Desert Research Institute

Climate Change and the Great Basin

Kelly T. Redmond

Western Regional Climate Center

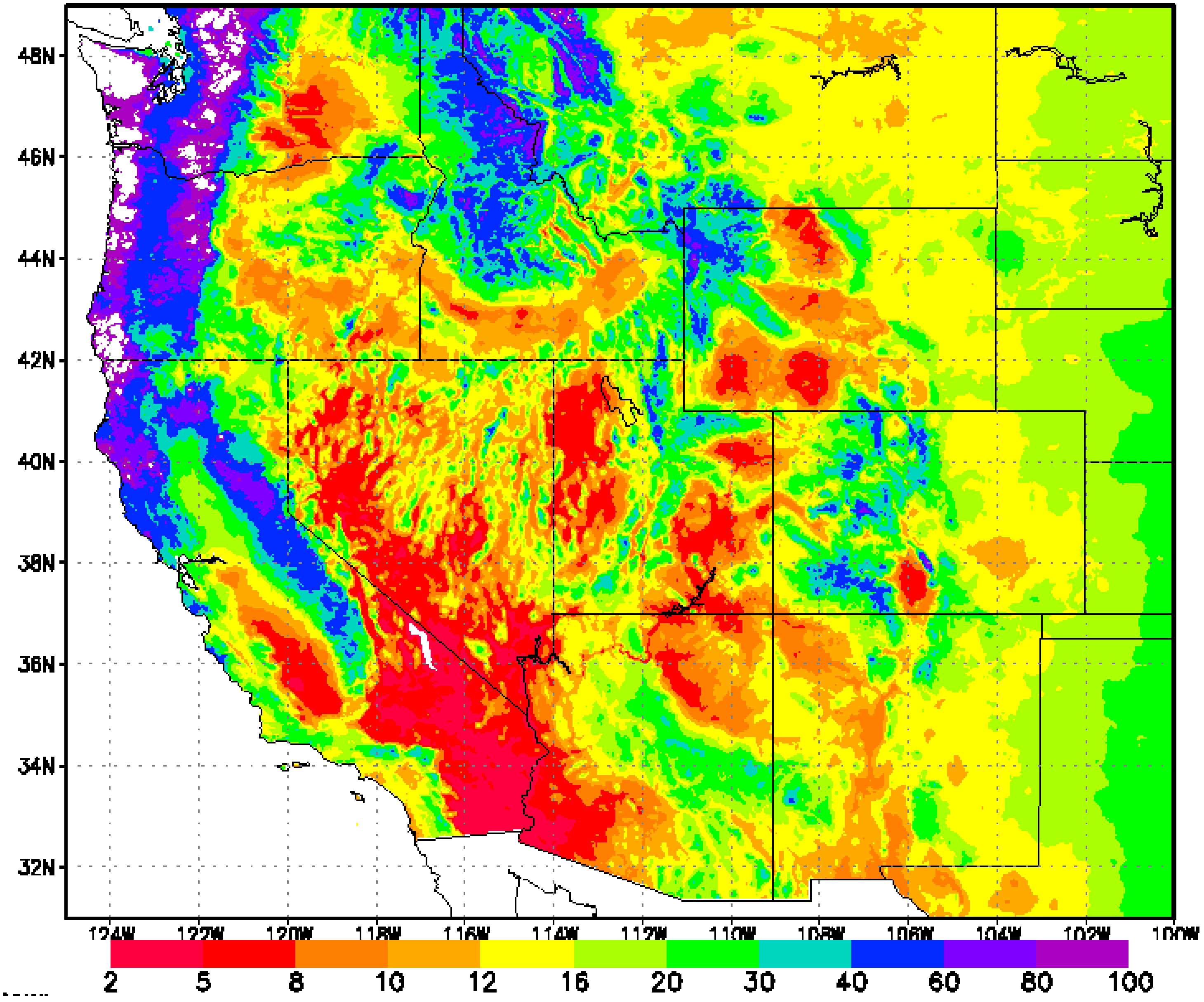
Desert Research Institute

Reno Nevada

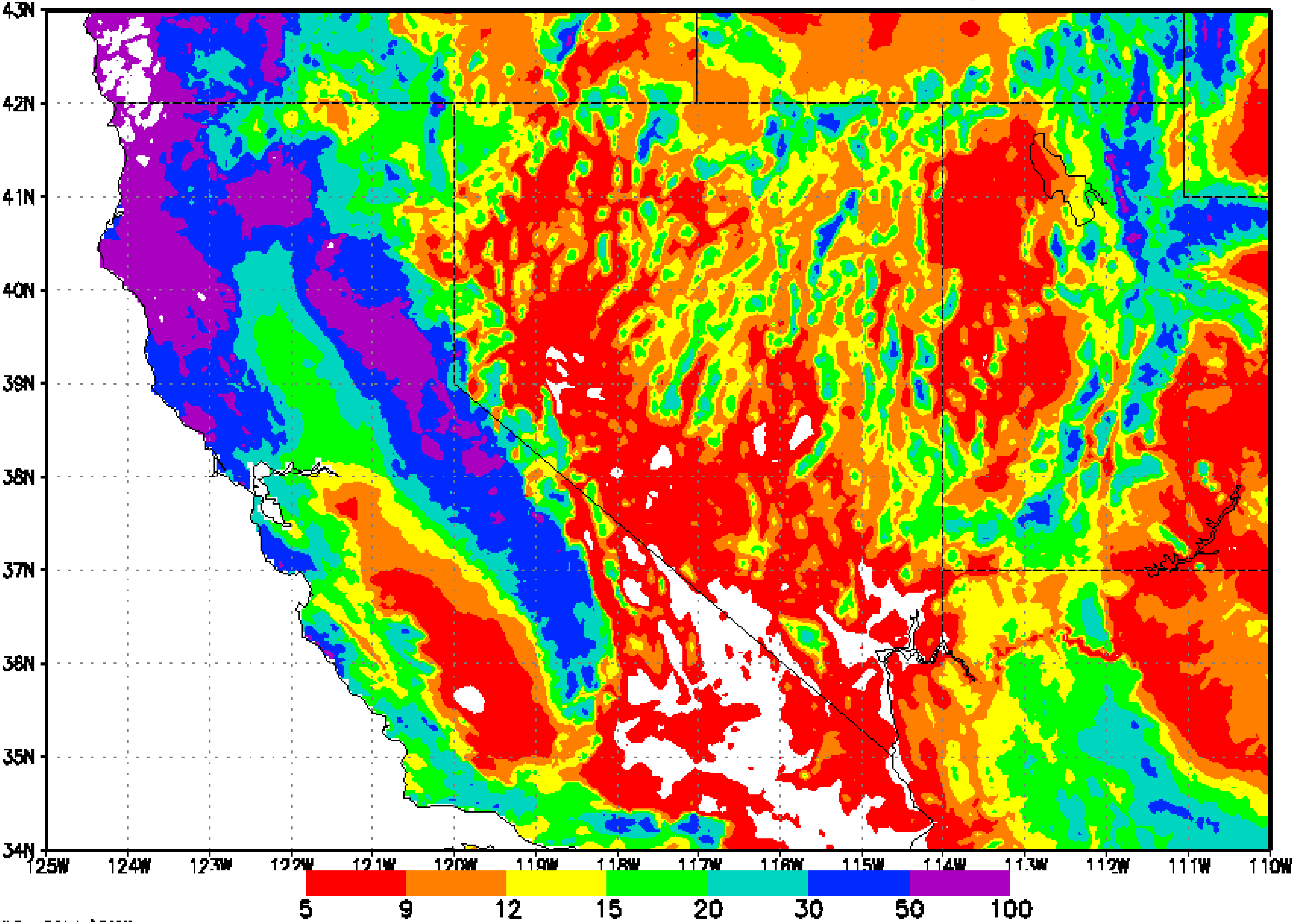
Community Environmental Monitoring Workshop
Bristlecone Convention Center
Ely Nevada
2009 July 29

Western Regional Climate Center

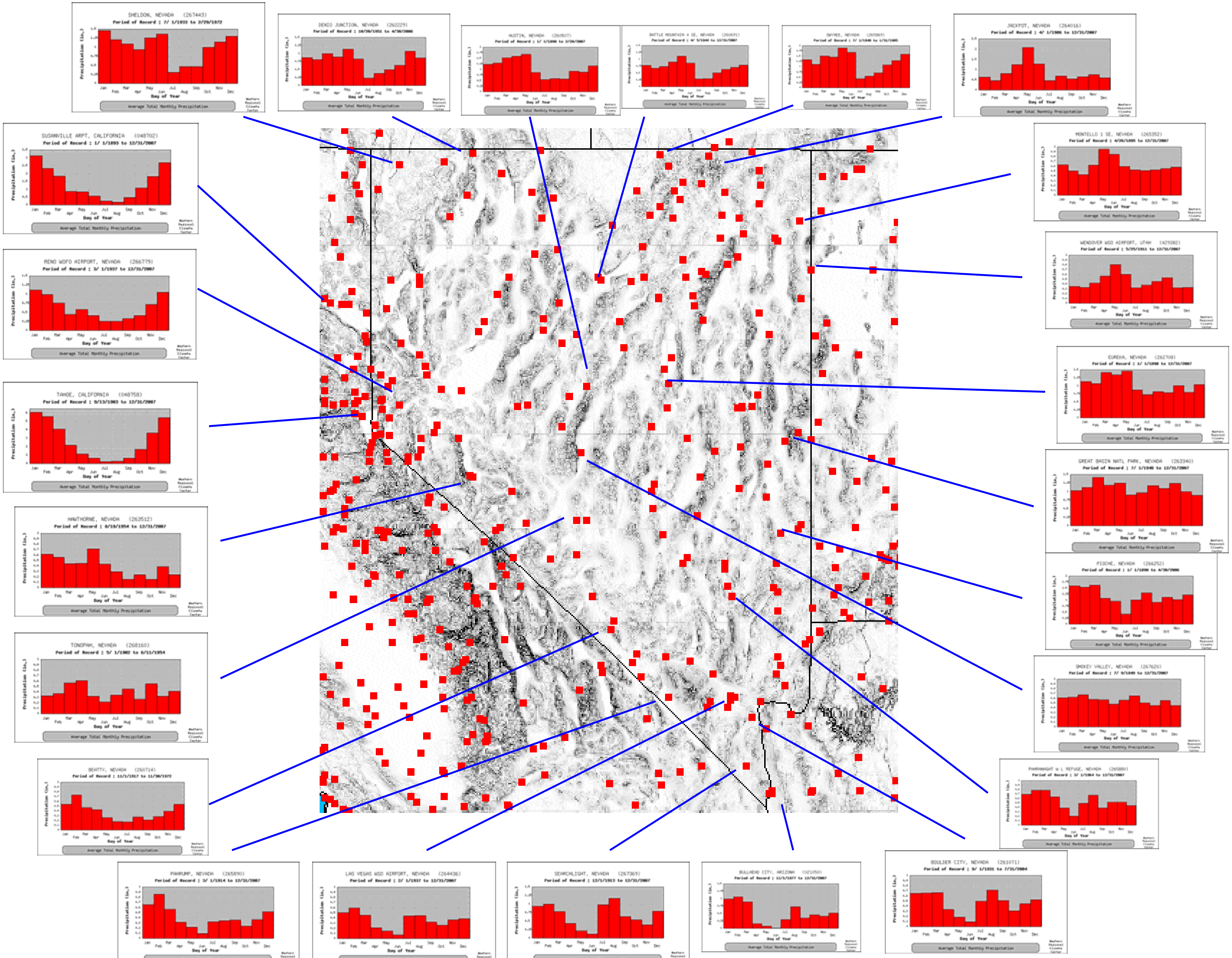
Annual Precipitation (inches)
1961–90 Average (PRISM OSU/WRCC)

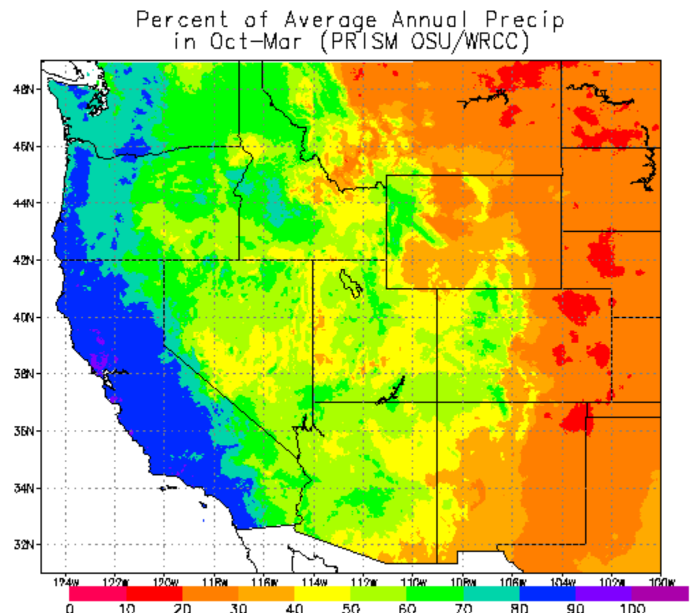


Annual Precipitation in Selected Ranges (inches)

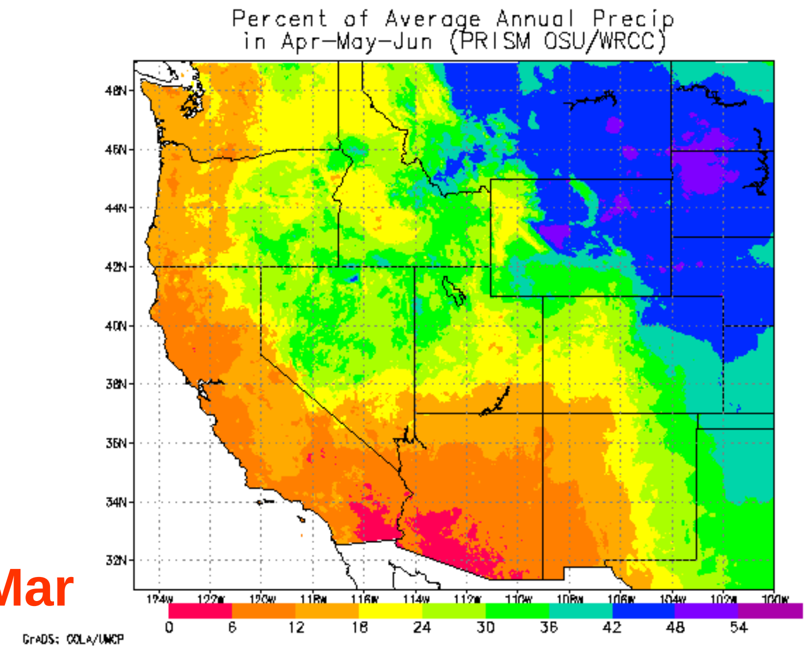


Nevada Annual Precipitation Cycle

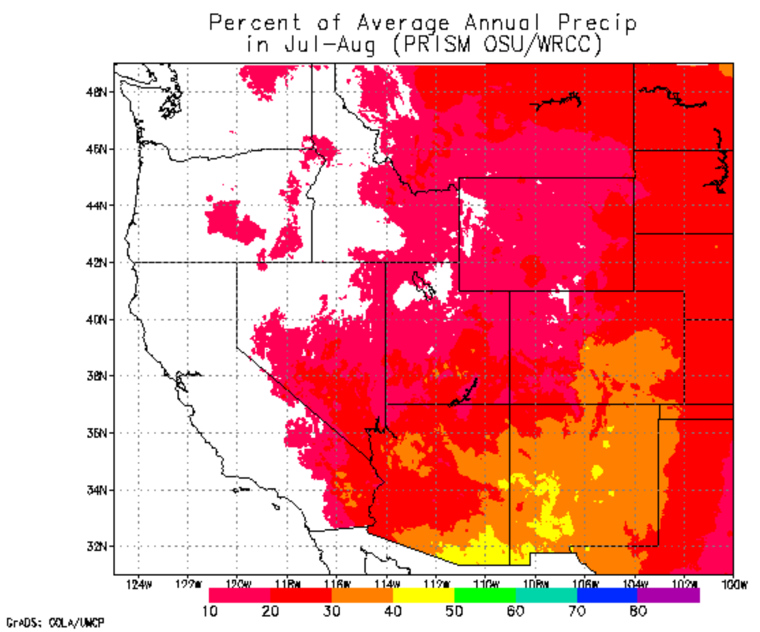




Oct-Mar



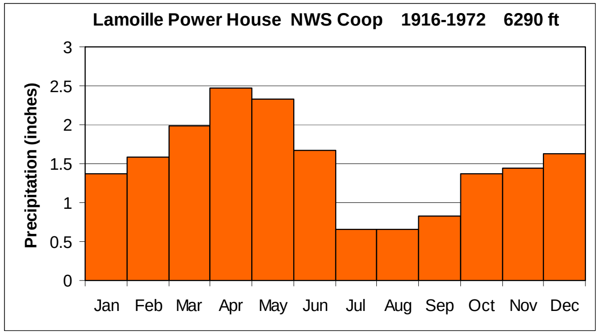
Apr-May-June

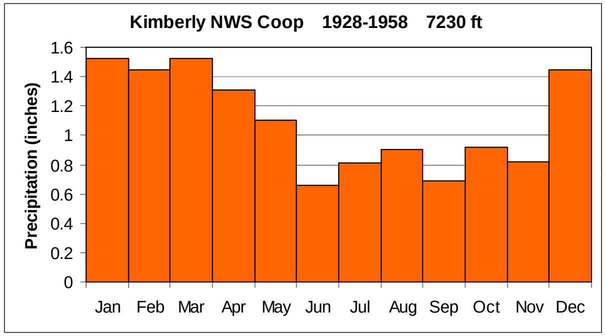


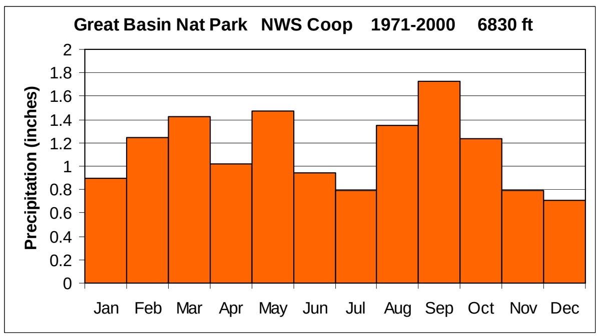
July-Aug

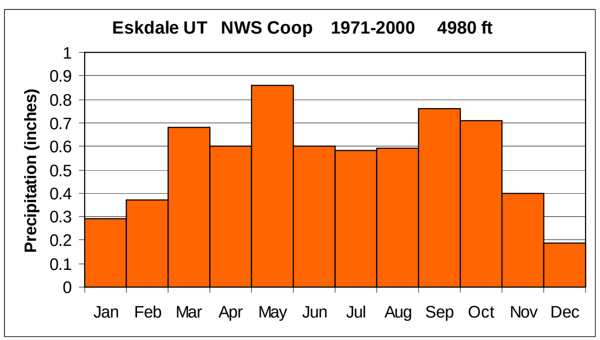
Fraction of Annual Total Precipitation, by Season

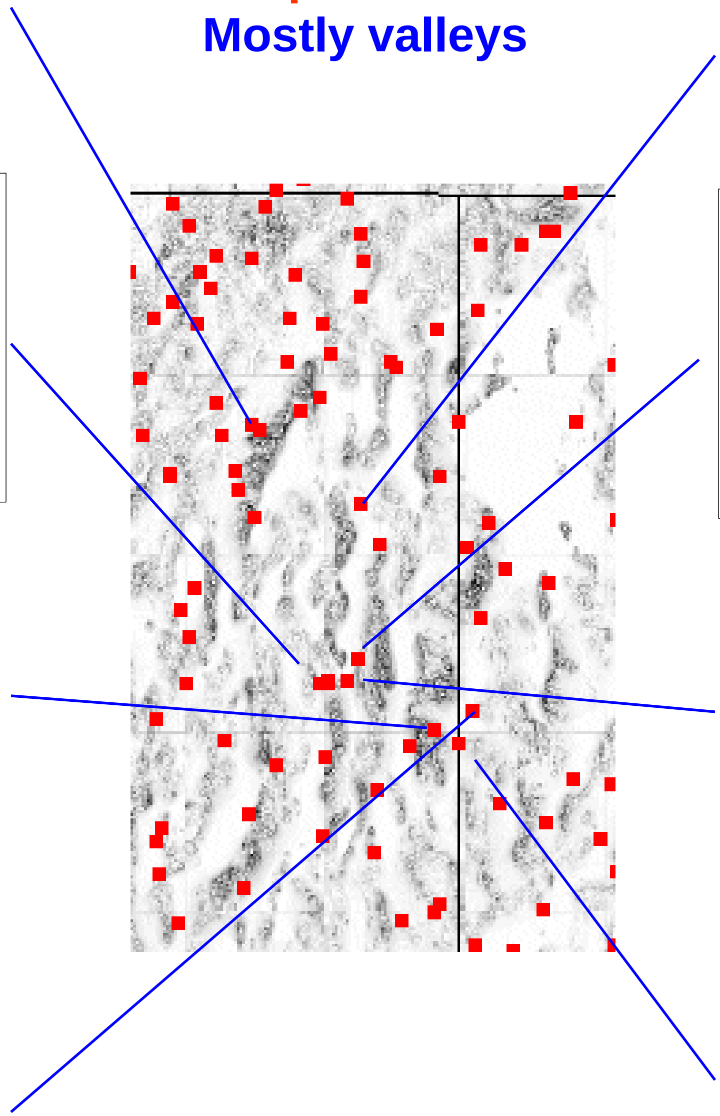
Seasonal Precipitation
NWS Cooperative Network
Mostly valleys

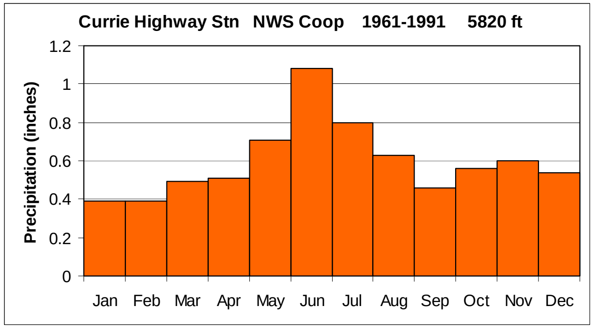


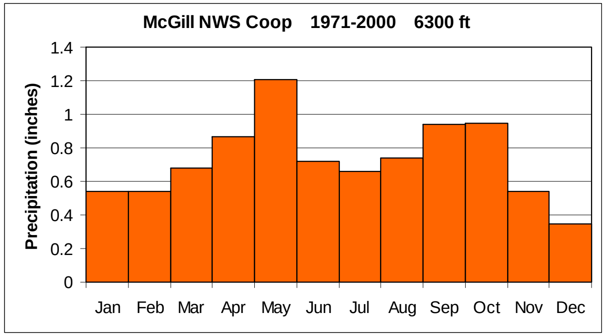


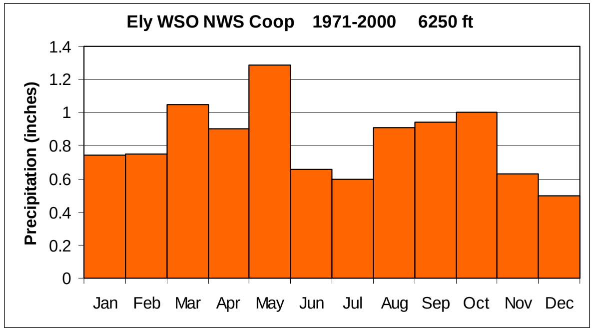


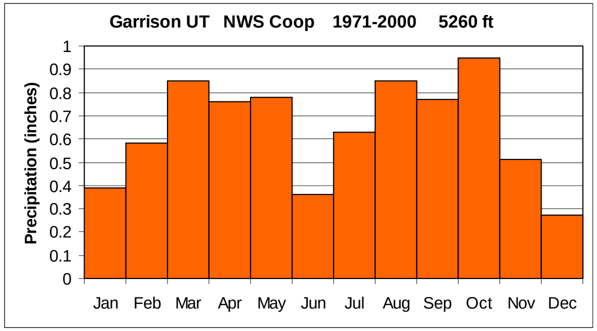




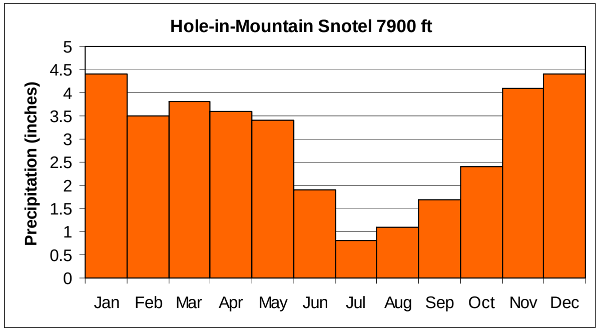


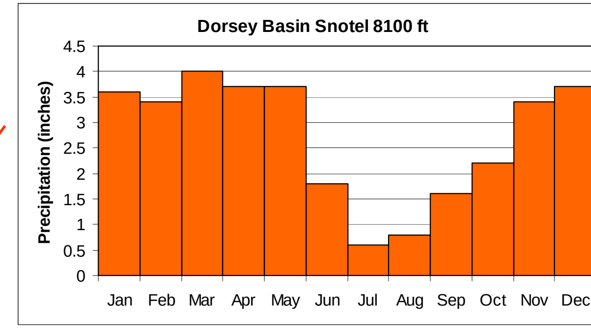


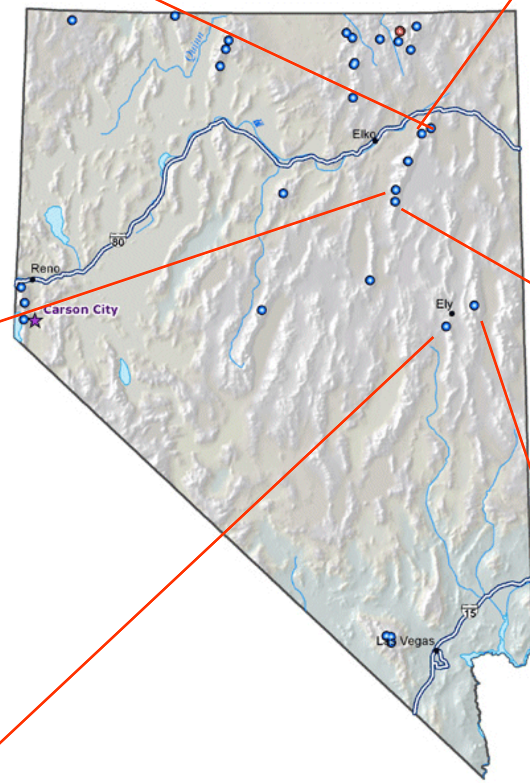


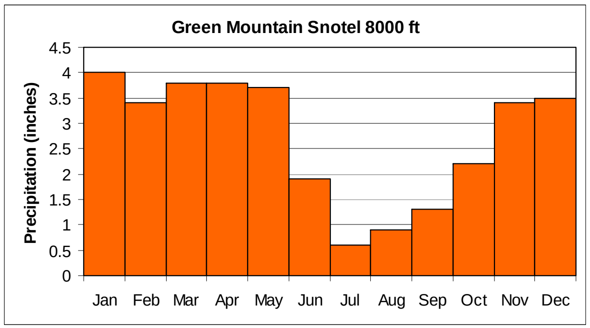


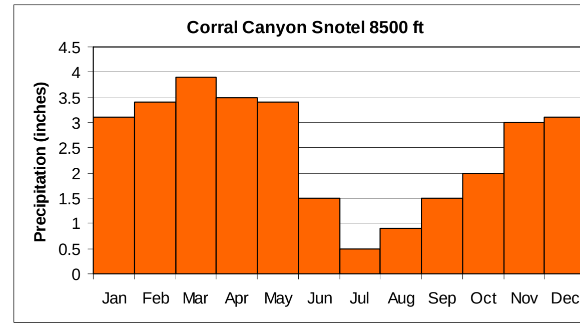
Seasonal Precipitation
NRCS Snotel Network
Mountains

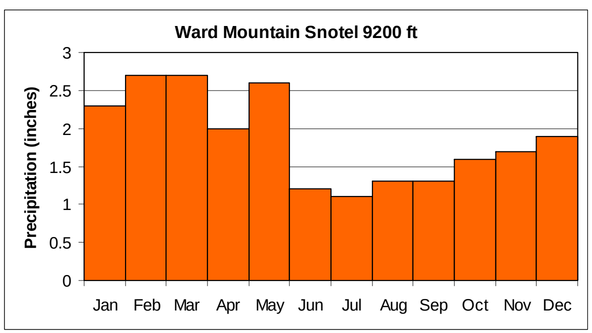


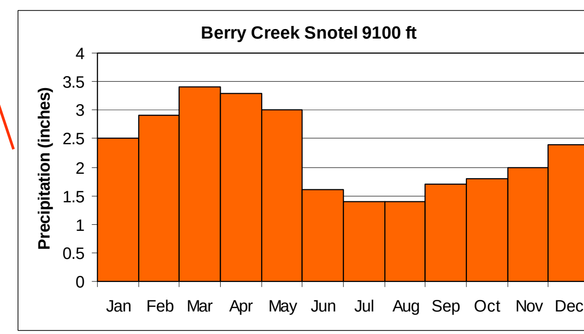












Potential external sources of climate change

Human

Greenhouse gasses
- Carbon dioxide
- Methane
- Nitrous oxide
- Ozone
- Chloroflourocarbons

Aerosols
- Radiative effects (the flow of radiant energy)
- Microphysics effects (how clouds form and how they work)

Land use / land cover changes
- Changes in albedo
- Changes in water vapor
- Changes in vegetative influence / participation in energy and mass flows

Natural

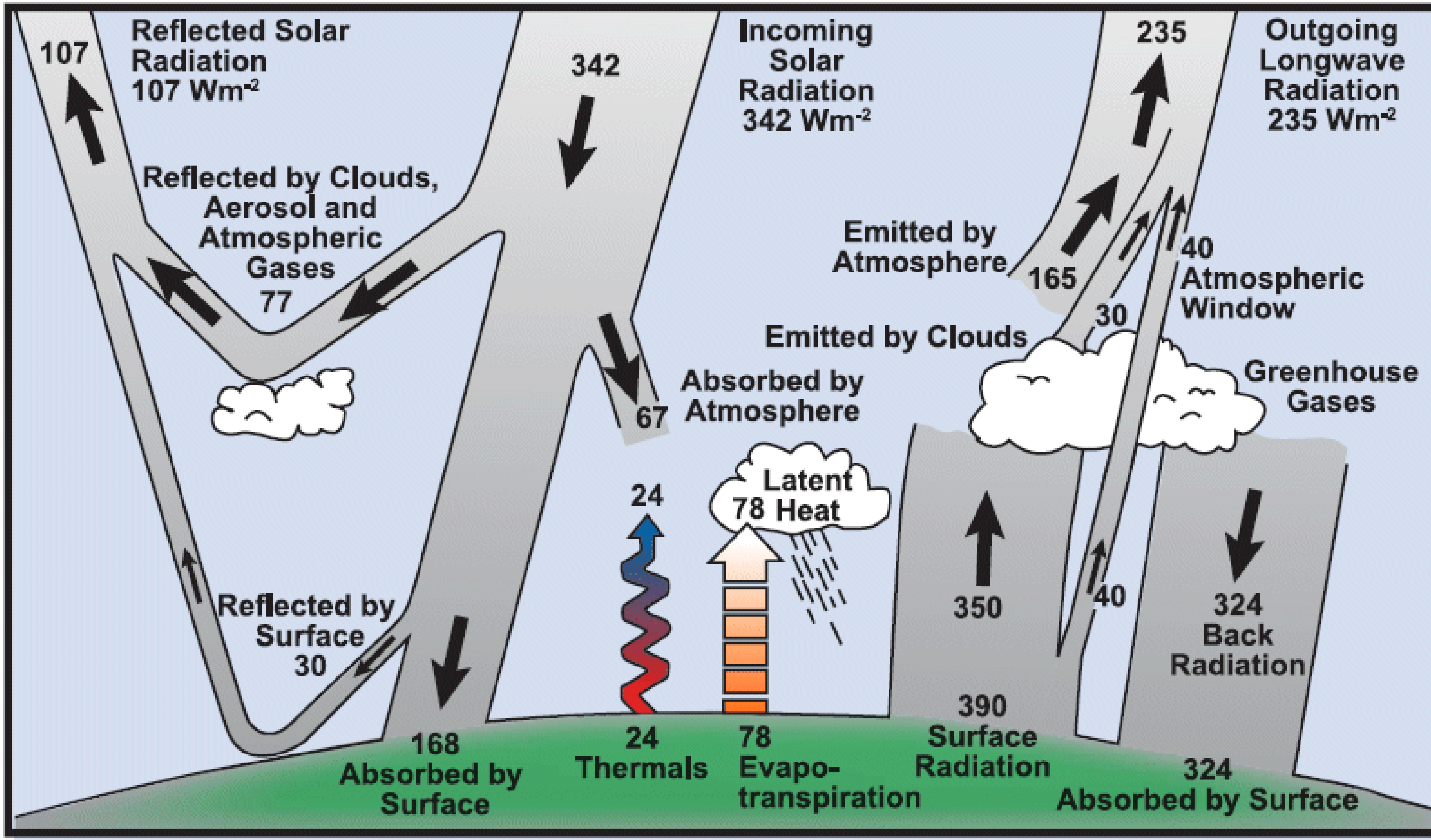
Astronomical radiation forcing

Solar variations

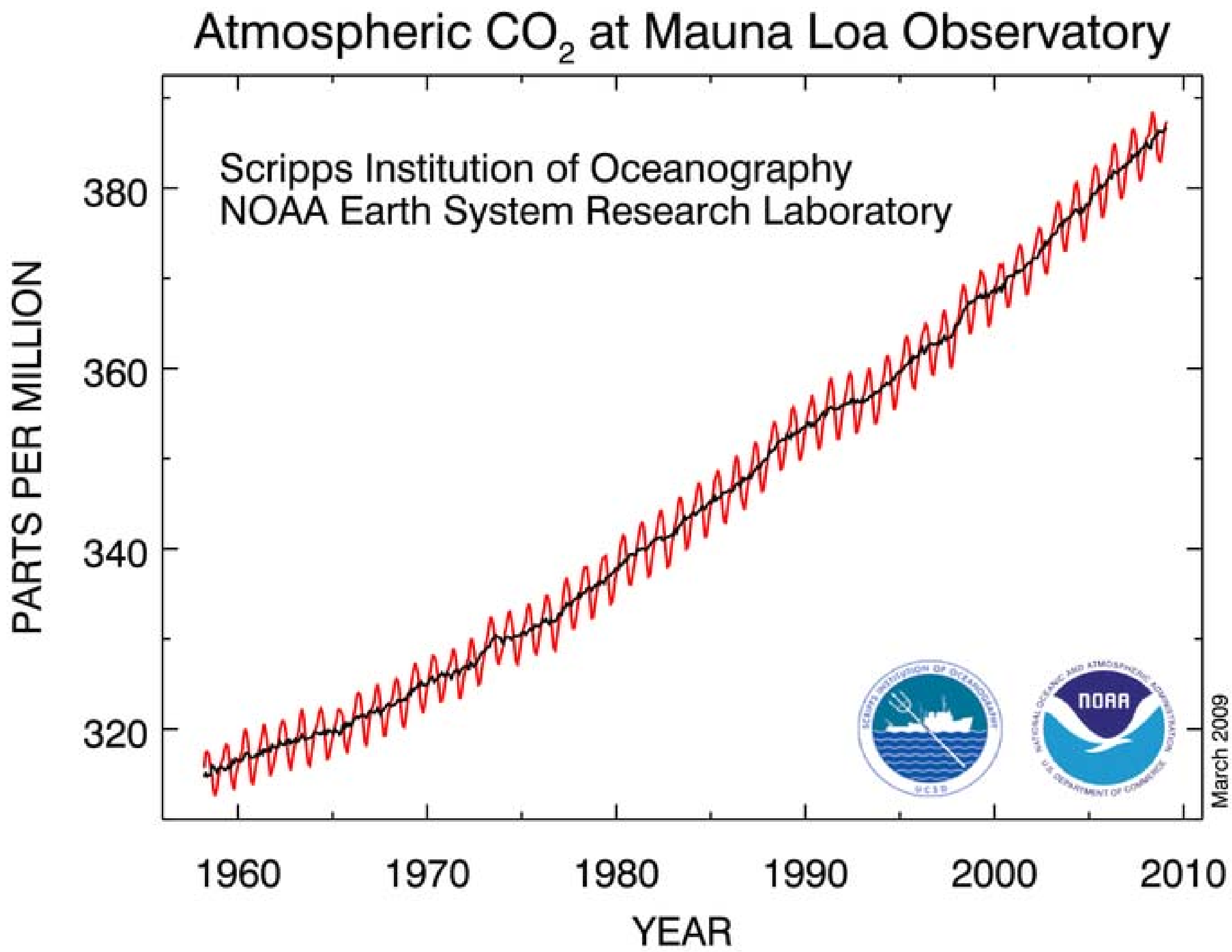
Volcanoes

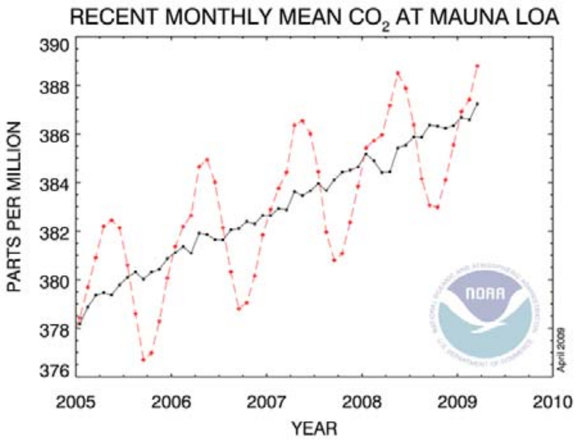
The Planetary Radiation Budget

Net incoming 342 – 107 = 235 W/m^2　　　**Net outgoing = 235 W / m^2**



IPCC AR4, Kiehl and Trenberth (1997)



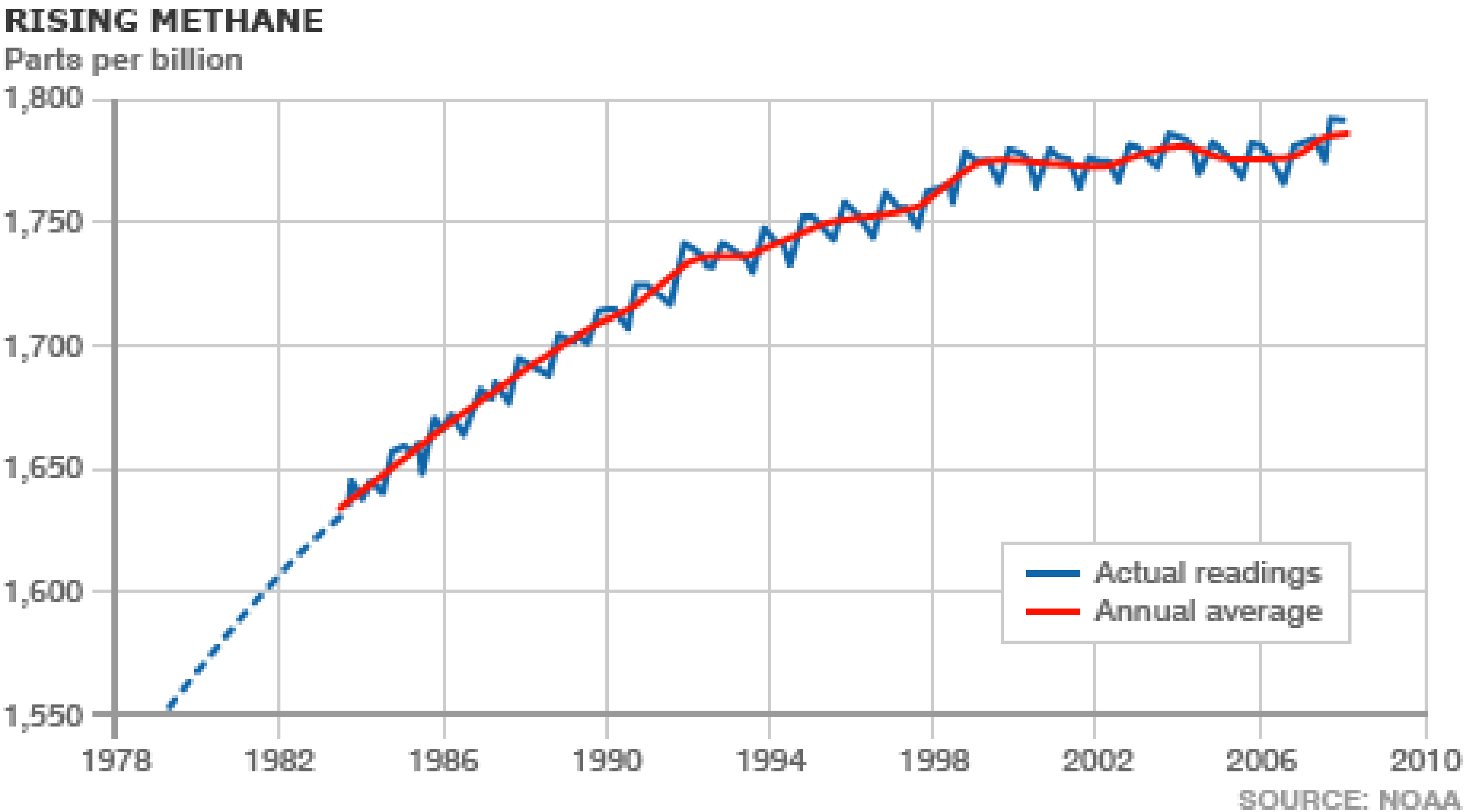


316 ppmv
1959

+22 %

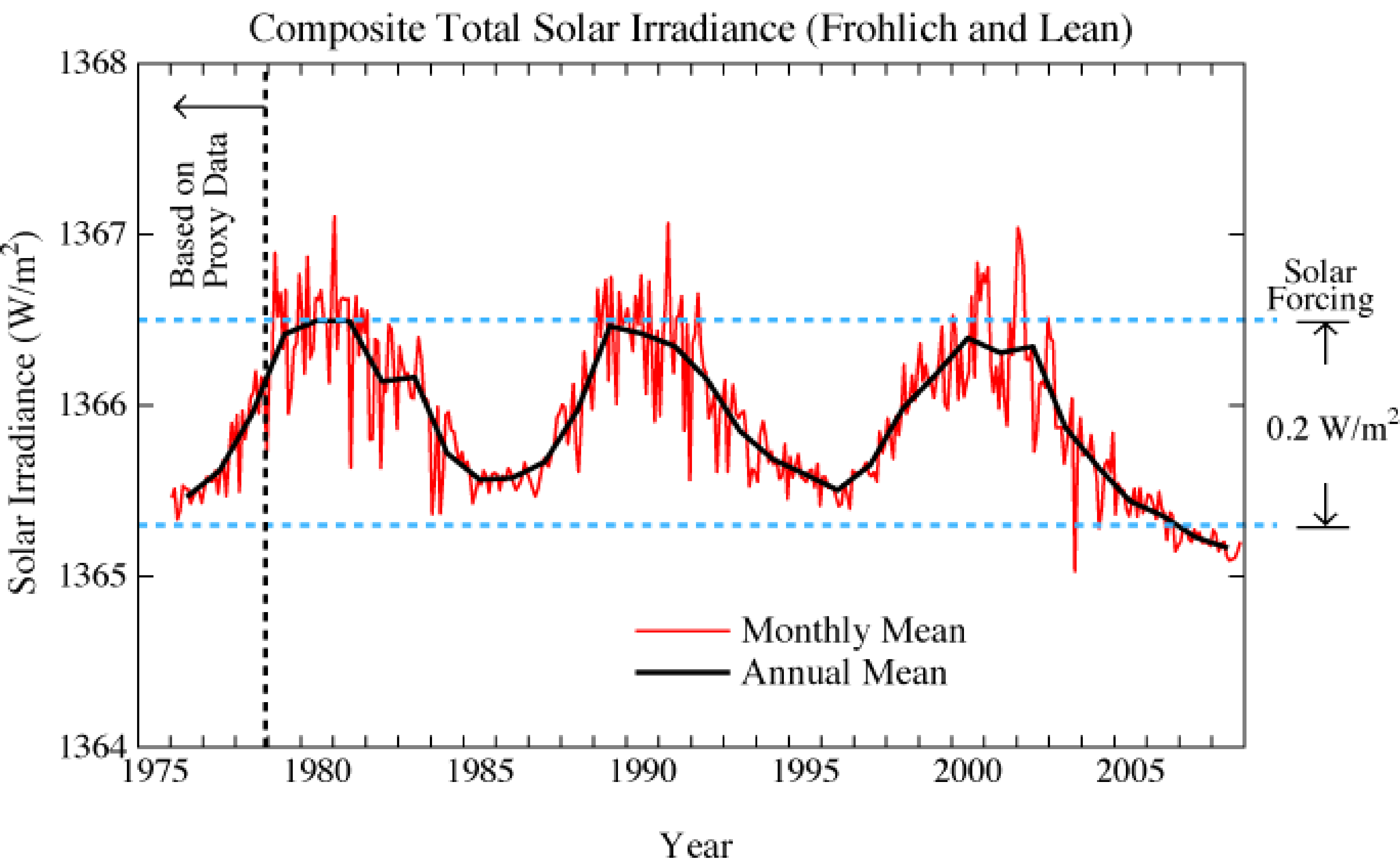
387
Mar 2009

Atmospheric Methane: Resumption of its Rise???
Methane is 23 times more potent as a greenhouse gas than CO_2

