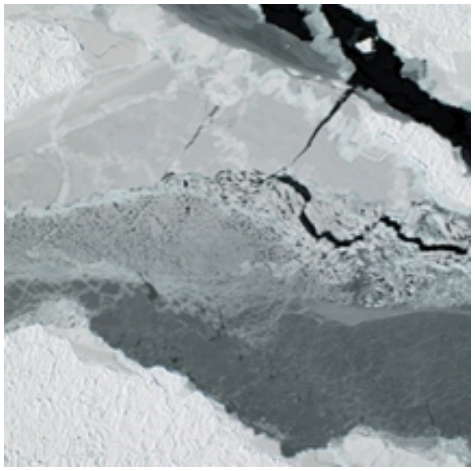
Sea Ice Concentration CDR at the National Centers for Environmental Information

2018 Sun-Climate Symposium
March 19-23

A. Windnagel
W. Meier
F. Fetterer
G. Peng



National Snow and Ice Data Center
Advancing knowledge of Earth's frozen regions

Outline

- What is a CDR
- What is the sea ice CDR
- CDR algorithm description
- Verification of the CDR
- Managing a CDR
- Sea ice animation

What is a CDR

- The National Research Council (NRC) defines a climate data record (CDR) as a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change (NRC 2004).

The SIC CDR: Description

- It is a sea ice concentration data set that conforms to the definition of a CDR.
- Provides daily and monthly averaged estimates of the fraction of Arctic and Southern Ocean area covered by sea ice in NetCDF format from July 1987 to present.
- Leverages two well-established passive microwave sea ice algorithms created at Goddard Space Flight Center:
  - NASA Team (NT) (Cavalieri et al. 1984)
  - Bootstrap (BT) (Comiso 1986)

Fulfills IOC Requirements

- Self-describing file format - NetCDF
- ISO 19115-2 compliant collection-level metadata
- CF compliant file-level metadata
- Grid-cell-level metadata (quality flags and uncertainty parameter)
- Fully automated and reproducible processing
- Open online access to data and source code

Why care about sea ice?

- Sea ice is an important climate change indicator.
- Changes in sea-ice extent and concentration reflect changes in air and ocean temperature as well as circulation patterns.
- Plays a key role in polar climate by reflecting incoming solar radiation during the summer and insulating the warmer ocean from the cold atmosphere during winter.
- It is a platform for numerous flora and fauna, from microscopic organisms to charismatic megafauna.
- In the Arctic, sea ice is a central component of the culture and life of indigenous people.

The SIC CDR: Input Data

- Derived from brightness temperature data from five successive passive microwave instruments gridded onto a 25 km resolution polar stereographic projection.

Platform and Instrument	Time Period
DMSP-F8 SSM/I	09 July 1987 - 02 December 1991
DMSP-F11 SSM/I	03 December 1991 - 30 September 1995
DMSP-F13 SSM/I	01 October 1995 - 31 December 2007
DMSP-F17 SSMIS	01 January 2008 - 27 February 2017
DMSP-F18 SSMIS	01 March 2017 - present (near-real-time)

Region	Columns	Rows
North	304	448
South	316	332

The SIC CDR: Output

- Sea ice concentration field
- Standard deviation & quality flag fields
- Melt detection field provides date of first melt
- Time, x/y grid, lat/lon, and projection fields
- Ancillary Fields
  - Goddard derived NT ice concentration
  - Goddard derived BT ice concentration

  Also available from NSIDC as their own data sets
  - Merged Goddard NT/BT version using the CDR algorithm

