Maritime-Relevant Arctic Science at NOAA

Dr. John A. Calder
NOAA Climate Program Office
Arctic Research Program

NOAA's Climate Goal

Understand climate variability and change to enhance society's ability to plan and respond

Program	Performance Objective
 Climate Observations and Monitoring	Describe and understand the state of the climate system through integrated observations, monitoring, and data management
 Climate Research and Modeling	Understand and predict climate variability and change from weeks to decades to a century
 Climate Service Development	Improve the ability of society to plan for and respond to climate variability and change

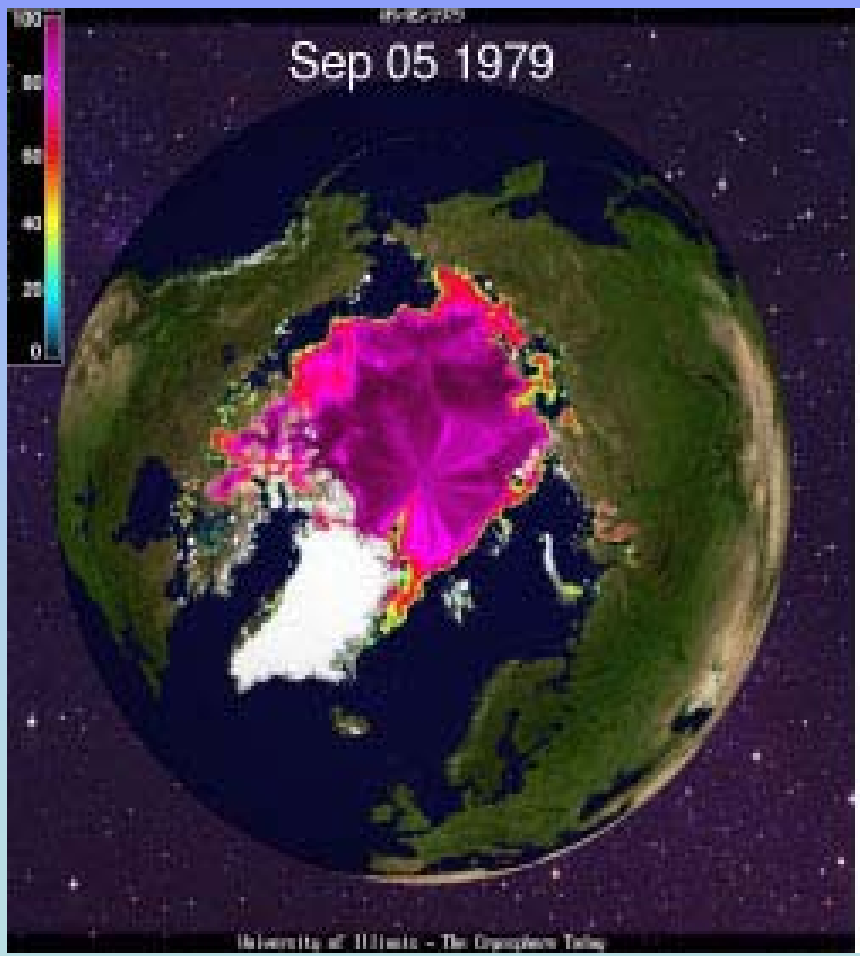
Outcomes

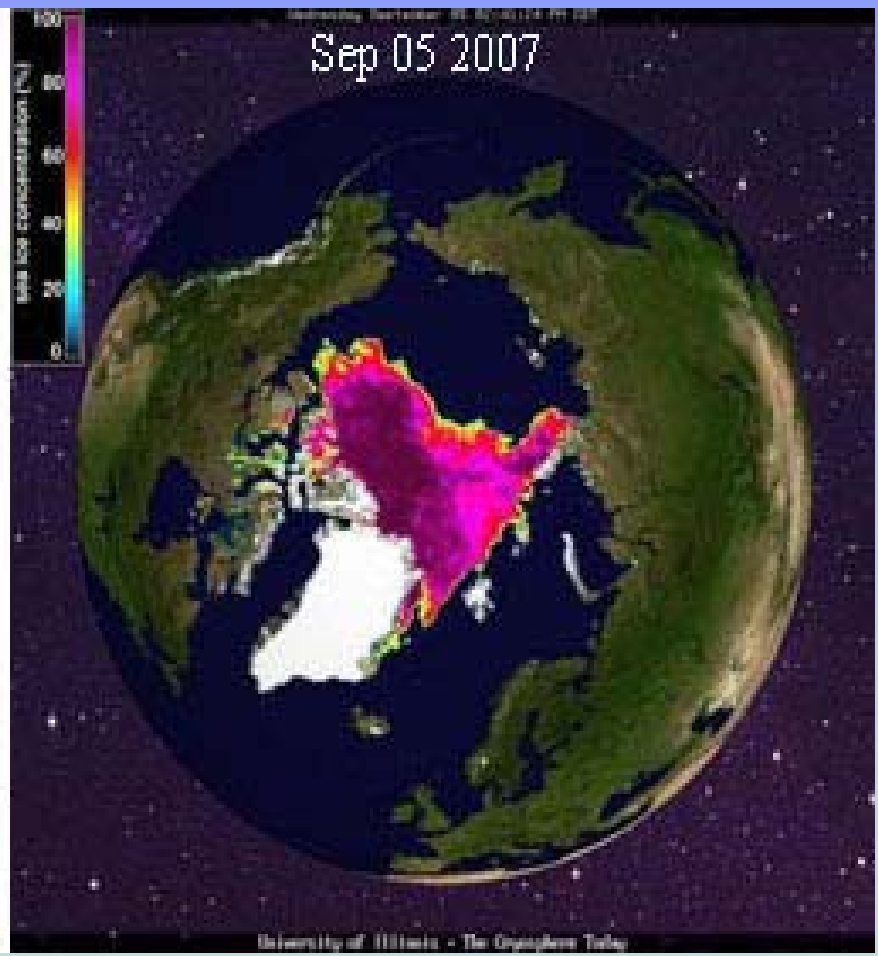
A predictive understanding of the global climate system on time scales of weeks to decades to a century with quantified uncertainties sufficient for making informed and reasoned decisions.

Climate-sensitive sectors and the climate-literate public effectively incorporating NOAA's climate products into their plans and decisions.

Sea ice changes in the Arctic

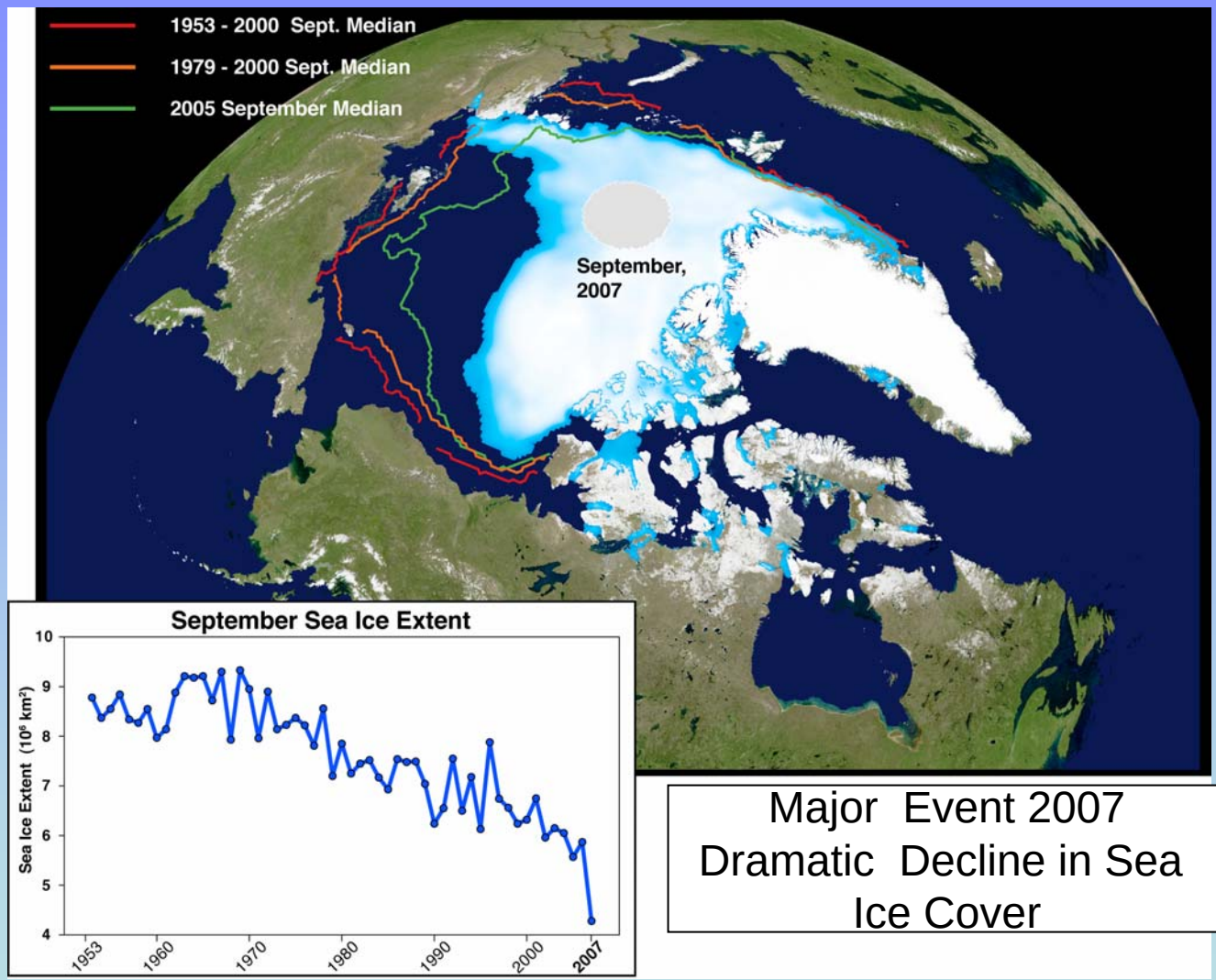
September 1979 - 2007





Ice Extent Easily Observed Via Satellite

Current observing is not adequate to support synthesis and modeling: essential for understanding the regional and global causes and consequences of Arctic Change.

