2016-2017 Winter Outlook and Challenges in Seasonal Forecasting: El Niño, La Niña, and La Nada

WINTER SEASON OUTLOOK AND IMPACTS FORUM
Las Cruces, New Mexico
October 25, 2016

Gregg Garfin, The University of Arizona

Institute of the Environment

CLIMAS
Climate Assessment for the Southwest

COLLEGE OF AGRICULTURE & LIFE SCIENCES
School of Natural Resources & the Environment

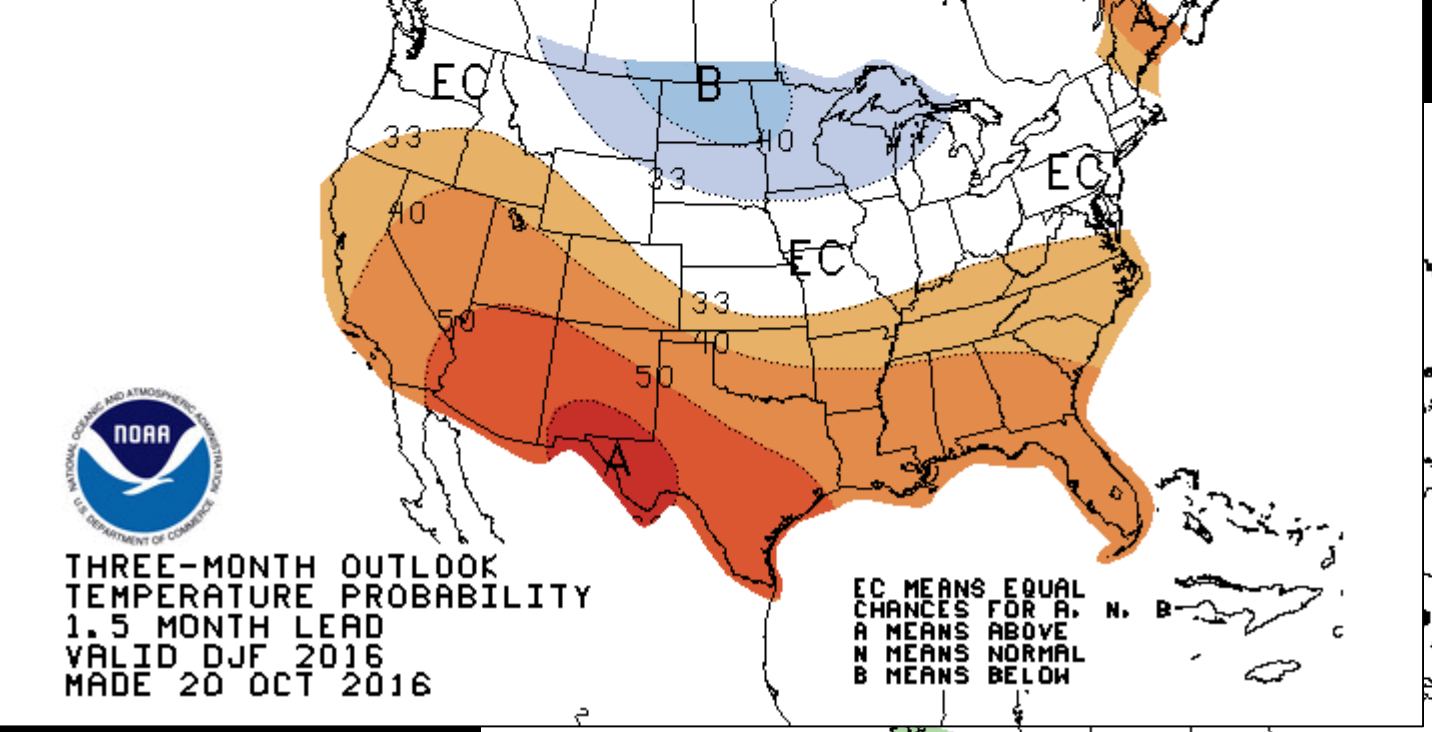
COOPERATIVE EXTENSION 1914-2014 100 SMITH-LEVER ACT EXTENDING KNOWLEDGE CHANGING LIVES

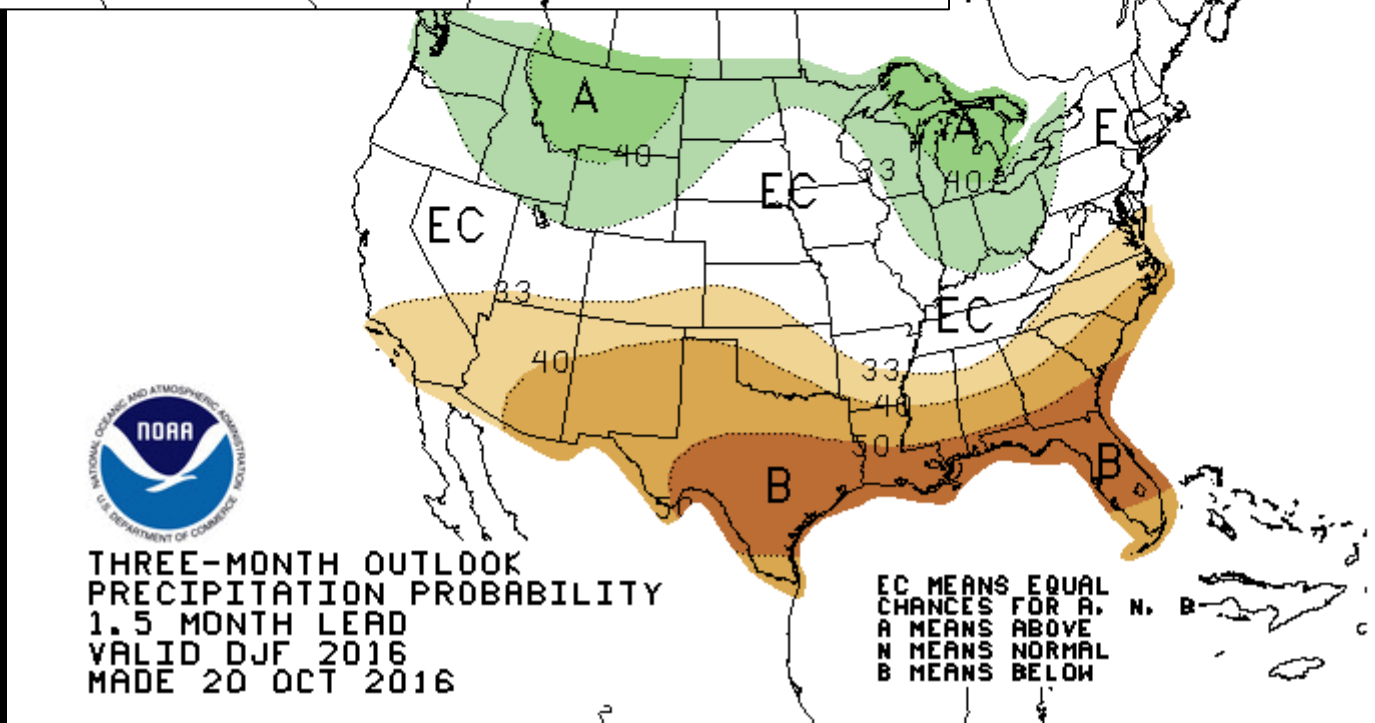
The Next 30-45 Minutes

- Seasonal forecasting
- El Nino-Southern Oscillation
- Focus on La Niña and New Mexico
- Winter 2016-2017 Seasonal Outlook

Three Key Points

- Seasonal precipitation forecasting skill depends on El Nino-Southern Oscillation
- A La Niña Watch suggests development of a weak La Niña this winter through early spring
- Forecasts predict slightly increased chances of lower seasonal precipitation and increased chances of higher seasonal temperature





NOAA Seasonal Outlooks – October 2016

http://www.cpc.ncep.noaa.gov/products/forecasts/

www.usatoday.com/story/weather/2016/09/15/fall-forecast-la-nada/90412734/

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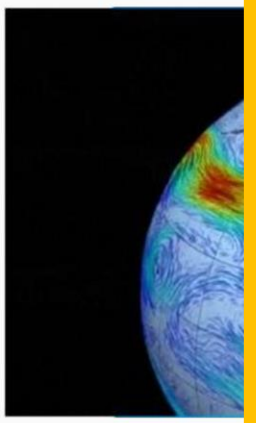
Warm fall predicted, but 'La Nada' is a challenge for the forecast

2235

Doyle Rice , USA TODAY

25



Don't break those sweaters just y
federal forecasters announced. B

Sections

The Washington Post

Capital Weather Gang

El Niño, La Niña, La Nada and forecast implications for the upcoming winter

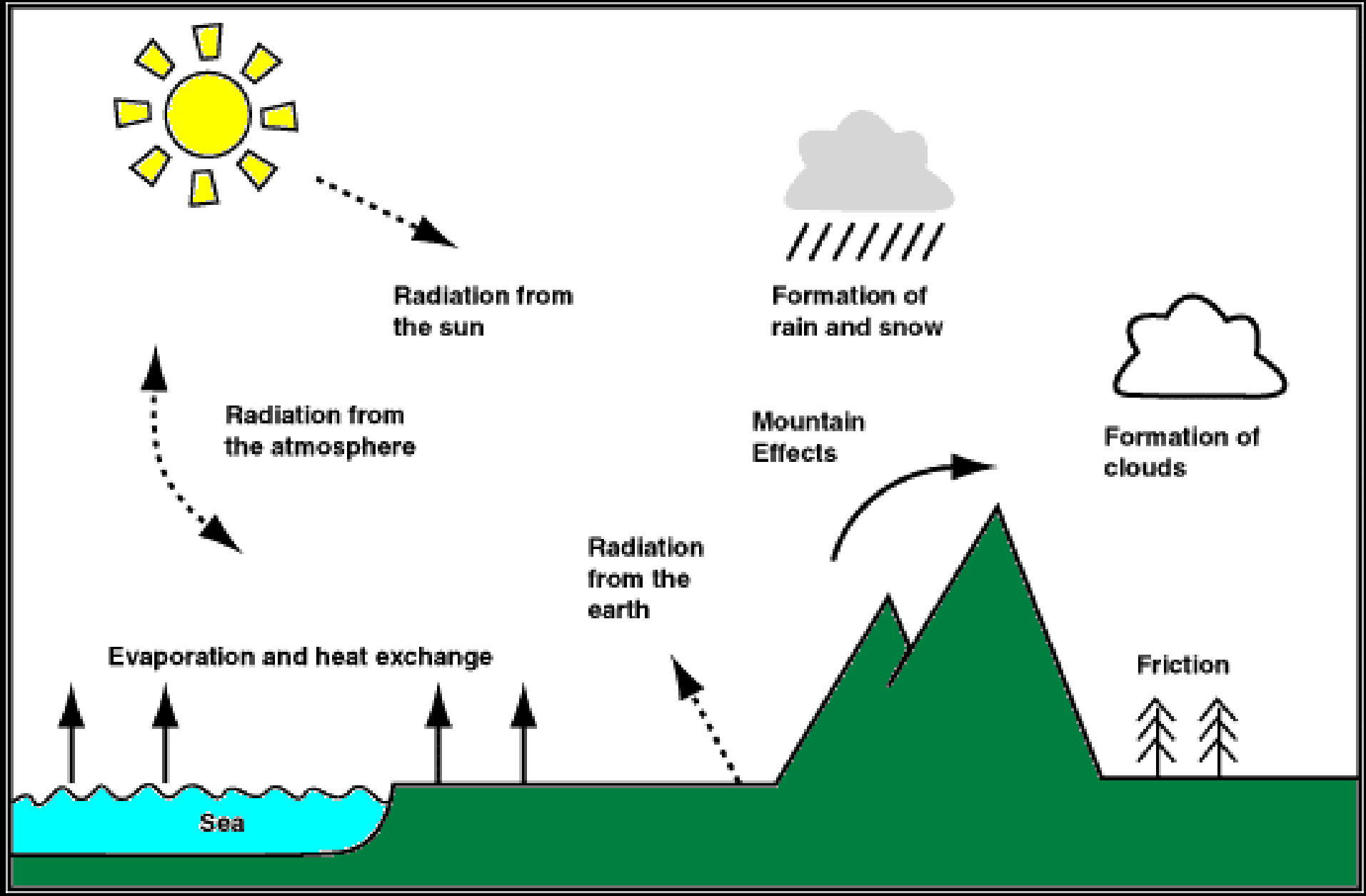
By Rick Grow September 23, 2013

SFGATE http://www.sfgate.com/bayarea/article/California-drought-worries-rise-as-La-Ni-a-10002760.php

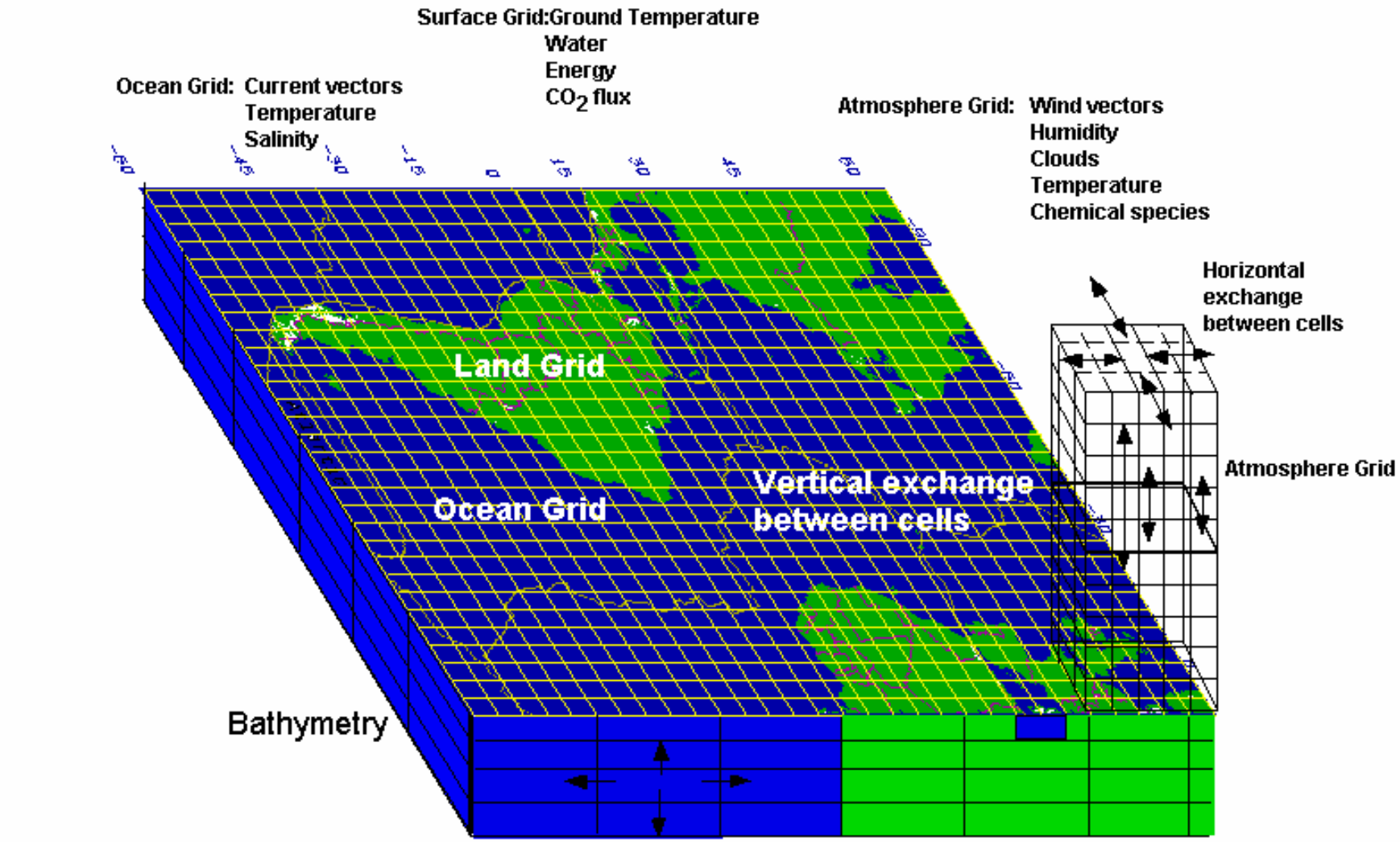
California drought worries rise as La Niña reemerges in forecast

By Peter Fimrite Updated 1:08 pm, Friday, October 21, 2016

Seasonal Forecasting



http://www.atmo.arizona.edu/students/courselinks/fall12/atmo336/lectures/sec6/modeling.html



Long Run of GCM at low resolution

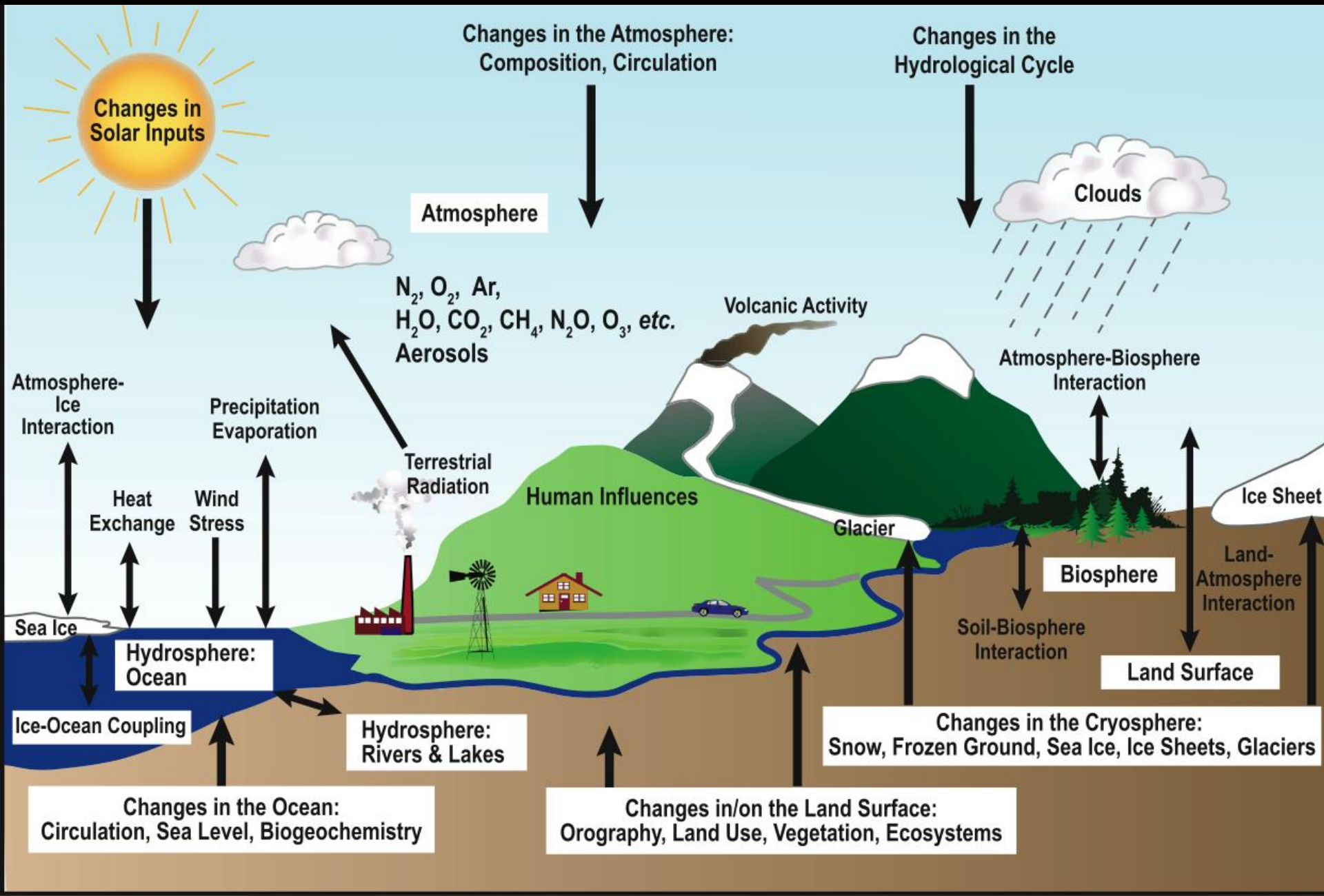
Statistical interpolation

Embedded regional model

Timeslice at higher resolution

Local Climate Prediction

http://www.atmo.arizona.edu/students/courselinks/fall12/atmo336/lectures/sec6/modeling.html



IPCC Fourth Assessment – 2007

Derivation [edit]

Let $\Sigma_{XX} = \operatorname{cov}(X, X)$ and $\Sigma_{YY} = \operatorname{cov}(Y, Y)$. The parameter to maximize is

$$\rho = \frac{a' \Sigma_{XY} b}{\sqrt{a' \Sigma_{XX} a} \sqrt{b' \Sigma_{YY} b}}.$$

The first step is to define a change of basis and define

$$c = \Sigma_{XX}^{1/2} a,$$

$$d = \Sigma_{YY}^{1/2} b.$$

And thus we have

$$\rho = \frac{c' \Sigma_{XX}^{-1/2} \Sigma_{XY} \Sigma_{YY}^{-1/2} d}{\sqrt{c' c} \sqrt{d' d}}.$$

By the Cauchy-Schwarz inequality, we have

$$\left(c' \Sigma_{XX}^{-1/2} \Sigma_{XY} \Sigma_{YY}^{-1/2}\right) d \leq \left(c' \Sigma_{XX}^{-1/2} \Sigma_{XY} \Sigma_{YY}^{-1/2} \Sigma_{YY}^{-1/2} \Sigma_{YX} \Sigma_{XX}^{-1/2} c\right)^{1/2} (d' d)^{1/2},$$

$$\rho \leq \frac{\left(c' \Sigma_{XX}^{-1/2} \Sigma_{XY} \Sigma_{YY}^{-1} \Sigma_{YX} \Sigma_{XX}^{-1/2} c\right)^{1/2}}{(c' c)^{1/2}}.$$

https://en.wikipedia.org/wiki/Canonical_correlation

Elements of the Forecast

Dynamical modeling

- State of the ocean
- Physics of ocean and atmosphere
- Ocean-atmosphere modeling
  - Many runs
  - Many models

Elements of the Forecast

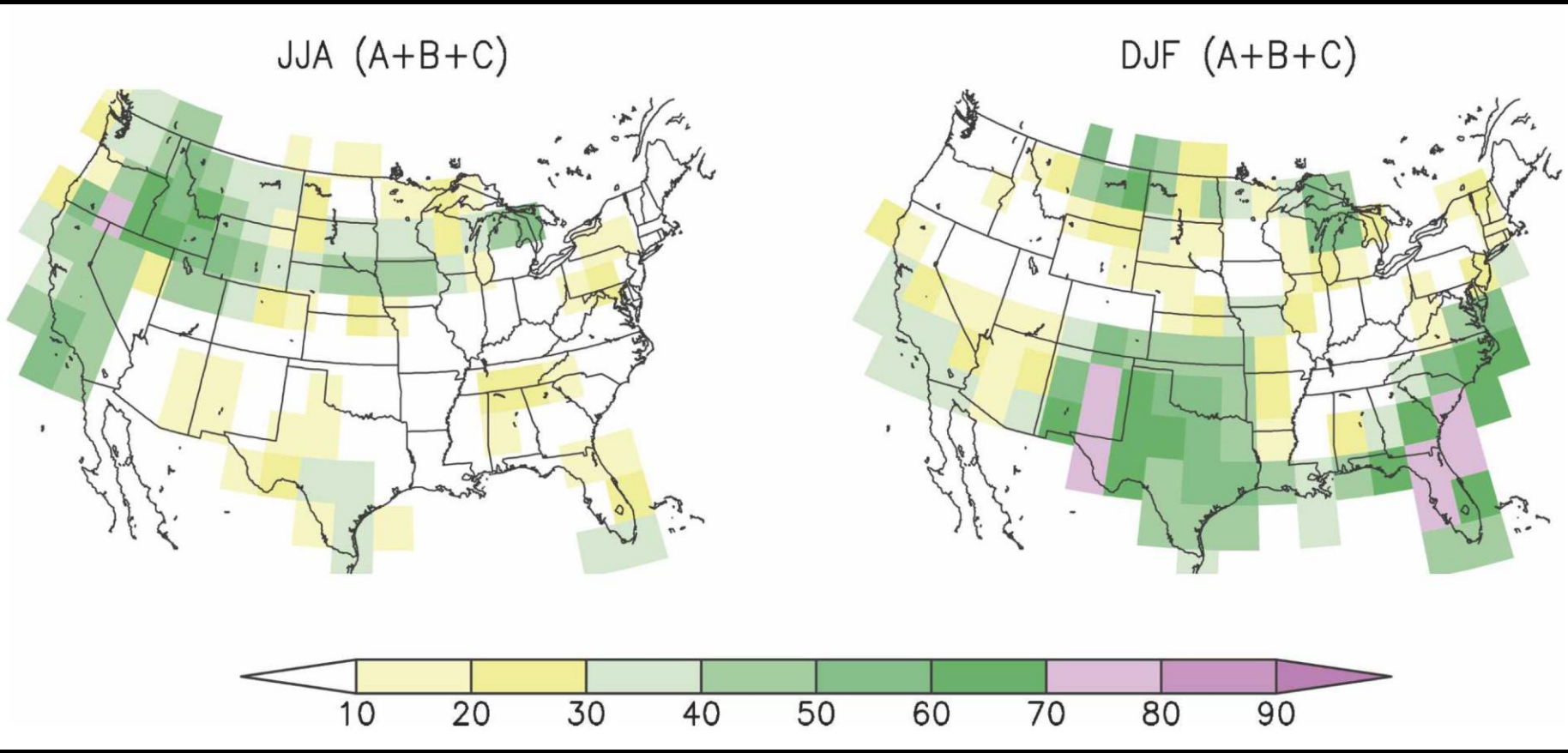
Statistical modeling

- Simple and advanced statistical methods, using historical data
  - Relationship between ocean surface temperatures and atmospheric height variations can be used to predict the time-varying changes in temperature and precipitation

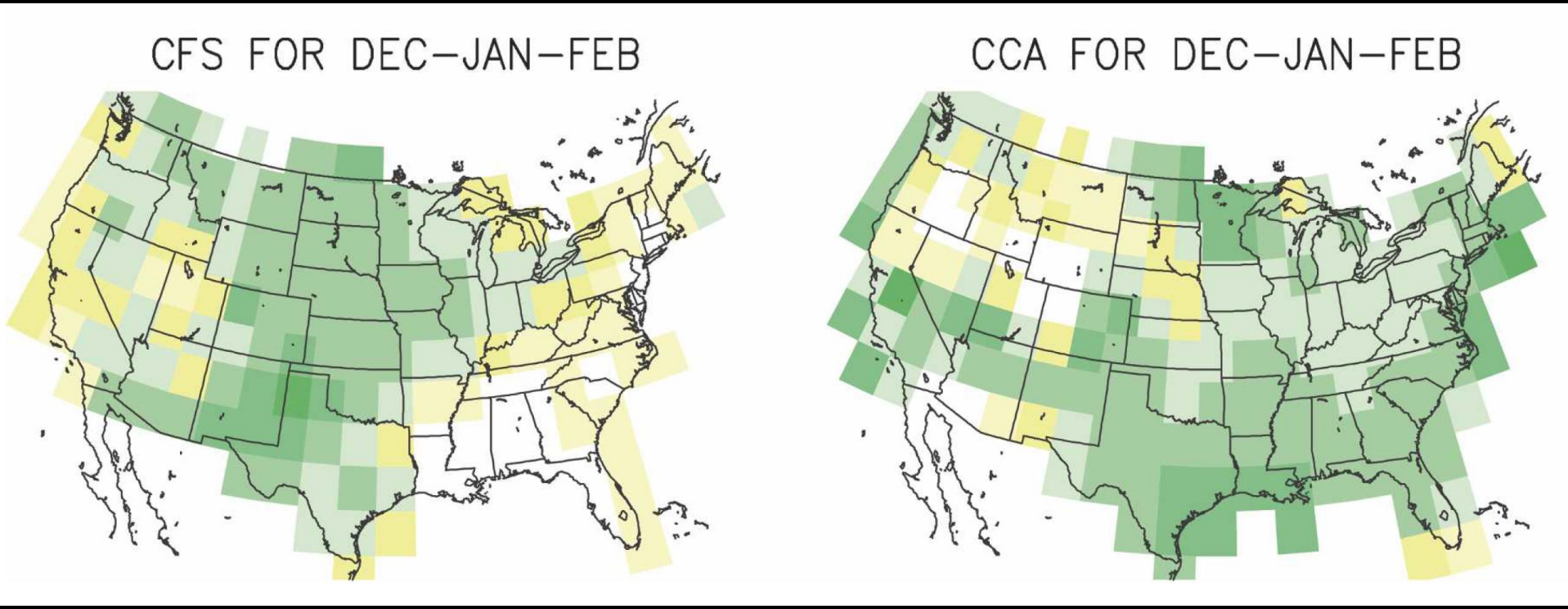
Elements of the Forecast

Consolidation and Consensus

- Model agreement
- Skill
- Guidance from experience



Example of seasonal forecast skill validation
Saha et al. 2006 – Journal of Climate



