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A GREAT LAKES ICE COVER DIGITAL DATA SET FOR WINTERS 1973-2000

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The Great Lakes Ice Cover Digital Data Set: Winter 1973 – 2000

Raymond A. Assel, David C. Norton and Kevin C. Cronk

ABSTRACT. A 28-winter digital ice cover data set consisting of 1122 ice charts was established for the Great Lakes. Data reduction and quality control procedures are described in Norton et al. (2000). The data are available in ARC/INFO export and ASCII grid formats. Three types of ice attribute data are given: ice concentration class (the fraction of a unit of surface area covered by ice), ice stage class (range of ice thicknesses), and ice form class (size of ice floes). Ice attribute data coding conventions are described and discussed. The temporal and spatial distribution of the ice chart dates and ice attribute data are summarized in a table and in graphs. Metadata is provided as appendices.

1. INTRODUCTION

There has been and continues to be concern over global warming and its potential impacts (Fitzharris, 1996). The cryosphere is an important indicator of climate and climate change, and lake ice is a sensitive index of regional winter climate (Magnuson et al., 2000). Therefore, the availability of improved information on Great Lakes ice is timely. The purpose of this report is to provide an overview of a new digital ice chart data set developed at the Great Lakes Environmental Research Laboratory (GLERL). The sources of the ice charts, information on ice codes, and file naming convention, structure, and formats are presented and discussed. The temporal and spatial distribution of the digital ice chart data is also discussed.

In 1994, under the auspices of NOAA's Earth System and Data Information Management Program, a project to update a 20-year (1960-1979) computerized ice concentration climatology (Assel et al., 1983) and database (Assel, 1983) was initiated. The project objective is to provide improved (computer) access to historical Great Lakes ice cover data that up until then was available only in paper format. The earlier digital ice data set is available on the Internet at: http://www.nsidc.org/data/g00804.html, and our new data set is also available on the Internet at ftp://ftp.glerl.noaa.gov/ice/charts/. The new digital ice data described here has a base period of 1973-2000 and is more comprehensive than Assel (1983) in the amount and type of information digitized. It also differs from the earlier data set in that it is based on composite ice charts, while the earlier data set (Assel, 1983) is based on synoptic ice charts. Synoptic ice charts are coincident observations, usually covering only a portion of the Great Lakes, while composite ice charts are a summary of all available ice information for the entire surface of the Great Lakes for a given date. Composite ice charts may contain estimated ice conditions in portions of the Great Lakes not observed, e.g., extrapolation from observations on earlier dates, interpolation, or climatology for areas not observed.

2. BASIC DATA AND DATA REDUCTION

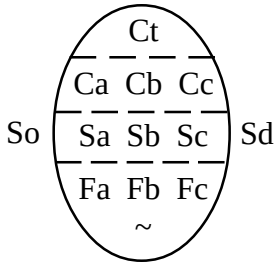
Methods and procedures to catalog, code, digitize, quality control, and format the digital ice charts were developed over several years and are described in Norton et al. (2000). Much of this work was accomplished by staff of the University of Michigan's Cooperative Institute for Limnology and Ecosystem Research under the direction of GLERL project scientists.

Paper copy ice charts obtained from the Canadian Ice Service (CIS) [winters 1973-1995] and the National Ice Center (NIC) [winters 1989-1994] were digitized. Paper copy ice charts for winters 1973-1995 were augmented by ARC/INFO export files obtained from the NIC for winters 1995-2000. These digital data were quality controlled for coding errors and processed to be consistent with the format of our existing digital ice cover data set.

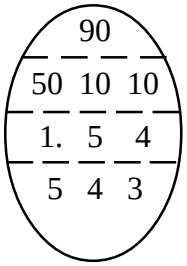
The entire 28-winter data set is produced in two formats, as ARC/INFO export coverages and as ASCII grids in a Mercator map projection at a nominal spatial resolution of approximately 2.5 km. There are a total of 1122 digital ice charts. Each ice chart is composed of a number of polygons that are encoded with ice attributes. The ice cover attributes encoded for each polygon include the polygon identification number and 13 ice polygon attributes (four categories of ice concentration, five categories of ice thickness, and four categories of ice floe size). The digital ice charts are standardized from several different map projections and ice attribute codes given in the original paper copy ice charts (see Norton et al., 2000 for details).

3. ICE POLYGON ATTRIBUTE CODES

The ice polygon attribute codes used here are a modification of the World Meteorological Organization (WMO) Codes for freshwater ice that is sometimes referred to as the egg-code, due to its oval shape, see http://www.natice.noaa.gov/egg.htm for details. The data on the original ice charts GLERL digitized were either in egg-code or SIGRID code, the WMO digital sea ice standard, (http://www.natice.noaa.gov/unused_images_pages/sigrid.htm). All of these input data were translated to a consistent all numeric form of the egg-code that GLERL established. The C's in the egg code indicate ice concentration, the S's indicate ice stage class, and the F's indicate ice form class, details are given below. The parameters within the WMO egg-code are interrelated by position. Thus, Ca should identify the concentration of Sa stage ice distributed in Fa form. On the original charts, floe size (Fa, Fb, Fc) cannot appear within a single egg-code coincident with the code "~" which is a code for concentration within belts and strips of ice, since they occupy the same position. However, when "~" was given adjacent to the polygon's egg-code; it was included within GLERL's implementation of the egg-code. The egg-code has the general appearance of:



The WMO Egg-Code



Example of a WMO Egg-Code for an ice polygon

The ice attributes from the above egg-code are listed polygon by polygon in a text file :

1 2 3 4 5 6 7 8 9 10 11 12 13 ← (Attribute Number)
ID,Ct,Ca,Cb,Cc,So,Sa,Sb,Sc,Sd,Fa,Fb,Fc,~

For example: 512, 90, 50, 10, 10, -8, 10, 5, 4, 1, 5, 4, 3, -8. Here, 512 is the polygon ID (identification) code that was manually assigned for every ice polygon, followed by the 13 possible ice attributes. The number of ice attributes recorded per polygon on the original ice charts varies substantially. In the above example the 5th (So) and 13th (~) parameters were not provided in the original encoding, so they were assigned –8, which is a code for no data. The WMO Sa value of "1." was changed to the integer 10. All parameters were stored as integers because of computer storage and processing advantages.

3.1 Ice Concentration Codes

The first four and 13th parameters are descriptors of the ice concentration. These are:

Ct total ice concentration
Ca ice concentration of the thickest ice
Cb ice concentration of the next thickest ice
Cc ice concentration of the thinnest ice
~ ice concentration within belts and strips of ice

The values of the ice concentration attribute have units of percent ice cover that range from 0 to 100 in increments of 5; code -88 is a placeholder (i.e. no data), and code –99 is missing data. The original ice charts sometimes had a range for Ct; in this case an average value was used, thus 7-9/10 was assigned 80. The 5% increments here are not in the standard WMO ice egg coding, but are required by our implementation of that code because the sum of any ice polygon's partial ice concentrations may not always equal Ct as described below. Also, 5% is used for WMO code "<1/10" ice concentration and 95% for the WMO code "9+/10" ice concentration.

On the original ice charts the total concentration, Ct, was not always equal to the sum of the partial concentrations (Ca+Cb+Cc plus So or Sd if present). The original coding was too coarse to always make equality possible. Since we require numeric internal consistency in our applications, the values of parameters Ca, Cb, and Cc were adjusted so that their sum was equal to Ct. These partial concentration values from the original ice charts were adjusted up or down in 5% increments so that their sum was equal to the total concentration. These adjustments were made preferentially to the thinnest ice type(s) present. Additionally, if present, So or Sd indicate at least a 5% concentration of that ice type accounted for part of the Ct value, so the Ca, Cb, and Cc partials were appropriately adjusted if needed. No partial concentration values were reduced to 0%. When working with Ca, Cb, and Cc, the user must account for partial concentrations indicated by So or Sd when present. If partial concentration(s) were erroneous, the previous and following ice charts were used to establish correct partial concentration values. A "~" value of 99 equates to 100%.

3.2 Stage of Development Codes

Stages of development (So, Sa, Sb, Sc, Sd) are listed using codes in decreasing order of thickness. These codes are directly correlated with the partial concentrations above. Ca is the concentration of stage Sa, Cb is the concentration of stage Sb, and Cc is the concentration of Sc. The code So is used to report a development of 5% ice with the thickest ice concentration that will not fit into the egg. The code Sd is used to report a development >5% of the thinnest ice concentration that will not fit into the egg. Either So or Sd may be present in a coding, but not both. The following codes are used to denote stage of development (range of ice thickness) of lake ice:

Code	Description	Ice Thickness Range
0	no stage of devel.	0 cm, no ice
1	new ice	0-5 cm
4	thin lake ice	5-15 cm
5	medium lake ice	15-30 cm
7	thick lake ice	30-70 cm
8	1st stage thick ice	30-50 cm
9	2nd stage thick ice	50-70 cm
10	very thick lake ice	70-120 cm
-8	place holder	
-9	missing data	

3.3 Ice Form Codes

Forms of lake ice (Fa, Fb, Fc) indicate sizes corresponding to the stages identified in Sa, Sb, and Sc respectively. Codes 0, 1, and 2 refer to the shape of the individual pieces of ice. Pancake ice is circular in shape. Ice cake is irregularly shaped but distinct pieces. Brash ice is composed of small ice fragments that are made up of the wreckage of other forms of ice. Codes 3, 4, 5, and 6 refer to sizes of the ice floes. Code 8 refers to ice that forms and remains attached to the shore. The following codes are used to denote forms of lake ice:

Code	Description of Form
0	pancake ice (30 cm – 3 m)
1	small ice cake (< 3 m) or brash ice (< 2m)
2	ice cake (3 m - 20 m)
3	small floe (20 m - 100 m)
4	medium floe (100 m - 500 m)
5	big floe (500 m - 2 km)
6	vast floe (2 km - 10 km)
8	fast ice
- 8	place holder
- 9	missing data

4. THE DIGITAL ICE CHART DATA SET

4.1 Data Availability

The ice data set is available as ARC/INFO export coverage and as formatted ASCII grids. Metadata, compiled in accordance with the Federal Geographic Data Committe's Content Standards for Digital Geospatial Metadata (Federal Geographic Data Committee, 1994), is given as Appendix A (coverage) and as Appendix B (grids). Figure 1 is an Arc View project of a CIS coverage of Ct (total ice concentration) saved as a graphic file. Similar graphic files of Ct were made for all coverage. These graphs are useful for browsing the data since all other ice

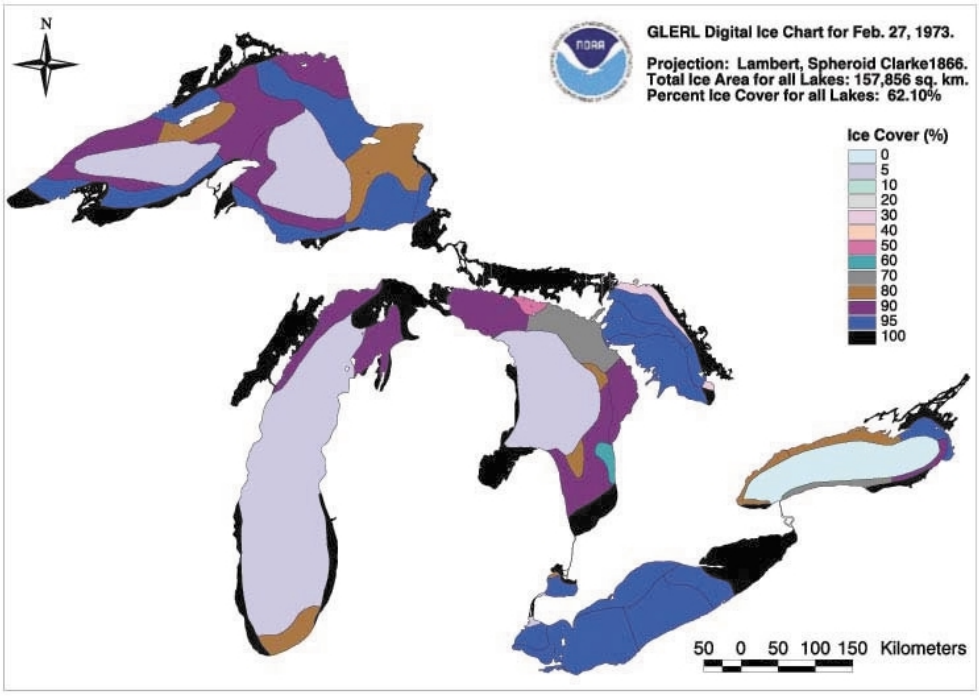


Figure 1. A coverage of February 27, 1973 (g19730227c.e00) for parameter Ct.

attributes are estimates of Ct's composition. All of these data are available at GLERL's anonymous ftp site, ftp://ftp.glerl.noaa.gov/ice/charts/ in subdirectories by winter season (e.g. 1973, 1974, 1975,...2000). A graphic user interface is being developed to facilitate browsing and downloading the data. If the entire data set is desired, it is recommend that, because of its large size, it is requested as a CD-ROM set (contact pubs.gler@noaa.gov). File name conventions are given below and as a Readme file at the ftp site.

