A NASA Look from Space at Changes in the Arctic

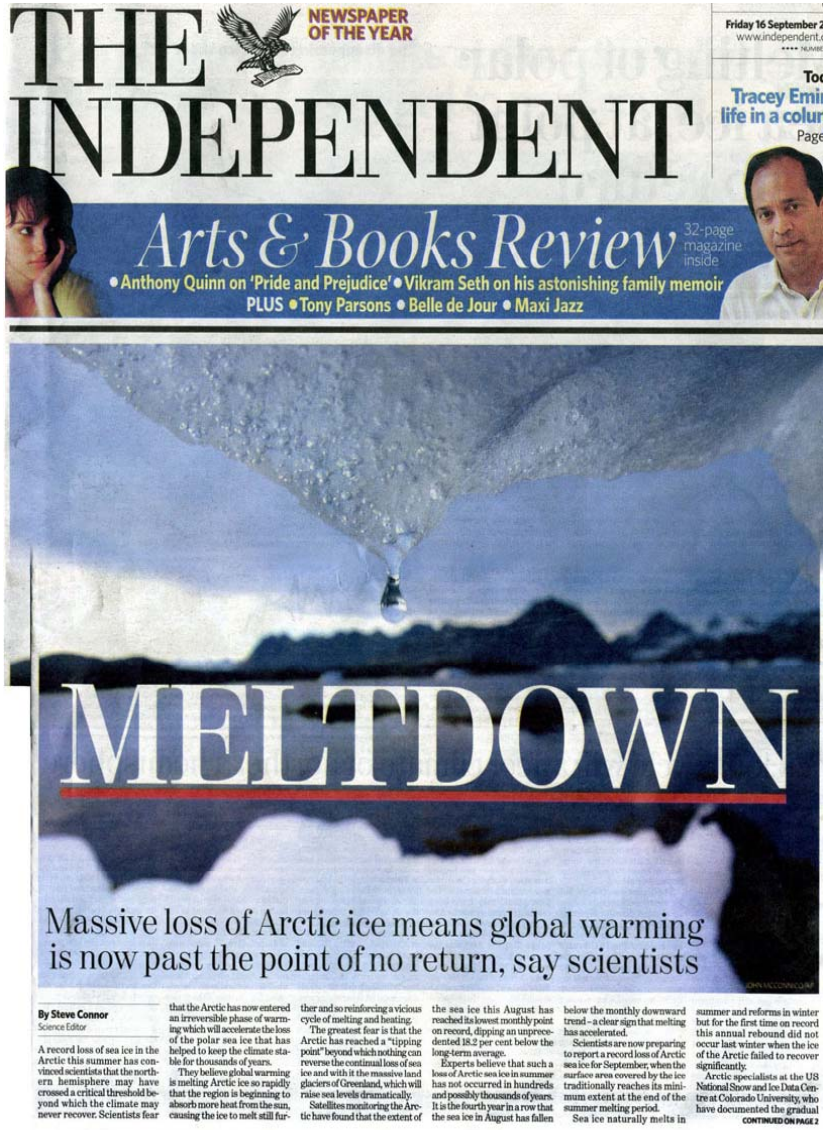
James Maslanik and Chuck Fowler, CCAR, University of Colorado

Julienne Stroeve and Terry Haran, NSIDC, University of Colorado

Ronald Kwok, Jet Propulsion Laboratory

Seymour Laxon, University College, London

Diminishing sea ice area-passive microwave



THE INDEPENDENT

NEWSPAPER OF THE YEAR

Friday 16 September

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MELTDOWN

Massive loss of Arctic ice means global warming is now past the point of no return, say scientists

By Steve Connor
Science Editor

A record loss of sea ice in the Arctic this summer has convinced scientists that the northern hemisphere may have crossed a critical threshold beyond which the climate may never recover. Scientists fear that the Arctic has now entered an irreversible phase of warming which will accelerate the loss of the polar sea ice that has helped to keep the climate stable for thousands of years.

They believe global warming is melting Arctic ice so rapidly that the region is beginning to absorb more heat from the sun, causing the ice to melt still further and so reinforcing a vicious cycle of melting and heating.

The greatest fear is that the Arctic has reached a "tipping point" beyond which nothing can reverse the continual loss of sea ice and with it the massive land glaciers of Greenland, which will raise sea levels dramatically.

Satellites monitoring the Arctic have found that the extent of the sea ice this August has reached its lowest monthly point on record, dipping an unprecedented 18.2 per cent below the long-term average.

Experts believe that such a loss of Arctic sea ice in summer has not occurred in hundreds and possibly thousands of years. It is the fourth year in a row that the sea ice in August has fallen below the monthly downward trend – a clear sign that melting has accelerated.

Scientists are now preparing to report a record loss of Arctic sea ice for September, when the surface area covered by the ice traditionally reaches its minimum extent at the end of the summer melting period.

Sea ice naturally melts in summer and reforms in winter but for the first time on record this annual rebound did not occur last winter when the ice of the Arctic failed to recover significantly.

Arctic specialists at the US National Snow and Ice Data Centre at Colorado University, who have documented the gradual

