March through August Ice Edge Positions in the Nordic Seas, 1750-2002, Version 1

USER GUIDE

How to Cite These Data

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

Divine, D. V. and C. Dick. 2007. *March through August Ice Edge Positions in the Nordic Seas, 1750-2002, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/N59884X1. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/G02169

National Snow and Ice Data Center

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1 OVERVIEW

Ice edge is defined by a consecutive set of geographical coordinates. These positions have at least a 30 percent ice concentration. This means that nominally the 30 percent contour line defines the ice edge.

This product is derived from four sea ice input products. In this document, the phrase "input products" refers to the four products in Table 1. The input products span a longer temporal period than does this product. For example, the Arctic Climate System Study (ACSYS) Historical Ice Chart Archive spans from 1553 through 2002, but only data from 1750 through 1978 are used as input to this product. In this document, the ACSYS archive is described as two subsets, constituting the files from 1750-1966 and the files from 1967-1978. These subsets differ in the way they characterize the sea ice conditions.

Table 1. The Four Input Products and their Dates

Date range used in this Nordic Seas data set	Input data source	Name referred to in this document
1750-1978	ACSYS Historical Ice Chart Archive (ACSYS 2003)	ACSYS archive (1750-1966); Norwegian Meteorological Institute (NMI) files, a subset of the ACSYS archive, (1967-1978)
1953-1965	Data based on Soviet aircraft reconnaissance files for the Barents Sea (Fetterer and Troisi 1997)	Soviet reconnaissance files
1978-1987	SMMR passive microwave data (Gloerson et al. 1990)	SMMR data
1987-2002	SSM/I passive microwave data (Cavalieri et al. 1996)	SSM/I data

2 DETAILED DATA DESCRIPTION

2.1 Background

This section summarizes the input products and describes how the ice edge is derived. See Divine and Dick (2006) for additional information, or refer to the original data sources.

2.1.1 Arctic Climate System Study (ACSYS) archive (1750-1966)

The original ACSYS archive is a compilation of historic sea ice data from various sources, including newspapers, ship observations, aircraft observations, diaries and more (ACSYS, 2003). The sea ice data from the original ACSYS archive from 1750-1966 are distributed as shapefiles (ACSYS, 2003), with polylines depicting the sea ice extent. A polyline is defined as straight line segments merged together to form a continuous line. The polylines characterize the ice conditions that are bounded by the line. For example, the red line in Figure 1 depicts the edge of ice concentrations that range from 70-80 percent ice concentration.

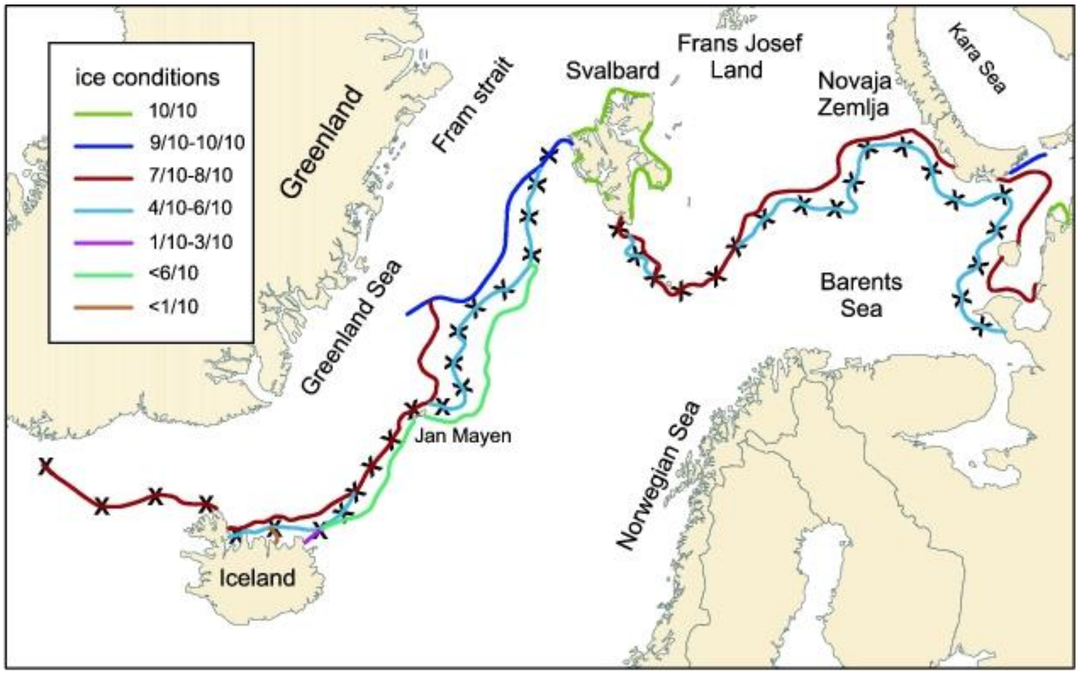


Figure 1. Ice file from the ACSYS archive from May 1906. Ice concentrations are shown with different colors (see legend). The X's in the figure indicate which polylines were selected to construct the ice edge from the original file for this Nordic Seas data set.

