Improved winter forecasts

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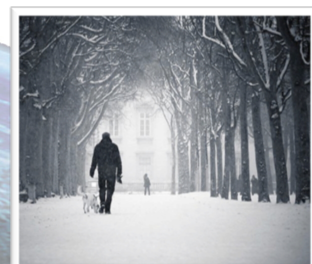
Justin Jones and Jason Furtado
March 26, 2014

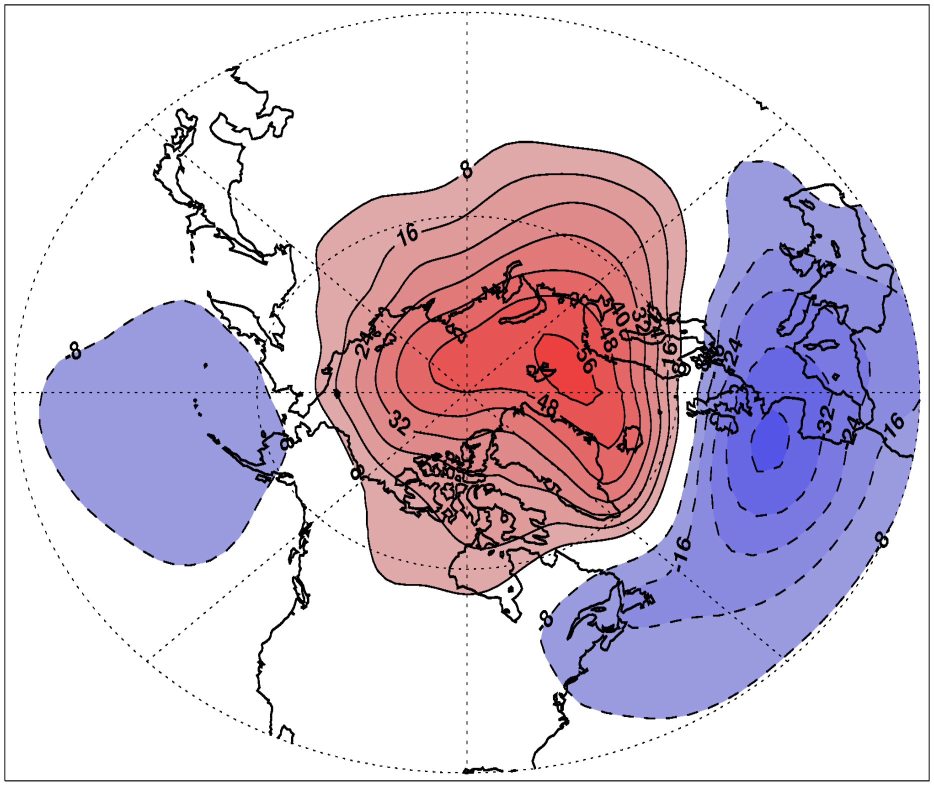


Outline

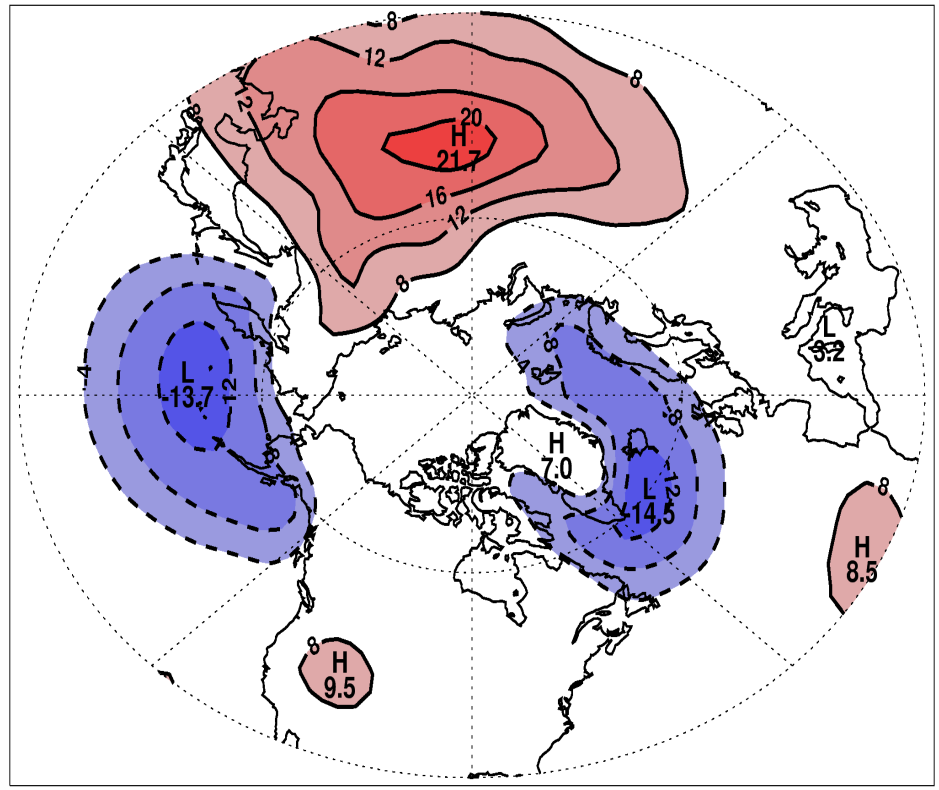
- Summary of old snow index and develop a six-step process how snow cover influences winter climate.
- Introduce a new snow advance index (SAI) that is much more highly correlated with winter climate variables.
- Present skill scores using the SAI in hindcasts and bundling the SAI with other statistical predictors for both temperature and precipitation.
- Examples of real-time forecasts for past three winters.
- Discuss this past winter and the "polar vortex."

Winter variability and centers of action

First Mode of DJF SLP Variability 1972-2004



Mean Sea Level Pressure DJF



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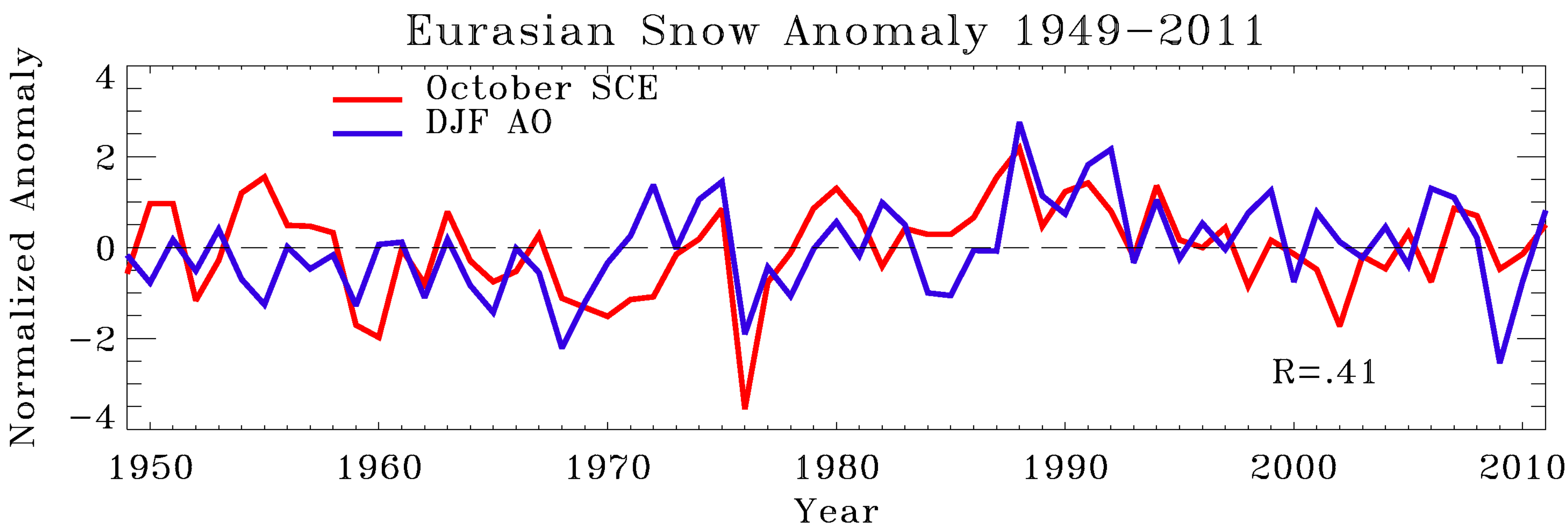
Simple Correlation Suggests Snow – Arctic Oscillation (AO) Relationship



Cohen and Entekhabi (1999)

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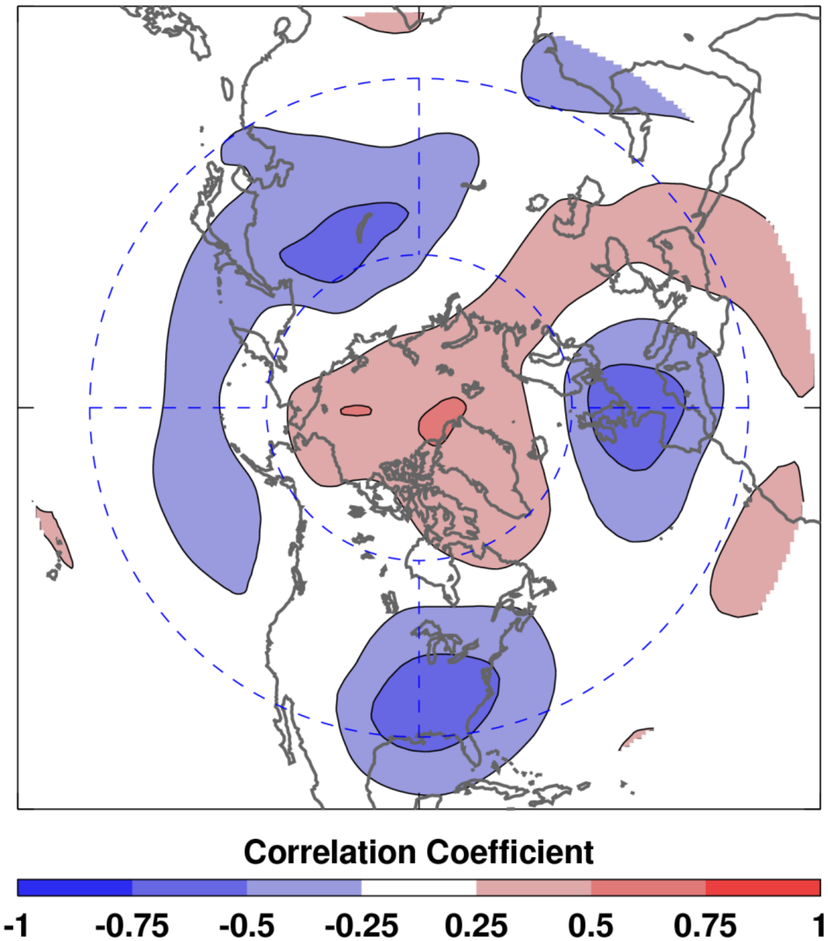
Tropospheric Response to Snow Forcing

r (SON Eurasian Snow, DJF Z500)



Cohen and Entekhabi [1999]

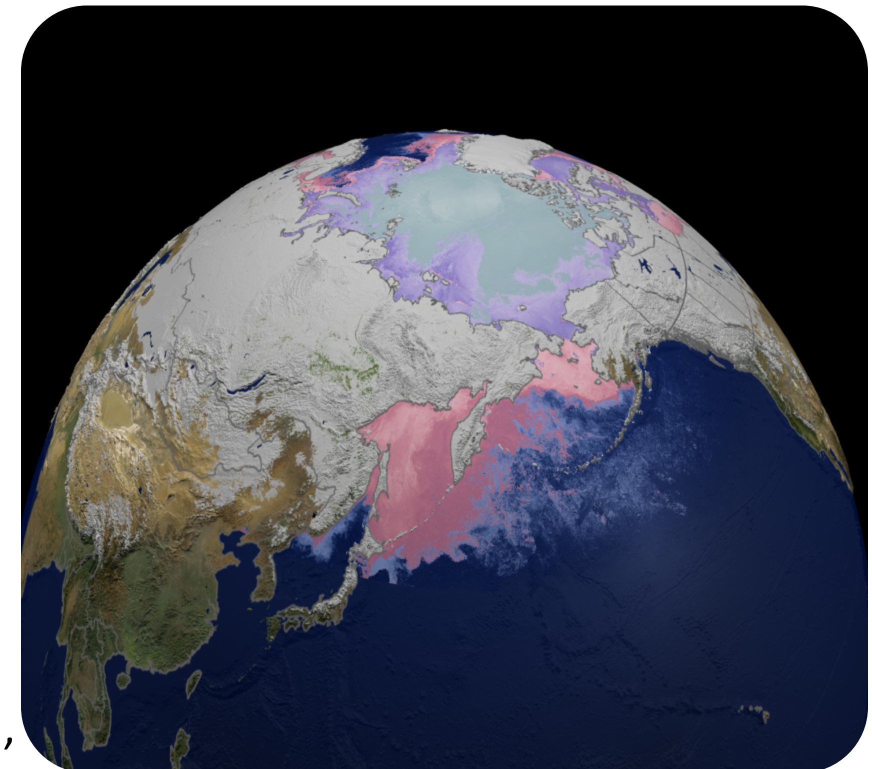
Siberia is the Refrigerator for the Northern Hemisphere

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.



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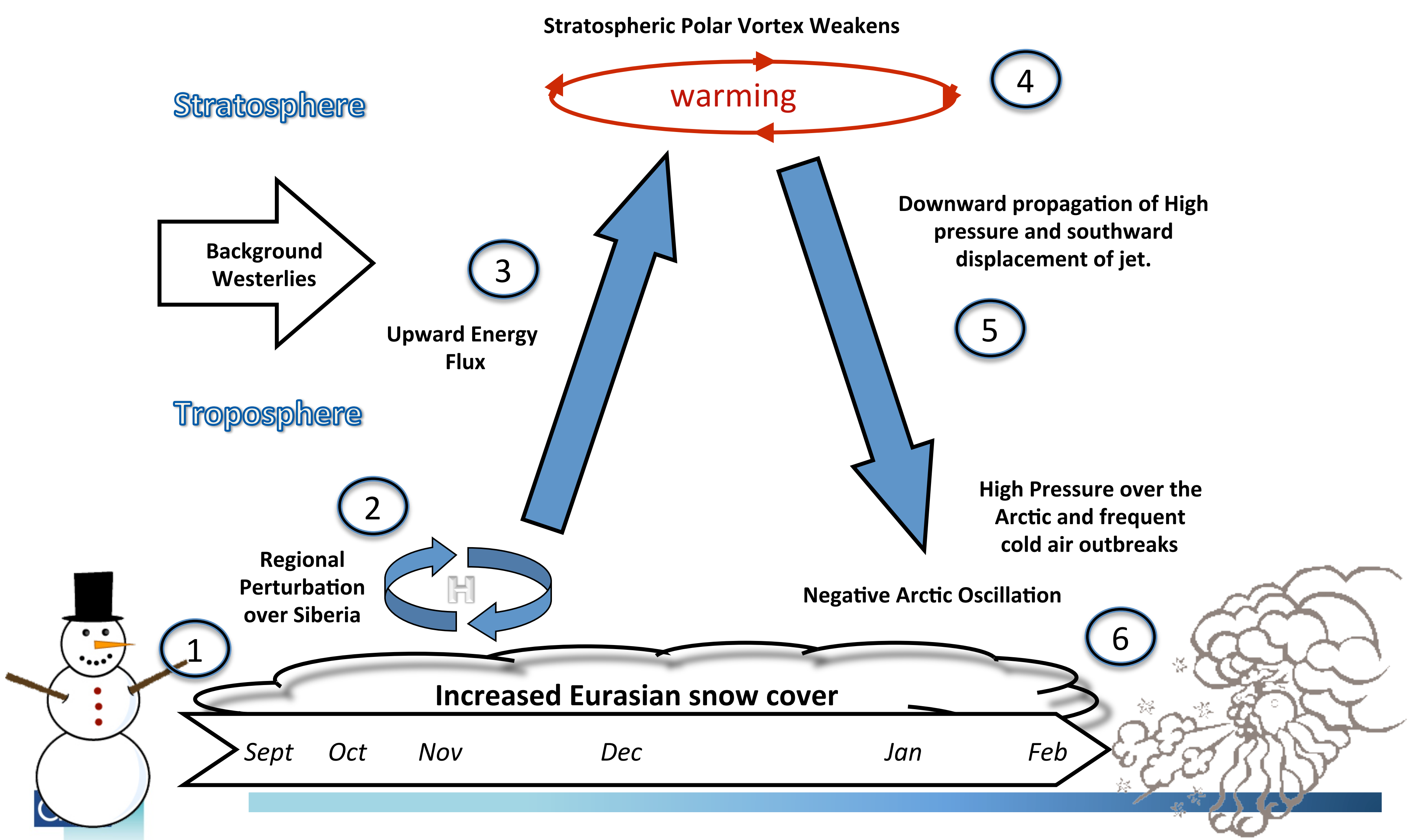
Snow Forced Cold Signal



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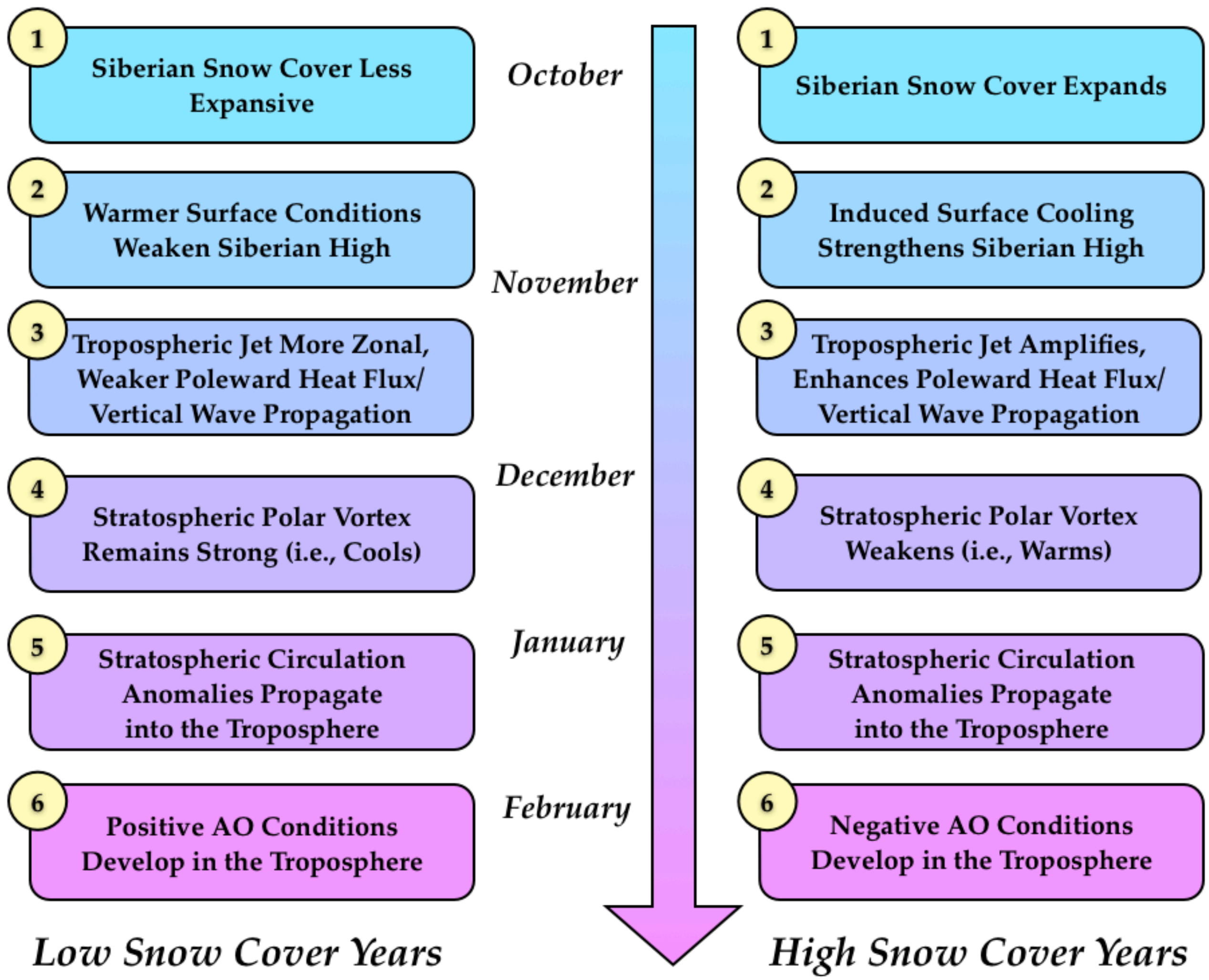
Climate Response to Snow Forcing

