Verification of hemispheric-wide winter temperature forecasts based on fall snow and atmospheric anomalies

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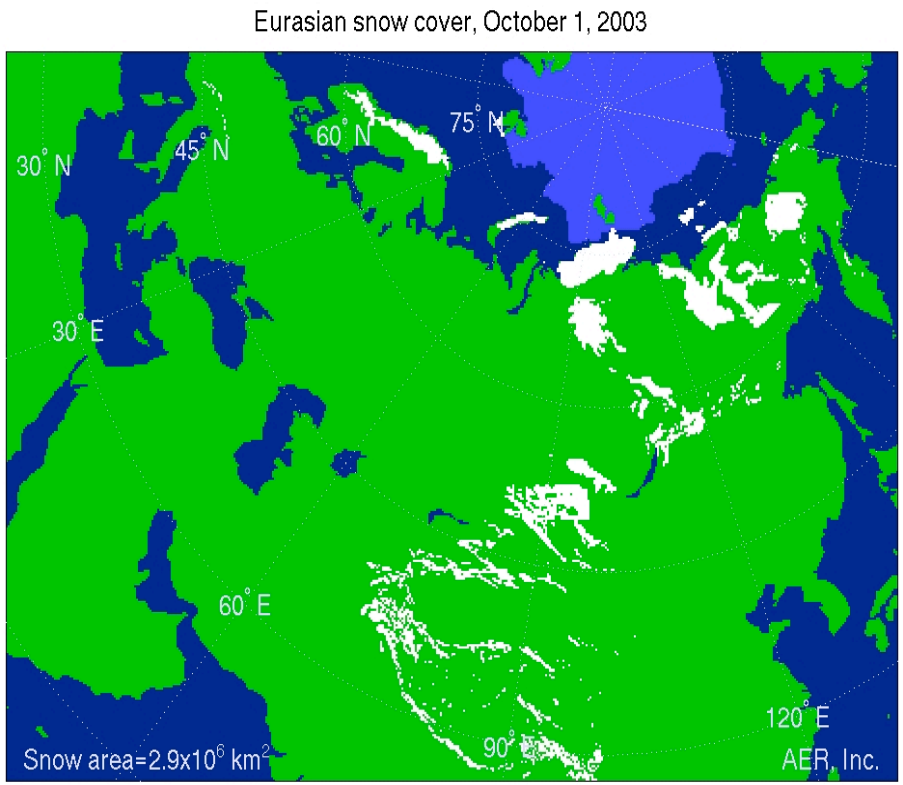
Outline

- Common Predictors in Seasonal Forecasts
    a) El Niño/Southern Oscillation
    b) Trend
- Proposed New Predictors
    a) Siberian Snow Cover
    b) Tropospheric Precursors
- Verification of Statistical Model with New Predictors
- Comparison of skill between snow model and ENSO driven models

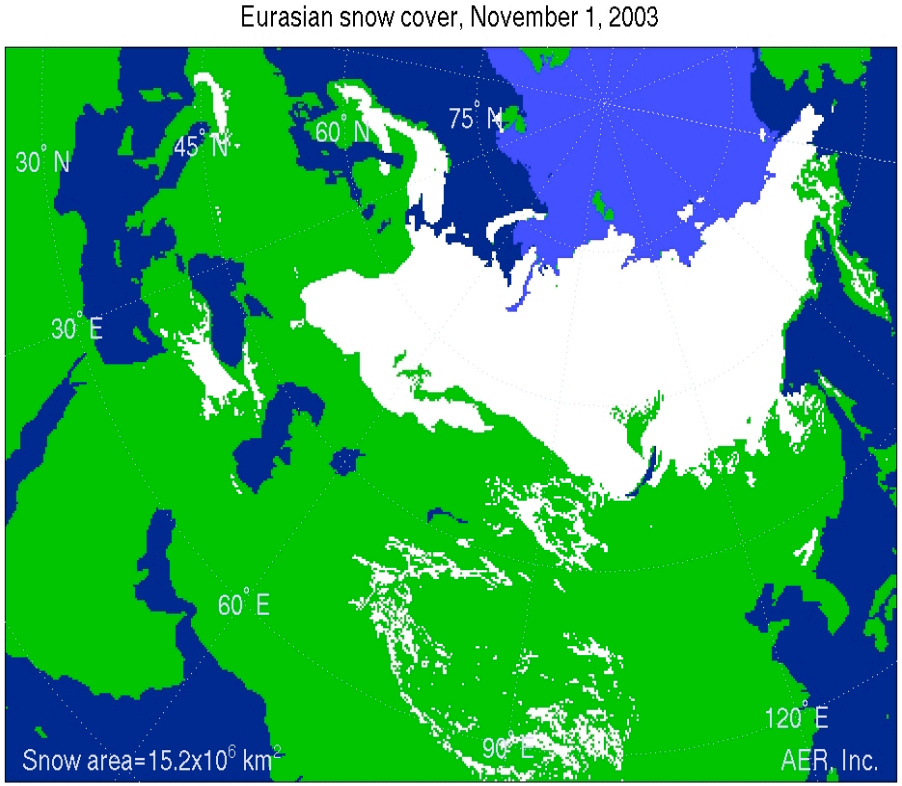
Variability in Siberian Snow

Large changes in fall snow cover can have large impact on earth's energy balance:

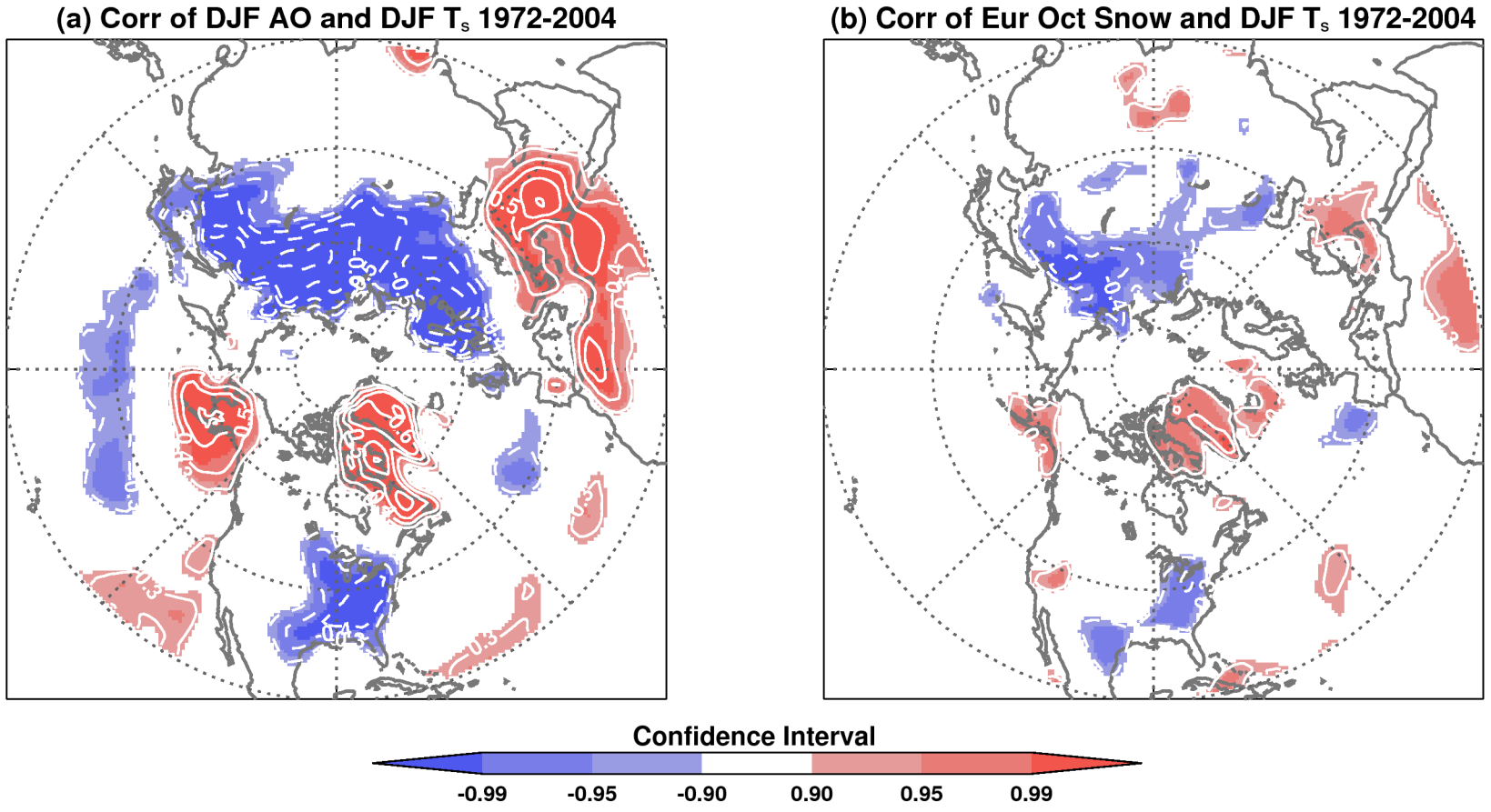
Below normal snow cover results in a net heating



Above normal snow cover results in a net cooling



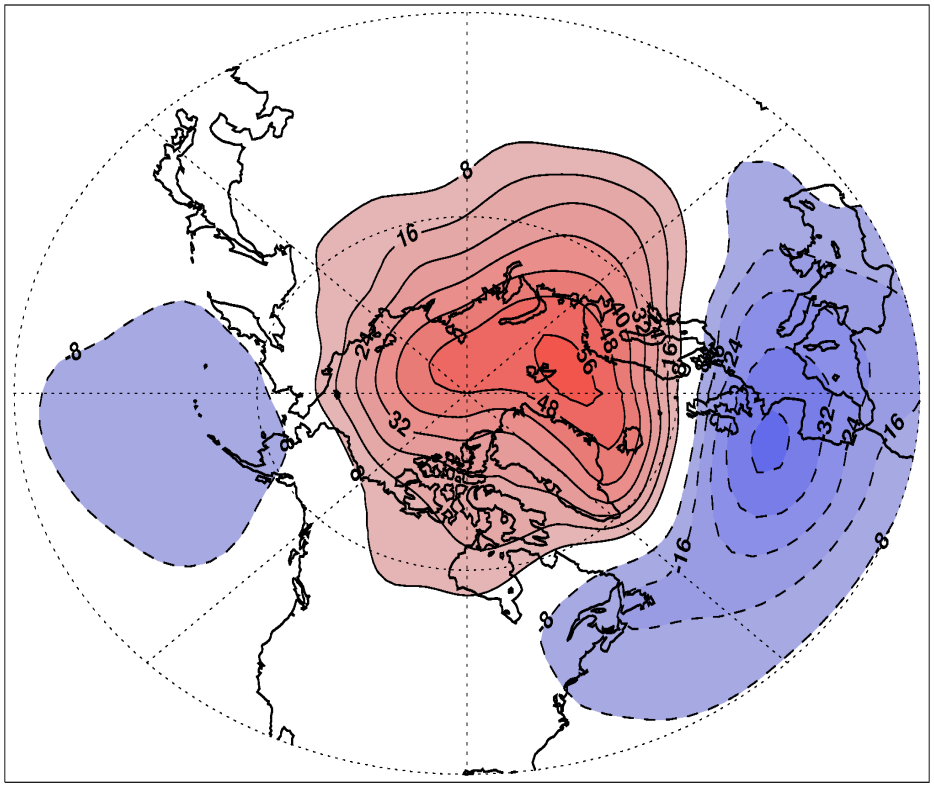
Correlation of October Snow and Surface Temperatures



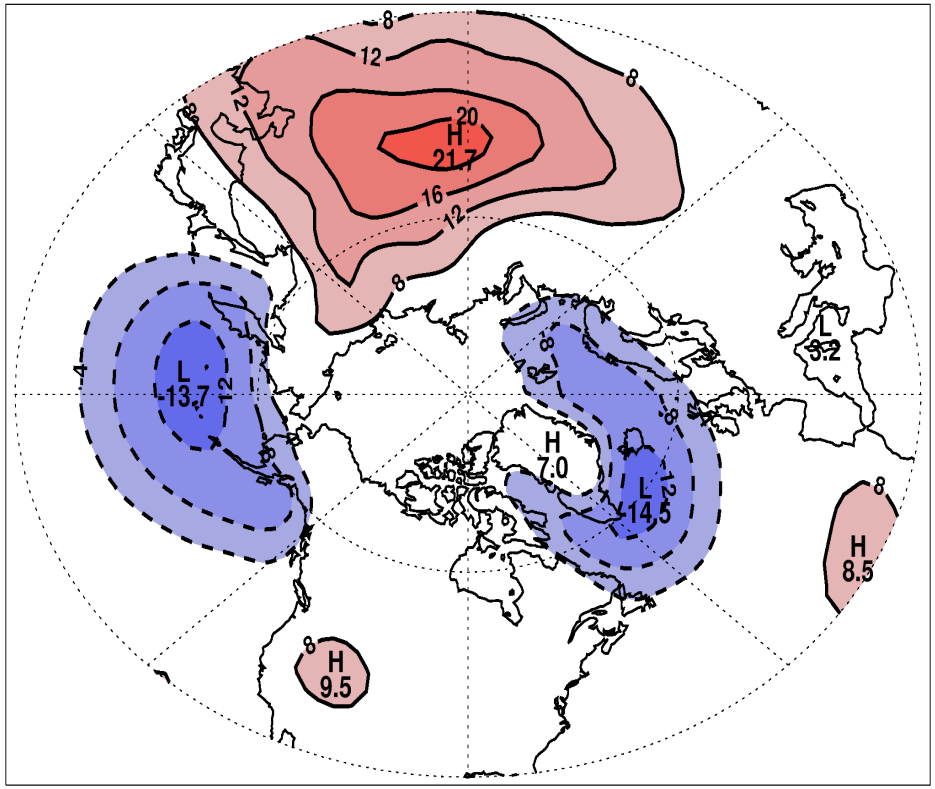
Eurasian snow cover significantly correlated with T_s in the eastern United States

