Impact of an Ice-Diminishing Arctic on Naval and Maritime Operations
Annapolis, Maryland, 10-12 July 2007

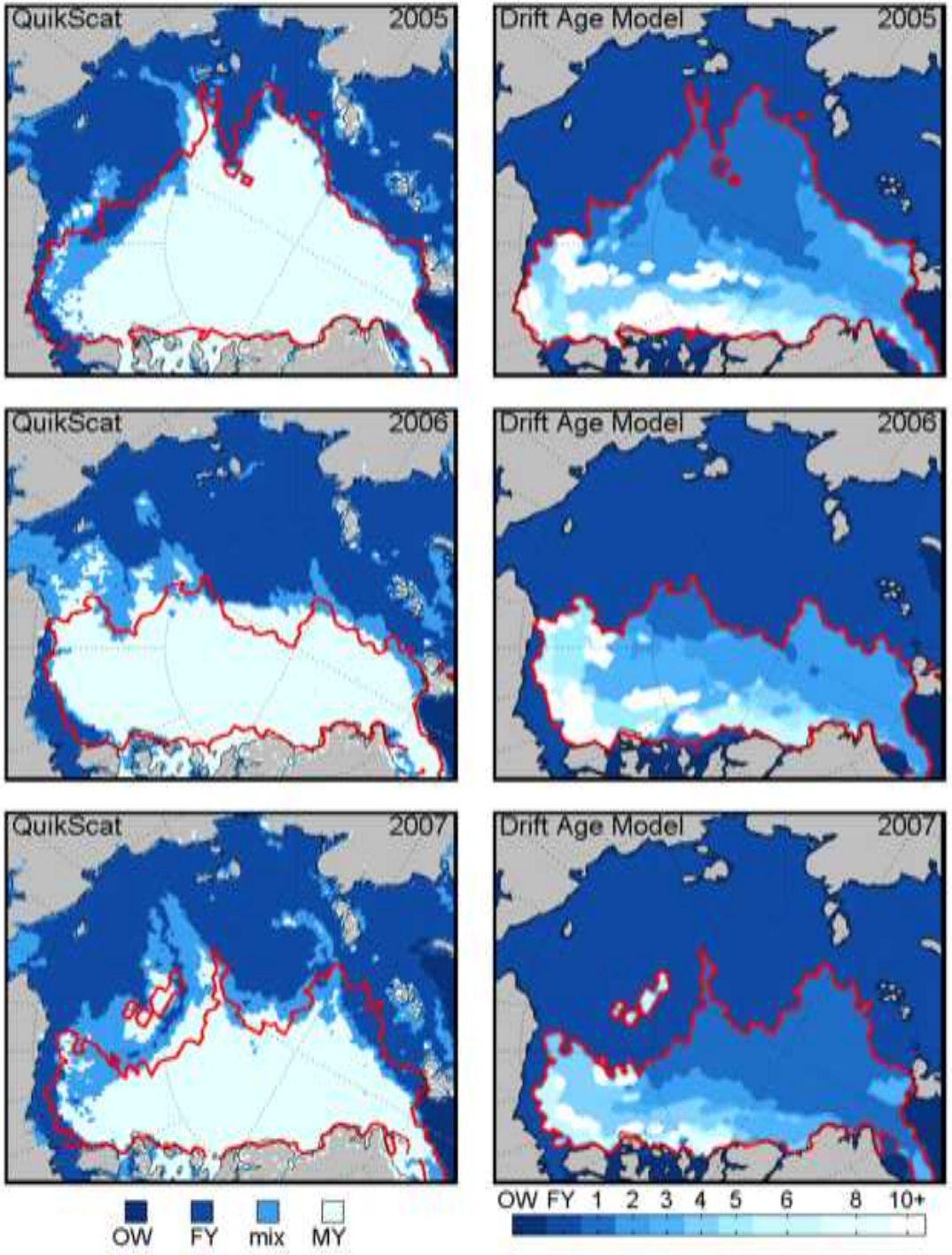
Update on the State of Arctic Sea Ice

S. V. Nghiem[1,2], I. G. Rigor[3], P. Clemente-Colón[4], D. K. Perovich[5], J. Richter-Menge[5], Y. Chao[1,2], G. Neumann[1], and M. Ortmeyer[3]

[1]Jet Propulsion Laboratory, California Institute of Technology, CA
[2]JIFRESSE, University of California at Los Angeles, CA
[3]Applied Physics Laboratory, University of Washington, WA
[4]U.S. Naval and National Ice Center, MD
[5]Cold Region Research and Engineering Laboratory, NH

Outline

- Arctic sea ice distribution: Half a century, 1957-2007
- Arctic sea ice distribution: Updates for 2008
- Atmospheric and oceanic effects on Arctic sea ice
- Update for 2009 & outlook



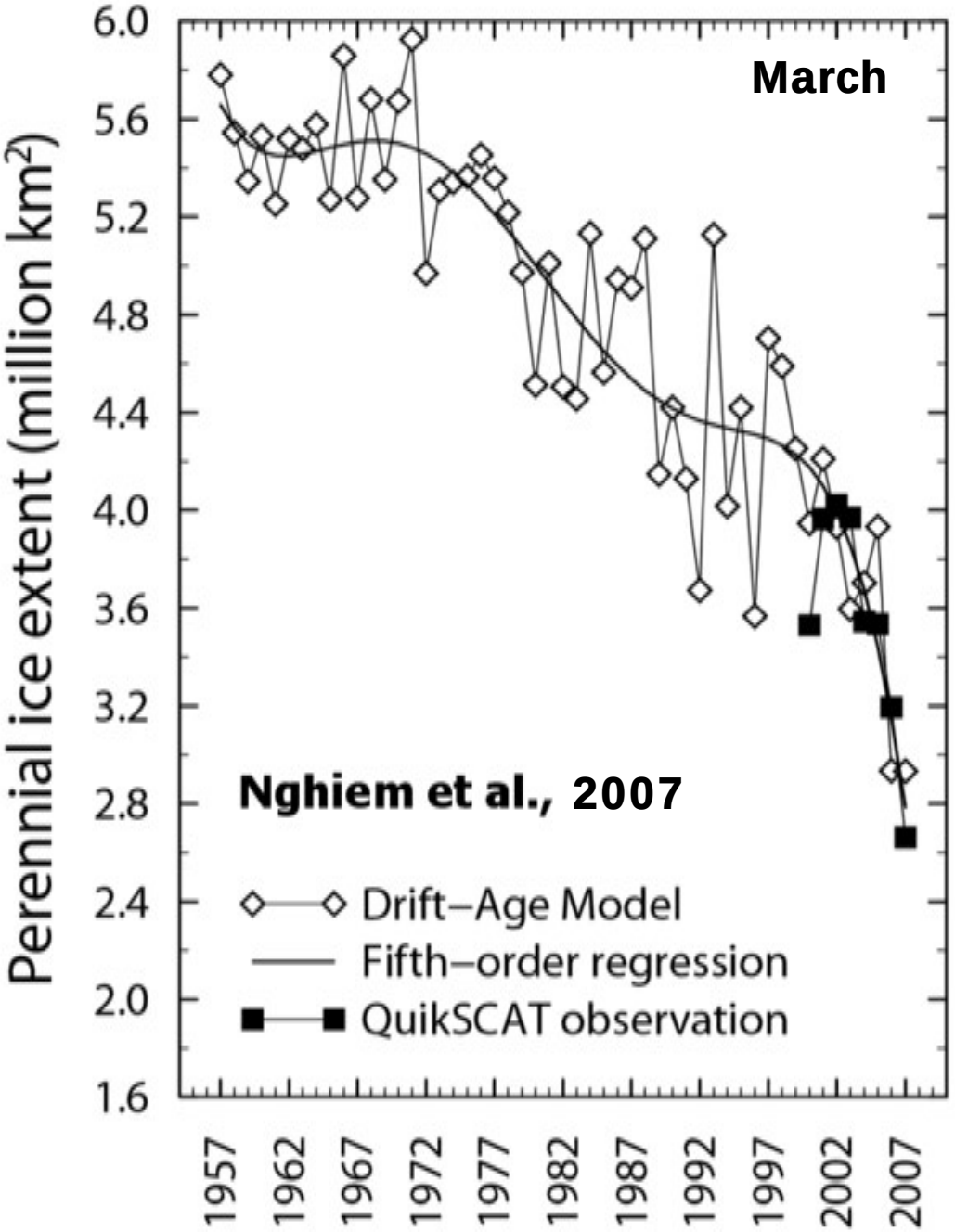
Comparison of QuikSCAT and Drift-Age Model