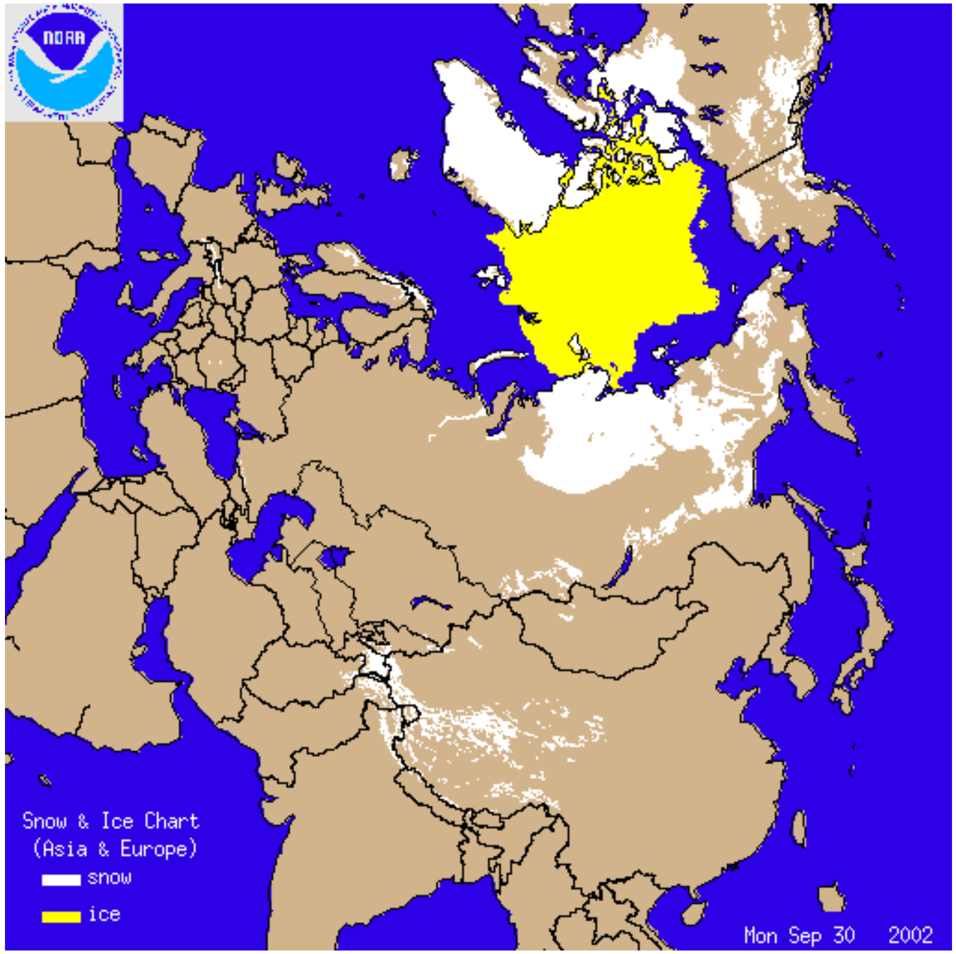


Two Paradigm winters:

- 1988/89 - low October Siberian snow cover and strongly positive winter AO
- 2009/10 – high October Siberian snow cover and strongly negative winter AO

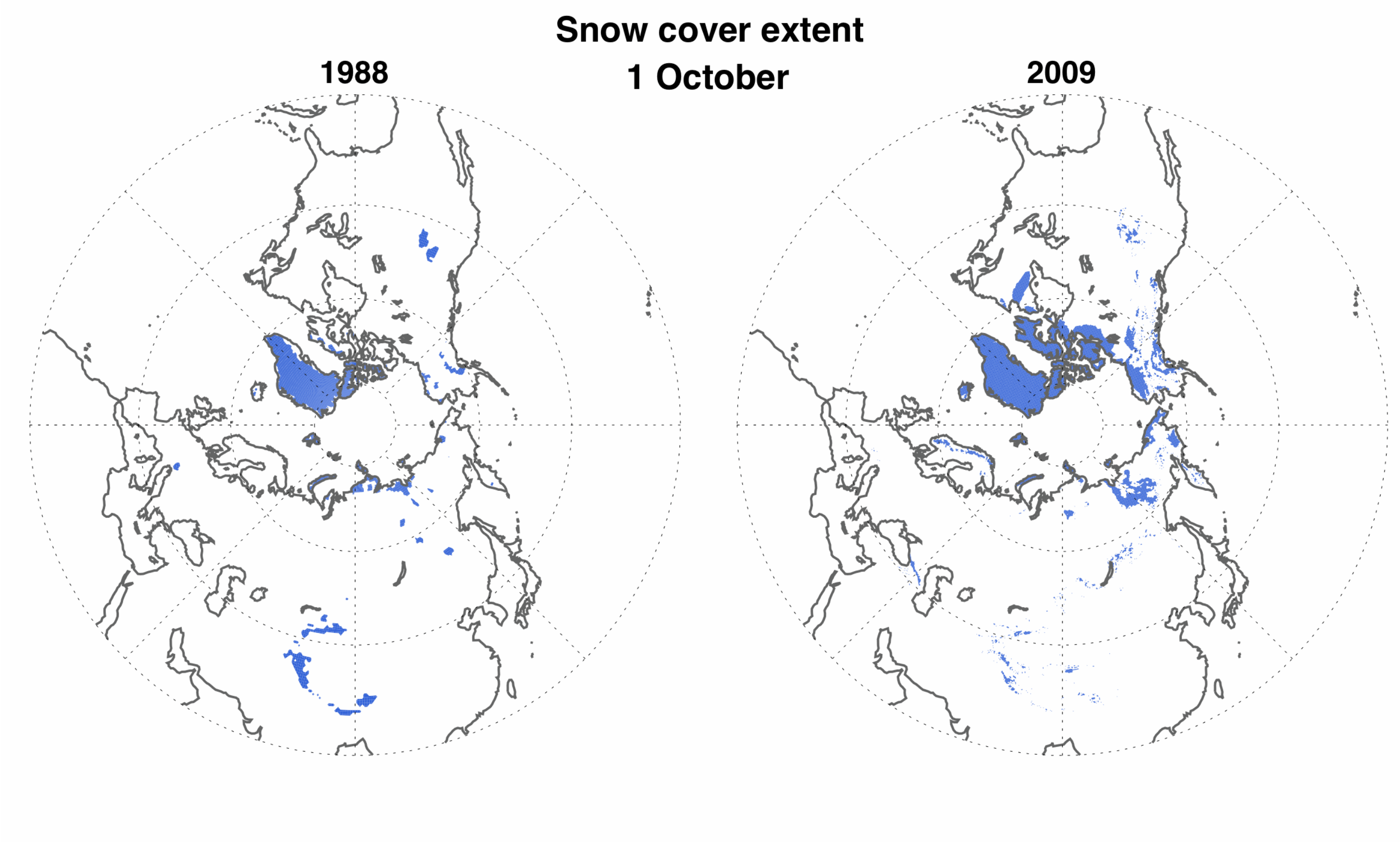
(1) Variability in Siberian Snow

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

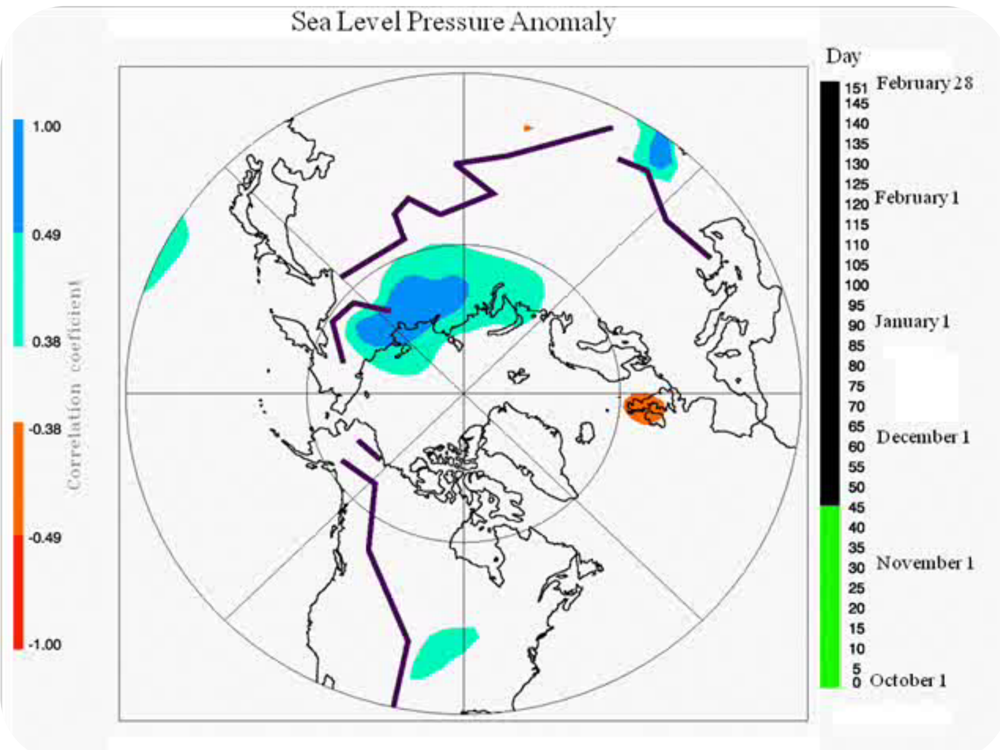


(1) Variability in Siberian Snow

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



(2) 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

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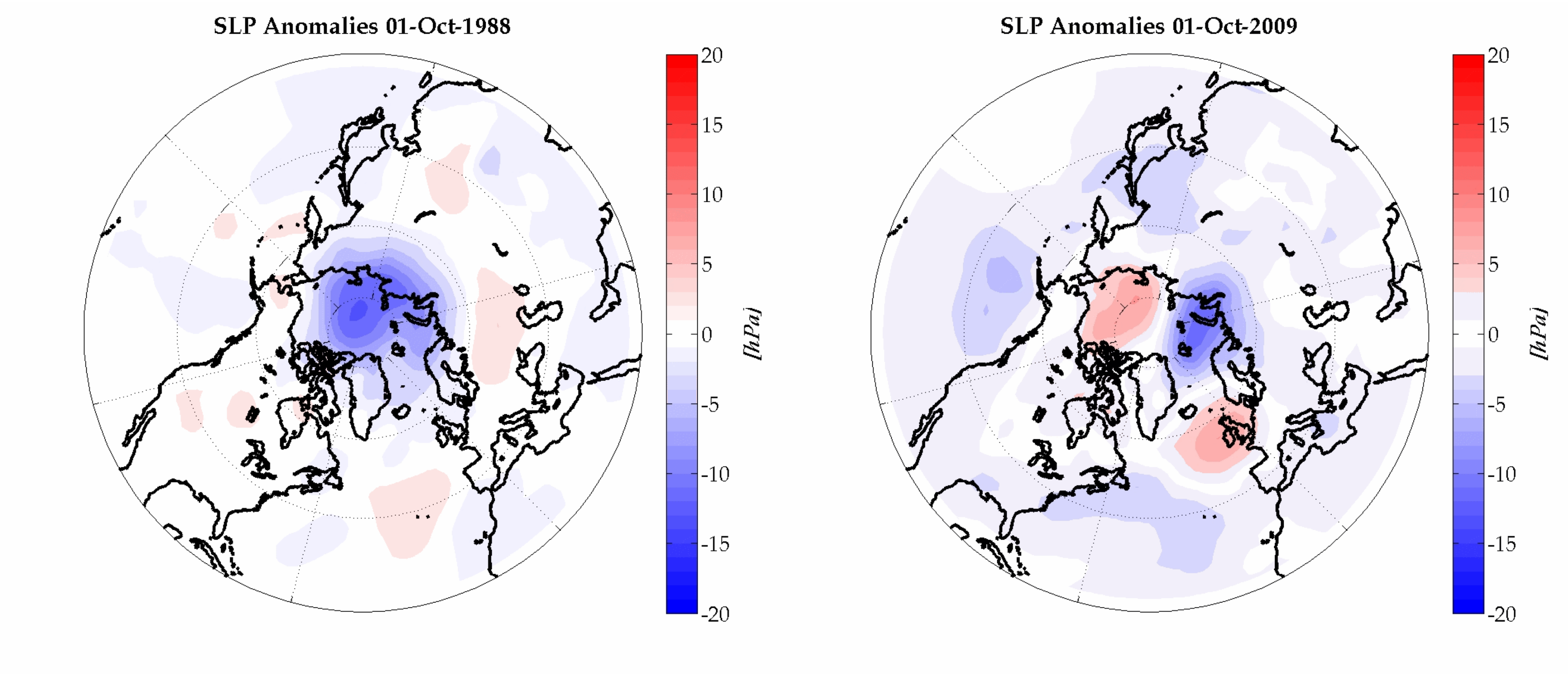
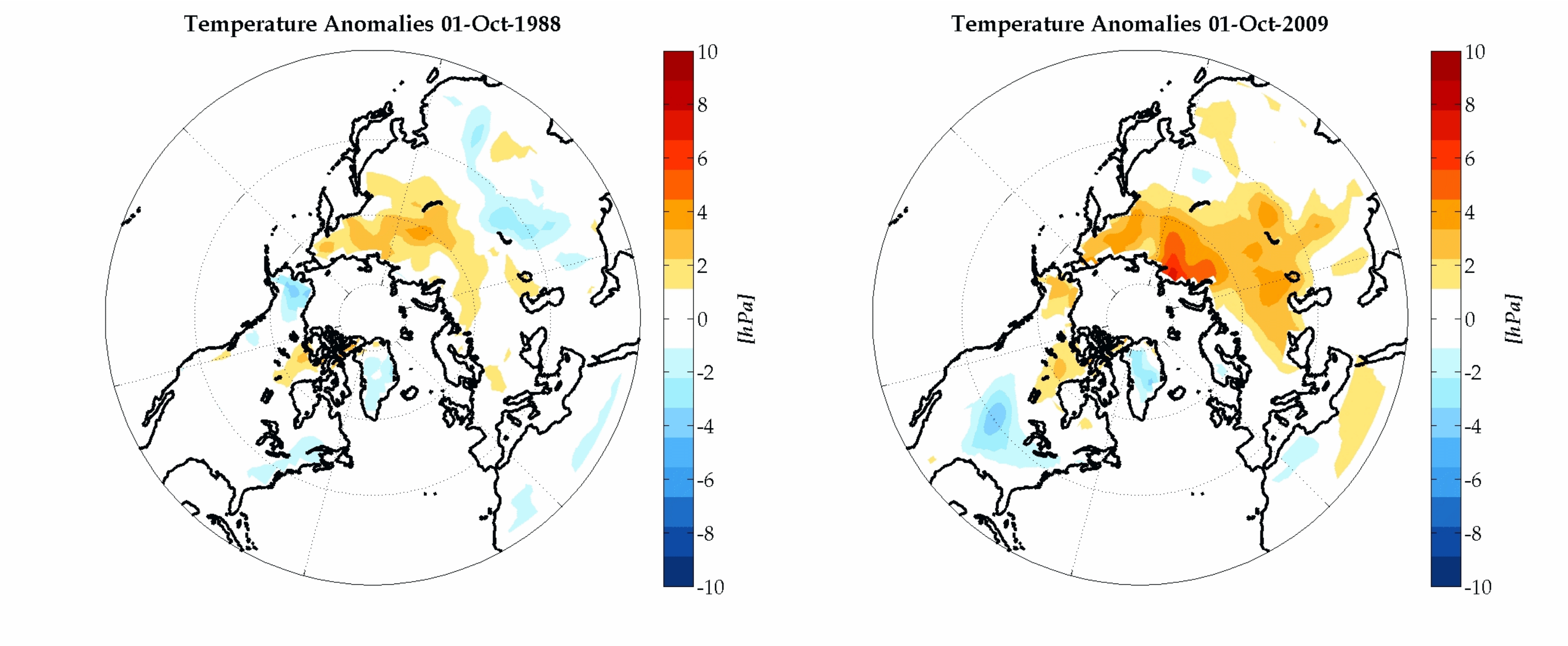
(2) Progression of Siberian High – from Regional to Hemispheric



Shading represents sea level pressure anomalies averaged for 20 day periods

(2) Progression of temperature anomalies associated with the Siberian High – from Regional to Hemispheric



Shading represents temperature anomalies averaged for 20 day periods

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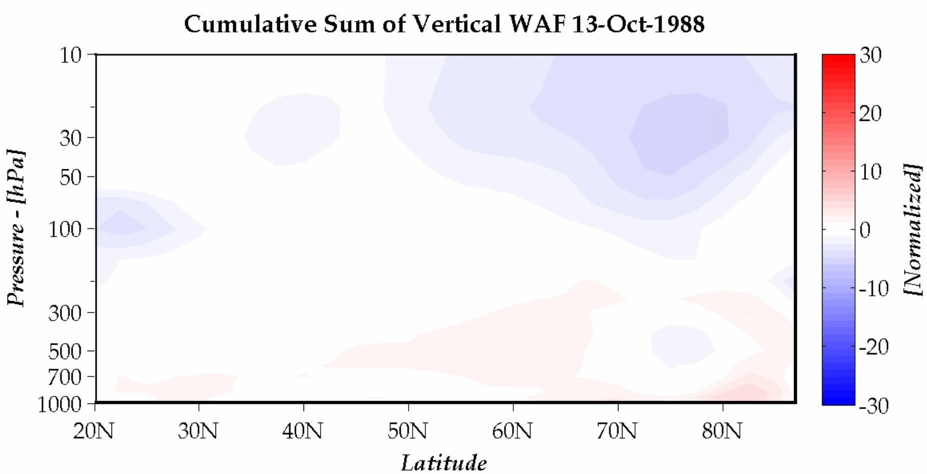
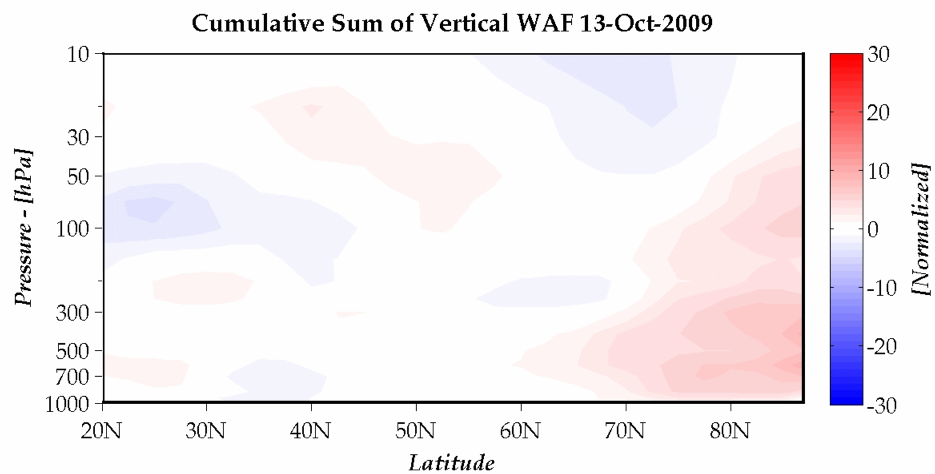
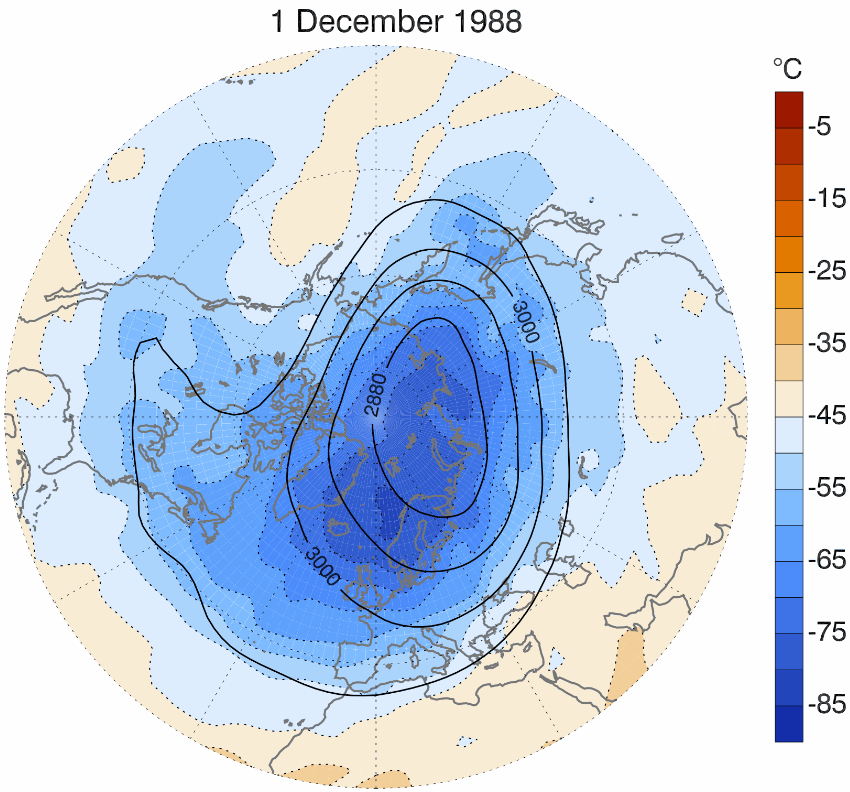
(3) Response in Wave Activity Flux



