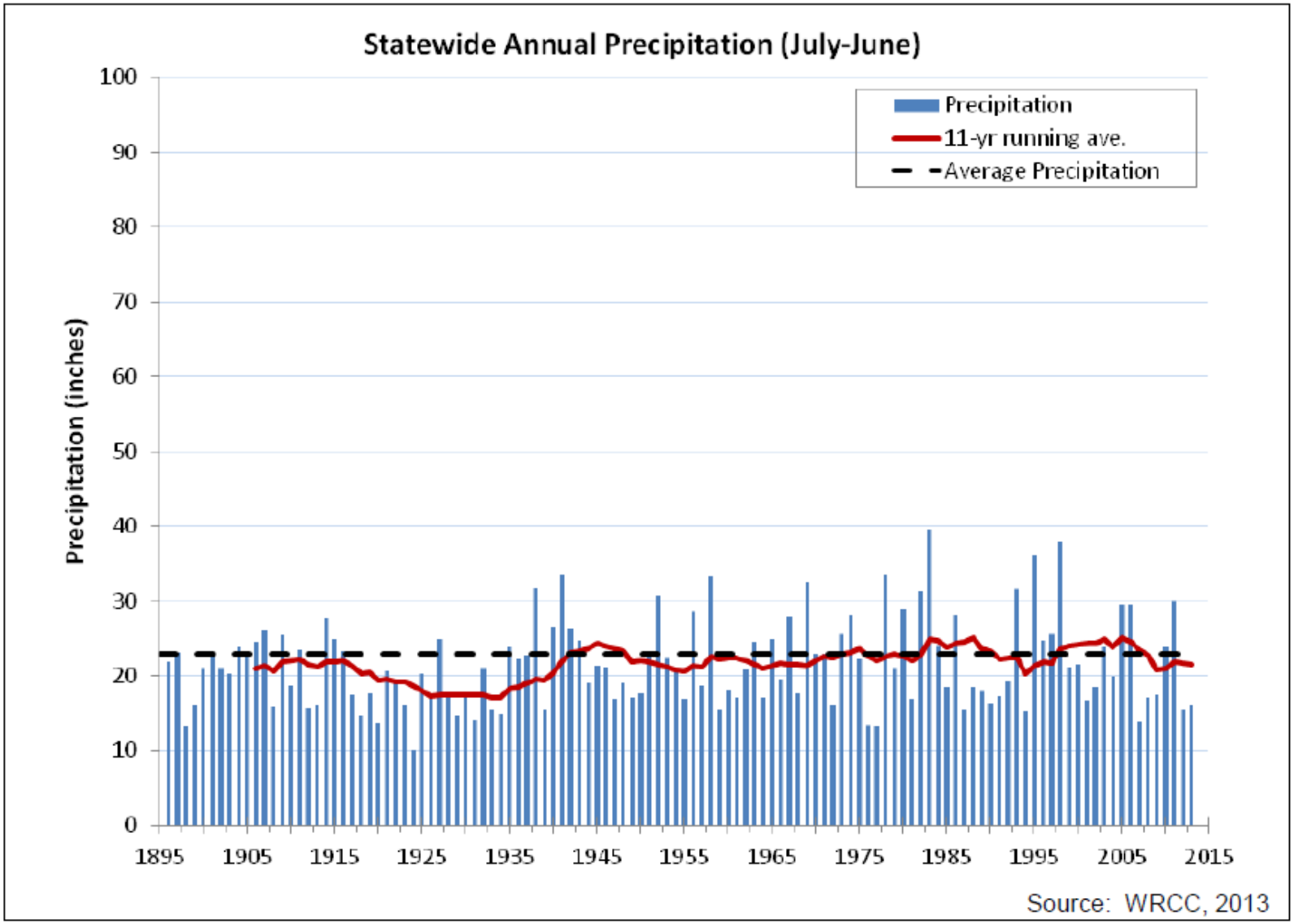
.Annual Sierra Nevada snowmelt runoff (updated)
.Snow-water content (updated)

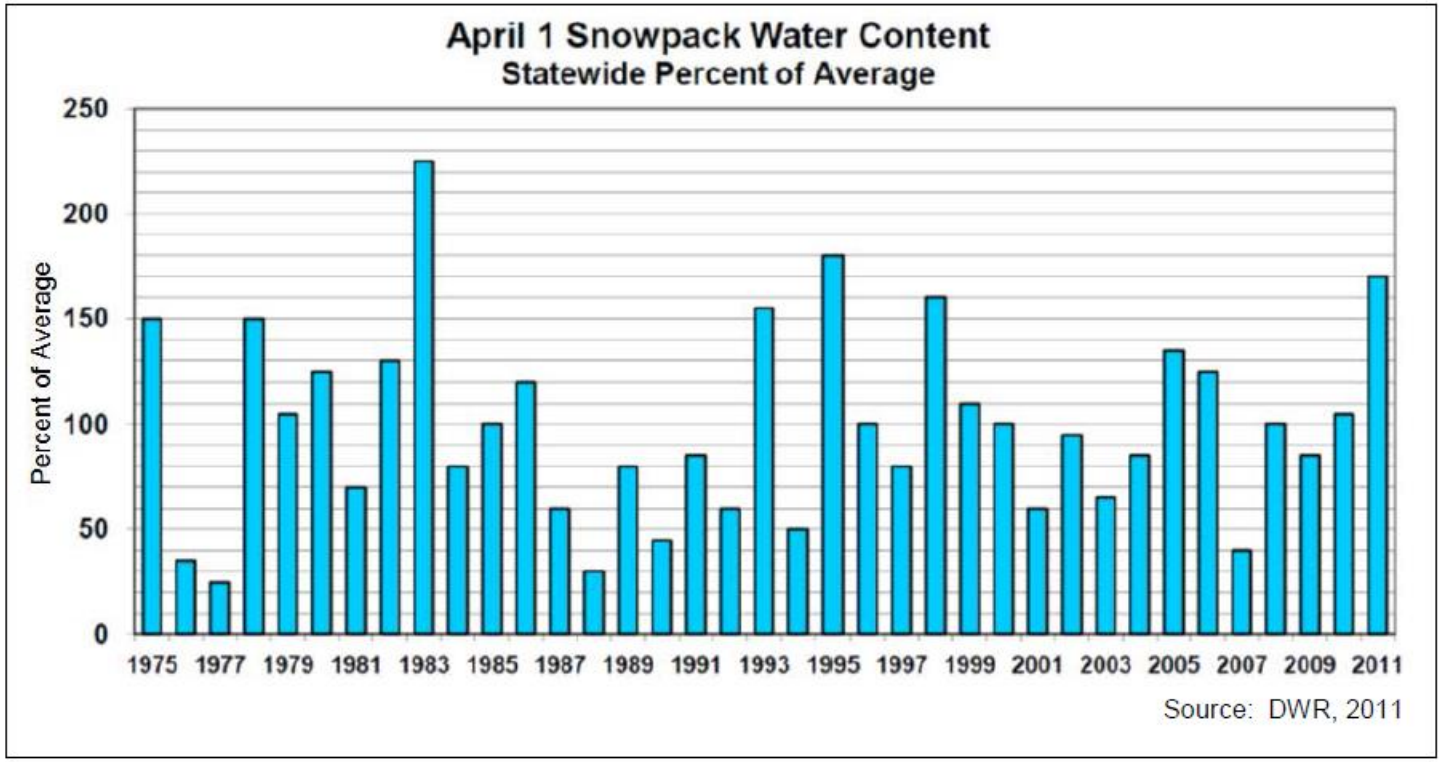


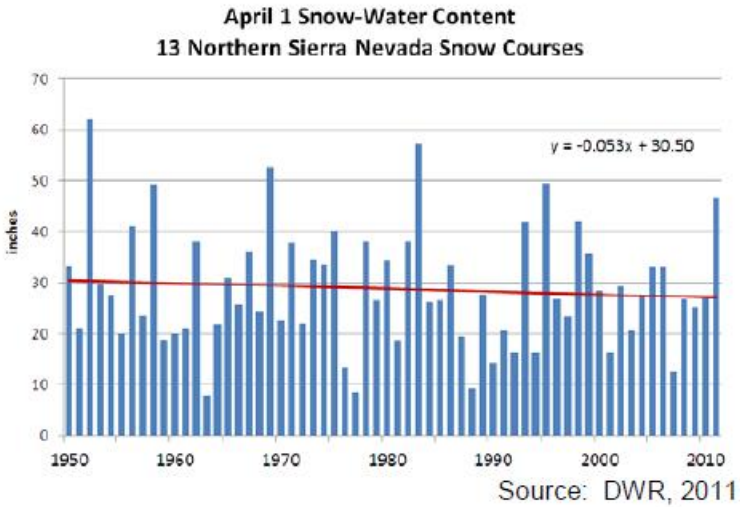

Statewide Annual Average Temperatures, 1895-2012
Temperature, °F
60
59
58
57
56
55
54
53
52
1895
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
2015
Bold line is the 11-year running average.
Source: WRCC, 2013

