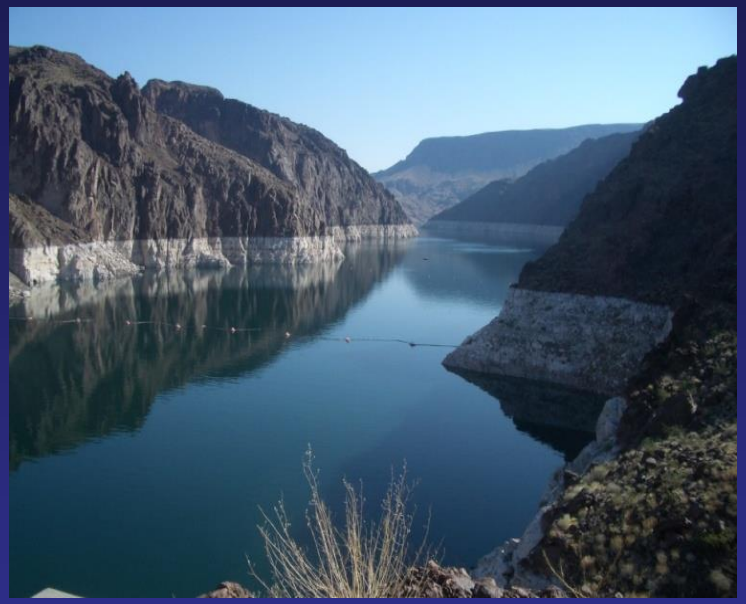
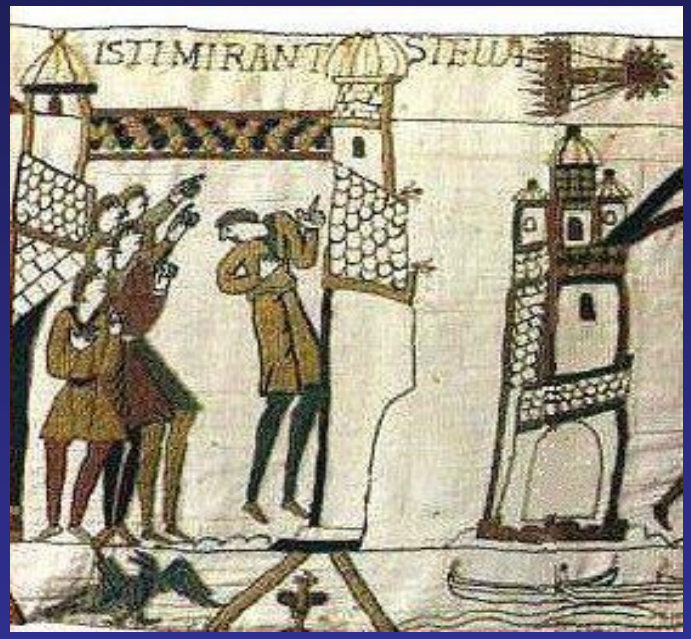
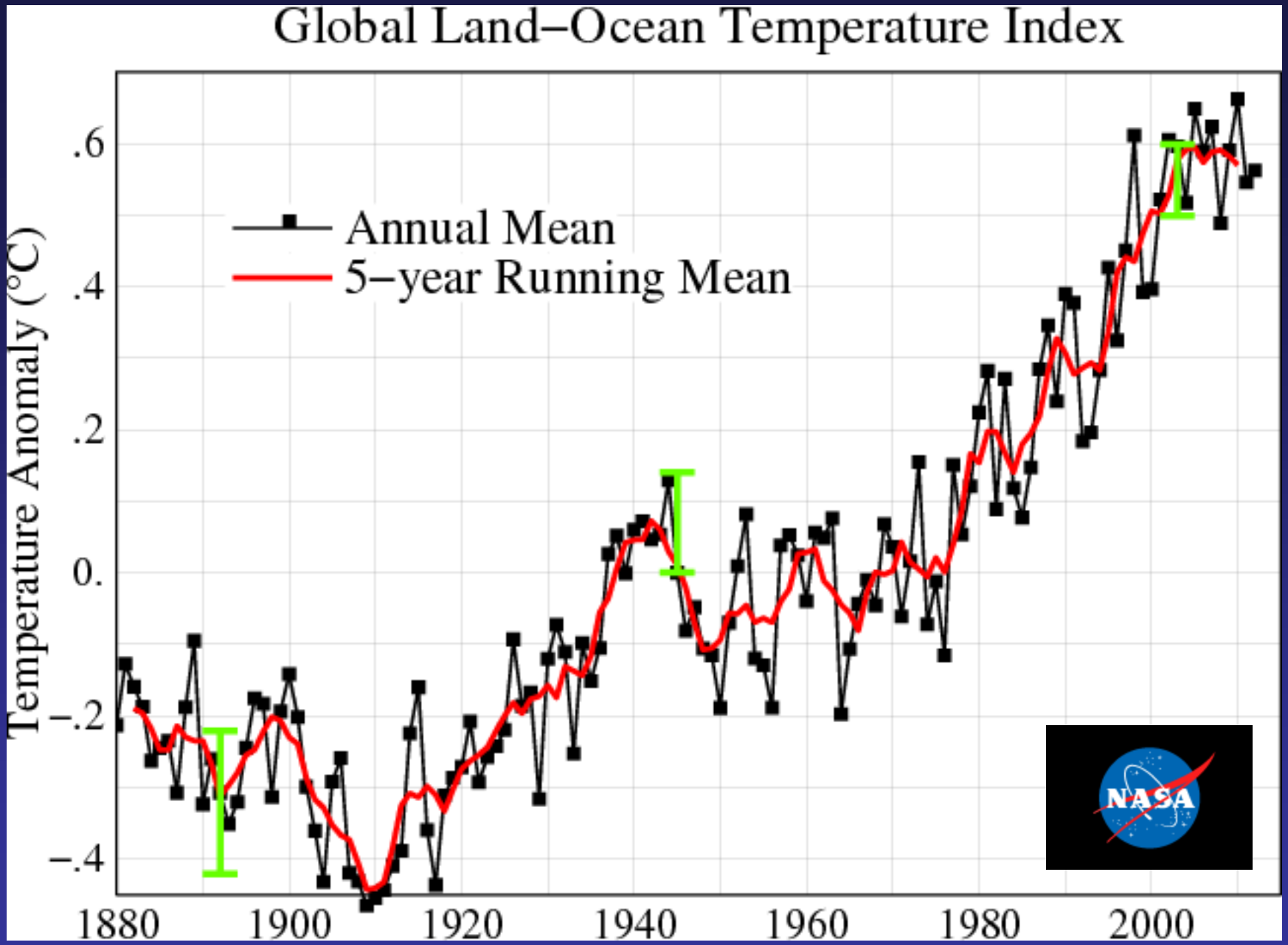
Climate Warming and Perfect Drought

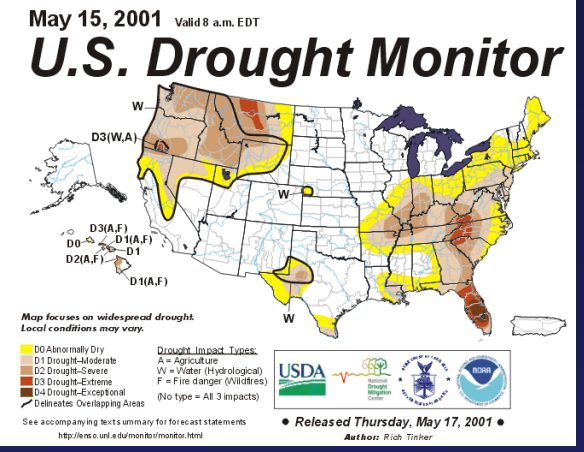


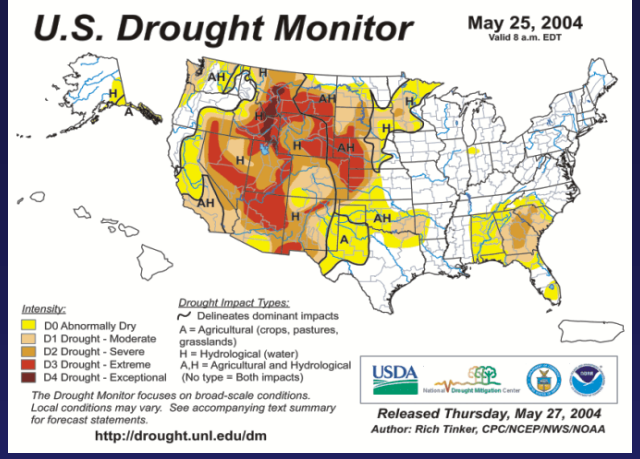


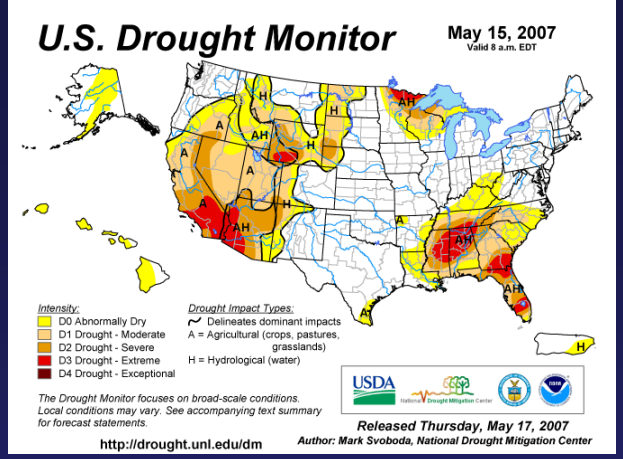
March 2013

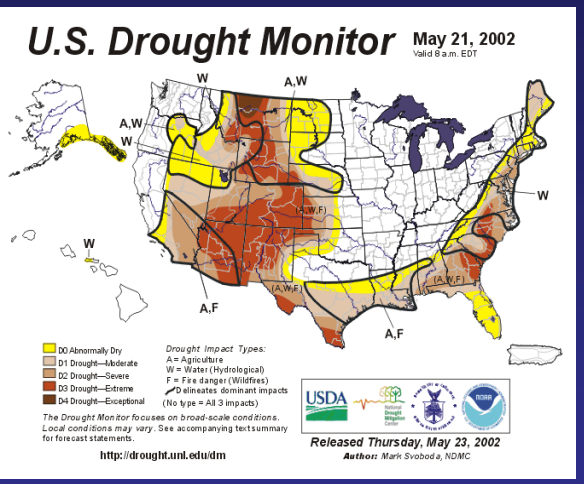
Glen M. MacDonald
Inst. of the Env. & Sust. UCLA

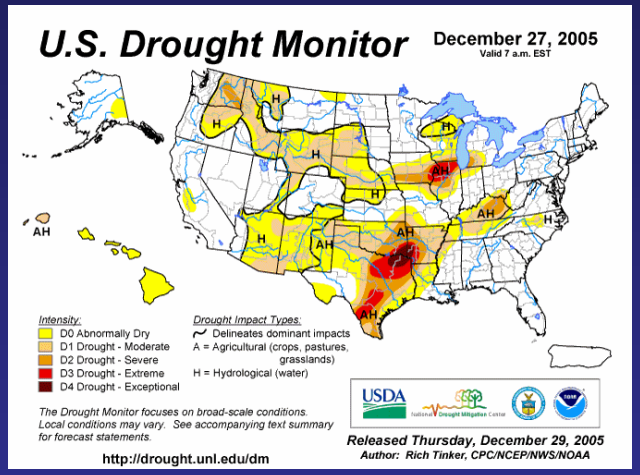

Global Land–Ocean Temperature Index
Annual Mean
5–year Running Mean
Temperature Anomaly (°C)
.6
.4
.2
0.
−.2
−.4
1880
1900
1920
1940
1960
1980
2000
NASA