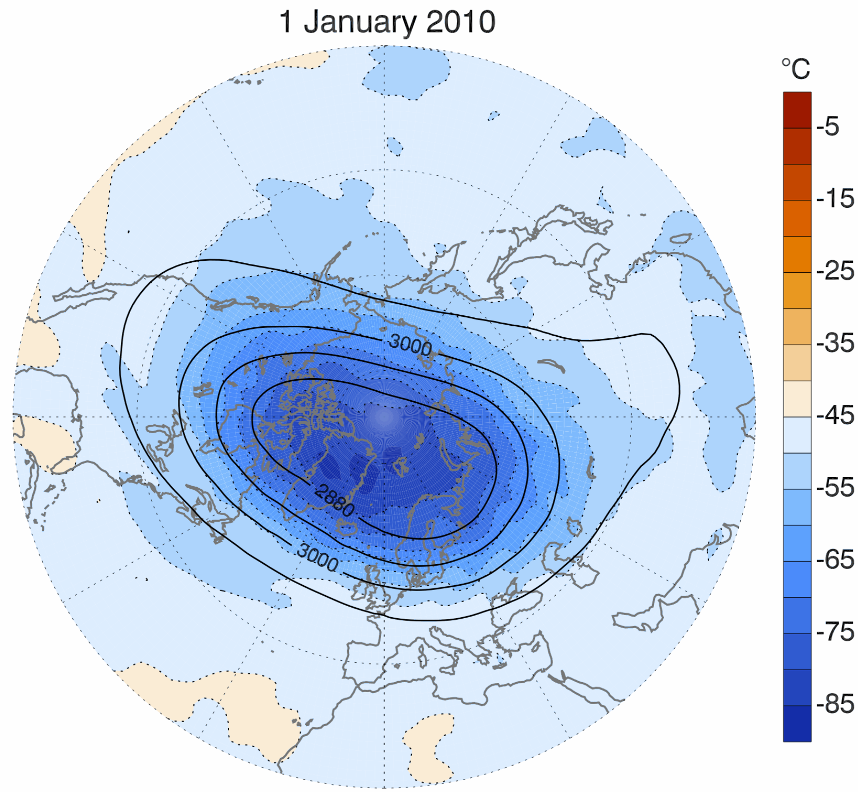


Shading represents accumulative anomalies through the shown date

(4) Stratospheric polar vortex strengthening (cold)/weakening (warm)



Atmospheric and Environmental Research (AER)



Atmospheric and Environmental Research (AER)

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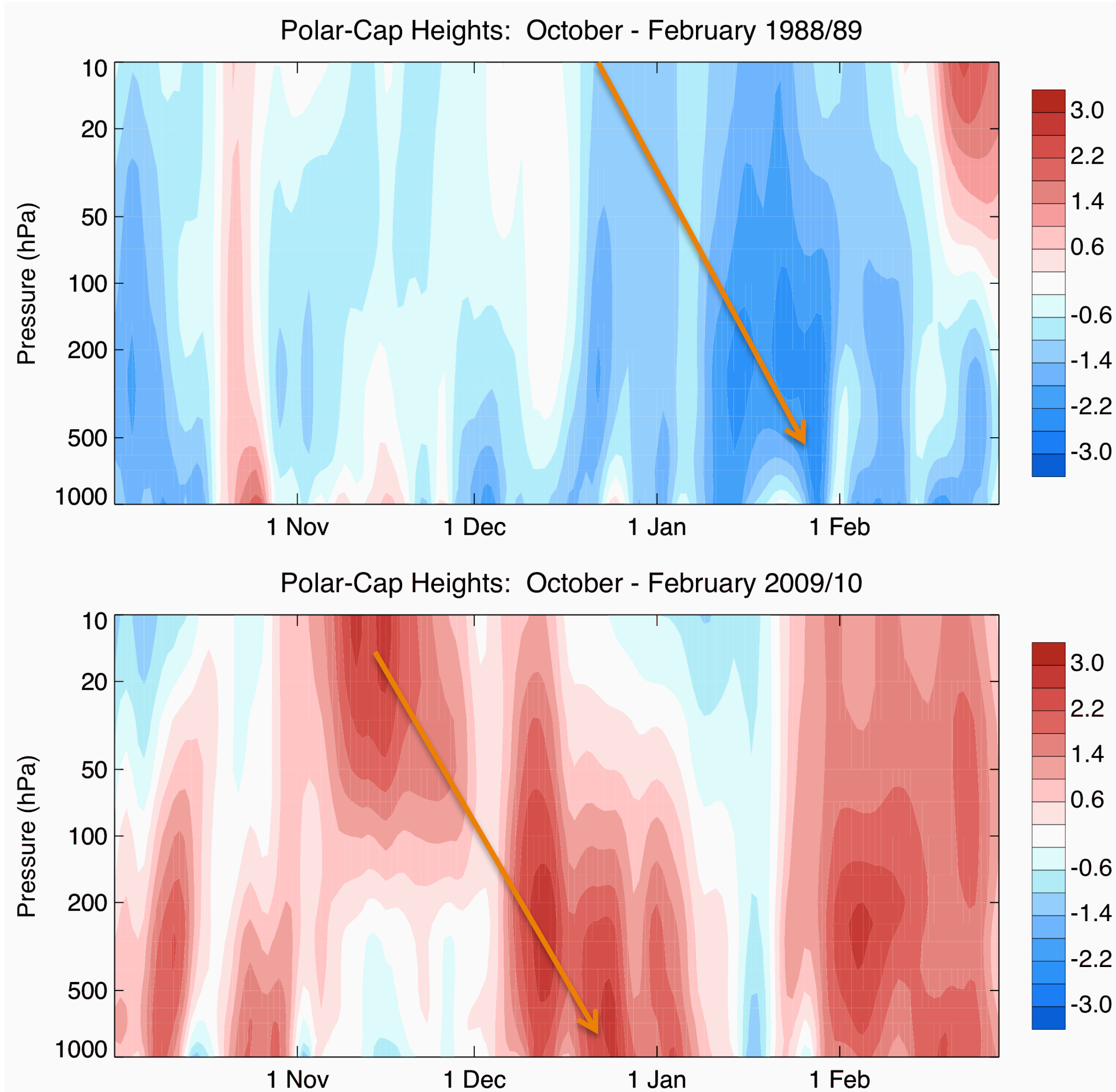
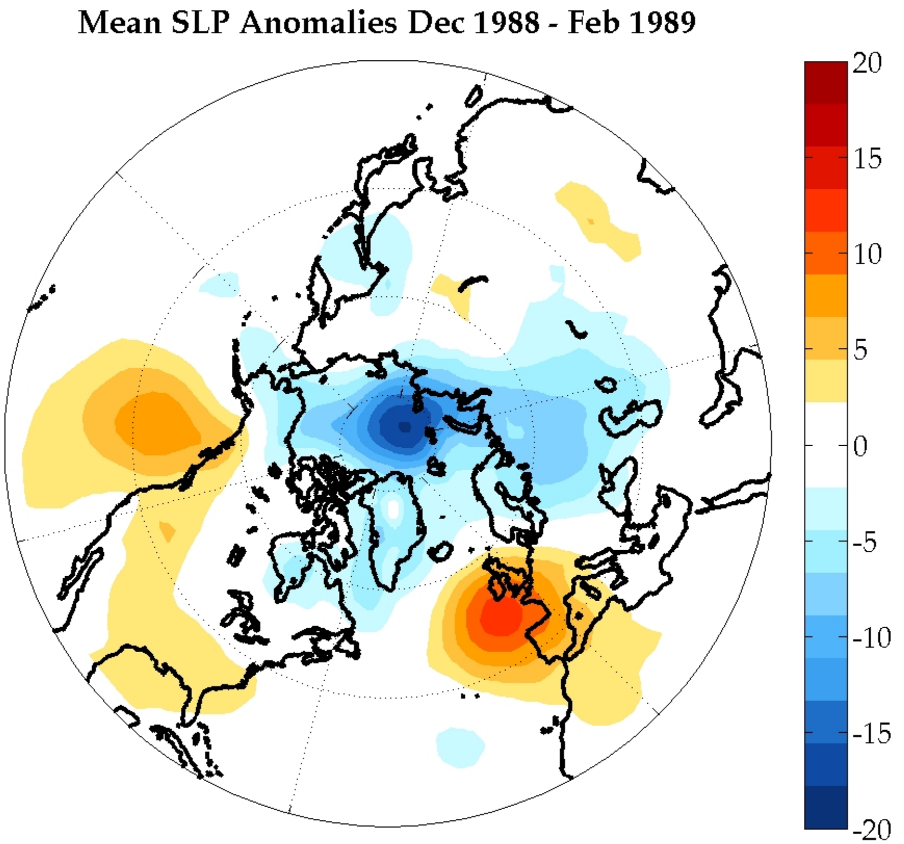
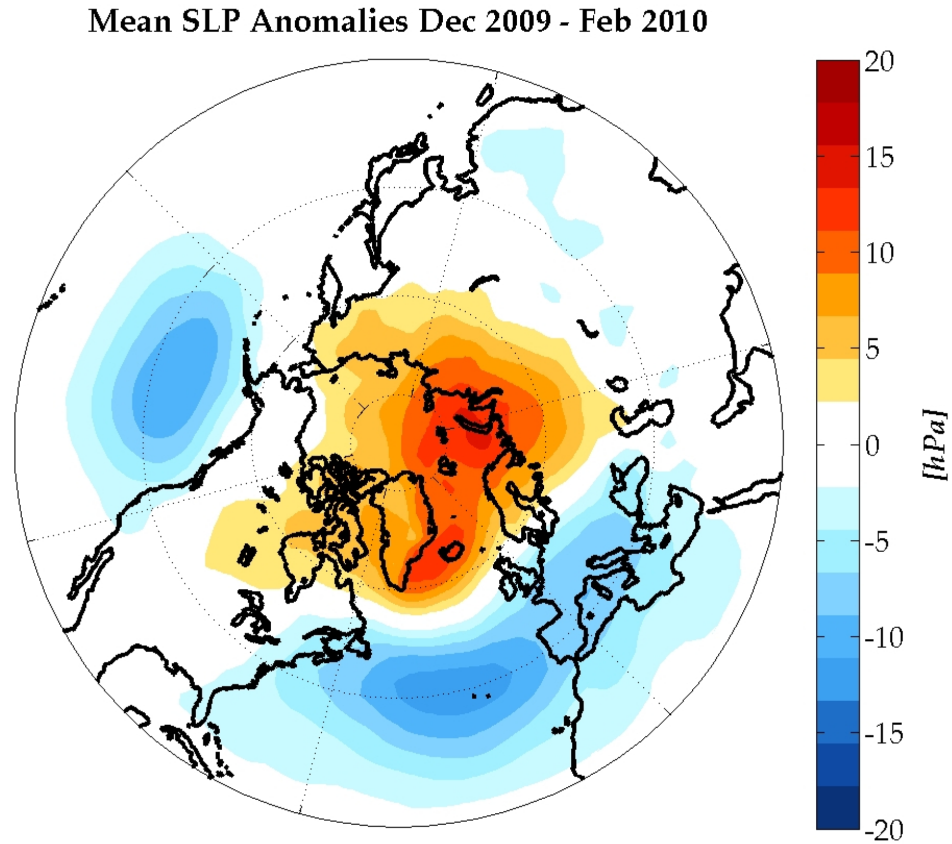
(5) Downward propagation of circulation anomalies



(6) Positive/negative phase of the AO- sea level pressure





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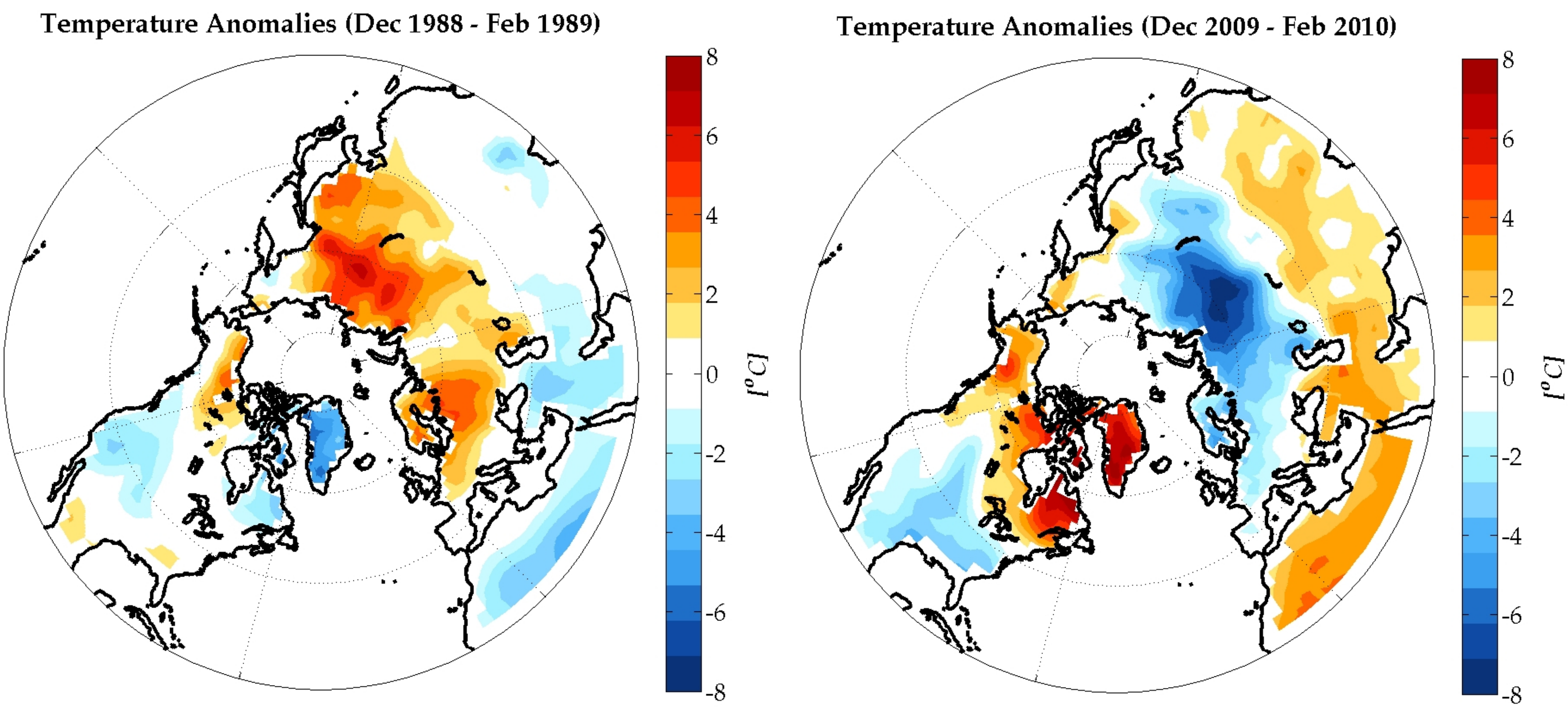
(6) Positive/negative phase of the AO – surface temperatures



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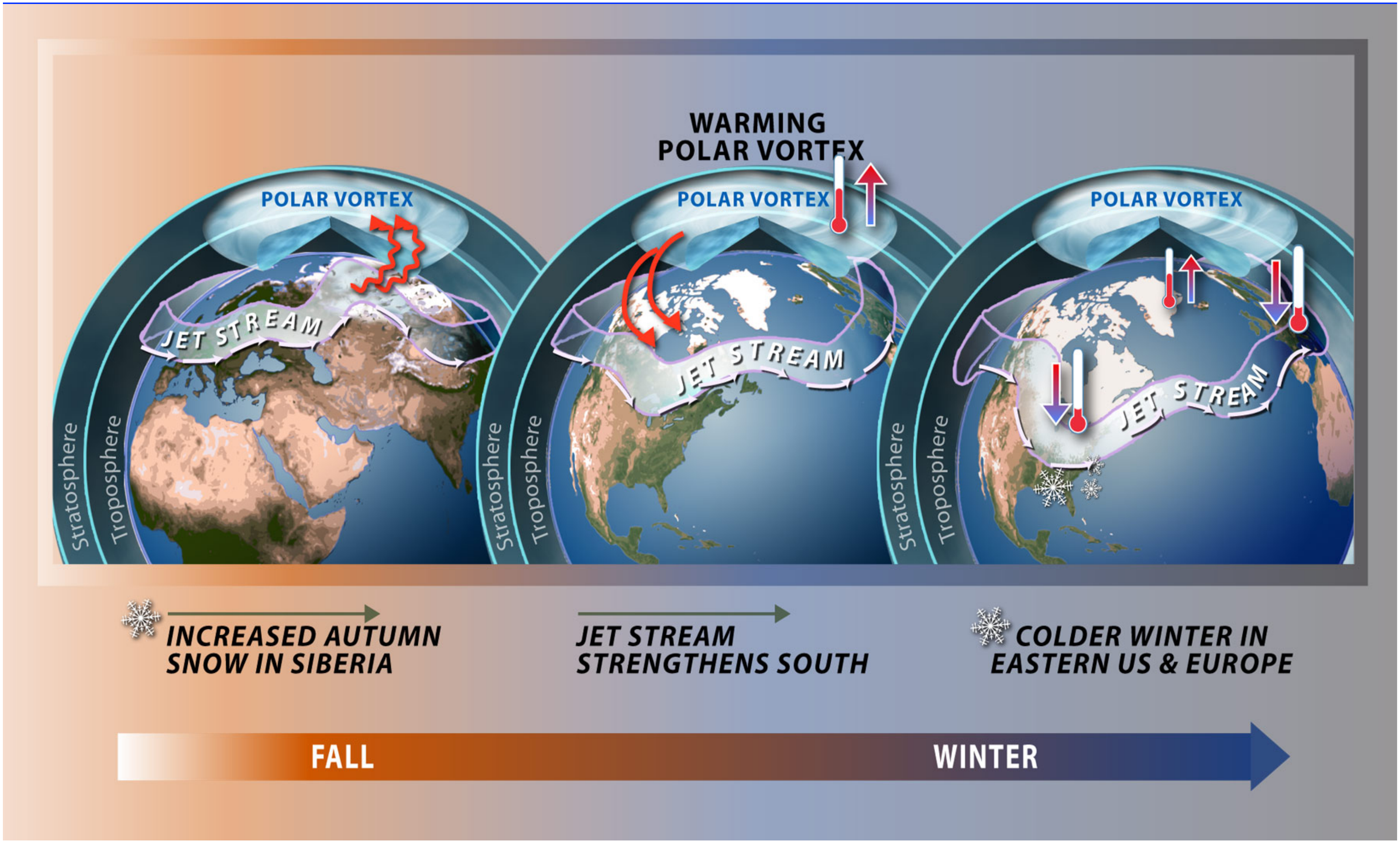
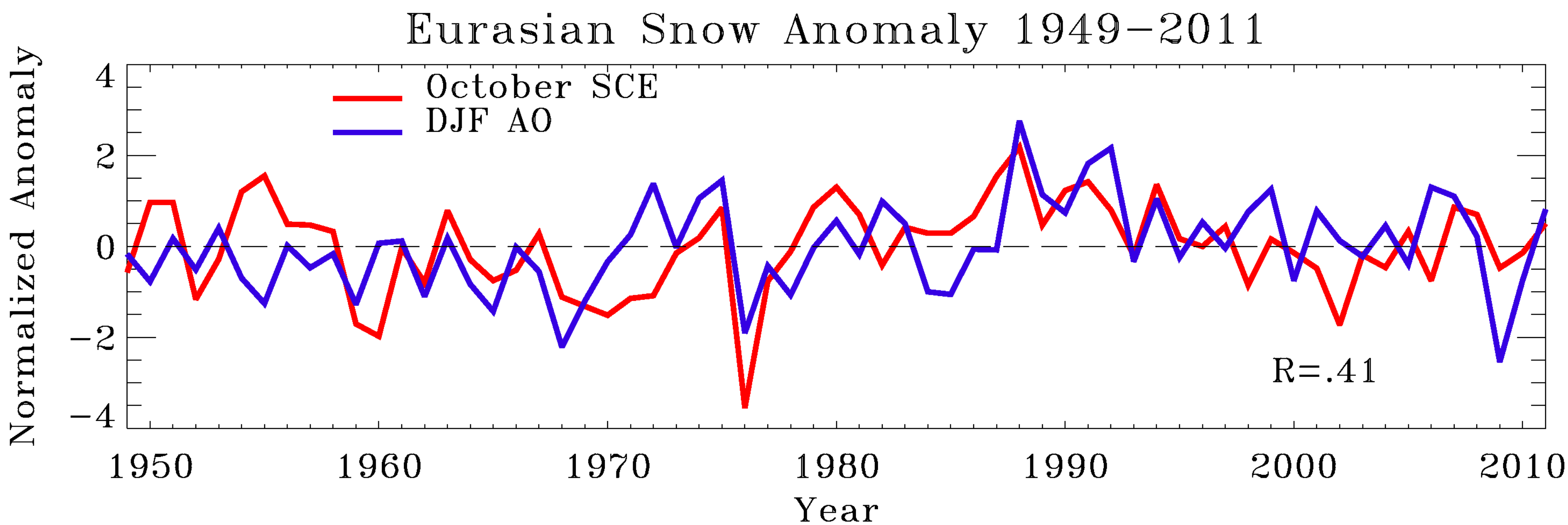
Snow Forced Cold Signal