Algorithm Description

- Channels used in NT and BT algorithms

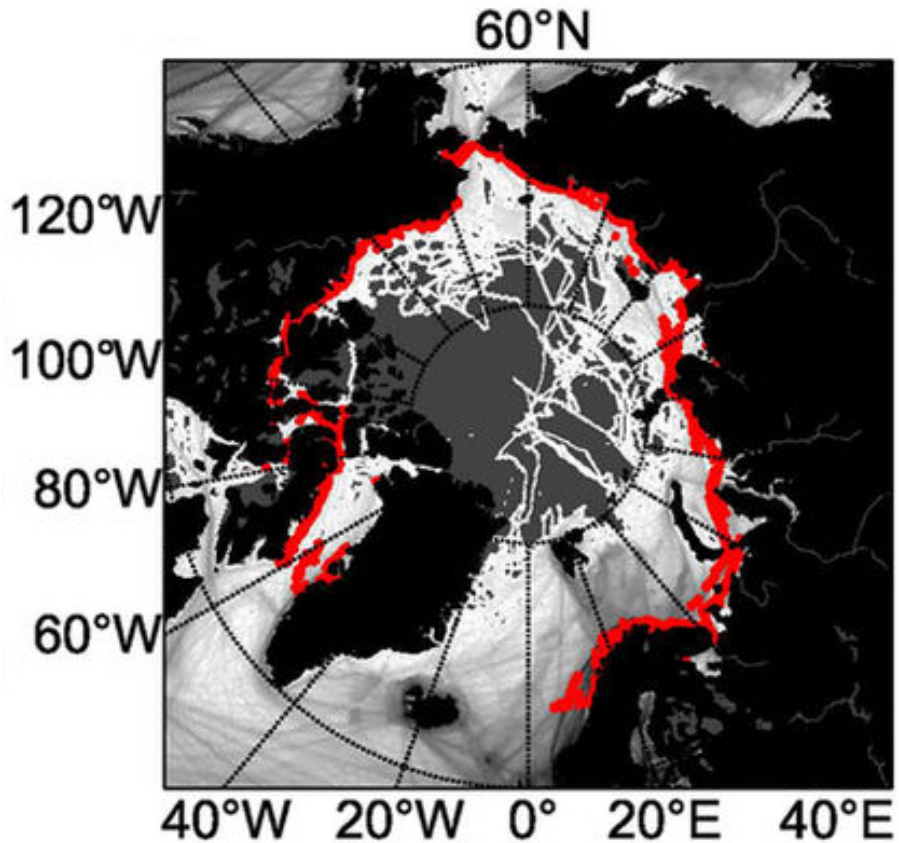
Algorithm	NASA Team	Bootstrap
Passive Microwave Channels	19H, 19V, and 37V	37H, 37V, and 19V

- The CDR algorithm combines the values from each:
  - Sea ice edge is defined using only the Bootstrap-derived data with a 10 percent concentration threshold cutoff
  - Within the ice pack, the NT and BT values are compared, whichever is greater is selected

