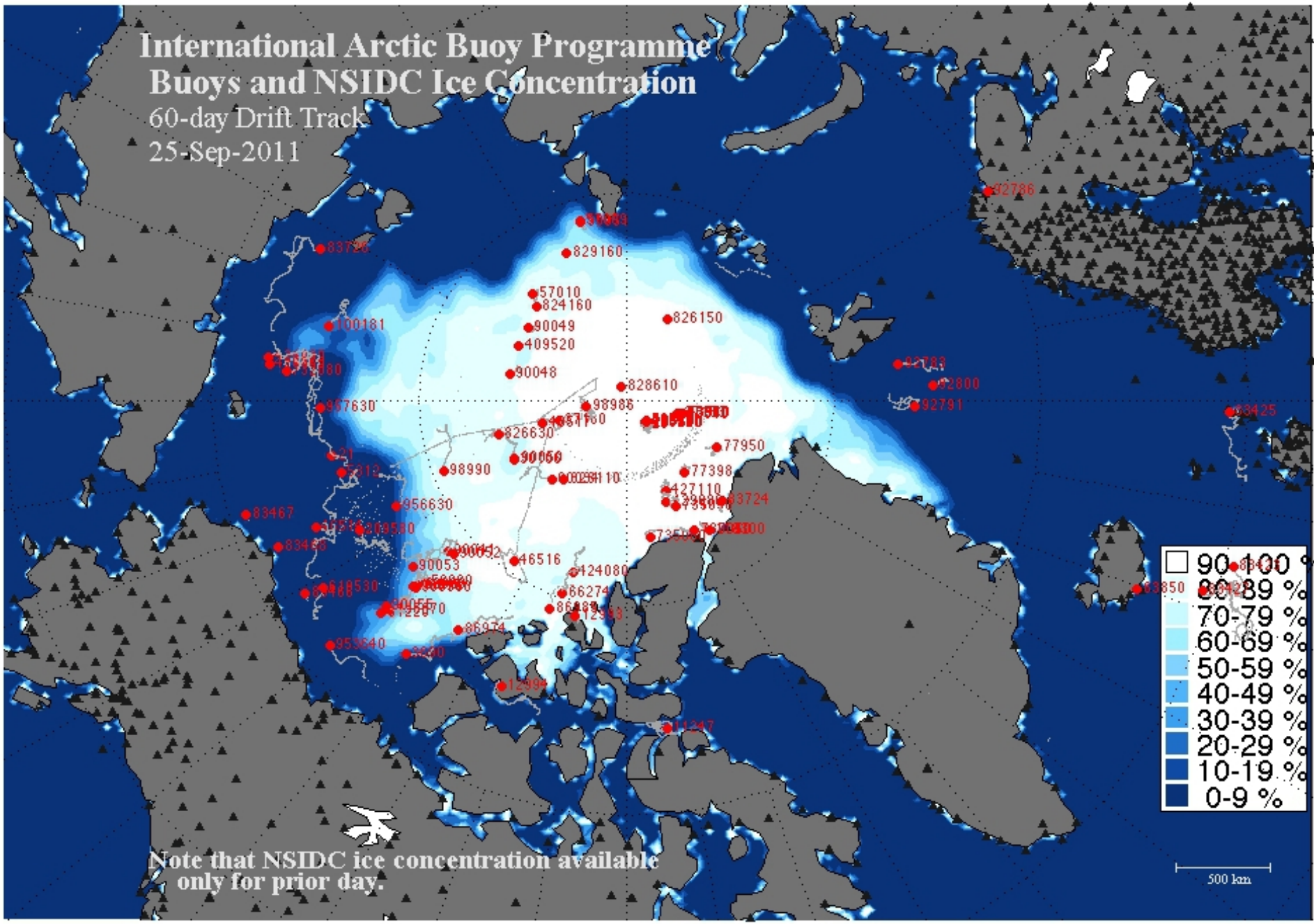
Observed Changes at the Surface of the Arctic Ocean

Ignatius G. Rigor , Mike Steele, Participants of the IABP, and many others

- Arctic Change
- IABP developments in response to changing conditions.
- Some new research on Summer SST and ocean heating.


International Arctic Buoy Programme
Buoys and NSIDC Ice Concentration
60-day Drift Track
25-Sep-2011
90-100 %
80-89 %
70-79 %
60-69 %
50-59 %
40-49 %
30-39 %
20-29 %
10-19 %
0-9 %
500 km
Note that NSIDC ice concentration available only for prior day.

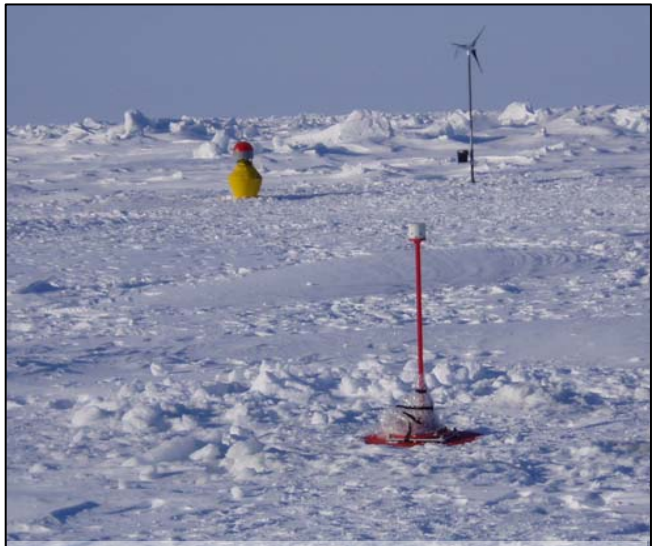
North Pole Environmental Observatory
April to October 2010

http://www.arctic.noaa.gov/gallery_np.html

International Arctic Buoy Programme (IABP)

