

# Arizona Climate

## An Overview for the Master Watershed Steward Program



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University of Arizona Cooperative Extension

# Overview

- Intro to Climatology
- Climatic Controls
- Regional Climate Variability and ENSO
- Climate Monitoring and Forecasts

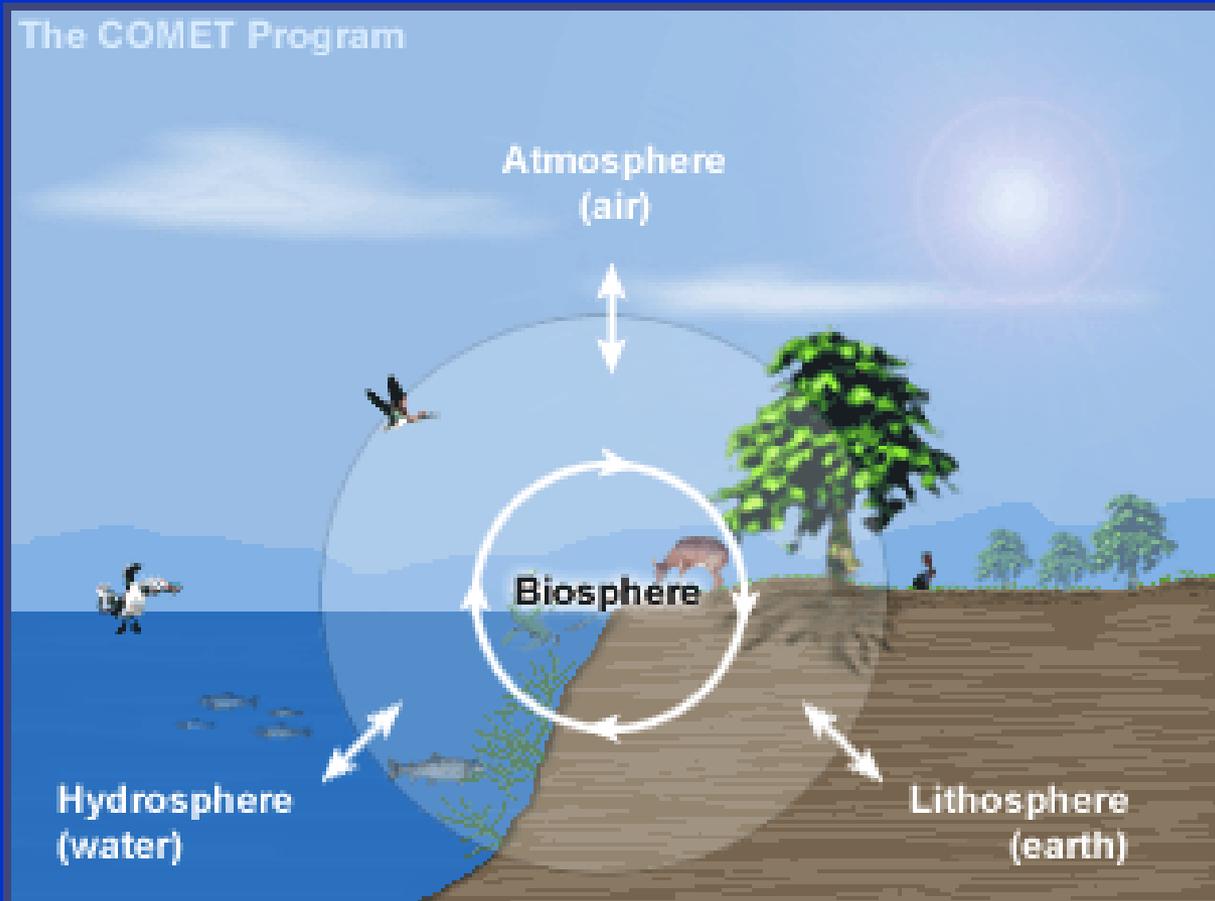
# Climatology

“Climate is what you expect, weather is what you get.”

-Robert Heinlein

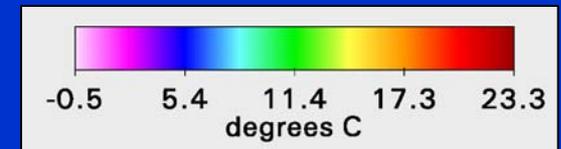
- Climatology: analyzes long-term weather patterns over time or space.
- Climate is a strong determinant of where major ecosystems are found.
- Climate Components
  - insolation
  - temperature
  - air pressure
  - air masses
  - precipitation

# Connections

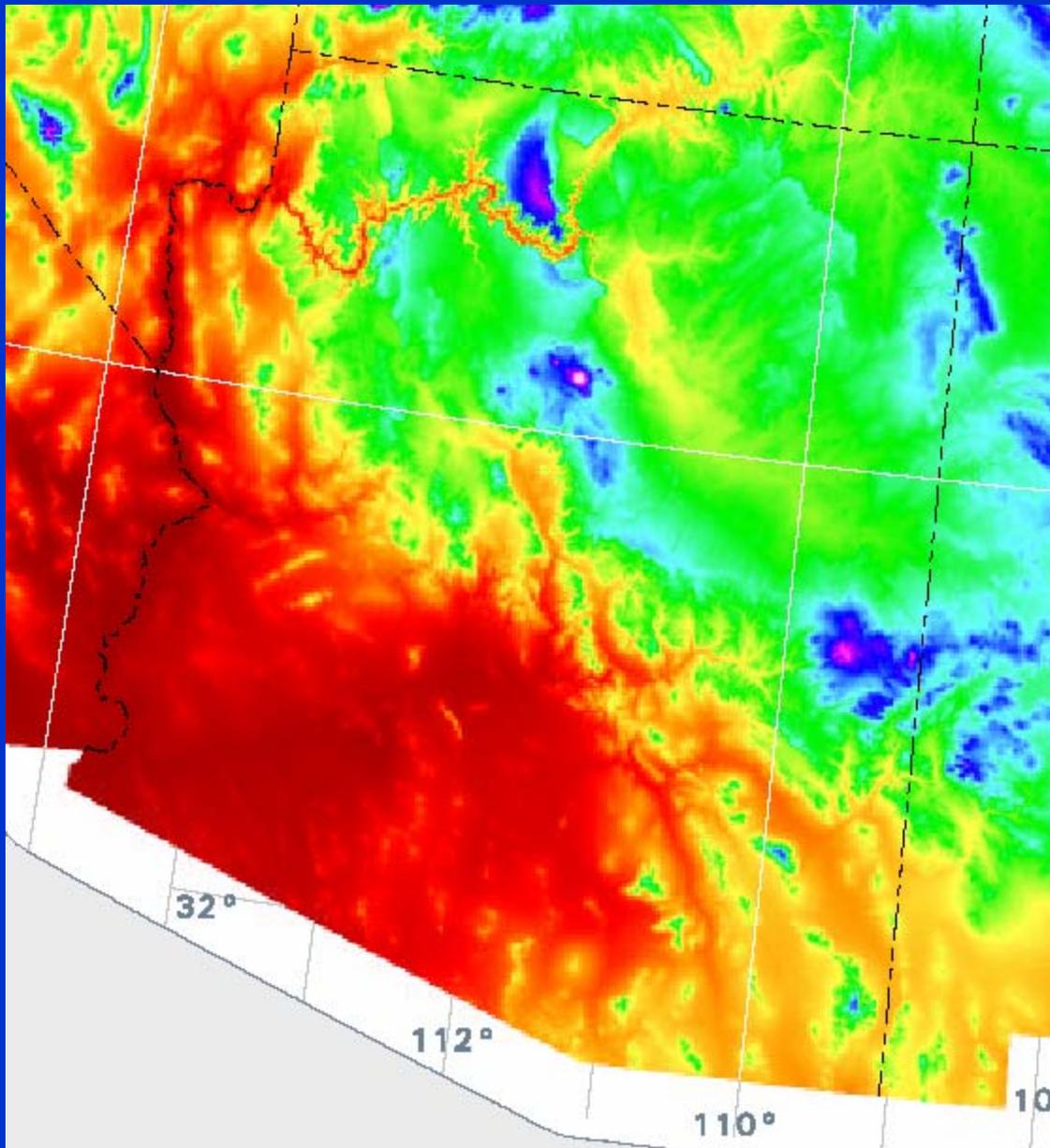


# Average Arizona Temperatures

- Inland, continental location
- Subtropical high position
- Governed by elevation

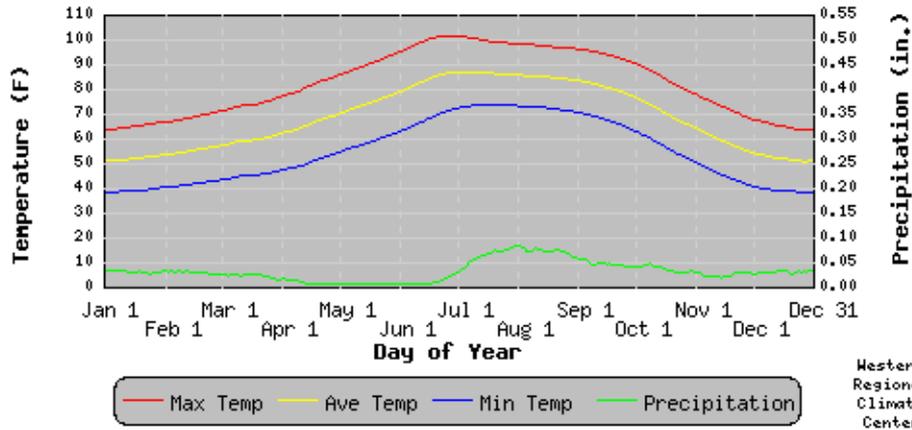


Map from <http://www.daymet.org>



# Elevation and Climate

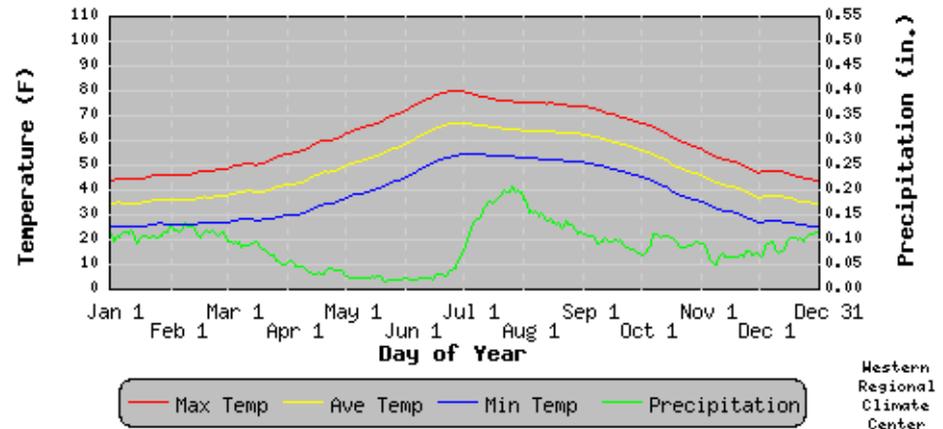
TUCSON WSD AP, ARIZONA (028820)  
1971-2000 30 Year Average



