MASAM2: Daily 4 km Arctic Sea Ice Concentration, Version 2

USER GUIDE

How to Cite These Data

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

Fetterer, F., J. S. Stewart, and W. N. Meier. 2023. *MASAM2: Daily 4 km Arctic Sea Ice Concentration, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/bqd9-vm28. [Date Accessed].

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

1.1 Summary

The MASIE-AMSR2 (MASAM2) daily 4 km sea ice concentration product is a blend of two other daily sea ice data products: ice coverage from the Multisensor Analyzed Sea Ice Extent (MASIE) product at a 4 km grid cell size and ice concentration from the Advanced Microwave Scanning Radiometer 2 (AMSR2) at a 10 km grid cell size. MASAM2 Version 2 has sea ice concentration values from 40 percent to 100 percent. Where MASIE detects ice, concentration values are determined by AMSR2 algorithm output except in cases where (1) the AMSR2 value is < 40%, or (2) where AMSR2 does not detect ice. In these cases, the MASAM2 ice concentration value is set to 40%. The data are provided in monthly NetCDF files that hold daily sea ice concentration fields. Two daily PNG format browse images are also provided. One shows a quick-view map of the MASAM2 sea ice concentration, and the other is an ice-source map indicating which data show the presence of ice: AMSR2, MASIE, both, or neither. Coverage begins in July 2012 and extends to present.

MASAM2 was developed to meet a need for greater accuracy and higher resolution in ice concentration fields that are used to initialize an operational sea ice forecast model. The MASAM2 algorithm uses simple rules that are based on the understanding that MASIE is more accurate than other daily products at showing where ice is present (Meier et al., 2015). If MASIE shows ice at a location, we believe ice exists at that location because U.S. National Ice Center (USNIC) analysts labeled it as ice when creating the IMS product, which MASIE uses as its input data source. However, sea ice prediction model initialization fields need an ice concentration value for every location in which ice is present. AMSR2 currently gives the best available daily arctic-wide sea ice concentration product. A blend of AMSR2 and MASIE yields a high-resolution ice concentration product for model initialization that improves short-term, on the order of days to weeks, forecast capability (Posey et al., 2015)

1.2 Parameters

The parameter in this data set is sea ice concentration. Because these data were created with particular model requirements in mind, their values are zero percent sea ice concentration (open water) and values ranging from 40 percent to 100 percent, inclusive. The values 1 to 39 are not used.

1.3 File Information

1.3.1   Format and File Contents

The daily MASAM2 data are on a 4 km grid provided in NetCDF format (.nc) CF 1.10 compliant files. The daily data have been bundled into monthly NetCDF files, so each .nc file contains 28 to 31 days of data depending on the month. The current month's NetCDF file is updated on a daily basis whereby the latest day of data is appended to the file until the month is complete. Browse images in PNG format are provided for quickly previewing each day's concentration data (Figure 1). In addition, corresponding source browse images show where only MASIE found ice, where only AMSR2 found ice, and where both found ice (Figure 2). Table 1 lists all the variables in the NetCDF files and their values.

Table 1. NetCDF Variable Description

Variable	Description
crs	Coordinate reference system description for the data.
latitude	Latitude in degrees north. Dimensions: [2550, 2100].
longitude	Longitude in degrees east. Dimensions: [2550, 2100].
sea_ice_concentration	Sea ice concentration in percent. Dimensions: [days in month, 2550, 2100]. <table><tr><th>Value</th><th>Description</th></tr><tr><td>0 and 40-100</td><td>Sea ice concentration in percent</td></tr><tr><td>104</td><td>Ocean out of AMSR2 bounds</td></tr><tr><td>110</td><td>Indeterminate or missing</td></tr><tr><td>119</td><td>Land out of AMSR2 bounds</td></tr><tr><td>120</td><td>Land</td></tr></table>
time	Days since 1970-01-01. Dimension ranges from [28] to [31] depending on the month.
x	Projection x coordinate. Dimension: [2100]
y	Projection y coordinate. Dimension: [2550]
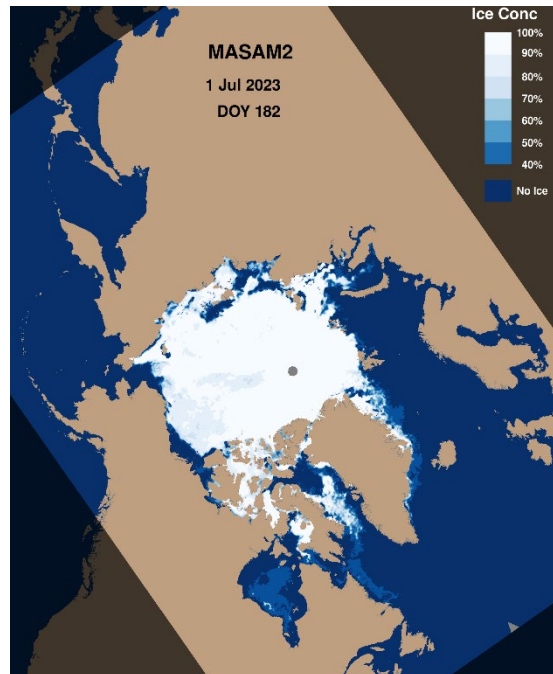
Figure 1. The ice concentration browse image for 01 July 2023
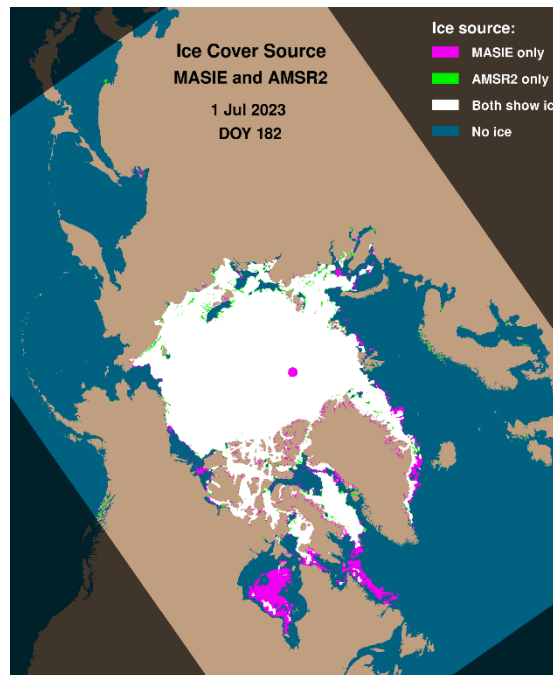
(masam2_minconc40_20230701_v2.png)

