U.S. National Ice Center Arctic and Antarctic Sea Ice Charts in SIGRID-3 Format, Version 1

USER GUIDE

How to Cite These Data

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

U.S. National Ice Center. 2022. *U.S. National Ice Center Arctic and Antarctic Sea Ice Charts in SIGRID-3 Format, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/4b7s-rn93. [Date Accessed].

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National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Summary

The U.S. National Ice Center (USNIC) produces analyst-drawn Arctic- and Antarctic-wide sea ice charts that have information on sea ice concentration, stage of development, and form, where these parameters are defined by the World Meteorological Organization (WMO, 2014). For most of the record, charts are weekly in frequency. These charts are in a WMO-defined vector format called SIGRID-3 (WMO, 2010). Note: USNIC ceased producing Antarctic charts regularly in June 2023.

These USNIC SIGRID-3 files are used as input for the U.S. National Ice Center Arctic and Antarctic Sea Ice Concentration and Climatologies in Gridded Format data set. Most researchers will find that the later data set, with shapefile as well as NetCDF-format files, will meet their needs for ice concentration fields that have the detail and accuracy of operational charts and will be easier to work with than the SIGRID-3 files of this data set. However, the SIGRID-3 format charts may allow analyses that are not possible with the derived data set.

1.2 Parameters

The parameters include total sea ice concentration, partial concentration, stage of development, and ice form as defined by the World Meteorological Organization (WMO, 2014).

1.3 File Information

1.3.1 Format

These data are available in a WMO-defined format, called SIGRID-3 (WMO, 2010). The SIGRID-3 format includes several files; a shape file (.shp), with associated files (.dbf,.prj, .shx), and a metadata file (.xml, .shp.xml, and .txt). Each set of files is combined into a zip file (.zip) for distribution. Note that for some years (2006 through 2020 for the north and 2004 through 2020 for the south) there are extra metadata files with the .xml or .txt file extension.

SIGRID-3 is a newer version of SIGRID that was developed so that vector files could be encoded using SIGRID codes and archived (WMO, 2010). SIGRID-3 is an open standard, meaning that SIGRID-3 shapefiles are independent of the geographical information system used to create them. For further details on SIGRID-3 see Section 2.1.

1.3.2 File Contents

The shapefiles contain USNIC ice charts that have been encoded using the SIGRID-3 format. Each polygon in the shapefile represents an area of sea ice that is defined by a set of attributes: total concentration, partial concentration, stage of development, and ice form. An example SIGRID-3 shapefile for the Arctic, as viewed in QGIS, is shown in Figure 1.

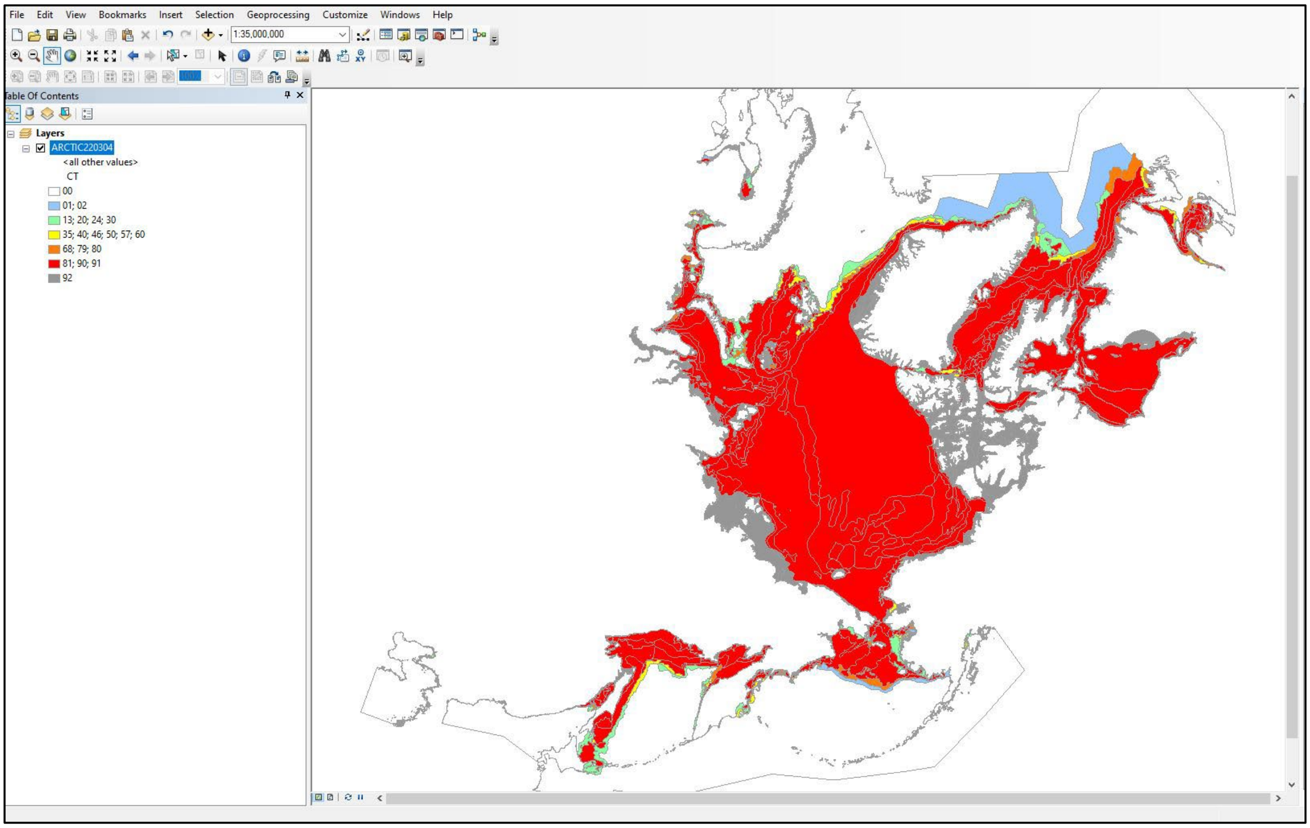

Figure 1. The ARCTIC22020304.shp file as viewed in ArcGIS, where the colors refer to the range of concentrations given by the indicated CT attributes. These colors that indicate concentration ranges are WMO recommended colors for operational ice charts (W. Clark, USNIC, April 2022). For details on what each of the CT values represent see Table A - 2.

