An Observational Analysis: Tropical Relative to Arctic influence on Mid-latitude Weather in the Era of Arctic Amplification

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Outline

- Over the past two decades the Arctic has undergone rapid and dramatic changes.
- Coincidently there has been an increase in extreme weather especially severe winter weather across the mid-latitudes.
- Arguing that the Arctic is influencing mid-latitude weather is much more controversial than arguing the tropics are – so I did an observational "bake-off."
- Presented observational analysis demonstrates linkages to Arctic forcing are more robust than linkages to tropical forcing over the era of Arctic amplification.
- I will also argue models that support the transcendence of the tropics/natural variability over the Arctic are fatally flawed.

USA TODAY

Boston breaks seasonal snowfall record with 108.6 inches

The Washington Post

Capital Weather Gang

How climate change may be producing more blockbuster snowstorms

2016 Blizzard Was NYC's Biggest Snowstorm on Record, NOAA Report Finds

4 NEW YORK

East Asia Hit by Record Snowfalls and Cold Weather

TIME

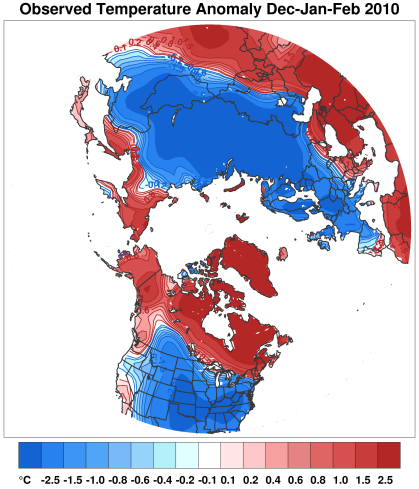
February 2015: One of the Coldest on Record in Many Midwest and Northeast Cities

Valentine's Day Arctic Outbreak Brings Coldest Temperatures in Decades to Boston, New York City

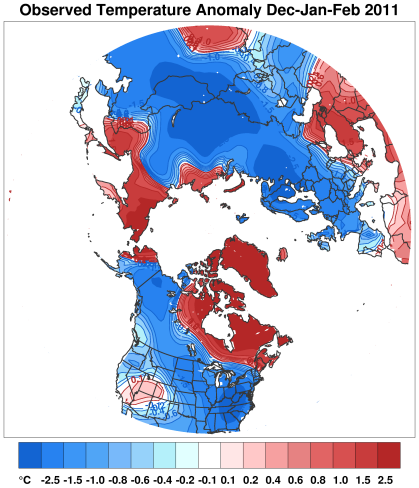
The Weather Channel

Observed Winter Temperatures 2009/10-14/15

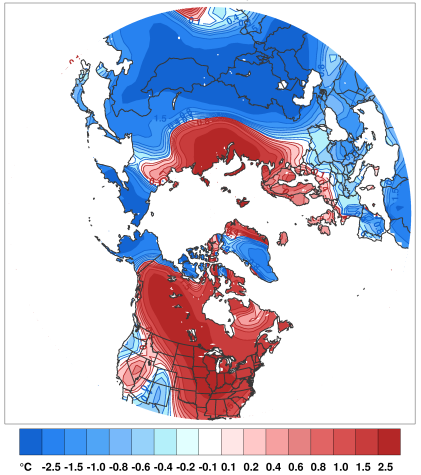
Observed Temperature Anomaly Dec-Jan-Feb 2010



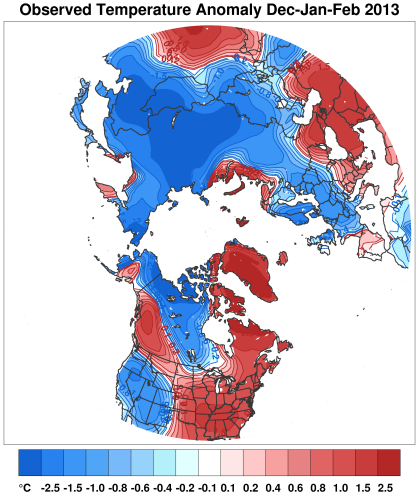
Observed Temperature Anomaly Dec-Jan-Feb 2011



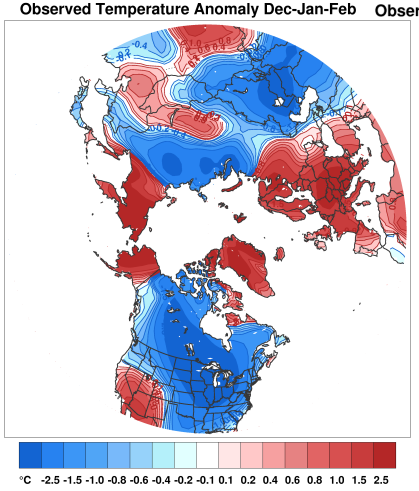
Observed Temperature Anomaly: Dec 1 - Feb 29 2012



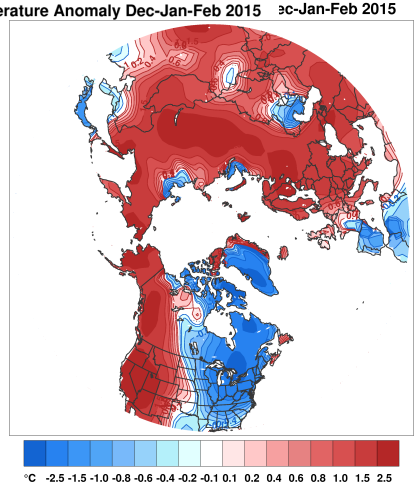
Observed Temperature Anomaly Dec-Jan-Feb 2013



Observed Temperature Anomaly Dec-Jan-Feb



Observed Temperature Anomaly Dec-Jan-Feb 2015



ɔc-Jan-Feb 2015

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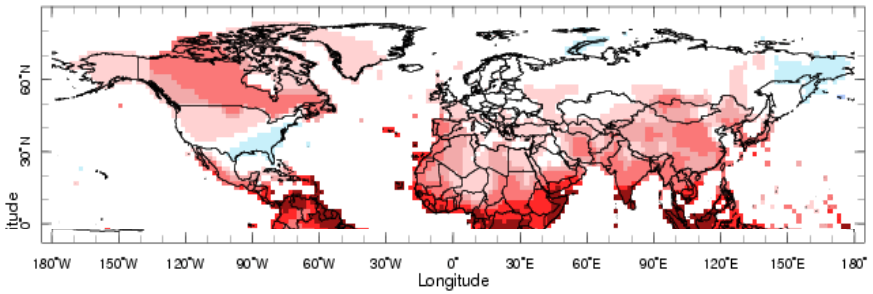
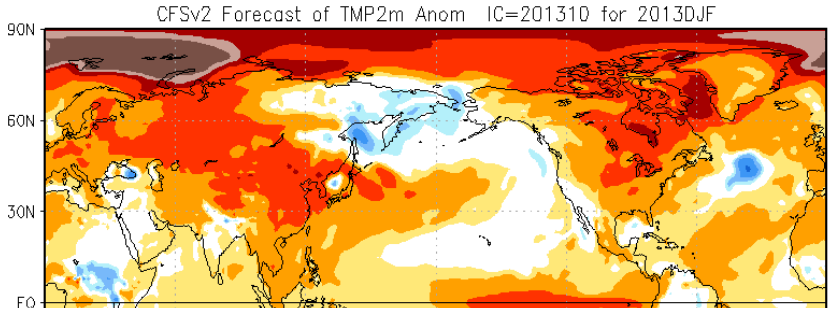
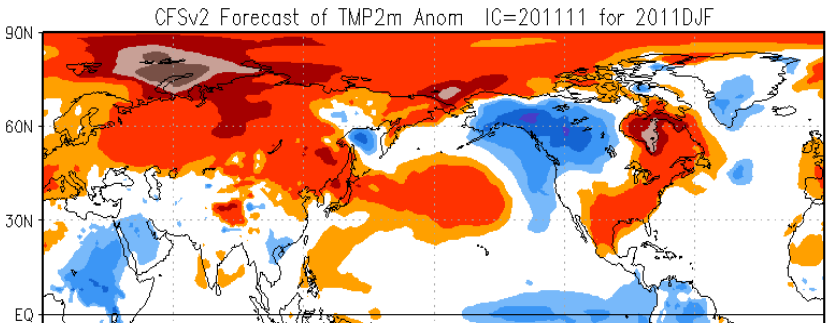
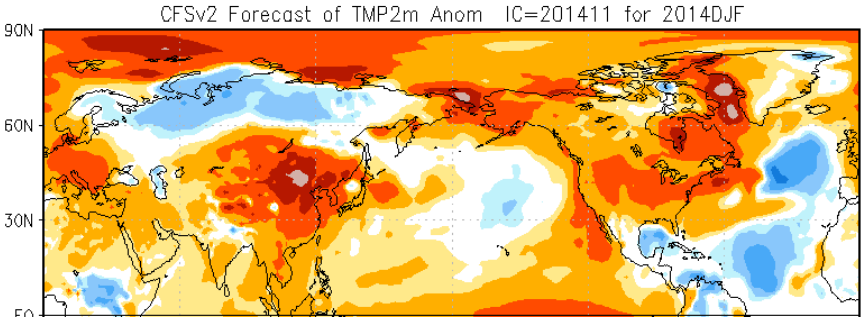
Dynamical Winter Forecasts 2009/10-14/15