Figure 2. The source browse image for 01 July 2023 (masam2_minconc40_source_20230701_v2.png).

Areas that are green, where only AMSR2 detects ice, have a corresponding concentration

of 0% (open ocean) in the MASAM2 data file. Areas that are pink, where only MASIE detects ice,

have a corresponding concentration of 40% in the MASAM2 data.

1.3.2   Directory Structure

Data are available at https://noaadata.apps.nsidc.org/NOAA/G10005_V2/. Within this directory, there are three sub-directories: Data, BrowseData, and BrowseSource. The Data directory contains the NetCDF data files; the BrowseData directory contains the PNG browse images, and the BrowseSource directory contains the PNG images describing the source of the data. The data are subdivided into directories by year within each of these sub-directories.

1.3.3   File Naming Convention

The files are named according to the following convention and as described in Table 2.

Generic File Name: masam2_minconc40_[source]_YYYYMM[DD]_v2.png

Example File Names:
NetCDF data file – masam2_minconc40_202301_v2.nc
Data browse image – masam2_minconc40_20230101_v2.png
Source browse image – masam2_minconc40_source_20230101_v2.png

Where:

Table 2. Data File Naming Convention Description

Variable	Description
masam2	Identifies this as containing MASAM2 sea ice concentrations
minconc40	Identifies that the minimum sea ice concentration is 40%
[source]	If this is in the file name, then this file is a source browse image file
YYYY	4-digit year
MM	2-digit month of year
[DD]	2-digit day of month (not applicable to the NetCDF data files)
v2	Indicates this is version 2
.ext	File extension (.nc: NetCDF file, .png: PNG image file)

1.4 Spatial Information

1.4.1 Coverage and Resolution

The MASAM2 data cover the Northern Hemisphere at a 4 km spatial resolution with the following bounding coordinates:

Southernmost latitude: 29.08° N
Northernmost latitude: 90° N
Westernmost longitude: 180° W
Easternmost longitude: 180° E

1.4.2 Projection and Grid Description

The MASAM2 grid is a 2100 x 2550 subsection of the full 6144 x 6144 polar stereographic MASIE grid. This was selected as the most relevant area for operational ice forecasts. The subregion begins at grid cell (2000,1688) of the MASIE grid. For more information on the MASIE grid, see the Multisensor Analyzed Sea Ice Extent - Northern Hemisphere (MASIE-NH) documentation.

Table 3 and Table 4 provide information for geolocating this data set.

Table 3.Geolocation Details

Geographic coordinate system	WGS84
Projected coordinate system	Polar stereographic north
Longitude of true origin	80° W
Latitude of true origin	60° N
Datum	WGS84
Ellipsoid/spheroid	WGS84
Units	m
False easting	0
False northing	0
PROJ4 string	+proj=stere +lat_0=90 +lat_ts=60 +lon_0=-80 +x_0=0+y_0=0 +datum=WGS84 +units=m +no_defs=True

Table 4. Grid Details

Grid cell size (X x Y pixel dimensions)	4 km x 4 km
Grid size (rows x columns)	2550 x 2100
Geolocated lower left point in grid	33.96° N, 122.59° W
Nominal gridded resolution	4 km
ulxmap – x-axis map coordinate of the center of the upper-left pixel	-4288000
ulymap – y-axis map coordinate of the center of the upper-left pixel	5536000

1.5 Temporal Information

The data span 03 July 2012 to the present at a daily resolution. Note that the current month's NetCDF file is updated on a daily basis whereby the latest day of data is appended to the file until the month is complete. Table 5 provides a list of the missing dates for MASAM2 data as of August 2023. We do not check for missing data as part of the processing for MASAM2, so this list may not be complete.