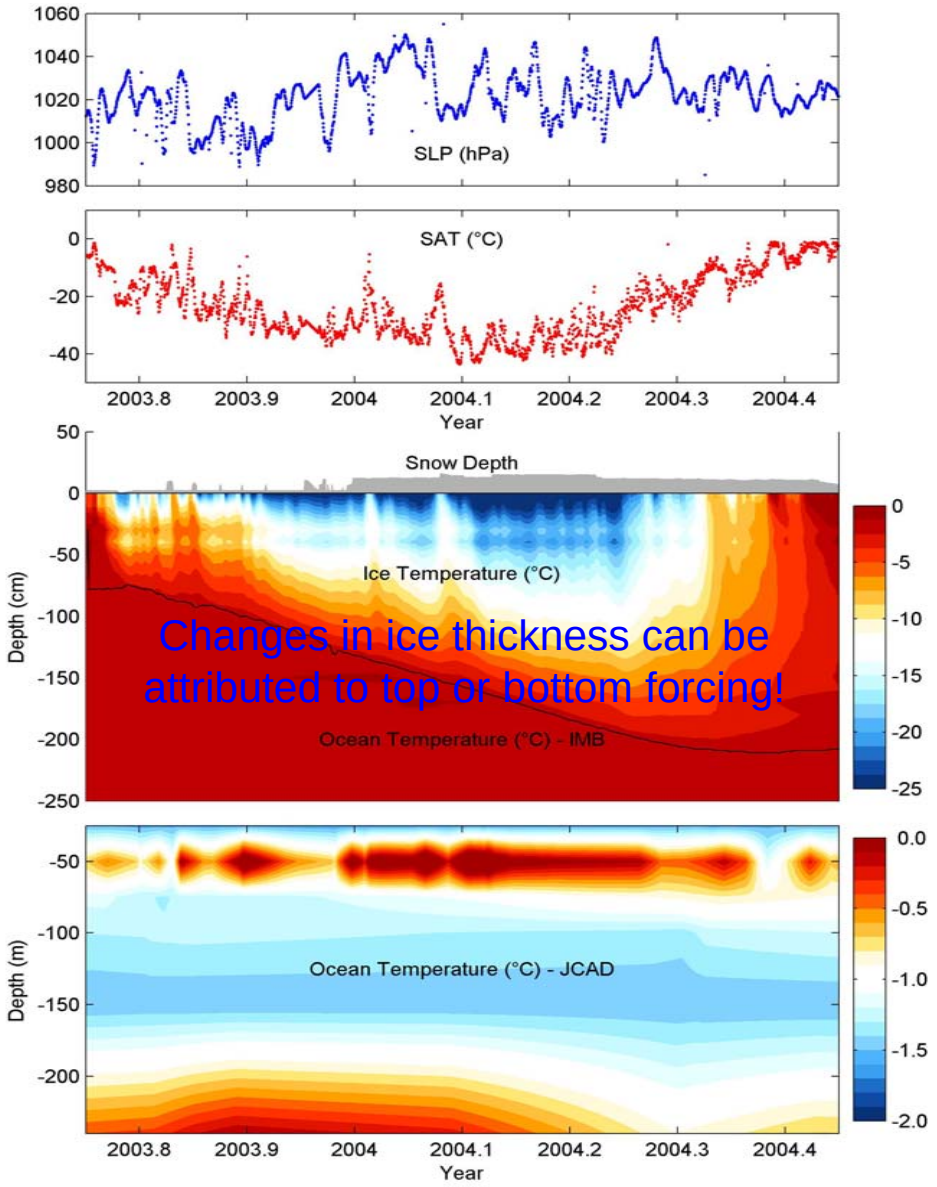
PSC/APL/UW North Pole Environmental Observatory

Ice Mass Balance buoy
Monitors Air and Sea Ice

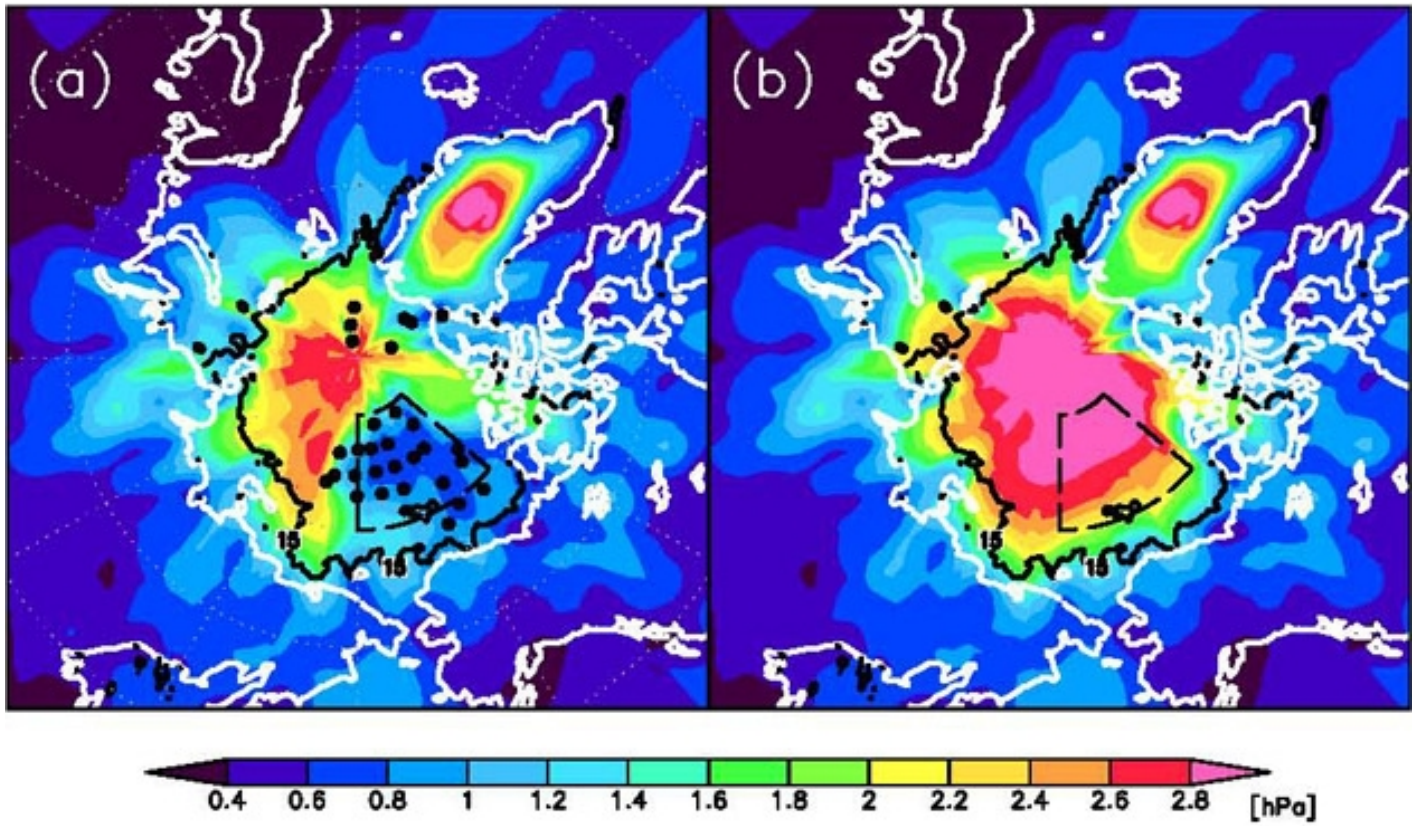


Polar Ocean Profiling System (foreground) & Ocean Flux buoy (yellow) *Monitors Air and Ocean (typically deployed with IMB buoys)*

