The declining Arctic sea ice cover: In situ insights and synthetic findings

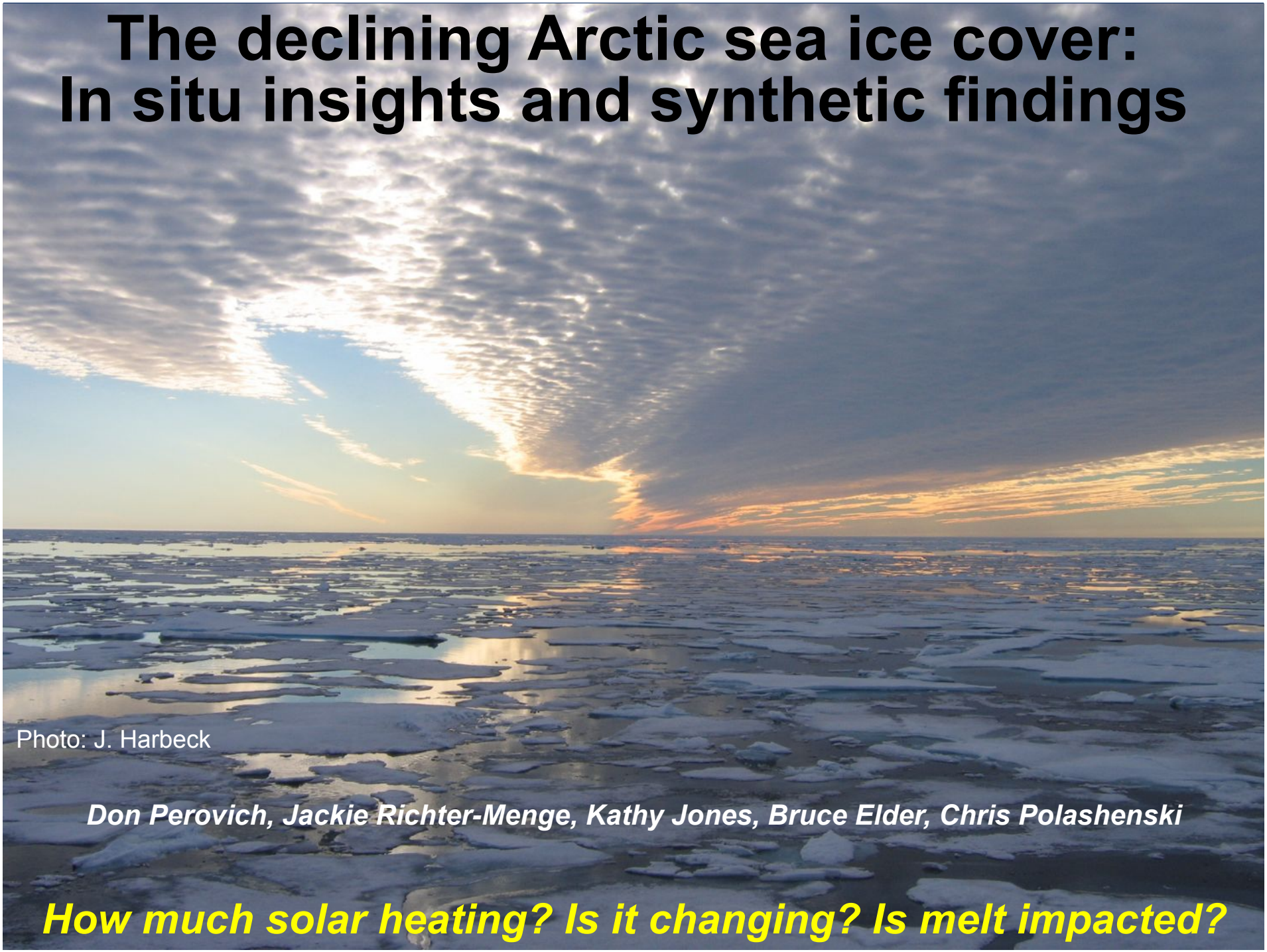


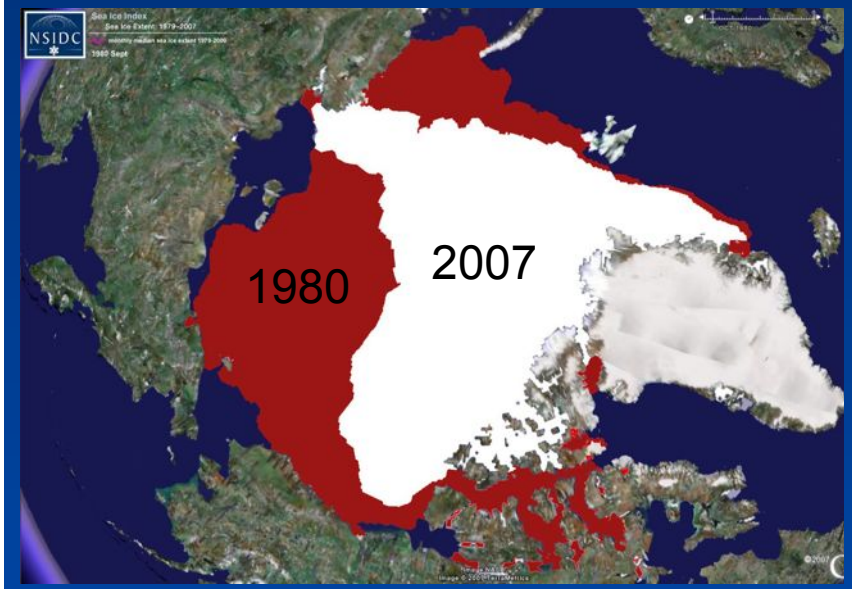
Photo: J. Harbeck

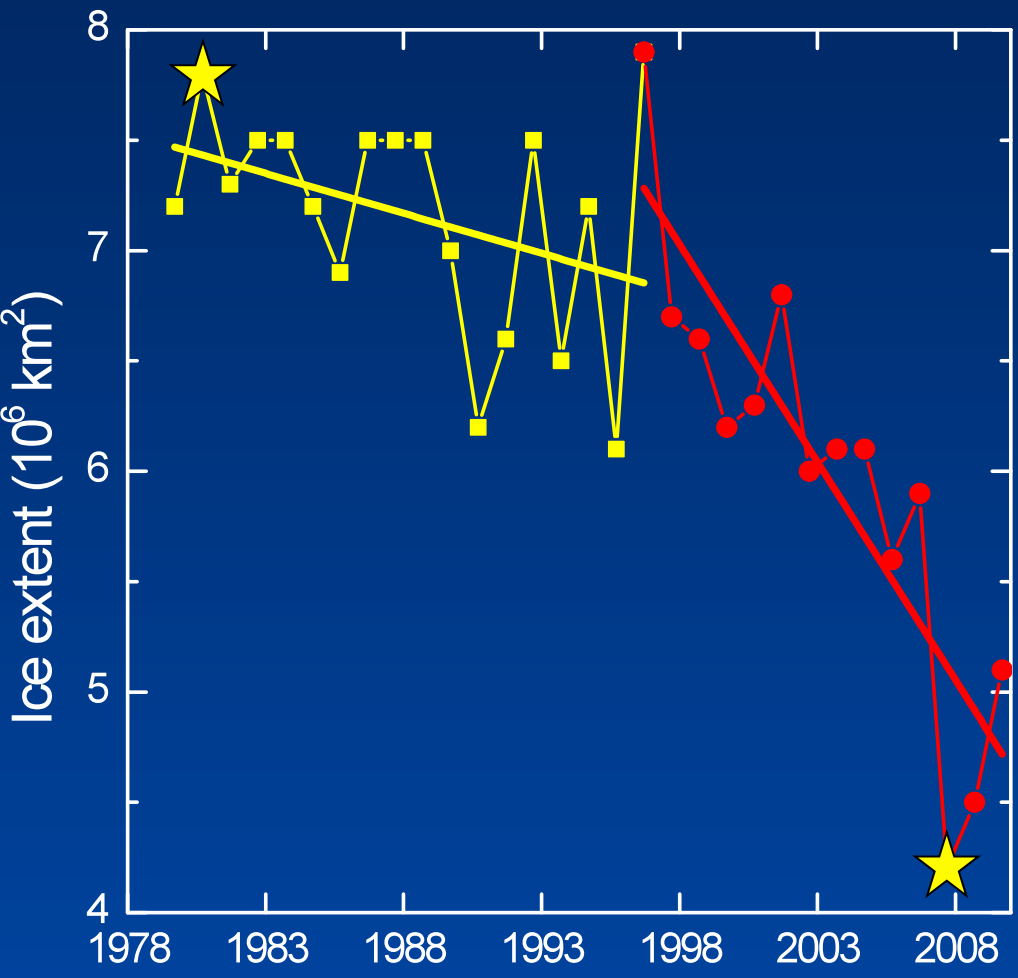
Don Perovich, Jackie Richter-Menge, Kathy Jones, Bruce Elder, Chris Polashenski

How much solar heating? Is it changing? Is melt impacted?