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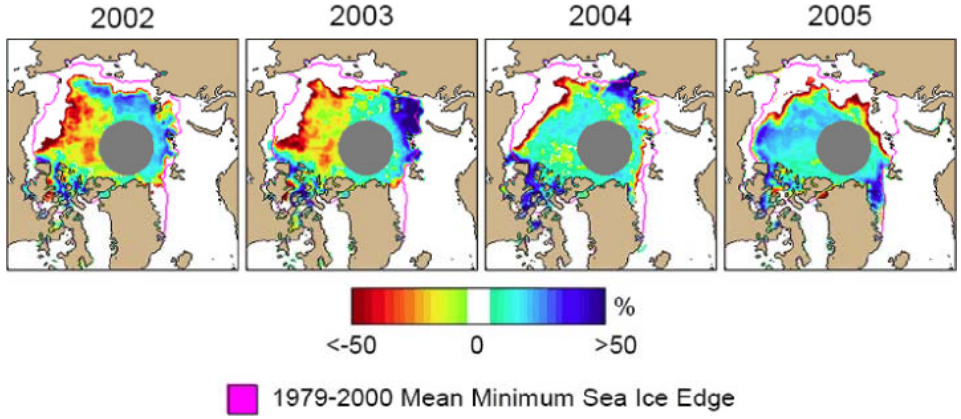
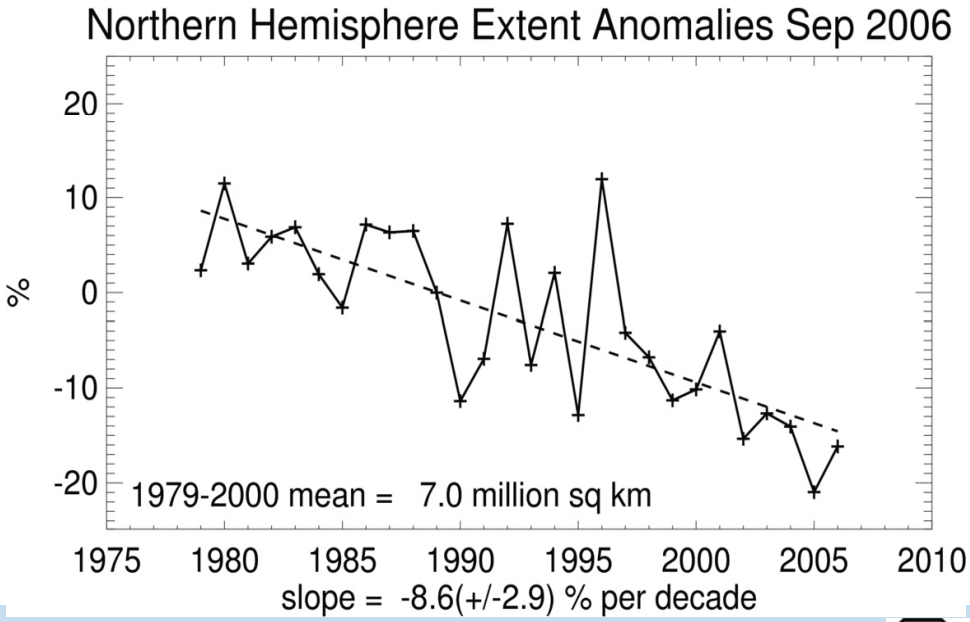
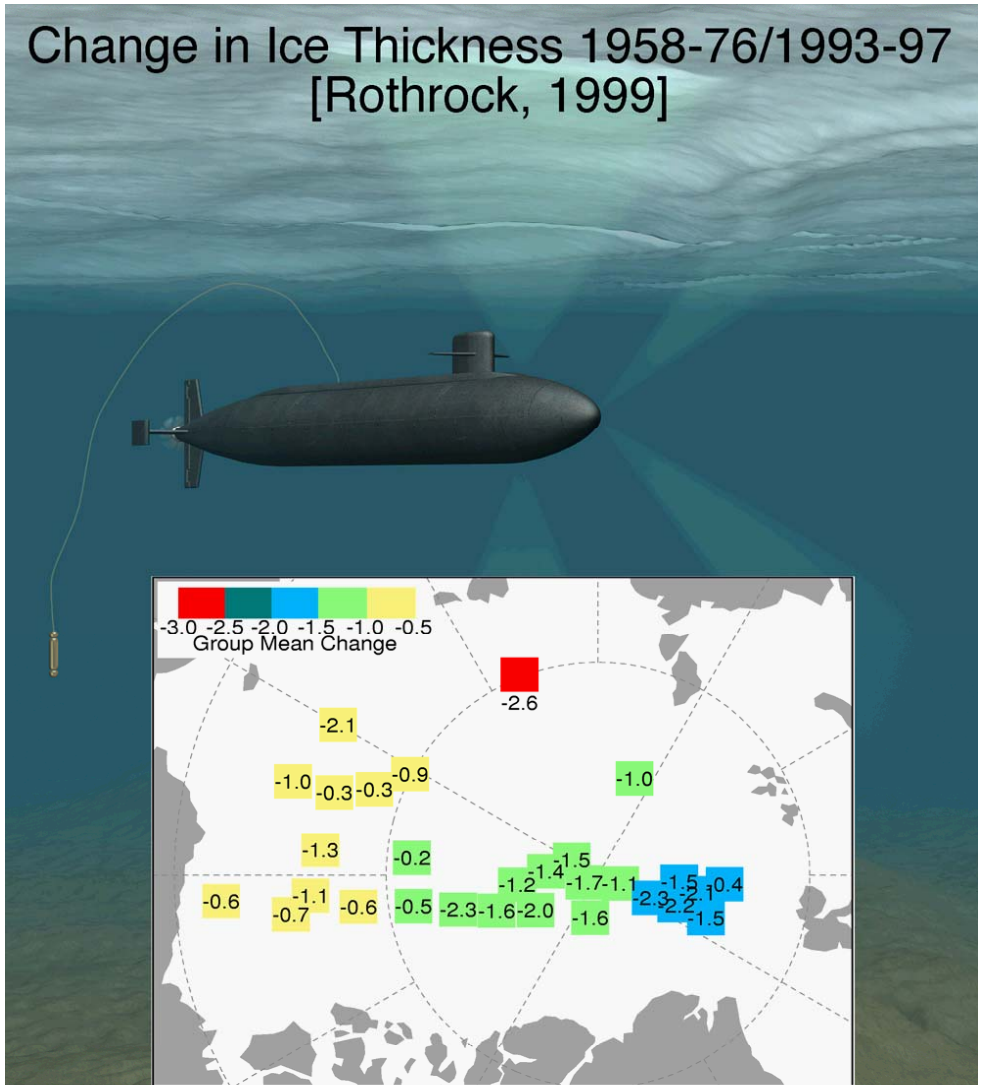


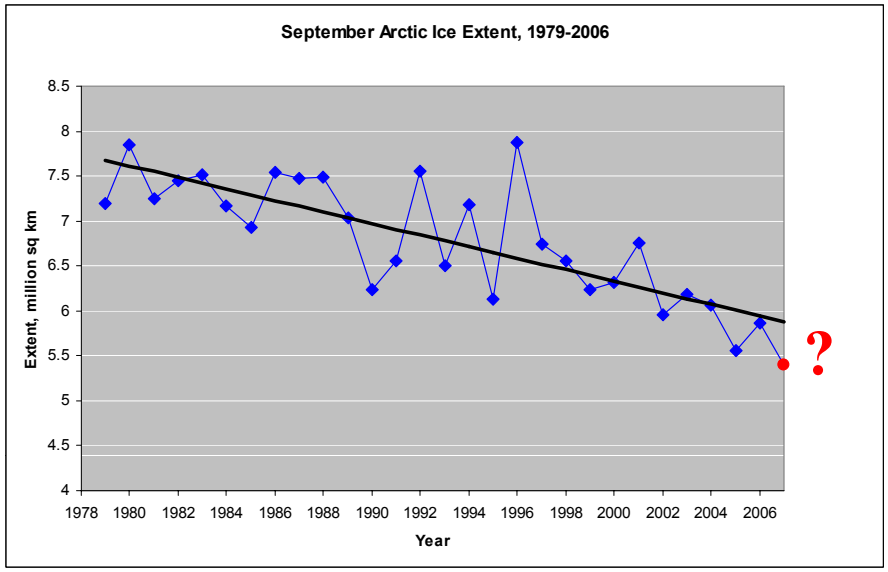


Submarine Observations of Thinning



Research Problem

- We know from satellite observations that the areal extent of sea ice is rapidly declining but except for Rothrock's pioneering work, we know little about changes in ice volume.
- Ice age data derived from AVHRR Polar Pathfinder (APP) products provide insights into trends and spatial variations in sea ice age from 1979 – present.
- GLAS data can provide information on ice thickness, but only from 2003 – present.



