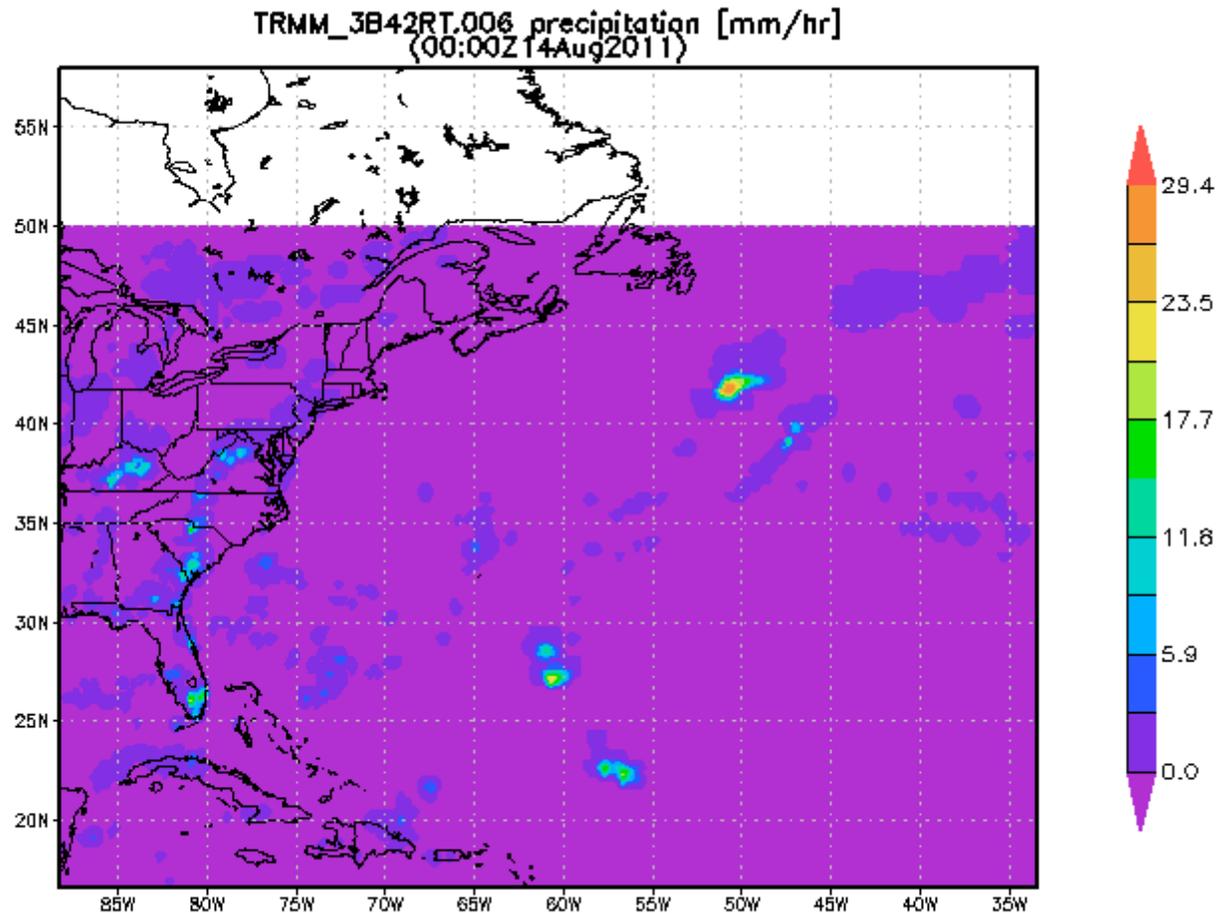


State of the Climate 2011



<http://disc2.nascom.nasa.gov/Giovanni/tovas/>

Jimmy Booth, Benjamin Cook

Goals for the Talk

- Introduce teleconnections and discuss their current state.
- Show online information related to teleconnections.
- Discuss the weather events of the past 3 months in the context of some of these teleconnections.
- Discuss the winter 2011 forecast.

Outline

(1) Motivation

(2) Introduction

(3) Discussion #1: El Nino Southern Oscillation

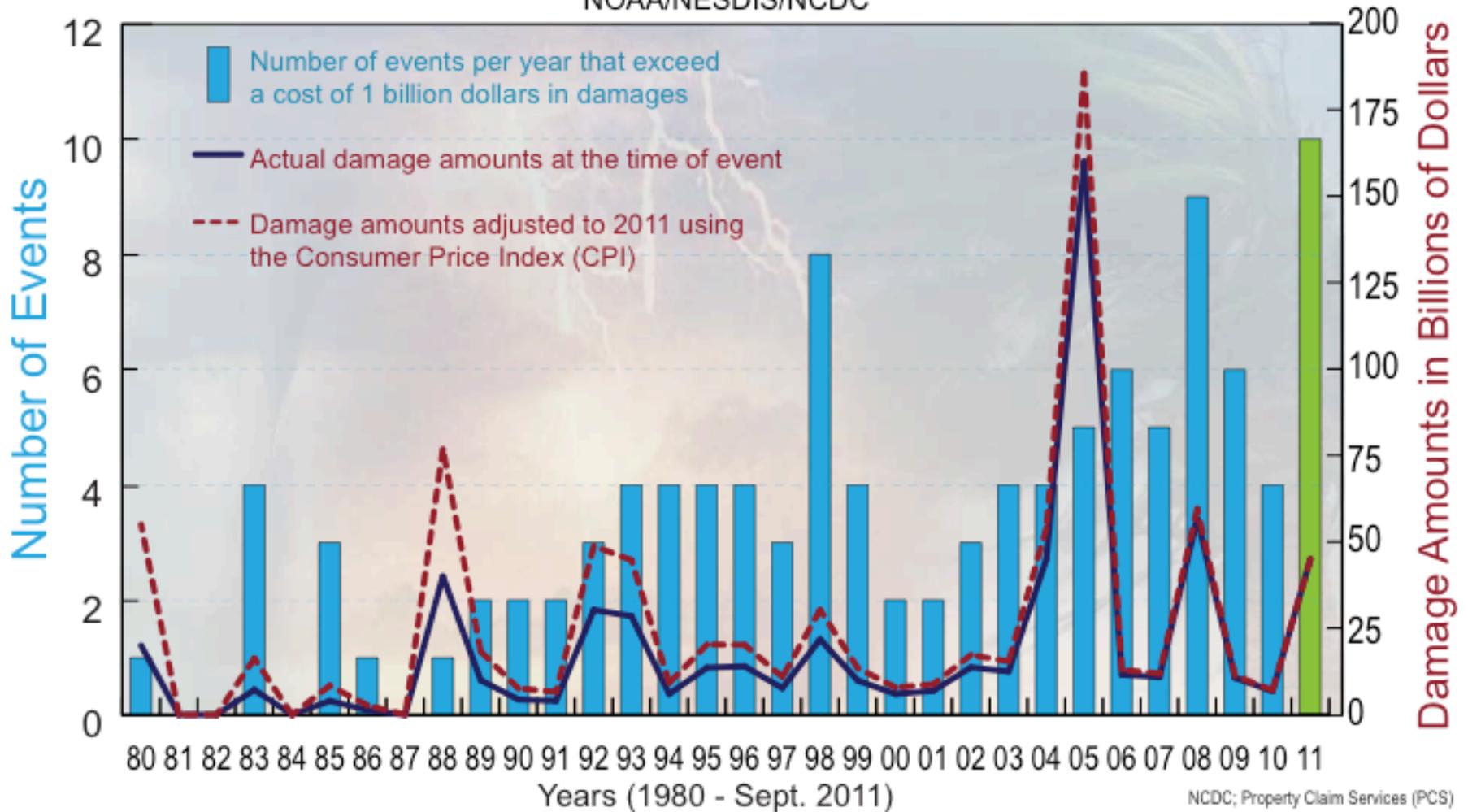
(4) Discussion #2: Northeast weather and
teleconnections.

(5) Winter 2011 Outlook.

Motivation



Billion Dollar Weather/Climate Disasters
1980 - September 2011
NOAA/NESDIS/NCDC



Motivation

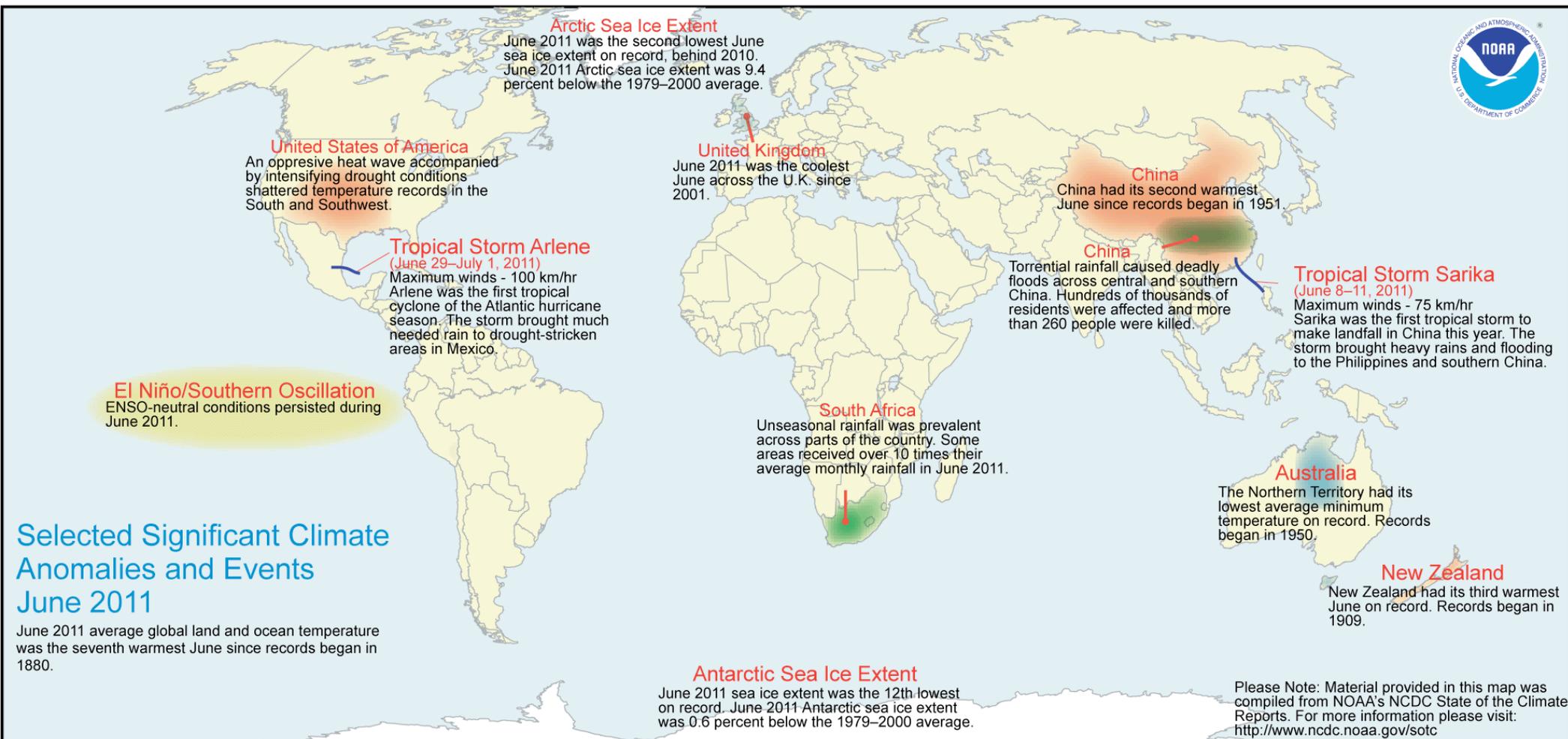
Some extreme weather events, especially those related to temperature extremes, can be connected to global climate patterns. *As such, we sometimes see extreme events occurring concurrently around the world.*

Other extreme weather events are connected with local weather patterns. And it is not yet known if the local patterns connect to the larger scale.

Next, we show some examples of the extreme events for 2011.

Motivation

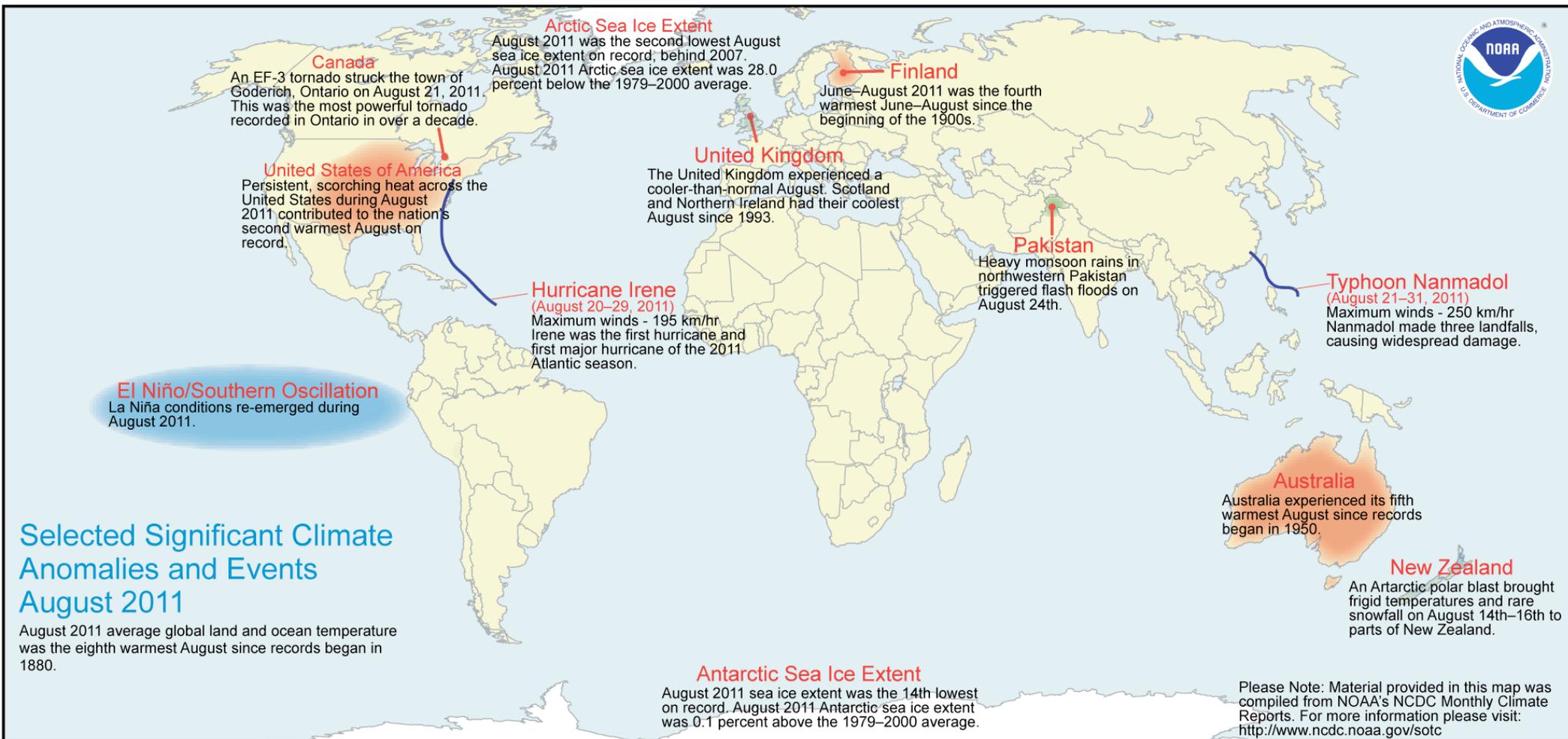
<http://www.ncdc.noaa.gov/sotc/service/global/extremes/>



The warm anomalies over N. America and East Asia are connected to a Wave-2 circulation anomaly.

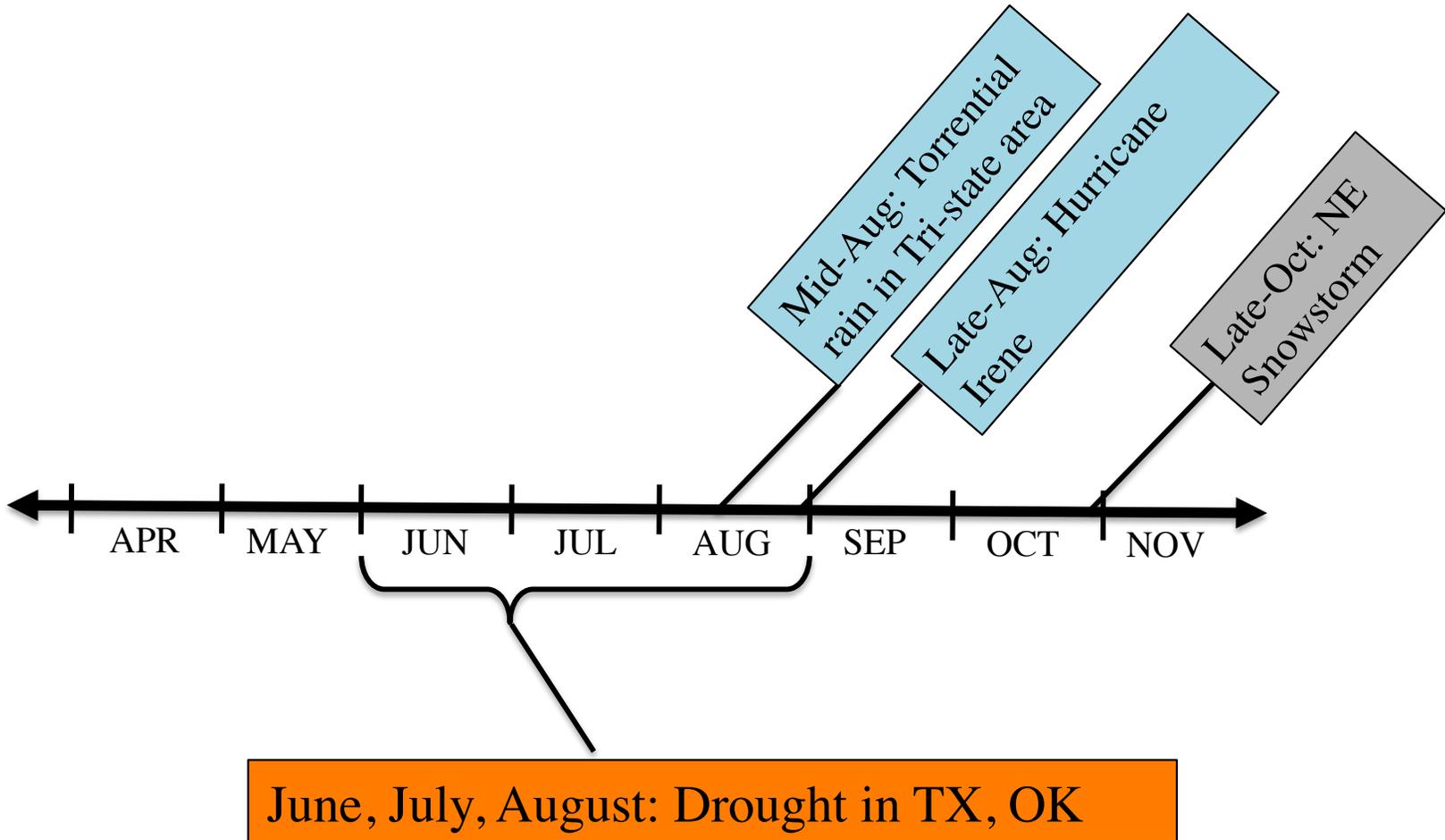
Motivation

<http://www.ncdc.noaa.gov/sotc/service/global/extremes/>



The path of Hurricane Irene may or may not be connected to the Azores High being shifted eastwards in 2011

Timeline of the events this talk will focus on.



Introduction

Some extreme weather events, especially those related to temperature extremes, can be connected to global climate patterns. *As such, we sometimes see extreme events occurring concurrently around the world.* WHY? HOW?



Contents lists available at ScienceDirect

Journal of Marine Systems

journal homepage: www.elsevier.com/locate/jmarsys

North Atlantic climate variability: The role of the North Atlantic Oscillation

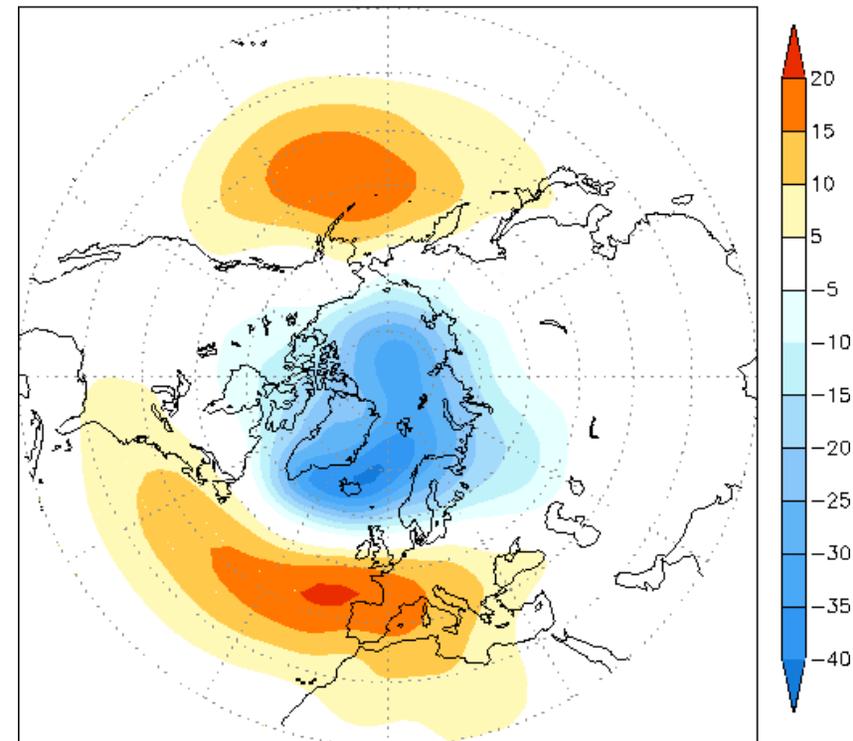
James W. Hurrell*, Clara Deser

National Center for Atmospheric Research¹, Climate and Global Dynamics Division, Climate Analysis Section, P.O. Box 3000, Boulder, CO 80307-3000, USA

A consequence of the transient behavior of the atmospheric planetary-scale waves is that anomalies in climate on seasonal time scales typically occur over large geographic regions. Some regions may be cooler or perhaps drier than average, while at the same time thousands of kilometers away, warmer and wetter conditions prevail. These simultaneous variations in climate, often of opposite sign, over distant parts of the globe are commonly referred to as “teleconnections” in the meteorological literature (Wallace and Gutzler, 1981; Esbensen, 1984; Barnston and Livezey, 1987; Kushnir and Wallace,

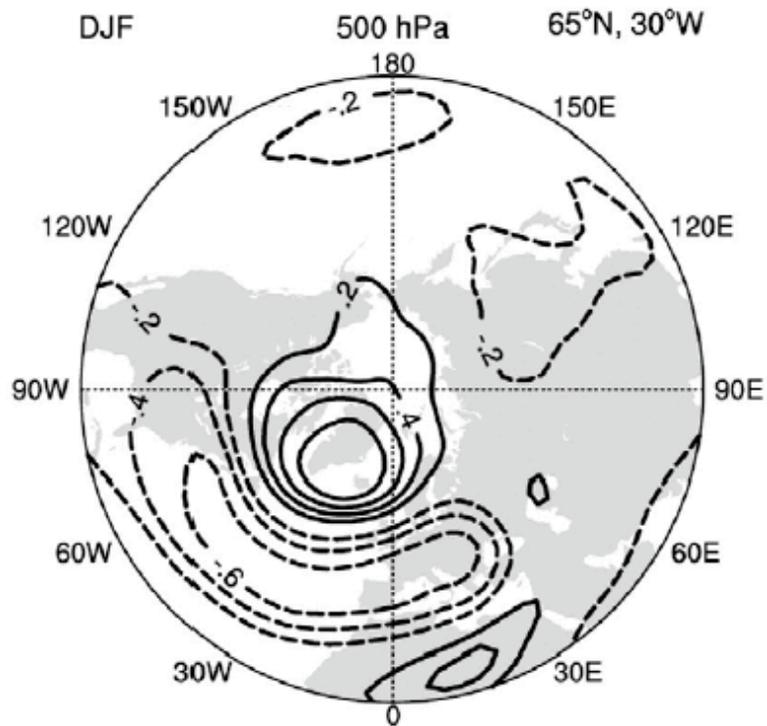
Teleconnection Example: The Arctic Oscillation, aka, *The North Atlantic Oscillation*

Leading EOF (19%) shown as
regression map of 1000mb height (m)



Introduction

Wallace and Gutzler [1981] constructed teleconnection maps by correlating the 500-hPa height time series at a “reference gridpoint” with the corresponding time series at all gridpoints.



