Trends and Patterns in Sea Ice Age Distributions within the Arctic Basin, and Their Implications for Changes in Ice Thickness and Albedo

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This presentation will address:

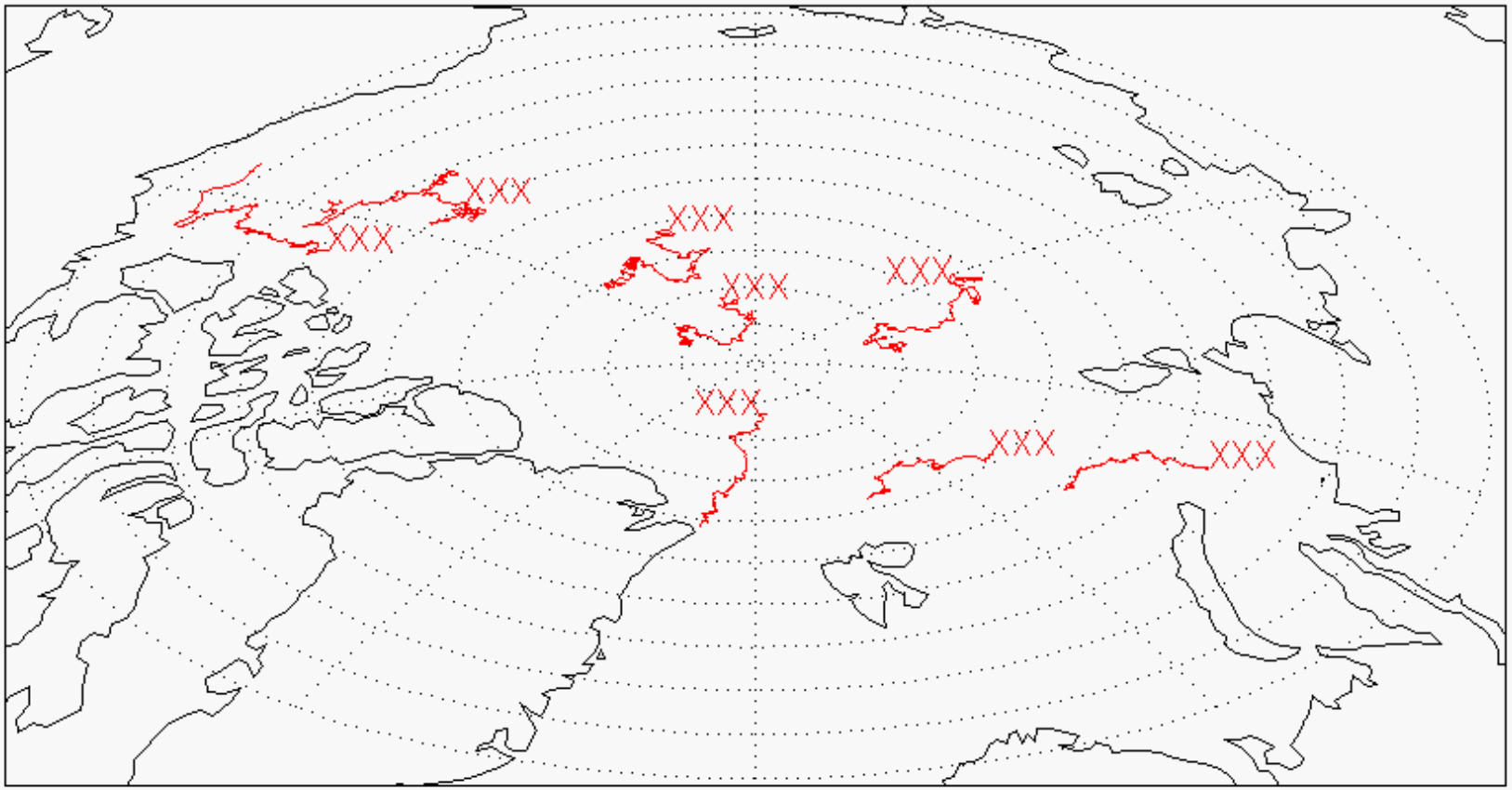
- Recent changes in Arctic ice age distribution and volume
  - CU Ice age research product
- Differences in albedo of FYI vs. MYI – implications of a shift to a first-year ice cover
  - Associated differences in absorption of shortwave energy by these ice types
  - Changes in amount of ice melt