IMB and Ocean Observations



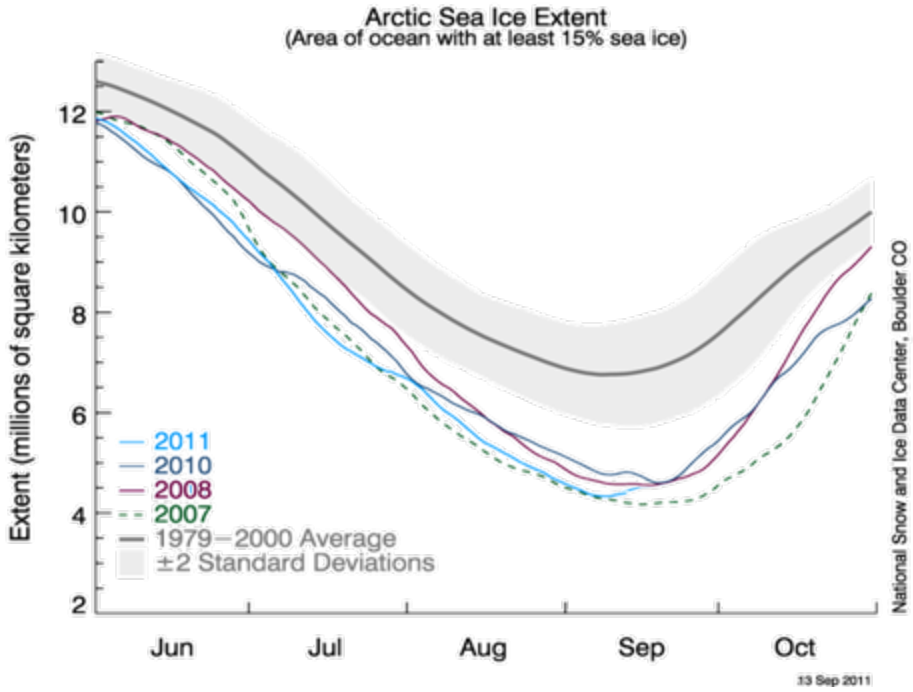
Spread of Sea Level Pressure (SLP) Reanalyses



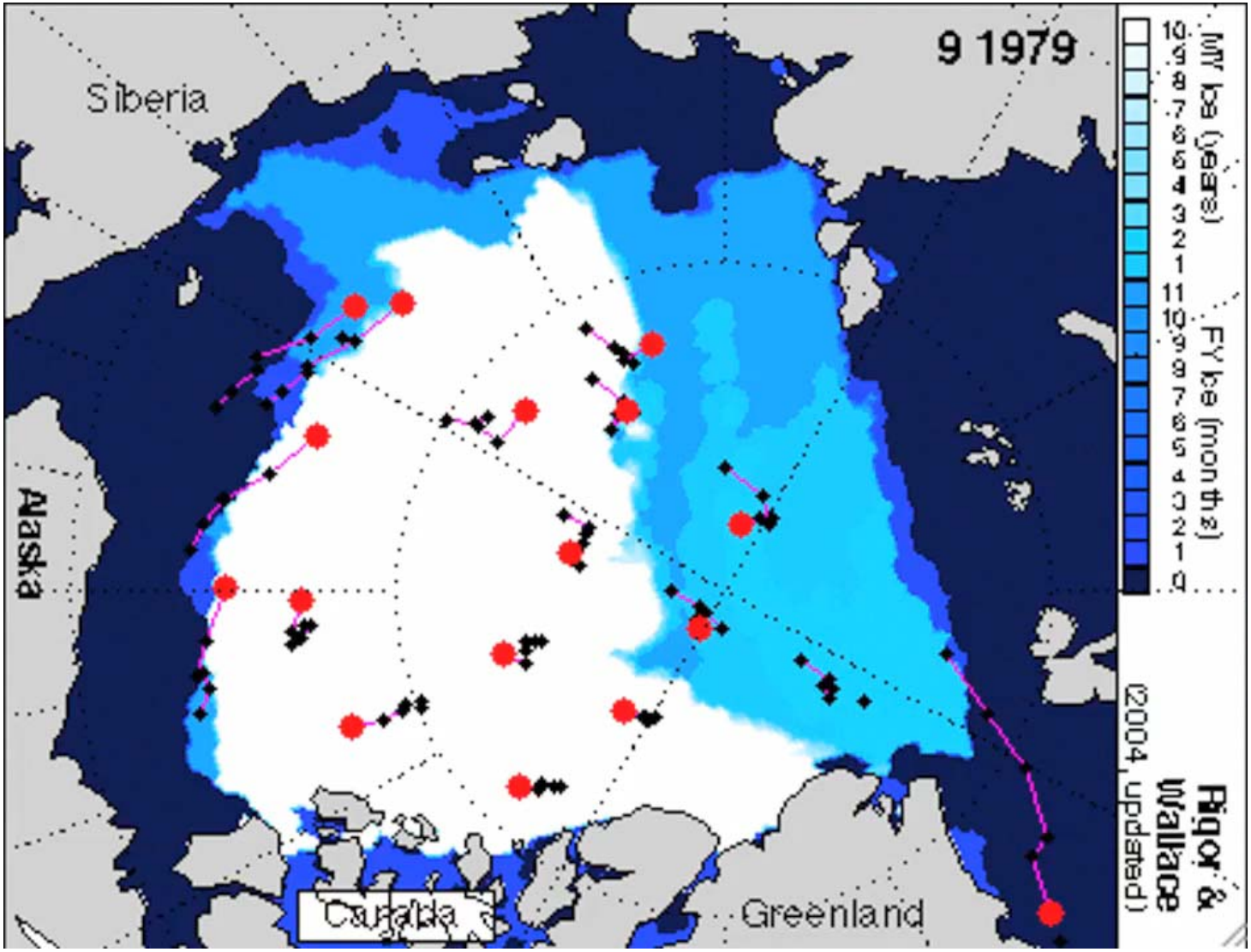
The spread between SLP Reanalyses is low in areas where there are buoy observations (left). The spread increases to cover the whole Arctic when the buoys are removed from the reanalyses (right). The buoy obs. also help constrain of estimates of wind and heat.