One-point correlation maps of Z-500hPa for DJF over 1958-2006. Reference gridpoint: 65N X 30W.

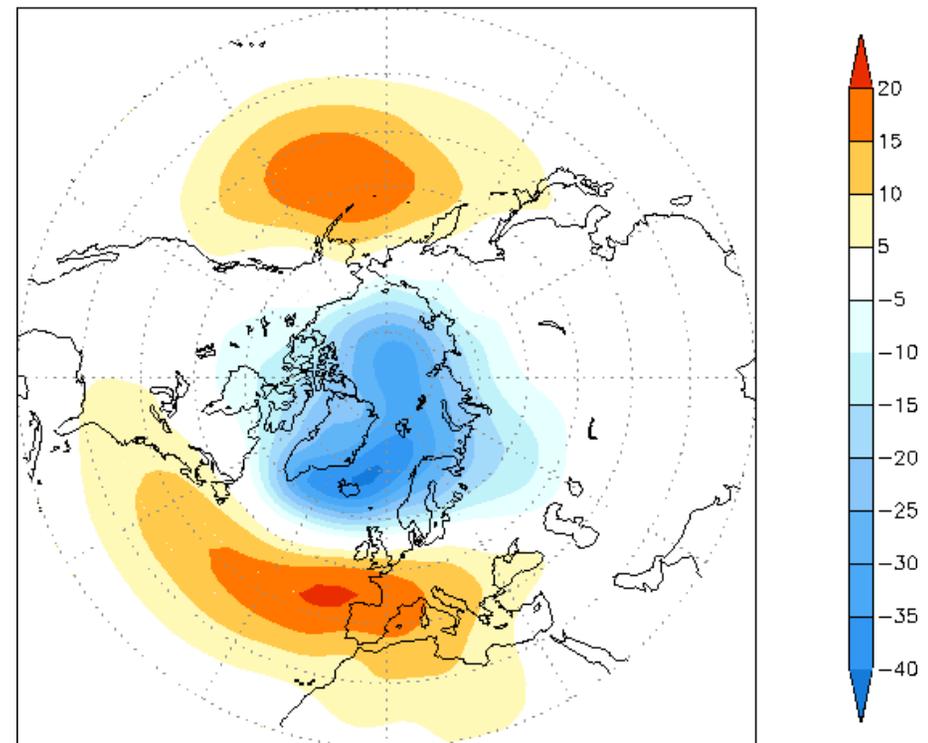
Solid: positive. Dashed: negative correlation.

[Hurrell and Deser 2009]

Teleconnection Example:

The Arctic Oscillation, aka,
The North Atlantic Oscillation.
Calculated using EOF analysis

Leading EOF (19%) shown as regression map of 1000mb height (m)



What is the NAO?

- A pattern of covariability in the North Atlantic, extending over Europe.
- **A combination of variability in the Icelandic Low and Azores High**
- *Manifestation of the interactions between midlatitude storms, blocks and the instantaneous mean state of the midlatitude troposphere.*
- Predictability time scale < 7 days.
- Strongest correlations occur in winter
- North Atlantic Oscillation (NAO)

Arctic Oscillation (AO)

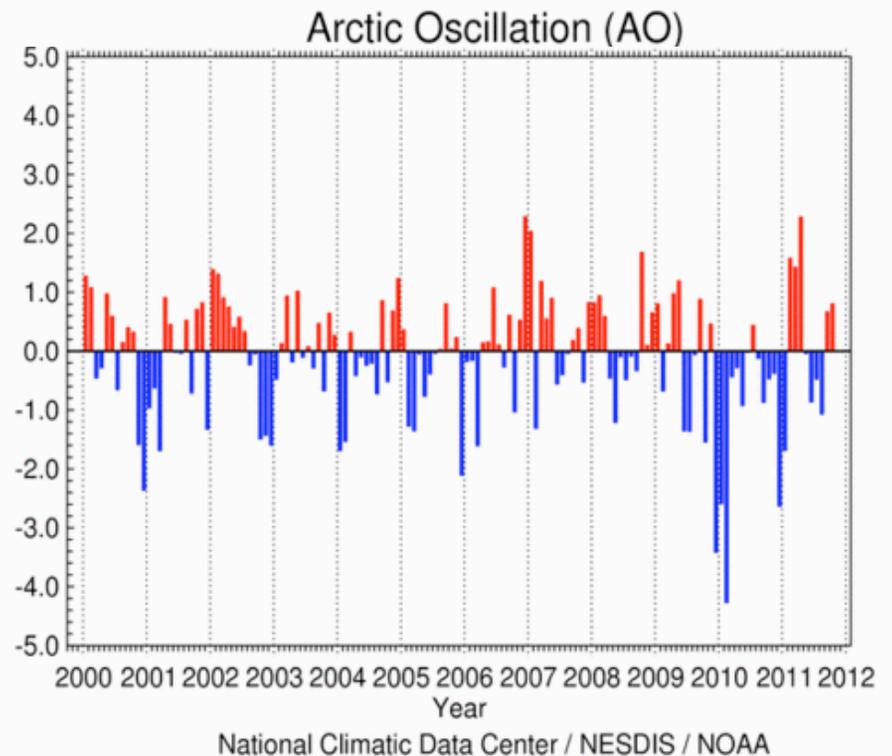
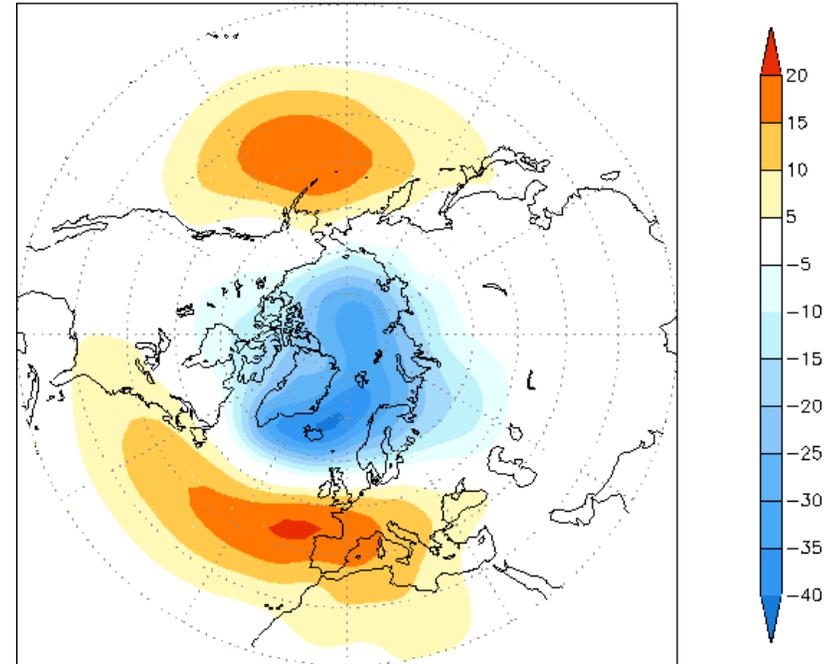
Northern Annular Mode (NAM)

$$\text{NAO} \in \text{AO} \in \text{NAM}$$

North Atlantic → Global Surface → AO at each press. level
Midlat/Polar NH

The Arctic Oscillation.

Leading EOF (19%) shown as regression map of 1000mb height (m)



Introduction

JOURNAL OF THE ATMOSPHERIC SCIENCES

JUNE 1981

BRIAN J. HOSKINS AND DAVID J. KAROLY

1179

The Steady Linear Response of a Spherical Atmosphere to Thermal and Orographic Forcing¹

FIG. 3. Steady state, linear solution of a five-layer baroclinic model for a deep elliptical heat source at 15° perturbing the Northern Hemisphere winter zonal flow. Shown are (a) height field in a longitude-height section at 18.1°N (contour interval 1 dam), (b) 300 mb vorticity perturbation (contour interval 0.05Ω), and (c) 300 mb height field perturbation (contour interval 2 dam). The contour convention is as in Fig. 1 except that the zero contours in (a) are thick continuous lines. The center of the source is indicated by a cross in (a) and the region of heating larger than 0.5 K day^{-1} by hatching in (c). Tick marks in (a) are at 100, 300, 500, 700 and 900 mb in the vertical and every 30° of longitude.

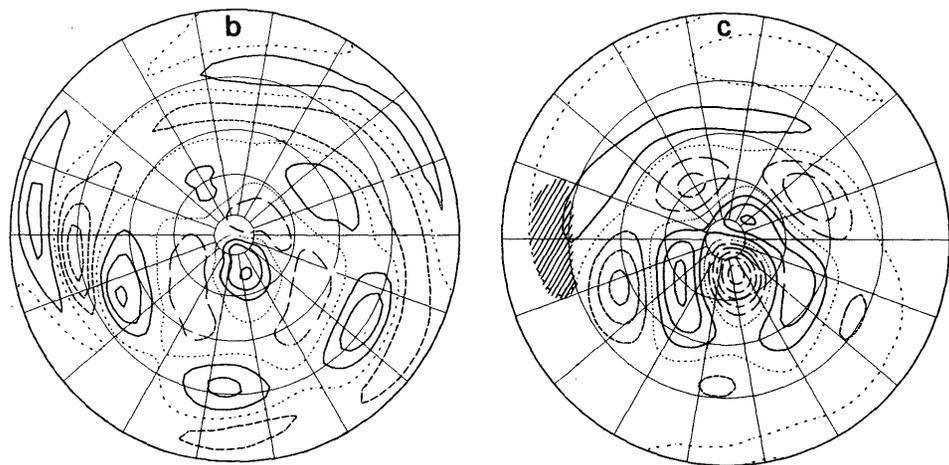
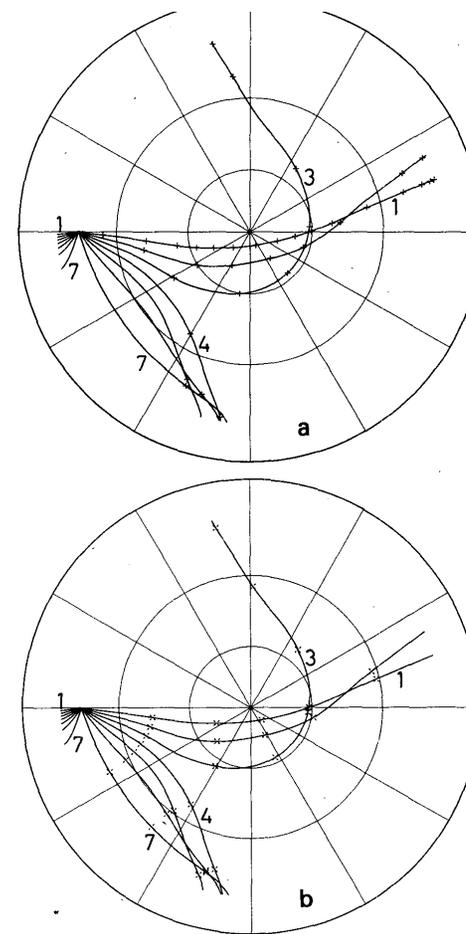


FIG. 15. A 15° source in the NH 300 mb zonal flow: (a) rays and propagation time marked by crosses every 2 days, and (b) rays and phases every 180° .





National Weather Service Climate Prediction Center

www.nws.noaa.gov



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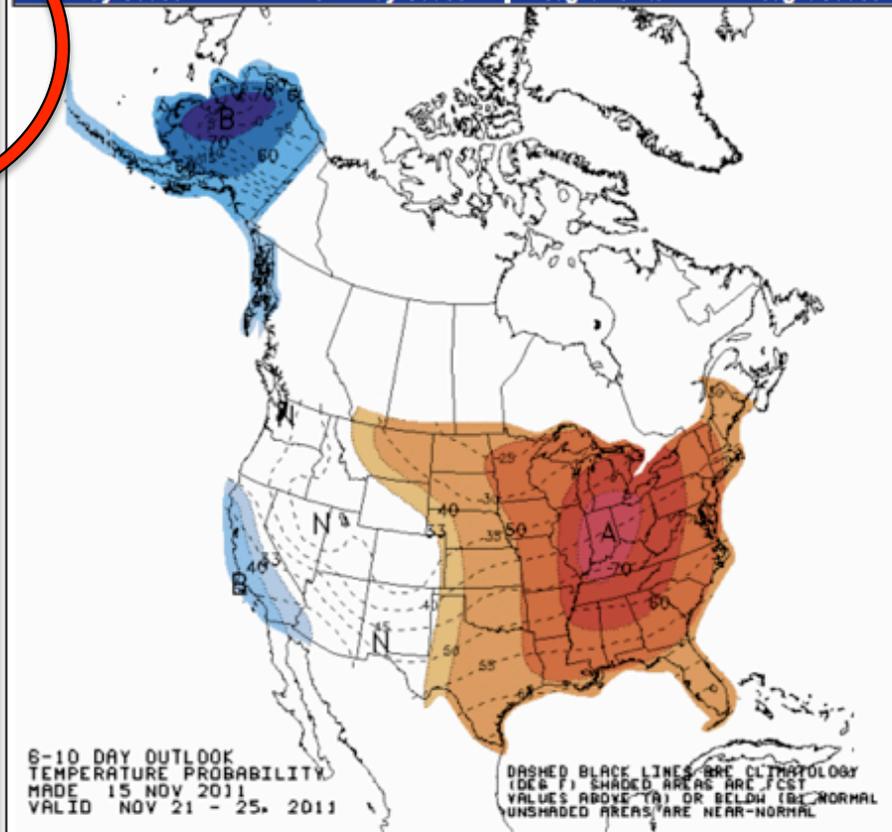
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Climate News

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- [La Niña Advisory Continues](#)
- [NOAA 2011 Atlantic Hurricane Season Outlook Update](#)

Click on product title to go to product page. Move cursor over product parameter name to display the graphic -- click to enlarge. Links to these same products are also available below.

6-10 Day Outlook		One Month Outlook	
Temperature	Precipitation	Temperature	Precipitation
8-14 Day Outlook		Three Month Outlook	
Temperature	Precipitation	Temperature	Precipitation
U.S. Hazards Outlook		U.S. Drought Assessment	
7 Day Outlook	8-14 Day Outlook	Drought Monitor	Drought Outlook



Related Products

[6-10 Day Outlook](#), [8-14 Day Outlook](#), [30 Day Outlook](#), [90 Day Outlook](#), [U.S. Hazards Assessment](#), [Drought Assessment](#)

Local Climate Water & Weather Topics:

[U.S. Hazards Assessment](#), [Drought Assessment](#), [ENSO Diagnostic Discussion](#), [Climate-Weather](#),

Introduction

What are the major Teleconnection Patterns?

- El Nino Southern Oscillation :: ENSO
 - Tropical Pacific 4-7 yr. period
 - Madden-Julian Oscillation :: MJO
 - Indian Ocean/Tropical Pacific 60-90 day period
-

- North Atlantic Oscillation (NAO),
a.k.a, Artic Oscillation (AO), a.k.a, Northern Annular Mode (NAM)

NAO \in AO \in NAM

- Pacific / North American pattern :: PNA

- Southern Annular Mode: SAM

<http://www.cpc.noaa.gov/>

Introduction

Why Study Teleconnections?

- They relate to the boundary state of the Atmosphere
- They can be reduced to simple indices
- They can improve seasonal predictability?

Introduction

Work in progress: MJO

The Madden-Julian Oscillation connects weather and climate.

What is it?

A disturbance in wind, rainfall, and cloudiness, that begins in the equatorial Indian Ocean every 30 to 90 days.

It is part of the Asian and Australian monsoon.

What can it affect?

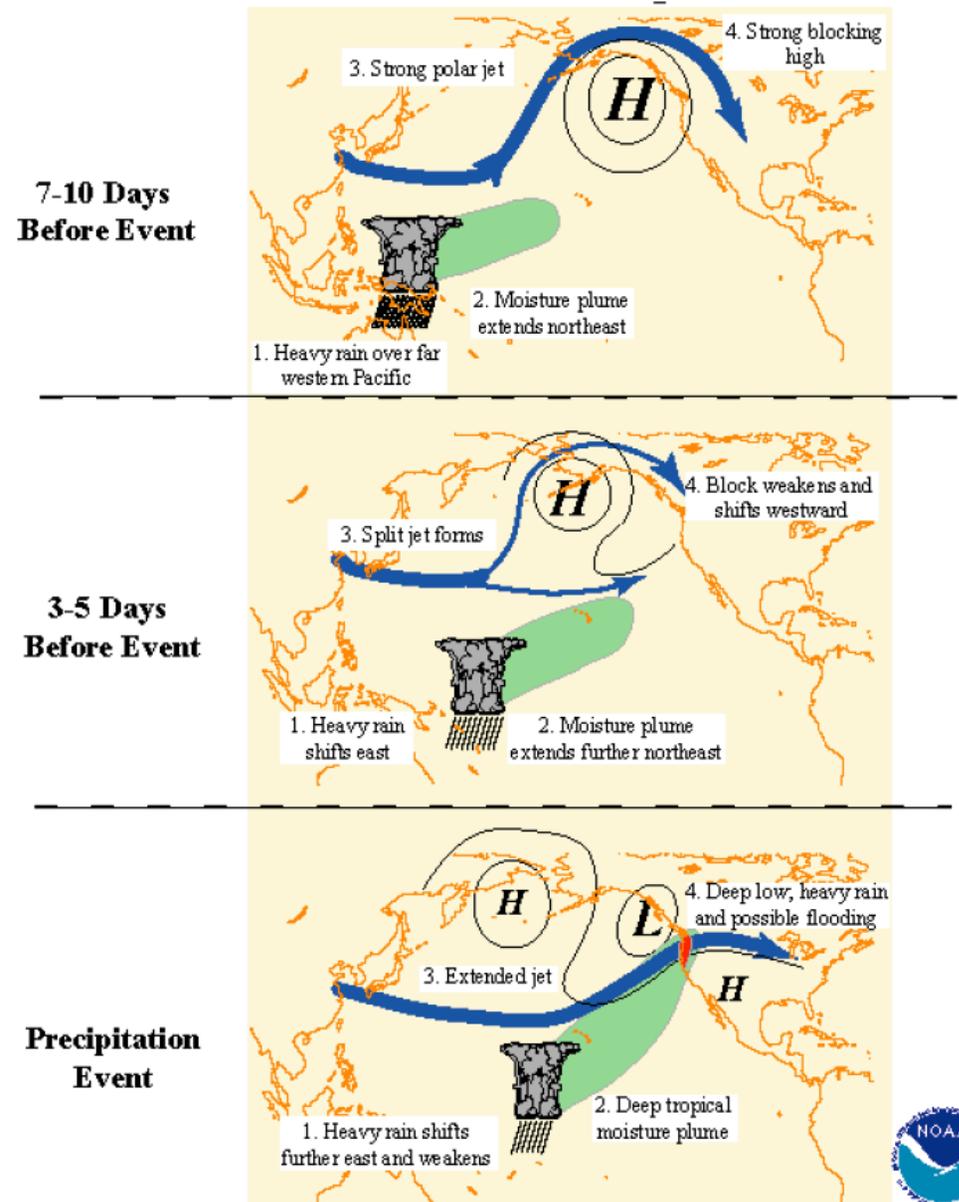
Hurricane activity in NE Pacific and Gulf of Mexico.

Rainfall along the west coast of North America.

What else?

Some researchers believe the MJO is the world's greatest source of atmospheric changes in the one- to three-month time frame.

Typical Wintertime Weather Anomalies Preceding Heavy West Coast Precipitation Events



Introduction

What are the major Teleconnection Patterns?

