



What do we know about surface-atmosphere
coupling?

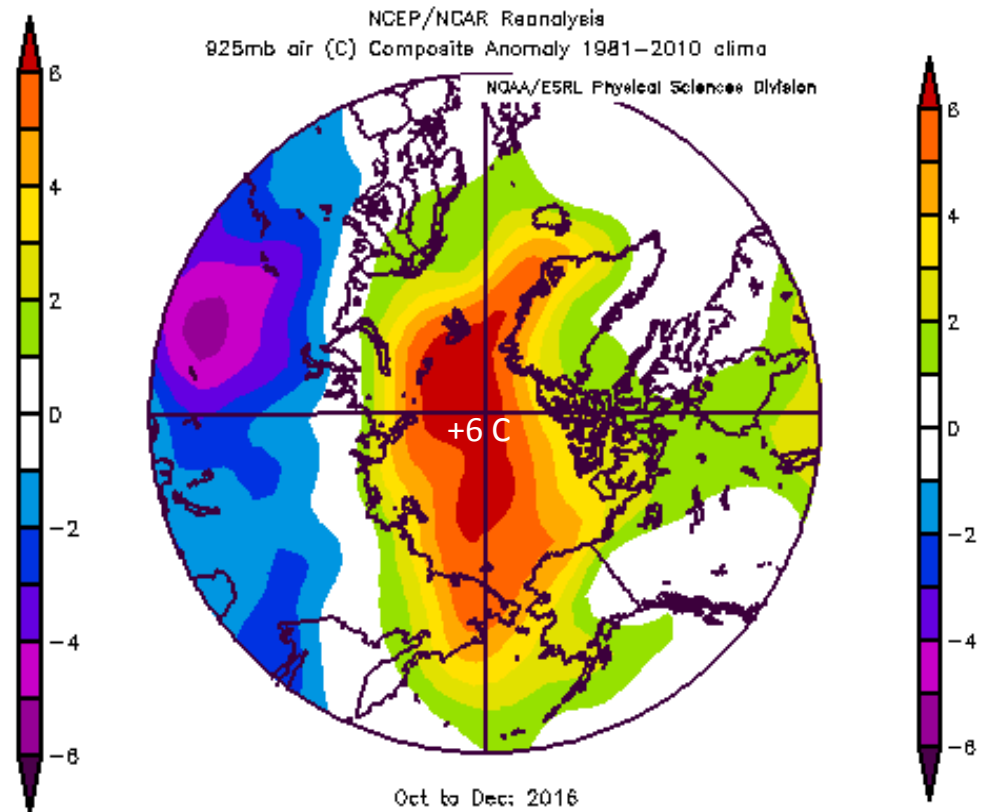
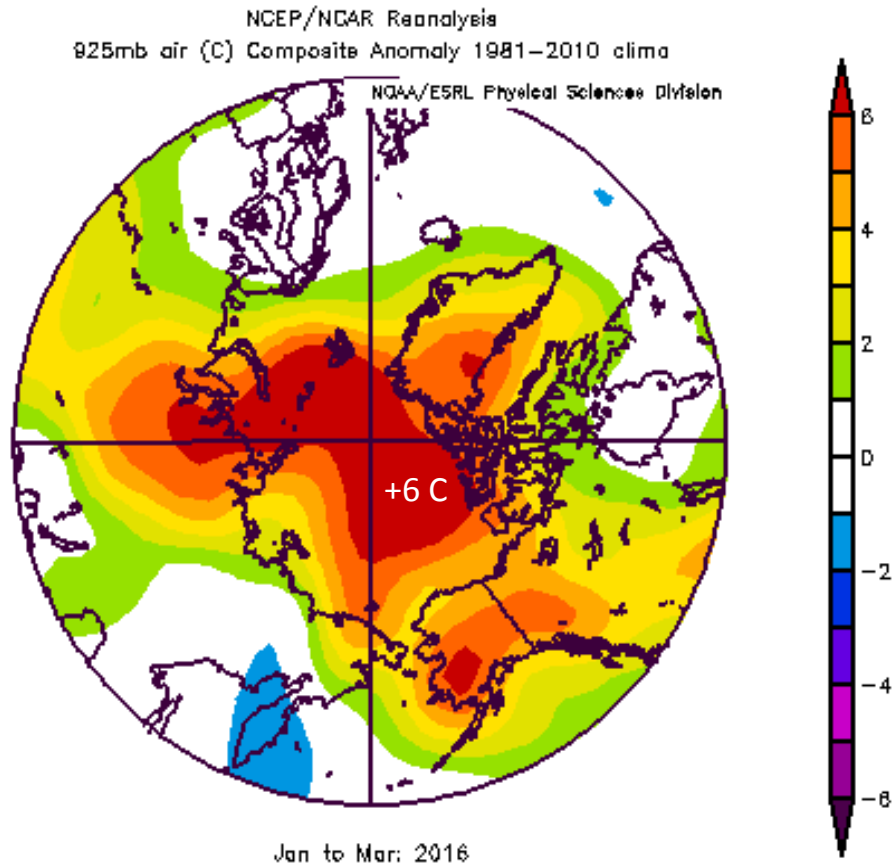
Nonlinear Response of Midlatitude Weather
to the Changing Arctic