Snow Cover Extent –
Arctic Oscillation (AO) Relationship



- Uses monthly values
- Includes all of Eurasia
- Measures snow cover extent

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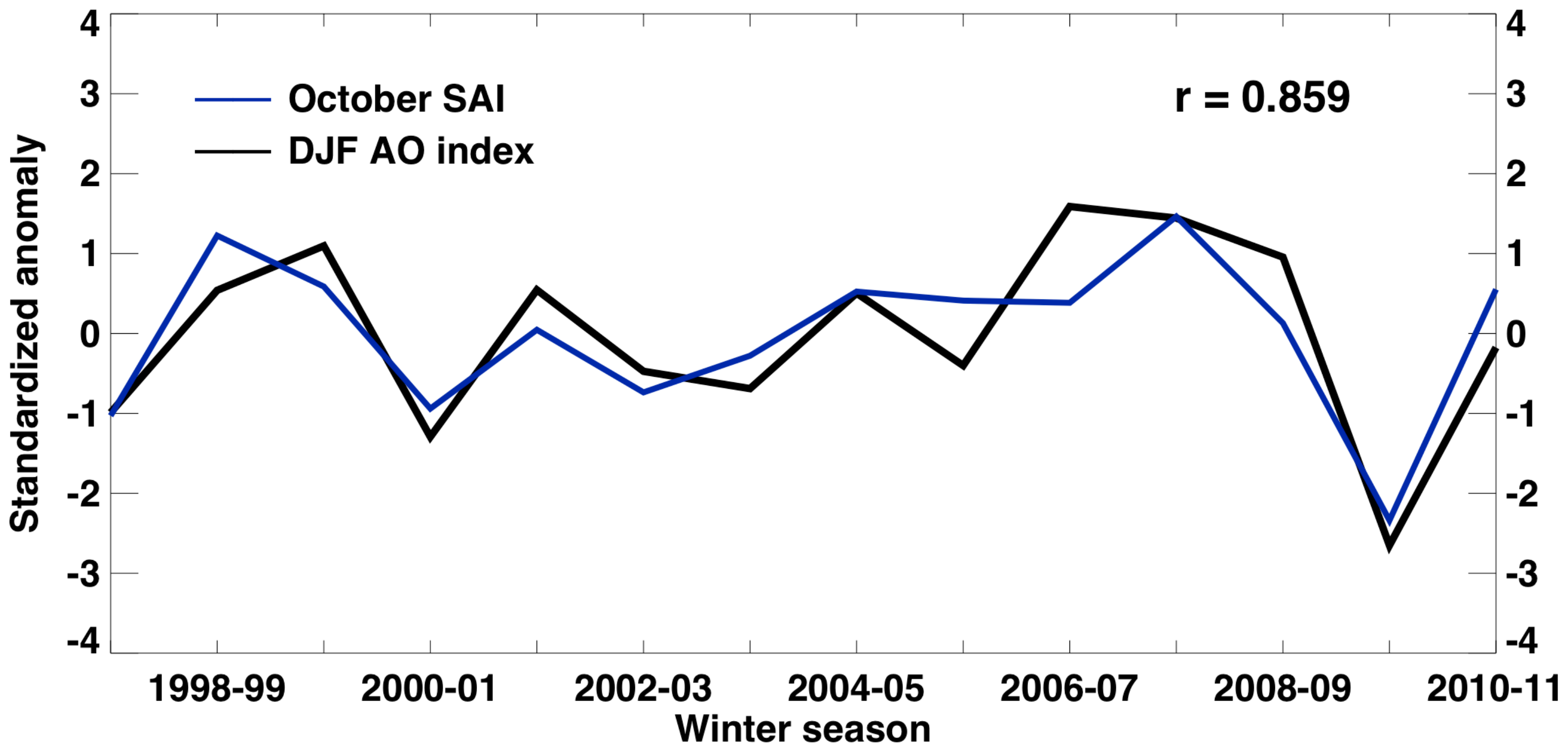
Snow Advance Index (SAI)



- Uses daily values
- Limited to equatorward of 60°N
- Measures rate of change of snow cover

Cohen and Jones (2011)

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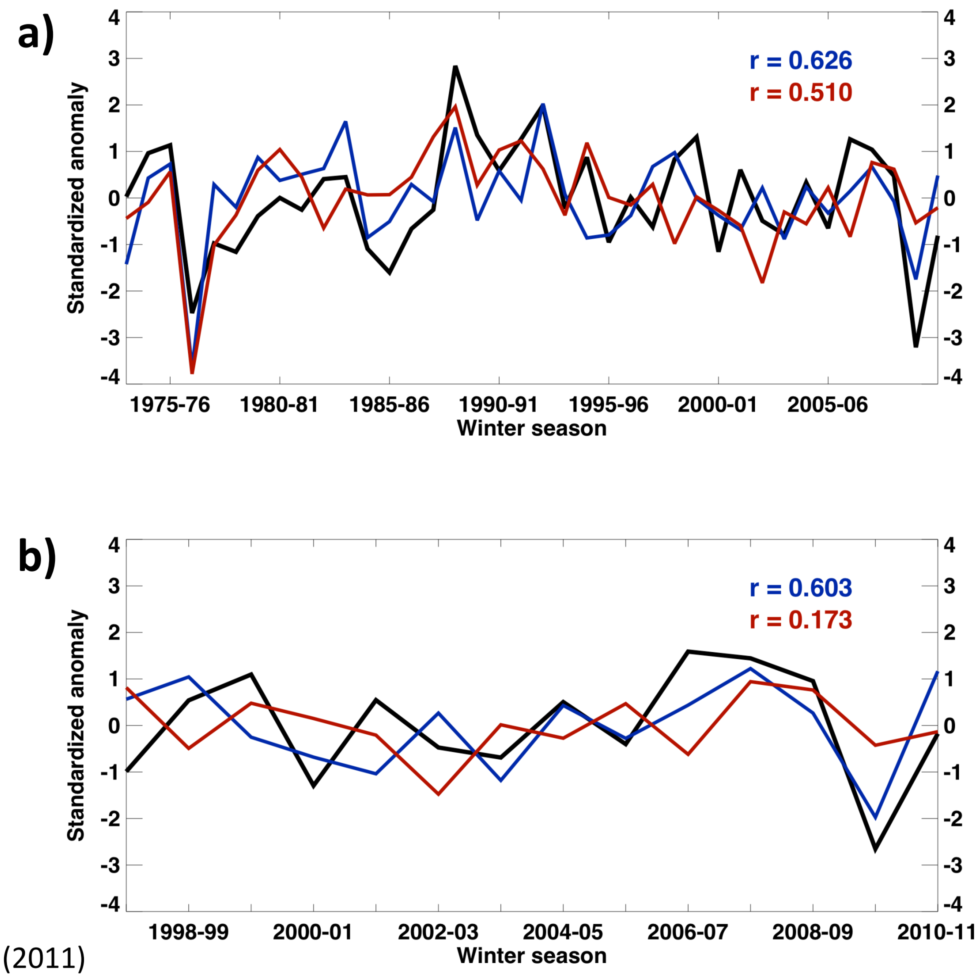
Snow Advance Index (weekly)



Cohen and Jones (2011)

The SAI index using weekly data still shows improved correlations with the winter AO compared with the monthly SCE index.

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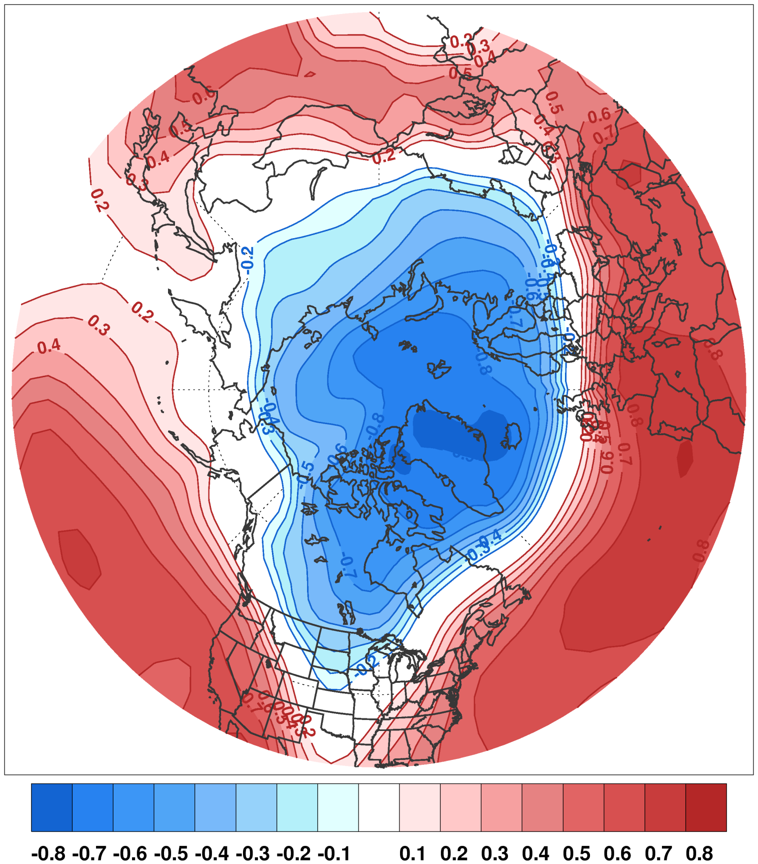
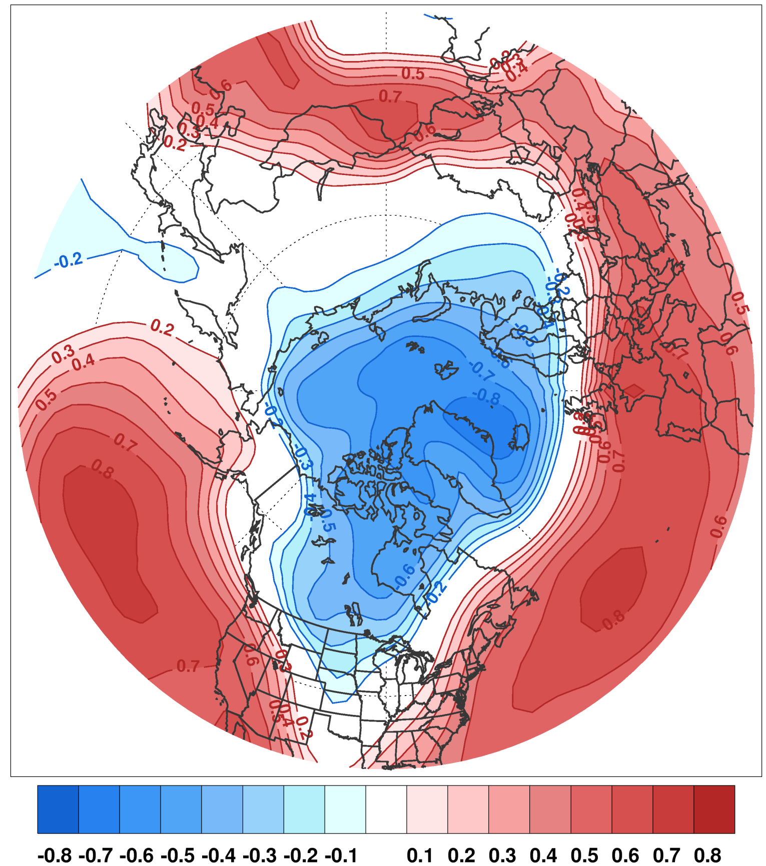
Correlations with sea level pressure

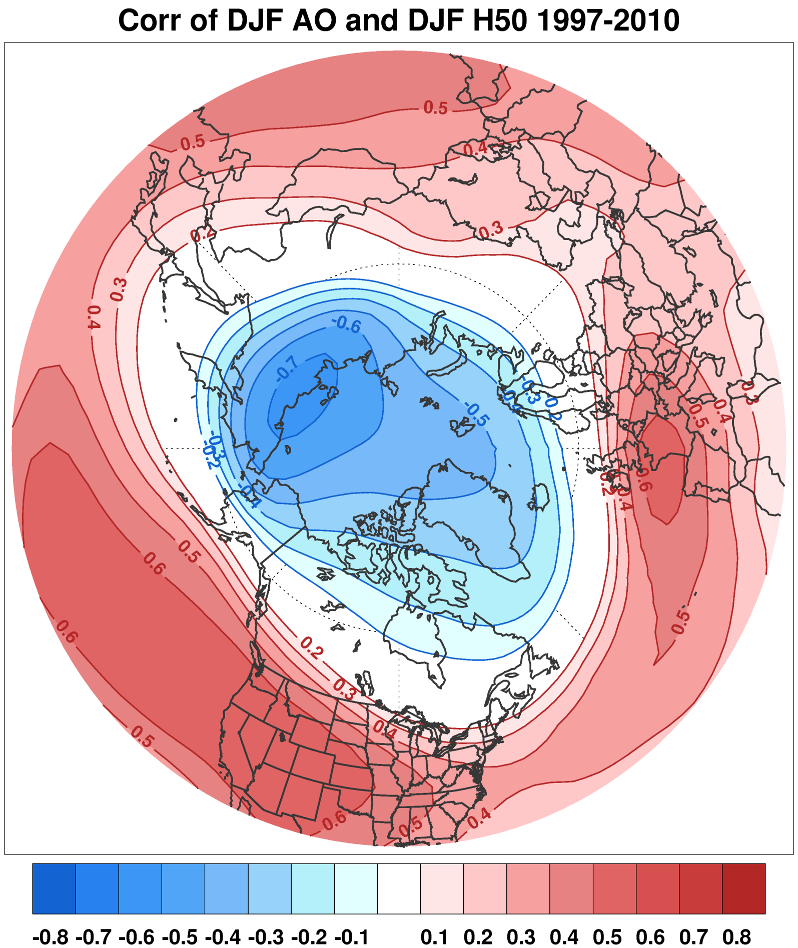
Corr of DJF AO and DJF SLP 1997-2010

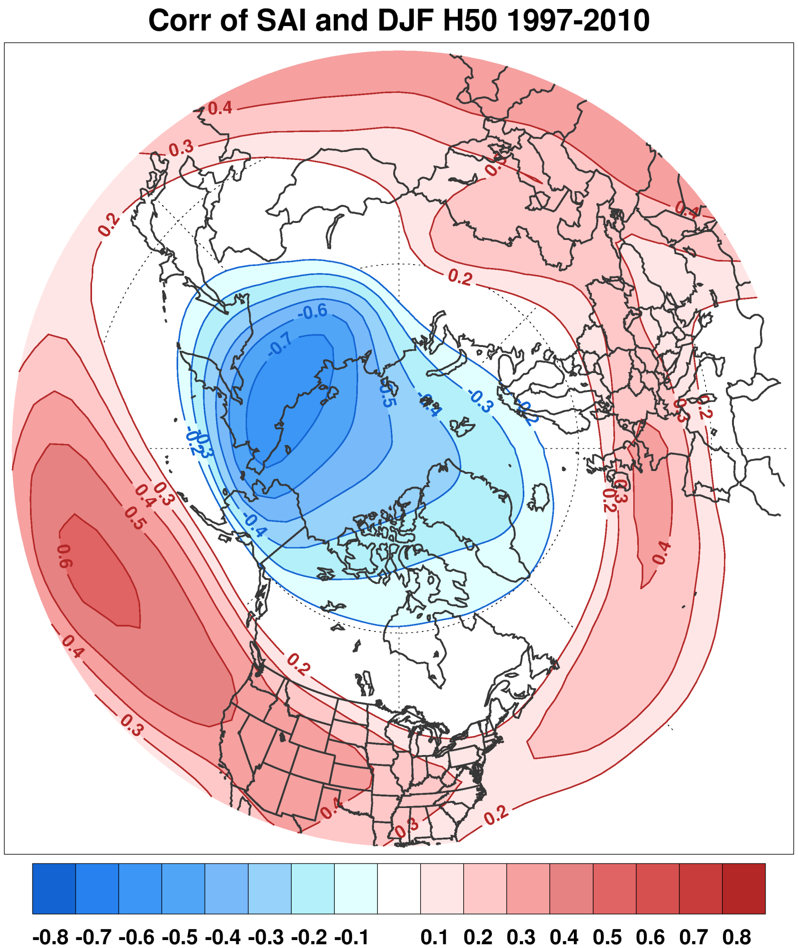


Corr of SAI and DJF SLP 1997-2010



Correlations with 50 hPa heights





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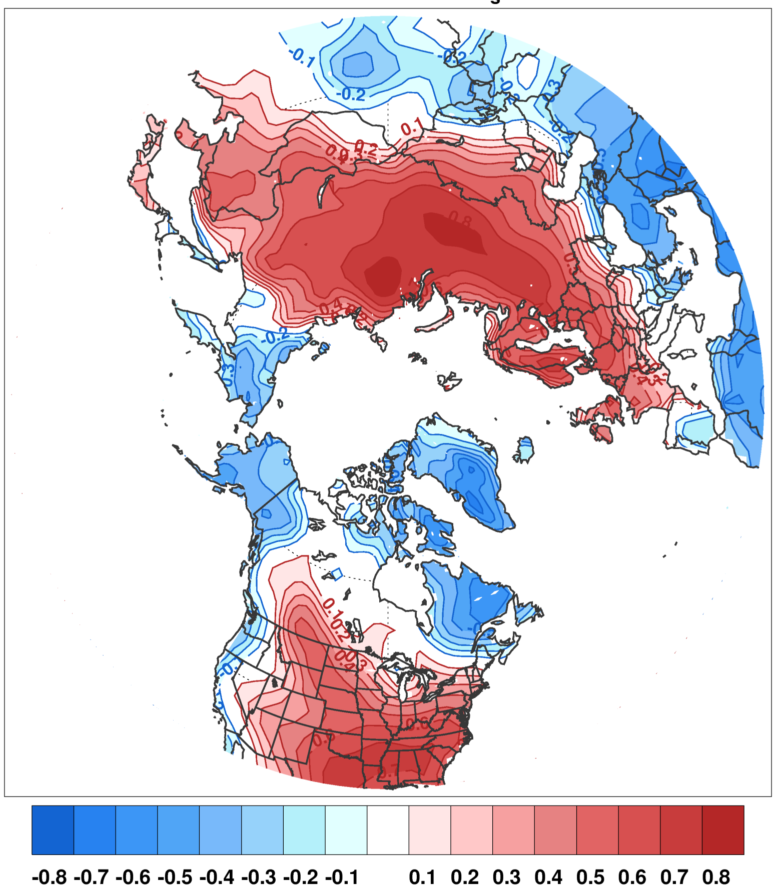
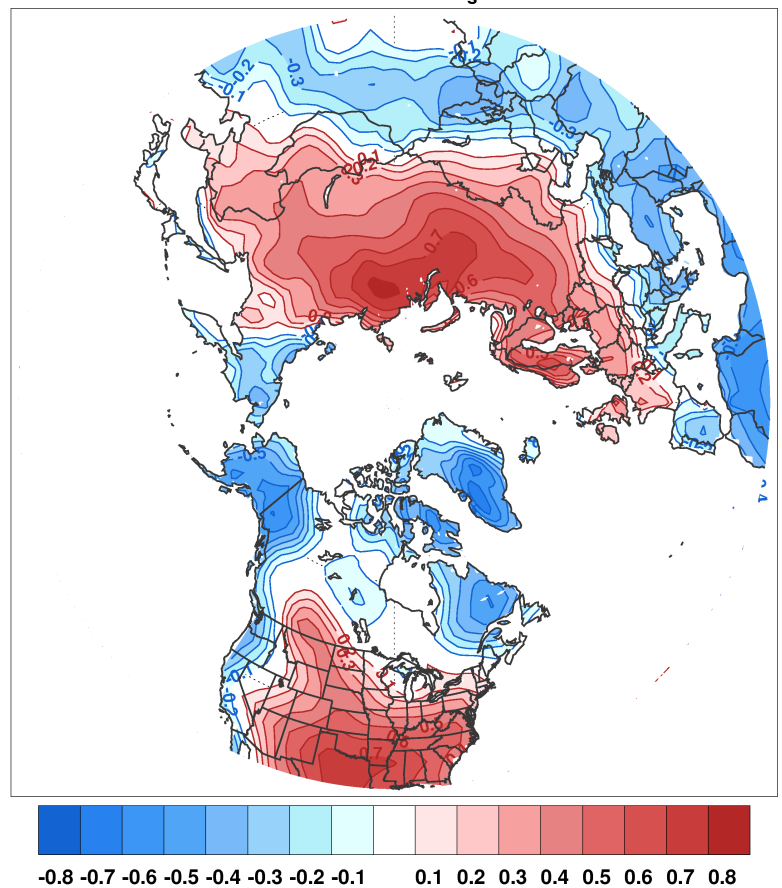
Correlations with surface temperature

