Recent Developments in Operational Climate Prediction

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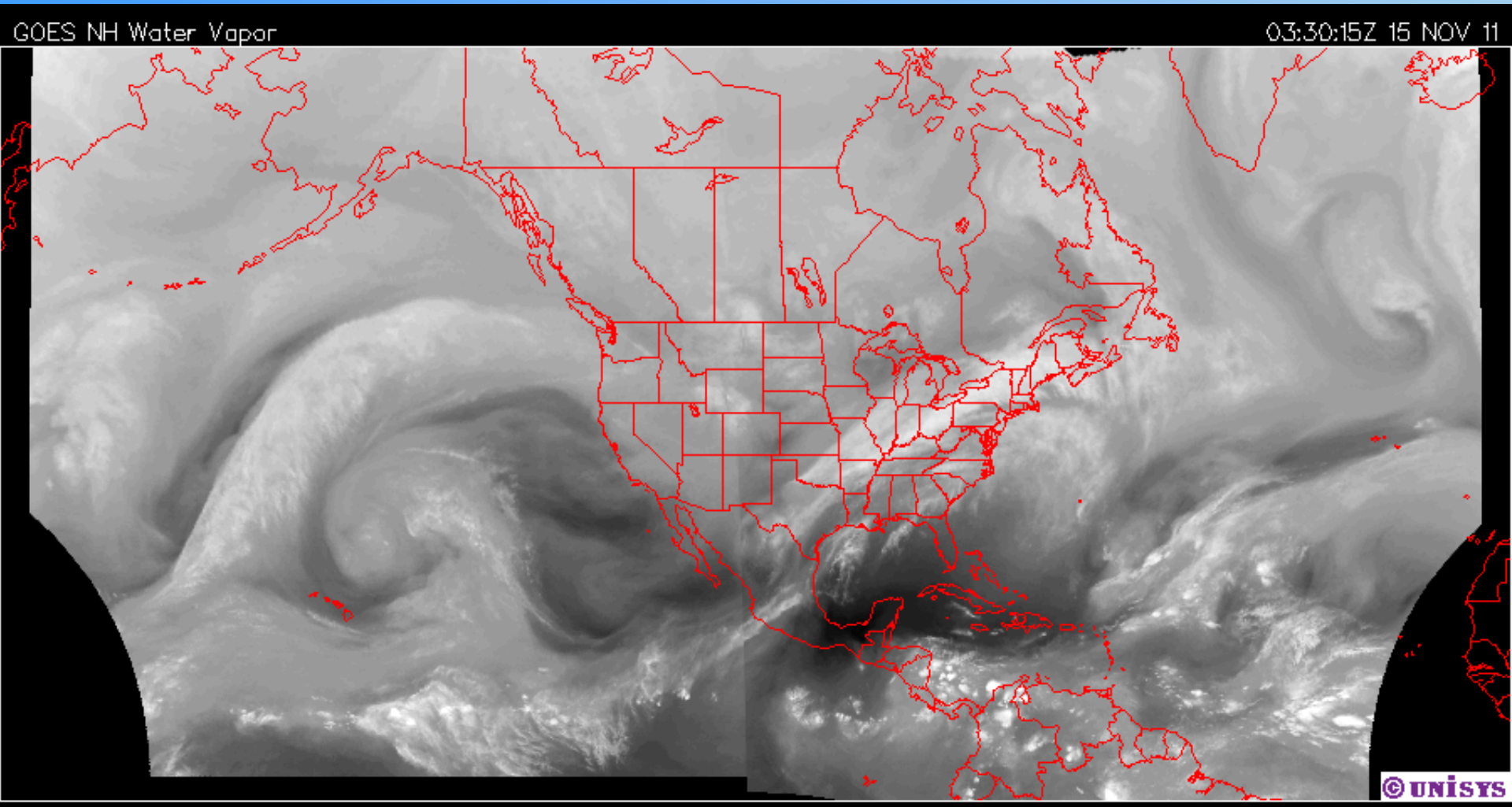
NOAA-NWS-Climate Prediction Center
Chair: AMS Committee on Climate Services
November 17, 2011

Outline

- Sources & Nature of Climate Variability
- The Making and Meaning of the Forecasts
- Relative Accuracy (skill) of Forecasts



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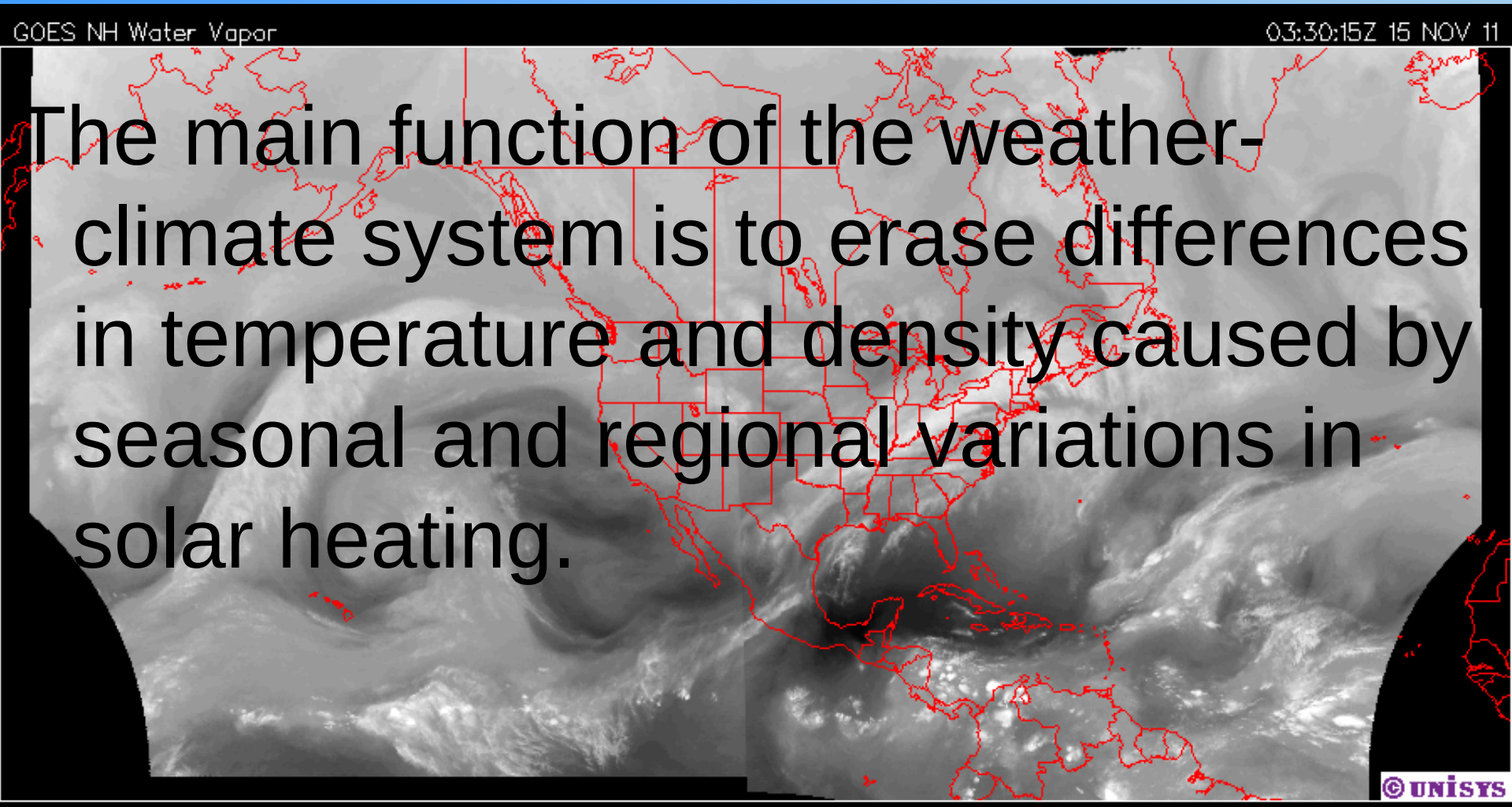


The main function of the weather-climate system is to erase differences in temperature and density caused by seasonal and regional variations in solar heating.

Where Forecasts Come From

NATURAL HAZARD

SOCIETAL NEED

OBSERVATIONS- Satellite, surface, aircraft, profilers

NOAA SCIENCE AND OPERATIONS INFRA-STRUCTURE

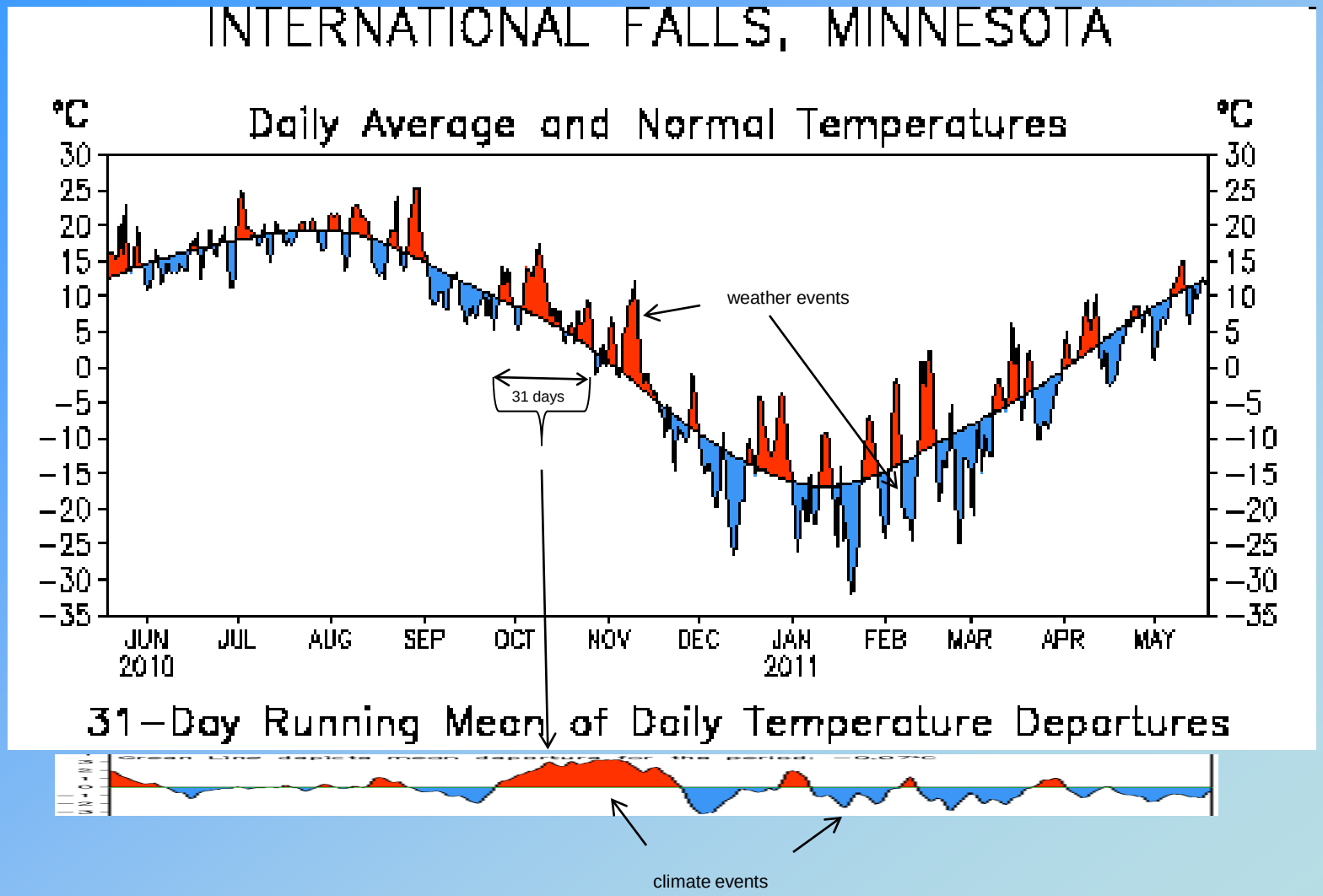
SCIENCE & MODELS Research, Int'l collab

KNOWLEDGE Publications, Forecast methods development

PRACTICAL APPLICATION (Operations, big computers)

