



National Ice Center Arctic Sea Ice Charts and Climatologies in Gridded Format, Version 1

USER GUIDE

How to Cite These Data

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

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

FOR CURRENT INFORMATION, VISIT <https://nsidc.org/data/G02172>



National Snow and Ice Data Center

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Notice: The data product titled *U.S. National Ice Center Arctic and Antarctic Sea Ice Concentration and Climatologies in Gridded Format* supersedes this product. It begins with charts from January 2003 and is updated weekly.

1 DETAILED DATA DESCRIPTION

NIC charts are produced through the analyses of available in situ, remote sensing, and model data sources. They are generated primarily for mission planning and safety of navigation. NIC charts generally show more ice than do passive microwave derived sea ice concentrations, particularly in the summer when passive microwave algorithms tend to underestimate ice concentration. The record of sea ice concentration from the NIC series is believed to be more accurate than that from passive microwave sensors, especially from the mid-1990s on (see references at the end of this documentation), but it lacks the consistency of some passive microwave time series.

NIC sea ice analyses are produced by manual interpretation of data sources that include observations from ships, air reconnaissance, remote sensing data (visible, infrared, active, and passive microwave), and model output. They are generated primarily for mission planning and safety of navigation and are delivered online to military and civilian customers. Most NIC products are freely available via the [NIC website](#).

Browse images are available for this data product and can be viewed and visually compared via the Browse Image Spreadsheet Tool (BIST):

- [View/Compare Climatologies](#)
- [View/Compare Weekly Charts](#)

1.1 Format

These data are available as weekly/biweekly data files and as 35-year, 10-year, and 5-year climatologies.

1.1.1 Weekly/Biweekly Charts

The weekly NIC charts, for which the climatology files are based, are available in NA25 EASE-Grid (.bin) format and are also presented as quick look browse images in GIF format (.gif).

1.1.1.1 EASE-Grid Format

The files are flat binary, 1-byte unsigned byte data presented in the NSIDC NA25 EASE-Grid format (north azimuthal equal area projection, nominal 25 km resolution 361 x 361 grid). The values of the data are shown in Table 1. **Note:** Since this is single byte data, endianness is not applicable. EASE-Grid is a map and grid combination used for many gridded NSIDC data sets. The NA25 EASE-Grid is also referred to as the Polar Pathfinder AVHRR 25 km polar subset because the upper left corner pixel of this subset is at row 180 and column 180 of the full EASE-Grid Northern Hemisphere array of 721 rows by 721 columns. See [Summary of NOAA/NASA Polar Pathfinder Grid Relationships](#) and [NA25 grid](#) for more information on this projection and grid scheme.

1.1.1.2 Browse Images

The browse image files for the chart data are in GIF format (.gif).

1.1.2 Climatology Charts

The climatology data files are presented in two formats: EASE-Grid binary (.bin) and ArcGIS geodatabase (.mdb). The files are also presented as quick look browse images in GIF format (.gif).

1.1.2.1 EASE-Grid Format

The files are flat binary, 1-byte unsigned byte data presented in the NSIDC NA25 EASE-Grid format (north azimuthal equal area projection, nominal 25 km resolution grid) in a 361 x 361 grid. **Note:** Since this is single byte data, endianness is not applicable. EASE-Grid is a map and grid combination used for many gridded NSIDC data sets. The NA25 EASE-Grid is also referred to as the Polar Pathfinder AVHRR 25 km polar subset because the upper left corner pixel of this subset is at row 180 and column 180 of the full EASE-Grid Northern Hemisphere array of 721 rows by 721 columns. See [Summary of NOAA/NASA Polar Pathfinder Grid Relationships](#) and [NA25 grid](#) for more information on this projection and grid scheme. The values in the files are described in Table 1.

Table 1. EASE-Grid Climatology Data File Values

Value	Description
0 - 100	Ice concentration (percent) or frequency of occurrence (percent) (in multiples of 5)
108	Fast ice
157	Undigitized (appears in some early charts)
253	Areas not covered
254	Land

Parameter values are given in percent. That is, each grid cell has a value between 0 and 100 representing the percentage of ice concentration, except in the case of frequency of occurrence, where the percentage is the frequency at which ice at any concentration occurred over the climatological period. Fast ice is 100 percent concentration by definition.

Climatological fields are constructed using total concentration and fast ice information from individual charts prior to 1995, where the source data for the climatology are data in EASE-Grid from the EWG Atlas. In this data set, each chart for the period prior to 1995 is represented by a binary file with total concentration and fast ice information. Climatological fields constructed from charts beginning in 1995 have information on partial concentrations as well. These charts, where the source data are E00 files from NIC, are converted from WMO SIGRID egg code to five layers of information: total ice concentration, multiyear (MY) ice concentration, first-year (FY) ice concentration, new ice concentration, and landfast ice (pixel-by-pixel yes/no), following a convention established with the AARI 10-Day Arctic Ocean EASE-Grid Sea Ice Observations (Fetterer and Troisi, 1997). There are four files for each chart beginning in 1995: Fast ice has a unique value of 108 in all parameter files. See the Data Acquisition and Processing section of this document for information on how these ice type concentrations are constructed from the source data.

1.1.2.2 ArcGIS Format

The climatology products are also available in Environmental Systems Research Institute (ESRI) ArcGIS geodatabase (.mdb) format. These were created by reprojecting the EASE-Grid files from Lambert azimuthal equal area projection to a polar stereographic projection and converting them to geodatabases. See [Appendix A - EASE-Grid to GIS Steps](#) for a list of the steps taken to perform the conversion.

At present, the spatial data in ArcGIS geodatabase files can only be accessed using ESRI software.

The ArcGIS climatologies were created to match those already in use at NIC. Figure 1 is an example that shows the color palate used at NIC. This is a standard WMO color table for ice concentration (see Environment Canada, 2005, for a quick overview of this and other ice charting conventions). See [National Ice Center Sea Ice Charts and Climatologies in Gridded Format - Code Conversions](#), an Excel file, for a table with the mapping between EASE-Grid values, WMO egg code values, how these are represented in the ArcGIS files, and how they are mapped to the WMO concentration color code for the GIS files used at NIC ("WMO ice charts").

The ArcGIS products are in the same projection used by NIC. The projection is defined as follows:

Map Projection Name: Stereographic North Pole
Standard Parallel: 60.000000
Longitude of Central Meridian: 180.000000
False Easting: 0.000000
False Northing: 0.000000
Linear Unit: Meter (1.000000)
Angular Unit: Degree (0.017453292519943299)

Geodetic Model
Horizontal Datum Name: WGS 1984
Ellipsoid Name: WGS 1984
Semi-major Axis: 6378137.000000
Denominator of Flattening Ratio: 298.257223563

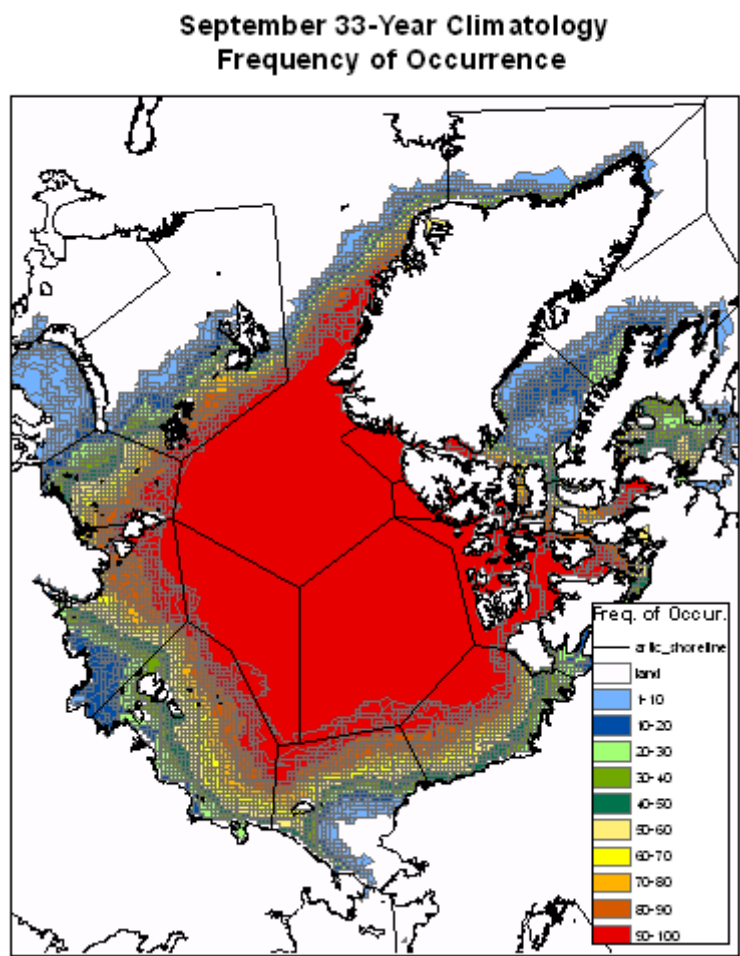


Figure 1. Example of an ArcGIS Frequency of Occurrence Data File
The values have been mapped to the WMO color table. Each polygon has a distinct value. The graphic can be overlaid on digital charts as the NIC analyst works (NIC analysis areas are shown).

1.1.2.3 Browse Images

Browse images for the climatology products are available in GIF (.gif) format and are displayed in two different styles: single images by month and concentration type or multiple images in tabular form of all concentration types (see Figure 2 and Figure 3, respectively).

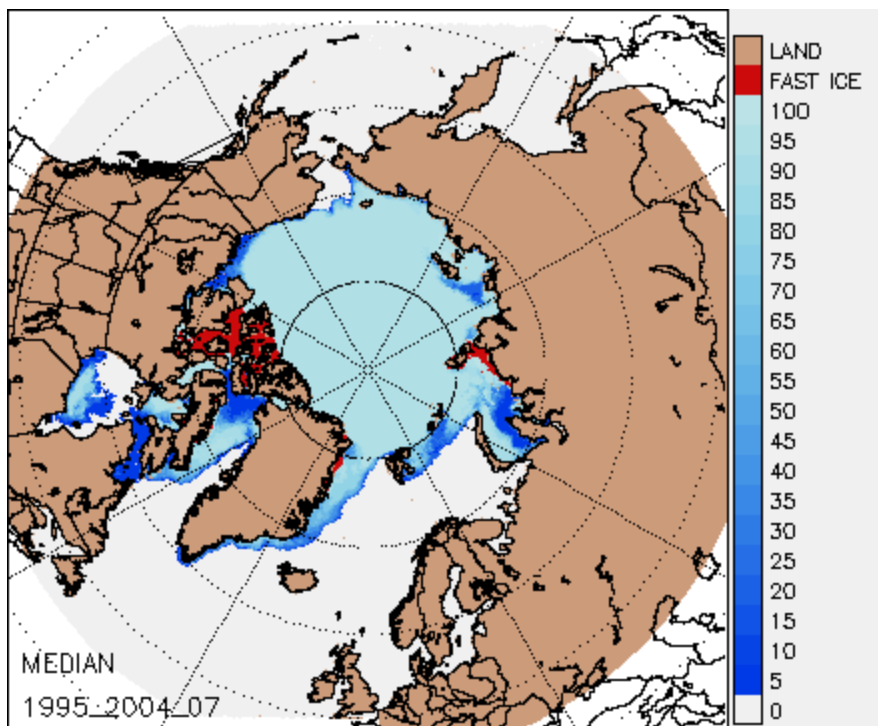


Figure 2. Browse image, nic_climo_1995_2004_07_med.v0.gif
This image shows the 10-year climatology median ice concentration file for July.

