



ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Sea ice thickness changes in the Arctic Ocean

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Marine Research

Finnish Meteorological Institute

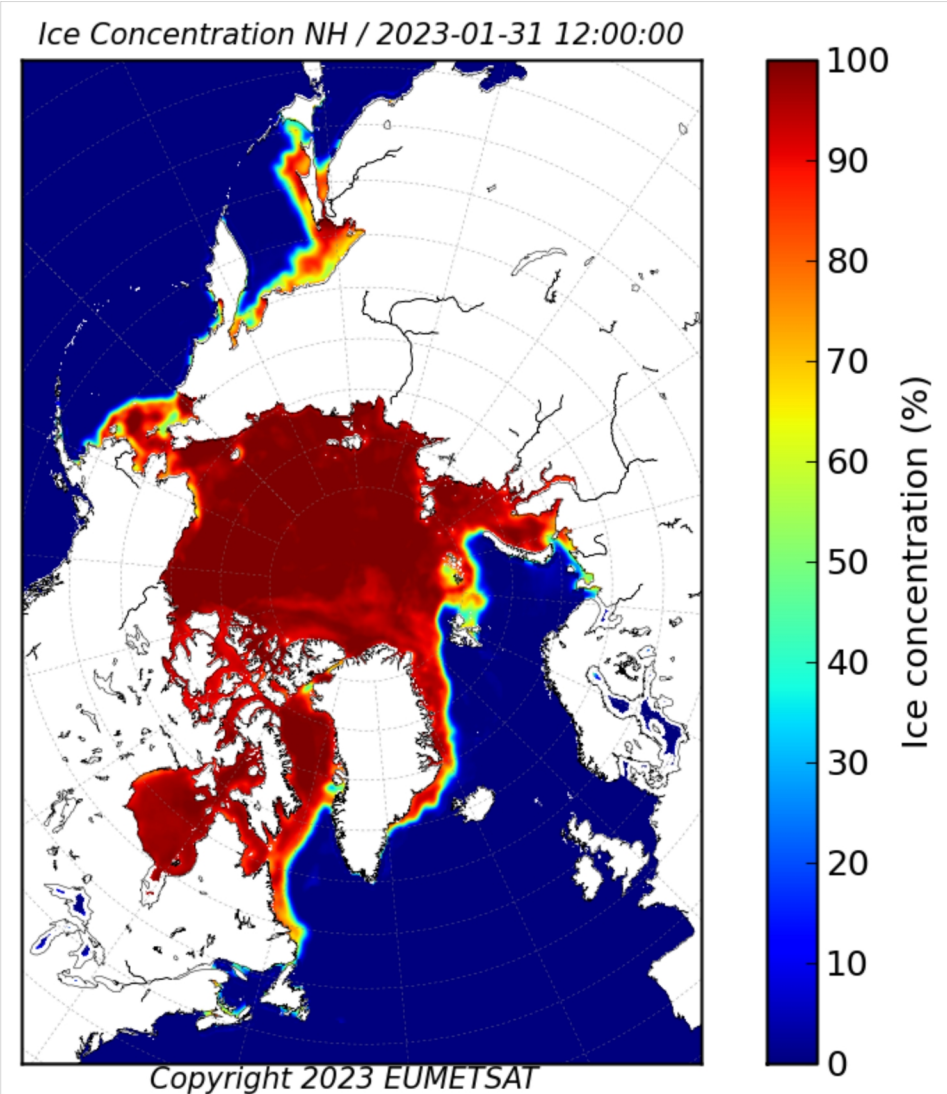
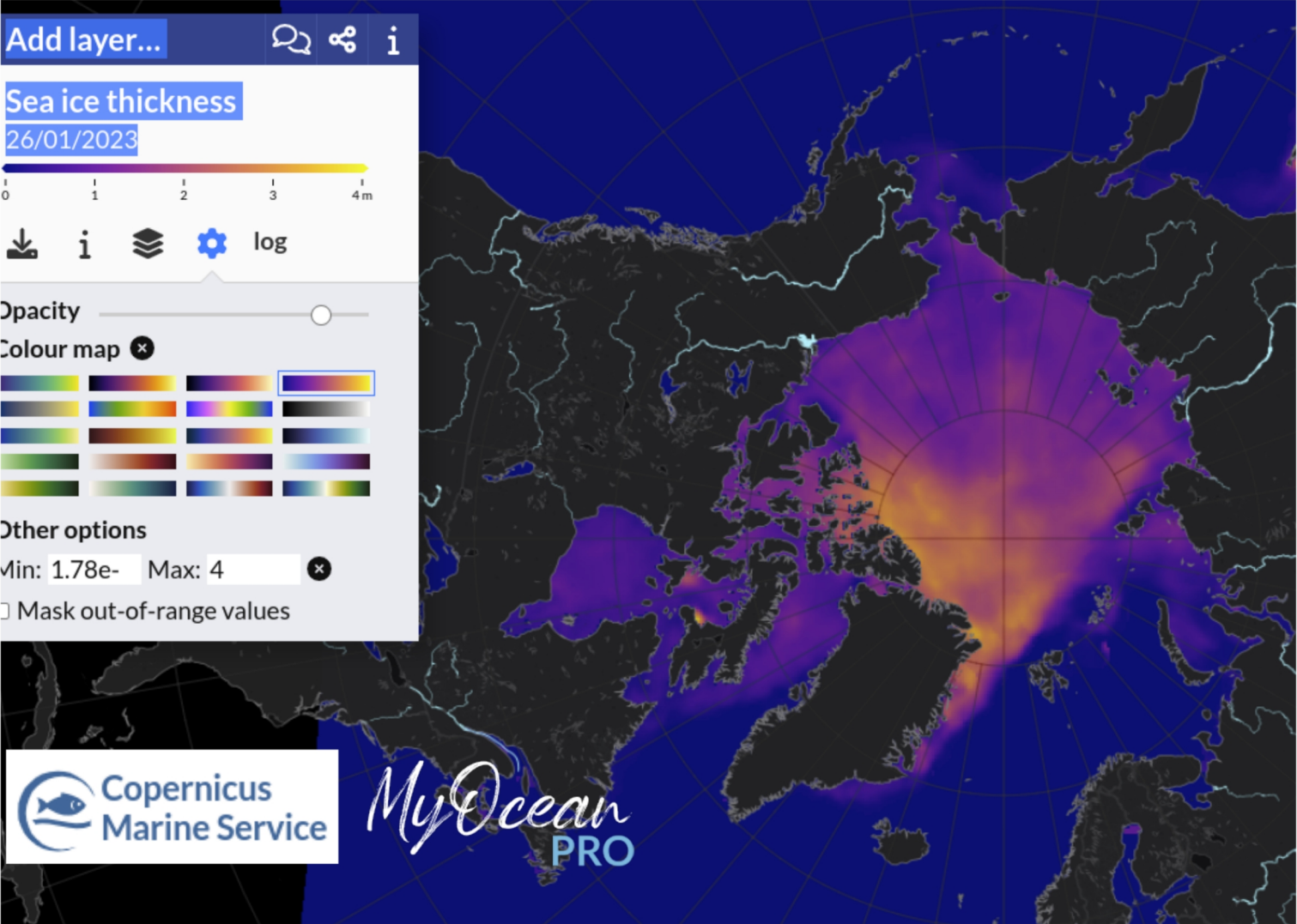