The attribute table contains a row for each polygon. Note that the fields in the attribute table do vary slightly throughout the time series, see section 1.3.4 for more details, but the main fields will be described here. The first field (ICECODE) holds the summary SIGRID code for the polygon. The following fields hold ice characteristics encapsulated in the summary SIGRID ICECODE (Figure 2). The SIGRID-3 format requires the use of a specific and ordered set of 16 characteristics. In the attribute table, there is a field for each one of these characteristics; and they are denoted by a code. Total concentration (CT) is followed by partial concentrations of the first, second, and third thickest ice (CA, CB, and CC) along with their respective stages of development (SA, SB, and SC) and form (FA, FB, FC, FP, and FS). The form variable CF is also used in charts between January 2003 and January 2006, see section 1.3.4 for more details. There are two additional stages of development fields, SO and SD. According to the Manual of Standard Procedures for Observing and Reporting Ice Conditions (MANICE, Environment Canada, 2005), SO is a further class that may be reported as a stage of ice development that is thicker than SA but has a concentration less than 1/10. The field SD is the fourth stage present after SA, SB, and SC, and it refers to the stage of development of the thickest remaining ice types (if more than one type remains). According to WMO (2010) SD refers to the orientation (direction) of sastrugi and SO refers to the Source of Information. USNIC follows the MANICE definition for these codes. (W. Clark, USNIC, April 2022). Lastly, the Shape_Leng and Shape_Area fields contain the perimeter and area of each of the polygons and are in the same units as those used for the projection. For a full description of the codes please see Table A - 1, Table A - 2, Table A - 3, Table A - 4, and Table A - 5 in Appendix A – SIGRID-3 FIELDS CODES.

Please note that while each of these variables must be present, they can hold the SIGRID code 99 which means Undetermined/Unknown. The USNIC uses the form variable FA to denote fast ice with FB and FC being filled with 99. USNIC does not report other forms of ice in SIGRID-3. In the absence of fast ice, all three form variables are filled with the code 99.

USNIC has sometimes used -9 to mean Undetermined/Unknown, in place of 99. Values of 99 and -9 appear throughout the time series. Values of 99 seems to be more common in earlier charts. In some cases, both 99 and -9 appear (e.g. ARCTIC20201224.shp).

1.3.3 How the Antarctic Charts differ from the Arctic Charts

USNIC analysts charting ice around Antarctica use the SIGRID codes for stage of development differently than in the Arctic. In much of Antarctica, the SIGRID code for the stage of development of the thickest, oldest sea ice, SA, is the reserved as a placeholder to mark the presence of icebergs. The stage of development of the thickest, oldest sea ice is given in the SIGRID code SB. When this is the case, the SIGRID-3 file will have the following encoding (WMO, 2010):

- CT = 02: total concentration is that of *bergy water*
- CA = -9: concentration of first thickest ice is *missing*
- SA = 98: stage of development of oldest ice is *glacier ice*
- FA = 10: form of oldest ice is *iceberg*

Another difference is that the USNIC analysts do not differentiate between medium and thick first-year ice in Antarctic charts.

From the beginning of the record through September 2007, most of the Antarctic charts were encoded with SIGRID ice codes that specified a range for the total concentration but did not have an interpretable breakdown of that percentage into partial ice concentrations.

1.3.4 How the Attribute Tables Vary Throughout the Time Series

The attribute table varies slightly throughout the time series for both hemispheres. As of March, 2022, here are some differences that we noted:

- 2003 to 2005 – Perimeter and Area are used instead of Shape_Leng and Shape_Area, respectively. There is no ICECODE included and unknown/missing fields are filled with NULL.
- 2003 to January 2006 – USNIC used form variable CF, filled with 0899, to identify some polygons as fast ice in the SIGRID-3 chart files. See WMO (2010) for a discussion of the use of CF.
- February 2006 onwards – the form variable FP is used to identify the predominant form of ice.
- 2006 – Perimeter and Area fields are still used. There are three additional fields for the Arctic shapefiles (ARCTIC0612, ARCTIC06_1, and ICECODE) and for the Antarctic shapefiles (ANTARC0612, ANTARC06_1 and ICECODE). Unknown/missing fields are filled with NULL. We are unable to determine the meaning of the extra fields.
- 2007 – There are no AREA or PERIMETER fields, but there is an ICECODE field.
- 2008 onwards – The Shape_Leng and Shape_Area fields are present, and the format looks the same as in Figure 2 for the Arctic. For the Antarctic, the same fields are present, however, the ICECODE field is not the first column, it is the fourth to last column.

ARCTIC201224 — Features Total: 2028, Filtered: 2028, Selected: 0

	ICECODE	CT	CA	CB	CC	SA	SB	SC	SO
1	CT92CA4087...	92	40	60	-9	87	83	-9	-9
2	CT92CA4087...	92	40	60	-9	87	83	-9	-9
3	CT92CA4087...	92	40	60	-9	87	83	-9	-9
4	CT92CA4087...	92	40	60	-9	87	83	-9	-9
5	CT92CA4087...	92	40	60	-9	87	83	-9	-9
6	CT92CA4087...	92	40	60	-9	87	83	-9	-9
7	CT92CA4087...	92	40	60	-9	87	83	-9	-9
8	CT92CA4087...	92	40	60	-9	87	83	-9	-9
9	CT92CA4087...	92	40	60	-9	87	83	-9	-9
10	CT92CA4087...	92	40	60	-9	87	83	-9	-9
11	CT92CA4087...	92	40	60	-9	87	83	-9	-9
12	CT92CA4087...	92	40	60	-9	87	83	-9	-9
13	CT92CA4087...	92	40	60	-9	87	83	-9	-9
14	CT92CA4087...	92	40	60	-9	87	83	-9	-9
15	CT92CA4087...	92	40	60	-9	87	83	-9	-9

