

# Utility of Seasonal Forecast Systems in Attribution

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# Outline

- Various levels of attribution
- Seasonal prediction datasets
- Examples of attribution using seasonal predictions data sets
- Summary



# Why are we interested in attribution?

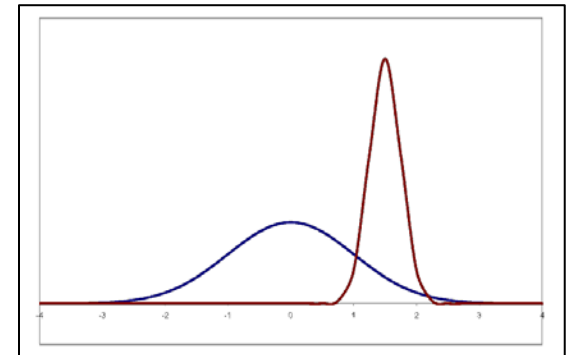
- CPC has operational real-time monitoring and forecasting responsibility
- Relevance of attribution
  - Explaining extremes or unusual seasonal climate anomalies
  - Understanding forecast successes and failures
  - Building up the knowledge base of various connections that could be used to improve forecasts
- Challenges
  - Translate what is being discussed into forecast practices
  - Uniqueness of forecast information in the background of historical skill
- Forecasts are made relative to a climatology

# Attributable Factors...

- Atmospheric initial conditions
- Anomalous boundary forcing: SST; Soil moisture; sea-ice;...
- Changes in atmospheric composition
- In the context of forecasting, the influence of these factors on monthly and seasonal extreme events is lead-time dependent. And so is the relative magnitude of the influence

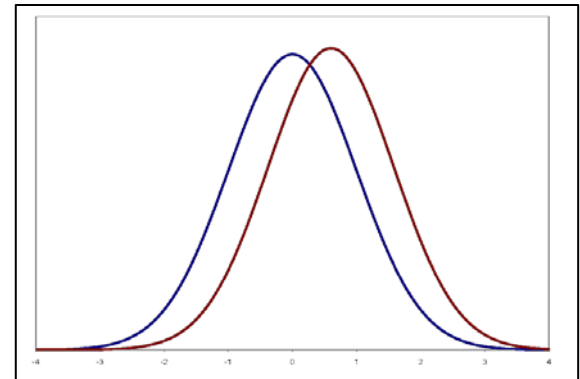
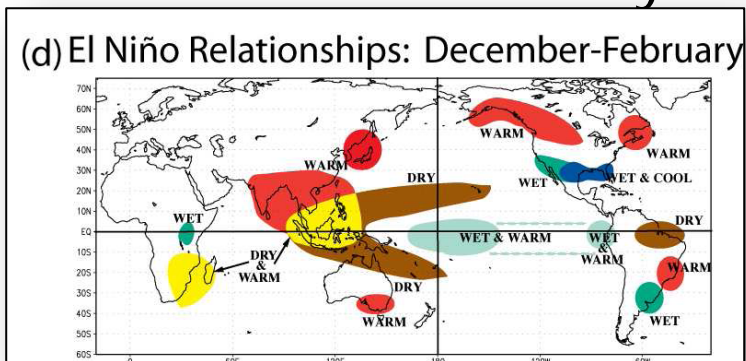
# Role of Initial Conditions

- Atmospheric ICs sub-sample a very narrow region of climatological PDF
- ICs have a large influence on very short forecast lead time
- Influence of boundary conditions or of atmospheric composition could modulate “consequences” of weather patterns
  - More extreme precipitation
  - More extreme heat waves



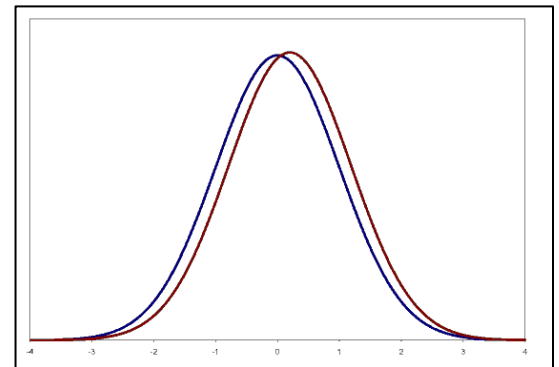
# Role of Boundary Conditions

- Well documented climate influence of slowly varying anomalous boundary conditions: sea surface temperature; soil moisture; sea ice
- In extratropics, moderate influence on “time-averaged quantities” with lead time of seasons; the influence is geographical and season dependent
- Influence of atmospheric composition could modulate the influence of boundary conditions

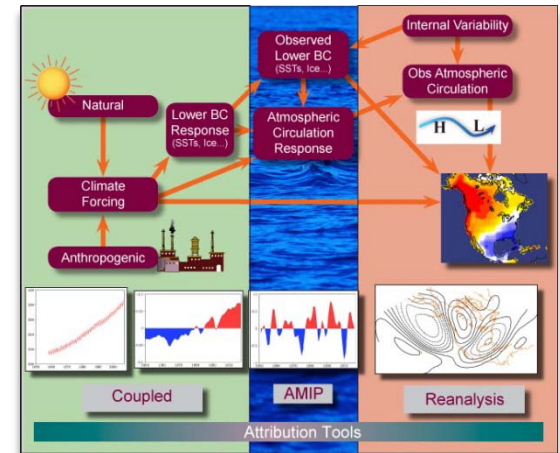
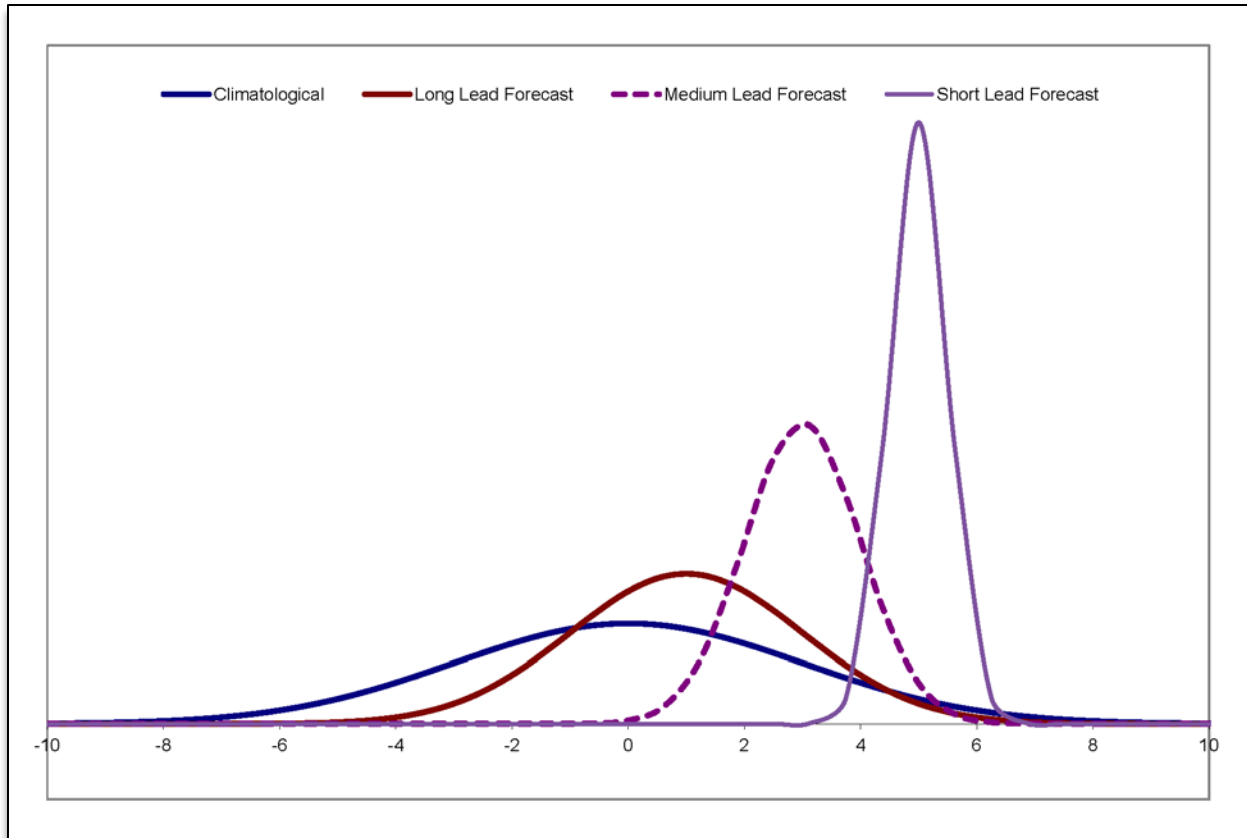


