EASE-Grid Sea Ice Age, Version 3

USER GUIDE

How to Cite These Data

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

Tschudi, M., C. Fowler, J. Maslanik, J. S. Stewart, and W. N. Meier. 2016. *EASE-Grid Sea Ice Age, Version 3*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/PFSVFZA9Y85G. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0611

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DETAILED DATA DESCRIPTION

The sea ice age data in these files are derived using data from satellite passive microwave instruments, drifting buoys, and a weather model. With these data sources, the formation, movement, and disappearance of sea ice can be observed; and these observations can, in turn, be used to estimate ice age Maslanik et al. 2007. The ice age data are derived from a number of passive microwave imagers: the Scanning Multichannel Microwave Radiometer (SMMR), the Special Sensor Microwave/Imager (SSM/I), and the Special Sensor Microwave Imager Sounder (SSMIS). Visible and infrared data from the Advanced Very High Resolution Radiometer (AVHRR) were also utilized through 2004. In addition, International Arctic Buoy Program (IABP) drifting-buoy vectors and the National Centers for Environmental Prediction (NCEP)/National Center for Atmospheric Research (NCAR) Reanalysis Project (CDAS) are used to augment the satellite data (Tschudi 2010). Each data file has a corresponding browse image for quick inspection of the data.

1.1 Format

The data are in flat binary, 1 byte files with little endian byte order that are stored by row. The data are gridded to a 722 x 722 subset of the 12.5 km Northern Hemisphere Equal Area Scalable Earth Grid (EASE-Grid) positioned over the Arctic. Each grid cell is a single, discrete age category; no ice concentration values are given. The browse images are in PNG (.png) format. Table 1 describes the values in the data files.

Table 1. Data File Values

Value	Description
0	Open water or < 15% sea ice concentration
5, 10, 15, ..., 80	Sea ice age [5: 1st year ice, 10: 2nd year ice, 15: 3rd year ice, ..., 80: 16th year ice] • Younger ice or open water may be present in a grid cell with older ice. First-year ice is ice that has yet to survive a melt period, while fifth-year ice is ice that has survived four melt cycles. • Past five years the values are not reliable and should just be considered old. • For more information, see the Derivation Techniques and Algorithms section.
254	Coastline
255	Land

There are no missing values over the mapped grid.

1.2 File and Directory Structure

Data are organized in two main subdirectories: `data` and `browse`. The `data` folder contains the binary data files and the `browse` folder contains the PNG browse images. To aid users, we also provide two flat binary files containing the latitude, Na12500-CF_latitude.dat and longitude, Na12500-CF_longitude.dat of each point in the grid. These were generated using MapX, and the format is: grid of signed decimal degrees, 4 byte floats by row.

1.3 File Naming Convention

1.3.1 Data Files

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

Example File Name:

`iceage.grid.week.2015.01.n.v3.bin`

`iceage.grid.week.yyyy.xx.n.v3.ext`

Refer to Table 2 for the valid values for the file name variables listed above.

Table 2. Data File Naming Convention

Variable	Description
`iceage`	Identifies this file as containing sea-ice-age data
`grid`	Identifies gridded data
`week`	Identifies weekly estimates of ice age for the Arctic Ocean
`yyyy`	4-digit year
`xx`	2-digit week of year
`n`	Northern Hemisphere
`v3`	Version 3 data
`.ext`	File extension: `.bin` refers to binary data files

1.3.2 Browse Files

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

Example File Name:

`iceage.week.2015.01.n.v3.png`

`iceage.week.yyyy.xx.n.v3.ext`

Refer to Table 3 for the valid values for the file name variables listed above.

Table 3. Browse File Naming Convention

Variable	Description
`iceage`	Identifies this file as containing sea-ice-age data
`week`	Identifies weekly estimates of ice age for the Arctic Ocean
`yyyy`	4-digit year
`xx`	2-digit week of year
`n`	Northern Hemisphere
`v3`	Version 3 data
`.ext`	File extension: `.png` refers to Portable Network Graphic files

1.4 Spatial Coverage and Resolution

This data set covers the Arctic Ocean at a 12.5 km resolution. The following coordinates provide the bounding box for the data:

- Southernmost Latitude: 48.4° N
- Northernmost Latitude: 90.0° N
- Westernmost Longitude: 180.0° W
- Easternmost Longitude: 180.0° E

1.4.1 Map Projection and Grid Description

Data are provided on the same projection as the 12.5 km Northern Hemisphere EASE-Grid, but on a different grid. The grid is described in a Grid Parameter Description (GPD) file: Na12500-CF.gpd.