Large reduction of perennial sea ice between years 2005-2007.

Red line represents the boundary of perennial ice from the the Drift-Age Model (>1 year)

Nghiem, Rigor, Perovich, Clemete-Colón, Weatherly, and Neumann, GRL, 2007.

Perennial Sea Ice Change 1957-2007



1970-2000:

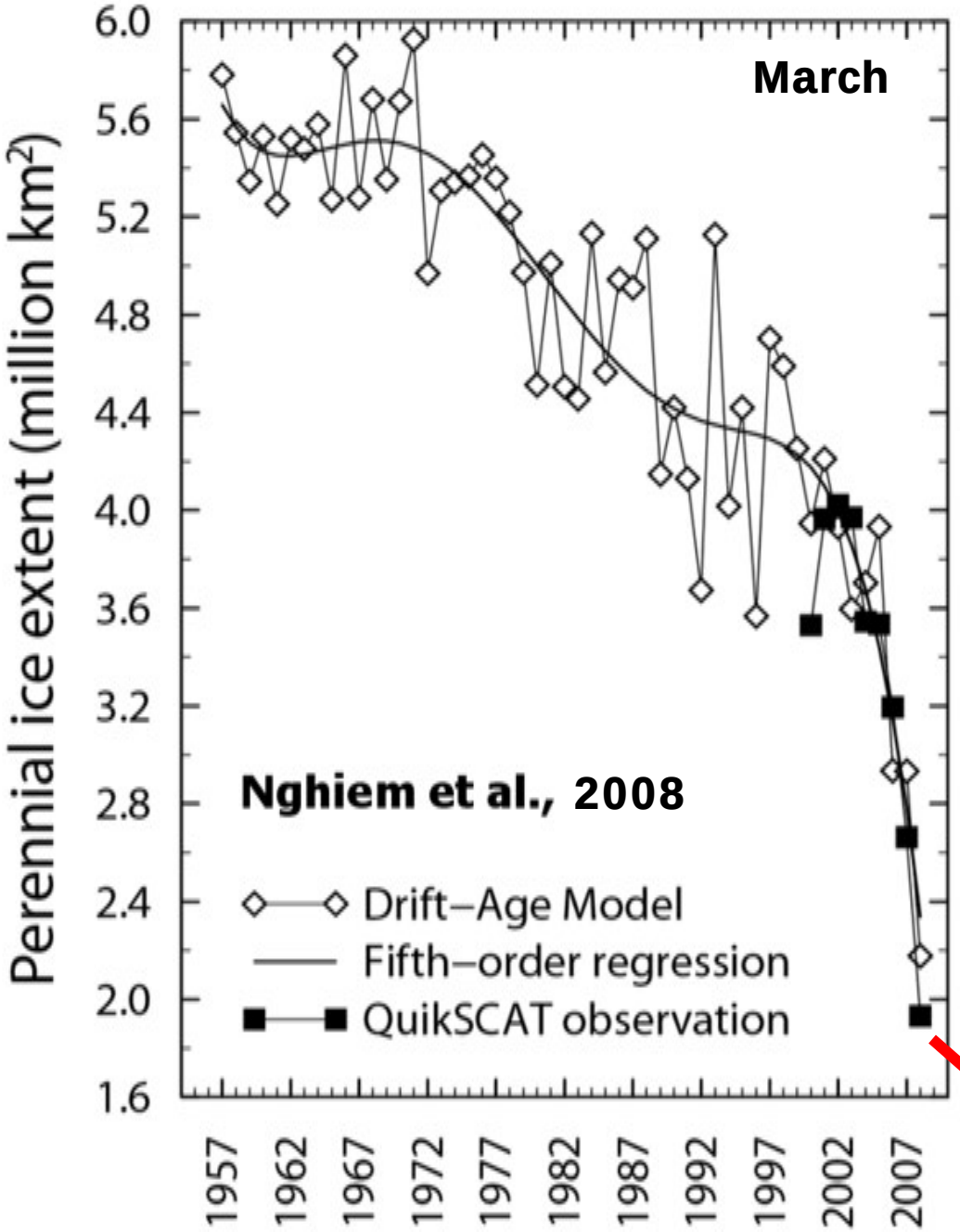
Decrease of 0.5×10^6 km^2/decade.

In the decade 2000s

Rapid reduction of perennial sea ice suggested by the model and verified by QuikSCAT data.

Decrease of 1.5×10^6 km^2/decade, triple that in 1970-2000.

Perennial Sea Ice Change 1957-2008



Update for 2008:

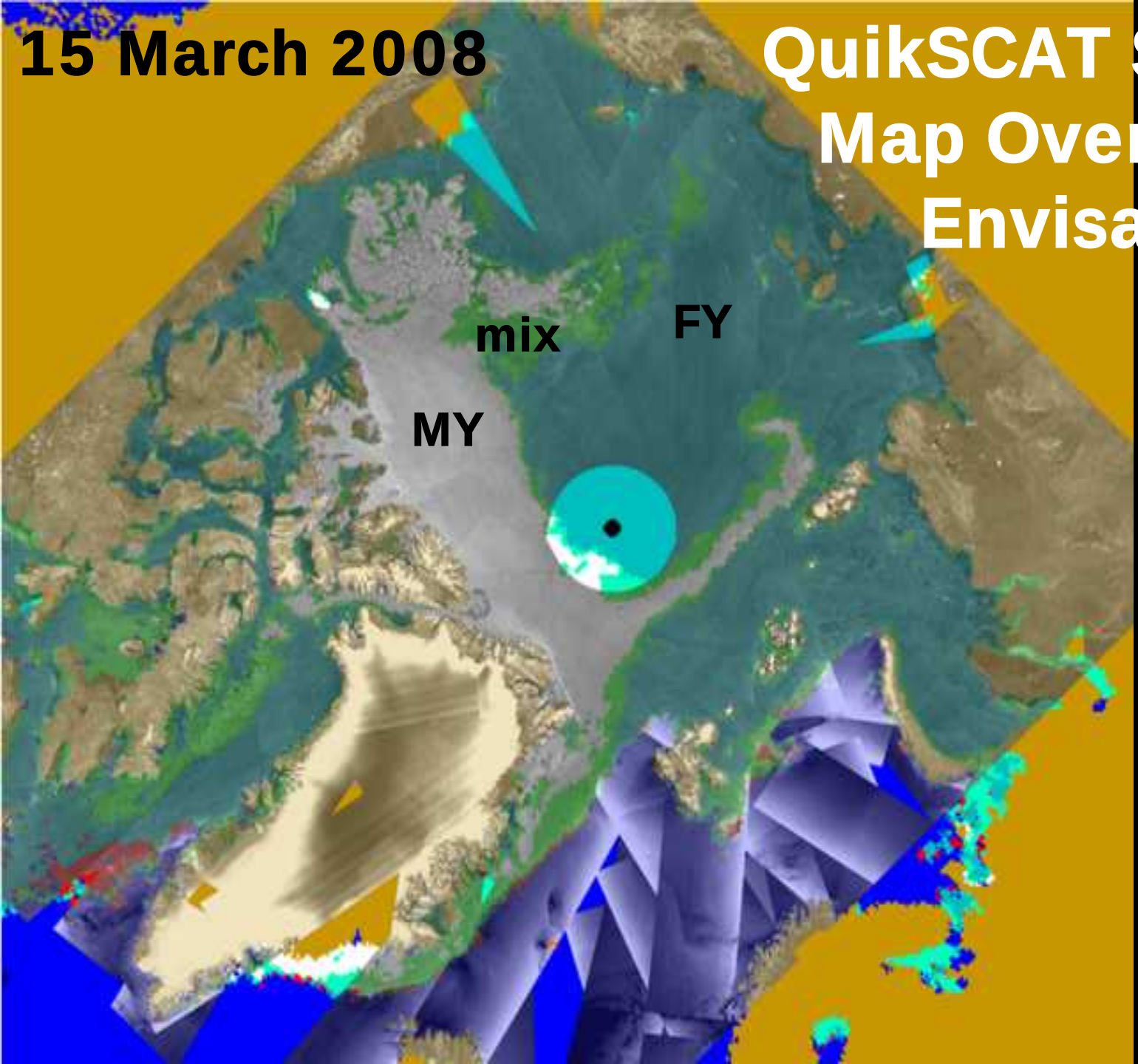
The reduction of perennial sea ice continues at the rapid decreasing rate as seen by both QuikSCAT and DM.

Perennial sea ice extent was 1 million km² smaller in March 2008 versus March 2007.

STOCK MARKET

Arctic Sea Ice

Drastic reduction of perennial ice



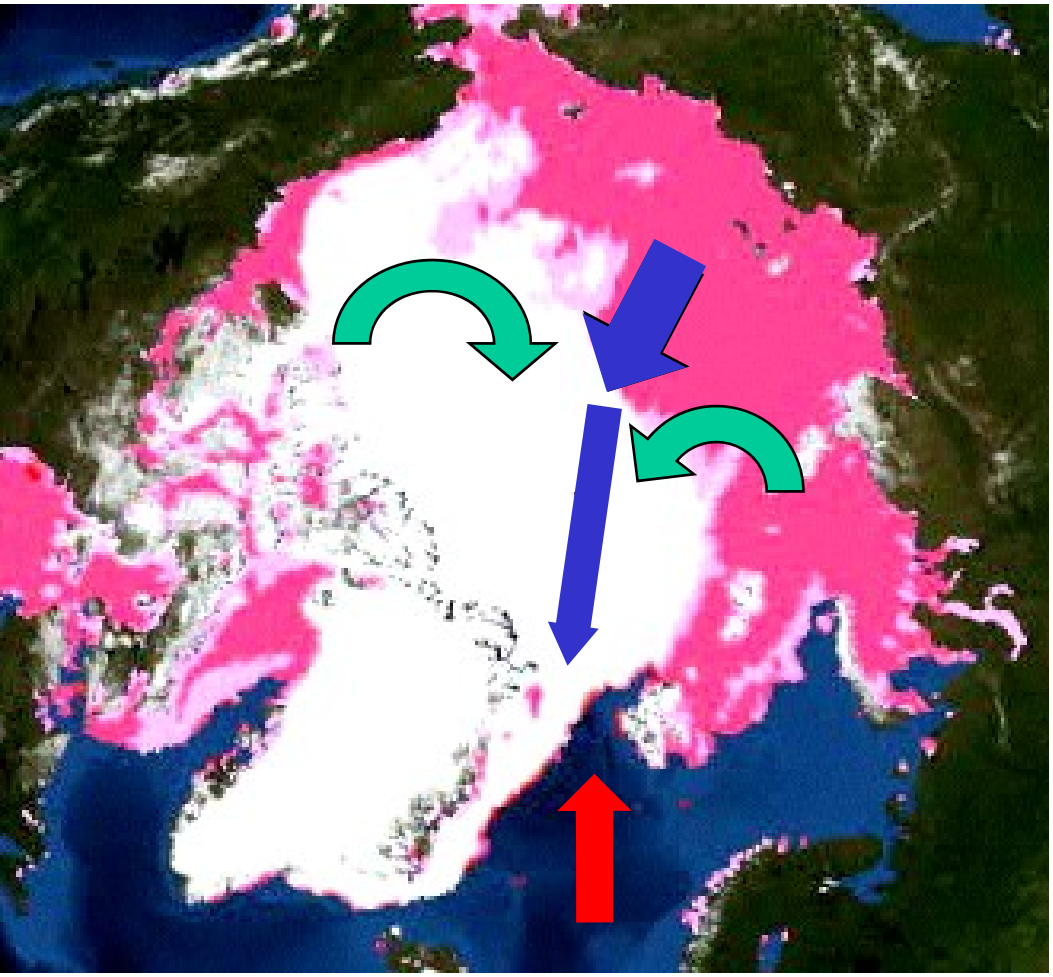
QuikSCAT Sea Ice Map Overlaid on Envisat ASAR Image

Summary of Recent Sea Ice Minima

- **Summer 2005:** Minimum sea ice extent in satellite data record in all previous years
- **Summer 2006:** Minimum extent was larger than that in 2005
- **Summer 2007:** Record minimum extent by far – about 1 million km^2 less than the 2005 minimum
- **Summer 2008:** Minimum extent was close to that in 2007, but slightly larger.

MINIMUM ICE in 2005 and 2007 – WHY ?

