Western Regional
Climate Center

Climate Variability and Change in the Great Basin: Observations and Projections

Kelly Redmond

Western Regional Climate Center

Desert Research Institute

Reno NV

Natural Resource Needs Related to Climate Change in the Great Basin and Mojave Desert: Research, Adaptation, Mitigation

Las Vegas, Nevada, 2010 April 20-22

What’s the Great Basin?

What’s the Mojave Desert?

Boise Aquatic Sciences Lab
RMRS
Rocky Mountain Research Station

USFS

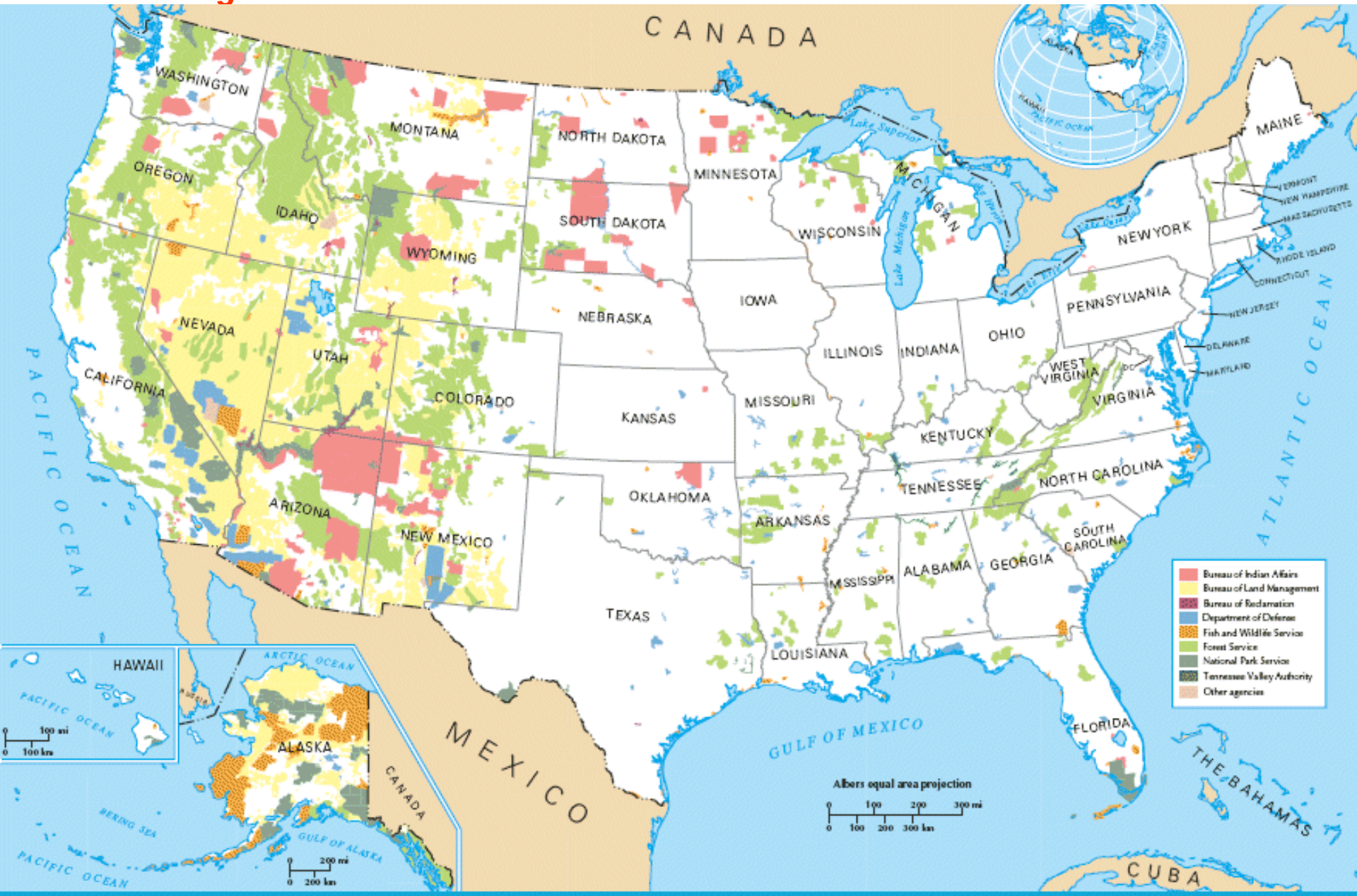
OREGON
IDAHO
WYOMING
GREAT
BASIN
NEVADA
Rocky
Mountains
UTAH
COLORADO
CALIFORNIA
Yucca Mountain
Las Vegas
Colorado
Plateau
ARIZONA
NEW MEXICO
Pacific Ocean
BASIN AND RANGE
100 0 100 200 300 Miles
100 0 100 200 300 Kilometers
N
GREAT BASIN AND
BASIN AND RANGE
PROVINCE

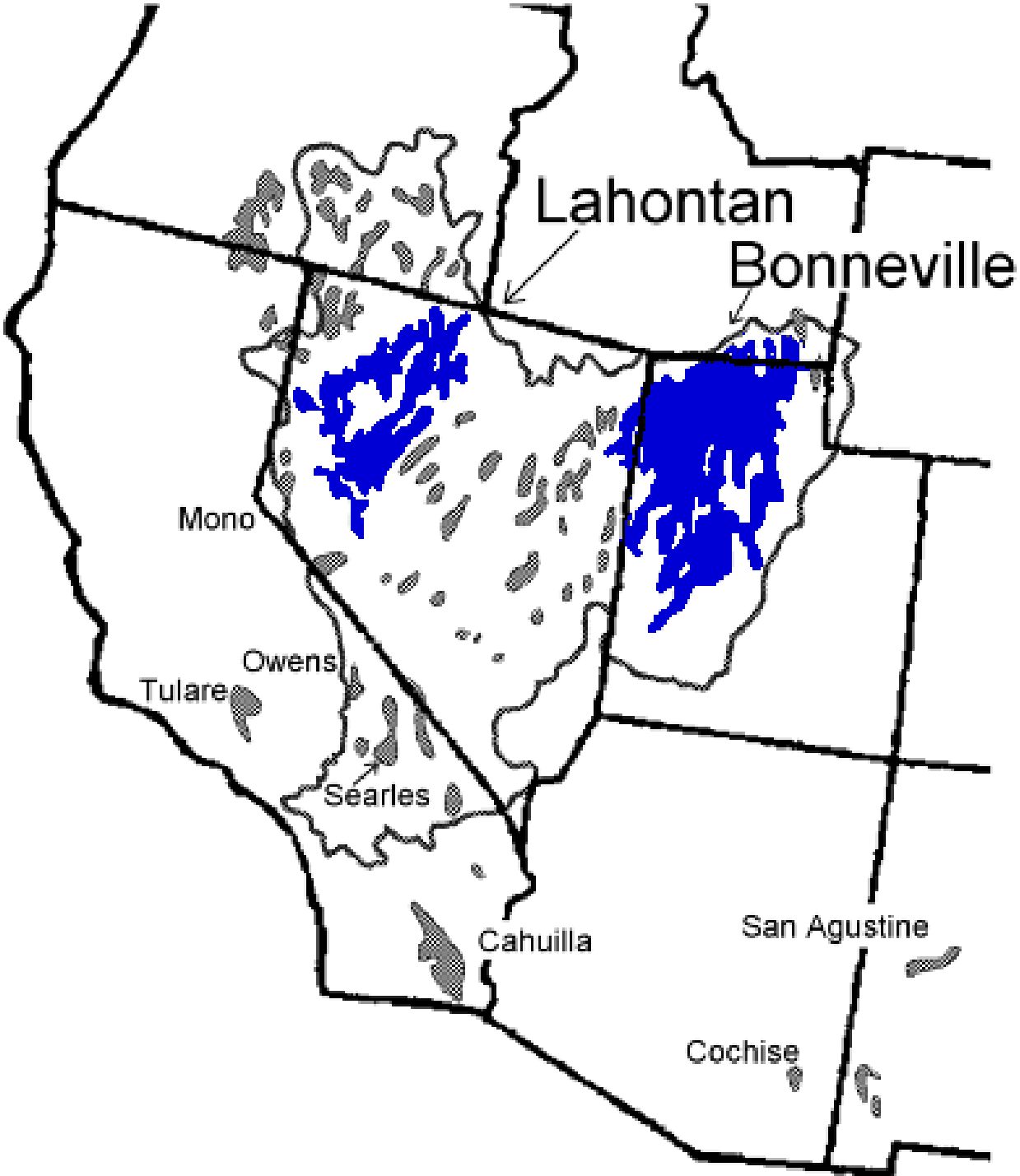
DOD

USGS

Mojavedesert.net

Federal Lands of the United States.
West Contiguous 47 %. West with Alaska-Hawaii 54 %. 13 States: 93 % US Total

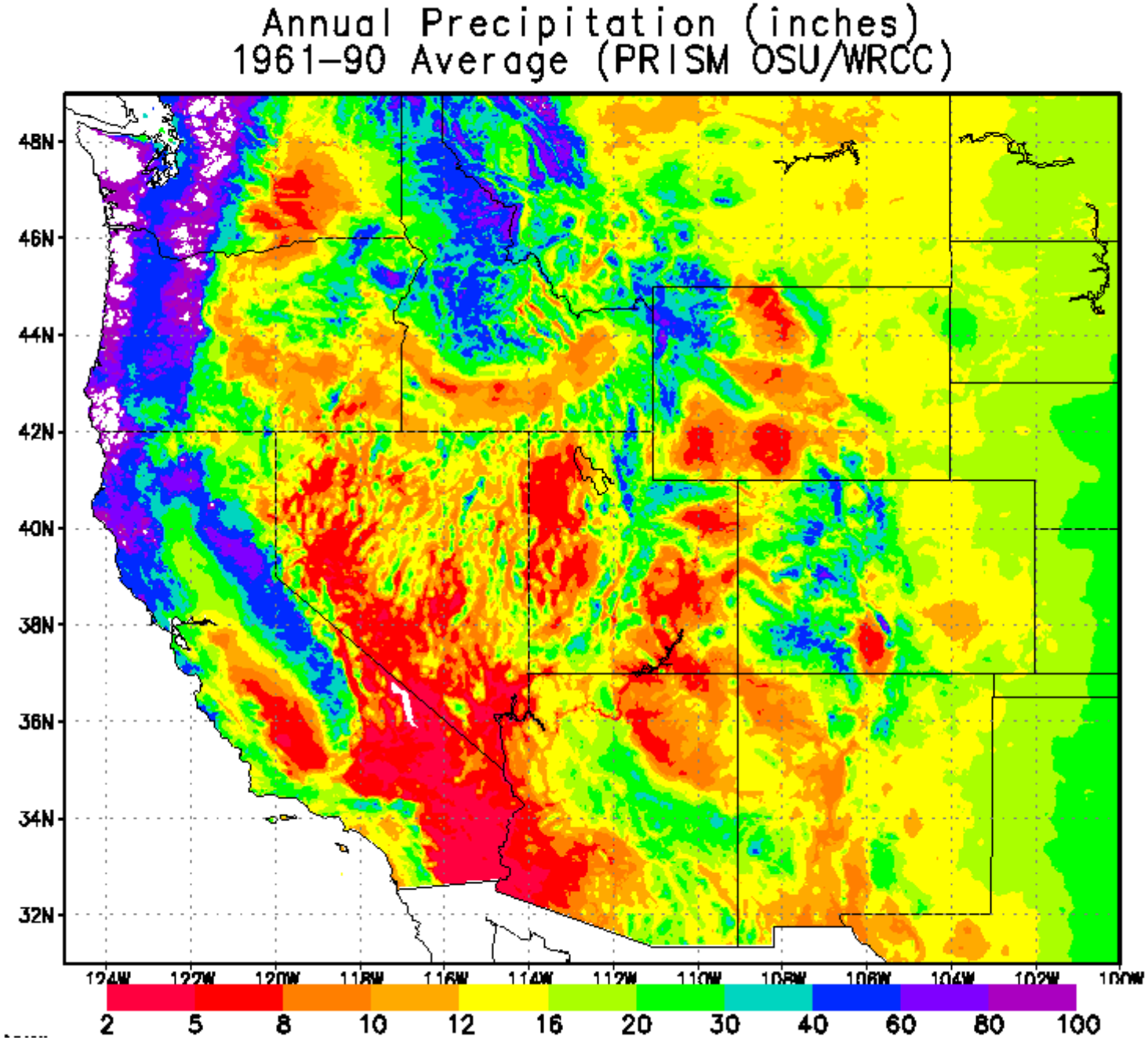




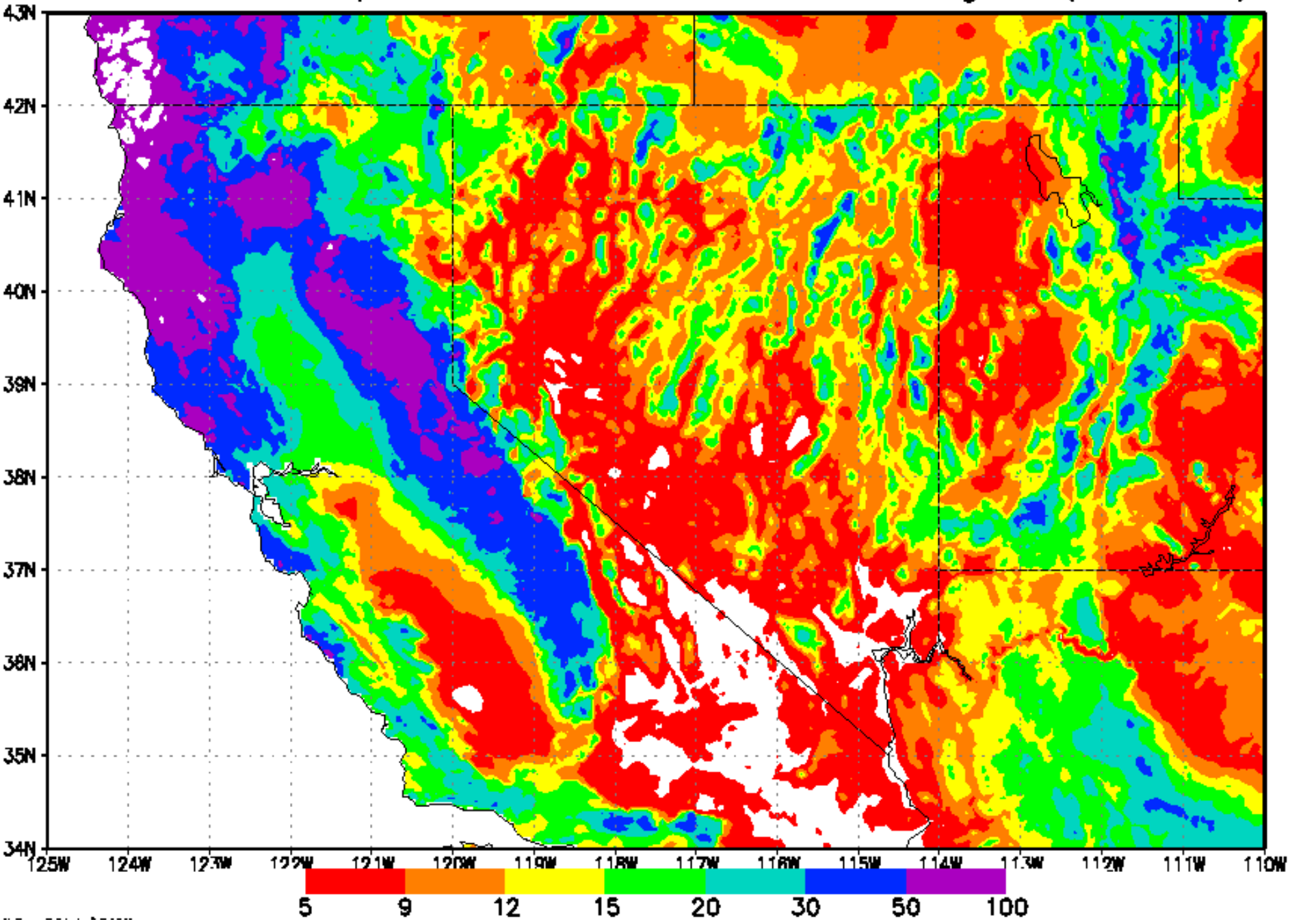
Climate Prehistory

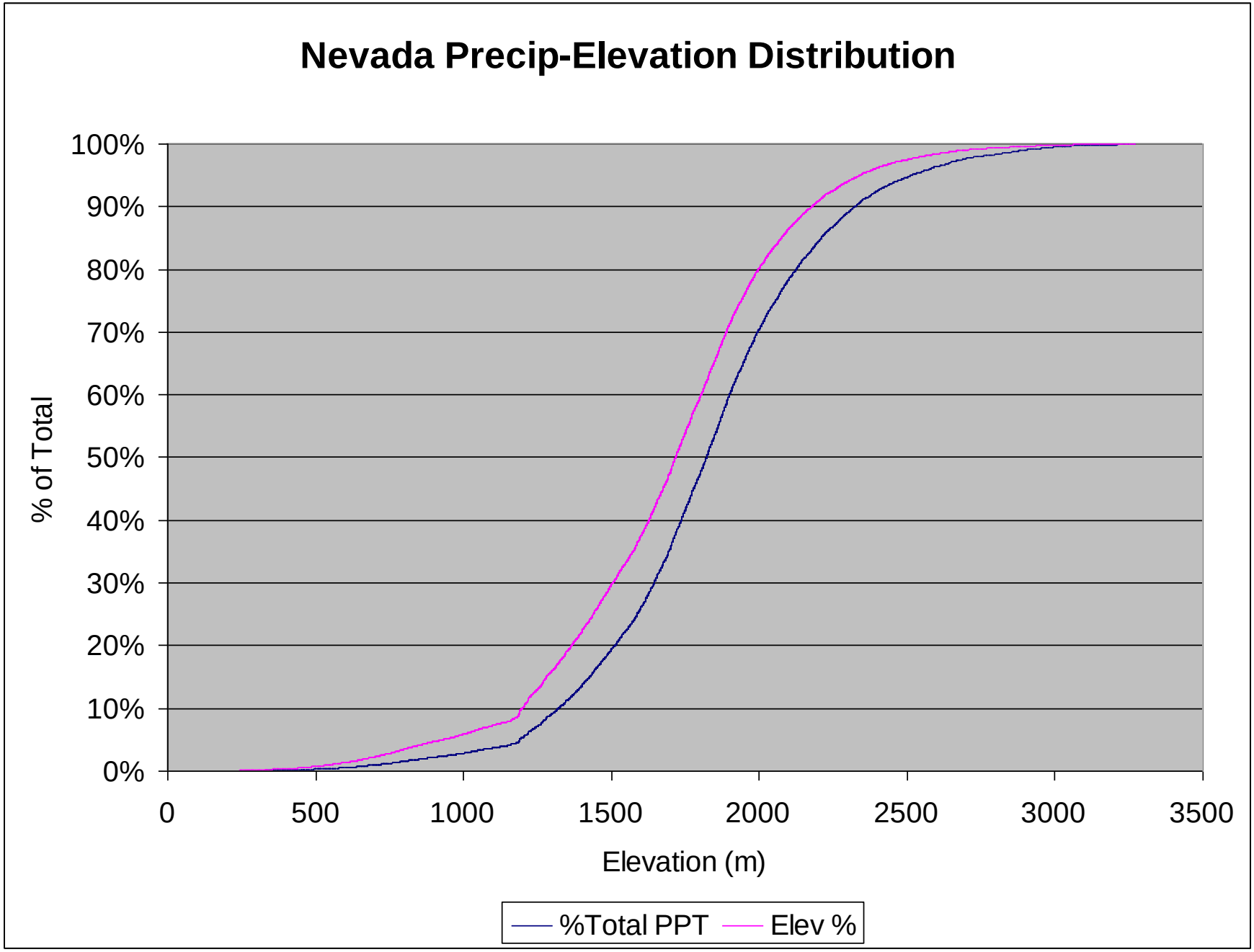
Last Glacial Maximum

Not the next one.


Annual Precipitation (inches)
1961–90 Average (PRISM OSU/WRCC)
48N
46N
44N
42N
40N
38N
36N
34N
32N
124W
122W
120W
118W
116W
114W
112W
110W
108W
106W
104W
102W
100W
2
5
8
10
12
16
20
30
40
60
80
100

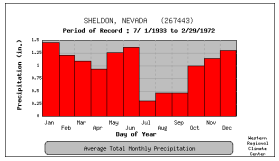
Annual Precipitation in Selected Ranges (inches)

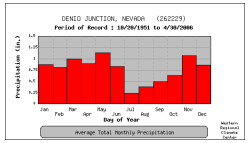


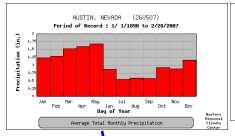


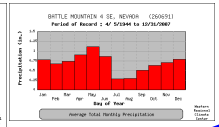
Courtesy of Chris Daly, OSU, Based on PRISM.

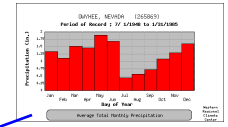
Nevada Annual Precipitation Cycle

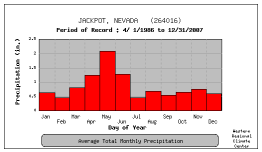


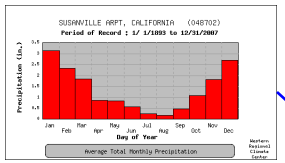


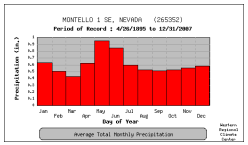


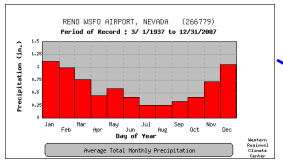


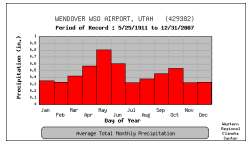


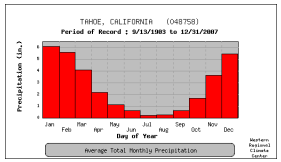


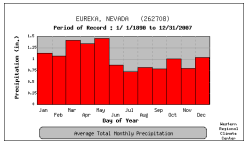


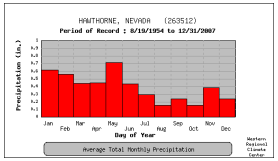


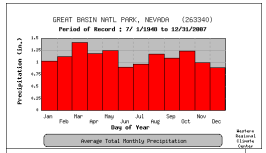


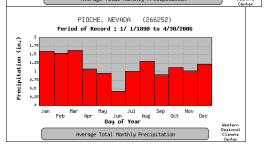


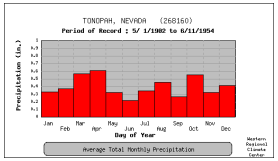


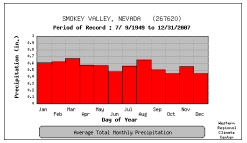


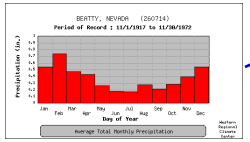


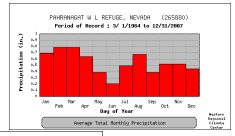


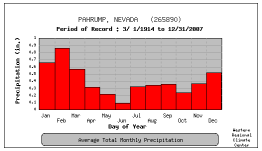


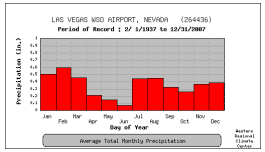


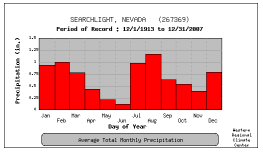


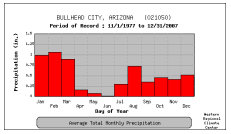


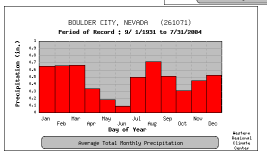


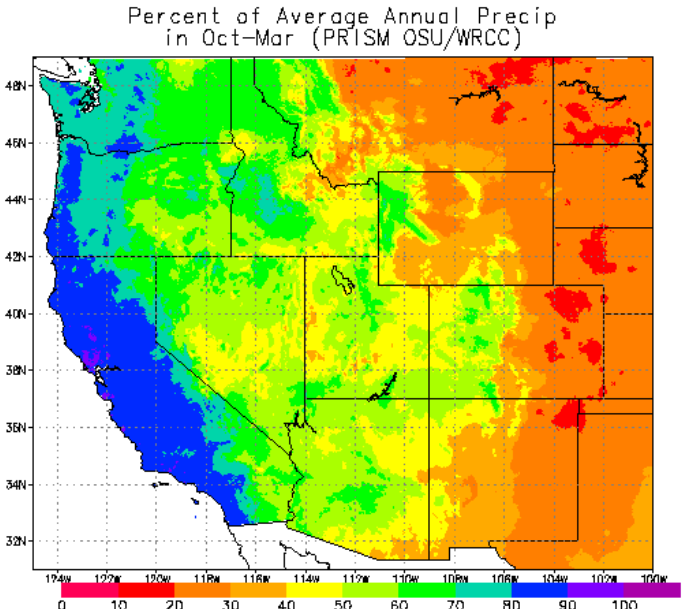




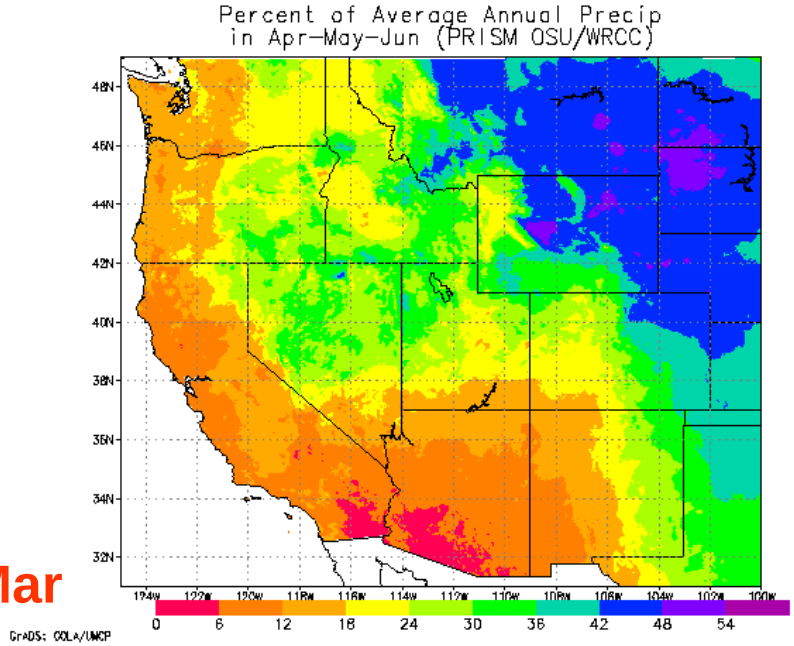




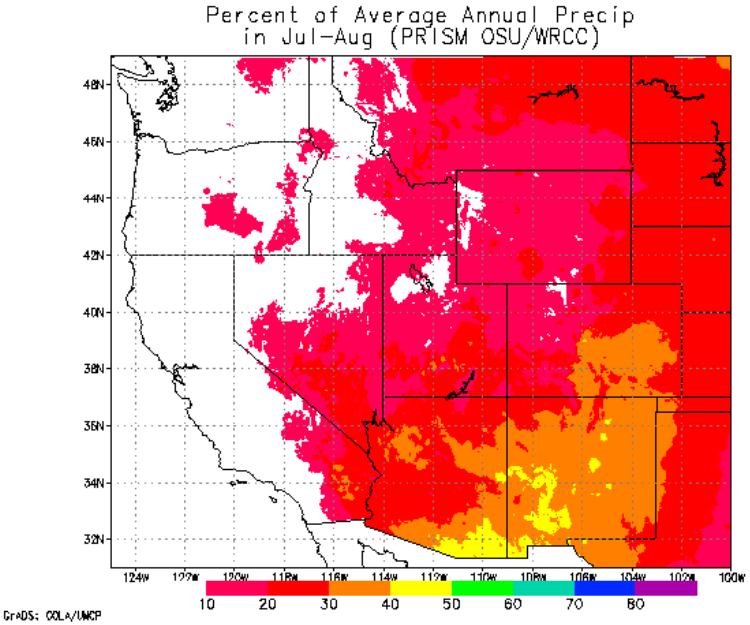




Oct-Mar



Apr-May-June



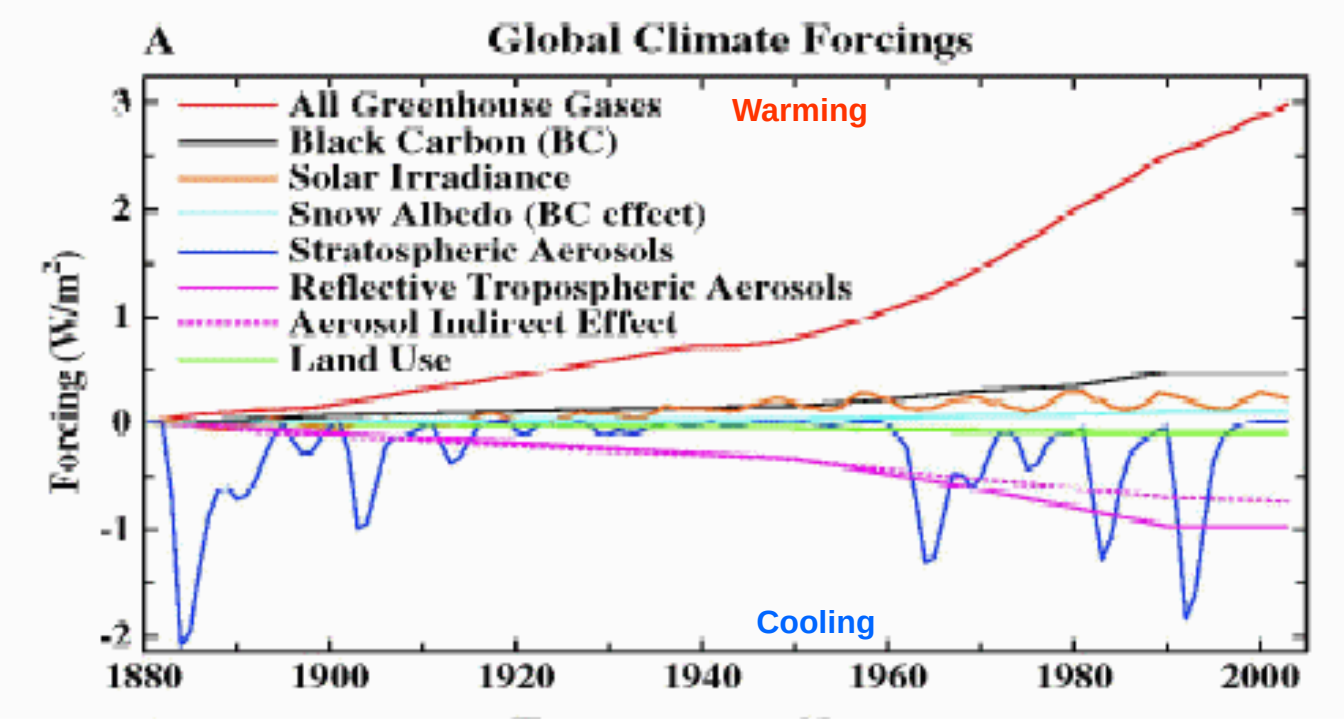
July-Aug

Fraction of Annual Total Precipitation, by Season

What’s the climate gonna do?

History of Global Atmospheric Forcings

Hansen et al, 2005. Earth's energy imbalance: Confirmation and implications.



1880 1900 1920 1940 1960 1980 2000

Radiative Factors that Control Global Climate

IPCC Emissions Scenarios.

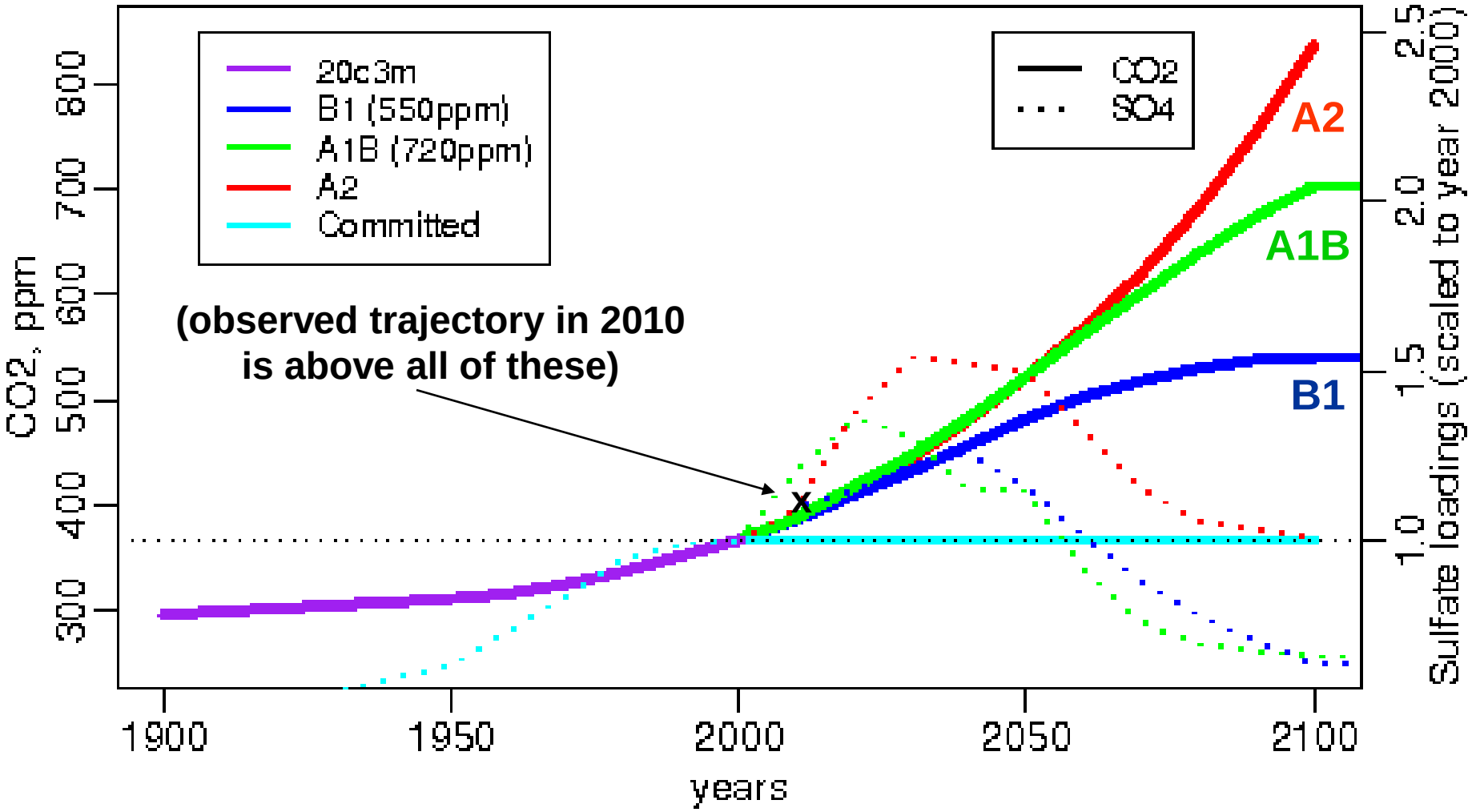


Figure from Environment Canada, 2005.

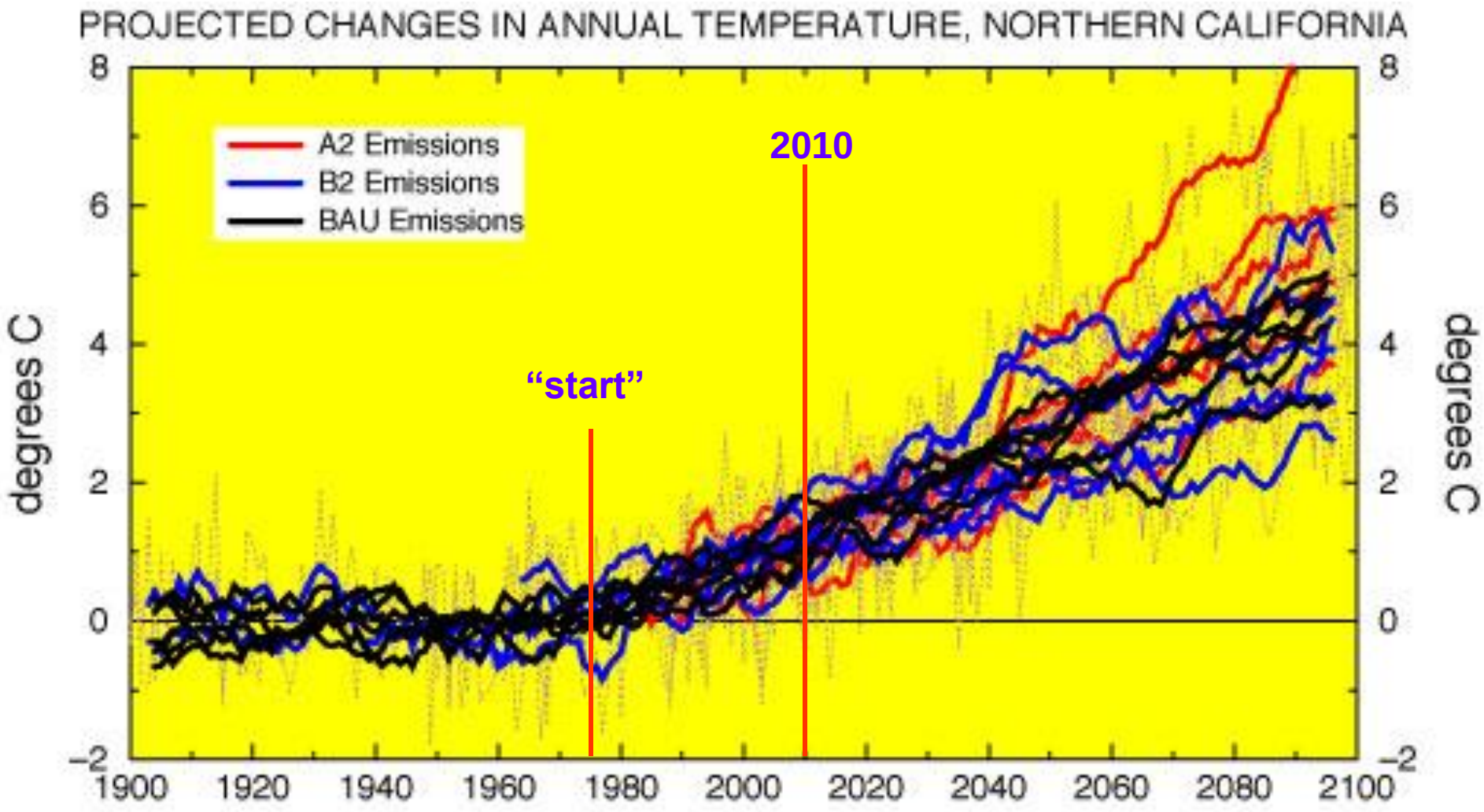
Western Great Basin

1900-2100

Temp and Precip

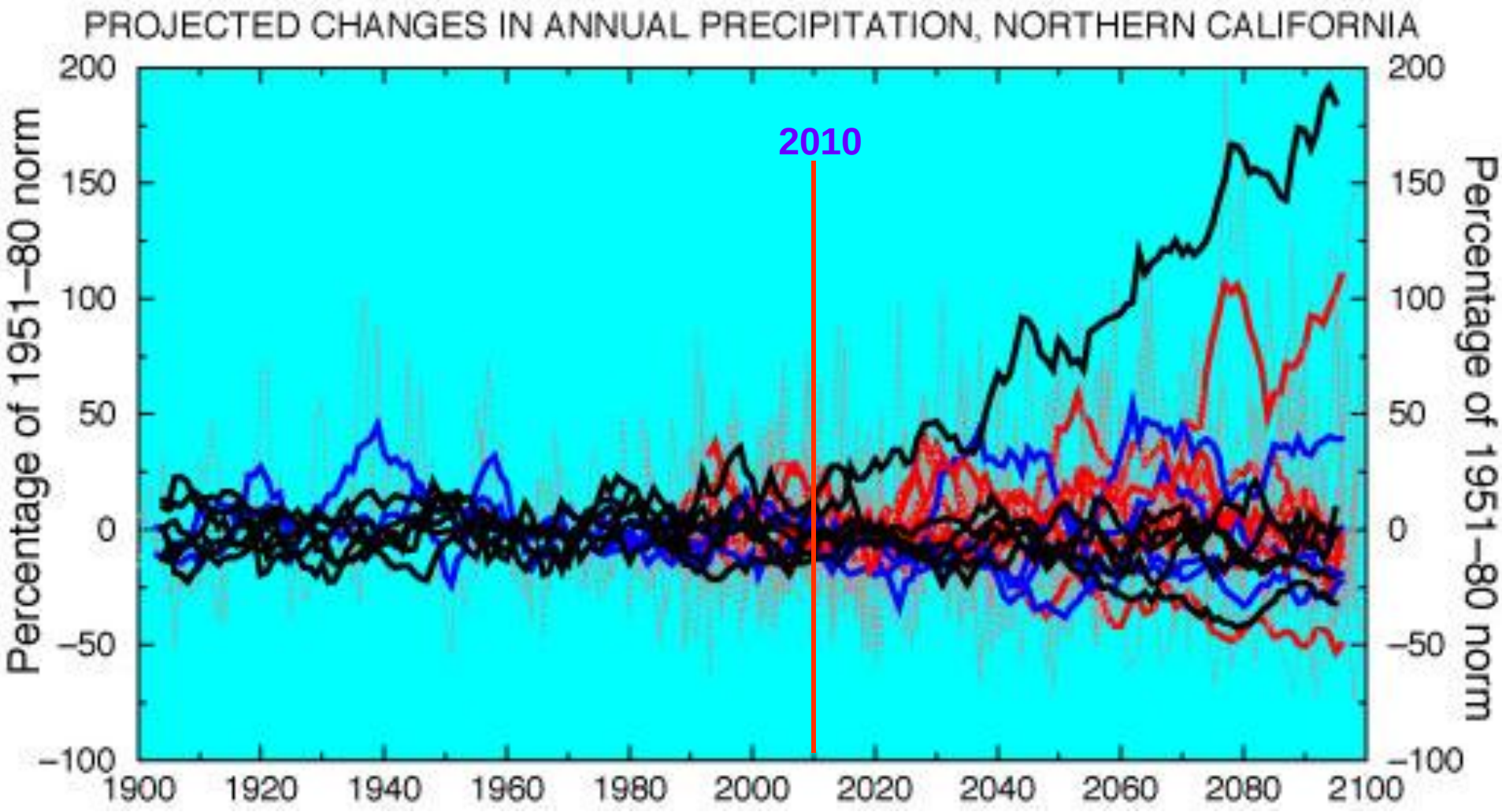
Projections

Courtesy of Mike Dettinger, USGS / Scripps.

