ICESat-2 and sea ice: Early results

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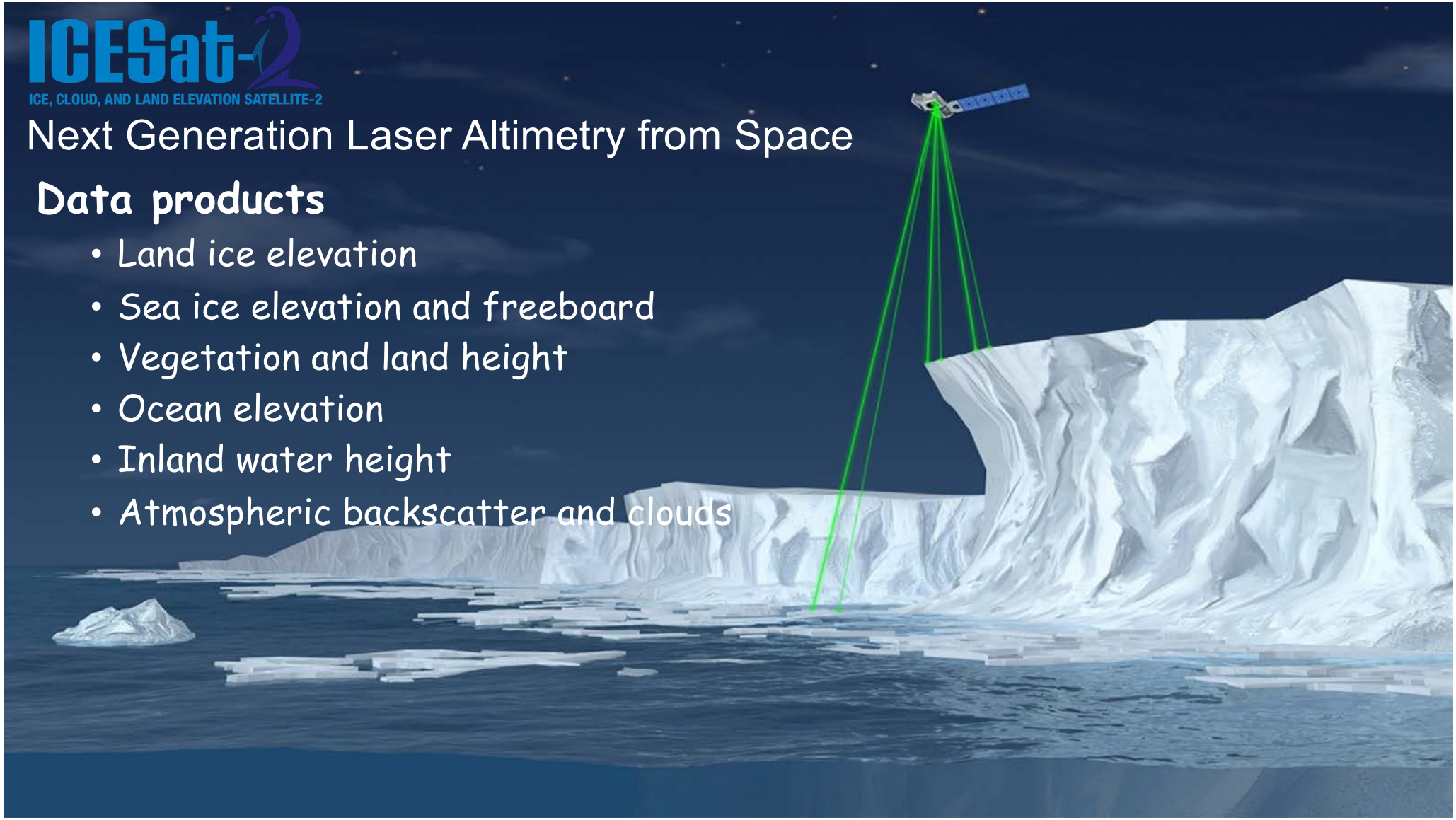
ICESat-2

ICE, CLOUD, AND LAND ELEVATION SATELLITE-2

Next Generation Laser Altimetry from Space

Data products

- Land ice elevation
- Sea ice elevation and freeboard
- Vegetation and land height
- Ocean elevation
- Inland water height
- Atmospheric backscatter and clouds

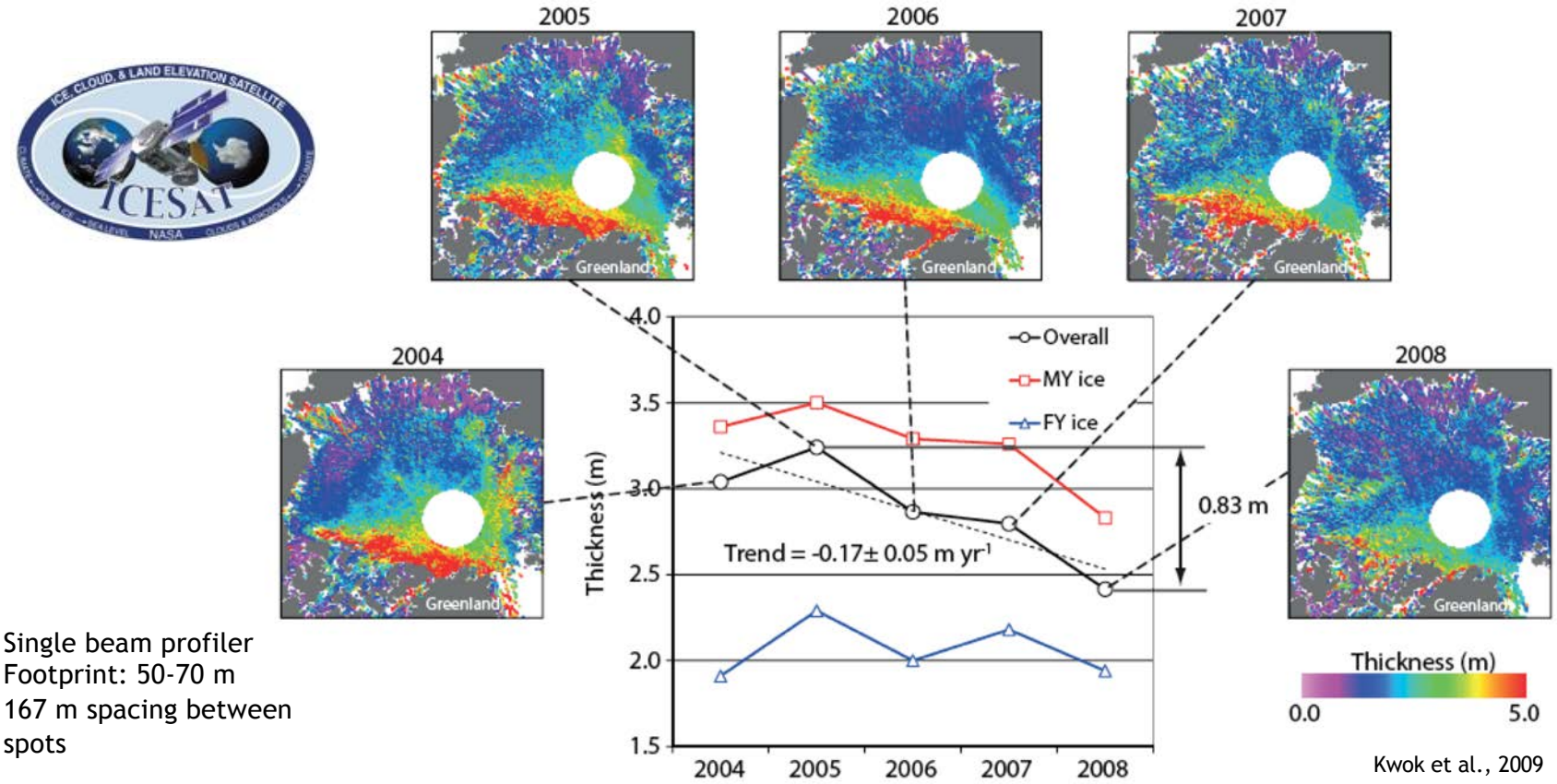


ICESat-2 – Launched
September 15, 2018
Science data collection from
October 14, 2018!

