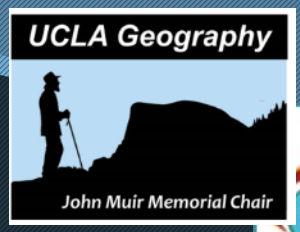
Tracking California's hydroclimatology and markers of drought

(EDUCATIONAL USE ONLY)

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



CURRENT WATER/DROUGHT RELATED INDICATORS OF CLIMATE CHANGE IN CALIFORNIA

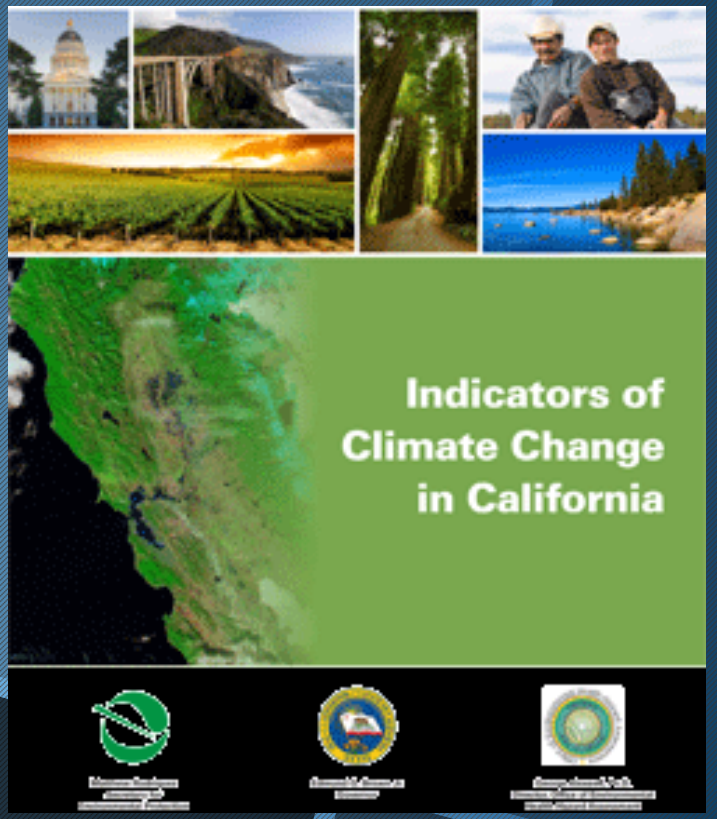
CHANGES IN CLIMATE

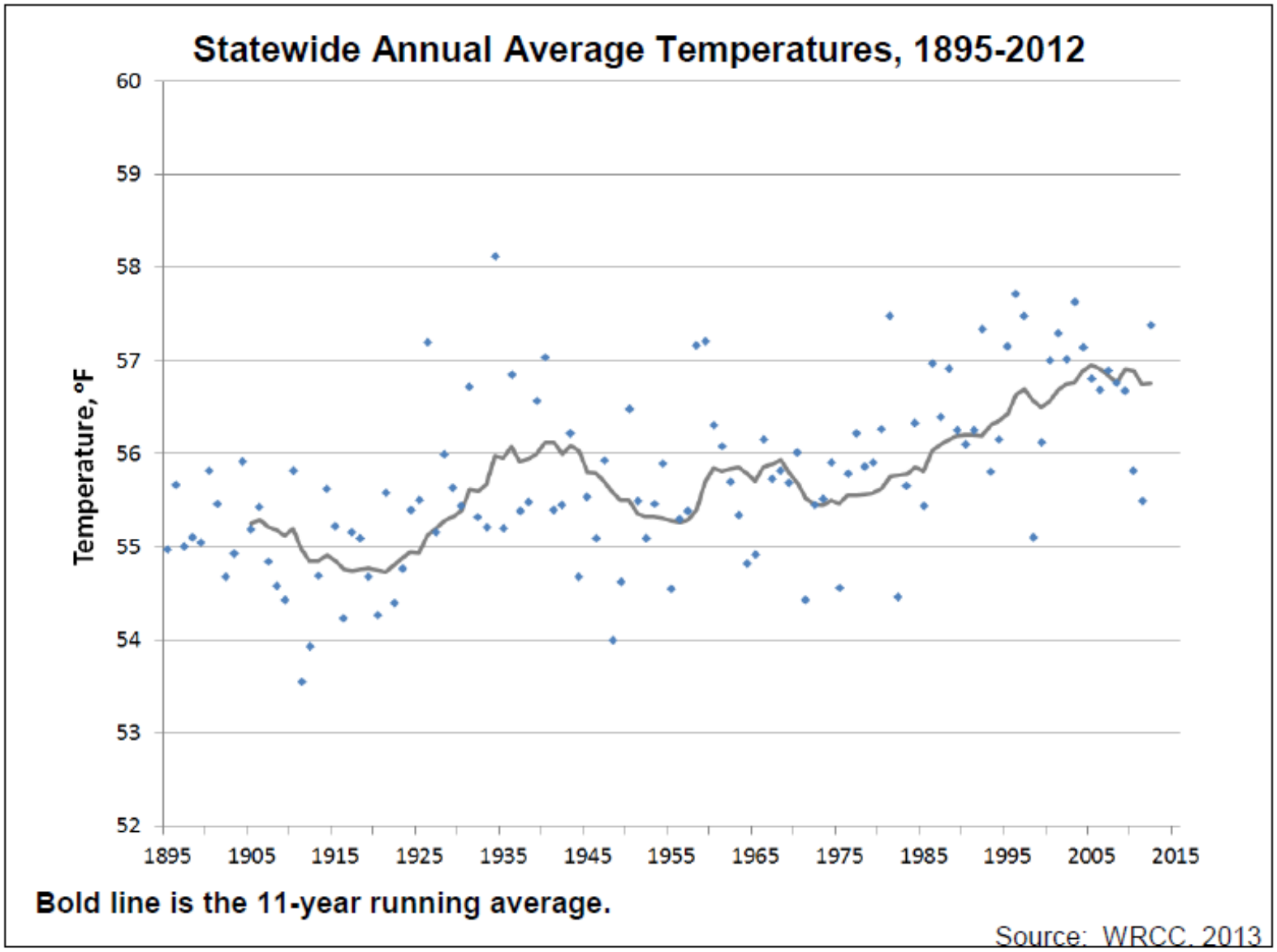
.Annual air temperature (updated)
.Annual precipitation (updated)

IMPACTS OF CLIMATE CHANGE

On physical systems

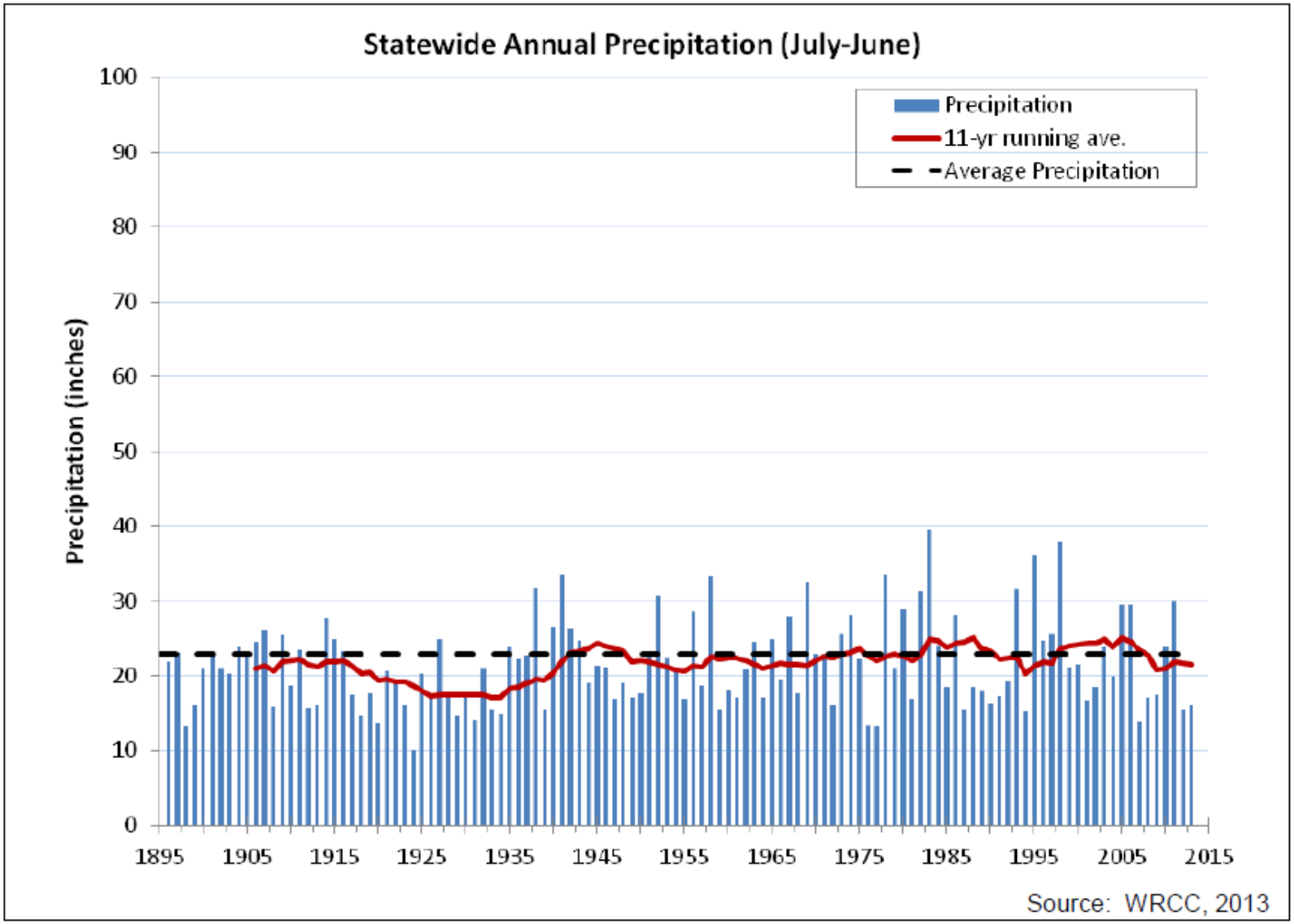
.Annual Sierra Nevada snowmelt runoff (updated)
.Snow-water content (updated)