Correlation of October Snow and Sea Level Pressure

First Mode of DJF SLP Variability 1972-2004



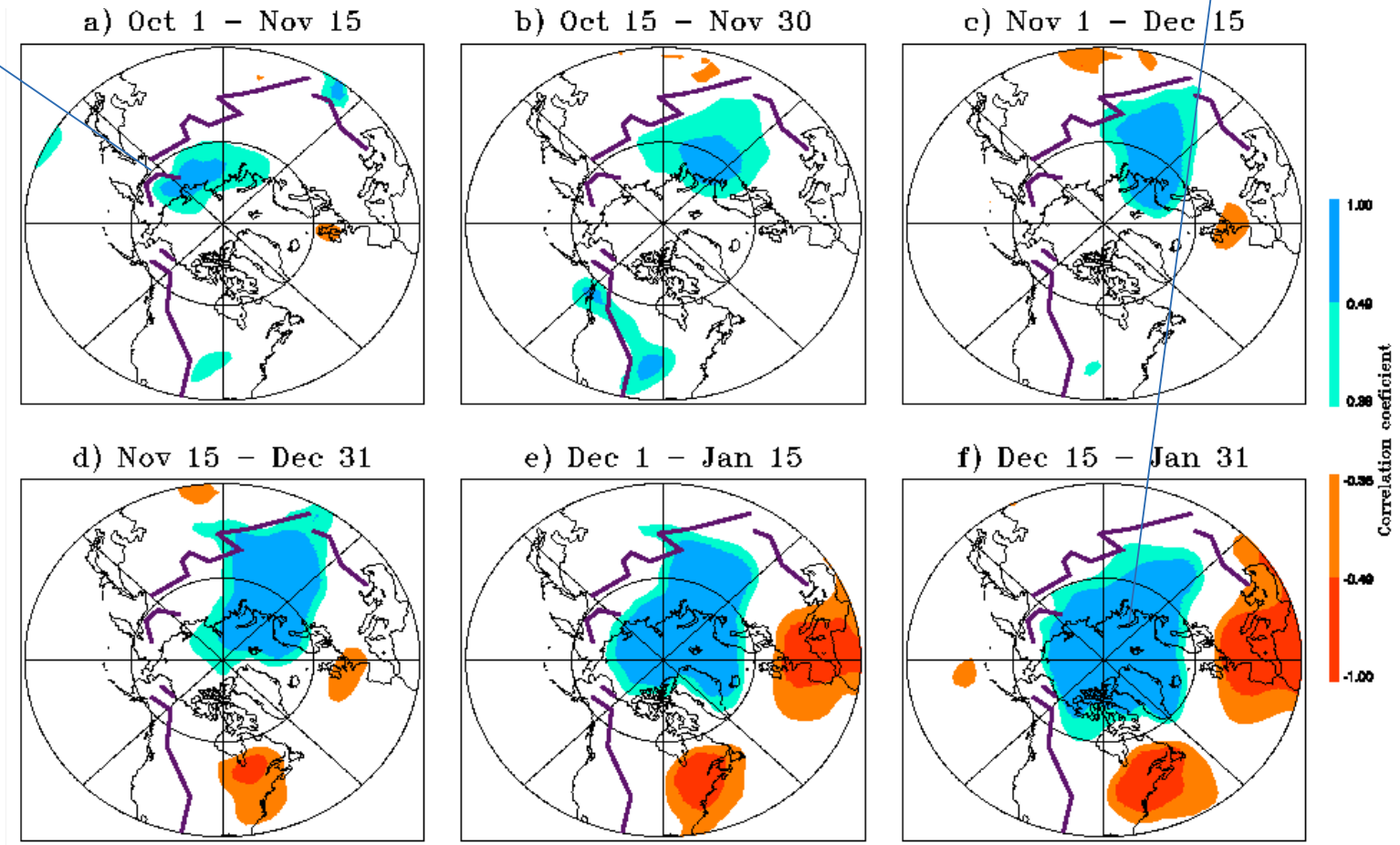
Mean Sea Level Pressure DJF



Arctic Oscillation is an index of the expansion and contraction of the Siberian High

Progression of Siberian High - from Regional to Hemispheric

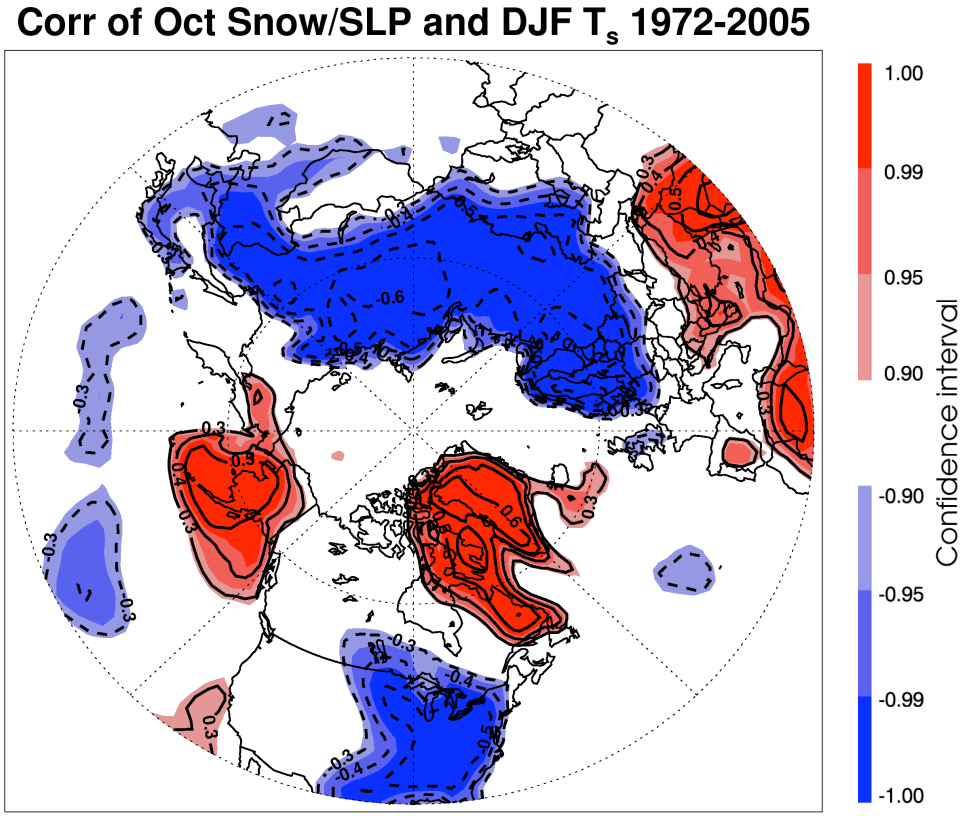
Winter AO events are preceded by same signed regional precursors related to the development of the Siberian High