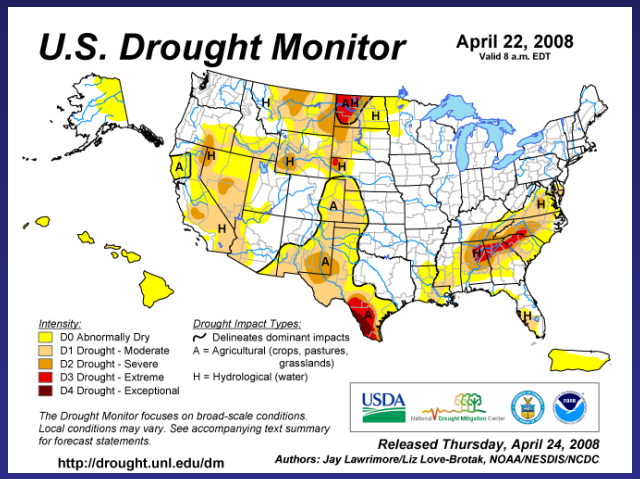

May 15, 2001 Valid 8 a.m. EDT
U.S. Drought Monitor
Map focuses on widespread drought.
Local conditions may vary.
D0 Abnormally Dry
D1 Drought--Moderate
D2 Drought--Severe
D3 Drought--Extreme
D4 Drought--Exceptional
Delineates Overlapping Areas
Drought Impact Types:
A = Agriculture
W = Water (Hydrological)
F = Fire danger (Wildfires)
(No type = All 3 impacts)
See accompanying texts ummary for forecast statements
http://lenso.unl.edu/monitor/monitor.html
USDA
Released Thursday, May 17, 2001
Author: Rich Tinker

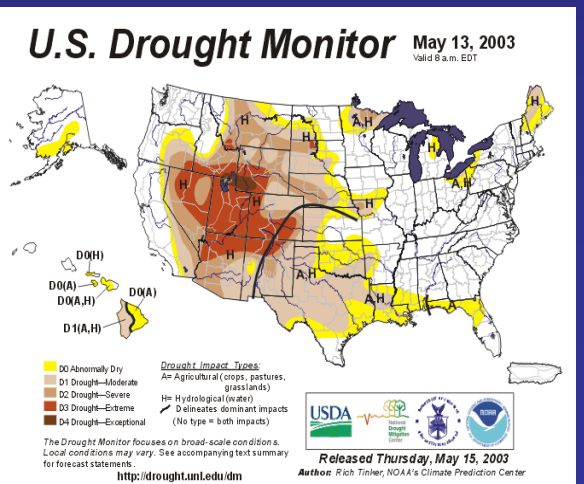

U.S. Drought Monitor
May 25, 2004
Valid 8 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
A,H = Agricultural and Hydrological
(No type = Both impacts)
The Drought Monitor focuses on broad-scale conditions.
Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
USDA
Released Thursday, May 27, 2004
Author: Rich Tinker, CPC/NCEP/NWS/NOAA

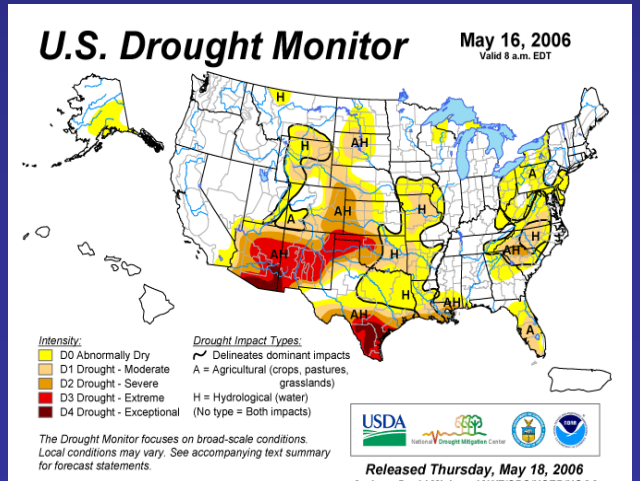

U.S. Drought Monitor
May 15, 2007
Valid 8 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
The Drought Monitor focuses on broad-scale conditions.
Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
USDA
Released Thursday, May 17, 2007
Author: Mark Svoboda, National Drought Mitigation Center

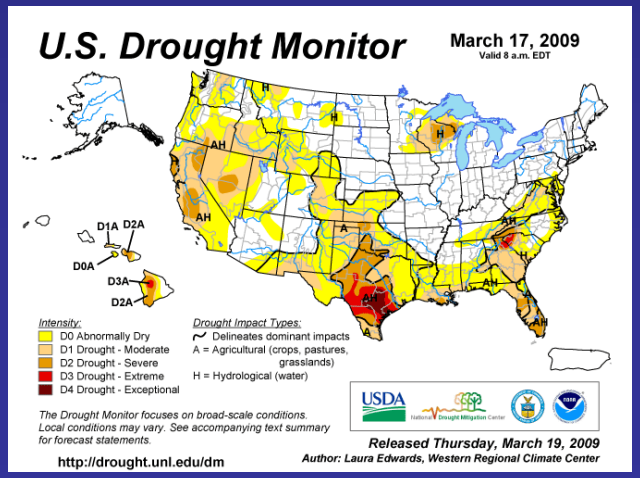

U.S. Drought Monitor
May 21, 2002
Valid 8 a.m. EDT
D0 Abnormally Dry
D1 Drought--Moderate
D2 Drought--Severe
D3 Drought--Extreme
D4 Drought--Exceptional
Drought Impact Types:
A = Agriculture
W = Water (Hydrological)
F = Fire danger (Wildfires)
(No type = All 3 impacts)
The Drought Monitor focuses on broad-scale conditions.
Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
USDA
Released Thursday, May 23, 2002
Author: Mark Svoboda, NDMC

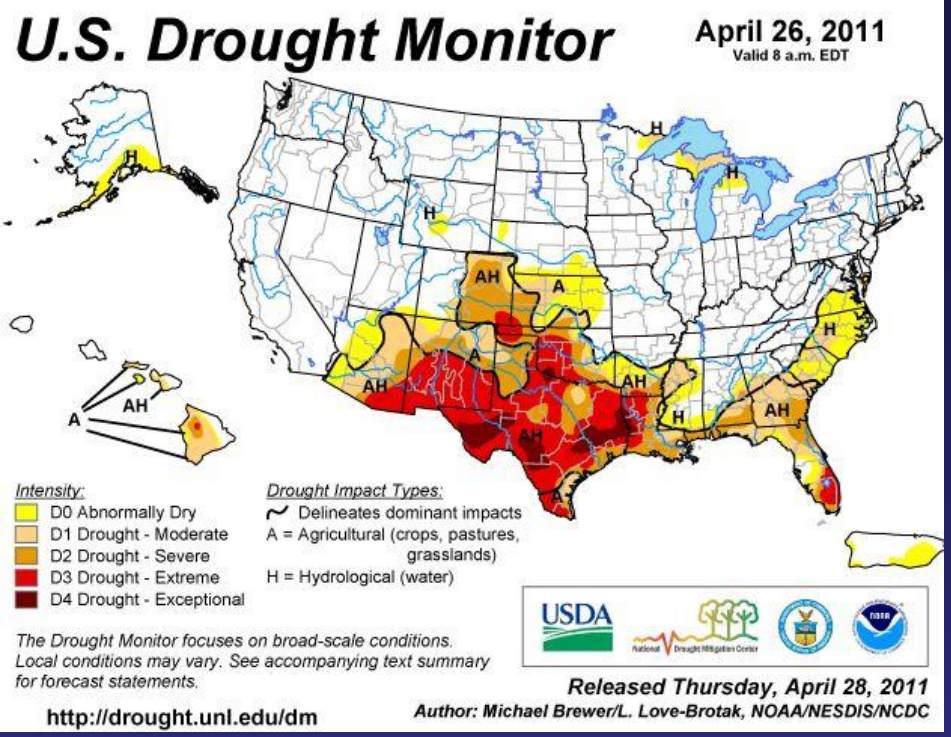

U.S. Drought Monitor
December 27, 2005
Valid 7 a.m. EST
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
The Drought Monitor focuses on broad-scale conditions.
Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
USDA
Released Thursday, December 29, 2005
Author: Rich Tinker, CPC/NCEP/NWS/NOAA

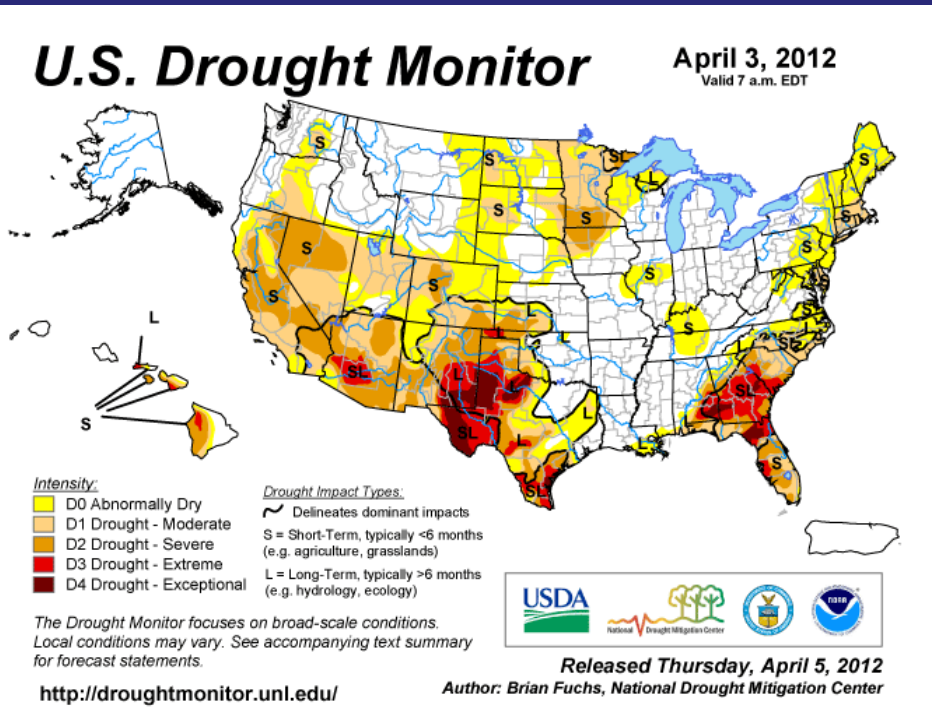

U.S. Drought Monitor
April 22, 2008
Valid 8 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
The Drought Monitor focuses on broad-scale conditions.
Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
USDA
Released Thursday, April 24, 2008
Authors: Jay Lawrimore/Liz Love-Brotak, NOAA/NESDIS/NCDC