ARCTIC201224 — Features Total: 2028, Filtered: 2028, Selected: 0

	SD	FA	FB	FC	FP	FS	POLY_TYPE	Shape_Leng	Shape_Area
1	9	-9	-9	-9	08	-9	I	38605.8840...	22960732.85...
2	9	-9	-9	-9	08	-9	I	24537.87017...	24917671.29...
3	9	-9	-9	-9	08	-9	I	27899.28373...	23757134.70...
4	9	-9	-9	-9	08	-9	I	24214.09147...	15063493.48...
5	9	-9	-9	-9	08	-9	I	29460.83931...	31012907.70...
6	9	-9	-9	-9	08	-9	I	39326.62700...	18684219.87...
7	9	-9	-9	-9	08	-9	I	26485.10106...	13934468.84...
8	9	-9	-9	-9	08	-9	I	21318.25416...	29473817.69...
9	9	-9	-9	-9	08	-9	I	48321.54715...	65531682.06...
10	9	-9	-9	-9	08	-9	I	11742.55384...	6109982.605...
11	9	-9	-9	-9	08	-9	I	102538.8722...	157298172.5...
12	9	-9	-9	-9	08	-9	I	20092.2620...	3266670.190...
13	9	-9	-9	-9	08	-9	I	35852.9995...	24866746.21...
14	9	-9	-9	-9	08	-9	I	301556.13711...	1595002331....
15	9	-9	-9	-9	08	-9	I	58653.5054...	70709410.00...

Figure 2. Attribute table for ARCTIC20201224.shp file. It has been split in two to show all of the fields. For a full description of the codes please see Table A - 1, Table A - 2, Table A - 3, Table A - 4, and Table A - 5 in Appendix A – SIGRID-3 FIELDS CODES. Please note that the codes are used slightly differently for the Antarctic, see section 1.3.3 for details, and the fields in the attribute table vary slightly throughout the period of record, see section 1.3.4.

1.3.5 Directory Structure

The data files are organized in two main directories by hemisphere: `north` and `south`. Within each of these there are subdirectories for each year, each year's directory contains the weekly zip files.

1.3.6 Naming Convention

The zip files and the files within them are named according to the following convention and as described in Table 1. Note that the names of these data files from the USNIC web site vary over time. NSIDC has renamed them for this data set to a consistent naming convention.

Generic File Name: `RRRRRRYYYYMMDD.ext`
Example File Name: `ARCTIC201224.zip`

Table 1. File Naming Convention

Variable	Description
RRRRRR	Denotes the region: ARCTIC = Arctic, ANTARC = Antarctica
YYYY	4-digit year
MM	2-digit month
DD	2-digit day
ext	File extension (.zip, .shp, .shx, .dbf,.prj, .shp.xml, .xml, and .txt)

1.4 Spatial Information

1.4.1 Coverage

The following are the approximate latitude/longitude bounding coordinates for the Northern Hemisphere:

Northernmost Latitude: 90° N
Southernmost Latitude: 19° N
Easternmost Longitude: 180° E
Westernmost Longitude: 180° W

The following are the approximate latitude/longitude bounding coordinates for the Southern Hemisphere:

Northernmost Latitude: 19° S
Southernmost Latitude: 90° S
Easternmost Longitude: 180° E
Westernmost Longitude: 180° W

1.4.2 Resolution

These data are provided as vector shapefiles so there is no inherent resolution.

1.4.3 Geolocation

The following table provides information for geolocating this data set

Table 2. Geolocation Details

Geographic coordinate system	WGS 1984
Projected coordinate system	Northern Hemisphere: WGS 1984 Stereographic North Pole Southern Hemisphere: WGS 1984 Stereographic South Pole
Longitude of true origin	0°
Latitude of true origin	Northern Hemisphere: 60° Southern Hemisphere: -60°
Scale factor at longitude of true origin	1
Datum	WGS 1984
Ellipsoid/spheroid	WGS 1984
Units	meter
False easting	0°
False northing	0°
PROJ4 string	Northern Hemisphere: +proj=stere +lat_0=90 +lat_ts=60 +lon_0=180 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs +type=crs Southern Hemisphere: +proj=stere +lat_0=-90 +lat_ts=-60 +lon_0=180 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs +type=crs

As of March 2022, we noted these discrepancies in geolocation details throughout the data set:

- The files for 2003 to 2005 do not contain CRS information which makes it trickier to plot in GIS programs. We presume they use the same CRS as the files for 2006 onwards.
- The outermost boundaries vary slightly between 2003-2005 and 2006 onwards.
- For files for 2007 and onwards, the land areas seem to be marked differently or not included in the shapefiles.

1.5 Temporal Information

1.5.1 Coverage

The coverage is 2003 to present. In 2003 and 2004, there are no files for April to September.

1.5.2 Resolution

For the years 2003 and 2004, the resolution is inconsistent with approximately a dozen files for each year. From January 2005 to September 2013, there are approximately two files per month. From October 2013 through March 2022, the files are weekly. Beginning in April 2022, the USNIC changed to producing the files every-other week. As of 9 June 2023, bi-weekly production of the Antarctic data in this data set has been suspended indefinitely. The Arctic data is not affected and will continue to be produced.

Since at least 2011, the ice charts are based on observational data from up to five days prior to the date of the chart. The analysts project information forward so the chart is valid on a given day. Thus, the ice charts represent the ice conditions for up to five days prior and including the date of the chart (A. Ottoson, personal communication, 2023).

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Sea ice charts from operational services are historically depicted as maps with areas containing ice of similar concentration and type outlined and labeled with a code. This code (known as the *egg code*, for its shape) has information on total sea ice concentration, usually given as a range (for example 7-9, meaning 7 to 9 tenths or 70 percent to 90 percent concentration). The egg code for a particular area may also have partial concentrations (that is, concentration by ice type), information on ice stage of development (often called ice type, usually expressed as ice age, and a proxy for ice thickness), and information on ice form as well. Fast ice, pancake ice, and brash ice are examples of ice form. As a rule, USNIC only uses the fast ice form in its charts. WMO designations are used for sea ice stage of development and ice form. See WMO (2014) and the NSIDC All About Sea Ice pages and Glossary for more information on ice types. The Canadian Ice Service (CIS) MANICE (Environment Canada, 2005) has a good explanation of how ice information is encoded using the egg code. Figure 3 summarizes the most important information that can be encoded.