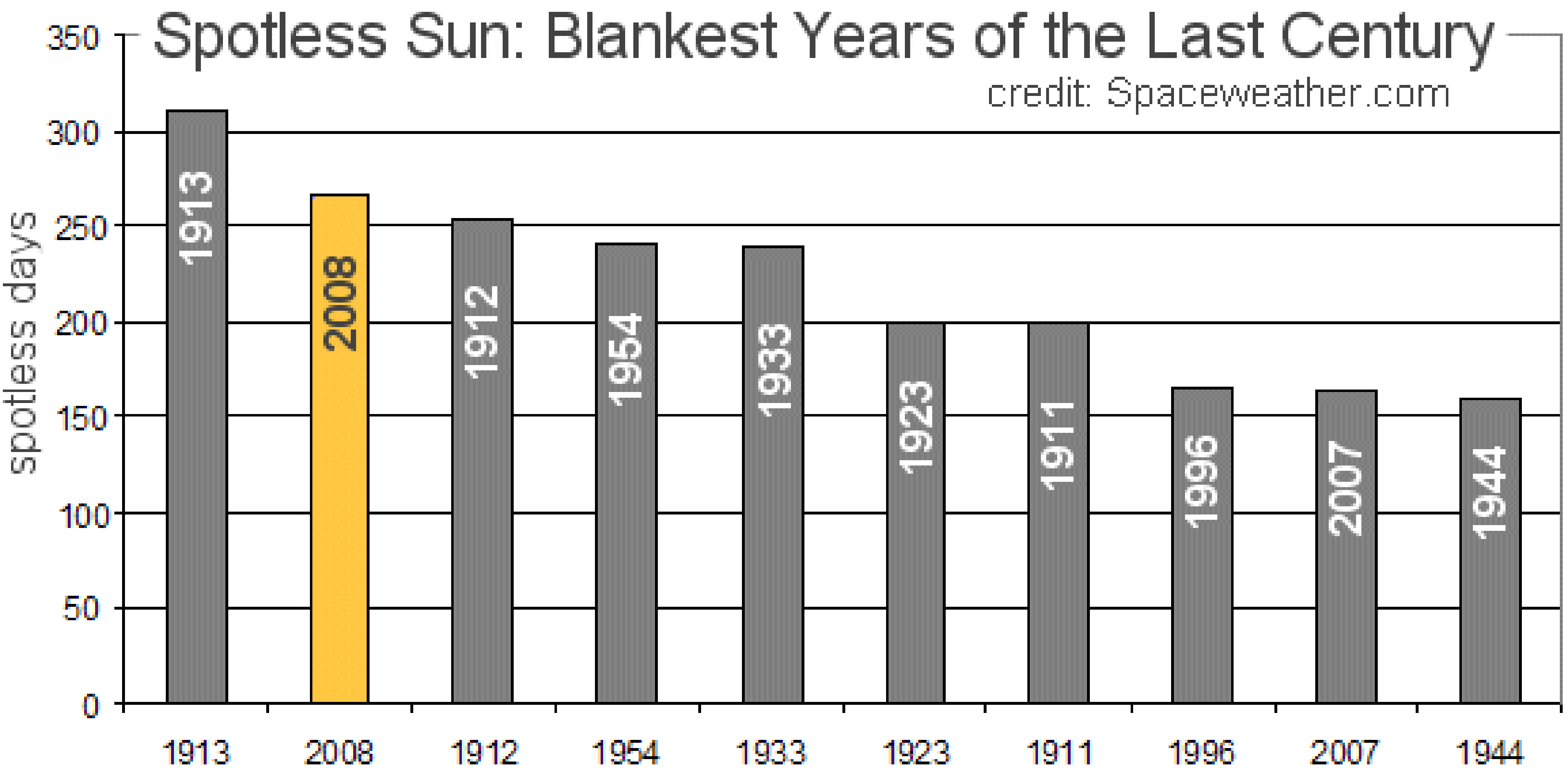


Solar Output During the Satellite Era

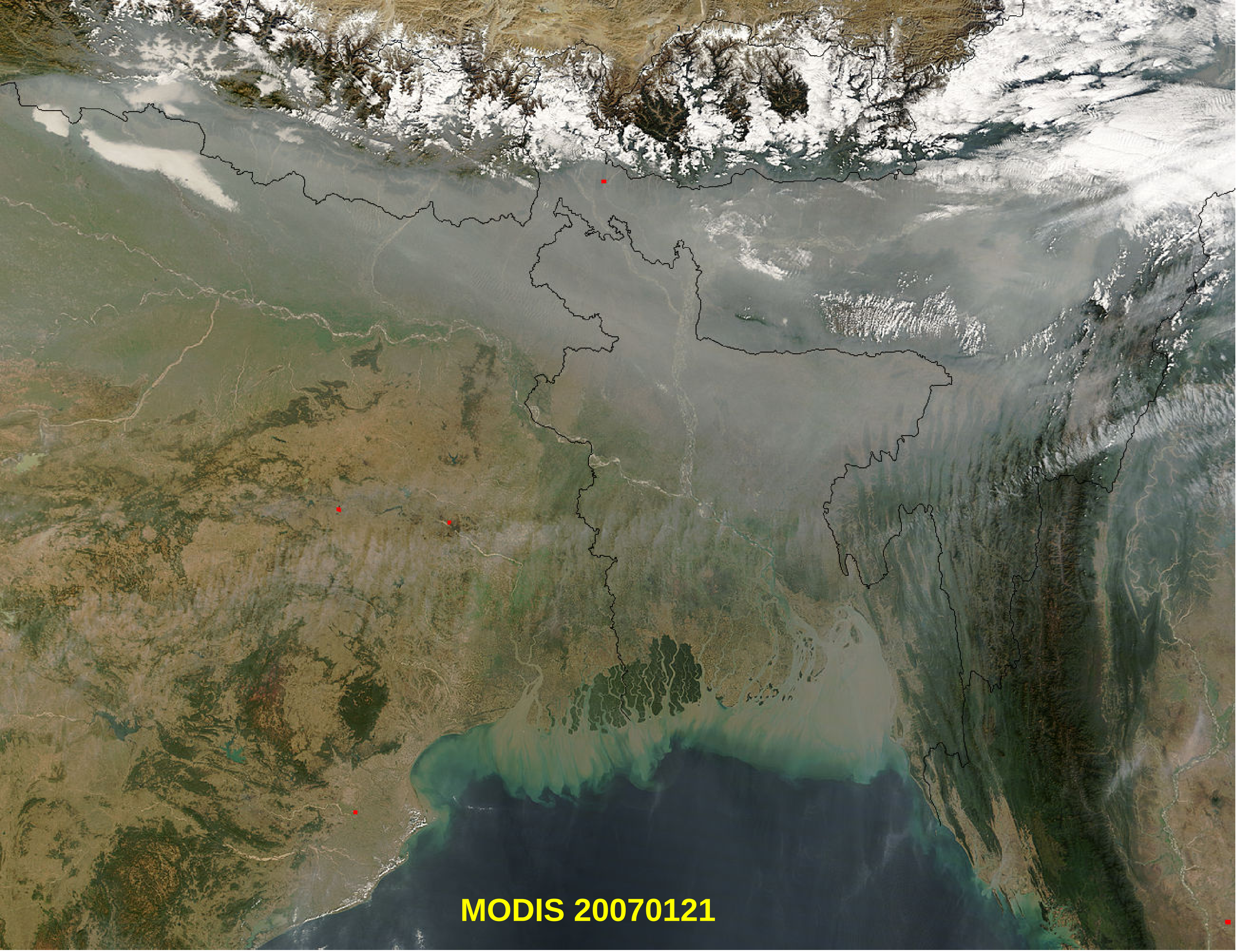
Through late December 2008

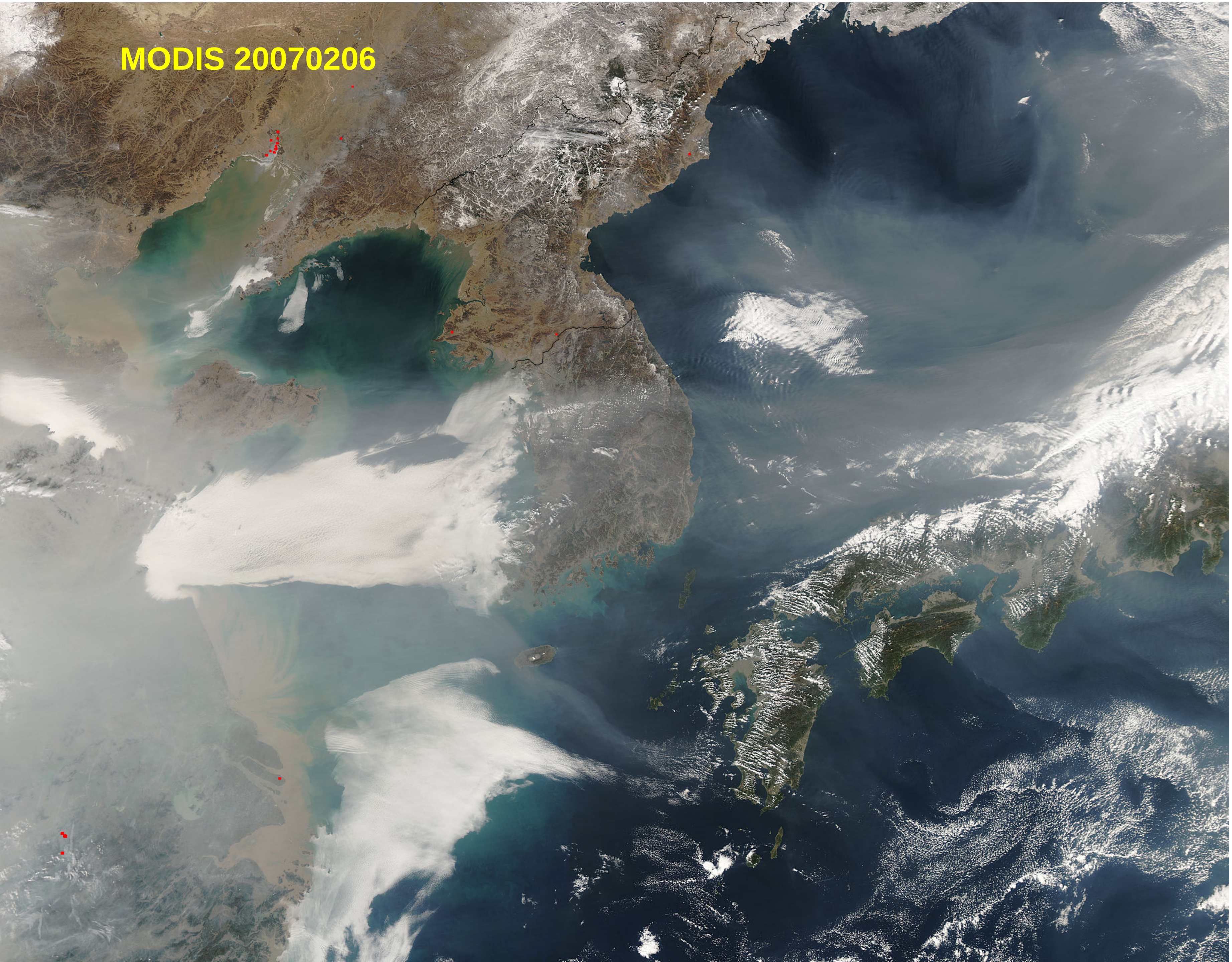


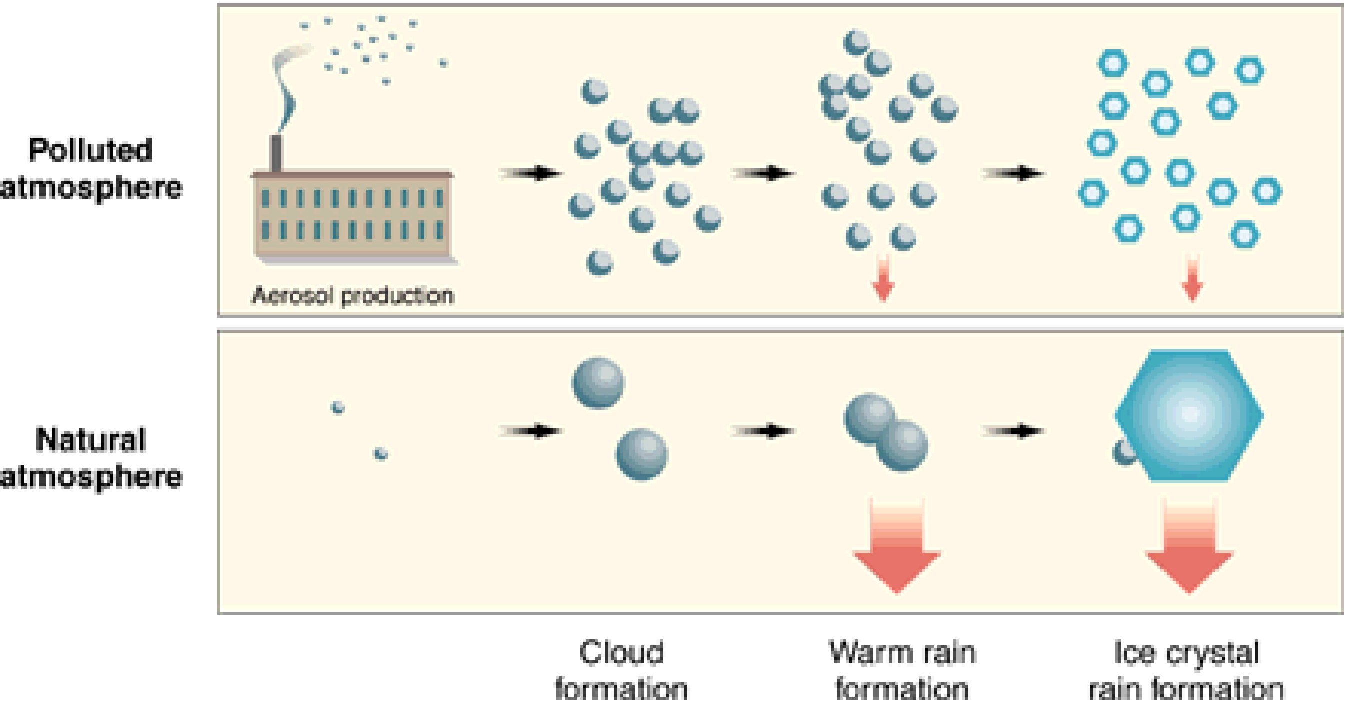
2008: 266 of 366 days, No sunspots. Most spotless days since 1913 with 311 days.
2009 through July 26: 158 days out of 208 (76 pct of year).
Typical solar min: 485 spotless days. This solar min thru July 26: 669 spotless days.



spaceweather.com


MODIS 20070121


MODIS 20070206



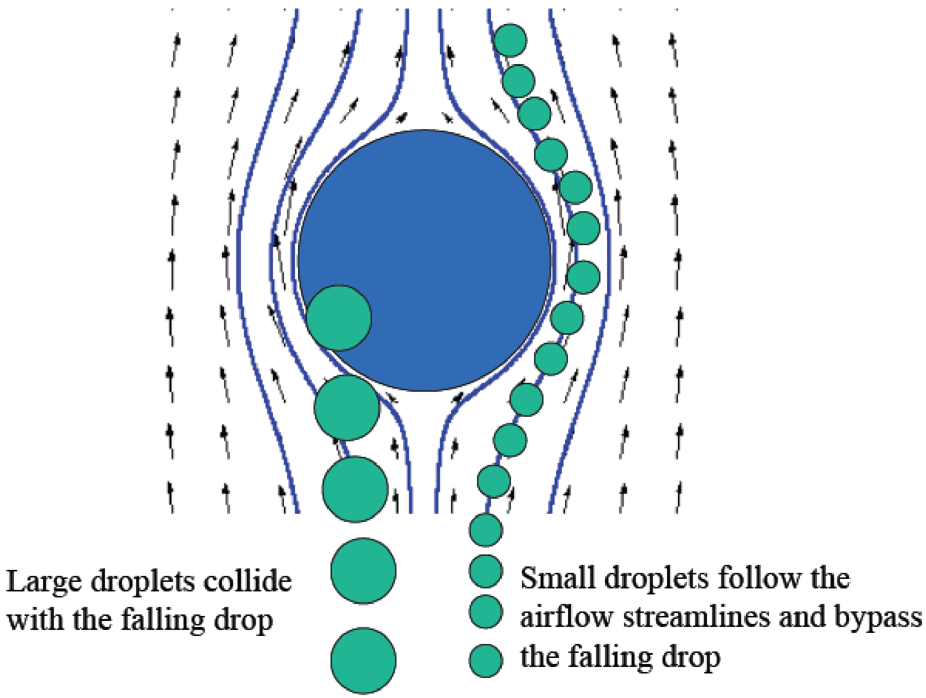
Owen B. Toon

How Pollution Suppresses Rain

Science Magazine,

10 March 2000

287 (5459), 1763-1765



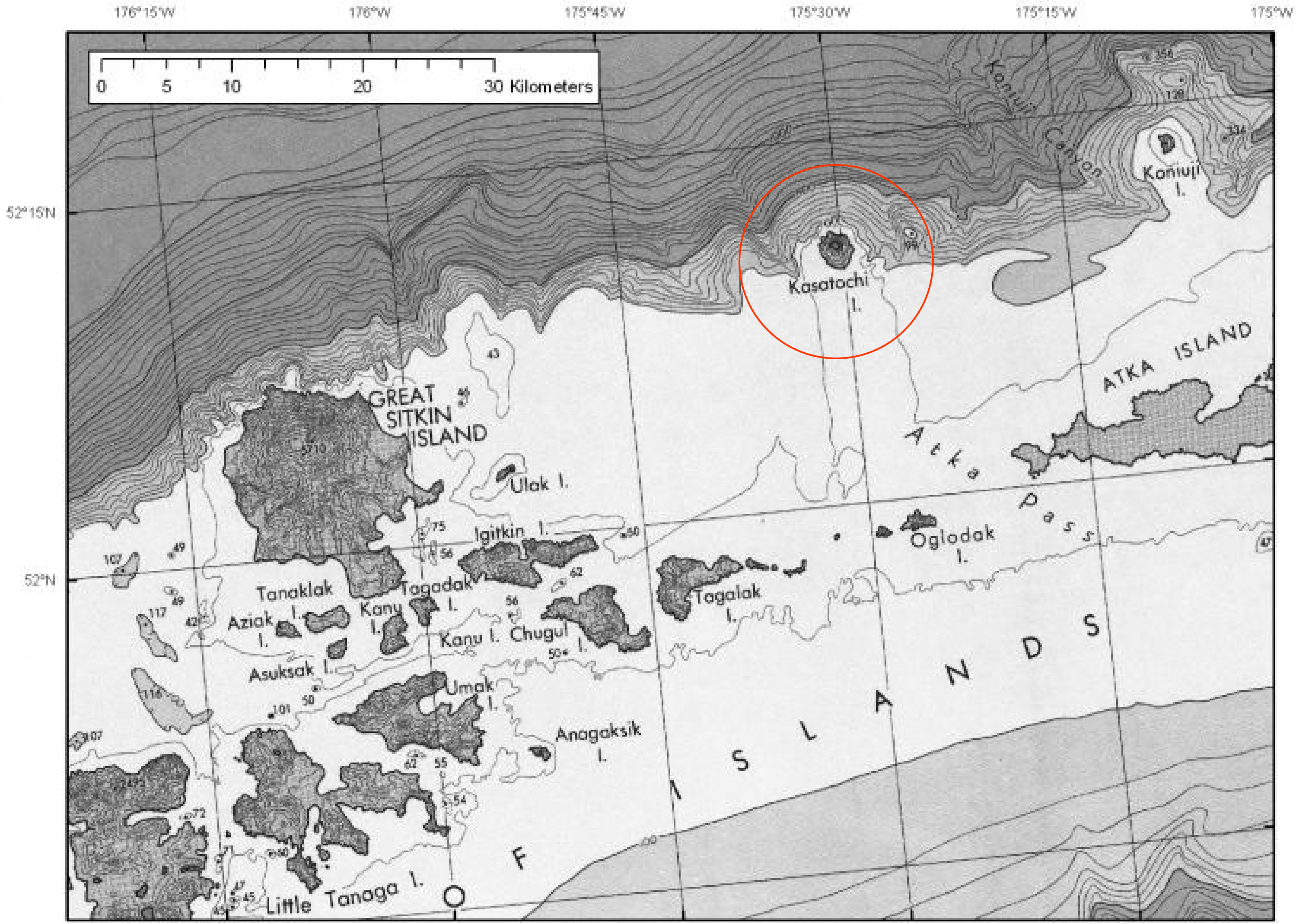
Daniel Rosenfeld

Aerosols Suppressing Precipitation in the Central Sierra: Results of the 2006 Winter Field Campaign

!4 Sep 2006. California Climate Change Research Conference.

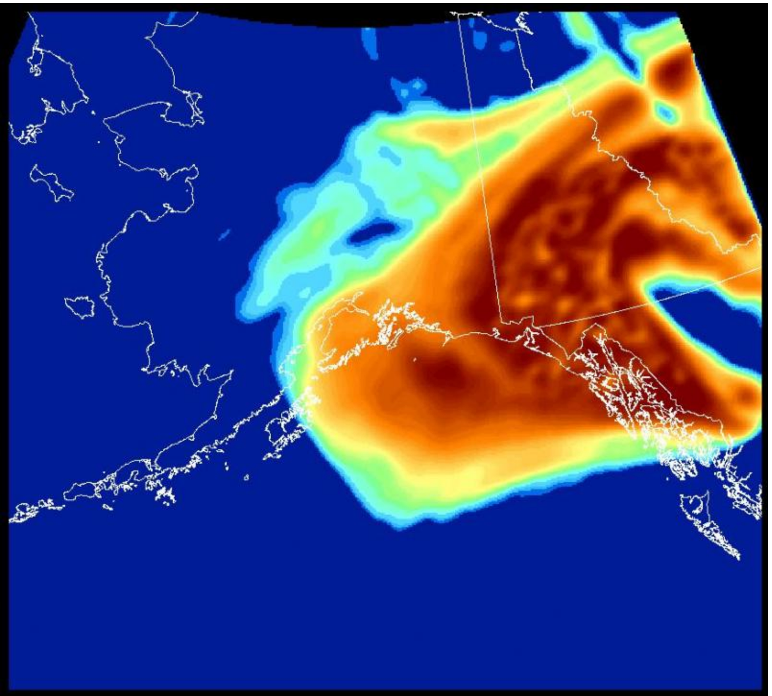
Suppression of Rain and Snow by Industrial and Urban Air Pollution. Science, 2000, March 10, 287, 1793-1796.

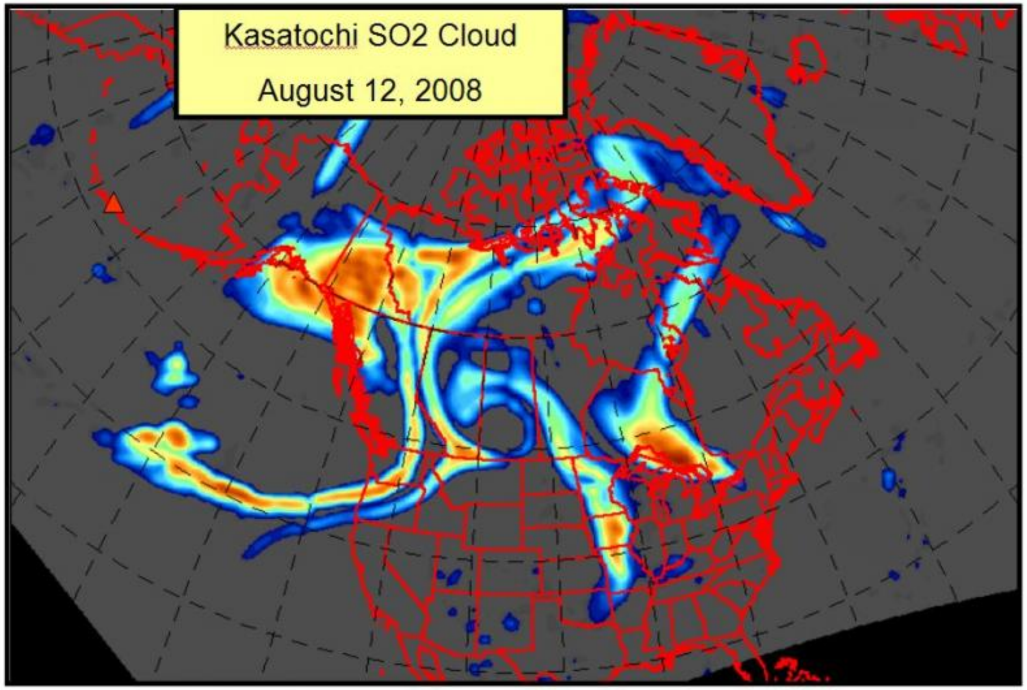
Kasatochi

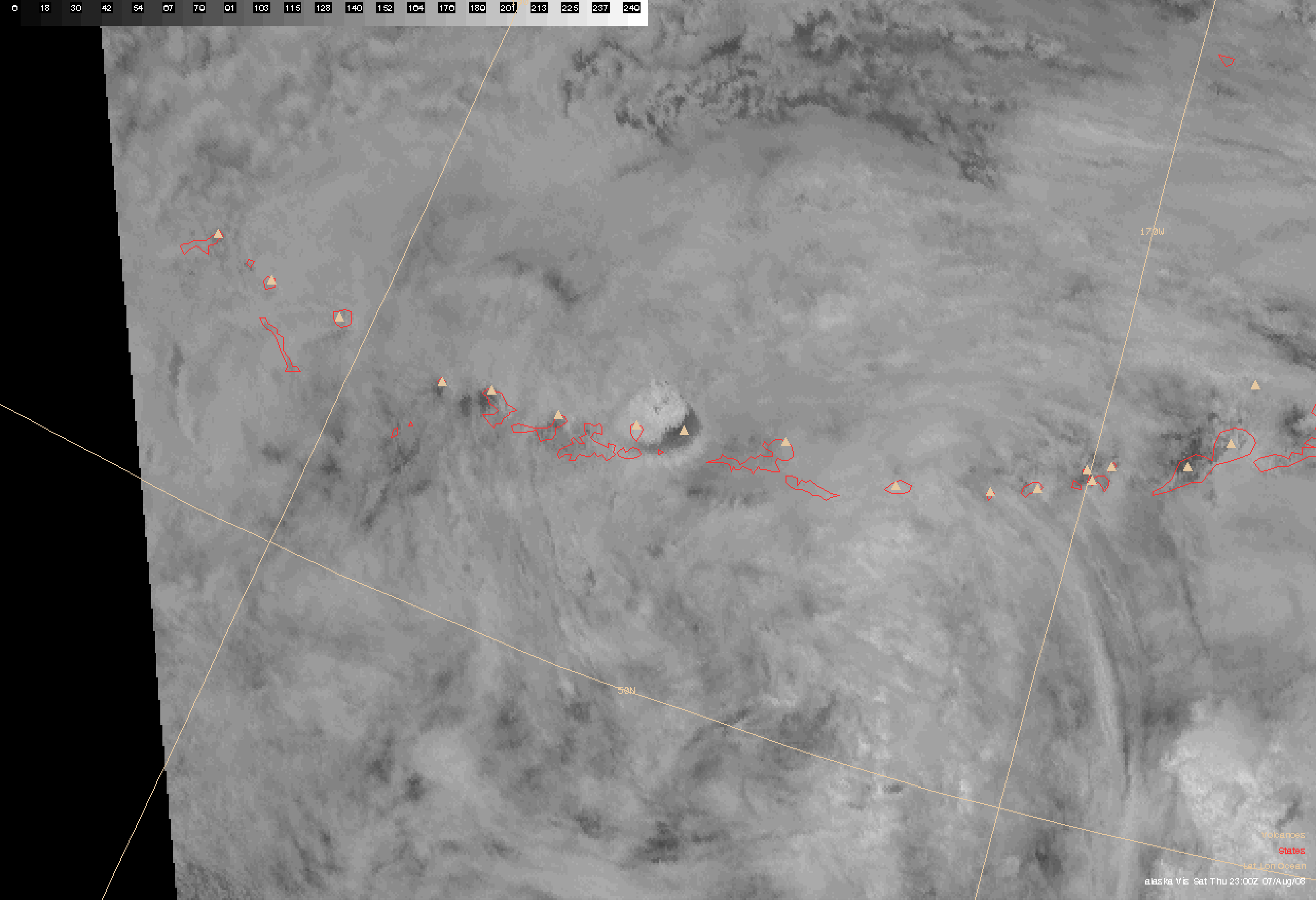


Nichols and Perry, 1966 Bathymetry
Contours in fathoms

Kasatochi 20081023:1500ADT Jerry Morris





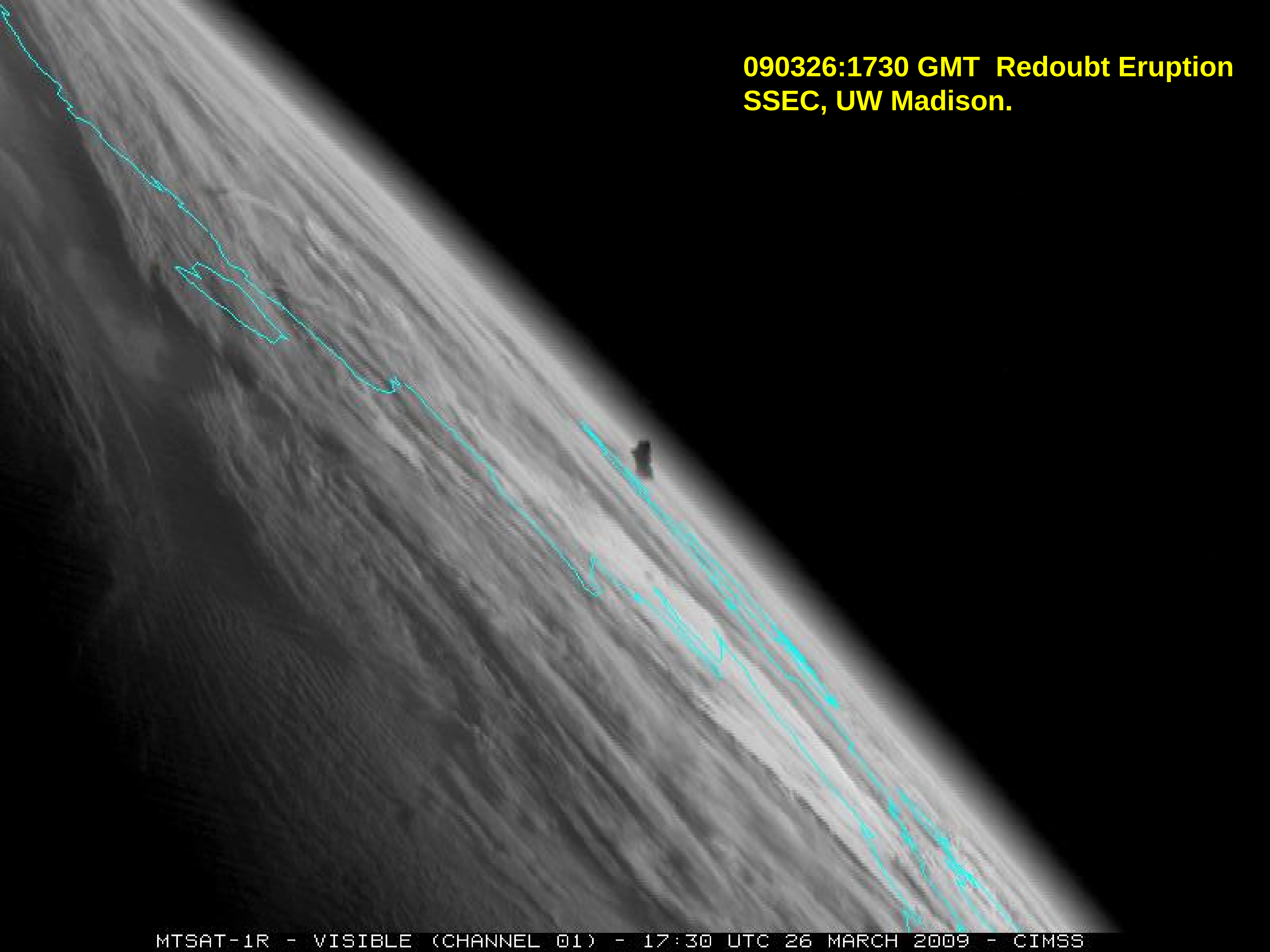


Kasatochi. August 07 eruption. Largest SO_2 input since Pinatubo.

Redoubt. Drift River lahar. 2009 March 23. Game McGimsey.

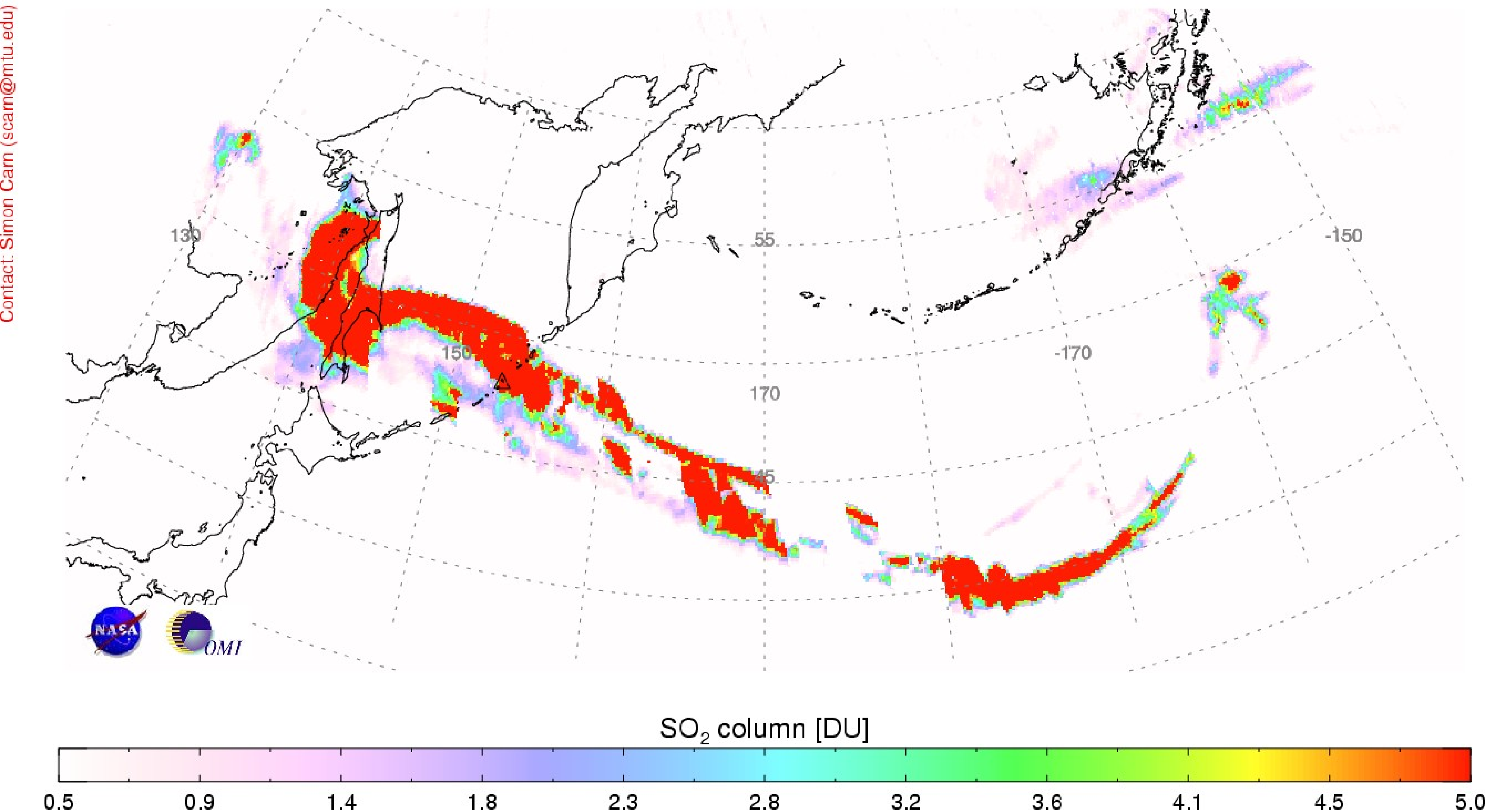
Redoubt. Mouth of Drift River. 2009 March 23. Cyrus Read.

090327:1925 GMT Redoubt Eruption
From Homer AK. Jonathan Dehn.


090326:1730 GMT Redoubt Eruption
SSEC, UW Madison.
MTSAT-1R - VISIBLE (CHANNEL 01) - 17:30 UTC 26 MARCH 2009 - CIMSS

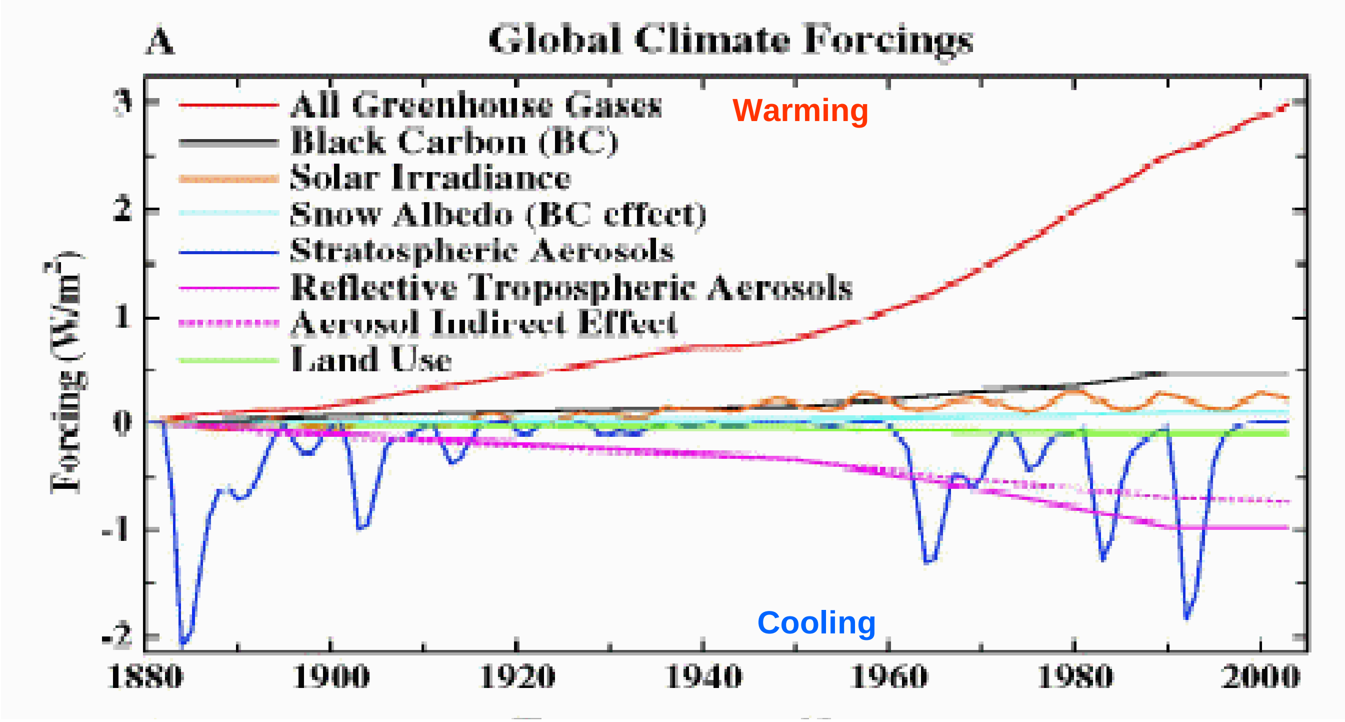
Sarychev Volcano, Kuril Islands, June 12, 2009. International Space Station.

Aura/OMI - Average column for 20090611-20090617



History of Atmospheric Forcings

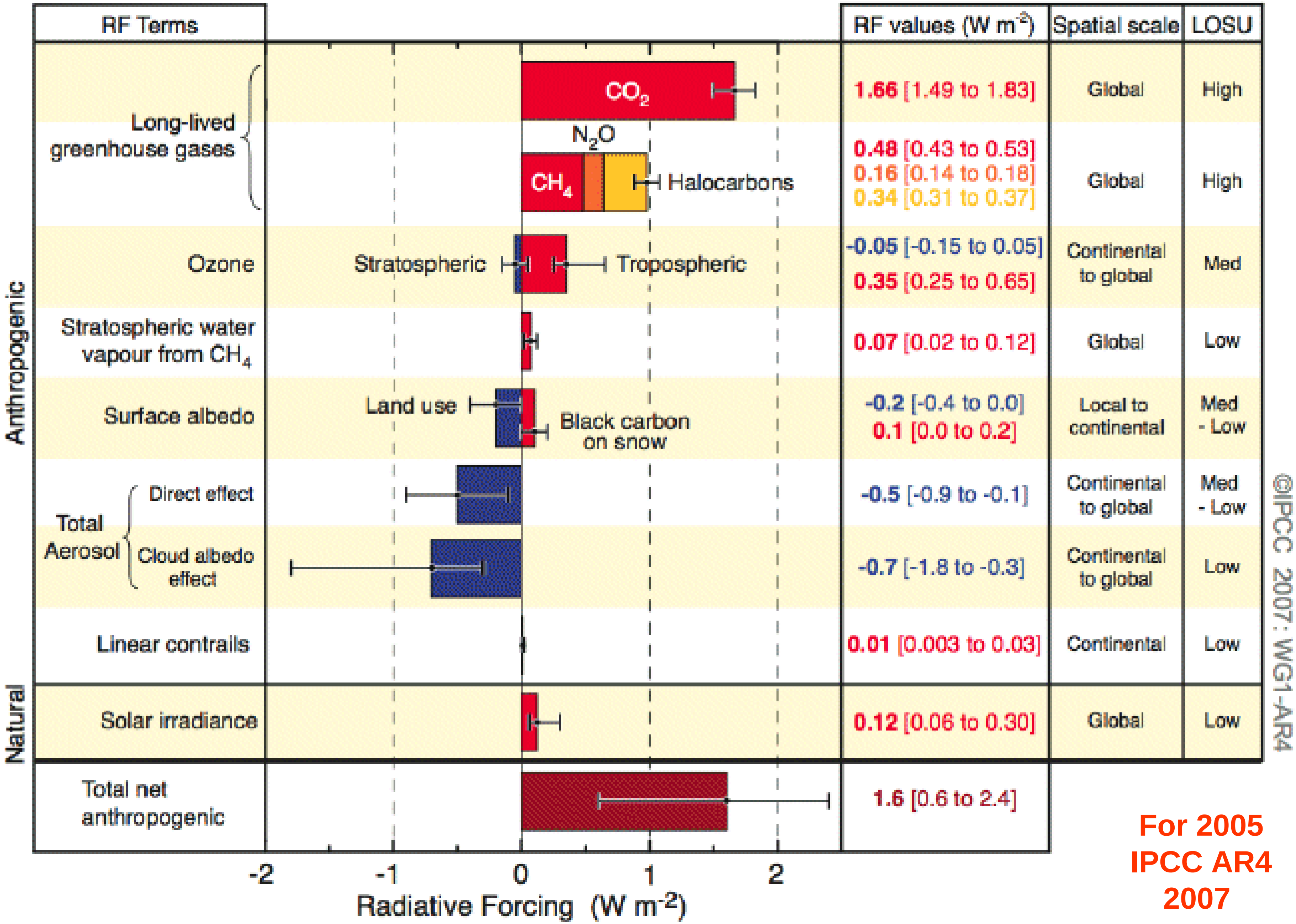
Hansen et al, 2005. Earth's energy imbalance: Confirmation and implications. *Science,* 308, 1431.



1880 1900 1920 1940 1960 1980 2000

Radiative Factors that Control Global Climate

Global Radiative Forcing Components



For 2005
IPCC AR4
2007

IPCC Emissions Scenarios.