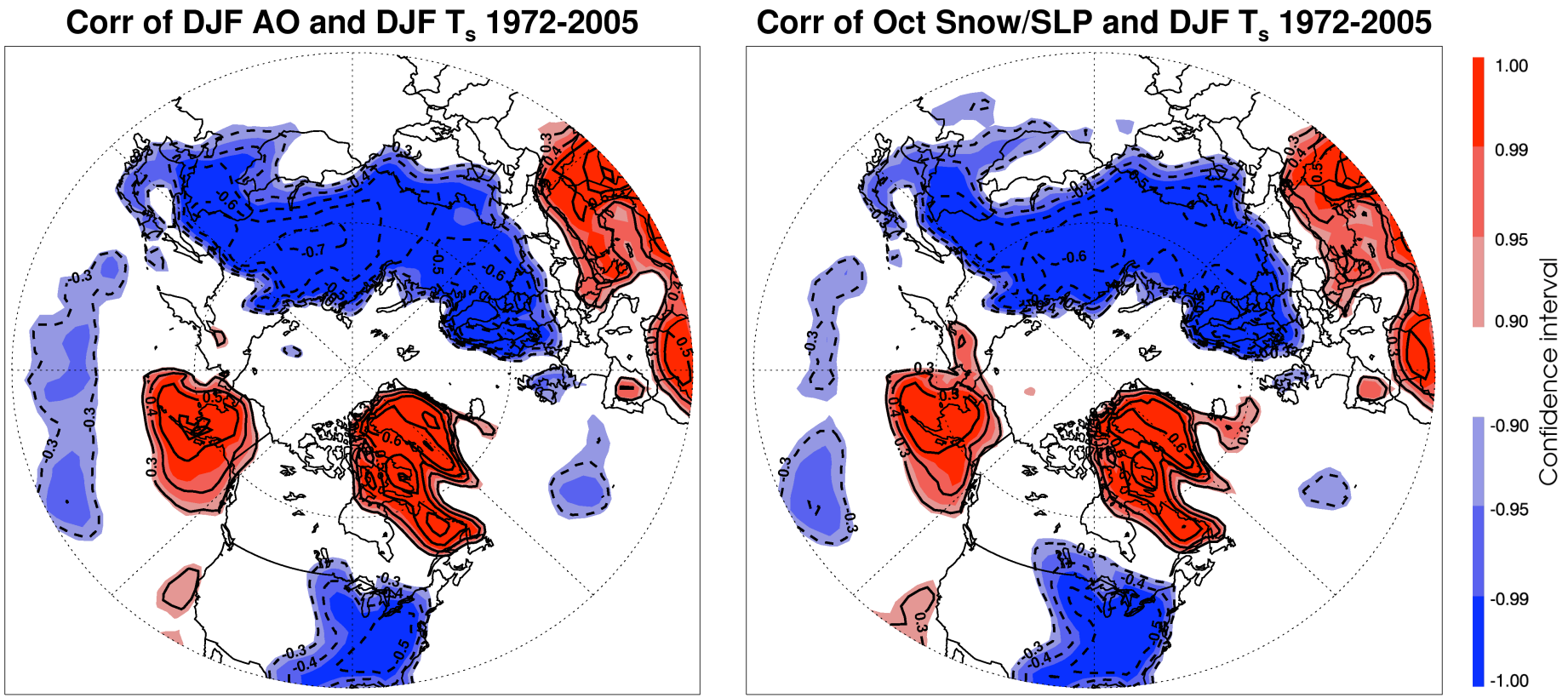
Shading represents sea level pressure anomalies averaged for 45 day periods

Correlation of October Snow/SLP index and Surface Temperatures

Eurasian snow/SLP index shows increased correlations when compared with simple snow index and includes significant correlations with Europe and the Mediterranean.



Correlation of October Snow/SLP index and Winter AO

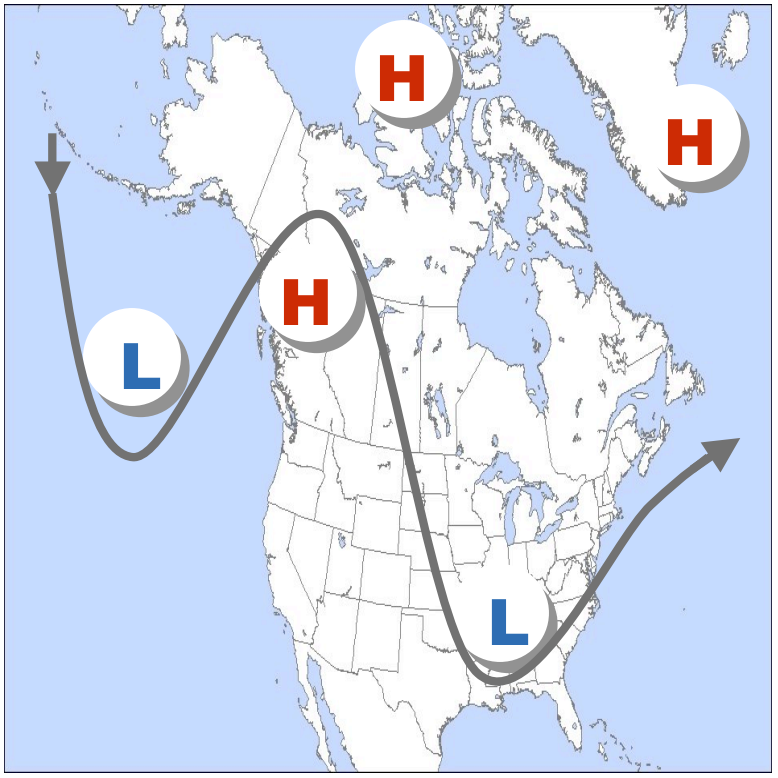


Siberia is the Refrigerator for the Northern Hemisphere

- Increased snow cover in the fall over Siberia leads to rapid development of Siberian High.

- Cold dense air needs to spread out, it is blocked to the south and east by high topographical barriers in Asia, so it spreads over the poles into North America and west into Europe.

- Once cold air is pooled over Canada it enters the lower 48 resulting in extended periods of increased frequency of Arctic outbreaks.



- Less snow means more low pressure over Siberia, which contracts and no cold air build-up over North America and extended periods where Arctic outbreaks do not occur.

AER Seasonal Forecast Model

Statistical model with three predictors for the winter months:

a) Eurasian October snow cover anomalies

b) Eurasian October sea level pressure anomalies lower tropospheric precursor seen in sea level pressure correlations with AO and correlation plot of STC index and geopotential height

c) Recent multi-annual trend

AER's Forecast Verification

- 7 years of real-time forecasts
- 34 years of hindcasts for sCast model

  – **Anomaly Correlation -** a measure of how well the forecast compares to the observations at one point for all the available forecasts. For the real-time forecasts there are a total of 7 forecasts and for the hindcasts there are 34 forecasts.