4.2 File Name Conventions

Files names incorporate the original ice chart issue date and source (NIC or CIS) and data format type (ARC/INFO export coverages or ASCII grids). The dates are in year, month, and day order. During winters 1989 through 1995, both NIC and CIS made ice charts, so they interleaf in each season's directory listings, because the files are arranged by date. Therefore, it is possible to have more than one ice chart on the same issue date for these winters. It is also possible to have apparent discontinuities in the data presented by the time series of ice charts for these winter seasons when NIC and CIS ice charts follow each other in temporal sequence. This is due in part to differences in analysis methods and procedures as well as possible differences in available observational data.

The NIC and CIS coordinated ice analysis over the more recent winter seasons to the extent that NIC and CIS provided copies of ice charts to each other and had their ice analyst exchange visits. The electronic ice charts NIC provided to GLERL for the most recent winters (1999, 2000) contains CIS ice chart information. With the exception of these winters for which NIC has a listing of the CIS ice charts at: http://www.natice.noaa.gov/pub/archive/great_lakes/, it is not possible to identify the extent, if any, to which CIS ice chart information is present in the 1996, 1997, and 1998 NIC data. Therefore, the ice chart data source for these years is identified as NIC.

Example of ARC/INFO Export Coverage File Name

g20000228u.e00, where: g = originating from GLERL, 2000 = year, 02 = month (Feb.), 28 = day, u = NIC source [if this was a CIS source the 'u' would be replaced by a 'c'] , and .e00 = ARC/INFO export coverage. A ".txt" extension is used for ice attribute files, such as g20000228u.txt for this coverage.

Example of ASCII Grid File Name

g19941230c.ct, where: g = originating from GLERL, 1994 = year, 12 = month (Dec.), 30 = day, c = CIS source. The extension ".ct" means this is a grid of the ice attribute: total ice concentration. There are 13 other grids for this source and date, they are: g19941230c.id, g19941230c.ca, g19941230c.cb**,** g19941230c.cc, g19941230c.so, g19941230c.sa, 19941230c.sb, g19941230c.sc, g19941230c.sd, g19941230c.fa, g19941230c.fb, and g19941230c.fc. Thus there are 14 grids for each ice chart, one grid for each of the 13 ice attributes, and one grid for the polygon identification numbers.

Example of a Ct Graphic File Name

c73apr06.jpg, c = CIS, apr = (April), 06 = day, for winters: 1973-1995.
u88dec14.jpg, u = NIC, dec = (December), 14 = day, for winters: 1989-1996.
gl00feb29.jpg, gl = NIC or CIS, feb = (February), 29 = day, for winters:1997-2000.

4.3 ARC/INFO Export Polygon Coverages

The export coverages can be directly opened and viewed using ArcView. If an ARC/INFO operating system is used, these export files must be "imported" into the new computer environment. Importing changes the export form of a coverage back into its original ARC/INFO form. This is done with the ARC command "import". The Arc Macro Language (AML) script, importer.aml (provided in Appendix C) uses the import command to process all export files in the default area. This AML was developed on a UNIX operating system. We did not test this aml in a PC ARC/INFO environment. To use this AML, first copy all the export files to be imported into an area, and

copy importer.aml into the same area. Create a directory area where the coverages are to be processed into. Bring up the ARC/INFO system, and then at the ARC prompt type "&r importer.aml" and press "enter". You will be prompted for the directory name where the files are to be written. Type the full path name, example: "/E/icedata/coverages" and press enter. If you want to keep the new coverages in the same directory area as the export files, simply press enter, and the AML output will default to the current directory. Although, the original ice charts were drawn on base maps of various projections, all charts have been re-projected to a consistent Mercator projection (Table 1). The coverages can now be used within an ARC/INFO environment.

Ice attributes of a polygon can be displayed by selecting and clicking on them in an ArcView session. A screen capture of an ArcView session (Figure 2) illustrates information on ice attributes for a selected polygon. Free software to view ARC/INFO export files is available at on the Internet at the following URL: http://www.esri.com/company/free.html.

Table 1. Single precision Mercator Coverage with Clarke 1866 Spheroid

Coverage Boundary		Lon. central meridian	-84.533
Xmin = -92.382	Xmax = -75.706	Lat. of true scale	45.433
Ymin = 38.835	Ymax = 50.539	false easting (m)	0.000
		false northing (m)	0.000

4.4 Formatted ASCII Grids

Fourteen grids were constructed per coverage making a total of 15,708 grids in (1,122 coverages x 14 attributes). The polygon "id" grid was created using ARC/INFO. The id grid was adjusted to match a master grid in order to obtain consistent water and land cells. This adjustment was necessary due to minor differences in the coverage shorelines created during digitizing and editing. The id grid was then used with an attribute file (example: g20000228u.txt) to generate the other 13 grids using FORTRAN software. This was done because ARC/INFO was sometimes inconsistent in grid creation for unknown reasons.

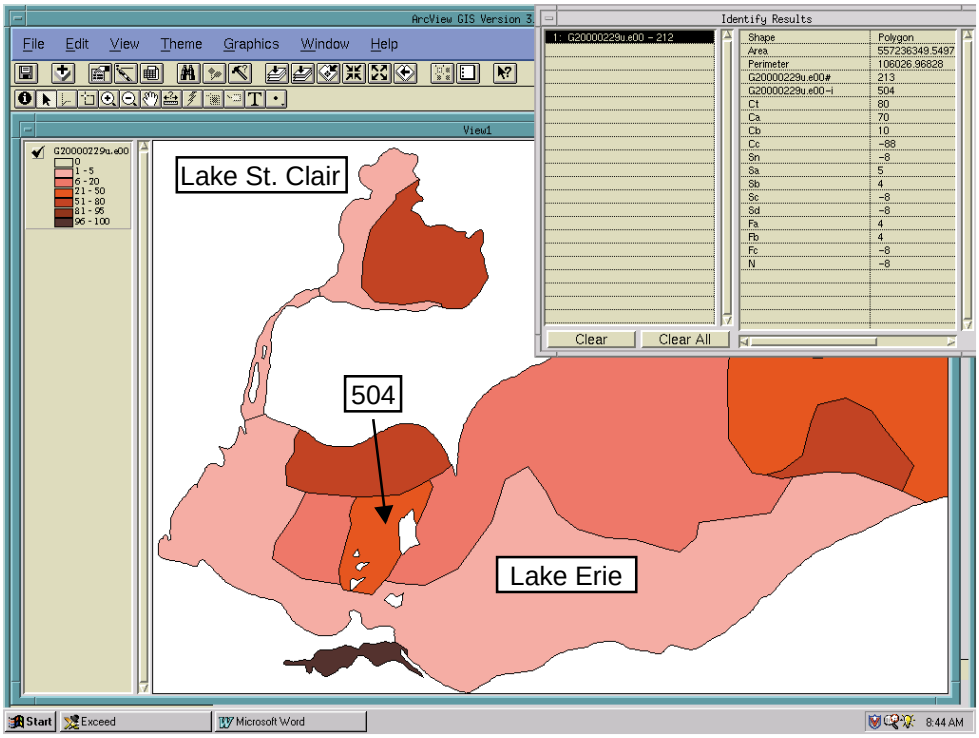


Figure 2. An ArcView session using export coverage g20000229u.e00. The image shown is a zoom in on Lake St. Clair, the Detroit River, and the western end of Lake Erie. Polygon 504 was selected, and its parameters are shown in the "Identify Results" table

4.4.1 Grid File Structure

There are 510 data records preceded by 6 header records in each grid. The header records contain the number of columns of data (516) in each grid, the number of rows of data (510) in each grid, the longitude of the lower left corner cell in meters (-649446.25), the latitude of the lower left corner cell in meters (3306260), the nominal cell size in meters (2550), and a no data code (-99), in that order. Each data record has 516 grid cells in a fixed I3 format; land cells and island cells in a lake have a code of –1.

4.4.2 Converting A Grid to An ARC/INFO Coverage

Some users may prefer to use these standardized grids in the ARC/INFO environment. Software to do this (reformat.f, asciiarc.aml) is given in Appendix C. Reformat.f is also available as an executable image (i.e. compiled and ready to execute on a PC) on the CD-ROM and GLERL online versions of the data set.

The grids can be converted back into the ARC/INFO format in two steps. First, FORTRAN program reformat.f is used to rewrite the grids into unformatted ASCII grids. This program requires an input list of the desired files in "reformat.inp". Then the ARC command "asciigrid" is used to put the grids back into their original binary form. This command has been embedded in asciiarc.aml, which makes its own input list and then processes all ice grids with the file name and format output by the reformat.f program. To use this AML, make a directory where you want the new files to go. When the AML is called (&r asciiarc), you will be prompted for the location where the new files are to be written, so give the complete path. The AML will end on an error if you try to write the new files into the same area as you are reading from. The new ARC grids will have the same names as the ASCII input grids.

4.5 Temporal Distribution of Ice Charts

It is apparent that there is a large increase in the number of ice charts per season (Figure 3a) and a large decrease in the average number of days between ice charts (Figure 3b) starting in winter 1989. This is attributed to the fact that NIC ice charts started to be digitized that winter. The average date of the first ice chart is December 17, the dates varied (Figure 3c) from mid-November (1996 winter, i.e. Nov. 1995) to early January (1988). The date of the last ice chart (Figure 3d) varied from early April (1987) to late May (1996) and averaged May 1. The number of days between the date of the first and last ice chart (Figure 3e) varied from 100 (1987) to close to 200 (1996) and averaged about 137 days. On a monthly bases (Figure 3f) the greatest number of ice charts occurred in January (239) and March (240) followed closely by February (219), and April (218).

4.6 Temporal Distribution of Ice Attributes

The abundance of data for each of the 13 ice attributes is summarized by two lines of data per ice chart (Appendix D). The top line is the percent of data available, i.e. the sum of the number of cells with data divided by the number of Ct cells with data greater than or equal to 10%. This method of computing abundance of data was used because ice parameters are seldom reported with Ct values less than 10%. However, when other ice parameters are reported with Ct less than 10%, the result in calculating the percent abundance relative to Ct is greater than 100. In these cases, the percent abundance value in Appendix were set to100%. Also, percentages greater than zero but less than 1% were set at 1%. The second line contains the sum of the grid cells with ice data for each ice attribute; for Ct this is the number of cells where Ct is greater than or equal to 10%.

Seasonal averaged (December-May) ice attributes are shown for CIS ice charts for winters 1973-1988 (Figure 4a) and for NIC ice charts for winters 1989-1995 combined with NIC and CIS ice charts for winters 1996-2000 (Figure 4b). Note Ct is not shown because it is 100% for all ice charts. There is a significant drop in percent of cells reporting ice attributes in CIS coverages in 1977 and 1983 and in combined NIC and CIS ice charts for winter 1998. The 1977-drop may be due to changing CIS ice chart analysis methods. The 1983 and 1998 drop is coincident with exceptionally mild winters (Assel et al., 1985, Assel et al., 2000). Individual monthly ice at-

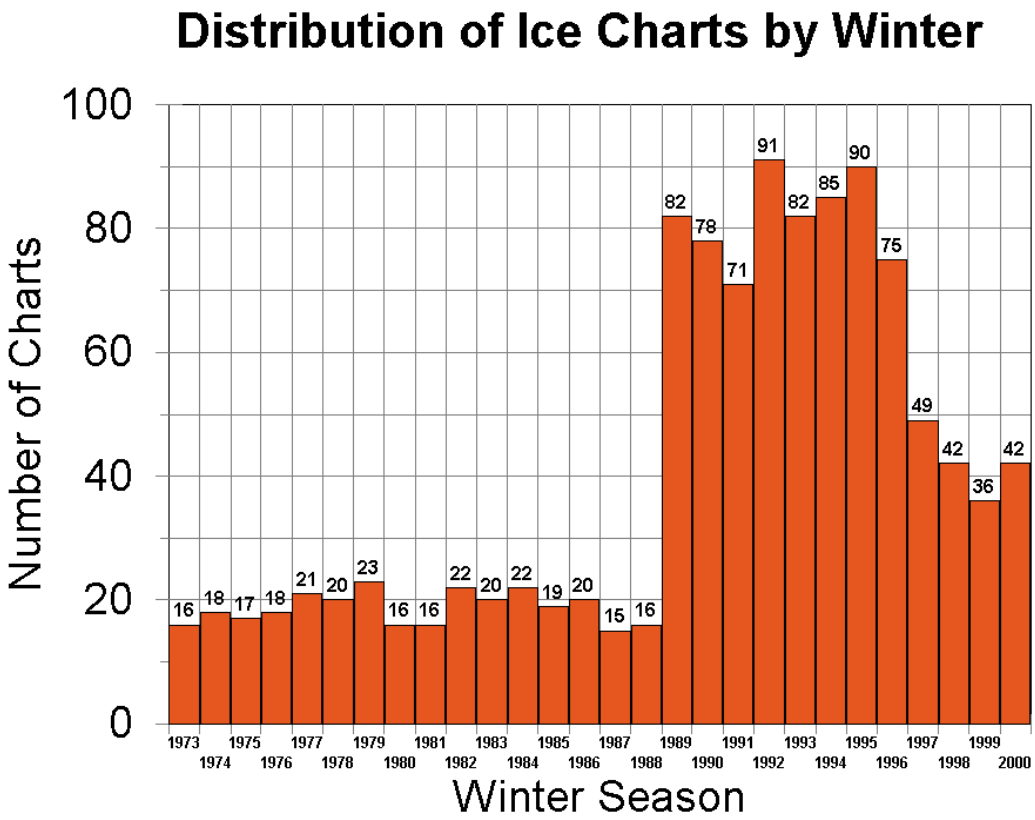


Figure 3a. Distribution of ice charts by winter season.