Arctic sea ice is in decline

- Warmer air temperature
- Longer melt season
- Clouds
- Winds
- Export of old, thick ice
- Import of ocean heat
- Ice albedo feedback

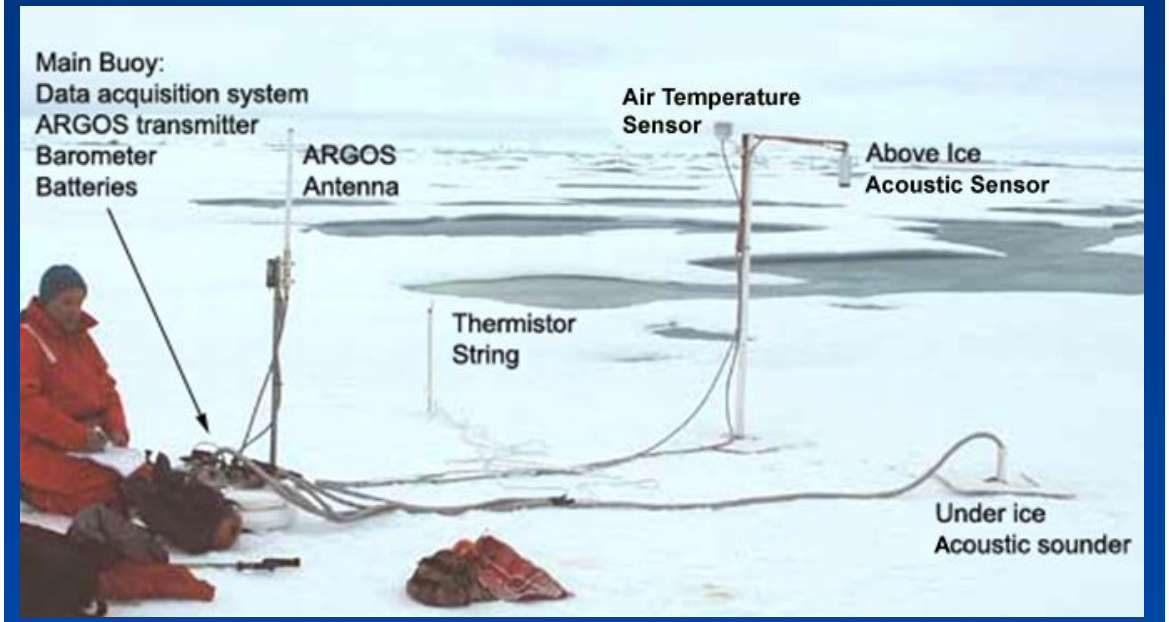


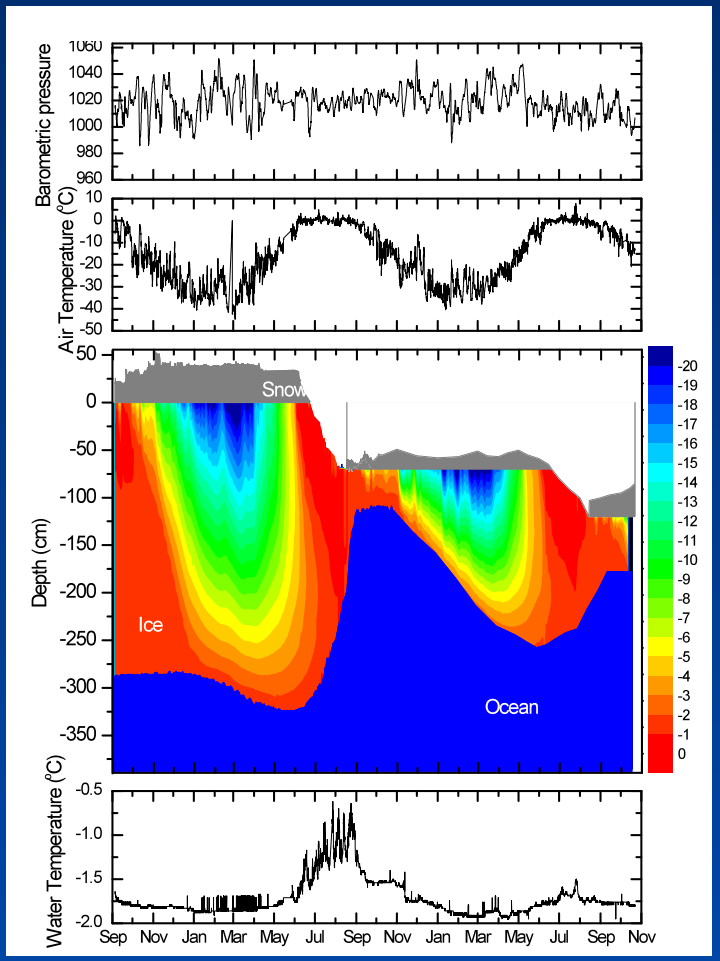


September ice extent is decreasing, but how

Autonomous mass balance observations

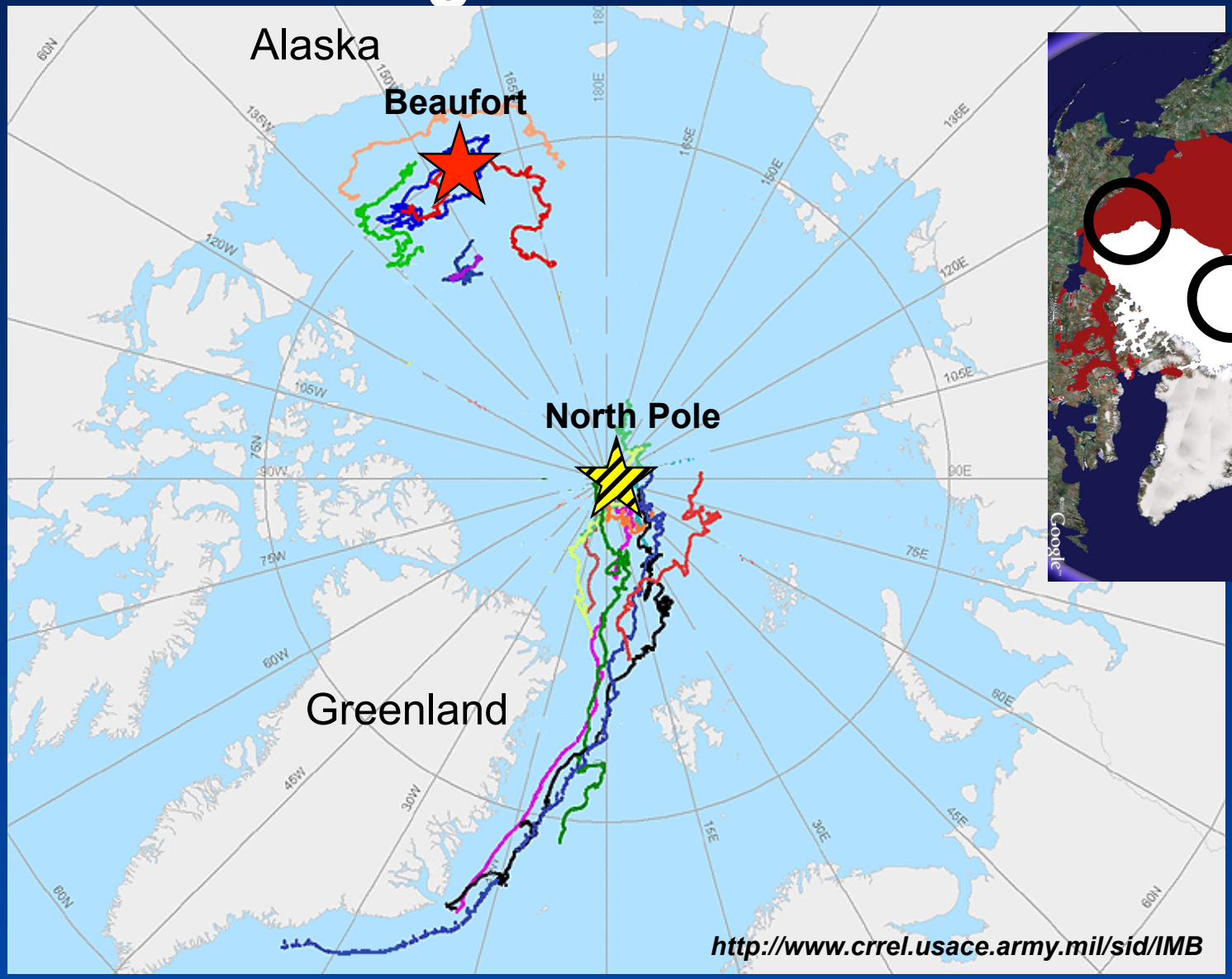
- Simple concept
  - ice growth
  - surface melt
  - bottom melt
- Camps, autonomous buoys
- Powerful tool – shows how