Example of seasonal forecast skill validation
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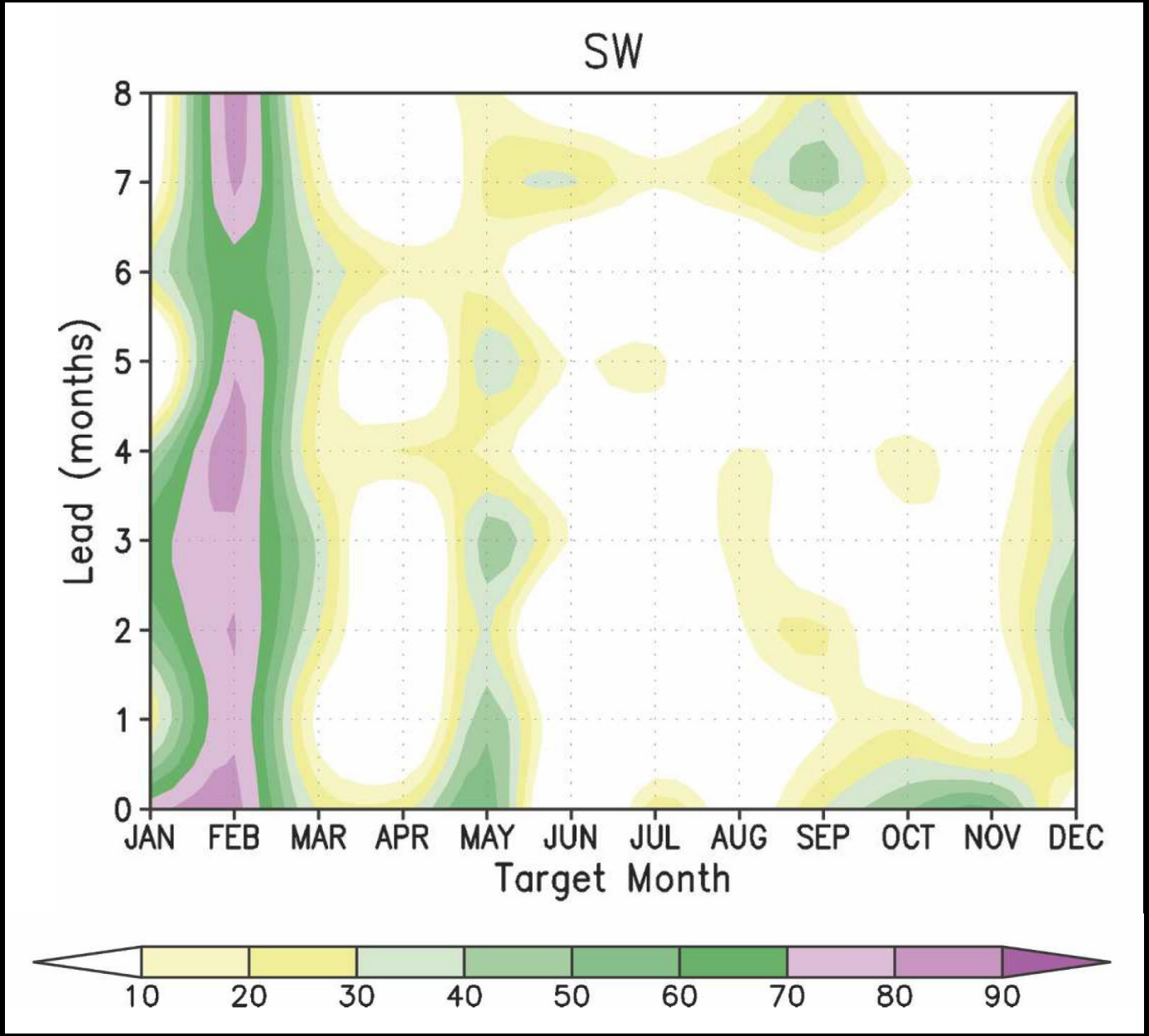

Example of seasonal forecast skill validation
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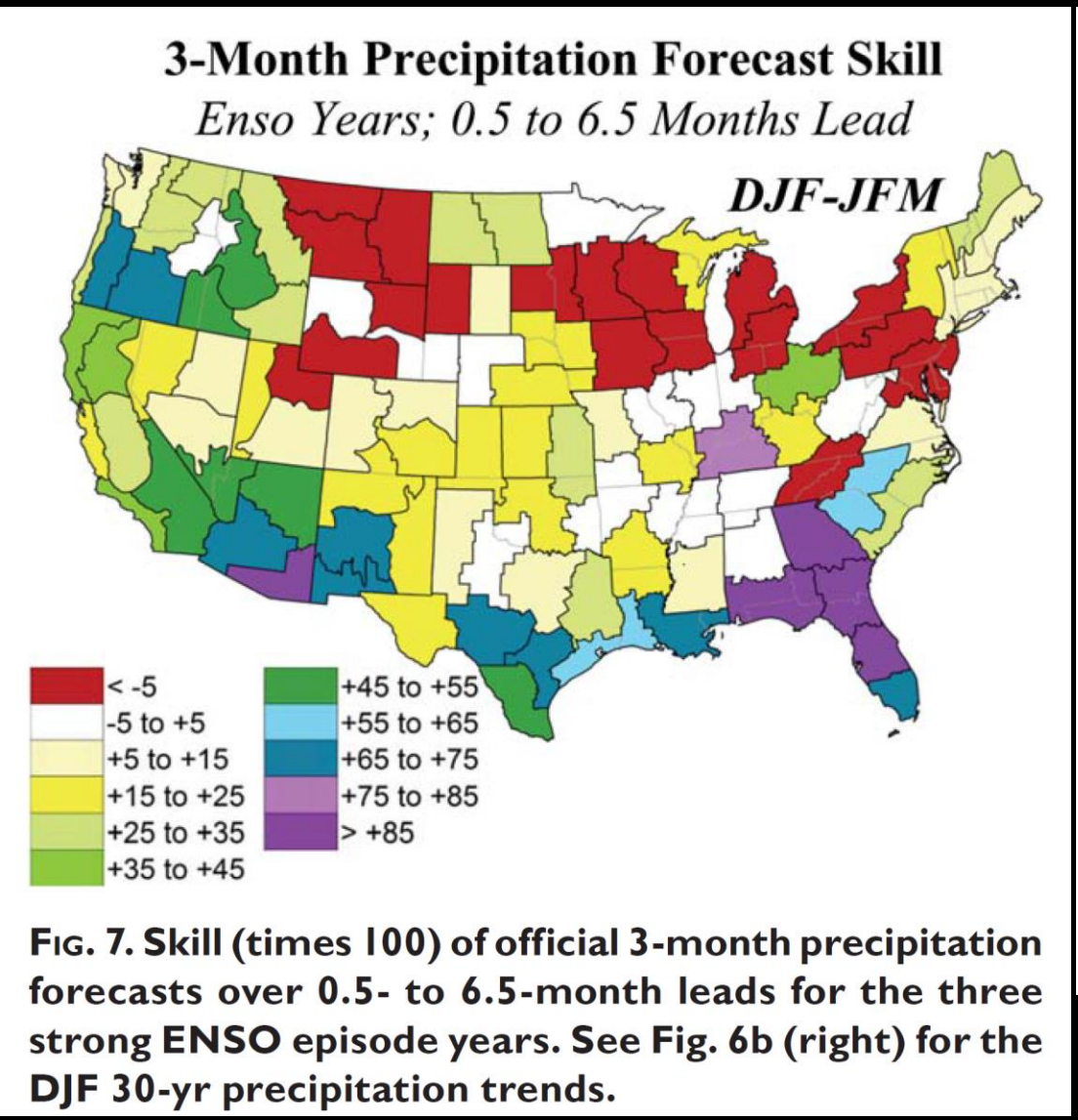
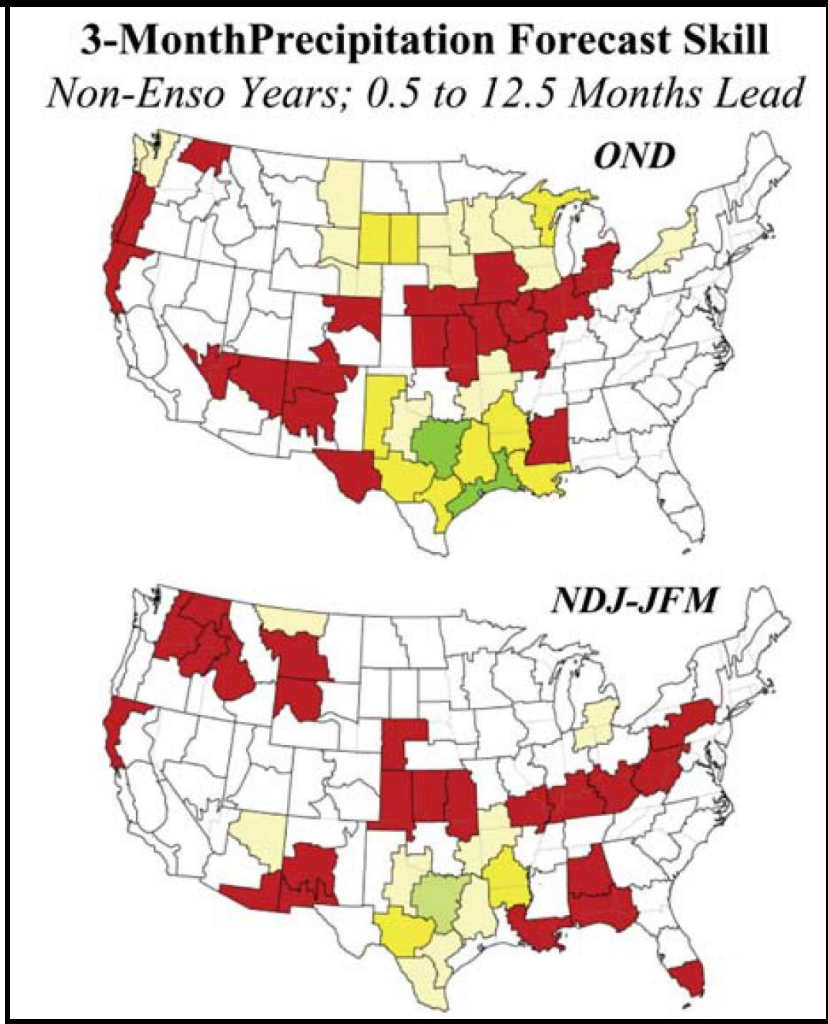


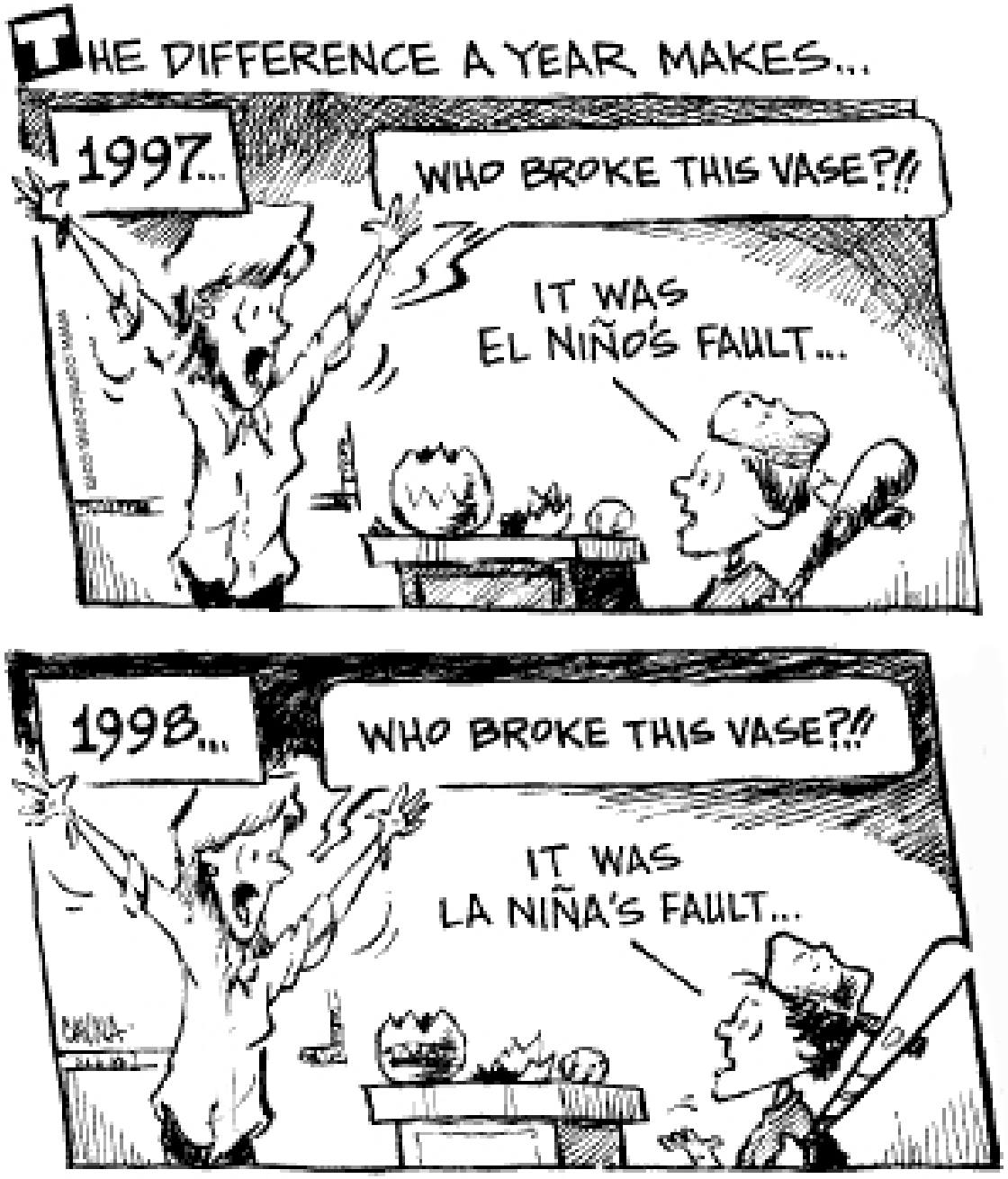
FIG. 7. Skill (times 100) of official 3-month precipitation forecasts over 0.5- to 6.5-month leads for the three strong ENSO episode years. See Fig. 6b (right) for the DJF 30-yr precipitation trends.

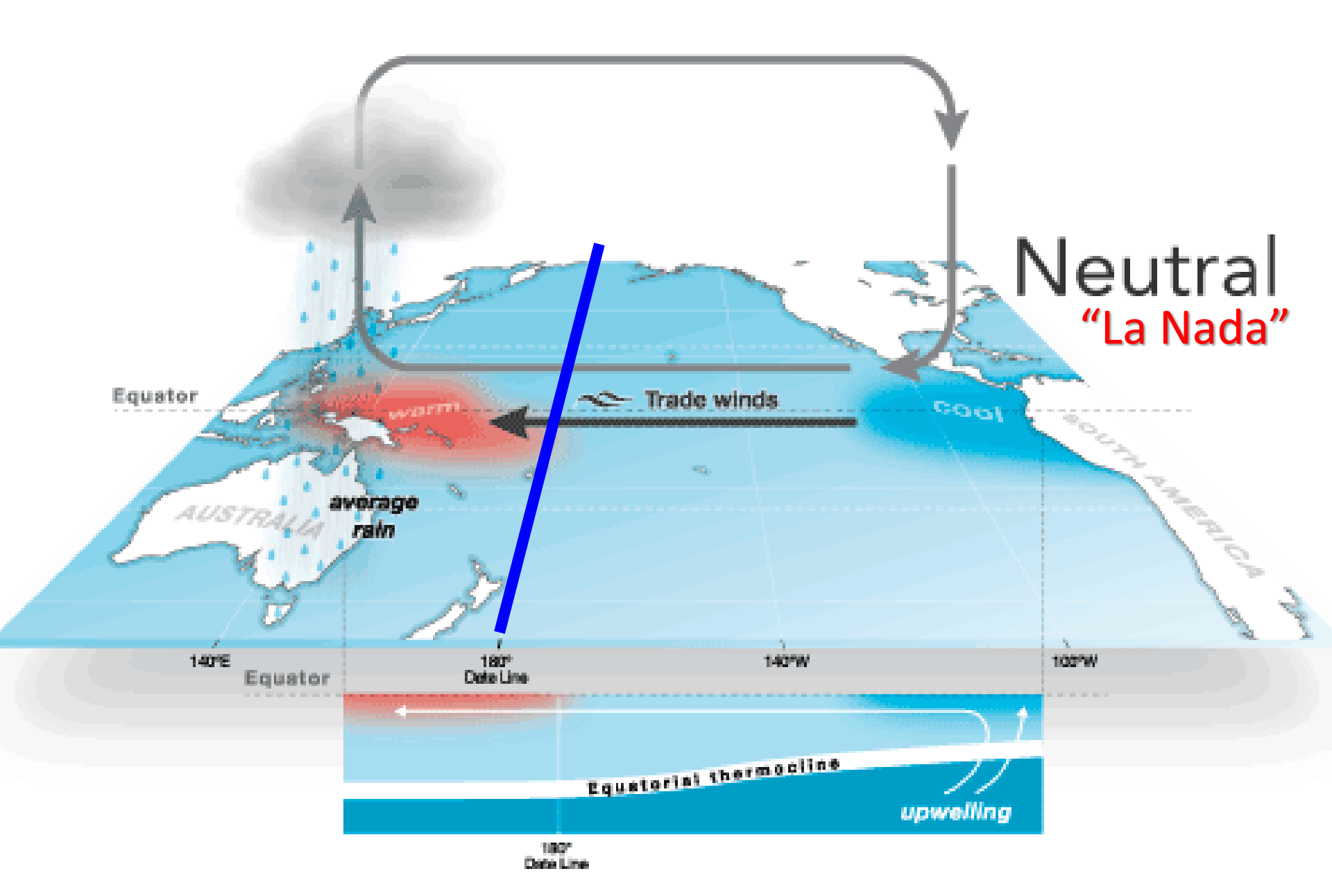


Livezey et al. 2008 – Bulletin of the American Meteorological Society

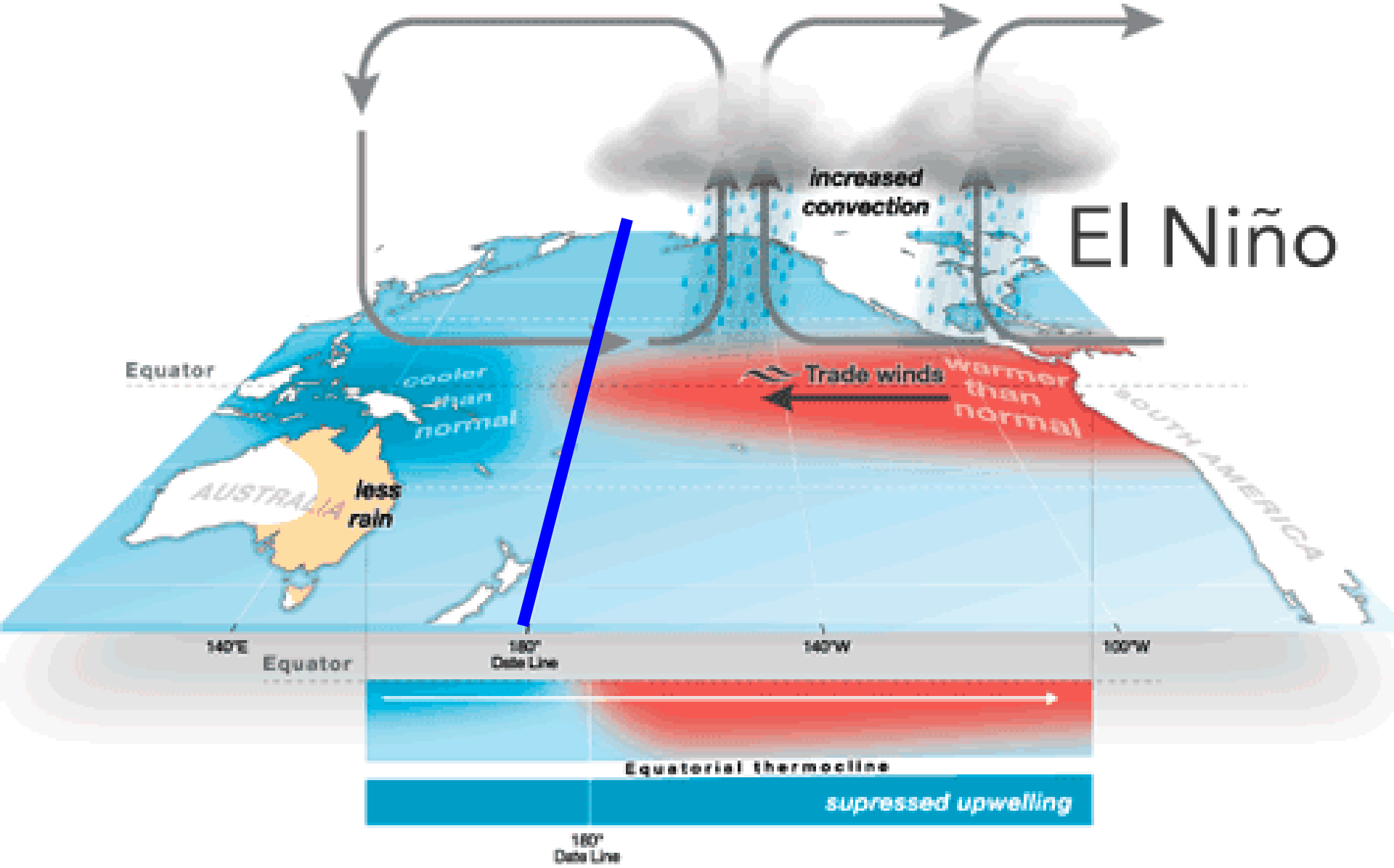
El Niño Southern Oscillation

http://www.nbc.com/saturday-night-live/video/el-nino/2861308





https://www.climate.gov/enso



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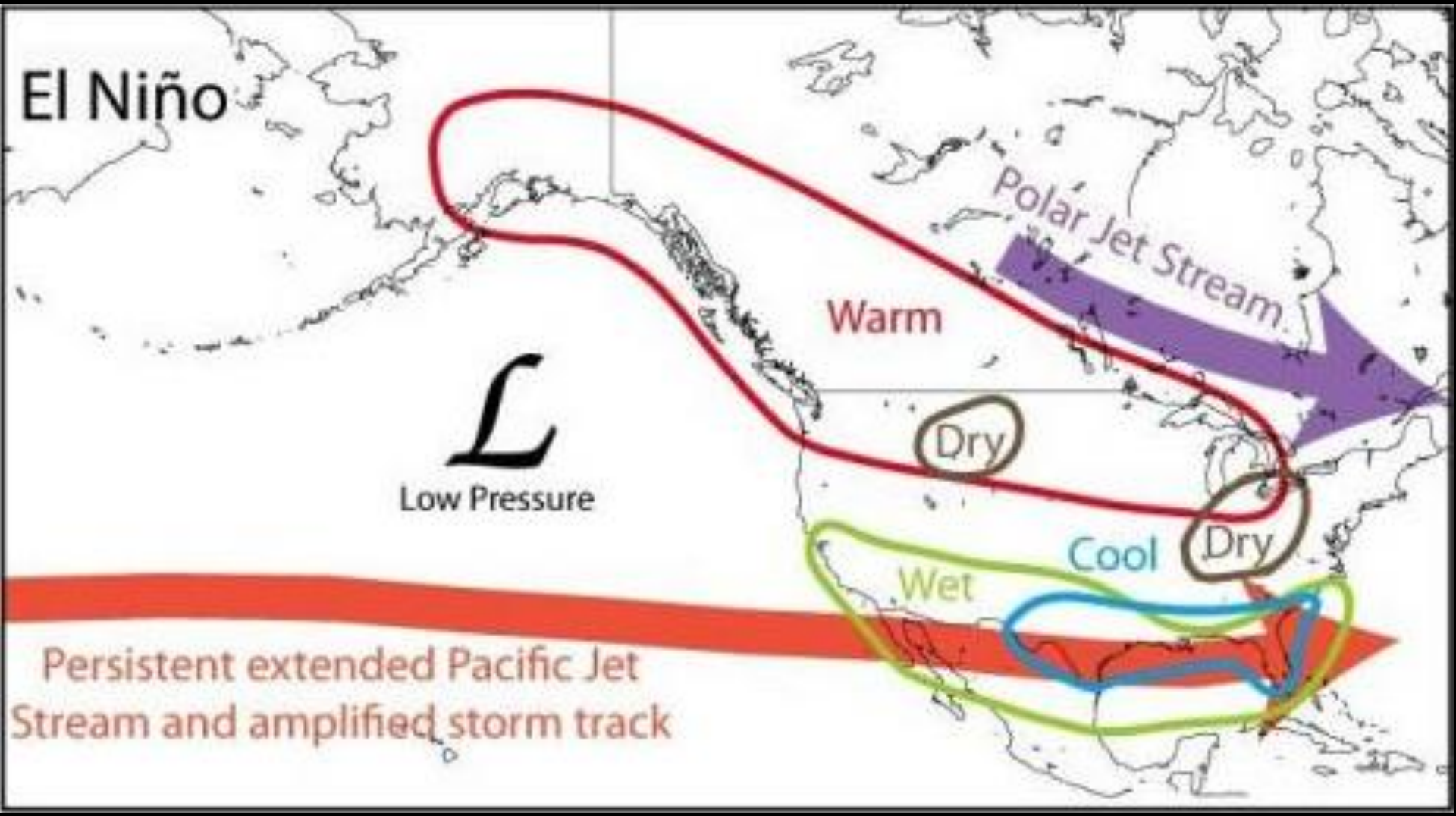
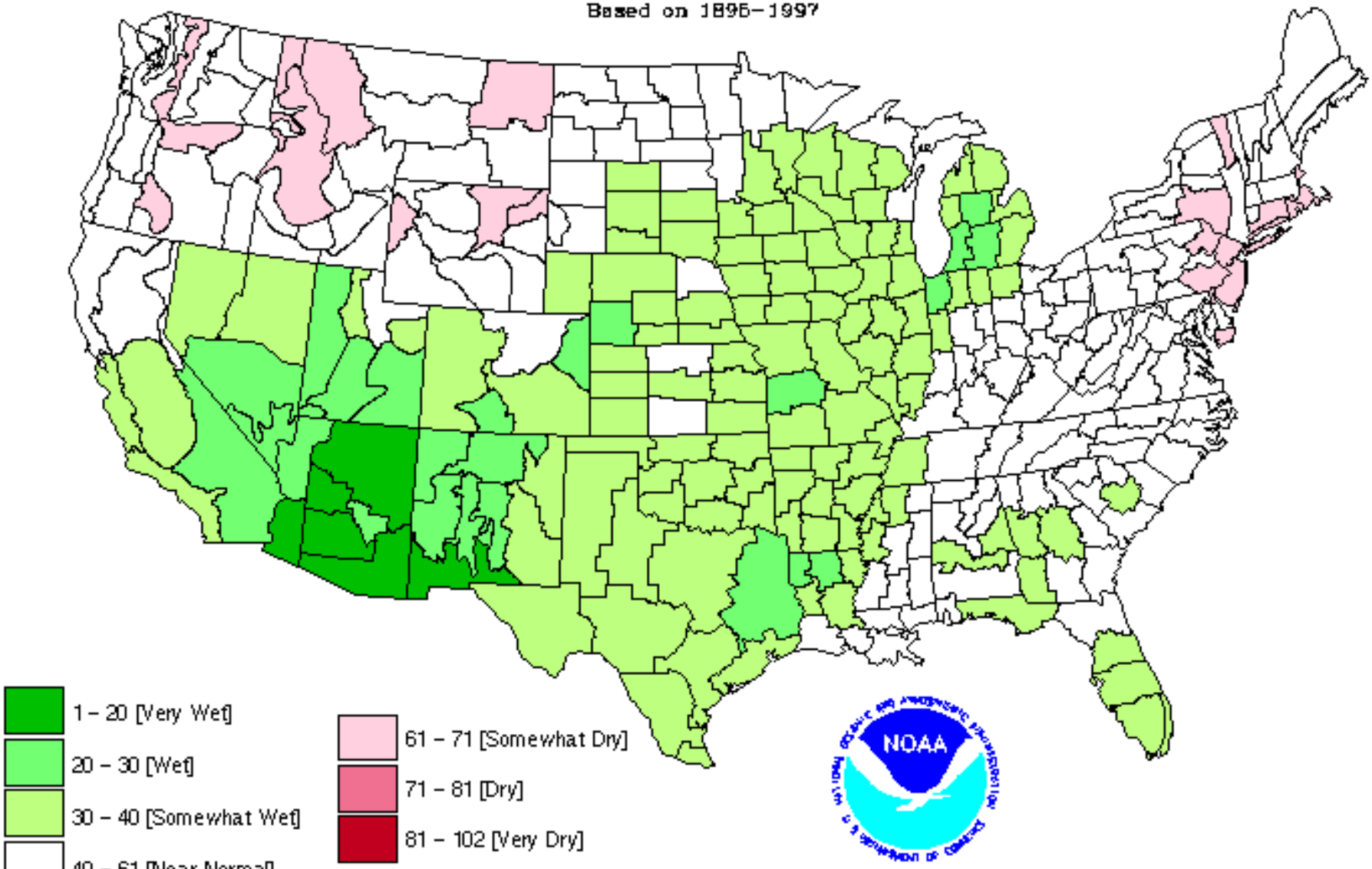