James Overland NOAA/Pacific Marine Environmental
Laboratory

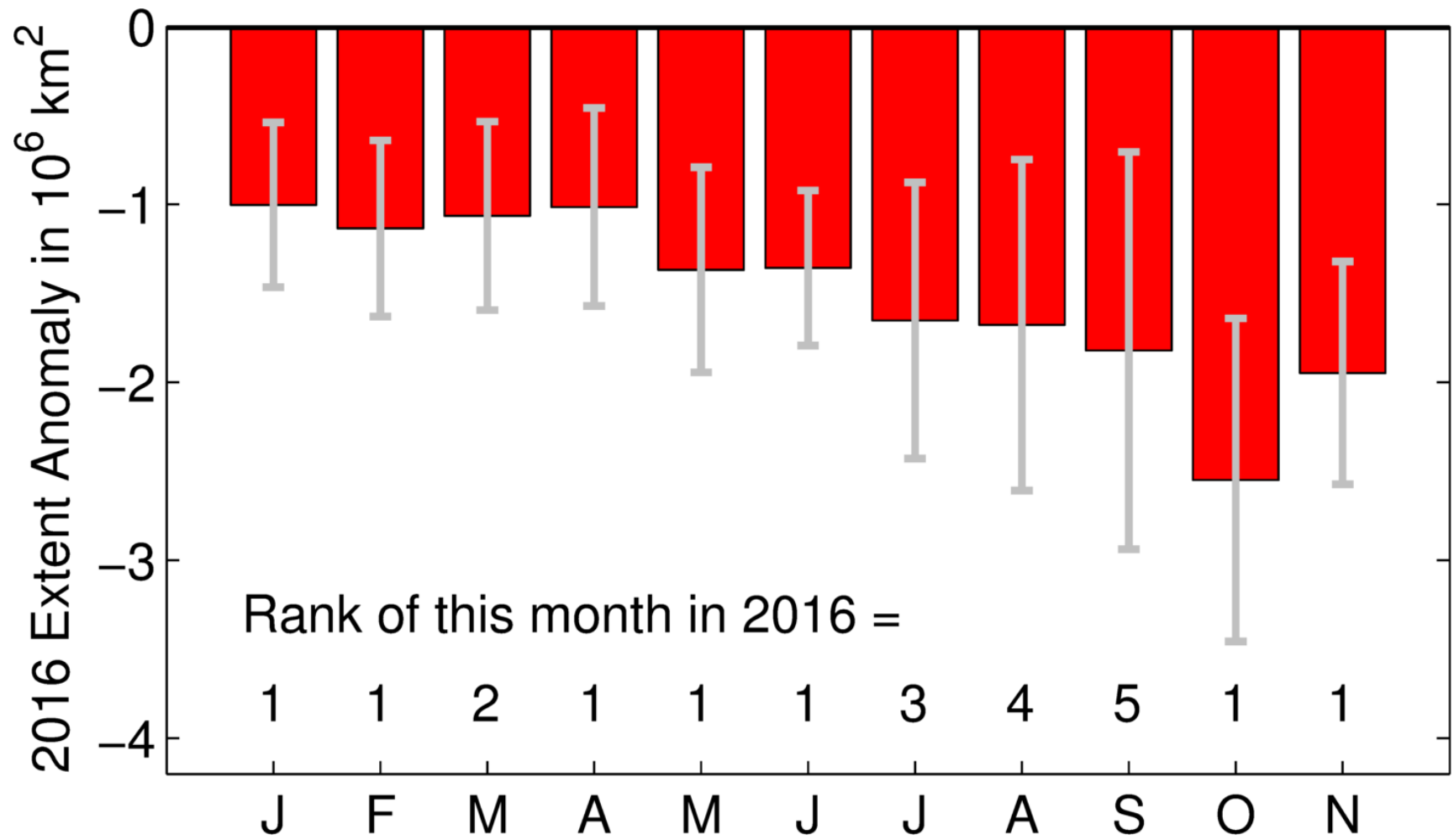
Seattle USA

M. Wang, Z. Han, G. Henderson, D. Smith,
M. Wendisch, W. Maslowski,

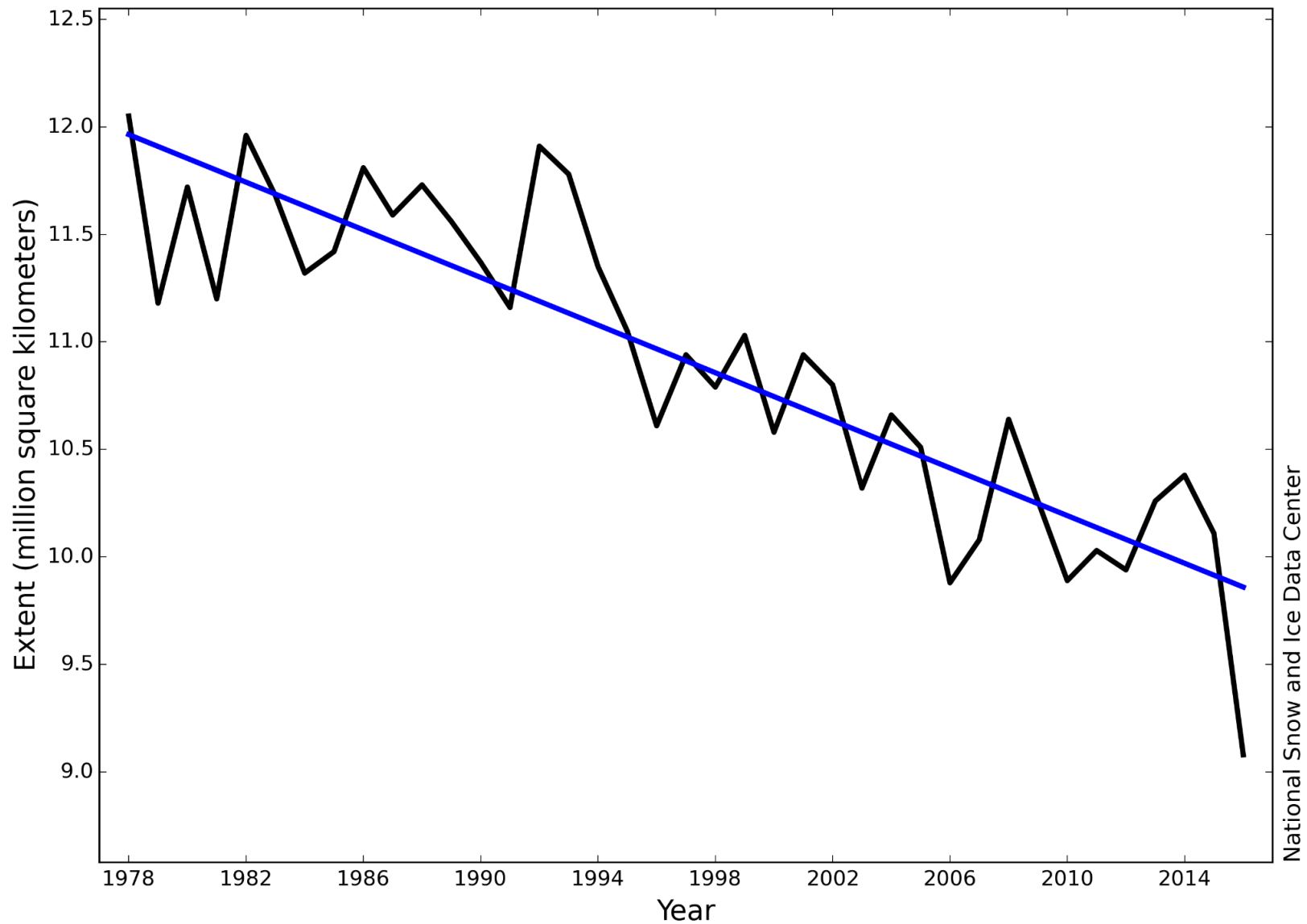
Back-to-Back Record Warm Arctic Temperature Anomalies Fall/Winter 2015-16 and 2016-17