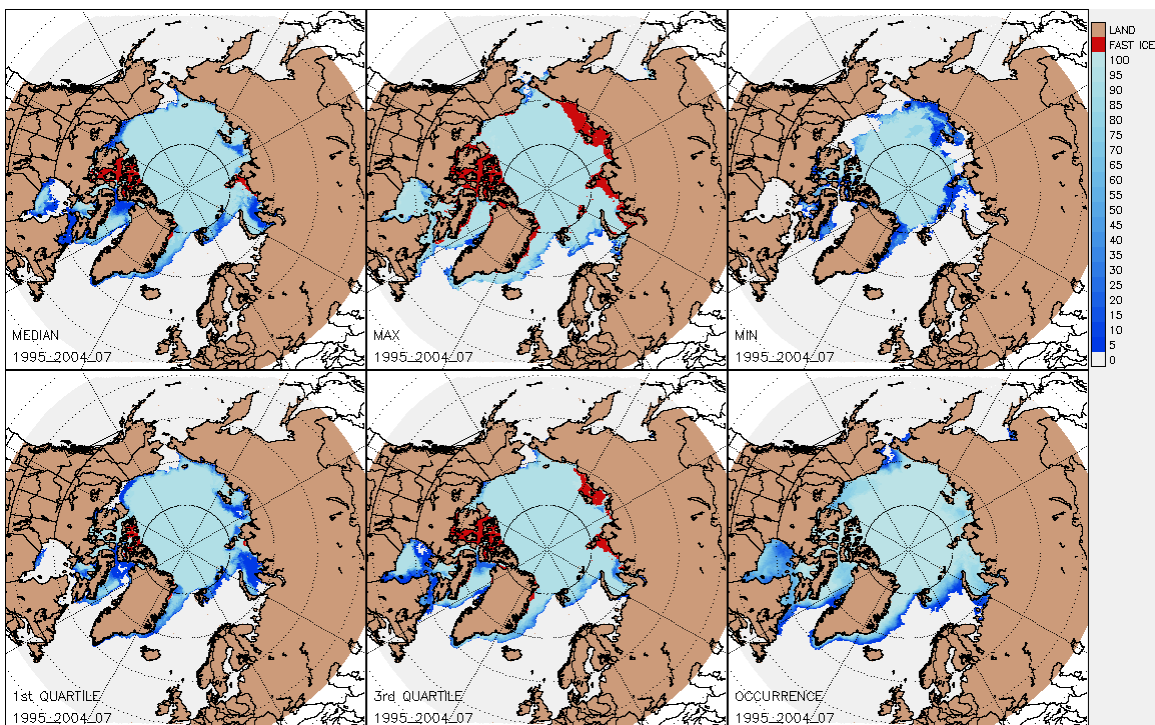


Figure 3. Browse image, nic_climo_1995_2004_07_all.v0.gif

Image shows all of the 10-year climatology products for a single month, July, in one image.

1.2 File and Directory Structure

The data are available on NSIDC's HTTPS site: <https://noadata.apps.nsidc.org/NOAA/G02172/>, in the G02172 directory. Within this directory, there are five subdirectories as described in Table 2.

Table 2. HTTPS Directory Structure

Directory	Description
binary	Contains all binary, EASE-Grid climatology files (.bin)
gifs_climo	Contains climatology product browse images (.gif)
gifs_weekly	Contains weekly and biweekly gridded chart browse images (.gif)
GIS	Contains all ArcGIS geodatabase climatology files (.mdb) in a single tar file (.tar)
weekly	Contains all binary, EASE-Grid weekly and biweekly chart data files (.bin)

Note: In the top-level directory (G02172), there are two tar files: G02172_binary.tar and G02172_gifs.tar. These files are provided as an easy option to download the entire data set in either binary or GIF format. The file G02172_binary.tar contains all of the binary format files that reside in the binary and the weekly directories. The file G02172_gifs.tar contains all of the GIF images that reside in the gifs_climo and gifs_weekly directories.

1.3 File Naming Convention

1.3.1 Weekly/Biweekly Chart Files

1.3.1.1 EASE-Grid Data Files and Browse Images

Both the EASE-Grid data and browse image chart files are named according to the following convention and as described in Table 3.

`nic_weekly_yyyy_mm_dd_ccc.vx.tag`

Table 3. Chart File Naming Convention

Variable	Description
nic	Identifies this as coming from the NIC sea ice charts
climo	Identifies this as a climatology file
yyyy	4-digit year
mm	2-digit month
dd	2-digit day of month
ccc	Ice type: tot: total myr: multiyear frst: first-year thn: thin
vx	Version number (v0: version 0)
tag	File format: gif: GIF format image file bin: binary (EASE-Grid) file

Note: The source data weekly charts from NIC are provided with a year and a chart number. NIC provides a lookup table for the chart number showing the date when each chart was produced. We have applied that lookup table and incorporated the date in the file name instead of the chart number.

1.3.2 Climatology Files

1.3.2.1 EASE-Grid Data Files and Browse Images

Both the EASE-Grid data and browse image climatology files are named according to the following convention and as described in Table 4.

`nic_climo_yyy1_yyy2_mm_ccc.vx.tag`

Table 4. EASE-Grid and Browse Image Climatology File Naming Convention

Variable	Description
nic	Identifies this as coming from the NIC sea ice charts
climo	Identifies this as a climatology file
yyy1	4-digit start year
yyy2	4-digit end year
mm	2-digit month
ccc	Concentration type: med: median max: maximum min: minimum 1st: 1st quartile 3rd: 3rd quartile occ: occurrence
vx	Version number (v0: version 0)
tag	File format: gif: GIF format image file bin: binary (EASE-Grid) file

1.3.2.2 ArcGIS Data Files

All of the ArcGIS climatology files are packaged into a single tar file (.tar) called `gis_seaice_climos.tar` on our HTTPS site.

Individual geodatabase (.mdb) files within the tar file are named according to the following convention and as described in Table 5.

`nic_climo_yyy1_yyy2_mm_ccc.mdb`

Table 5. ArcGIS Climatology File Naming Convention

Variable	Description
nic	Identifies this as coming from the NIC sea ice charts
climo	Identifies this as a climatology file
yyy1	4-digit start year
yyy2	4-digit end year
mm	2-digit month (Note: If the month is not present in the file name, that file has been "packaged up" and contains all the months of the year.)

Variable	Description
ccc	Concentration type: med: median max: maximum min: minimum occ: occurrence
.mdb	Identifies this as an ArcGIS geodatabase file

Note: Each .mdb file is accompanied by a directory with the same name, except with an extension of .idb. For example, the file nic_climo_1972_1974.mdb is accompanied by a directory called nic_climo_1972_1974.idb. The .mdb file and its .idb directory must remain in the same root directory in order to open the file using ESRI ArcGIS software.

Note: The first and third quartile concentrations are not provided in ArcGIS geodatabase format. They are only provided in EASE-Grid.

1.4 File Size

Weekly/Biweekly Chart Files

Table 6 lists the file sizes for the different weekly chart file formats.

Table 6. File Size of Chart Files

Format	Size
EASE-Grid binary (.bin)	130 KB each
Browse image (.gif)	14 KB - 20 KB each

Climatology Files

Table 7 lists the file sizes for the different climatology file formats.

Table 7. File Size of Climatology Files

Format	Size
EASE-Grid binary (.bin)	130 KB each
ArcGIS geodatabase (.mdb)	830 KB - 26.7 MB each
Browse image (.gif)	16 KB - 90 KB each

Note: The ArcGIS files reside in a single tar file (.tar) of 302 MB.

1.5 Spatial Coverage and Resolution

The data cover the Arctic with a resolution of 25 km x 25 km and bounded by the following lat/lon:
Southernmost Latitude: 45° N
Northernmost Latitude: 90° N
Westernmost Longitude: 180° W
Easternmost Longitude: 180° E

The EASE-Grid used here is a 361 by 361 grid of 25-km cells. The North Azimuthal (NA25) EASE-Grid is used. Refer to the Format section of this document and the [Summary of NOAA/NASA Polar Pathfinder Grid Relationships](#) Web page, by M. J. Brodzik, NSIDC, for more information. The nominal grid cell size is 25.067525 km x 25.067525 km. Few cells actually have these dimensions, but all cells have the same area.

Two geolocation files, [Na25_LAT_LSB.bin](#) and [Na25_LON_LSB.bin](#), are available that describe the 361 by 361 grid cell subset of the complete Northern Hemisphere EASE-Grid and contains the latitude and longitude of each grid cell. Refer to NSIDC's [Geolocating and Displaying EASE-Grid Data Sets](#) web page for more information.

The minimum latitude of the NA25 grid is 29.89694° N, and the maximum latitude is 90.00000° N. However, the sea ice chart files from 1972 through 1994 on the EWG Atlas only have information north of 45° N as a result of the original conversion from paper to SIGRID carried out at NCDC. The post-1995 concentration files also only have information north of 45° in order to match the EWG Atlas for the purpose of constructing the climatology.

The operational charts are created using a variety of source data with varying resolutions. When the charts from 1972 to 1994 were converted from a vector format to SIGRID format, they acquired a resolution of about 25 km. Refer to the History of Ice Chart Digitization section of this document for more information on SIGRID. The products on the EWG Atlas are at 25 km; so to match these products, the climatology products in this data set are also 25 km. However, charts after 1994 were acquired from NIC in vector format (.e00). With these, higher resolution gridded products are possible. Refer to Note on Resolution in the Data Acquisition and Processing section of this document for more information.

1.6 Temporal Coverage and Resolution

These data span 1972 through 2007. The climatology products are constructed from weekly (January 1972 through June 2001) or biweekly (July 2001 through December 2007) charts. There is a climatology that covers the entire series as well as 10-year and 5-year climatologies. Since the last 5-year climatology extends from 2000 to 2004, interim 5-year climatologies are available (for example, 2003 to 2007). There are also climatology products for the three year period at the

beginning of the series (1972-1974). See the File Naming Convention section of this document for more information on temporal coverage. The file name indicates the period covered by the file.

The charts in the weekly series are based on data that are not a snapshot of conditions but, rather, were assembled over several days. However, the analysts project information forward so the chart is valid on a given day (the day in its file name). [Special Report 13](#) and Dedrick et al. (2001) have more information on the process of creating a chart analyses.

In June 2001, NIC started producing the hemispheric (arctic wide) ice charts every other week instead of weekly.

1.7 Parameter or Variable

Sea ice concentration (fast ice identified separately) is the geophysical parameter of this data set. However, sea ice extent may be derived using the ice concentration files by summing the number of equal area EASE-Grid cells. This data set consists of gridded and vector (GIS-compatible) sea ice concentration climatology products in the following concentrations: monthly median, maximum, minimum, first quartile, and third quartile concentrations. It also consists of the frequency of occurrence of ice at any concentration for the entire period of record as well as 10-year and 5-year periods. Also included are weekly (January 1972 through June 2001) and biweekly (June 2001 through December 2007) ice chart files consisting of total concentration with fast ice coverage and concentration of first year ice, multiyear ice, and thin ice (for files after 1994). Interim 5-year files are also available. For example, the 2003-2007 files show the more current changes in sea ice than the 2000-2004 files. See the File Naming Convention section of this document for a list of all file types.