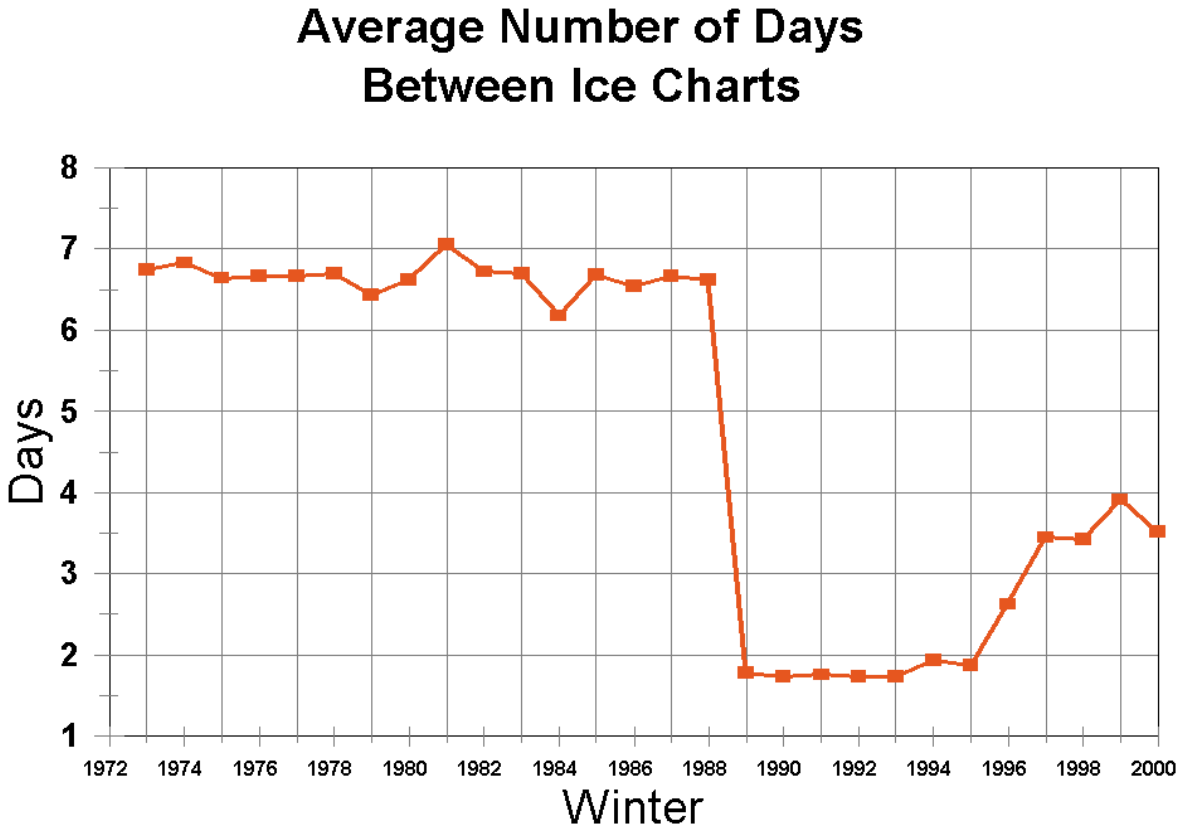


Figure 3b. Average number of days between ice charts.

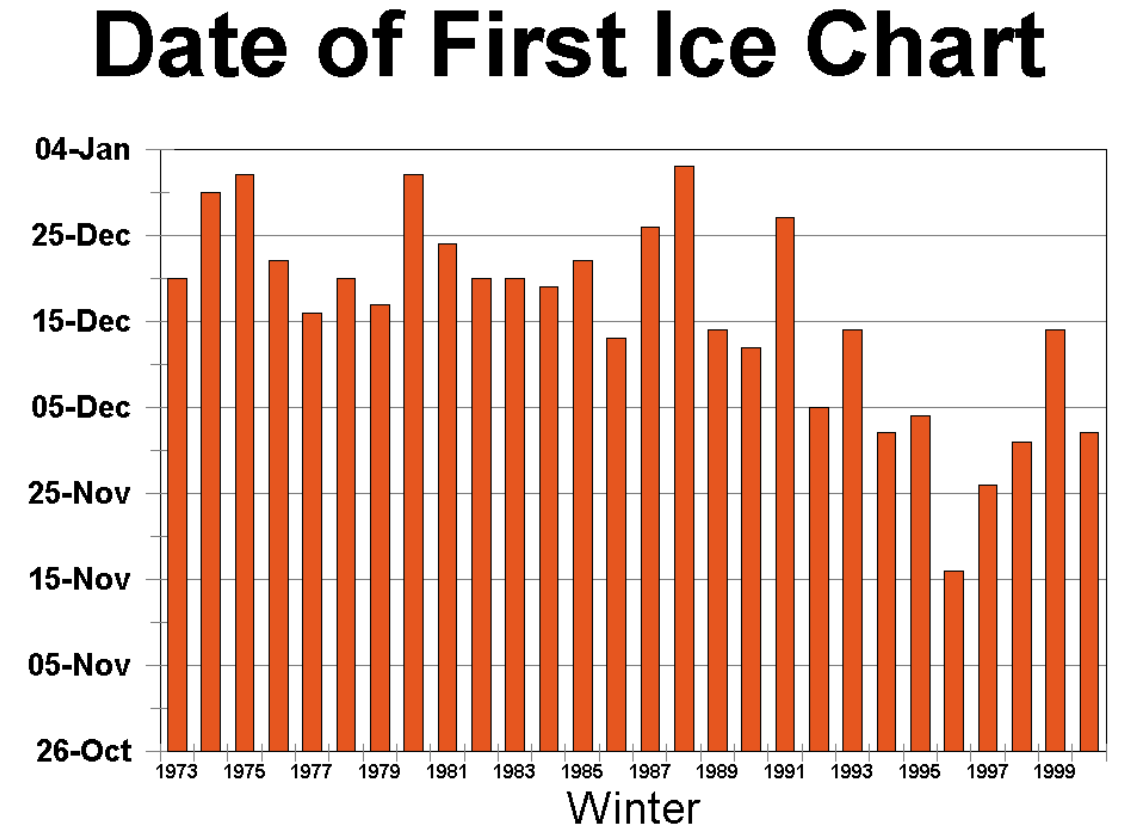


Figure 3c. Date of first ice chart.

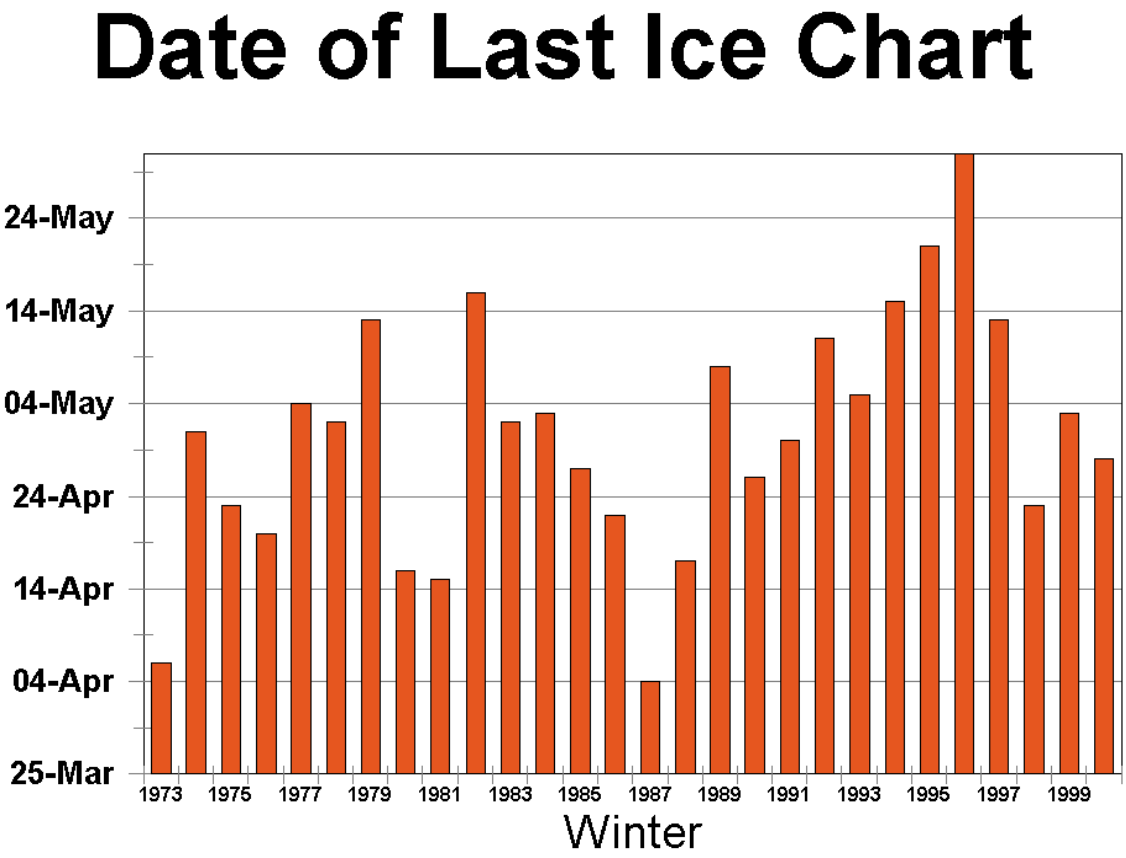


Figure 3d. Date of last ice chart.

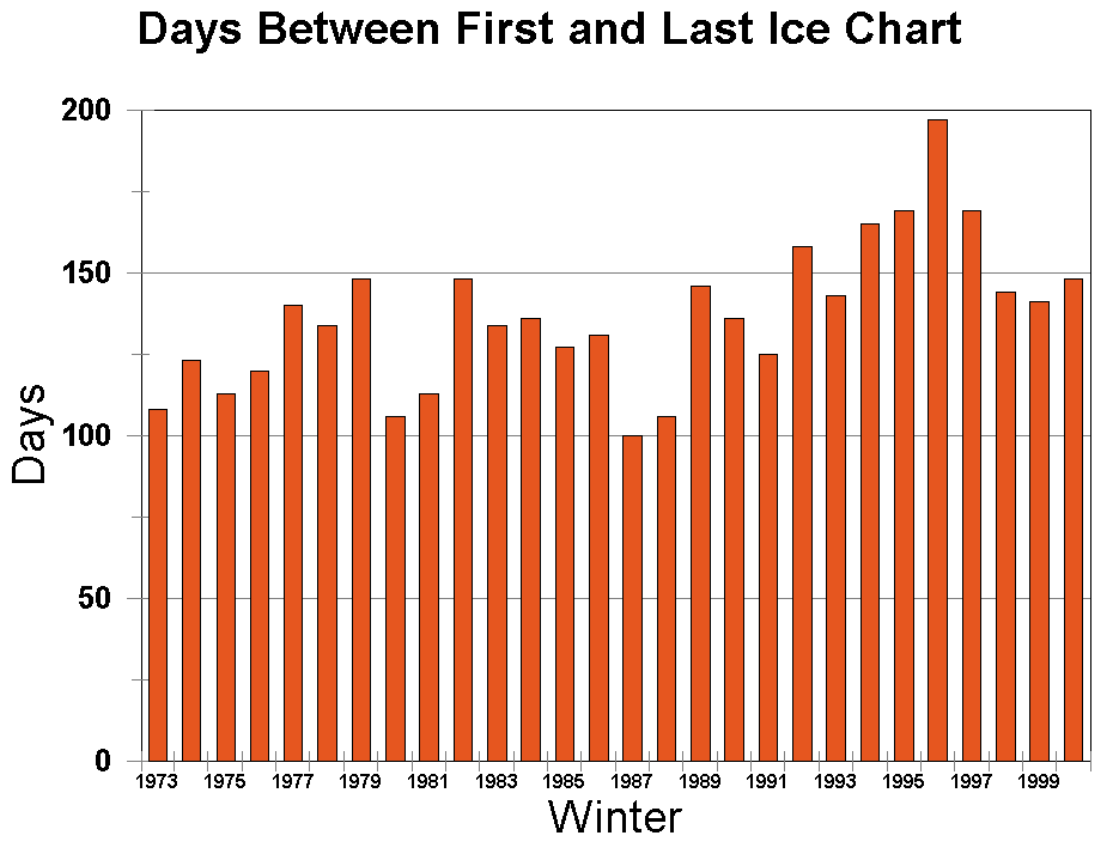


Figure 3e. Days between first and last ice chart.