Ice age product

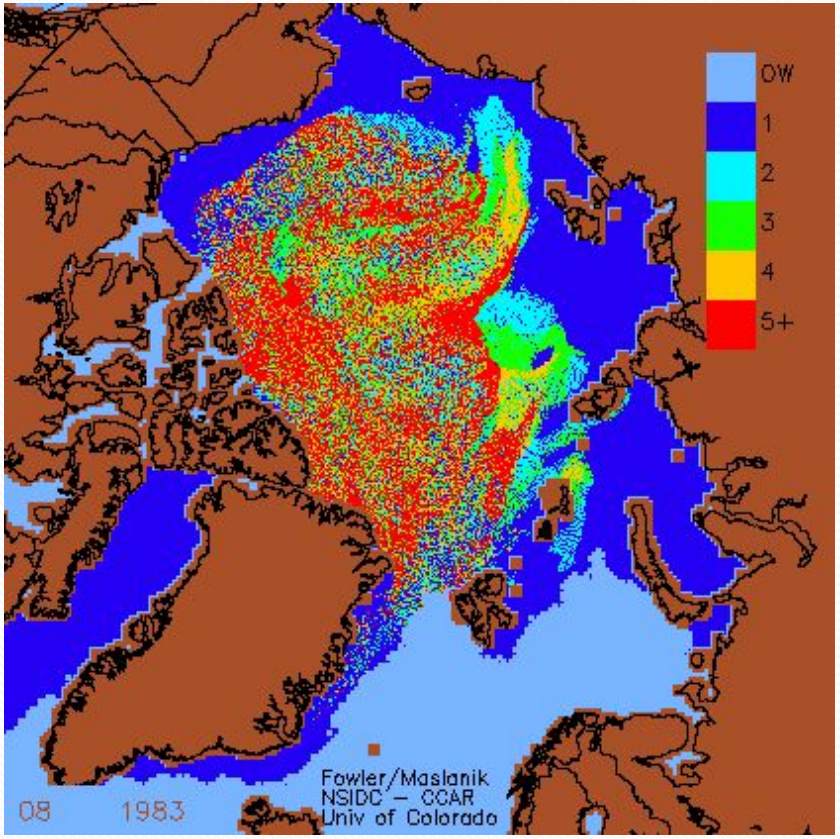
- Weekly, 12km grid
- Uses the Lagrangian ice tracking method and daily ice extent maps to continue following ice parcels (floes) for several years
- Classifies parcels as first-year, second-year, etc. based on how many summer melt seasons the ice parcel survives
- Has been shown to relate to ice thickness (*Maslanik et al., 2007; GRL*)
- See *Fowler et al., 2004*.

Sea Ice Motion

8 one-year drift tracks (2004)



Ice age, last week of Feb (1983-2010)

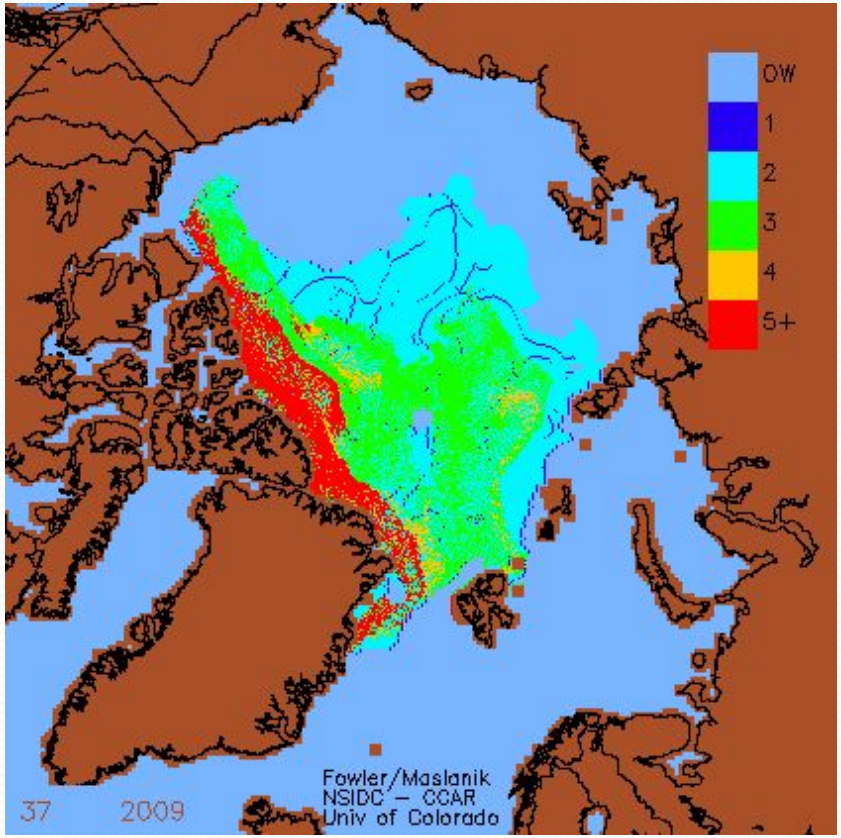


- Bottom left: week 8, year

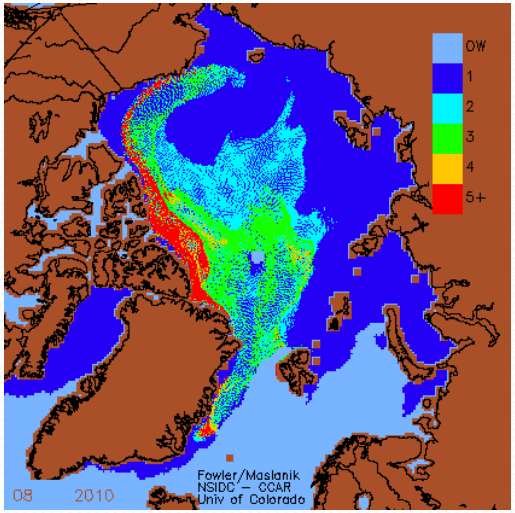
- Transition from a pack with significant amount of old (> 2 yr) ice to a pack dominated by younger ice