2 SOFTWARE AND TOOLS

The GIS files can be opened with any GIS software such as ArcGIS. The browse images can be viewed using any image reading software. The EASE-Grid binary files need special written software to be read.

The National Ice Center Climatologies and Weekly Chart Products browse files may be viewed, and climatological periods compared visually, using the Browse Image Spreadsheet Tool (BIST):

- [View/Compare Climatologies](#)
- [View/Compare Weekly Charts](#)

3 DATA ACQUISITION AND PROCESSING

Data files for the climatology came from two sources. For the period from 1972 to 1994, the 25-km EASE-Grid products from the EWG Atlas (Arctic Climatology Project, 2000) were used (EWG CD 1: `visual_atlas/sea_ice_data_sets/nic_7_day_grids/`). These files provide total ice concentrations, with no partial concentrations. For 1995-2004, weekly or biweekly ice charts in the ESRI E00 format were used. This series of chart files set was obtained from the NIC Public Arctic Archive in the Fall of 2005. EASE-Grid files were created from the weekly 1995-2004 E00 files, combined with the 1972-1994 EASE-Grid files, and used to generate the climatology products. These EASE-Grid formatted climatology products were then converted into ArcGIS geodatabases (.mdb). In 2008, the data set was updated through 2007.

Using two different data sources with different formats and resolutions was unavoidable (because the EWG Atlas is the only source for NIC's quality controlled pre-1995 arctic charts, and the charts on the EWG Atlas do not have a format and resolution in common with the NIC charts for 1995-2007). As a result, there are, unfortunately, discontinuities between the pre- and post-1995 data. These are discussed in the Quality Assessment section of this document.

3.1 Data Processing

3.1.1 Conversion of ESRI E00 Files to EASE-Grid

The E00 format is an ESRI proprietary format in ASCII. Detailed descriptions of the E00 format are available over the Internet. IDL routines were developed to extract the needed information from the E00 files to produce ice concentration files in EASE-Grid for years 1995-2007.

For our purposes, the E00 files consist of four parts:

1. Projection information
2. Locations of arc/line segments
3. Polygon information
4. Ice concentration information for each polygon

A polar stereographic projection is used by NIC for the generation of their operational ice charts. The E00 files primarily consist of the geographic locations of arcs or line segments. The polygon information details which arcs are needed to make a polygon. Finally, there is a SIGRID code for every polygon. Querying the polygon would reveal the string of SIGRID needed to encode that polygon's egg code.

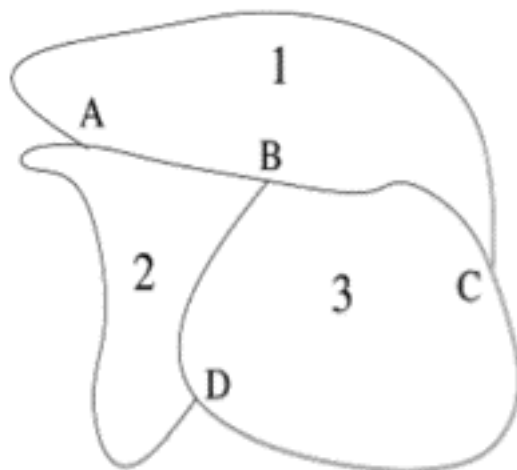


Figure 4. Simple ARC/POLYGON example.

A simple example is shown in Figure 4. Polygon 1 is made up of arcs A-B, B-C, and C-A, polygon 2 is made up of arcs A-B, B-D, and D-A, etc. The arcs are initially in a polar stereographic projection as false eastings and northings in meters from the North Pole. (ArcGIS uses false eastings and northings as a way of describing the position of a point relative to an origin). An intermediate file is created that includes each polygon in a projection independent form using latitude and longitude coordinates and the SIGRID code for each polygon. This intermediate form allows final mapping at variable resolutions depending upon a user's needs. This process is fairly straightforward except for one variation. A "hole" such as an island may lie within the polygon. The detection and processing of the holes complicated processing routines.

The intermediate files are used for mapping the ice concentrations. At this point, any projection and resolution could be used. For the climatology products, the EASE-Grid at 25-km resolution (NA25) was used in order to match the resolution and format of the files available on the EWG Atlas. The polygon latitudes and longitudes were converted to pixel locations, and each polygon was drawn and filled with the appropriate ice concentration taken from the SIGRID code.

Each EASE-Grid chart for weekly charts and climatology products after 1994 consists of five layers of information: total ice concentration, multiyear (MY) ice concentration, first-year (FY) ice concentration, thin ice concentration, and landfast ice (pixel-by-pixel yes/no), following a convention established with the AARI 10-Day Arctic Ocean EASE-Grid Sea Ice Observations (Fetterer and Troisi, 1997). See Table 8. Charts prior to 1995 contain only total and fast ice information. Figure 5 shows an example of a data file containing partial concentrations.

Table 8 shows the correspondence between EASE-Grid file layers and SIGRID encoded stage of development, for files from 1995 on. In effect, the partial concentrations are categorized into three

types: multiyear ice (2 - 4 m thick), first-year ice (30 cm - 200 cm thick), and thin ice (less than 30 cm thick). Thickness ranges are those established by the WMO ice classification scheme.

Table 8. Correspondence Between EASE-Grid and SIGRID

Ice concentration by type (EASE-Grid)	Stage of development in source data (SIGRID)
Total ice concentration (all types)	Total ice concentration (all types)
Multiyear ice	Old ice 2nd year ice Multi-year ice
First-year ice	First year ice (FYI) Thin FYI Thin FYI _ stage1 Thin FYI _ stage2 Medium FYI Thick FYI
Thin ice	New ice Nilas, ice rind Young ice Gray ice Gray-white ice
Fast ice	Ice form (landfast ice is the only form)

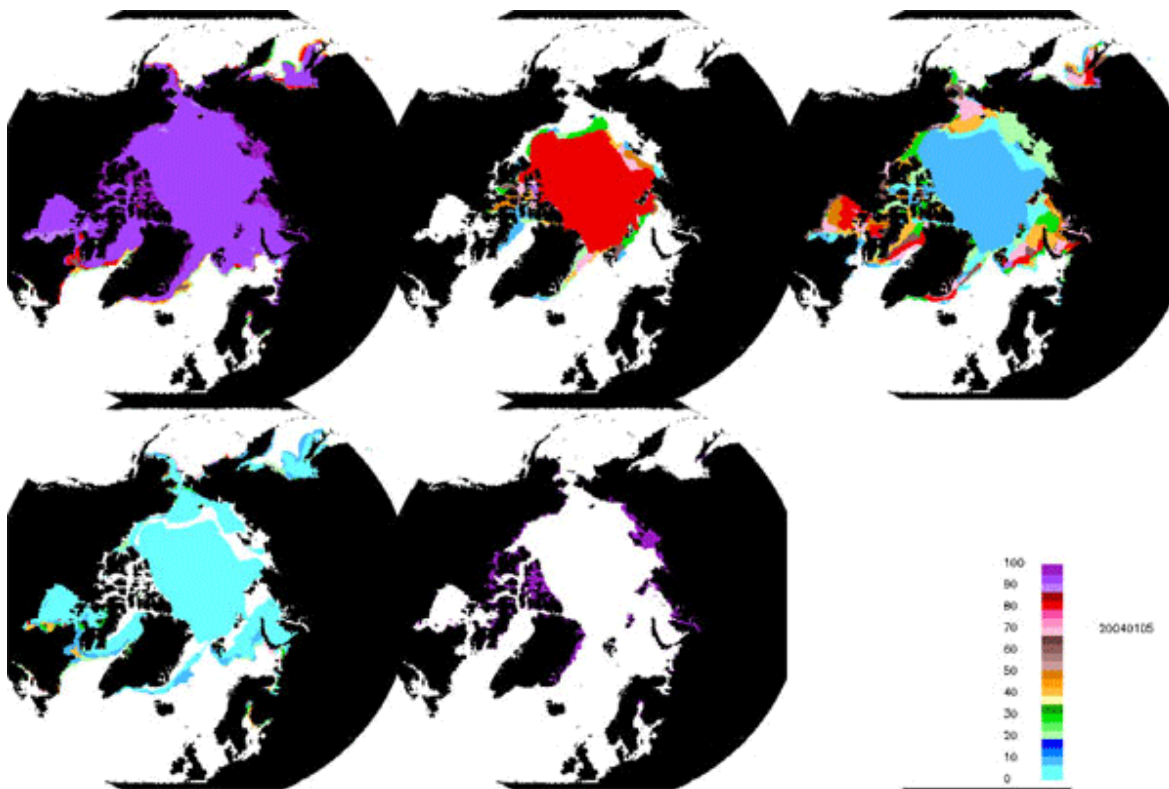


Figure 5. Data File Showing Partial Concentrations

An EASE-Grid file from 5 January 2004 was used to create these images by applying a color bar to the binary data for each of the five layers. From upper left, total ice concentration, multiyear, first-year, new ice, and fast ice partial concentrations. The color bar shows concentrations.

Sea ice charts often use ranges for ice concentration. A typical SIGRID code might be: CT79CA609599CB209199. The value after CT indicates the total concentration, in this case 79 meaning the concentration is between 70 and 90 percent. This is translated to 80 percent for the corresponding EASE-Grid cell. Other SIGRID values might be 70 for 70 percent, 91 for between 90 and 100 percent, and 92 for 100 percent. The corresponding value used to fill the EASE-Grid cell is always the average value if the concentration given is a range between two values. In the SIGRID code, the CA refers to the concentration of the first thickest ice. In the example CA609599, 60 is the concentration of this ice type, 95 denotes old ice, and 99 is undetermined or unknown floe size. These partial concentrations should, but do not always, sum to the same value as the total concentration. Table 9 summarizes how EASE-Grid files encode SIGRID.

Table 9. Codes and Values for Ice Concentrations

Ice Concentration from Egg Code	SIGRID Code	EASE-Grid Product Value for % Concentration
Ice free	00	0
Less than 1/10 (open water)	01	5
Bergy water	02	5
1/10	10	10
2/10	20	20
3/10	30	30
4/10	40	40
5/10	50	50
6/10	60	60
7/10	70	70
8/10	80	80
9/10	90	90
More than 9/10, less than 10/10	91	95
10/10	92	100
Concentration Intervals (CI = lowest concentration in interval (Ch = highest concentration in interval)	CICh	
Examples:		
1/10 - 3/10	13	20
4/10 - 6/10	46	50
7/10 - 9/10	79	80
7/10 - 10/10	71	85

3.1.2 Note on Resolution

Vector data do not have an inherent resolution and can be converted to a raster grid format at any desired resolution. SIGRID raster data are limited in that a point within a grid cell represents the entire cell, and the shape of the boundary between regions is lost. Kokaly (1996) addresses some considerations of sea ice chart data conversions, and notes that in converting from "true" SIGRID (with 15-minute nominal resolution) to EASE-Grid an EASE-Grid cell size of 12.5 km, rather than 25 km, should be used in order to avoid losing concentration information. Unfortunately, the vector files that NCDC created from the 1972-1994 paper charts were inadvertently discarded after SIGRID files at 25-km nominal resolution were created ([Special Report 13](#)), so 12.5 km (or finer) resolution charts for this period are not possible without re-digitizing the paper charts. The GIS

format files on the EWG Atlas were created using these 25-km SIGRID files; so, they offer no better resolution.