# Role of External Forcings

- Smaller shifts in the climatological PDF due to changes in atmospheric compositions: CO<sub>2</sub>; Volcanic aerosols; ...
- Influence could be
  - Direct (radiative heating/cooling)
  - Indirect (via changes in the boundary conditions, e.g., SST)



# Inevitability of the evolution of the PDF in initialized predictions



- The spread with lead time increases
- PDF shifts towards the climatological PDF



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- **Seasonal prediction datasets**
- Examples of attribution using seasonal predictions data sets
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# Seasonal Prediction Systems

- Coupled general circulation models
- Real-time forecasts
- Accompanying hindcasts
- All components of seasonal prediction system (atmosphere, ocean, land, sea ice) are initialized from observed conditions (analysis)
- Horizontal resolution is ~ 100Km; Vertical resolution is > 40 levels
- Most seasonal prediction systems have observed CO<sub>2</sub>, solar constant etc.

# Seasonal Prediction Systems

- Real-time forecasts
  - Usually run on a daily or a weekly basis
  - Ensemble size over a month is typically 50-100 members
- Hindcasts
  - Generally extend back to 1980
  - Forecasts initialized from ~ 50 start dates in a year; 1500 (= 30 year \* 50 IC) start dates

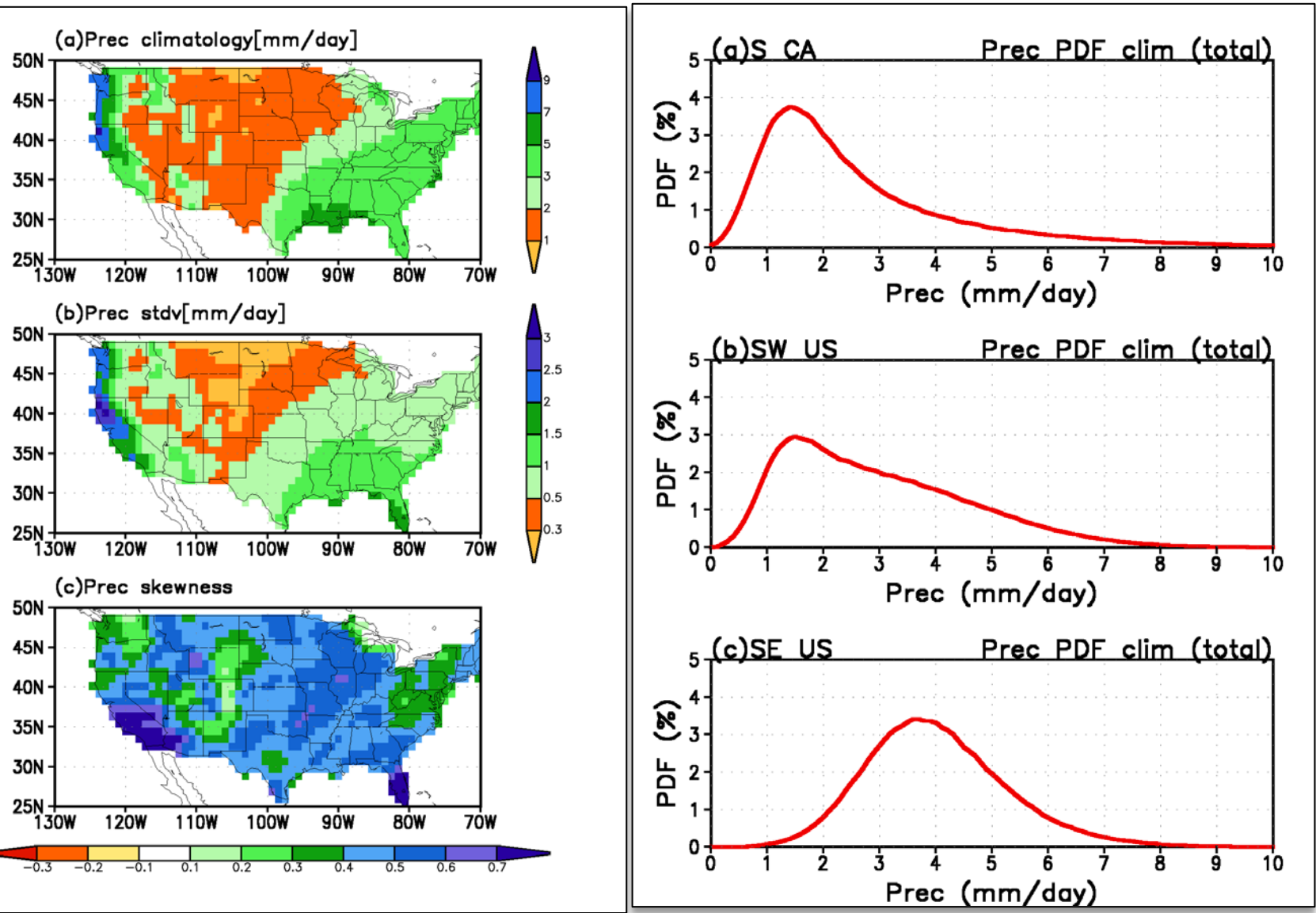
# Seasonal Prediction Systems

- Forecasts can be validated
- Forecast reliability could be tested
- Hindcasts are a huge data base to quantify statistical characteristics of climate variability