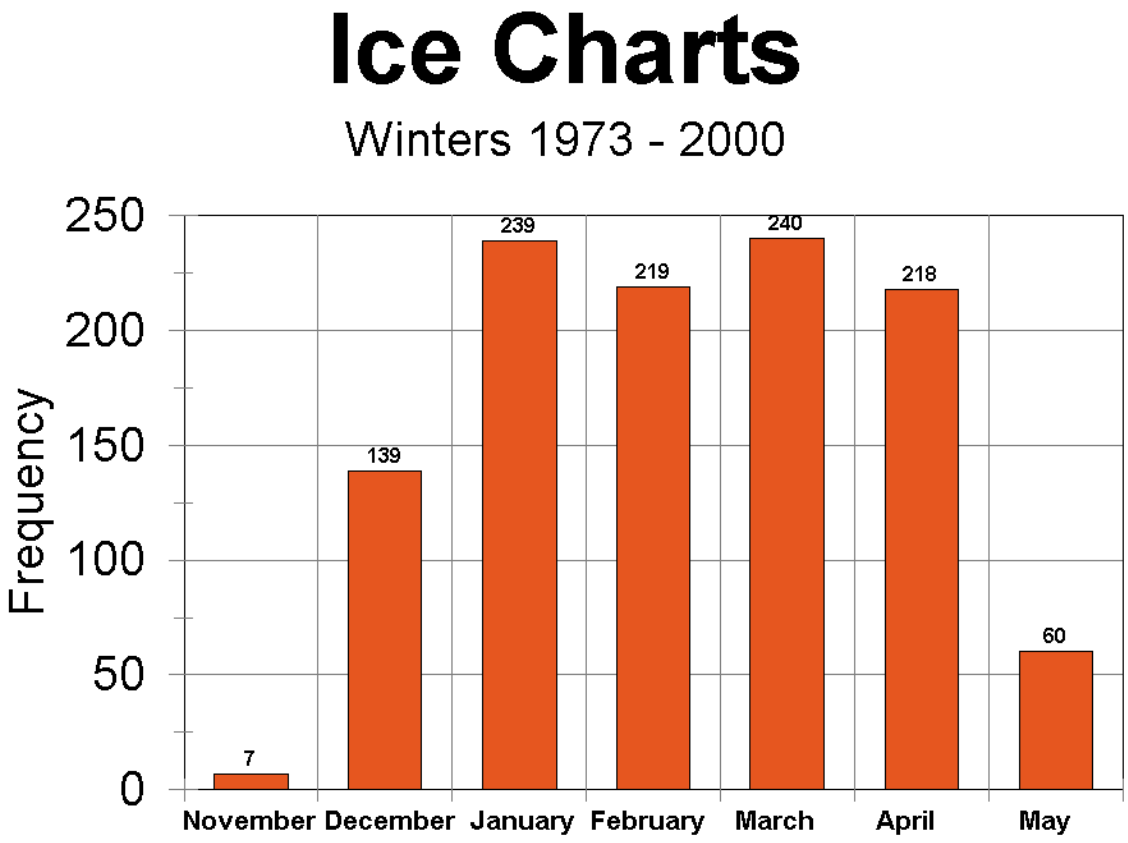


Figure 3f. Distribution of ice charts by month.

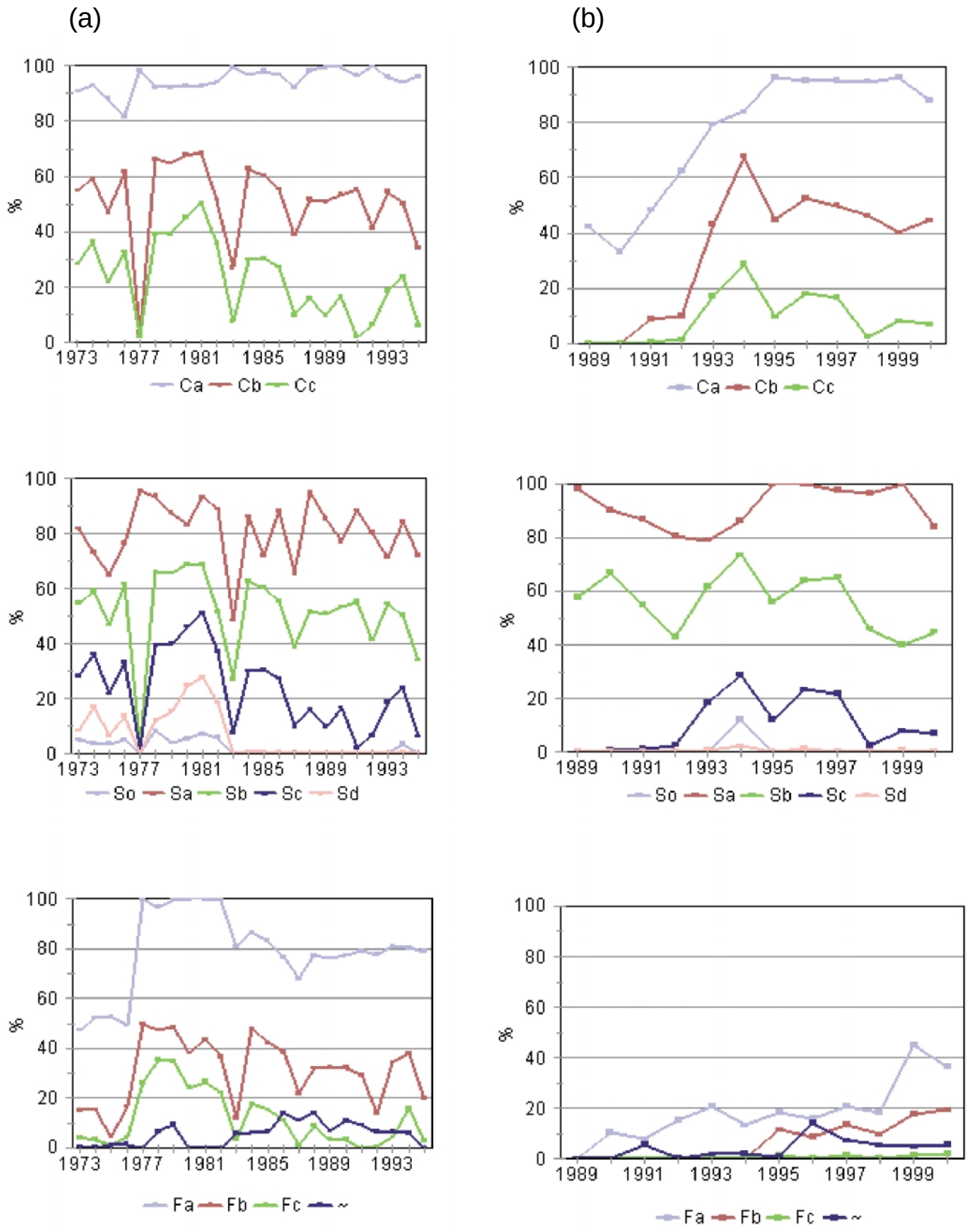


Figure 4. Seasonal averages of partial ice concentrations (top), partial ice stages (center), and partial ice form (bottom) for a) CIS and b) combined NIC and CIS ice charts.

tributes averaged by month, January through April (Figure 5-Figure 8 respectively) were also calculated and show trends that are similar to the trends in the annual average curves. Ice charts are sporadic in November, December, and May, so those months were not analyzed.

From the above, one can conclude that it is most feasible to make an analysis over all winter seasons using Ct because of its abundance. A statistical analysis of Ct across the 28-winter base period is being made and will be published within a year. Progress to date is summarized on GLERL's Web Page at: http://www.glerl.noaa.gov/res/Milestone/2001/Q4/2001q4assel.html. The first analysis product that has been made using Ct is a series of computer animations that portray the seasonal and spatial progression of Ct over each winter season from 1973 to 2000 (Assel and Norton, 2001). The animations can be viewed or downloaded from GLERL's Web Page at: ftp://ftp.glerl.noaa.gov/ice/animations/.

It is problematic to make a climatological analysis over all winters for the other ice attributes because of varying degrees of missing data. The abundance of the ice attribute data decreases going from its first partial (Ca, Sa, Fa) to its last partial (Cc, Sd or So, Fc). Ice forms (Fa, Fb, Fc) as a group were the least abundant data. Care should be taken in making any analysis over the entire base period as a unit for any of the partial ice cover attributes.

5. DATA USAGE

These data in their various forms constitute a unique time series, valuable for many uses. These data are based on observer estimates that were drawn by eye on the original charts. GLERL's processing of these data to digital forms and extensive quality control has made the data internally consistent and readily accessible, but did improve upon this original accuracy. These data should not be used where high precision is required.

6. ACKNOWLEDGMENTS

This work would not have been possible without the initial funding the NOAA ESDIM program and the contributions of the many CILER employees (D. Meyers, B.A. Hibner, N. Morse, P.J. Trimble, K. Cronk, and M. Rubens). Ms. Deborah H. Lee, formerly of GLERL, provided valuable advice and assistance on the ARC/INFO system routines and procedures. We also thank the United States (NOAA, Navy, U.S. Coast Guard) National Ice Center and the Canadian Ice Service who provided the ice charts and acted as consultants and advisors in this project.

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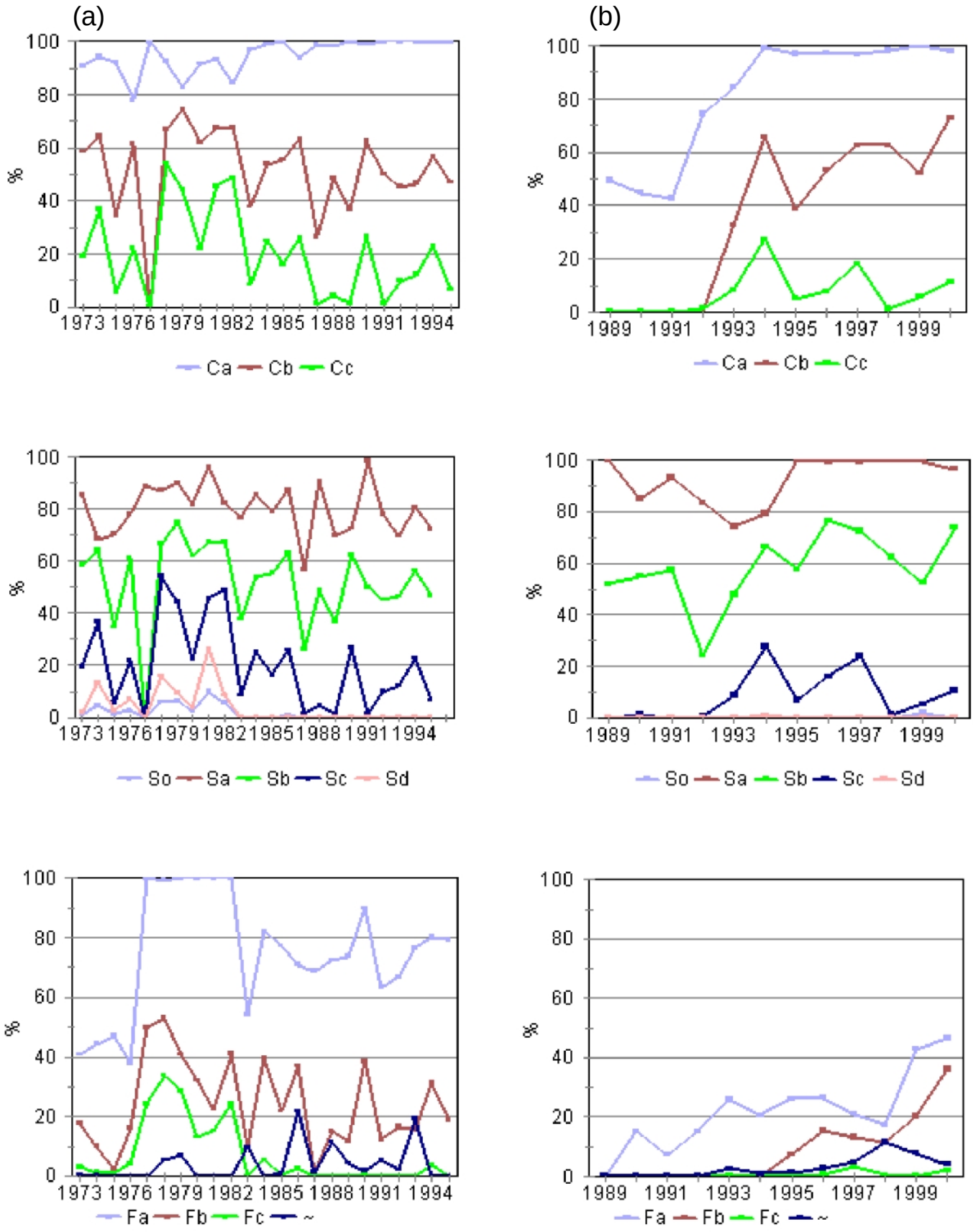

Figure 5. January averages of partial ice concentrations (top), partial ice stages (center), and partial ice form (bottom) for a) CIS and b) combined NIC and CIS ice charts.