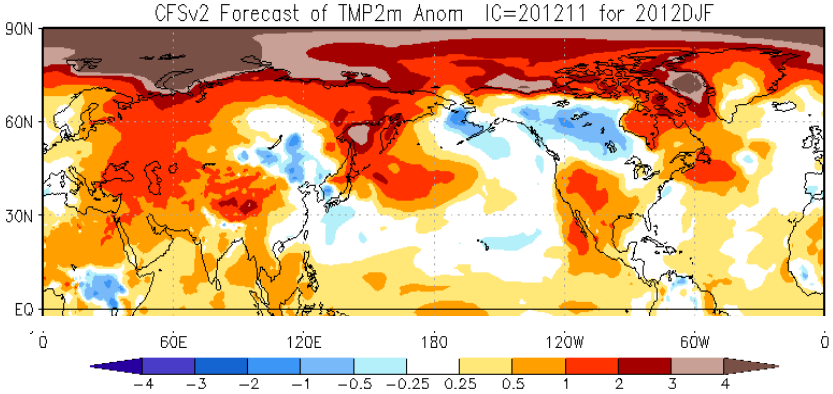


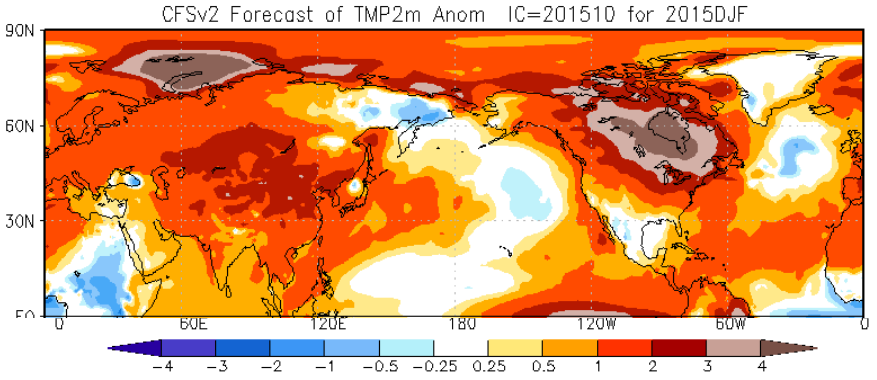
Dec 2009 - Feb 2010 IRI Seasonal Temperature Forecast issued Nov 2009











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The fact that the models are always too warm relative to the observations is not a flaw with the observations but a flaw with the models.

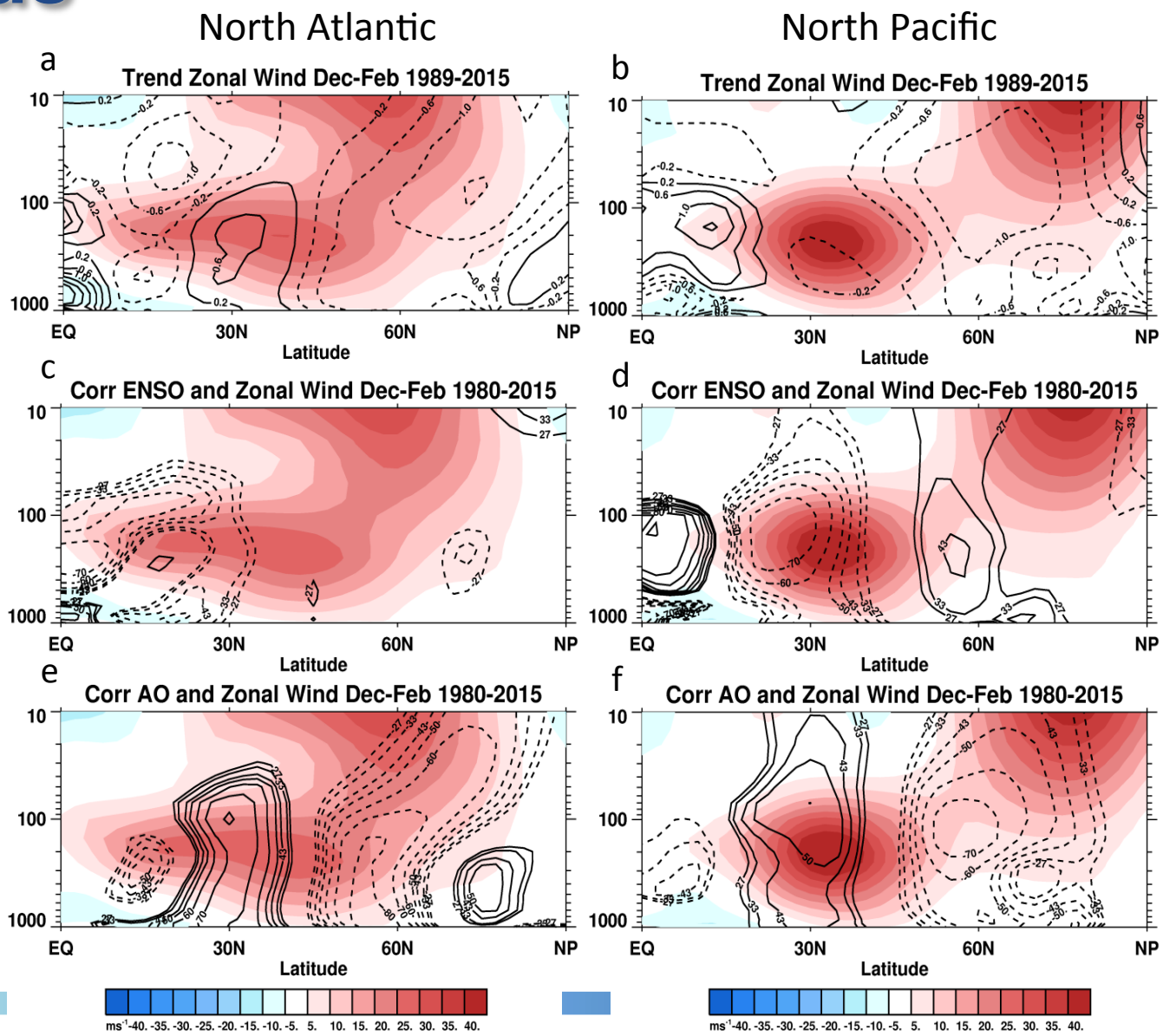
Source of observation-model discrepancy (In era of Arctic amplification (AA))

- Natural or internal variability of mid-latitude weather (streak of poor forecasts is just a matter of bad luck)
  - ✓ If we had many more iterations of the observations the mean of the observations and the model forecasts would converge.

- Remote forcing (that are either poorly sampled from the observations or poorly simulated in the models)
  - ✓ Tropical forcing – established theory
  - ✓ Arctic forcing – controversial, fringe theory

Wind trends

Variability associated with the AO is symmetric about both ocean basins and is strongest in the mid-latitudes. Variability associated with ENSO is focused in the North Pacific and is strongest in the tropics and subtropics.