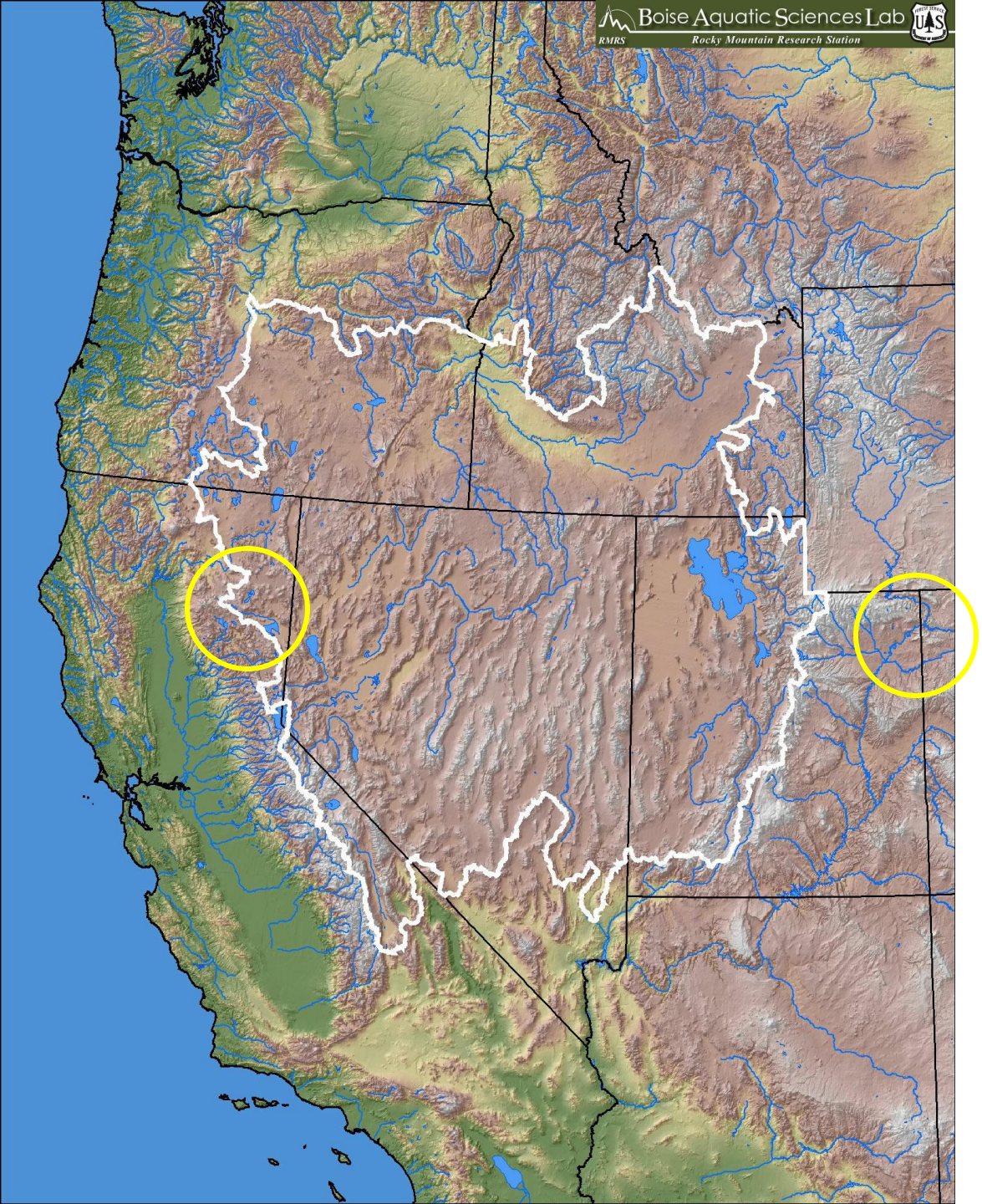


Dettinger MD. 2005. From climate change spaghetti to climate-change distributions for 21st Century California. San Francisco Estuary and Watershed Science. Vol. 3, Issue 1, (March 2005), Article 4. http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art4

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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RMRS
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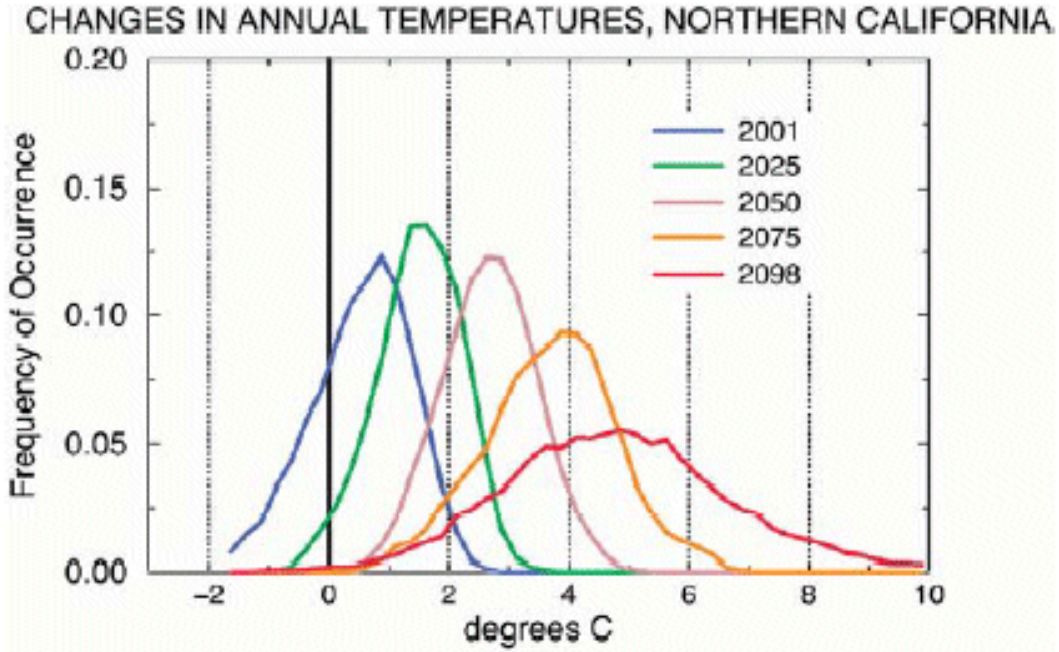


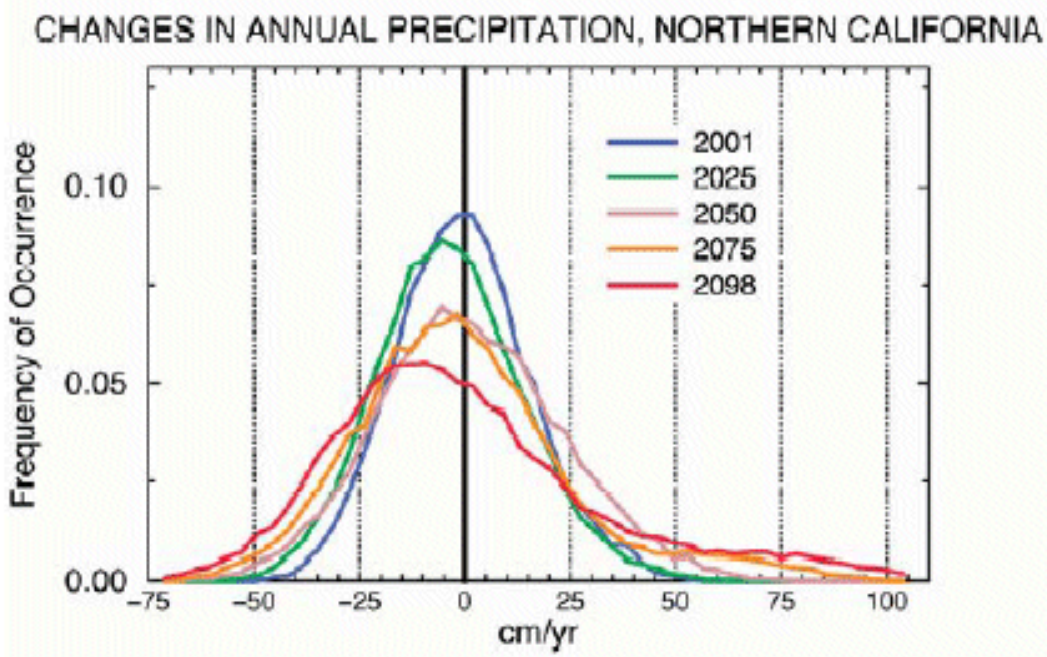
40 North, 120 West, PCM

(Reno + Susanville) / 2

20,000 resamplings

Distribution of

Annual Mean Temperature (C)



Annual Mean Precipitation (cm)

Michael D. Dettinger, 2004. From climate-change spaghetti to climate-change distributions for 21st Century California. San Francisco Estuary Watershed Science, v. 3(1), 14 pp.

repositories.cdlib.org/jmie/sfews/vol3/iss1/art4

Projections for Utah

6 climate models
3 emissions scenarios

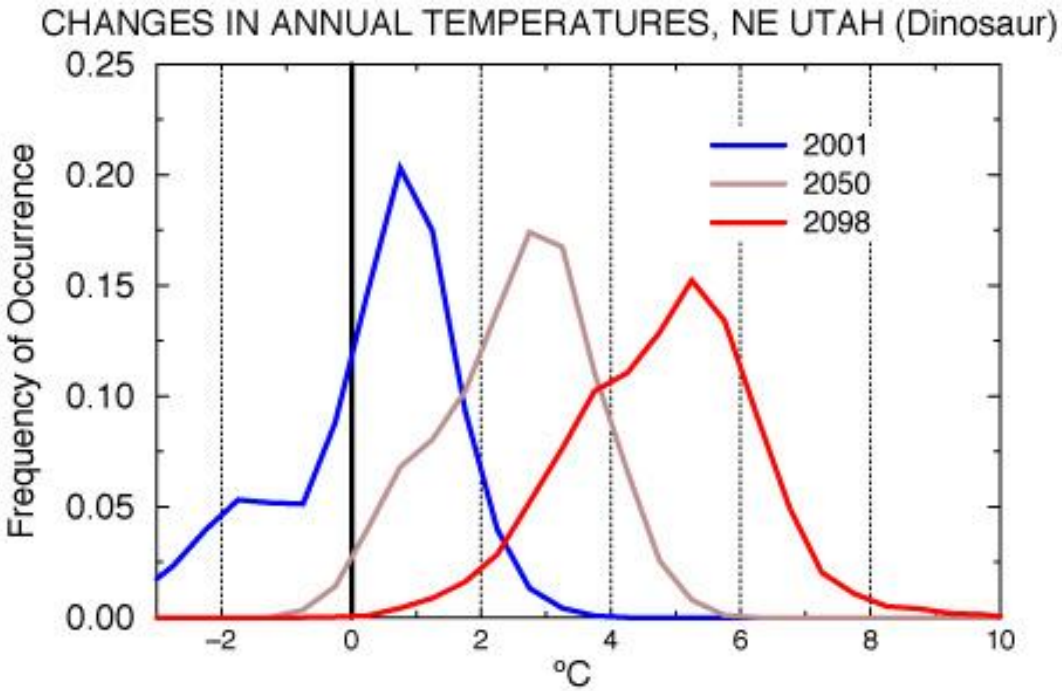
Projections for interior West not very different from those for California

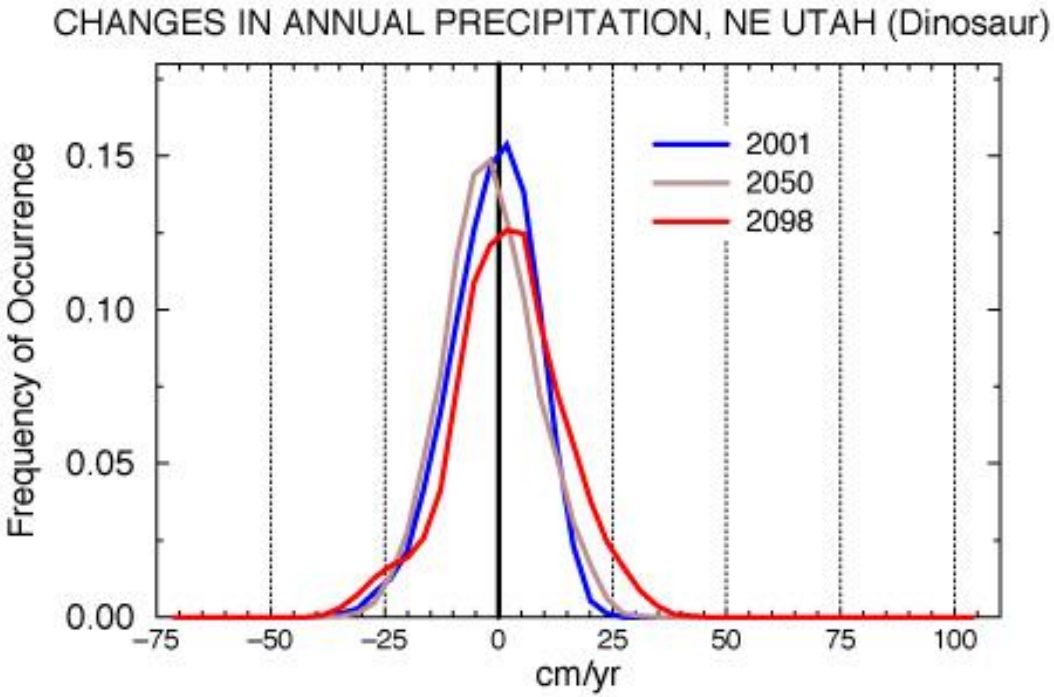
Warming
- **2001: +1 C**
- **2050: +3 C**
- **2098: +5 C**

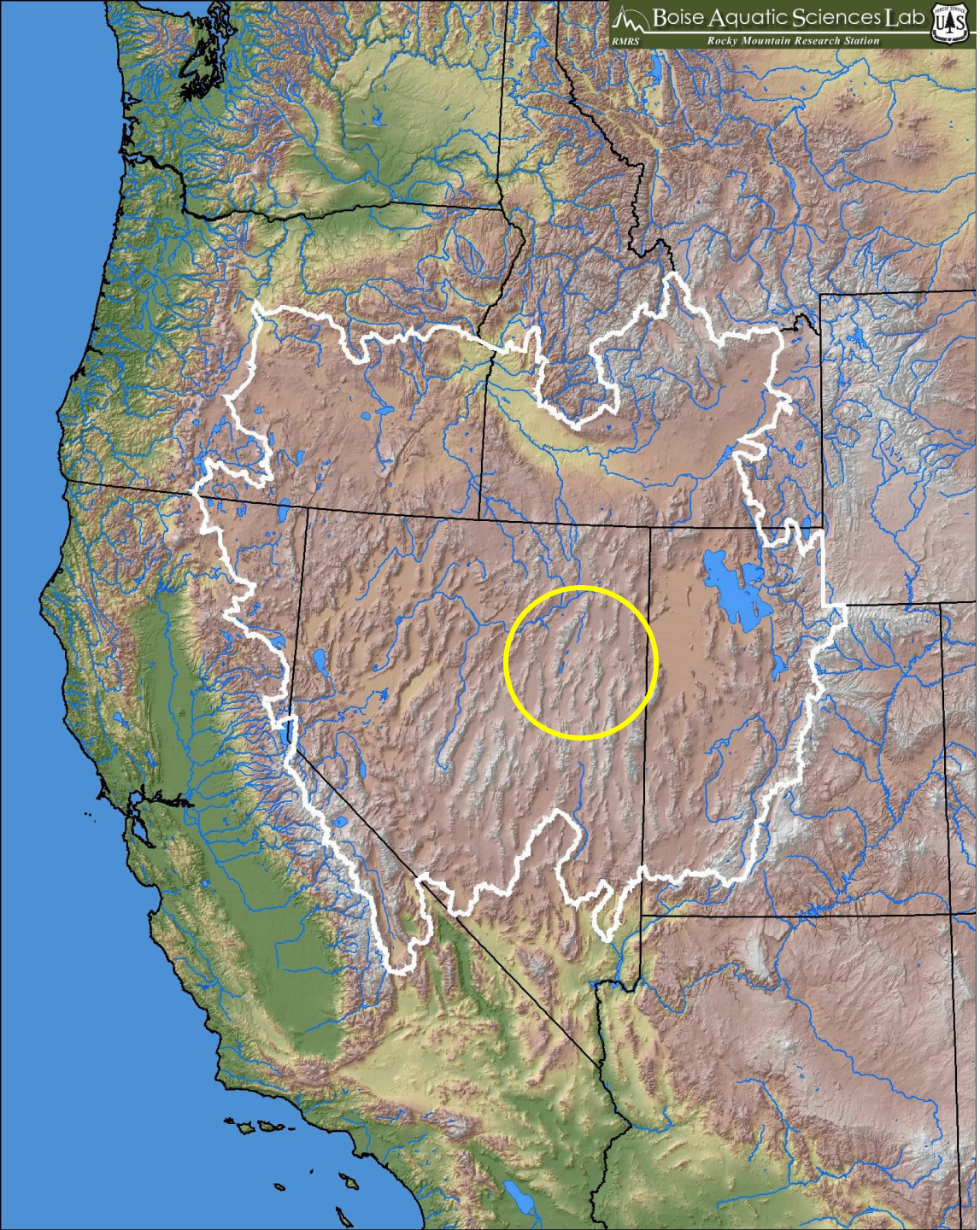
Strong indication of no annual precipitation change

Resampling used.

Thanks to
Mike Dettinger
USGS / Scripps



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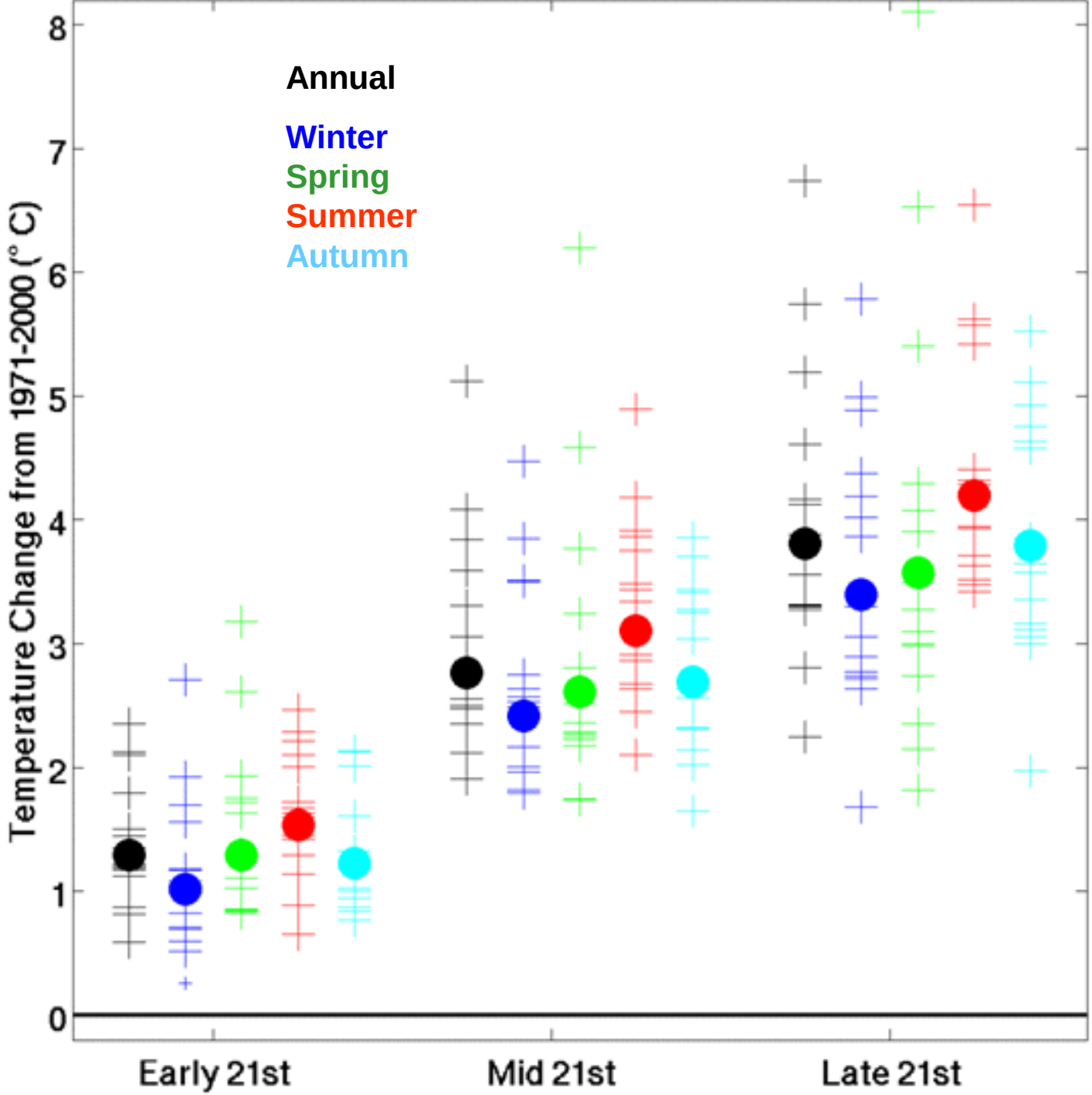

East Central Nevada

Projected Temperature Changes (C)

15 Models

IPCC A1B

Early 21st

2011-2040

Middle 21st

2041-2070

Late 21st

2071-2100

John Abatzoglou

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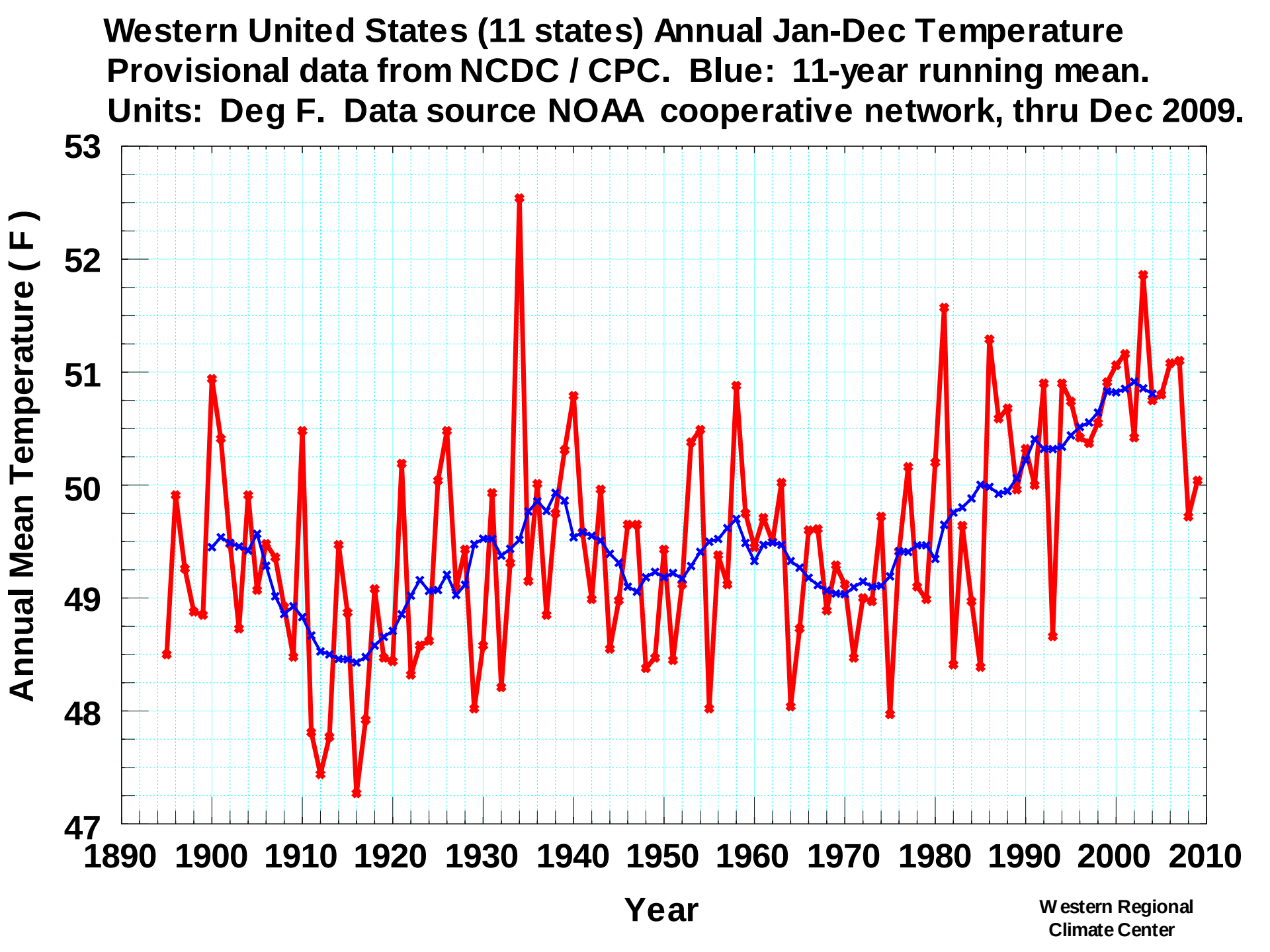
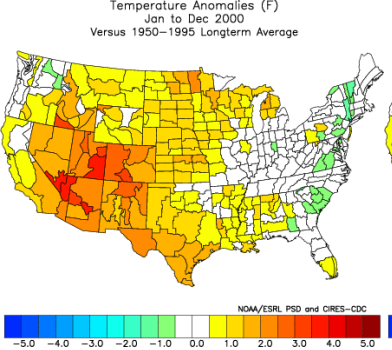
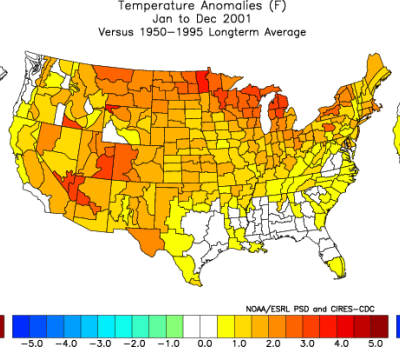
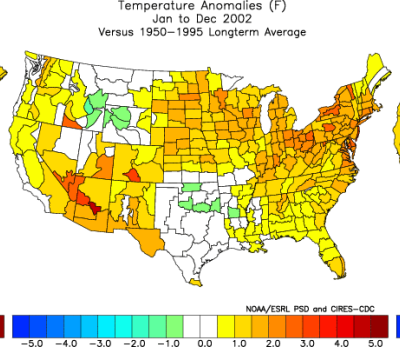

Western United States (11 states) Annual Jan-Dec Temperature
Provisional data from NCDC / CPC. Blue: 11-year running mean.
Units: Deg F. Data source NOAA cooperative network, thru Dec 2009.
Annual Mean Temperature (F)
53
52
51
50
49
48
47
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Western Regional
Climate Center



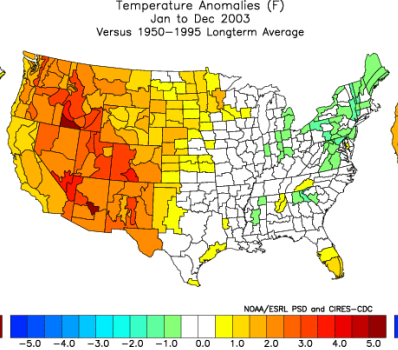
2000



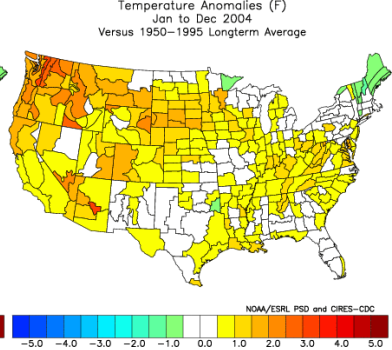
2001



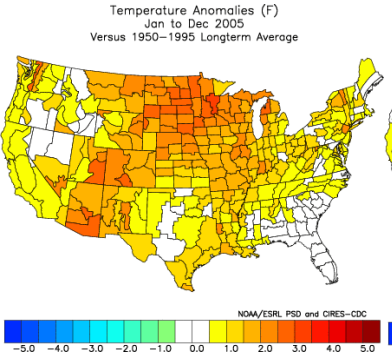
2002



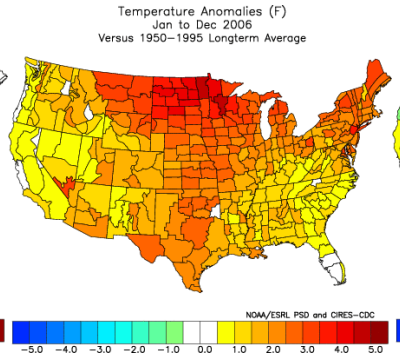
2003



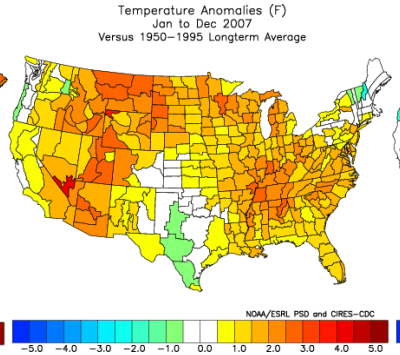
2004



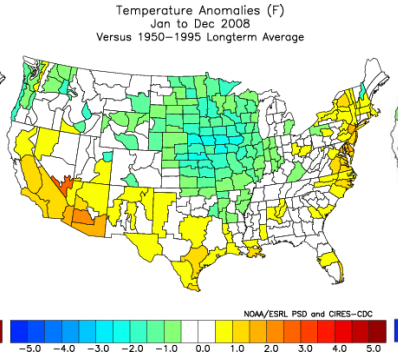
2005



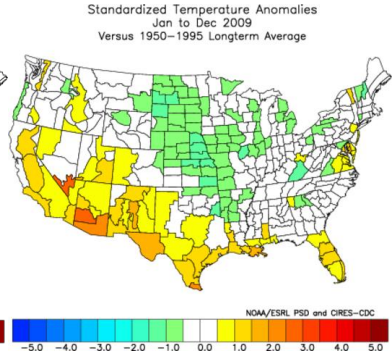
2006



2007



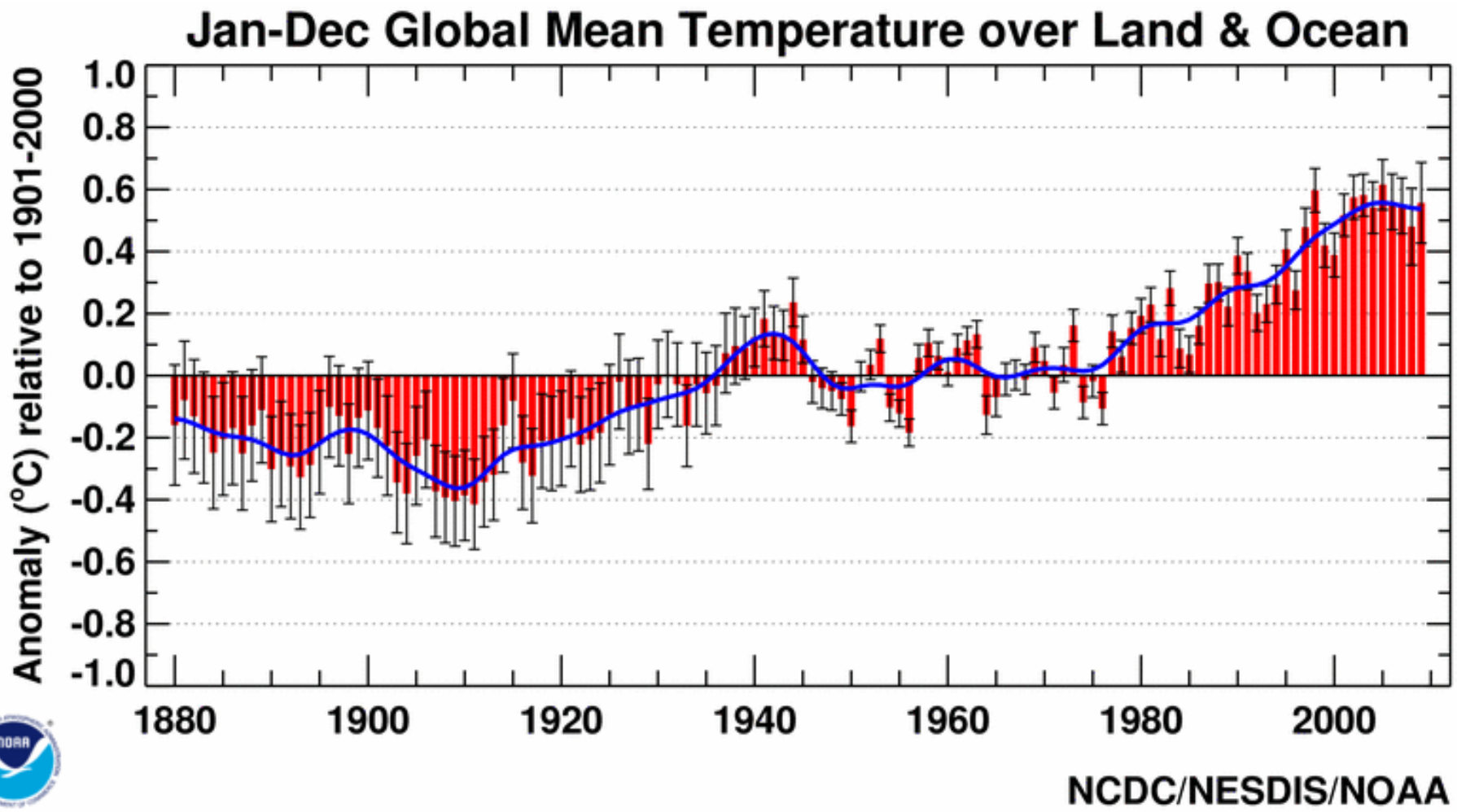
2008



2009

United States Annual Temperature Departure from 1950-1995 Mean

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



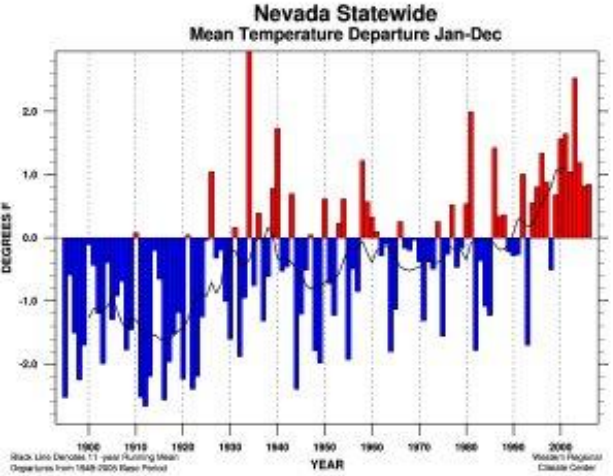
Thru Dec 2009

NOAA
National
Climatic Data
Center

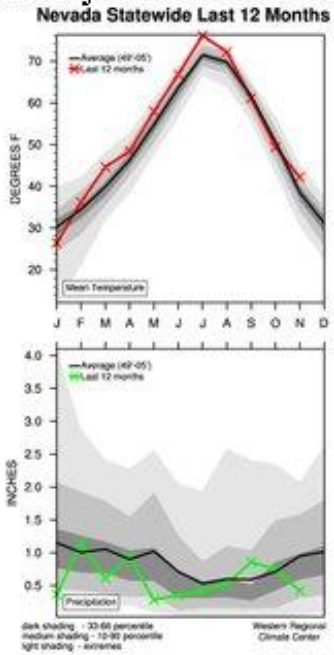
With thanks to John Abatzoglou

Select from the Menu to the Right

Time Series



Summary of Past 12 Months



Nevada Climate Tracker

Time Series

Select Variable

Select Time Period

Select

Summary of Past 12 Months

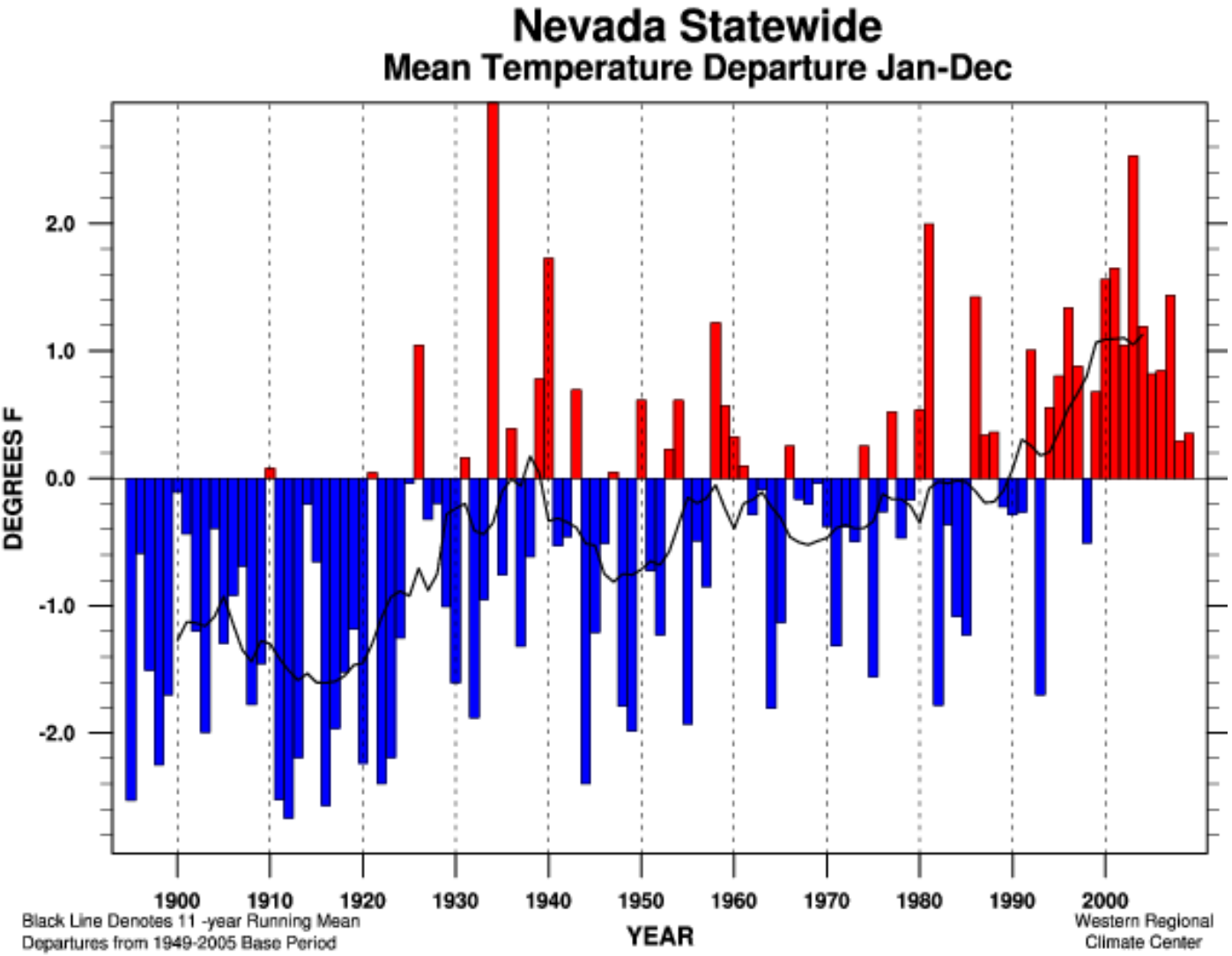
Plot Time Series
List Entire History
More Info

Return to the WRCC

Western Regional Climate Center

Desert Research Institute

Powered by ACIS
NOAA Regional Climate Centers



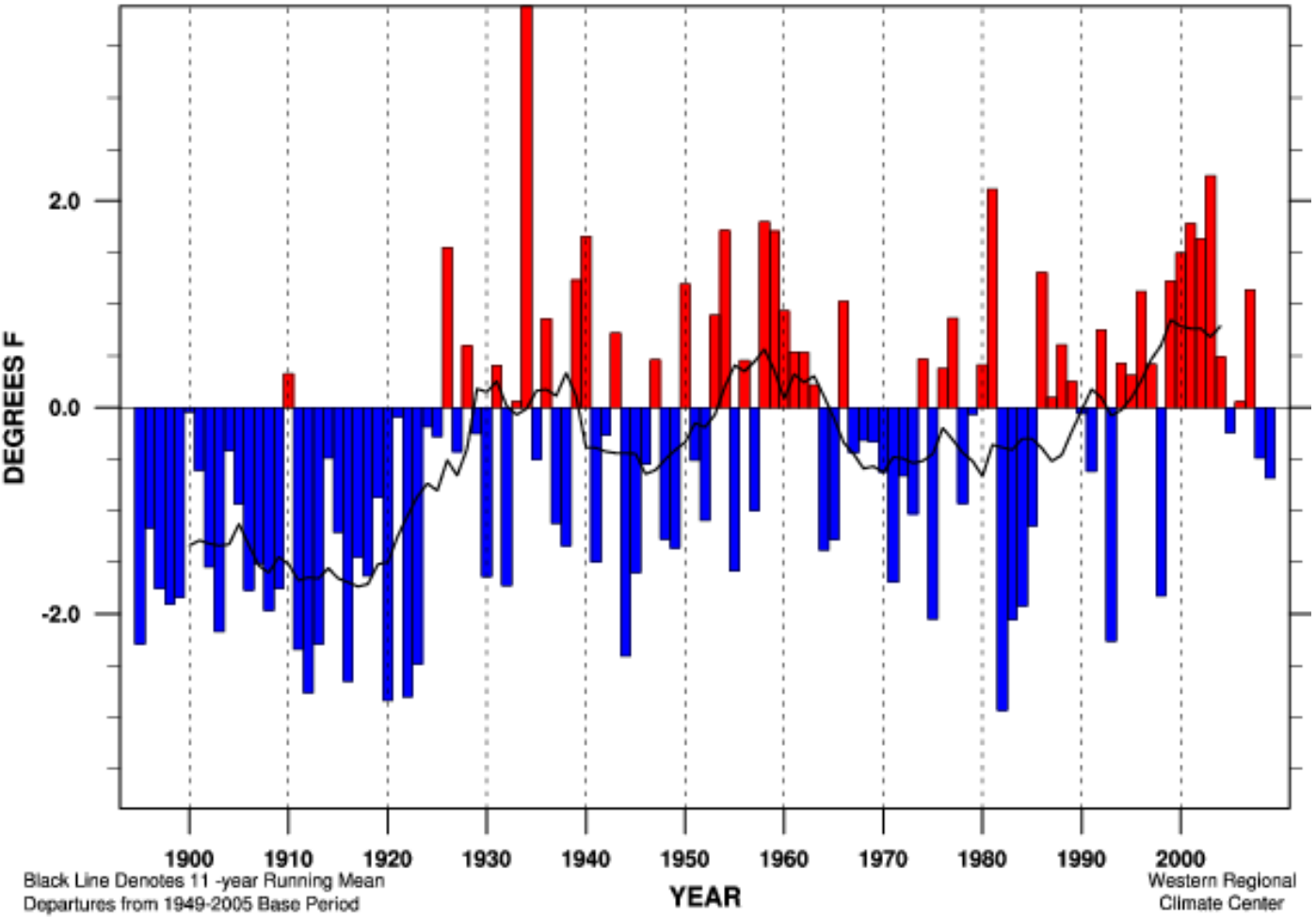
Linear Trend 1895-present		+ 1.93 ± 0.55 °F/100yr		
Linear Trend 1949-present		+ 2.71 ± 1.31 °F/100yr		
Linear Trend 1975-present		+ 5.02 ± 3.14 °F/100yr		
Warmest Year		52.3 °F (+ 2.9 °F) in 1934	MEAN	49.4 °F
Coldest Year		46.7 °F (- 2.7 °F) in 1912	STDEV	1.02 °F
Jan-Dec	2009	49.7 °F (+ 0.3 °F)	RANK	86 of 115

Nevada Statewide Temperature

Annual

1895 thru 2009

Nevada Statewide
Maximum Temperature Departure Jan-Dec



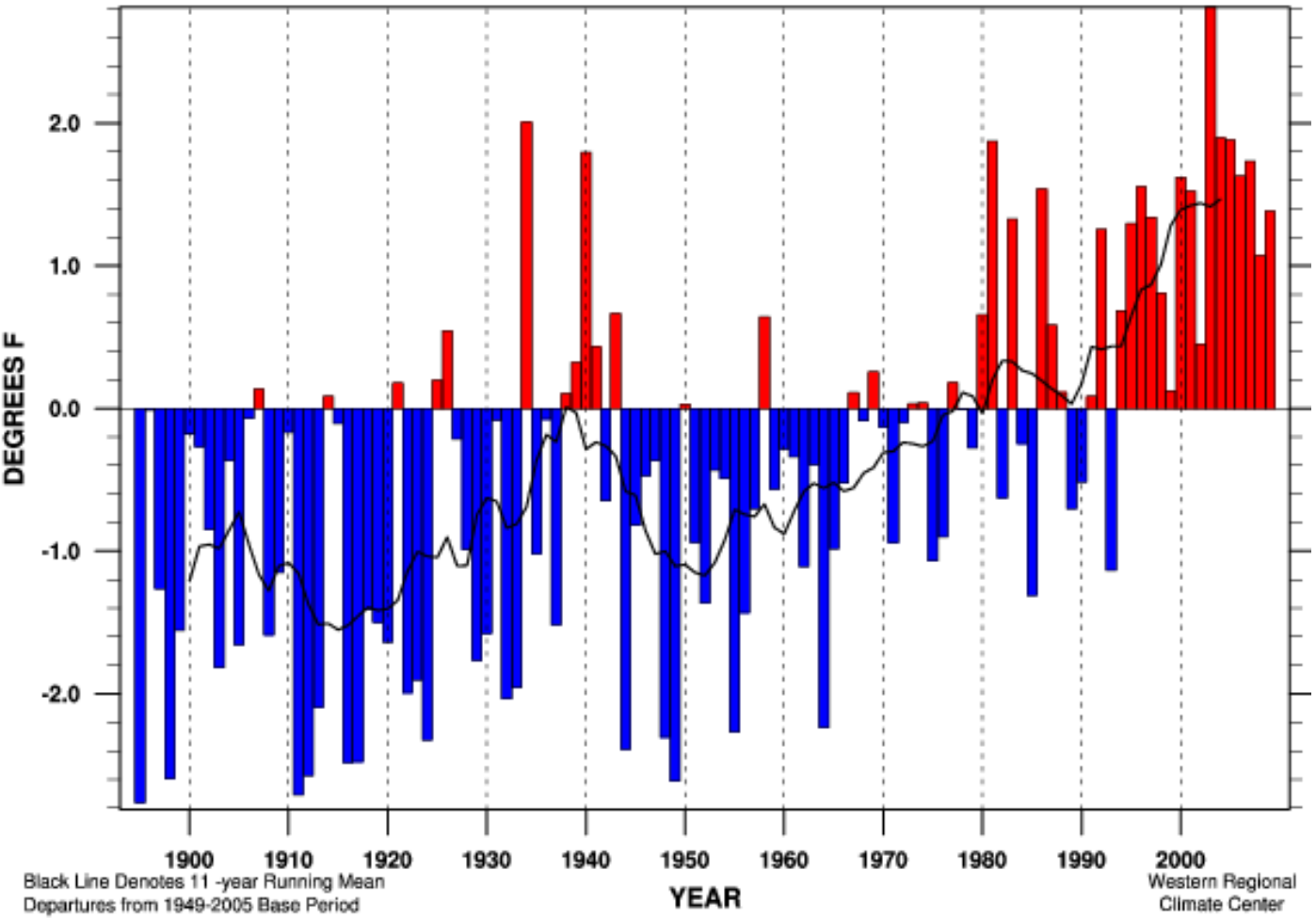
Linear Trend 1895-present		+ 1.63 ± 0.68 °F/100yr		
Linear Trend 1949-present		+ 0.77 ± 1.76 °F/100yr		
Linear Trend 1975-present		+ 3.80 ± 4.32 °F/100yr		
Warmest Year		67.9 °F (+ 3.9 °F) in 1934	MEAN	64.0 °F
Coldest Year		61.1 °F (- 2.9 °F) in 1982	STDEV	1.23 °F
Jan-Dec	2009	63.3 °F (- 0.7 °F)	RANK	48 of 115