September ice extent trend = -9%/decade

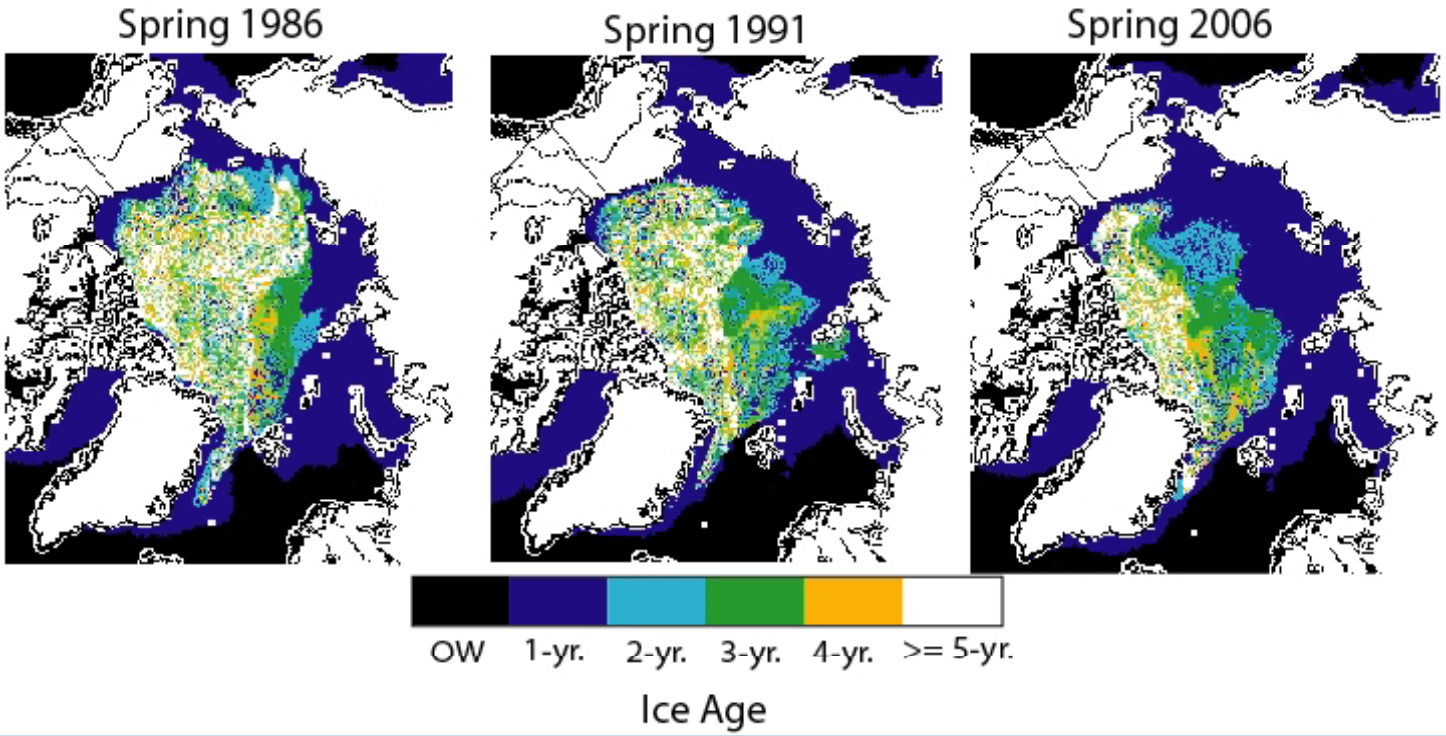
Can we use relationships between GLAS-derived ice thickness and Pathfinder ice age to reconstruct ice thickness variations back to 1979?

Data Sources

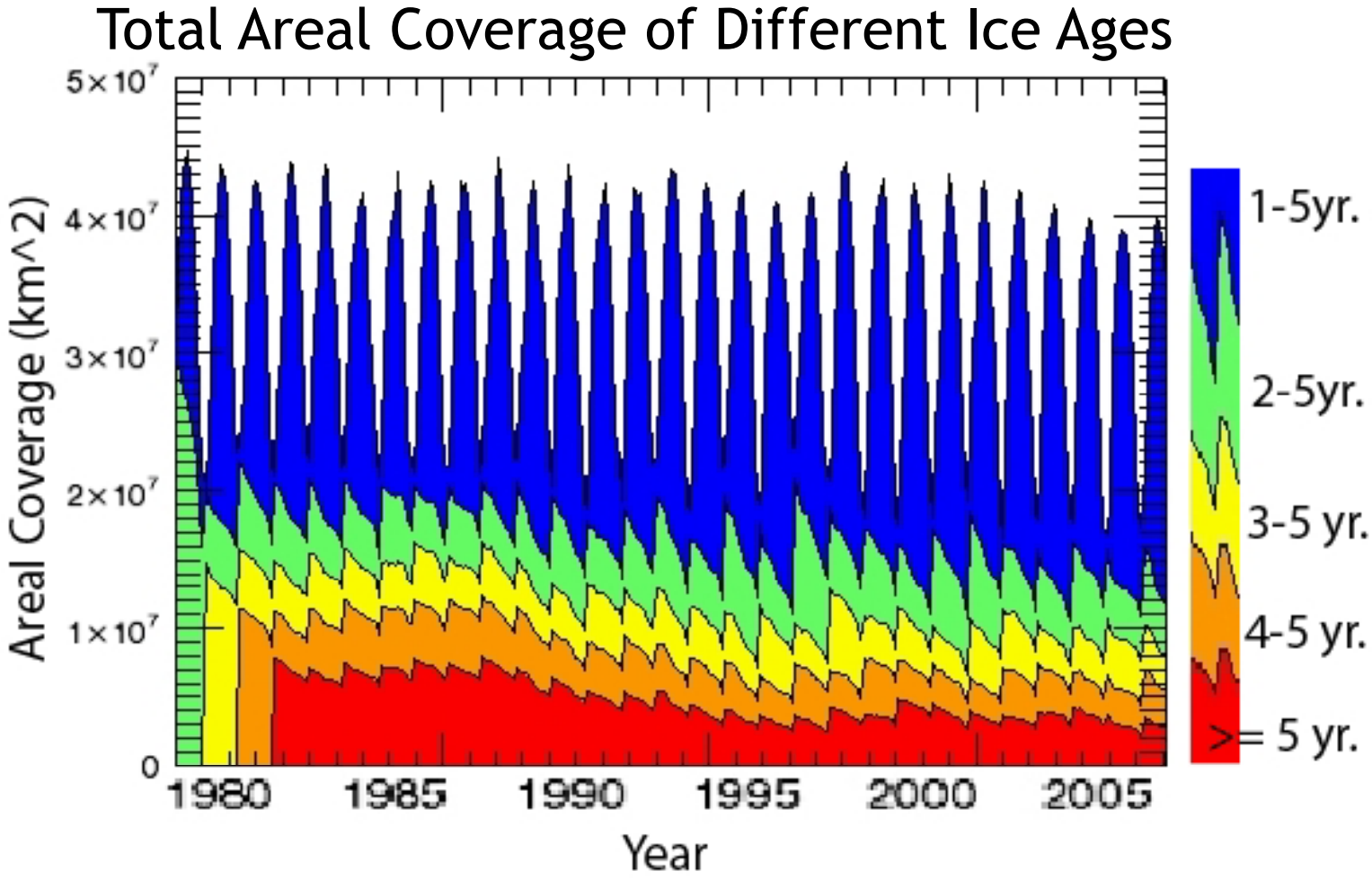
- Ice age is estimated using Langrangian tracking of ice drift estimated from Pathfinder-derived ice motion fields combined with daily sea ice extent maps from passive microwave (Fowler et al., 2004).
  - November 1979 to present
- GLAS-derived ice thickness fields provided by Donghui Yi/Jay Zwally/ Ron Kwok
  - Spring 2003 to Fall 2006