(observed trajectory in 2009 is above all of these)

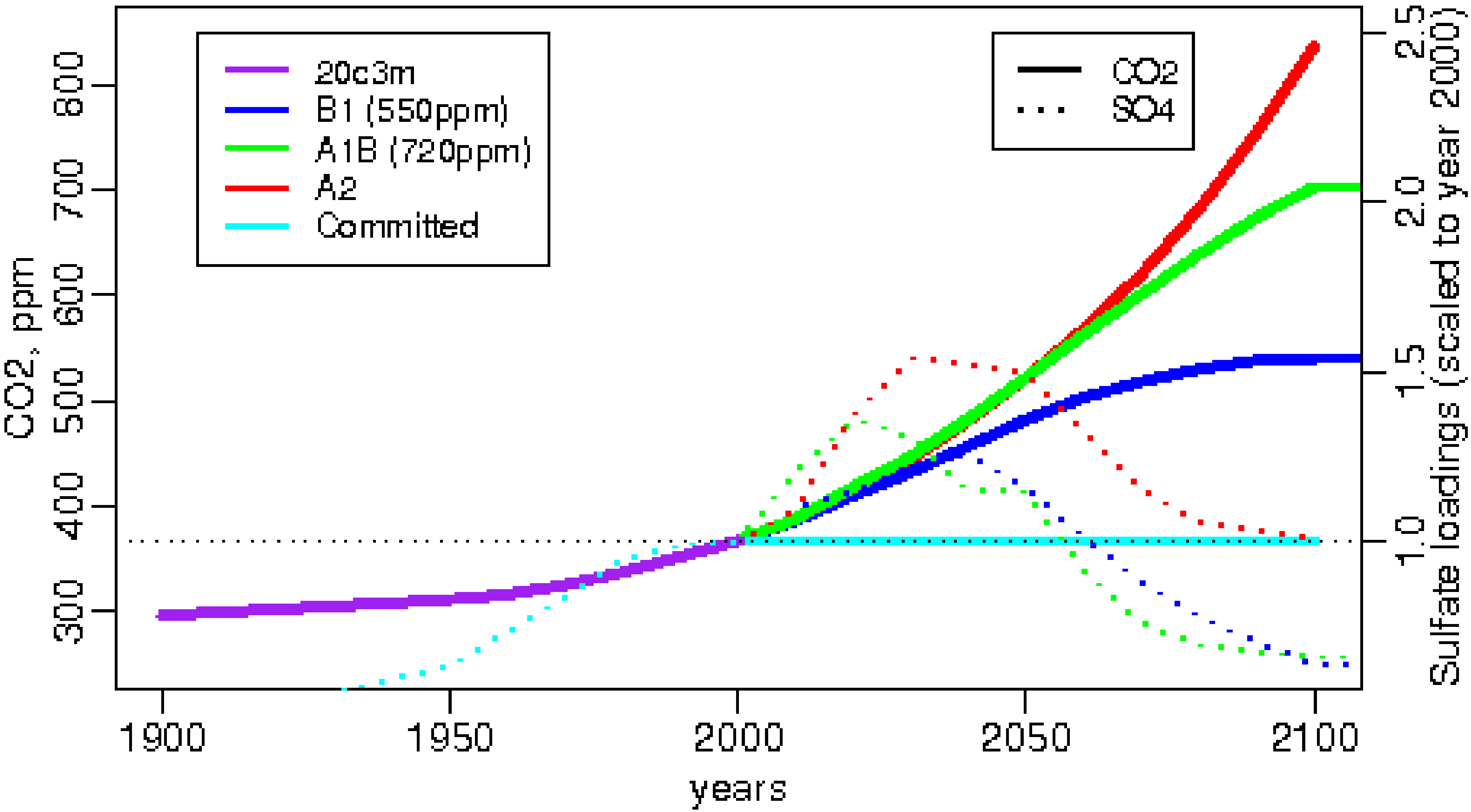
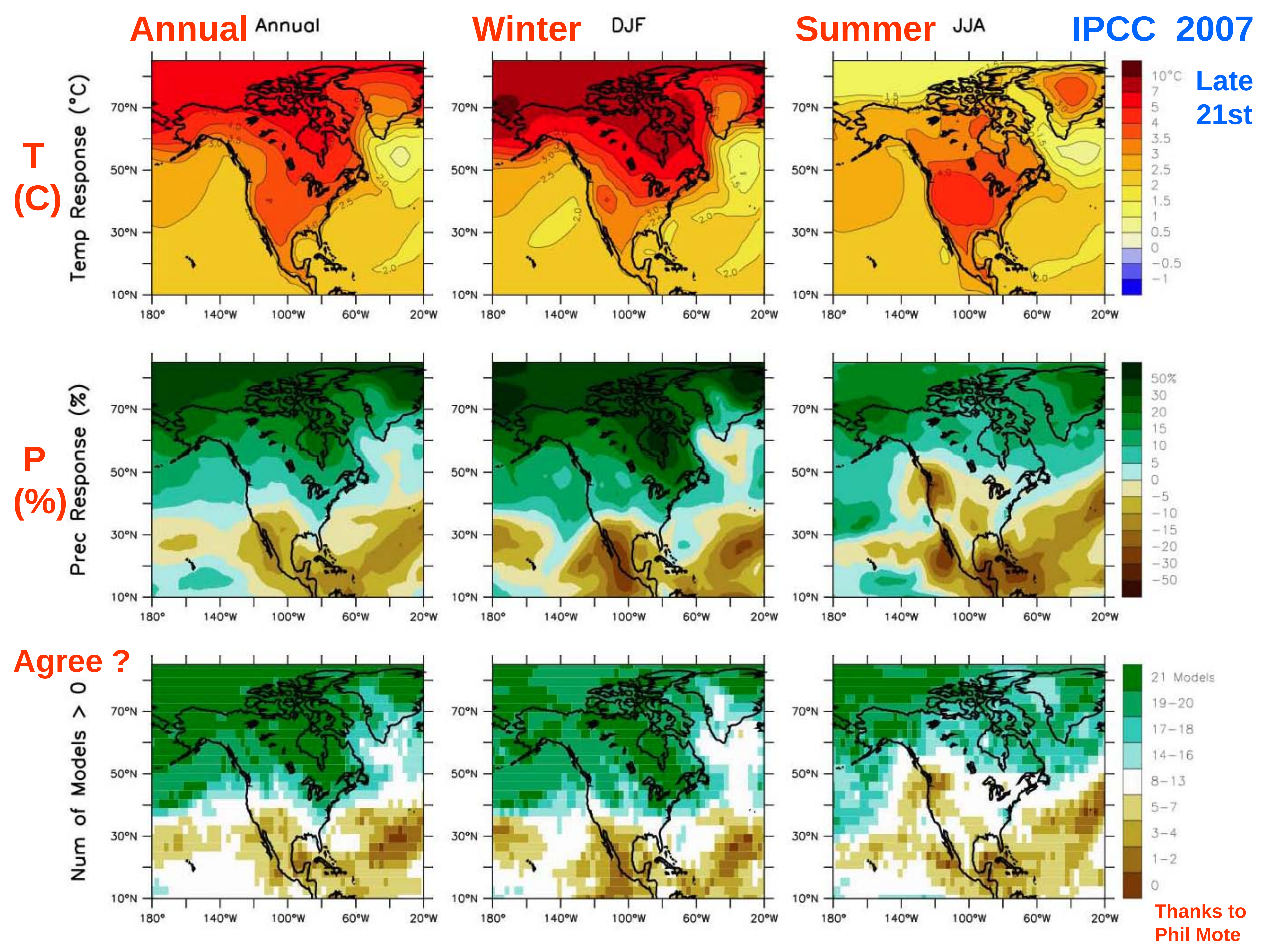
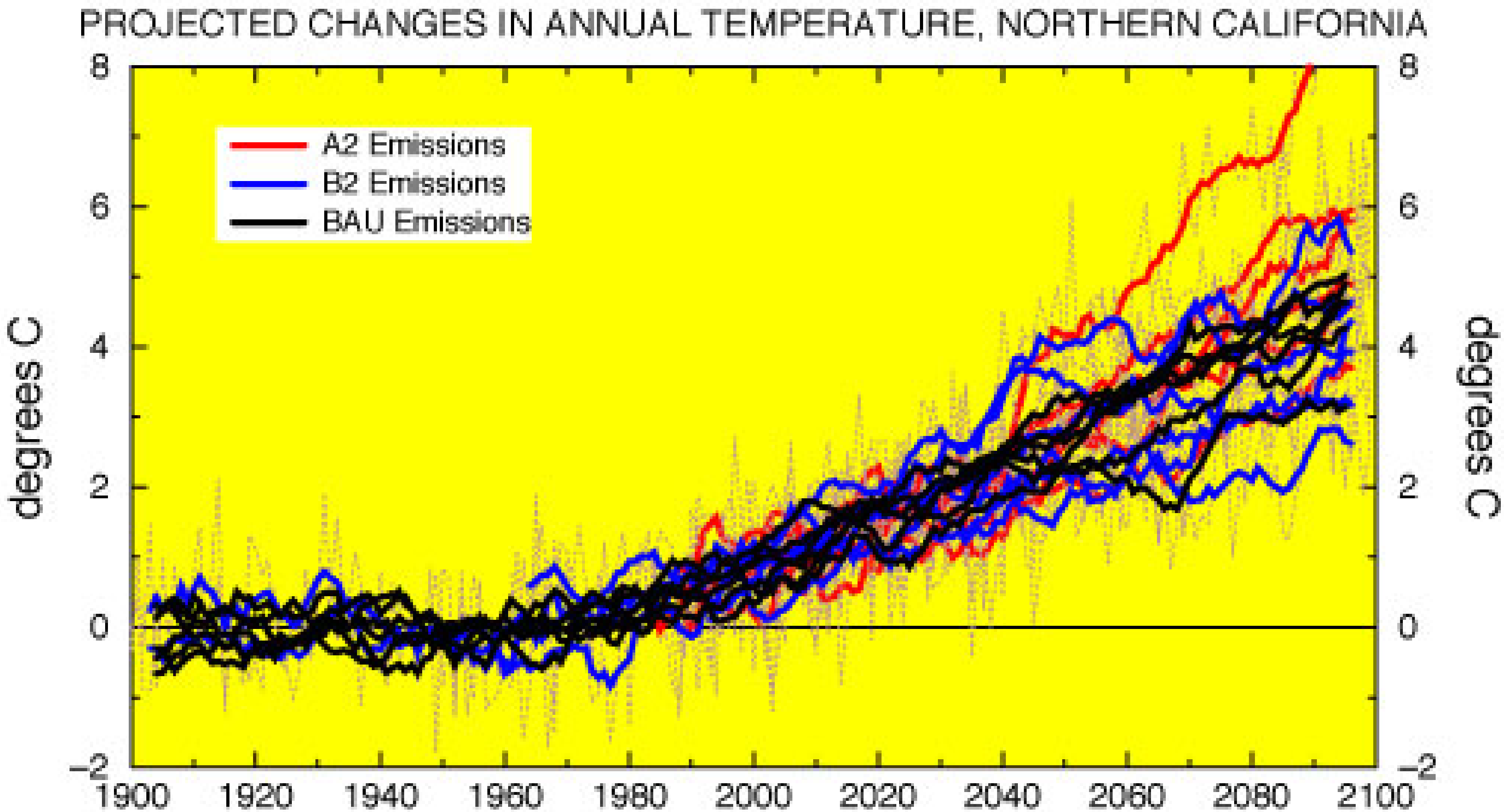


Figure from Environment Canada, 2005.

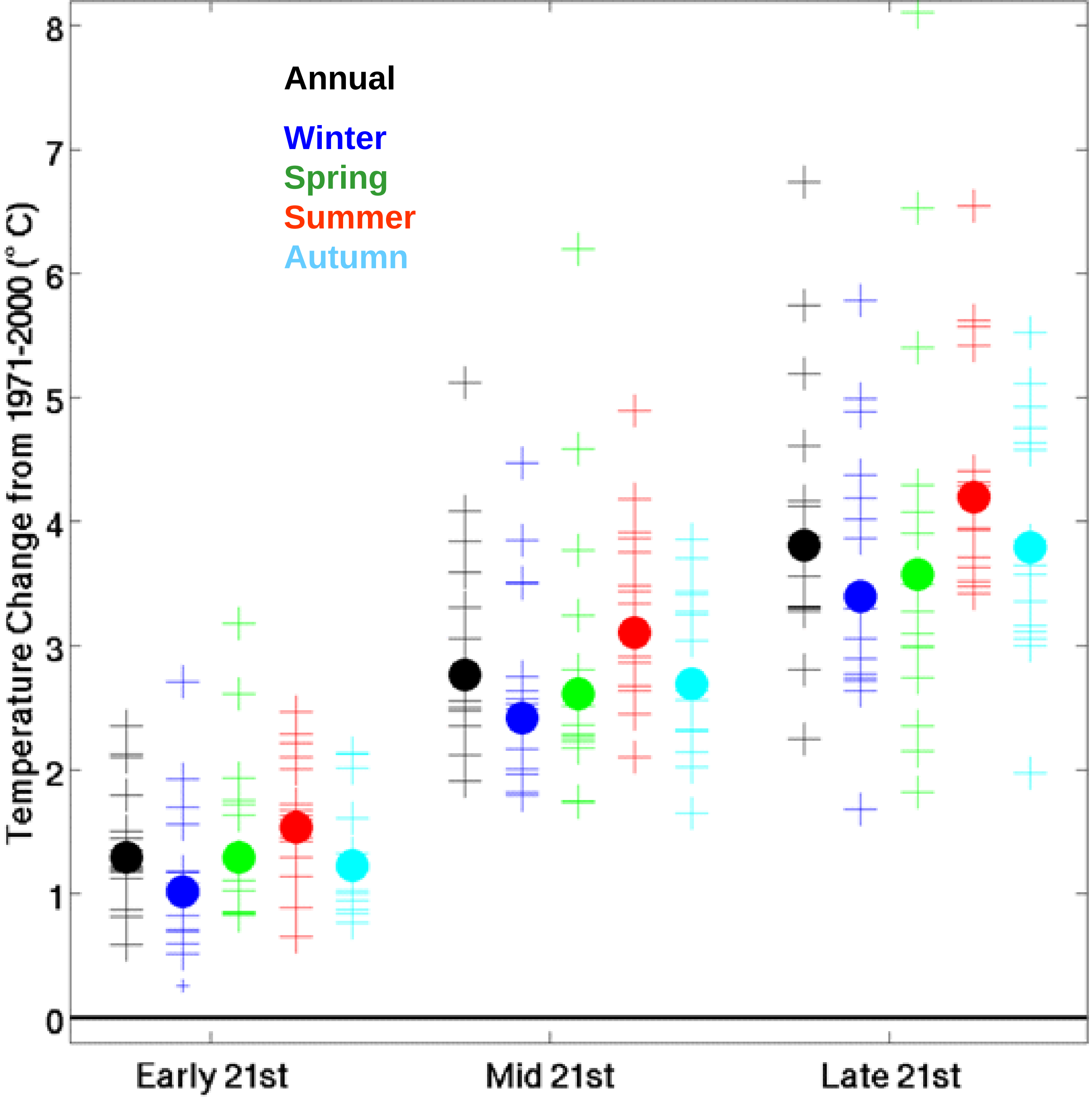


Annual
Annual
Winter
DJF
Summer
JJA
IPCC 2007
Late 21st
T (C)
P (%)
Agree ?
Temp Response (°C)
Prec Response (%)
Num of Models > 0
70°N
50°N
30°N
10°N
180°
140°W
100°W
60°W
20°W
10°C
7
5
4
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
−1
50%
30
20
15
10
5
0
−5
−10
−15
−20
−30
−50
21 Models
19−20
17−18
14−16
8−13
5−7
3−4
1−2
0
Thanks to Phil Mote

Courtesy of Mike Dettinger, USGS / Scripps.



Dettinger MD. 2005. From climate change spaghetti to climate-change distributions for 21st Century California. San Francisco Estuary and Watershed Science. Vol. 3, Issue 1, (March 2005), Article 4. http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art4



East Central Nevada

Projected Temperature Changes (C)

Early 21st
2011-2040

Middle 21st
2041-2070

Late 21st
2071-2100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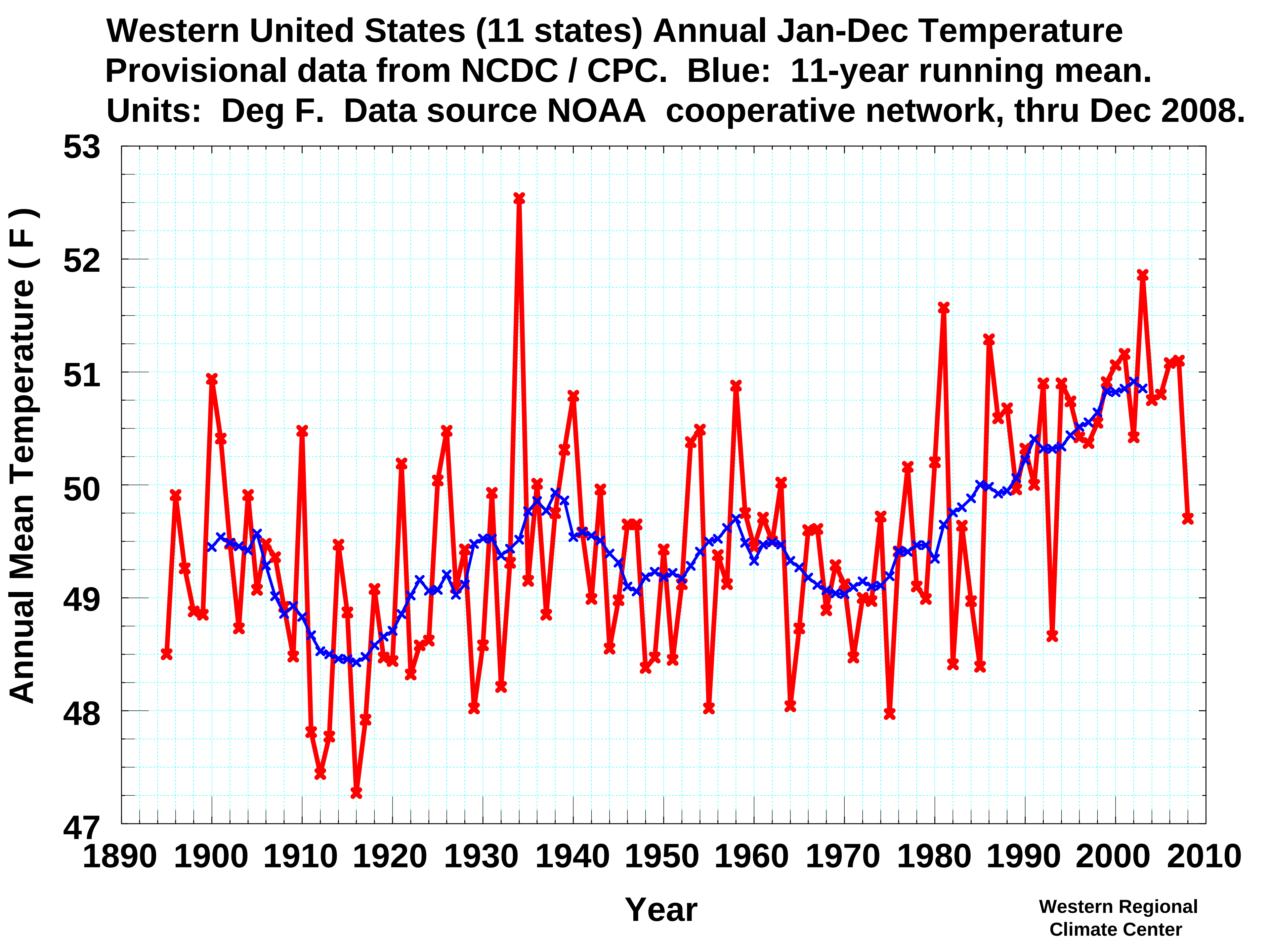
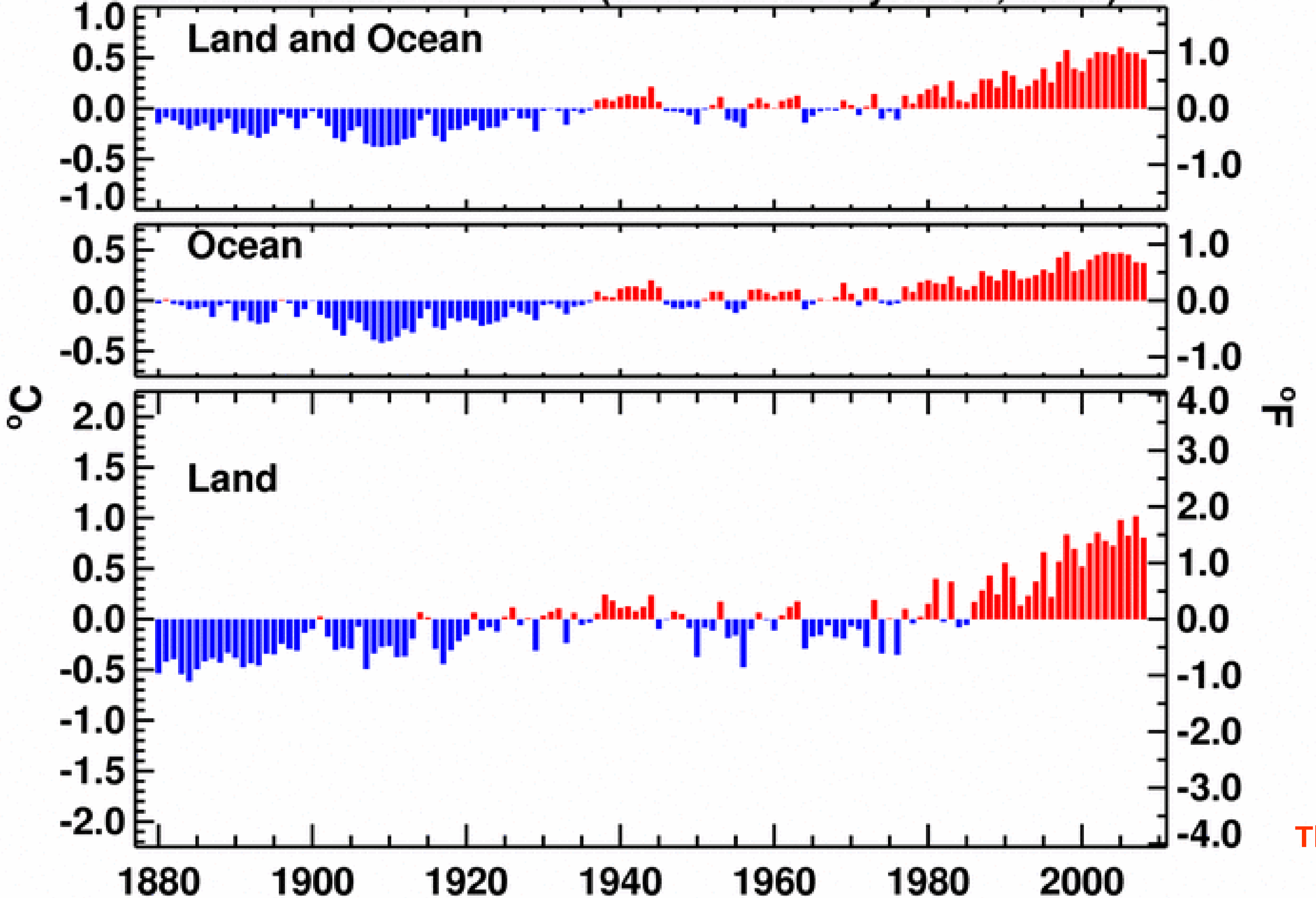

Western United States (11 states) Annual Jan-Dec Temperature
Provisional data from NCDC / CPC. Blue: 11-year running mean.
Units: Deg F. Data source NOAA cooperative network, thru Dec 2008.
Annual Mean Temperature (F)
53
52
51
50
49
48
47
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Western Regional
Climate Center

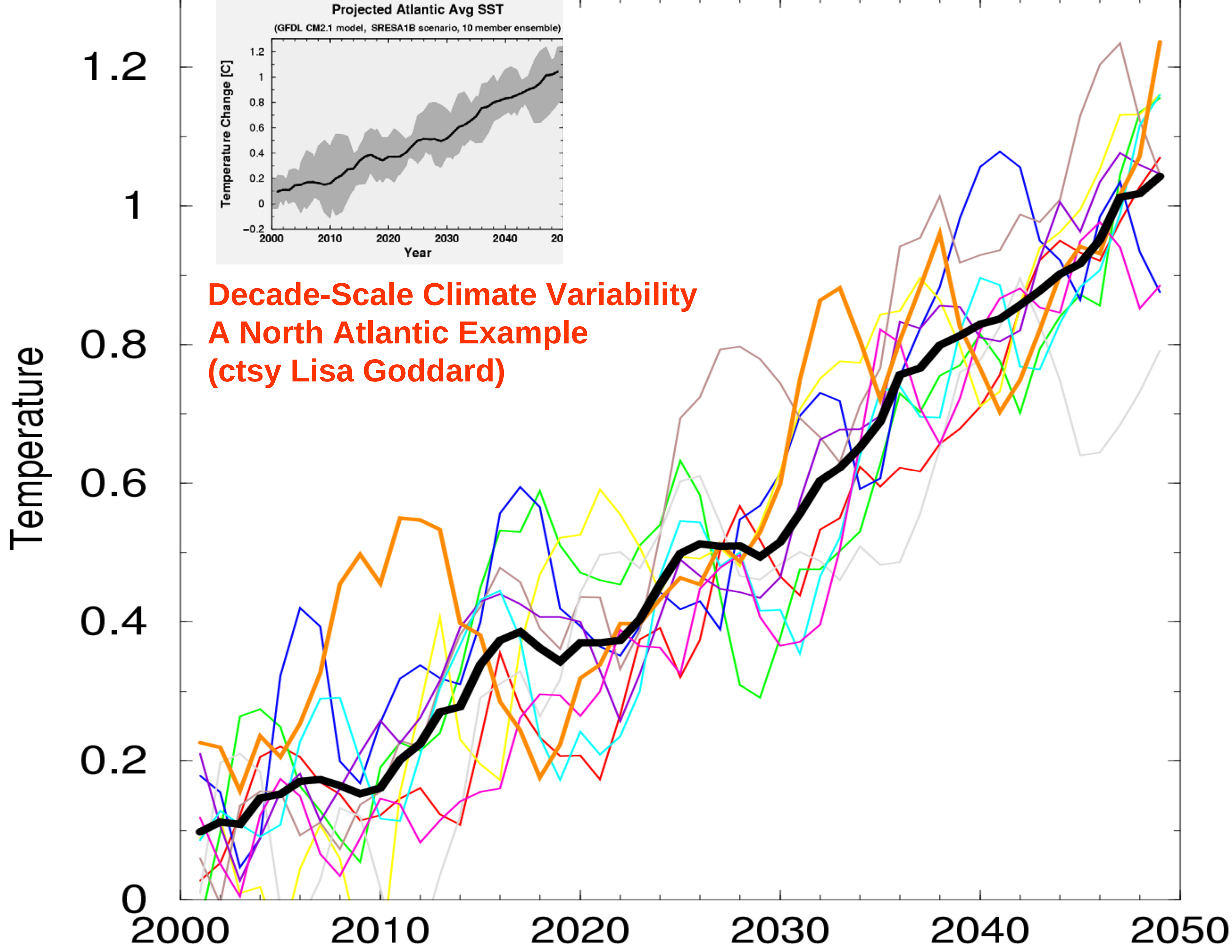
Jan-Dec Global Surface Mean Temp Anomalies

NCDC/NESDIS/NOAA (Smith and Reynolds, 2005)



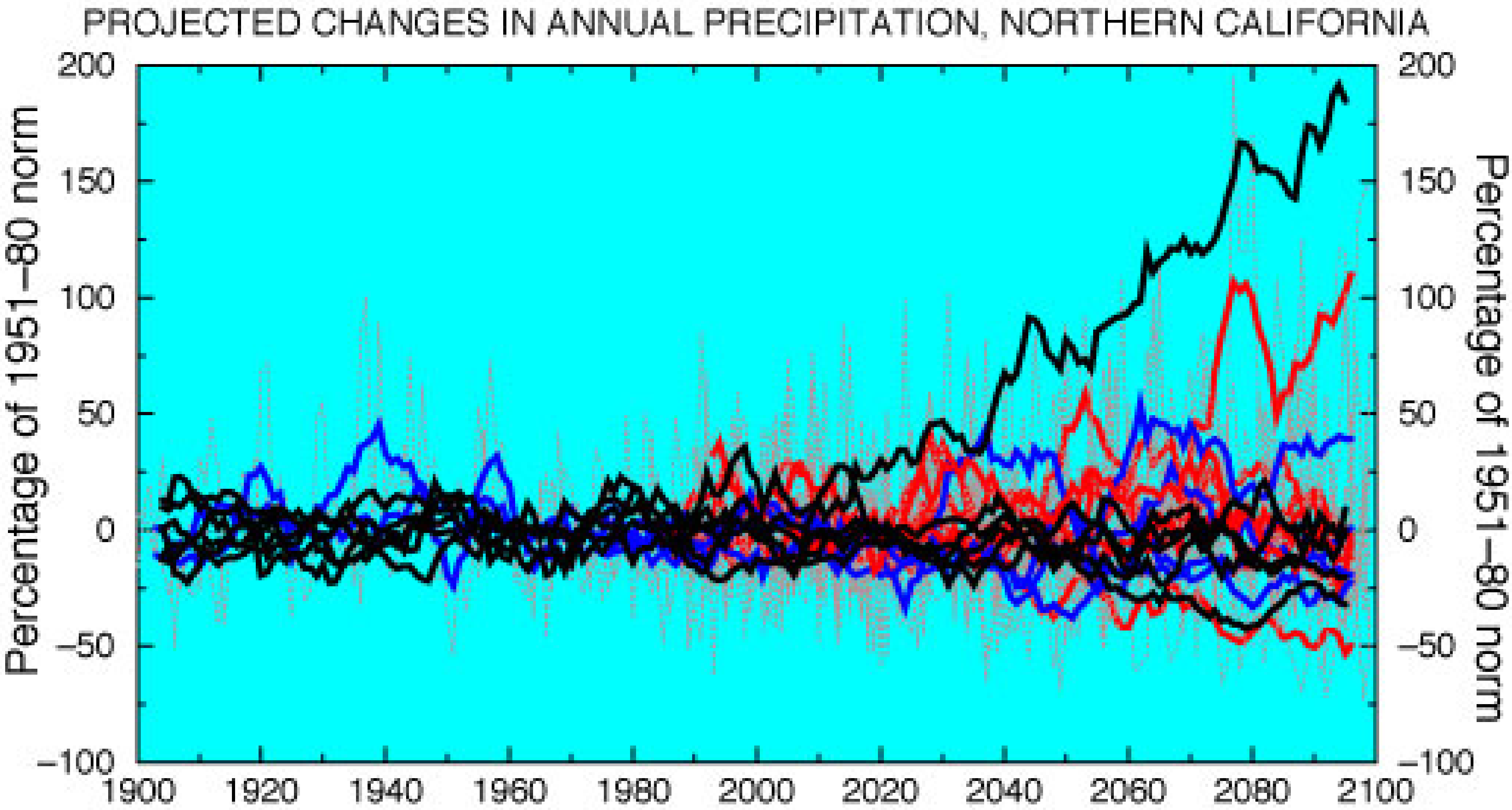
Thru Dec 2008

NOAA National Climatic Data Center



Projected Atlantic Avg SST
(GFDL CM2.1 model, SRESA1B scenario, 10 member ensemble)
Temperature Change [C]
Year
Decade-Scale Climate Variability
A North Atlantic Example
(ctsy Lisa Goddard)
Temperature
1.2
1
0.8
0.6
0.4
0.2
0
2000
2010
2020
2030
2040
2050

Courtesy of Mike Dettinger, USGS / Scripps.



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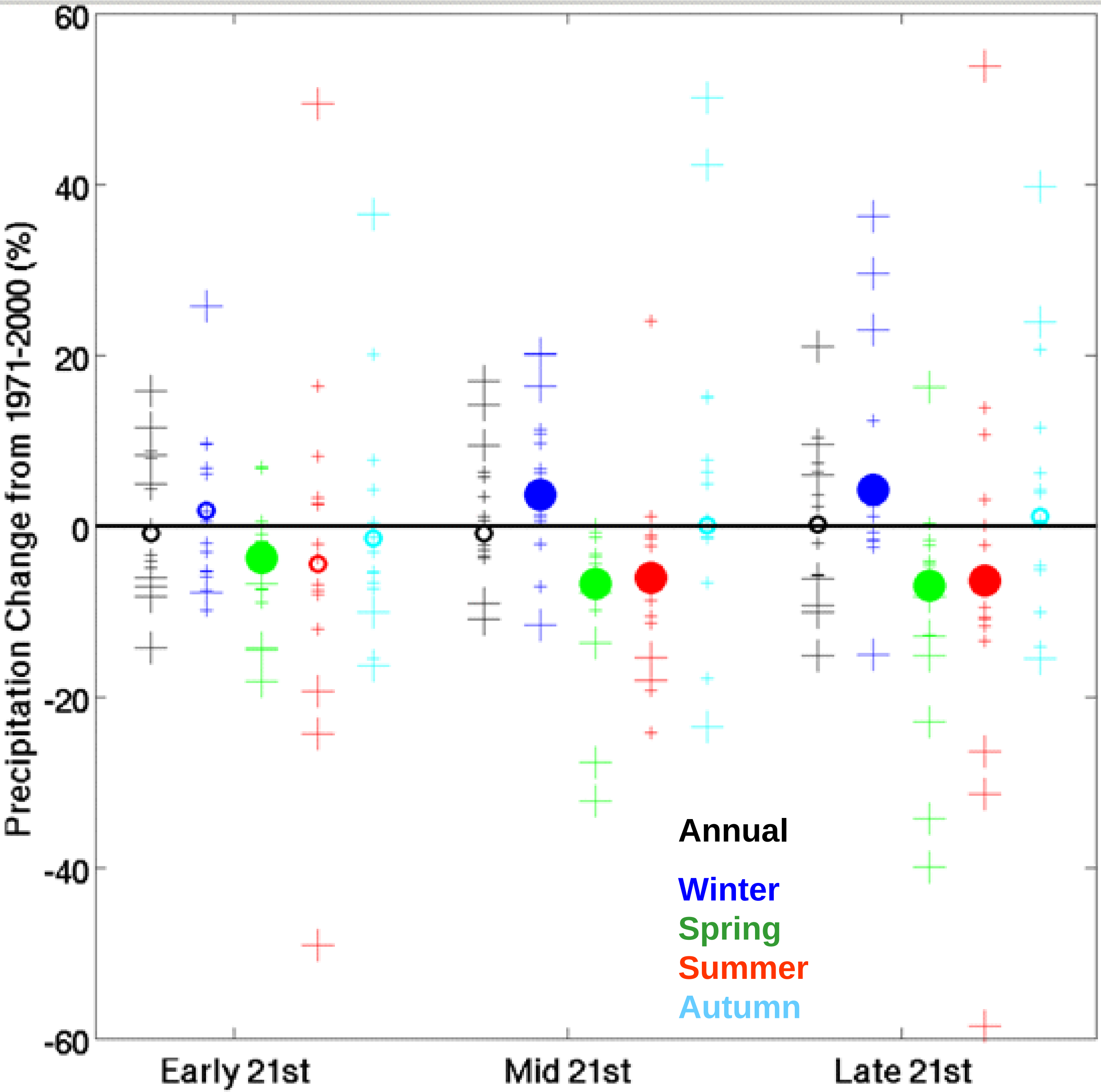


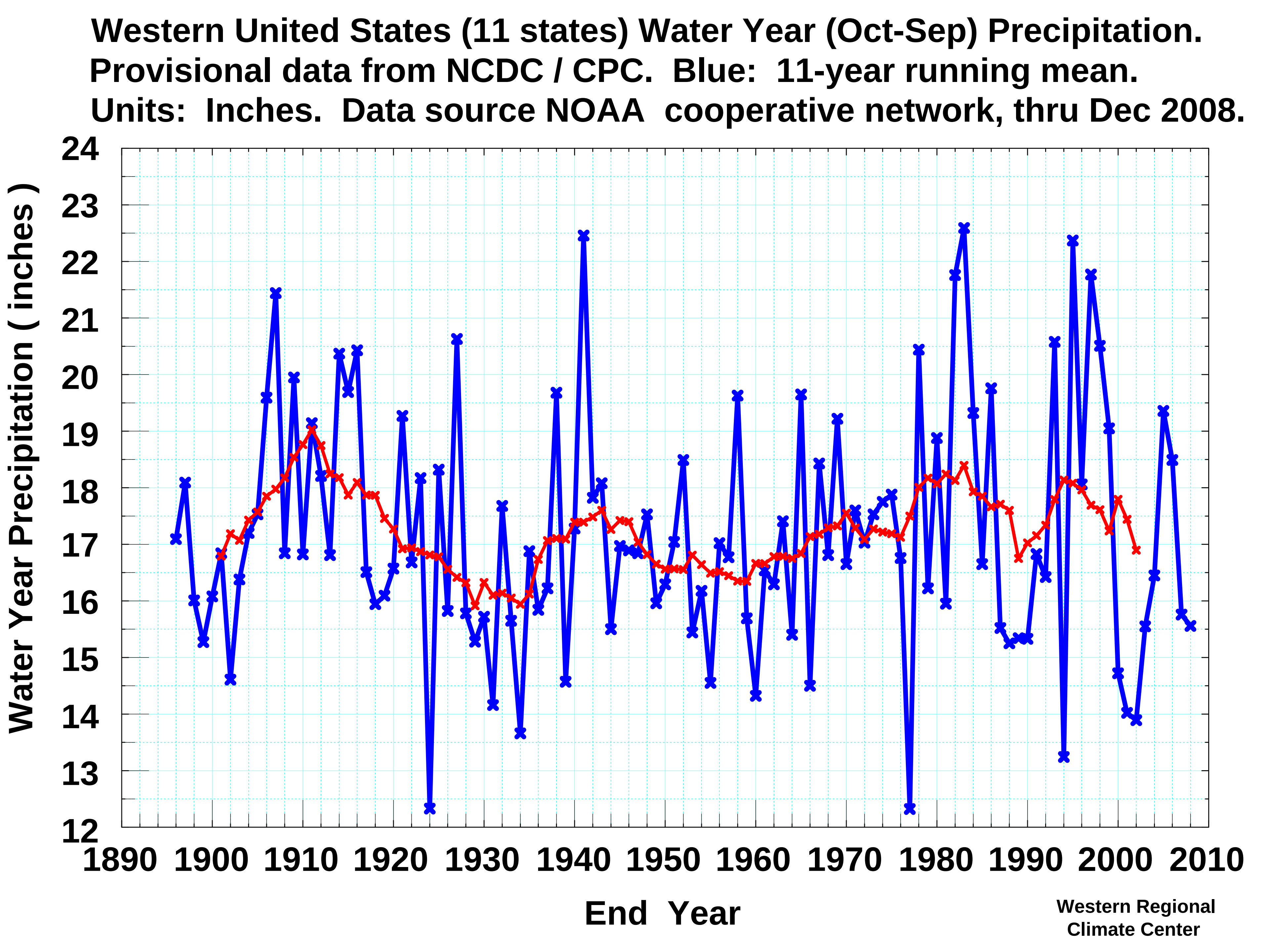
East Central Nevada

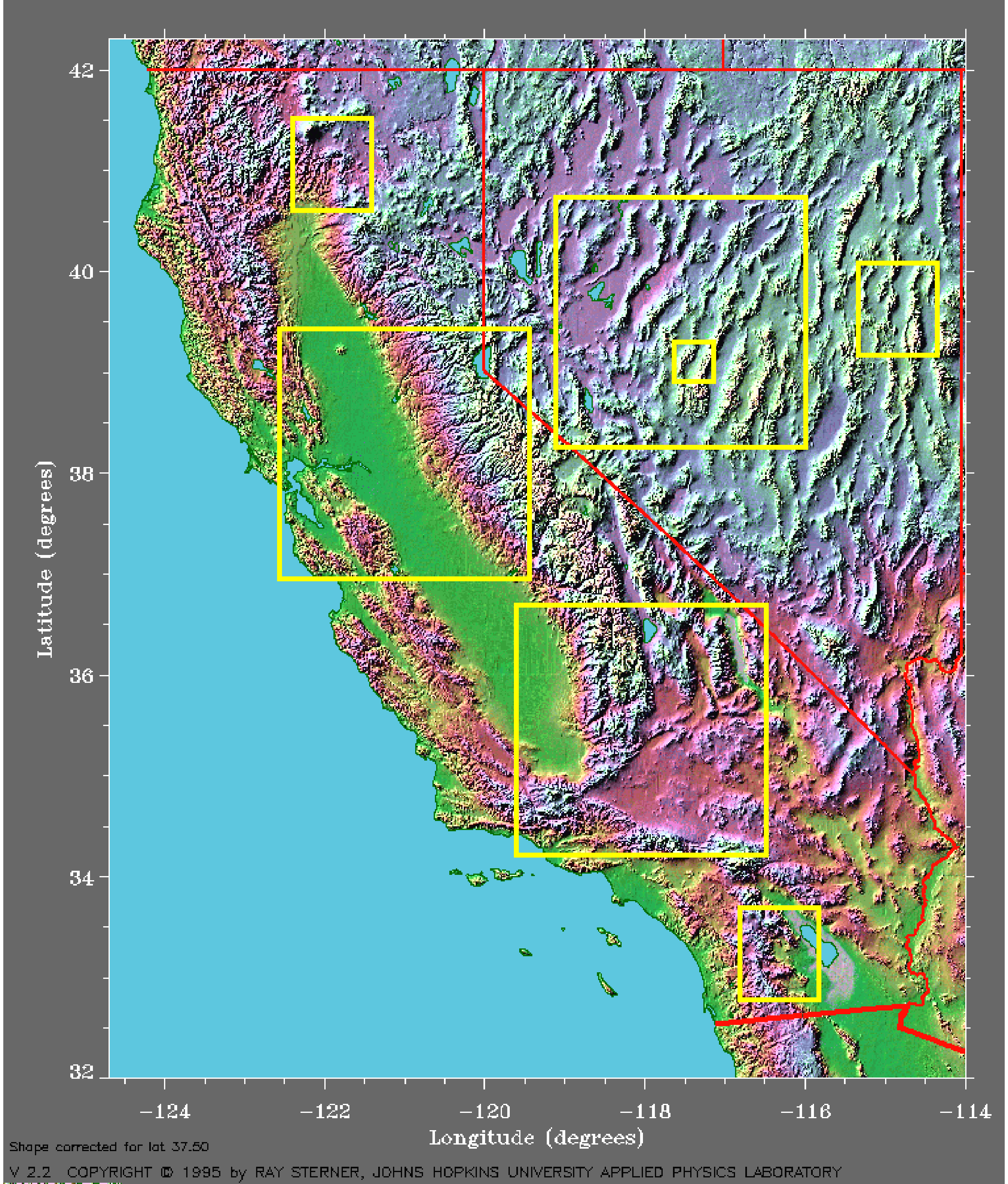
Projected Precipitation Changes (%)

Early 21st 2011-2040

Middle 21st 2041-2070

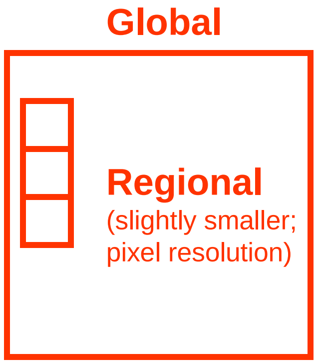
Late 21st 2071-2100

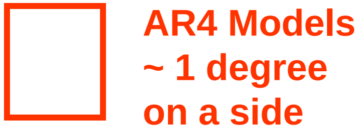

Western United States (11 states) Water Year (Oct-Sep) Precipitation.
Provisional data from NCDC / CPC. Blue: 11-year running mean.
Units: Inches. Data source NOAA cooperative network, thru Dec 2008.
Water Year Precipitation (inches)
24
23
22
21
20
19
18
17
16
15
14
13
12
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
End Year
Western Regional Climate Center



Grid resolution:

Global Climate Model and Reanalysis





Desired Resolution

About 1 km

.