Public Forecasts/ Decision Support Services

Relationship between Climate and Weather

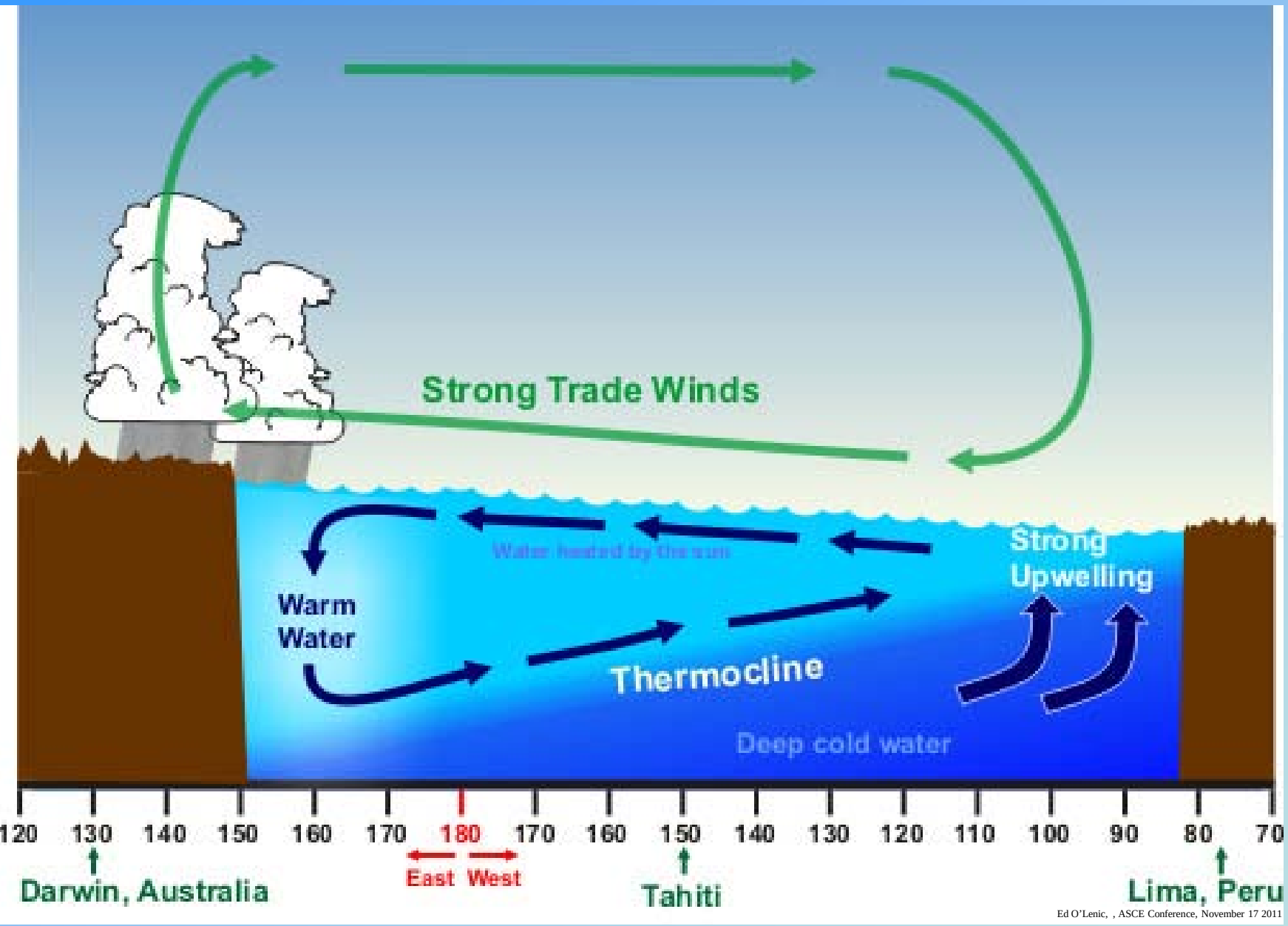


Events on short time scales (weather)
are related to longer-lived events (climate) .

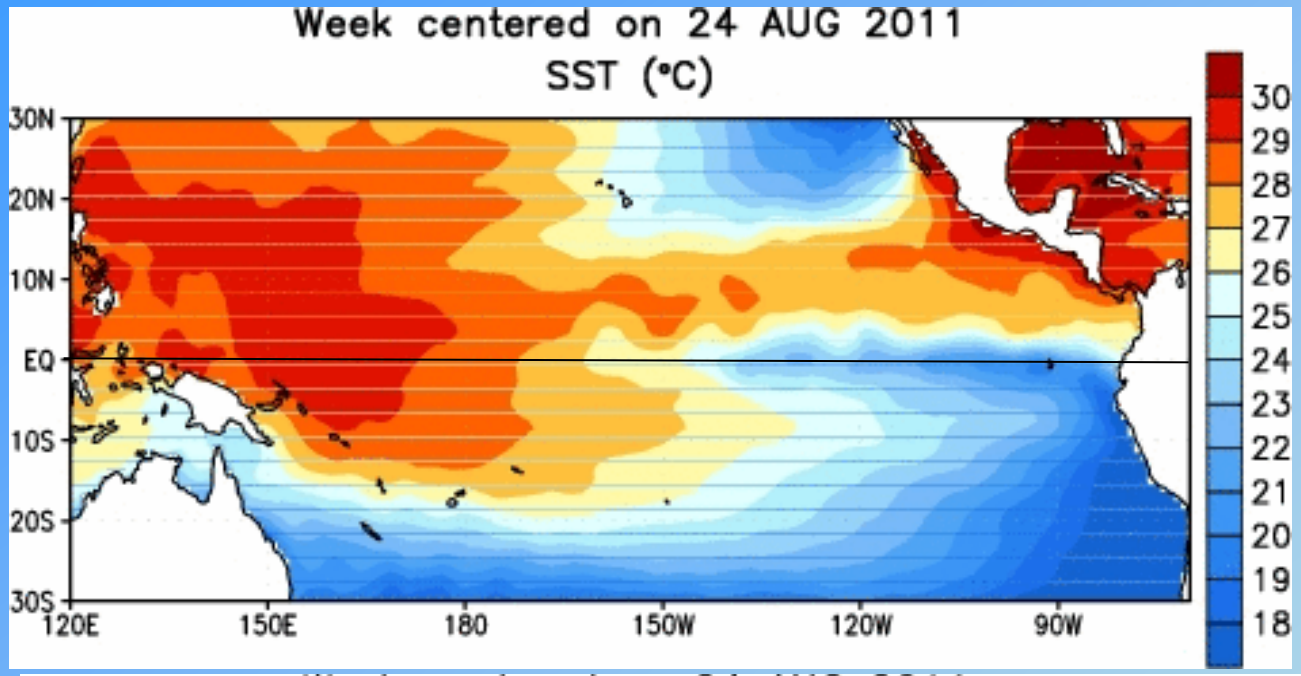
Sources of Predictability: Weeks → Years

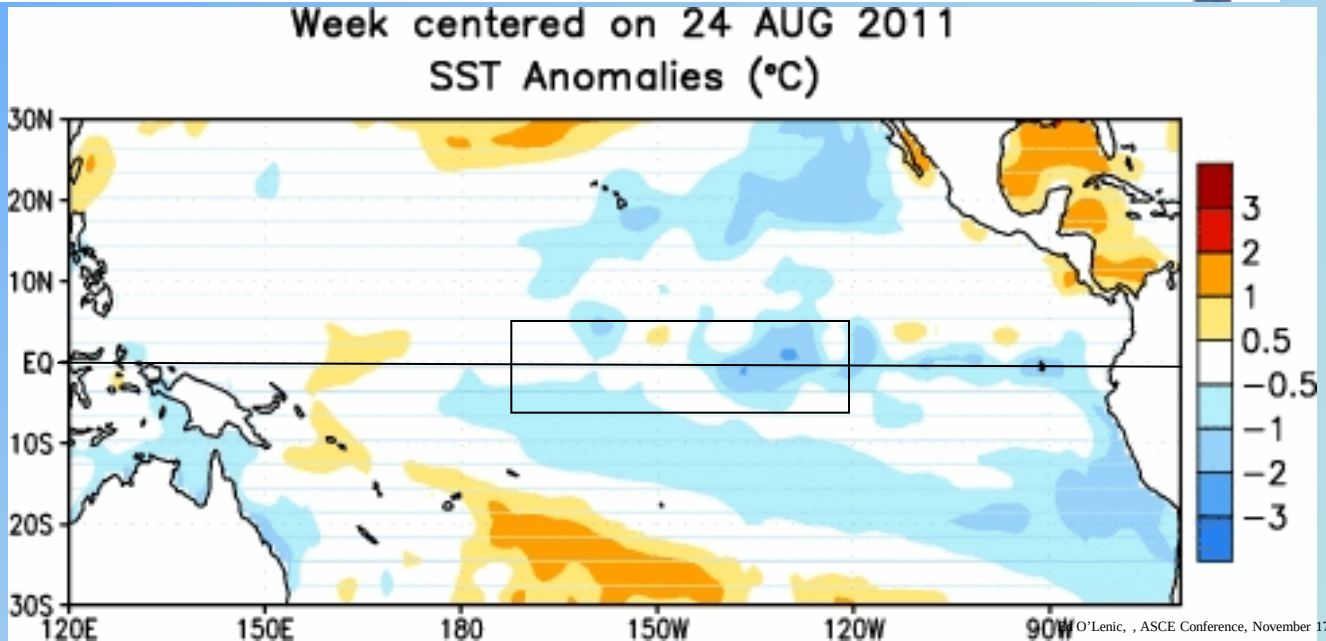
- Tropical ocean temperatures drive low-frequency variability
- El Nino and La Nina (ENSO) – Walker & Bliss (1932), Bjerknes (1969), Rasmussen and Carpenter (1982)
- Trend (Court (1967), Huang et al (1996))
- Linear Statistics (Barnston, 1994)
- Ocean-Land-Atmosphere (van den Dool (2006)
- Pacific Decadal Mode (PDO) (Hare, 1997)
- 30-60-Day Tropical Mode (MJO) (Madden, Julian, 1994)
- Dynamical model-derived signals (Saha et al, 2006)

