

Satellite Observations Over the Next Decade: Sea Ice



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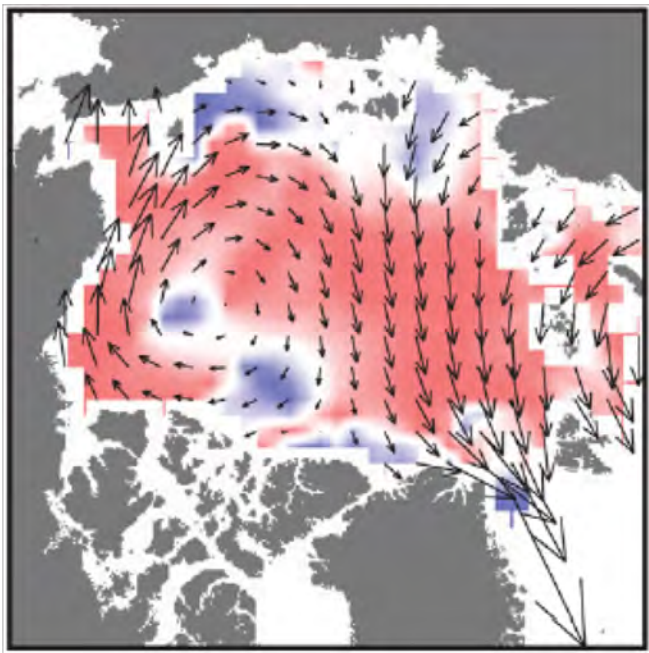
The Future of Earth System Modeling: Polar Climates
November 28-30, 2018
Keck Center/Caltech

- Drift and deformation
- Freeboard and thickness
- Snow depth
- Sea surface height over the ice-covered oceans