Spatial and Temporal Variability in Ice Age

- Results indicate area of oldest (> 4 yrs) ice is decreasing in the Arctic Basin and is being replaced by younger, First Year Ice
- Older ice retreats to small area north of the Canadian Archipelego, with narrow bands that spread across the central Arctic



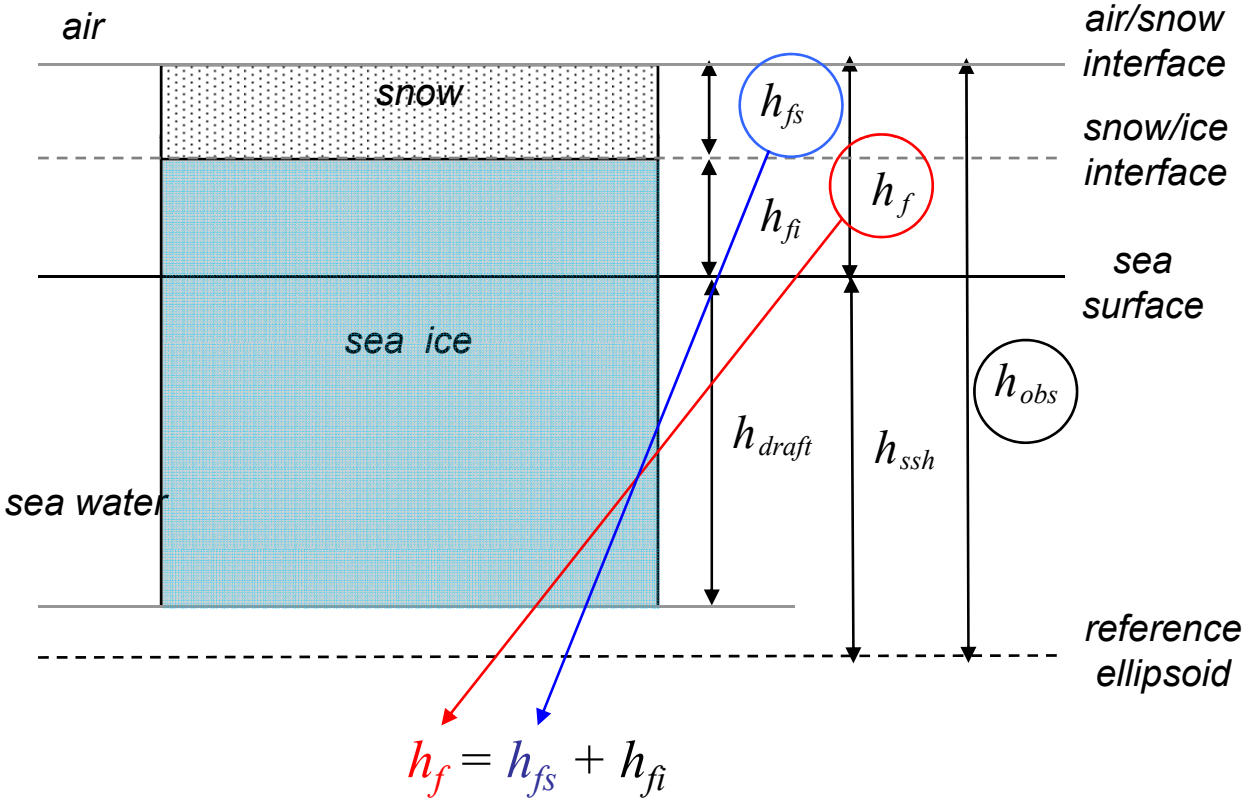
Temporal Variability in Ice Age



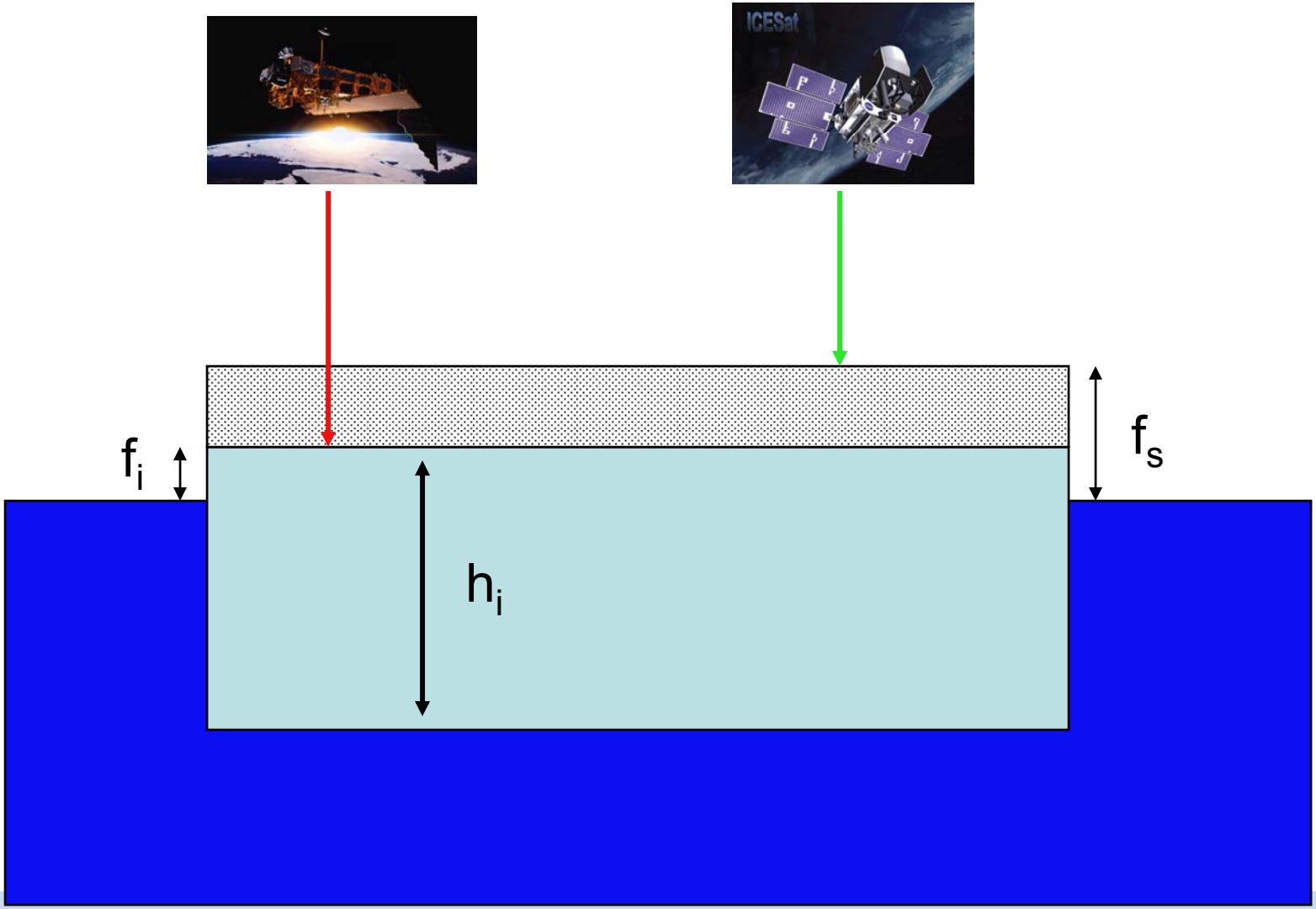
Over last few years, not much overall change in oldest ice, but it's now located over a much smaller region of the Arctic Basin.