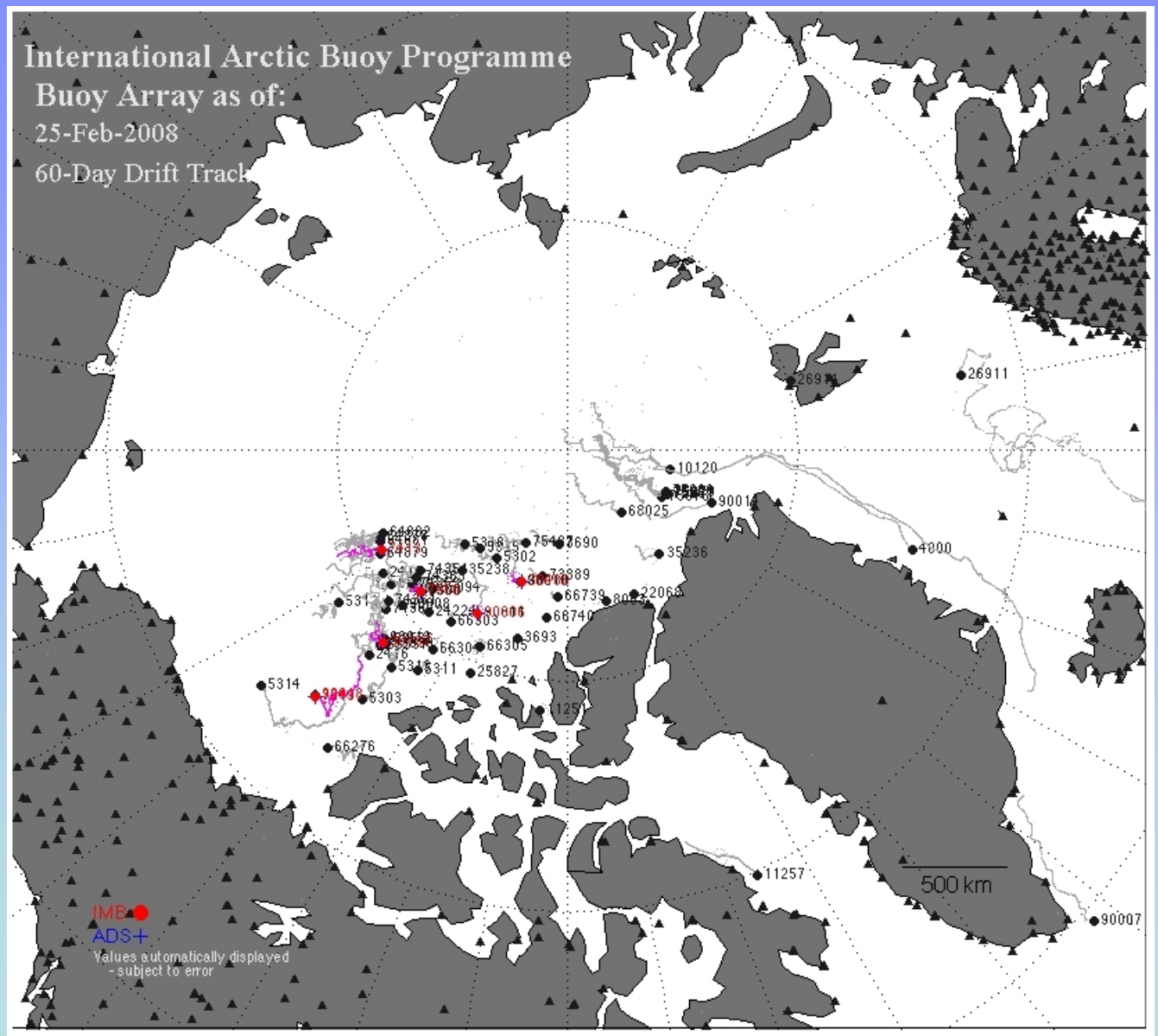


Major Event 2007
Dramatic Decline in Sea Ice Cover

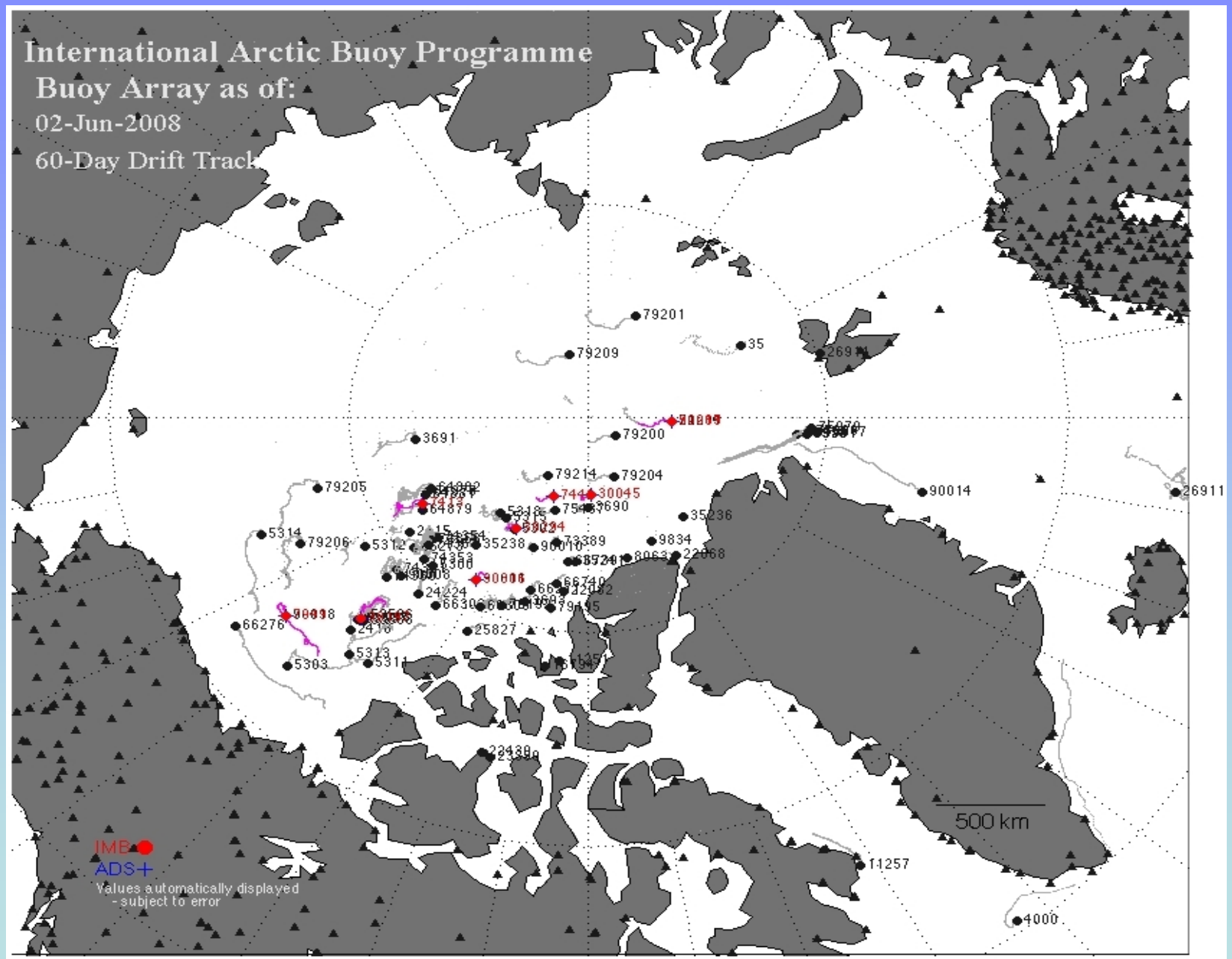
Ice Thickness and Mass Balance

- NOAA supports CRREL and IOS (Canada) to deploy and analyze results from buoys and moorings that determine ice thickness and other key variables
- Goal: provide long-term ice thickness trends and improve understanding of factors controlling ice thickness

IABP and IMB Locations



IABP/IMB Jun 2



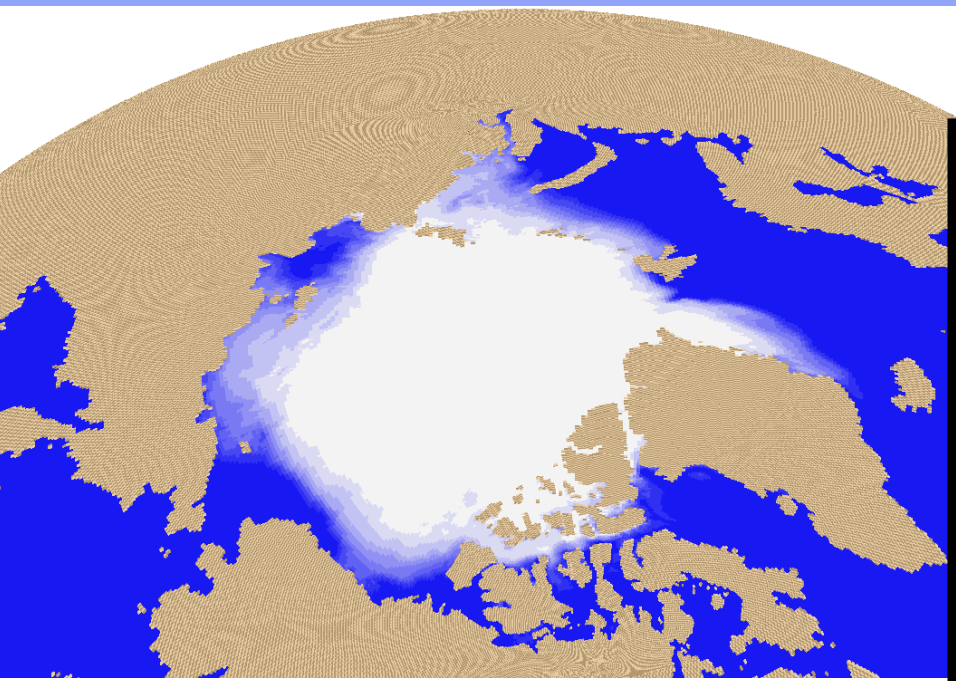
NOAA-GFDL Sea Ice Model: Current Formulation

- Full sea ice dynamics with elastic-viscous-plastic rheology
- 5 ice thickness categories + open water (leads) to represent subgrid heterogeneity
- 3 layer thermodynamics; 2 ice layers, 1 snow layer; representation of sensible and latent (internal brine) heat capacity

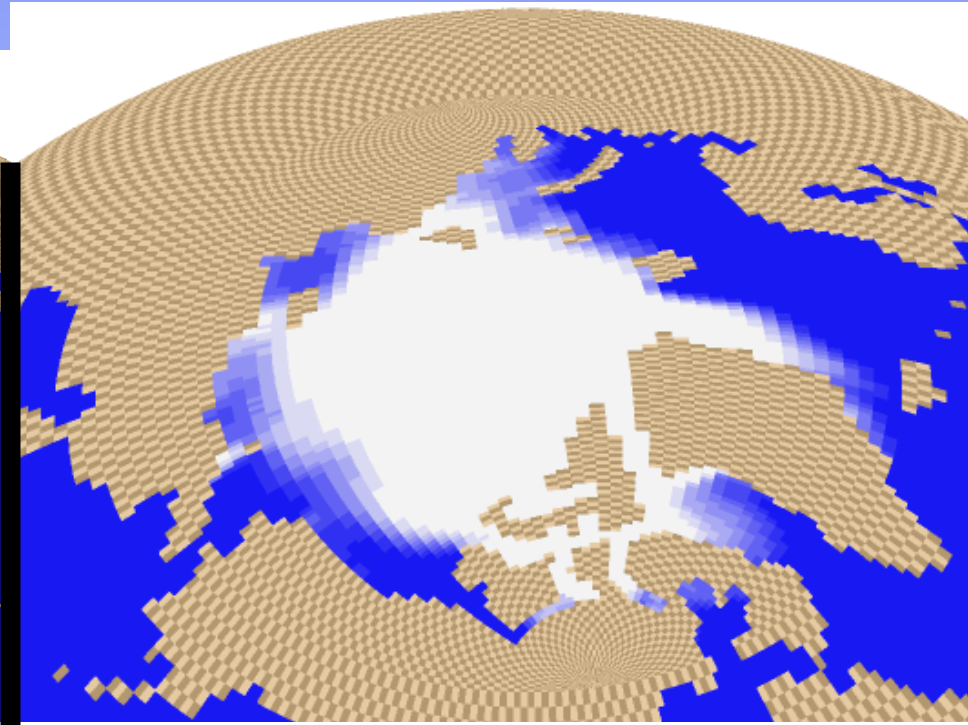
NOAA-GFDL Sea Ice Model: Future Plans

- Review and tune-up of dynamical parameters to reproduce satellite and buoy drift observations
- Implement ridging scheme for better representation of subgrid ice deformation
- Explicit representation of visible/near-ir and direct/diffuse solar radiation streams
- Simulate, rather than parameterize, apparent optical properties (reflectivity and transmissivity) based upon inherent optical properties of ice and snow

Planned improvements in sea ice model component of GFDL's global climate model



Next generation GFDL Model? running test cases now ("workhorse" circa 20??)