‘The Polar Express’
Nghiem et al. GRL, 2007



Ice compression from East to West Arctic

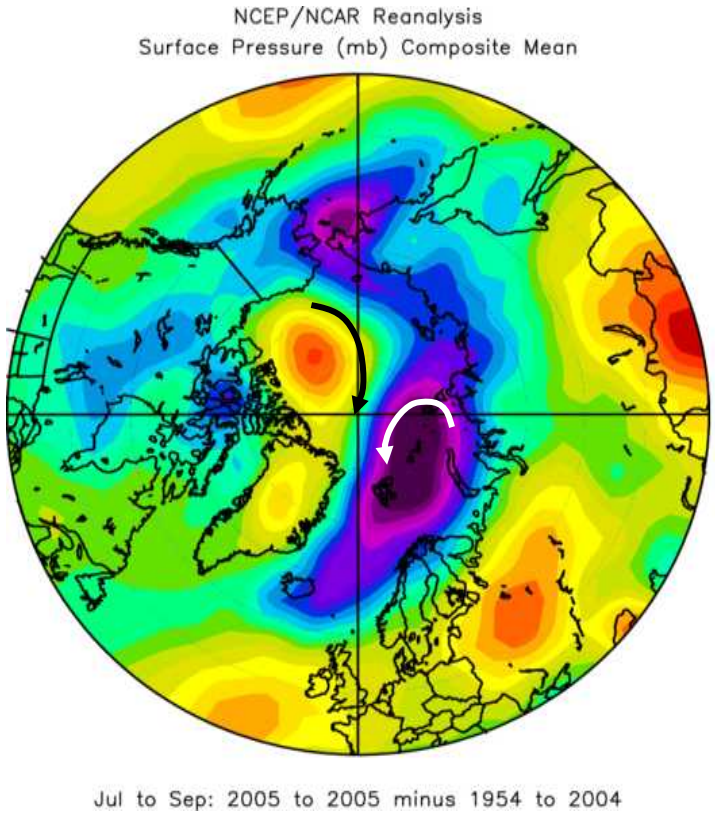
Ice compression into Transpolar Drift (TD)

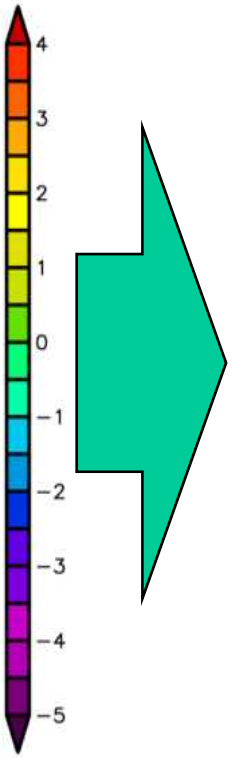
Acceleration of TD carrying ice out of Arctic via Fram Strait

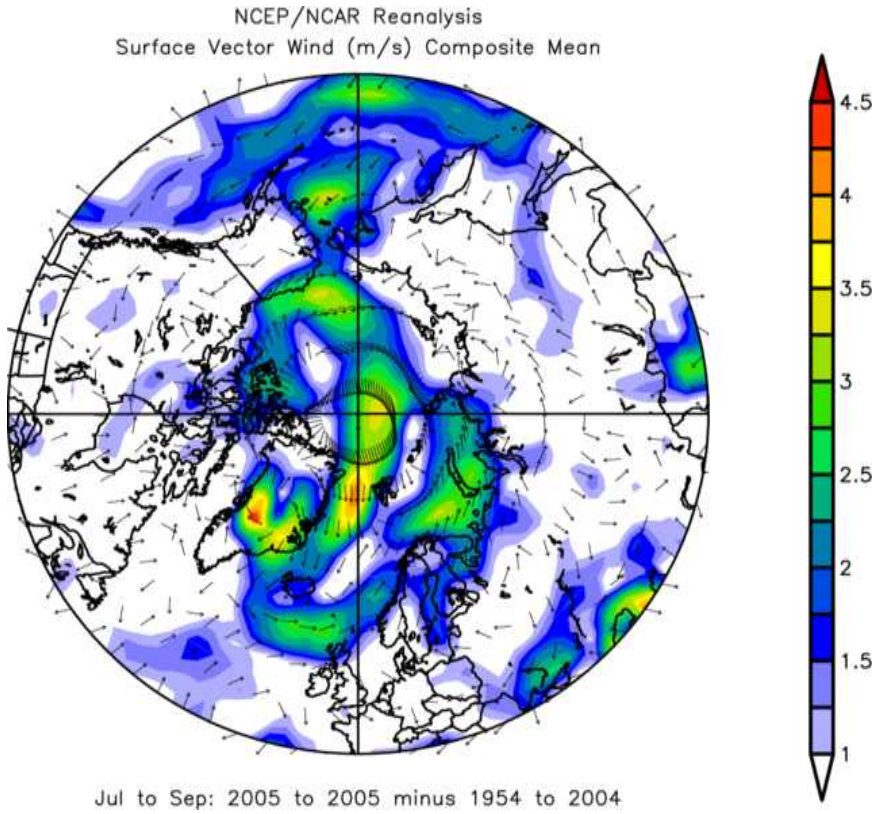
Warm Atlantic water effectively melted ice in Greenland Sea

The Polar Express in 2005

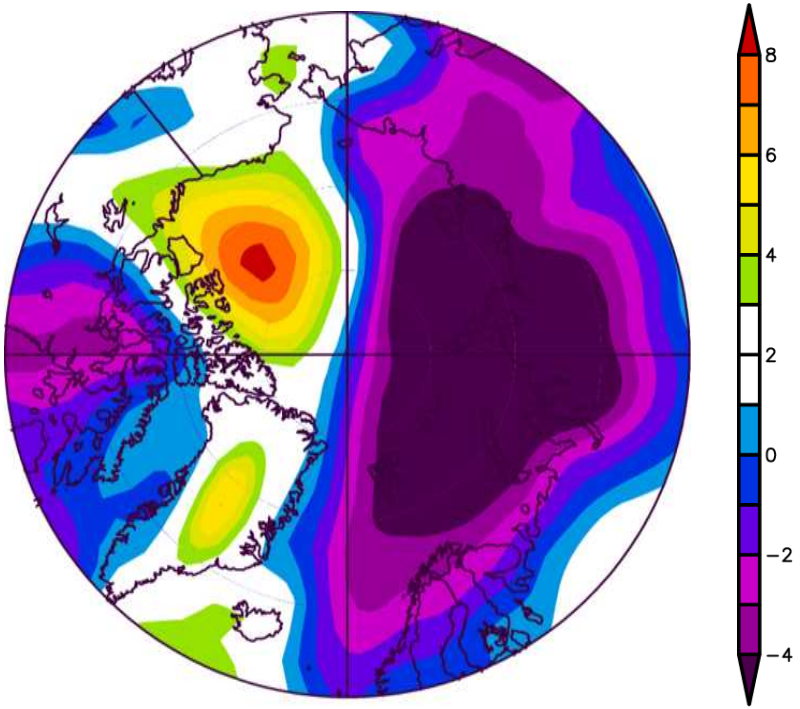
Barents-Sea low and Canadian-Basin high anomalies set up anomalous winds over Fram Basin and Greenland Sea