(Inoue et al, 2009)

Sea Ice Extent Retreat



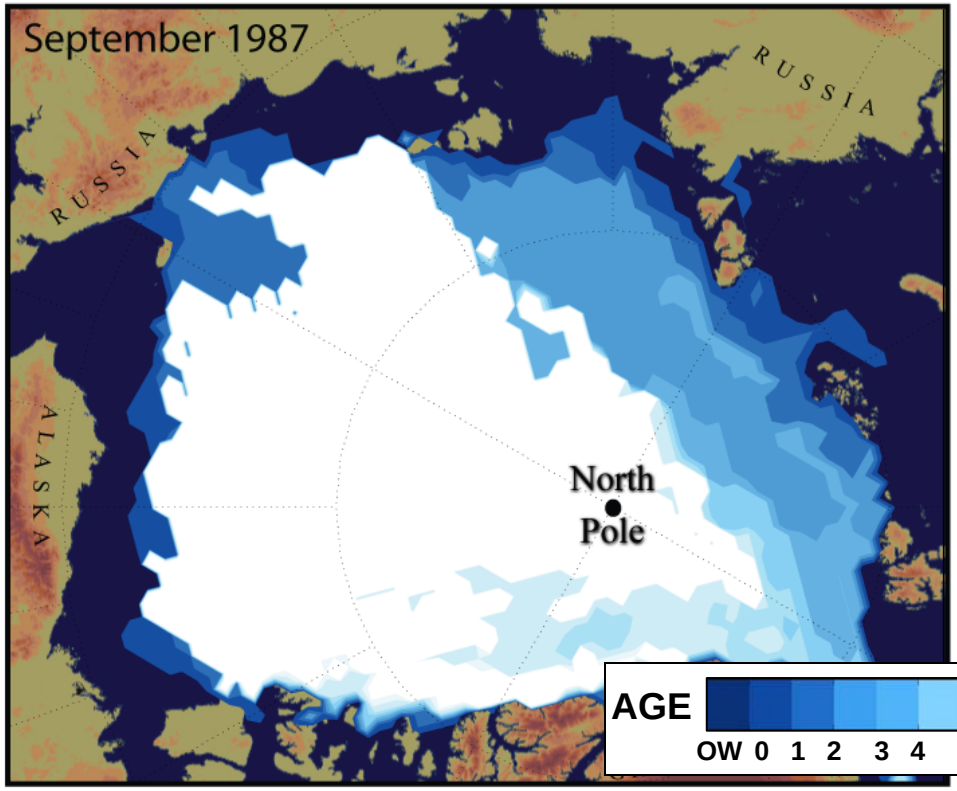
Changes in Wind, Ice Drift, Age and Thickness



- Retreat of sea ice is usually attributed to warmer temperatures.
- Changes in wind and ice drift are also important.
- Sea ice grows thicker with age.
- Younger (thinner) Ice persist through today.

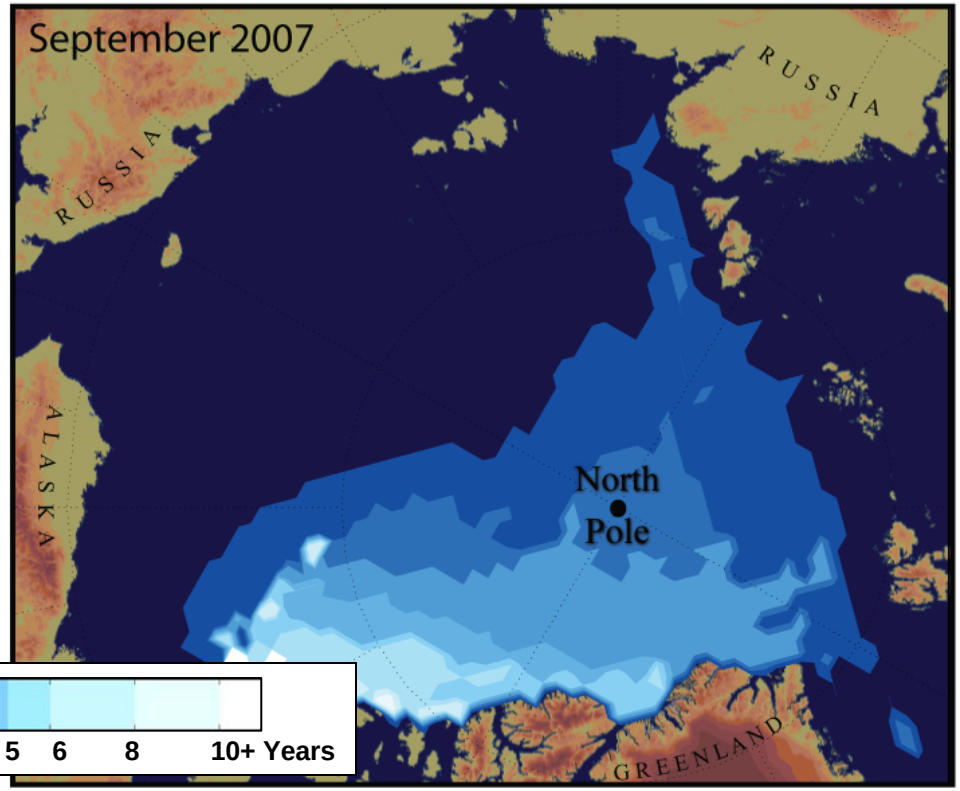
Positive Feedbacks

1980's (low AO, large gyre)

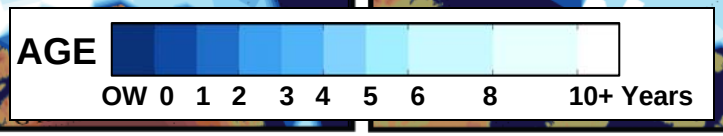


- More older, thicker ice.
- Later onset of melt, earlier onset of freeze.
- Winter and summer forcing is more important.

Present (high AO, small gyre)