The Walker Circulation:
Weaker=El Nino, Stronger=La Nina



SST Observations, Aug-Nov, 2011



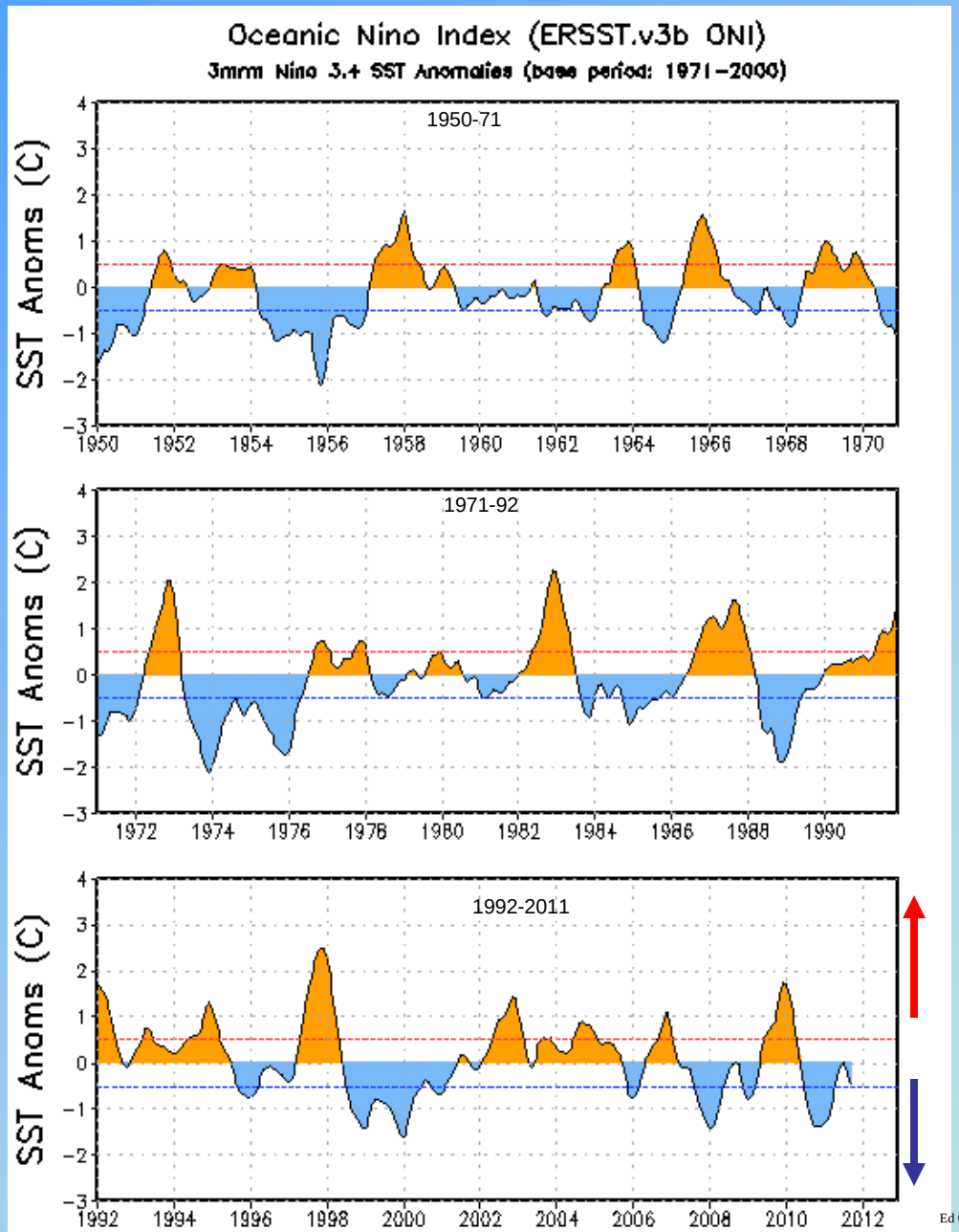


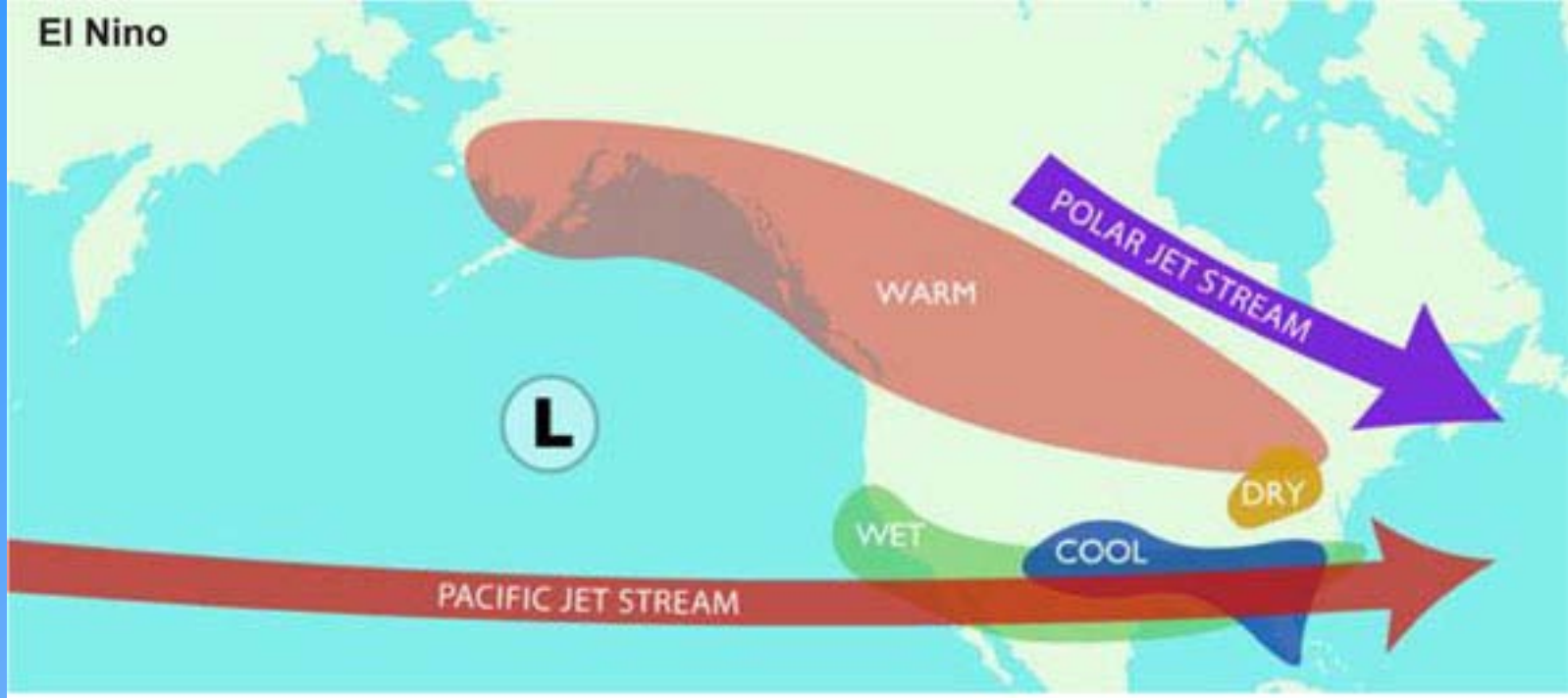
ONI (ºC): Evolution since 1950

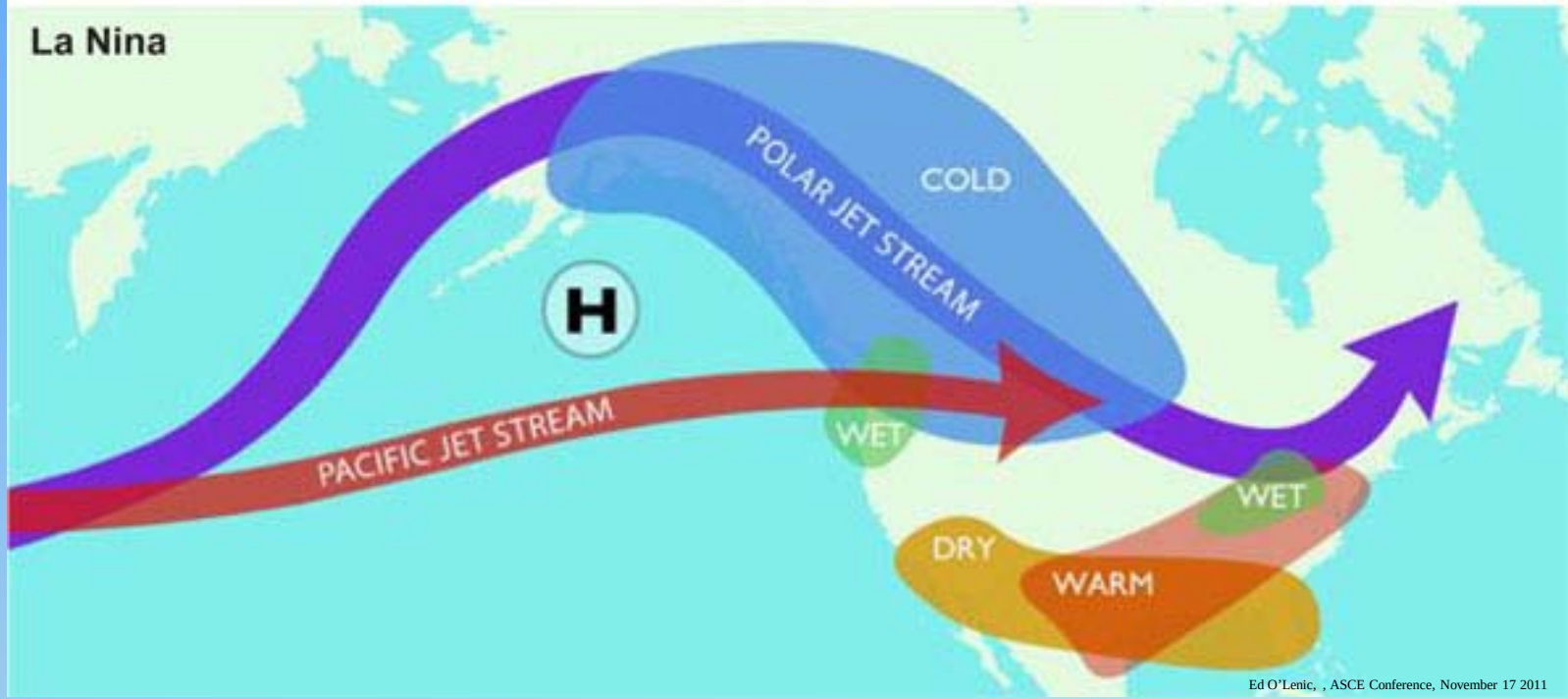
ONI:

AN INDEX OF ENSO STATUS

The Oceanic Nino Index (ONI) is the 3-month average Nino 3.4 value. The most recent ONI value (August – October 2011 average) is -0.4ºC.




El Nino
WARM
POLAR JET STREAM
L
DRY
WET
COOL
PACIFIC JET STREAM


La Nina
COLD
POLAR JET STREAM
H
PACIFIC JET STREAM
WET
WET
DRY
WARM

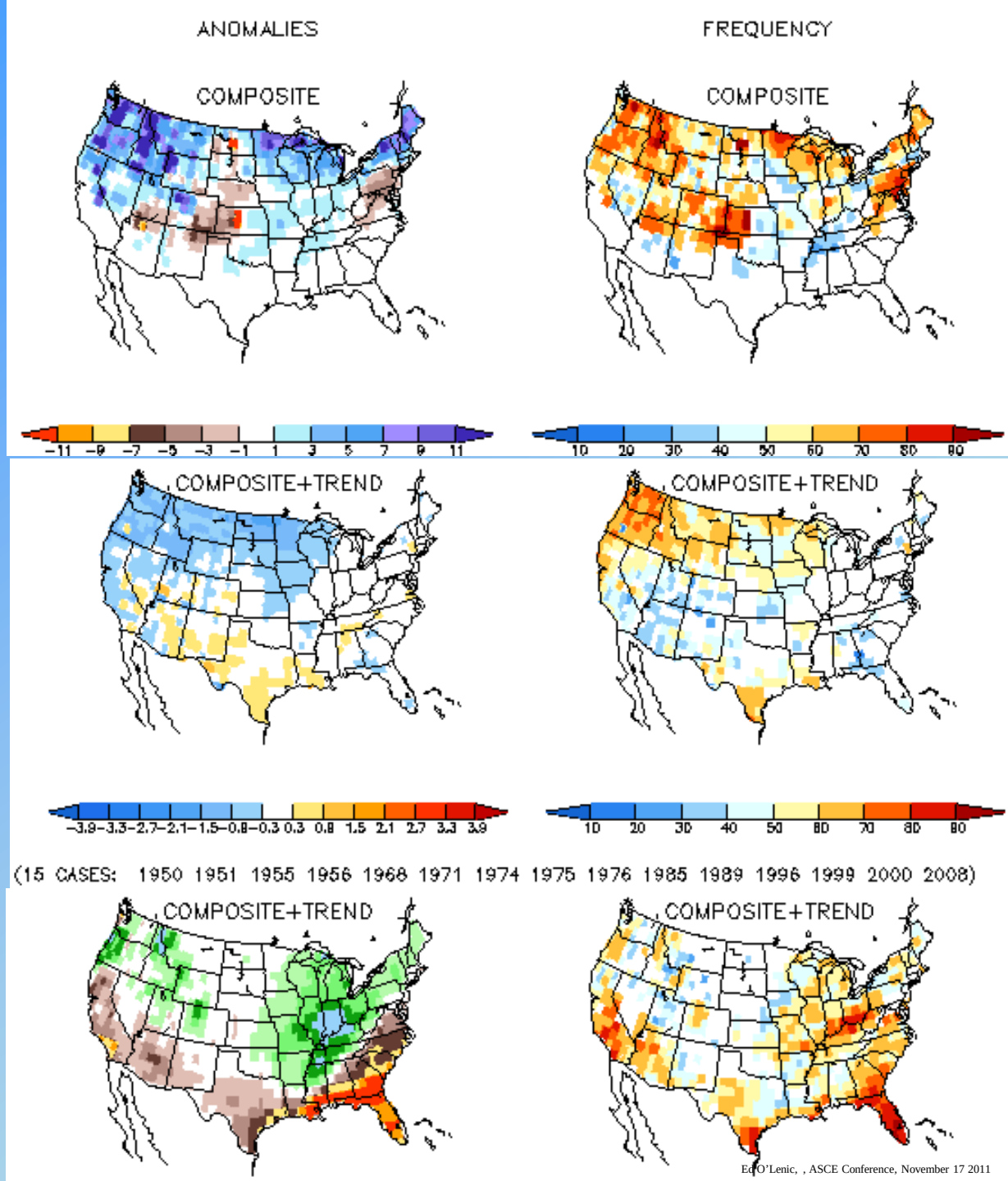
Near- and Long-Trends and Prediction

- Short-term trends over the last 10-15 years work very well, until they change.
- Long-term trends:
  - Precipitation time series is non-stationary
  - Temperature is rising rapidly
  - CO2 concentration is ~400 ppm, ~ 150 ppm higher than the prior 650K years.
  - The absolute moisture content of the atmosphere is rising.
  - We are currently in a relatively wet period, relative to 1250-1800 or so.

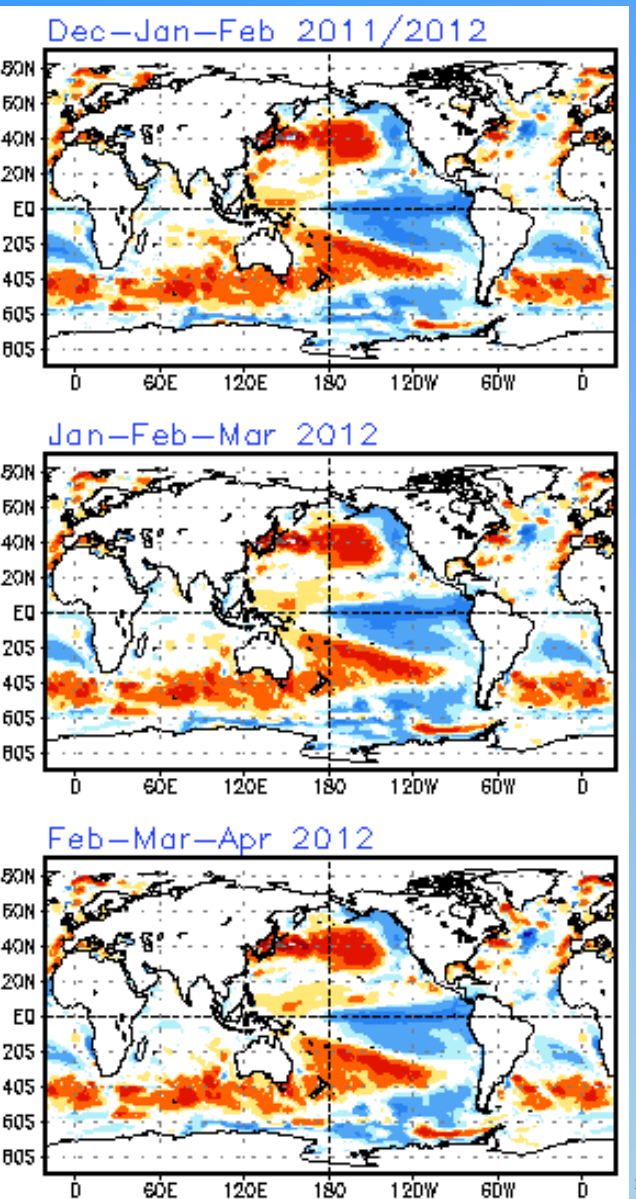
Feb-Mar-Apr
La Nina
Snow
Composites

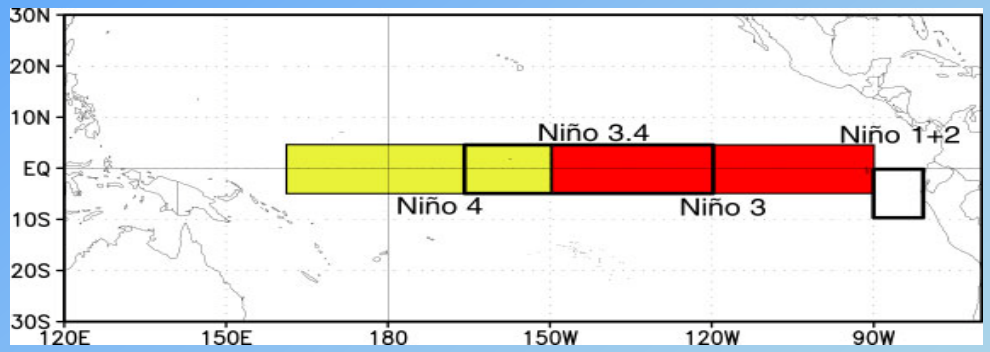
Feb-Mar-Apr
La Nina
Temperature
Composites