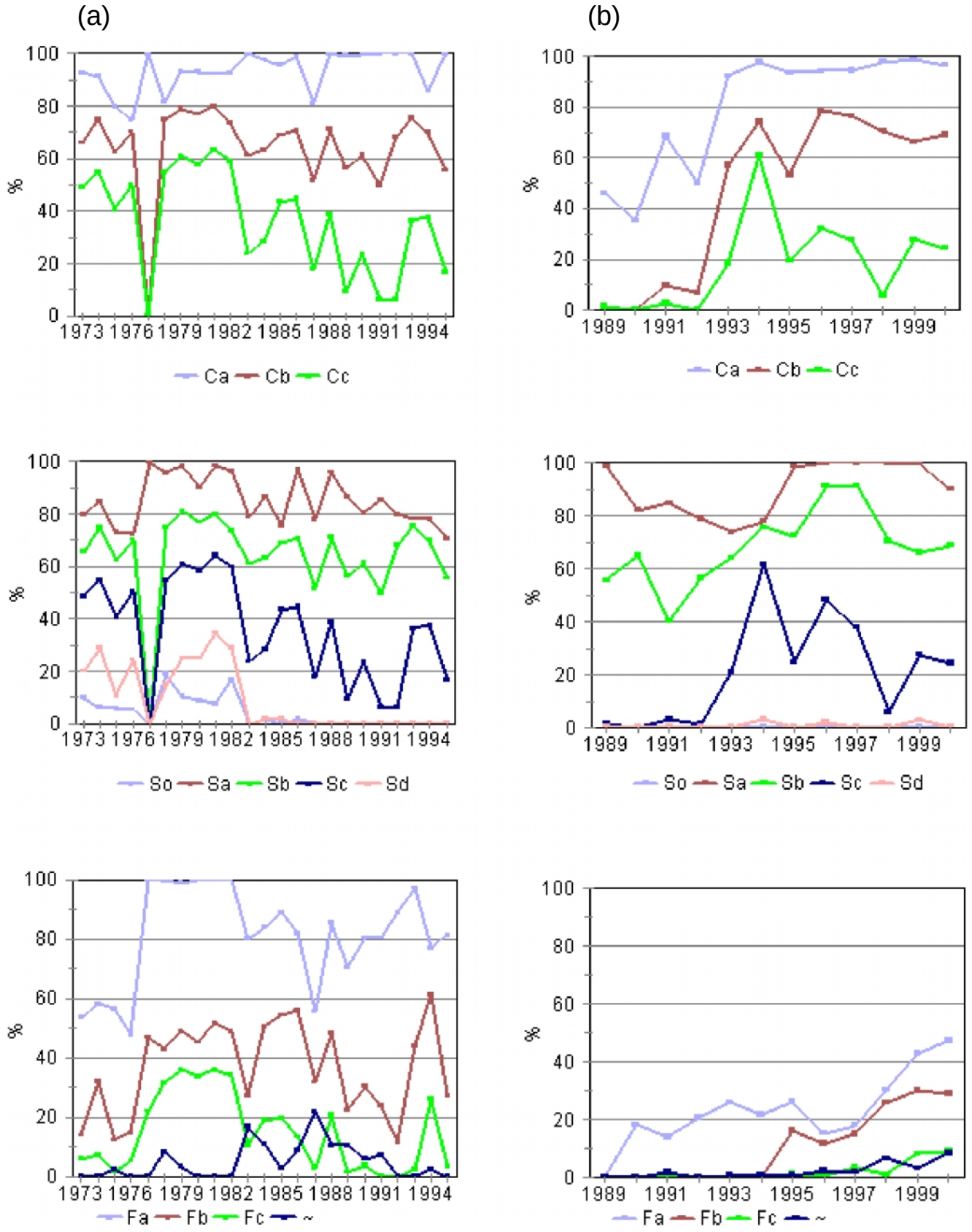

Figure 6. February averages of partial ice concentrations (top), partial ice stages (center), and partial ice form (bottom) for a) CIS and b) combined NIC and CIS ice charts.

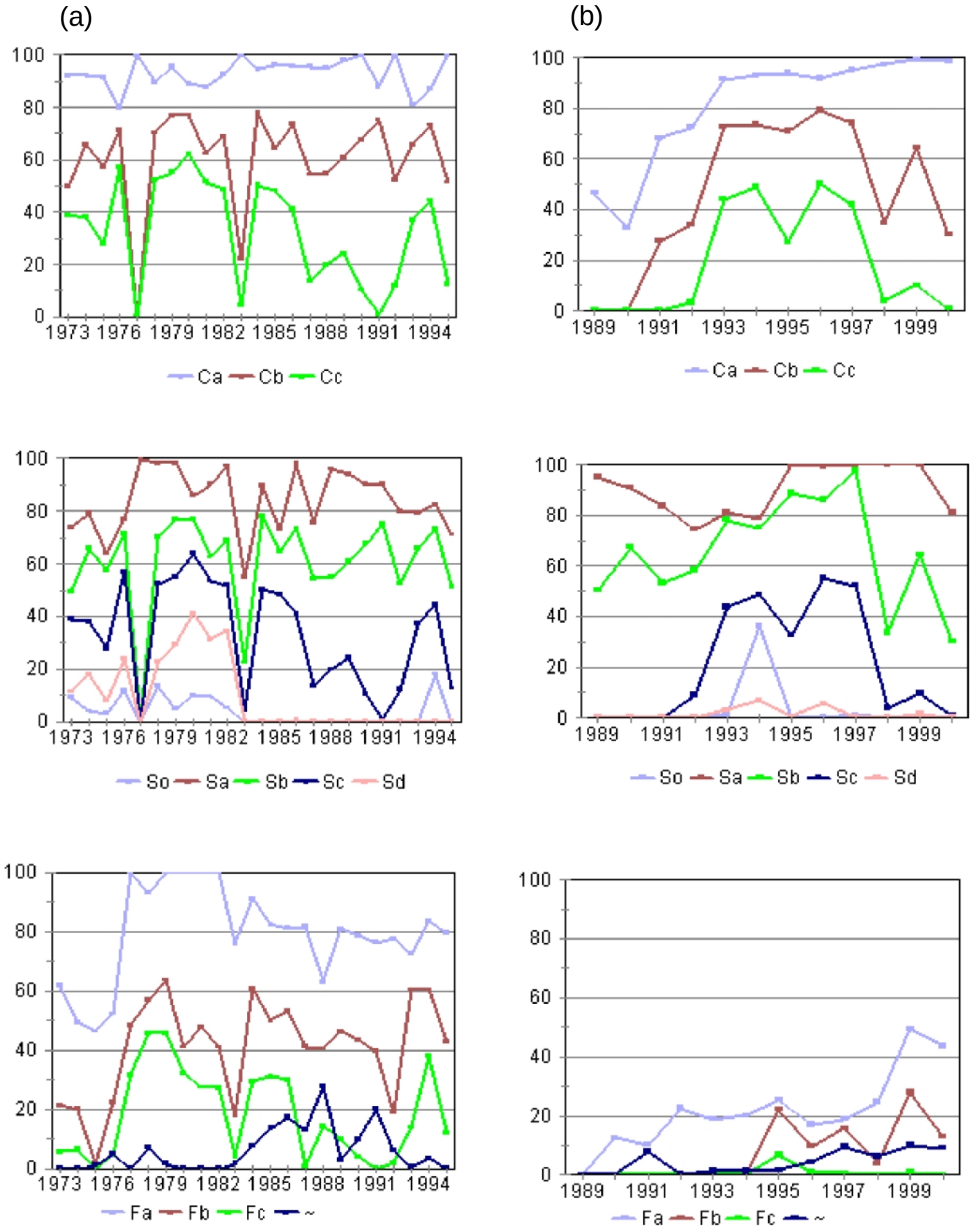

Figure 7. March averages of partial ice concentrations (top), partial ice stages (center), and partial ice form (bottom) for a) CIS and b) combined NIC and CIS ice charts.

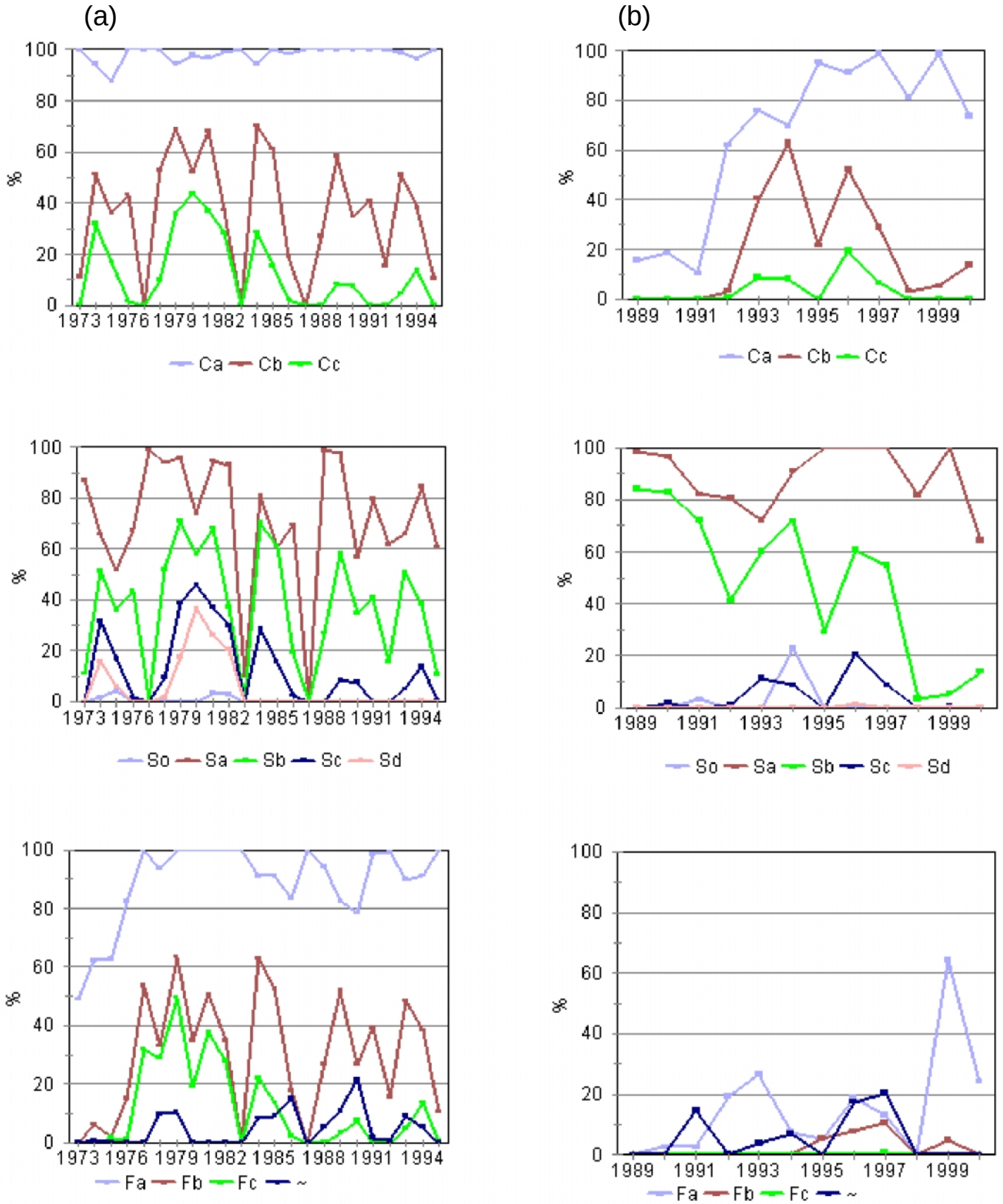

Figure 8. April averages of partial ice concentrations (top), partial ice stages (center), and partial ice form (bottom) for a) CIS and b) combined NIC and CIS ice charts.

Appendix A. Metadata for the ARC/INFO Export Coverage

Identification_Information:
Citation:
Originator: Great Lakes Environmental Research Laboratory (compiler)
Publication_Date: 20020302
Publication_Time: 00000000
Title: Great Lakes Ice Cover Vector Data
Edition: 1.0
Geospatial_Data_Presentation_Form: Map
Publication_Information:
Publication_Place: Ann Arbor, MI, U.S.A.
Publisher: Great Lakes Environmental Research Laboratory
Other_Citation_Details: NOAA Technical Memorandum ERL-GLERL-121
Online_Linkage: ftp://ftp.glerl.noaa.gov/ice/charts/
Larger_Work_Citation: A Great Lakes Ice Cover Digital Data Set For Winters 1973-2000.
Scale_Denominator:

Description:
Abstract: These data are a set of 1122 ice charts in ARC/INFO Export format. A medium resolution vector base map of the Canadian and U.S. Great Lakes and St. Lawrence River shoreline was used and ice polygons were added to it via digitizing historic ice charts. Ice attribute data were encoded and linked to the polygons. The attributes are in an all integer form of the egg code.

The base map coordinate system description is:
Projection: Mercator
Spheroid: Clarke 1866
Units: meters
Longitude of central meridian: -84 8 24.000
Latitude of true scale: 45 2 24.000

Each polygon has a set of 13 possible attributes assigned to it. Not all attributes are present for any given ice polygon. Represented as a line of code in a data file the egg code takes the form:

ID,Ct,Ca,Cb,Cc,Sa,Sb,Sc,Fa,Fb,Fc,So,Sd,~

Where: **ID** is a 3-digit integer identifier of a polygon

Ct is total ice concentration as a percent, includes the percentage of **So** or **Sd** when present
Ca is the percentage concentration of the thickest ice type
Cb is the percentage concentration of the next thickest ice type
Cc is the percentage concentration of the next thickest ice type

So is a code for the thickest ice present, assigned 5%, percent concentration included in **Ct**
Sa is a code for the thickness of **Ca**
Sb is a code for the thickness of **Cb**
Sc is a code for the thickness of **Cc**
Sd is a code for the thinnest ice present, normally greater than 10%, percent concentration included in **Ct**

Fa is a code for the floe size of **Ca**

Fb is a code for the floe size of **Cb**
Fc is a code for the floe size of **Cc**

~ is the percentage concentration of strip & patch.

