Sea ice type distribution in the Antarctic from Microwave Satellite Observations (SITAnt)

DFG project in the Antarctic priority pogram
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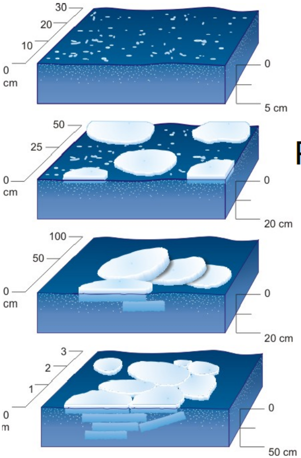
Overview

1 Motivation: Sea Ice Types

2 Background: New Ice Type Retrieval

3 Planned Work

Motivation: Sea Ice Types

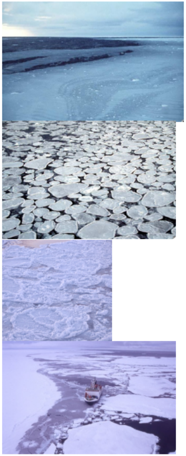


Frazil ice, Grease Ice

Pancake Ice

Larger Floes

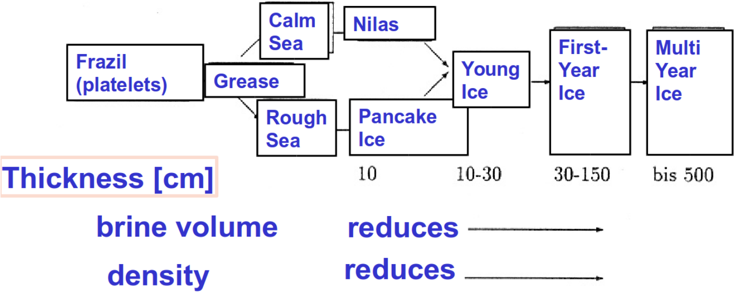
One-year Ice, Multi-year Ice



Motivation: Sea Ice Types

Motivation: Sea Ice Types

- Sea ice can look very different, depending on its formation and history



Motivation: Who cares?

- Physical properties depend on the sea ice type:
  - heat conductivity
  - brittleness/elasticity
  - wind drag
- Sea ice ecosystem depends on the type as well

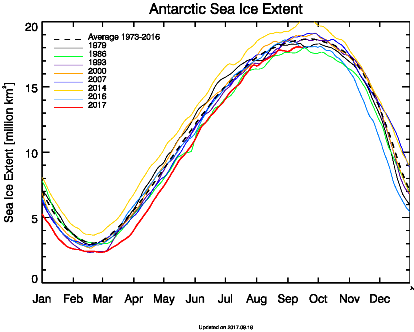
⇒ Affects ice mass balance, energy fluxes, ecosystems

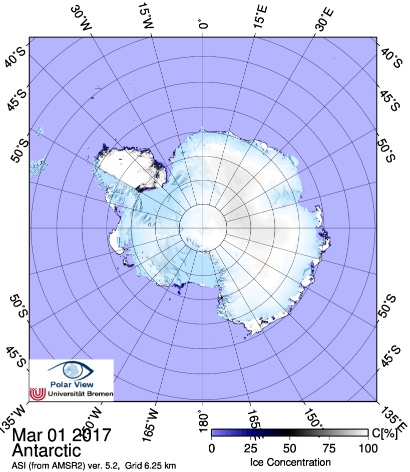
- Main types: first-year ice (FYI) & multiyear ice (MYI)

Motivation: Why Antarctic? Why us?

- There is multiyear ice in the Antarctic
- Much less investigated than in the Arctic
- New remote sensing methods: improved ice type detection

- We have an algorithm that works reasonably well in the Arctic


Antarctic Sea Ice Extent
Sea Ice Extent [million km²]
20
15
10
5
0
Average 1973-2016
1979
1986
1993
2000
2007
2014
2016
2017
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Updated on 2017.09.18


30°W
15°W
0°
15°E
30°E
40°S
45°S
50°S
135°W
150°W
165°W
180°
165°E
150°E
135°E
Polar View
Universität Bremen
Mar 01 2017
Antarctic
ASI (from AMSR2) ver. 5.2, Grid 6.25 km
0 25 50 75 100
C[%]
Ice Concentration

New ice type retrieval – Overview

Two components:

- ECICE (Environment Canada's Ice Concentration Extractor)
    - Microwave radiometer and scatterometer data: SSM/I, AMSR-E, AMSR2; QuikSCAT, ASCAT
    - constrained optimisation technique to get ice types: multiyear (MYI), first-year (FYI), young ice (YI)
- Output of ECICE corrected for effects of warm-air advection, sea-ice deformation, snow wetness/metamorphism
    - ancillary data: ice drift (NSIDC, OSISAF), temperature (ECMWF analysis, ERA Interim)
    - Correction from autumn to spring (excluding summer melt)