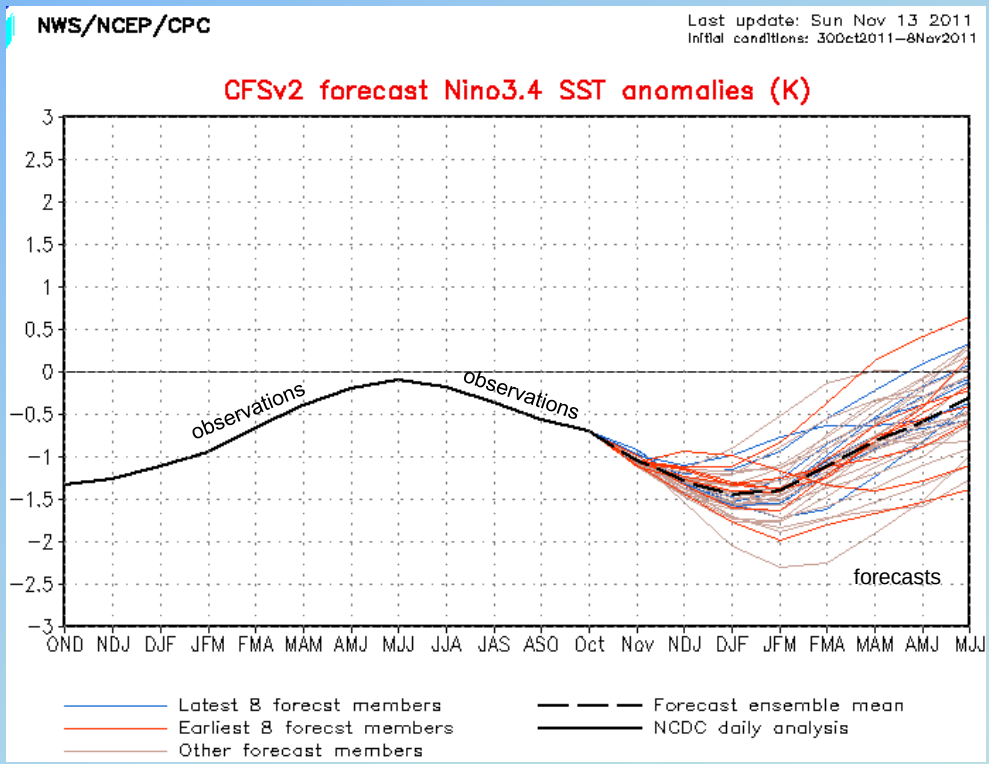
Feb-Mar-Apr
La Nina
Precipitation
Composites



Dynamical Model Forecast: NCEP CFS Nino 3.4 Sea Surface Temperature Forecast 13 Nov 2011







The CFS ensemble mean=dashed line

Dealing with Uncertainty at CPC: Skill Masking

Canonical Correlation Analysis (regression) temperature forecast at stations, in units of 1/10 standard deviation. Font size indicates 4 Categories of skill:

"+" ~ 0.3>AC

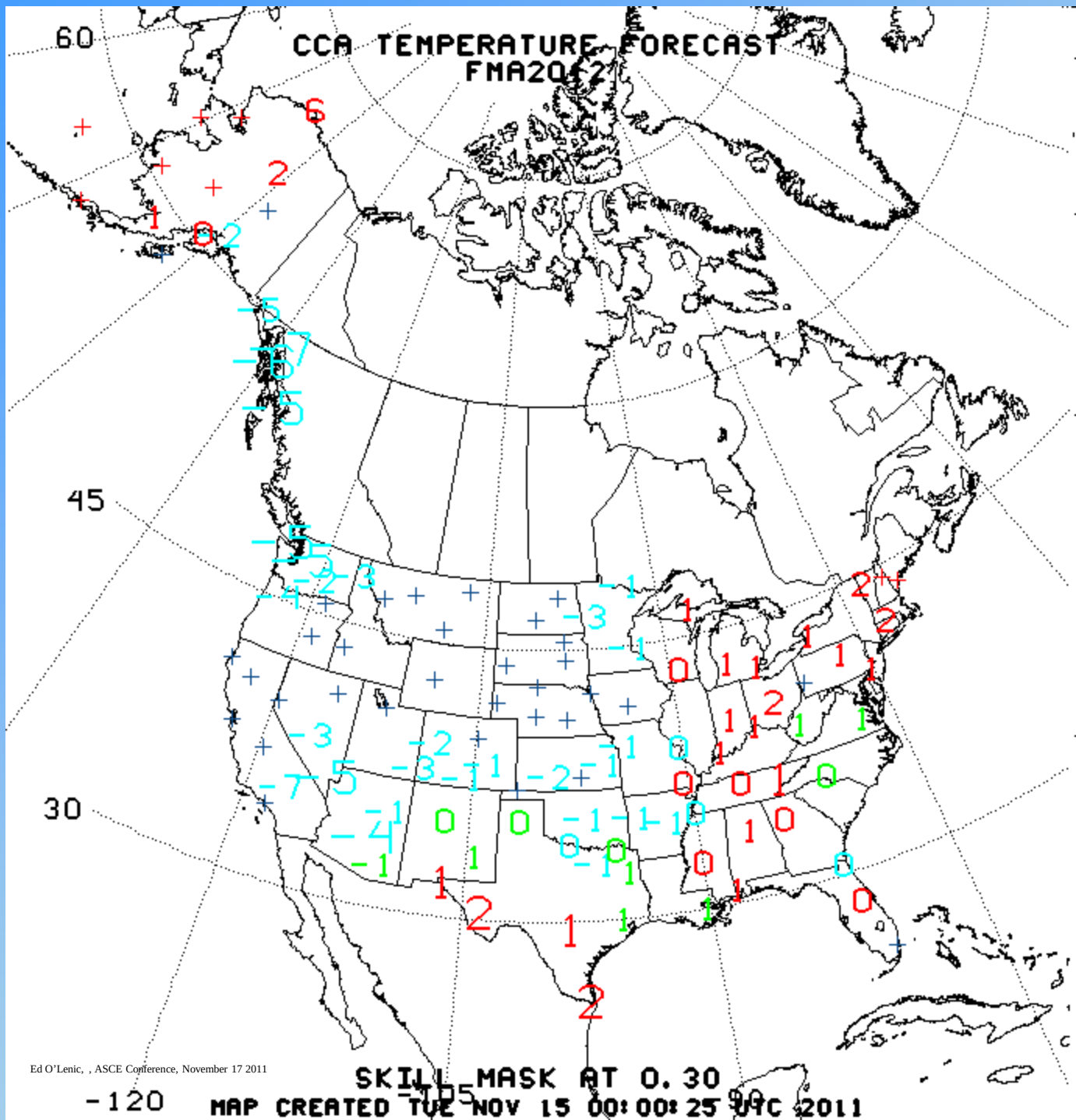
"8" ~ 0.3≤AC≤0.44

"8" ~ 0.45<AC≤0.59

"8" ~0.6≤ AC

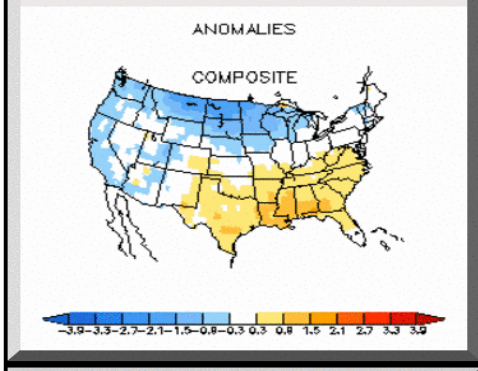
AC = Anomaly Correlation

Source: NOAA-NWS-Climate Prediction Center

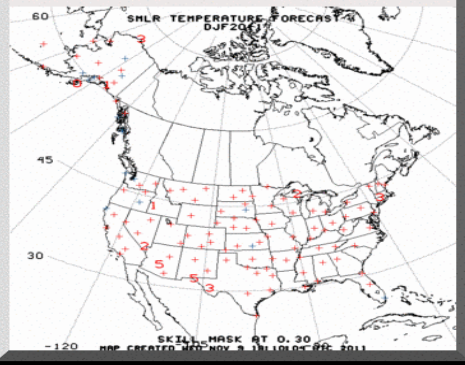


DJF Season [Temperature]

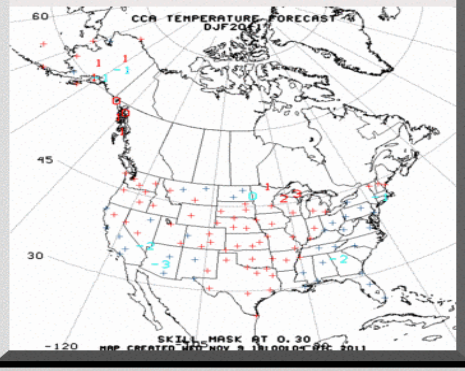
LA NINA COMPOSITES



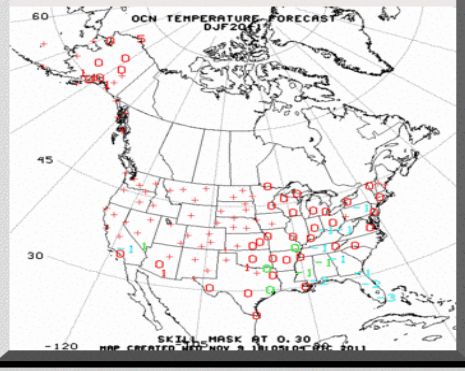
SMLR



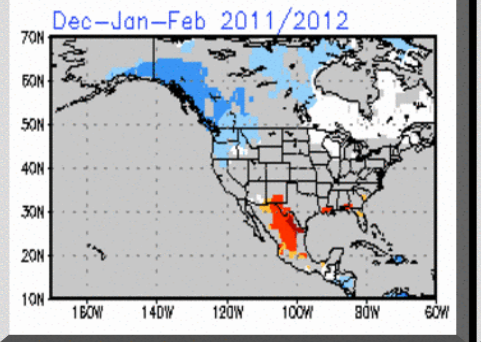
CCA



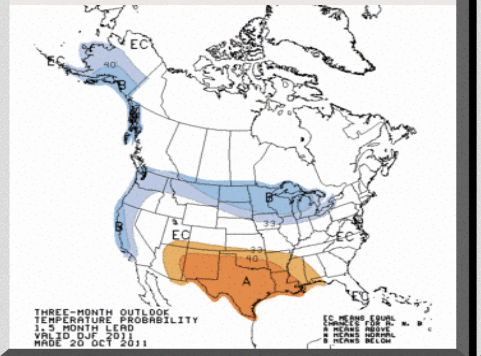
OCN



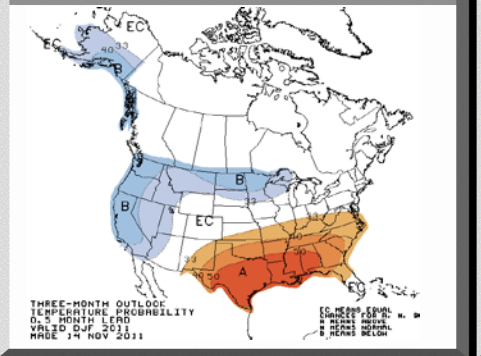
CFS(V2) STD/MSKD



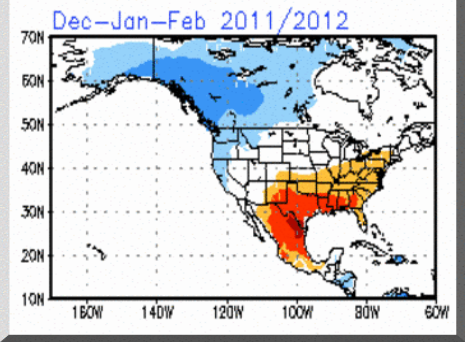
OLD OUTLOOK



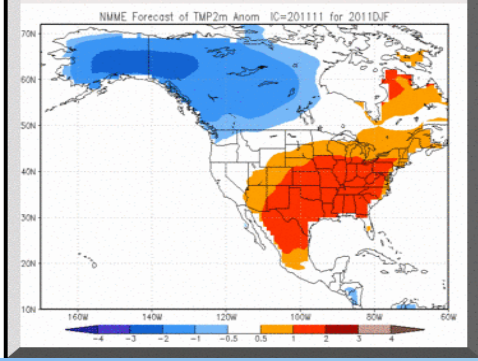
** NEW OUTLOOK **



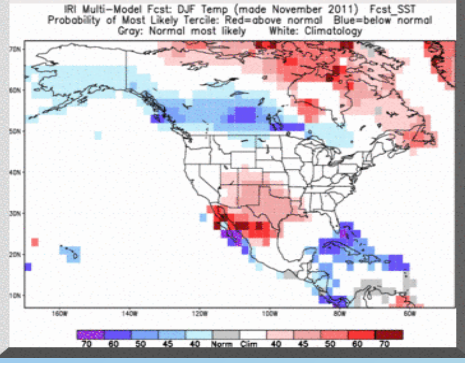
CFS(V2) STD/UNMSKD



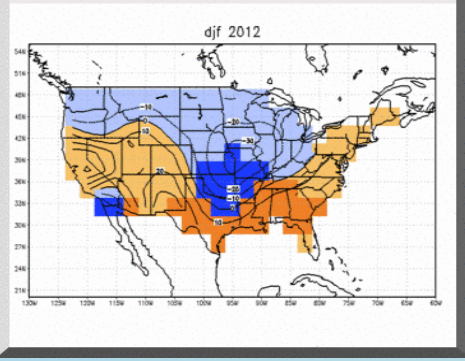
NMME



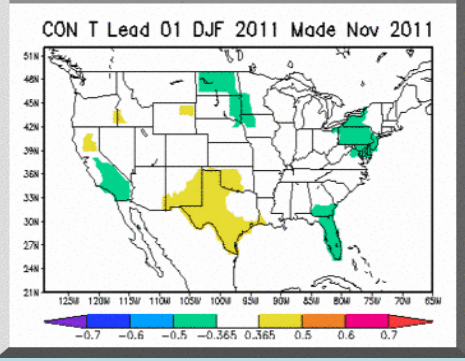
IRI



ENSEMBLE CCA (ECCA)