- El Nino Southern Oscillation :: ENSO

- Madden-Julian Oscillation :: MJO

- North Atlantic Oscillation (NAO),
a.k.a, Artic Oscillation (AO), a.k.a, Northern Annular Mode (NAM)

NAO \in AO \in NAM

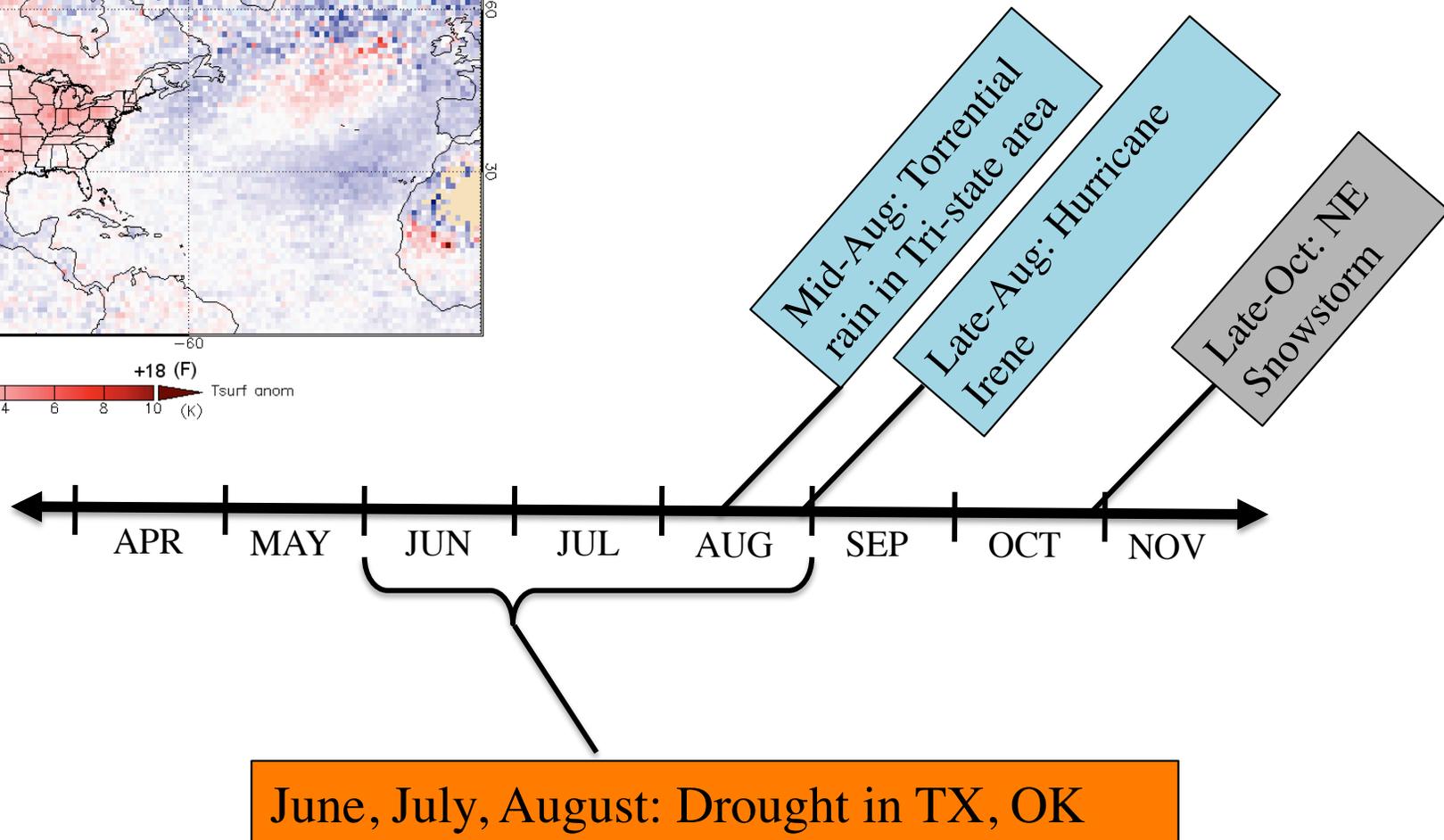
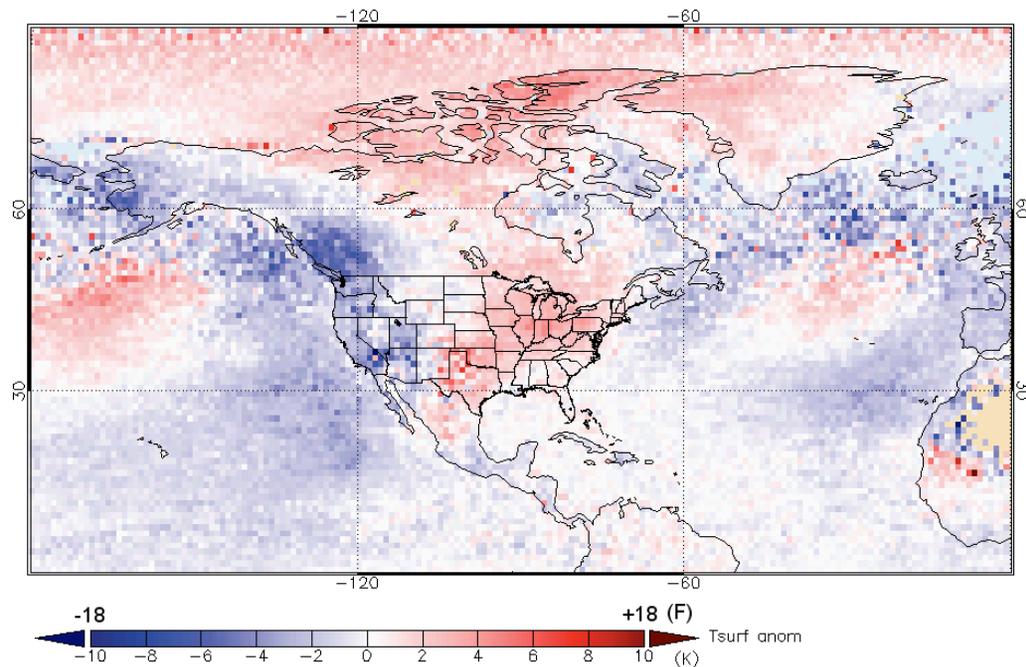
- Pacific / North American pattern :: PNA

- Southern Annular Mode: SAM (Our apologies to the SH for our neglect.)

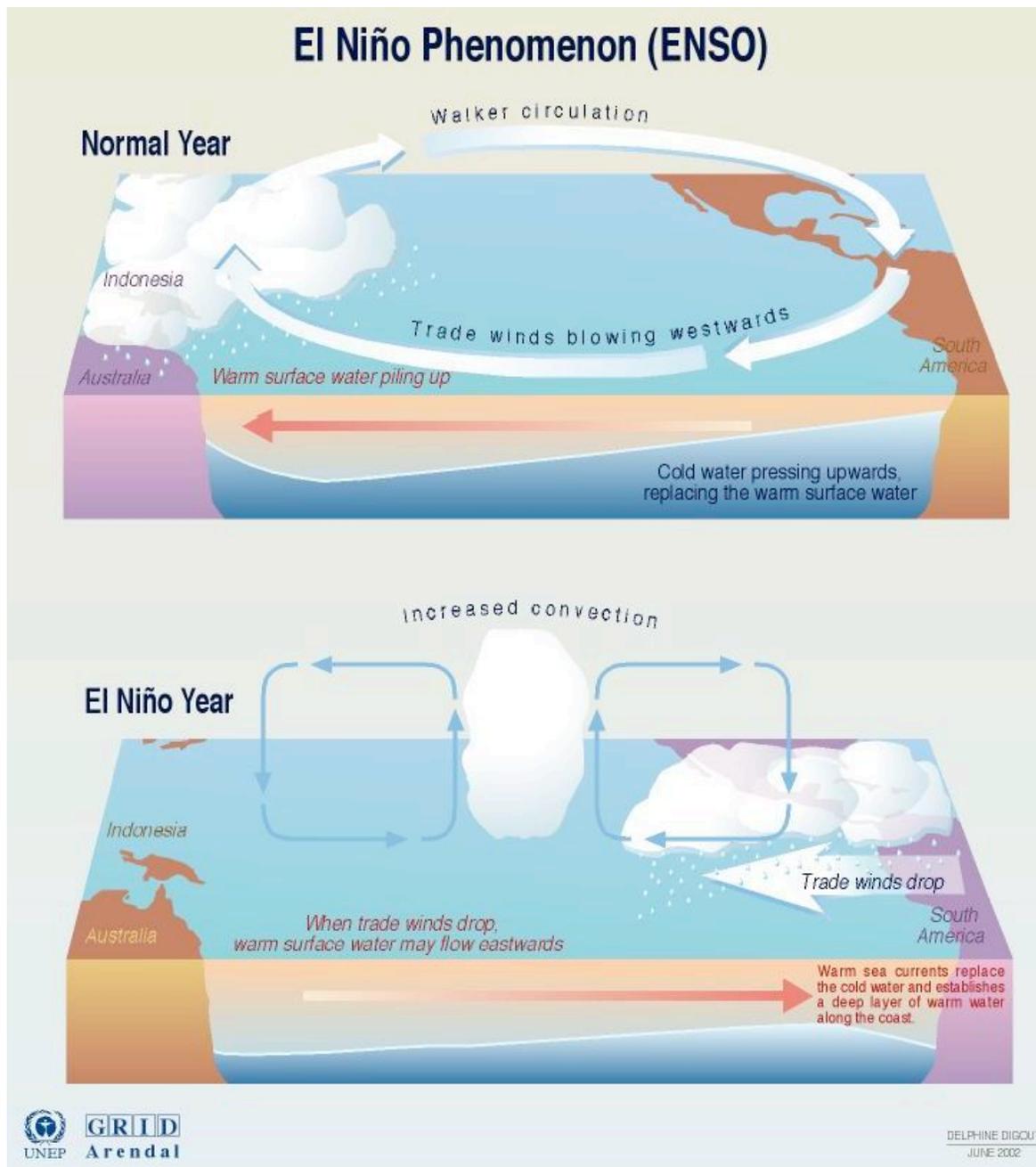
SOURCE: <http://www.cpc.noaa.gov/>

Discussion #1: ENSO and the 2011 N. American Drought

AIRS; Day; Surface Air Temperature Anomaly; July 2011



El Niño Southern Oscillation

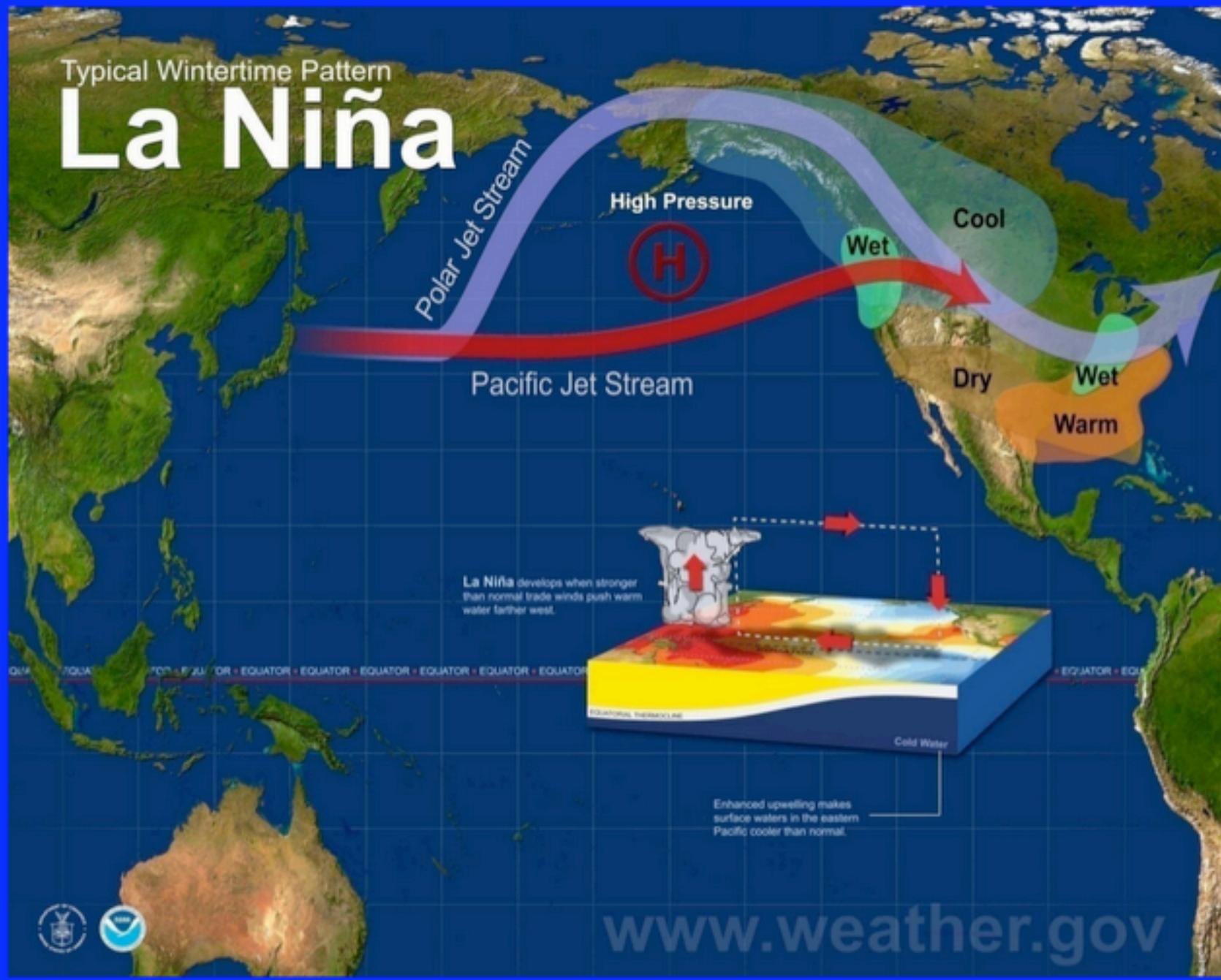


Sources: Climate Prediction Center-NCEP; NOAA.

source: CPC

Typical Wintertime Pattern

La Niña



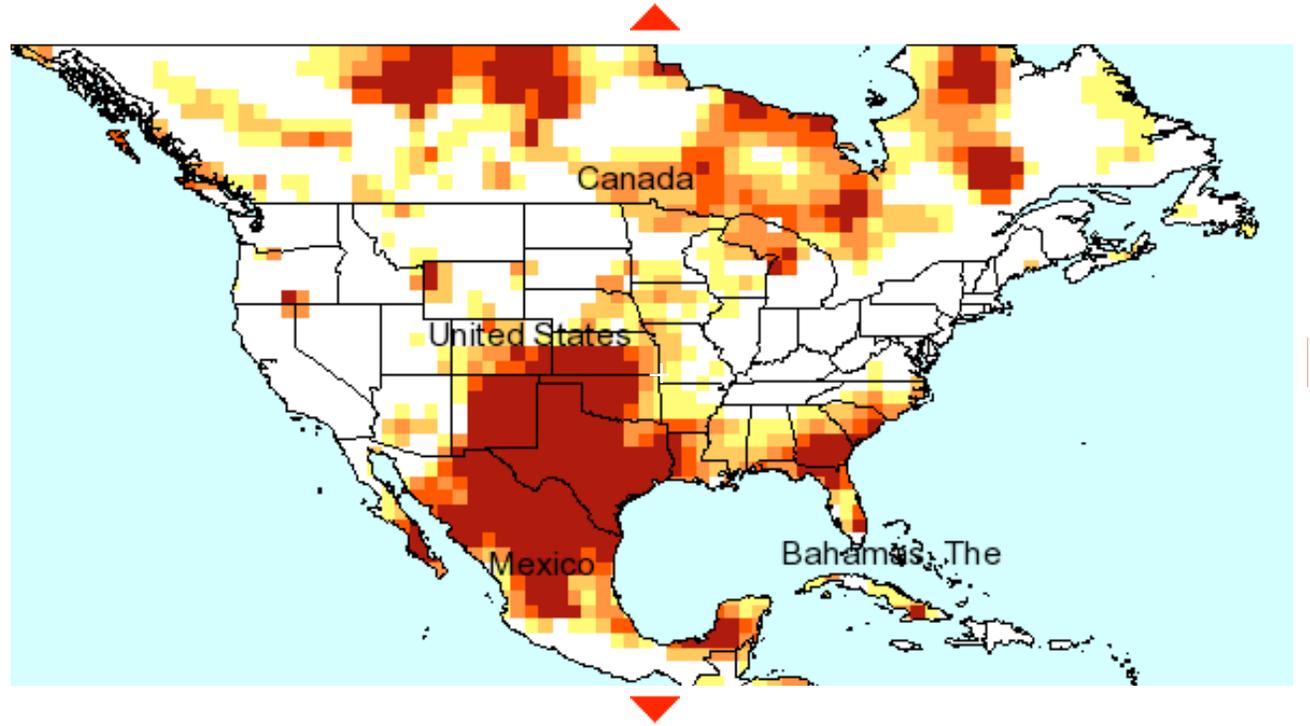
www.weather.gov

Can La Nina Explain the recent drought?

Global Drought Monitor

November 2011

Data updated on the 16th of each month



0 2300 4600 6900 9200 km

Drought Severity

Minor Drought

Moderate Drought

Severe Drought

Extreme Drought

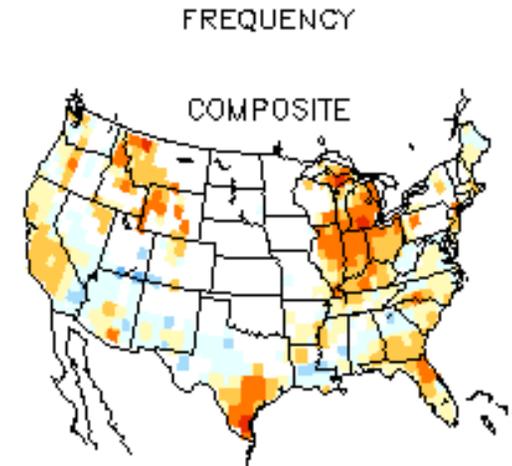
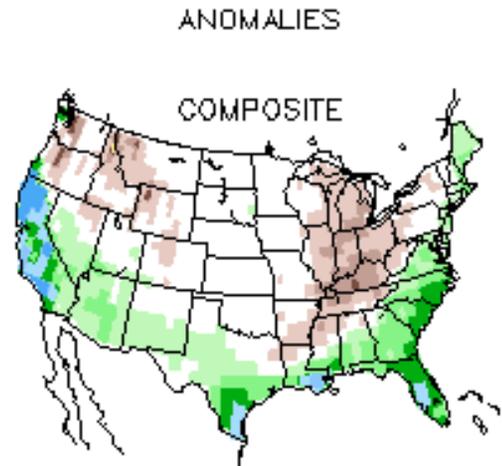
Exceptional Drought

Population in the current view under exceptional drought: **52,245,000**

ENSO Impacts, North America

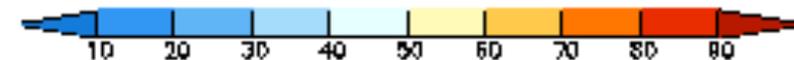
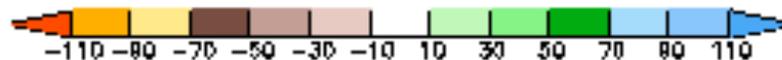
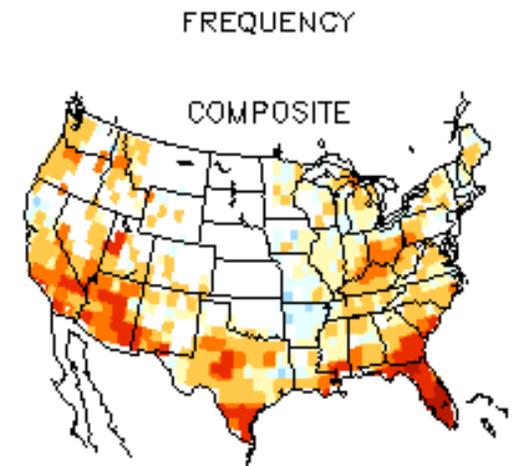
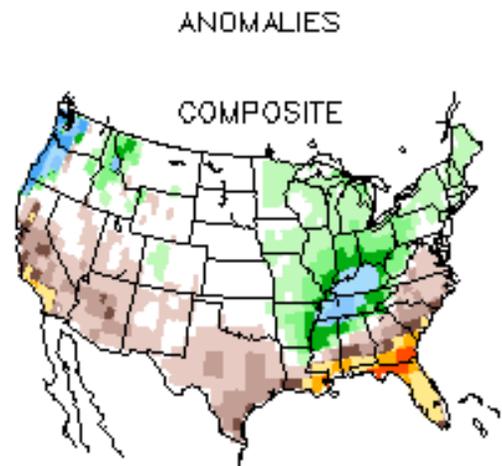
JFM EL NINO PRECIPITATION ANOMALIES (MM)
AND FREQUENCY OF OCCURRENCE (%)

El Nino ->



JFM LA NINA PRECIPITATION ANOMALIES (MM)
AND FREQUENCY OF OCCURRENCE (%)

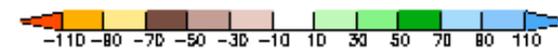
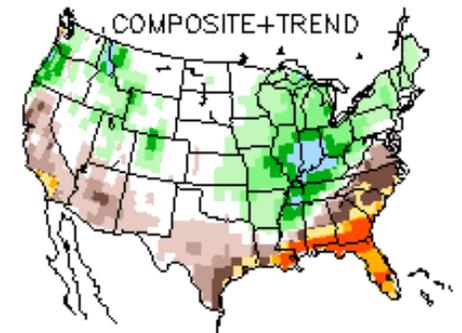
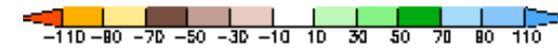
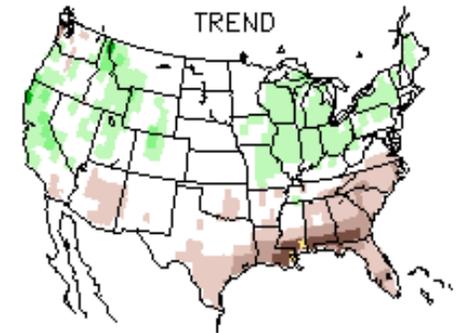
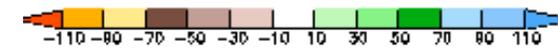
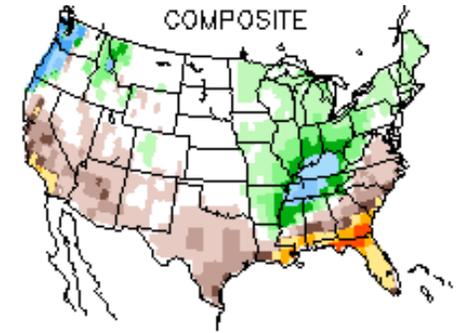
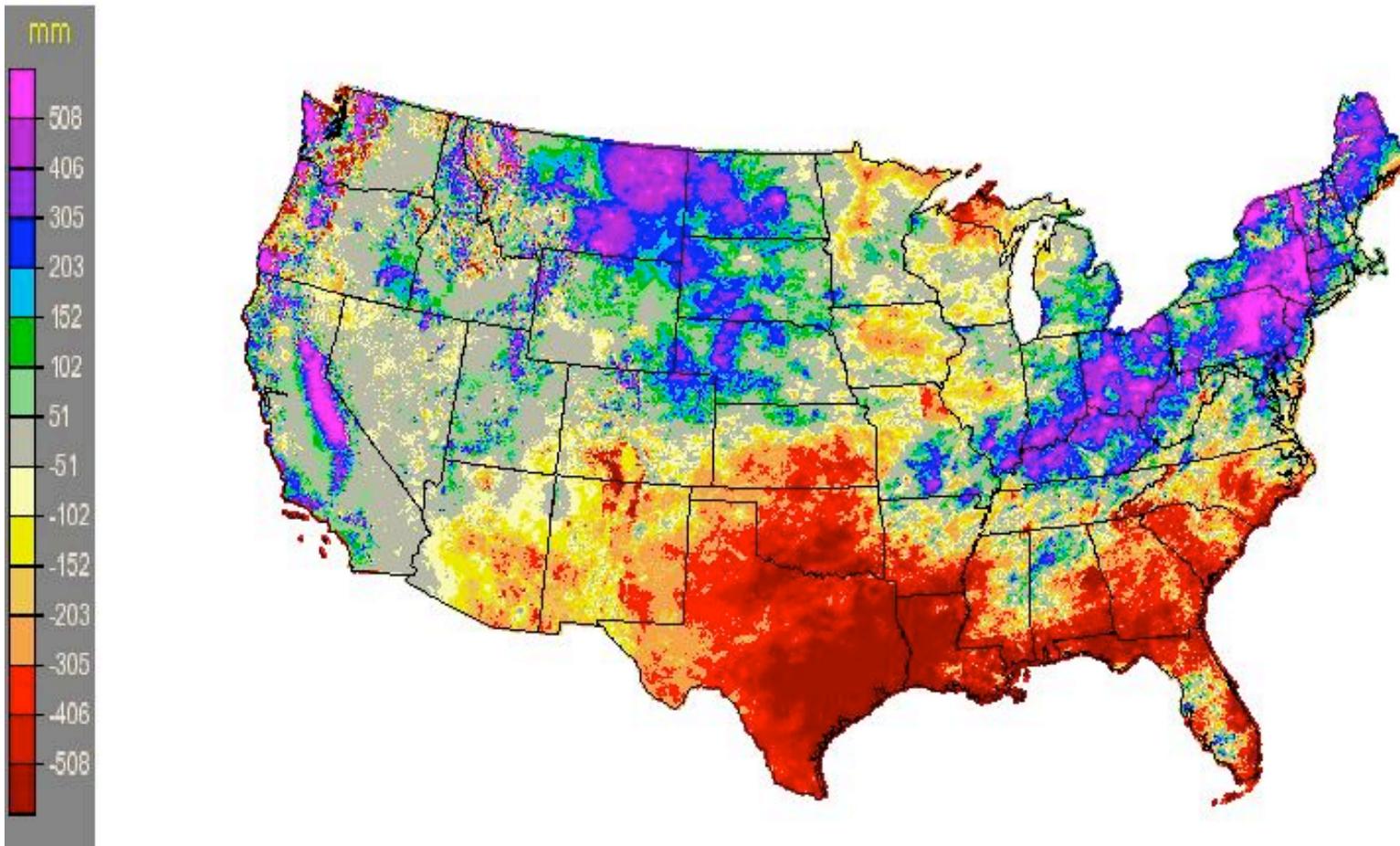
La Nina ->