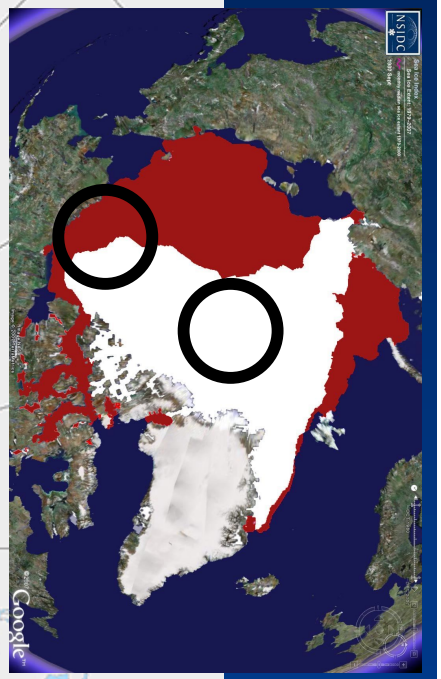




Next best thing to being there

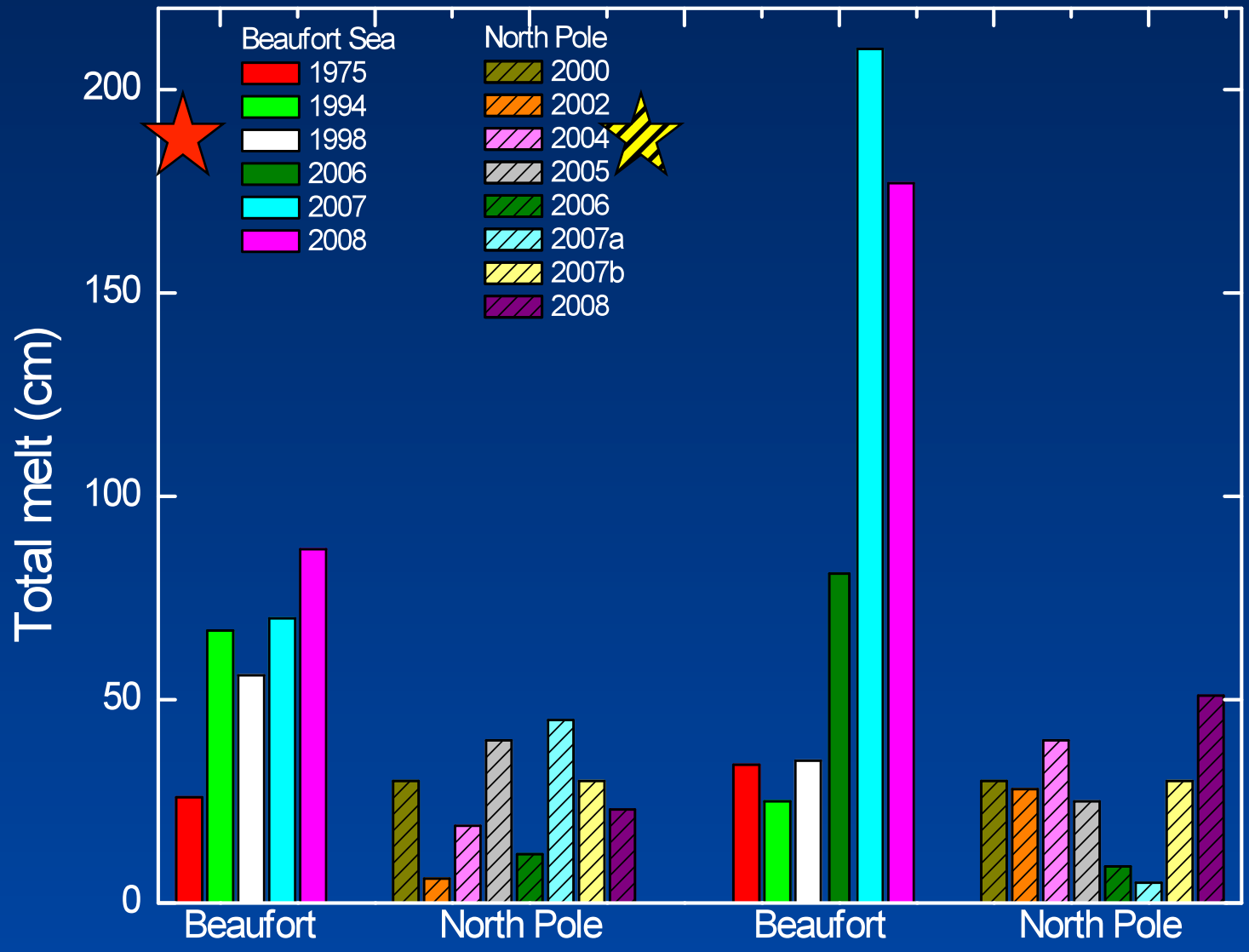
Observing the mass balance

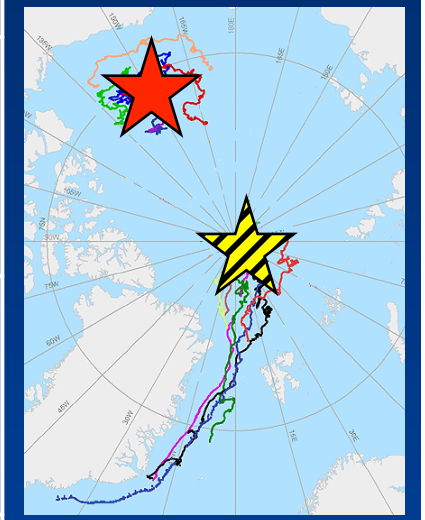




Observations in Beaufort and North Pole

Summer ice melt





Increases in bottom melt in Beaufort

Solar heating of the ice – ocean system

Total solar heat = heat ice + heat ocean

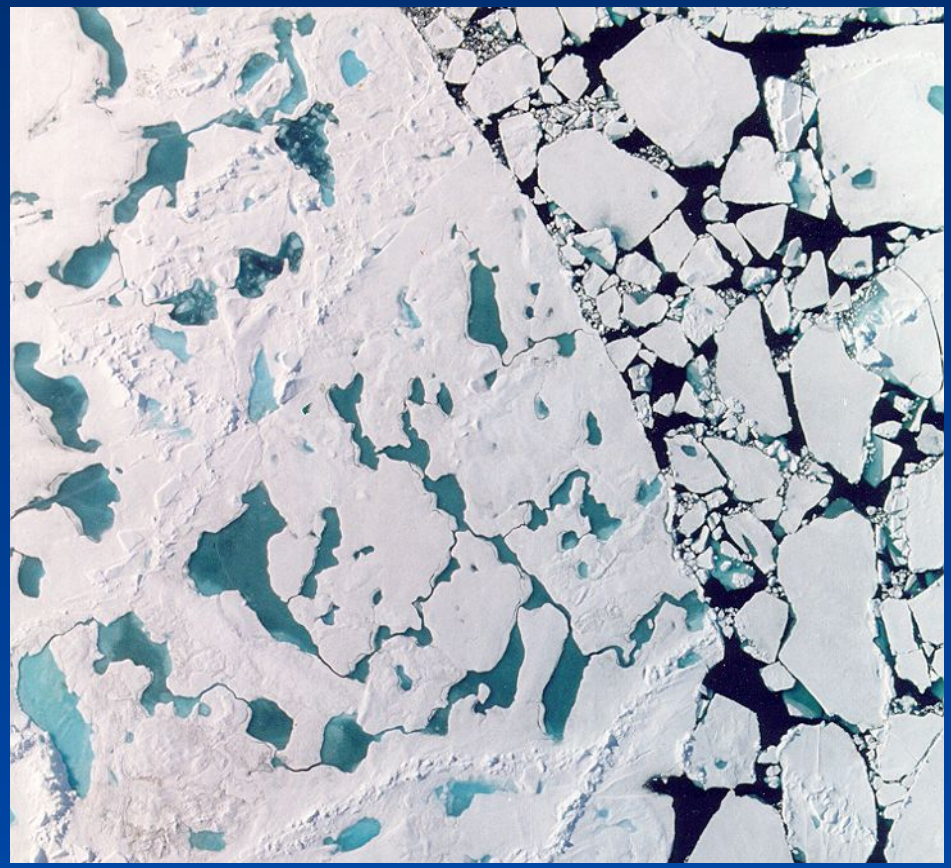
$$F_{in} = (F_r)(A_i)(1 - \alpha_{ice}) + (F_r)(A_w)(1 - \alpha_{ocn})$$