http://www.climas.arizona.edu/sw-climate/el-ni%C3%B1o-southern-oscillation/faq

AVERAGE OCTOBER - DECEMBER [3-month] PRECIPITATION RANKINGS DURING ENSO EVENTS

1914 1918 1941 1957 1963 1965 1972 1982 1987 1991 1994

Based on 1895-1997

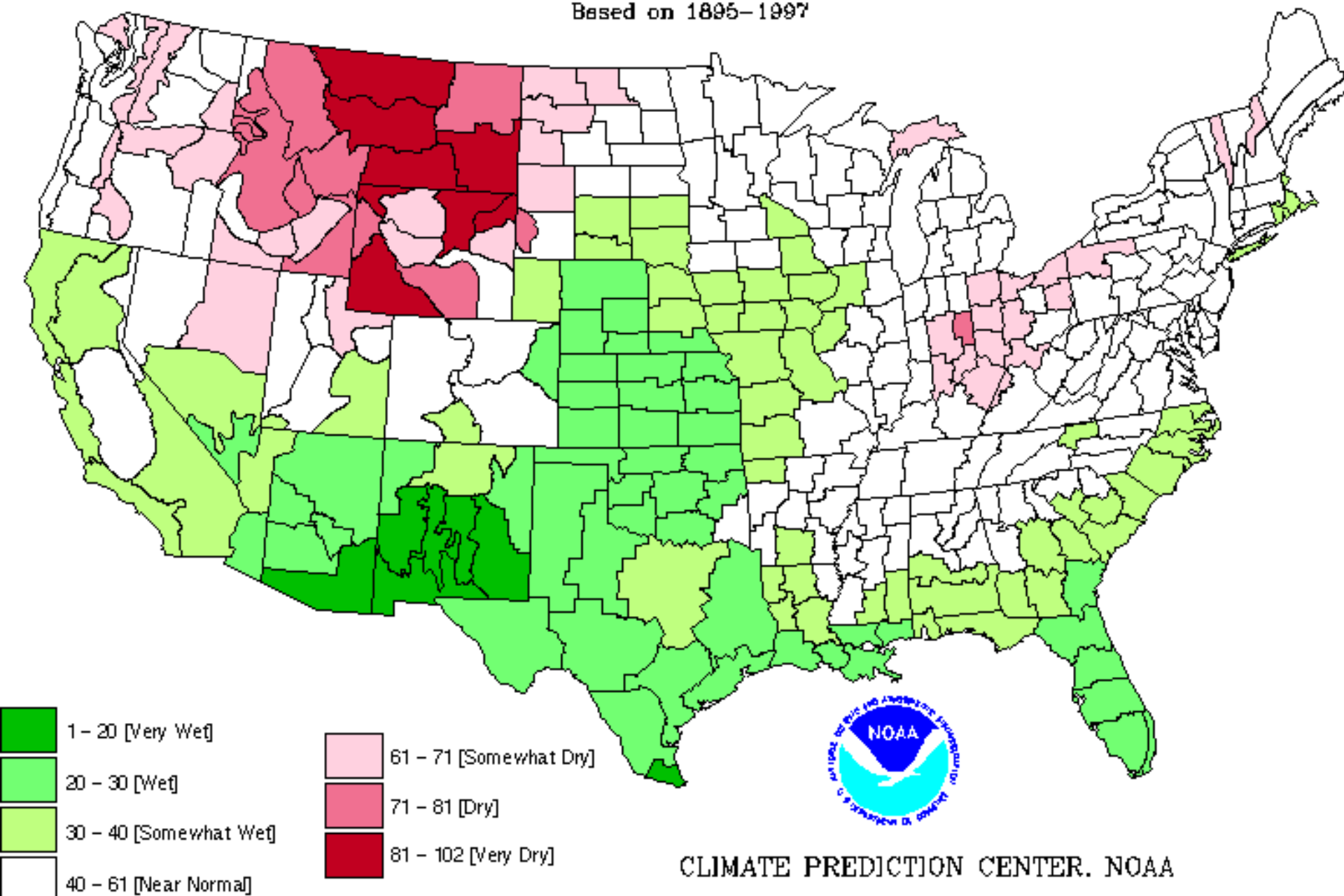


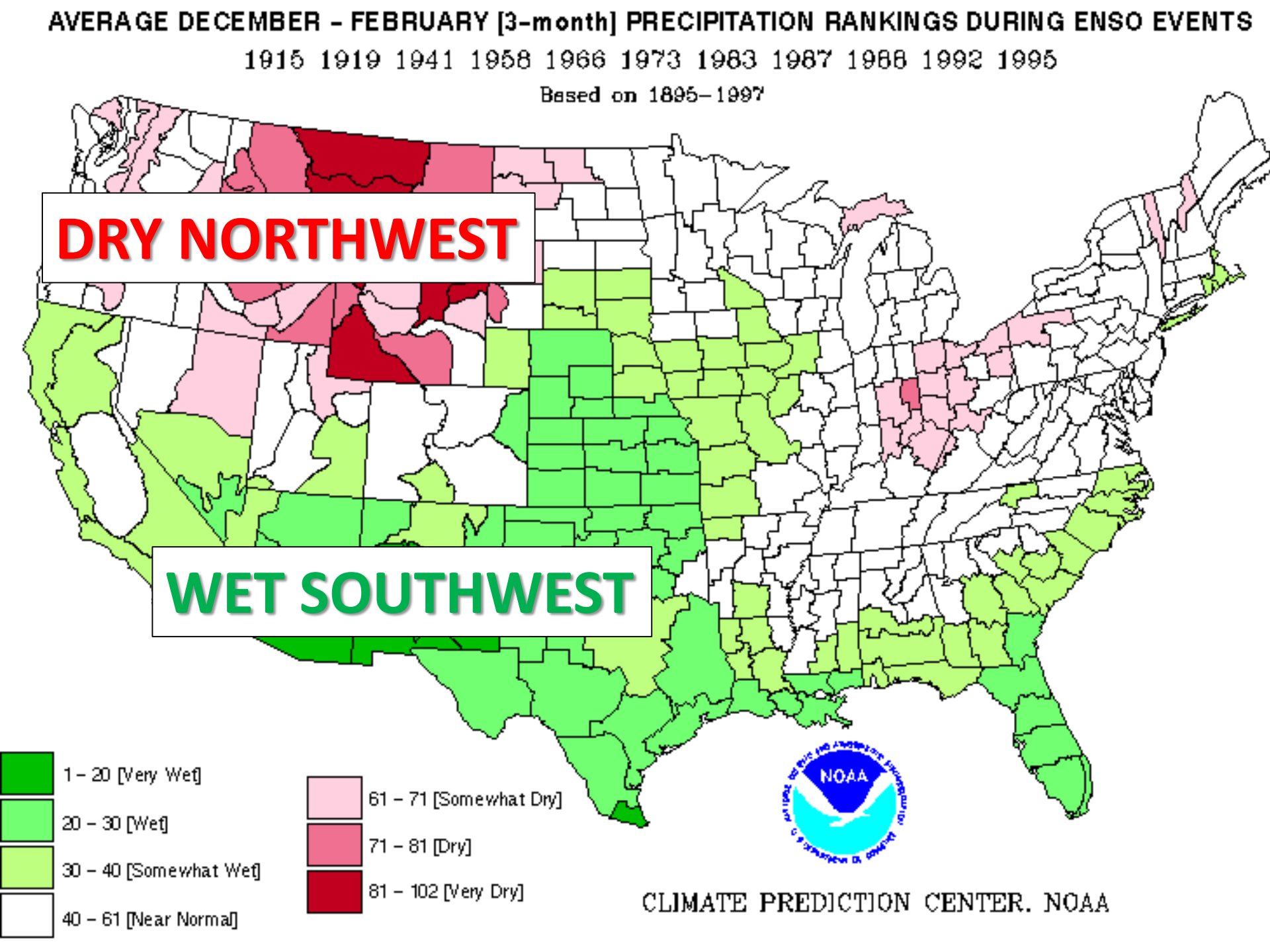
CLIMATE PREDICTION CENTER, NOAA

AVERAGE DECEMBER - FEBRUARY [3-month] PRECIPITATION RANKINGS DURING ENSO EVENTS

1915 1919 1941 1958 1966 1973 1983 1987 1988 1992 1995

Based on 1895-1997

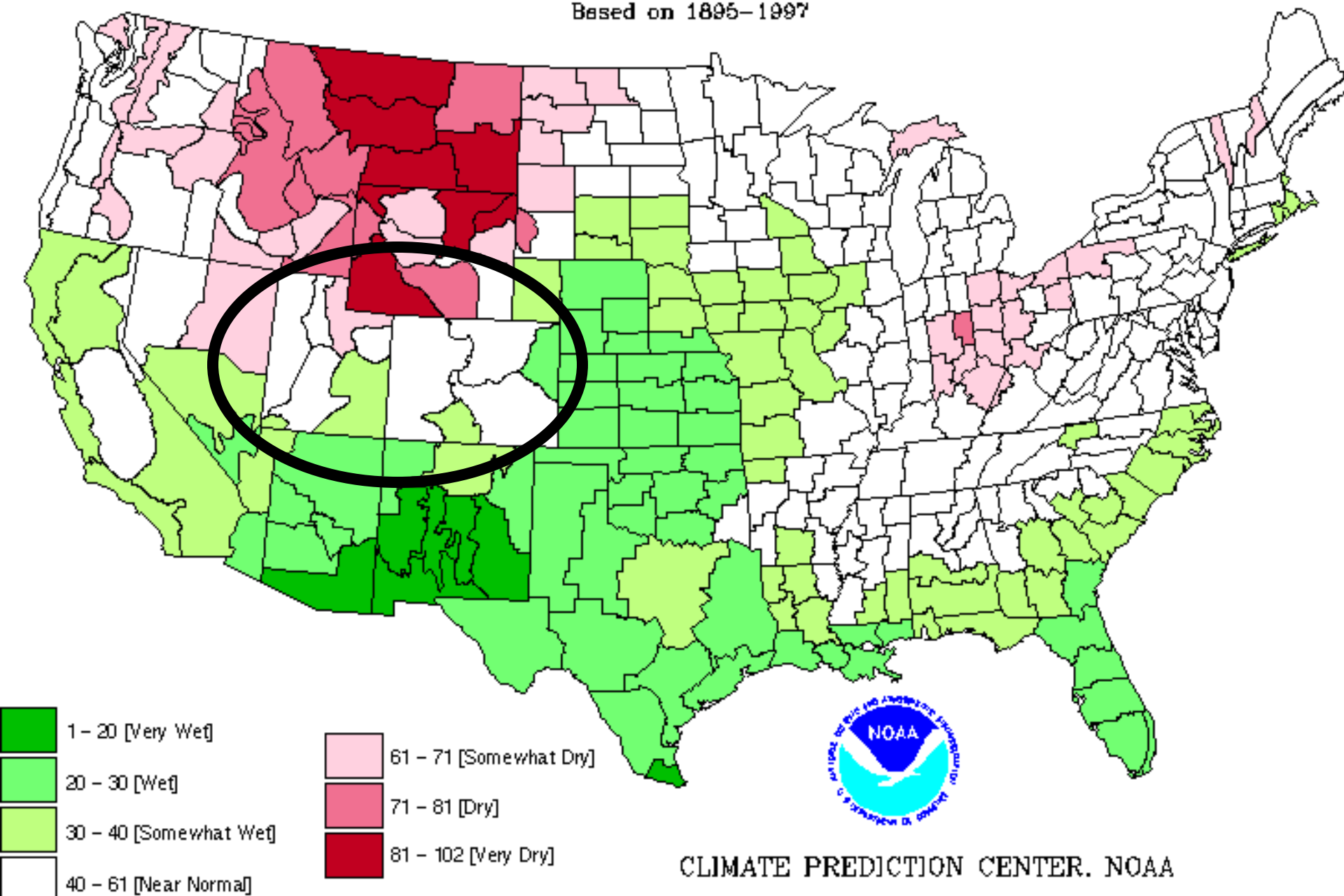



AVERAGE DECEMBER - FEBRUARY [3-month] PRECIPITATION RANKINGS DURING ENSO EVENTS
1915 1919 1941 1958 1966 1973 1983 1987 1988 1992 1995
Based on 1895-1997
DRY NORTHWEST
WET SOUTHWEST
1 - 20 [Very Wet]
20 - 30 [Wet]
30 - 40 [Somewhat Wet]
40 - 61 [Near Normal]
61 - 71 [Somewhat Dry]
71 - 81 [Dry]
81 - 102 [Very Dry]
NOAA
CLIMATE PREDICTION CENTER, NOAA

AVERAGE DECEMBER - FEBRUARY [3-month] PRECIPITATION RANKINGS DURING ENSO EVENTS

1915 1919 1941 1958 1966 1973 1983 1987 1988 1992 1995

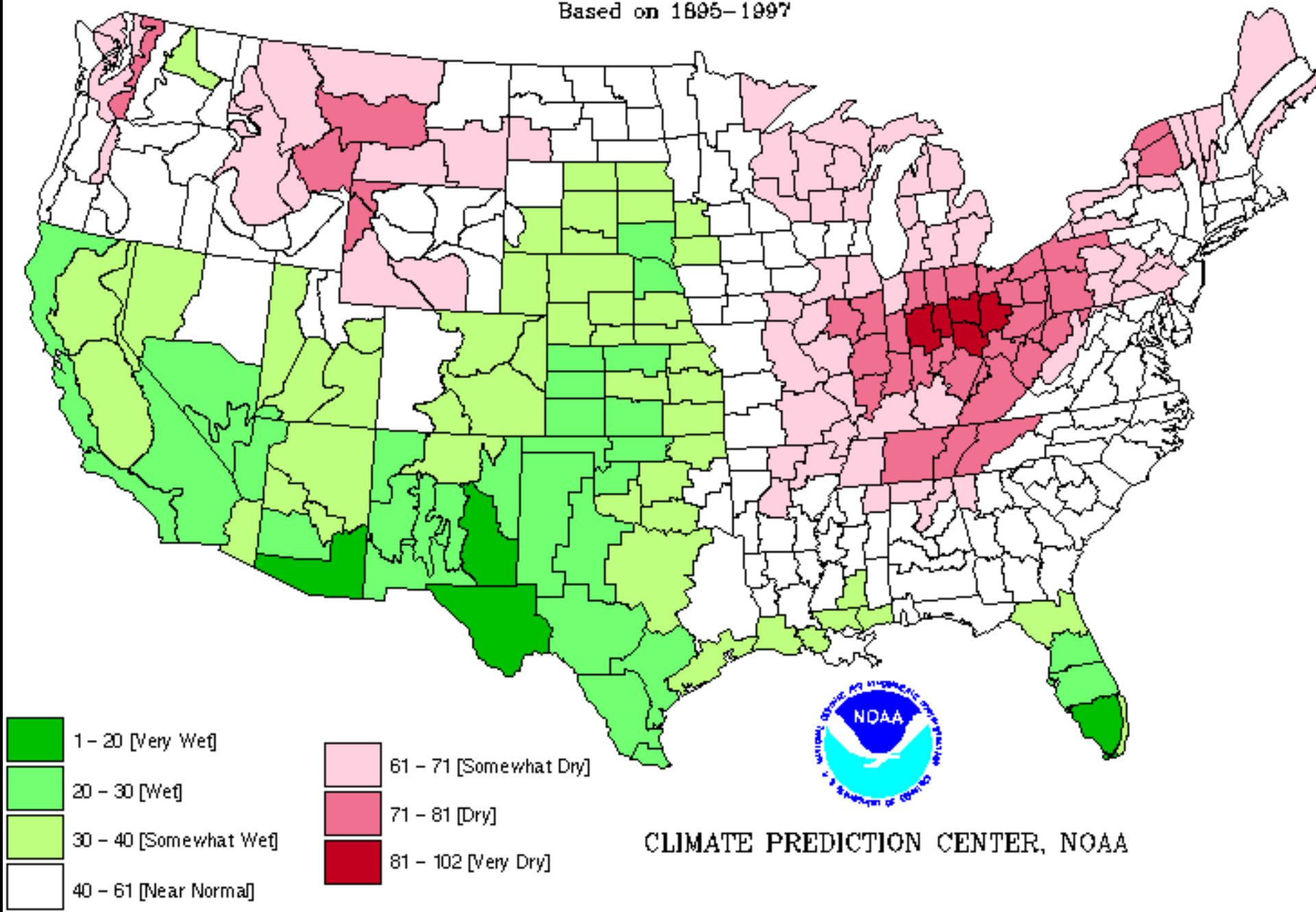
Based on 1895-1997

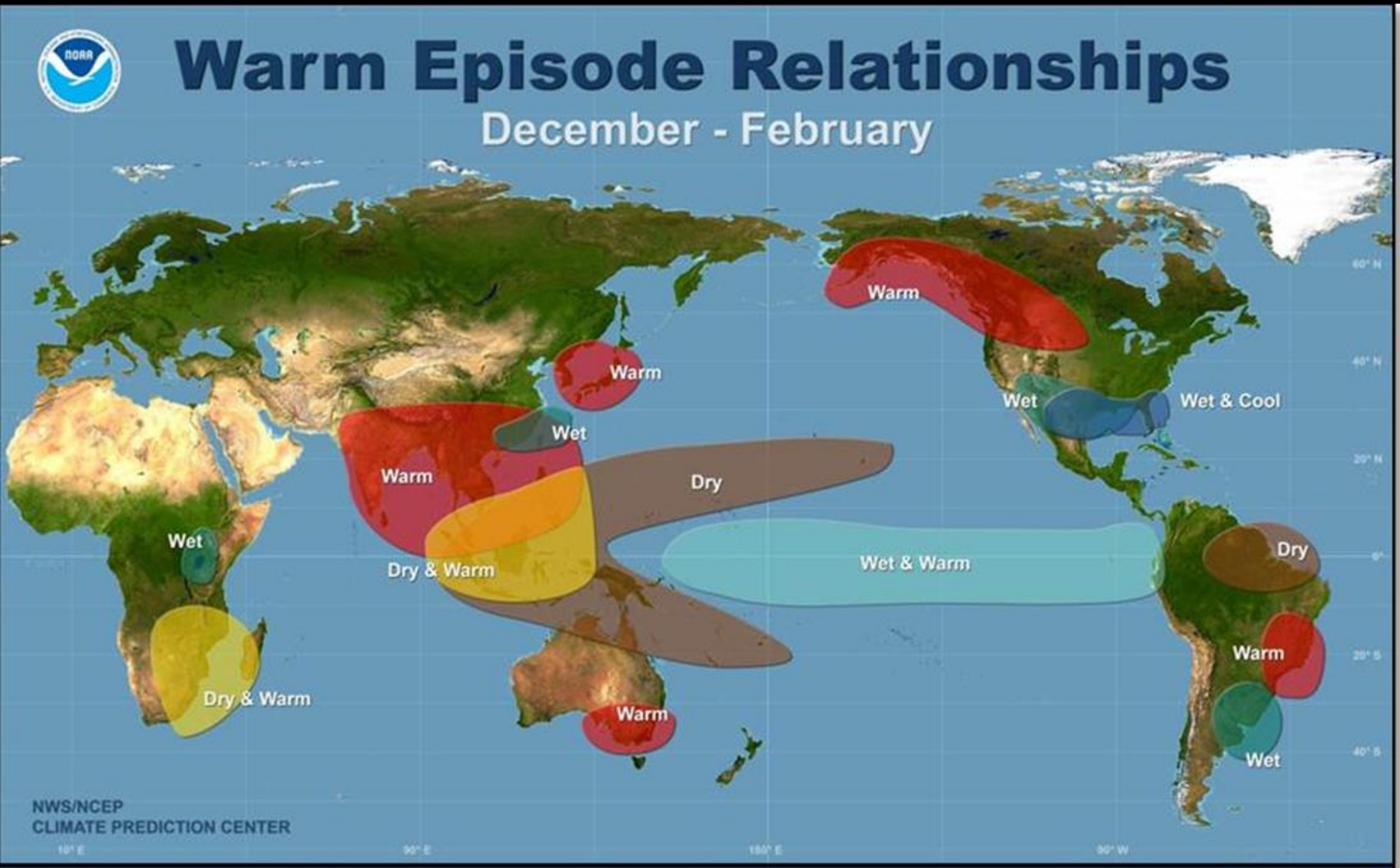


AVERAGE FEBRUARY - APRIL [3-month] PRECIPITATION RANKINGS DURING ENSO EVENTS

1915 1919 1941 1958 1966 1969 1983 1987 1992

Based on 1895–1997





https://www.climate.gov/enso

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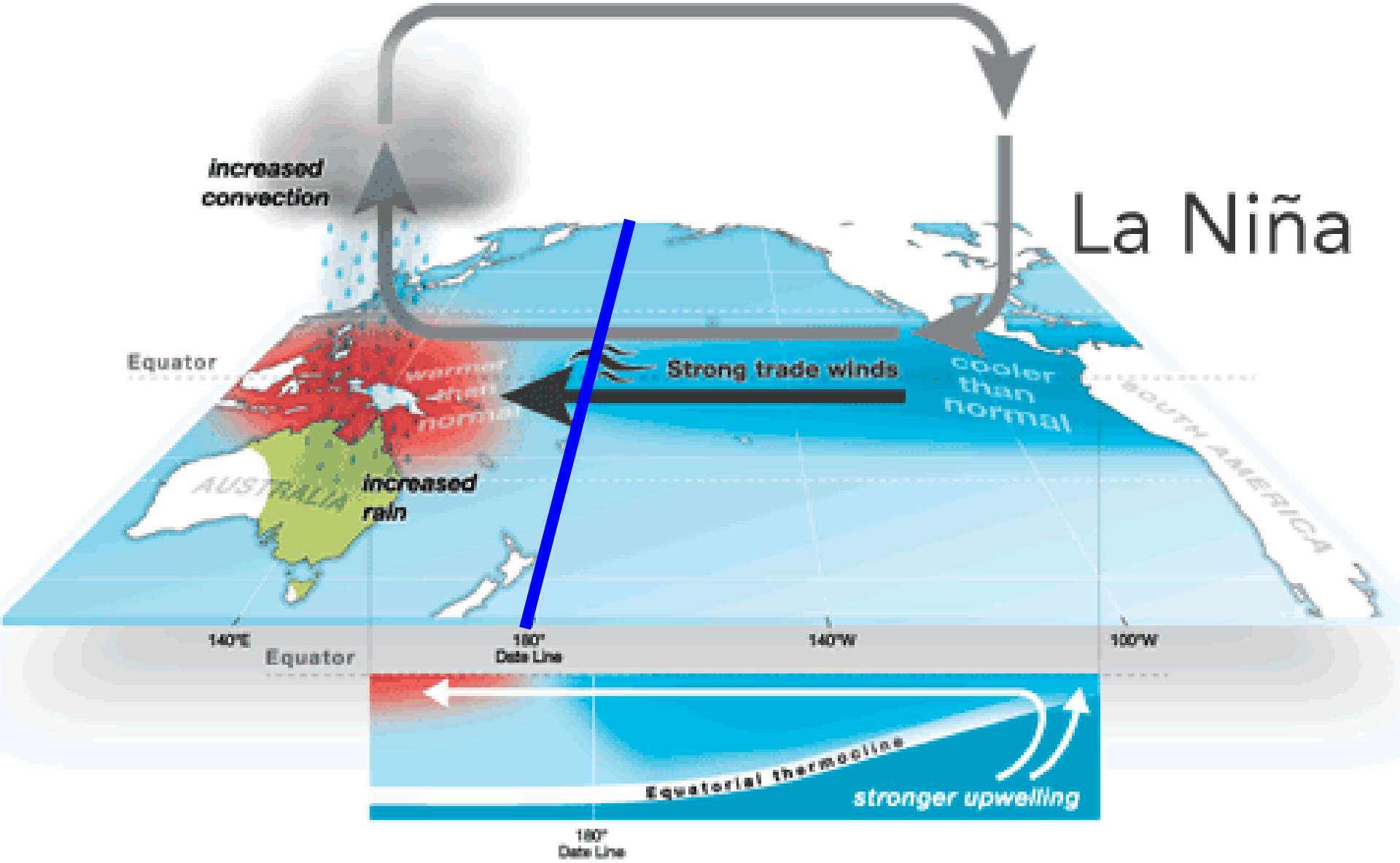

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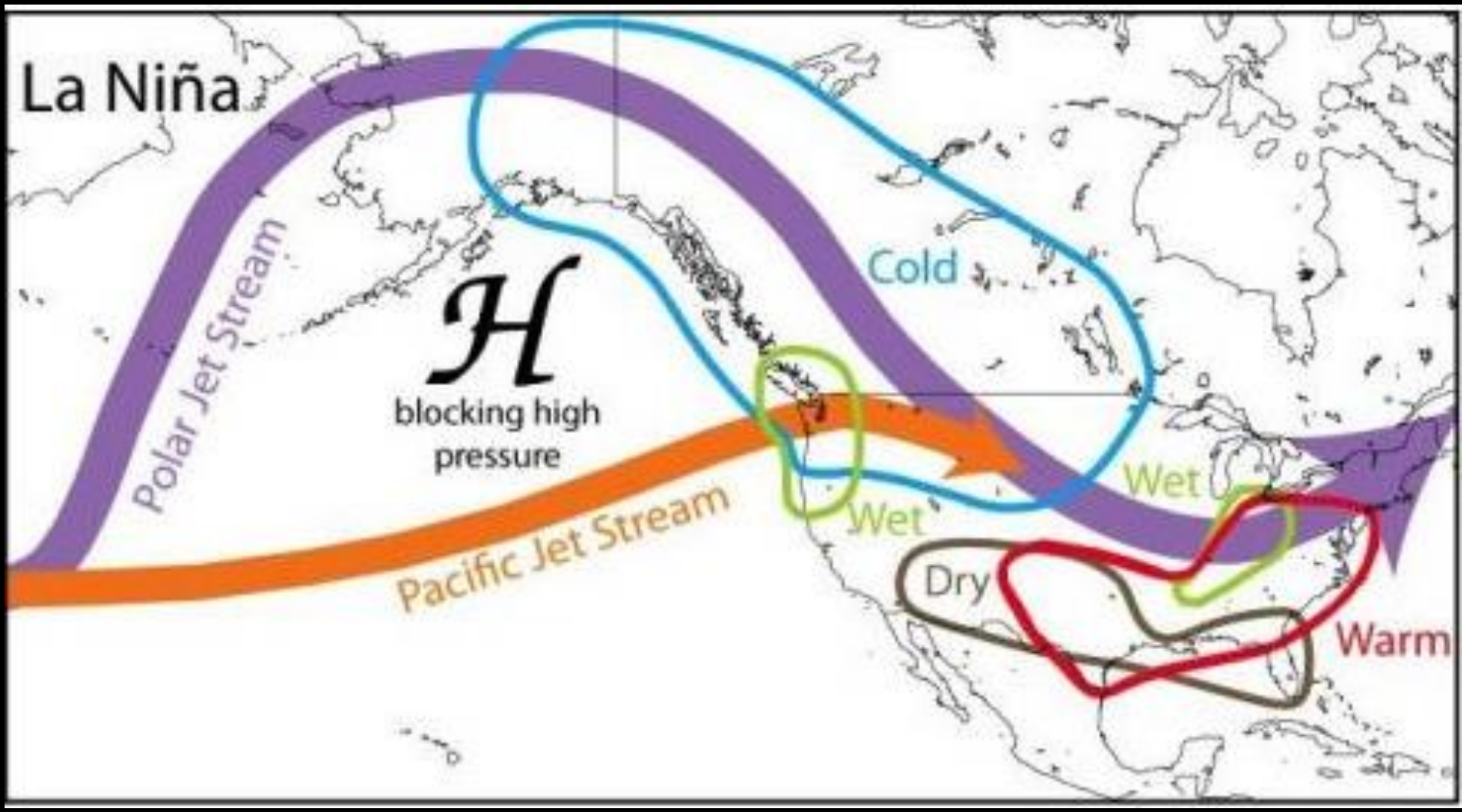
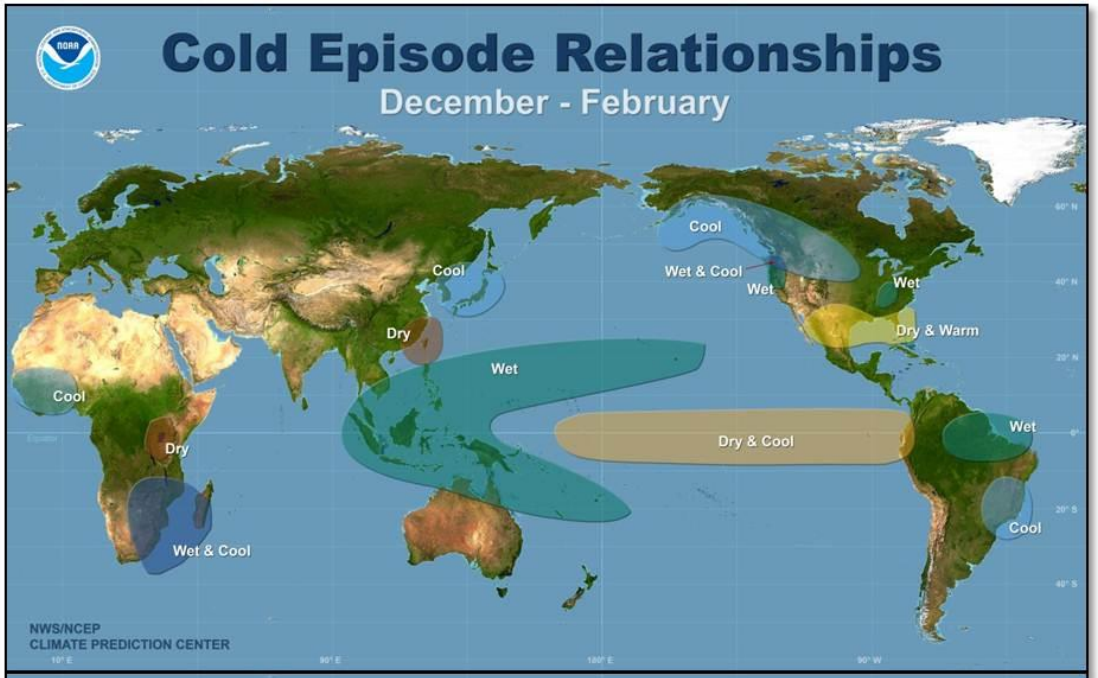
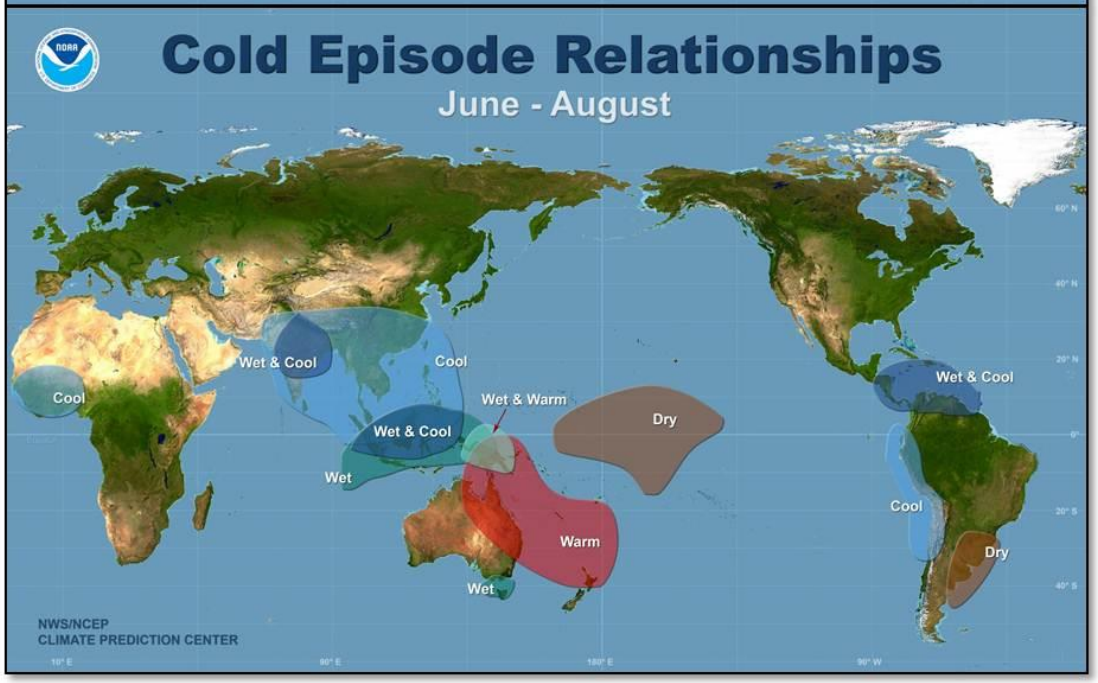