Nevada Statewide Maximum Temperature

Annual

1895 thru 2009

Nevada Statewide
Miniumum Temperature Departure Jan-Dec

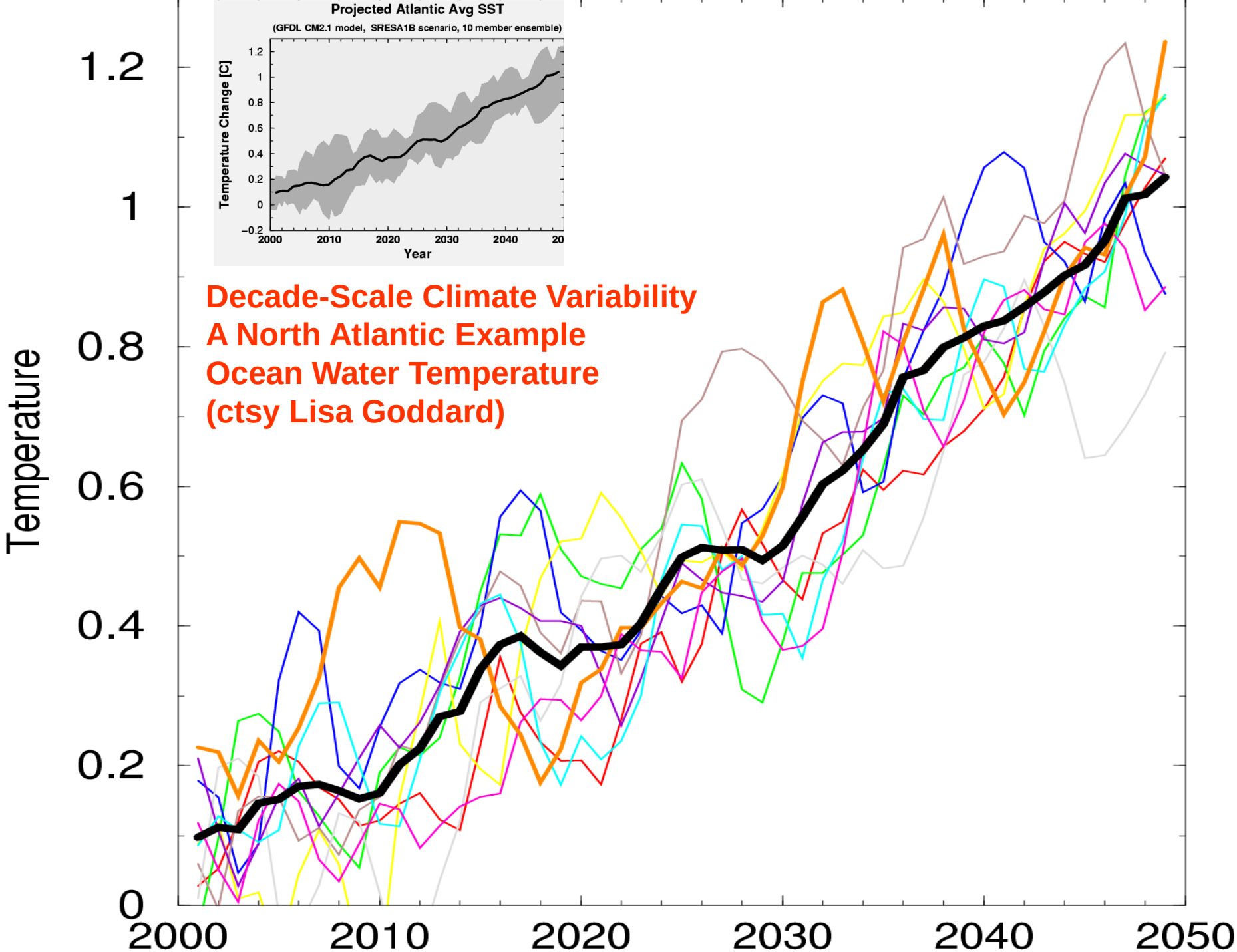


Linear Trend 1895-present	+ 2.23 ± 0.56 °F/100yr		
Linear Trend 1949-present	+ 4.64 ± 1.16 °F/100yr		
Linear Trend 1975-present	+ 6.23 ± 2.88 °F/100yr		
Warmest Year	37.5 °F (+ 2.8 °F) in 2003	MEAN	34.7 °F
Coldest Year	32.0 °F (- 2.8 °F) in 1895	STDEV	1.13 °F
Jan-Dec 2009	36.1°F (+ 1.4 °F)	RANK	103 of 115

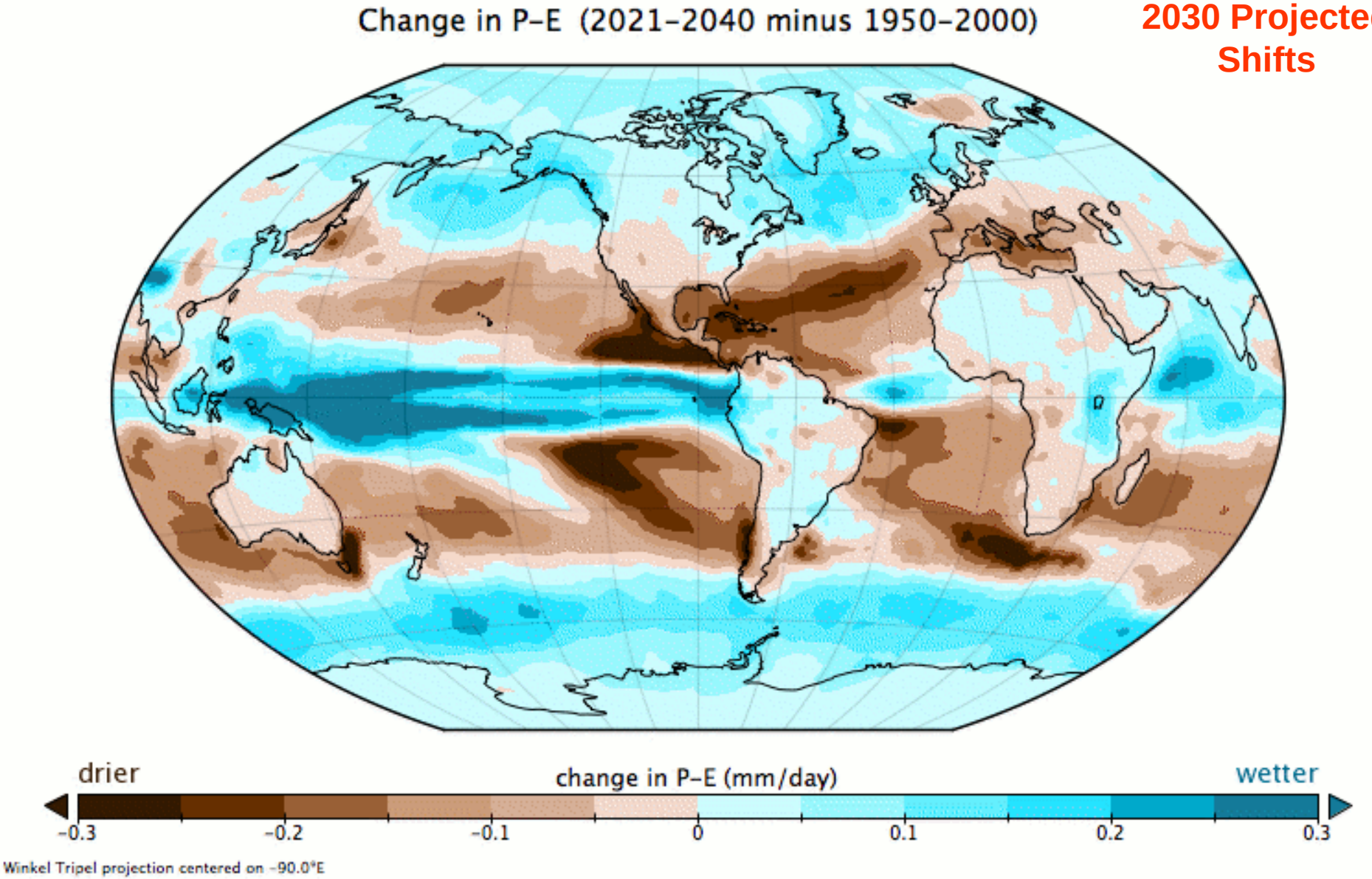
Nevada Statewide Minimum Temperature

Annual

1895 thru 2009


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
Ocean Water Temperature
(ctsy Lisa Goddard)
Temperature
0
0.2
0.4
0.6
0.8
1
1.2
2000
2010
2020
2030
2040
2050

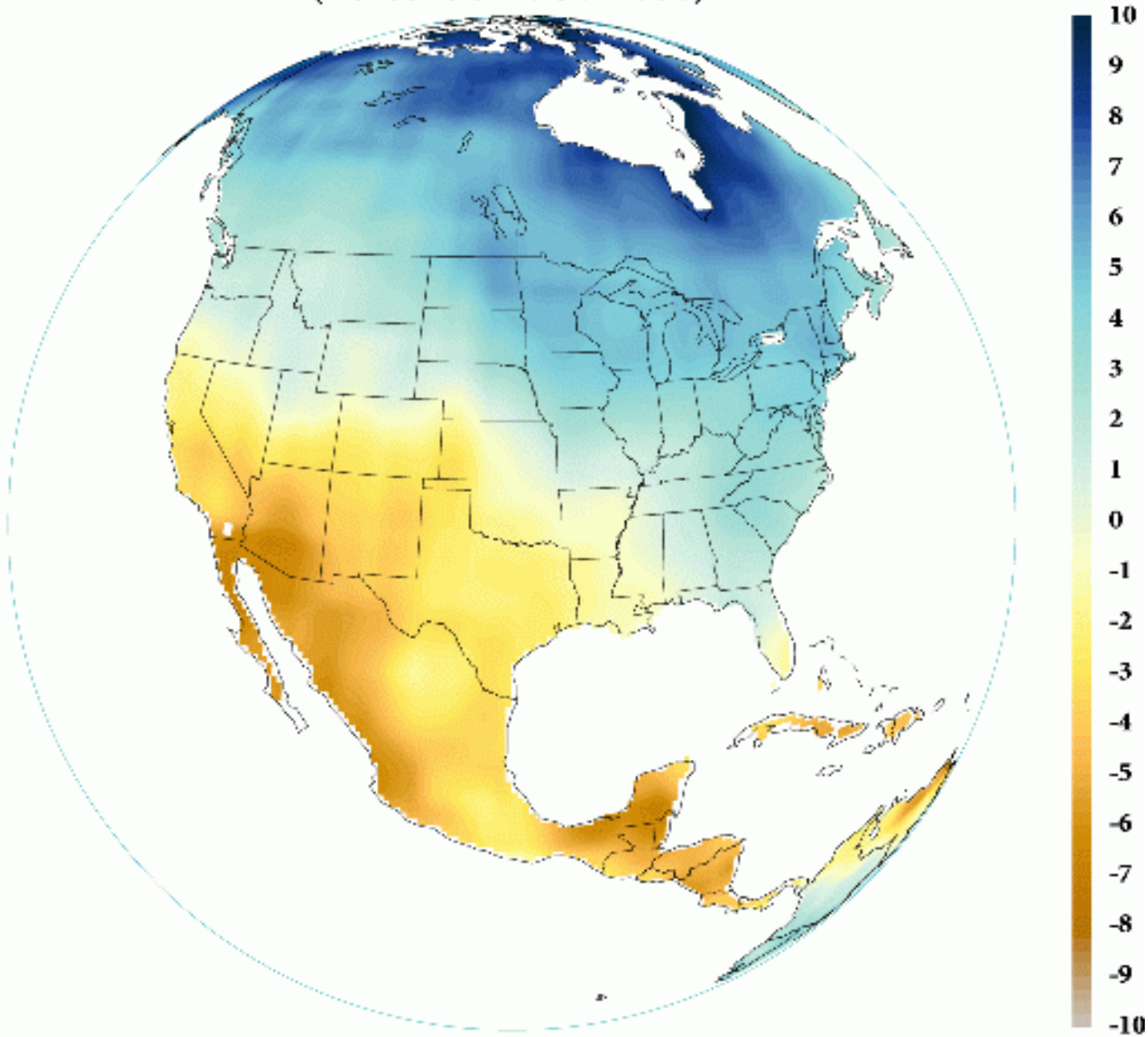
2030 Projected Shifts



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

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

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



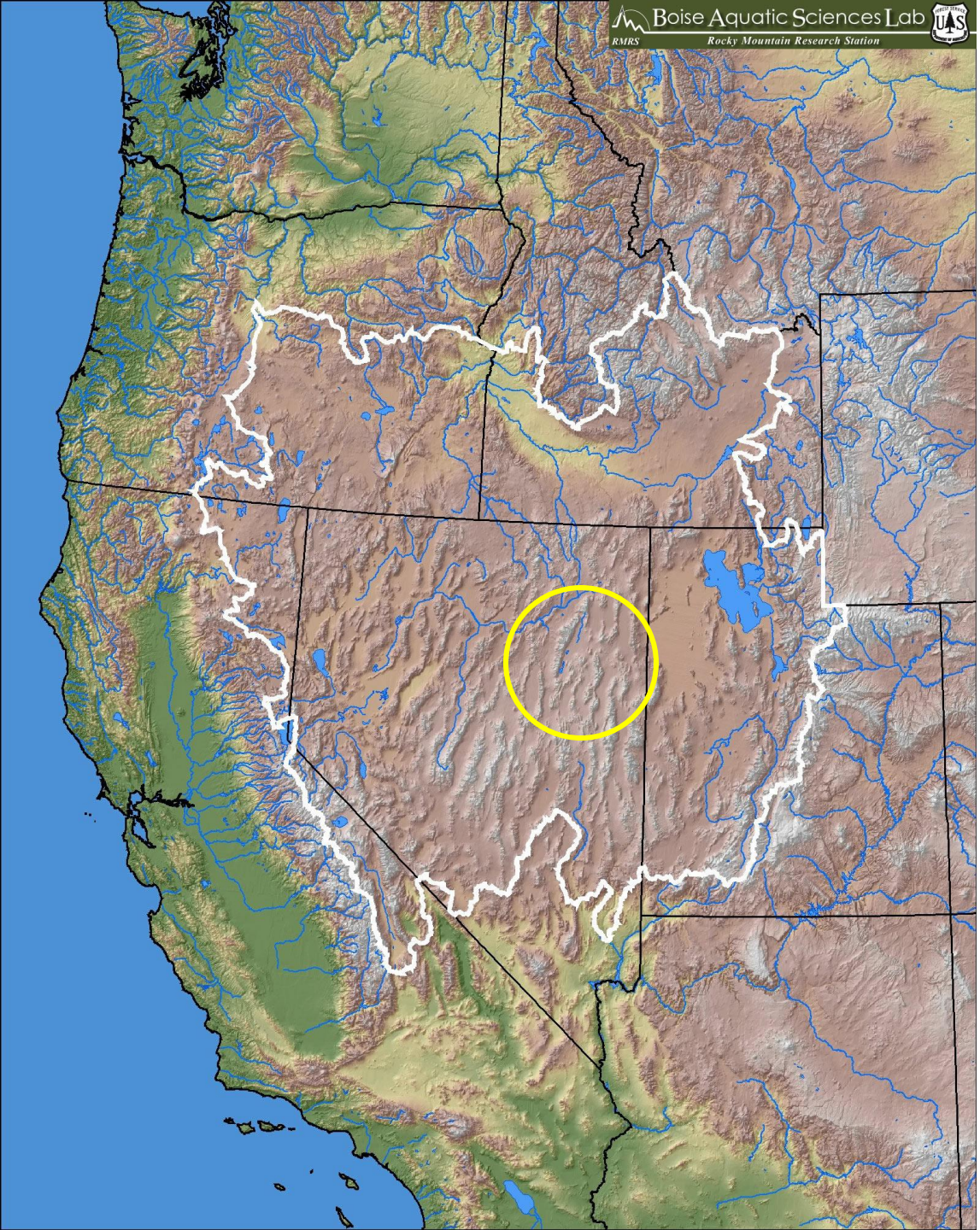
Average of 19 climate models. 2007.

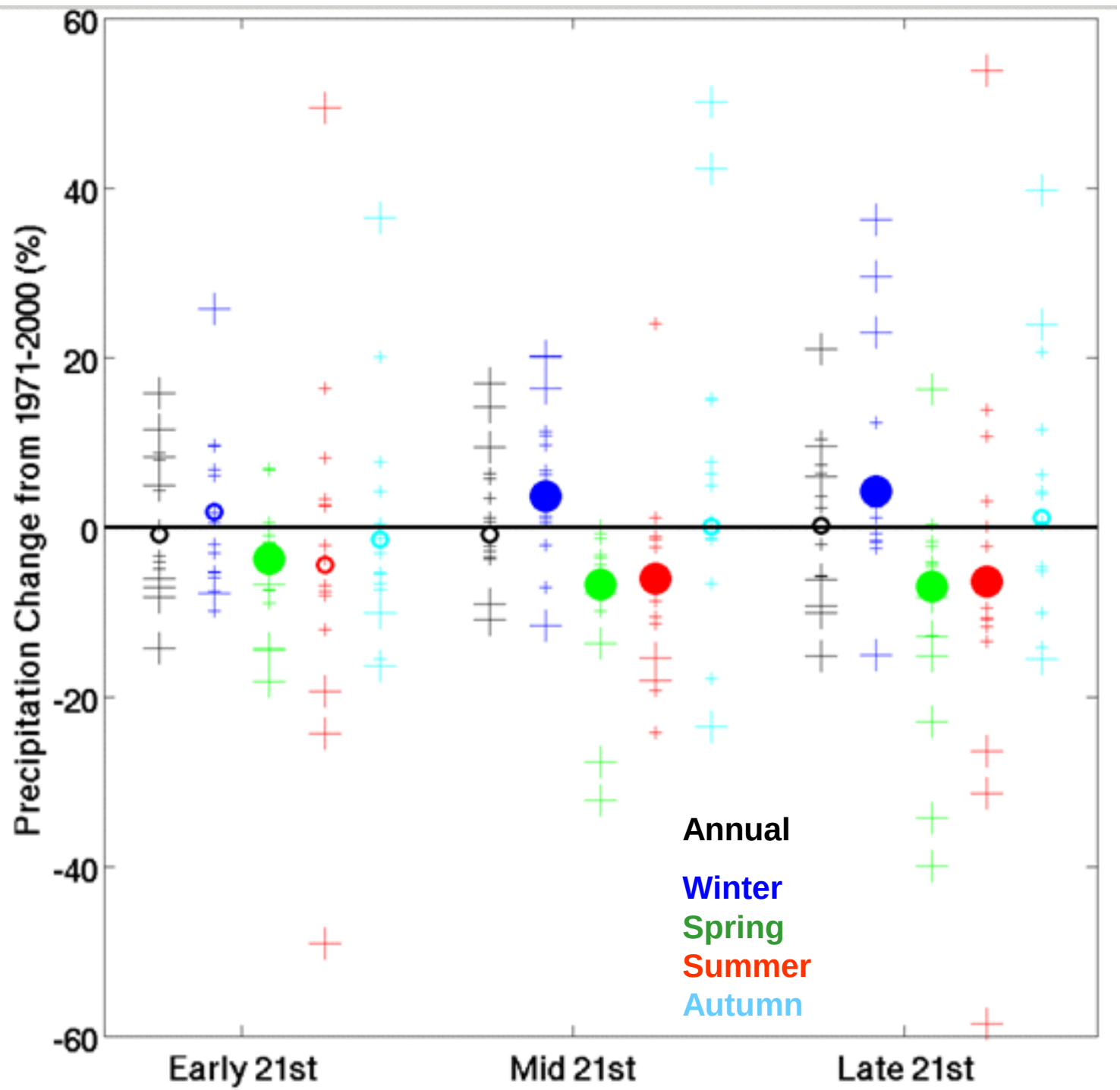
Figure by Gabriel Vecchi.

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

20 Years From 2010

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


Boise Aquatic Sciences Lab
RMRS
Rocky Mountain Research Station



East Central Nevada

Projected Precipitation Changes (%)

15 Models

IPCC A1B

Early 21st

2011-2040

Middle 21st

2041-2070

Late 21st

2071-2100

John Abatzoglou

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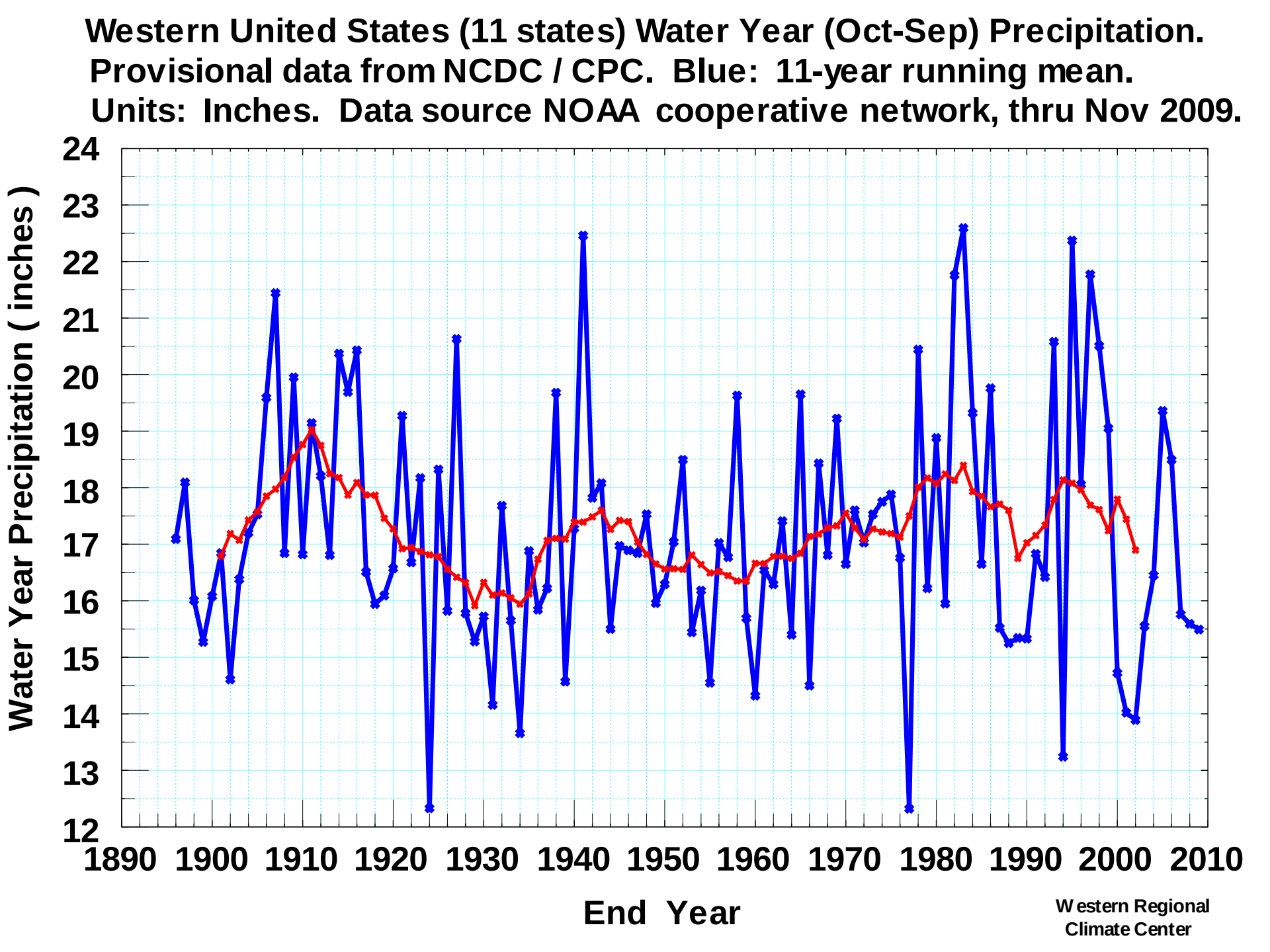
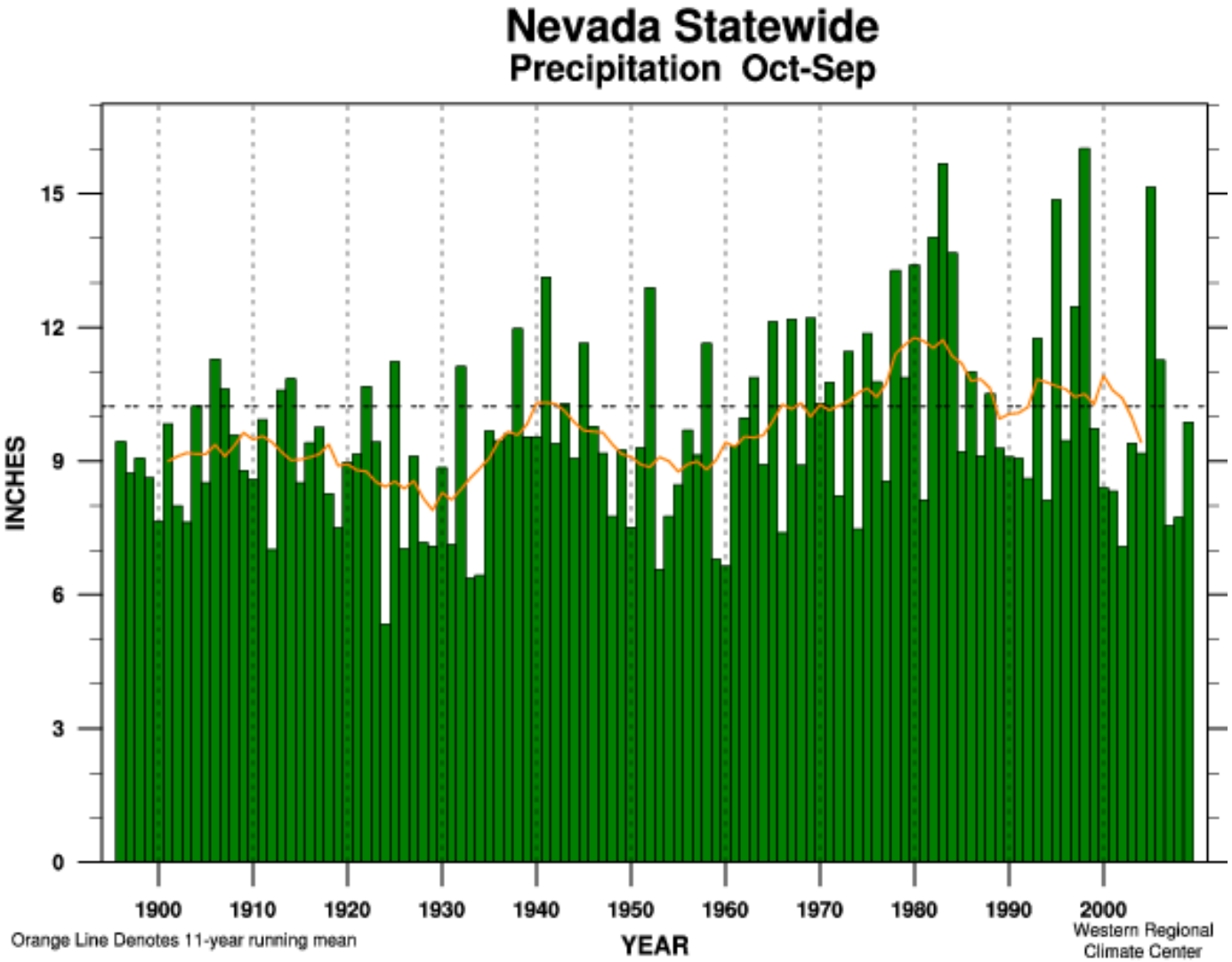

Western United States (11 states) Water Year (Oct-Sep) Precipitation.
Provisional data from NCDC / CPC. Blue: 11-year running mean.
Units: Inches. Data source NOAA cooperative network, thru Nov 2009.
Water Year Precipitation (inches)
24
23
22
21
20
19
18
17
16
15
14
13
12
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
End Year
Western Regional
Climate Center



Linear Trend 1895-present	+ 1.76 ± 1.11 in.	(+ 17 ± 10%) per 100 yr			
Linear Trend 1949-present	+ 2.06 ± 3.47 in.	(+ 20 ± 33%) per 100 yr			
Linear Trend 1975-present	- 6.10 ± 8.89 in.	(- 59 ± 86%) per 100 yr			
Wettest Year	16.02 in. (156%)	in 1998	MEAN	10.22 in.	
Driest Year	5.34 in. (52%)	in 1924	STDEV	2.35 in.	
Oct-Sep 2009	9.88 in. (96%)		RANK	75 of 114	

Nevada Statewide Precipitation

Water Year Oct-Sep

1895-96 thru 2008-09

www.cefa.dri.edu/Westmap/

WestMap

Climate Analysis & Mapping Toolbox

WestMap Home

TOOLBOX

Map & Graph

Create Time Series

Create Map

Tutorial

Custom Requests

Climate 101

Local Climate

Educational Resources

Climate Links

WestMap

Overview

About PRISM

About Us

User Feedback

Survey!

Publications

Applications

Select Element: Precipitation

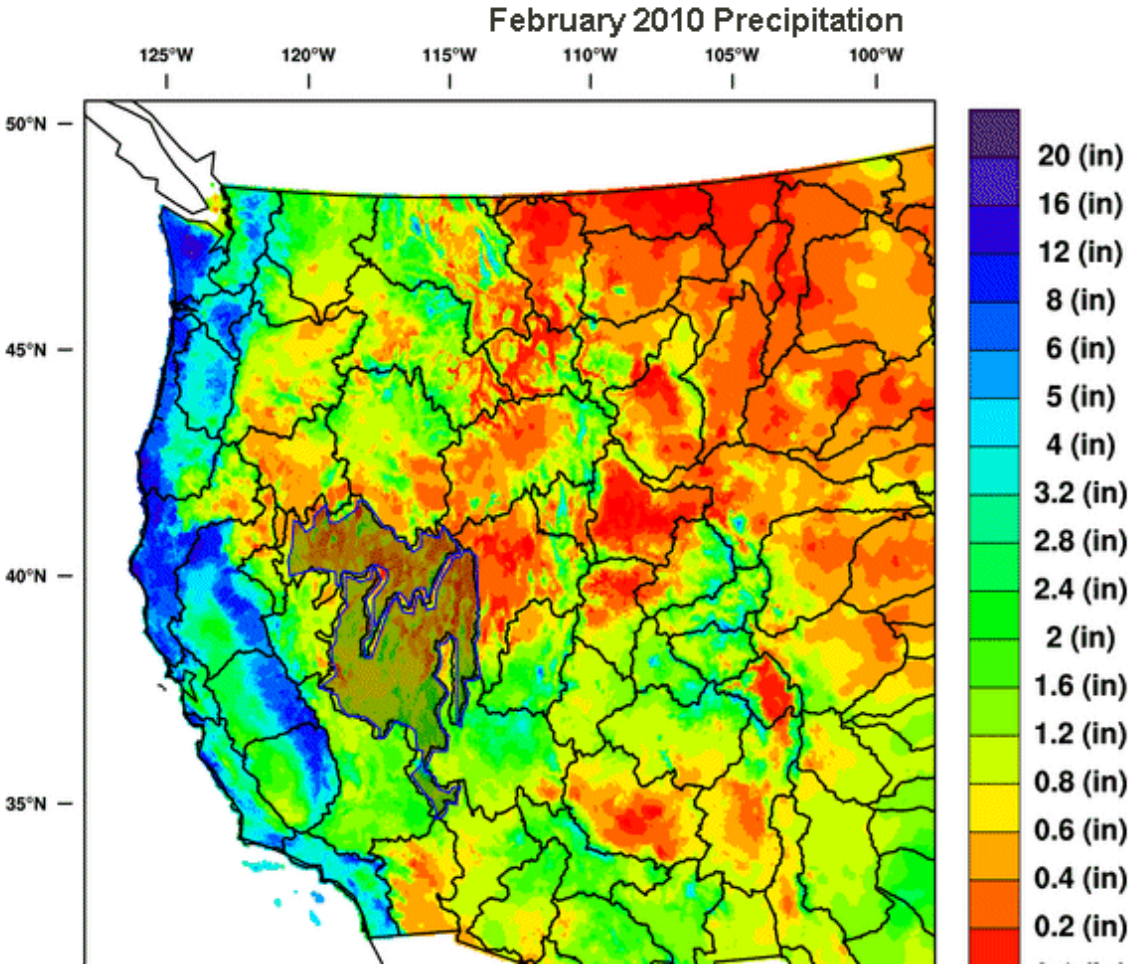
Select Region By: Hydro Units

Select Record: Most Recent

Map Click: Select Multiple Areas

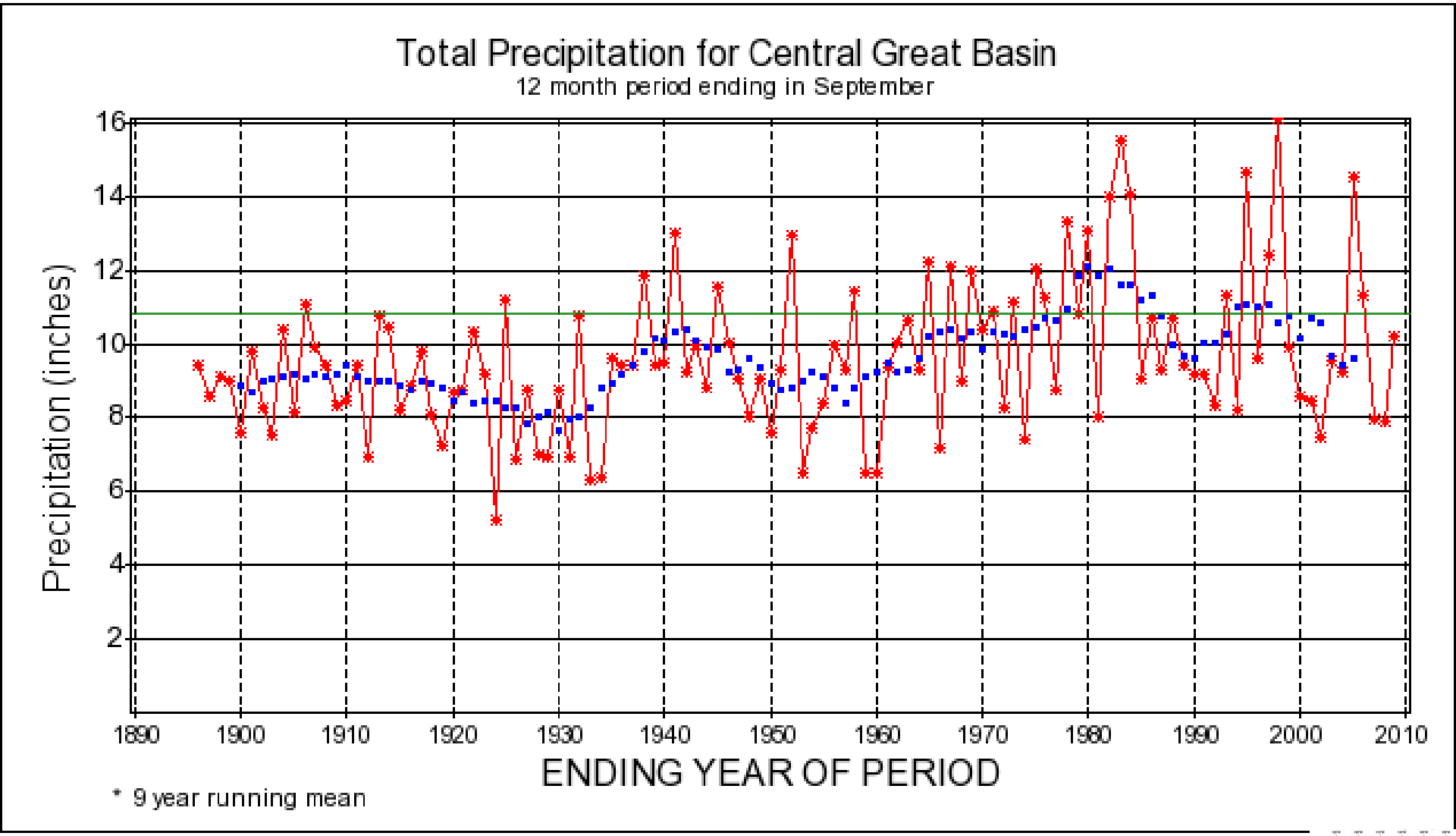
Clear Selections

Get Timeseries

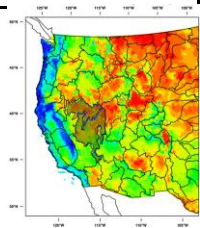


or, access via WRCC web "Projects" at www.wrcc.dri.edu

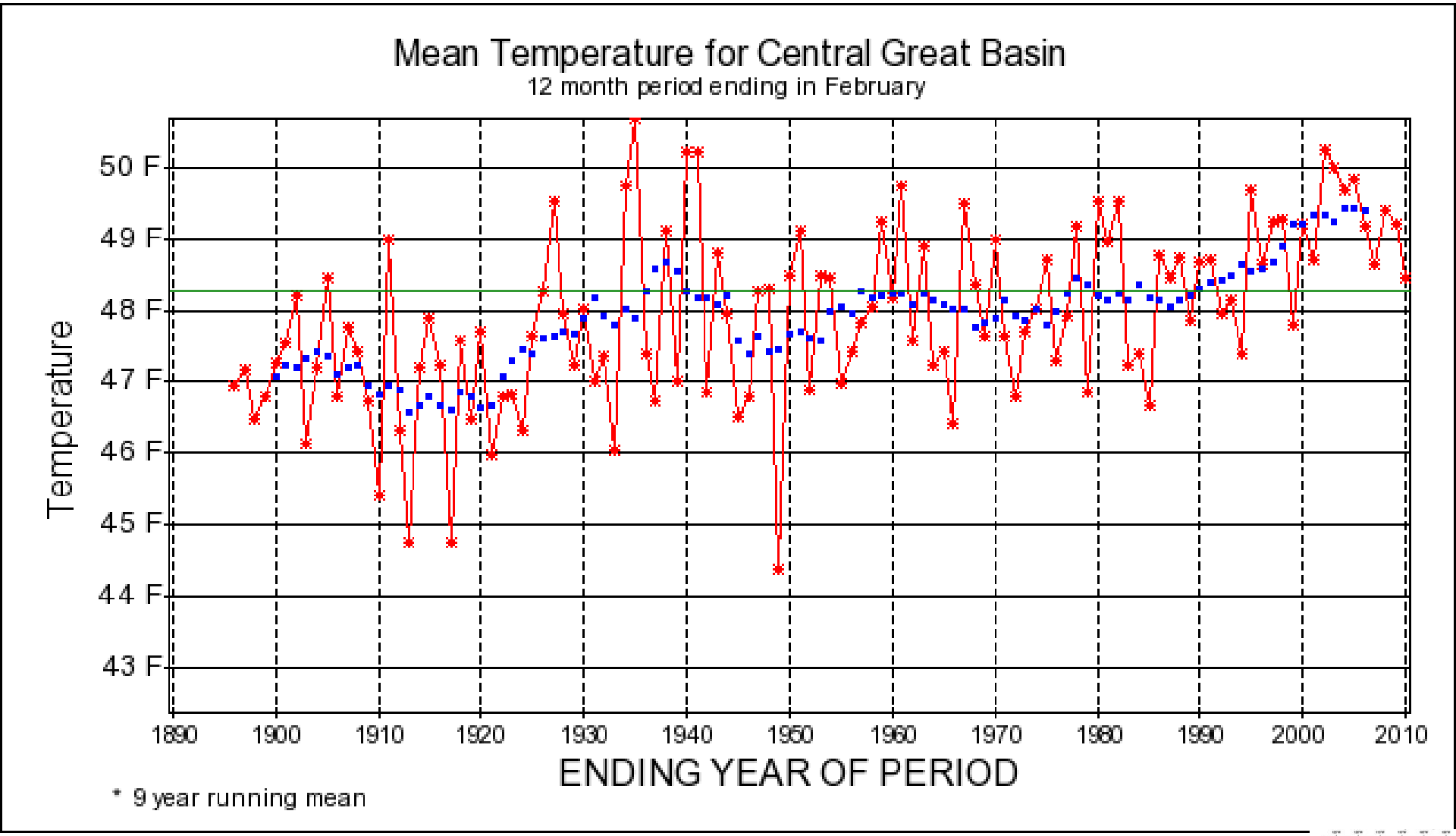
Water Year Precipitation (Oct-Sep) thru Sep 2009. Central Great Basin.



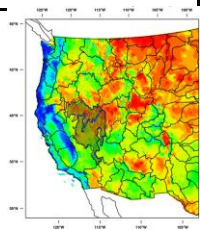
Green: 1971-2000 Mean.



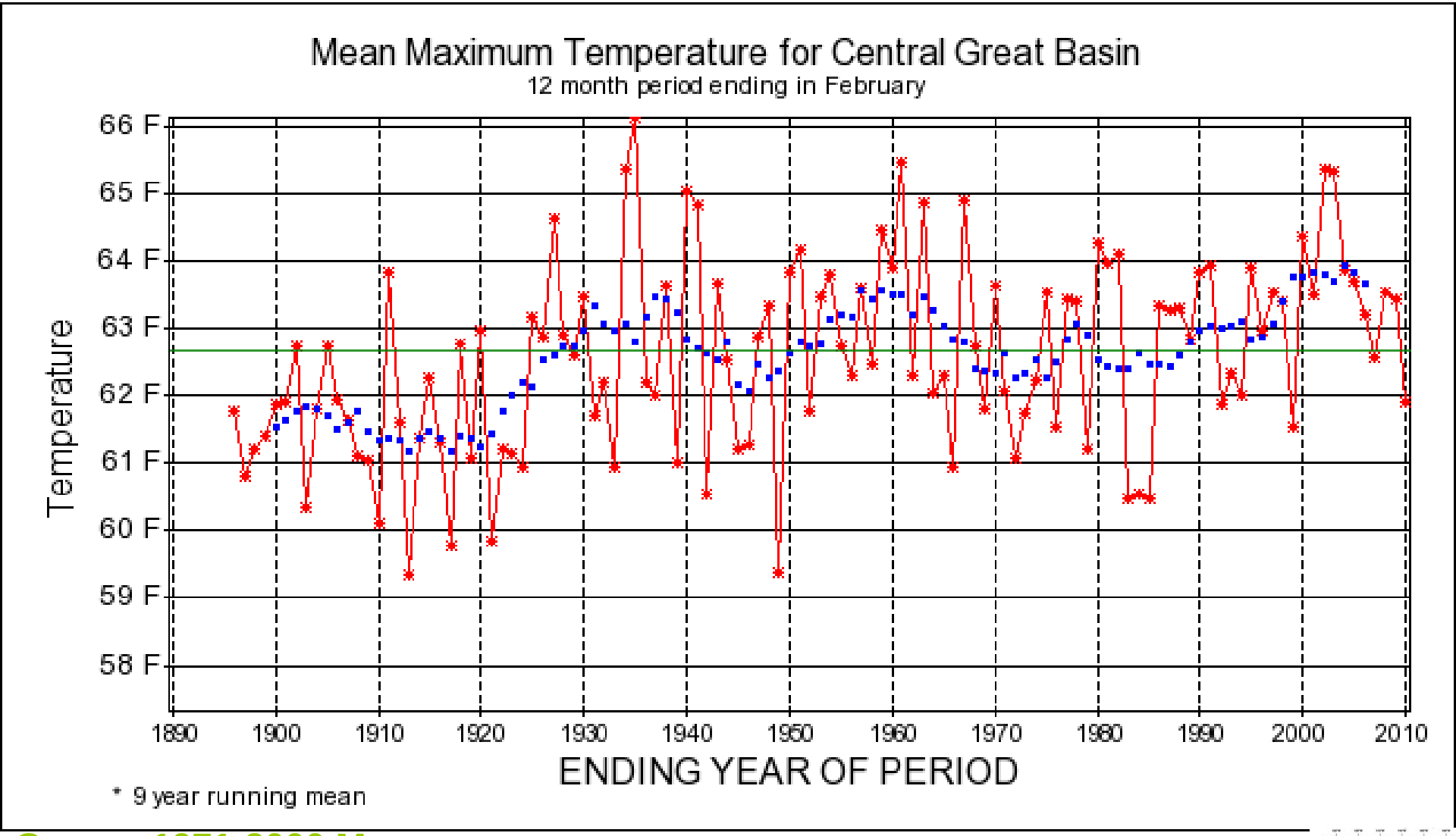
March-Feb Mean Temperature thru Feb 2010. Central Great Basin.



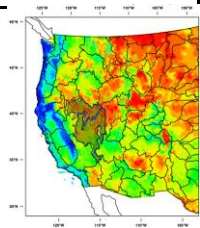
Green: 1971-2000 Mean.



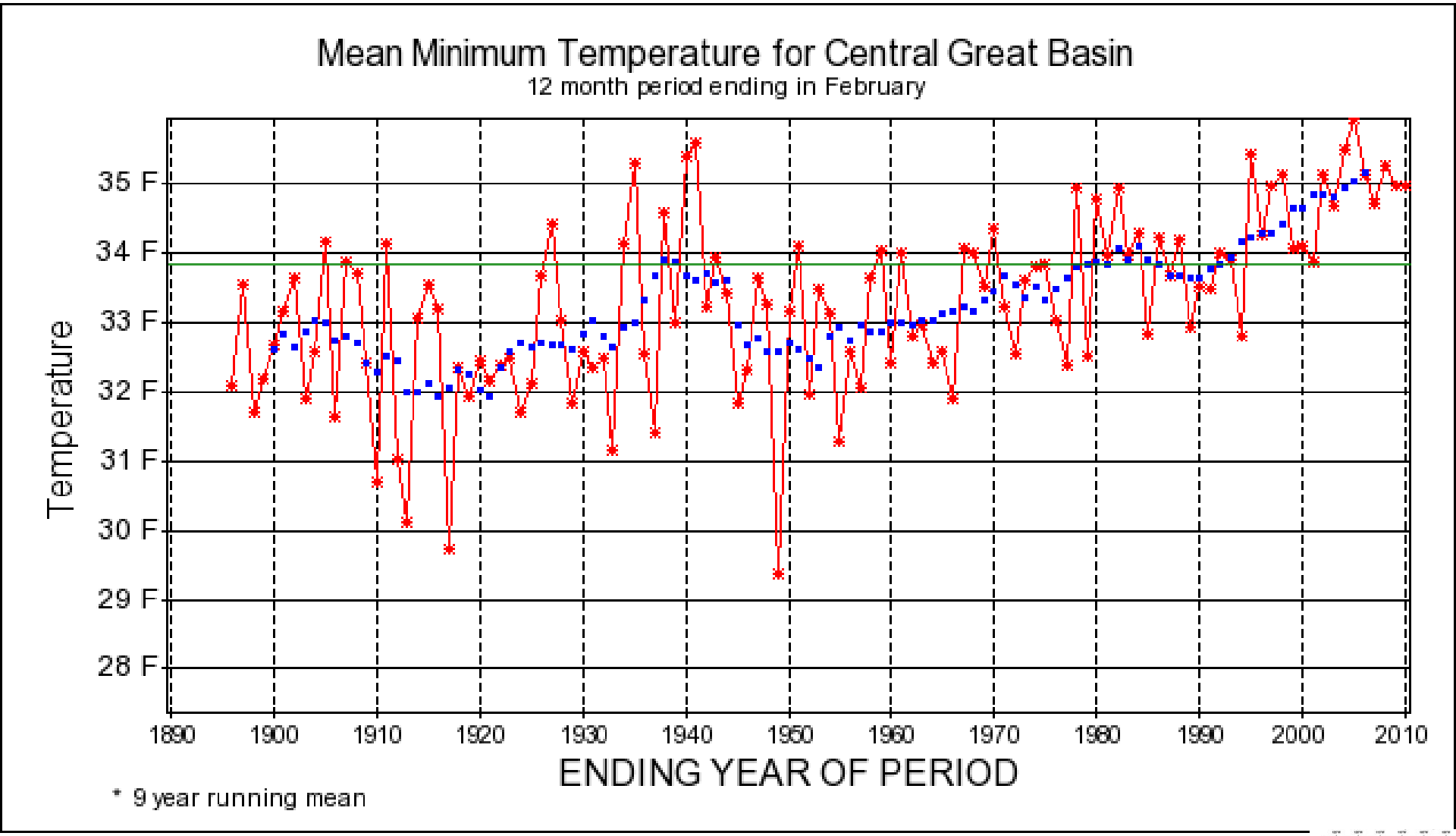
March-Feb Mean Maximum Temperature thru Feb 2010. Central Great Basin.