Ice services around the world implement the egg code in differing ways depending on what information the charts routinely capture. USNIC charts, for example, have never contained CD, SE, FD, or FE information, but USNIC often uses SO and SD. See MANICE (Environment Canada, 2005) for more information on these codes.

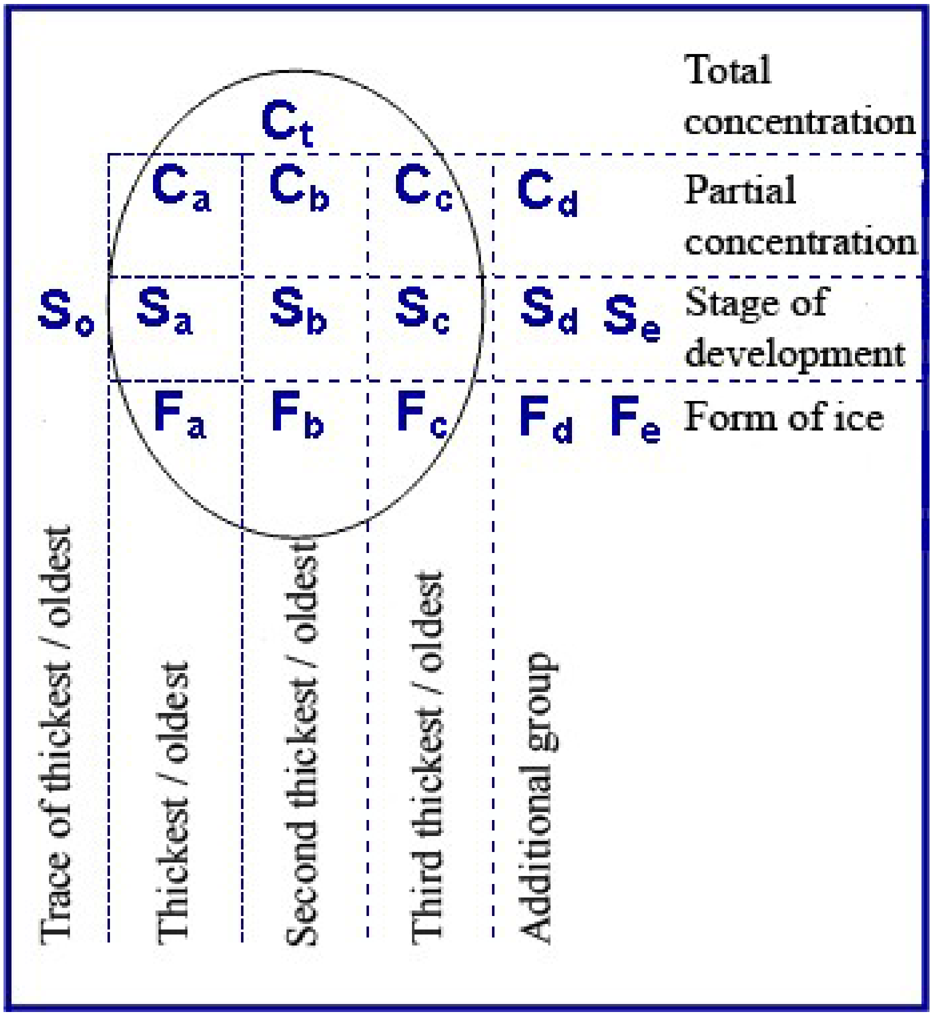

Figure 3. Diagram describing the egg code. After a figure in MANICE (Environment Canada, 2005). Used with permission.

In the early 1980s, the international ice charting community discussed ways of encoding and digitally preserving information in hand-drawn ice charts. A format called Sea Ice Grid (SIGRID) was developed and adopted as a WMO format. Essentially, a sea ice chart encoded in SIGRID is a text file where the information in each egg code is a string of text. There is information for each grid point. Grid resolution is nominally 15 minutes in latitude and a variable amount in longitude.

One limitation of the original SIGRID is that ice charts are more like vector (point, line, polygon) data, with no inherent resolution, than gridded data. In converting chart information to a grid with fixed points, information is lost. A new version of SIGRID, SIGRID-3, was developed so that vector files could be encoded using SIGRID codes and archived (WMO, 2010). Several ice services, including the USNIC, have adopted the SIGRID-3 format (Intergovernmental Oceanographic Commission, 2004). See the GDSIDB Data Formats section of NSIDC Special Report 24 for an overview of SIGRID development and related references.

When the USNIC moved to producing ice charts in a GIS environment, USNIC continued to label areas of ice having similar characteristics (these areas are called polygons in the GIS environment) using the egg code (Figure 4 and Figure 5). The attributes for each polygon in the attribute table for each ice chart file use the SIGRID string that encodes that polygon''s egg (Figure 5).

As of the publication of this data set in 2022, USNIC does not display charts with egg codes on its website. Instead, it displays graphical representations of ice concentrations and of the estimated stages of development/ice thickness based on the weekly ice analysis. However, USNIC continues to produce SIGRID-3 files for archival purposes. The SIGRID-3 files contain the most complete and detailed description of sea ice available in one USNIC product. See USNIC for weekly ice concentration and stage of development maps and other products, all of which can be downloaded in a choice of formats.