The primary problem of converting vector data to raster format can be seen in Figure 6. Assume two polygons A and B. If a 4 by 4 grid is overlaid on the polygons, should the colored grid cells be assigned to have the ice concentration information from polygon A, polygon B, or an intermediate value? For this product, no mixing or averaging was done. In converting the E00 files from 1995 to EASE-Grid, the last polygon processed contributes its concentration values to the overlapping grid cells. Note that this can have the effect of shifting boundaries between regions of the same ice characteristics.

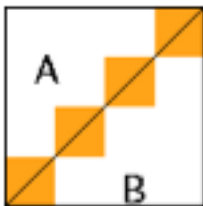


Figure 6. An illustration of the vector to raster conversion problem.

3.2 Quality Assessment

A detailed quality assessment of this data set has not been completed. However, it is possible to make some generalizations, drawing heavily on two studies based on EWG Atlas data (Dedrick et al., 2001, and Partington et al., 2003). The history of changes in data sources and charting practices is also relevant.

3.2.1 Accuracy and Precision

The accuracy and precision of the original charts is not known with certainty. Partington (2003) cites ± 5 percent to ± 10 percent as the accuracy of ice concentration estimates. Total ice concentration for an individual polygon is recorded in a range. That range is expressed in tenths. The mean value of that range is used in the EASE-Grid files. Thus, the precision can vary from grid cell to grid cell depending on the range with which the concentration was originally charted.

An analysis by H. Stern, University of Washington (personal communication, 2005) indicated that fast ice information is unreliable prior to 1976.

Geiger (2006) published an error analysis of NIC's Antarctic charts.

Meier et al. (2006) compared NIC charts with passive microwave concentrations in a poster titled *Operational sea ice charts: An integrated data product suitable for observing long-term changes in Arctic sea ice?* available on NSIDC FTP at ftp://ftp.nsidc.org/pub/ppp/conf_ppp/Meier/.

3.2.2 Strengths and Weaknesses

The primary strength of the NIC chart series is that the charts were 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. NIC 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 estimated to be accurate to within about +/- 10% (Partington, 2003). Ice type (stage of development) is more difficult to gauge. High resolution visible and IR imagery, and especially SAR imagery used to distinguish MY 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 chart series is inconsistency in the quality of the analyses. Such inconsistency arises from a number of sources. However, it is important to note that the operational source data from NIC received additional quality control by NIC before being added to the archive for this product.

Sources of inconsistency include the following:

1. Increasing number of data sources for analysis, increasing resolution and volume of satellite data, evolving analysis systems.

In the 1970s, analysts often had to make educated guesses based on climatology or persistence. As data sources grew to include active as well as passive sensor data, analysts could chart ice in increasing detail, as suggested by Figure 7 and Figure 8.

From 1972 through 1979, only total concentration was recorded. Analysts depended heavily on visible, infrared, and single channel passive microwave imagery. Passive microwave data from SMMR and SSM/I were added in 1980 and 1989 respectively. In 1990, NIC's first computer assisted production system (DIFAS1) was fully installed. In 1991, NIC began to use OLS visible

and IR imagery, with roughly .5-km resolution, versus the 1-km resolution of already available AVHRR. In 1992, increasing use of digital data along with improved prediction models made it possible for analysts to break down the amount of ice at each stage of development; or in other words, report partial concentrations for each ice type (this advance happened later, in 1994, for Antarctic data, although it has been restricted to the Ross Sea region since 2000).

NIC began to use ERS-1 SAR (at 240 m resolution) in 1995, and RADARSAT-1 (at 200 m, 100 m, and 25 m resolutions) in 1996, while continuing to add to the capabilities of its computer system for image analysis and beginning to move toward a GIS production environment. Scatterometer data (QuikSCAT) was added in 2004.

More recently, beginning in 2005, Moderate Resolution Imaging Spectroradiometer (MODIS) and Envisat Advanced SAR (ASAR) Global Monitoring Mode (GMM) data have been available to analysts. In January 2006, the NIC installed the Satellite Image Processing and Analysis System (SIPAS), an almost completely ESRI-based analysis and production system, which allows the analyst to both analyze imagery and produce spatial data (ice chart) files in a common environment.

Average Number of sea ice polygons per NIC (Northern Hemispheric) Chart

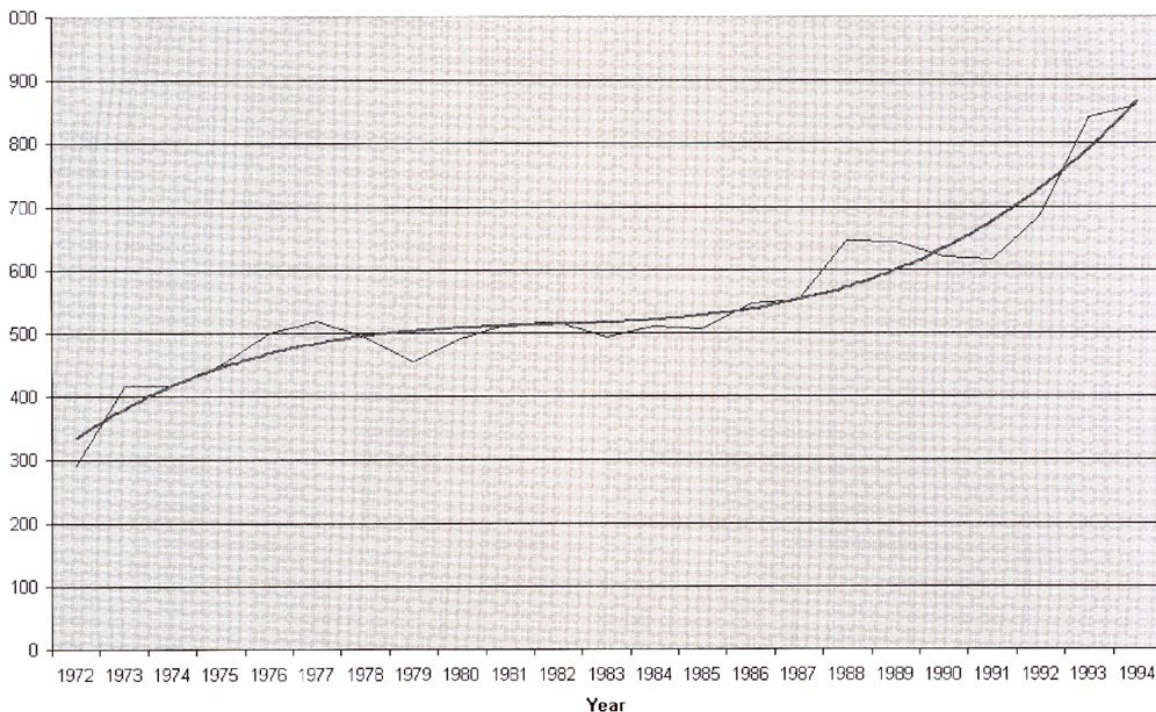


Figure 7. Average Number of Sea Ice Polygons per NIC (Northern Hemisphere) Chart
 Increasing ice chart detail over the record period on the EWG Atlas (1972-1994) is represented by the increasing number of polygons in each ice chart. From Dedrick et al. (2001).

Thematic Content of NIC Sea Ice Charts By Year

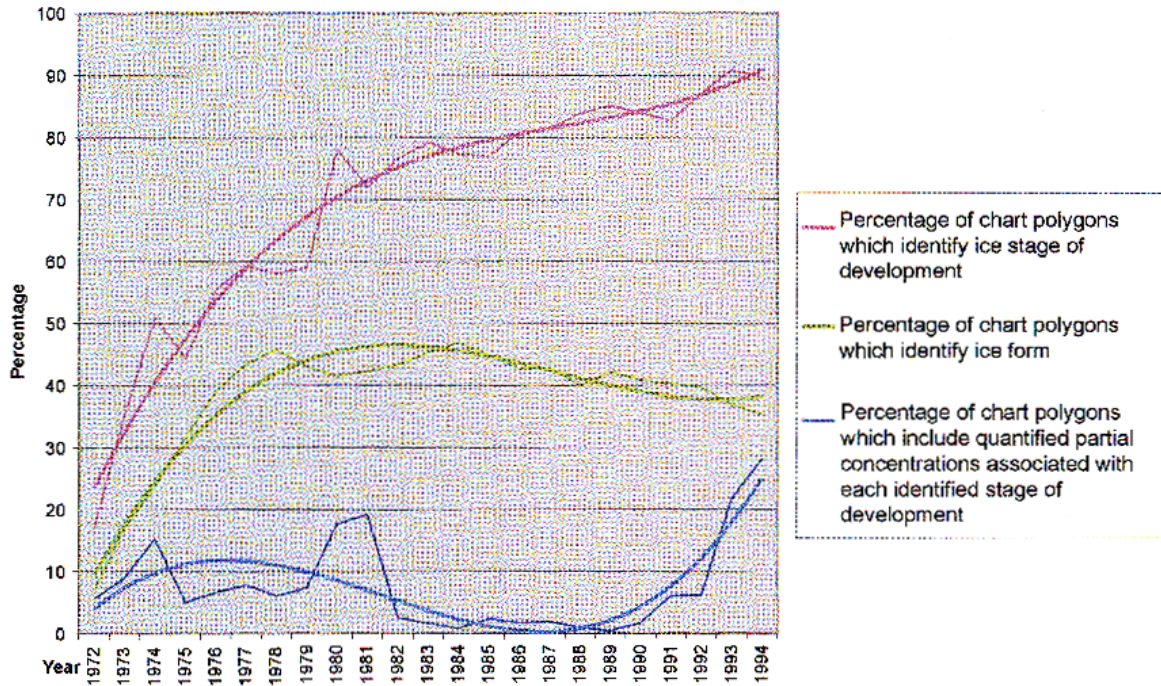


Figure 8. Thematic Content of NIC Sea Ice Charts by Year

Increasing ice chart information content over the record period on the EWG Atlas (1972-1994). From Dedrick et al. (2001).

2. The operational nature of chart production.

Charts produced to support operations or in areas of high national interest are naturally created with more attention to detail and often with greater frequency. Usually, the ice edge; marginal ice zone; and seas such as the Bering, Chukchi, and Beaufort that have important U.S. economic activity are given a higher priority than the central Arctic, where operations take place less frequently.

A large proportion of the NIC analyses are produced by analysts who are military personnel on two to three year rotations. Analysts vary in skill and level of training, thus a consistent bias in a particular analyst's output is possible. In order to mitigate this effect, the analyst training curriculum was codified and standardized in the early 2000s.

