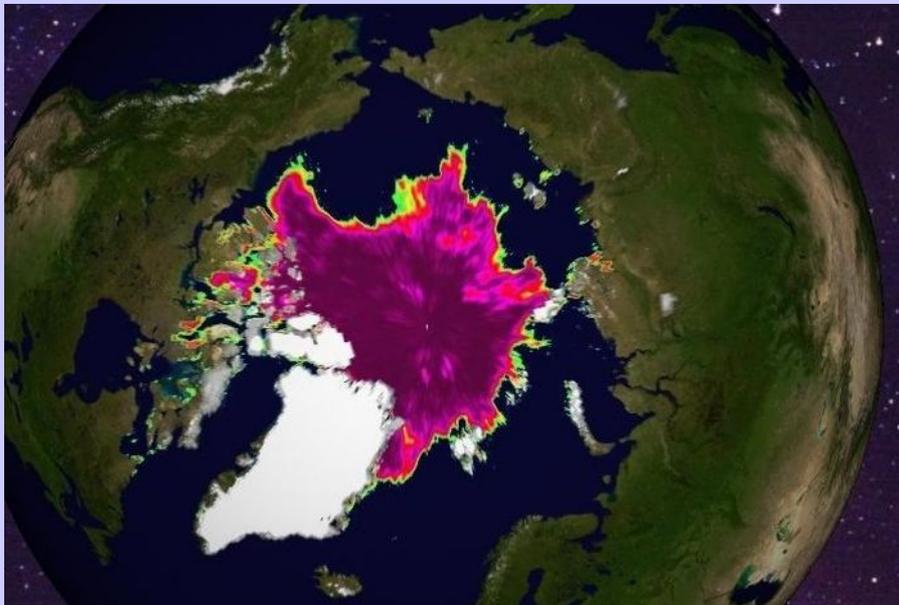


Linkages Between the Arctic and the Earth System: What Should We Be Watching?

John Walsh

*International Arctic Research Center
University of Alaska, Fairbanks*



Five key Arctic-global linkages:

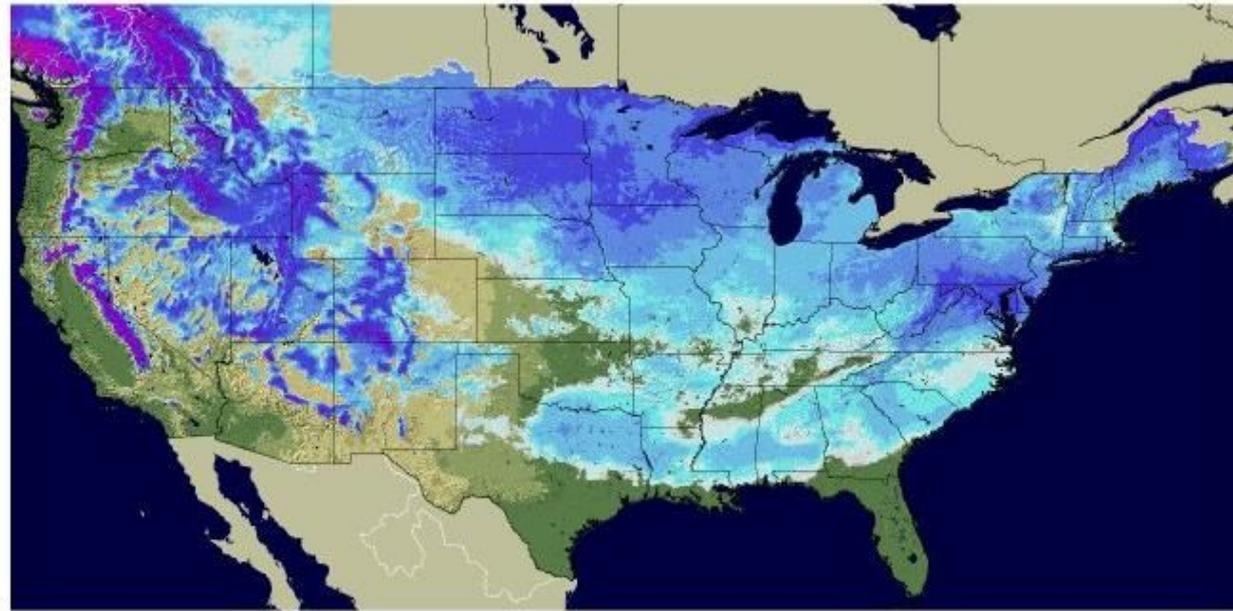
- What have we learned recently about each linkage?
- Why does the linkage bear watching?
- What should we be watching?

1. Are changes in the Arctic impacting mid-latitude weather and climate?

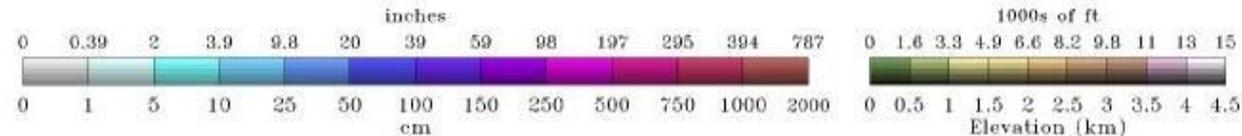


National Snow 2009-
Analysis 2010

Snow Depth
2010-02-13 06

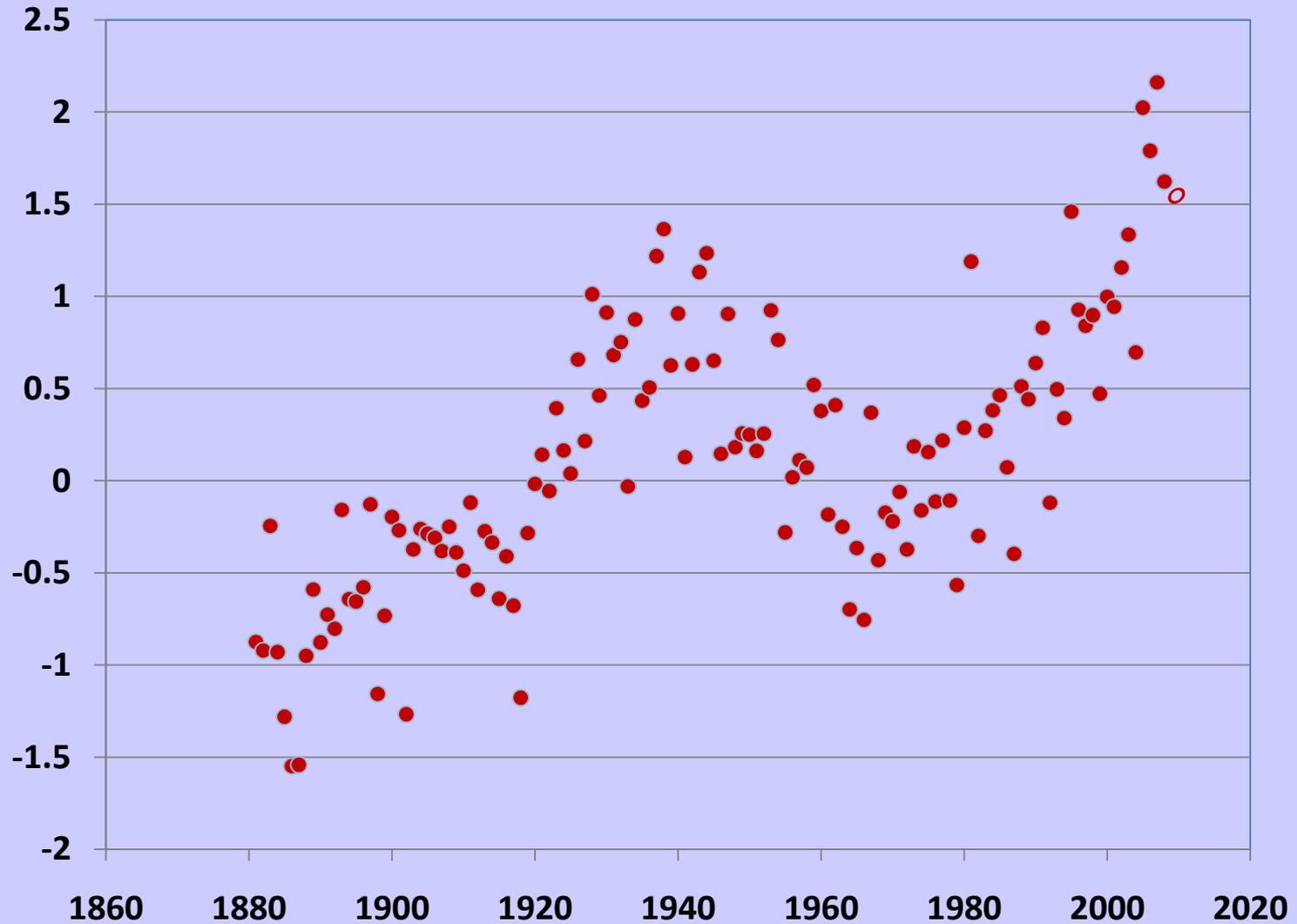


NOHRSC



Record snowfall during the winter of 2009-10

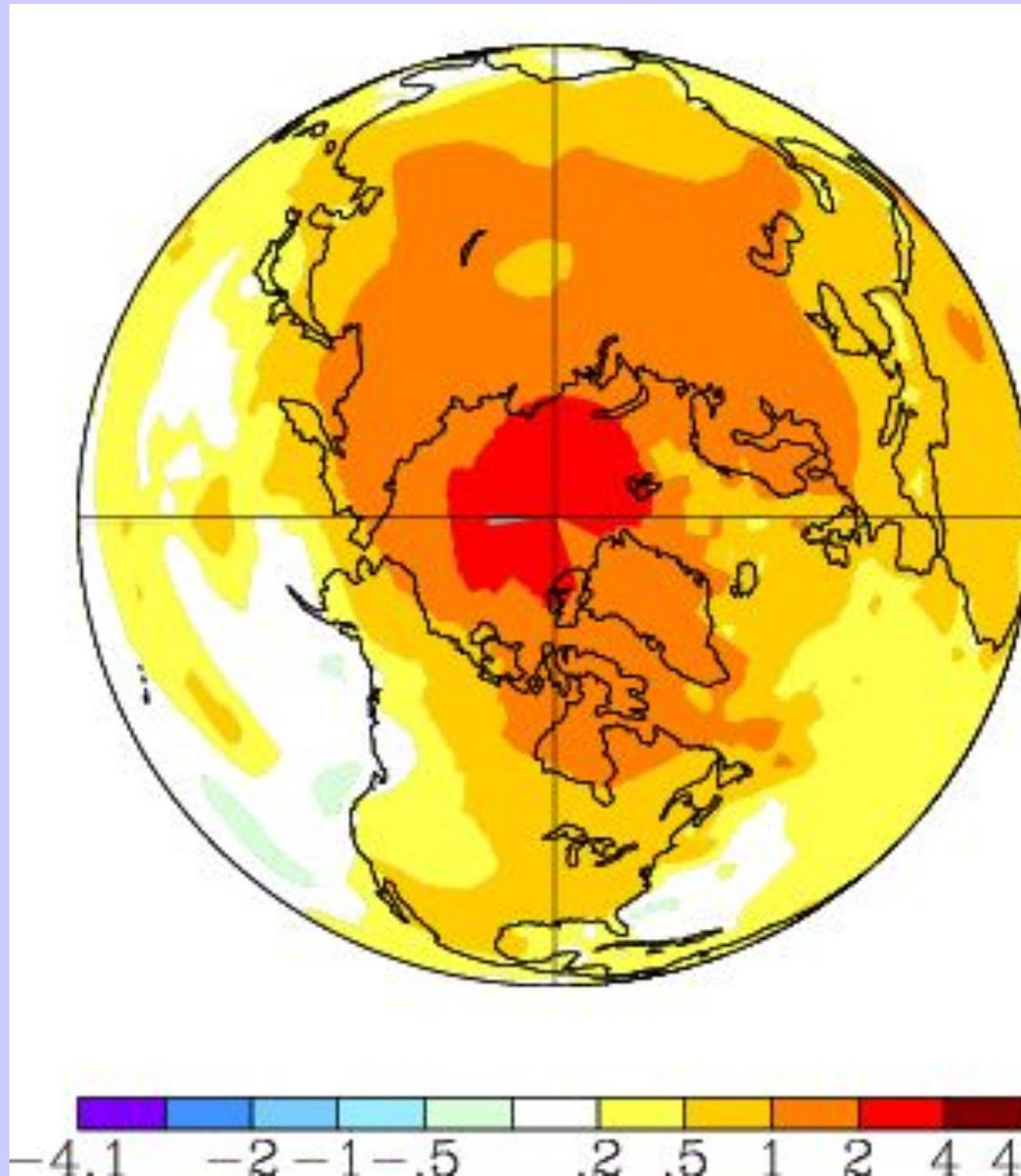
Annual surface air temperature area averaged over the 60°N - 90°N latitudinal zone



