North Atlantic warming, disappearing sea ice and implications for climate in Northern Eurasia

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with contributions from
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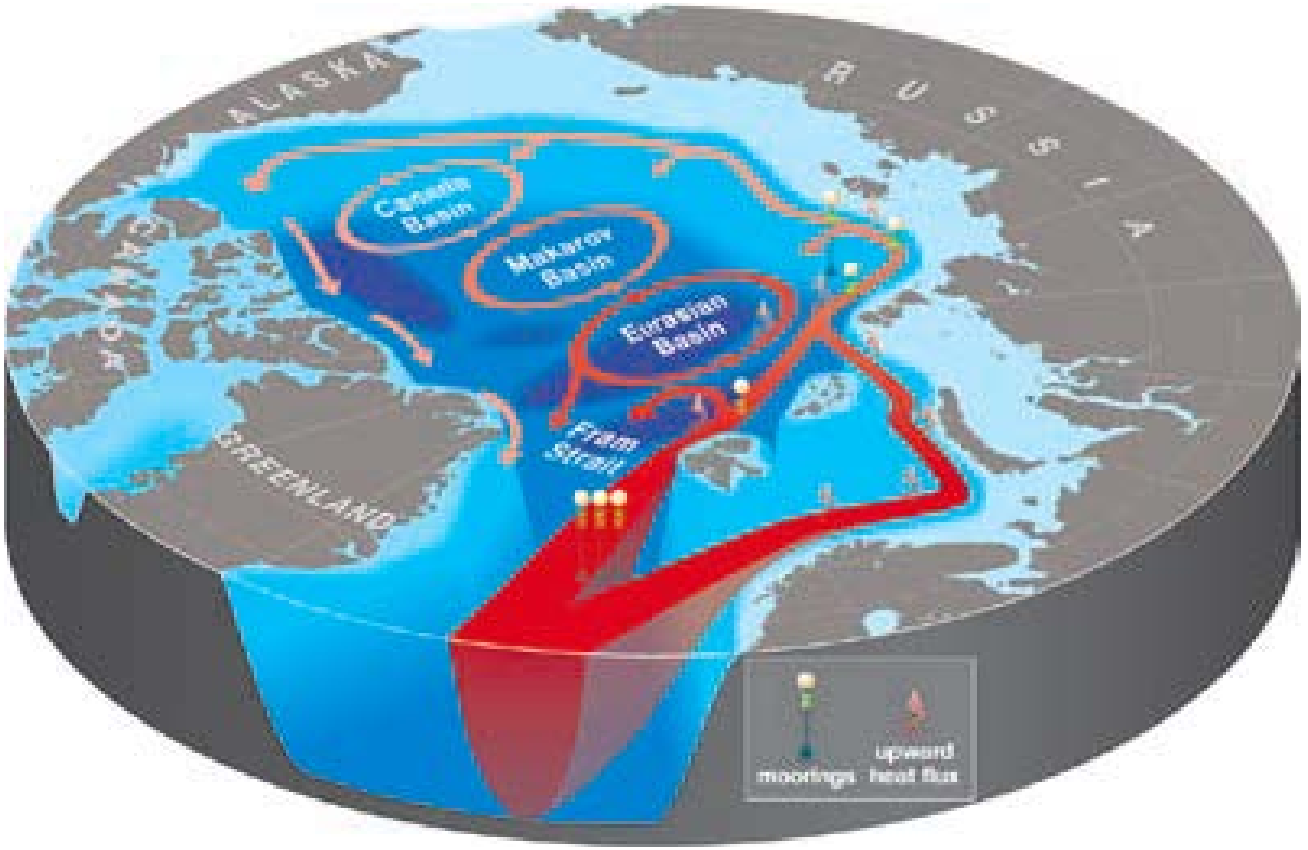
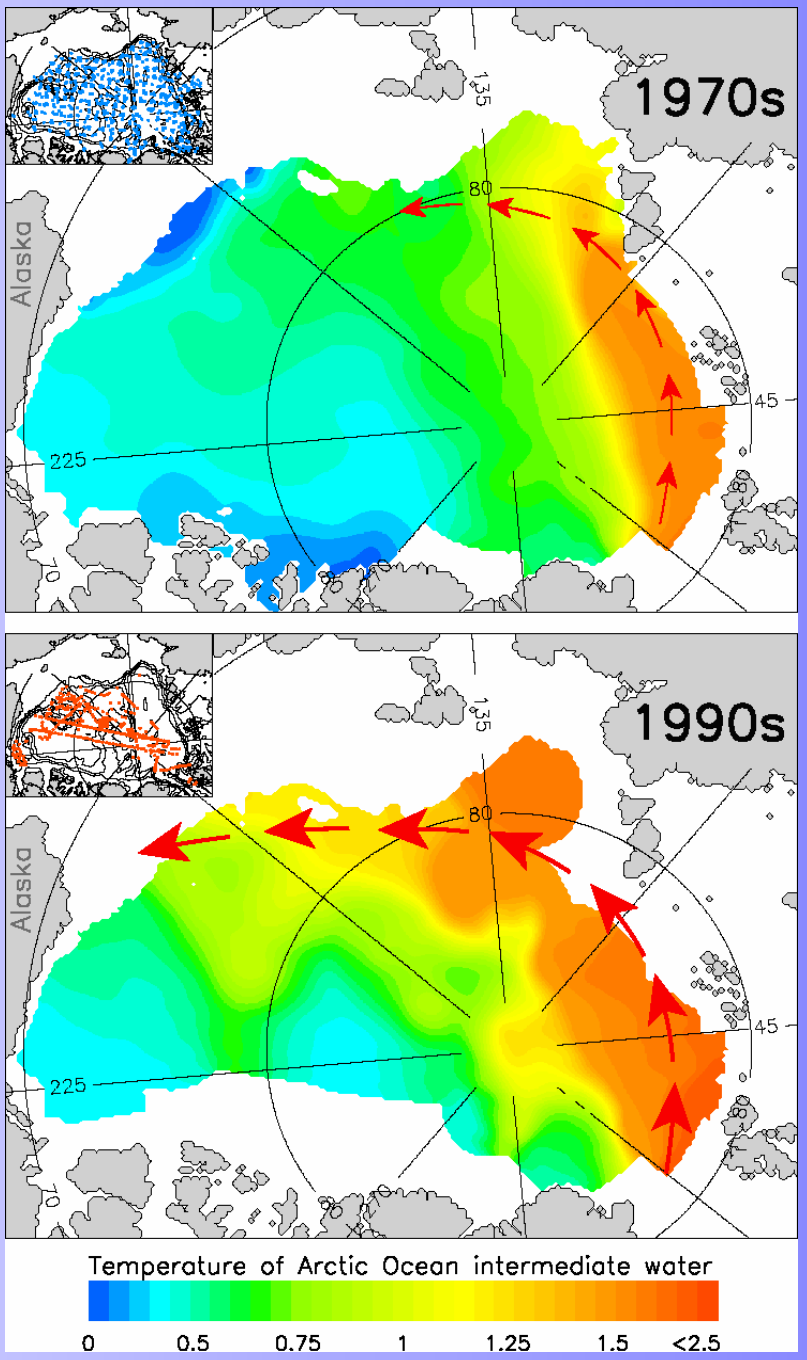
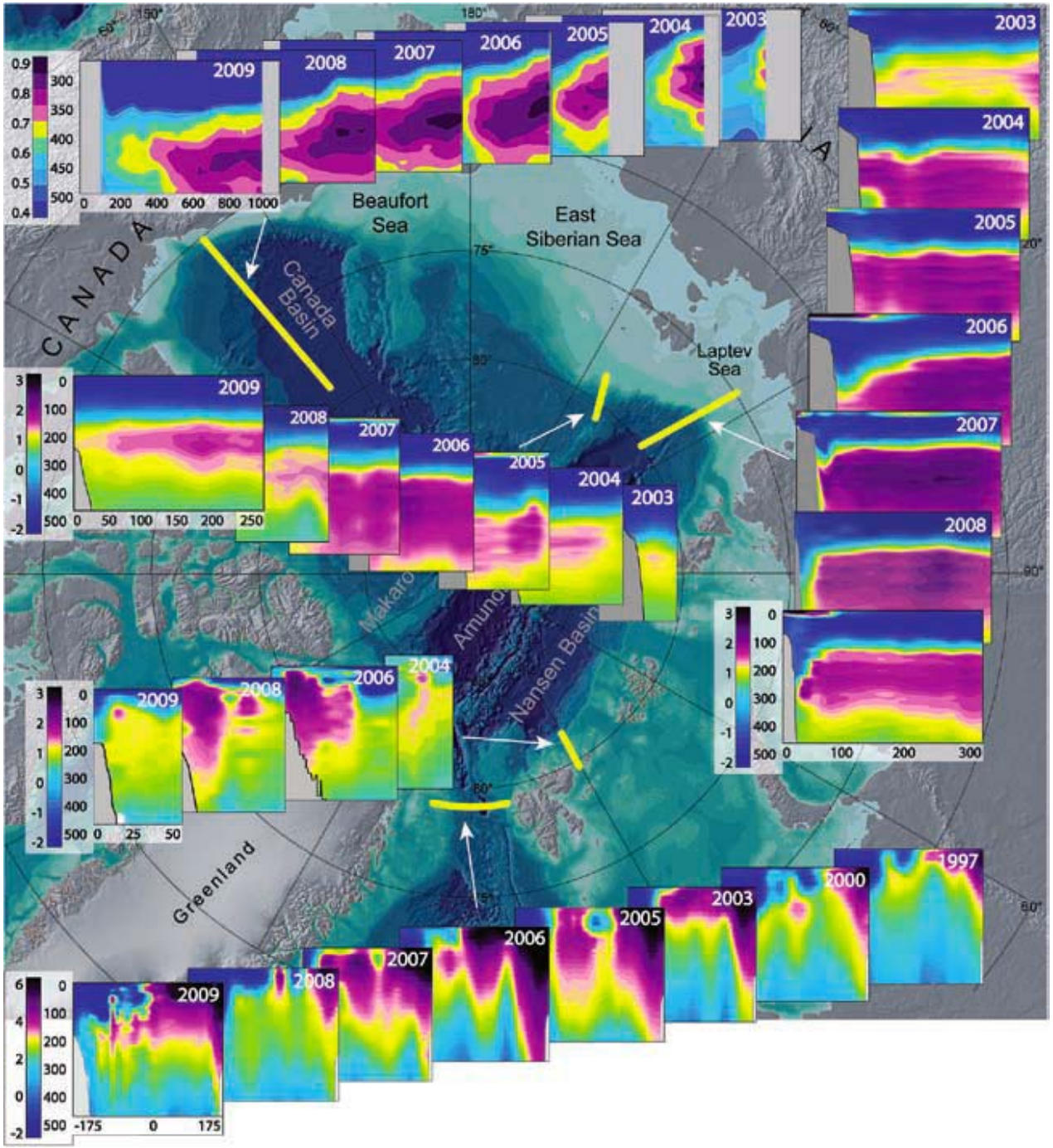
J.Cohen, J.Furtado, M.Barlow, J.Cherry

Atlantic Water in the Arctic Ocean





Propagation of warm Atlantic Water (AW) temperature anomalies into the Arctic Ocean in the 1970s and 1990s. The pathways of AW are shown schematically by red arrows. [Adapted from *Polyakov et al., 2004*]



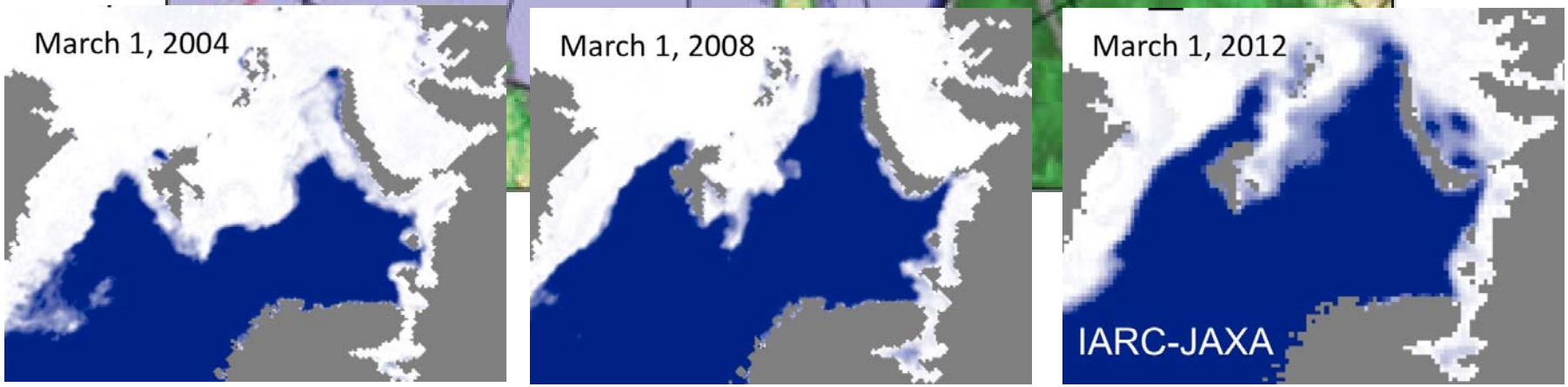
Fate of Early 2000s Century Arctic Warm Water Pulse