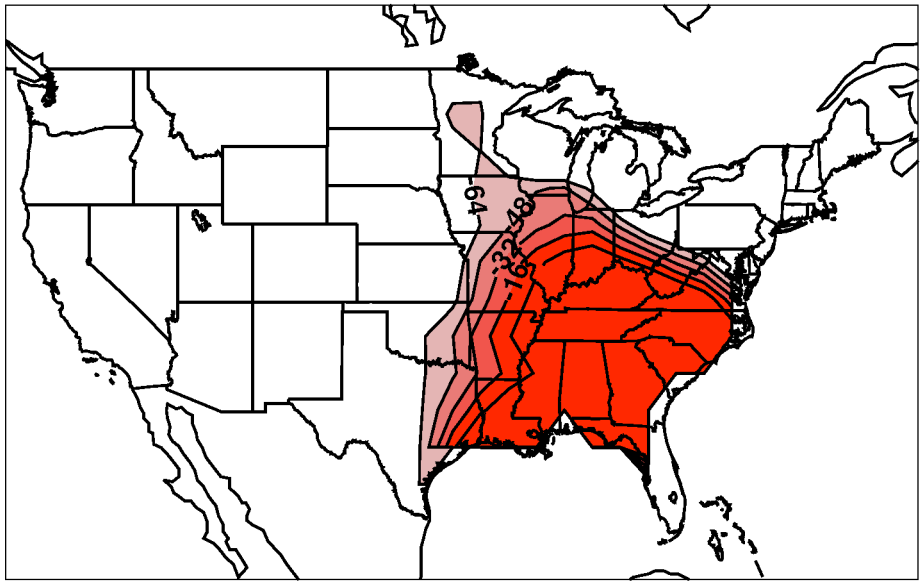
  – **Pattern Correlation -** provides one number that measures how well the large-scale pattern compares between the forecast and the observations for just one forecast.

  – **Skill Score**

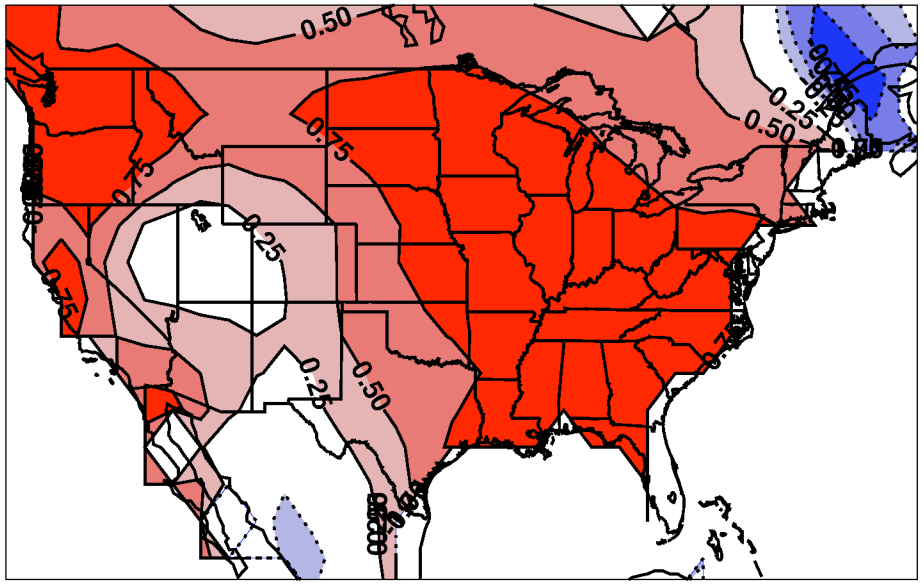
$$SS = \frac{MSE_{c\lim ato\log y} - MSE_{forecast}}{MSE_{c\lim ato\log y}}$$