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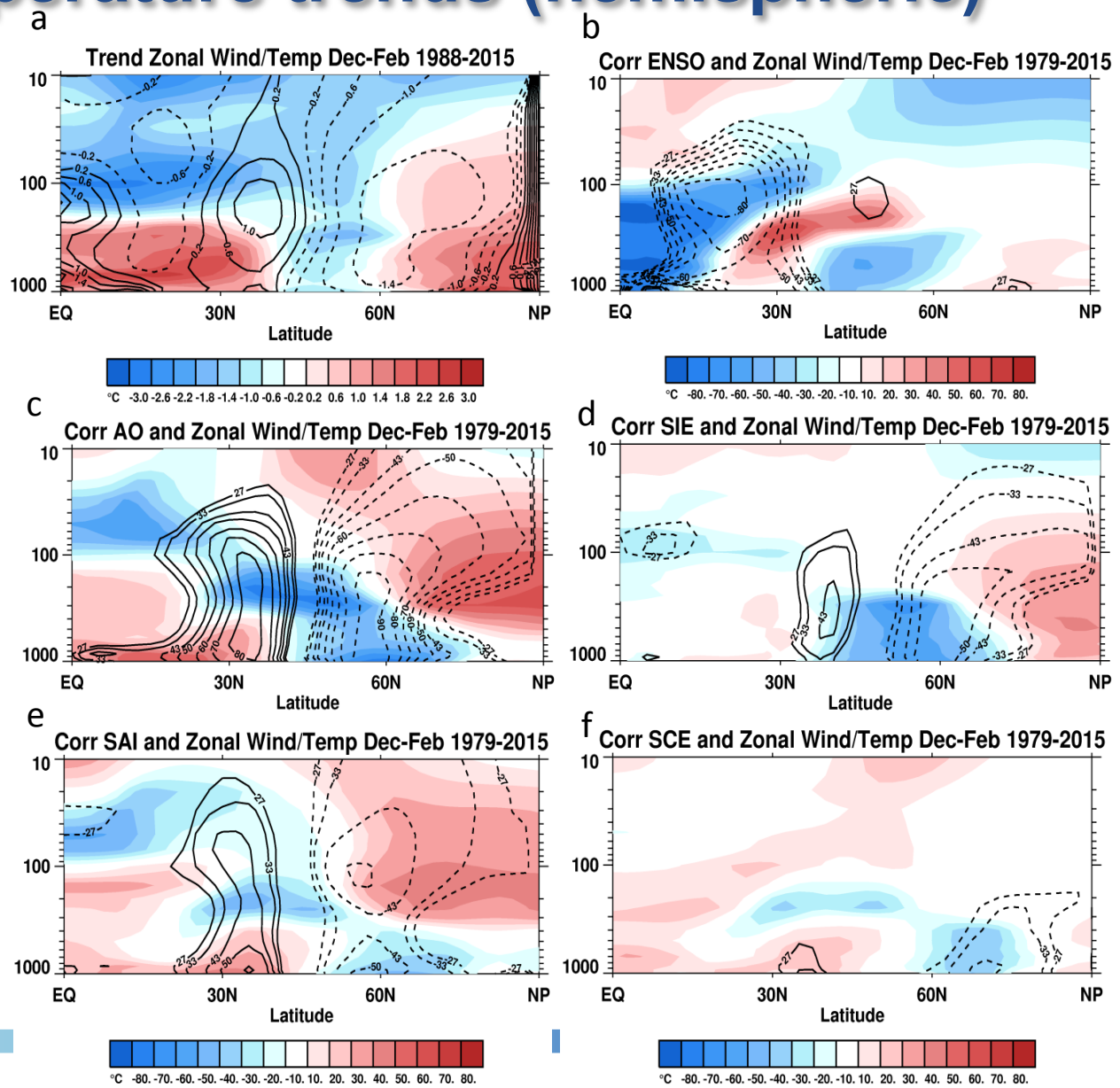
Wind and temperature trends (hemispheric)

Dipole structure in winds and tripole structure in temperatures, seen in trends and correlations with Arctic indices (AO, Arctic sea ice, Siberian snow cover) but not ENSO.



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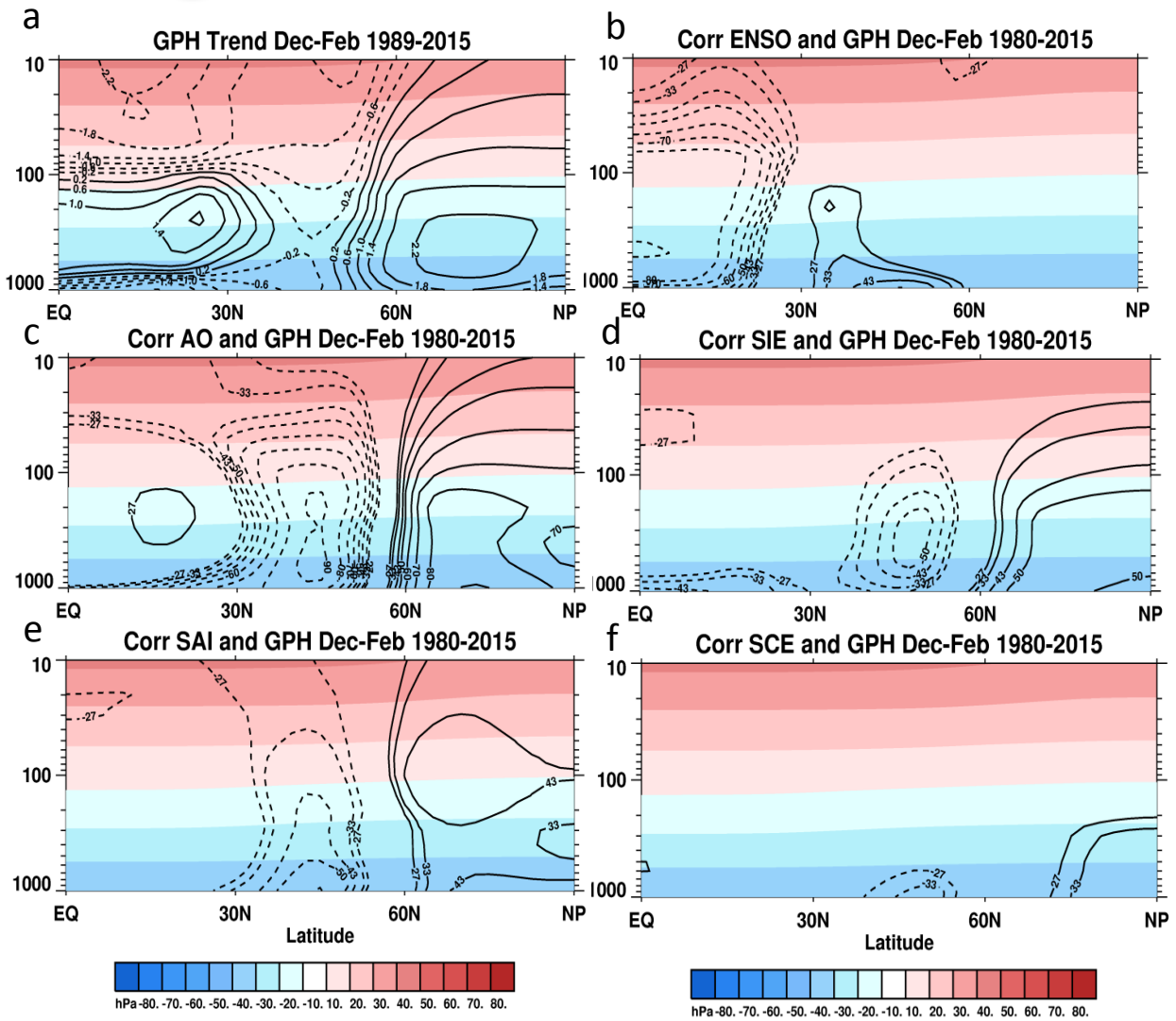
Geopotential height trends

Dipole structure in mid- to high-latitude geopotential heights, seen in trends and correlations with Arctic indices (AO, Arctic sea ice, Siberian snow cover) but not ENSO.