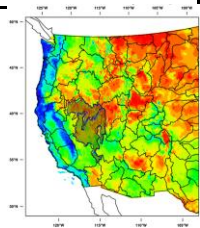
Green: 1971-2000 Mean.



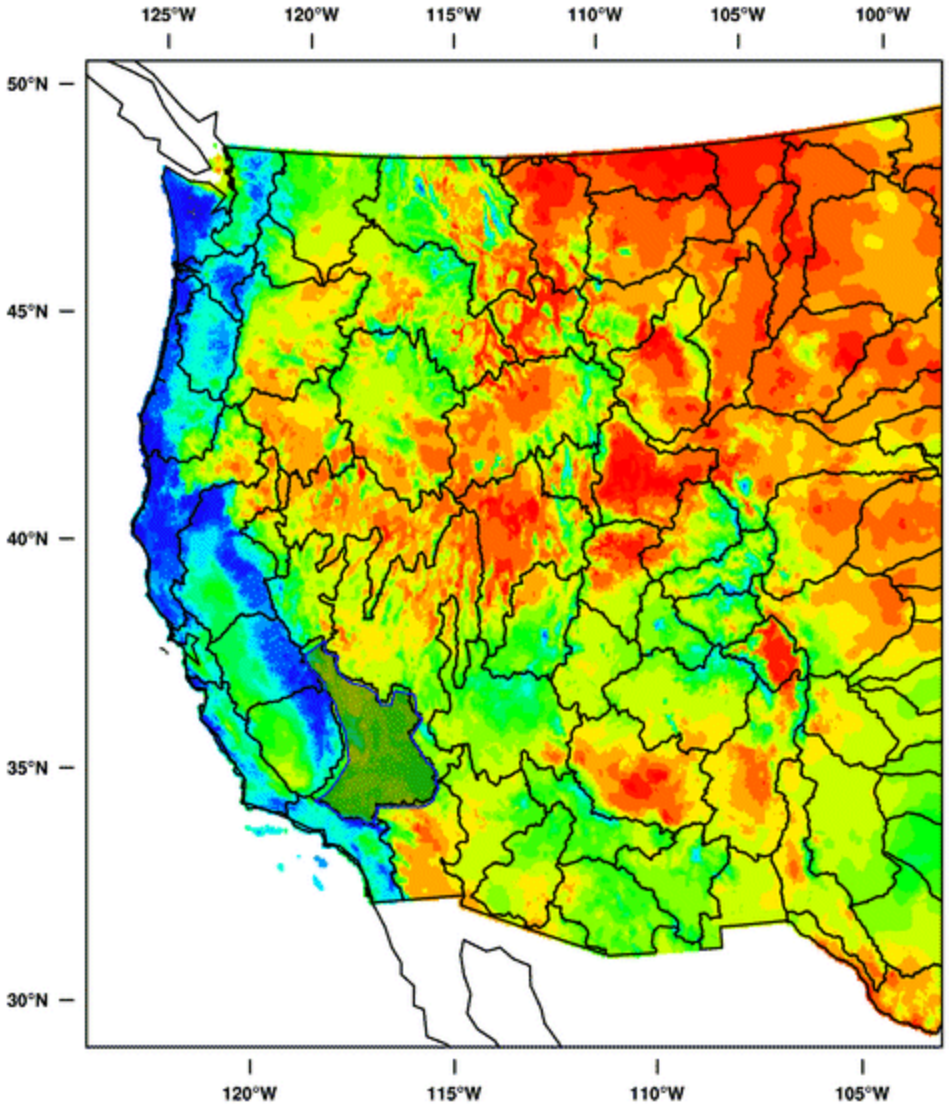
March-Feb Mean Minimum Temperature thru Feb 2010. Central Great Basin.



Green: 1971-2000 Mean.

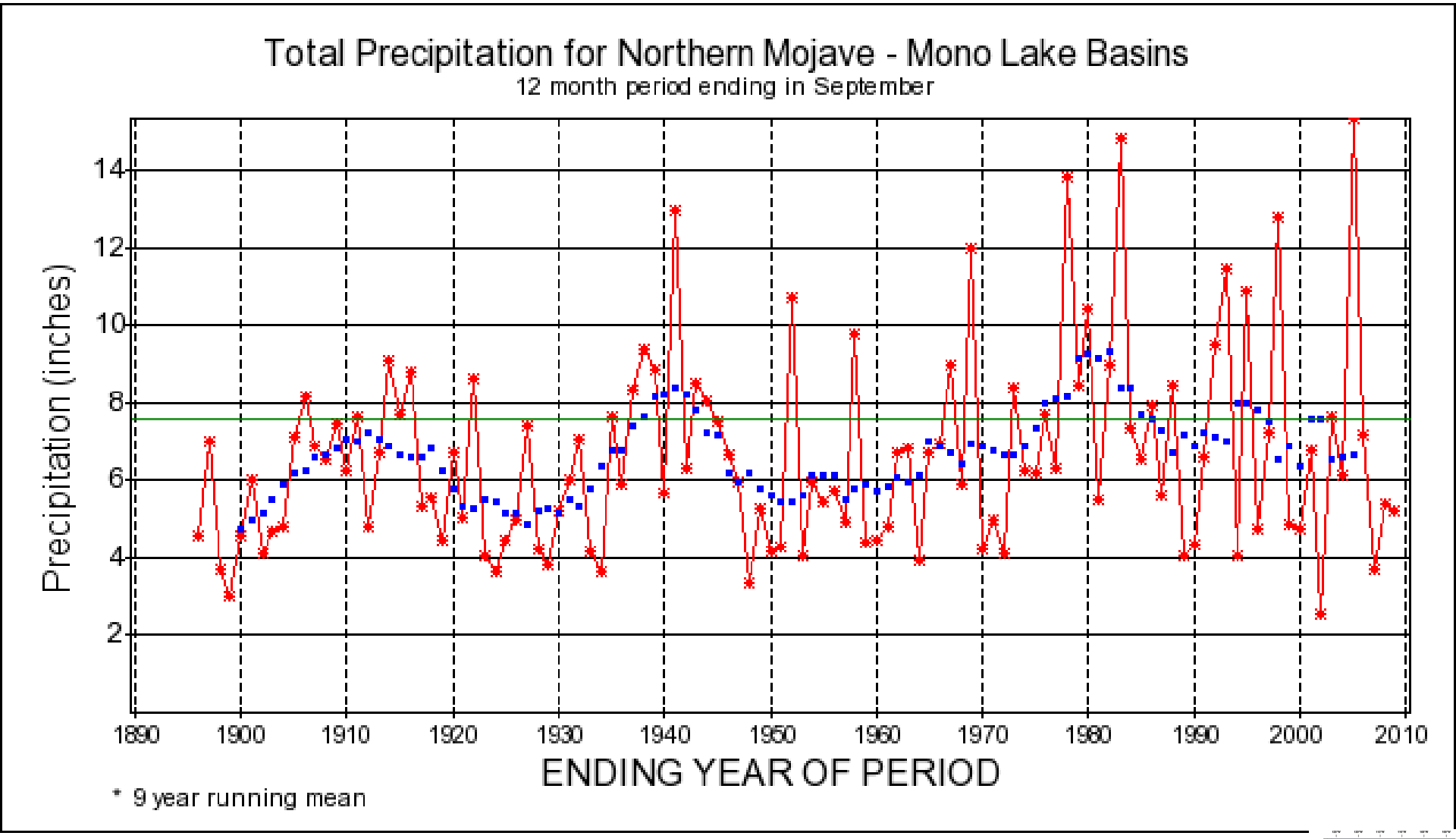


www.cefa.dri.edu/Westmap/

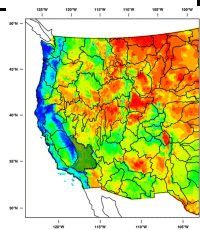


or, access via
WRCC web
"Projects" at
www.wrcc.dri.edu

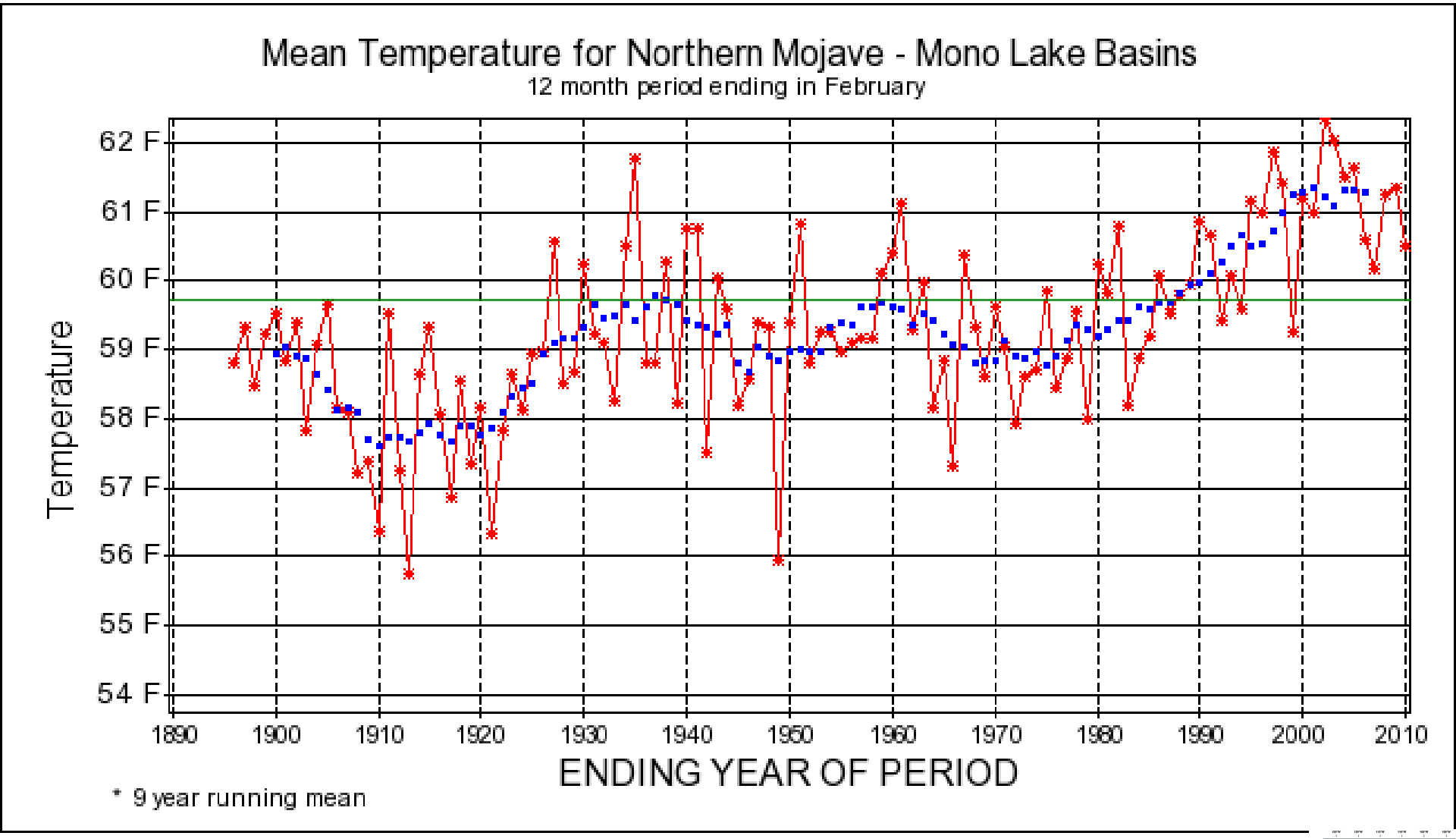
Water Year Precipitation (Oct-Sep) thru Sep 2009. Mojave-Mono Basins.



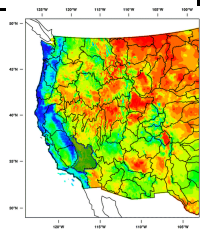
Green: 1971-2000 Mean.



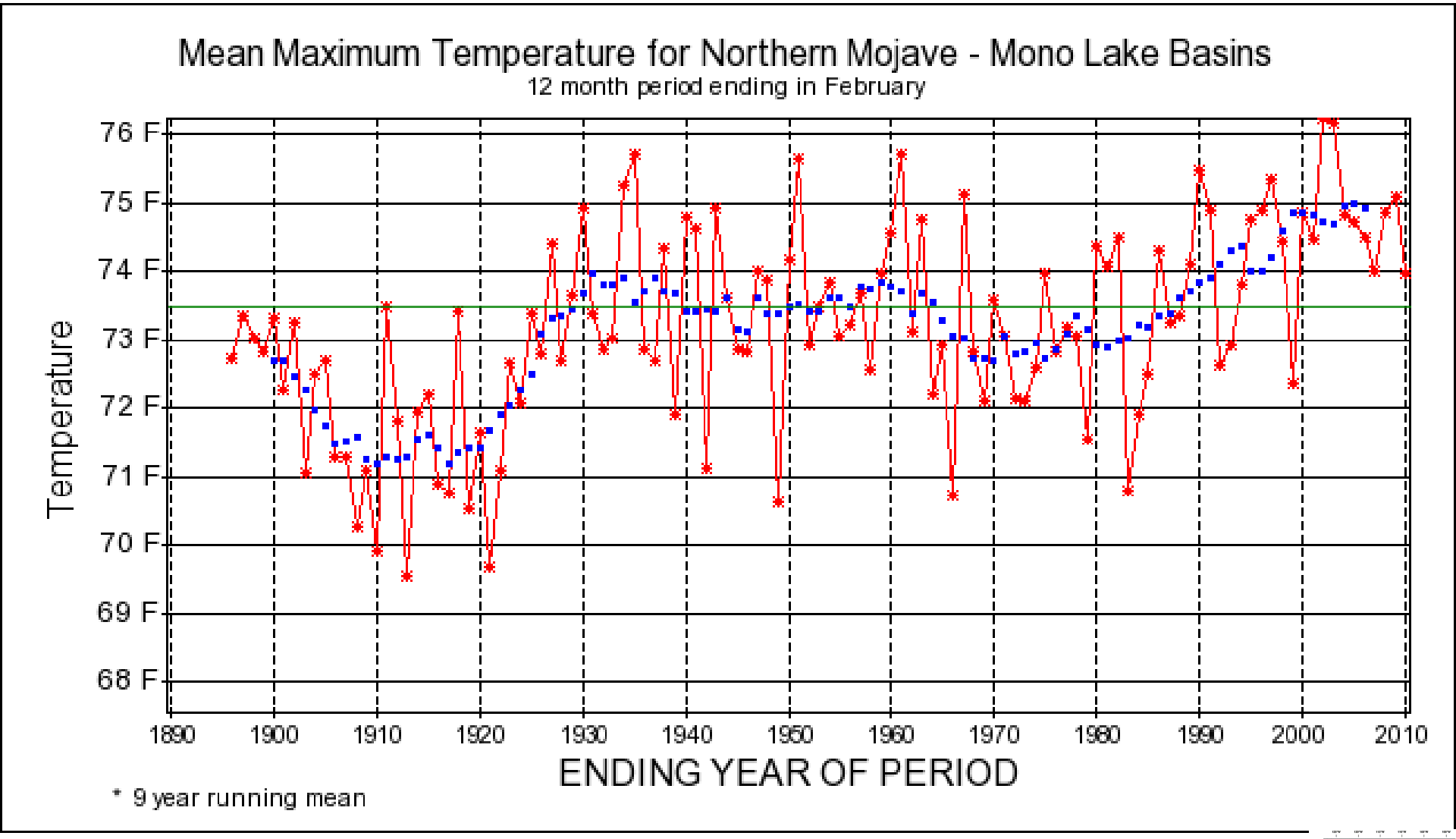
Mar-Feb Mean Temperature thru Feb 2010. Mojave-Mono Basin.



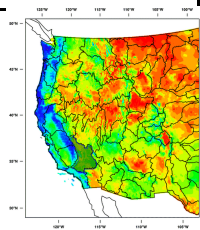
Green: 1971-2000 Mean.



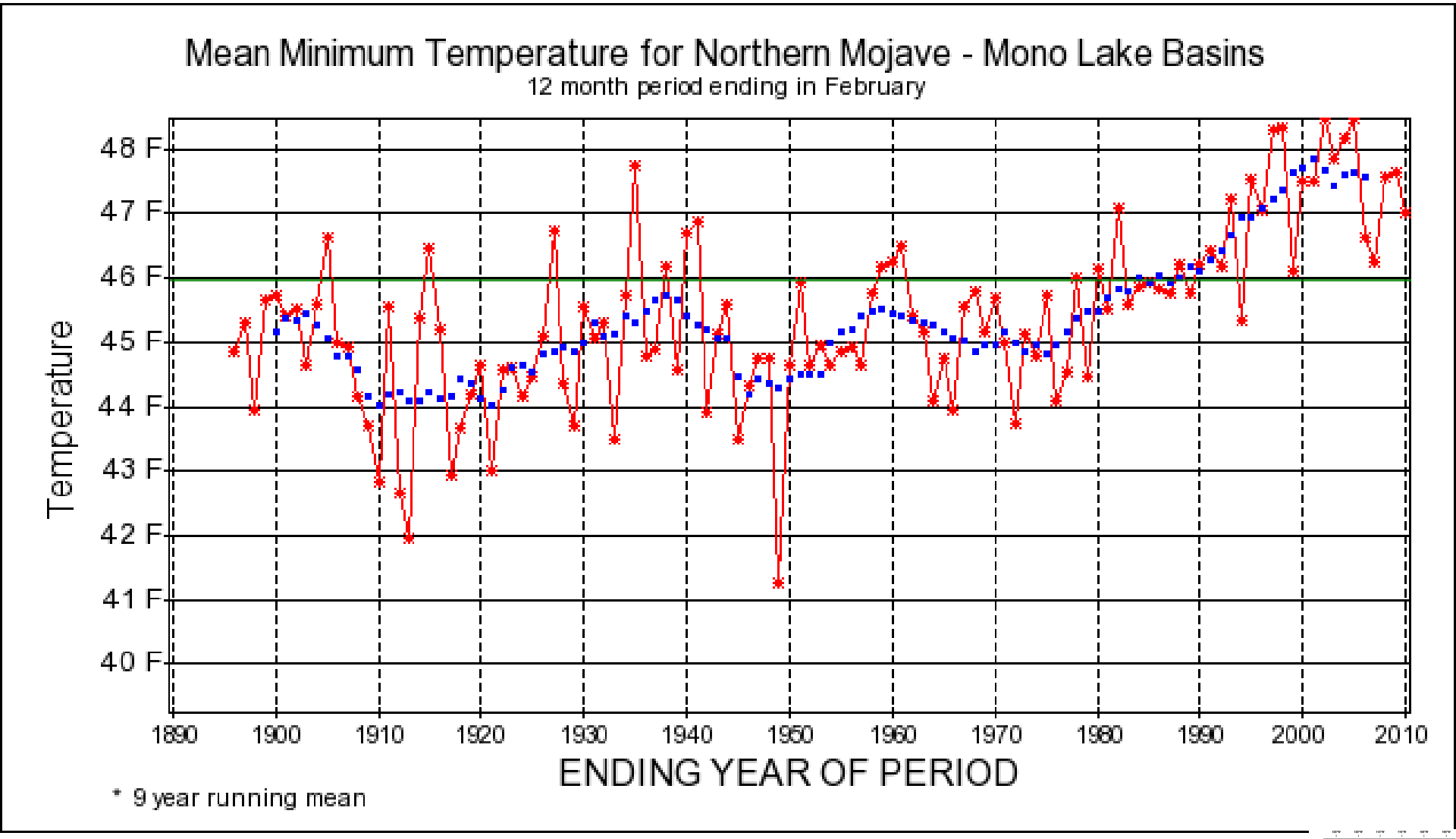
Mar-Feb Mean Maximum Temperature thru Feb 2010. Mojave-Mono Basin.



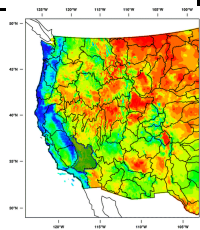
Green: 1971-2000 Mean.

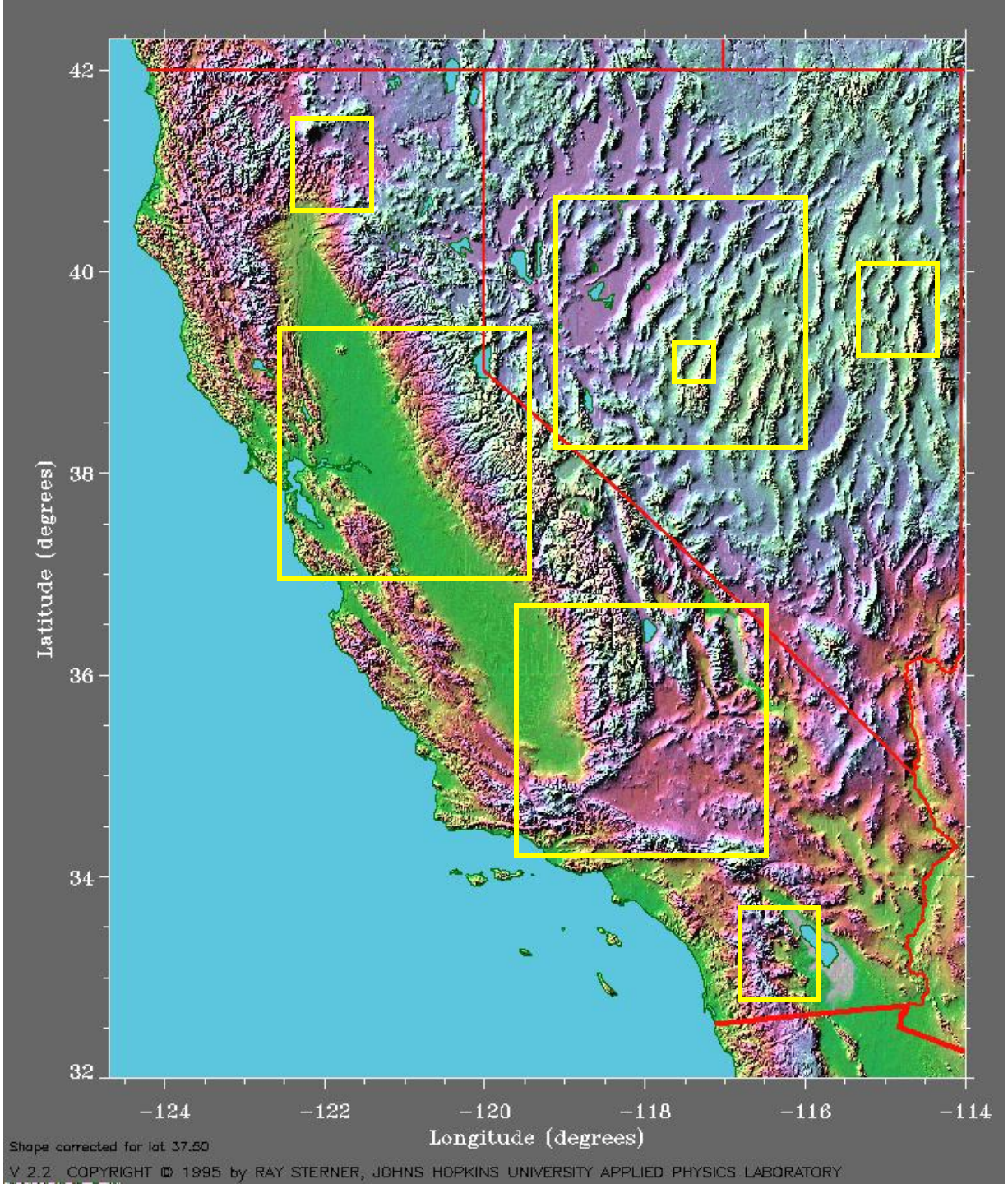


Mar-Feb Mean Minimum Temperature thru Feb 2010. Mojave-Mono Basin.



Green: 1971-2000 Mean.





Grid resolution:

Global Climate Model and Reanalysis

Global

Regional
(slightly smaller; pixel resolution)

AR4 Models ~ 1 degree on a side

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

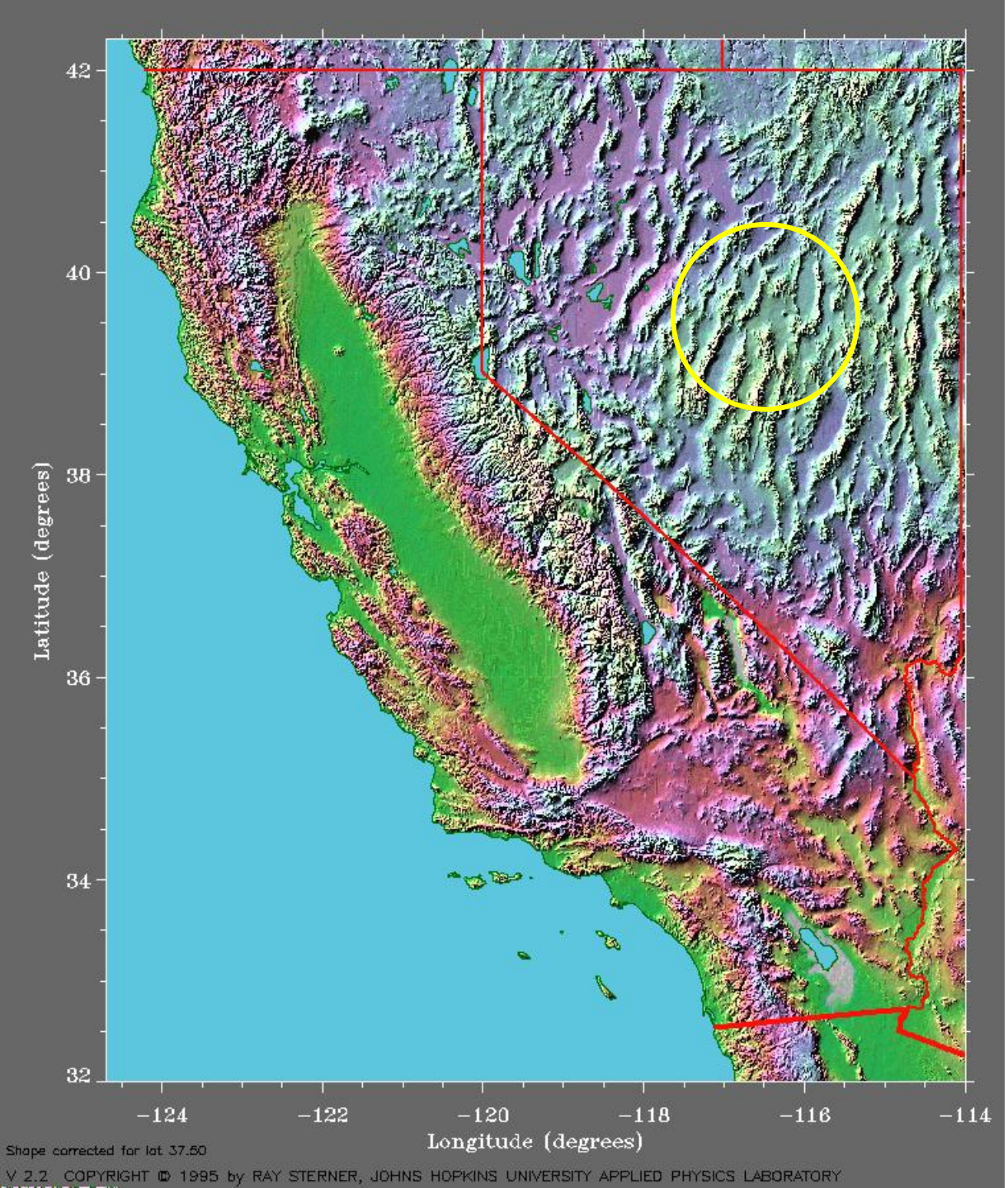
Anticipating Challenges to Western Mountain Ecosystems and Resources

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

July 2006

20 February 2007

White Mtn Summit, 14246 ft
Reconfigured July 2004



North American Freezing Level Tracker

Freezing Level Has Important Hydrologic Effects

Temperature as a hydrologic element

Select: Central Nevada, 12 months ending in Jan, Temperature 0 C, 9-year running mean.

North American Freezing Level Tracker

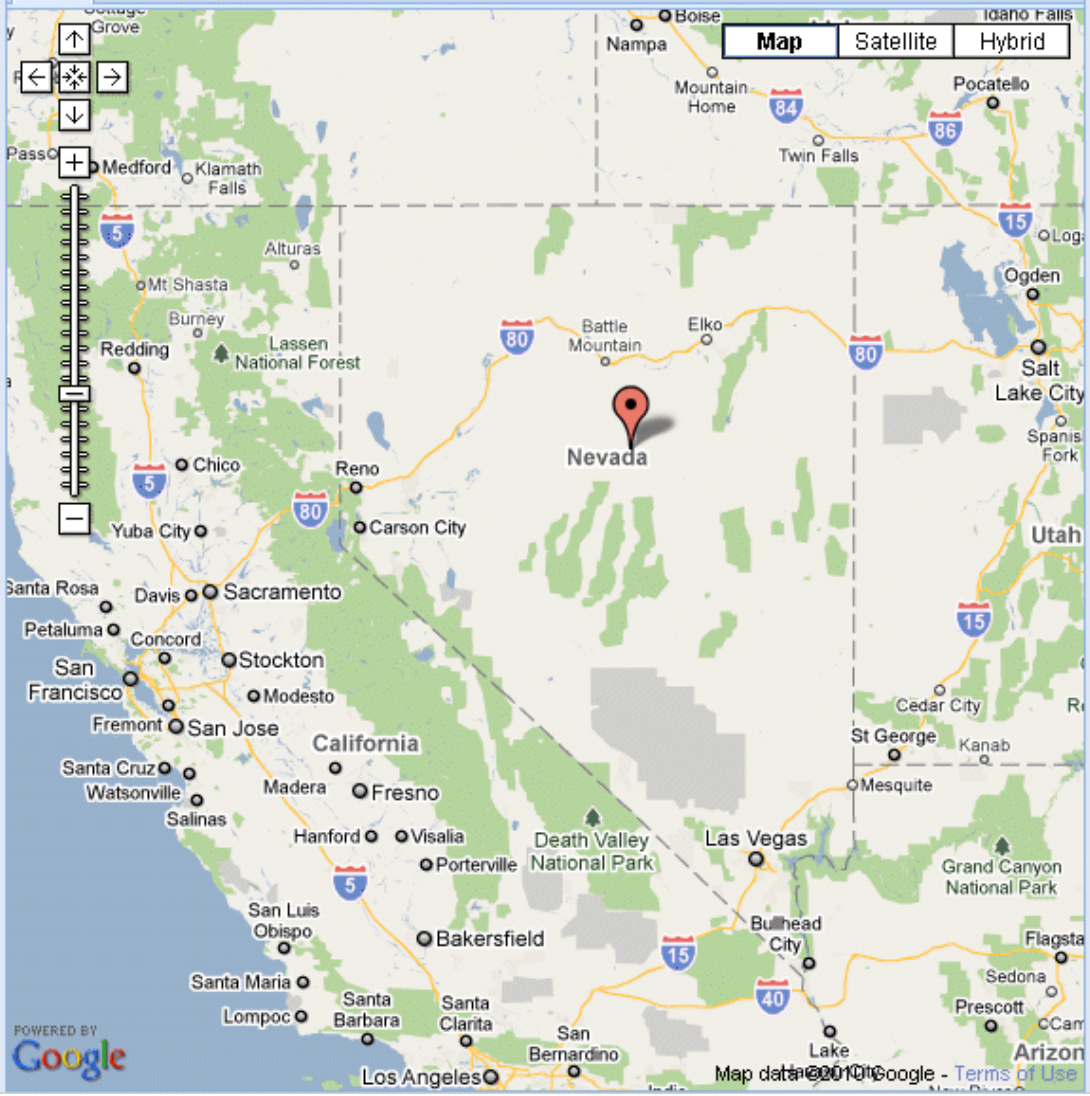
About

Contact

Location Selection

Display Options

Map



How to use

Monthly/Seasonal Listings

Help

Lat: 39.85915479295669

Lon: -116.65283203125

Span: 12 Months

End Month: Dec

Level: 0 C

Running average: 9 Years

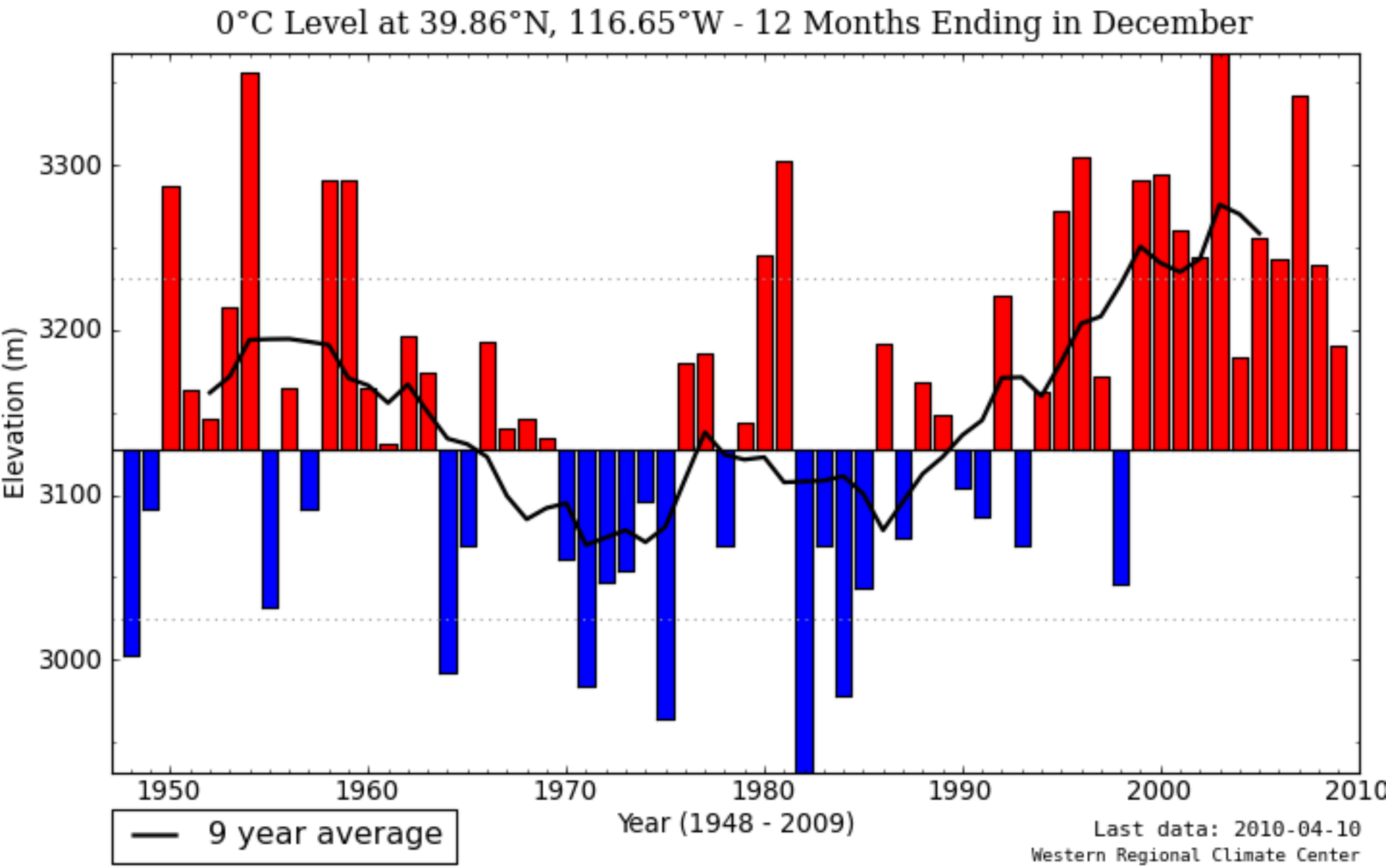
9 Years

Go

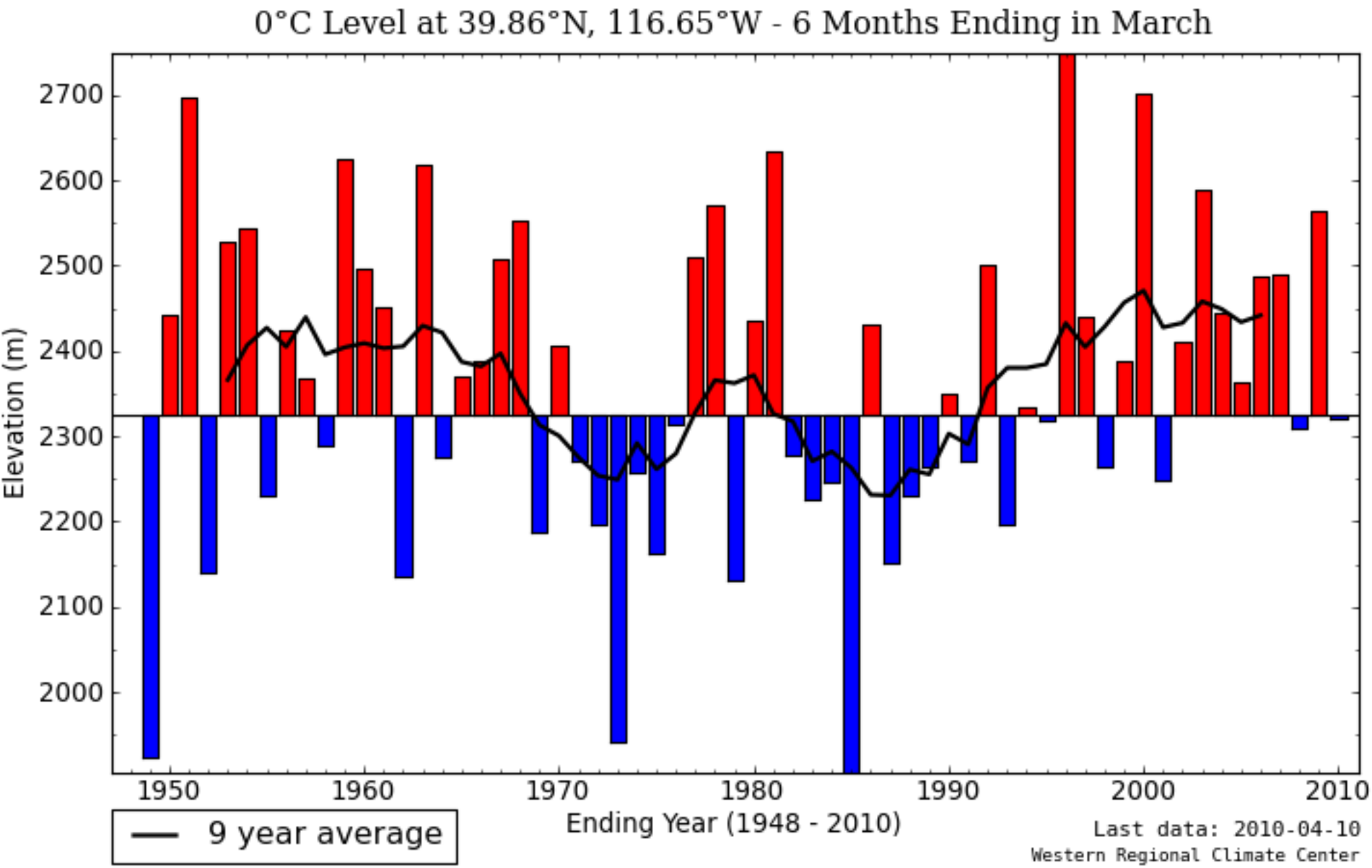
Last 12 Months

/www.wrcc.dri.edu/cwd/products/

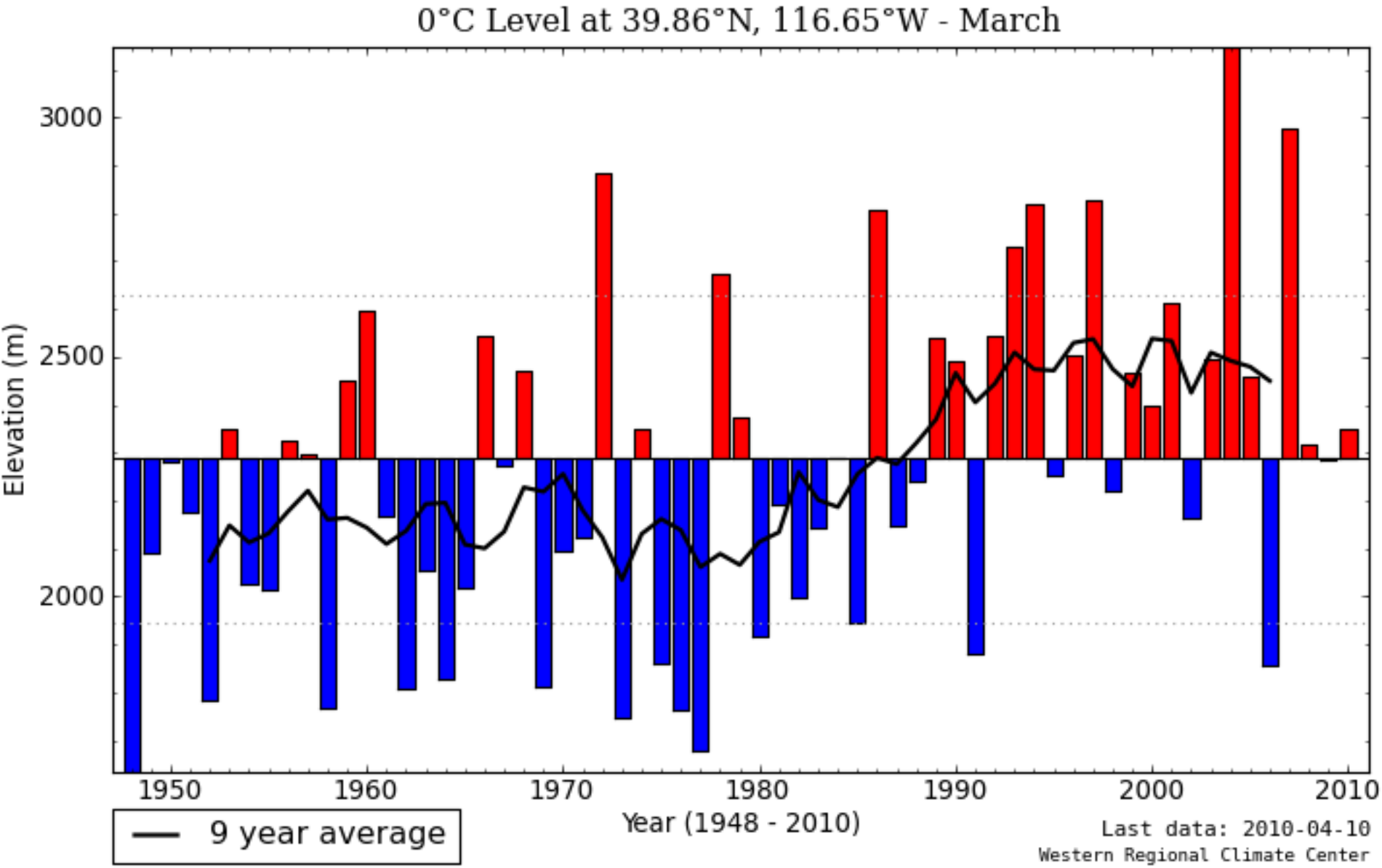
Elevation of Freezing Level over Central Nevada. Annual. 1948 through 2009.



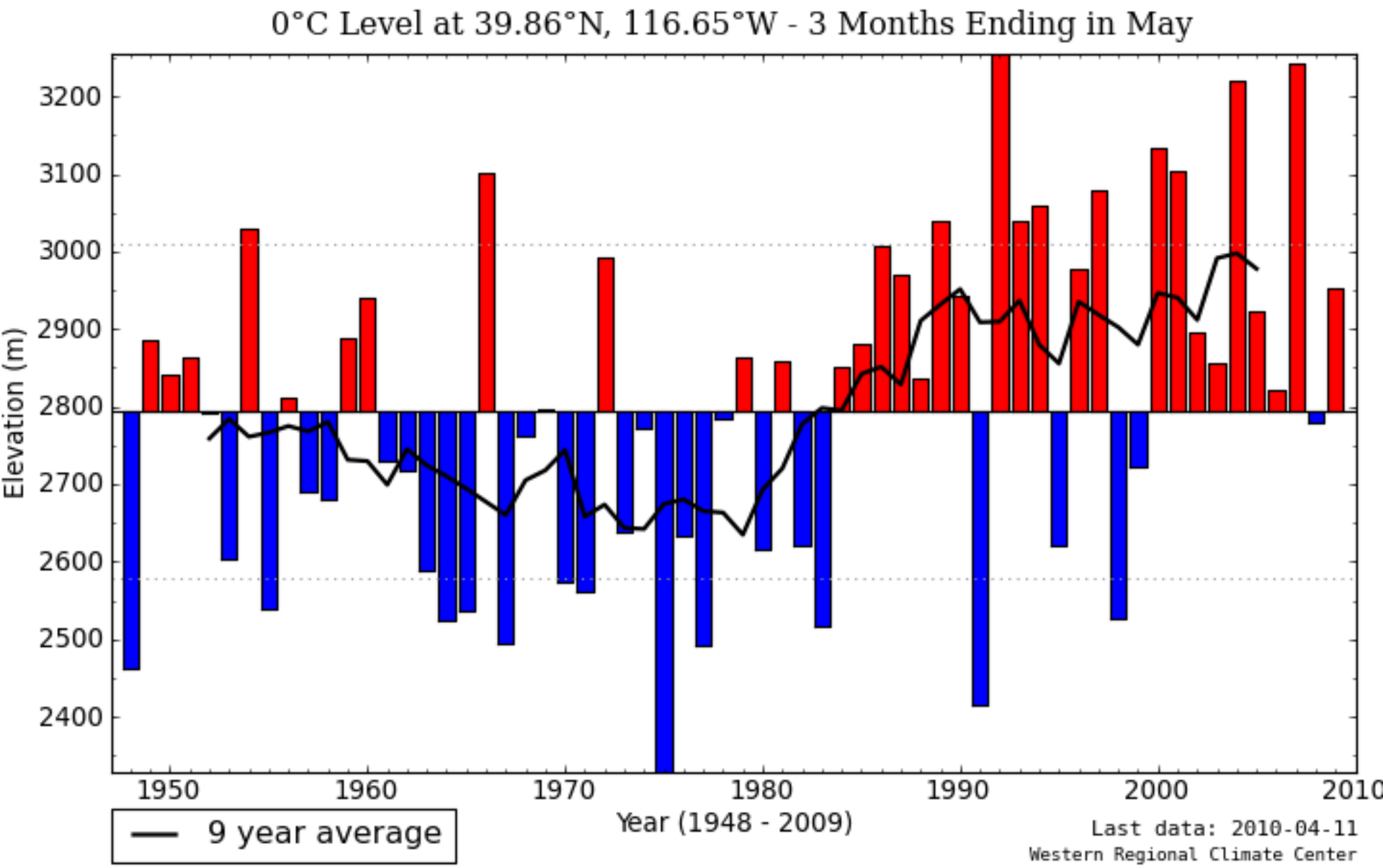
Elevation of Freezing Level over Central Nevada. Oct - Mar. 1948 through 2010.



