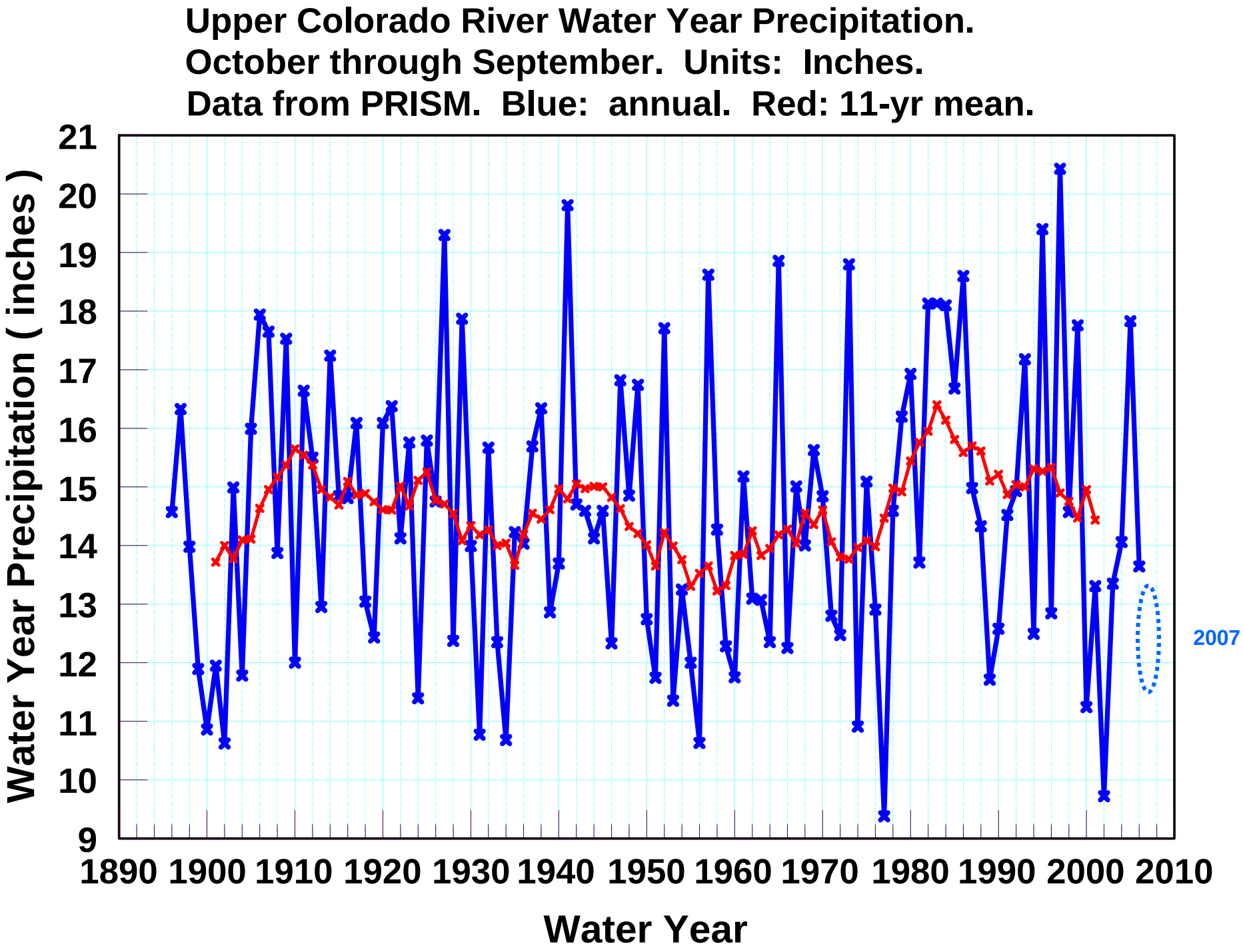
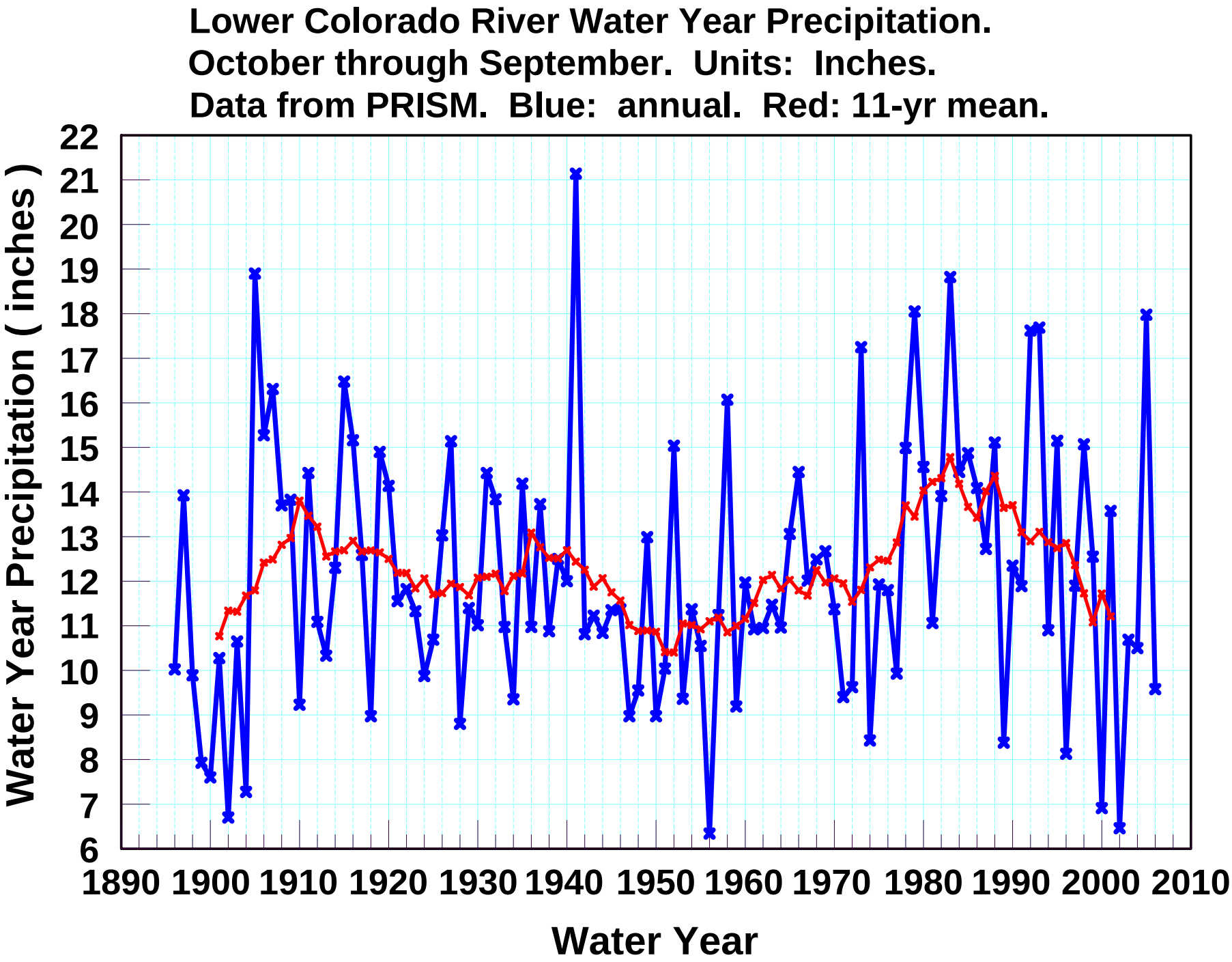

Upper Colorado River Water Year Precipitation.
October through September. Units: Inches.
Data from PRISM. Blue: annual. Red: 11-yr mean.
Water Year Precipitation (inches)
21
20
19
18
17
16
15
14
13
12
11
10
9
1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
Water Year
2007


Lower Colorado River Water Year Precipitation.
October through September. Units: Inches.
Data from PRISM. Blue: annual. Red: 11-yr mean.
Water Year Precipitation (inches)
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Water Year

Estimated effects of climate change on Colorado River streamflow (Lees Ferry):

By mid-Century, water managers can expect:

Small decrease (0-8 percent (-6)) Christensen and Lettenmaier, 2007

Large decrease (up to 40 percent) Hoerling and Eischeid 2007

Moderate decrease (in between) Seager et al 2007

More moderate decrease (10 to 25 pct, -13 pct) from Milly et al 2005

A. None of these show streamflow going up !

B. Any decrease is a source of concern !

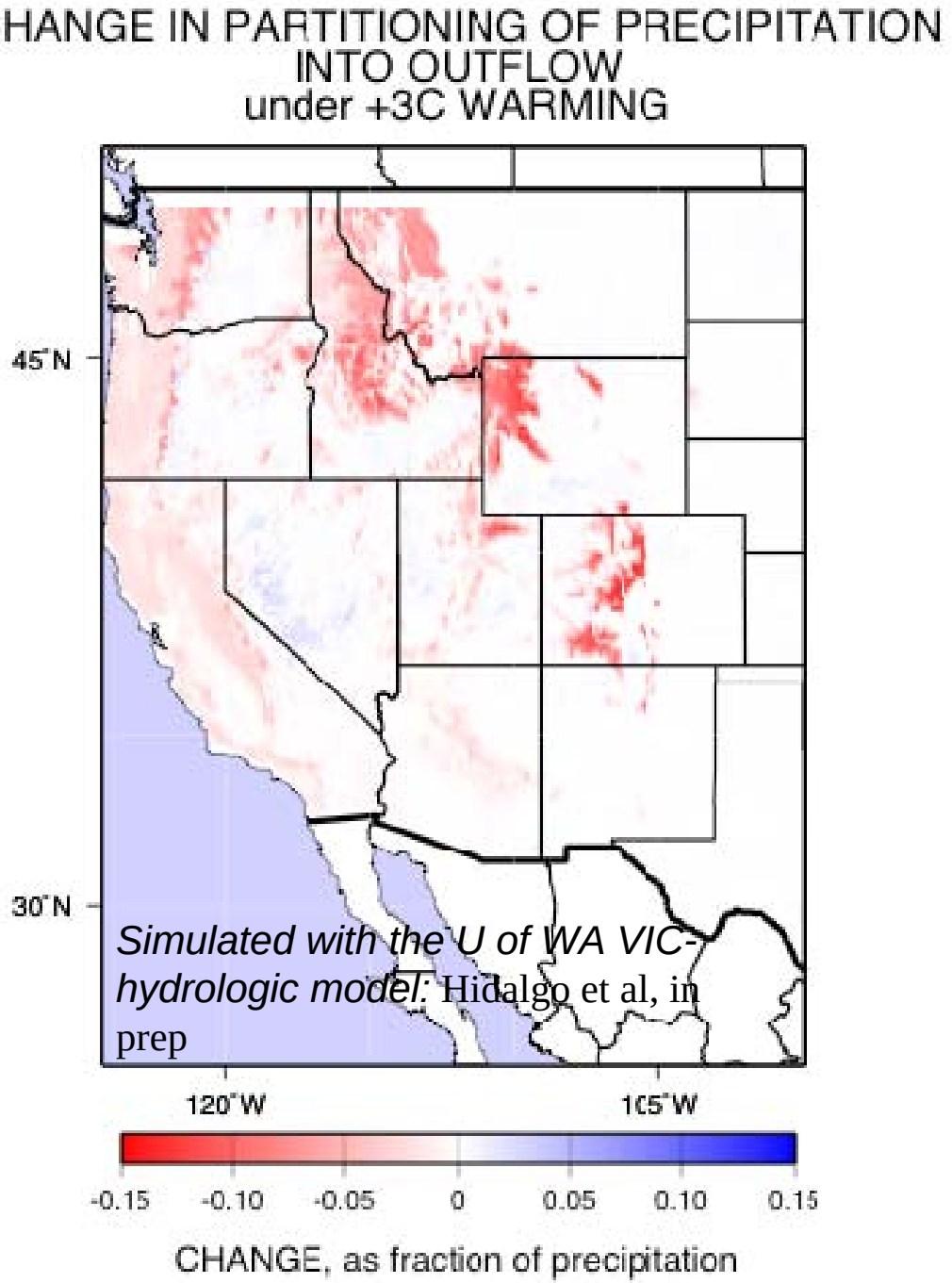
C. We have to resolve these differences !

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 under a uniform +3ºC warming



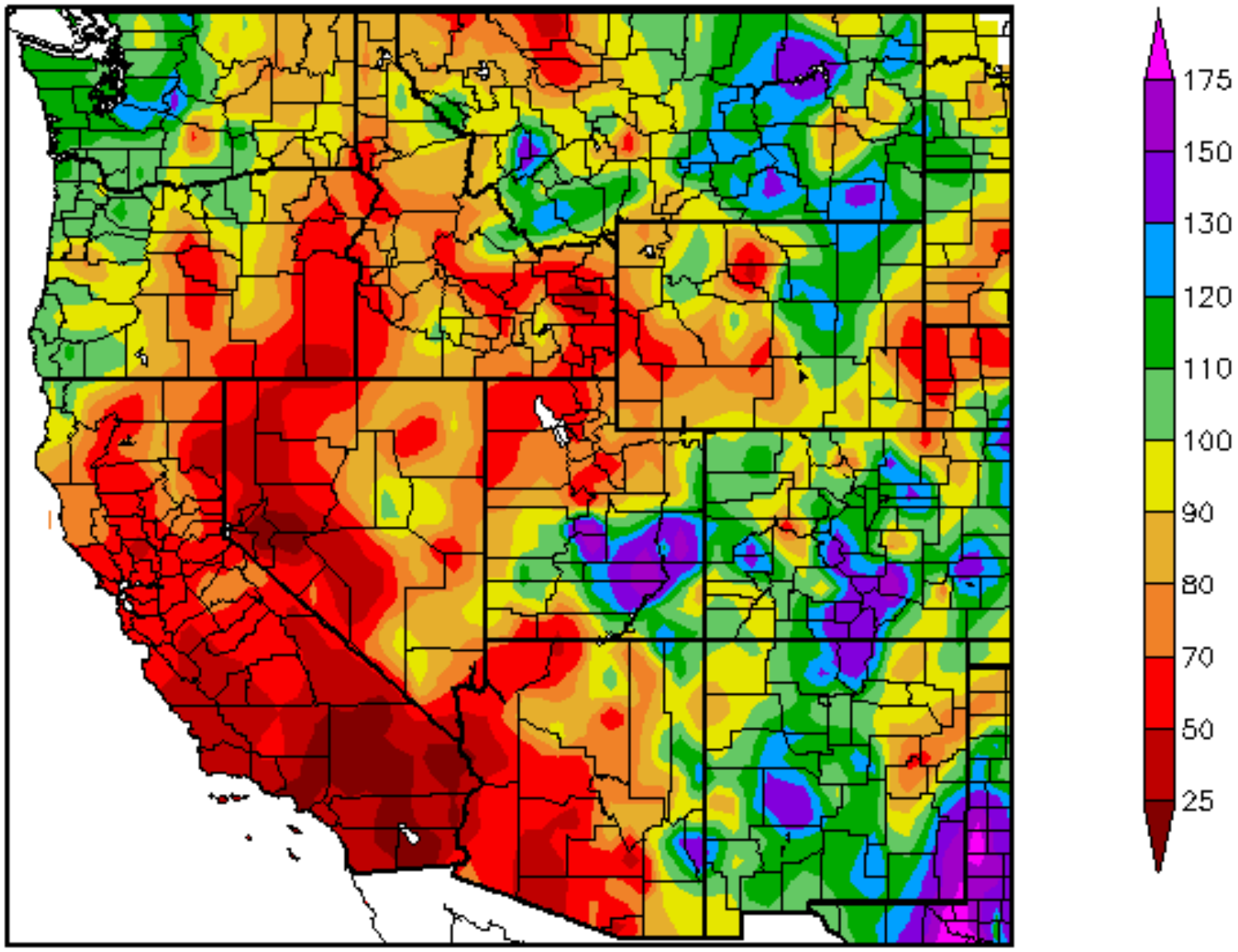
Climate change presents a very real risk. It seems worth a very large premium to insure ourselves against the most catastrophic scenarios. Denying the risk seems utterly stupid. Claiming we can calculate the probabilities with any degree of skill seems equally stupid.

Carl Wunsch
Professor of Physical Oceanography
Massachusetts Institute of Technology
December 2006

Water Year

Oct 2006
Thru
Sep 2007

Percent of Normal Precipitation (%)
10/1/2006 – 9/30/2007

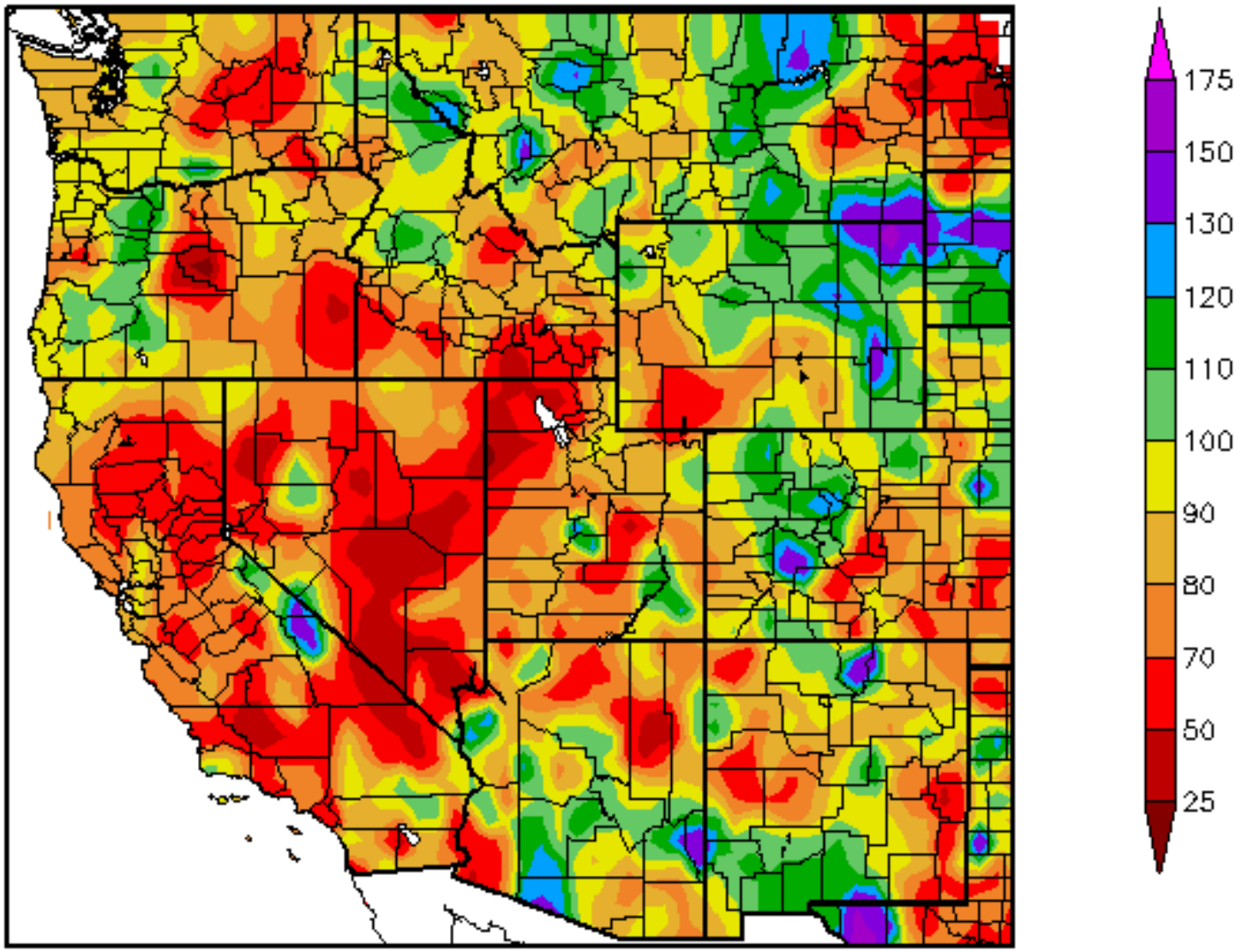


Generated 10/11/2007 at HPRCC using provisional data

NOAA Regional Climate Centers

Water Year 2007-2008 Oct 2007 Thru Sep 2008

Percent of Normal Precipitation (%)
10/1/2007 – 9/30/2008



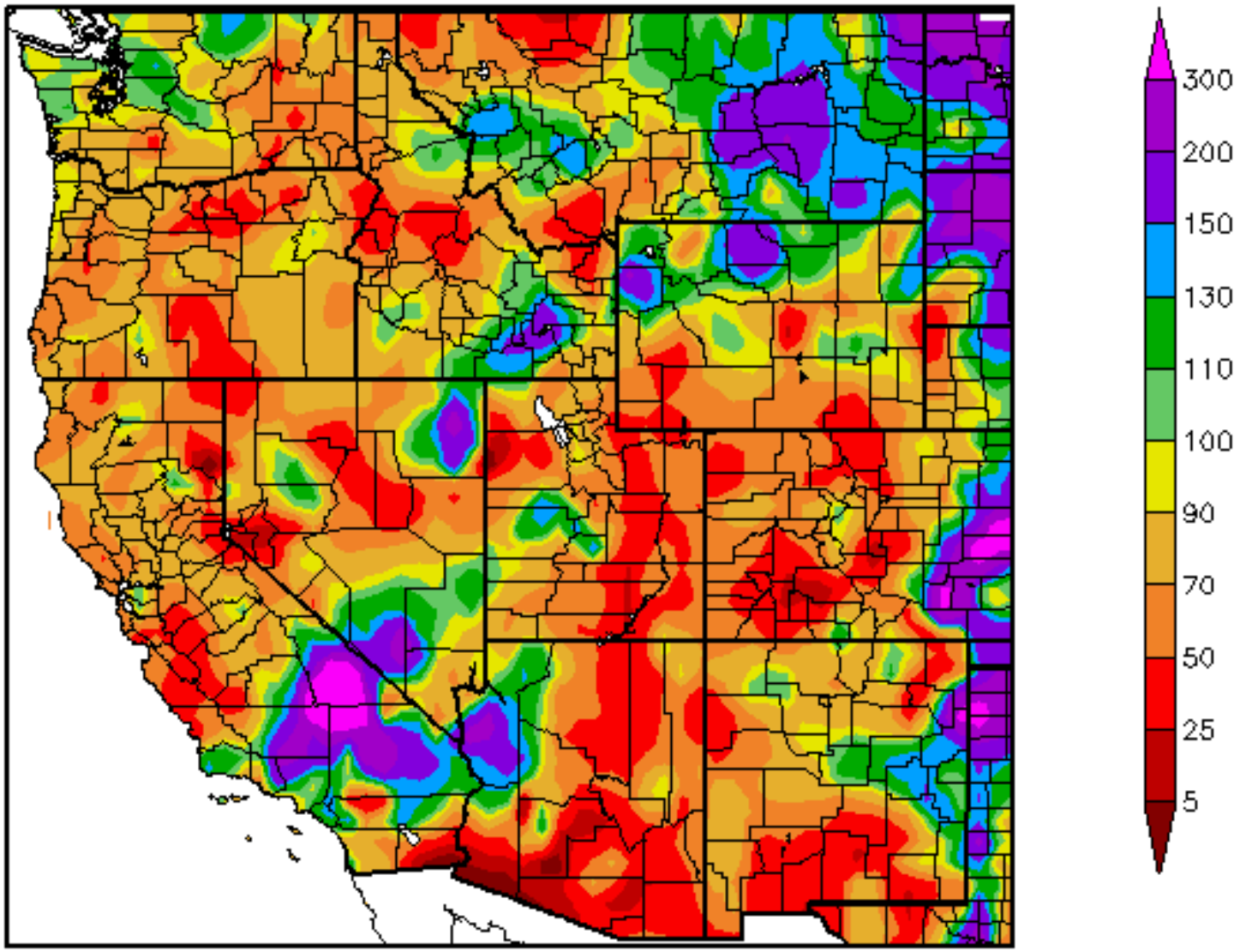
Generated 10/11/2008 at HPRCC using provisional data.