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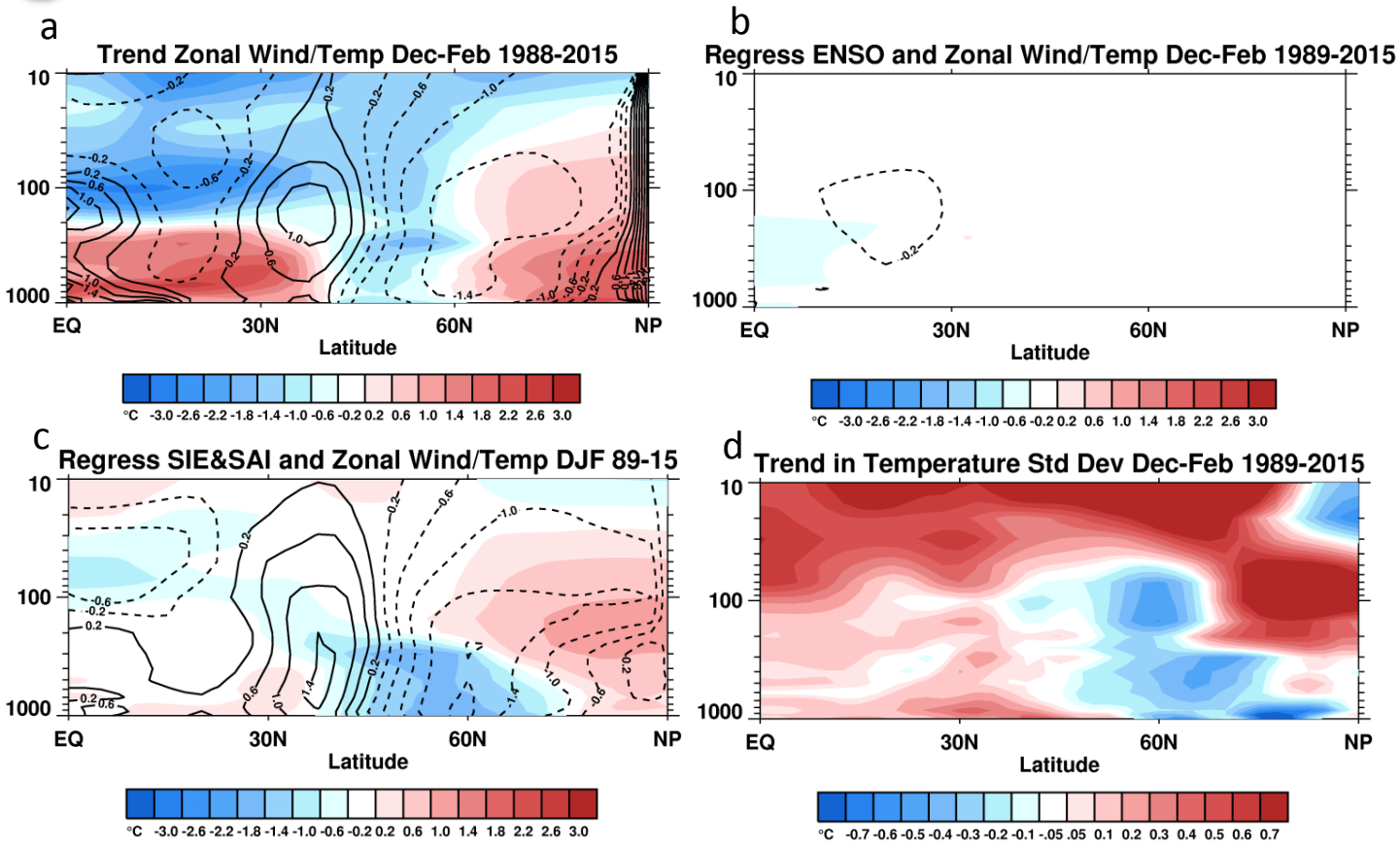
Regression of Arctic and ENSO



Dipole structure in winds and tripole structure in temperatures, seen in regression of change in Arctic indices (Arctic sea ice, Siberian snow cover) but not ENSO. Also temperature variability in mid-latitudes is increasing not decreasing as predicted by models (a hint model and natural variability diverge).

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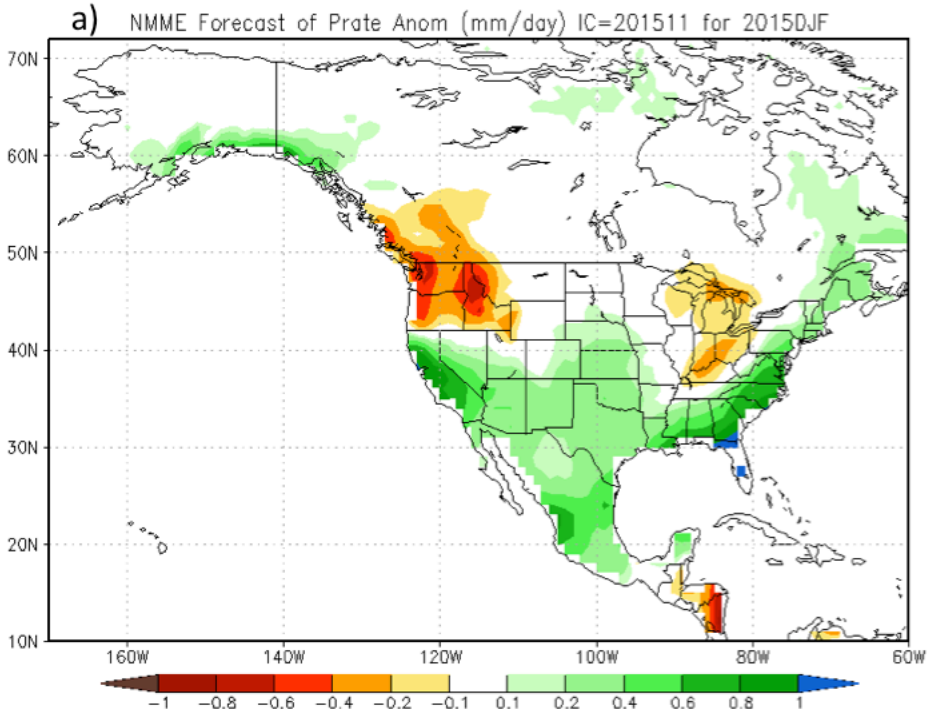
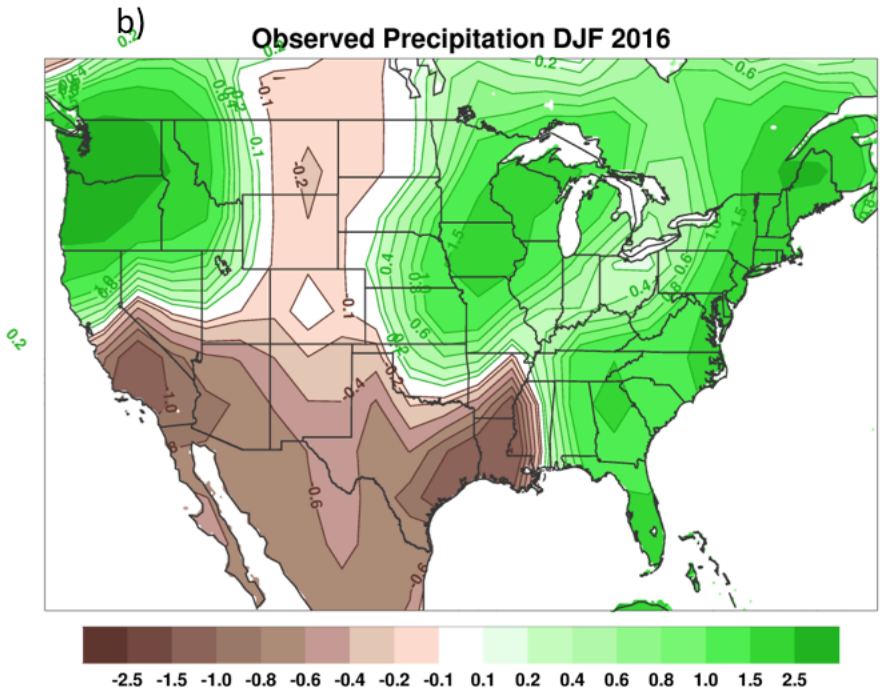
Caveats

- Observational evidence just presented in my opinion looks compelling. At least based on the observations, it is hard to argue that the tropics are a more significant influence than the Arctic - in era of AA.
- Conventional wisdom - observational record is short, natural variability is large so better to use models where we can develop more confident statistics.
- Tropical forcing was **record strong** this past winter and should have been a showcase study of tropical forcing and models.
- Yet observed climate anomalies were outside the realm of possibility based on model forecasts.