Topics

- Sea ice heights and freeboard from multi-beam photon counting altimetry
- Examples from the Arctic/Antarctic
- Sea Ice Products
  - Sea Ice Height, Sea ice Freeboard
- Data Release
- Summary Remarks

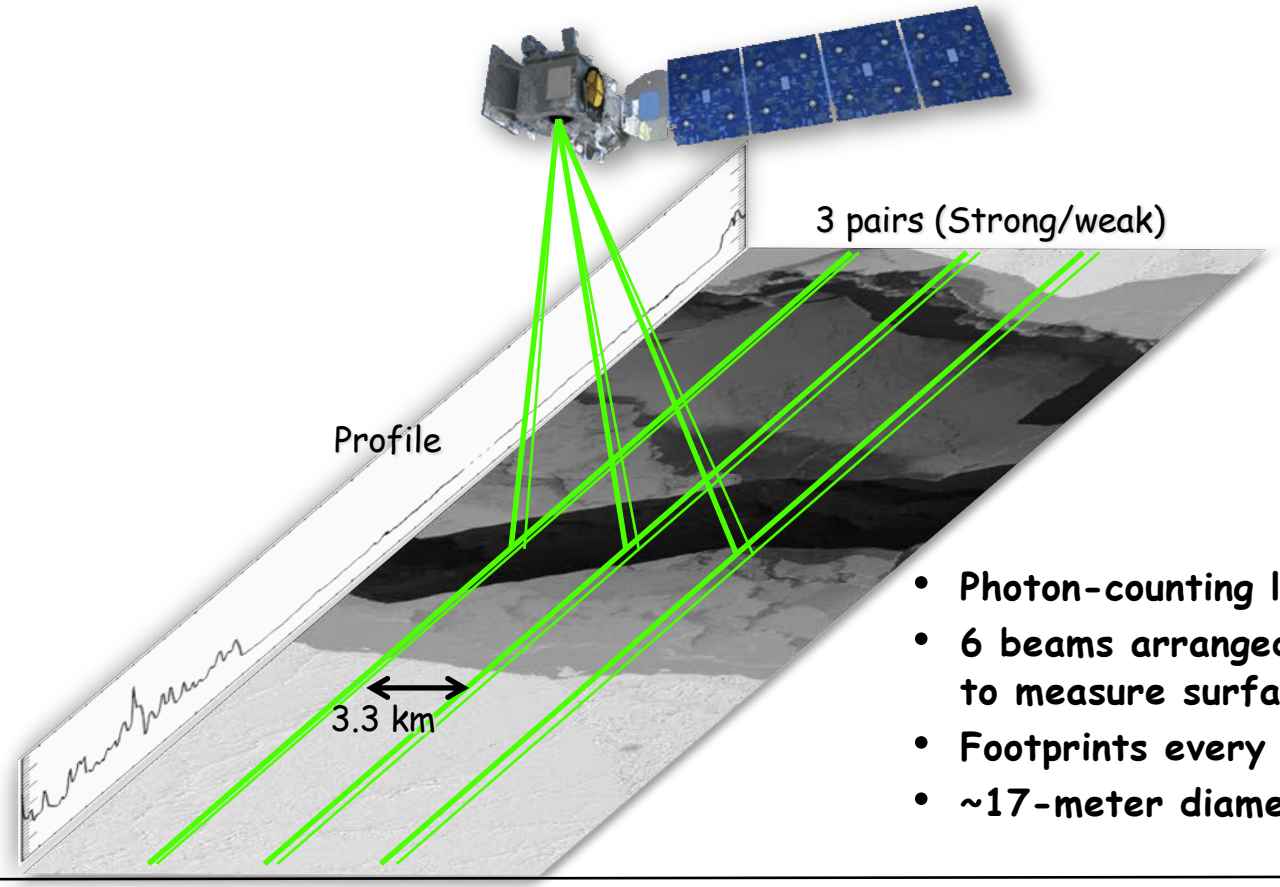
Arctic ice thickness from ICESat: 2004-2008



- Single beam profiler
- Footprint: 50-70 m
- 167 m spacing between spots

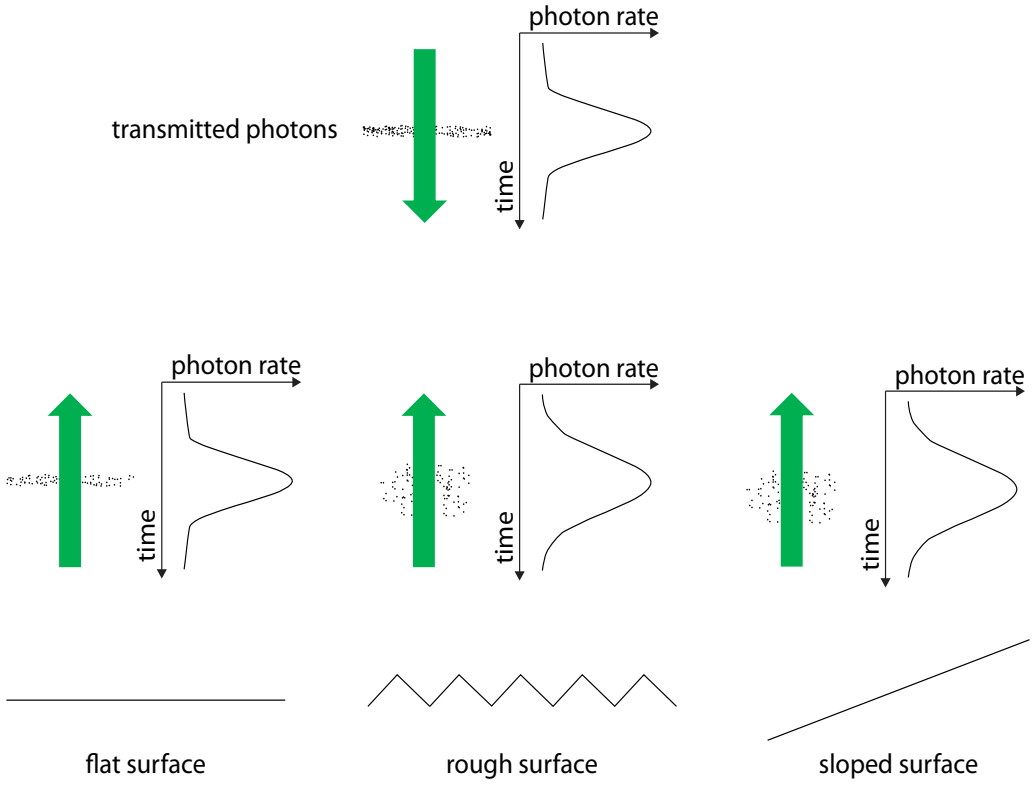
Kwok et al., 2009

Multibeam Photon Counting Altimetry



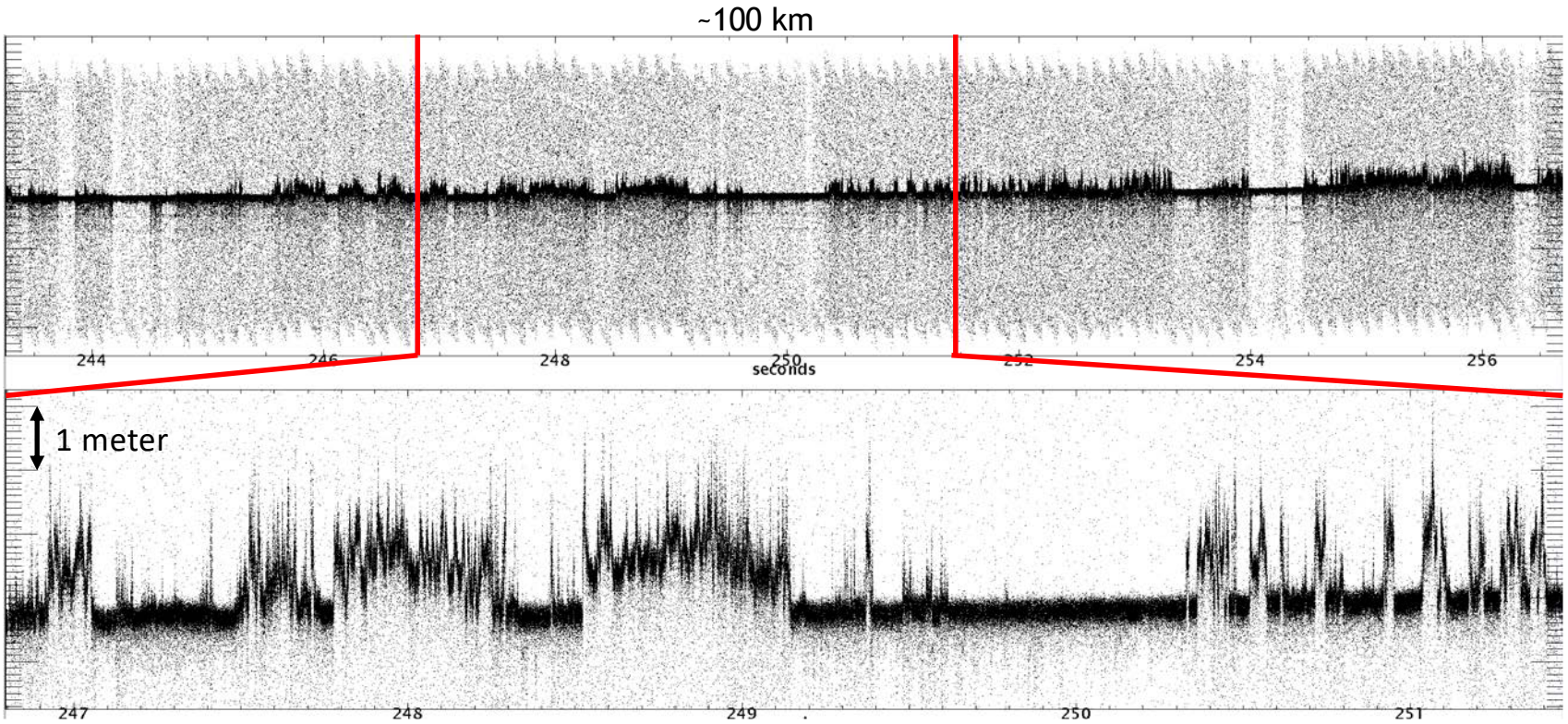
- Photon-counting lidar
- 6 beams arranged in 3 (Strong/weak) pairs to measure surface slope directly
- Footprints every 0.7 m (ICESat-1 167 m)
- ~17-meter diameter (ICESat-1 50-70 m)

Multibeam Photon Counting Altimetry



Height estimate for every detected photon event !

