

Constructing a Composite of Teleconnection Indices to Better Forecast Temperatures over the Eastern United States



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Introduction

- A temperature forecasting tool could improve decision making efforts in transportation, energy, and agriculture.
- A new index is constructed to better forecast the temperature over the eastern half of the country.
- **Teleconnections** are the base of this new index.

Past Events & Energy Prices

● Heat Waves

-1995 July Heat, 830 U.S. Deaths, 525 deaths in Chicago (Changnon et al. 1996)



● Cold Waves

-January 1985 cold outbreak, 126 deaths & *2.5 billion dollars in damages



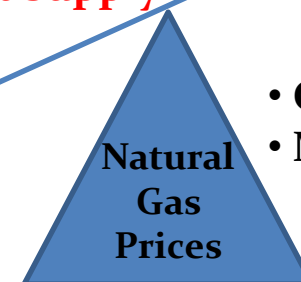
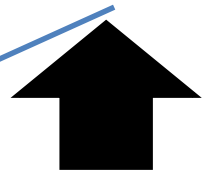
● Drought

-1988 Drought/Heat *77.6 billion dollars in damages, 7500 deaths (NCDC 2012)

● Energy Prices

-The relationship of energy prices to temperature, most applicable for boreal winter.

- Warm Weather
- Low Demand
- Robust Storage
- Abundant Supply



- Cold Weather
- More Demand

*2012 CPI Adjusted

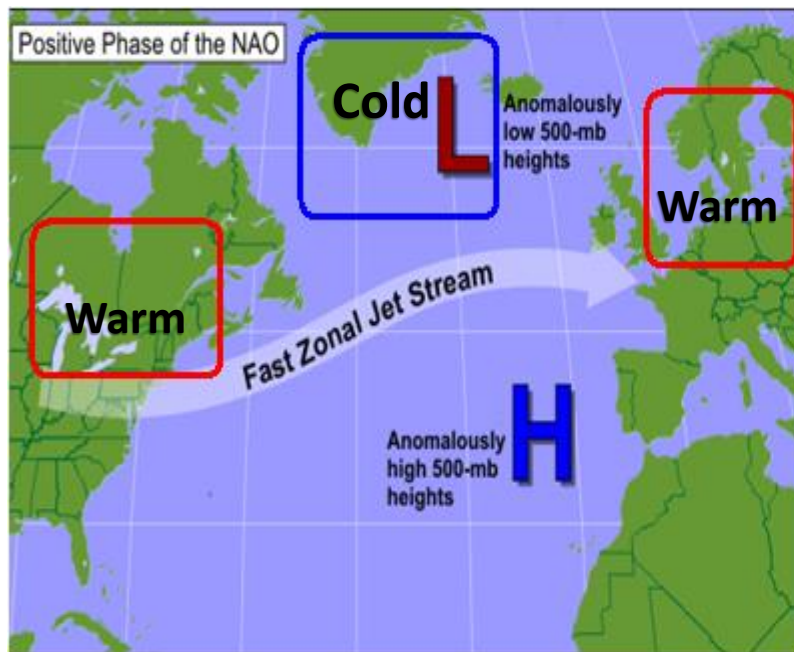
Background

- What is a **teleconnection**?

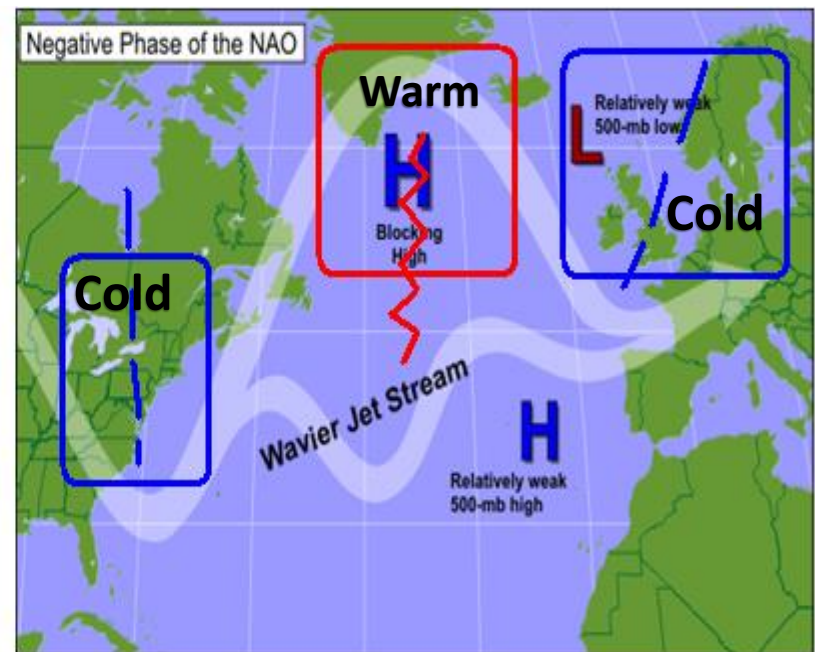
Teleconnection - defined as a linkage between weather changes occurring in widely separated regions of the globe. (A.M.S.)