GLAS Snow depth, Ice Thickness and Freeboard

ICESat measures height of snow surface relative to sea surface; in order to determine freeboard, we must estimate snow depth. This involves at least three factors: snow fall, ice advection, and an estimate of snow density.



The Importance of snow



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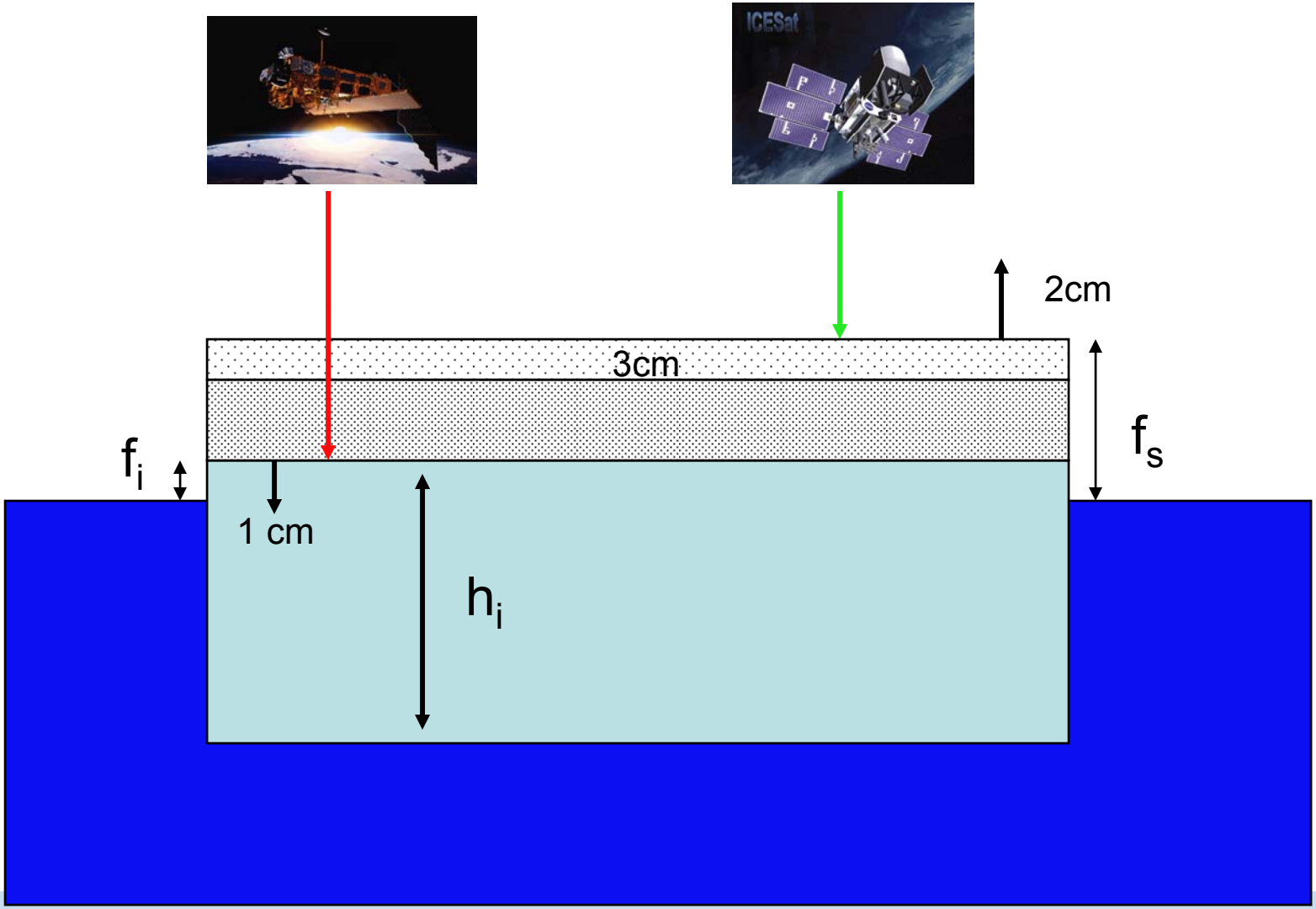
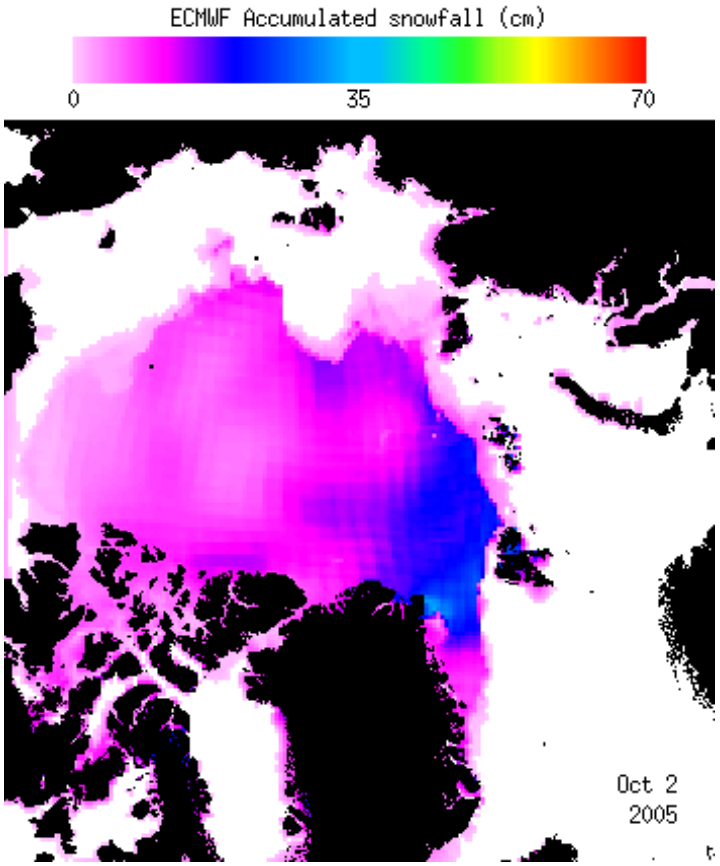
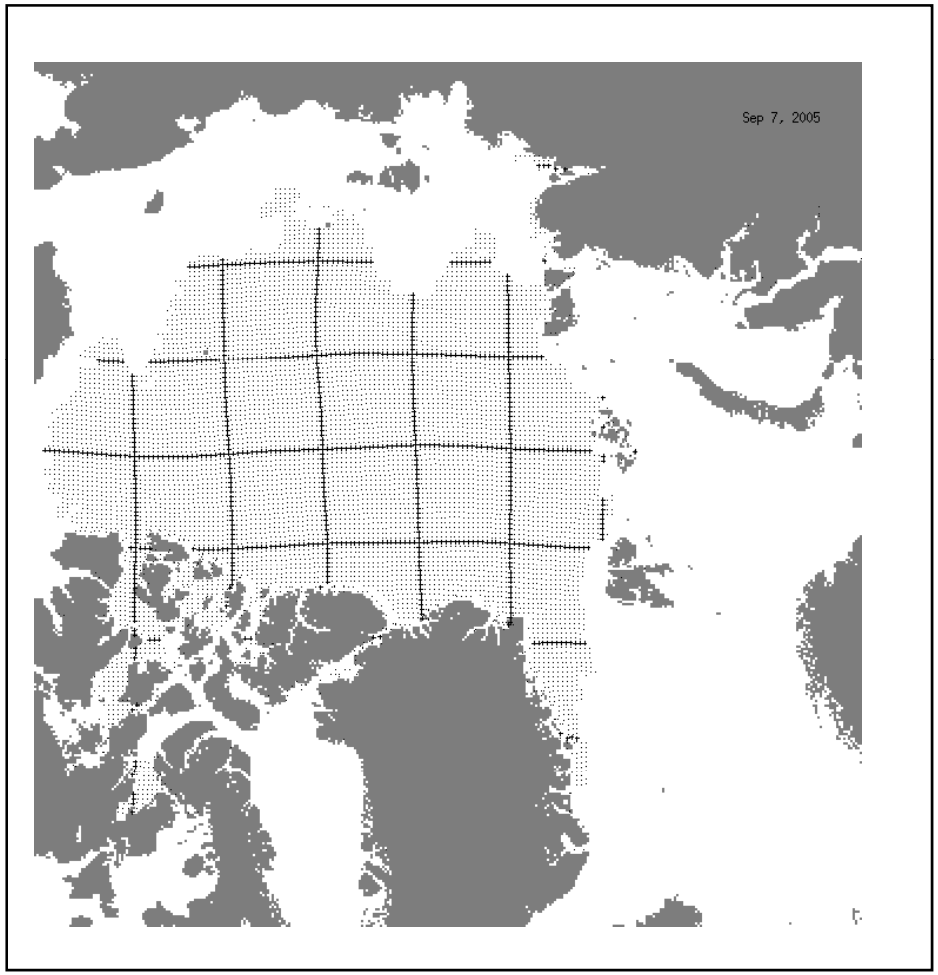