sCast Forecasts RMSS & ACC

(a) Realtime RMSS



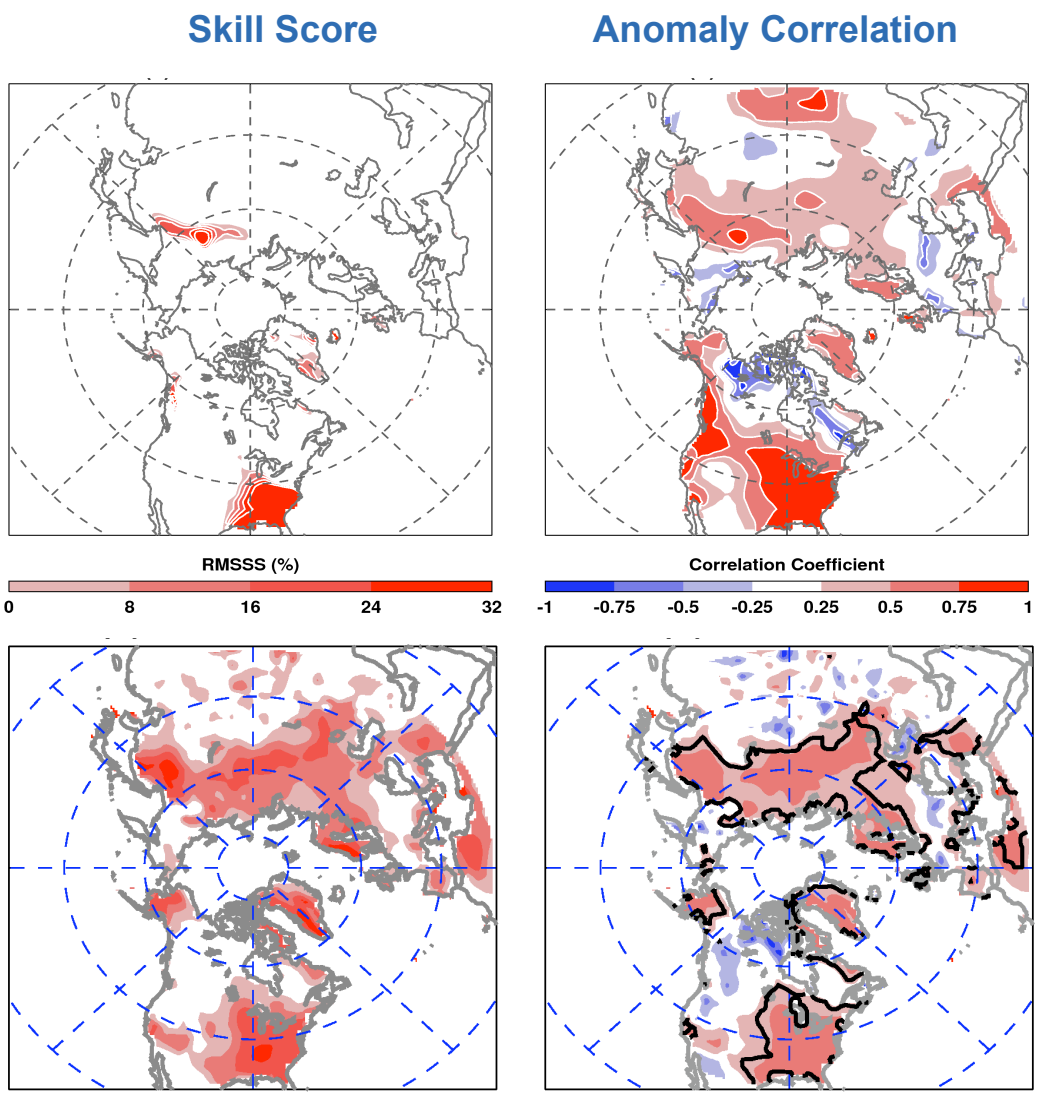
(b) Realtime ACC



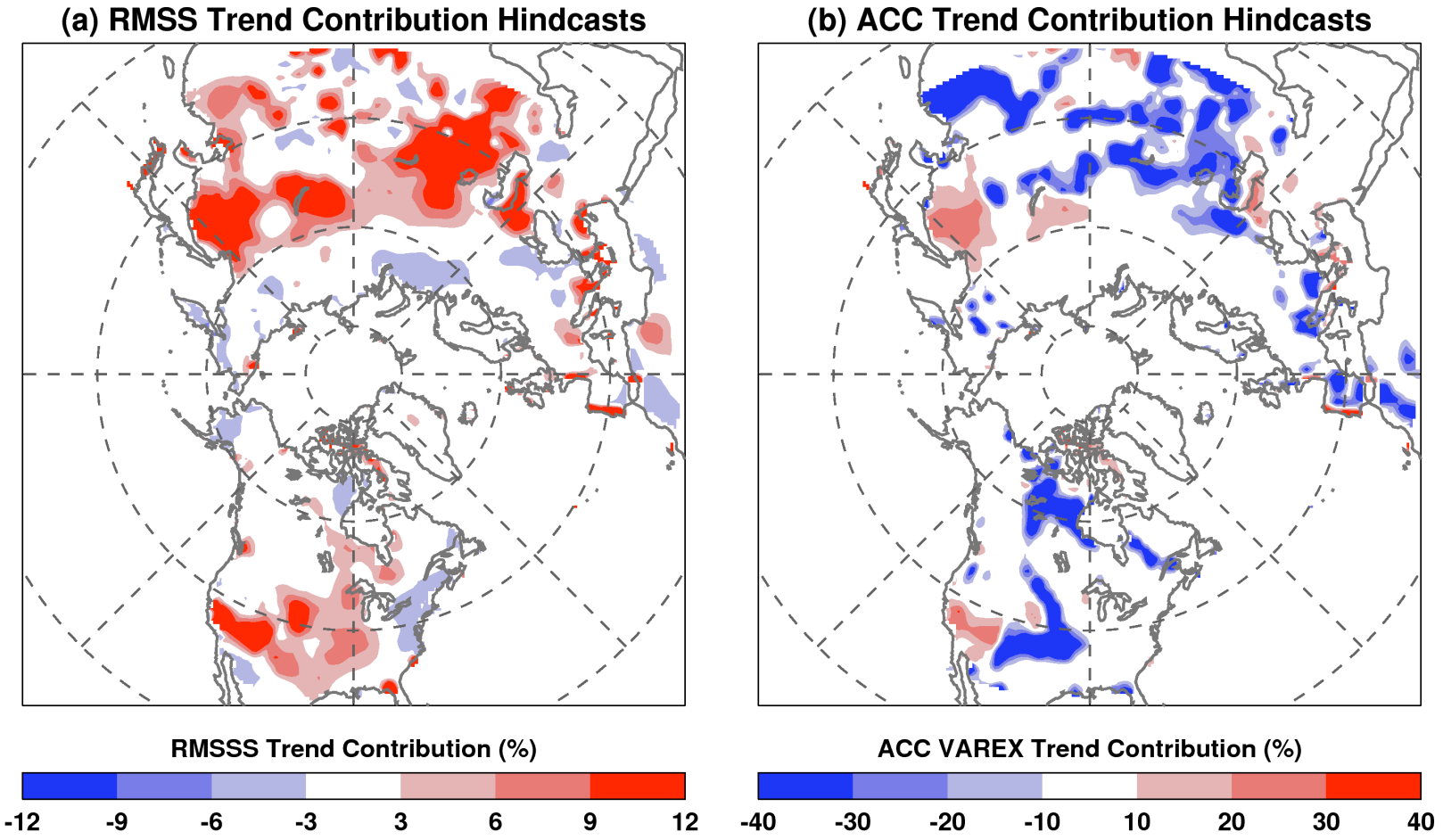
sCast Forecasts and Hindcasts

Forecasts:
sCast model

Hindcasts:
sCast model



Contribution from Trend



Contribution of positive skill from trend mostly outside the regions of high correlations with snow/SLP index

Forecast Skill Comparison

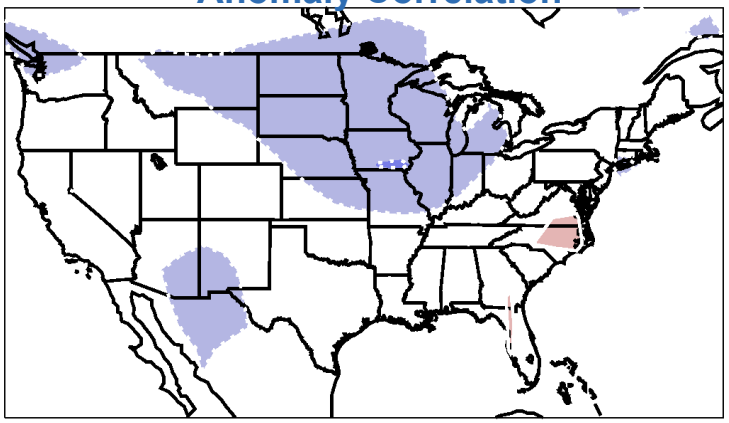
- AER statistical model - skill is mostly derived from Siberian snow cover and atmospheric precursors

- Dynamical models used by leading government forecast centers - skill is mostly derived from ENSO phenomenon (though models are complex and try to capture many ocean/atmosphere processes).