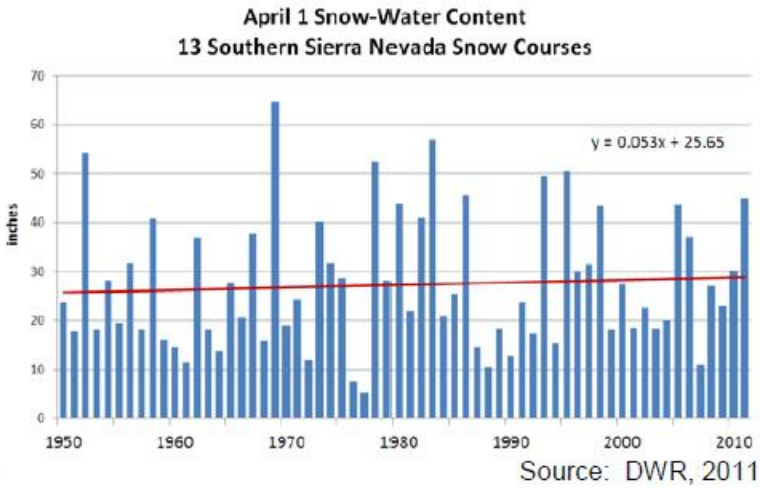
## Annual Precipitation (Updated)

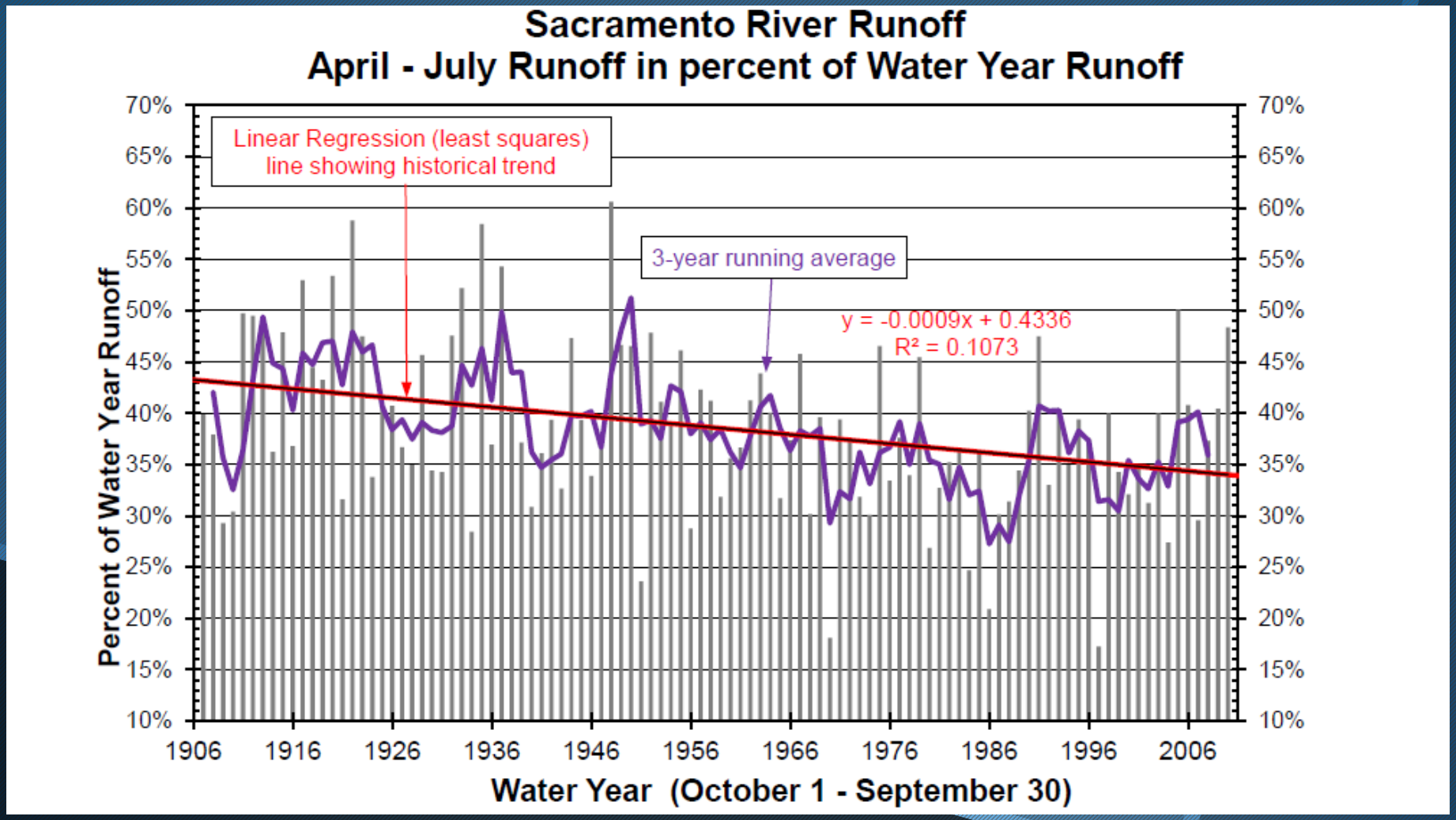
*Large year-to-year variations in annual precipitation are evident, with no apparent trend.*