ECICE

- Radiometer input: SSM/I or SSMIS or AMSR-E or AMSR2: brightness temperatures and/or gradient ratios
- Scatterometer input: QuikSCAT or ASCAT backscatter (σ^0)
- For each surface class: Distributions of input parameters

Correction Schemes

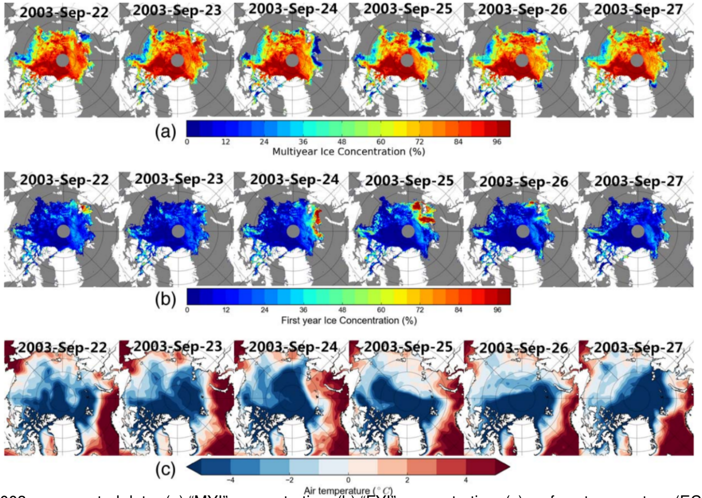
Two correction schemes (Y.Ye, IUP):

- Correcting for effect of increased snow wetness when surface temperature approaches melt temperature (from below) for short time.
- Correcting for snow metamorphosis and wetness, and constraining possible MYI using ice drift data

Temperature Correction

Increased snow wetness makes MYI be misclassified as FYI temporarily

- Look for pixels where
  - temperature rises above $-2^\circ C$ and later falls below $1^\circ C$ for up to 10 days
  - coinciding MYI concentration drops by more than 10% and subsequent rise back to normal
- MYI concentration of such pixels is interpolated between the values before and after the anomaly



Sept. 2003, uncorrected data: (a) “MYI” concentration, (b) “FYI” concentration, (c) surface temperature (ECMWF),

[Fig. 1 from *Ye et al.*, 2016a]

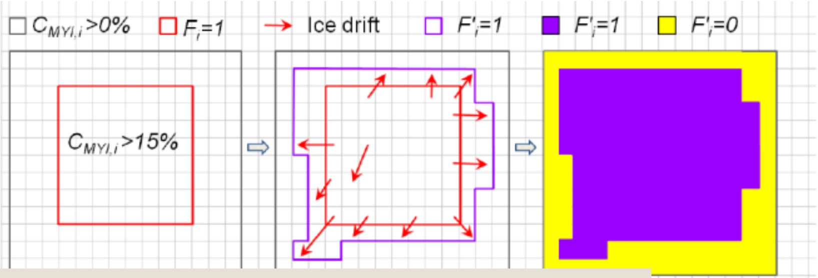
Drift and Snow Metamorph. Correction

Two separate things:

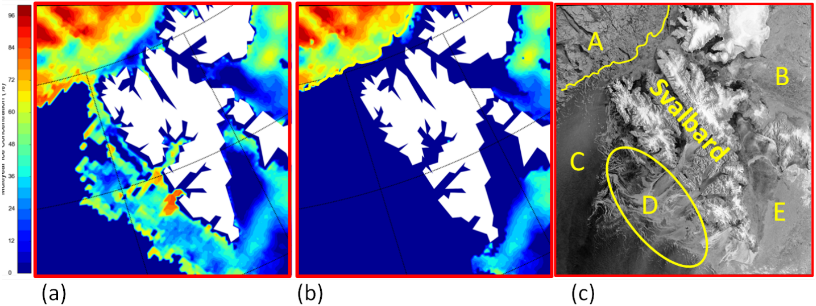
1. In winter, “new” MYI can only have drifted from elsewhere – it cannot just appear far away from other MYI
2. Find and correct pixels with anomalous radiometric properties from snow metamorphosis and wetness that cause too high MYI concentration

Drift Correction

- Take MYI domain (pixels with MYI>15%) from previous day
- Construct the drifted domain by advecting all its pixels using previous day's ice drift.
- Union of the previous day's domain and the drifted domain is the domain where MYI is allowed to exist.
- All MYI which appears outside this united domain is erased