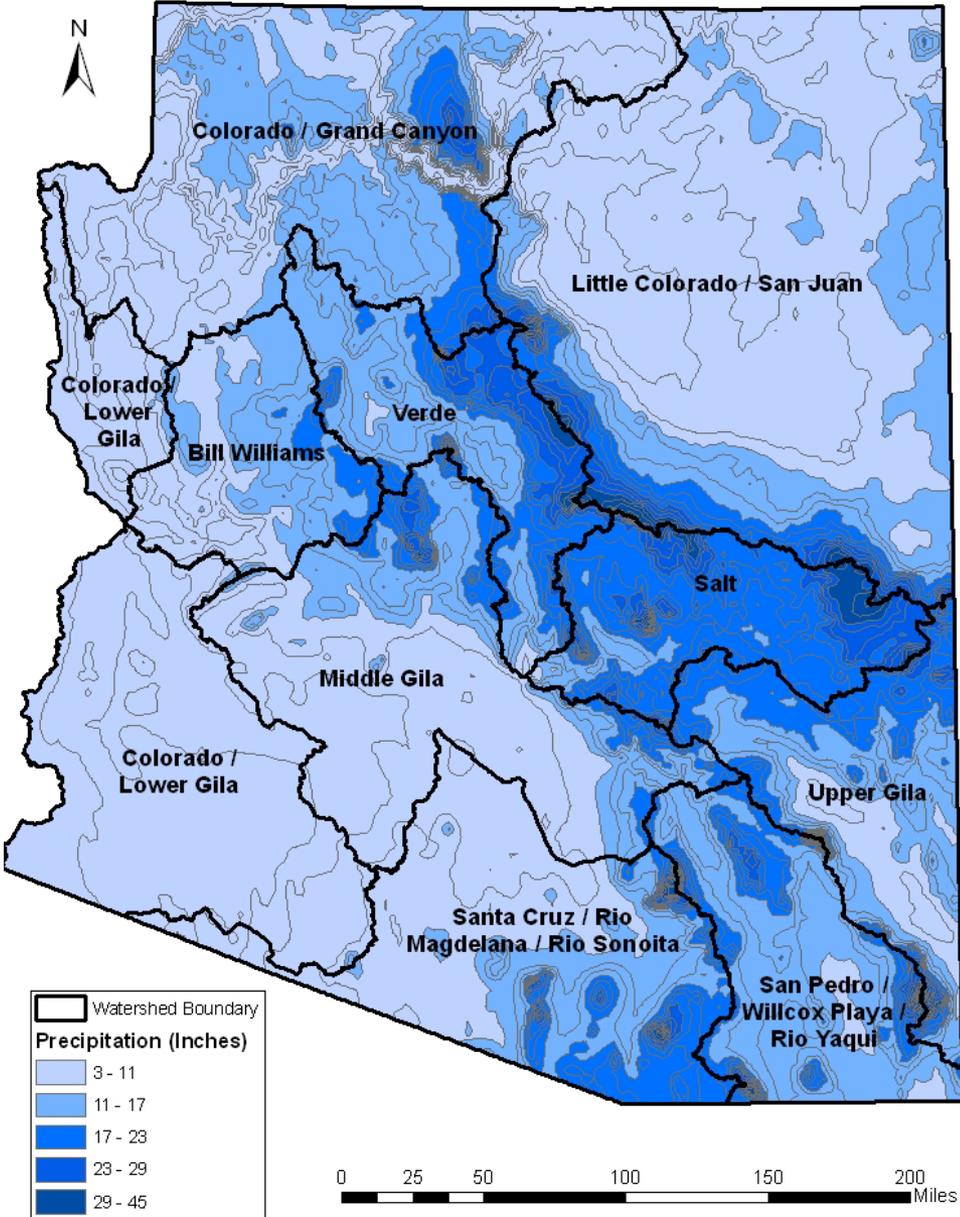
Tucson: 2560 ft.

Palisades: 7960 ft.

PALISADE RANGER STN, ARIZONA (026202)  
1971-2000 30 Year Average



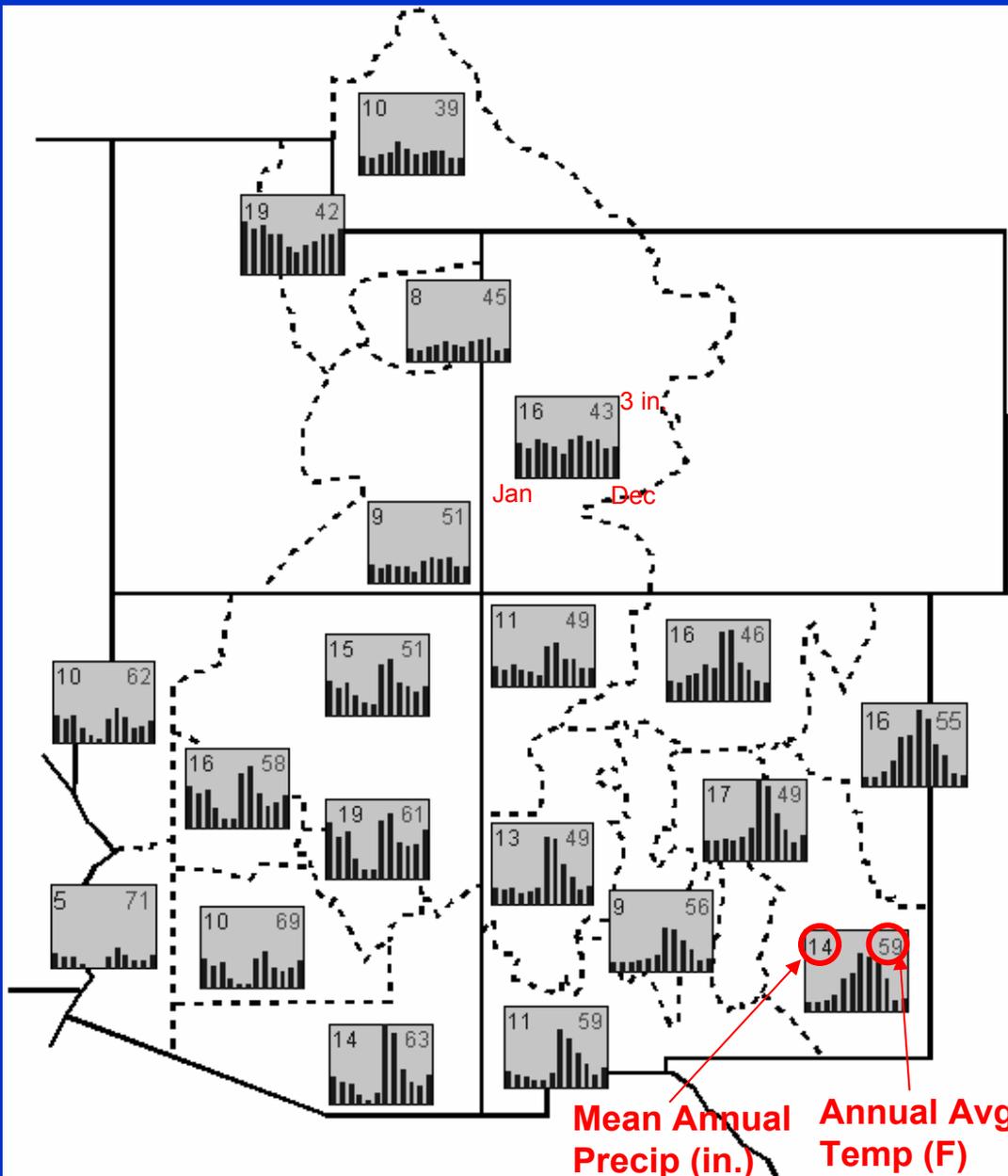
# Average Arizona Precipitation



# Seasonal Distribution of Precipitation

- More winter precip in northern AZ
- Stronger monsoon signal in southeast AZ (more summer precip)

(graphic from Sheppard, et al. 2000)



# Synoptic Circulation Patterns

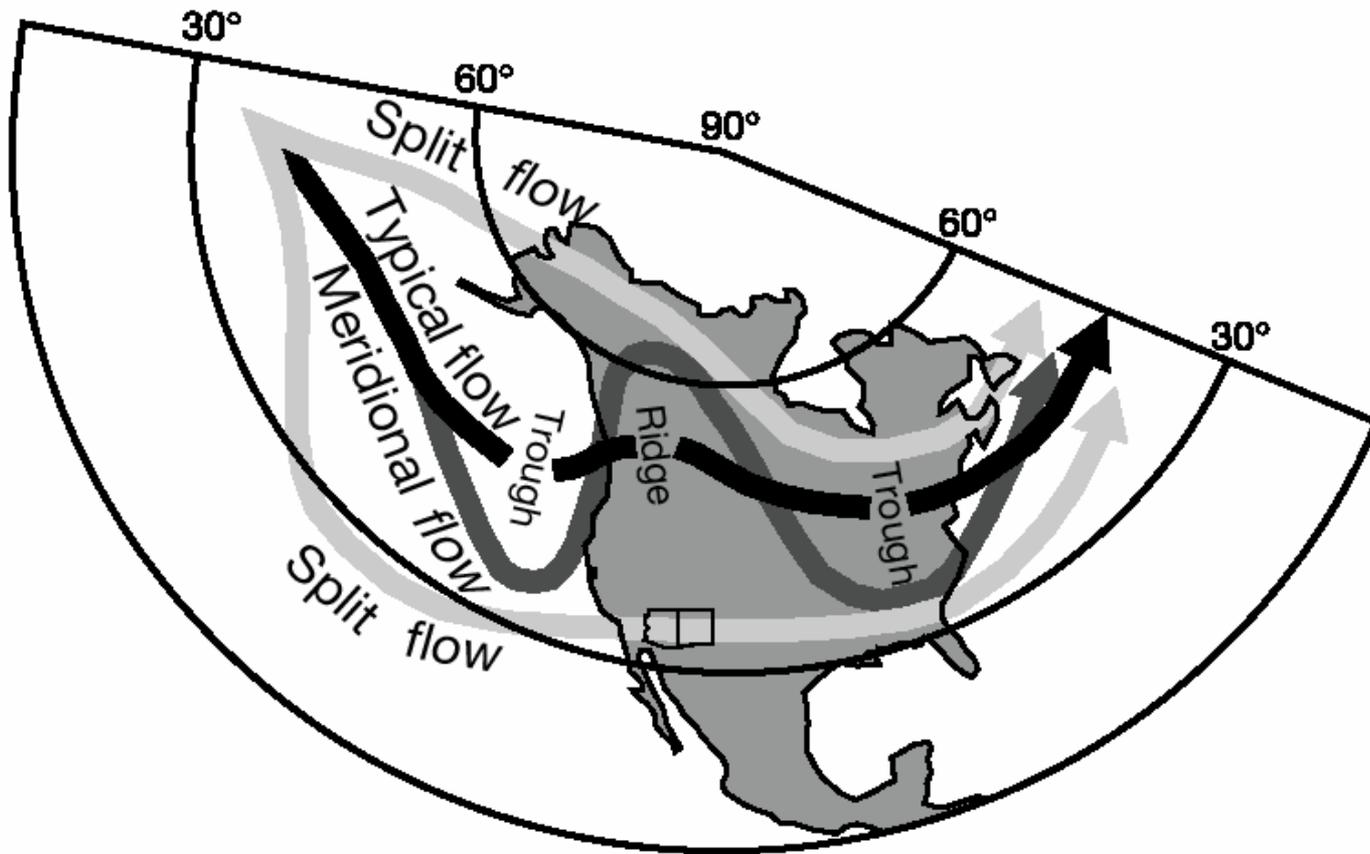


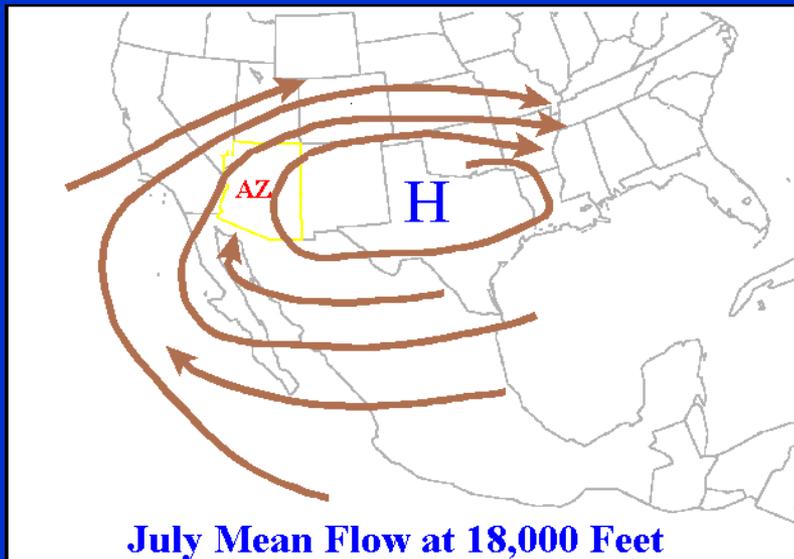
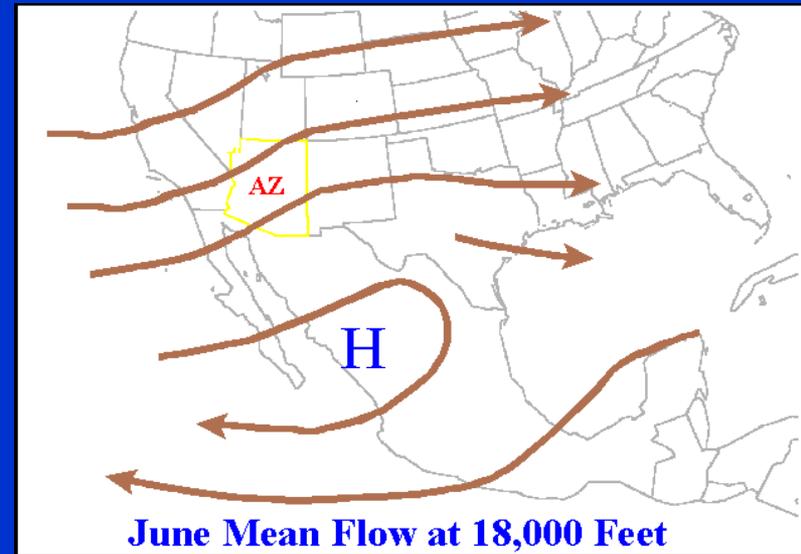
Fig. 6. Winter flow patterns drawn from circulation patterns at the 700 mb geopotential height, which relates well to the climate over North America (Jorgensen et al. 1967)