By I.Polyakov, V.Alexeev, I.Ashik, S. Bacon, A.Beszczynska-Möller, E.Carmack, I.Dmitrenko, L.Fortier, J.-C.Gascard, E.Hansen, J.Hölemann, V.Ivanov, T.Kikuchi, S.Kirillov, Y-D.Lenn, F.A.McLaughlin, J.Piechura, I.Repina, L.Timokhov, W.Walczowski , and R.Woodgate

Bull. Of the Amer Met Soc, 2011

Atlantic Water and arctic sea ice. Winter

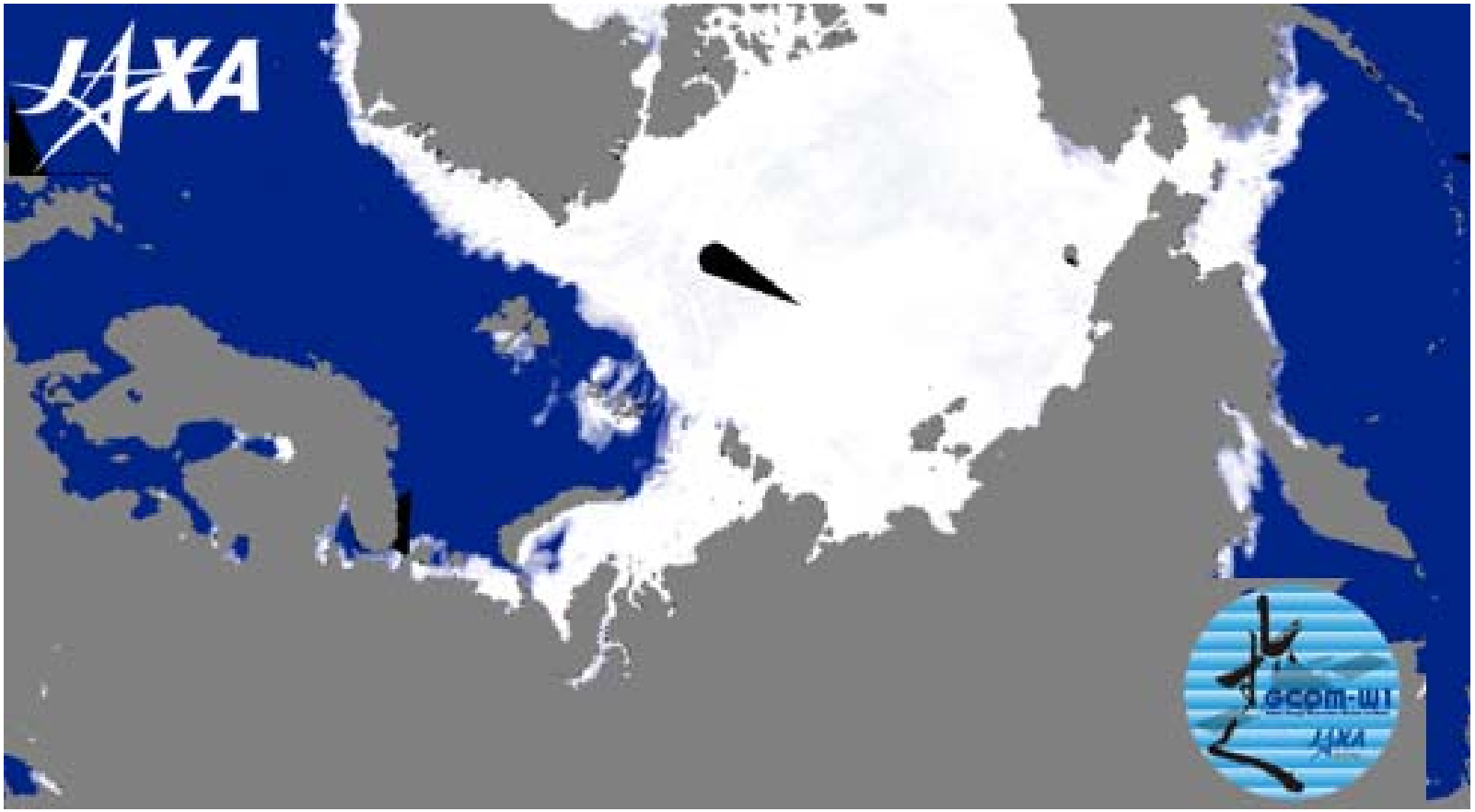
March 2012



http://www.ijis.iarc.uaf.edu

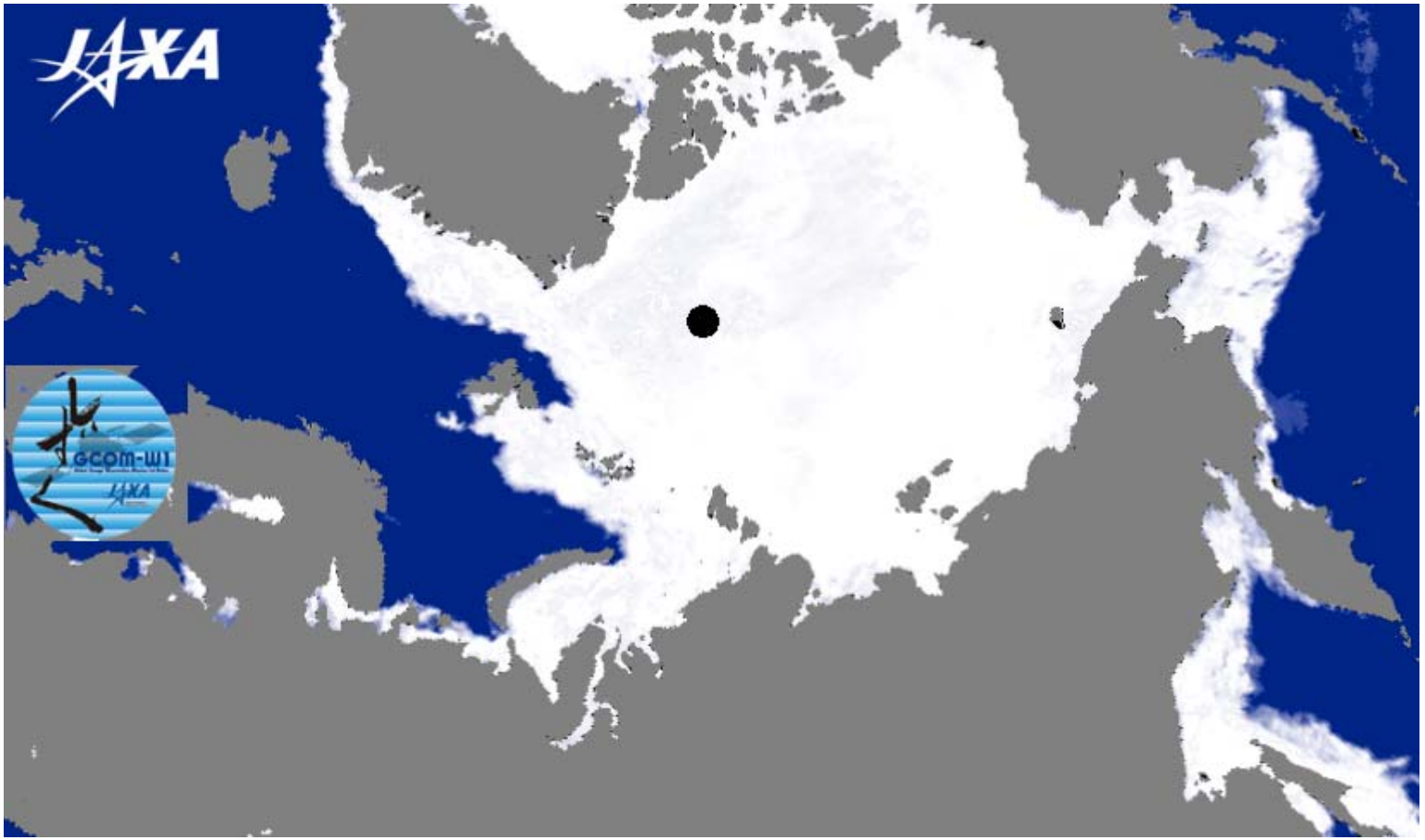
Alexeev et al, 2013, submitted

Sea ice as of January 9, 2013