Input:

- Sunlight (F_r) – reanalysis (ERA-40)
- Area fractions (A_i, A_w) – satellite
- Ocean albedo (α_{ocn}) = 0.07
- Ice albedo (α_{ice}) – very complicated

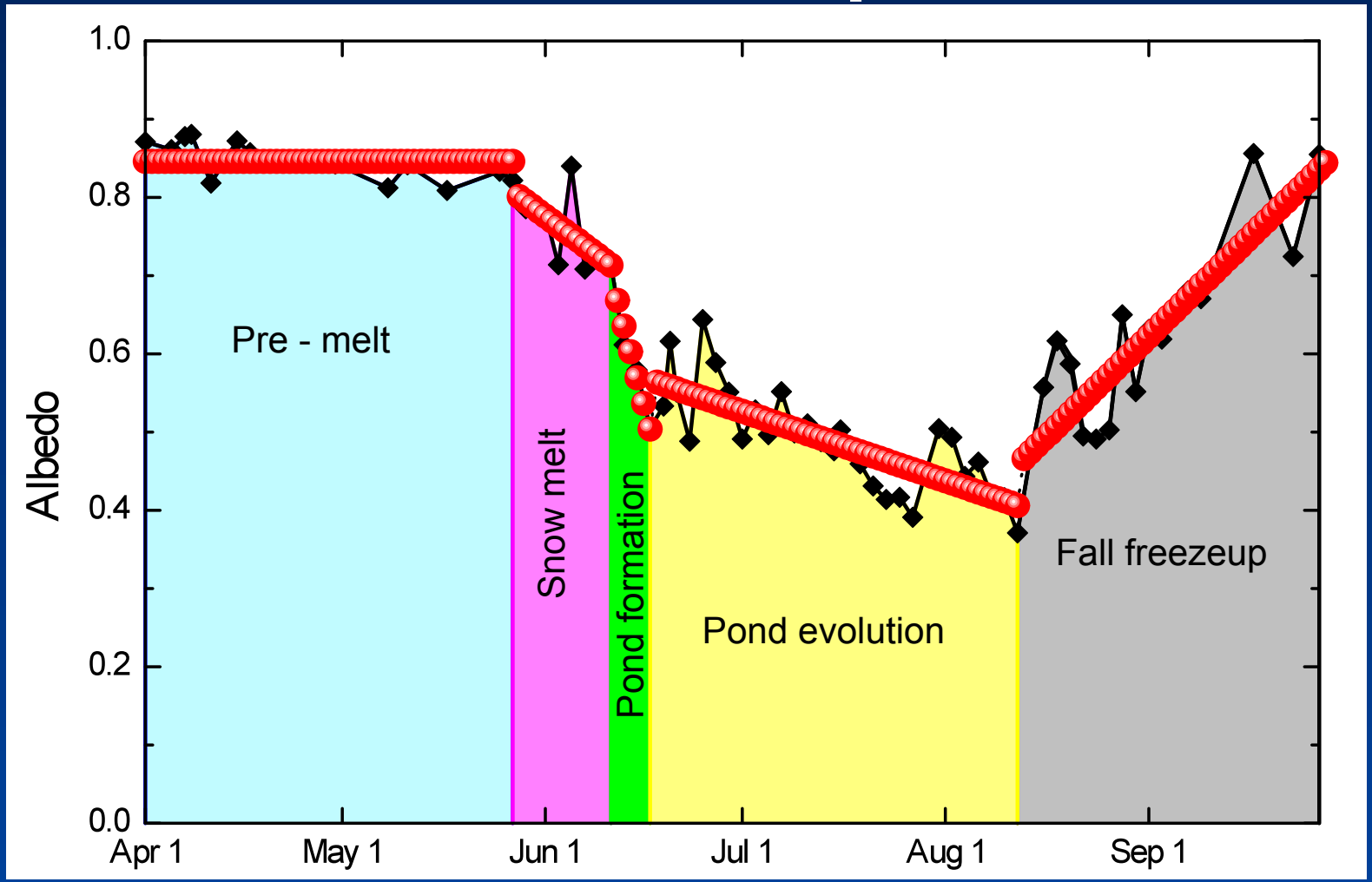
Output:

Solar input to ice - ocean (F_{in})