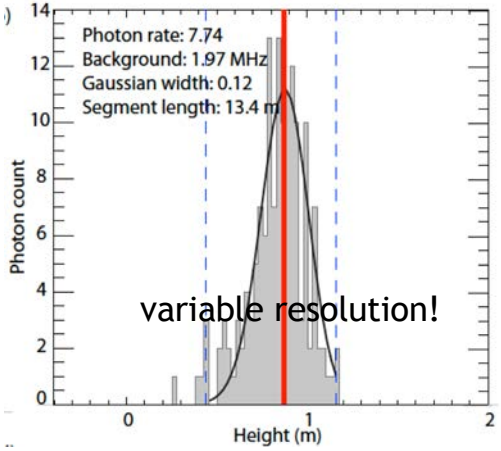
Photon Cloud (Returns from sea ice)

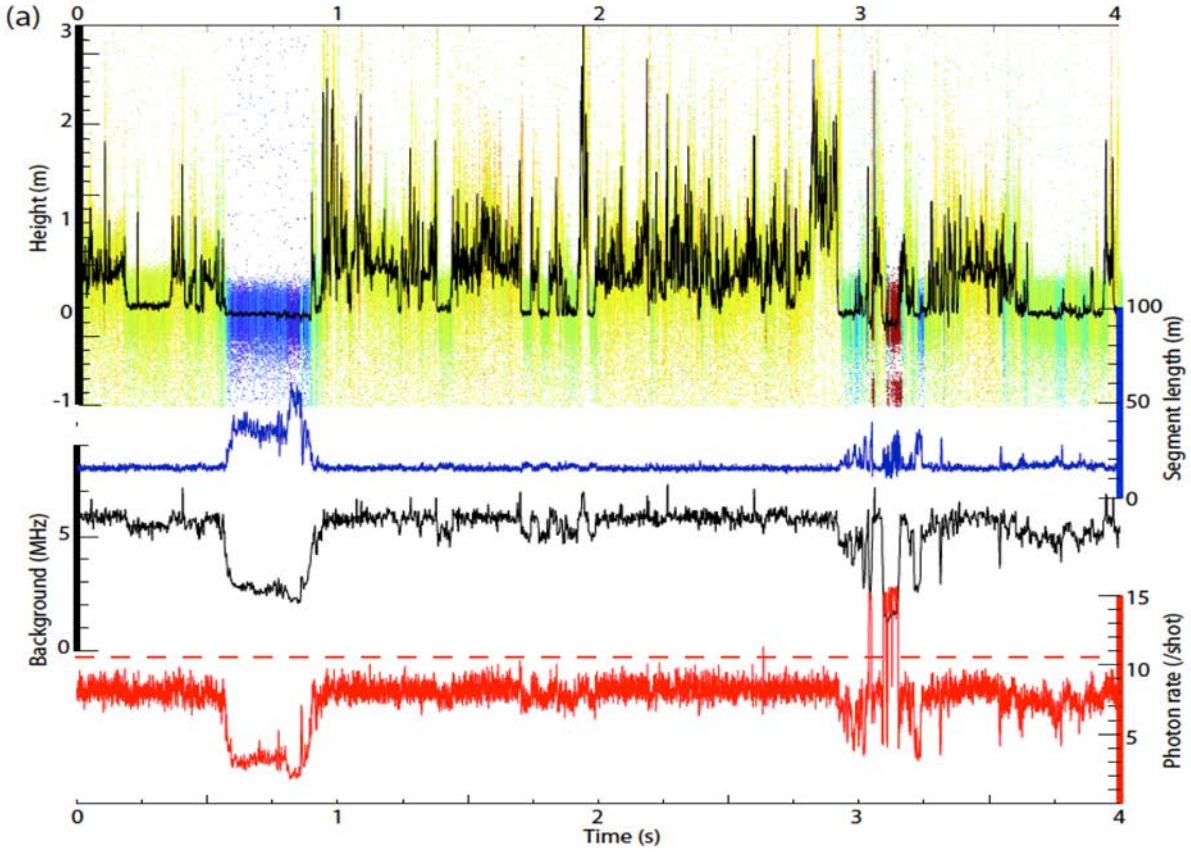


Sea Ice: Single Beam Parameters

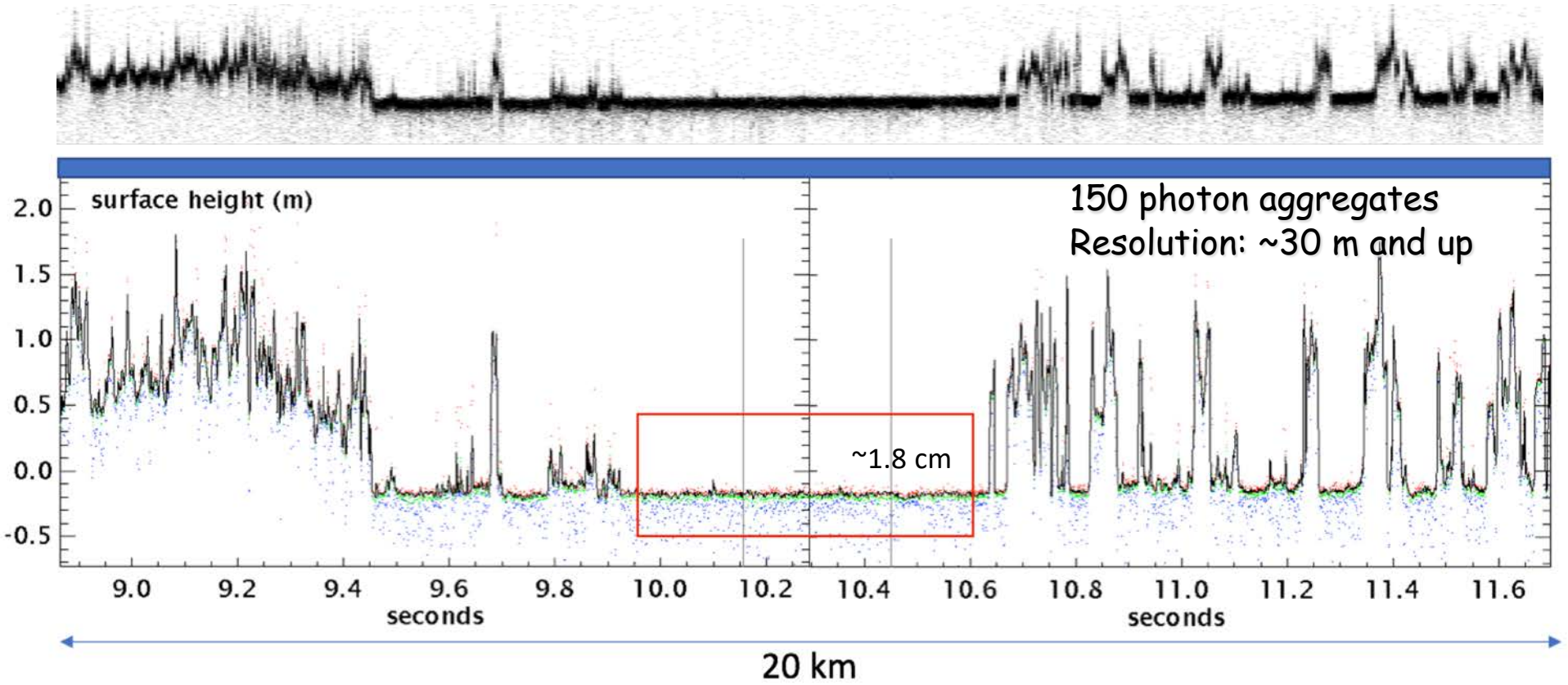
What's important for freeboard determination?
Spatial resolution:
Local sea level in narrow openings in the ice (leads/cracks)