- Can change on daily timescales, but vary on multiple timescales
- Characteristic of mean S.L.P. , geopotential height, or sea surface temperature fields
- Generally represented using a daily, monthly, or seasonal time series dataset
- Example: The **North Atlantic Oscillation (NAO)**

+NAO (No Block)



-NAO (Greenland Block)



Background

Example: The **North Atlantic Oscillation (NAO)** Continued....

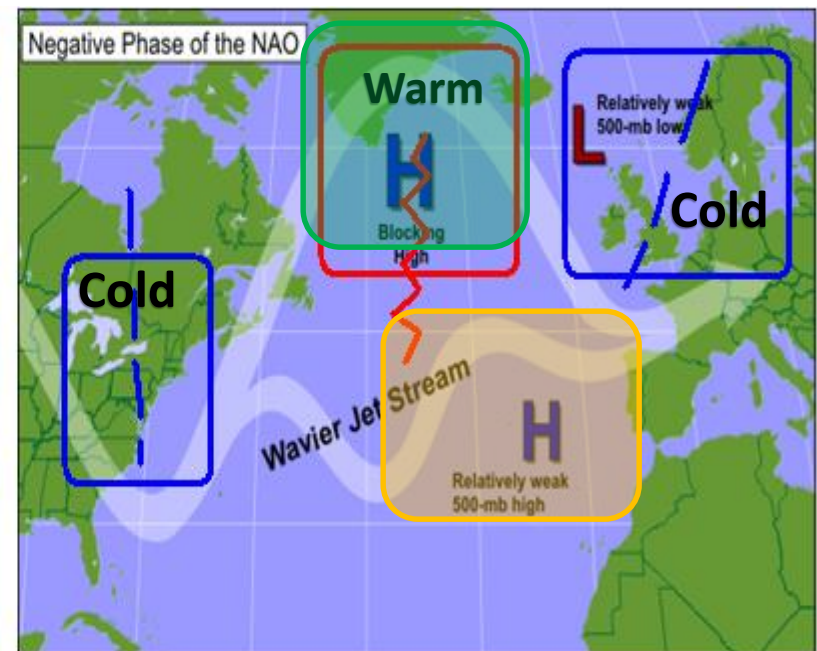
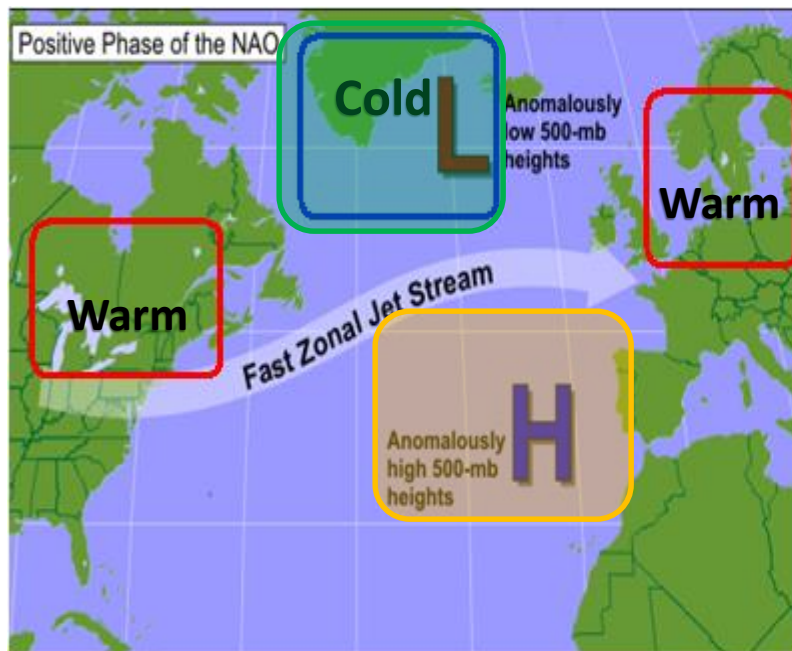
The NAO teleconnection index is calculated using the difference between the yellow and green fields in 500 mb Geopotential Heights.

Higher pressure around Greenland (green) & lower pressure around the Azores (yellow) will promote a **-NAO regime**.

Lower pressure around Greenland (green) & higher pressure around the Azores (yellow) will promote a **+NAO regime**.