Nearly Double Previous Record



Average Monthly Arctic Sea Ice Extent November 1978 - 2016



Thermal Wind (Connection of Temperature Gradient to Wind)

$$\mathbf{v}_T = \frac{R}{f} \ln \left[\frac{p_0}{p_1} \right] \mathbf{k} \times \nabla_p \bar{T}.$$

Geopotential (Φ) Tendency Equation

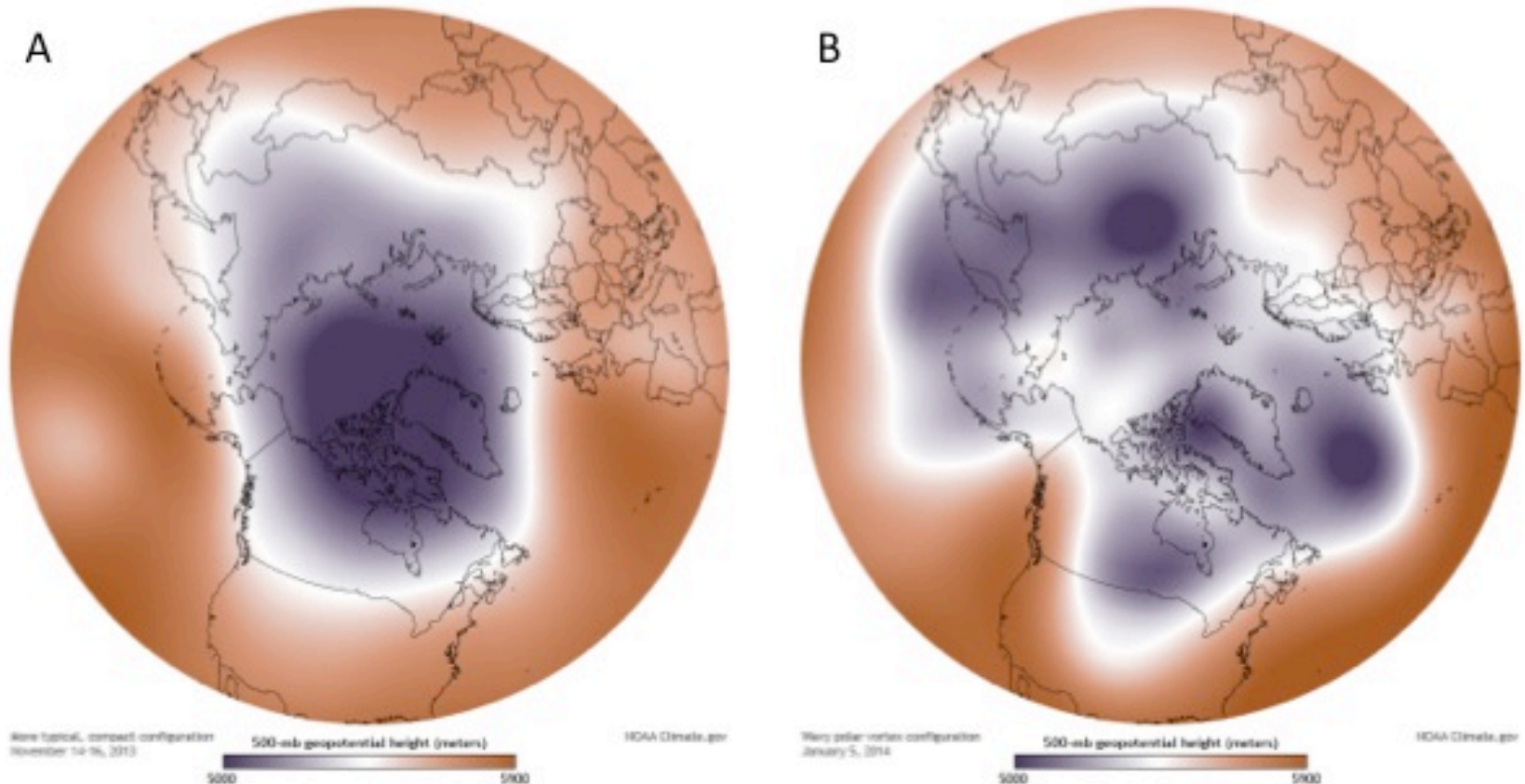
in pressure coordinates (notation after Holton 1979)

$$\frac{\partial \Phi}{\partial t} \propto \int_0^1 \mathbf{V} \cdot \mathbf{g} \cdot \nabla (1/f \int_0^1 \nabla^2 \Phi + f) + \int_0^1 \nabla^2 / \sigma \frac{\partial}{\partial p} [\mathbf{V} \cdot \mathbf{g} \cdot (\partial \Phi / \partial p)] + \int_0^1 \nabla^2 R$$