# North American Monsoon

# Monsoon

## Monsoon start dates for Tucson

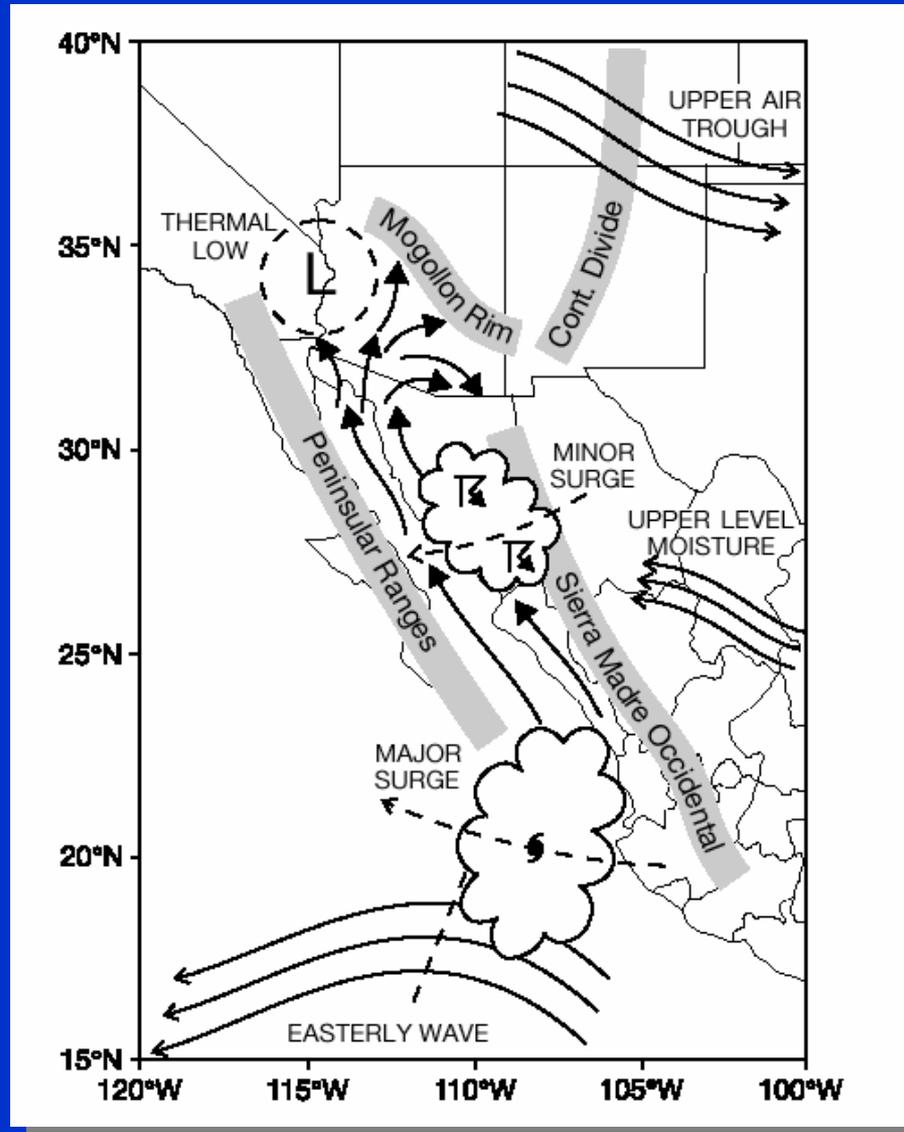
- Average start July 3<sup>rd</sup>
- Earliest start June 17 2000
- Latest start July 25 1987



## Monsoon season rainfall (June 15th to September 30th)

- Average monsoon season rainfall 6.06"
- Driest monsoon season 1.59" in 1924
- Wettest monsoon season 13.84" in 1964

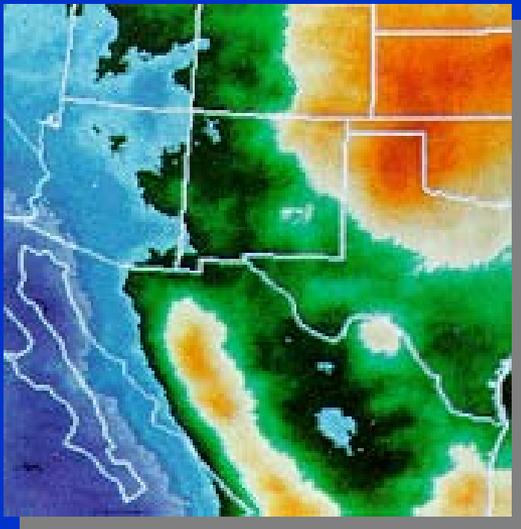
# Monsoon Dynamics



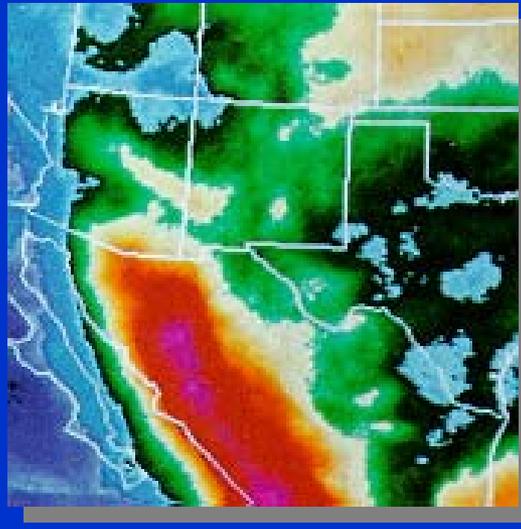
From Adams & Comrie 1997

# Satellite View of Monsoon

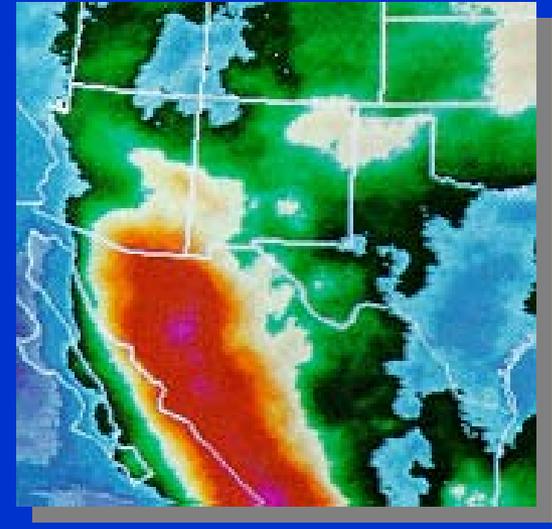
June



July



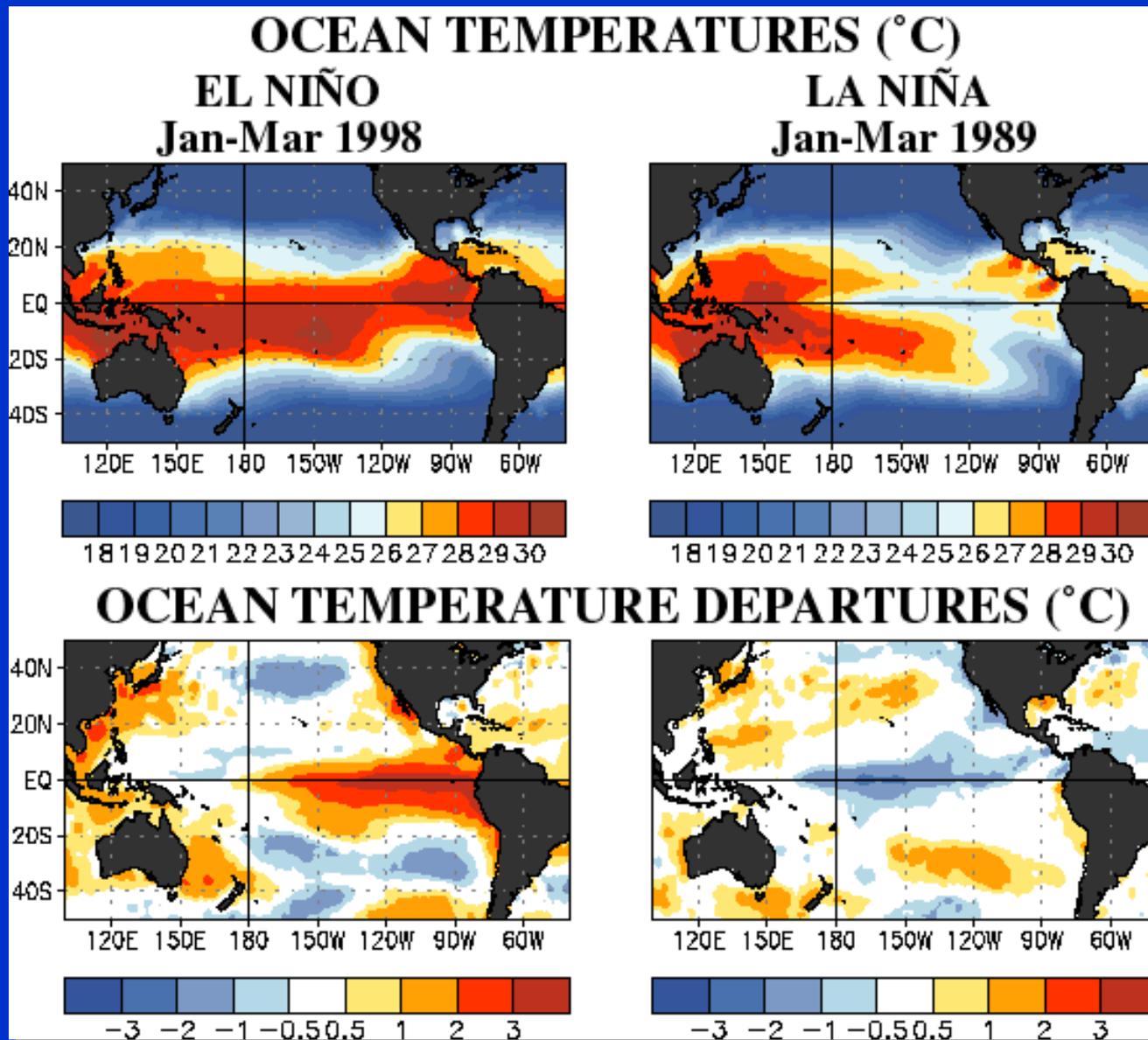
August



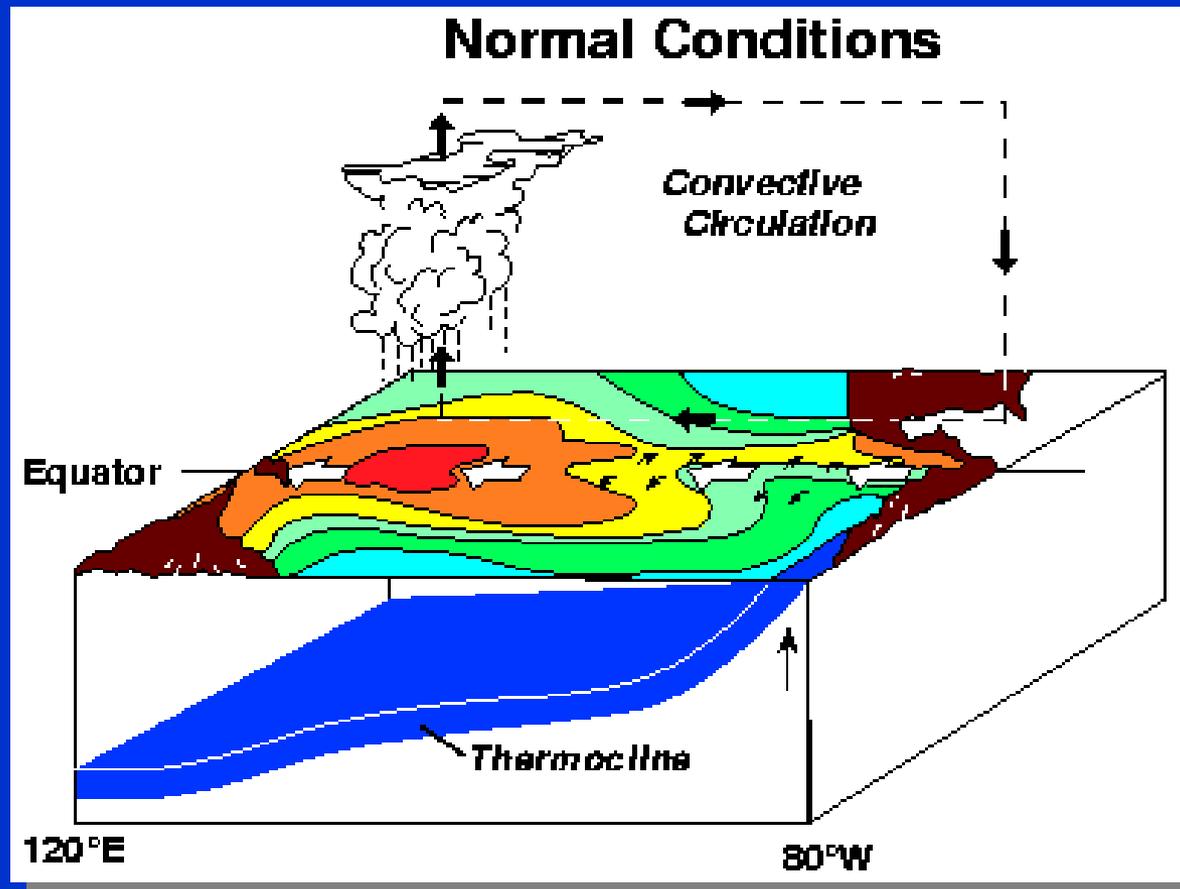
- Colors indicate cloud top heights (reds:high, greens:low)
- Higher the clouds, the more intense the convection