3. Changes in analysis conventions or procedures

Prior to 1976 and after 1986, pack ice in the central Arctic was charted as 9 to 10 tenths concentration, if not known to be otherwise (Partington et al., 2003). Between those years, such ice was labeled 10 tenths. Therefore, the central Arctic area concentration may be labeled in the SIGRID code as 92, meaning 100 percent, or 91 for between 90 and 100 percent. In the EASE-Grid files, this is either 95 percent or 100 percent concentration.

There have been no changes in the convention of charting the ice edge as the boundary between no ice and ice of any concentration including concentrations of less than 10 percent.

Fast ice has been charted continuously, but the information appears to be unreliable prior to 1976 (H. Stern, personal communication, 2005). When fast ice breaks up, it is classified as either FY or MY ice, but this designation may not be consistent with the ice type it was assigned before becoming fast ice, if any. If the ice was MY when the fast ice formed, then the MY stage would be carried through in the resulting polygon for the fast ice area. If the fast ice formed from young or new ice, normally it would hold together until reaching a first year stage of development, thus it would naturally not be the same stage during breakup as during freezeup (P. Seymour, personal communication, October 2006.)

After 1994, all polygons carried partial concentrations (See Figure 5). Only total concentration was consistently reported over the entire operational chart period.

There have been no changes through 2004 in the convention of recoding all ice in stages of development younger than second year to old ice on 1 October of each year. (However, beginning in October 2005, NIC adopted the CIS practice of recoding younger types to second year, and second year to MY on 1 October in much of the Western Arctic)

For 1972 through 1994, NIC produced separate Eastern and Western Arctic charts. The Western Arctic chart was produced on Tuesday and the East Arctic on Wednesday. (On the EWG Atlas these are combined into one Arctic-wide file). By 1996, NIC began producing thirty-nine non-overlapping regional charts like those in Figure 15. These were combined into an Arctic-wide file for the online archive, with boundaries between regions matched for consistency. Beginning in January 2006, however, NIC adopted a new architecture whereby the hemispheric analysis is created first with the regional charts cut out after the entire hemisphere is completed.

NIC changed from producing charts on a weekly basis to biweekly chart production in mid-June 2001.

In June 2003, the North American Ice Service (NAIS) was formed. Under the NAIS umbrella, CIS, NIC, and the International Ice Patrol (IIP) are working together toward harmonizing Canadian and U.S. charting practices and operations in support of the joined U.S. and Canadian ice requirements. More changes in charting practices over the coming years will result.

4. Introduction of error from data transformations and regridding.

The transformation of chart data from paper or vector format to gridded format results in some unavoidable loss of information and introduction of error. These have not been quantified. The

documentation related to the precursor data sets offers information relevant to understanding this source of error. Also see the Note on Resolution in the Data Processing section.

The climatology products on the EWG Atlas precursor data set used 25-km resolution weekly data, obtained by hand digitizing paper ice charts. Later, post 1994 weekly data in vector interchange (.e00) format allowed ice concentration to be represented at a much finer resolution. We encountered difficulties, partially resolved at this time, in merging these two data sources related to differences in the representation of land. Land is masked (actually embedded in the source data) at differing resolutions (and may have been determined differently in the EWG products); and when transferred to a common 25-km grid for this data set, differences can remain. Figure 9 shows an example for the Canadian Queen Elizabeth Islands. At the time of publication of this data set (October 2006), our solution is to merge the land masks by creating a new land mask where either of the old masks had land. Preliminary testing has shown this to be only a partially acceptable solution, especially in the study of relatively small areas of fast ice near the coast.



Figure 9. An example of the difference in the source data land mask for pre and post 1995 data. Black is land in both masks, white is non-land in both. Yellow is land in the older mask but not the newer, and red is land in newer mask but not in older. The area shown is a portion of the Canadian Queen Elizabeth Islands.

3.2.3 Discontinuities

The factors listed above result in inconsistency, but not necessarily in discontinuities. Based on preliminary analysis, a discontinuity probably resulted from changes taking place over the period 1994-1997. We believe that total concentrations before 1997 are biased low relative to those after, due primarily to the lack of high resolution active microwave data for tactical use before that year (T. Street, personal communication, September 2005). Other changes from 1994 to 1997:

- NIC transitioned to digital imagery analysis tools for OLS and AVHRR imagery in 1996 and 1997.
- NIC began creating regional analyses rather than hemispheric or semi-hemispheric analyses.
- Source files for this data set changed from the EWG Atlas EASE-Grid files to ArcInfo interchange (.e00) files from NIC.

Other discontinuities are noted in the Changes in Analysis Conventions or Procedures section of this document.

3.2.4 Errors Discovered After the October 2006 Publication of the Data Set

Users working with the chart data have found the following errors, as of 20 January 2007.

- There are errors in partial concentration fields. It is important to note that the corresponding total concentration fields do not have errors. Thus, while the total concentration fields are correct, the thin, FY, and MY fields do not sum to the total concentration values when errors in one or more of the partial concentration fields are present.
- There may also be some error in the MY fields, particularly during 1997 through 1998 where the values are higher than other years. This needs to be investigated further. Examples include MY ice appearing and disappearing suddenly along the coasts of Labrador and Newfoundland in 1995 (starting 21 March), in 1997 (starting 17 March), in 1999 (starting 31 May) and in 2002 (starting 18 March).
- Throughout 1997, thin ice appears and disappears in an unrealistic fashion. In Baffin Bay and Hudson Bay in 2001, thin ice disappears on 12 March, 19 March, and 2 April.
- On the chart of 1978_01_22, there is a large section in Hudson Bay and Baffin Bay with pixels coded with a value of 157. This value represents *undigitized* in SIGRID code. On the chart of 1979_05_29, in about the same area, there is a large area of 0 percent or 5 percent concentration, when the concentration should be much higher over most of the area. These errors, combined, resulted in a 1 to 3 mill. sq. km. underestimate of total extent (W. Meier, personal communication, 17 Nov 2006).

The above errors in partial concentrations are in the E00 source files and are not a result of processing. Two errors that apparently resulted from processing have been noted and further investigation is underway:

- The thin ice and total concentration files for 1999_12_20 are erroneous: thin ice is falsely present over the entire Baltic Sea and the Gulf of Bothnia, and total concentration is erroneous.
- The fast ice and total concentration files for 2000_04_24 are erroneous: Fast ice is falsely present over the entire Baltic Sea and the Gulf of Bothnia, and total concentration is erroneous.

See the poster titled *Operational sea ice charts: An integrated data product suitable for observing long-term changes in Arctic sea ice?* by Meier et al., available on NSIDC FTP at ftp://ftp.nsidc.org/pub/ppp/conf_ppp/Meier/, for more information on data set inconsistencies.

3.3 NIC Sea Ice Chart Production and Relevance for Research

From 1972 through 1995, weekly charts were produced manually on paper or other hard copy material. (Whereas products were produced in analog format, satellite images were displayed and enhanced or analyzed digitally using custom image analysis software beginning in about 1990.) Three analyses were available: Western Arctic, Eastern Arctic, and Antarctica. (See **Figure 10**). A larger scale Alaska Regional chart was also produced between two and three times per week. This included the Bering Sea and Cook Inlet as well as the southern portions of the Chukchi and Beaufort Seas. Beginning in 1996 and extending into 1997, NIC began to produce regional analyses for all Arctic areas. One reason for this was the growing availability of high-resolution synthetic aperture radar (SAR) data (Bertoia et al., 1998). SAR imagery made detailed analyses possible. At about the same time, NIC began to use GIS systems for analyses, starting with Geographic Resources Analysis Support System (GRASS) software in 1996 and moving to Environmental Systems Research Institute (ESRI) Arc/Info software.

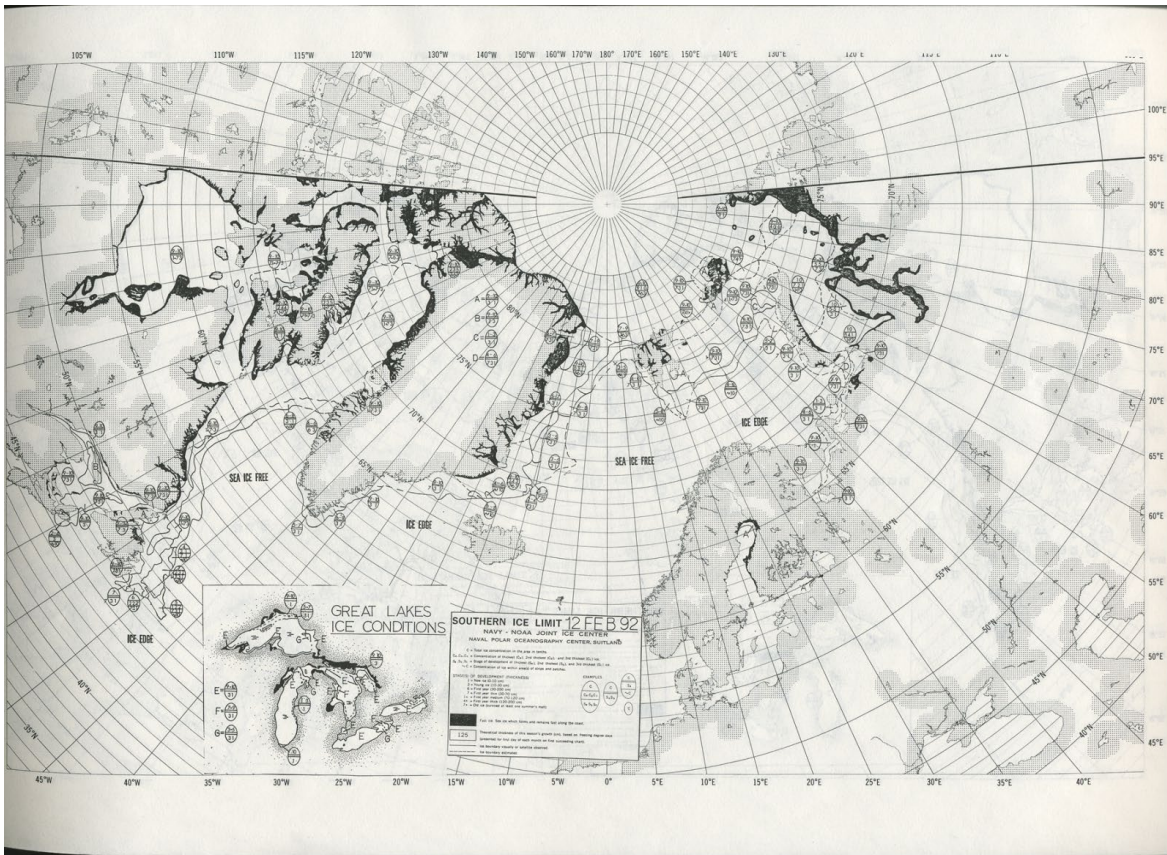


Figure 10. Scan of a NIC Western Arctic Analyses from February 1992

The dashed lines indicate areas for which ice conditions are estimated or inferred because data are not available. Generally, this is due to cloudiness.

In the late 1990s, after production had mostly shifted to a digital environment, NIC suspended production of charts that covered all of the Eastern and Western Arctic because the products were less useful operationally than smaller format regional charts. However, NIC began to produce a hemispheric (Arctic-wide) product in addition to the regional analyses. This product line was created in response to a request from NSIDC and the World Climate Research Program (WCRP) Climate and Cryosphere (CliC) Project speaking on behalf of researchers who valued the Arctic-wide snapshot and timely nature of the NIC paper chart analyses.