EASE-Grid was designed as a versatile format for global-scale gridded data, specifically remotely sensed data. For a complete description, visit NSIDC's EASE-Grid Format Description page.

The original EASE-Grid projection locates the North Pole at the center of a grid cell. While this is convenient for locating the pole, it makes resizing the grid problematic. If you change the resolution of the grid, the new grids either (1) aren't properly nested within each other, or (2) don't have the North Pole at the center of a grid cell. Thus, for this data set, the grid being used is not a subset of EASE-grid, but a grid using the same map projection described in the Na12500-CF.gpd file. By using the Mapx Library and the Na12500-CF.gpd file, you can get all the right grid parameters. The data set is gridded using the same map projection, but a different grid. Also, to aid users, we provide two flat binary files containing the latitude (Na12500-CF_latitude.dat) and longitude (Na12500-CF_longitude.dat) of each point in the grid.

1.5 Temporal Coverage and Resolution

The temporal coverage is from January 1984 to February 2017 at a weekly resolution. Table 4 describes the temporal coverage and resolution of each sensor and instrument used.

Table 4. Temporal Coverage and Resolution

Sensor	Coverage	Resolution
AMSR-E	June 2002 - October 2011	Data are available every day for any given grid cell.
AVHRR	November 1978 - December 2004	Four satellite passes are used each day when available.
Buoys	November 1978 - to present data release	The 12:00 Greenwich Mean Time (GMT) buoy positions were used to compute 24-hour mean velocities.
NCEP/NCAR	November 1978 - to present data release	Data are available every day for any given grid cell.
SMMR	November 1978 - July 1987	Data are available every two days for any given grid cell.
SSM/I-SSMIS	July 1987 - to present data release	Data are available every day for any given grid cell.

1.6 Parameter Description

The parameter of this data set is sea ice age. In the data files, each grid cell is a single, discrete age category; no ice concentration values are given. Thus, the data are best described as extent maps that show where ice of different ages exists. Here, the word extent is defined as the sum of all the grid cells that contain ice of the specified age and not the actual areal coverage of the ice.

Because of the course spatial resolution of passive microwave data, the age estimates cover open ocean areas only where ice motion can be resolved in the microwave data. This results in some small ice-covered areas, such as passages in the Canadian Archipelago, to be omitted (Maslanik et al. 2011).