Supplemental_Information:
Revisions: None

Reviews_Applied_to_Data:
The original ice charts were obtained from the Canadian Ice Service (CIS) and the National Ice Center (NIC). These charts were digitized into vector format using ARC/INFO. Digitizing errors were fixed and the electronic coverages were visually compared to the original charts. The ice attributes on the chart for each polygon were entered into a file. These attribute files were checked against the charts. The attributes were linked to the coverages. The coverages were in three different projections. A standard projection and extent was established, and all coverages were reprojected into that Mercator projection. Since the 1995-1996 ice season, the ice charts were provided as ARC/INFO electronic coverages. These were similarly processed. Processing and quality control details are provided in Norton et. al., 2000.

Related_Spatial_and_Tabular_Data_Sets:
The Great Lakes Ice Cover Digital Data Set: Grids

Other_References_Cited:
Norton, D. C., Assel, R. A., Myers, D., Hibner, B. A., Morse, N., Trimble, P. J., Cronk, K., Rubens, M., 2000. Great Lakes Ice Data Rescue Project. NOAA Technical Memorandum GLERL-117, Great Lakes Environmental Research Laboratory, ftp://ftp.glerl.noaa.gov/publications/tech_reports/glerl-117/

Time_Period_of_Content:
Calendar_Date:
Winter 1972-1973 through 1999-2000.
Currentness_Reference:
Current data is obtained from the NIC web page: http://www.natice.noaa.gov/home.htm

Access_Constraints:
There are no access constraints on these data. Unlimited use and reference of the Digital Great Lakes Ice Cover Data Set is granted upon condition that the National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory is credited as the source.

Data_Set_Credit:
The Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan digitized and processed the data into a standardized electronic format to enhance the accessibility of the data. This work was done in conjunction with the CIS and NIC acting as advisors. This project was funded in part by NOAA's NESDIS ESDIM Program as a data rescue project.

Completeness_Report:
The data include vector representations of the Great Lakes shoreline, Lake St. Clair shoreline, the St. Lawrence River, many (but not all) islands, and lake ice polygons. Some man-made features such as the Keweenaw Waterway (Lake Superior) are excluded. The shoreline representation is not sufficiently accurate for other uses, such as navigation.

Cloud_Cover:
Not applicable.

Status:
Progress: Complete
Maintenance_and_Update_Frequency: An annual update is under discussion.

Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -92.382 decimal degrees
East_Bounding_Coordinate: -75.706 decimal degrees
North_Bounding_Coordinate: 50.539 decimal degrees
South_Bounding_Coordinate: 38.835 decimal degrees

Keywords:
Theme:
Theme_Keyword_Thesaurus: None
Theme_Keyword: Great Lakes, shoreline, lake shore, lake ice, ice concentration, ice type, ice age, stage of development, ice thickness, ice form, ice floe, World Meteorological Organization egg code.
Place:
Place_Keyword_Thesaurus: None
Place_Keyword: Great Lakes, Lake St. Clair, St. Mary's River, Detroit River, St. Lawrence River, St. Lawrence Seaway
Stratum:
Stratum_Keyword_Thesaurus: None
Stratum_Keyword: Lake ice
Temporal:
Temporal_Keyword_Thesaurus: None
Temporal_Keyword: Contemporary

Use_Constraints:
Vector Shoreline:
The vector data are intended for general planning, study, and illustrative purposes. The data are not intended for uses that require a high degree of positional accuracy.

Lake ice classification:
The WMO egg code was used throughout to represent these data. Where the original data were not in egg code, we translated the data to the egg code. Our implementation of the egg code is all numeric and is detailed in Norton et. al., 2000. We adjusted partial concentrations (Ca, Cb, and Cc) so that their sum equals the total concentration.

Procedures_Used:
A detailed explanation of the procedures used has been published (Norton et. al, 2000).

Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Data Manager
Contact_Organization: Great Lakes Environmental Research Laboratory
Contact_Position: Computer Services
Contact_Address:
Address_Type: mailing and physical address
Address: 2205 Commonwealth Blvd.
City: Ann Arbor

State_or_Province: MI
Postal_Code: 48105-2945
Country: U.S.A.
Contact_Voice_Telephone: 734-741-2127
Contact_Facsimile_Telephone: 734-741-2055
Contact_Electronic_Mail_Address: data-manager@glerl.noaa.gov
Hours_of_Service: 8:00-4:30 Eastern

Security_Information:
Security_Classification_System: None
Security_Classification: Unclassified
Security_Handling_Description: None

Native_Data_Set_Environment: HP-UX UNIX, ARC/INFO version 7.0.4

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report: See Entity_Attribute_Information
Quantitative_Attribute_Accuracy_Assessment:
Attribute_Accuracy_Value: Observer defined.
Attribute_Accuracy_Explanation: Observer estimates.
Logical_Consistency_Report: Chain-node topology present, all data parameter positions filled.
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report: 2.5 km digitizing accuracy.
Vertical_Positional_Accuracy:
Vertical_Positional_Accuracy_Report: N/A

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: Point
Point_and_Vector_Object_Count: 0
SDTS_Point_and_Vector_Object_Type: String
Point_and_Vector_Object_Count: varies
SDTS_Point_and_Vector_Object_Type: GT-polygon composed of chains
Point_and_Vector_Object_Count: 0

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar
Map_Projection:
Map_Projection_Name: MERCATOR
Longitude_of_Central_Meridian: -96 8 24.000 degrees
Latitude_of_True Scale: 45 2 24.000 degrees
Latitude_of_First_Standard_Parallel: 29.5 decimal degrees
Latitude_of_Second_Standard_Parallel: 45.5 decimal degrees
False_Easting: 0.00000
False_Northing: 0.00000
Geodetic Model

Horizontal_Datum_Name:
Ellipsoid_Name: Clarke 1866
Semi-major_Axis: 6,378,206.4
Denominator_of_Flattening: 294.98

Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: <cover>.AAT
Entity_Type_Definition: Arc Attribute Table
Entity_Type_Definition_Source: ESRI, Inc.
Attribute:
Attribute_Label: FNODE#
Attribute_Definition: Internal number of from-node
Attribute_Definition_Source: Computed
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Sequential unique positive integer
Attribute:
Attribute_Label: TNODE#
Attribute_Definition: Internal number of to-node
Attribute_Definition_Source: ComputedAttribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Sequential unique positive integer
Attribute:
Attribute_Label: LPOLY#
Attribute_Definition: Internal number of poly to left of arc
Attribute_Definition_Source: Computed
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Sequential unique positive integer
Attribute:
Attribute_Label: RPOLY#
Attribute_Definition: Internal number of poly to right of arc
Attribute_Definition_Source: Computed
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Sequential unique positive integer
Attribute:
Attribute_Label: LENGTH
Attribute_Definition: Length of arc in coverage units
Attribute_Definition_Source: Computed
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Positive real numbers
Attribute:
Attribute_Label: <cover>#
Attribute_Definition: Internal feature number
Attribute_Definition_Source: Computed
Attribute_Domain_Values:
Enumerated_Domain:

Enumerated_Domain_Value: Sequential unique positive integer
Attribute:
Attribute_Label: <cover>-ID
Attribute_Definition: User-assigned feature number
Attribute_Definition_Source: User-defined
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Integer
Attribute:
Attribute_Label: Ct
Attribute_Definition: Total ice concentration
Attribute_Definition_Source: World Meteorological Organization egg code, modified from tenths coverage to percent coverage, ranges assigned average value, ex: 7-9/10 is 80%.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: 0
Enumerated_Domain_Value_Definition: Ice free, (WMO 0)
Enumerated_Domain_Value: 5
Enumerated_Domain_Value_Definition: 5%, (WMO <1/10)
Enumerated_Domain_Value: 10
Enumerated_Domain_Value_Definition: 10%, (WMO 1/10)
Enumerated_Domain_Value: 15
Enumerated_Domain_Value_Definition: 15%
Enumerated_Domain_Value: 20
Enumerated_Domain_Value_Definition: 20%, (WMO 2/10)
Enumerated_Domain_Value: 25
Enumerated_Domain_Value_Definition: 25%
Enumerated_Domain_Value: 30
Enumerated_Domain_Value_Definition: 30%, (WMO 3/10)
Enumerated_Domain_Value: 35
Enumerated_Domain_Value_Definition: 35%
Enumerated_Domain_Value: 40
Enumerated_Domain_Value_Definition: 40%, (WMO 4/10)
Enumerated_Domain_Value: 45
Enumerated_Domain_Value_Definition: 45%
Enumerated_Domain_Value: 50
Enumerated_Domain_Value_Definition: 50%, (WMO 5/10)
Enumerated_Domain_Value: 55
Enumerated_Domain_Value_Definition: 55%
Enumerated_Domain_Value: 60
Enumerated_Domain_Value_Definition: 60%, (WMO 6/10)
Enumerated_Domain_Value: 65
Enumerated_Domain_Value_Definition: 65%
Enumerated_Domain_Value: 70
Enumerated_Domain_Value_Definition: 70%, (WMO 7/10)
Enumerated_Domain_Value: 75
Enumerated_Domain_Value_Definition: 75%
Enumerated_Domain_Value: 80
Enumerated_Domain_Value_Definition: 80%, (WMO 8/10)
Enumerated_Domain_Value: 85

Enumerated_Domain_Value_Definition: 85%
Enumerated_Domain_Value: 90
Enumerated_Domain_Value_Definition: 90%, (WMO 9/10)
Enumerated_Domain_Value: 95
Enumerated_Domain_Value_Definition: 95%, (WMO 9+/10)
Enumerated_Domain_Value: 100
Enumerated_Domain_Value_Definition: 100%, (WMO 10/10)
Enumerated_Domain_Value: -88
Enumerated_Domain_Value_Definition: placeholder, no data (WMO blank)
Enumerated_Domain_Value: -99
Enumerated_Domain_Value_Definition: missing data

Attribute:
Attribute_Label: Ca
Attribute_Definition: Partial ice concentration of thickest ice present
Attribute_Definition_Source: World Meteorological Organization egg code, modified from tenths coverage to percent coverage.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as attribute label Ct
Enumerated_Domain_Value_Definitions: Same as attribute label Ct

Attribute:
Attribute_Label: Cb
Attribute_Definition: Partial ice concentration of next thickest ice present after Ca
Attribute_Definition_Source: World Meteorological Organization egg code, modified from tenths coverage to percent coverage.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as attribute label Ct
Enumerated_Domain_Value_Definitions: Same as attribute label Ct

Attribute:
Attribute_Label: Cc
Attribute_Definition: Partial ice concentration of next thickest ice present after Cb
Attribute_Definition_Source: World Meteorological Organization egg code, modified from tenths coverage to percent coverage.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as attribute label Ct
Enumerated_Domain_Value_Definitions: Same as attribute label Ct

Attribute:
Attribute_Label: So
Attribute_Definition: Thickest stage of development (sometimes called ice age or thickness) for 5% of the ice extent contained in Ca, but Ca is primarily defined by Sa.
Attribute_Definition_Source: World Meteorological Organization egg code, modified for blank and “1.” values.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: 0
Enumerated_Domain_Value_Definition: No stage of development (no ice)
Enumerated_Domain_Value: 1
Enumerated_Domain_Value_Definition: New ice, 0-5cm
Enumerated_Domain_Value: 4

Enumerated_Domain_Value_Definition: Thin lake ice, 5-15cm
Enumerated_Domain_Value: 5
Enumerated_Domain_Value_Definition: Medium lake ice, 15-30cm
Enumerated_Domain_Value: 7
Enumerated_Domain_Value_Definition: thick lake ice, 30-70cm
Enumerated_Domain_Value: 8
Enumerated_Domain_Value_Definition: 1st stage thick ice, 30-50cm
Enumerated_Domain_Value: 9
Enumerated_Domain_Value_Definition: 2nd stage thick ice, 50-70cm
Enumerated_Domain_Value: 10
Enumerated_Domain_Value_Definition: Very thick lake ice, 70-120cm (WMO 1.)
Enumerated_Domain_Value: -8
Enumerated_Domain_Value_Definition: Placeholder (WMO blank)
Enumerated_Domain_Value: -9
Enumerated_Domain_Value_Definition: Missing data

Attribute:
Attribute_Label: Sa
Attribute_Definition: Thickest stage of development (sometimes called ice age or thickness) after So, corresponding to concentration Ca, and form Fa.
Attribute_Definition_Source: World Meteorological Organization egg code, modified for blank and "1." values.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Same as So
Enumerated_Domain_Value_Definition: Same as So

Attribute:
Attribute_Label: Sb
Attribute_Definition: Thickest stage of development (sometimes called ice age or thickness) after Sa, corresponding to concentration Cb, and form Fb.
Attribute_Definition_Source: World Meteorological Organization egg code, modified for blank and "1." values.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Same as So.
Enumerated_Domain_Value_Definition: Same as So.