NOAA Regional Climate Centers

Water Year 2008-2009

Oct 01 Thru Dec 02

Percent of Normal Precipitation (%)
10/1/2008 – 12/2/2008



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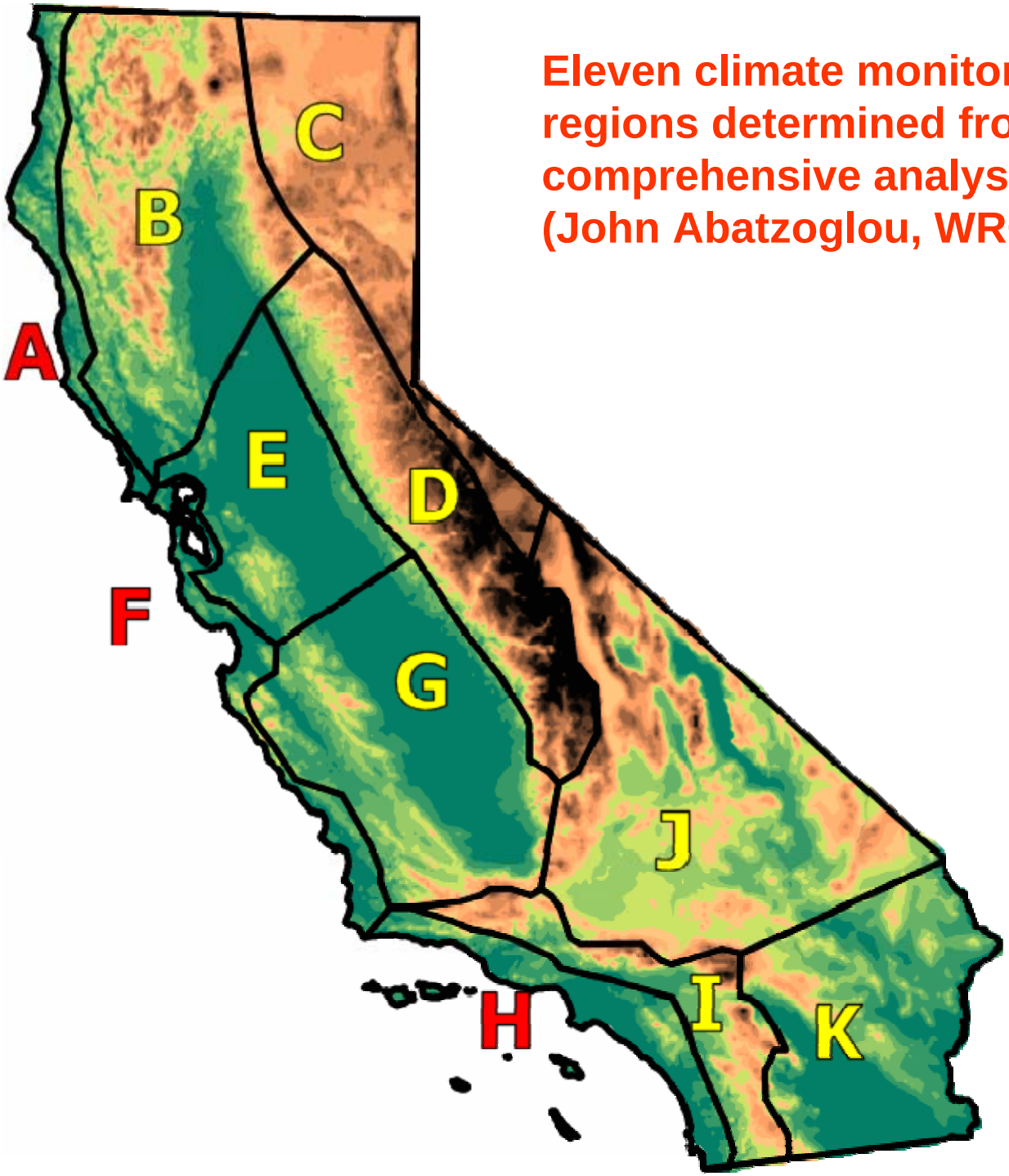
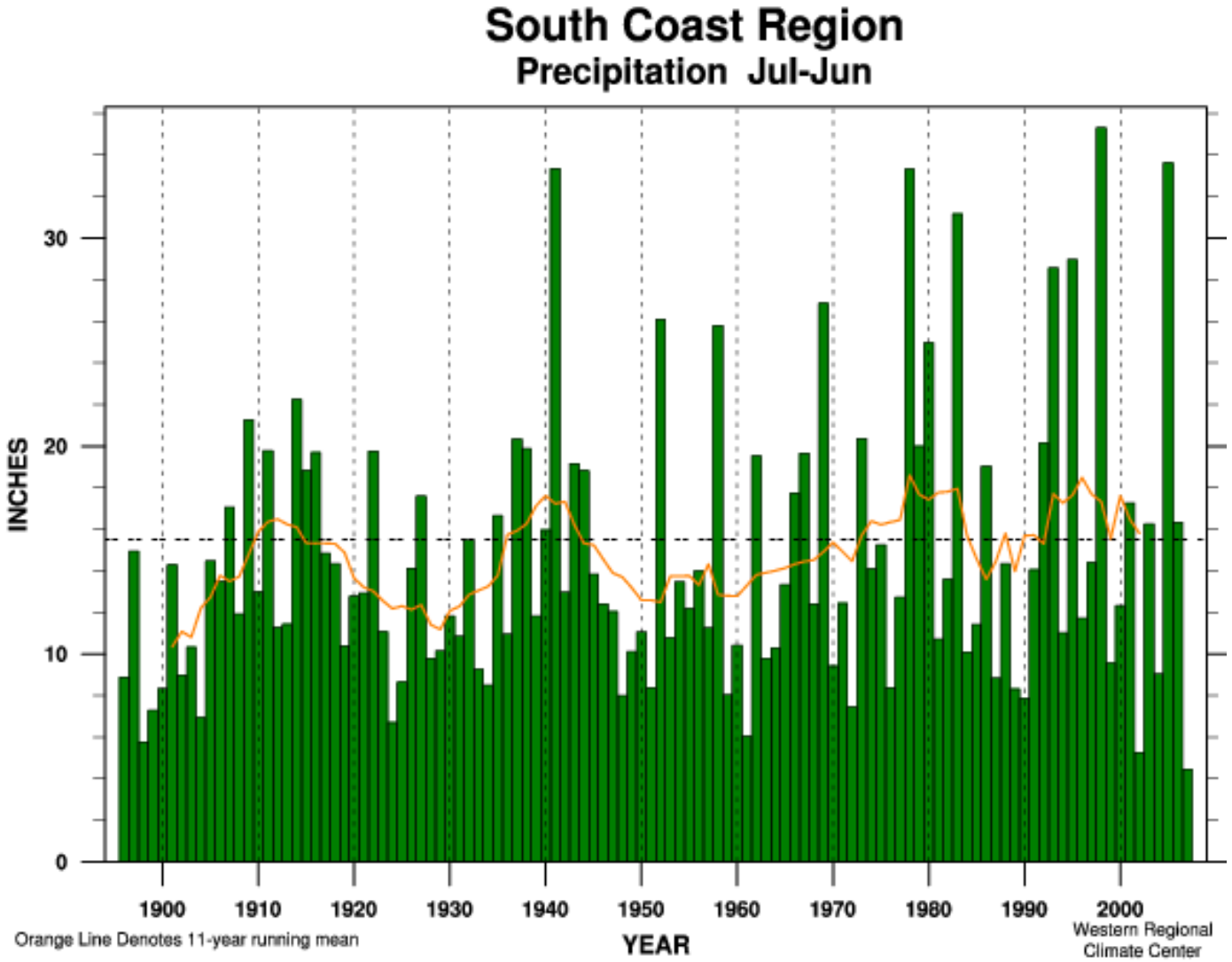
NOAA Regional Climate Centers



Eleven climate monitoring regions determined from a comprehensive analysis. (John Abatzoglou, WRCC)



Linear Trend 1895-present	+ 3.71 ± 3.73 in.	(+ 23 ± 24%) per 100 yr	
Linear Trend 1949-present	+ 5.24 ± 12.00 in.	(+ 33 ± 77%) per 100 yr	
Linear Trend 1975-present	- 7.09 ± 34.77 in.	(- 45 ± 224%) per 100 yr	
Wettest Year	35.32 in. (227%)	in 1998	MEAN 15.51in.
Driest Year	4.47 in. (28%)	in 2007	STDEV 7.56 in.
Jul-Jun 2007	4.47 in. (28%)		RANK 1 of 112

July-June Precipitation

South Coastal California

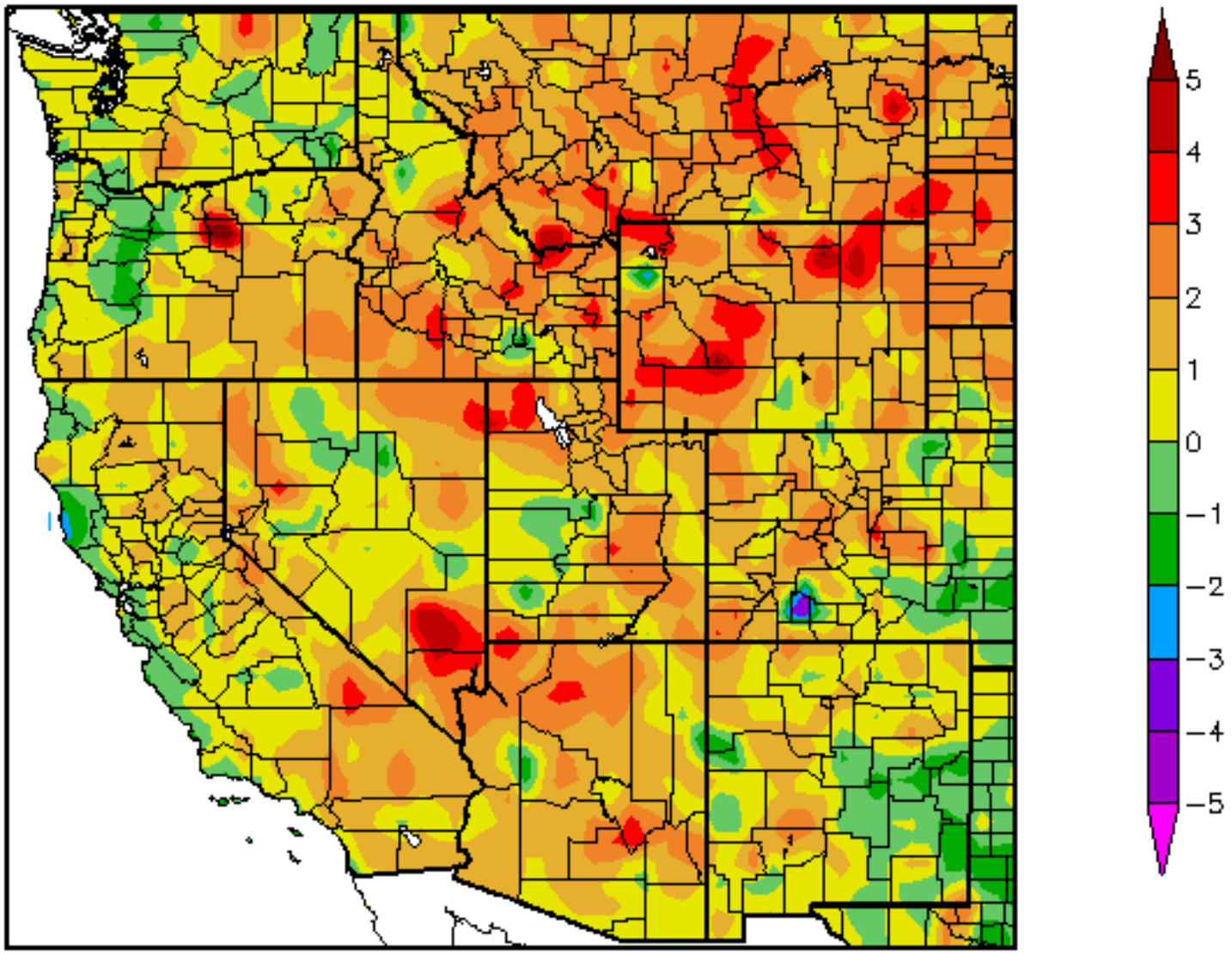
1895-1896 thru 2006-2007

Water Year

Oct 2006 Thru Sep 2007

Departure from Normal Temperature (F)

10/1/2006 – 9/30/2007

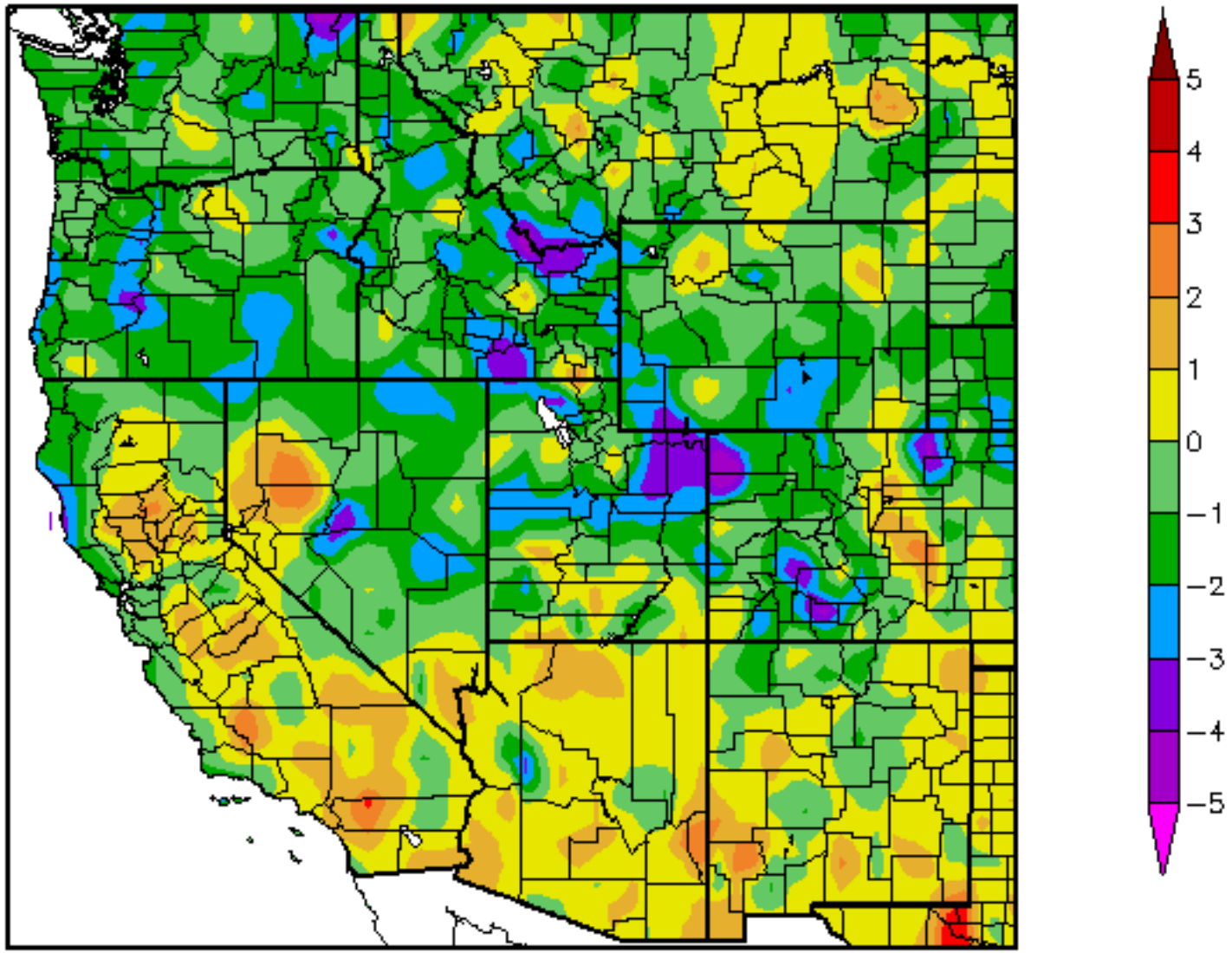


Generated 12/12/2007 at HPRCC using provisional data.

NOAA Regional Climate Centers

Water Year 2007-2008 October Thru September

Departure from Normal Temperature (F)
10/1/2007 – 9/30/2008



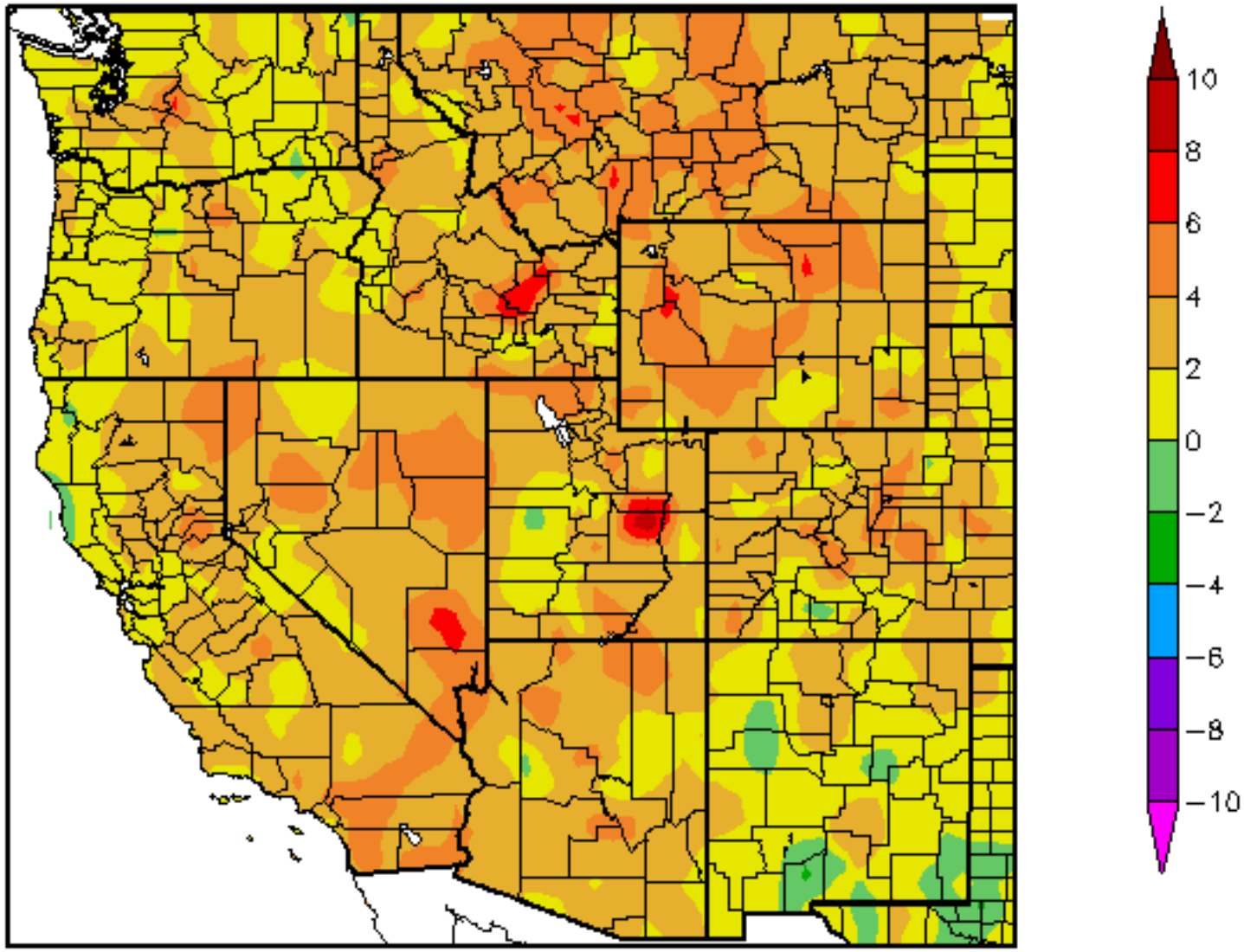
Generated 10/11/2008 at HPRCC using provisional data.

NOAA Regional Climate Centers

Water Year 2008-2009

Oct 01 Thru Dec 02

Departure from Normal Temperature (F)
10/1/2008 – 12/2/2008

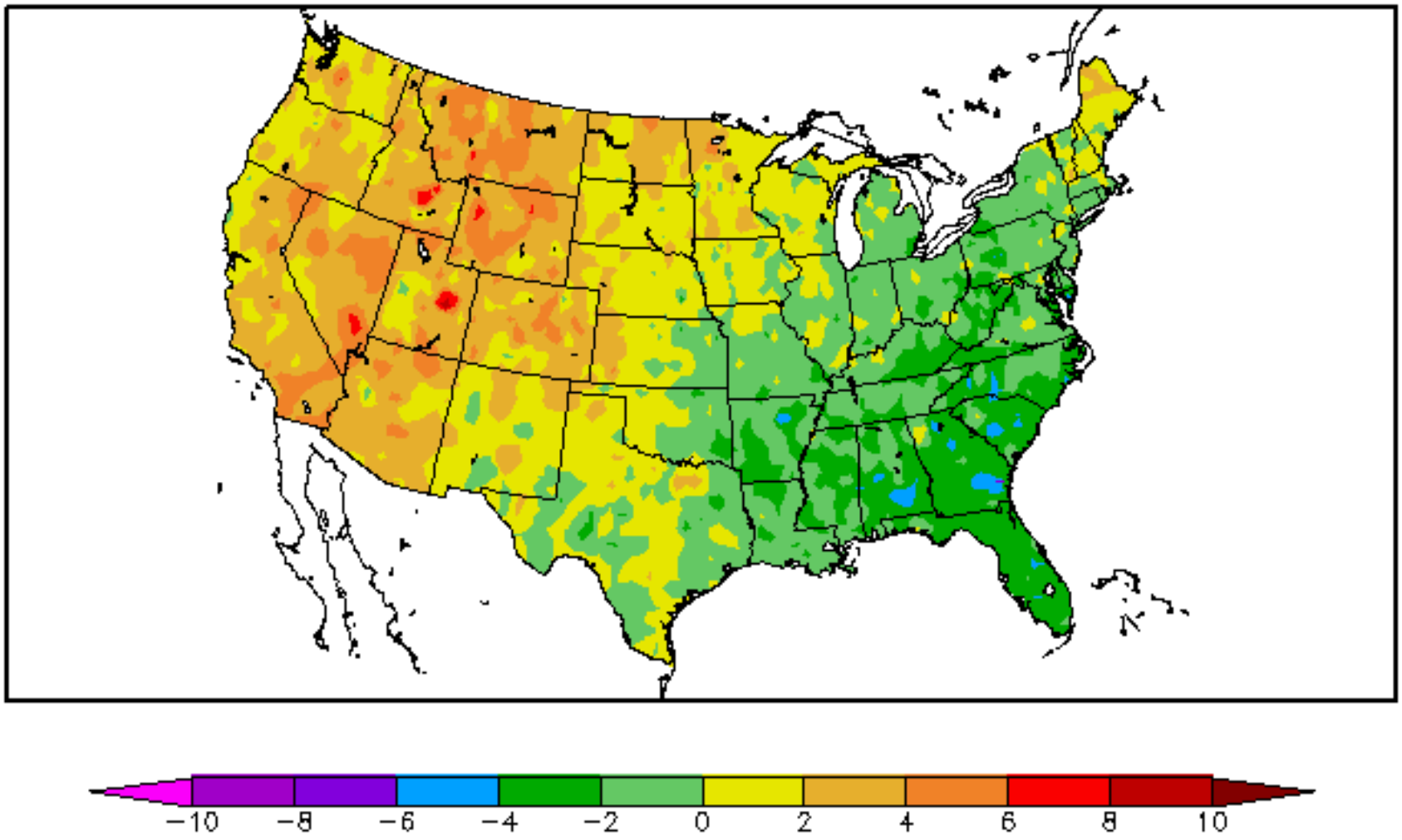


Generated 12/3/2008 at HPRCC using provisional data.

NOAA Regional Climate Centers

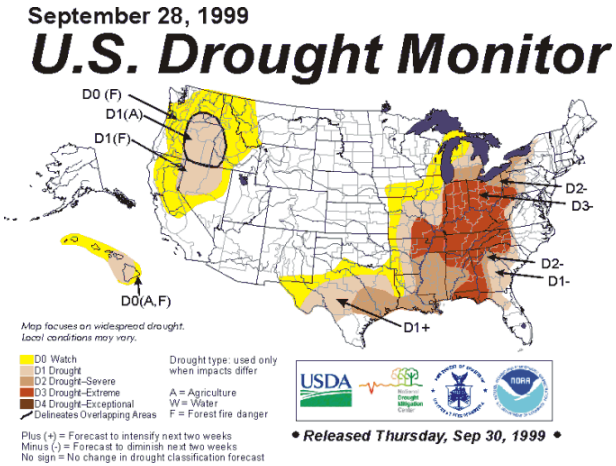
Water Year 2008-2009 Oct 01 Thru Dec 02

Departure from Normal Temperature (F)
10/1/2008 – 12/2/2008

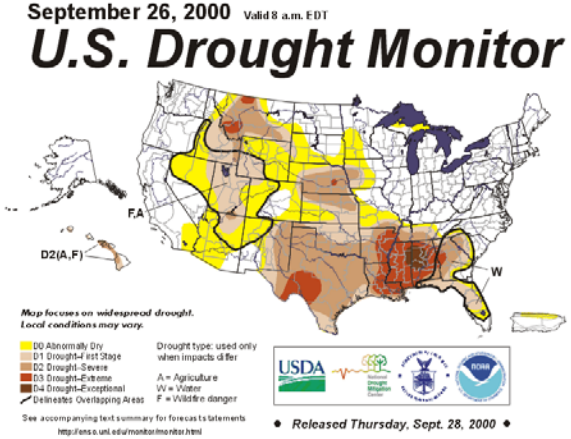


Generated 12/3/2008 at HPRCC using provisional data.

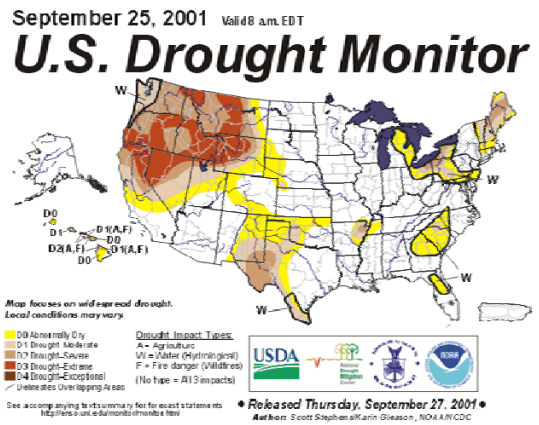
NOAA Regional Climate Centers



Sep 28, 1999



Sep 26, 2000



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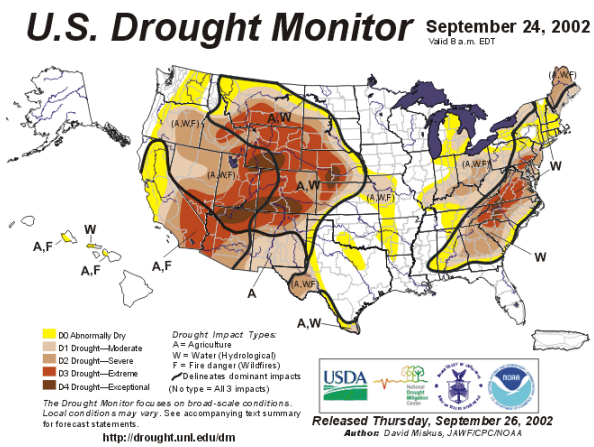

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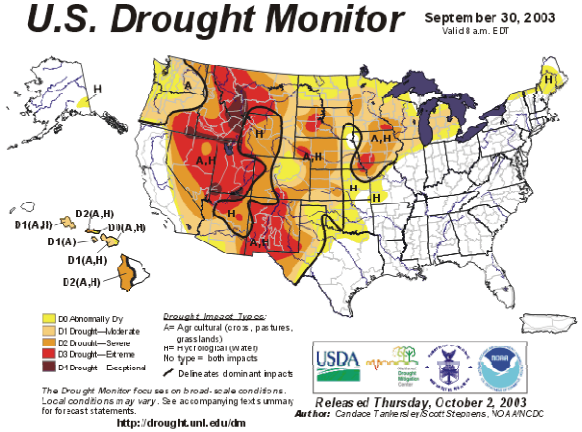
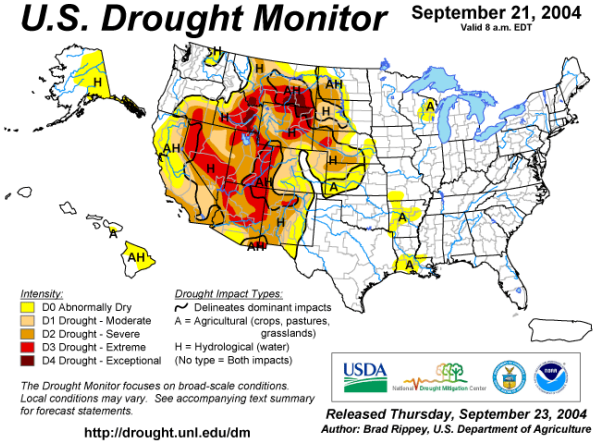


Sep 30, 2003



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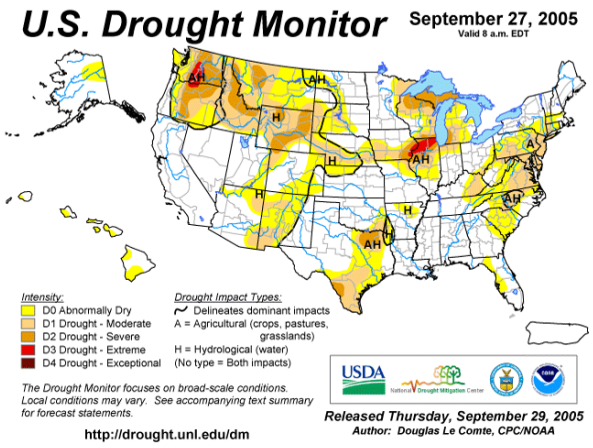
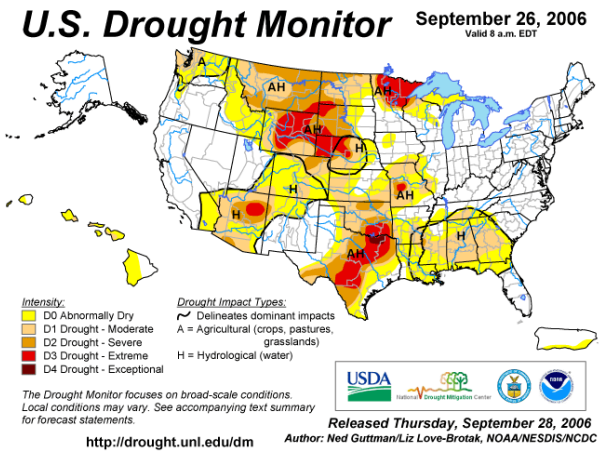
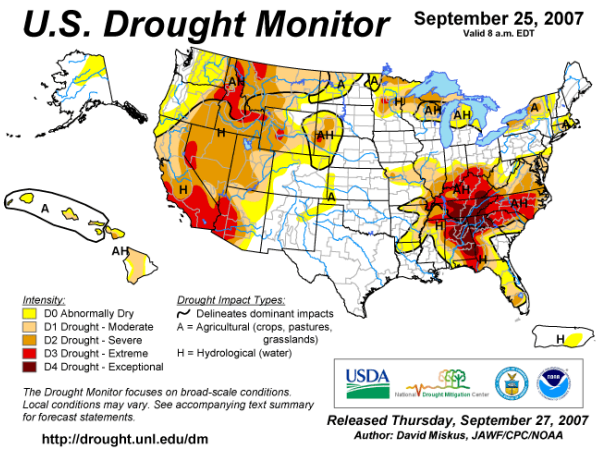