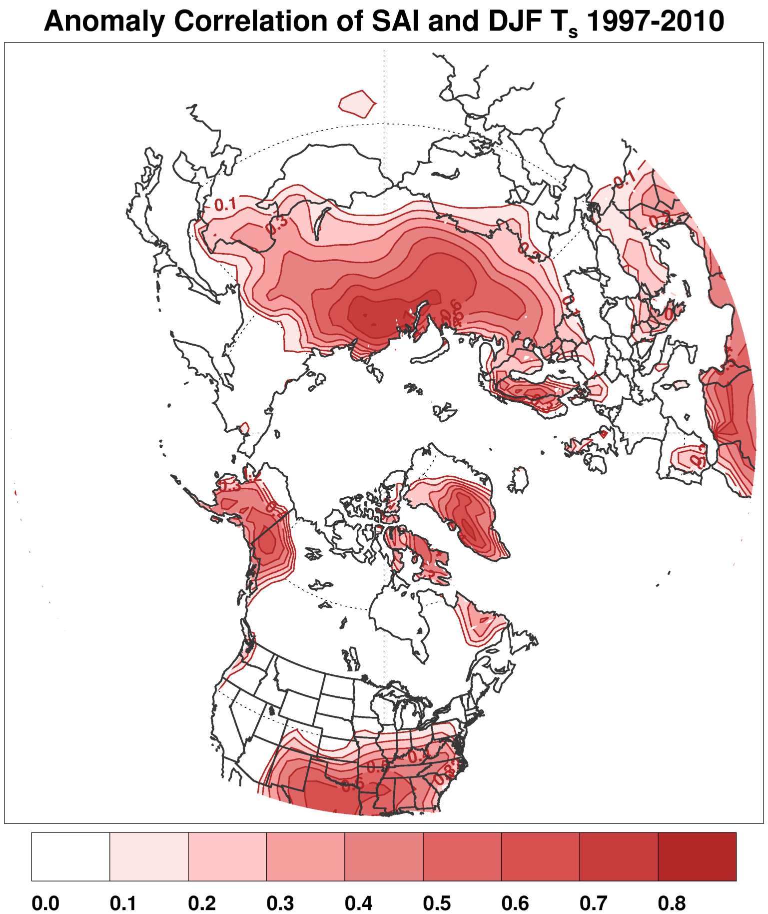
Corr of DJF AO and DJF T_s 1997-2010

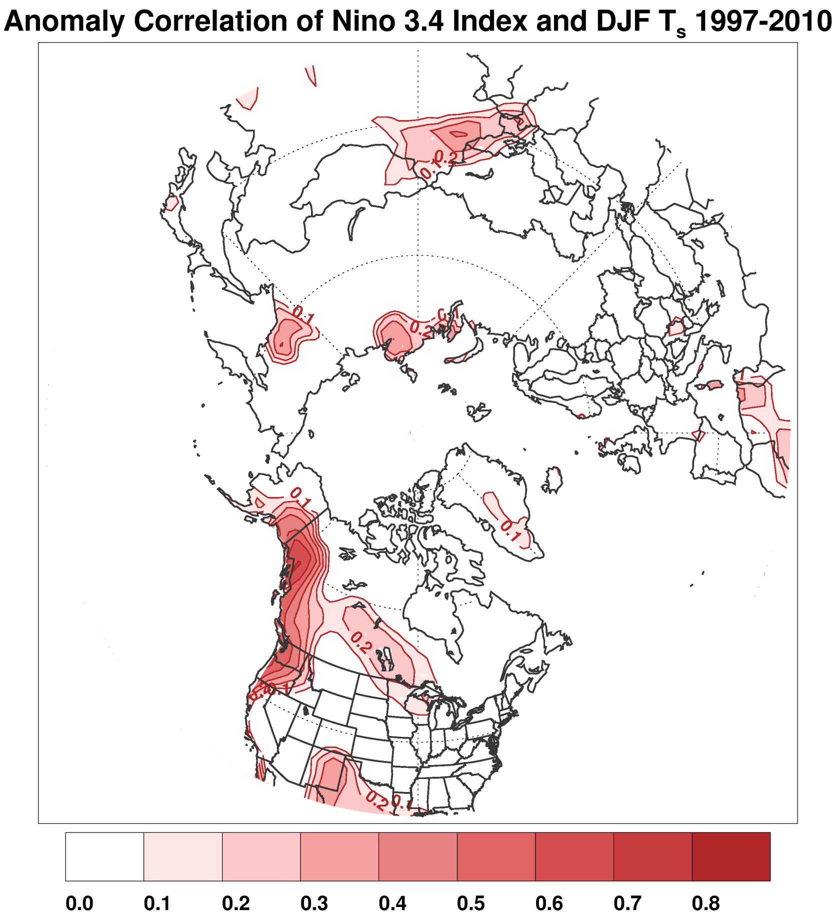


Corr of SAI and DJF T_s 1997-2010



Anomaly correlations of cross validated hindcasts





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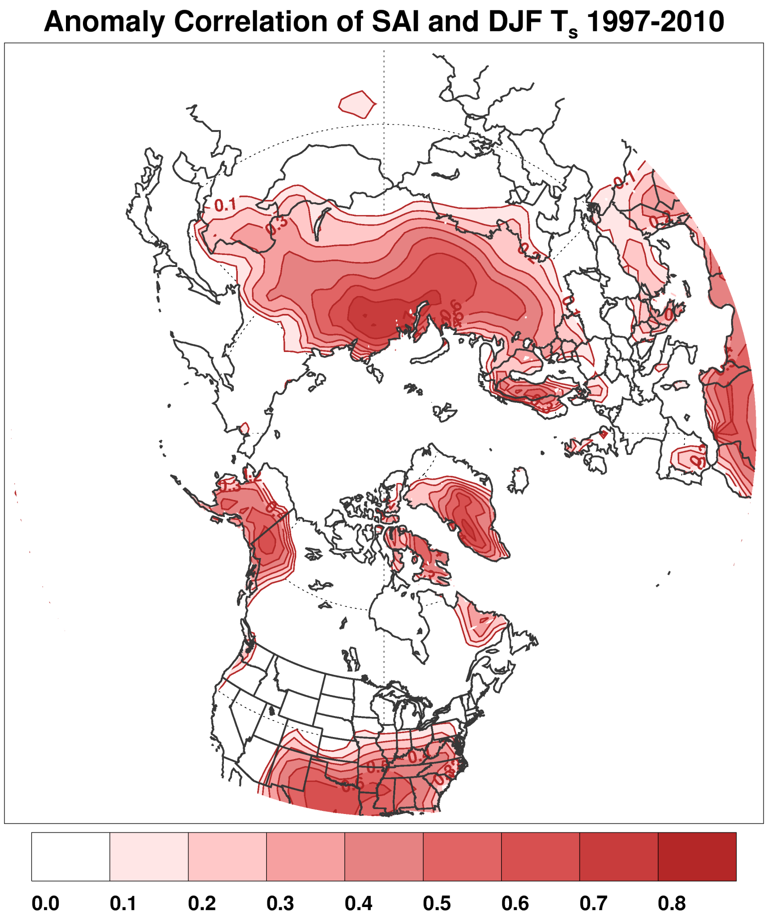
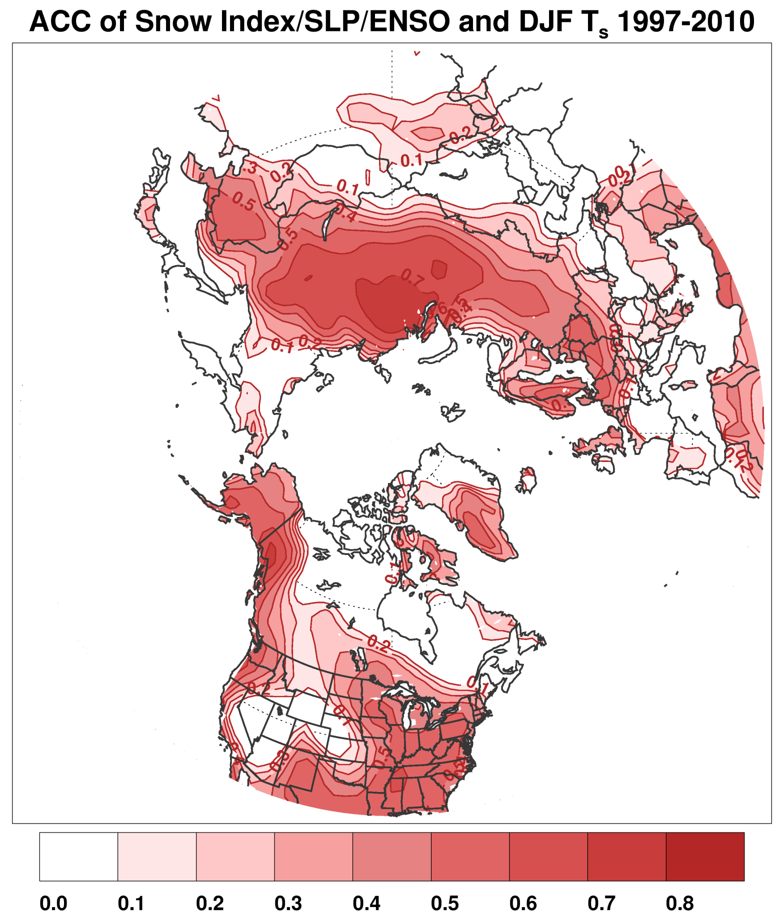
Anomaly correlations of cross validated hindcasts with a simple statistical model





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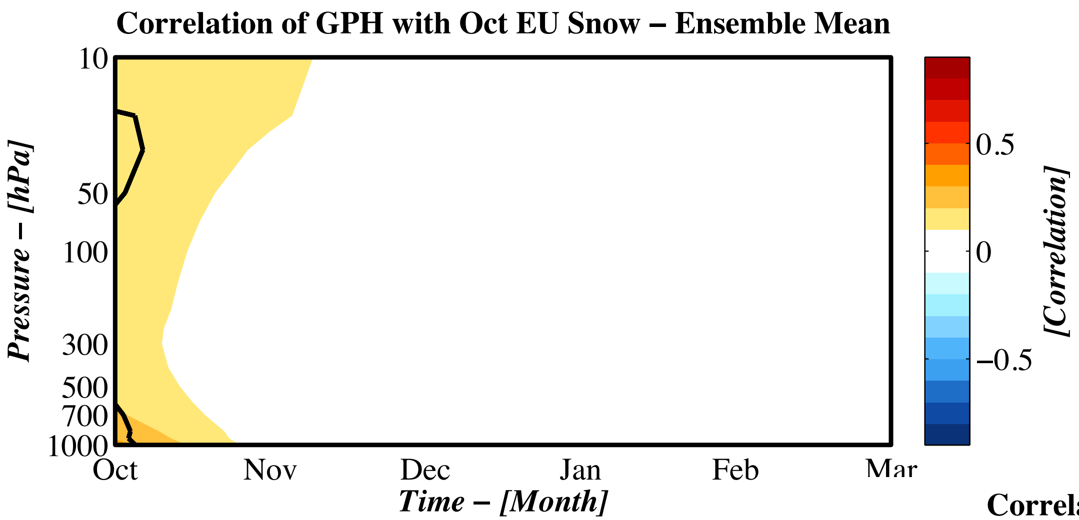
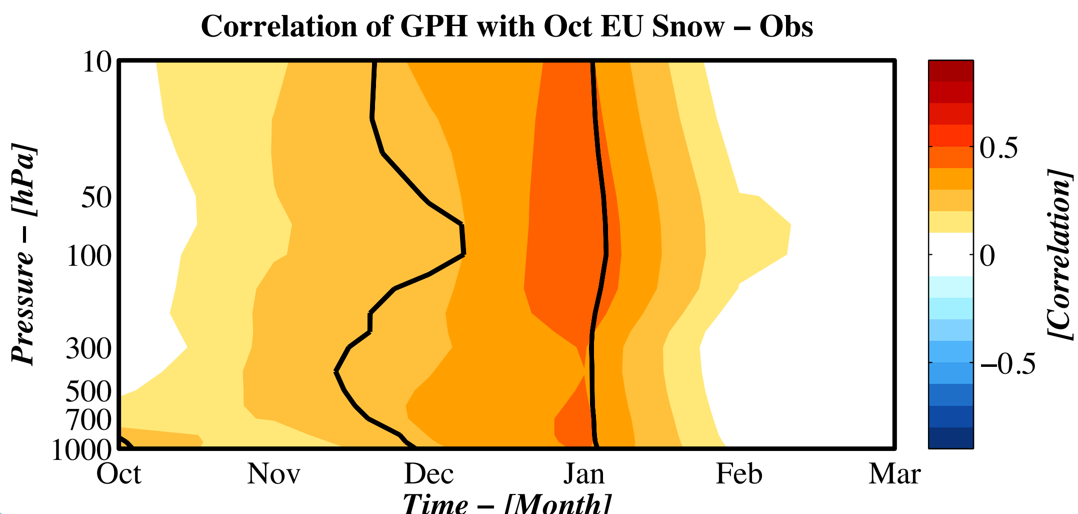
Correlation of Polar Cap GPH w/ Oct. EU Snow Observations and CMIP5



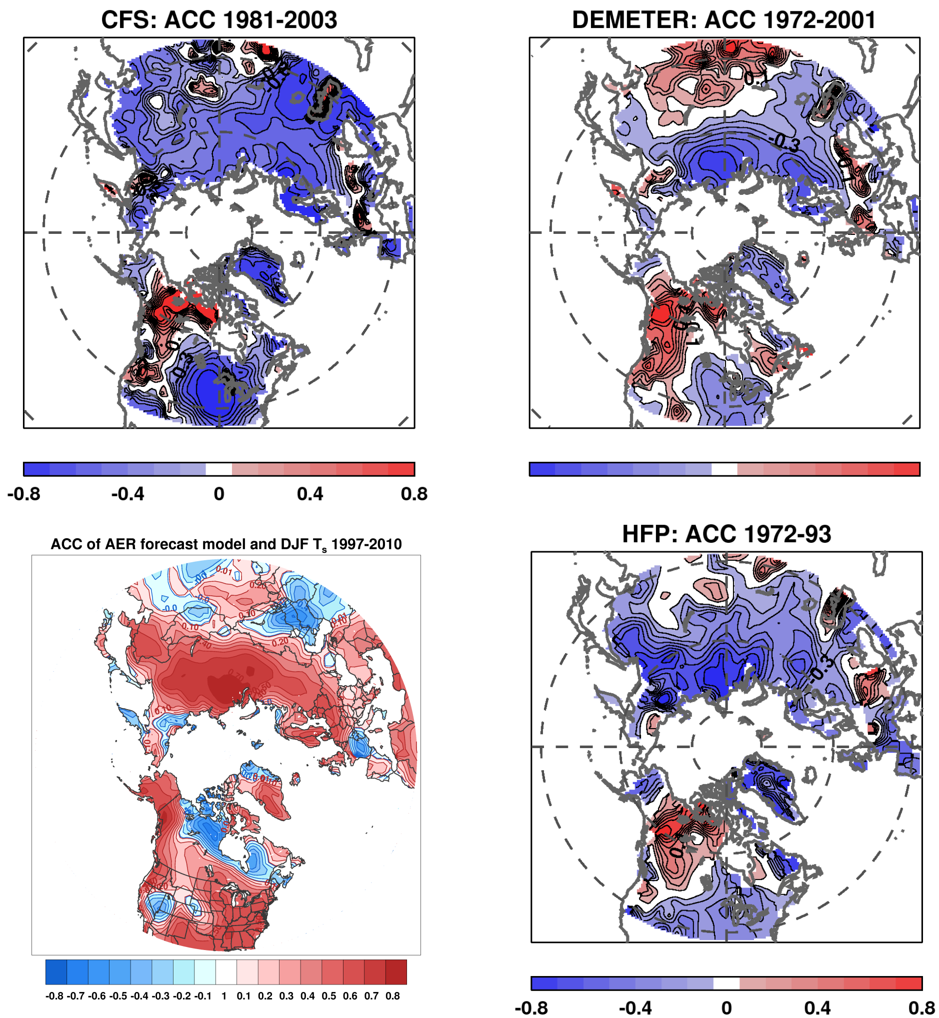
Almost no significant correlations from the models for the snow index and GPH.

Black contour = 95% significance



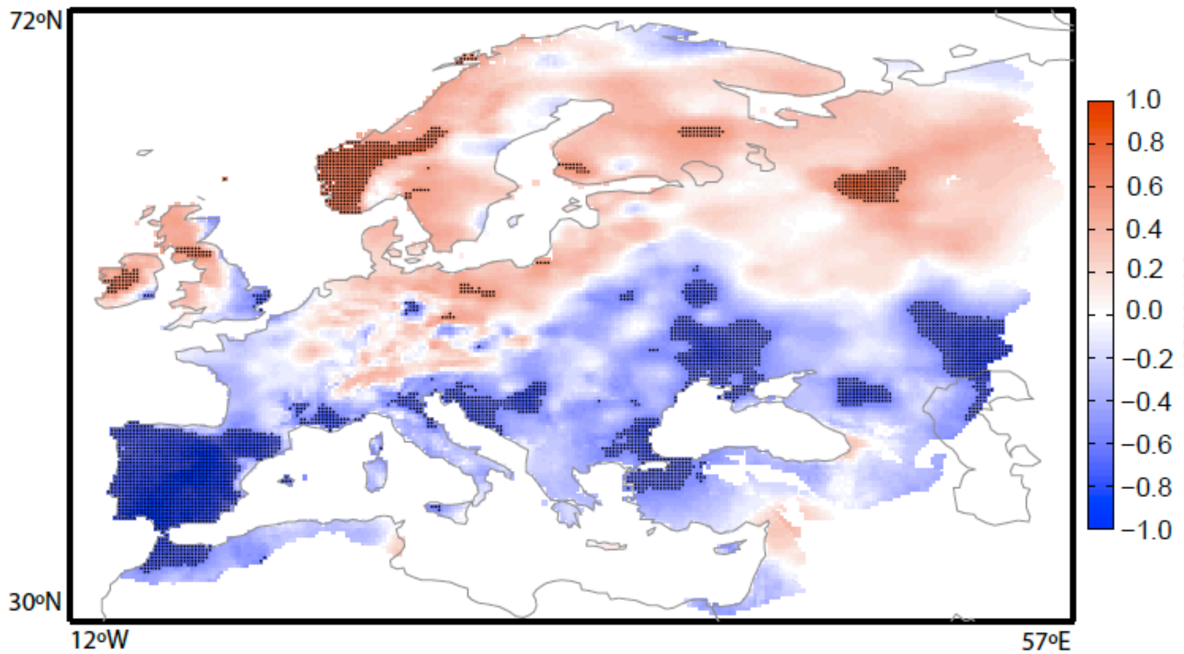
For the observations, the significant observations exist in December and January.

Comparison with Dynamical Models



Cohen and Fletcher (2007)