Current "workhorse" GFDL CM2.1 Model (circa 2005)

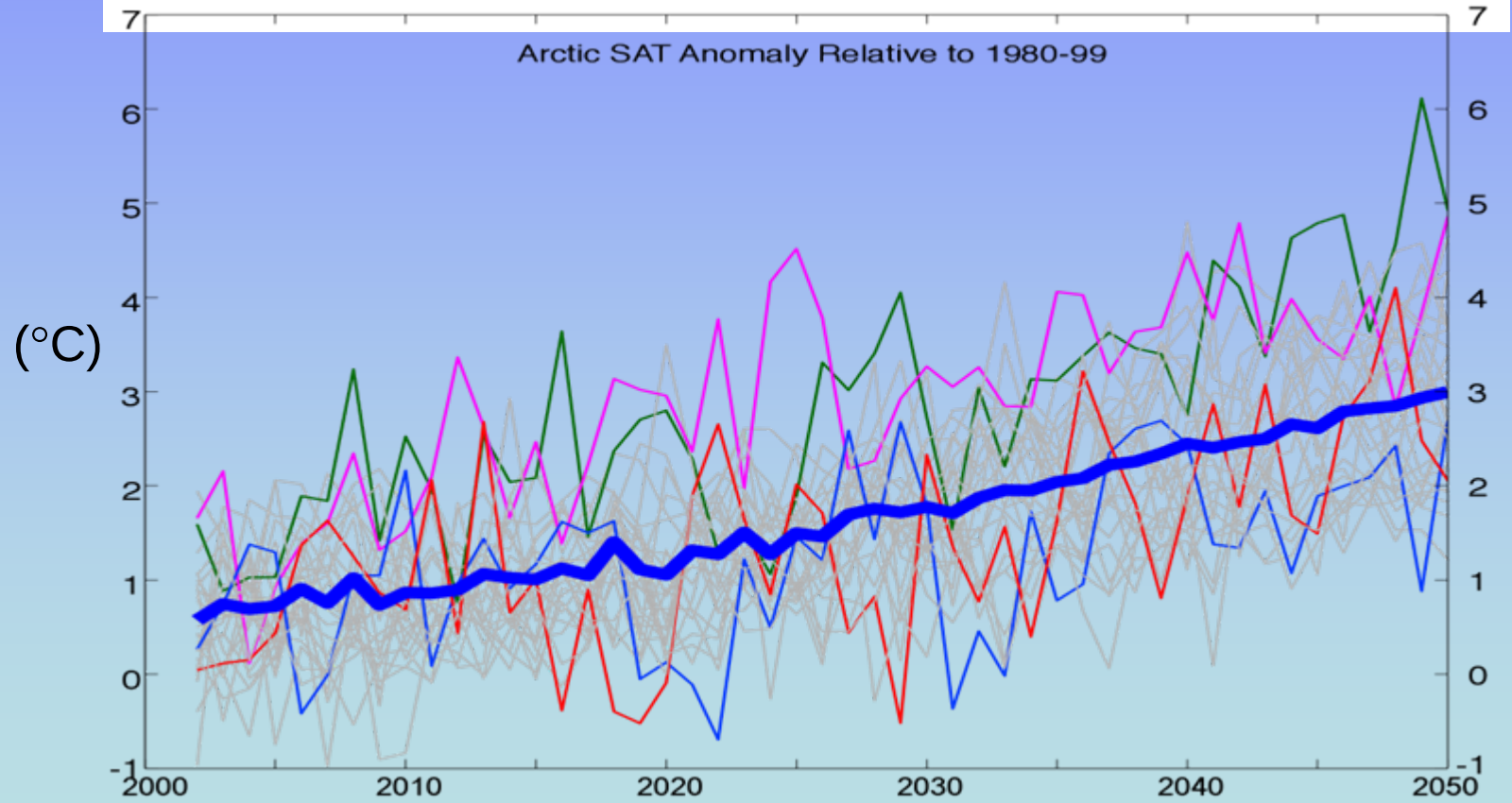
What Drives Sea Ice Loss?

- Global Warming – a persistent secular trend, unless GHG release is curtailed
- Natural Variability – includes changes in atmospheric circulation patterns, perhaps influenced by the warming trend
- Ice-Ocean Albedo Feedback – more open water absorbs more solar heat, creating more open water…
- Increasing low cloud cover and resulting heat trapping – likely a result of the warming trend
- Influx of warmer Atlantic and Pacific water – perhaps influenced by the warming trend through the atmosphere
- Likely to be large interannual, decadal, and regional variability around the long-term trend (Overland)

GLOBAL WARMING: Arctic land temperature forecasts from 12 IPCC models that hindcast well for the 20th Century

*Thick blue line is average of all forecasts and shows the anthropogenic contribution for medium emissions scenario with a 3 °C increase by 2050

*Other lines are possible futures combining natural climate variability and the long term trend. (From J. Overland, M. Wang)

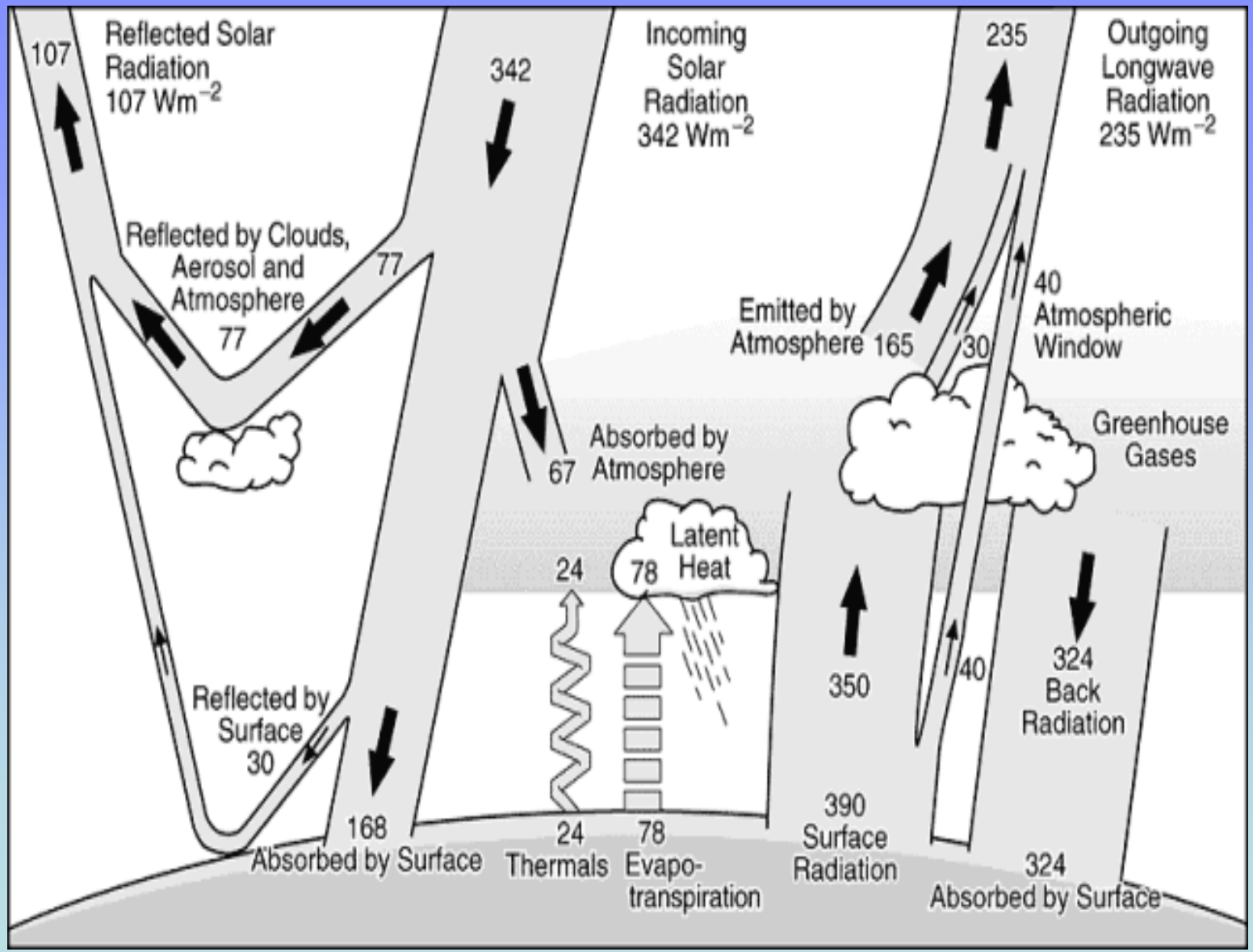


Role of the Atmosphere in Sea Ice Loss

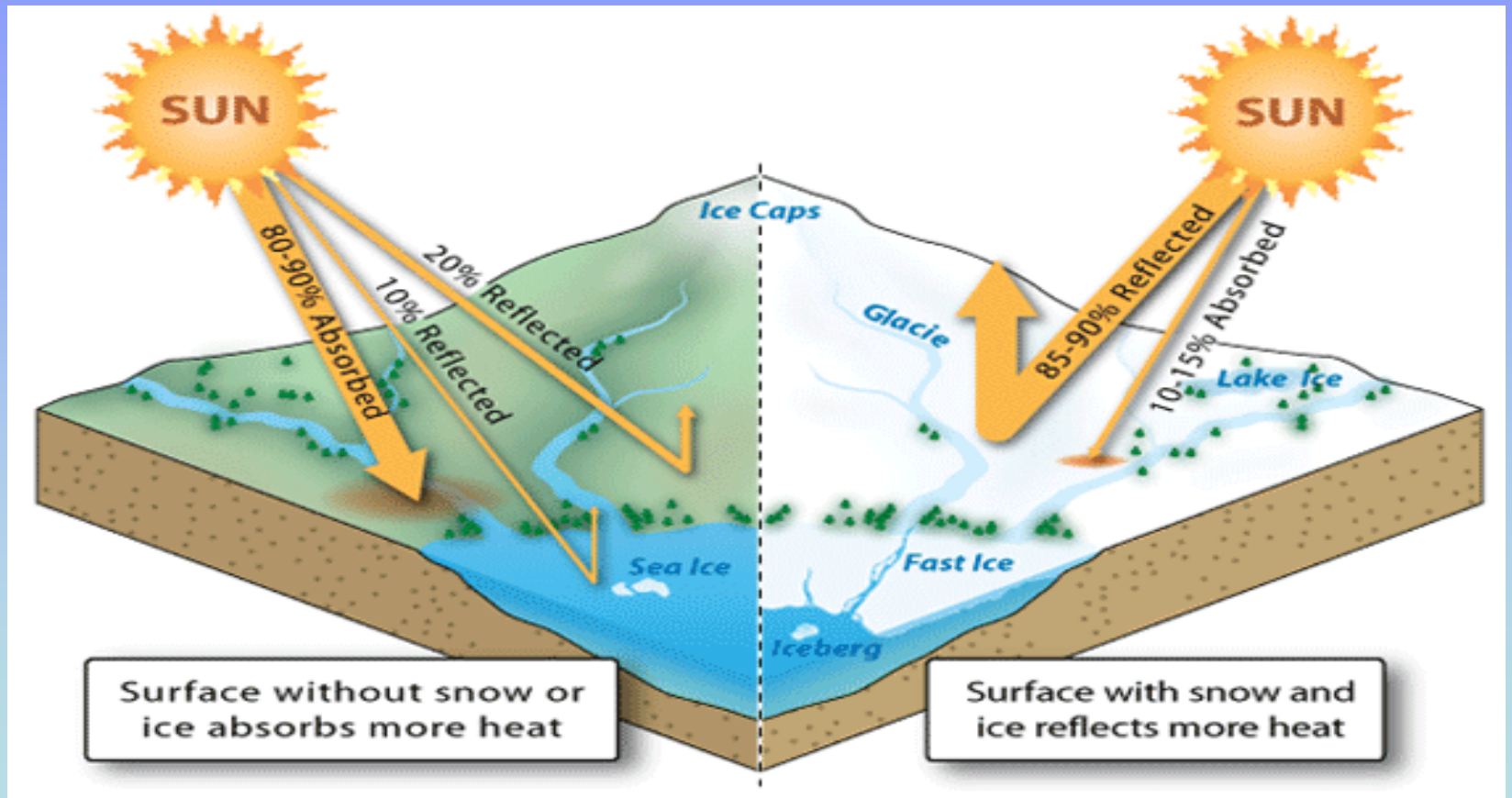
- Late 20th Century dominated by high AO index – favored accelerated drift of sea ice to Fram Strait
- Early 21st Century not a high AO period, yet sea ice loss continues
- Unusual southerly winds in Pacific sector of Arctic since 2000 may be responsible
- Natural variability in atmospheric circulation could lead to variability in sea ice conditions

(J. Overland – NOAA PMEL)