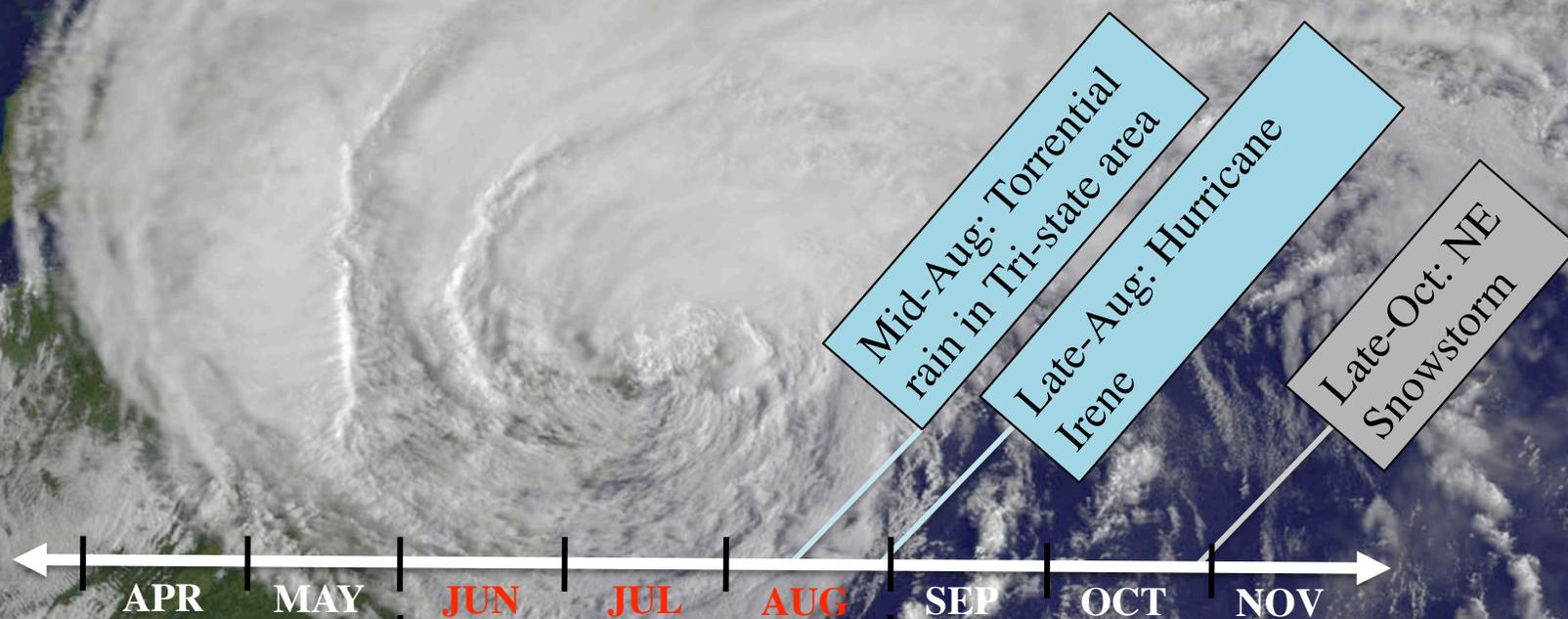
Most Recent Water Year

La Nina

CONUS + Puerto Rico: 2011 Water Year, Departure from Normal Precipitation
Valid at 10/1/2011 1200 UTC- Created 10/3/11 21:34 UTC



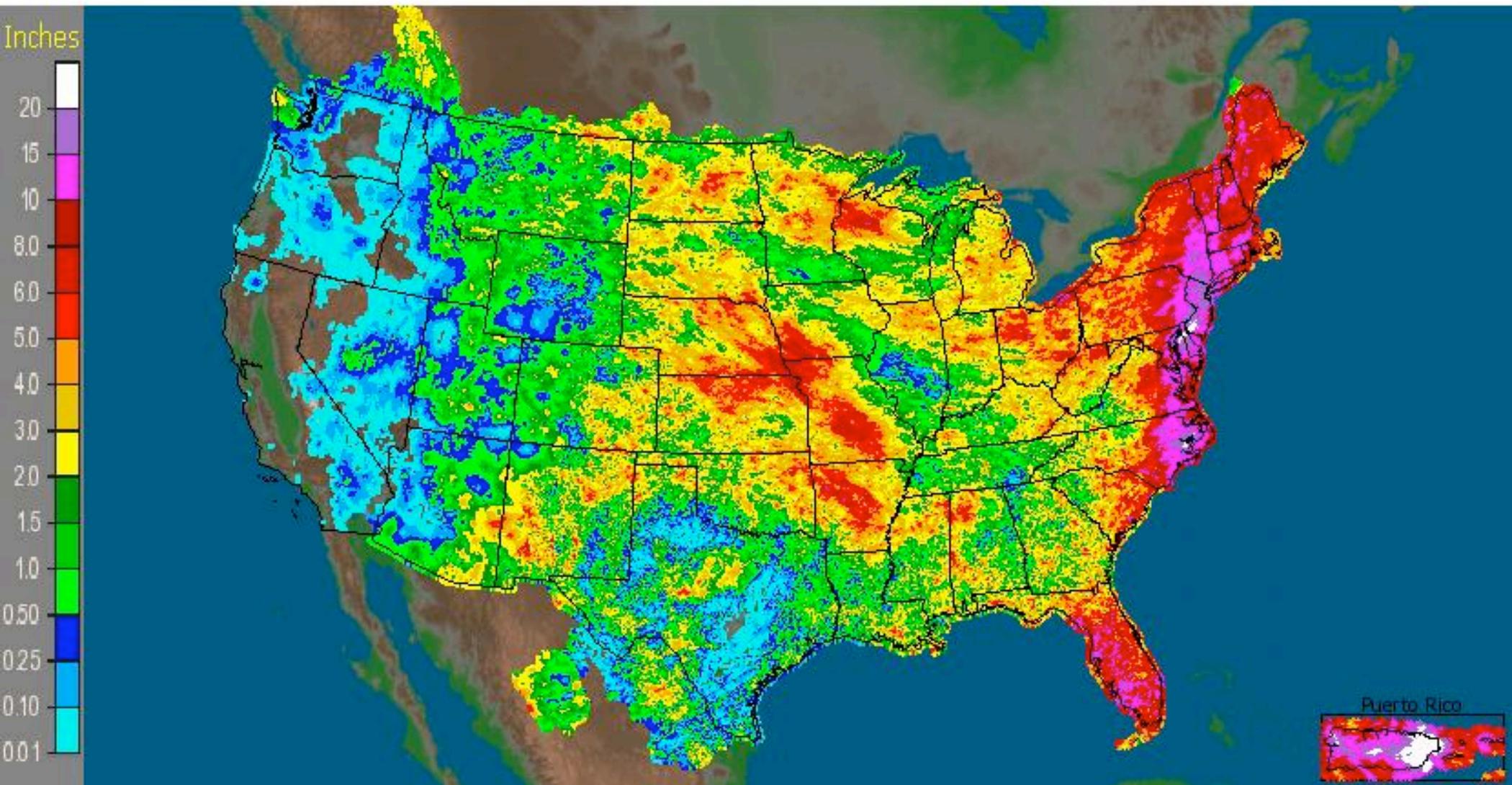
Discussion #2: Summer 2011 Precipitation in the Northeast and the Arctic Oscillation



June, July, August: Drought in TX, OK

Accumulated Precipitation for August 2011 (units: inches)

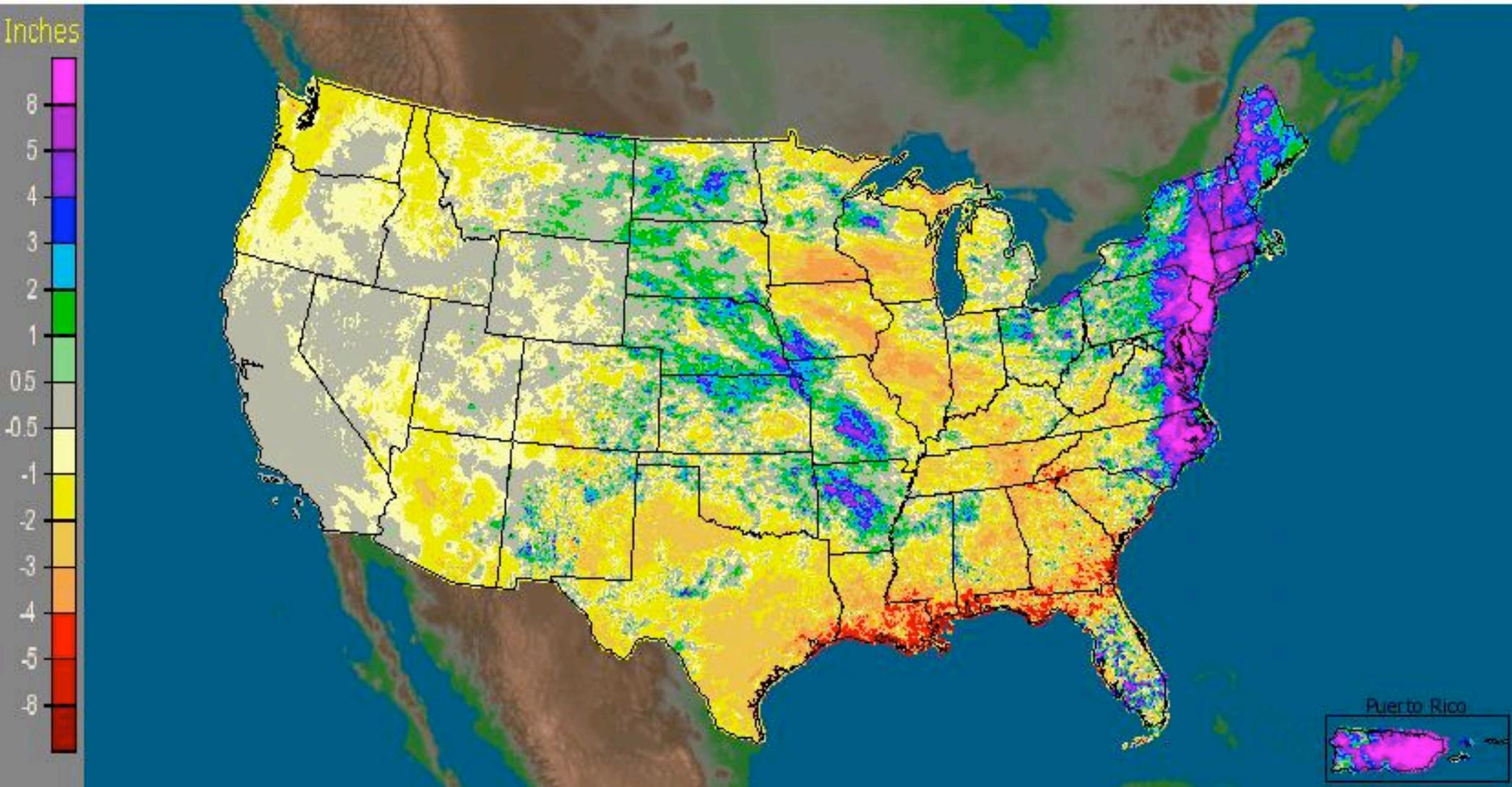
CONUS + Puerto Rico: August, 2011 Monthly Observed Precipitation
Valid at 9/1/2011 1200 UTC- Created 9/3/11 21:33 UTC



<http://water.weather.gov/precip/>

Accumulated Precipitation Anomaly for August 2011 (units: inches)

CONUS + Puerto Rico: August, 2011 Monthly Departure from Normal Precipitation
Valid at 9/1/2011 1200 UTC- Created 9/3/11 21:33 UTC



<http://water.weather.gov/precip/>

NYC PRECIP.

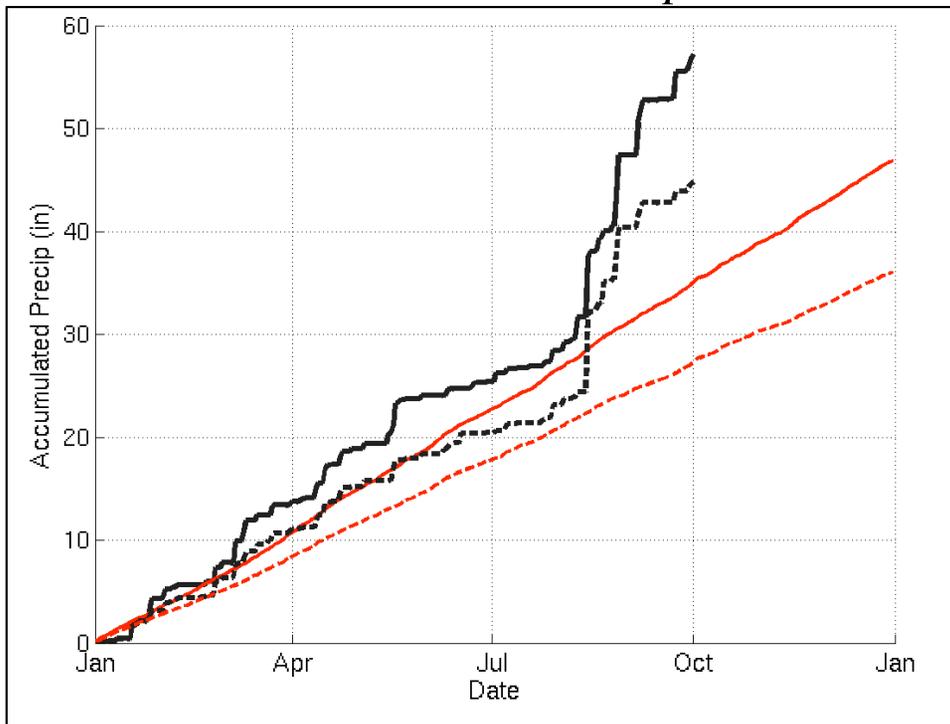
Accumulated Precipitation for 2011 in NYC (inches)

RED: Climatology for 1950-2010

BLACK: 2011

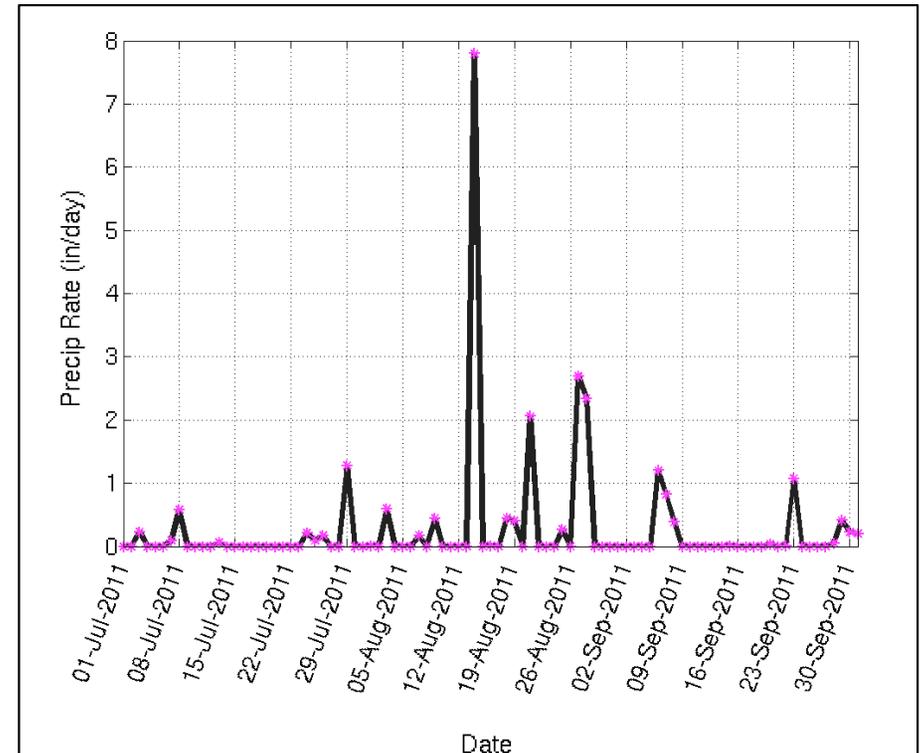
Solid: Central Park

Dashed: JFK Intl. Airport



Daily Precip (inches/day) for July-Sept, 2011 at JFK International Airport

Magenta and Black show the same data.



Two big events made August extreme. Irene's damage would have been less if not for all of the prior rain.

<http://climexp.knmi.nl>

Northeast Regional Climate Center

New York Climate

AUGUST 2011

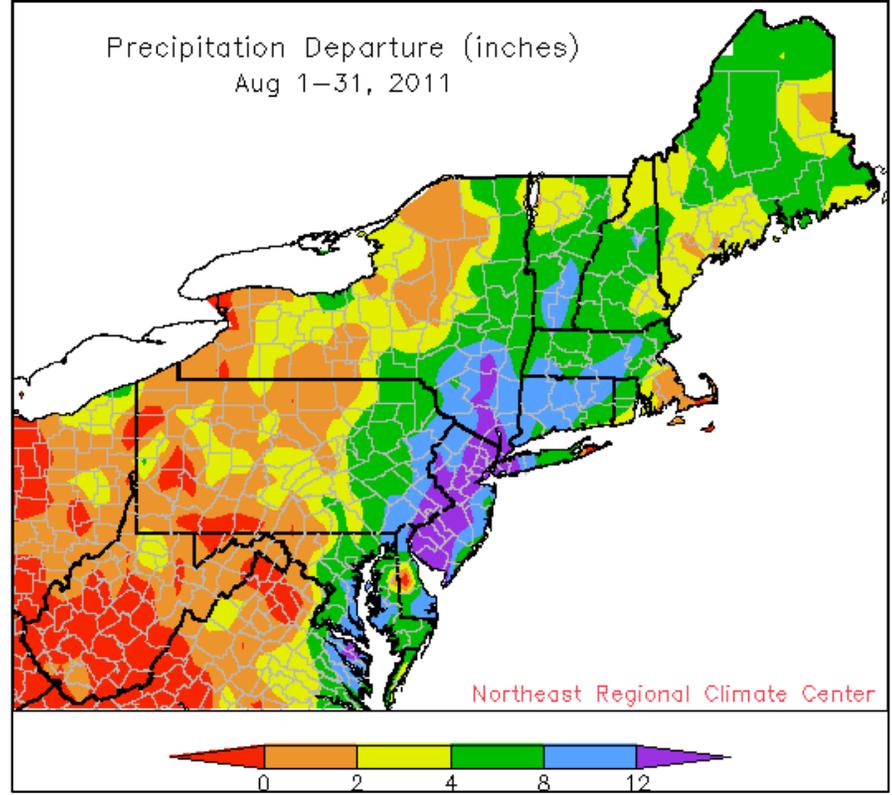
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 Cornell University Email: nrcc@cornell.edu
 Ithaca, NY 14853



AUGUST WEATHER HIGHLIGHTS

Most of New York saw more than enough rain to make up for the drier than normal conditions last month. The state average was 8.23 inches, which was 212% of normal.



STATION	TEMPERATURE (F)										PRECIPITATION (INCHES)								
	MONTHLY AVERAGES				EXTREMES				NUMBER OF DAYS				MONTHLY TOTALS			EXTREMES		SNOWFALL	
	AVG MAX	AVG MIN	MON AVG	DEPRT	MON MAX	DAY MIN	MON MAX	DAY MIN	MAX 90+	MIN 70-	65+	50-	MON TOT	DEPRT	DAYS 0.1+	DLY MAX	DAY	MON TOT	DLY MAX
BRIDGEHAMPTON	80.2	64.1	72.1	0.4	88	9+	53	12	0	1	16	0						0	
CENTERPORT *	81.8	64.8	73.3	0.3	90	1	58	30+										0	
GREENPORT PWR HOUS	80.6	67.3	74.0	1.7	88	1	59	12	0	0	23	0						NM	
ISLIP LI MACARTHUR	82.0	66.3	74.2	1.4	91	8	55	29	2	0	21	0	11.58	7.60	10	5.32	14	0	
NEW YORK CNTRL PK	82.9	67.6	75.3	0.1	94	1	59	29	3	0	25	0	18.95	14.51	11	5.81	14	0	
NEW YORK JFK INTL	82.5	68.5	75.5	0.6	92	8+	61	29	2	0	26	0	17.24	13.56	10	7.80	14	0	

Discussion #2: Summer 2011 Precipitation in the Northeast and the Arctic Oscillation

NYC Breaks Record: 2 Months of Rain in One Day

AccuWeather.com weathermatrix - Monday, August 15, 2011, 10:40

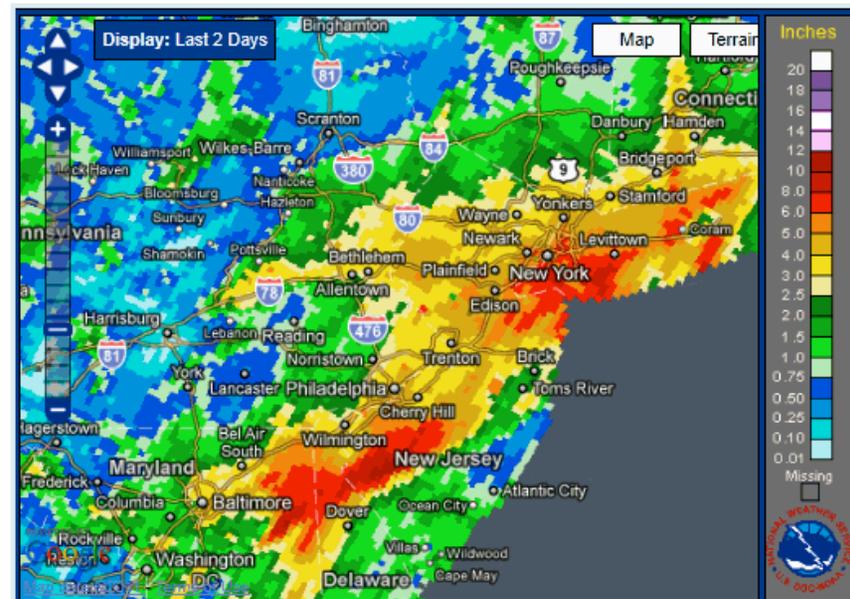
Read More: AccuWeather - Weathermatrix

Like 1 Tweet 0 Share

NYC Breaks Record: 2 Months of Rain in One Day

Aug 15, 2011; 10:40 AM ET

The rainfall across New Jersey and New York City over the weekend was just incredible. You can get a list of all amounts reported via the HPC, and we have a story detailing the records broken.