ECMWF Accumulated Snowfall (cm)



Advection with AMSR-E ice motion



Ice mass balance buoys deployed by CRREL

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

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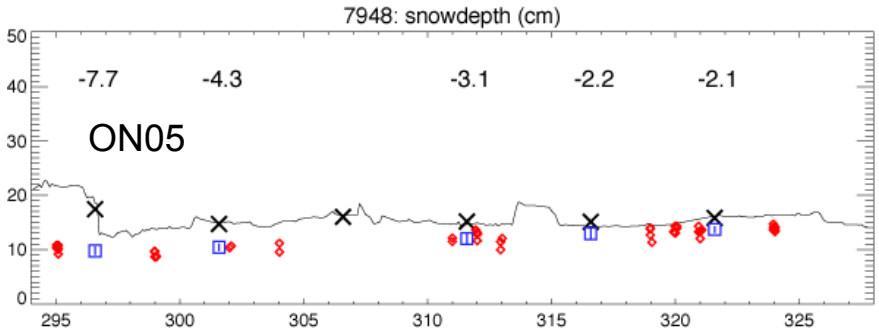
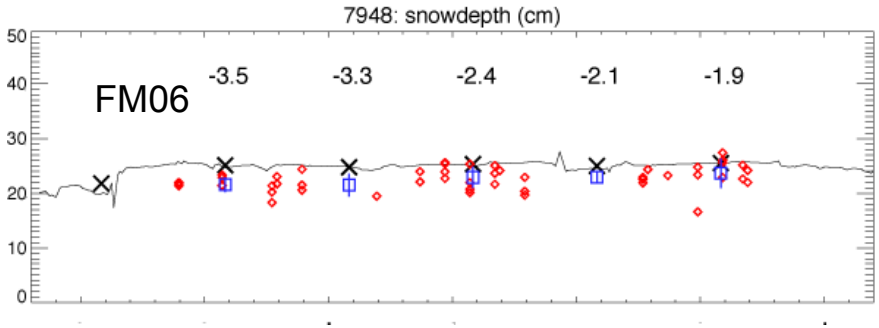
Measurements:
Thickness, snow depth, ice temperature profile, surface pressure, air/water temperature.

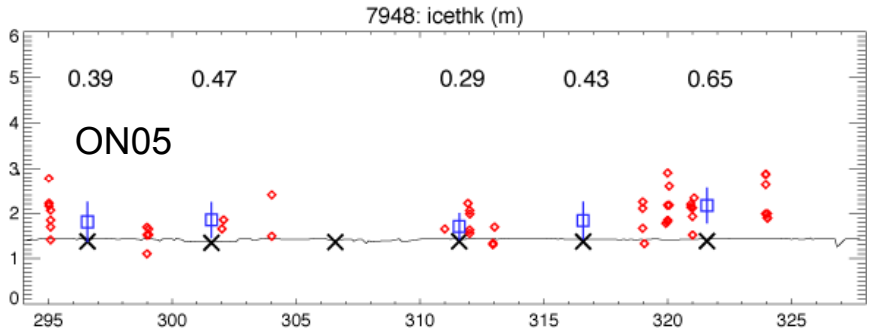
Comparison of ICESat with mass balance buoy