150 photon aggregates

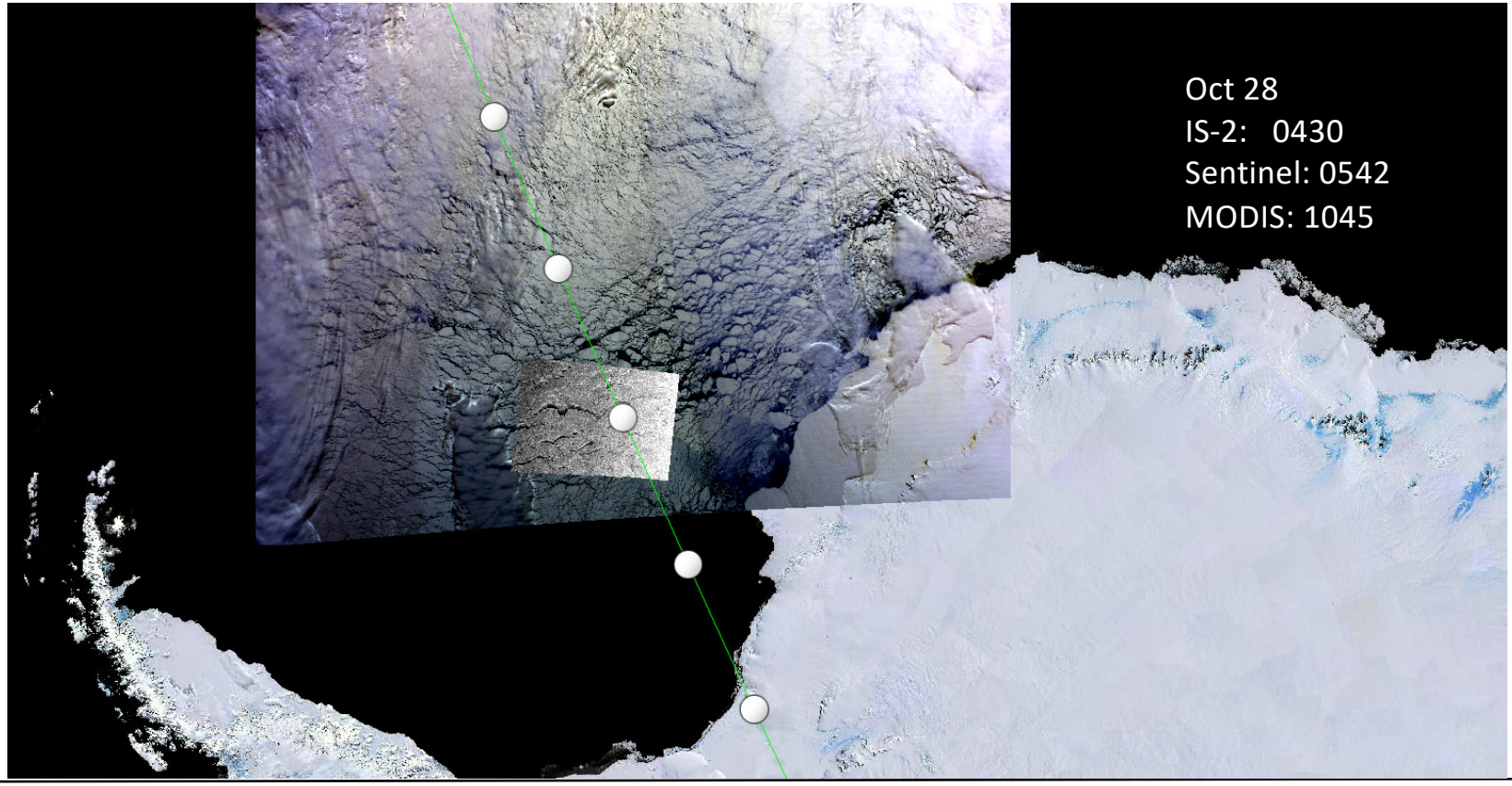




Height Precision after surface finding

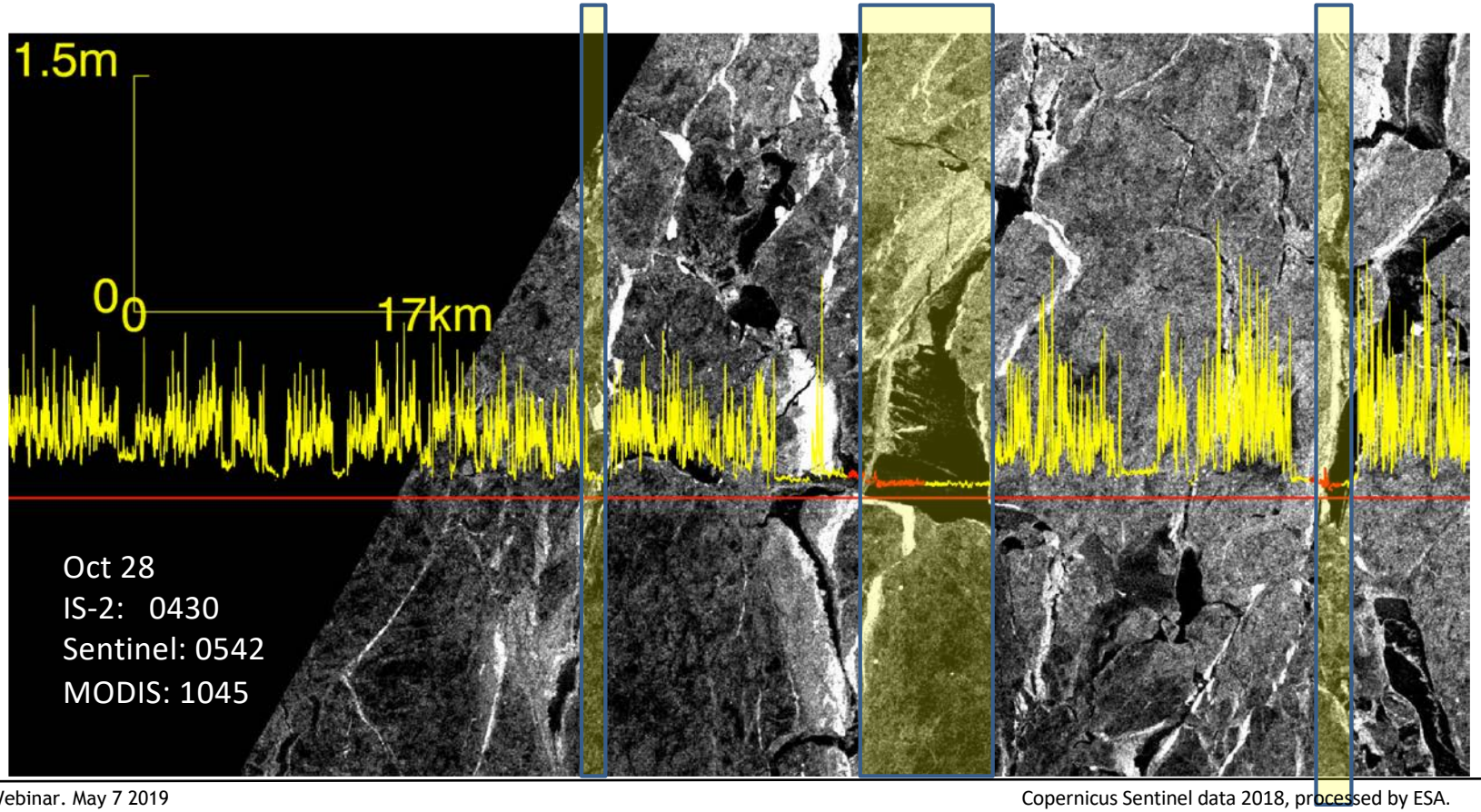


Near Coincident IS-2, Sentinel, and MODIS coverage



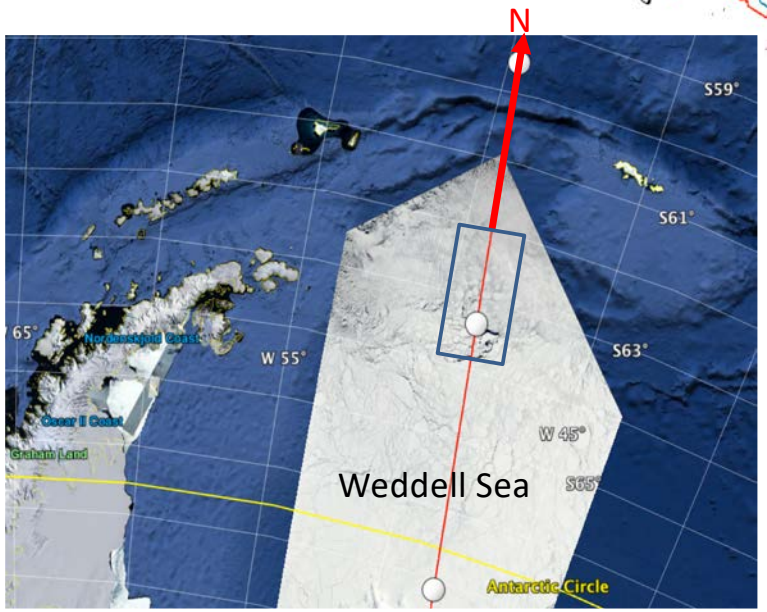
Copernicus Sentinel data 2018, processed by ESA.