Figure 2 shows the attribute table that corresponds to Figure 1. Notice the ICE_COND column that is highlighted. These numbers represent different ice conditions. For example, the number "3" corresponds to the red line in Figure 1 that represents 70-80 percent ice concentration. The data in the SOURCE column provides information on how each polyline can be traced back to its original source (for example, the newspaper the sea ice data originated from).

Attributes of 19060520

FID	Shape	LENGTH	ICE_	ICE_ID	ICE_COND	SOURCE
0	Polyline	0.911	1	38	3	8
1	Polyline	4.425	2	34	3	4
2	Polyline	7.659	3	38	3	8
3	Polyline	5.275	4	38	3	8
4	Polyline	7.798	5	34	3	4
5	Polyline	8.939	6	38	3	8
6	Polyline	24.325	7	28	2	8
7	Polyline	8.93	8	44	4	4
8	Polyline	0.951	9	108	10	8
9	Polyline	1.126	10	58	5	8
10	Polyline	7.518	11	64	6	4
11	Polyline	21.312	12	48	4	8
12	Polyline	15.325	13	68	6	8

Record: 0 Show: All Selected Records (0 out of 30 Selected.) Options

Figure 2. Sample attribute table from the ACSYS archive from May of 1906. The ICE_COND column contains numbers that reference different ice concentration ranges.

There are usually two files per month in the ACSYS archive from 1750 through 1966. However, only data from one file per month is used in this data set.

Once the shapefile was chosen, the data providers decided which polylines to use to construct the ice edge. Preference was given to lines with 30 percent or more ice concentration. An ASCII file with geographical coordinates of the ice edge (at least 30 percent ice concentration) was produced.

Hunters, primarily consisting of sealers and whalers, collected most of the data prior to 1950 and consistently reported ice concentrations ranging from 30 percent to 60 percent. Therefore, users should understand that the ice edge is not defined exactly at the 30 percent ice concentration contour. If sea ice edge data were available as a set of segments (likely from varying sources), they were lined up in sequence to form a continuous set of coordinates in the ice edge file. See Divine and Dick (2006) for further details.

2.1.2 NMI Files (subset of ACSYS archive from 1967-1978)

The ACSYS ice chart archive from 1967-1978 contains ice charts collected by the Norwegian Meteorological Institute (NMI) and then digitized at the Norwegian Polar Institute (NPI). These data are based primarily on satellite imagery. Whereas the earlier ACSYS subset from 1750-1966 are distributed as polylines, the data from 1967-1978 use polygons to denote the different classifications of ice concentration (see Figure 3). The ice conditions are categorized as follows: open water (ice concentration below 10 percent), very open drift ice (10-40 percent), open drift ice (40-70 percent), close drift ice (70-90 percent), very close drift ice (90-100 percent) and fast ice (ACSYS, 2003). The boundary between very open drift ice and open drift ice was used by the data providers to determine the ice edge. Occasionally, the shape of the marginal ice zone made this inappropriate, and a different boundary (eg. between close drift ice and open drift ice) was used. The file selected contained the best spatial coverage, but if both charts were of comparable coverage and quality, the later file was used (Divine and Dick, 2006). The polygons were converted to a gridded (raster) format directly in the GIS and then the `grdcontour` program of the Generic Mapping Tools (GMT) was used (Wessel and Smith, 1998) to draw the boundary.

Figure 3 shows an example of the original ACSYS file `ice19750403.shp` containing polygons with the different `ICE_TYPE` categories.