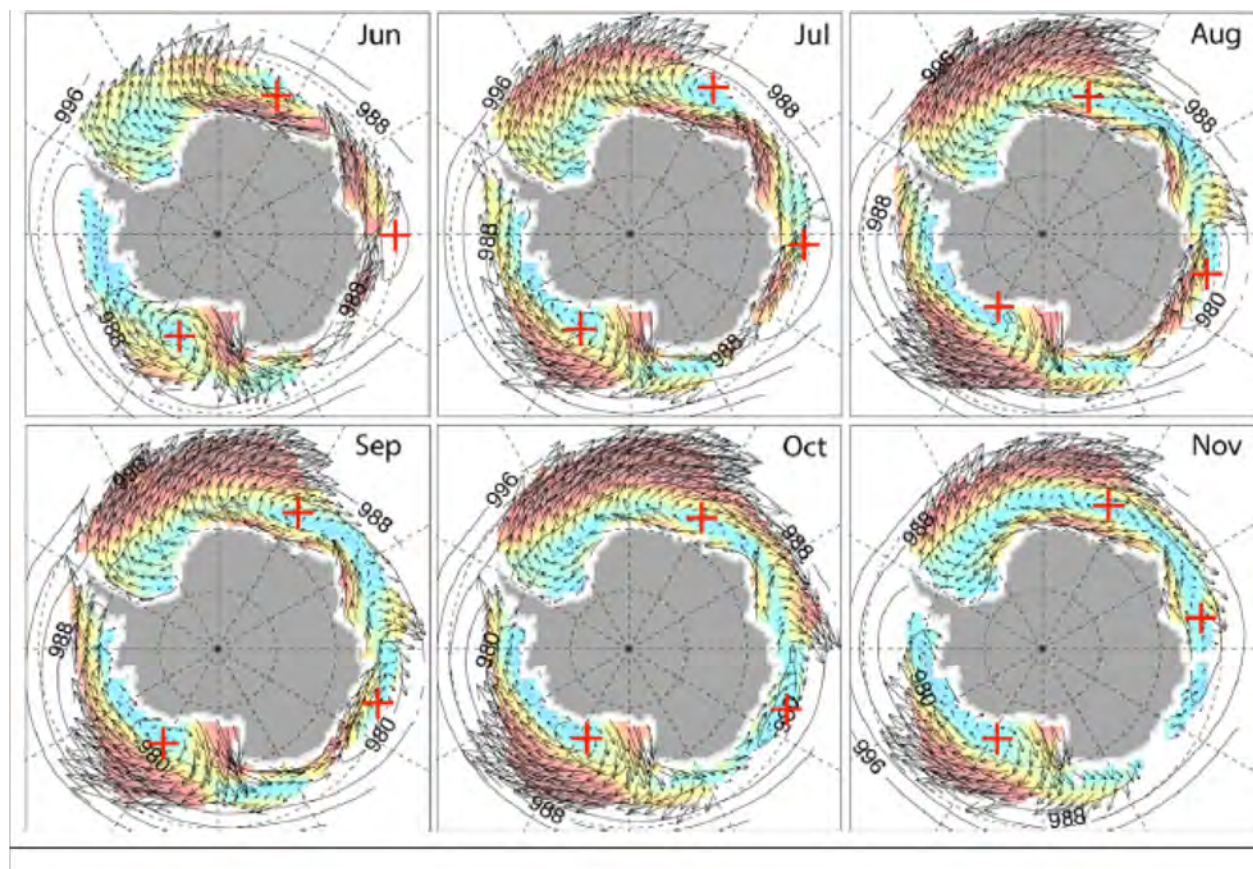
Examples

Daily/Monthly fields

Arctic

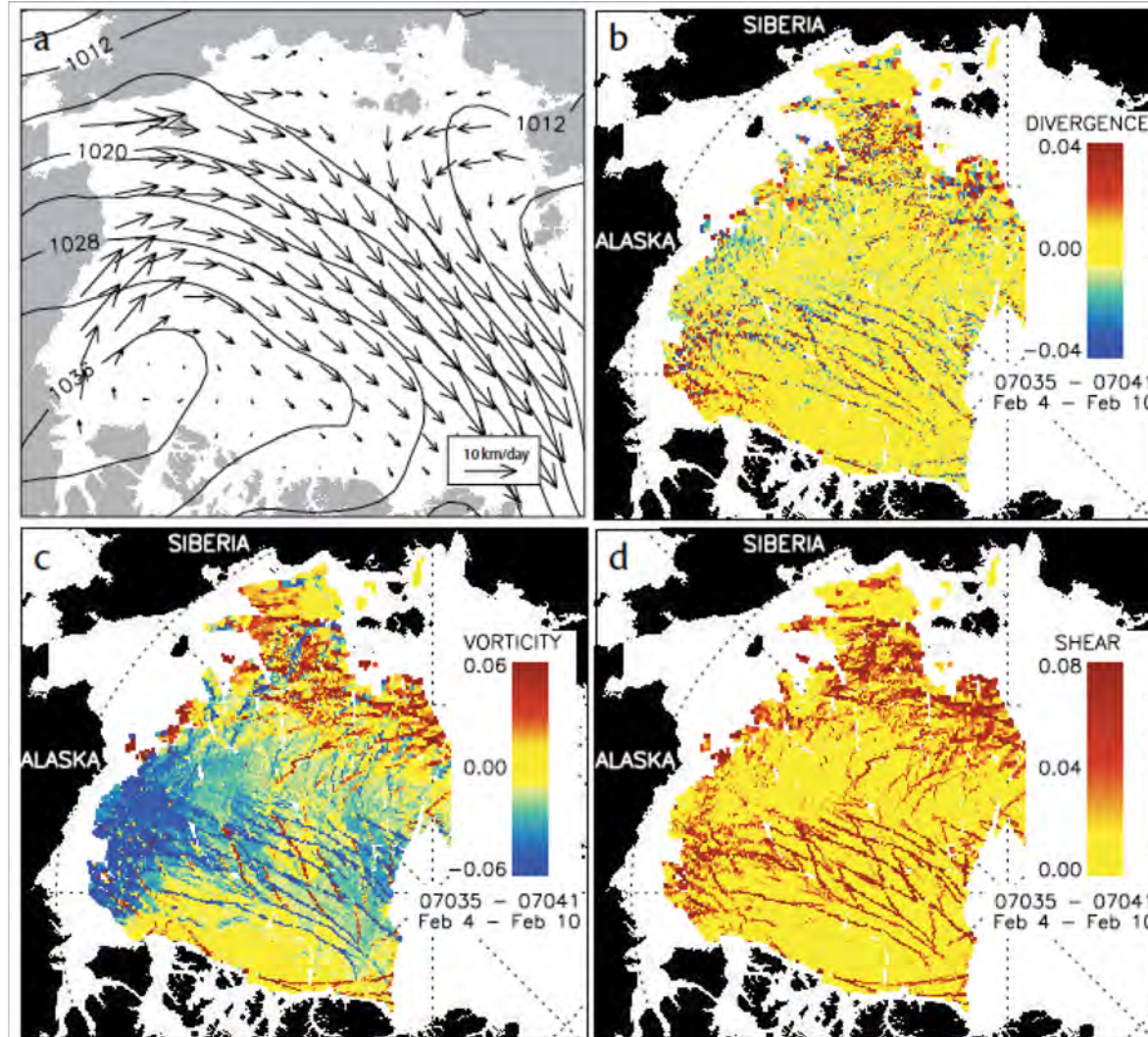


Antarctic



advection and flux, circulation patterns, trends

Ice Kinematics: 3 to 6-day deformation from wide-swath RADARSAT imagery 1996-2007

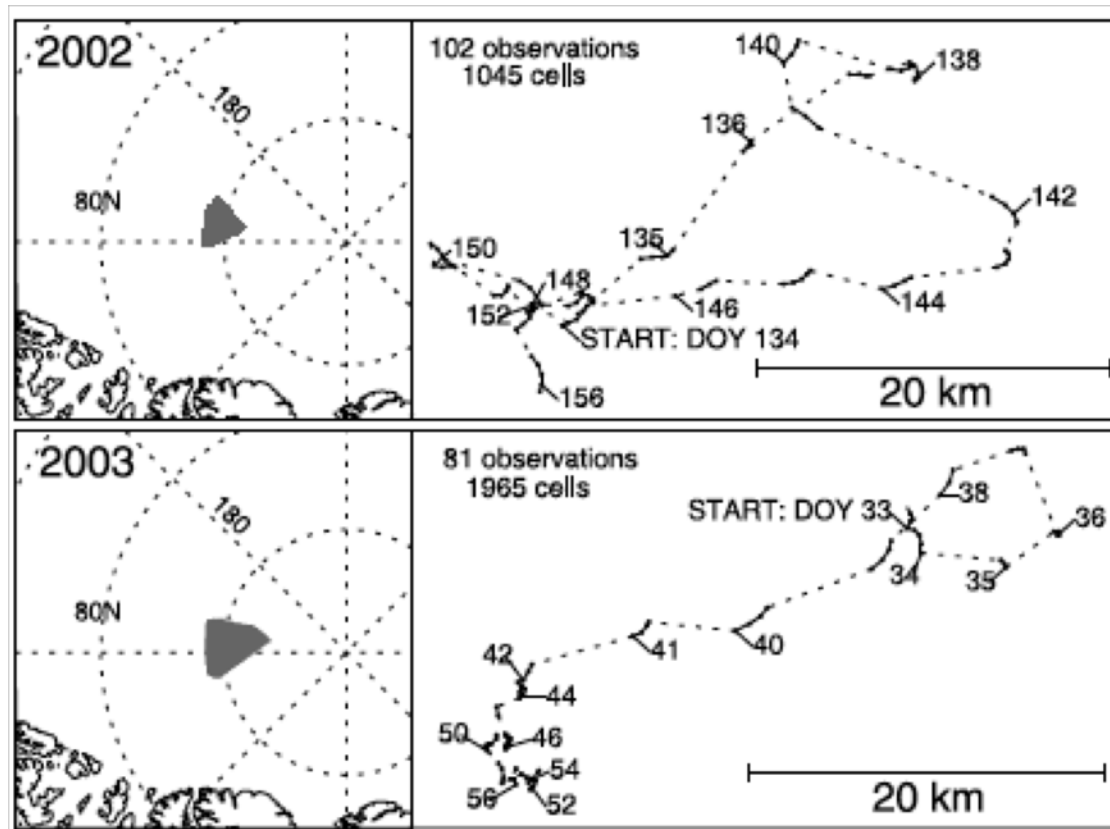


model assessment
model development
ocean interactions
ice thickness redistribution

