MEaSUREs Arctic Sea Ice Characterization Daily 25km EASE-Grid 2.0, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Anderson, M., A. C. Bliss, and M. Tschudi. 2014. *MEaSUREs Arctic Sea Ice Characterization Daily 25km EASE-Grid 2.0, Version 1.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/MEASURES/CRYOSPHERE/nsidc-0532.001. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0532

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

This data set, part of the NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) program, provides a daily record of Arctic sea ice characteristics for the years 1979 through 2012 derived from passive microwave brightness temperatures. Parameters include the location of sea ice cover, sea ice age, day of melt onset, and status of melt onset. Data are gridded in the 25 km Equal-Area Scalable Earth Grid (EASE-Grid) 2.0 and provided as netCDF files.

1.1 Format

Data are provided in Network Common Data Form, Version 4 (NetCDF4) format (.nc) following version 1.6 of the Climate and Forecast (CF) metadata conventions. For more information about working with NetCDF formatted data, visit the UCAR Unidata Network Common Data Form Web site.

1.2 File and Directory Structure

Data are available on the HTTPS site in the https://n5eil01u.ecs.nsidc.org/MEASURES/NSIDC-0532.001 directory.

1.3 File Naming Convention

This section explains the file naming convention used for this product with an example.

Example File Name:
asicd25e2_20060615_v01r02.nc

asicd25e2_YYYYMMDD_v01r02.nc

Refer to Table 1 for the valid values for the file name variables listed above.

Table 1. File Naming Convention

Variable	Description
asicd25e2	Arctic Sea Ice Characterization Daily 25 km, Ease-Grid 2.0
YYYY	Year
MM	Month
DD	Day
v01r02	Version 1.2
.nc	netCDF file

1.4 File Size

Data files are about 4.8 MB.

1.5 Volume

The entire volume is roughly 50 GB.

1.6 Spatial Coverage

Northern Hemisphere:

Southernmost Latitude: 0.0°
Northernmost Latitude: 90.0°
Westernmost Longitude: -180.0°
Easternmost Longitude: 180.0°

1.6.1 Spatial Resolution

25 km

1.6.2 Projection and Grid Description

Projection Parameters

- Azimuthal Equal-Area Projection (WGS84 ellipsoid)
- Map Equatorial Radius (m): 6,378,137.0
- Map Eccentricity: 0.081819190843

Grid

Data are provided in the 25 km Northern Hemisphere Equal Area Scalable Earth Grid 2.0 (EASE-Grid 2.0). Grid dimensions are 720 x 720.

EASE-Grid was designed as a versatile format for global-scale gridded data—specifically remotely sensed data—although it has gained popularity as a common gridding scheme for other data as well. Data from various sources can be expressed as digital arrays of varying grid resolutions which are defined in relation to one of three possible projections: Northern and Southern Hemisphere (Lambert's equal-area, azimuthal) and full global (cylindrical, equal-area). For a complete description, visit NSIDC's EASE-Grid 2.0 Format Description page.

1.7 Temporal Coverage

Sea ice cover, day of melt onset, and status of melt onset are available from 1979 to 2012. Sea ice age is only included for the years 1985-2012.

1.7.1 Temporal Resolution

Sea ice cover is available every other day for the years 1979 to 1987, during the SMMR period, and daily from 1988 to 2012. Sea ice ages are updated weekly but provided as a pseudo daily parameter; that is, values in daily NetCDF files remain the same for each seven-day period until new ice ages are available the following week. For example, the value on January 1 is reported for the first seven days of the year (week one), the value on January 8 is reported for the next seven days (week two), and so on. Extra days during leap years are added to week 52.