Vorticity advection

decrease with height of
Thickness Advection and Heating

Chaos in Atmospheric Dynamics: Zonal and Wavy States



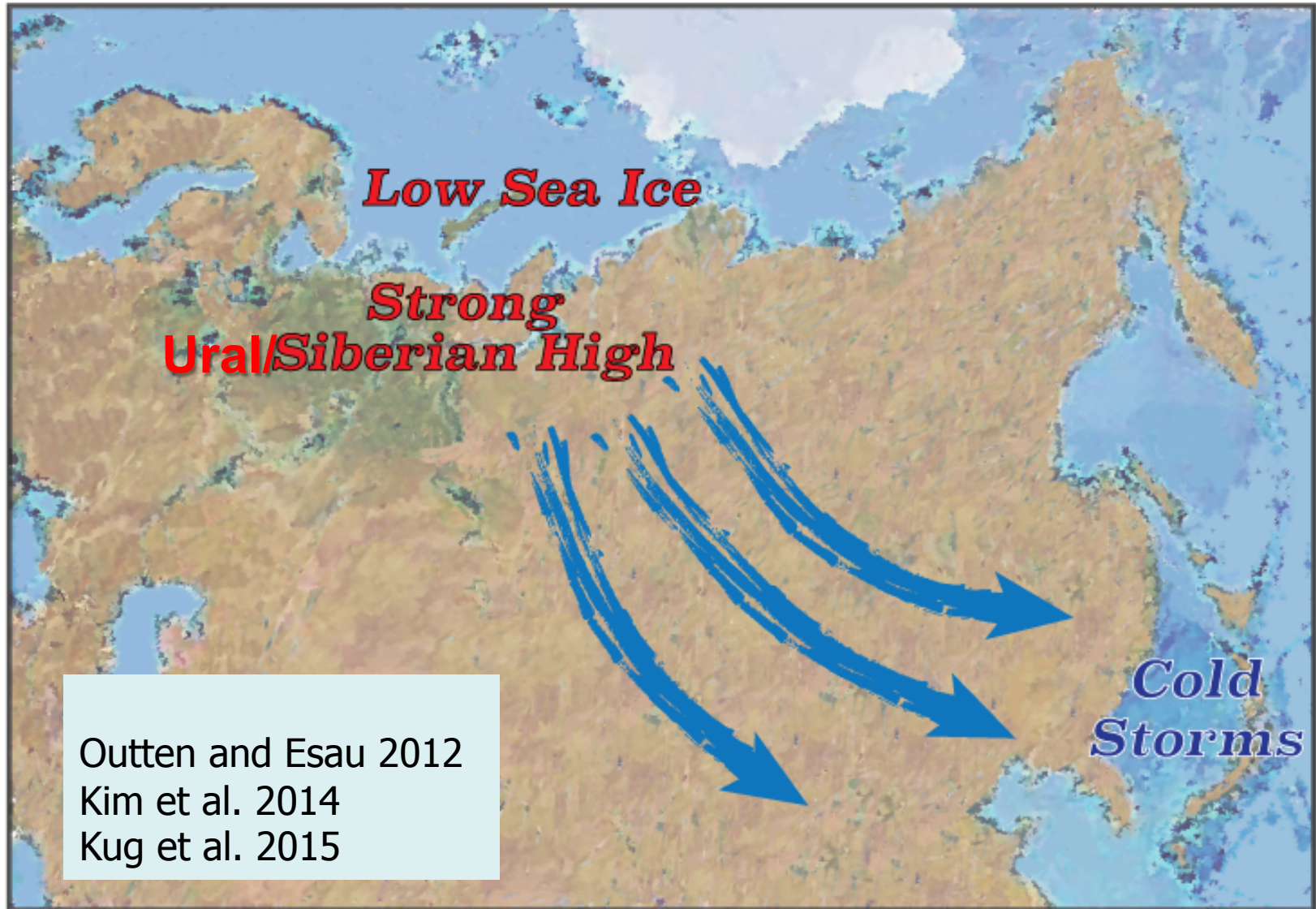
500 hPa Pressure surfaces: Geopotential Heights

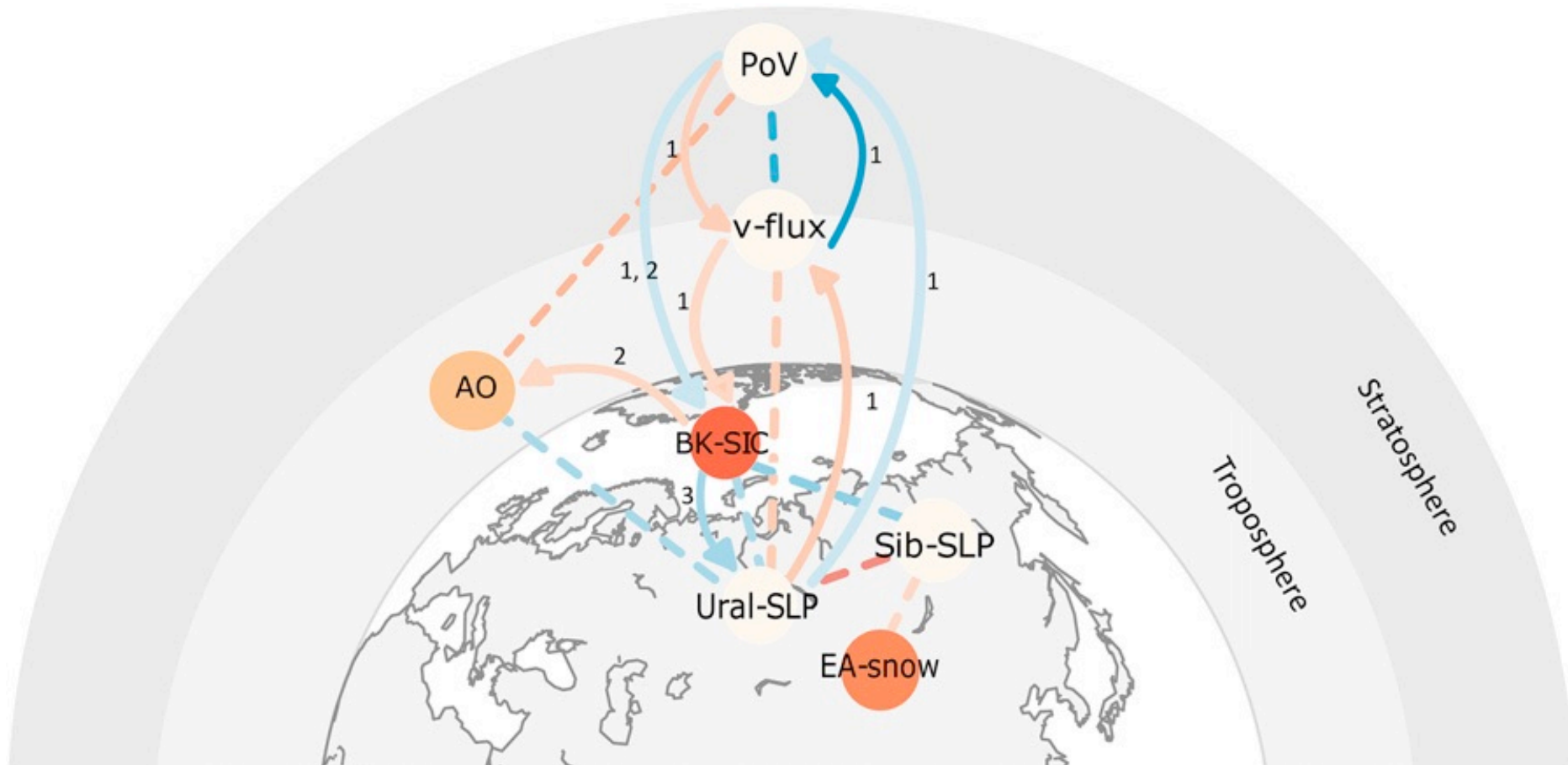
Nonlinear Limitations:
(No one-to-one cause and effect)