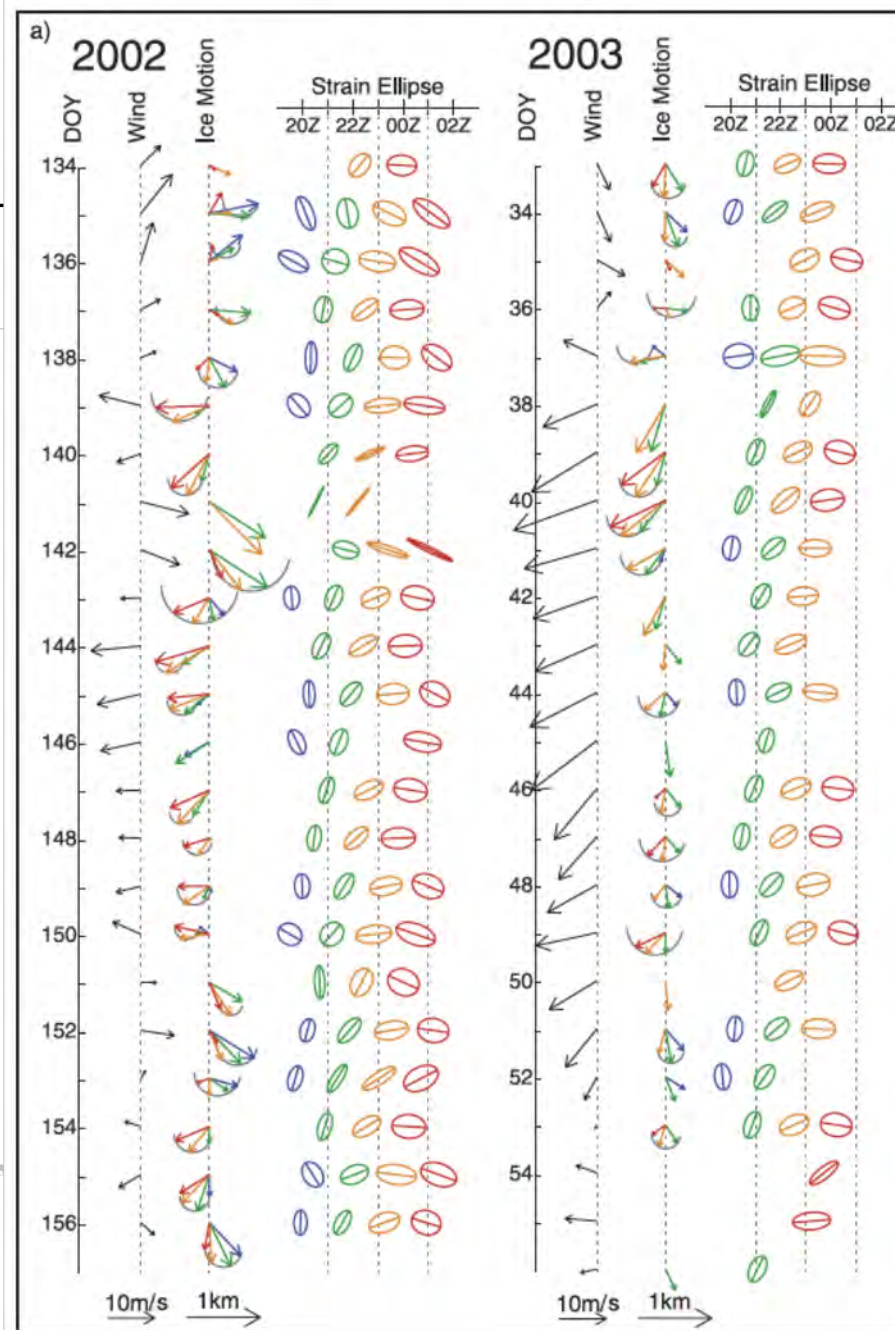
JPL-RGPS

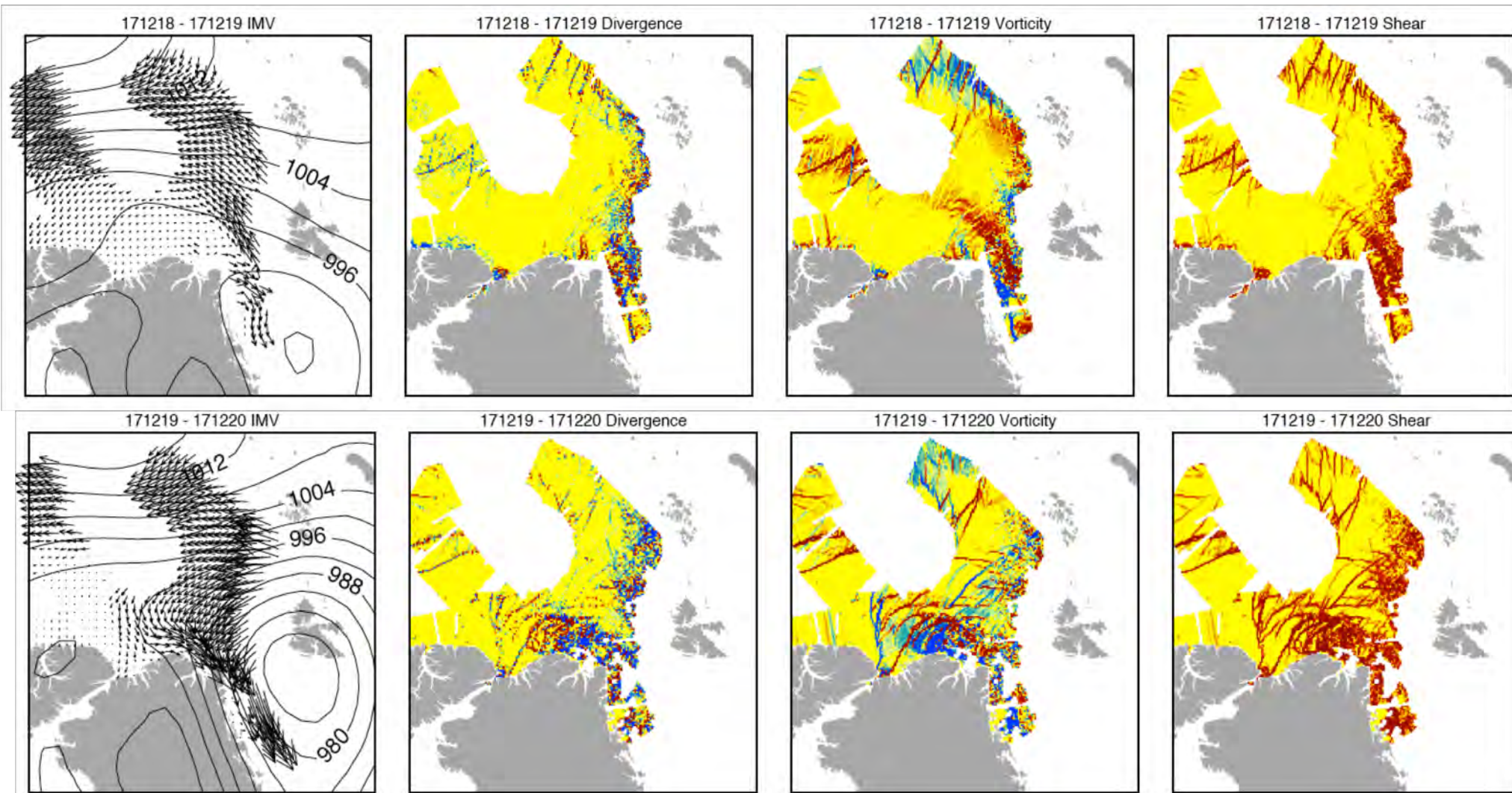
Sub-daily ice motion and deformation from RADARSAT ice drift

(Kwok, Cunningham and Hibler, 2003)



90 minute separation between observations





1A launched
in 2014



JPL-RGPS

higher quality in ice margin and summer

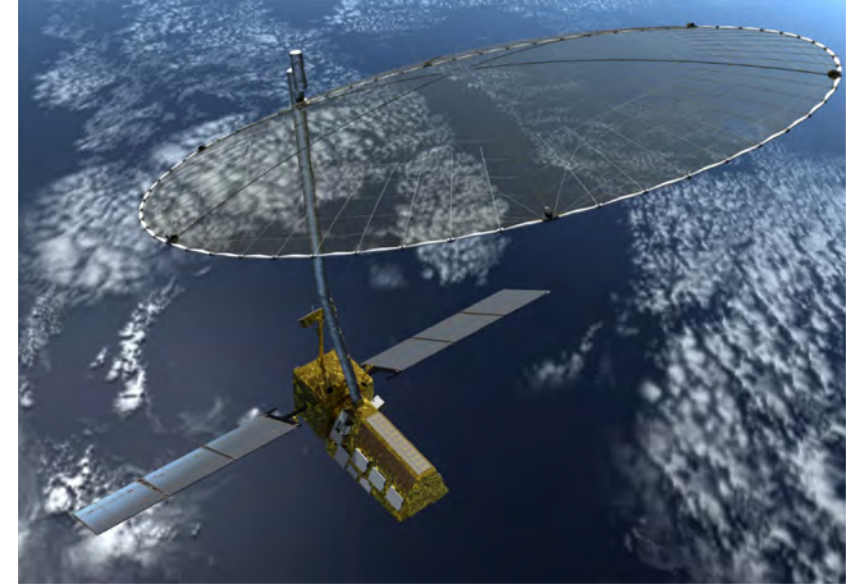
Based on Copernicus Sentinel Imagery 2017, processed by ESA.