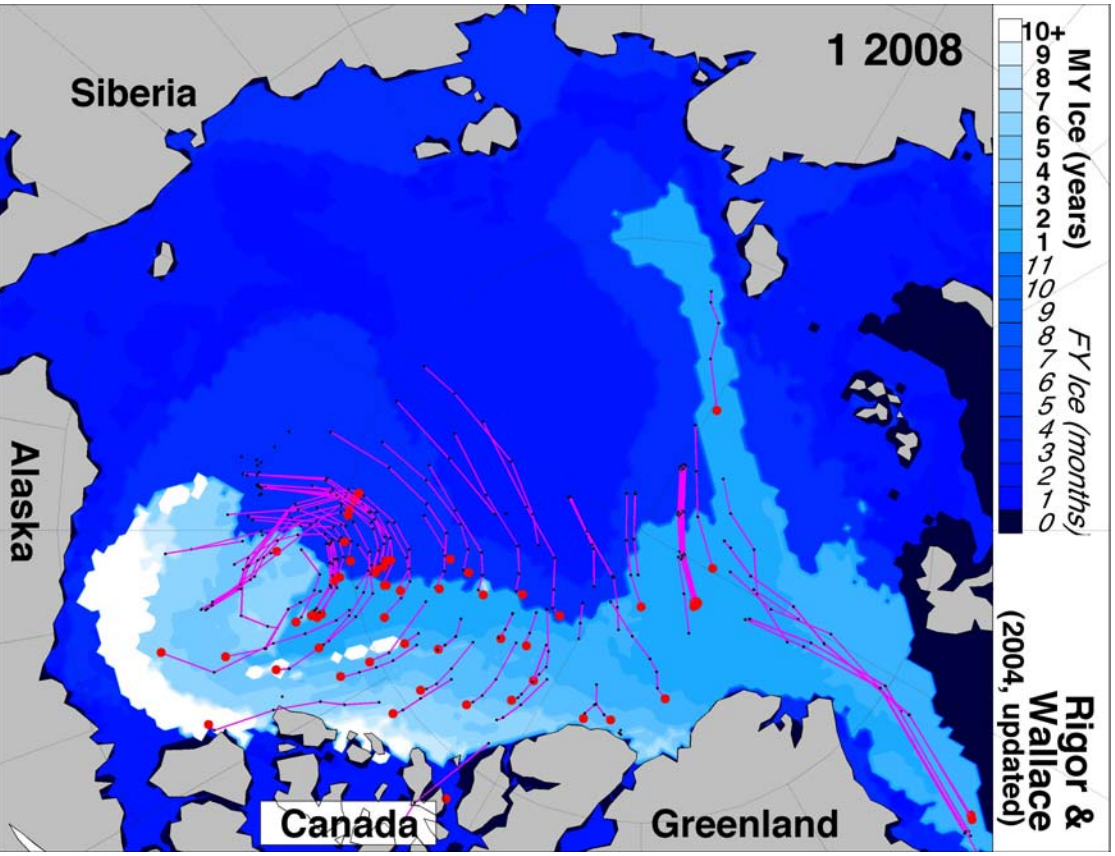


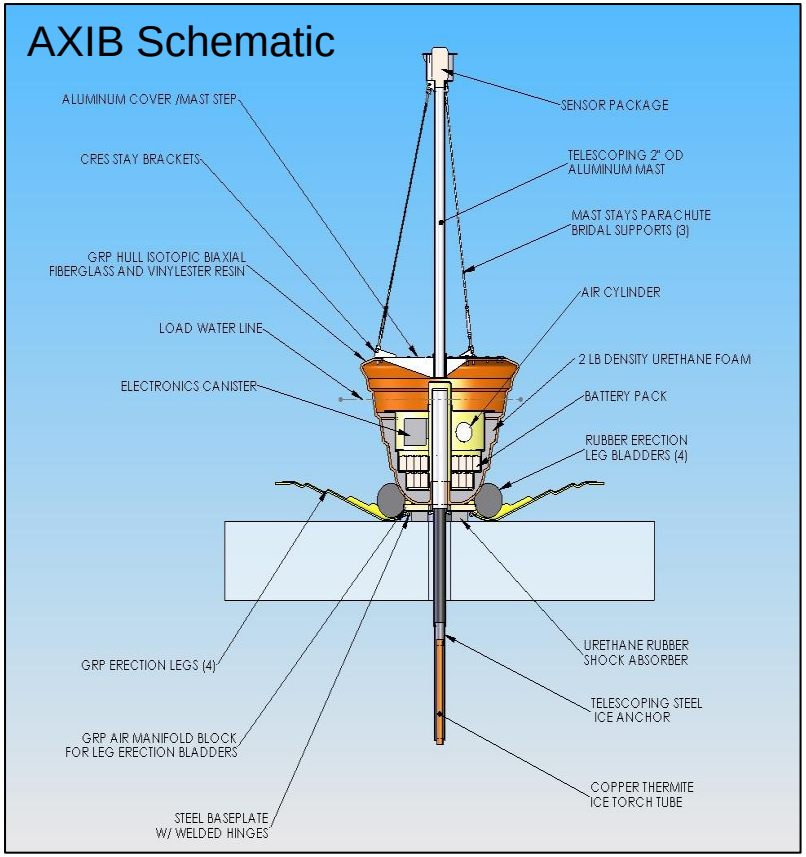
- Less older, thicker ice.
- Earlier onset of melt, more absorbed sunlight, later onset of freeze, longer melt season.
- Warmer temperatures.



- Positive Feedbacks maintain either state.

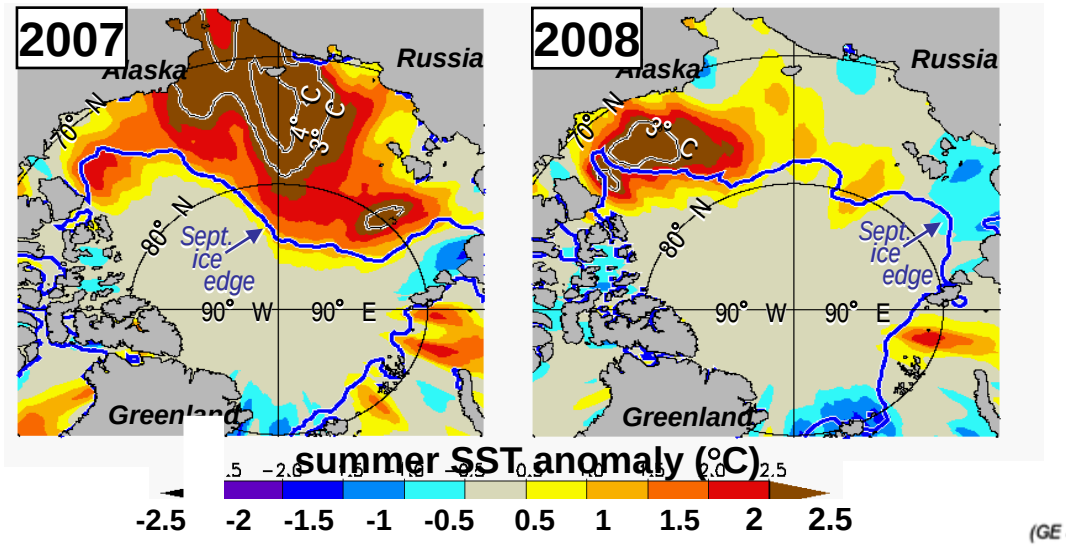
Airborne eXpendable Ice Buoys (AXIB)





- Developed by US-IABP through a NOAA SBIR.
- Capable of operation in ice, and open water through freeze/thaw cycles.
- Sensors include air and ocean temperature, surface pressure, GPS location, and Argos transmitter.
- Currently 6 AXIBs reporting (9/26/2011).