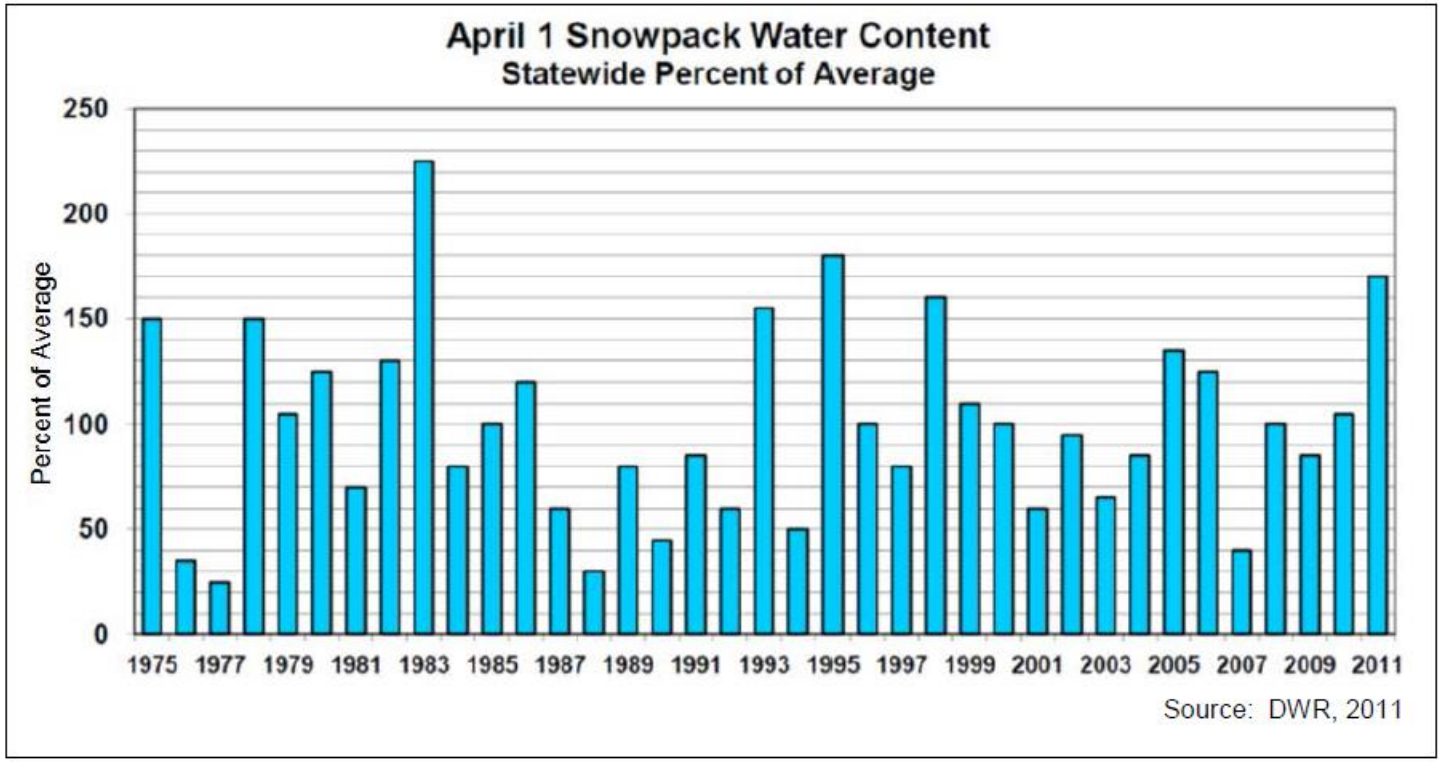


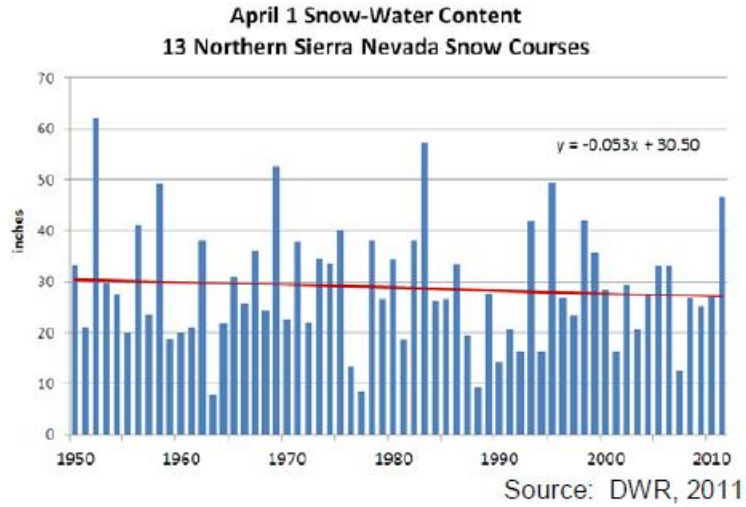

Statewide Annual Average Temperatures, 1895-2012
Temperature, °F
60
59
58
57
56
55
54
53
52
1895
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
2015
Bold line is the 11-year running average.
Source: WRCC, 2013

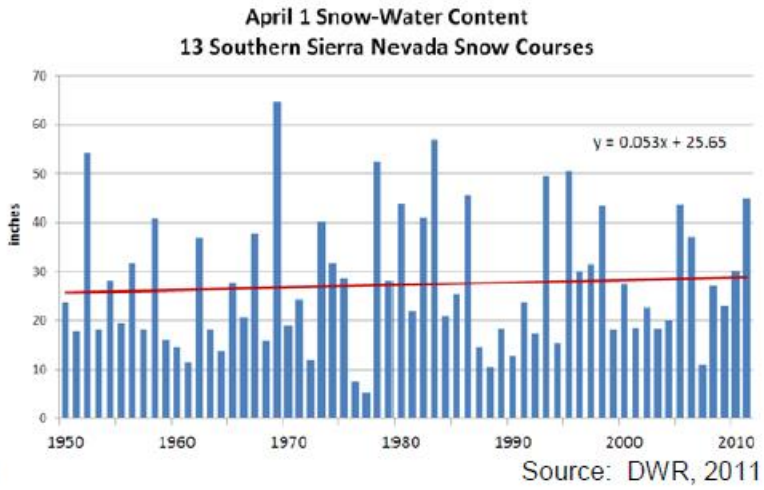
Annual Precipitation (Updated)