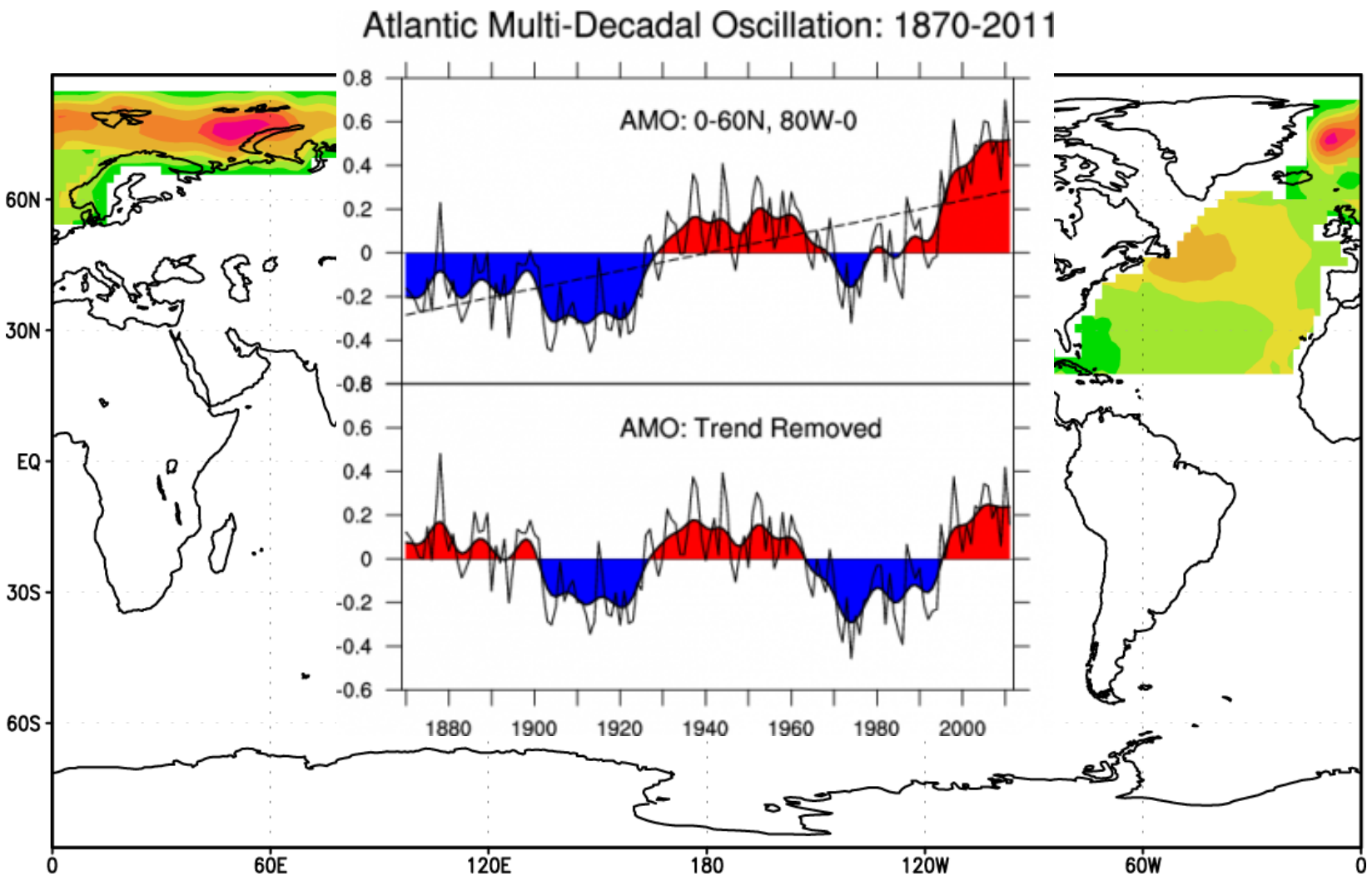
http://www.ijis.iarc.uaf.edu

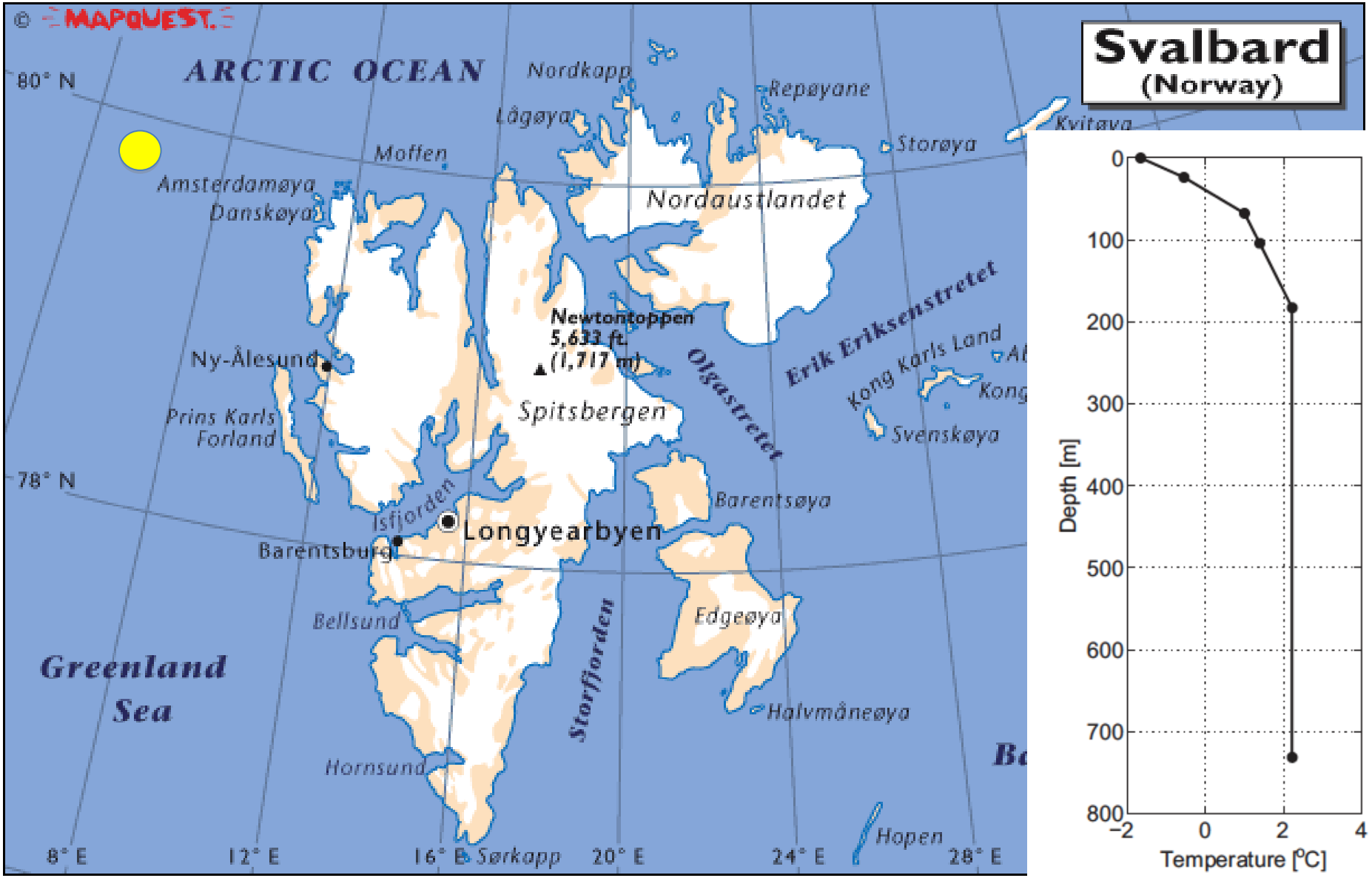
Sea ice as of February 19, 2013



http://www.ijis.iarc.uaf.edu

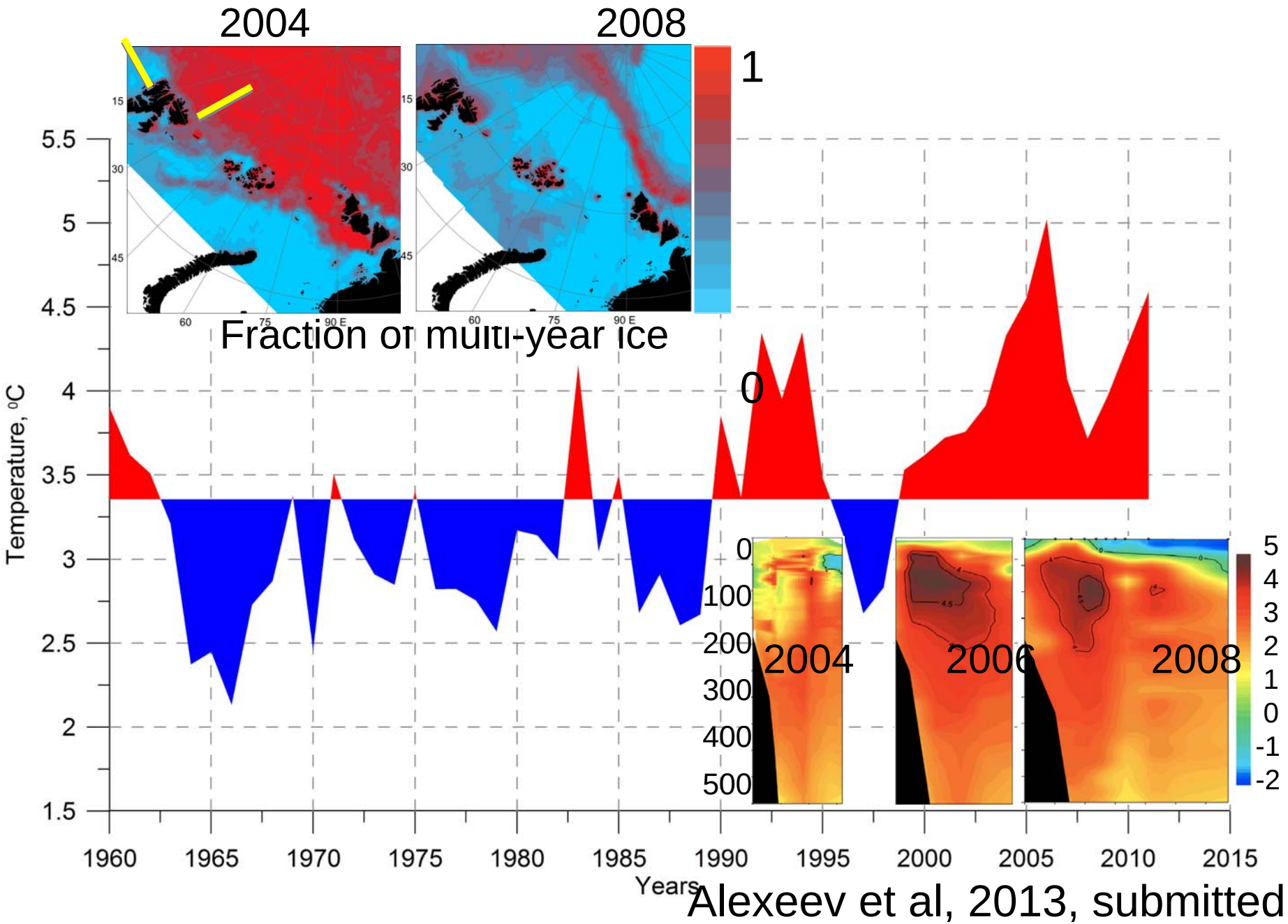
North Atlantic SST





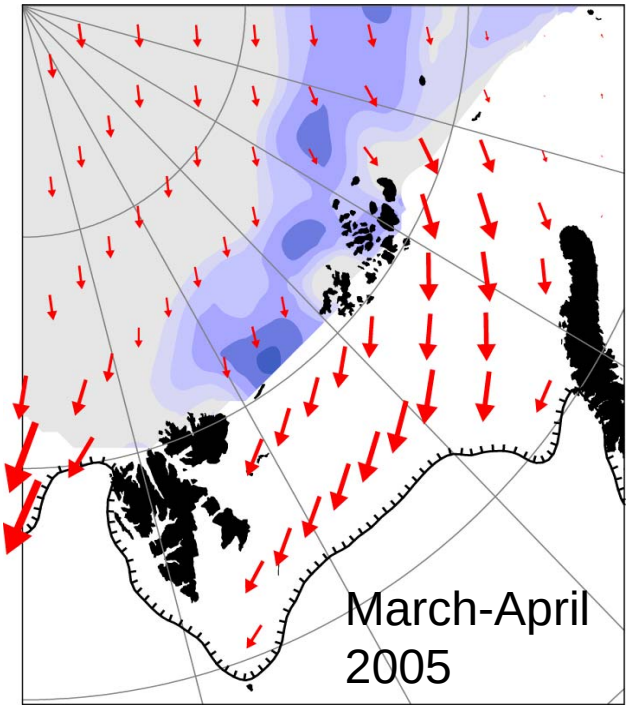
Scoresby, W. 1820. An account of the Arctic regions with a history and description of the Northern whale fishery, (PhD Thesis by S.H.Teigen)

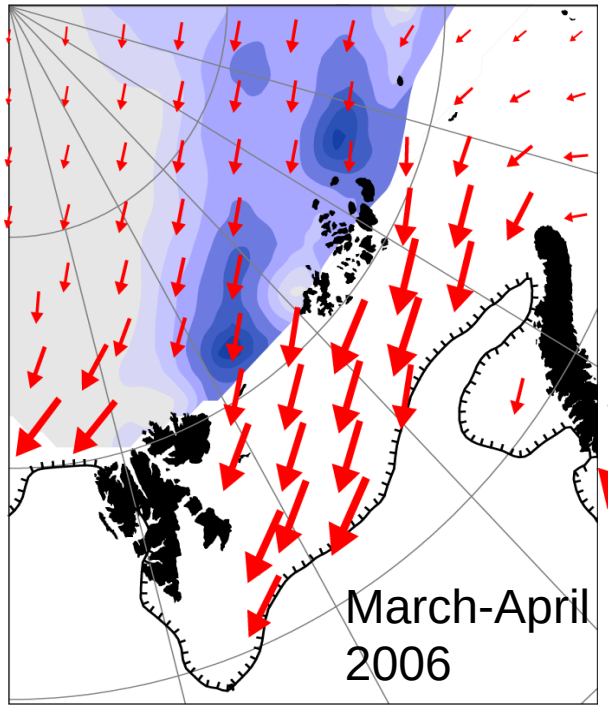
AW temperature. Fram Strait and Svalbard