Table 5. Dates Missing from MASAM2 because Either
MASIE or AMSR2 are Missing (YYYY-MM-DD)

Missing AMSR2 Data	Missing MASIE Data
2013-05-11	2012-09-06
2013-05-12	2012-09-08
2013-05-13	2014-08-29
2018-11-17	2014-10-17
2018-11-18	2014-10-20
	2014-10-21
	2015-04-18
	2017-11-03
	2017-11-04

2   DATA ACQUISITION AND PROCESSING

2.1 Background

MASAM2 takes advantage of the best features of both the MASIE and AMSR2 products. MASIE is more likely to be accurate in showing where ice is present, but the AMSR2 sea ice concentration product gives concentration information not available from MASIE alone. While AMSR2 passive microwave sea ice concentrations are derived using an algorithm, MASIE is derived from a product that is drawn each day by ice analysts. The USNIC ice analysts classify each 4 km grid cell as either ice-covered or not ice-covered, using synthetic aperture radar, IR, visible band, and in situ data. Passive microwave data are not generally used by USNIC analysts unless no other source is available.

If MASIE indicates ice, the corresponding MASAM2 grid cell is set to the AMSR2 sea ice concentration if that concentration value is greater than 40 percent, else it is set to 40 percent. Other rules for setting the MASAM2 concentration values are described in the Processing section of this document.

The following considerations were taken into account when formulating these rules:

1. The AMSR2 sea ice concentration product from JAXA has a different spatial resolution and therefore a different land mask than MASIE.
2. The MASIE land mask is more precise than the AMSR2 land mask, therefore:
    *   If AMSR2 indicates ocean but MASIE indicates land, MASIE is trusted; and MASAM2 is set to land for that grid cell.
    *   If AMSR2 indicates land but MASIE indicates ocean, neither is trusted; and MASAM2 is set to indeterminate for that grid cell.
3. The MASIE extent field is considered to be a more accurate map of where ice is present than the ice extent from AMSR2, therefore:
    *   If MASIE indicates no ice, MASIE is trusted and the corresponding MASAM2 grid cell is set to zero percent sea ice concentration.
    *   If MASIE indicates ice, the corresponding MASAM2 grid cell is set to the bilinearly interpolated AMSR2 sea ice concentration if that concentration value is greater than 40 percent, else it is set to 40 percent sea ice concentration.

2.2 Acquisition

The MASAM2 product has two input data sources: MASIE 4 km sea ice extent data from NSIDC and AMSR2 10 km sea ice concentrations from the Japan Aerospace Exploration Agency (JAXA).

MASIE uses the USNIC 4 km IMS Daily Northern Hemisphere Snow and Ice Analysis as its input data source. It reformats the IMS sea ice field as described in the Multisensor Analyzed Sea Ice Extent - Northern Hemisphere (MASIE-NH) User Guide.

AMSR2 is on board JAXA's Global Change Observation Mission - Water (GCOM-W) satellite. It is a passive microwave instrument that provides, among other products, sea ice concentration at a 10 km resolution. For more information about AMSR2, see JAXA's About AMSR2 web page.

AMSR2 Level 3 gridded 10 km passive microwave sea ice concentration fields are downloaded from JAXA via the GCOM-W1 Data Providing service. See the JAXA Web site for details on these data and JAXA's AMSR Data Catalog: Cryosphere documentation for more information on the versions.

2.3 Processing

Daily files are created for each day for which both AMSR2 and MASIE data are available. The lower-resolution AMSR2 data are bilinearly interpolated to the 4 km MASIE grid subregion. The sea ice concentration values at each 4 km grid cell are assigned using simple empirically derived rules. See Table 1 for a list of possible values for the grid cells in the NetCDF files.

The steps for creating the MASAM2 product are as follows:

1. Read in a day's MASIE data file and take a subset of the 6144 x 6144 MASIE grid from grid cell (2000,1688) to create a 2100 x 2550 subsection of the full MASIE array.
2. Read in AMSR2 sea ice concentration data and bilinearly interpolate it to the MASIE grid.
3. Look at MASIE subset and AMSR2 data to decide the concentration value for MASAM2
   a. If MASIE grid cell is land and AMSR2 is ocean, MASAM2 is set to land (119) for that grid cell.
   b. If MASIE grid cell is ocean and AMSR2 land, MASAM2 is set to indeterminate (110) for that grid cell.
   c. If MASIE grid cell indicates no ice, the corresponding AMSR2 value is ignored and the MASAM2 grid cell is set to zero percent sea ice concentration.
   d. If MASIE grid cell indicates ice and the AMSR2 concentration value is greater than or equal to 40 percent, MASAM2 is set to the AMSR2 sea ice concentration value for that grid cell.
   e. If MASIE grid cell indicates ice but AMSR2 concentration value is less than 40 percent, the MASAM2 sea ice concentration is set to 40 percent for that cell.
4. Repeat for all days in this month for which both MASIE and AMSR2 data are available.
5. Save daily data to monthly NetCDF files.
6. Repeat for each month of available data.