+NAO (No Block)

-NAO (Greenland Block)





Background

- Existence of teleconnections such as the North Atlantic Oscillation, North Pacific Oscillation, & Southern Oscillation
 - Walker (1924)
- The discovery of longwaves or Atmospheric Rossby Waves
 - Rossby (1939)
- Atmospheric Rossby waves propagating pole ward explain teleconnections between lower and higher latitudes
 - Hoskins and Karoly (1981)
- Multiple datasets of modern N.H. teleconnections are created using 500mb height data.
 - Barnston and Livezey (1987)
- Teleconnections are most important in and around boreal winter because of seasonally increased meridional flow.
 - Hurrell (2000)



Research Objectives

- To examine the dynamic relationships between teleconnections and Eastern United States surface temperatures .
- If relationships exist, then each teleconnection found to have a dynamic relationship can be combined into a composite index that best represents the temperature in the Eastern United States. Seasonal emphasis will be placed on winter.
- Question: Will this composited & weighted time series derived from dynamic teleconnections using multiple regression create a more comprehensive tool to describe, forecast, and model surface temperatures for the eastern U.S. ?

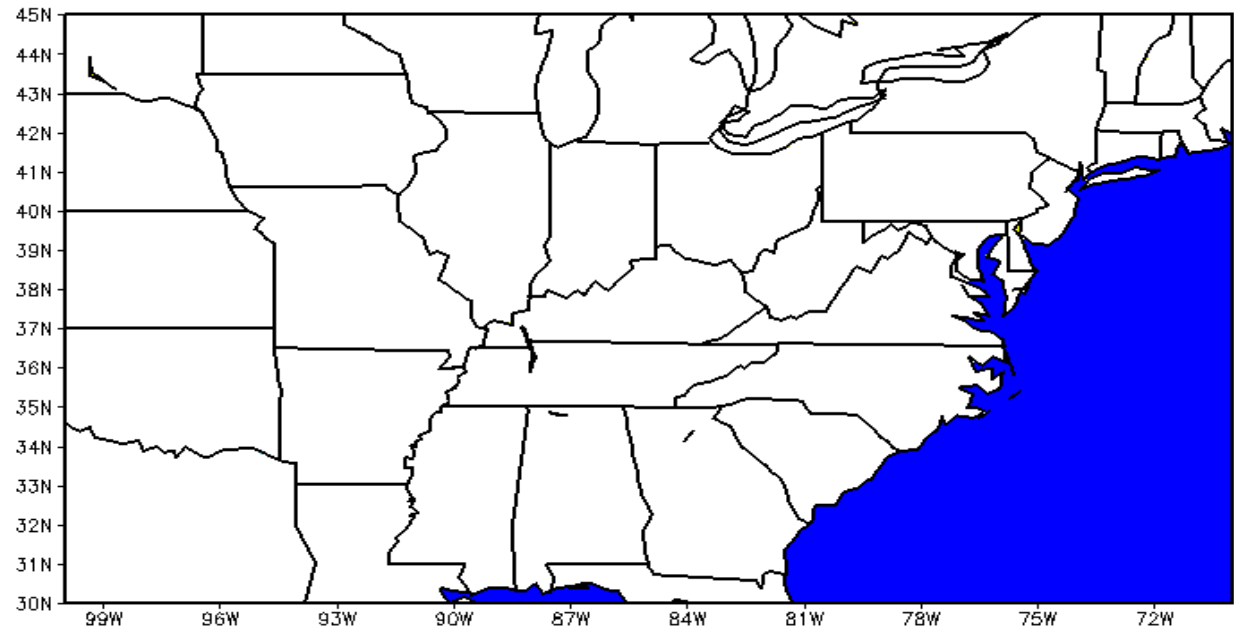
Approach / Data

Eastern United States Mean Temperature Area

45° N



30° N



NOAA/ESRL Physical Sciences Division

100° W



70° W

- Monthly temperature area-weighted using gridded data from the NCDC from January 1950 to July 2012.