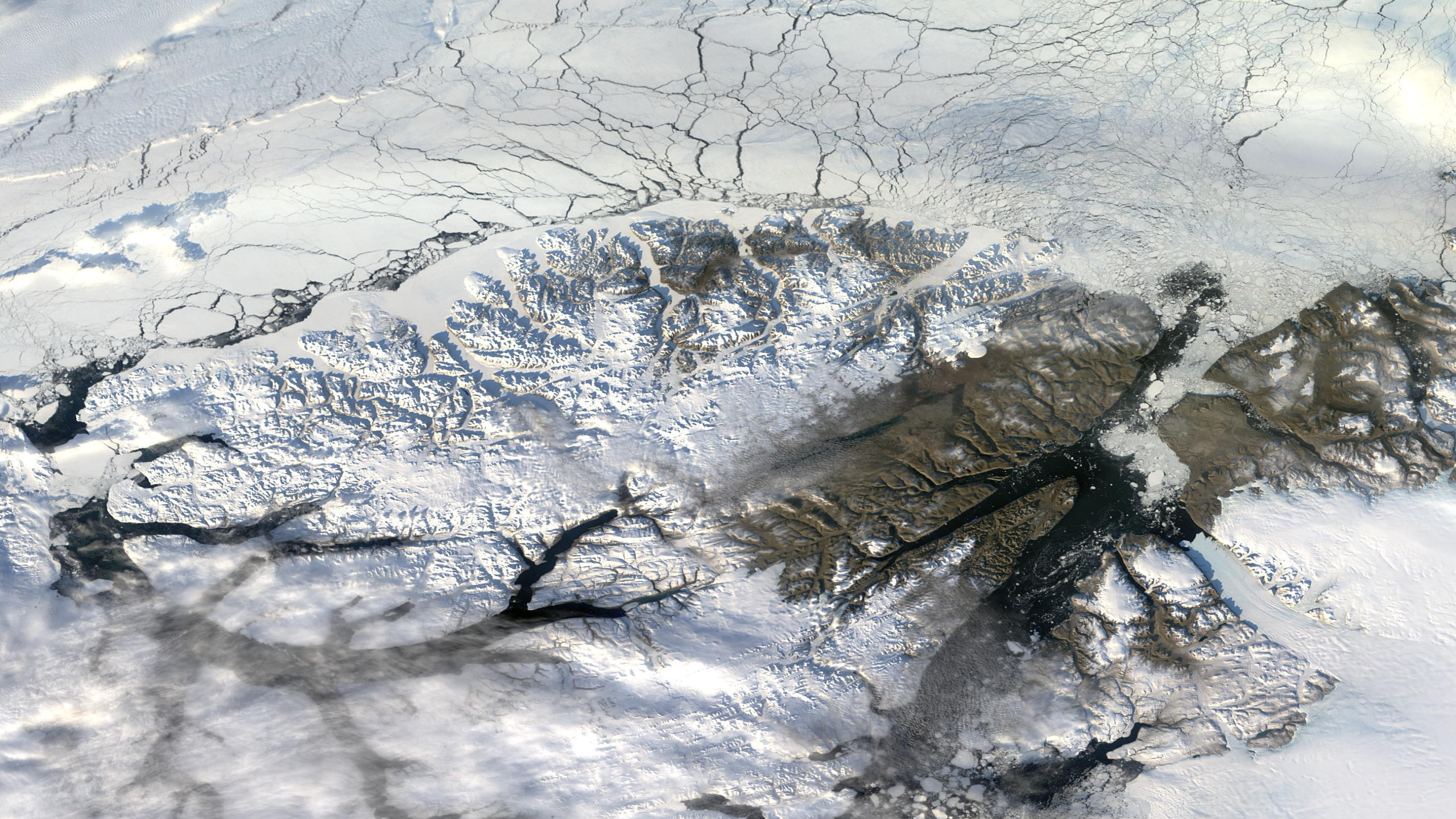
Outline

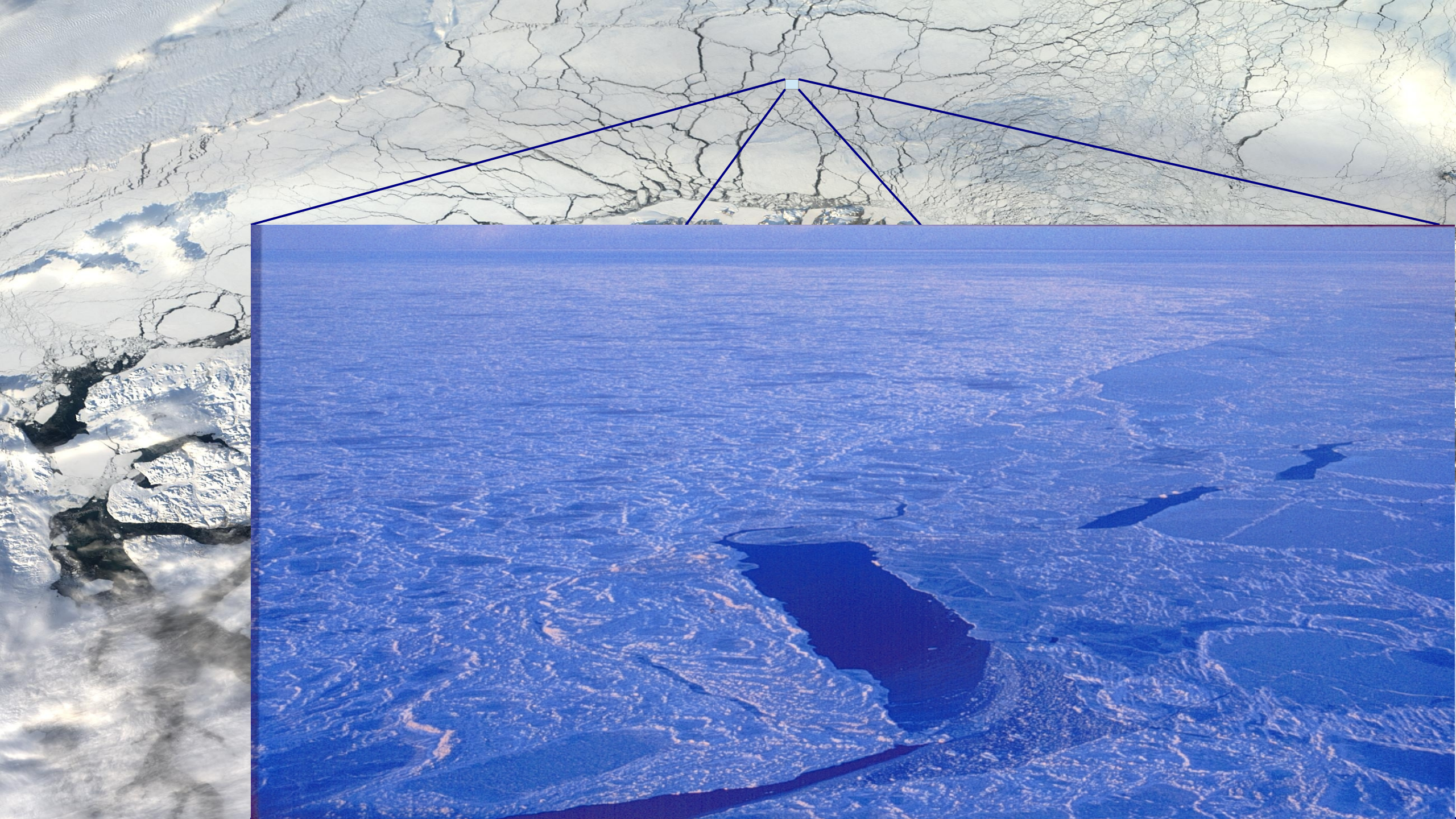
- 1) How sea ice thickness vary in space and time?
- 2) Pro's and con's of sea ice thickness data sets
- 3) Observation on sea ice thickness change
- 4) New findings from the MOSAiC campaign