[From P. Groisman, NOAA/NCDC]

Arctic temperature anomalies: 2005-09 vs. 1951-2000

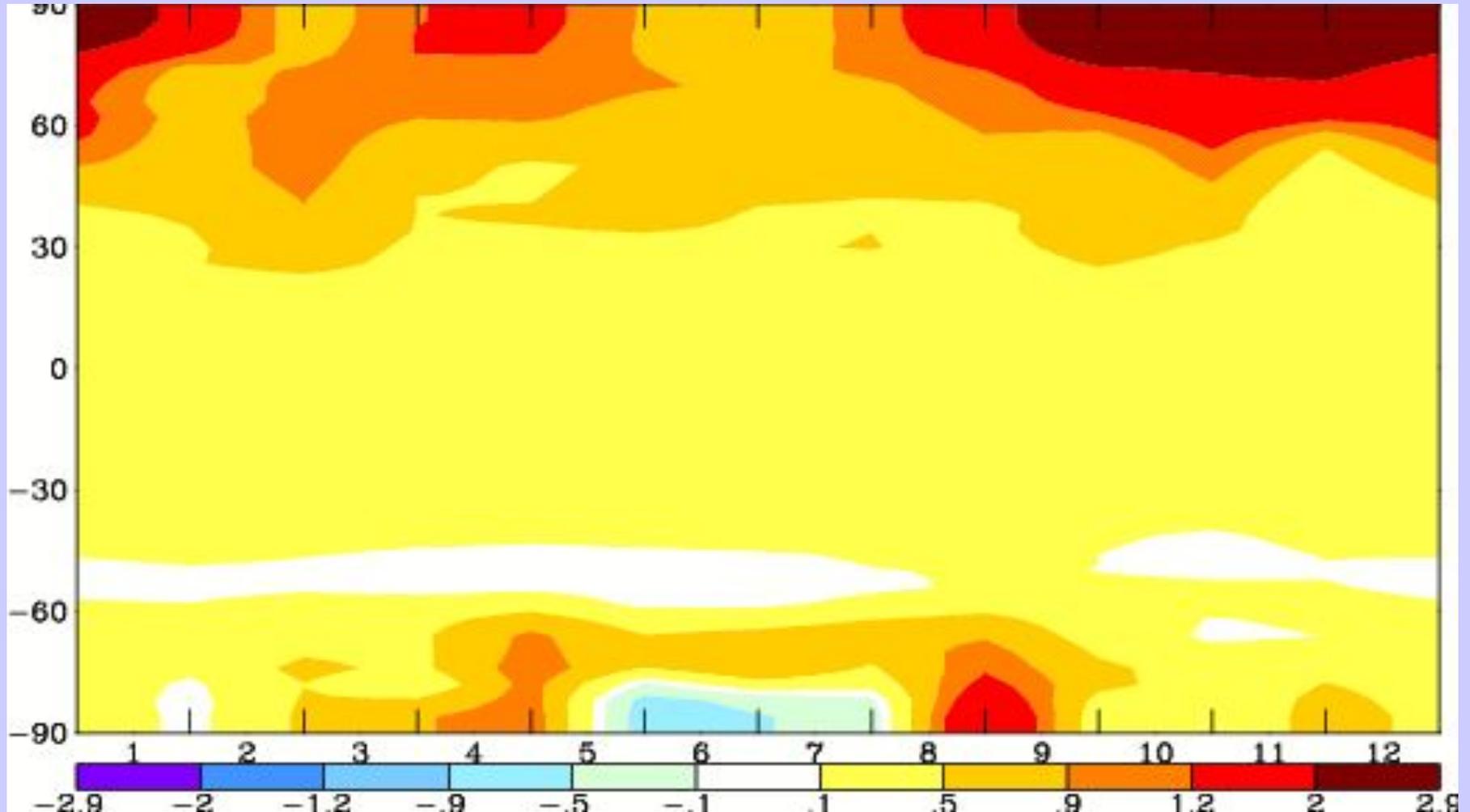
[from NASA GISS]



Arctic temperature anomalies: 2001-09 vs. 1951-2000

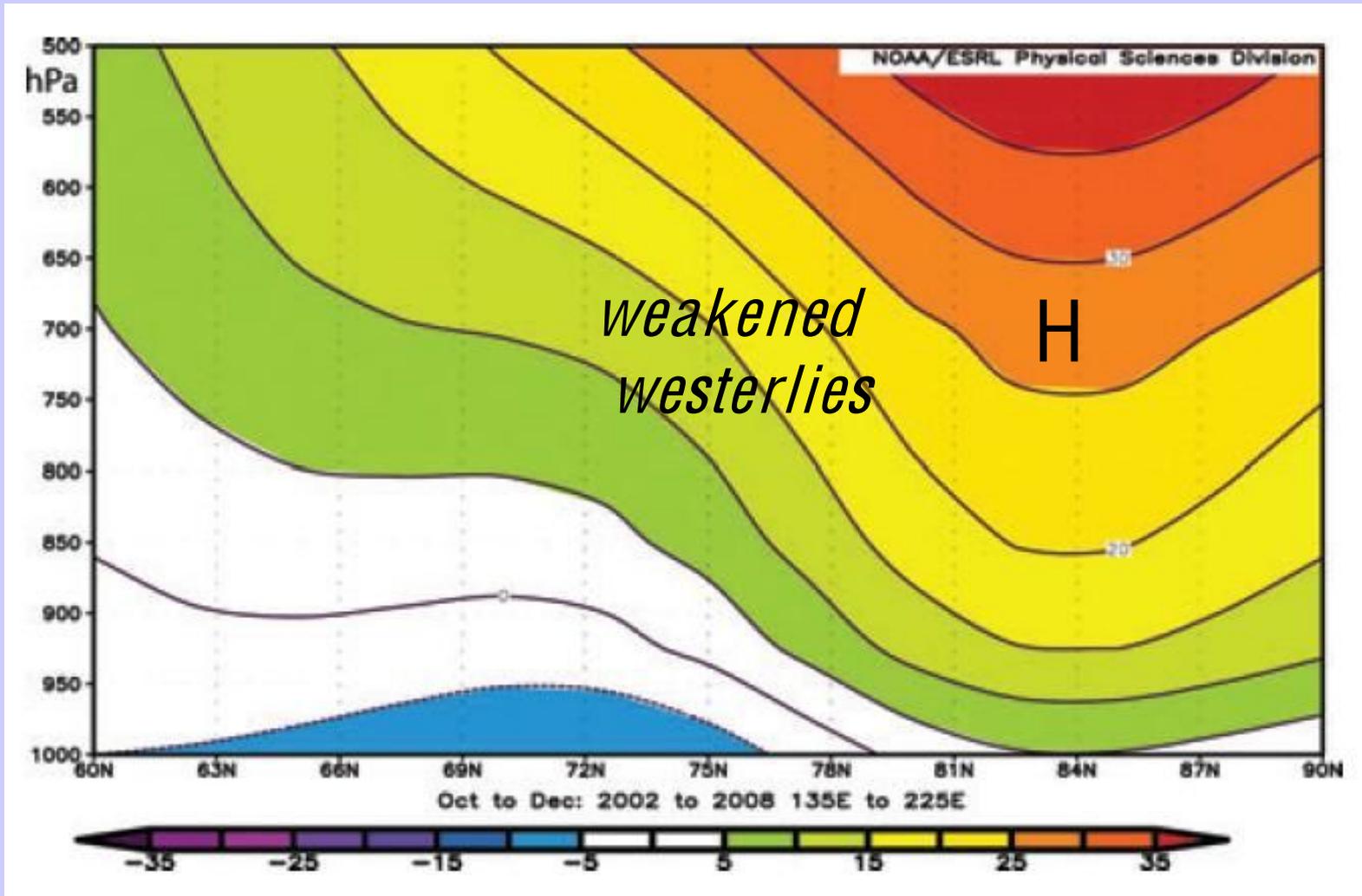
[from NASA GISS]

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec



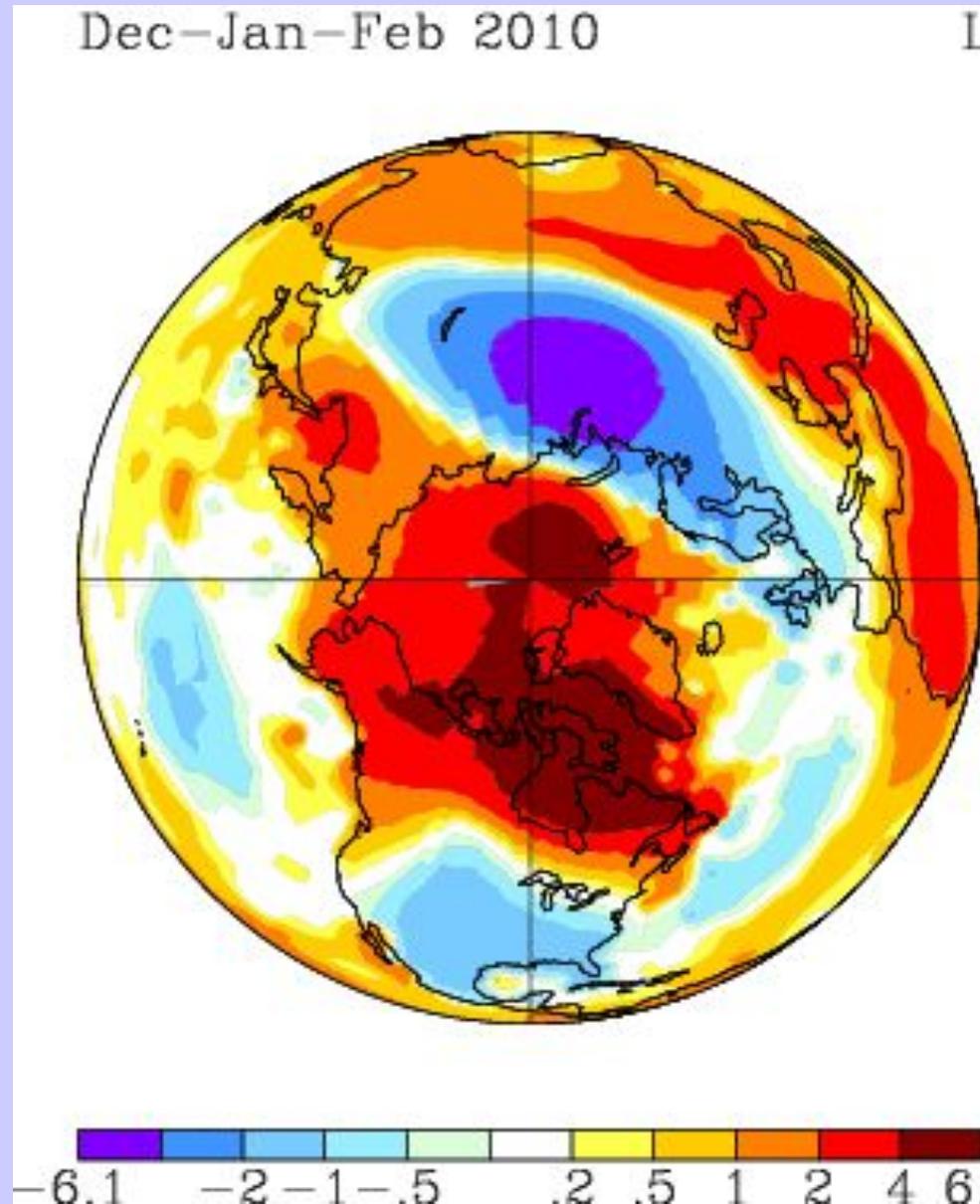
Latitude-height cross-section of pressure anomalies in Pacific sector of Arctic: Oct-Dec, 2002-2008