CFSv2: Number of Forecasts for a Target Season  
24 ICs/month ; 30-year Hindcast

May	June	July	August	September	October	November	# of Forecasts for a Target Season: DJF
						x	720
					x	720	1440
				x	720	1440	2160
			x	720	1440	2160	2880
		x	720	1440	2160	2880	3600
	x	720	1440	2160	2880	3600	4320
x	720	1440	2160	2880	3600	4320	5040

# Use of large hindcasts...5208 Samples



2.67  
1.97  
1.81

2.97  
1.63  
0.8

4.02  
1.26  
0.6

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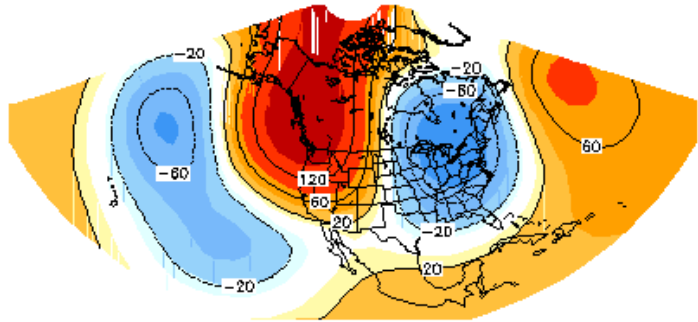


# Internal Variability

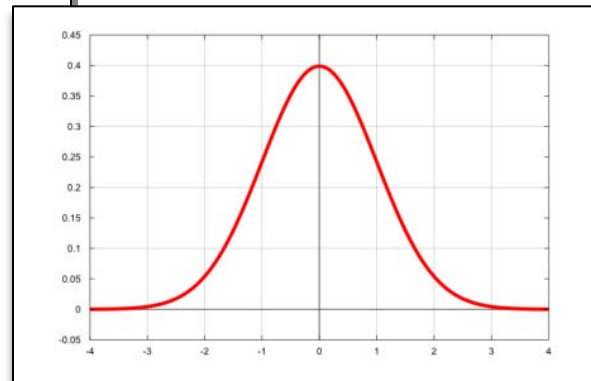
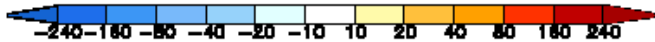
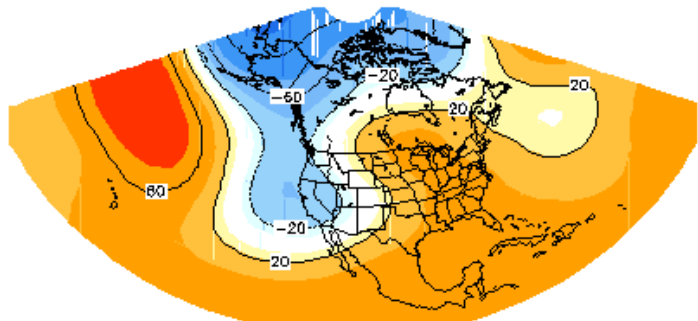


