

SIGRID-3: A VECTOR ARCHIVE FORMAT FOR SEA ICE CHARTS

Developed by the International Ice Charting Working Group's Ad Hoc Format Team for the WMO "Global Digital Sea Ice Data Bank" project

WMO/TD-No. 1214

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NOTE

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariats of the Intergovernmental Oceanographic Commission (of UNESCO), and the World Meteorological Organization concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

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1 Introduction

Through the International Ice Charting Working Group (IICWG), the world's ice centers developed a vector format for archiving digital ice charts. The ice centers most actively involved in this effort are the Arctic and Antarctic Research Institute, Russia (AARI), the Canadian Ice Service (CIS), the Danish Meteorological Institute (DMI), and the U.S. National Ice Center (NIC). This new archive format joins the current World Meteorological Organization (WMO) standards for ice charts in the Global Digital Sea Ice Data Bank (GDSIDB). WMO ice chart archive formats are the Sea Ice Grid (SIGRID) format developed in 1981 and formalized in 1989, and its successor SIGRID-2. The vector format defined in this document, SIGRID-3, joins SIGRID and SIGRID-2 as standard WMO formats.

SIGRID-3 is based on a format called "shapefile." The shapefile format is an open vector file format (see Appendix 2 for more information). In contrast to raster formats such as SIGRID-2, where ice characteristics are represented on a grid, vector formats represent features (such as areas of ice outlined on a chart) as a series of vertices that define the outline of the feature in space. An associated list of attributes (such as the concentration, stage of development, and form of ice within) characterizes ice within the outlined area.

Storing ice chart data in vector format rather than raster format has advantages. The vector file preserves all of the information in the original chart, and charts can be re-projected or re-scaled without loss of information. It is also possible to convert a vector product to raster if necessary. These qualities make the vector format attractive to the researchers who are the main users of the GDSIDB. In addition, charts in SIGRID-3 format will be easy for ice centers to produce using many of the current production systems that employ Geographical Information Systems (GIS). Shapefiles can be produced without commercial GIS software but this requires the development of custom software.

1.1 Overview of the SIGRID-3 format

This document describes the SIGRID-3 format so that it may be understood by a variety of users and implemented by chart-producing ice centers or services. SIGRID-3 evolved from earlier SIGRID formats and incorporates much of their content (see Appendix 1 for notes on earlier SIGRID formats and their application in SIGRID-3). For example, SIGRID variable identifiers such as "CT" for total concentration are used in SIGRID-3. While all SIGRID variable identifiers may be used in SIGRID-3, those that are commonly used are required, such as concentration, stage of development, and form. Users familiar with SIGRID encoding of ice chart information will therefore find that they are already familiar with how ice is described in SIGRID-3.

A chart encoded in SIGRID-3 has two main components: the chart information itself in shapefile format, and metadata describing the chart.

1.1.1 GIS and Shapefiles

Some definitions may be helpful to readers who are not familiar with GIS or vector formats.

Feature: A representation of a geographic object that has both a spatial representation (a "shape") and a set of attributes. In an ice chart, an ice area feature is a polygon that is often described using the "egg code." In addition to polygons, other feature types that may appear in ice charts are lines and points.

Vector: A coordinate-based (x,y) data structure used to represent geographic features using one or more vertices.

Topology: The spatial relationship between connecting or adjacent features.

Shapefile: An open (non-proprietary) spatial data format developed by Environmental Systems Research Institute (ESRI) to store non-topological geometry and attribute information for the

spatial features in a data set. Feature geometry is stored as a shape comprising a set of vector coordinates. At least three files are needed to represent data in shapefile format.

Note that shapefiles can be created using ESRI GIS software. Readers may be familiar with the proprietary ESRI “e00” file export format. Some differences between e00 files and shapefiles are that while only one e00 file is needed to completely describe an ice chart, including topology, at least three files are needed for each shapefile format ice chart, and a shapefile rendition of an ice chart does not include topology.

A shapefile consists of three core files (but may include several optional files). Each file in the set shares the shapefile name with a different extension. The main file (*.shp) stores shape geometry and must always have an index file (*.shx). A database file (*.dbf) stores all the attributes of the shapes in the main file.

1.1.2 Metadata

SIGRID-3 uses the widely accepted, public domain eXtensible Markup Language (XML) for metadata (information on the ice chart and how it was generated). A file in XML stores the metadata that pertains to each ice chart. Metadata includes projection, location, keywords, and contact information. A file in XML can be read using a web browser, and it is easy to make it available for searches via the Internet.