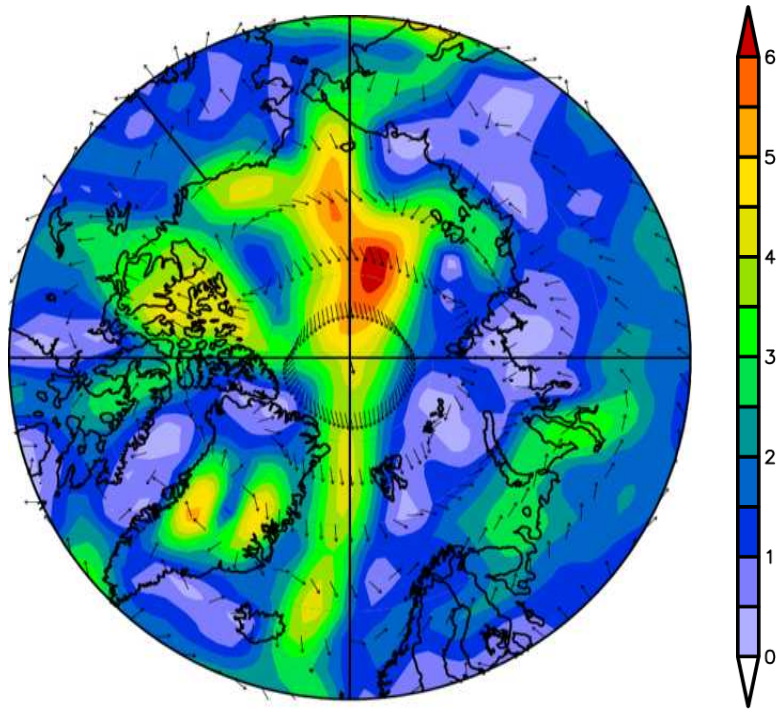




The Polar Express in 2007



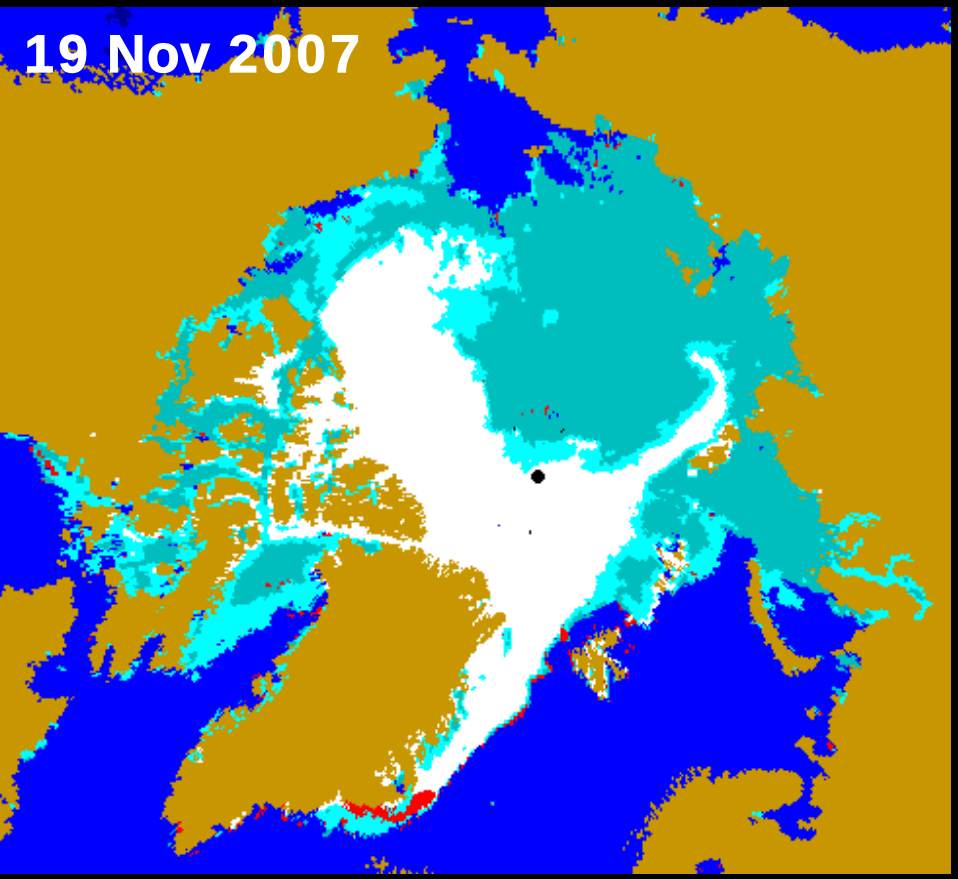
Aug: 2007 to 2007 minus 1950 to 2006



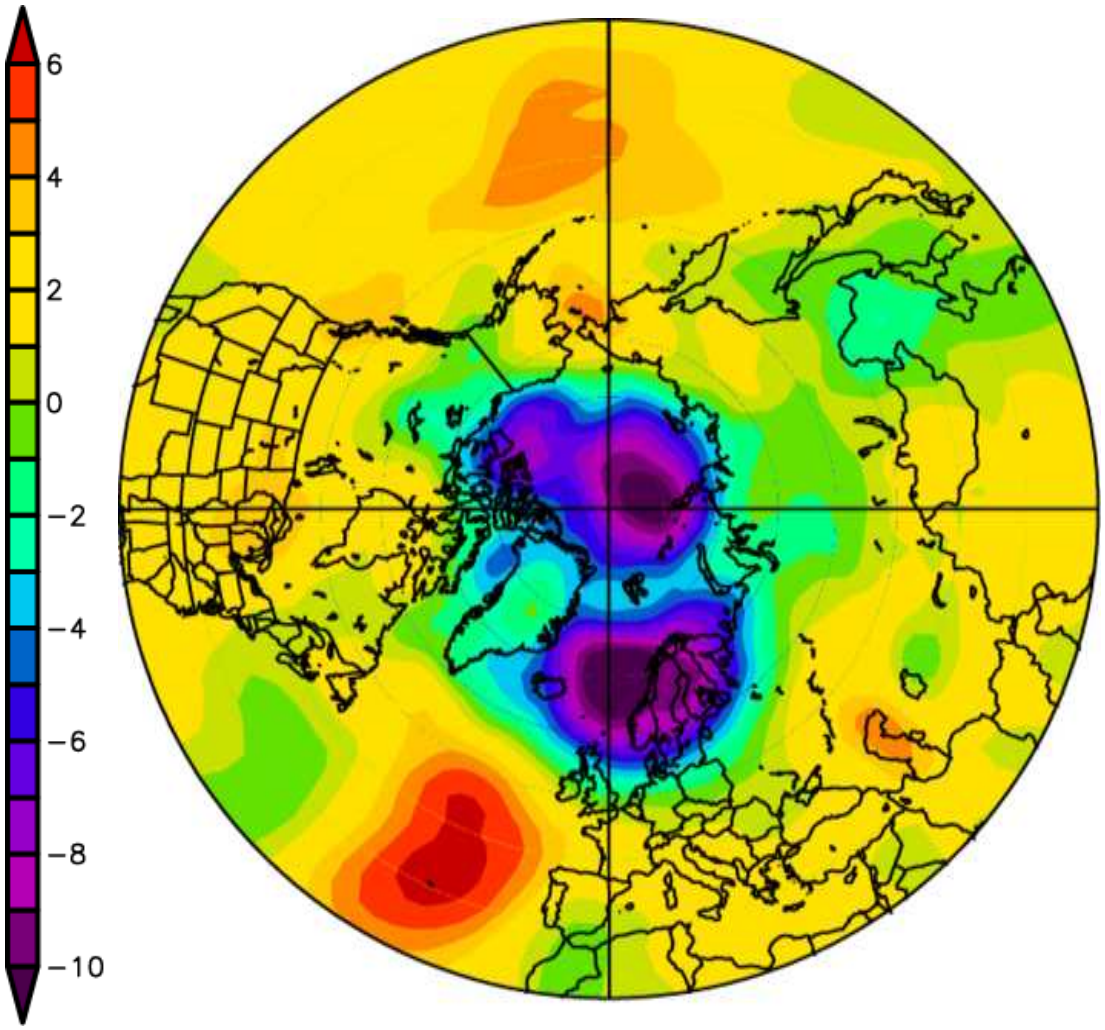
Aug: 2007 to 2007 minus 1950 to 2006

Sea ice after summer 2008?

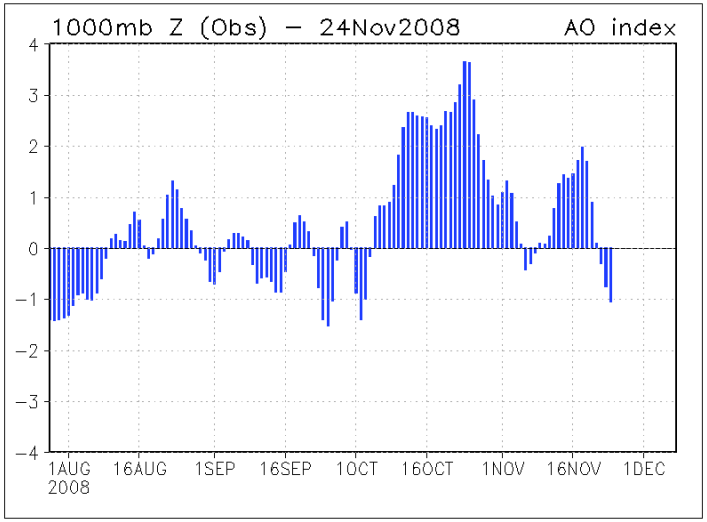
Reduction of perennial ice extent in 2008 catching up with that in 2007