March 10, 2004
70” / 1800 mm
55” / 1400 mm
12” / 300 mm
7.5” / 170 mm

Mapping New Terrain

Climate Change and America's West

Anticipating Challenges to Western Mountain Ecosystems and Resources

The Consortium for Integrated Climate Research in
Western Mountains
(CIRMOUNT)

July 2006

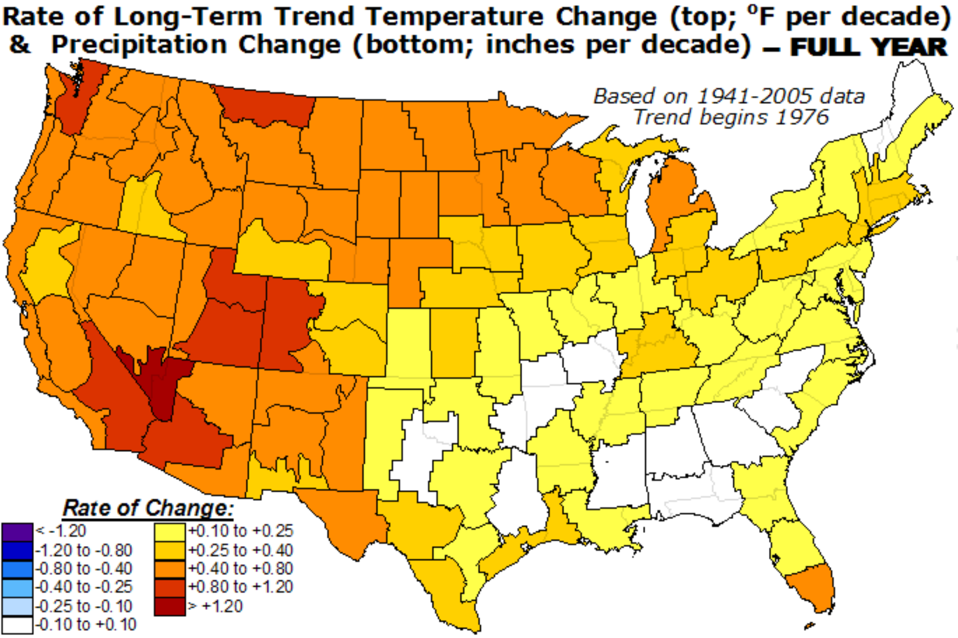

20 February 2007

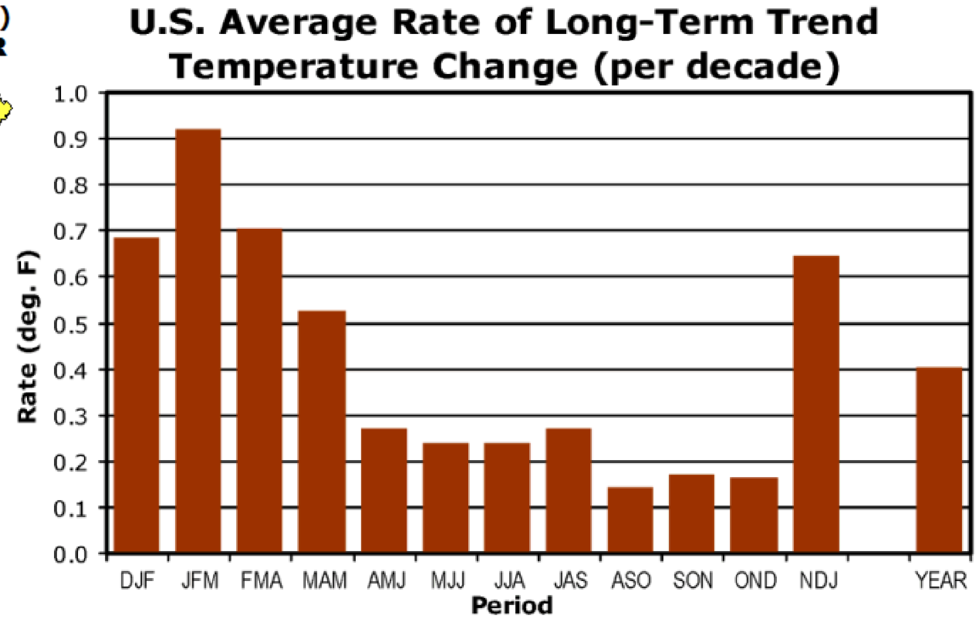

20 February 2007

White Mtn Summit, 14246 ft
Reconfigured July 2004

Western United States Warming Climate Evidence

1. Warming - thermometers (NOAA coop surface data network)
2. Warming - thermometers (NOAA upper air data network)
3. Warming - thermometers (subsurface, western boreholes)
4. Snowpack decrease in spring months (Snotel network)
5. More rain / less snow in winter months (NOAA coop network)
6. Earlier snowmelt runoff pulse (date shift, USGS stream gage network)
7. Earlier blooming of lilacs and honeysuckles (phenology networks)
8. Mountain glacier recession and mass loss
9. Upward movement of plant / animal habitat zones
10. Warmer river and lake temperatures



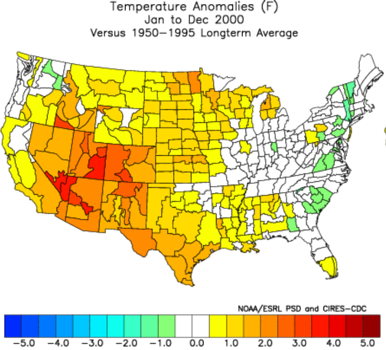


Winter Spring Summer Autumn Annual

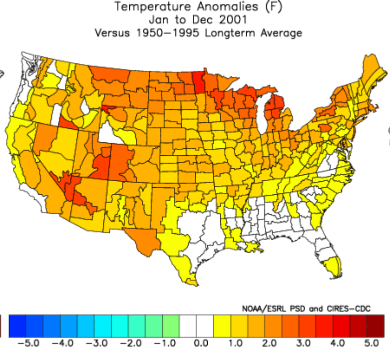
Annual Temperature Trend 1976 - 2005

National Temperature Trend by Season

The Last 30 Years



2000



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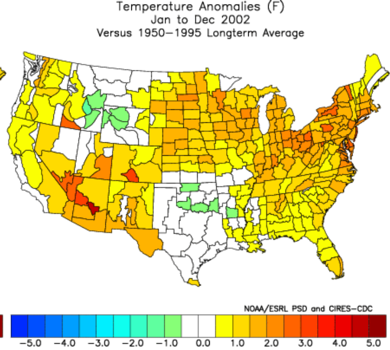

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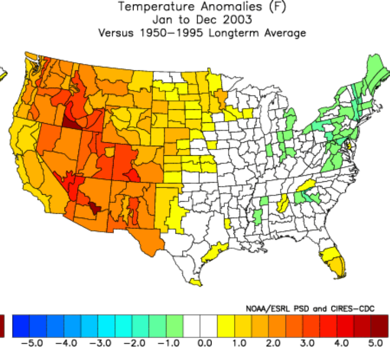

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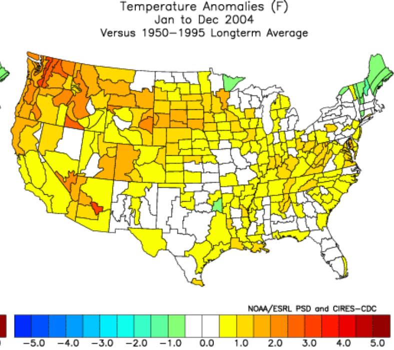

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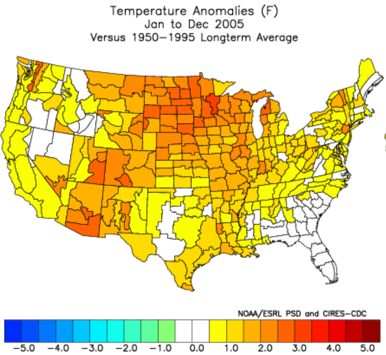
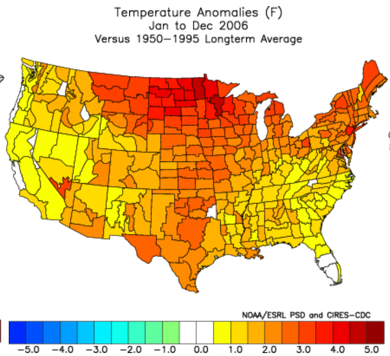


2005



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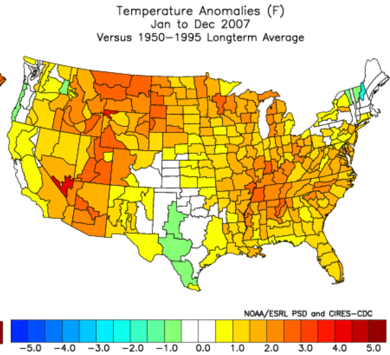

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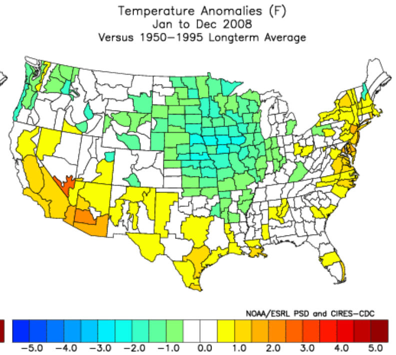
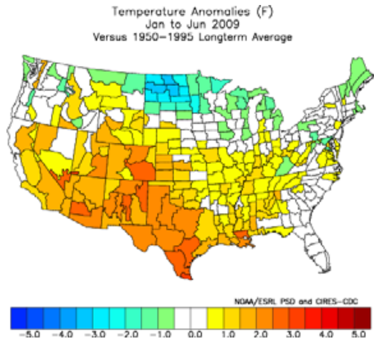


2008

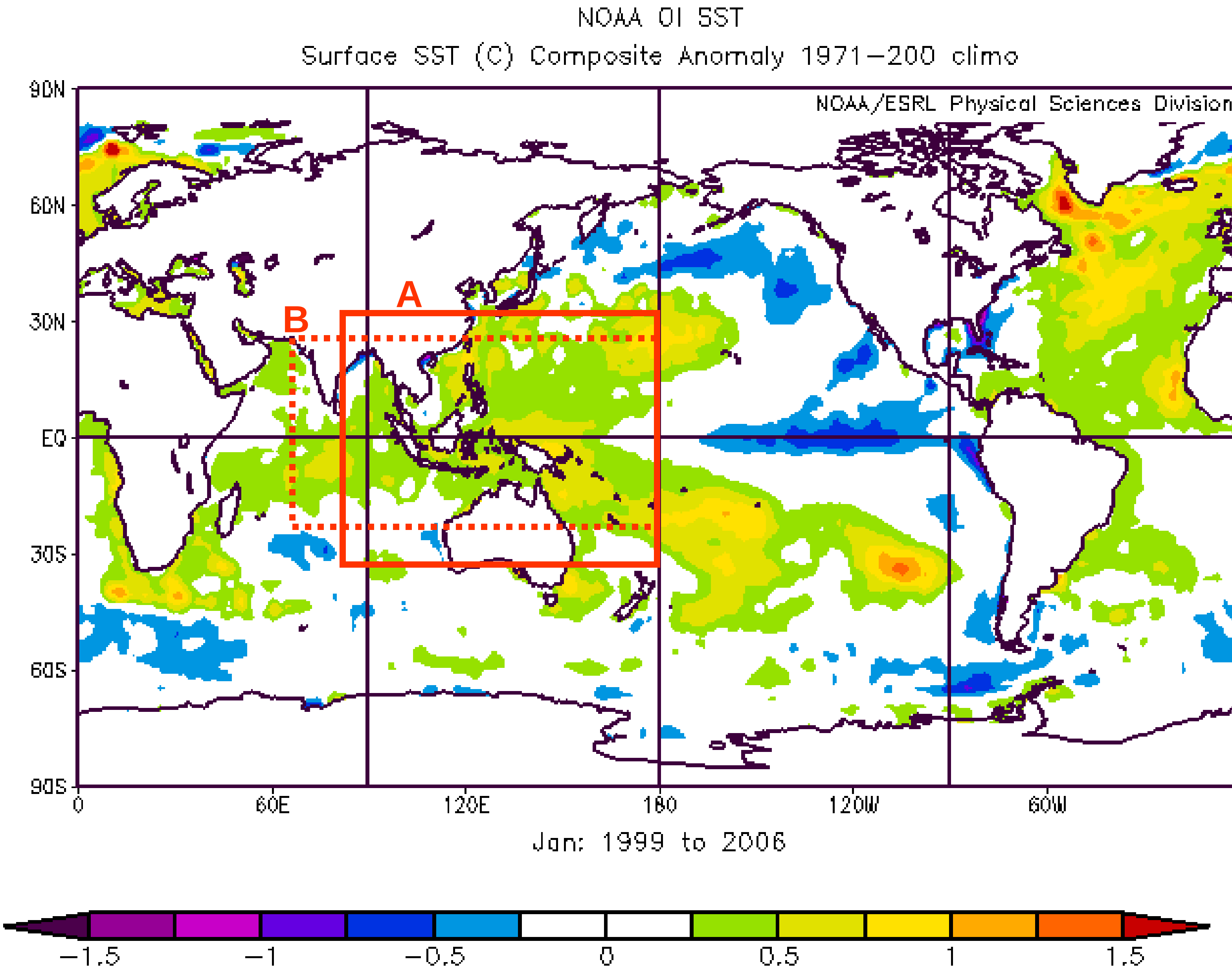


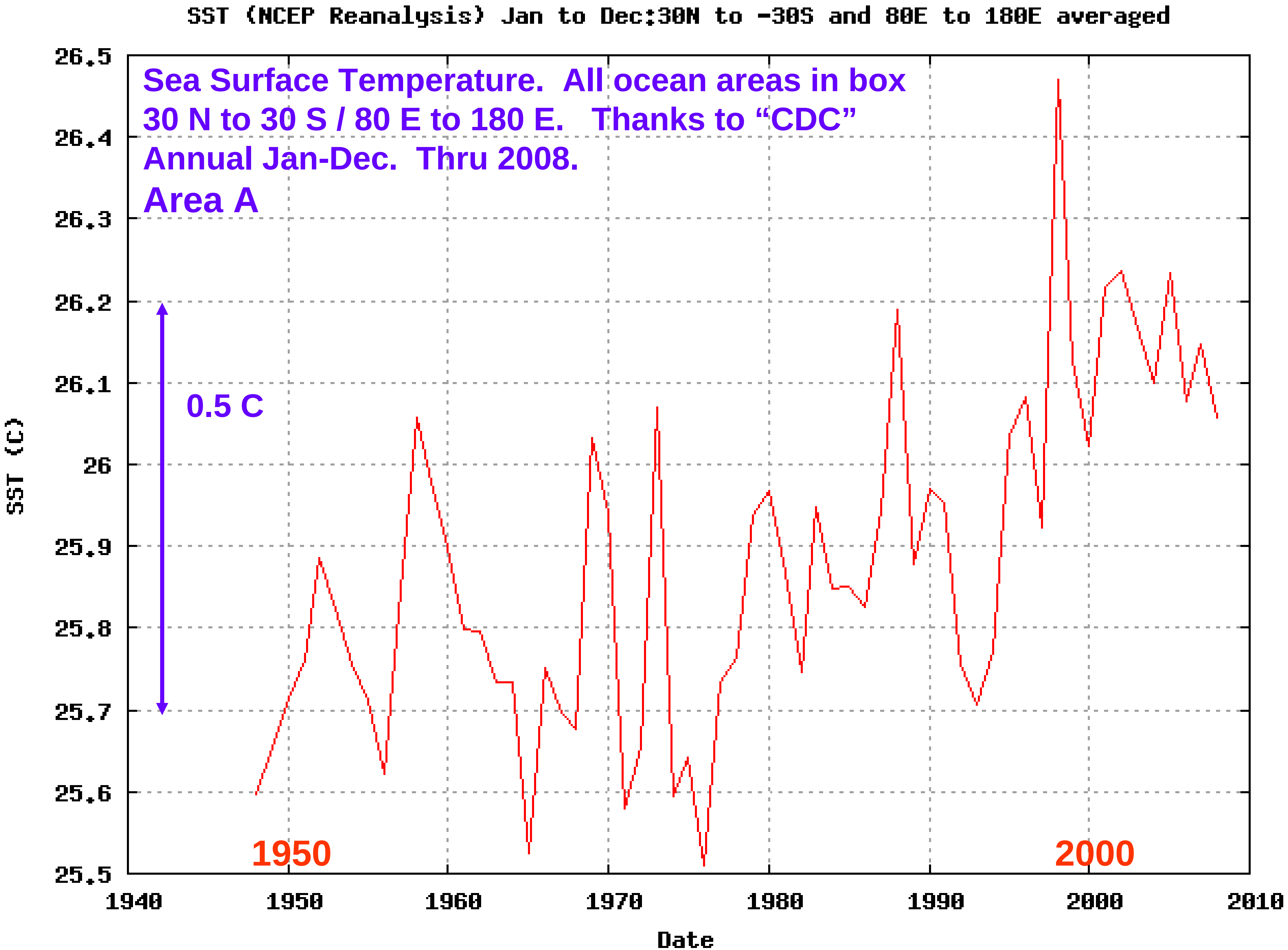
2009 (Jun)

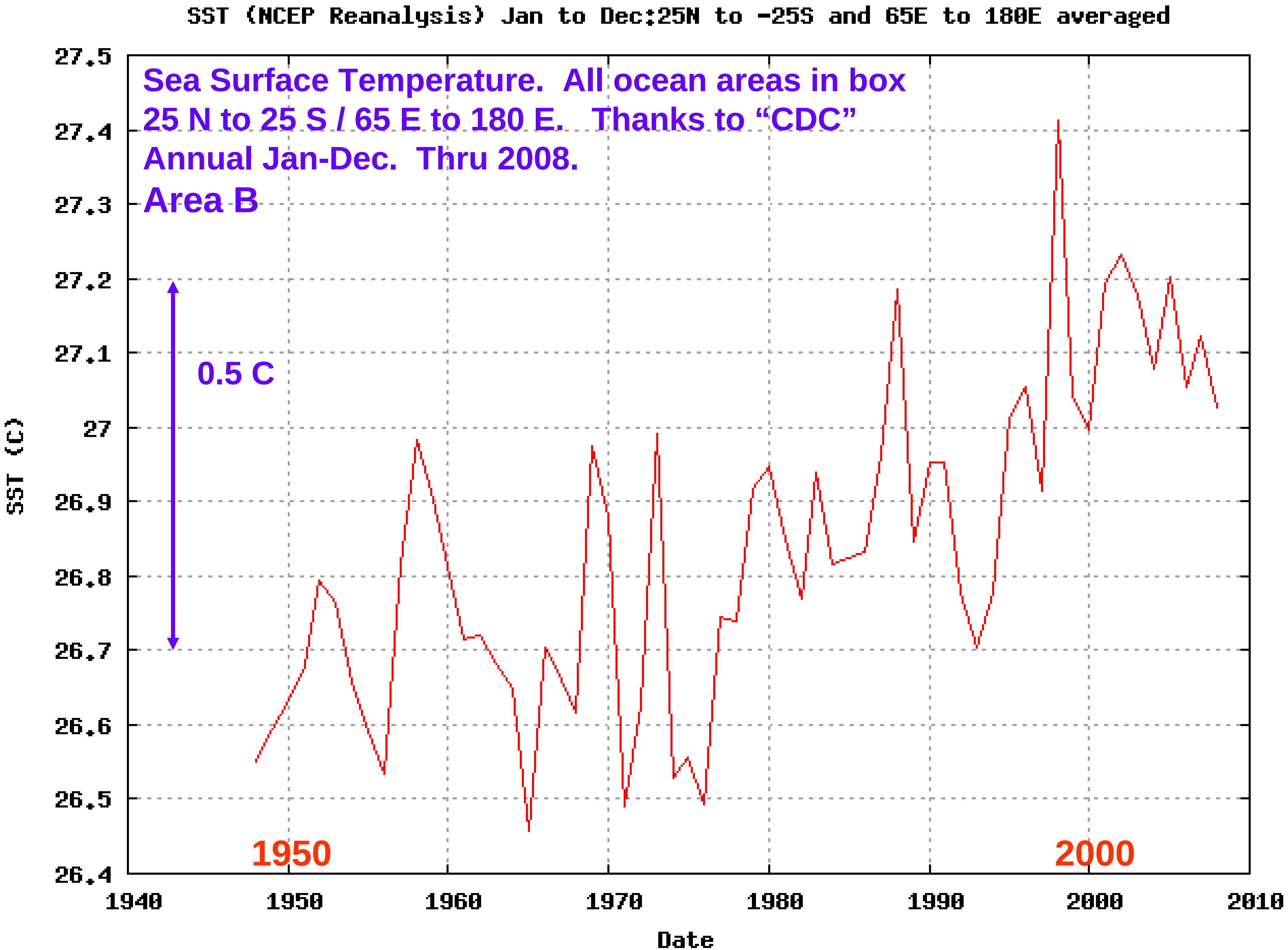
United States Annual Temperature Departure from 1950-1995 Mean

NOAA Divisional Data, Western Regional Climate Center, Plotted by ESRL PSD

SST Departure from Climatology, Annual Jan-Dec, for 8 years 1999-2006.

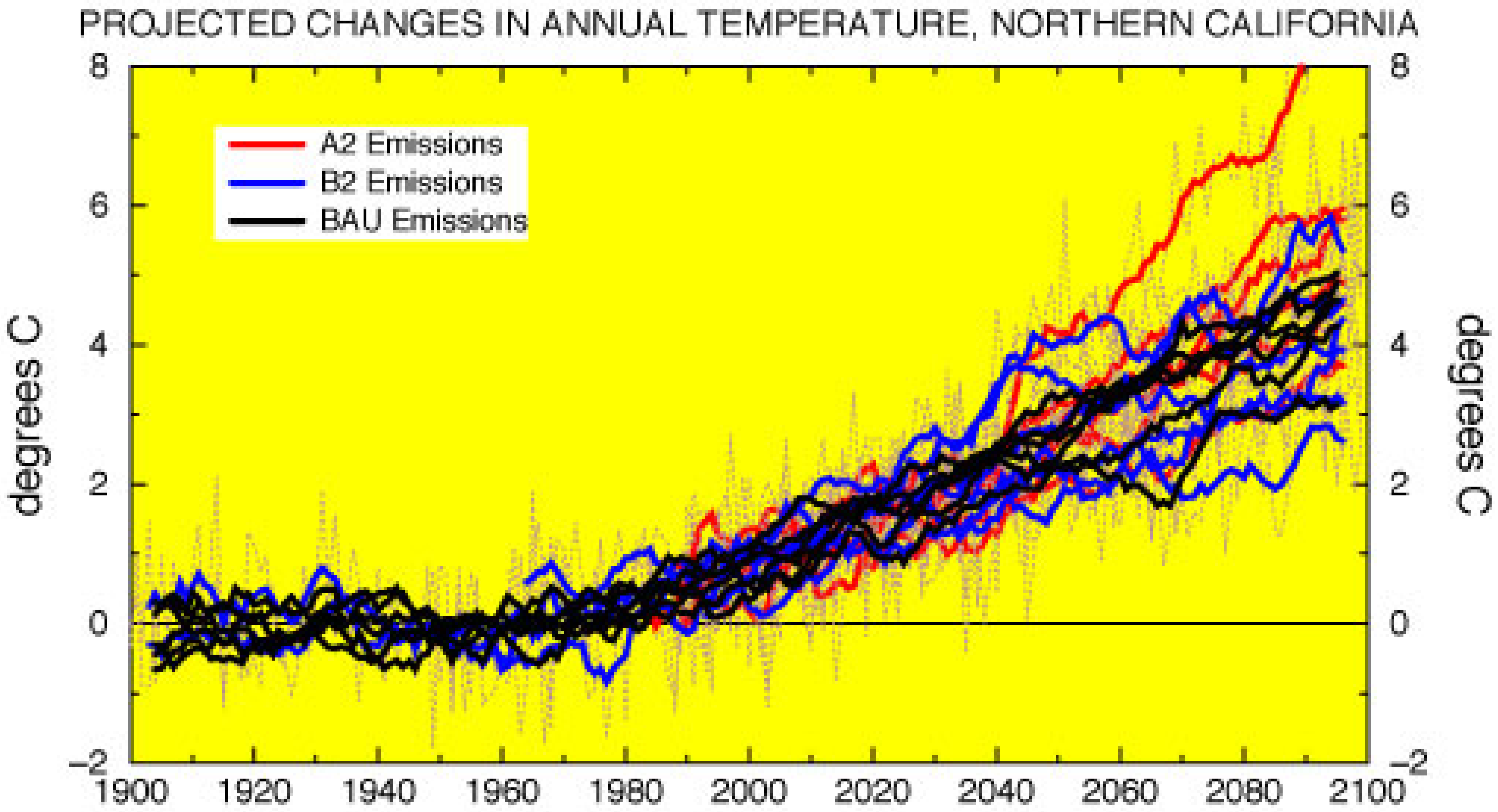



SST (NCEP Reanalysis) Jan to Dec:30N to -30S and 80E to 180E averaged
Sea Surface Temperature. All ocean areas in box
30 N to 30 S / 80 E to 180 E. Thanks to “CDC”
Annual Jan-Dec. Thru 2008.
Area A
0.5 C
1950
2000
SST (C)
26.5
26.4
26.3
26.2
26.1
26
25.9
25.8
25.7
25.6
25.5
1940
1950
1960
1970
1980
1990
2000
2010
Date



SST (NCEP Reanalysis) Jan to Dec:25N to -25S and 65E to 180E averaged
Sea Surface Temperature. All ocean areas in box
25 N to 25 S / 65 E to 180 E. Thanks to "CDC"
Annual Jan-Dec. Thru 2008.
Area B
0.5 C
1950
2000
27.5
27.4
27.3
27.2
27.1
27
26.9
26.8
26.7
26.6
26.5
26.4
SST (C)
1940
1950
1960
1970
1980
1990
2000
2010
Date

So, is Nevada warming, … or not ???



Dettinger MD. 2005. From climate change spaghetti to climate-change distributions for 21st Century California. San Francisco Estuary and Watershed Science. Vol. 3, Issue 1, (March 2005), Article 4. http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art4

With thanks to John Abatzoglou

Nevada Climate Tracker

Select from the Menu to the Right

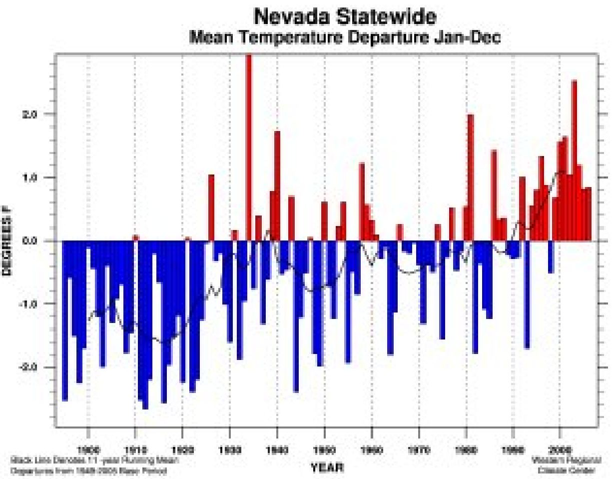
Time Series

Select Variable

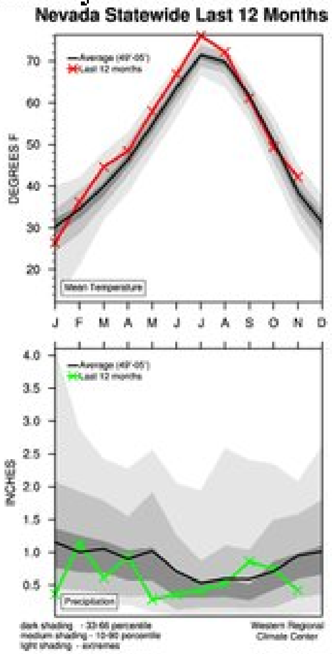
Select Time Period

Select

Time Series



Summary of Past 12 Months



Summary of Past 12 Months

Plot Time Series

List Entire History

More Info

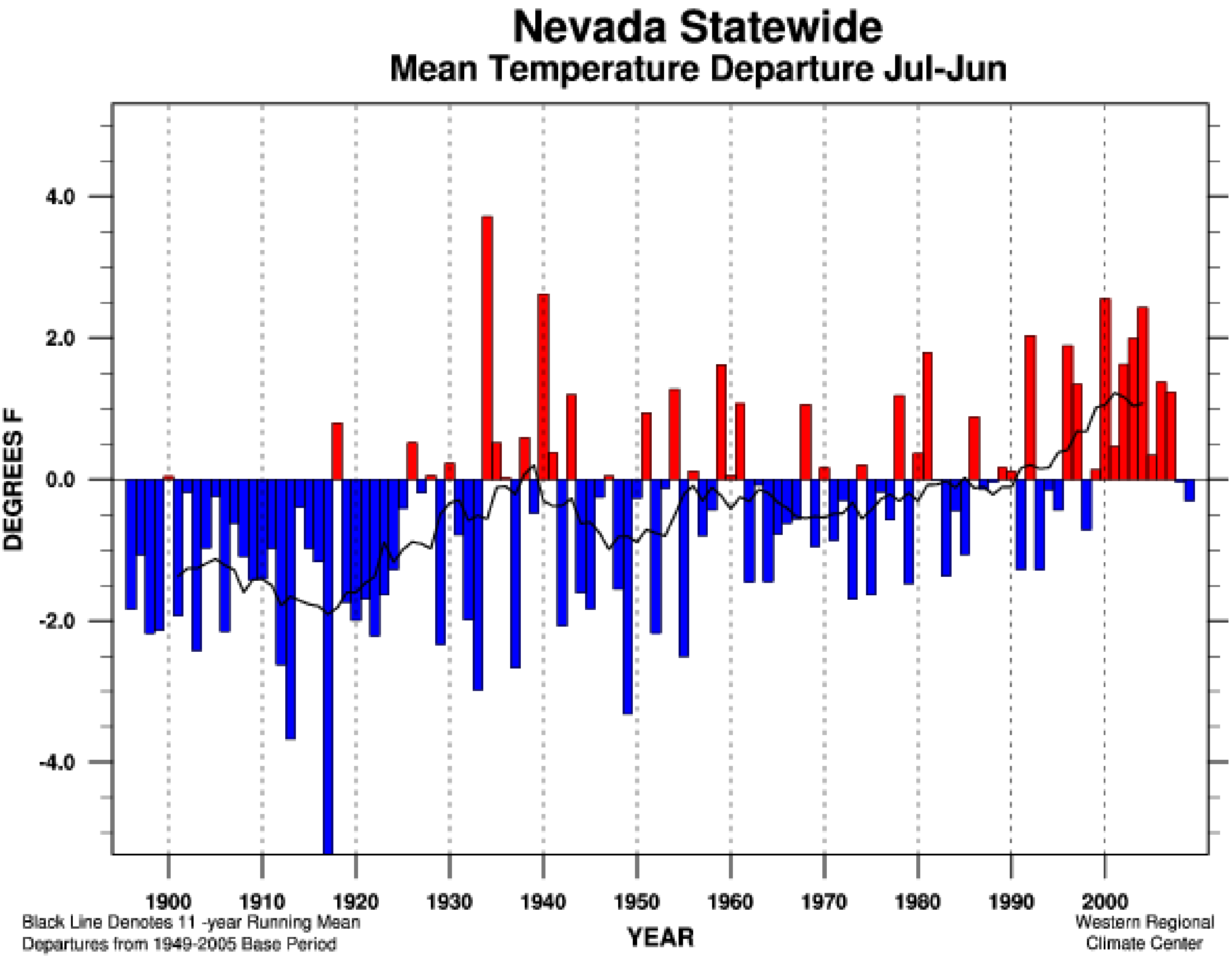
Return to the WRCC

Western Regional Climate Center

DRI Desert Research Institute

Powered by ACIS

NOAA Regional Climate Centers

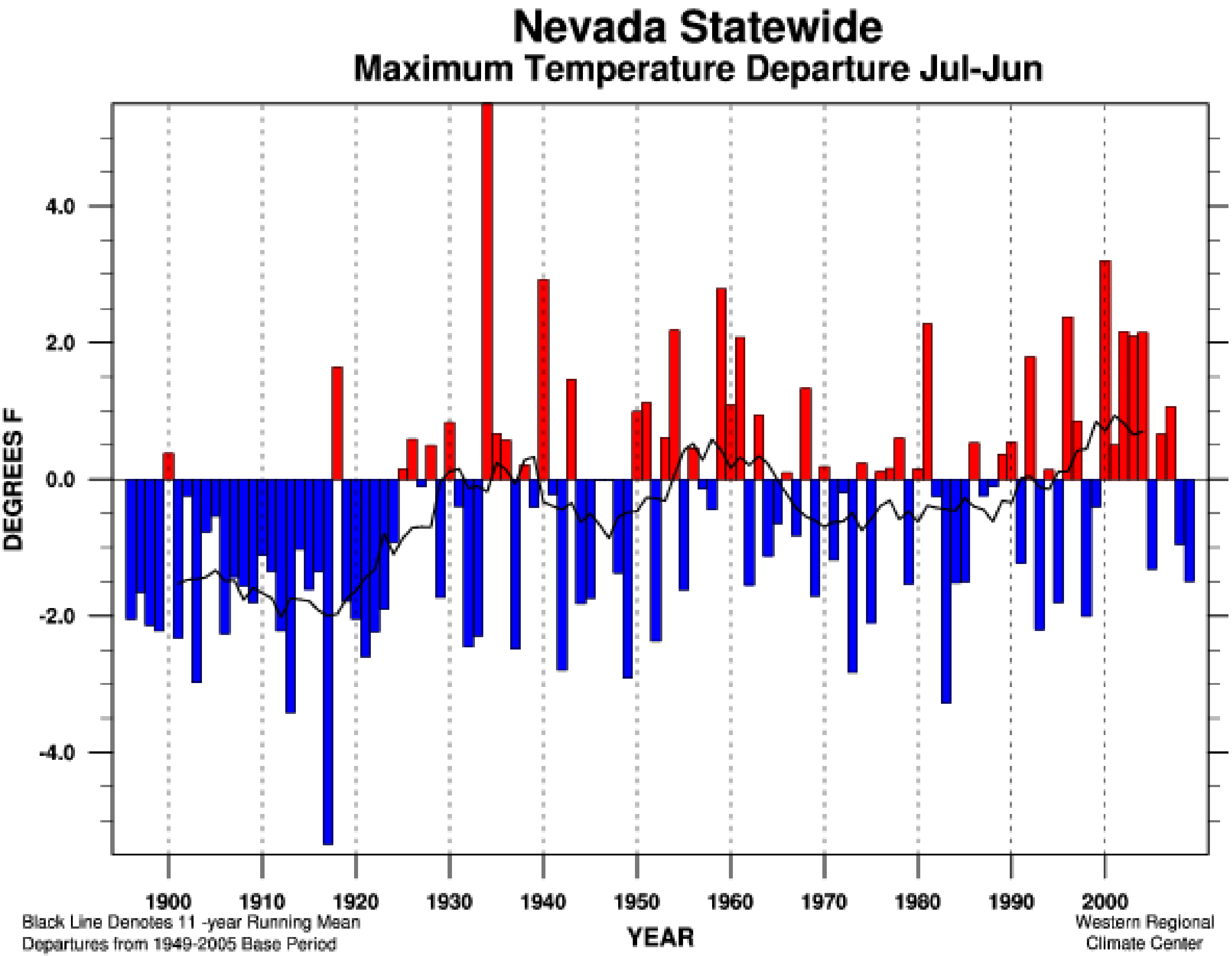


Nevada Statewide Temperature

July thru June

July 1895 thru June 2009

Linear Trend 1895-present		+ 2.03 ± 0.71°F/100yr		
Linear Trend 1949-present		+ 2.46 ± 1.62°F/100yr		
Linear Trend 1975-present		+ 4.26 ± 3.82°F/100yr		
Warmest Year		57.6 °F (+ 3.7 °F) in 1934	MEAN	53.9 °F
Coldest Year		48.6 °F (- 5.3 °F) in 1917	STDEV	1.18 °F
Jul-Jun	2009	53.6 °F (- 0.3 °F)	RANK	60 of 114

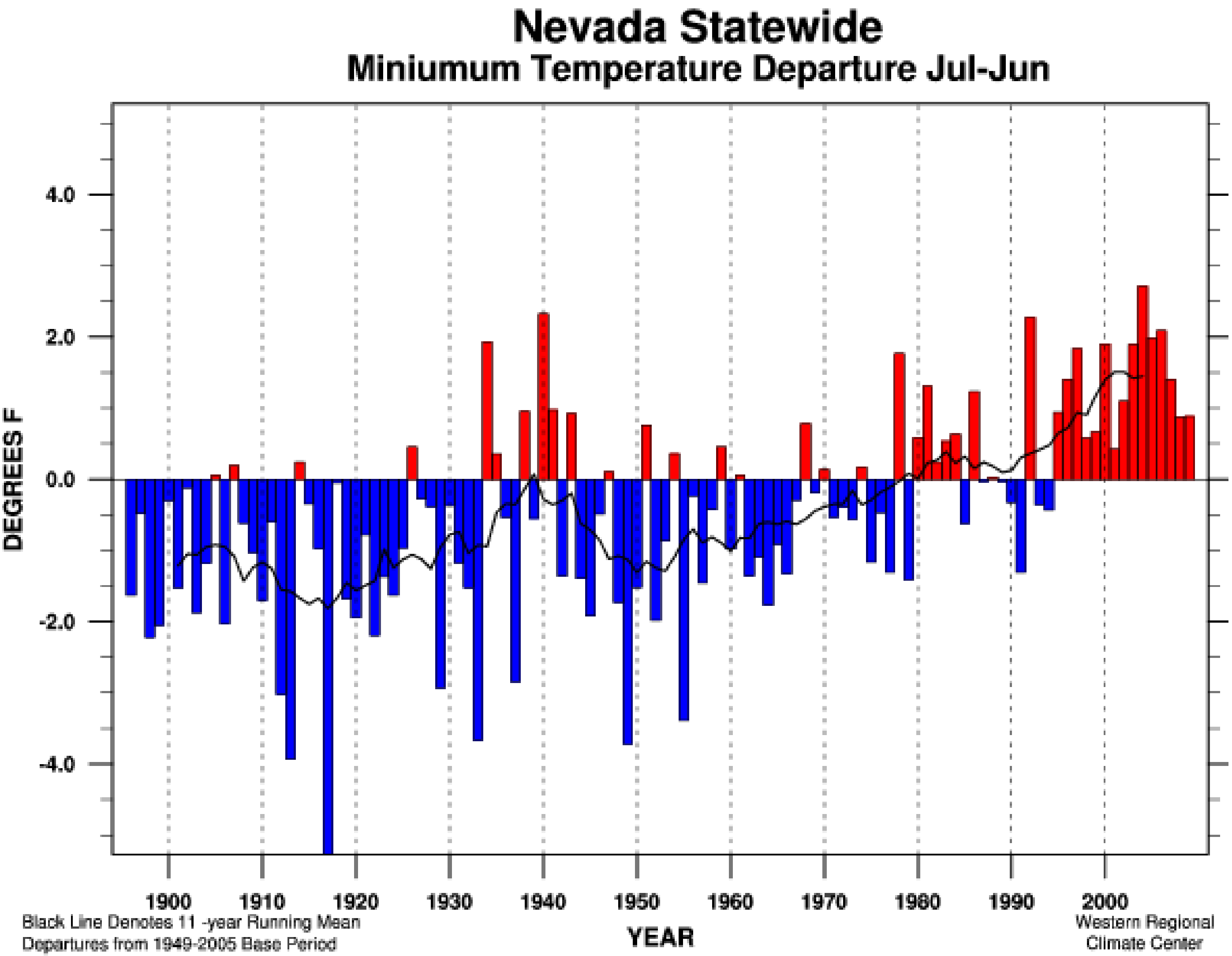


Nevada Statewide
Maximum
Temperature

July thru June

July 1895
thru
June 2009

Linear Trend 1895-present		+ 1.72 ± 0.89 °F/100yr		
Linear Trend 1949-present		+ 0.33 ± 2.24 °F/100yr		
Linear Trend 1975-present		+ 2.79 ± 5.45 °F/100yr		
Warmest Year		75.4 °F (+ 5.5 °F) in 1934	MEAN	69.9 °F
Coldest Year		64.5 °F (- 5.3 °F) in 1917	STDEV	1.50 °F
Jul-Jun	2009	68.4 °F (- 1.5 °F)	RANK	40 of 114



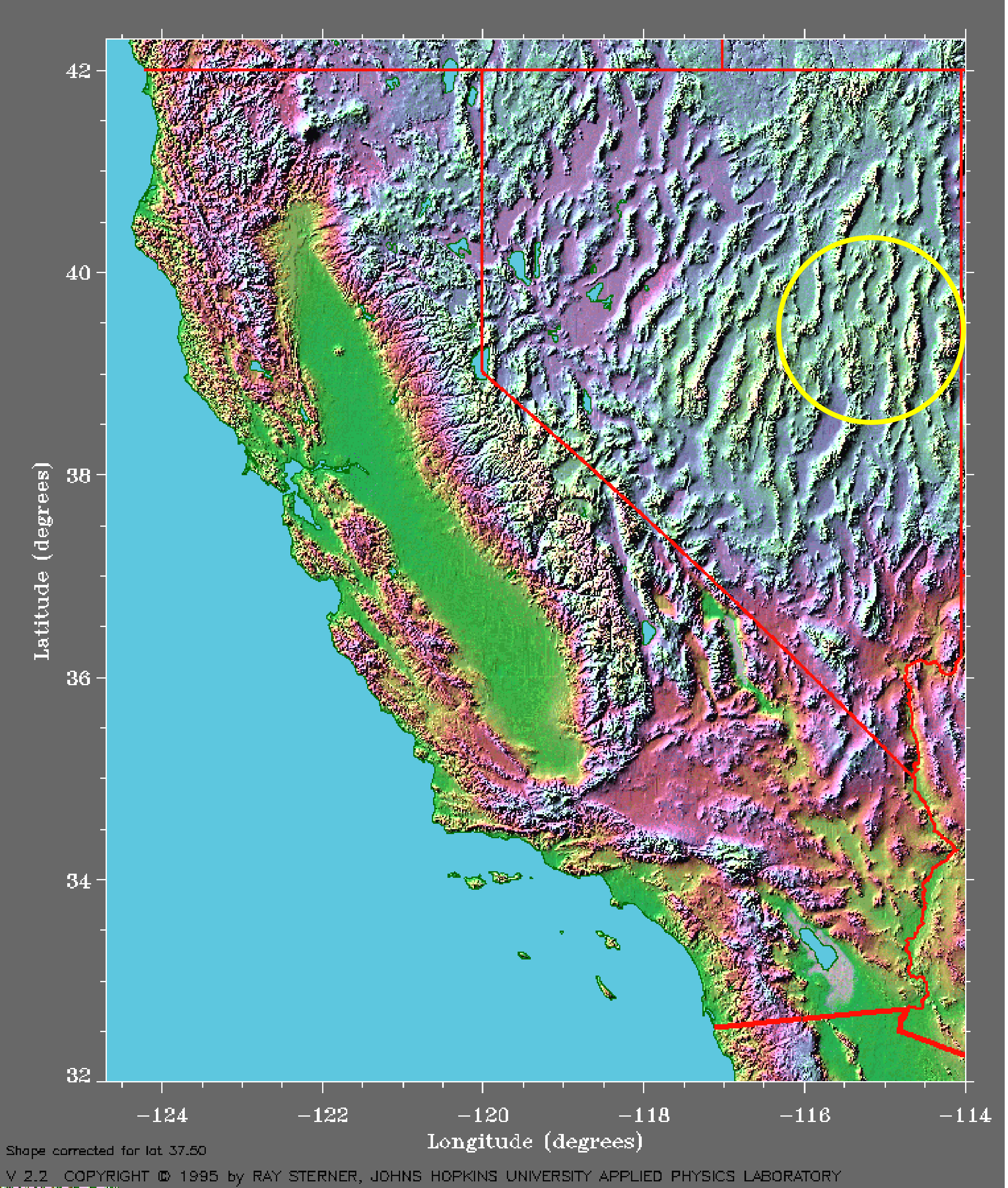
Nevada Statewide Minimum Temperature

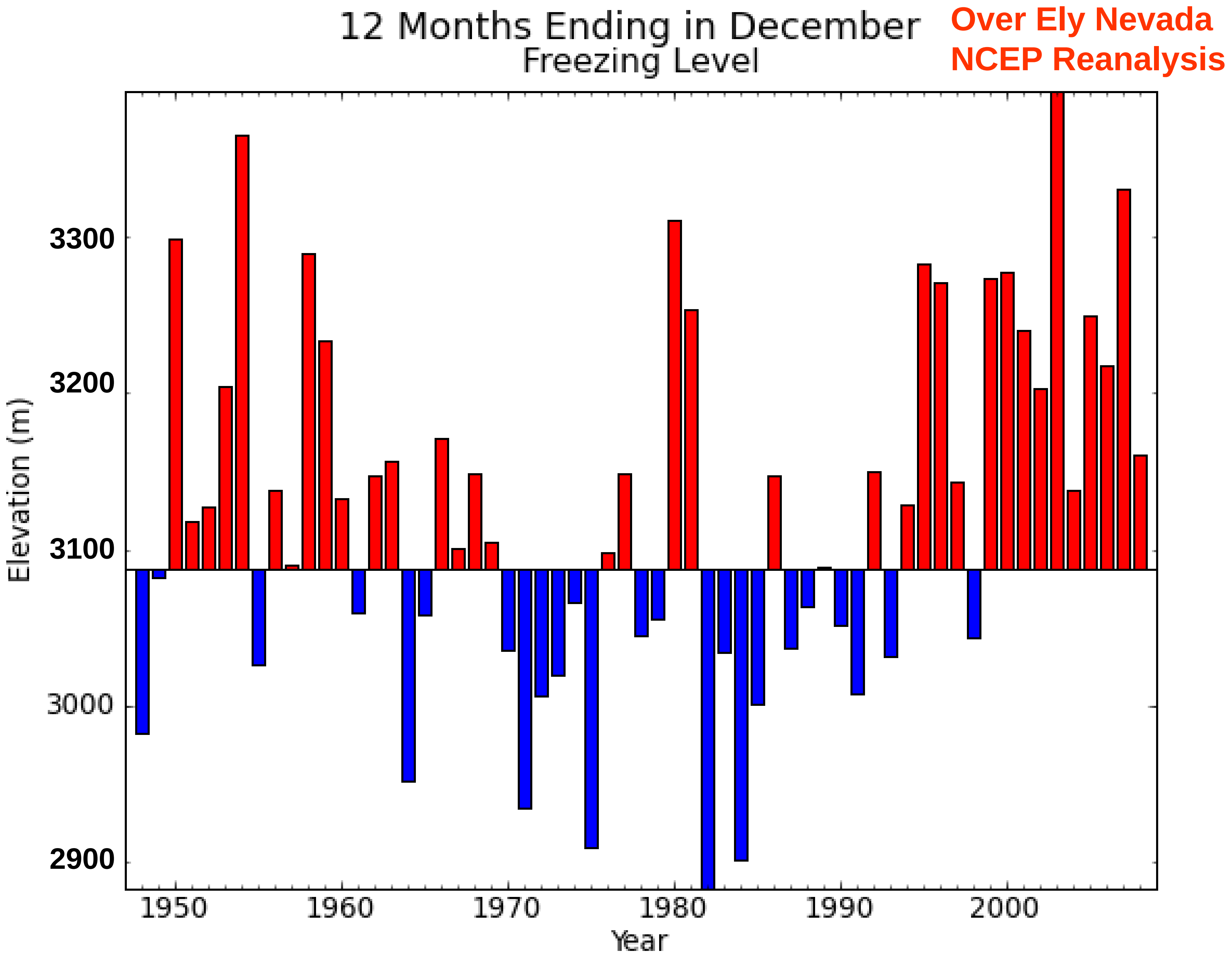
July thru June

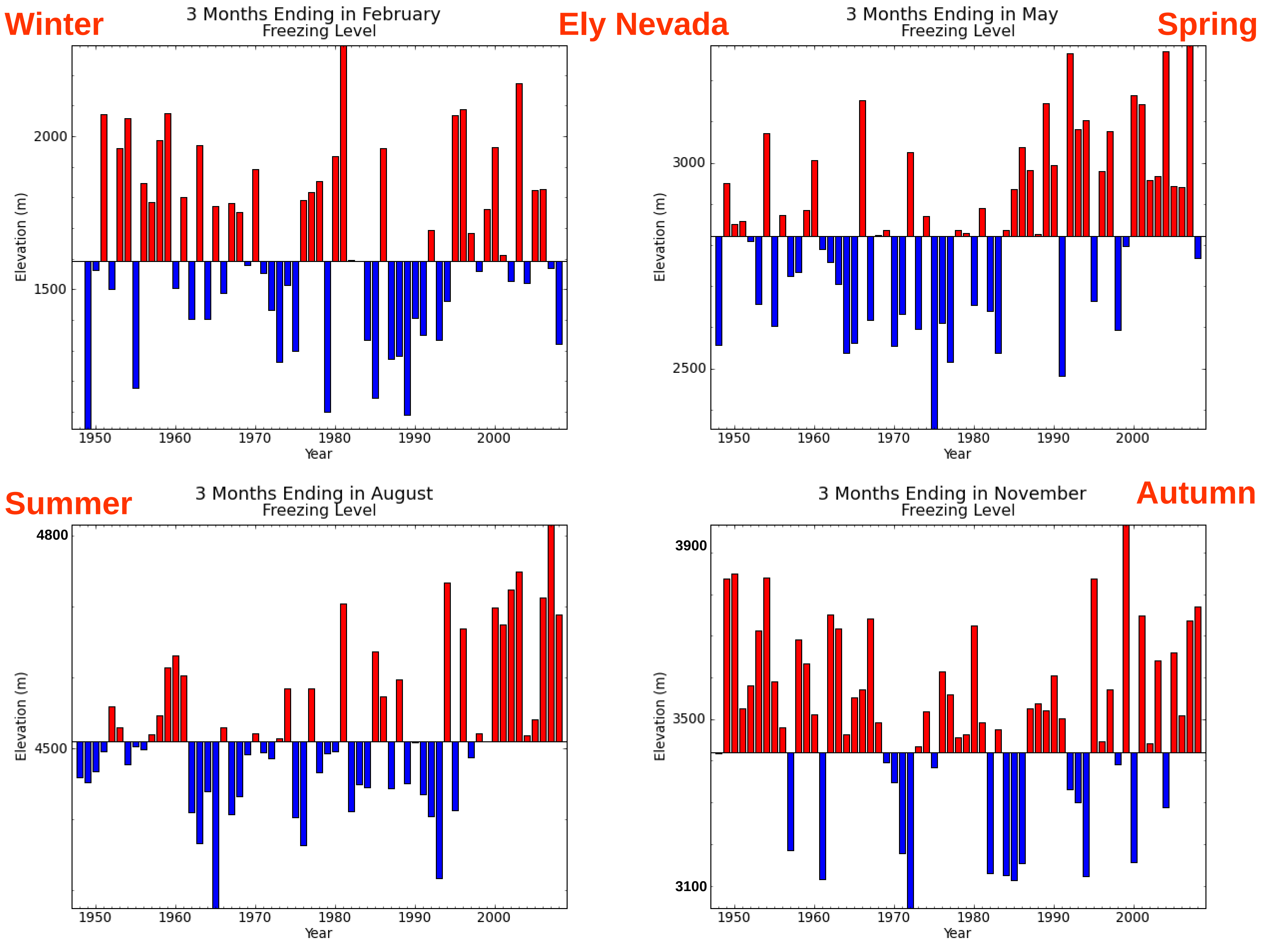
July 1895 thru June 2009

Linear Trend 1895-present		+ 2.33 ± 0.68 °F/100yr		
Linear Trend 1949-present		+ 4.60 ± 1.37 °F/100yr		
Linear Trend 1975-present		+ 5.73 ± 3.29 °F/100yr		
Warmest Year		40.6 °F (+ 2.7 °F) in 2004	MEAN	37.9 °F
Coldest Year		32.6 °F (- 5.3 °F) in 1917	STDEV	1.23 °F
Jul-Jun	2009	38.8 °F (+ 0.9 °F)	RANK	95 of 114