Intermittency/State Dependency
(Arctic reinforces existing weather patterns)

Multiple Regional Influences

Asia: Arctic-Midlatitude Weather Linkages



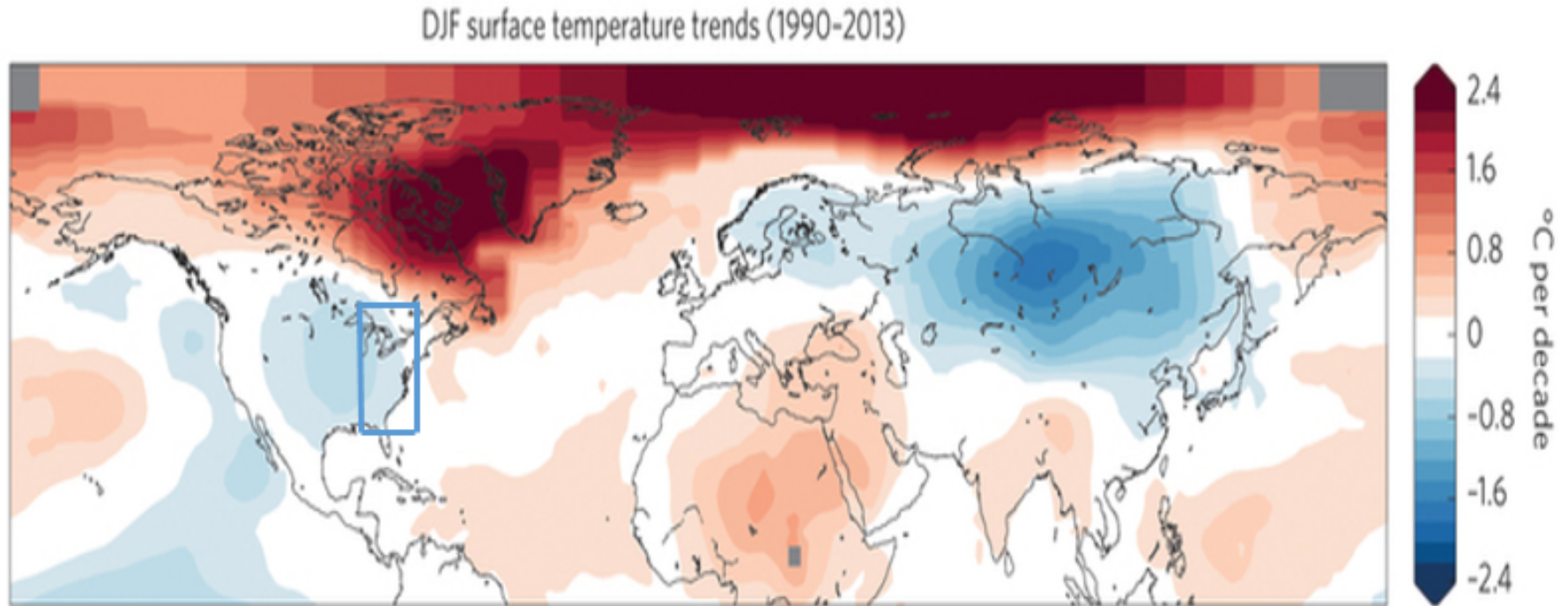


The regional actors BK-SIC, Ural-SLP, Sib-SLP, and EA-snow are presented according to their approximate geographical location, and the hemispheric actors AO, γ flux, and PoV are presented according to their approximate latitude and pressure levels.

MARLENE KRETSCHMER, et al.

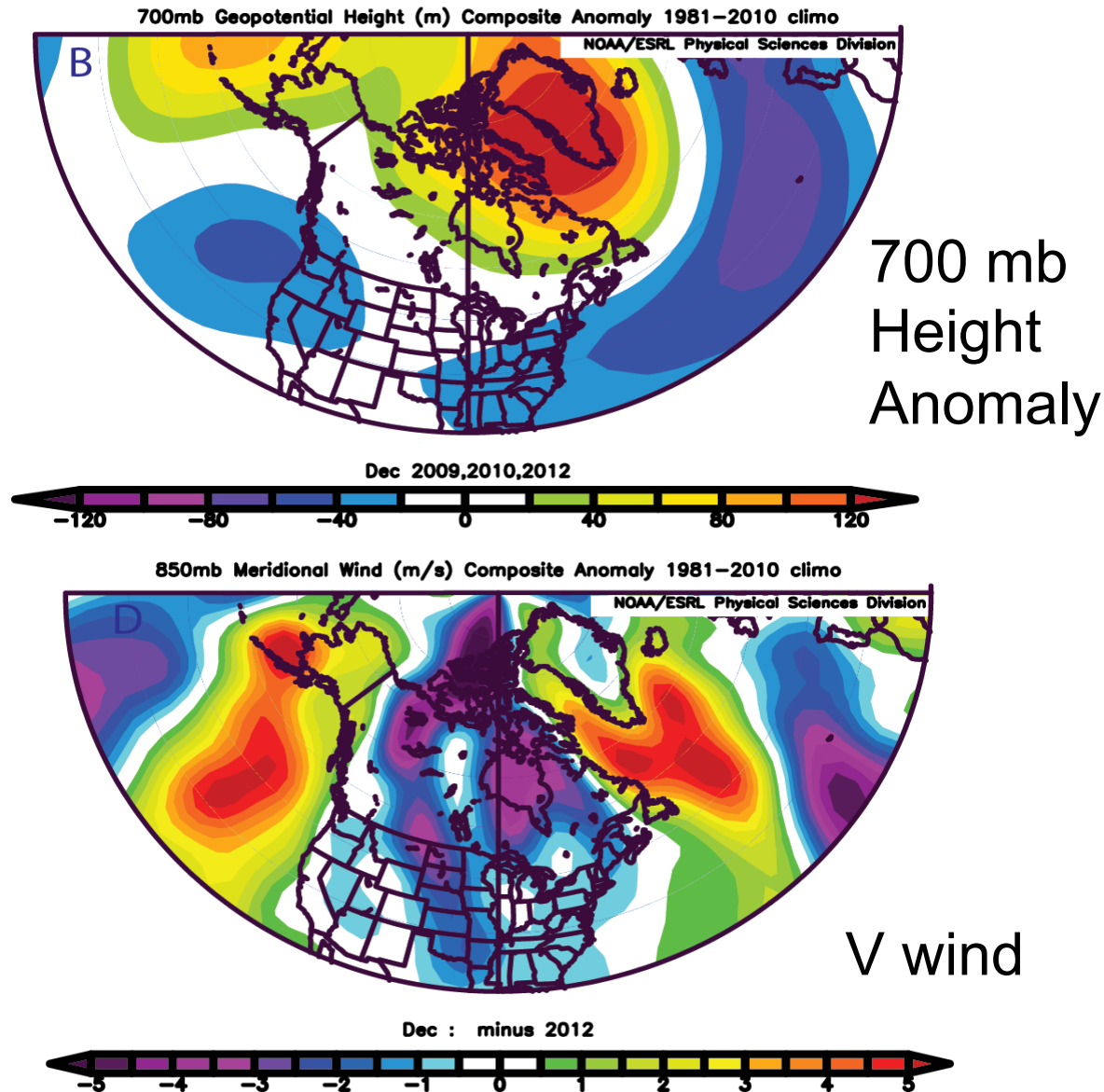
Using Causal Effect Networks to Analyze Different Arctic Drivers ... JClimate 2016