- Calculated for ice from 1 to 10 years old

Weekly ice age: July week 1, 2009 – Feb week 4, 2010



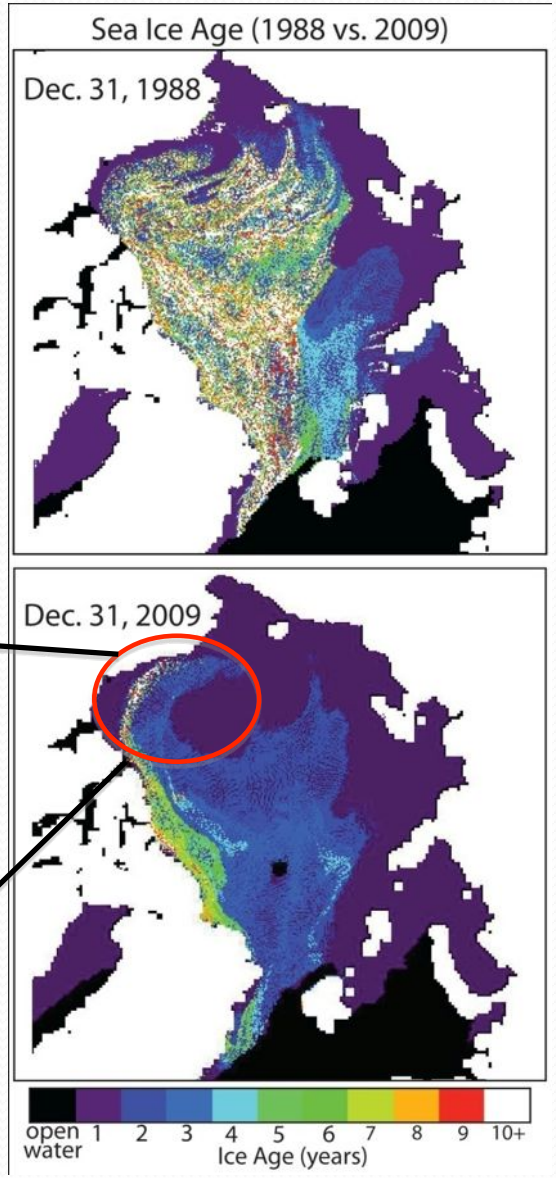
- Bottom left: week #, year
- Mostly first- and second-year ice
- Differentiation by age within the multiyear pack – but is this significant for other physical properties such as thickness and albedo?