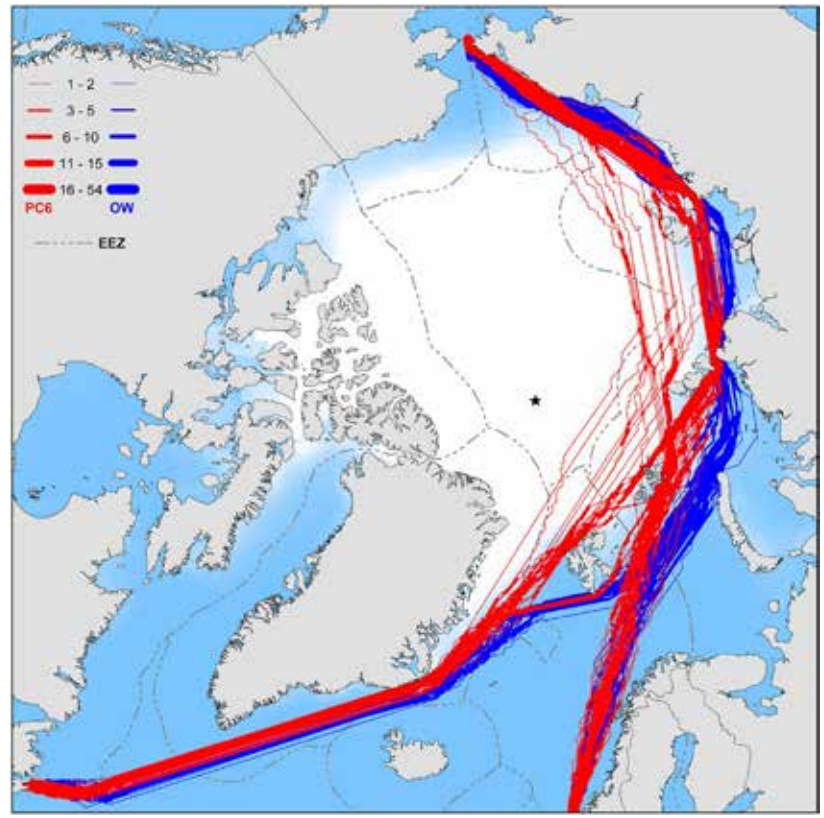
Why Combine NT and BT

- Mitigate issue that both algorithms tend to underestimate sea ice concentrations.
- Selecting the higher concentration, the low biases in both NT and BT are ameliorated, and the CDR results in a concentration product with a lower average bias.
- Produce a more accurate sea ice concentration product than is possible with each algorithm alone.

Why Combine NT and BT



Eguíluz et al. (2016)



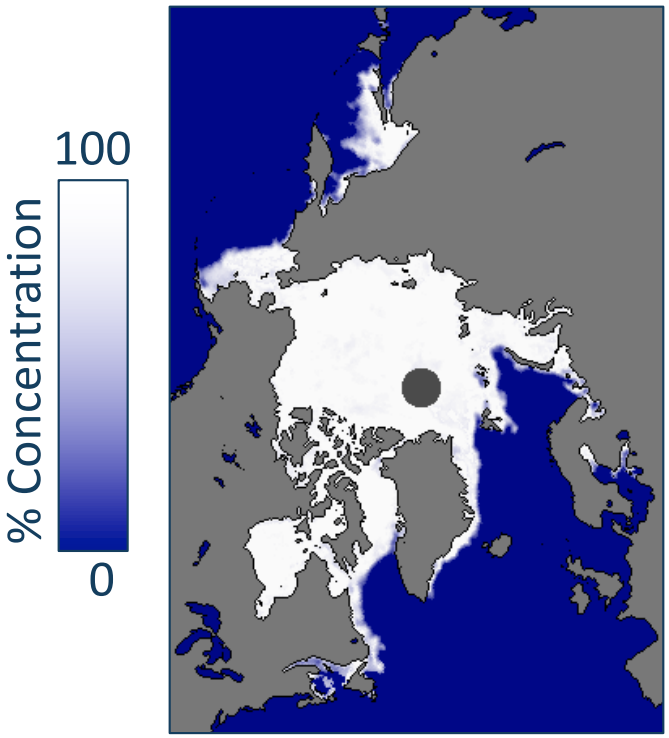
Smith and Stephenson (2013)

Why Combine NT and BT

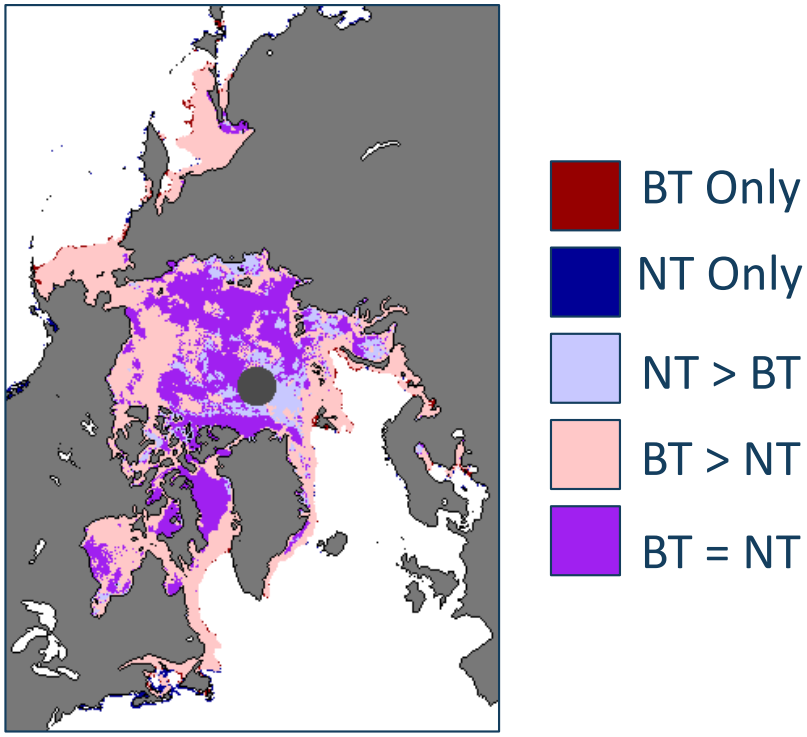
- Coarse spatial resolution leads to ambiguous ice edge
  - Using only one algorithm (BT) for ice removes some ambiguity and provides a consistent ice edge
    - BT is less course than NT since it only uses 37 GHz for edge detection where NT uses 19 and 37 GHz
    - 37 GHz channel has smaller footprint (38 km x 30 km) and more sensitive to thin ice than 19 GHz (70 km x 45 km)
- Max(BT|NT) for each grid cell
  - NT underestimates for thin ice and melt in summer months
  - BT underestimates for interior cold winter temps