Attribute:
Attribute_Label: Sc
Attribute_Definition: Thickest stage of development (sometimes called ice age or thickness) after Sb, corresponding to concentration Cc, and form Fc.
Attribute_Definition_Source: World Meteorological Organization egg code, modified for blank and "1." values.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Same as So.
Enumerated_Domain_Value_Definition: Same as So.

Attribute:
Attribute_Label: Sd
Attribute_Definition: Thickest stage of development (sometimes called ice age or thickness) after Sc, Sd's concentration value is included in Ct.
Attribute_Definition_Source: World Meteorological Organization egg code, modified for blank and "1." values.

Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Same as So.
Enumerated_Domain_Value_Definition: Same as So.
Attribute:
Attribute_Label: Fa
Attribute_Definition: Ice form
Attribute_Definition_Source: World Meteorological Organization egg code, indicates floe size corresponding to concentration Ca, and stage Sa.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: 0
Enumerated_Domain_Value_Definition: pancake ice
Enumerated_Domain_Value: 1
Enumerated_Domain_Value_Definition: small cake ice; brash ice
Enumerated_Domain_Value: 2
Enumerated_Domain_Value_Definition: ice cake
Enumerated_Domain_Value: 3
Enumerated_Domain_Value_Definition: small floe, < 100m
Enumerated_Domain_Value: 4
Enumerated_Domain_Value_Definition: medium floe, 100-500m
Enumerated_Domain_Value: 5
Enumerated_Domain_Value_Definition: big floe, 500-1000m
Enumerated_Domain_Value: 6
Enumerated_Domain_Value_Definition: vast floe, > 1000m
Enumerated_Domain_Value: 8
Enumerated_Domain_Value_Definition: fast ice
Enumerated_Domain_Value: -8
Enumerated_Domain_Value_Definition: no data, place holder
Enumerated_Domain_Value: -9
Enumerated_Domain_Value_Definition: missing data
Attribute:
Attribute_Label: Fb
Attribute_Definition: Ice form
Attribute_Definition_Source: World Meteorological Organization egg code, indicates floe size corresponding to concentration Cb, and stage Sb.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as Fa.
Enumerated_Domain_Value_Definitions: Same as Fa.
Attribute:
Attribute_Label: Fc
Attribute_Definition: Ice form
Attribute_Definition_Source: World Meteorological Organization egg code, indicates floe size corresponding to concentration Cc, and stage Sc.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as Fa.
Enumerated_Domain_Value_Definitions: Same as Fa.
Attribute:
Attribute_Label: ~

Attribute_Definition: Belts and strips (also known as: strip and patch)
Attribute_Definition_Source: World Meteorological Organization egg code, indicates the ice concentration portion within the ice floes
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as Ct.
Enumerated_Domain_Value_Definitions: Same as Ct.

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Data Manager
Contact_Organization: Great Lakes Environmental Research Laboratory
Contact_Position: Computer Services
Contact_Address:
Address_Type: mailing and physical address
Address: 2205 Commonwealth Blvd.
City: Ann Arbor
State_or_Province: MI
Postal_Code: 48105-2945
Country: U.S.A.
Contact_Voice_Telephone: 734-741-2127
Contact_Facsimile_Telephone: 734-741-2055
Contact_Electronic_Mail_Address: data-manager@glerl.noaa.gov
Hours_of_Service: 8:00-4:30 Eastern
Resource_Description: Great Lakes Ice Data Coverages

Distribution_Liability:
DISCLAIMER:
The ice coverage data contained in this publication were generated for use by NOAA's Great Lakes Environmental Research Laboratory (GLERL). Although GLERL is making these data available to others who may find them of value, GLERL does not warrant, endorse, or recommend the use of these data for any given purpose. In no event will GLERL be liable to you or any third party for any direct, indirect, incidental, consequential, special, or exemplary damages or lost profits resulting from any use or misuse of these data.

Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: SDTS Spatial Data Transfer Standards (FIPS 173)
Format_Name: ARC/INFO Export format (Mercator Projection)
Format_Name: ARC/INFO Generate format (Mercator Projection)
Format_Name: ARC/INFO Generate format (geographic coordinates)
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name: ftp://ftp.glerl.noaa.gov/
Access_Instructions: Connect to GLERL's anonymous ftp site - ftp.glerl.noaa.gov.
Move to the subdirectory ../ice. Download files as desired
Online_Computer_and_Operating_System: Hewlett Packard - HP-UX 9.05

Offline_Option:
Offline_Media: CD-ROM
Recording_Capacity:
Recording_Density:
Recording_Density_Units:
Fees: to be determined
Ordering_Instructions: Contact GLERL, data-manager@glerl.noaa.gov

Turnaround:
Custom_Order_Process: None
Technical_Prerequisites: Able to import/use ARC/INFO export files.
Available_Time_Period:
Beginning_Date/Time: 20020302
Ending_Date/Time: Undetermined

Metadata_Reference_Section:
Metadata_Date: 20020302
Metadata_Contact: Data Manager
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: 19940608
Metadata_Time_Convention: Local Time
Metadata_Security_Information:
Metadata_Security_Classification_System: None
Metadata_Security_Classification: Unclassified
Metadata_Security_Handling_Description: None

Appendix B. Metadata for The ASCII Grids

Identification_Information:
Citation:
Originator: Great Lakes Environmental Research Laboratory (compiler)
Publication_Date: 20020302
Publication_Time: 00000000
Title: Great Lakes Ice Cover ASCII Grid Data
Edition: 1.0
Geospatial_Data_Presentation_Form: ASCII Grid
Publication_Information:
Publication_Place: Ann Arbor, MI, U.S.A.
Publisher: Great Lakes Environmental Research Laboratory
Other_Citation_Details: NOAA Technical Memorandum ERL-GLERL-121
Online_Linkage: ftp://ftp.glerl.noaa.gov/ice/charts/
Larger_Work_Citation: A Great Lakes Ice Cover Digital Data Set For Winters 1973-2000.
Scale_Denominator:

Description:
Abstract: These data are a set of 15,708 ASCII grids derived from the Great Lakes Ice Cover Vector Data. The grid cells are 2.56 km by 2.56 km, the same as GLERL's CoastWatch data. Each coverage yielded 14 attribute grids. Not all attributes have data values for any given ice polygon. For consistency sake all 14 attribute grids were produced for all coverages, even if they contained no data. The grids produced are: **ID,Ct,Ca,Cb,Cc,Sa,Sb,Sc,Fa,Fb,Fc,So,Sd,~**

Where: **ID** is a 3-digit integer identifier of a polygon
Ct is total ice concentration as a percent, includes the percentage of **So** or **Sd** when present
Ca is the percentage concentration of the thickest ice type
Cb is the percentage concentration of the next thickest ice type
Cc is the percentage concentration of the next thickest ice type

So is a code for the thickest ice present if < 10%, assigned 5%, included in **Ct**
Sa is a code for the thickness of **Ca**
Sb is a code for the thickness of **Cb**
Sc is a code for the thickness of **Cc**
Sd is a code for the thinnest ice present, normally greater than 10%, percentage concentration included in **Ct**

Fa is a code for the floe size of **Ca**
Fb is a code for the floe size of **Cb**
Fc is a code for the floe size of **Cc**

~ is the percentage concentration of strip & patch ice

Supplemental_Information:
Revisions: None

Reviews_Applied_to_Data:
The cell values in every grid were checked against a table of possible values and any illegitimate values found were corrected. Some of these illegitimate values had been input errors and others were created by ARC/INFO.

Since the coverage shorelines varied slightly, so did the grids produced from them. The grids were processed so that the overland and over water cells were consistent throughout the data set. Processing and quality control details are provided in Norton et. al., 2000.

Related_Spatial_and_Tabular_Data_Sets:
The Great Lakes Ice Cover Digital Data Set: Coverages

Other_References_Cited:
Norton, D. C., Assel, R. A., Myers, D., Hibner, B. A., Morse, N., Trimble, P. J., Cronk, K., Rubens, M., 2000. Great Lakes Ice Data Rescue Project. NOAA Technical Memorandum GLERL-117, Great Lakes Environmental Research Laboratory, ftp://ftp.glerl.noaa.gov/publications/tech_reports/glerl-117/

Time_Period_of_Content:
Calendar_Date:
Winter 1972-1973 through 1999-2000.
Currentness_Reference:
Current data is obtained from the NIC web page: http://www.natice.noaa.gov/home.htm

Access_Constraints:
There are no access constraints on these data. Unlimited use and reference of the Great Lakes Ice Grid Data is granted upon condition that the Great Lakes Environmental Research Laboratory is credited as the source.

Data_Set_Credit:
The Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan digitized and processed the data into a standardized form to enhance the accessibility of the data. This work was done in conjunction with the CIS and NIC acting as advisors. This project was funded in part by NOAA's NESDIS ESDIM Program as a data rescue project.

Completeness_Report:
The data include irregular grid representations of the Great Lakes shoreline, Lake St. Clair shoreline, the St. Lawrence River, many (but not all) islands, and lake ice polygons. Some man-made features such as the Keewenaw Waterway (Lake Superior) are excluded. The shoreline representation is not sufficiently accurate for other uses, such as navigation.

Cloud_Cover:
Not applicable.

Status:
Progress: Complete
Maintenance_and_Update_Frequency: An annual update is under discussion.

Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -92.382
East_Bounding_Coordinate: -75.694
North_Bounding_Coordinate: 50.562
South_Bounding_Coordinate: 38.835

Keywords:
Theme:
Theme_Keyword_Thesaurus: None

Theme_Keyword: Great Lakes, shoreline, lake shore, lake ice, ice concentration, ice type, ice age, ice stage, ice thickess ice form, ice floe, World Meteorological Organization egg code.
Place:
Place_Keyword_Thesaurus: None
Place_Keyword: Great Lakes, Lake St. Clair, St. Mary's River, Detroit River, St. Lawrence River, St. Lawrence Seaway
Stratum:
Stratum_Keyword_Thesaurus: None
Stratum_Keyword: Lake ice
Temporal:
Temporal_Keyword_Thesaurus: None
Temporal_Keyword: Contemporary

Use_Constraints:
Grid ice data and shoreline:
The grid data are intended for general planning, study, and illustrative purposes.
The data are not intended for uses that require a high degree of positional accuracy.

Lake ice classification:
The WMO egg code was used throughout to represent these data. Where the original data were not in egg code, we translated the data to the egg code. Our implementation of the egg code is all numeric and is detailed in Norton et. al., 2000. We adjusted partial concentrations (Ca, Cb, Cc, and implied So, Sd) so that their sum equals the total concentration, Ct.

Procedures_Used:
A detailed explanation of the procedures used has been published (Norton et. al, 2000).

Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Data manager
Contact_Organization: Great Lakes Environmental Research Laboratory
Contact_Position: Computer Services
Contact_Address:
Address_Type: mailing and physical address
Address: 2205 Commonwealth Blvd.
City: Ann Arbor
State_or_Province: MI
Postal_Code: 48105-2945
Country: U.S.A.
Contact_Voice_Telephone: 734-741-2127
Contact_Facsimile_Telephone: 734-741-2055
Contact_Electronic_Mail_Address: data-manager@glerl.noaa.gov
Hours_of_Service: 8:00-4:30 Eastern

Security_Information:
Security_Classification_System: None
Security_Classification: Unclassified
Security_Handling_Description: None

Native_Data_Set_Environment: HP-UX UNIX, ARC/INFO version 7.0.4

Data_Quality_Information:
  Attribute_Accuracy:
  Attribute_Accuracy_Report: See Entity_Attribute_Information
  Quantitative_Attribute_Accuracy_Assessment:
  Attribute_Accuracy_Value: Observer defined.
  Attribute_Accuracy_Explanation: Observer estimates.
  Logical_Consistency_Report: Consistent grids, all data parameter positions filled.
  Positional_Accuracy:
  Horizontal_Positional_Accuracy:
  Horizontal_Positional_Accuracy_Report: 2.5 km digitizing accuracy
  Vertical_Positional_Accuracy:
  Vertical_Positional_Accuracy_Report: N/A

Spatial_Data_Organization_Information:
  Direct_Spatial_Reference_Method: Grid

Spatial_Reference_Information:
  Horizontal_Coordinate_System_Definition:

Attribute:
  Attribute_Label: Ct
  Attribute_Definition: Total ice concentration
  Attribute_Definition_Source: World Meteorological Organization egg code, modified from tenths coverage to percent coverage; ranges assigned average value, ex: 7-9/10 is 80%.
  Attribute_Domain_Values:
    Enumerated_Domain:
      Enumerated_Domain_Value: 0
      Enumerated_Domain_Value_Definition: Ice free, (WMO 0)
      Enumerated_Domain_Value: 5
      Enumerated_Domain_Value_Definition: 5%, (WMO <1/10)
      Enumerated_Domain_Value: 10
      Enumerated_Domain_Value_Definition: 10%, (WMO 1/10)
      Enumerated_Domain_Value: 15
      Enumerated_Domain_Value_Definition: 15%
      Enumerated_Domain_Value: 20
      Enumerated_Domain_Value_Definition: 20%, (WMO 2/10)
      Enumerated_Domain_Value: 25
      Enumerated_Domain_Value_Definition: 25%
      Enumerated_Domain_Value: 30
      Enumerated_Domain_Value_Definition: 30%, (WMO 3/10)
      Enumerated_Domain_Value: 35
      Enumerated_Domain_Value_Definition: 35%
      Enumerated_Domain_Value: 40
      Enumerated_Domain_Value_Definition: 40%, (WMO 4/10)
      Enumerated_Domain_Value: 45
      Enumerated_Domain_Value_Definition: 45%
      Enumerated_Domain_Value: 50
      Enumerated_Domain_Value_Definition: 50%, (WMO 5/10)
      Enumerated_Domain_Value: 55