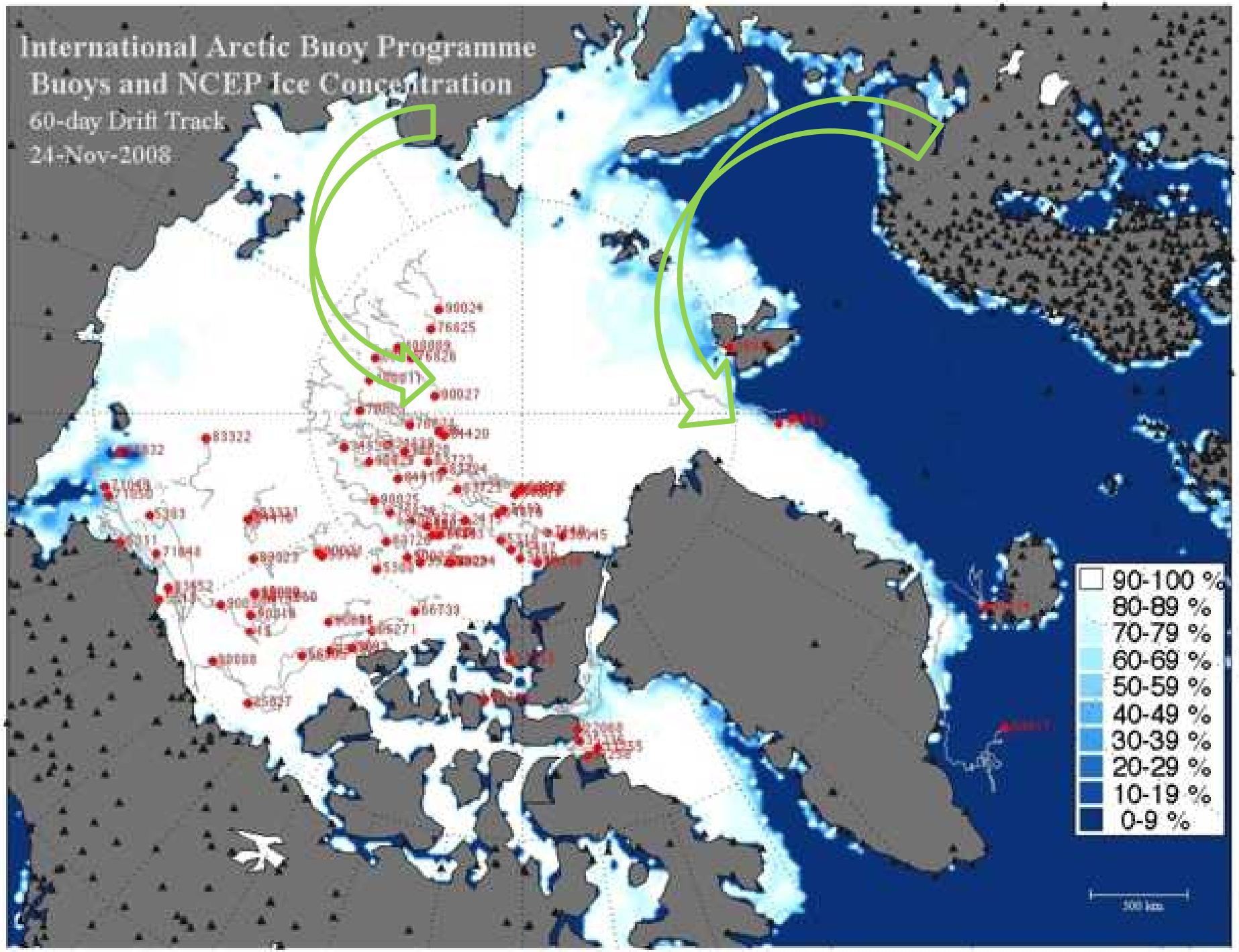


Cause of the rapid reduction of perennial ice in fall 2008

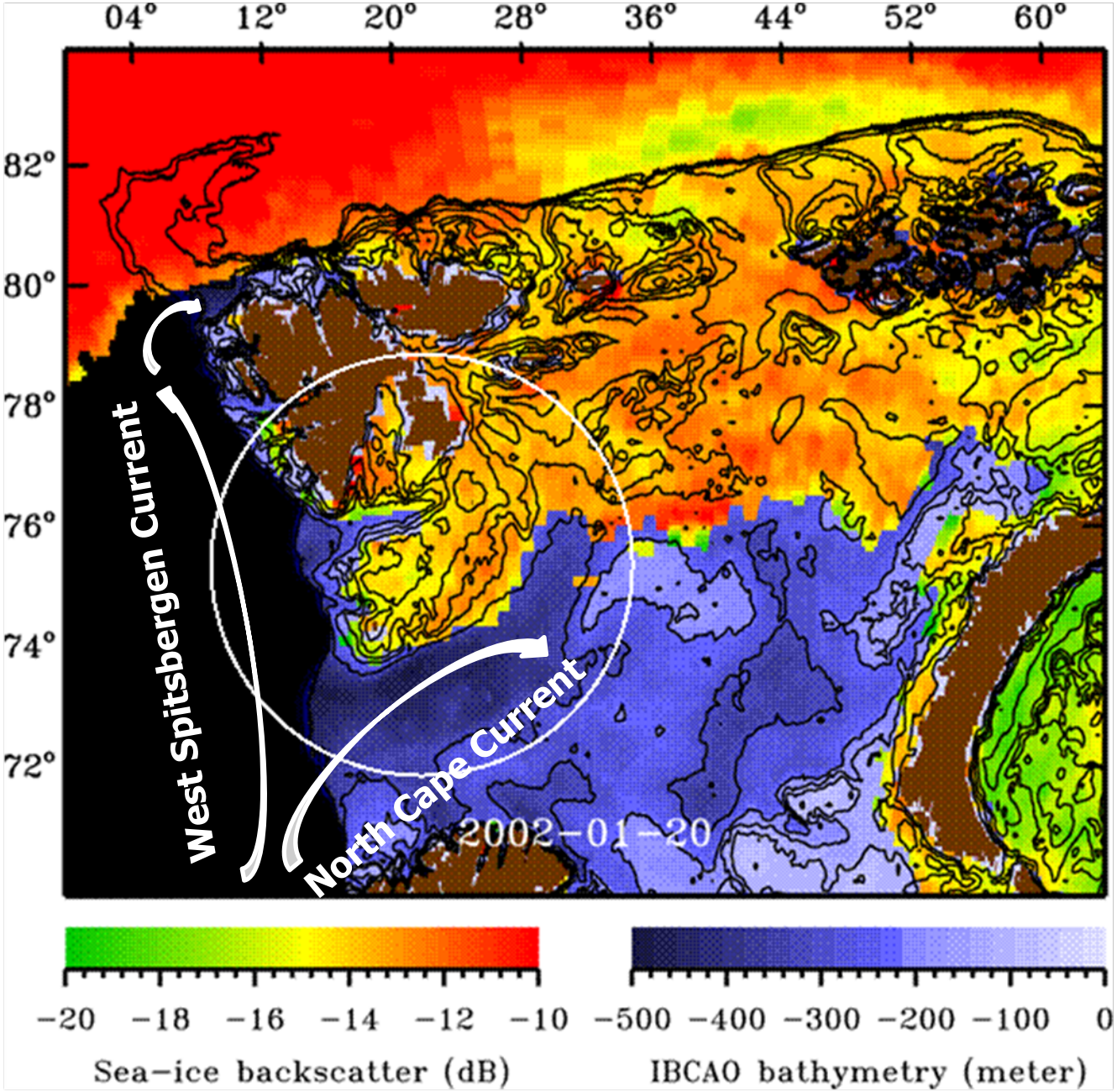


Oct: 2008 to 2008 minus 1948 to 2008



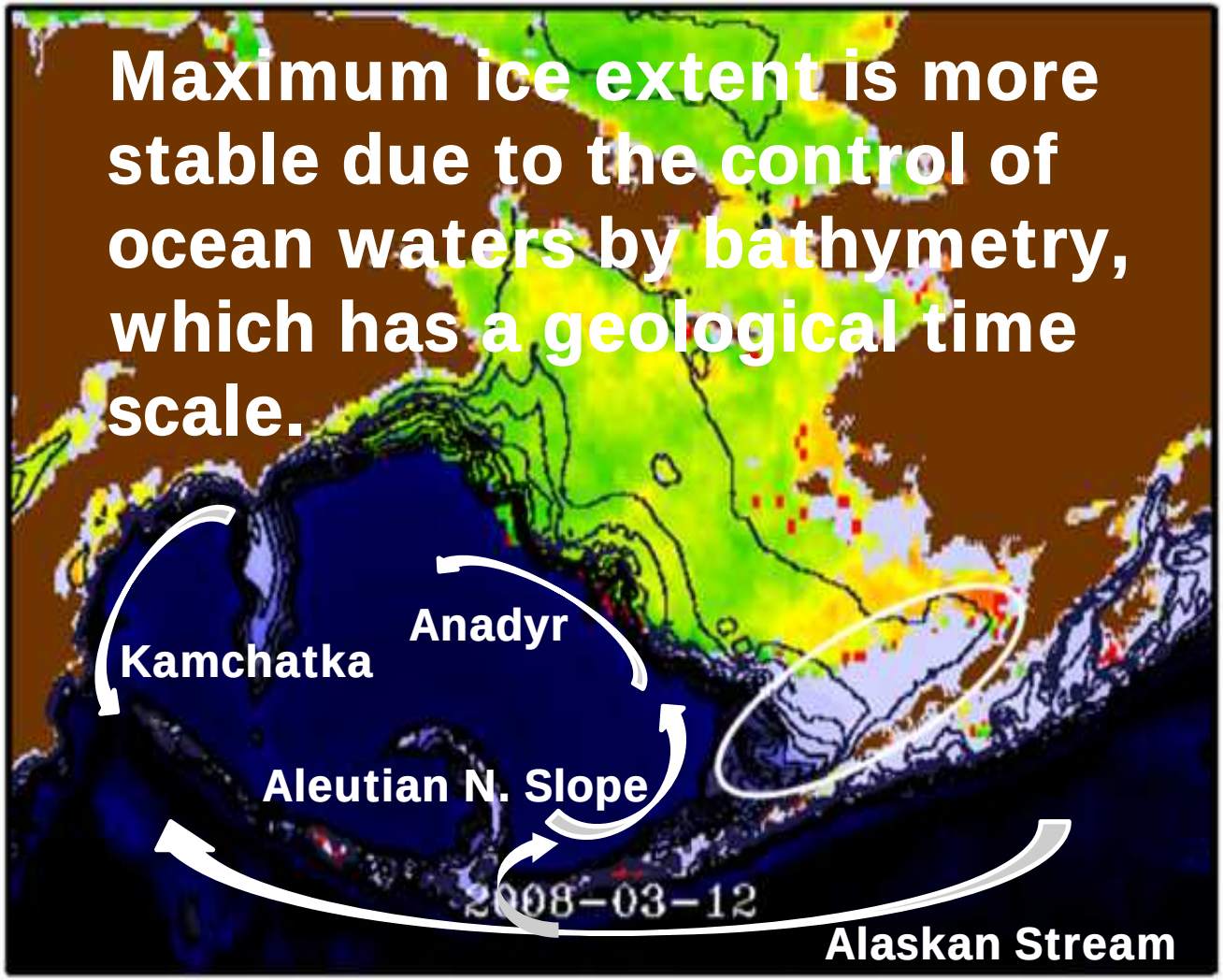

International Arctic Buoy Programme
Buoys and NCEP Ice Concentration
60-day Drift Track
24-Nov-2008
90-100 %
80-89 %
70-79 %
60-69 %
50-59 %
40-49 %
30-39 %
20-29 %
10-19 %
0-9 %
500 km