Measuring the Upper Layer Temperature of the Arctic Ocean: UpTempO Buoys

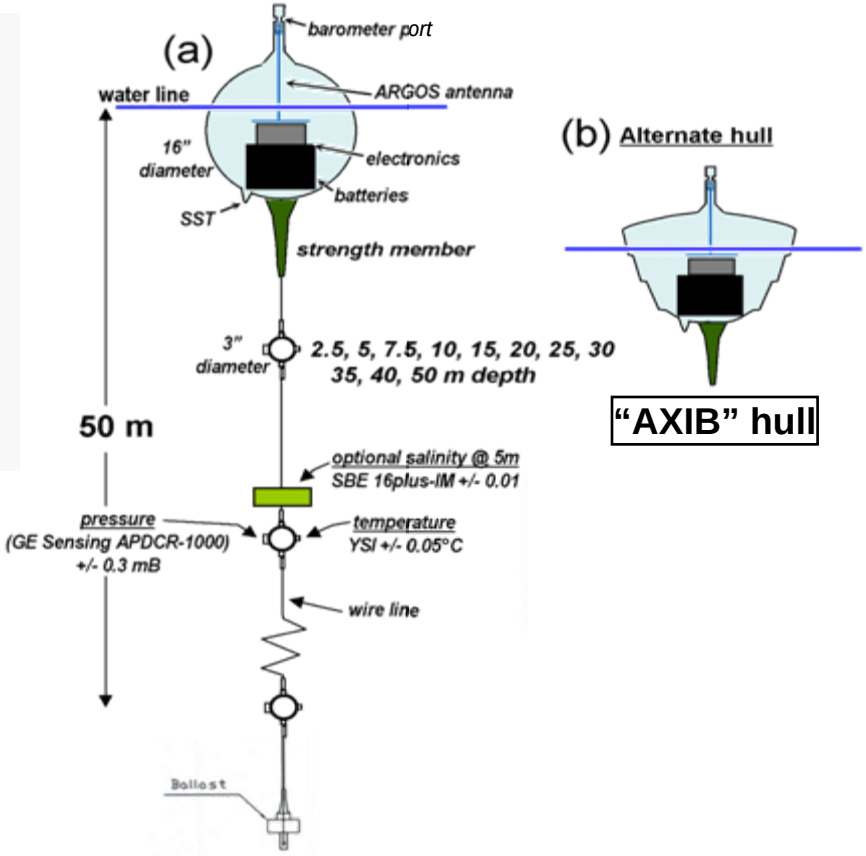


Satellite (AVHRR) SST anomalies (relative to 1982-2006 mean, from R. Reynolds data, NCDC)

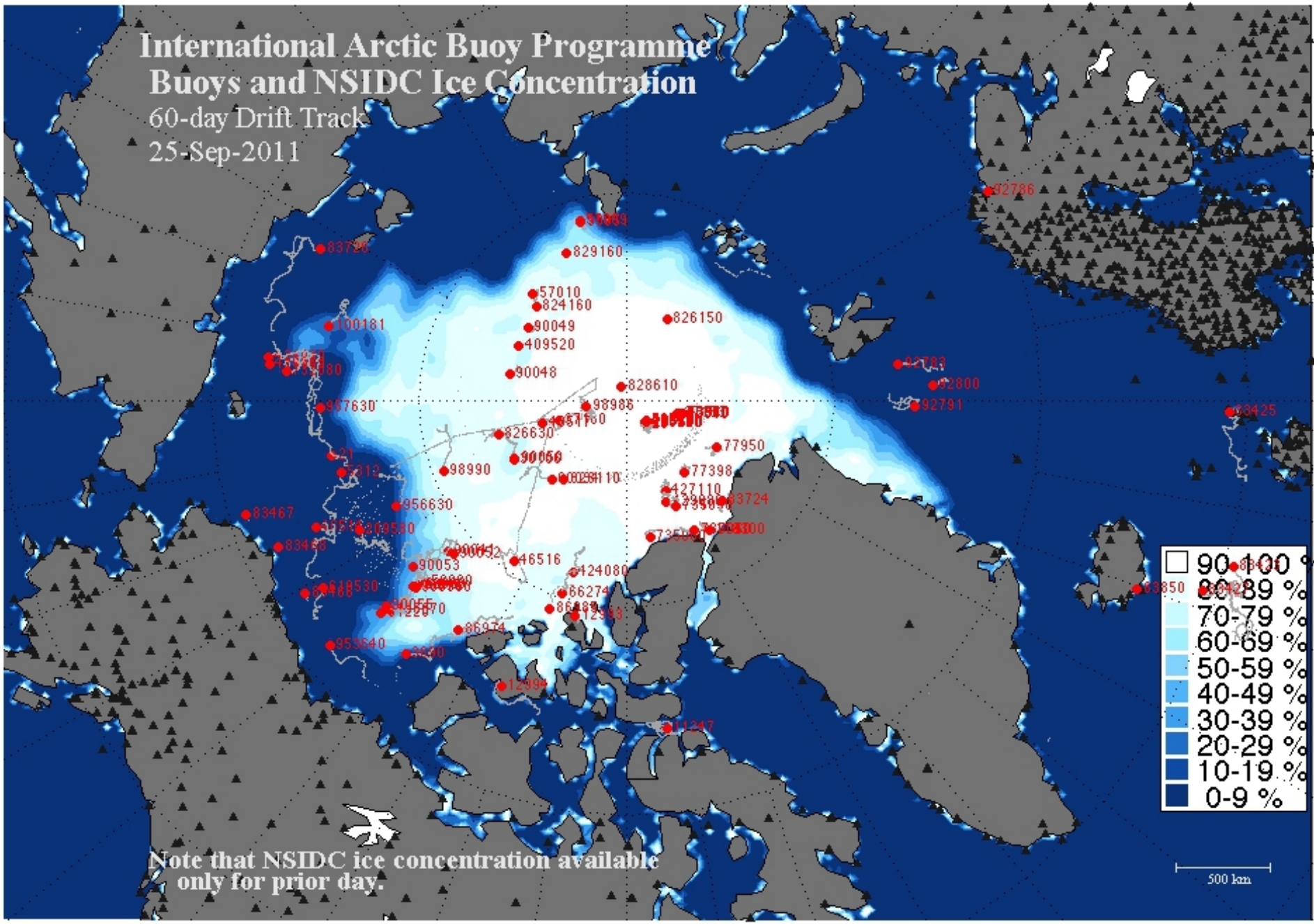
This is historically unprecedented warming!