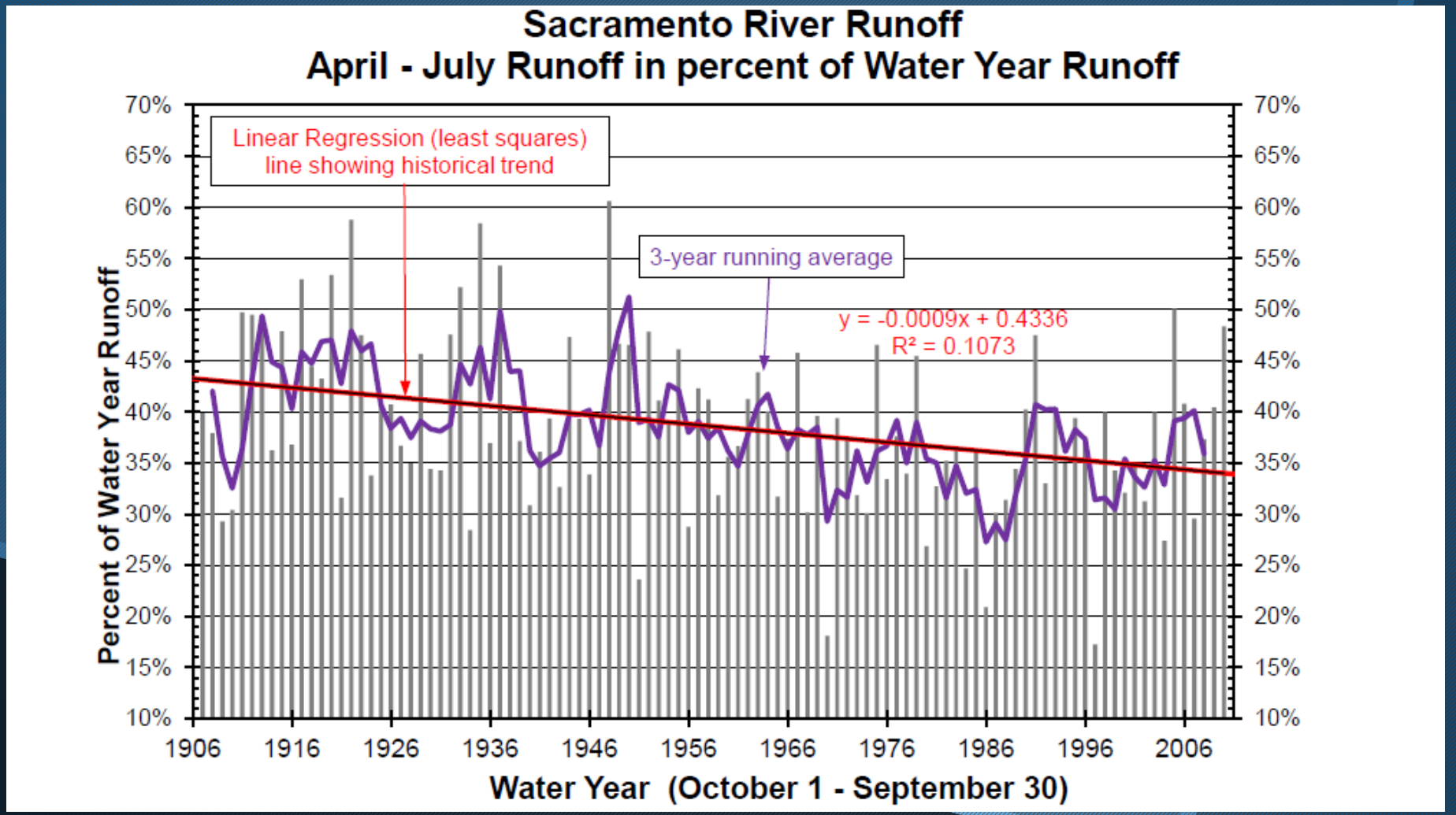
Large year-to-year variations in annual precipitation are evident, with no apparent trend.



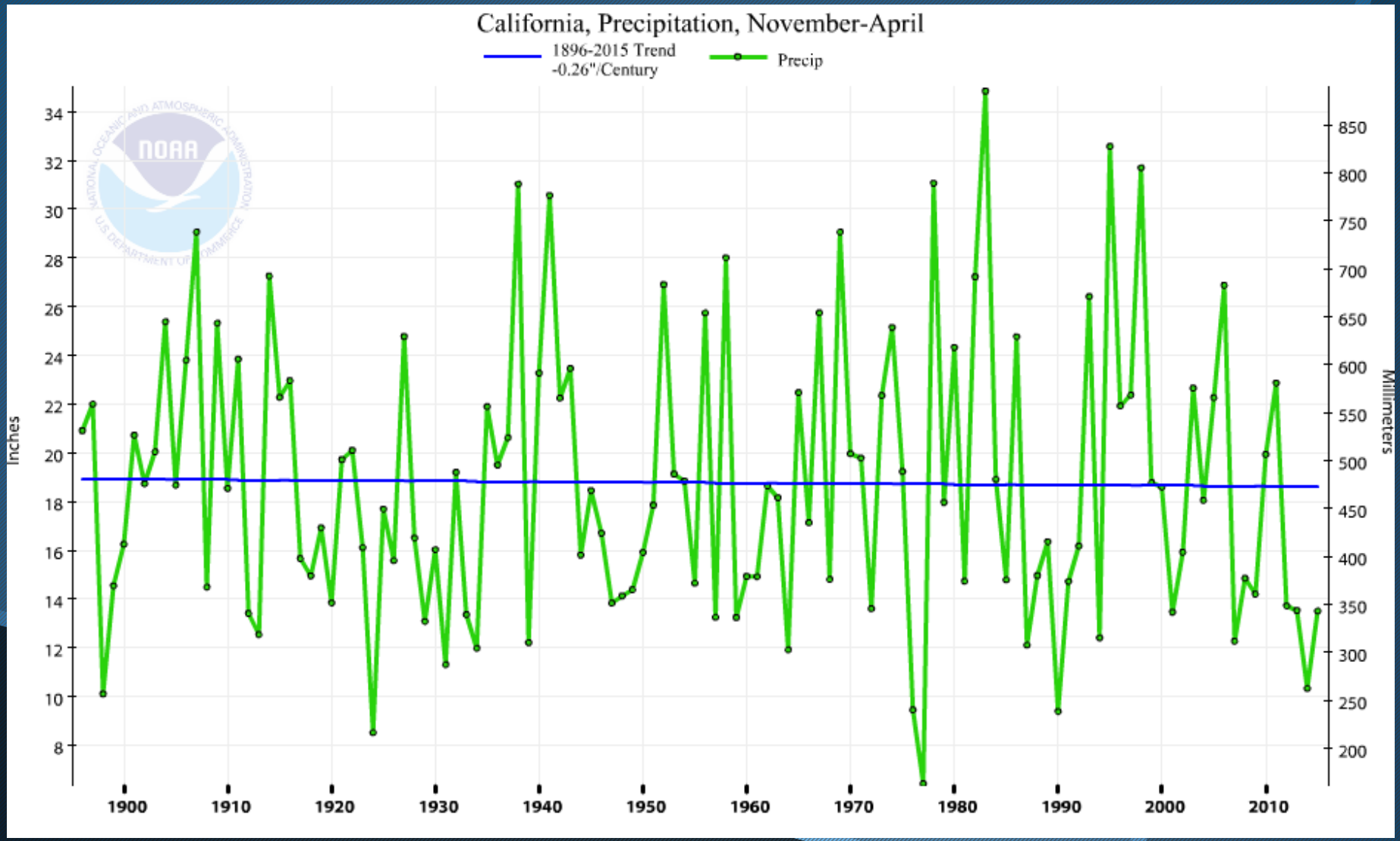

April 1 Snowpack Water Content
Statewide Percent of Average
Percent of Average
250
200
150
100
50
0
1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011
Source: DWR, 2011

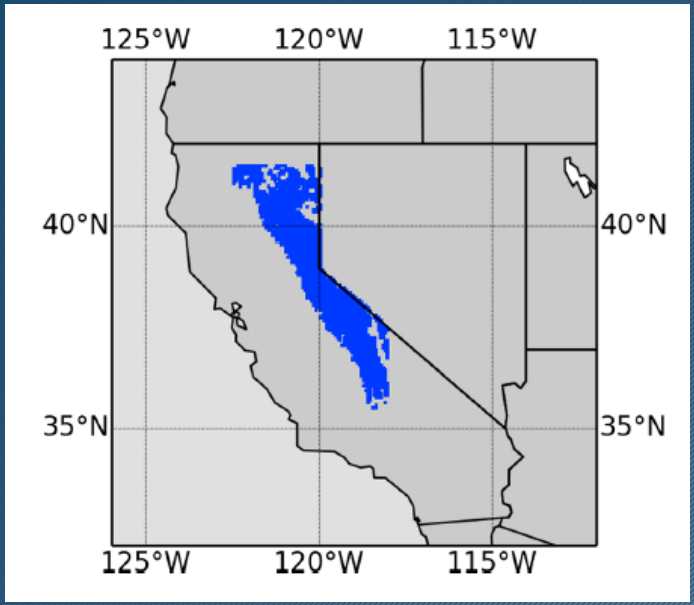

April 1 Snow-Water Content
13 Northern Sierra Nevada Snow Courses
y = -0.053x + 30.50
inches
70
60
50
40
30
20
10
0
1950 1960 1970 1980 1990 2000 2010
Source: DWR, 2011