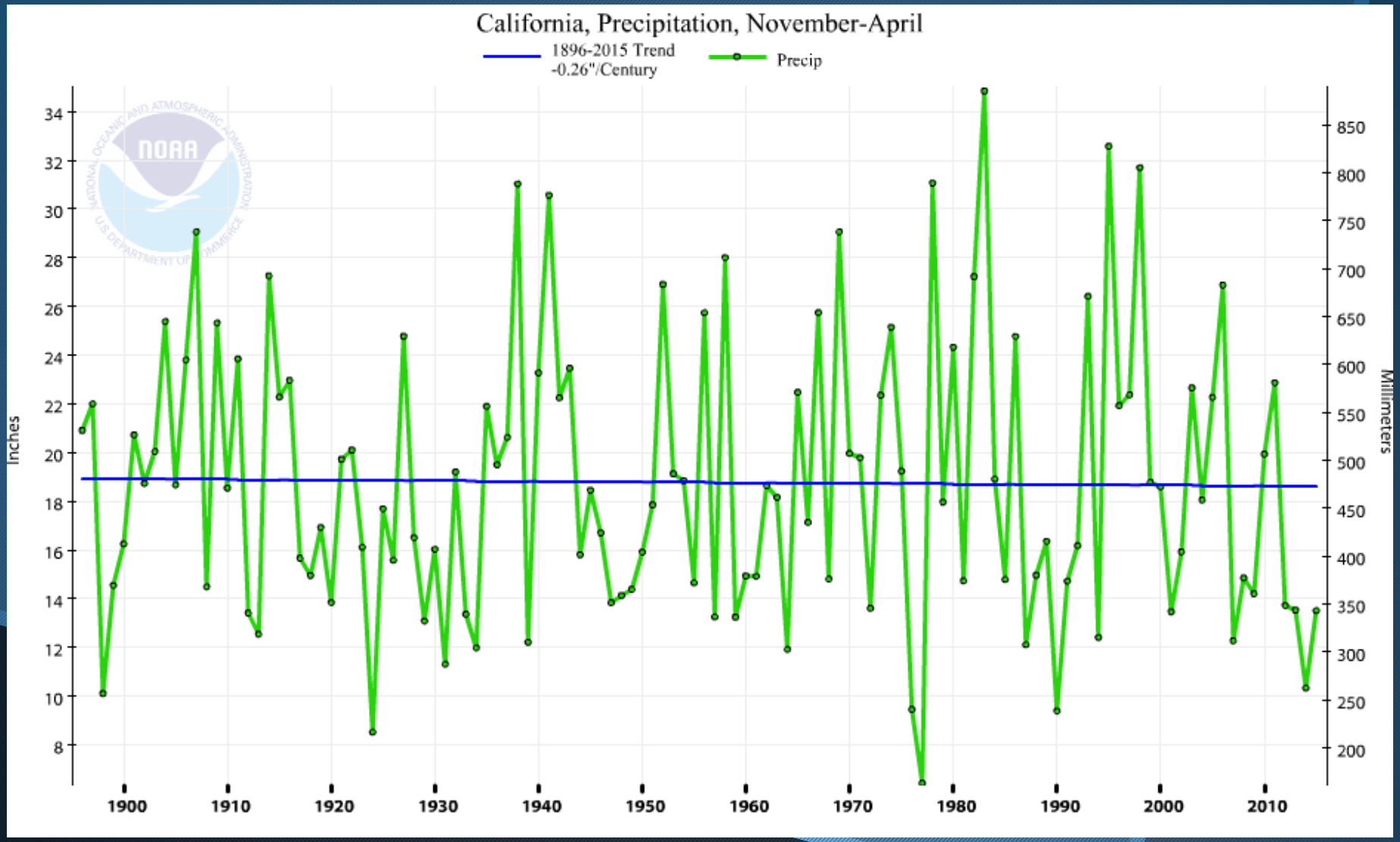

April 1 Snowpack Water Content
Statewide Percent of Average
Percent of Average
250
200
150
100
50
0
1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011
Source: DWR, 2011

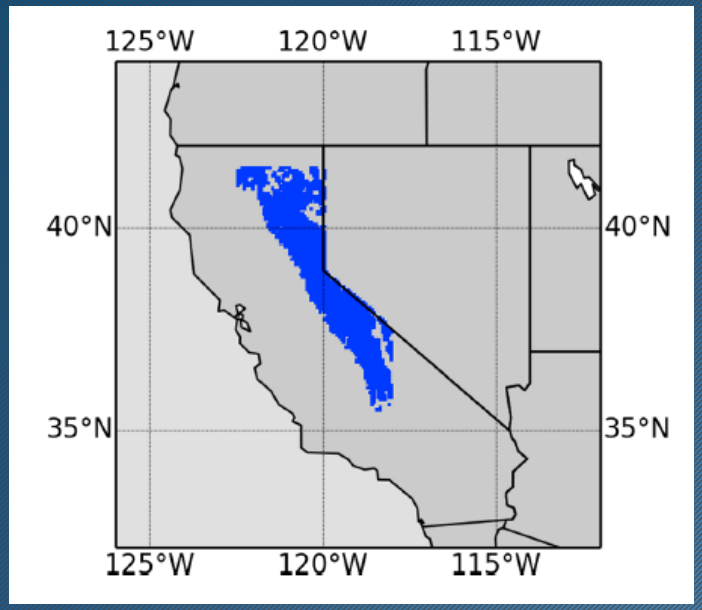

April 1 Snow-Water Content
13 Northern Sierra Nevada Snow Courses
y = -0.053x + 30.50
inches
70
60
50
40
30
20
10
0
1950 1960 1970 1980 1990 2000 2010
Source: DWR, 2011

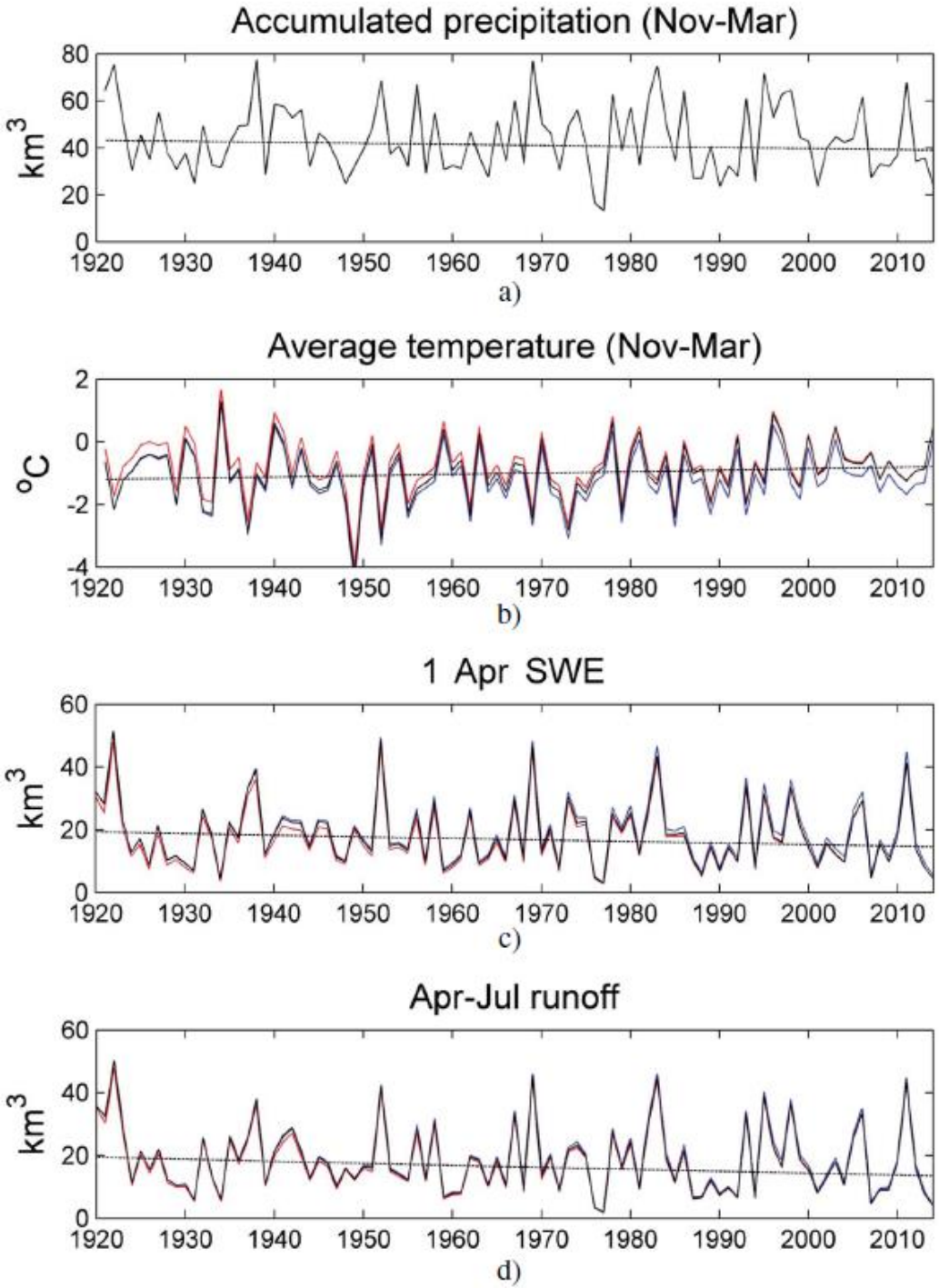

April 1 Snow-Water Content
13 Southern Sierra Nevada Snow Courses
y = 0.053x + 25.65
inches
70
60
50
40
30
20
10
0
1950 1960 1970 1980 1990 2000 2010
Source: DWR, 2011


Sacramento River Runoff
April - July Runoff in percent of Water Year Runoff
Linear Regression (least squares) line showing historical trend
3-year running average
y = -0.0009x + 0.4336
R² = 0.1073
Percent of Water Year Runoff
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
1906
1916
1926
1936
1946
1956
1966
1976
1986
1996
2006
Water Year (October 1 - September 30)