Combining NT and BT

CDR Concentration
(Combined NT & BT)



Value
Selected

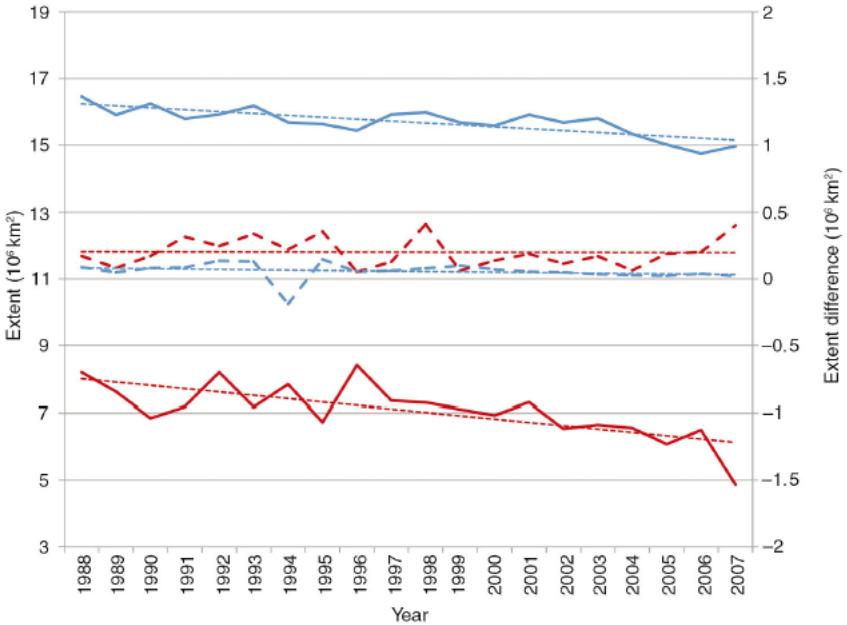


Meier et al. (XXXX)

15 March 2007

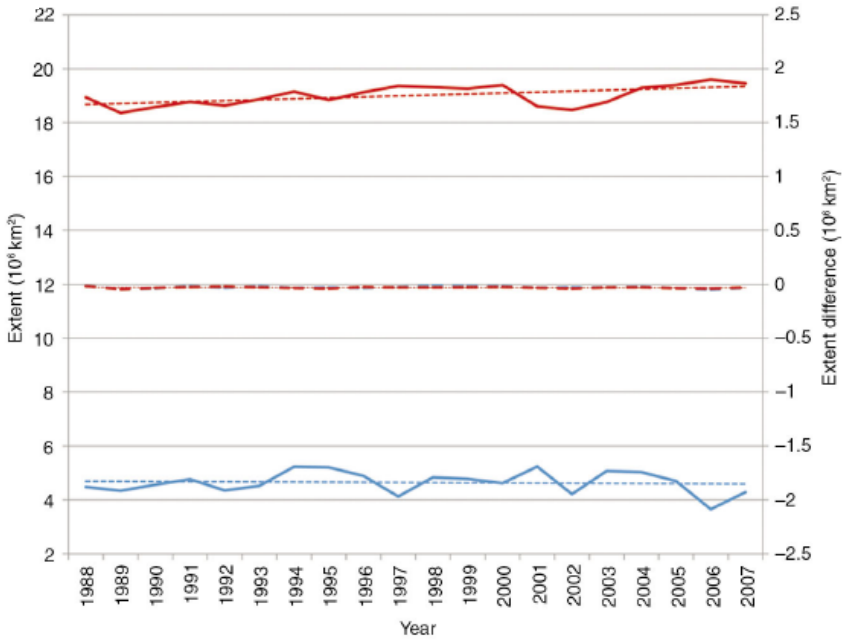
Verification of CDR

Arctic



Meier et al. (2014)