Correlations of SAI with European Precipitation

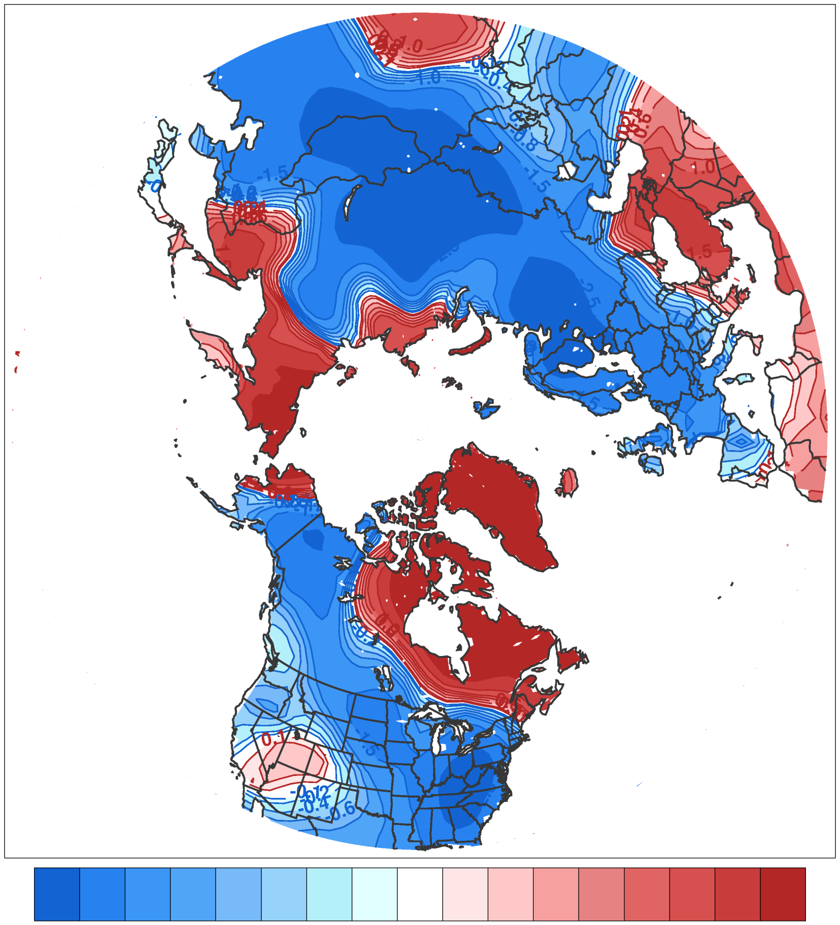


Stippling shows regions of statistical significance

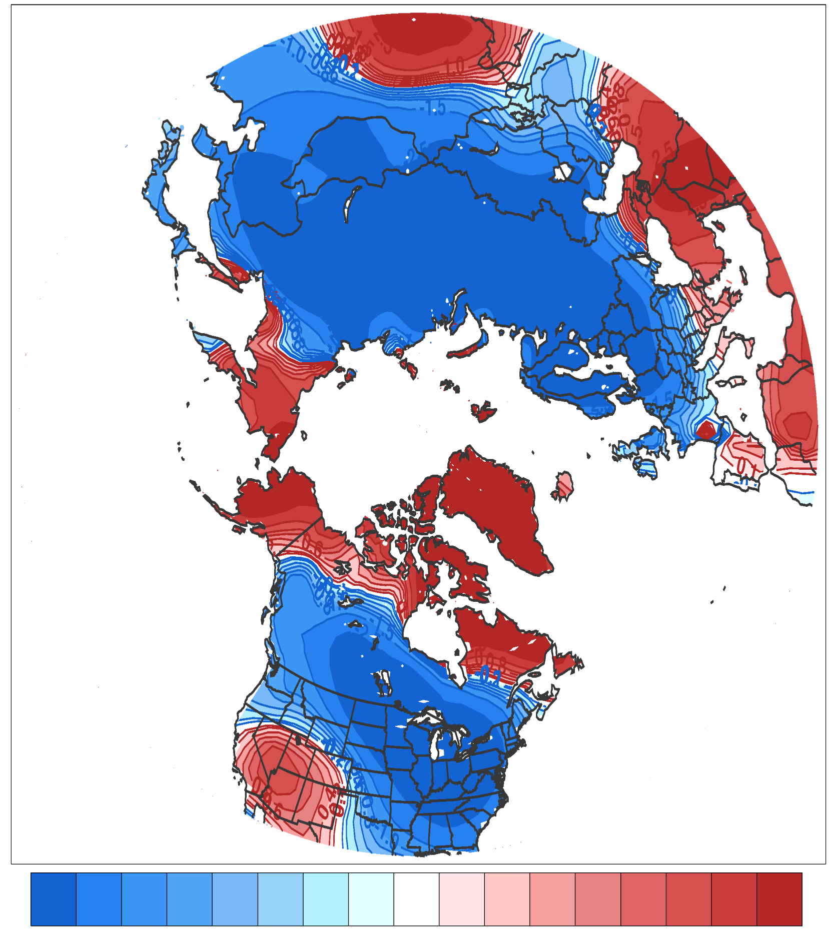
Brands et al. 2012a

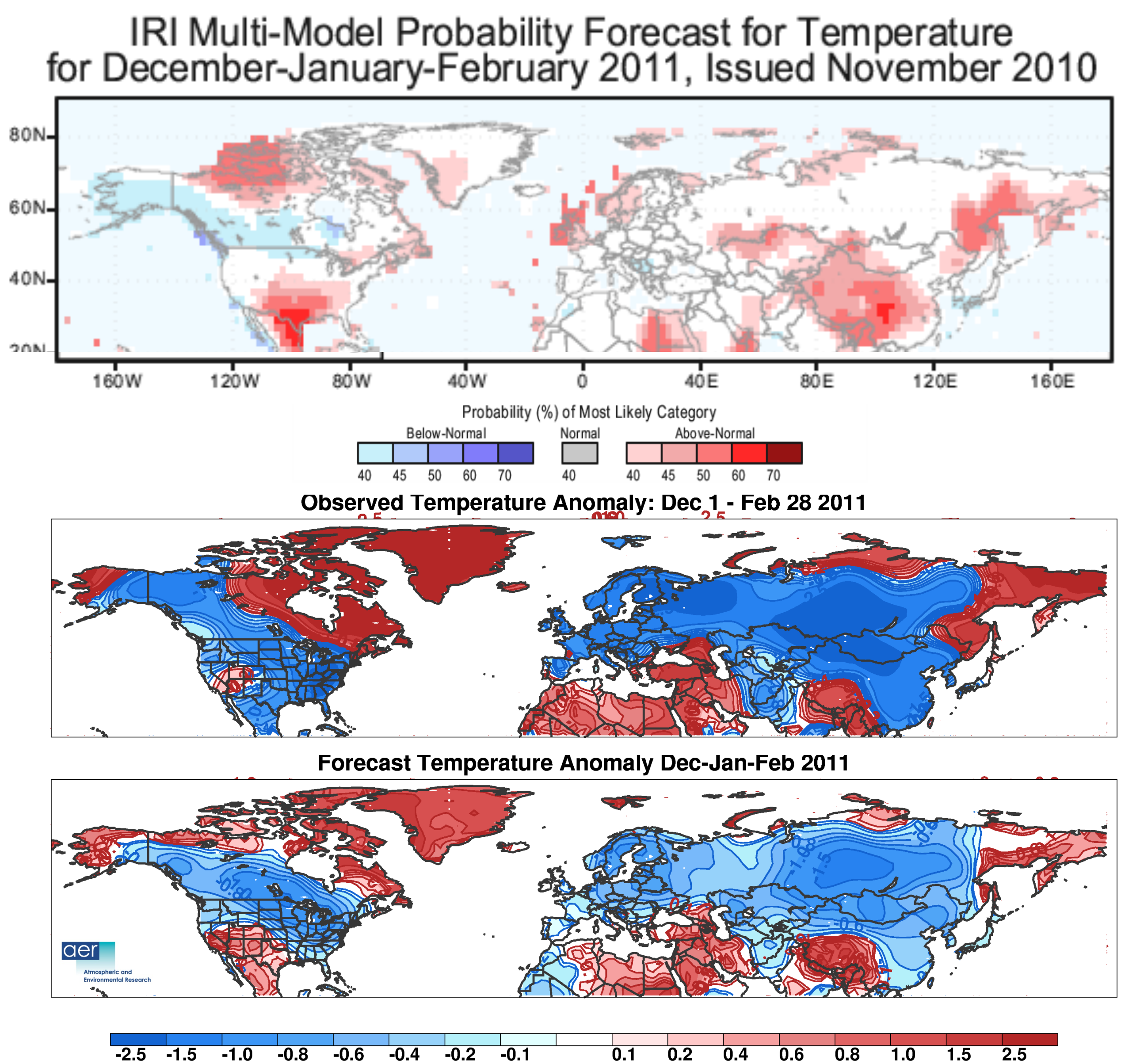
Observed and forecast (shown at the WCRP Prediction Workshop in Bergen, Norway October 28th) temperatures in °C for December-February 2010/11 for the Northern Hemisphere.

Observed Temperature Anomaly Dec-Jan-Feb 2011



Forecast Temperature Anomaly Dec-Jan-Feb 2011





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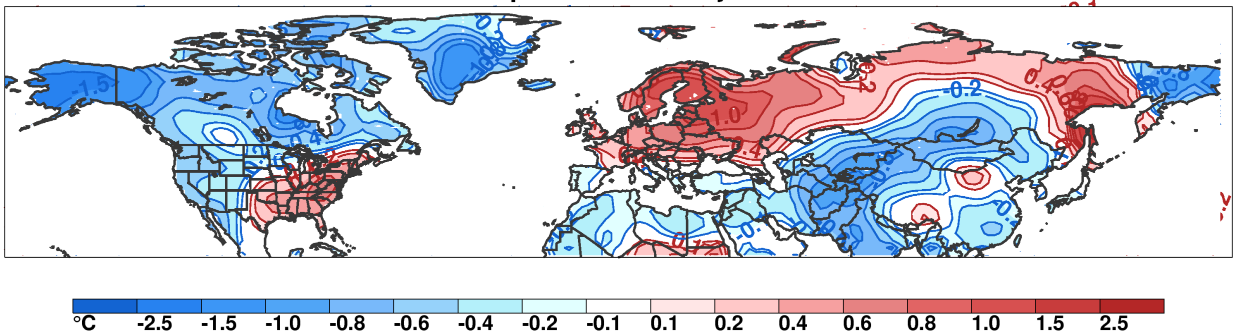
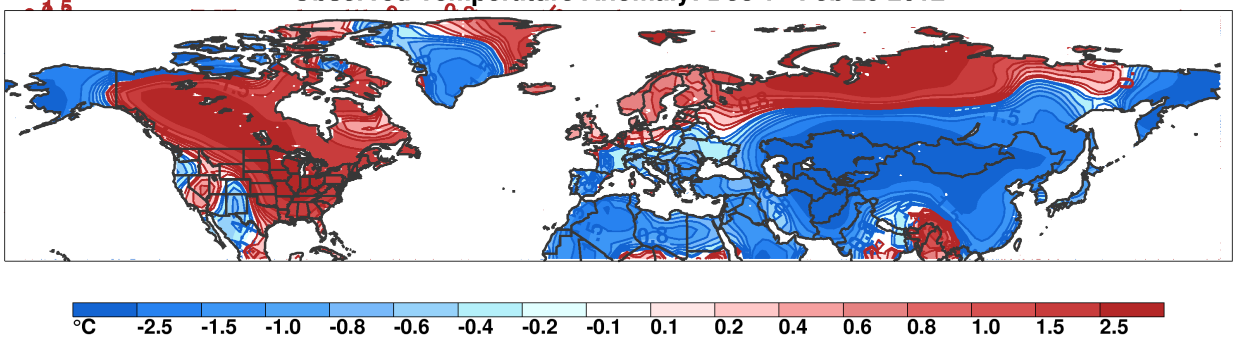
Winter Temperatures

- R=0.52 Eu
- R=0.44 NA

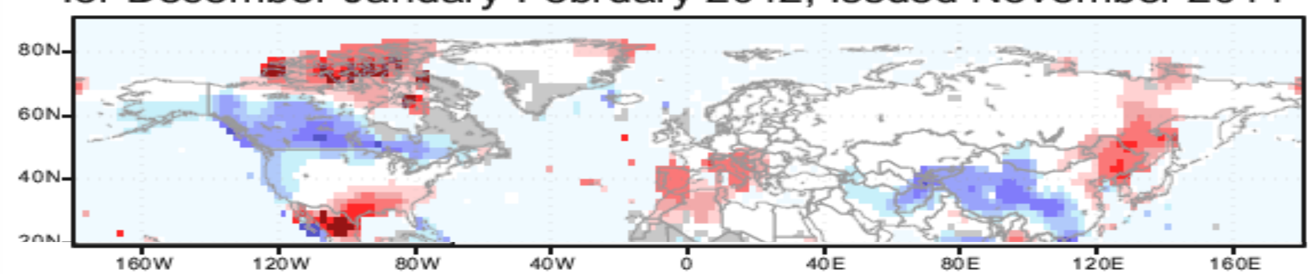
AER Forecast Temperature Anomaly Dec-Jan-Feb 2012



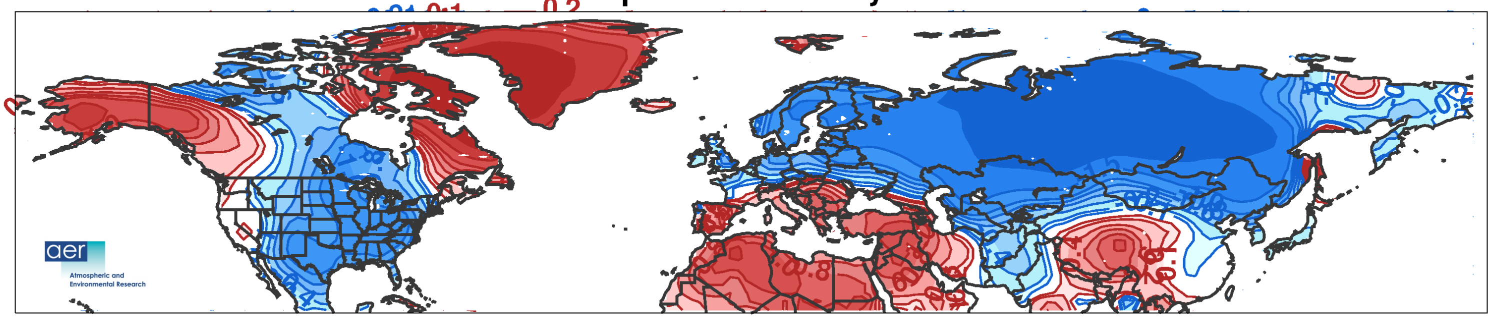
Observed Temperature Anomaly: Dec 1 - Feb 29 2012



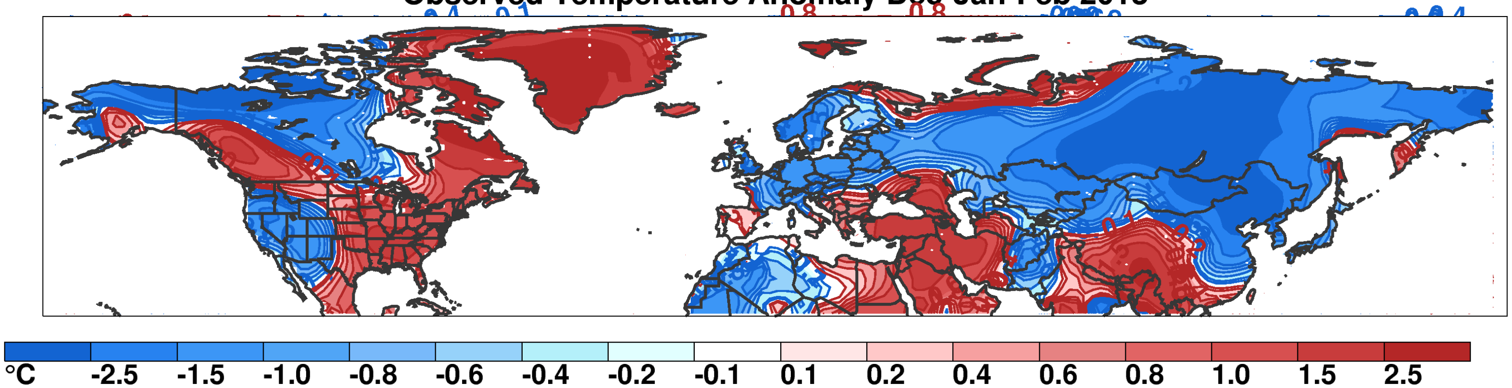
IRI Multi-Model Probability Forecast for Temperature
for December-January-February 2012, Issued November 2011



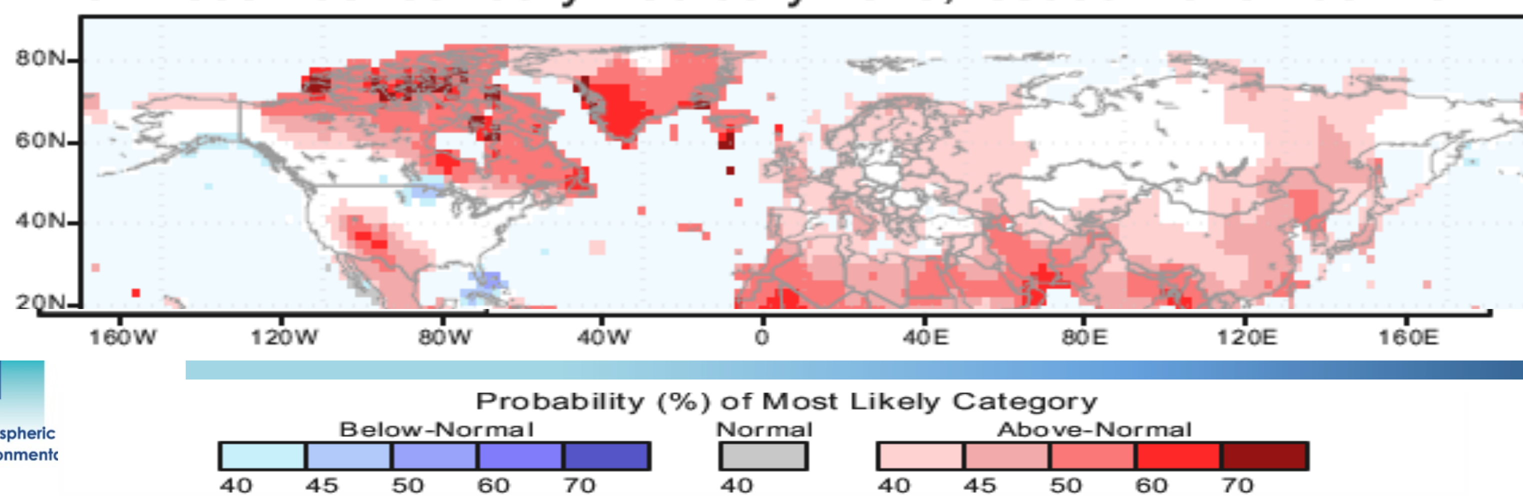
AER Forecast Temperature Anomaly Dec-Jan-Feb 2013



Observed Temperature Anomaly Dec-Jan-Feb 2013



IRI Multi-Model Probability Forecast for Temperature for December-January-February 2013, Issued November 2012



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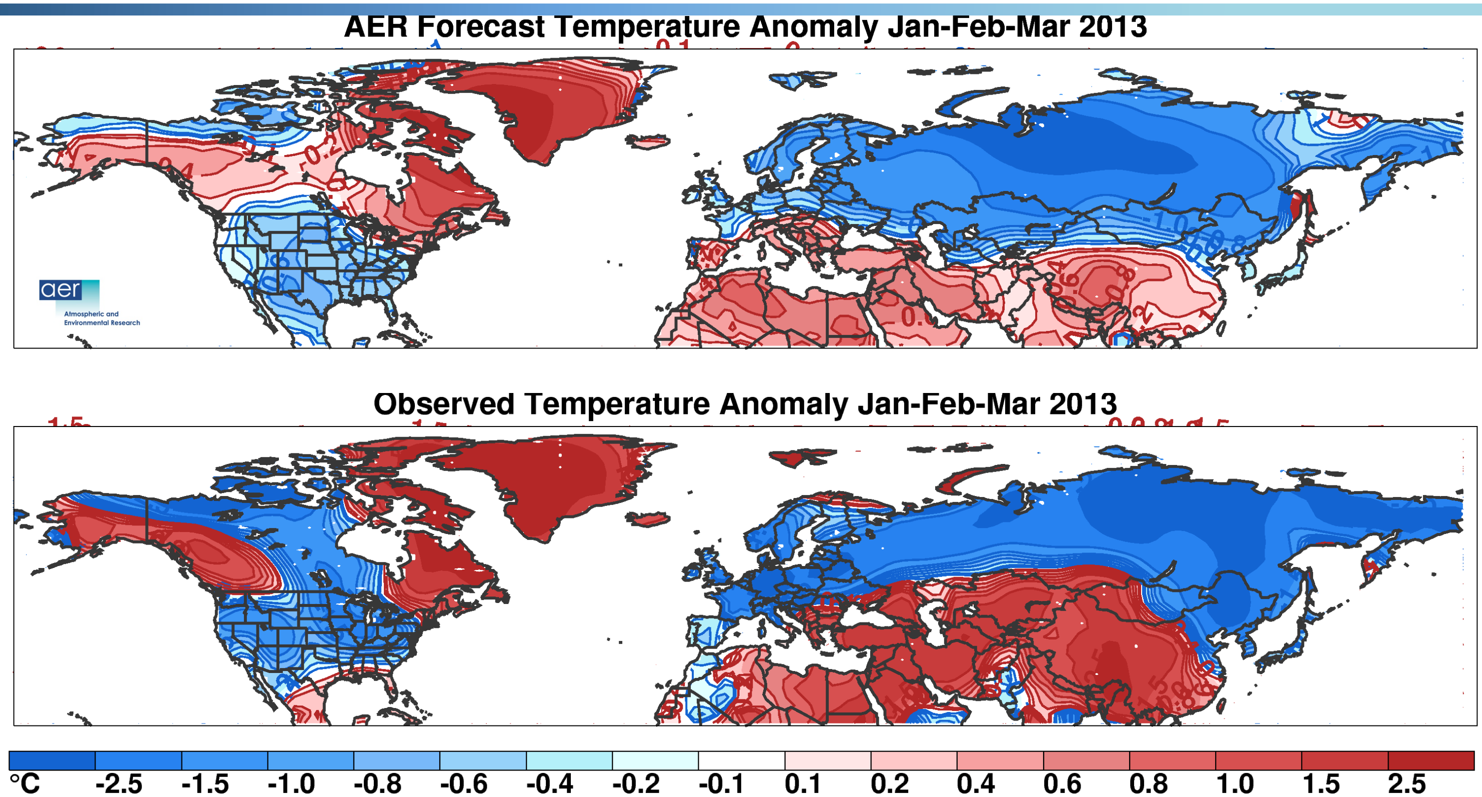
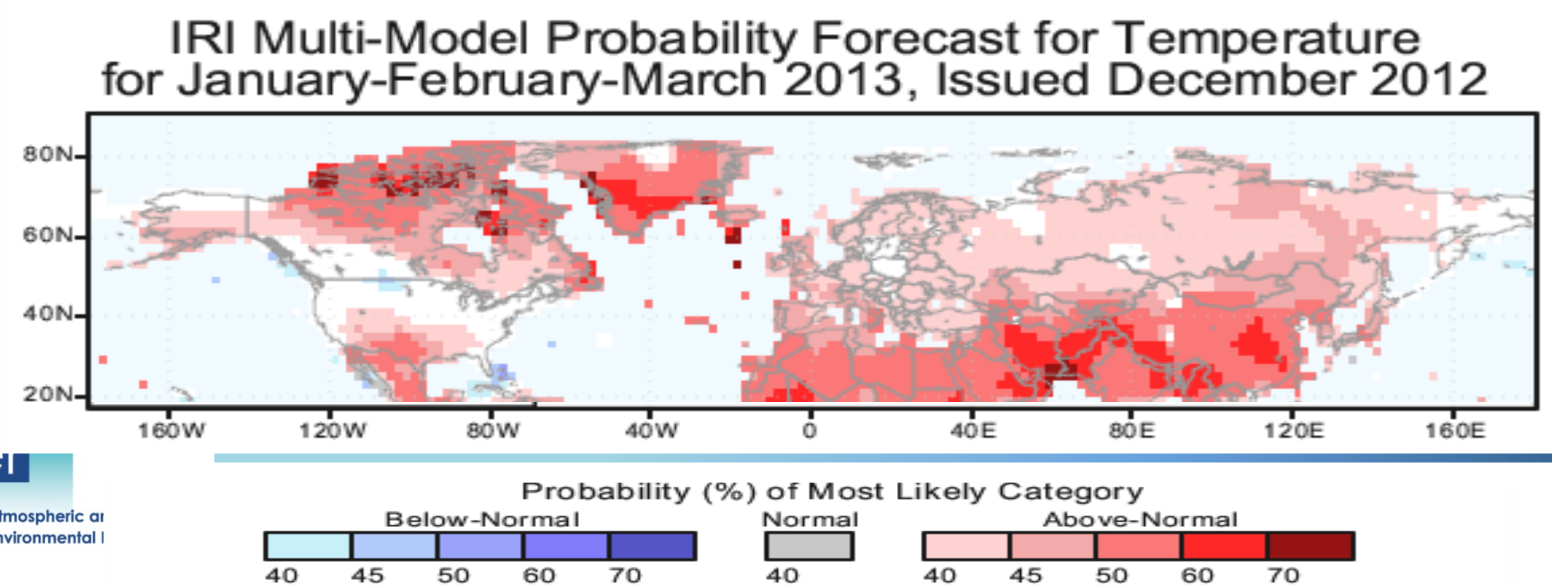
Environment