[from Overland and Wang, 2010, Tellus]



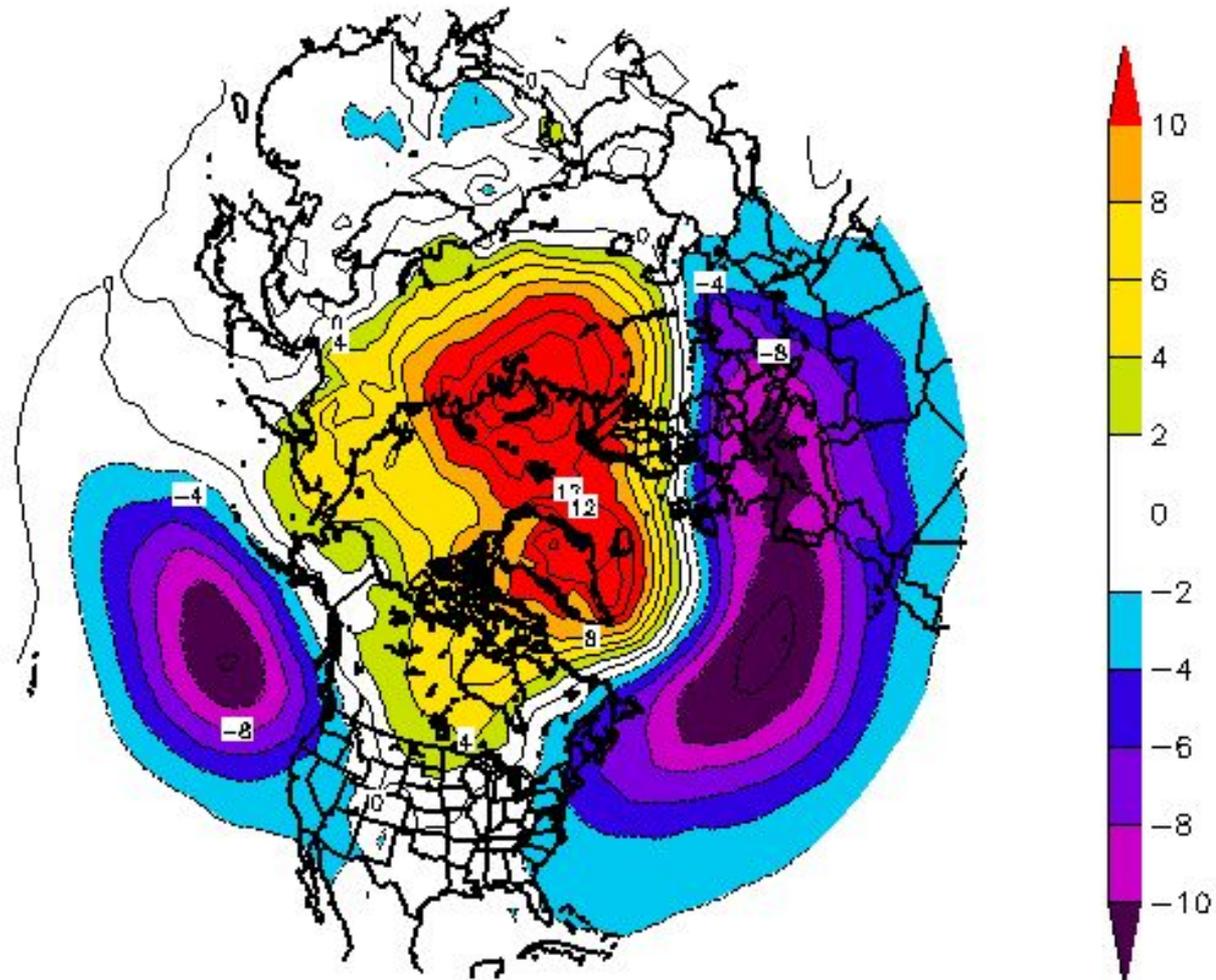
Temperature anomalies (C), Dec-Feb, 2009-2010

[from NASA GISS]



Sea level pressure anomalies: Dec-Feb, 2009-10

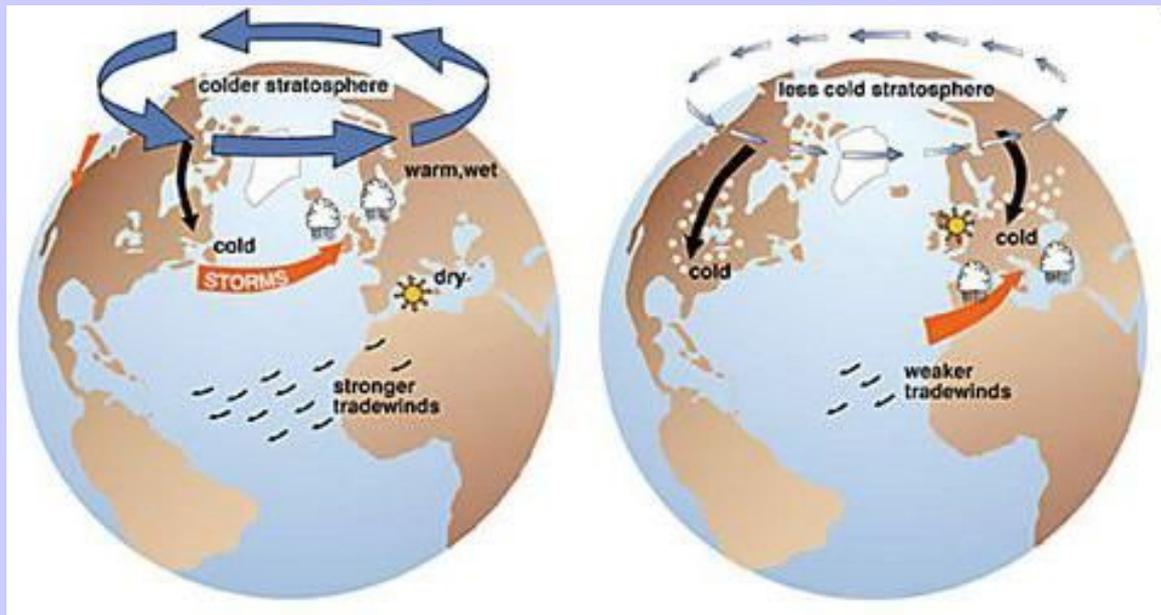
[from NOAA ESRL]



SEA LEVEL PRESSURE (mb) 90-DAY ANOMALY FOR:
Tue DEC 01 2009 - Sun FEB 28 2010

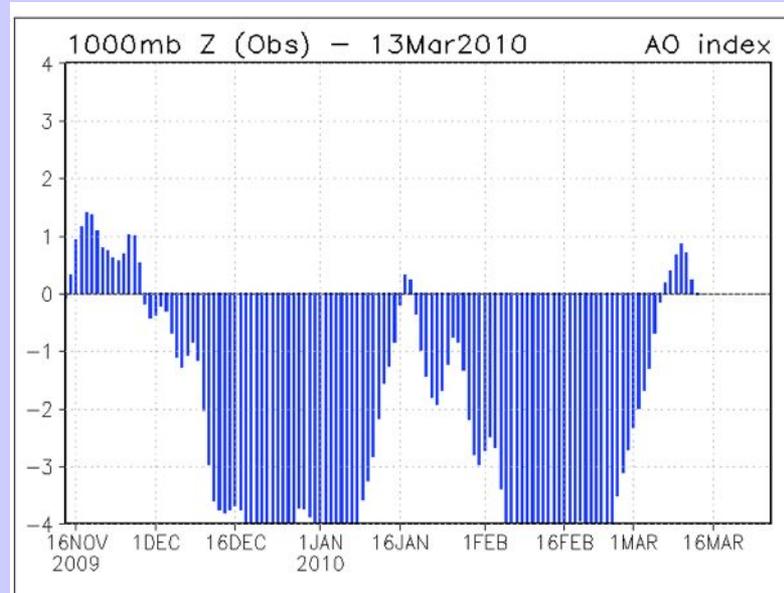
Arctic Oscillation [D. Thompson and M. Wallace]

+ve



-ve

Winter 2009-10:
Extremely negative AO →



Factors contributing to severity of winter of 2009-10:

- El Niño event in tropical Pacific
- Extreme negative phase of Arctic Oscillation

[M. Hoerling et al., NOAA ESRL, preliminary assessment]

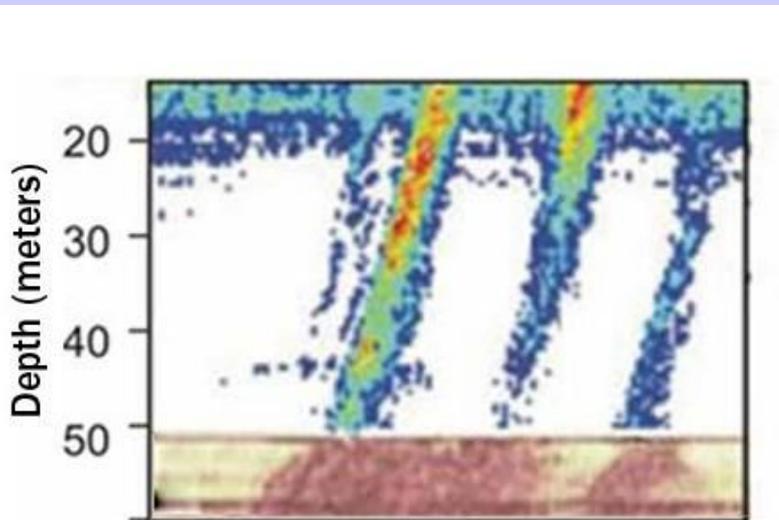
Sea ice loss, winter warmth in the central Arctic and -'ve **AO**

-- a coincidence?