U.S. Drought Monitor
May 13, 2003
Valid 8 a.m. EDT
D0 Abnormally Dry
D1 Drought--Moderate
D2 Drought--Severe
D3 Drought--Extreme
D4 Drought--Exceptional
Drought Impact Types:
A= Agricultural (crops, pastures, grasslands)
H= Hydrological (water)
Delineates dominant impacts
(No type = both impacts)
The Drought Monitor focuses on broad-scale conditions.
Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
USDA
Released Thursday, May 15, 2003
Author: Rich Tinker, NOAA's Climate Prediction Center


U.S. Drought Monitor
May 16, 2006
Valid 8 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
(No type = Both impacts)
The Drought Monitor focuses on broad-scale conditions.
Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
USDA
Released Thursday, May 18, 2006
Author: David Miskus, JAWF/CPC/NCEP/NOAA

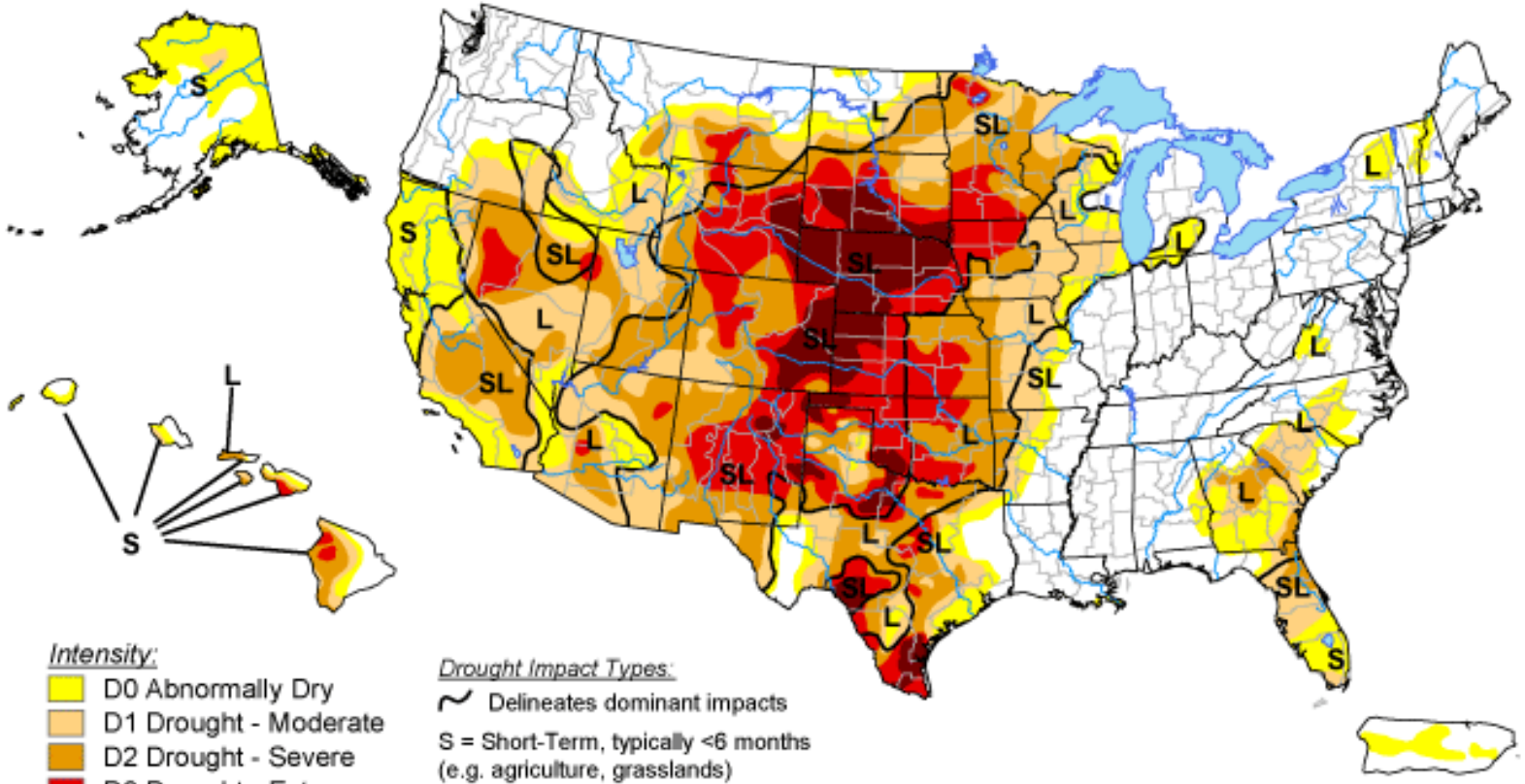

U.S. Drought Monitor
March 17, 2009
Valid 8 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
The Drought Monitor focuses on broad-scale conditions.
Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
USDA
Released Thursday, March 19, 2009
Author: Laura Edwards, Western Regional Climate Center


U.S. Drought Monitor
April 26, 2011
Valid 8 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
Released Thursday, April 28, 2011
Author: Michael Brewer/L. Love-Brotak, NOAA/NESDIS/NCDC
http://drought.unl.edu/dm


U.S. Drought Monitor
April 3, 2012
Valid 7 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
L = Long-Term, typically >6 months (e.g. hydrology, ecology)
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
Released Thursday, April 5, 2012
Author: Brian Fuchs, National Drought Mitigation Center
http://droughtmonitor.unl.edu/

U.S. Drought Monitor

March 5, 2013
Valid 7 a.m. EST



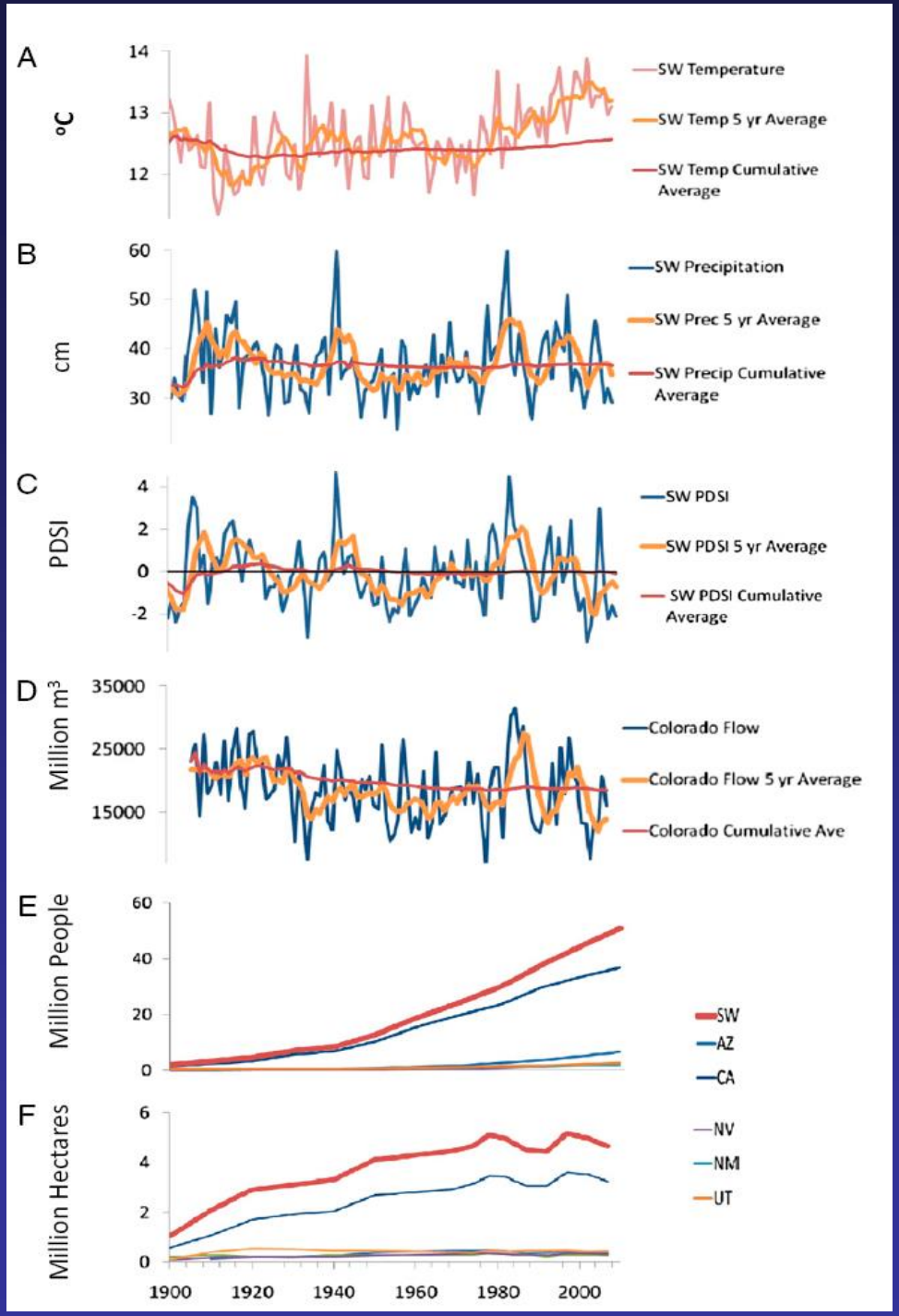
Intensity:
- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

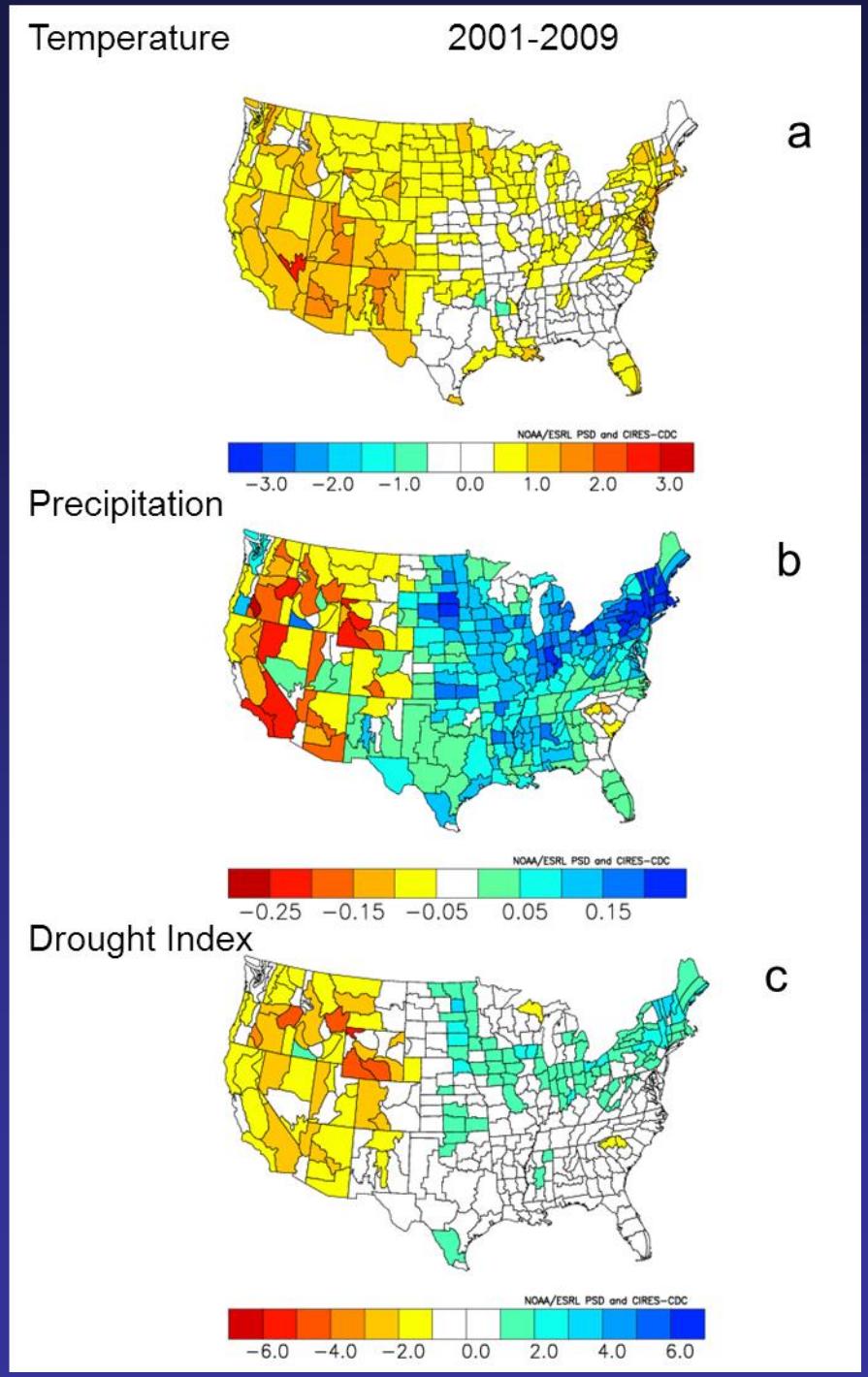
Drought Impact Types:
Delineates dominant impacts
S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
L = Long-Term, typically >6 months (e.g. hydrology, ecology)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