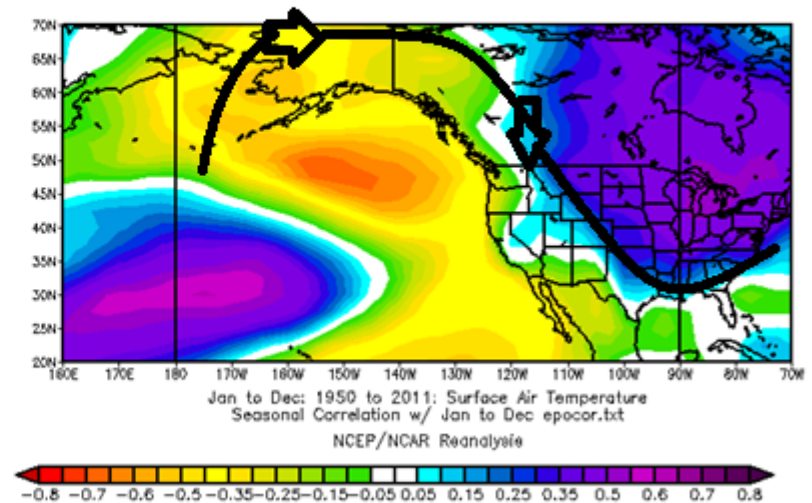
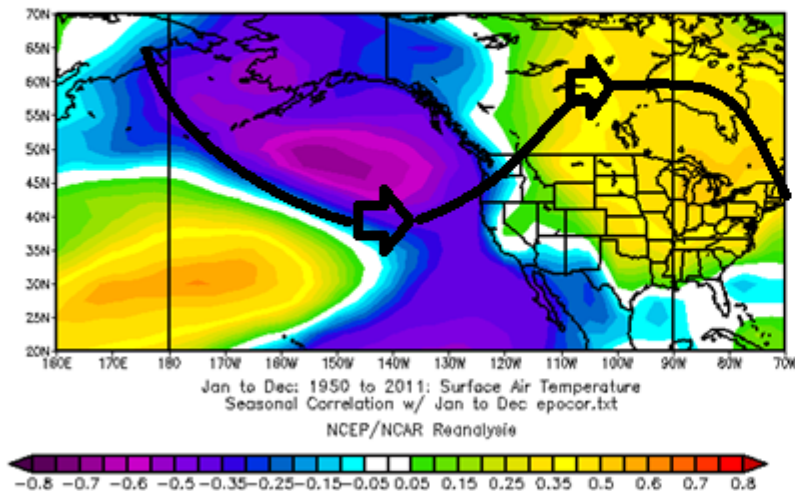
Approach / Data

The Dynamic Teleconnections

The East Pacific Oscillation

+ EPO

-EPO

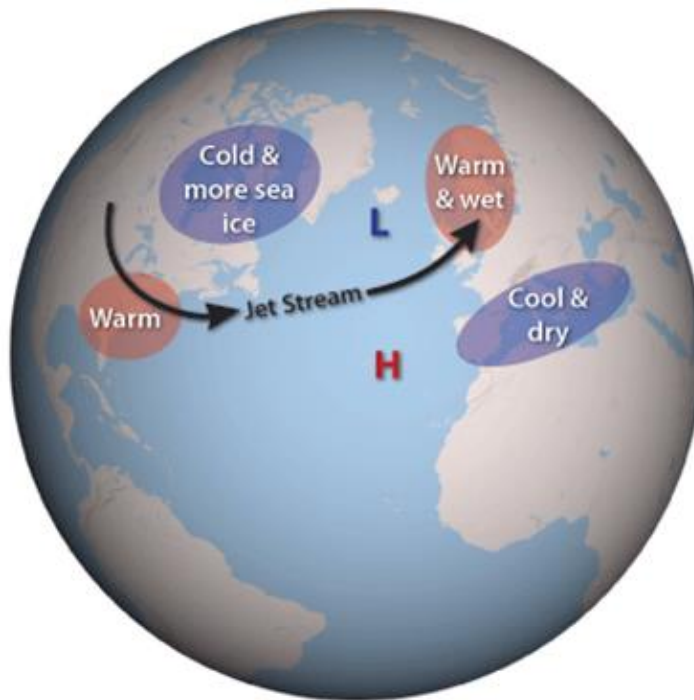


Relationship: When a blocking event (-EPO) occurs, it causes cP and cA air masses to flow into **downstream troughs** over the East Central U.S. . A (+EPO) incites High Pressure & Warm Temps over this area.