Refer to Table 2 for a matrix of this data set's temporal coverage and resolution, broken down further by parameter and sensor:

Table 2. Temporal Resolution for MEaSUREs Arctic Sea Ice Characterization Daily 25 km EASE-G

Variable	Start Year	End Year	Sensor			Annual Coverage (Day of Year)
			SMMR (1979-1987)	SSM/I 1988-2007	SSMIS (2008-2012)	
Sea ice cover	1979	2012	Every other day	Daily	Daily	1 - 365 or 366
Day of melt onset	1979	2012	Every other day	Daily	Daily	61 - 245[1]
Status of melt onset	1979	2012	Every other day	Daily	Daily	61 - 245[1]
Sea ice age	1985	2012	Pseudo daily (weekly)	Pseudo daily (weekly)	Pseudo daily (weekly)	1 - 365 or 366
Grid Conversions	1979	2012	Every other day	Daily	Daily	1 - 365 or 366
[1]No melt data before day 61 and after day 245.						

1.8 Parameter or Variable

Data files contain five parameters stored as 720 x 720 NetCDF variables plus latitude and longitude geolocation arrays. Table 3 lists the NetCDF variables with coded integer keys and descriptions:

Table 3. Variable Names and Descriptions

Name	Dimensions	Data Type	Values	Description
sea_ice_cover	720 x 720	short (signed)	20	Land or permanent ice on land
			30	Sea ice (concentration ≥ 15%)
			40	Open water
			90	Missing data, grid corners
			91	Pole hole (satellite coverage gap)
day_of_melt_onset	720 x 720	short (signed)	61-245[1]	Day of year of melt onset, for cells with melt onset prior to or on file date.
			0	No data (or no melt), grid corners
status_of_melt_onset	720 x 720	short (signed)	11	Melt onset begins prior to file date.
			12	Melt onset begins on file date.
			13	Melt onset begins on a future date.
			14	No data or no melt date calculated
			0	No data, grid corners
age_of_sea_ice	720 x 720	short (signed)	1-9	Age in years of oldest ice in cell (younger ice or open water may be present).
			10	Ten year or older ice
			0	No ice age calculated, grid corners
grid_conversions[2]	720 x 720	short (signed)	21	Land
			22	Land mask mismatch assigned to land
			31	Sea ice
			32	Land mask mismatch assigned to sea ice
			41	Open water
			42	Land mask mismatch assigned to open water

Name	Dimensions	Data Type	Values	Description
			90	Missing data, grid corners
			91	Pole hole
latitude	720 x 720	float (IEEE single-precision floating point)	0° to 90° N	Latitude at center of EASE-Grid 2.0 cell
longitude	720 x 720	float (IEEE single-precision floating point)	-180° E to 180° E	Longitude at center of EASE-Grid 2.0 cell
cols	1 x 720	int	—	x coordinate, center of EASE-Grid 2.0 cell (m from origin)
rows	720 x 1	int	—	y coordinate, center of EASE-Grid 2.0 cell (m from origin)
[1]No melt data (filled with a value of 0) before day 61 and after day 245; [2]See Land Mask Mismatches for details about this array.				

Data files also contain two additional variables which users may find helpful:

- coord_system: projection and grid parameters (char)
- time: days since 31 December, 1978 (int)

1.8.1 Land Mask Mismatches

Re-gridding to EASE-Grid 2.0 resulted in land type mismatches due to minor differences between the EASE-Grid 2.0 land mask from the Boston University MODIS and the Polar Stereographic Data land mask. The NetCDF variable grid_conversions specifies where the land masks agreed and disagreed after regridding and how mismatches were reconciled. Refer to Table 4 to see how values in grid_conversions correspond to values in the sea_ice_cover variable.

Table 4. Assigned Value by Pixel Type for Sea Ice, Water, and Land

Pixel Type	Value in sea_ice_cover	Value in grid_conversions	BU-MODIS Land Mask	SSM/I Polar Grid Land Mask	Land Mask Comparison	Assigned Value
Land	20	21	Land	Land	Match	—
		22	Land	Water	Mismatch	Land
Sea Ice	30	31	Water	Water	Match	—
		32	Water	Land	Mismatch	Sea Ice[1]
Water	40	41	Water	Water	Match	—
		42	Water	Land	Mismatch	Water[1]
No Data	90	90	No Data	—	—	—
Pole Hole	91	91	Water	Pole Hole	Mismatch	Pole Hole
[1]See New Water Pixels for details.						