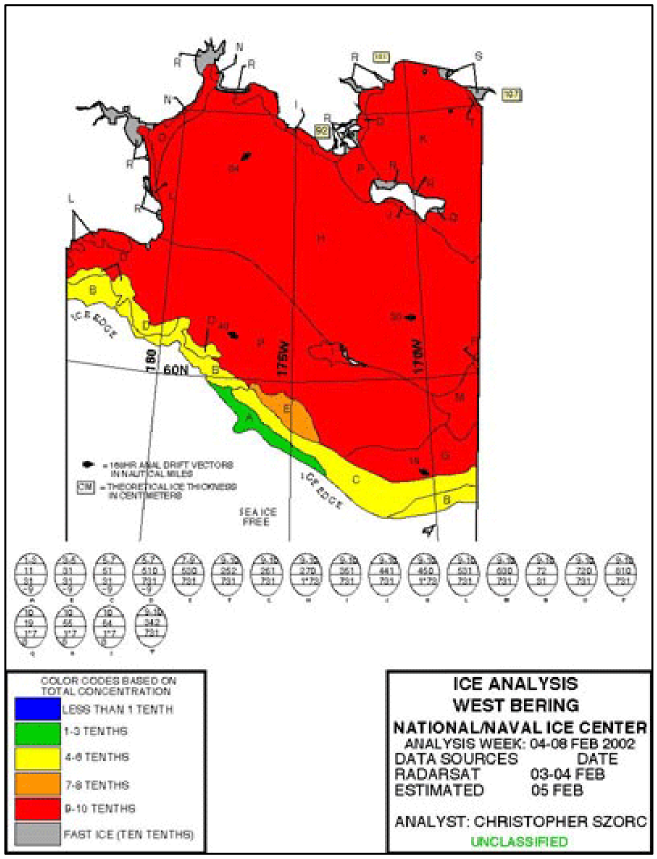

Figure 4. Example of a NIC Regional Chart showing polygons with their associated egg codes. Unlike the older hemispheric scale charts, these are produced entirely in a digital environment.

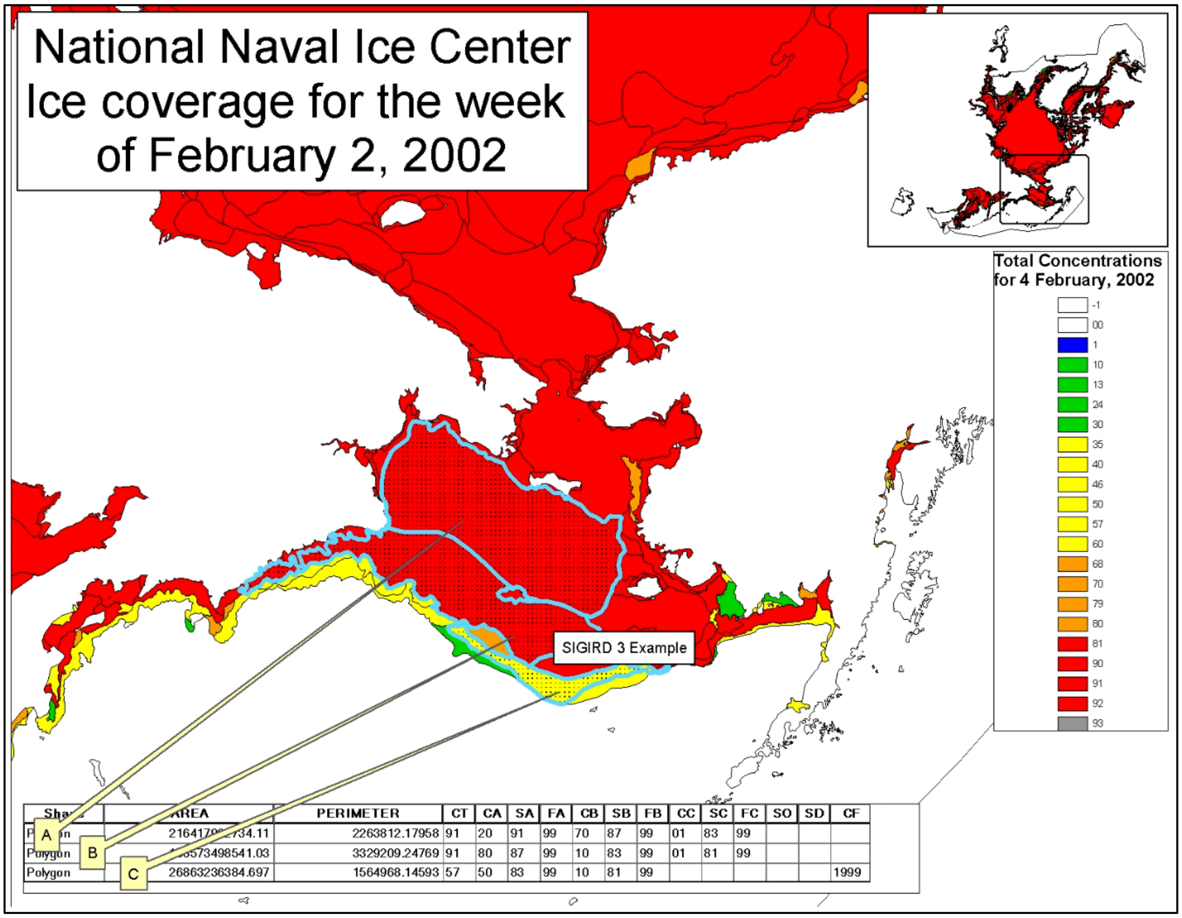

Figure 5. An example of a NIC chart showing how polygons are represented in attribute tables. The column heading beginning CT are egg code designations, while the numbers filling those columns are the SIGRID code.

2.2 Acquisition

These charts are produced by USNIC analysts and are archived at NSIDC. The mission of the USNIC is to provide ice and snow products, ice forecasting, and other environmental intelligence services for the U.S. government. USNIC products are designed to meet operational needs. In cooperation with USNIC, NOAA@NSIDC archives and distributes a selection of these products. See Appendix B – U.S. NATIONAL ICE CENTER DATA PRODUCTS AT NSIDC: AN OVERVIEW for more information.

2.3 Processing

The charts are constructed by analysts at the USNIC using imagery and ancillary data from various sources. In the past, these data sources generally have been acquired plus or minus three days from the publication date of the Regional Ice Analyses described below. Since at least 2011, observational data from up to five days prior to the date of the chart are used (A. Ottoson, personal communication, 2023). Synthetic Aperture Radar (SAR) imagery is the core imagery preferred by USNIC analysts due to its balance of resolution and swath and its ability to penetrate clouds and distinguish between ice features (e.g., floes, leads, and ridges) and ice types. Typically, as of 2022, data from the Sentinel-1 and Radarsat platforms are used. Visible imagery from VIIRS, MODIS, and GOES geostationary satellites also play an important role. At certain times of the year and in certain regions other types of imagery may be used. For example, when daylight is lacking, infrared imagery is important. Passive microwave data are also used to infer motion of the ice pack. Ancillary data sources include: wind, surface and air temperatures, surface pressure, and sea ice model output (but model output is only used as a last-resort) (USNIC, 2022).