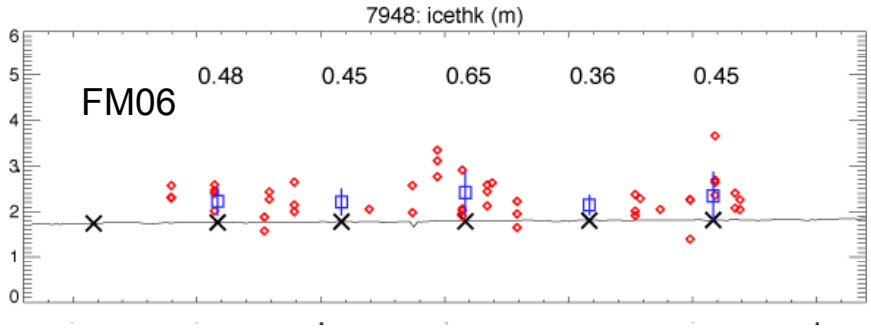
Snow depth



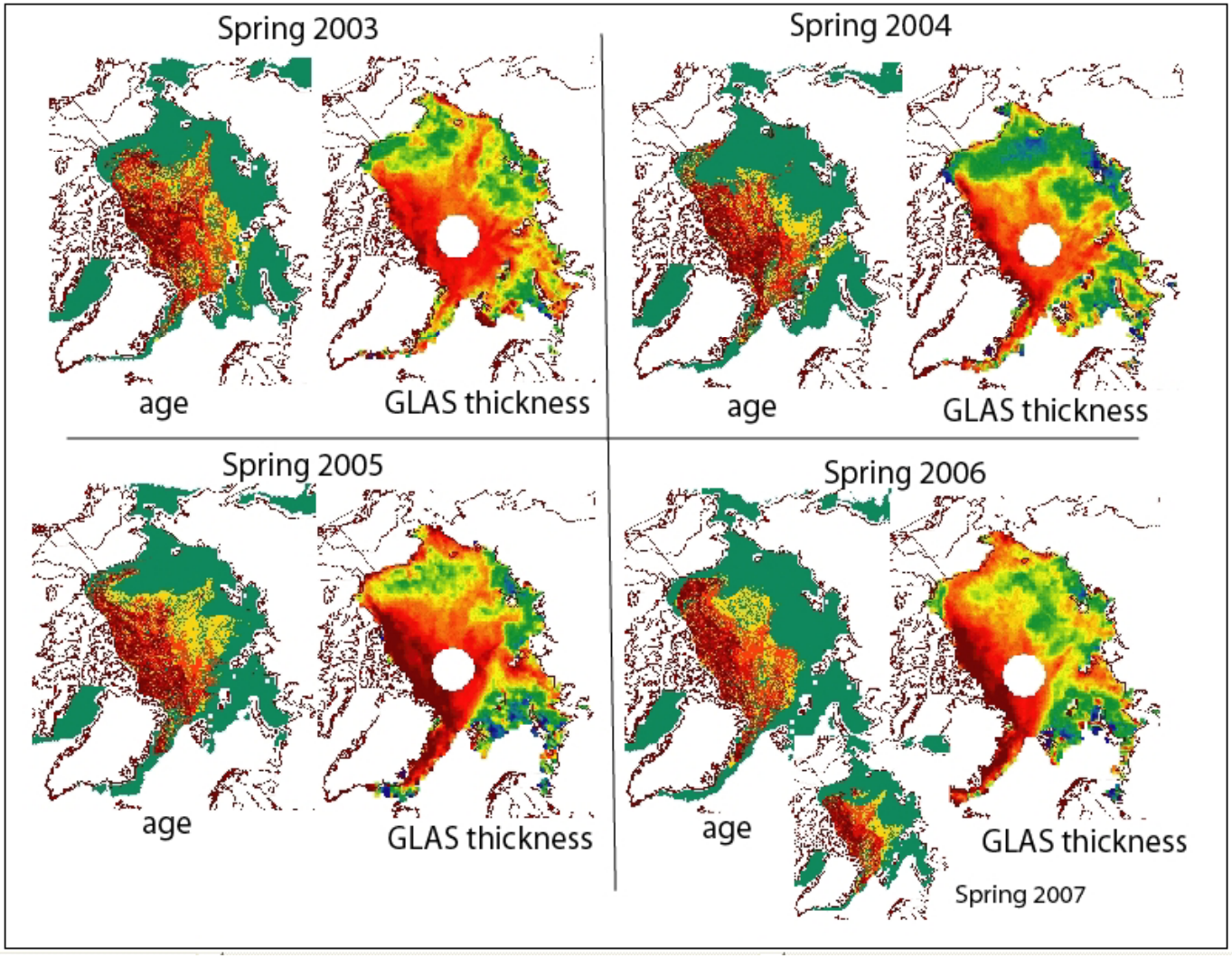


Thickness



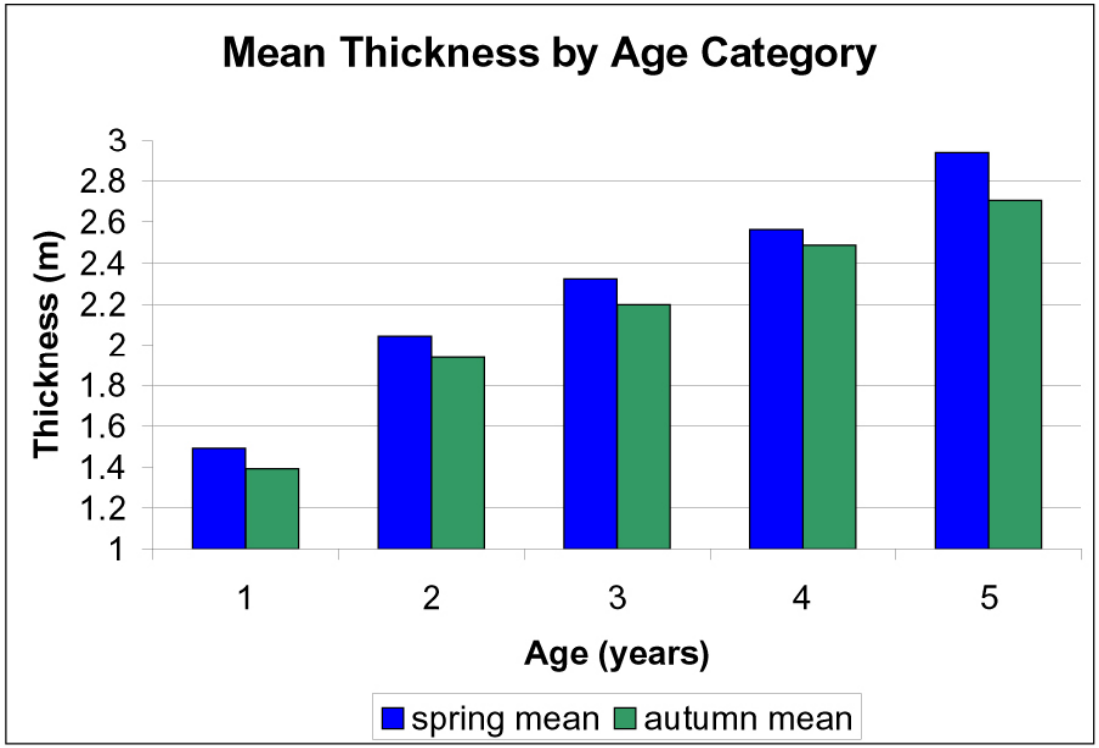


Ice Age and GLAS-Estimated Ice Thickness



Relationship between Thickness and Age

- Results suggest:
  - Pathfinder ice age can be used as a proxy for ice thickness and
  - Thickness increases nearly linearly with age within the multiyear ice pack.
- Impact?
  - Since 2nd yr ice is thinner than 5 yr ice, a fairly large portion of remaining ice extent is near a thickness threshold for how thick ice needs to be to survive summer melt season.