CONSOLIDATION

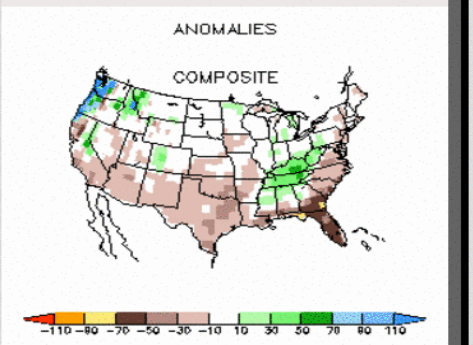


La Nina Composites:

(20 CASES: 1950 1951 1955 1956 1957 1963 1965 1968 1971 1972 1974 1975 1976 1985 1989 1996 1999 2000 2001 2008)

DJF Season [Precipitation]

LA NINA COMPOSITES



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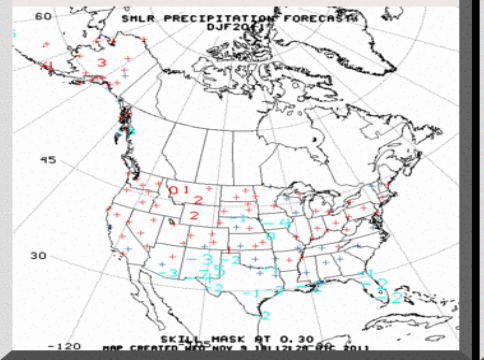

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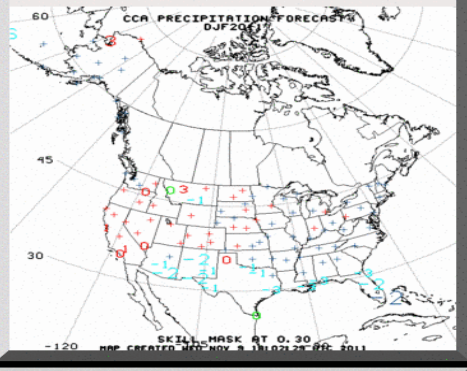

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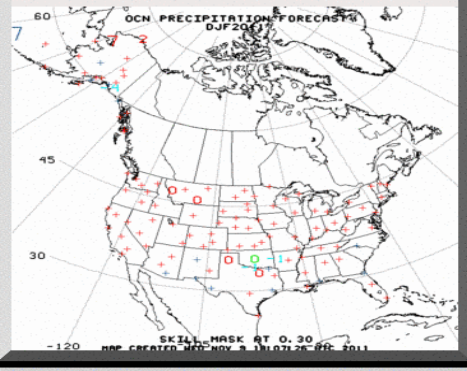

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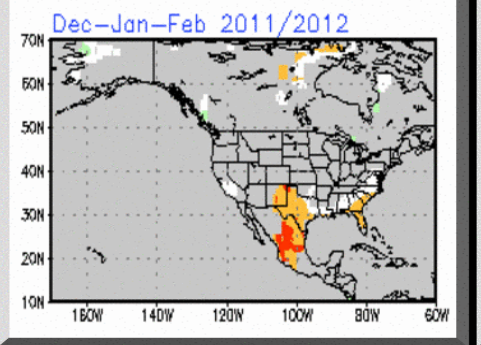

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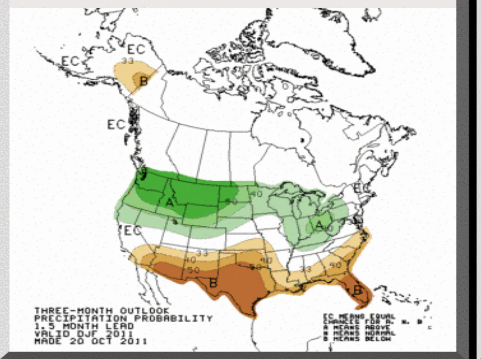

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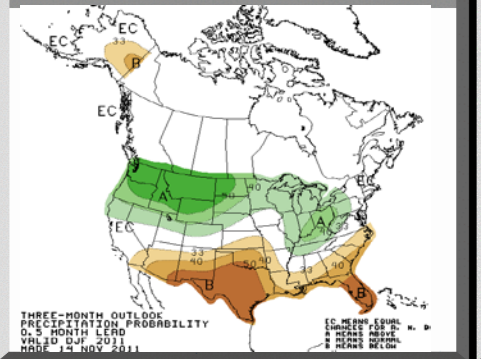

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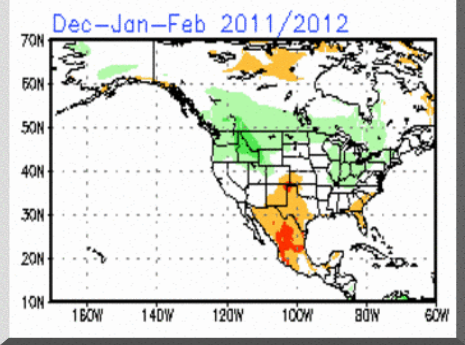

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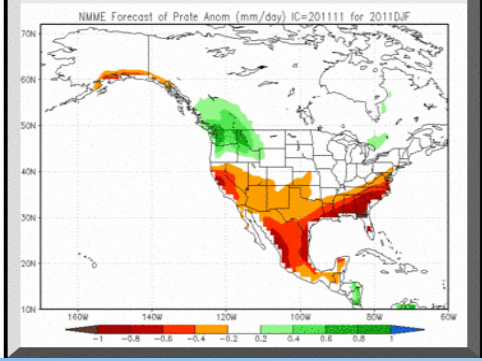

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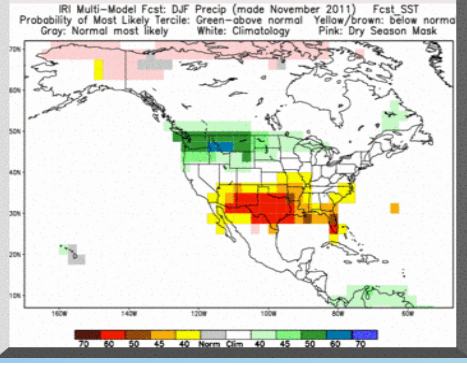

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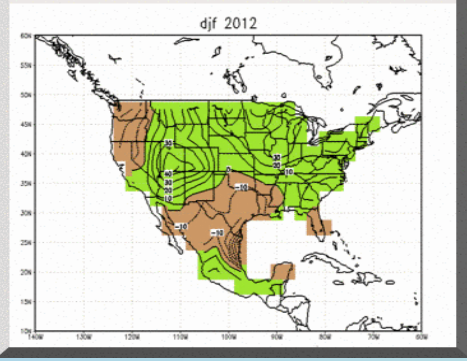
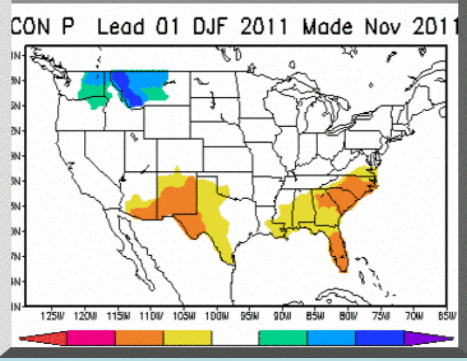


CONSOLIDATION



La Nina Composites:

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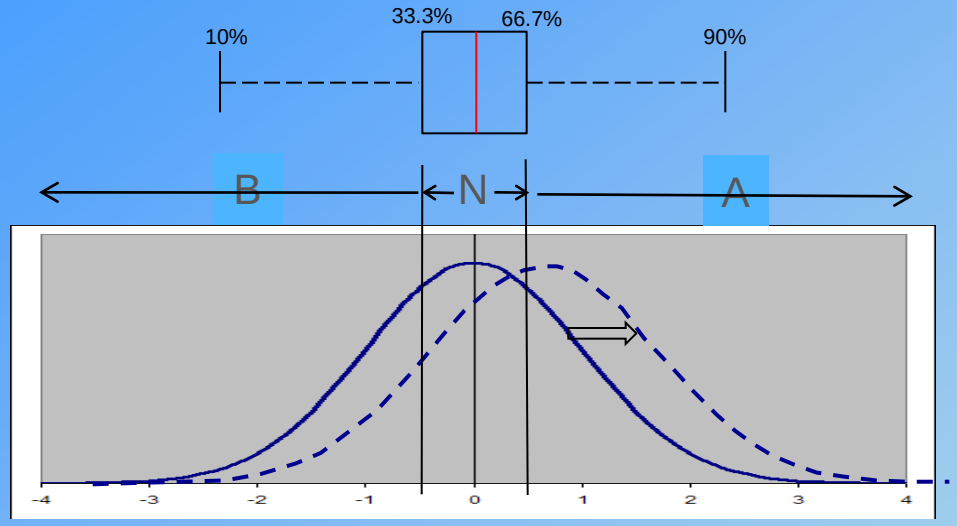
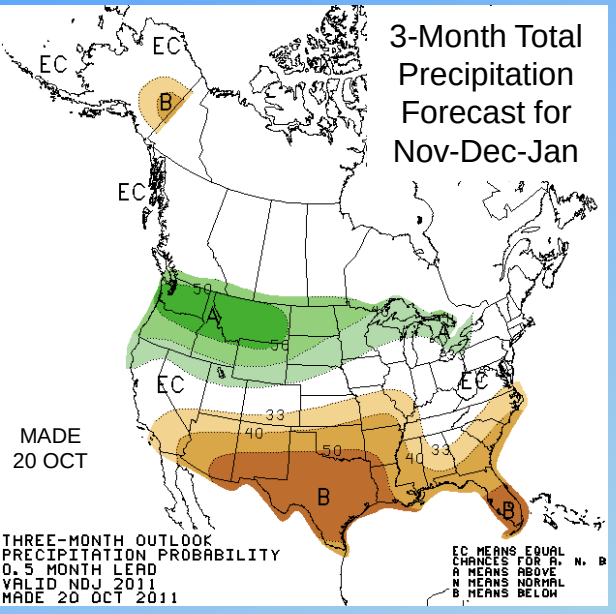
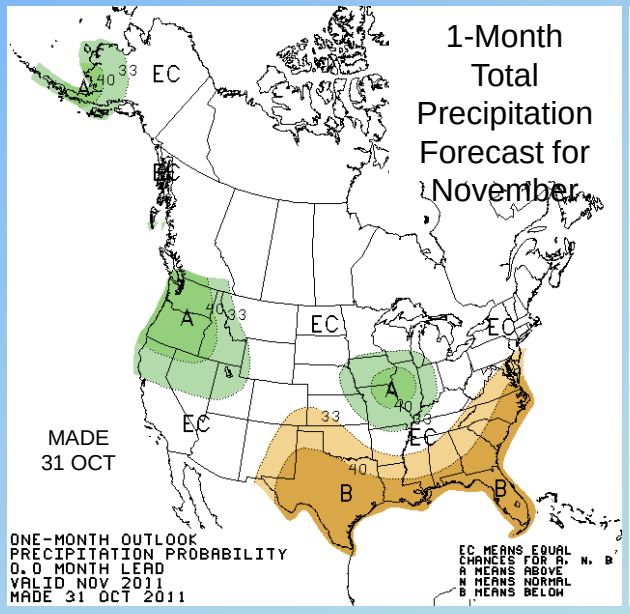
CPC Probabilistic Forecasts