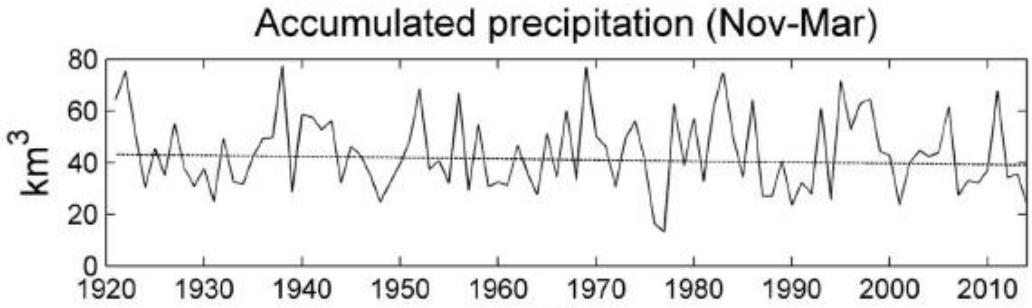

April 1 Snow-Water Content
13 Southern Sierra Nevada Snow Courses
y = 0.053x + 25.65
inches
70
60
50
40
30
20
10
0
1950 1960 1970 1980 1990 2000 2010
Source: DWR, 2011

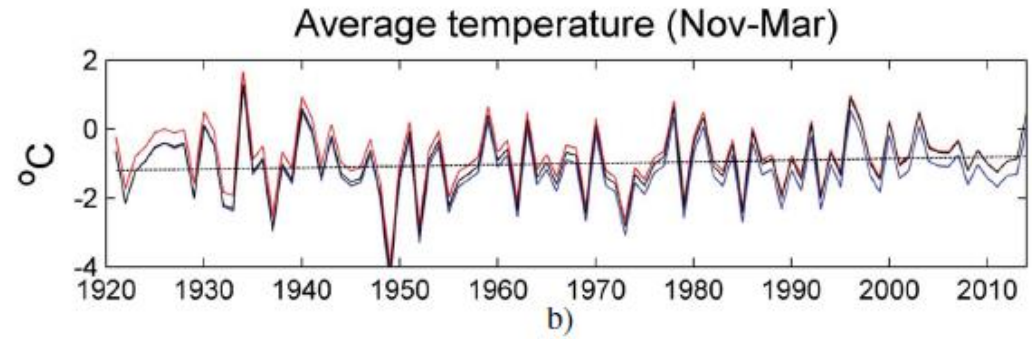

Sacramento River Runoff
April - July Runoff in percent of Water Year Runoff
Linear Regression (least squares) line showing historical trend
3-year running average
y = -0.0009x + 0.4336
R² = 0.1073
Percent of Water Year Runoff
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
1906
1916
1926
1936
1946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

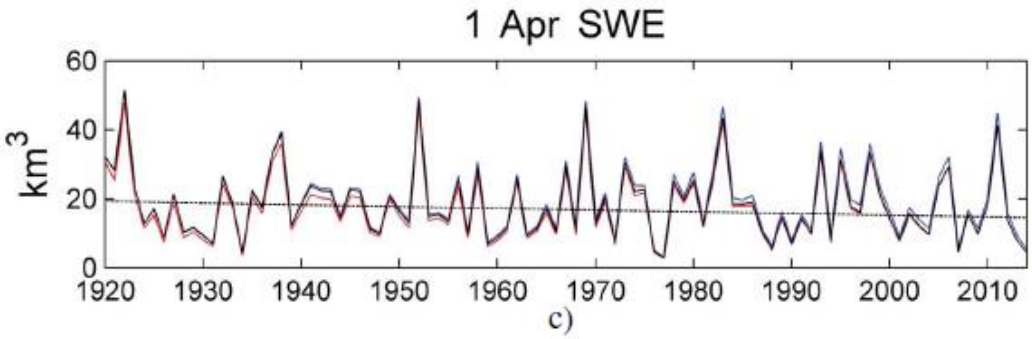
LESSONS FROM CURRENT DROUGHT FOR APPROPRIATE WATER RESOURCES/DROUGHT INDICATORS

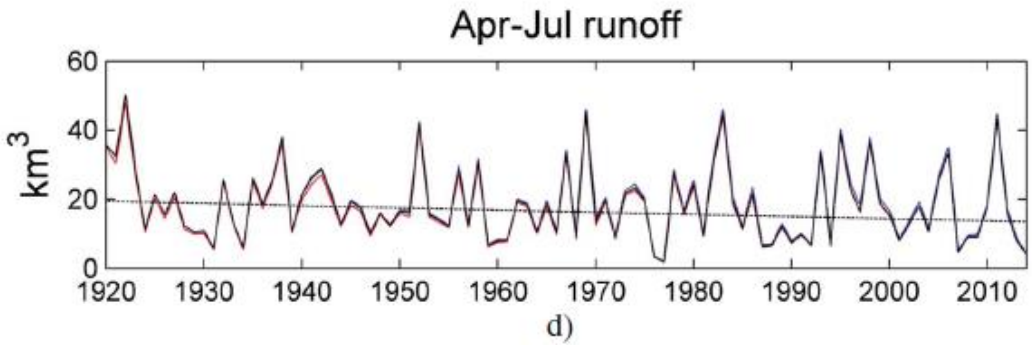

California, Precipitation, November-April
1896-2015 Trend
-0.26"/Century
Precip
Inches
Millimeters
34
32
30
28
26
24
22
20
18
16
14
12
10
8
850
800
750
700
650
600
550
500
450
400
350
300
250
200
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010



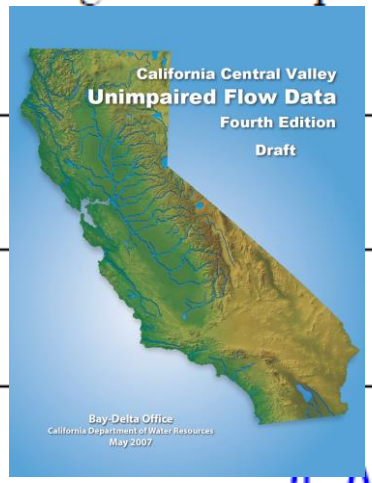








Mao, Y., Nijssen, B., & Lettenmaier, D. P. (2015). Is climate change implicated in the 2013–2014 California drought? A hydrologic perspective. Geophysical Research Letters, 42(8), 2805-2813.



Sacramento River Index

Annual Flow (TAF)