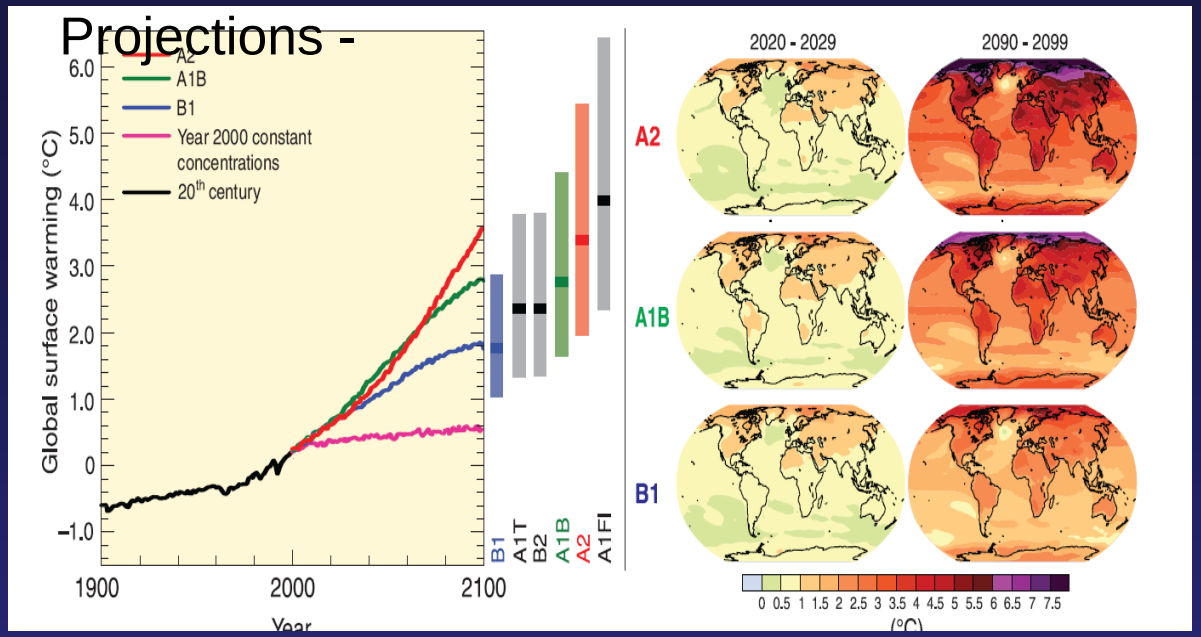
http://droughtmonitor.unl.edu/

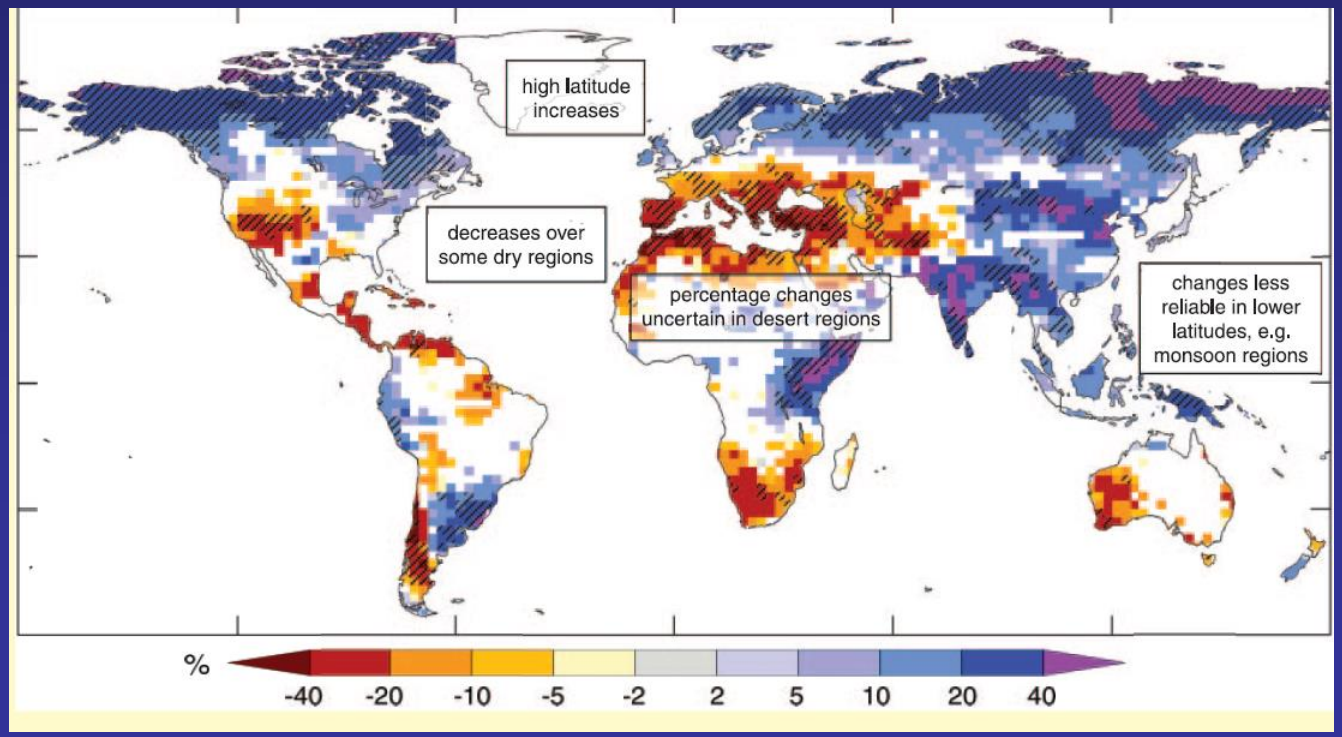
Released Thursday, March 7, 2013
Author: Matthew Rosencrans, NOAA/NWS/NCEP/CPC

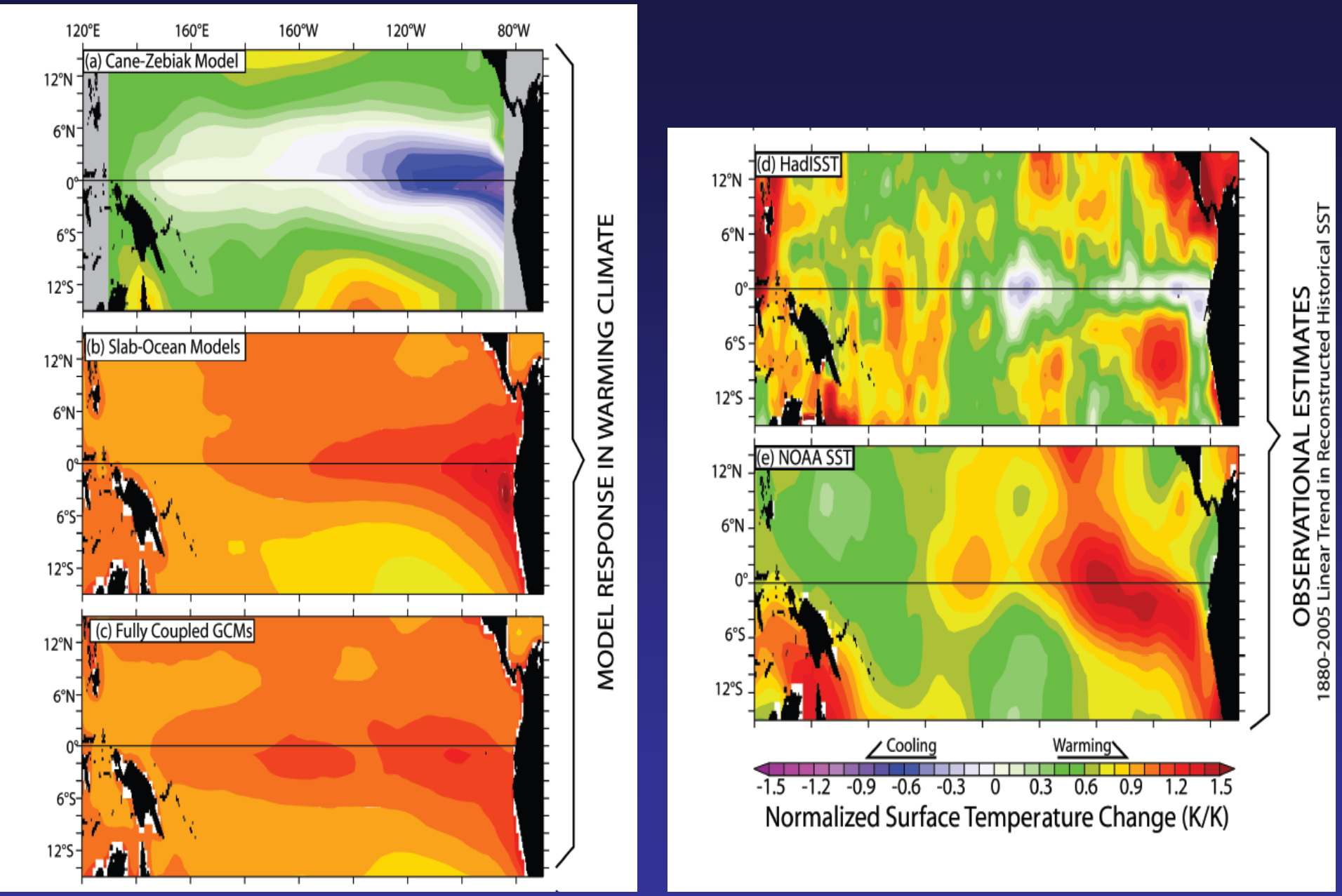

A
°C
14
13
12
SW Temperature
SW Temp 5 yr Average
SW Temp Cumulative Average
B
cm
60
50
40
30
SW Precipitation
SW Prec 5 yr Average
SW Precip Cumulative Average
C
PDSI
4
2
0
-2
SW PDSI
SW PDSI 5 yr Average
SW PDSI Cumulative Average
D
Million m³
35000
25000
15000
Colorado Flow
Colorado Flow 5 yr Average
Colorado Cumulative Ave
E
Million People
60
40
20
0
SW
AZ
CA
F
Million Hectares
6
4
2
0
NV
NM
UT
1900
1920
1940
1960
1980
2000