1.8.2 New Water Pixels

Re-gridding created some new open water pixels between the sea ice and coastline in areas where the ice cover in the original Polar Stereographic grid extended all the way to the coast. To address this issue, the Goddard Space Flight Center Polar Sterographic land mask was regridded to EASE-Grid 2.0 and compared point by point to the BU-Modis land mask. Based on the comparison, the investigators created an intermediate mask to locate and classify disagreements between land masks based on pixel type. The mask is used when creating the grid_conversions, sea_ice_cover, day_of_melt_onset, and status_of_melt_onset NetCDF variables. Refer to the 3.2.1 section for additional details.

Note: The mask is static; it is created from land masks and does not change from day to day.

To assess whether or not to reassign new open water pixels as ice, a 3 x 3 pixel neighborhood filter is applied through several iterations. On the first iteration, pixels are reassigned if at least 51 percent of their surrounding eight pixels are ice covered. The second through seventh iterations reassign pixels if at least 33 percent of the surrounding pixels are ice covered. Iterations continue until no more changes are found.

2 SOFTWARE AND TOOLS

2.1 Software and Tools

Unidata at the University Corporation for Atmospheric Research maintains an extensive list of freely available Software for Manipulating or Displaying NetCDF Data.

3 DATA ACQUISITION AND PROCESSING

3.1 Data Acquisition Methods

For both melt onset and sea ice age, brightness temperatures were acquired from SMMR, SSM/I, and SSMIS from Nimbus-7 and DMSP F08, F11, F13, and F17 platforms. In addition to these primary data sources, ice age also utilizes: the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) from the AQUA platform for the period 19 June, 2002 to 27 September, 2011; and the NOAA 6-16 platform series for the Advanced Very High Resolution Radiometer (AVHRR) through the end of 2000. AVHRR visible (Channel 1) data is utilized for daytime ice age and infrared (Channels 4 and 5) for nighttime. National Centers for Environmental Prediction (NCEP) re-analysis near surface winds were downloaded via NOAA's FTP site and buoy data were downloaded from the International Arctic Buoy Programme at the University of Washington.

Note that these data are ingested into the algorithm for Sea Ice Motion Vectors (Fowler, 2013), which is then input to the ice age program.

3.2 Derivation Techniques and Algorithms

- The sea ice parameter reports the location of sea ice concentrations ≥ 15 percent based on the goddard_merged_seaice_conc parameter in the NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration (9 July – 31 July 1987 use the seaice_conc_cdr parameter because the merged data are unavailable). The NOAA/NSIDC climate data record estimates fractional sea ice coverage by combining estimates from two algorithms developed at the NASA Goddard Space Flight Center (GSFC): the NASA Team algorithm (Cavalieri et al., 1984) and the Bootstrap algorithm (Comiso, 1986).
- Snow melt onset is derived from the Snow Melt Onset Over Arctic Sea Ice from SMMR and SSM/I Brightness Temperatures data set using the Advanced Horizontal Range Algorithm (AHRA) developed by Drobot and Anderson, 2001.
- Status of melt onset is created by assigning integer values which indicate whether the cell has a melt onset date prior to the current day (11), on the current day (12), or later in the year (13).

Cells with no melt onset date are filled with 0. Melt onset is calculated for days 61-245 of the year.

- Day of melt onset corresponds to status of melt onset by providing the day of the year on which past and current melt is observed. In other words, for pixels with status_of_melt_onset equal to 11 or 12, the day on which melt began is recorded in the day_of_melt_onset array.
- Ice age is derived from Polar Pathfinder Daily 25 km EASE-Grid Sea Ice Motion Vectors. Using these data as input, ice age is calculated by tracking the ice and comparing adjacent satellite passive microwave images, as well as utilizing wind forcing on the ice and movement of buoys. The oldest ice in each 25 km pixel determines the age which is mapped for any pixel with at least 15 percent ice concentration. If ice from a grid cell is still tracked after the day of minimum ice extent, its age is increased by one year. Thereafter, grid cells that are encountered with ice but have not yet been assigned an age are considered first-year ice (assigned a value of 1).
- grid_conversions is discussed in detail in the 1.8.1section above. This parameter records post-regridding mismatches due to land mask differences between the source data and EASE-Grid 2.0 and is used to create the final sea ice cover data array. The locations of pixel mismatches in grid_conversions (values 32 and 42) point to locations in the sea_ice_cover array that were not directly calculated from the original brightness temperatures and as such should be interpreted with lower confidence.