# Climate Variability and ENSO

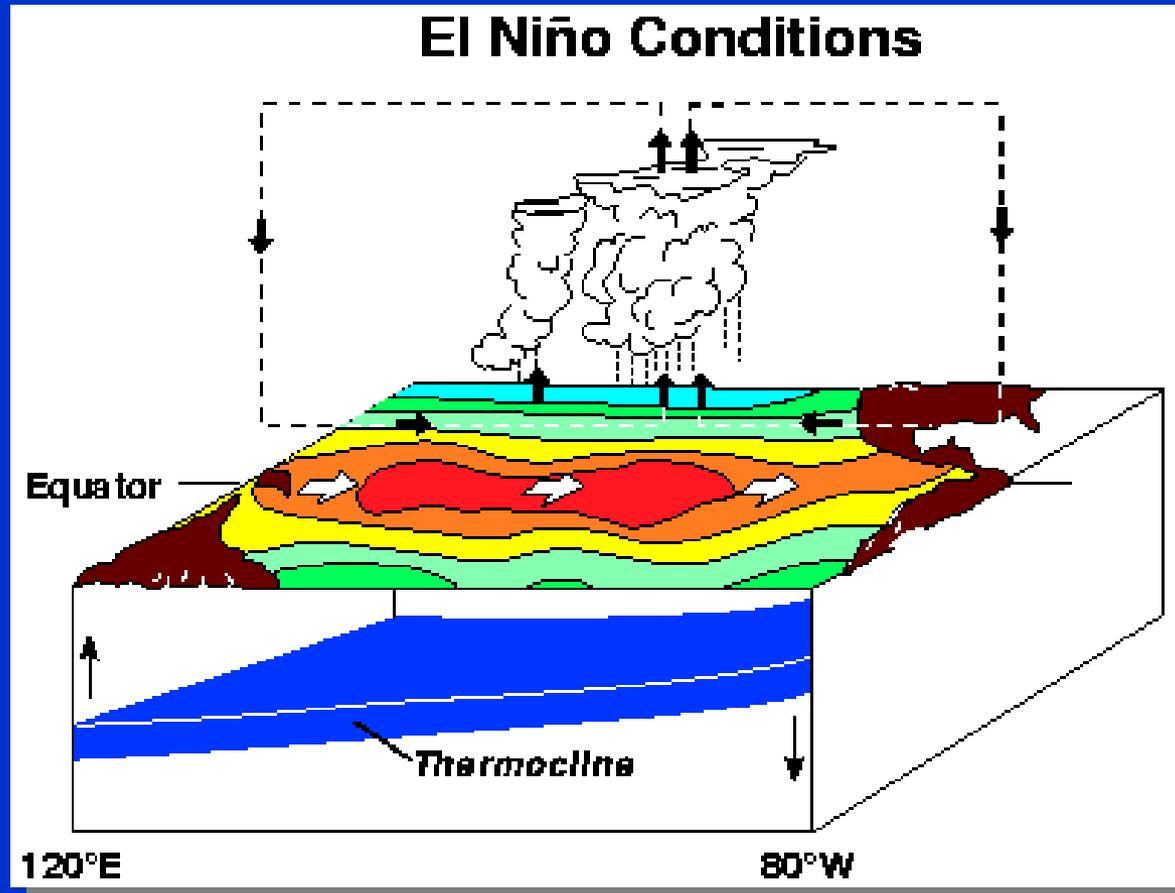
# What are El Niño and La Niña?



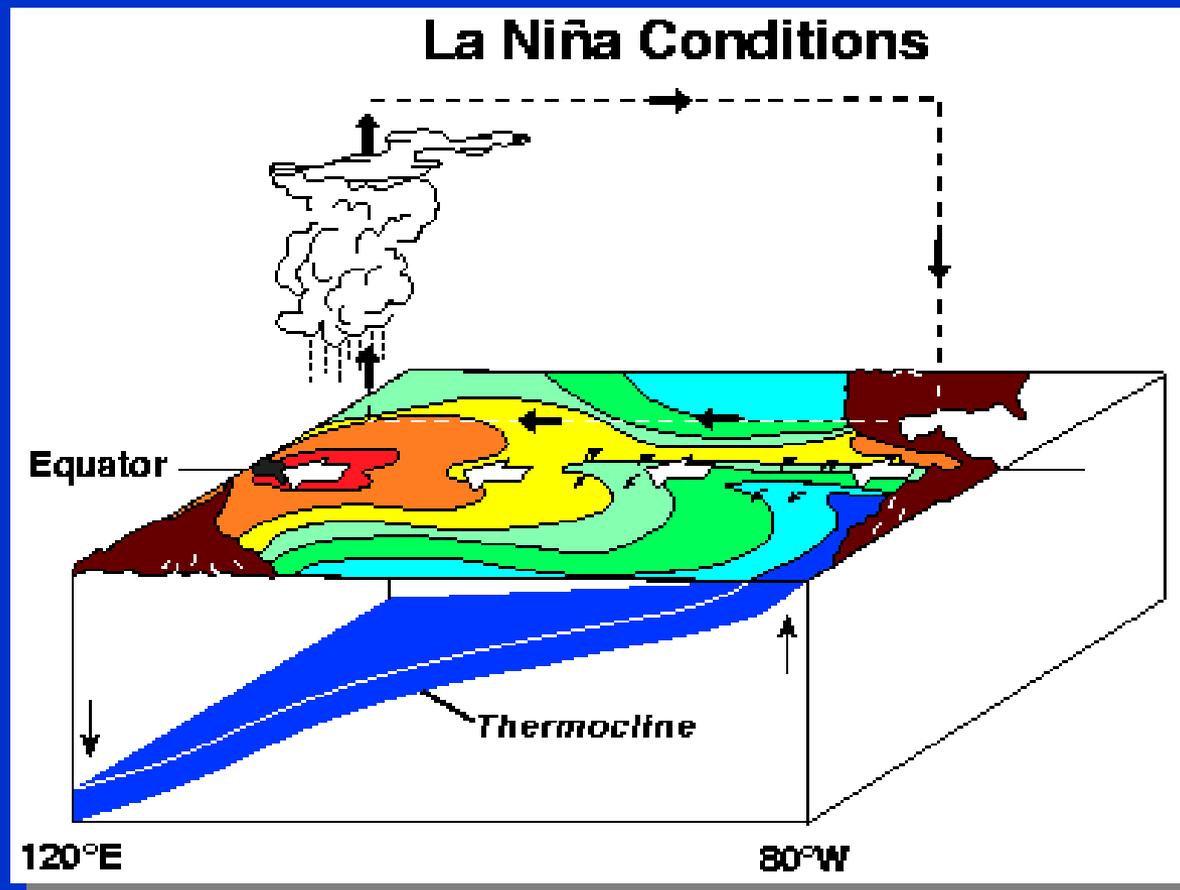
# Atmosphere-Ocean Coupling



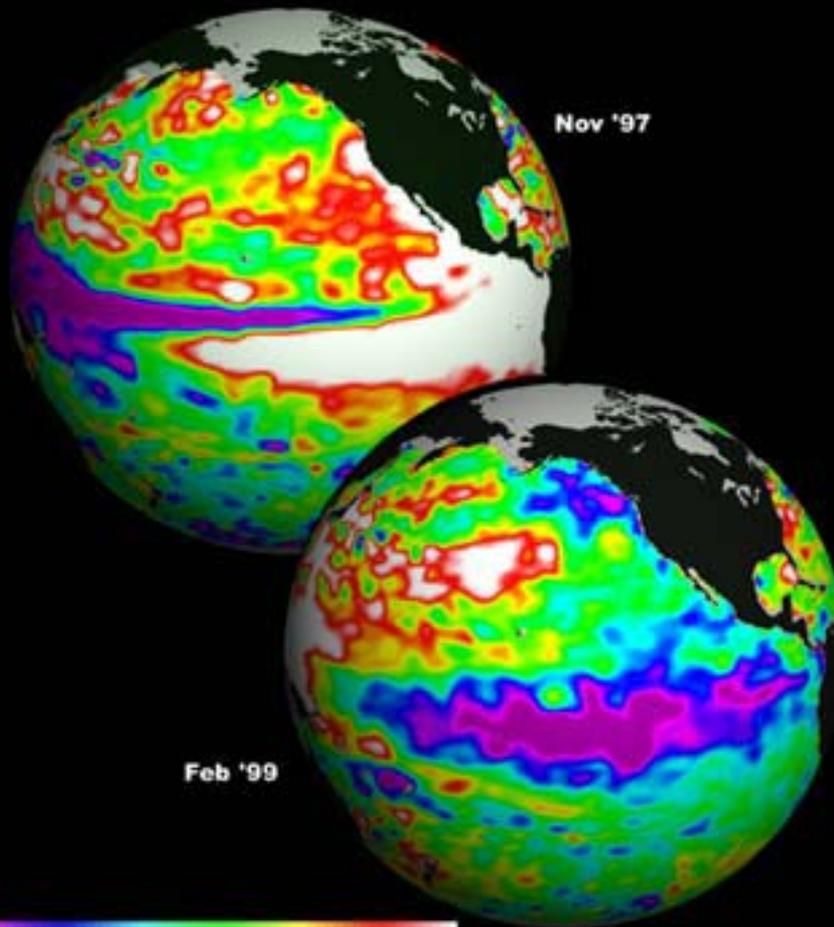
# Atmosphere-Ocean Coupling



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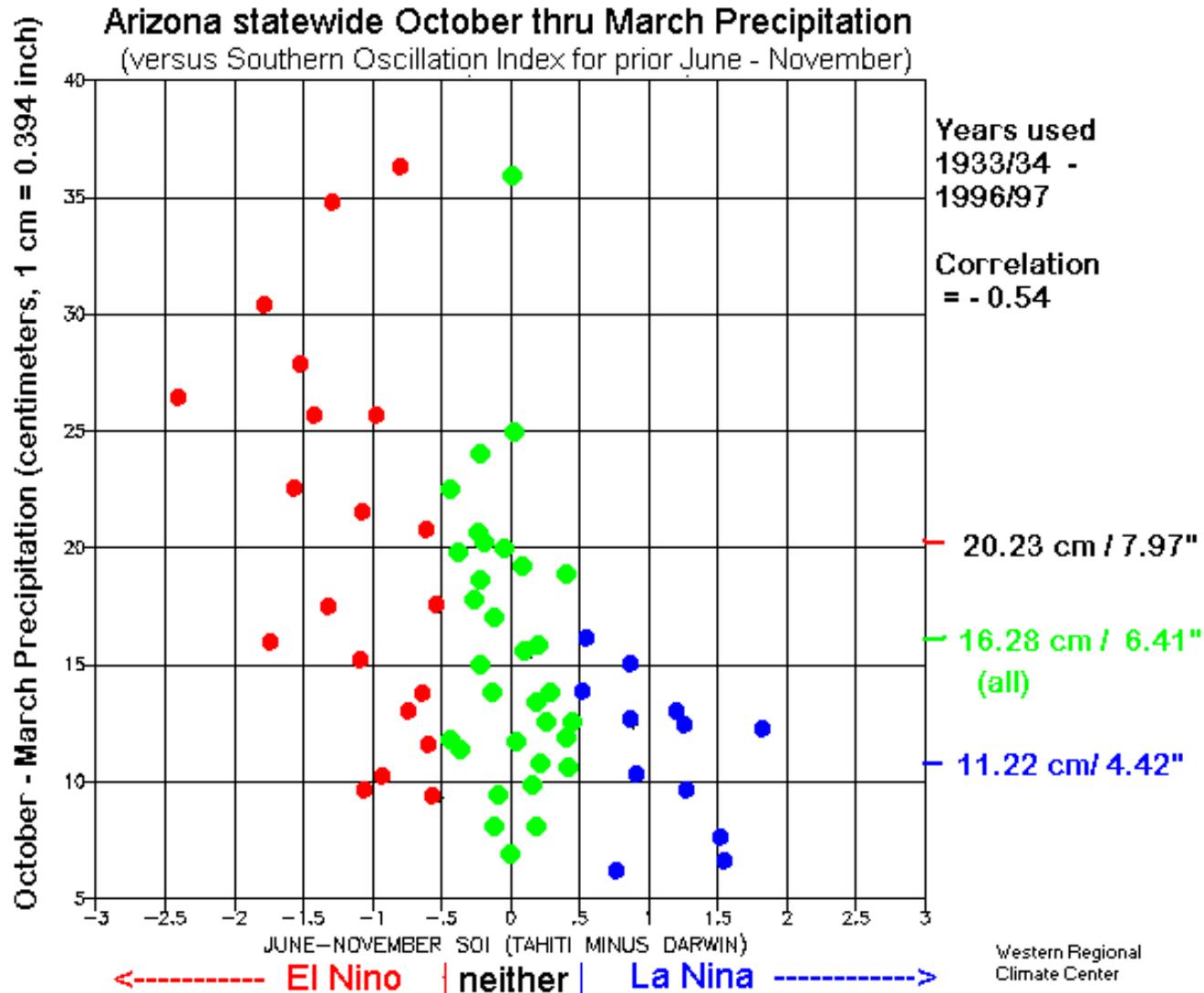