DJF 04/05 200 mb height

(a) NCEP run1

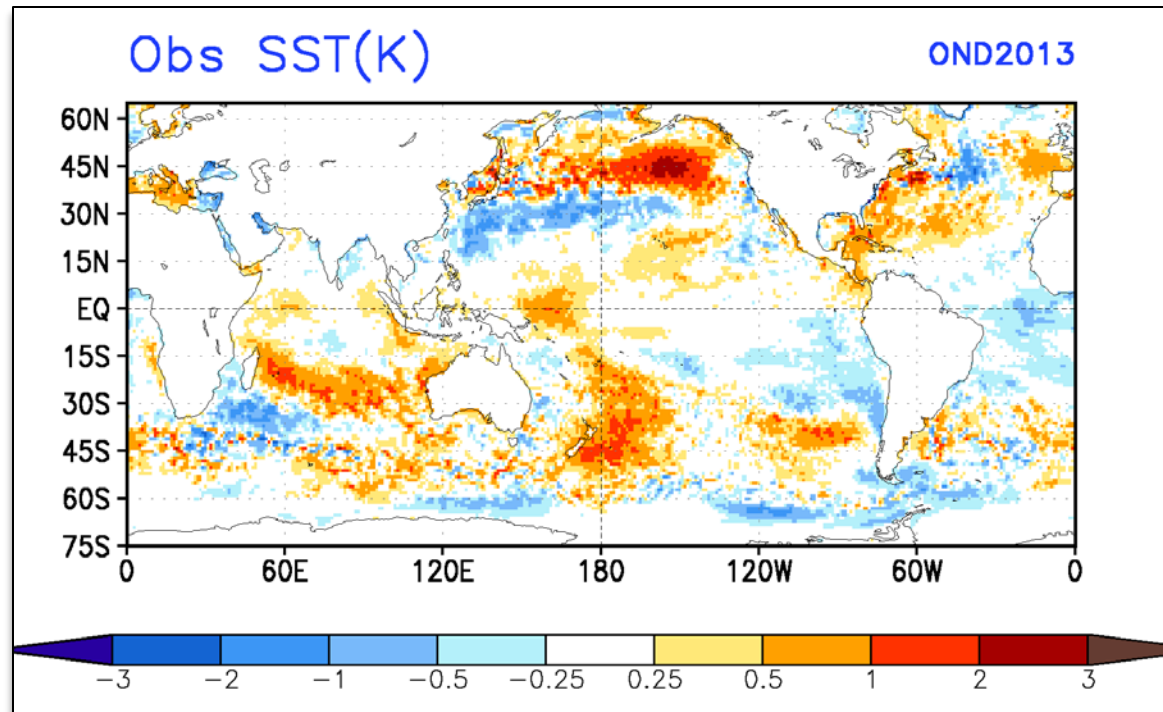


(b) NCEP run5



...outcome of two model runs  
with identical boundary and  
external forcings

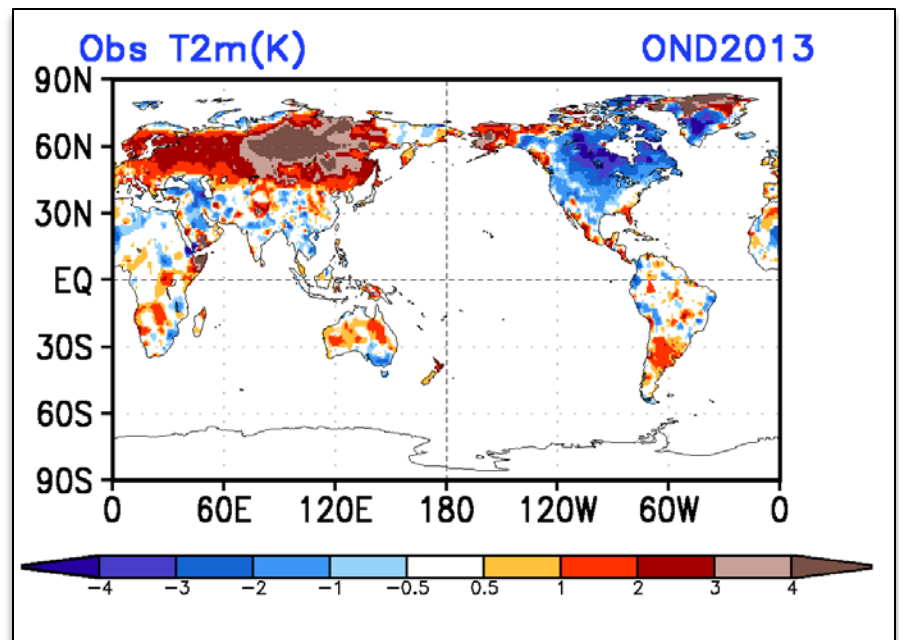
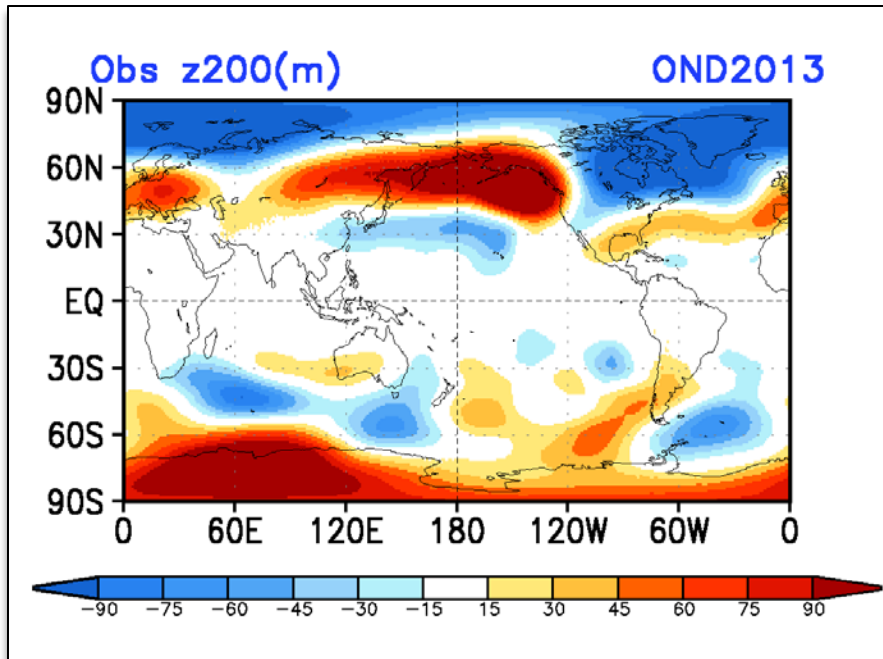
# An Example for OND 2013



...what is the influence of this SST forcing on the changing the PDF of atmospheric variability?



# An Example for OND 2013

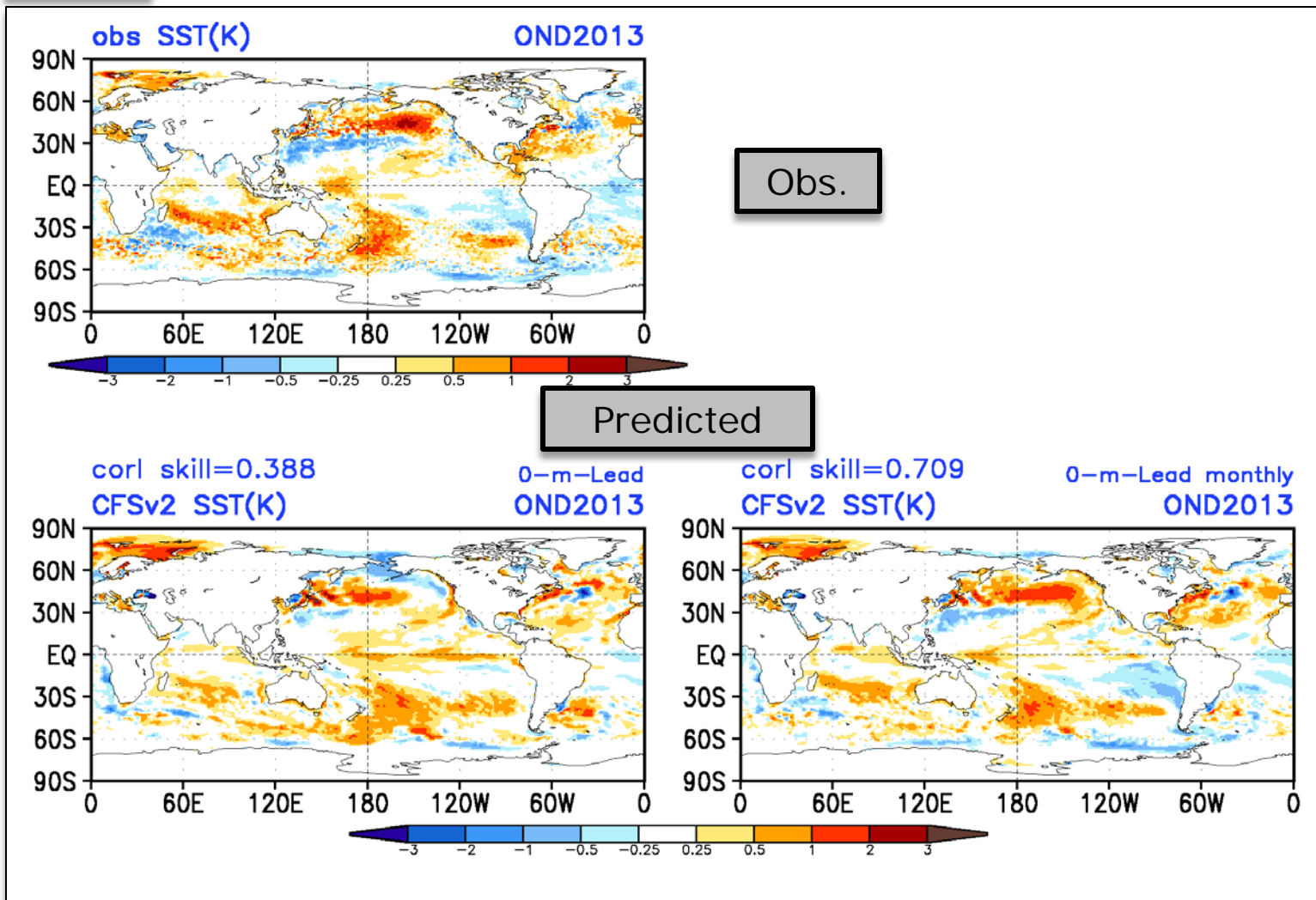


# Inferring Role of Initial Conditions: CFSv2 Seasonal Forecasts

- Seasonal mean predicted anomaly based on forecasts from latest 40 initial conditions – OND seasonal means from ICs from the end of September
- Seasonal mean anomaly constructed based on prediction of individual monthly means from latest ICs – October from September ICs; November from October ICs; and December from November ICs