Suffice to say, it was heavy. Above is a 48-hour total map via NOAA, but most of this fell in one day. Nearly 11 inches of rain was recorded at Lido Beach, and JFK's (seemingly lame) 7.80" surpassed their all-time daily rainfall record – it had never rained as much there as it did on Sunday, through all of recorded history. (You can download a huge rainfall estimate from the NYC radar here). The photo below was taken by an AccuWeather.com Facebook reader in NYC.



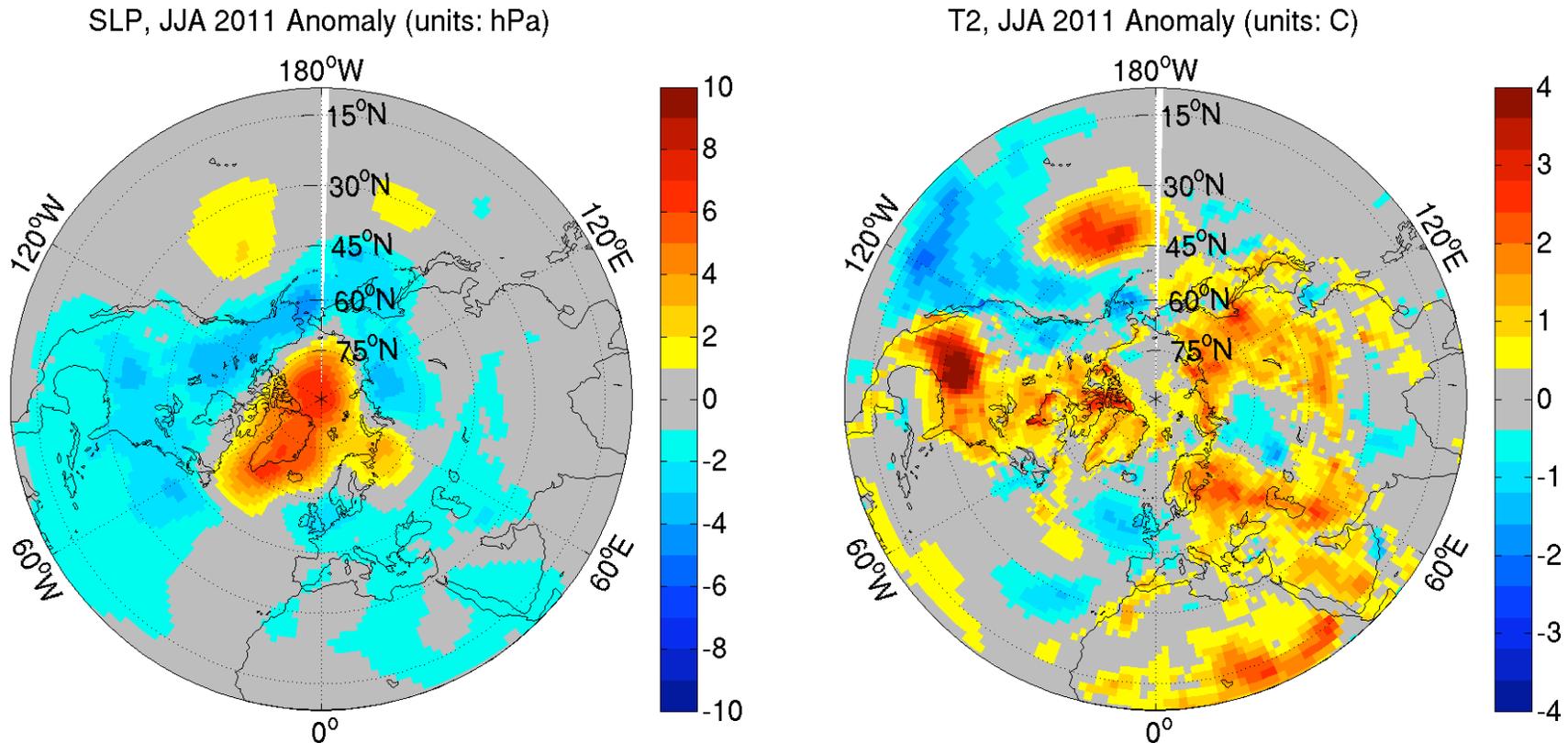
<http://www.worldweatherpost.com/2011/08/15/nyc-breaks-record-2-months-of-rain-in-one-day/#.TsA9IGDfjNI>

Did the NE precipitation relate to polar teleconnections?

Discussion #2: Summer 2011 Precipitation in the Northeast and the Arctic Oscillation

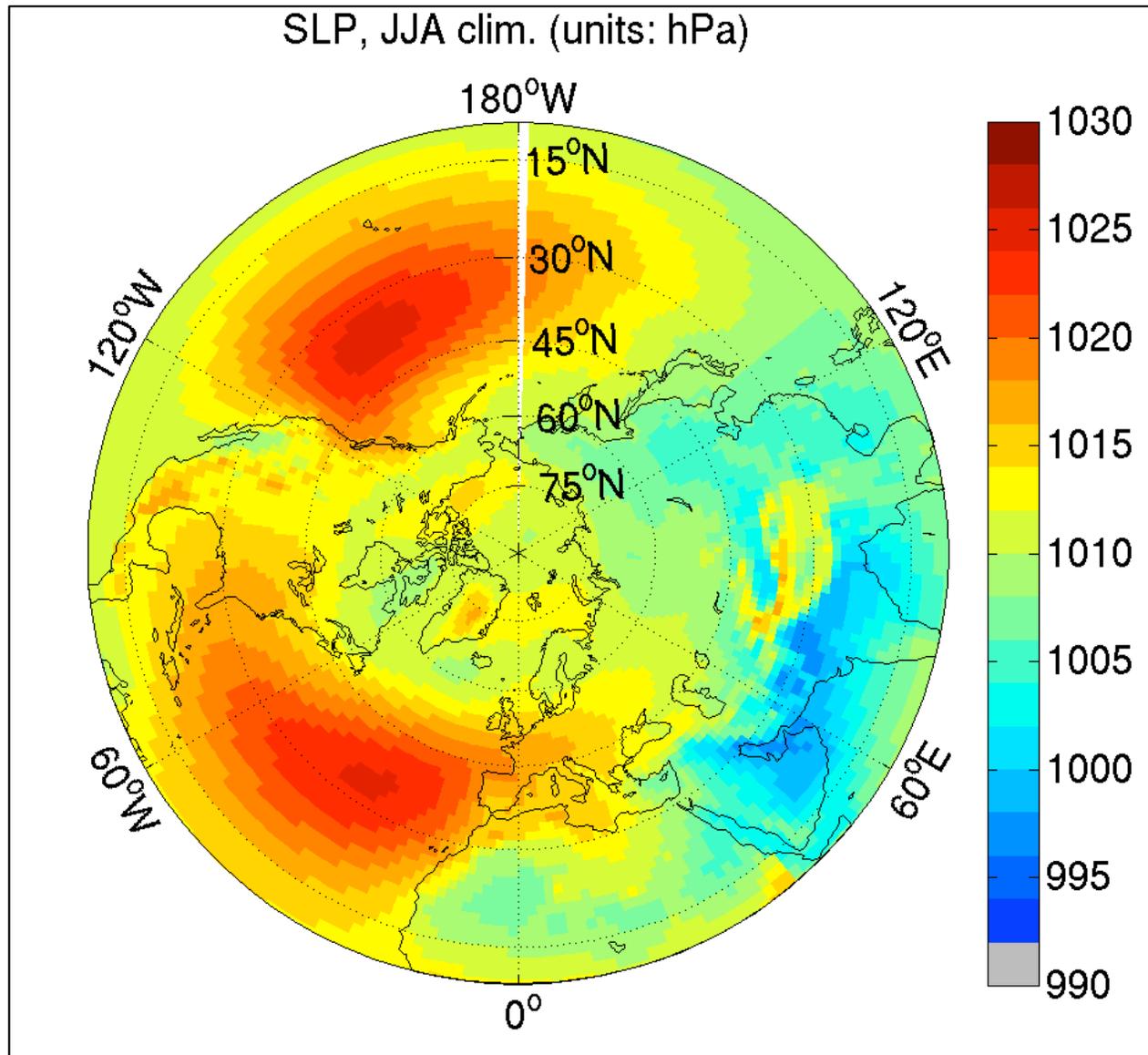
What was the state of the NH climate for summer 2011?

- Hot over the centers of the continents, and low pressures as well.
- High pressure over Greenland and North Pole



ECMWF Interim. Climatology: 1979-2010

SUMMERTIME CLIMATOLOGY FOR SLP

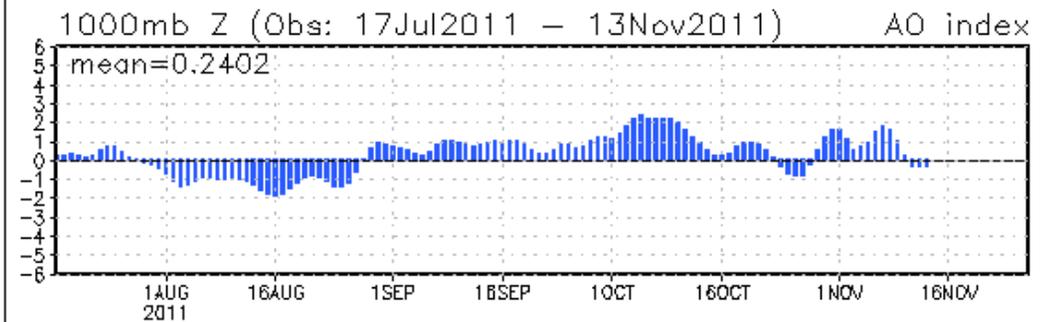


Discussion #2

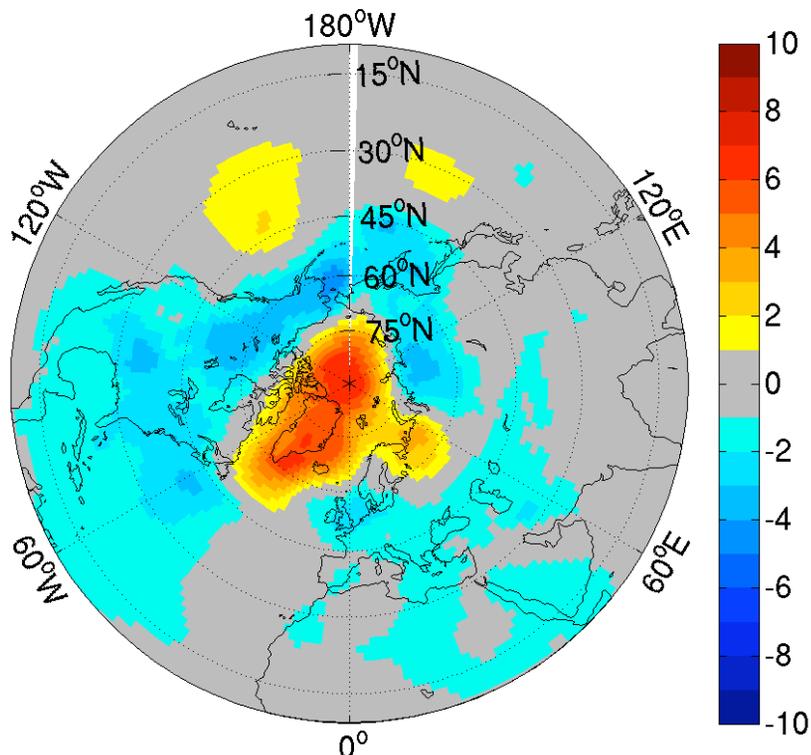
What was the state of the AO?

- Weak Negative for June
- Weak Positive for July.
- Negative for August

AO: Observed & GFS forecasts

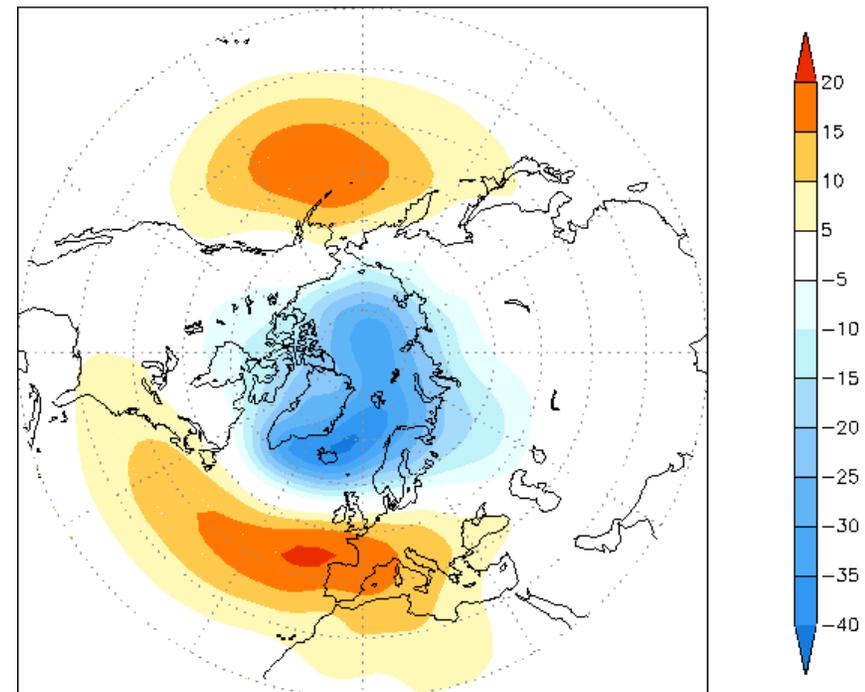


SLP, JJA 2011 Anomaly (units: hPa)



ECMWF Interim. Climatology: 1979-2010

Leading EOF (19%) shown as regression map of 1000mb height (m)



<http://www.cpc.noaa.gov/>

How does the AO relate to NE precipitation in summer?

Influence of the Arctic oscillation on central United States summer rainfall

Qi Hu¹ and Song Feng¹

Correlation between the summer AO and the summer precipitation index shows: decrease in precipitation in the central US during AO+ phase.

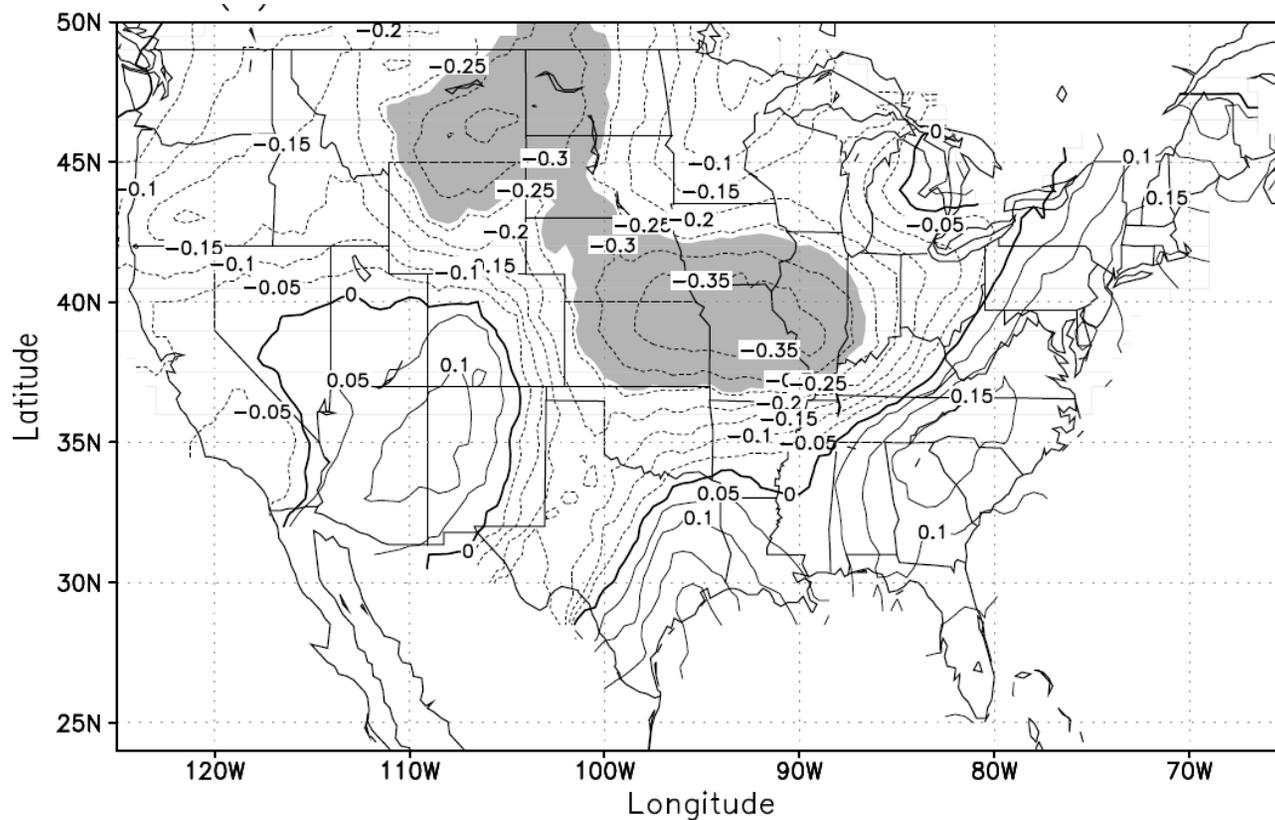
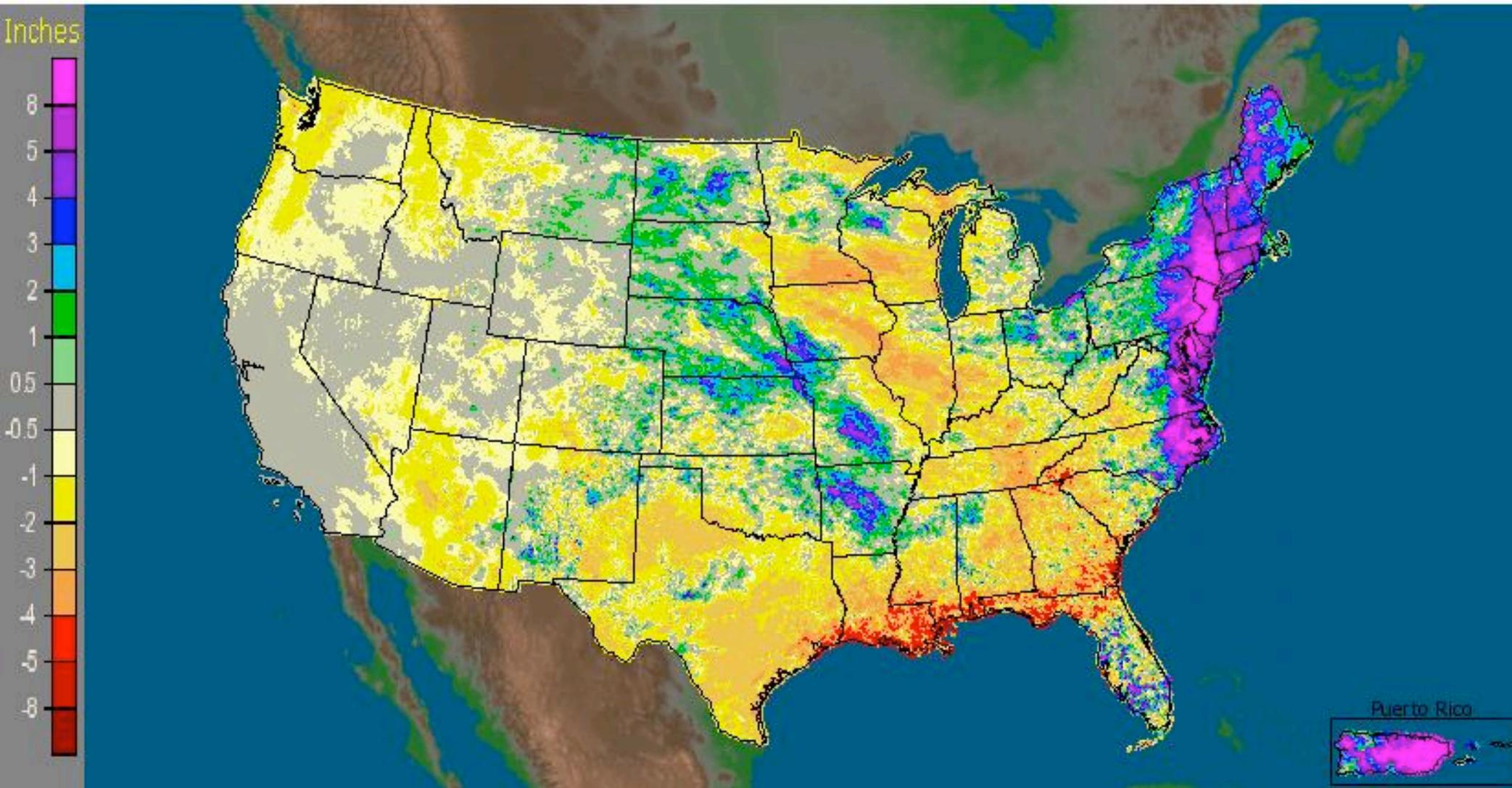


Figure 2. Spatial patterns of the correlation between the summer AO index and the summer SPI for (a) 1900–1948 and (b) 1949–2007. Shading indicates correlation significant at the 95% confidence level.