Heights of thin ice and leads

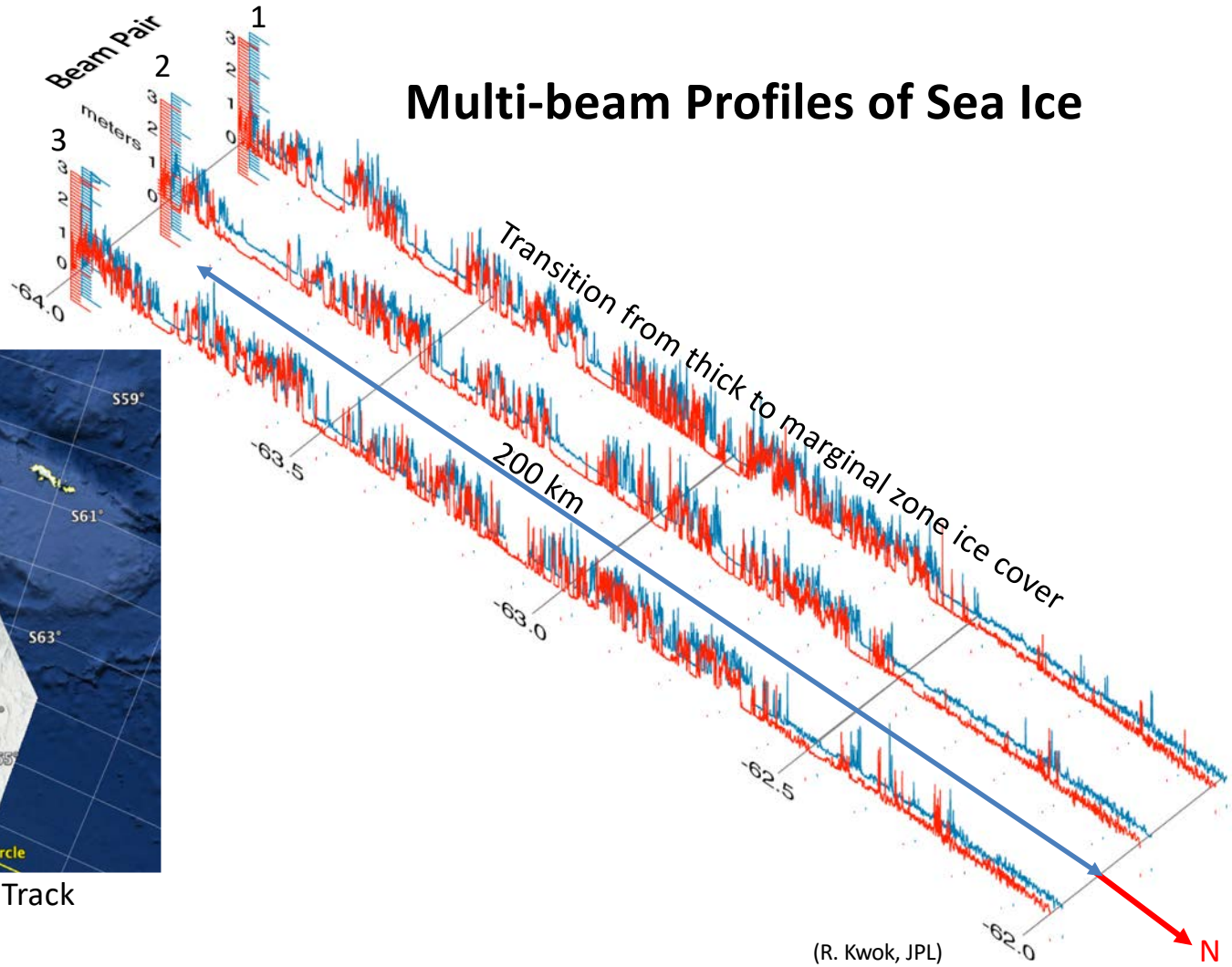


Copernicus Sentinel data 2018, processed by ESA.

Multi-beam Profiles of Sea Ice



October 17, 2018 – Ascending Track



(R. Kwok, JPL)

Freeboard from IS-2

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Sea Ice Freeboard from Space
Ice/Water discrimination

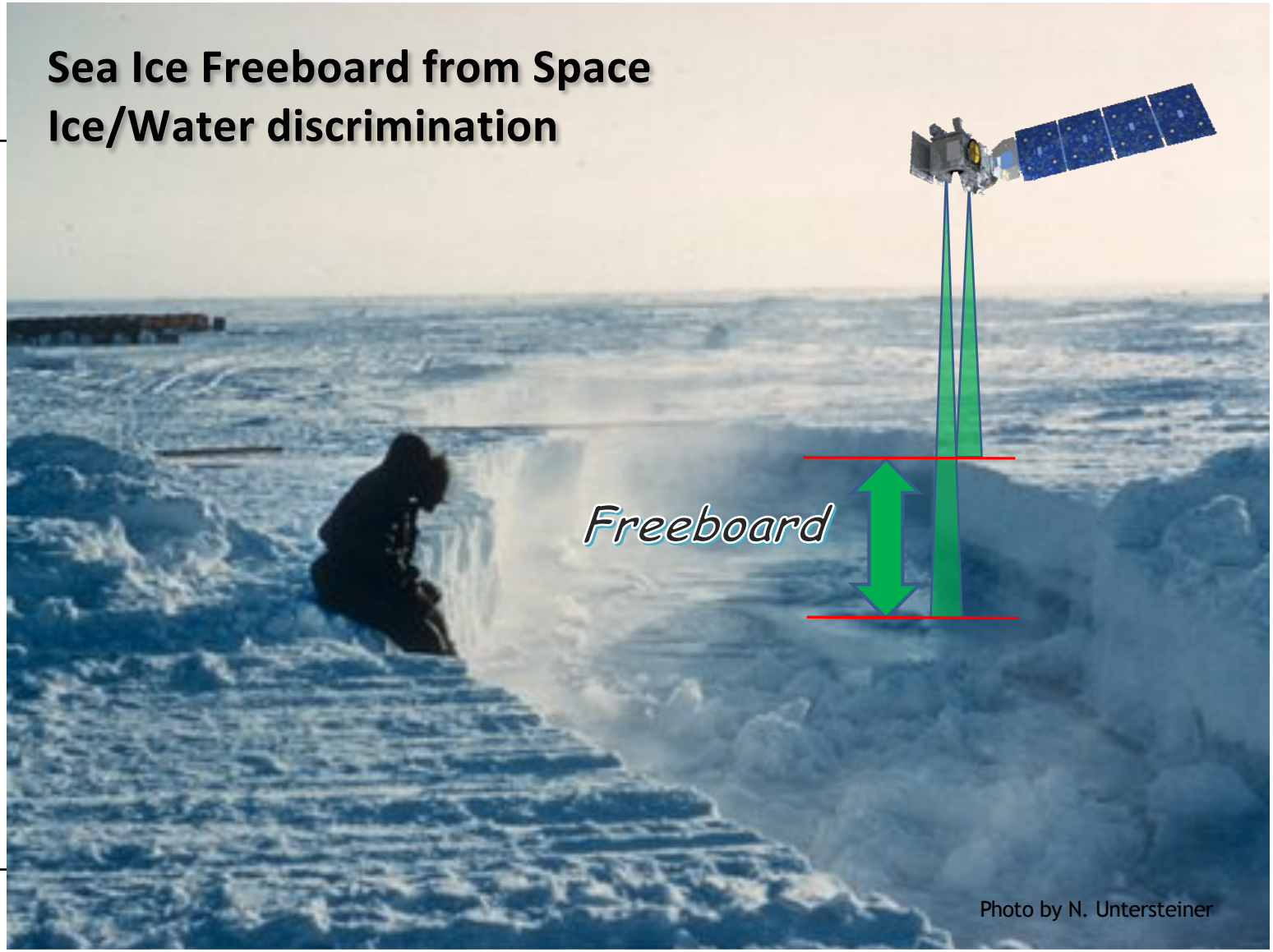
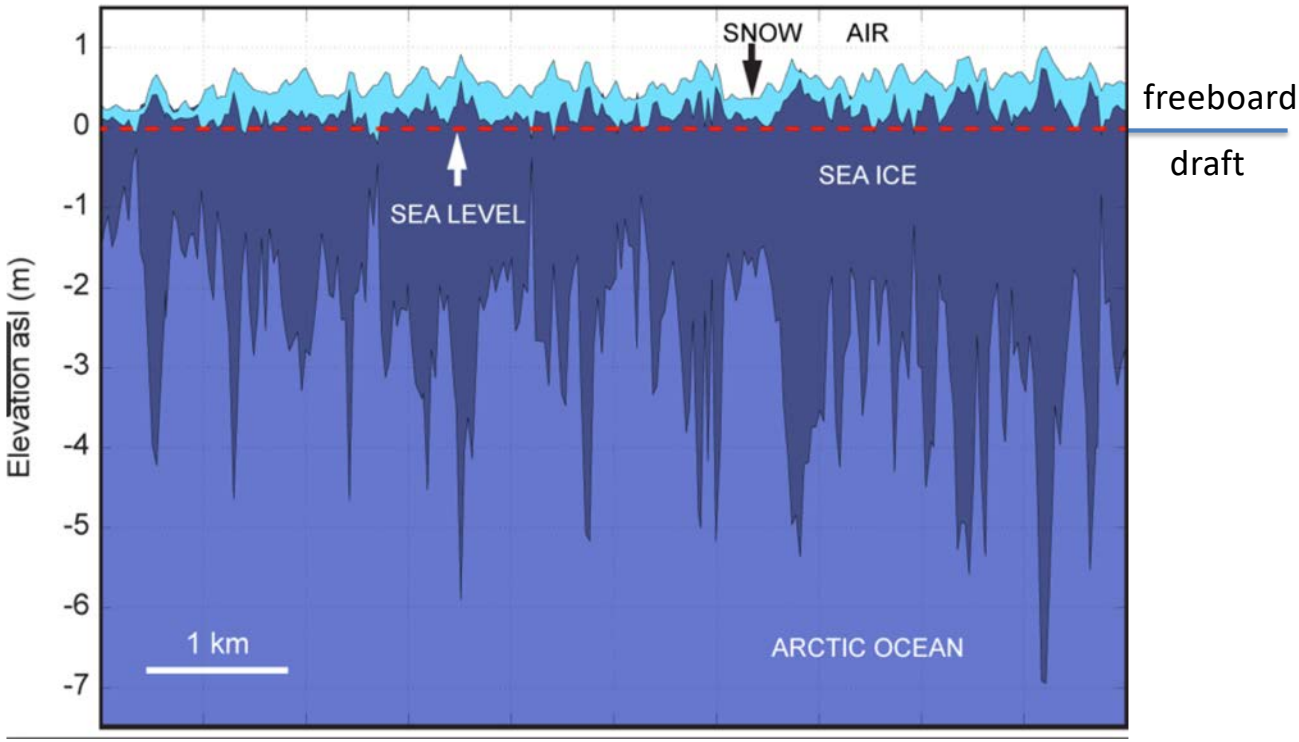