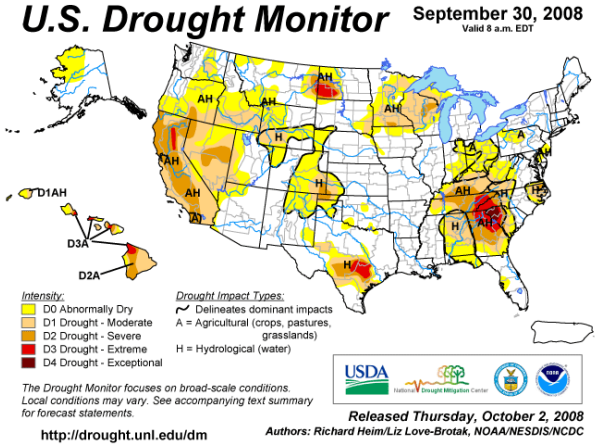
Sep 27, 2005



Sep 26, 2006



Sep 25, 2007



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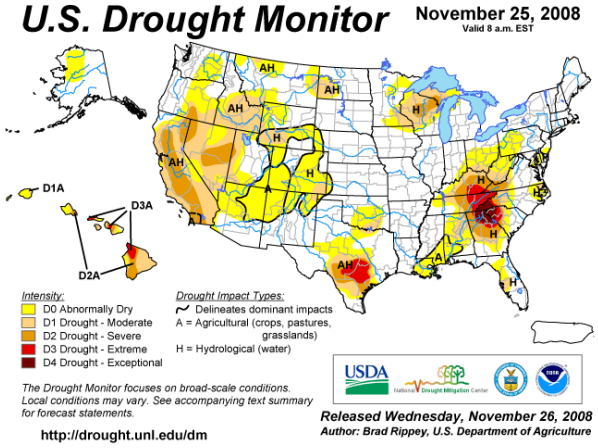
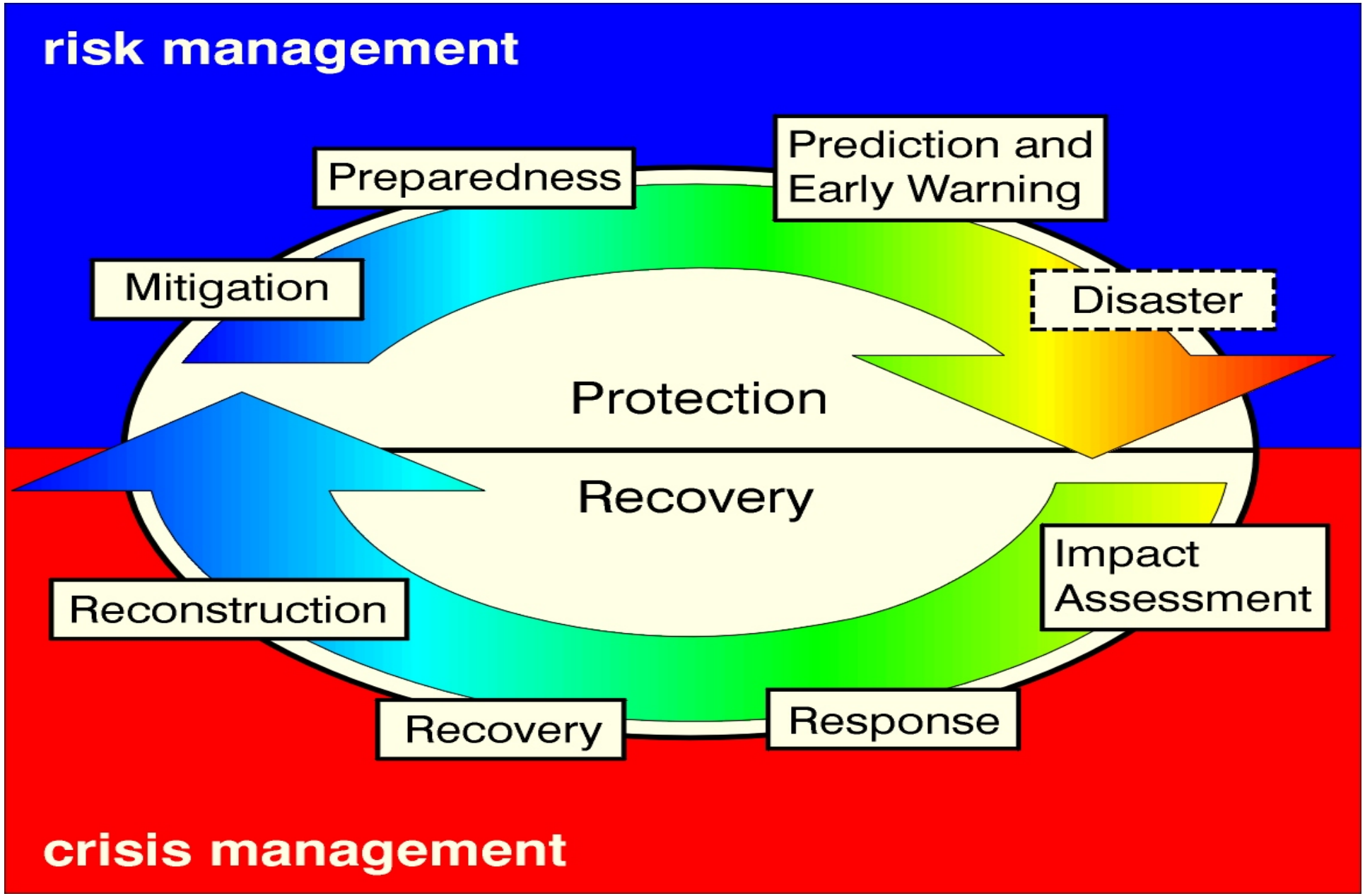
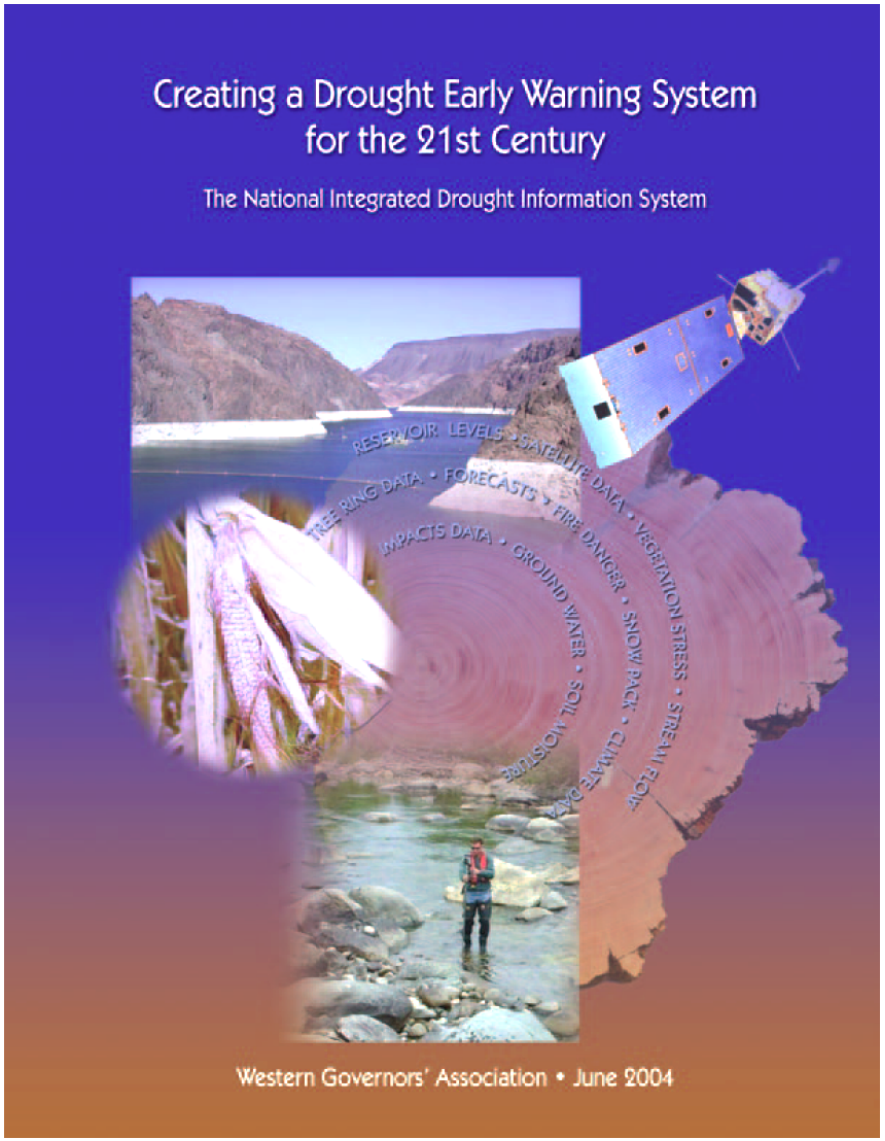


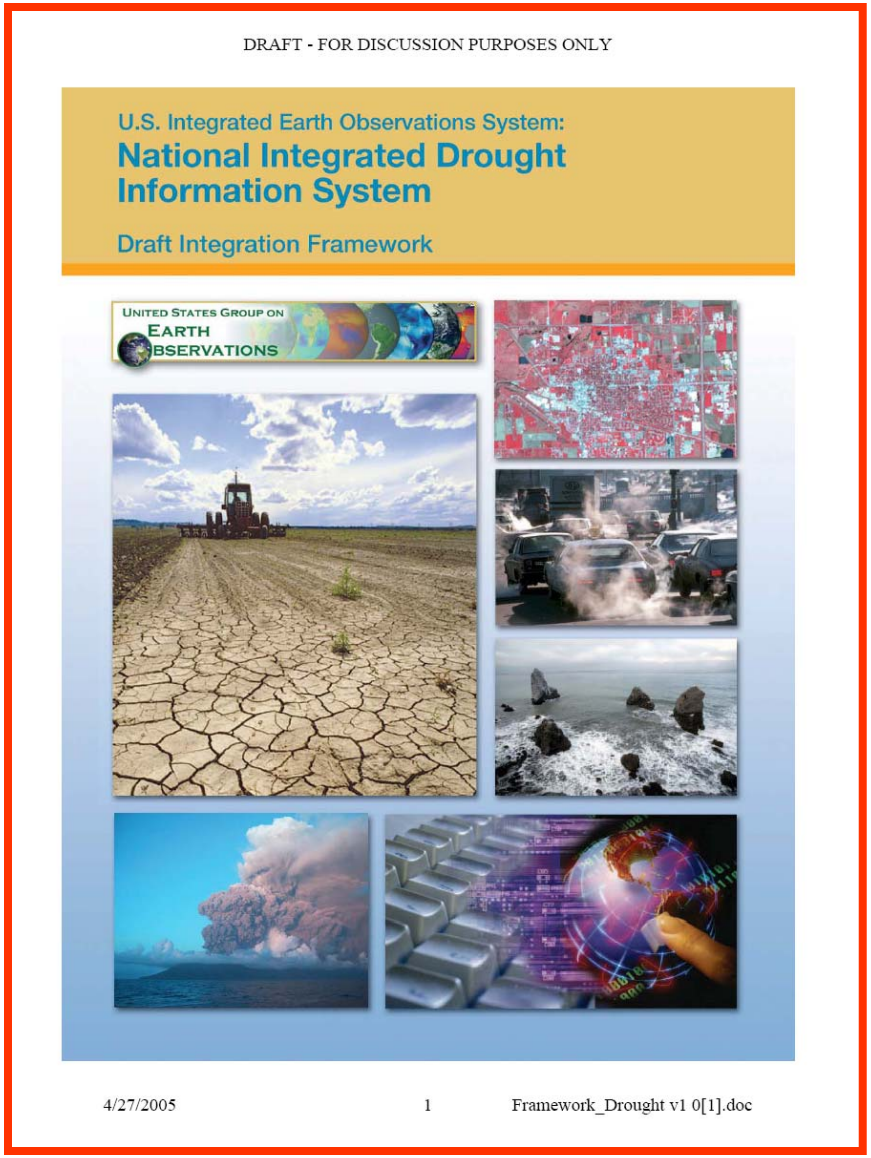
Nov 25, 2008

The Disaster Management Cycle: Getting off the Merry-Go-Round



Western Governors Association, 2004.





Ctsy Jim Verdin

NIDIS Vision and Goals

"A dynamic and accessible drought information system that provides users with the ability to determine the potential impacts of drought and the associated risks they bring, and the decision support tools needed to better prepare for and mitigate the effects of drought."

Public Law 109-430 (Signed by the President December 2006)

NIDIS Objectives

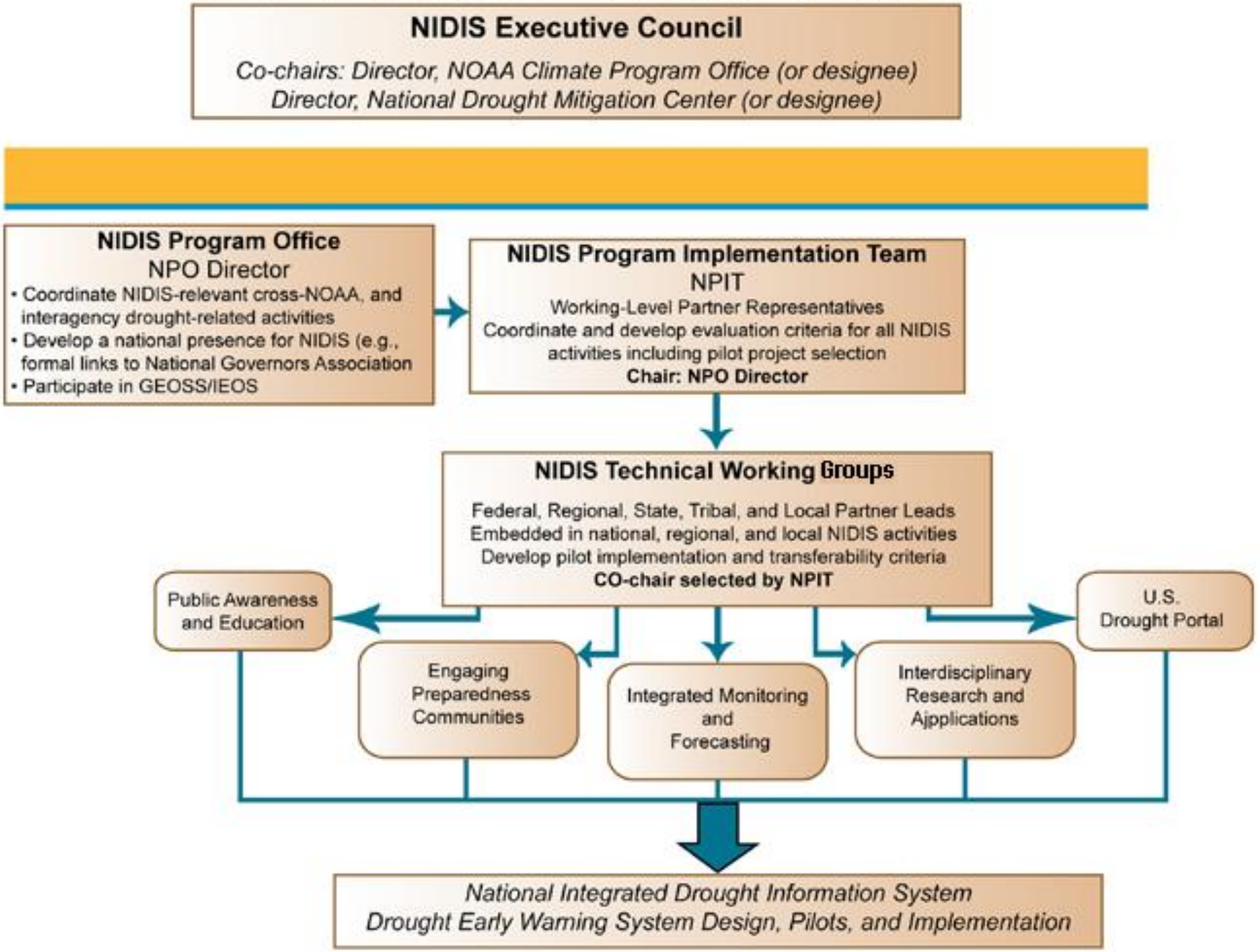
Creation of a drought early warning *information* system

- **Coordination of a national drought monitoring and forecasting system**
- **Development of an interactive drought information clearinghouse and delivery system for products and services—including an internet portal and standardized products (databases, forecasts, Geographic Information Systems (GIS), maps, etc)**
- **Design of mechanisms for improving information to support coordinated preparedness and planning**

Drought Early Warning System Components

- Monitoring and forecasting
- Risk assessment: Indicators and triggers
- Drought risk planning and preparedness
- Drought Portal
- Communication and Education

Governance Structure for NIDIS Implementation



NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM — DROUGHT.GOV

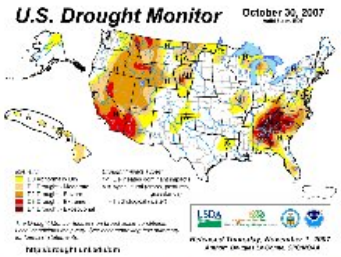
NIDIS

Home | Contact Us | Log In

Search: Everywhere

What is NIDIS? | Current Drought | Forecasting | Impacts | Planning | Education | Research

Current Drought



Where are Drought Conditions Now?

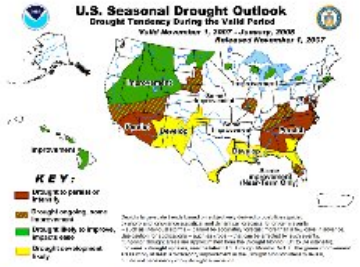
The U.S. Drought Monitor integrates many types of data into a single map each week. It shows drought's location and intensity. Drought trackers look at climate and water data, satellite imagery, and reported impacts. Local resource managers establish their own criteria for stages of drought.

Impacts

How is the Drought Affecting Me?

Drought affects agriculture, water supply and quality, energy, tourism, ecosystems, and communities. The Drought Impact Reporter compiles accounts from different sources such as media, Extension agents, the National Weather Service, and farmers and ranchers.

Forecast



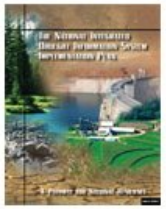
Will the Drought Continue?

Forecasting drought in the continental United States is still highly experimental. The U.S. Seasonal Drought Outlook is issued twice each month, looking three months ahead. The Drought Outlook identifies areas where forecasters expect drought to appear, continue, get better or get worse.

What's New

The U.S. Drought Portal was officially launched on November 1, 2007. It was created to provide comprehensive information on emerging and ongoing droughts, and to enhance the nation's drought preparedness. The Drought Portal is part of the National Integrated Drought Information System (NIDIS), which was recommended by the Western Governors Association in 2004 and enacted into law in 2006.

To learn more about NIDIS see the Overview page, or visit the 'What is NIDIS' section found in the menu above.



View Plan

The NIDIS Implementation Plan, published in June 2007, provides a detailed overview of the NIDIS initiative (pdf version).

We will continue to add content to this web site. Please visit us again to find more and updated information.

Recent Drought News

Executive Summary of The US Economic Impacts of Climate Change and the Costs of Inaction - *Center for Integrative Environmental Research (CIER) at the University of Maryland (October, 2007)*
(view report)

"Unnatural Hazards in the Fire Zone and Beyond" - *New York Times (October 27, 2007)*
(view article)

"Feds Form Drought Panel Amid Water Talks" - *Washington Post (October 26, 2007)*
(view article)

More Drought News...

USA.gov

The US Drought Portal

drought.gov

==========

NIDIS Program Office

Director

Roger Pulwarty, NOAA

Deputy Director

Jim Verdin, USGS

Research Meteorologist

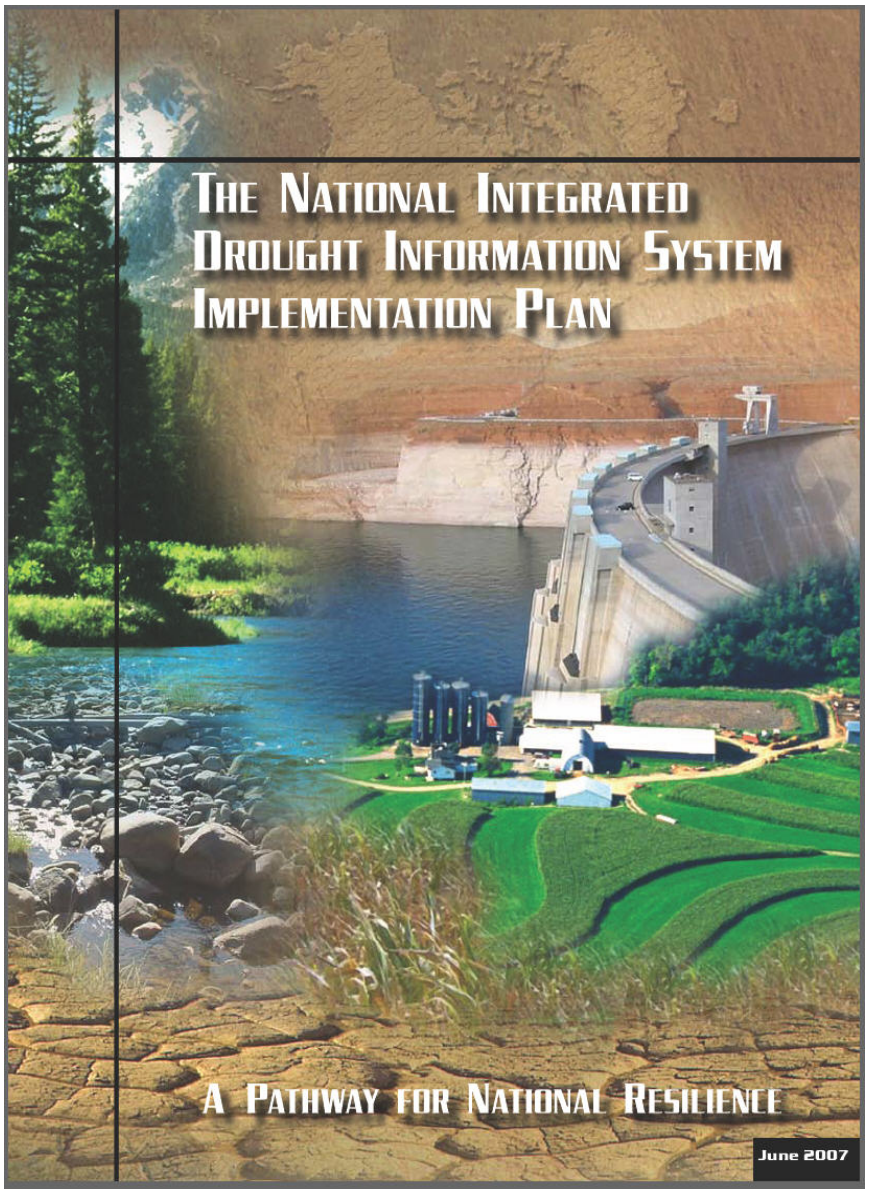
Lisa Darby, NOAA

NIDIS Implementation Team Leads

Kelly Redmond, WRCC

Shaun McGrath, WGA

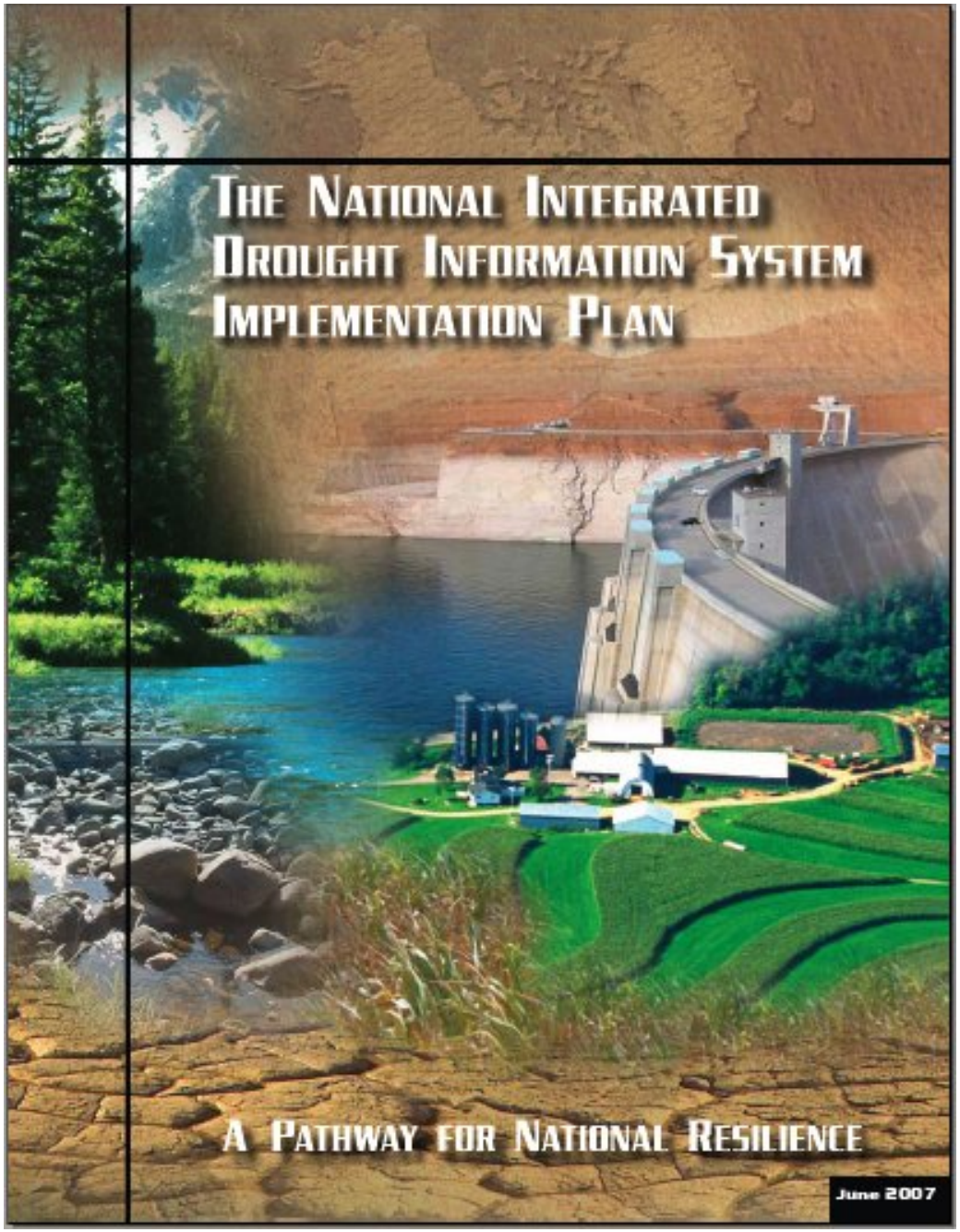
PL109-430 **www.drought.gov**



NIDIS Pgm Implementation Team affiliations:

- Western Governors Association
- NOAA
- USGS
- Dept. of Interior (BoR)
- U.S. Army Corps of Engineers
- USDA (NRCS, ARS, CSREES)
- NASA
- Indigenous Waters Network
- Regional Climate Centers
- National Drought Mitigation Center
- Association of State Climatologists
- Cornell University
- New Mexico State University
- Rutgers University
- South Dakota State University
- University of Oklahoma
- University of South Carolina
- University of Washington
- The Weather Channel

(more added recently)