Antarctic



Meier et al. (2014)

March Extent

CDR - Goddard Merged

Linear Trends

September Extent

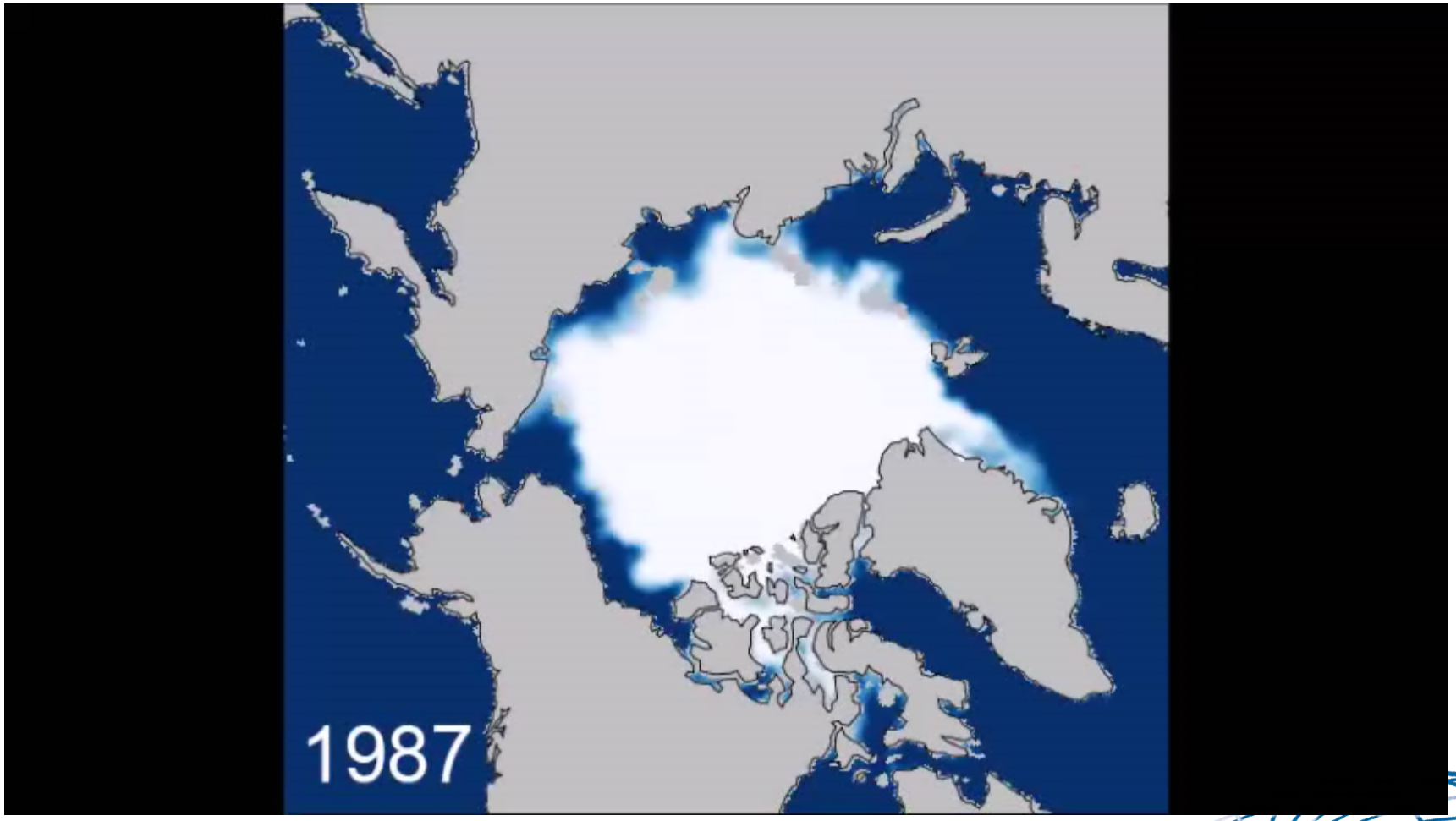
CDR - Goddard Merged

Linear Trends

Managing a CDR: Challenges

- Sustaining the data for future generations: cost, accessibility, continued collection.
- Reprocessing as errors are discovered and as new versions of source data are released.
- Integrating new data products, algorithms, and data technologies that are developed.
- Evolving with user community needs.

September Animation




Thank You!

References

Cavalieri, D. J., P. Gloersen, and W. J. Campbell. 1984. Determination of Sea Ice Parameters with the NIMBUS-7 SMMR. *J. Geophys. Res.* 89: 5355–5369.

Comiso, J. C. 1986. Characteristics of Arctic Winter Sea Ice from Satellite Multispectral Microwave Observations. *J. Geophys. Res.* 91: 975–994.

Eguíluz, V. M., J. Fernández-Gracia, X. Irigoien, and C. M. Duarte. 2016. A quantitative assessment of Arctic shipping in 2010–2014. *Scientific Reports* 6. doi: 10.1038/srep30682.

Meier, W., F. Fetterer, M. Savoie, S. Mallory, R. Duerr, and J. Stroeve. 2017. *NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration, Version 3*. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. doi: https://doi.org/10.7265/N59P2ZTG.

Meier, W., F. Fetterer, and A. K. Windnagel. 2017. *Near-Real-Time NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration, Version 1*. doi: https://doi.org/10.7265/N5FF3QJ6.

Meier, W. N., M. Savoie, and S. Mallory. 2011, updated 2017. CDR Climate Algorithm and Theoretical Basis Document: Sea Ice Concentration, Rev 6. ed. F. Fetterer and A. Windnagel. NOAA NCDC CDR Program.

Meier, W. N., G. Peng, D. J. Scott, and M. Savoie. 2014. Verification of a new NOAA/NSIDC passive microwave sea-ice concentration climate record. Polar Research 33(21044). doi: http://dx.doi.org/10.3402/polar.v33.21004.