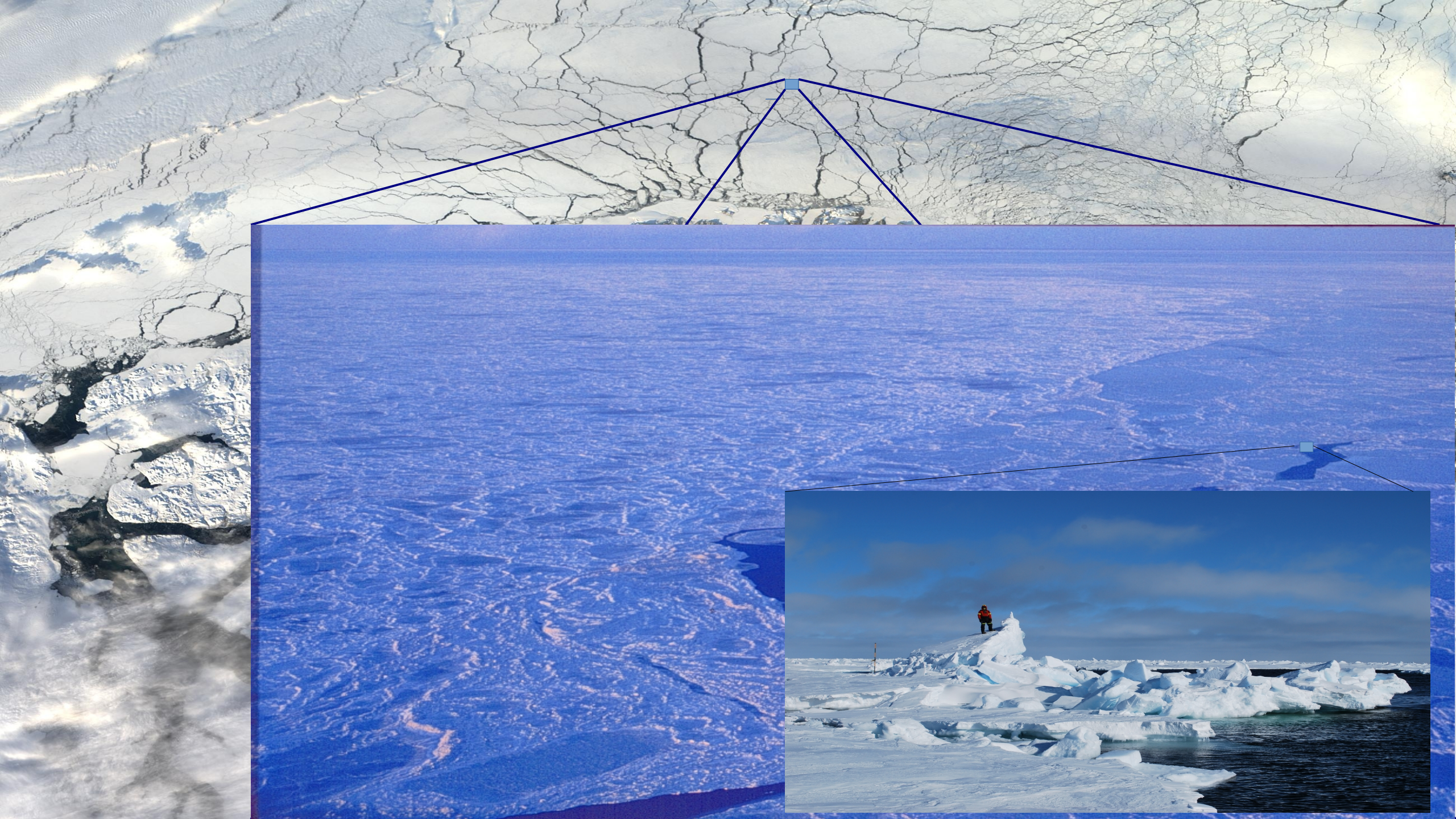


Present sea ice conditions

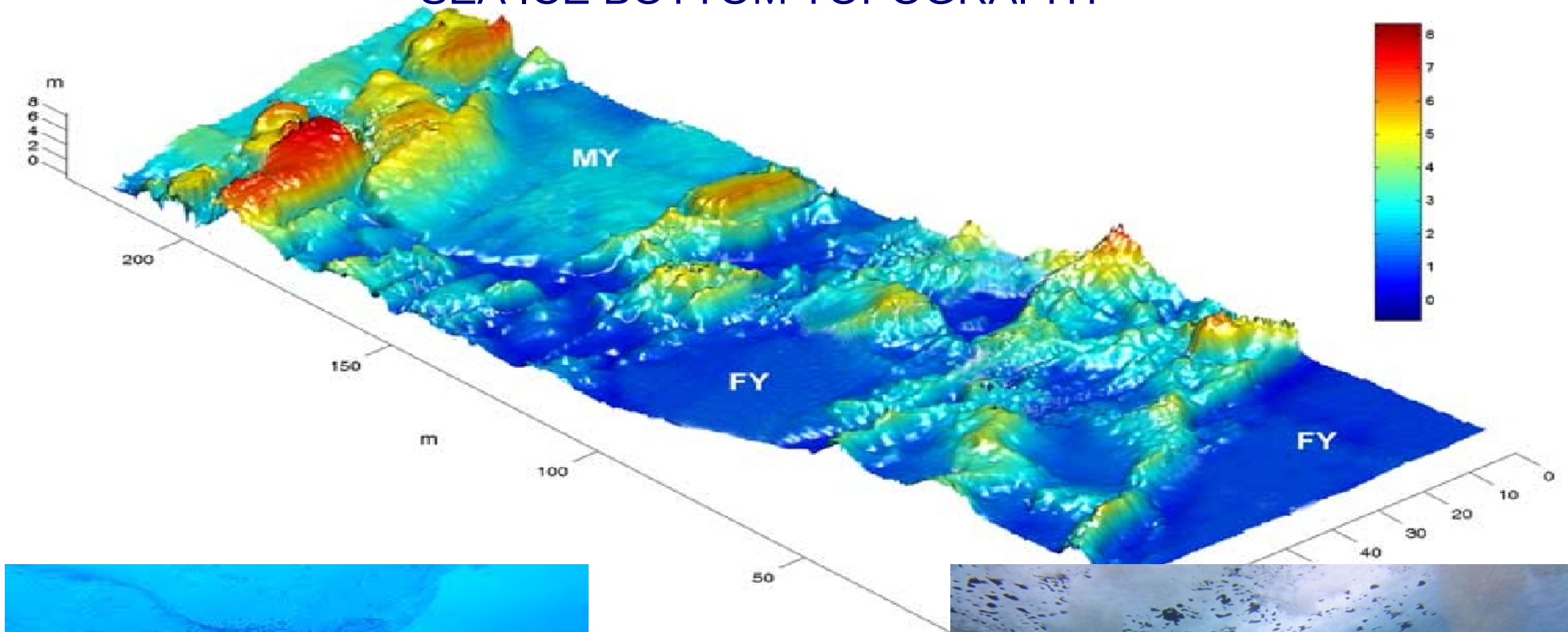




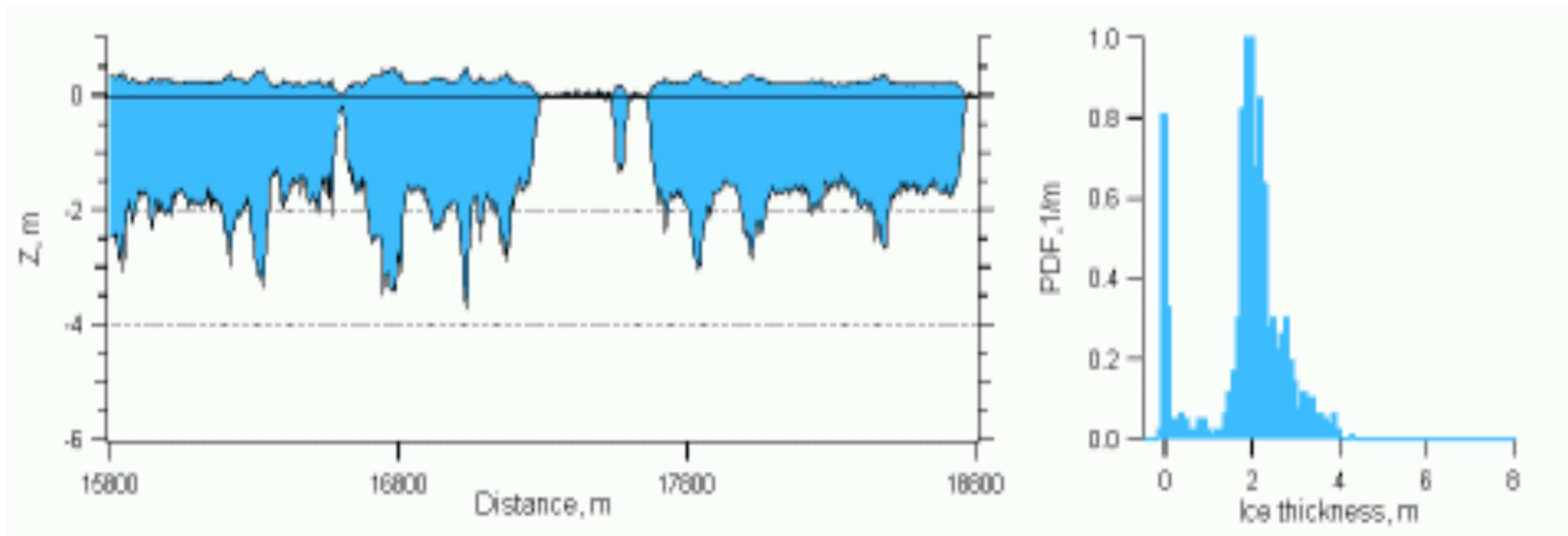




SEA ICE BOTTOM TOPOGRAPHY



Pack ice exhibits large spatial variability in ice thickness



Courtesy of Christian Haas

Ice thickness measurement techniques

- Drilling: accurate in spot, bad in spatial representation.
- Ice mass balance buoys: as drilling but provides timeserie
- Electromagnetic methods: larger footprint, good in regional data collection.
- Sonar: most accurate method, data coverage poor
- Satellite altimeters: areal averages, good spatial and temporal coverage