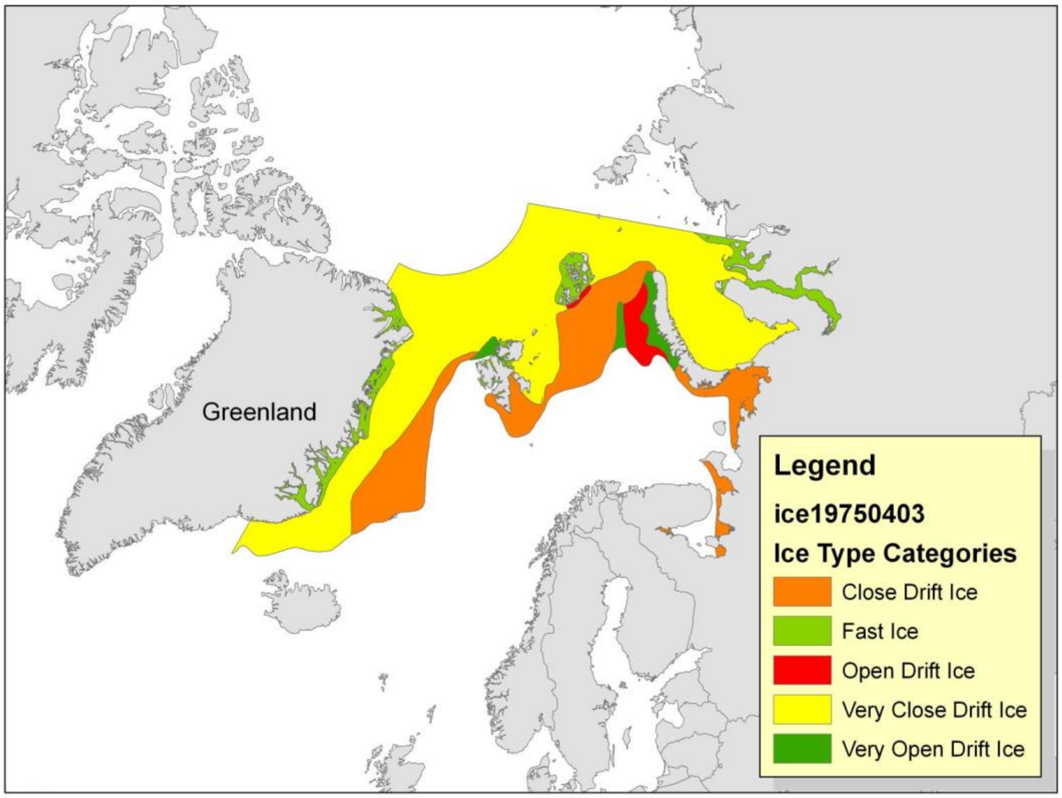


Figure 3. This image shows the ice19750403.shp file from the ACSYS archive (ACSYS, 2003). The different polygons contain different ice type (ICE_TYPE) categories as displayed in the legend.

2.1.3 Soviet Reconnaissance Files (1953-1965)

Data from Fetterer and Troisi (1997) were used to fill in gaps in the Barents Sea that exist in the ACSYS archive. These data are available as gridded ice concentrations with 12.5 km cell spacing. The data set is a 10-day product and usually only one 10-day file per month falls within the spatial extent of this data set. Therefore, the Soviet reconnaissance files provide ice edge data for approximately one file per month from 1953-1965. To produce contour lines corresponding to a given ice concentration, the `grdcontour` program was used (Wessel and Smith, 1998) with the 30 percent ice concentration denoting the ice edge.

In some instances, the Soviet reconnaissance data overlapped temporally with the ACSYS files. When this overlap occurred, data from both sources were merged, meaning that a file in the current data set can contain data from more than one input product. For example, there may be segments in an ice edge file with one segment from the ACSYS archive and another segment from the Soviet reconnaissance files. For a complete list of merged files, see the Appendix.

The segments of the ice edges obtained for the Barents Sea were subsequently merged with the respective data for the eastern part of the study area. Figure 4 shows an example of an ice edge file.