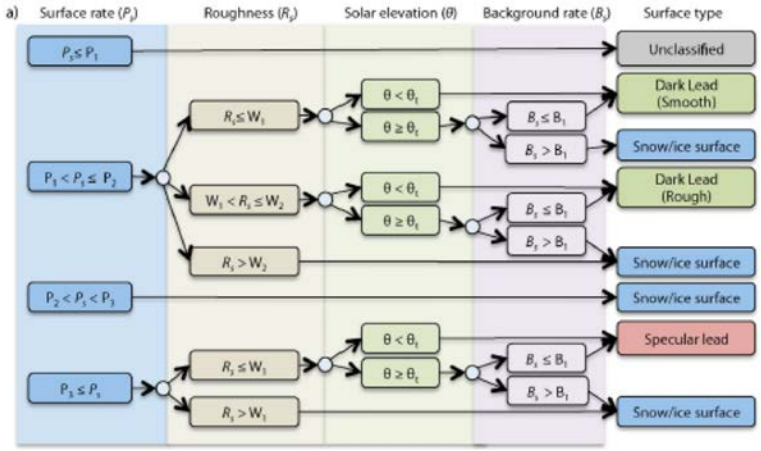
Photo by N. Untersteiner

Reconstruction of thickness from freeboard



Graphics from Operation IceBridge:
NASA airborne mission

Separation of Ice/water samples for freeboard calculations



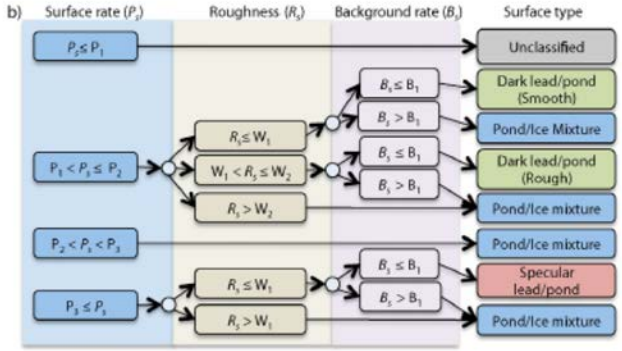


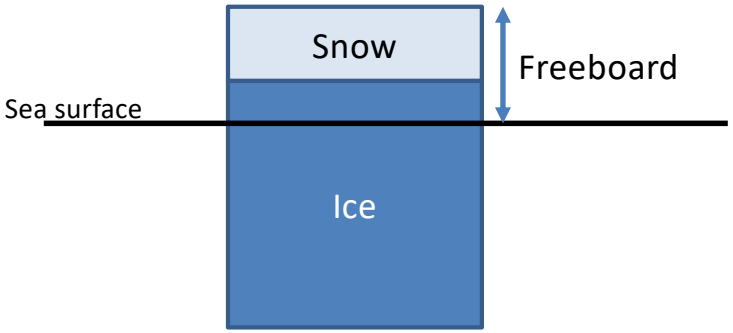
Fig. 5. Decision tree for ice-water classification in (a) winter and (b) summer.

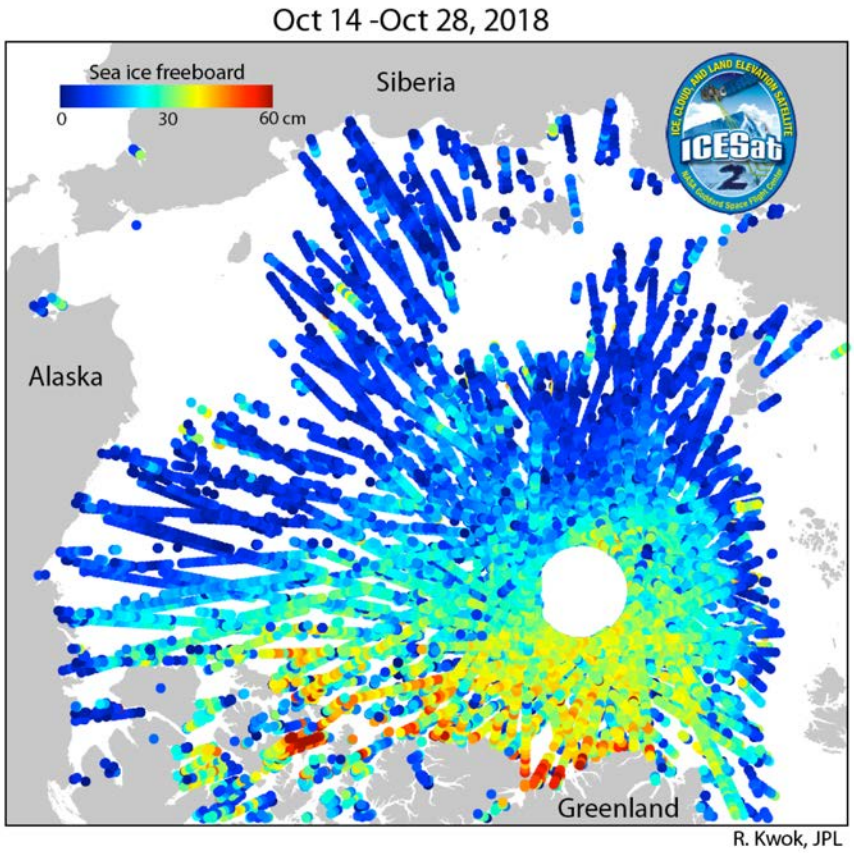
- Based on contrasts in:
  - Photon rate (average count/per shot); apparent surface reflectance
  - Surface roughness
  - Background rate
    - When sun elevation is high
    - Varies along an orbit
- Surface types
  - Dark lead (smooth, rough)
  - Snow covered ice
  - Shadow
  - Specular (open water)
  - Rough surface