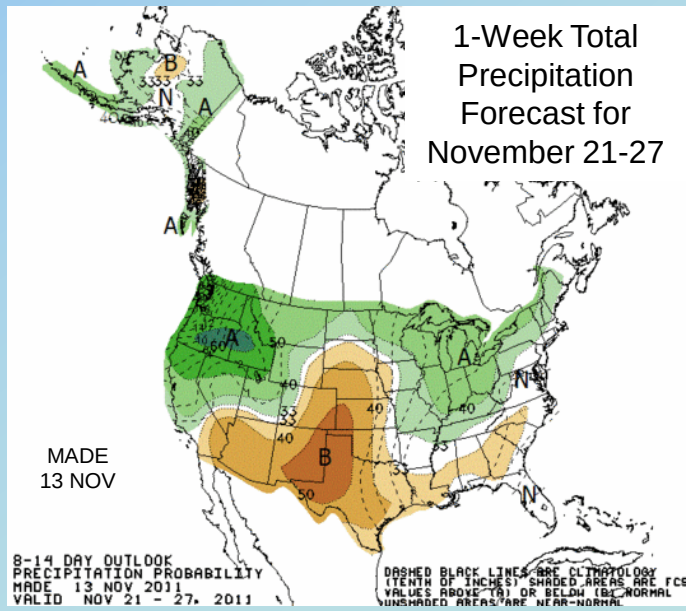
3-MonthForecast, Made 1x / Month

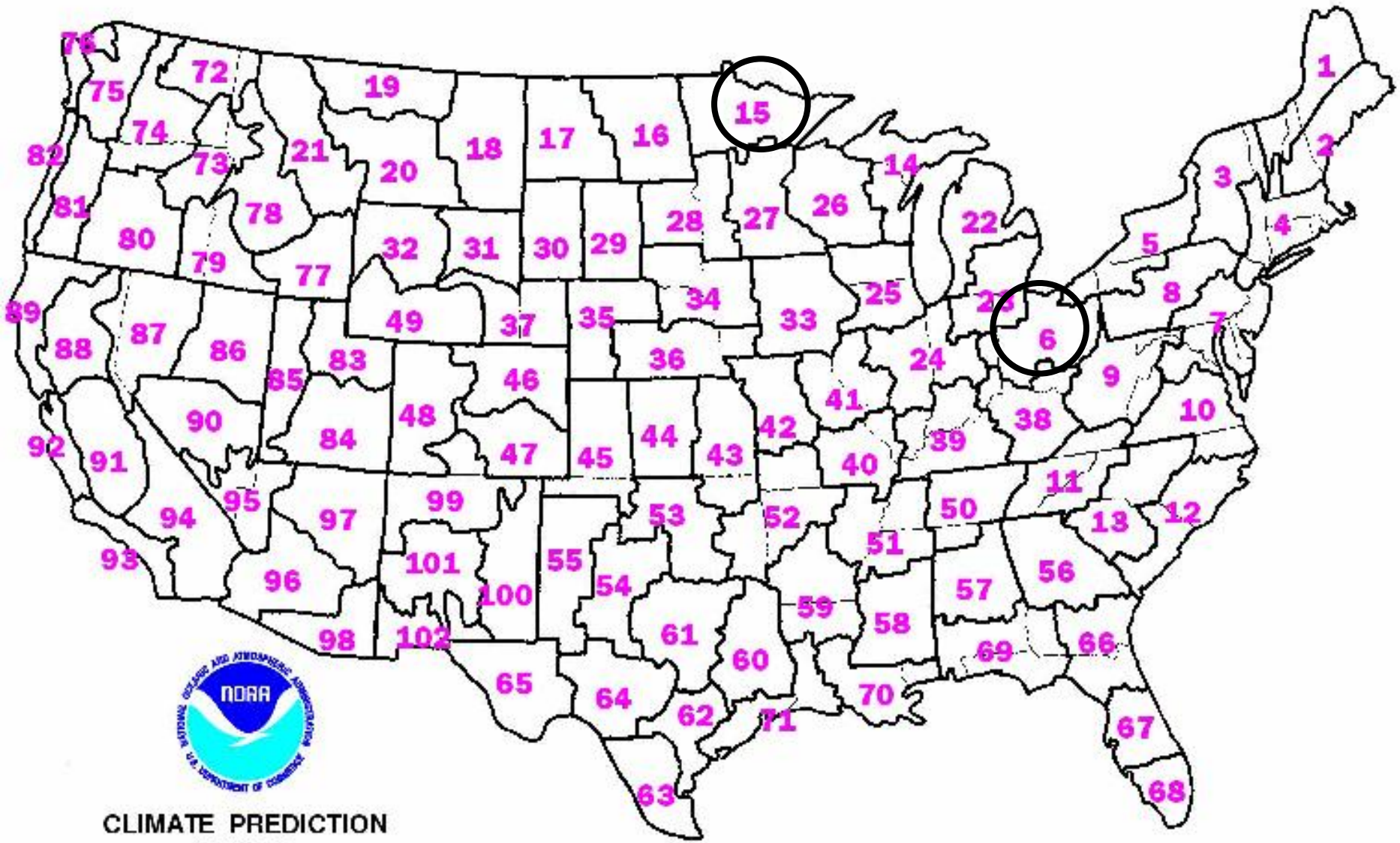


1-Month Forecast, Made 2x / Month



8-14-Day Forecast, Made Daily

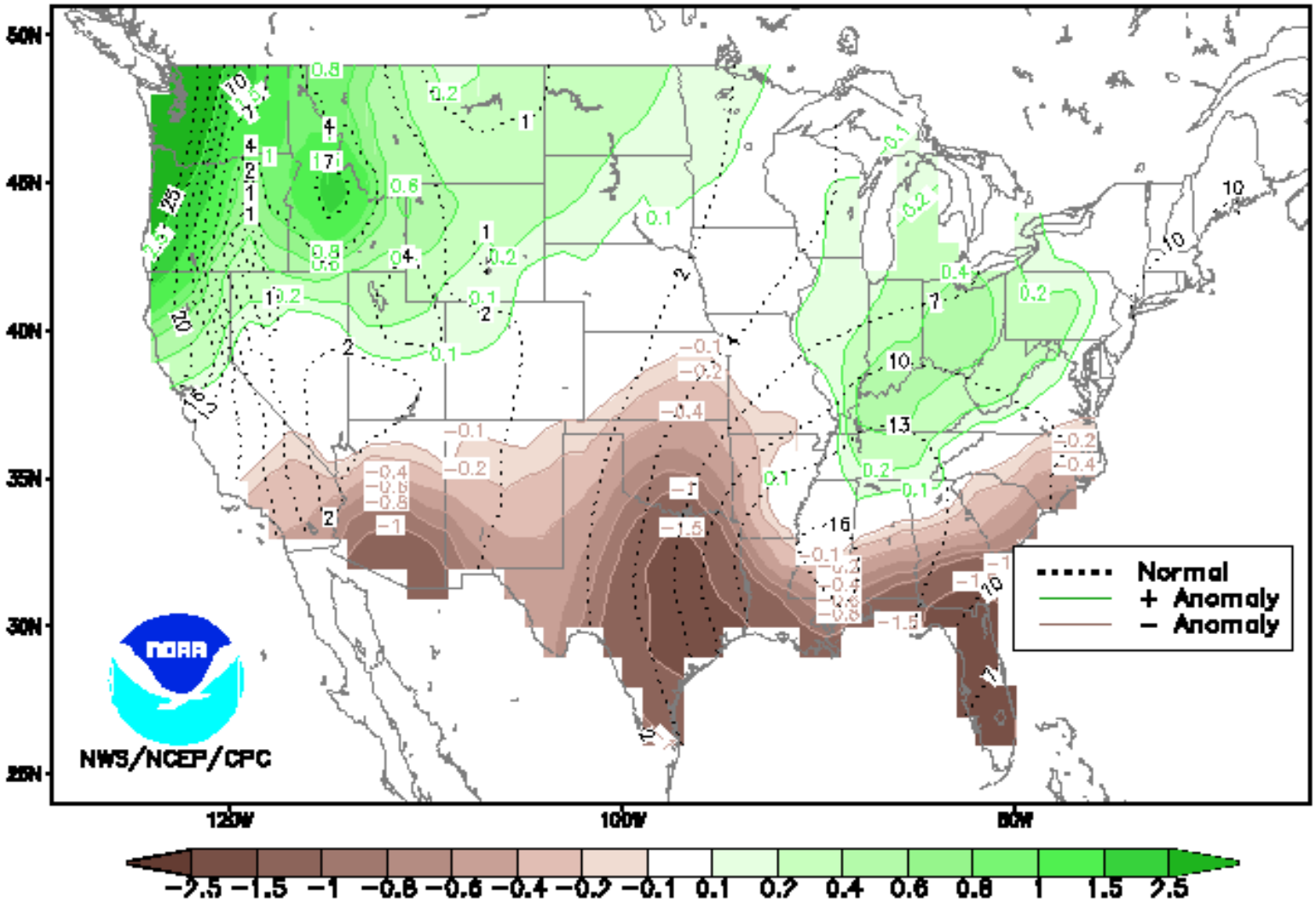




CLIMATE PREDICTION CENTER

Anomaly (Inches) of the Mid-value of the 3-Month Precipitation Outlook Distribution for DJF 2011-12

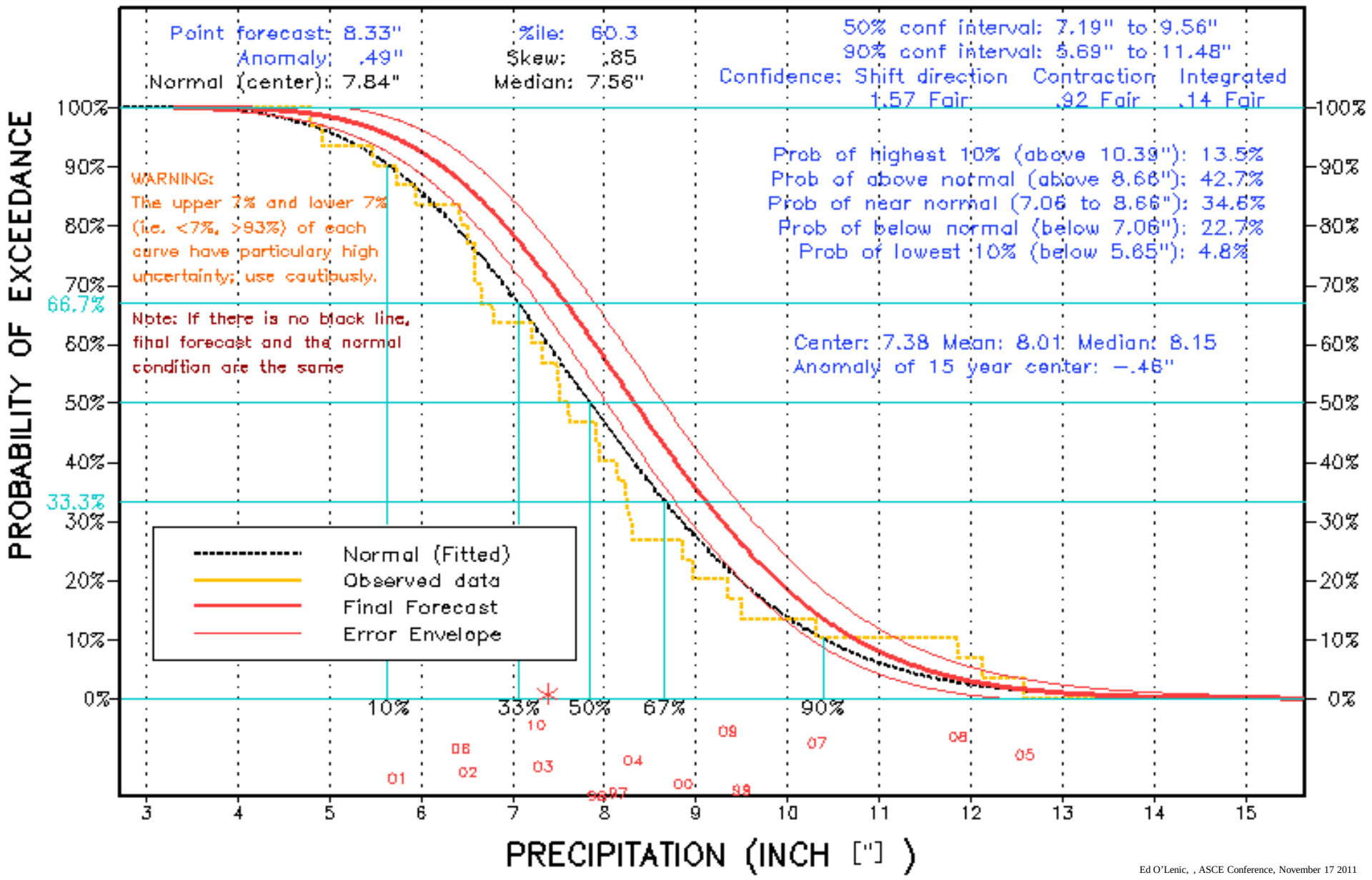
Dashed lines are the median 3-month precipitation (inches) based on observations from 1981-2010. Shaded areas indicate whether the anomaly of the mid-value is positive (green) or negative (brown) compared to the 1981-2010 average. Non-shaded regions indicate that the absolute value of the anomaly of the mid-value is less than 0.1. For a given location, the mid-value of the outlook may be found by adding the anomaly value to the 1981-2010 average. There is an equal 50-50 chance that actual conditions will be above or below the mid-value. Please note that this product is a limited representation of the official forecast, showing the anomaly of the mid-value, but not the width of the range of possibilities. For more comprehensive forecast information, please see our additional forecast products.