# El Niño / La Niña

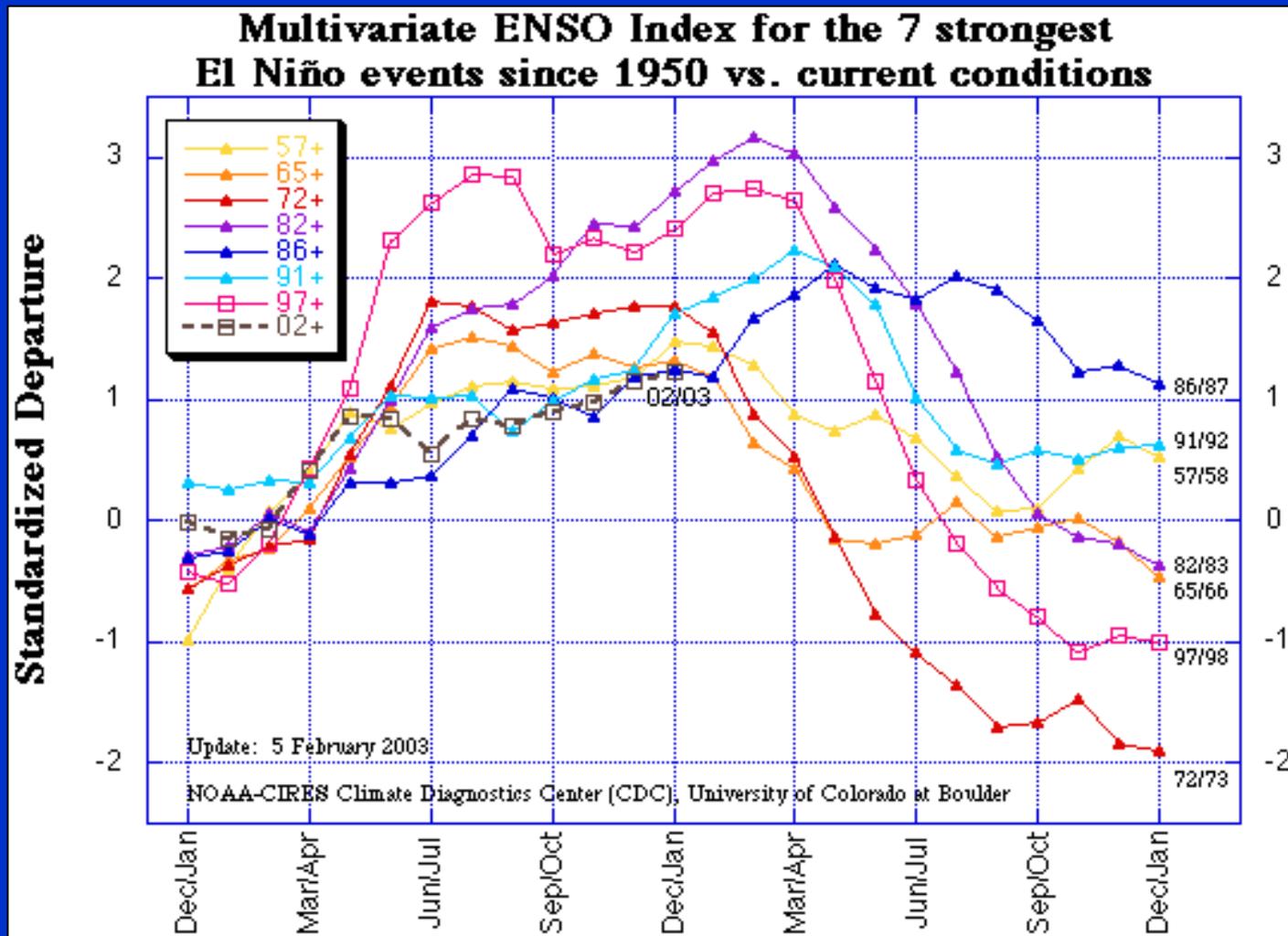


Sea Surface  
Height

# Local ENSO Connection

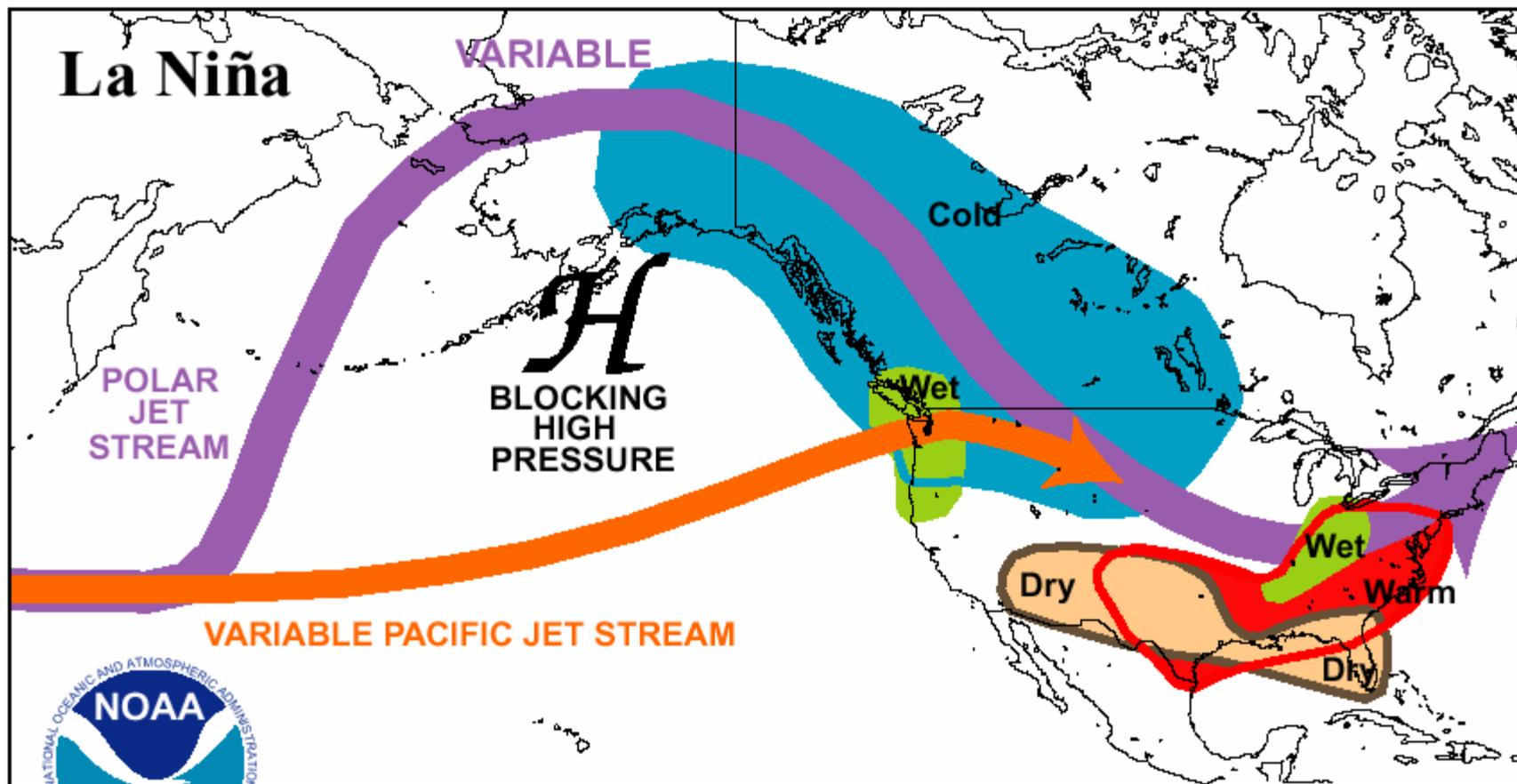


# El Nino Comparisons



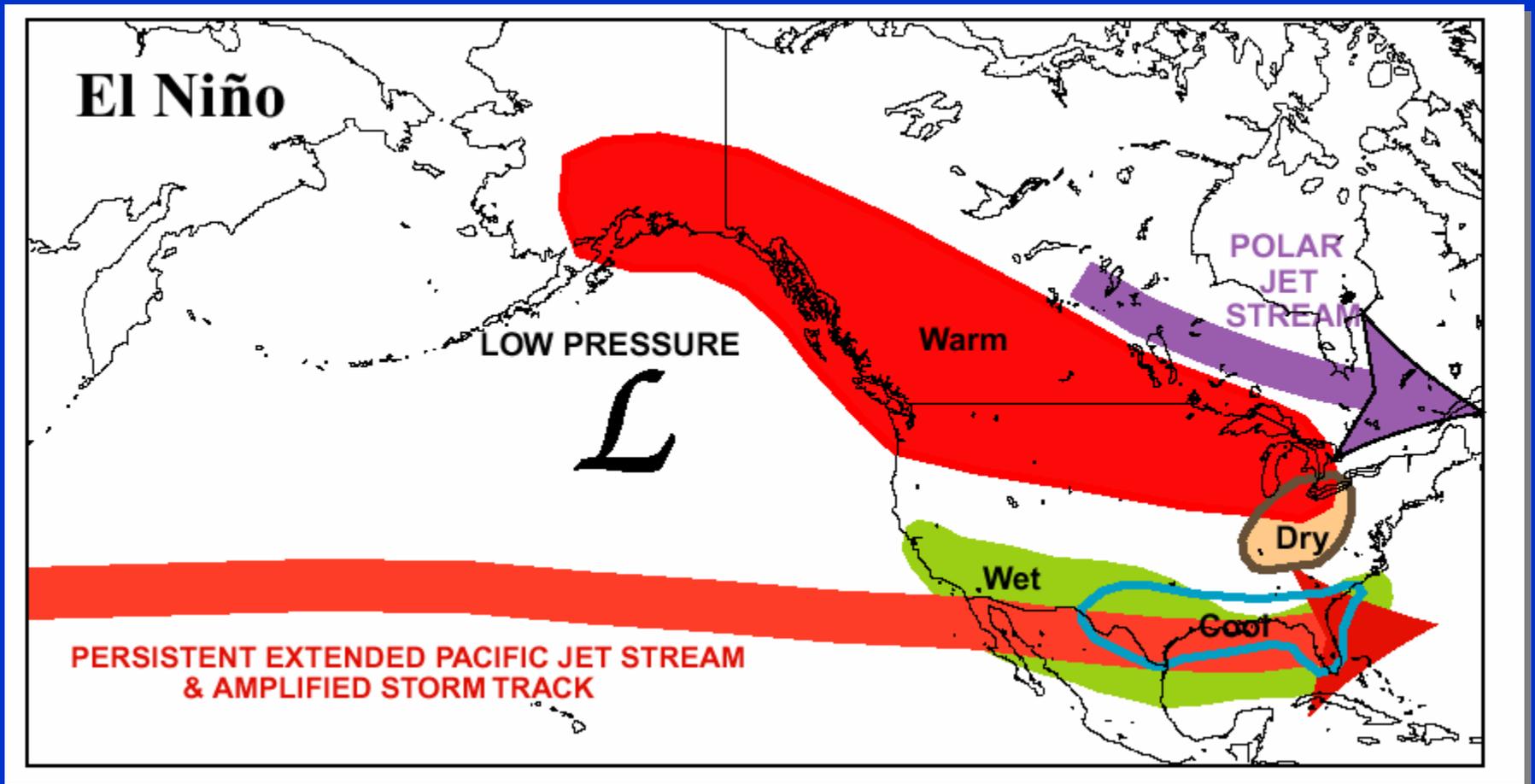
(From <http://www.cdc.noaa.gov/>)