Temperature
2001-2009
a
NOAA/ESRL PSD and CIRES-CDC
−3.0 −2.0 −1.0 0.0 1.0 2.0 3.0
Precipitation
b
NOAA/ESRL PSD and CIRES-CDC
−0.25 −0.15 −0.05 0.05 0.15
Drought Index
c
NOAA/ESRL PSD and CIRES-CDC
−6.0 −4.0 −2.0 0.0 2.0 4.0 6.0

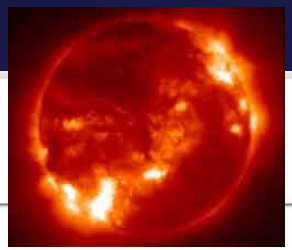
Projections -

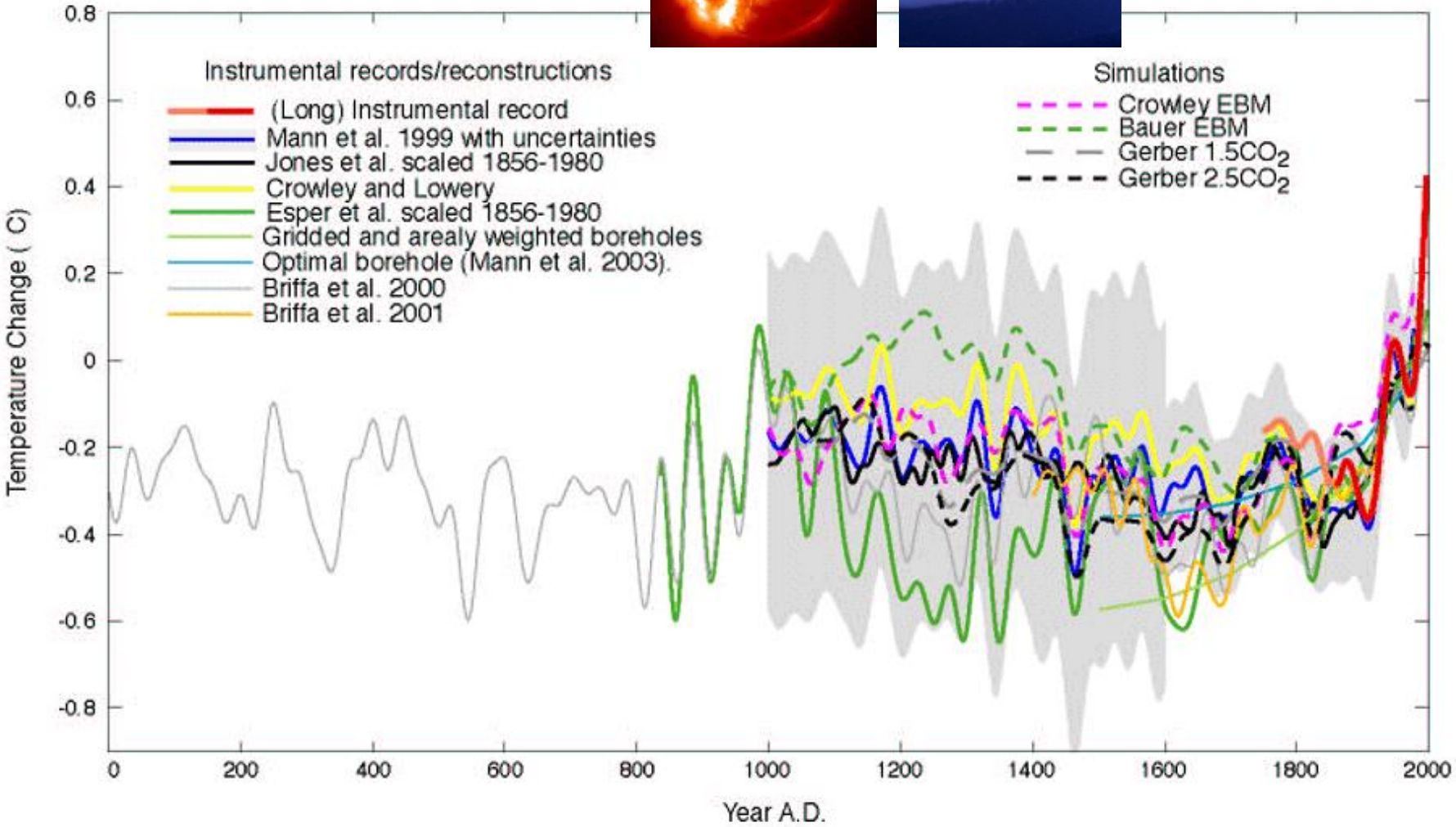






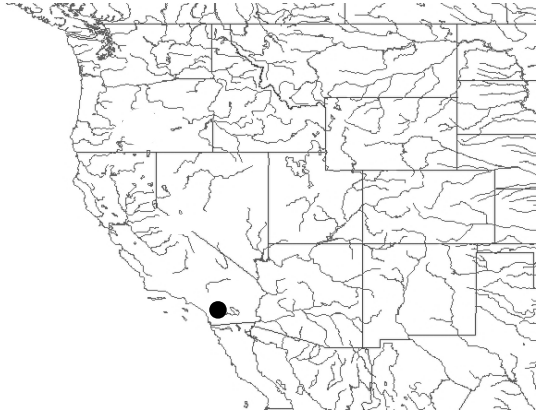
Vecchi et al. EOS 2008

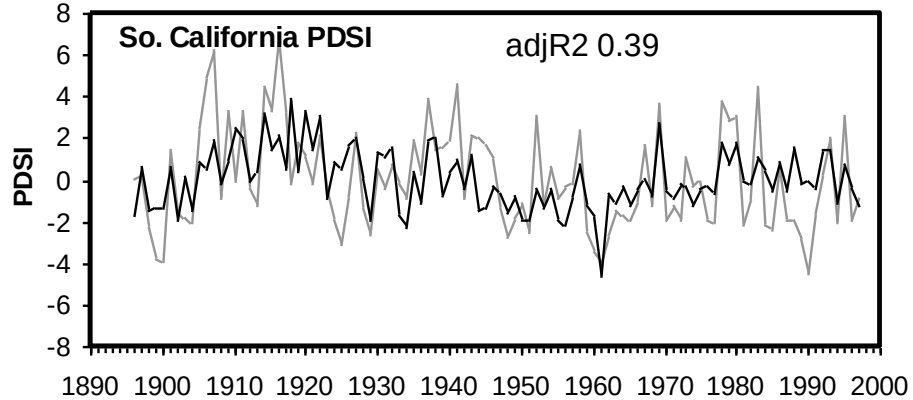




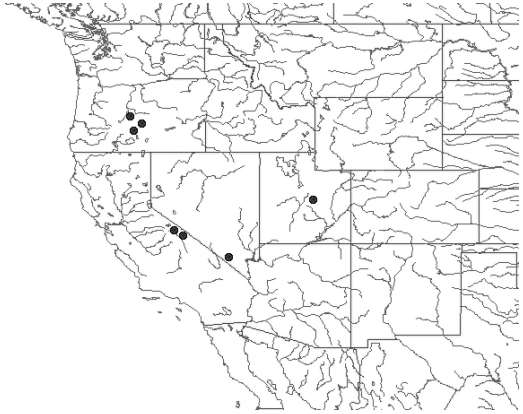
Mann et al. 2003

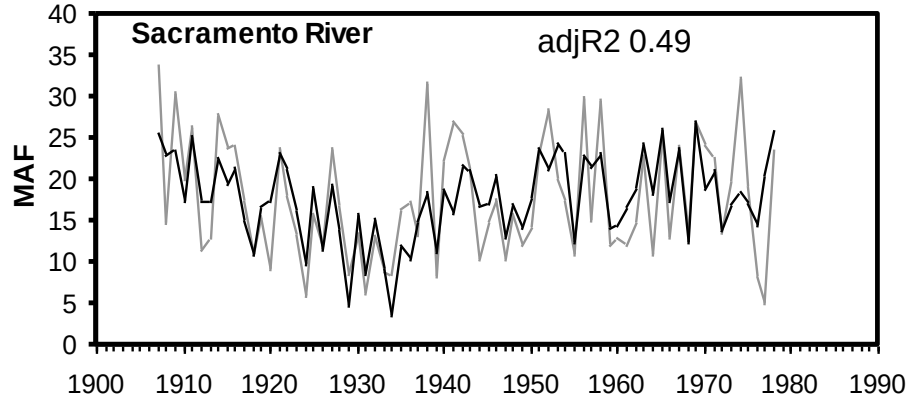
San Gorgonio



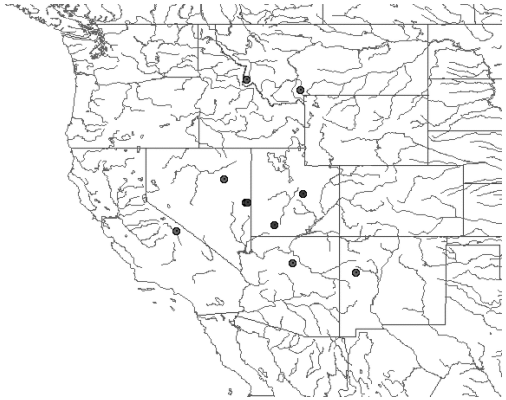


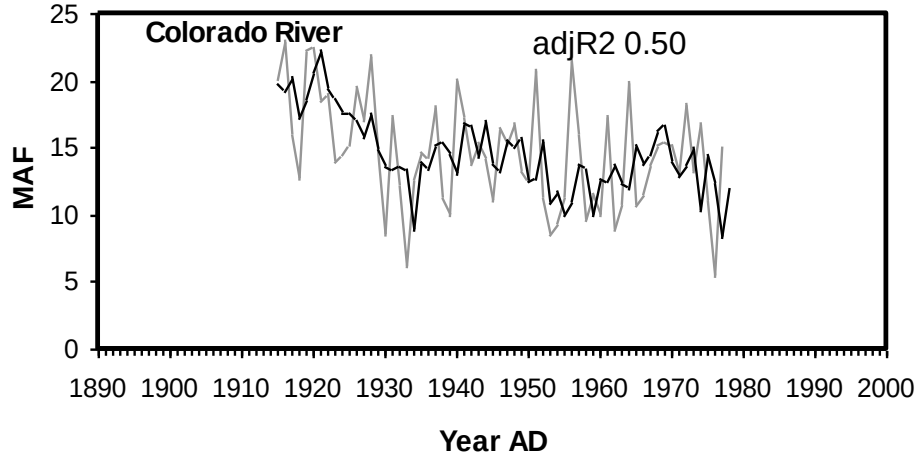
Sacramento River