To archive a chart in SIGRID-3, four files are required: three for the ice chart in shapefile format and one for the metadata in XML format (all described in the following sections).

1.2 Writing and displaying files in SIGRID-3

At present, shapefiles are being produced by the Canadian Ice Service using ESRI ArcGIS software, the Danish Meteorological Institute using ESRI ArcView software, and the U.S. National Ice Center using ESRI ArcGIS software. Contact the ice services directly for information regarding shapefile production. Shapefiles may also be produced without commercial software using custom software developed for that purpose.

A chart in SIGRID-3 shapefile format may be viewed using one of the ESRI products: ArcExplorer (available free of charge) or ArcGIS. Several other GIS and image processing software products have import utilities for handling shapefiles.

A basic understanding of GIS software packages on the part of producers and users of SIGRID-3 shapefiles is assumed and details are not given here. For detailed descriptions of tools and functions in ArcView or other GIS software, the user should refer to the software documentation.

2 Description of SIGRID-3 Shapefiles

This description provides an overview of the shapefile format as implemented in SIGRID-3. Programmers and others requiring a detailed technical description of shapefiles are referred to the ESRI document “ESRI Shapefile Technical Description,” referenced in Appendix 2.

2.1 Main and index files

When in a GIS display, the shapefile will portray the continental shoreline, islands, and all the ice lines as drawn by the analyst. This positional information about coastlines and ice is stored as shapes in the first file of the shapefile set, the main file (*.shp). Each record in the main file describes a shape with a list of vertices. The index file (*.shx) links shapes to their attributes. Attributes are stored in a database file (*.dbf), in a one-to-one relationship with shapes.

Note that points and lines, as well as polygons, are features that can be encoded using shapefiles. This description of SIGRID-3 covers only polygons. A description that includes the treatment of points and lines may be added later in a revision. Each feature type used (polygon,

point, and line) requires a separate shapefile set, therefore using all three types for a single ice chart necessitates nine shapefile files.

2.2 Database files

The database file (*.dbf) stores the attribute information for each polygon. This file is in dBase format, which is a format originally held by Borland, Inc., and used by ESRI in shapefile production. Conceptually, it is easiest to think of the dBase file as a table in which every row corresponds to a different polygon on the ice chart, and columns (fields) contain attributes describing the ice in the form of SIGRID variables. Figure 1 illustrates the structure of a dBase file and its relationship to ice chart polygons. The dBase file can be directly accessed by reading the header record and the attribute record, or can be viewed in a columnar format using ESRI software, Microsoft Excel, or a number of other object-oriented or relational database software packages. The dBase file must have the same prefix as the main and index files, and it must contain a record of SIGRID-3 attributes for each polygon. These records must be in the same order as their corresponding polygons in the main file.

Appendix 3 gives a detailed description of the structure of a dBase file, with information on header and record length that will allow programmers to work with dBase files. The dBase file is accessed as two lines of input: a header, followed by a line containing every polygon record without field separators or record terminators.

2.3 Required database fields

The database file consists of a set of mandatory and optional fields. As a minimum, all mandatory fields must be created and all fields present in the database file must be described in the metadata file (see Section 3). It is important that the sequence, naming, type and length of the individual fields follow the layout defined in Table 1. The easiest way to create the database file is to use software capable of creating shapefiles, but it is also possible to create database files by database software or custom software. See the reference listed in Appendix 2 for more information.

Table 1 lists the sixteen fields required in a SIGRID-3 dBase file, along with the mandatory size, name and type for each field. SIGRID-3 is different from previous SIGRID versions in that it requires use of a specific set of ice characteristics. Total Concentration (CT) is followed by partial concentrations of the first, second, and third thickest ice (CA, CB, and CC) along with their respective stages of development (SA, SB, and SC) and form (FA, FB, FC). The next three fields are used for variables depicting the stage of development of ice thicker than that reported in SA, but having a concentration of less than 1/10th (CN), the stages of development of any remaining class of ice (CD), and the predominant and secondary form of ice (CF, see usage notes in Appendix 1).