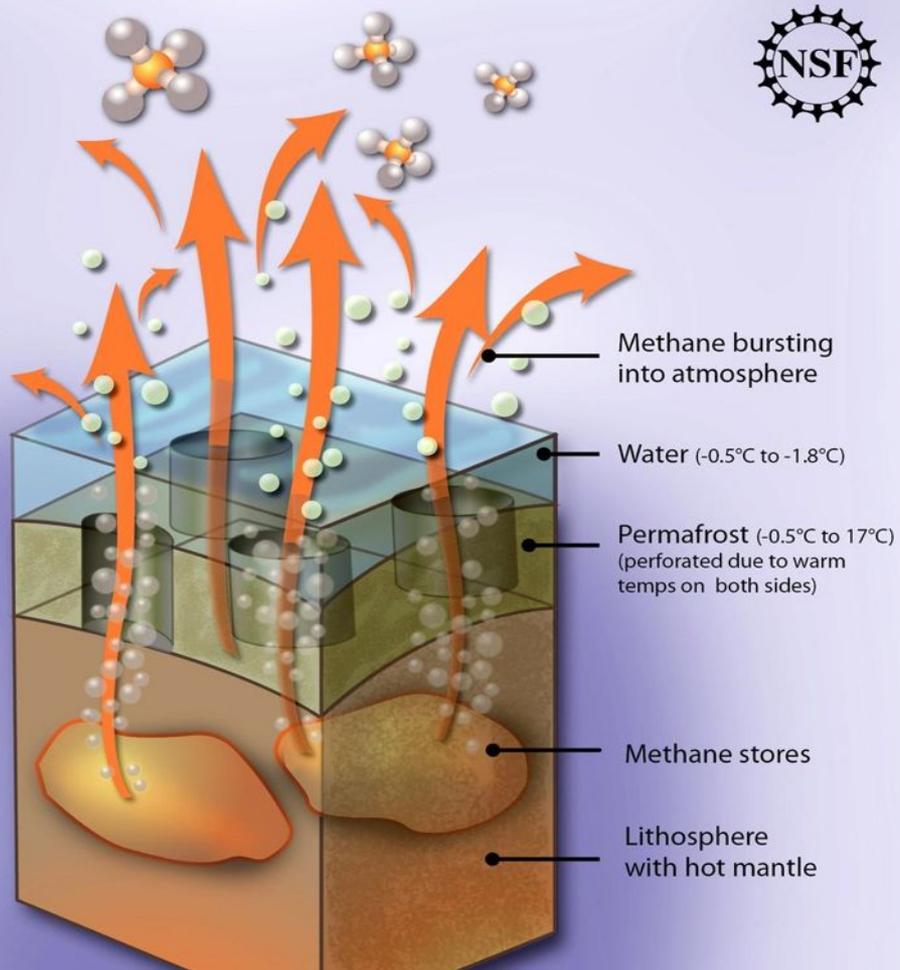
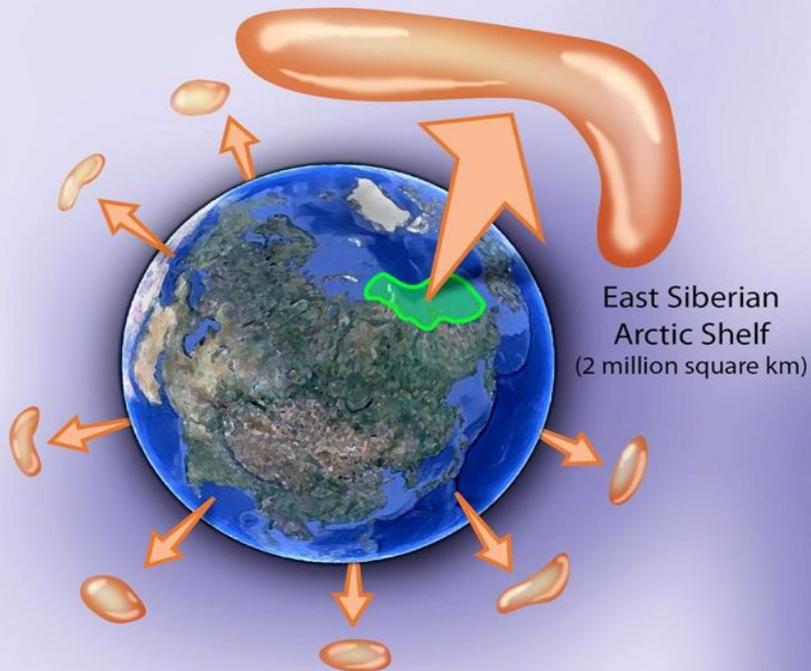
2. Methane from the Arctic: Global consequences?

“Remobilization to the atmosphere of only a small fraction of the methane held in the East Siberian Arctic Shelf sediments could trigger abrupt climate warming... The current atmospheric venting flux ... is on a par with estimates of methane venting from the entire world ocean.”

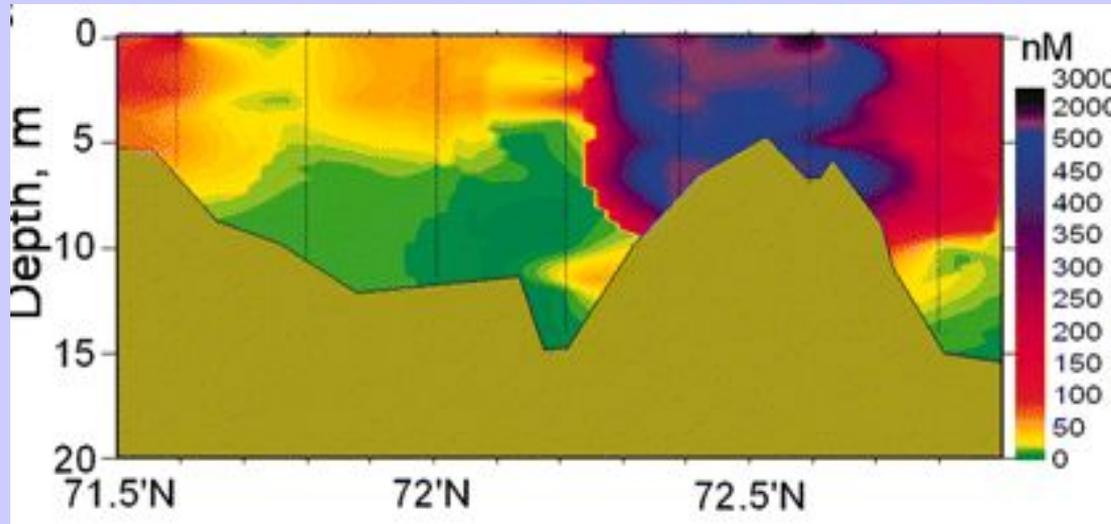
-- Shakhova et al., 5 March 2010, Science



