Sea Ice Remote Sensing – Applications for Climate and Shipping –

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and members of the Remote Sensing Group for Polar Regions, collaborators at AWI, NPI, JPL, UHH, and more
Effects of a Changing Arctic

- **Arctic Amplification**: increase in air temperature at twice the global rate
- **Sea ice albedo feedback** contributes to warming
- **Changes of weather and precipitation patterns**

**Changing marginal ice zone** effects Arctic marine eco-system and biogeochemical cycles

**More wave action** on coasts → damages

Temperature Anomaly (Kelvin), Reference: 1951-1980

Trend of Arctic sea ice cover

- FYI
- MYI
What do we do?

• Remote sensing of sea ice and the polar atmosphere
  • variety of sensors from low resolution passive microwave to higher resolution optical and SAR sensors; altimetry

• Key research questions
  • Retrieve new quantities and establish reliable error estimates
  • Merge existing observations to new products
  • Closing the gap between sea ice monitoring and climate system understanding

• Strong collaboration with Alfred-Wegener-Institute and other partners
  • Field observations for validation and case studies
  • Bringing satellite observations and modeling studies together
Sea Ice Concentration

- Most widely used sea ice quantity
- Based on AMSR-E/2 89 GHz
- University of Bremen: 89 GHz channels/higher spatial resolution (5 km)

[www.seaice.uni-bremen.de](http://www.seaice.uni-bremen.de)
[www.meereisportal.de](http://www.meereisportal.de)

[Spreen et al., 2008]
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Sea Ice Concentration – Time Series

Arctic Sea Ice

September 2017

1981–2010 September Median

March 2017

1981–2010 March Median
Sea Ice Concentration – Time Series

- Time series since 1972
- Annual trend: −4.5%/decade
- Summer trend: −13%/decade

*www.seaice.uni-bremen.de*

- Data since 2002
- 6 and 3 km resolution
- daily 2 hemispherical, 27 regional maps

-FYI- MYI-
Current Improvements – Ice Concentration

- Merging radiometer and optical data at 1 km resolution

- Correcting atmospheric influence at 89 GHz using reanalysis data

2015-03-28

Laptev Sea
Improved Multiyear Ice Concentration

April 2, 2003

Before correction

After correction

Radarsat-1 image

0% 100%

(Ye et al., Rem. Sens., 2016)

- Multiyear ice concentration suffer from misclassification due to
  - Rough first-year ice
  - Melt-refreeze cycle in the snow
- New filters to improve dataset

A: MYI floes
B, E: smooth texture
C: open water
D: streaks of high values

After correction
- a reduction of MYI area
  (5.2x10^5 km^2 on average)
- better monotonic decrease
Thickness of Thin Sea Ice: SMOS & SMAP

- L-band radiometers SMOS (ESA) and SMAP (NASA)
- <50 cm ice thickness
- SMOS since 2010; merged SMAP/SMOS soon
- U Bremen algorithm uses intensity $I$ and polarization difference $Q$ at 40–50°

Huntemann et al., TC, 2014
Patilea et al., TCD, 2017

www.seaice.uni-bremen.de
www.meereisportal.de
Melt Pond Fraction retrieval from MERIS

- **Data 2002–2011:** MERIS (412–900 nm) on ENVISAT, 1 km x 1 km resolution, 6 wavelengths, 9/15 ch. used.

- **Forward model:** ice as random mixture of grains with inclusions (air bubbles, brine, sediments, etc.), melt ponds, in VIS/NIR, scattering by Rayleigh-Gans approx.

- **Constraints on the model parameters** to remove the unphysical solutions are developed analyzing a set of ~200 field spectra of ponds and ice. **Model does not use a priori values for sea ice or pond optical properties!**

Istomina et al. 2015 and 2015a

Data at: [www.seaice.uni-bremen.de](http://www.seaice.uni-bremen.de)
Leads are important for heat & gas fluxes and for shipping

- Sentinel-1 Synthetic Aperture Radar (SAR) data since 2015

- Two polarizations (HH, HV)

- Covers large parts of the Arctic daily at 100 m resolution

- Daily lead and lead frequency maps for the European Arctic

SAR data (Sentinel-1) Optical data (Sentinel-2)

Murashkin et al., Ann. Glac., in review
Climate System Understanding

Sea Ice Speed Trend

- Positive trend in sea ice drift speed in most of the Arctic Basin
- Sea ice drift from SSM/I satellite radiometer

Spreen et al., GRL, 2011
1992–2009 Wind and Ice Speed Trend

- winter: Oct-May
- 1992 - 2009

* North Pole

➢ all 4 reanalyses: only small trend in wind speed
• Wind and ice drift increase in the Beaufort and north of Kara and Laptev Seas

• NCEP wind speed and IFREMER ice drift trend pattern show strong correspondence during the last 10 years.
Positive trend of $0.9 \pm 0.1 \text{ cm/s/decade}$ or $11\%$ per decade in sea ice speed.

Only small positive trends (1 to 2%/decade) in wind speed in all 4 reanalyses.

Strongest ice drift trend after 2004 (+46%/decade).

Spreen et al., 2011
• Smaller trend of 3%/decade ($p=0.98$).
• No continuation of 2004–2009 trend of 46%/decade.
• Wind speed shows similar trend, 4%/decade ($p>0.99$) and variability ($R=0.7$) could explain ice speed trend.
• Strong decrease in ice thickness from combined submarine and satellite altimeters (ICESat (laser), CryoSat-2 (radar)) record for 1976–2014.

• Recent years, however, show strong variability and no clear trend

• Is there a shift in the Arctic climate system during the last 10–15 years?
Climate System Understanding

- Changes in sea ice deformation from SAR data
- Create long time series from several sensors
- Comparison to coupled model and reanalysis data
- Understand why did ice moves faster and deforms more ➔ ocean & atmosphere coupling


- Phytoplankton bloom below sea ice in May
- Leads in the ice provide light for bloom
- Satellite data can be used for upscaling

Shear Rate, Nov. 1999

Assmy et al. (2017)

Leads in Arctic pack ice enable early phytoplankton blooms below snow-covered sea ice. *Scientific Reports.*
Remote Sensing of Sea Ice at The University of Bremen

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Thank you!