The final mandatory field is used to identify the surface type of the polygon. Using a single character, polygons are identified as depicting water, land, ice, ice shelf, or no data. Water polygons are defined as those that are sea ice free: polygons containing any concentration of sea ice greater than zero are coded as ice polygons. An ice shelf is a floating ice sheet of considerable thickness attached to the coast. The characters for each type are listed in Appendix 5, Table 4.4.

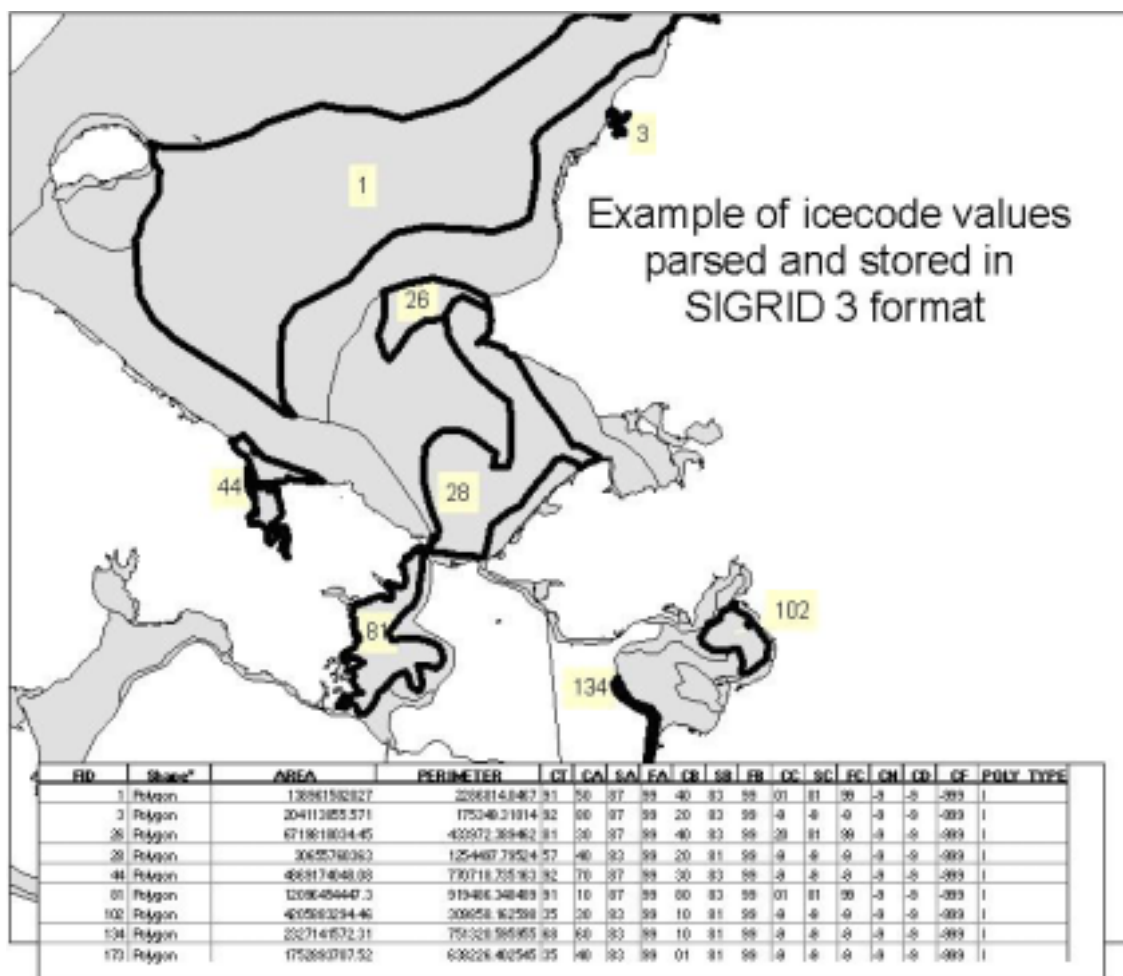


Figure 1. Illustration of the linkage between records in a dBase file and polygon attributes.

The Area and Perimeter fields contain the area and perimeter of each polygon, in units that are the same as those used for the projection. For example, for shapefiles from CIS and NIC, where a polar stereographic projection is used, these units are meters. For shapefiles from DMI, units are in degrees.)

The Code Table Reference column in Table 1 refers to code tables given in Annex 3 of SIGRID (WMO, 1989), and included in this document (with minor changes) as Appendix 5. The Code Figure columns in the code tables give the values that the ice services will use to fill a given variable field, depending on the ice conditions present.