40000
35000
30000
25000
20000
15000
10000
5000
0

1920 1930 1940 1950 1960 1970 1980 1990 2000

Year

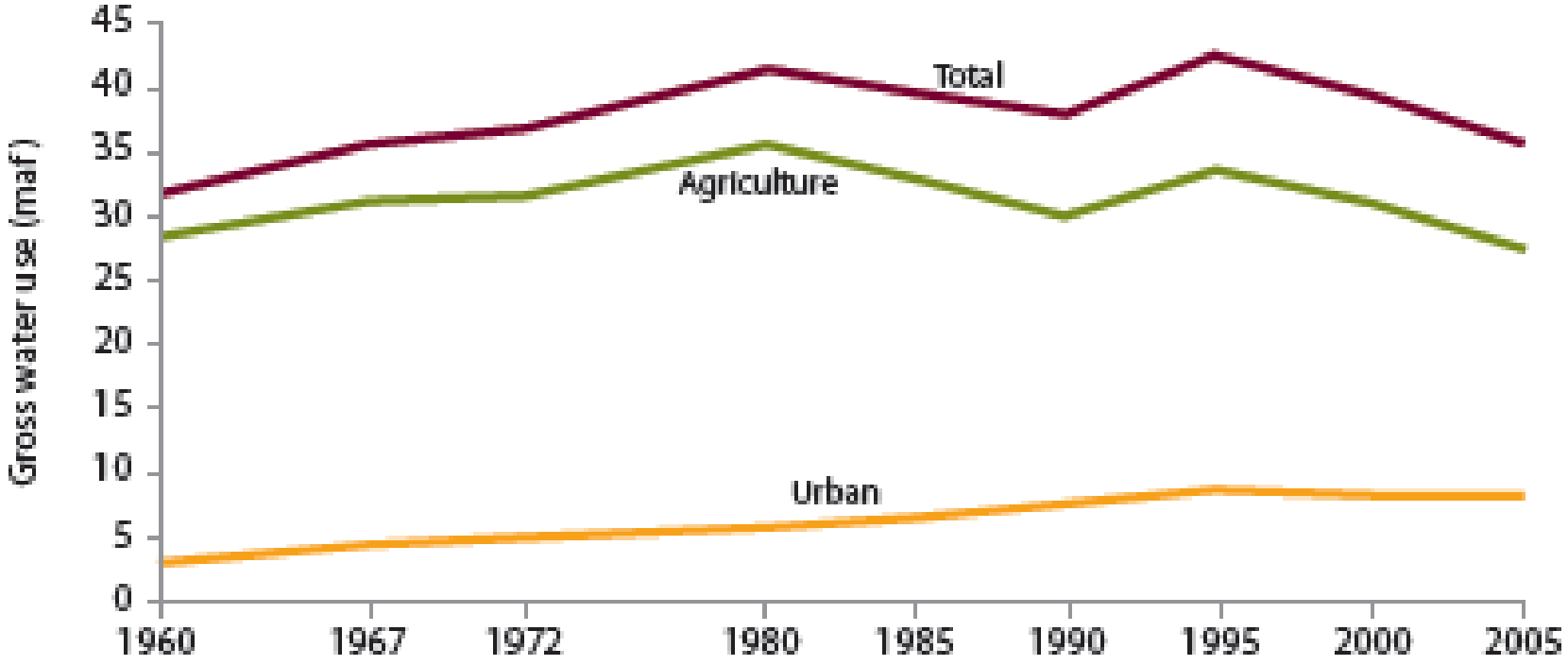
y = 48.574x - 77680

2014 = 7500 TAF

1977 (Min) = 5100 TAF 28% of average

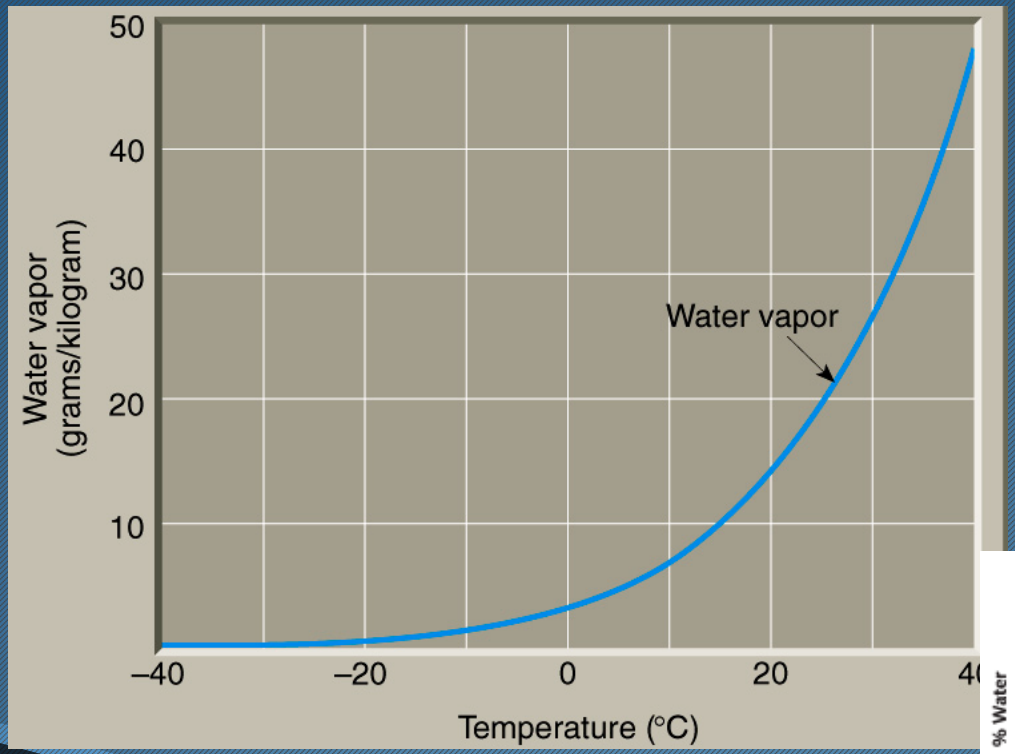
So – why so bad?

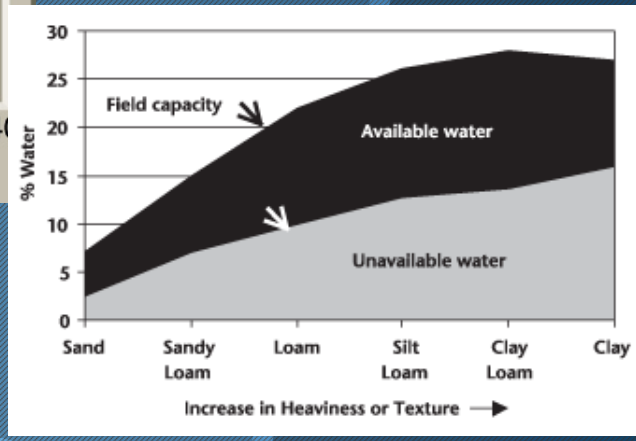
Figure 2.8
Total gross agricultural and urban water use has been decreasing



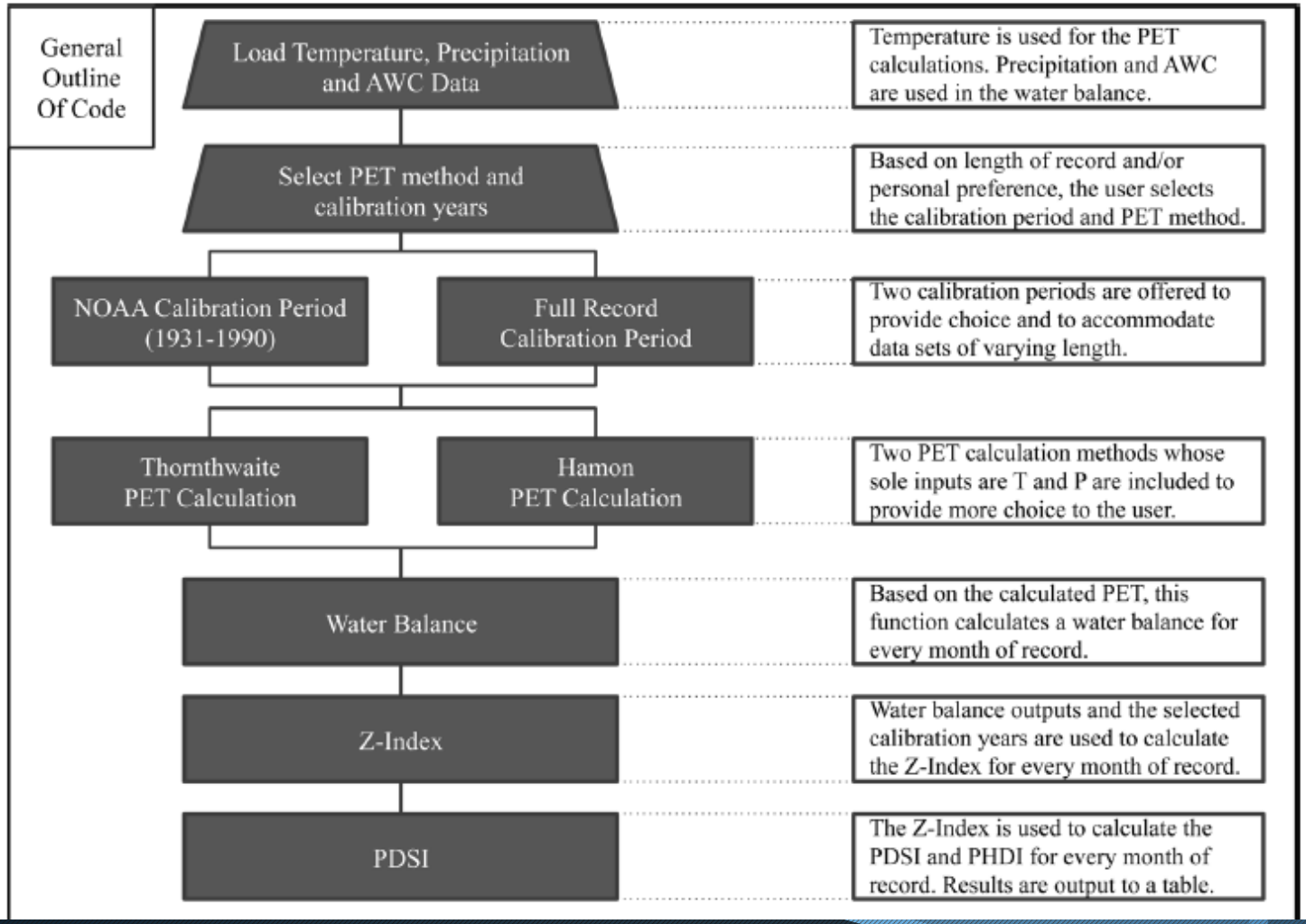
Hanak, Ellen et al. Managing California's water: from conflict to reconciliation. Public Policy Instit. of CA, 2011.