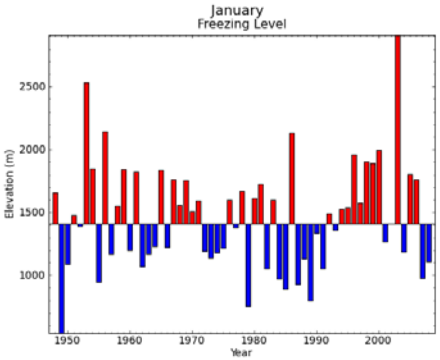
North American Freezing Level Tracker




12 Months Ending in December
Freezing Level
Over Ely Nevada
NCEP Reanalysis
3300
3200
3100
3000
2900
Elevation (m)
1950
1960
1970
1980
1990
2000
Year


Winter
Ely Nevada
Spring
Summer
Autumn
3 Months Ending in February
Freezing Level
3 Months Ending in May
Freezing Level
3 Months Ending in August
Freezing Level
3 Months Ending in November
Freezing Level
Elevation (m)
Year
2000
1500
3000
2500
4800
4500
3900
3500
3100
1950
1960
1970
1980
1990
2000

Ely Nevada Freezing Levels 1948-2008 NCEP Reanalysis



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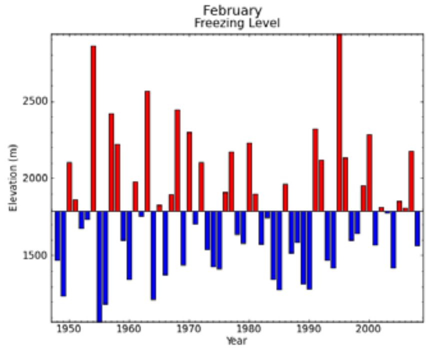
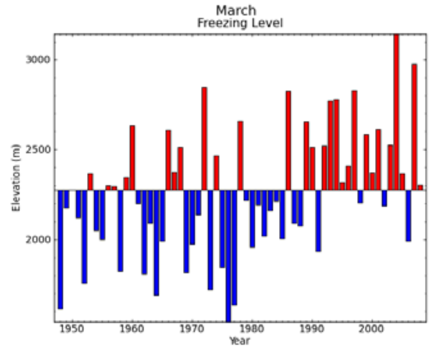
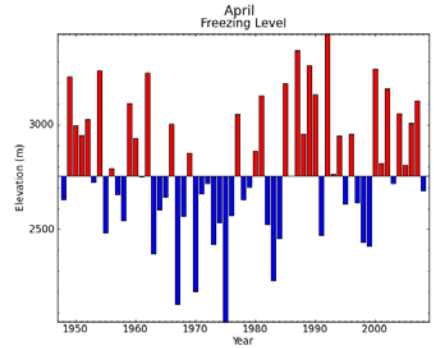


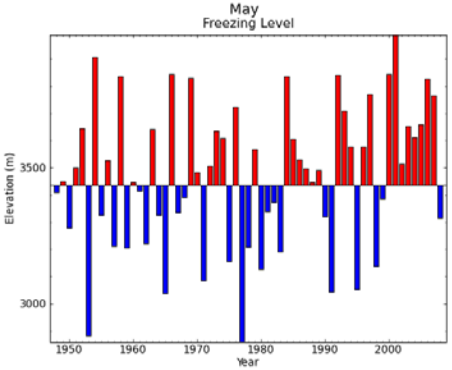
February



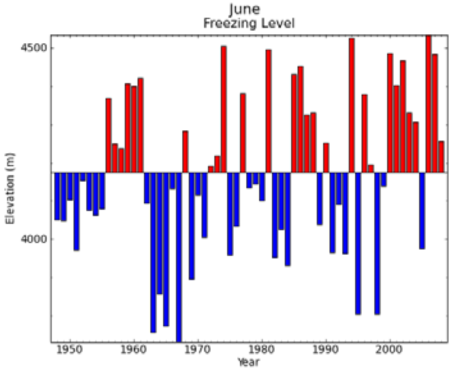
March



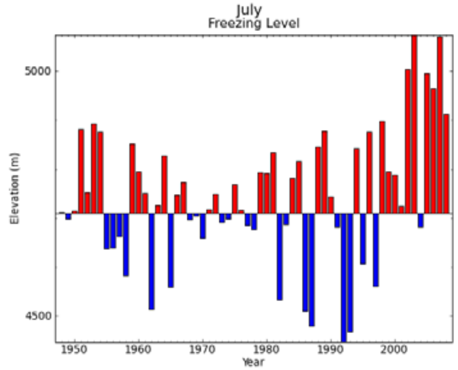
April



May



June



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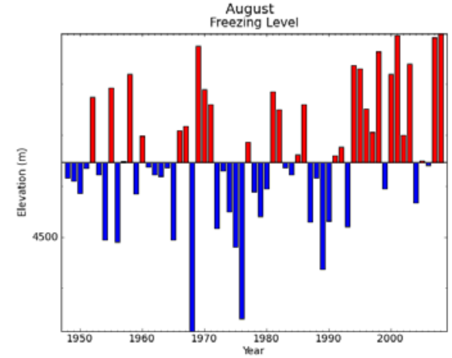

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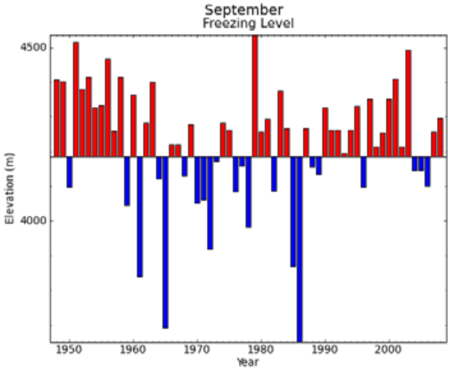

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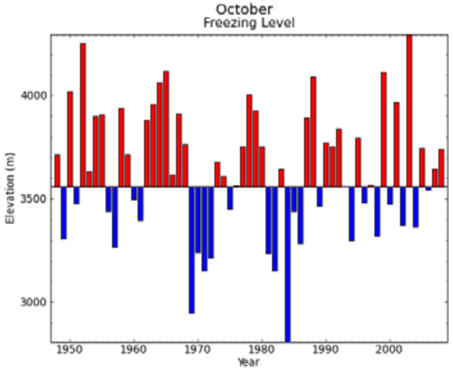

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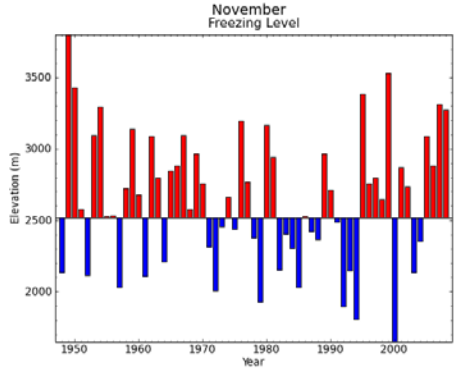
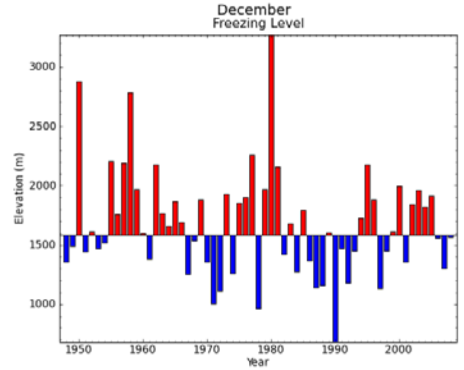
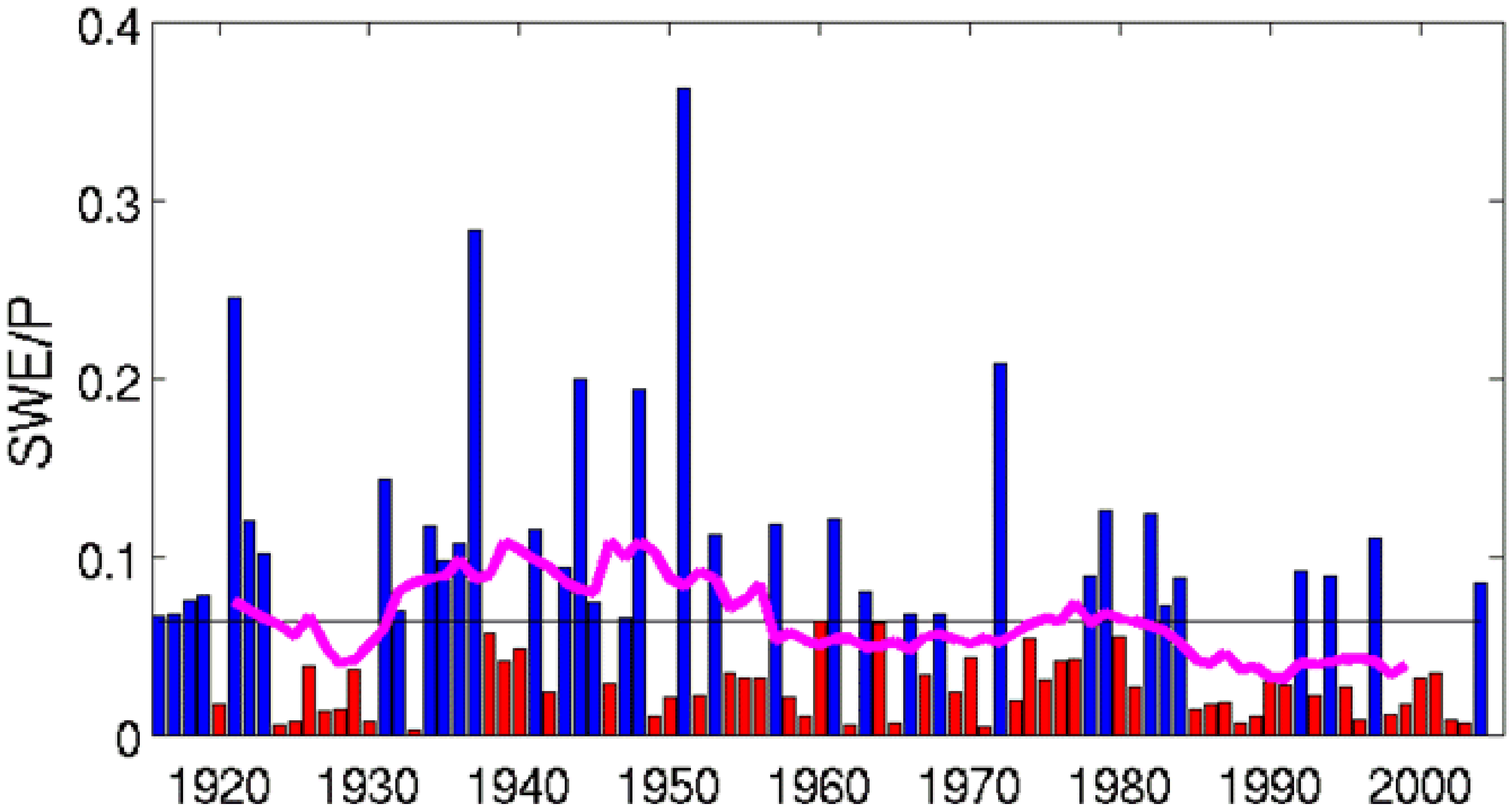


November



December

Eastern Nevada. April 1 Snow Water Equivalent / Oct-Mar Precipitation. From VIC Model



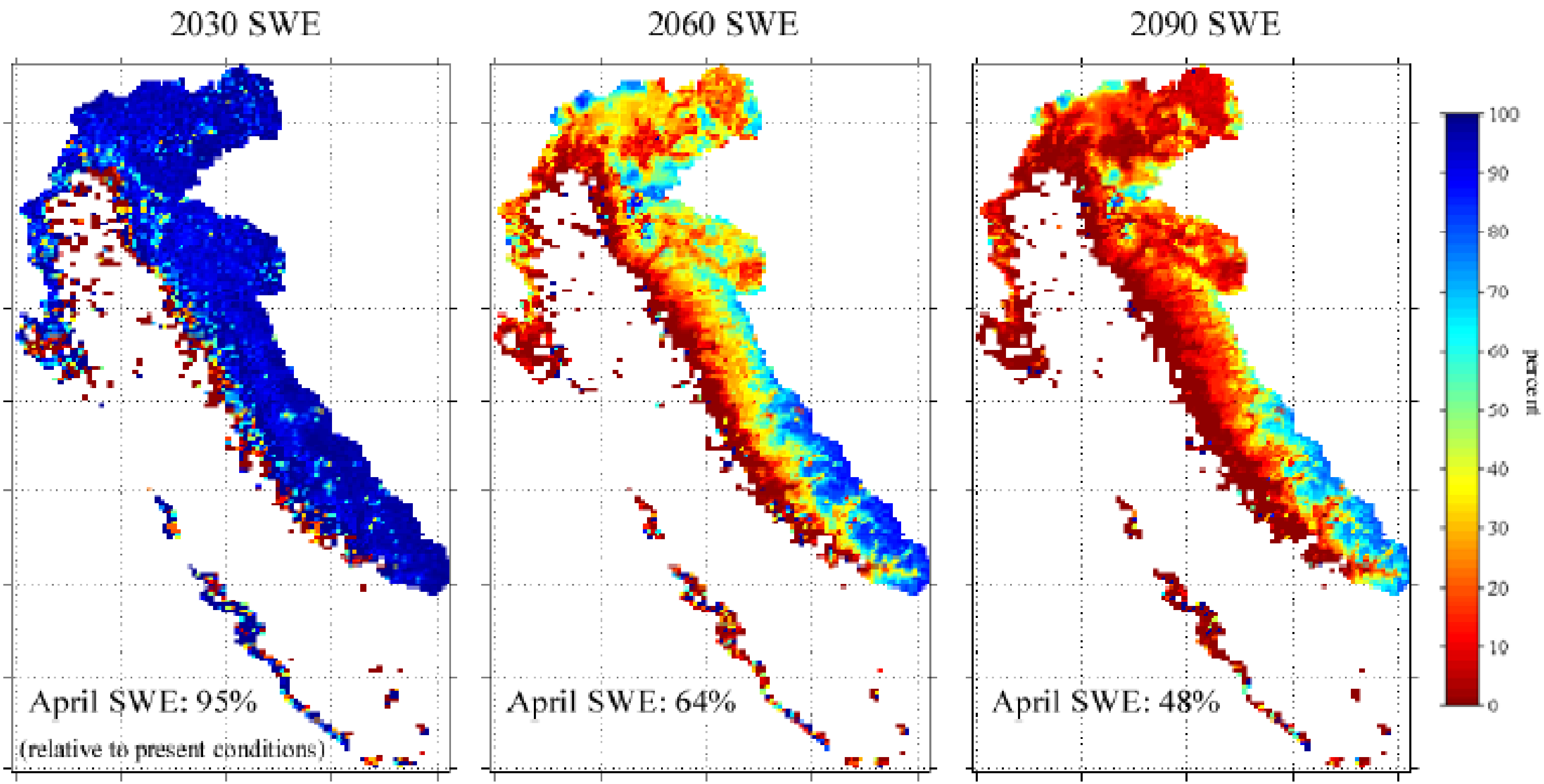


Figure 3. Simulated snow water equivalent (SWE) under a projected temperature increase for the periods 2020-2039, 2050-2069 and 2080-2099, expressed as a percentage of average present conditions.

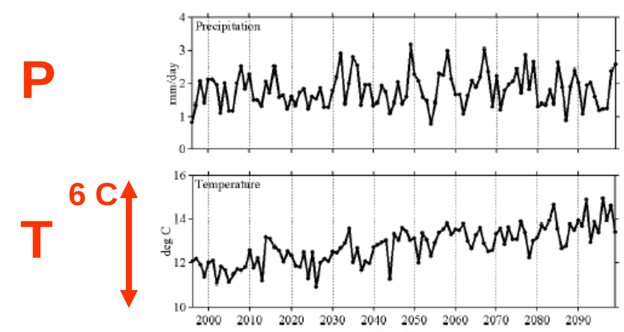
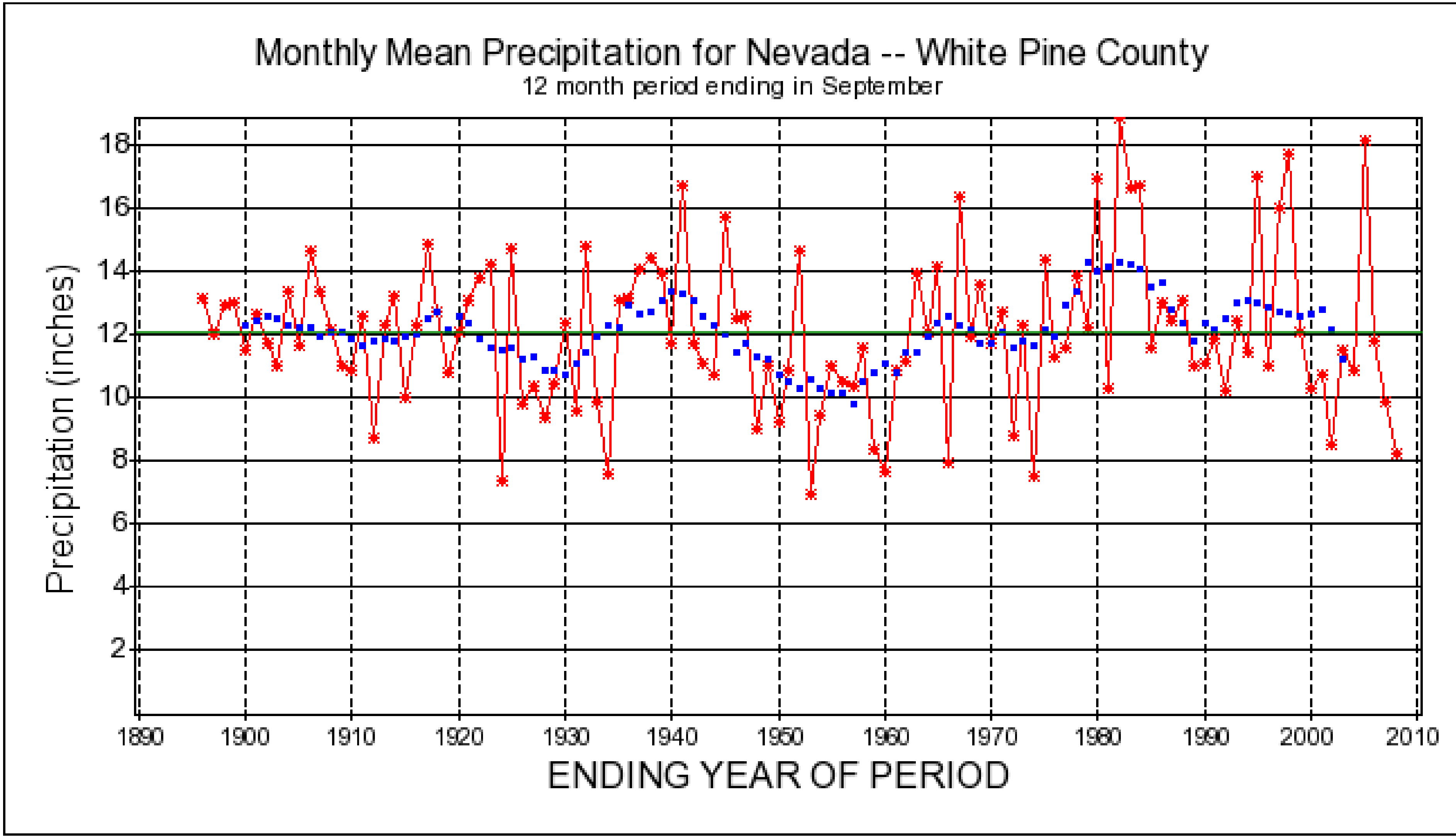


Figure 2. PCM-simulated watershed-averaged annual precipitation and temperature for WY 1995-2099.

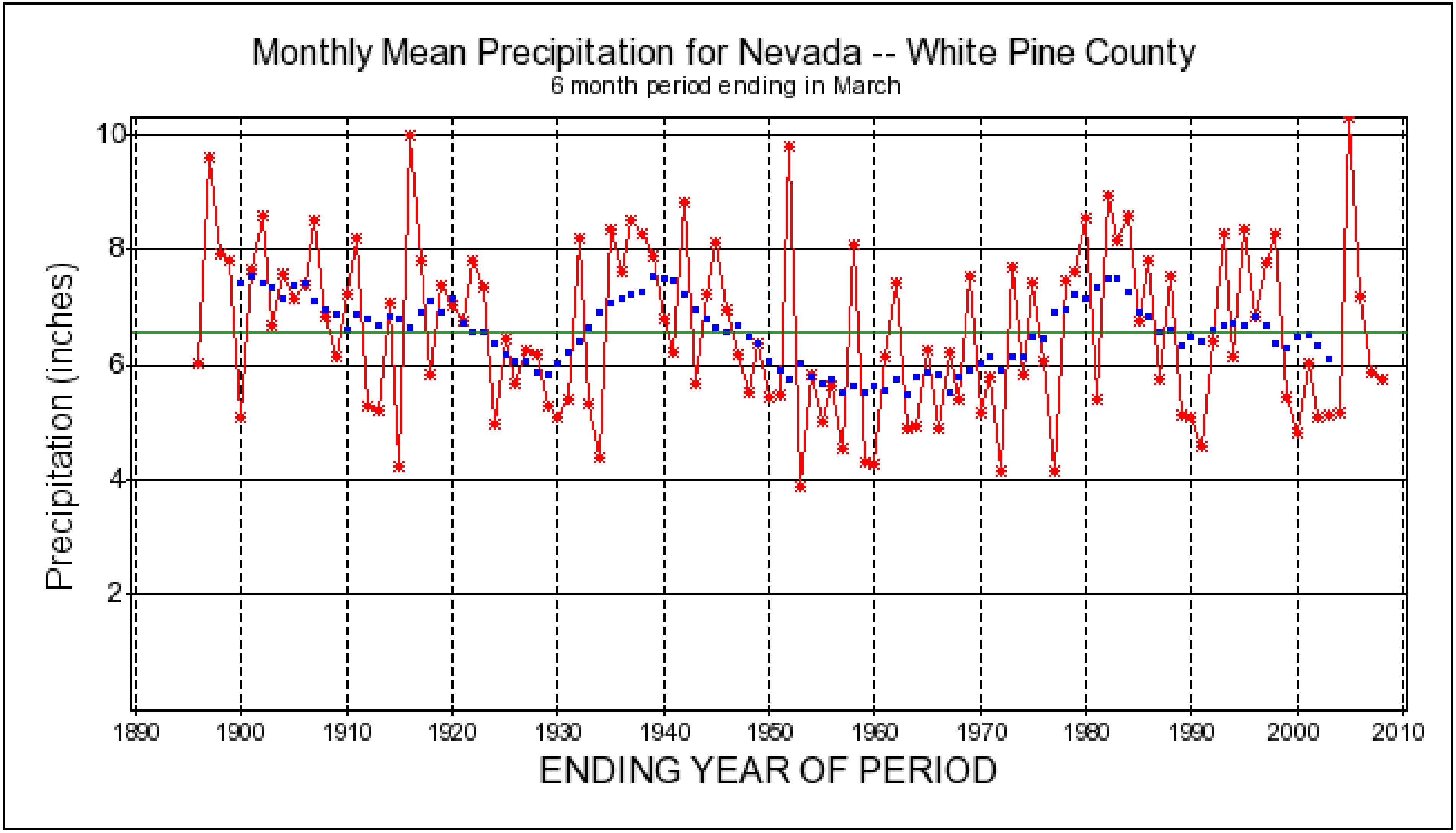
Potential effects of global warming on the Sacramento / San Joaquin watershed and the San Francisco estuary

Noah Knowles and Dan Cayan, Climate Research Division, Scripps Institution of Oceanography

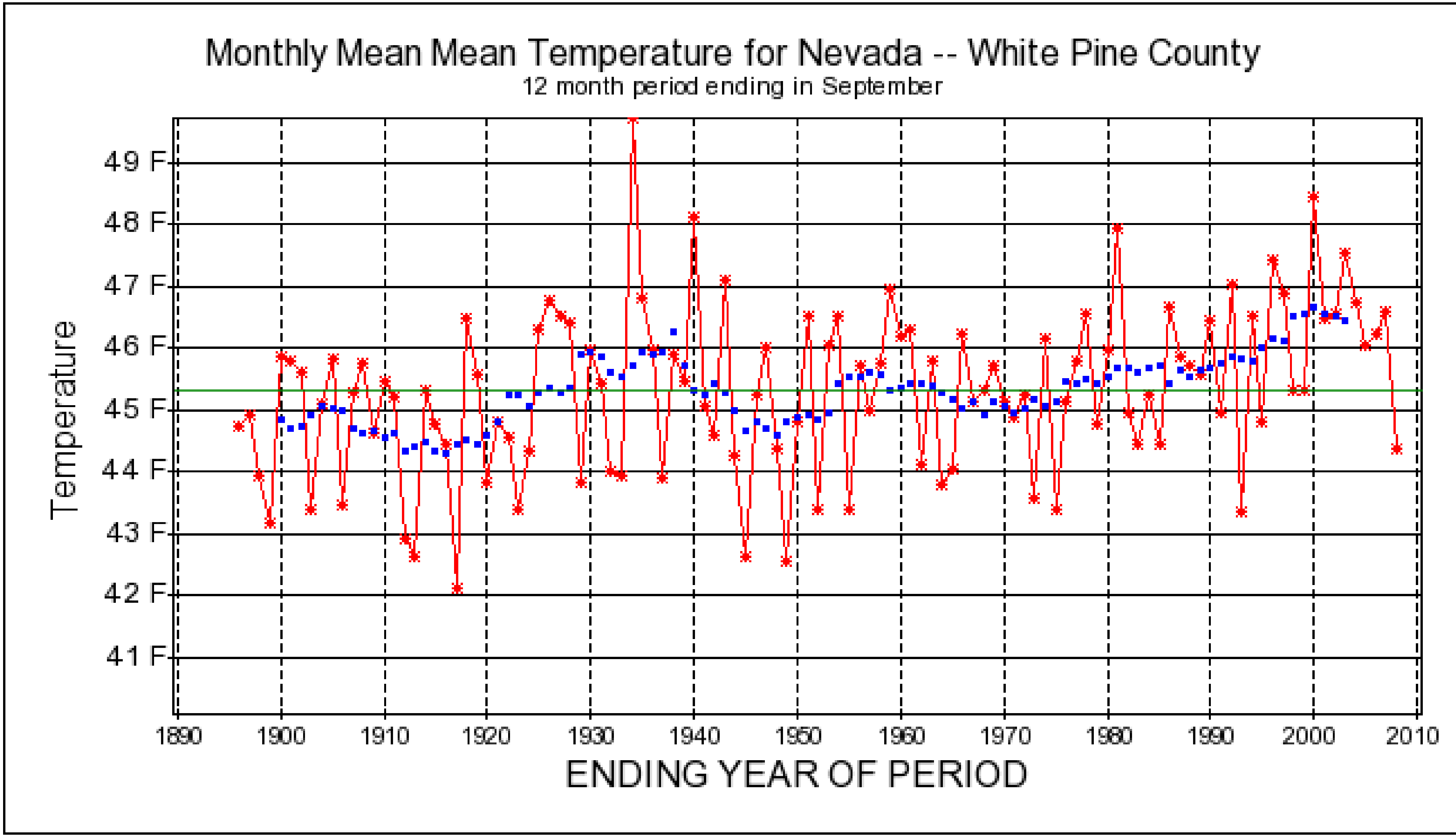
White Pine County October-September Precipitation 1985-2008



White Pine County Total October-March Winter Precipitation 1985-2008



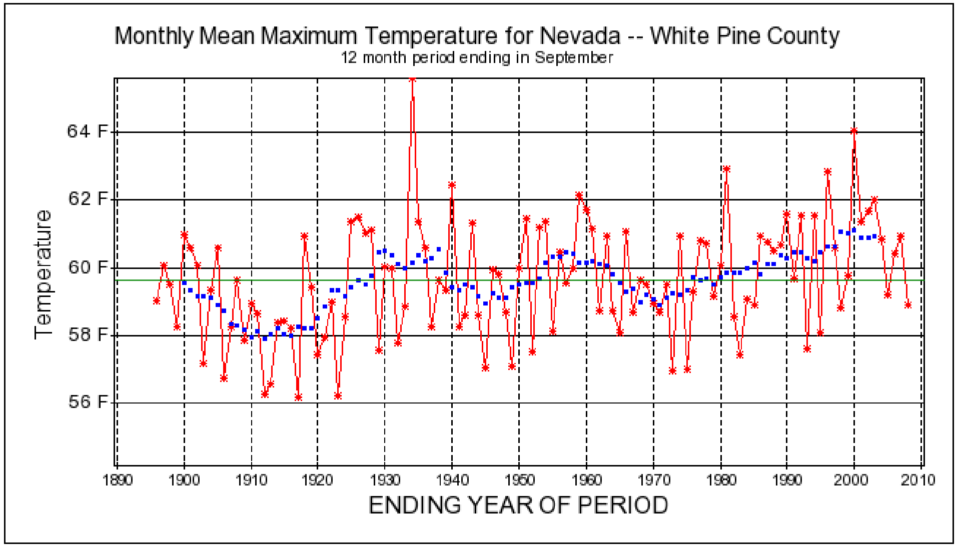
White Pine County October-September Temperature 1985-2008

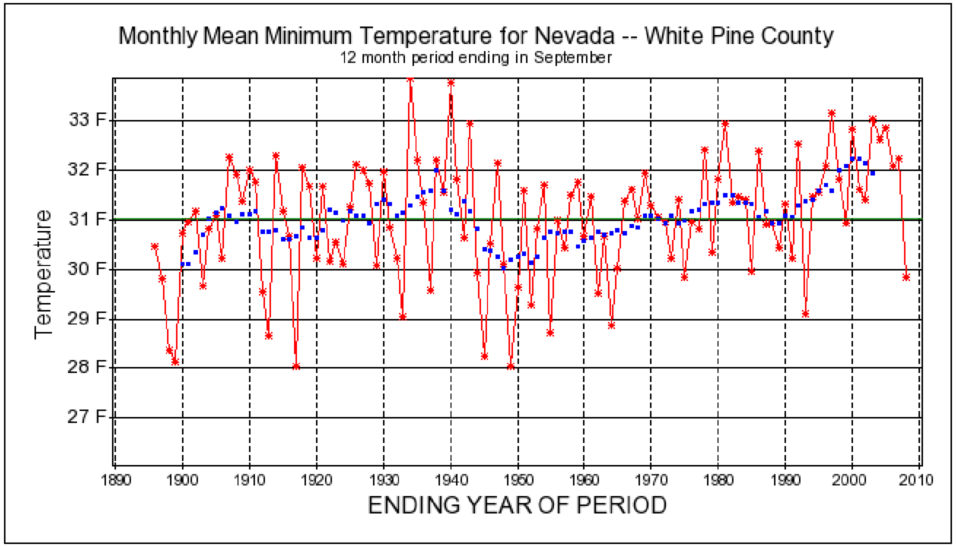


White Pine County October-September Temperature 1985-2008

Maximum (Daytime)

Minimum (Nighttime)





The 1980s-90s Drought: Sierra, Nevada, & Colorado Basin

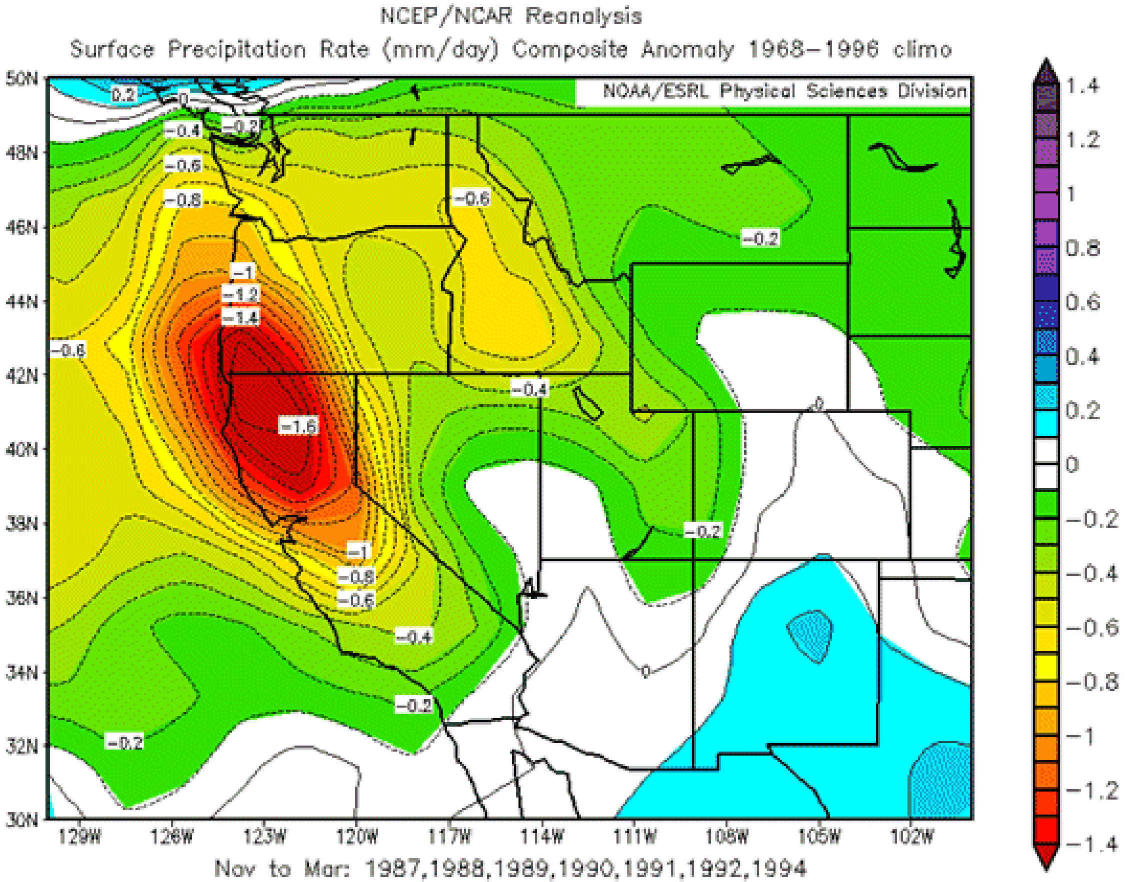
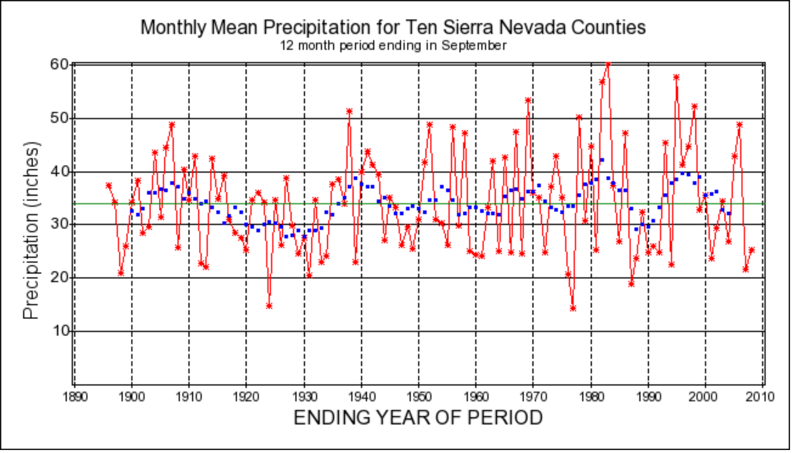


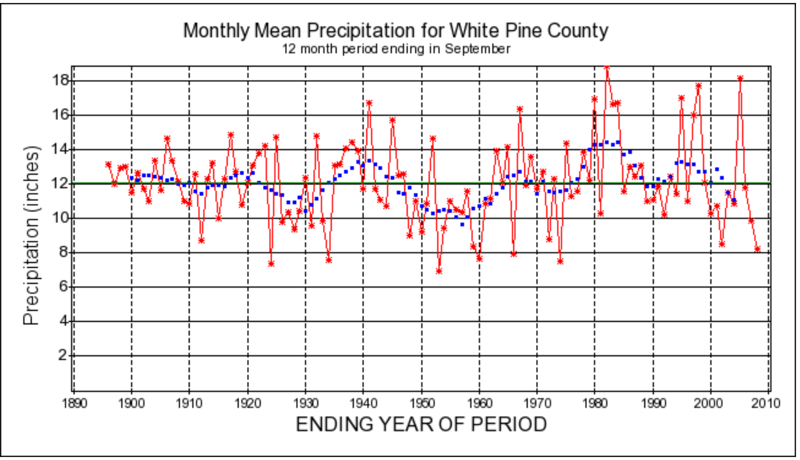
Figure D18. Departure from average, Nov-Mar, during the Sierra Nevada drought from 1986-87 through 1993-94 (1992-93 left out), expressed in mm/day, with respect to a base period of 1968-1996. Derived from NCEP/NCAR Reanalysis, software courtesy of NOAA ESRL.

Precipitation Histories
Water Years 1985-2008

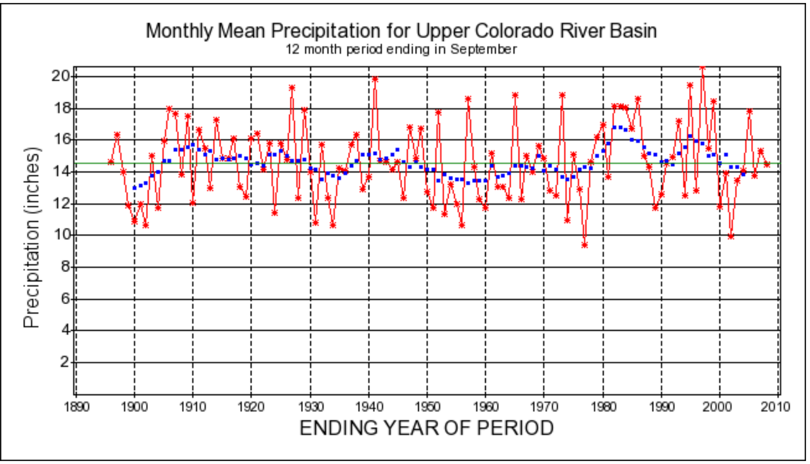
Sierra Nevada



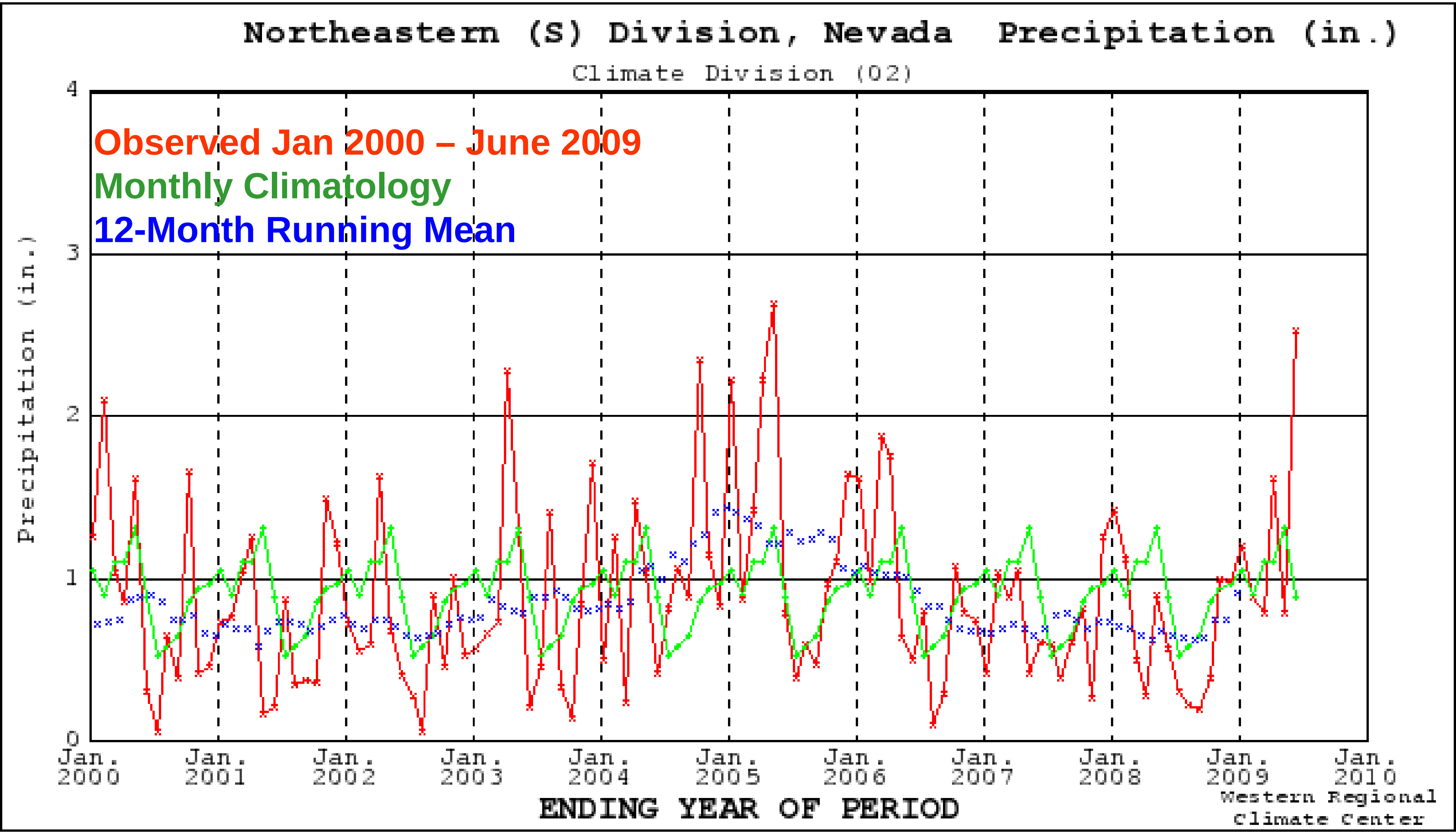
White Pine County



Colorado River Basin



Northeast Nevada Monthly Precipitation since 2000



National Integrated Drought Information System

U.S. Drought Portal

www.drought.gov

drought.gov

Area Drought Information

Select State... Go updated!