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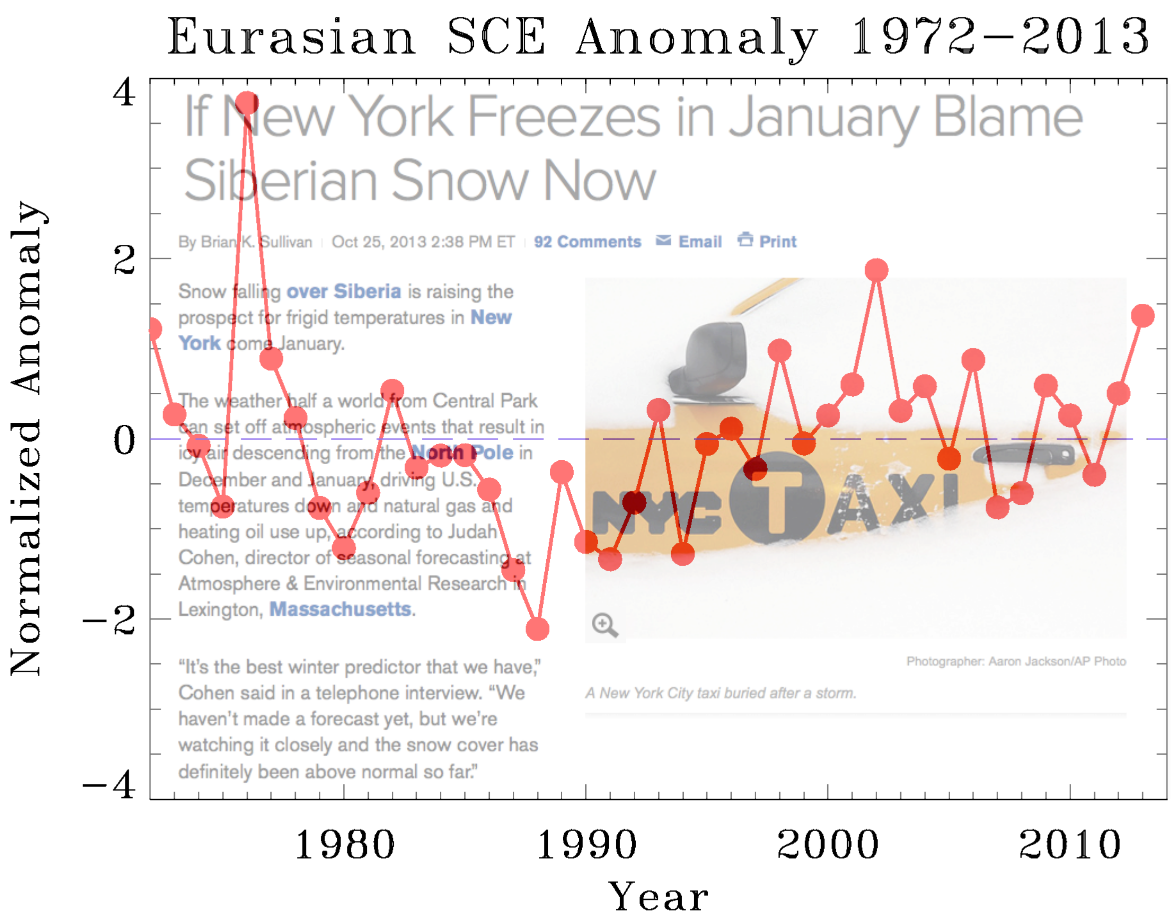
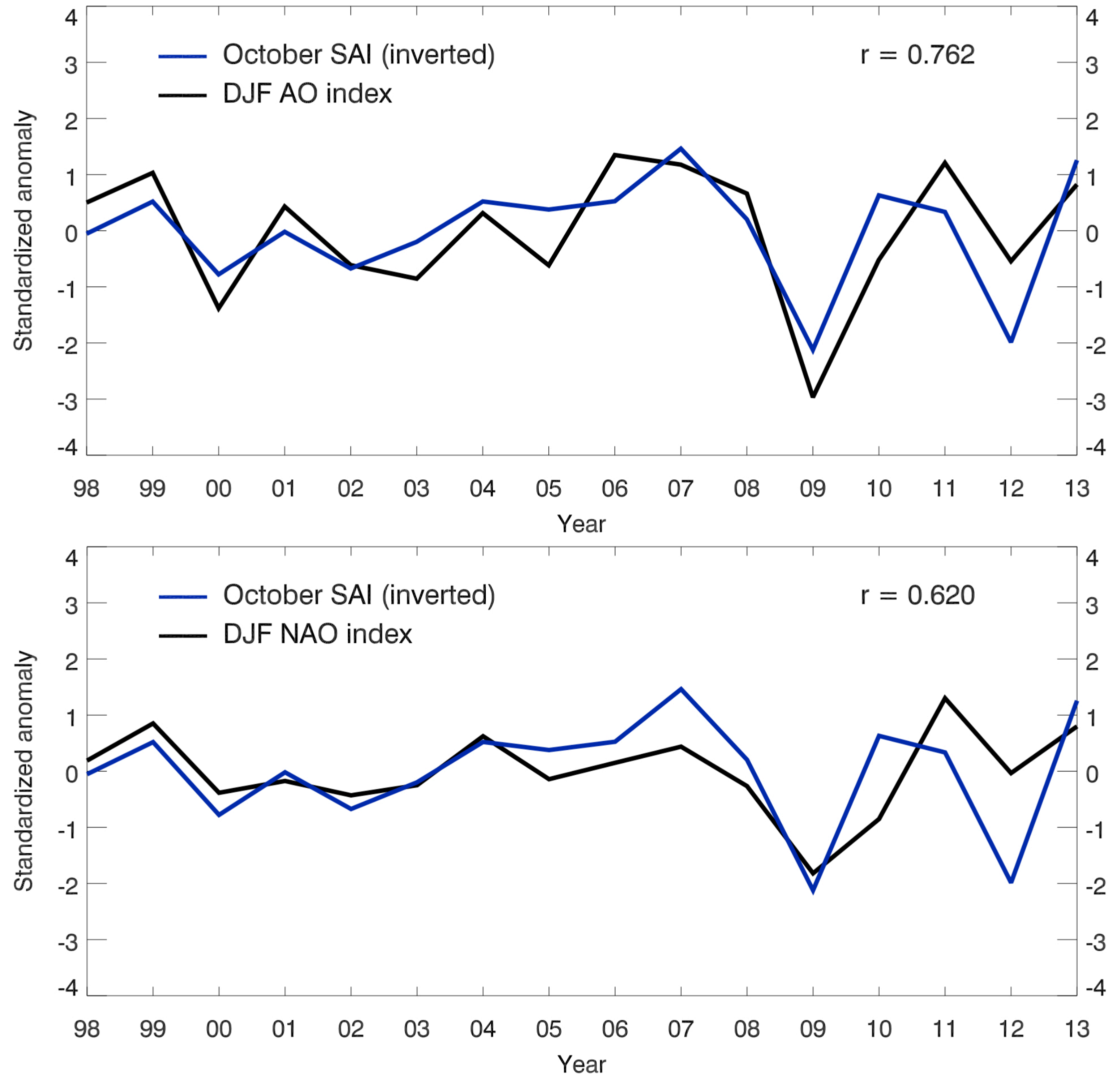
Eurasian Snow Cover Anomalies

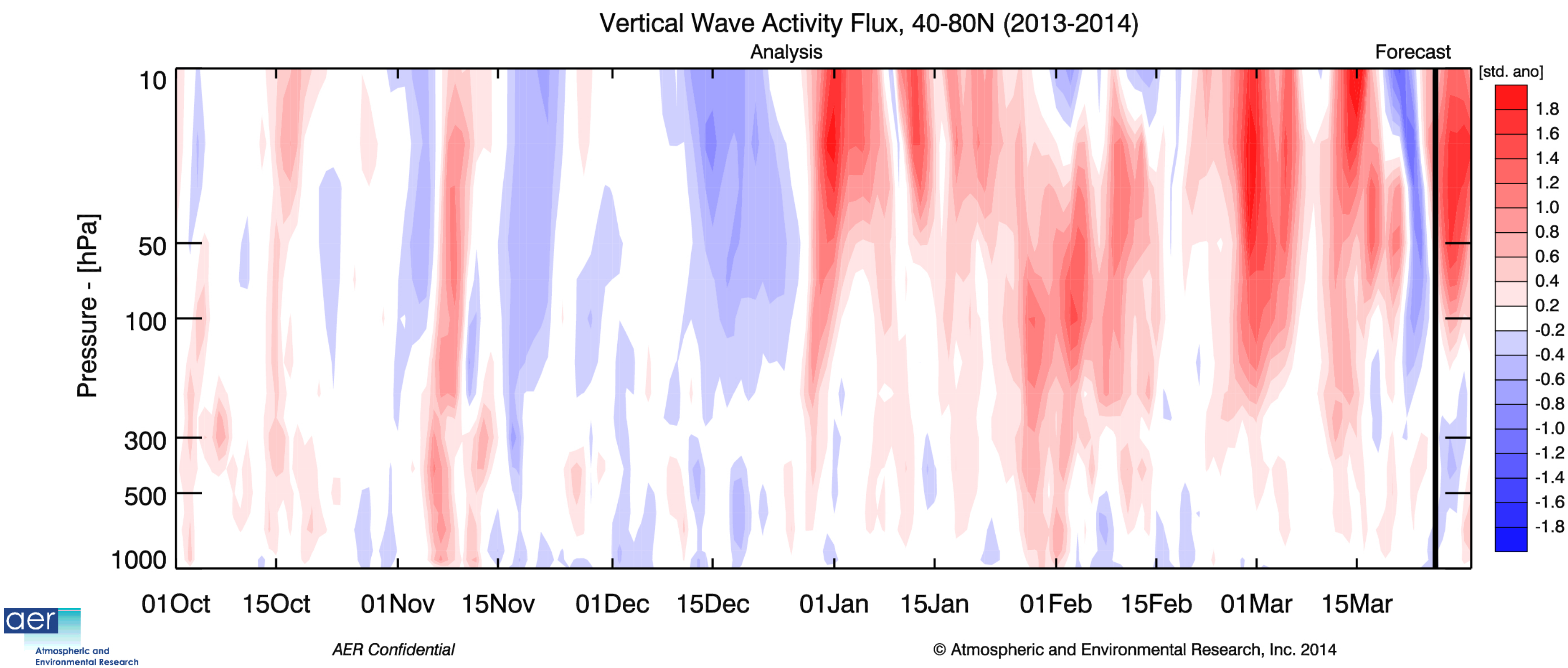


October 2013 Eurasian snow cover is third highest on record.

SAI and the AO and NAO

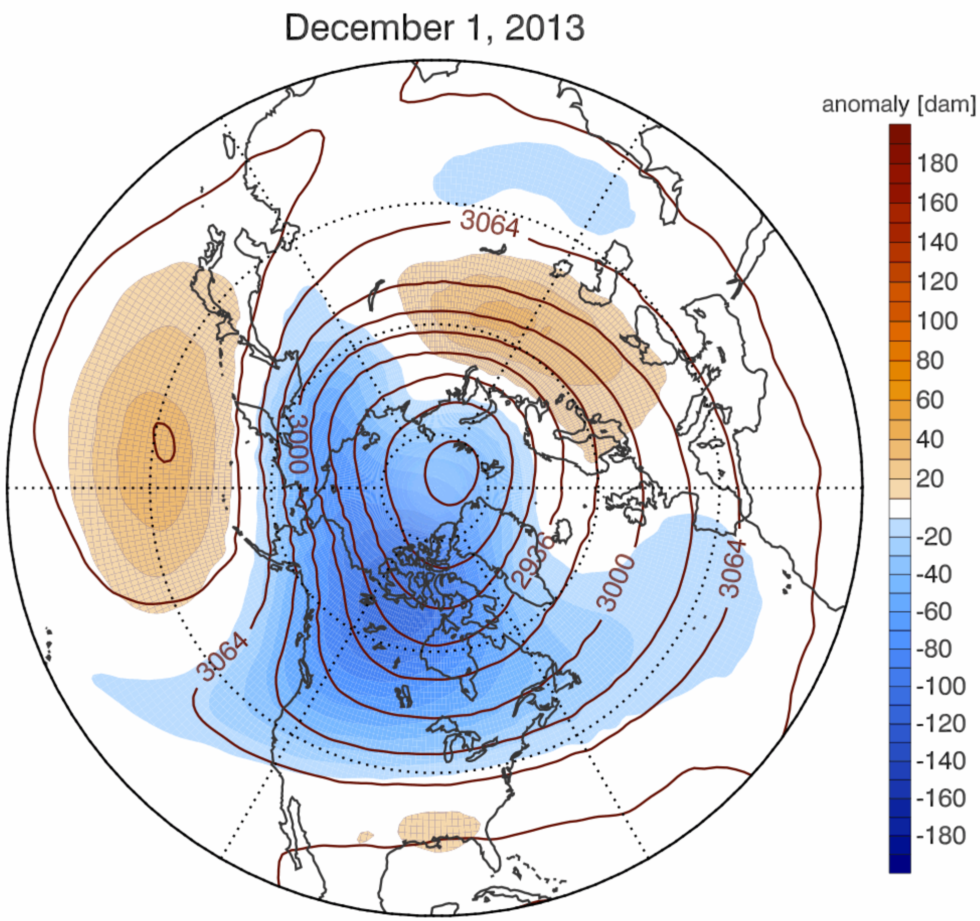


Atmospheric Energy Transfer



Red shows periods of more active energy transfer

Stratospheric polar vortex winter 2014



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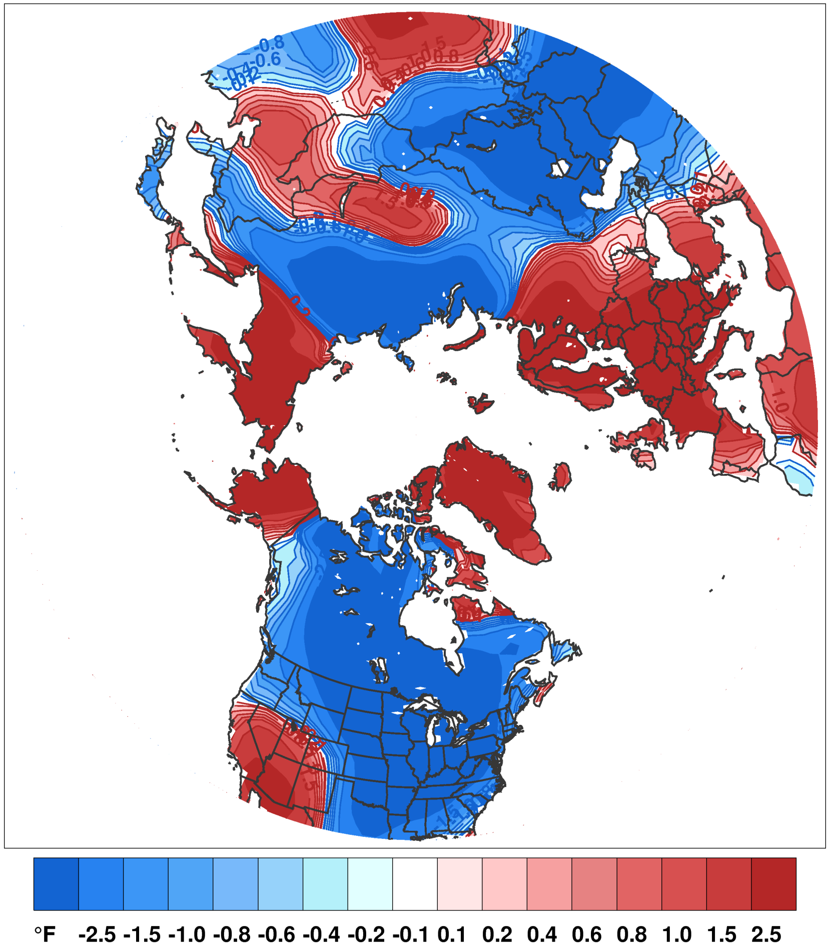
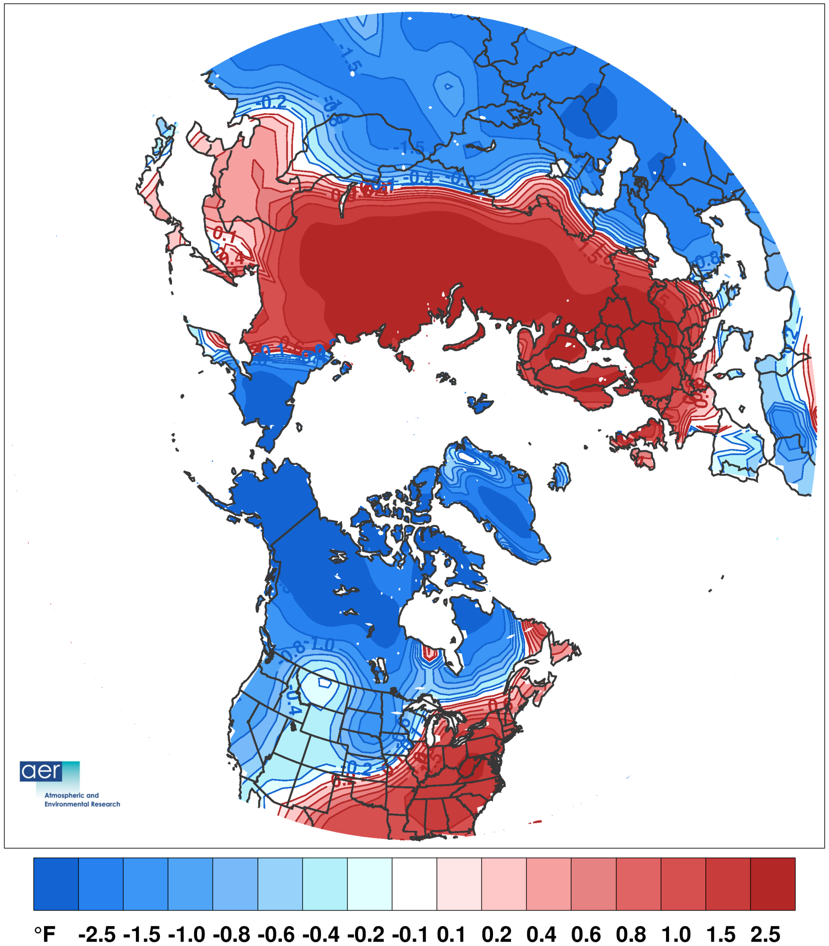
Winter 2014 Temperatures