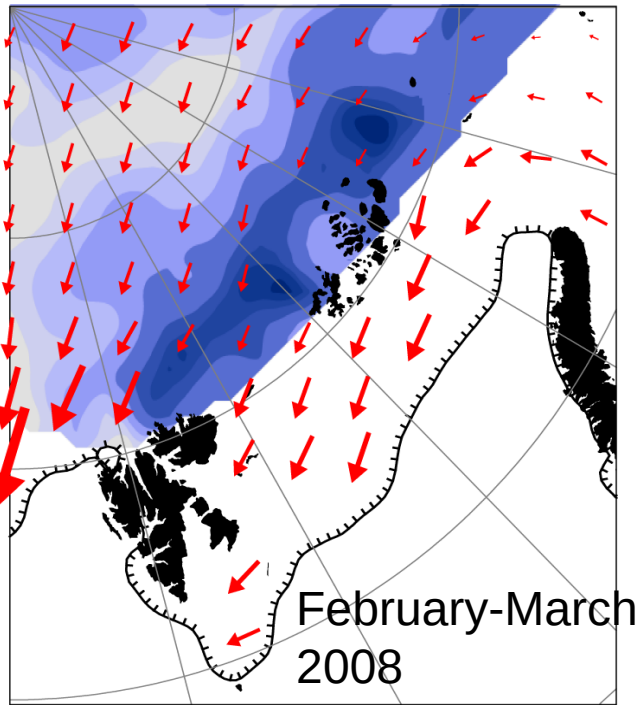


Alexeev et al, 2013, submitted

Winter sea ice thickness. Atlantic sector

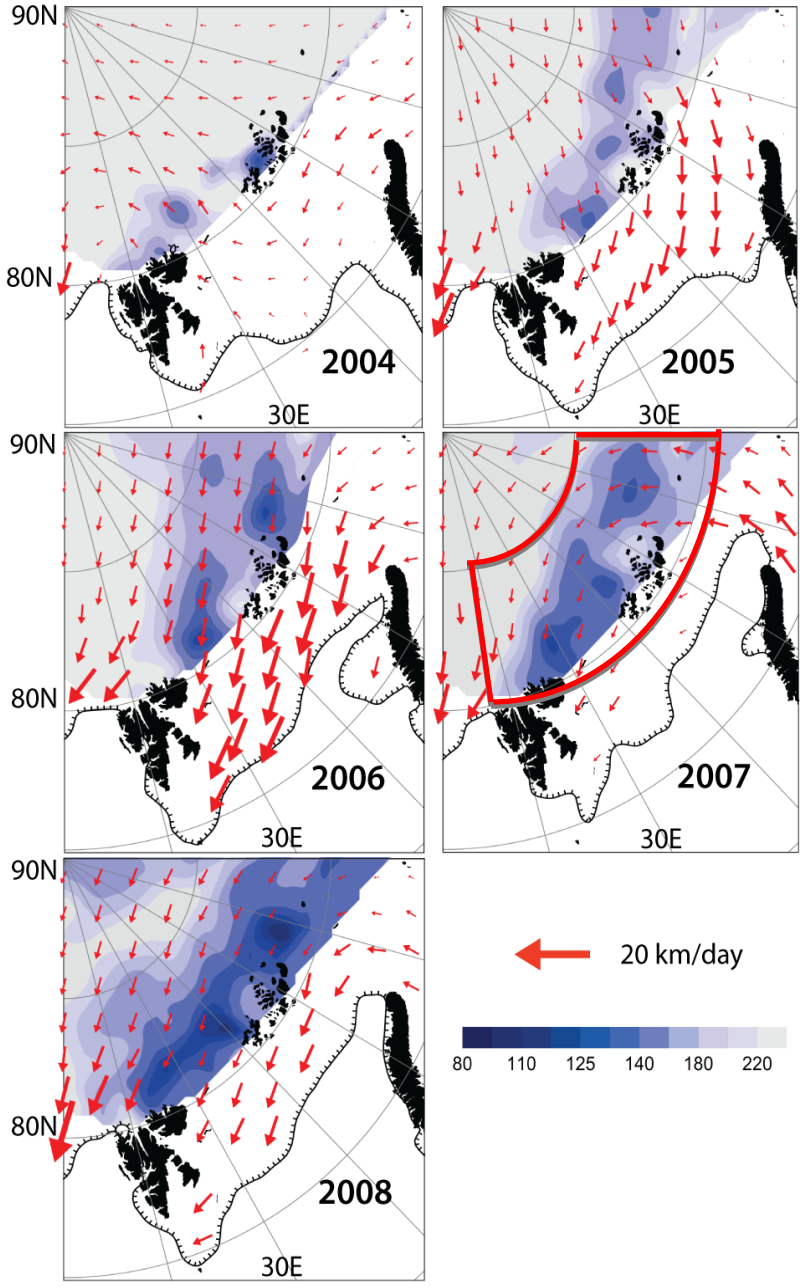




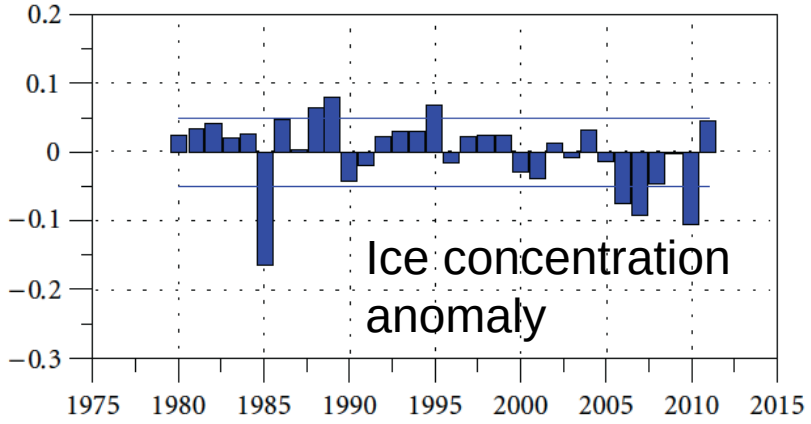


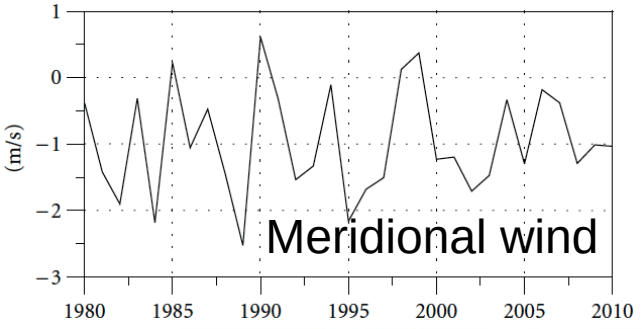
Thinning of ice is local

Alexeev et al, 2013, submitted

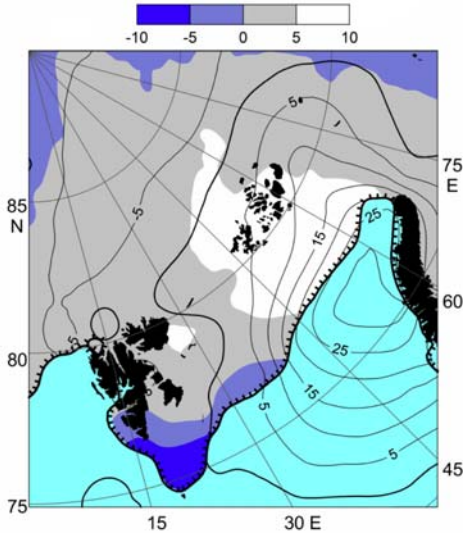


Ice thickness and motion vectors, ICESat



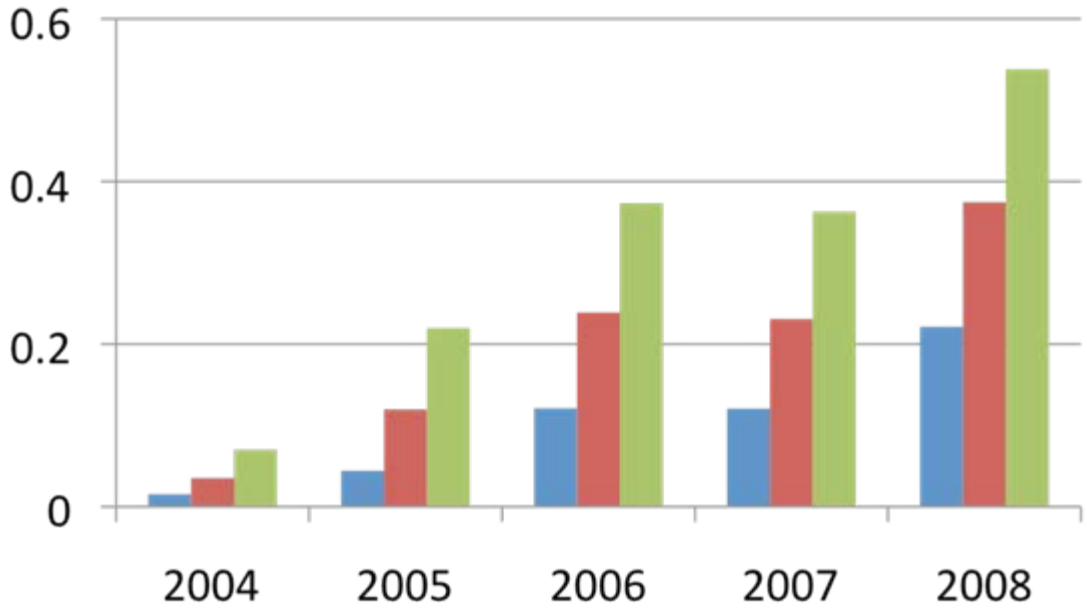


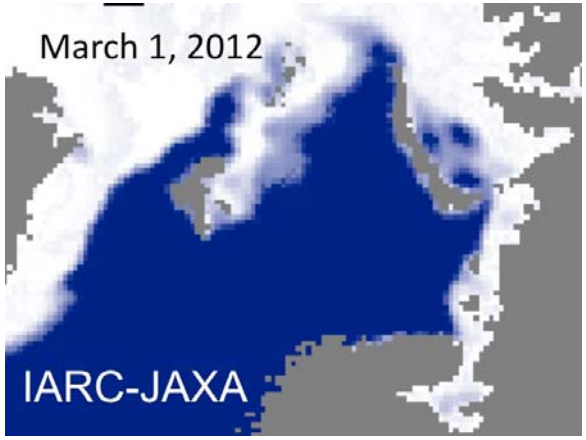
DLW (contours)
snow anomalies
Feb-Mar2008



Ivanov et al, 2012, Alexeev et al 2013

How much ice does AW melt?



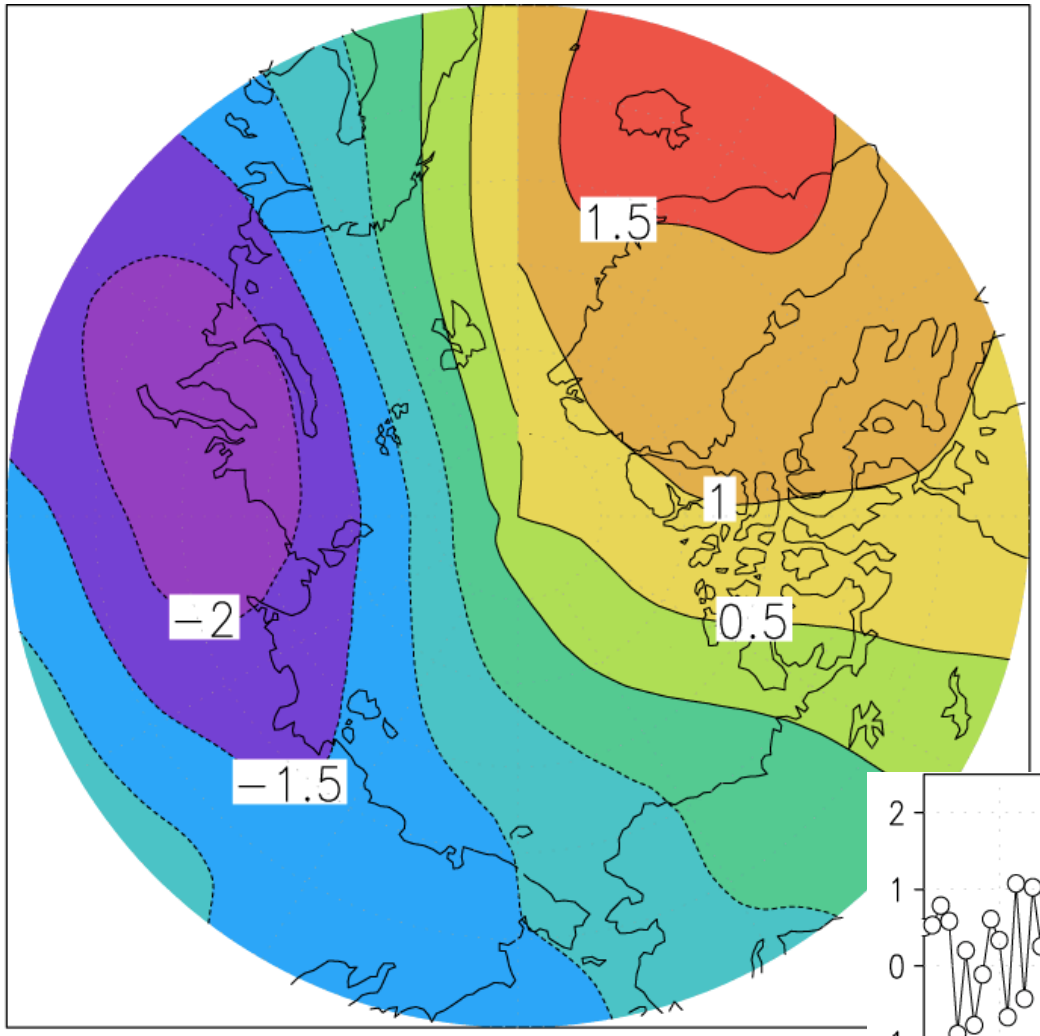


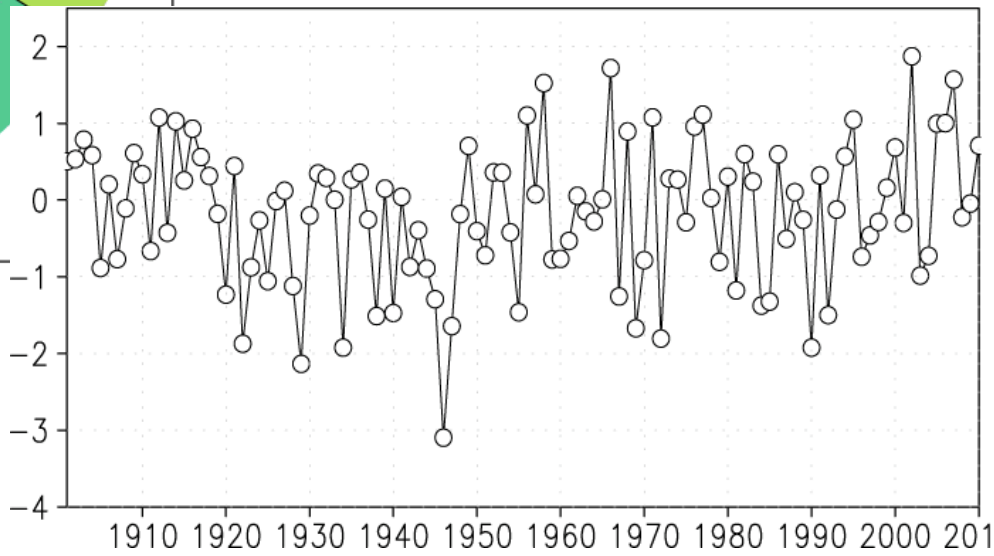
Explains at least 20% of the negative 2004-08 trend (volume-wise)