Elements of NIDIS

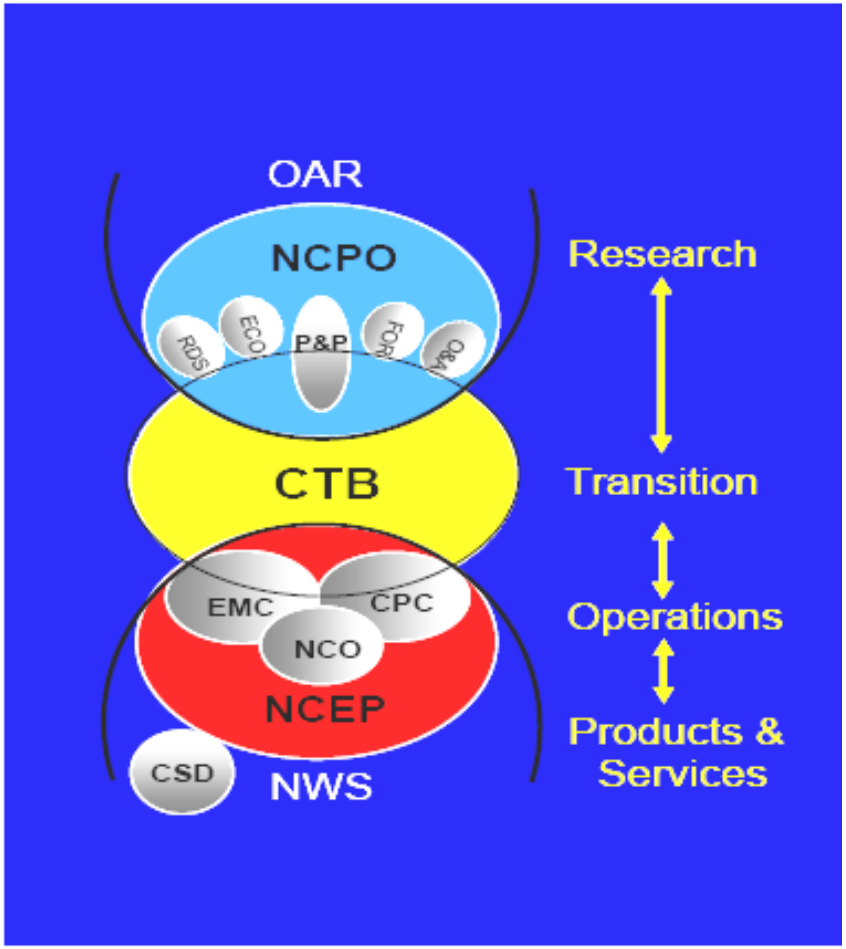
- **US Drought Portal**
- **NIDIS Pilot Projects**
  - Upper Colorado River Basin (first one)
  - Upper Missouri Basin (soon)
  - Lower Missouri River / MO / OK
  - Southeast (soon, maybe next?)
  - Chesapeake
- **Climate Test Bed Projects**
- **Coping With Drought Projects**
- **Knowledge Assessment Workshops**
- **Work Groups**
  - Education and Public Awareness
  - Engaging Preparedness Communities
  - Integrating Monitoring & Forecasting
  - Interdisciplinary Research/Applications
  - The US Drought Portal

Drought Portal Home Page www.drought.gov

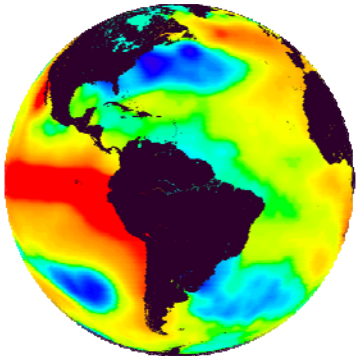
NIDIS Knowledge and Service Assessment Workshops

- **“Reconciling Projections of Future Colorado River Stream Flow”, Sept 2007/November 2008**
- **“Remote Sensing Contributions to Drought Monitoring”, February 6-7, 2008, Boulder**
- **“NIDIS Southeast Drought Workshop” – April 29-30, 2008, Peachtree City, Georgia**
- **“National Status of of Drought Early Warning Systems”, June 17-19, 2008, Kansas City**

NOAA Climate Test Bed



Accelerating the transition from research into improved climate forecasts, products, and applications (including drought early warning)



Global Climatic-Drought Contributors: A continuum

— SCALES OF DROUGHT —

Heat Waves

Storm Track Variations

Madden-Julian Oscillation

El Niño-Southern Oscillation

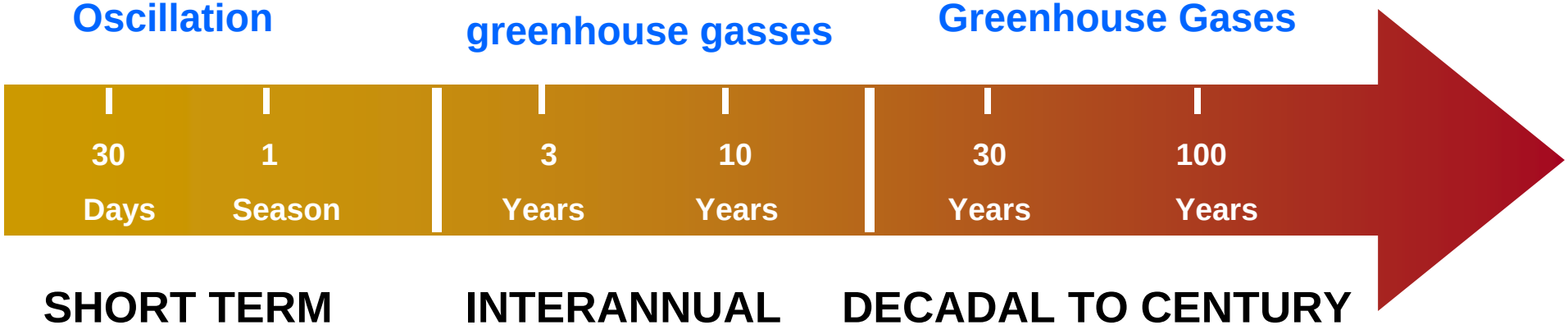
Aerosols and some greenhouse gasses

Decadal Variability

Solar Variability

Deep Ocean Circulation

Greenhouse Gases



Droughts span a wide range of time scales.

“Early” Warning varies according to time scale.

Managing Western Water as Climate Changes

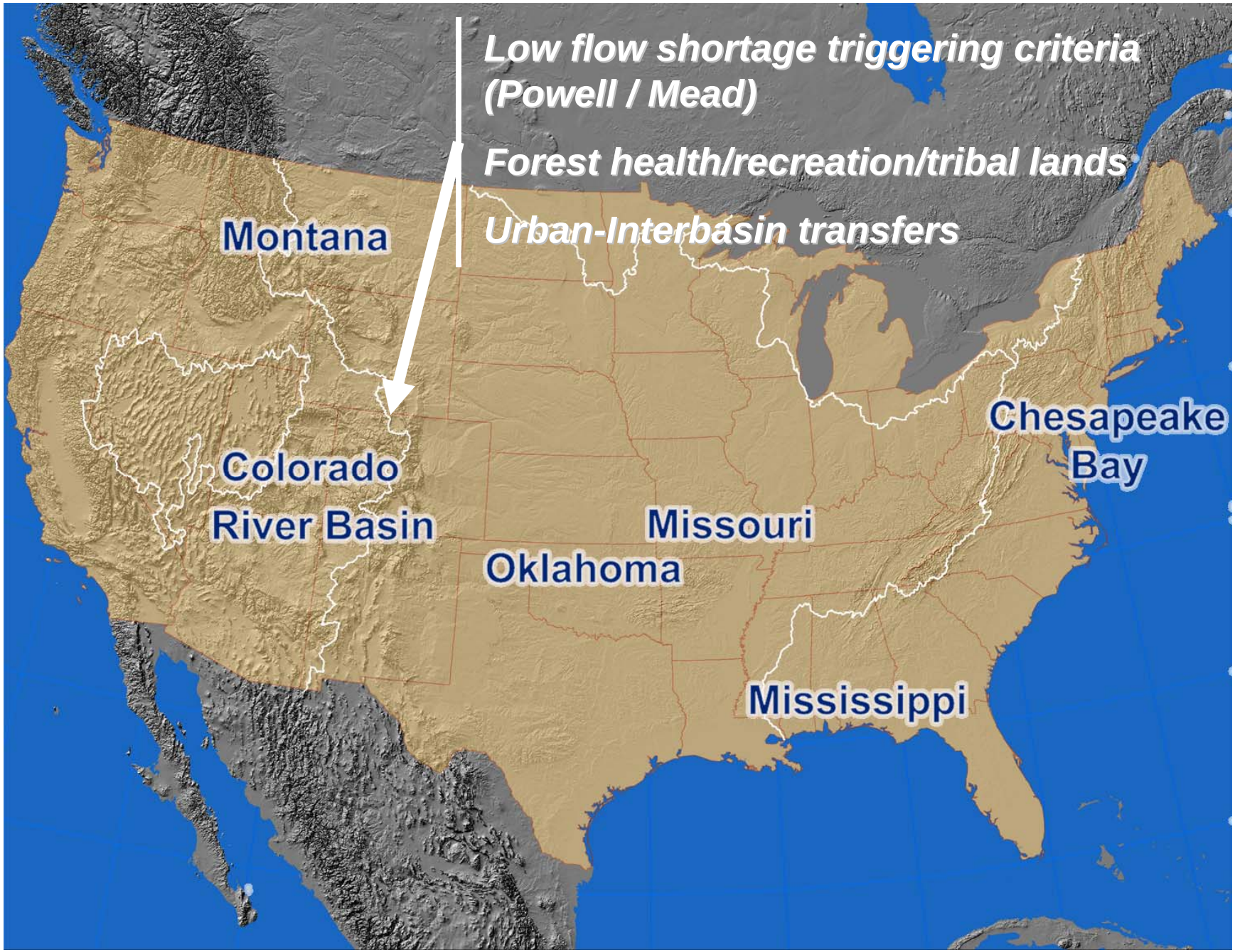
- **The combination of the inherent uncertainty of natural variability, plus projections for a warmer climate in the 21st century, make *early warning* and *adaptation* more important than ever**

- **NIDIS offers a framework for integration and mainstreaming of vulnerability and hazard information to support adaptation strategies**

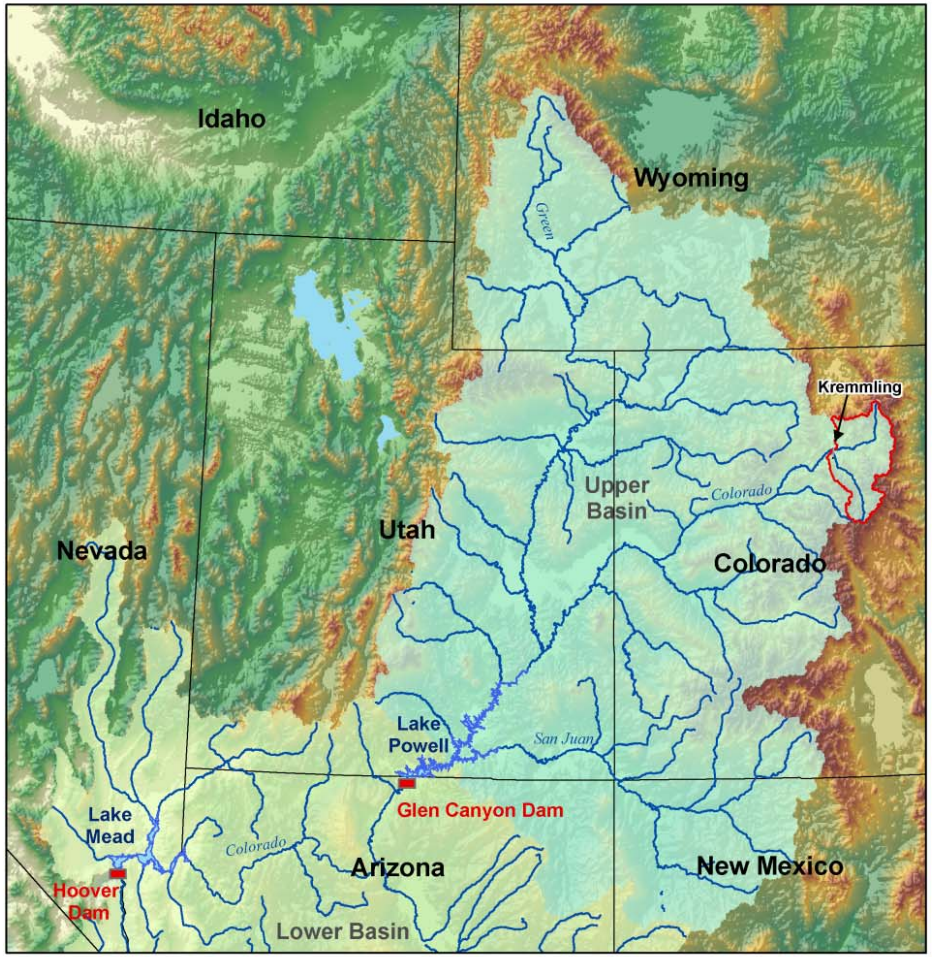
- **Risk management for variability and climate change not appreciably different**

- **NIDIS is viewed as a prototype for a *National Climate Service***

NIDIS Pilots



NIDIS Colorado River Pilot Study

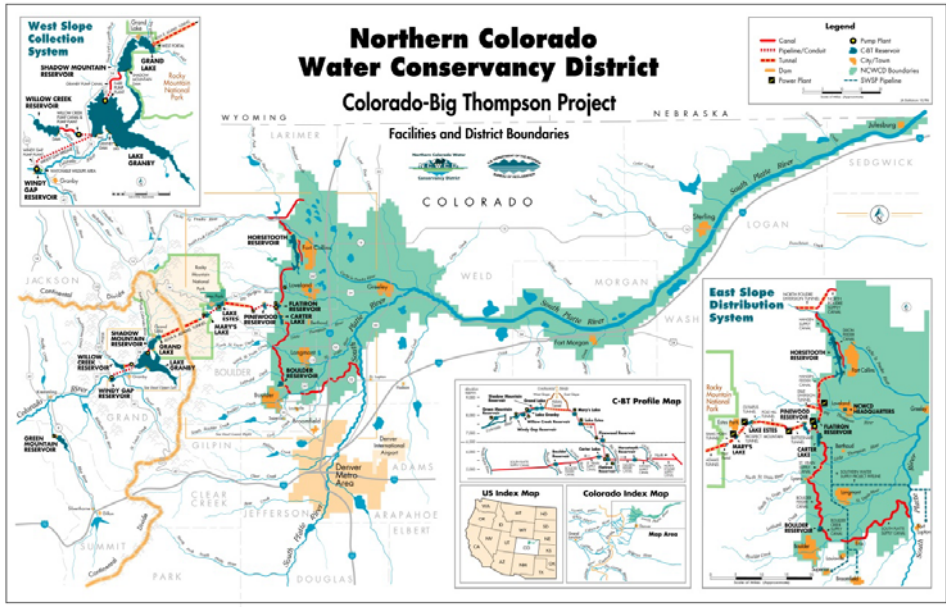


NIDIS
NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

States
Dams
Streams
Reservoirs
Upper Basin
Lower Basin

Elevation
High
Low

0 25 50 100 150 200 Miles



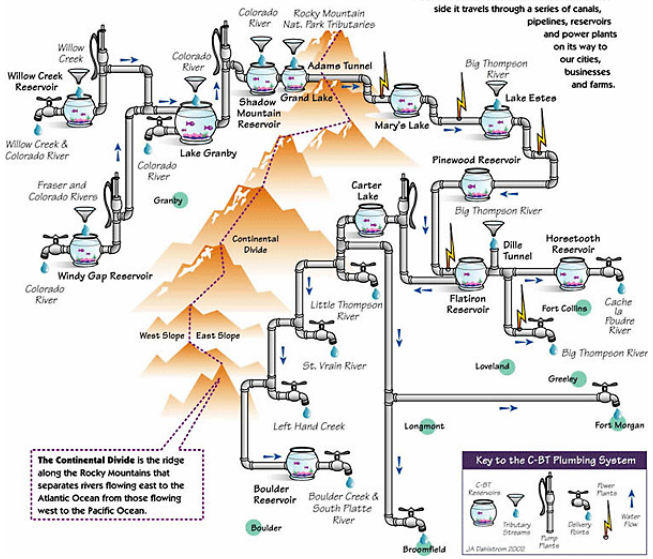
THE COLORADO-BIG THOMPSON PROJECT

Source of Water

We live in a pretty dry region here in northeastern Colorado. The area receives approximately 14 inches of precipitation each year. This amount does not meet all our needs.

So what do we do? We bring water from the other side of the Continental Divide, where more than 80 percent of Colorado's rain and snow fall, through and around the beautiful Rocky Mountains to supplement what Mother Nature provides naturally. If we didn't this region would look far different and many of us would not be living here.

The Colorado-Big Thompson Project, or C-BT, was built over 50 years ago to help us water the thirsty plains of northeastern Colorado. The C-BT collects water from melting snows on the west side of the mountains, then pumps it uphill and through the 13-mile long Adams Tunnel and under Rocky Mountain National Park. Once the water reaches the east side it travels through a series of canals, pipelines, reservoirs and power plants on its way to our cities, businesses and farms.



Upper Colorado River (down to Lake Mead)
Pilot Meeting
Boulder, CO, October 1 & 2, 2008

Assessment study of gaps in monitoring, in process understanding, and in prediction

- **Gather and synthesize information from observation network operators, researchers, and forecasts/projection producers**

- **Identify unmet needs for drought early warning**

- **Provide the basis for initiatives to strengthen and enhance monitoring, understanding and prediction in support of drought early warning**

NIDIS Colorado River Pilot Project Scoping Meeting

Drought early warning client organizations convened from three categories:

- **Water managers from Reclamation and State governments of Utah, Wyoming, and Colorado**
- **Urban/local water supply managers (Denver, Aurora, Northern Colorado Water Conservancy District)**
- **Ecosystems/environmental/recreational resource managers (Forest Service, BLM, States, NPS, USGS/BRD, NGOs)**
- **State and Federal climate researchers**
- **Explore existing mandates, decision cycles, and organizational capacities to determine a team to implement the pilot**

NIDIS Colorado River Pilot Project Scoping Meeting

Four main topics emerged for near-term action:

- **Assessment of gaps in present monitoring and forecasting systems within the Basin**
- **Assimilation of existing drought-related indicators, triggers and trends into one accessible location**
- **Promoting interaction (existing websites, datasets) with the US Drought Portal to begin developing a Colorado Basin drought portal and information clearinghouse**
- **Begin efforts to develop an Upper Colorado basin-specific drought monitor (including interbasin transfer locations and ecosystem impacts)**

Questions of interest from Colorado Pilot Scoping Meeting

- Drought monitor-U.S. Seasonal Drought Outlook Basin specifics

- Insufficient number of high-elevation sites collecting weather and streamflow data

- Tie global indices and signals (e.g., PDO, AMO, ENSO) to regional drought signals

- How often are droughts on the west side of the divide “in-phase” with droughts on the east side?

- Northern Colorado Water Conservation District (NCWCD) has no explicit triggers or formulas related to quota allocation

- Potential fate of the UCRB snowpack in early March with respect to the degree that above-average temperatures and windy conditions in March and April might decrease the April-July forecasted runoff to Lake Powell

Transbasin Cross-Divide Issues

- **Assist in demand projections**
  - **Northern Water**
  - **Denver Water**
  - **Grand Valley**
- **Assist USFWS in setting target flows**
  - **Peak enhancement**
  - **Late summer flows in 15-Mile Reach**
- **Initiate drought mitigation discussions (e.g. Shoshone call reduction)**

(BoR Eastern CO Area office)

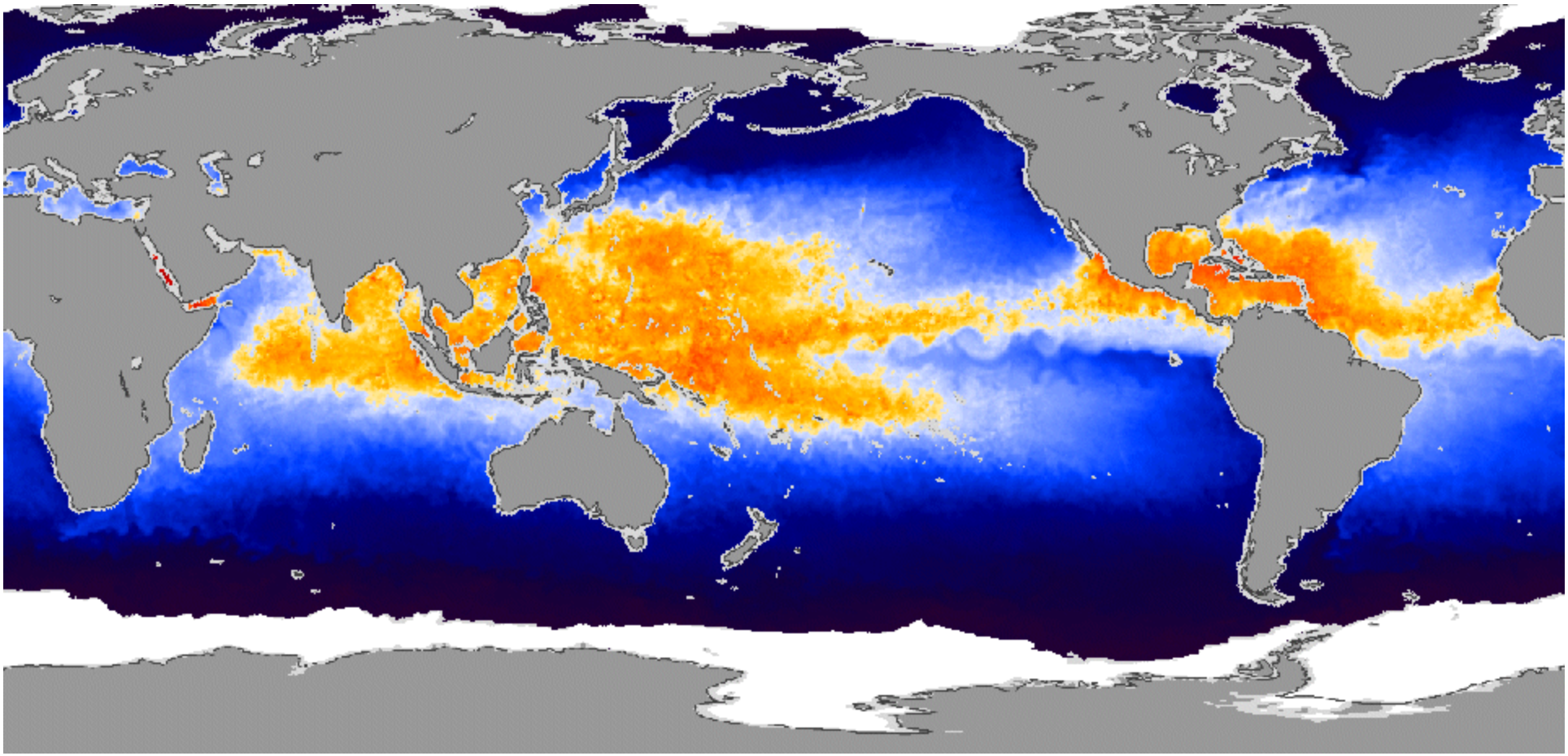
NIDIS Southwest Pilot Project Approximate Timeline

- **Year 1: Designing a Drought Early Warning Information System**
  - **What exists. Gap analysis monitoring and forecasting**
  - **Key players-Existing planning processes**
    - **What partnerships and actions are needed (to improve information development, coordination and flow)**

- **Year 2. Implementation of the Drought Early Warning System (across timescales from a season multi-year, longer term trends):**
  - **Improving coordination, feedback into "Colorado Basin" Drought Portal, ongoing briefings on impacts and projections across climate timescales**

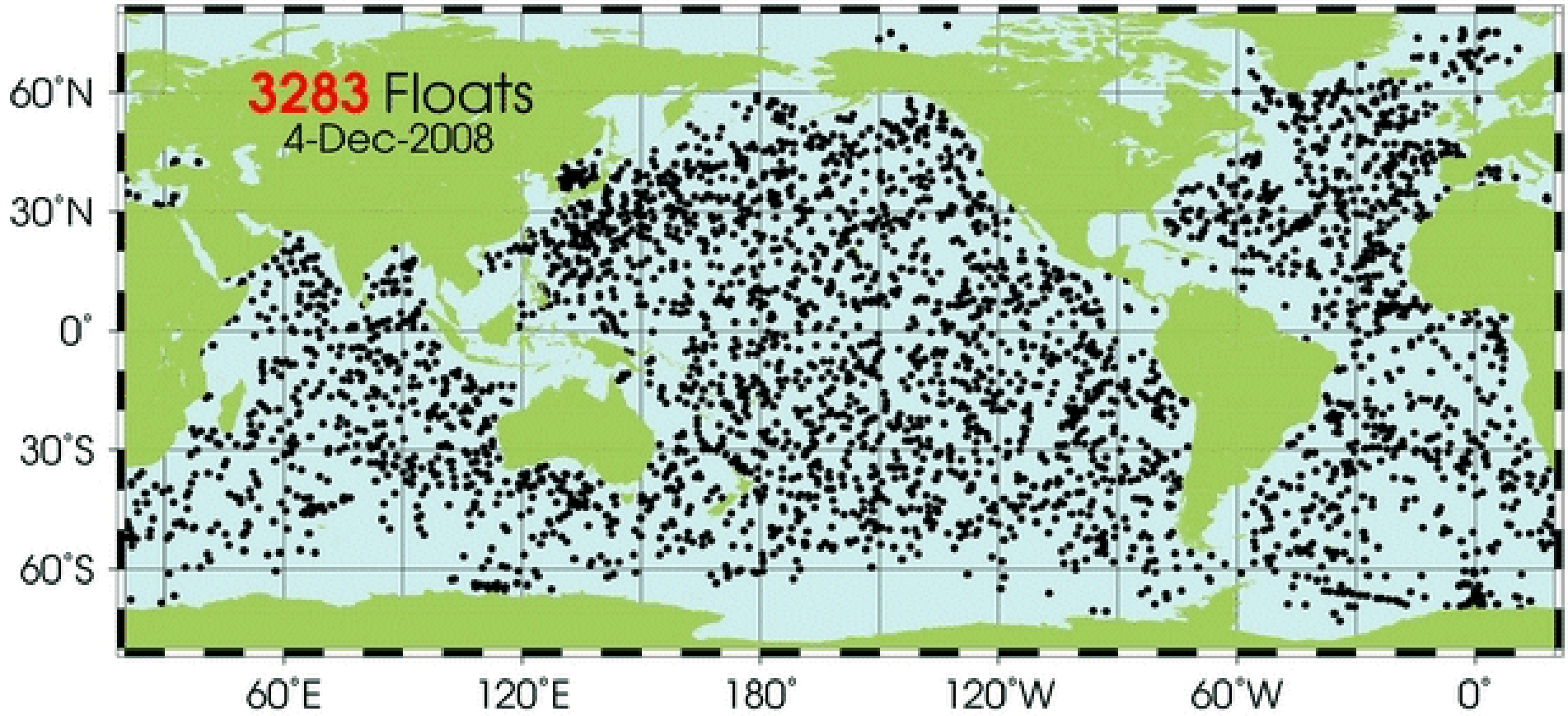
  - **Years 3 and beyond : Early Warning System transferability and support**

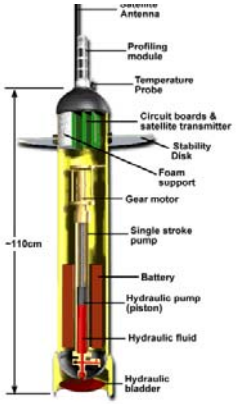
The World's Warm Oceans

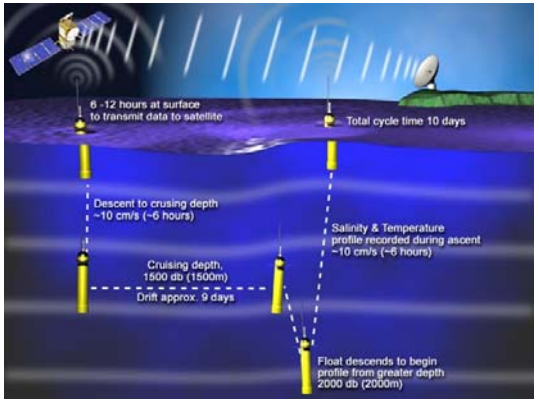


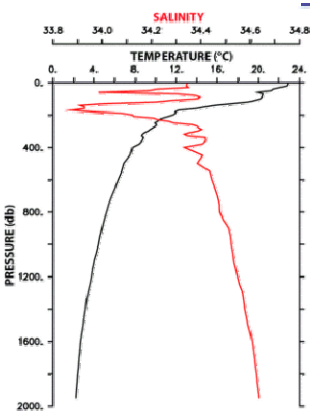
2007 November. 3000-th Argo float deployed.