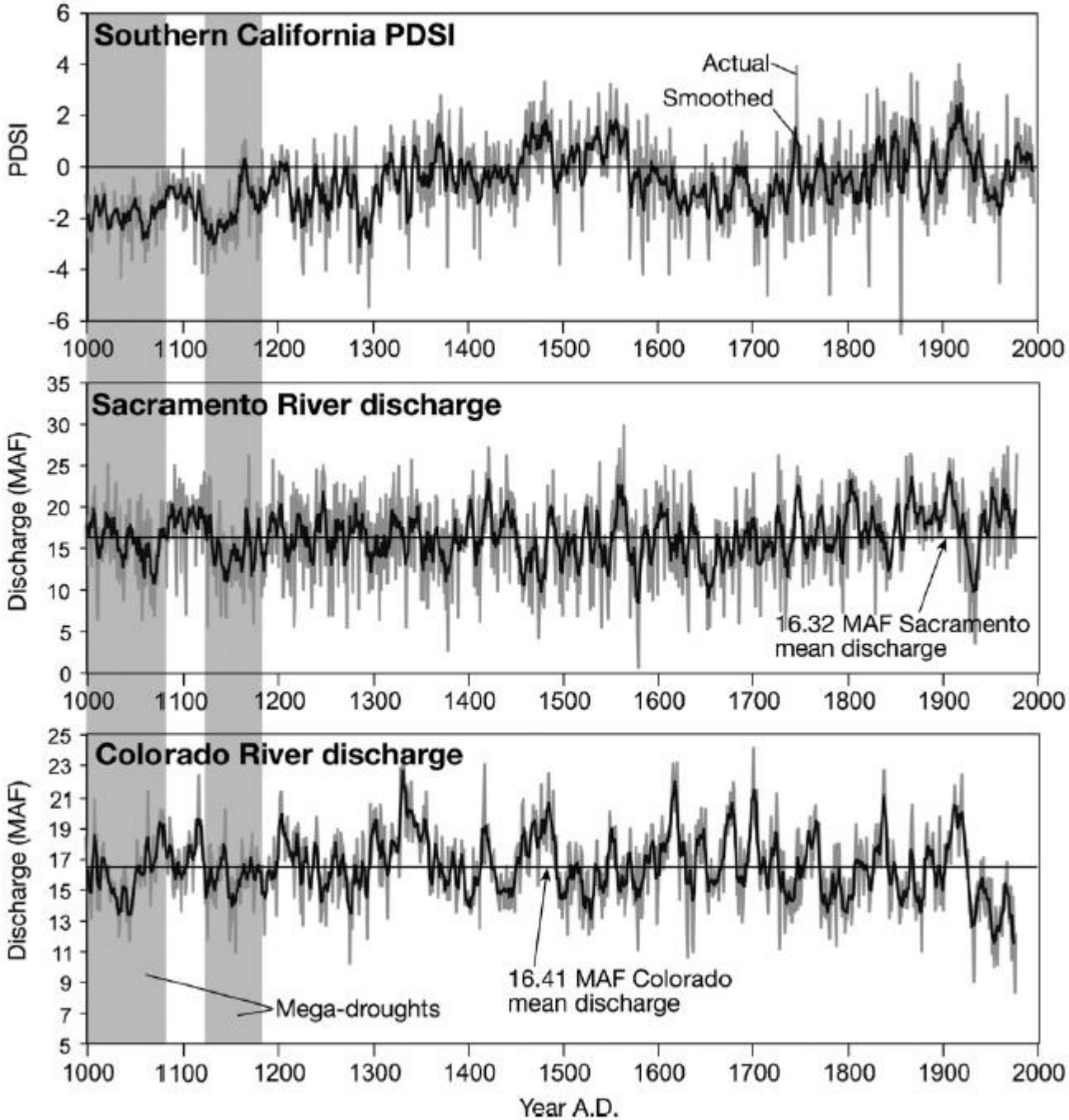
Colorado River

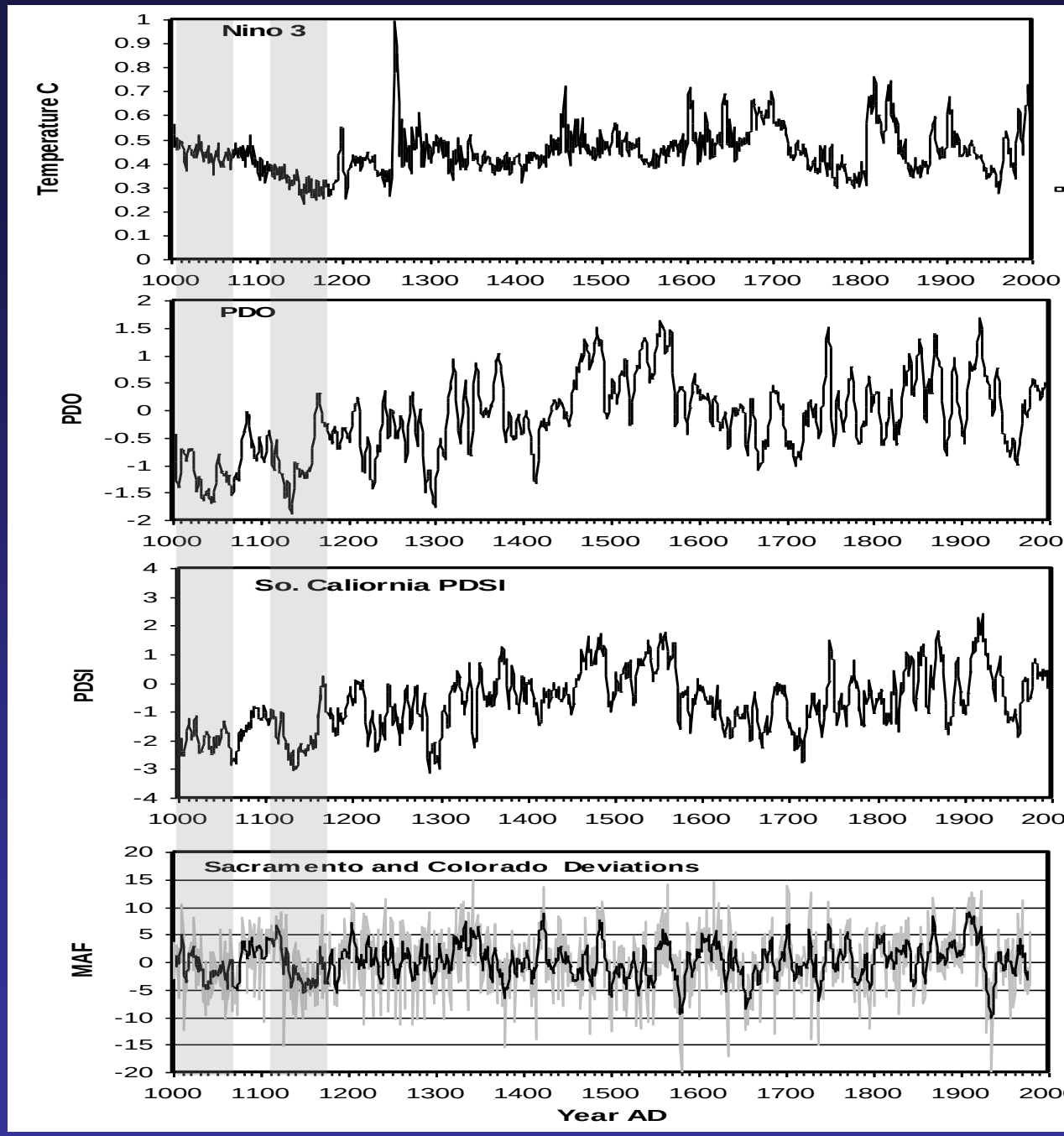




MacDonald, G.M., Kremenetski, K.V. and Hidalgo, H. 2007. Southern California and the Perfect Drought: simultaneous prolonged drought in Southern California and the Sacramento and Colorado River systems. Quaternary International. doi:10.1016/j.quaint.2007.06.027

MacDonald et al. 2007

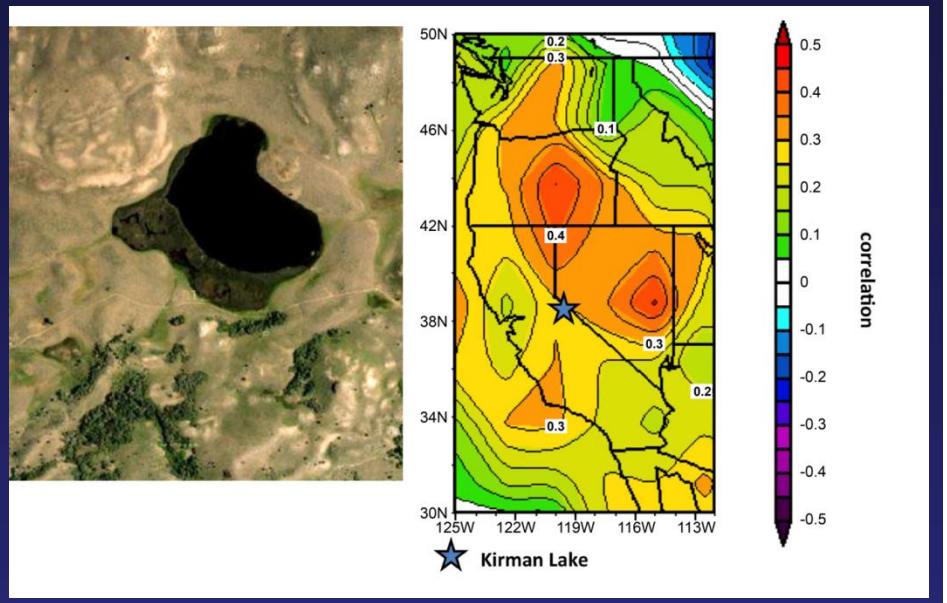

Southern California PDSI
PDSI
Actual
Smoothed
Sacramento River discharge
Discharge (MAF)
16.32 MAF Sacramento mean discharge
Colorado River discharge
Discharge (MAF)
16.41 MAF Colorado mean discharge
Mega-droughts
Year A.D.