Winter 2015/16 – strongest El Niño on record





North-south dipole in precipitation anomalies is iconic signature of ENSO for North America. Yet the model forecasts missed everywhere except along the East Coast and attribution to ENSO is tenuous.

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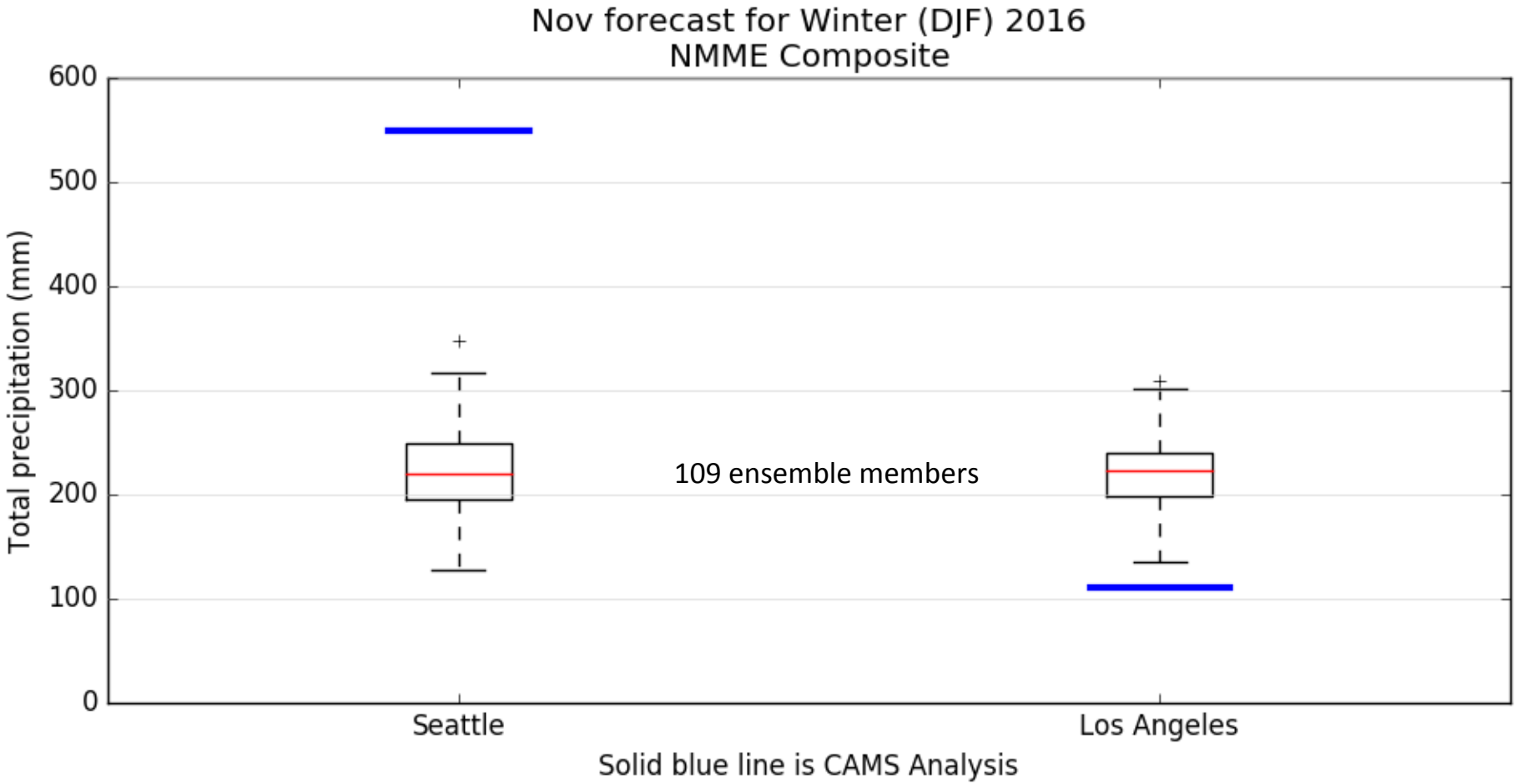
Winter 2015/16 model precipitation forecasts



- ✓ Models are overly sensitive to tropical forcing
- ✓ Internal variability of models does not match natural variability

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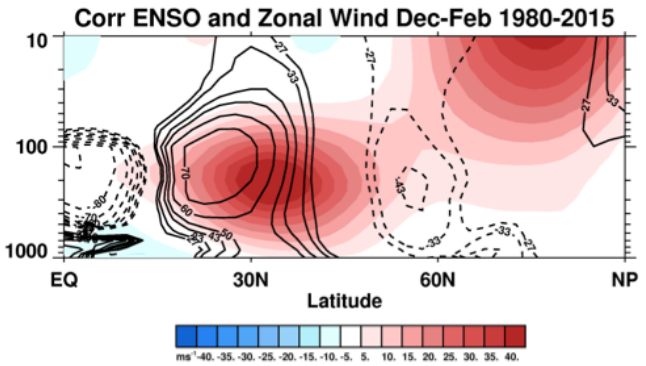
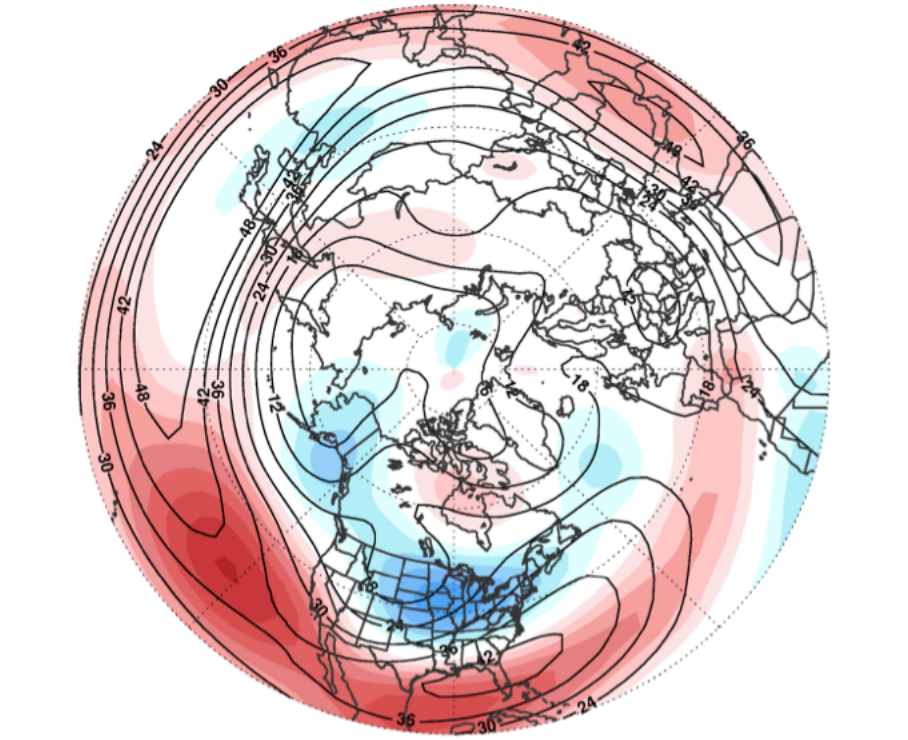
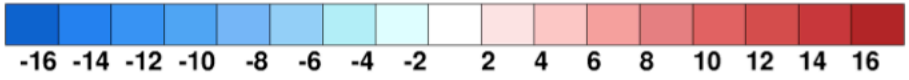
Zonal wind anomalies