Figure 11 and Figure 12 give an overview of how NIC charts were produced in 2006. Information is integrated and charts are produced within a customized GIS environment. More information on changes in charting practices can be found in the Quality Assessment section of this document.

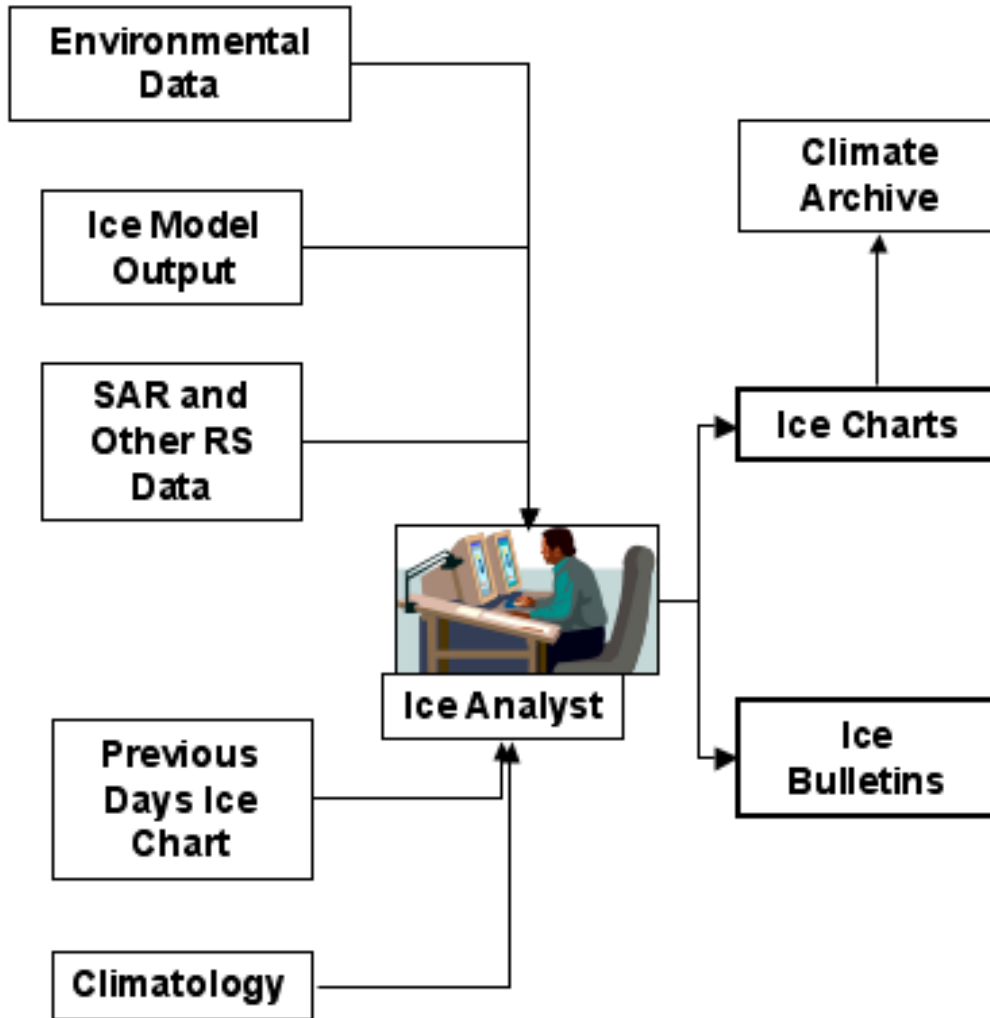


Figure 11. Flow Chart of NIC Ice Chart Production
Information from satellite and other data is extracted manually and visually mostly by NIC analysts who manually assimilate the information into operational products.

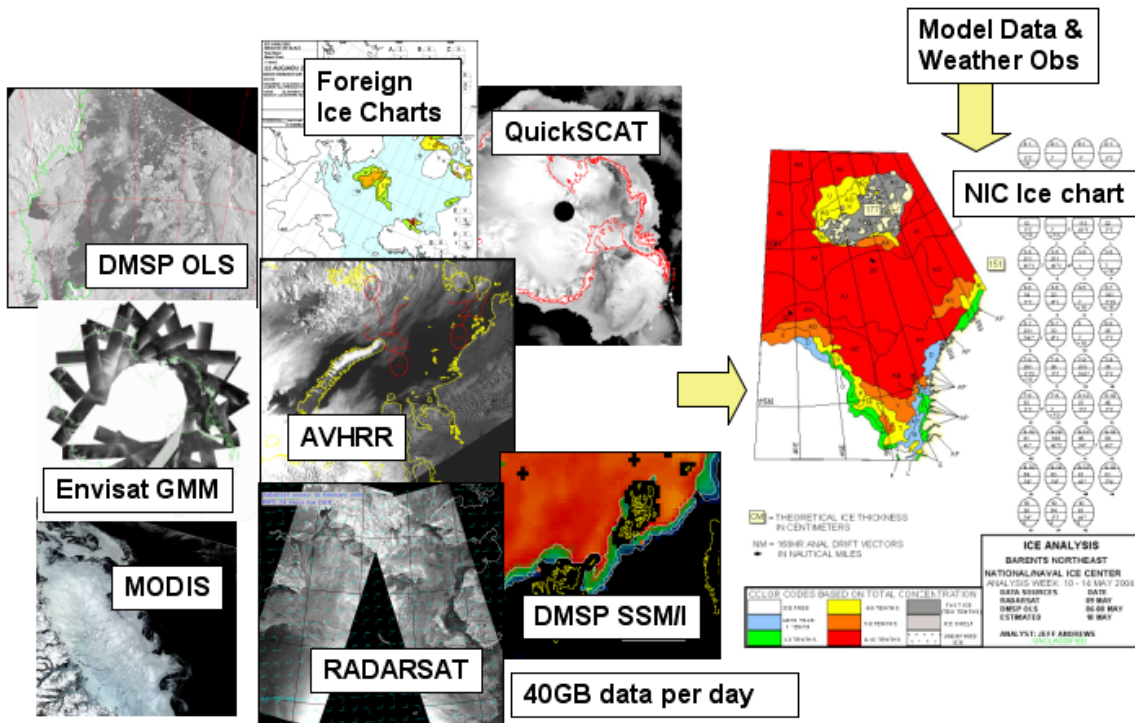


Figure 12. Pictorial Representation of NIC Ice Chart Production

Data for NIC analyses are available from many sources in varying coverages and resolutions (left). Data are manually integrated, resulting in highly detailed regional ice charts (right).

While the NIC sea ice analyses are operational products, they have application for scientific studies. The operational chart series begins in 1972, six years before the ice concentration record that is derived from the Scanning Multichannel Microwave Radiometer (SMMR) and the Special Sensor Microwave/Imager (SSM/I) passive microwave instruments. Passive microwave ice concentration data underestimate sea ice concentration. This is particularly true in the summer due in part to melt ponding on the sea ice surface (Comiso and Kwok, 1996; Fetterer and Untersteiner, 1998). Ice charts consistently depict more ice than shown by passive microwave data alone, with a seasonally varying difference (Partington et al., 2003). However, NIC analysts do use passive microwave concentrations when other information is unavailable - thus the charts are not completely independent of passive microwave data. Canadian Ice Service charts, which do not rely on passive microwave data, show even larger differences when compared with passive microwave data (Agnew and Howell, 2003). Sea ice chart concentration data can be used to provide a bias correction to passive microwave data and have been used for that purpose in reanalyses (Rayner et al., 2003).

Ice charts are more accurate and detailed at the ice edge than passive microwave data because they are often made using higher resolution data. Also, analysts pay particular attention to regions near the ice edge because the characteristics and extent of ice in the marginal ice zone are

important for operations taking place within or near that region. (Conversely, analysts generally do not characterize the central Arctic with as much attention to detail, because most of the time there are no supported operations there.) Figure 13 is an illustrative example of how ice concentration from charts may differ from concentration from passive microwave data.

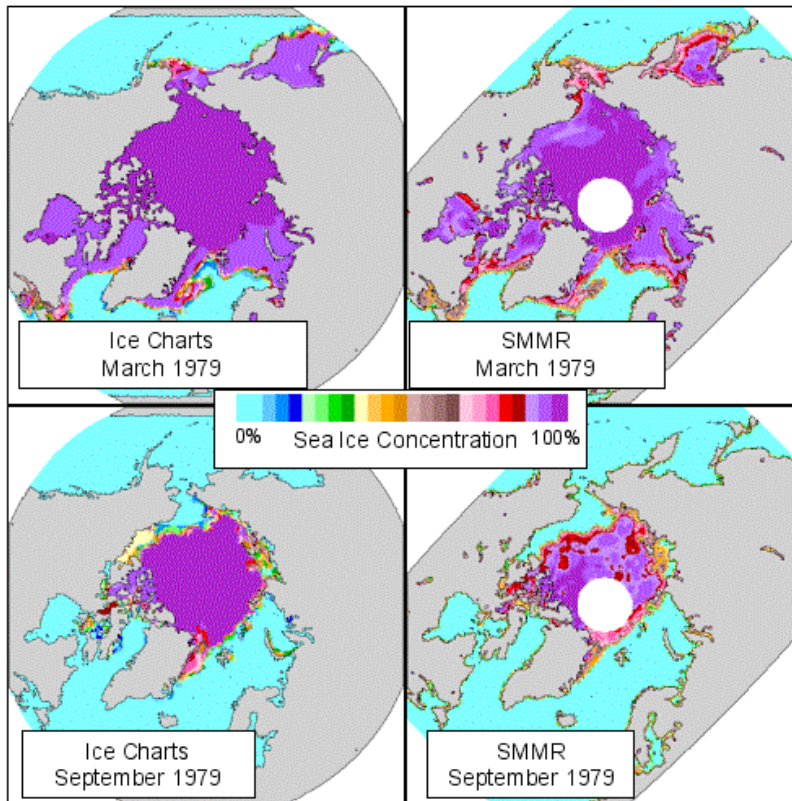


Figure 13. Differences in NIC Charts and Passive Microwave Data
 An example of how ice concentration from NIC ice charts and from SMMR passive microwave data tend to differ. The ice chart images are averages over the four weekly charts for the indicated month. The SMMR images are from the NASA Team ice concentration algorithm. The greatest differences are seen in coastal areas and at the ice edge. There are also large differences in the central pack, where SMMR derived concentrations are inaccurately low, especially in summer. Figure courtesy of H. Stern, December 2005.

NIC has been involved in a number of efforts to make operational ice chart data in general, and NIC charts in particular, more useful for scientific applications. These include participation in the [Global Digital Sea Ice Data Bank \(GDSIDB\)](#) at the Arctic and Antarctic Research Institute, St. Petersburg, Russia; the [International Ice Charting Working Group \(IICWG\)](#) with its research component; and two previous efforts to provide NIC charts in digital form for research use. These

resulted in the data products on the EWG Atlas CD-ROM described in the Precursor Data Sets section of this document.