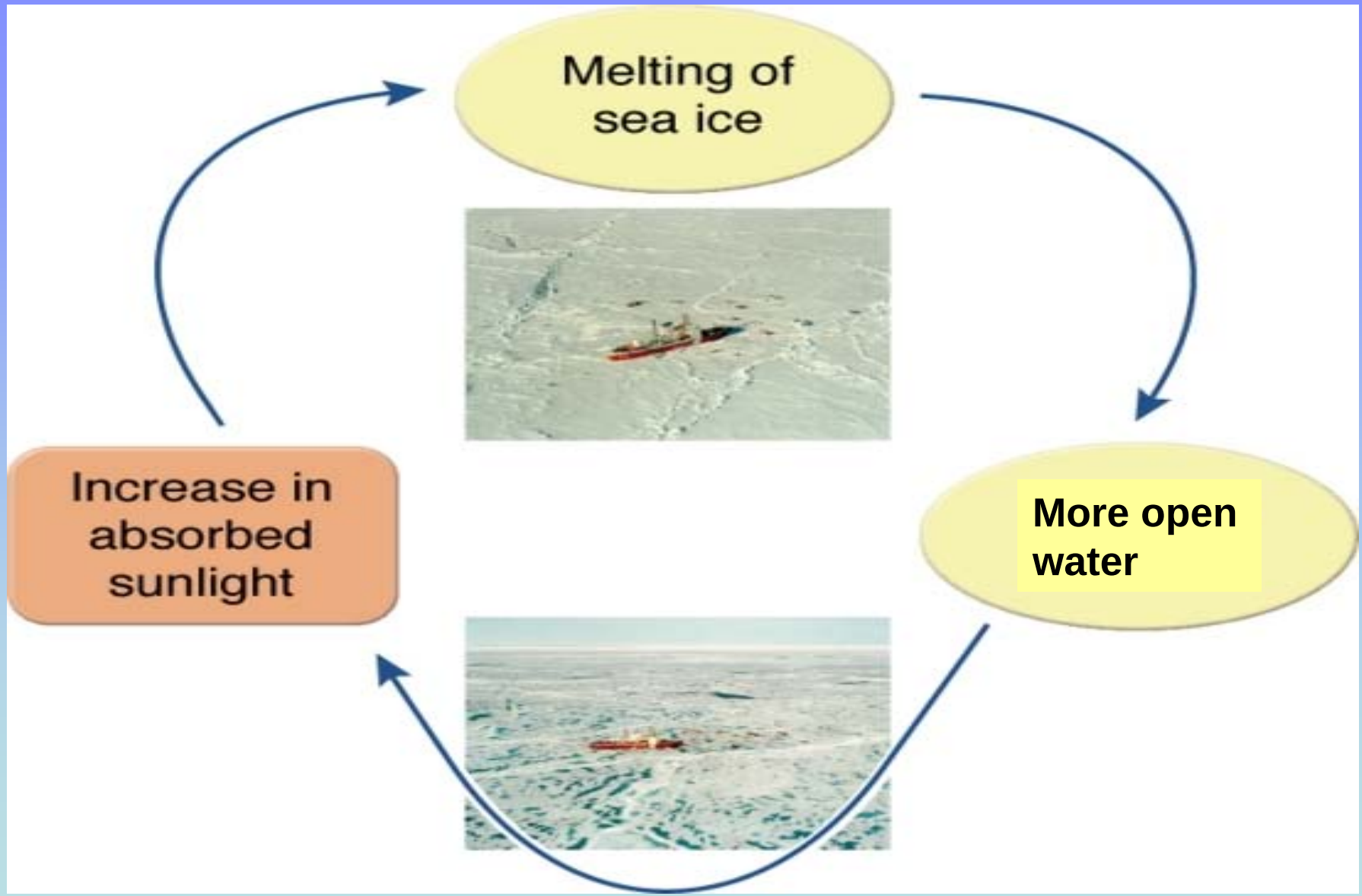
Balanced Radiation Budget



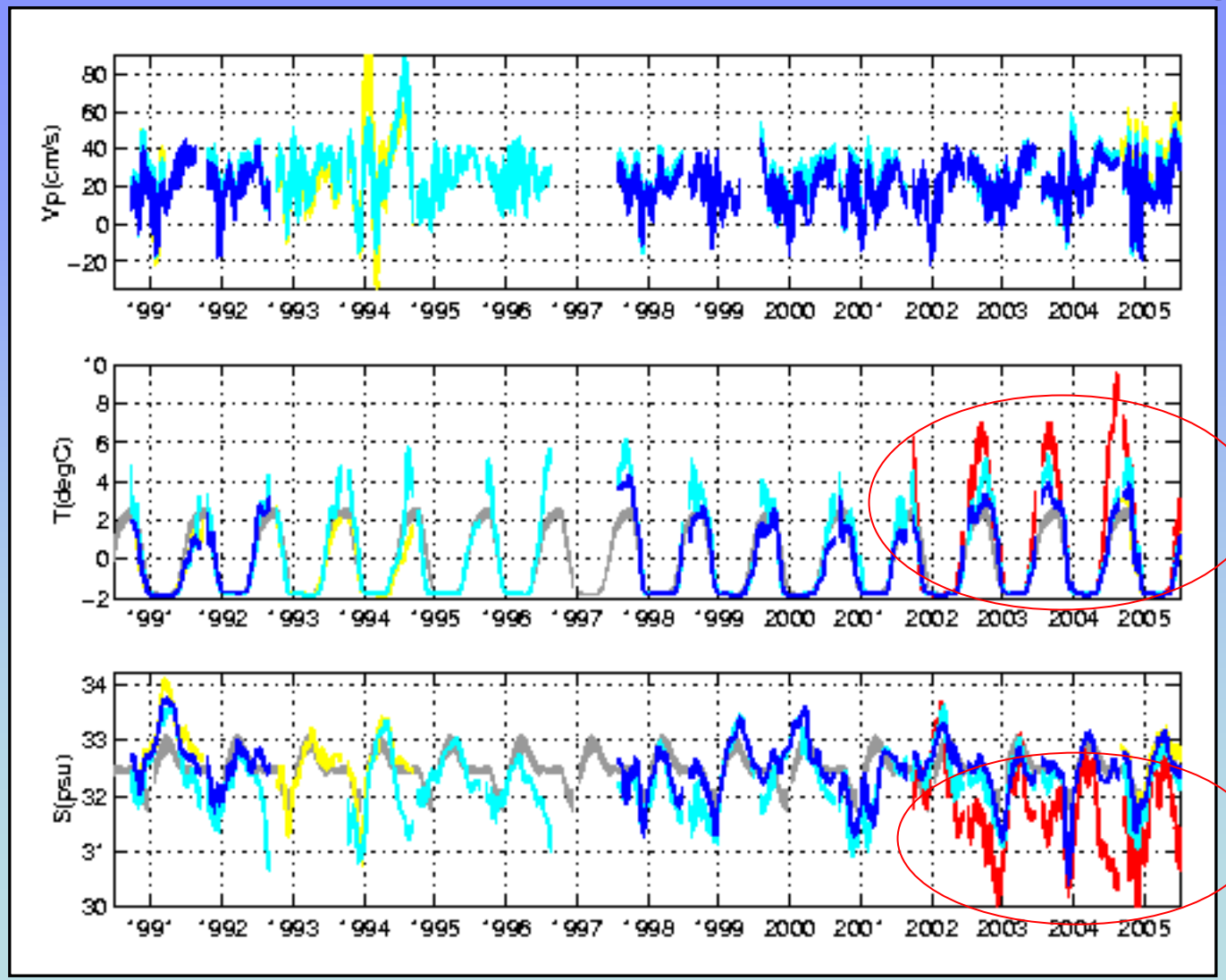
Effect of Snow and Ice Cover on Albedo



Ice-Ocean Albedo Feedback



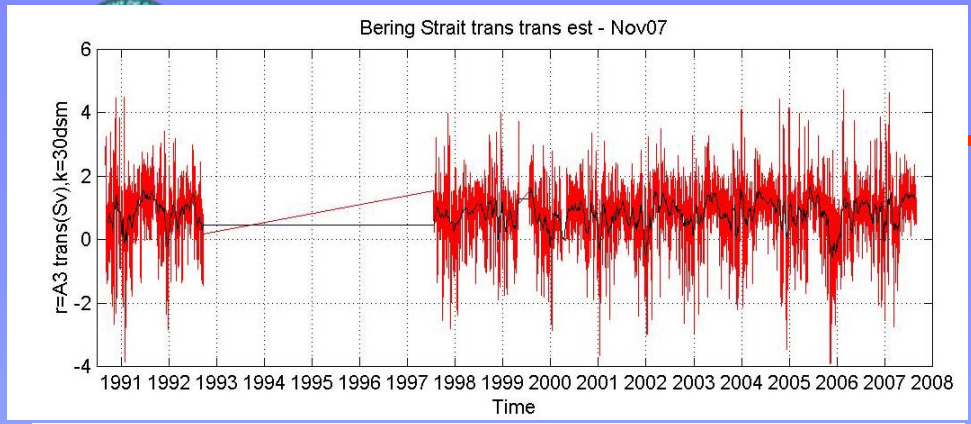
Flow Through Bering Strait As a Driver to Arctic Change