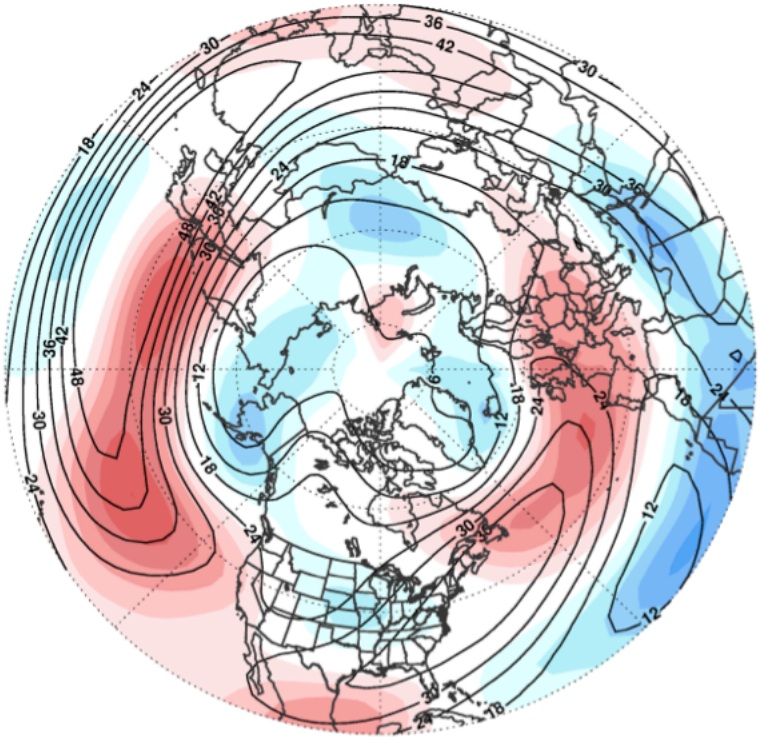


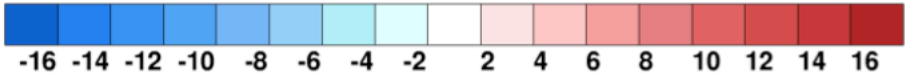
a) 250 U Wind Anomaly: Dec 1 - Feb 28 1997





b) 250 U Wind Anomaly: Dec 1 - Feb 28 2015





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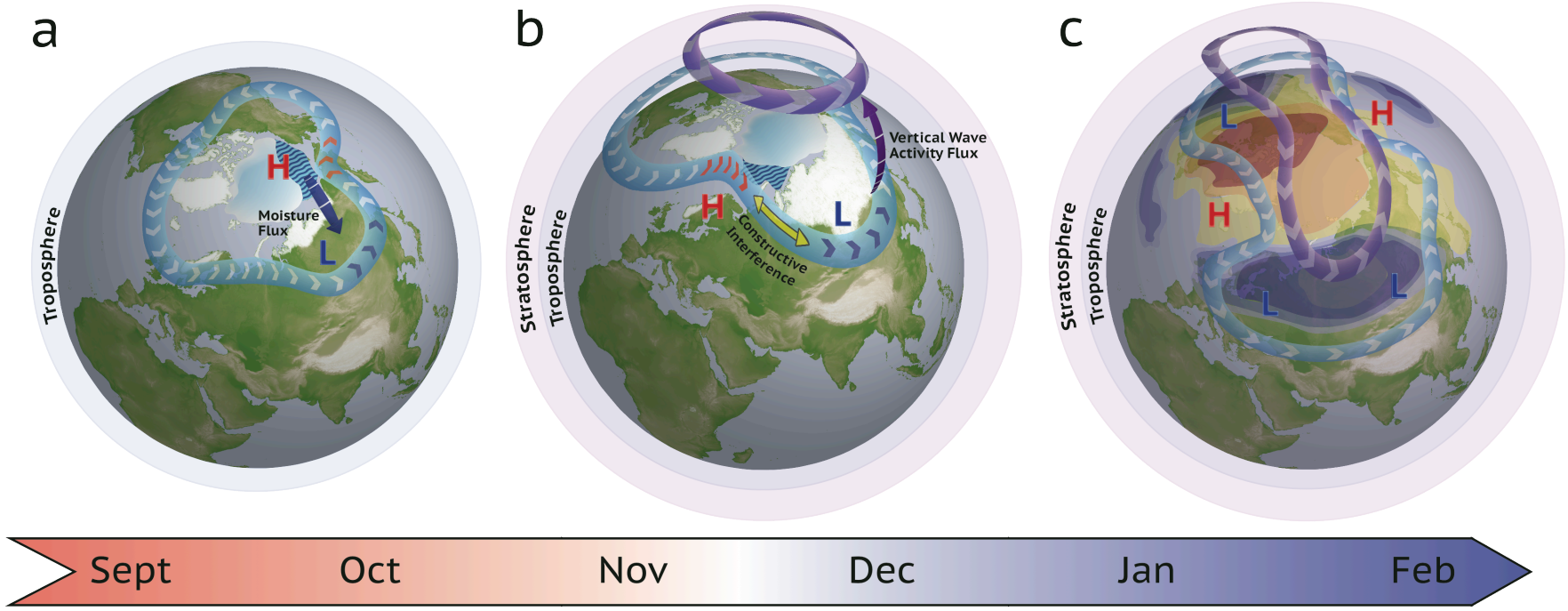
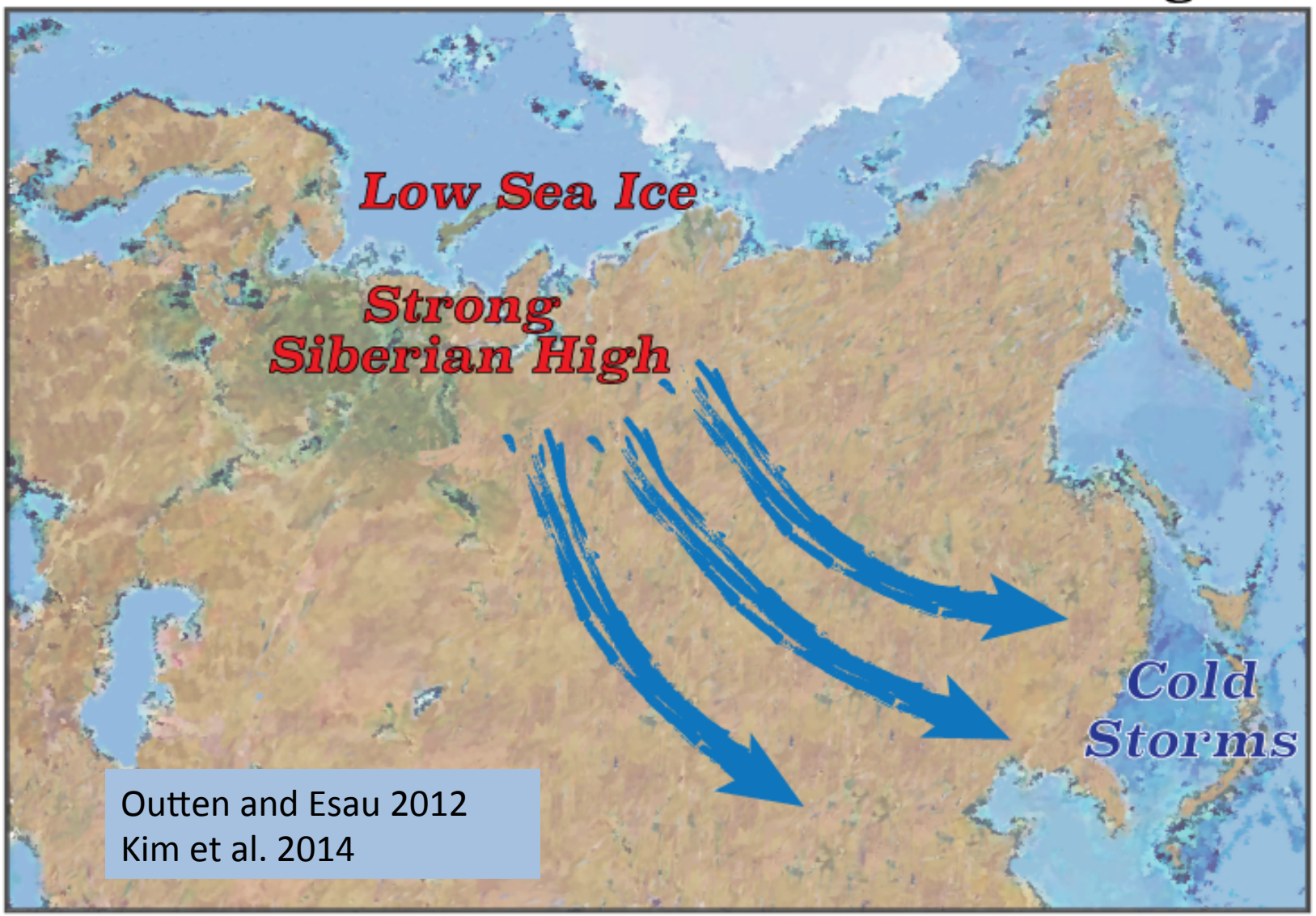
Synthesis of Sea Ice and Snow Cover