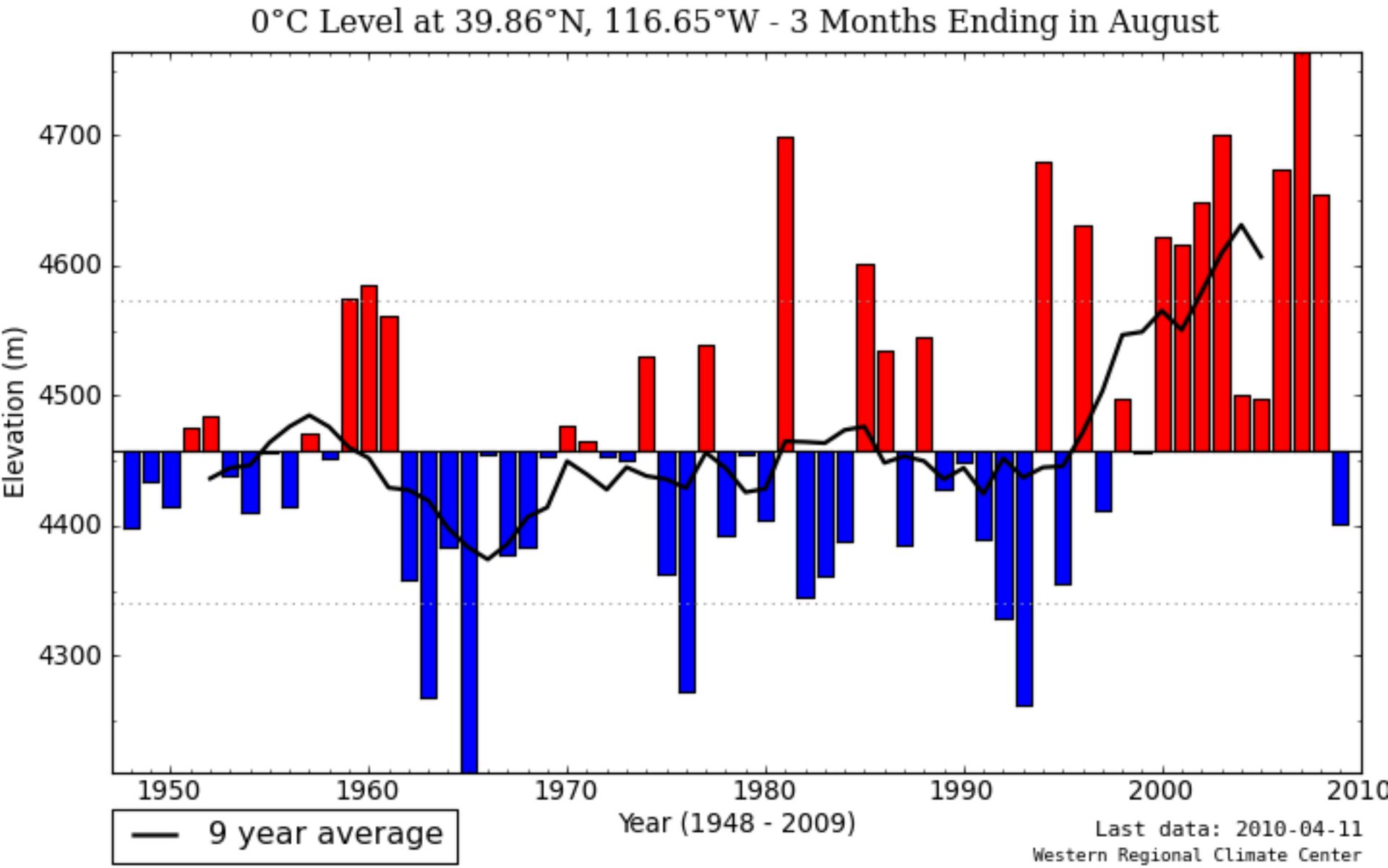
Elevation of Freezing Level over Central Nevada. March. 1948 through 2010.



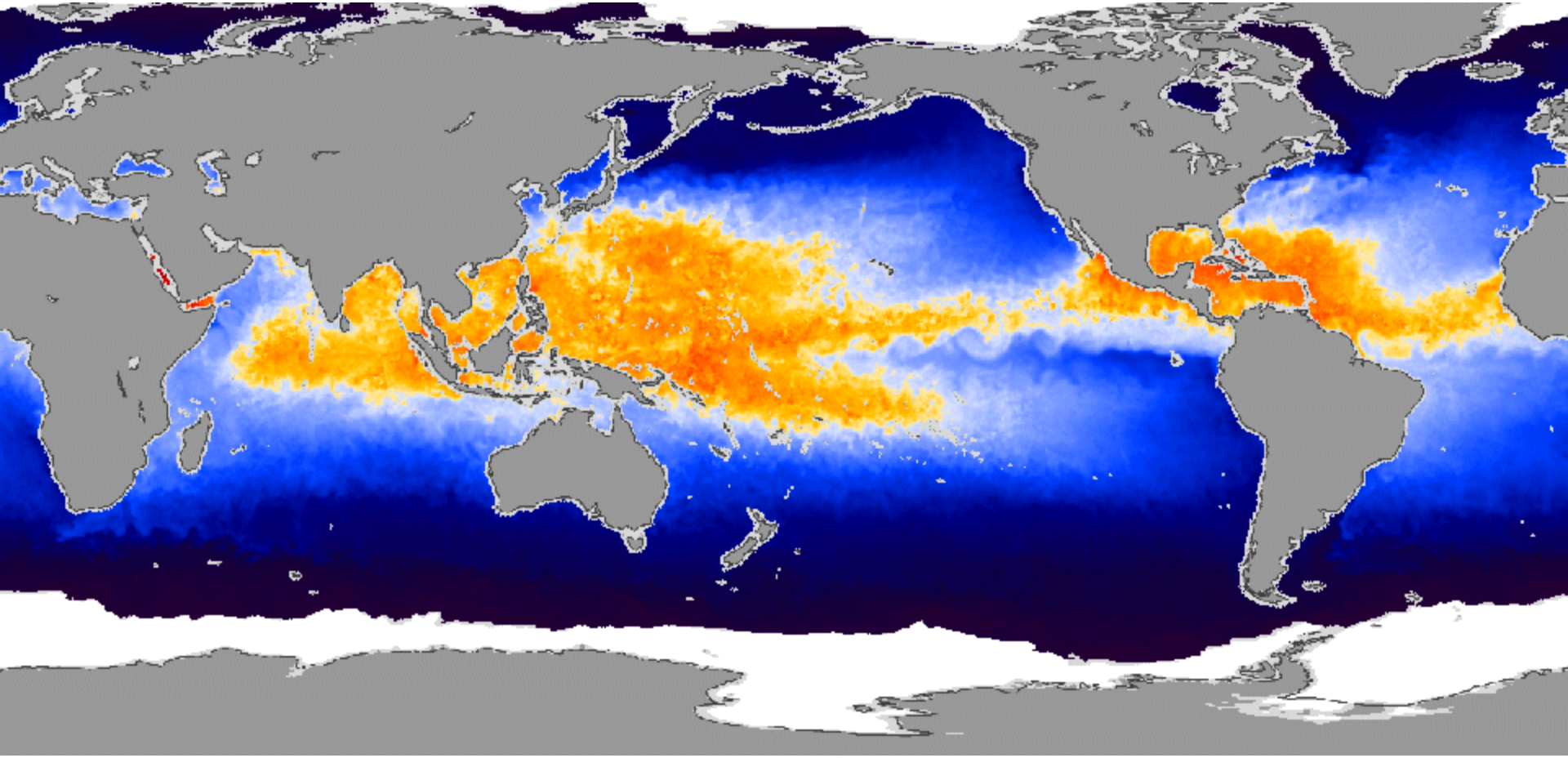
Elevation of Freezing Level over Central Nevada. Mar-Apr-May. 1948 thru 2009.



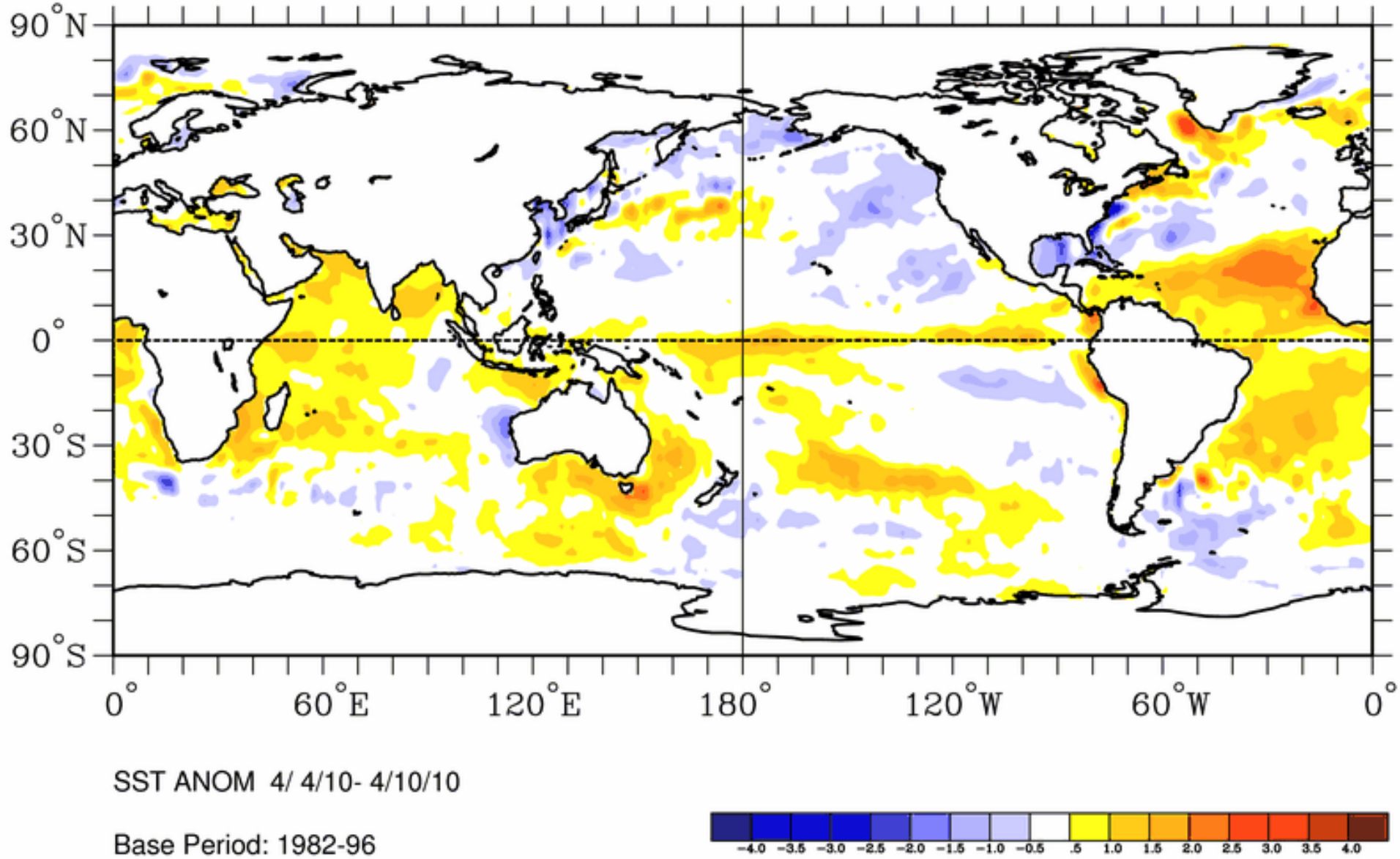
Elevation of Freezing Level over Central Nevada. Jun-Jul-Aug. 1948 thru 2009.



The World's Warm Oceans

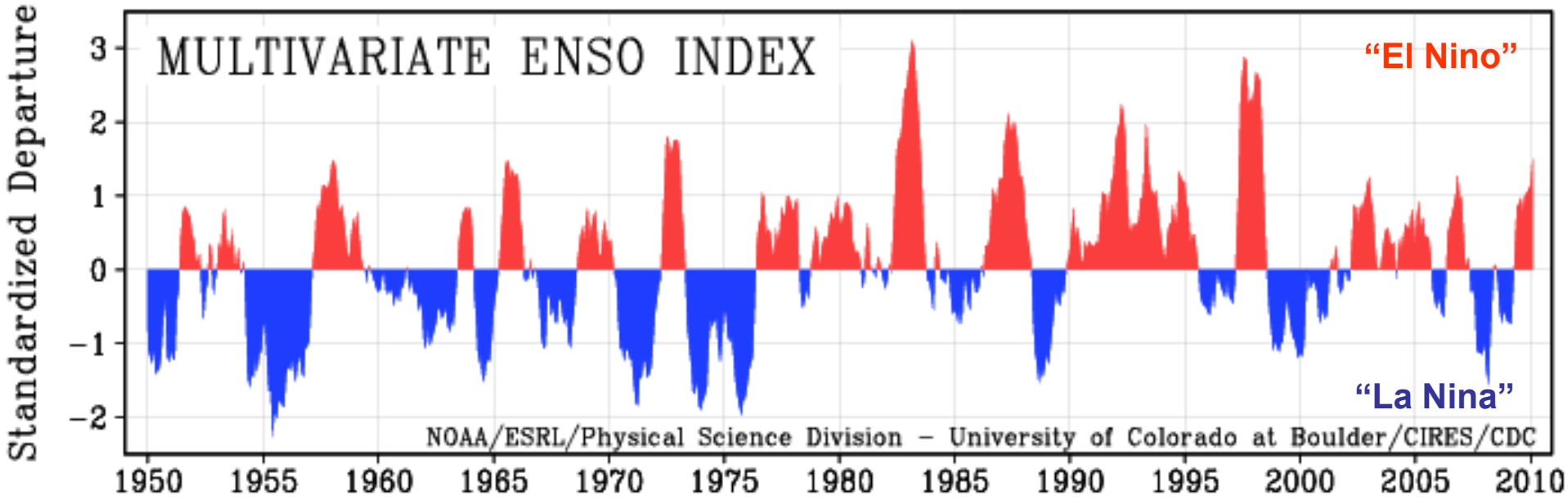


Global Sea Surface Temperature Anomalies (C) 2010 April 4-10

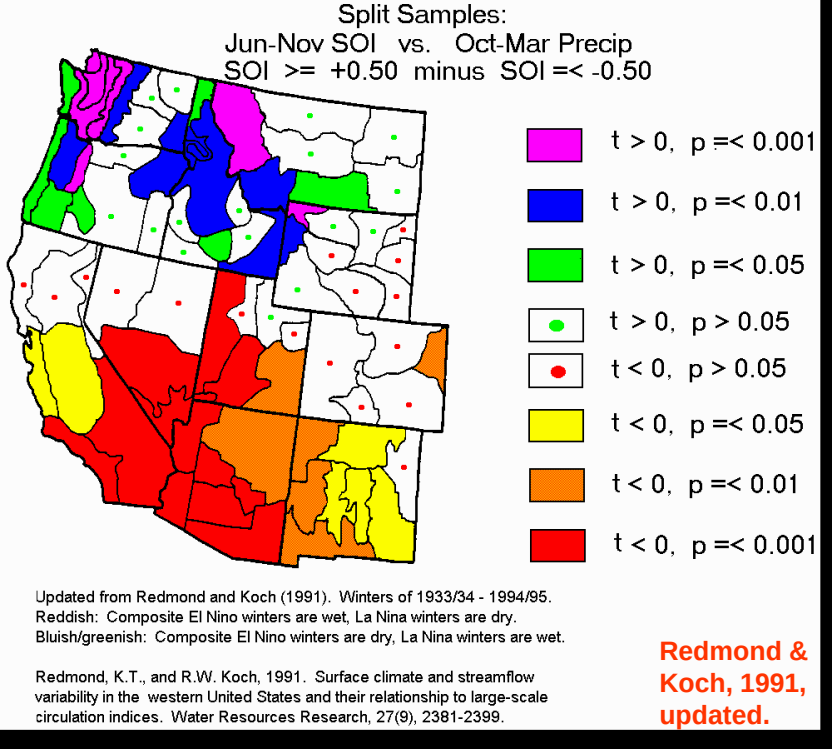


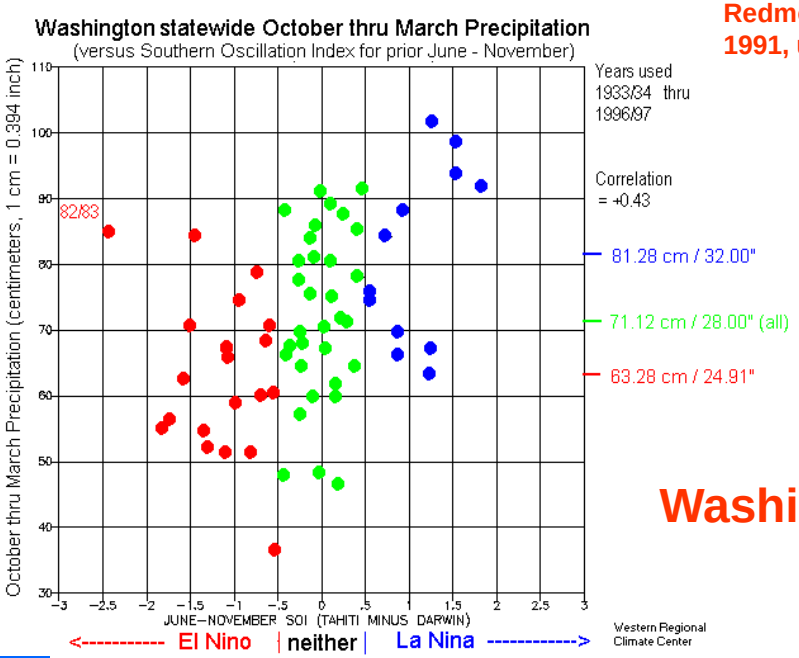
NOAA ESRL

Through February 2010

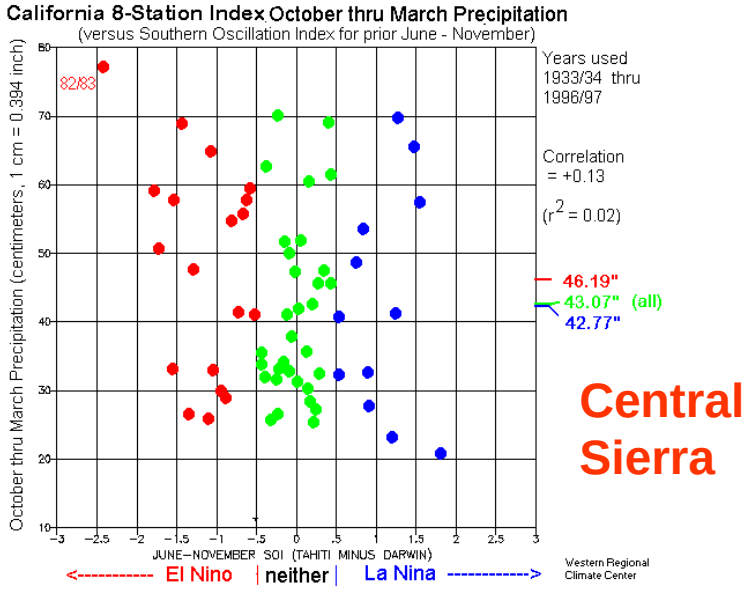


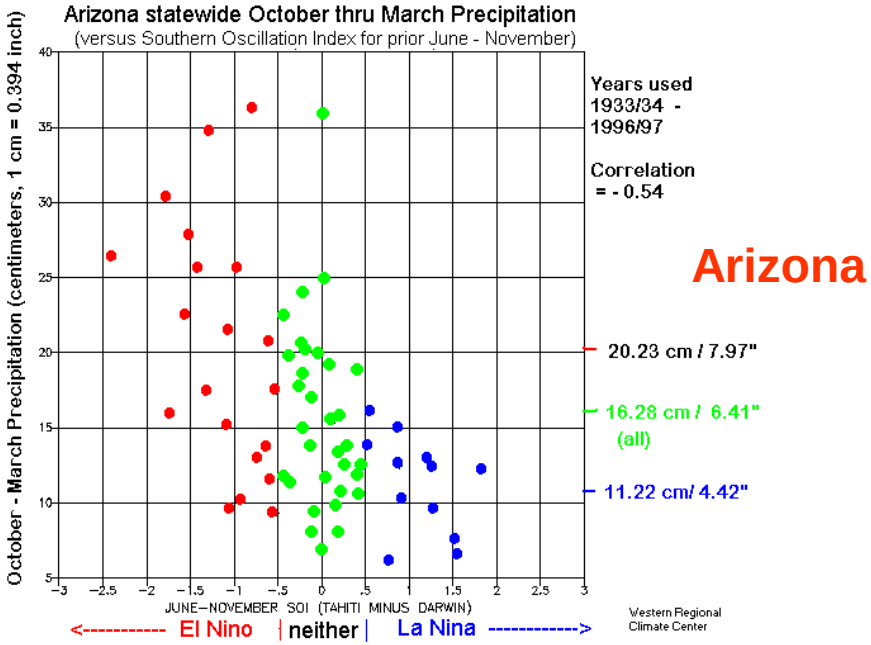
NOAA ESRL ("CDC"), Wolter and Timlin


Split Samples:
Jun-Nov SOI vs. Oct-Mar Precip
SOI >= +0.50 minus SOI =< -0.50
t > 0, p =< 0.001
t > 0, p =< 0.01
t > 0, p =< 0.05
t > 0, p > 0.05
t < 0, p > 0.05
t < 0, p =< 0.05
t < 0, p =< 0.01
t < 0, p =< 0.001
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.

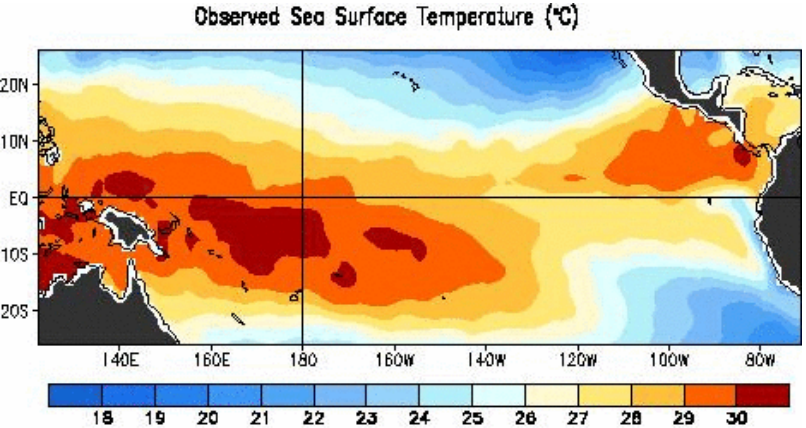

Redmond & Koch, 1991, updated.
Washington statewide October thru March Precipitation
(versus Southern Oscillation Index for prior June - November)
October thru March Precipitation (centimeters, 1 cm = 0.394 inch)
Years used 1933/34 thru 1996/97
Correlation = +0.43
82/83
81.28 cm / 32.00"
71.12 cm / 28.00" (all)
63.28 cm / 24.91"
JUNE–NOVEMBER SOI (TAHITI MINUS DARWIN)
<---------- El Nino | neither | La Nina ---------->
Western Regional Climate Center
Washington

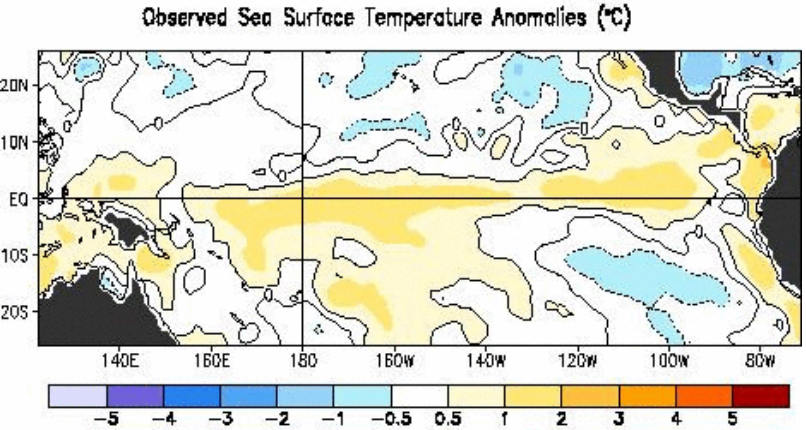
ENSO

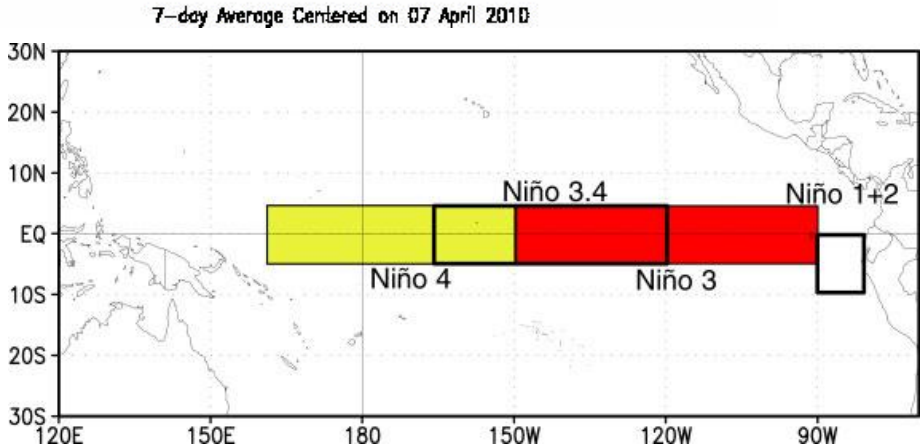

California 8-Station Index October thru March Precipitation
(versus Southern Oscillation Index for prior June - November)
October thru March Precipitation (centimeters, 1 cm = 0.394 inch)
Years used 1933/34 thru 1996/97
Correlation = +0.13
(r^2 = 0.02)
82/83
46.19"
43.07" (all)
42.77"
JUNE–NOVEMBER SOI (TAHITI MINUS DARWIN)
<---------- El Nino | neither | La Nina ---------->
Western Regional Climate Center
Central Sierra

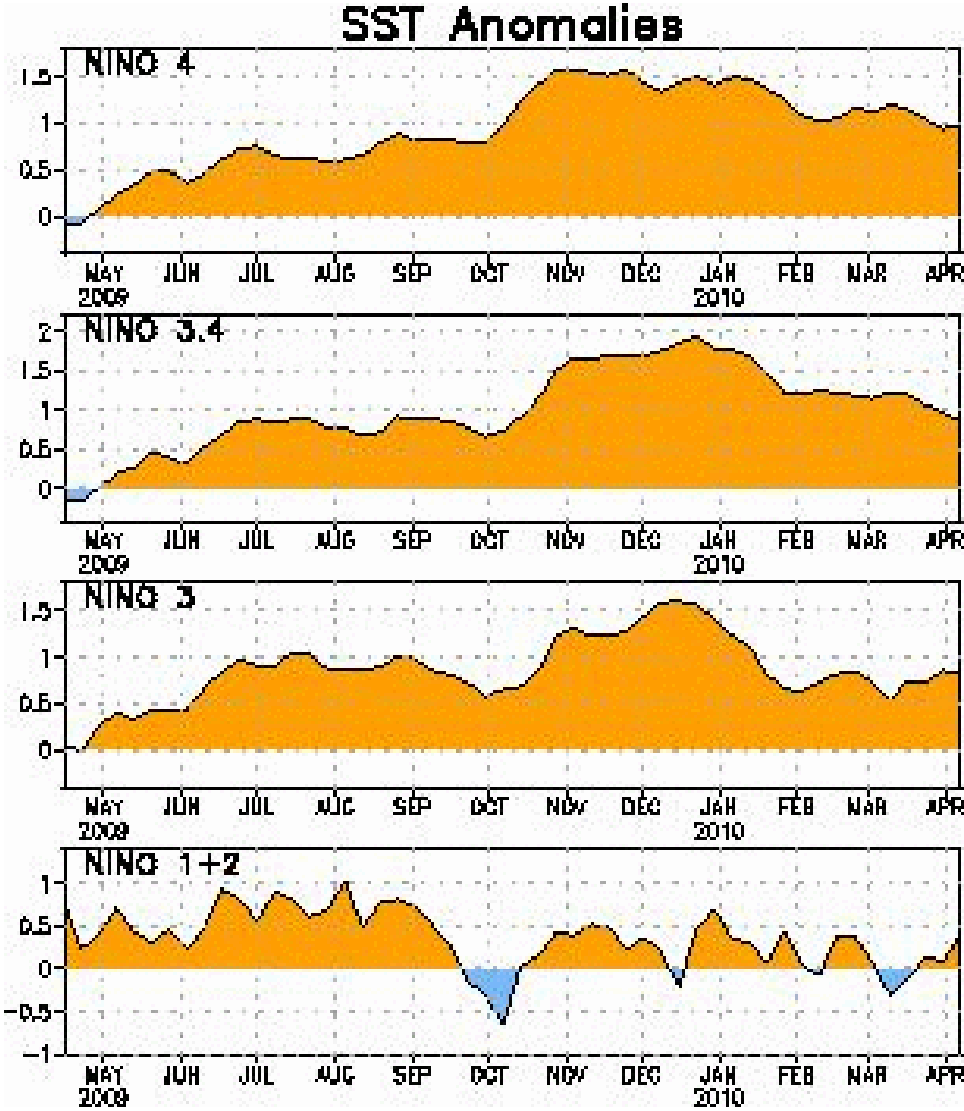

Arizona statewide October thru March Precipitation
(versus Southern Oscillation Index for prior June - November)
October - March Precipitation (centimeters, 1 cm = 0.394 inch)
Years used 1933/34 - 1996/97
Correlation = - 0.54
20.23 cm / 7.97"
16.28 cm / 6.41" (all)
11.22 cm/ 4.42"
JUNE–NOVEMBER SOI (TAHITI MINUS DARWIN)
<---------- El Nino | neither | La Nina ---------->
Western Regional Climate Center
Arizona

Recent Evolution of Equatorial Pacific SST Departures





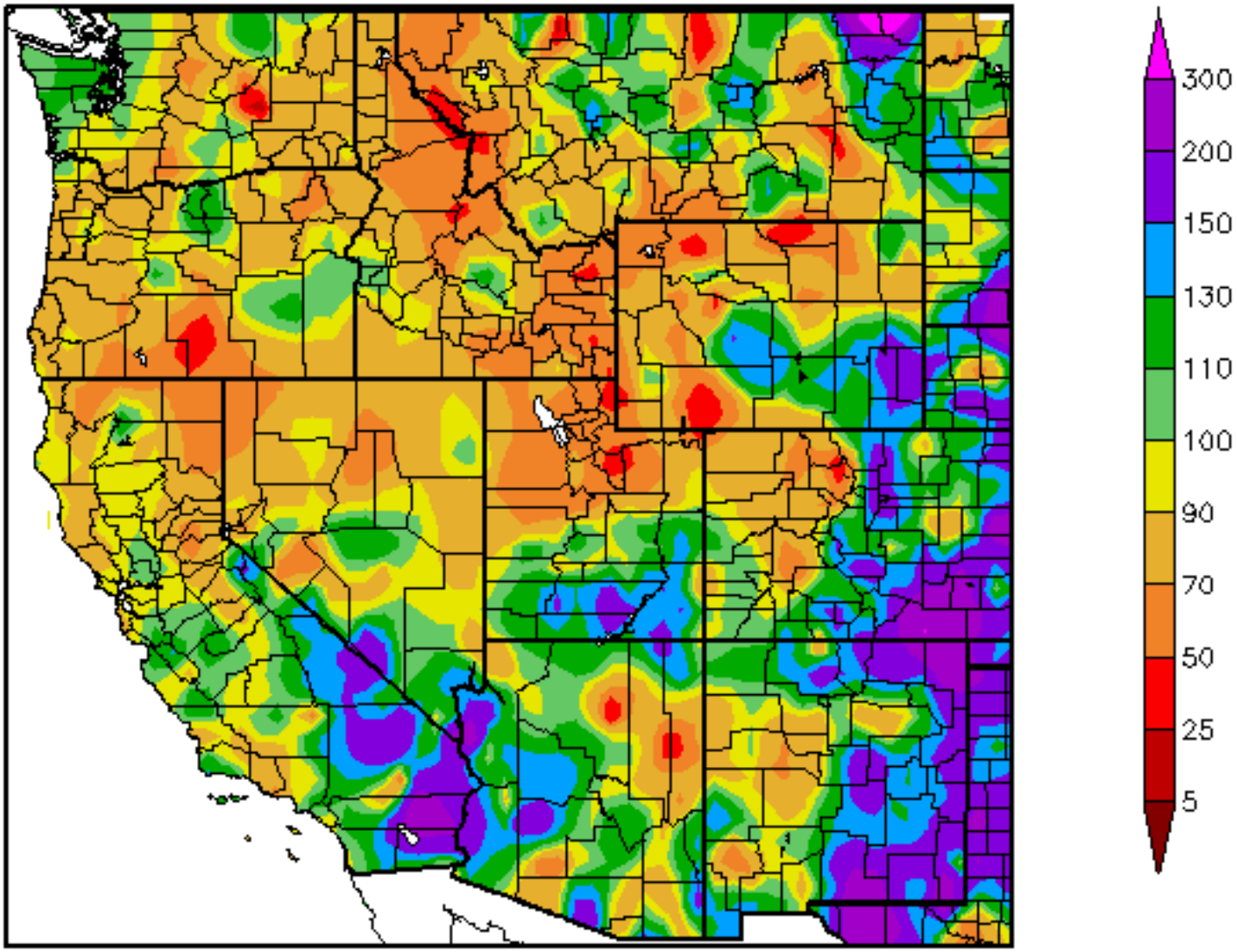




Updated through 2010 April 04-10

Percent of Average Precipitation Water Year To Date 1 Oct 2009 thru 29 Mar 2010

Percent of Normal Precipitation (%)
10/1/2009 – 3/29/2010



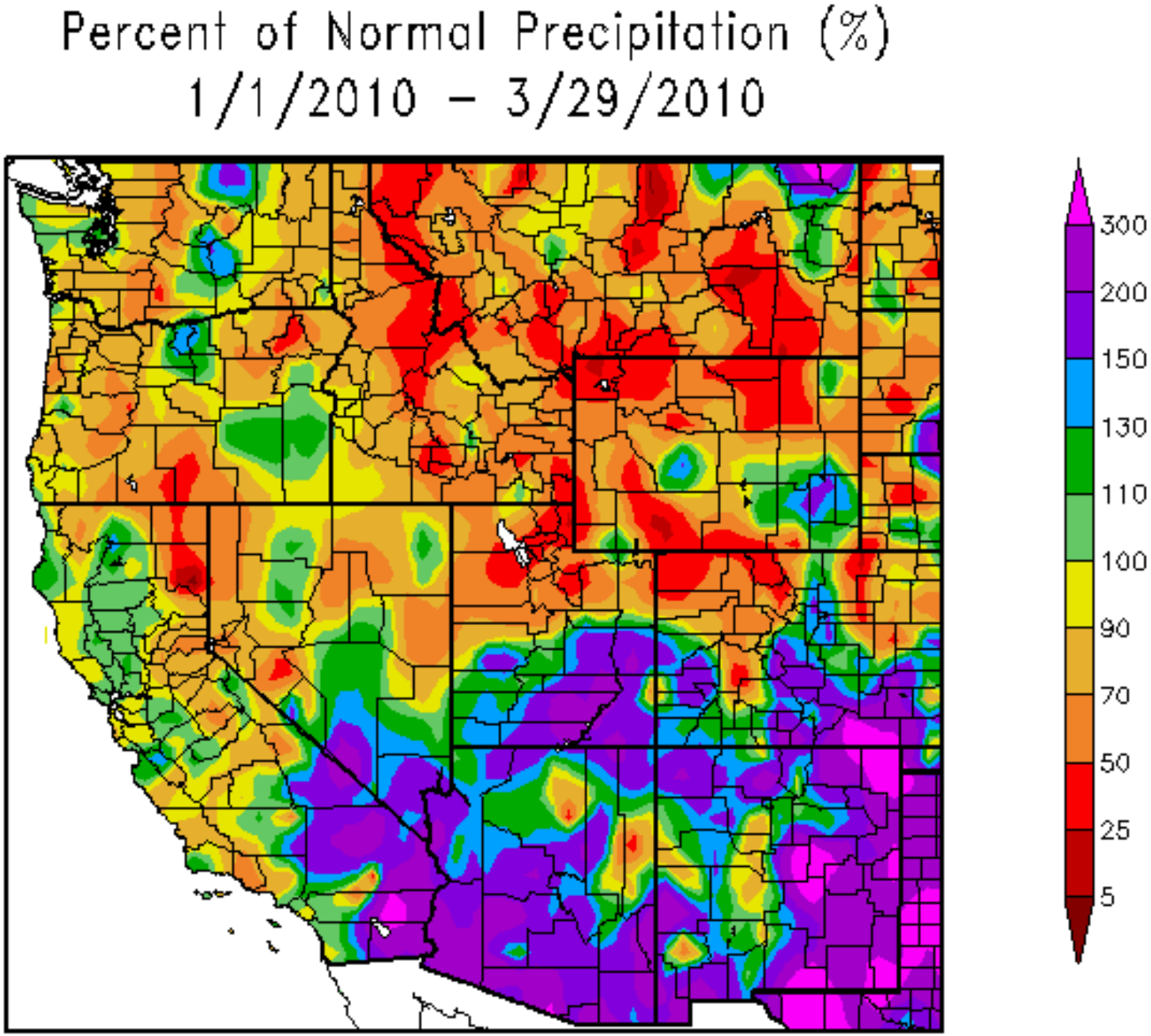
Generated 3/30/2010 at HPRCC using provisional data.

NOAA Regional Climate Centers

Percent of Average Precipitation

Calendar Year to Date

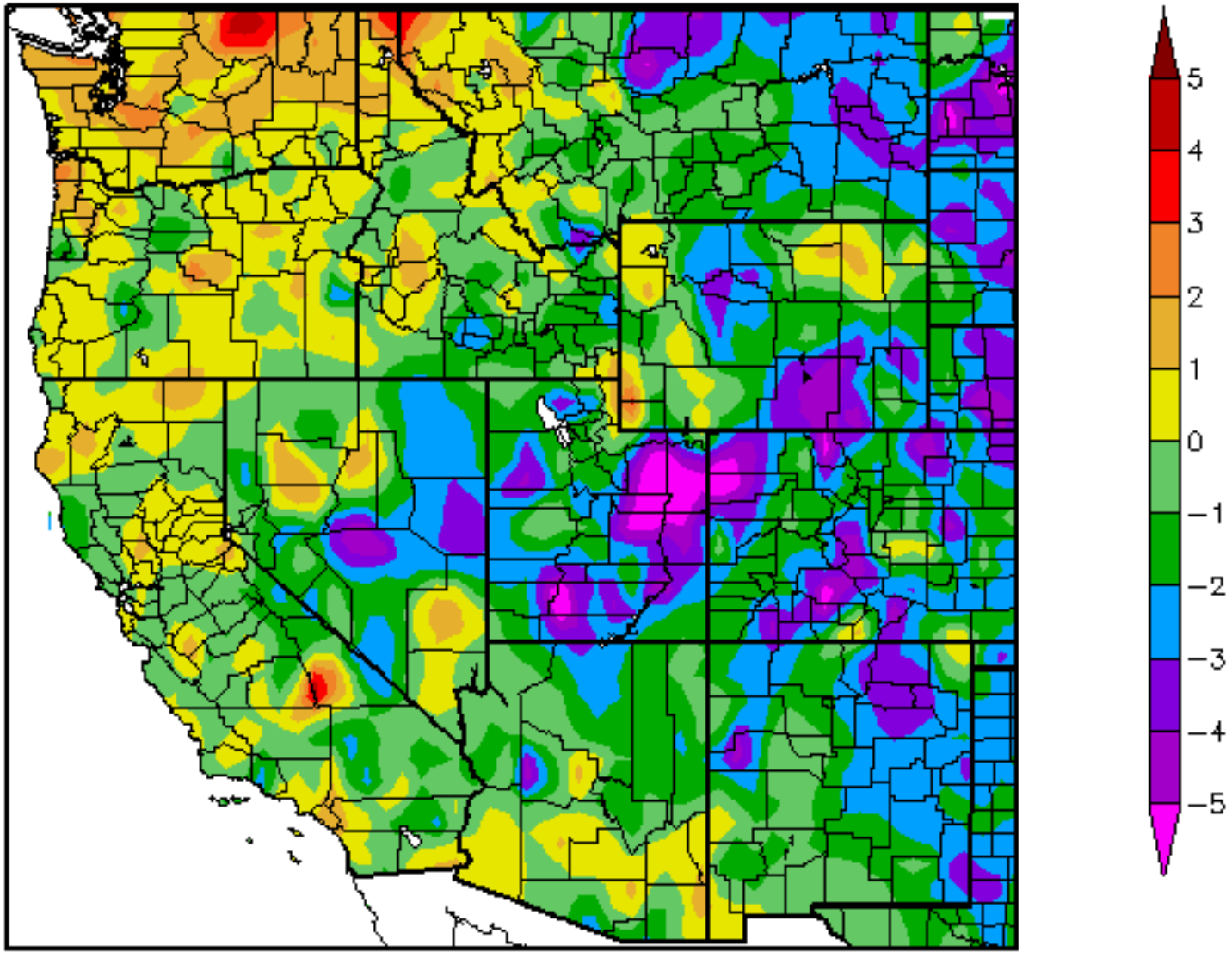
01 Jan 2010 thru 29 Mar 2010



Temp Departure

Water Year To Date 1 Oct 2009 thru 29 Mar 2010

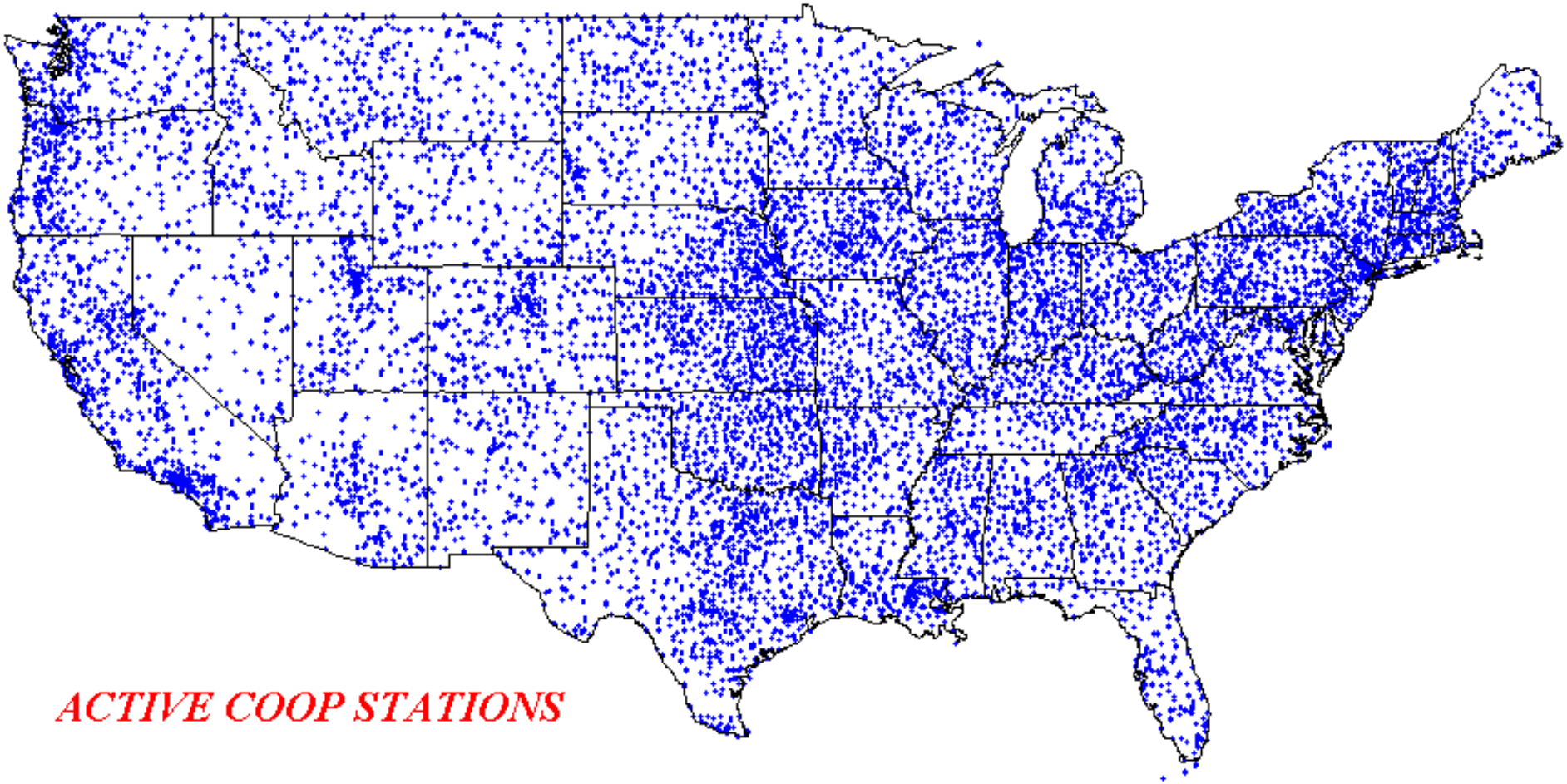
Departure from Normal Temperature (F)
10/1/2009 – 3/29/2010



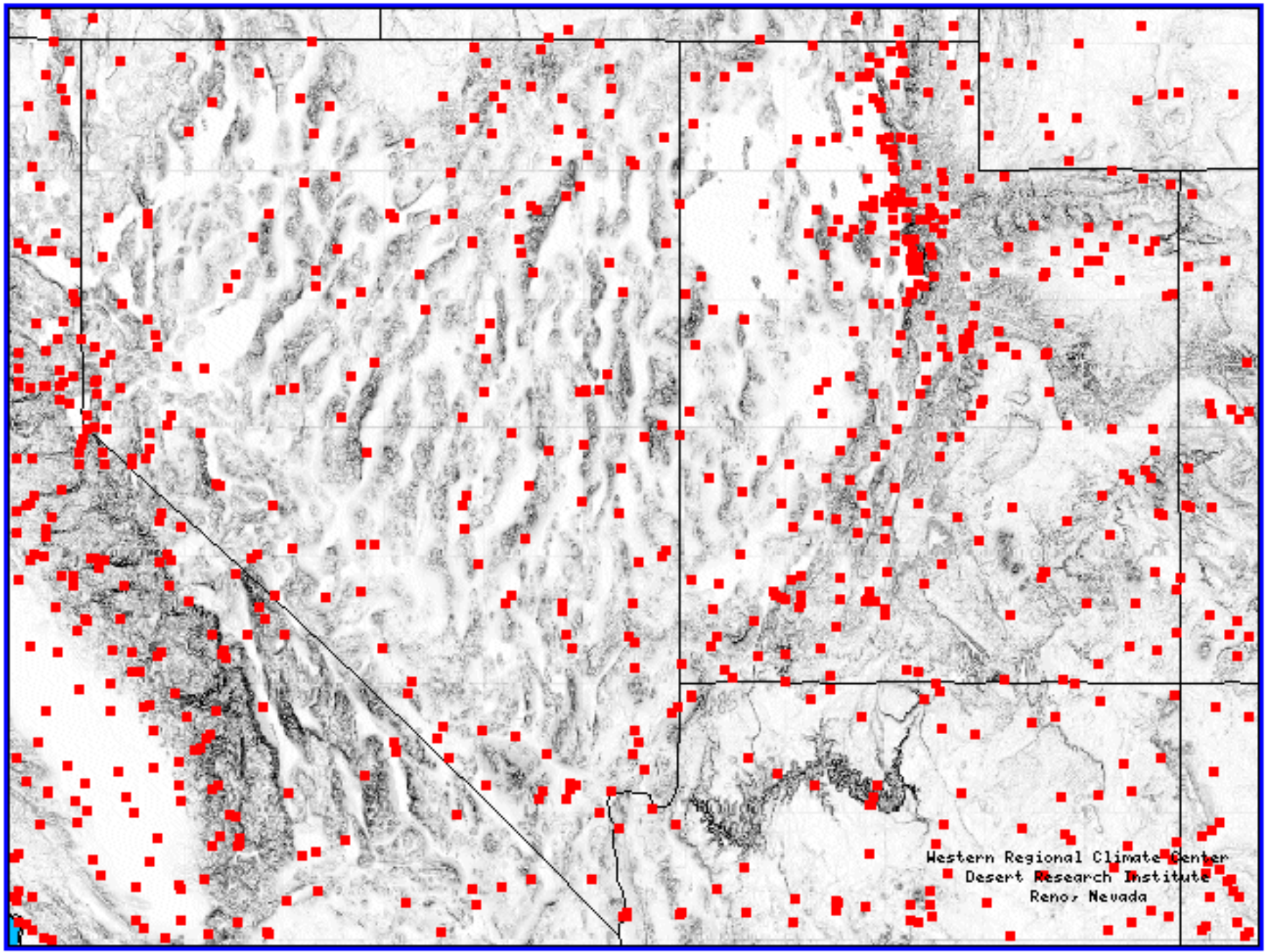
Generated 3/30/2010 at HPRCC using provisional data.