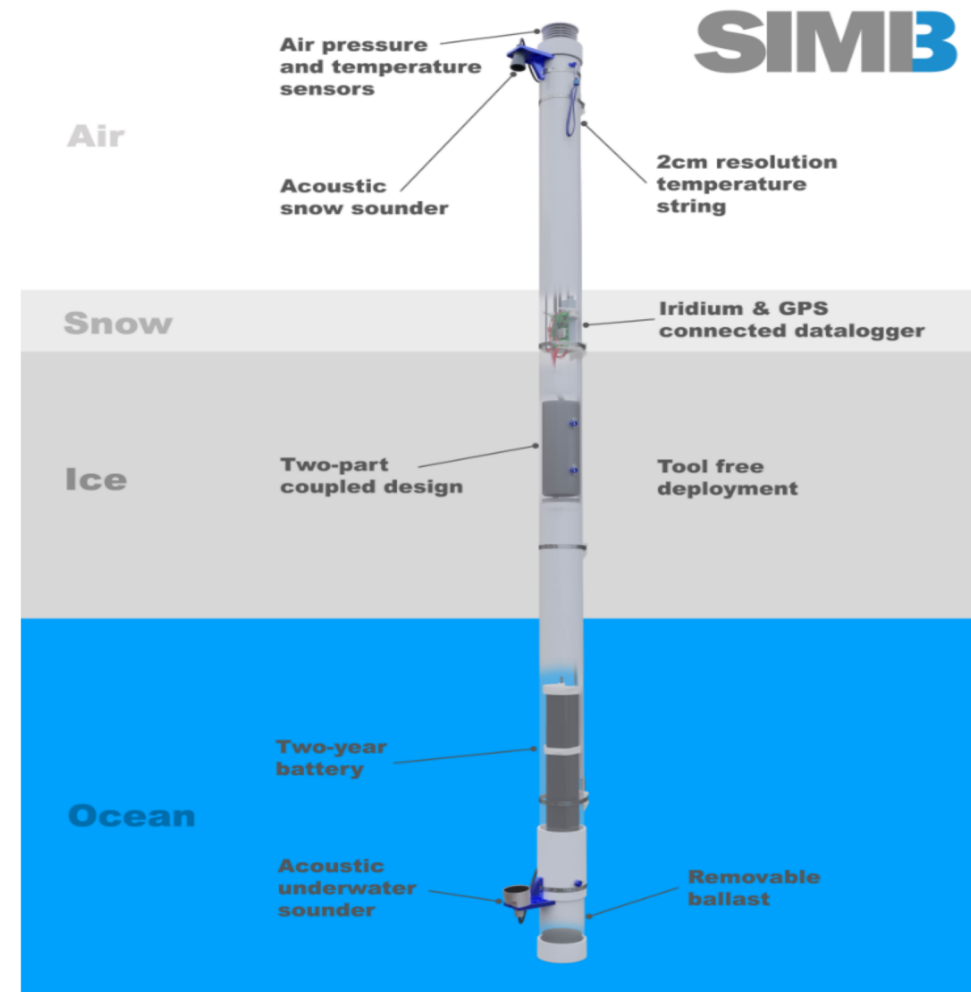
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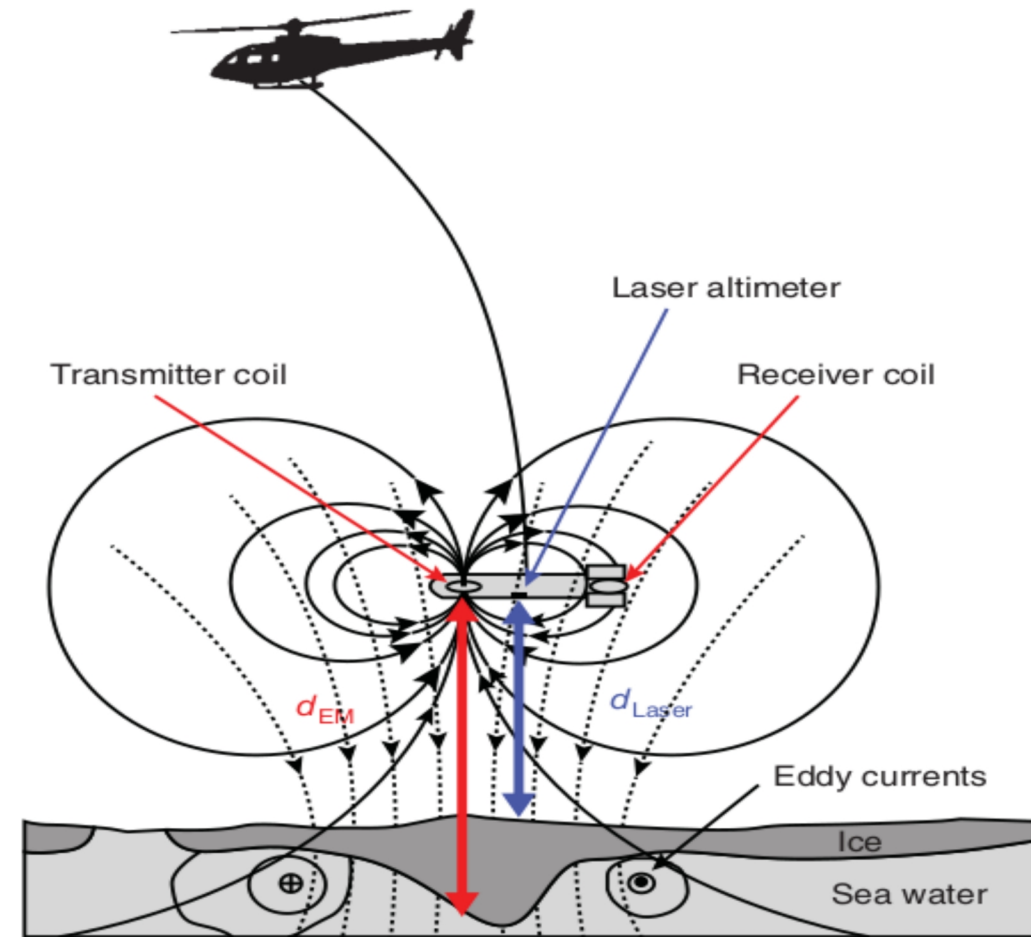
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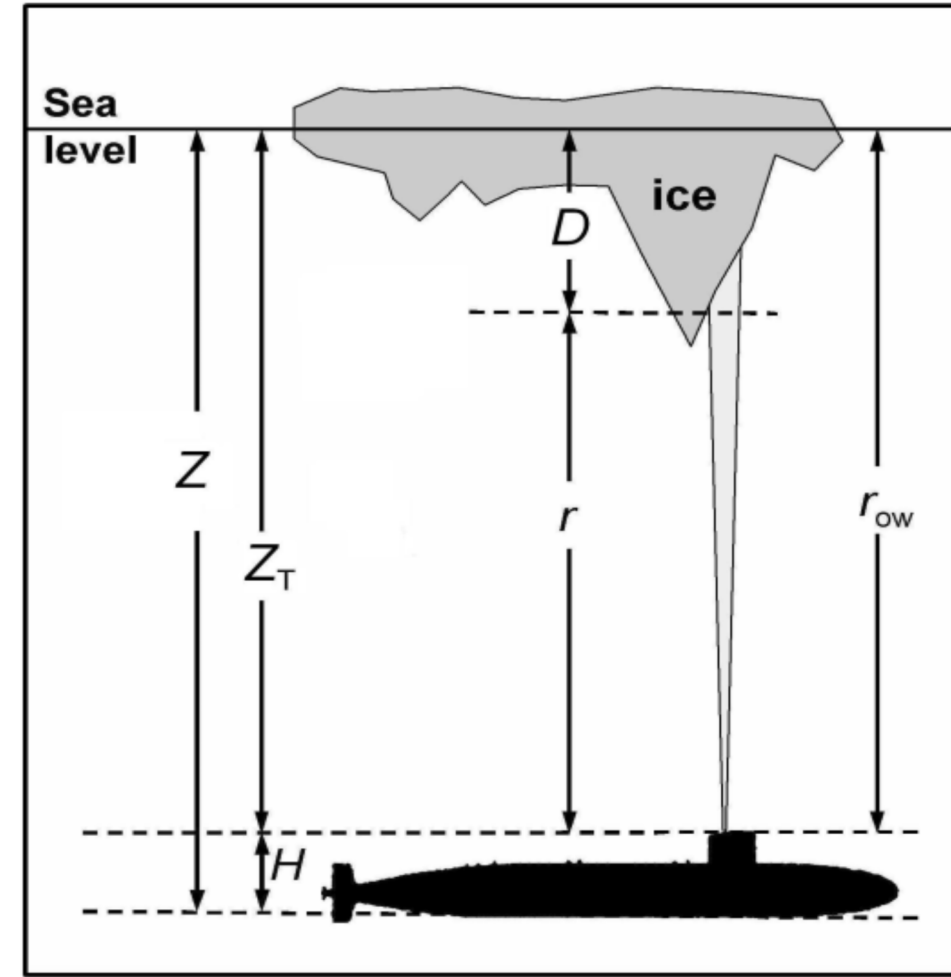
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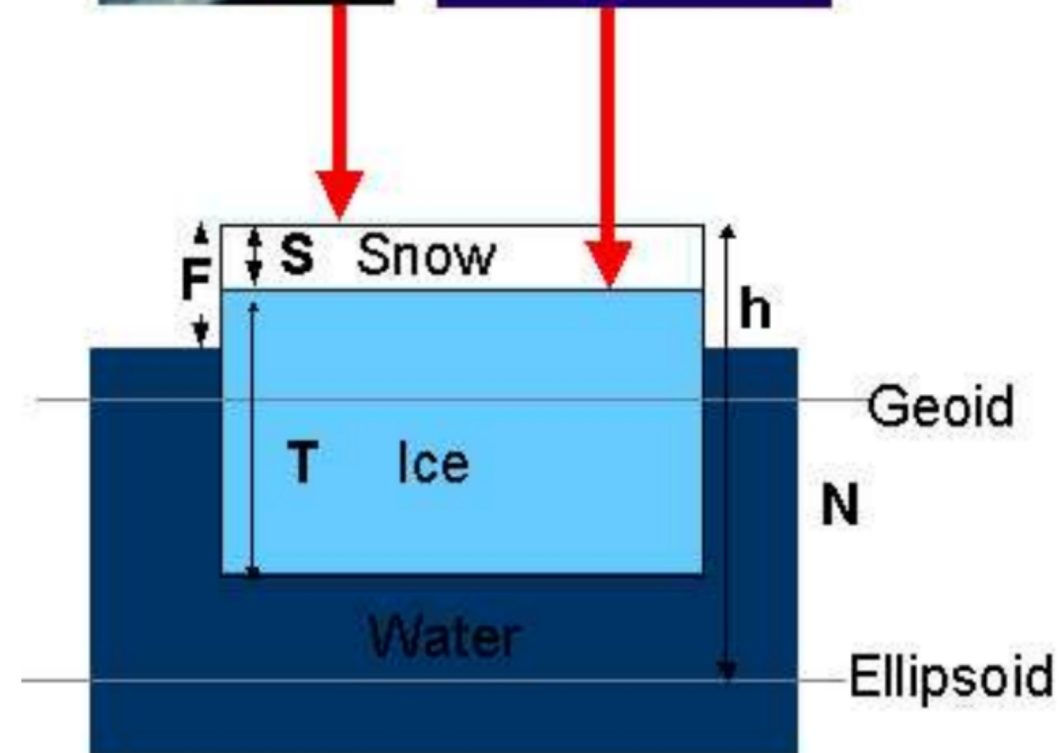
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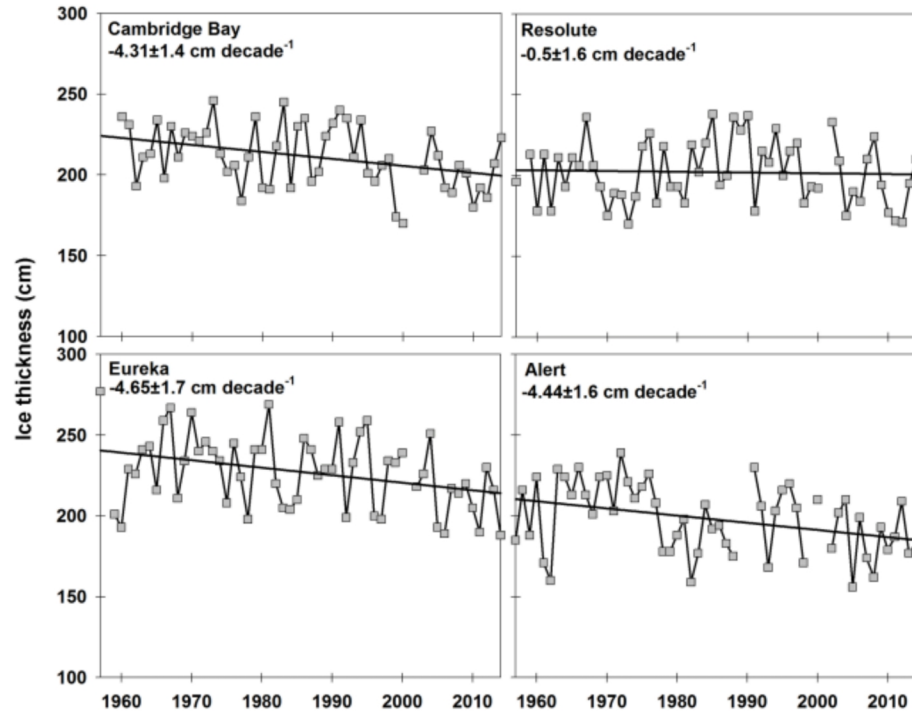
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Laser (IceSat) Radar (CryoSat)