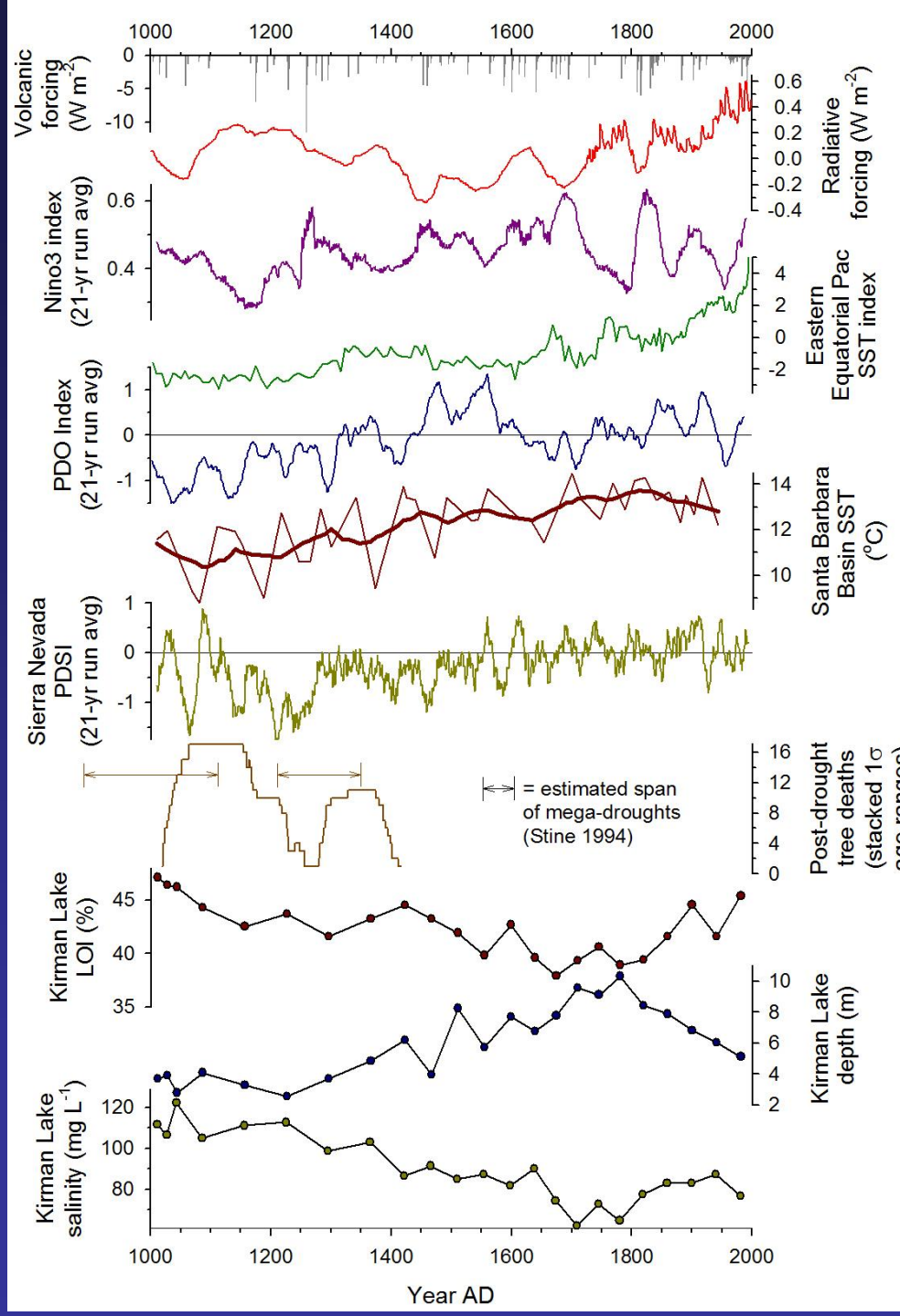


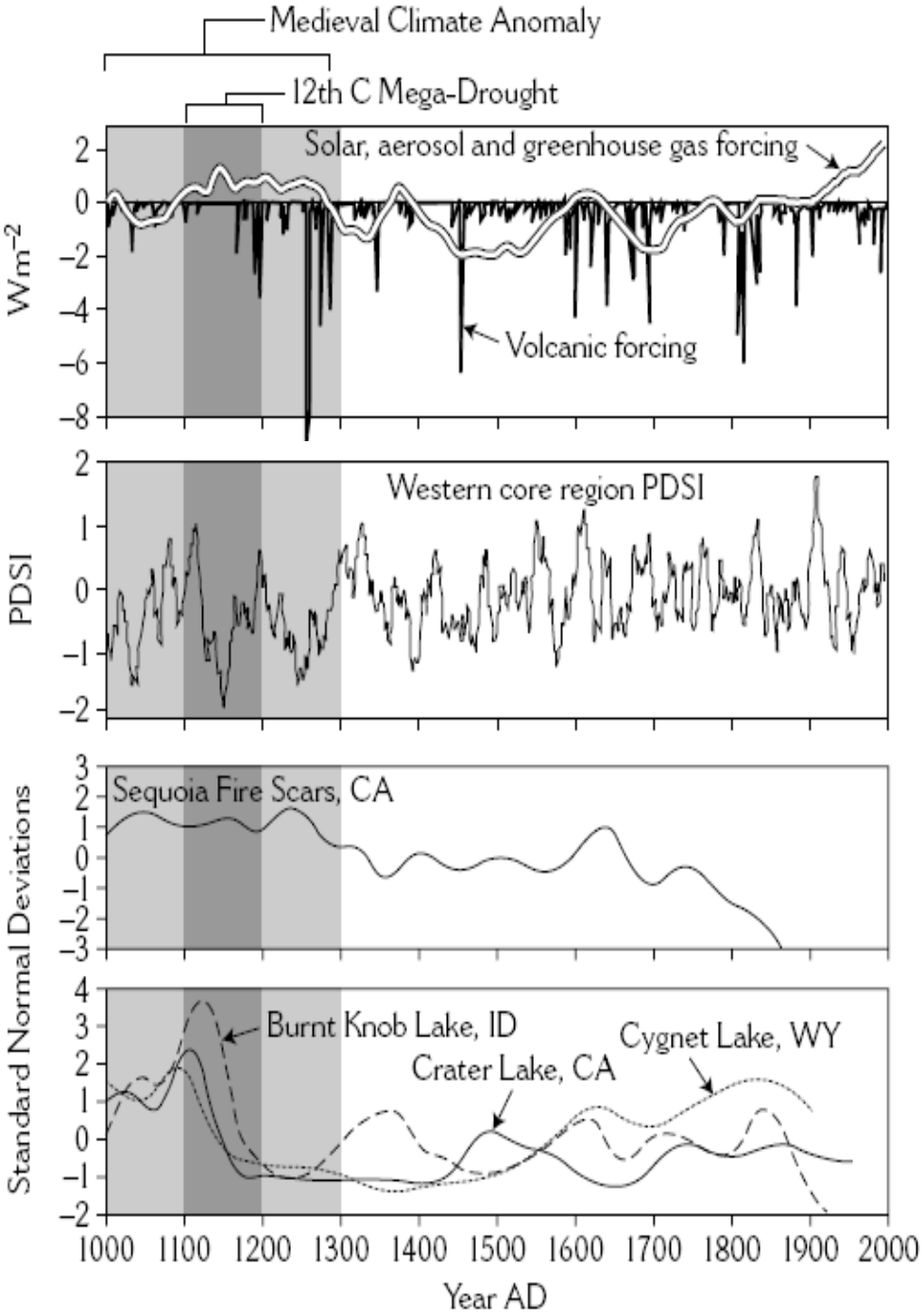
Perfect Drought Periods (~60 years)

~AD 1012-1075
~AD 1130-1192

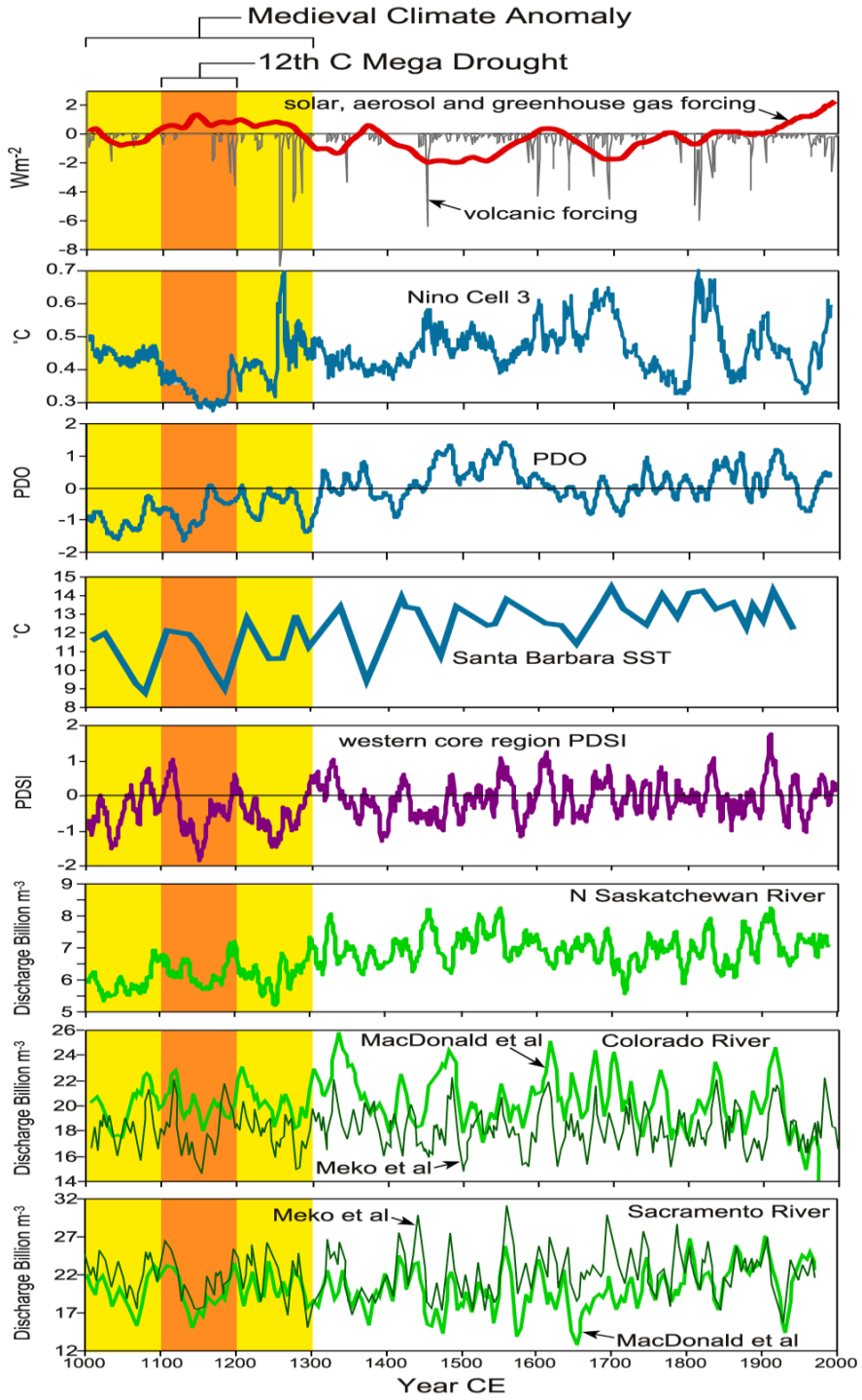
Depressed E Tropical and NE Pacific SST's and prolonged droughts in California and Colorado Bsin during Medieval Warm Period. (Mann et al. 2005; MacDonald and Case, 2005, MacDonald et al. 2007)