http://www.climas.arizona.edu/sw-climate/el-ni%C3%B1o-southern-oscillation/faq



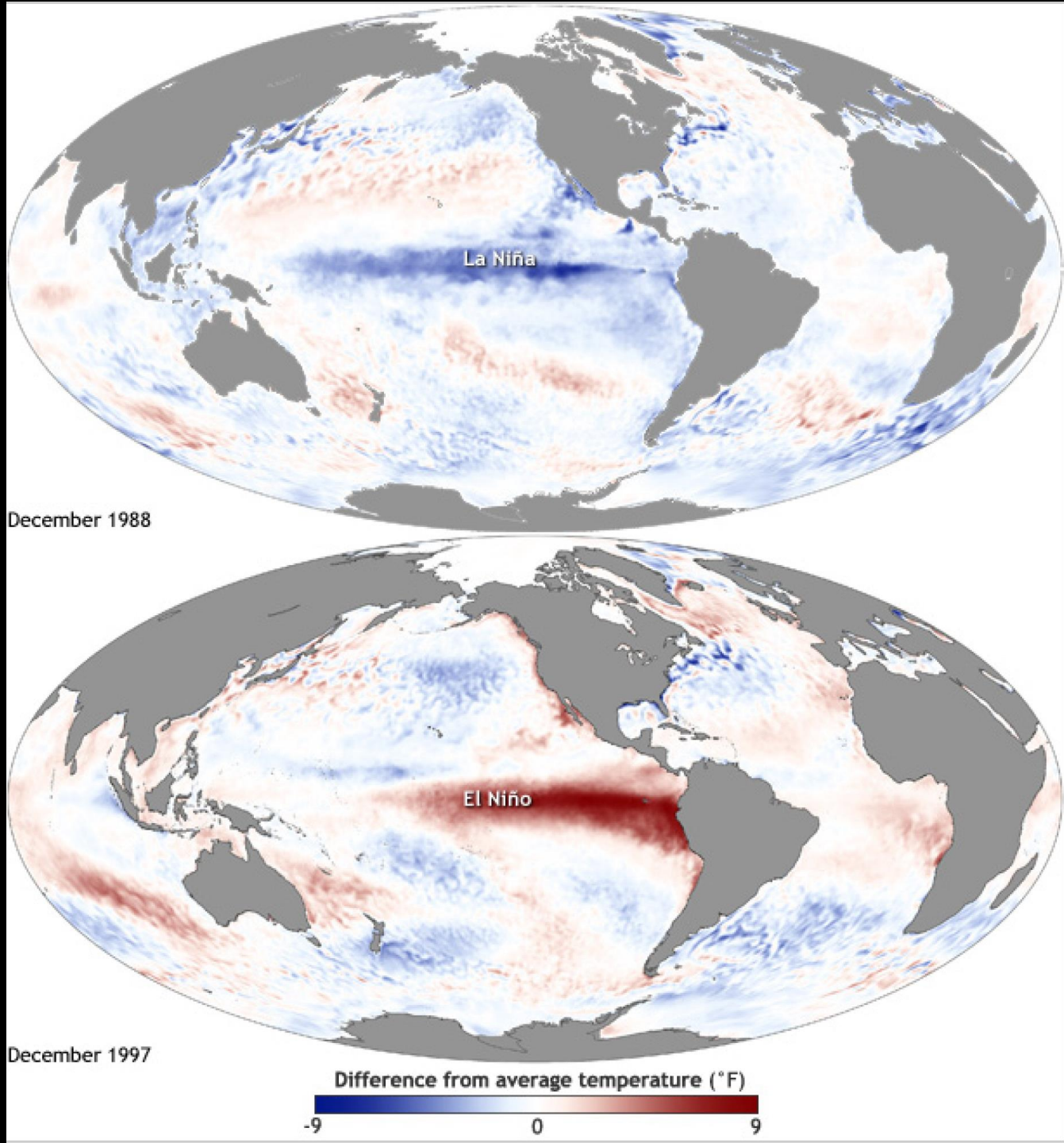


High Resolution Images can be found at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ENSO/ENSO-Global-Impacts/

Tracking ENSO

Typical ocean surface temperature patterns for strong La Nina (top) and strong El Nino (bottom)

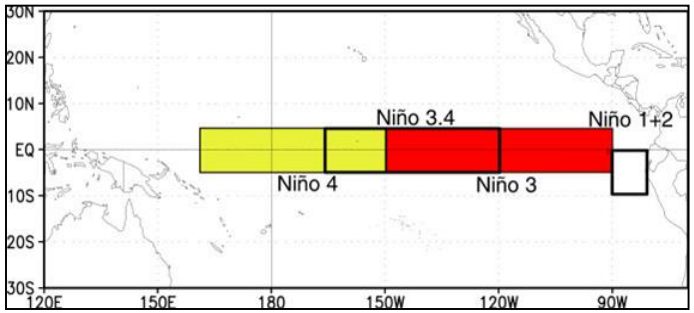
https://www.climate.gov/news-features/blogs/enso/what-el-ni%C3%B1o%E2%80%93southern-oscillation-enso-nutshell



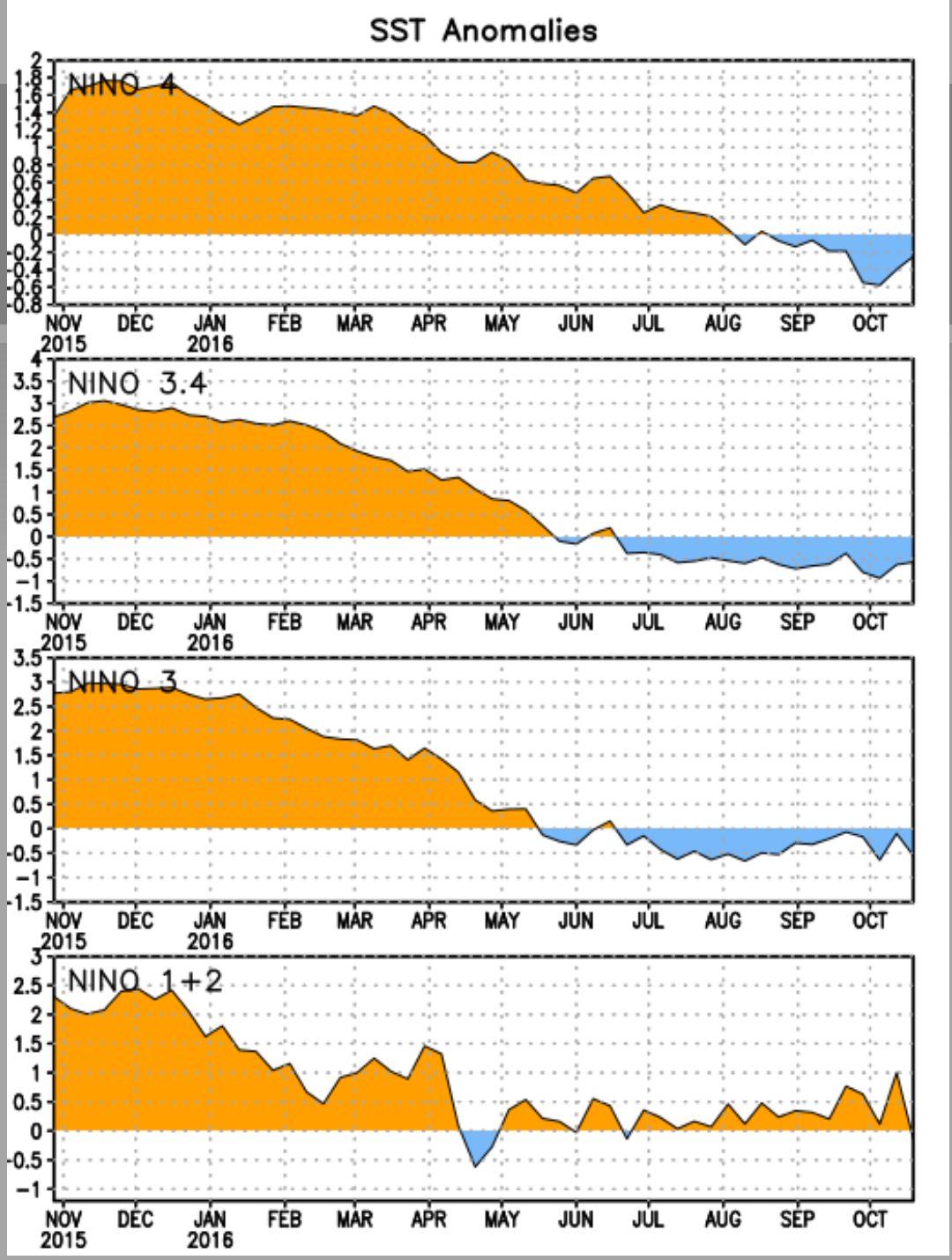
Niño Region SST Departures (ºC) Recent Evolution

The latest weekly SST departures are:

Niño 4	-0.2ºC
Niño 3.4	-0.6ºC
Niño 3	-0.6ºC
Niño 1+2	-0.2ºC

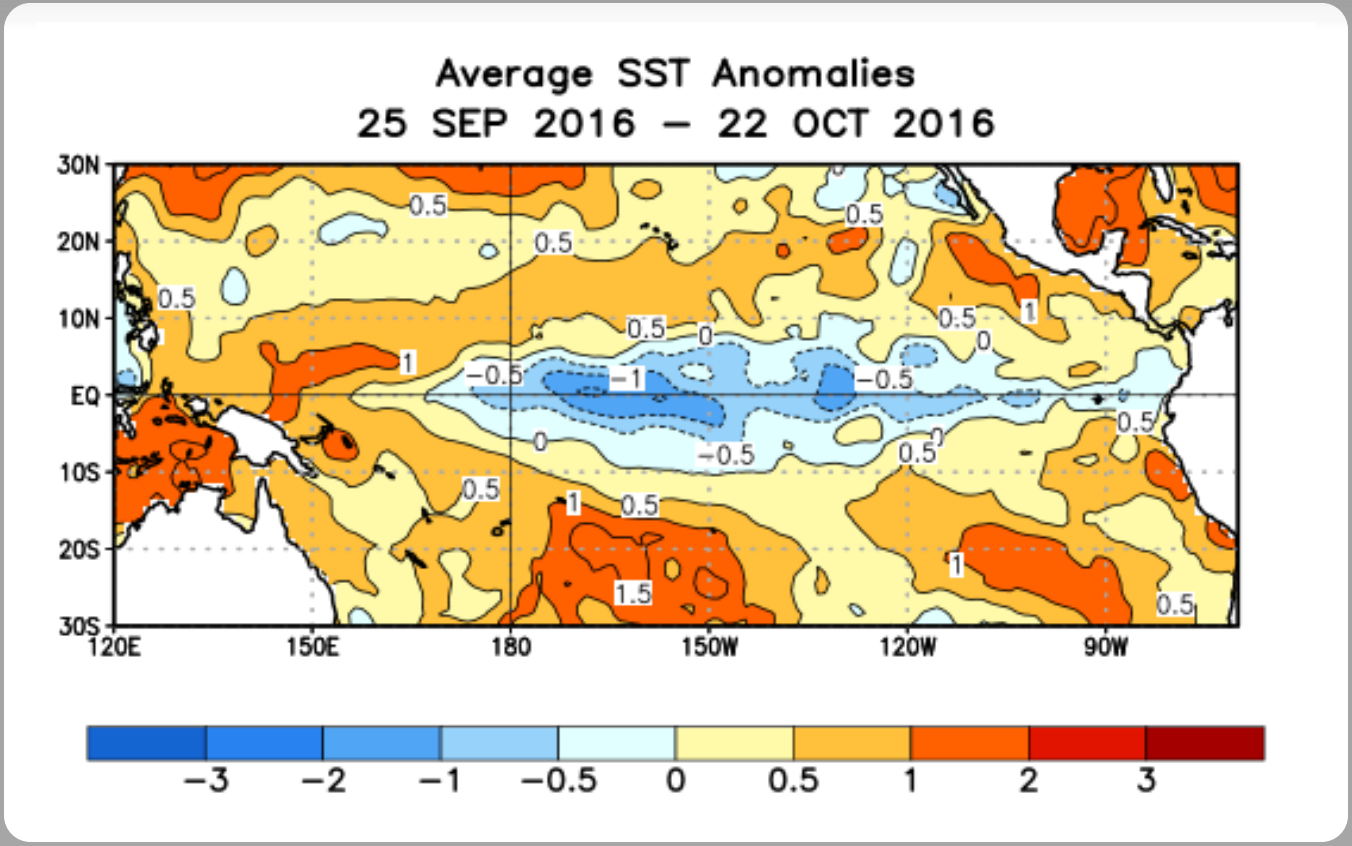


http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/

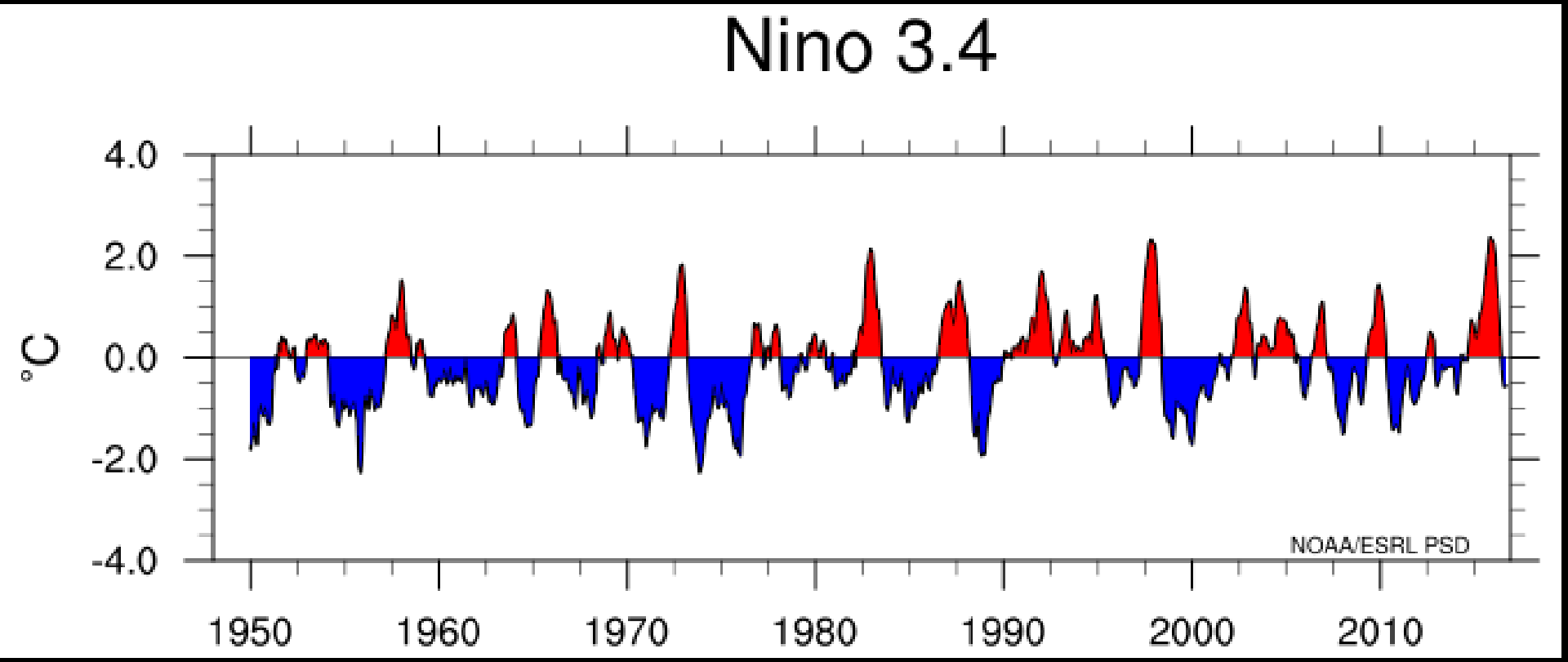


SST Departures (°C) in the Tropical Pacific During the Last Four Weeks

During the last four weeks, equatorial SSTs were below average across the central and east-central Pacific, and near average in the eastern Pacific.

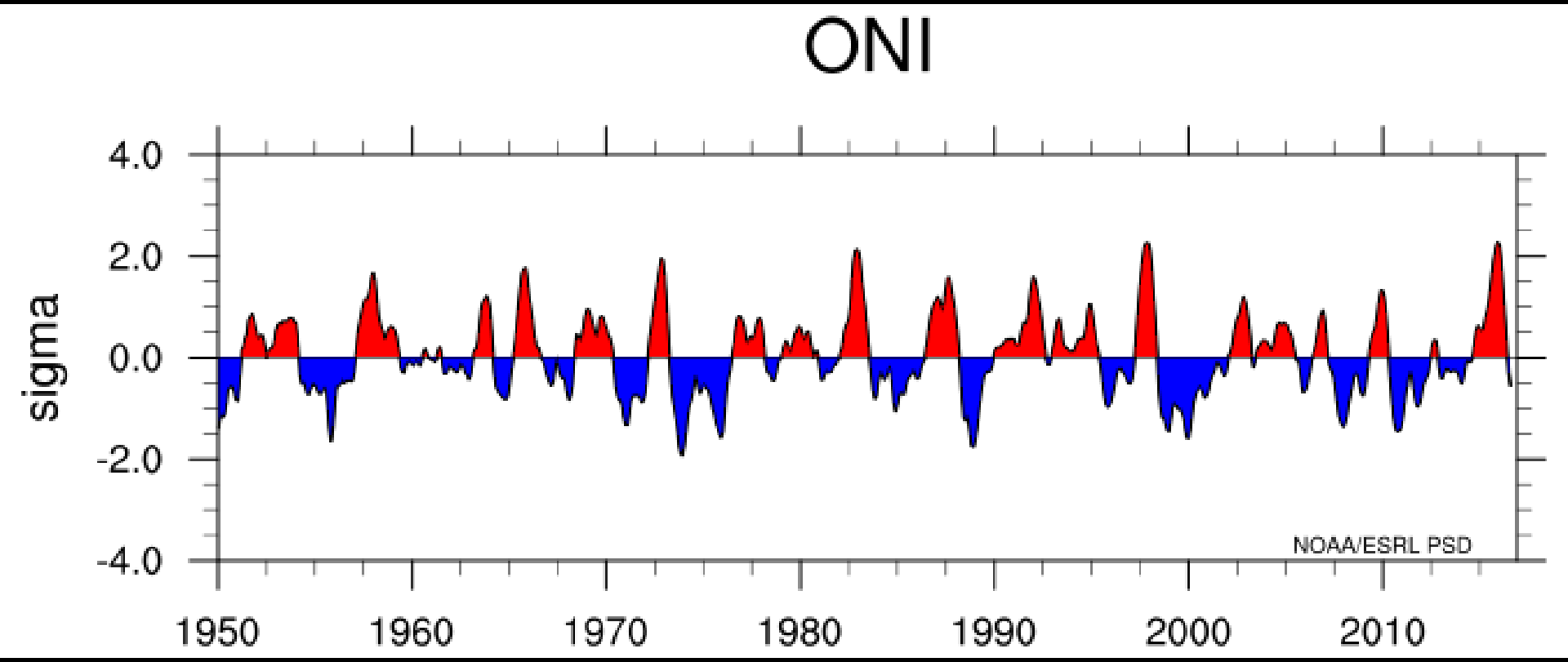


http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/



Explanation of many El Nino-Southern Oscillation Indices:
https://www.climate.gov/news-features/blogs/enso/why-are-there-so-many-enso-indexes-instead-just-one

http://www.esrl.noaa.gov/psd/enso/dashboard.html



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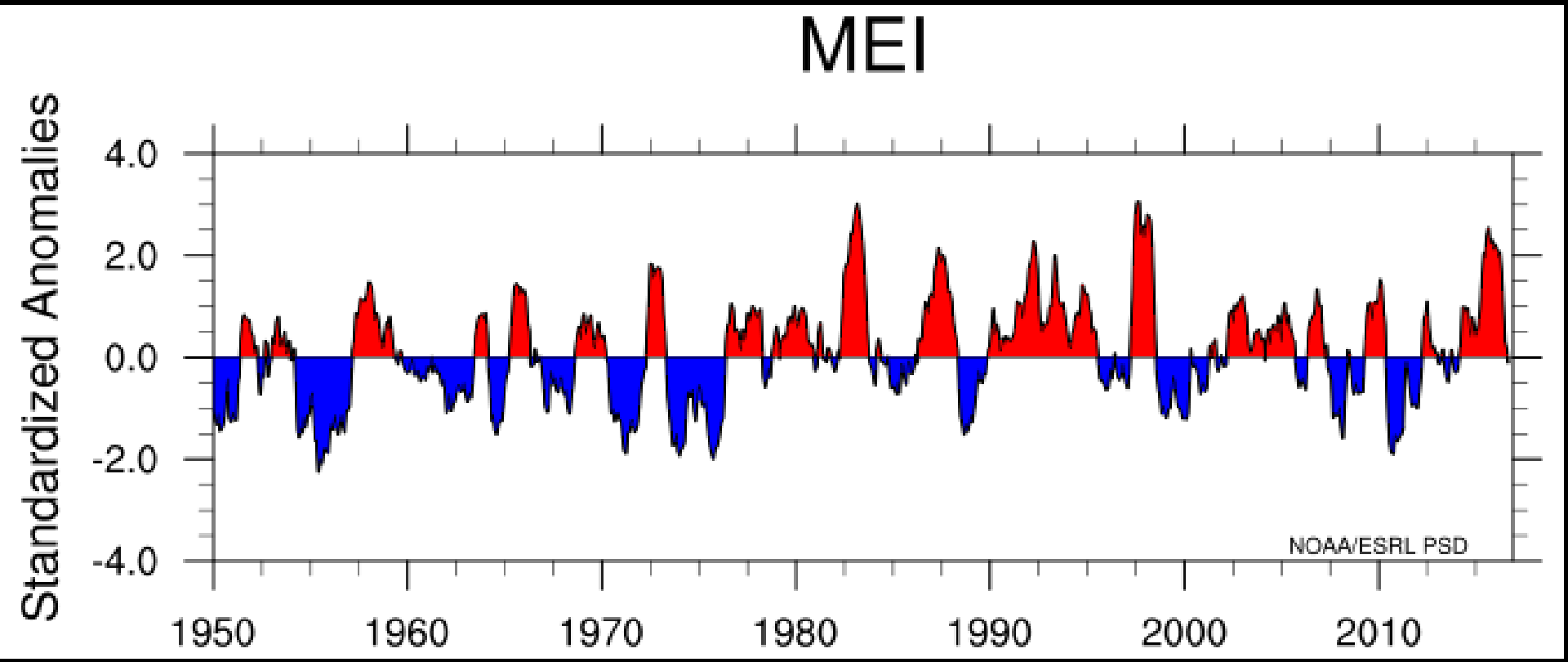

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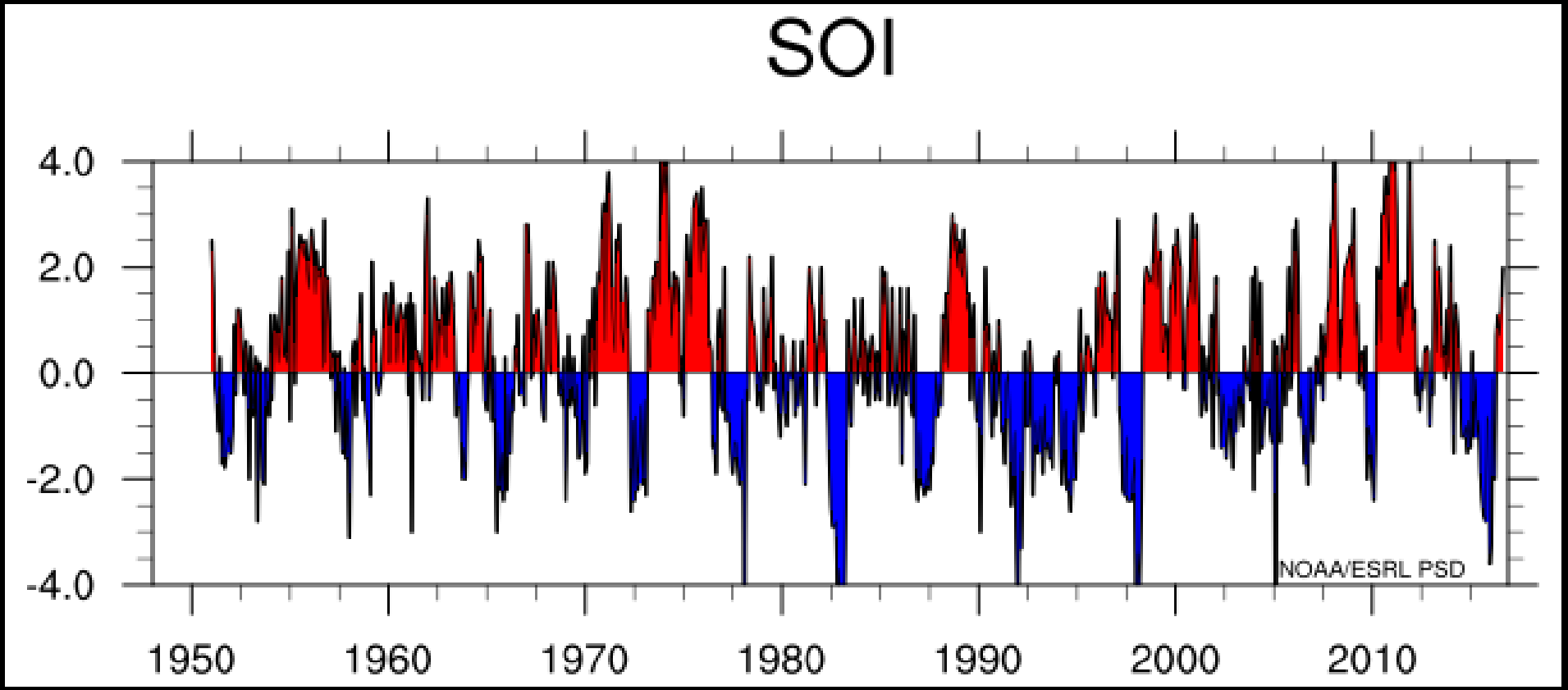

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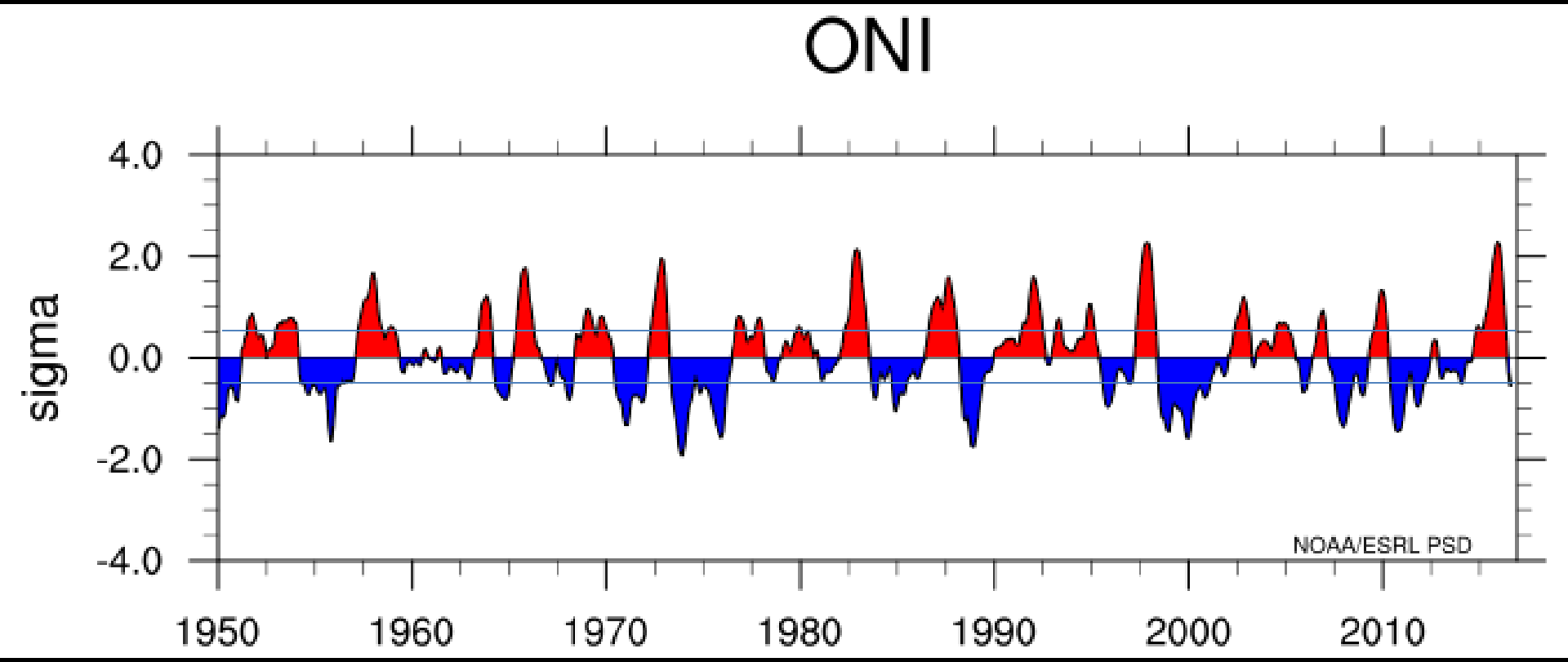
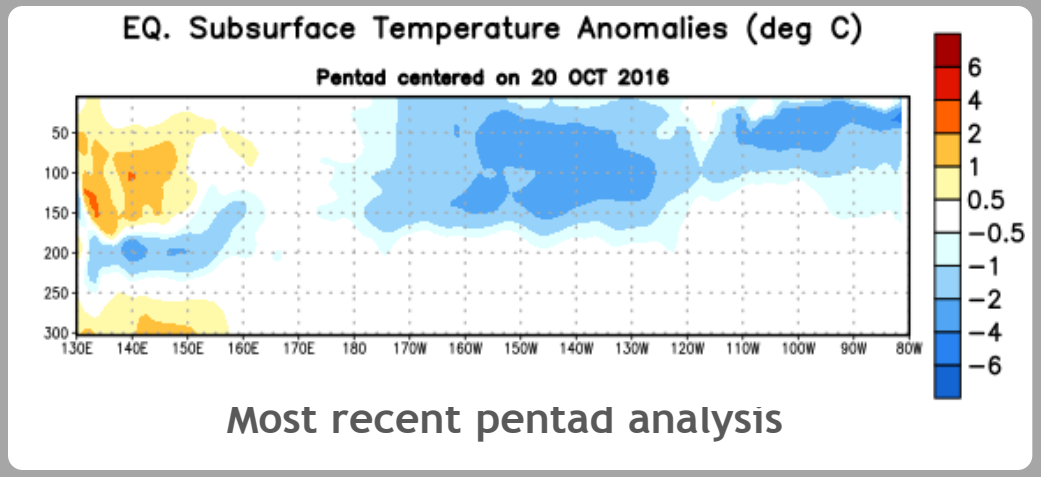


http://www.esrl.noaa.gov/psd/enso/dashboard.html

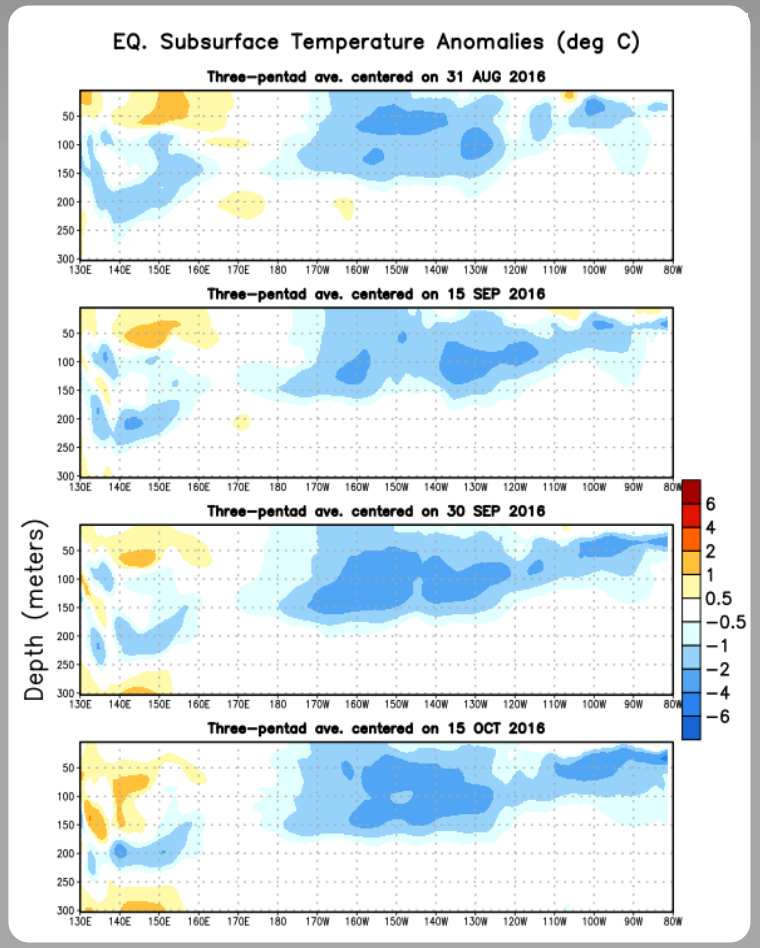
Sub-Surface Temperature Departures in the Equatorial Pacific

During the last two months, negative subsurface temperature anomalies have extended to the surface in the central and east-central Pacific Ocean.