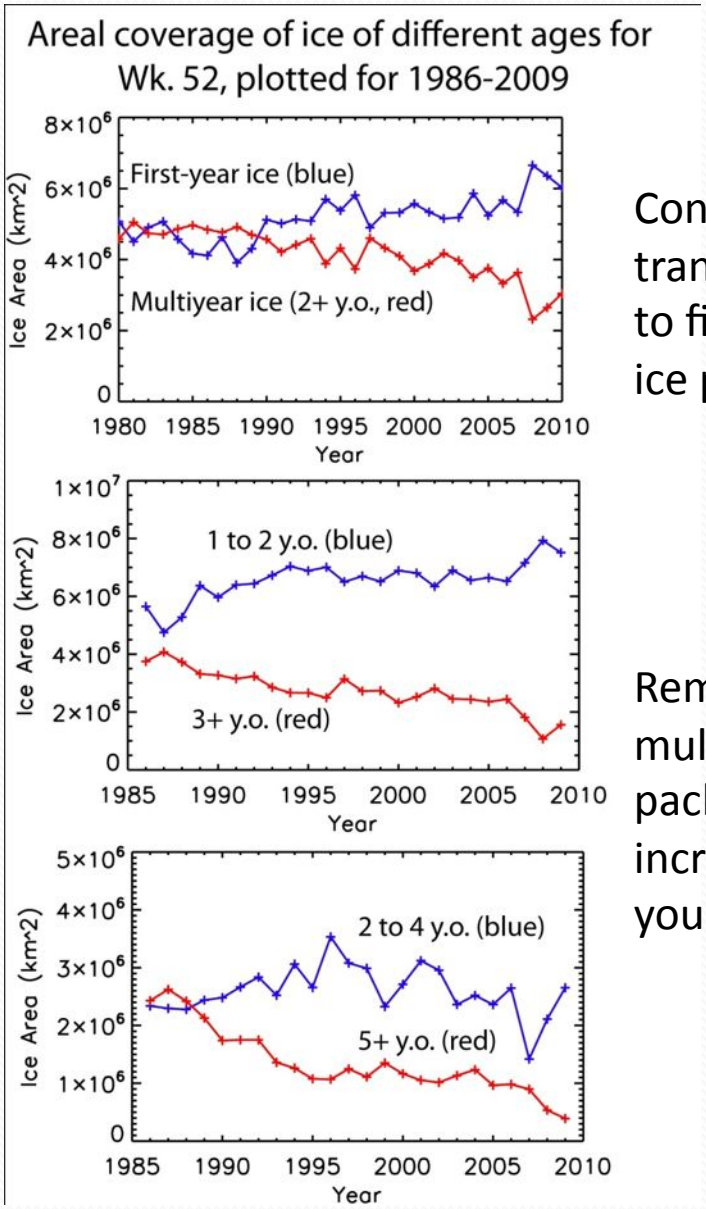


Sea Ice Age from Langrangian Tracking: Spatial and Temporal Variability

Result of strong Beaufort Gyre in 2009-2010.

Will this 7+ year-old ice survive summer melt?



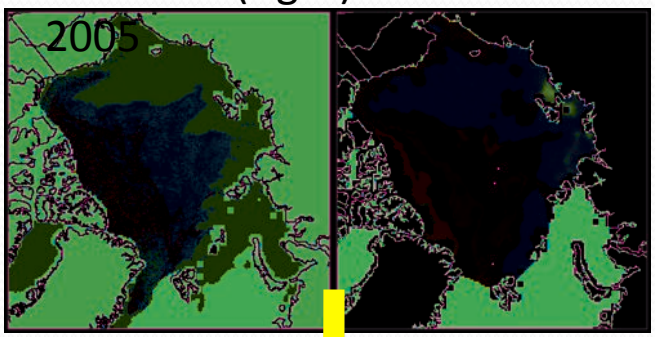


Continuing transition to first-year ice pack

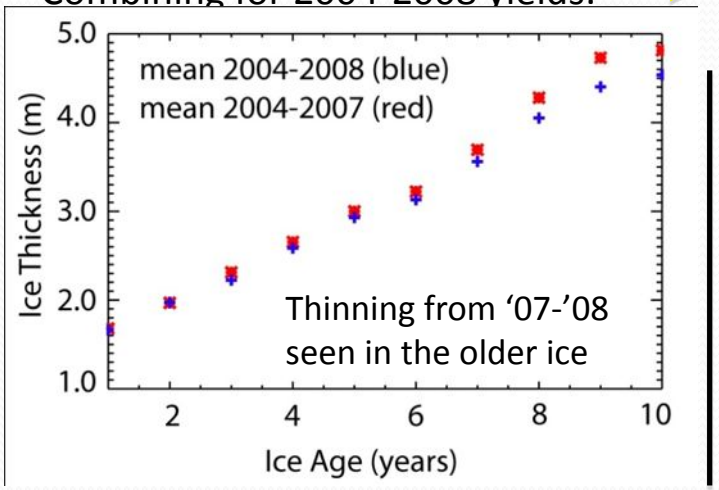
Remaining multiyear pack is increasingly young

Ice age is combined with ICESat thicknesses (Kwok et al., 2009) to yield median thickness per age class. Volume is then calculated from these proxy thicknesses.

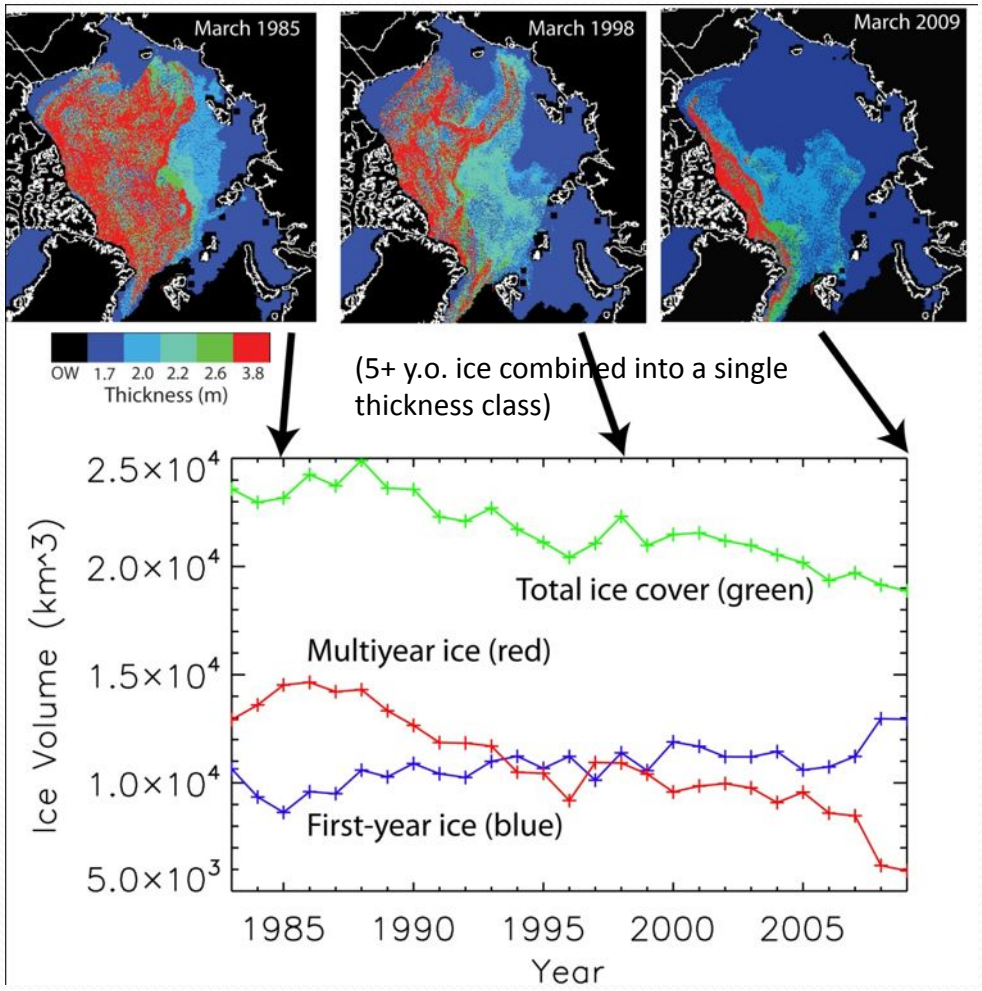
Ice age (left) and ICESat ice thickness (right) for March 2005