Once the analysts have gathered all the relevant data and information, they carry out their analysis using Geographic Information System (GIS) ESRI ArcMap software and a small selection of internal tools and scripts (USNIC, 2022). Analysts first manually create a Regional Ice Analysis coverage. Then, automated validity checks are performed during attribute and line entry, where the attributes are the WMO egg codes. A topological polygon build is carried out to clean the coverage; and if required, corrections are made and a chart is produced for manual quality control. Next, the Regional Ice Analysis coverage is converted to a shapefile, the metadata are generated, and these are packaged into the SIGRID-3 product. For further details on the processing, refer to the .xml file that accompanies each shapefile.

NSIDC runs a weekly script to download the files. No processing takes place at NSIDC, apart from renaming the files to a standard naming convention as described in section 1.3.6 Naming Convention.

2.4 Quality, Errors, and Limitations

The primary strength of the USNIC chart series is that the charts are created by specialists using manual analyses of data from many sources. Where the ice concentration might be difficult to gauge in the summer in some places using SAR imagery because of surface melt, for example, the analyst has the option of checking visible band imagery. If the ice edge cannot be located in visible band imagery because of clouds, the analyst can use scatterometry. USNIC software allows image manipulation to enhance imagery. To date, this mostly manual form of multisensor data fusion, or data assimilation, produces ice information more accurately than using any single data source or automated approach.

Manual analysis does have weaknesses. One is the subjective nature of image interpretation for ice concentration and for ice type. Ice concentration is generally estimated visually by looking at what are generally bright ice floes against a dark background. Ice concentration estimated in this way is assessed to be accurate to within about +- 10% (Partington, 2003). Ice type (stage of development) is more difficult to gauge. High resolution visible and infrared imagery, and especially SAR imagery used to distinguish multiyear ice from younger forms, along with a time series of charts and imagery from the area being analyzed, makes it possible.

The primary weakness of the time series of USNIC charts is that they are not consistent over the period of record because the charts are an operational product drawn with available information and following the standard procedures in place at the time they are made. There are inconsistencies in methodology, input data sources, and subjective interpretation of satellite imagery used throughout the record.

2.4.1 Inconsistencies Due to Changes in Method or Practices

The range that USNIC analysts conventionally use to assign a concentration range to pack ice in the wintertime central Arctic changed from 9/10-10/10 to 8/10-10/10 sometime in 2012. The decision to change the range was based on operational workflow and not on an assessment of ice conditions (USNIC analyst C. Szorc, personal communication 2020).

2.4.2 Erroneous Data

Occasionally, polygons have a combination of codes that is inconsistent. For example, a polygon could be erroneously encoded in SIGRID-3 as both fast-ice for form and 0% for concentration. Additionally, in some cases, valid SIGRID codes have been incorrectly assigned in the original analysis. One example is that ice-filled straits in the Canadian Archipelago were incorrectly assigned to polygon type Water in a number of charts. Please see Appendix C – ERRONEOUS DATA for a list of files that contain erroneous data.

3 SOFTWARE AND TOOLS

The shapefiles can be read using GIS software and the zip files can be opened using zip extraction software.

4 VERSION HISTORY

Table 3. Version History Summary

Version	Release Date	Description of Changes	Citation

1	August 2022	Initial release of data set	U.S. National Ice Center. 2022. *U.S. National Ice Center Arctic and Antarctic Sea Ice Charts in SIGRID-3 Format, Version 1*. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/4b7s-rn93.

5 RELATED DATA SETS AND WEBSITES

NSIDC archives the USNIC data sets listed in Table 4. As of August 2022, not all are yet available for download from NSIDC.

Table 4. USNIC products currently archived at NSIDC.

Data set identifier	NSIDC product name	Available for download
G02156	IMS Daily Northern Hemisphere Snow and Ice Analysis at 1 km, 4 km, and 24 km Resolutions	Yes
G02172	National Ice Center Arctic Sea Ice Charts and Climatologies in Gridded Format	Yes
G10013	U.S. National Ice Center Arctic and Antarctic Regional Sea Ice Charts in SIGRID-3 Format	Yes
G10017	U.S. National Ice Center Daily Marginal Ice Zone Products	Yes
G10019	U.S. National Ice Center Daily Outer Ice Edge	No
G10020	U.S. National Ice Center Daily 48 Hour Edge Forecast	No
G10033	U.S. National Ice Center Arctic and Antarctic Sea Ice Concentration and Climatologies in Gridded Format. This product was developed by and is processed at NSIDC using USNIC shapefiles (G10013).	Yes

The following are other data sets that originate from operational ice charting organizations and are archived and distributed by NSIDC:

- International Ice Patrol Iceberg Sightings Database - Iceberg activity in the North Atlantic since 1960 through the present from the International Ice Patrol (IIP) including latitude and longitude of sighted icebergs, coded iceberg size and shape class, and date and time of the sighting.
- International Ice Patrol Iceberg Drift Tracks – Drifting tracks of icebergs from 1977 through 1989 from the IIP.
- International Ice Patrol Annual Count of Icebergs South of 48 Degrees North, 1900 to Present – The number of icebergs that drift south across the 48° N line of latitude within the western Atlantic Ocean since 1900 through the present from the IIP.
- Multisensor Analyzed Sea Ice Extent - Northern Hemisphere (MASIE-NH) – Provides measurements of daily sea ice extent and sea ice edge boundary for the Northern Hemisphere and 16 Arctic regions, created by NSIDC with data from the USNIC.

- Canadian Ice Service Arctic Regional Sea Ice Charts in SIGRID-3 Format – Digital Arctic regional sea ice charts with information on ice concentration, stage of development, and ice form for Canadian Arctic from 2006 through the present from the Canadian Ice Service (CIS).
- Daily Great Lakes Ice Concentration, 1973 Onward – Daily gridded lake ice concentration for the Laurentian Great Lakes from the NOAA Great Lakes Environmental Research Laboratory (GLERL).