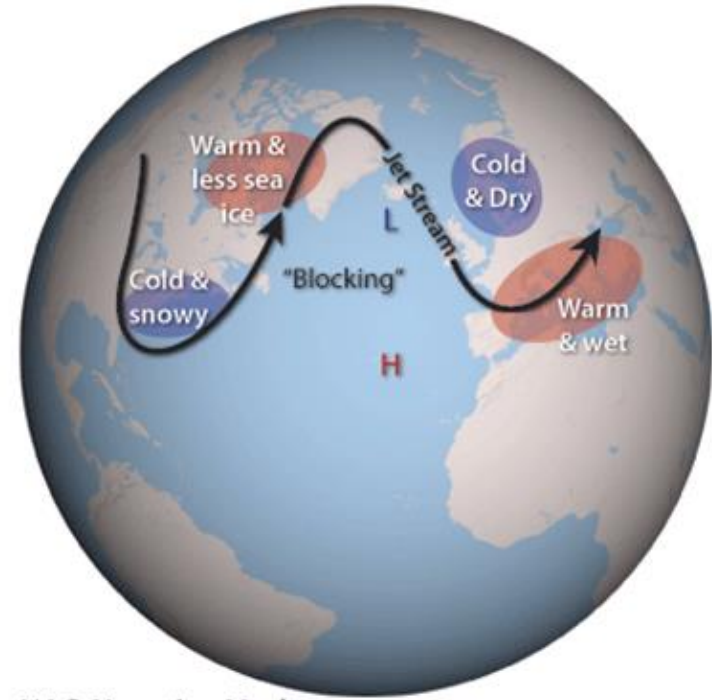
Approach / Data

The Dynamic Teleconnections

The North Atlantic Oscillation



NAO Positive Mode



NAO Negative Mode

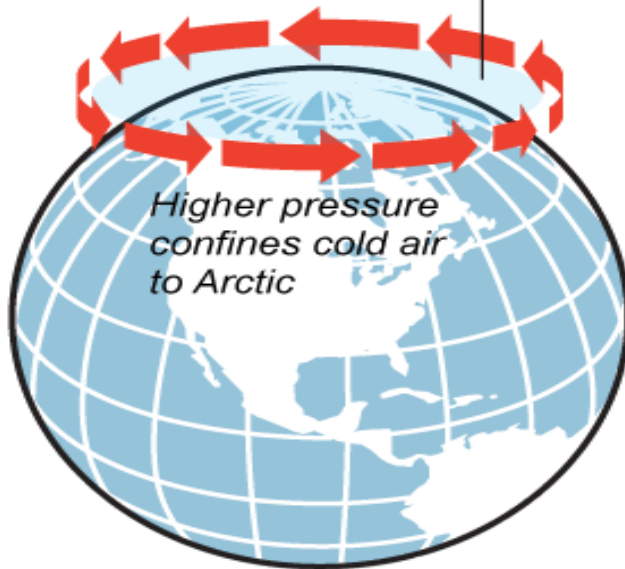
Relationship: When a blocking event (-NAO) occurs, it causes cP and cA air masses to flow into **upstream troughs** over the East Central U.S. A (+NAO) incites High Pressure & Warm Temps over this area.

Approach / Data

The Dynamic Teleconnections

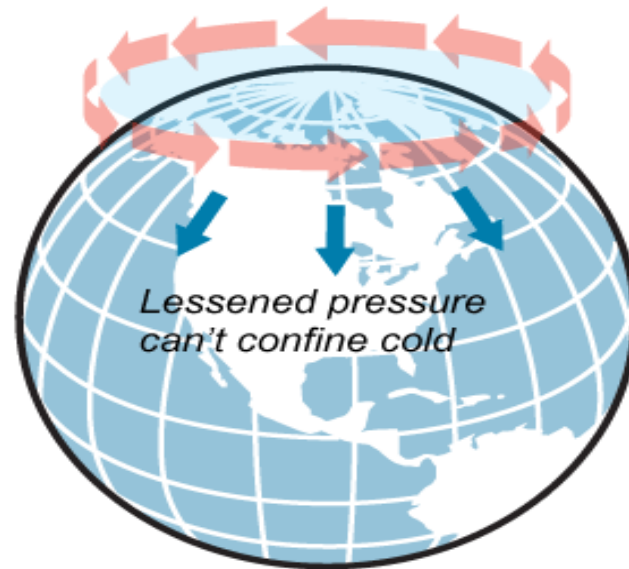
THE ARCTIC OSCILLATION

Low-pressure air mass



POSITIVE PHASE

Higher-pressure air mass over North America, Europe and Asia confines extremely cold air to Arctic, causing the northern hemisphere to be warmer.



NEGATIVE PHASE

Pressure systems weaken, allowing colder air to move south and warmer air to move north, causing the northern hemisphere to be colder.

Sources: NASA, NATIONAL SNOW AND ICE DATA CENTER

The Arctic Oscillation



Approach / Data

A Composite Approach

- Using these three teleconnections, one can build a composite index with regards to these dynamic relationships with Eastern U.S. Temperatures.
- The EPO was reconstructed because December values are not calculated by the CPC's equivalent index called the EP/NP (East Pacific/North Pacific). The NOAA's Physical Sciences Division definition was used to reconstruct the EPO using gridded NCDC data.
- The NAO, EPO, & AO are part of the "Composite Blocking Index" or **CBI**. Appropriate weights per each teleconnection were assigned automatically in the SPSS stats process via multiple regression.
- The **CBI** is created using multi-regression of the Climate Prediction Center's NAO & AO indices and a Reconstructed EPO index monthly from Jan-1950 to Jul-2012 against monthly Eastern U.S. Temperatures. The **CBI** is standardized monthly using a 30-year climate (1981-2010) base period.

Results

Composite Blocking Index – Multi-Regression Equation

$$\text{CBI} = 0.011 + 0.430\text{A} + 0.084\text{B} + 0.380\text{C}$$

Equation Variable	Coefficients
Intercept	0.011
A = Recon EPO	0.430
B = CPC NAO	0.084
C = CPC AO	0.380

The Composite Blocking Index represents Eastern U.S. temperatures better than its individual components.