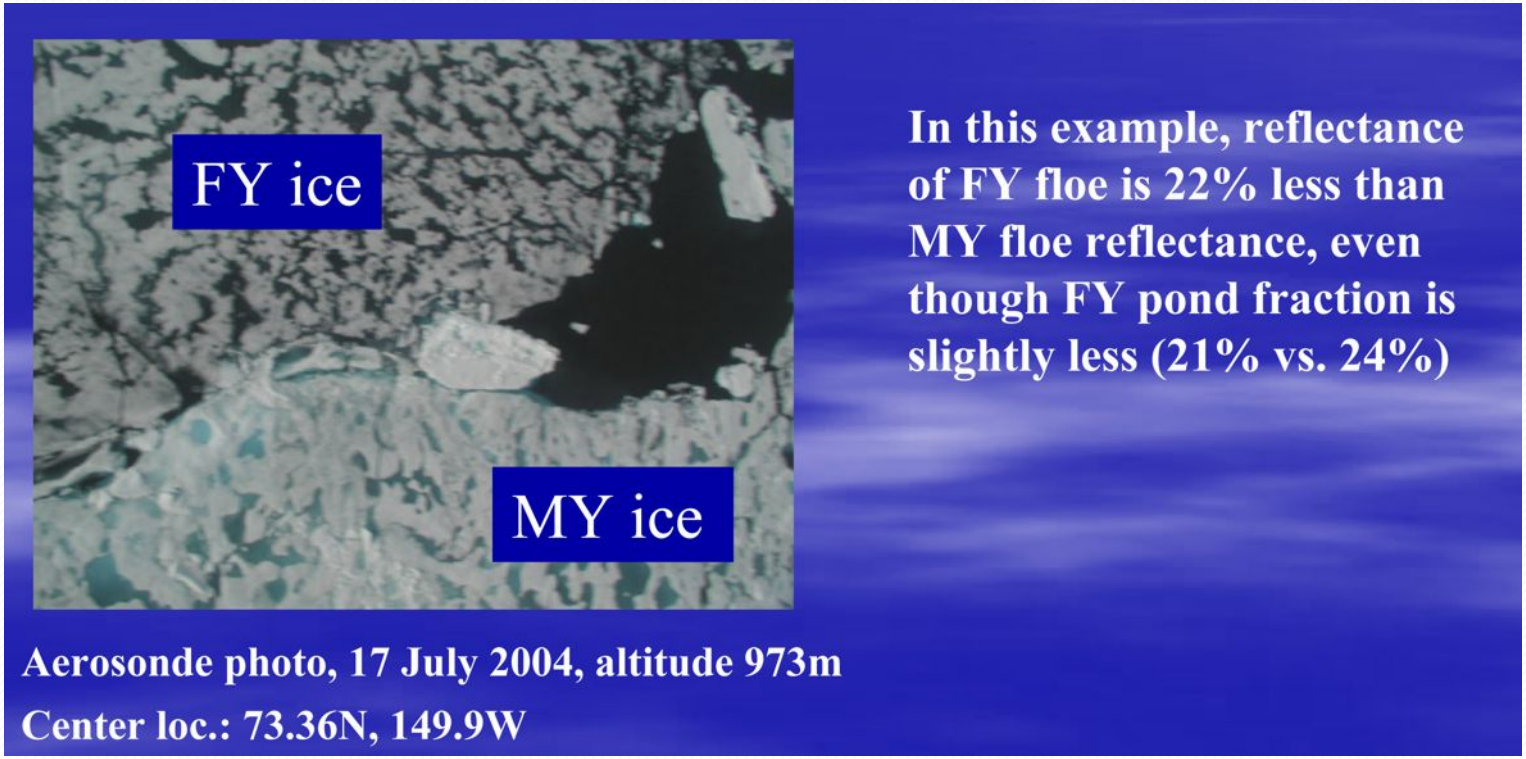
Combining for 2004-2008 yields:



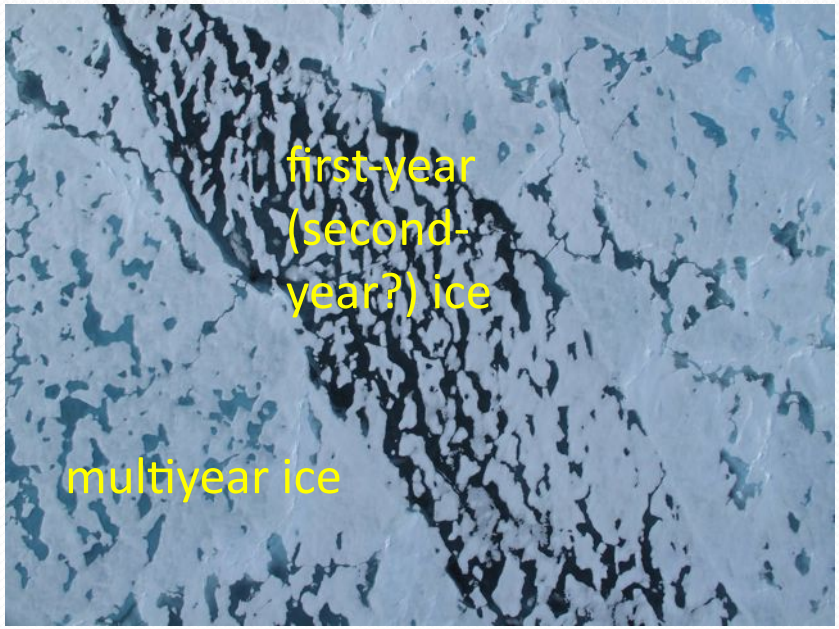
Proxy ice thicknesses for 1985, 1998 and 2009 (March)

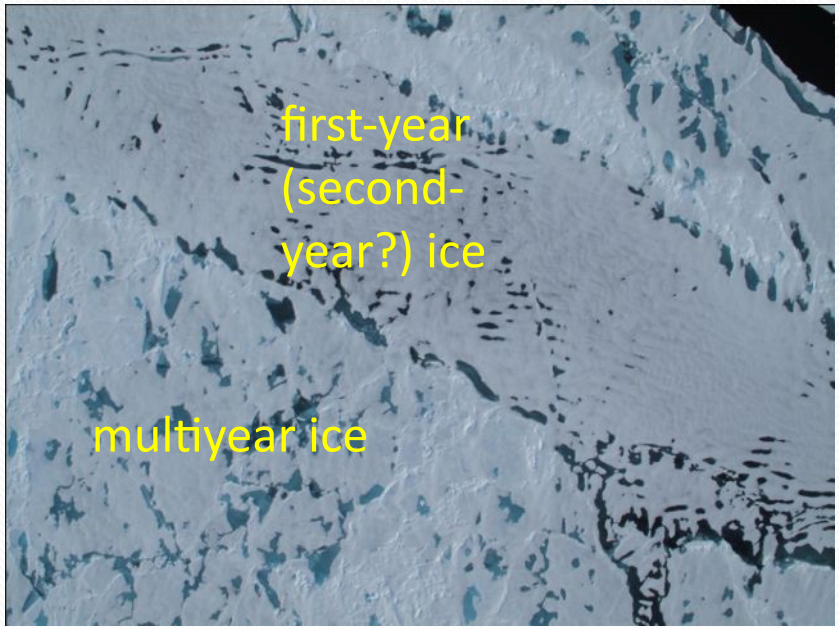


FYI vs. MYI albedo (Beaufort Sea UAV imagery)



Aerial photo of Fram Strait ice, acquired during CASIE UAV flight on 25 July 2009





Approx. reflectance:

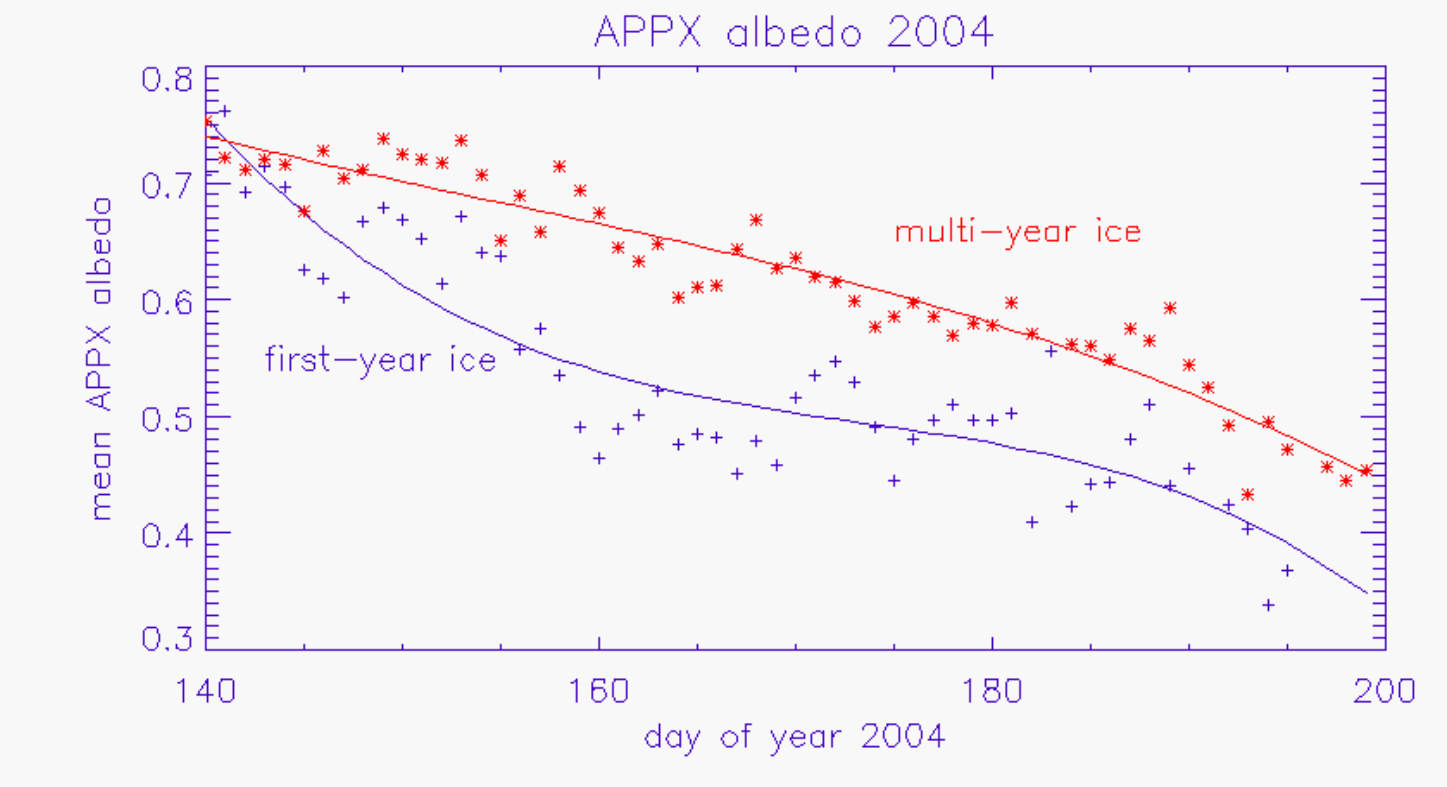
multiyear ice = 0.71; first-year ice = 0.48
multiyear ponds = 0.37
first-year ponds/flooded ice = 0.10

Approx. reflectance:

multiyear ice = 0.66; first-year ice = 0.67

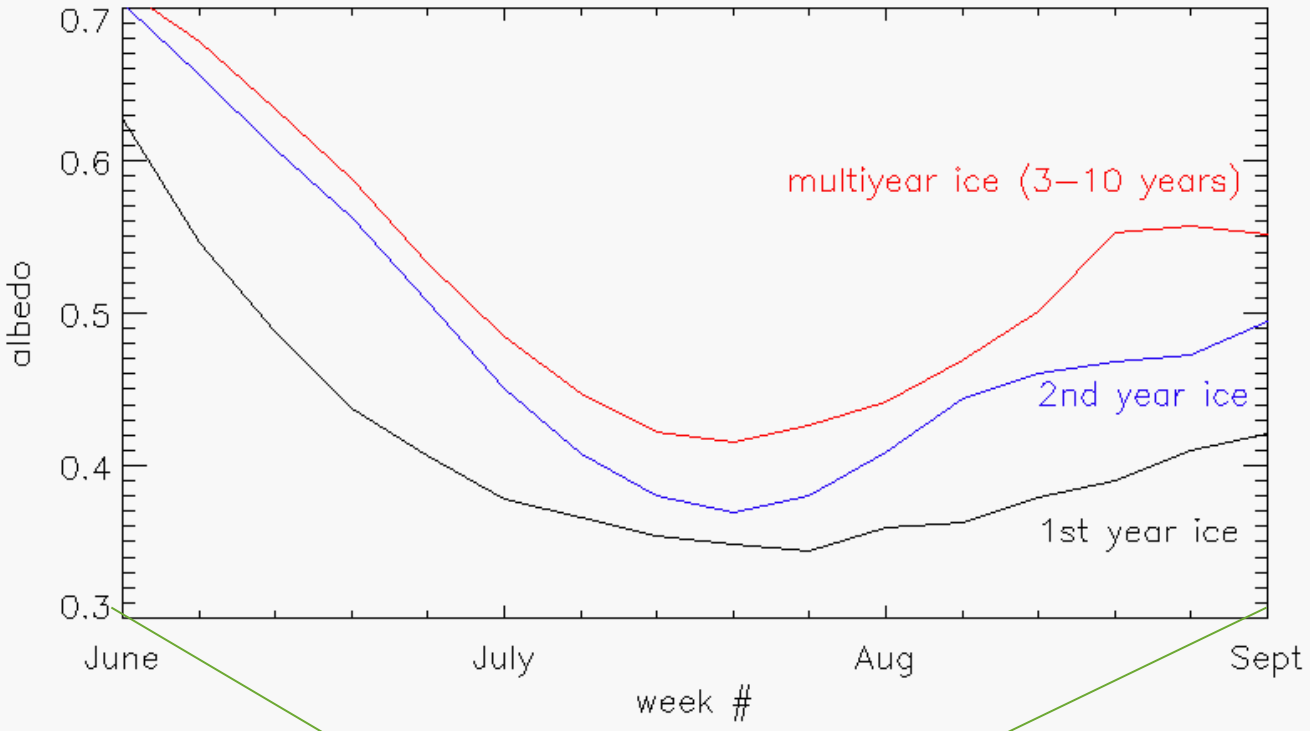
Reflectances for surface types were estimated from the mean of the red, green, blue digital numbers, with "atmospheric correction" done by subtracting DN of darkest features from pixel DNs. Mean DNs were then converted to reflectances, assuming reflectances of 0.75 for white ice and 0.06 for open water.