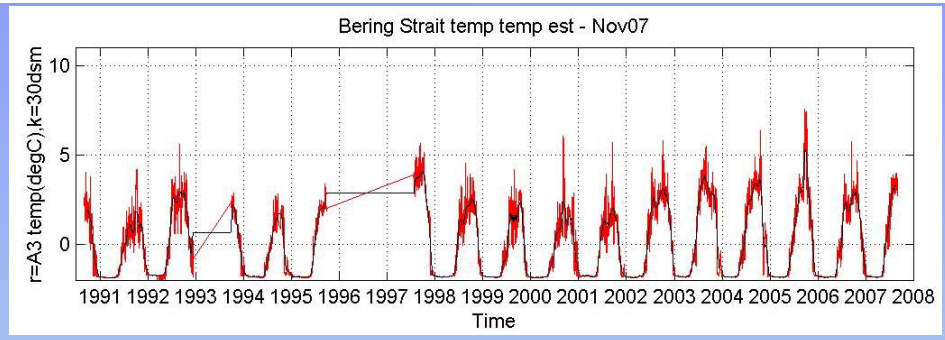


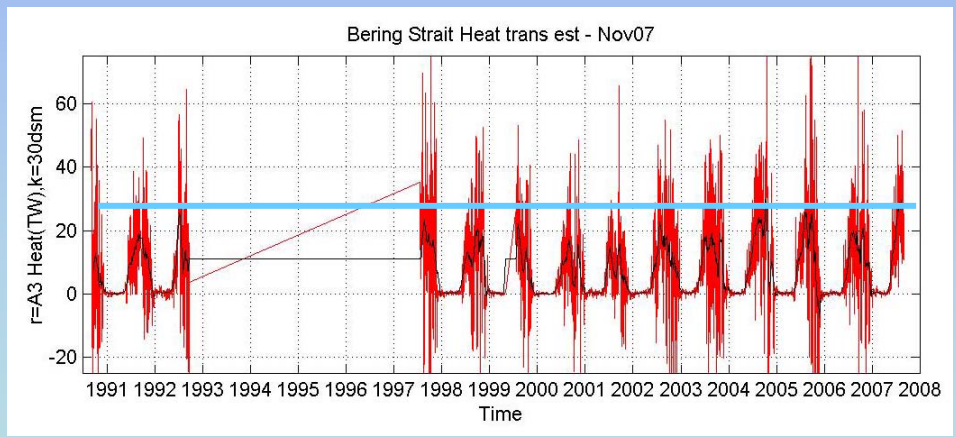
Temperature Is Rising

Salinity Is Falling

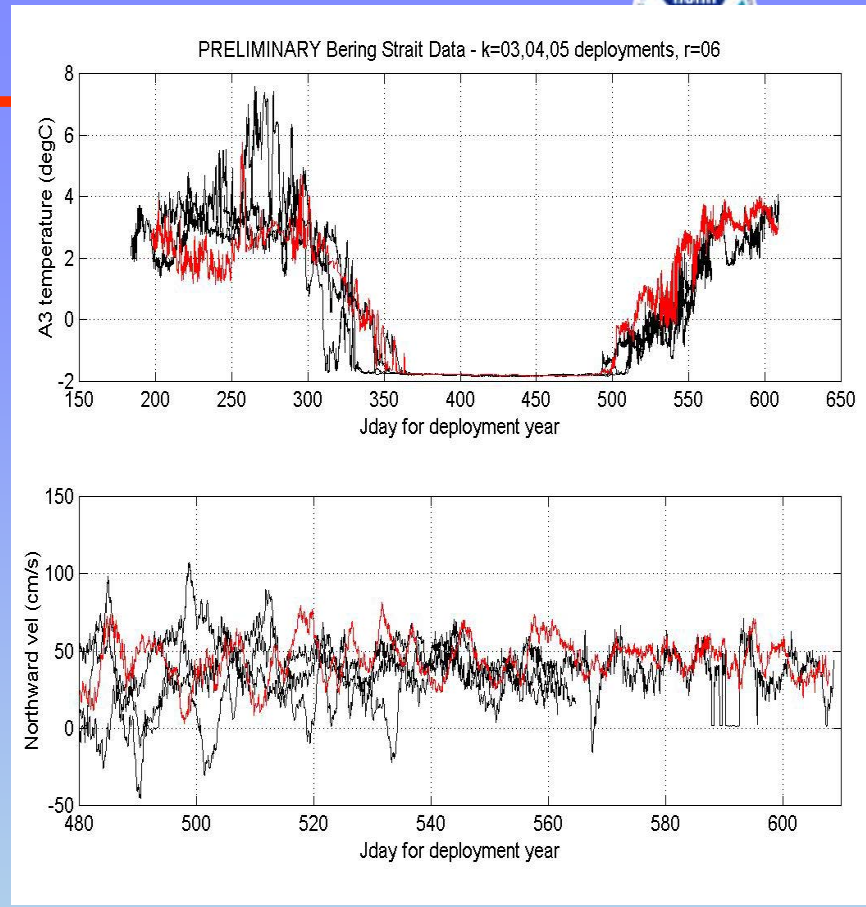
From Rebecca Woodgate - UW/APL







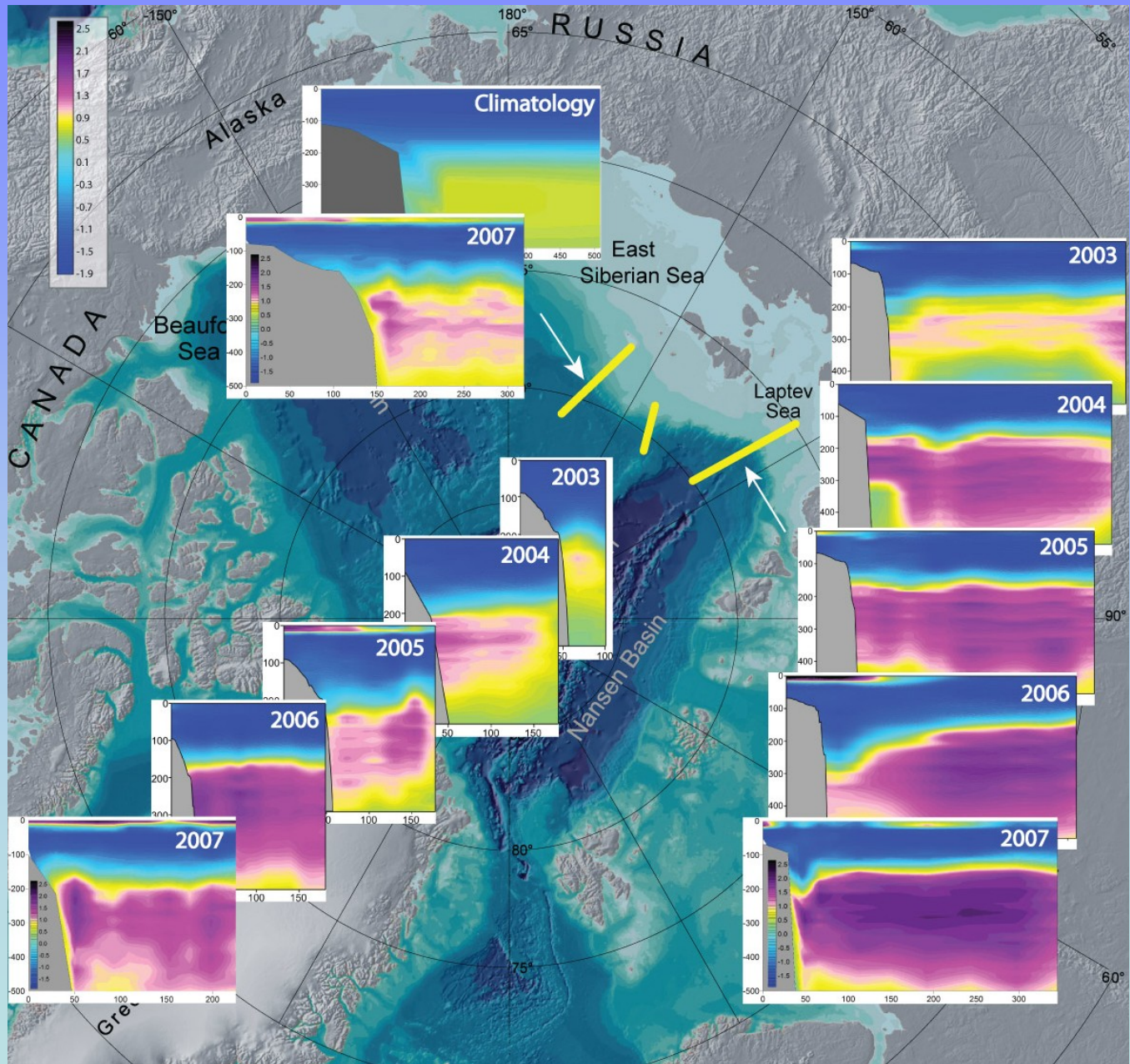
Transport (top), temperature (middle) heat transport (bottom) estimated for the whole strait from A3.
Red = hrly, black=30 day smoothed



Above: Summer 2007 (red) warmer and perhaps more consistently northward flow than preceding 3 years (black)

PRELIMINARY DATA
Before use, please contact Rebecca Woodgate, woodgate@apl.washington.edu

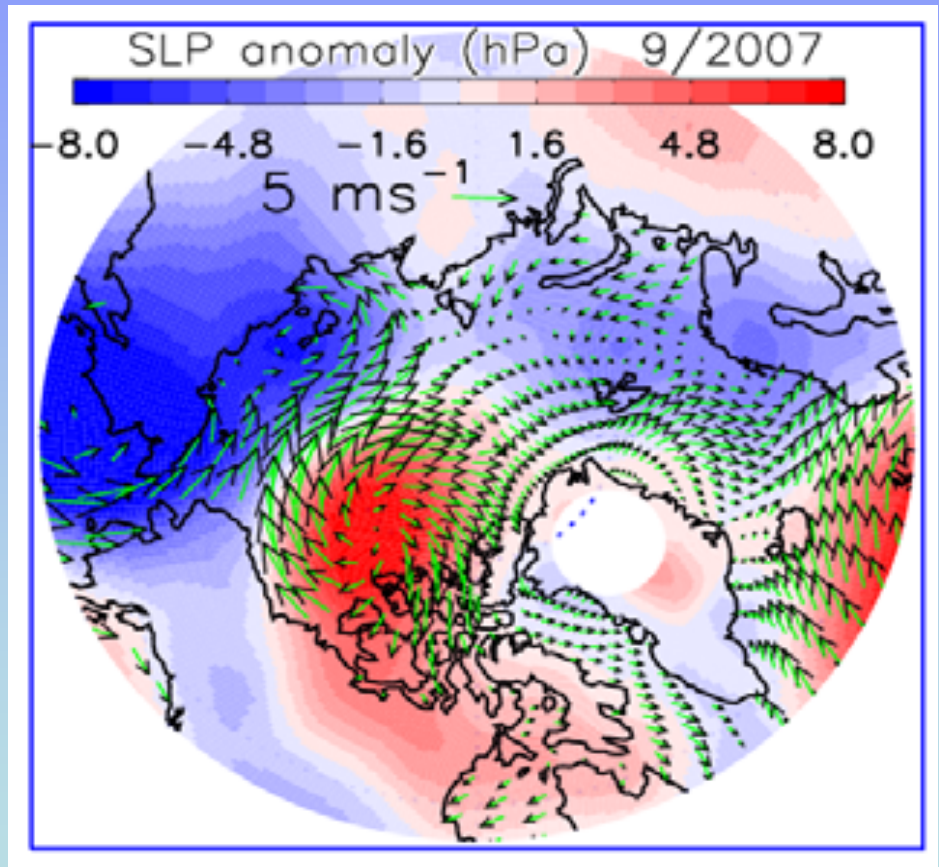
Recent Data on Atlantic Influx (I. Polyakov)



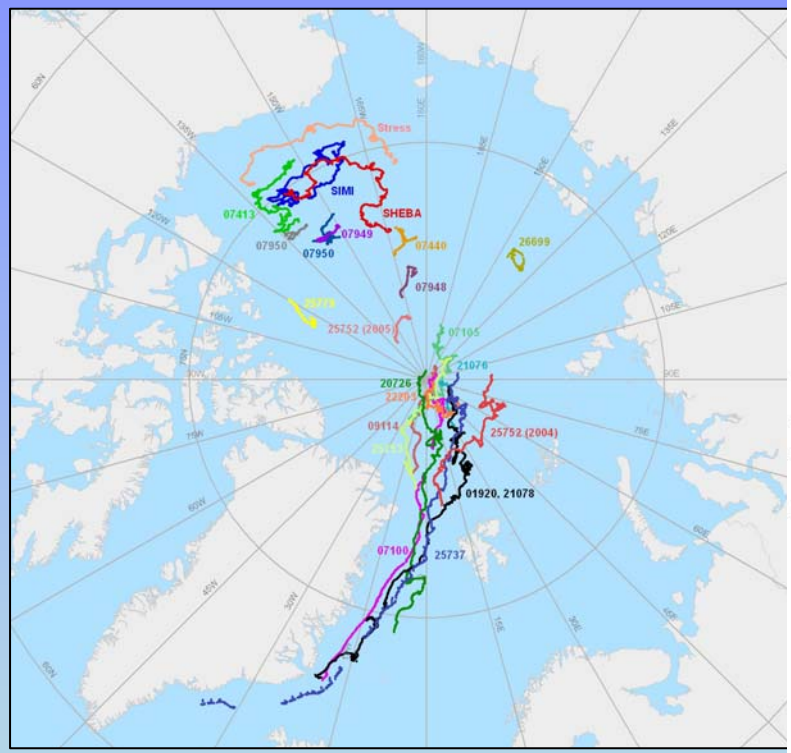
Why the Record Sea Ice Loss in Summer 2007

- Positive mode of Dipole Anomaly predominated
- Southerly winds forced sea ice toward Russia and into transpolar drift
- Accentuated ice export, input of Pacific water, and albedo feedback