Similar amount of methane generated here as from the rest of the World Ocean

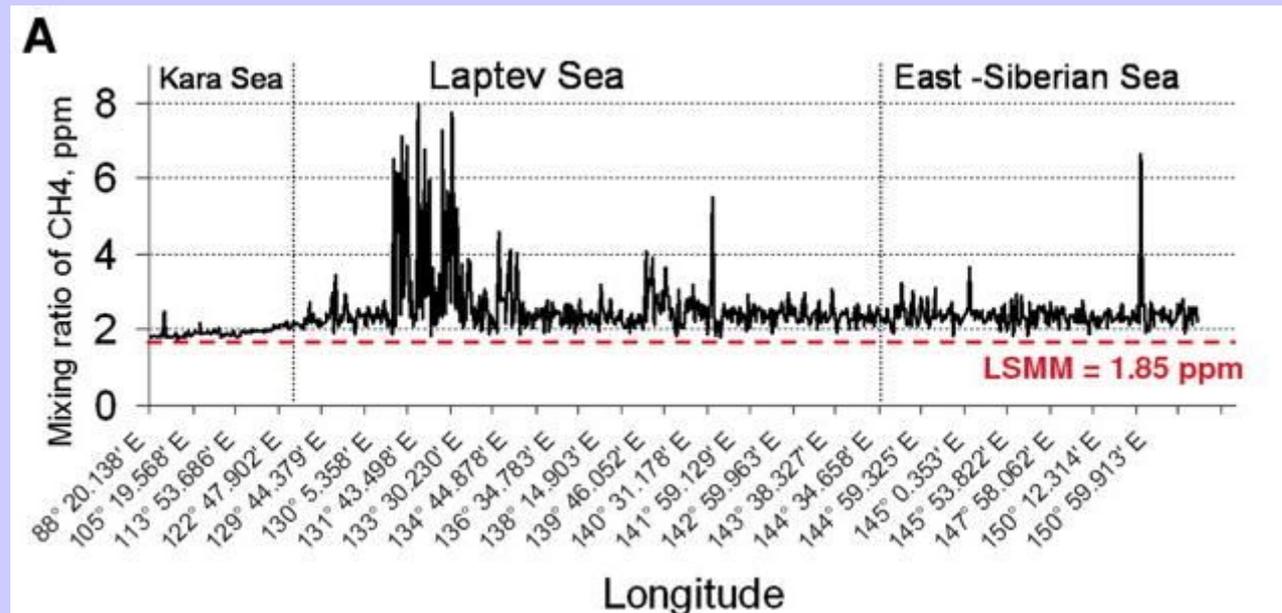


Credit: *Zina Deretsky, National Science Foundation*

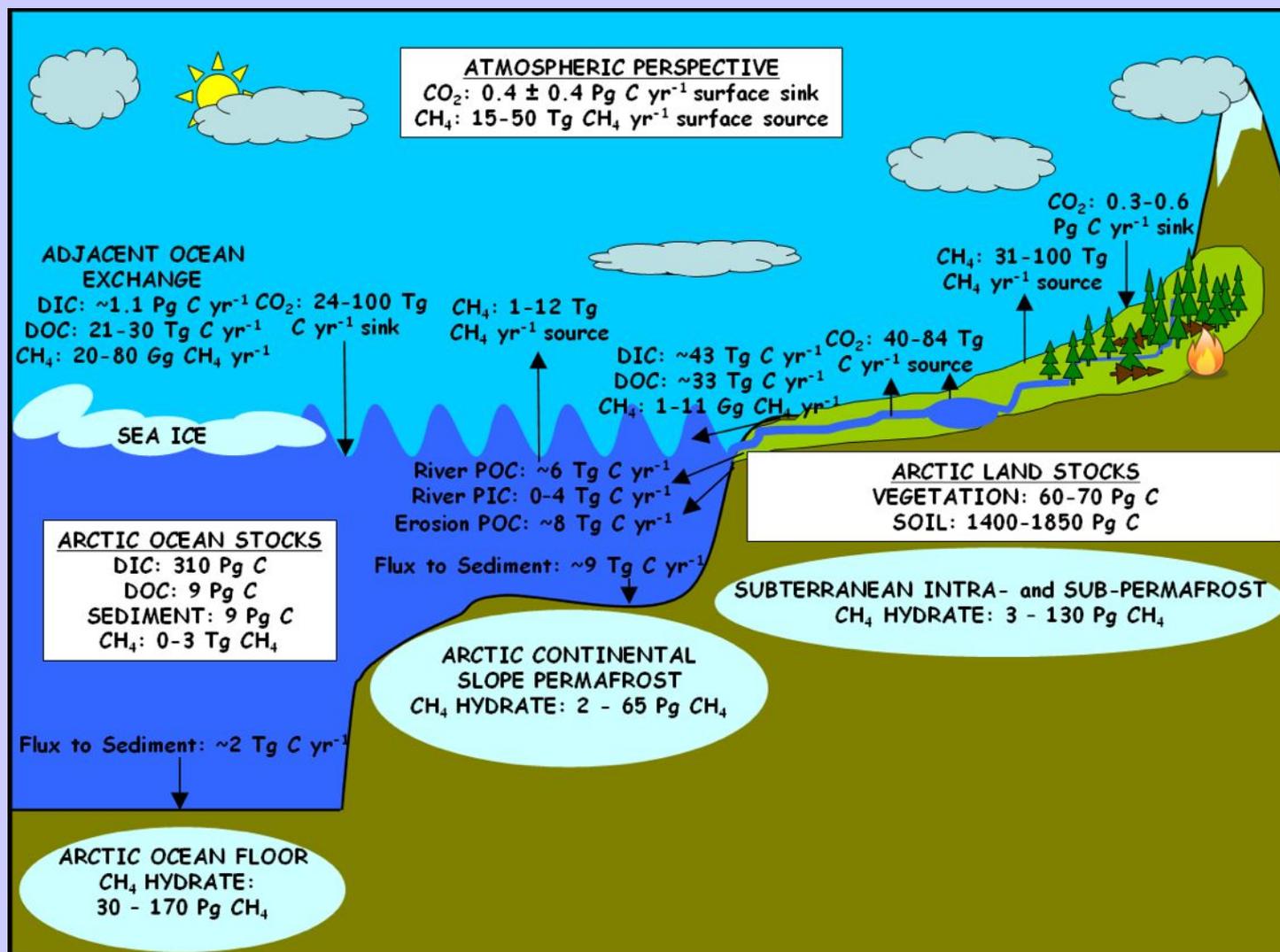


Methane in the Siberian shelf seas

-- Shakhova et al., 2010



Carbon in the Arctic – Pools & Fluxes



From **McGuire et al. (2009; *Ecological Monographs*)**

M. Heimann, *Science*, 5 March 2010:

“Considering the global emissions of ~440 Tg C as methane per year (IPCC, 2007), the Siberian Arctic Ocean emissions and the changes in northern wetland emissions are negligible.... But will this persist into the future under sustained warming trends? We do not know.”

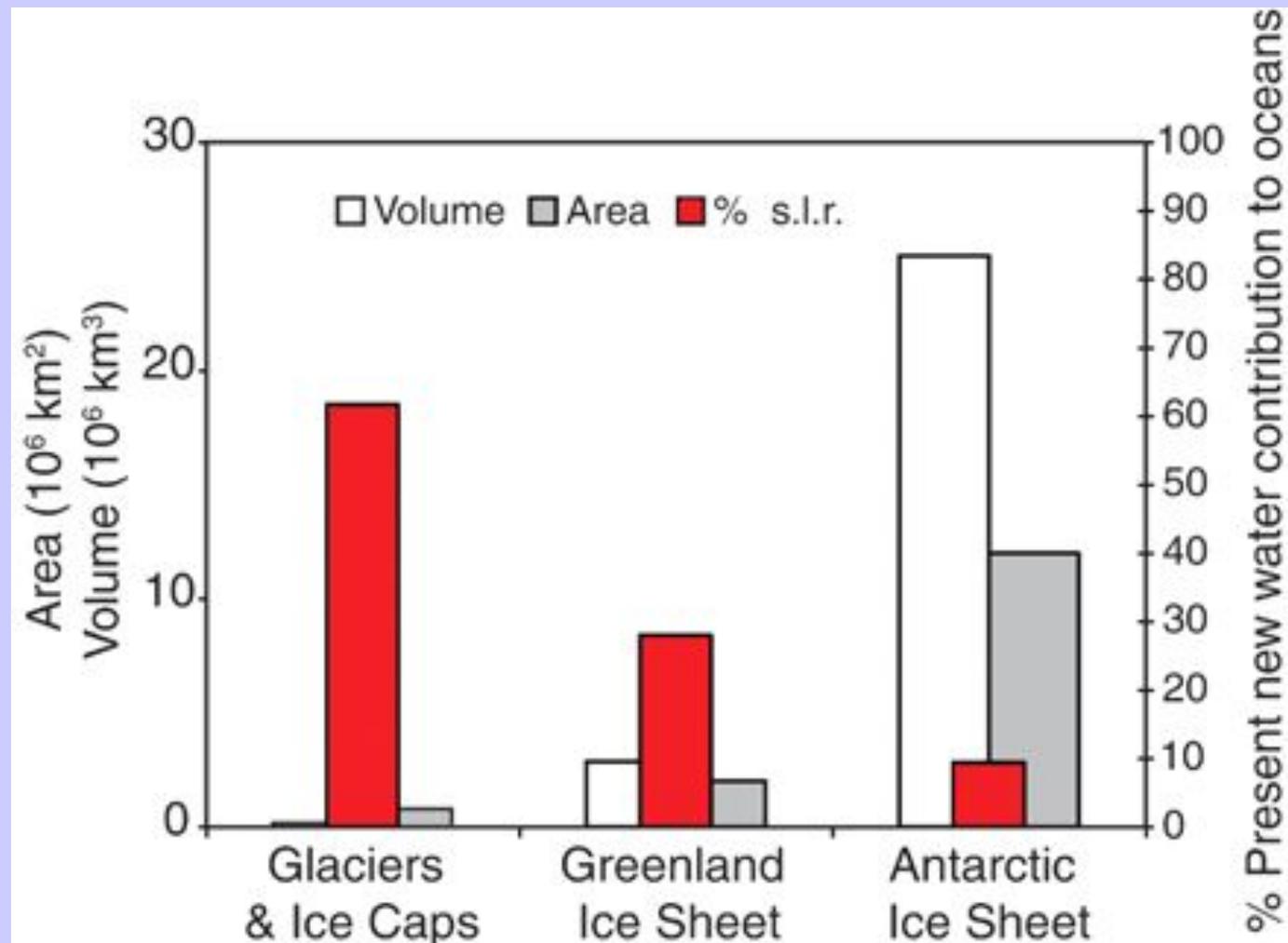
3. Greenland and Arctic glaciers: Wild cards for global sea level

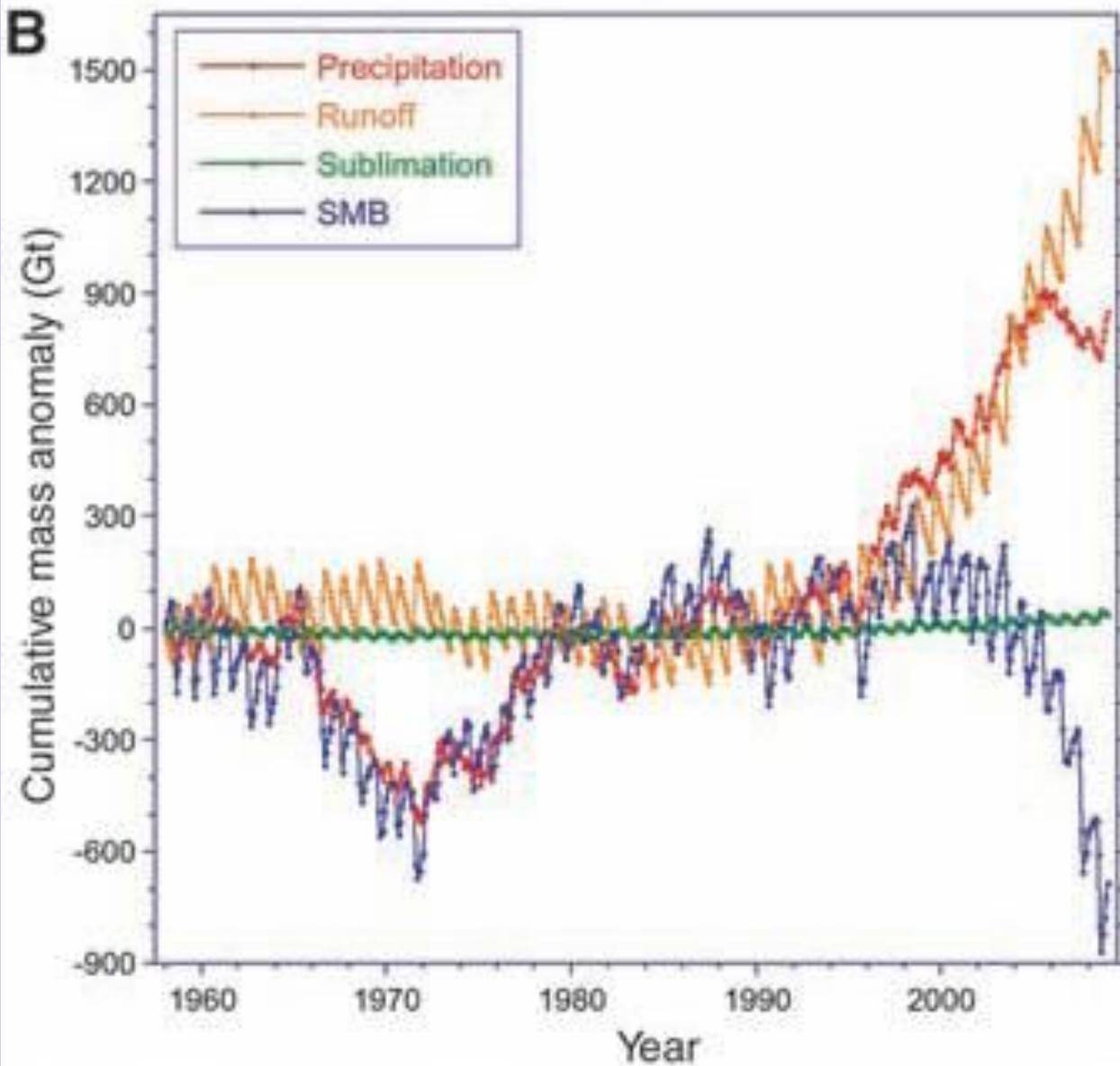


[from NASA/ R. Braithwaite]

Estimated contributions of Glaciers & Ice Caps, Greenland and Antarctic Ice Sheets to present sea level rise