3.2.1 Processing Steps

The following sections outline the processing steps used to create each NetCDF variable stored data set:

sea_ice_cover

- Input data: NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration
- Processing:
    - Extract merged sea ice concentration variable and convert concentrations ≥ 15 percent to sea ice cover (9 July – 31 July 1987 use the seaice_conc_cdr parameter because the merged data are unavailable)
    - Regrid from Polar Stereo 304 x 448 array to 25 km EASE 2.0 using mapx (nearest neighbor regridding scheme);
    - Use mask to locate cells that change between BU-MODIS and SSM/I Polar grid land or water type due to coastal land/water configuration differences between the land masks;
    - Assign land values to cells as described in 1.8.1and 1.8.2;
    - Run additional filter passes until no changes are found.

day_of_melt_onset, status_of_melt_onset

- Input data: Snow Melt Onset Over Arctic Sea Ice from SMMR and SSM/I-SSMIS Brightness Temperatures
- Initial Processing:
  - Regrid from Polar Stereo 304 x 448 array to 25 km EASE 2.0 using mapx (nearest neighbor regridding scheme);
  - Use mask to locate and fill in melt onset dates for new open water pixels produced by regridding. A filter determines whether each new water pixel needs a melt onset date by examining its eight neighboring pixels. If any neighbors have melt onset dates, the new water pixel is filled with the earliest date. Refer to 1.8.2.
- Melt Onset Date and Status Processing:
  - Identify pixels with current and past melt dates;
  - Assign current and past dates to day_of_melt_onset variable;
  - Assign other pixels as no data;
  - Identify pixels with current, past, and future melt onset dates;
  - Assign melt onset status values. Refer to Table 3 to status_of_melt_onset variable.

age_of_sea_ice

- Input data: Polar Pathfinder Daily 25 km EASE-Grid Sea Ice Motion Vectors
- Processing:
  - Regrid from EASE-Grid to EASE-Grid 2.0
  - Construct pseudo daily values by assigning the same value to each day of the week.

grid_conversions

- Input data: NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration
- Processing:
  - Regrid from Polar Stereo 304 x 448 array to 25 km EASE 2.0 using mapx (nearest neighbor regridding scheme);
  - Extract merged sea ice concentration variable and convert concentrations ≥ 15 percent to sea ice cover;
  - Run filter to locate cells that change between BU-MODIS and SSM/I Polar grid land or water type due to coastal land/water configuration differences between the land masks;
    - If cell changed from water to land, keep track of assigned cell land value. Refer to Table 4.
    - If cell changed from land to water, determine if new water pixel should be filled with sea ice or water using eight pixel neighborhood and keep track of which locations were changed.

- First pass: need at least 51 percent of water neighbor pixels equal to ice to convert cell to sea ice, otherwise cell is set to ocean;
- Second through seventh passes: need at least 33 percent of water neighbor pixels equal to ice to convert cell to sea ice otherwise cell is set to ocean. Passes are conducted until no changes are found.

3.2.2 Version History

Table 5. Version History

Version	Description
V1.2 (Jul, 2015)	Added 1D arrays named `cols` and `rows` that contain x and y coordinates (meters from origin) of the projection. New data files designated v01r02.
V1.1 (May, 2015)	Data type of `latitude/longitude` arrays changed to float (IEEE single-precision floating point); DOI corrected in metadata; v01r01 appended to data file names.
V1 (Jun, 2014)	Initial version

3.2.3 Error Sources and Limitations

Cases where land mask mismatches required applying the 3 x 3 pixel neighborhood filter generally occur along the coastline, where it is assumed that the sea ice extends to the coastline. New open water pixels resulted from differences between the source data and EASE-Grid 2.0 land masks in addition to changes in the data due to regridding.