NOAA Regional Climate Centers

Some Observations on Observations

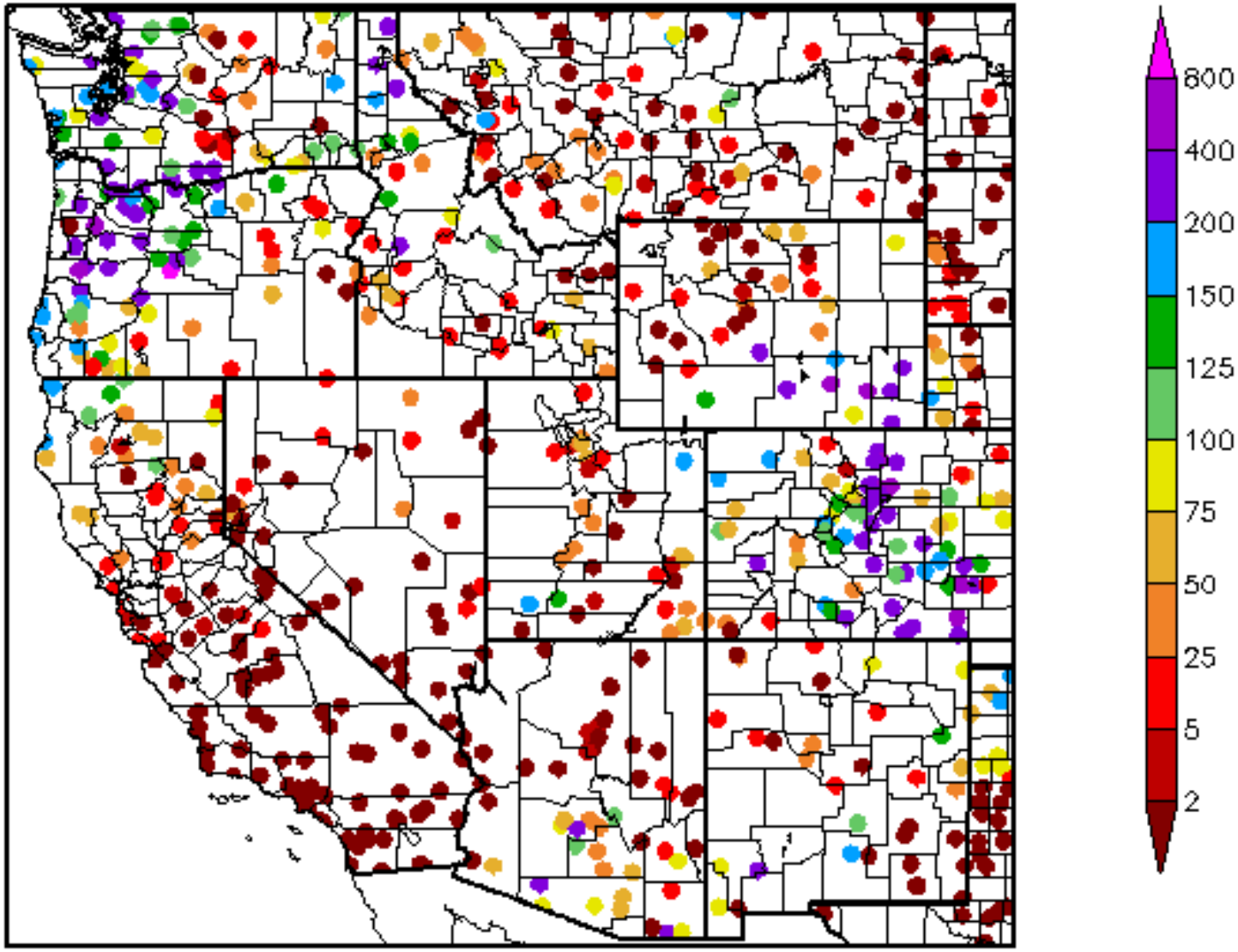

ACTIVE COOP STATIONS

Coop stations with long enough record to summarize temperature (~5 years)
WRCC Summary Graphics



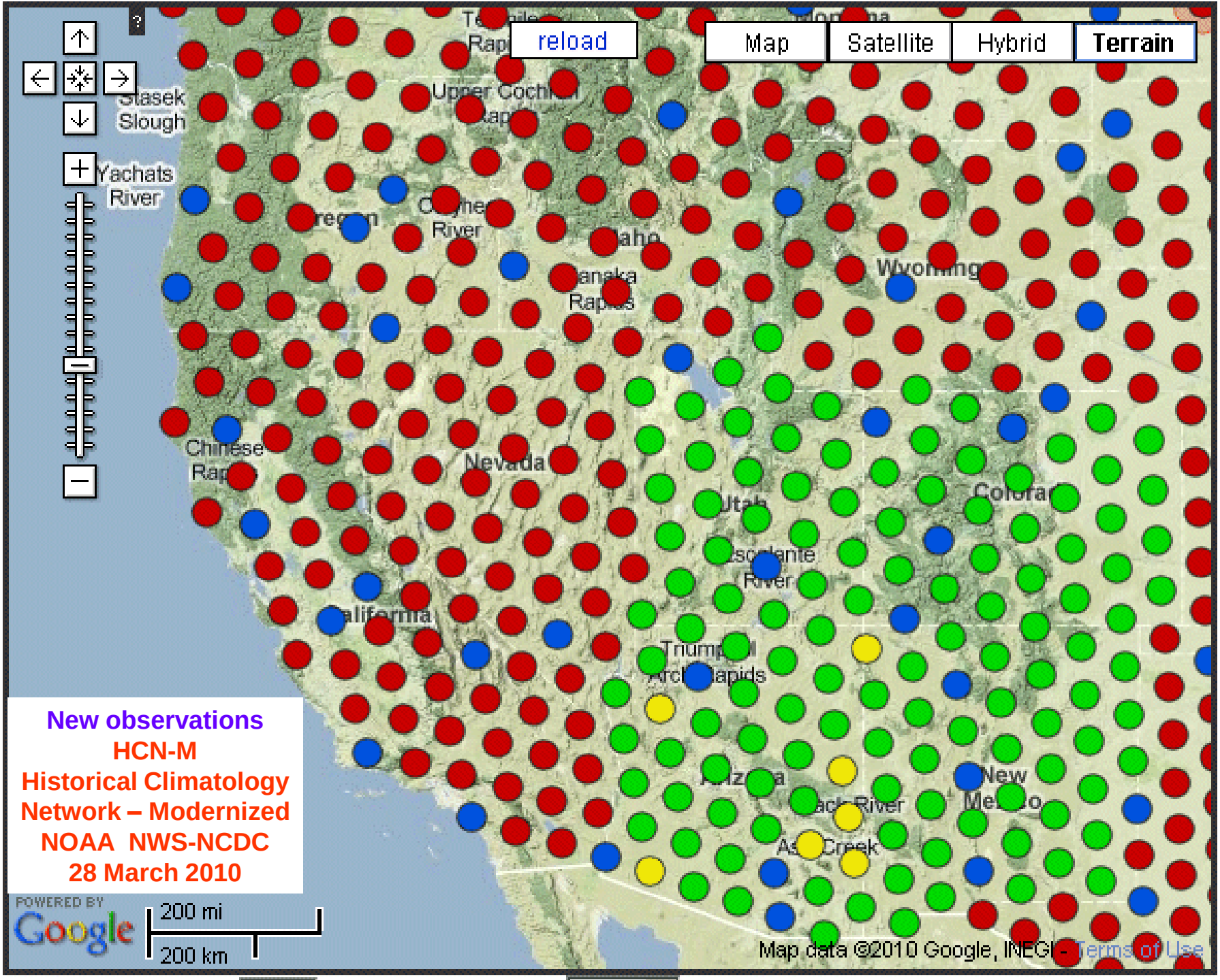
Stations Ingested by ACIS Applied Climate Information System

Percent of Normal Precipitation (%)
3/23/2010 – 3/29/2010

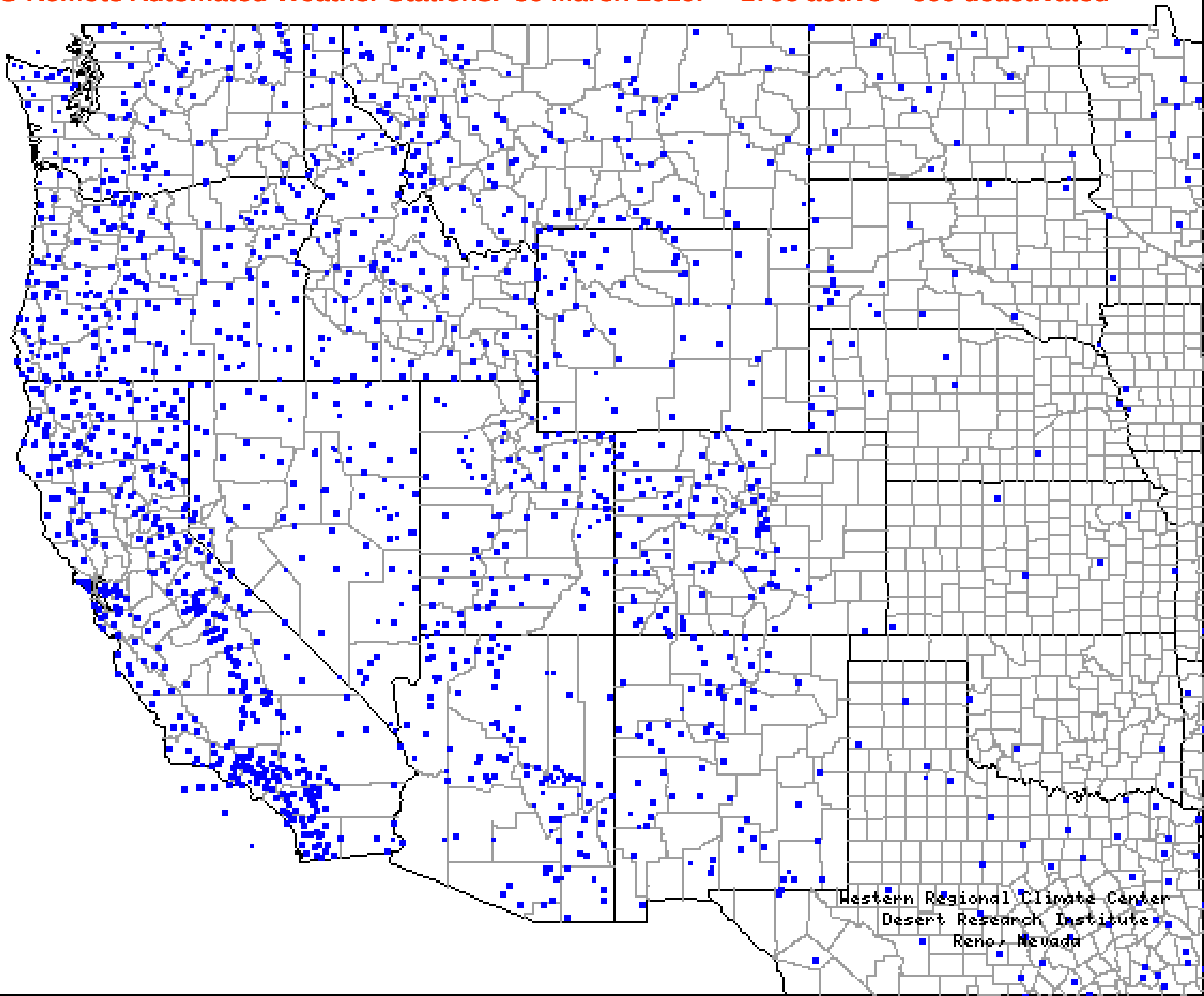


Generated 3/30/2010 at HPRCC using provisional data.

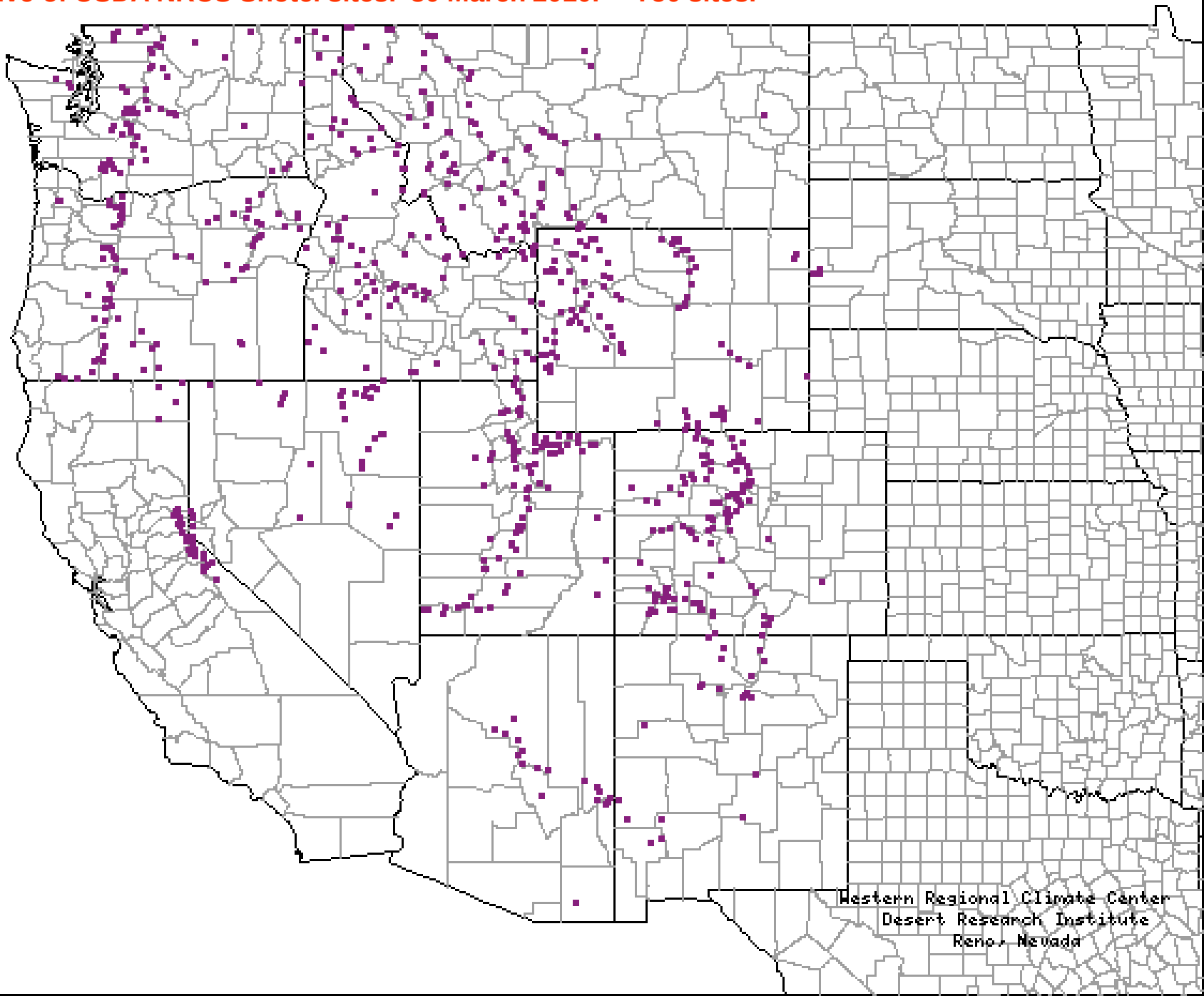
NOAA Regional Climate Centers


reload
Map
Satellite
Hybrid
Terrain
Stasek Slough
Yachats River
Upper Cochran Rapids
Cougher River
Wyoming
Chinese Rapids
Nevada
Utah
Colorado
Triumph Arch Rapids
New Mexico
Ash Creek
New observations
HCN-M
Historical Climatology Network – Modernized
NOAA NWS-NCDC
28 March 2010
POWERED BY Google
200 mi
200 km
Map data ©2010 Google, INEGI - Terms of Use

WRCC RAWS Remote Automated Weather Stations. 30 March 2010. ~1700 active + 600 deactivated



WRCC Archive of USDA NRCS Snotel sites. 30 March 2010. ~750 sites.



A prime candidate for federal interagency coordination

For Weather a "Network of Networks" is under development

For Climate, a "Climate Network of Networks" is needed

This is especially a pertinent issue in the western states

Climate stations need to meet higher standards

Temporal consistency in site exposure, methods, documentation.

An excellent candidate for a

National Climate Service

Interagency Collaboration and Coordination activity

News - updated March 17, 2010

USGS Water Data for the Nation

Data Category

Real-time data — **Current-conditions** data transmitted from selected surface-water, groundwater, and water-quality sites.

Site information — Descriptive site information for all sites with links to all available water data for individual sites.

Surface water — Water flow and levels in streams, lakes, and springs.

Groundwater — Water levels in wells.

Water quality — Chemical and physical data for streams, lakes, springs, and wells.

Mapper — Map of all sites with links to all available water data for individual sites.

Introduction

These pages provide access to water-resources data collected at approximately 1.5 million sites in all 50 States, the District of Columbia, and Puerto Rico. Online access to this data is organized around the categories listed to the left.

The USGS investigates the occurrence, quantity, quality, distribution, and movement of surface and underground waters and disseminates the data to the public, State and local governments, public and private utilities, and other Federal agencies involved with managing our water resources.

About us | Help | Tutorial

Title: USGS Water Data for USA
URL: http://waterdata.usgs.gov/nwis?

USA.gov
TAKE PRIDE IN AMERICA

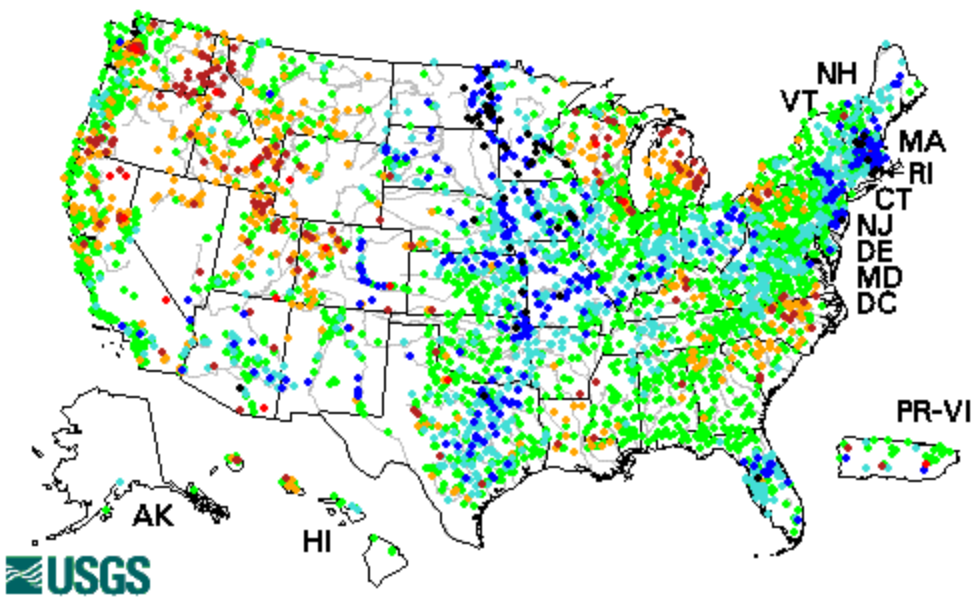
USGS Real-Time Water Data for the Nation

--- Predefined displays --- | Group table by | Select sites by number or name

Introduction | -- no grouping -- | go

Daily Streamflow Conditions

Sunday, March 28, 2010 00:30ET



Explanation

- High
- ≥ 90th percentile
- 75th - 89th percentile
- 25th - 74th percentile
- 10th - 24th percentile
- < 10th percentile
- Low
- Not ranked

The colored dots on this map depict streamflow conditions as a percentile, which is computed from the period of record for the current day of the year. Only stations with at least 30 years of record are used.

The **gray circles** indicate other stations that were not ranked in percentiles either because they have fewer than 30 years of record or because they report parameters other than streamflow. Some stations, for example, measure stage only.

Select a state from the map to access real-time data

Real-time data typically are recorded at 15-60 minute intervals, stored onsite, and then transmitted to USGS offices every 1 to 4 hours, depending on the data relay technique used. Recording and transmission times may be more frequent during critical events. Data from real-time sites are relayed to USGS offices via satellite, telephone, and/or radio and are available for viewing within minutes of arrival.

All real-time data are provisional and subject to revision.

Build Table	Build a custom summary table of the most recent data for one or more sites, states, or hydrologic regions.
Build Sequence	Build a custom sequence of graphical or tabular data for one or more sites, states, or hydrologic regions.

A data access asymmetry

A national capability exists for anyone to be able to access the basic historical public data base for water (National Water Information System)

There is no equivalent access to the basic historical public data base for climate

Technological barriers to such access have disappeared

There is widespread ability to access large portions of the main climate data base within the climate services community (eg, RCCs via ACIS, even within WRCC can access the whole country)

Techniques and interfaces for this already exist, but not accessible to the public.

There seems to be no real reason to preserve this disparity

There are ample reasons for all federal agencies to have wide access to public data and to methods for summary and visualization (e.g., NPClime for NPS, ACIS) could serve many more users

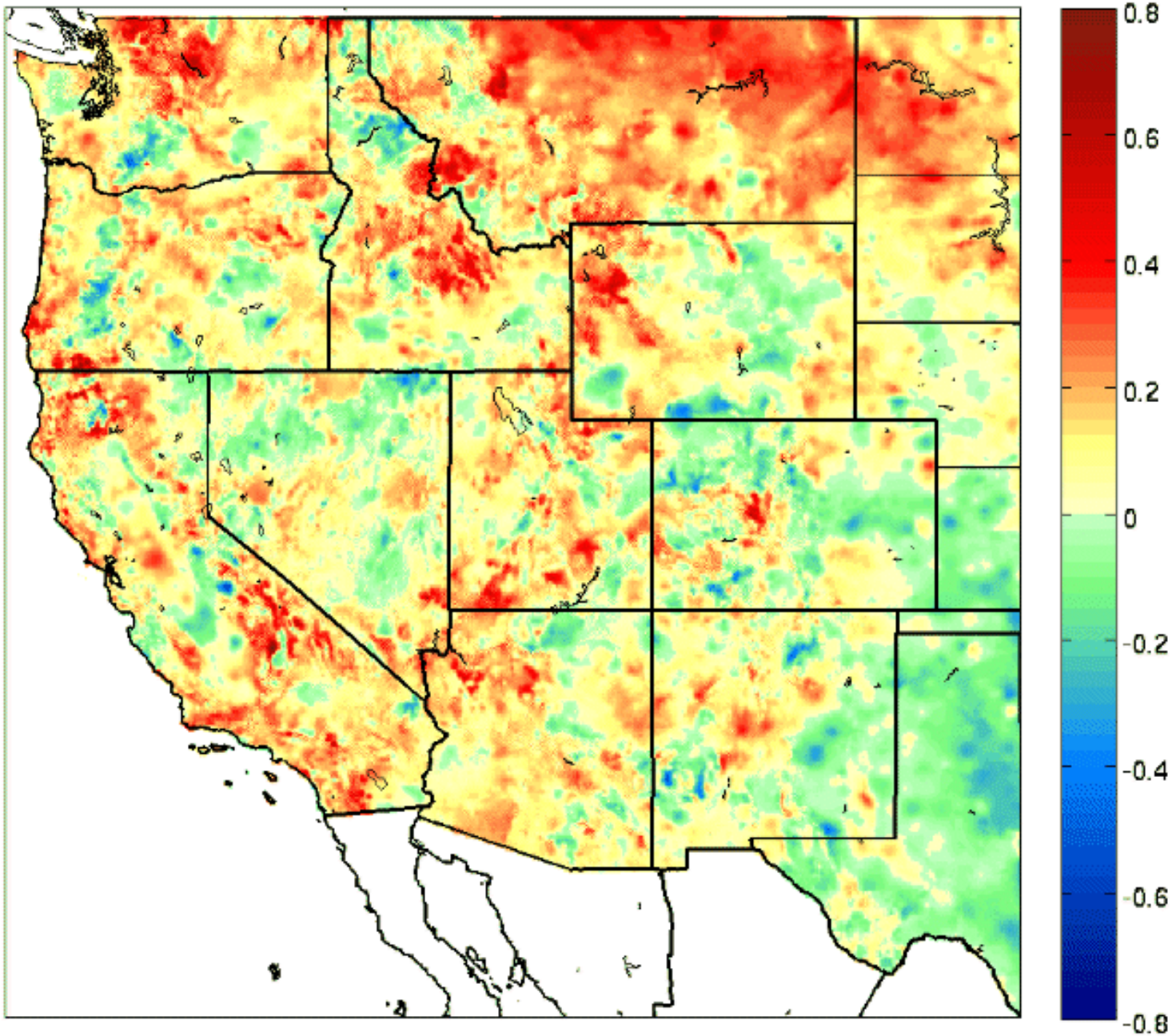
How is water data different from climate data ?

This could include both point data, and assimilated and gridded data.

Should be a component of a National Climate Service

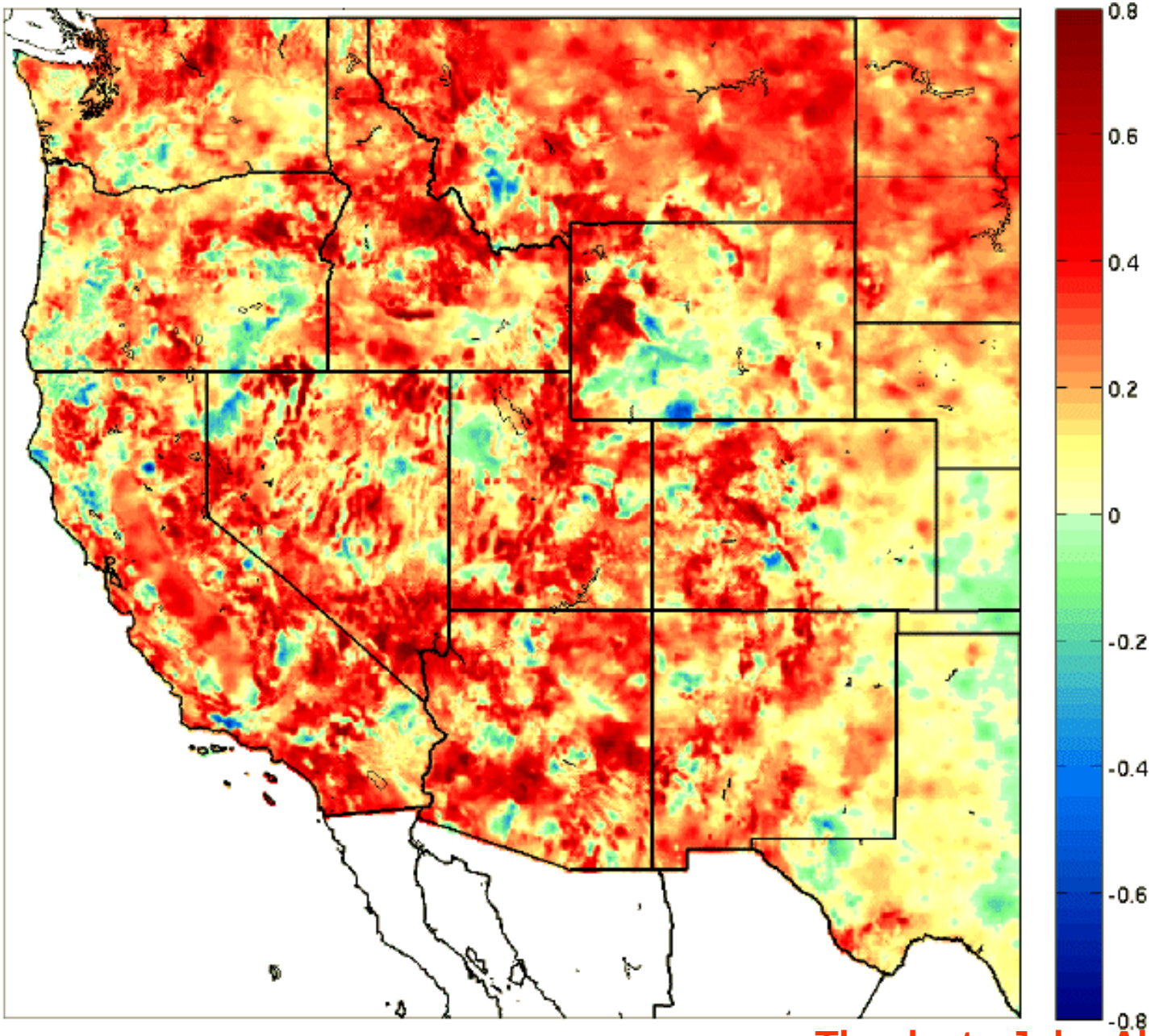
No reason to wait for a formal National Climate Service

Annual Tmax Trend from 1950-2008 from PRISM (recent, not latest version).



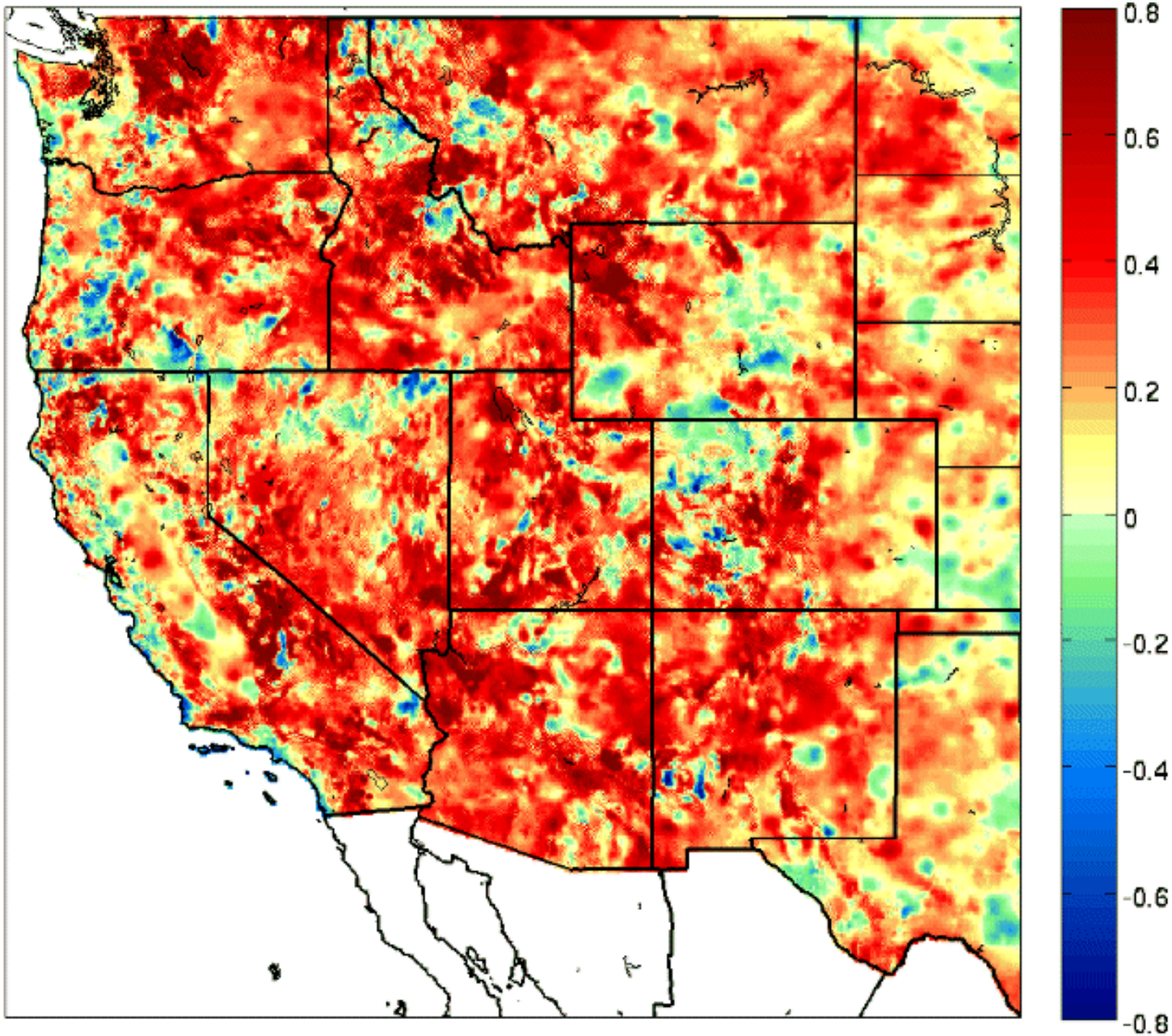
Thanks to John Abatzoglou

Annual Tmin Trend from 1950-2008 from PRISM (recent, not latest version).



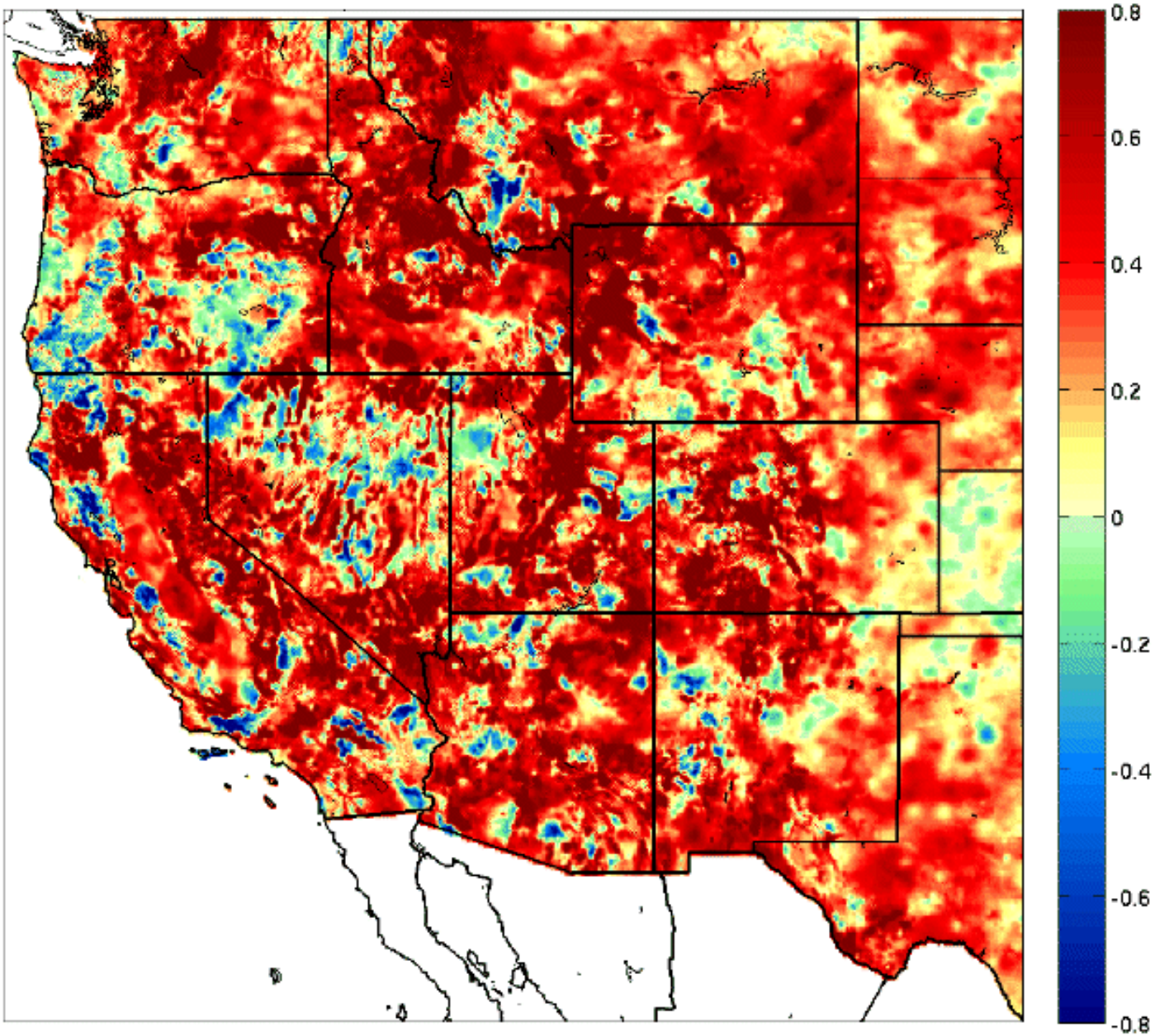
Thanks to John Abatzoglou

Annual Tmax Trend from 1975-2008 from PRISM (recent, not latest version).

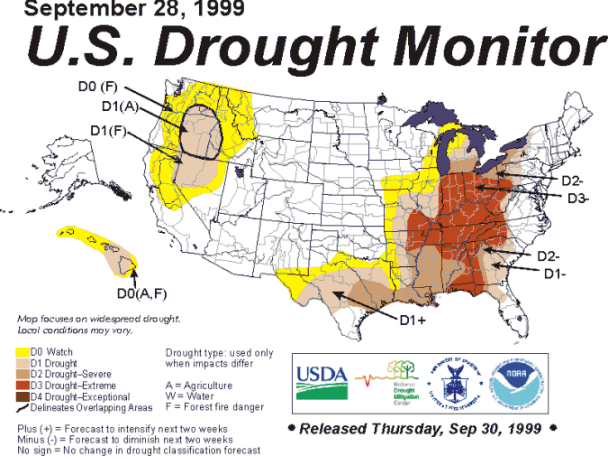


Thanks to John Abatzoglou

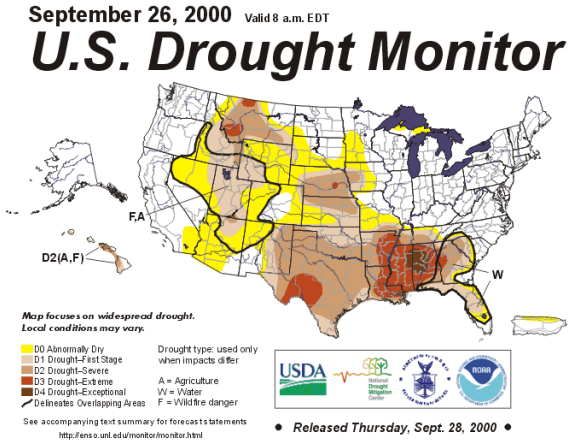
Annual Tmin Trend from 1975-2008 from PRISM (recent, not latest version).