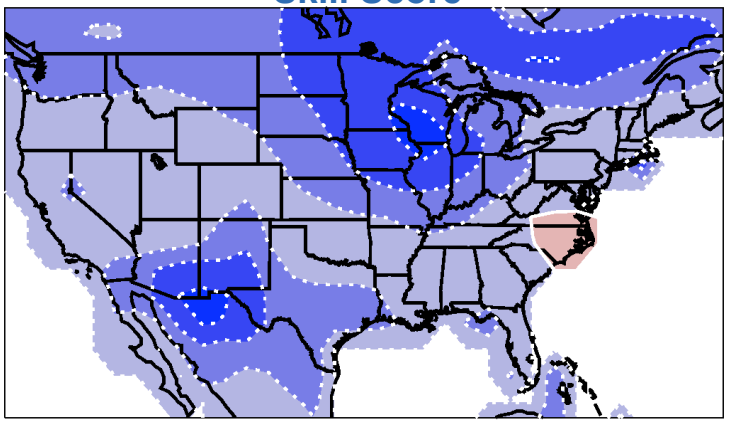
Forecast Verification
US Skill Score sCast & CPC

CPC compared with climatology

Anomaly Correlation

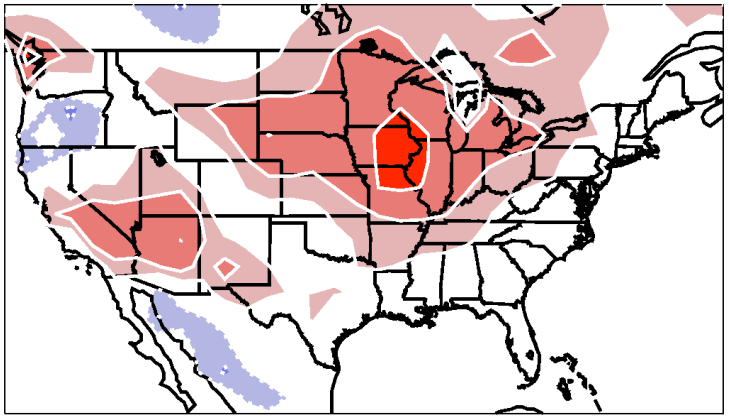


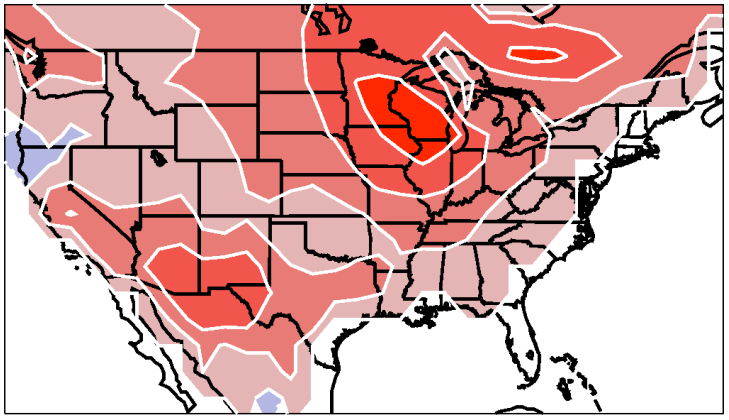
Skill Score

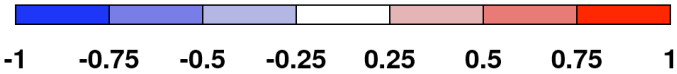


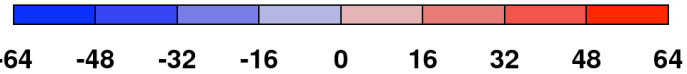
Areas shaded in "red" depict where the CPC model has skill.

CPC compared with sCast model







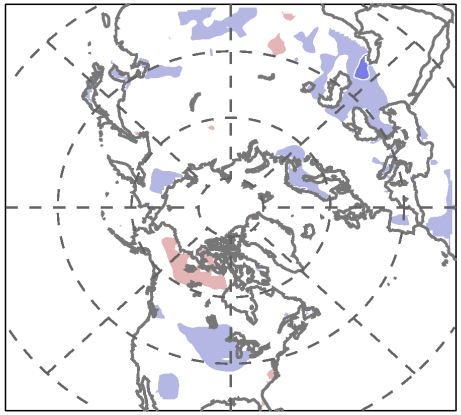


Areas shaded in "red" depict superior skill of AER model

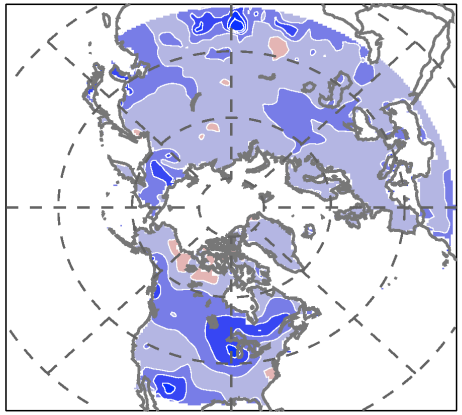
Forecast Verification
NH Skill Score sCast & CPC

CPC compared with climatology

Anomaly Correlation



Skill Score



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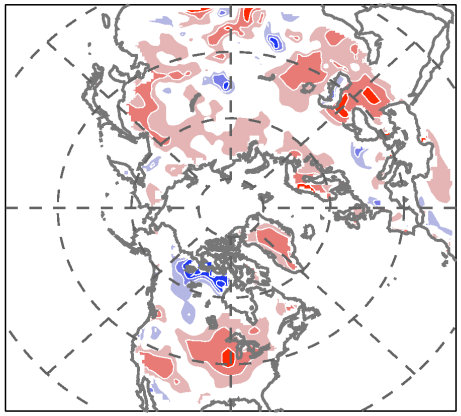
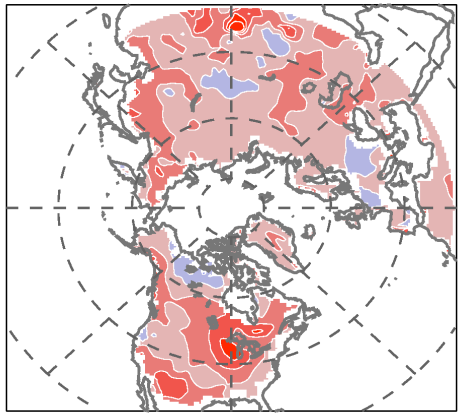
CPC compared with sCast model





Correlation Coefficient

-1 -0.75 -0.5 -0.25 0.25 0.5 0.75 1

RMSSS (%)

-64 -32 0 32 64

Areas shaded in"red" depicts superior skill of AER model

Summary

- Land and ocean are key predictors when trying to produce a skillful seasonal forecast.

- For winter forecasts, Siberian snow cover and lower tropospheric precursors are skillful predictors.