Accumulated Precipitation Anomaly for August 2011 (units: inches)

CONUS + Puerto Rico: August, 2011 Monthly Departure from Normal Precipitation
Valid at 9/1/2011 1200 UTC- Created 9/3/11 21:33 UTC



<http://water.weather.gov/precip/>

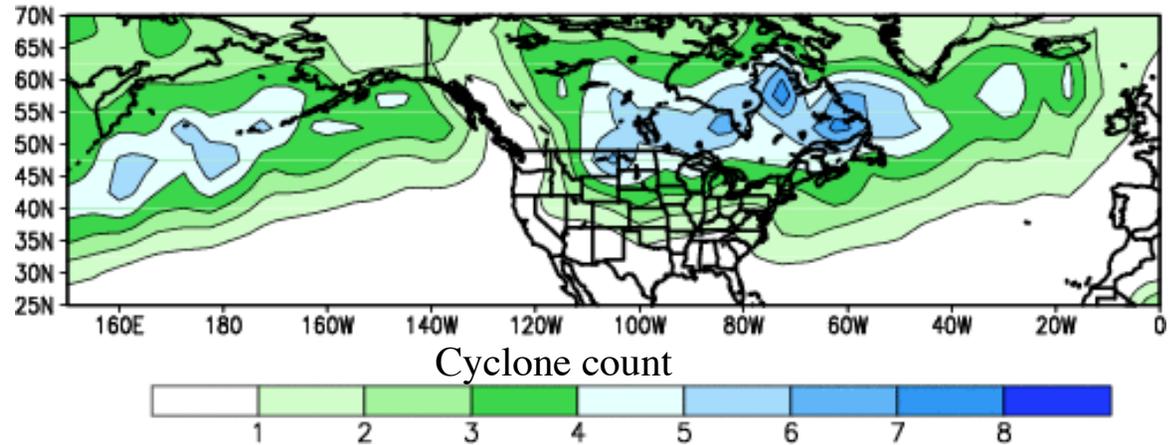
PRECIP anomaly does not look like the canonical AO response.

Discussion #2: Summer 2011 Precipitation in the Northeast and the Arctic Oscillation

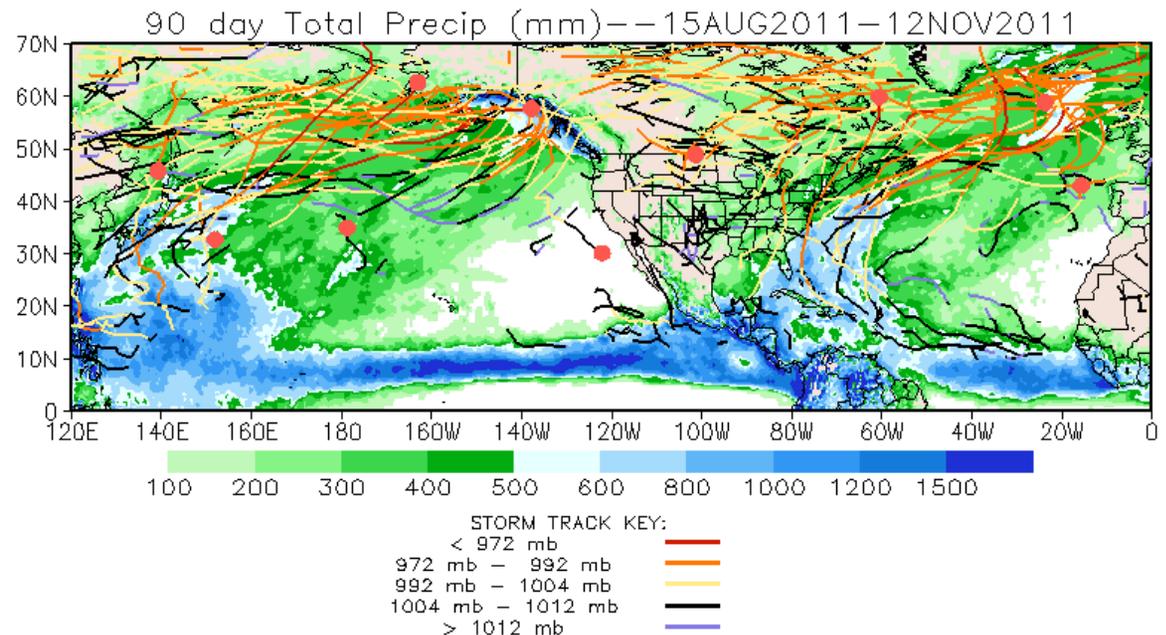
What caused the increased precipitation?

Anomalously large number of storms along the eastern seaboard.

Climatological Storm Track density for JJA

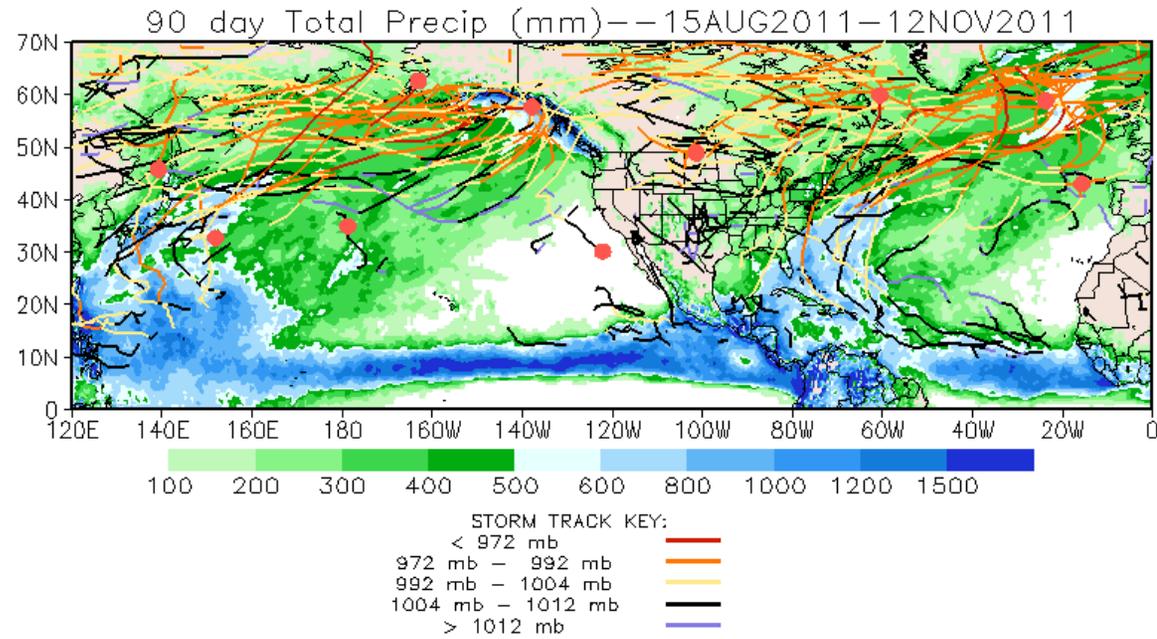


Storm Tracks and Precipitation for Aug 15 – Nov.

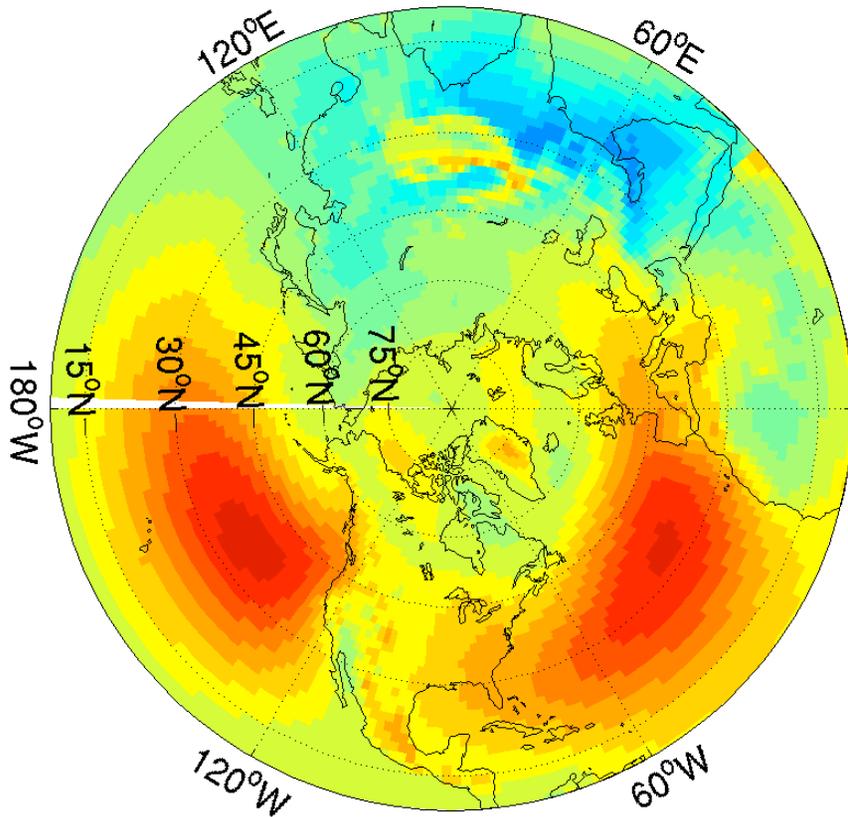


Discussion #2:
NE Precip.

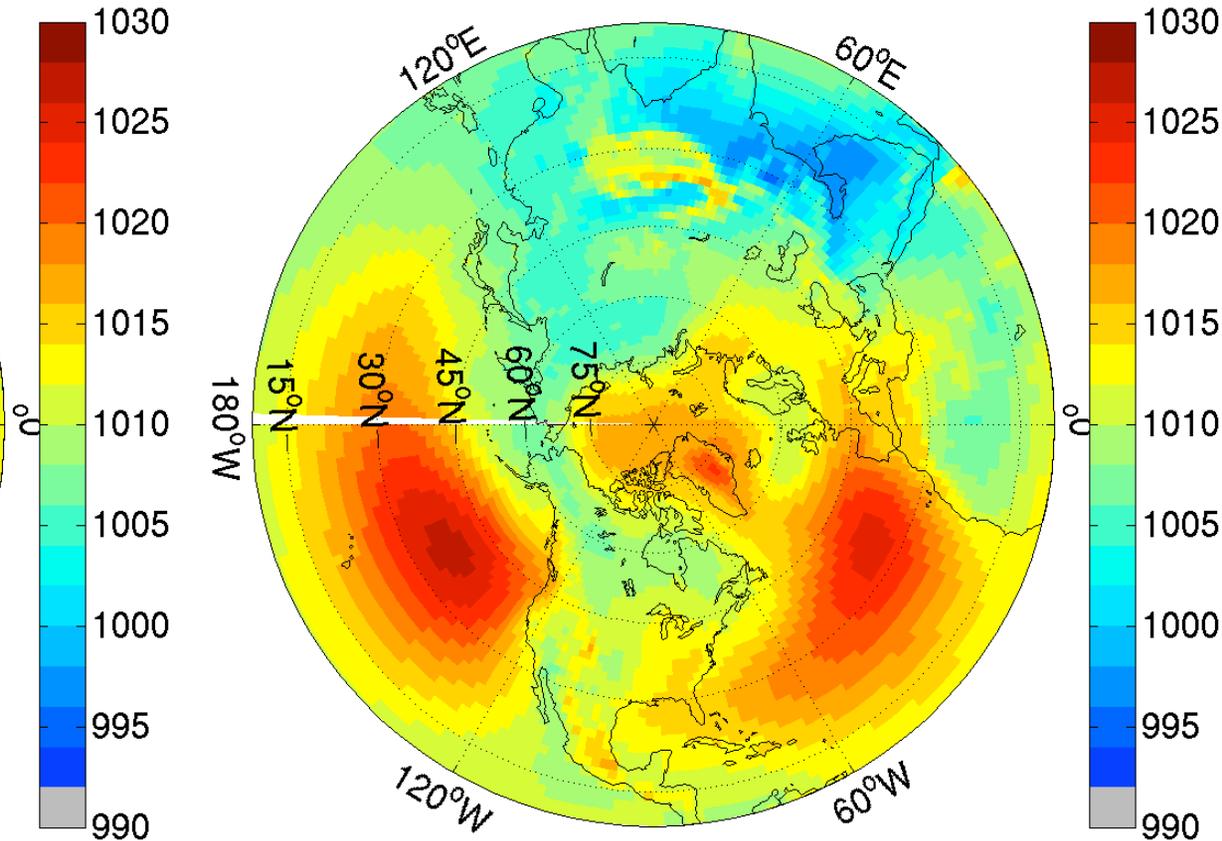
Hypothesis: the storms tracks along the eastern seaboard respond to changes in the westward extend of the Azores High.



SLP, JJA clim.

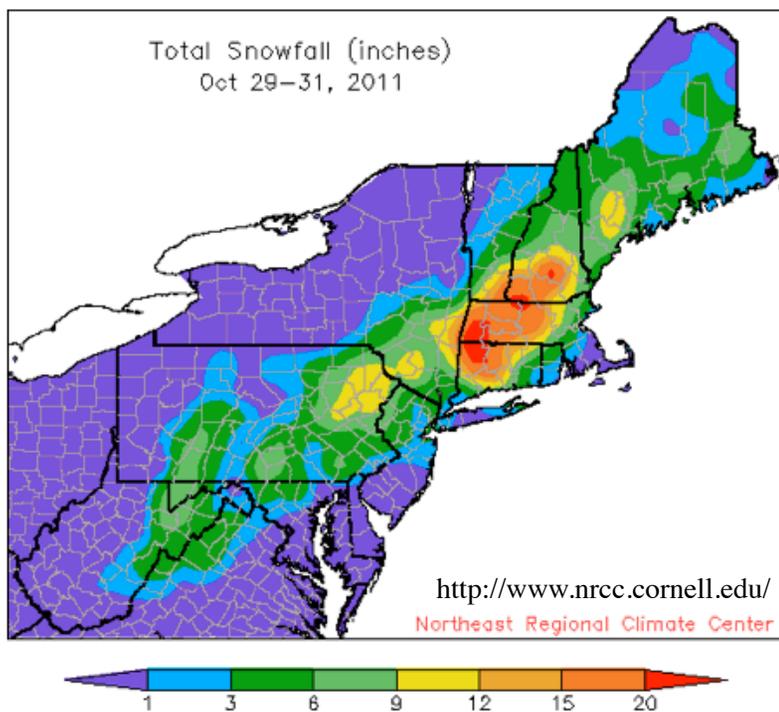


SLP, JJA 2011

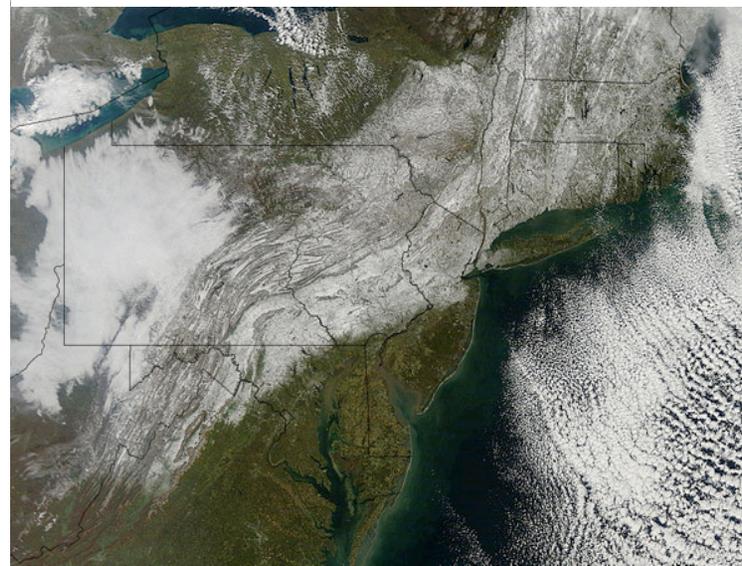


Discussion #2: Summer 2011 Precipitation in the Northeast and the Arctic Oscillation

The Great October Snowstorm



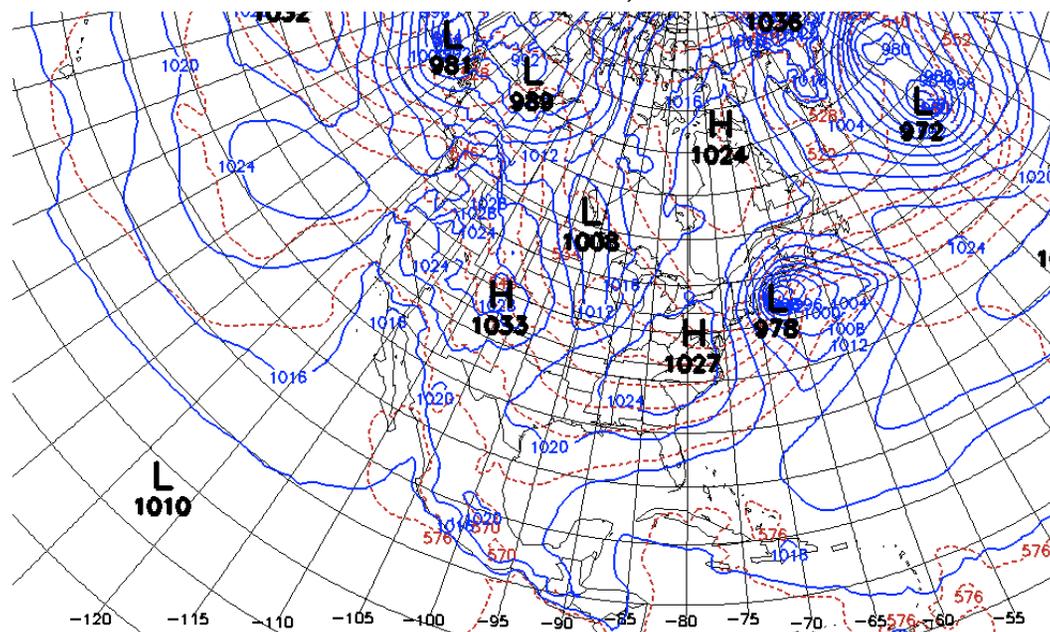
Modis Satellite Imagery post-storm



The Halloween snow storm:

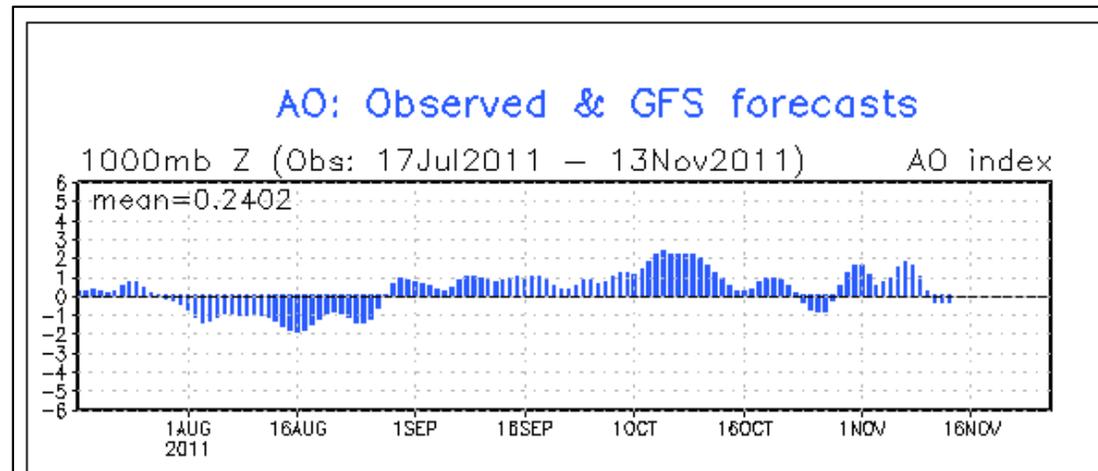
- typical fall midlatitude storm
- high pressure over eastern Canada advected cold air into the storm

ANALYSIS MEAN SEA LEVEL PRESSURE/1000–500MB THICKNESS



10/30/2011 12UTC 000HR FCST VALID SUN 10/30/2011 12UTC NCEP,

Discussion #2: Summer 2011 Precipitation in the Northeast and the Arctic Oscillation



The North Atlantic Oscillation is a critical factor in controlling the day-to-day weather, and it is a helpful phase to keep in mind when doing short to medium-range predictions.

It is NOT, however, a good parameter to use as an input analog parameter for seasonal prediction. It fluctuates too wildly.

<http://www.millenniumweather.com/winter/season.html>

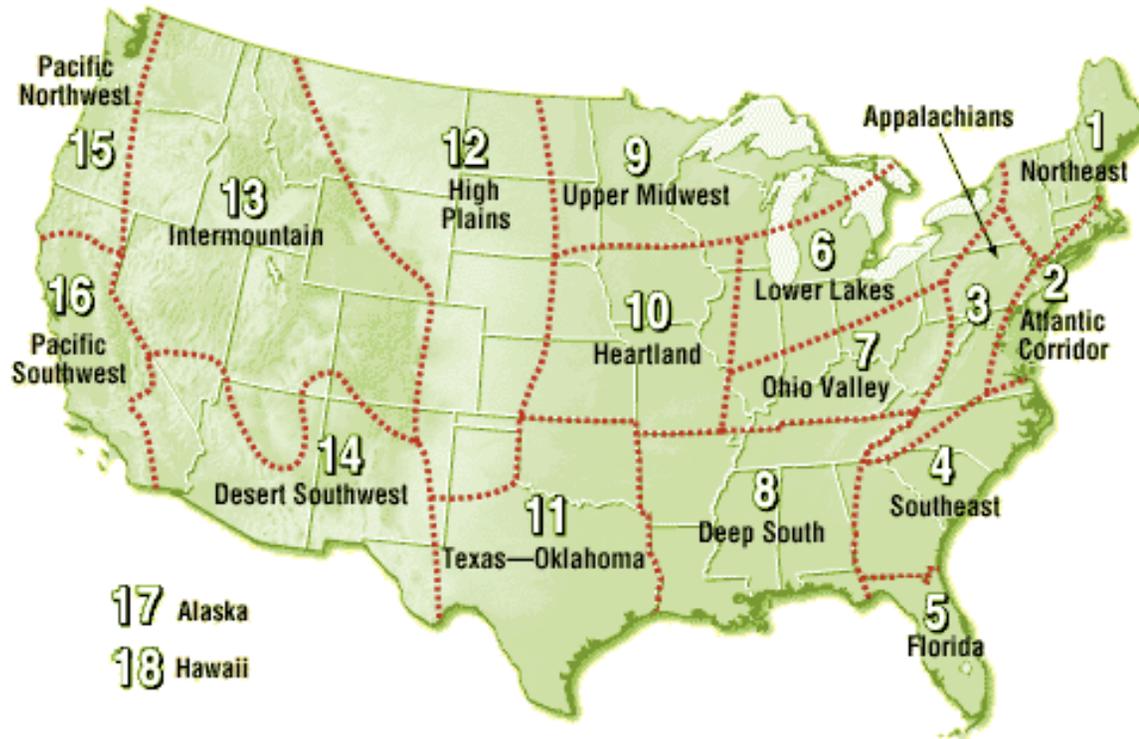
Seasonal Forecasting

- Memory in the climate system
 - Sea surface temperatures, soil moisture, snow and ice cover
- Persistent dynamics
 - ENSO, MJO, Pacific Decadal Observation
- Black Box Approaches



2012 Long-Range Weather Forecast

Find The Old Farmer's Almanac long range weather forecast.