Positions of the floats that have delivered data within the last 30 days (AIC, updated daily):

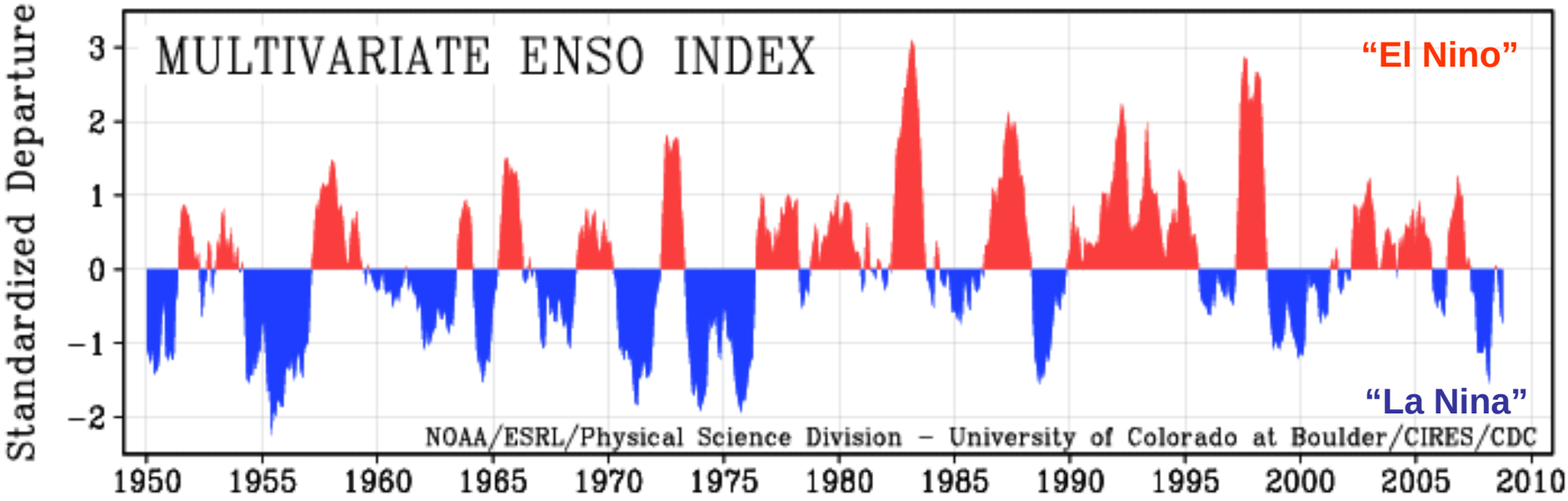






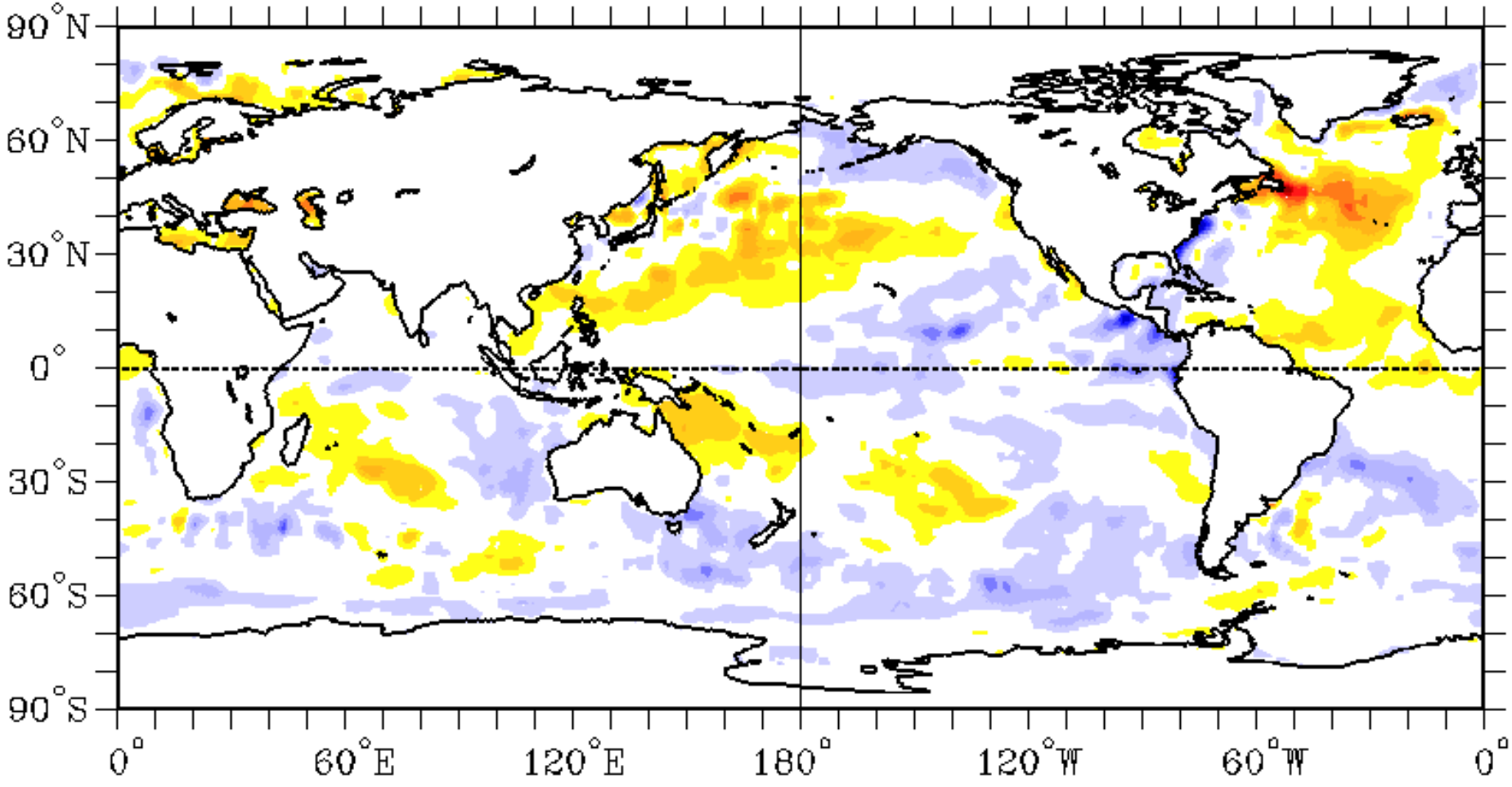


Through October 2008



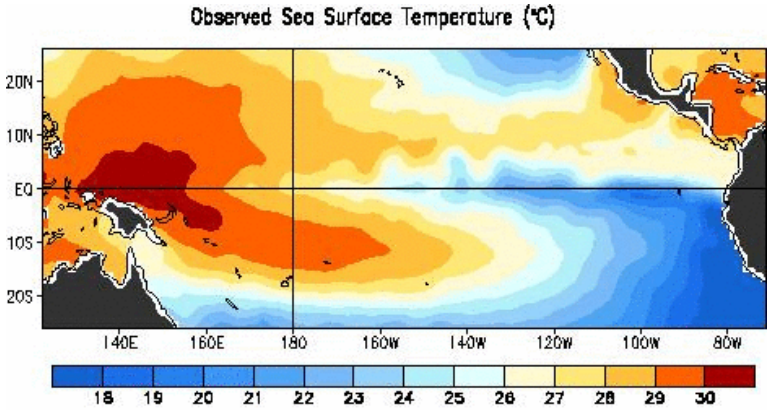
NOAA ESRL (“CDC”), Wolter and Timlin

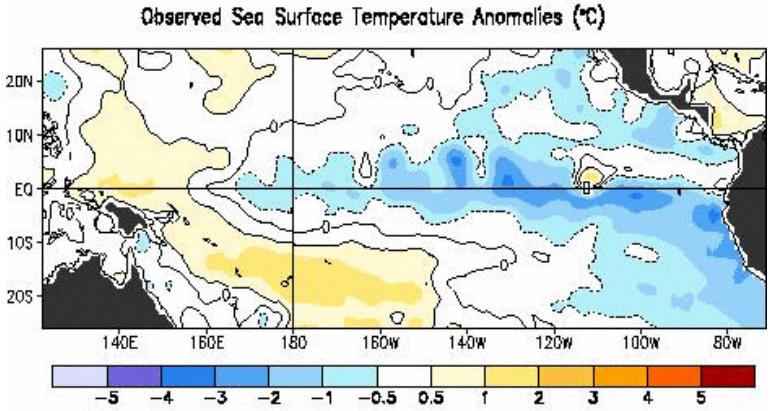
Global Sea Surface Temperature Anomalies (C) 2008 November 23-29

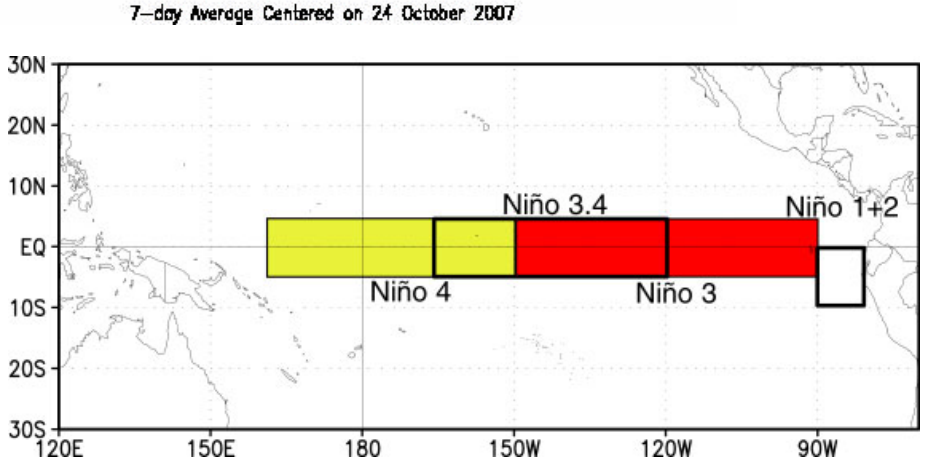


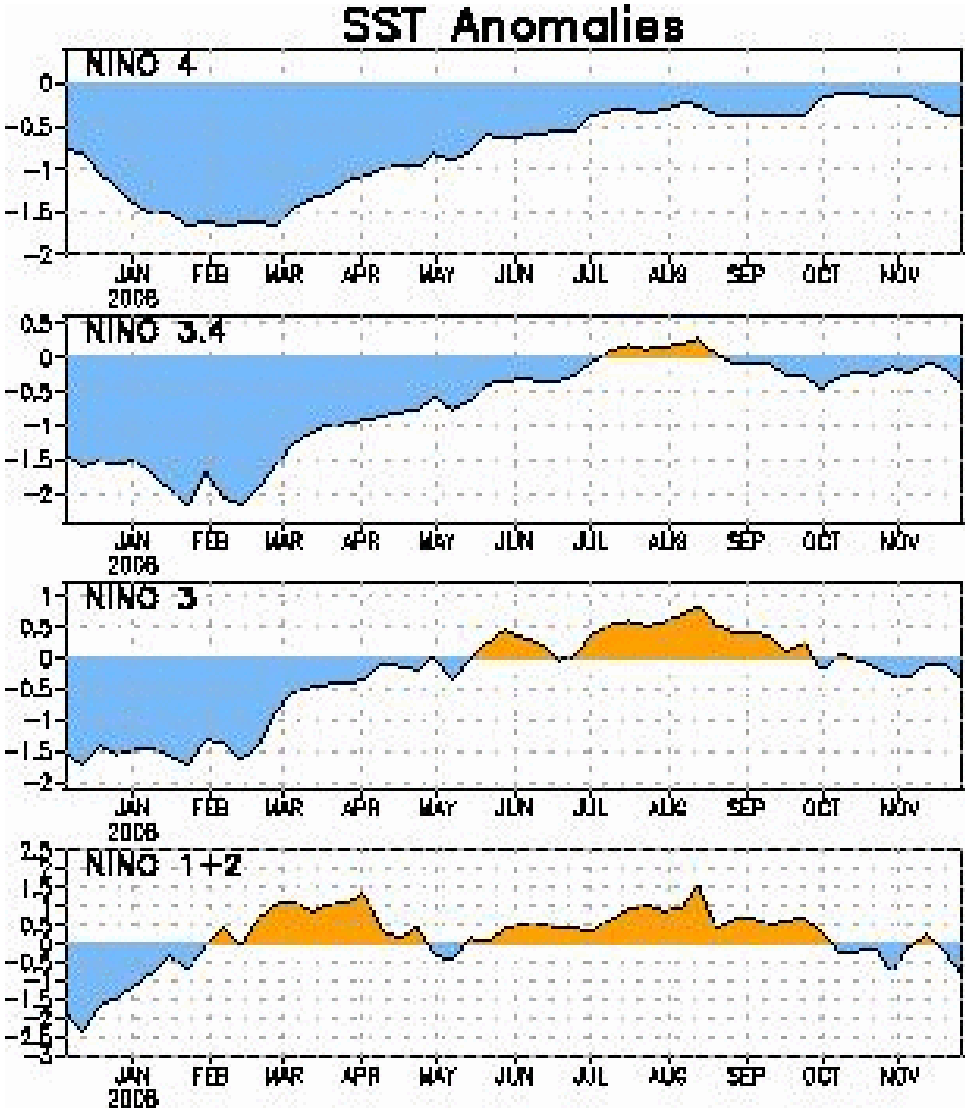
NOAA ESRL (“CDC”)

Recent Evolution of Equatorial Pacific SST Departures

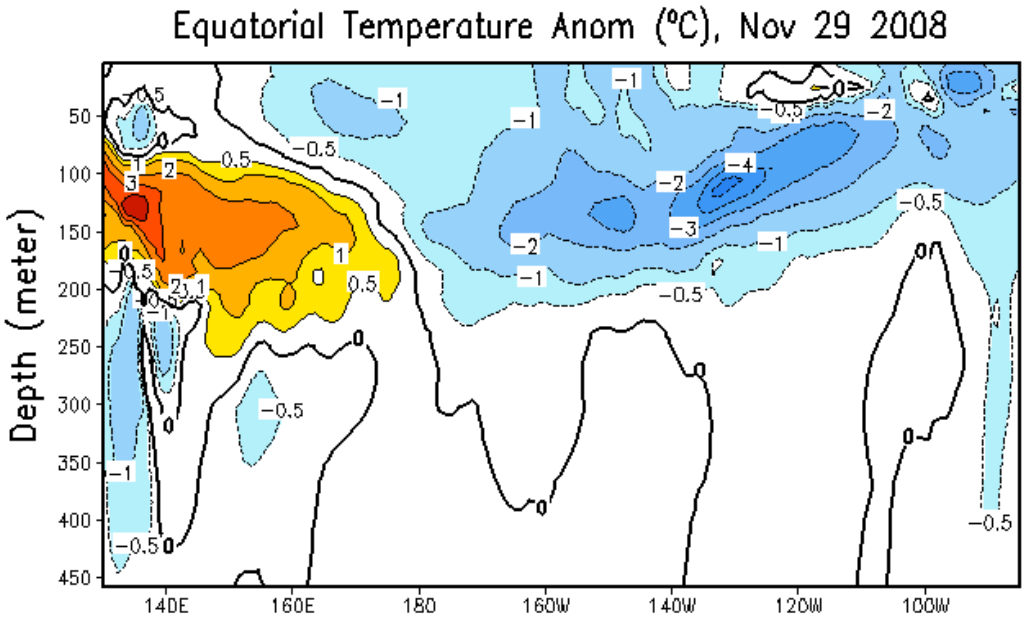


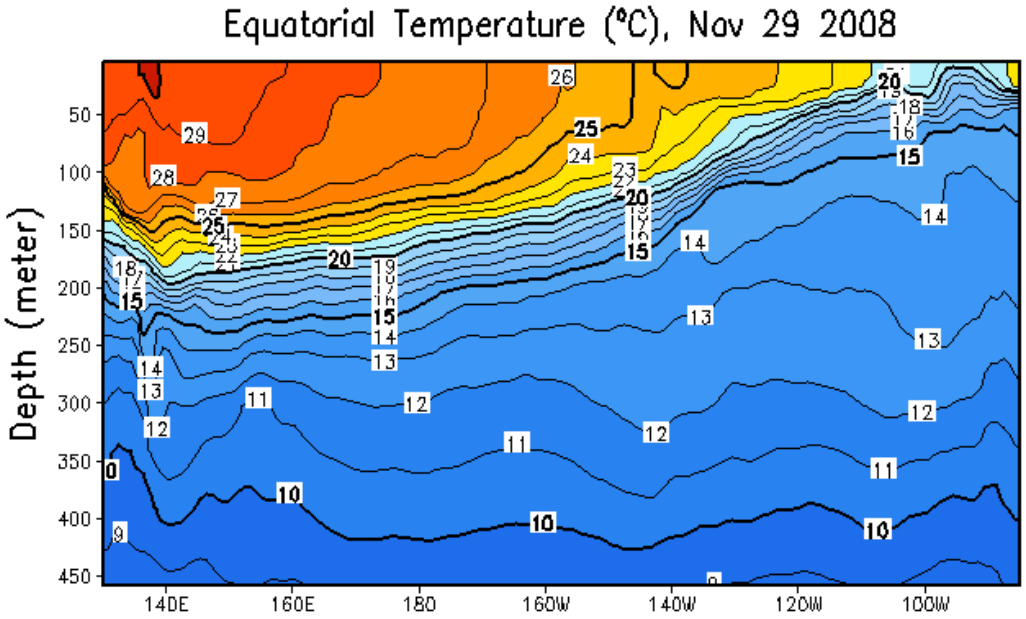






Updated through 2008 November 23-29





Pacific Ocean
South America to Indonesia
Surface to 450 m depth
Surface to 1500 ft depth

2008 November 29

Departure from
Average Temperature (C)

Temperature (C)

Correlation of Atmospheric Pressure with Southern Oscillation Index, Dec-Jan-Feb

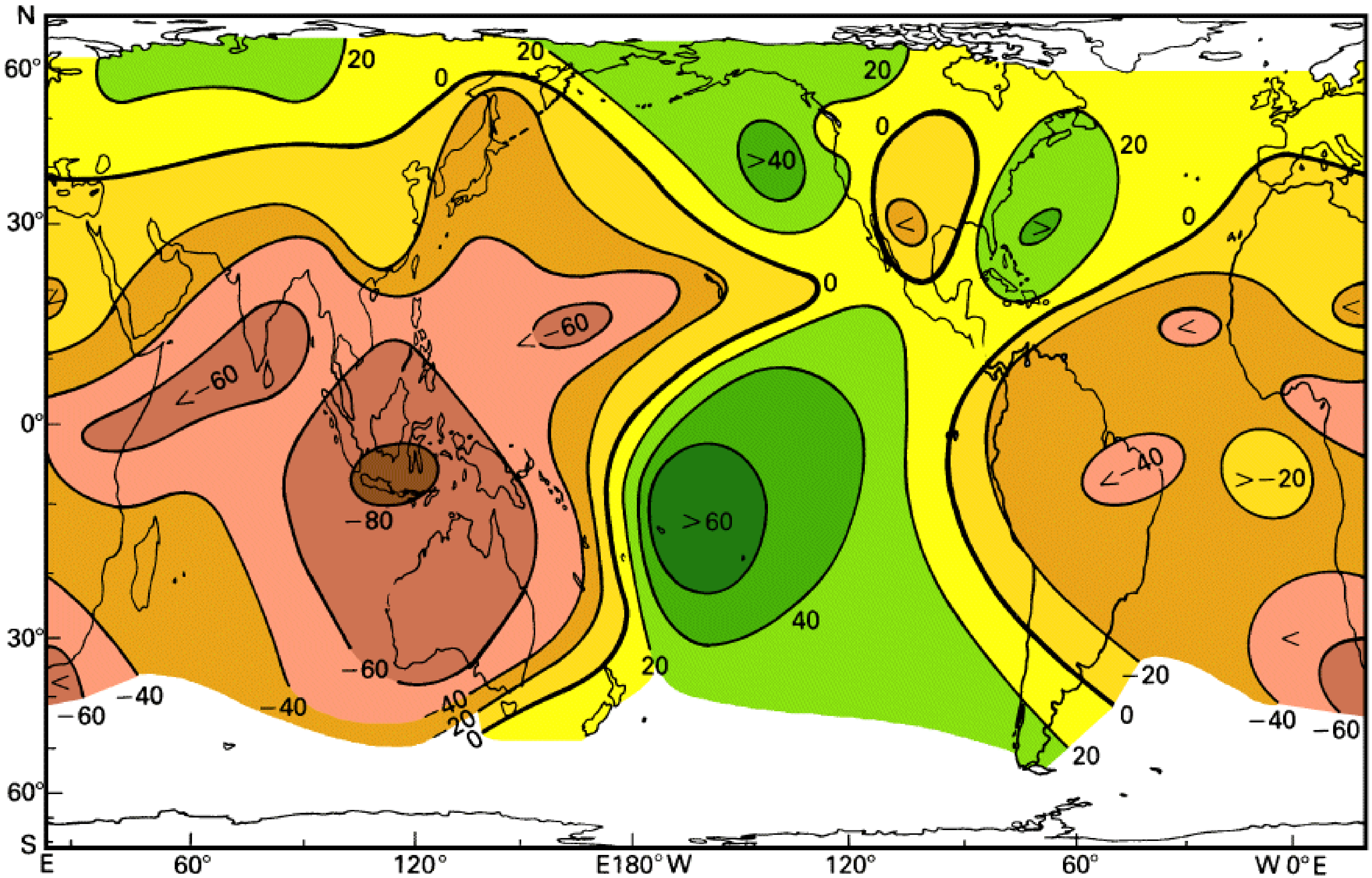


Fig 19.3 in Tomczak and Godfrey (2003), Regional Oceanography: An Introduction. After Wright (1977)

Correlation of Southern Oscillation Index and Sea Surface Temperature.
Dec-Jan-Feb. From merchant ships. Insufficient data in gray.

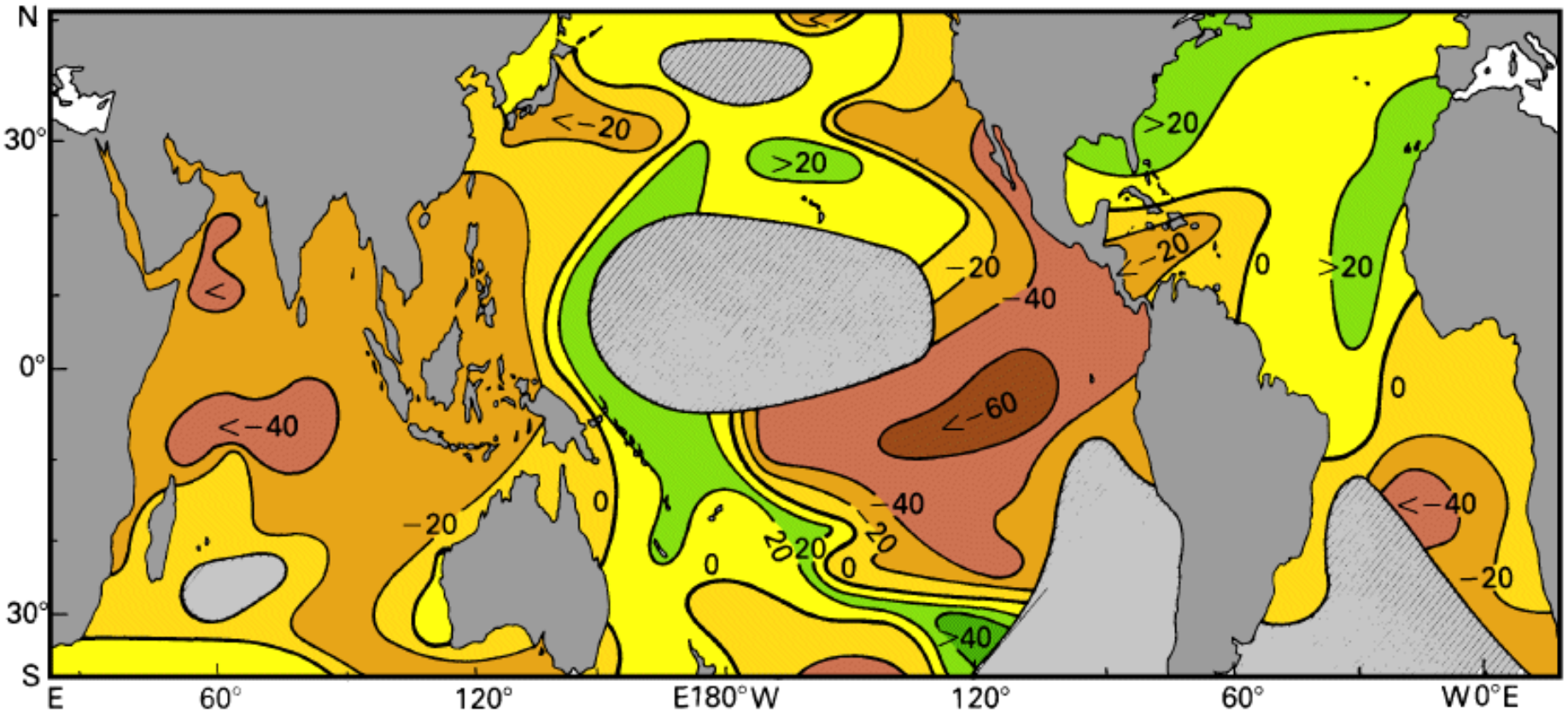
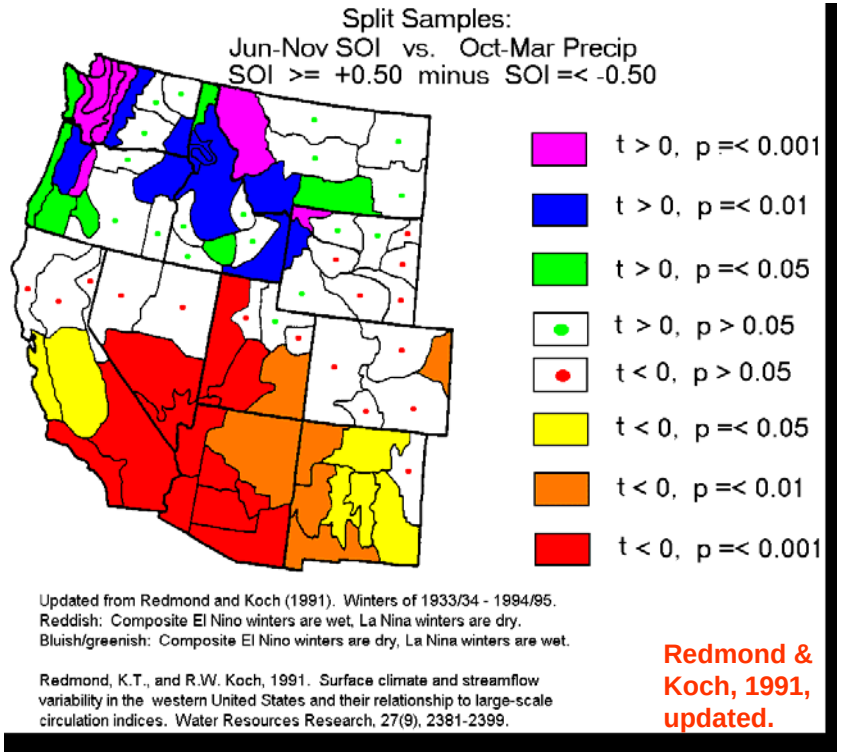
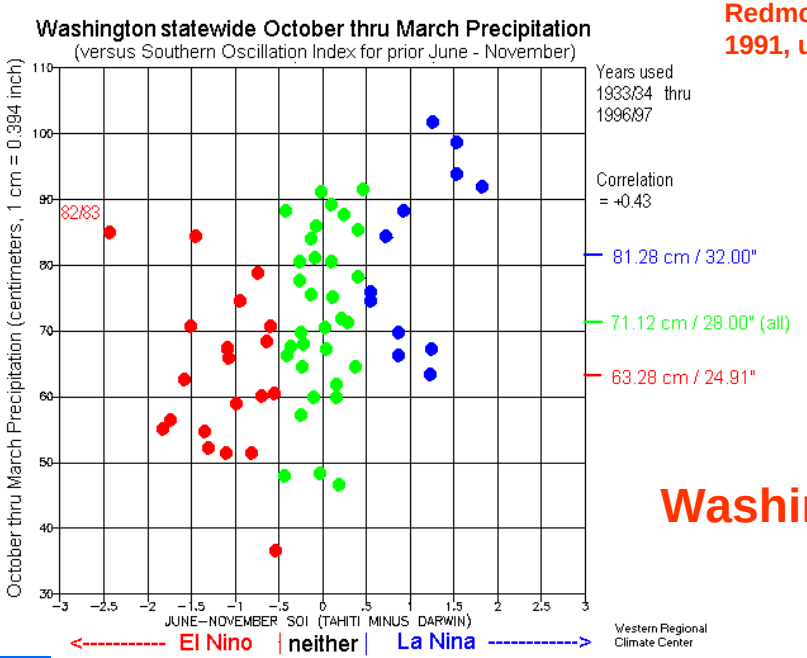


Fig 19.6 in Tomczak and Godfrey (2003), Regional Oceanography: An Introduction



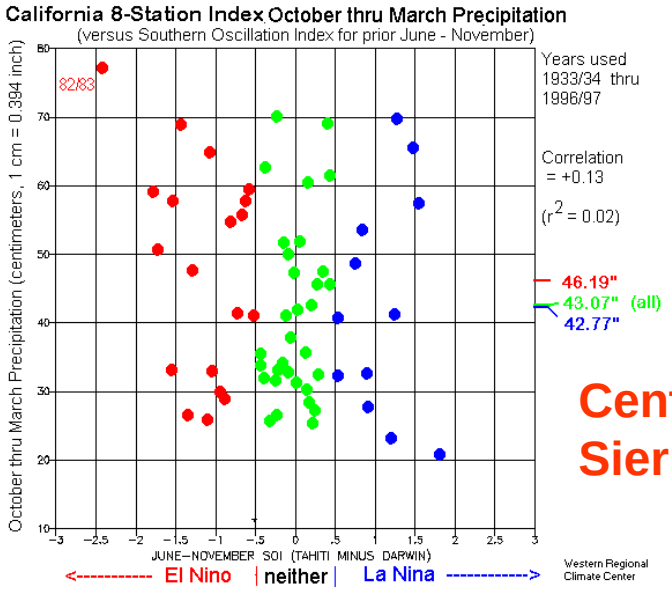
Redmond & Koch, 1991, updated.