Alexeev et al, 2013, submitted

Arctic Dipole: 2nd EOF in SLP

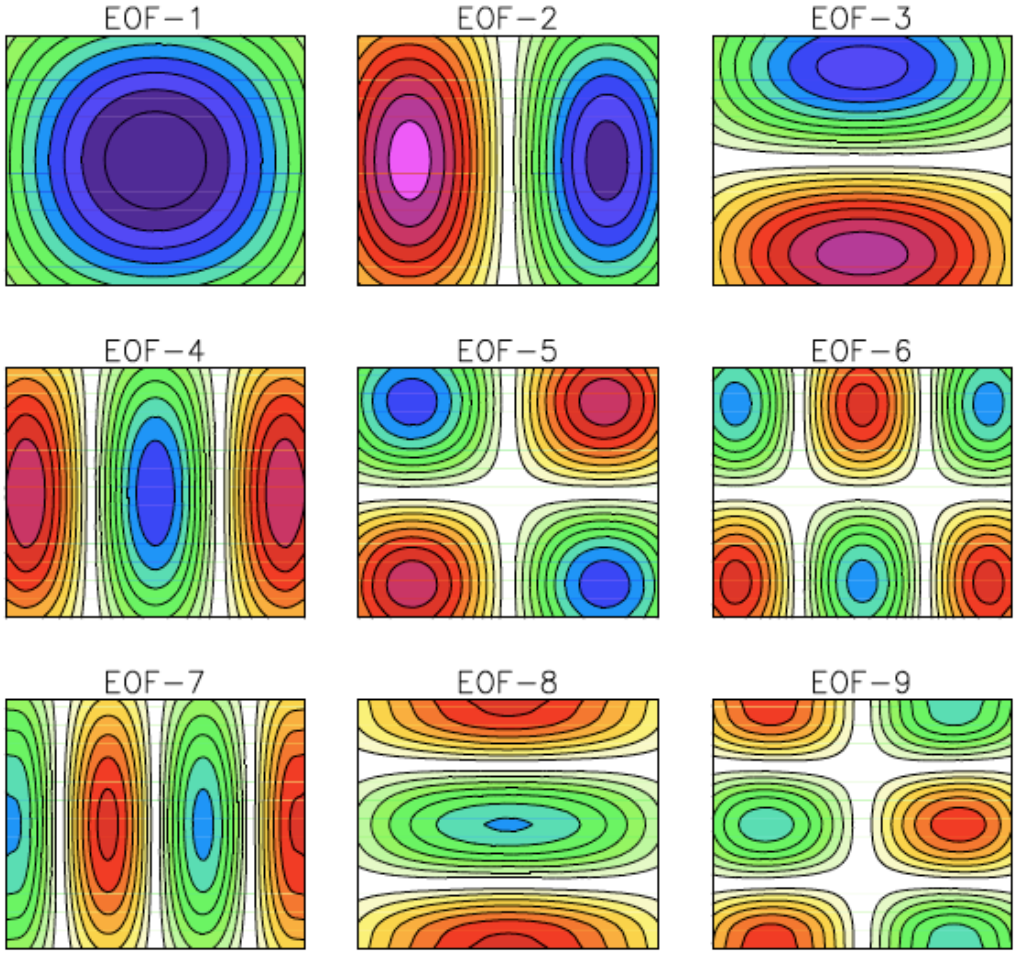
Other names: ARP, Barents oscillation, Dipole pattern, Transpolar drift





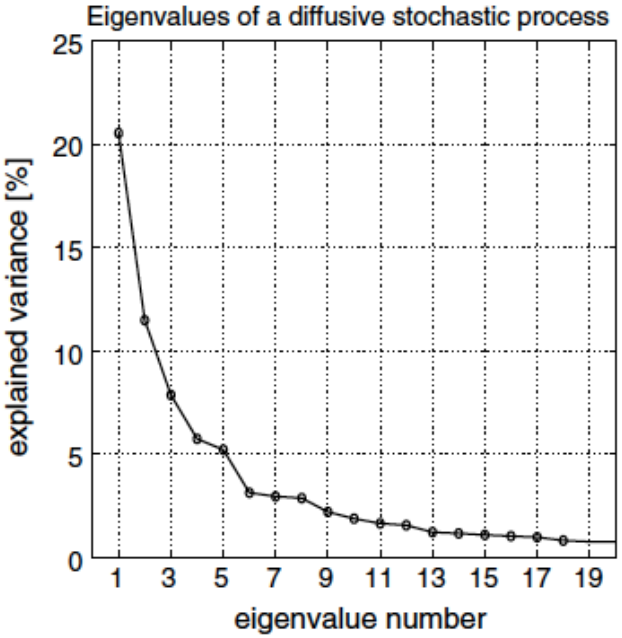
20th Century Reanalysis

Artifacts of EOF analysis

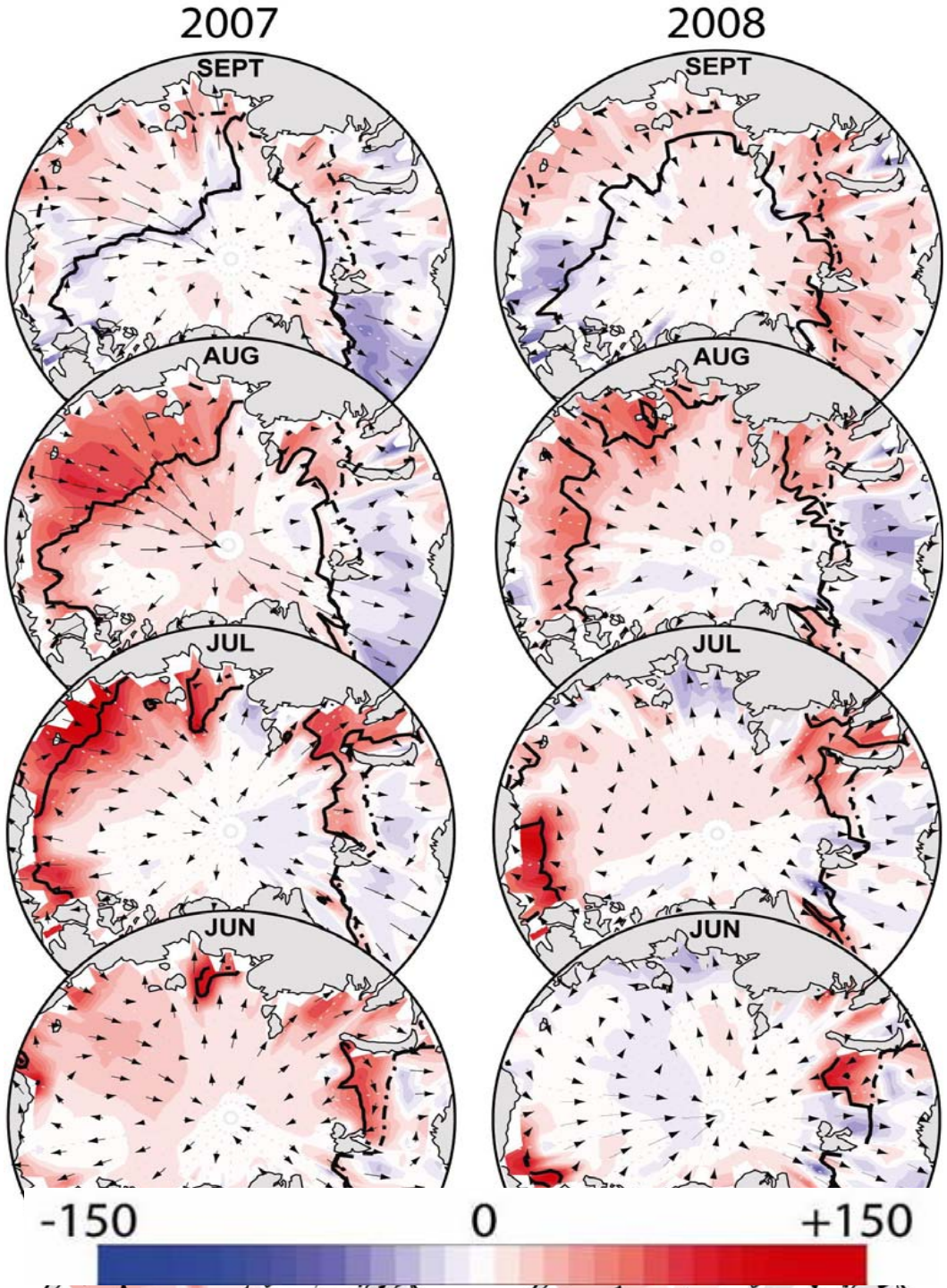


$$\frac{\mathrm{d}}{\mathrm{d}t}\Phi = c_{\mathrm{damp}} \cdot \Phi + c_{\mathrm{diffuse}} \nabla^2 \Phi + f$$

f – white noise

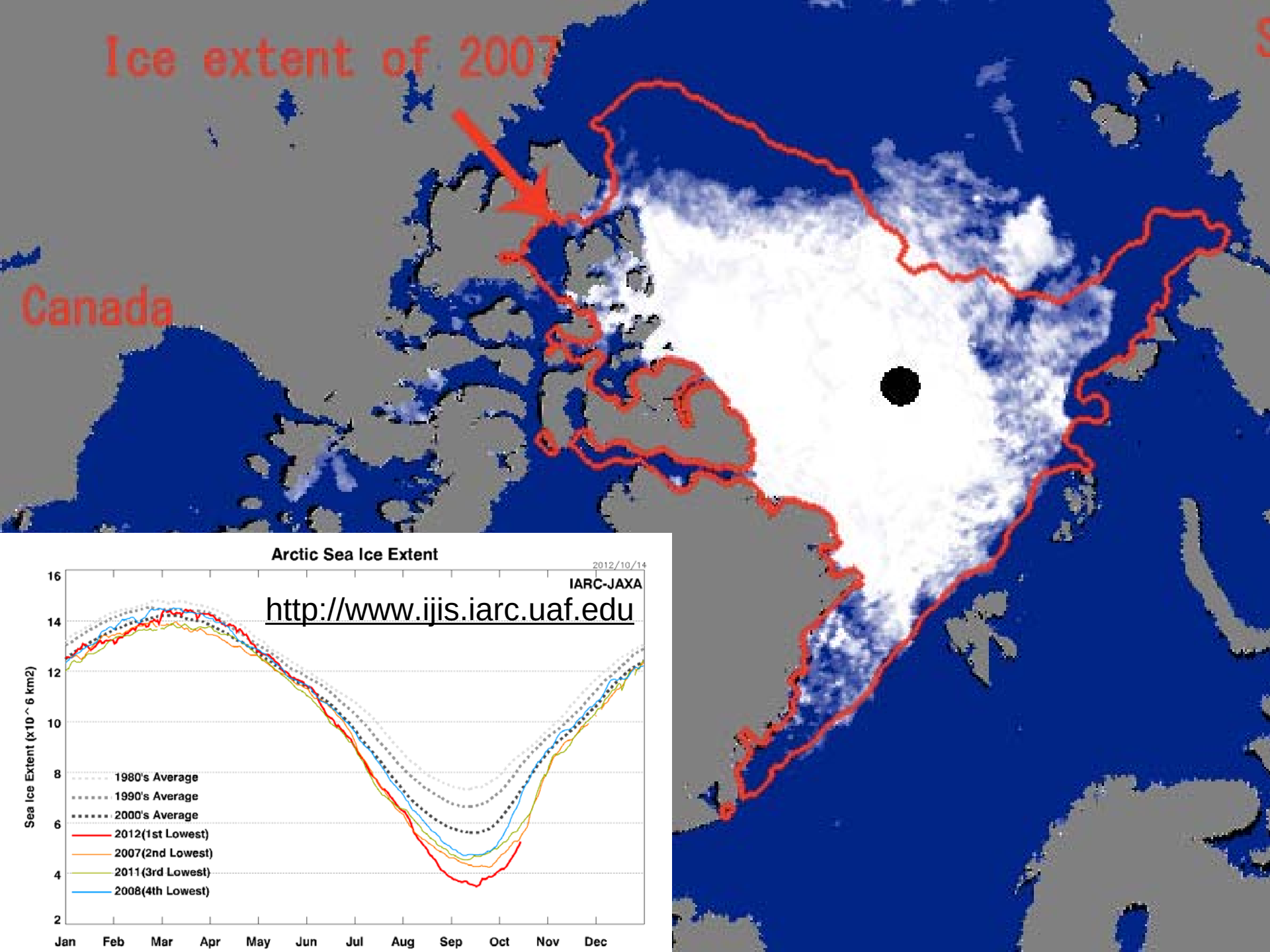


D.Dommenget, Climate Dynamics, 2007



Sea ice extent and ocean heat content
(also delayed freeze up)

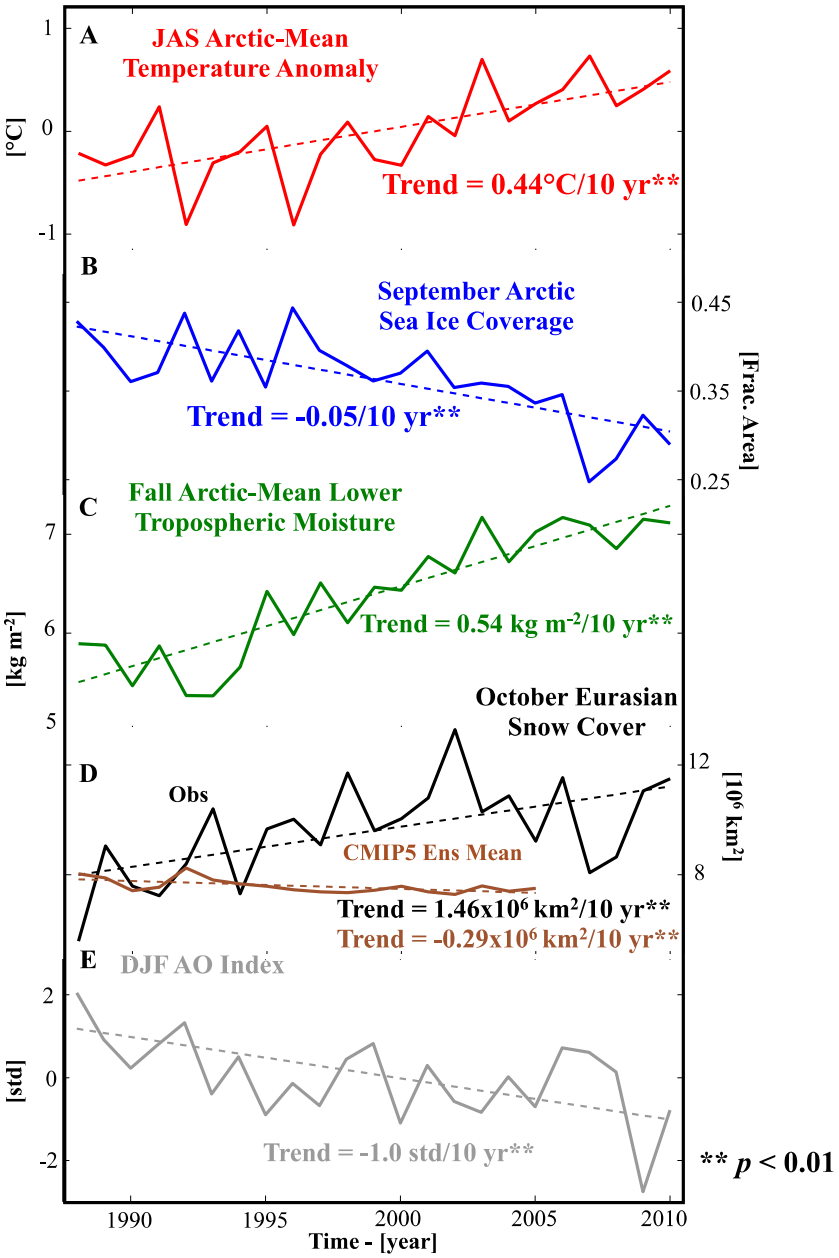
Surface-based mechanisms are the most likely contributors to the recent Arctic warming


Ice extent of 2007
Canada
Arctic Sea Ice Extent
2012/10/14
IARC-JAXA
http://www.ijis.iarc.uaf.edu
Sea Ice Extent (x10^6 km2)
16
14
12
10
8
6
4
2
1980's Average
1990's Average
2000's Average
2012(1st Lowest)
2007(2nd Lowest)
2011(3rd Lowest)
2008(4th Lowest)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Part 2: Is warming in the Arctic causing colder winters in Eurasia?