-- Meier et al., 2007, Science

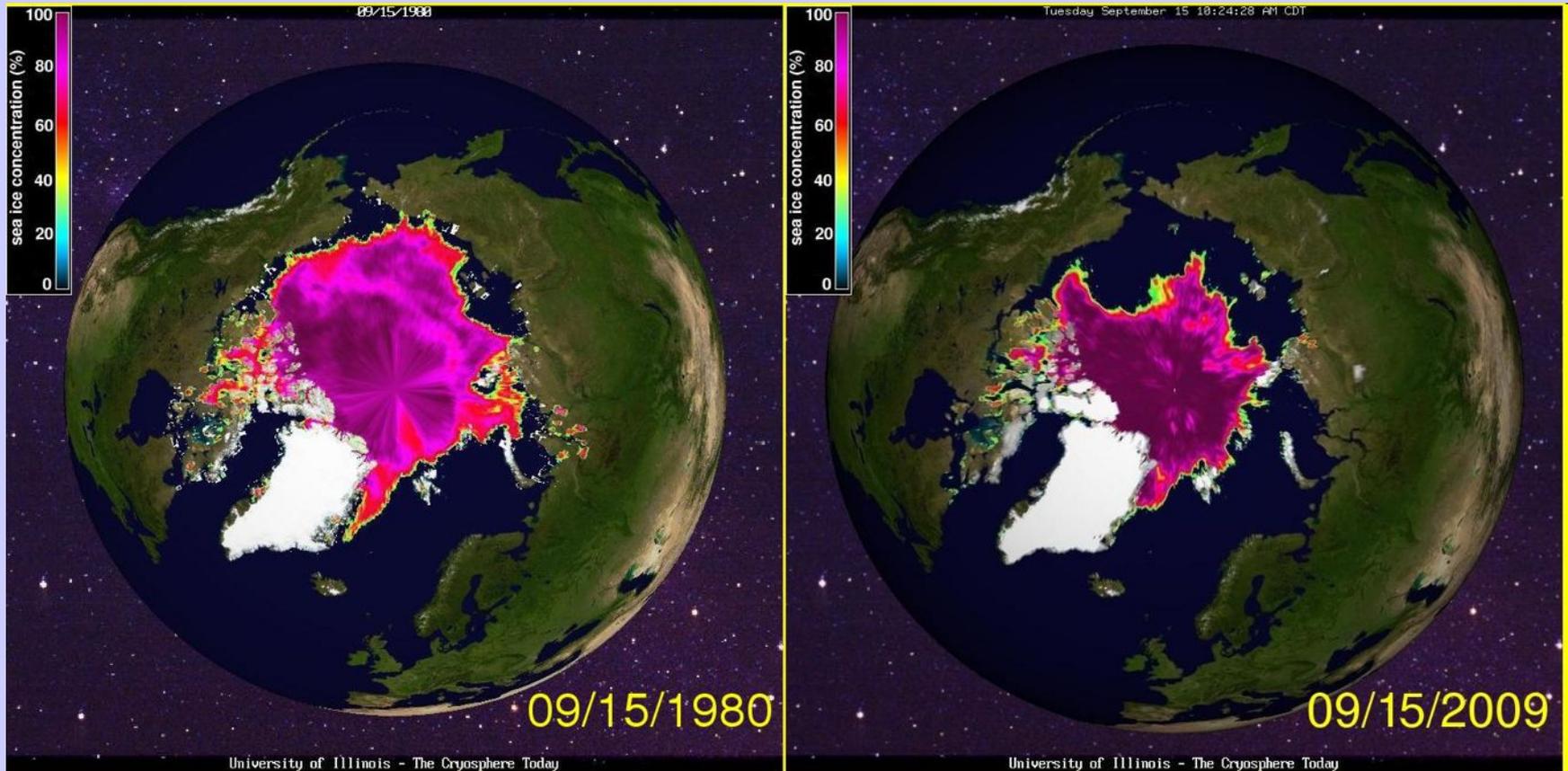


B

“Since 2006, high summer melt rates have increased Greenland Ice Sheet mass loss to 273 Gt per year (0.75 mm/yr of equivalent sea level rise.)”

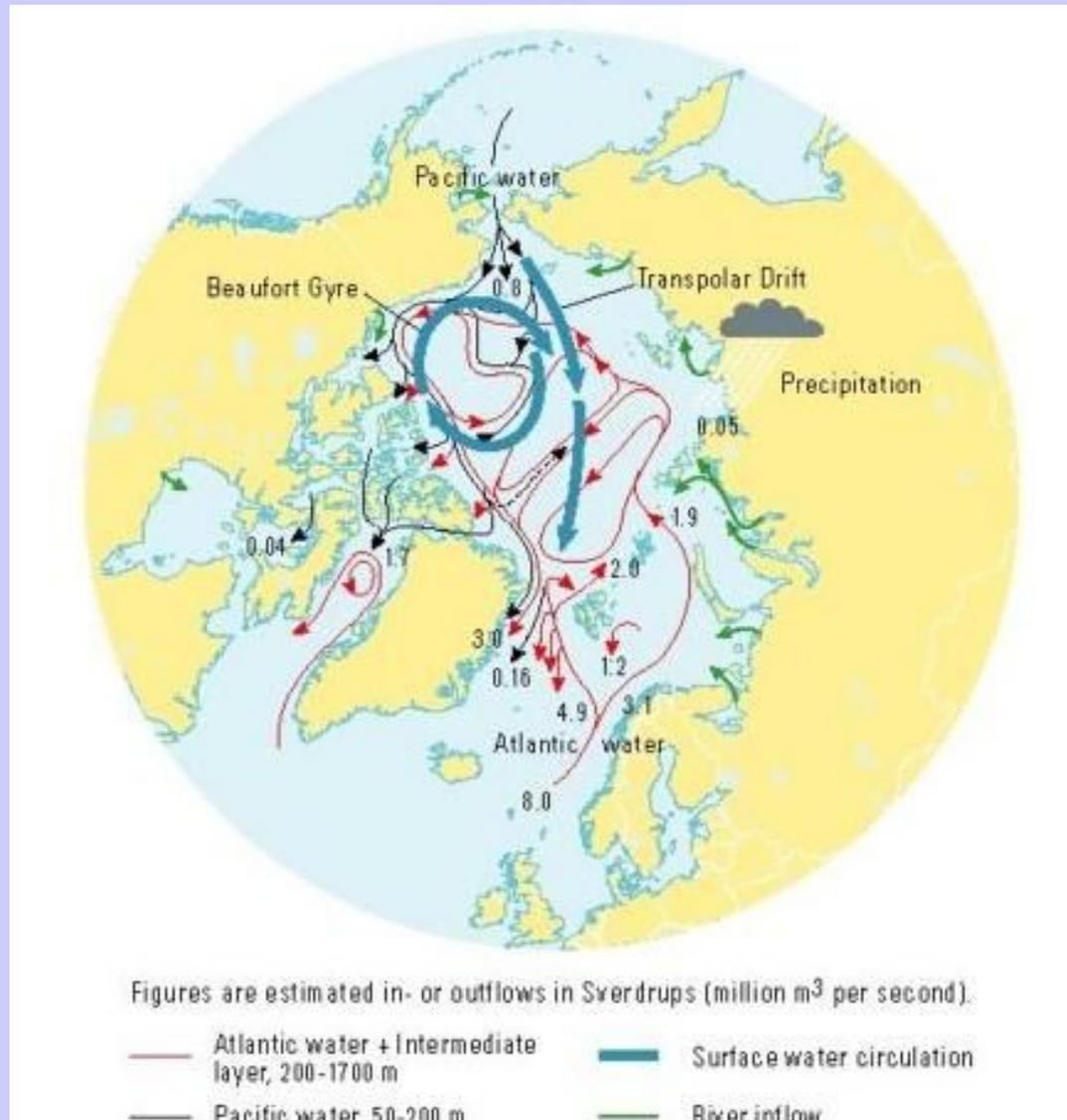
-- van den Broeke et al., 2009, Science

4. Atlantic and Pacific Ocean inflows to the Arctic: Drivers of Arctic change?

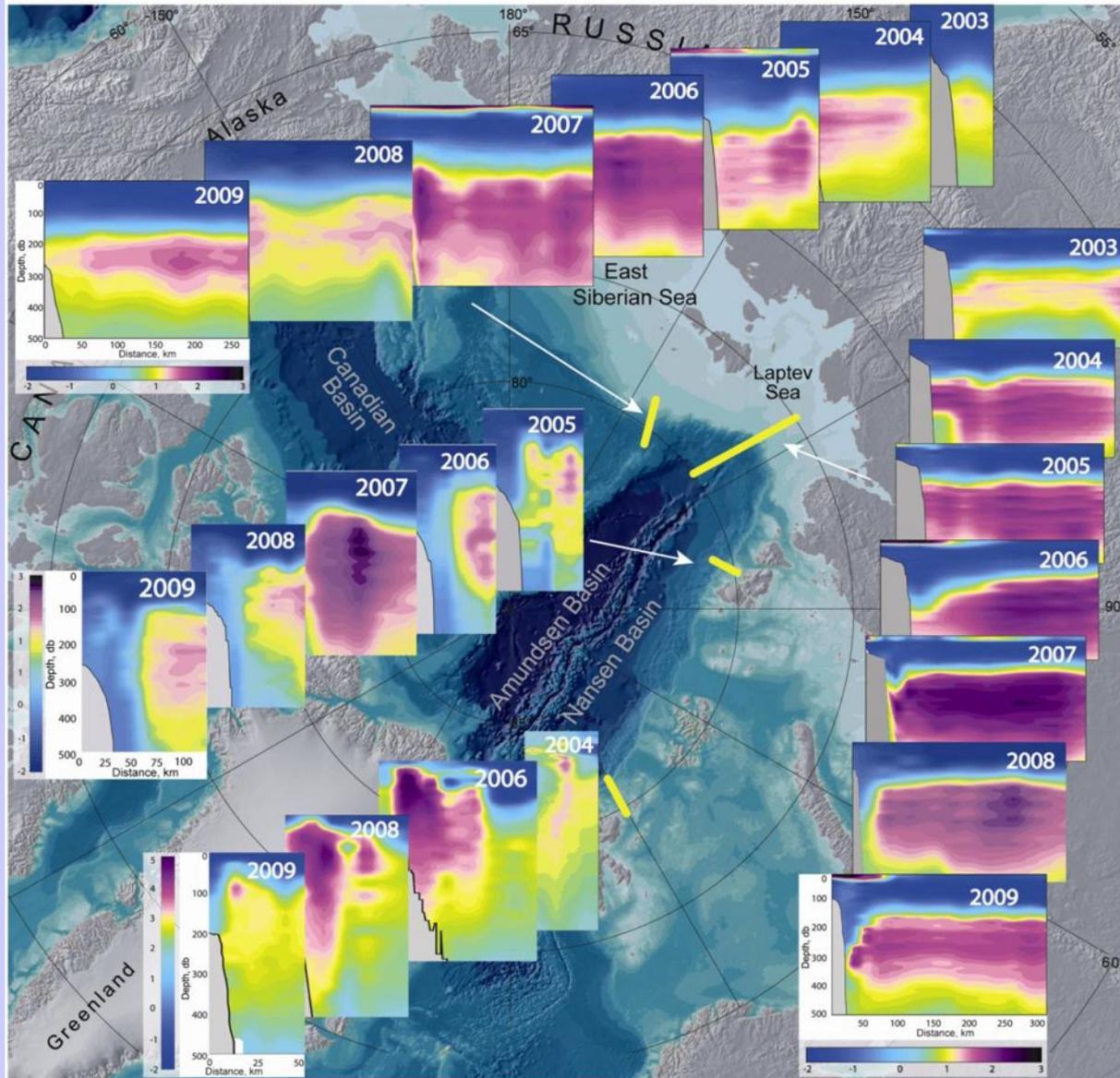


Arctic Ocean currents

[from Arctic Monitoring and Assessment Program]