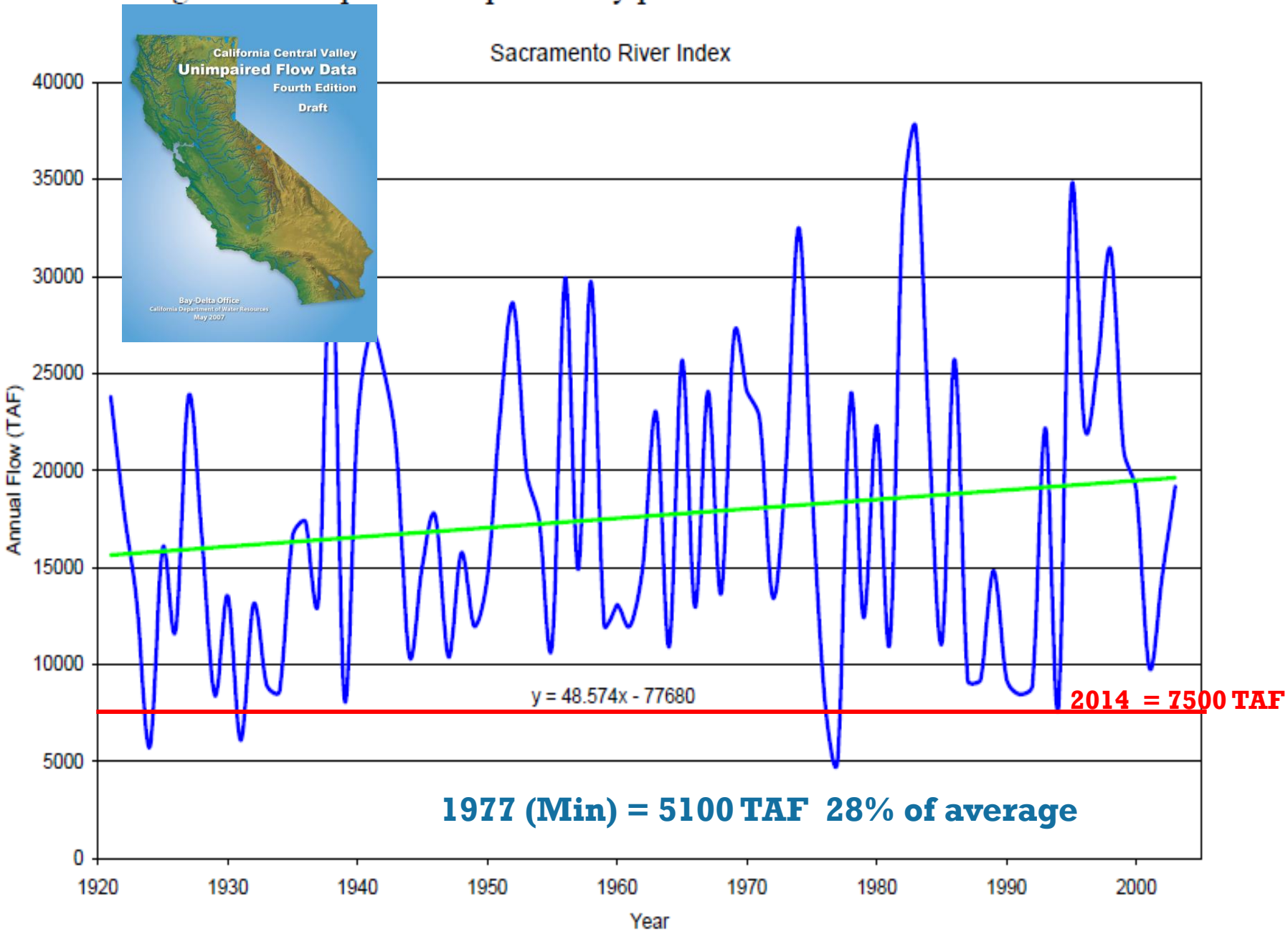
# LESSONS FROM CURRENT DROUGHT FOR APPROPRIATE WATER RESOURCES/DROUGHT INDICATORS


California, Precipitation, November-April
1896-2015 Trend
-0.26"/Century
Precip
Inches
Millimeters
34
32
30
28
26
24
22
20
18
16
14
12
10
8
850
800
750
700
650
600
550
500
450
400
350
300
250
200
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010



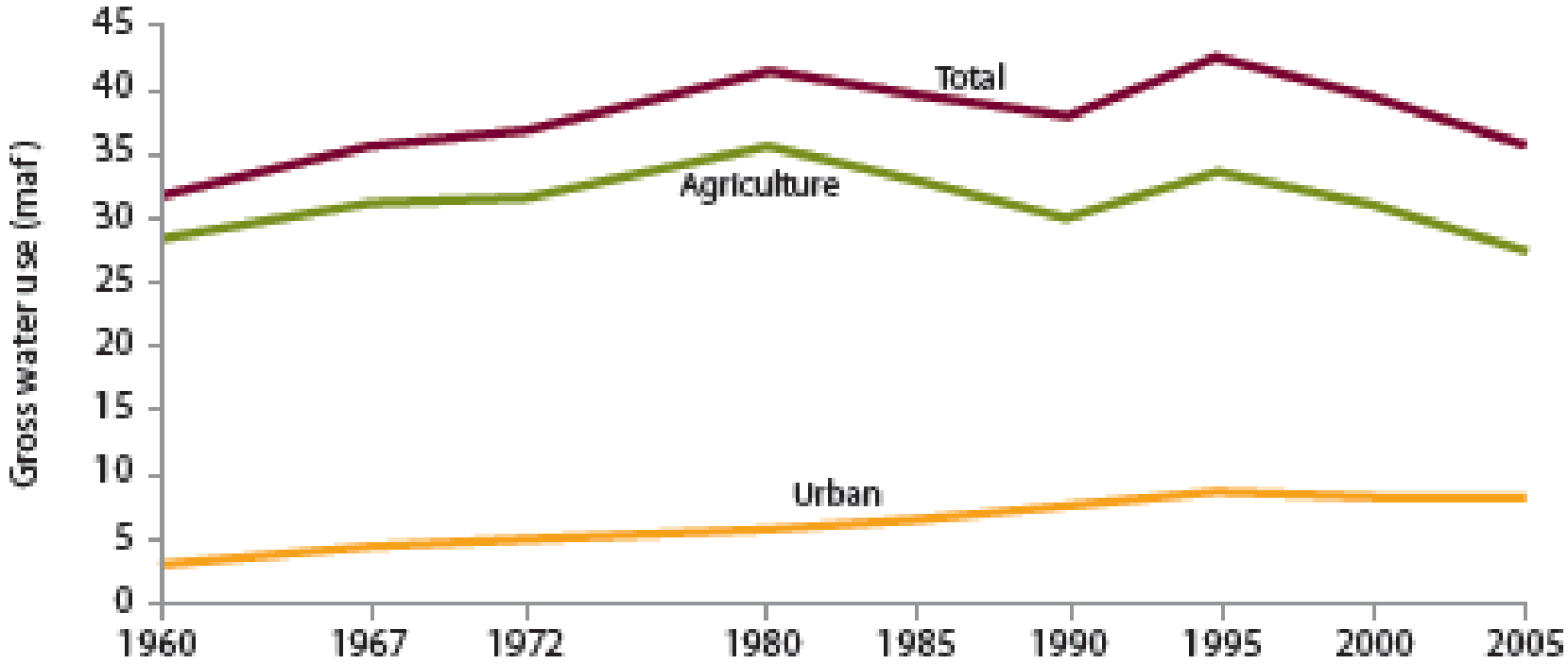




Mao, Y., Nijssen, B., & Lettenmaier, D. P. (2015). Is climate change implicated in the 2013–2014 California drought? A hydrologic perspective. Geophysical Research Letters, 42(8), 2805-2813.


California Central Valley
Unimpaired Flow Data
Fourth Edition
Draft
Bay-Delta Office
California Department of Water Resources
May 2007
Sacramento River Index
Annual Flow (TAF)
Year
y = 48.574x - 77680
2014 = 7500 TAF
1977 (Min) = 5100 TAF 28% of average

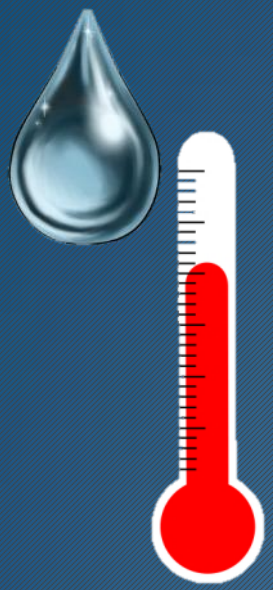
# So – why so bad?