Drift Correction



MYI concentration, 2 Apr, 2003 [Fig. 8 from *Ye et al.*, 2016]

(a) Before correction, lots of unrealistic MYI west of Svalbard

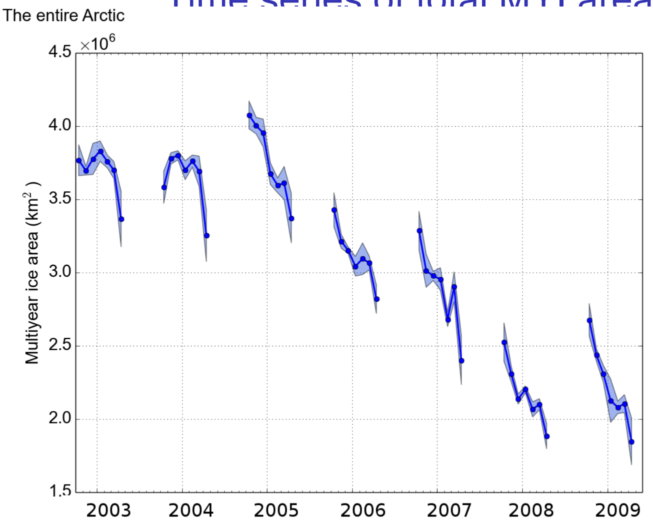
(b) After drift correction.

(c) Radarsat image: typical streaks of young ice (region D)

Snow Metamorph. Correction

- Look for anomalies, i.e. for pixels where
  - $T_{B,37h}$ drops by more than 20 K in one day
  - MYI concentration rises by more than 10% in one day
- MYI concentration of such pixels replaced by value from previous day

Time series of total MYI area



Goals

- Adapt and apply the algorithm to Antarctic sea ice
- Find at least Antarctic MYI (mainly second-year ice), possibly more ice types
- Establish time series of Antarctic and Arctic MYI for the whole period of available satellite data, i.e. 1999 to present
- Investigate and (try to) understand spatial and temporal patterns of change

Workplan

WP 1: Adapt and apply algorithm, establish time series

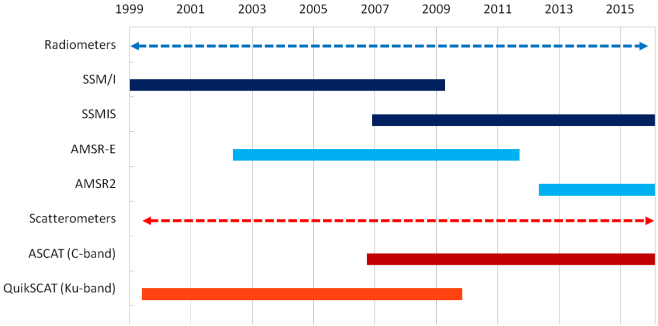
WP 2: Validate (evaluate? intercompare?) with observations

WP 3: Investigate/Understand changes

Some Details (WP 1): Long time series

Appropriate input data 1999–present:

- Five different scatterometer/radiometer combinations
- Needs sensor intercalibration



Some Details (WP 1): Ice Type and Ice Thickness

IUP & AWI (S. Hendricks) :

New MYI data ↔ radar altimeter sea ice thickness

- Compare pattern of MYI with patterns of sea ice thickness (from radar altimeters)
- Discrepancies? ← Reasons

Some Details (WP 2): Evaluation

IUP & AWI (S. Hendricks) & Uni HH (S. Kern) :

Intercompare with in-situ observations from

- Campaigns, ships
- autonomous platforms (ice buoys)

IUP & ECCC (M. Shokr) :

Intercompare with high-res. satellite observations

- Radarsat-1 and Sentinel-1 images
- MODIS for new ice

IUP & AWI (S. Arndt) :

Intercompare with new snow melt type data

- Onset of temporary and continuous snow melt

$\Rightarrow$ limits of period of possible ice type detection

Some Details (WP 3): Investigate/Understand changes

Time series analysis

- Monthly, annual, interannual variabilities (regional, hemispheric)
- Bias between different sensor combinations?
- Spatial/temporal pattern analysis
- Characteristic regions: Ross Sea, Antarctic Peninsula
- Test possible reasons for ice type changes: atmospheric drivers (wind, temperature, precipitation)?
- Compare to Arctic

People

- Yufang Ye, Chalmers Univ. of Technology, Göteborg
- Mohammed Shokr, Environment and Climate Change Canada
- Stefan Hendricks, AWI Bemerhaven
- Stefanie Arndt, AWI Bemerhaven
- Stefan Kern, University of Hamburg
- Gunnar Spreen, Christian Melsheimer, Georg Heygster, IUP