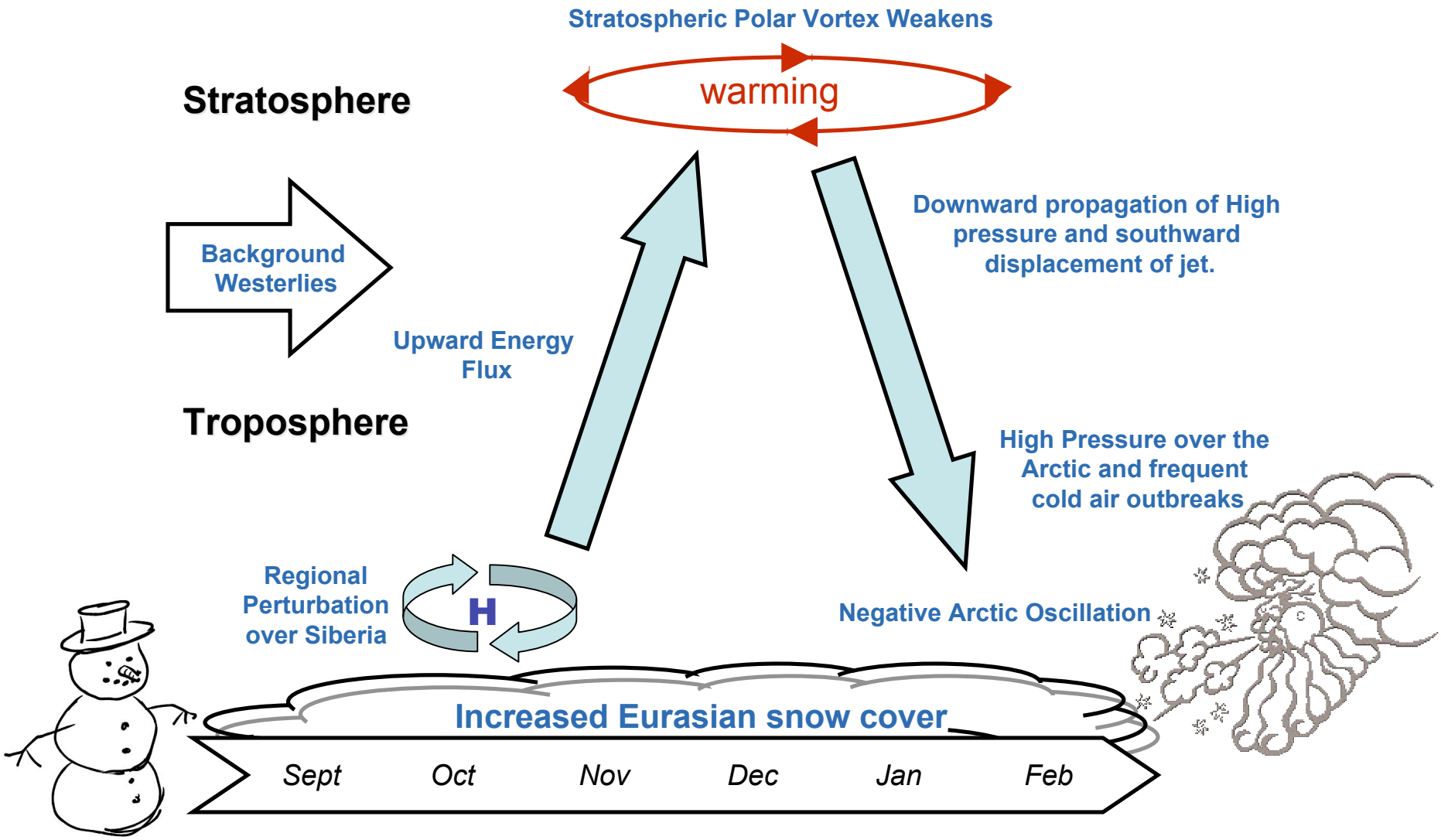
- Early fall anomalies result in large-scale wave propagation during the late fall/early winter, which is instrumental in forcing the dominant mode of wintertime, extratropical NH climate variability.

- Operational real-time winter forecasts, show positive skill for the eastern US and northern Eurasia; areas not well predicted by ENSO.

- Hindcasts also show positive skill and higher skill than dynamical models at the leading operational forecast centers in the same locations.

- Dynamical models can be improved to capture described processes.

Snow Forced Cold Signal

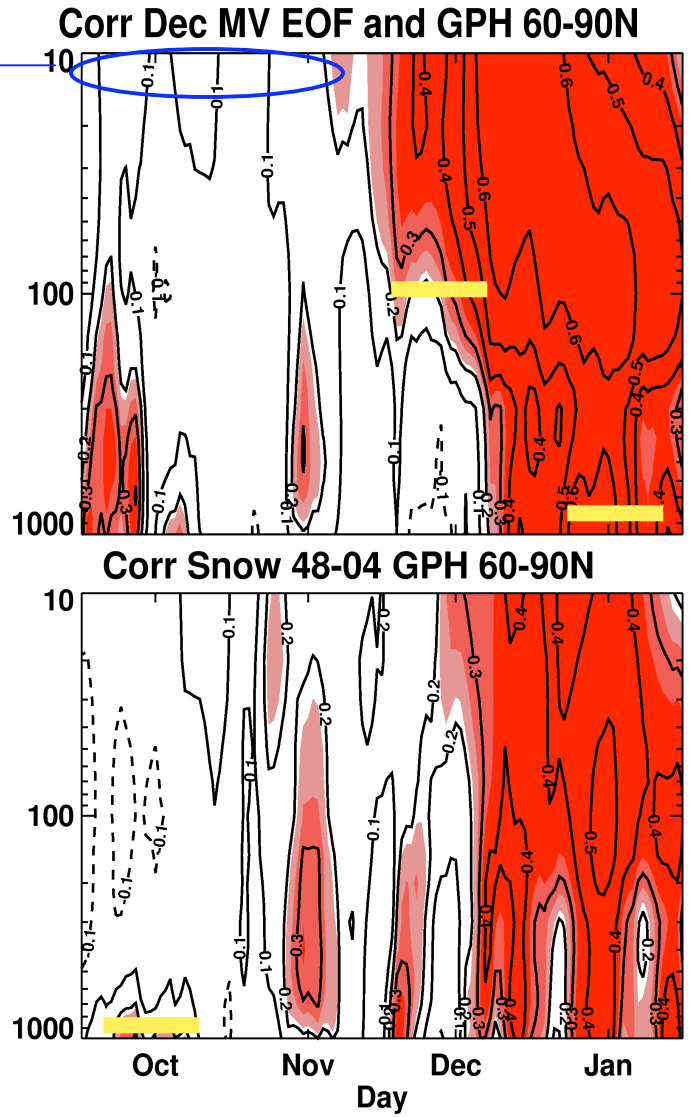


Connecting Snow & Strat-Trop Interactions

No prior information at time of forecast

Polar-Cap Z
&
Srat-Trop
Coupling Index

Polar-Cap Z
&
October Snow



Papers in Press

Cohen, J., and C. Fletcher, 2007: Improved Skill for Northern Hemisphere winter surface temperature predictions based on land-atmosphere fall anomalies. *J. Climate*, in press.

Cohen, J., M. Barlow, P. Kushner and K. Saito 2007: Stratosphere-Troposphere coupling and links with Eurasian Land-Surface Variability *J. Climate*, in press.

http://web.mit.edu/jlcohen/www/papers.html