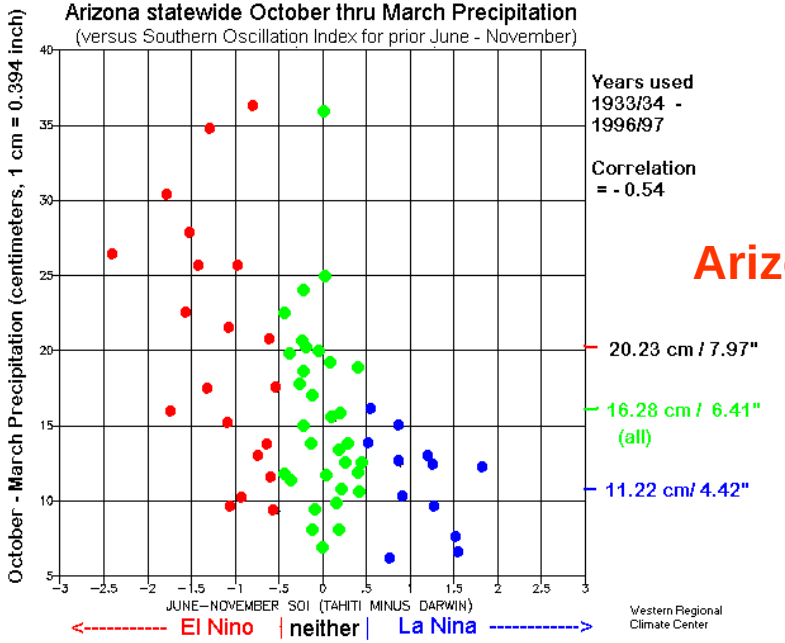
Redmond & Koch, 1991, updated.

Washington

ENSO



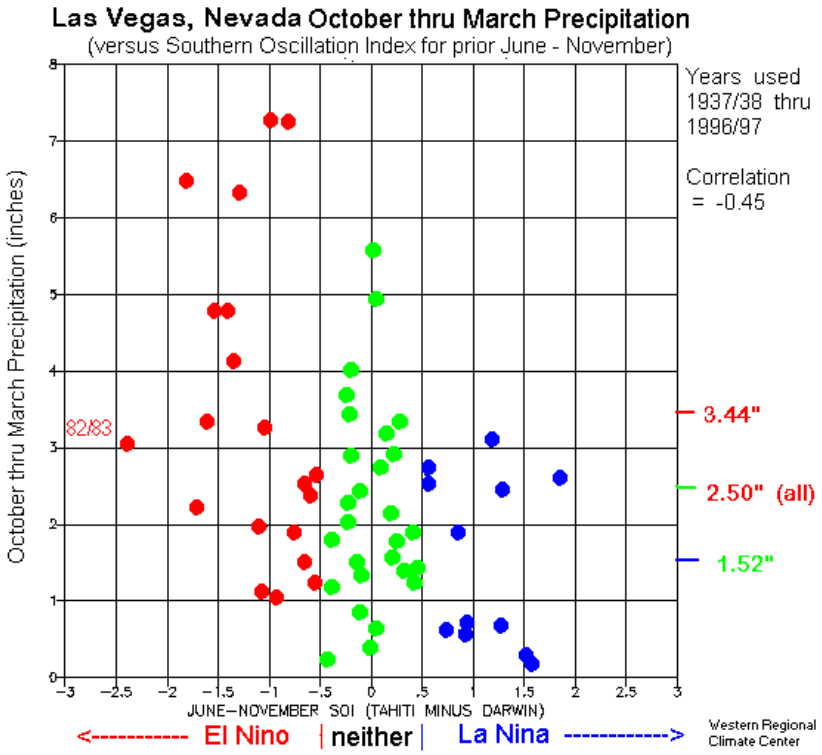
Central Sierra



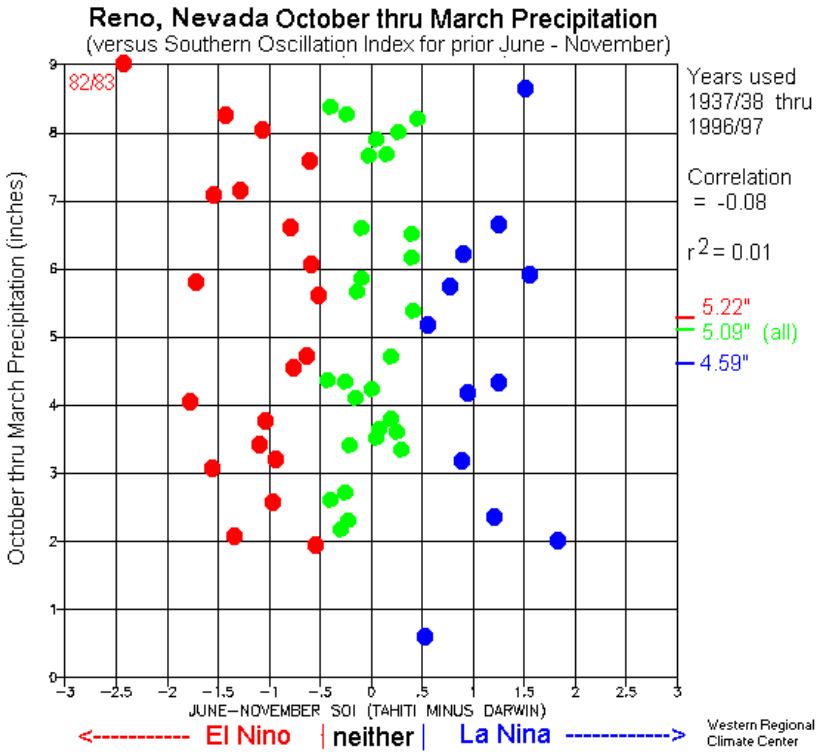
Arizona

Southern Oscillation Index (Jun-Nov) versus Subsequent October thru March Precipitation

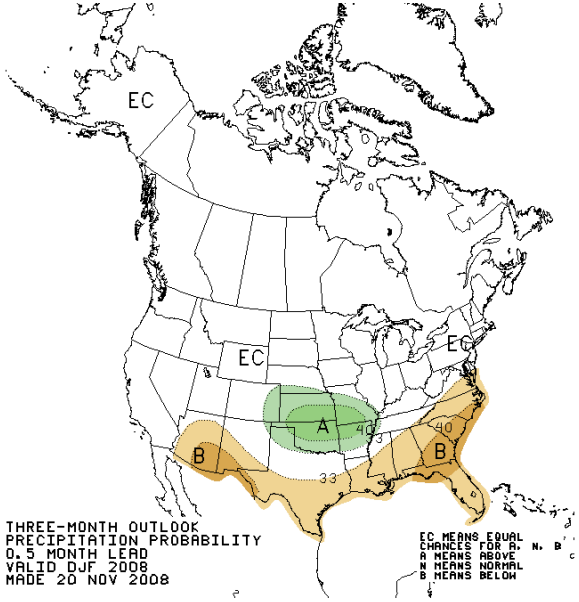
Las Vegas



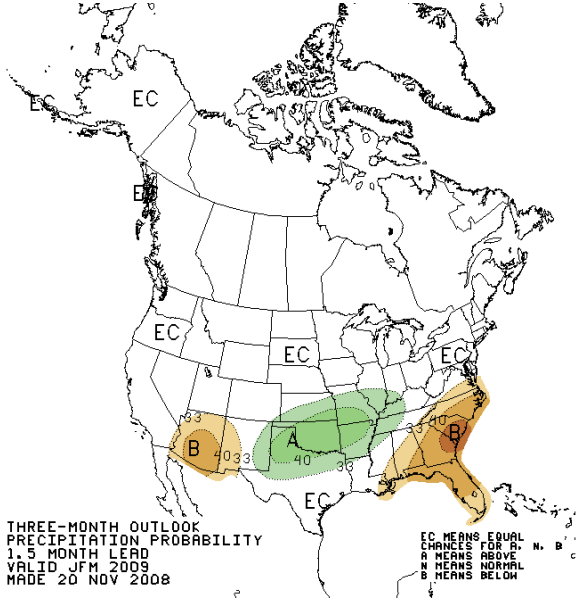
Reno



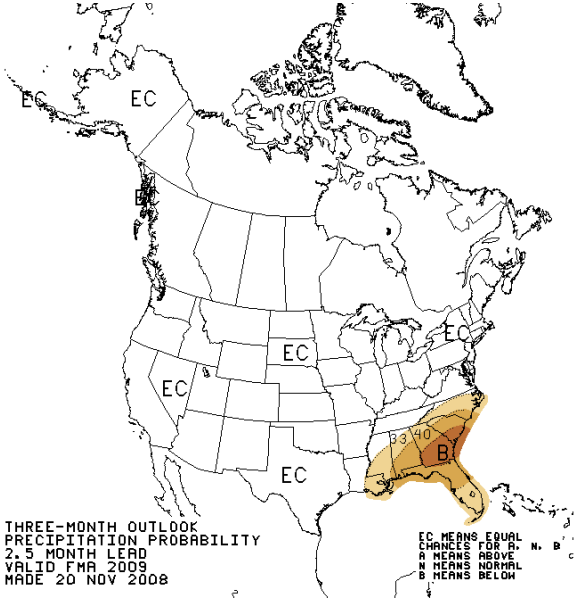
After Redmond and Koch, 1991.