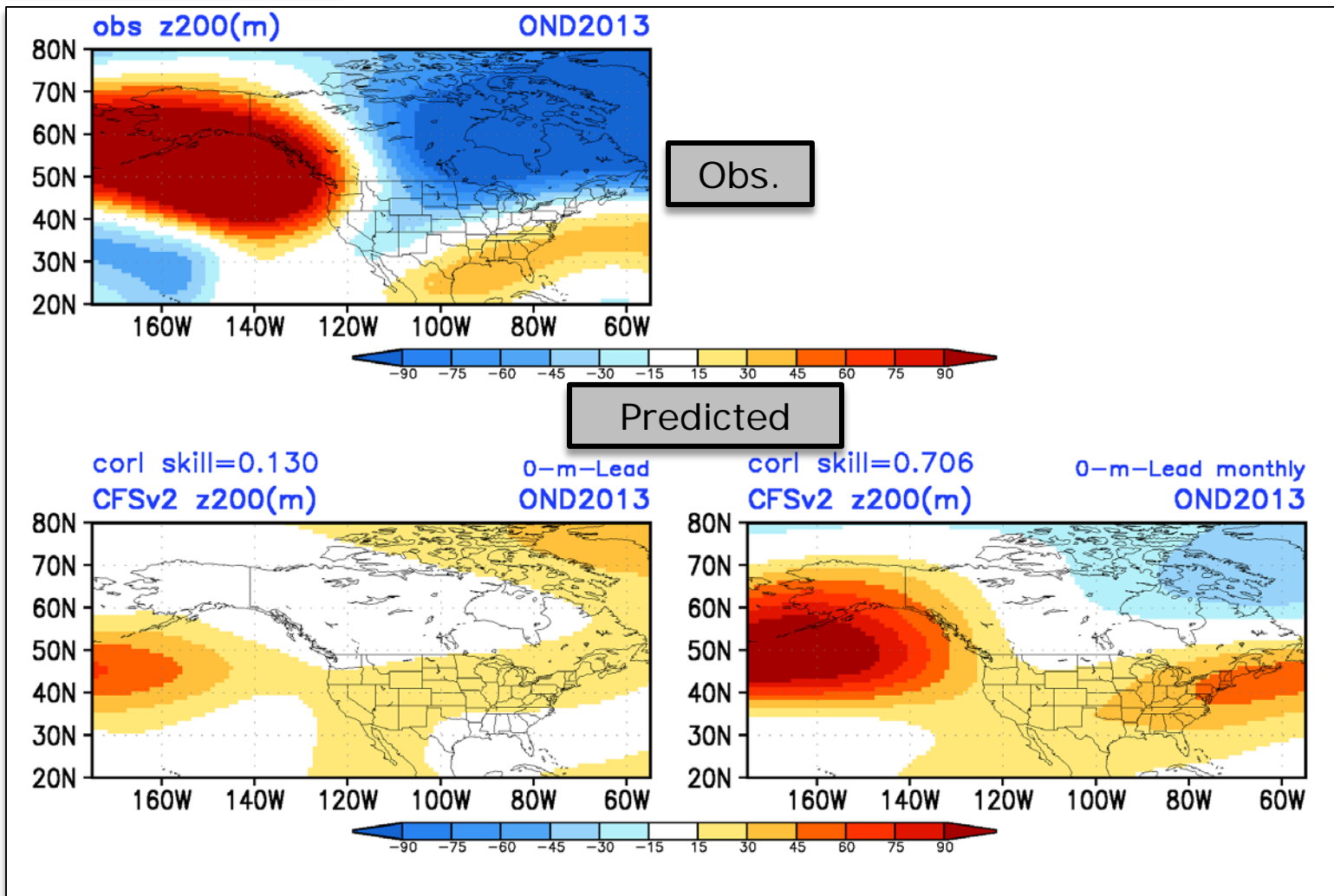
# An Example for OND 2013

SST



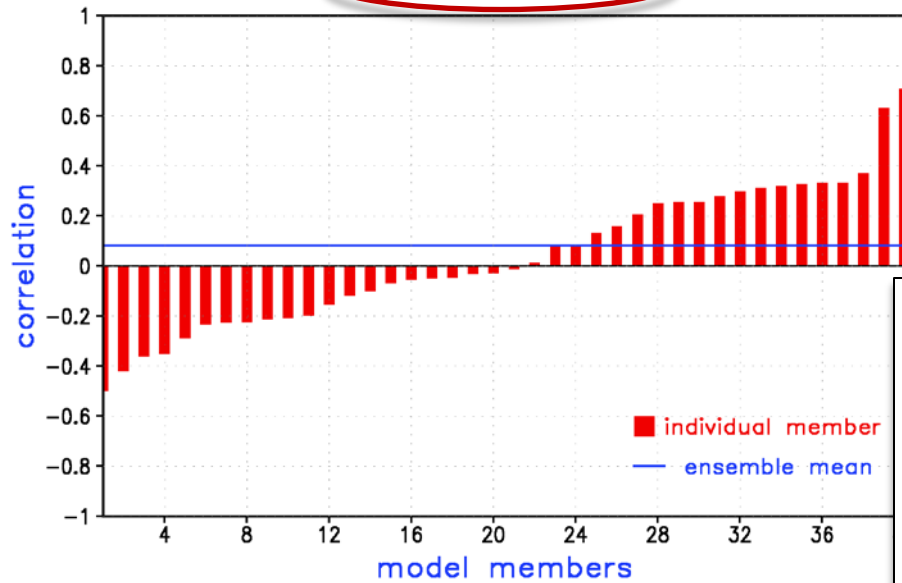
# An Example for OND 2013

200 hPa Height



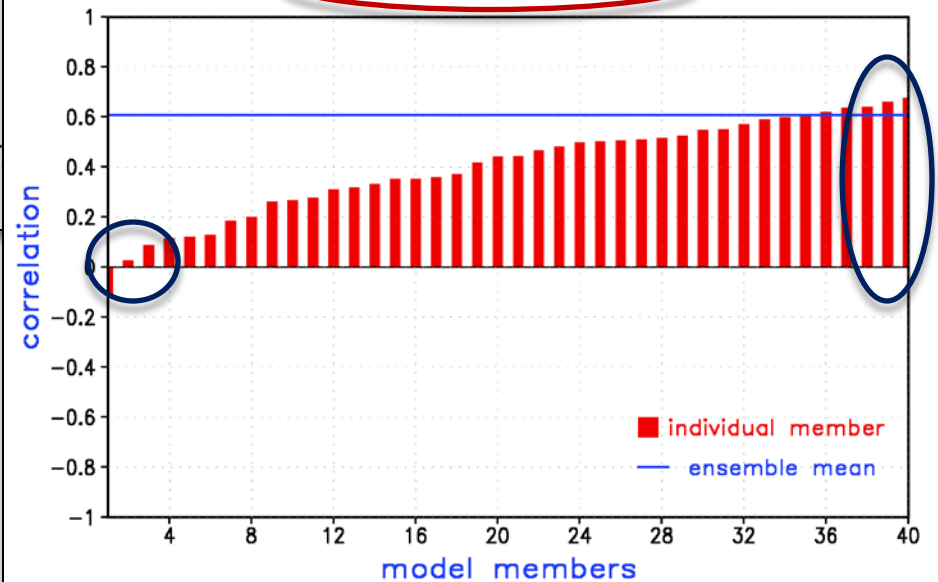
# An Example for OND 2013

CFSv2 z200 OND2013 skill (20N-90N)  
0-m-Lead

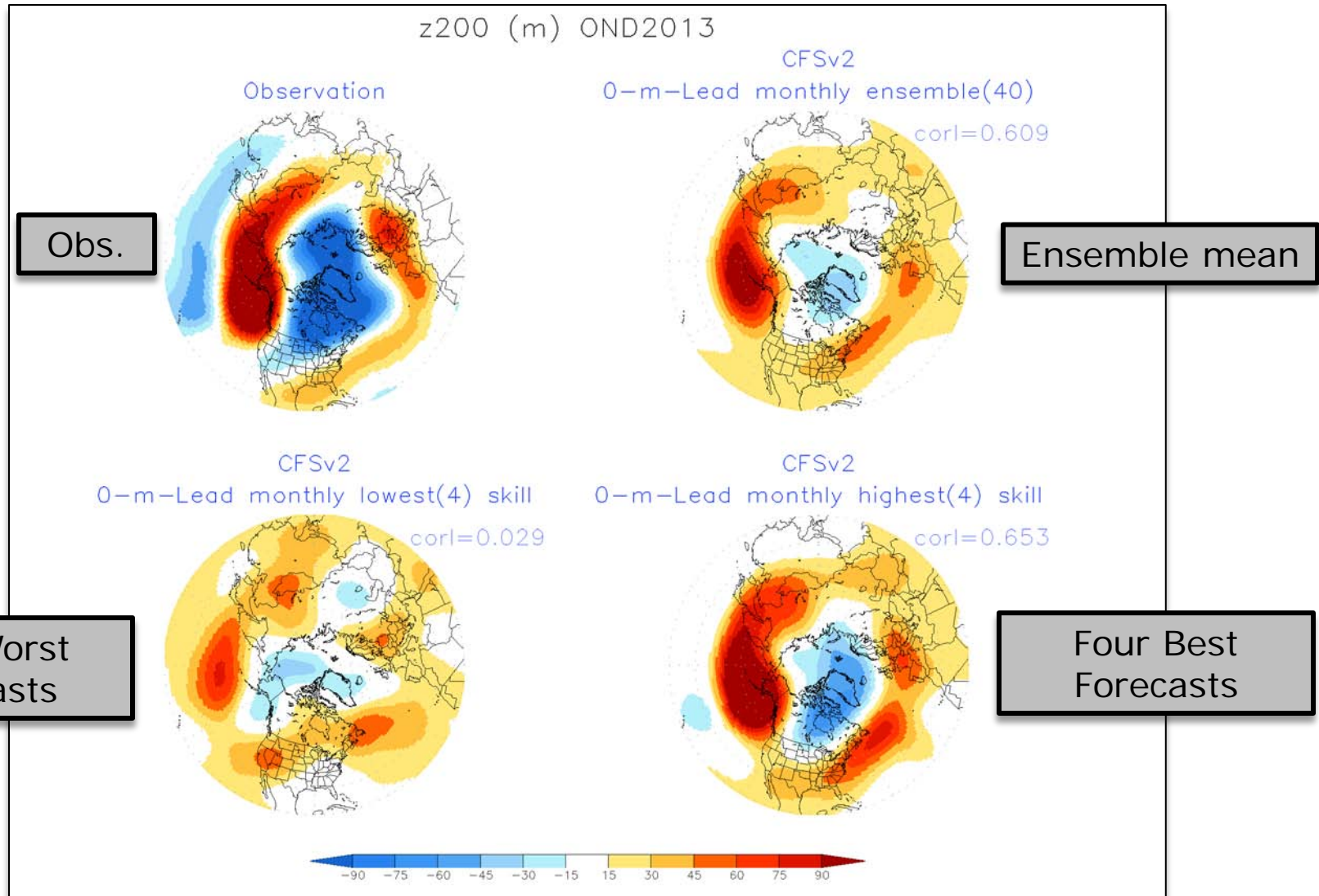


Spatial Anomaly Correlation

CFSv2 z200 OND2013 skill (20N-90N)  