Sentinel 1A/B (in orbit)
ESA



RADARSAT Constellation
(Feb 2019)
CSA



NISAR (2021)
NASA

Ice Drift and other sea ice parameters (for use in operations and research)

MOSAiC

Multidisciplinary drifting Observatory
for the Study of Arctic Climate



- **Science Objective:** collect the measurements needed to develop a better understanding of the important coupled-system processes in the Arctic Ocean so they can be more accurately represented in regional- and global-scale models.
- **Current plan** is to deploy the yearlong MOSAiC central observatory and its associated network of sensors in September of 2019. Prior to that, there will be a MOSAiC pre-study program (SPOT) that will take place starting in March 2019.
- **Remote sensing** serves a critical role in bridging the spatial and temporal scales for linking the detailed MOSAiC observations with larger scale regional and global processes through high-resolution process/coupled models.

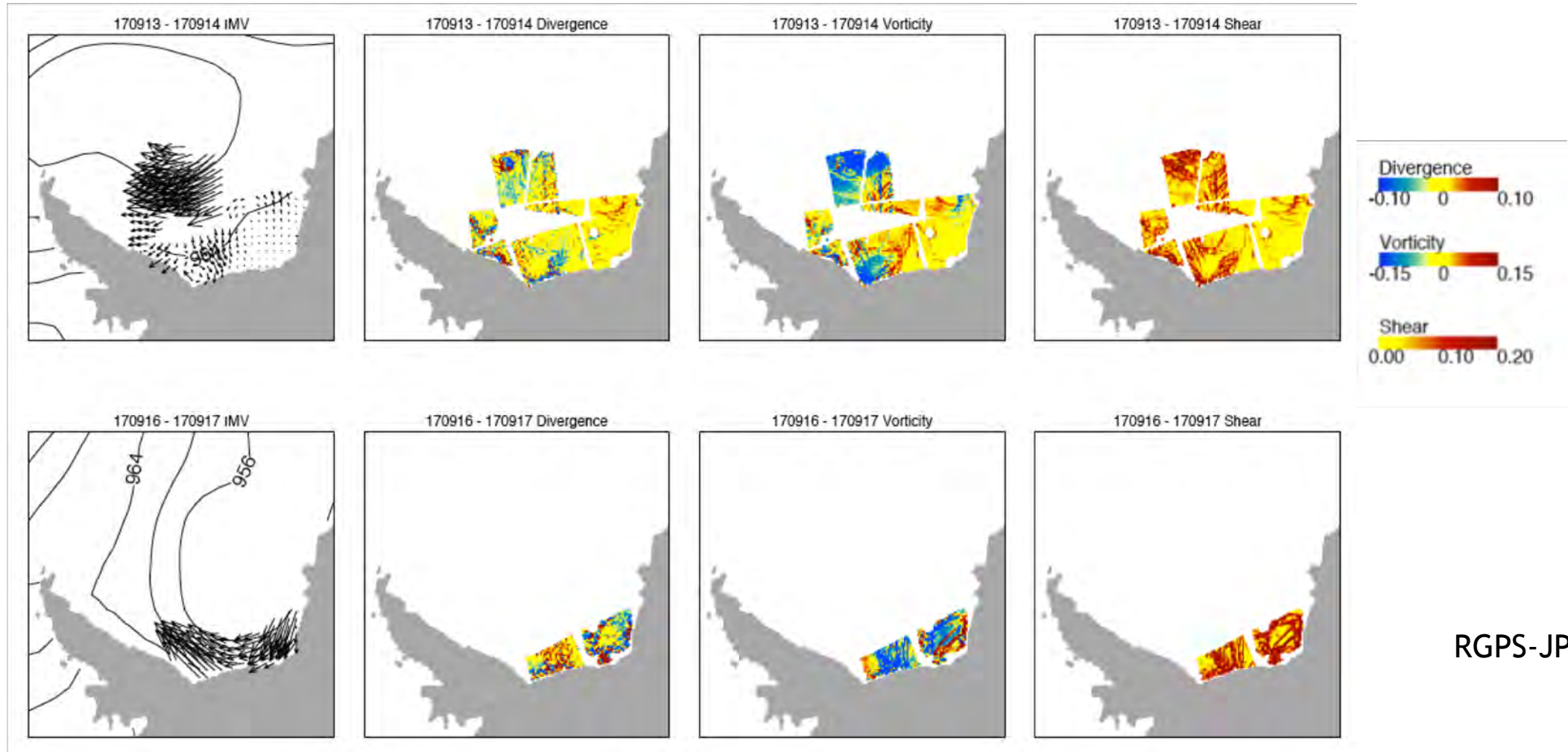
Request to the WMO Polar Space Task Group:

- Space-time sampling
 - 4X daily (within 100 km of the drifting central observatory)
 - 2X daily (within the Arctic Basin)
 - Duration (three periods): before, during, and after the MOSAiC drift/ nine months before (to include the MOSAiC pre-study period) and three months after
- Our Request: To use available international SAR assets to provide the needed spatial and temporal sampling of the Arctic ice cover