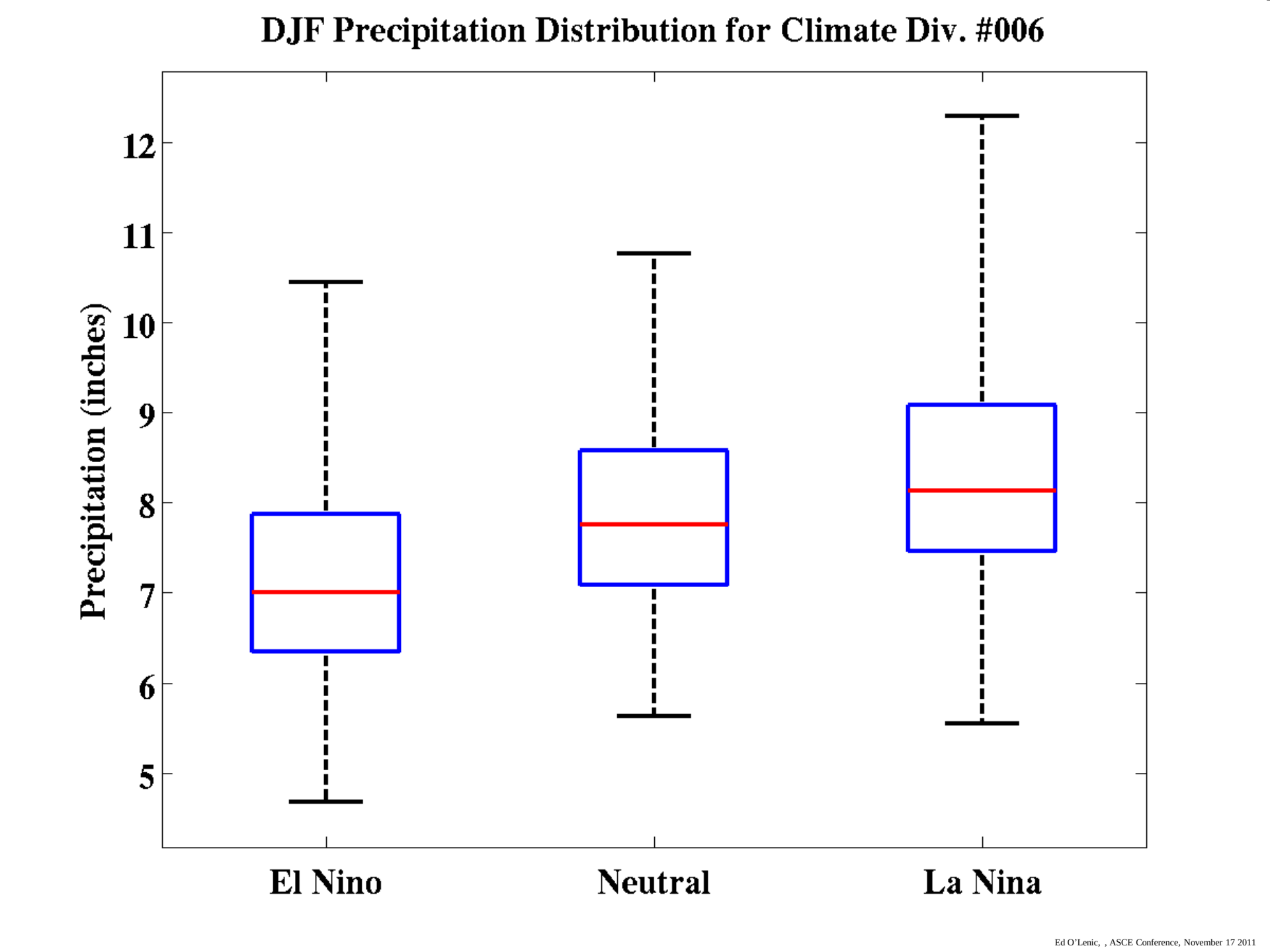


PRECIPITATION OUTLOOK FOR DJF 2011–12

1.5 MONTH LEAD OUTLOOK – MADE October 20 2011

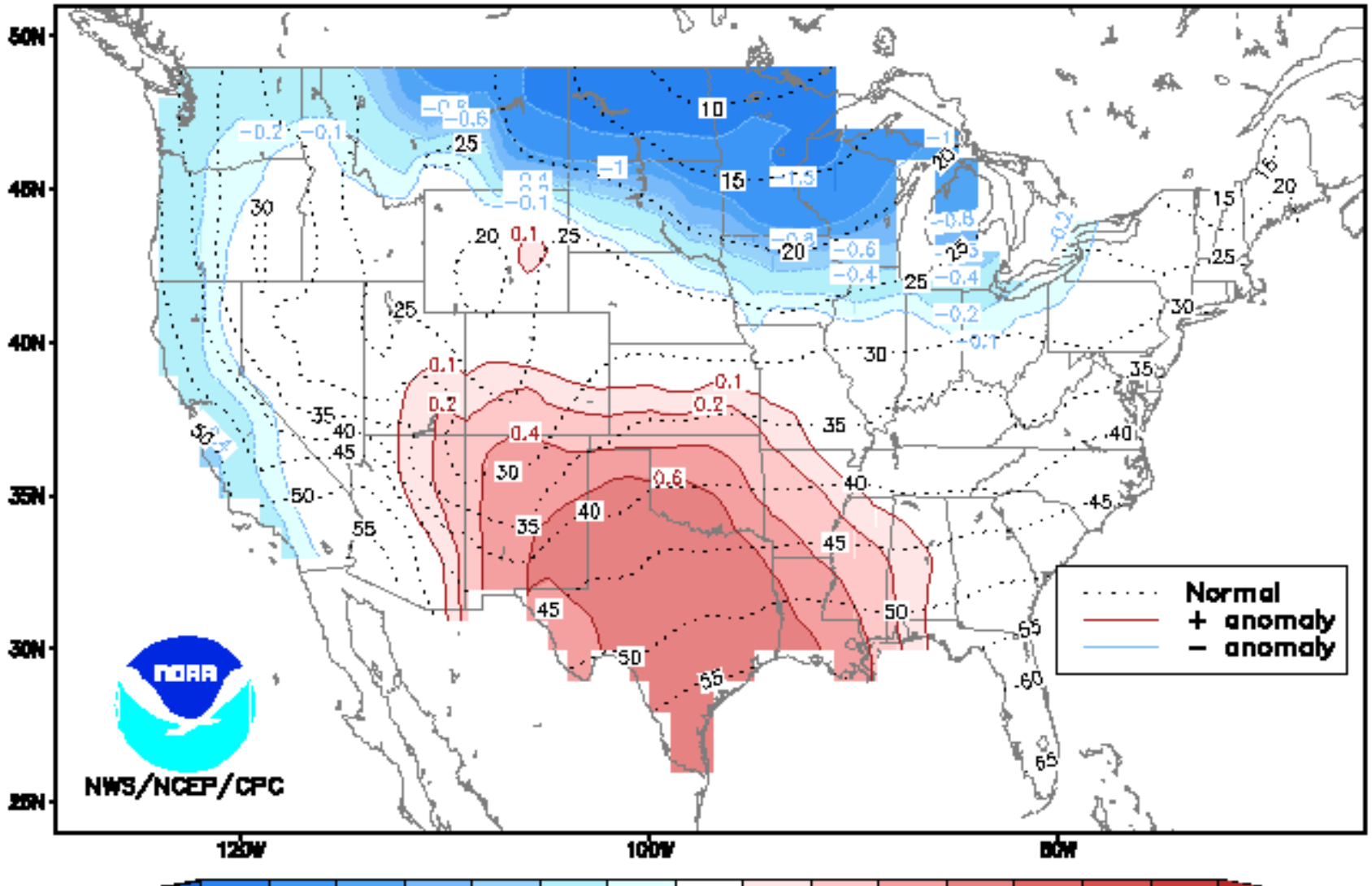
Climate Division 6 (Ohio)




DJF Precipitation Distribution for Climate Div. #006
Precipitation (inches)
12
11
10
9
8
7
6
5
El Nino
Neutral
La Nina

Anomaly (deg F) of the Mid-value of the 3-Month Temperature Outlook Distribution for DJF 2011-12

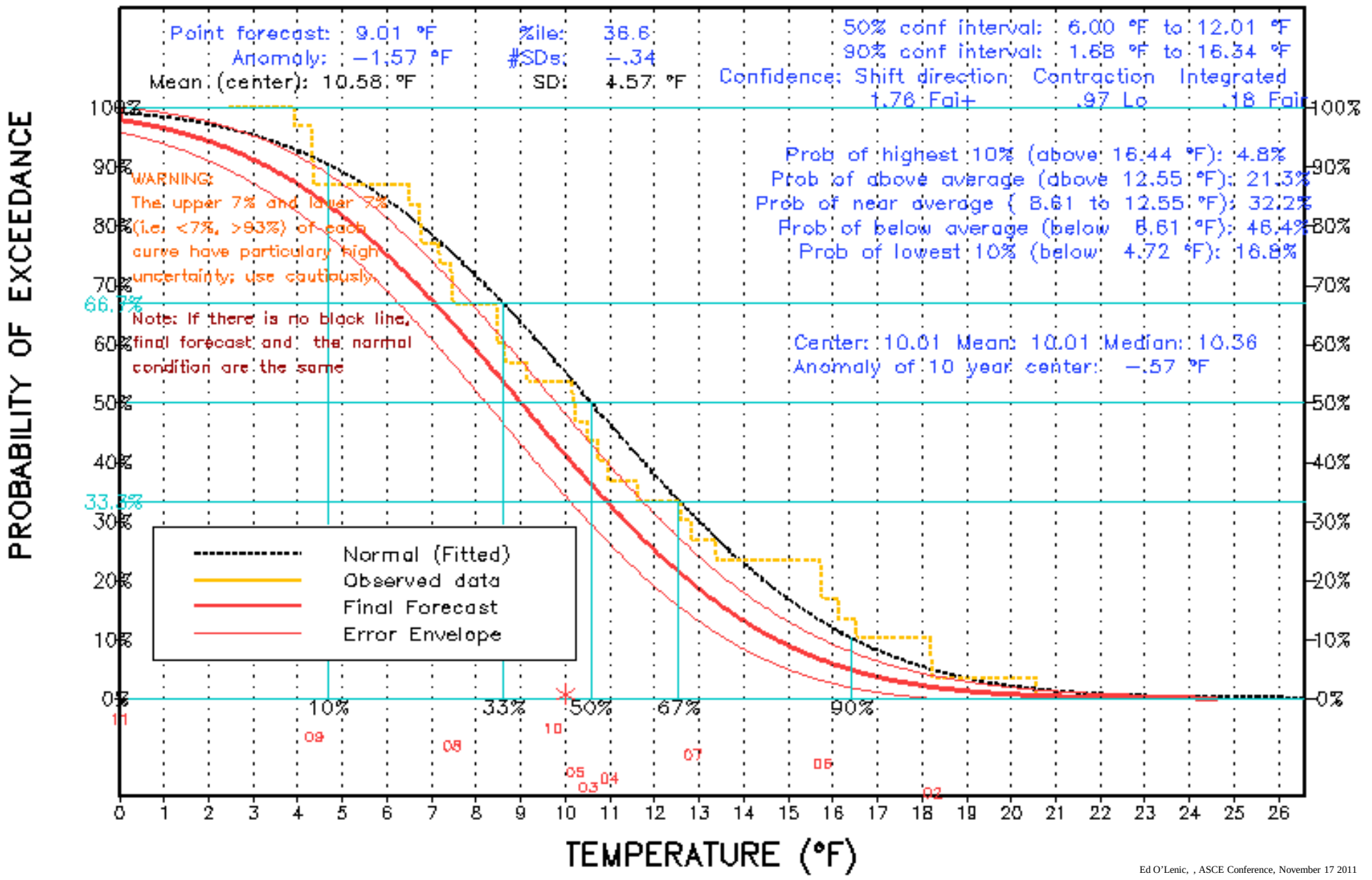
Dashed lines are the median 3-month temperature (degrees F) based on observations from 1981-2010. Shaded areas indicate whether the anomaly of the mid-value is positive (red) or negative (blue) compared to the 1981-2010 average. Non-shaded regions indicate that the absolute value of the anomaly of the mid-value is less than 0.1. For a given location, the mid-value of the outlook may be found by adding the anomaly value to the 1981-2010 average. There is an equal 50-50 chance that actual conditions will be above or below the mid-value. Please note that this product is a limited representation of the official forecast, showing the anomaly of the mid-value, but not the width of the range of possibilities. For more comprehensive forecast information, please see our additional forecast products.

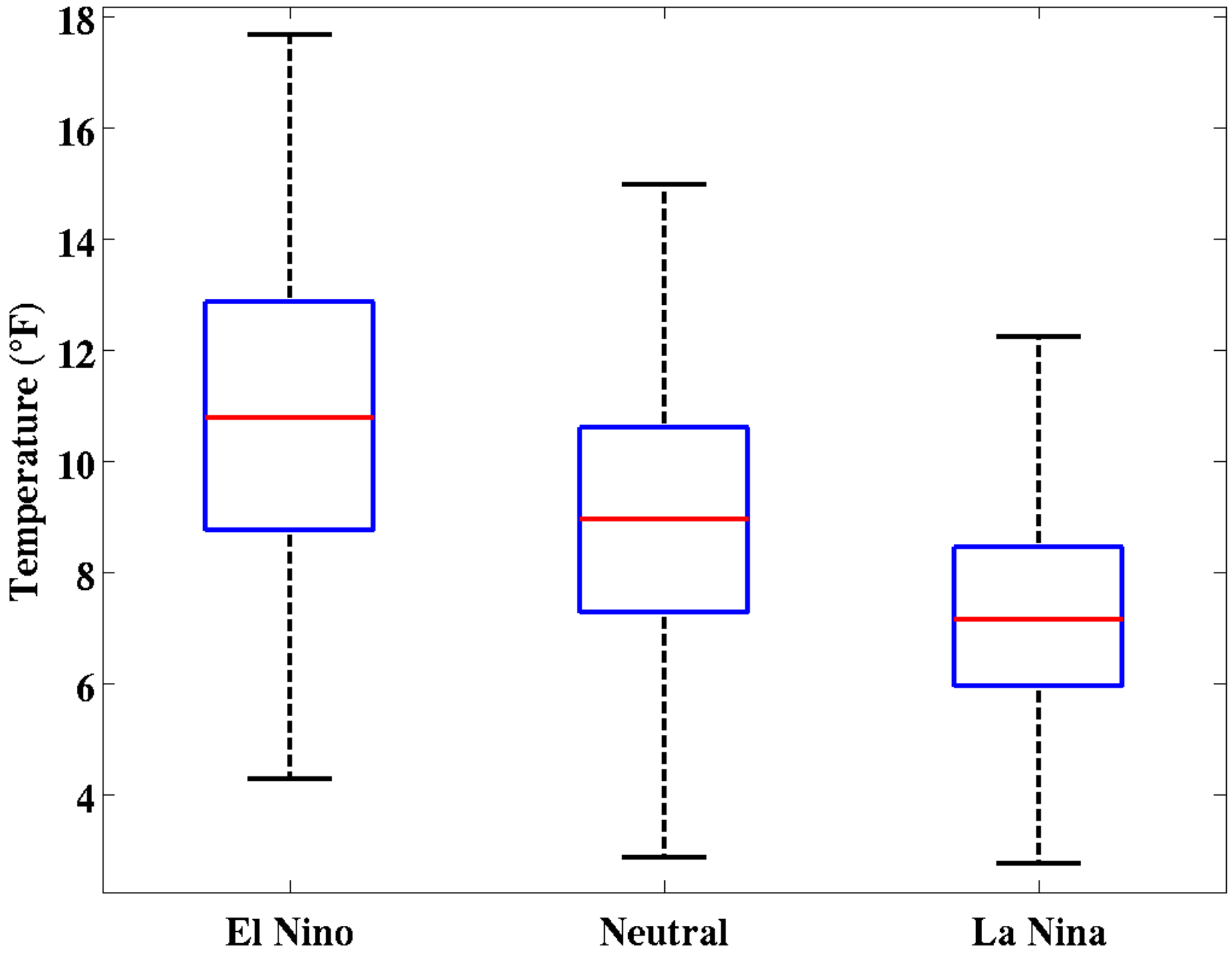


MEAN TEMPERATURE OUTLOOK FOR DJF 2011–12

1.5 MONTH LEAD OUTLOOK – MADE October 20 2011

Climate Division 15 (Northern Minnesota)




DJF Temperature Distribution for Climate Div. #015
Temperature (°F)
18
16
14
12
10
8
6
4
El Nino
Neutral
La Nina