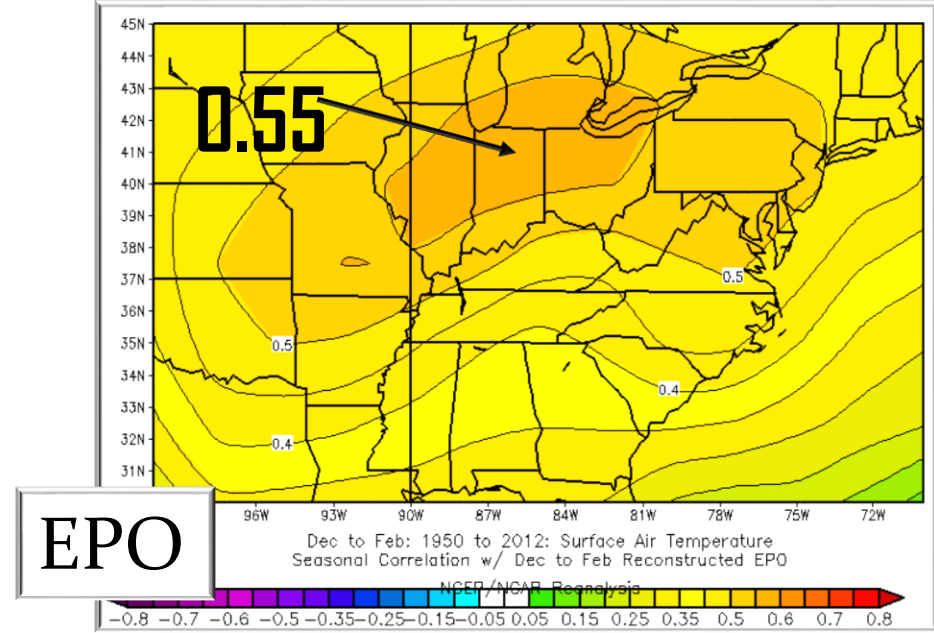
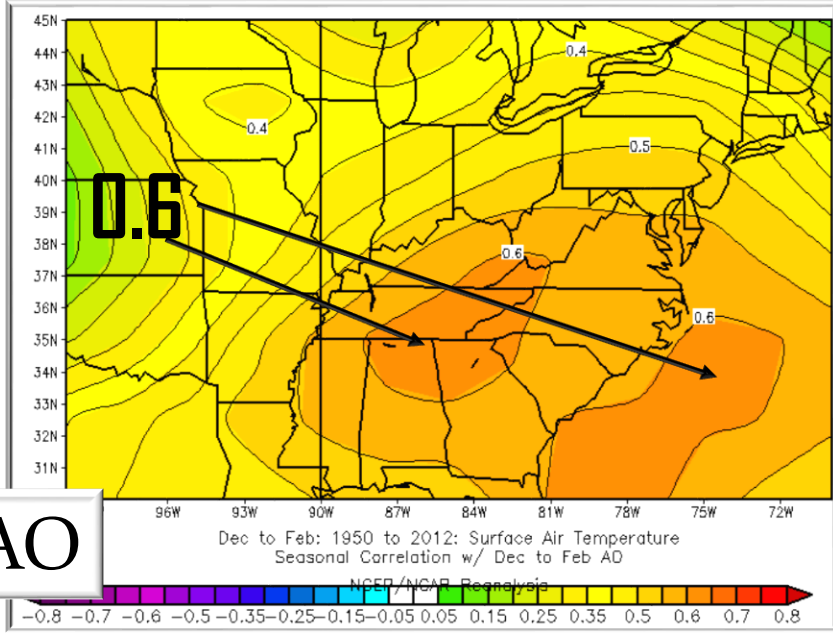
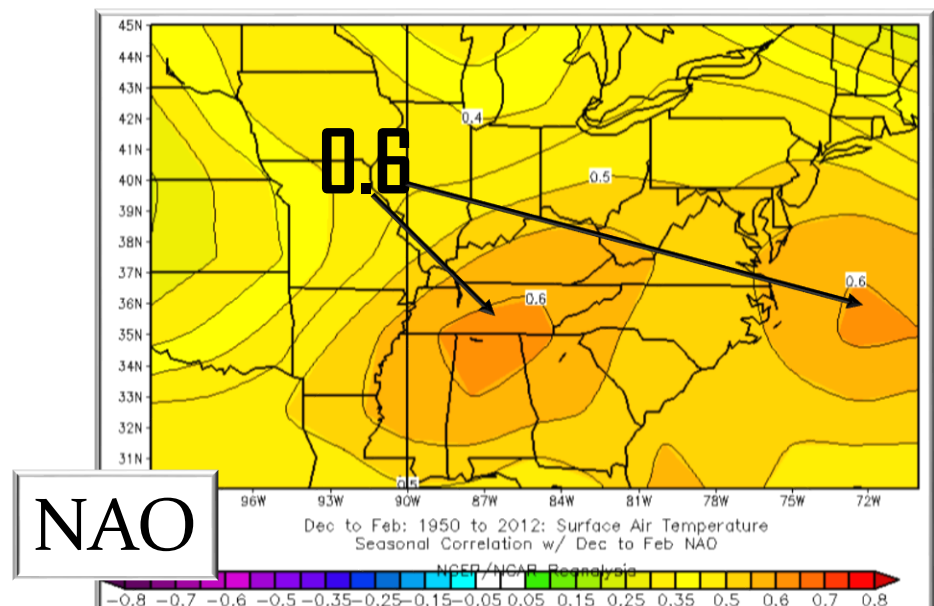
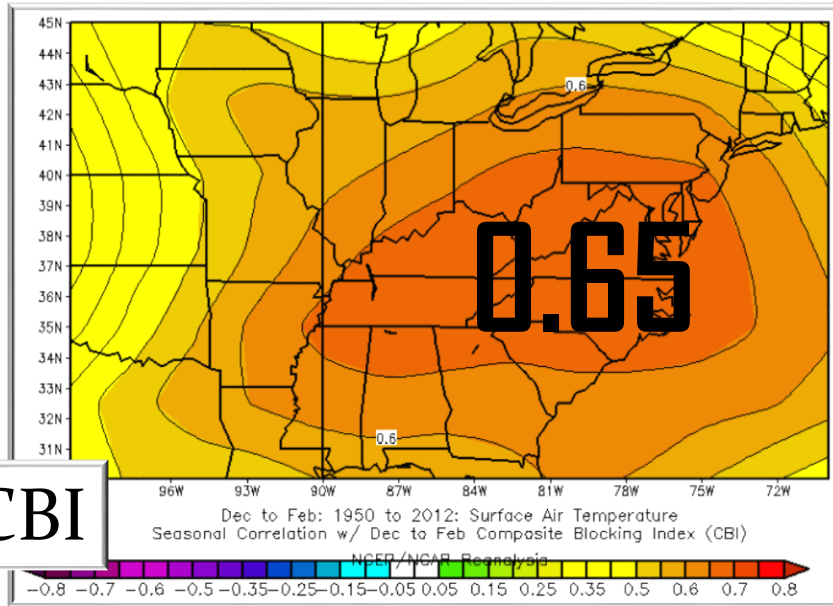
Correlation with Monthly Teleconnections & Composite Blocking Index Vs Mean Eastern U.S. Temperature