Lagrangian tracking of albedo

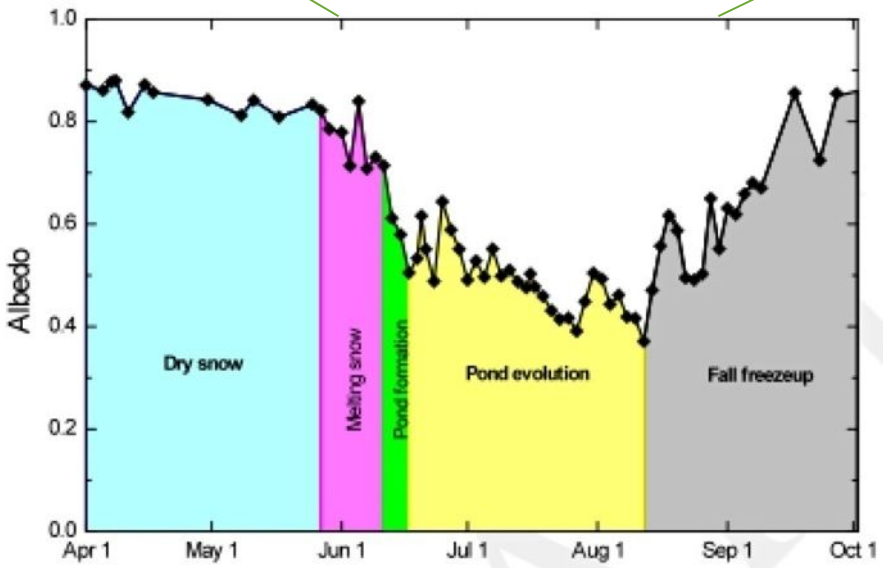


153=June 1 183=July 1

Mid-May through mid-July



Albedo vs ice age (2004)



Albedo at SHEBA
[*Perovich et al., 2002*]

More SW energy absorbed = more ice melt

$$\Delta I = (\Delta A * t)/(L_{fusion} * \rho_{ice}), \quad (1)$$

I = depth of ice melted, A = SW absorption t = time(secs),
L_{fusion} = latent heat of fusion, ρ_{ice} = density of ice

0.56 m additional melt of FYI over MYI through summer!

- Does not include basal melting (which is also increased due to ocean warming)
- Does not include changes in LW downwelling
- "Ice Type" albedo feedback

(1) e.g. Kay et al, 2008

Summary

- The ice pack is, on average, much younger in recent years. We have related age to thickness, which shows that the younger ice is also thinner.
- In Feb 2010, a lobe of older ice exists in the Western Arctic. Melting of this lobe during the coming summer may be a "tipping point" towards a summer ice-free Arctic in the coming years.
- Albedo for young (< 3 years) ice appears lower than multiyear ice during the summer months, resulting in more absorption of SW energy by 1st year ice.
- Since younger (and thinner) ice is more dominant now, it is absorbing more downwelling radiation, enhancing the melt process - an "ice type albedo feedback."

Thanks to:

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CULPIS-x in C-130 flare tube

Thank you!

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NASA Sierra UAV at CASIE, Svalbard, summer 2009

References:

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D.K. Perovich et al., 2002: Seasonal evolution of the albedo of multiyear Arctic sea ice. *J. Geoph. Res., 107, C10, 8044.*