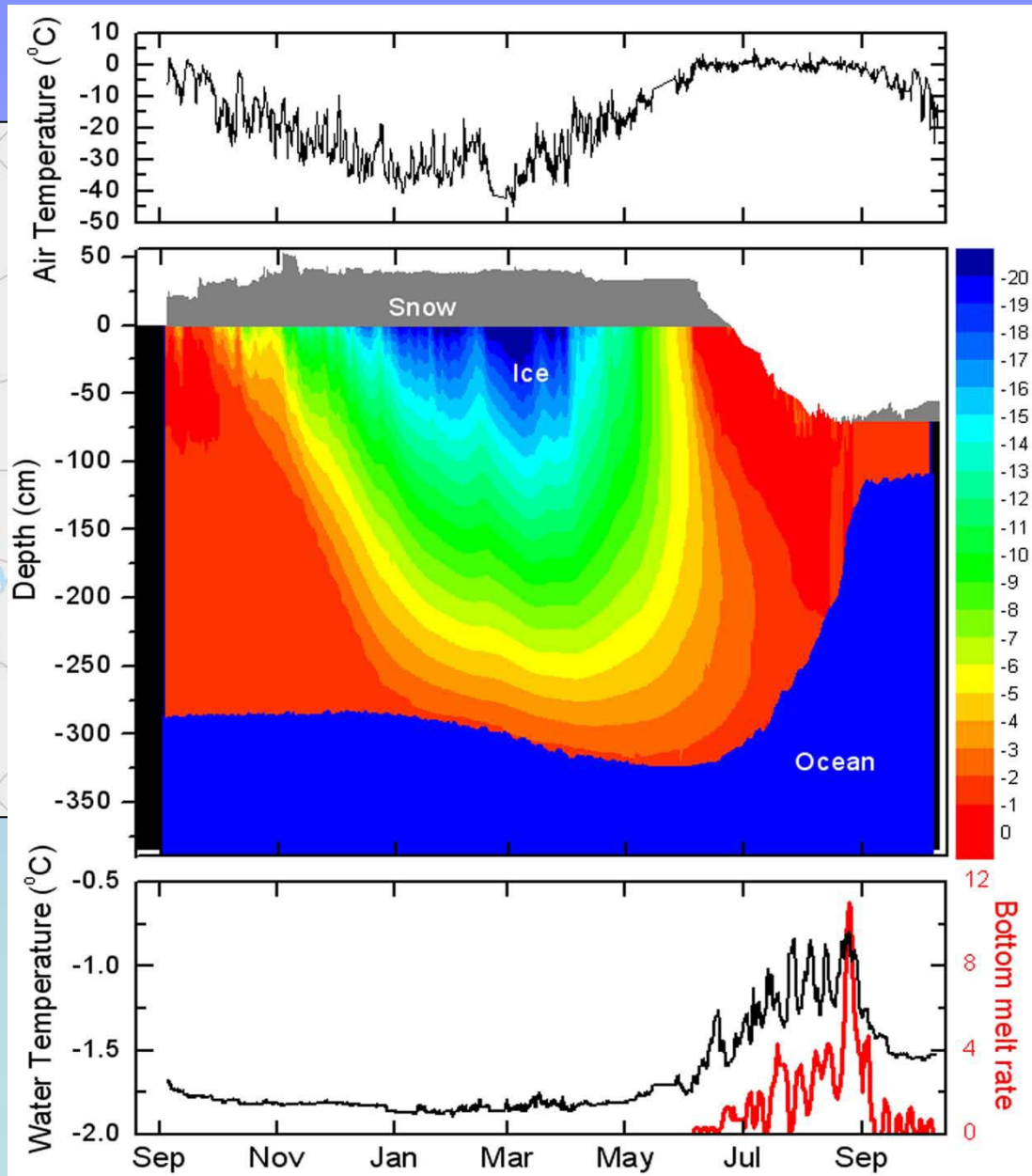
(J. Wang, NOAA-GLERL)



Ice Mass Balance Buoy Network



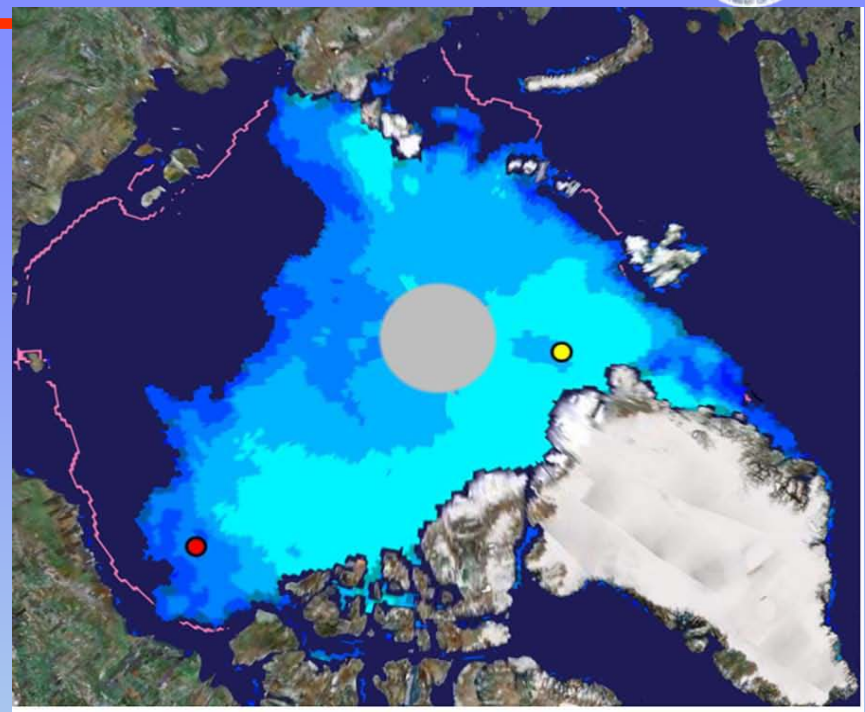
- Repeated installations:
  - North Pole Environmental Observatory
  - Beaufort Gyre
- IPY deployments as part of Arctic Observing Network

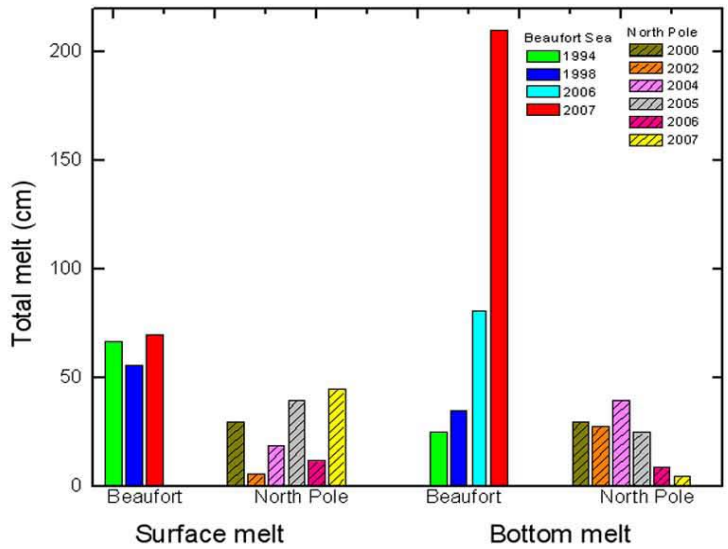


2007 IMB Data

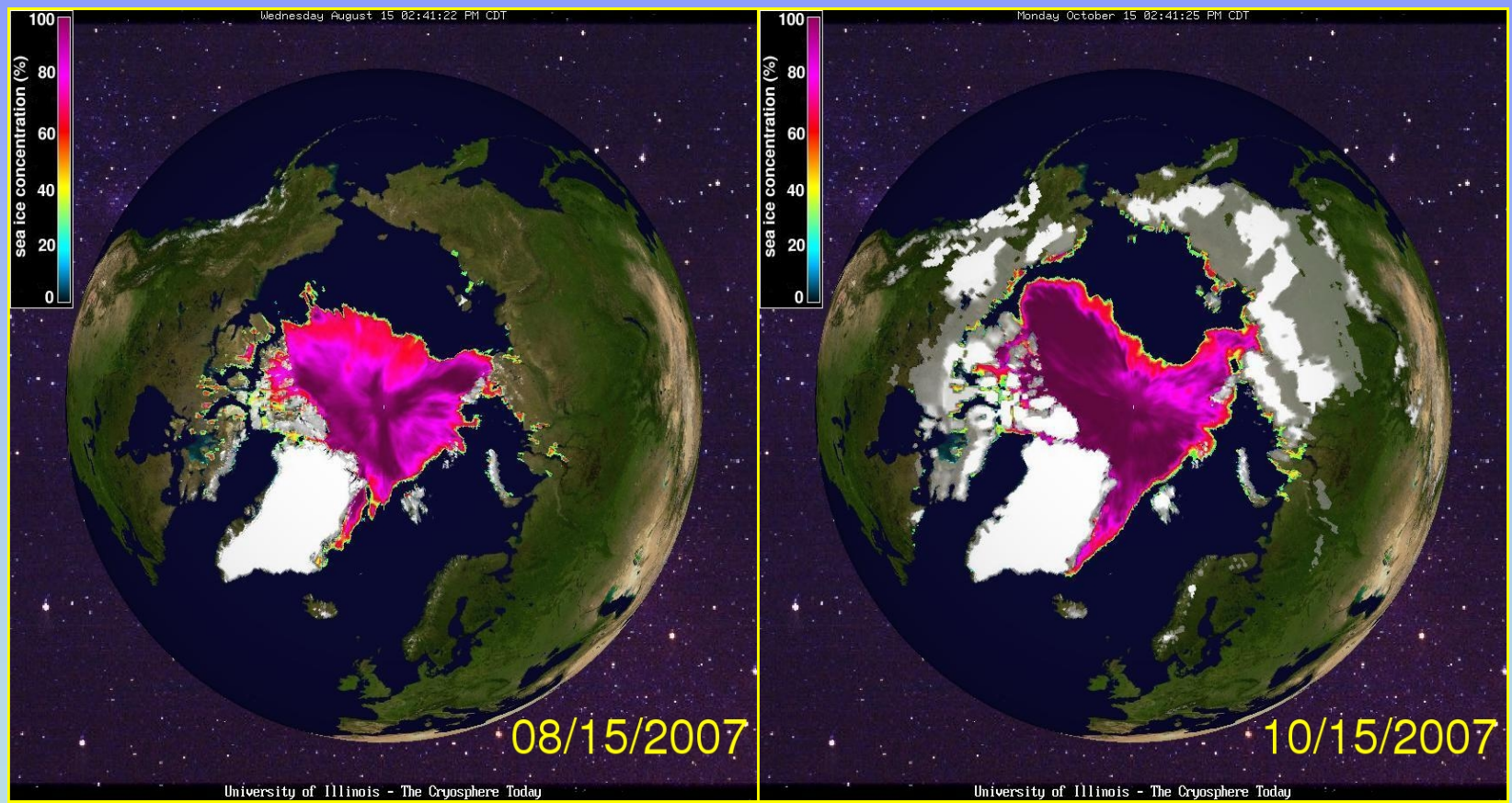
- Large bottom melting of Beaufort Sea ice in summer 2007
- Implies heat from upper ocean was responsible
- Open water area double in summer 2007 relative to climatology
- Up to 500% more solar heat captured by ocean in buoy drift area in ’07

(Perovich et al, 2008)