Most recent pentad analysis

During September and mid October, negative temperature anomalies strengthened at depth east of the International Date Line.

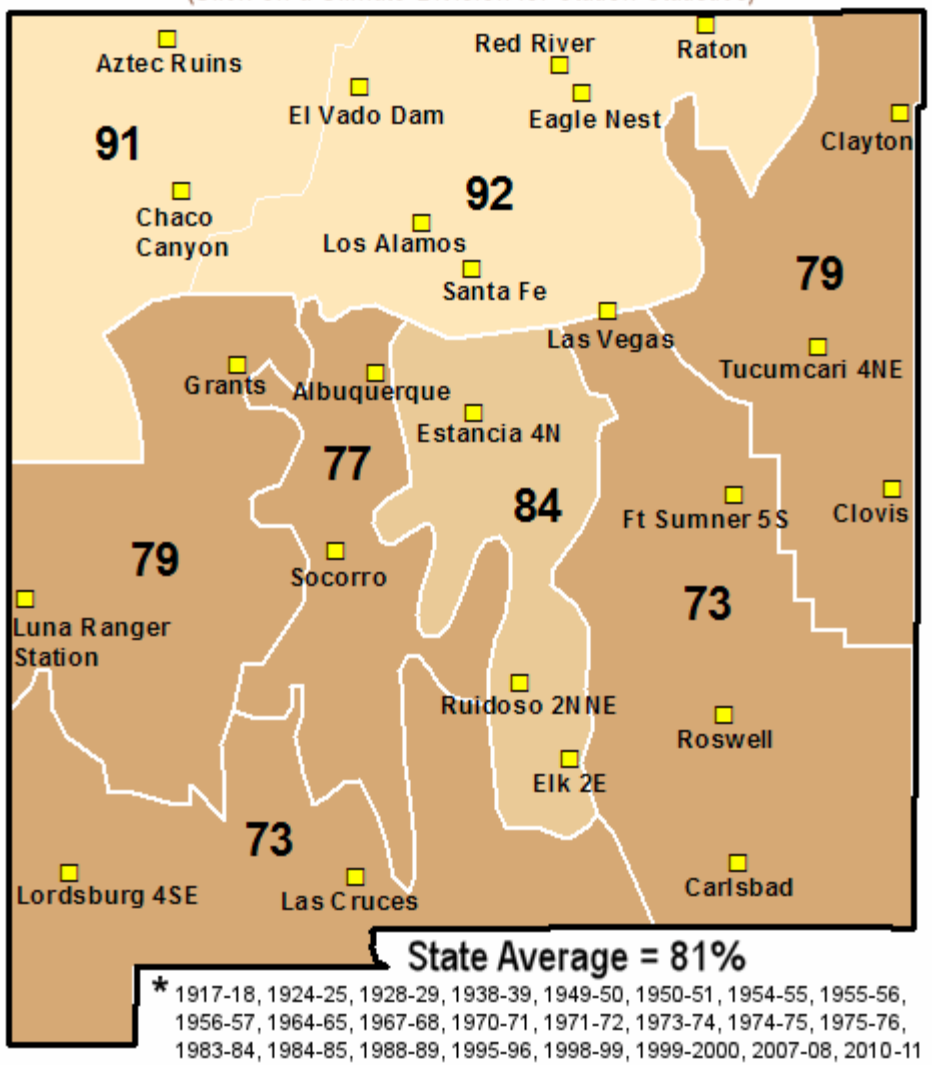


http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/

Impacts: Southern New Mexico

Percent of Normal December-January-February Precipitation during 24 La Niña Events *

(Click on a Climate Division for Station Statistics)

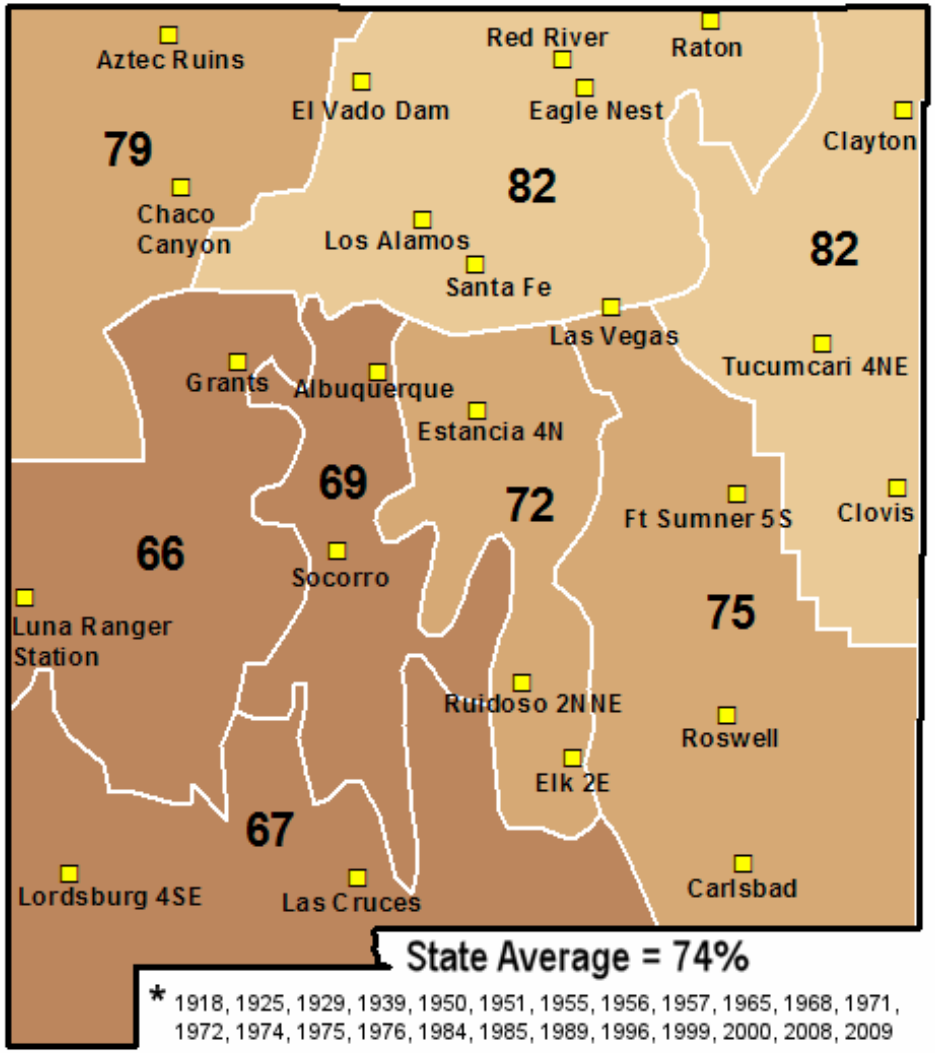


State Average = 81%

* 1917-18, 1924-25, 1928-29, 1938-39, 1949-50, 1950-51, 1954-55, 1955-56, 1956-57, 1964-65, 1967-68, 1970-71, 1971-72, 1973-74, 1974-75, 1975-76, 1983-84, 1984-85, 1988-89, 1995-96, 1998-99, 1999-2000, 2007-08, 2010-11

Percent of Normal March-April-May Precipitation during 24 La Niña Events *

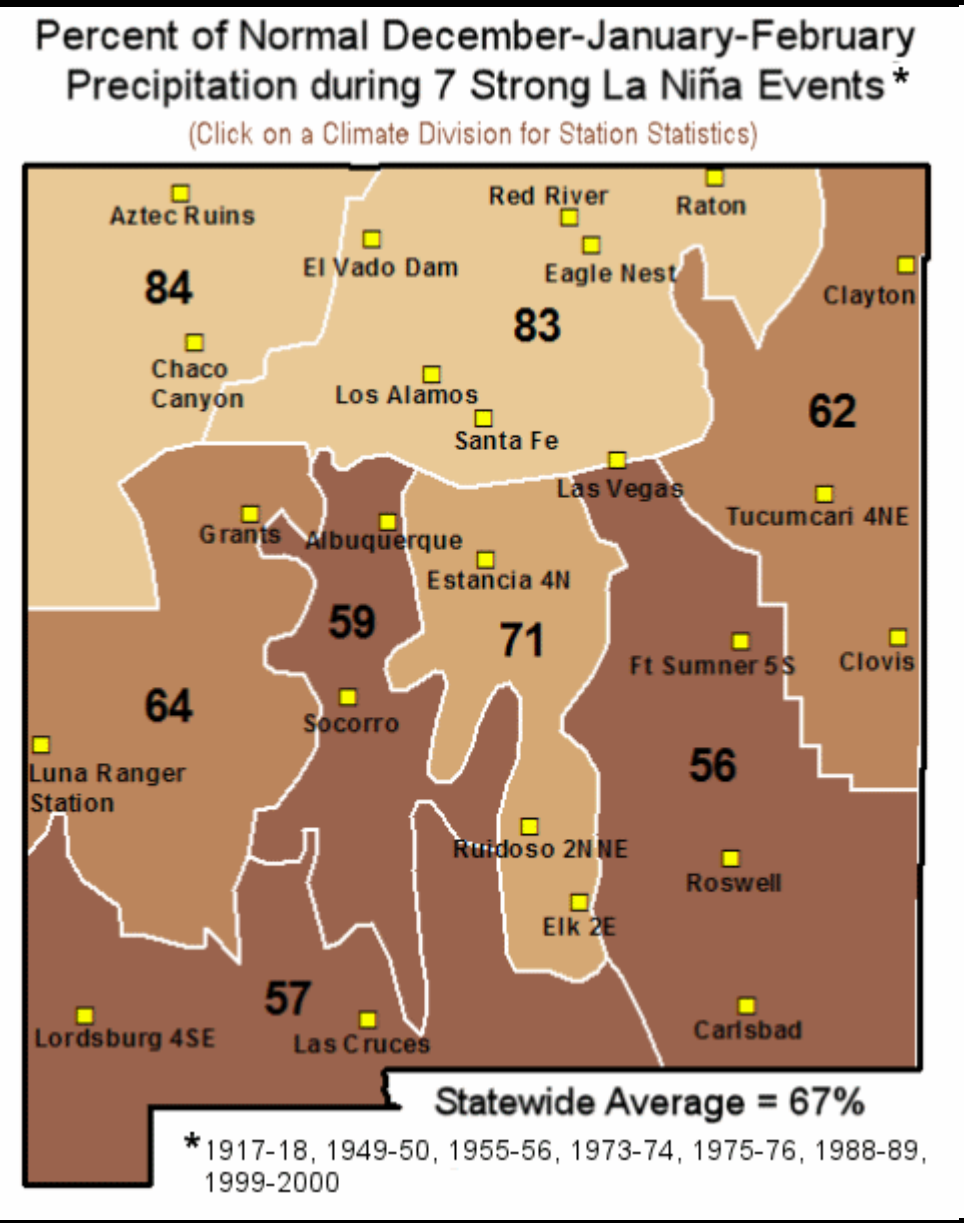
(Click on a Climate Division for Station Statistics)

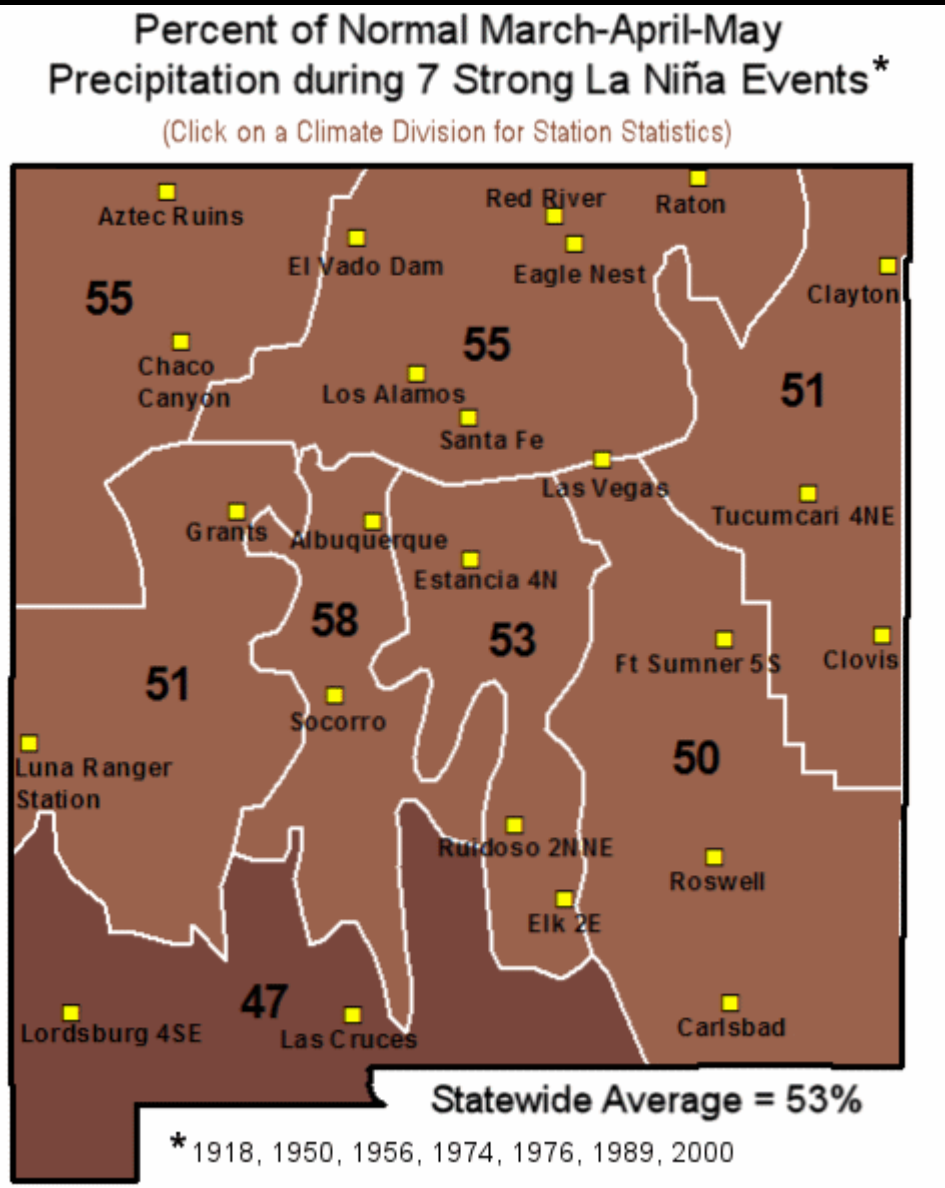


State Average = 74%

* 1918, 1925, 1929, 1939, 1950, 1951, 1955, 1956, 1957, 1965, 1968, 1971, 1972, 1974, 1975, 1976, 1984, 1985, 1989, 1996, 1999, 2000, 2008, 2009

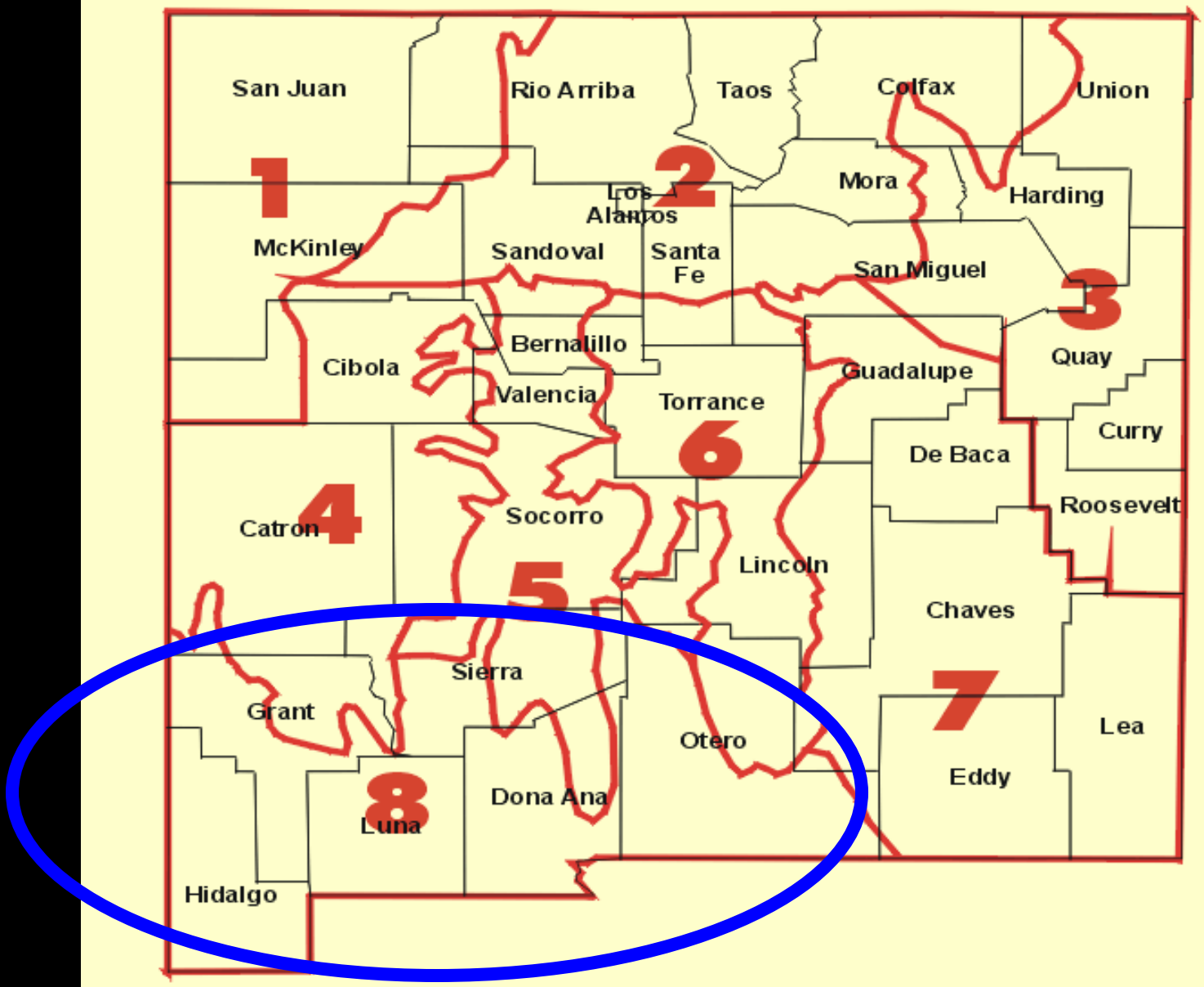
National Weather Service, Albuquerque, NM Forecast Office
https://www.weather.gov/abq/clifeature_laninaprecip





National Weather Service, Albuquerque, NM Forecast Office
https://www.weather.gov/abq/clifeature_laninaprecip

New Mexico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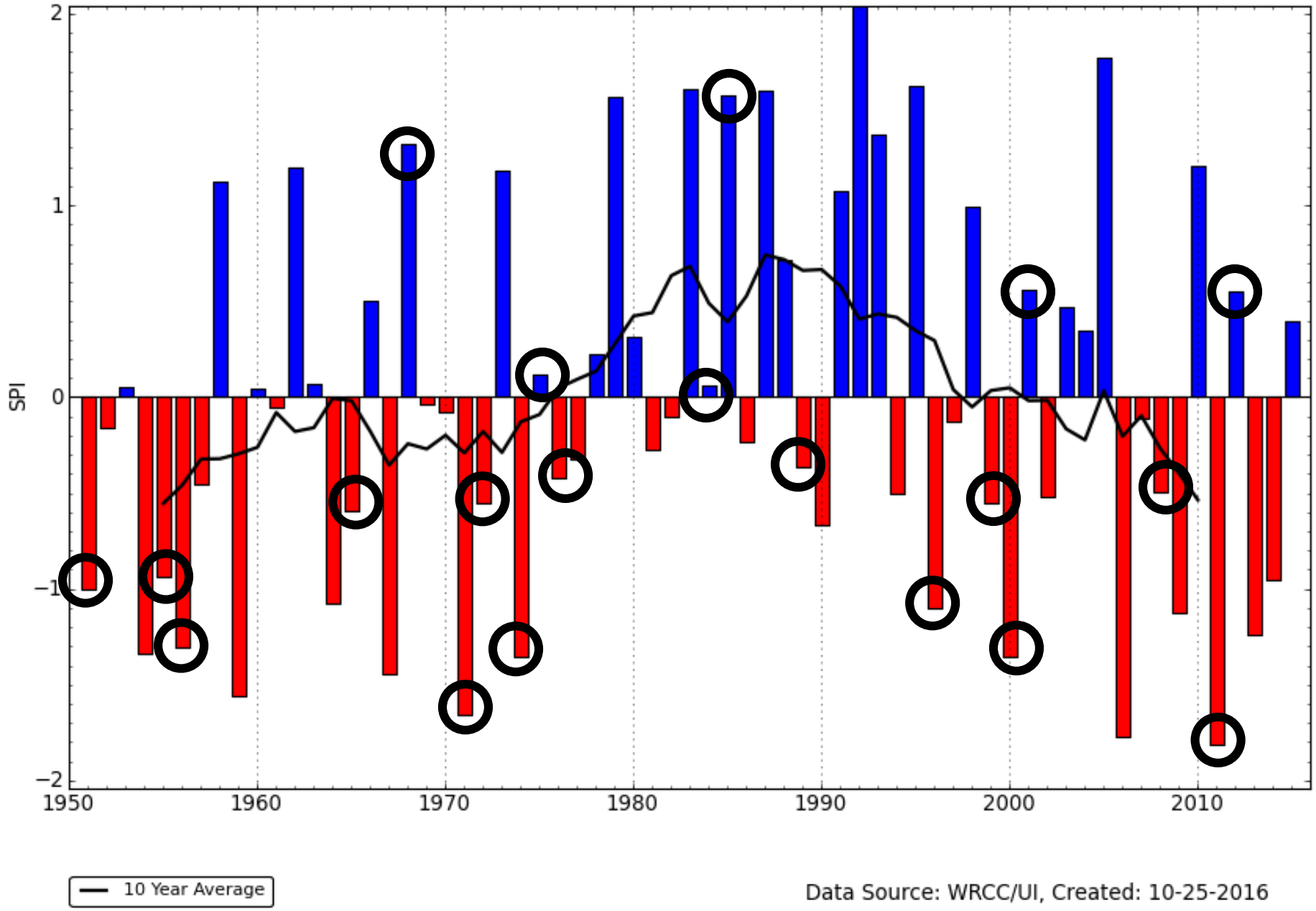
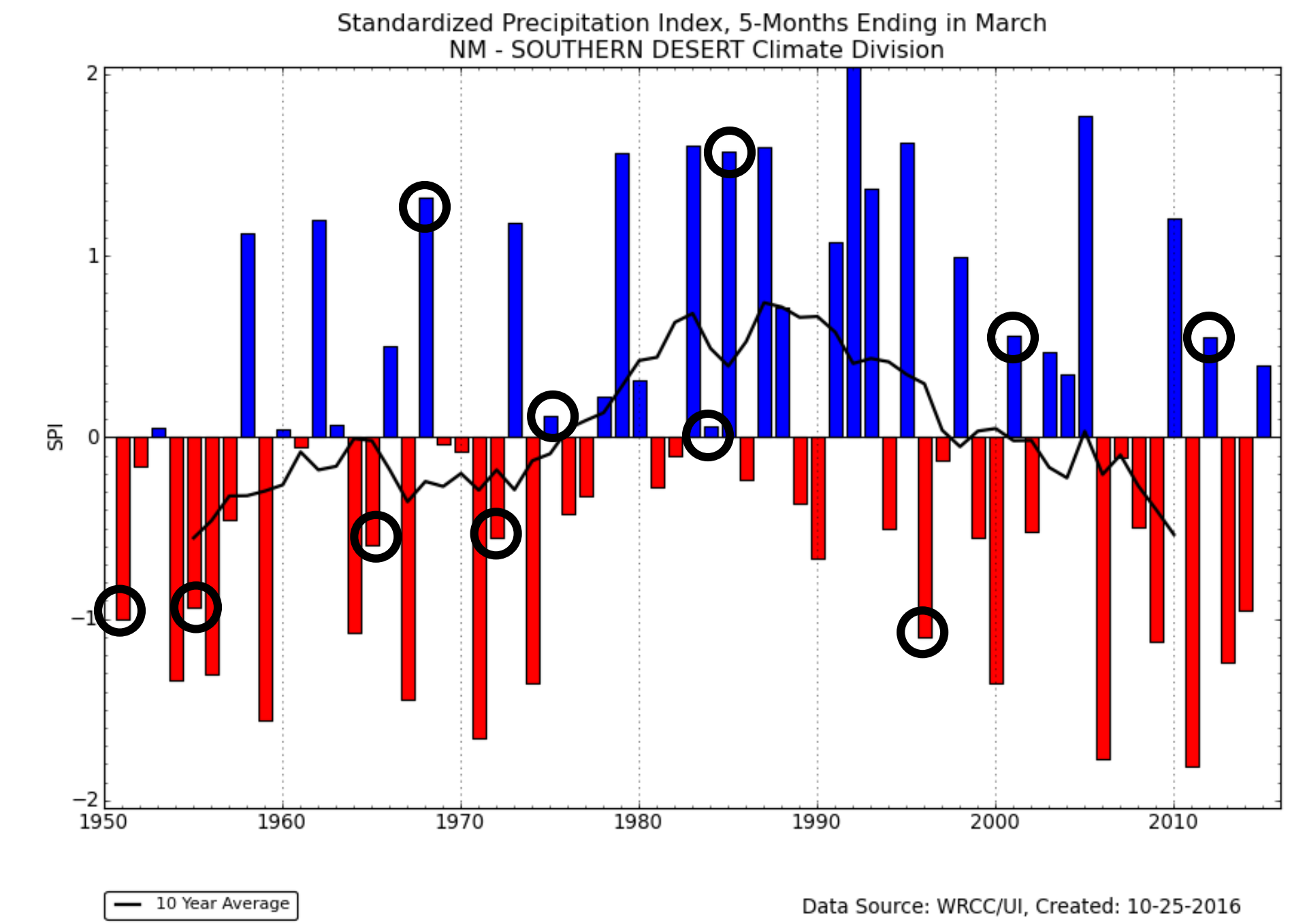
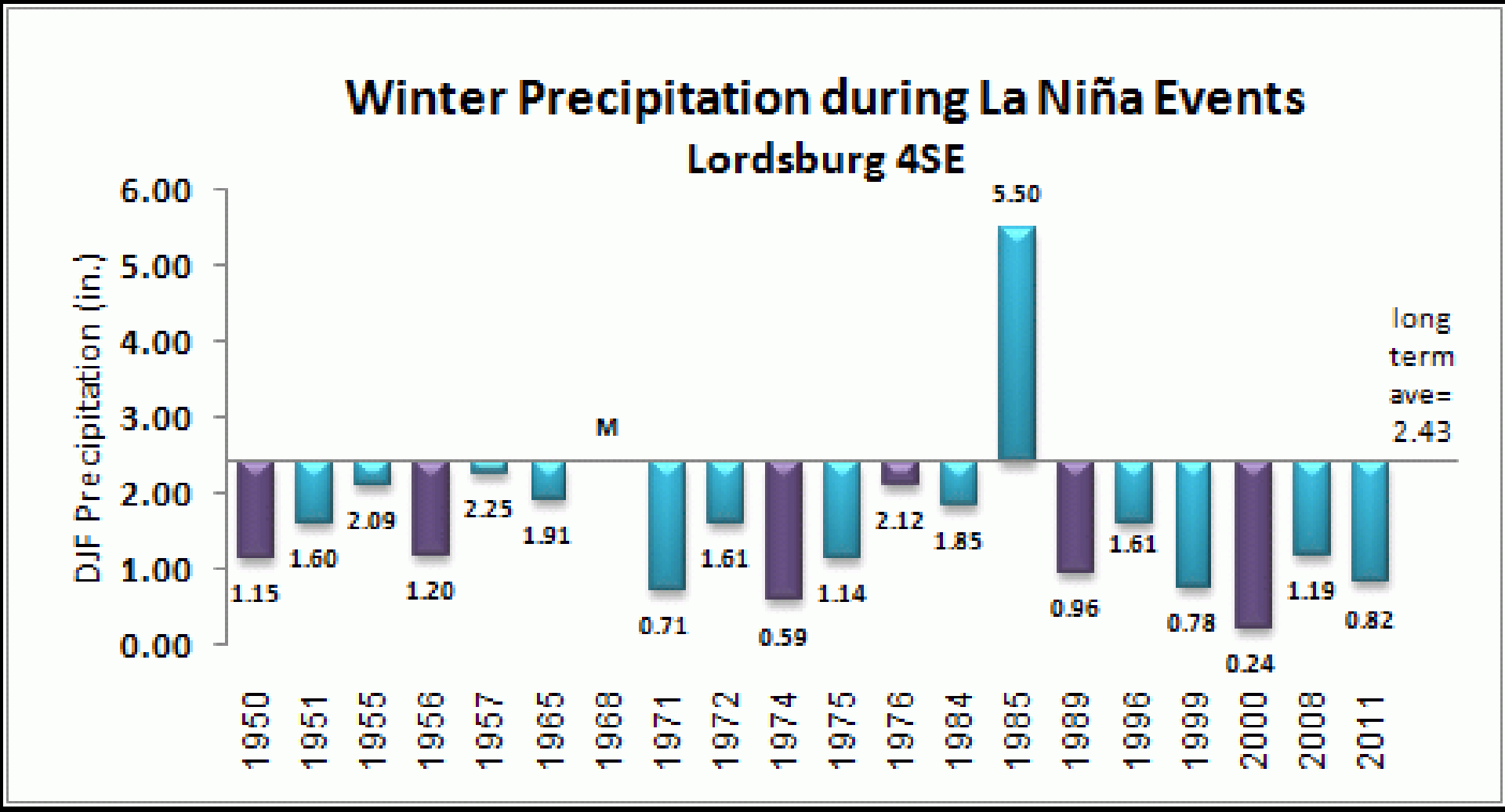
Valencia
Torrance
Guadalupe
Quay
Curry
De Baca
6
4
Roosevelt
Catron
Socorro
Lincoln
5
Chaves
Sierra
7
Grant
Otero
Lea
Eddy
8
Dona Ana
Luna
Hidalgo