Sample fields

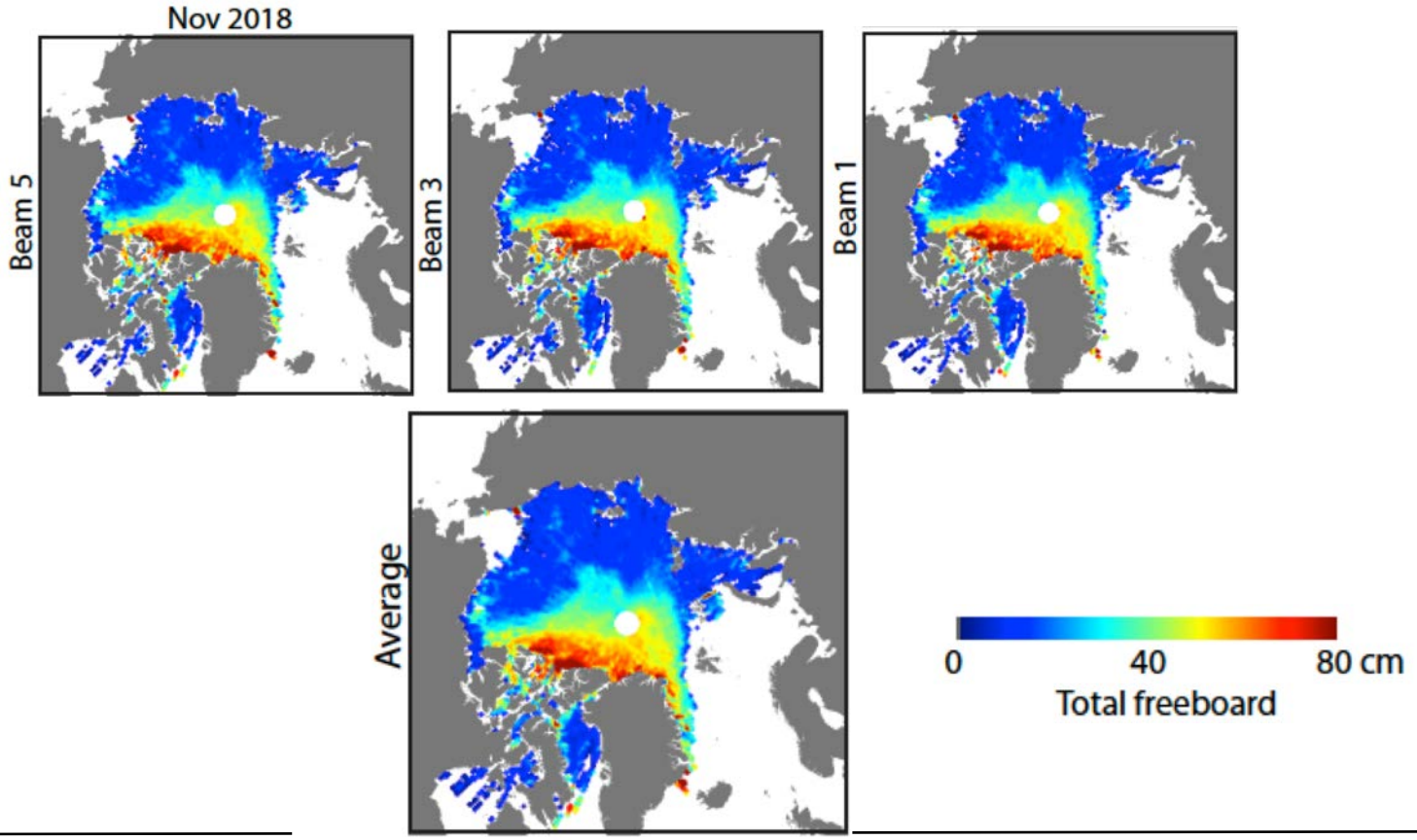
Arctic Sea Ice Freeboard from 14-days of ICESat-2 data