The following data sets come from operational ice services or are derived from operational ice service charts:

- The Dehn Collection of Arctic Sea Ice Charts, 1953-1986
- Environmental Working Group Joint U.S.-Russian Arctic Sea Ice Atlas
- Sea Ice Charts of the Russian Arctic in Gridded Format, 1933-2006
- Sea Ice Edge Location and Extent in the Russian Arctic, 1933-2006
- Morphometric Characteristics of Ice and Snow in the Arctic Basin: Aircraft Landing Observations from the Former Soviet Union, 1928-1989

The following is a list of related web sites:

- U. S. National Ice Center
- NOAA PolarWatch – the PolarWatch portal provides access to a growing number of USNIC and NOAA NSIDC data sets. The portal includes options for manipulating and displaying data.
- The Evolution of Operations at the U. S. National Ice Center: From Paper to Pixel (USNIC, 2006) - This article, written in 2006, gives a brief history of USNIC's operations that will help users of USNIC products understand the setting in which products are created.
- International Ice Charting Working Group - The IICWG is a forum where the world's national ice services meet to share and improve methods of serving maritime clients.
- Global Digital Sea Ice Data Bank - The GDSIDB fostered international collaboration to develop digital formats for archiving and sharing ice charts produced by national services. The group promoted and further developed the WMO SIGRID code for describing ice conditions. The linked document is a short history of GDSIDB at NSIDC (Fetterer,2022).

6 CONTACTS AND ACKNOWLEDGMENTS

NOAA's National Weather Service and USNIC provide support for this product at NSIDC through a service agreement with NOAA's National Centers for Environmental Information (NCEI).

7 REFERENCES

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8 DOCUMENT INFORMATION

8.1 Author

J. Roebuck with reviews from A. Windnagel and F. Fetterer.

8.2 Publication Date

August 2022

8.3 Revision History

February 2023: J. Roebuck added information regarding the time period of observational data used for each chart to sections 1.5.2 and 2.3.

December 2022: J. Roebuck added information regarding the use of the form variable “CF” to sections 1.3.2 and 1.3.4, and Table A - 1.

APPENDIX A – SIGRID-3 FIELDS CODES

Table A - 1. Mandatory columns (fields) in a SIGRID-3 database file, based on Table 1 from WMO (2010).

Column or Field Number	Column or Field Name	Data Type	Length (bytes)	Begin/End Byte	Code Table Reference	Ice Variable Description
1	AREA	Double precision binary	20	2-21		
2	PERI-METER	Double precision binary	20	22-41		
3	CT	Text	2	42-43	A-2	Total Concentration
4	CA	Text	2	44-45	A-2	Partial concentration of thickest ice
5	SA	Text	2	46-47	A-3	Stage of development of thickest ice
6	FA	Text	2	48-49	A-4	Form of thickest ice
7	CB	Text	2	50-51	A-2	Partial concentration of second thickest ice
8	SB	Text	2	52-53	A-3	Stage of development of second thickest ice
9	FB	Text	2	54-55	A-4	Form of concentration of second thickest ice
10	CC	Text	2	56-57	A-2	Partial concentration of third thickest ice
11	SC	Text	2	58-59	A-3	Stage of development of third thickest ice
12	FC	Text	2	60-61	A-4	Form of third thickest ice

Column or Field Number	Column or Field Name	Data Type	Length (bytes)	Begin/End Byte	Code Table Reference	Ice Variable Description
13	CN	Text	2	62-63	A-3	Stage of development of ice thicker than SA but with concentration less then 1/10
14	CD	Text	2	64-65	A-3	Stage of development of any remaining class of ice
15	FP	Text	2	66-67	A-4	Predominant form of ice
16	FS	Text	2	68-69	A-4	Secondary form of ice
17	Poly_type	Text	1	70	A-5	
18…56	Optional fields, see Appendix 4 Table 3.3 in WMO (2010)[1]	Text			Tables 4.5-4.15 in WMO (2010)	

[1] CF is not one of the optional fields, but it was a valid SIGRID identifier until 2010 (WMO 2010), and it was used by the USNIC until January 2006 to identify fast ice (CF = 0899).

Table A - 2. Concentration codes for variable identifiers CT, CA, CB, CC, AV, AK, AM and AT. Based on Table 4.1 in WMO (2010).

Definition	Code Figure
Ice Free	55
Less than 1/10 (open water)	01
Bergy Water	02
1/10	10
2/10	20
3/10	30
4/10	40

Definition	Code Figure
5/10	50
6/10	60
7/10	70
8/10	80
9/10	90
10/10	92
Concentration intervals (lowest concentration in interval followed by highest concentration in interval)	
9/10-10/10 or 9+/10	91
8/10-9/10	89
8/10-10/10	81
7/10-9/10	79
7/10-8/10	78
6/10-8/10	68
6/10-7/10	67
5/10-7/10	57
5/10-6/10	56
4/10-6/10	46
4/10-5/10	45
3/10-5/10	35
3/10-4/10	34
2/10-4/10	24
2/10-3/10	23
1/10-3/10	13
1/10-2/10	12
Undetermined / Unknown	99

Table A - 3. Thickness of ice or stage of development codes for variable identifiers SA, SB, SC, CN, and CD. Based on Table 4.2 in WMO (2010).

Stage of Development	Thickness	Code Figure
Ice Free		55
Brash Ice	Given by AV, AT, AM, AT	70
No Stage of Development		80
New Ice	< 10 cm	81

Stage of Development	Thickness	Code Figure
Nilas, Ice Rind	< 10 cm	82
Young Ice	10 - < 30 cm	83
Grey Ice	10 - < 15 cm	84
Grey – White Ice	15 - < 30 cm	85
First Year Ice	≥30 – 200 cm	86
Thin First Year Ice	30 - < 70 cm	87
Thin First Year Stage 1	30 - < 50 cm	88
Thin First Year Stage 2	50 - < 70 cm	89
For Later Use		90
Medium First Year Ice	70 - < 120 cm	91
For Later Use		92
Thick First Year Ice	≥ 120 cm	93
For Later Use		94
Old Ice		95
Second Year Ice		96
Multi-Year Ice		97
Glacier Ice		98
Undetermined/Unknown		99

Table A - 4. Form of ice codes for variable identifiers FA, FB, FC, FP and FS. Based on Table 4.3 in WMO (2010).