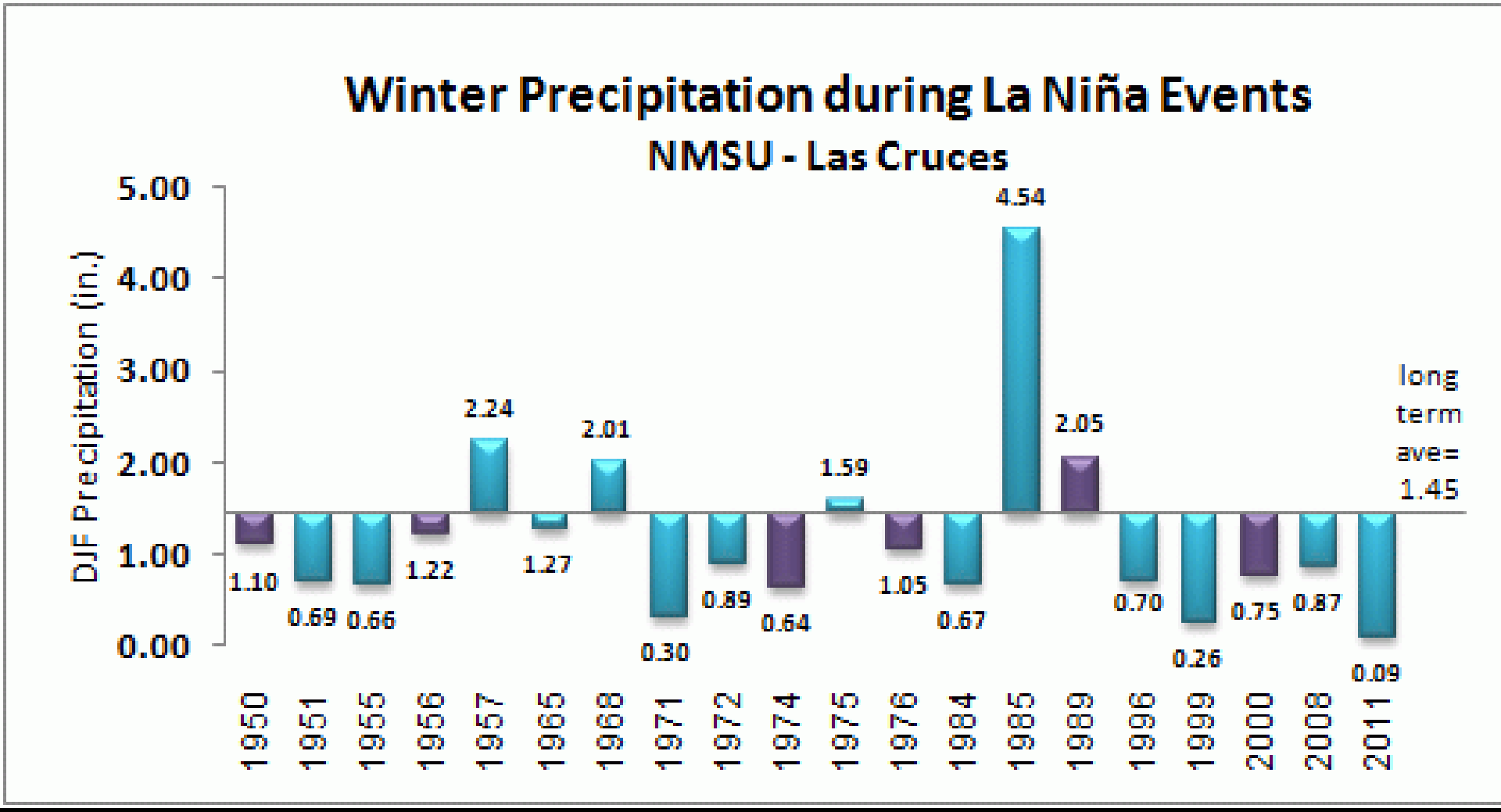

Standardized Precipitation Index, 5-Months Ending in March
NM - SOUTHERN DESERT Climate Division
SPI
2
1
0
−1
−2
1950
1960
1970
1980
1990
2000
2010
10 Year Average
Data Source: WRCC/UI, Created: 10-25-2016



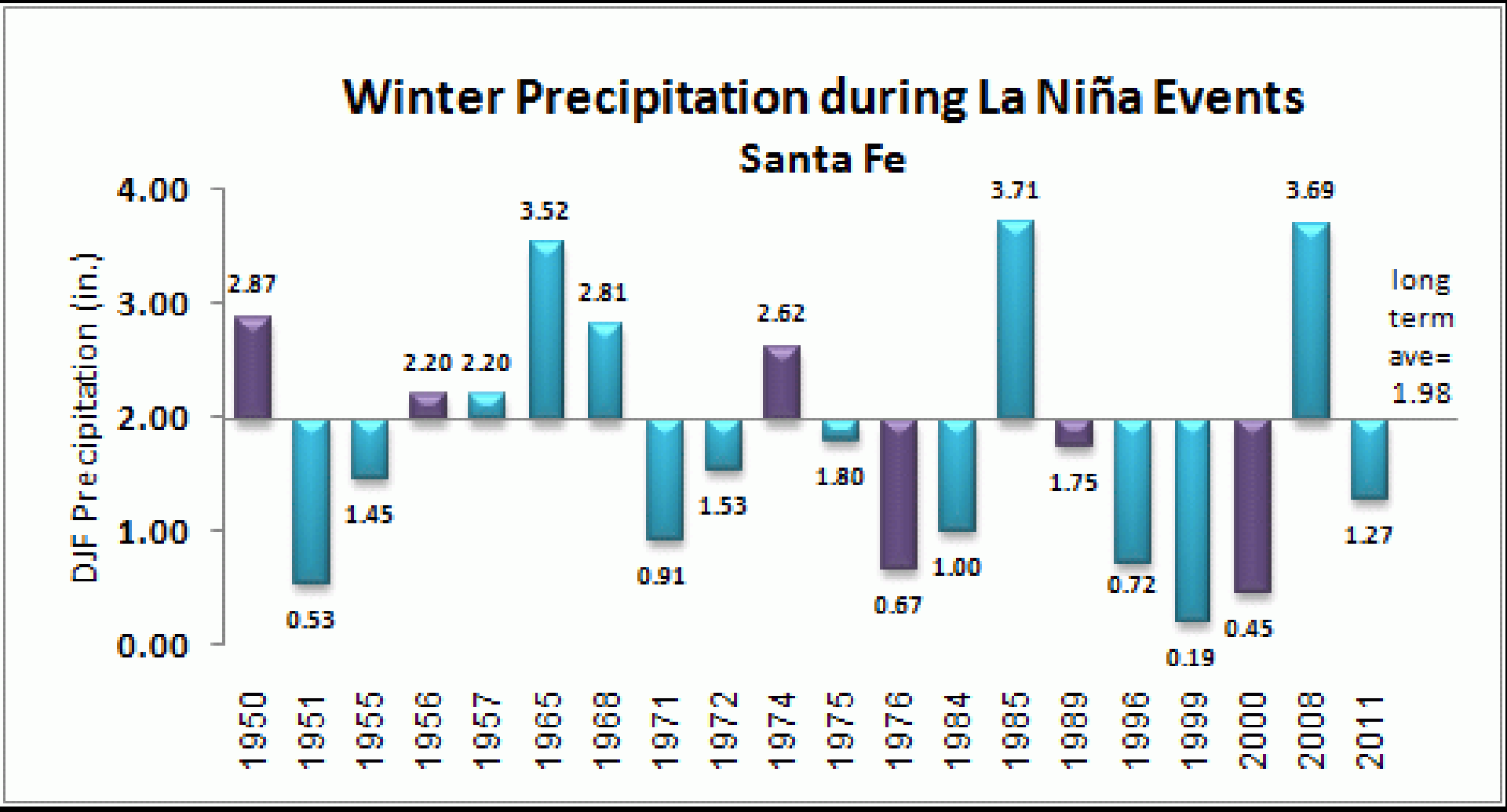
Data: Westwide Drought Tracker - http://www.wrcc.dri.edu/wwdt/



https://www.weather.gov/abq/clifeature_laninaprecip#winter



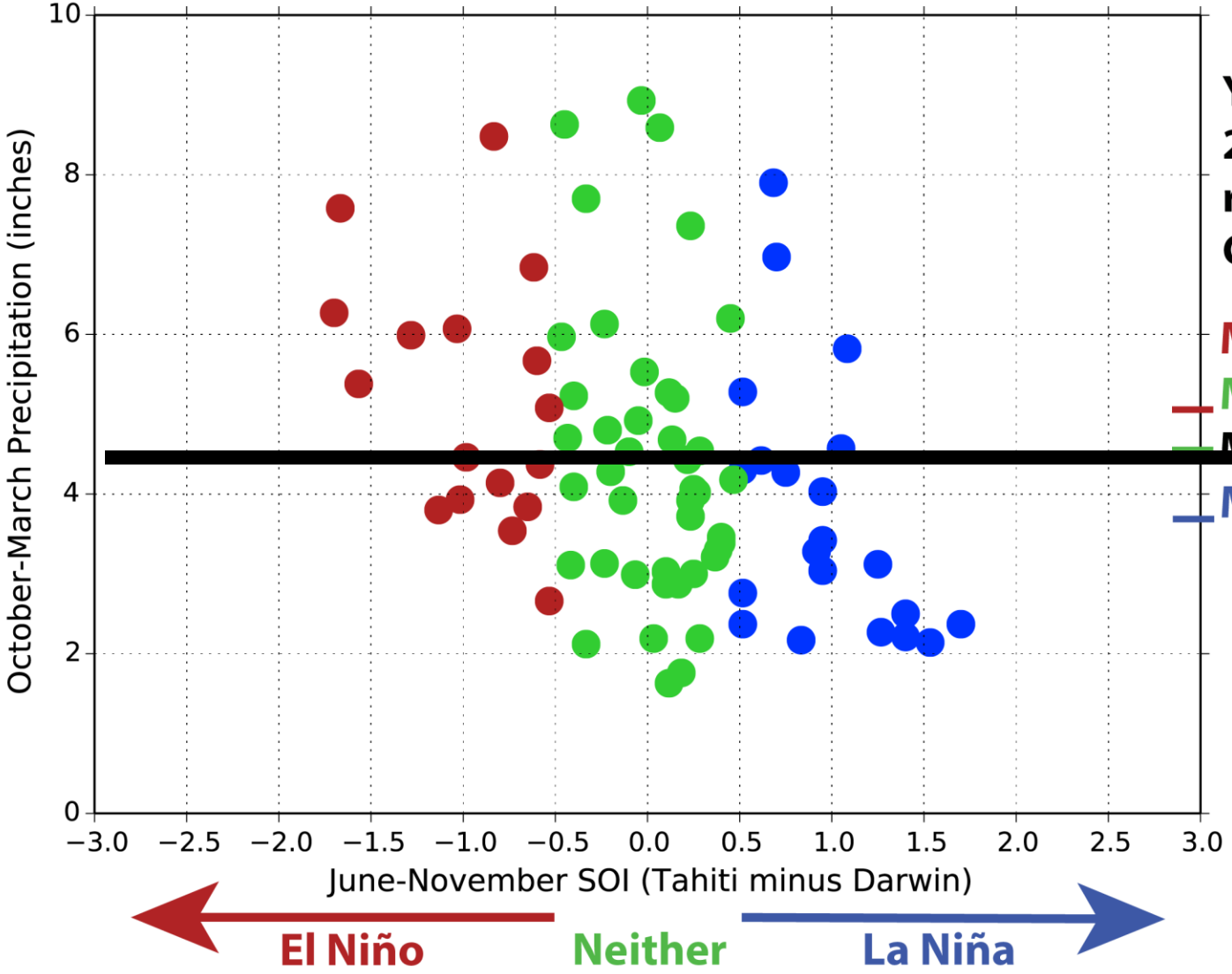
https://www.weather.gov/abq/clifeature_laninaprecip#winter



https://www.weather.gov/abq/clifeature_laninaprecip#winter

New Mexico Statewide October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



Years 1933/1934-2013/2014

$r^2 = 0.15$

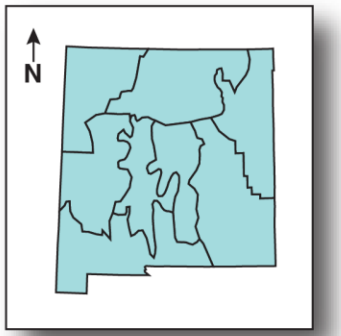
Correlation = -0.39

Mean = 5.18 in

Mean = 4.41 in

Mean all = 4.41 in

Mean = 3.77 in

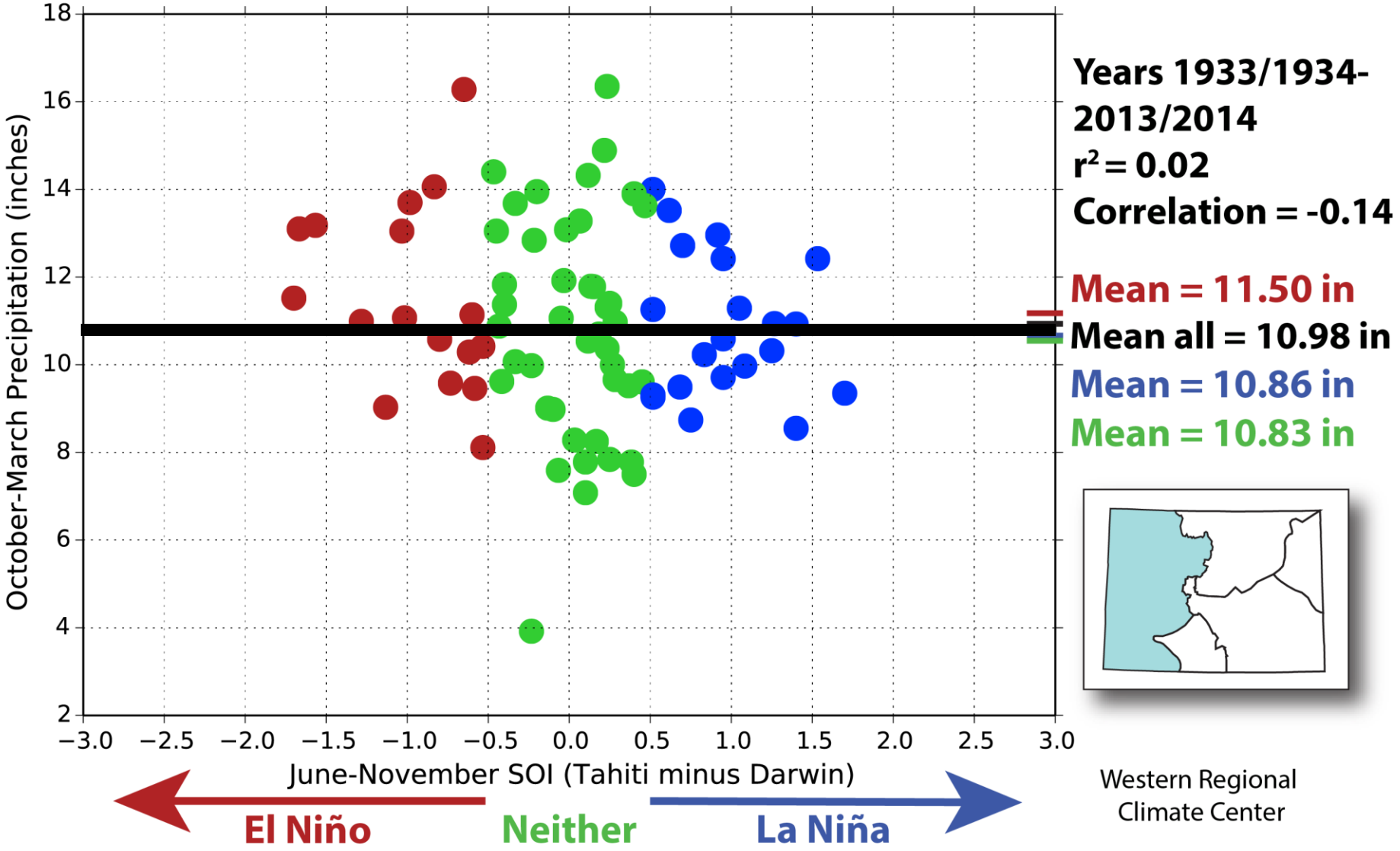


Western Regional Climate Center

http://www.wrcc.dri.edu/enso/soipcpn.html

CO Division 2 October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



http://www.wrcc.dri.edu/enso/soipcpn.html

Winter 2016-2017 Climate Outlook

October 20, 2016

- The CPC SST Consolidation Forecast, which includes three statistical forecasts along with the CFS, predicts a weak La Niña from NDJ 2016-2017 through JFM 2017 with ENSO-neutral conditions favored thereafter.

http://www.cpc.ncep.noaa.gov/products/predictions/90day/fxus05.htm

Summary

ENSO Alert System Status: La Niña Watch

ENSO-neutral conditions are present.*

Equatorial sea surface temperatures (SST) are below average in the central and east-central Pacific Ocean.

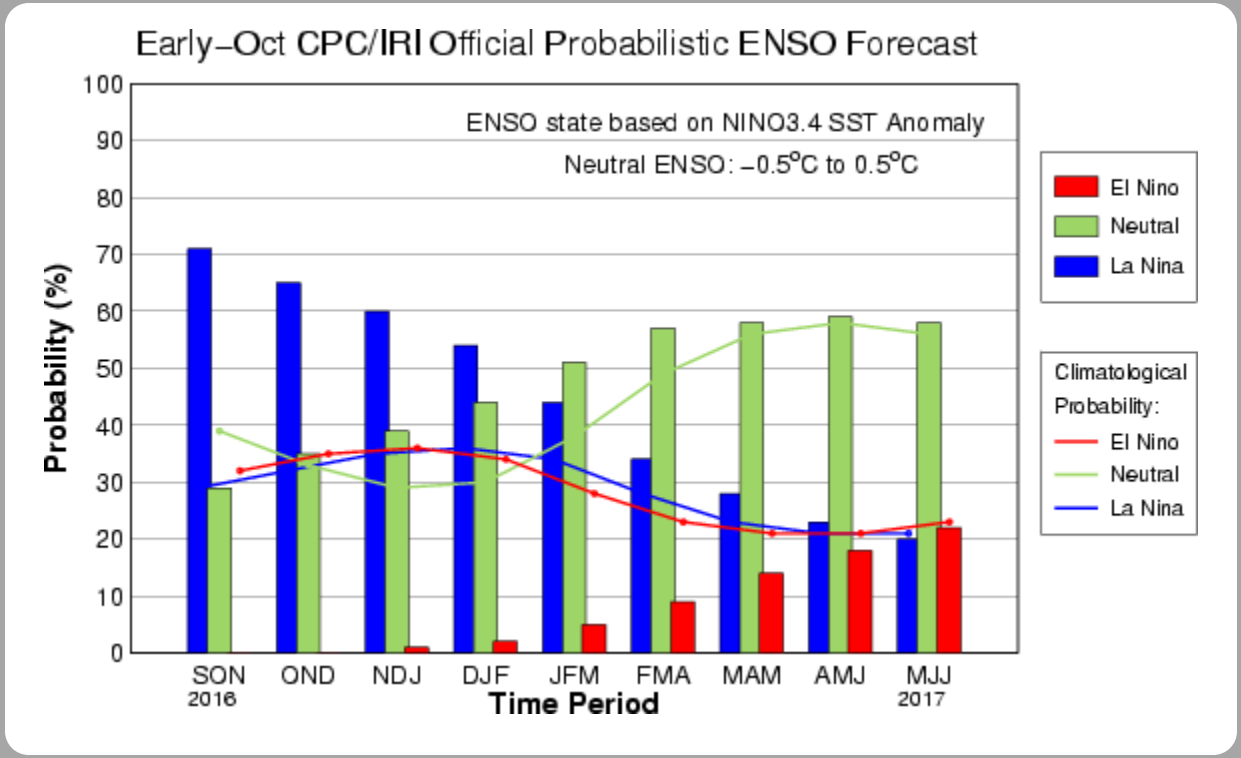
La Niña is favored to develop (~70% chance) during the Northern Hemisphere fall 2016 and slightly favored to persist (~55% chance) during winter 2016-17.*

* Note: These statements are updated once a month (2nd Thursday of each month) in association with the ENSO Diagnostics Discussion, which can be found by clicking here.

CPC/IRI Probabilistic ENSO Outlook

Updated: 13 October 2016

La Niña is favored to develop (~70% chance) during the Northern Hemisphere fall 2016 and slightly favored to persist (~55% chance) during winter 2016-17.



http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/

IRI/CPC Pacific Niño 3.4 SST Model Outlook

Most multi-model averages indicate weak La Niña conditions during the Northern Hemisphere fall and early winter 2016-17.

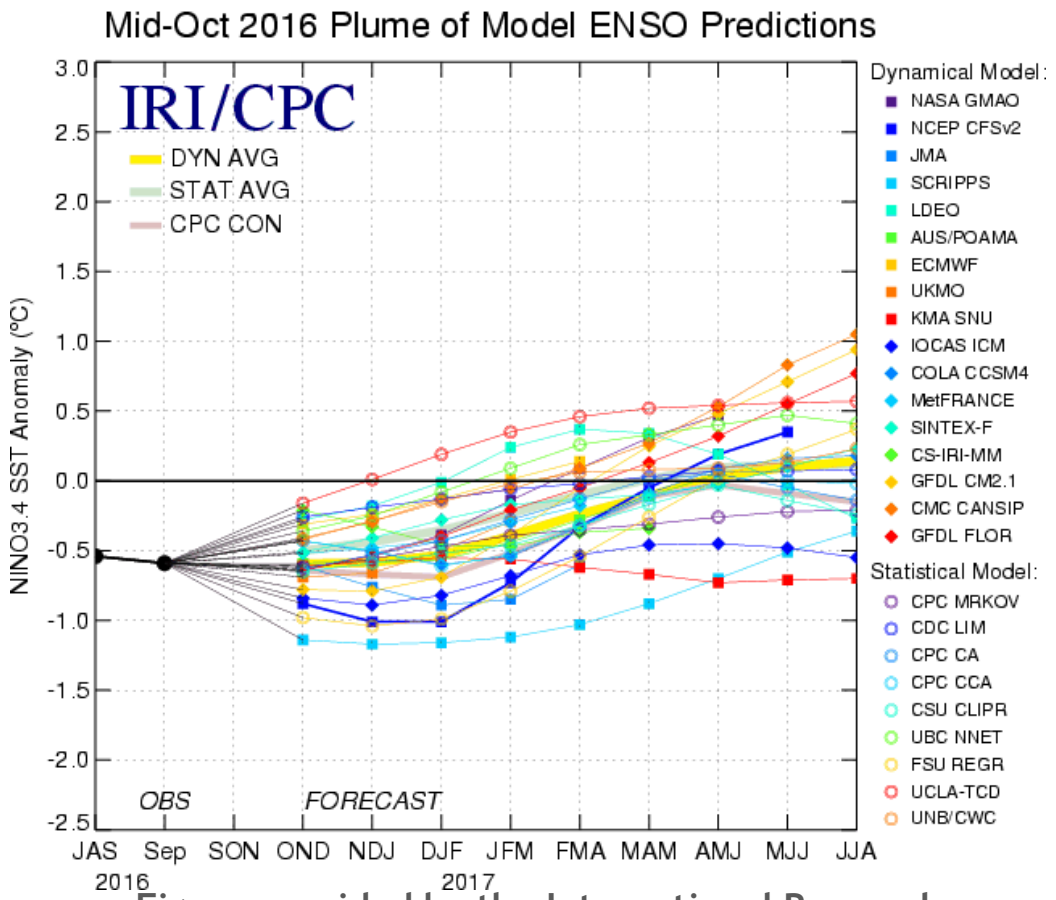


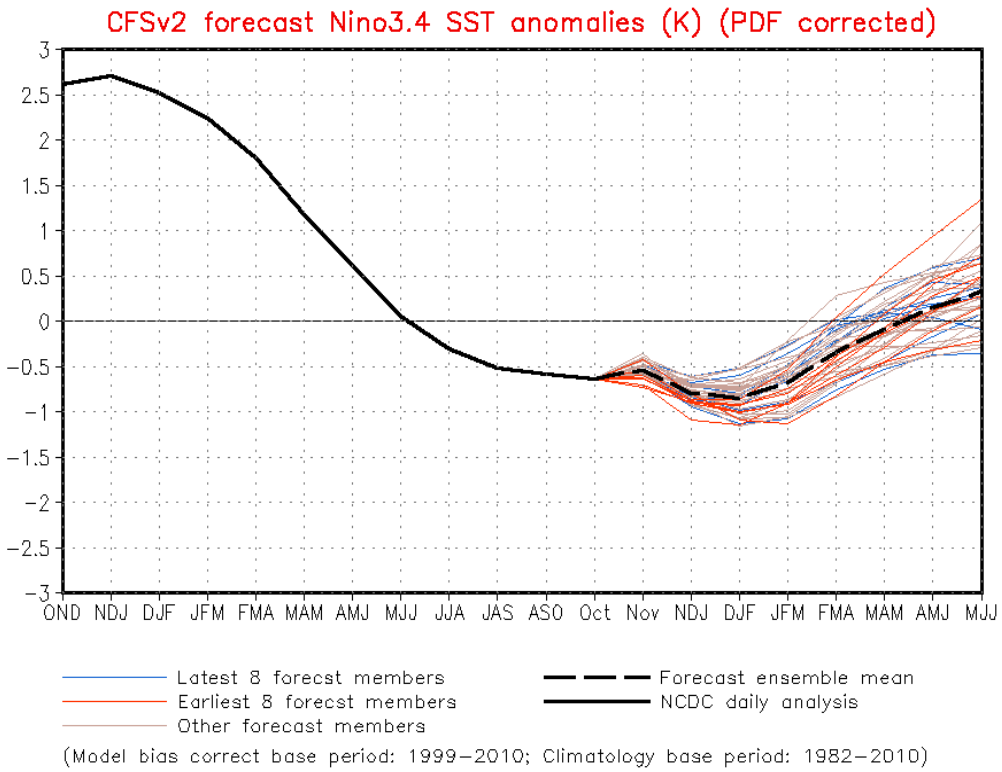
Figure provided by the International Research Institute (IRI) for Climate and Society (updated 18 October 2016).