A PNG browse image of the MASAM2 sea ice concentrations fields is also created with the NetCDF files. A PNG image comparing the AMSR2 and MASIE ice extent fields is also generated showing which source was used. This indicates where AMSR2 sea ice concentration estimates have either been set to zero percent in the MASAM2 product or to a minimum of 40 percent sea ice concentration.

2.4 Quality, Errors, and Limitations

This blended product is a more accurate map of where ice truly is compared to AMSR2 alone. See Appendix A – MASAM2 Compared with Passive Microwave-Only Sea Ice Concentration for one example. AMSR2 can underestimate ice concentration during melt conditions and can show ice where none exists by misinterpreting weather effects on the open ocean. The MASIE product does not have these systematic errors. MASIE can, however, be inaccurate. If the USNIC analysts do not have what they judge to be a sufficient amount of information with which to update an analysis for a region or regions, they may not change the ice extent in the IMS product upon which MASIE is based. Later data may show that the area was ice free when MASIE showed it as ice covered, for example. The products are not corrected for earlier errors. We do not know how frequently this type of error happens.

For further discussion of sources of error or uncertainty in passive microwave sea ice concentration, see the discussion on this subject in the Sea Ice Index User Guide and the references therein. For a discussion of sources of error or uncertainty in the MASIE product, see that product's User Guide section on Error Sources. For the IMS product, see the IMS User Guide sections on Derivation Techniques and Algorithms and Quality Assessment.

3   SOFTWARE AND TOOLS

For information on the NetCDF data format, see NSIDC's What is NetCDF? web page.

4   VERSION HISTORY

MASAM2 was developed in order to provide improved daily initialization fields for short-term ice prediction models. It was designed in partnership with an Oceanography Division modeling group at the U.S. Naval Research Laboratory (NRL) and is a contribution to the Sea Ice Prediction Network (SIPN). The Naval Oceanographic Office adopted the method for operational use in February 2015. Please send feedback on this product to NSIDC.

Table 6 provides a summary of the version history of this product. The text below provides detailed information.

In Version 1, a minimum of 70 percent concentration was used. This was based on the needs of the NRL modeling group and the experience of the authors of the MASAM2 data product, in consultation with USNIC scientists and ice analysts. However, using an ice concentration "floor" of 70 percent resulted in large continuous areas of ice at 70 percent with no spatial variability, especially near the ice edge where concentrations are frequently less than 70 percent.

In Version 2, this was changed to a minimum of 40 percent concentration. This was chosen because when USNIC analysts make the IMS product, analysts label a 4 km cell as *ice* if it is visually judged to have more than 40 percent ice concentration. With this lower concentration floor, the ice concentration fields show more realistic spatial variability. Still, it's important to remember that the concentration values for 4 km cells are determined by bilinear interpolation of the value of overlying 10 km AMSR2 cells, and not by a true 4 km ice concentration field.

In both Version 1 and Version 2 data, the floor value is essentially a flag meaning "ice concentration unknown (but it is greater than 70 or 40 percent, respectively)". In Version 1, the 70 percent floor was somewhat arbitrary. In Version 2, the 40 percent floor matches the minimum 40 percent concentration used to designate that a grid cell is ice-covered in the MASIE source data.

Figure 3 illustrates the V1 concentration field on a day in September, 2022. There is a large swath of unvarying 70 percent concentration along the ice edge. Figure 4 shows V2 for the same day. While there is a wide band of 40 percent concentration ice, there are also areas with ice concentration between 40 percent and 70 percent.