Far Field Causes of Cold Eastern US Region

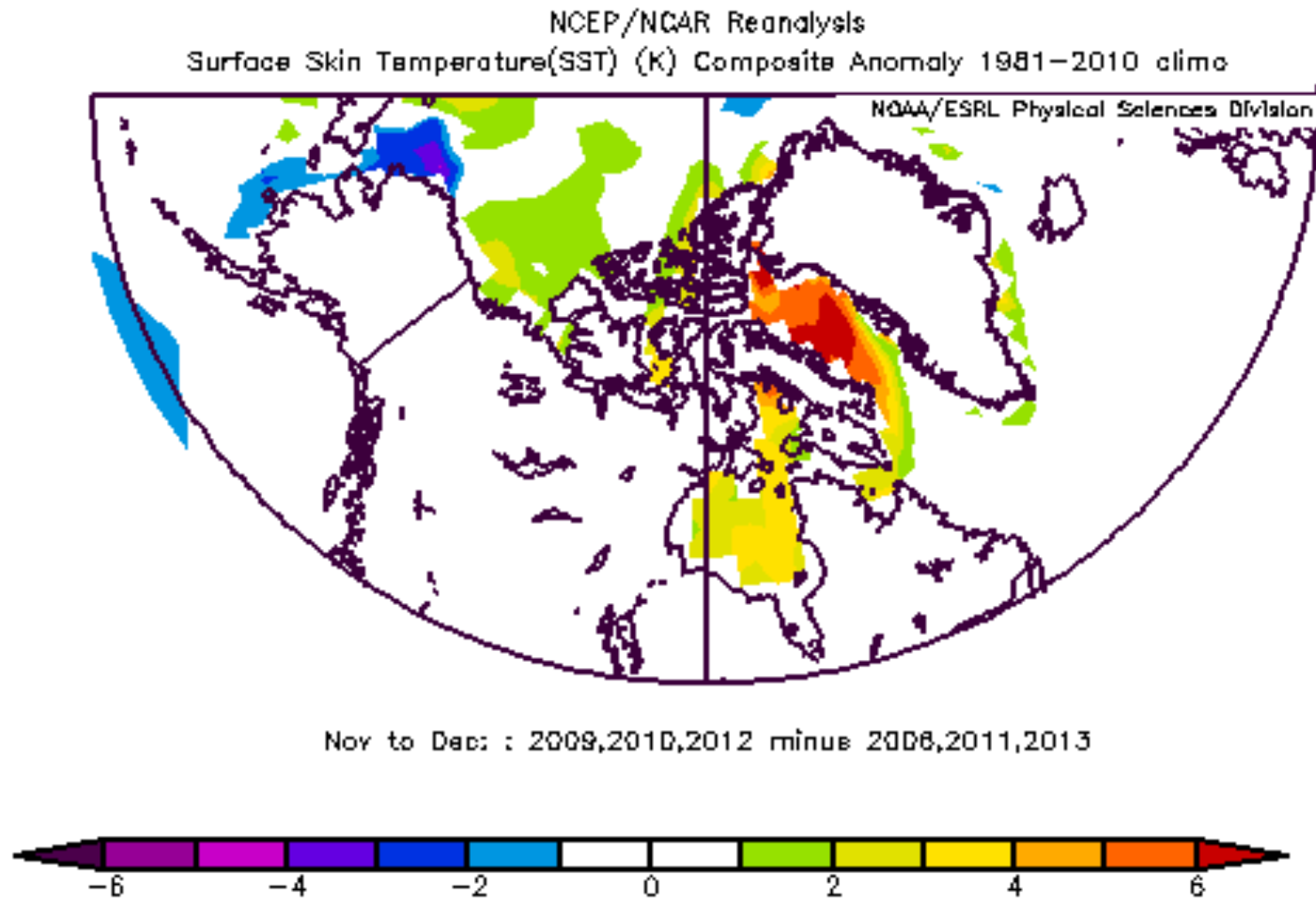


Patterns: Greenland Block
Reinforced Pacific Ridge (N. Pacific SST)
Mixed

Greenland Block (-AO)