# Dominant Circulation Pattern: La Nina Winter

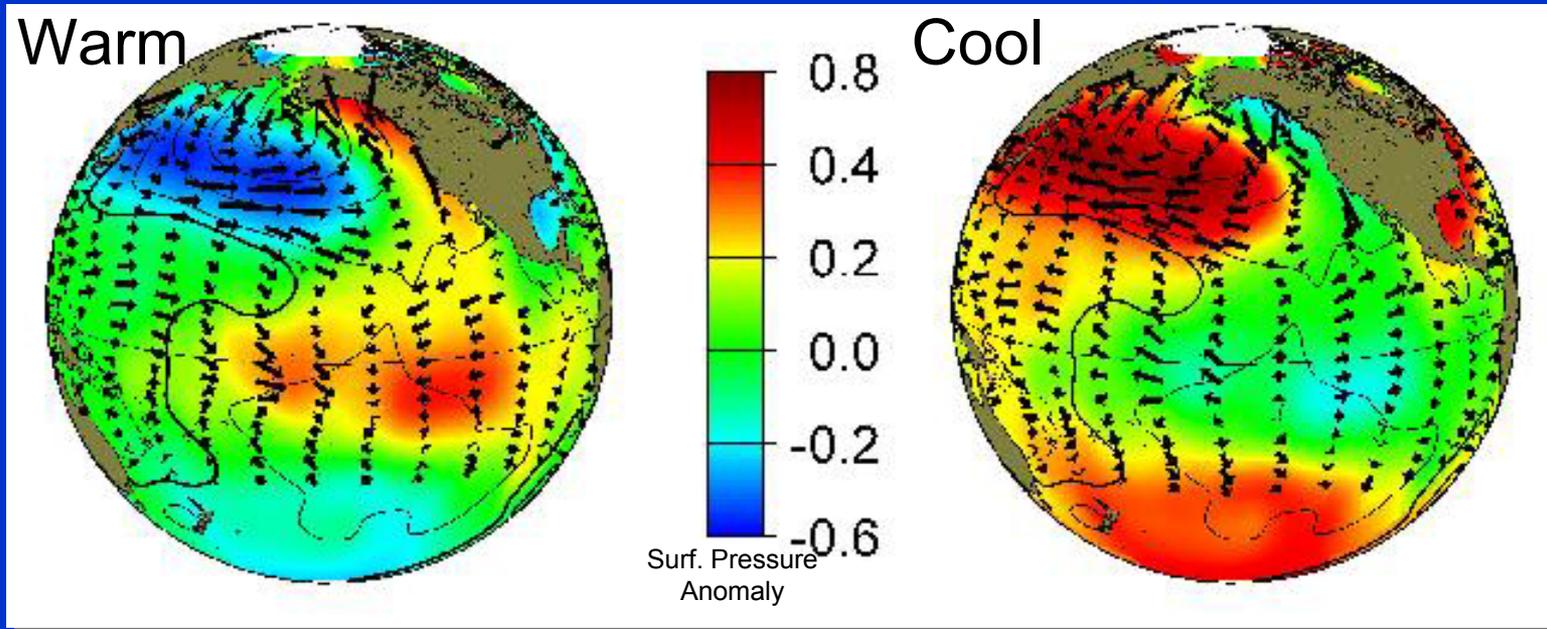


Climate Prediction Center/NCEP/NWS

# Dominant Circulation Pattern: El Niño Winter



# Pacific Decadal Oscillation



(from <http://tao.atmos.washington.edu/pdo>)

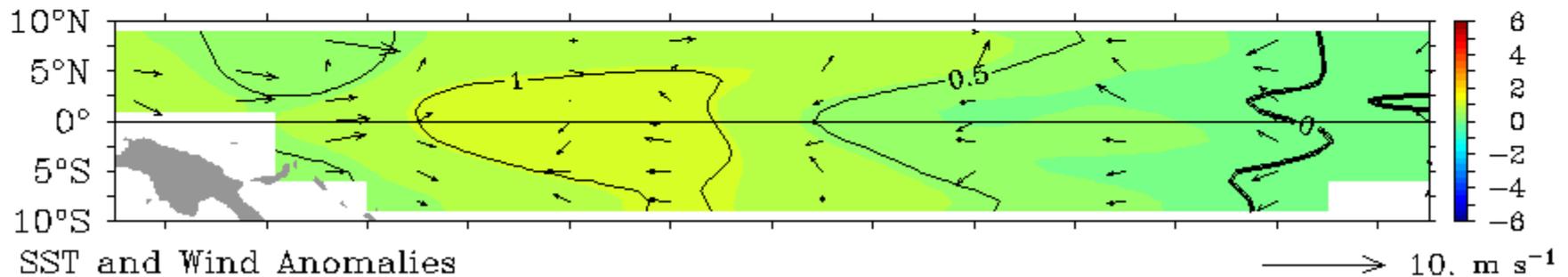
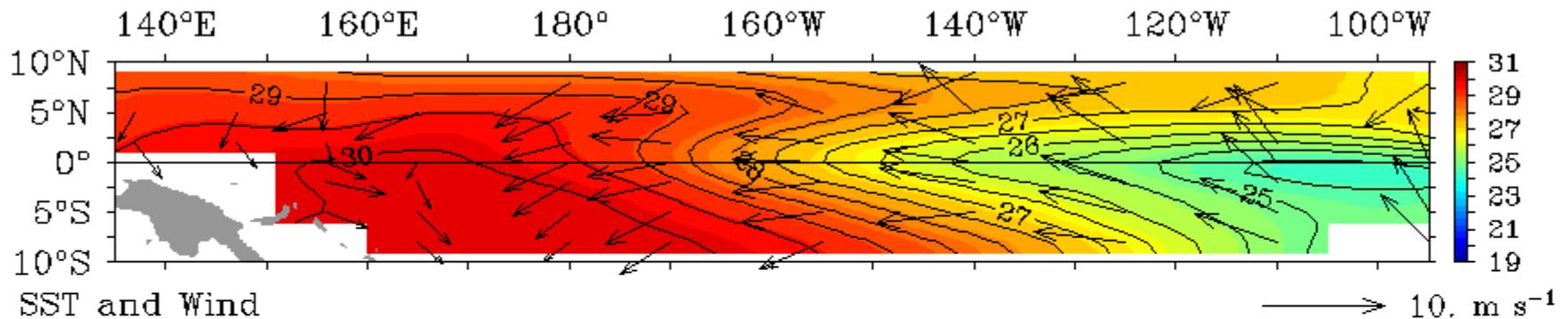
| Period       | North Pacific SSTs | Southwest Winters |
|--------------|--------------------|-------------------|
| 1920s-1940s  | Cold               | Wetter            |
| 1940s-1970s  | Warm               | Drier             |
| 1970s-1990s  | Cold               | Wetter            |
| 1995-present | Warm               | Drier?            |

(from Pagano 1999)

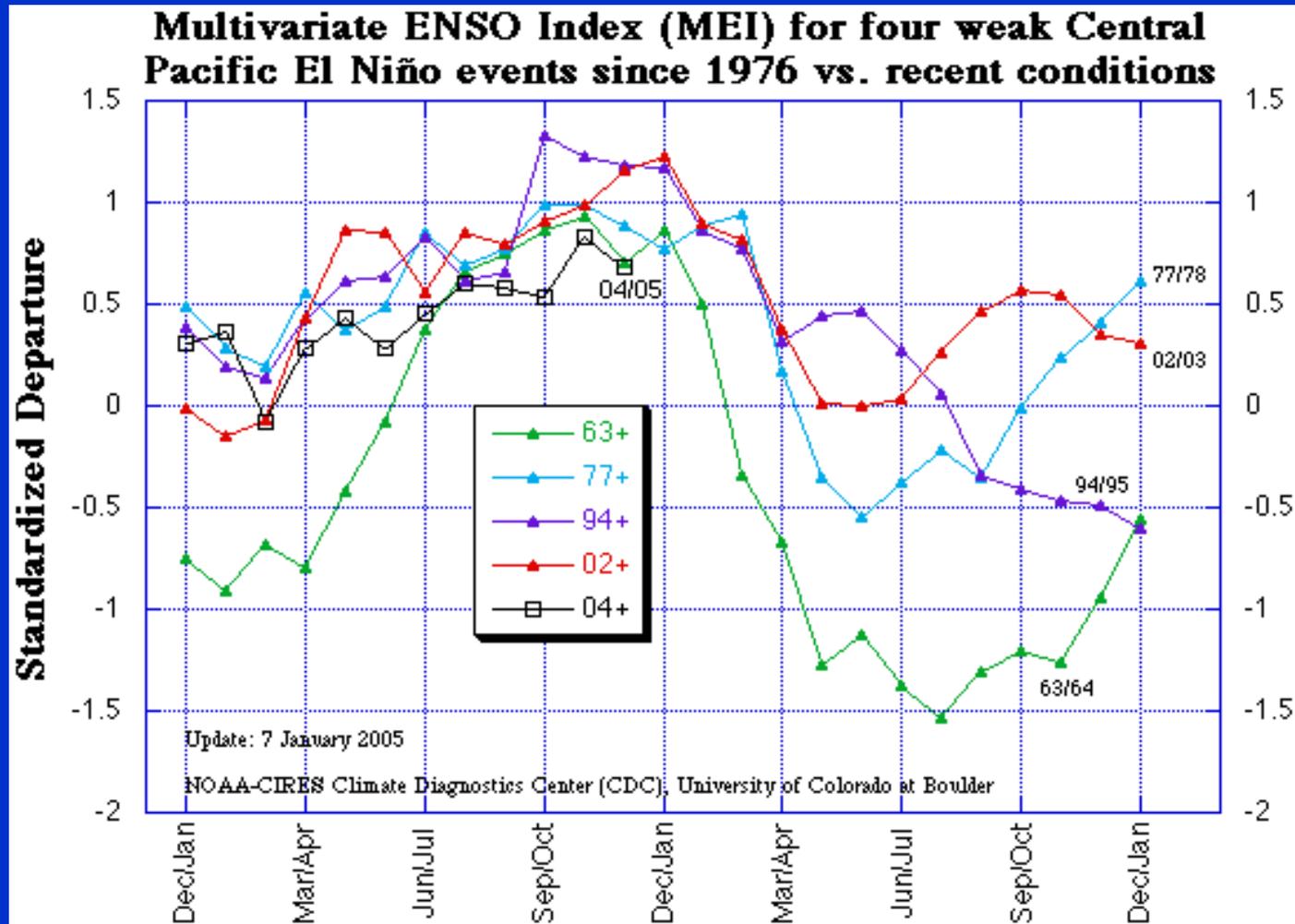
# Recent Conditions

TAO/TRITON Monthly Data January 2005

SST (°C)



# ENSO Comparison

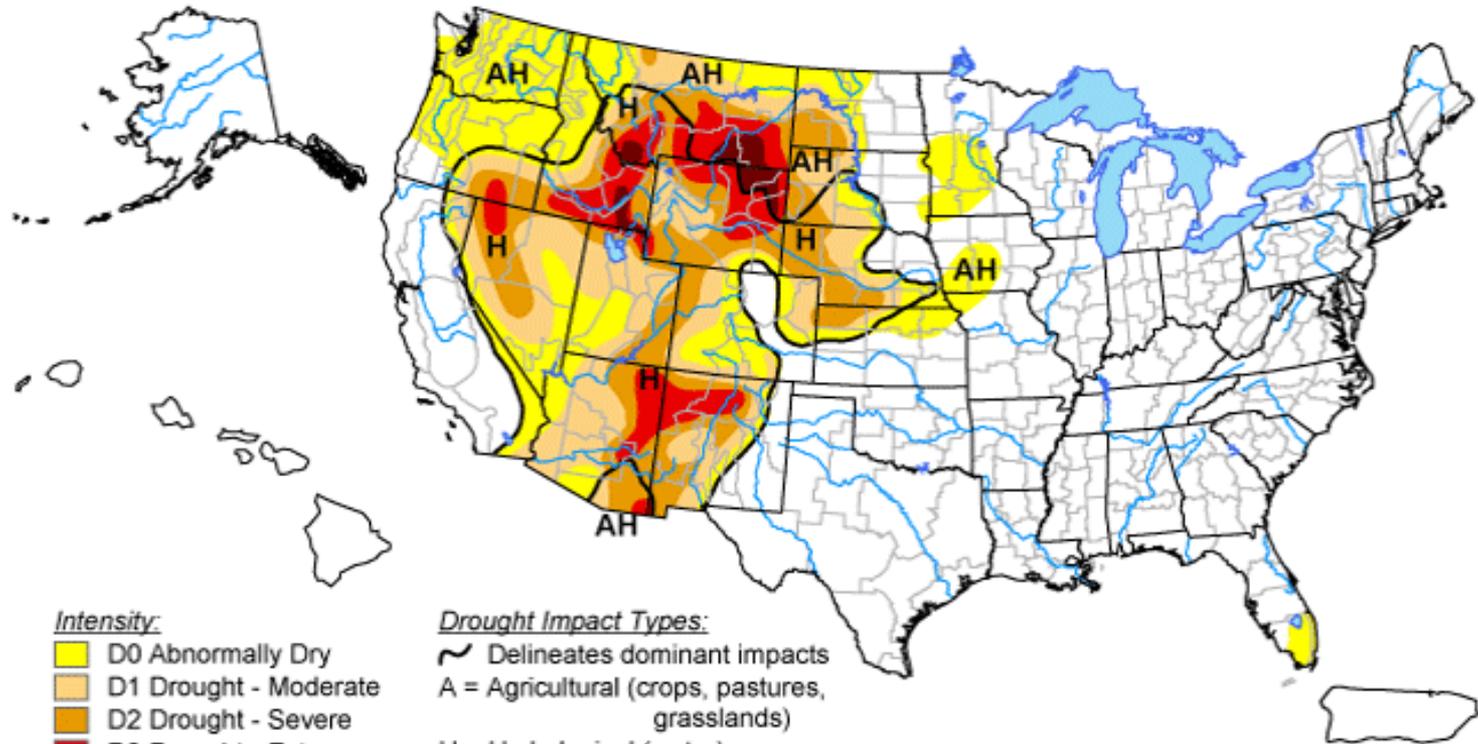


# Climate Monitoring and Prediction

# National Products

## U.S. Drought Monitor

January 11, 2005  
Valid 7 a.m. EST



Intensity:

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

Drought Impact Types:

- Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)
- (No type = Both impacts)

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

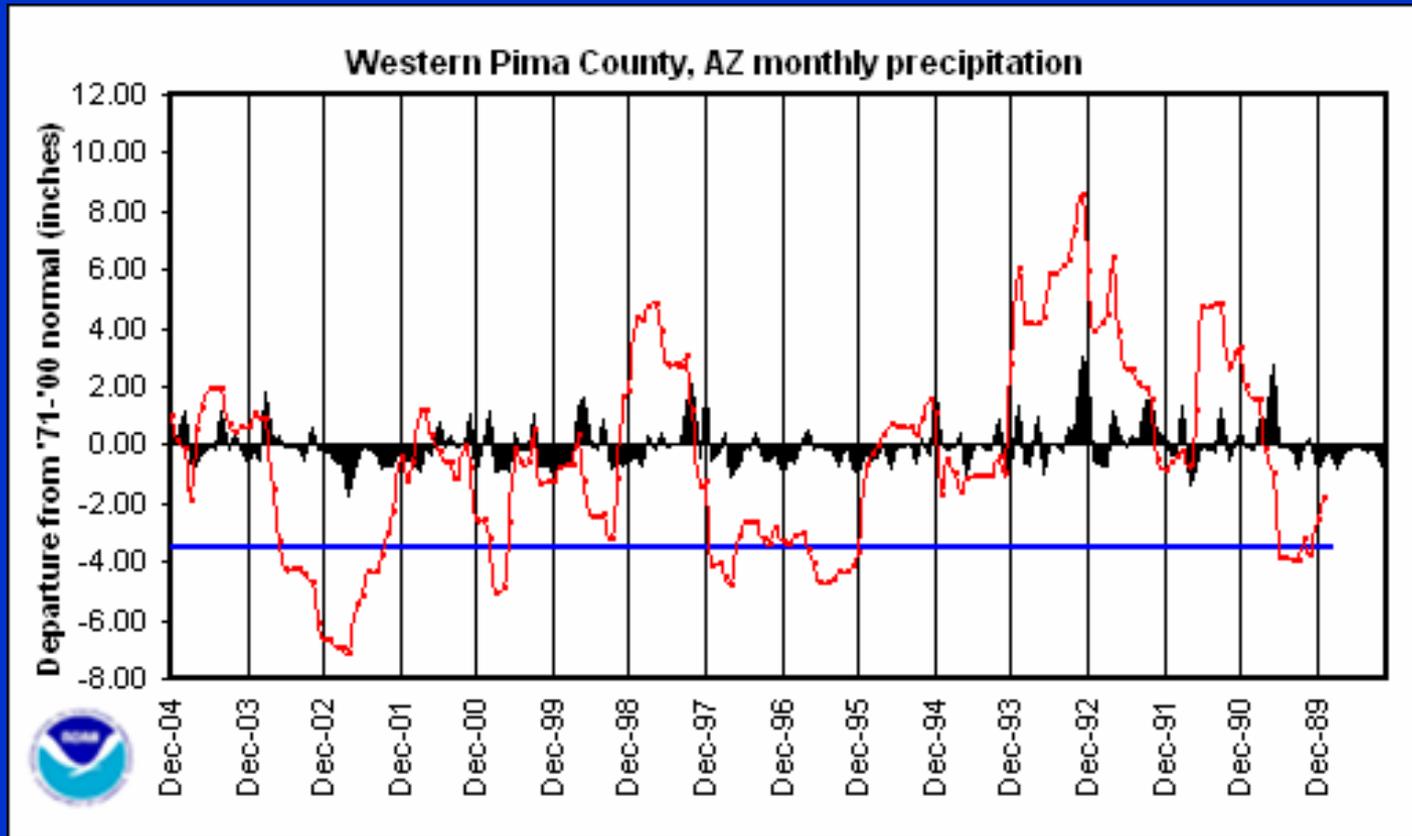
<http://drought.unl.edu/dm>



Released Thursday, January 13, 2005

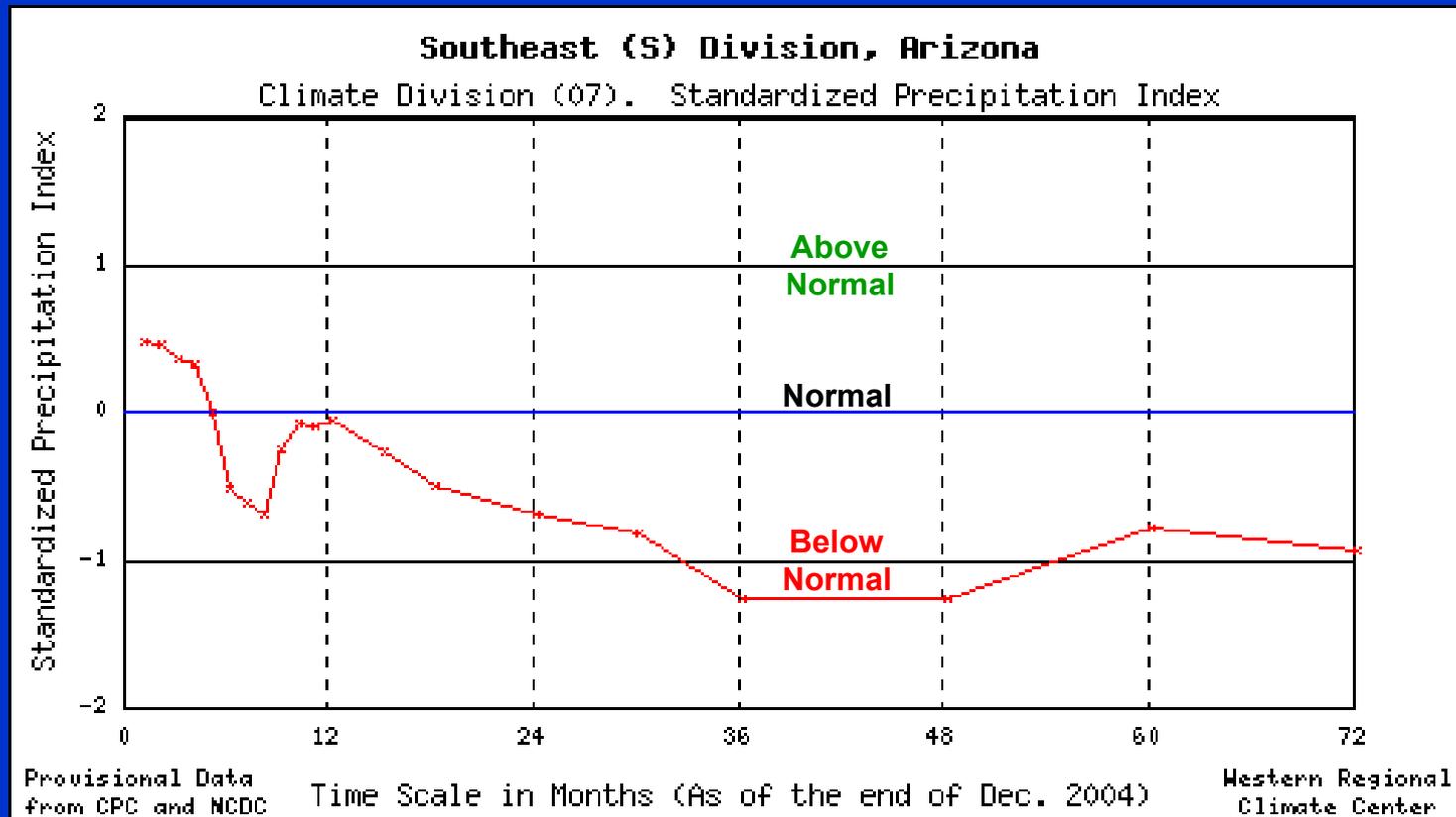
Author: Mark Svoboda, NDMC

# Accumulated Precipitation



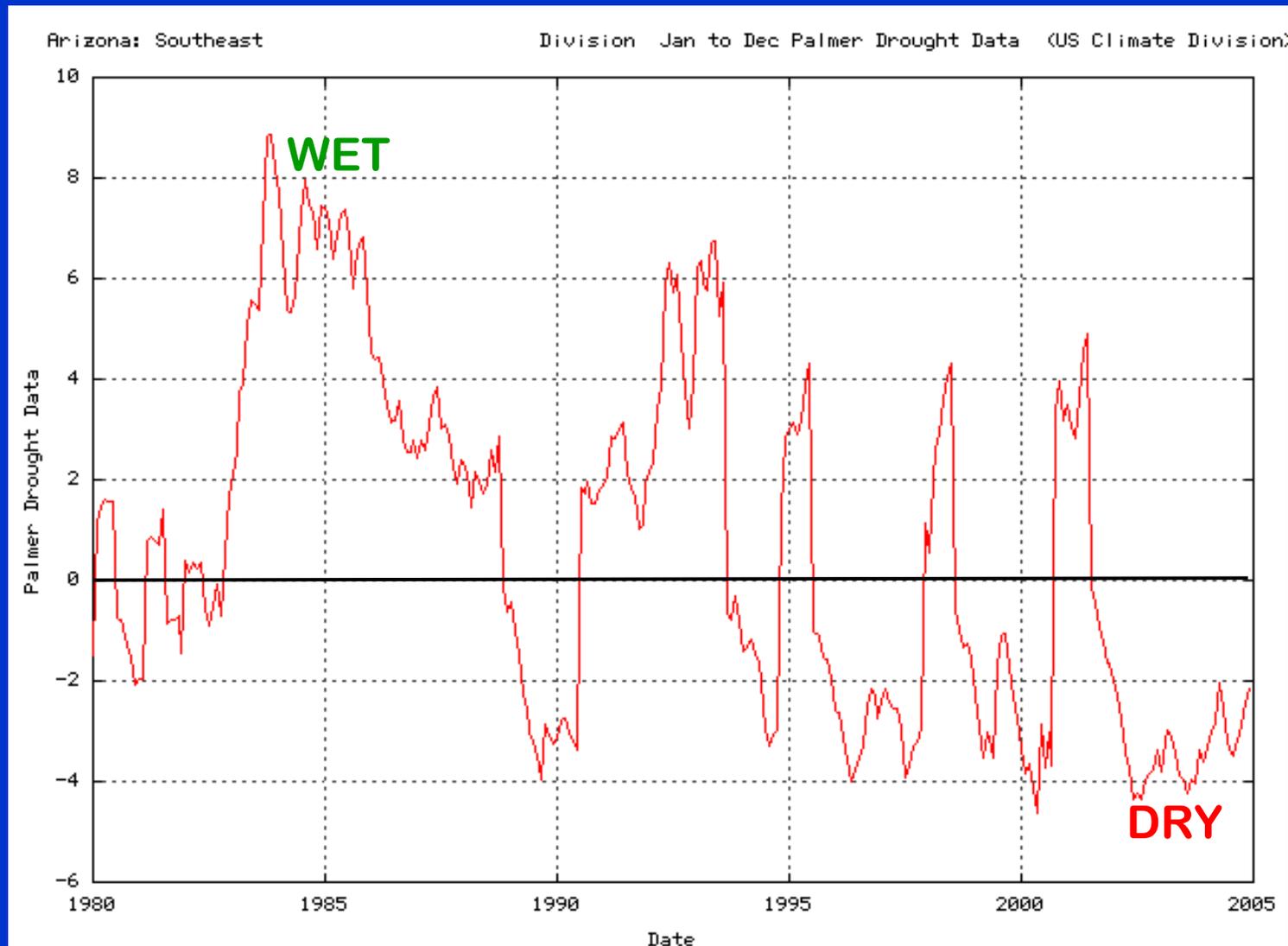
(from <http://www.wrh.noaa.gov/twc>)