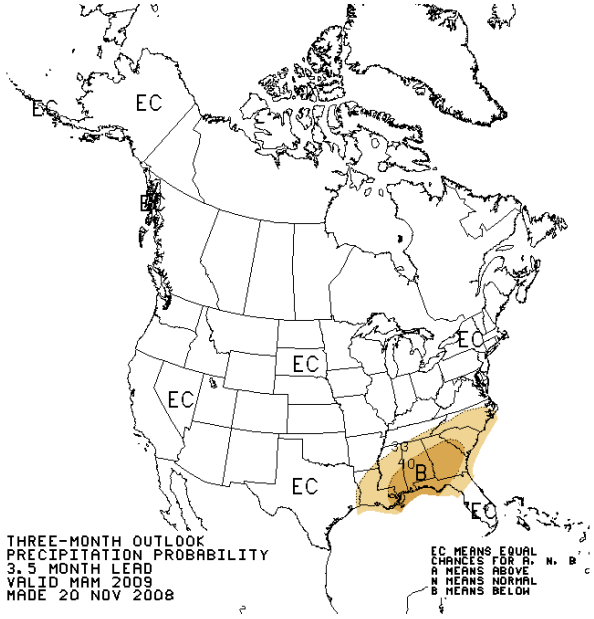
Dec-Jan-Feb



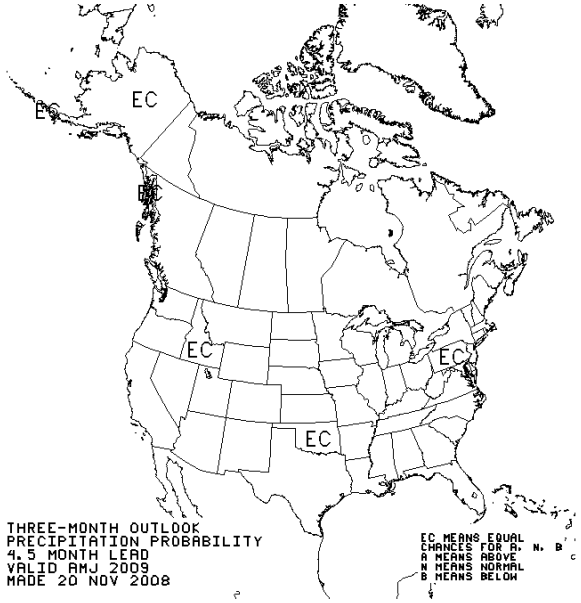
Jan-Feb-Mar



Feb-Mar-Apr



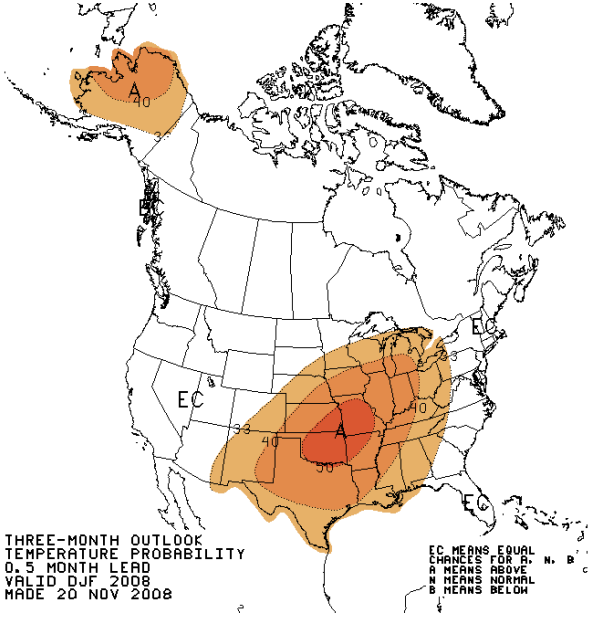
Mar-Apr-May



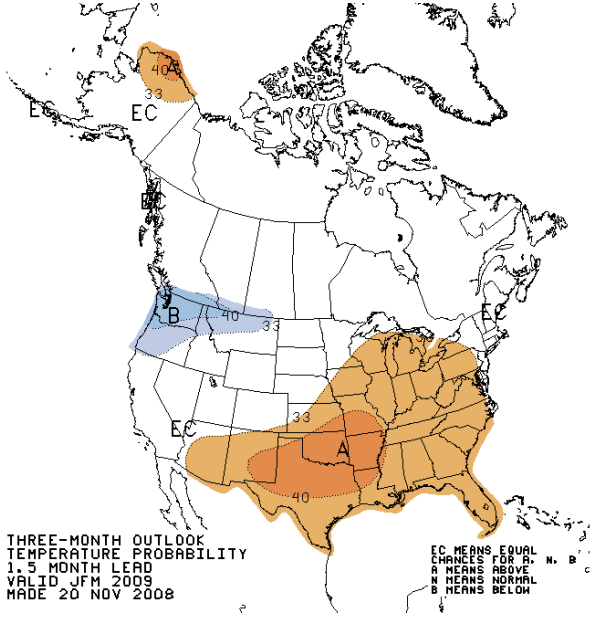
Apr-May-Jun

CPC Precipitation Outlooks

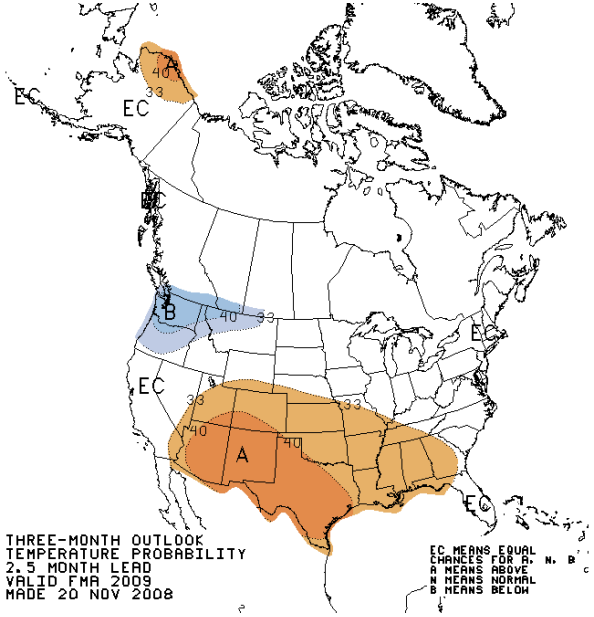
Winter 2008-2009



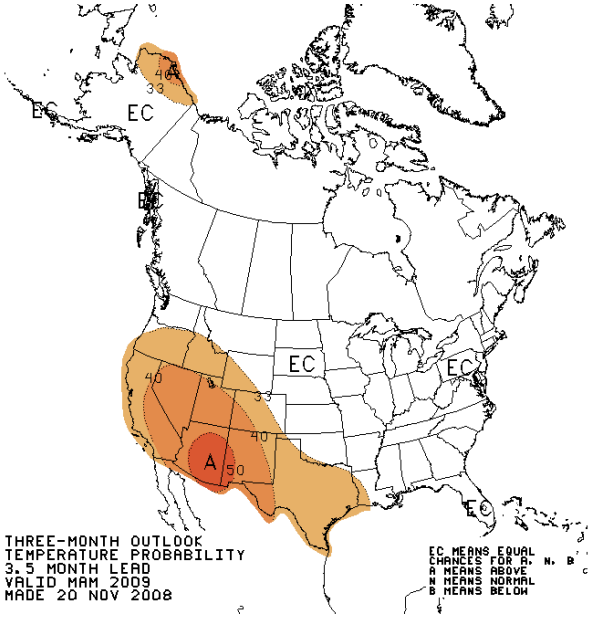
Dec-Jan-Feb



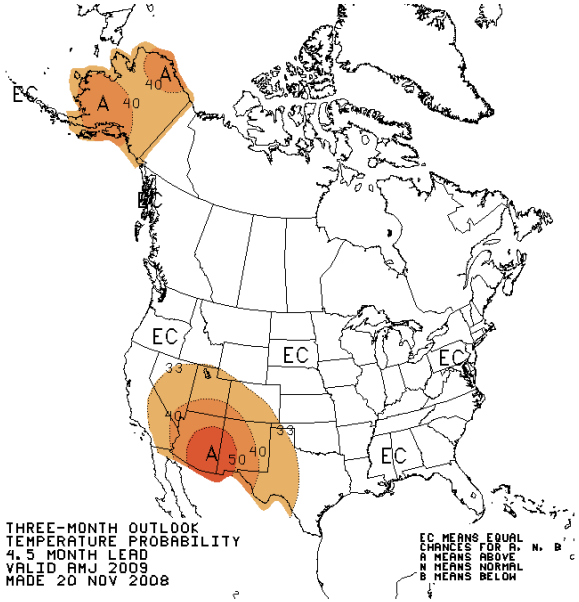
Jan-Feb-Mar



Feb-Mar-Apr



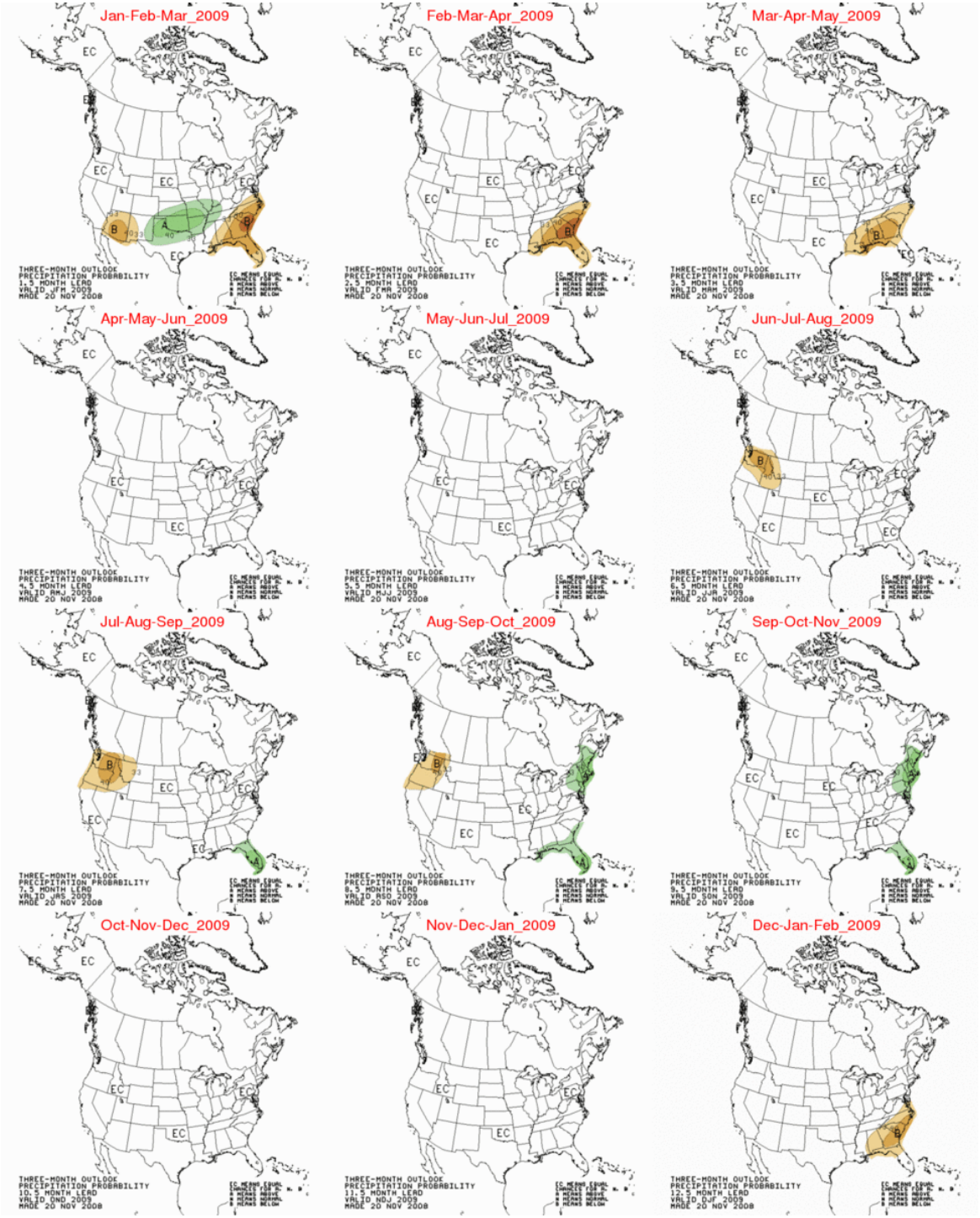
Mar-Apr-May



Apr-May-Jun

CPC Temperature Outlooks

Winter 2008-2009

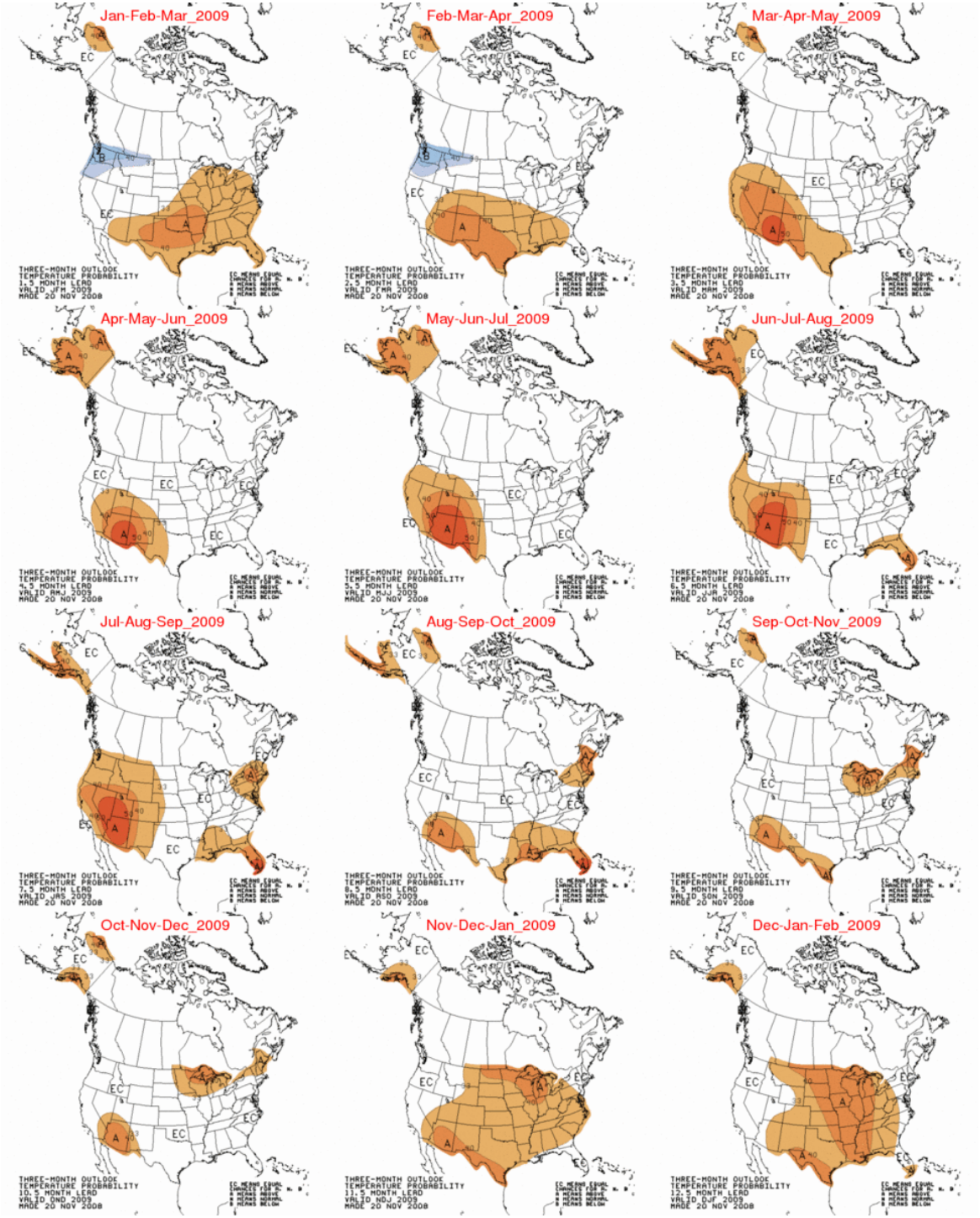


All Precipitation Outlooks

Jan-Feb-Mar 2008-2009

Thru

Dec-Jan-Feb 2009-2010



All Temperature Outlooks

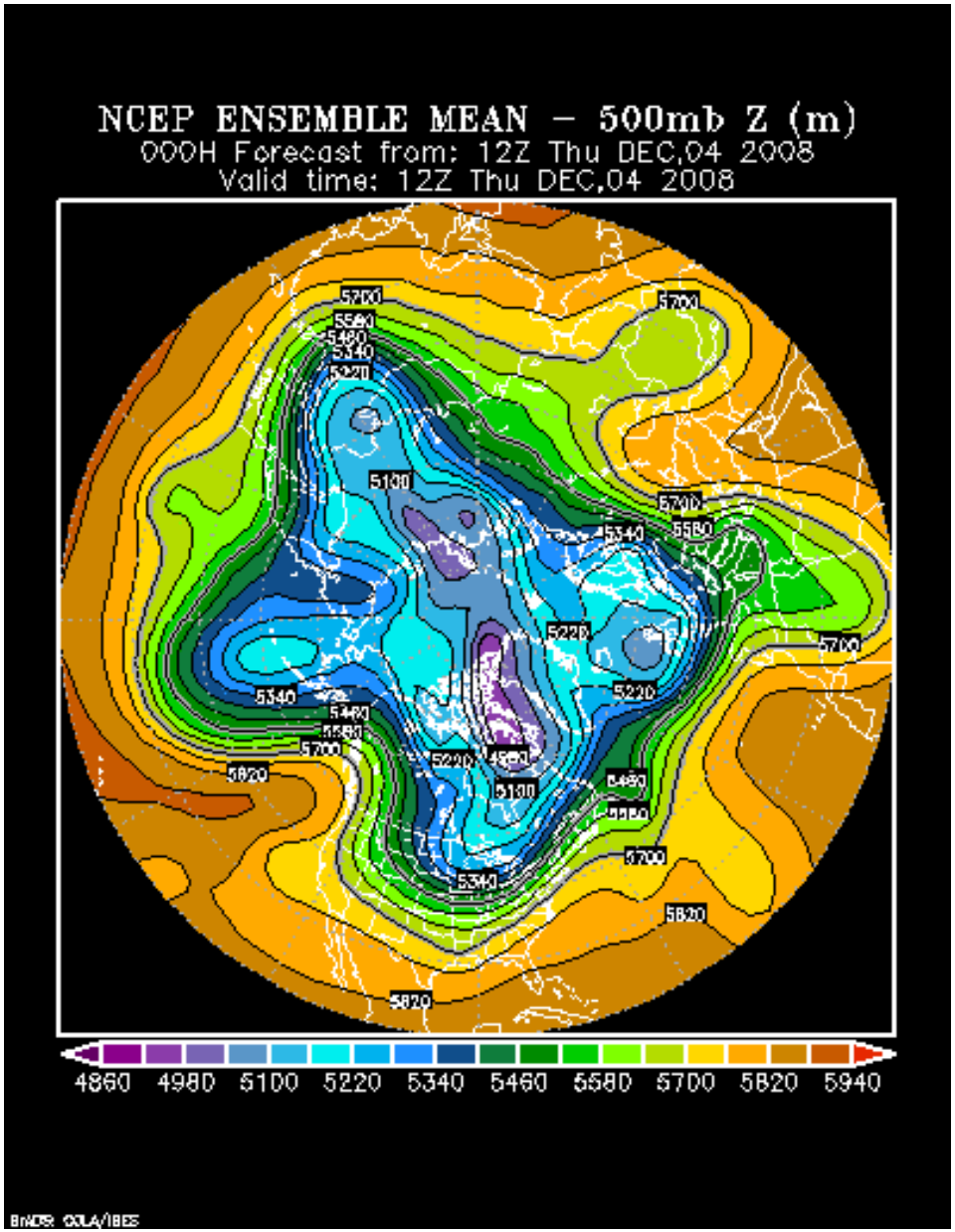
Jan-Feb-Mar 2008-2009

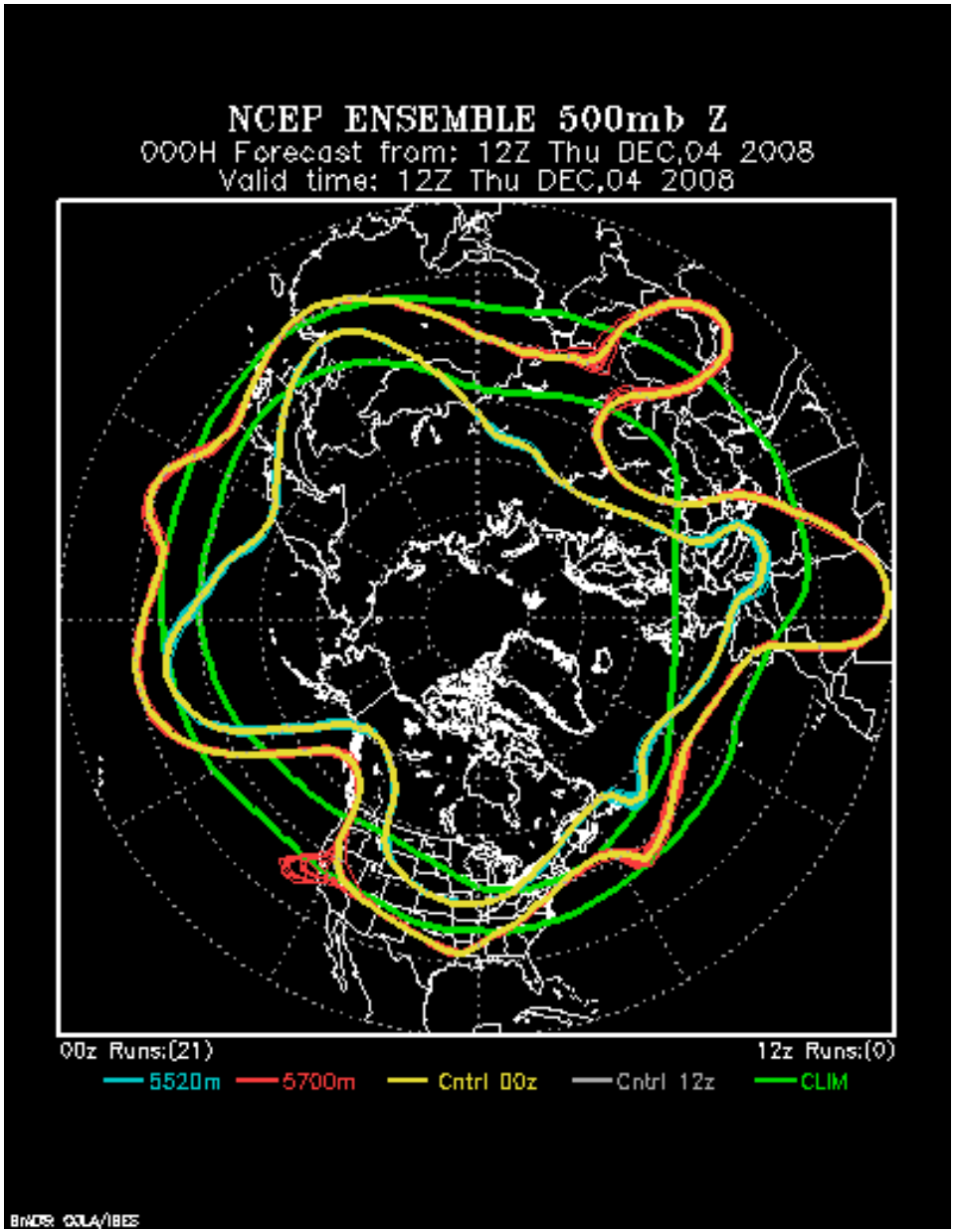
Thru

Dec-Jan-Feb 2009-2010

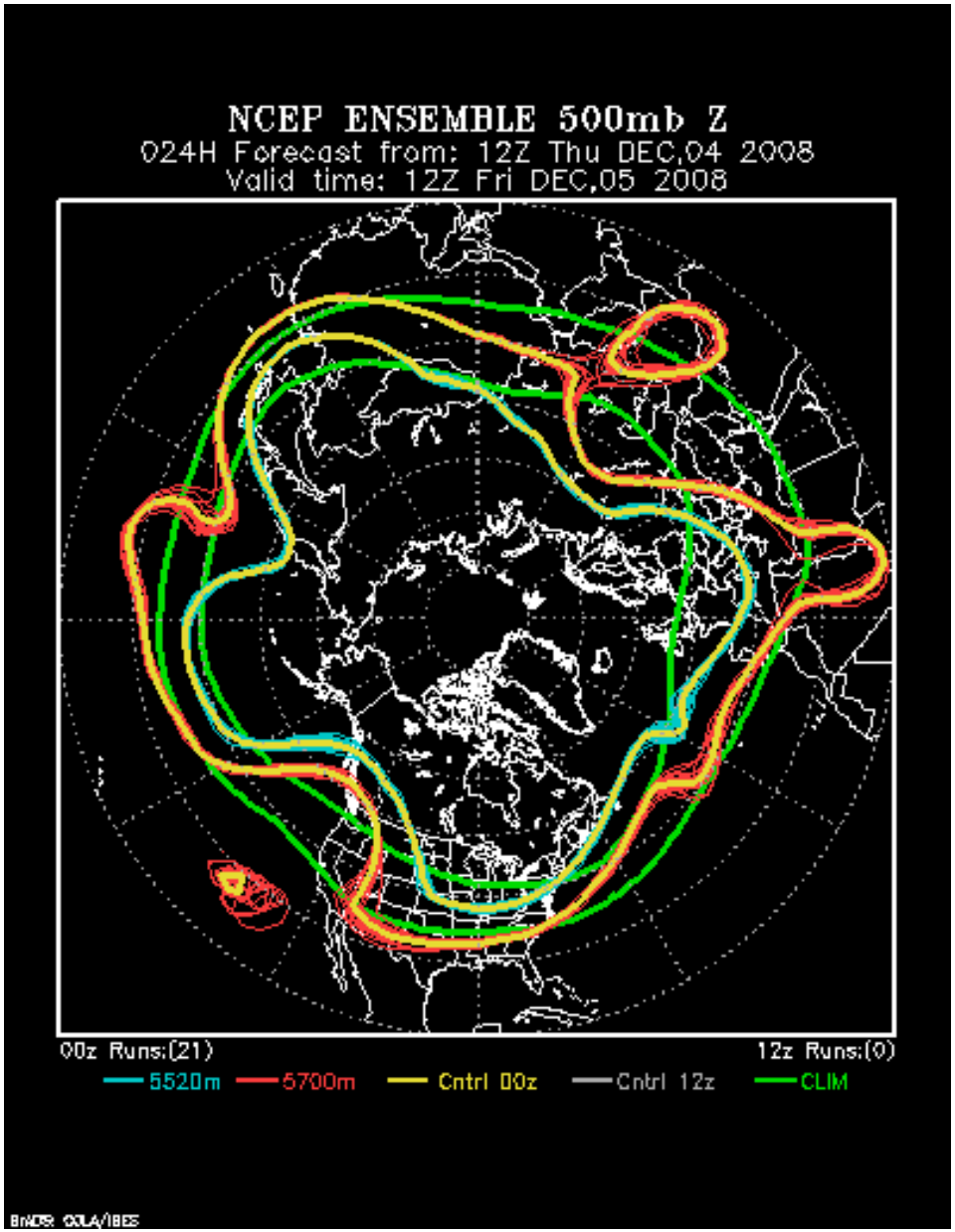
The Ensemble Method … An Example

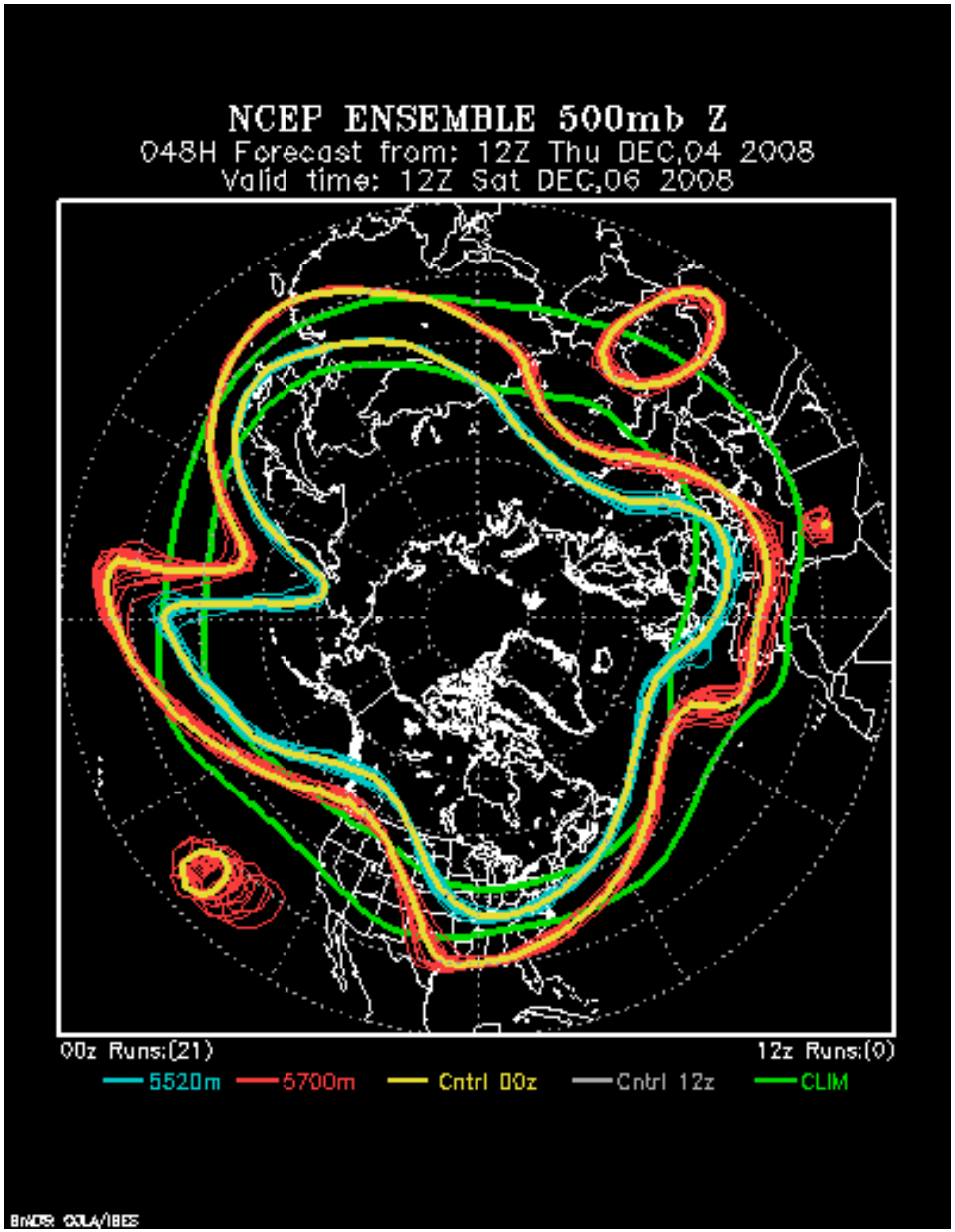
500 mb. Starting conditions. 2008 December 4 at 1200 GMT (4 am PST)



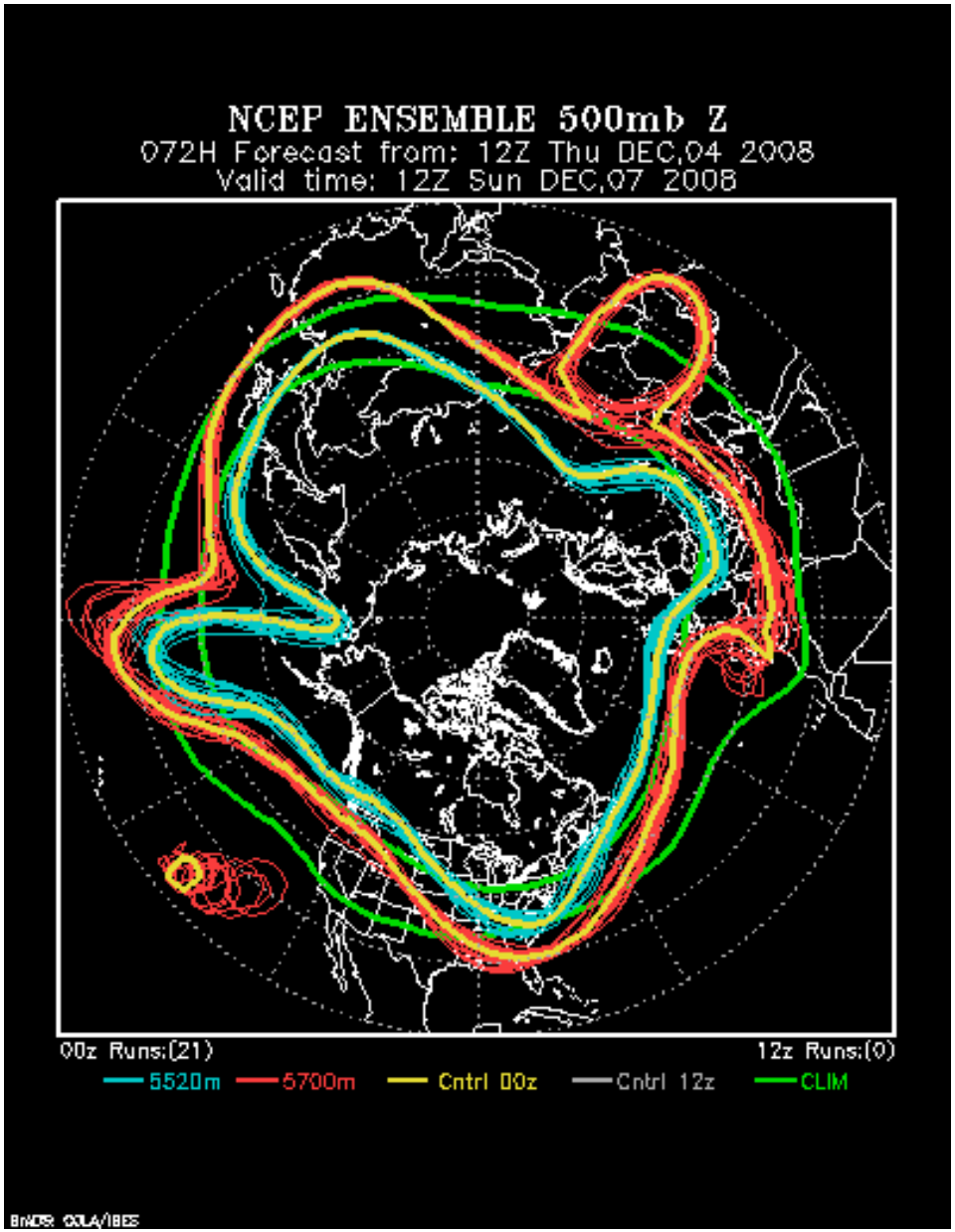


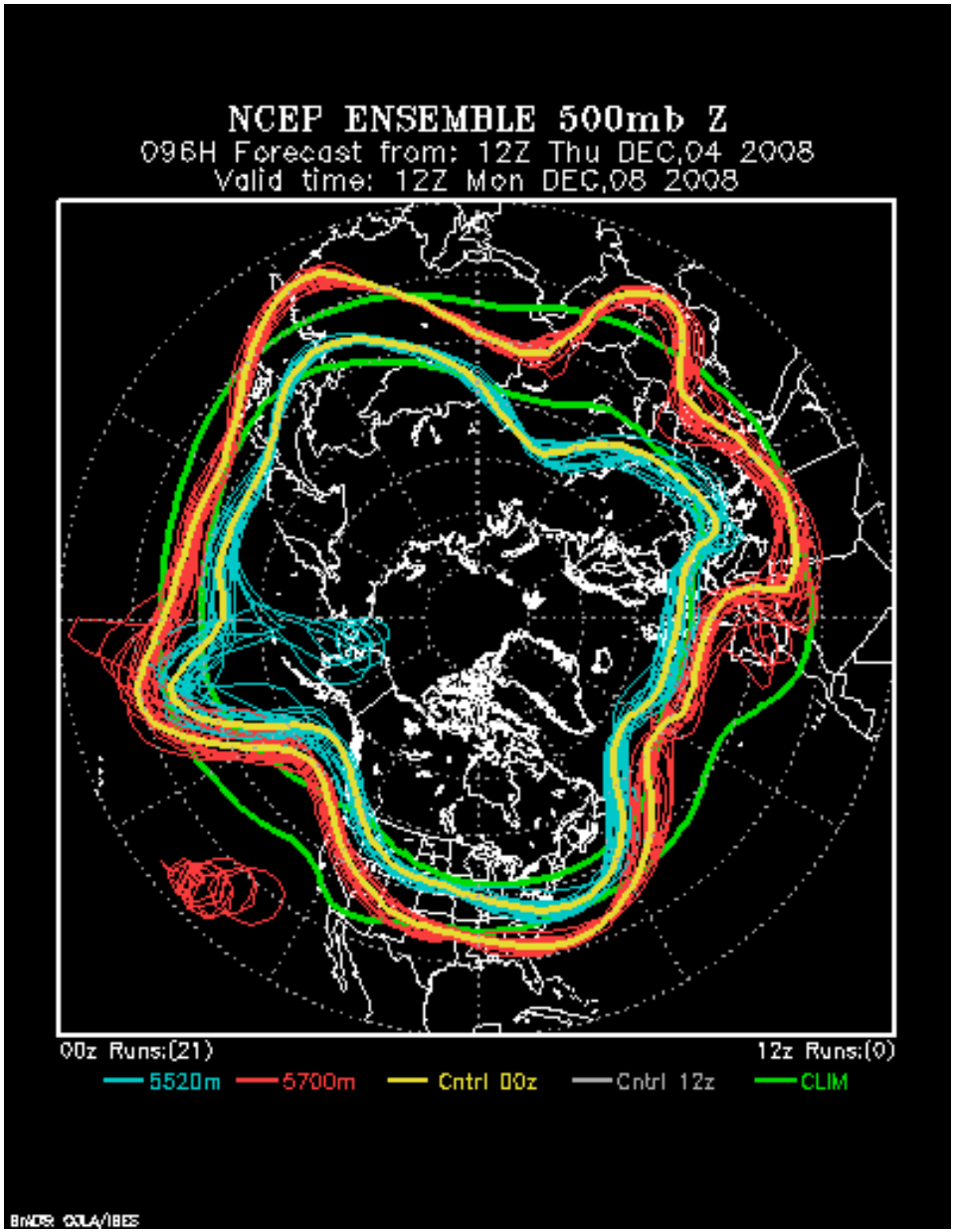
24-hour forecast **2008 December 4 at 1200 GMT** **48-hour forecast**



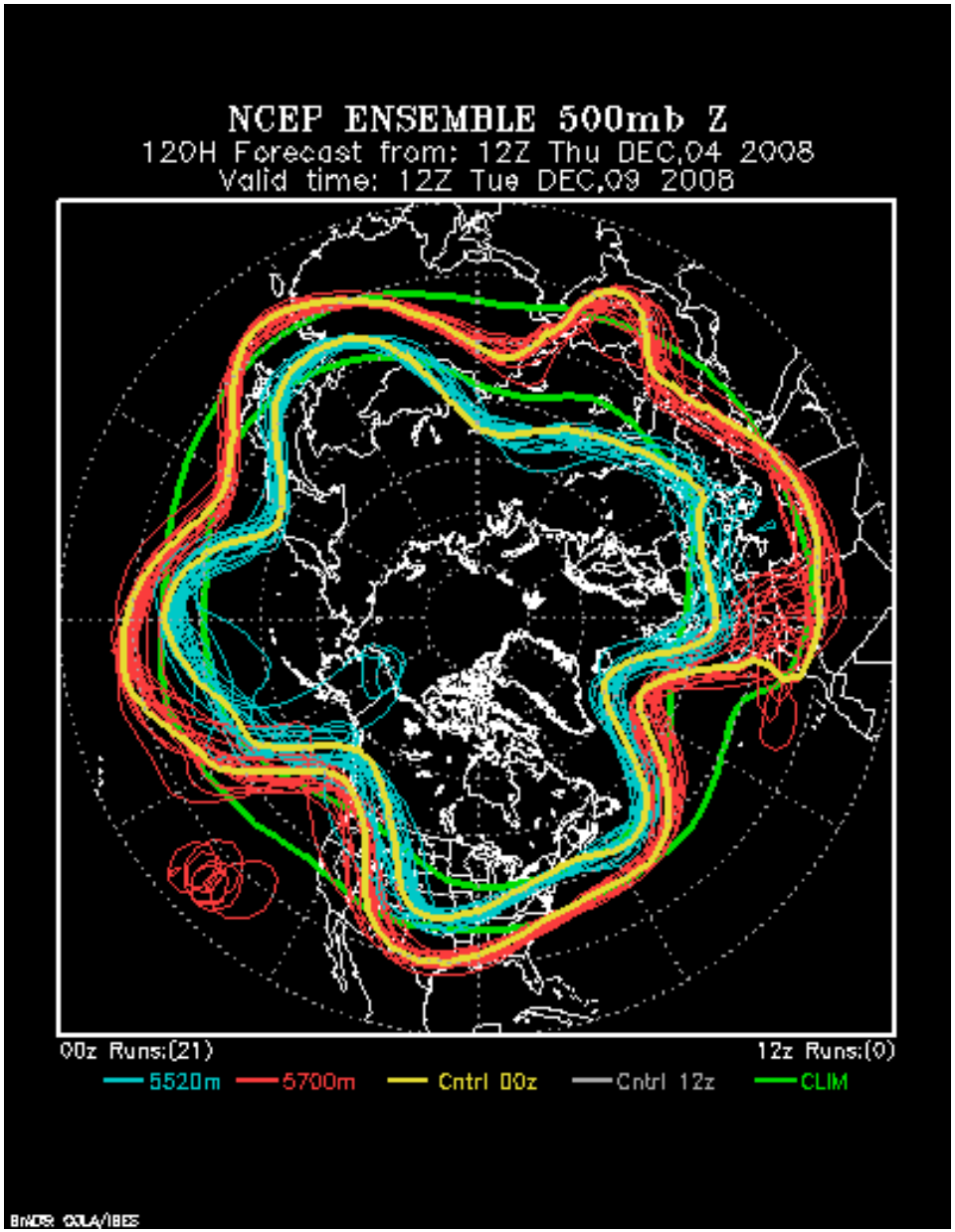


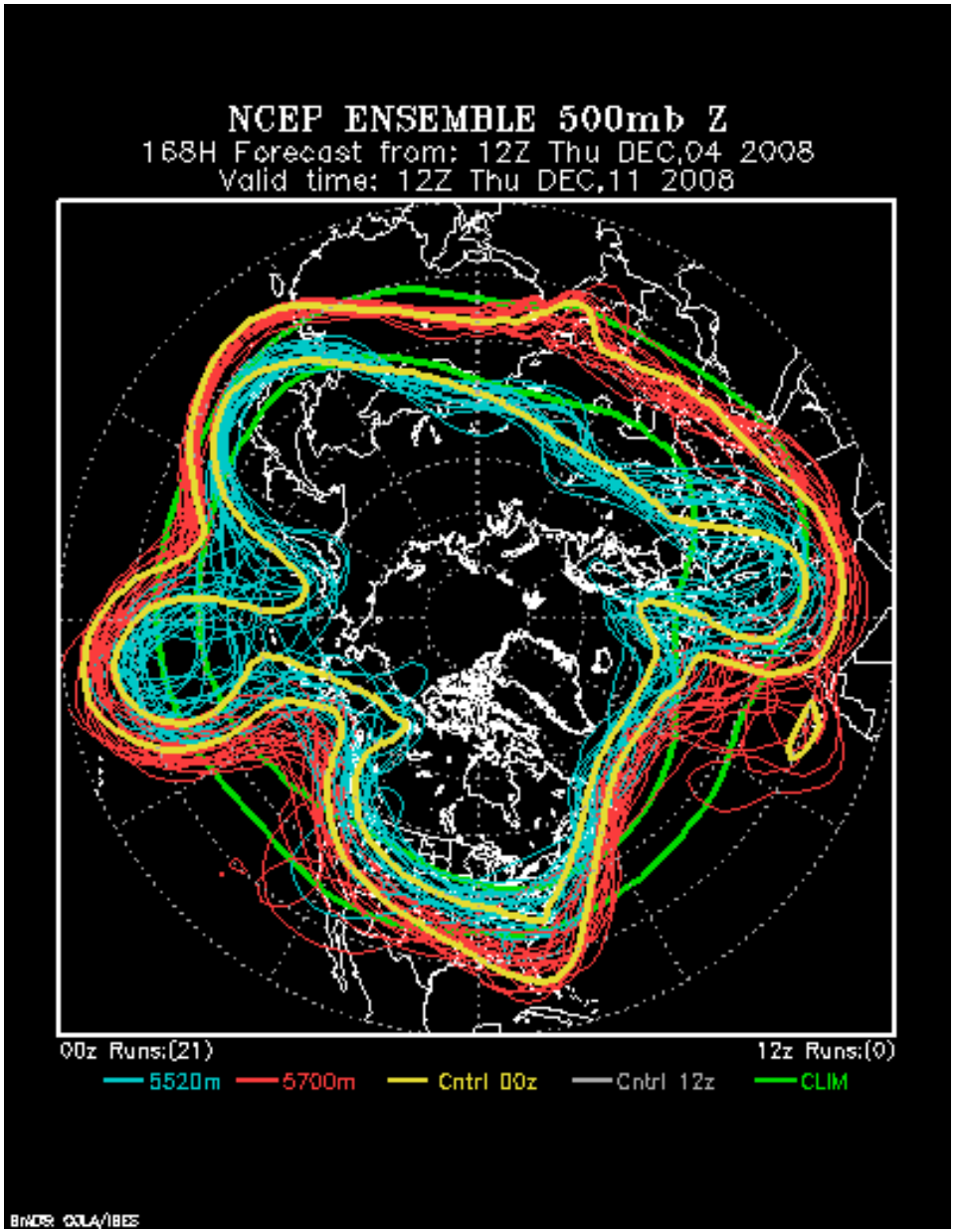
72-hour forecast **2008 December 4 at 1200 GMT** **96-hour forecast**