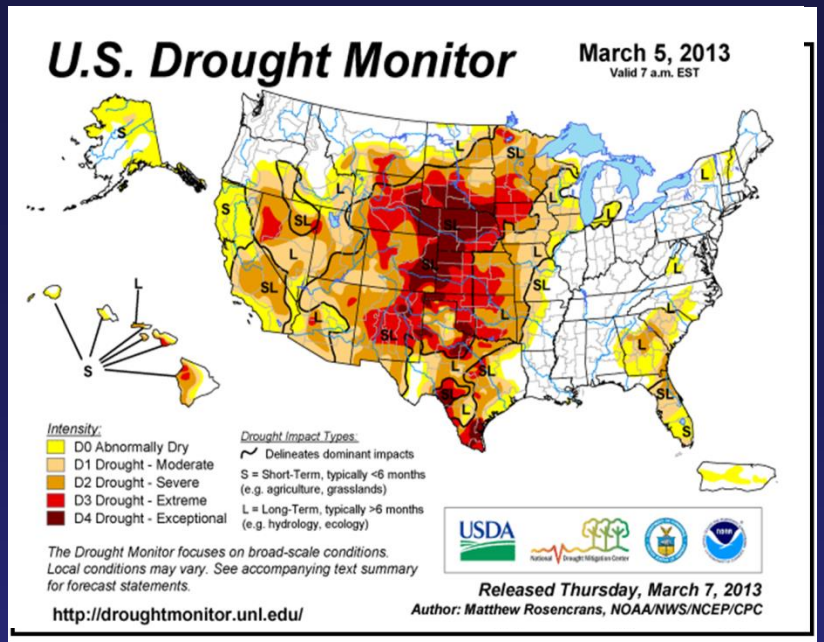

50N
46N
42N
38N
34N
30N
125W
122W
119W
116W
113W
0.2
0.3
0.1
0.4
0.3
0.2
0.3
Kirman Lake
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
correlation


1000
1200
1400
1600
1800
2000
Volcanic forcing (W m^{-2})
Radiative forcing (W m^{-2})
Nino3 index (21-yr run avg)
Eastern Equatorial Pac SST index
PDO Index (21-yr run avg)
Santa Barbara Basin SST (°C)
Sierra Nevada PDSI (21-yr run avg)
= estimated span of mega-droughts (Stine 1994)
Post-drought tree deaths (stacked 1σ age range)
Kirman Lake LOI (%)
Kirman Lake depth (m)
Kirman Lake salinity (mg L^{-1})
Year AD

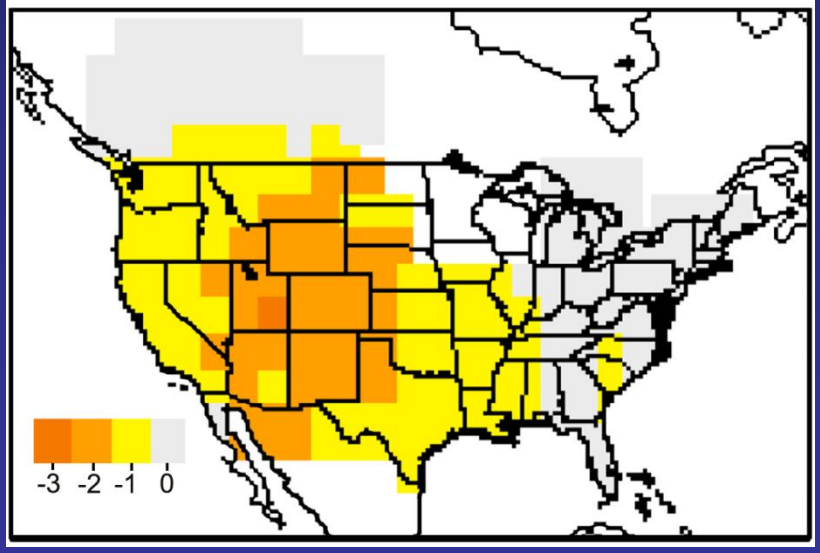


G.M. MacDonald, G.M., Bennett, K.D., Jackson, S.T., Parducci, L., Smith, F.A., Smol, J.P. and Willis, K.J. 2008. Impacts of climate change on species, populations and communities: palaeobiogeographical insights and frontiers Progress in Physical Geography 32, 139-172.

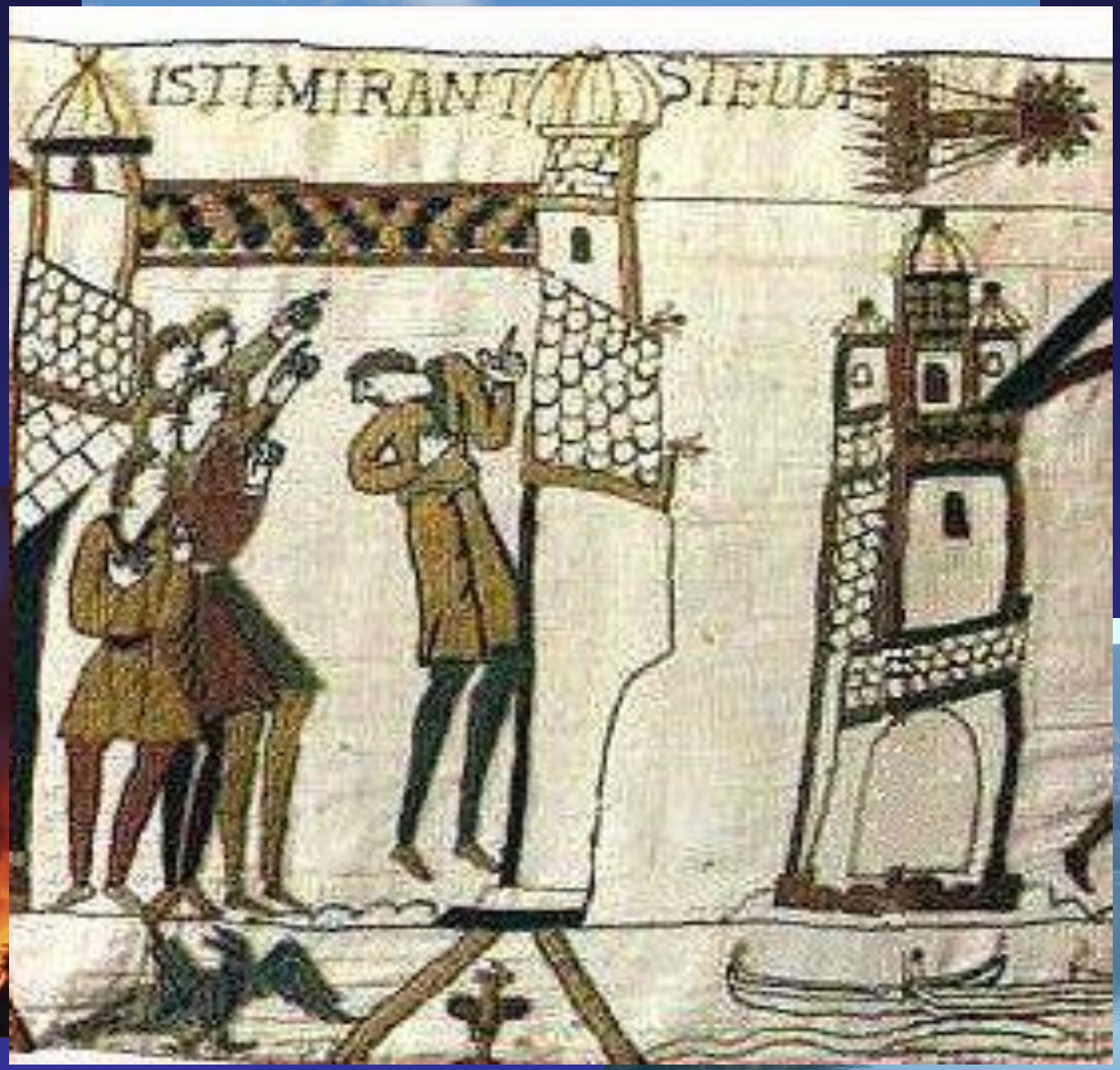




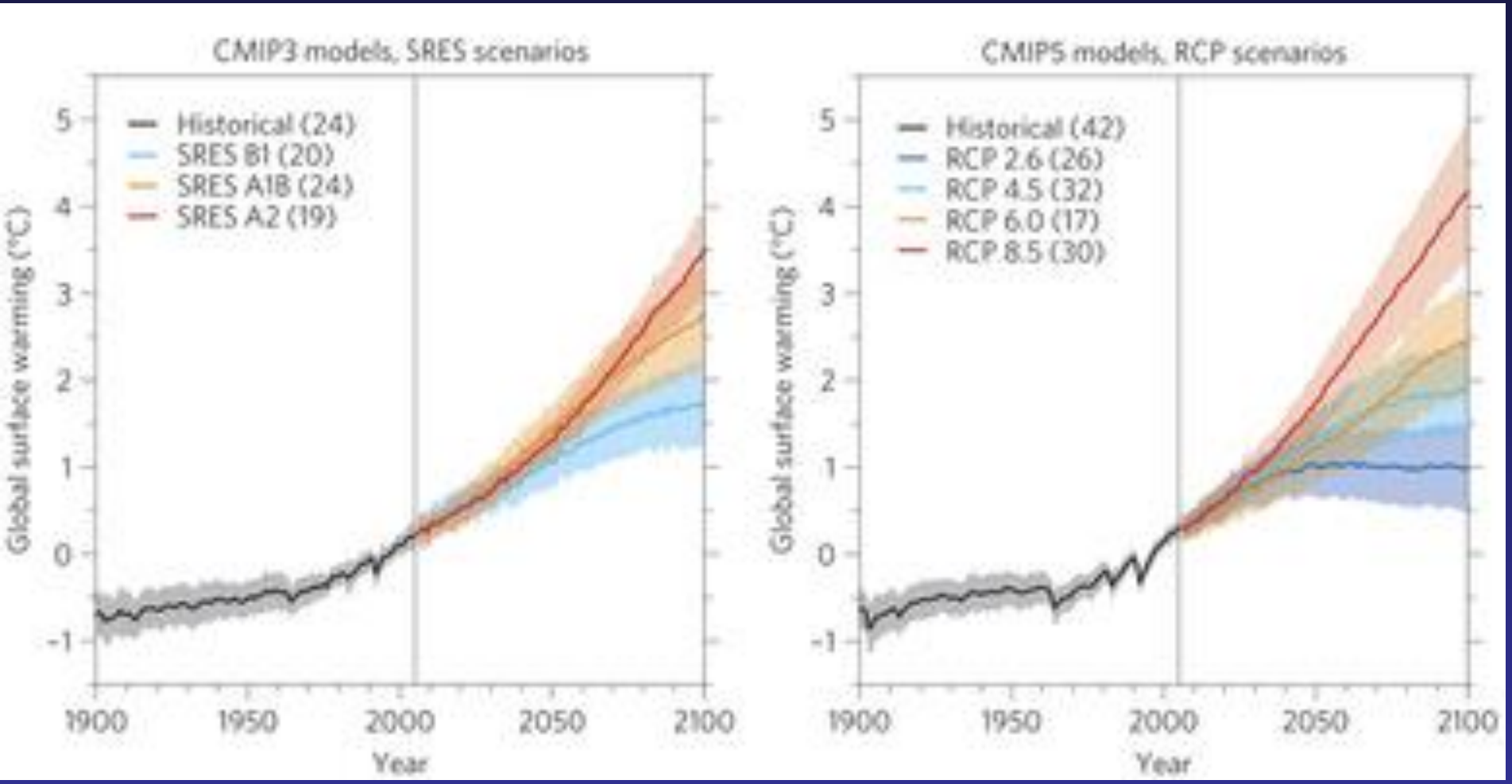
b. 1130-1180



MacDonald et al 2008



Thank you -



Reto Knutti & Jan Sedláček 2012 Robustness and uncertainties in the new CMIP5 climate model projections. Nature Climate Change doi:10.1038/nclimate1716

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