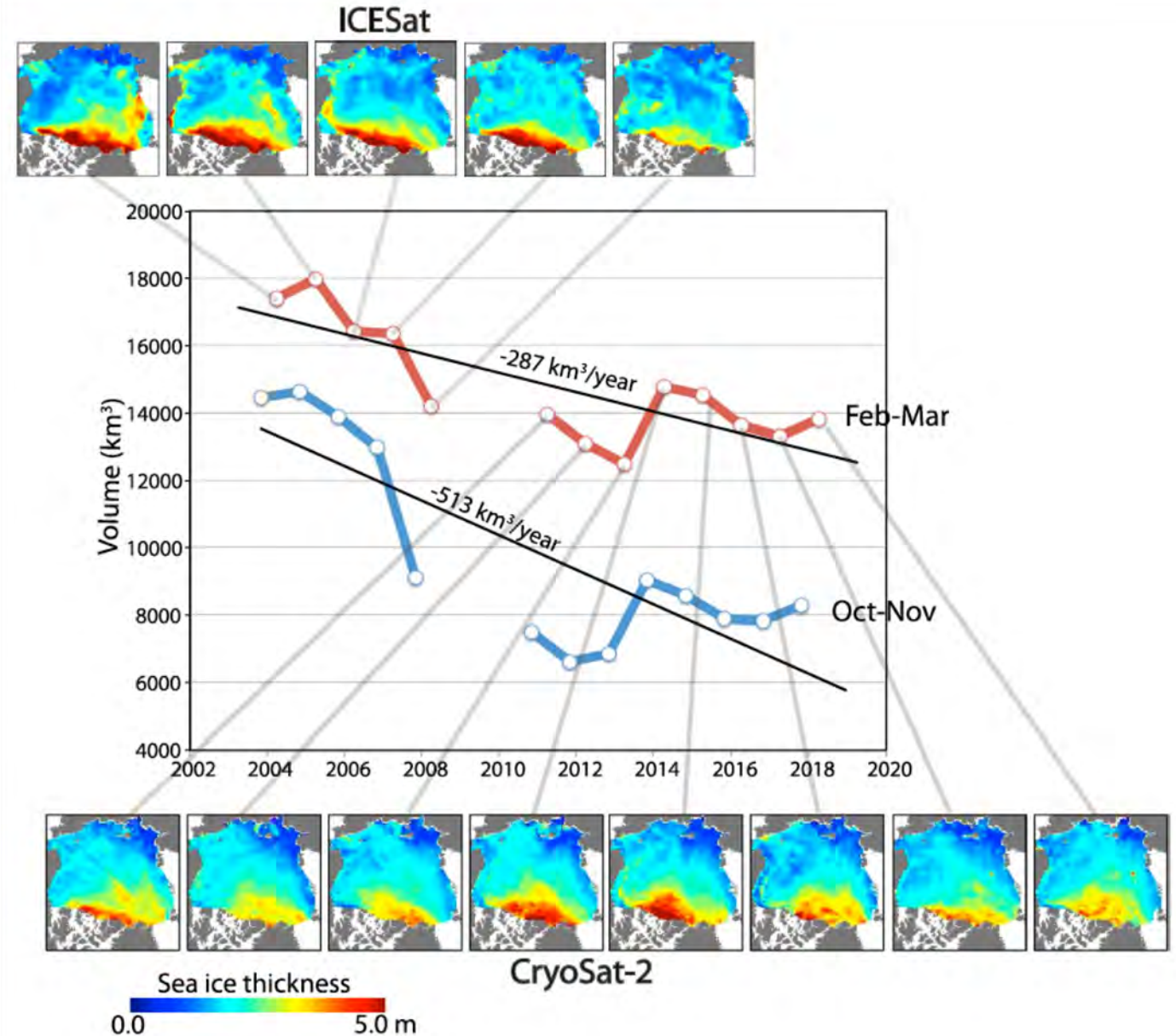
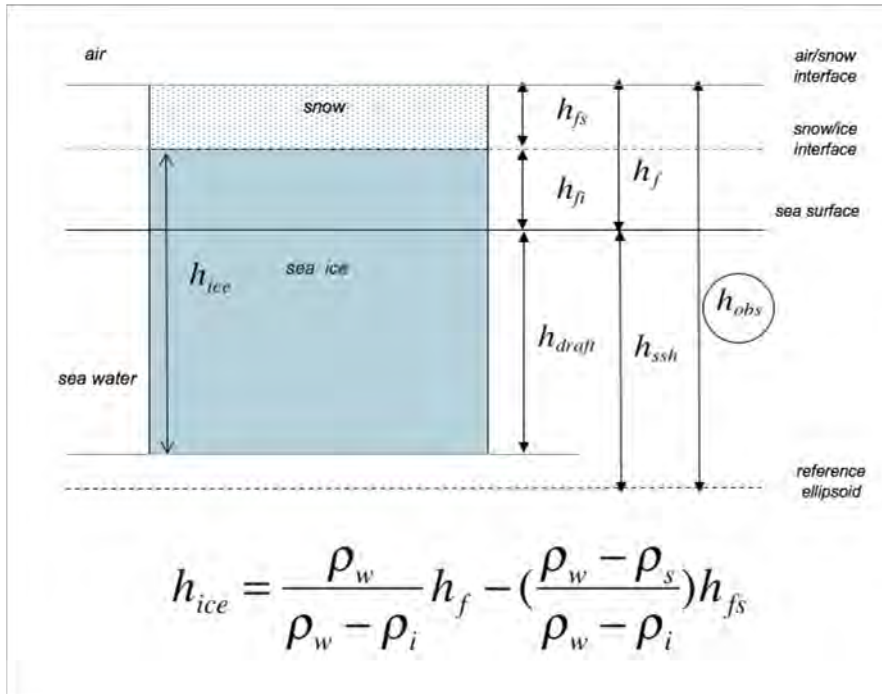


Antarctic ice drift - small-scale

Limited availability (focus of SAR coverage still in the Arctic)