Form	Size/Concentration	Code/Figure
Pancake Ice	30 cm – 3 m	22
Shuga/Small Ice Cake, Brash Ice	< 2 m across	01
Ice Cake	< 20 m across	02
Small Floe	20 m – 100m across	03
Medium Floe	100 m – 500 m across	04
Big Floe	500 m – 2 km across	05
Vast Floe	2 km – 10 km across	06
Giant Floe	< 10 km across	07
Fast Ice		08
Growlers, Floebergs or Floebiits		09
Icebergs		10
Strips and Patches	Concentrations 1/10	11

Form	Size/Concentration	Code/Figure
Strips and Patches	Concentrations 2/10	12
Strips and Patches	Concentrations 3/10	13
Strips and Patches	Concentrations 4/10	14
Strips and Patches	Concentrations 5/10	15
Strips and Patches	Concentrations 6/10	16
Strips and Patches	Concentrations 7/10	17
Strips and Patches	Concentrations 8/10	18
Strips and Patches	Concentrations 9/10	19
Strips and Patches	Concentrations 9+/10	91
Strips and Patches	Concentrations 10/10	20
Level Ice		21
Undetermined/Unknown		99

Table A - 5. List of Poly_type character variables. Based on Table 4.4 in WMO (2010).

Land	L
Water – sea ice free	W
Ice – of any concentration	I
No Data	N
Ice Shelf / Ice of Land Origin	S

APPENDIX B – U.S. NATIONAL ICE CENTER DATA PRODUCTS AT NSIDC: AN OVERVIEW

The U.S. National Ice Center (USNIC) is operated by the United States Navy (USN), the National Oceanic and Atmospheric Administration (NOAA), and the United States Coast Guard (USCG). USNIC's mission is to provide ice and snow products, ice forecasting, and other environmental intelligence services for the U.S. government. The organization's website has information that includes a short history: History of the National/Naval Ice Center.

At the USNIC, analysts from the U.S. Navy and from NOAA produce an evolving suite of products. Most of these products are designed to meet the needs of operational users: that is, those planning or conducting operations in ice-infested waters. USNIC products and services that are available to external customers are listed and described in a product catalog (USNIC, 2019).

While USNIC exists to serve operational users, many USNIC products are valued by environmental scientists because they tend to be accurate, timely, and of high spatial resolution. Their use in scientific studies may be hampered by the fact that they are not necessarily produced in a uniform way from day to day and year to year. Analysts at USNIC strive to make the best possible product on a given day, without regard to long-term consistency. If researchers understand the limitations, the information contained in the USNIC products can be exploited for projects such as validating algorithms for satellite data analysis or for initializing or validating sea ice forecast model output.

With support from USNIC, NSIDC redistributes a subset of USNIC products that have been selected for their research value. We add documentation that describes how analysts assemble each product, how products interrelate, and what potential limitations for research may be. We may reformat products to make them easier to use for research. The User Guide includes standard metadata and a citation with digital object identifier (DOI). NSIDC's User Services office answers or fields questions about the products.

During a 2015 visit by USNIC representatives to NSIDC, we discussed the potential value to scientific researchers and others of archiving and serving USNIC products from NSIDC. Thereafter, we began downloading and archiving the data files. NSIDC's role was formalized in agreements with USNIC in 2019. We thank John Woods, Caryn Panowicz, and Sean Helfrich for early discussions and support that led to these products being available through NSIDC.

USNIC products are archived with the NOAA@NSIDC collection. We serve as an informal intermediary between operations focused USNIC and the research community that uses their data products. Many of the products are also archived at USNIC and can be obtained through the USNIC website. The NSIDC archive therefore acts as a redundant archive for some products.

APPENDIX C – ERRONEOUS DATA

Table C - 1 lists the files that are known to have erroneous data.

Table C - 1. File errors and dates.

File date	Error
2003-01-20	The value *00* is used to mean 100%
2003-02-17	The value *00* is used to mean 100%
2003-12-22	Part of the Arctic Ocean has been coded as land
2004-01-05	Part of the Arctic Ocean has been coded as land
2014-07-03 through 2016-03-03	The Canadian Archipelago had been omitted from the analysis
2016-07-28	The Canadian Archipelago had been omitted from the analysis

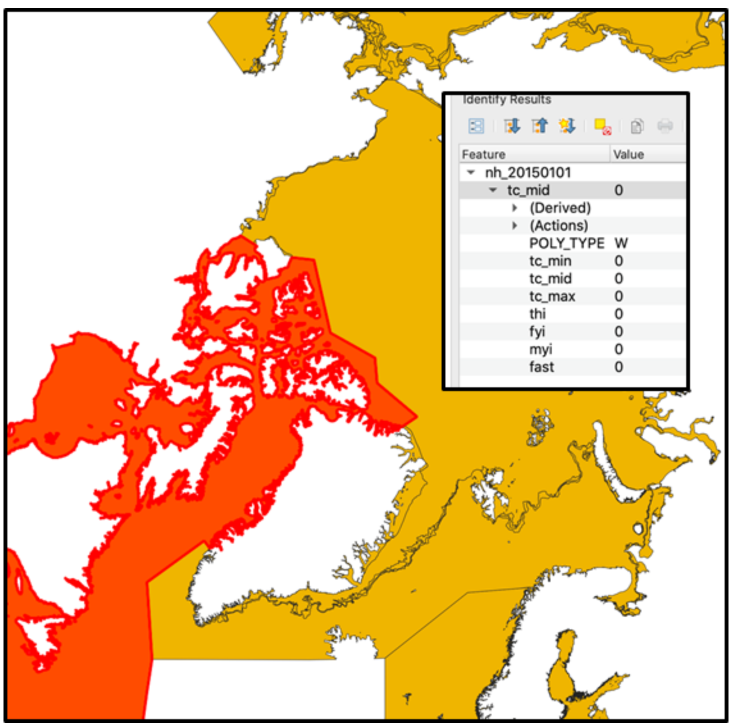

Figure C - 1. The shapefile for 1 Jan 2015 is derived from a SIGRID-3 file in which a large area including the Canadian Archipelago was omitted from analysis and assigned polytype *W* for water.