Albedo of the ice is the hard part

Albedo assumptions



Timing is critical – Use satellite results for onset of melt and freezeup

Now calculate solar heat input

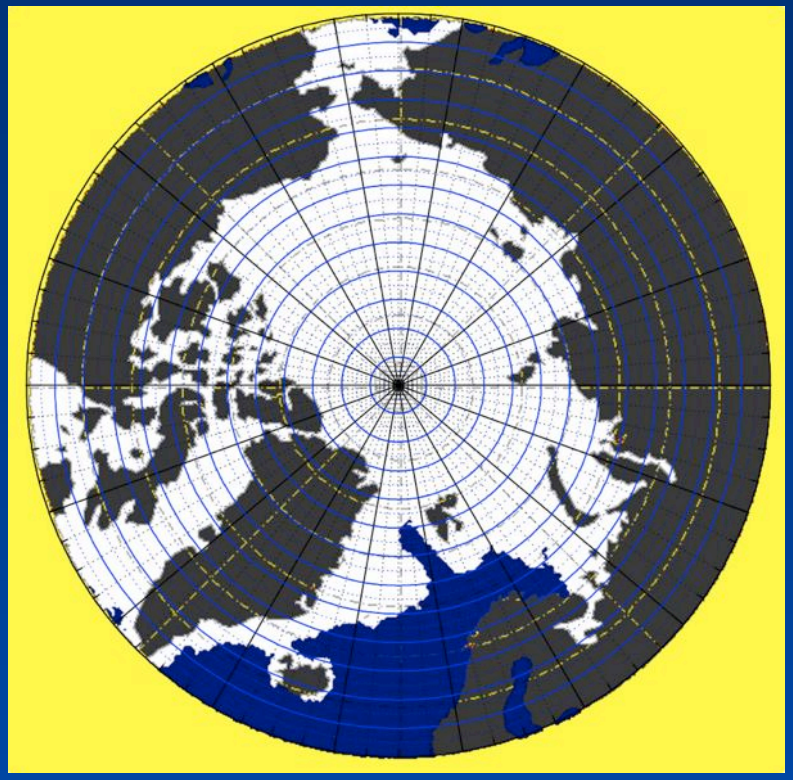
Region of interest

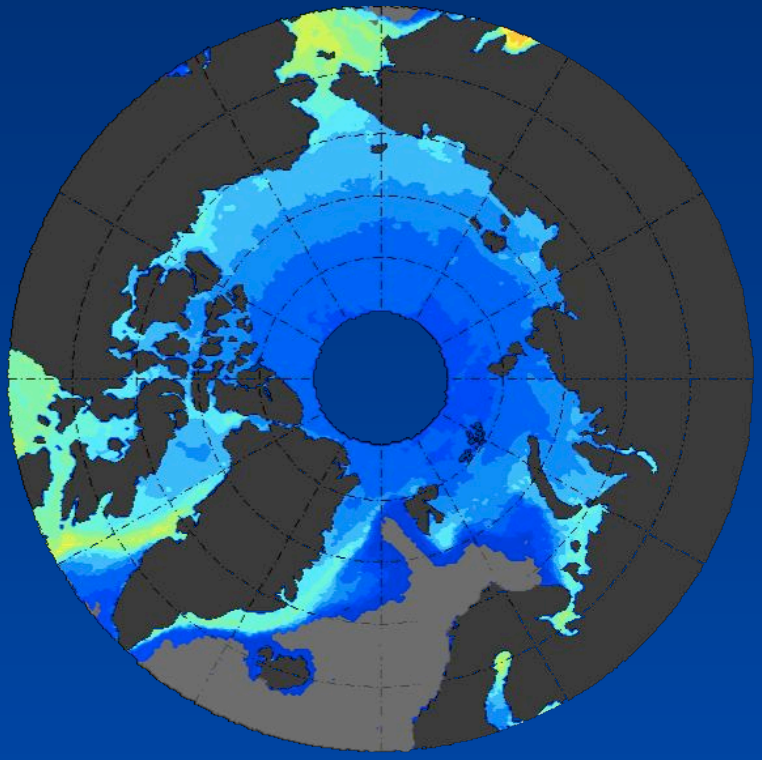
- Anyplace there was sea ice
- Pan – Arctic Ocean
- 25 x 25 km equal area scalable grid
- From 1979 – 2008

Total heat = ice + ocean

$$F_{in} = F_{ice} + F_{ocn}$$

$$F_{in} = (F_r)(A_i)(1 - \alpha_{ice}) + (F_r)(1-A_w)(1 - \alpha_{ocn})$$

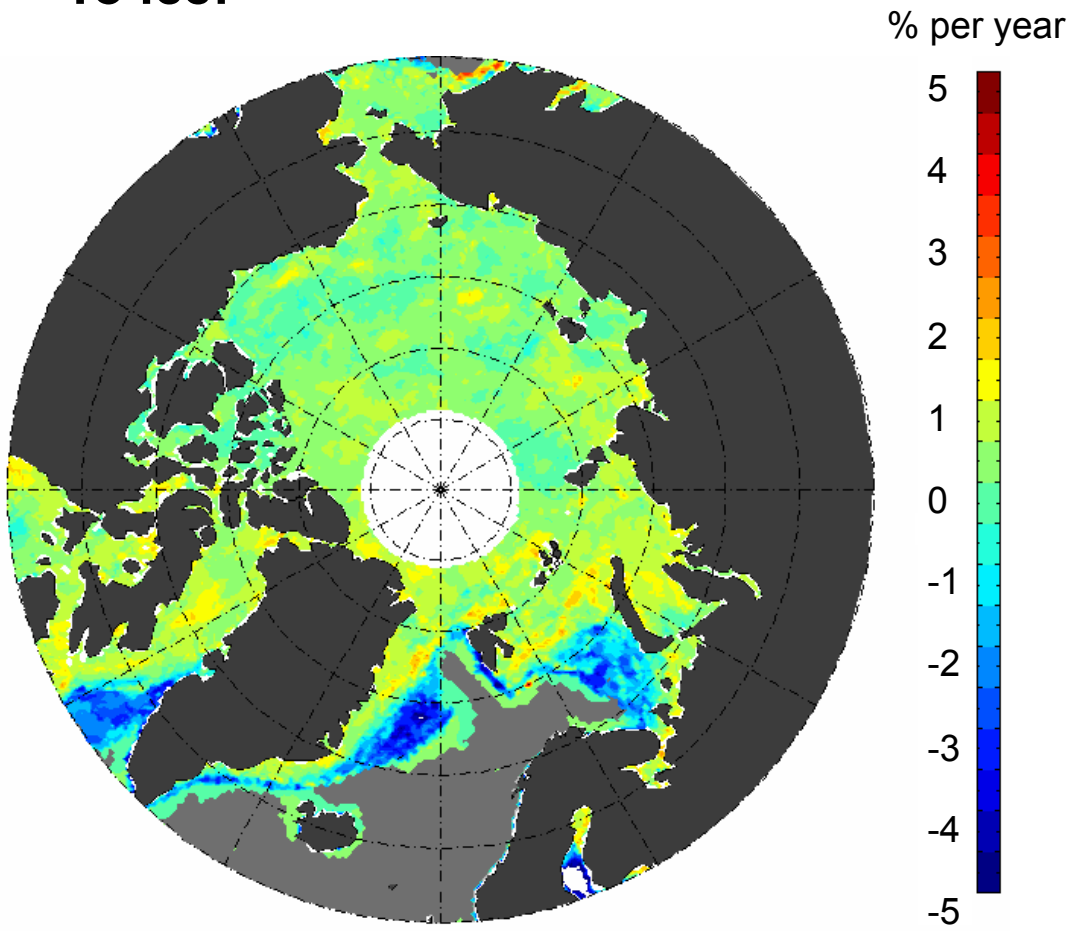




Day by day, year by year, everywhere

Trends of annual solar heat input

To ice:

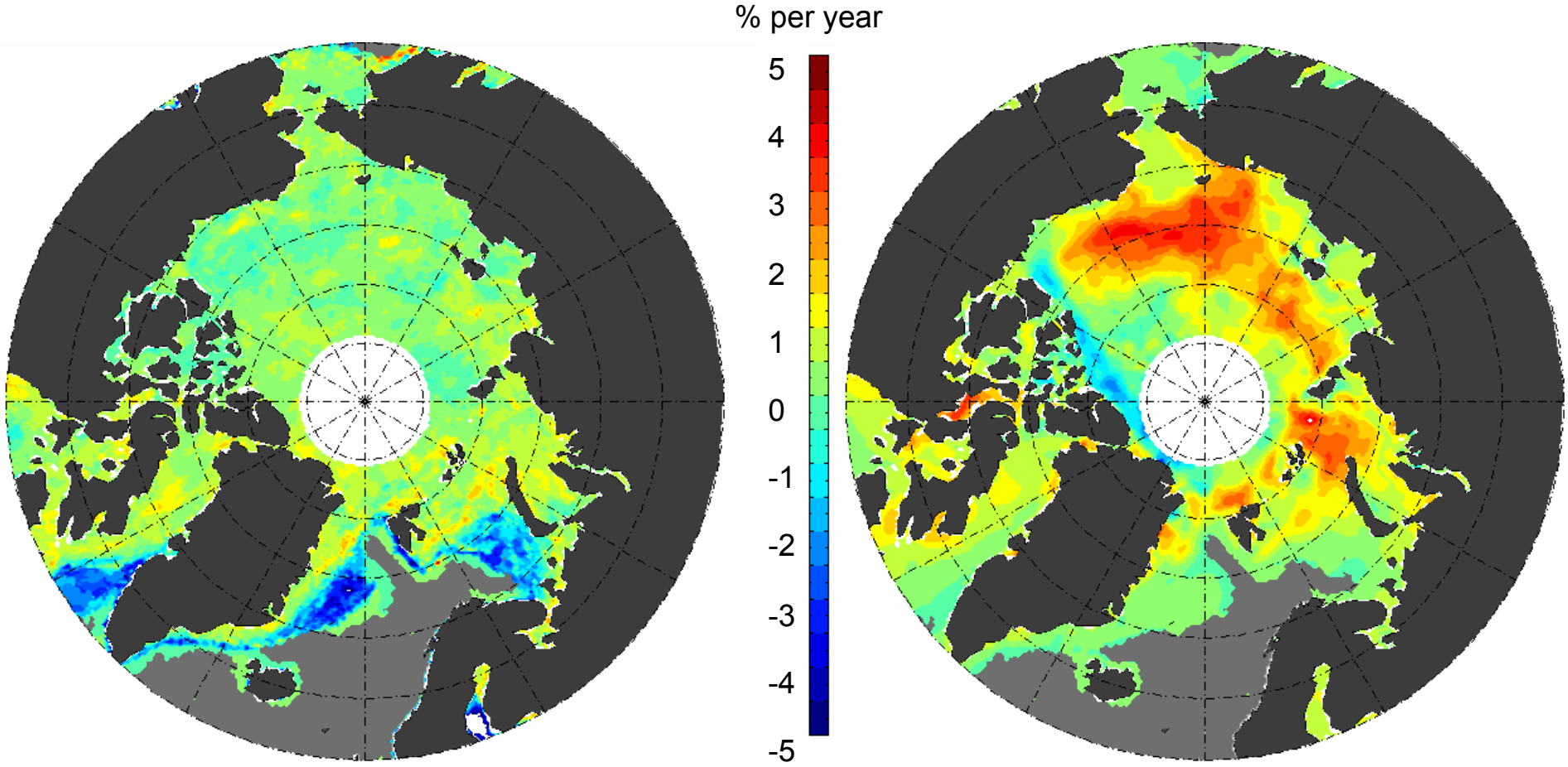


Modest increases in 70% of area due to longer melt seasons

Trends of annual solar heat input

To ice:

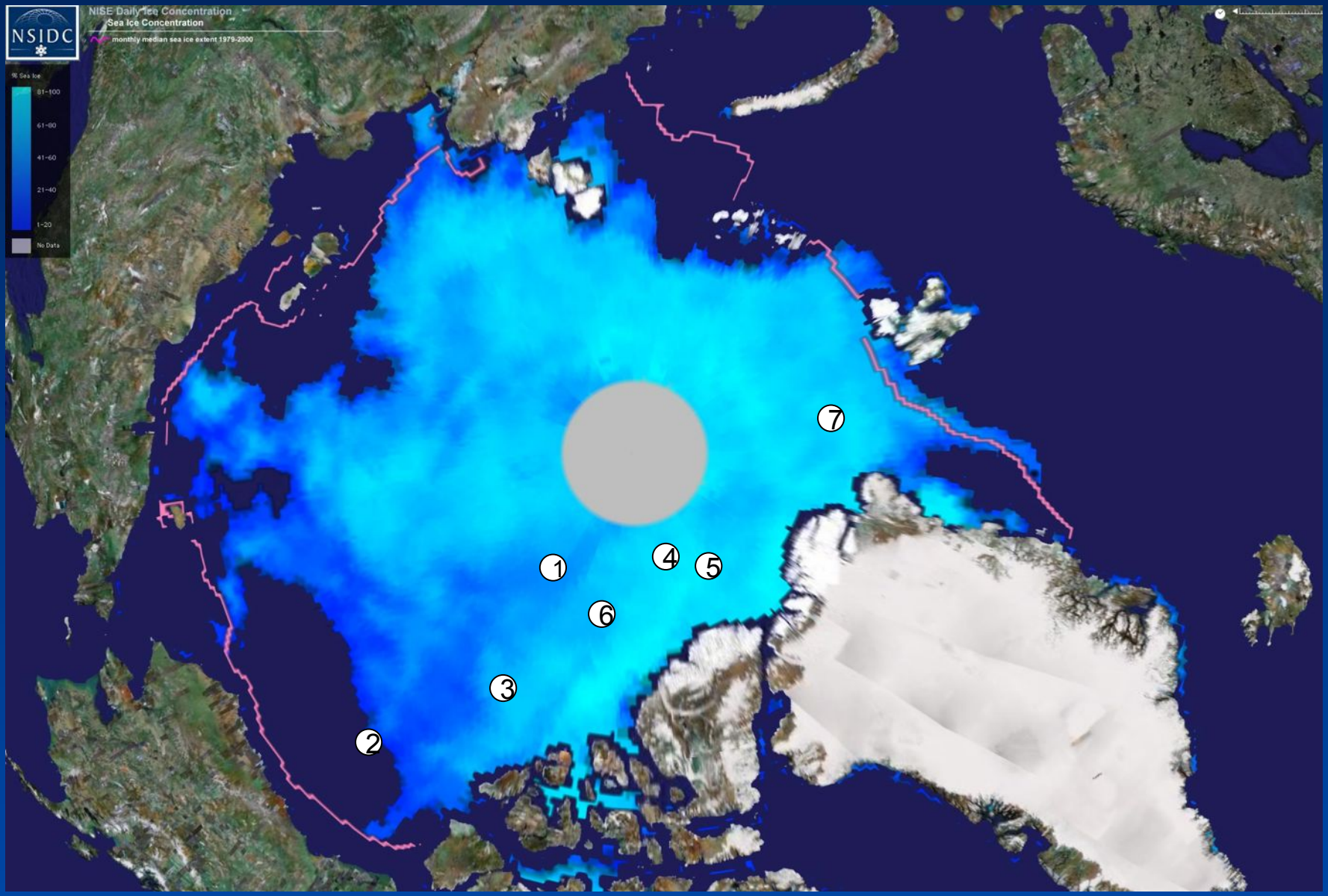
To ocean:



Modest increases in 70% of area

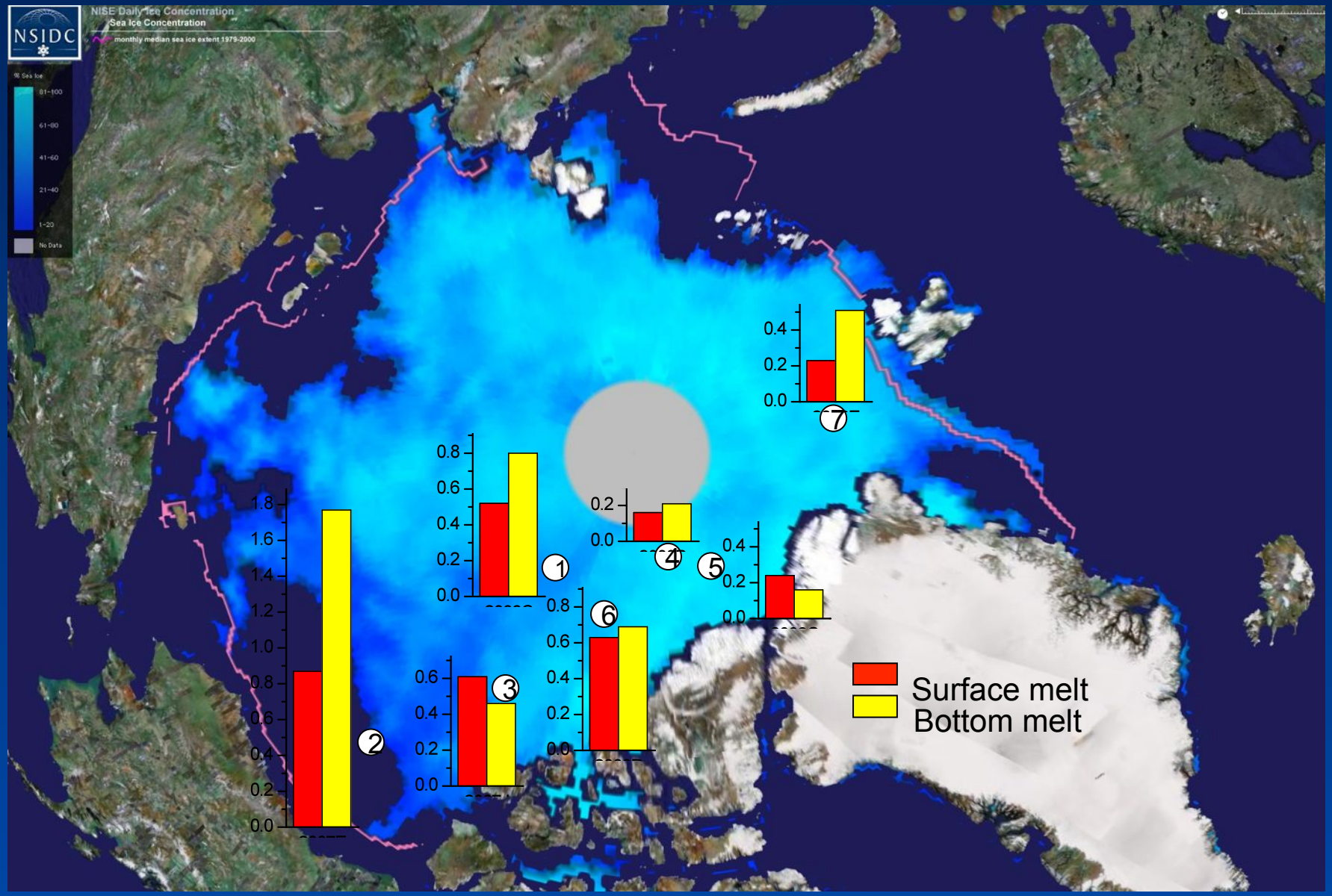
Increase in 90% of area, average of 0.8 % per year