Table 6. MASAM2 Version History

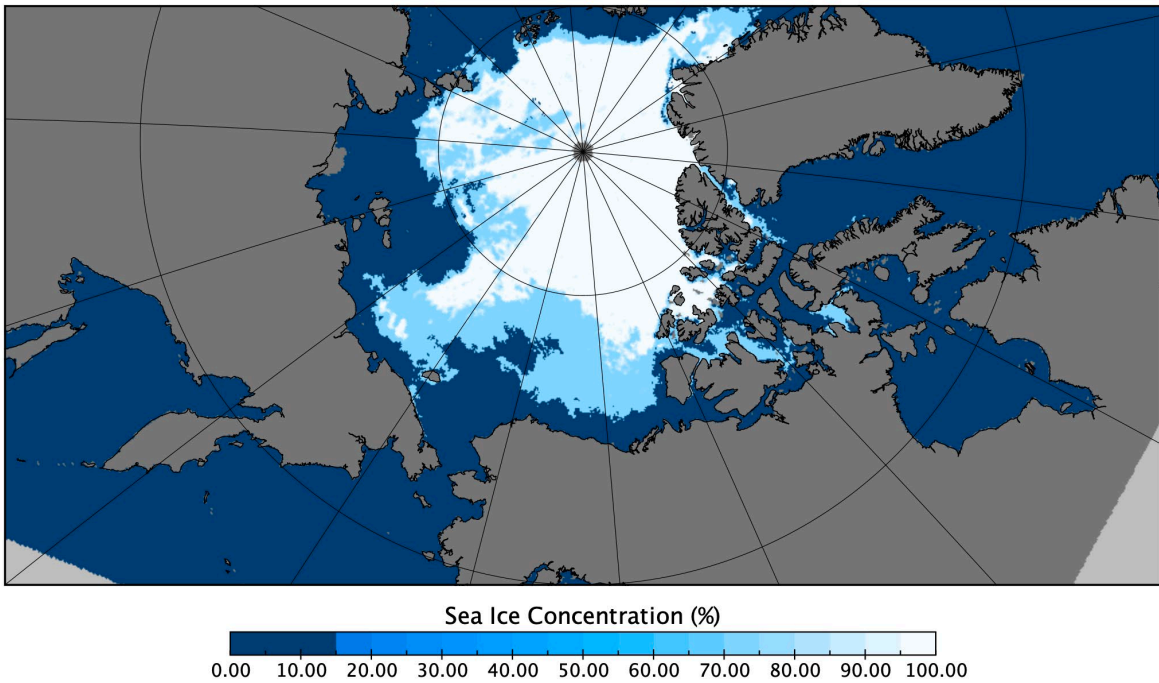| Version	Date	Description
2.0	August 2023	Release of version 2 product that changed the minimum concentration from 70% to 40%. Also updated the NetCDF files to be CF 1.10 compliant.
1.0	October 2015	Addition of a near-real-time product.
1.0	March 2015	Initial release of the MASAM2 prototype for 03 July 2012 to 12 November 2014.

Figure 3. Version 1 sea ice concentration on 01 Sep 2022, plotted using the NASA Panoply application. The lowest non-zero sea ice concentration value is 70%.
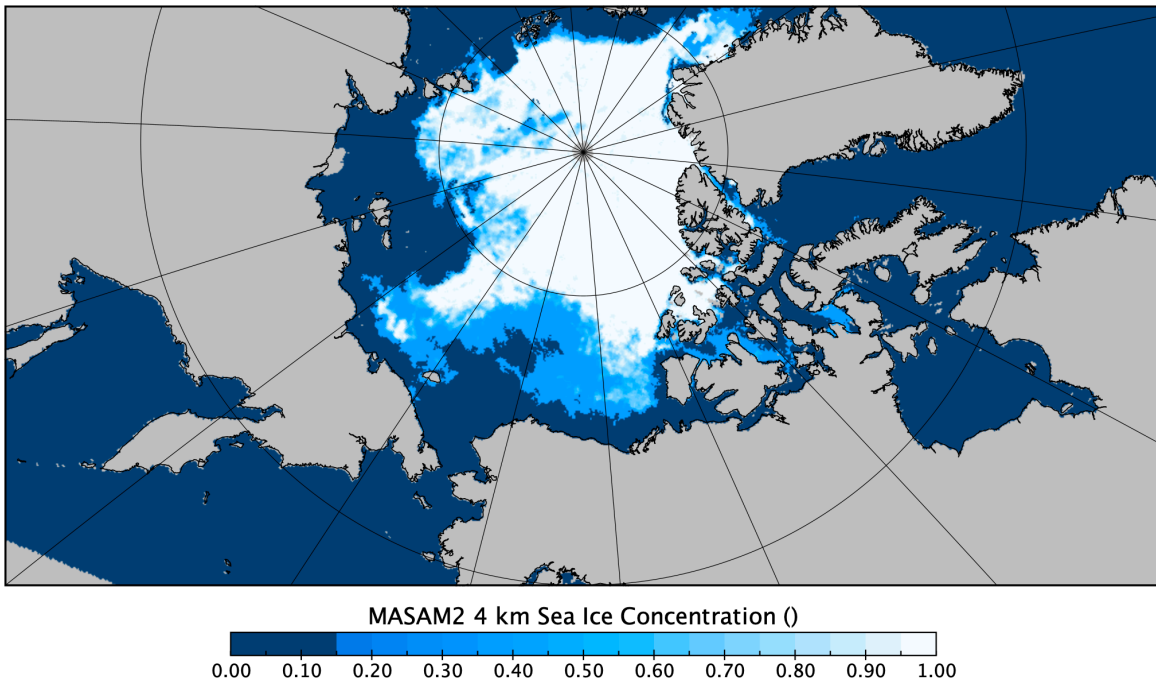

Figure 4. Version 2 sea ice concentration on 01 Sep 2022, plotted using the NASA Panoply application. The lowest non-zero sea ice concentration value is 40%.