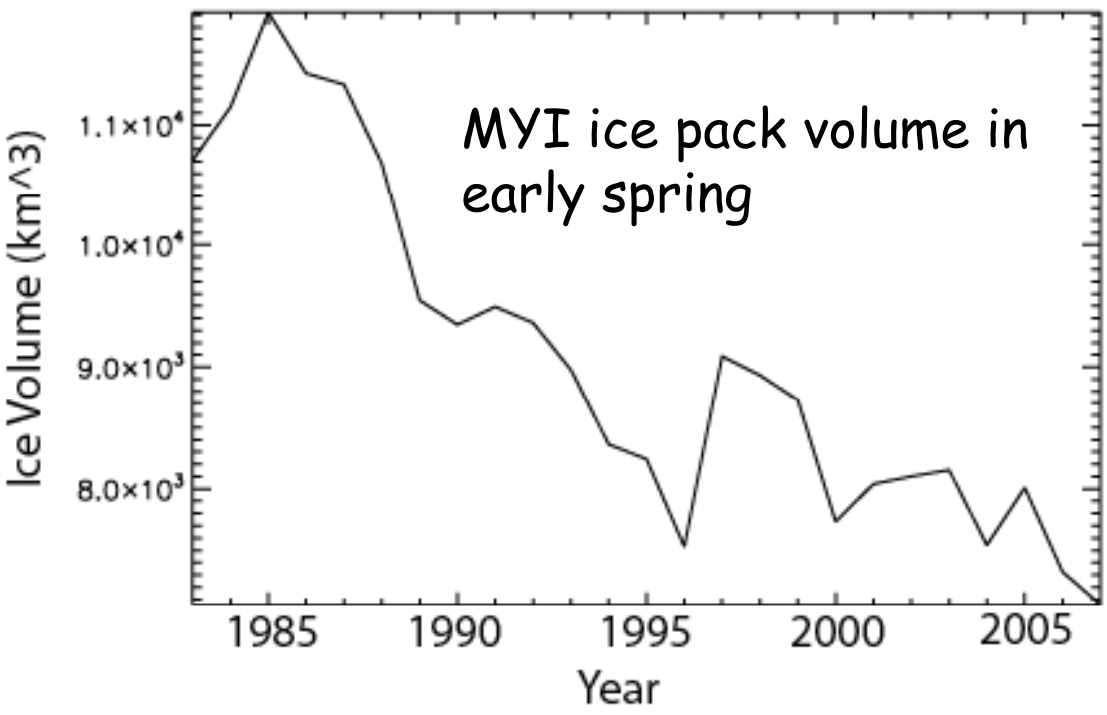


Means averaged over thickness/age for 2003-2006

→ Ice extent may also decrease due to easier ridging/rafting

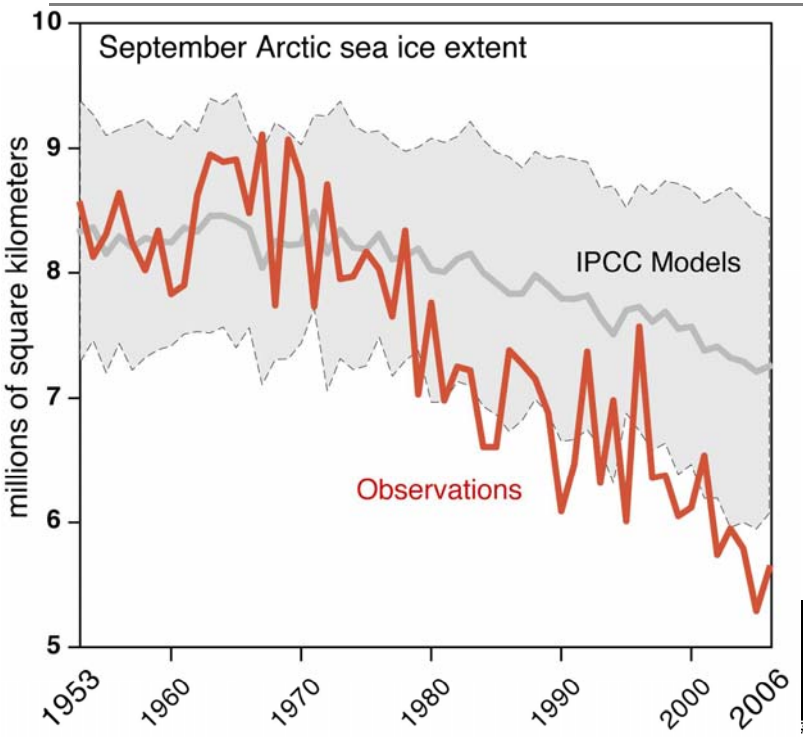
Time-Series of Ice Volume within Perennial Ice Pack

- Assign mean thickness to each age category to produce thickness maps at bi-weekly intervals for 1979-present;
- Calculate ice volume using age-based thickness fields.

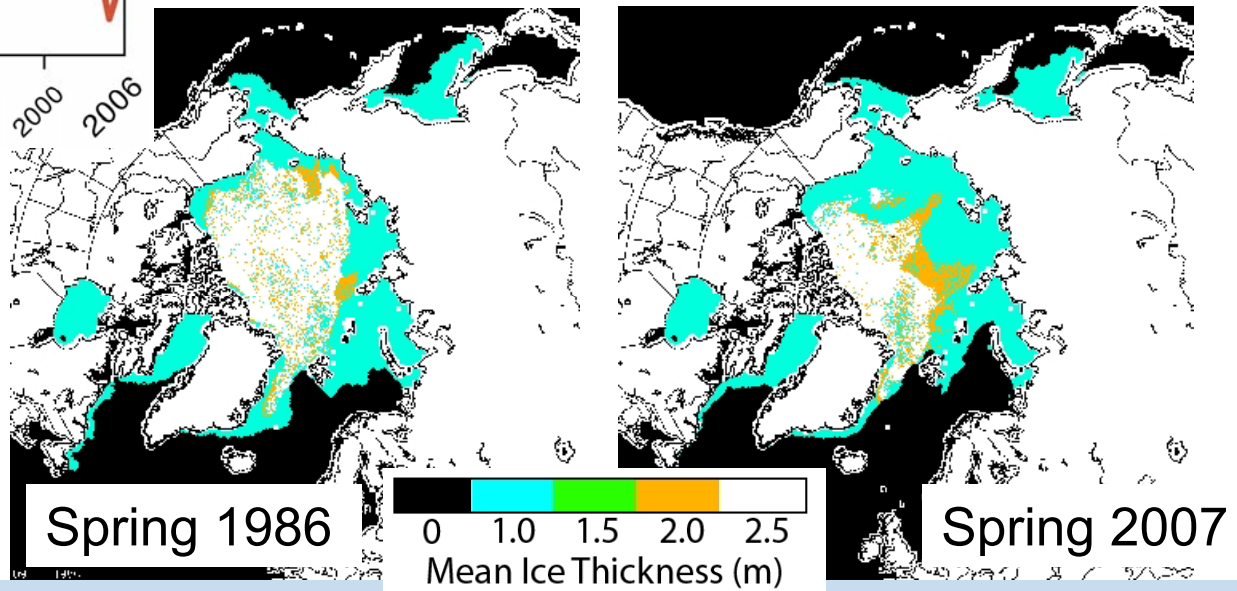


Results suggest a 41% loss in MYI volume from 1985-2006 due to transition to younger ice types

Implications for Decreases in Ice Extent and Thickness



- Little ability of the pack to resist large ice-edge retreats due to melt and/or transport;
- Underestimates of ice extent loss in GCMs may reflect inaccurate simulation of large-scale transport that has helped confine oldest, thickest ice to a small portion of the Arctic Basin in recent years.



Conclusions

- Good correspondence between APP-derived ice age and GLAS-derived ice thickness;
  - Allows us to estimate thickness as a function of age;
  - Changes in ice age distribution since 1979 translate into significant changes in ice thickness and ice volume.
- GLAS-derived thickness estimates appear to be more accurate in spring than autumn;
- PM-derived MYI concentration corresponds to differences in ice ages;
- Oldest, thickest ice is confined to much smaller portion of the Arctic Basin in recent years;
  - Thus, overall loss of ice inferred from shift from MYI to FYI is greater than loss assumed, since there's been a greater loss of the oldest ice w/in the MYI coverage.
- Underestimate of ice loss in GCM simulations may relate to importance of accurately simulating details of ice transport.