Observed Temperature Anomaly Dec-Jan-Feb 2014

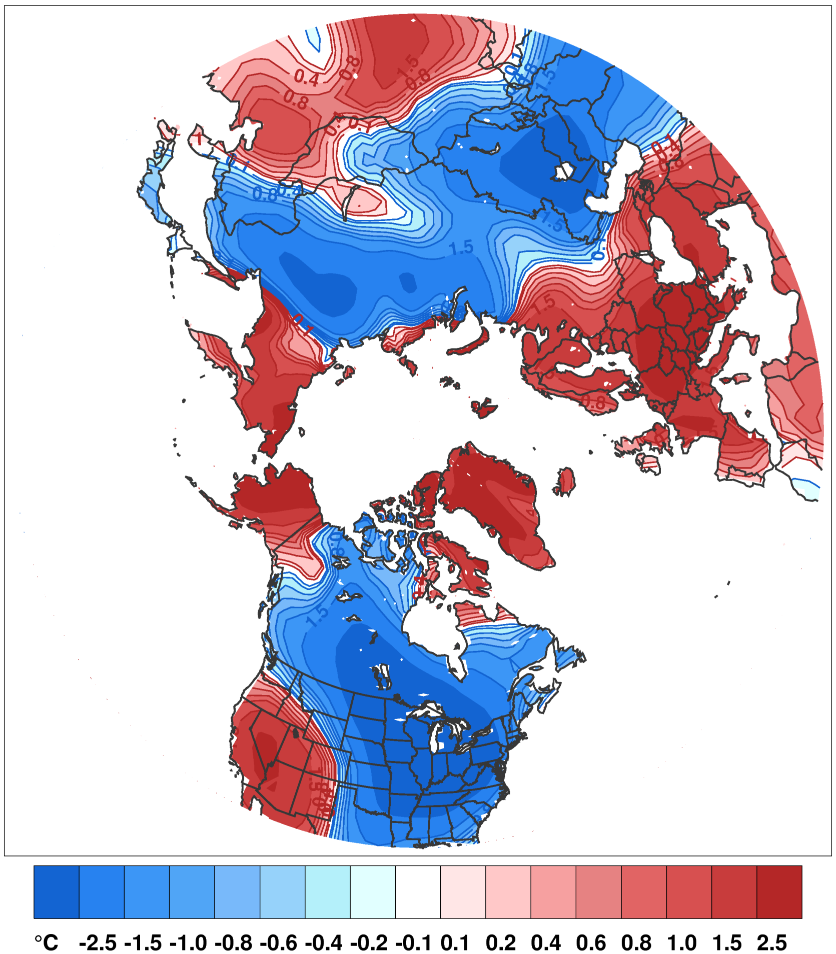


Forecasted Temperature Anomaly Dec-Jan-Feb 2014

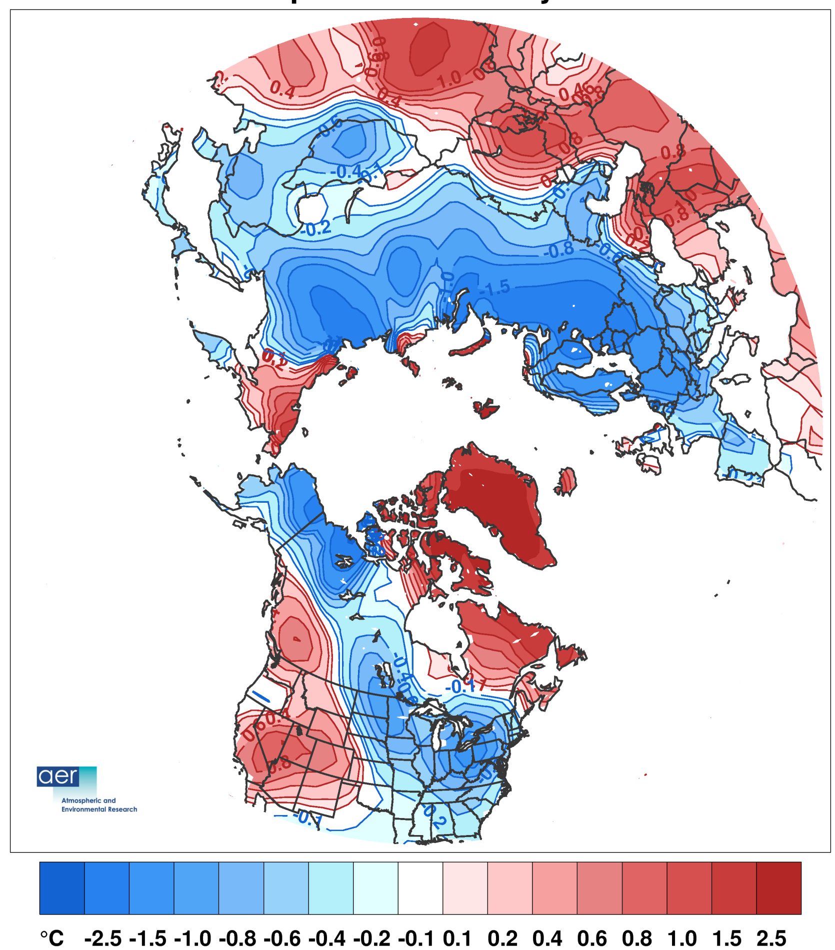


Winter 2014 Temperatures

Observed Temperature Anomaly: Jan 1 - Mar 23 2012

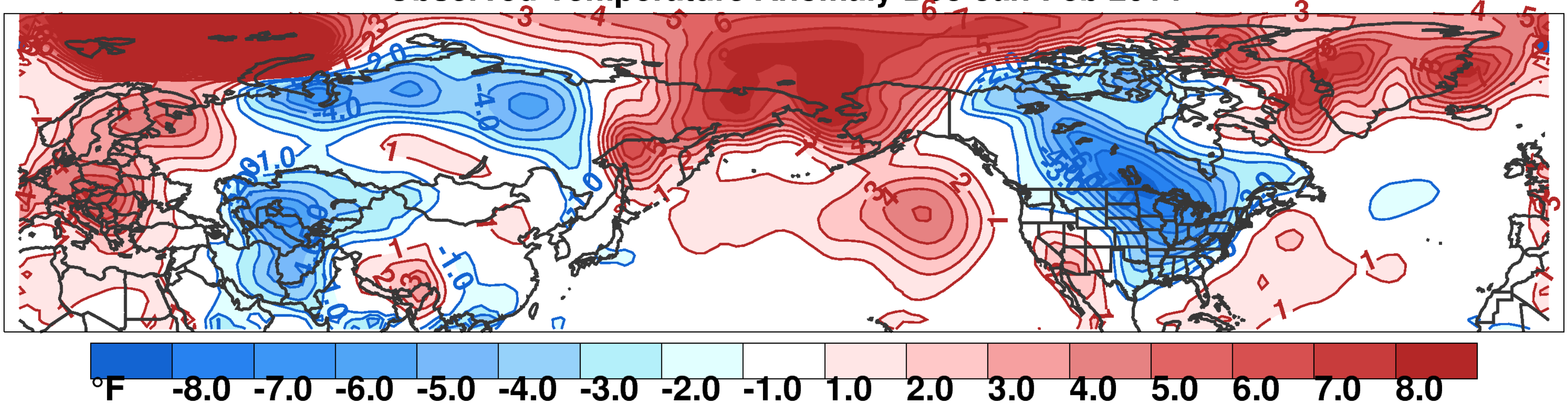


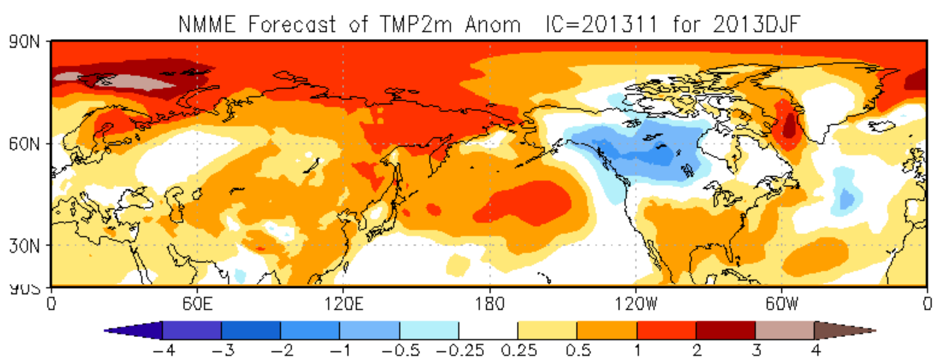
AER Forecast Temperature Anomaly Jan-Feb-Mar 2014

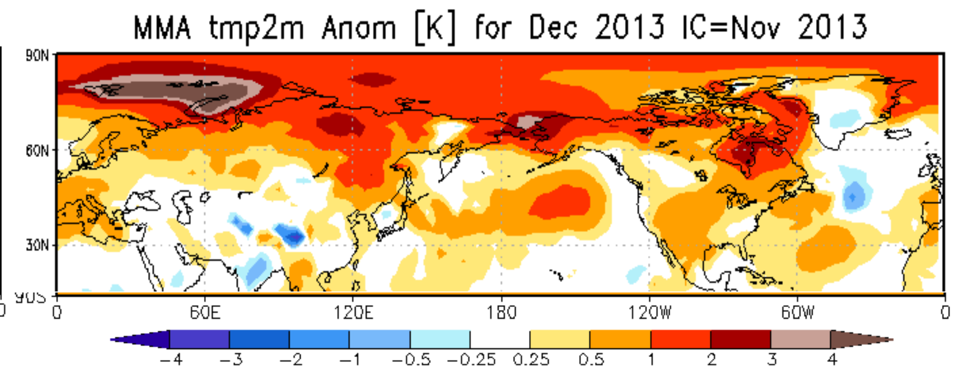


Winter 2014 Temperature Forecast and Observed

Observed Temperature Anomaly Dec-Jan-Feb 2014





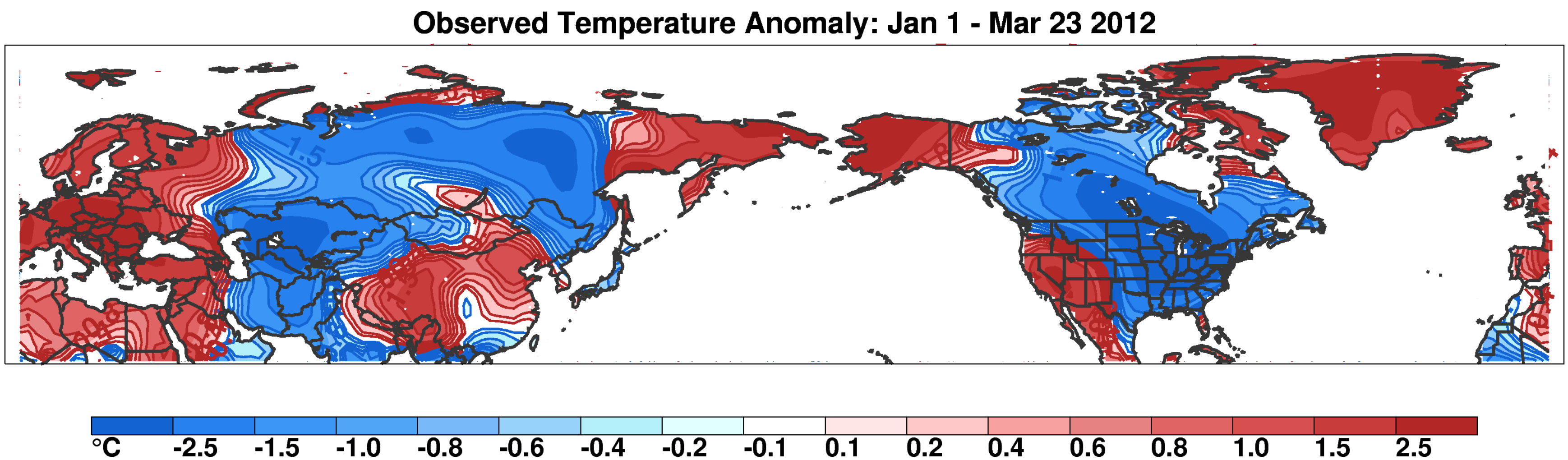


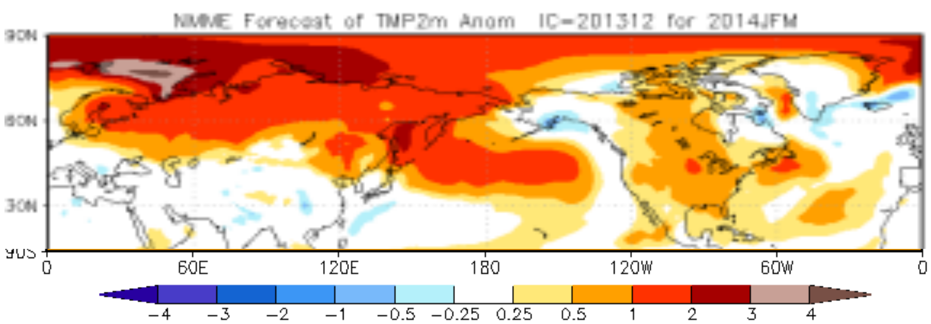
North American models forecast winter 2014

International models forecast winter 2014

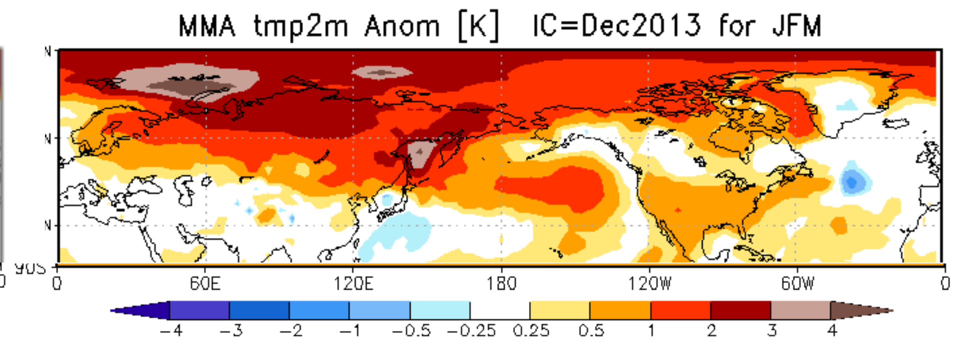
Atmospheric and Environmental Research

Winter 2014 Temperature Forecast and Observed





North American models forecast winter 2014



International models forecast winter 2014

Atmospheric and Environmental Research

USA TODAY

A GANNETT COMPANY

Nowhere to hide from extreme weather

Extreme weather to leave Detroit shivering, Southern California drenched

CNN

Bloomberg

Extreme Weather Wreaking Havoc on Food as Farmers Suffer

theguardian

World begins 2014 with unusual number of extreme weather events

Wavier jet stream 'may drive weather shift'

BBC

Climate change

Jet set

The Economist

Is polar warming to blame for America's and Britain's bad winter weather?

Global Warming, Winter Weather and the Olympics – Leading Climate Scientists Weigh In

The New York Times

Updated below | There's a noteworthy letter in today's edition of the journal Science, titled "Global Warming and This Winter's Cold Weather," that aims to cut through the flood of overwrought assertions about recent Northern Hemisphere winter weather in the context of global warming.

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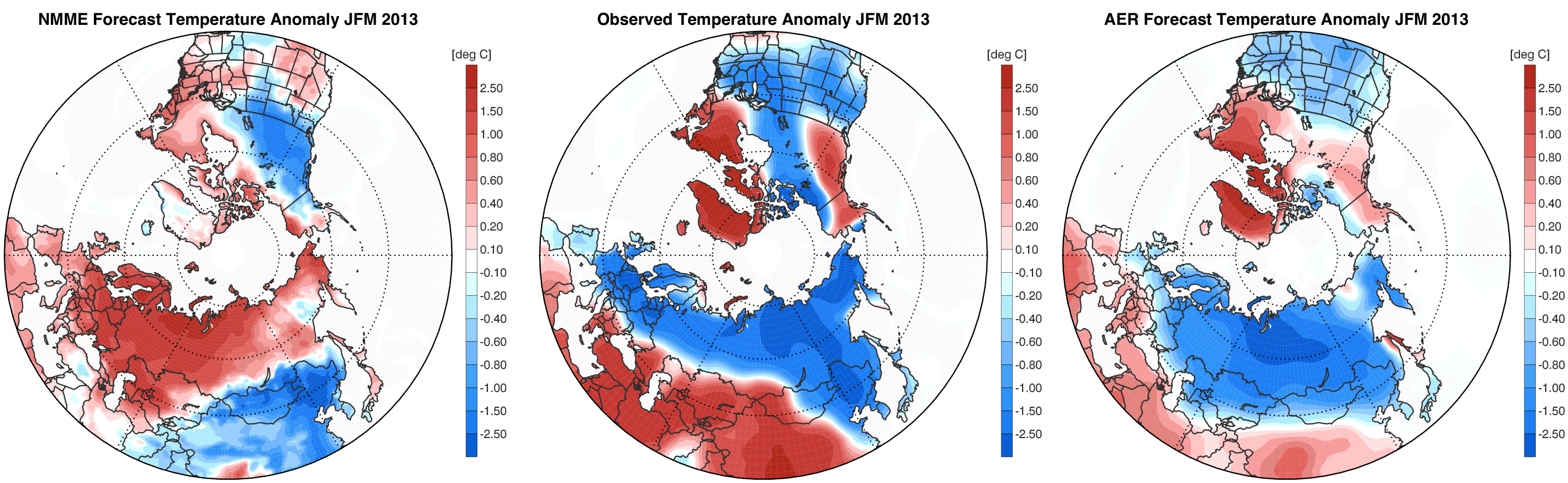
Winter 2013 Temperature Forecasts



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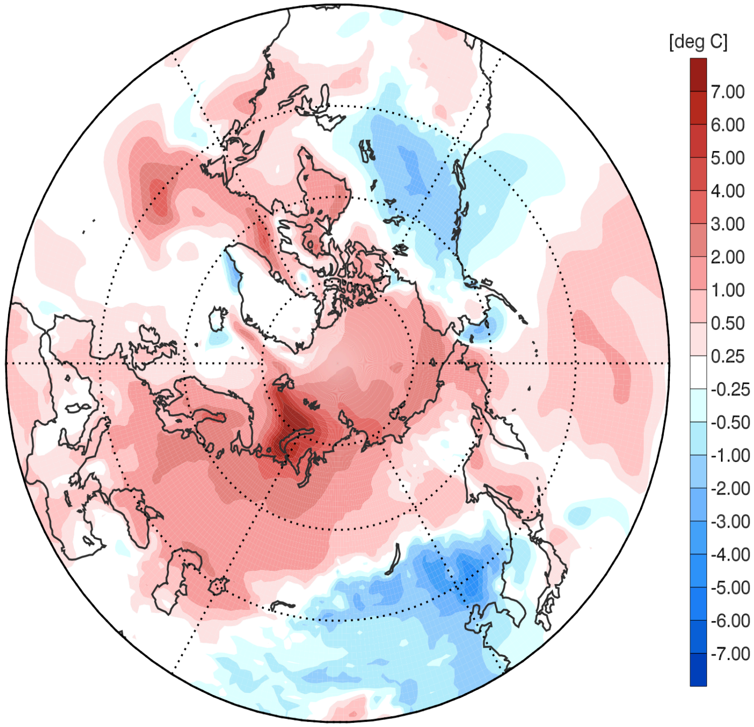
Cohen et al. 2013

Winter 2013 Temperature Forecast



January-March 2013 Dynamical model surface temperature anomaly forecast. Warmth spreads out from Arctic to the continents in contrast to observed cold across the continents.

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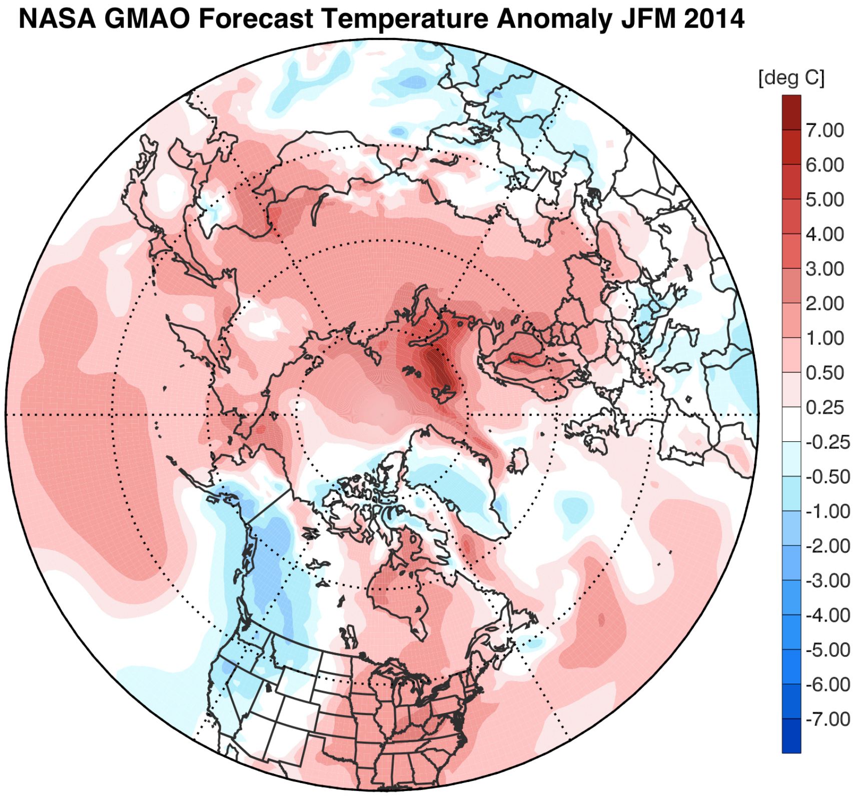
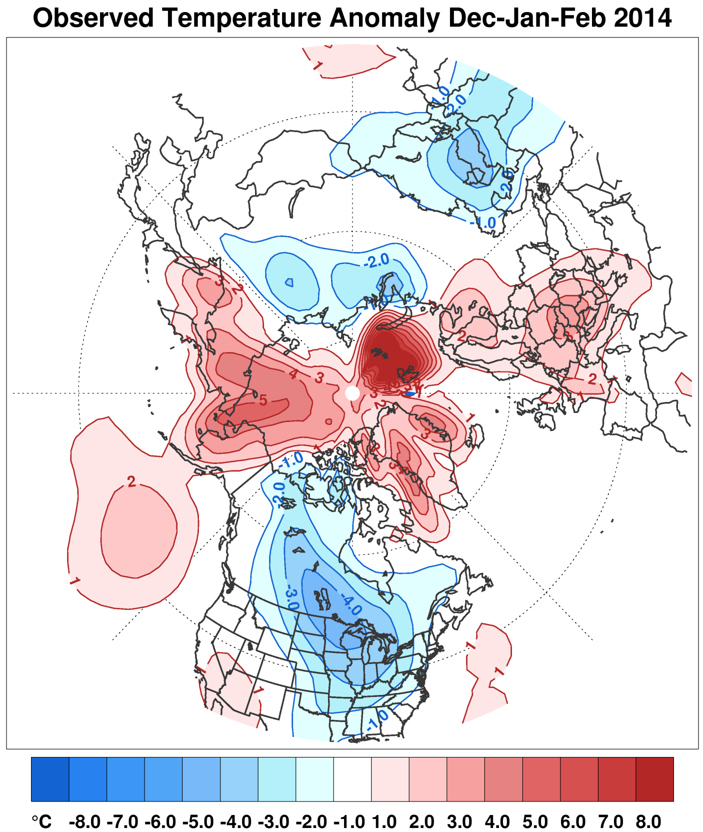
Winter 2014 Temperatures





In models Arctic warmth is advected ot the continents but not seen in nature.

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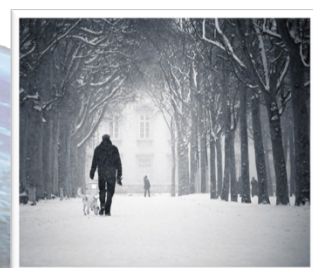
Summary

- A six step process has been identified starting with snow cover advance in the fall, development of the Siberian high, stratosphere-troposphere coupling and the phase and amplitude of the winter Arctic Oscillation.
- An index of the rate of change of daily snow cover extent (SAI) in October is more strongly correlated with the winter Arctic Oscillation than snow cover extent.
- The SAI shows great potential in improving winter temperature forecasts for many regions that are not well correlated with ENSO variability including the Eastern US and Europe.
- The seasonal forecast is not static but can be monitored and updated in real time (the six step process).

Cohen and Jones, 2011, A new index for more accurate winter predictions, *Geophysical Research Letters*, 38, L21701, doi: 10.1029/2011GL049626.

Brands, S., R. Manzanas, J.M. Gutierrez and J. Cohen, 2012, Seasonal Predictability of Wintertime Precipitation in Europe using the Snow Advance Index, Journal of Climate, 25, 4023-4028.

Cohen, J., J. Jones, J. Furtado, and E. Tziperman, 2013, Warm Arctic, Cold Continents: A Common Pattern Related to Arctic Sea Ice Melt, Snow Advance, and Extreme Winter Weather, *Oceanography*, 014007 in press.



Thank you!