OK, but what is the evolution *below the surface* of:

- **summer upper ocean heating?**
- **fall upper ocean cooling?**



Eleven UpTempO buoys will be deployed this summer.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Impacts of Retreating of Arctic Sea Ice

Solar heating penetrates down into the Ocean

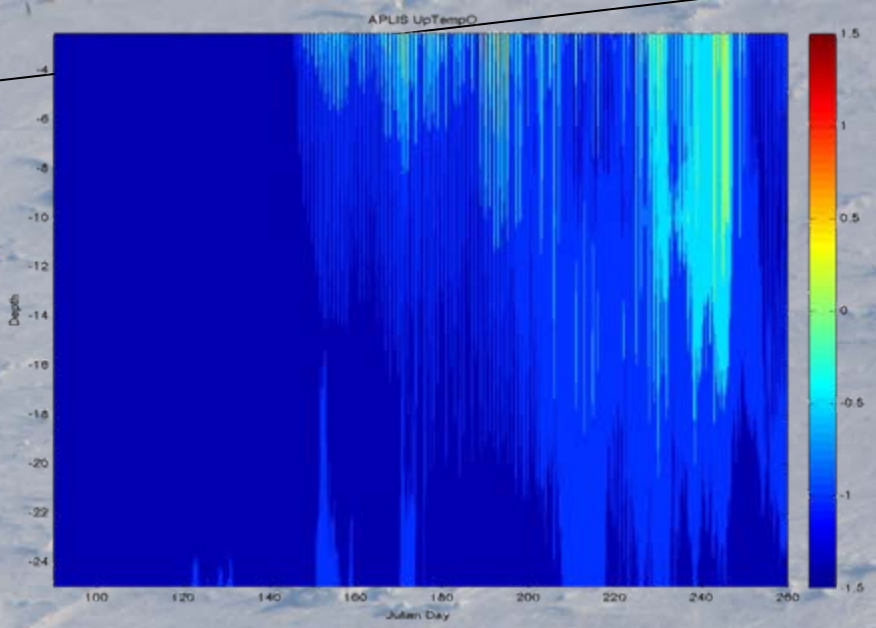

Photo by LCDR John Woods
from NASA ICEBRIDGE P-3

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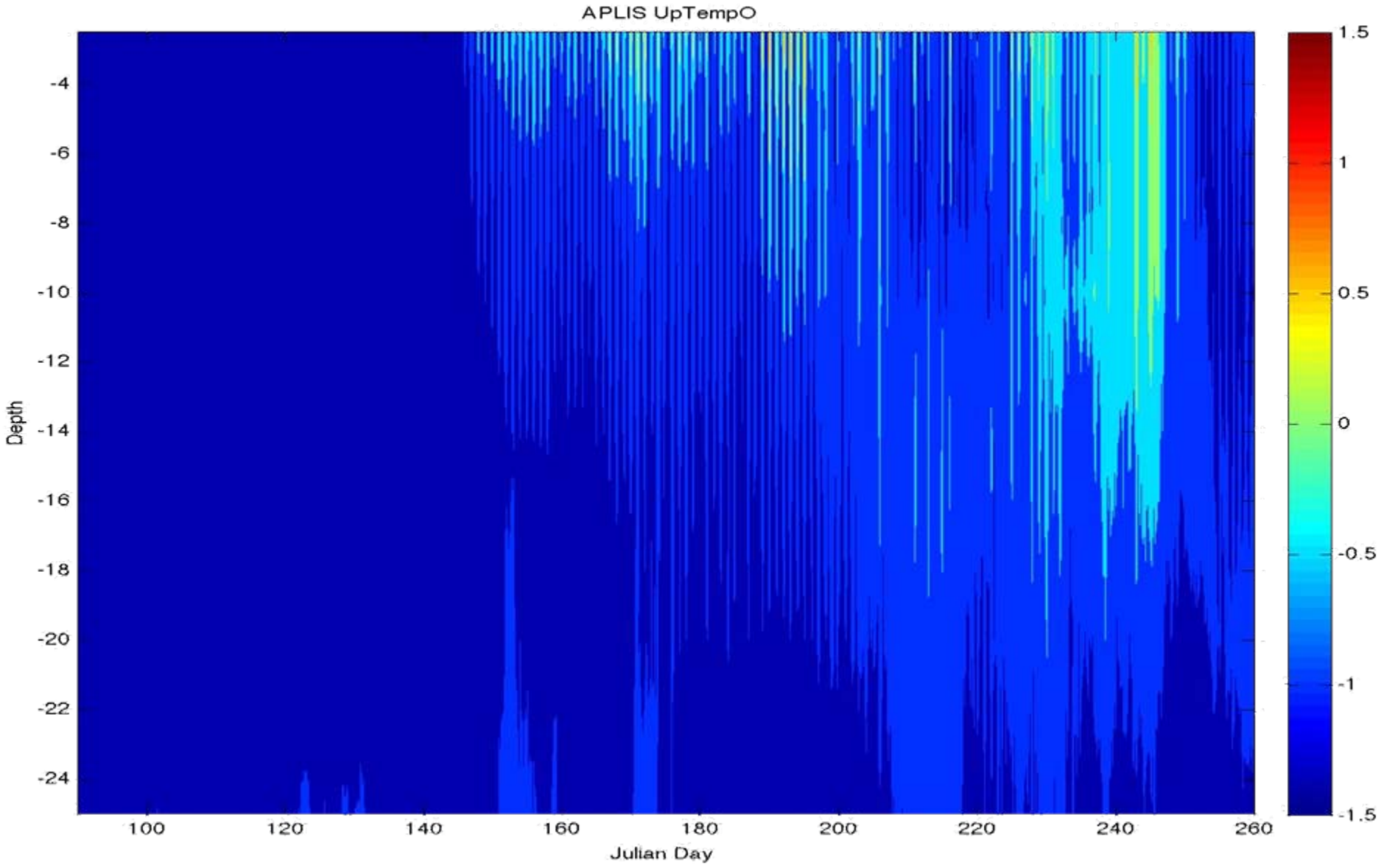
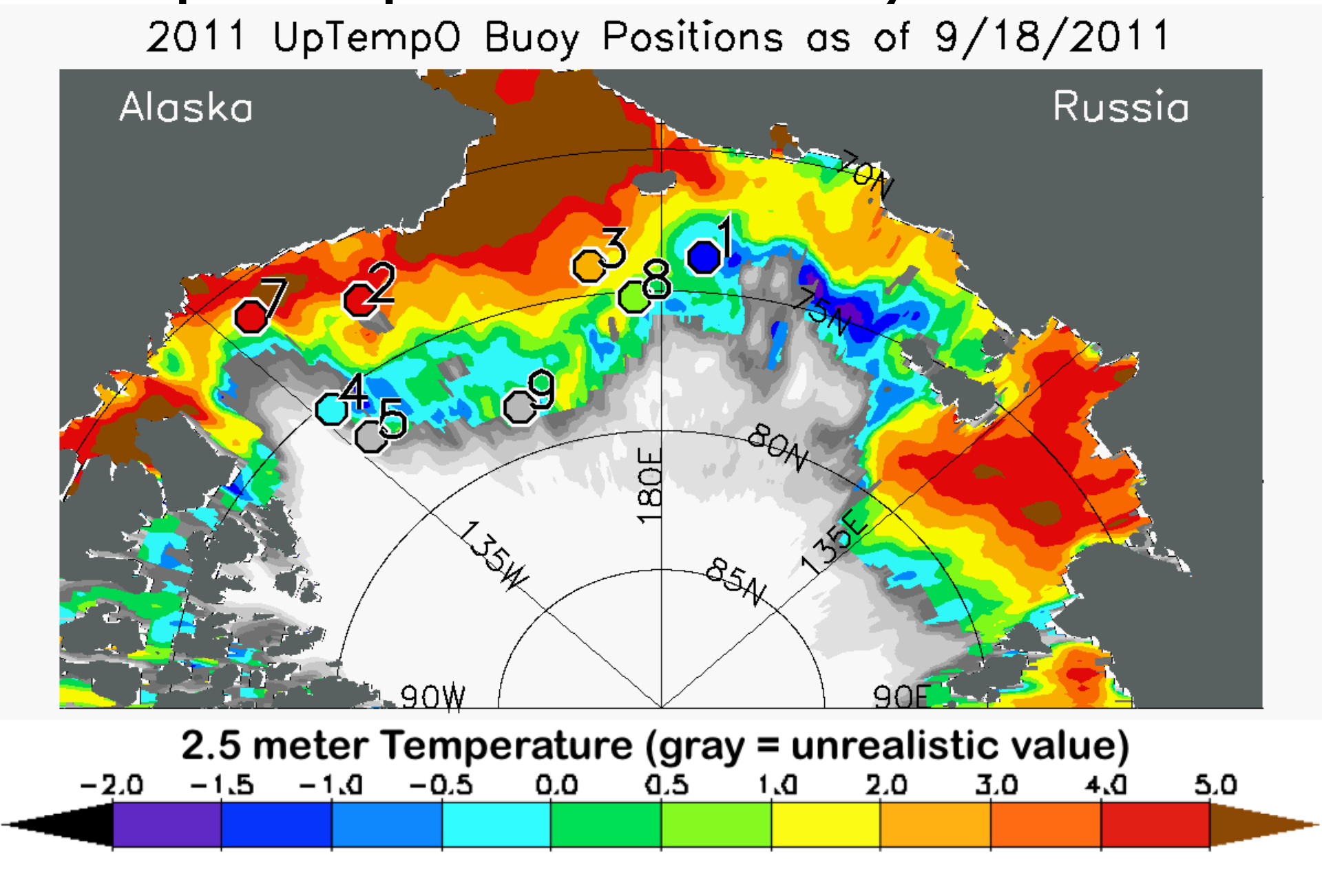