1.6.1 Sample Data Record

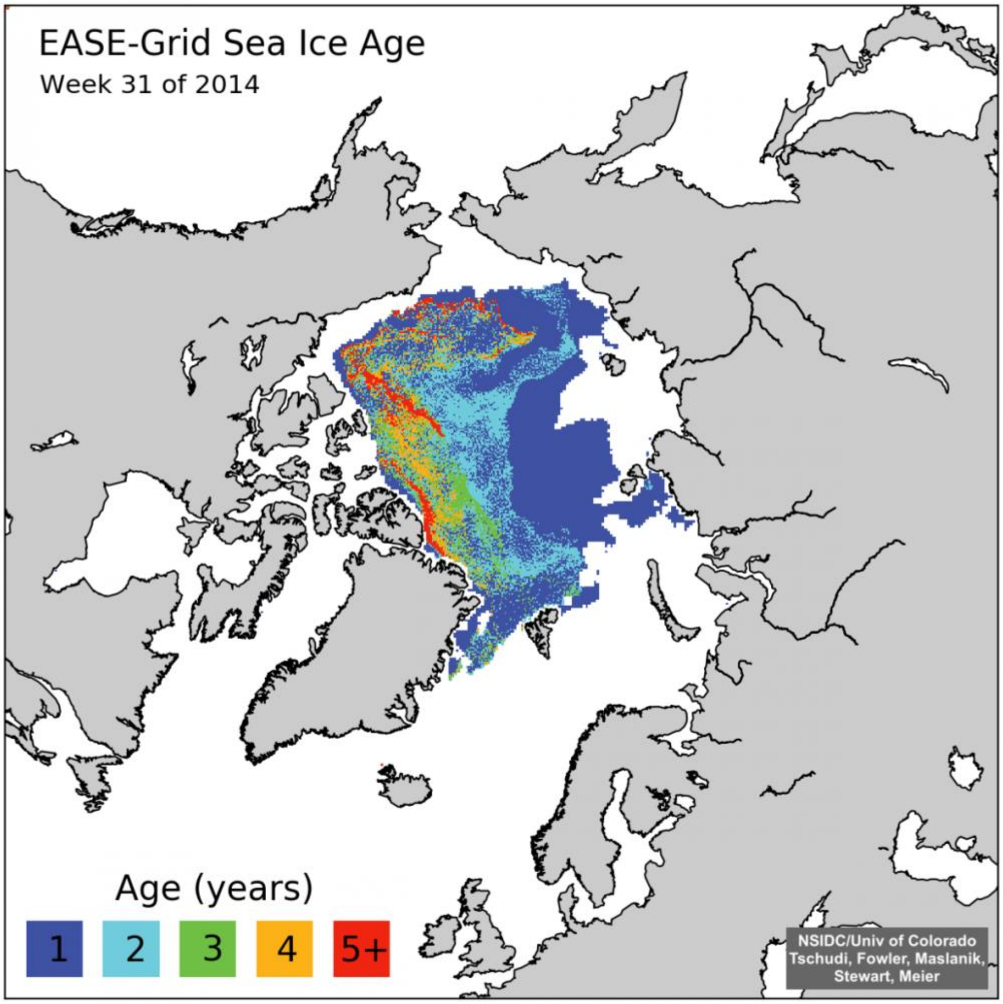

Figure 1. Browse Image of Ice Ages for week 31 in 2014

2 DATA ACQUISITION AND PROCESSING

2.1 Theory of Measurements

The method used here to estimate sea ice age is one that involves tracking the sea ice from year-to-year using gridded ice motion vectors; this is called Lagrangian tracking. Using 12.5 km x 12.5 km EASE-Grid vector fields for 1979 onward, ice age can be estimated by treating each grid cell that contains ice as a discrete, independent Lagrangian parcel and tracking the parcels at weekly time steps. The process can be viewed as a set of stacked planes overlying the grid used, with each plane corresponding to an age category. Parcels move around on their respective planes, independent of parcels of other age categories, which in turn lie in their own planes. Then, to produce maps of ice age, the set of parcels for each weekly time increment is rasterized by assigning parcels to the 12.5 km x 12.5 km grid cell within which each parcel's position lies. In cases where parcels of different ages fall within a single grid cell, the age of the grid cell is assigned to the oldest parcel. Physically, this is based on the assumption that younger ice will deform more easily, such that more of the area within the grid cell would be covered by the older ice type. For example, if two parcels, one that represents first-year ice and one that represents third-year ice, both fall within the domain of a single grid cell, then the age of that cell will be assigned as third-year ice. If the passive microwave-derived ice concentration at the corresponding grid cell remains at least 15 percent throughout the melt season, then that parcel is assumed to have survived the summer, and the parcel's age is incremented by one year. It is important to note that while grid cells with less than 15 percent concentration are treated as open water in terms of the age product generation, the cells could still contain some ice.

2.2 Data Acquisition Methods

The input ice motion vectors used to create this sea ice age data set are the weekly Polar Pathfinder Daily 25 km EASE-Grid Sea Ice Motion Vectors, Version 3. For details on how these ice motion vectors are created, see the Data Acquisition and Processing section of that data set’s User Guide.

2.3 Derivation Techniques and Algorithms

The sea ice age in this data set is estimated using input gridded ice motion vector fields. Each grid cell that contains ice at a concentration of greater than 15 percent, as derived by the NASA Team Algorithm (Cavalieri et al. 1984), is treated as a discrete, independent Lagrangian parcel and is transported at weekly time steps (Maslanik et al. 2011). In this approach, the actual age of the ice is followed for each ice parcel, and a parcel is categorized as first-year ice, second-year ice, and so forth based on how many summer melt seasons the ice parcel survives (Tschudi et al. 2010). If the grid cell remains at or above 15 percent throughout the melt season, then that parcel is assumed to have survived the summer, and the age of the parcel is incremented by one year. The 15 percent value was used here because it captures greater detail within the marginal ice zone and is the more conservative approach in terms of assessing net loss of areas where some multiyear ice is present, where multiyear ice is ice that is second-year ice or older. If a grid cell contains ice of different ages, the oldest ice determines the grid cell's ice age value (Maslanik et al. 2011).

The basic procedure for estimating sea ice age is by advecting ice with the weekly sea ice motion vectors. This is done by first dividing the Arctic region into a 12.5 km grid. Each grid cell, treated like an independent Lagrangian parcel, is advected at each time step using the weekly mean velocity fields. If the ice survives from the minimum sea ice extent, typically in September, of one year to the minimum extent of the next year, then it is aged one year. This process is continued for each year of the data record (Fowler et al. 2004).