0-m-Lead monthly



# An Example for OND 2013

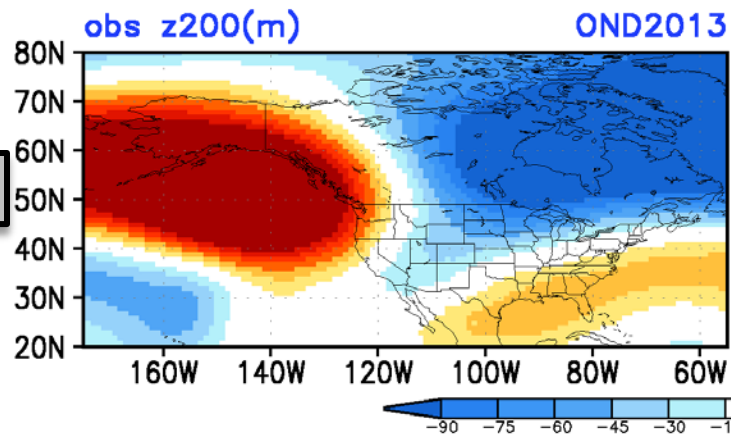


# Inferring the Role of Boundary Conditions

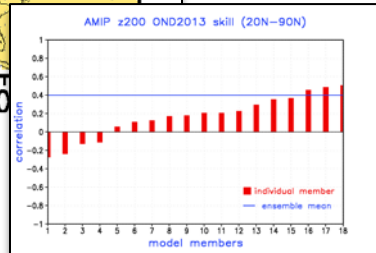
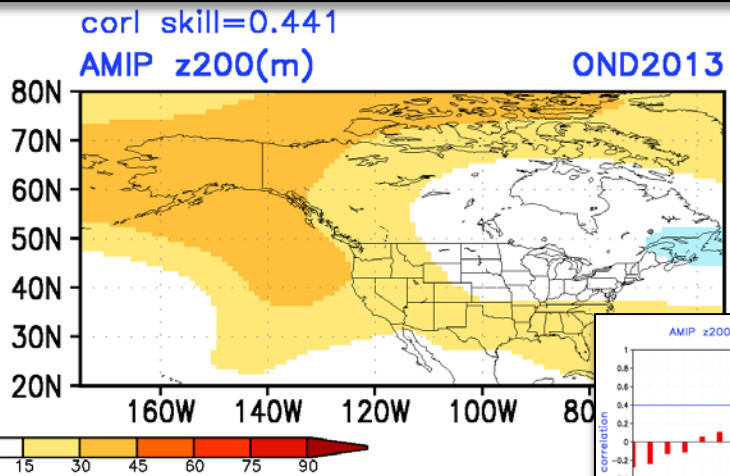
# An Example for OND 2013

## Influence of Boundary Conditions

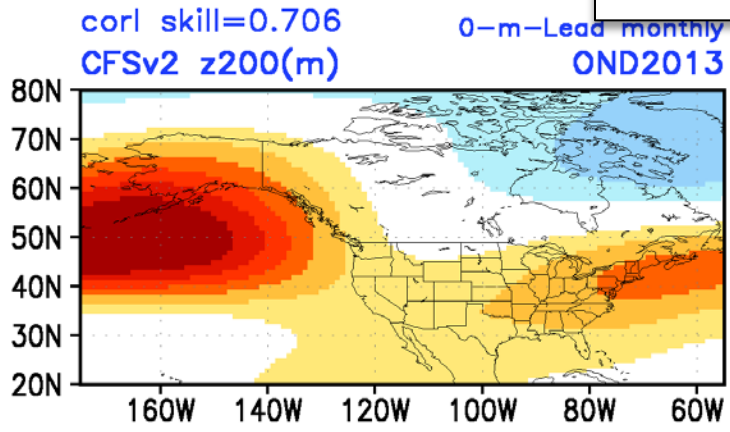
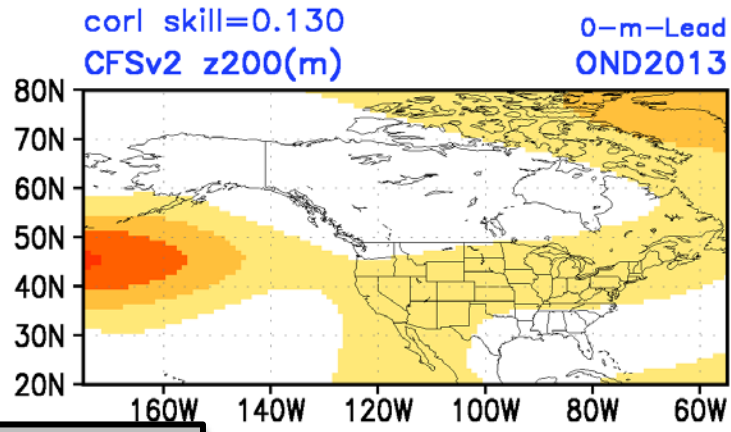
Obs.