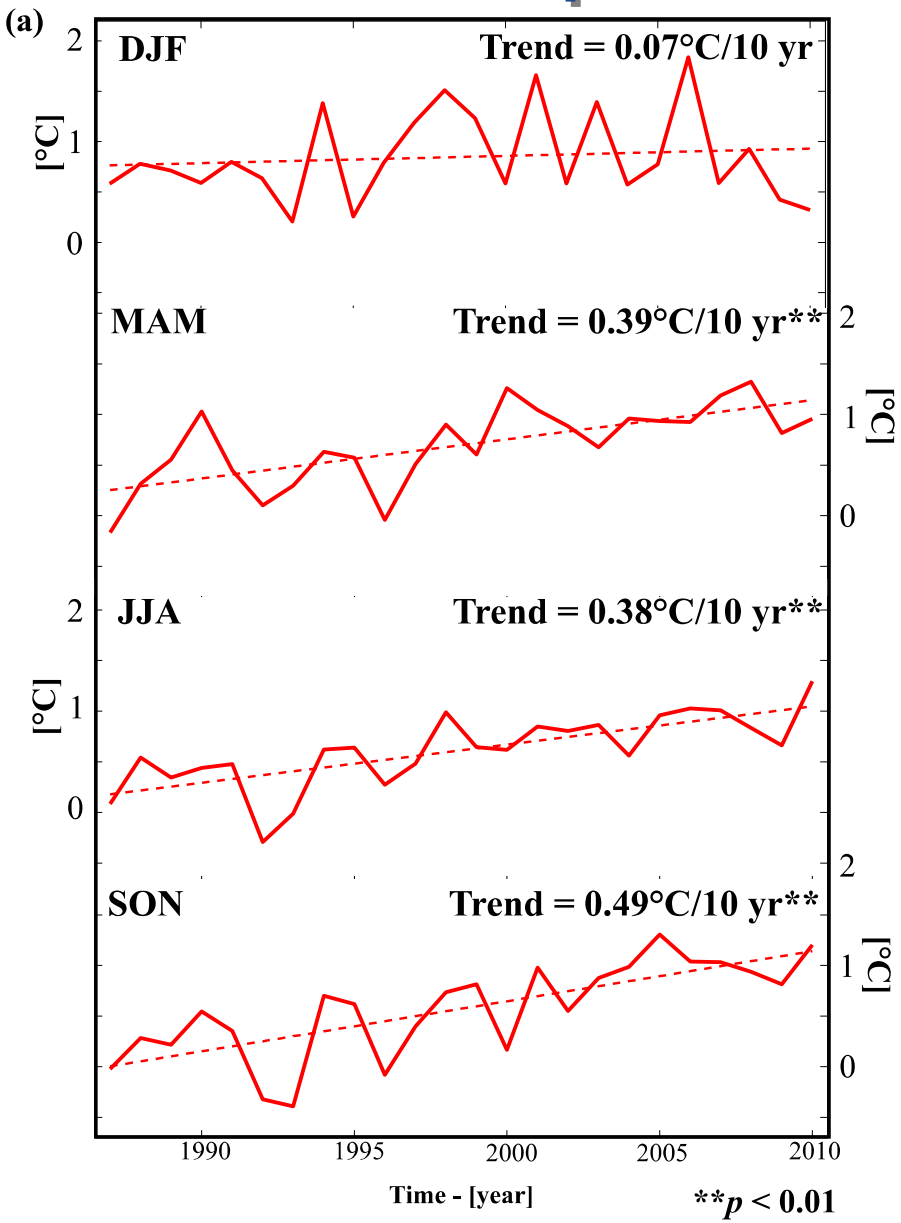
Arctic Trends 1988-2010

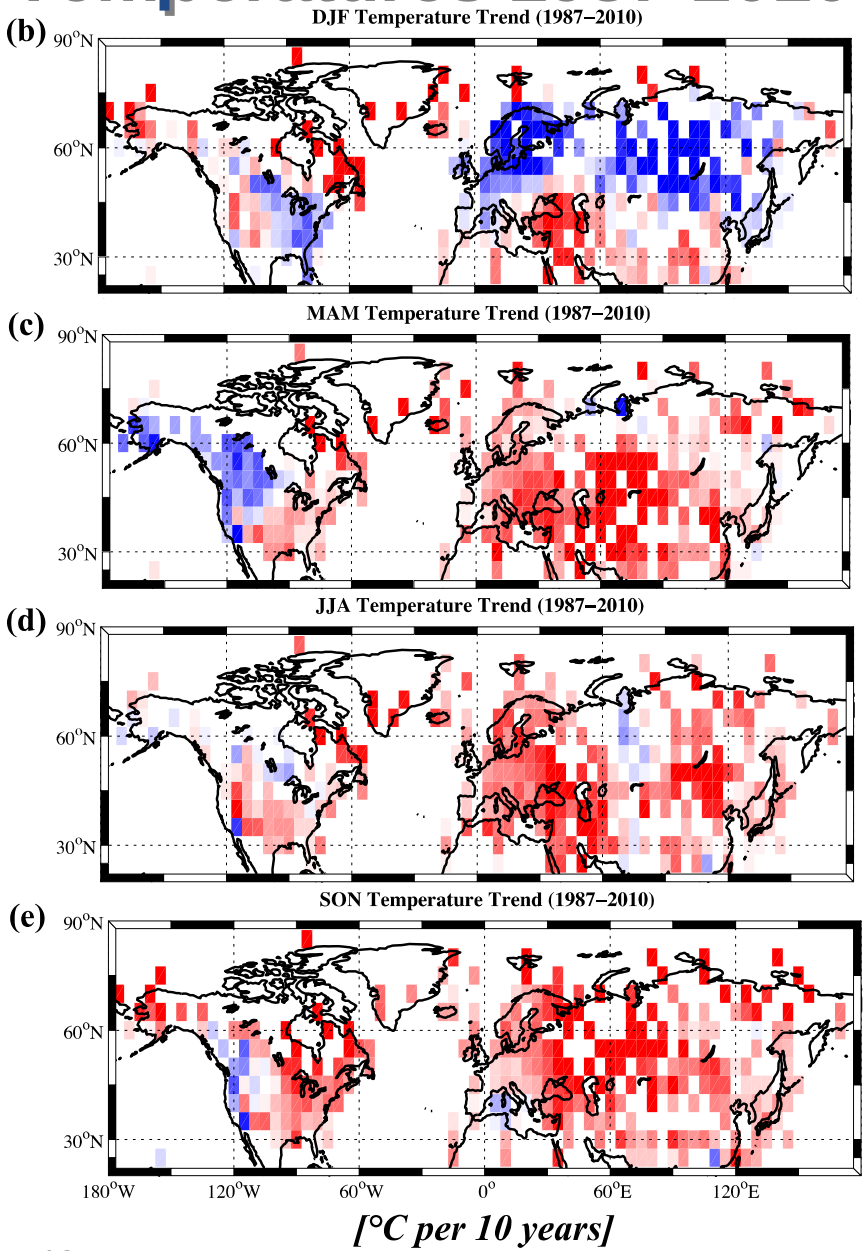
- ✓Warming Arctic
- ✓Less sea ice
- ✓More atmospheric moisture
- ✓Increasing snow cover
- ✓Decreasing Arctic Oscillation trend



Alexeev et al, 2005, Clim Dyn; Cohen et al, 2012, ERL

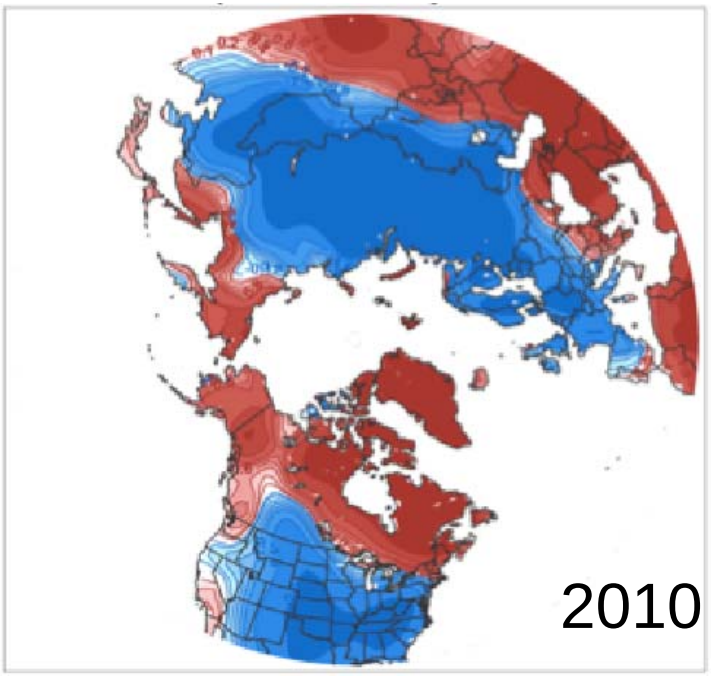
Northern Hemisphere Land Temperatures 1987-2010

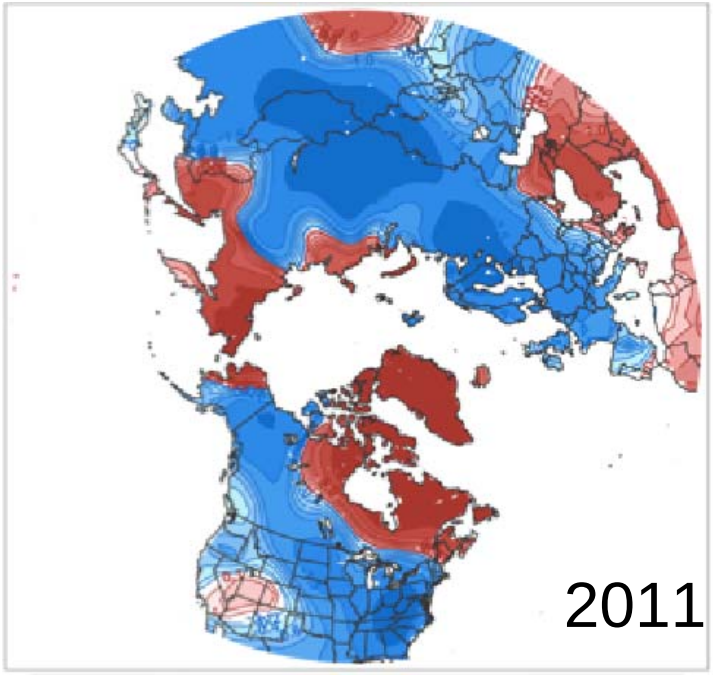


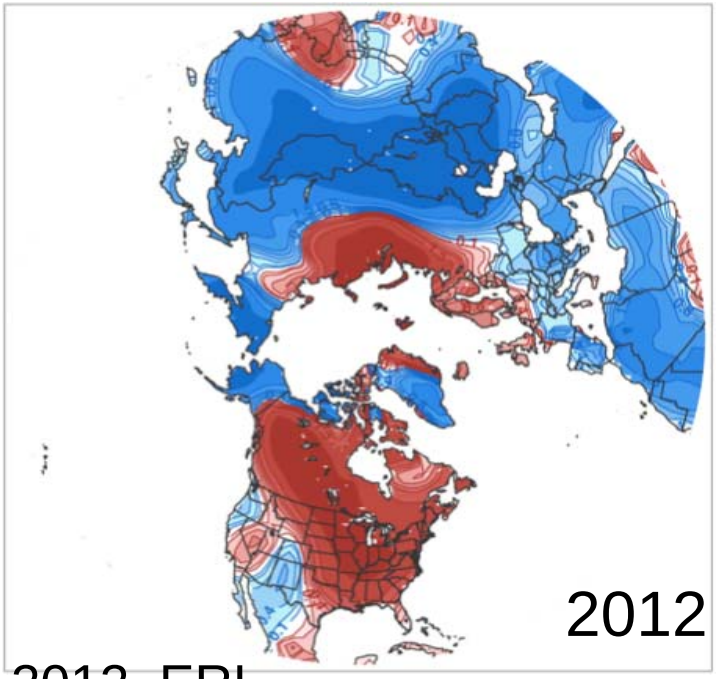


Data: CRU temperature

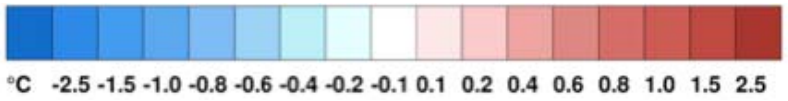
Alexeev et al, 2012, Clim Change; Cohen et al, 2012, ERL