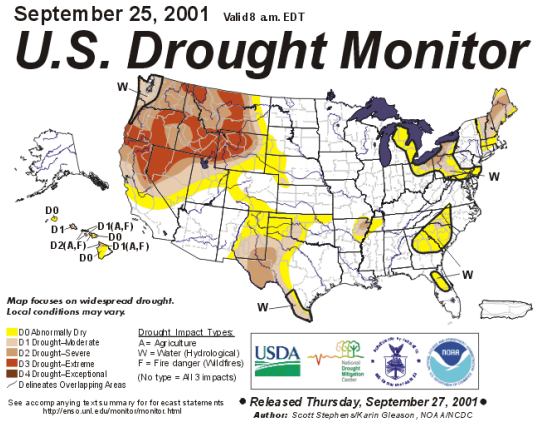
Thanks to John Abatzoglou



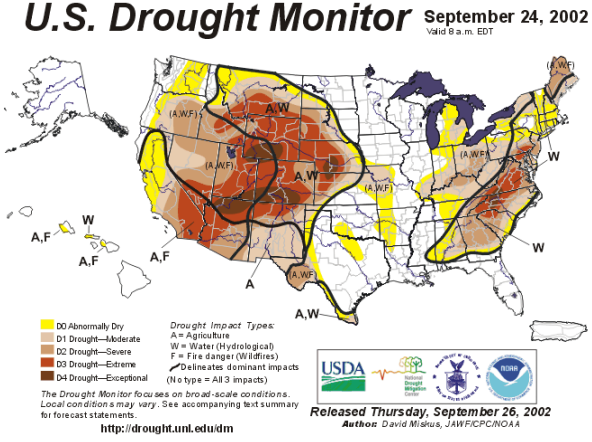
Sep 28, 1999



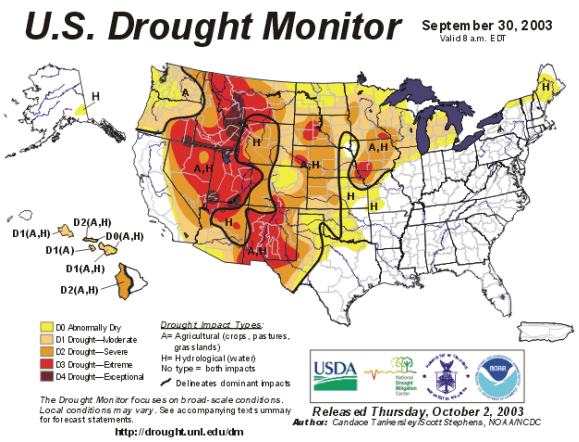
Sep 26, 2000



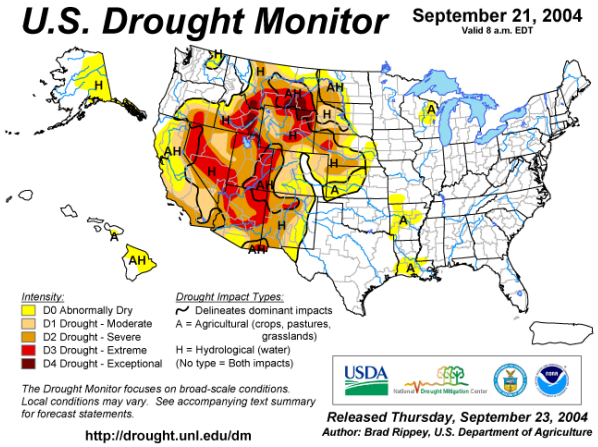
Sep 25, 2001



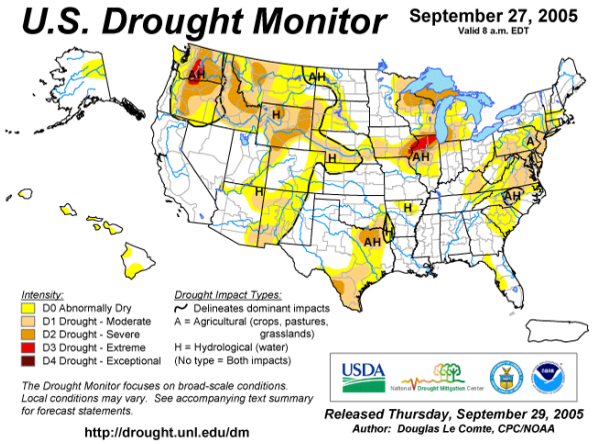
Sep 24, 2002



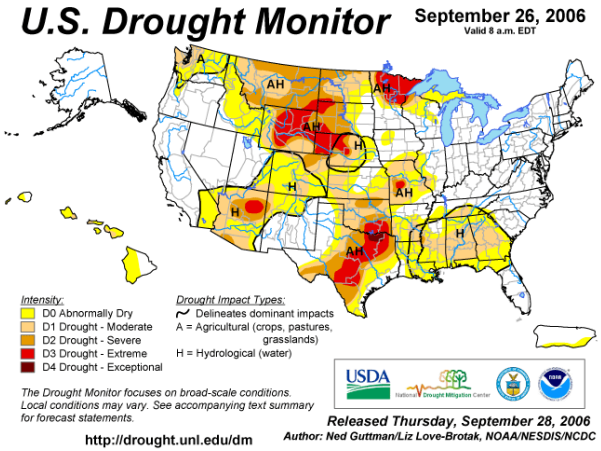
Sep 30, 2003



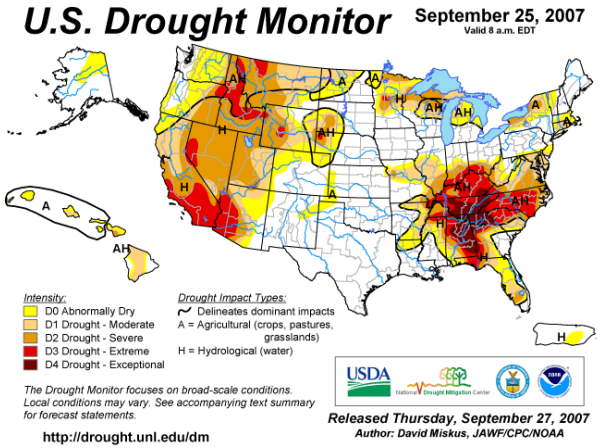
Sep 21, 2004



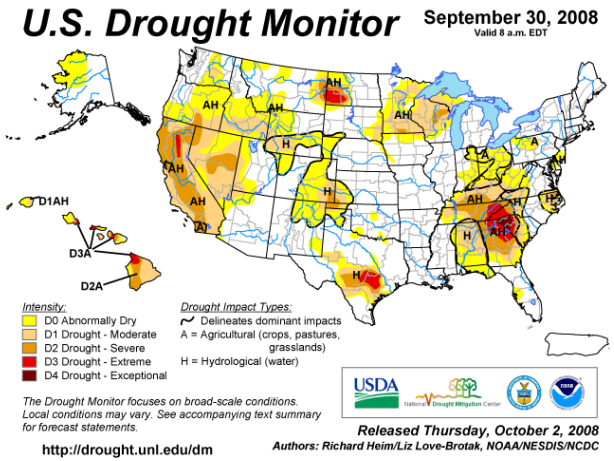
Sep 27, 2005



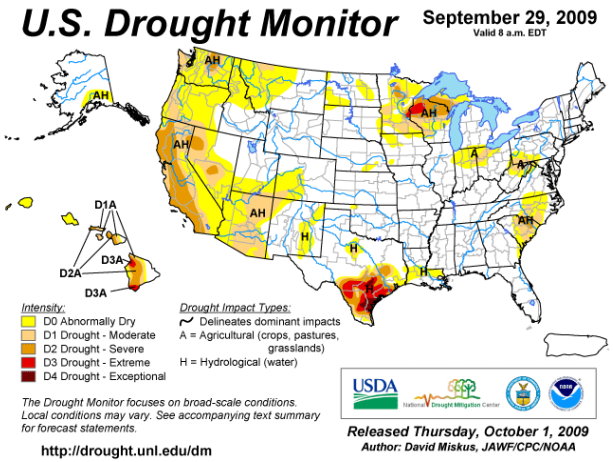
Sep 26, 2006



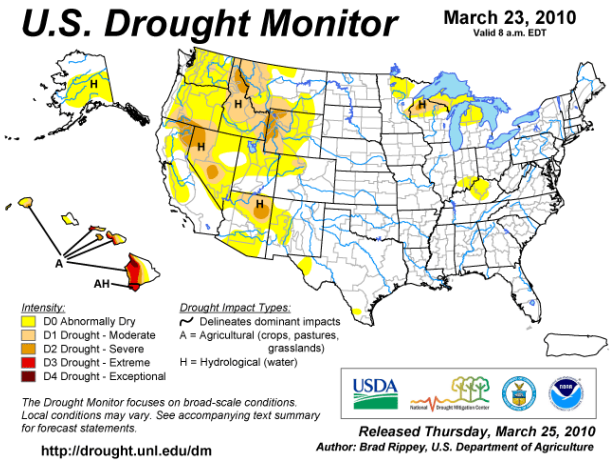
Sep 25, 2007



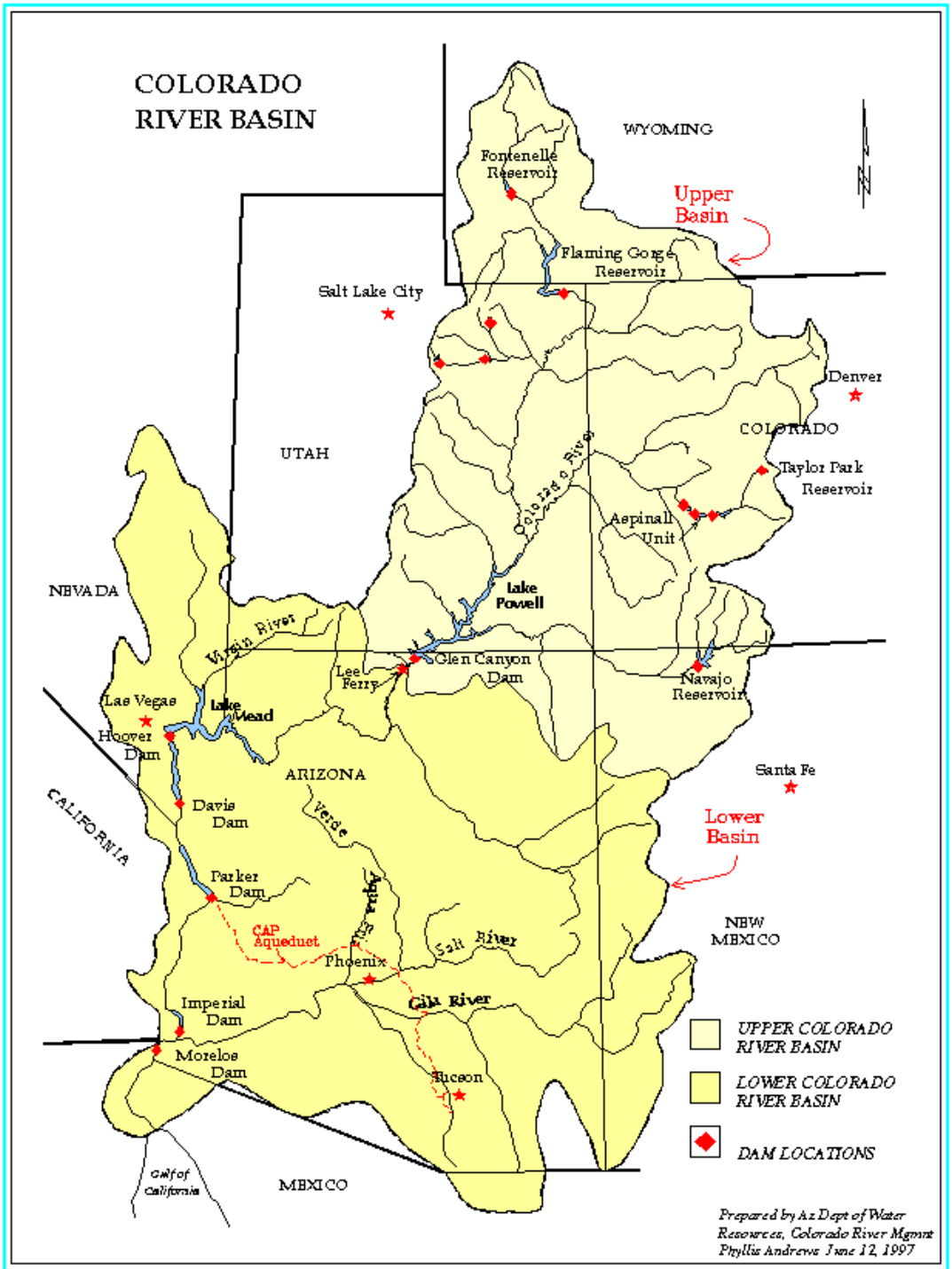
Sep 30, 2008



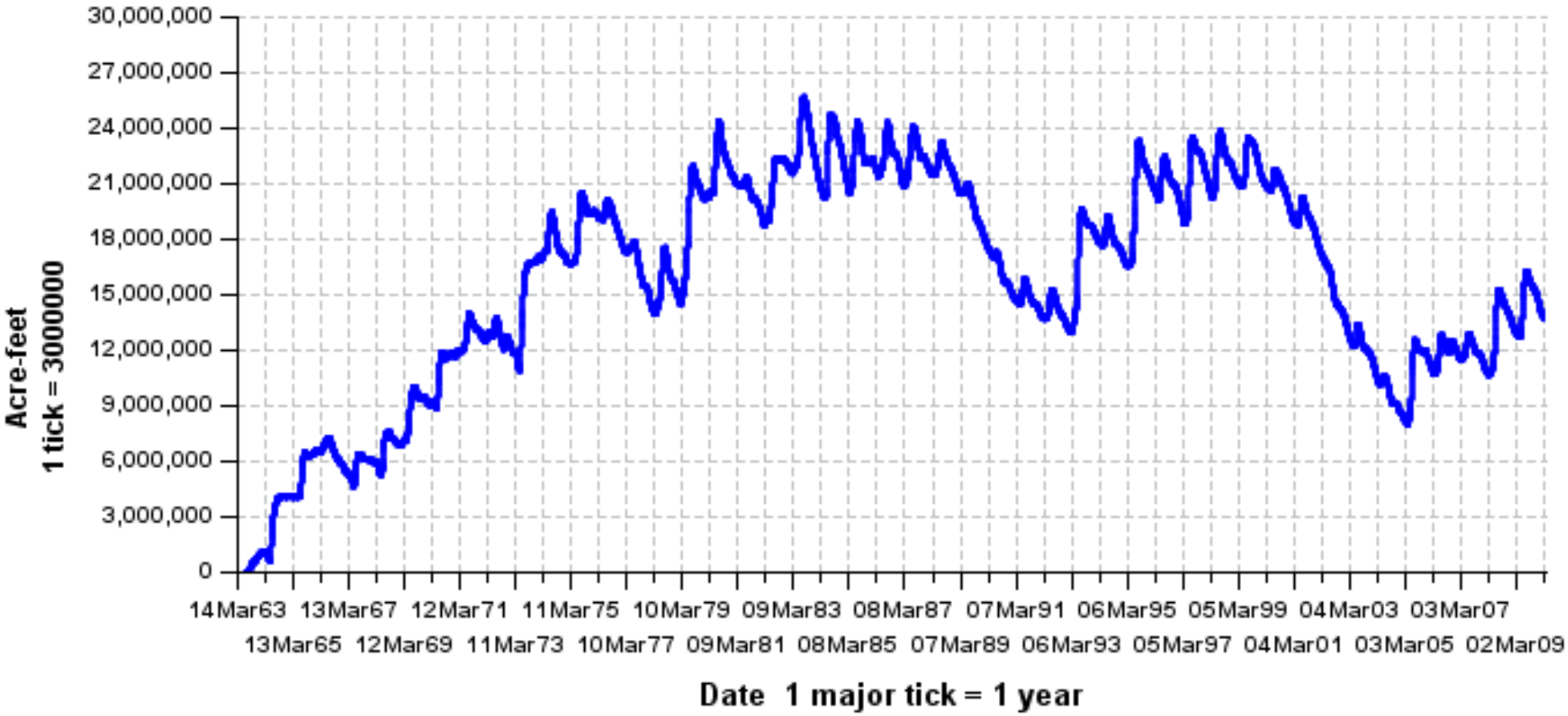
Sep 29, 2009



Mar 23, 2010

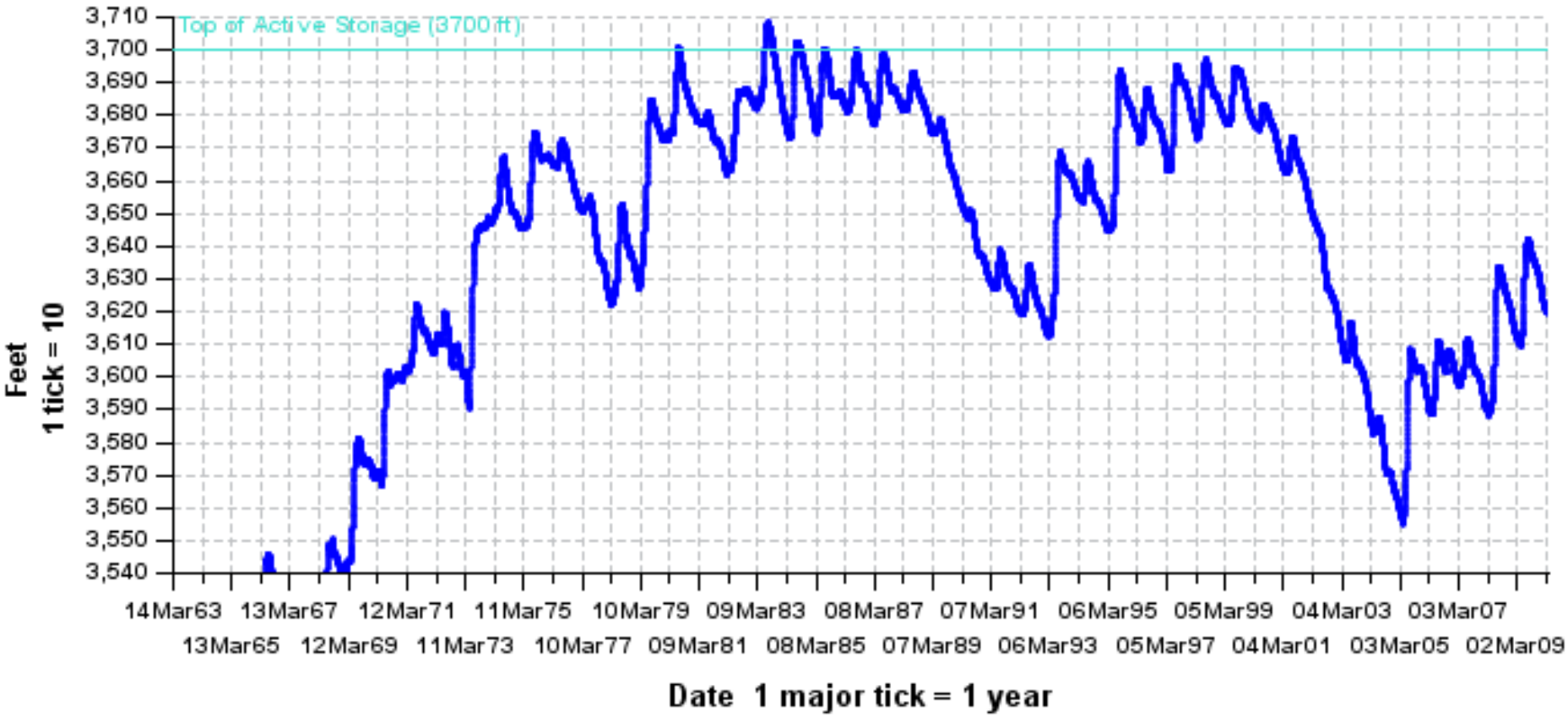

COLORADO
RIVER BASIN
WYOMING
Fontenelle Reservoir
Upper Basin
Flaming Gorge Reservoir
Salt Lake City
Denver
COLORADO
UTAH
Taylor Park Reservoir
Colorado River
Aspinall Unit
NEVADA
Lake Powell
Virgin River
Glen Canyon Dam
Lee Ferry
Navajo Reservoir
Las Vegas
Lake Mead
Hoover Dam
ARIZONA
Santa Fe
CALIFORNIA
Davis Dam
Verde
Lower Basin
Parker Dam
Salt River
CAP Aqueduct
Phoenix
NEW MEXICO
Gila River
Imperial Dam
Morelos Dam
Tucson
UPPER COLORADO RIVER BASIN
LOWER COLORADO RIVER BASIN
DAM LOCATIONS
Gulf of California
MEXICO
Prepared by Az Dept of Water Resources, Colorado River Mgmnt
Phyllis Andrews June 12, 1997

Lake Powell Storage Through April 13, 2010



As of 13 April 2010: 56 % full (capacity 24.17 MAF)
Minimum: 33 % full on April 8, 2005

Lake Powell Elevation Through April 13, 2010



Water level on April 13, 2010 was 3618.65 ft, - 81 ft below full.

Minimum level on April 8, 2005 was 3555 ft, -145 ft below full.

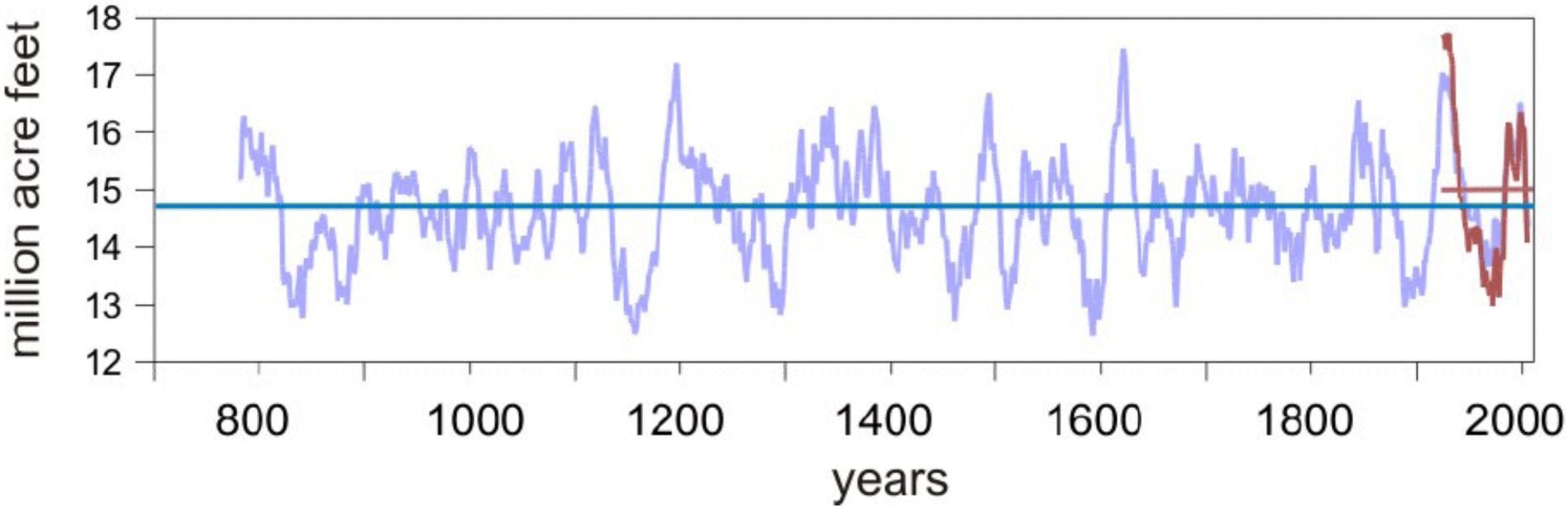
Source: www.usbr.gov/uc/water/index.htl

Lake Mead, October 2007

Photo by Ken Dewey

Lessons from History.

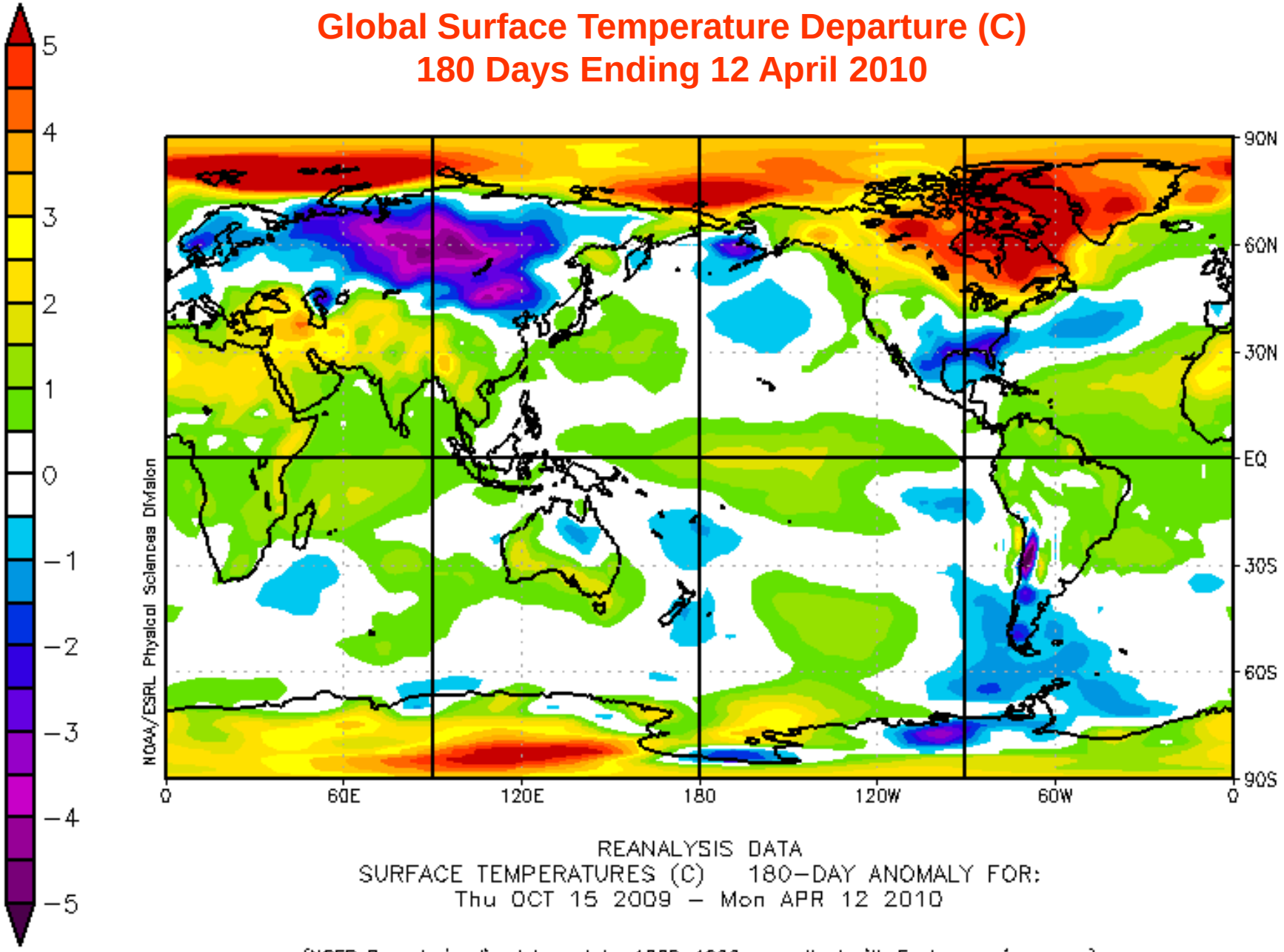
Colorado River Flow. Lees Ferry. Reconstructed 762 thru 2005 A.D.



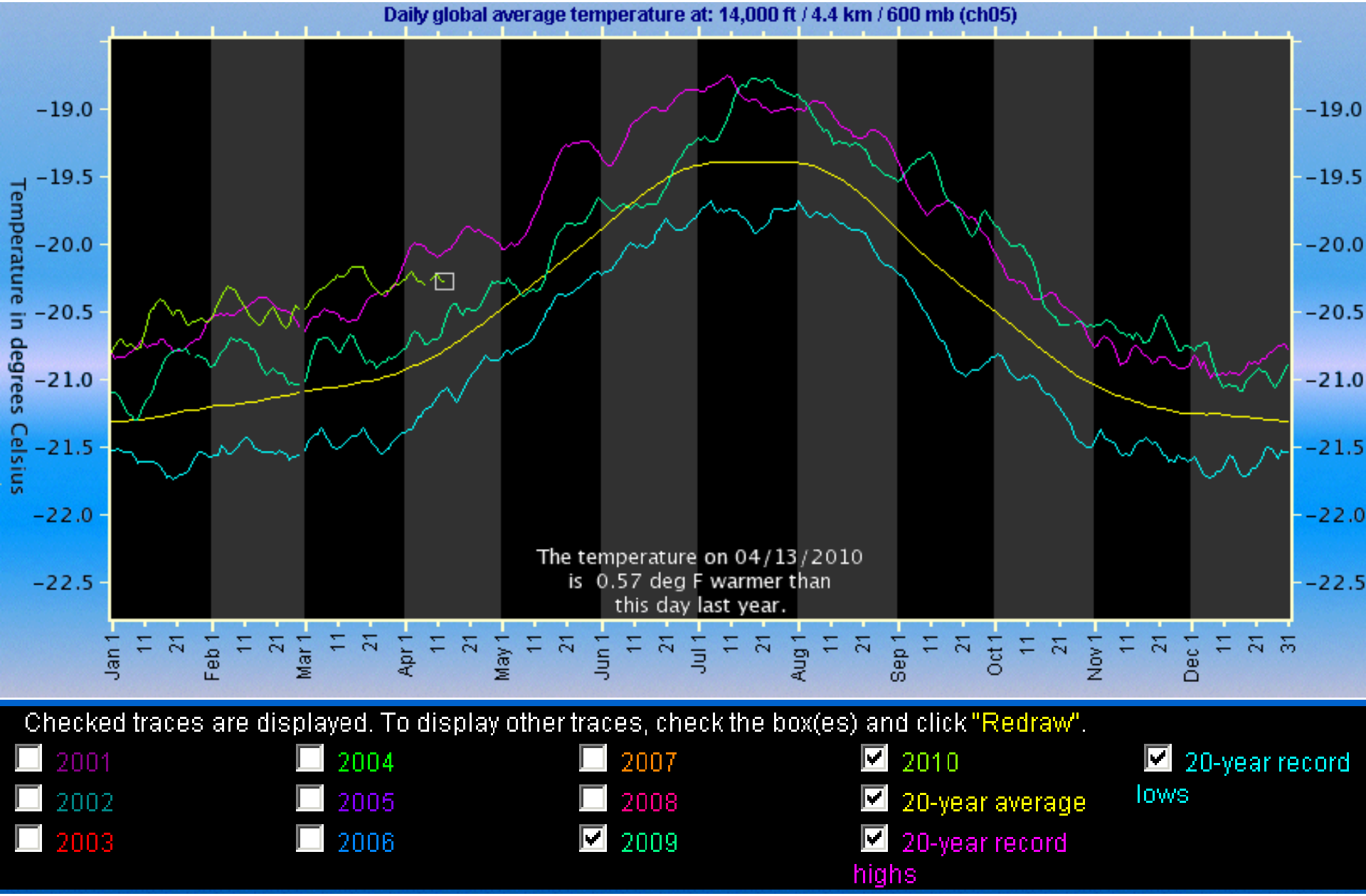
Red: Gauged record.
Blue: Reconstructed record.
20-Year moving averages.

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

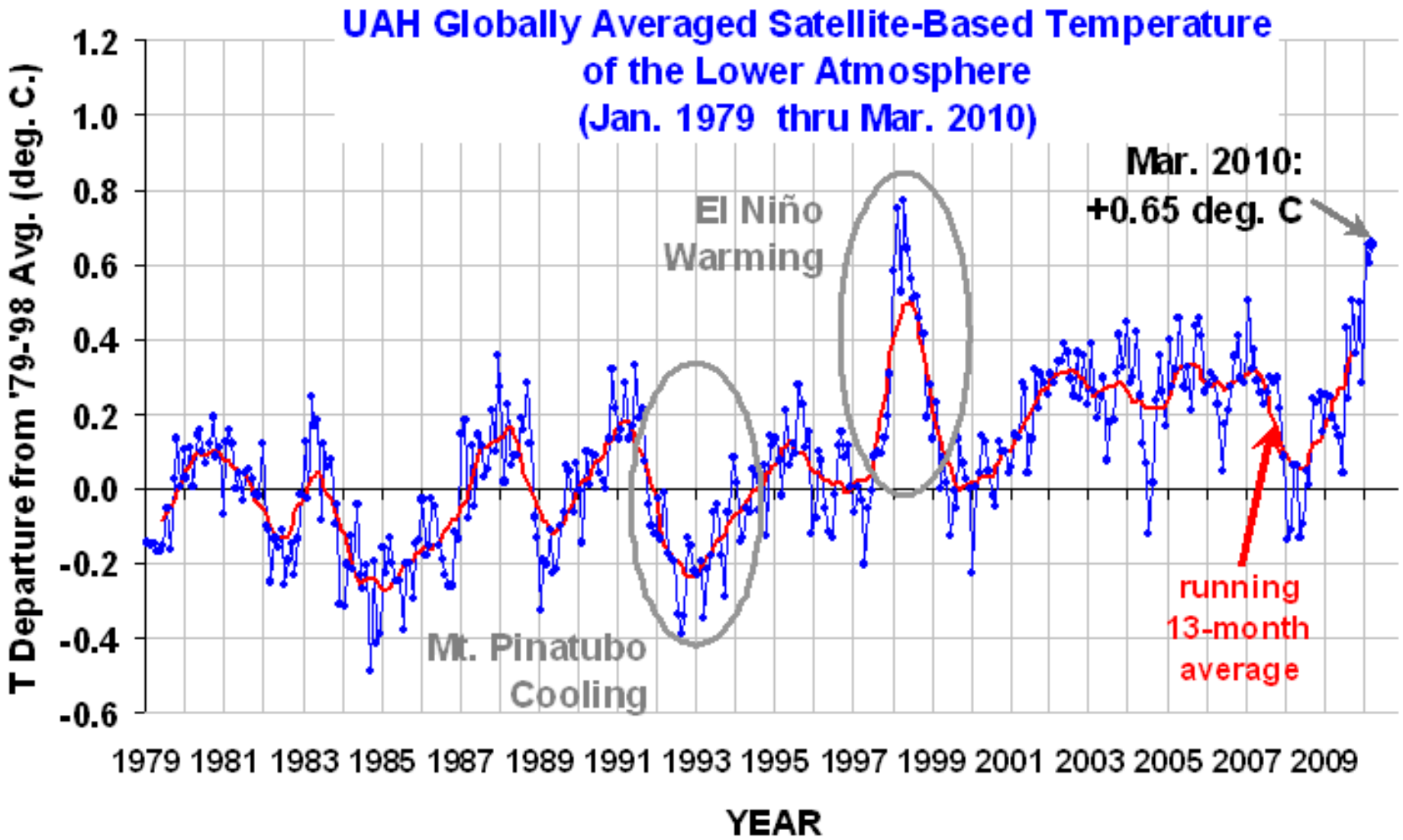
Global Surface Temperature Departure (C)
180 Days Ending 12 April 2010



Daily Global Temperature from Microwave Sounding Unit, Ch 5, 4.4 km.



University of Alabama – Huntsville. Roy Spencer


UAH Globally Averaged Satellite-Based Temperature
of the Lower Atmosphere
(Jan. 1979 thru Mar. 2010)
Mar. 2010:
+0.65 deg. C
El Niño
Warming
Mt. Pinatubo
Cooling
running
13-month
average
T Departure from '79-'98 Avg. (deg. C.)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009
YEAR

Research needs (1/1)

Thorough elucidation of temperature effects of climate change
- Because of much greater confidence in temperature projections

Effects of climate change on fine spatial scales
- For hydrology
  - "Fine" is on the order of 1-4 km
- For ecology
  - "Fine" is on the order of a few meters to a few km
- Mountains and complex terrain issues
  - Snow hydrology and temperature issues

Particular interest in recharge
- Effects of rising temperatures
- What is the "equivalence" between precipitation and temperature effects ?
  - Appears to be that about +1 C is ~ "like" 2-4 % less precipitation
- Mountain block recharge – how does it work, in detail ?

Downscaling
- Dynamical. To how small scales can this be pushed?
- Statistical. Will eventually be needed at some small scale.

Climate change uncertainty. Quantification and depiction.

Research needs (2/2)

Long-term ultimate goal for water accounting:
Ability to determine and depict all water budget components throughout the region on a small scale grid, by month, through time (simple !!!)
- **Sizes and rates of change of reservoirs (all types, natural/human) and**
- **Flows of water between reservoirs**

Supporting fine scale data sets

More attention to water demand, human and natural

Improved estimates of soil moisture status throughout the West
- **Measurements and modeling combined**

Continued attention to detection and attribution techniques

Better forecast systems (not merely forecasts) to address Year 2 and beyond

Better climate forecasts
- **Incorporation of regional climate forcings into forecast systems**
- **Ability to resolve mountains and their effects. ~0.5 to 1 km resolution**
- **Knowledge of, and depiction of, forecast uncertainty**

Improvements in quality of gridded climate analyses
- **A climate-change-compatible version of fine-scale approaches like PRISM**

Climate data and observational needs for research and outreach/education

Greater density of surface observations. Very sparse observations at present.
- Better sampling of mid and high elevations

Dense networks operating for long periods that sample climate in regions of high spatial gradients in climate
- Transects
- Clusters
- Great Basin: mountains ~like other mountains, valleys ~like other valleys

<u>Operational production</u> of fine-spatial-scale gridded climate observations
- e.g., PRISM

Climate Network of Networks. Cross-agency network coordination.
- Climate observations need higher standards than "weather" observations
- We are not even adequately using what we now observe

Coordination between USDI centers and existing NOAA centers

Linkages to existing climate data distribution systems and product generators
- Build on existing infrastructure for climate services
- Coordinate with existing data networks to avoid duplication

More "Trackers" for wide audiences

Climate data and observational needs for research and outreach/education

More information on “demand” side of drought

- Evaporation
- Transpiration
- Sublimation

Groundwater status . . . very patchy information

Information displays to simply convey complex water information as a complement Drought Monitor maps

How to describe and depict drought in a dry climate

Improved, more frequent, and more dense reports of climate/drought impacts

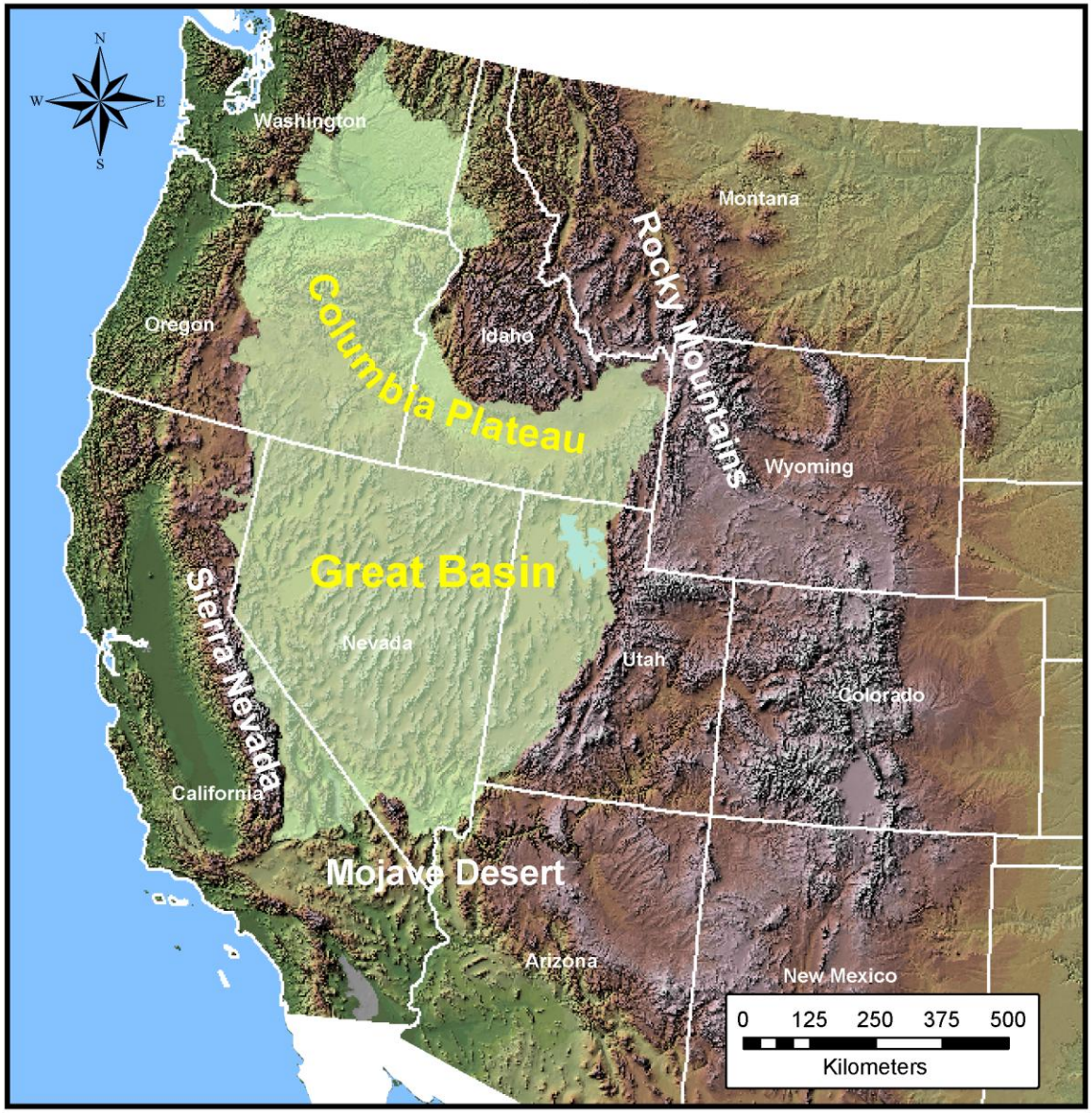
Recent Farm Services Agency visit to WRCC – still many uncertainties

Ability to view via the web all components of the water budget

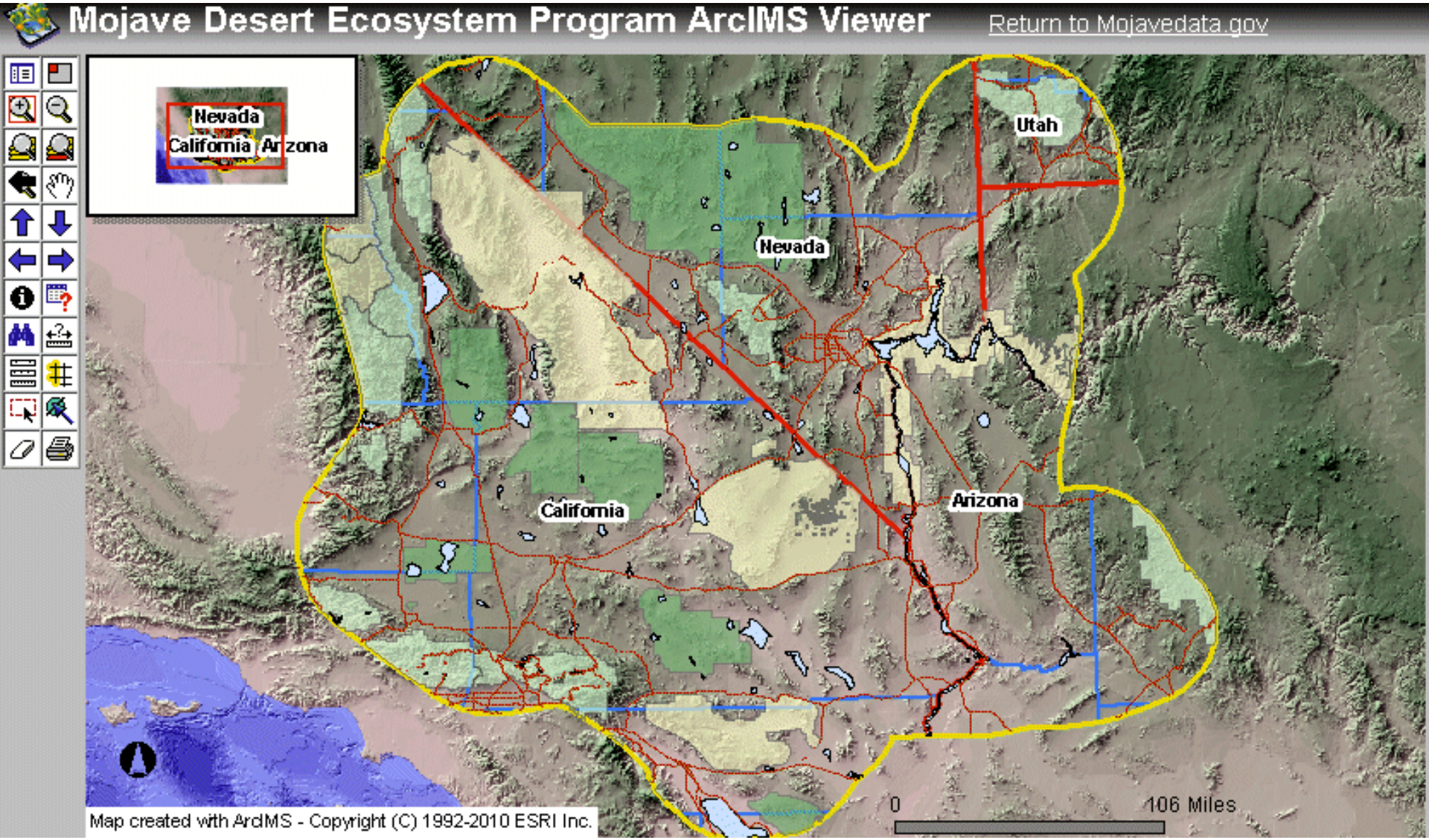
Thank You !