Table 1. Mandatory columns (fields) in the SIGRID-3 database file.

Column or Field number	Column or Field name	Data Type	Length (bytes)	Begin/End Byte	Code Table Reference	Ice Variable Description
1	AREA	Double precision binary	20	2-21		
2	PERIMETER	Double precision binary	20	22-41		
3	CT	Text	2	42-43	Table 4.1	Total concentration
4	CA	Text	2	44-45	Table 4.1	Partial concentration of thickest ice
5	SA	Text	2	46-47	Table 4.2	Stage of development of thickest ice
6	FA	Text	2	48-49	Table 4.3	Form of thickest ice

7	CB	Text	2	50-51	Table 4.1	Partial concentration of second thickest ice
8	SB	Text	2	52-53	Table 4.2	Stage of development of second thickest ice
9	FB	Text	2	54-55	Table 4.3	Form of second thickest ice
10	CC	Text	2	56-57	Table 4.1	Partial concentration of the third thickest ice
11	SC	Text	2	58-59	Table 4.2	Stage of development of third thickest ice
12	FC	Text	2	60-61	Table 4.3	Form of third thickest ice
13	CN	Text	2	62-63	Table 4.2	Stage of development of ice thicker than SA but with concentration less than 1/10
14	CD	Text	2	64-65	Table 4.2	Stage of development of any remaining class of ice
15	CF	Text	4	66-69	Table 4.3	Predominant and secondary forms of ice
16	Poly_type	Text	1	70	Table 4.4	
17...55	Optional fields, see Appendix 4 Table 3.3.	Text			Tables 4.5 - 4.15	

2.4 Additional or optional variables

Ice services may choose to archive additional information using columns placed after the section of required columns. The additional variables are not limited to ice data, but may record information such as snow, temperature, observation method or source. When the optional variables are defined in SIGRID (WMO, 1989; see the list in Tables 4.5 - 4.15 of Appendix 5) and are taken from SIGRID (WMO, 1989) they must be labeled with WMO SIGRID variable identifiers (Appendix 4). Additional variables must be defined in the XML metadata (see "Entity_and_Attribute_Information" in Table 3). The dBase format places limitations on size: the maximum number of fields is 255, maximum length of a field name is 10 characters, and maximum length of a string is 254 characters.

2.5 The "dummy" or "missing" variable

Any mandatory ice field that is not used must be filled with a dummy variable of -9. The presence of -9 makes it clear that the field is deliberately not used. If the polygon type is not "I," fields other than poly_type will be filled with blanks.

3 Metadata

Metadata files contain important descriptive information about associated chart data. The Ad Hoc Format Working Group chose to use a format for SIGRID-3 that is sanctioned by the U.S. Federal Geographic Data Committee (FGDC): the Content Standard for Digital Geospatial Metadata (CSDGM). Some advantages of this format (hereafter referred to as the FGDC standard, or FGDC-compliant metadata) are that it is becoming widely used internationally, it is specially designed to accurately describe geospatial data, and tools for creating, validating, and displaying FGDC compliant metadata are available. FGDC metadata has standard field names with information needed to search for spatial data over a network or through a data set clearinghouse. Information on metadata in general and on working with the FGDC standard can be found on the FGDC web site (<http://www.fgdc.gov/metadata/metadata.html>).

FGDC coordinates the development of the U.S. National Spatial Data Infrastructure (NSDI). The NSDI develops policies, standards, and procedures for U.S. organizations to produce and share geographic data. The U.S. National Ice Center must follow the FGDC format. The International Organization for Standardization (ISO) coordinates the international development of policies, standards, and procedures for the production and distribution of geographic data. Under ISO/TC 211, ISO members are continuing to develop the ISO/TC 211 standardization of geographic data. Project 19115 of TC 211 specifically deals with metadata. Since the United States is a member of ISO, FGDC metadata will eventually be harmonized with the ISO standard. Adopting the FGDC standard for SIGRID-3 will minimize the steps needed to make SIGRID-3 ISO compliant.