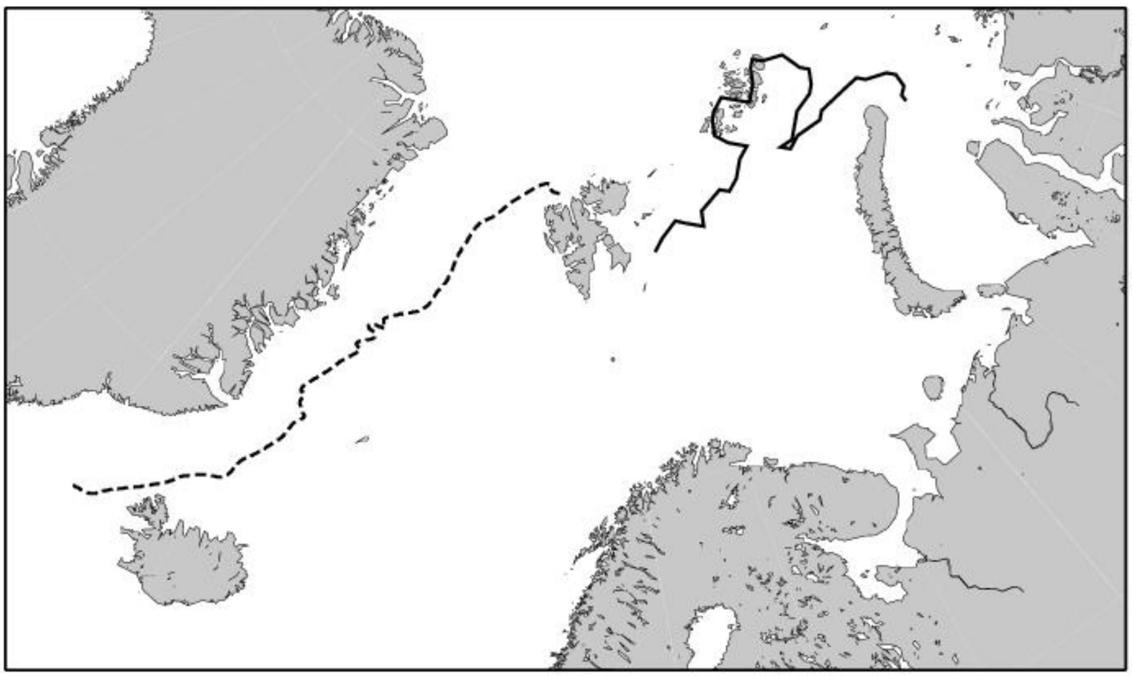


Figure 4. Merged ice edge file for July 1956 based from the ACSYS archive (second 10-day period of July 1956, dashed line) and Soviet reconnaissance data (from Fetterer and Troisi, 1997; third 10-day period of July 1956, solid line).

2.1.4 SMMR and SSM/I data (1978-2002)

Passive microwave ice concentration data were used from SMMR (1978-1987) and SSM/I (1987-2002). The input data are in an approximate 25 km grid in a polar stereographic projection. The region over the Nordic Seas was extracted and ice concentrations were passed through the `grdcontour` program of the Generic Mapping Tools (GMT) (Wessel and Smith, 1998). The 30 percent contour line determined the ice edge.

2.1.5 Monthly Means

Monthly means were derived using a technique described by Shapiro et al. (2003). With this technique, each ice edge is expressed as a sequence of rectangular coordinates, parameterized by their distance along the ice edge from a fixed location. Points can then be grouped into bins according to their distance along the edge. The monthly mean ice edge is then computed by calculating the mean location of points for each bin for each month of each year.

2.1.6 Multidecadal Means

The multidecadal means are calculated from the monthly means described above. They are calculated for each calendar month for these subperiods: 1870-1920, 1921-1961, 1962-1988 and 1989-2002. These subperiods were chosen to correlate with the warming and cooling in the Arctic region described by Polyakov et al (2003).

2.2 Spatial and Temporal Coverage and Resolution

Temporal and spatial coverage vary over the period of record. The data density is irregular throughout the data set, with approximately one data file per month from 1850-1966. The ice edge data gradually increase from one file per month to weekly files per month to daily files per month. Spatial coverage varies as well, as seen in Figures 4 and 8.

The geographic domain of the product is shown in Figure 5.

Northernmost Latitude: 86° N
Southernmost Latitude: 57.7° N
Easternmost Longitude: 64.2° E
Westernmost Longitude: 36.2° W

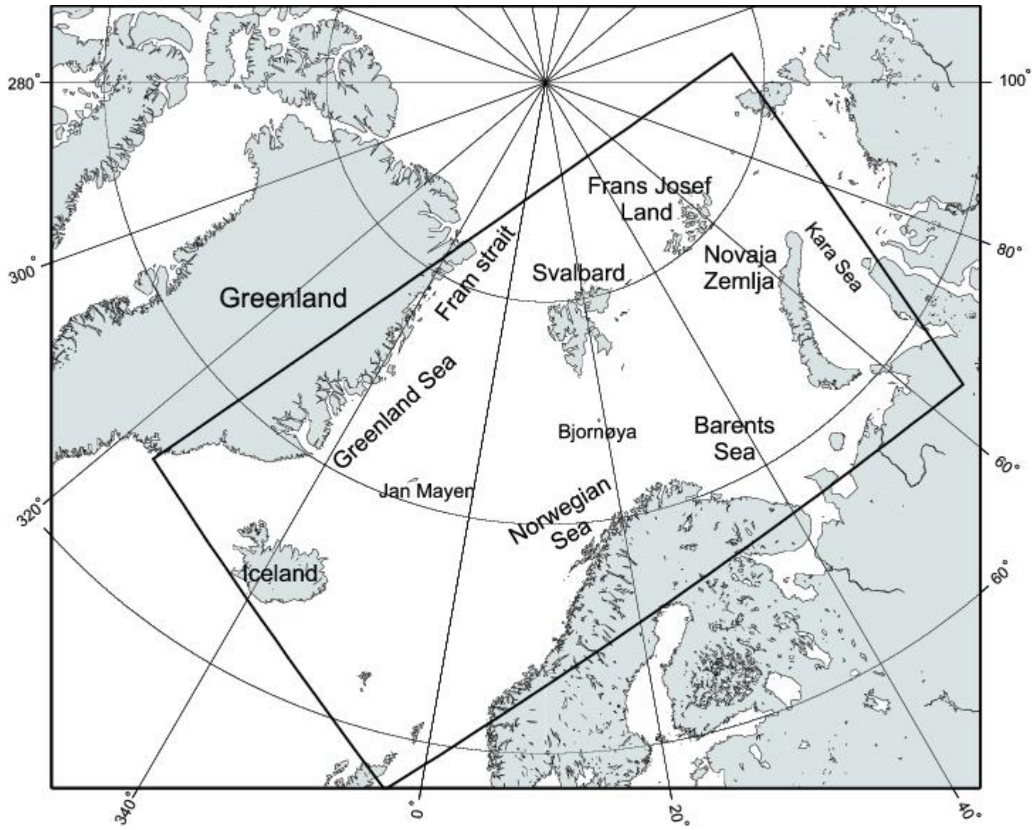


Figure 5. Map of the Nordic Seas with surrounding areas. The ice edge coordinates in this data set fall within the bounding box.