Ice mass balance



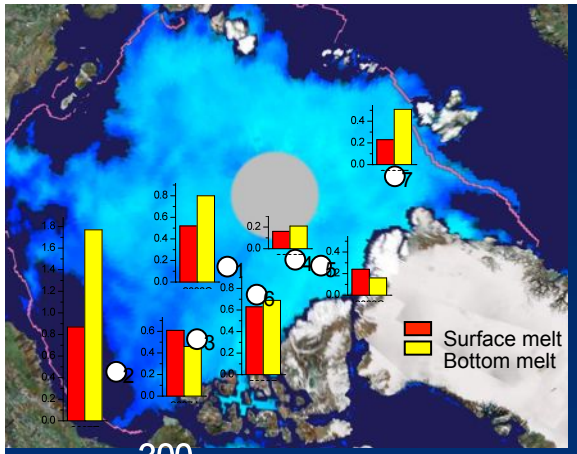
A wide range of sites

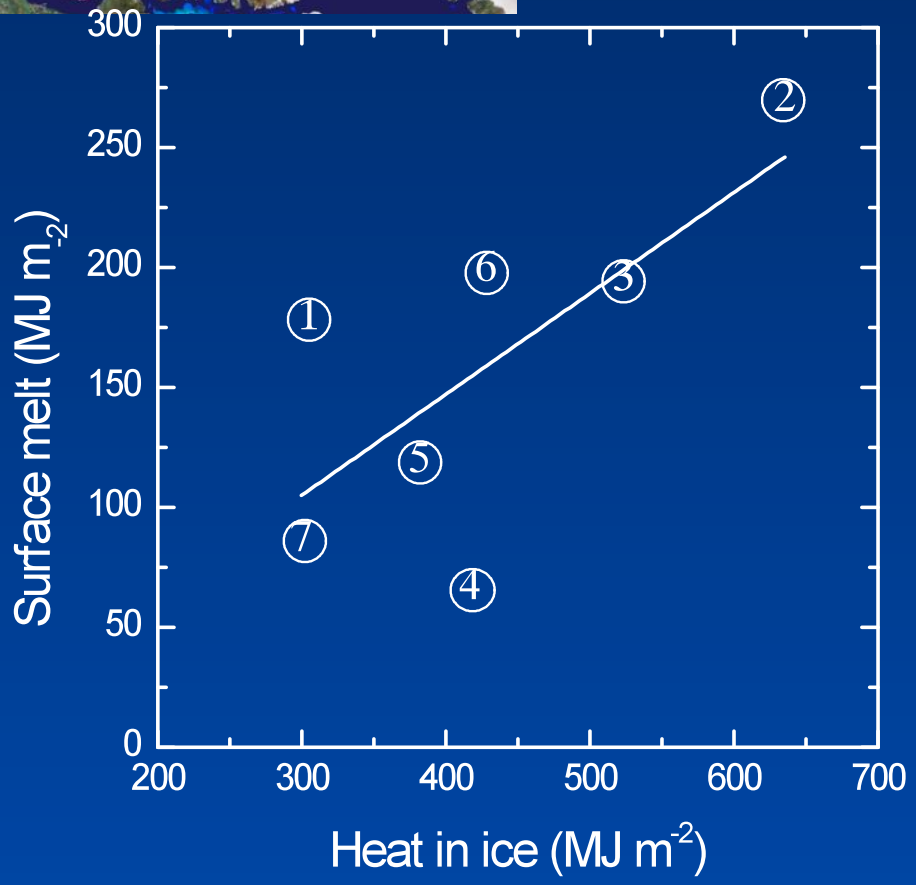
Ice mass balance

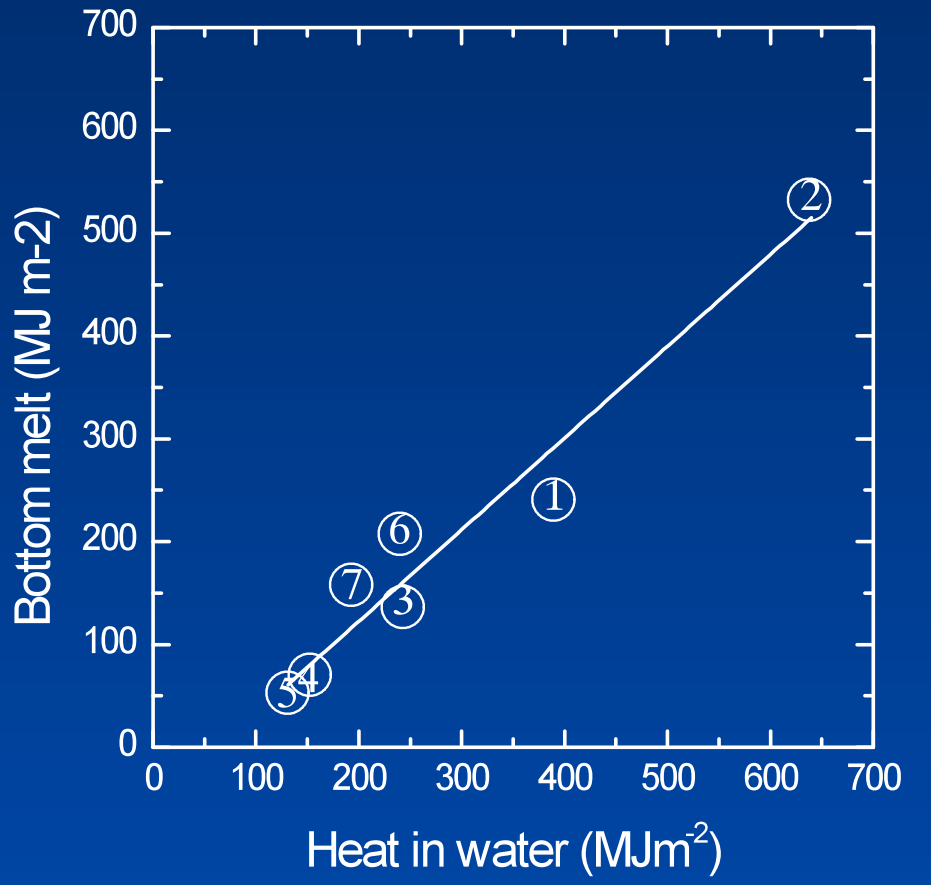


Large variability in melting

Ice mass balance



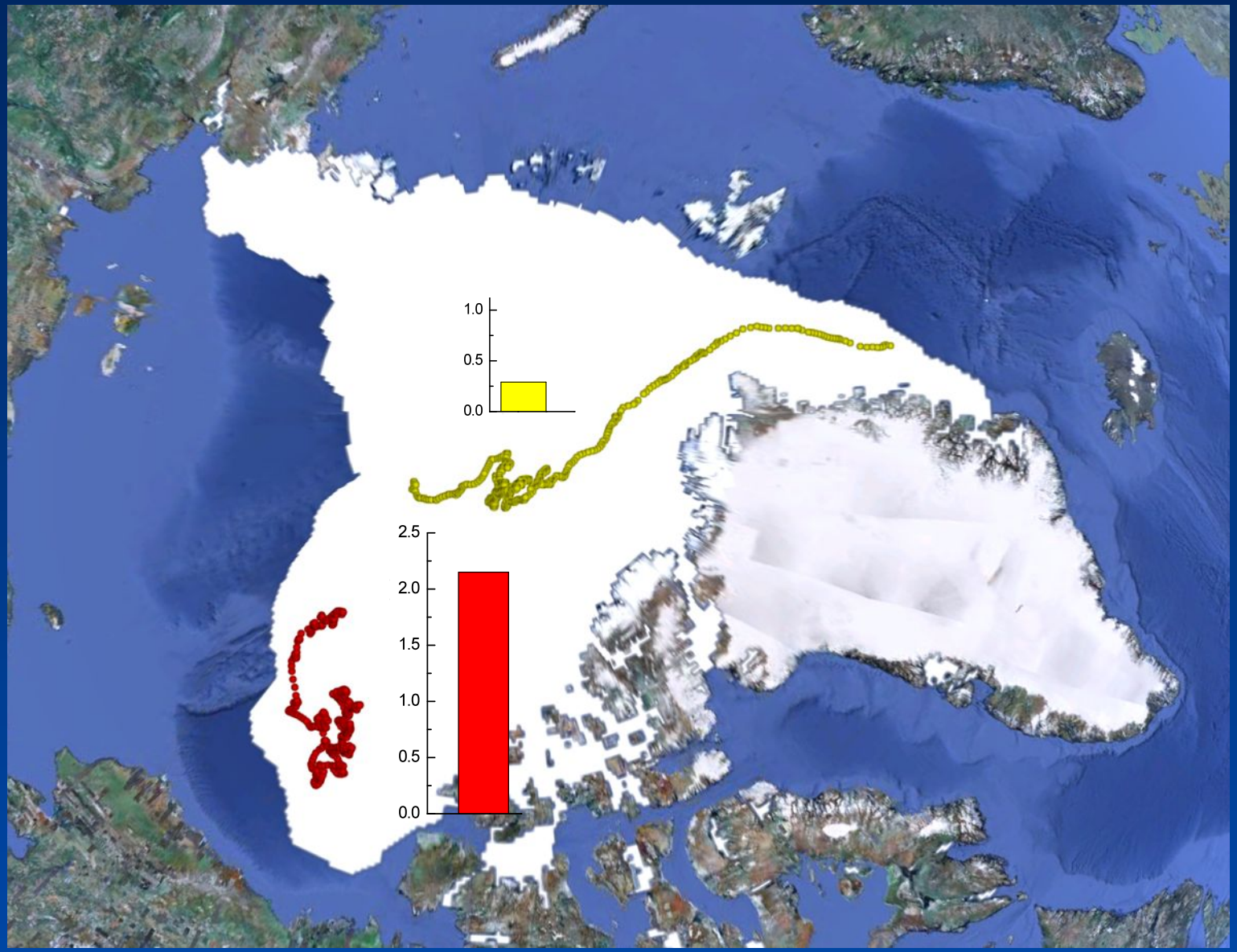




Surface melt – weak

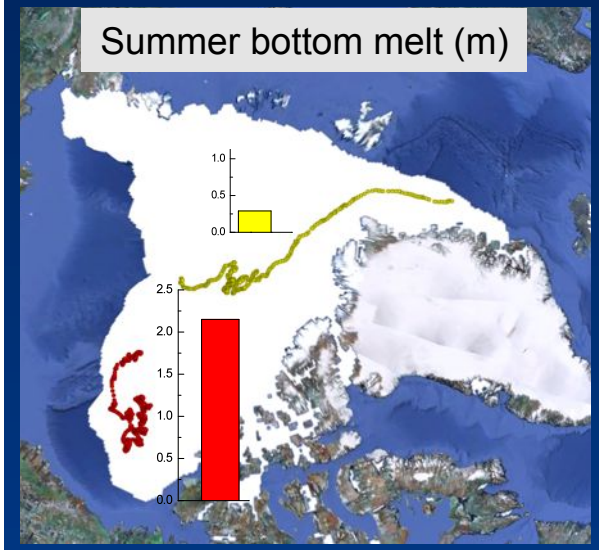
Bottom melt – linear (0.9)

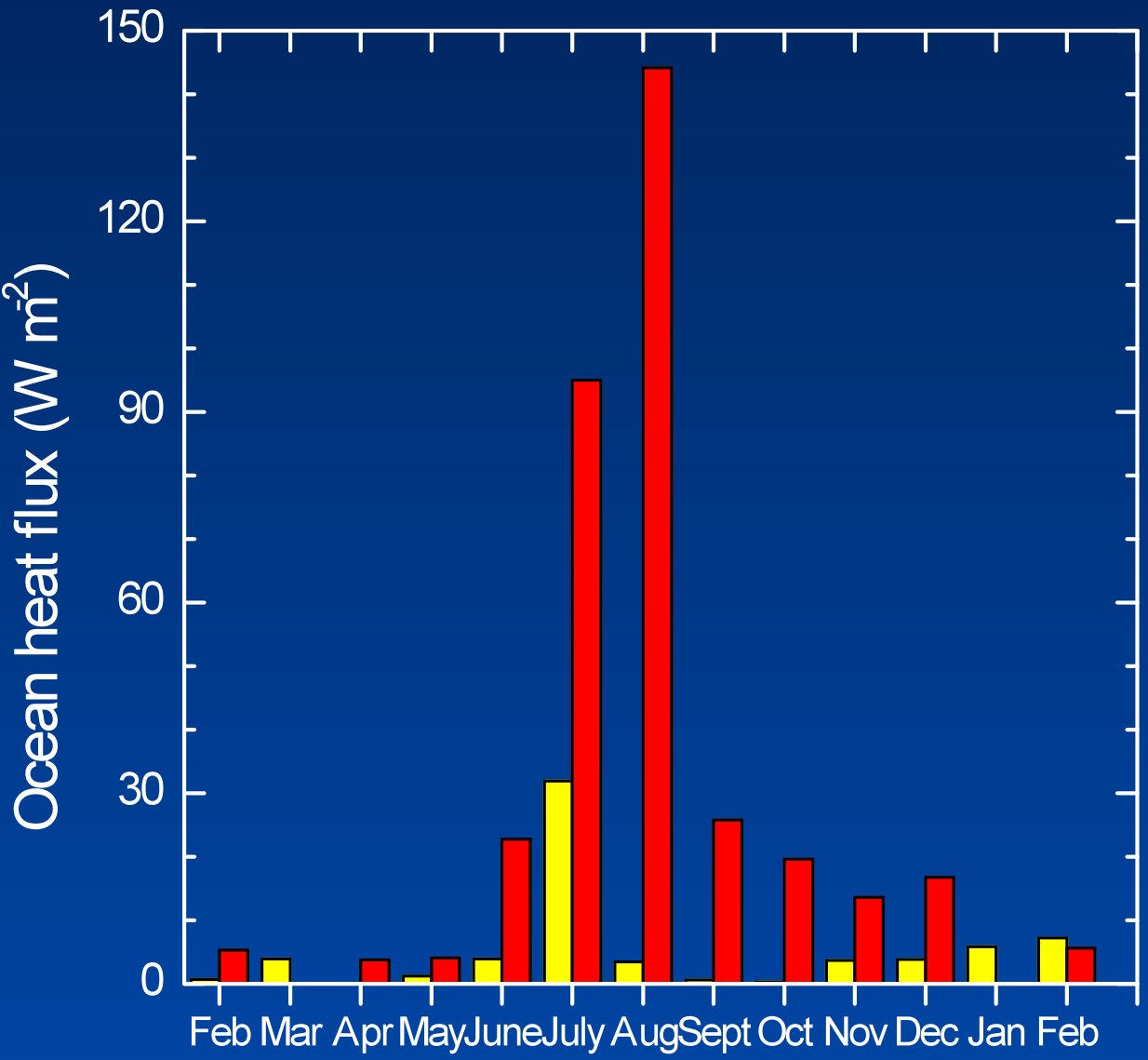
Summer bottom melt