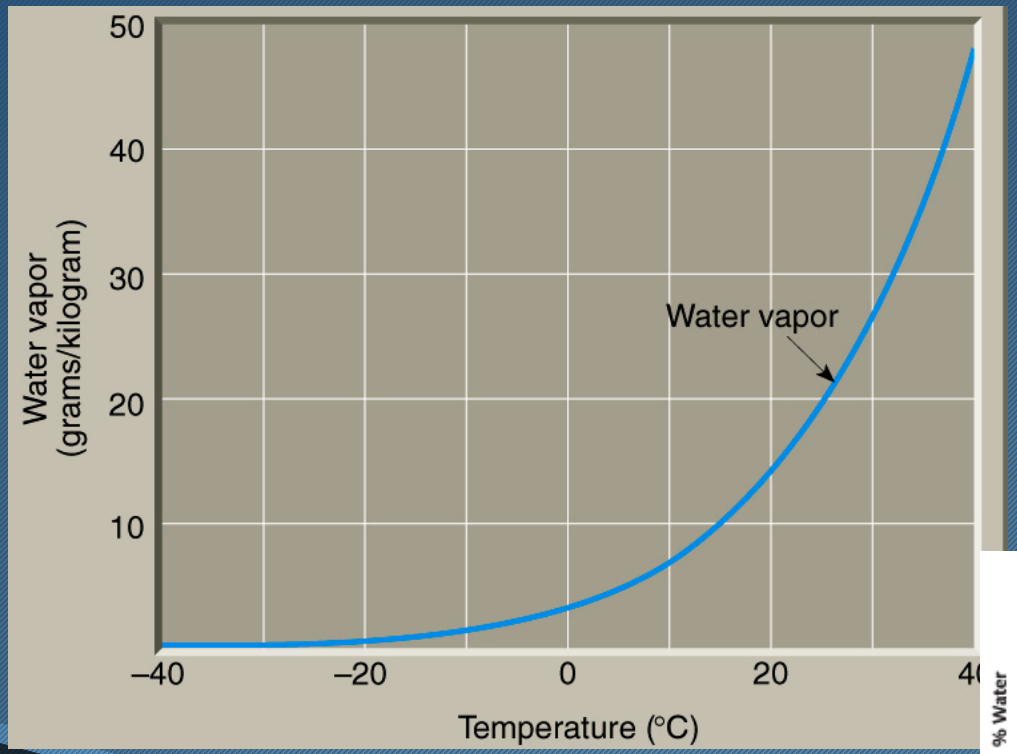
**Figure 2.8**
Total gross agricultural and urban water use has been decreasing

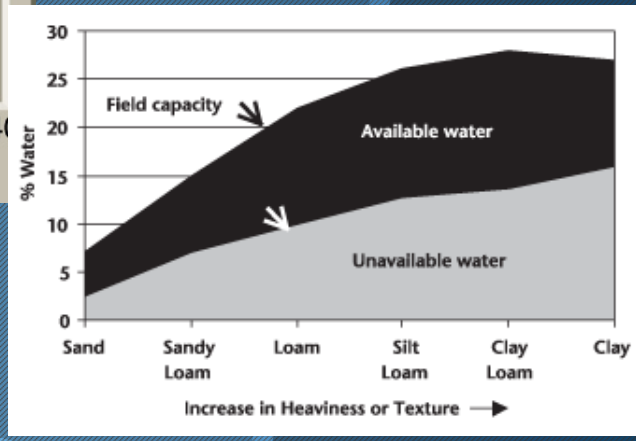



Hanak, Ellen et al. Managing California's water: from conflict to reconciliation. Public Policy Instit. of CA, 2011.

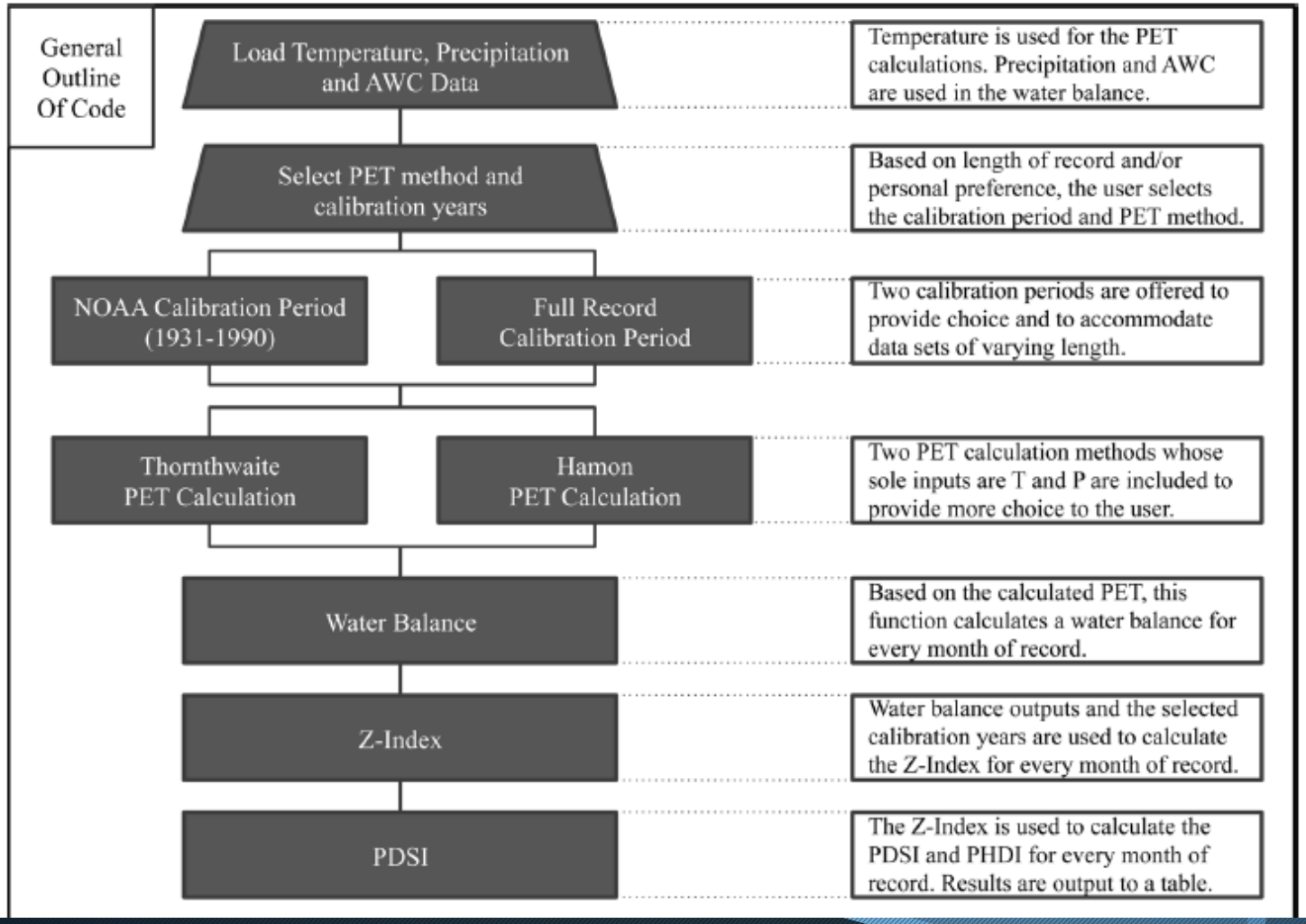
# Palmer Drought Severity Index (PDSI)