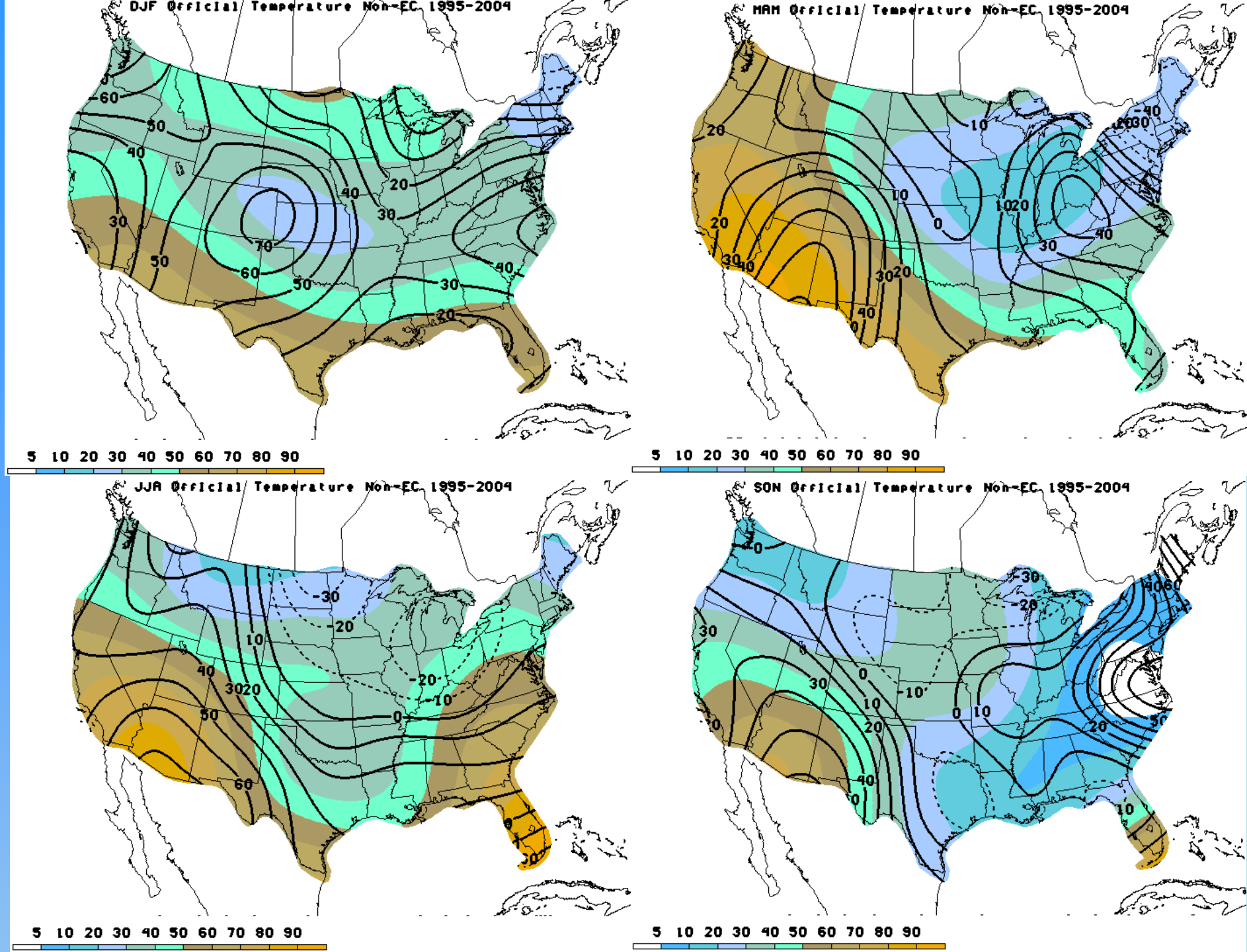
SKILL: A RELATIVE MEASURE OF PERFORMANCE

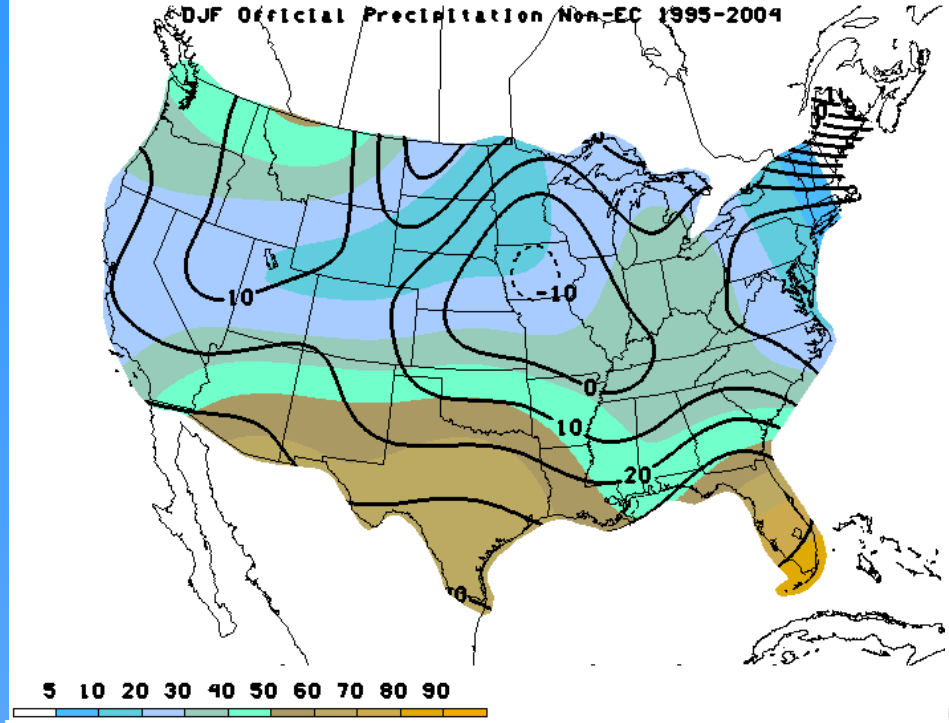
$$\text{Skill} = \frac{\#\text{ Forecasts Correct} - \#\text{ Correct by chance}}{\#\text{ Forecasts, Total} - \#\text{ Correct by chance}}$$

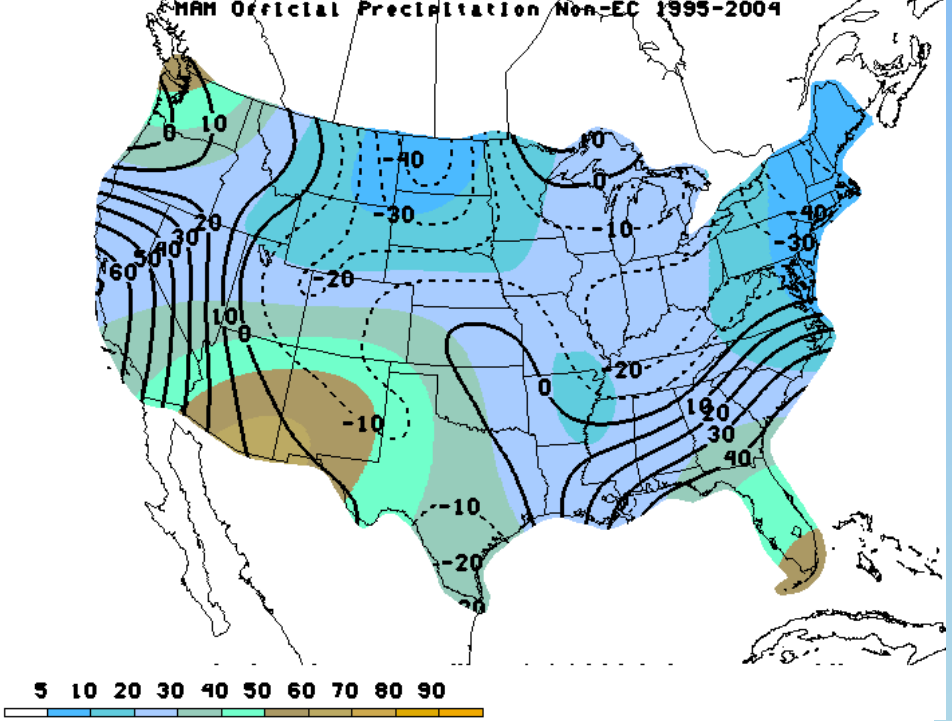
Skill = Fractional Improvement by forecast over random

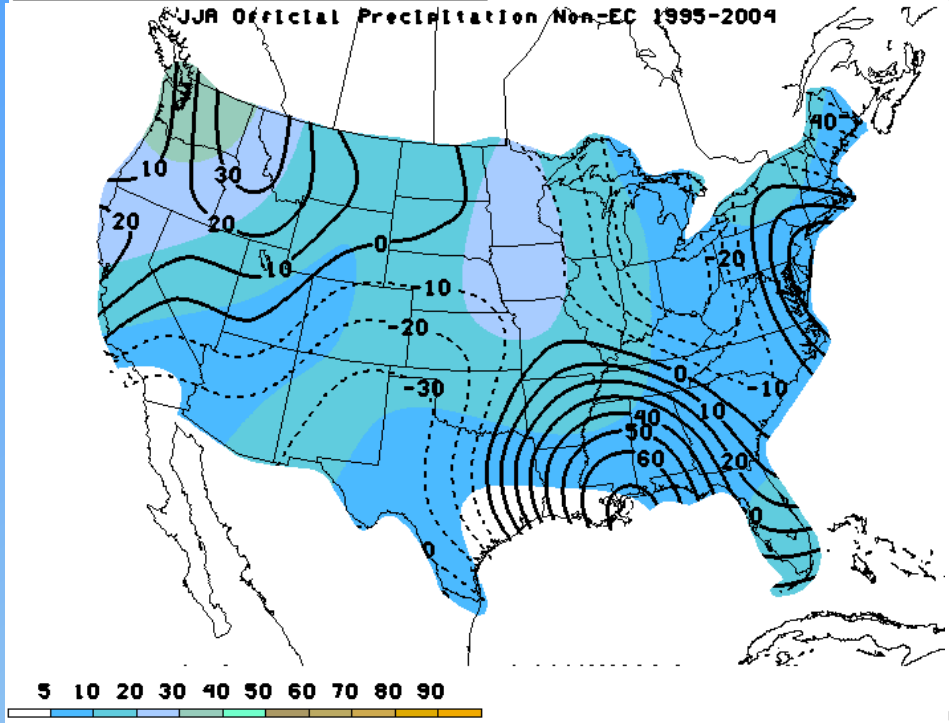
$-1 \le Skill \le 1$ for a 2-class (Above, Below only) system.

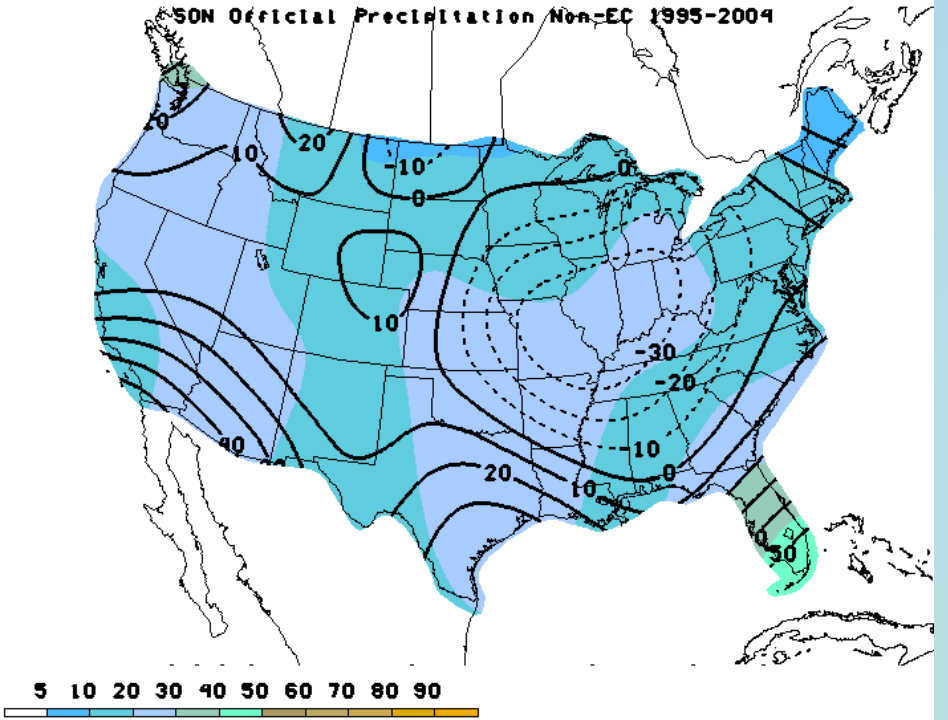
$-.5 \le Skill \le 1$ 3-class (Above, Normal, Below) system.


DJF Official Temperature Non-EC 1995-2004
MAM Official Temperature Non-EC 1995-2004
JJA Official Temperature Non-EC 1995-2004
SON Official Temperature Non-EC 1995-2004
5 10 20 30 40 50 60 70 80 90


DJF Official Precipitation Non-EC 1995-2004
5 10 20 30 40 50 60 70 80 90


MAM Official Precipitation Non-EC 1995-2004
5 10 20 30 40 50 60 70 80 90


JJA Official Precipitation Non-EC 1995-2004
5 10 20 30 40 50 60 70 80 90


SON Official Precipitation Non-EC 1995-2004
5 10 20 30 40 50 60 70 80 90

SUMMARY

- Tropical ocean temperatures drive low-frequency variability
- El Nino, La Nina, PDO, MJO are nominally predictable
- Statistical and dynamical models are used.
- Uncertainty in observations, models, and the chaotic nature of the atmosphere lead to probabilistic forecasts…
- Which have some accuracy, relative to random.
- Most applications focus on energy trading, and extreme event impacts.