5   RELATED DATA SETS

U.S. National Ice Center, F. Fetterer, M. Savoie, S. Helfrich, and P. Clemente-Colón. 2010. Multisensor Analyzed Sea Ice Extent - Northern Hemisphere (MASIE-NH), Version 1. Boulder, Colorado USA: National Snow and Ice Data Center. https://doi.org/10.7265/N5GT5K3K.

U.S. National Ice Center. (2008). IMS Daily Northern Hemisphere Snow and Ice Analysis at 1 km, 4 km, and 24 km Resolutions, Version 1. Boulder, Colorado USA. National Snow and Ice Data Center. https://doi.org/10.7265/N52R3PMC.

6   RELATED WEBSITES

- U.S. National Ice Center (NIC)
- U.S. Naval Research Laboratory
- Japan Aerospace Exploration Agency (JAXA) data repository

7   ACKNOWLEDGMENTS

8   REFERENCES

Japan Aerospace Exploration Agency. 2012. AMSR2 Level 3 10 km Sea Ice Concentration. Tokyo, Japan: JAXA.

Japan Aerospace Exploration Agency. 2012. Global Change Observation Mission Water (GCOM - W1): AMSR2 Higher Level Product Format Specification. Tokyo, Japan: JAXA.

Meier, W. N., F. Fetterer, J. Scott Stewart, and S. Helfrich. 2015. How do sea-ice concentrations from operational data compare with passive microwave estimates? Implications for improved model evaluations and forecasting. Annals of Glaciology 56(69): 332-340. doi:3189/2015AoG69A694.

Posey P. G., E. J. Metzger, A. J. Wallcraft, D. A. Hebert, R. A. Allard, O. M. Smedstad, M. W. Phelps, F. Fetterer, J. S. Stewart, W. N. Meier, and S. R. Helfrich. 2015. Improving Arctic sea ice edge forecasts by assimilating high horizontal resolution sea ice concentration data into the US Navy's ice forecast systems. Cryosphere 9: 1735-1745. doi:10.5194/tc-9-1735-2015.

9   DOCUMENT INFORMATION

9.1 Author

A. Windnagel and F. Fetterer created this document.

9.2 Publication Date

March 2015

9.3 Revision History

August 2023: A. Windnagel and F. Fetterer updated the documentation describing the version 2 release.

APPENDIX A – MASAM2 COMPARED WITH PASSIVE MICROWAVE-ONLY SEA ICE CONCENTRATION

The images below illustrate how the MASAM2 sea ice concentration product often differs from traditional passive microwave sea ice concentration products. MASAM2 shows 40 percent ice concentration in the southern part of Hudson Bay, in the middle of Baffin Bay, and off east Greenland where one might assume ice is present at lower concentrations. The example illustrates a positive aspect of MASAM2 in that ice is more likely to be represented where it is present; but the concentration of that ice may not be accurately represented. The only information we have about ice shown by MASIE and not by AMSR2 is that it is likely at least 40 percent concentration.
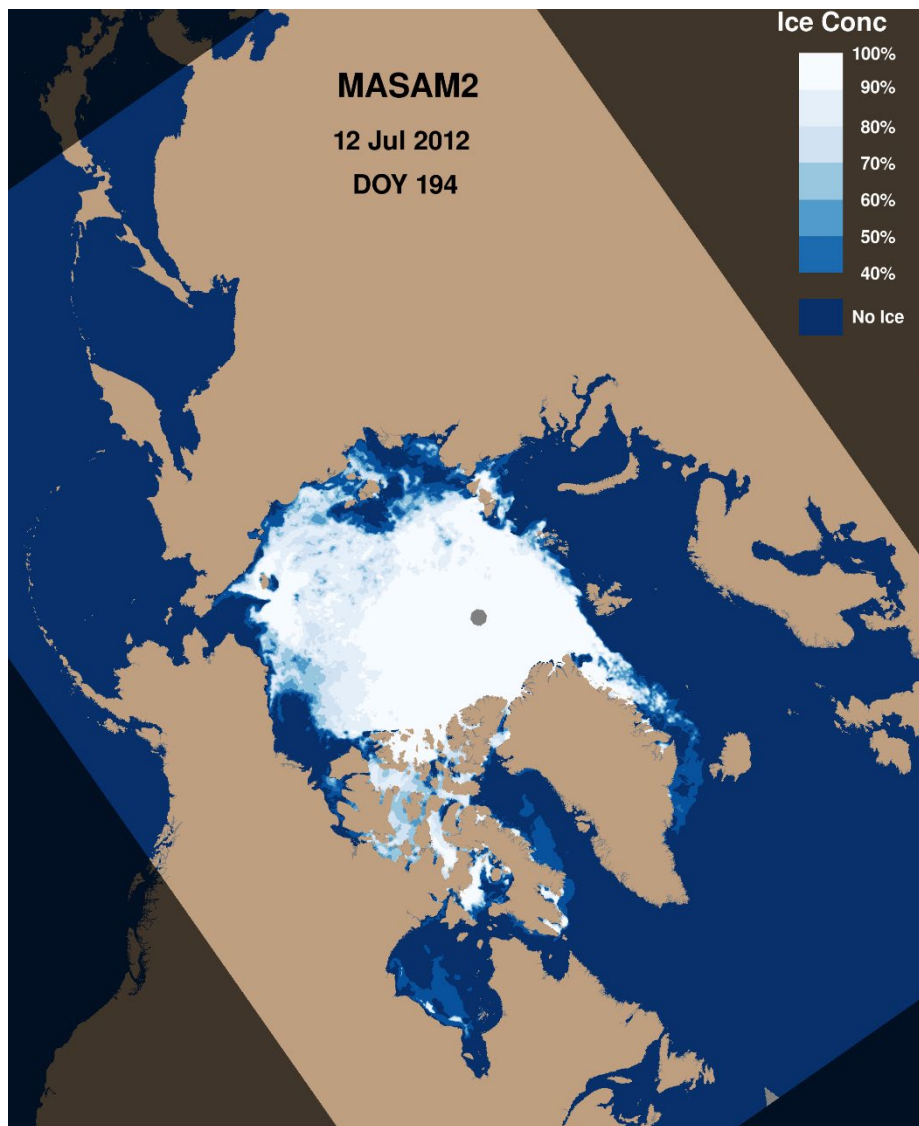