Enumerated_Domain_Value_Definition: 55%
Enumerated_Domain_Value: 60
Enumerated_Domain_Value_Definition: 60%, (WMO 6/10)
Enumerated_Domain_Value: 65
Enumerated_Domain_Value_Definition: 65%
Enumerated_Domain_Value: 70
Enumerated_Domain_Value_Definition: 70%, (WMO 7/10)
Enumerated_Domain_Value: 75
Enumerated_Domain_Value_Definition: 75%
Enumerated_Domain_Value: 80
Enumerated_Domain_Value_Definition: 80%, (WMO 8/10)
Enumerated_Domain_Value: 85
Enumerated_Domain_Value_Definition: 85%
Enumerated_Domain_Value: 90
Enumerated_Domain_Value_Definition: 90%, (WMO 9/10)
Enumerated_Domain_Value: 95
Enumerated_Domain_Value_Definition: 95%, (WMO 9+/10)
Enumerated_Domain_Value: 100
Enumerated_Domain_Value_Definition: 100%, (WMO 10/10)
Enumerated_Domain_Value: -88
Enumerated_Domain_Value_Definition: placeholder, no data (WMO blank)
Enumerated_Domain_Value: -99
Enumerated_Domain_Value_Definition: missing data

Attribute:
Attribute_Label: Ca
Attribute_Definition: Partial ice concentration of thickest ice present
Attribute_Definition_Source: World Meteorological Organization egg code, modified from tenths coverage to percent coverage.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as attribute label Ct
Enumerated_Domain_Value_Definitions: Same as attribute label Ct

Attribute:
Attribute_Label: Cb
Attribute_Definition: Partial ice concentration of next thickest ice present after Ca
Attribute_Definition_Source: World Meteorological Organization egg code, modified from tenths coverage to percent coverage.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as attribute label Ct
Enumerated_Domain_Value_Definitions: Same as attribute label Ct

Attribute:
Attribute_Label: Cc
Attribute_Definition: Partial ice concentration of next thickest ice present after Cb
Attribute_Definition_Source: World Meteorological Organization egg code, modified from tenths coverage to percent coverage.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as attribute label Ct
Enumerated_Domain_Value_Definitions: Same as attribute label Ct

Attribute:
Attribute_Label: So

Attribute_Definition: Thickest stage of development (sometimes called ice age or thickness) for 5% of the ice extent contained in Ca, but Ca is primarily defined by Sa.
Attribute_Definition_Source: World Meteorological Organization egg code, modified for blank and "1." values.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: 0
Enumerated_Domain_Value_Definition: No stage of development (no ice)
Enumerated_Domain_Value: 1
Enumerated_Domain_Value_Definition: New ice, 0-5cm
Enumerated_Domain_Value: 4
Enumerated_Domain_Value_Definition: Thin lake ice, 5-15cm
Enumerated_Domain_Value: 5
Enumerated_Domain_Value_Definition: Medium lake ice, 15-30cm
Enumerated_Domain_Value: 7
Enumerated_Domain_Value_Definition: thick lake ice, 30-70cm
Enumerated_Domain_Value: 8
Enumerated_Domain_Value_Definition: 1st stage thick ice, 30-50cm
Enumerated_Domain_Value: 9
Enumerated_Domain_Value_Definition: 2nd stage thick ice, 50-70cm
Enumerated_Domain_Value: 10
Enumerated_Domain_Value_Definition: Very thick lake ice, 70-120cm (WMO 1.)
Enumerated_Domain_Value: -8
Enumerated_Domain_Value_Definition: Placeholder (WMO blank)
Enumerated_Domain_Value: -9
Enumerated_Domain_Value_Definition: Missing data

Attribute:
Attribute_Label: Sa
Attribute_Definition: Thickest stage of development (sometimes called ice age or thickness) after So, corresponding to concentration Ca, and form Fa.
Attribute_Definition_Source: World Meteorological Organization egg code, modified for blank and "1." values.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Same as So
Enumerated_Domain_Value_Definition: Same as So

Attribute:
Attribute_Label: Sb
Attribute_Definition: Thickest stage of development (sometimes called ice age or thickness) after Sa, corresponding to concentration Cb, and form Fb.
Attribute_Definition_Source: World Meteorological Organization egg code, modified for blank and "1." values.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Same as So.
Enumerated_Domain_Value_Definition: Same as So.

Attribute:
Attribute_Label: Sc
Attribute_Definition: Thickest stage of development (sometimes called ice age or thickness) after Sb, corresponding to concentration Cc, and form Fc.
Attribute_Definition_Source: World Meteorological Organization egg code, modified for blank and "1." values.

Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Same as So.
Enumerated_Domain_Value_Definition: Same as So.
Attribute:
Attribute_Label: Sd
Attribute_Definition: Thickest stage of development (sometimes called ice age or thickness) after Sc, Sd's concentration value is included in Ct.
Attribute_Definition_Source: World Meteorological Organization egg code, modified for blank and "1." values.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Same as So.
Enumerated_Domain_Value_Definition: Same as So.
Attribute:
Attribute_Label: Fa
Attribute_Definition: Ice form
Attribute_Definition_Source: World Meteorological Organization egg code, indicates floe size corresponding to concentration Ca, and stage Sa.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: 0
Enumerated_Domain_Value_Definition: pancake ice
Enumerated_Domain_Value: 1
Enumerated_Domain_Value_Definition: small cake ice; brash ice
Enumerated_Domain_Value: 2
Enumerated_Domain_Value_Definition: ice cake
Enumerated_Domain_Value: 3
Enumerated_Domain_Value_Definition: small floe, < 100m
Enumerated_Domain_Value: 4
Enumerated_Domain_Value_Definition: medium floe, 100-500m
Enumerated_Domain_Value: 5
Enumerated_Domain_Value_Definition: big floe, 500-1000m
Enumerated_Domain_Value: 6
Enumerated_Domain_Value_Definition: vast floe, > 1000m
Enumerated_Domain_Value: 8
Enumerated_Domain_Value_Definition: fast ice
Enumerated_Domain_Value: -8
Enumerated_Domain_Value_Definition: no data, place holder
Enumerated_Domain_Value: -9
Enumerated_Domain_Value_Definition: missing data
Attribute:
Attribute_Label: Fb
Attribute_Definition: Ice form
Attribute_Definition_Source: World Meteorological Organization egg code, indicates floe size corresponding to concentration Cb, and stage Sb.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as Fa.
Enumerated_Domain_Value_Definitions: Same as Fa.
Attribute:

Attribute_Label: Fc
Attribute_Definition: Ice form
Attribute_Definition_Source: World Meteorological Organization egg code, indicates floe size corresponding to concentration Cc, and stage Sc.
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as Fa.
Enumerated_Domain_Value_Definitions: Same as Fa.

Attribute:
Attribute_Label: ~
Attribute_Definition: Belts and strips (also known as: strip and patch)
Attribute_Definition_Source: World Meteorological Organization egg code, indicates the ice concentration portion within the ice floes
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Values: Same as Ct.
Enumerated_Domain_Value_Definitions: Same as Ct.

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Data Manager
Contact_Organization: Great Lakes Environmental Research Laboratory
Contact_Position: Computer Services
Contact_Address:
Address_Type: mailing and physical address
Address: 2205 Commonwealth Blvd.
City: Ann Arbor
State_or_Province: MI
Postal_Code: 48105-2945
Country: U.S.A.
Contact_Voice_Telephone: 734-741-2127
Contact_Facsimile_Telephone: 734-741-2055
Contact_Electronic_Mail_Address: data-manager@glerl.noaa.gov
Hours_of_Service: 8:00-4:30 Eastern
Resource_Description: Great Lakes Ice Data Coverages

Distribution_Liability:
DISCLAIMER:
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Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: SDTS Spatial Data Transfer Standards (FIPS 173)
Format_Name: ARC/INFO Export format (Mercator Projection)

Format_Name: ARC/INFO Generate format (Mercator Projection)
Format_Name: ARC/INFO Generate format (geographic coordinates)
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name: ftp://ftp.glerl.noaa.gov/
Access_Instructions: Connect to GLERL's anonymous ftp site - ftp.glerl.noaa.gov.
Move to the subdirectory ../ice. Download files as desired .
Online_Computer_and_Operating_System: Hewlett Packard - HP-UX 9.05
Offline_Option:
Offline_Media: CD-ROM
Recording_Capacity:
Recording_Density:
Recording_Density_Units:
Fees: to be determined
Ordering_Instructions: Contact GLERL, data-manager@glerl.noaa.gov
Turnaround:
Custom_Order_Process: None
Technical_Prerequisites: None
Available_Time_Period:
Beginning_Date/Time: 20020302
Ending_Date/Time: Undetermined

Metadata_Reference_Section:
Metadata_Date: 20020302
Metadata_Contact: Data Manager
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: 19940608
Metadata_Time_Convention: Local Time
Metadata_Security_Information:
Metadata_Security_Classification_System: None
Metadata_Security_Classification: Unclassified
Metadata_Security_Handling_Description: None

Appendix C. Software

importer.aml:

```
/* importer.aml  converts ARC/INFO export ".e00" files to coverages
/* the export files and the new files will be in the same work area.

&type
&s count := [filelist *.e00 covlist -file]
&if %count% = 0 &then
  &return No export coverages found in the current workspace.

/* Read export coverage names, strip off .e00 extension
&s unit := [open covlist ok -read]
 &s cov = [read %unit% ok]
 &s cov = [before %cov% .e]

&do &until %ok% = 102
  &if [exists %cov% -cover] &then &do
     kill %cov% all
  &end

  import auto %cov% %cov%

  &s cov := [before [read %unit% ok] .e]
&end

&s ok := [close %unit%]
&s ok := [delete covlist -file]

&return
```

reformat.f:

```
c     reformat.f  Makes a new ice grid file.  The new file is named
c     as the original, but without the "." in the name.  The new
c     file is also ASCII, the header is the same, but the data is now
c     variable format ASCII.

c     On a UNIX system compile this program as:
c     f77 -o reformat reformat.f

c     ON a PC with Lahey FORTRAN compile this program as:
c     LF90 reformat.f -winconsole

      CHARACTER name*13,STRING*25,name2*12
      integer*2 idata(516)

      open (unit=15,file='reformat.inp',status='old')

    1 READ(15,1001,END=999)NAME

      if(name(13:13).ne.' ')then
        name2 = name(1:10)//name(12:13)
      else
        name2 = name(1:10)//name(12:12)
      endif

      open (unit=10,file=NAME,status='old',recl=1548)
      open (unit=11,file=name2,status='new',recl=2064)

       READ (10,1001)STRING(1:17)
       WRITE(11,1001)STRING(1:17)
       READ (10,1001)STRING(1:17)
       WRITE(11,1001)STRING(1:17)
       READ (10,1001)STRING(1:24)
       WRITE(11,1001)STRING(1:24)
       READ (10,1001)STRING(1:21)
       WRITE(11,1001)STRING(1:21)
       READ (10,1001)STRING(1:18)
       WRITE(11,1001)STRING(1:18)
       READ (10,1001)STRING(1:17)
       WRITE(11,1001)STRING(1:17)

      do j=1,510
       read(10,2000,end=889)(idata(k),k=1,516)
       write(11,*)(idata(L),L=1,516)
      enddo
```

```
889   continue
      close(10)
      close(11)

      GOTO 1

 999  CONTINUE
1001  FORMAT(A)
2000  format(516i3)
      CLOSE(15)
      STOP
      END
```

asciiarc.aml:

```
/* asciiarc.aml converts ascii grids to ARC/INFO format.
/* converts all grids in current workarea to a user defined area
/* Note:  User should be in the workspace of the source coverages.
/* Note:  The new ARC grid will have the same name as the ascii grid,
/* so it must be written to a different workspace.  Have no other files
/* starting with a “g” in the work area you will process.
&setvar dest := [response ‘Enter the </path/workspace> where you want to put ~
the new grids’ .]
&type
&s count := [filelist g* gridlist -file]
&if %count% = 0 &then
  &return No grids found in the current workspace.
&s unit := [open gridlist ok -read]
&do I := 1 &to %count%
  &s grid := [read %unit% ok]
  &type
  asciigrid %grid% %dest%/%grid%
    &type Converted ascii %grid% to ARC/INFO %dest%/%grid%
&end
&s ok := [close %unit%]
&s ok := [delete gridlist -file]
&return
```

Appendix D. The percentage of each grid containing data on line 1, and the sum of the cells containing data on line 2. See text for computation details.

Data are contained in a Microsoft Excel file at
ftp://ftp.glerl.noaa.gov/publications/tech_reports/glerl-121/
filename: AppendixD.xls