Palmer Drought Severity Index (PDSI)

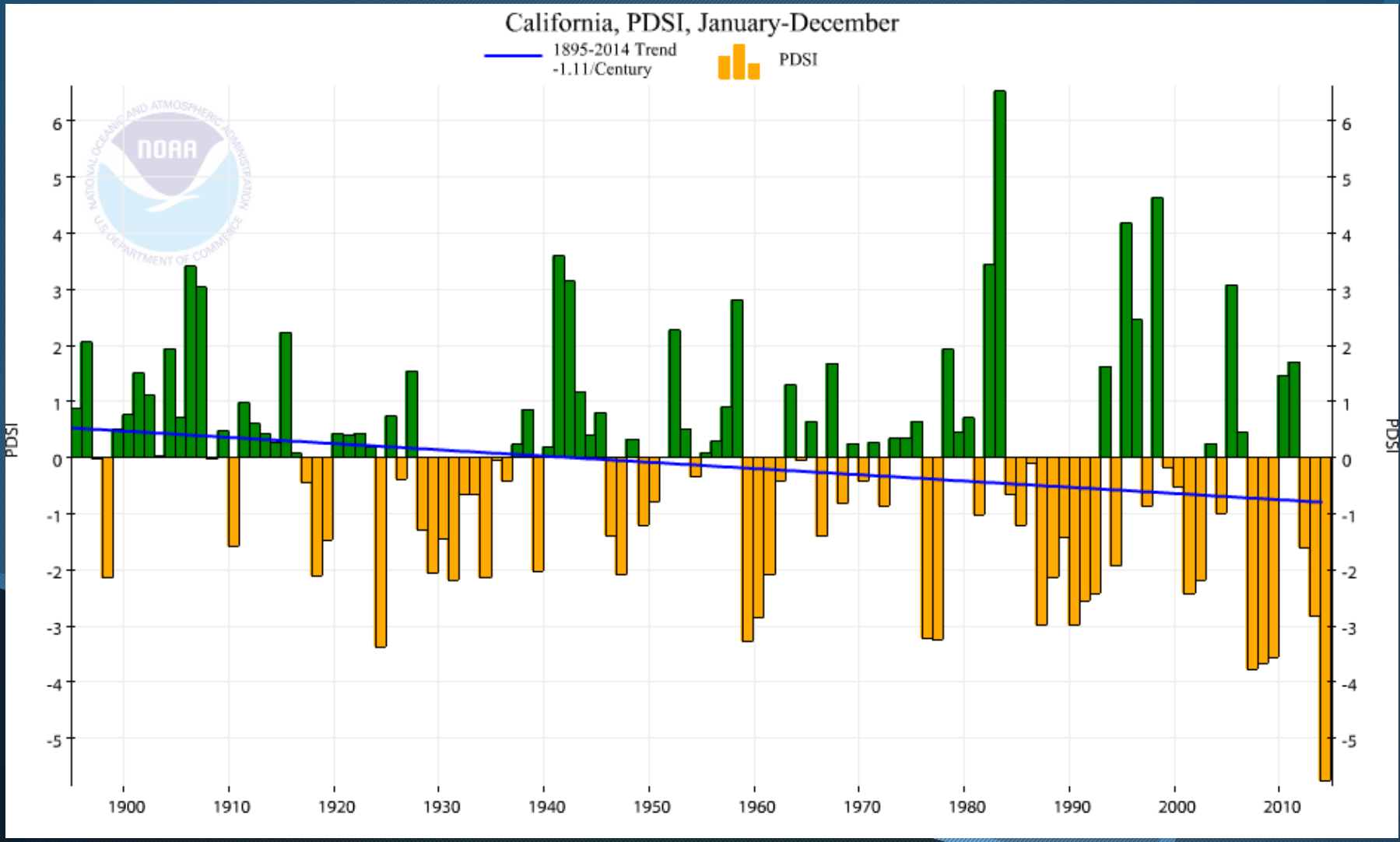




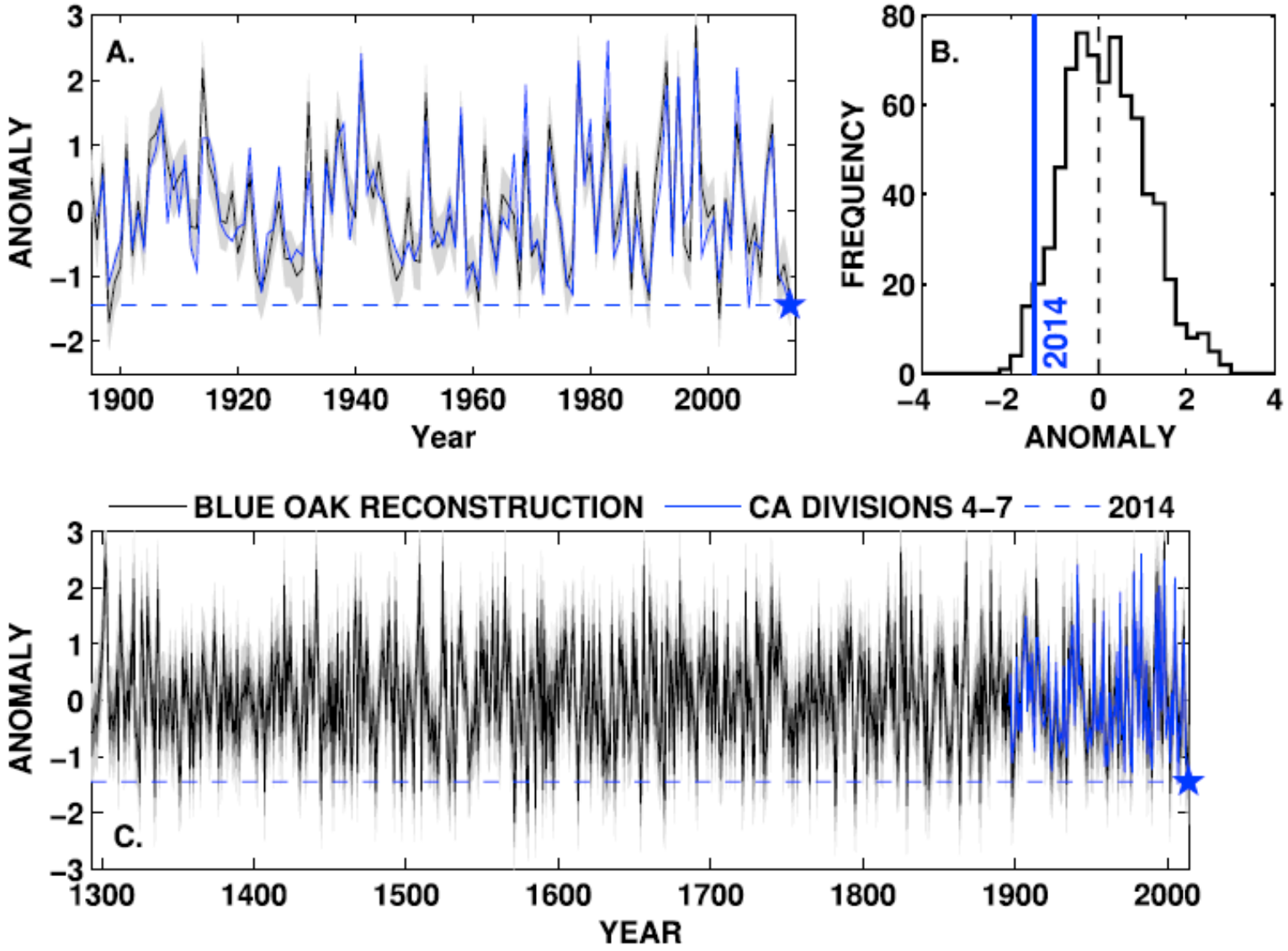
Palmer, W. 1965. "Meteorological Drought". Research paper no.45, U.S. Department of Commerce Weather Bureau, February 1965 (58 pgs). Available online http://www.ncdc.noaa.gov/temp-and-precip/drought/docs/palmer.pdf