2.3.1 Processing Steps

- Input ice motion data, Polar Pathfinder Daily 25 km EASE-Grid Sea Ice Motion Vectors, Version 3, are converted to 12.5 km x 12.5 km EASE-Grid.
- The daily ice motion vectors are averaged into weekly ice motion estimates on the 12.5km EASE grid.
- Ice is tracked in yearly increments, where a year is the melt season which runs from one season's minimum Arctic ice extent (usually in September) to the next year's minimum.
- Each year's ice is tracked from year to year as a Lagrangian tracer parcel that starts at the center of each grid cell and moves according to the weekly mean ice velocity.
- If a parcel remains at 15 percent or more for a melt season, then it is aged one year. If a parcel travels to a grid cell that has less than 15 percent ice concentration, the tracer parcel is assumed to have melted away.
- The age of a grid cell is the age of the oldest tracer parcel that exists in the grid cell.

2.3.2 Quality Assessment

A 15% ice concentration threshold was chosen since the intent is to be as conservative as possible regarding changes in areas where multiyear ice is present. For example, at the end of summer melt, a grid cell within the marginal ice zone might have a total passive microwave-derived concentration of 15 percent. Even though, upon freeze-up, 85 percent of the grid cell would consist of first-year ice, the age of that grid cell is assigned to the oldest ice that survived within that grid cell. Hence, the maps indicate the coverage of areas that contain at least some, 15 percent or more, multiyear ice but do not provide information on proportions of ice of different ages within individual grid cells.

In the past, sea-ice-cover studies have been based on passive microwave data computed from algorithms that employ multiple microwave frequencies to estimate total ice concentration and multiyear ice. Although these algorithms are good estimates of these parameters, they are hindered by secondary factors that change microwave emission in ways that adversely affect these estimates of ice concentration and type. The ice age data in this data set are calculated using an alternative technique of estimating ice age where ice ages are determined primarily based on transport calculated from ice velocities and are not affected by the types of error sources that are present in passive microwave ice concentration estimates. In instances where ice concentration is used, a conservative threshold is chosen to delineate ice extent. Thus, this technique is fundamentally independent of the factors affecting studies that rely on passive microwave estimates of ice concentration or ice age (Fowler et al. 2004).

2.3.3 Error Sources and Limitations

When age classes are aggregated into first-year and multiyear ice categories, the information is comparable to the passive and active microwave satellite-derived time series of first-year and multiyear ice analyzed by previous studies. Overall, this remote sensing-based age product is similar in nature and information content to the buoy-derived age fields produced by Rigor and Wallace (2004), but with greater spatial detail. The age estimates are restricted to open ocean areas only, where ice motion can be resolved in the microwave data. Note that this excludes the passages in the Canadian Archipelago. The cited values for ice coverage are therefore less than the actual amount of ice present in the Arctic.

Errors in the method of estimating sea ice age are dependent on the following ice motion errors:

- Resolution of the satellite sensor
- Geolocation and binning errors of each image pixel
- Atmospheric effects and temporal variability of the surface, especially during the summer months

The sea ice age shown in this dataset is the *oldest* age within each grid cell, and does not necessarily indicate that all ice in that cell is of that age. Ice may also be present in grid cells that are designated as open water if the concentration is less than 15 percent.

2.3.4 Version History

Table 5. Version History

Version	Date	Description
V3	April 2016	The input ice motion data used for this data set is now derived from NSIDC-0116 Version 3 data.
V2	December 2014	Initial release of these data as an NSDIC data set.

2.4 Sensor or Instrument Description

Refer to the following for information on each sensor:

- AMSR-E Instrument Description
- International Arctic Buoy Program Air Droppable RAMS (ADRAMS) Buoy
- NCEP/NCAR Reanalysis Data
- SMMR, SSM/I, and SSMIS Sensors Summary

3 REFERENCES AND RELATED PUBLICATIONS

Cavalieri, D. J., P. Gloersen, and W. J. Campbell. 1984. Determination of Sea Ice Parameters with the NIMBUS-7 SMMR. *Journal of Geophysical Research*, 89(D4): 5355-5369. http://dx.doi.org/10.1029/JD089iD04p05355

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3.1 Related Data Collections

- Polar Pathfinder Daily 25 km EASE-Grid Sea Ice Motion Vectors, Version 3
- MEaSUREs Arctic Sea Ice Characterization 25 km EASE-Grid 2.0

4 CONTACTS AND ACKNOWLEDGMENTS

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5 DOCUMENT INFORMATION

5.1 Publication Date

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5.2 Date Last Updated

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