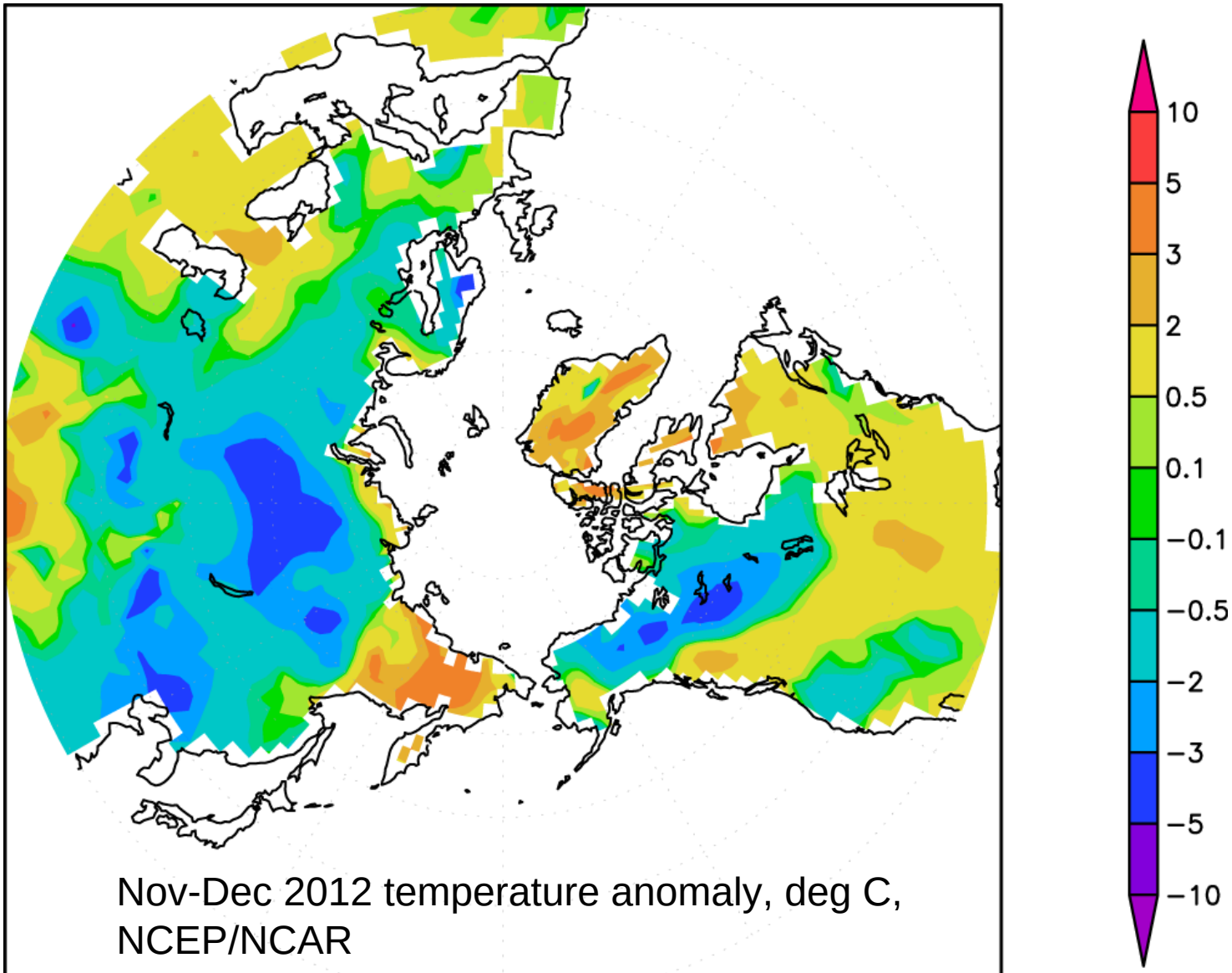


Winter temperature anomalies, NCEP/ NCAR Reanalysis data set



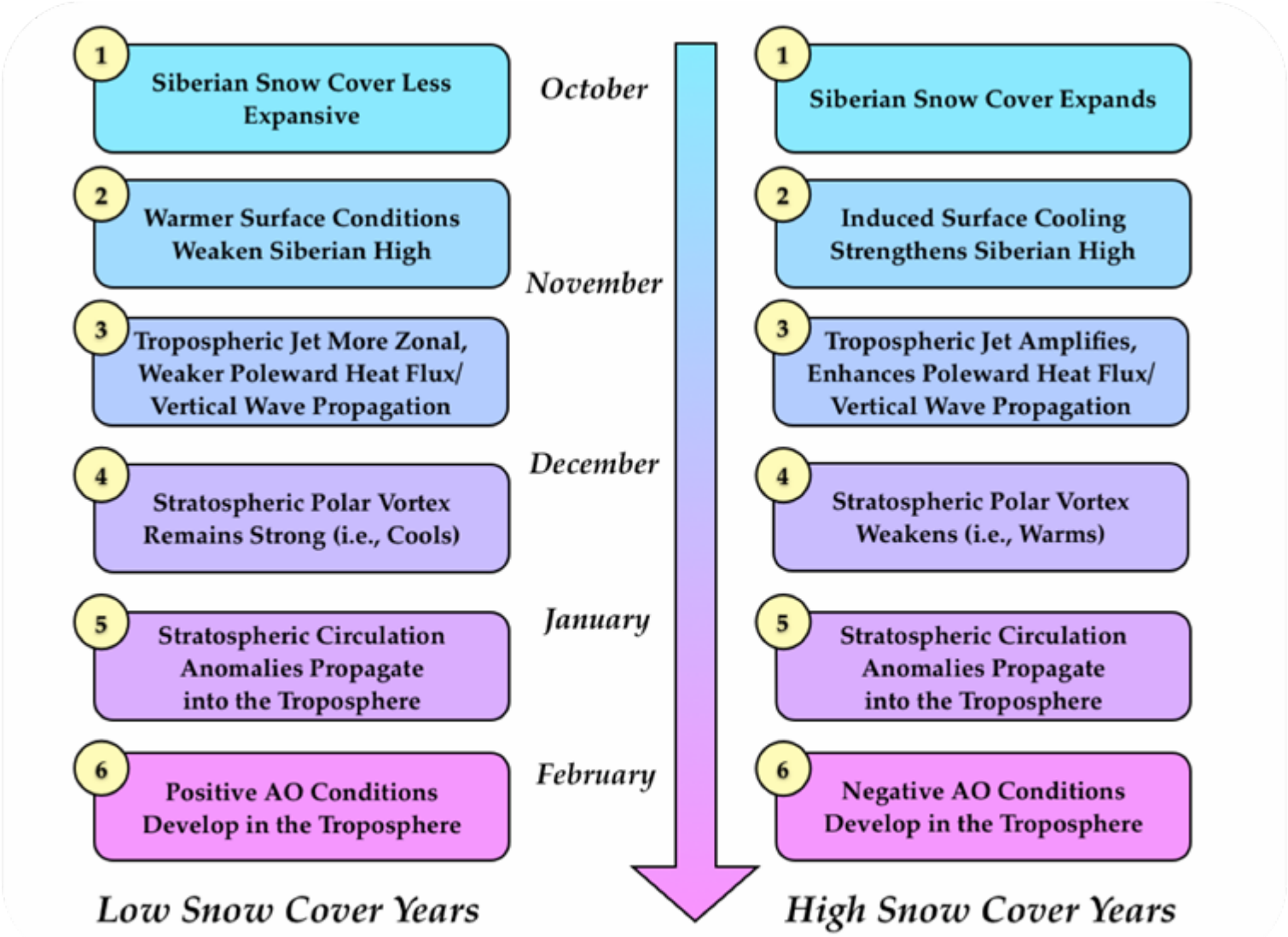
Cohen, Barlow, Furtado, Alexeev, Cherry, 2012, ERL

This winter so far:

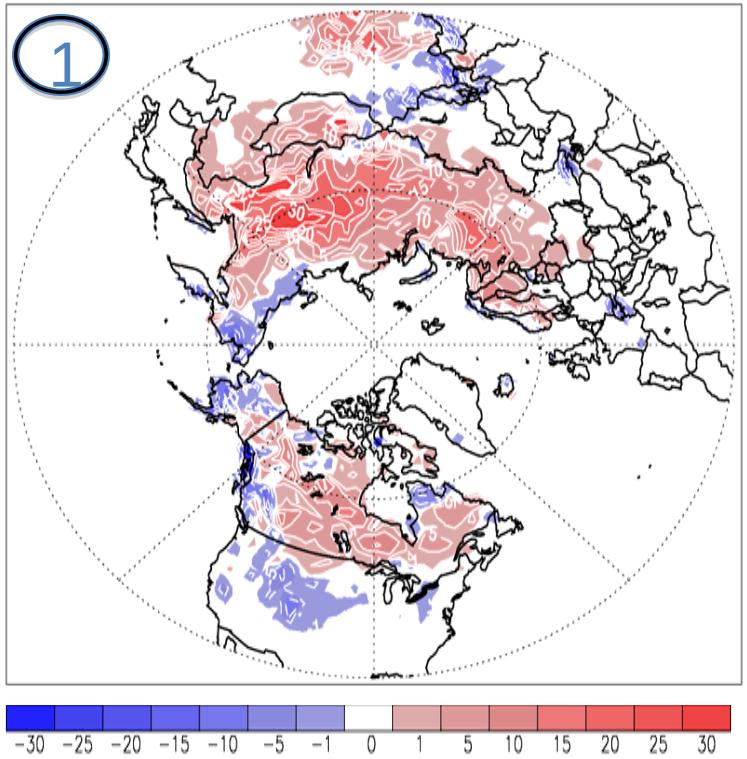


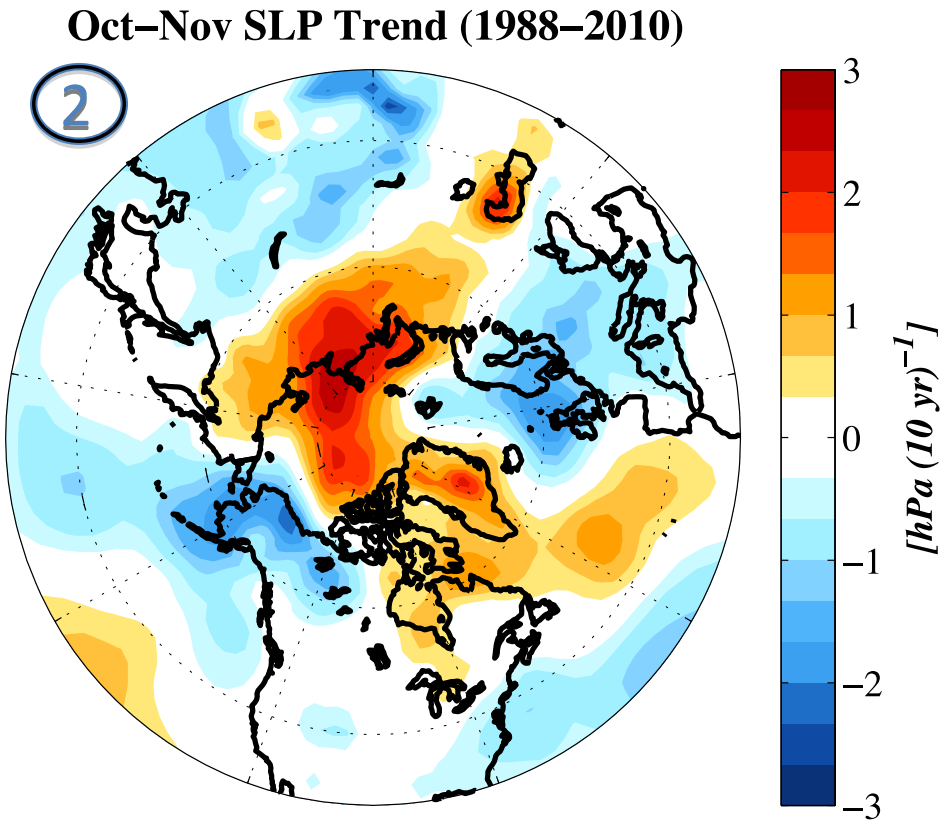
Nov-Dec 2012 temperature anomaly, deg C, NCEP/NCAR