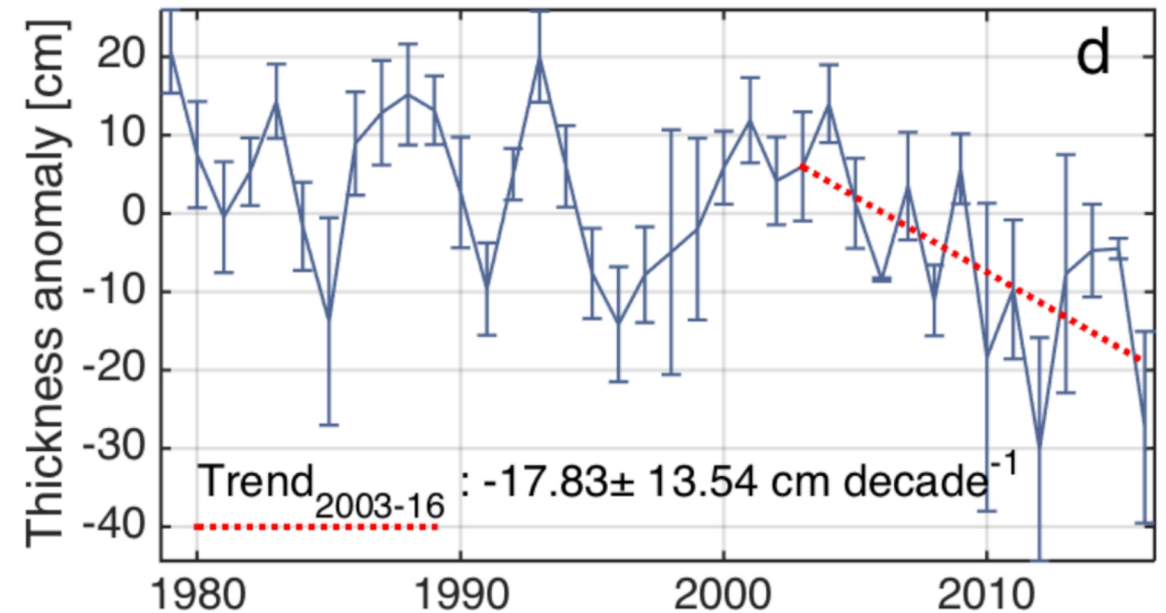
Changes of fast ice thickness

Canadian Arctic



Howell et al., 2016

Laptev Sea

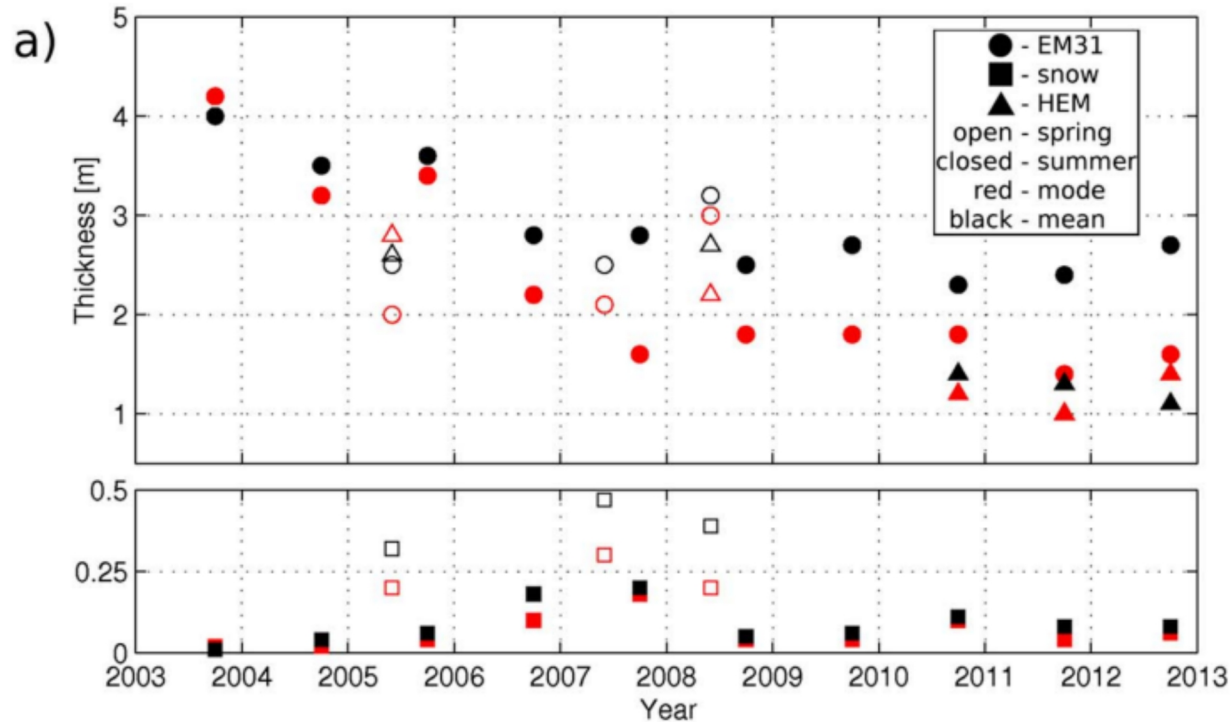


Polyakov et al., 2016

- Large interannual variability but clear thinning trend.