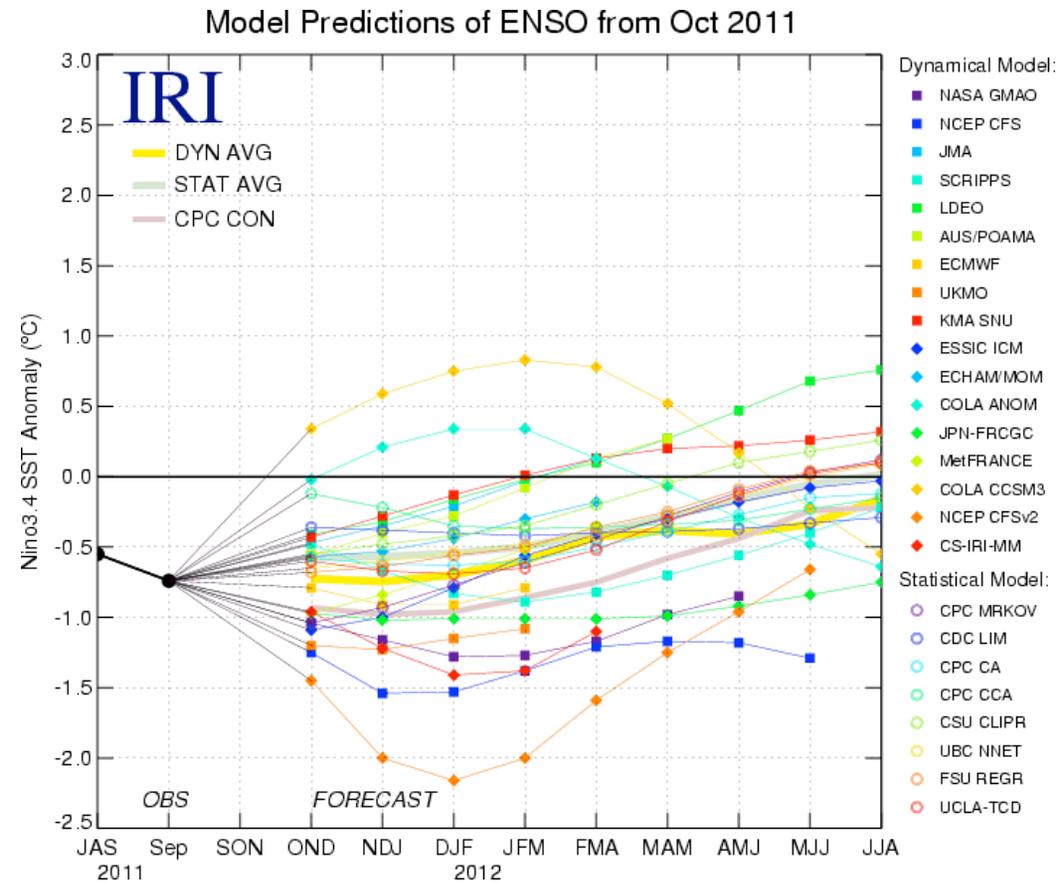
“Annual Weather Summary: November 2011 to October 2012

Winter will be drier than normal, with near-normal temperatures but above-normal snowfall. The coldest periods will be in mid-December and early and mid-February. The snowiest periods will be in mid-December, mid- and late January, and late February.

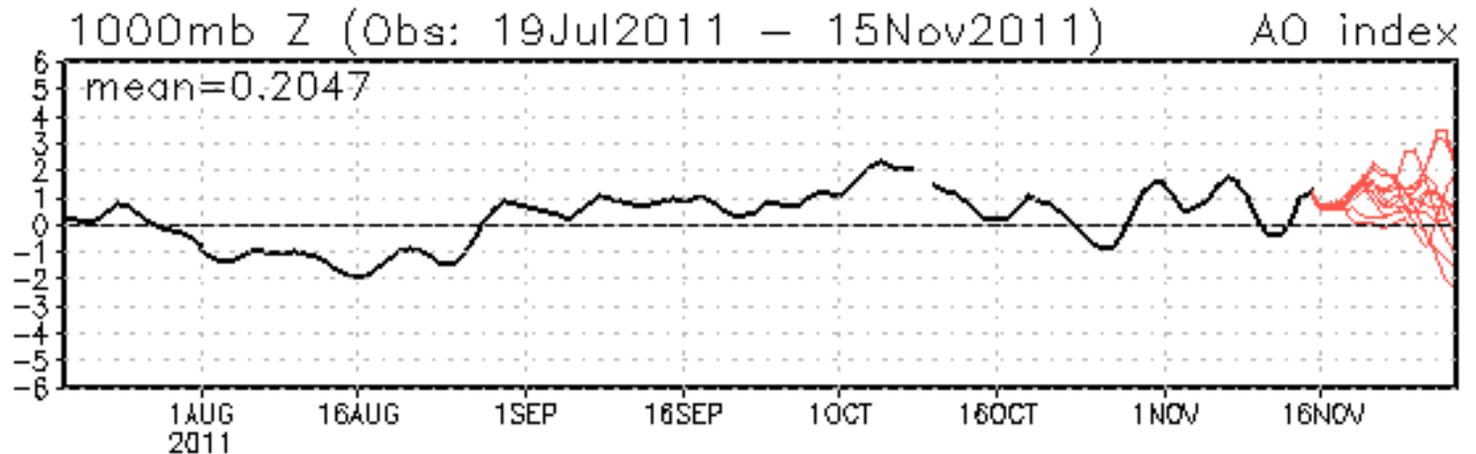
April and May will be much cooler than normal. Rainfall will be above normal in the north and below normal in the south. Summer will be cooler and rainier than normal, with the hottest periods in early and mid-July. September and October will be cooler and drier than normal.”

“Dec 28-31: Rain and snow showers”

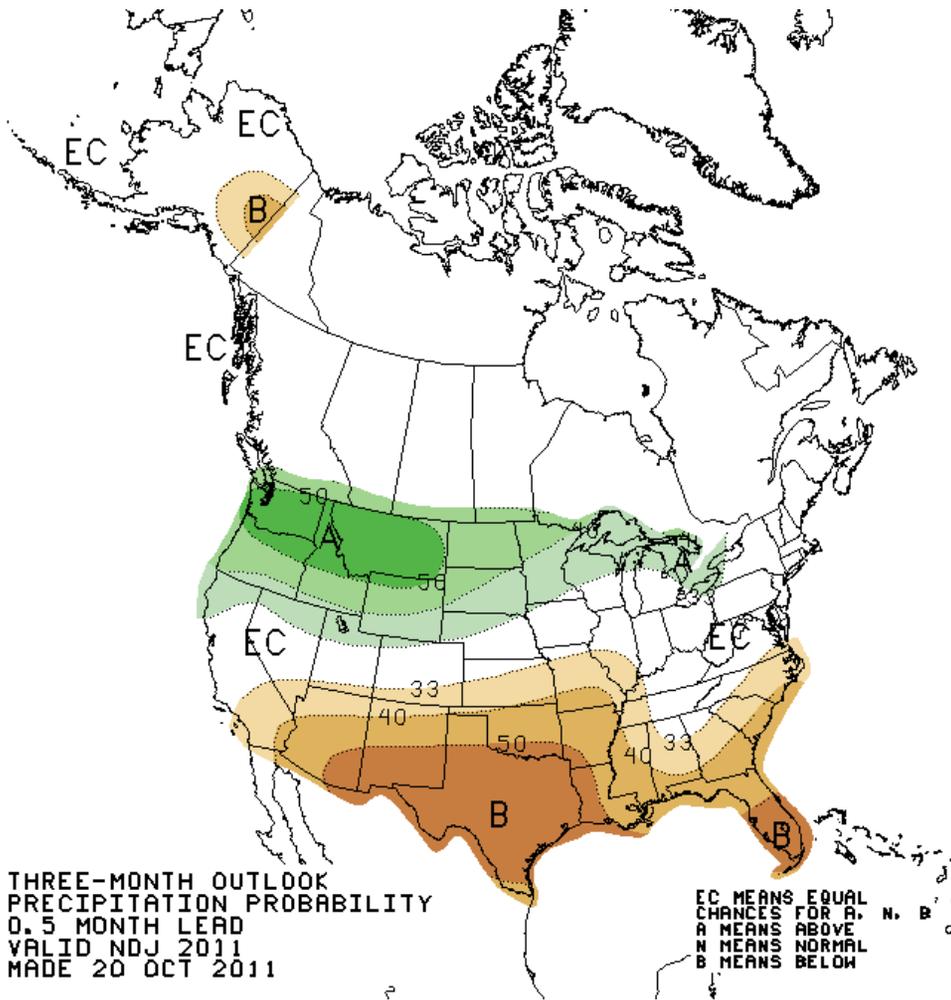
Predictability: AO vs ENSO



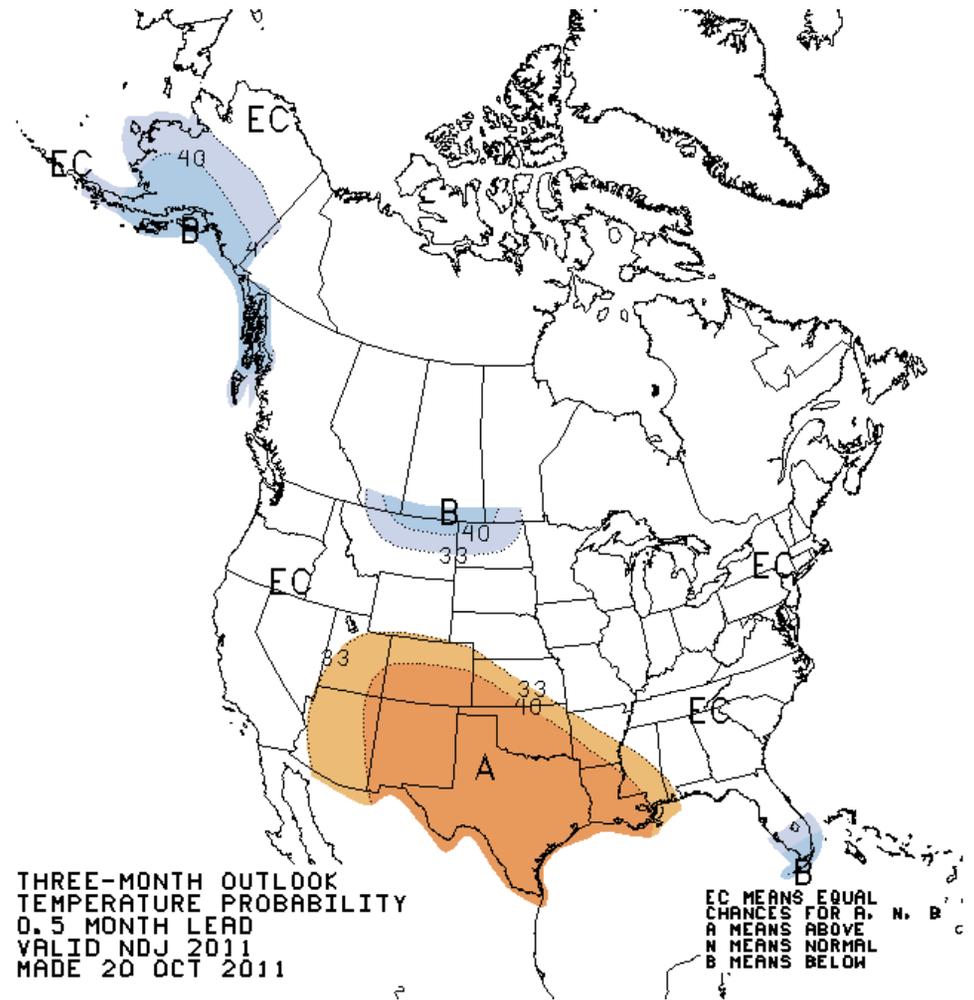
AO: Observed & ENSM forecasts



Season Forecast (CPC)



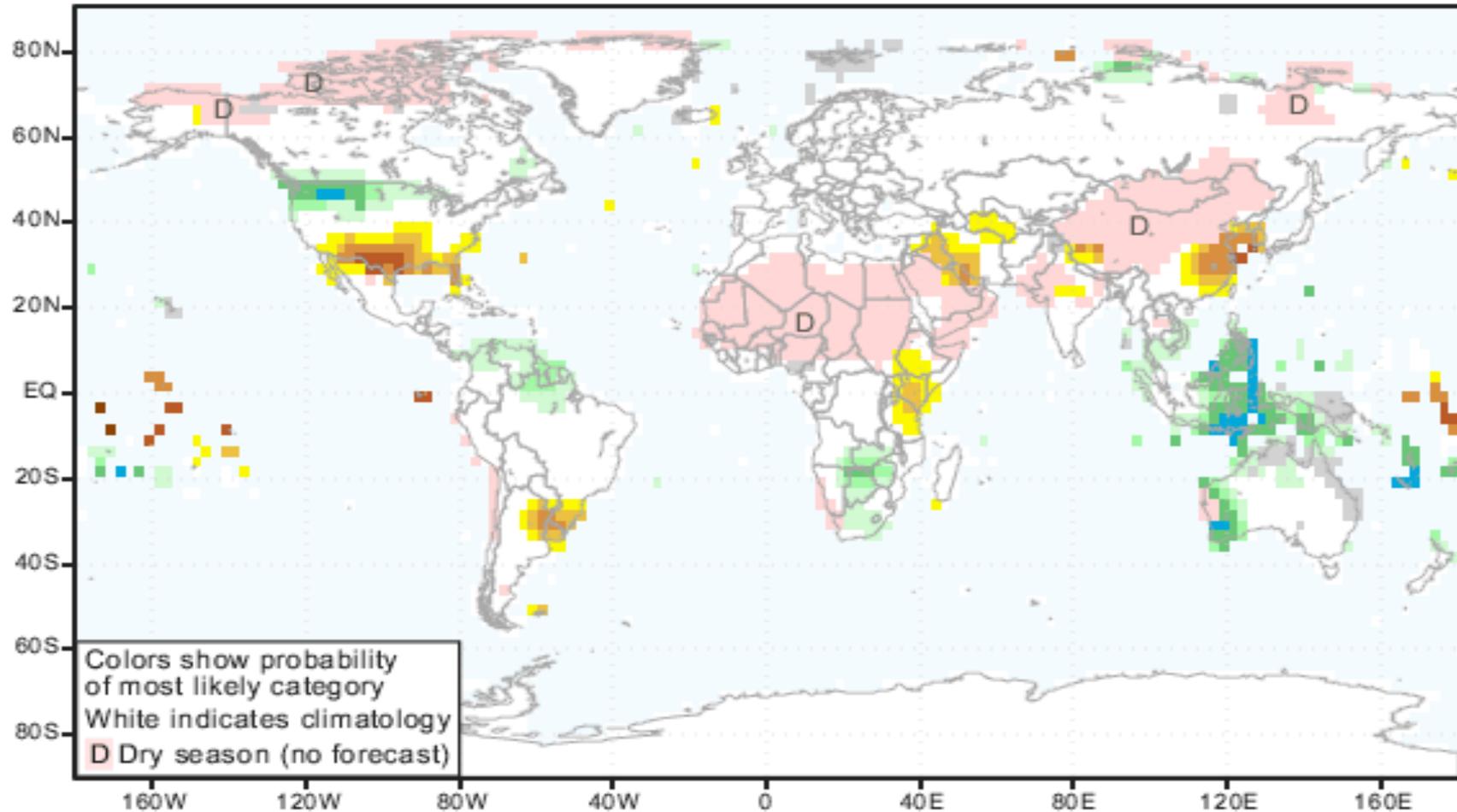
Precipitation



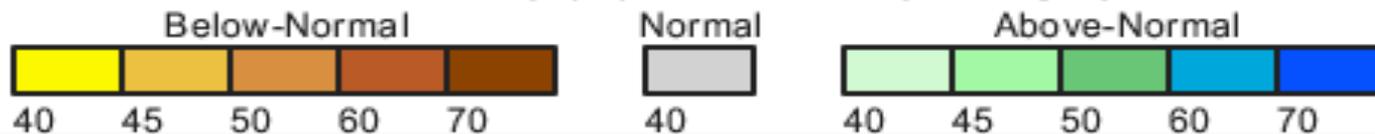
Temperature

Seasonal Forecast (IRI)

IRI Multi-Model Probability Forecast for Precipitation
for November-December-January 2012, Issued October 2011

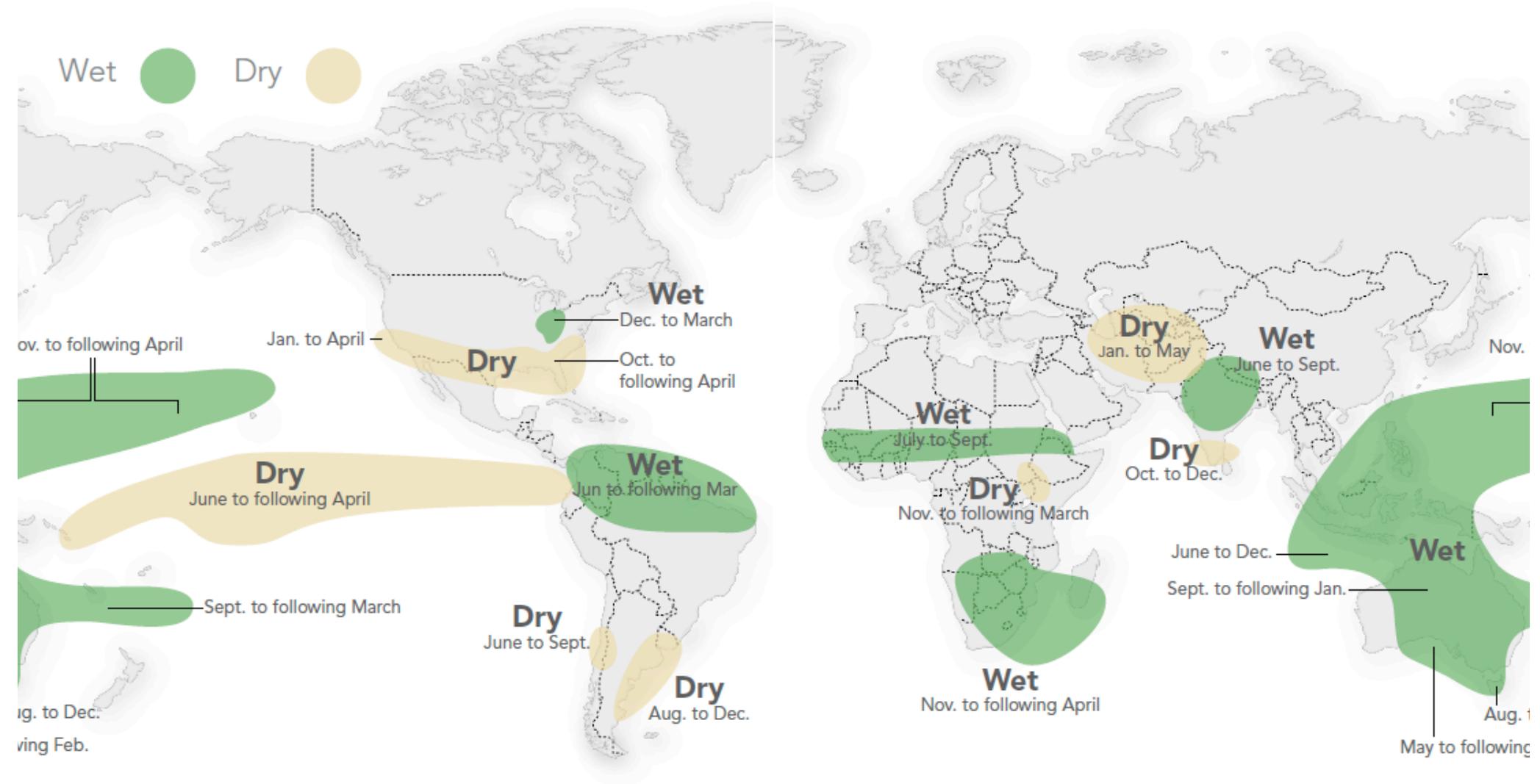


Probability (%) of Most Likely Category



La Niña and Rainfall

Wet  Dry 



<http://iri.columbia.edu/ENSO>

Resources

- **Current State of the Teleconnections, Weather and Climate**

- ENSO, MJO, AO, PNA
 - <http://www.cpc.ncep.noaa.gov/>
- Drought (US)
 - <http://droughtmonitor.unl.edu/>
- Drought (Global)
 - <http://drought.mssl.ucl.ac.uk>
- Weather Events
 - <http://www.ncdc.noaa.gov/sotc/national/>

- **Recent Past Weather**

- Precipitation
 - Global: <http://water.weather.gov/precip/>
 - Northeast Regional: <http://www.nrcc.cornell.edu/>
 - NYC Weather Station: <http://www.erh.noaa.gov/okx/>
 - Satellite: <http://disc2.nascom.nasa.gov/Giovanni/tovas/>

- **General**

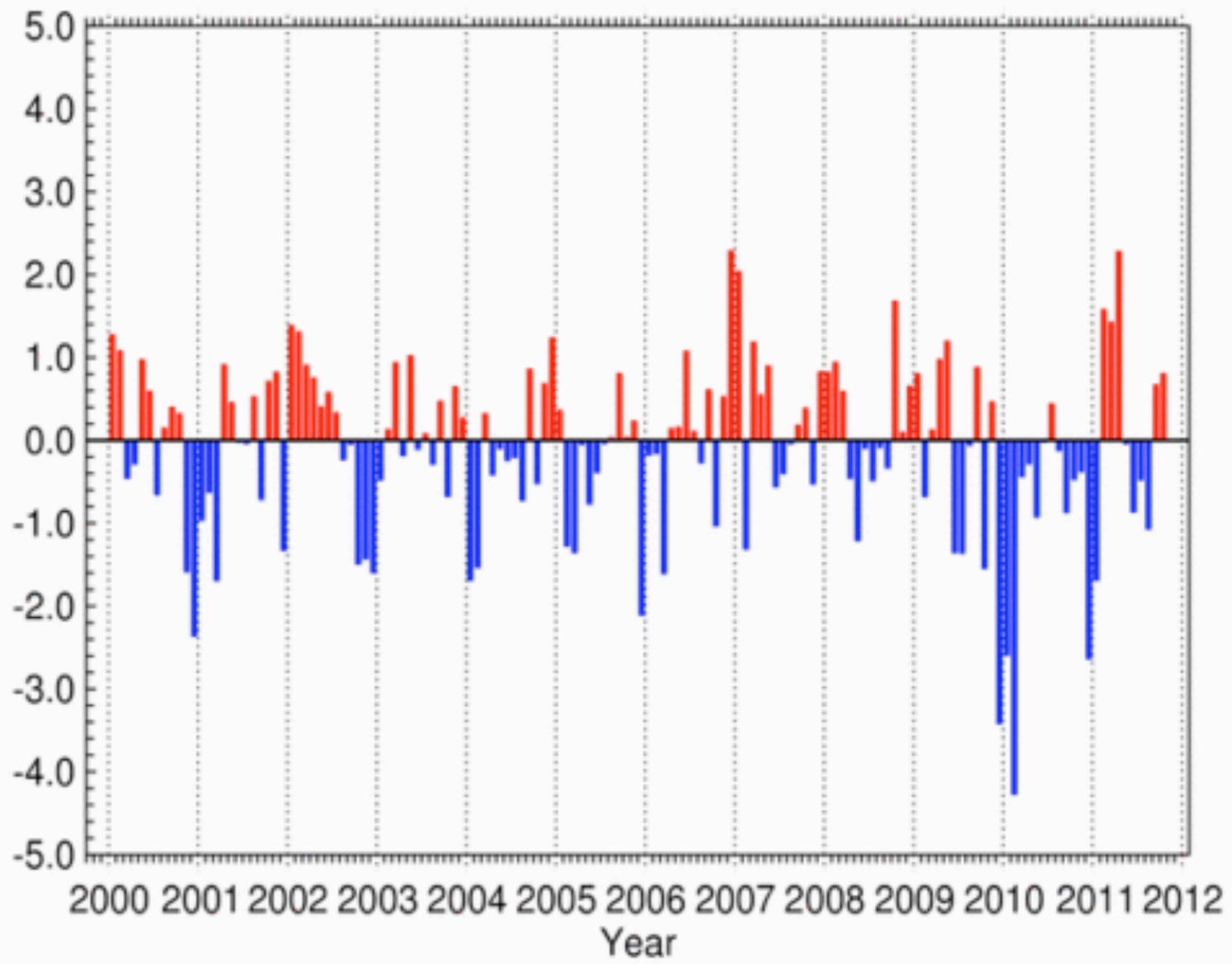
- ENSO Impact
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/us_impacts/ustp_impacts.shtml