Thin ice (low freeboard in dark blue) at the beginning of growth season



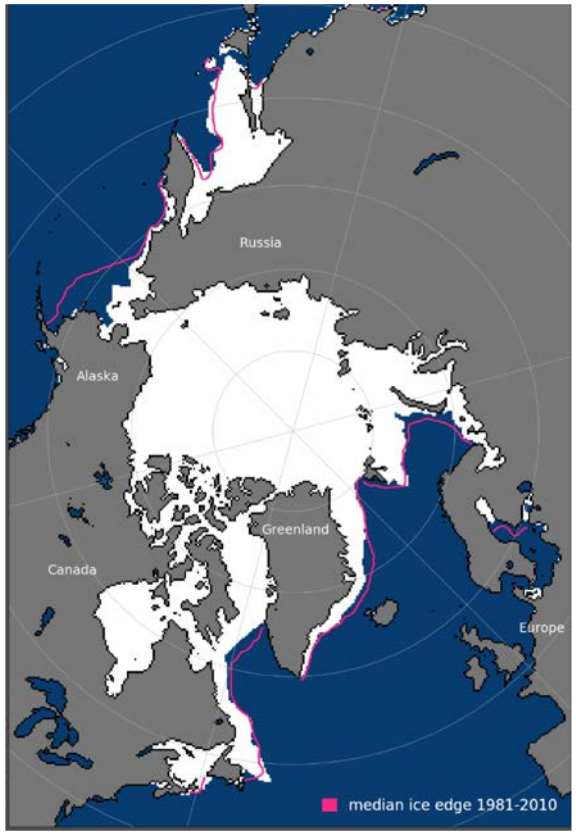


Three Strong Beams – Gridded fields

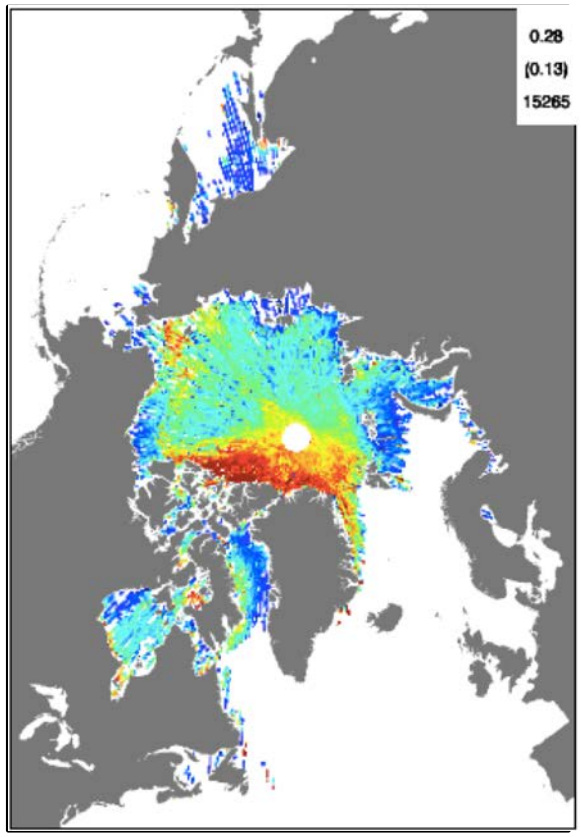


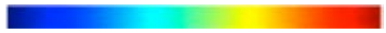
Northern Hemisphere sea ice freeboard

March 2019



sea ice extent -NSIDC

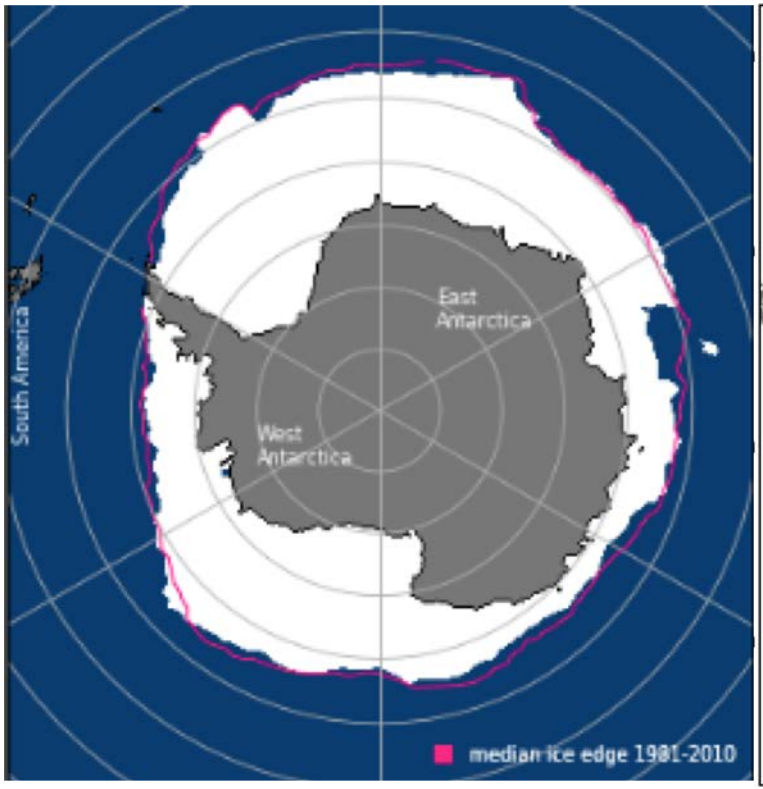




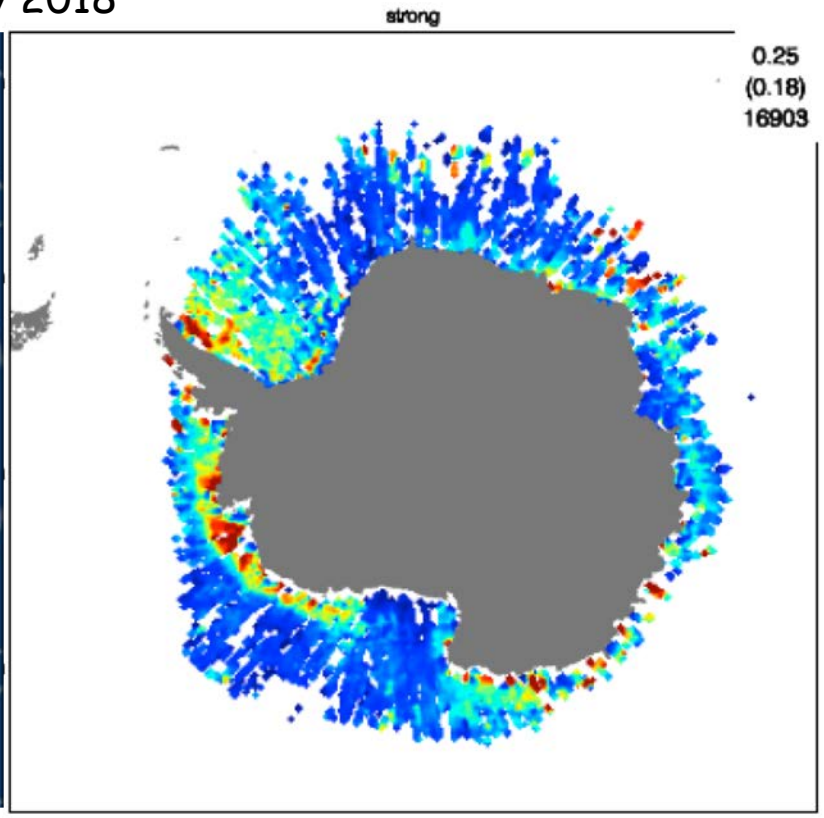
0 60 cm

Southern Hemisphere sea ice freeboard

Nov 2018

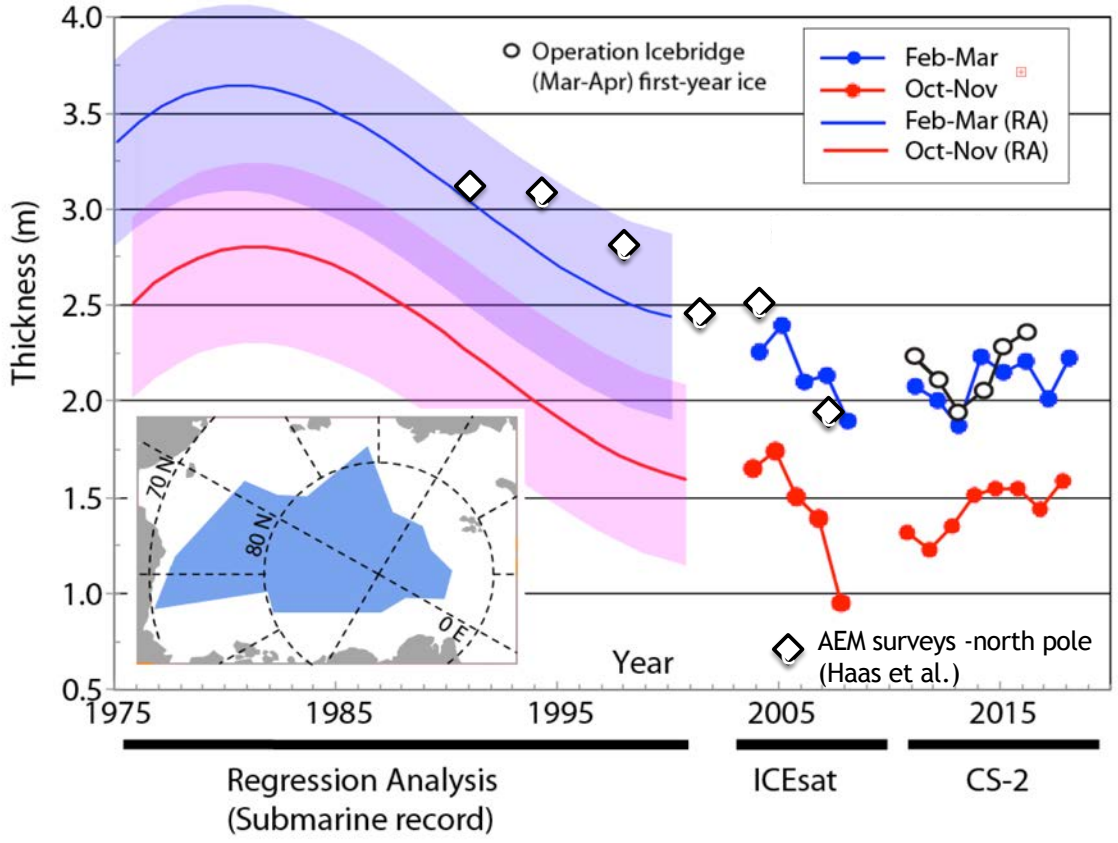


sea ice extent -NSIDC



0 80 cm

Decline in sea ice thickness (Central Arctic Ocean): (Submarine, AEM, CS-2, OIB, and ICESat)



Kwok, 2018

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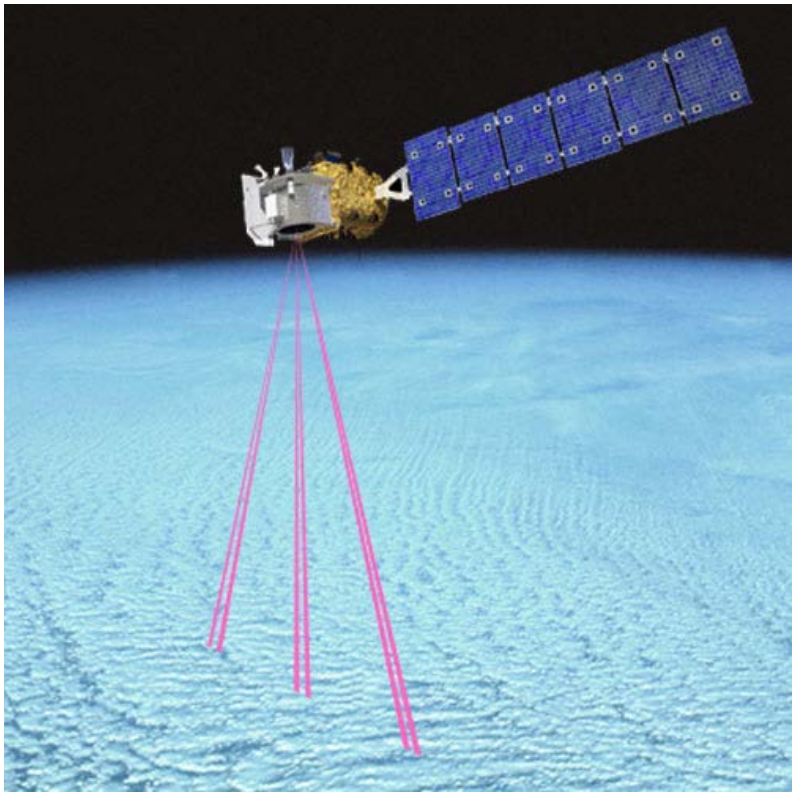
CryoSat-2 altimetry data are from ESA' s data portal (URL: https://earth.esa.int)

Multibeam Sea Ice Products



- Science data collection from October 14
- Routine Products
  - Along-track (from 6 beams)
    - sea ice and sea surface heights (Product: ATL07/L3A).
    - sea ice freeboard (ATL10/L3A).
    - Available at the end of May at NSIDC
      - Oct 14 thru Dec 27, 2018
- Research Products (GSFC)
  - Along-track sea ice thickness.
  - Gridded monthly sea ice thickness.