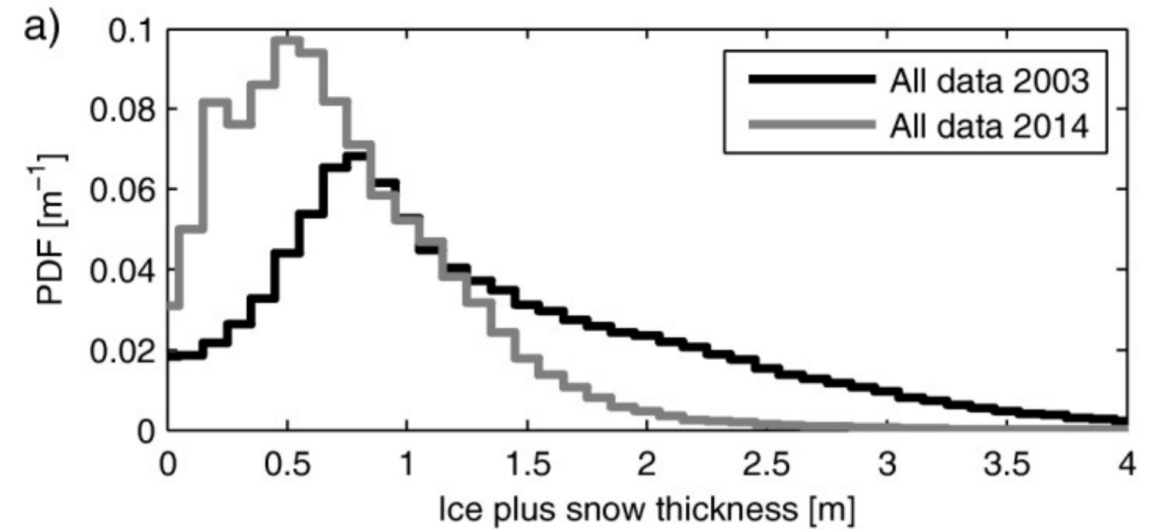
Changes in ice thickness based on HEM

Fram Strait



Renner at al, 2014

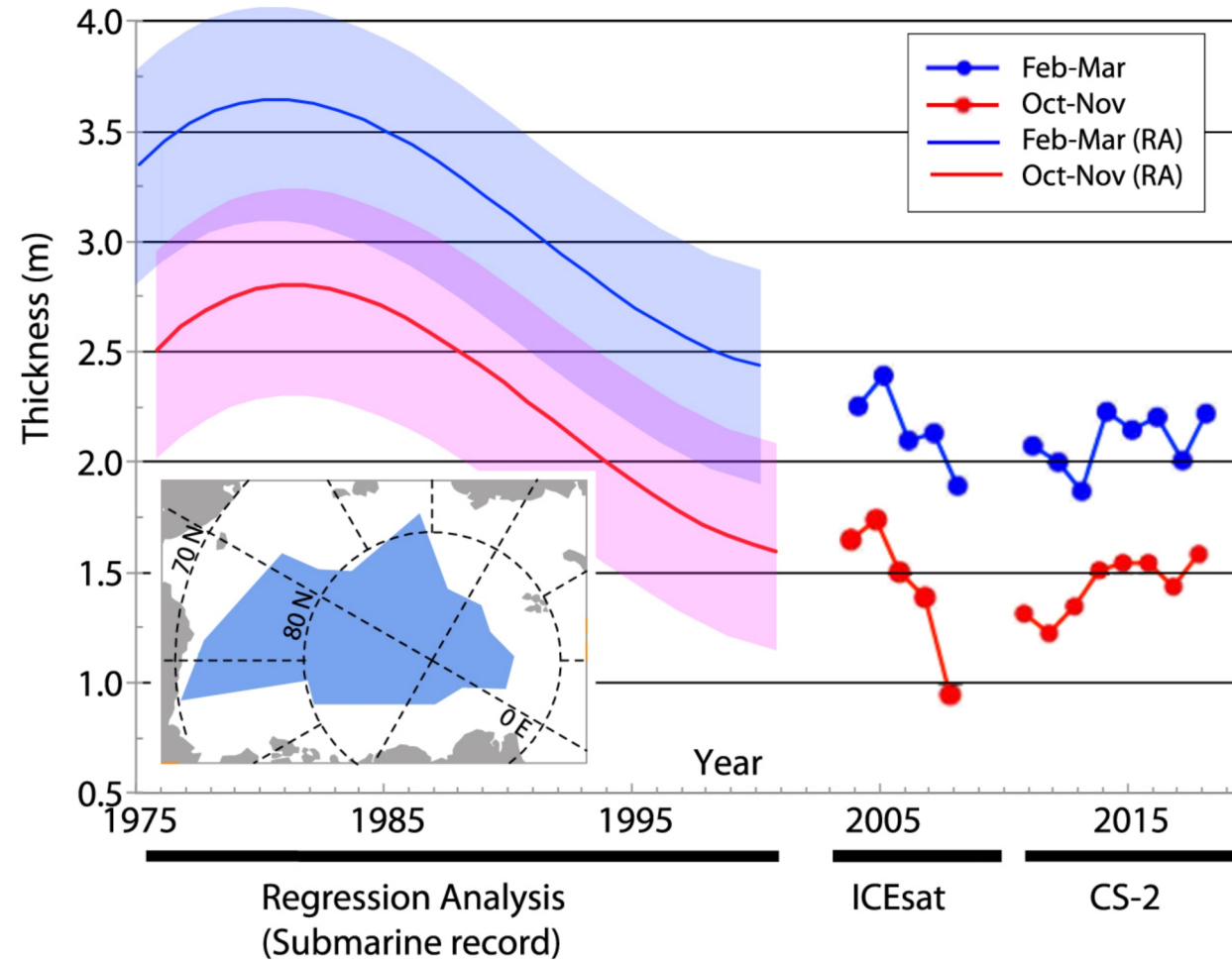
North-West Barents Sea



King at al, 2017

- Large change from 2003 to 2014, thick ice disappeared

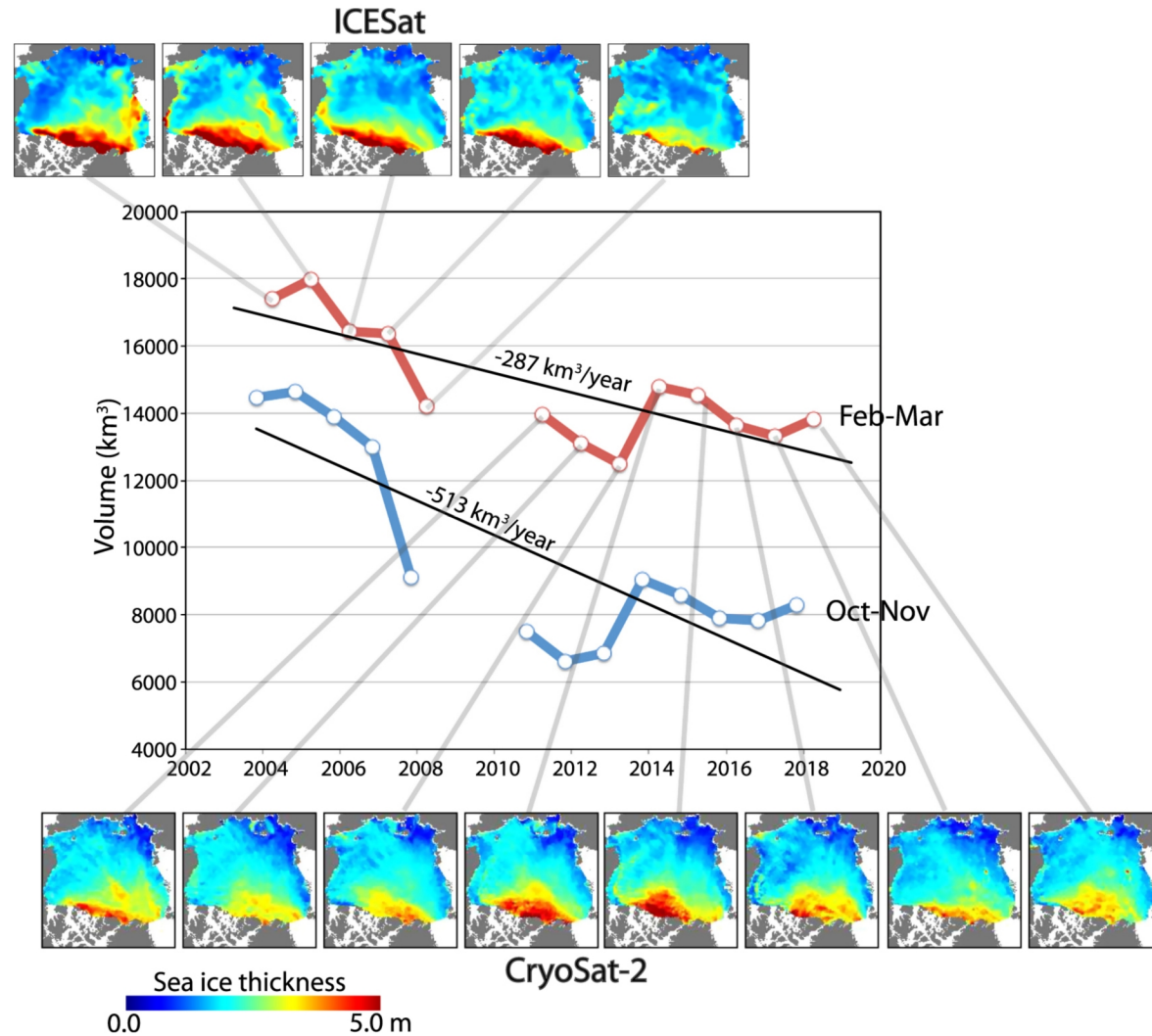
Changes in mean ice thickness based on submarine and satellite data



Kwok, 2018

- Large change since 1980's, minor during last 10 years

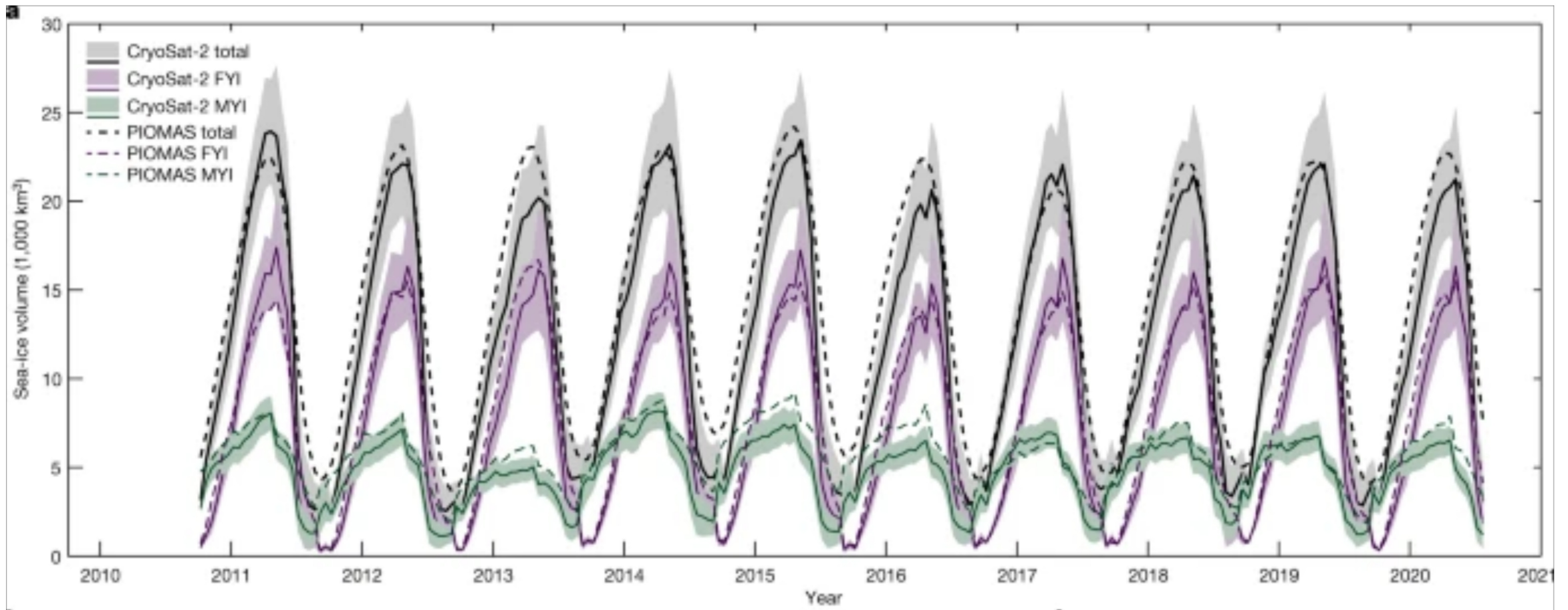
Changes in mean ice thickness



Kwok, 2018

- Decrease during 2003-2010, 2010-2017 stable

Mean ice thickness based satellite data III



Landy et al, 2022

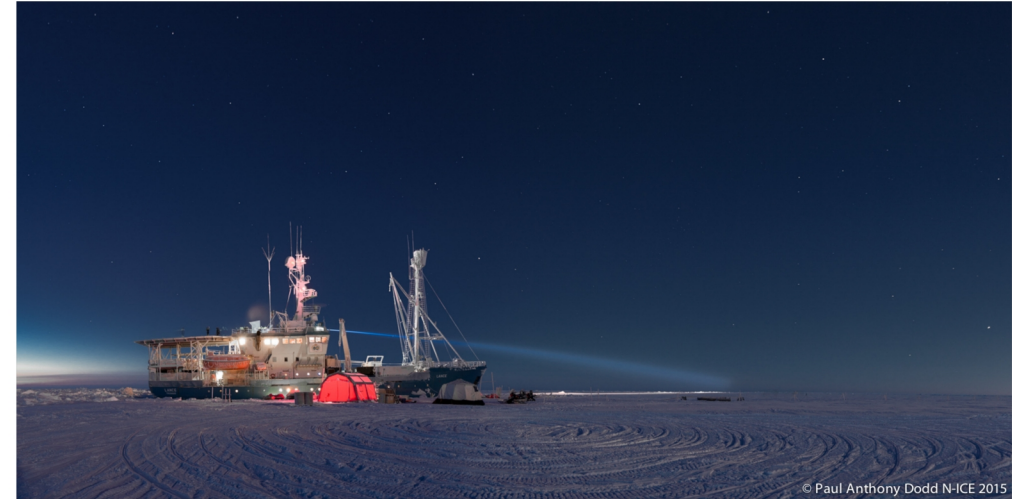
- Years 2010-2020 dominated by natural variability
- Too short period to detect climate change signal

Arctic drifting stations

Tara 2006 - 2007



N-ICE 2015



FRAM 1893-1896



Russian drifting stations 1937 →

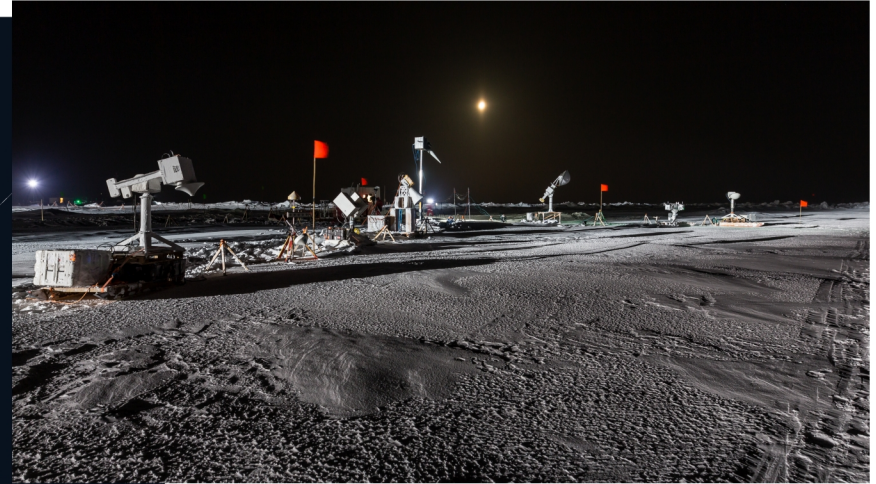
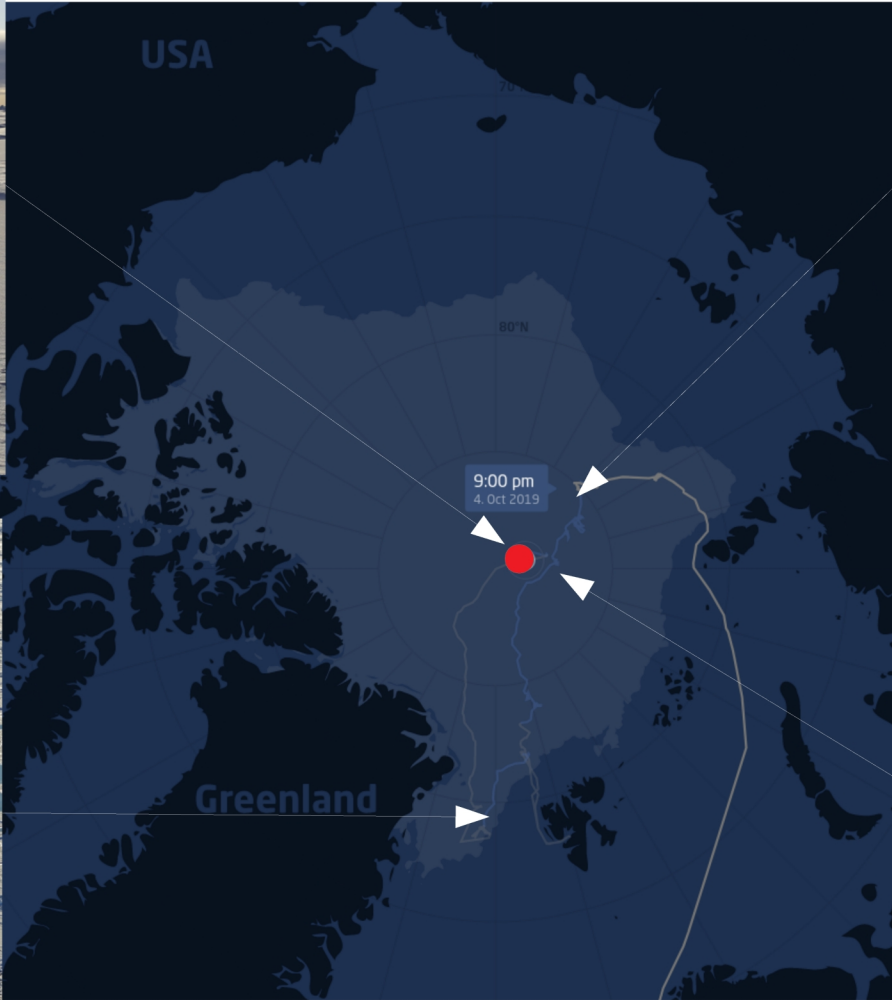