An example of data coverage from one 50-year period from 1850-1899 is shown in Figure 6.

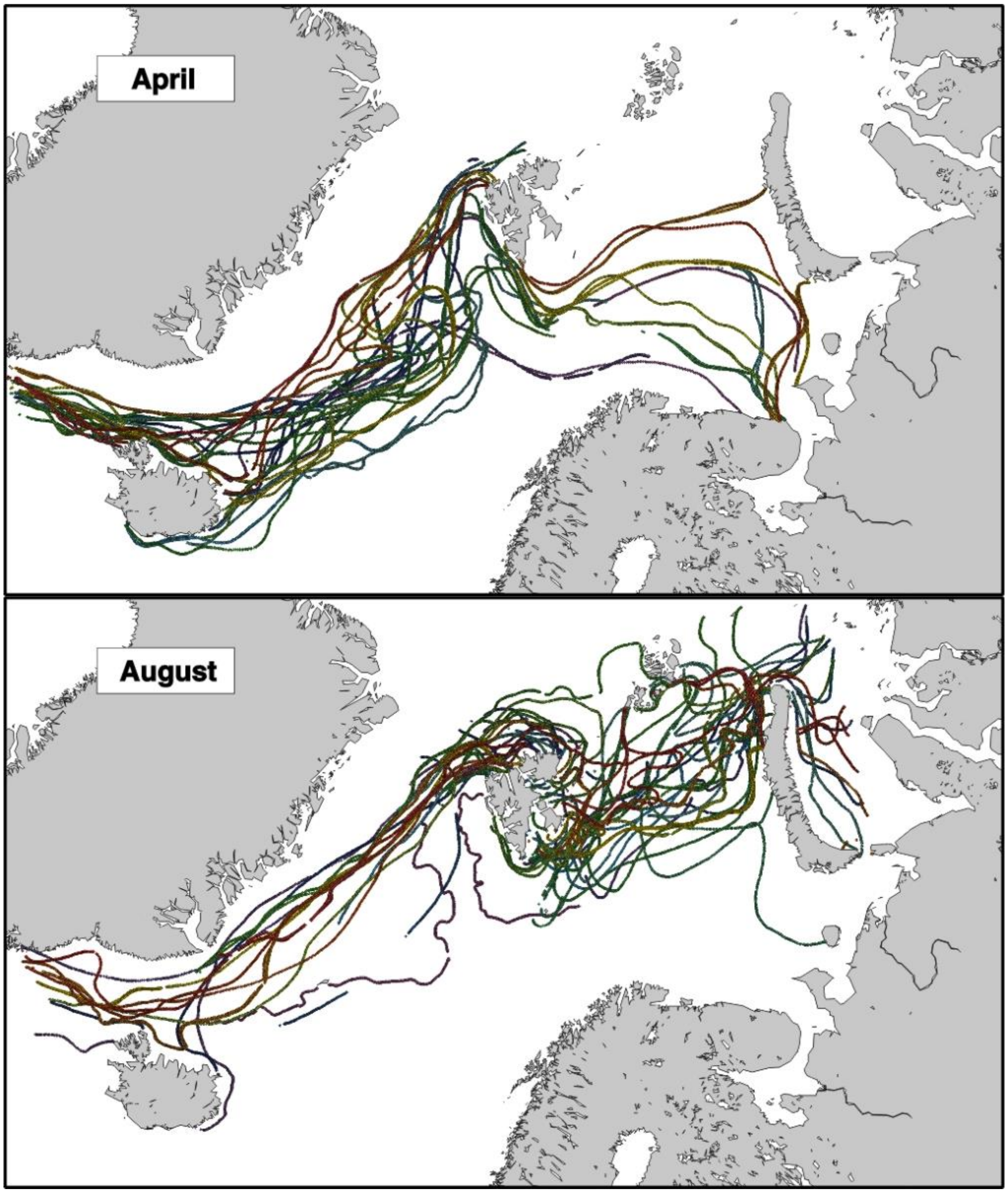


Figure 6. Images illustrate the data density in April (a) and August (b) of sea ice edge positions from the ACSYS archive.