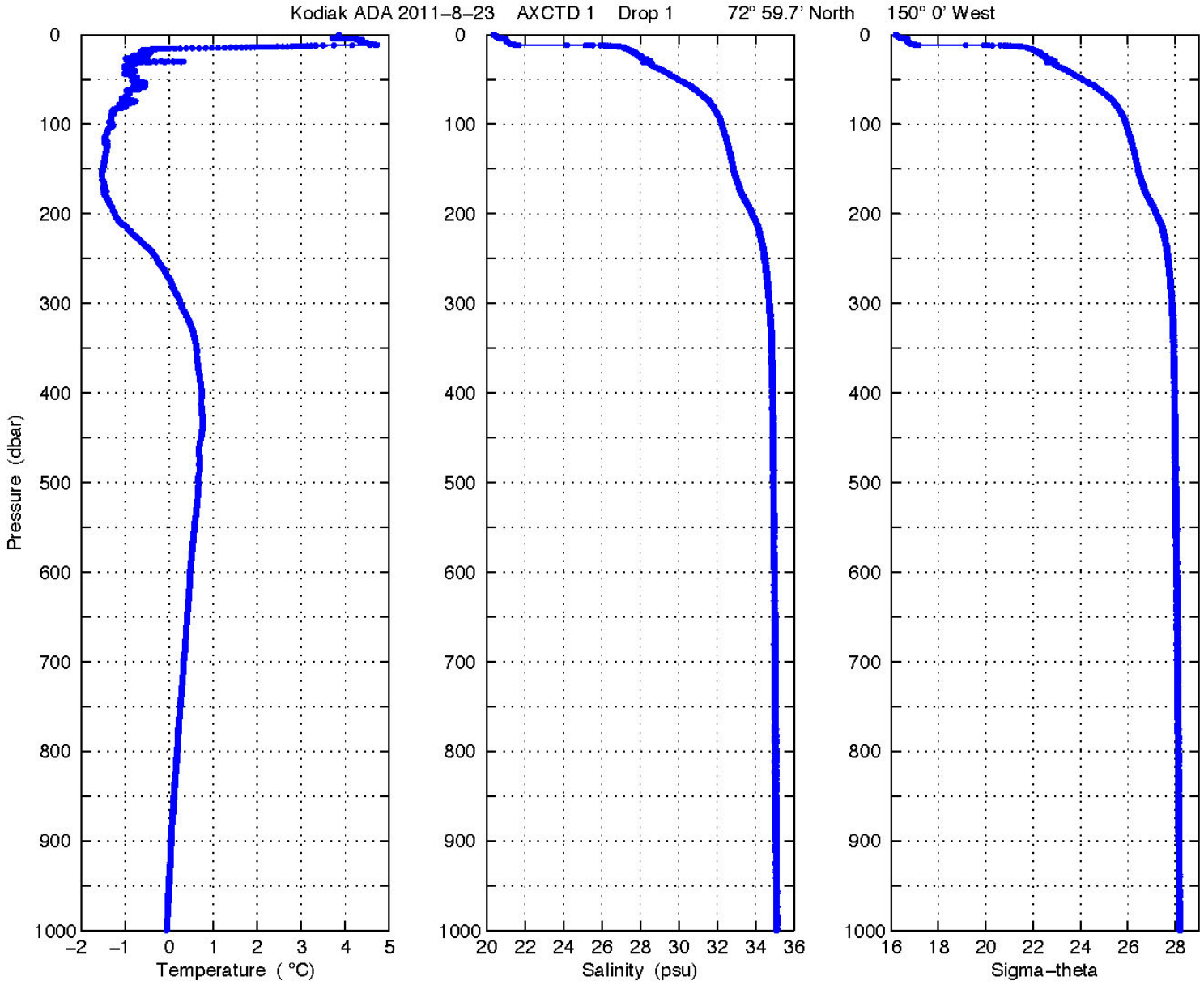
UpTempO Preliminary Results



Coast Guard

Arctic Domain Awareness Flight

Aug 24, 2011


Kodiak ADA 2011–8–23 AXCTD 1 Drop 1 72° 59.7' North 150° 0' West
Pressure (dbar)
0
100
200
300
400
500
600
700
800
900
1000
–2 –1 0 1 2 3 4 5
Temperature (°C)
20 22 24 26 28 30 32 34 36
Salinity (psu)
16 18 20 22 24 26 28
Sigma–theta

Summary

- The Arctic has been changing rapidly. Multi-year sea ice has decreased, and the area of open water during summer has increased.
- The IABP has been developing season ice zone buoys to meet this challenge.
- In Situ observations show that satellite derived SSTs in this increasing area of open water during summer may have a cold bias.