AMIP



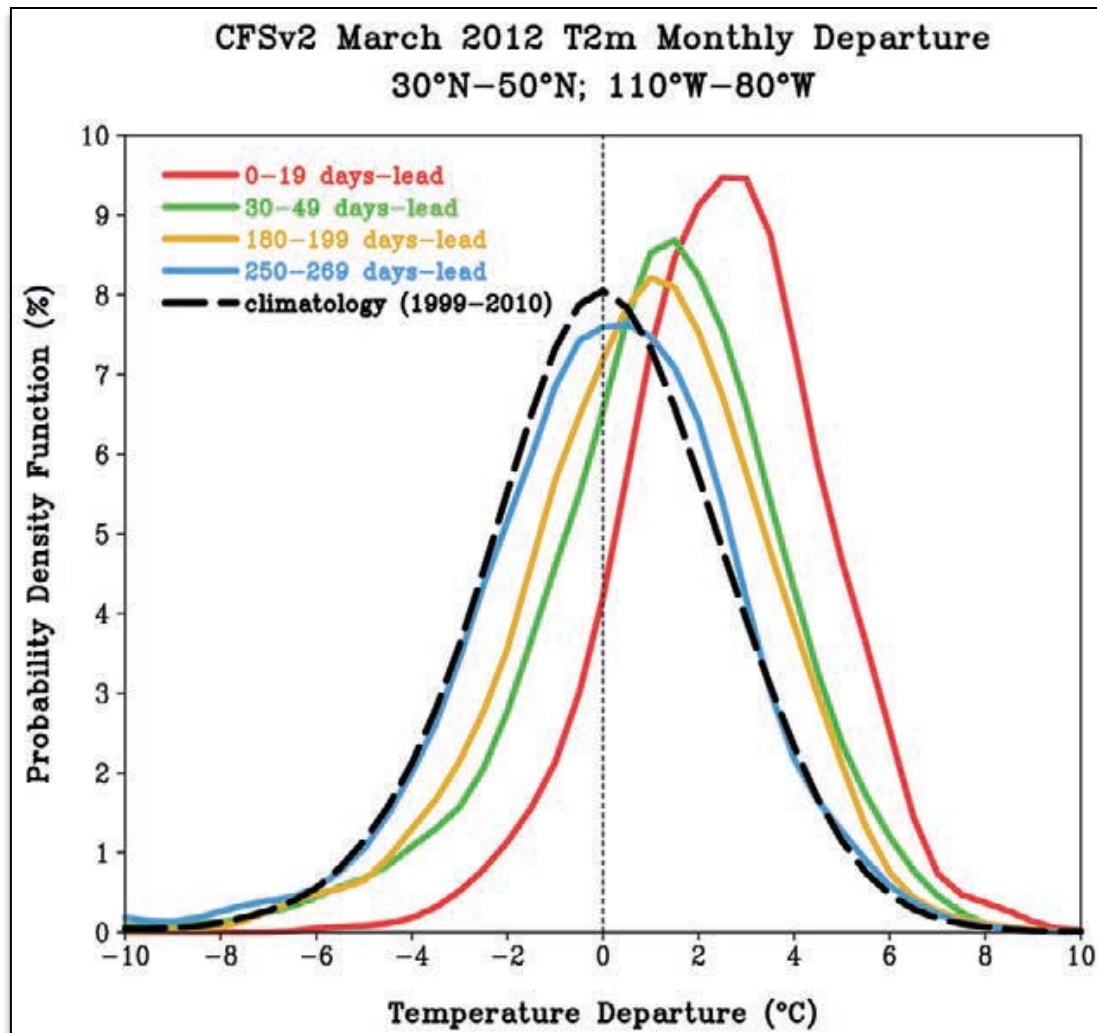
Predicted





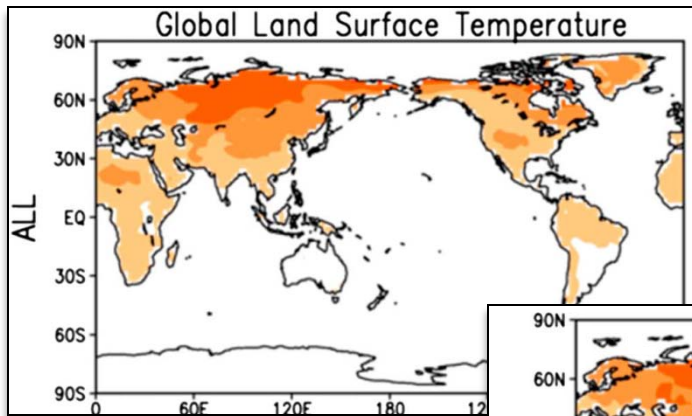
# Inferring the Role of Changes in External Conditions (Forcings)

# March 2012 U.S. Heat Wave

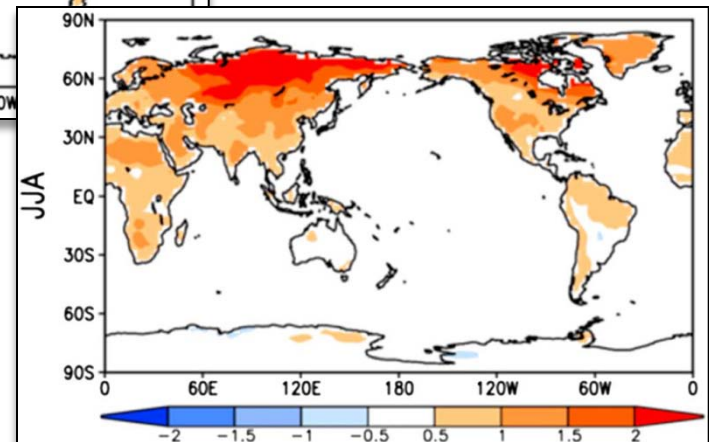
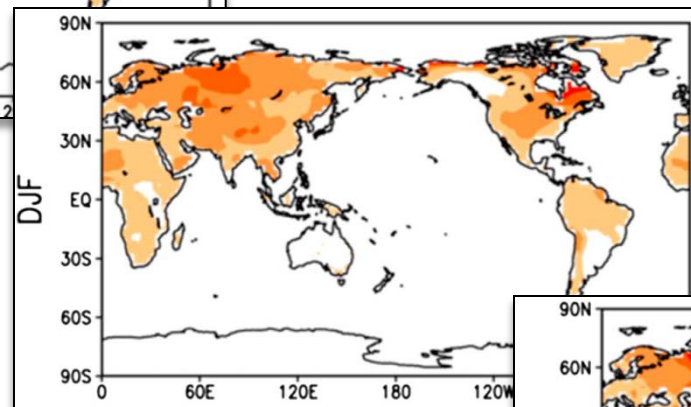


Dole et al.  
2014

# Influence of External Forcings ( $\text{CO}_2$ ) on Seasonal Extremes

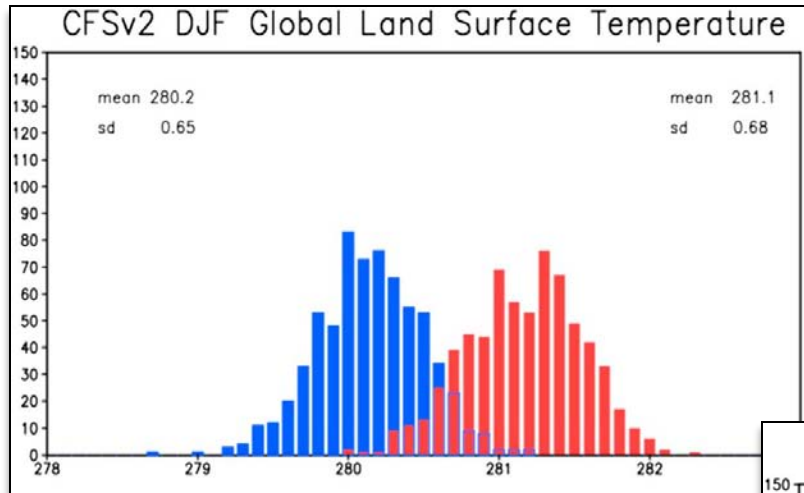


Sf. Temp. Difference  
(2009:2012) – (1983:1986)  
CFSv2; 672 Realizations

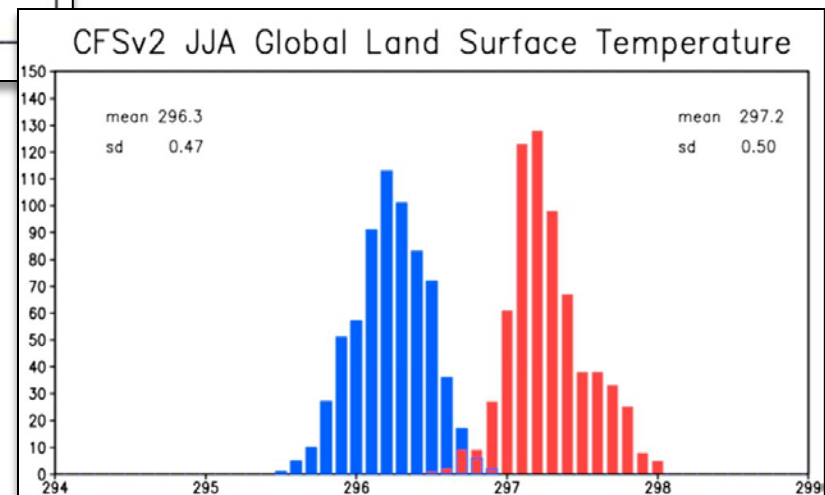


Weaver et al.  
2014

# Influence of External Forcings (CO<sub>2</sub>) on Seasonal Extremes



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- Use seasonal hindcast data from multiple prediction systems
- Evaluate skill in predicting extremes
- Quantify influence of ENSO on extremes
- Assess the influence of warming climate on extremes
- Look at prediction of specific extreme events with different lead time