2.3 Projection (GIS Files)

The GIS shapefiles were created at NSIDC and are distributed in a geographic projection with WGS84 datum. Here is an example projection (.prj) file:

```
GEOGCS["GCS_WGS_1984",DATUM["D_WGS_1984",SPHEROID["WGS_1984",
6378137.0,298.257223563]],PRIMEM["Greenwich",0.0],UNIT["Degree",
0.0174532925199433]]
```

2.4 Format

The ice edge positions, monthly means and multidecadal means are stored in the form of ASCII files. Each row in a data file contains coordinates in sequence specifying points along the ice edge. The coordinates are space delimited by longitude (0-360) and latitude (0-90) in decimal degrees.

If the ice edge positions were available as a set of segments (a situation typical for historical ice charts) the points constituting the segments were sequenced as if they stemmed from a continuous line. In this case the ">" symbol is used to separate the ice edge segments in the data file. For example, the `iep19660715.dat` file from the ACSYS archive contains three">" symbols to separate the ice edge segments in this file. Figure 7 is an example from `iep19660715.dat` showing a portion of this file with the ">" symbols:

```
    343.622406    70.132629
    344.190063    70.375839
>
    345.074097    70.786743
    345.794189    71.054543
    346.380676    71.279549
    346.905457    71.500641
    347.451263    71.750435
    347.839996    71.938232
    348.235199    72.130737
    348.668091    72.339241
    349.023102    72.535835
    349.470093    72.749924
    349.906982    72.937141
    350.426483    73.138741
    350.782654    73.271141
    351.115906    73.398140
    351.542358    73.571541
    351.967865    73.715340
    352.429596    73.897942
    352.851013    74.085533
    353.306946    74.305428
    353.696747    74.518829
    353.997772    74.710136
    354.166138    74.837128
    354.309509    74.936234
    354.409943    75.016144
    354.462616    75.057739
    354.474213    75.099228
    354.423950    75.130142
    354.398499    75.153633
    354.381439    75.172722
>
    357.484955    76.186142
    357.548157    76.211037
```

Figure 7. An example ice edge file (iep19660715.dat) with ">" symbols, which indicate different segments.

Browse images are also available. They are JPEG images that depict the ice line shown in the corresponding data file. Figure 8 (below) shows the `iep19660715.jpg` browse image that corresponds to the `iep19660715.dat` file in Figure 7 (above). Although the ice edge appears as line segments in the browse images, the data are actually distributed as points (coordinates). If the ice edge points were connected, lines similar to the ones in Figure 8 (below) would appear.

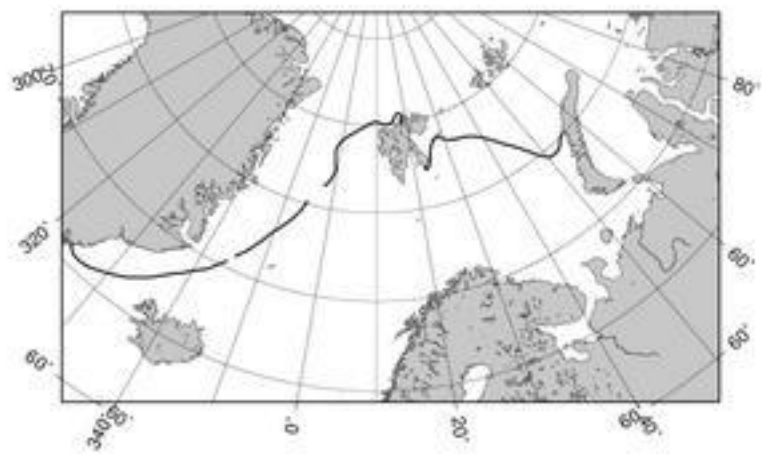


Figure 8. The iep19660715.jpg file that corresponds to the iep19660715.dat file from Figure 7.

GIS shapefiles are also available. These files can be imported into a GIS software application.

2.5 File and Directory Structure

/ice_edge_positions
  /data
  /browse

/monthly_means
  /data
  /browse
  /shapefiles

/multidecadal_means
  /data
  /browse
  /shapefiles

2.6 File Naming Convention

Ice edge position data: `iepYYYYMMDD.dat`

Example: `iep17650422.dat`

Monthly means (1967-2002): `mmiepYYYYMM.dat`

Example: `mmiep198404.dat`

Multidecadal means (1870-2002, divided into ranges: 1870-1920, 1921-1961, 1962-1988, and 1989-2002): `mdmiepYYYY-YYYYMMM.dat`