Before and After the Minimum



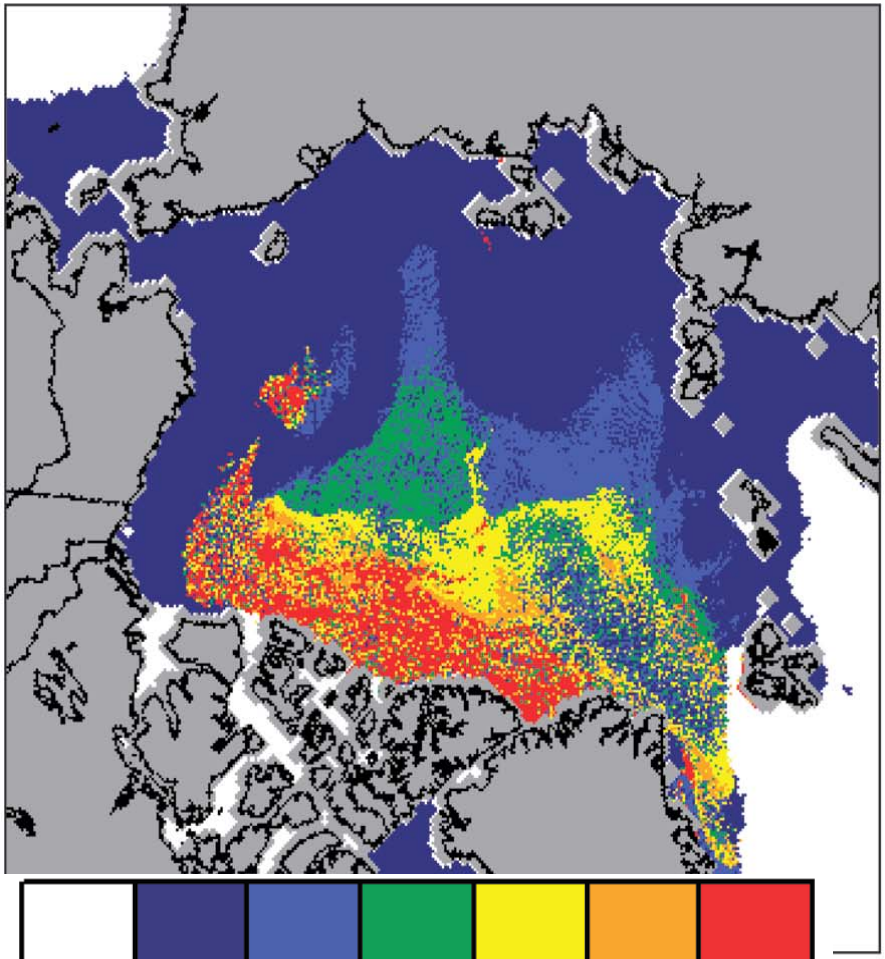
Sea Ice Facts From NSIDC

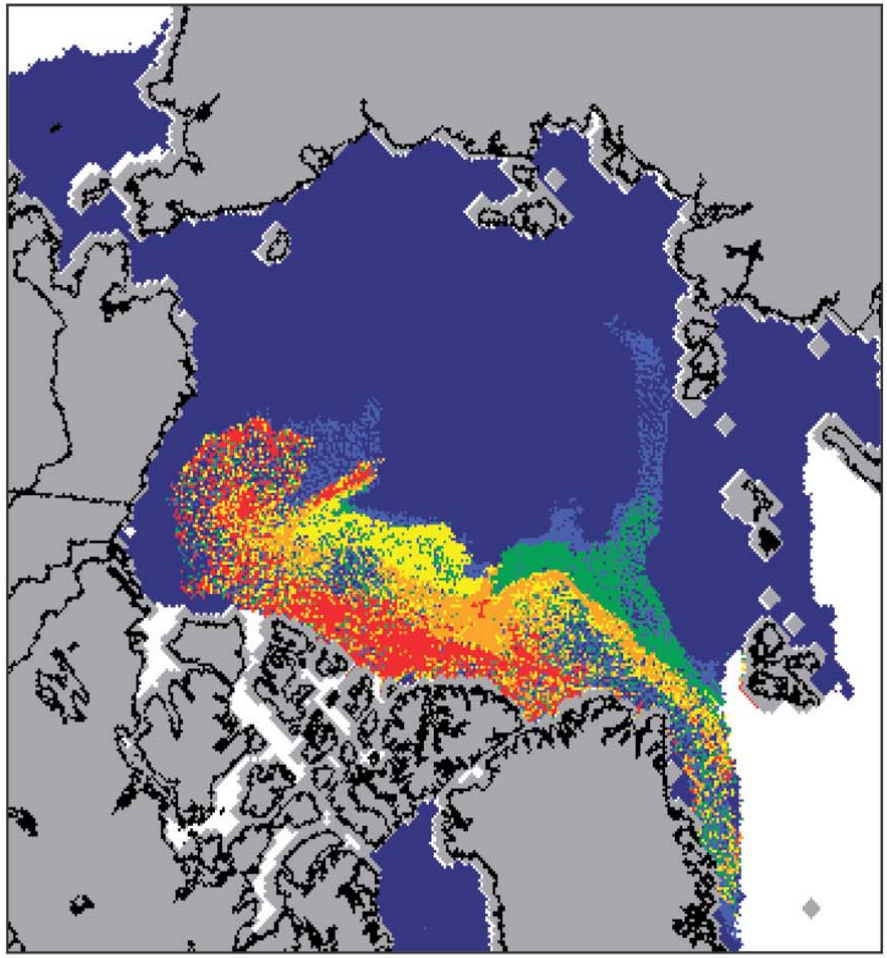
- Sept. 07 record sea ice minimum of 4.28 million km^2; 23% less than 2005 previous record
- Five year old and older sea ice now accounts for only 10% of ice pack; this is mostly concentrated along the Canadian Archipelago
- In spring 2007, the amount of first year ice was 58%; but in spring 2008, 77% is first year ice
- Seasonal ice cover is 5-10 cm thinner in spring 08 than in spring 07

Thick Ice is Diminishing

March 2007

March 2008





MULTI-YEAR ICE AMOUNTS

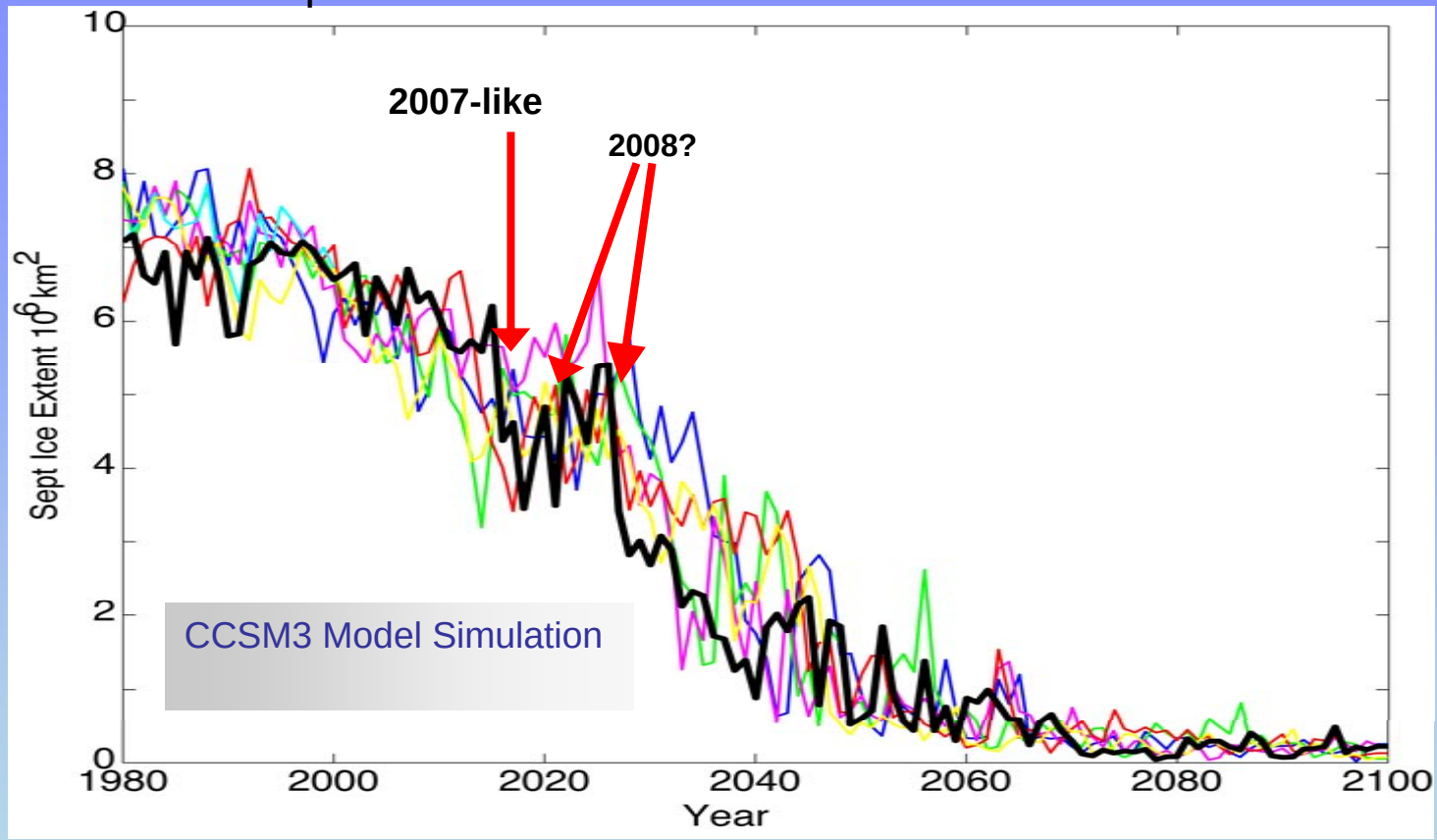
(From Ron Kwok)

Summer 2008 Sea Ice?

- International community of sea ice experts are pooling their knowledge to create an “outlook” for the September minimum - to be released on June 6
- Anomalous winds of 2007 may not repeat, but more extensive and thinner ice existing in spring 2008 will be easier to melt
- Most expect a very great area of open water, but perhaps not another record, while there are arguments for another large drop in sea ice extent

Ahead of the Curve?

September Sea Ice Extent



Plausible Physics

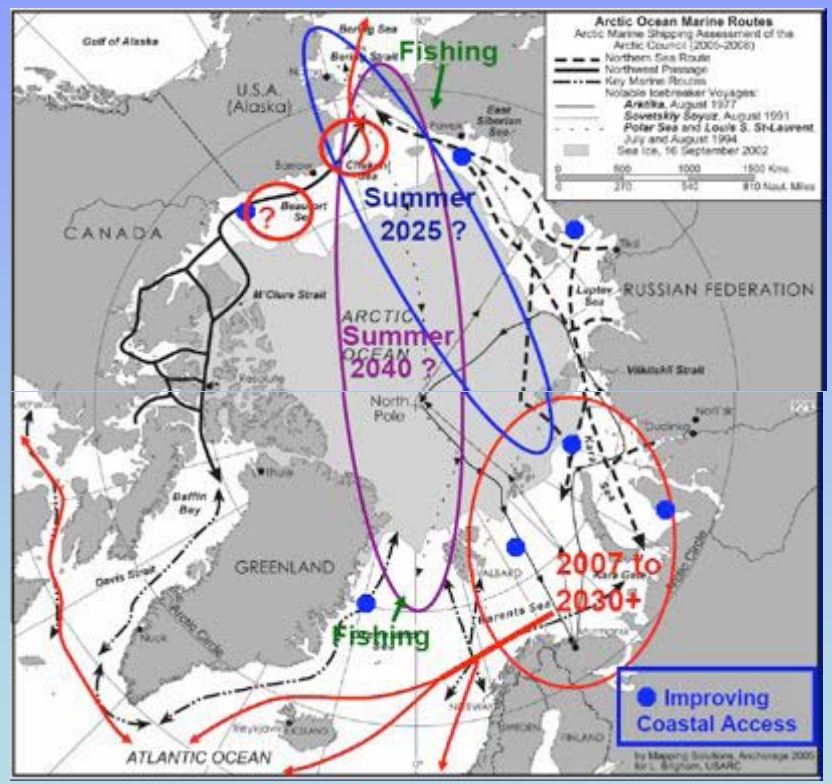
Anthropogenic + Unusual Climate patterns + Ice/ocean feedbacks
= NEW STATE

Marika Holland, Cecilia Bitz, Bruno Tremblay, Julienne Stroeve

Speculative Access to the Arctic

- Global warming and sea ice retreat are fueling speculation about access to the Arctic for shipping, mineral resources, fishery development, and other uses
- Military and homeland security issues are emerging
- Scenarios ranging from peaceful co-development to armed competition have been prepared
- Greater regional governance (UNCLOS, IMO, ~~treaty~~, emergency response) seems inevitable and desirable

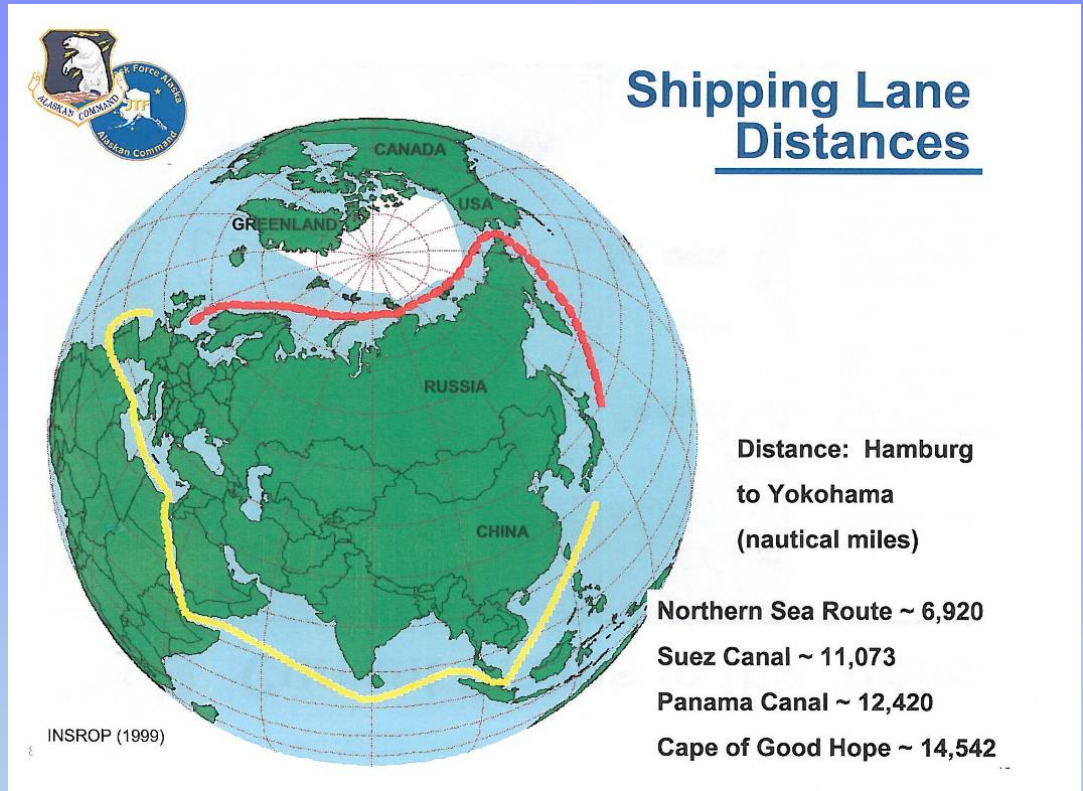
(Arctic Foreign Ministers say "treaty" not needed. May, 2008)