Meier, W. N., J. Maslanik, C. Fowler, R. Duerr, J. Stroeve. 2011. Development of passive microwave cryospheric climate data records. Presented at AAG April 2011, Seattle Washington; Session - The Generation and Use of Climate Data Records.

Meier, W. N., M. Savoie, and S. Mallory. 2011, updated 2017. CDR Climate Algorithm and Theoretical Basis Document: Sea Ice Concentration, Rev 6. ed. F. Fetterer and A. Windnagel. NOAA NCDC CDR Program.

National Research Council of the National Academies. 2004. Climate Data Records from Environmental Satellites: Interim Report. National Academies Press, Washington, D.C., 150 pp.

Peng, G., W. N. Meier, D. J. Scott, and M. H. Savoie. 2013. A long-term and reproducible passive microwave sea ice concentration data record for climate studies and monitoring. *Earth Sys. Sci. Data* 5: 311-318.

Smith, L. C. and S. R. Stephenson. 2013. New Trans-Arctic shipping routes navigable by midcentury. *PNAS* 110(13). doi: https://doi.org/10.1073/pnas.1214212110.

Abstract

The NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration is a CDR that provides a consistent daily and monthly-averaged record of the fraction of ocean covered by sea ice for both the North and South poles. It spans 9 July 1987 to present and meets current standards and guidelines for climate data records. It is based on a long-term passive microwave satellite record on a 25 km grid that is superior to other measurement methods such as in situ or ship-based that cannot reproduce the spatial and temporal coverage of these satellites. This talk will present a basic description and characterization of this ice concentration CDR along with the challenges of creating and maintaining such a record. In addition, a discussion of the scientific relevance of this CDR and its validation with other sea ice products will be included.