Stats (Monthly) N = 751	Recon. EPO	CPC NAO	CPC AO	CBI
R Correlation Coefficient	*0.383	*0.271	*0.393	*0.512
R ² Variance	0.147	0.073	0.155	0.262
All Teleconnection Indices and new Composite Blocking Index easily exceed the threshold for statistical significance.				

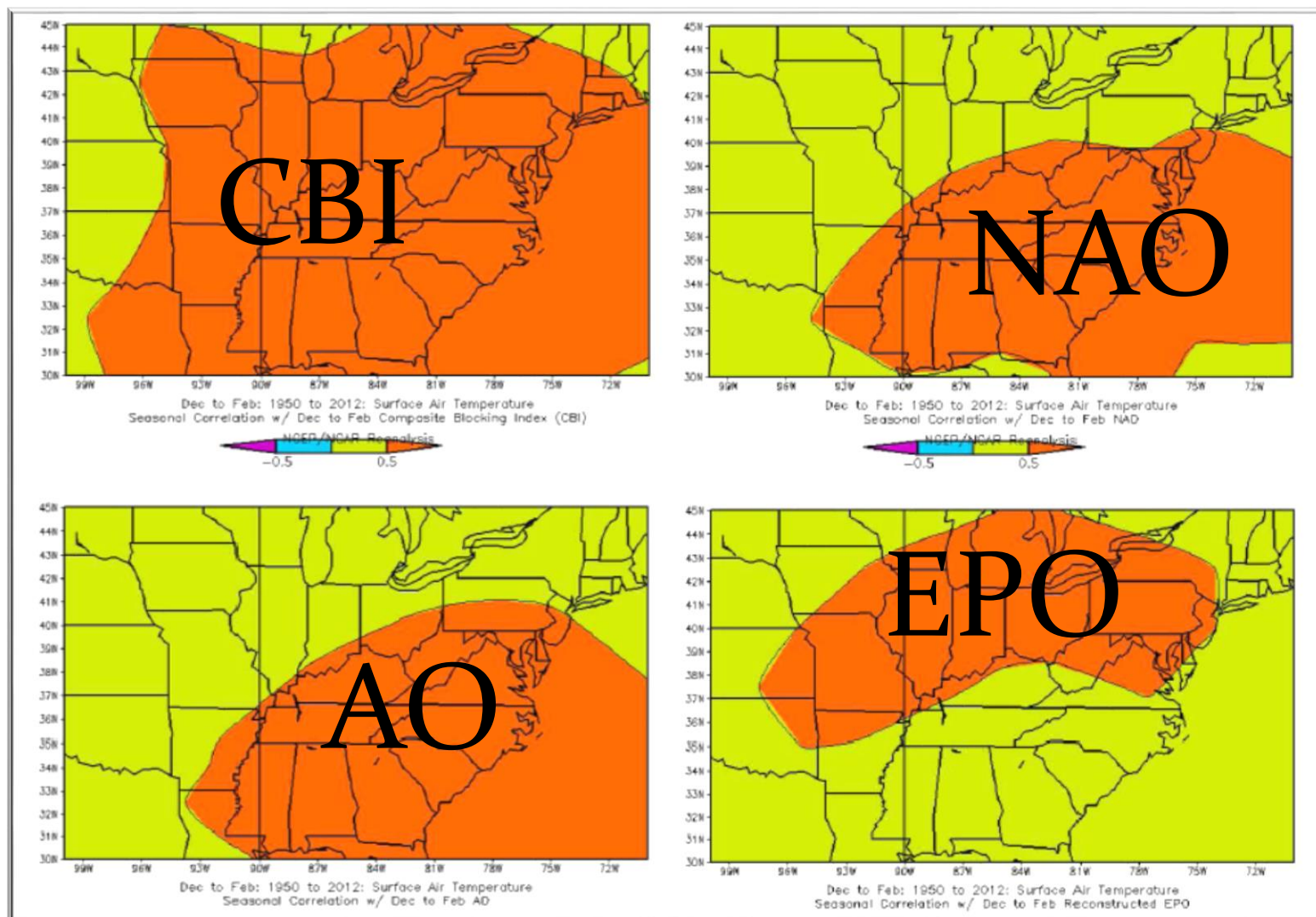
How much more does The CBI explain East U.S. Temps ----> R ² _{CBI} - R ² _x <----	then the EPO?	NAO?	AO?
	11.50%	18.83%	10.72%