The Ice-Free Arctic

- Such a state has not yet occurred
- Ice-free shipping channels existed in summer 2007 for a few weeks
- By 2050, there may be 2-3 months of ice-free channels
- The Northern sea route from Europe to Asia is 4,500 miles shorter - a 40% savings for commercial shipping

- For reliable, year-round Arctic shipping, ice-capable cargo vessels (and ice breaker escorts?) are likely to be needed for a very long time
- However, much of the Arctic, even in winter, will be covered in first year ice, ~ 1m thick, so transit across the Arctic will be feasible with proper ships



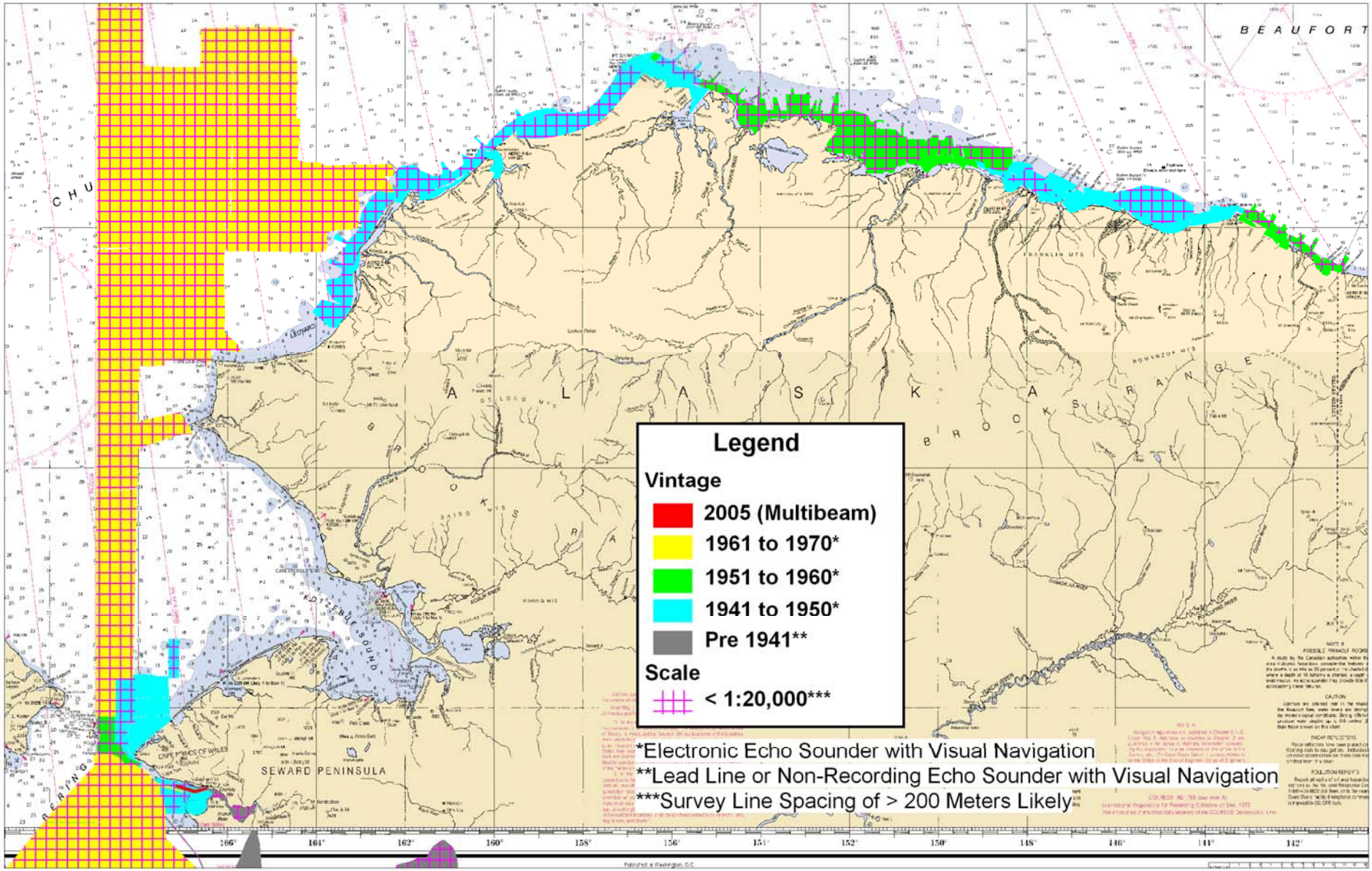
NOAA Services to Arctic Marine Transportation

- Weather forecasts, warnings of extreme events
- Climate outlooks and trends
- Ocean and ice services
- Marine living resources

Ocean Services

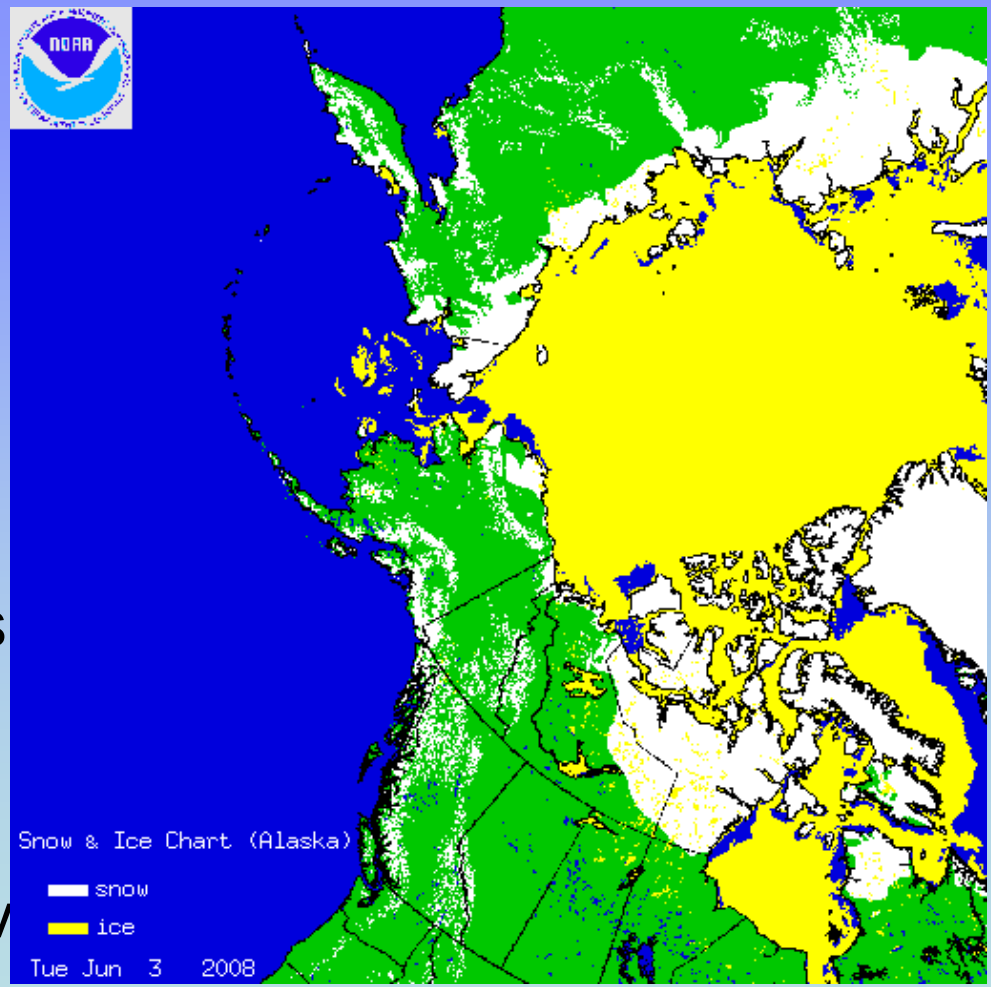
- Water levels and currents
- Shoreline determination and bathymetry for nautical charting
  - Russian charts from 1800's are source for some Alaskan hydrographic data
- Fundamental geospatial infrastructure
  - Tools for accurate positioning
  - Heights/elevations
- Response to emergencies or spills
  - Where might oil go? What treatment is best?
  - Safety of response vessels in uncharted waters?
- Marine Protected Areas
  - Should they be created in the Alaskan Arctic?

NOAA Hydrography Vintage
Northern Slope of Alaska
6/1/08



National Ice Center

- Ice services tailored to meet the operational requirements of U.S. national interests
- Specialized meteorological and oceanographic services to United States government agencies
- Web-based distribution at www.natice.noaa.gov

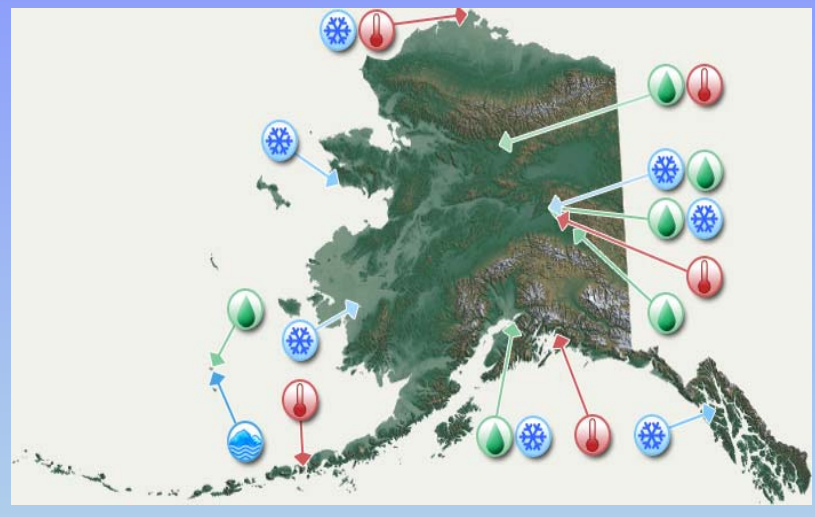


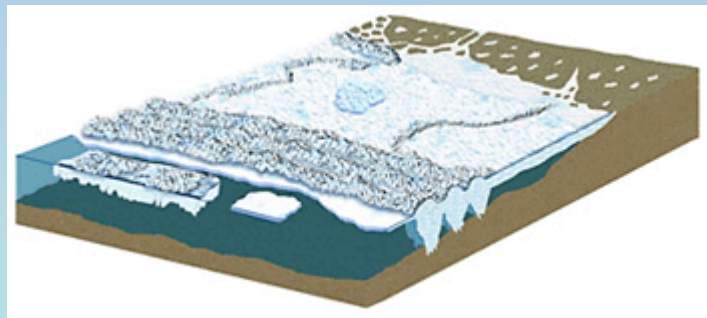
Marine Living Resources

- Expansion of commercial or subsistence fisheries to new northern areas
  - More fishing vessels, more risk
- Marine mammal conservation and protection
  - More vessel traffic, more risk
- Consultation on new development or transportation
  - Possible new regulations and restrictions to protect whales and seals

Regional Integrated Sciences and Assessments

- NOAA supports the Alaska Center for Climate Assessment and Policy
  - Assess impacts of climate variability in Alaska, make this information available to local and regional decision-makers, and improve the ability of Alaskans to adapt to a changing climate
  - Sea ice is a major focus area





NOAA Science and Service

- NOAA science will provide essential information to describe and anticipate change in the Arctic environment
- NOAA services will aid business and society to use information to their benefit
- NOAA will manage aspects of the Arctic to conserve and protect resources

Thank You!!