Climate Response to Snow Forcing

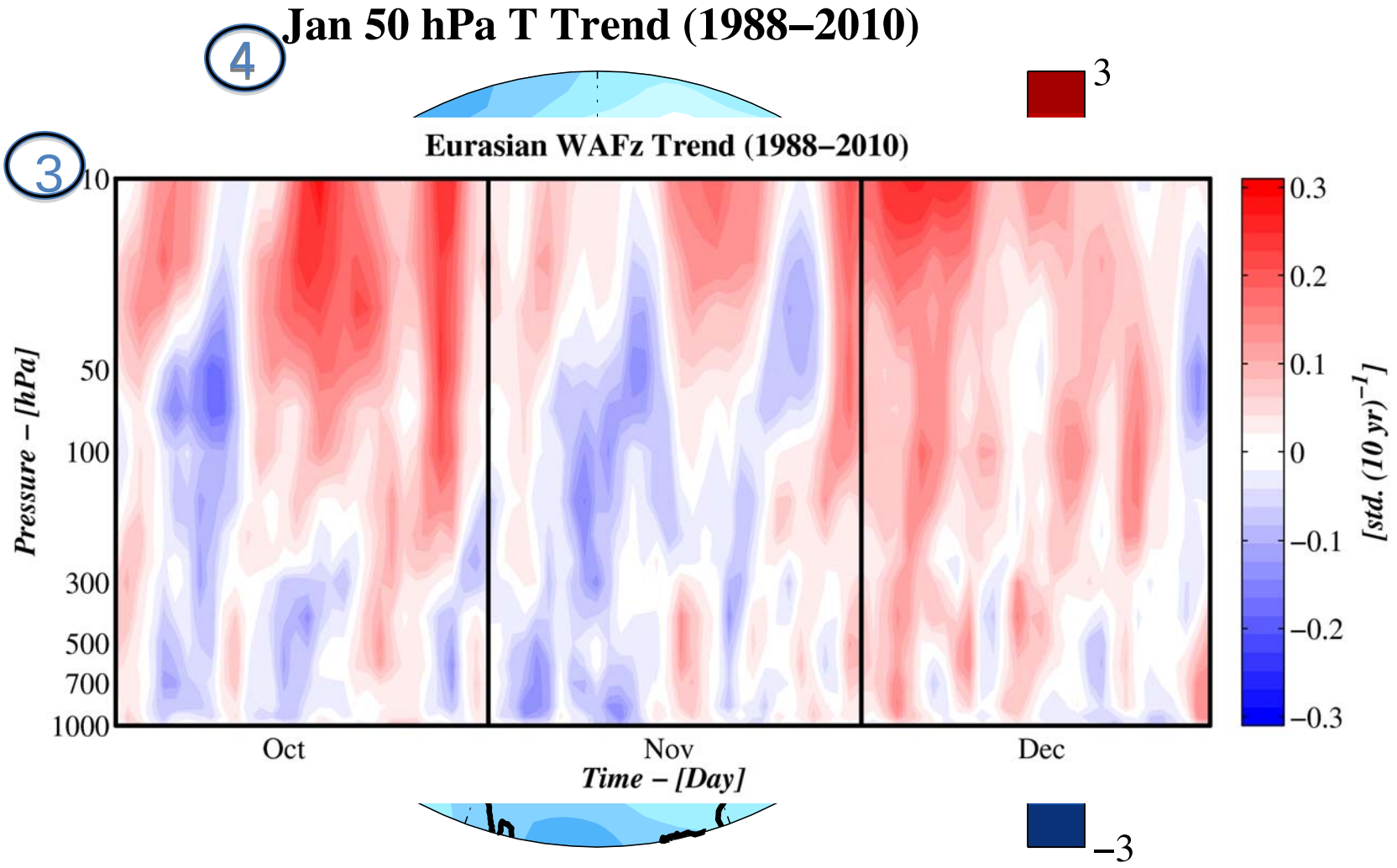


Tropospheric Fall Trends

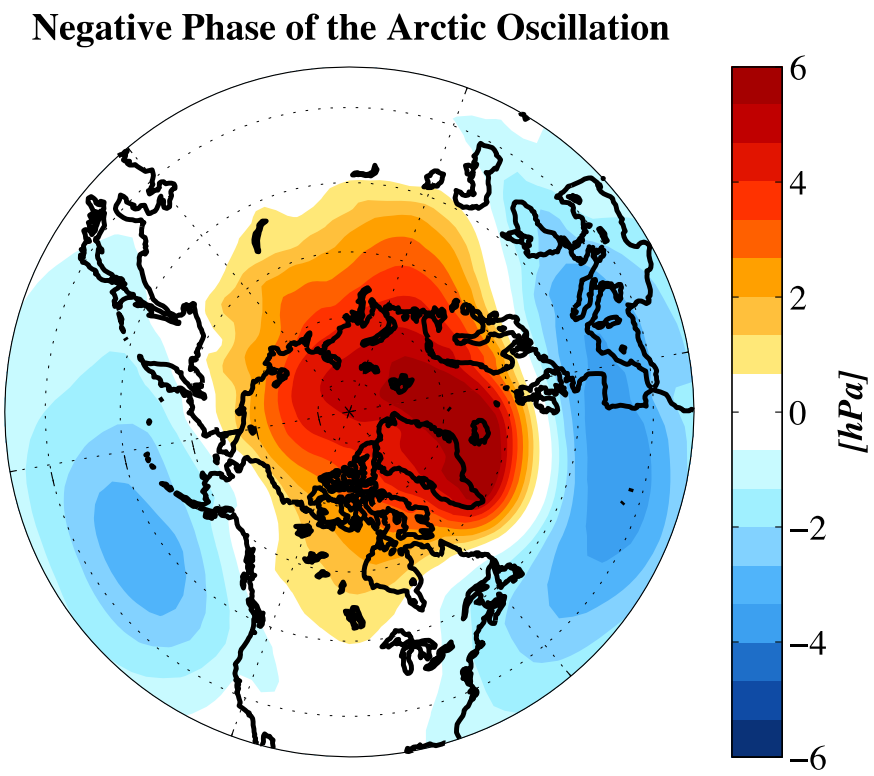


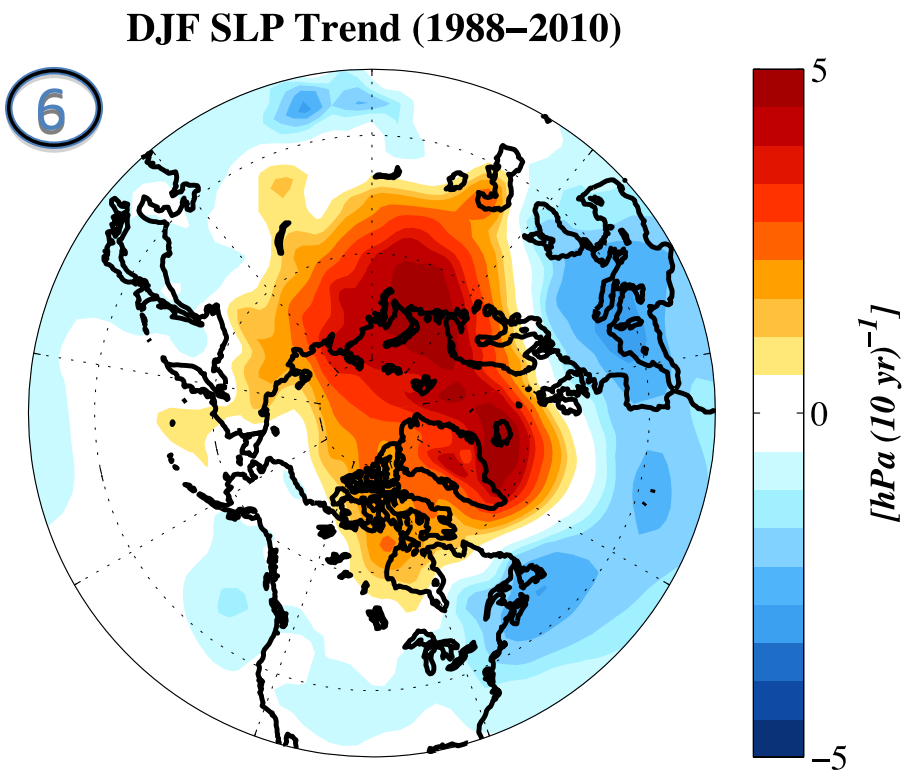


Stratospheric Fall-Winter Trends

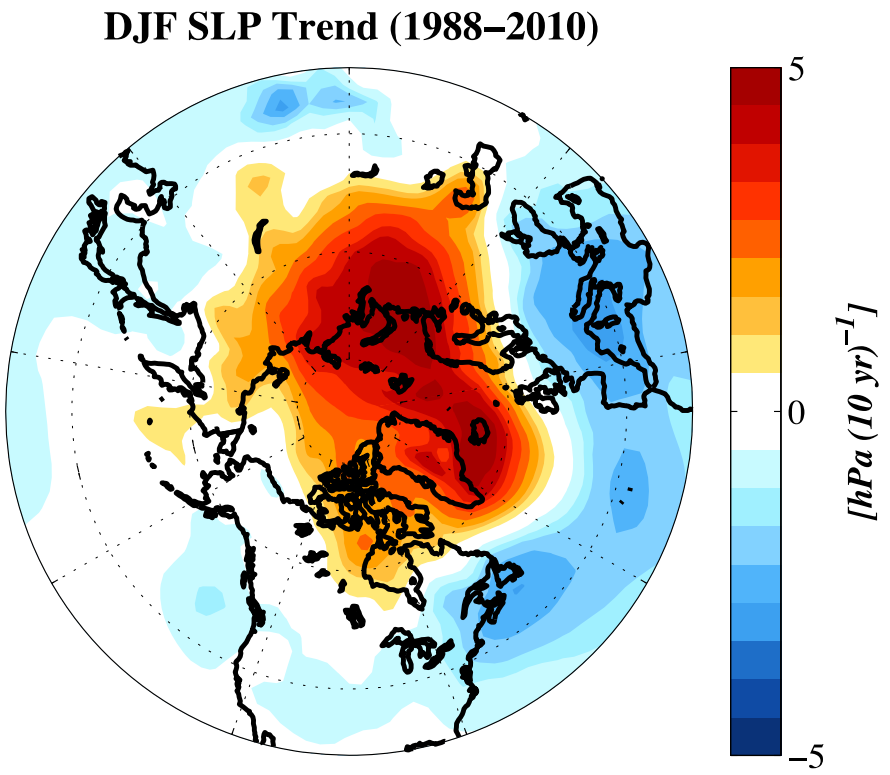


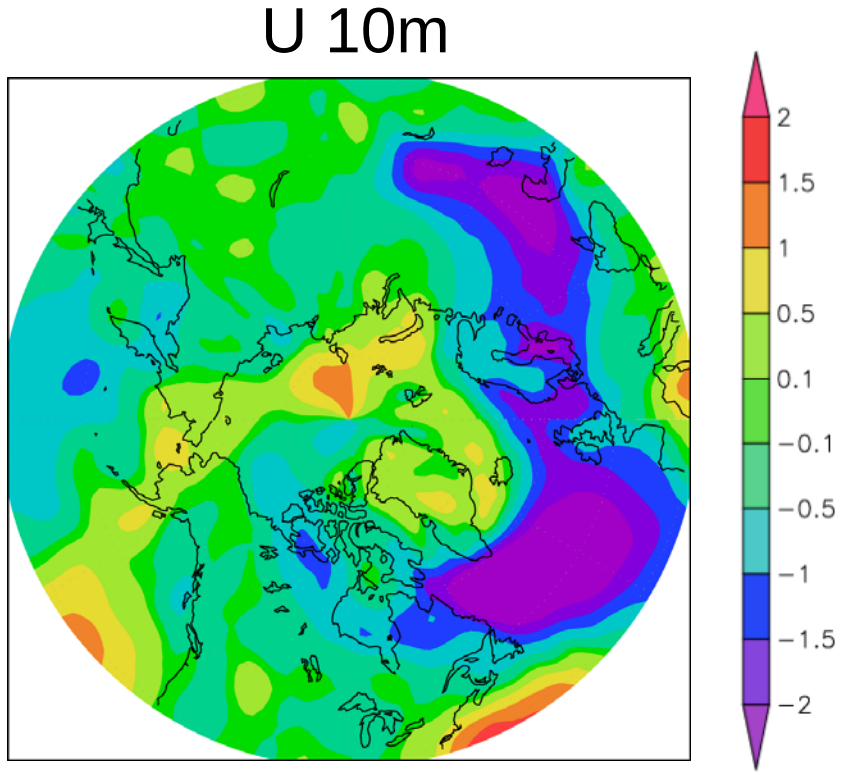
Tropospheric Winter Trends





Trend in SLP and zonal wind at 10m (ERA-Interim)





Cohen, J., J. Furtado, M. Barlow, V. Alexeev and J. Cherry, 2012, Arctic warming, increasing snow cover and widespread winter cooling, *Environmental Research Letters*, 014007 doi:10.1088/1748-9326/7/1/014007.

Cohen, J., J. Furtado, M. Barlow, V. Alexeev and J. Cherry, 2012, Asymmetric seasonal temperature trends, *Geophysical Research Letters*, 014007 doi:10.1029/2011GL050582.

Summary/conclusions

- The Arctic is warming, sea ice is disappearing
- North Atlantic warming and associated increase in the AW temperature are responsible for melting of a significant portion of arctic sea ice
- Delayed freeze-up, more open water and consequent heat input to the atmosphere lead to significant changes in atmospheric circulation, including switching the polarity of the transpolar drift to positive phase.
- Significant negative AO/NAO trend in the recent years is a manifestation of the warming in the Arctic Ocean
- Negative AO/NAO trends are responsible for the negative winter temperature trends in Northern Eurasia (also in the lower 48)

Thank you!