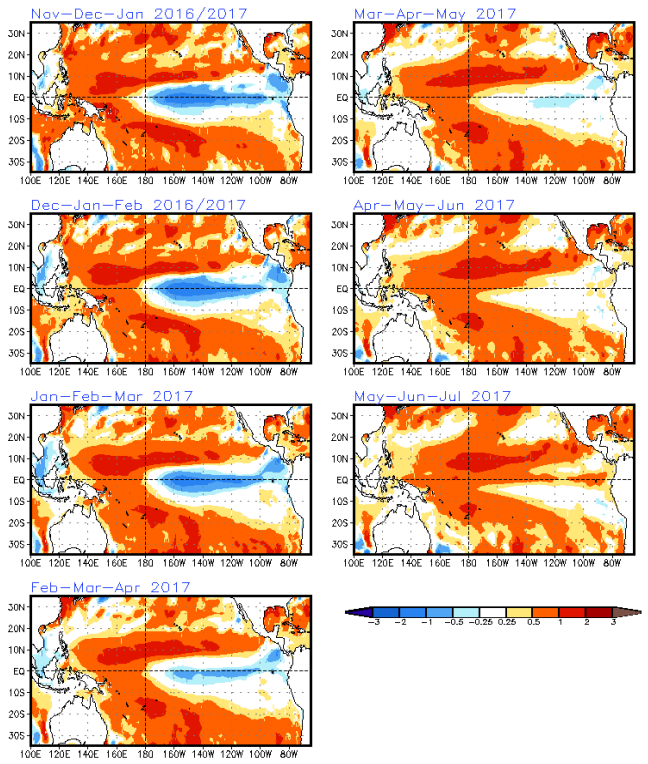
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/

SST Outlook: NCEP CFS.v2 Forecast (PDF corrected)

Issued: 24 October 2016

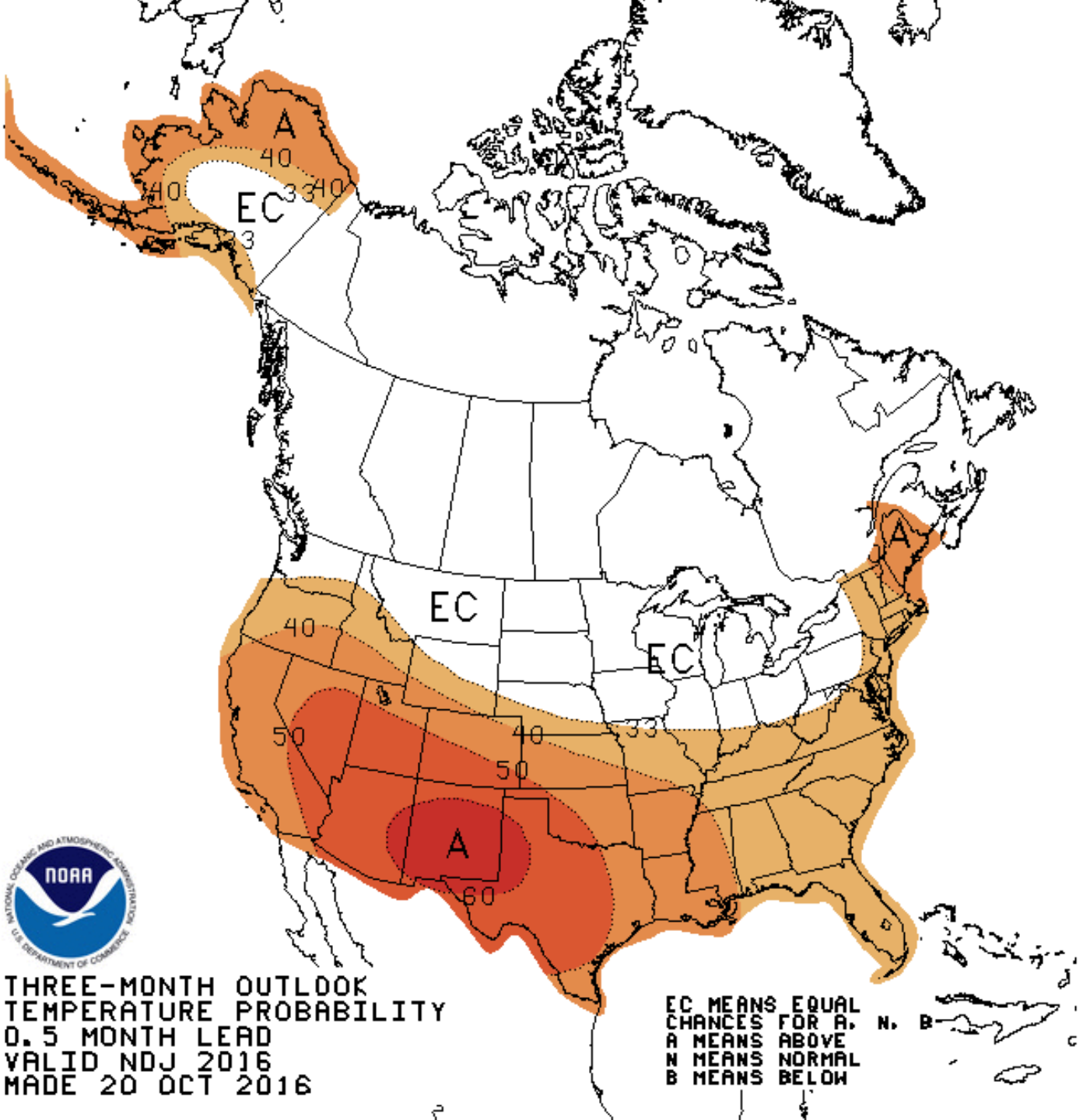
The CFS.v2 ensemble mean (black dashed line) favors La Niña during the Northern Hemisphere fall and winter 2016-17.





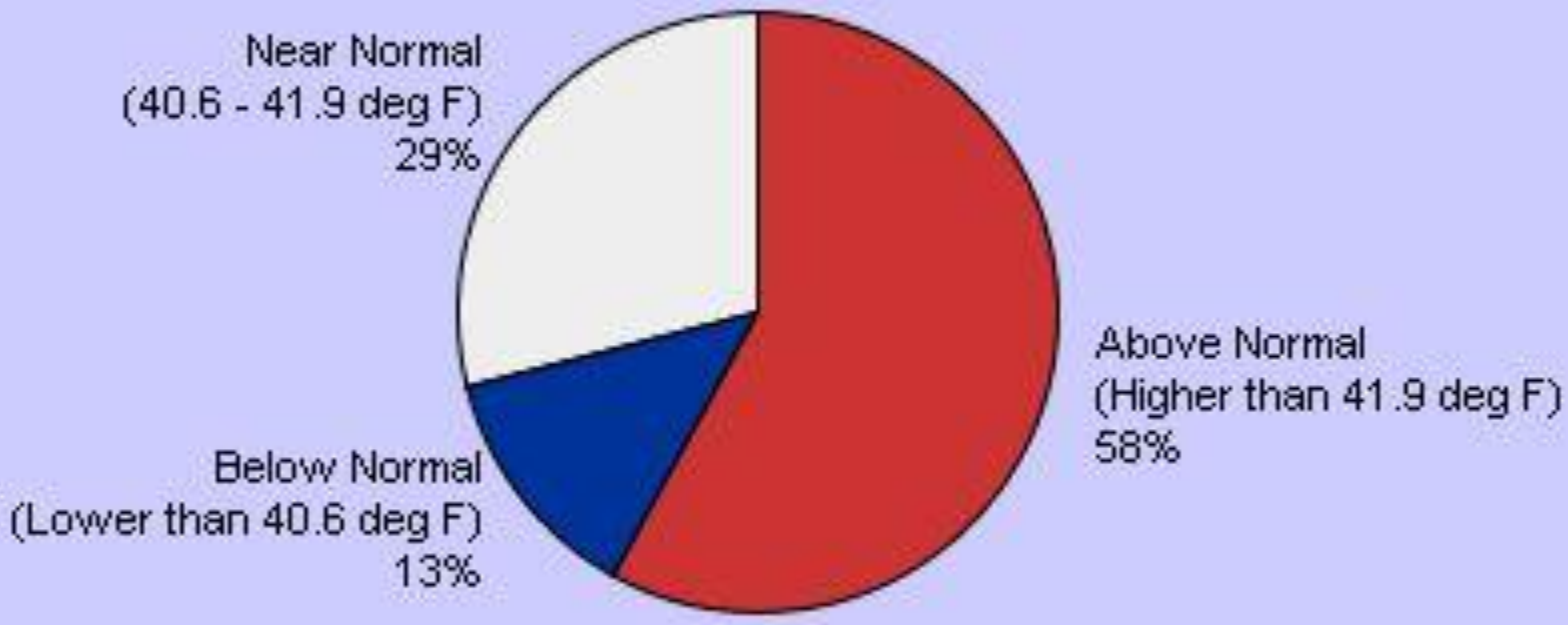
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/

http://www.cpc.ncep.noaa.gov/products/forecasts/



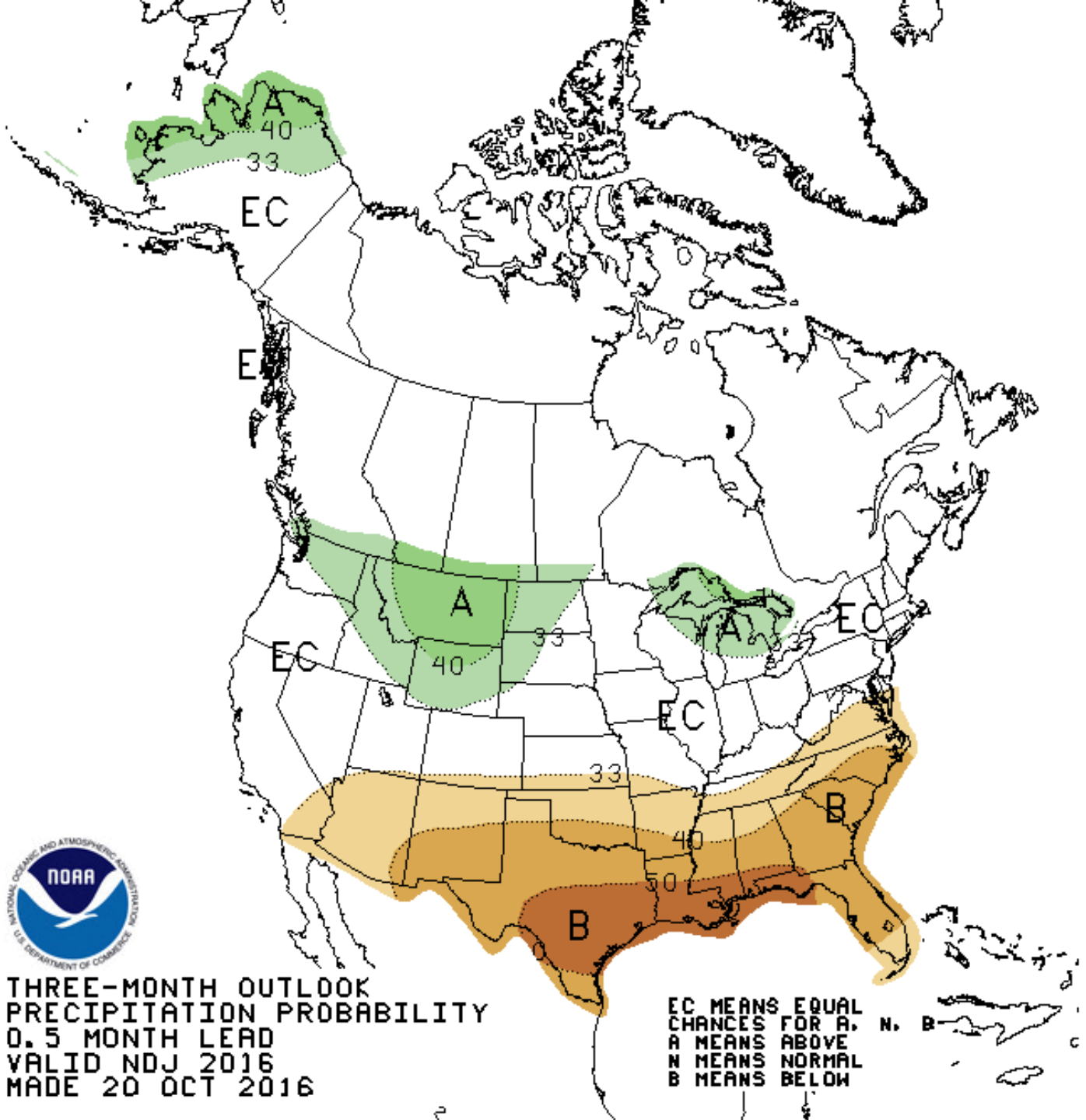
Jornada Range Station

November through January

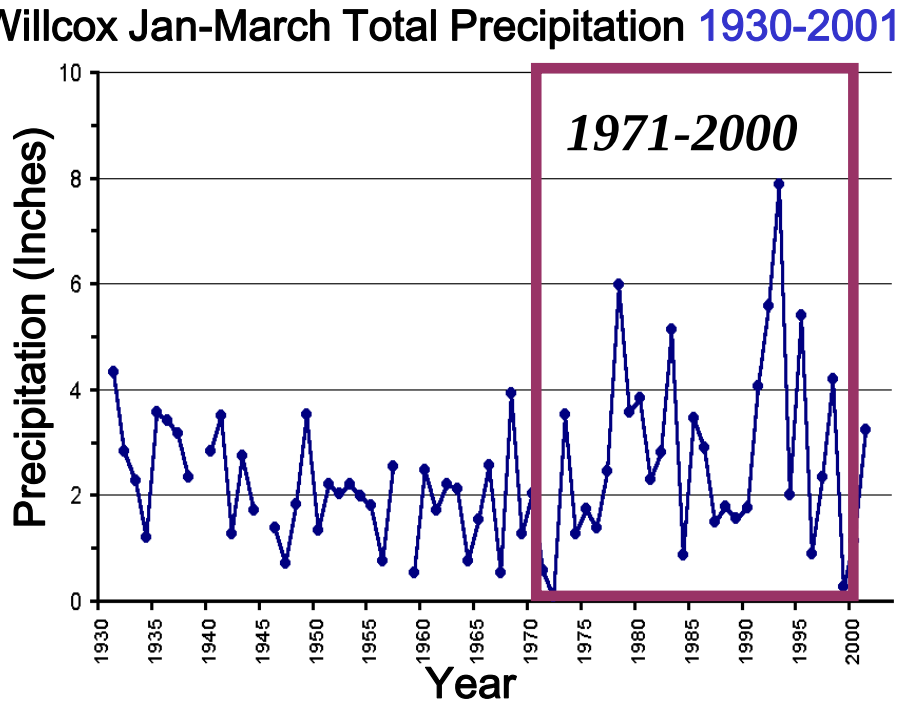


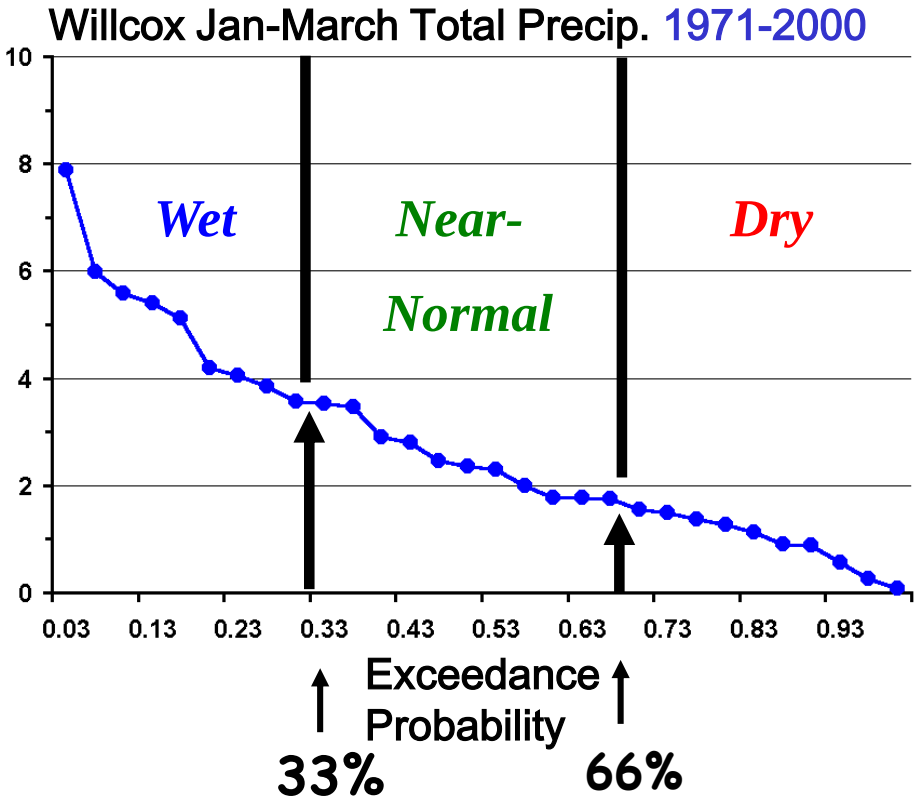
NOAA Local 3-month Temperature Outlooks
https://www.weather.gov/climate/l3mto.php

http://www.cpc.ncep.noaa.gov/products/forecasts/



Wet, Dry, Normal – Compared to What?



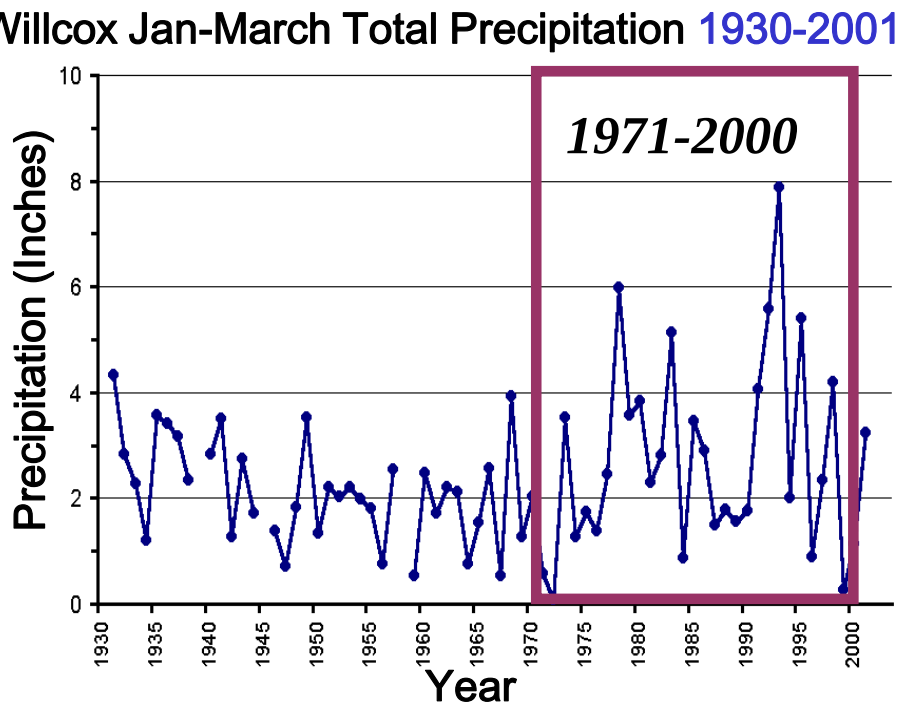


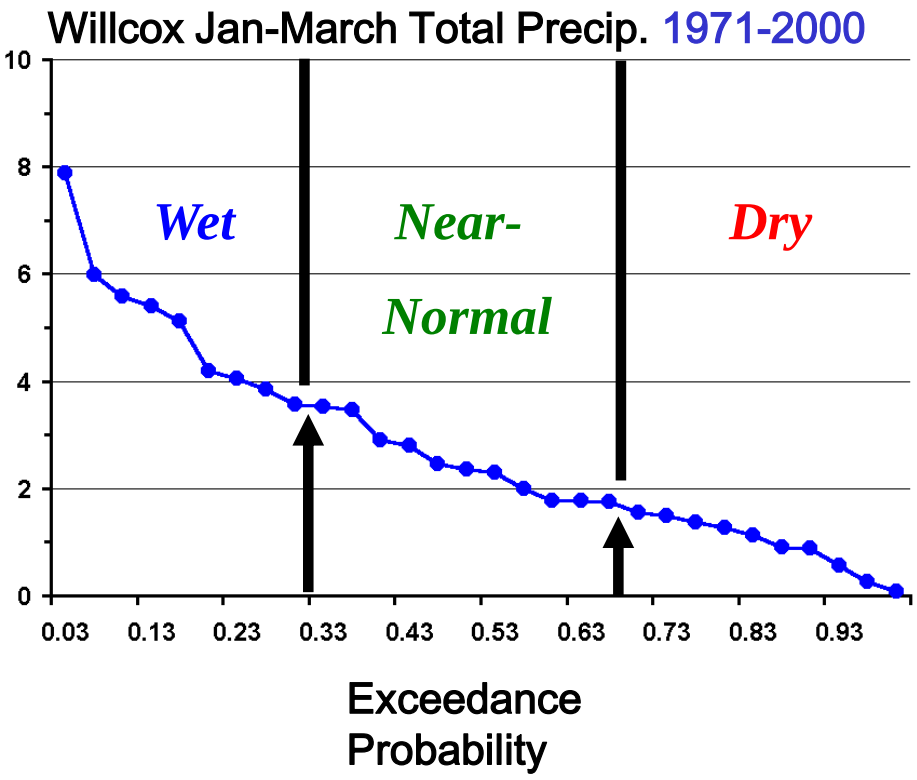
Normal chances are based only on 30 years of data.

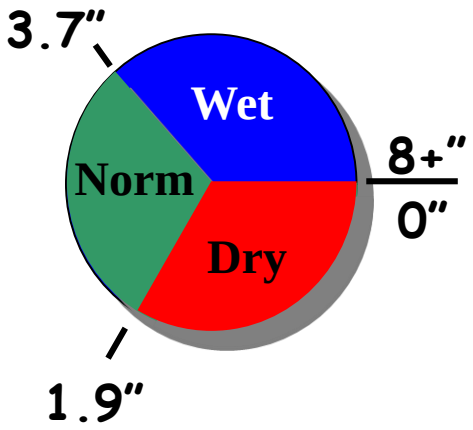
The data are ranked and divided into three categories of equal probability, with roughly 10 years in each category.

Courtesy of Holly C. Hartmann Consulting

Wet, Dry, Normal – Compared to What?







10 years had more than 3.7 inches
10 years had less than 1.9 inches
10 years were in the middle

Courtesy of Holly C. Hartmann Consulting

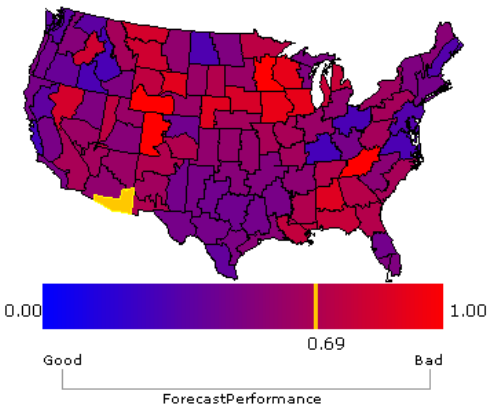
ForecastPerformance ForecastPerformance

Show Data Behind the Map

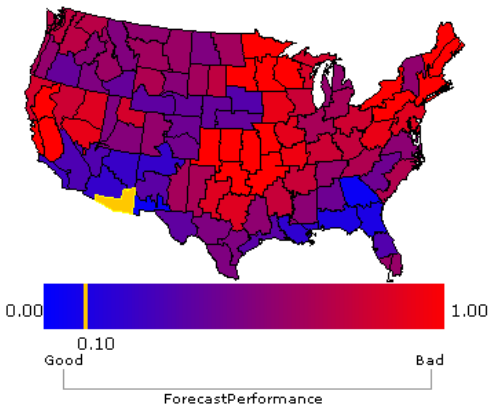
5 False Alarm Rate Results

This pair of maps
shows the False Alarm Rate for wet (left) and dry (right) conditions. The False Alarm Rate tracks how often the category given the greatest probability has turned out "wrong", compared to how many times that category has been forecast. It indicates how well you can trust what the forecast say. The legend shows the False Alarm Rate as a percentage.

WET



DRY



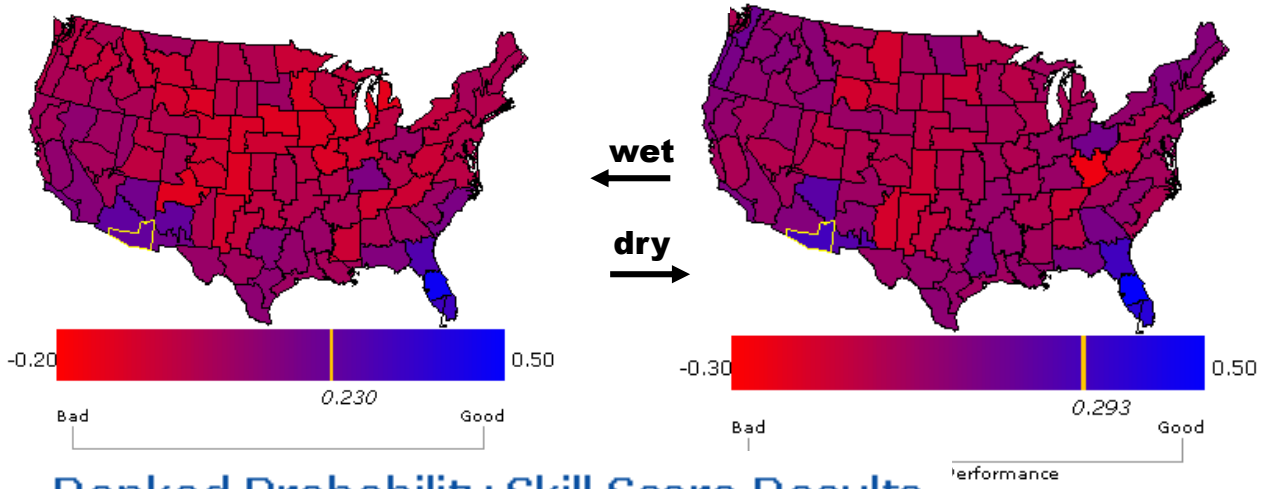
Show Data Behind the Map

Precipitation
Made in: ASO
For: NDJ, JFM

For comments about forecasts, contact Holly Hartmann: hollyoregon@juno.com
For comments or suggestions about this website, contact the HyDIS Team: hydis_team@hwr.arizona.edu

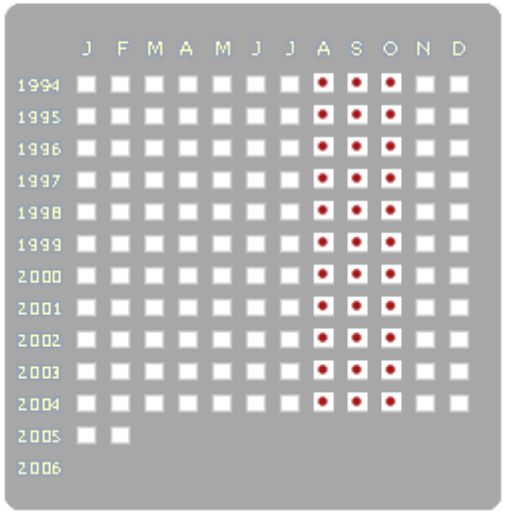
Forecast Performance Evaluation

Brier Skill Score Results

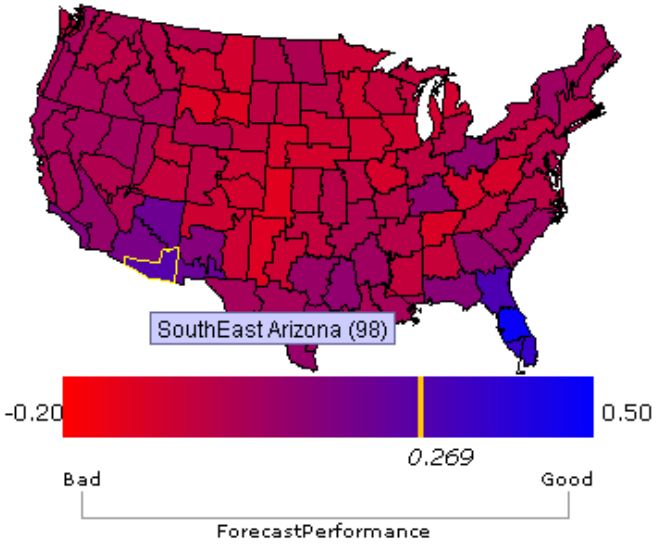


You Chose:

- CPC Forecasts
- Precipitation forecasts
- Covering seasons DJF - FMA
- Issued in:

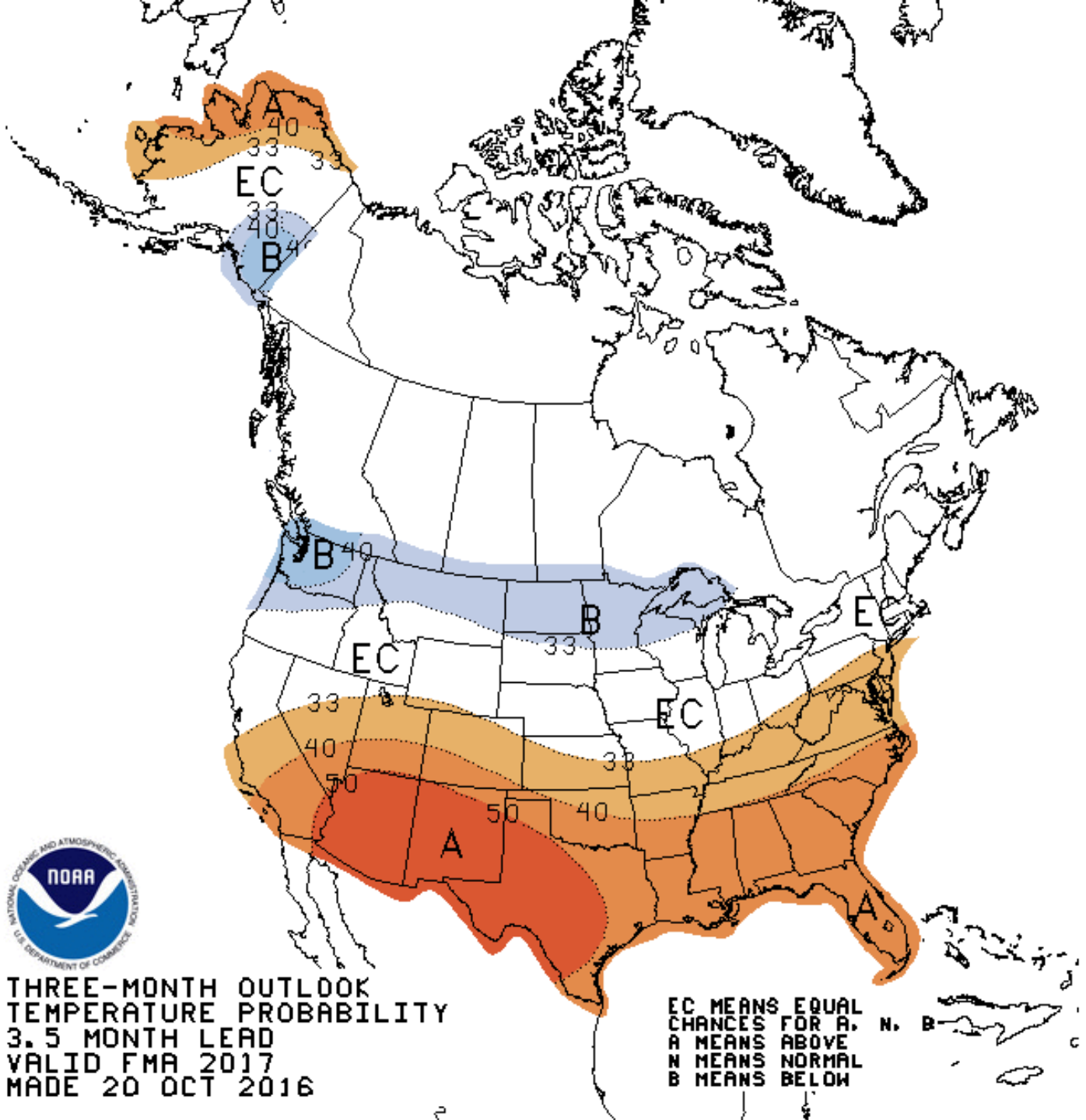


Ranked Probability Skill Score Results

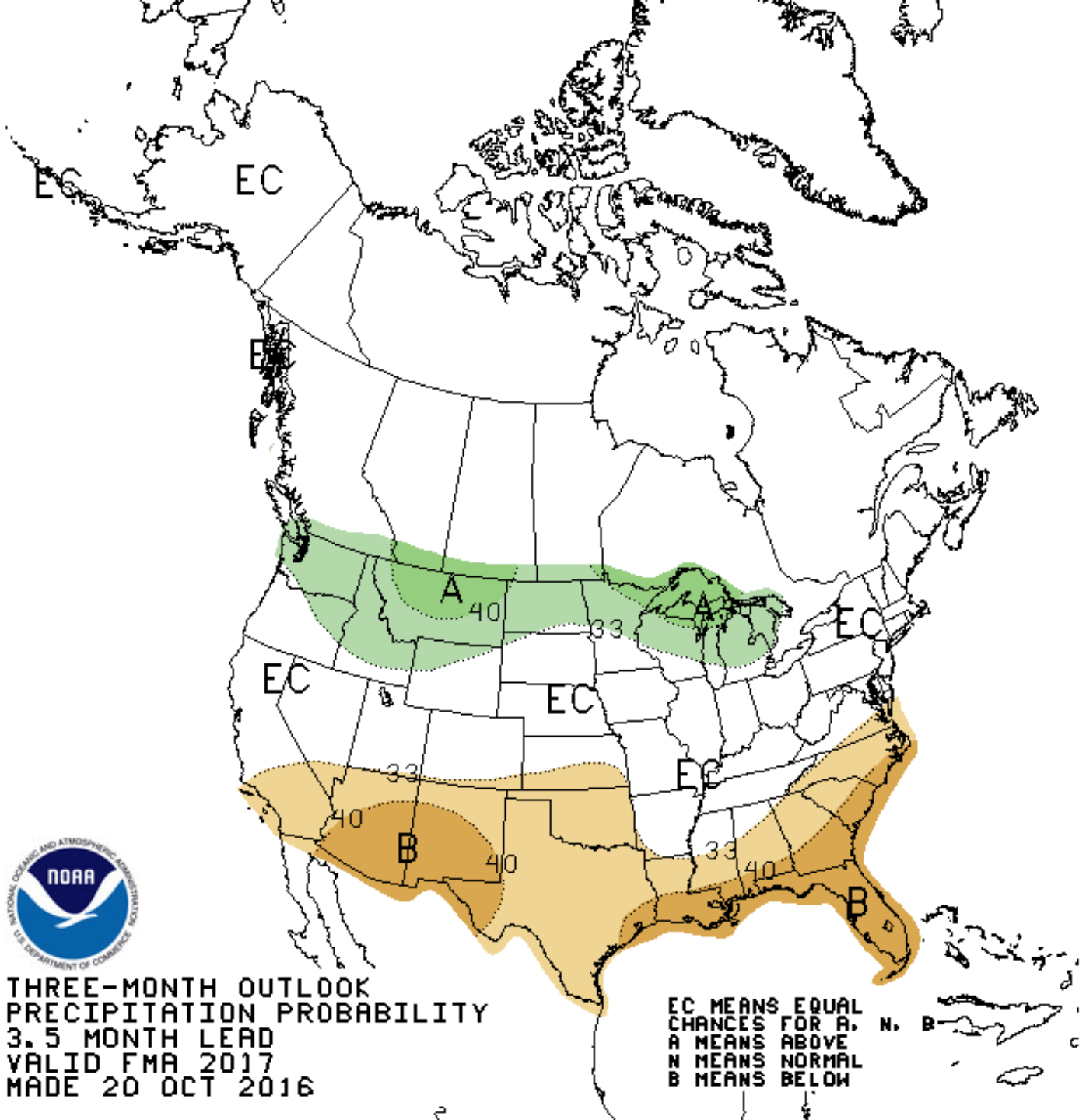


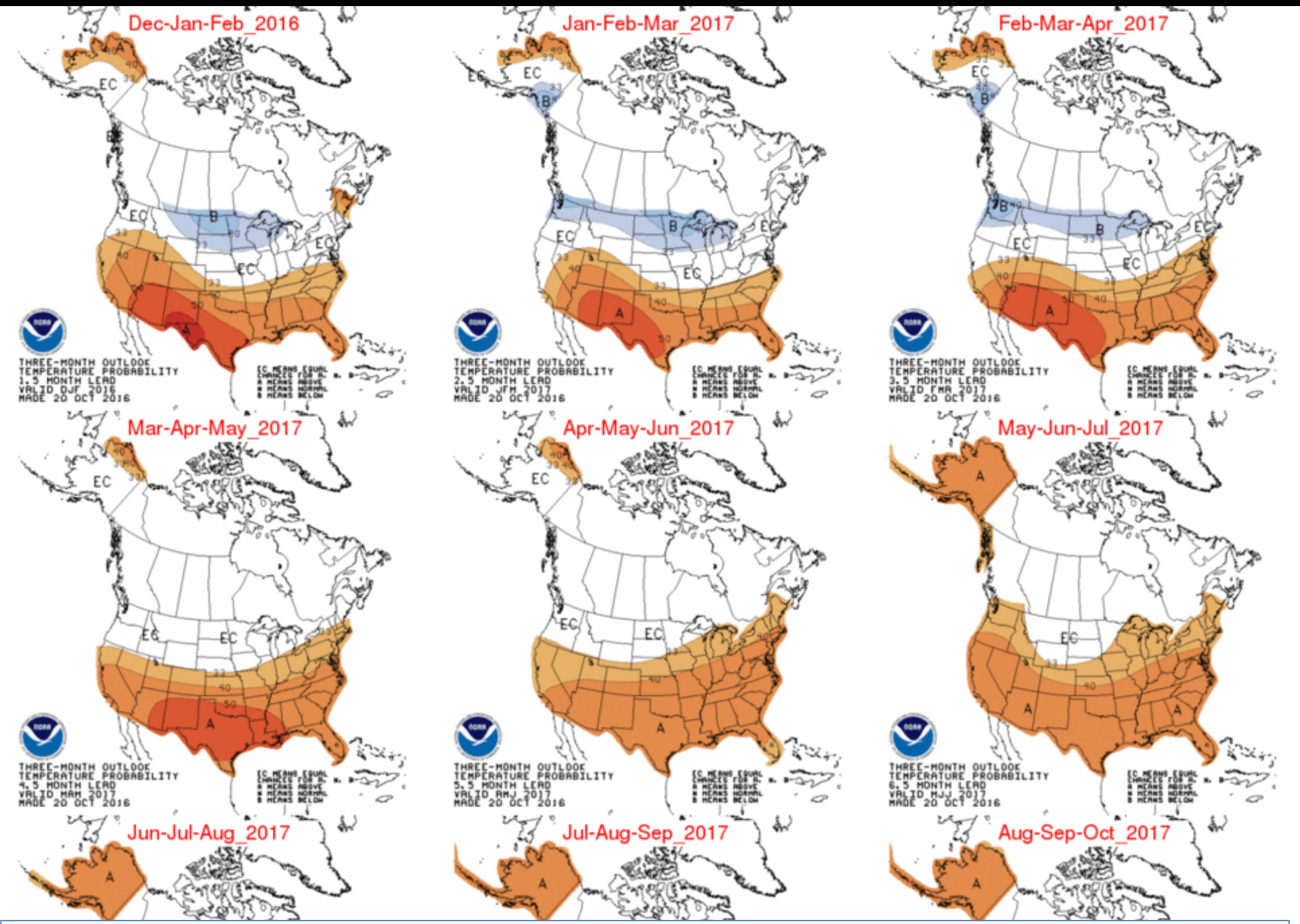
Courtesy of Holly C. Hartmann Consulting

http://www.cpc.ncep.noaa.gov/products/forecasts/



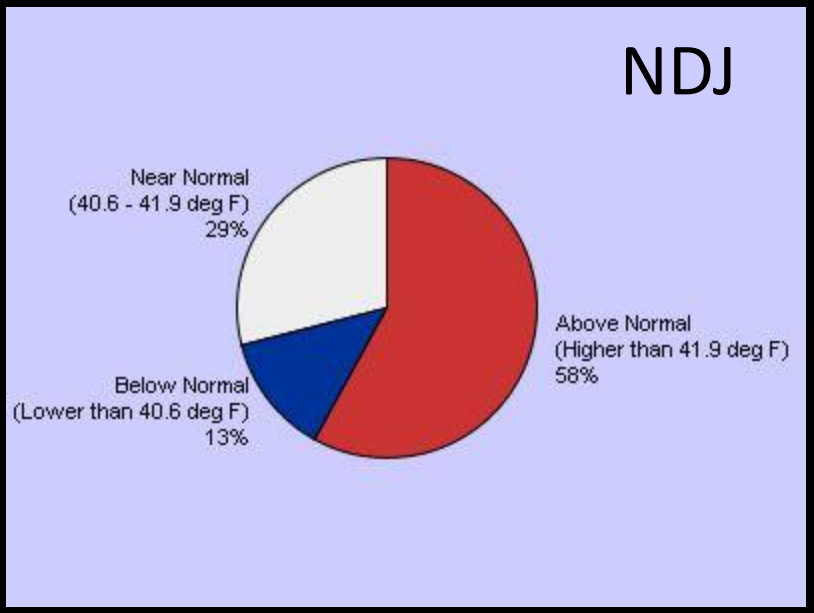
http://www.cpc.ncep.noaa.gov/products/forecasts/



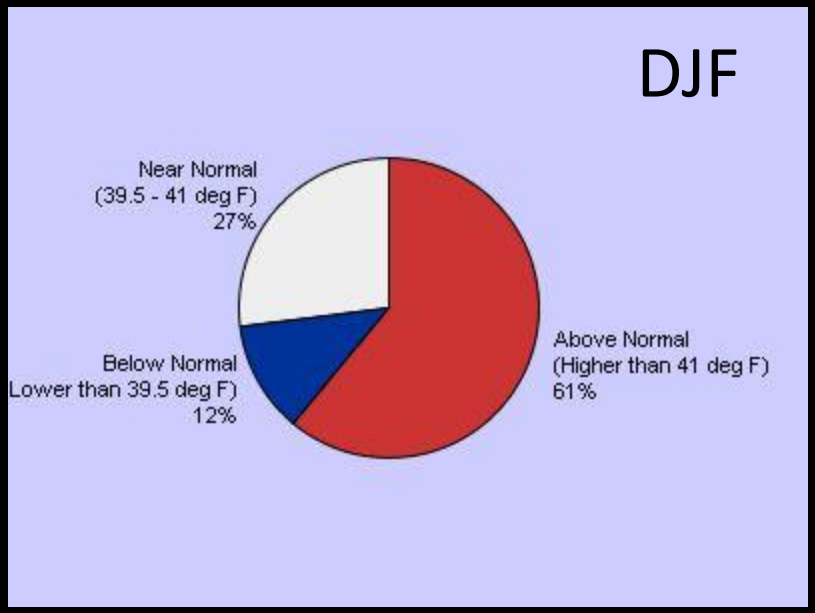


http://www.cpc.ncep.noaa.gov/products/forecasts/

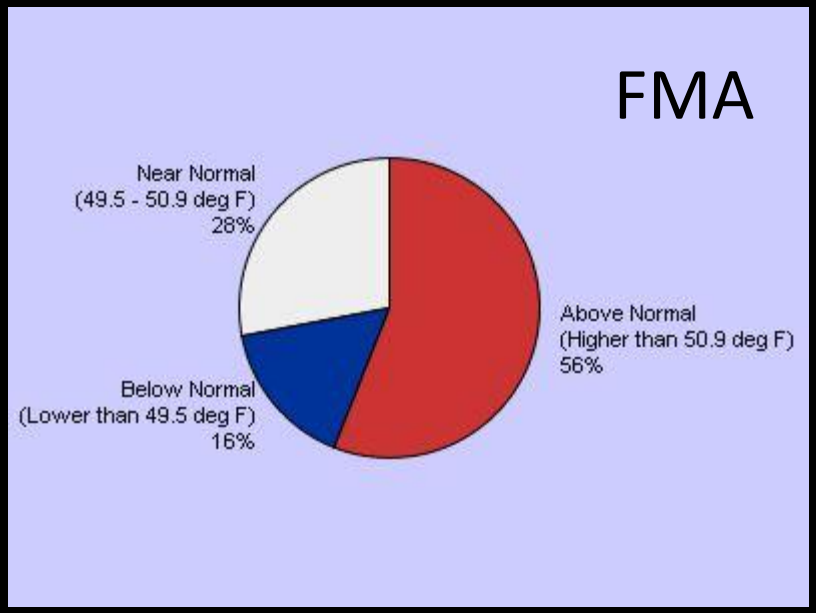
NDJ



DJF

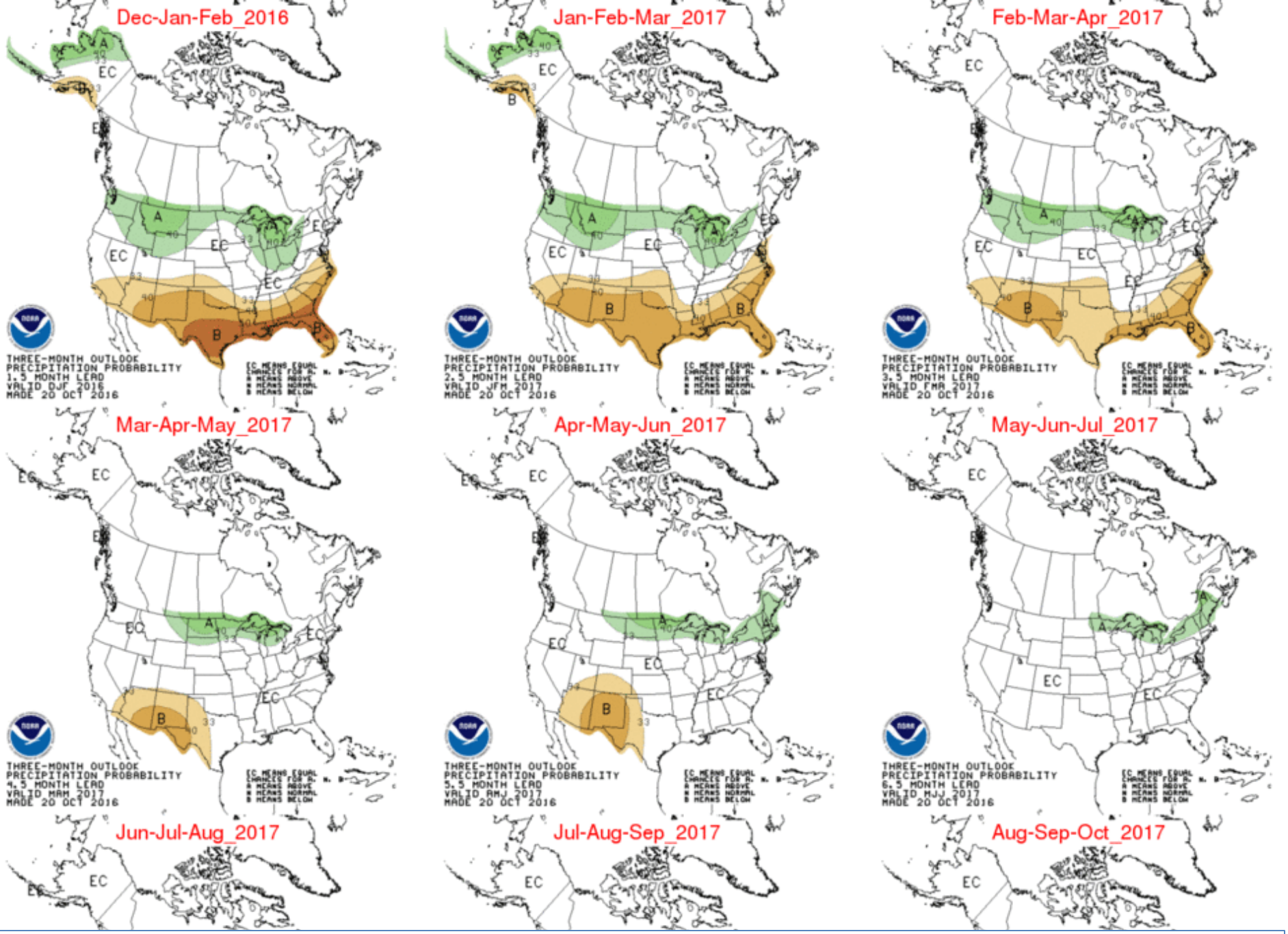


FMA



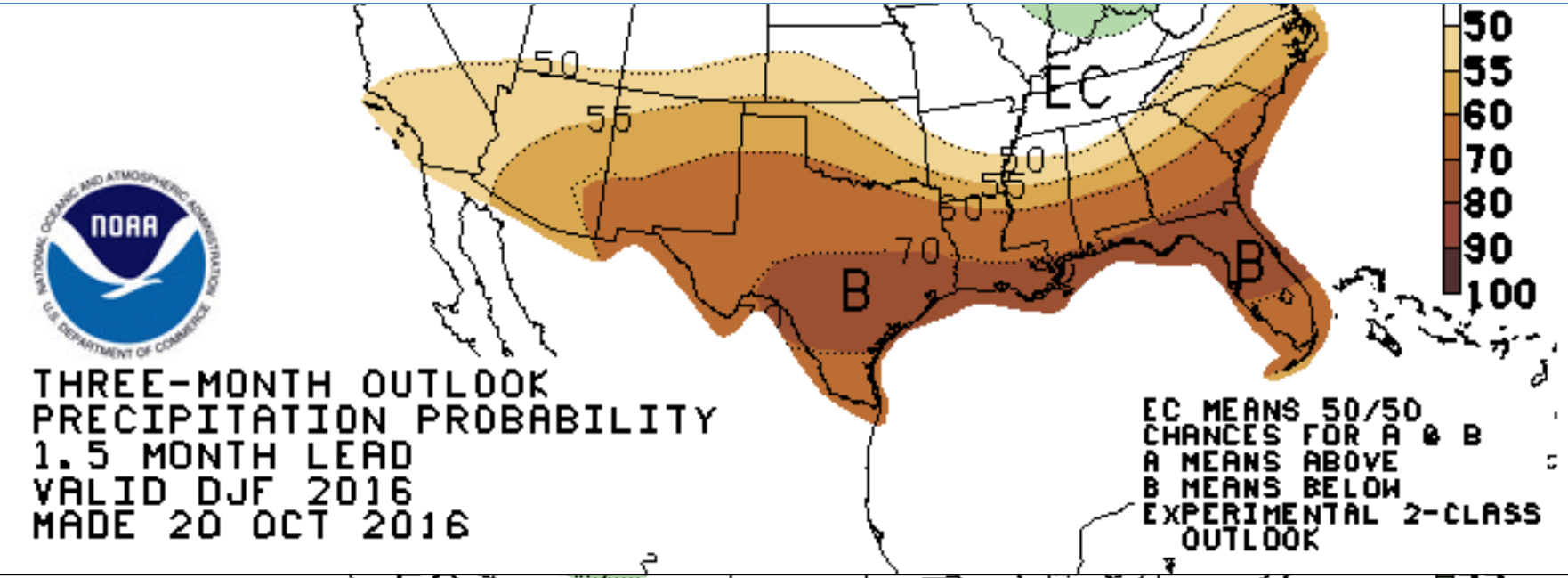
Jornada Range Station

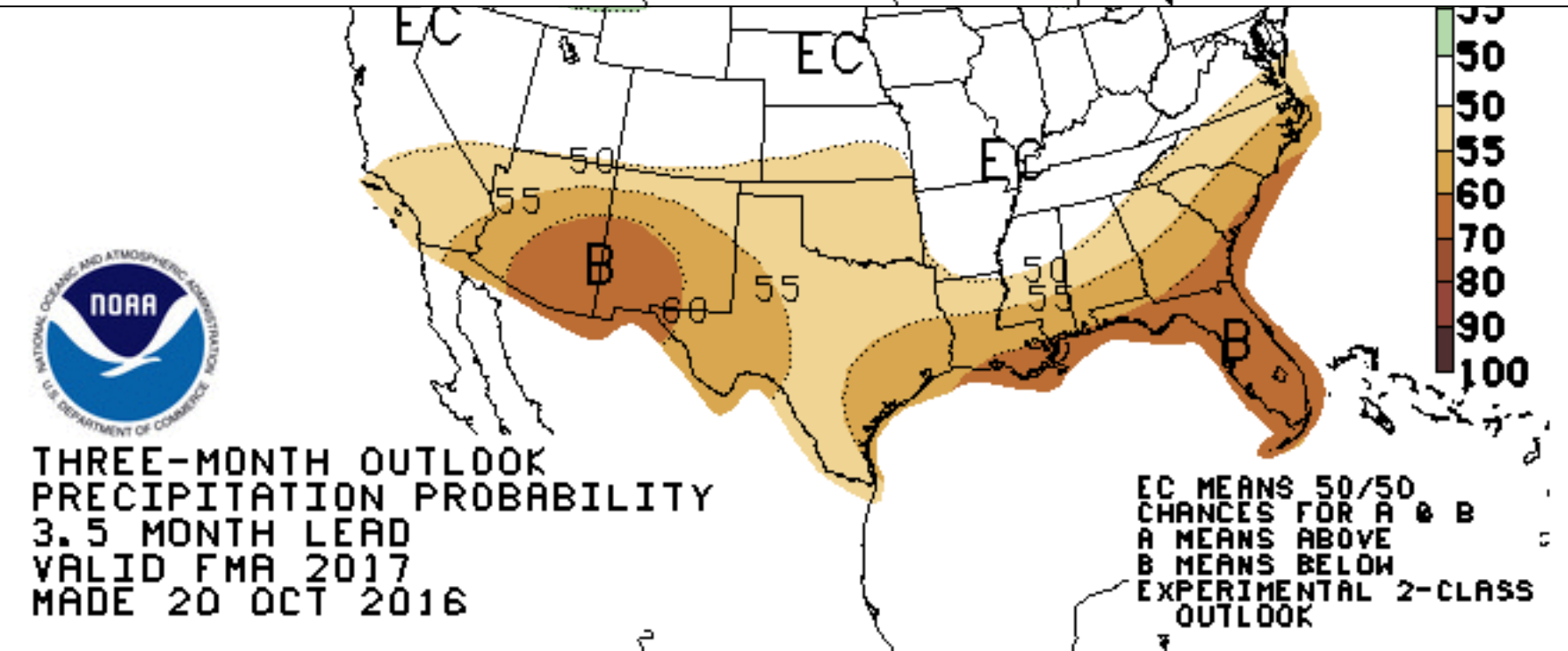
NOAA Local 3-month Temperature Outlooks
https://www.weather.gov/climate/l3mto.php



http://www.cpc.ncep.noaa.gov/products/forecasts/

http://www.cpc.ncep.noaa.gov/products/predictions/long_range/two_class.php





- Not every El Niño produces the same effect.
- La Niña has a more consistent signal, in general, than El Niño.
- The relations are not perfect, other things are happening in the climate system.
- Patterns for large events may differ in some ways from typical ENSO patterns.
- The relationship is lagged. Best associations are found between summer/autumn index and the following winter climate, and the following spring and summer streamflow runoff.

Kelly Redmond, Western Regional Climate Center

- Dry seems like a fair bet, but we can get extreme precipitation days during La Nina.
- Warm is a good bet, but we can get individual very cold days during La Nina.

CLIMAS
Climate Assessment for the Southwest

Gregg Garfin
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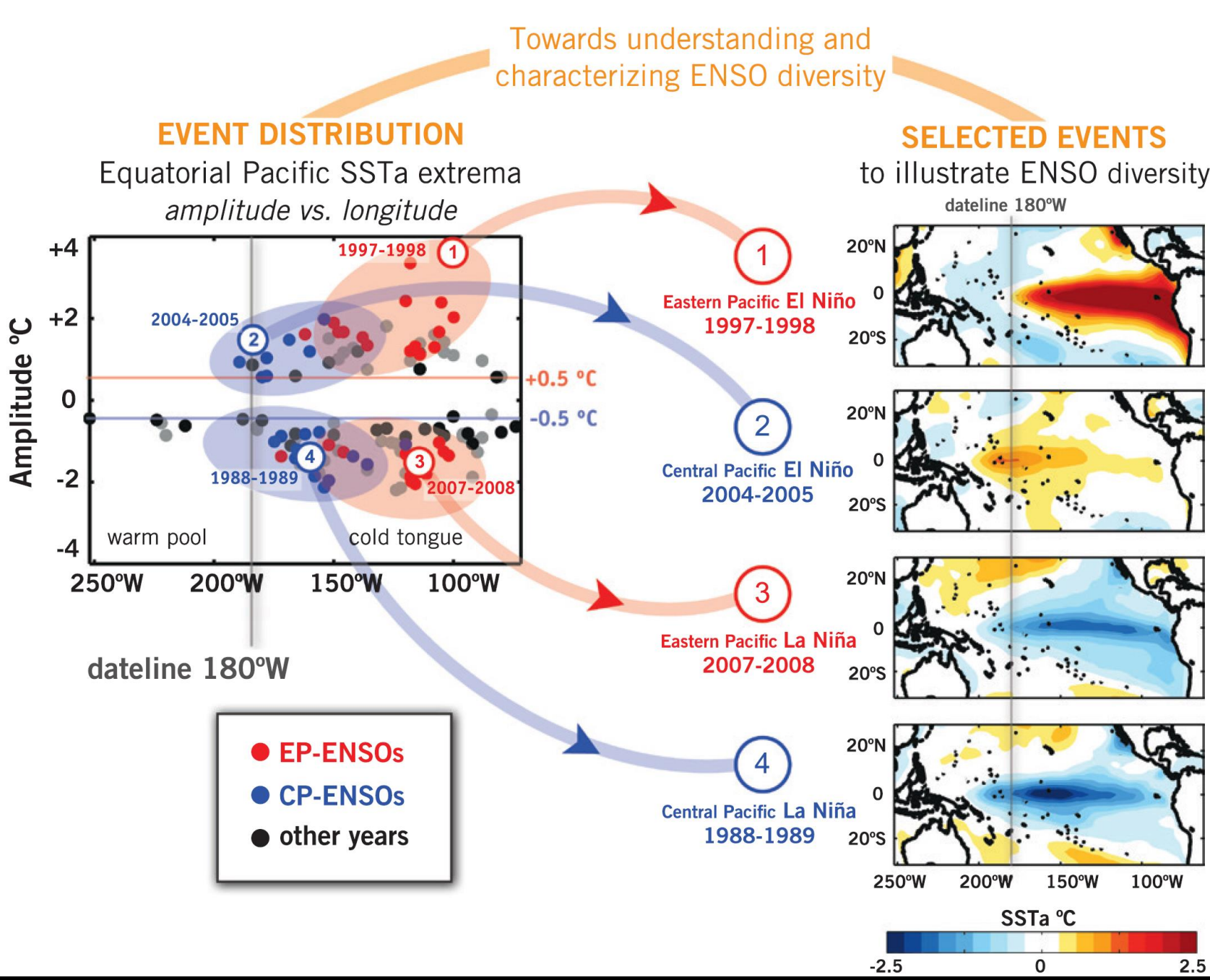
and
Institute of the Environment
The University of Arizona
gmgarfin@email.arizona.edu
520-626-4372

Institute of the Environment
CLIMAS Climate Assessment for the Southwest
ARIZONA COOPERATIVE EXTENSION



Capotondi et al. 2015 – Understanding ENSO Diversity