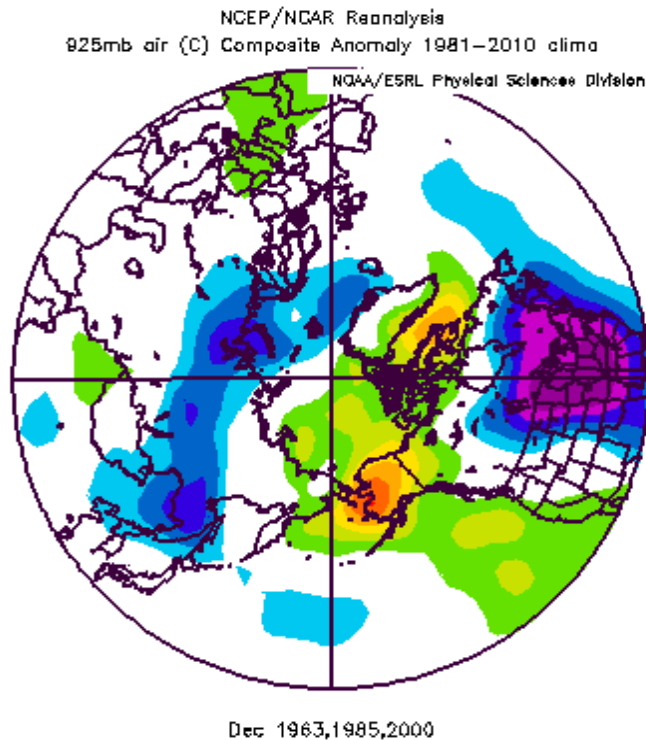


Increased Surface Temps over sea ice areas in Negative AO Years

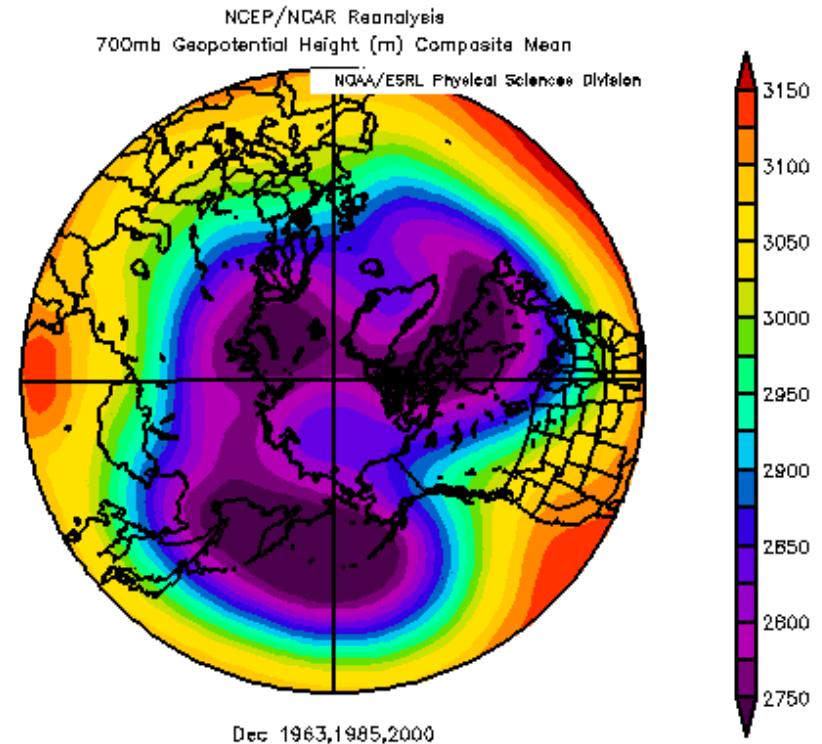


Arctic reinforces existing atmospheric pattern

Pacific Ridge Climate Pattern



Air Temperature Anomalies



700 mb Geopotential Height
Field

NE Pacific SST Influence & ENSO

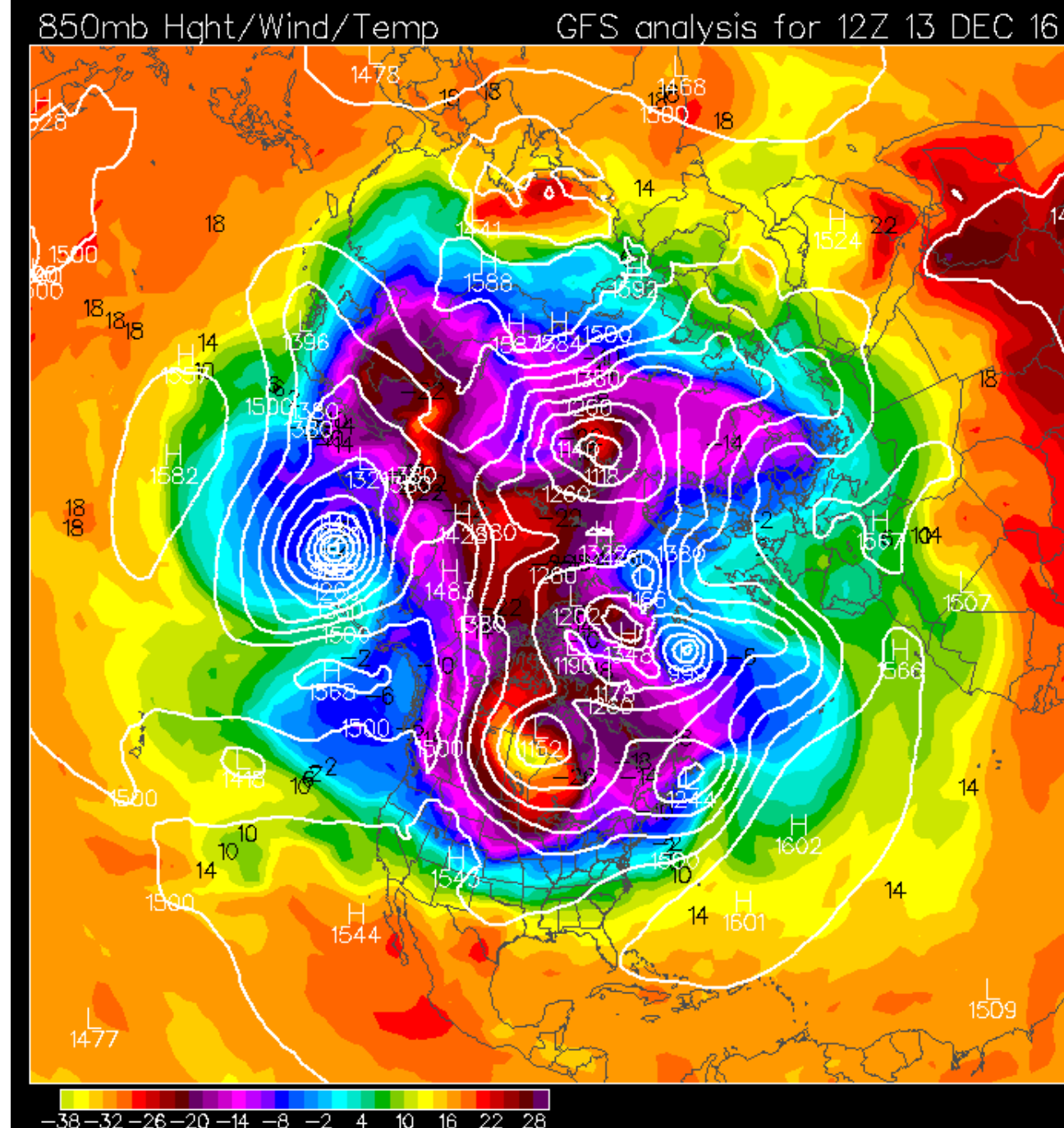
Extreme Pacific Ridge

13 December 2016
850 mb heights

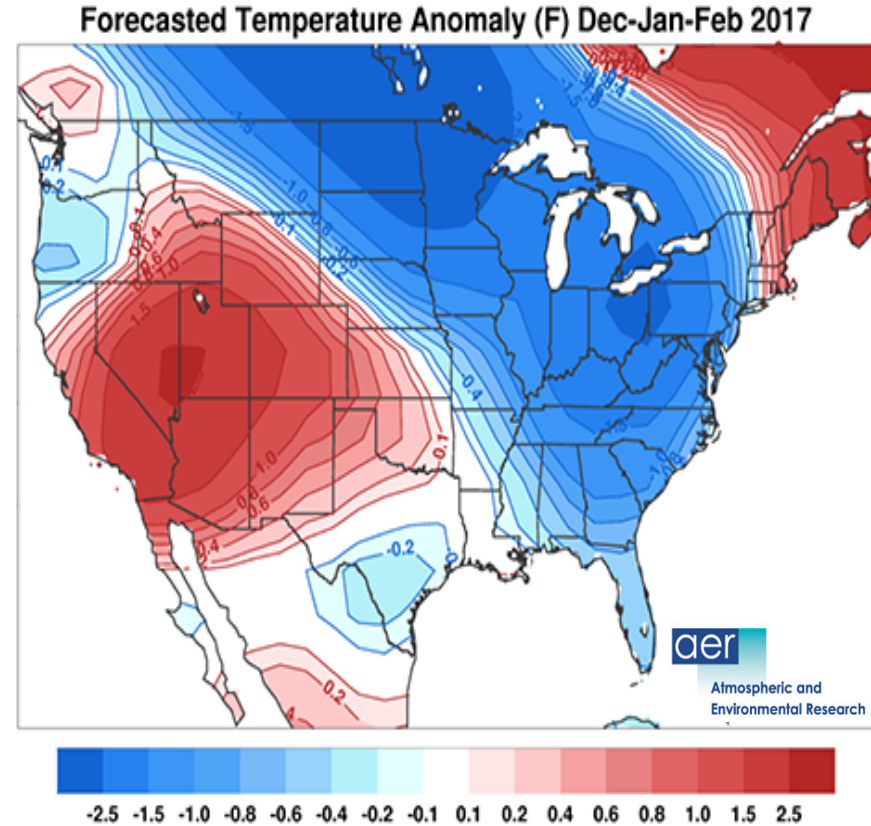
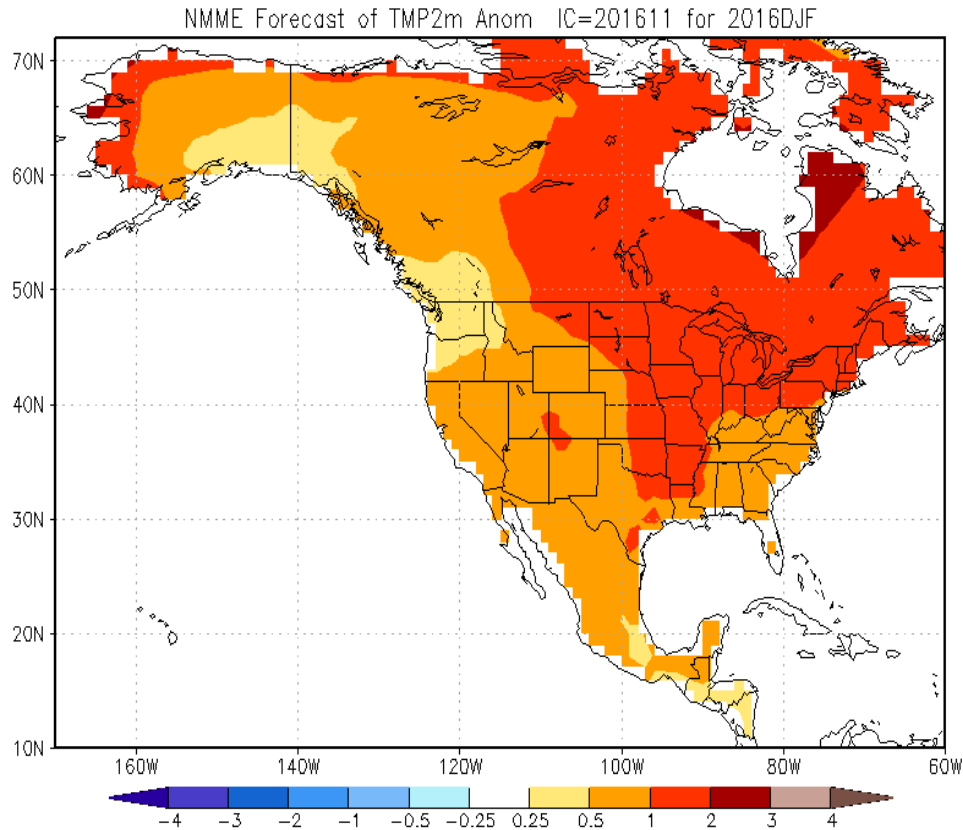
Case for Arctic
Influence



November Sea Ice



Different Forecasts for DJF 2017:



Francis and Cohen 2016 AGU

https://www.nsf.gov/news/special_reports/autumnwinter/predicts.jsp

More Research needed!

A wide-angle photograph of an Arctic landscape. In the foreground, dark, choppy water is filled with numerous small, white ice floes. A small red boat is visible in the lower-left corner. The middle ground features rugged, snow-covered mountains with patches of dark rock. The background shows more distant, snow-covered land under a sky filled with heavy, grey clouds. The overall scene is cold and desolate.

Summary

Uncertainty: Arctic forcing is buried in chaos

Recent validation: Case studies of E. Asia and North America; weather linkages will be State Dependent with Nonlinear Connections

**New: December is important month;
Delayed freezeup meets energetic jet stream**