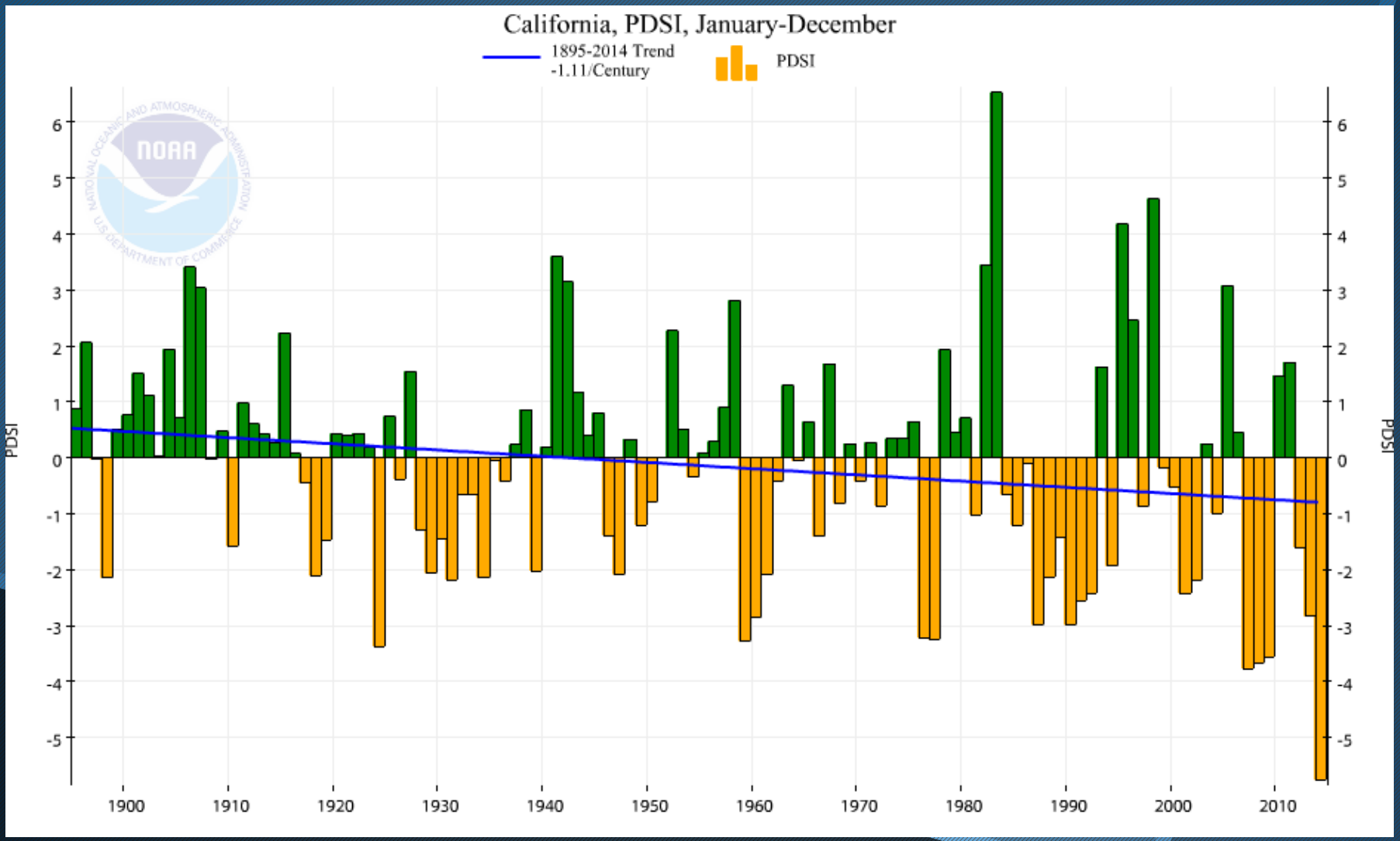


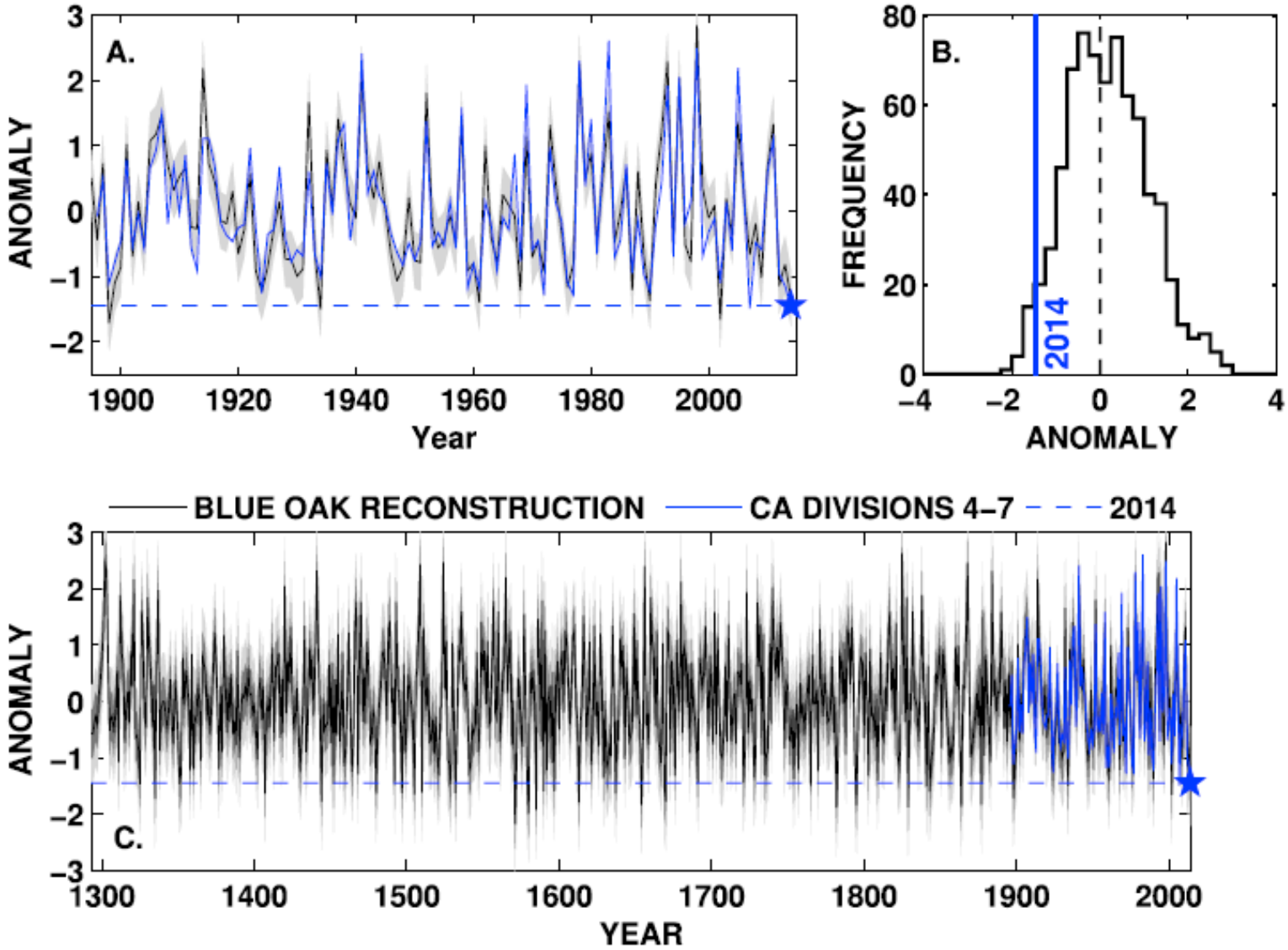

Palmer, W. 1965. "Meteorological Drought". Research paper no.45, U.S. Department of Commerce Weather Bureau, February 1965 (58 pgs). Available online http://www.ncdc.noaa.gov/temp-and-precip/drought/docs/palmer.pdf



