Inter-Comparison of Passive Microwave Sea Ice Concentration Algorithms

Natalia Ivanova¹, Leif T. Pedersen², Thomas Lavergne³, Rasmus T. Tonboe², Roberto Saldo⁴, Georg Heygster⁵, Anja Rösel⁶, Stefan Kern⁶, Marko Mäkynen⁷, Contributions from: Ola M. Johannessen¹, Ludovic Brucker⁸, Mohammed Shokr⁹

¹Nansen Environmental and Remote Sensing Center, ²Danish Meteorological Institute, ³Met.no, ⁴Danish Technological University, ⁵University of Bremen, ⁶University of Hamburg, ⁷Finnish Meteorological Institute, ⁸NASA, ⁹Environment Canada
Outline

• Motivation

• Comparison of 11 sea ice concentration algorithms

• Why the algorithms differ

• Sea ice concentration as an essential climate variable

• Conclusions
Motivation: Arctic sea ice decrease

Sea ice concentration average September

1979

2012

MYI fraction 1 January

2004

2005

2006

2007

2008

[Kwok et al., 2009]
Motivation: Uncertainty in existing methods

Daily Arctic sea ice area and extent 2012

Area and Extent charts showing changes in million km² from January to January 2012, with various methods represented by different lines.
Annual Arctic sea ice area 1979–2012
Spatial distribution of the differences among the sea ice algorithms

1979–2012
5 algorithms

1992–2012
11 algorithms

Standard deviation of all the algorithms (sea ice concentration) from the mean, %
Possible causes of uncertainties in the sea ice algorithms

Sea ice concentration standard deviation of 11 sea ice algorithms from the mean

Typical for this season:
- melt ponds
- thin ice
- re-freezing cycles

Weather-related effects:
- water vapor
- cloud liquid water
- sea surface roughening by wind
- rain

Resolution:
- mixture of different surface types within the coarse footprint

2 – 12% (~20% daily)
Most of the algorithms agree on the trends

![Diagram showing Arctic sea ice area from 1979 to 2012 with linear trends and correlation coefficients.](image)

- **ASI**: -0.766
- **Bootstrap**: -0.956
- **Bristol**: -0.966
- **CalVal**: -0.923
- **NASA Team**: -0.883
- **NASA Team2**: -0.978
- **Near90GHz**: -0.808
- **NORSEX**: -0.975
- **NORSEX85H**: -0.977
- **TUD**: -0.835
- **UMass–AES**: -0.866

**mil km²/decade**
Trends in September Sea Ice Concentration

1979–2012

1992–2012

5 algorithms

11 algorithms

% per decade
Sea ice concentration as an essential climate variable

Leif Toudal Pedersen, DMI
Natalia Ivanova, NERSC
Roberto Saldo, DTU
Georg Heygster, U-Bremen
Rasmus Tonboe, DMI
Thomas Lavergne, Met Norway
Marko Mäkynen, FMI
Stefan Kern, U-Hamburg
Contributions from
Ludovic Brucker, NASA
Mohammed Shokr, Environment Canada
Round Robin Data Package

• Accurate reference data (SIC=0 and SIC=1)
• Collocated microwave brightness temperatures from:
  – SMMR (NSIDC)
  – SSMI (CM-SAF)
  – AMSR-E (NSIDC)
• Co-located NWP data (ERA Interim)
Algorithm comparison, SIC=15%, AMSR, no WF
Algorithm comparison, SIC=85%, AMSR, no WF
Thin ice (SMOS, University of Bremen)

SIC(SMOS Ice Thickness)
Melt ponds (MODIS by U-Hamburg)


ather filter

\[ \frac{37V - 18V}{37V + 18V} > 0.05 \text{ or } \frac{22V - 18V}{22V + 18V} > 0.045 \]

- C = 0%
- C = 15%
- C = 20%
- C = 30%
Conclusions

Methods of sea ice retrieval from passive microwave satellite data are

gain: up to 1.3 million km² in area, 12% in concentration

ever, most of them agree on the trend for the last 30 years

Differences in the algorithms have regional and seasonal features. Winter:

lal seas due to the weather-related effects and resolution, central Arctic due

tivity variations. Summer: areas with melt-ponds and refreezing cycles, and

er-related effects in areas with lower concentrations, thin ice

gorithms are sensitive to the tie-points adjustments

weather filters contribute to the uncertainty and need to be used with

. Apply atmospheric correction to TBs to reduce atmospheric noise.

The best method would be a combination of algorithms Bootstrap F and Bristol

mic tie-points to accommodate residual sensor drift and seasonal cycle in