Select Region... Go

Maps & Tools

- Map Viewer
- GIS Resources
- Geodata Portal
- Drought Monitor Graphics - new!
- Data Visualizations - new!

Events & Announcements

- Climate, Drought and Early Warning on Western Native Lands - June 2009
- Climate Reference Network Soil Moisture Meeting - March 2009
- Monitoring Gaps Assessment Workshop - December 2008
- Wildfire: National Seasonal Assessment Workshop - February 2009
- National Hydrologic Warning Council - May 2009

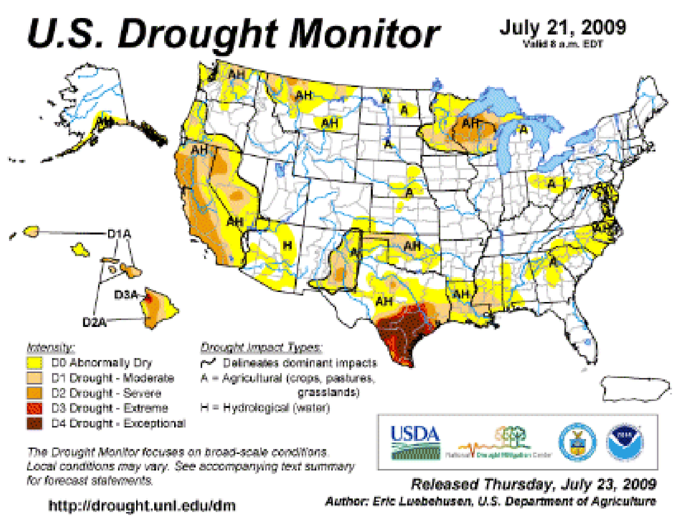
View Archive | Portal Release Notes

Drought In The News

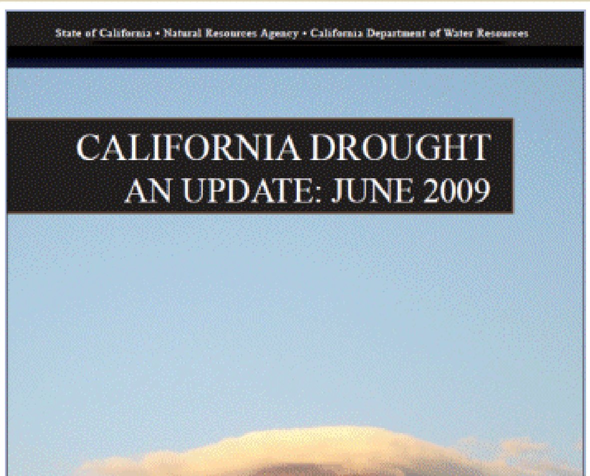
- In Texas, drought means conserving every last drop - USATODAY.com
- Shorter shower device: a key to fighting drought? - Sacramento News
- Climate Change Increases Runoff In Eastern U.S. Forests - Environment News Service (ENS)
- Many Texas waterways lowered by drought - Houston Chronicle
- Report: California can save water by investing in farm conservation measures instead of dams - Los Angeles Times
- House passes bill including funds for Calif. water - Sacramento Bee

Featured Products

Where are Drought Conditions Now? | How is the Drought Affecting Me? | Will the Drought Continue?

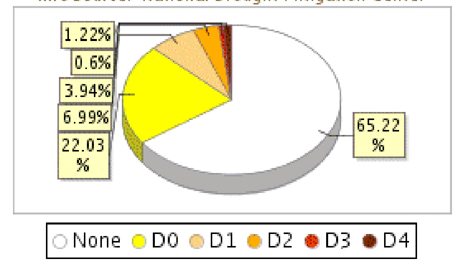


NIDIS Feature



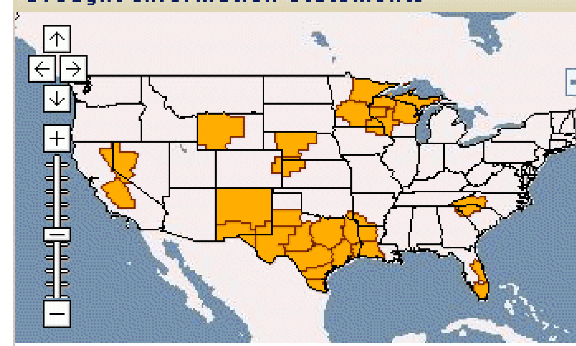
Drought Conditions

% Area for U.S.,including, AK, HI & PR
(As of 7.21.2009)
Info Source: National Drought Mitigation Center



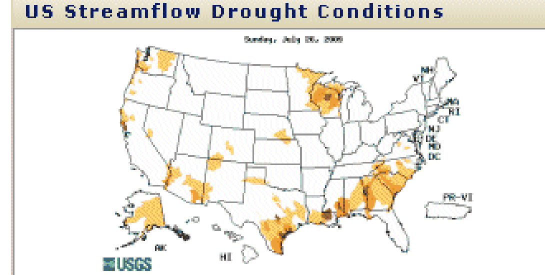
Drought Classifications | View Time Series

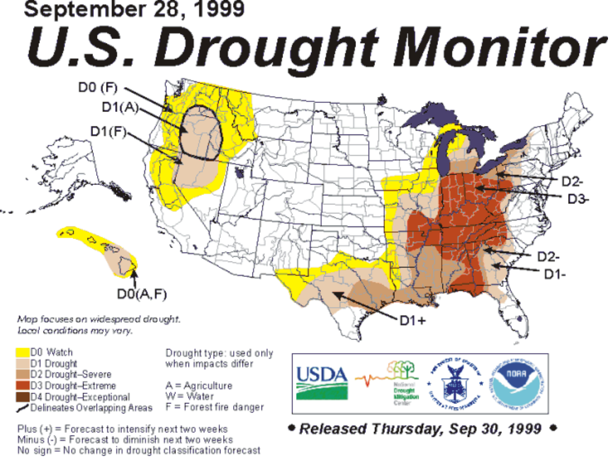
Drought Information Statements



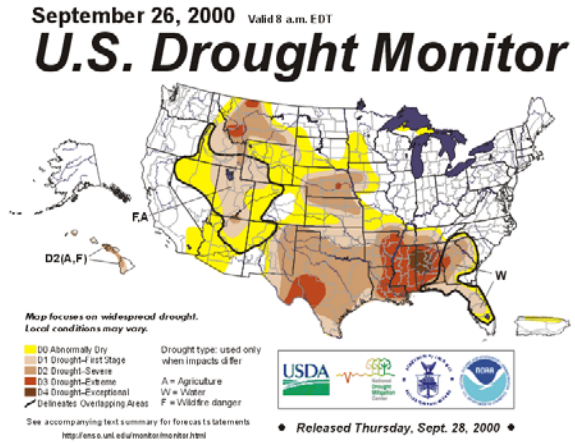
Click on a highlighted area to view the current NWS Drought Information Statement or Click Here to select from a list

US Streamflow Drought Conditions

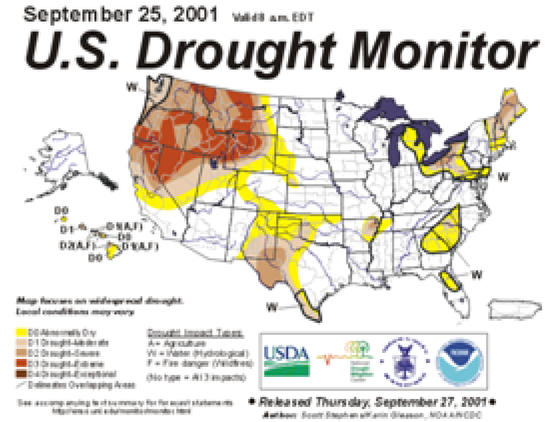




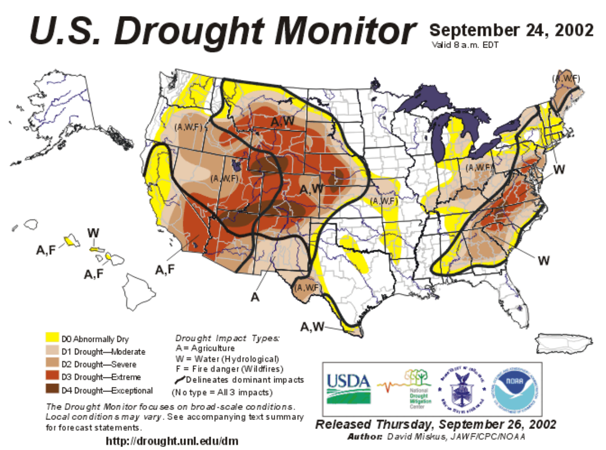
Sep 28, 1999



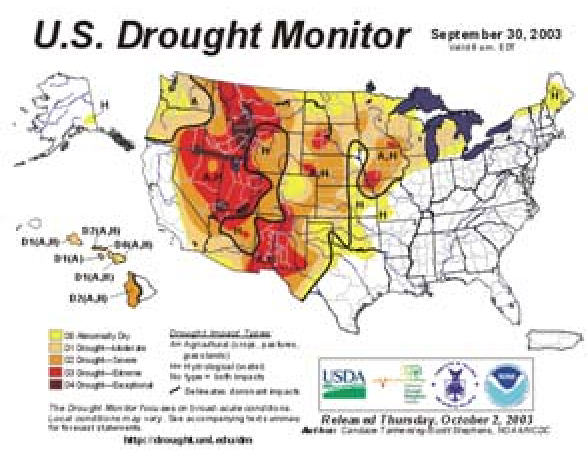
Sep 26, 2000



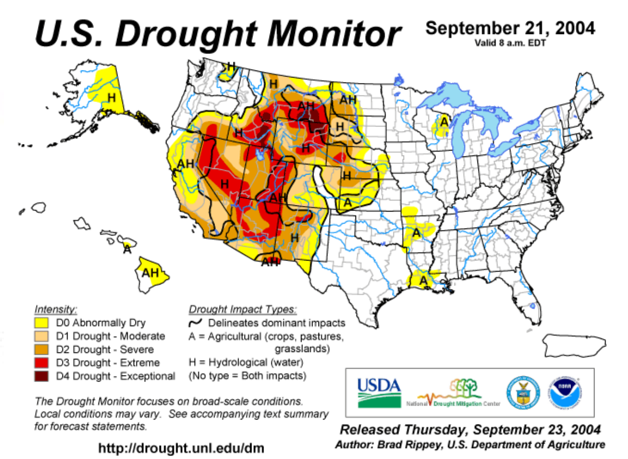
Sep 25, 2001



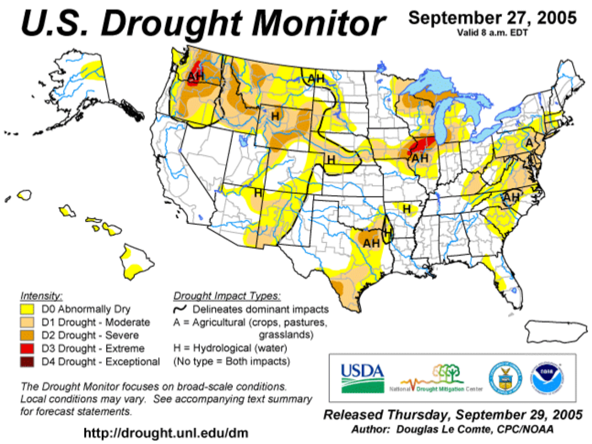
Sep 24, 2002



Sep 30, 2003



Sep 21, 2004



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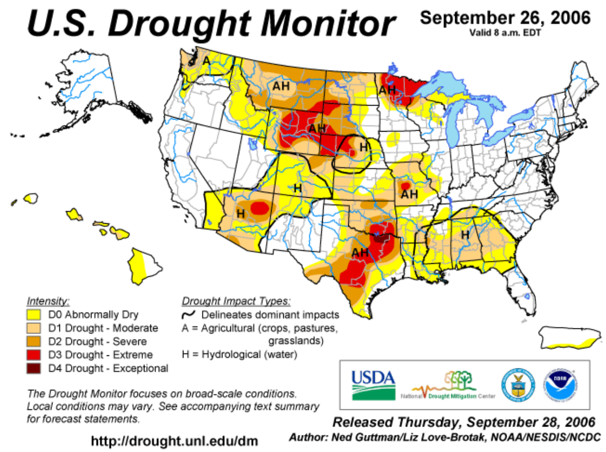

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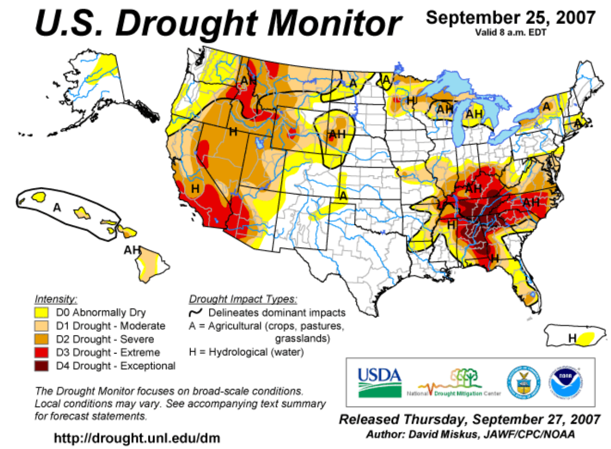
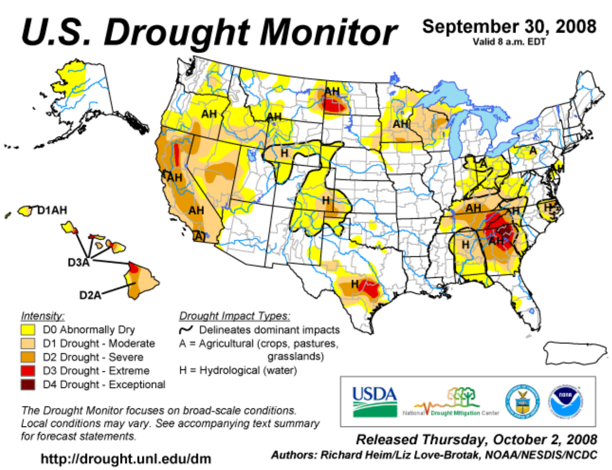
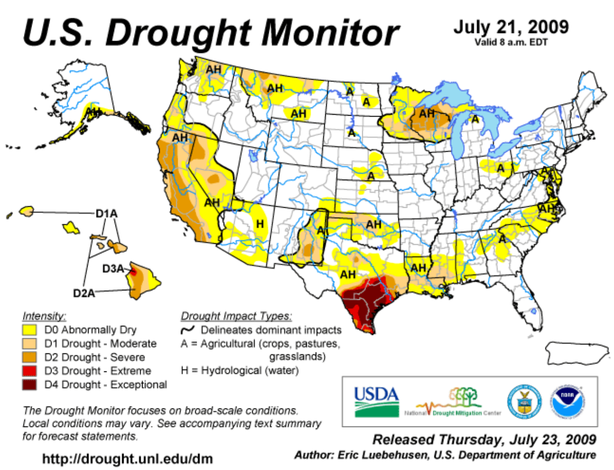


Sep 25, 2007

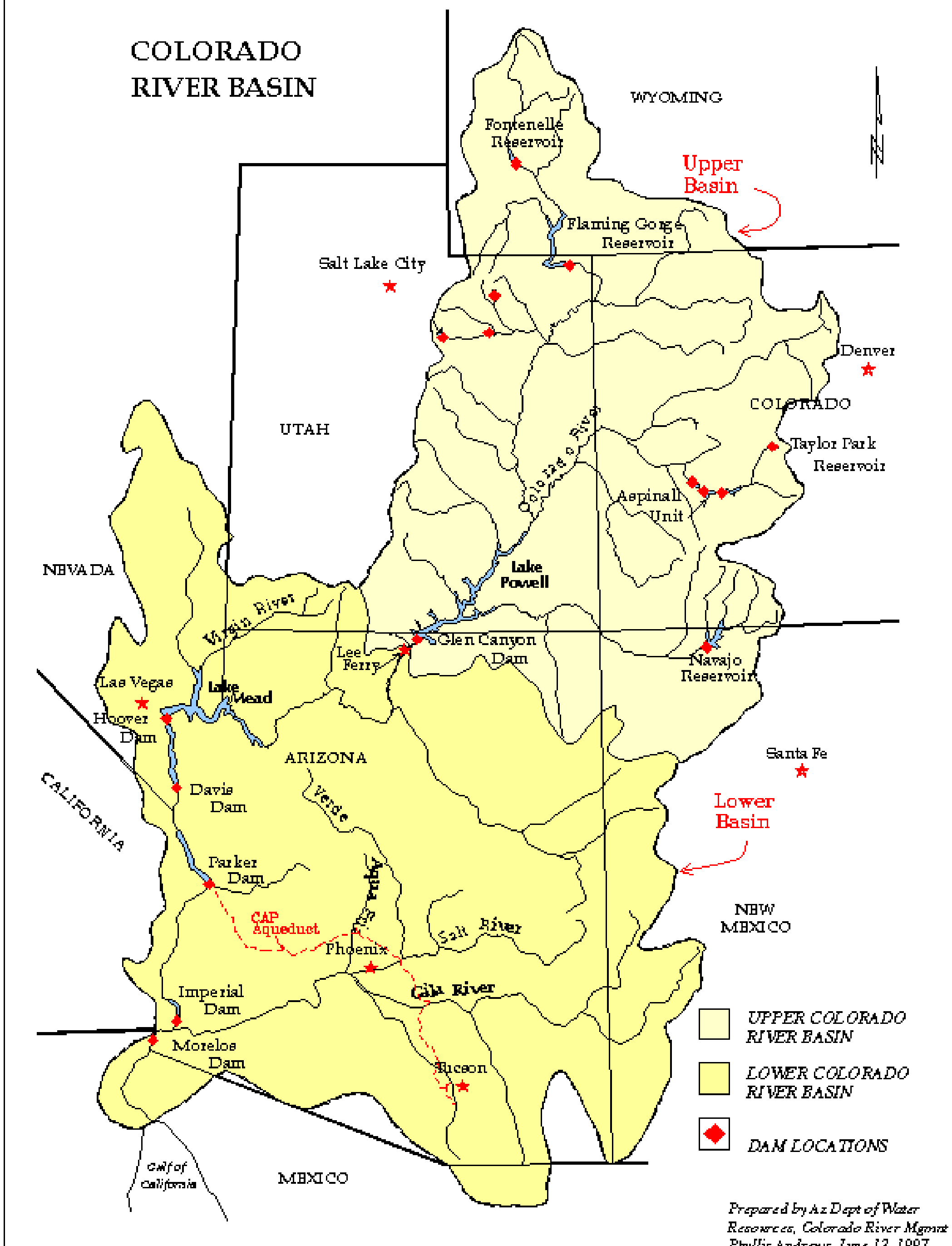


Sep 30, 2008



Jul 21, 2009

COLORADO RIVER BASIN



www.cefa.dri.edu/Westmap/

WestMap
Climate Analysis & Mapping Toolbox

TOOLBOX

Map & Graph
- Interactive Toolbox
- Tutorial
- Custom Requests

Climate 101
- Local Climate
- Educational Resources
- Climate Links

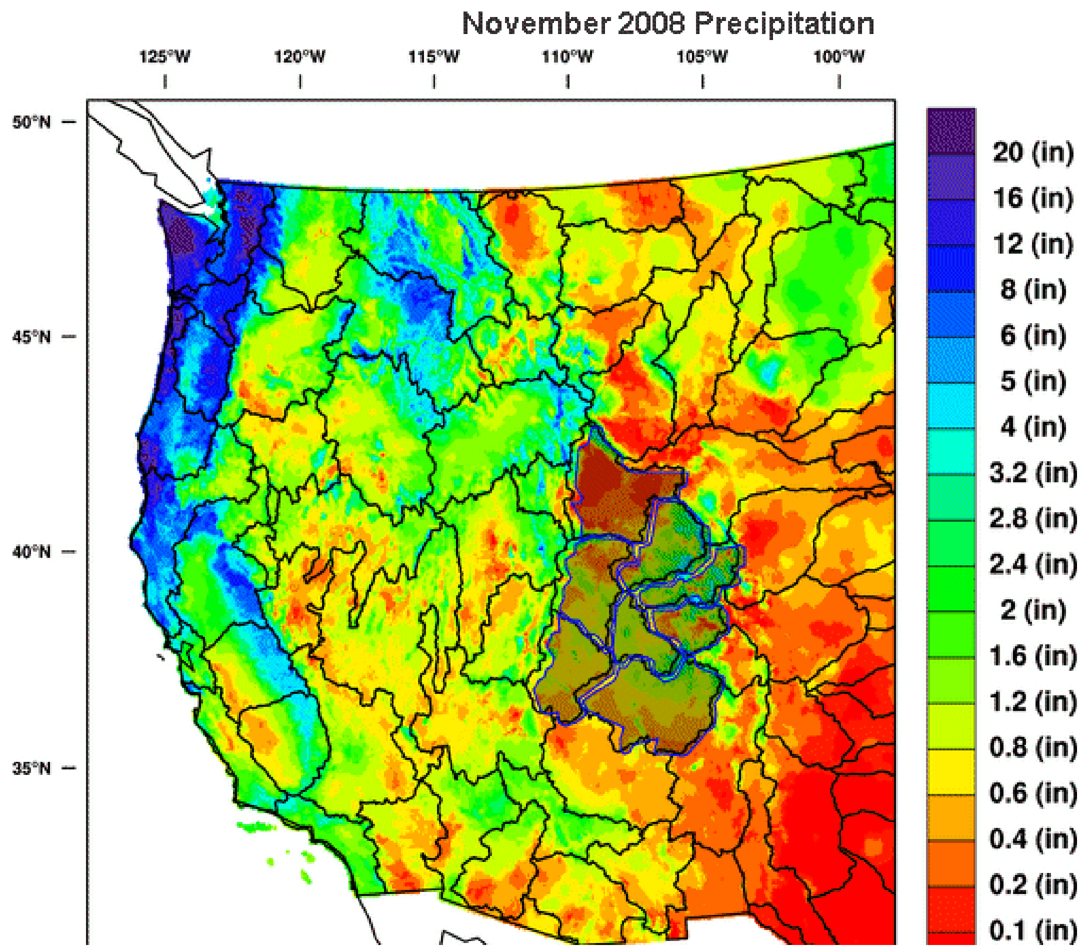
WestMap
- Overview
- About PRISM
- About Us

User Feedback
- Survey!
- Publications
- Applications

FAQs

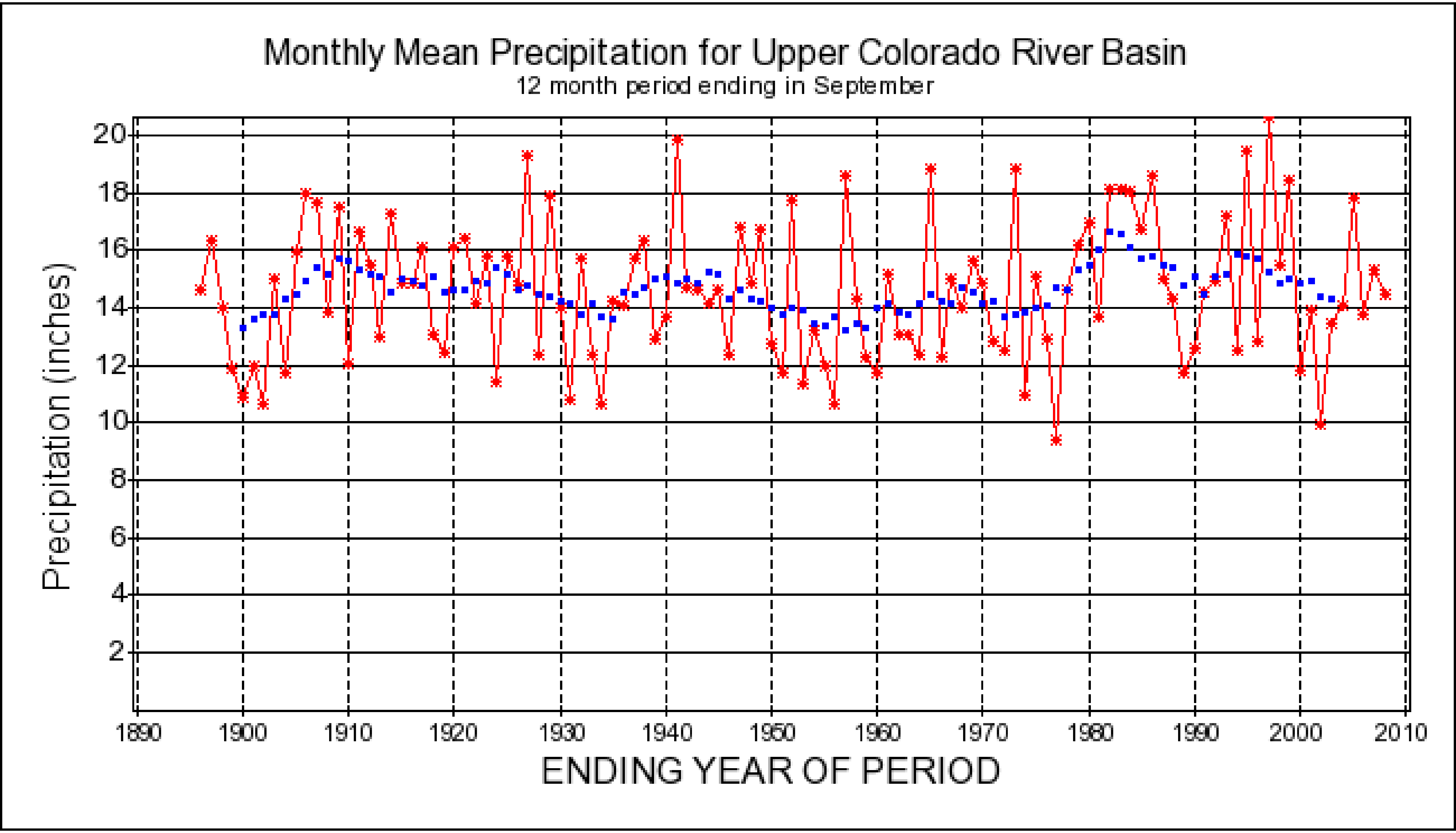
CONTENTS UNDER CONSTRUCTION

Select Element	Select Region By	Select Record	Map Click	Clear Selections
Precipitation	Hydro Units	Most Recent	Select Multiple Areas	Get Timeseries

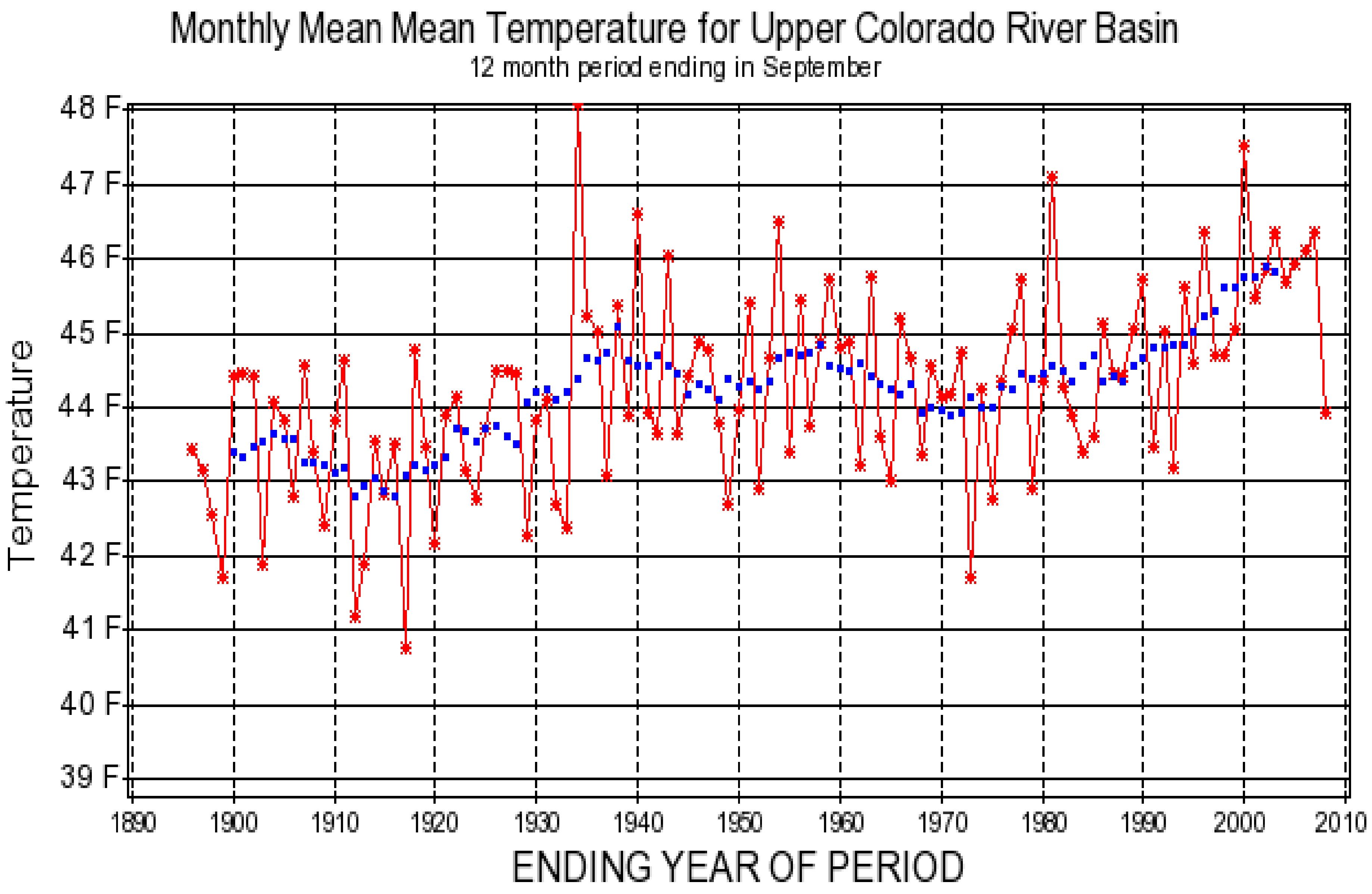


or, access via WRCC web "Projects" at www.wrcc.dri.edu

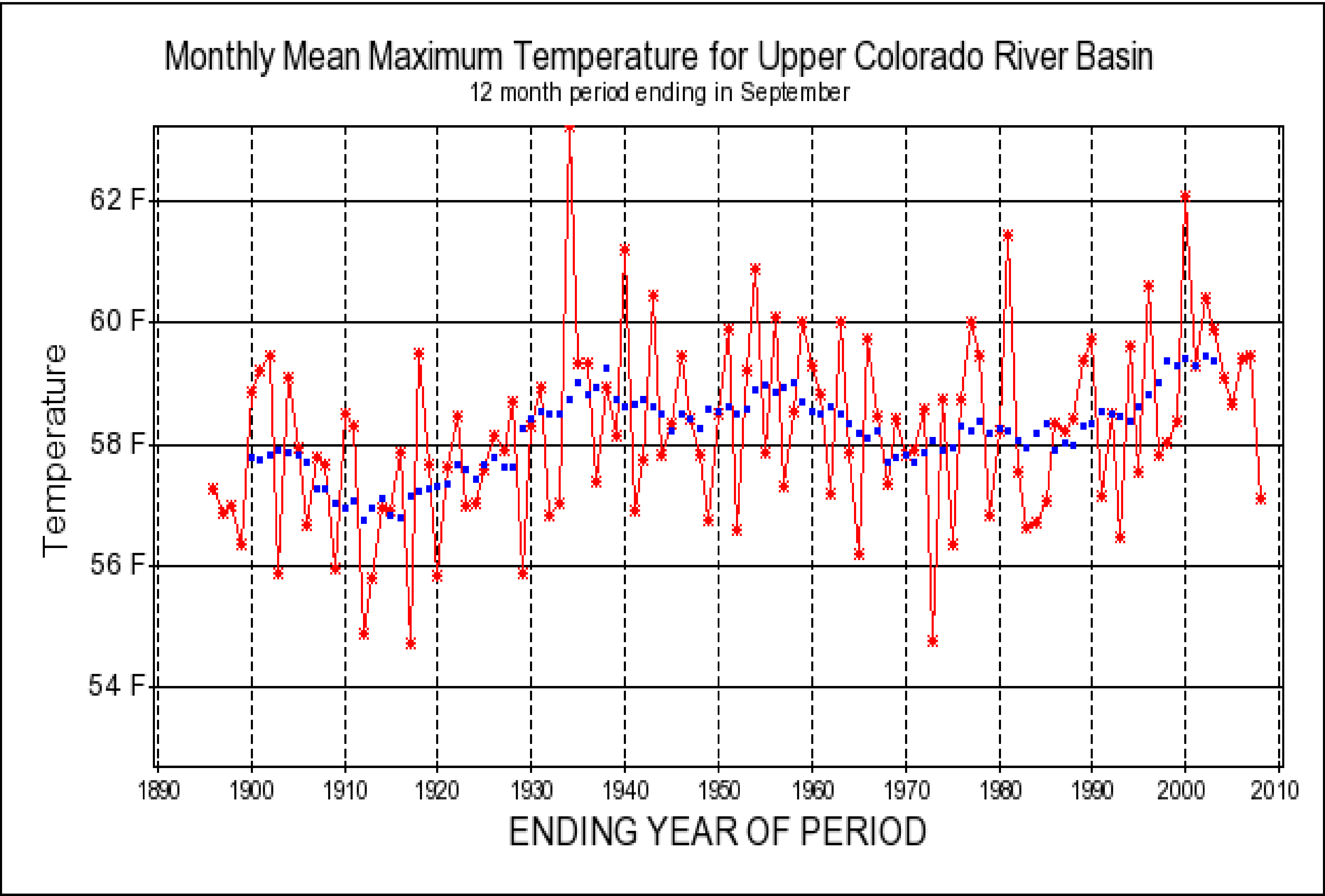
Water Year Precipitation (Oct-Sep) thru Sep 2008. Upper Colorado River Basin.



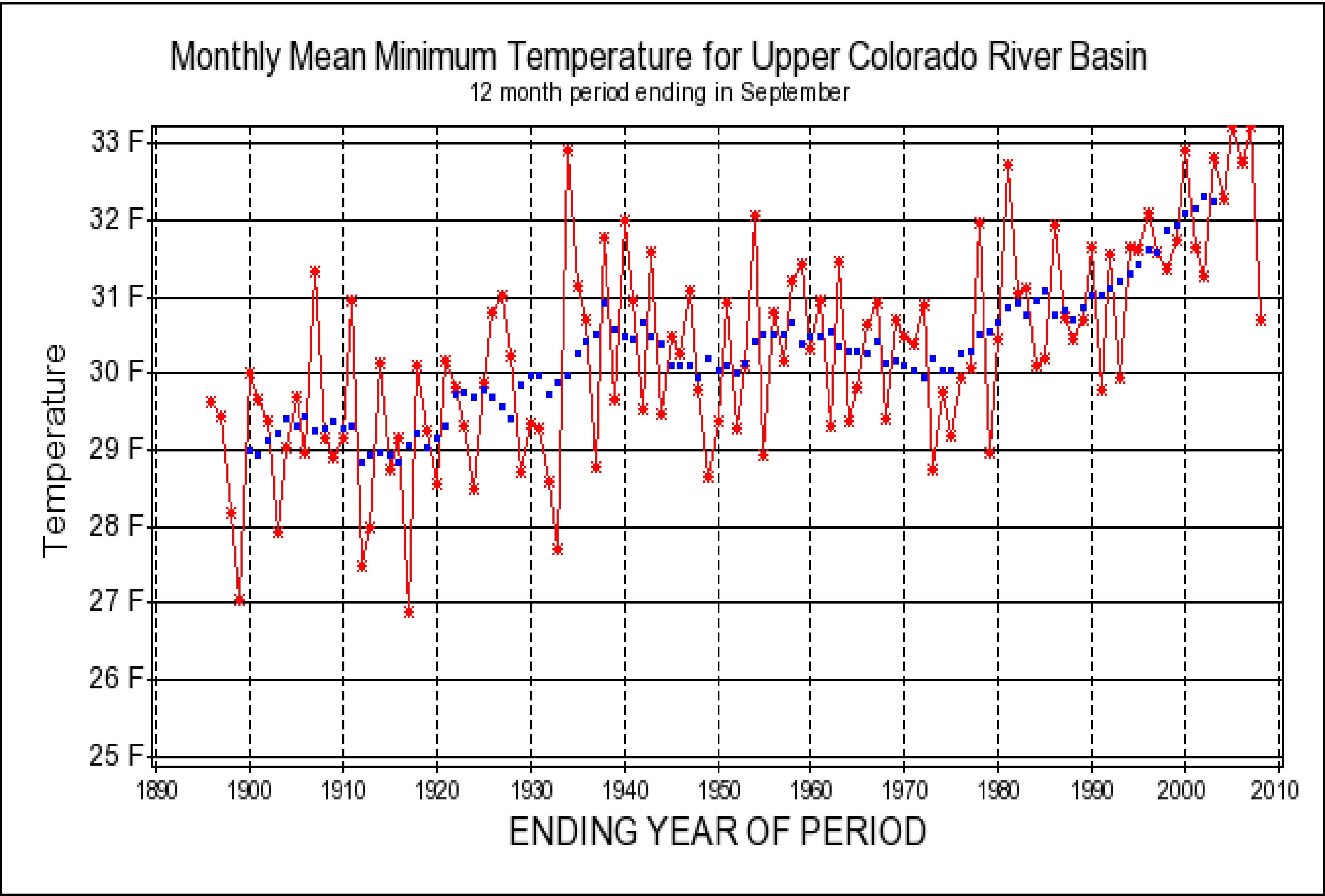
Water Year Mean Temperature (Oct-Sep) thru 2008. Upper Colorado River Basin.



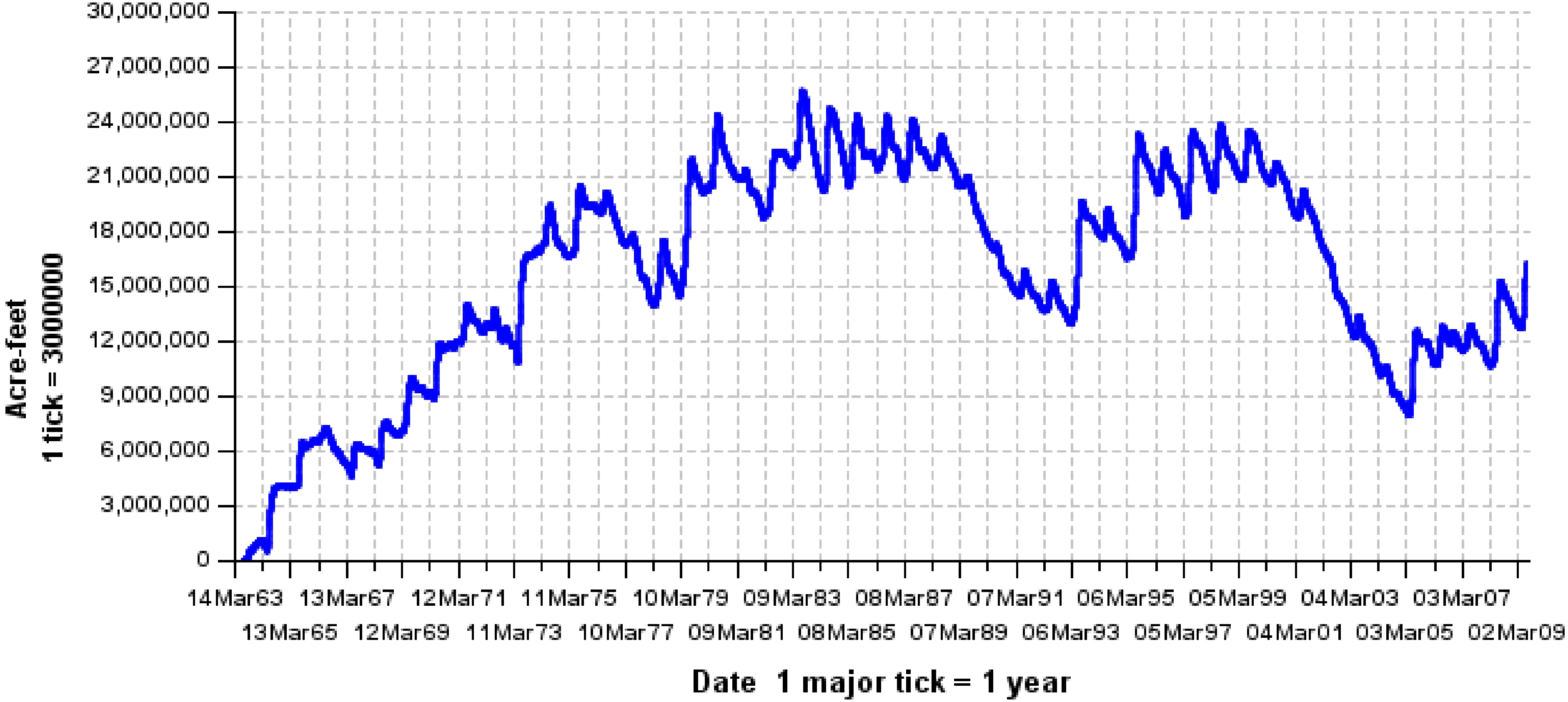
Water Year MAX Temperature (Oct-Sep) thru 2008. Upper Colorado River Basin.



Water Year MIN Temperature (Oct-Sep) thru 2008. Upper Colorado River Basin.