Northwestward expansion of Siberian high is emerging as one of the more robust responses to Arctic amplification (low Arctic sea ice/high Eurasian snow cover).

Cohen et al. 2014

Asia: Arctic-Midlatitude Weather Linkages



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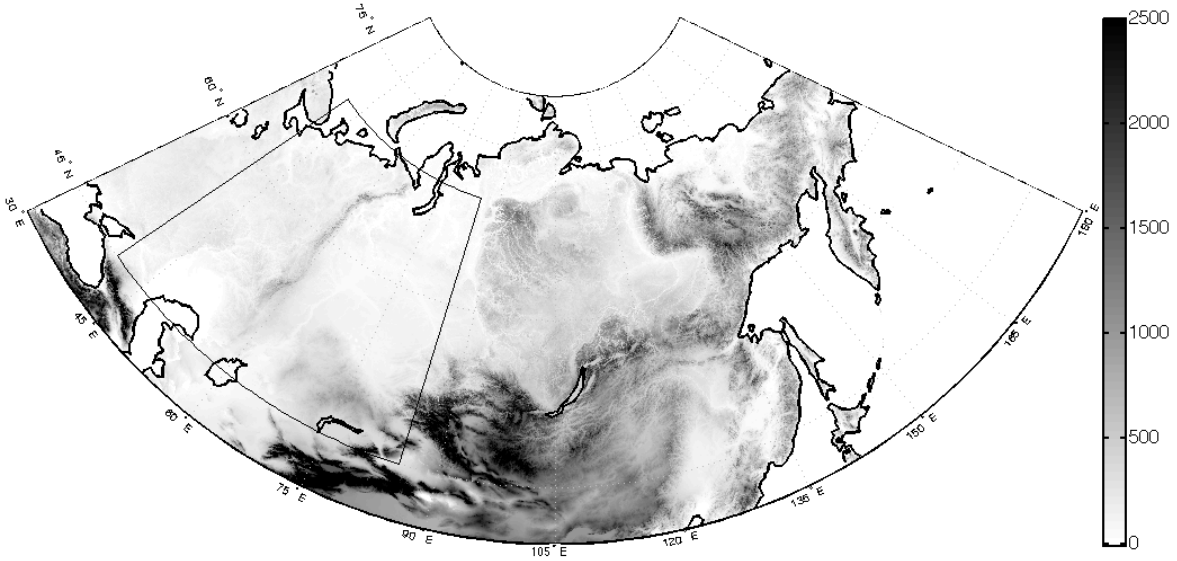
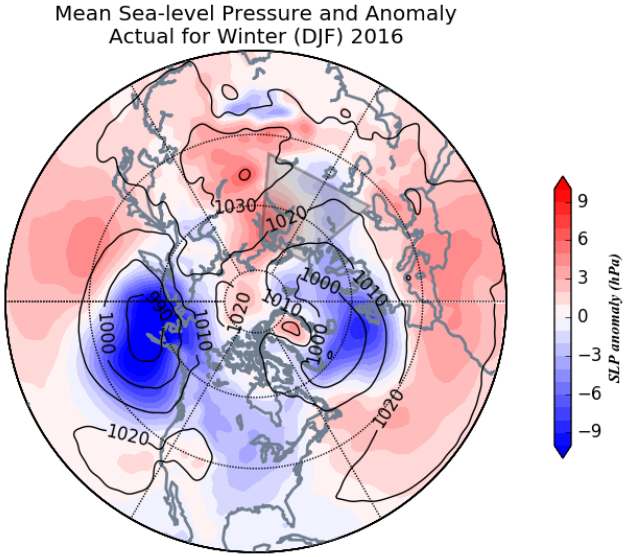
James Overland

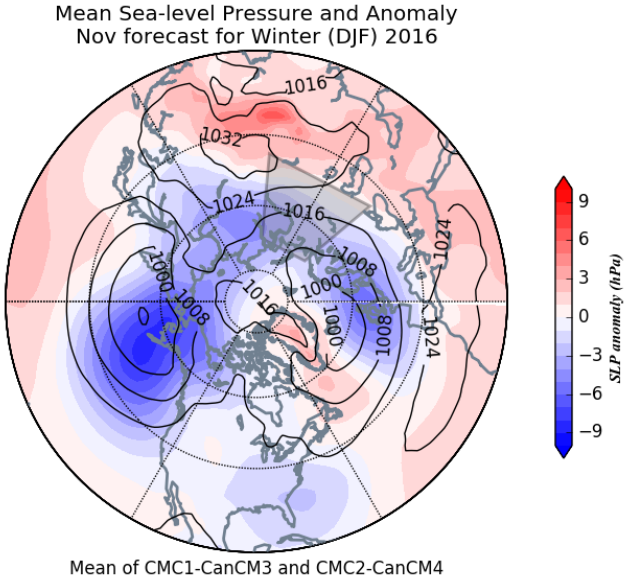
Northwest expansion of Siberian high associated with high snow cover and low sea ice



Siberian high domain from Cohen et al. 2014

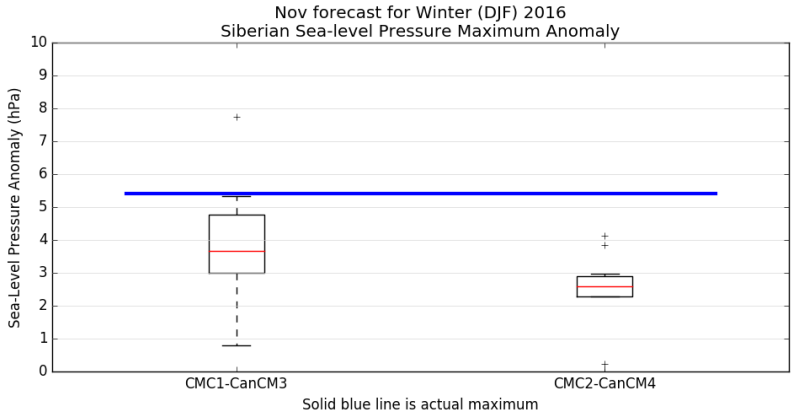
Winter 2015/16 and model SLP forecasts





Mean of CMC1-CanCM3 and CMC2-CanCM4

Eurasian snow cover was high and Arctic sea ice was low favorable for a strong Siberian high.