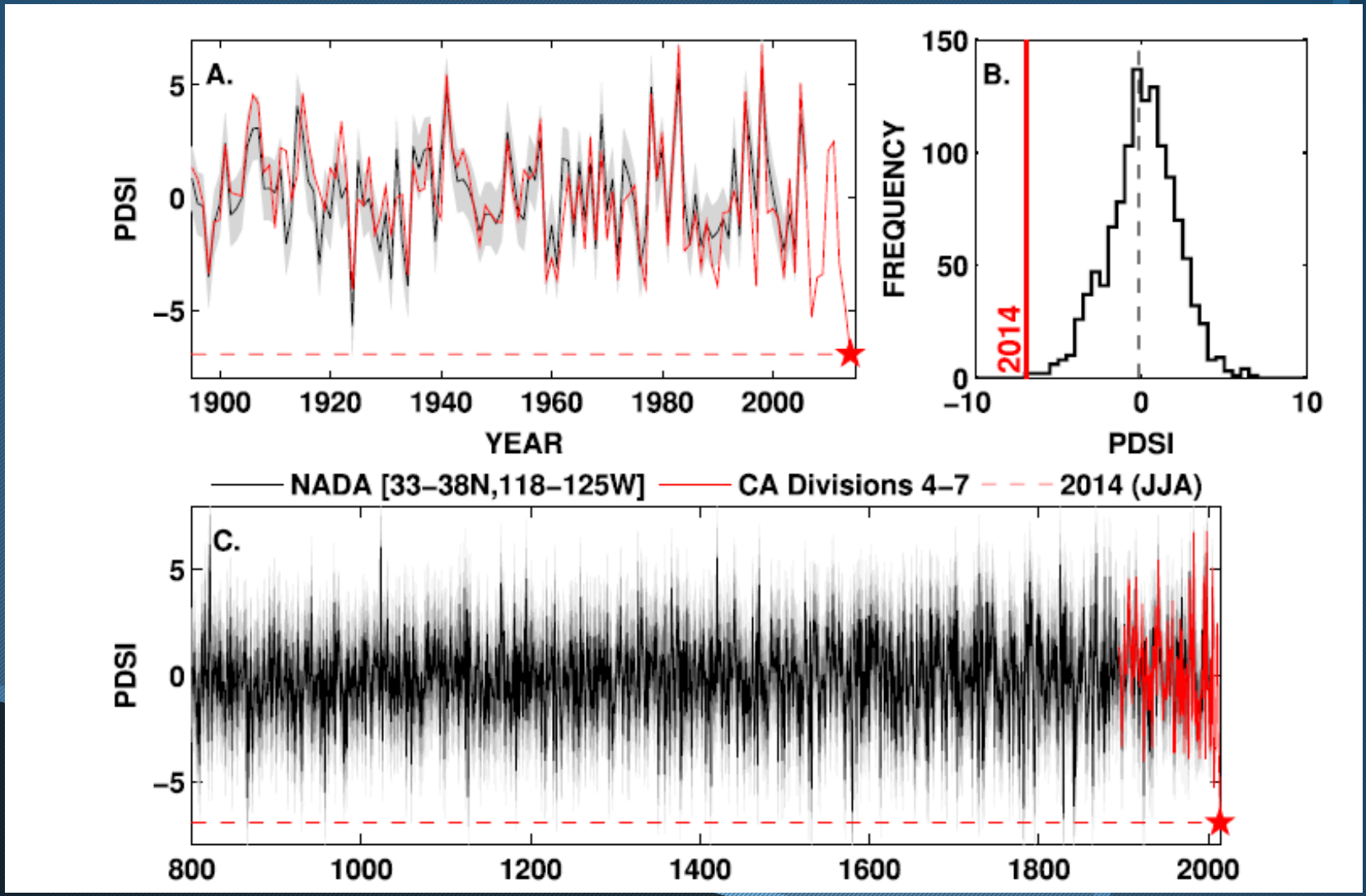
Jacobi, J., Perrone, D., Duncan, L. L., & Hornberger, G. (2013). A tool for calculating the Palmer drought indices. Water Resources Research, 49(9), 6086-6089.



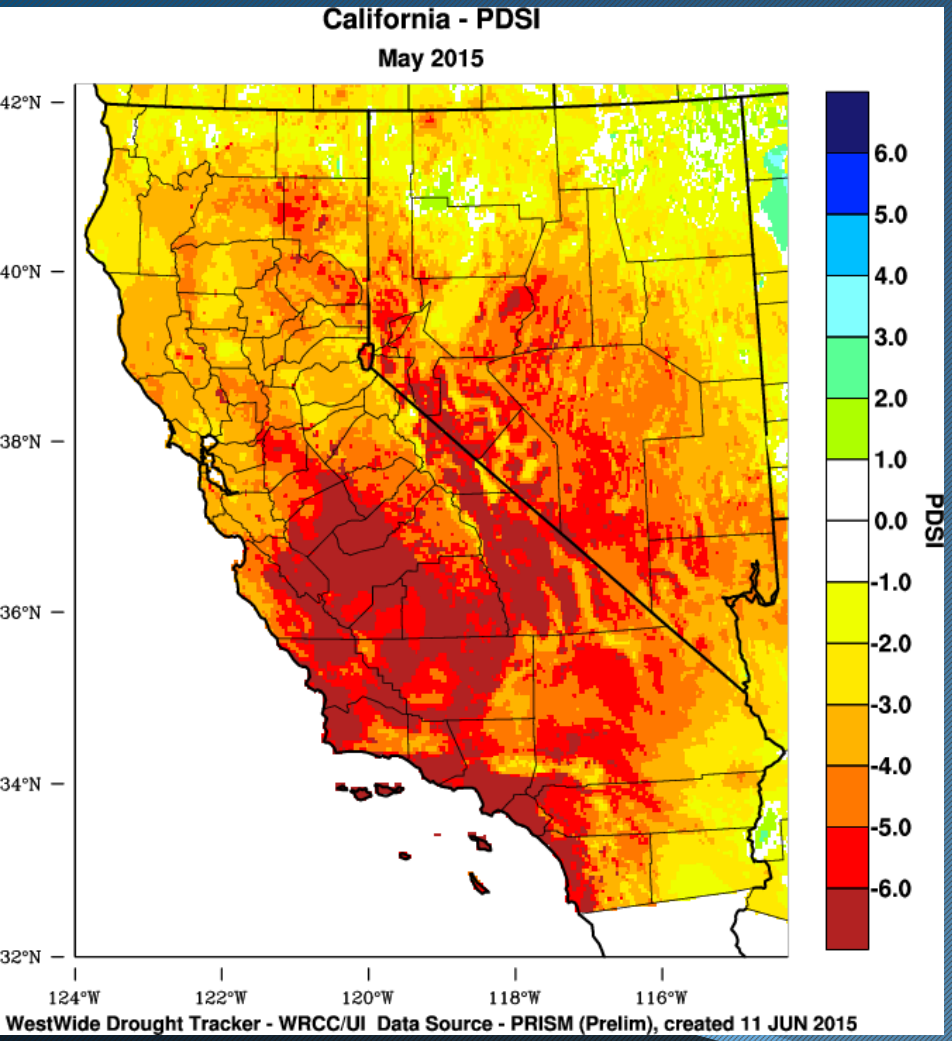
http://www.ncdc.noaa.gov/cag/time-series/us