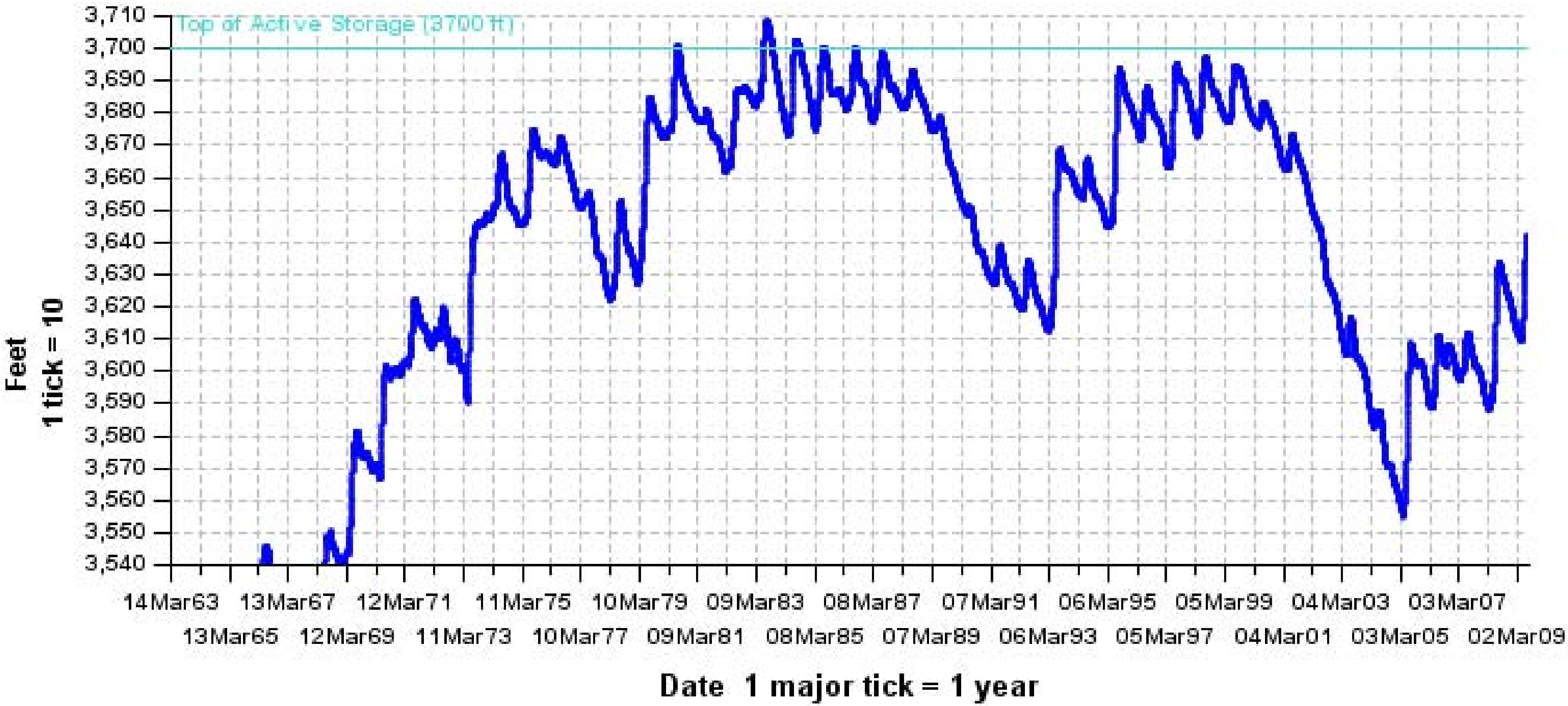
Lake Powell Storage Through July 23, 2009



As of 23 July 2009: 67 % full **(capacity 24.17 MAF)**

Minimum: 33 % full on April 8, 2005

Lake Powell Elevation Through July 23, 2009

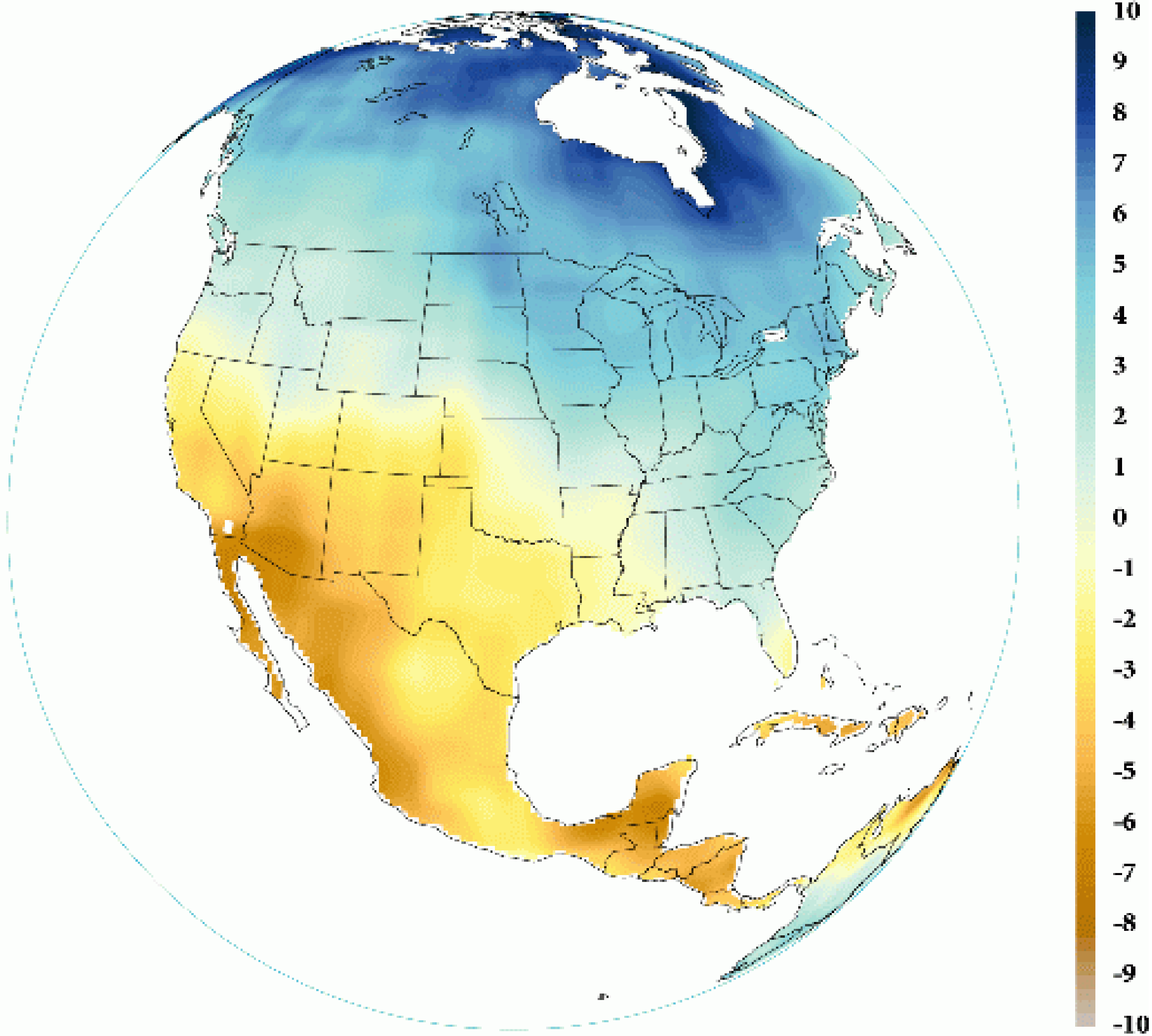


Water level on July 23, 2009 was 3641.76 ft, - 58 ft below full.
Minimum level on April 8, 2005 was 3555 ft, -145 ft below full.
Source: www.usbr.gov/uc/water/index.htl

Lake Mead, October 2007

Photo by Ken Dewey

Projected Change in Precipitation 1950-2000 to 2021-2040
(Percent of 1950-2000)

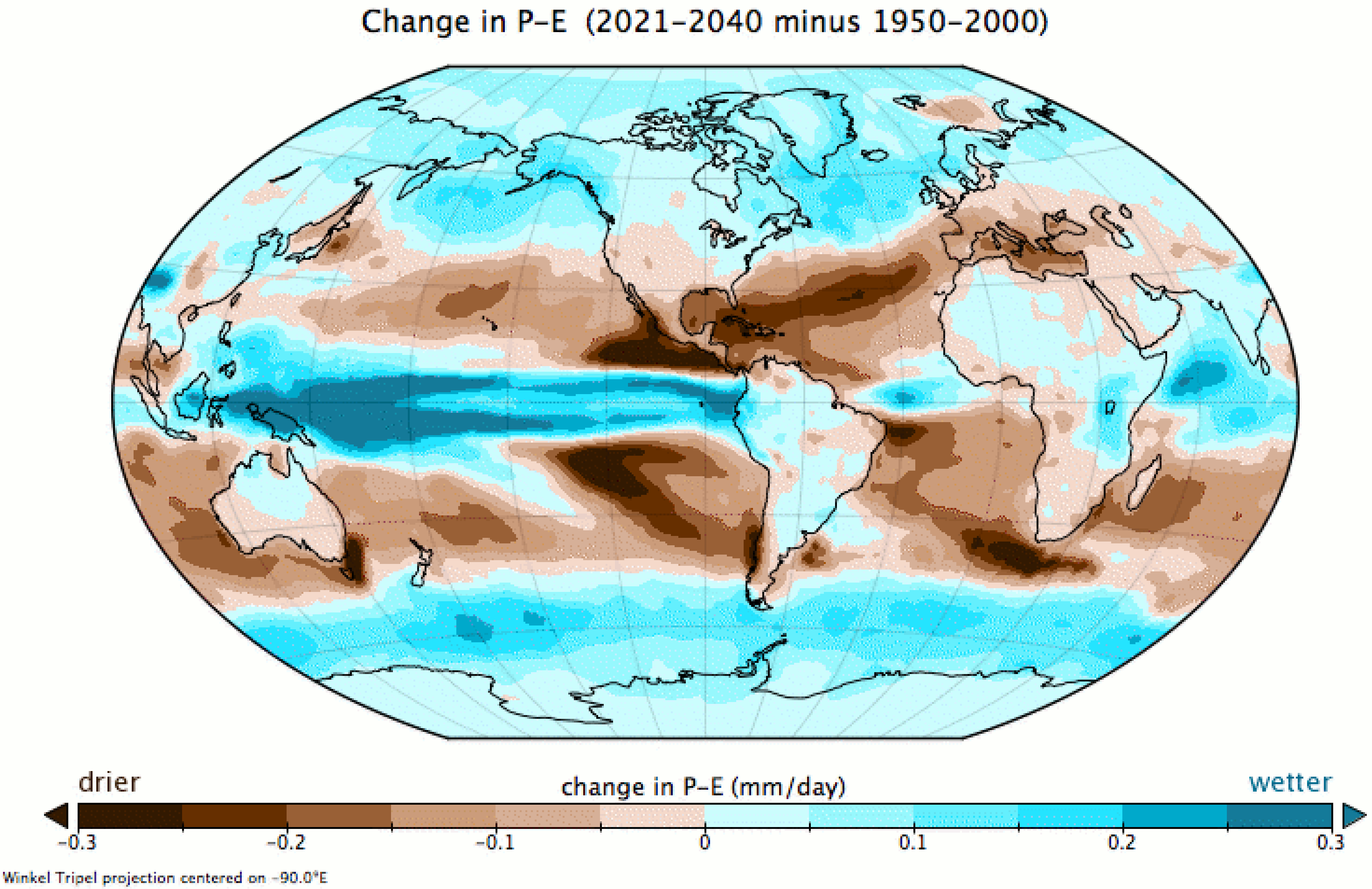


Average of 19 climate models. 2007.

Figure by Gabriel Vecchi.

www.ldeo.columbia.edu/res/div/ocp/drought/science.shtml

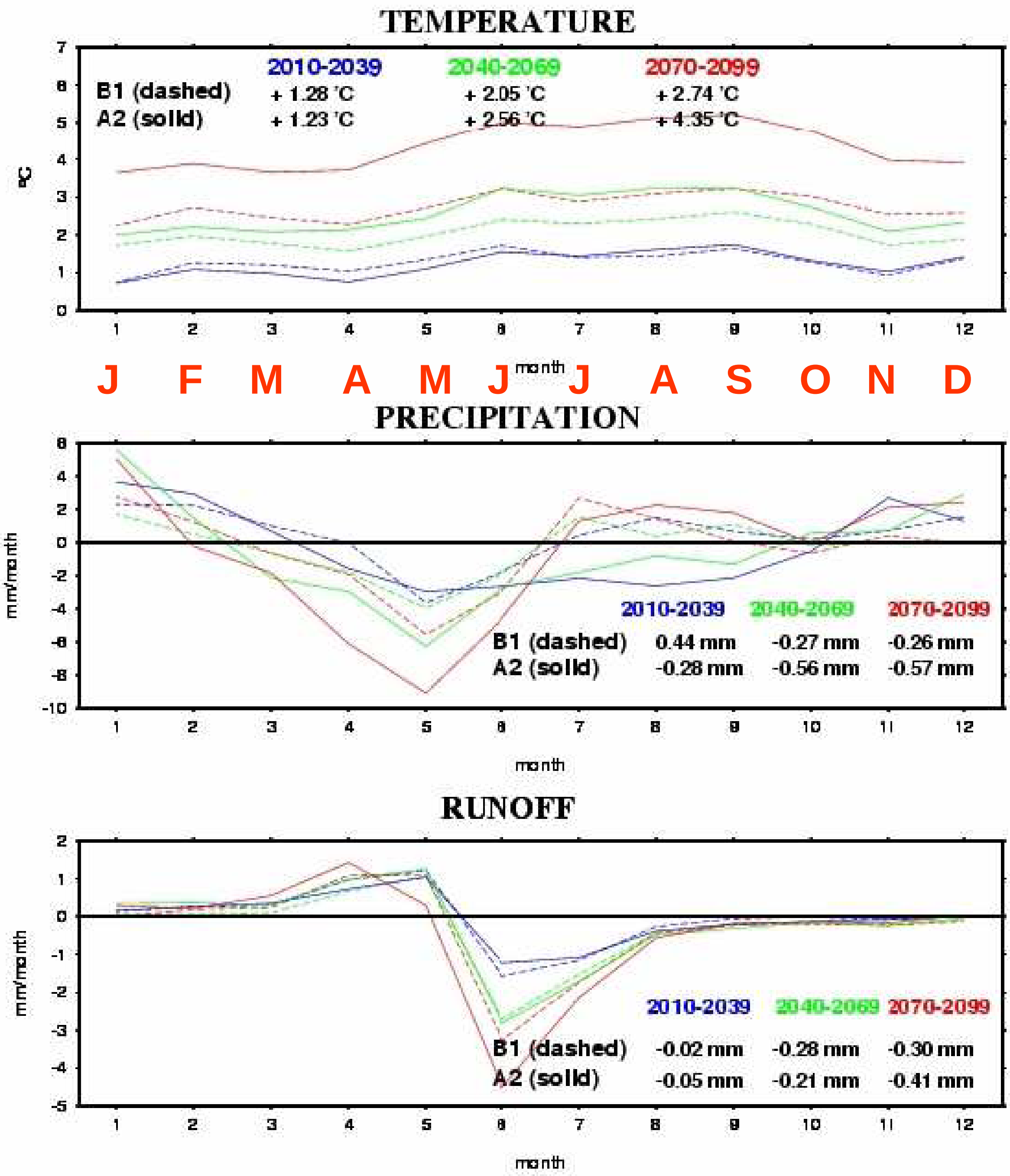
R. Seager, M.F. Ting, I.M. Held, Y. Kushnir, J. Lu, G. Vecchi, H.-P. Huang, N. Harnik, A. Leetmaa, N.-C. Lau, C. Li, J. Velez, N. Naik, 2007. Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America. *Science*, DOI: 10.1126/science.1139601



Seager et al, 2007. Average of 19 climate models. Figure by Naomi Naik.

www.ldeo.columbia.edu/res/div/ocp/drought/science.shtml

GCMs AVERAGE DEPARTURES FROM 1950-1999 MEAN



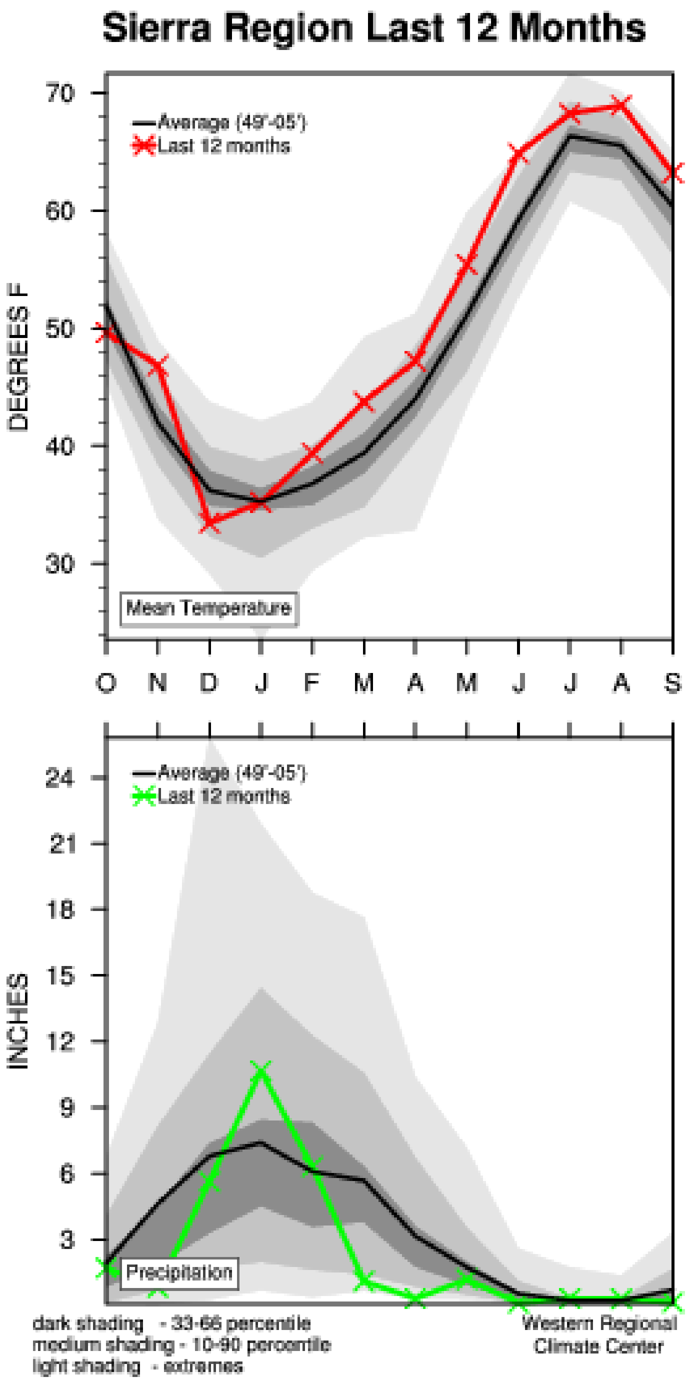
11-Model Consensus
2 Scenarios

Colorado River Basin

By Month

3 Future Periods

From Christensen and Lettenmaier, in review, 2007



Sierra Nevada

Winter of 2007-2008

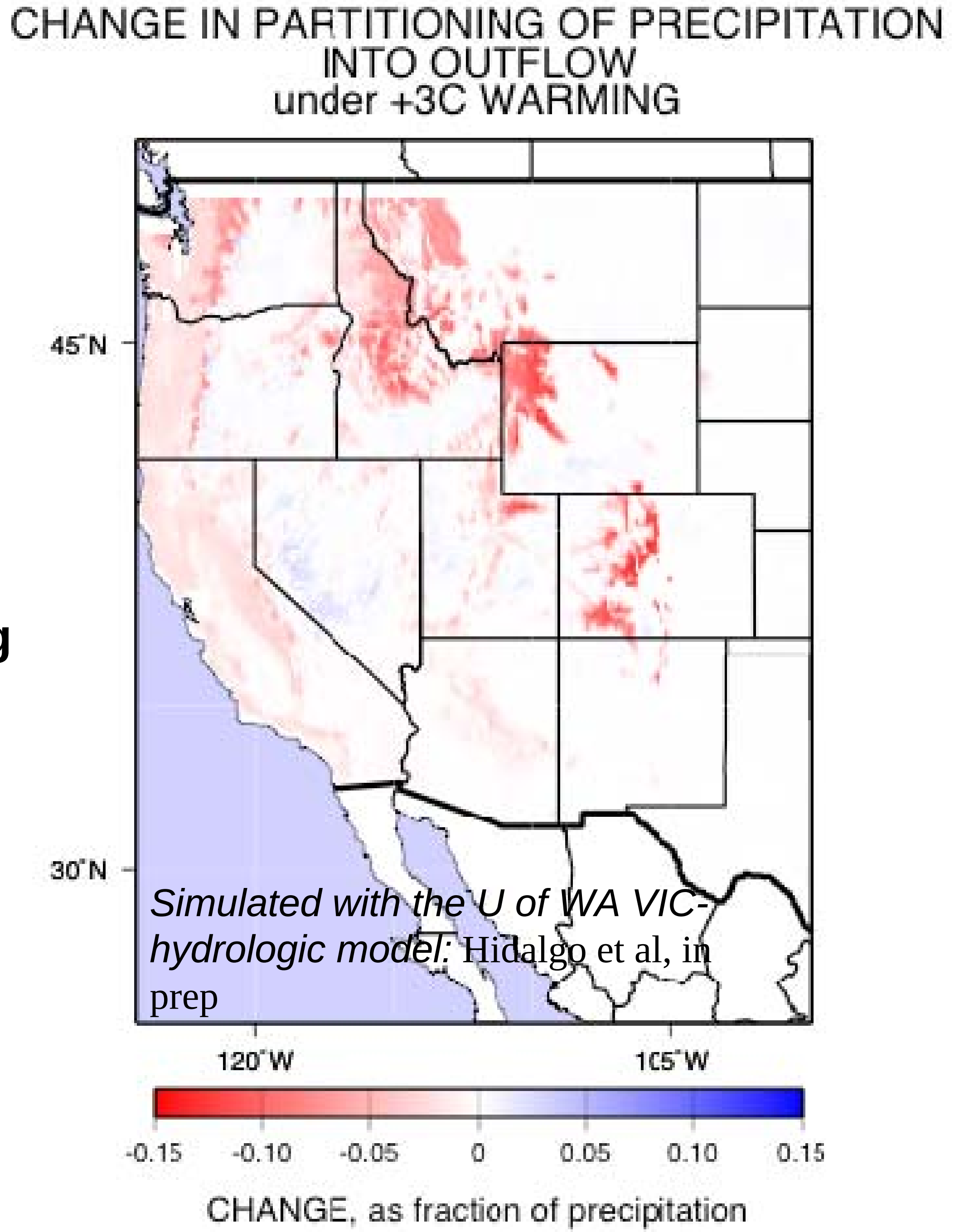
A potential analog for climate change ???

Mike Dettinger, Sam Earman, Hugo Hidalgo, Dan Cayan

Exploration of runoff, and recharge sensitivity to climate warming.

??? A Looming Issue ???

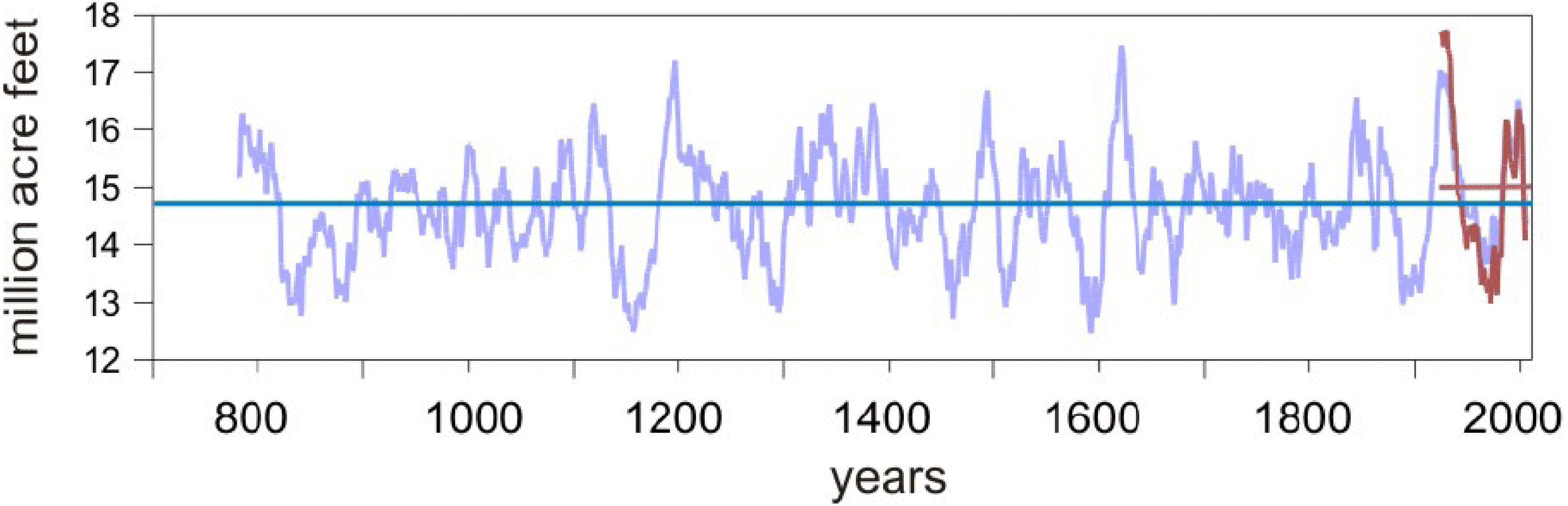
SIMULATED CHANGES IN RUNOFF+RECHARGE with a uniform +3ºC warming



Simulated with the U of WA VIC-hydrologic model: Hidalgo et al, in prep

Lessons from History.

Colorado River Flow. Lees Ferry. Reconstructed 762 thru 2005 A.D.



Red: Gauged record.
Blue: Reconstructed record.
20-Year moving averages.

Meko, D.M., C.A. Woodhouse, C.H. Baisan, T. Knight, J.J. Lukas, M.K. Hughes, and M.W. Salzer, 2007.
Medieval drought in the upper Colorado River basin.
Geophysical Research Letters 34m L10705, doi: 10.1029/2007GL029988

?

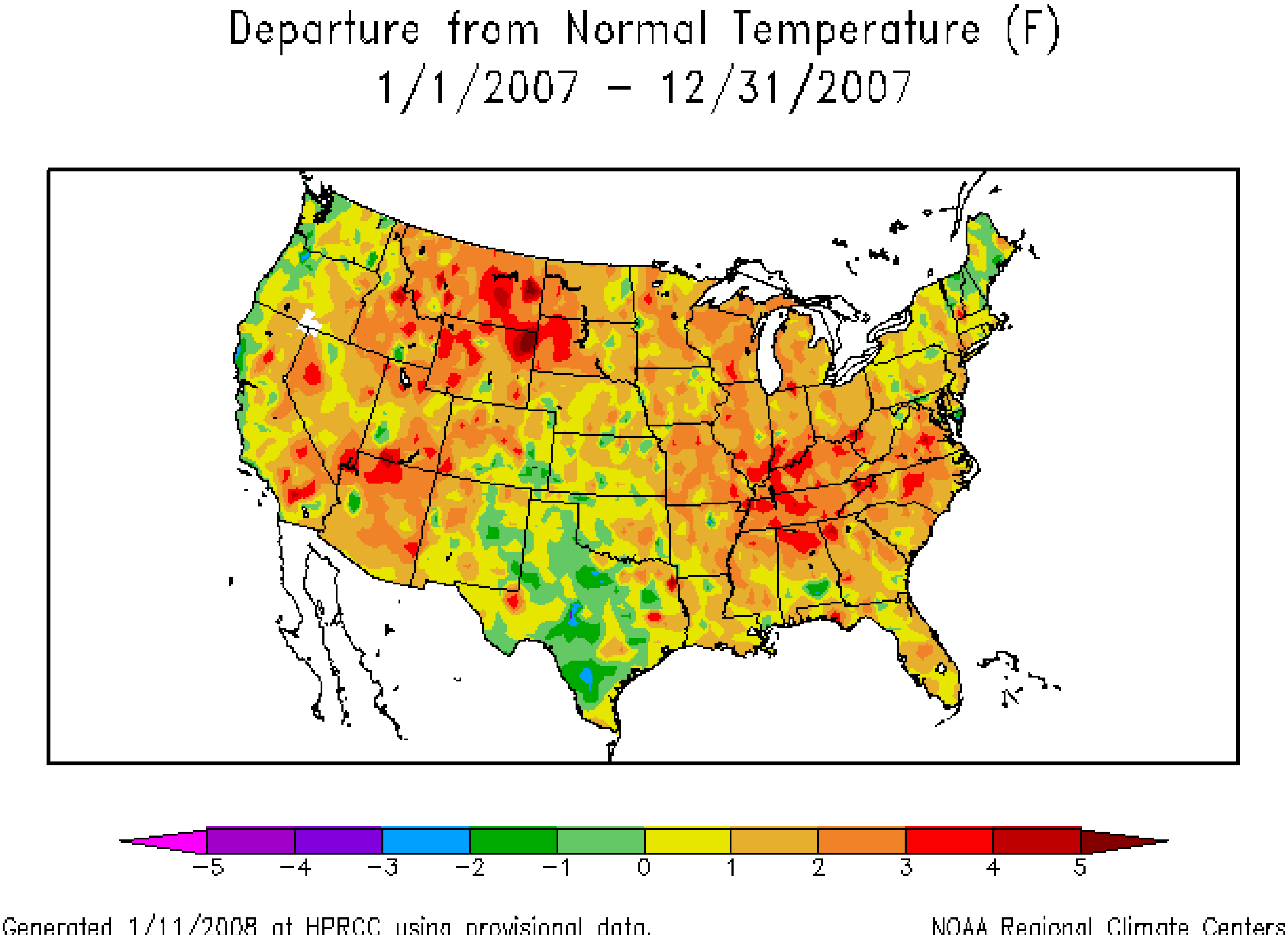
Is the current Southwest drought a once-or-twice-a-century drought like those of the past 500 years …

? … or … ?

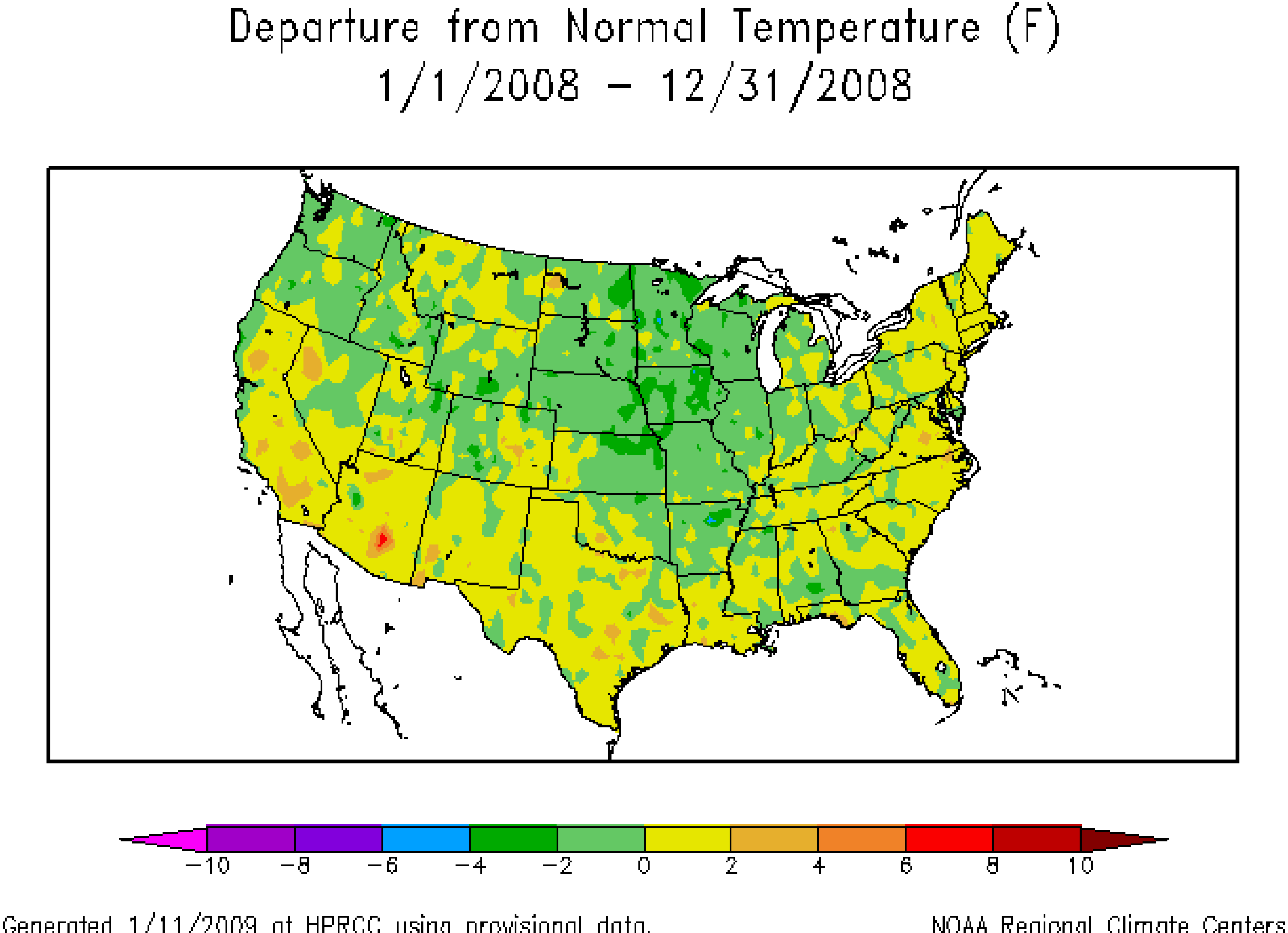
a harbinger of things to come, a different type of drought that we have not observed before ?

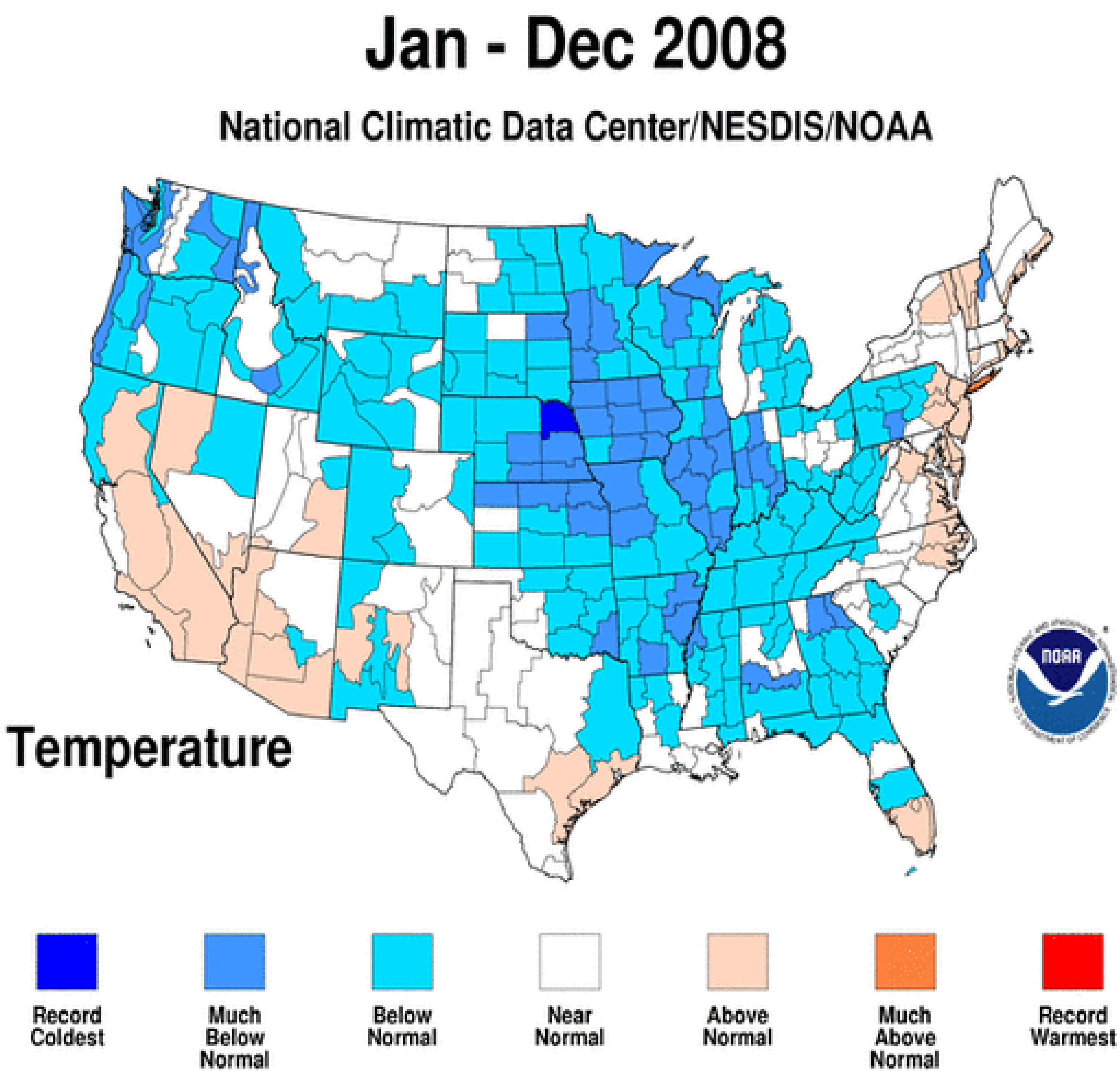
?