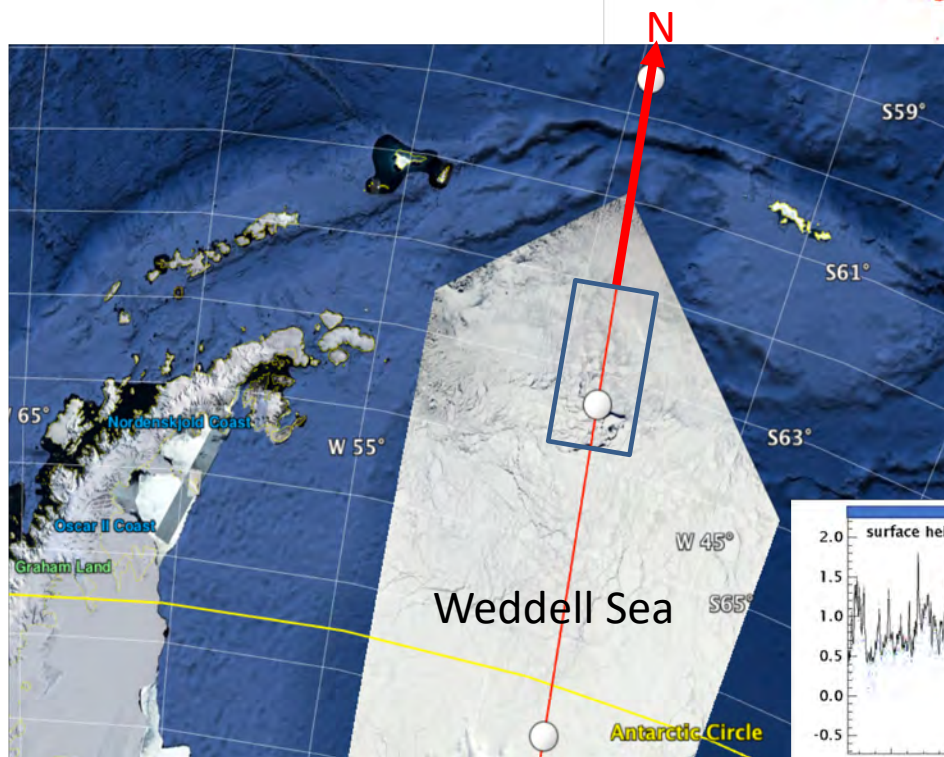


Sea ice thickness from freeboard

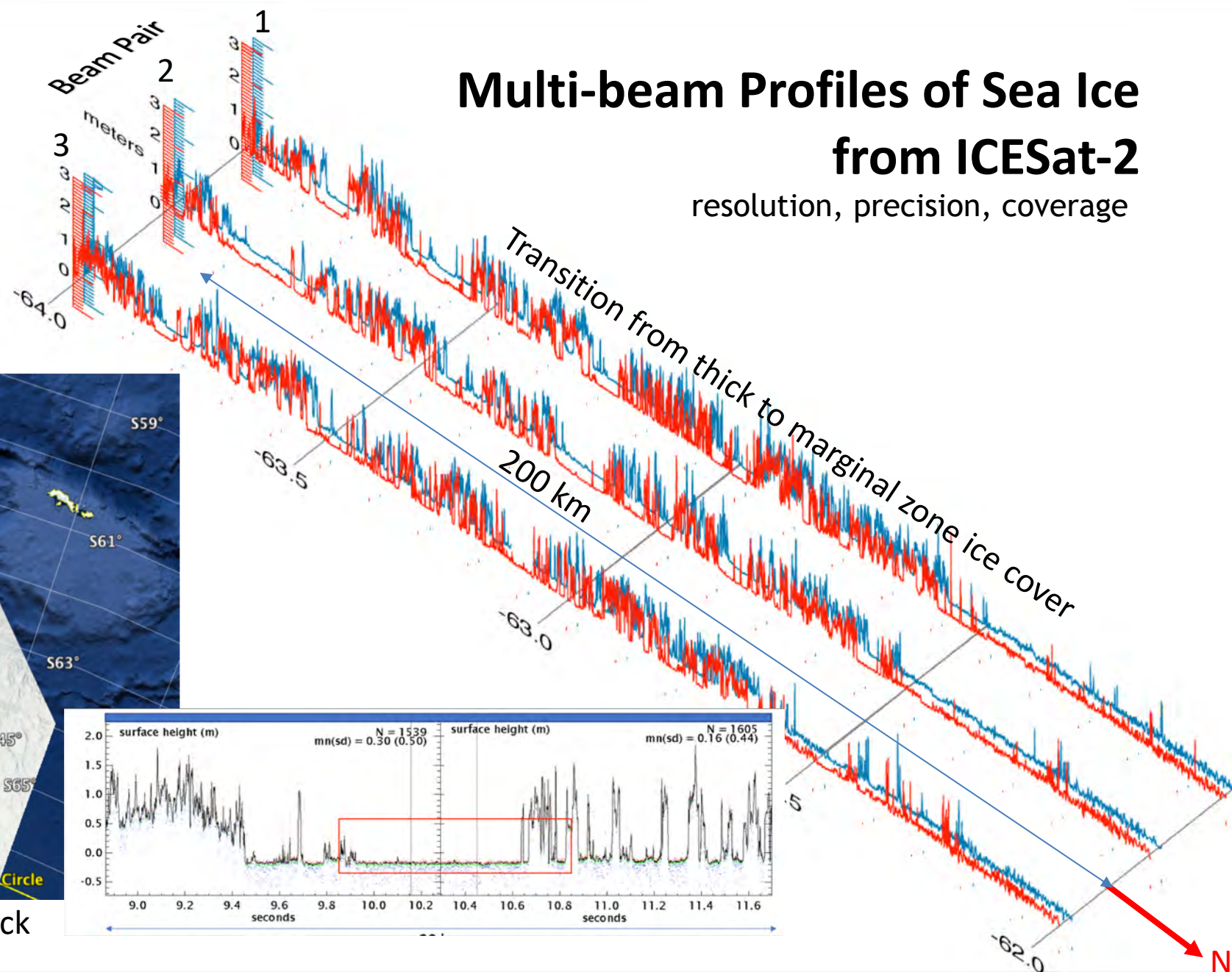


Multi-beam Profiles of Sea Ice from ICESat-2

resolution, precision, coverage



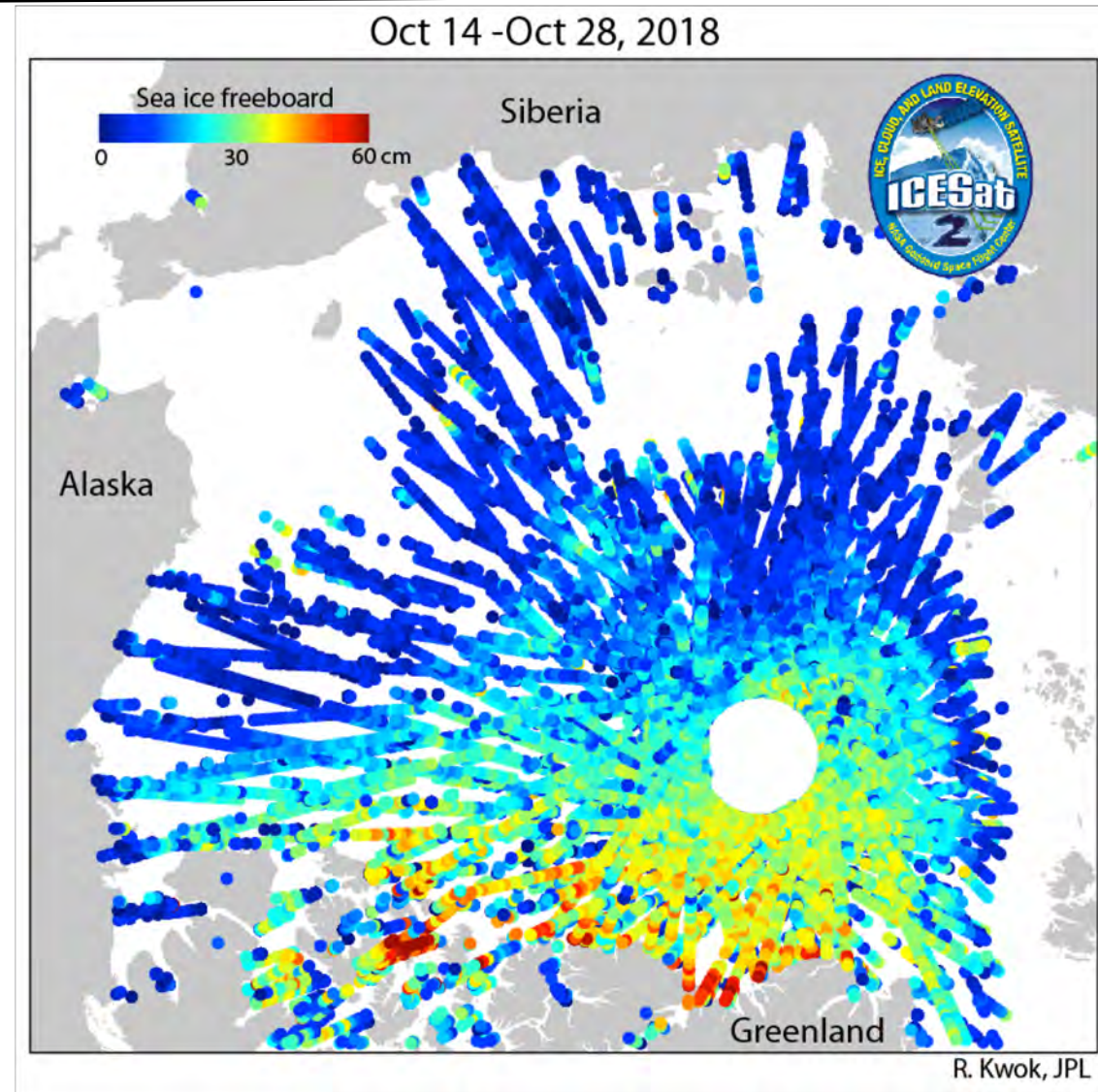
October 17, 2018 – Ascending Track



(R. Kwok, JPL)