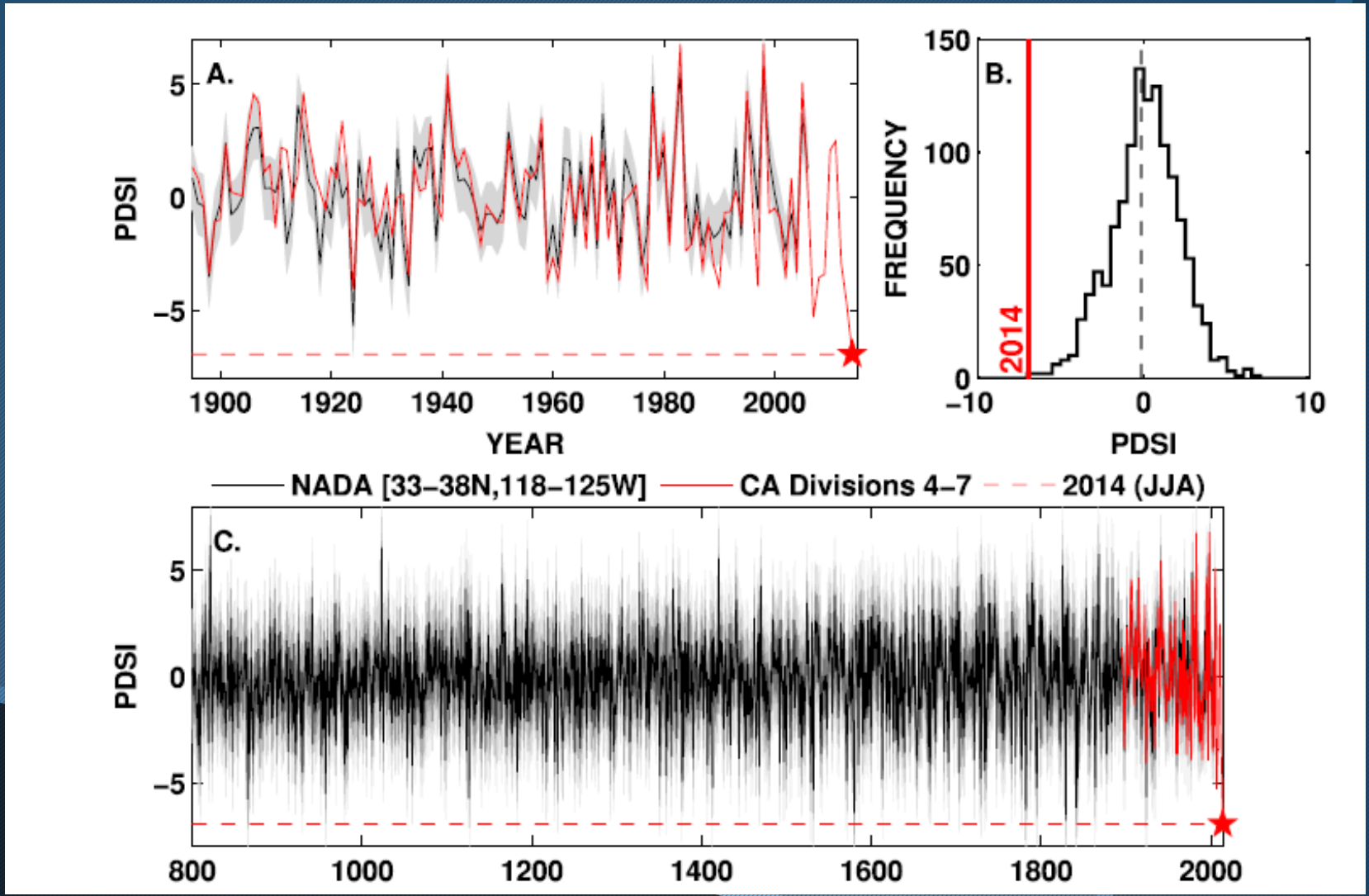

Jacobi, J., Perrone, D., Duncan, L. L., & Hornberger, G. (2013). A tool for calculating the Palmer drought indices. Water Resources Research, 49(9), 6086-6089.