Annual Mean Temperature Departure 2007



Annual Mean Temperature Departure 2008





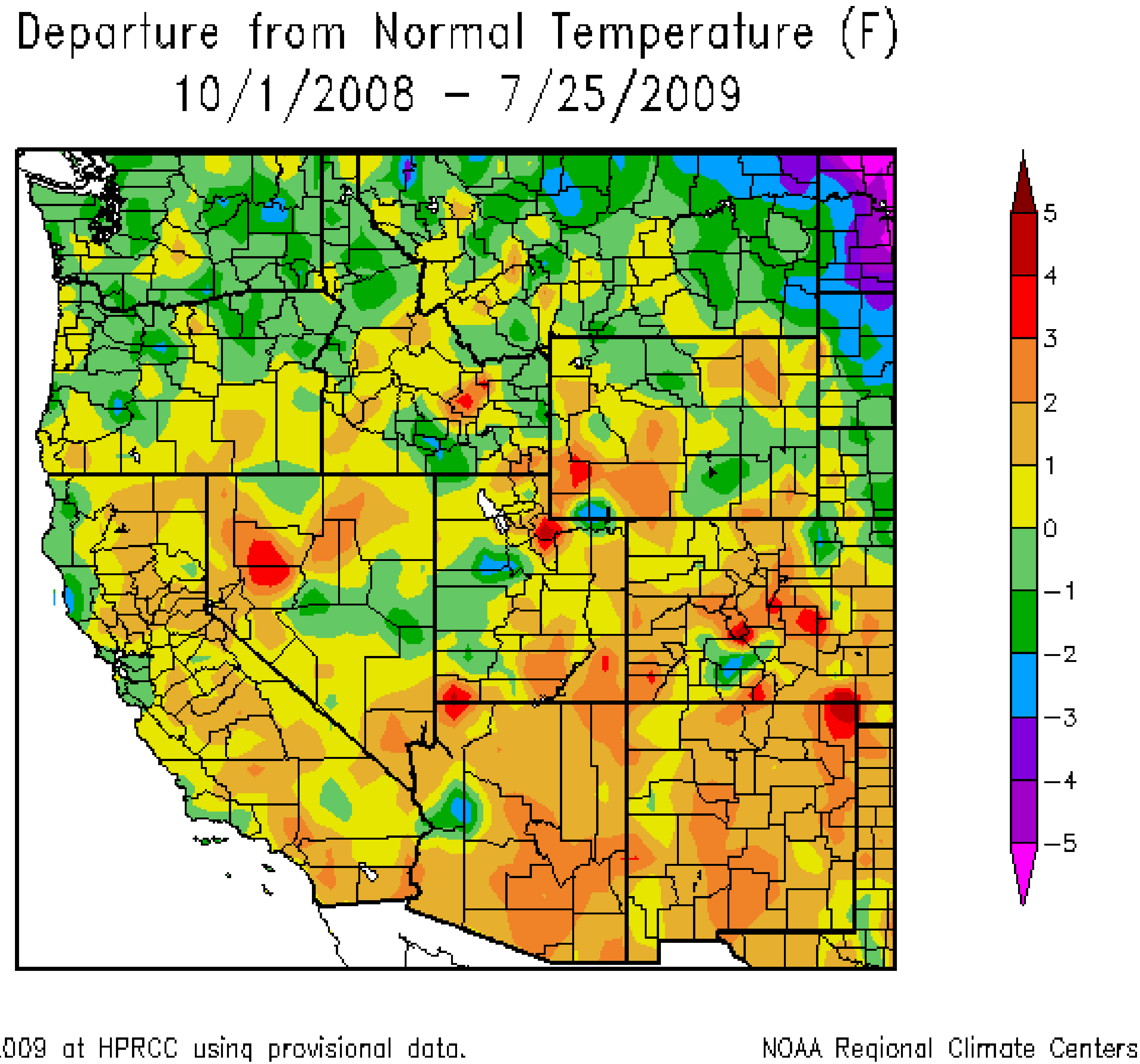
2008

Relative

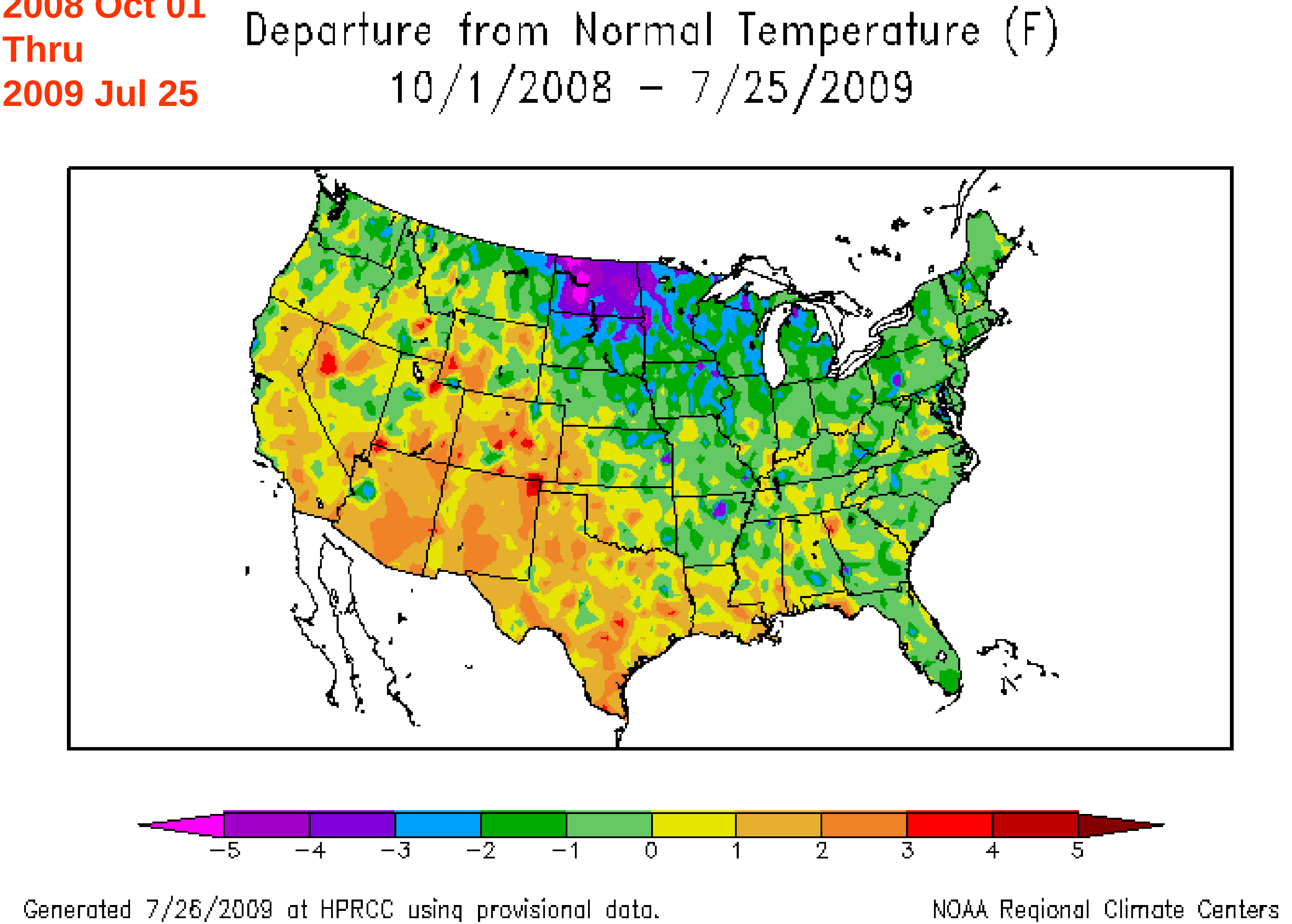
Warmth or Coolth

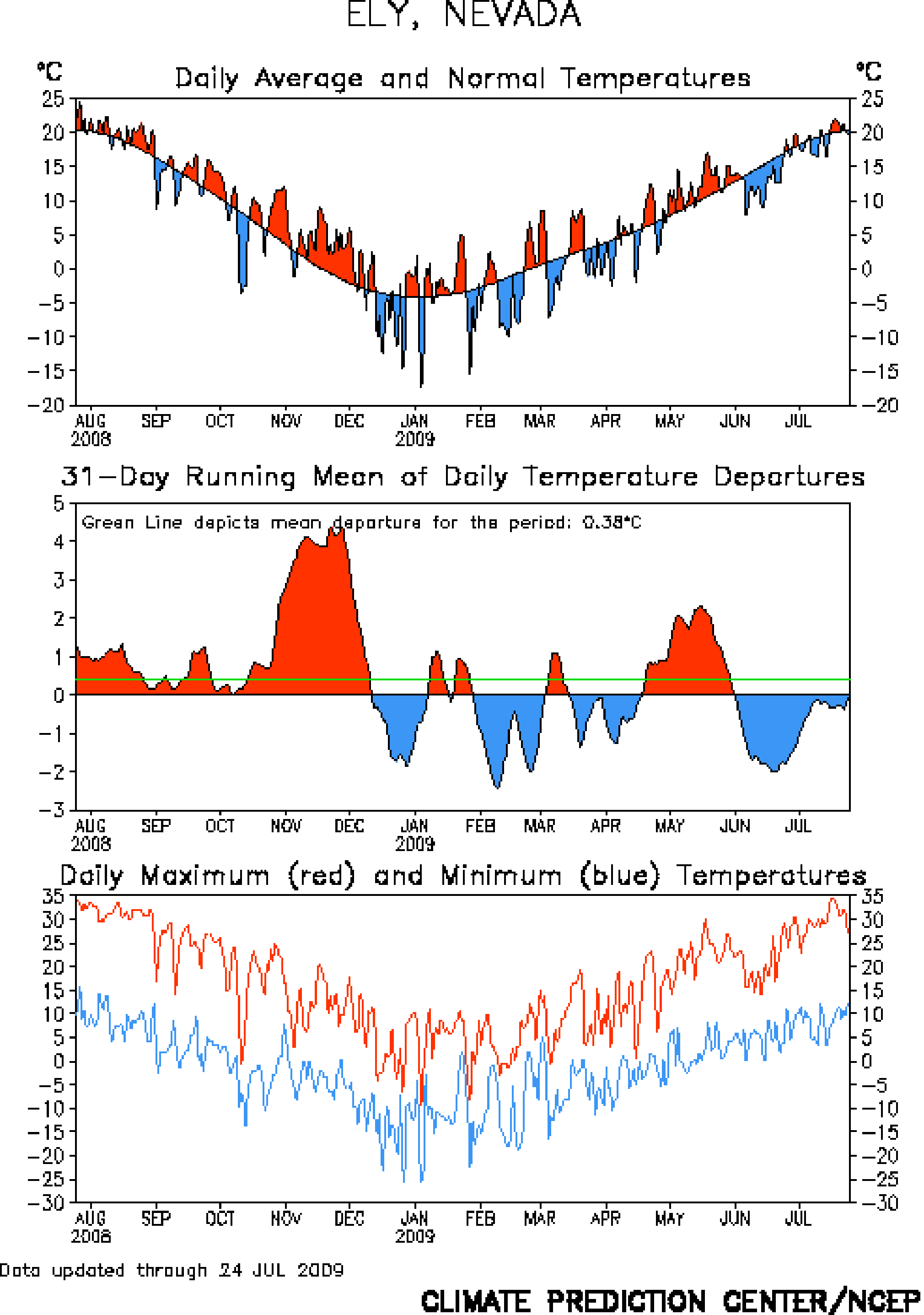
National Climatic Data Center

Water Year
2008 Oct 01
Thru
2009 Jul 25



Water Year
2008 Oct 01
Thru
2009 Jul 25

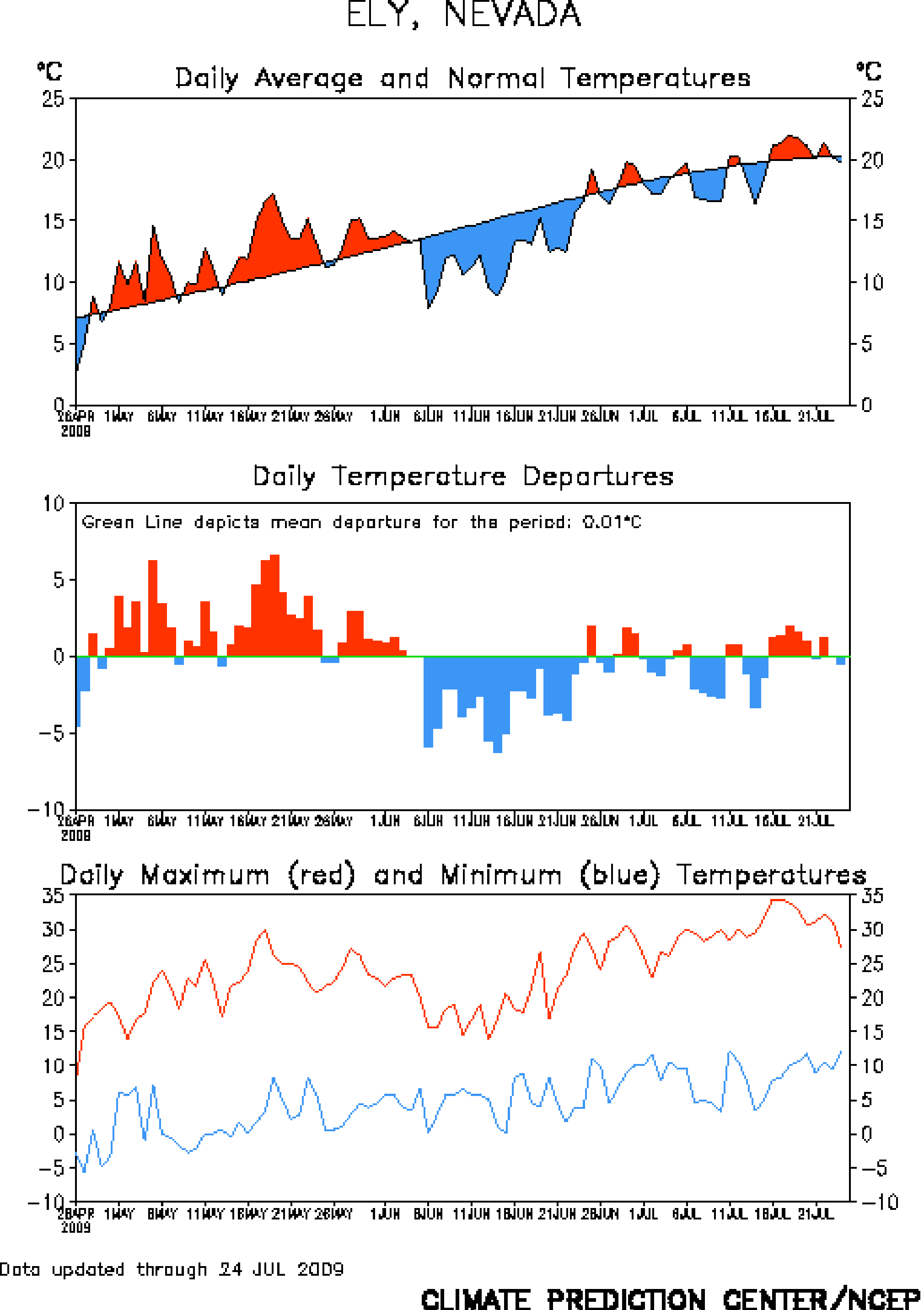




Ely Nevada

Temperature Departures

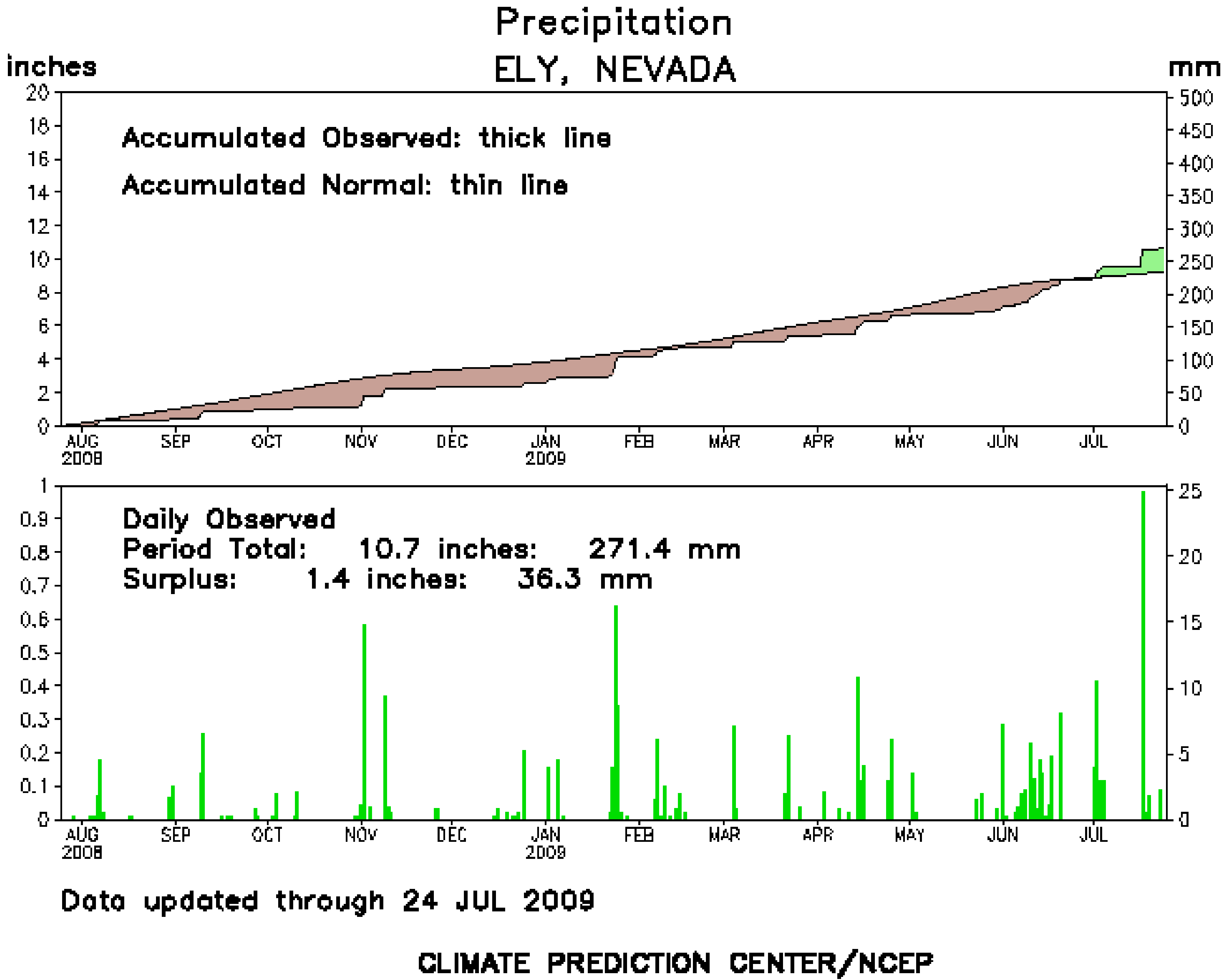
365 Days ending 24 July 2009



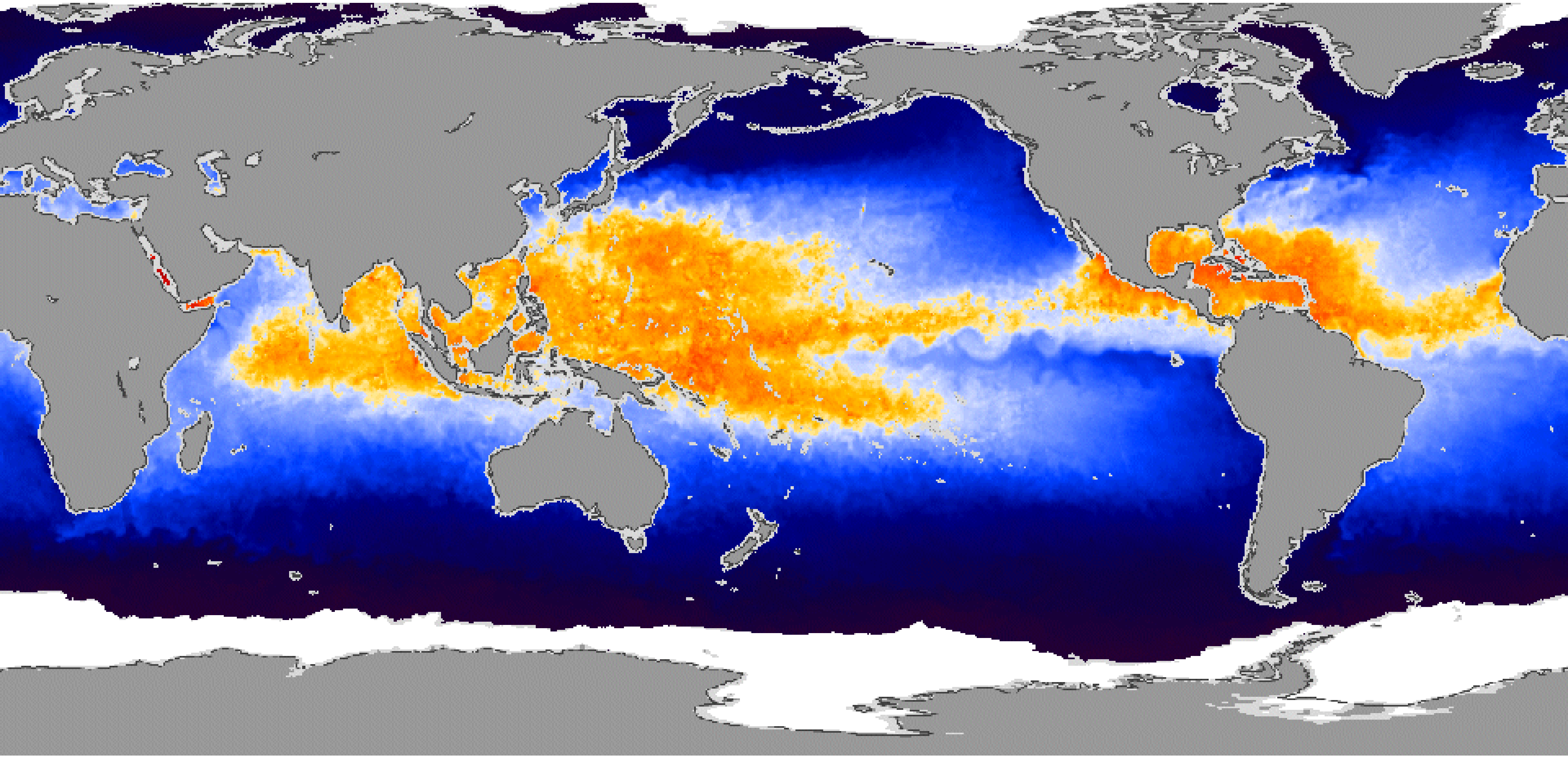
Ely Nevada

Temperature Departures

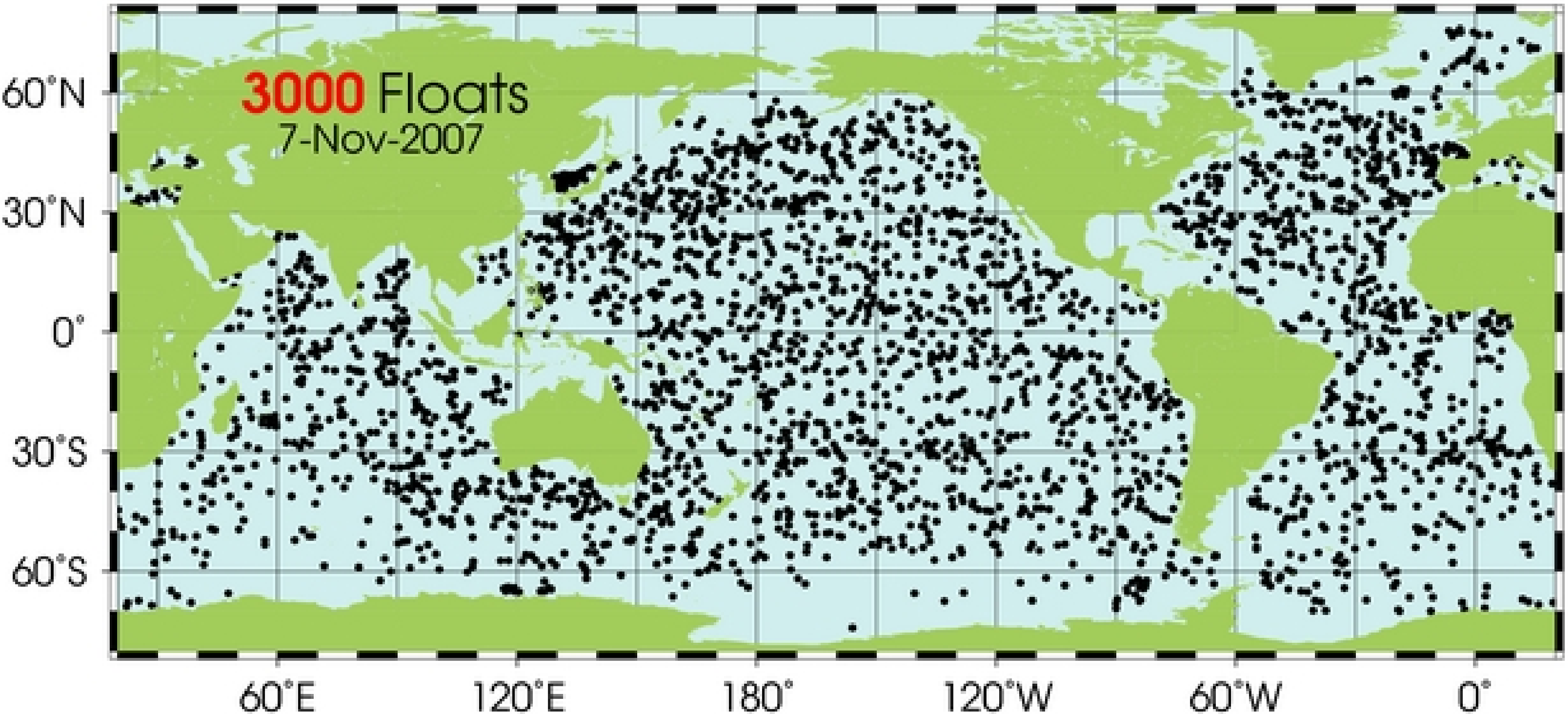
90 Days ending
24 July 2009

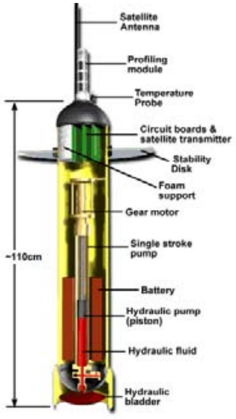

Precipitation
ELY, NEVADA
inches
mm
Accumulated Observed: thick line
Accumulated Normal: thin line
0
2
4
6
8
10
12
14
16
18
20
0
50
100
150
200
250
300
350
400
450
500
AUG 2008
SEP
OCT
NOV
DEC
JAN 2009
FEB
MAR
APR
MAY
JUN
JUL
Daily Observed
Period Total: 10.7 inches: 271.4 mm
Surplus: 1.4 inches: 36.3 mm
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
5
10
15
20
25
AUG 2008
SEP
OCT
NOV
DEC
JAN 2009
FEB
MAR
APR
MAY
JUN
JUL
Data updated through 24 JUL 2009
CLIMATE PREDICTION CENTER/NCEP

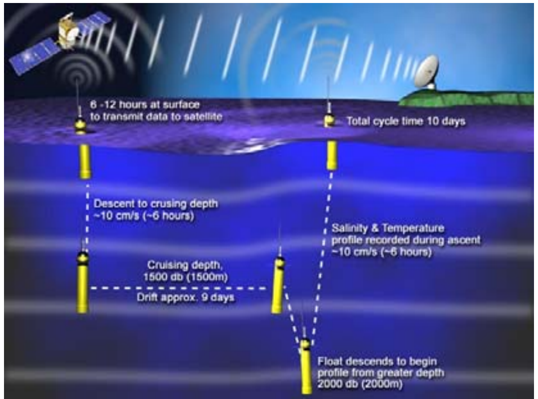
The World's Warm Oceans

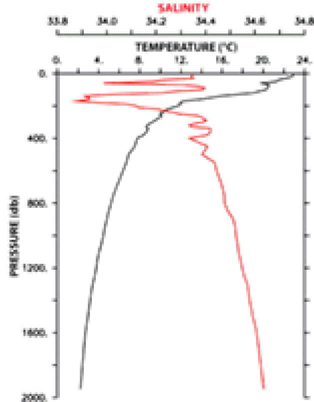


2007 November. 3000-th Argo float deployed.

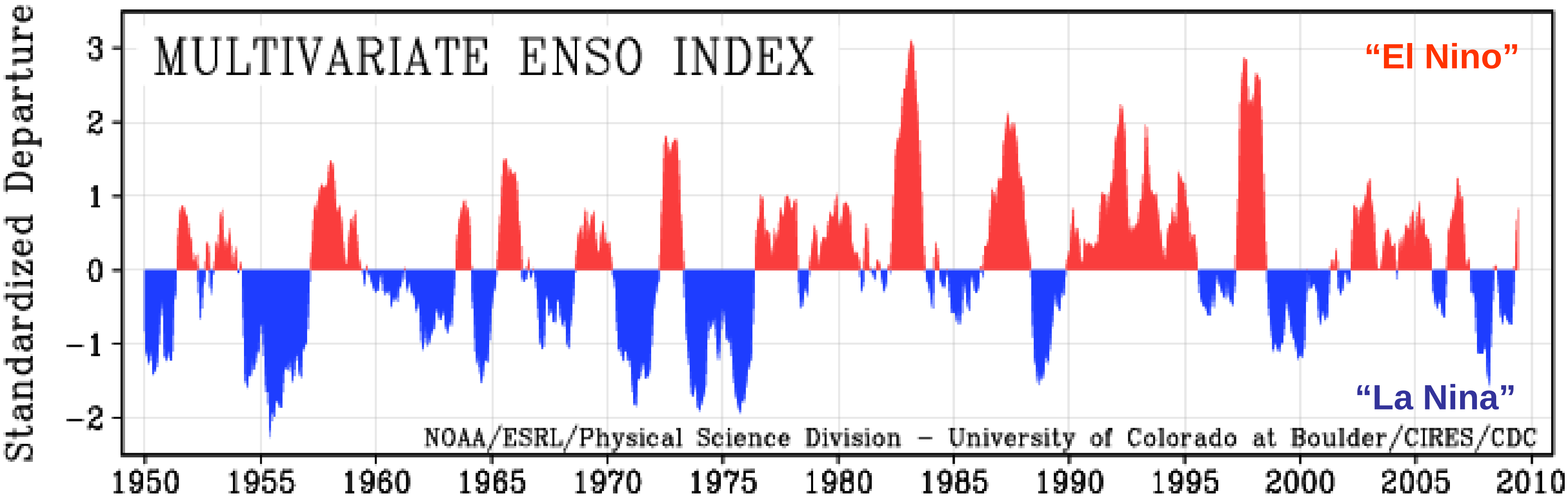






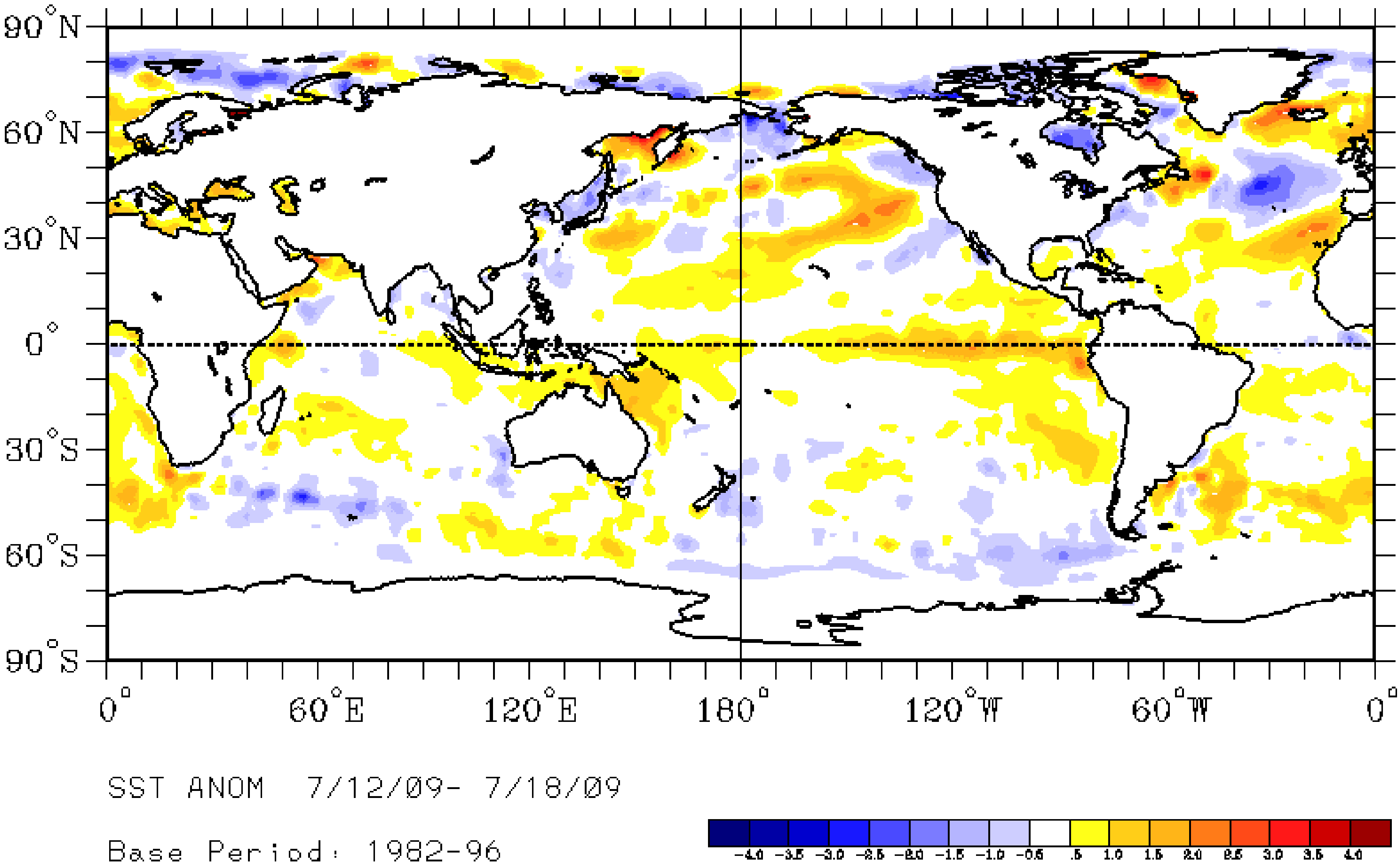


Through June 2009



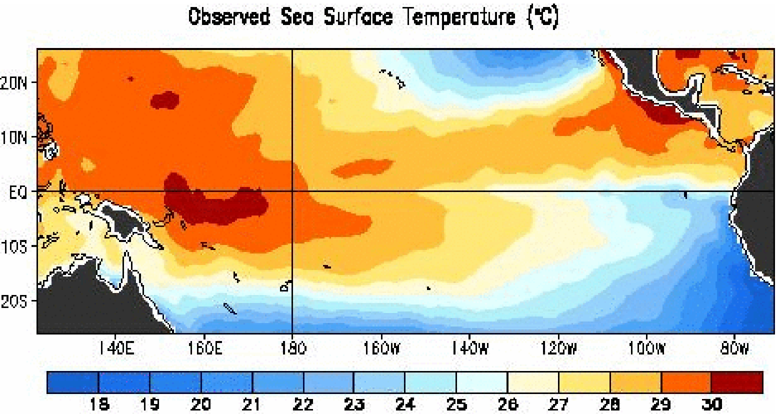
NOAA ESRL ("CDC"), Wolter and Timlin

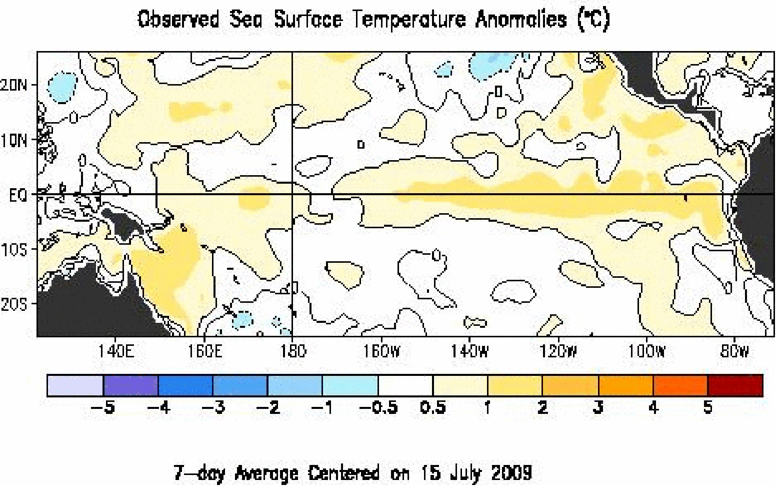
Global Sea Surface Temperature Anomalies (C) 2009 July 12-18

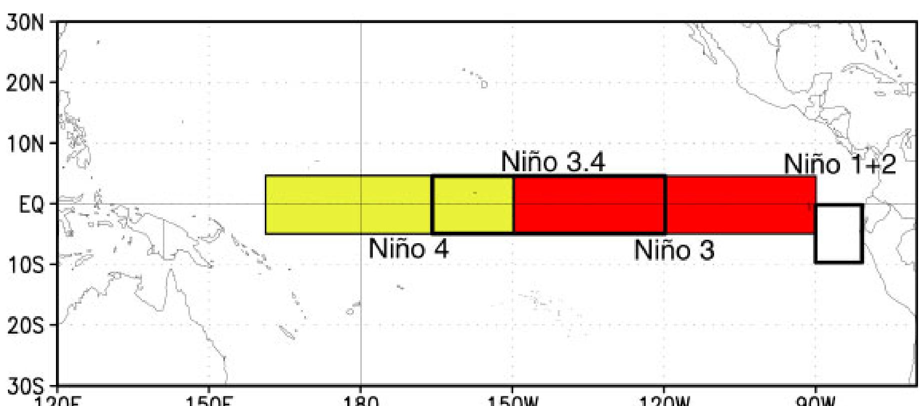


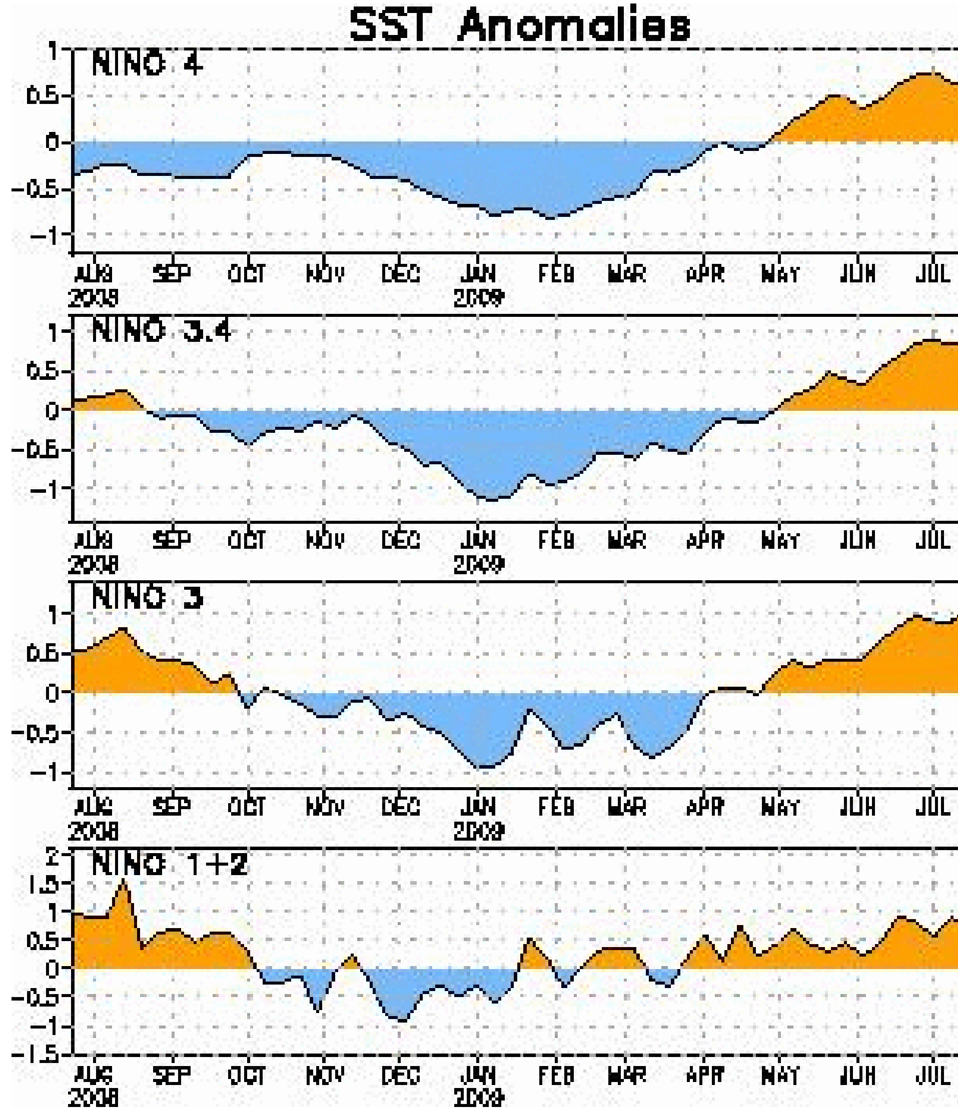
NOAA ESRL (“CDC”)

Recent Evolution of Equatorial Pacific SST Departures

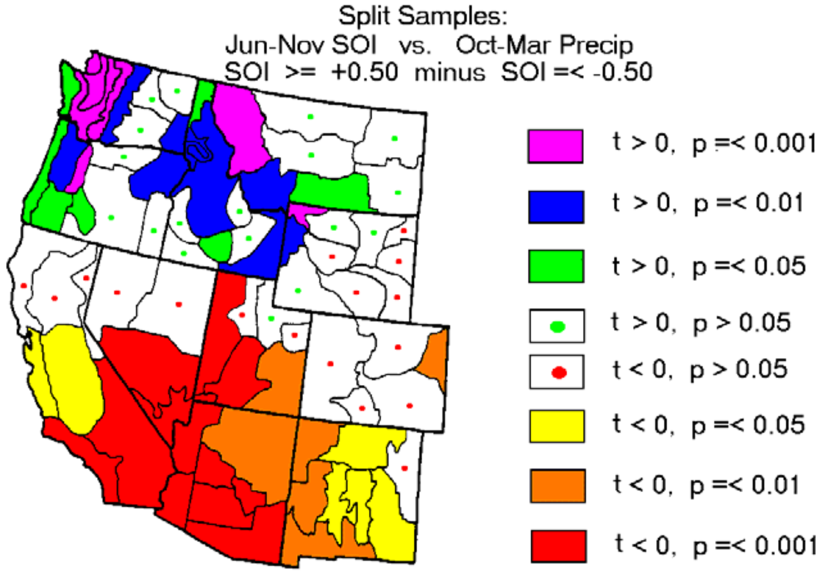








Updated through 2009 July 12-18

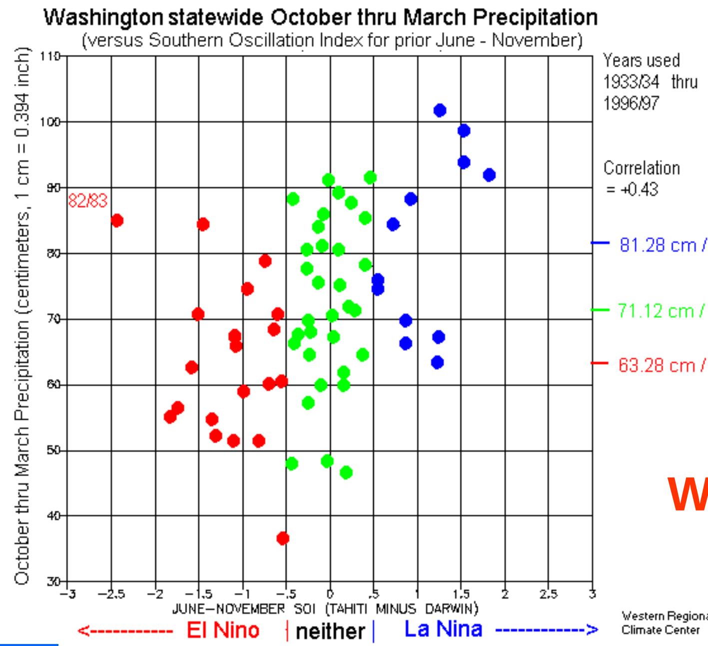


Updated from Redmond and Koch (1991). Winters of 1933/34 - 1994/95.
Reddish: Composite El Nino winters are wet, La Nina winters are dry.
Bluish/greenish: Composite El Nino winters are dry, La Nina winters are wet.

Redmond, K.T., and R.W. Koch, 1991. Surface climate and streamflow variability in the western United States and their relationship to large-scale circulation indices. Water Resources Research, 27(9), 2381-2399.

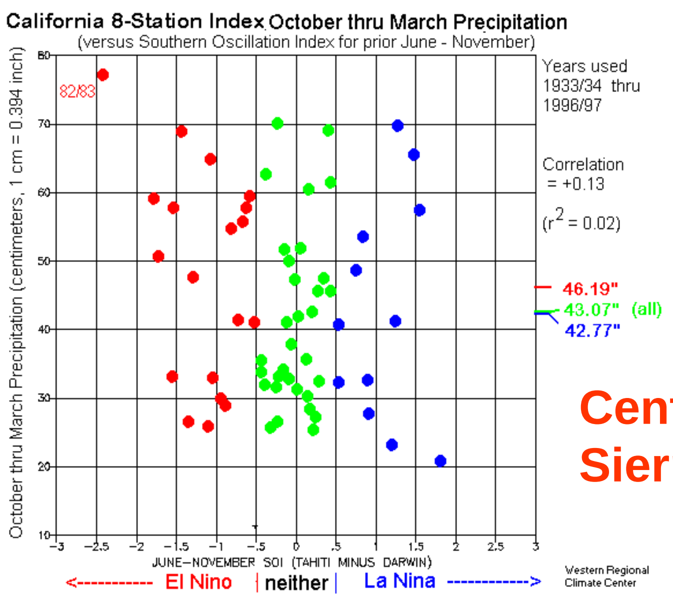
Redmond & Koch, 1991, updated.

Redmond & Koch, 1991, updated.

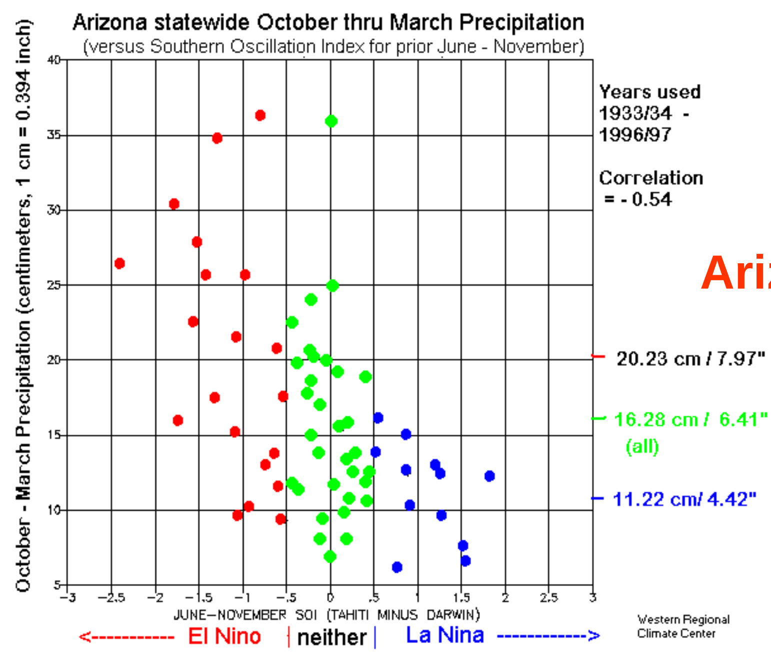


Washington

ENSO



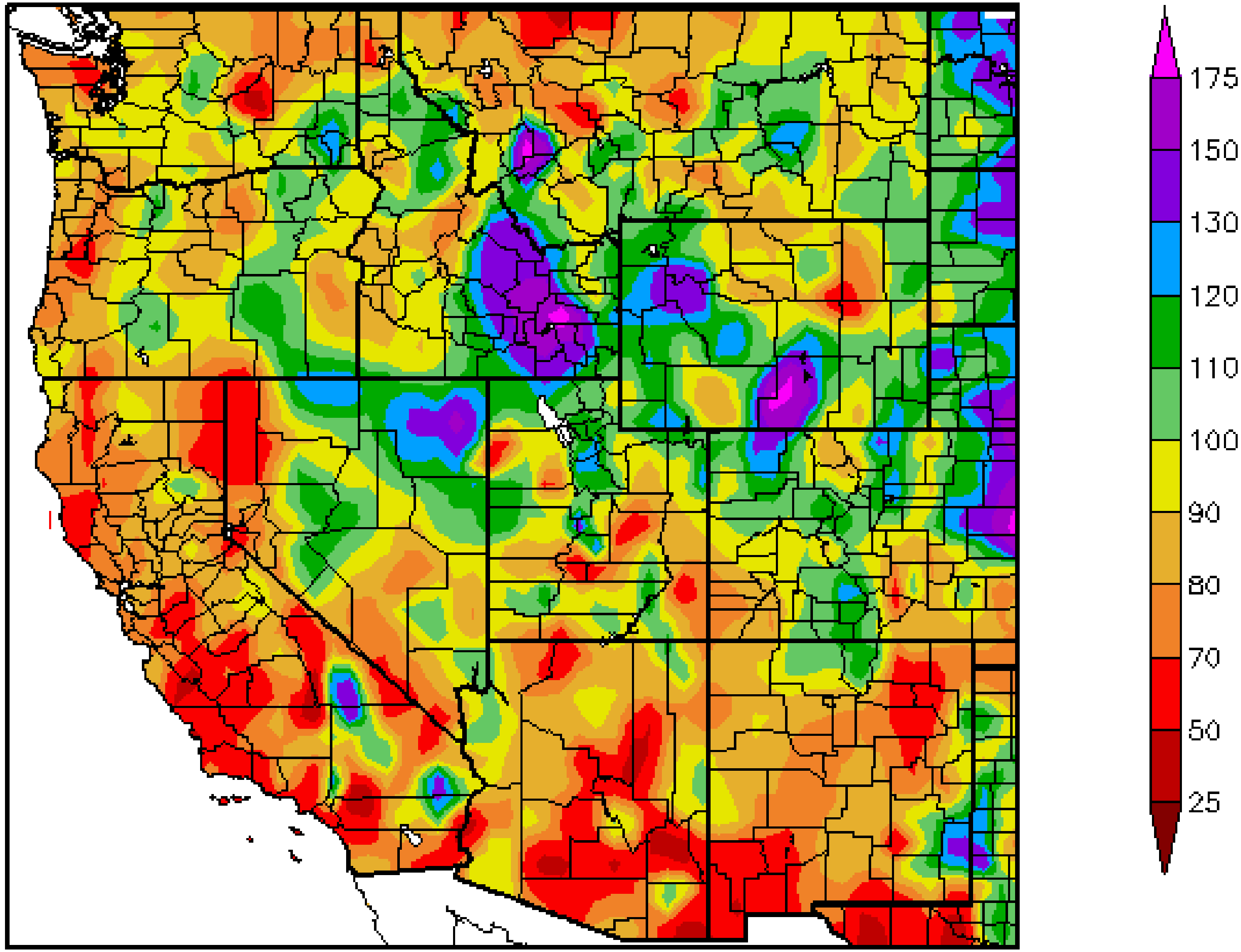
Central Sierra



Arizona

Water Year
2008 Oct 01
Thru
2009 Jul 25

Percent of Normal Precipitation (%)
10/1/2008 – 7/25/2009



Generated 7/25/2009 at HPRCC using provisional data

NOAA Regional Climate Centers

Climate Change and Nevada

Provides one more source of variability. “Old” variability continues.
Local and regional responses do not have to be the same as global scale.
  Temp – Strongest consensus among the various climate elements
  Temp – All show warming, amounts differ modestly among projections.
  Precip – Sign, and amounts, and seasonality, and frequency all differ.
  Precip – Character of precipitation can be as important as amount.
  Precip – Consensus much slower in forming but some progress
Precipitation change – more midwinter, less late winter and spring
Precipitation change – No big changes. More floods & droughts possible.
Temperature is a hydrologic element – has significant implications
Temperature change is under way, began without our noticing.
Much recent climate warming in the U.S. has taken place in the West
West warming appears related to Indian Ocean & Indonesian Warm Pool
Western Mountains seem particularly vulnerable to climate change
System still has “unrealized warming;” earth radiation not in balance

Adaptation versus mitigation
    “Managing the unavoidable and avoiding the unmanageable”

Summary Points 2 of 2

Climate Change and Nevada

Needs

- **Comprehensive understanding of western water budget**
  - **Spatial patterns, temporal trends: top of atmosphere to deep aquifer**
  - **Effects of temperature increase on recharge and runoff efficiency**
  - **Mountain recharge processes**
- **High elevation climate history**
- **Measurements that facilitate attribution of climate variability**
- **High quality gridded data sets (atmosphere, surface, subsurface)**
- **Better tools to make information available to public and researchers**

Unknowns. Could still change things :

- **Clouds – a perpetually difficult problem**
- **Aerosols (via both radiation and cloud microphysics)**
- **Deep ocean mixing and circulation – do we have it right?**
- **Biology – complicated, but probably more of a role than we imagine**
- **Ice sheets – potential for asymmetry: slow formation, rapid demise**

It's all one big <u>system</u>. Nonlinear dynamics galore. Expect surprises.


Thank You !

Discards