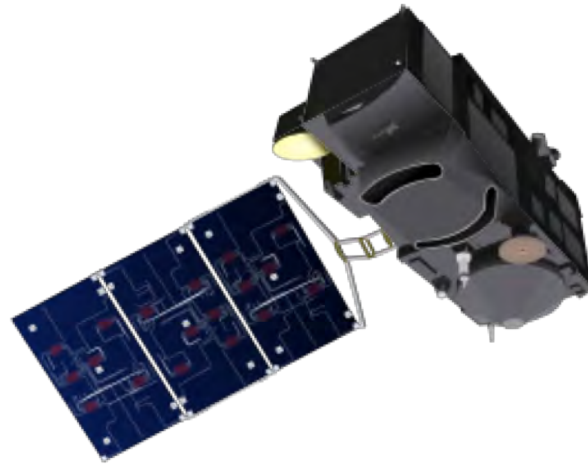
14-day map of Arctic
Ocean freeboard
-very thin ice, waves

Southern Ocean?





ESA CryoSat-2

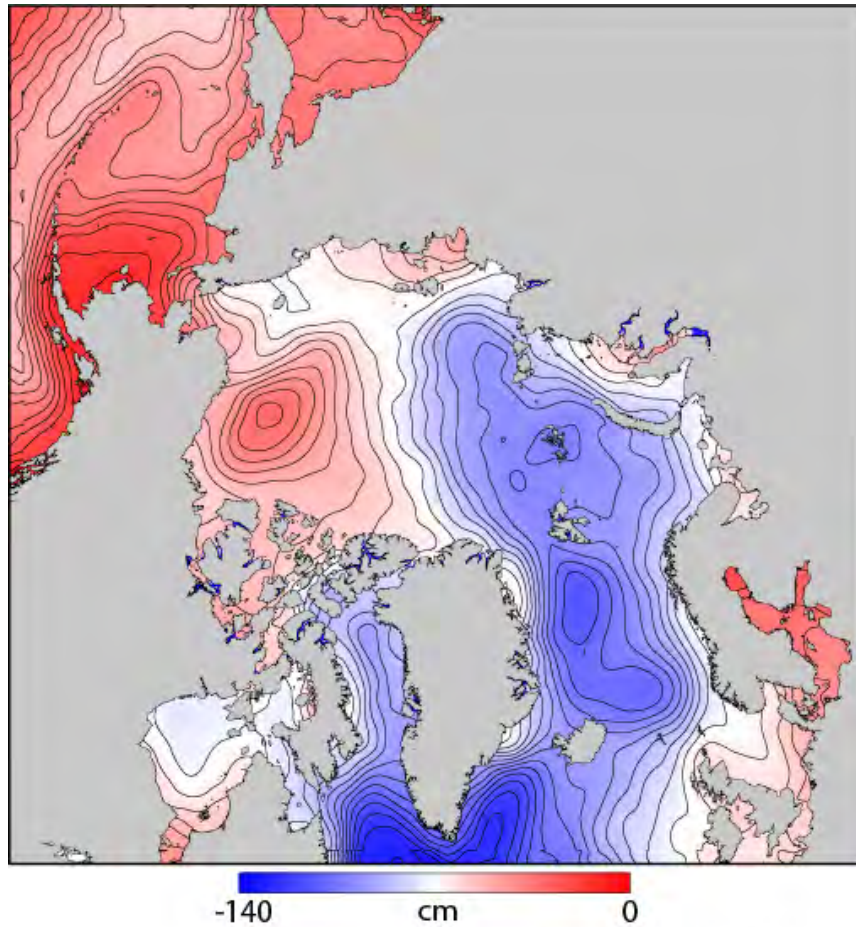


ESA Sentinel 1A/B



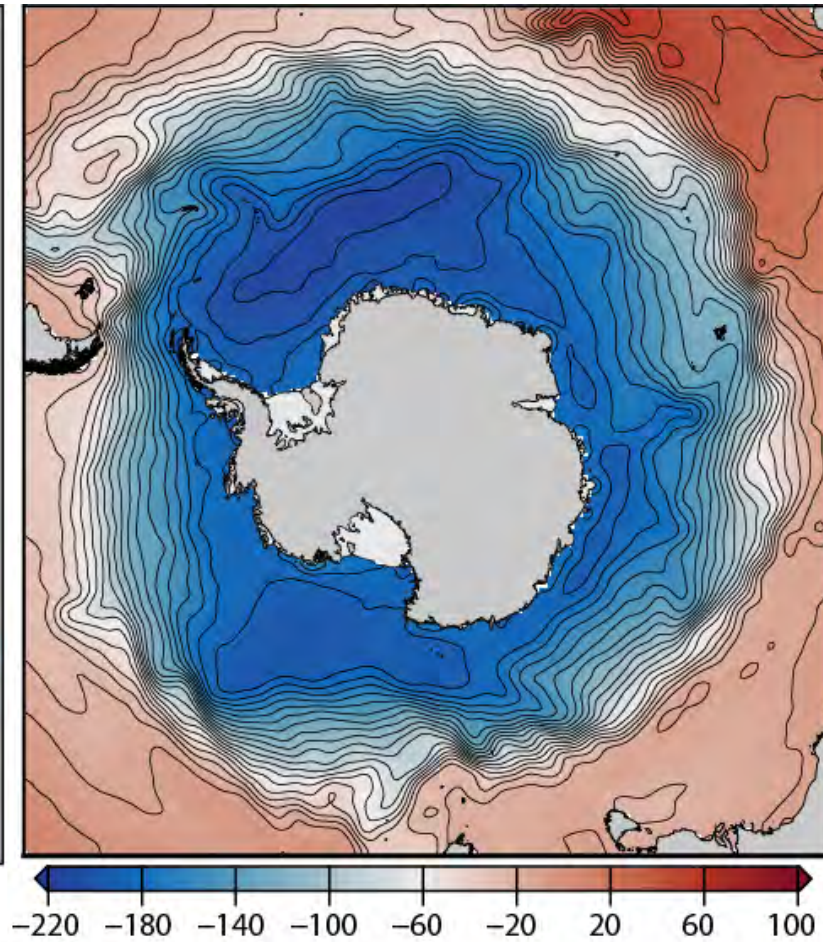
NASA ICESat-2

Dynamic Topography of Ice-covered Oceans (monthly fields)



CryoSat-2 mean DOT 2011–2016 (cm)

