Satellite Observations Over the Next Decade: Sea Ice

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Sea Ice Observations: Arctic and Antarctic

- Drift and deformation
- Freeboard and thickness
- Snow depth
- Sea surface height over the ice-covered oceans
Moderate Resolution Ice Drift (Passive Microwave)

Examples

Arctic

Daily/Monthly fields

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
Daily deformation from Sentinel 1A/B

Based on Copernicus Sentinel Imagery 2017, processed by ESA.

1A launched in 2014

higher quality in ice margin and summer

JPL-RGPS

Based on Copernicus Sentinel Imagery 2017, processed by ESA.
International Constellation of Imaging SARs

- 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.
MOSAiC SAR coverage requirements

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

\[ h_{\text{ice}} = \frac{\rho_w}{\rho_w - \rho_i} h_f - \left( \frac{\rho_w - \rho_s}{\rho_w - \rho_i} \right) h_{fs} \]
Multi-beam Profiles of Sea Ice from ICESat-2

resolution, precision, coverage

Transition from thick to marginal zone ice cover

200 km

October 17, 2018 – Ascending Track

(R. Kwok, JPL)
First sea ice freeboard map from ICESat-2

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

Southern Ocean?
Altimeters for sea ice (2010-present)

- ESA CryoSat-2
- ESA Sentinel 1A/B
- NASA ICESat-2
Dynamic Topography of Ice-covered Oceans
(monthly fields)

Kwok and Morison, 2014

Armitage et al., 2018

Data holes in ocean altimeters
Sampling up to the coast - especially with IS-2
Snow depth on sea ice

Airborne measurements compared to reconstruction of snow depth from precipitation

No direct measurements from space, but potential approaches being investigated

Webster et al., 2018
Antarctic snow depth

Webster et al., 2018
Summary Remarks

• 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
Multiyear sea ice coverage

QuikSCAT

ASCAT/Eumetsat