Discard Pile

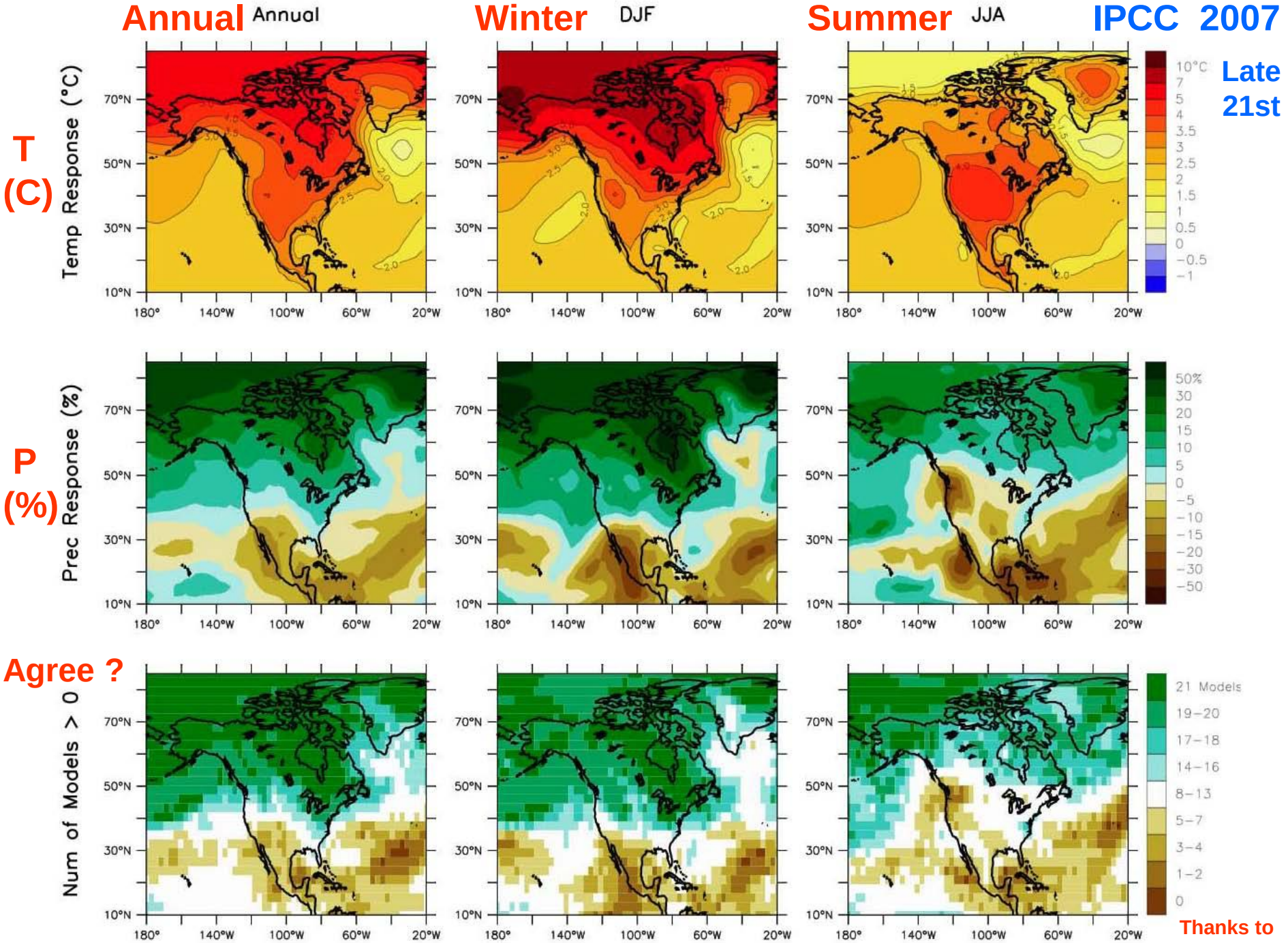
Great Basin and Columbia Plateau Regions in the western United States

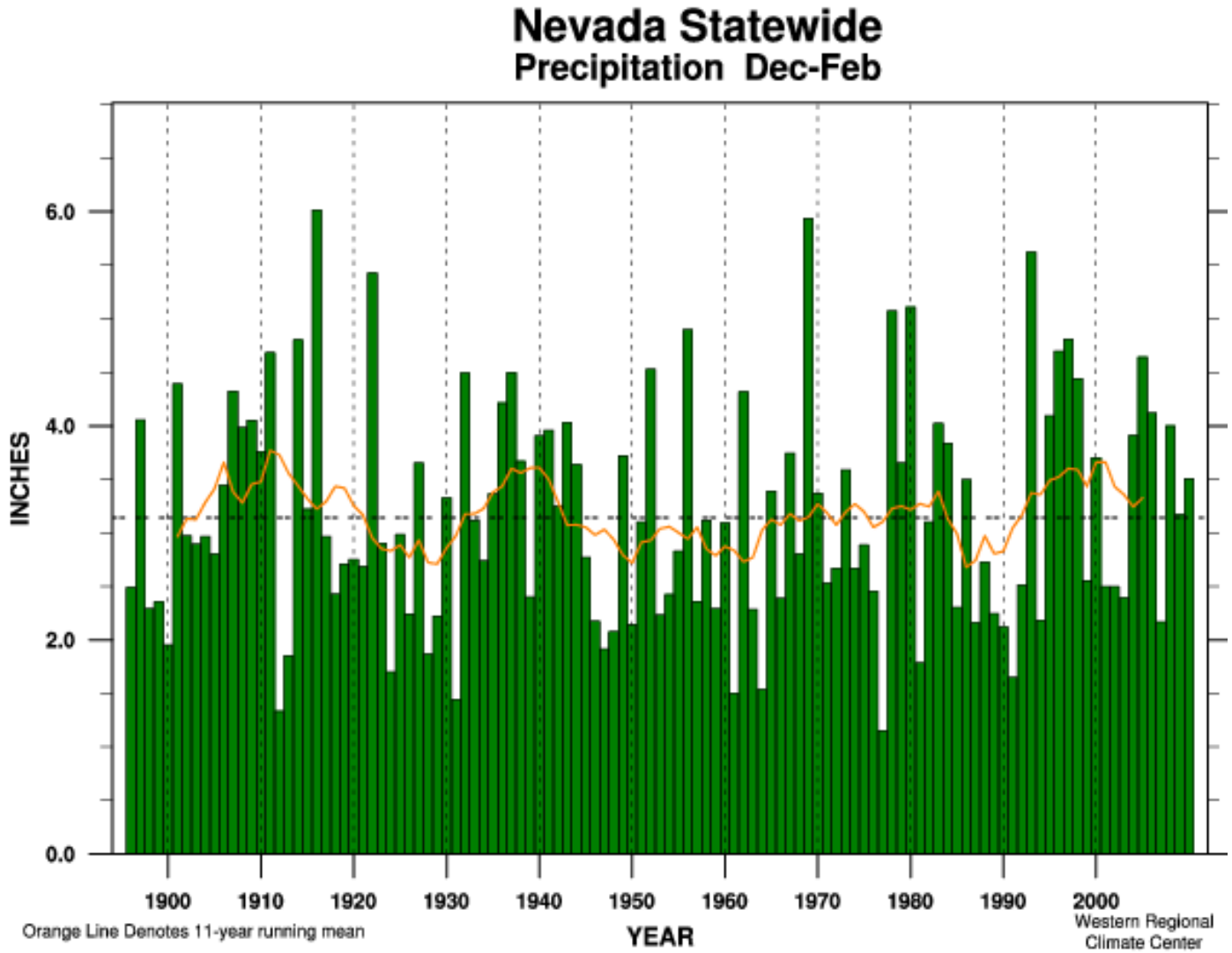


USGS



Mojavedata.gov


Annual
Annual
Winter
DJF
Summer
JJA
IPCC 2007
Late 21st
T (C)
Temp Response (°C)
P (%)
Prec Response (%)
Agree ?
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

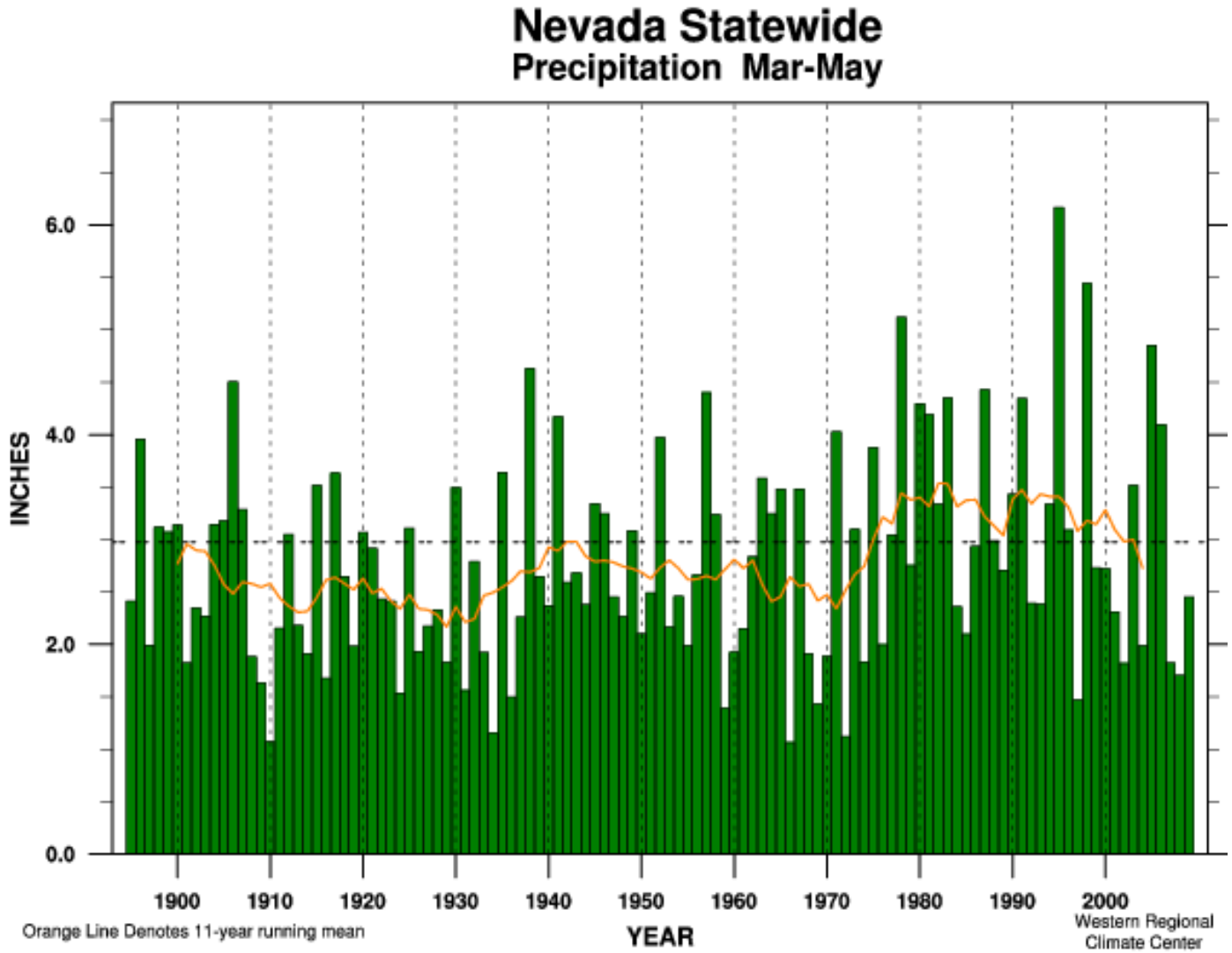


Linear Trend 1895-present		+ 0.10 ± 0.58 in.	(+ 3 ± 18%) per 100 yr		
Linear Trend 1949-present		+ 0.94 ± 1.57 in.	(+ 29 ± 49%) per 100 yr		
Linear Trend 1975-present		+ 1.44 ± 3.88 in.	(+ 45 ± 123%) per 100 yr		
Wettest Year		6.02 in. (191%)	in 1916	MEAN	3.15 in.
Driest Year		1.15 in. (36%)	in 1977	STDEV	1.11 in.
Dec-Feb	2010	3.51 in. (111%)		RANK	74 of 115

Nevada Statewide Precipitation

Winter Dec-Jan-Feb

1895-96 thru 2009-10

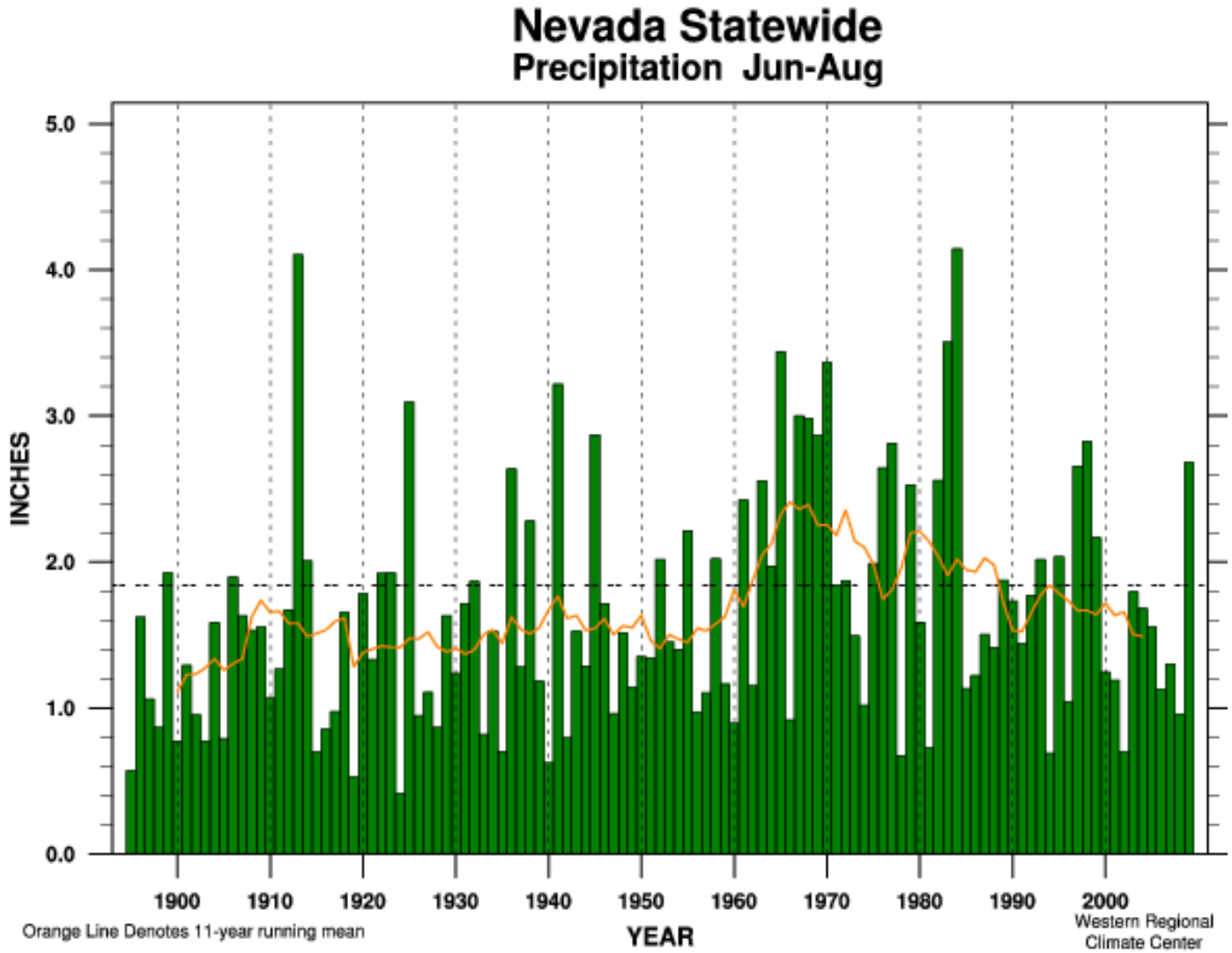


Linear Trend 1895-present		+ 0.57 ± 0.54 in.	(+ 19 ± 18%) per 100 yr		
Linear Trend 1949-present		+ 0.91 ± 1.60 in.	(+ 30 ± 53%) per 100 yr		
Linear Trend 1975-present		- 2.42 ± 3.89 in.	(- 81 ± 130%) per 100 yr		
Wettest Year		6.17 in. (207%)	in 1995	MEAN	2.97 in.
Driest Year		1.07 in. (36%)	in 1910	STDEV	1.11 in.
Mar-May	2009	2.45 in. (82%)		RANK	53 of 115

Nevada Statewide Precipitation

Spring Mar-Apr-May

1895 thru 2009

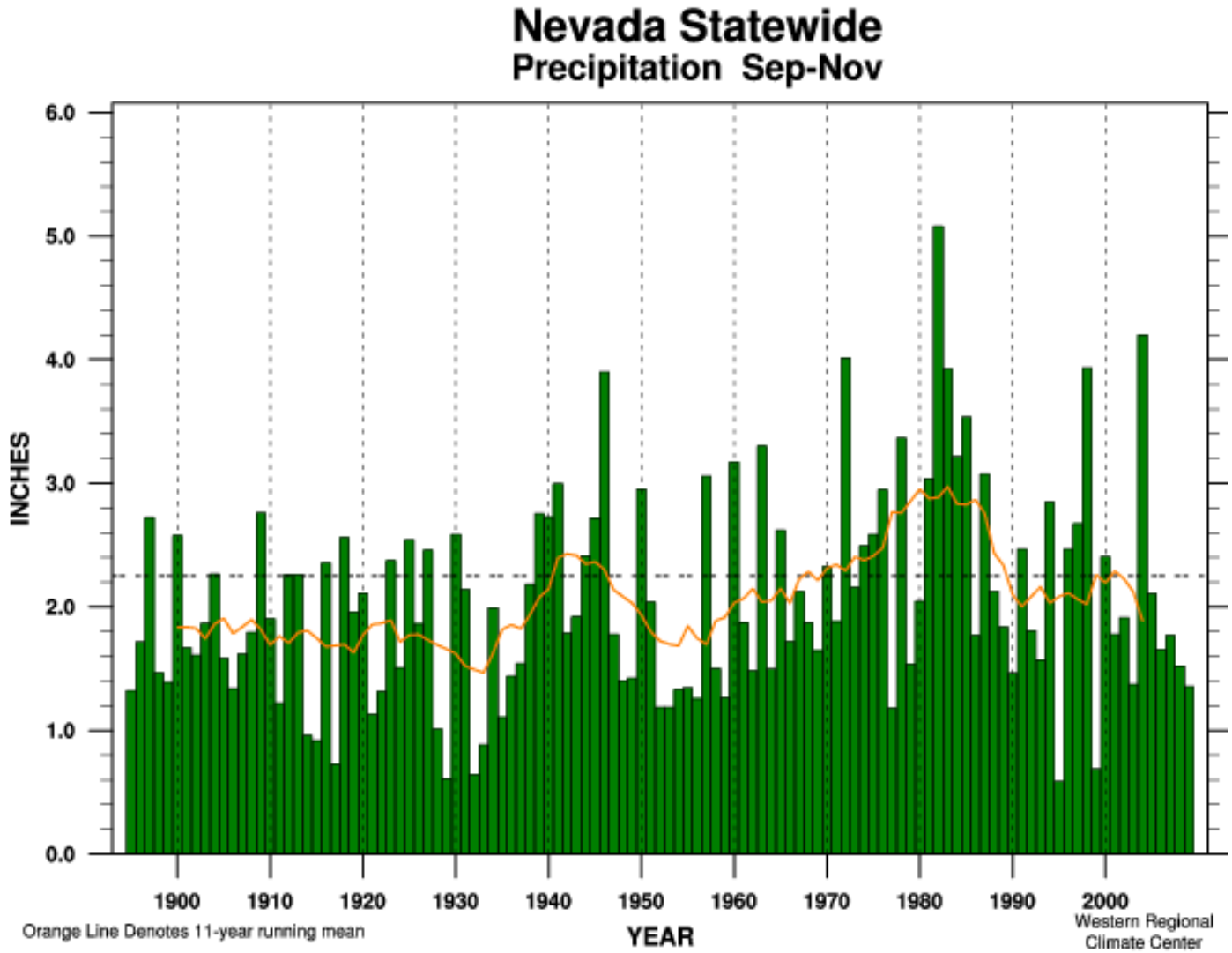


Linear Trend 1895-present		+ 0.52 ± 0.42 in.	(+ 28 ± 22%) per 100 yr		
Linear Trend 1949-present		- 0.21 ± 1.17 in.	(- 11 ± 63%) per 100 yr		
Linear Trend 1975-present		- 2.07 ± 2.73 in.	(-112 ± 148%) per 100 yr		
Wettest Year		4.14 in. (225%)	in 1984	MEAN	1.84 in.
Driest Year		0.41 in. (22%)	in 1924	STDEV	0.81 in.
Jun-Aug	2009	2.68 in. (145%)		RANK	102 of 115

Nevada Statewide Precipitation

Summer Jul-Aug-Sep

1895 thru 2009



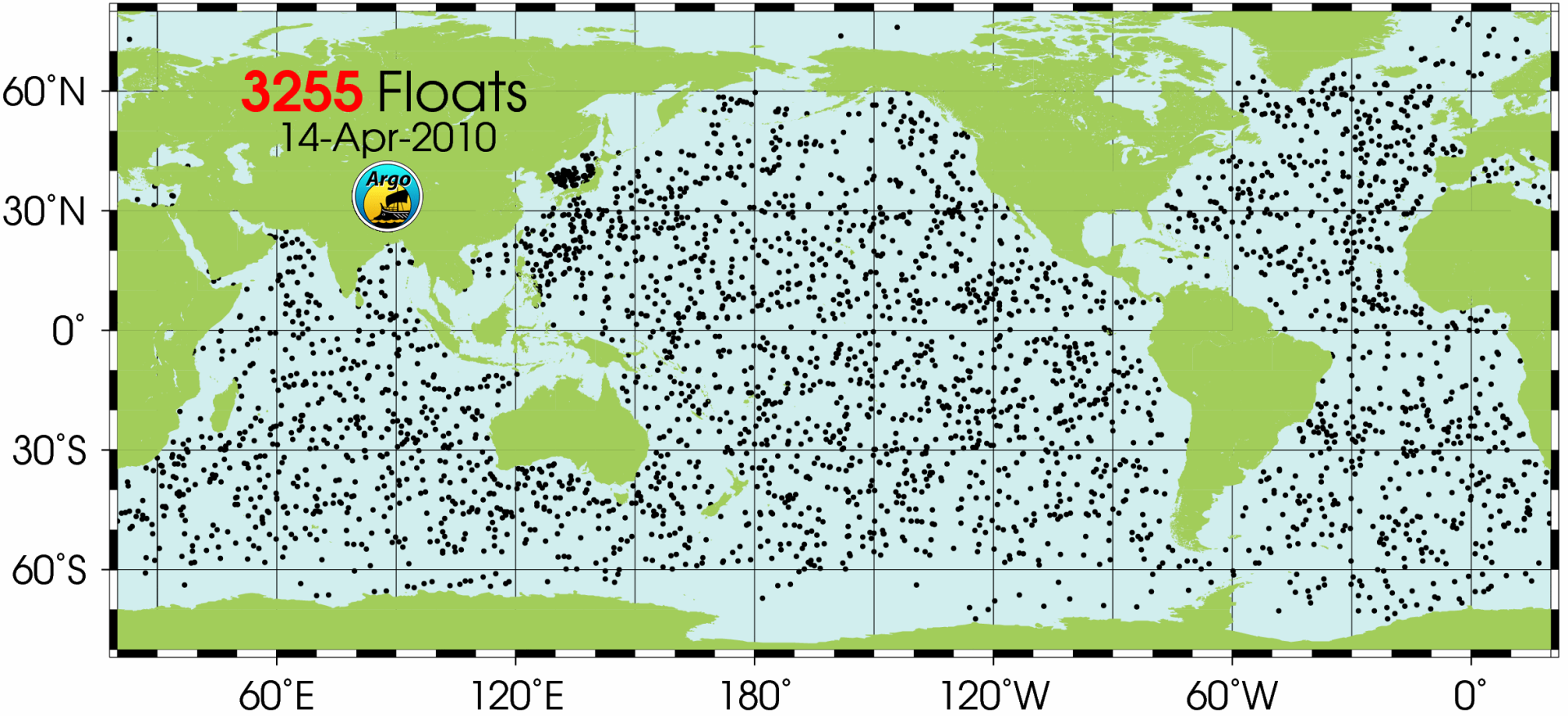
Linear Trend 1895-present		+ 0.58 ± 0.45 in.	(+ 25 ± 19%) per 100 yr		
Linear Trend 1949-present		+ 0.42 ± 1.34 in.	(+ 18 ± 59%) per 100 yr		
Linear Trend 1975-present		- 3.10 ± 3.33 in.	(-137 ± 147%) per 100 yr		
Wettest Year		5.08 in. (225%)	in 1982	MEAN	2.25 in.
Driest Year		0.59 in. (26%)	in 1995	STDEV	0.94 in.
Sep-Nov	2009	1.36 in. (60%)		RANK	23 of 115

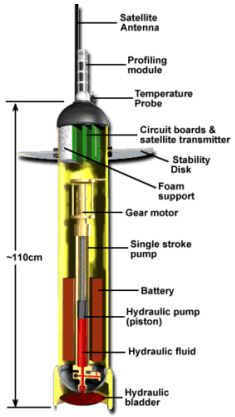
Nevada Statewide Precipitation

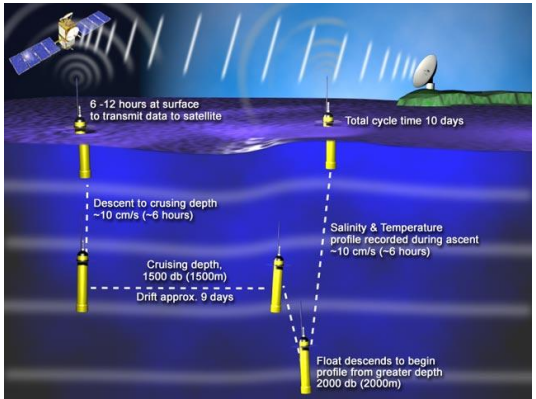
Autumn Sep-Oct-Nov

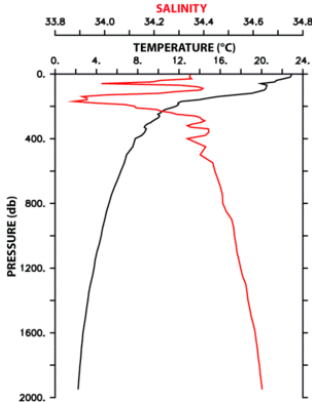
1895 thru 2009

2010 April. ARGO Floats



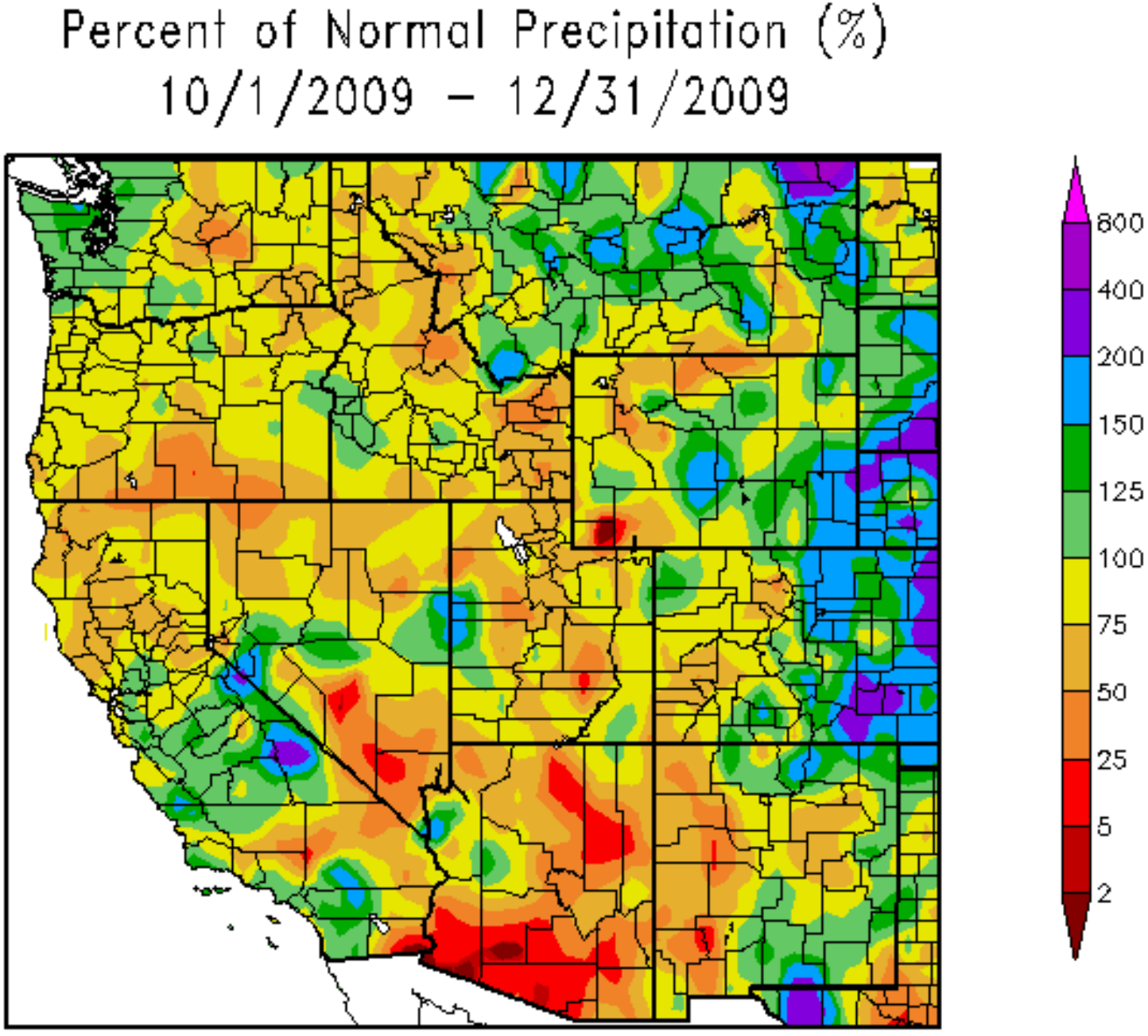






Percent of Average Precipitation

Oct – Dec 2009

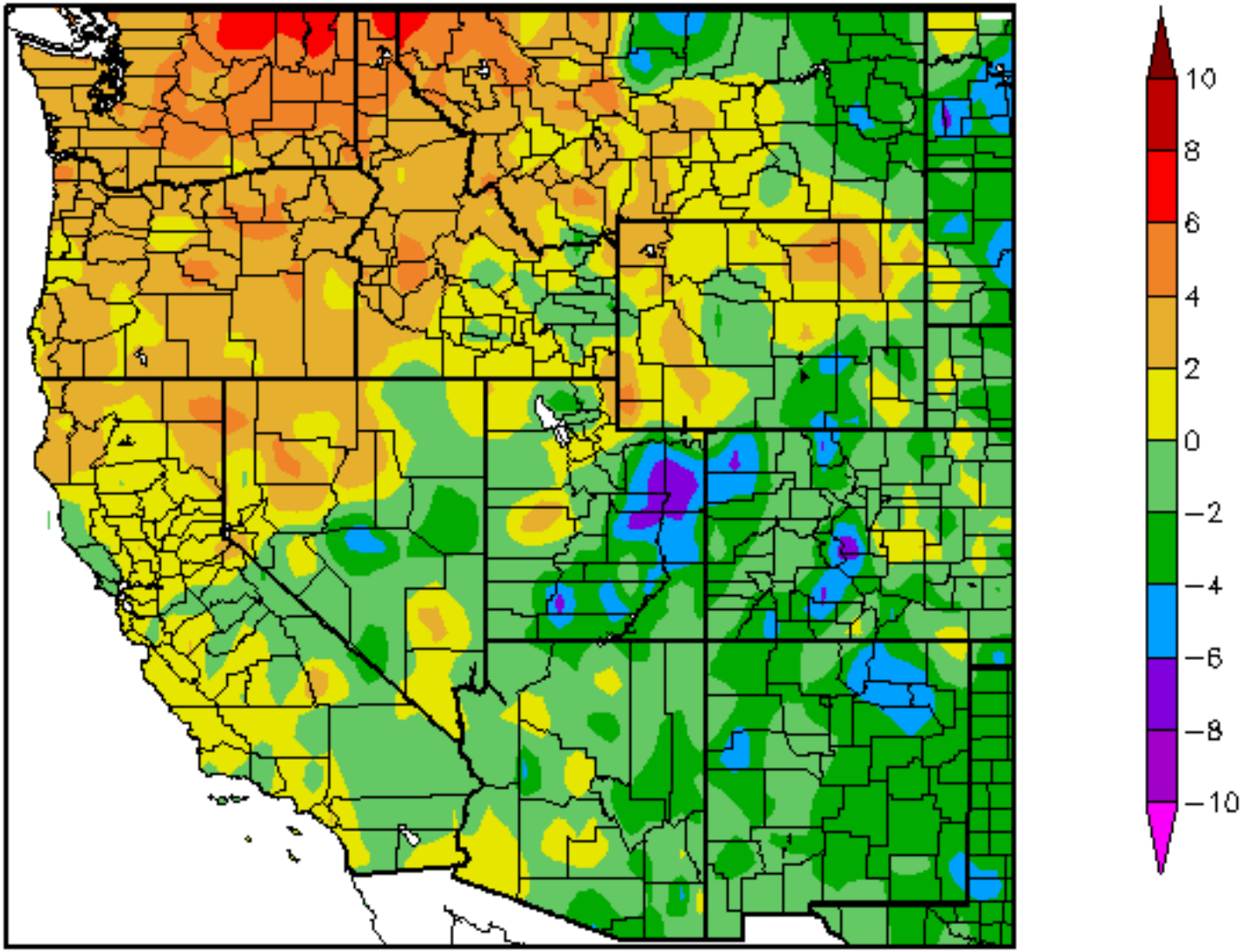


Temp Departure

Calendar Year to Date

01 Jan 2010 thru 29 Mar 2010

Departure from Normal Temperature (F)
1/1/2010 – 3/29/2010

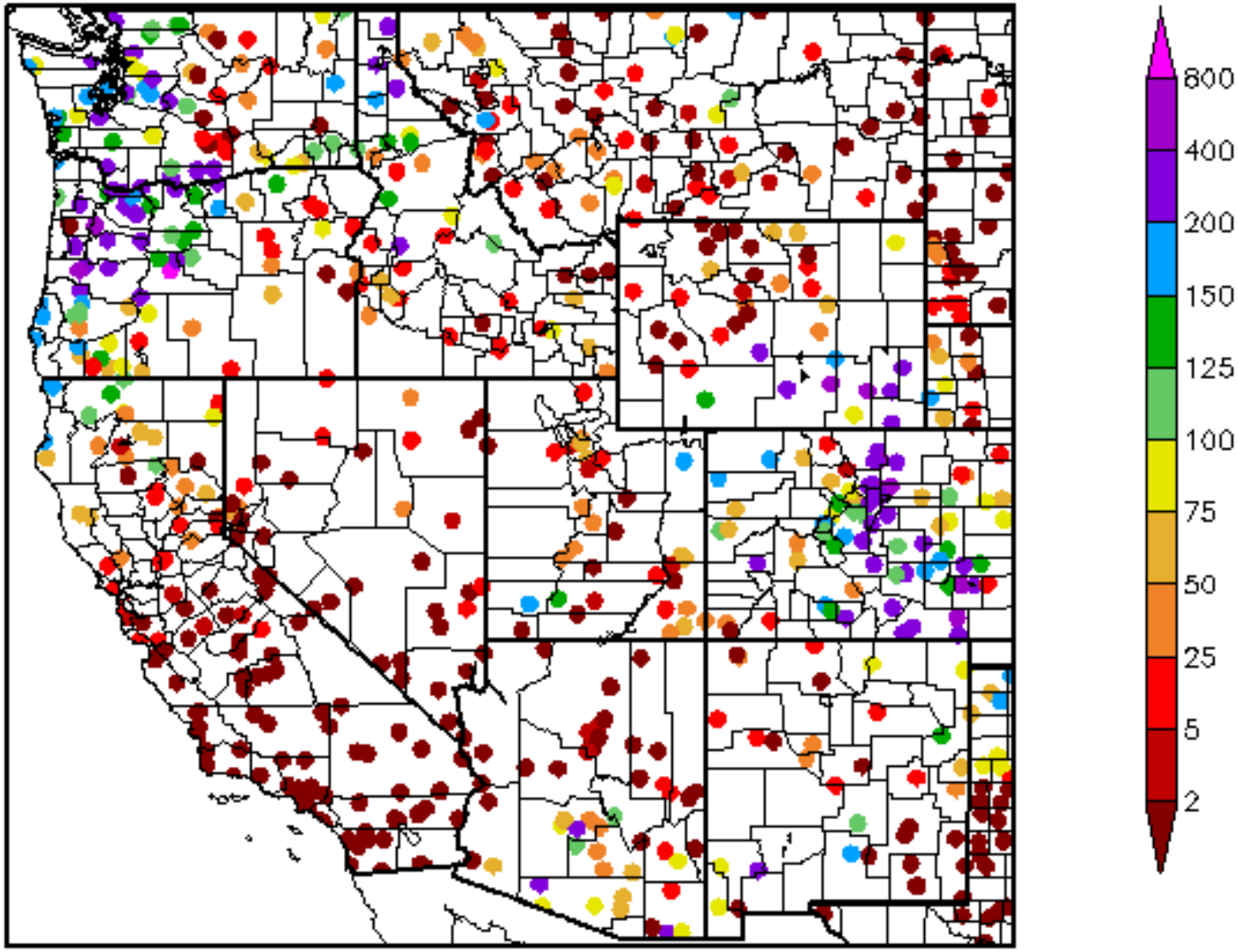


Generated 3/30/2010 at HPRCC using provisional data.

NOAA Regional Climate Centers

Stations Ingested by ACIS Applied Climate Information System

Percent of Normal Precipitation (%)
3/23/2010 – 3/29/2010



Generated 3/30/2010 at HPRCC using provisional data.

NOAA Regional Climate Centers

USGS Surface-Water Data for the Nation

Real-time data (9,043 sites)

Real-time data are time-series (recorded at fixed intervals) data from automated equipment and represent the most current hydrologic conditions. Measurements are commonly recorded at 5-60 minute intervals and transmitted to the NWIS database every 1-4 hours. Real-time data are available online for 120 days.

Daily data (25,165 sites)

Daily values are summarized from time-series data for each day for the period of record and may represent the daily mean, median, maximum, minimum, and/or other derived value. Daily values include approved, quality-assured data that may be published, and more recent provisional data, whose accuracy has not been verified. Example.

Statistics (23,988 sites)

Daily **Monthly** **Annual**

Statistics are computed from approved daily mean time-series data at each site. These links provide summaries of approved historical daily values for daily, monthly, and annual (water year or calendar year) time periods.

Peak-flow data (27,623 sites)

Annual maximum instantaneous peak streamflow and gage height

Field measurements (47,974 sites)

Periodic manual measurements of streamflow and

Introduction

Nationally, USGS surface-water data includes more than 850,000 station years of time-series data that describe stream levels, streamflow (discharge), reservoir and lake levels, surface-water quality, and rainfall. The data are collected by automatic recorders and manual measurements at field installations across the Nation.

Data are collected by field personnel or relayed through telephones or satellites to offices where it is stored and processed. The data relayed through the Geostationary Operational Environmental Satellite (GOES) system are processed automatically in near real time, and in many cases, real-time data are available online within minutes.

Once a complete day of readings are received from a site, daily summary data are generated and stored in the data base. Recent provisional daily data are updated on the web once a day when the computation is completed.

Annually, the USGS finalizes and publishes the daily data in a series of water-data reports. Daily streamflow data and peak data are updated annually following publication of the reports.

Tutorial

Tutorial explaining how to perform a surface water retrieval and understand the results

WestWideDroughtTracker

NOAA TRACS

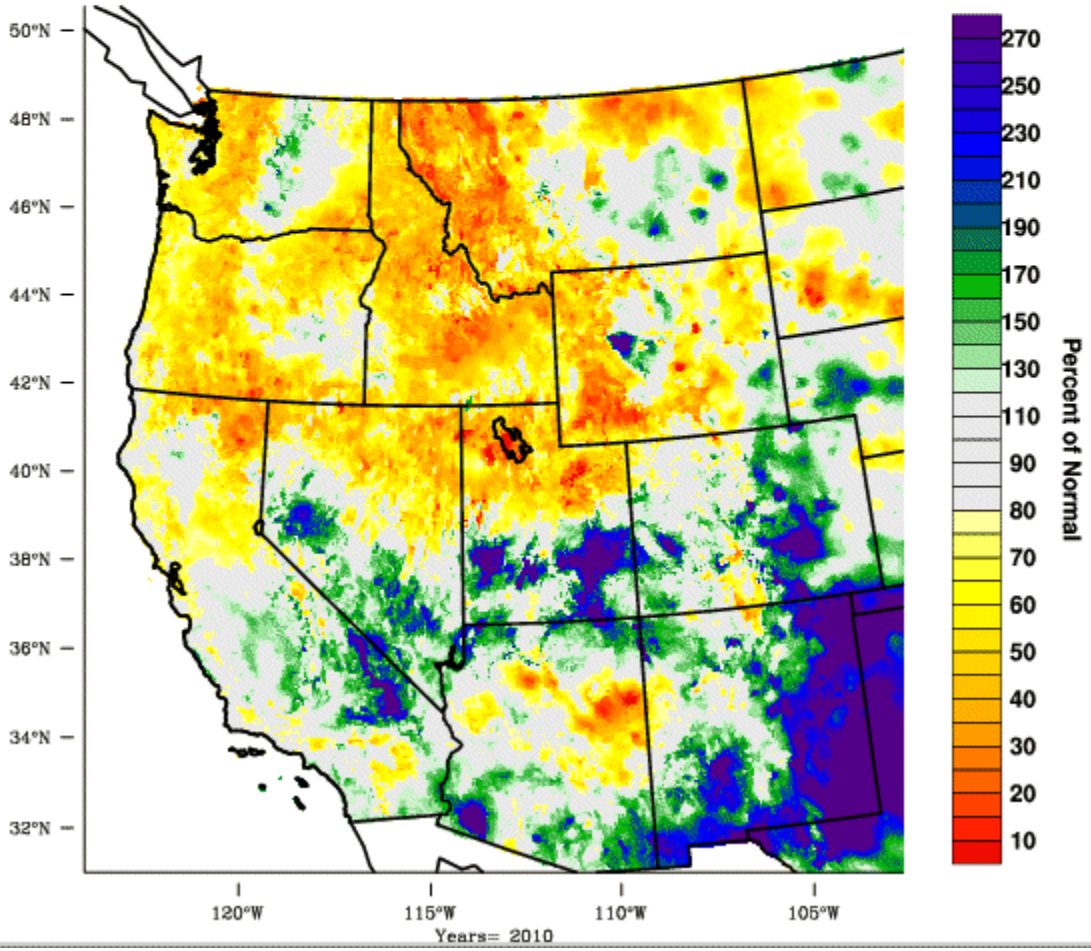
Home SPI Precipitation Temperature Palmer Snowpack Soil Moisture About

Click on state to zoom-in for county view.

Then, click on desired county to zoom-in for an even more detailed view (CA ONLY).

Western United States Precipitation Percent of Normal

February Departure from 1971-2000 Mean

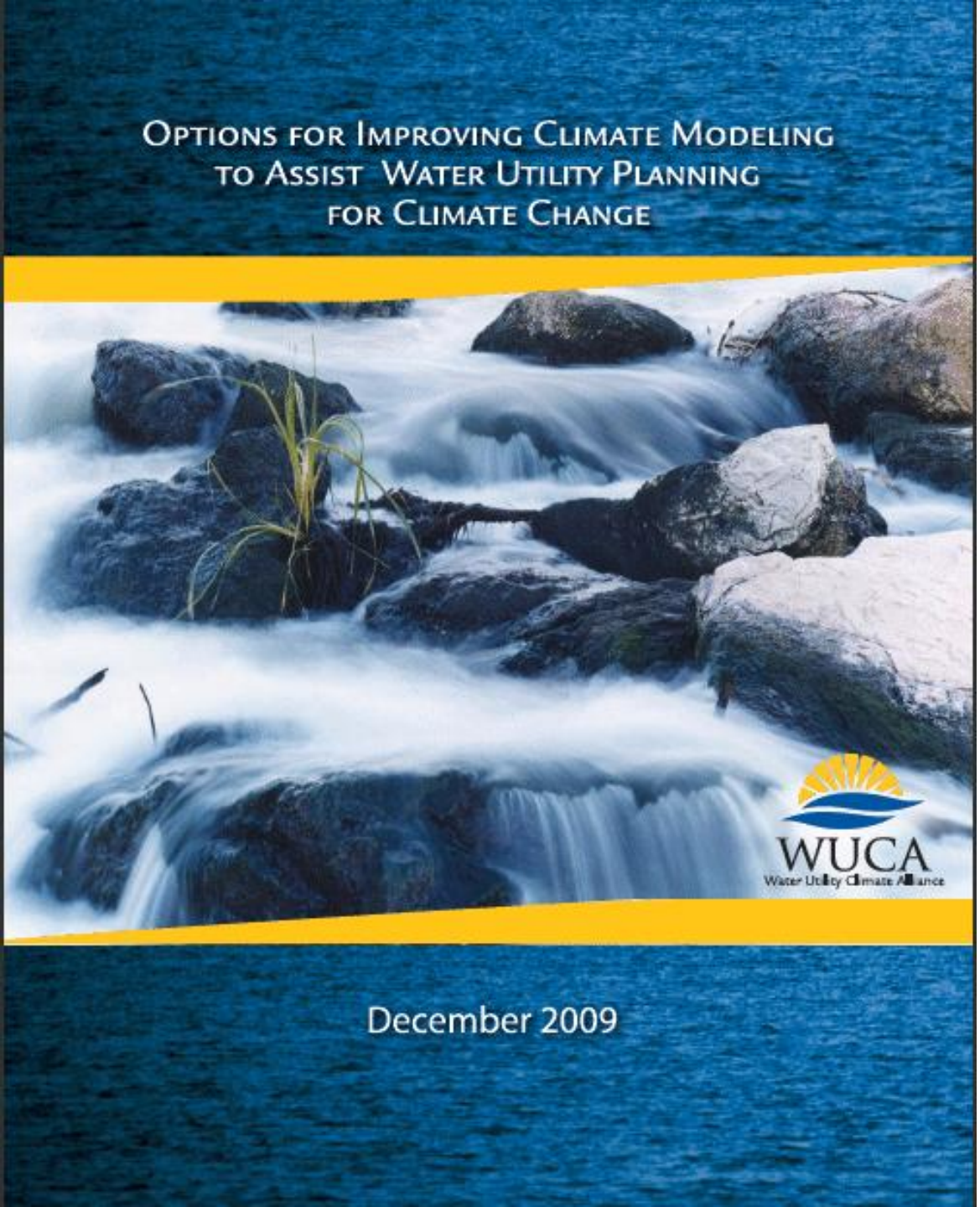


Fine scale

Uses PRISM Data

A NOAA TRACS Project

WRCC



Water Utilities Climate Alliance
David Behar (lunch speaker)

Denver Water
Metropolitan Water District of SoCal
NYC Dept Environmental Protection
Portland Water Bureau
San Diego County Water Authority
San Francisco Public Utilities Comm
Seattle Public Utilities
Southern Nevada Water Authority

Authors
Joe Barsugli, WWA, UC-Boulder
Chris Anderson, Iowa St Univ
Joel Smith, Stratus Consulting
Jason Vogel, Stratus Consulting

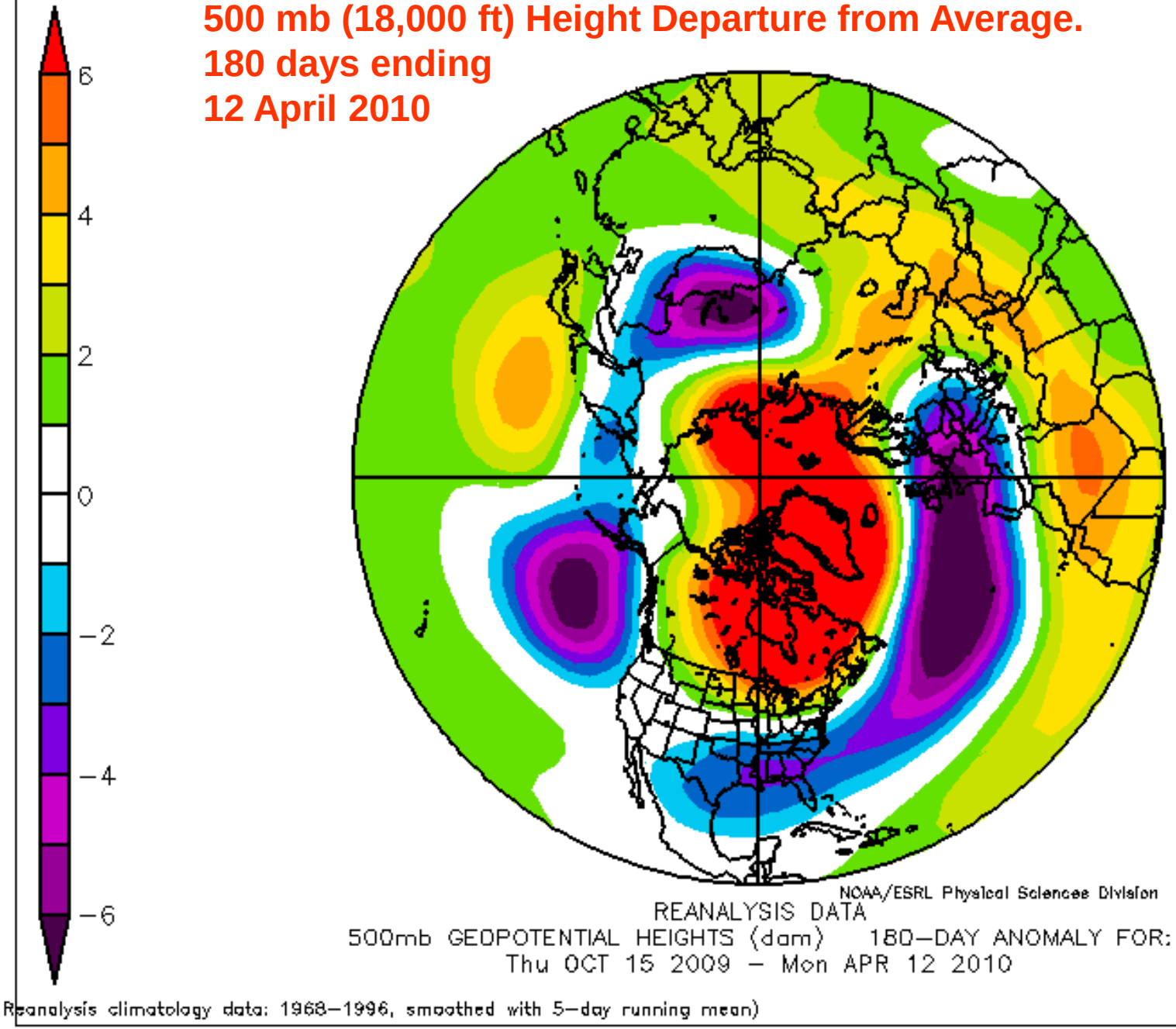
Lots of practical recommendations

What next ???

Actionable Science:

> **"Data, analysis, and forecasts that are sufficiently predictive, accepted, and understandable to support decision-making, including capital investment decision-making."**

- David Behar
San Francisco Public Utilities Commission

From:
Water Utilities Climate Alliance, December 2009. "Options for Improving Climate Modeling to Assist Water Utility Planning for Climate Change"

500 mb (18,000 ft) Height Departure from Average.
180 days ending
12 April 2010