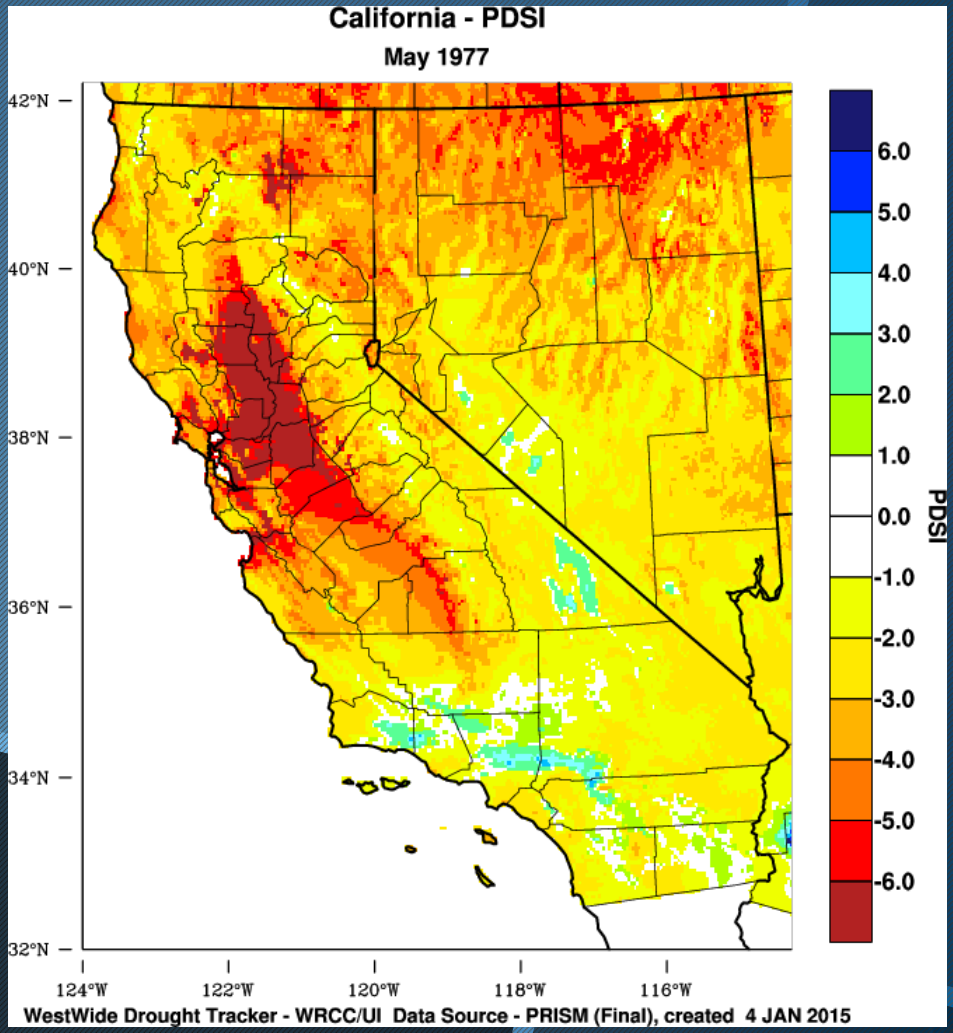


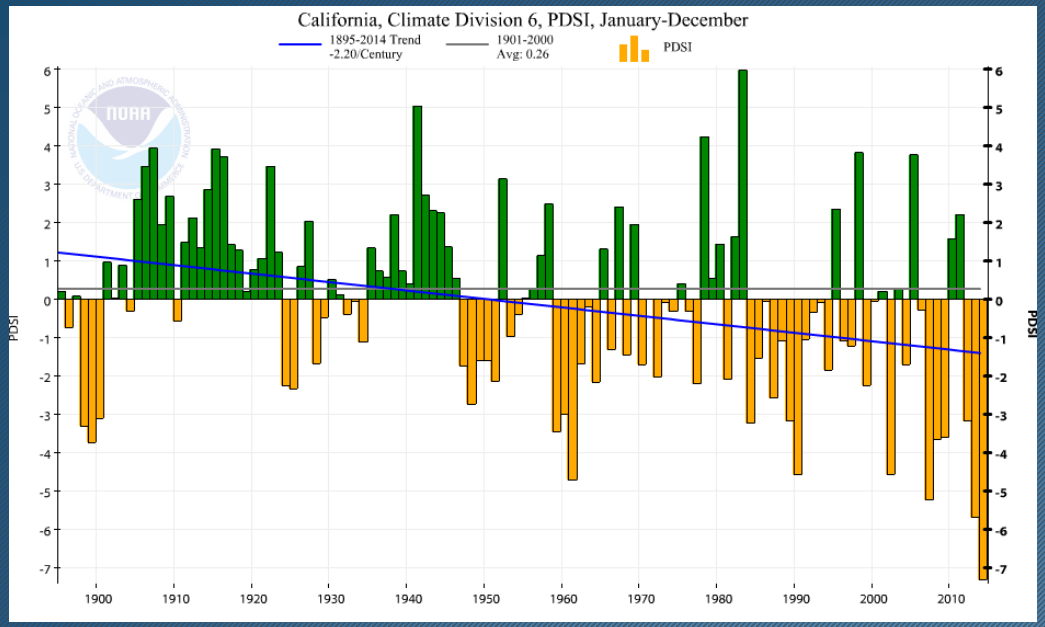
Griffin, D., & Anchukaitis, K. J. (2014). How unusual is the 2012–2014 California drought?. Geophysical Research Letters, 41(24), 9017-9023.

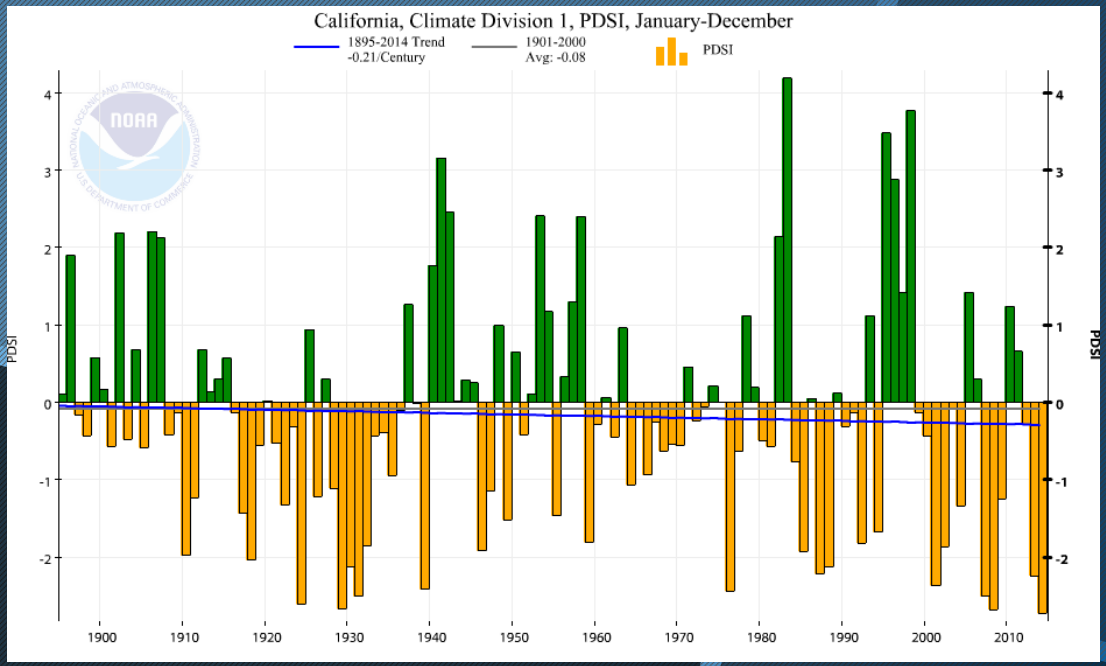


Griffin, D., & Anchukaitis, K. J. (2014). How unusual is the 2012–2014 California drought?. Geophysical Research Letters, 41(24), 9017-9023.


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
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010


California, Climate Division 1, PDSI, January-December
1895-2014 Trend
-0.21/Century
1901-2000
Avg: -0.08
PDSI
PDSI
PDSI
4
3
2
1
0
-1
-2
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

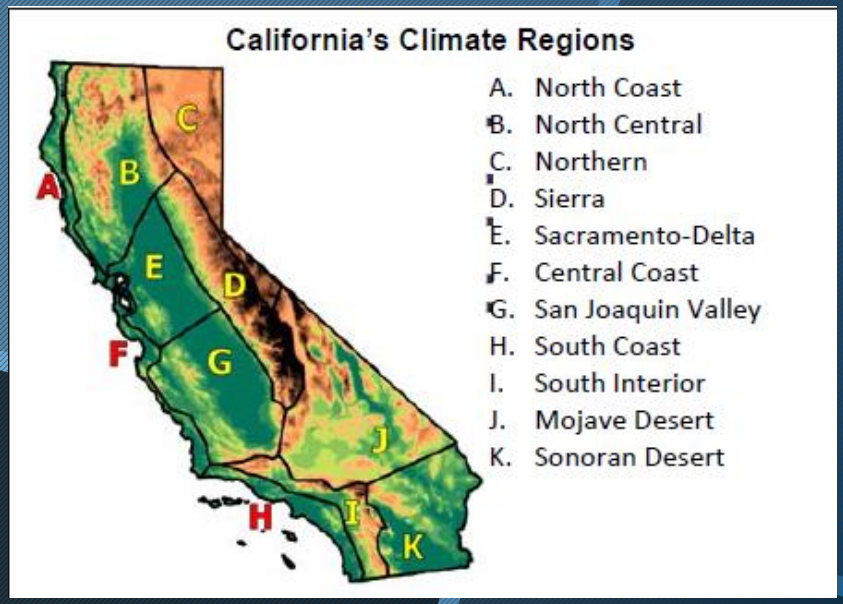
SUGGESTED DROUGHT/WATER RESOURCES INDICATORS OF CLIMATE CHANGE IN CALIFORNIA

CHANGES IN CLIMATE

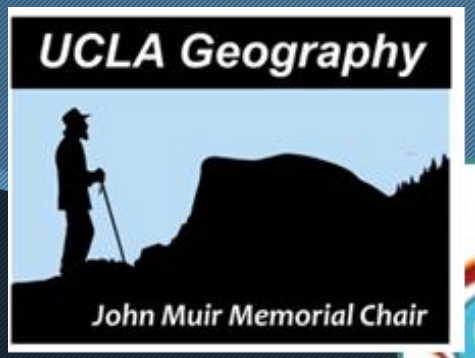
.Annual and Monthly air temperature
.Annual and Monthly precipitation
.Annual and Monthly Palmer Drought Severity Index
.Paleo Perspectives?

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