Figure A - 1. Browse image of Version 2 MASAM2 sea ice concentration for 12 July 2012.
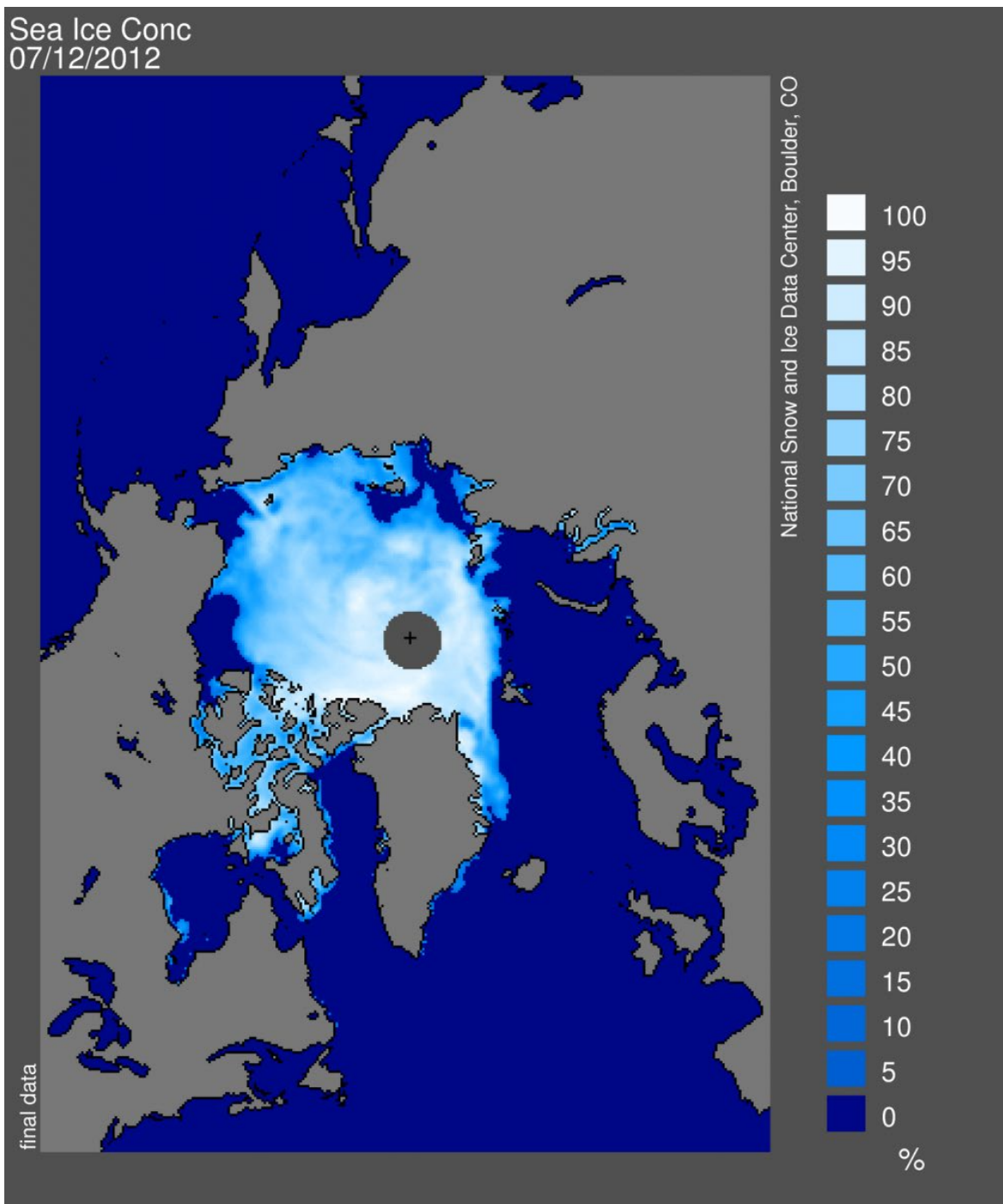
Figure A - 2. Browse image of sea ice concentration from the