Bathymetric Control of Sea Ice



Nghiem, Van Woert, Neumann, JGR, 2005

Bathymetric Control of Sea Ice



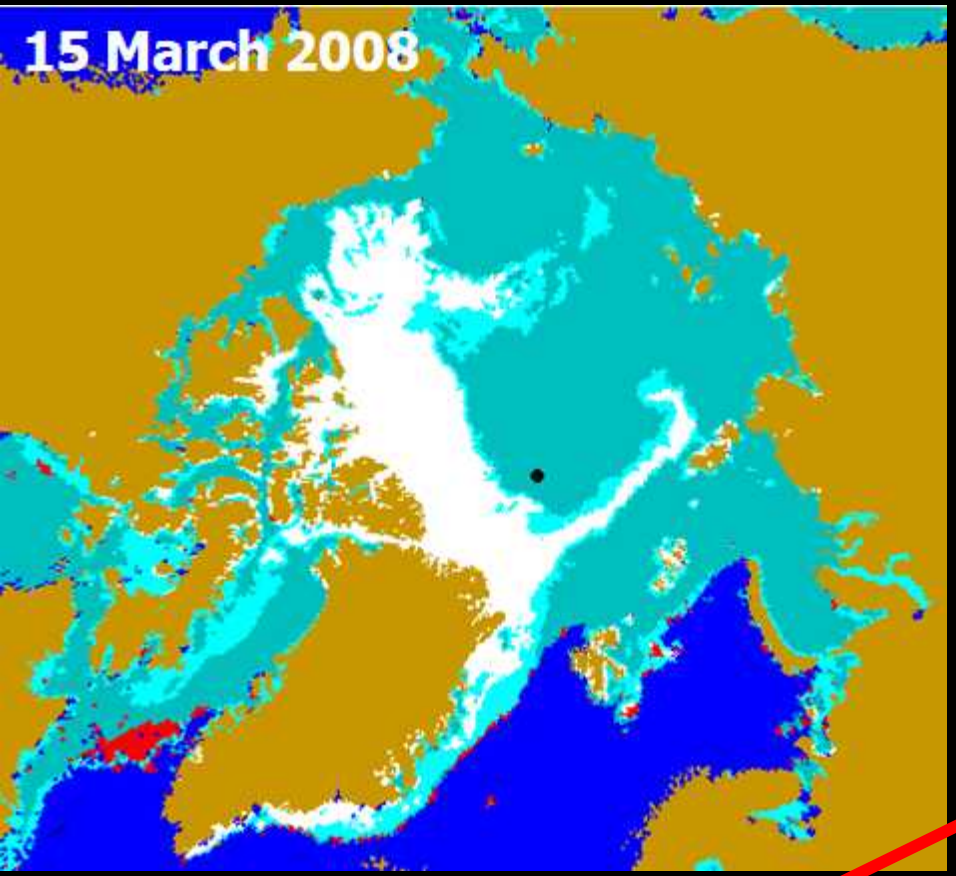
Sea ice:
Green-orange

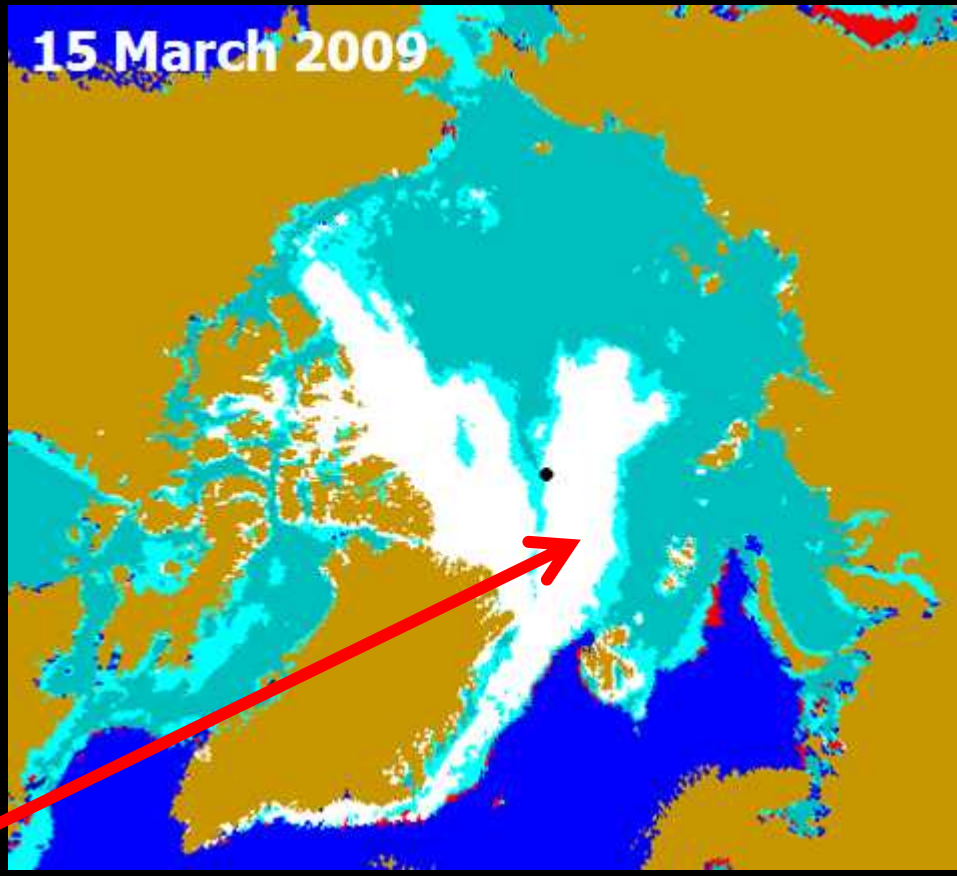
Melt on ice:
Red

Ocean:
Blue shades

Update for 2009

Extent of perennial sea ice remains low – precondition for a possible minimum extent in summer 2009





However perennial ice may plug Fram Strait?

Summary

- Rapid reduction of perennial ice extent in the 2000s; continued to be rapid: Decrease in ice age, thickness, and mass.
- Atmospheric anomalies led to the Polar Express effects causing record loss of perennial ice in 2005 and 2007.
- Different type of atmospheric anomalies occurred in Fall 2008 causing significant loss of perennial ice.
- Perennial ice loss in Fall-Spring preconditions summer melt. Dynamic ice loss can occurs different seasons including summer.
- Maximum total ice extent is more stable: Topographic and bathymetric controls.
- Low perennial ice in 2009 – Precondition summer 2009.