3.4 History of Ice Chart Digitization

Sea ice charts are 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, NIC only uses the fast ice form in its charts. World Meteorological Organization (WMO) designations are used for sea ice stage of development and ice form. See WMO (1970) and the NSIDC [All About Sea Ice](#) pages and [Glossary](#) for more information on ice types. The Canadian Ice Service (CIS) Manual of Standard Procedures for Observing and Reporting Ice Conditions, or MANICE (Environment Canada, 2005), has a good explanation of how ice information is encoded using the egg code. Figure 14 summarizes the information that can be encoded.

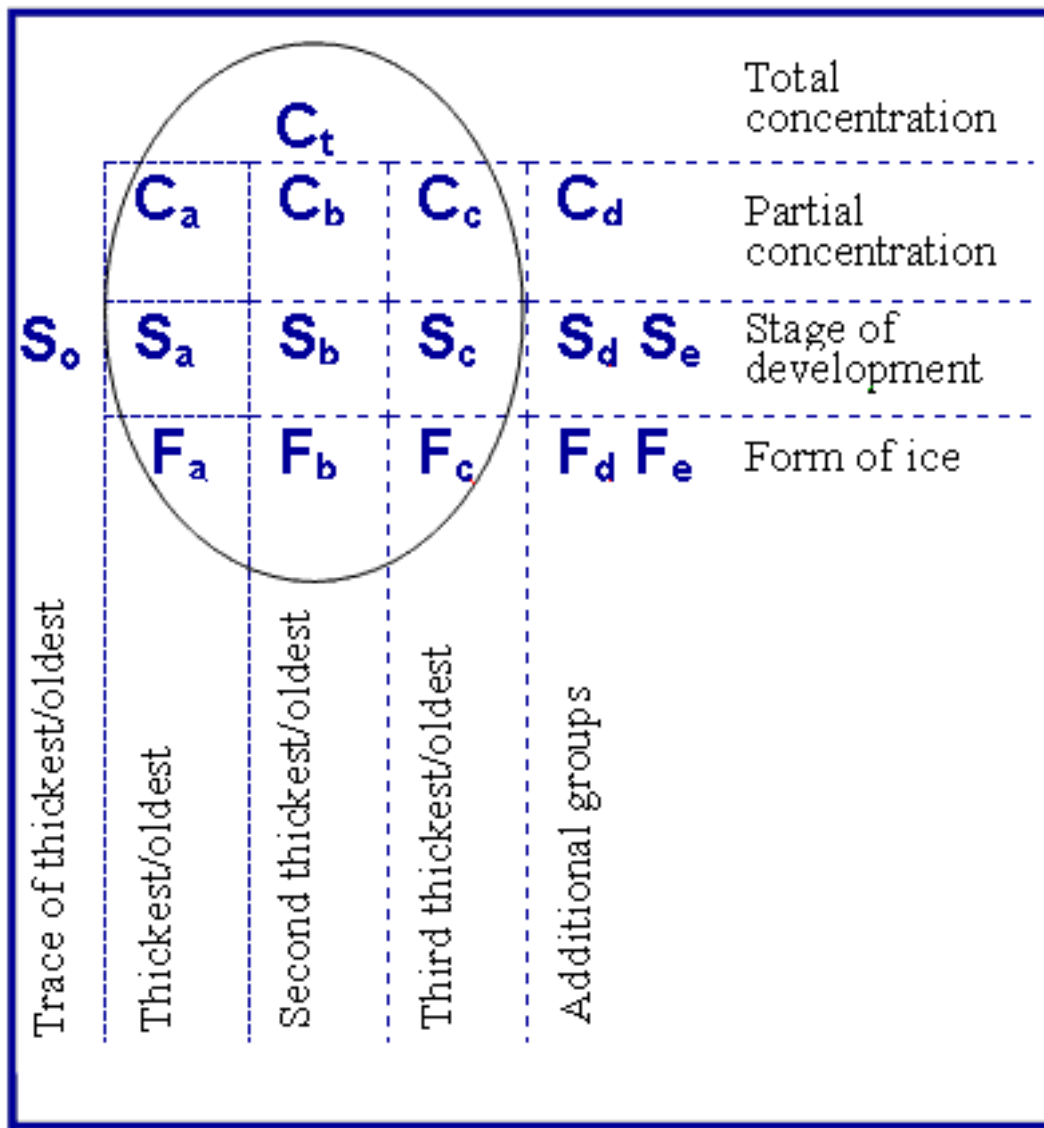


Figure 14. Diagram Describing the Egg Code

After a figure in the Manual of Standard Procedures for Observing and Reporting Ice Conditions (MANICE), Environment Canada, 2005. Used with permission.

Ice services around the world implement the egg code in differing ways depending on what information the charts routinely capture. NIC charts, for example, have never contained C_d, S_e, F_d, or F_e information, but NIC often uses S_o and S_d. See MANICE (Environment Canada, 2005) for more information on these codes.

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) (Thompson, 1981) 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 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. Several ice services have adopted a vector archive format, SIGRID-3, that overcomes this limitation (Intergovernmental Oceanographic Commission, 2004). See [GDSIDB Data Formats](#) for an overview of SIGRID development and related references.

As NIC moved to producing ice charts in a GIS environment, NIC continued to label areas of ice having similar characteristics (these areas are called polygons in the GIS environment) using the egg code (Figure 15 and Figure 16). However, 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 16).

Originally, ice charts were digitized to archive them and to make them easier to use for research. Now, with charts produced in a digital environment, there is less of a distinction between operational or vector format and archive or research format. However, many NSIDC users continue to request charts in gridded rather than the operational vector format. A further distinction in the case of this data set is that the source charts received additional quality control by NIC before being added to the archive.

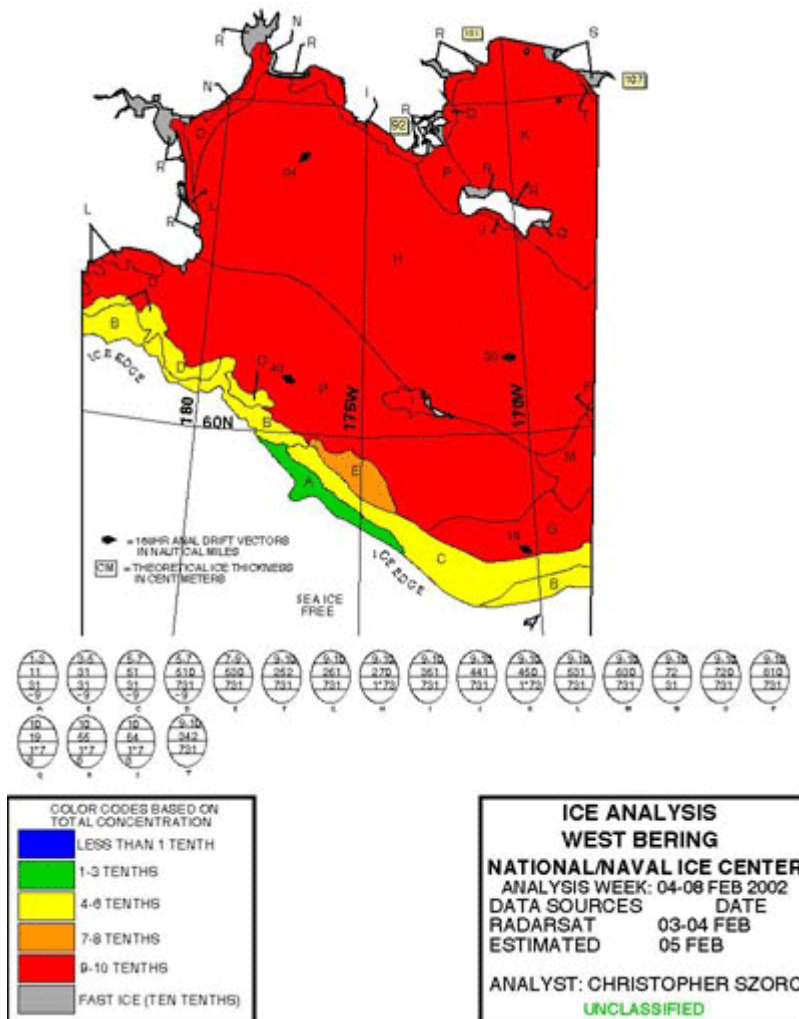


Figure 15. Example of a NIC Regional Chart showing polygons with their associated egg codes. Unlike the older hemispheric scale charts, these are produced entirely in a digital environment.

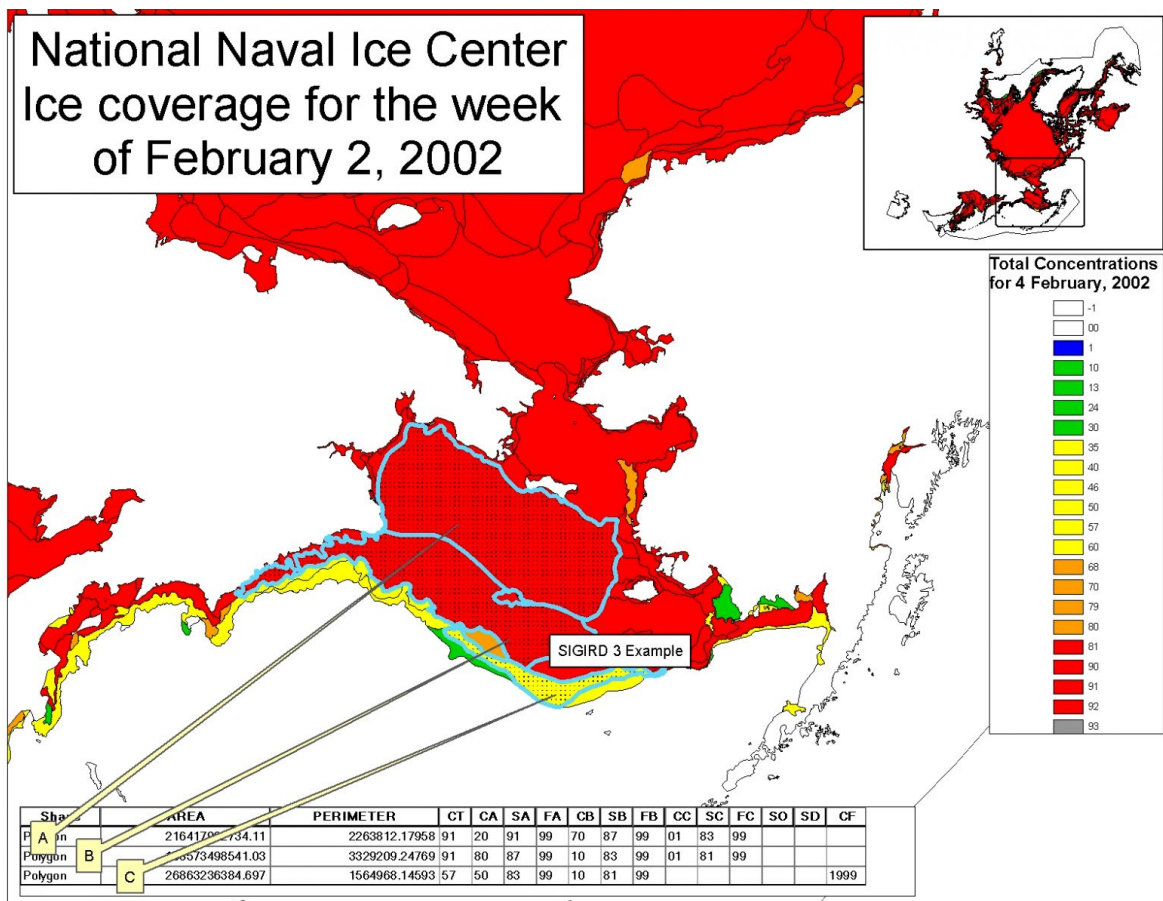


Figure 16. An Example of a NIC Chart Showing how Polygons are Represented in Attribute Tables

The column heading beginning CT are egg code designations, while the numbers filling those columns are the SIGRID code.