SHEBA 1997 - 1998



Measurements from Oct2019 to Sep2020

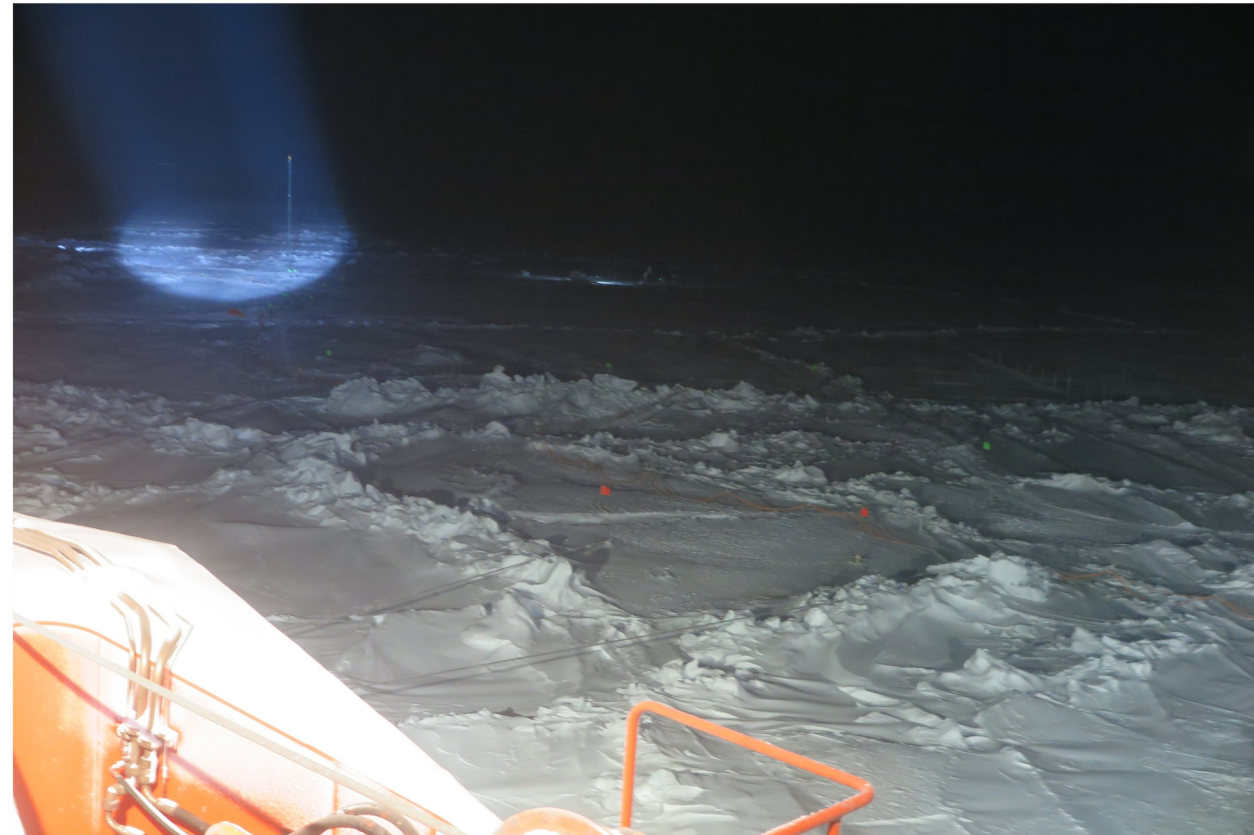
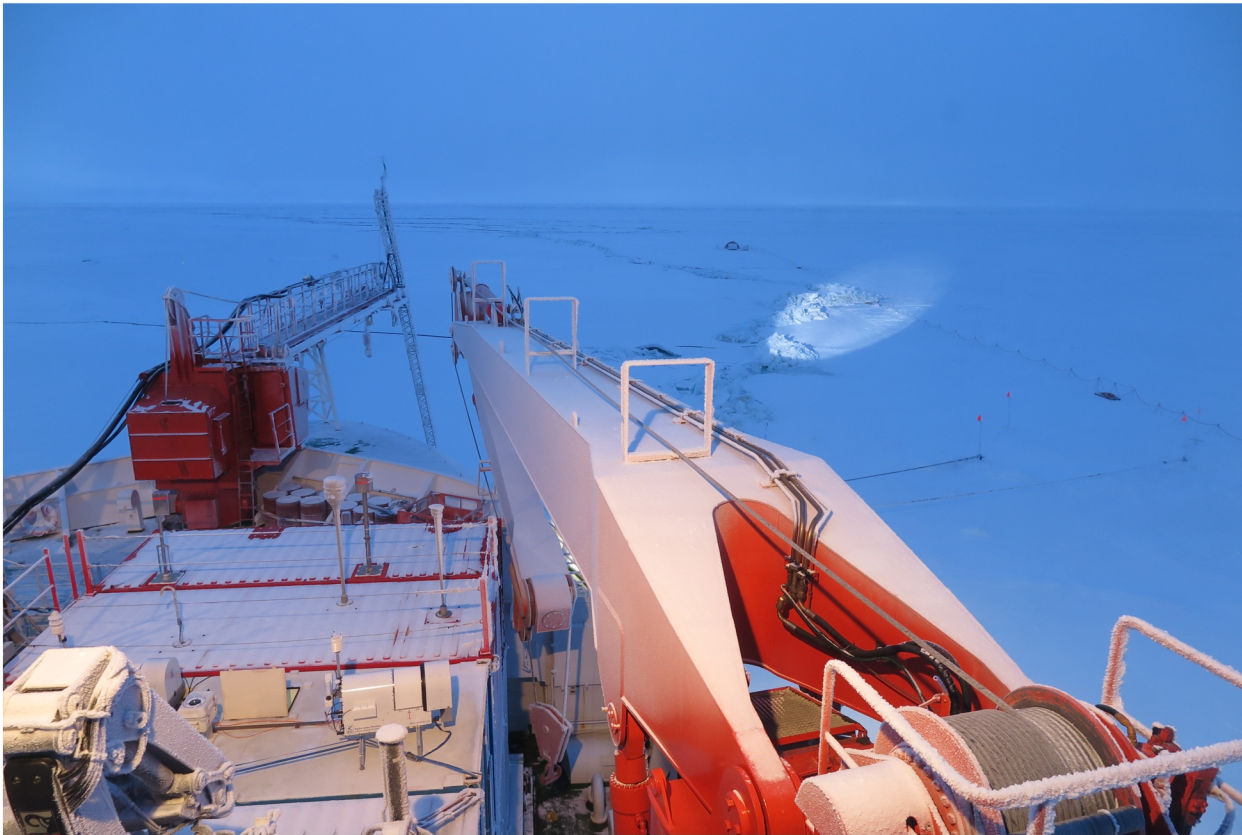
10.9. 2020