Sea Ice Index for 12 July 2012 which uses the SSMIS sensor on DMSP-17.
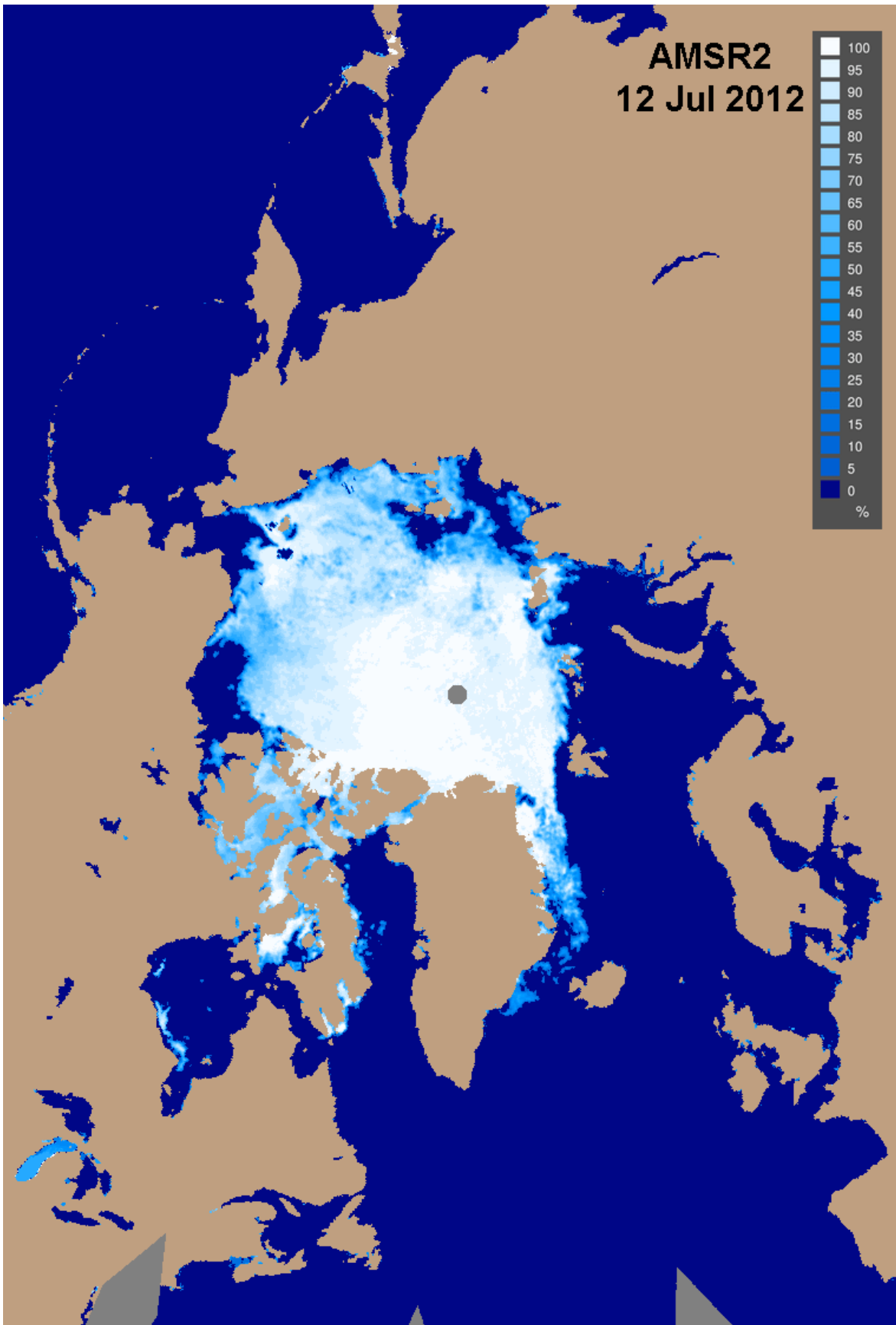
Figure A - 3. Browse image of AMSR-2 sea ice concentration for 12 July 2012