# Standardized Precipitation Index



- Drought index like the Palmer Severity Drought Index
- More responsive to short term changes in precipitation
- Evaluates precip. deviations at different timescales (short-term and long-term)

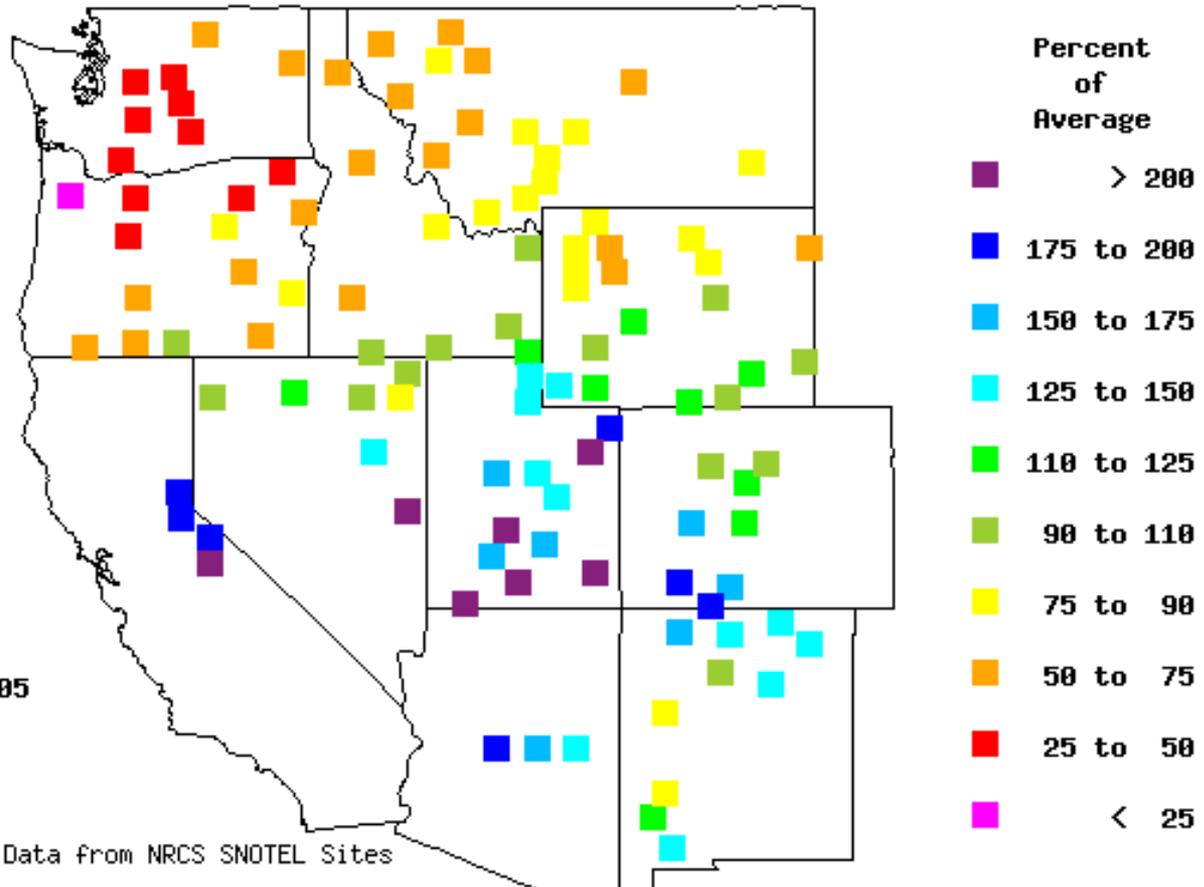
# Palmer Drought Severity Index



(From <http://www.cdc.noaa.gov/>)

# Snowpack

Basin Average Snow Water Content. ( % of Average.)



Report Date:

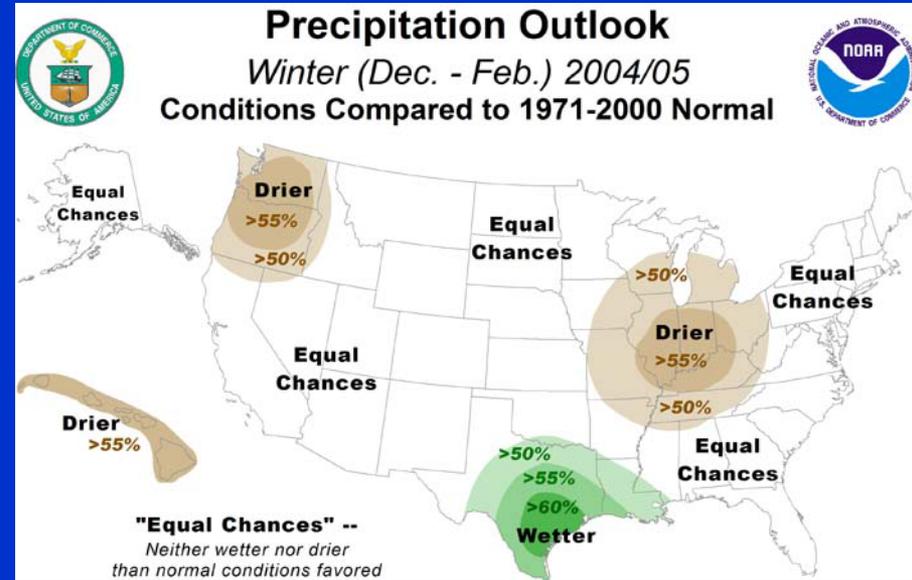
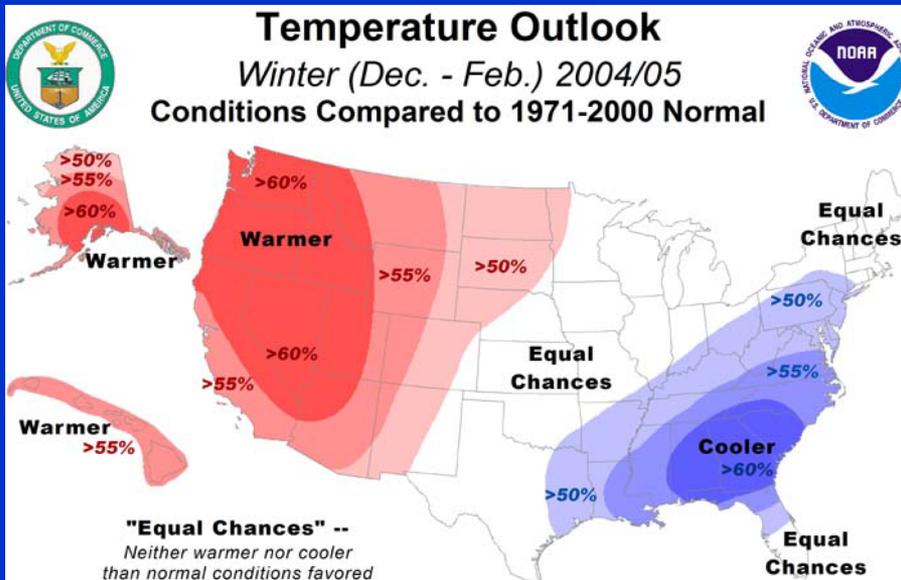
JANUARY 19 , 2005

Provisional Data  
Based on Mountain Data from NRCS SNOTEL Sites

Data provided by  
Water and Climate Center  
National Resource Conservation Service  
Portland, Oregon

Western Regional Climate Center  
Desert Research Institute  
Reno, Nevada

# Forecasts for this Winter: Dec-Feb '05

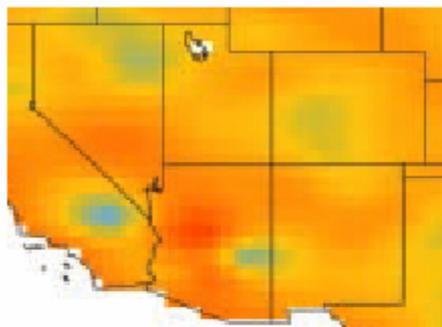


(From <http://www.cpc.noaa.gov>)

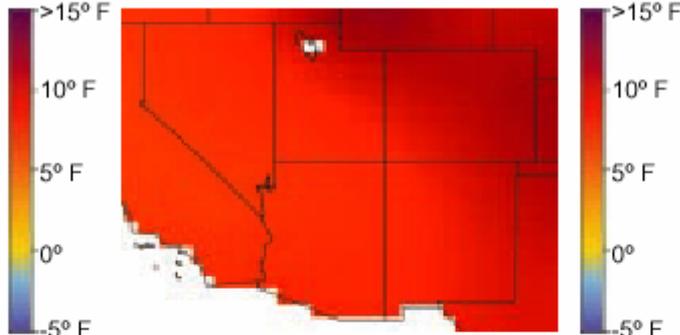
- Forecasts are based on statistical/dynamical models and expert assessment
- Greater forecast confidence during strong El Nino/La Nina conditions

# Climate Change

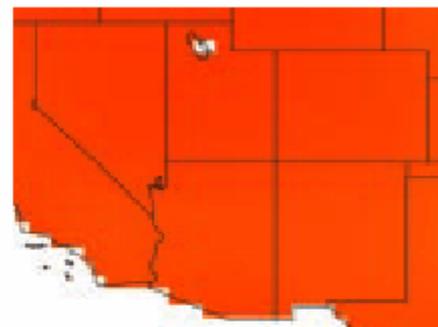
Observed 20th



Canadian Model 21st

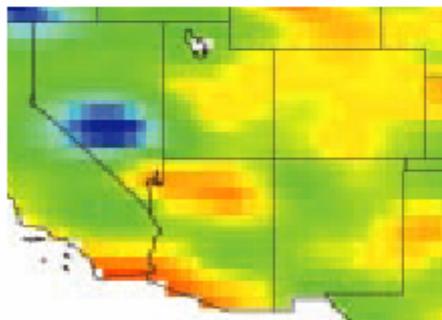


Hadley Model 21st

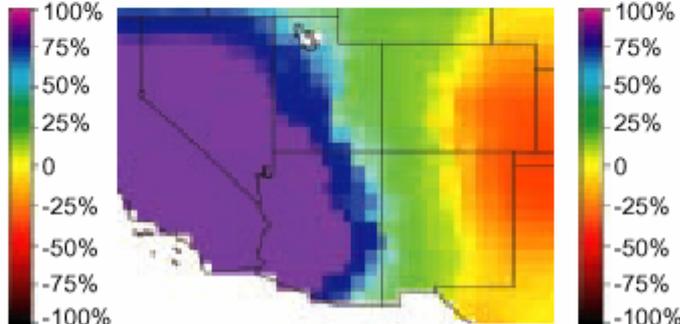


**Figure 12.** Temperature trend comparisons between 20th century observation and modeled scenarios of the 21st century. Compiled by: Benjamin Felzer, National Center for Atmospheric Research

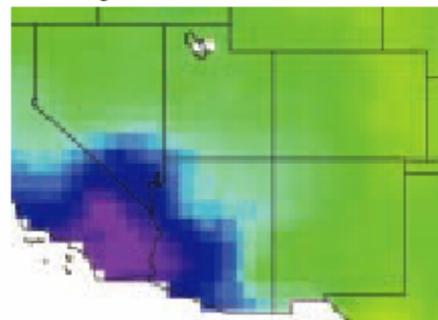
Observed 20th



Canadian Model 21st



Hadley Model 21st



**Figure 13.** Precipitation trend comparisons between 20th century observation and modeled scenarios of the 21st century. Compiled by: Benjamin Felzer, National Center for Atmospheric Research

# Key Summary Points

- Southeast AZ and seasonal precip
  - Winter storms and summer monsoon
  - Different mechanisms and variability
- El Nino and La Nina teleconnections with AZ
  - El Nino usually means above normal winter precip (not always consistent)
  - La Nina means below normal
  - PDO?
- Many monitoring products are available on the web; precipitation still difficult to find
- Use climate forecasts carefully

# Resources

- Climate Assessment for the Southwest  
(<http://www.ispe.arizona.edu/climas>)
- National Weather Service  
(<http://www.weather.gov>)
- Climate Prediction Center  
(<http://www.cpc.noaa.gov/>)
- Western Regional Climate Center  
(<http://wrcc.dri.edu/>)
- National Drought Monitor  
(<http://www.drought.unl.edu/dm/index.html>)
- **Climate Science Applications Program**  
(<http://cals.arizona.edu/climate>)