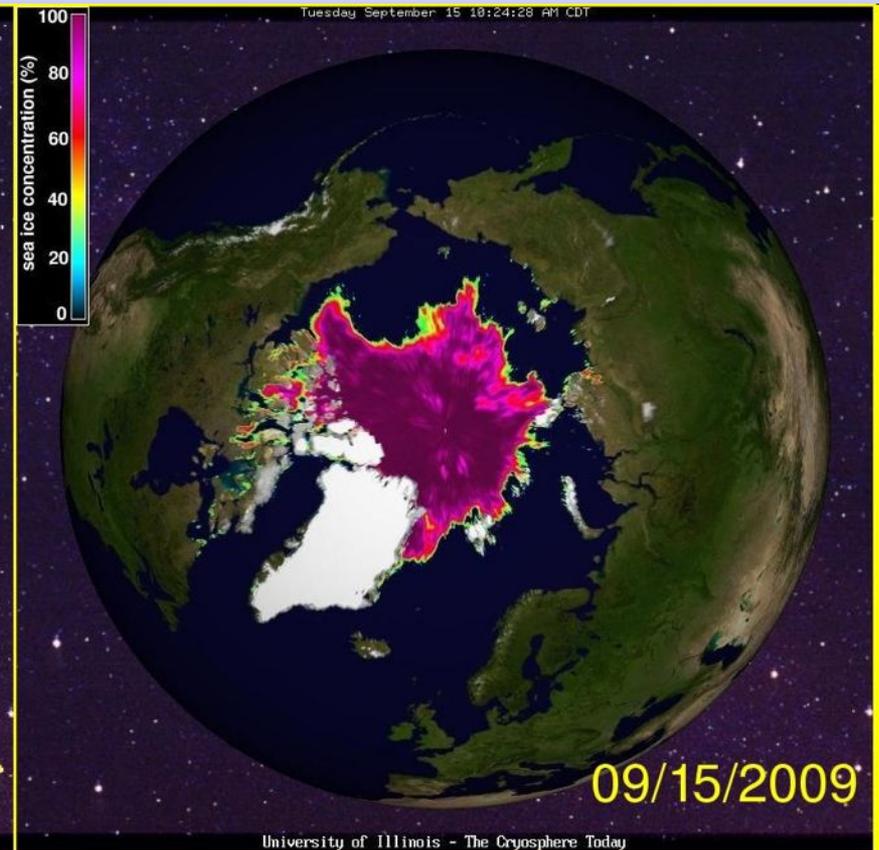
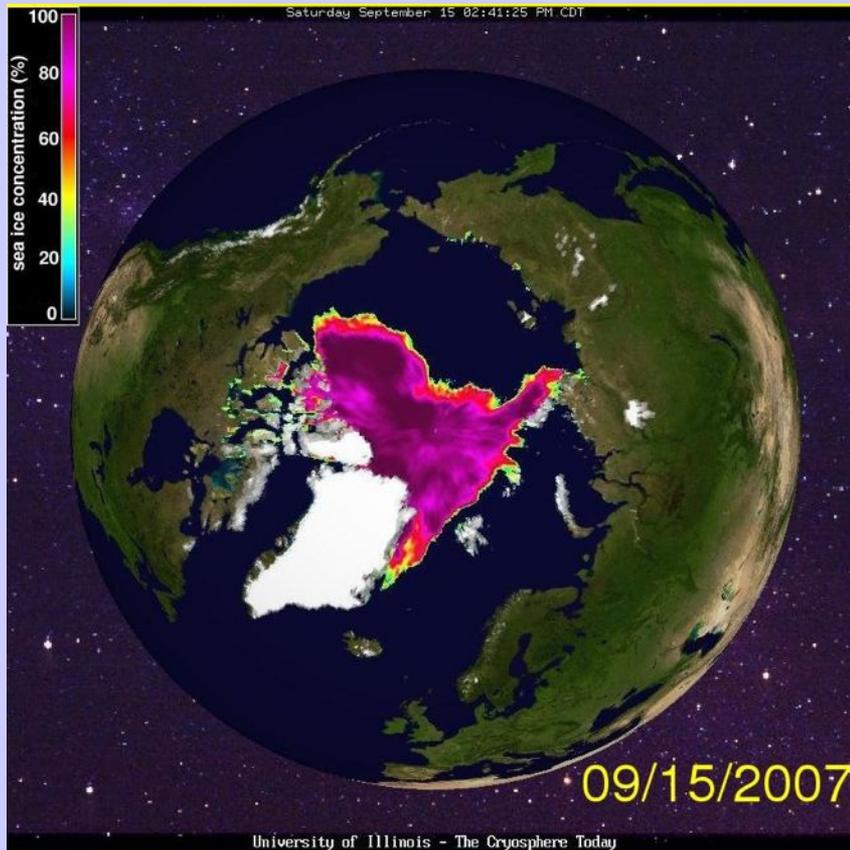
2003-2009 NABOS cruise results: Cross-sections of Arctic Ocean temperature *[from I. Polyakov, IARC/UAF]*



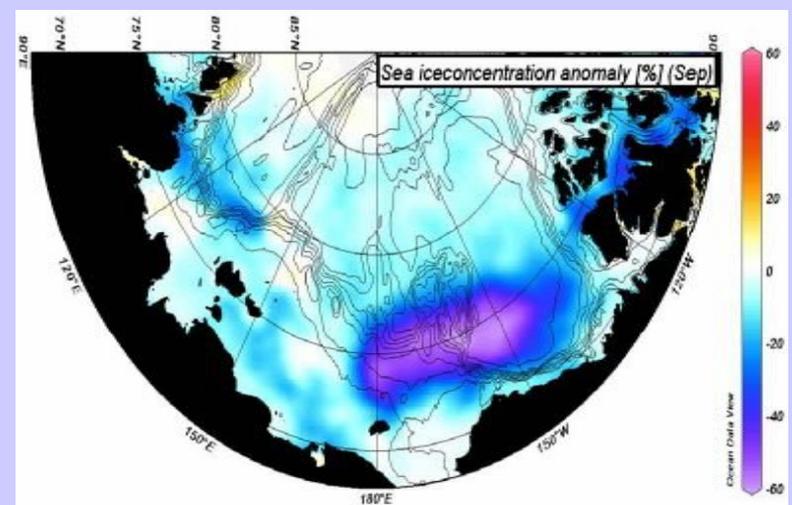
Arctic sea ice concentrations

Sep. 15, 2007

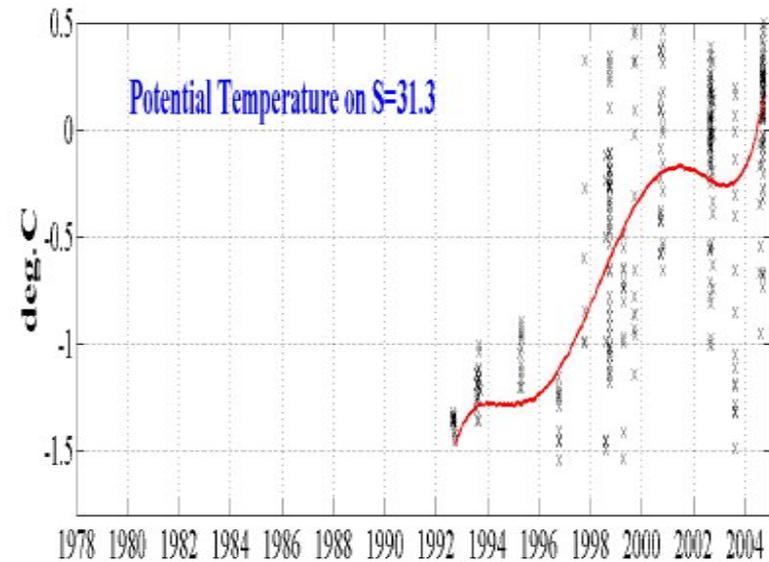
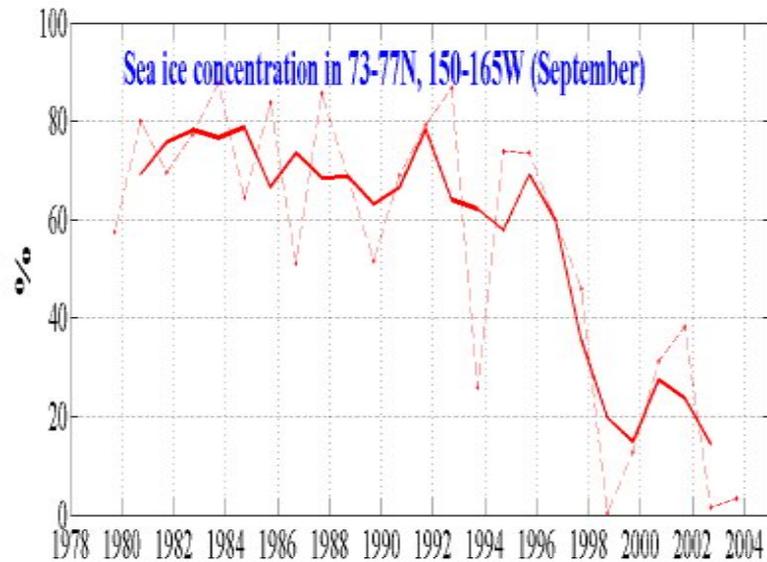
Sep. 15, 2009



[Shimada et al. 2006]



September sea ice concentration anomaly (post-1998 minus pre-1998)

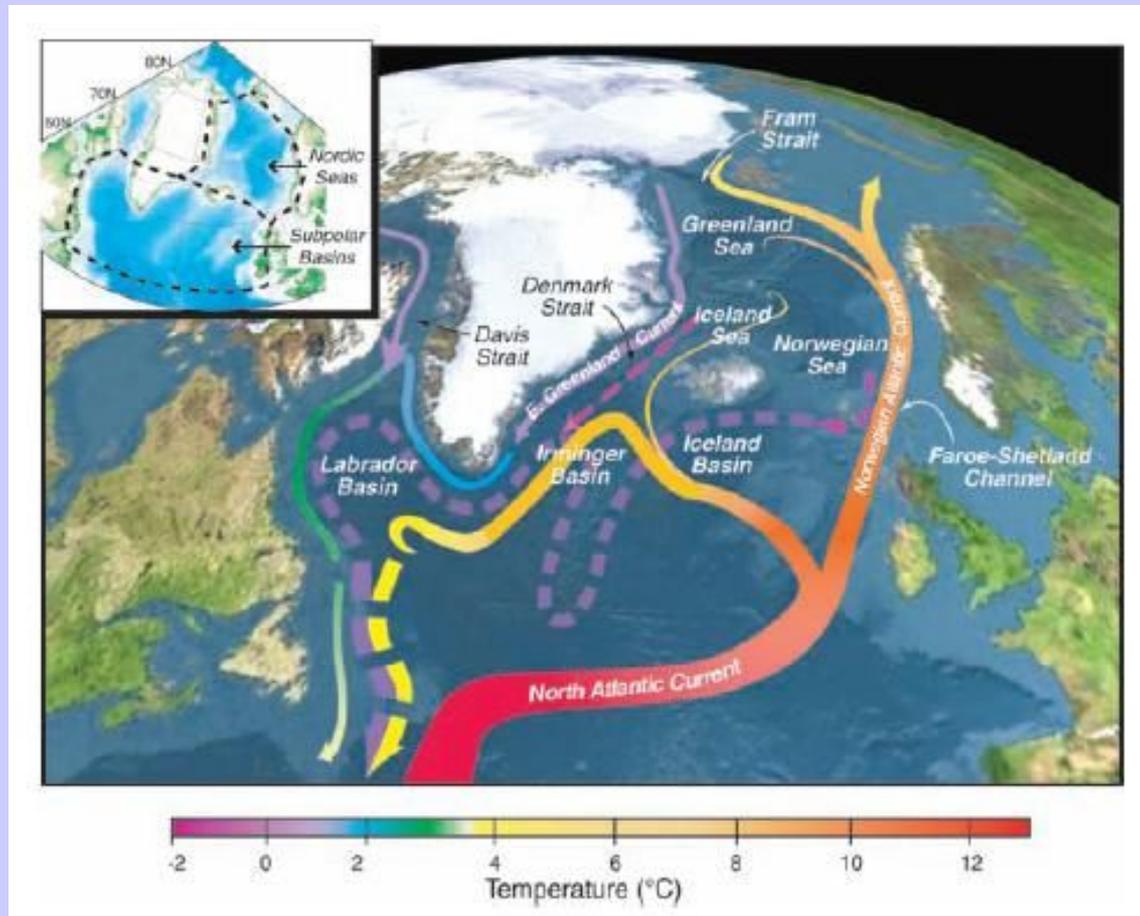


Warming of subsurface water due to increase of Pacific Water circulation

Likely suspects in the summer recent retreat of Arctic sea ice:

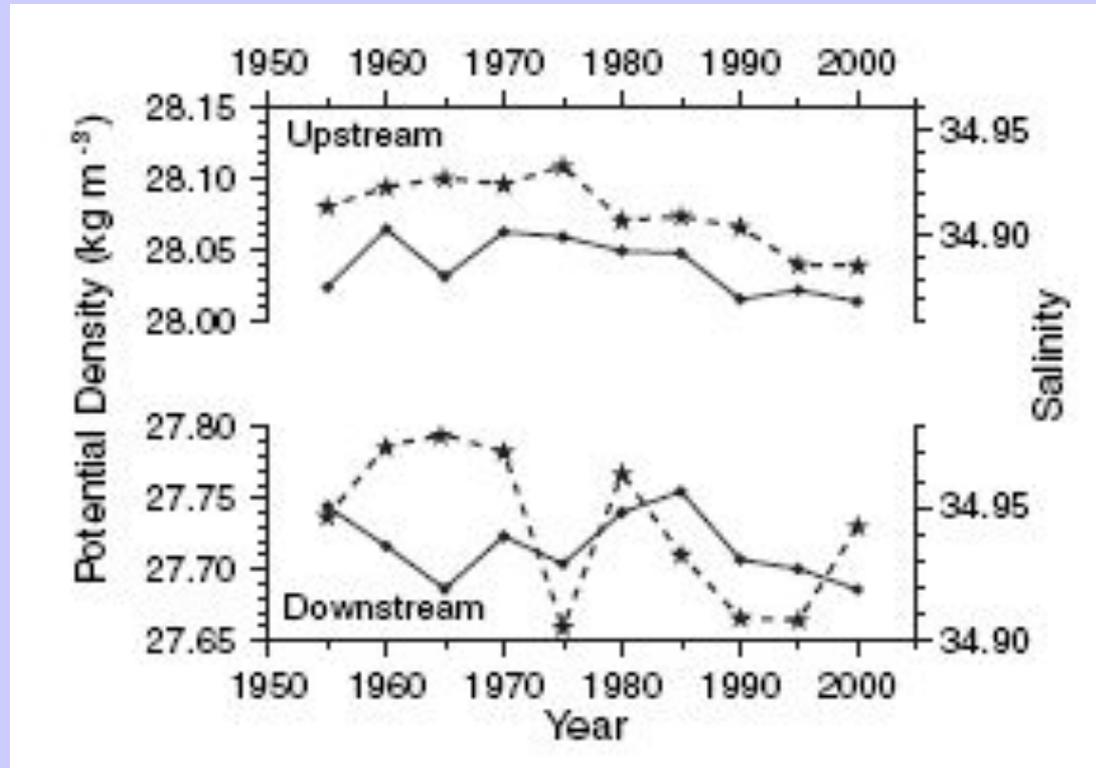
- preconditioning by wind-driven export of older ice
- preconditioning by Atlantic, Pacific inflows
- anomalous summer wind patterns, leading to
 - albedo feedback
 - storage of heat through coming autumn, winter

5. Freshening of the subpolar North Atlantic Seas: Effects on the global ocean conveyor?



[Curry and Mauritzen, 2005, Science]

Salinity (dashed) and density (solid) upstream and downstream of Denmark Strait sill depth

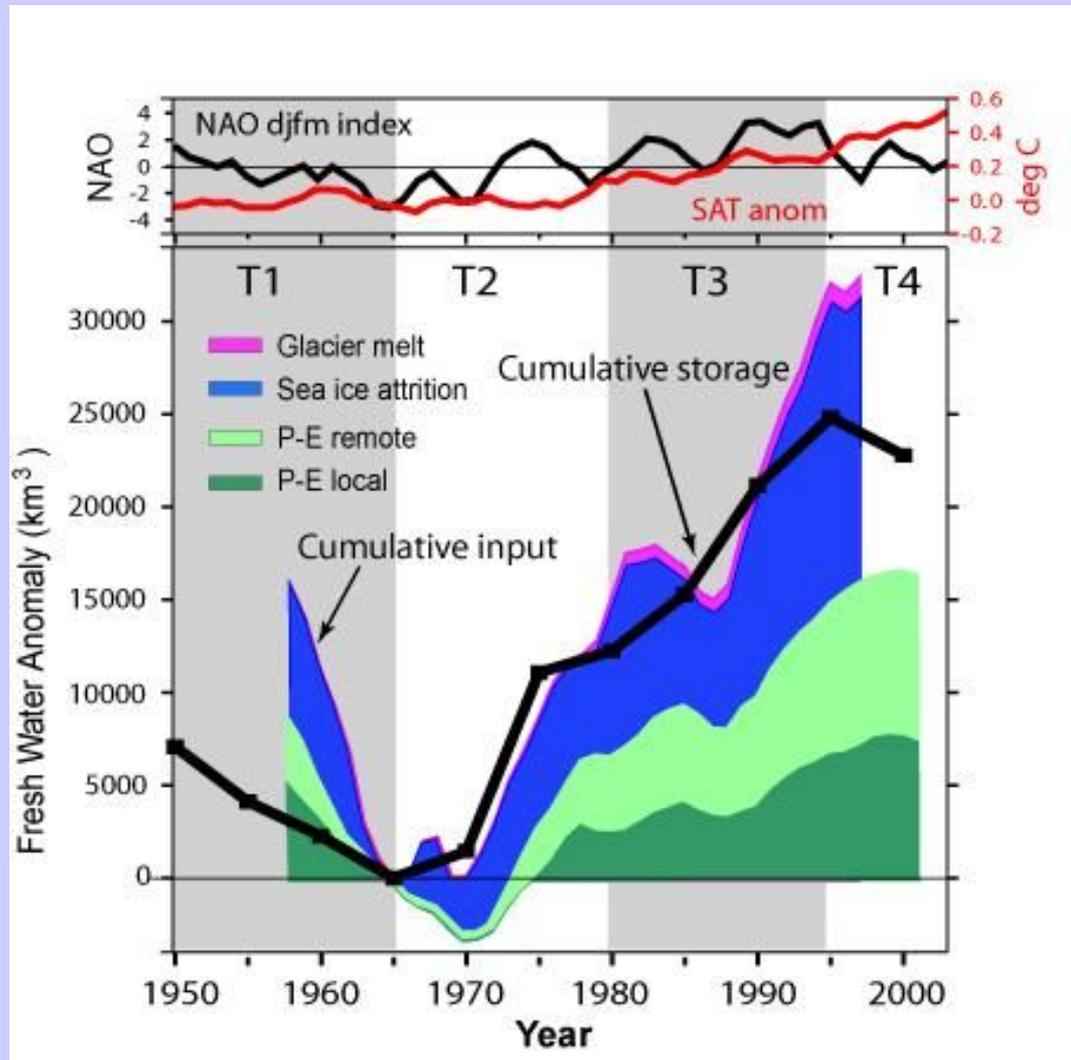


← Iceland Sea

← Irminger Basin

[Curry and Mauritzen, 2005, Science]

North Atlantic freshwater source anomalies and freshwater storage anomalies (cumulative relative to 1965)

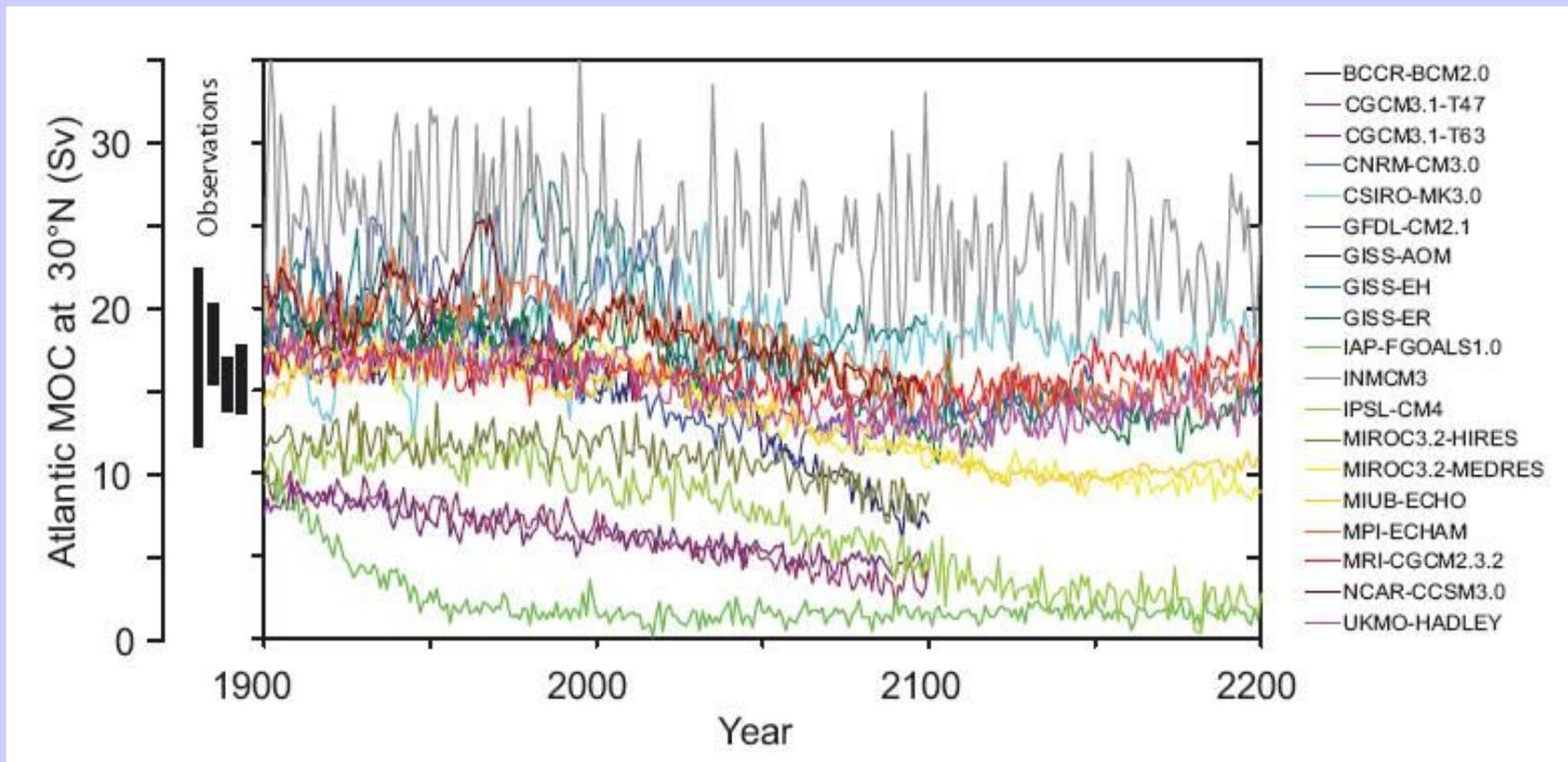


[Peterson et al., 2006, Science]

“At the observed rate [of freshening], it would take about a century to accumulate enough fresh water to substantially affect the ocean exchanges across the Greenland-Scotland Ridge...”

-- Curry and Mauritzen (2005)

Future trajectory of thermohaline circulation intensity?



[from IPCC WG I, 2007, Ch. 10]

Summary: Potential foci for Arctic-global connections

- Arctic warming \Rightarrow midlatitude weather and climate impacts
- Arctic methane release \Rightarrow global greenhouse enhancement
- Arctic freshwater releases \Rightarrow global sea level
- Global ocean inflows to Arctic \Rightarrow Arctic warming, ice loss
- Arctic hydrologic cycle trajectory \Rightarrow global ocean impacts