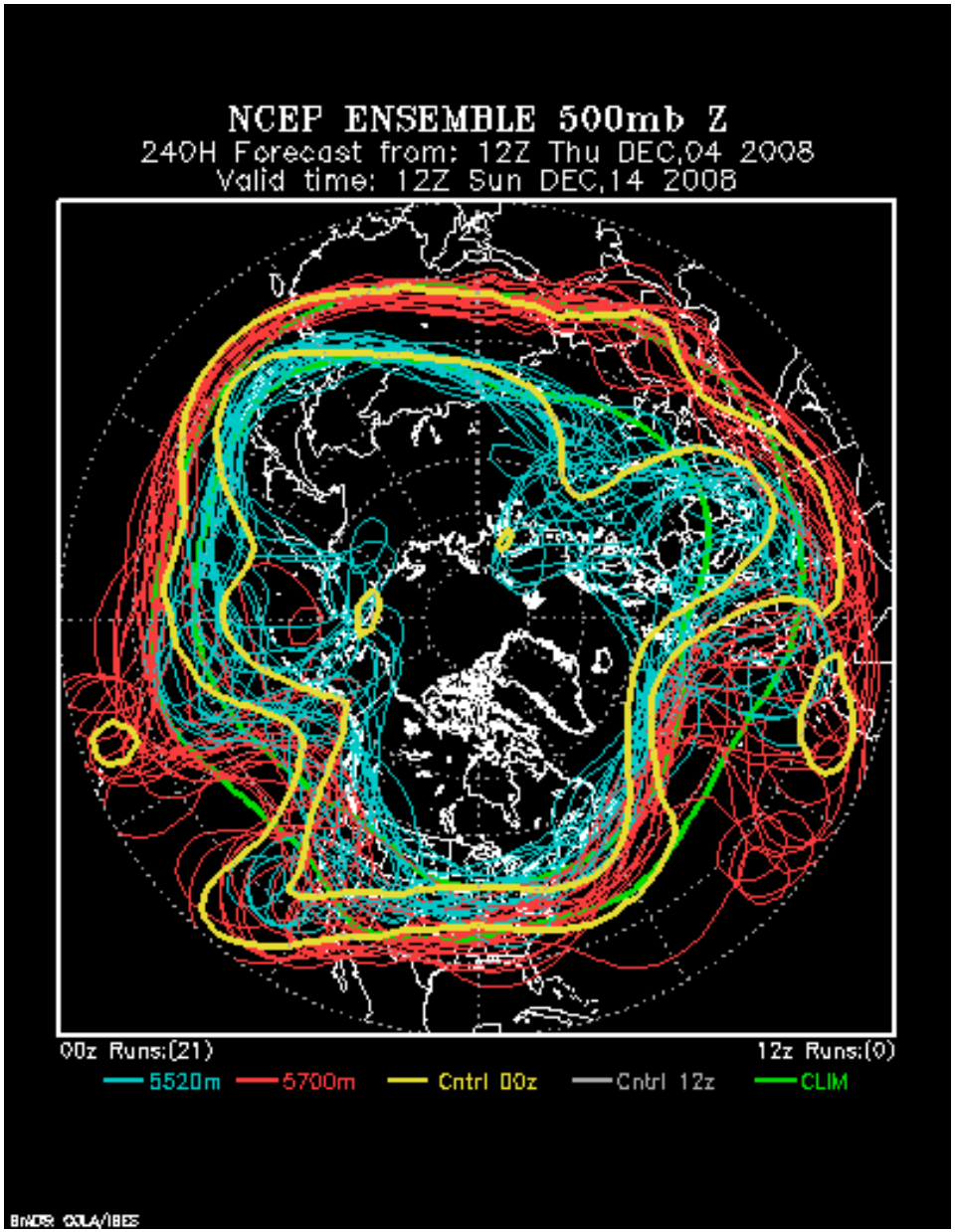


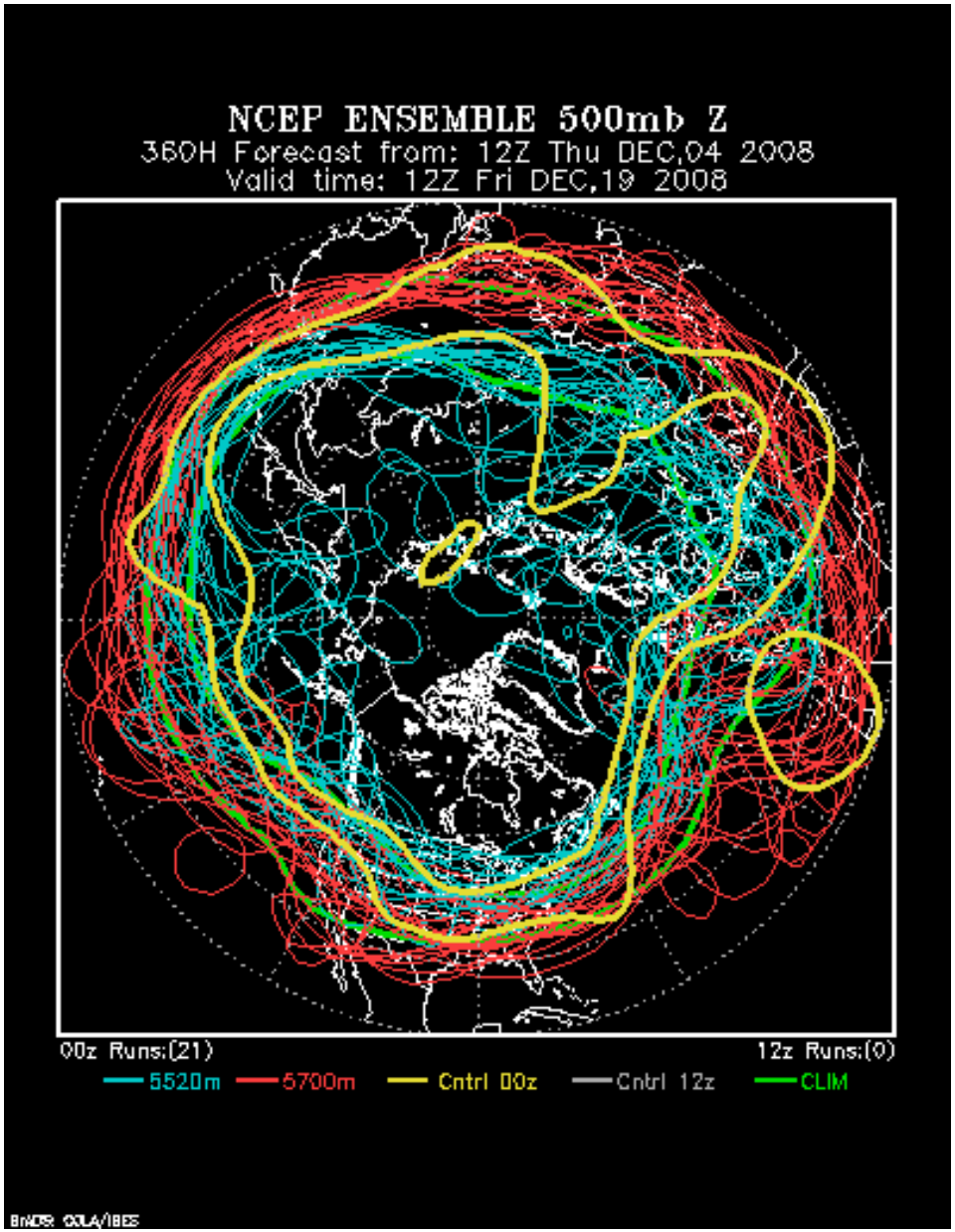
120-hour forecast **2008 December 4 at 1200 GMT** **168-hour forecast**





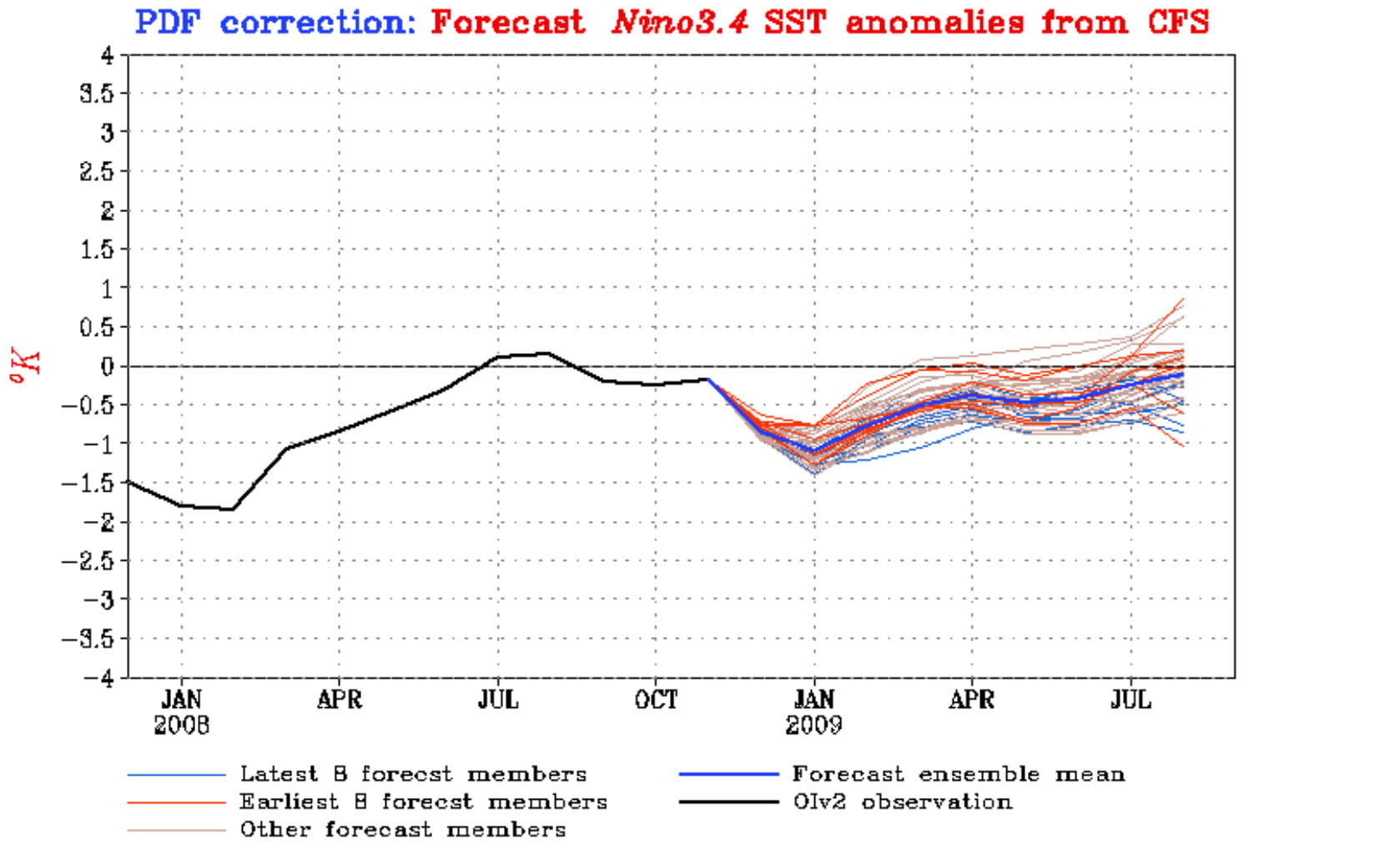
240-hour forecast 2008 December 4 at 1200 GMT 360-hour forecast





NWS/NCEP

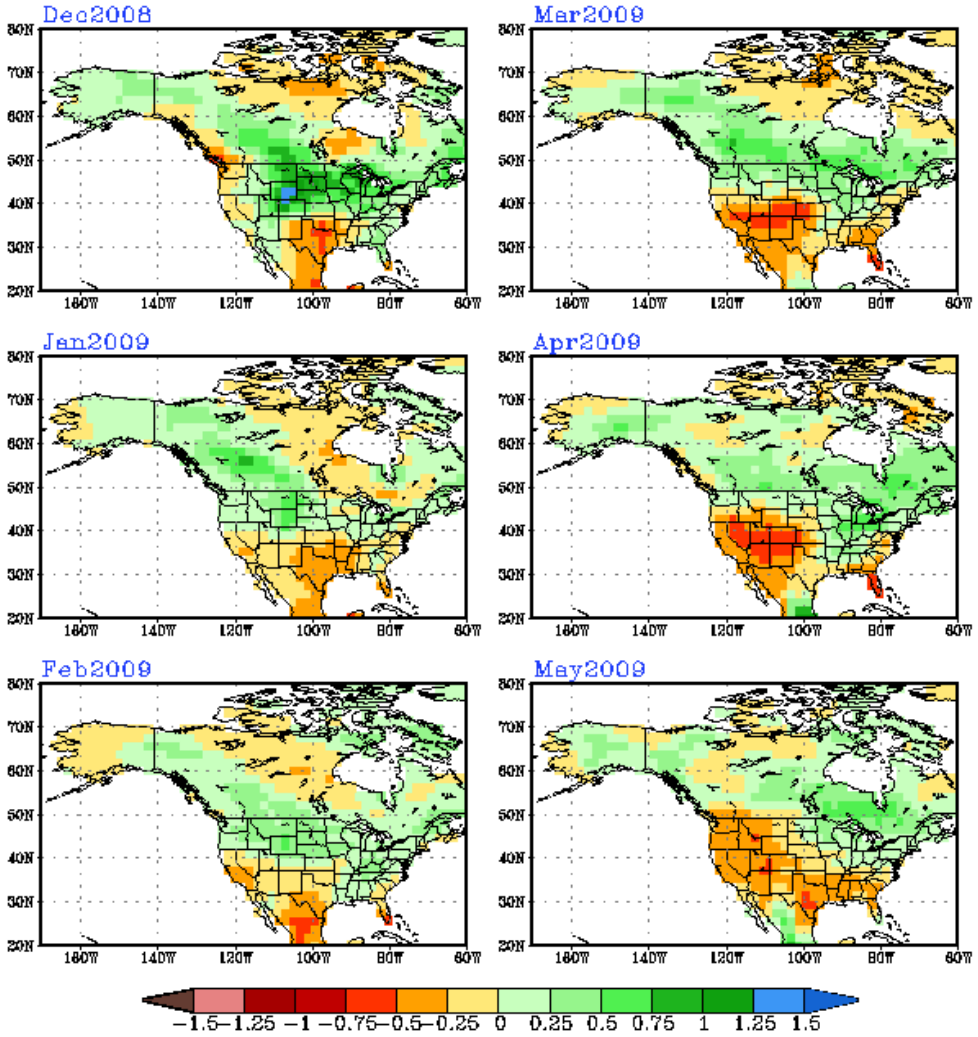
Last update: Wed Dec 3 2008
Initial conditions: 22Nov2008–01Dec2008



NWS/NCEP

Last update: Wed Dec 3 2008
Initial conditions: 22Nov2008–01Dec2008

CFS monthly standardized Prec forecast

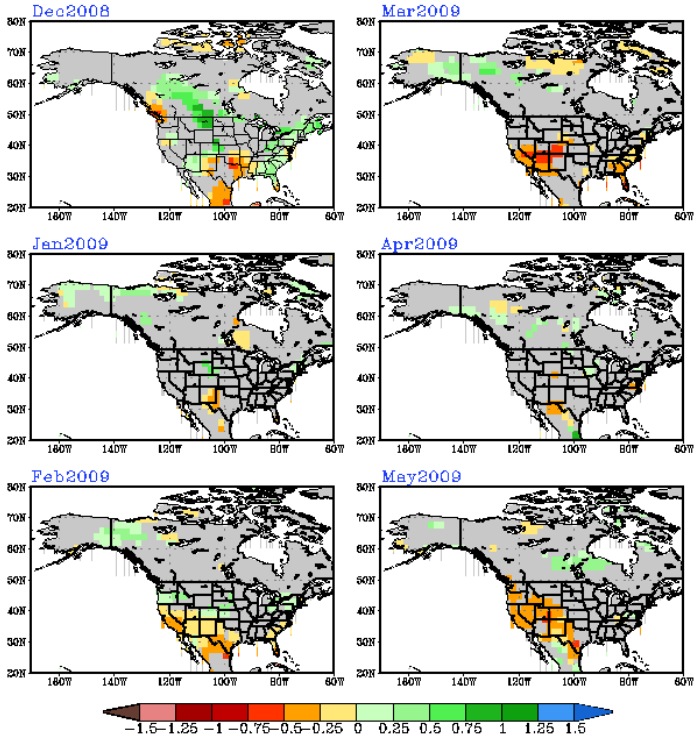


Ensemble average of 40 members from initial conditions of 22Nov2008 to 01Dec2008.
Base period for climatology is 1982–2003. Base period for bias correction is 1982–2003.

NWS/NCEP

Last update: Wed Dec 3 2008
Initial conditions: 22Nov2008–01Dec2008

CFS monthly standardized Prec forecast

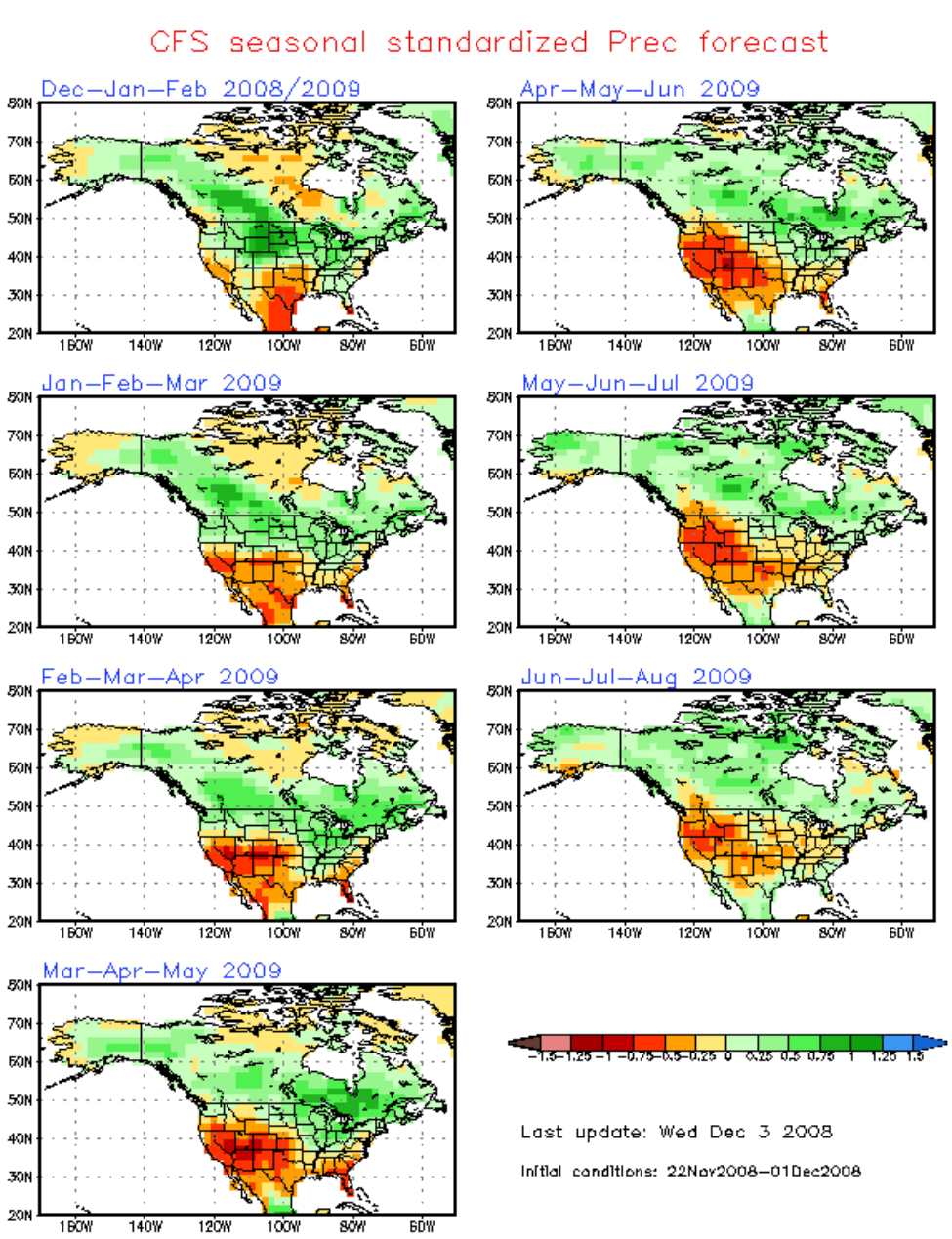


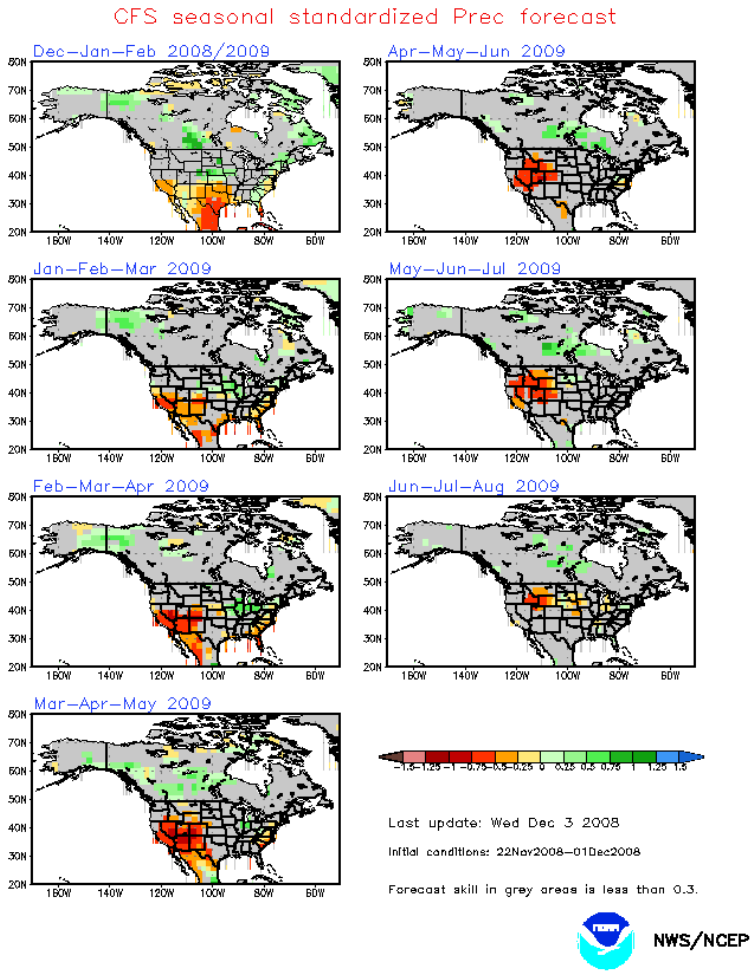
Ensemble average of 40 members from initial conditions of 22Nov2008 to 01Dec2008.
Base period for climatology is 1982–2003. Base period for bias correction is 1982–2003.
Forecast skill in grey areas is less than 0.3.

Masked for skill.

All areas.

Monthly Dec 08 – May 09





Masked for skill.

All areas.

Seasonal DJF – JJA 2008-09

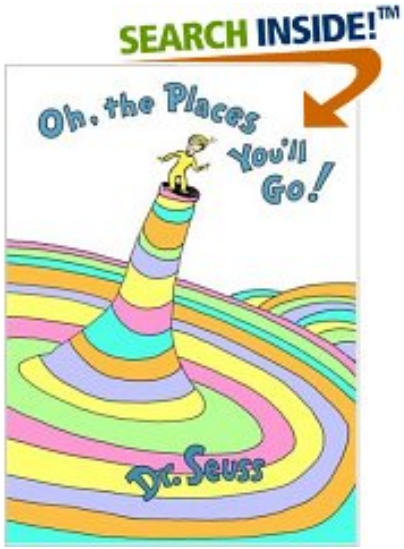
?

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 ?

?



Simple it's not, I'm afraid you will find,

for a mind-maker-upper to make up his mind.

Dr. Seuss, 1990. Oh, The Places You'll Go! Random House. 56 pp.
With thanks to Roberta Balstad, Columbia University


Thank You !
20 February 2007

Discards and spares