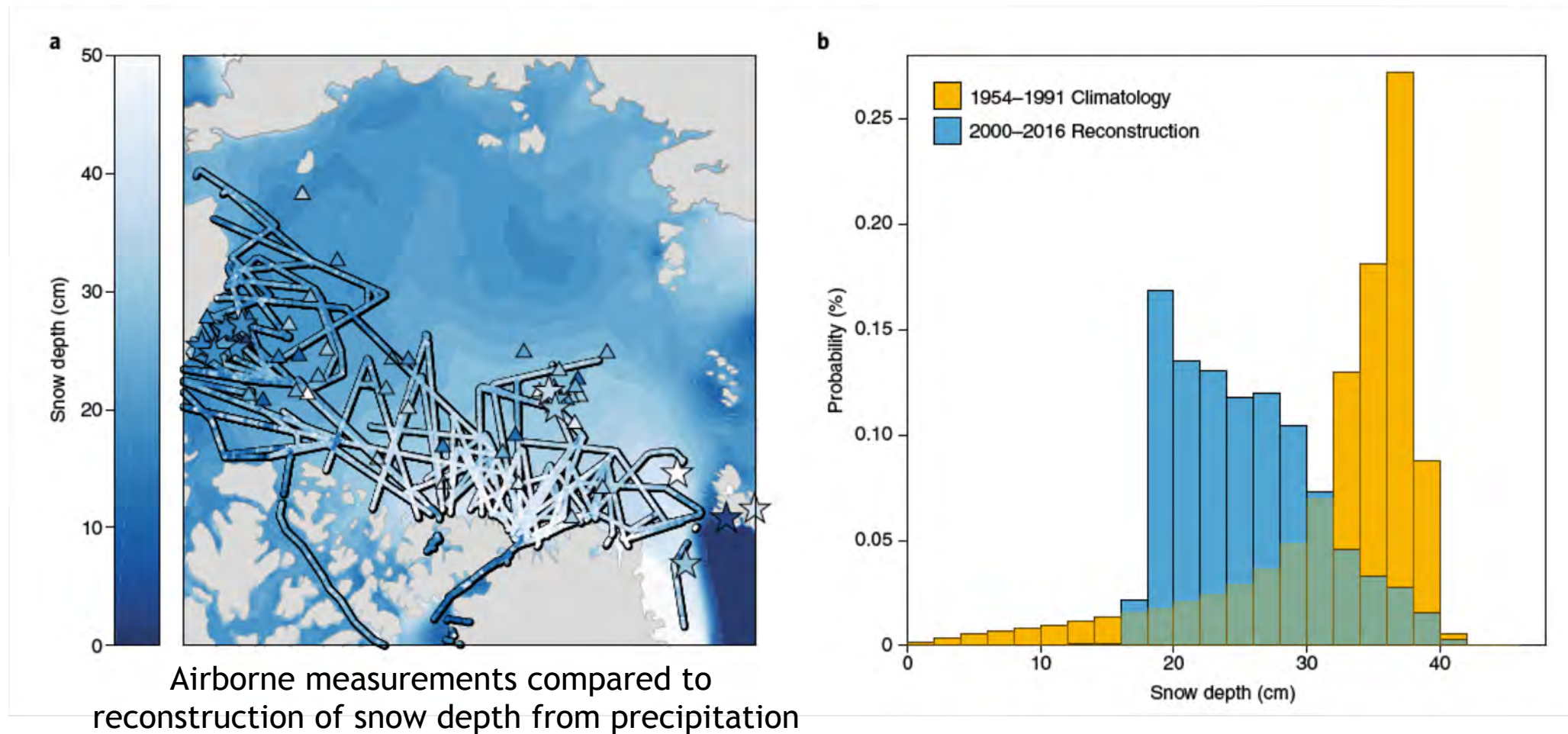
Kwok and Morison, 2014



Armitage et al., 2018

Data holes in
ocean altimeters

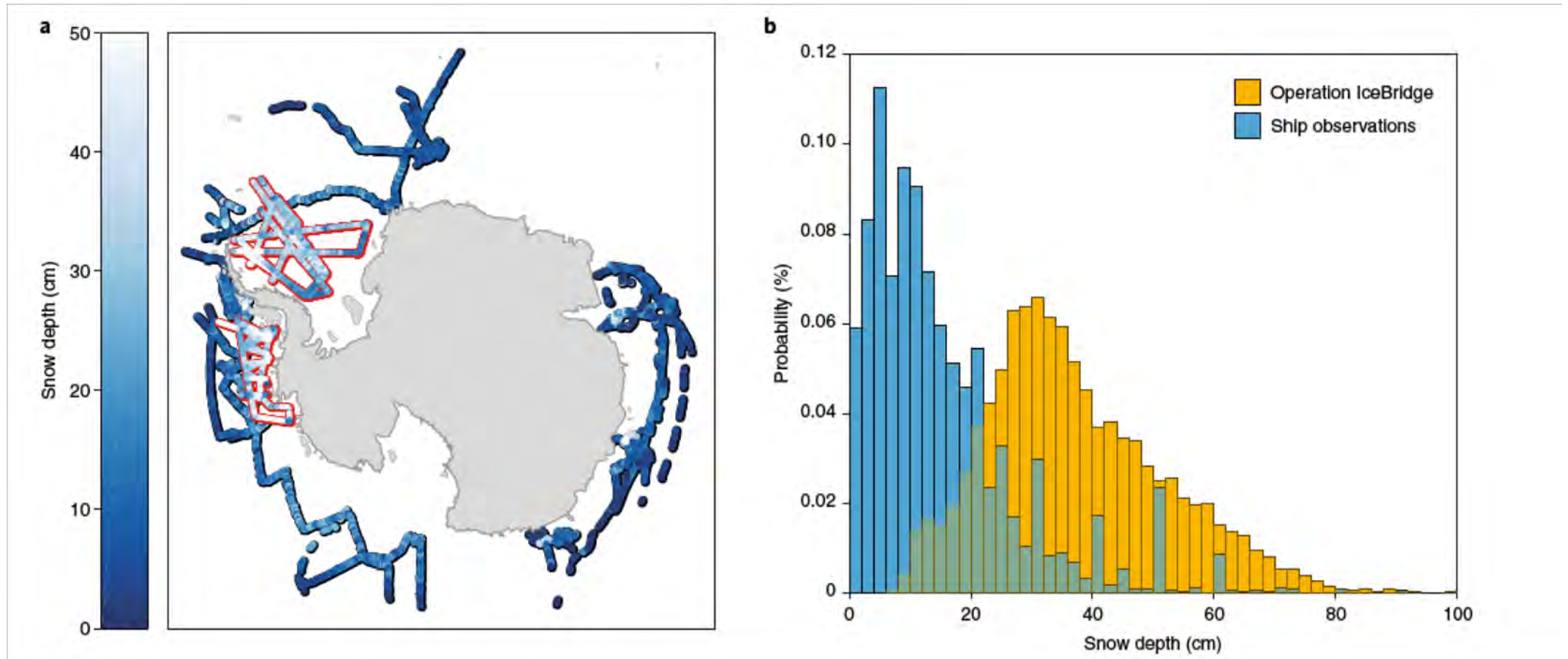
Sampling up to the
coast - especially
with IS-2



Airborne measurements compared to reconstruction of snow depth from precipitation

Webster et al., 2018

No direct measurements from space, but potential approaches being investigated



Webster et al., 2018

- Ice drift
 - potential for increased spatial and temporal sampling
- Ice thickness (from freeboard)
 - with current assets, sea ice thickness will be available in the near term
- Sea surface height
 - a product from freeboard derivations will be available along with freeboard products
- Snow depth
 - Difficult from space without new technology
 - Potentially useful retrievals from combined radar-lidar estimates or multifrequency radar systems
- Note: Concurrent better-sampled observations, Southern Ocean

QuikSCAT



ASCAT/Eumetsat