- **Seasonal Forecasts**

- IRI, ENSO
 - http://iri.columbia.edu/climate/ENSO/currentinfo/archive/201110/SST_table.html
- CPC Winter Outlook
 - http://www.cpc.ncep.noaa.gov/products/predictions/long_range/fxus05.html

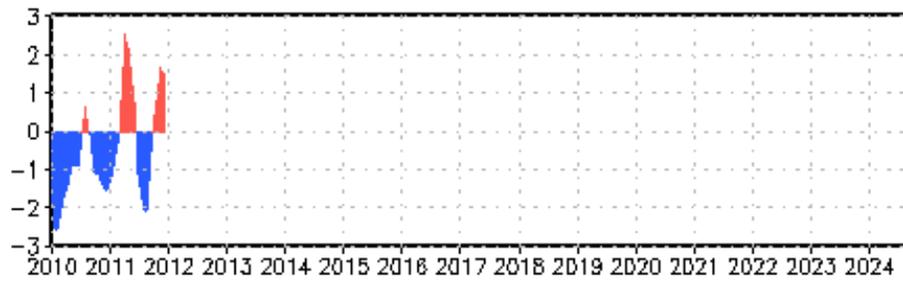
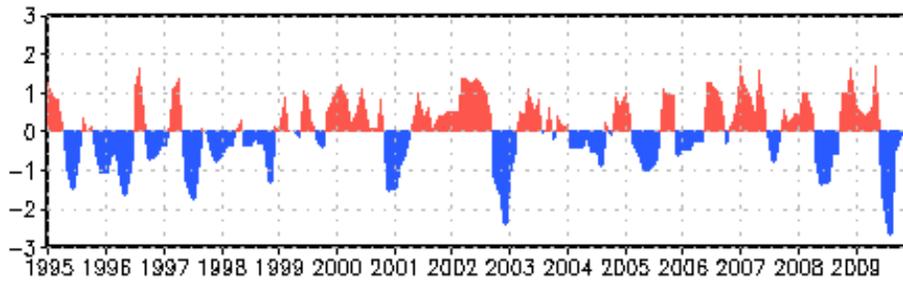
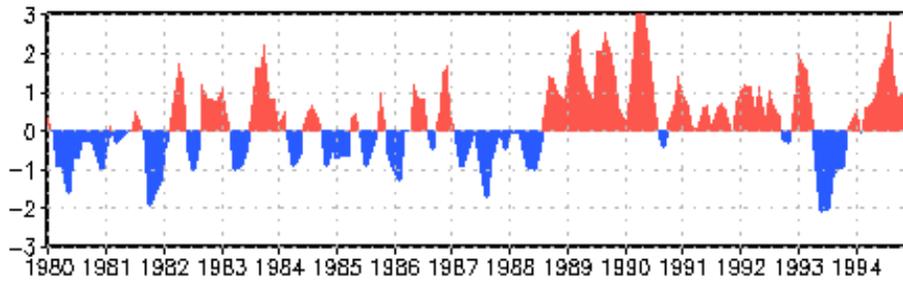
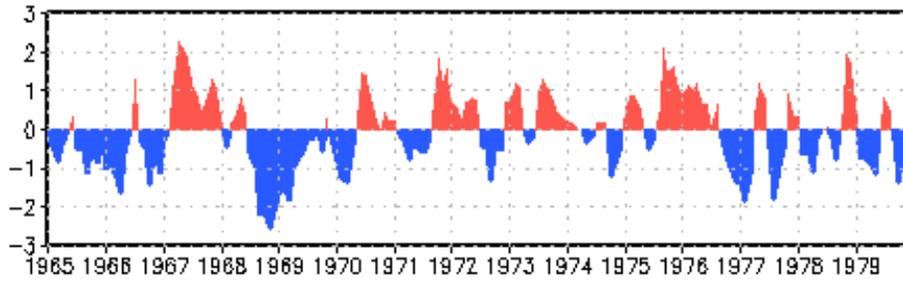
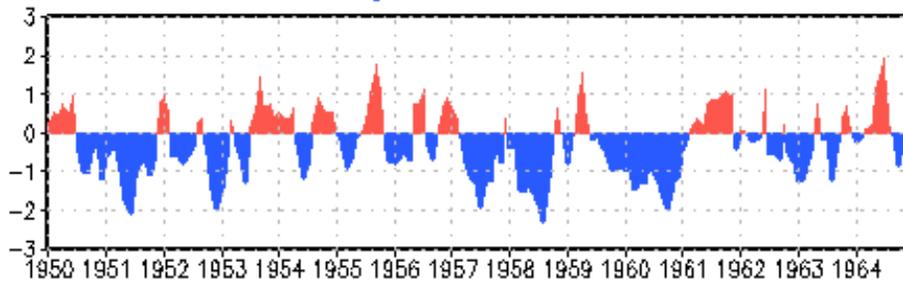
FIN. Thank you.

Arctic Oscillation (AO)



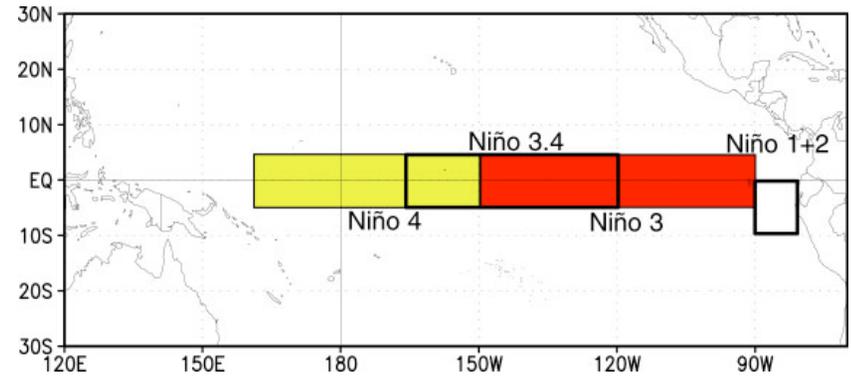
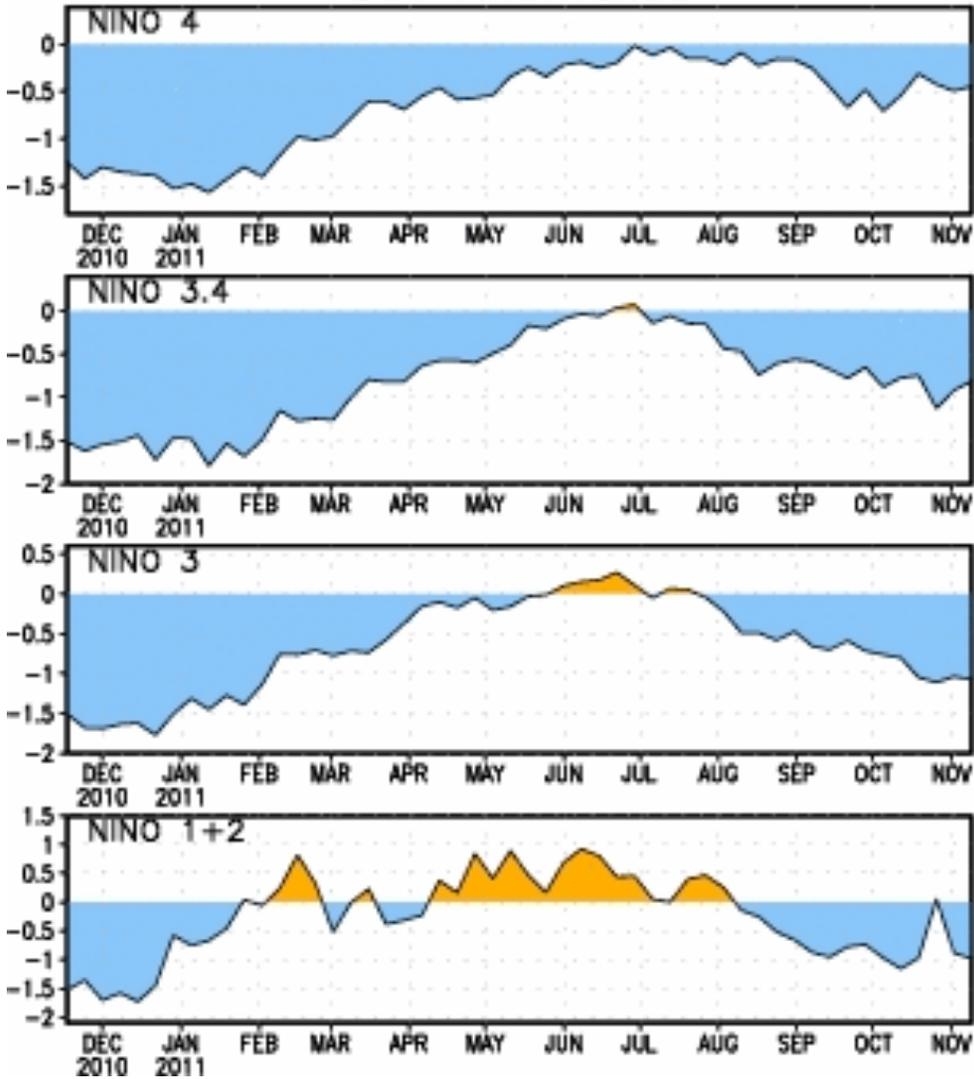
National Climatic Data Center / NESDIS / NOAA

Standardized 3-Month Running Mean AO Index Through October 2011



ENSO INDICES FOR 2011

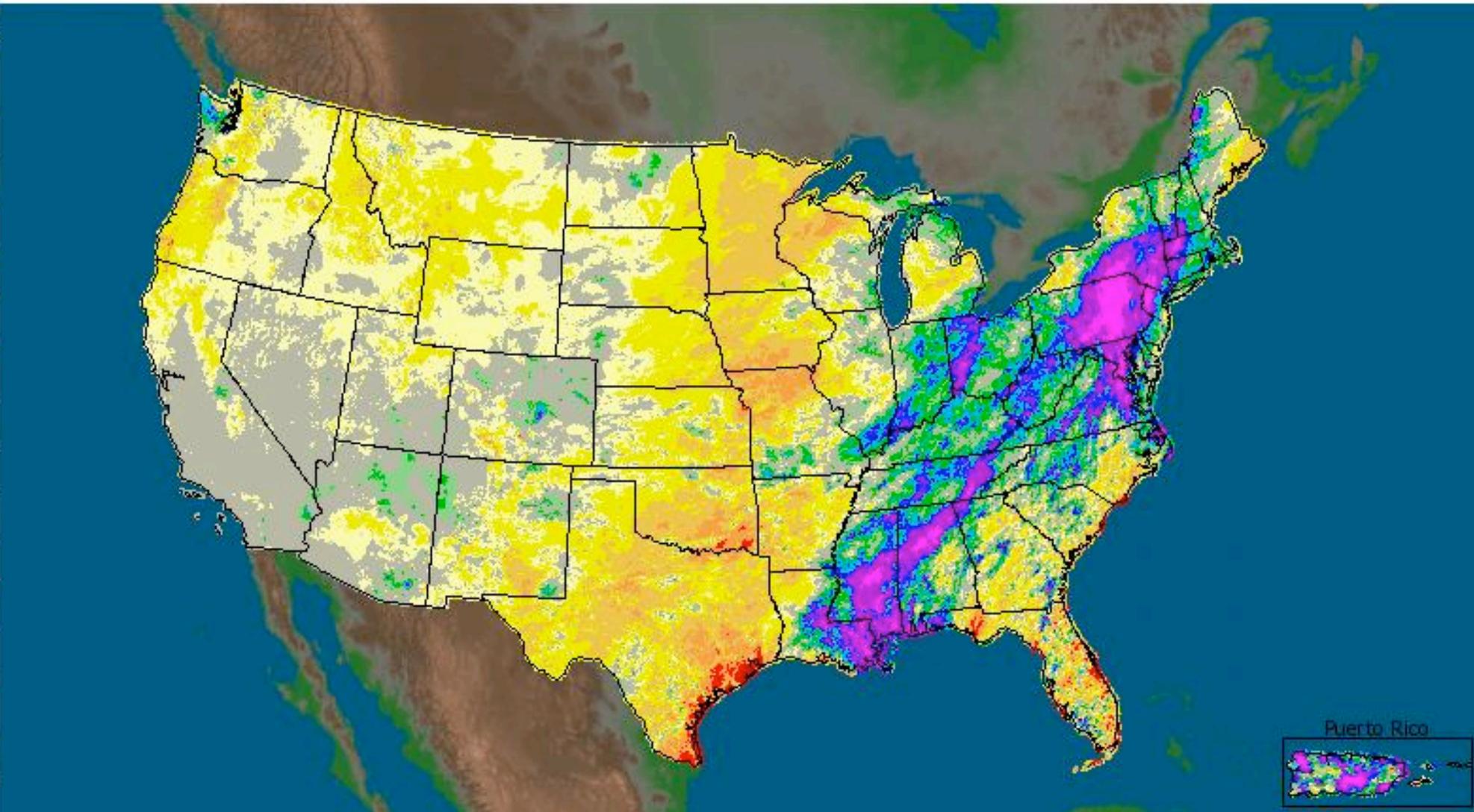
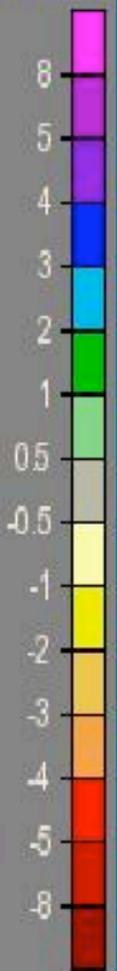
SST Anomalies



September 2011 Anomaly (units: inches)

CONUS + Puerto Rico: September, 2011 Monthly Departure from Normal Precipitation
Valid at 10/1/2011 1200 UTC- Created 10/3/11 21:33 UTC

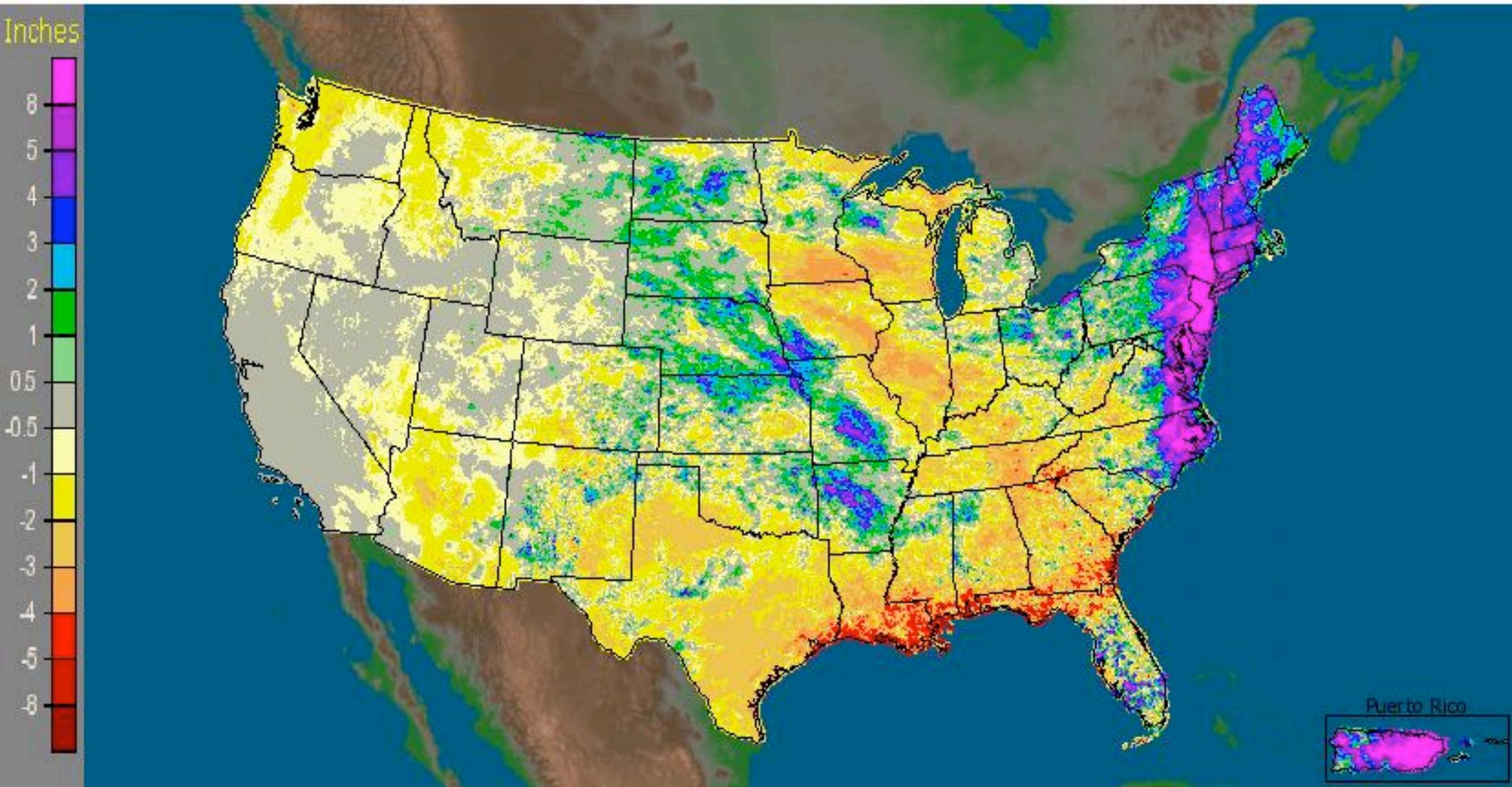
Inches



<http://water.weather.gov/precip/>

Accumulated Precipitation Anomaly for August 2011 (units: inches)

CONUS + Puerto Rico: August, 2011 Monthly Departure from Normal Precipitation
Valid at 9/1/2011 1200 UTC- Created 9/3/11 21:33 UTC



<http://water.weather.gov/precip/>

D01102

HU AND FENG: ARCTIC OSCILLATION EFFECTS ON RAINFALL

D01102

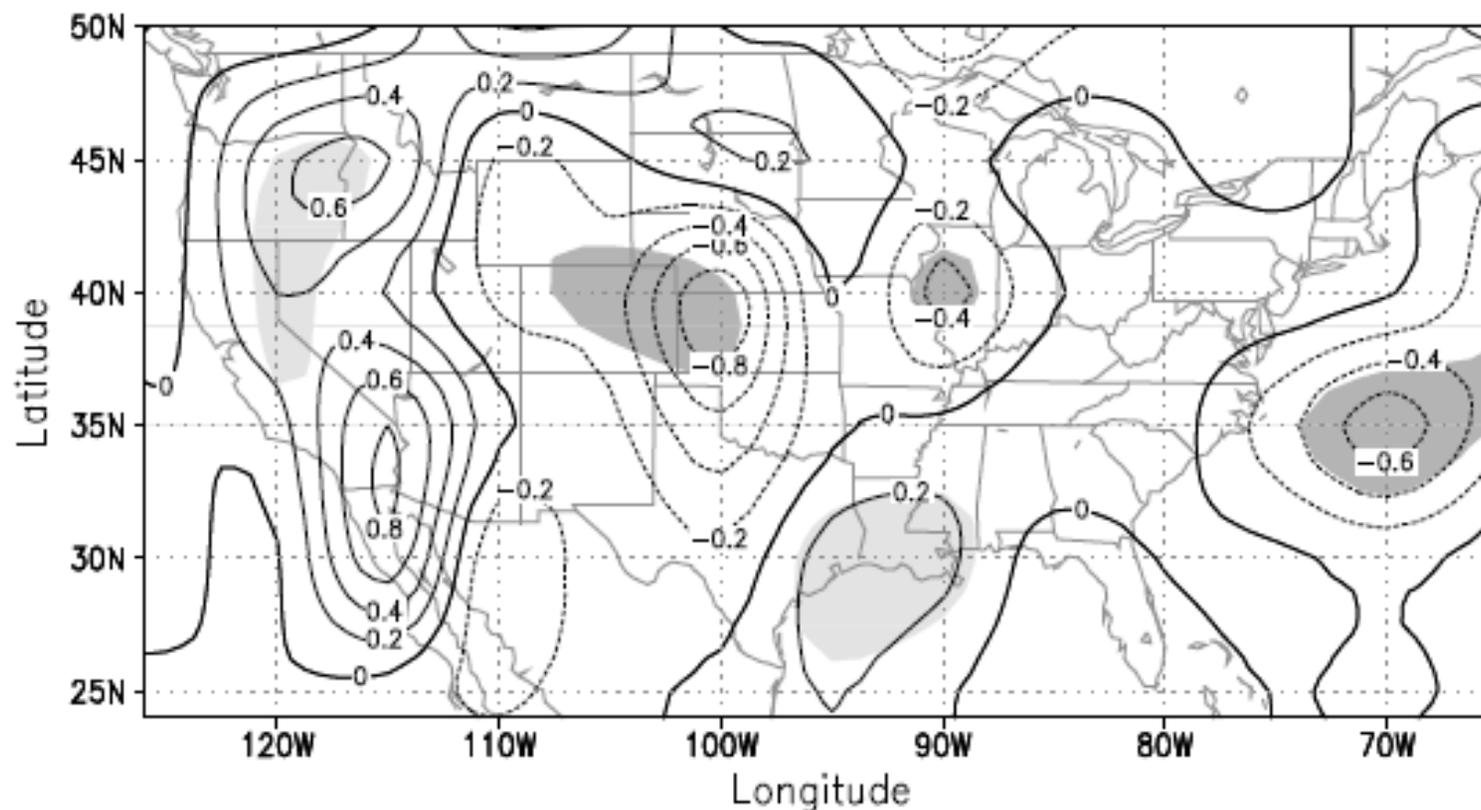


Figure 7. Changes in summer surface cyclone frequency corresponding to a unit deviation of the summer AO index on interannual time scale. Contour interval is 0.2 cyclones. Regions of the above 95% confidence level are shaded.

Discussion #2: Summer 2011 Precipitation in the Northeast and the Arctic Oscillation