New water pixels which were converted to sea ice are filled with a value of 32 in grid_conversions. Less confidence is associated with these locations because they were not explicitly evaluated for sea ice concentration in the source data. The previously described 3 x 3 pixel neighborhood filter was used to determine whether or not to classify these cells as ice-covered.

Similarly, five iterations of the 3 x 3 pixel neighborhood filter were run to fill the day_of_melt_onset and status_of_melt_onset variables in areas where a melt onset date was not calculated for the early March maximum sea ice extent for each annual snow melt onset grid. For pixels with a value of 32 in the grid_conversions layer, the 3 x 3 filter was applied. If one or more melt onset dates existed within the eight surrounding pixels, the filter selected the earliest melt date.

Error sources for the melt onset dates used to create the day_of_melt_onset and status_of_melt_onset variables include: pixel averaging, sensor errors, and weather effects in the brightness temperature data (Anderson et al. 2014). The Advanced Horizontal Range Algorithm used to calculate melt onset dates for this project has been shown to have an estimated error of about two days, which is consistent with other methods (Drobot and Anderson 2001).

Ice age is computed for the oldest ice in each grid cell, which may or may not reflect the predominant age of ice in the cell. Younger ice or open water may also be present.

3.3 Sensor or Instrument Description

The Scanning Multichannel Microwave Radiometer (SMMR) on board Nimbus 7 measured dual-polarized microwave radiances, at 6.63, 10.69, 18.0, 21.0, and 37.0 GHz. The instrument operated from 25 October 1978 until 20 August 1987.

The Special Sensor Microwave Imager (SSM/I) on board DMSP satellites F8, F11, F13, F17 is a seven-channel, four-frequency, orthogonally polarized, passive microwave radiometric sensor system that measures atmosphere, ocean, and land microwave brightness temperatures at 19.35, 22.2, 37.0, and 85.5 GHz.

The Special Sensor Microwave Imager/Sounder (SSMIS) replaced the SSM/I and became operational in November 2005. The sensor is a passive conically scanning microwave radiometer that measures microwave energy at 24 discrete frequencies from 19 to 183 GHz.

See the following Web pages for additional details about these instruments:

- Scanning Multi-channel Microwave Radiometer (SMMR)
- Special Sensor Microwave Imager (SSM/I)
- Special Sensor Microwave Imager/Sounder (SSMIS)

For more information about AMSR-E and AVHRR, see:

- AMSR-E/Aqua Data at NSIDC
- NOAA Satellite Information System | Advanced Very High Resolution Radiometer - AVHRR

4 REFERENCES AND RELATED PUBLICATIONS

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4.1 Related Data Collections

- MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km EASE-Grid 2.0

- MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Weekly 100km EASE-Grid 2.0
- MEaSUREs Greenland Surface Melt Daily 25km EASE-Grid 2.0
- MEaSUREs Northern Hemisphere State of Cryosphere Daily 25km EASE-Grid 2.0
- MEaSUREs Northern Hemisphere State of Cryosphere Weekly 100km EASE-Grid 2.0
- NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration
- Snow Melt Onset Over Arctic Sea Ice from SMMR and SSM/I-SSMIS Brightness Temperatures
- Polar Pathfinder Daily 25 km EASE-Grid Sea Ice Motion Vectors

4.2 Related Websites

- MEaSUREs Data: Overview

5 CONTACTS AND ACKNOWLEDGMENTS

Investigator(s) Name and Title

Mark R. Anderson
University of Nebraska–Lincoln
Department of Earth and Atmospheric Sciences
214 Bessey Hall
Lincoln, NE 68588

Angela C. Bliss
University of Nebraska–Lincoln
Department of Earth and Atmospheric Sciences
214 Bessey Hall
Lincoln, NE 68588

Mark Tschudi
University of Colorado Boulder
Colorado Center for Astrodynamics Research
UCB 431
Boulder, CO 80309

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6 DOCUMENT INFORMATION

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6.2 Date Last Updated

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