Dynamical icescape

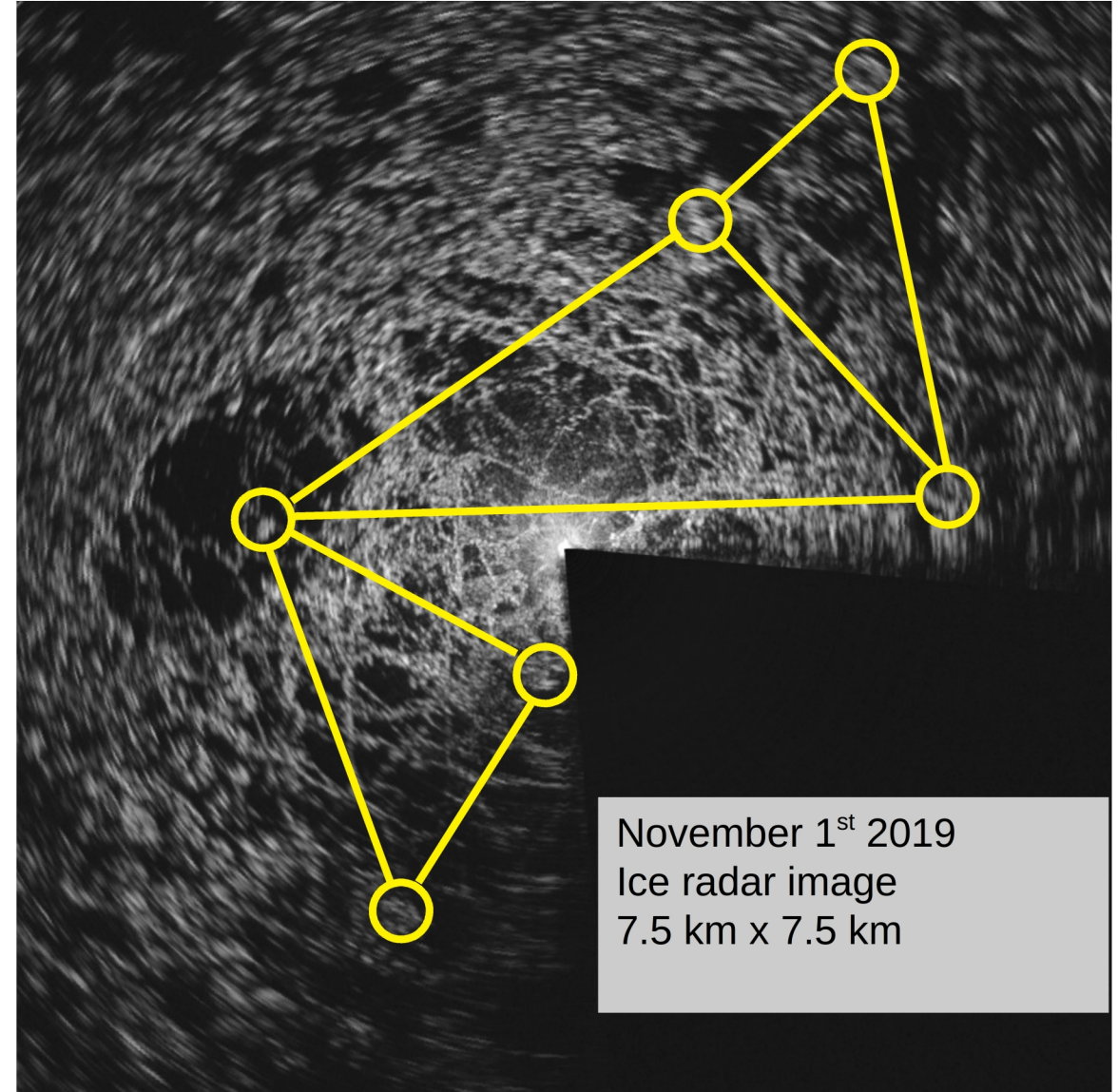
October 16th 2019

December 9th 2019



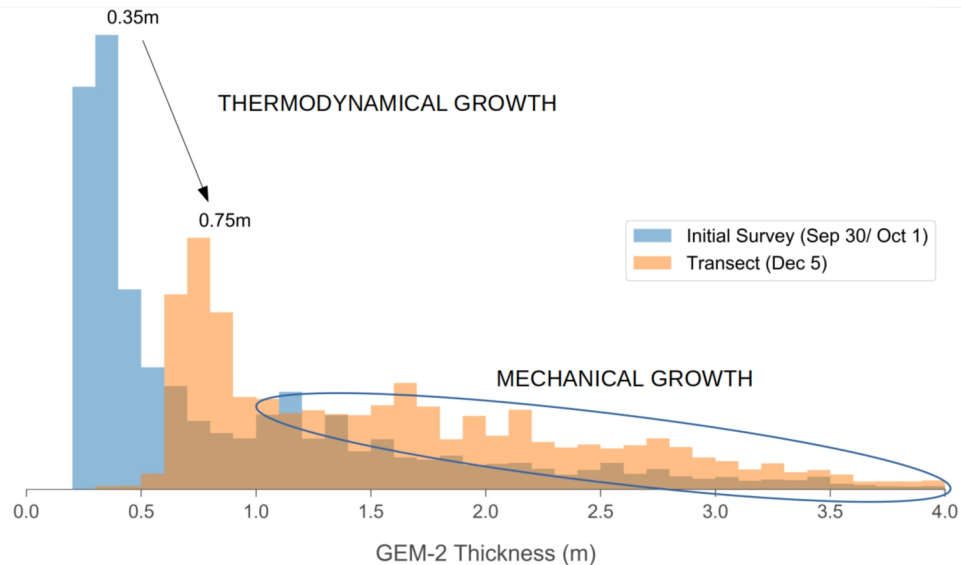
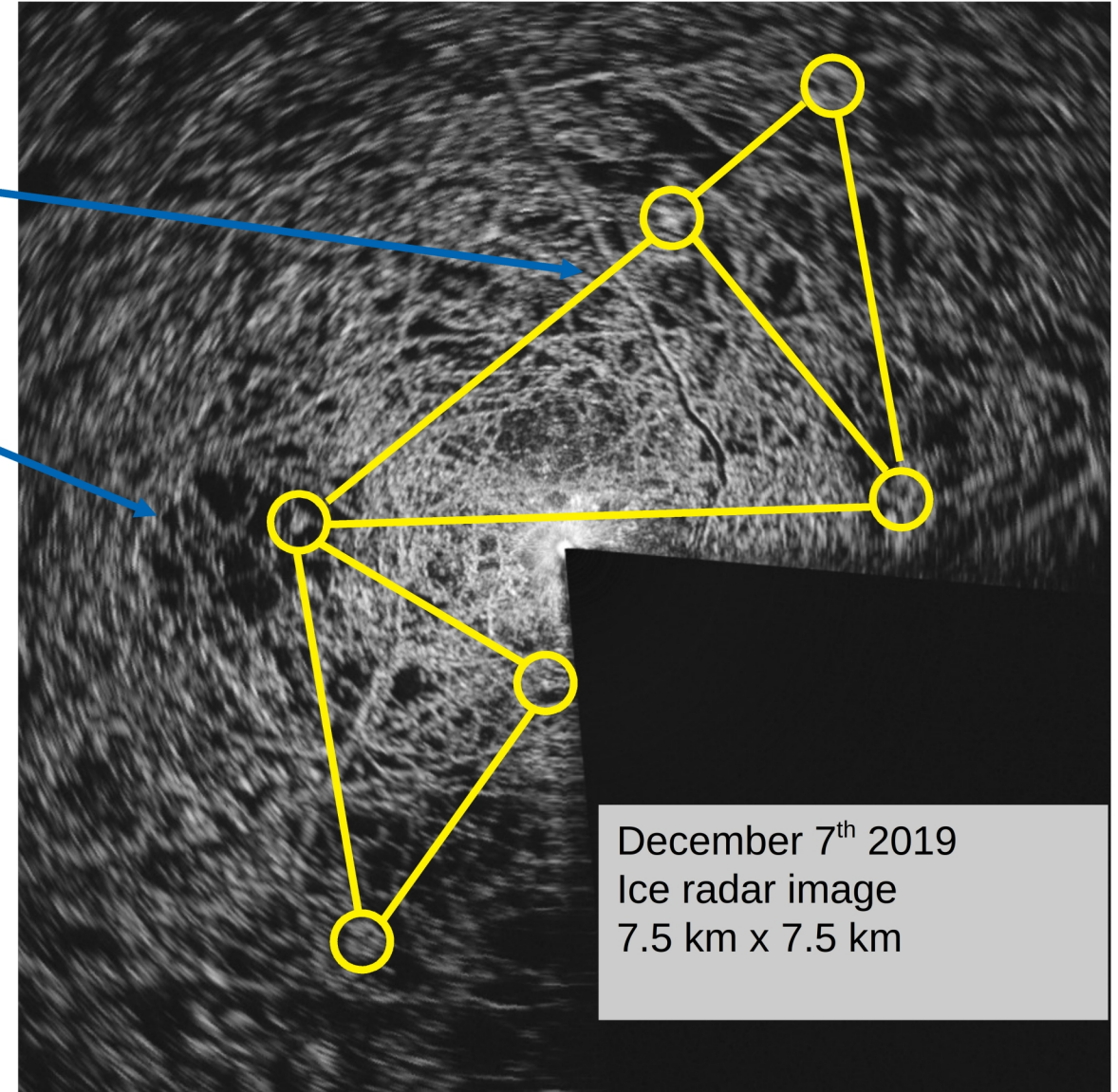
Dynamical icescape

- At the beginning, the MOSAIC study area was composed of thick heavily deformed remnant ice floe, undeformed remnant ice areas and new ice.
- Ice pack experiences episodic fracturing, shearing, opening and compression.
- Large dark areas are undeformed remnant ice, bright echoes are from ridges and edges of fractures.



Dynamical icescape

- As a result of the deformations, both local fracturing and large scale shear zones were observed.
- Underformed ice areas were compressed and new ridges were formed.
- Dynamical thickening of pack ice was evident from ice thickness measurements.



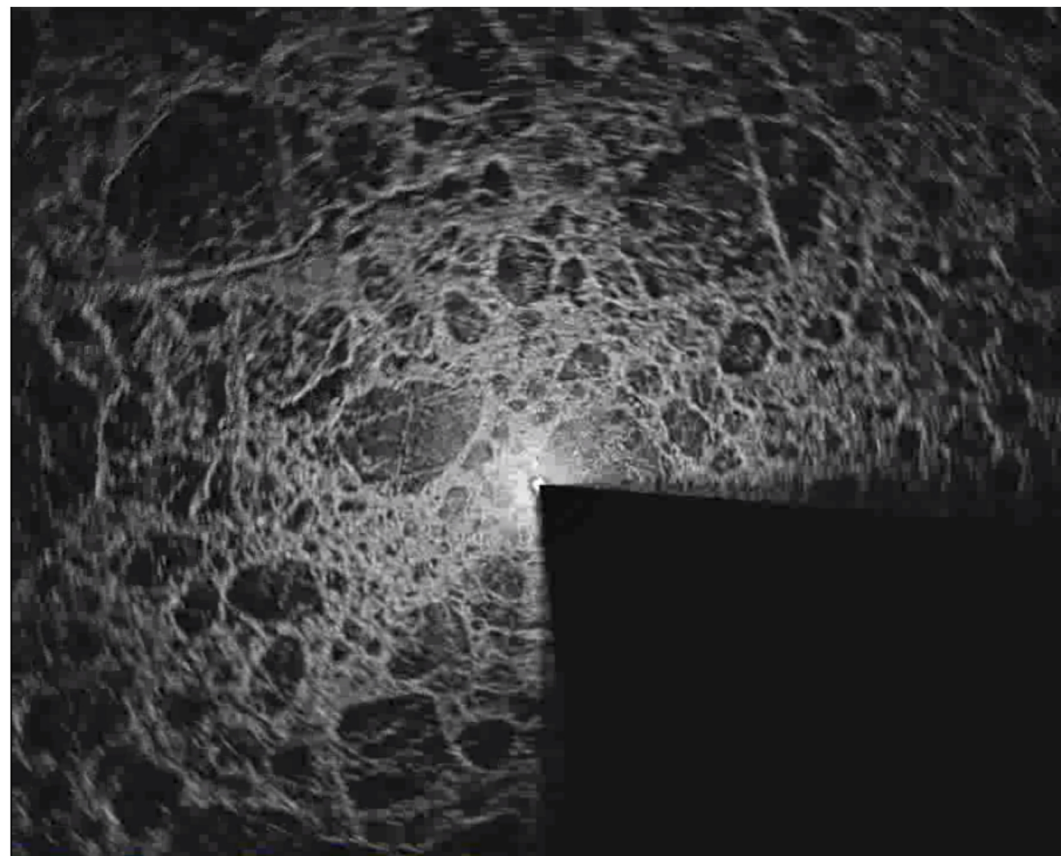
Ice radar movies

Early winter



201911171420 7.5 km x 7.5 km

Late summer



202007161530 7.5 km x 7.5 km

POLARSTERN



Thank you!