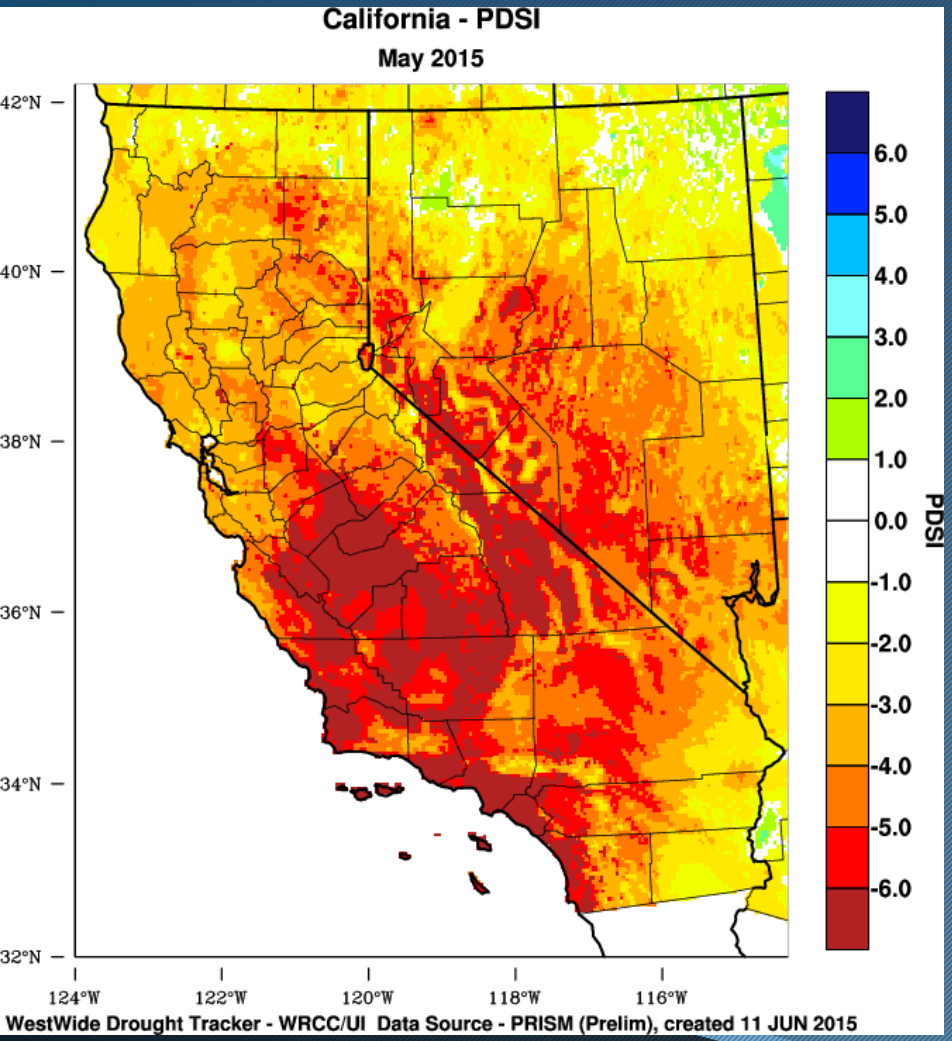

http://www.ncdc.noaa.gov/cag/time-series/us

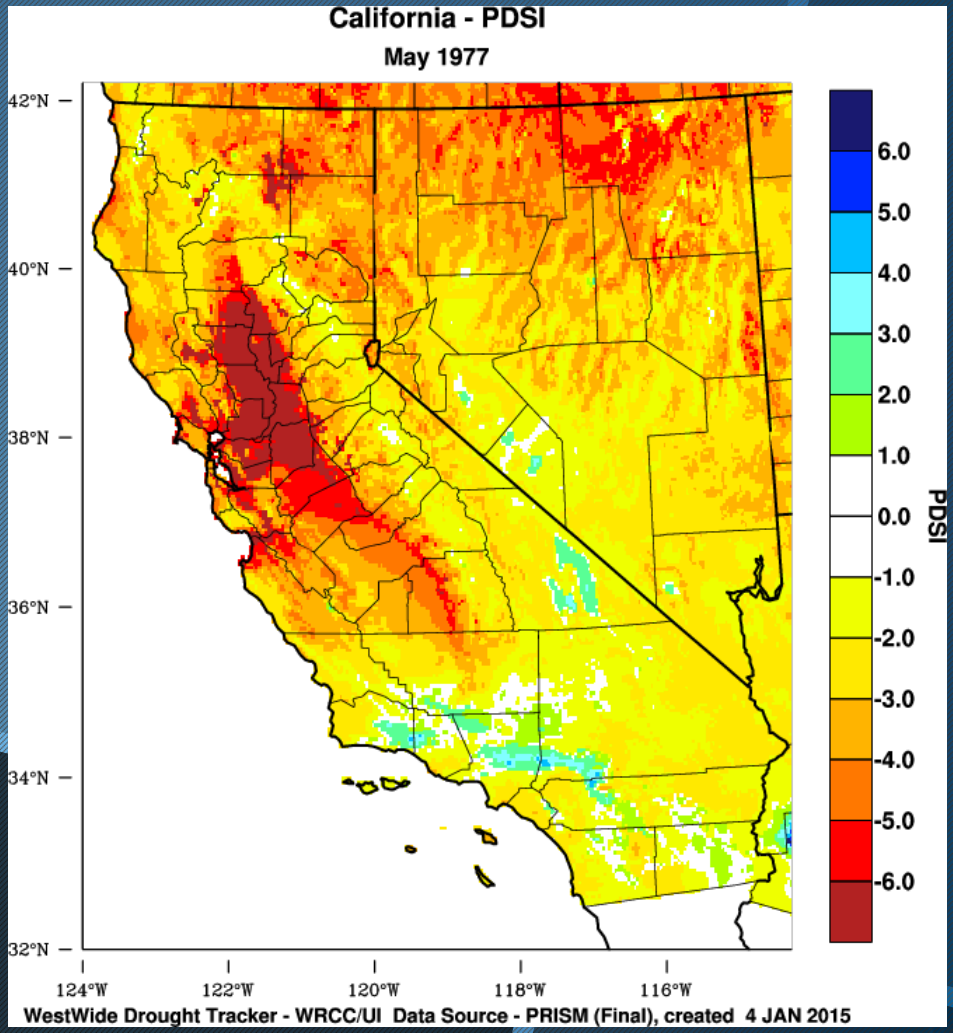


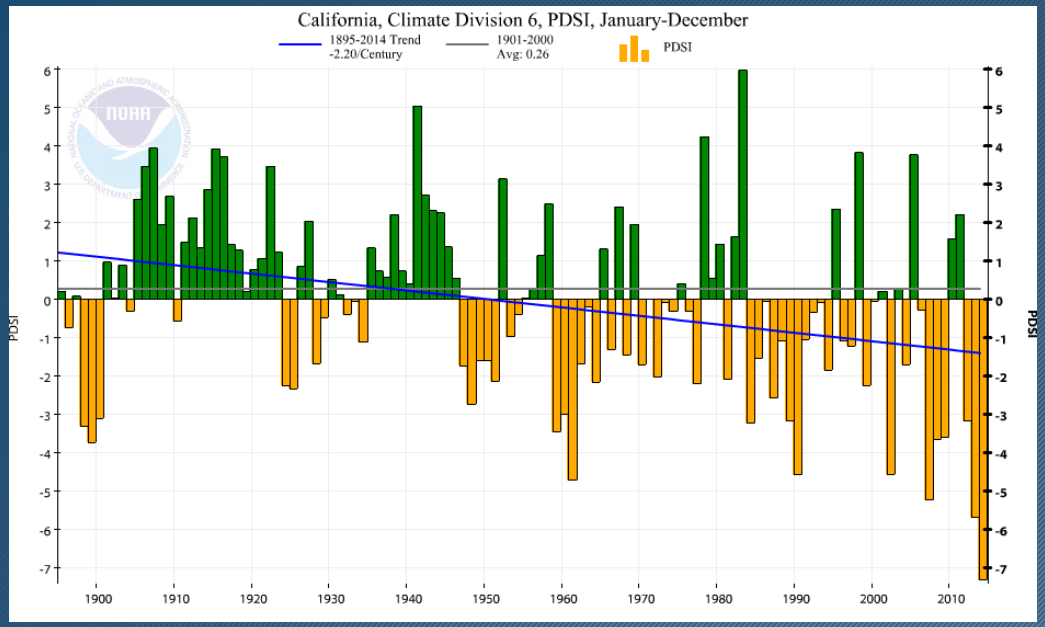

Griffin, D., & Anchukaitis, K. J. (2014). How unusual is the 2012–2014 California drought?. Geophysical Research Letters, 41(24), 9017-9023.

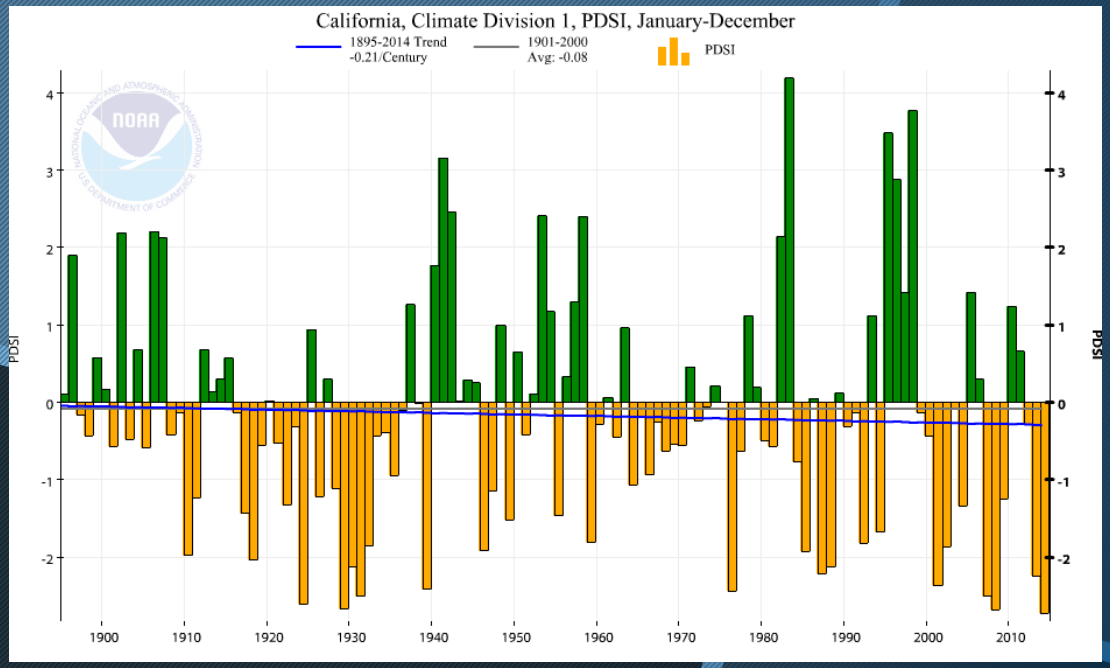



Griffin, D., & Anchukaitis, K. J. (2014). How unusual is the 2012–2014 California drought?. Geophysical Research Letters, 41(24), 9017-9023.


California - PDSI
May 2015
42°N
40°N
38°N
36°N
34°N
32°N
124°W
122°W
120°W
118°W
116°W
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
PDSI
WestWide Drought Tracker - WRCC/UI Data Source - PRISM (Prelim), created 11 JUN 2015


California - PDSI
May 1977
42°N
40°N
38°N
36°N
34°N
32°N
124°W
122°W
120°W
118°W
116°W
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
PDSI
WestWide Drought Tracker - WRCC/UI Data Source - PRISM (Final), created 4 JAN 2015


California, Climate Division 6, PDSI, January-December
1895-2014 Trend
-2.20/Century
1901-2000
Avg: 0.26
PDSI
PDSI
PDSI


California, Climate Division 1, PDSI, January-December
1895-2014 Trend
-0.21/Century
1901-2000
Avg: -0.08
PDSI
PDSI
PDSI

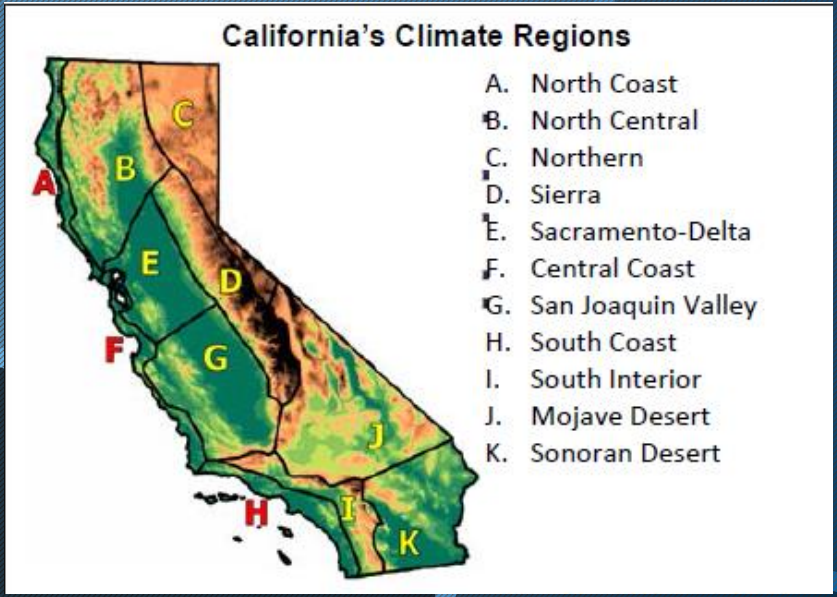
# SUGGESTED DROUGHT/WATER RESOURCES INDICATORS OF CLIMATE CHANGE IN CALIFORNIA

## CHANGES IN CLIMATE

.Annual and Monthly air temperature
.Annual and Monthly precipitation
.Annual and Monthly Palmer Drought Severity Index
.Paleo Perspectives?

## IMPACTS OF CLIMATE CHANGE

.Monthly and 'April 1' Sierra Snow Water .Equivalent
.Annual and Monthly Sierra Nevada runoff
.Annual and Monthly Soil Water Content
.Paleo Perspectives



# Thank you

UCLA Geography

John Muir Memorial Chair

Southwest Climate Science Center