- ✓ Models lack sensitivity to Arctic forcing
- ✓ Internal variability of models does not match natural variability

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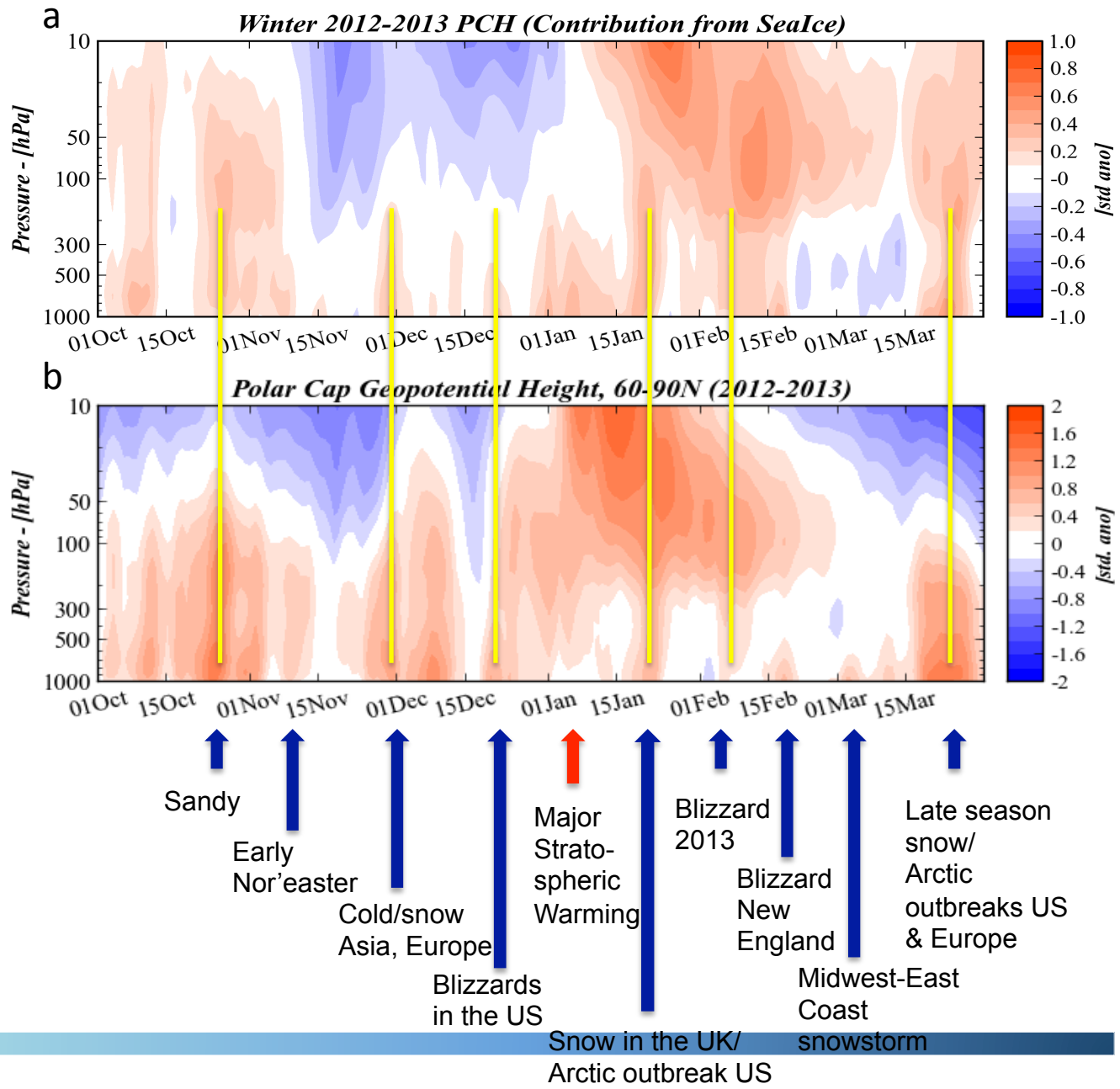
Polar Cap Height Oct-Mar 2012/13



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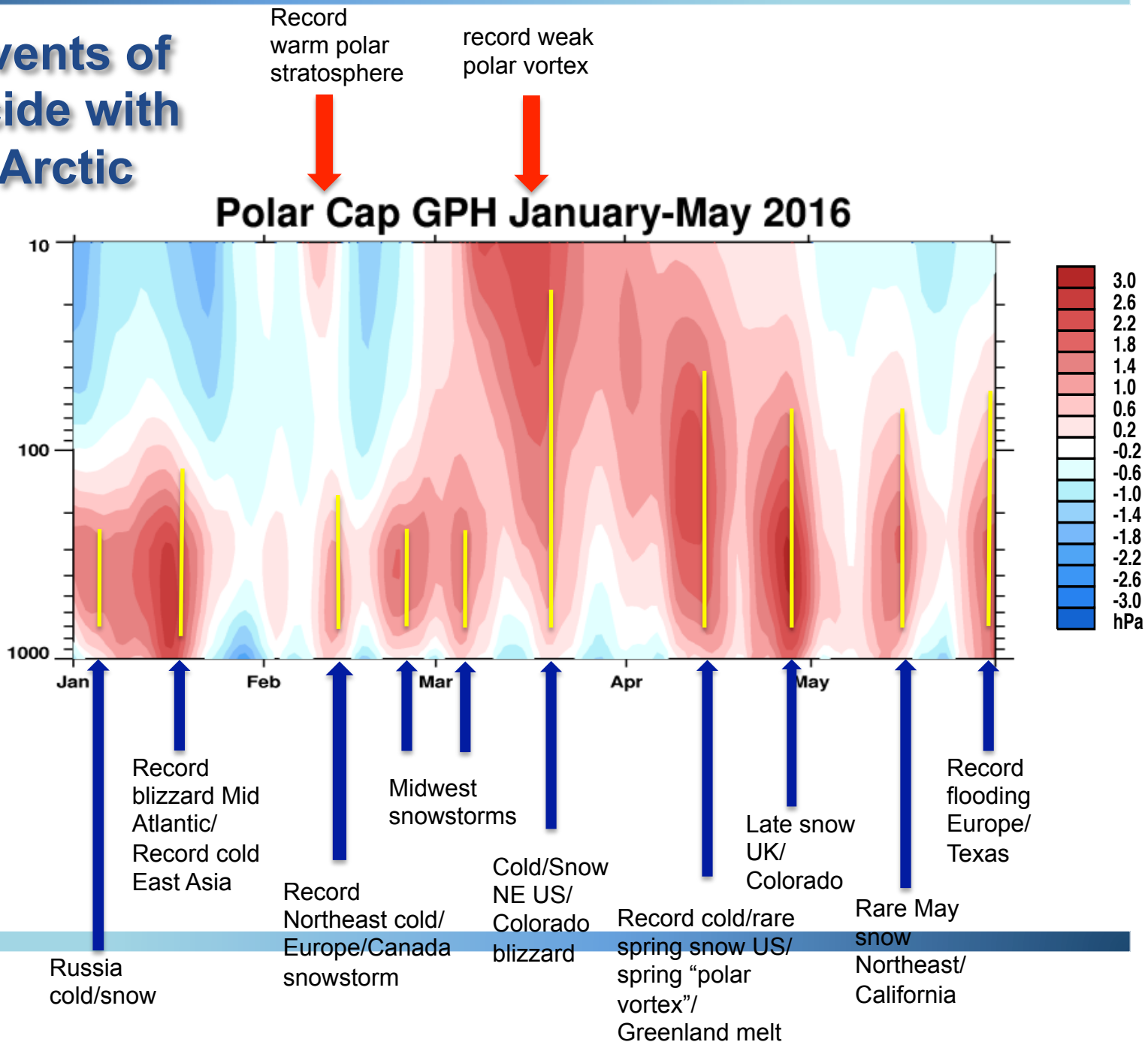
Extreme events of 2016 coincide with pulsing of Arctic warming



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Arctic-Midlatitude Linkage Workshop

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Summary

- Attribution of “cold continents” to “warm Arctic” is controversial and results are inconsistent especially in model experiments.
- In contrast tropics are universally accepted as the most important remote forcing of mid-latitude weather.
- Observations that I presented show Arctic mid-latitude weather linkage is more robust than ENSO/tropical mid-latitude weather in era of Arctic amplification.
- Numerous model simulations demonstrate that “cold continents” are due to tropical forcing and/or natural variability.
- However winter 2015/16 demonstrated that models are fatally flawed. The models are overly sensitive to tropical forcing while lacking sensitivity to Arctic forcing. Furthermore their internal variability differs from natural variability.
- The argument that “only” the tropics are important for mid-latitude weather variability is not supported by the observations or the models. I would argue even further the argument that the tropics are “more” important than the Arctic is also not supported.