3.5 Precursor Data Sets

Against a background of steadily improving satellite instrumentation and chart production methods at NIC, two major efforts produced the data products that are the foundation for this data set.

3.5.1 1972-1994 Arctic and Antarctic Sea Ice Data

In 1995, NIC used services provided by the NOAA National Climatic Data Center (NCDC) to digitize its hardcopy archive of unclassified sea ice charts. (NIC also has products that are classified, that is, not available to the general public.) According to documentation reproduced in [NSIDC Special Report 13](#) (Fetterer, 2006), NCDC started working with NIC in 1981 on digitizing charts into vector files that were then converted to 25-km ASCII SIGRID files using automated processing (Knight, 1984). In 1996, NIC, the Fleet Numerical Meteorology and Oceanography Detachment, and NCDC jointly released a CD-ROM titled *1972-1994 Arctic and Antarctic Sea Ice Data*. This product corrected errors in earlier versions of SIGRID ice files. The CD-ROM was distributed by NCDC and NSIDC. In 1997, NSIDC became aware of errors in the SIGRID coding

for partial concentrations on this product and consequently removed the entry for this product from our online catalog. The Arctic charts on the Environmental Working Group CD-ROM described below served as a replacement.

3.5.2 Environmental Working Group Joint U.S. – Russian Sea Ice Atlas

In October 2000, NIC, in cooperation with the U.S./Russia Environmental Working Group (EWG), released the 1972-1994 Arctic ice analyses in digital format (Arctic Climatology Project, 2000). This CD-ROM product, hereafter referred to as the EWG Atlas, is distributed by NSIDC. The undertaking included reviewing and correcting all of the historical weekly ice analyses in order to provide the most accurate products possible for archiving and for creating a climatology. Russian ice chart data are included in the product as well.

According to documentation provided by NIC, the weekly ice charts on the EWG Atlas originated with the SIGRID files that NCDC had produced, and these in turn originated with the vector format files created by hand digitizing the original paper charts as described above and in Knight (1984). The SIGRID files were then further converted into ArcInfo polar stereographic grids with associated tables of SIGRID codes, creating gridded fields relationally linked to tabular attribute information. These ArcInfo grids were given to Environmental Research Institute of Michigan (ERIM) International, the contractor responsible for the producing the EWG Atlas CD-ROM product.

NSIDC asked that the ice chart files on the CD-ROM be made available in EASE-Grid as well as in SIGRID and GIS compatible formats. In response, ERIM International created EASE-Grid files and included them on the CD-ROM, following the convention established with the data set AARI 10-Day Arctic Ocean EASE-Grid Sea Ice Observations (Fetterer and Troisi, 1997). This convention groups the many possible stages of development in a SIGRID source data file into five layers in the EASE-Grid file. For example, the EASE-Grid multiyear concentration layer has the combined concentrations of the WMO categories of old ice, second year ice, and multiyear ice stages of development from the source SIGRID file. Refer to the Data Acquisition & Processing section of this document for more information.

The EWG Atlas also contains a climatology for total ice concentration constructed using both classified and unclassified NIC chart data. See *National Ice Center Sea Ice Climatology* in [Special Report 13](#) for a description of the work that was done at NIC and ERIM International using both classified and unclassified data sources in order to create this climatology.

3.6 Chart Conversion Project Outline

In 2005, NIC contracted with NSIDC to update the EWG Atlas climatology (which was based on an ice chart series that ended with 1994). The first goal of the project was to create 5-year, 10-year,

and 33-year total ice concentration climatology products for the Arctic region using the weekly NIC ice chart data from 1972 to 2004 and provide climatology products to NIC that matched the appearance and functionality of the climatology products on the EWG Atlas. (One difference, however, is that this new climatology, unlike that on the EWG Atlas CD-ROM, does not incorporate any information from classified sources.) The second goal of the project was to make these climatology products, along with the entire series of weekly or biweekly ice charts, available in EASE-Grid. The equal area projection and gridded format of EASE-Grid data (Brodzik and Knowles, 2002), along with the existence of many other polar data sets in EASE-Grid, makes EASE-Grid data more useful for many researchers than are ice chart data in the GIS format distributed by NIC.

We plan to continue extending these climatologies through periodic updates in cooperation with NIC.

3.7 Plans for Product Evolution

We anticipate that this initial version (v0) of the data may be replaced at a later date as researchers work with the data, means of improving the digital chart record are developed, and the period of the climatology is extended beyond 2004.

Current (October, 2006) plans for improving and updating this product include, in priority order:

- Adding a Web Image Spreadsheet Tool to facilitate browsing of the gif files (completed, September 2007).
- Adding GIS format climatology files that are compatible with other GIS software.
- Producing a 721 by 721 array 12.5 km (or even 5 km) EASE-Grid product (the need for this is explained in Note on Resolution). Ideally, this product would include the weekly charts beginning in 1972 and extending through the most recently available chart. Although a cell size smaller than 25 km is not meaningful in regard to data resolution for the charts prior to 1995, the entire series should be available at the smaller grid cell sizes for ease of use.
- Updating the weekly charts in this data set annually (with the assistance of the National Ice Center and if resources are available).
- Updating documentation as new information becomes available regarding chart accuracy and consistency.
- Adding SIGRID-3 format files.
- Adding online access to the scanned original paper charts for the early (before 1996) part of the series.

4 REFERENCES AND RELATED PUBLICATIONS

The following references are either about the NIC operational charts or make use of them, either directly or indirectly. Some papers related to NIC operations and Canadian Ice Service charts, or the use of them in research, are included as well.

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4.1 Related Data Collections

- [U.S. National Ice Center Arctic and Antarctic Sea Ice Concentration and Climatologies in Gridded Format](#)
- [Multisensor Analyzed Sea Ice Extent - Northern Hemisphere \(MASIE-NH\)](#)
- [Canadian Ice Service Arctic Regional Sea Ice Charts in SIGRID-3 Format](#)
- [Sea Ice Charts of the Russian Arctic in Gridded Format, 1933-2006](#)
- [Sea Ice Edge Location and Extent in the Russian Arctic, 1933-2006](#)
- [Arctic and Southern Ocean Sea Ice Concentrations](#)
- [The Dehn Collection of Arctic Sea Ice Charts, 1953-1986](#)
- [Environmental Working Group Joint U.S.-Russian Arctic Sea Ice Atlas](#)
- [Morphometric Characteristics of Ice and Snow in the Arctic Basin: Aircraft Landing Observations from the Former Soviet Union, 1928-1989](#)

4.2 Other Related Data Collections

- [An Electronic Atlas of Great Lakes Ice Cover, Winters 1973-2002](#)
- [Sea Ice Climatic Atlas: Northern Canadian Waters 1971-2000/Atlas climatique des glaces de mer: Eaux du nord canadien 1971-2000](#), Canadian Ice Service, SBN 0-662-61973-3
- The ice services of the [International Ice Charting Working Group](#) may have collections as well.

4.3 Related Publications

Smith, O. P. 2000. [Observers Guide to Sea Ice](#). National Oceanic and Atmospheric Administration, Hazardous Materials Response Division, Office of Response and Restoration: http://response.restoration.noaa.gov/book_shelf/695_seaice.pdf.

5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

6.1 Document Author

F. Fetterer wrote this documentation based on information from the cited references in addition to information provided by C. Fowler and the National Ice Center.

6.2 Publication Date

October 2006

6.3 Date Last Updated

June 2022: A. Windnagel updated the links to the new GDSIDB URLs and the EASE-Grid documentation and tools URLs.

February 2021: A. Windnagel added a note that a new data set (G10033) supercedes this one

July 2010: A. Windnagel added a paper to the related publications section.

January 2010: A. Windnagel. Updated the Directory Structure section.

July 2009: A. Windnagel: Edited this document to include data through 2007, intermediate 5-year files, and binary data information. Also, reorganized the Format and File Naming Convention section to make them easier to understand.

February 2007: F. Fetterer: Added information on errors discovered by users to the Quality Assessment section.

January 2007: F. Fetterer: Added a link to EASE-Grid geolocation files

7 APPENDIX A - EASE-GRID TO GIS STEPS

Following are steps taken to convert the EASE-Grid data to GIS compatible files using a Perl script from B. Melchior at the National Ice Center (NIC). The Perl script was provided to NSIDC (L. Ballagh) on September 26, 2006. The processing steps were run at NSIDC using Perl for Windows (version 5.8.7). These steps process the climatologies into a GIS compatible format.

The steps performed were:

1. Renamed binary file extension from .bin to .bil and removed the "v0" from the filename:

For example: nic_climo_2000_2004_02_min.v0.bin to
 nic_climo_2000_2004_02_min.bil

2. Copied .blw and .hdr template files to have same file name as the .bil file, but with the .hdr and .blw extensions.

Sample .blw and .hdr files:

Template.hdr

```

    BYTEORDER      M
    LAYOUT          BIL
    NROWS          361
    NCOLS          361
    NBANDS         1
    NBITS          8
    BANDROWBYTES   361
    TOTALROWBYTES  361
    BANDGAPBYTES   0
    
```

Template.blw

```

    25067.52500000000146
    0.0000000000000000
    0.0000000000000000
    -25067.52500000000146
    -4512154.49949999991804
    4512154.500500000008196
    
```

Sample header filename: nic_climo_2000_2004_02_min.hdr

3. Define projection (NSIDC EASE-Grid) and then reproject data (from NSIDC EASE-Grid format to NIC polar stereographic).

National Ice Center polar stereographic information (in .prj format):

```
PROJCS['WGS_1984_Stereographic_North_Pole',GEOGCS['GCS_WGS_1984',DATUM['D_WGS_1984',SPHEROID['WGS_1984',6378137.0,298.257223563]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['Stereographic_North_Pole'],PARAMETER['False_Easting',0.0],PARAMETER['False_Northing',0.0],PARAMETER['Central_Meridian',180.0],PARAMETER['Standard_Parallel_1',60.0],UNIT['Meter',1.0]]
```

NSIDC EASE-Grid projection information (in .prj format):

```
PROJCS['ease_grid',GEOGCS['ease_grid',DATUM['<custom>'],SPHEROID['<custom>',6371228.0,0.0]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]]PROJECTION['Lambert_Azimuthal_Equal_Area'],PARAMETER['False_Easting',0.0],PARAMETER['False_Northing',0.0],PARAMETER['Central_Meridian',0.0],PARAMETER['Latitude_of_Origin',90.0],UNIT['Meter',1.0]]
```

4. Raster to feature class, except for the frequency of occurrence files (i.e. files that contain “occ” in the filename). The “occ” files were kept in raster format. Note that the 1st and 3rd quartile files were not converted to a GIS compatible format. The resulting format is a geodatabase.