Large differences, but what happens after summer?

Ocean heat flux



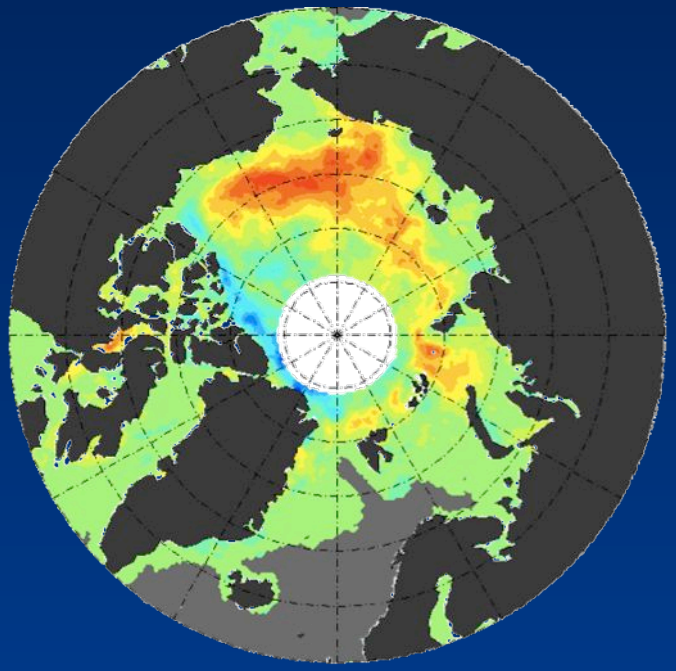


Solar heat – the gift that keeps on giving

Summary

Mass balance
- Interannual variability
- Increased bottom melt in Beaufort

Solar heat input
- Modest increase to ice
- Considerable increase to ocean (5% per year)
- Due to decrease in ice concentration
- Solar heat lingers



Solar heating is enhancing ice melt