Example: `mdmiep1870-1920apr.dat`

Browse images: `iepYYYYDDYY.jpg; mmiepYYYYDD.jpg; mdmiepYYYY-YYYYMMM.jpg`

Example: `iep17650422.jpg`

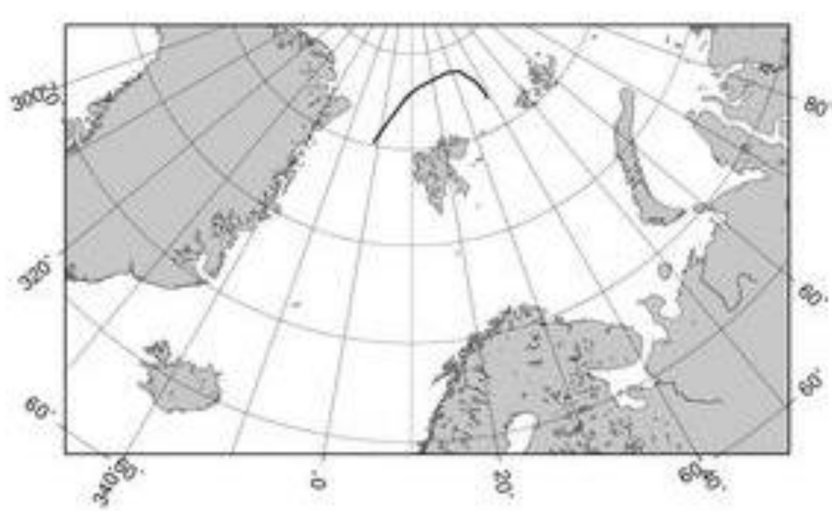
Shapefiles: `mdmiepYYYY-YYYYMMM.shp; mmiepYYYYMM_GIS.zip`

Example: `mdmiep1870-1920.zip; mmiep196703_GIS.zip`

Where `iep` = ice edge position, `mm` = monthly mean, `mdm` = multidecadal mean, `GIS` = geographic information system, `YYYY` = year, `MM` = month and `MMM` = month (for example, `04` = April and `apr` = April), and `DD` = day of when the data were collected.

2.7 Sample Data Record

A sample browse image from `iep17510715.jpg`:



The first portion of `iep17510715.dat`:

```
358.472565    80.112923
358.665894    80.229630
358.732178    80.259132
358.801086    80.290733
358.873108    80.317528
358.942261    80.346024
359.004089    80.372231
359.054443    80.394836
359.116821    80.420929
359.190735    80.447632
359.245697    80.478333
359.329132    80.510429
359.401123    80.538933
359.477539    80.568535
359.550354    80.597023
359.647369    80.629532
359.750732    80.662323
359.845886    80.696632
359.954254    80.734528
  0.067001    80.770531
  0.177132    80.808334
  0.296143    80.841530
  0.391422    80.870537
  0.489548    80.905632
```

2.8 Quality Assessment

There are some known limitations in the input data collections referenced in Divine and Dick (2006). March through August months were selected since these months contain a high data density. Therefore, the annual cycle of sea ice advance and retreat is not captured. Some other known limitations are listed below, by data collection:

2.8.1 ACSYS Archive (1750-1966)

- The observations are irregular and infrequent.
- Most ships avoided ice greater than 30 percent concentration, but there are instances when an ice edge observation originally documented was greater than 30 percent concentration.
- Gaps in the data exist during World War I (1914-1918) and World War II (1939-1945).

2.8.2 The NMI Data (subset of ACSYS archive, 1967-1978)

The frequency of files increased from four (at the beginning of this period) to eight (by the end of this period) files per month.

2.8.3 Soviet Reconnaissance Files (1953-1965)

Each input data file falls in one of three 10-day periods of the month. Typically, only one file was available over the study region per month.

2.8.4 SMMR and SSM/I Data (1978-2002)

Ice concentration fields from passive microwave data were available every other day from 1979-1987 (SMMR data) and on a daily basis after 1987 (SSM/I data).

2.8.5 Monthly Mean

If only one file is available for a given month, that one file is used as the monthly mean.

2.8.6 Merged Data

Between 1953 and 1965, data from more than one source (Soviet reconnaissance data and ACSYS data) are included in a file. See the Appendix for files that contain more than one source of data.

Users should consider the uncertainties related to the ice edge definition and the difficulty of navigating in the Arctic and sub-Arctic areas prior to the satellite era. An additional source of errors is uncertainty in ice concentrations derived from passive microwave data; this is of particular importance during the melting season, when the emissivity of the ice surface undergoes substantial changes.

Note that the historical ice files from the ACSYS archive were used “as they are”, without applying any reconstruction or interpolation procedures.

NSIDC did not perform a quality check on the sea ice edge data.

3 REFERENCES AND RELATED PUBLICATIONS

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Polyakov, I., R.V. Bekryaev, G.V. Alekseev, U. Bhatt, R. Colony, M.A. Johnson, A.P. Makshtas and D. Walsh. 2003. Variability and trends of air temperature and pressure in the maritime Arctic, 1875-2000, J. Climate, 16, 2067-2077.

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Vinje, T. 2001. Anomalies and trends of sea ice extent and atmospheric circulation in the Nordic Seas during the period 1864-1998, J. Climate, 14, 255-267.

Wessel, P., and W. H. F. Smith. 1998. New, improved version of the Generic Mapping Tools Released, EOS Trans. AGU, 79, 579.