N=number of pairs of scores		α level for two-tailed test					
N	df=N-2	0.2	0.1	0.05	0.02	0.01	0.001
751	749	0.060	0.072	0.082	0.094	0.102	0.127

Spatial correlation between Eastern U.S. Temperature in the Wintertime (DJF) from 1950 to 2012 in regards to Teleconnections/CBI



R=0.5 correlation threshold area between Eastern U.S. Temperature in the Wintertime (DJF) from 1950 to 2012 & Teleconnections/CBI

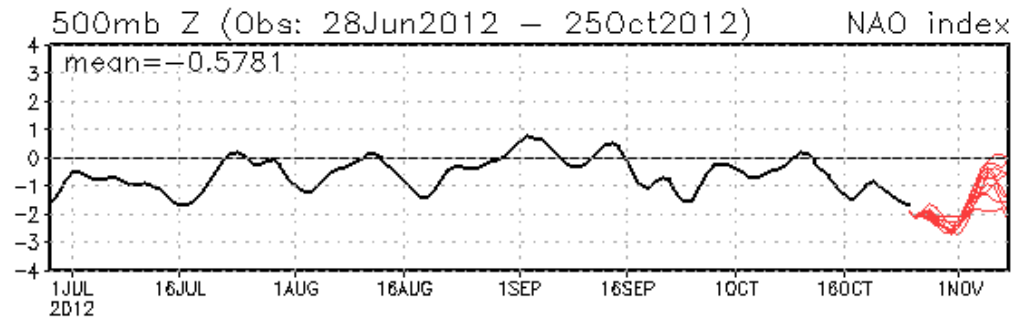


Conclusion

A tool for medium range forecasting

- The **CBI** represents 3 different teleconnecting patterns in regards to temperatures over the Eastern United States. A “collective” of blocking mechanism modes as opposed to just one.
- The **CBI** could be modeled easily by any computer model, like the Global Forecast System Ensembles or ECMWF (European Model)

NAO: Observed & ENSM forecasts

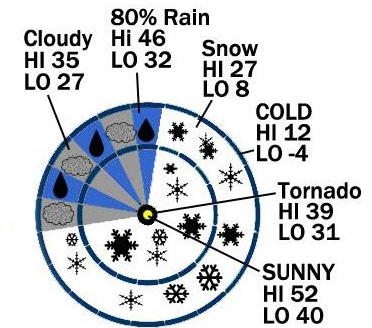


- The **CBI**, as a guidance tool can be used like the rest of the teleconnection indices up to a max of 14-16 days (NAO as an example).
- Until models improve, just like teleconnections, there is little skill in forecasting the **CBI** outside of 14-16 days. The Earth's climate system is too stochastic.

Acknowledgements

- Dr. Dave Changnon , Dr. Jie Song , and Dr. Mace Bentley

- Have a good one!



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