3.1 Related NSIDC Data Collections

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Cavalieri, D. J., C. L. Parkinson, P. Gloersen, and H. J. Zwally. 1996, updated yearly. *Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS Passive Microwave Data, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: http://dx.doi.org/10.5067/8GQ8LZQVL0VL.

Fetterer, F., and V. Troisi. 1997. AARI 10-Day Arctic Ocean EASE-Grid Sea Ice Observations. Boulder, CO, USA: National Snow and Ice Data Center. Digital media. http://nsidc.org/data/nsidc-0050.html

Gloerson, P., D. Cavalieri, W.J. Campbell, and J. Zwally. 1990. Nimbus-7 SMMR polar radiances and Arctic and Antarctic sea ice concentrations. Boulder, CO: National Snow and Ice Data Center. CD-ROM. http://nsidc.org/data/nsidc-0007.html

National Ice Center. 2006. National Ice Center Arctic sea ice charts and climatologies in gridded format. Edited and compiled by F. Fetterer and C. Fowler. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media. http://nsidc.org/data/g02172.html

National Snow and Ice Data Center. 2004. Morphometric characteristics of ice and snow in the Arctic Basin: aircraft landing observations from the Former Soviet Union, 1928-1989. Compiled by I.P. Romanov. Boulder, CO: National Snow and Ice Data Center. Digital media. http://nsidc.org/data/g02140.html

3.2 Other Related Data Collections

ACSYS. 2003. ACSYS Historical Ice Chart Archive (1553-2002), IACPO Informal Report No. 8. Tromsø, Norway: Arctic Climate System Study.

Historical Sea Ice Atlas

4 CONTACTS AND ACKNOWLEDGMENTS

Dmitry Divine
Norwegian Polar Institute
Tromsø, Norway

Chad Dick
CliC International Project Office, Norwegian Polar Institute
Tromsø, Norway

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5 DOCUMENT INFORMATION

5.1 Document Authors

L. Ballagh prepared this document based on Divine and Dick (2006), ACSYS (2003) and on correspondence with D. Divine and F. Fetterer.

5.2 Publication Date

June 4, 2007

5.3 Date Last Updated

November 2020

APPENDIX

Merged ACSYS and Soviet reconnaissance data

Some files in this data set use ice edge data from two input sources. The left column below is the name of the file in this current data set (originating from the ACSYS archive) while the right-hand column lists the file name from the Soviet reconnaissance files (Fetterer and Troisi (1997)). There are 43 combined data files.

April

iep19540408.dat	w540408_aari_ease.ice
iep19590422.dat	w590411_aari_ease.ice
iep19600422.dat	w600415_aari_ease.ice
iep19610429.dat	w610417_aari_ease.ice
iep19620429.dat	w620419_aari_ease.ice
iep19630401.dat	w630421_aari_ease.ice
iep19640408.dat	w640418_aari_ease.ice
iep19650401.dat	w650412_aari_ease.ice

May

iep19560520.dat	w560512_aari_ease.ice
iep19570506.dat	w570510_aari_ease.ice
iep19590506.dat	w590514_aari_ease.ice
iep19600506.dat	w600519_aari_ease.ice
iep19610506.dat	w610519_aari_ease.ice
iep19620519.dat	w620519_aari_ease.ice
iep19630506.dat	w630515_aari_ease.ice
iep19640506.dat	w640518_aari_ease.ice
iep19650527.dat	w650505_aari_ease.ice

June

iep19540603.dat	w540625_aari_ease.ice
iep19560617.dat	w560618_aari_ease.ice
iep19570617.dat	w570621_aari_ease.ice
iep19590617.dat	w590622_aari_ease.ice
iep19600617.dat	w600622_aari_ease.ice

iep19610621.dat	w610621_aari_ease.ice
iep19630610.dat	w630622_aari_ease.ice
iep19640624.dat	w640624_aari_ease.ice
iep19650603.dat	w650622_aari_ease.ice

July

iep19560715.dat	w560721_aari_ease.ice
iep19570715.dat	w570722_aari_ease.ice
iep19580715.dat	w580724_aari_ease.ice
iep19590729.dat	w590722_aari_ease.ice
iep19600729.dat	w600722_aari_ease.ice
iep19610715.dat	w610721_aari_ease.ice
iep19620715.dat	w620721_aari_ease.ice
iep19630729.dat	w630724_aari_ease.ice

August

iep19530812.dat	w560824_aari_ease.ice
iep19570812.dat	w570821_aari_ease.ice
iep19580826.dat	w580823_aari_ease.ice
iep19590826.dat	w590819_aari_ease.ice
iep19600812.dat	w600822_aari_ease.ice
iep19620819.dat	w620824_aari_ease.ice
iep19630805.dat	w630823_aari_ease.ice
iep19640819.dat	w640819_aari_ease.ice
iep19650826.dat	w650820_aari_ease.ice