Extensible Markup Language (XML) provides a powerful way of documenting, defining, and communicating the metadata about each ice chart. An additional benefit of XML is that XML allows metadata to be easily communicated over the Internet. XML may be challenging to use initially but its benefits are significant. XML, like HTML, is a descendent of the mark-up language SGML developed in the early 1980s. These mark-up languages are not programming languages but are written in text. XML documents are intended to be used with stylesheets (see Section 4.2) and viewed with a browser. If viewed as plain text using a word processing program, the document's mark-up language tags will be visible. Note that ArcGIS can read FGDC compliant XML files directly, when the XML file name includes the extensions ".shp.xml"(for example, "shapefilename.shp.xml").

XML provides structure to a metadata document while at the same time describing that document's content. For example, projection information will always be located within the same set of XML tags. Those tags will always be the same for each chart and unique from every other tag used in the XML document. The structure of a FGDC standard SIGRID-3 metadata file is illustrated in Tables 2 and 3. (The XML tags are not displayed.). Tables 2 and 3 illustrate parts of a single metadata file. Examples of complete SIGRID-3 metadata files from the ice centers, along with lists of acceptable keywords, will be posted on the GDSIDB web sites (<http://nsidc.org/noaa/gdsidb/> and http://www.aari.nw.ru/gdsidb/gdsidb_2.html).

A Document Type Declaration (DTD) file defines the document structure with a list of legal elements. It thereby provides a schema for metadata that can be used to validate the metadata. For instance, use of a DTD with an XML metadata editor matches fields in the metadata file against acceptable keywords and formats for that field. The GDSIDB plans to develop its own DTD that checks metadata for acceptable keywords in metadata fields such as Originator (DMI, AARI,), Theme (Sea Ice,...), and Place (Arctic, Baltic, Greenland,...).

Table 2. The upper half of a FGDC standard SIGRID-3 metadata file, as it would appear displayed in a browser, and using a stylesheet (XML tags are not shown). Fields that should be filled in are indicated by **bold** text. Notes on usage that are not part of the metadata file are in brackets (“{...}”). Examples of metadata files from various ice centers are posted on the GDSIDB web sites (<http://nsidc.org/noaa/gdsidb/> and http://www.aari.nw.ru/gdsidb/gdsidb_2.html). Table 2 and Table 3 are only examples, different tools for creating or displaying FGDC compliant metadata may have slightly different fields in a different order.

<p>Identification_Information:</p> <p>Citation:</p> <p> Citation_Information:</p> <p> Originator:</p> <p> Publication_Date:</p> <p> Title: Organization-Code_Region-Name_YYYYMMDD_feature-type_version {This field is filled with the shapefile name, in the format shown}</p> <p>Description:</p> <p> Abstract:</p> <p> Purpose:</p> <p> Supplemental_Information: {Supplemental information is not required}</p> <p>Time_Period_of_Content:</p>

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date:

Ending_Date:

Currentness_Reference:

Status:

Progress:

Maintenance_and_Update_Frequency:

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: {Western-most coordinate of the limit of coverage expressed in longitude. }

East_Bounding_Coordinate: {Eastern-most coordinate of the limit of coverage expressed in longitude. }

North_Bounding_Coordinate: {Northern-most coordinate of the limit of coverage expressed in latitude. }

South_Bounding_Coordinate: {Southern-most coordinate of the limit of coverage expressed in latitude. }

Keywords:

Theme: {At least one theme keyword must be entered. The keywords below are examples.}

Theme_Keyword_Thesaurus: none

Theme_Keyword: Sea Ice

Theme_Keyword: Sea Ice Maps

Theme_Keyword: Pack Ice

Theme_Keyword: Fast Ice

Theme_Keyword: Marginal Ice Zone

Theme_Keyword: Ice Thickness

Theme_Keyword: Ice Concentrations

Theme_Keyword: Ice Extent

Theme_Keyword: Polynya

Theme_Keyword: additional :theme keywords

Place: {At least one place keyword must be entered. The keyword below is an example.}

Place_Keyword_Thesaurus: None

Place_Keyword: Arctic

Access_Constraints:

Use_Constraints:

Metadata_Reference_Information:

Metadata_Date:

Metadata_Contact:

Contact_Information:

Contact_Organization_Primary:

Contact_Organization:

Contact_Address:

Address_Type:

City:

State_or_Province:

Postal_Code:

Contact_Voice_Telephone:

Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata {This field must be filled with this text.}

Metadata_Standard_Version: FGDC-STD-001-1998 {This field must be filled with this text.}

3.1 Mandatory Elements

When an XML editor is used to create the metadata file, the XML tags provide a series of blanks or questions that need to be answered for each data set. In the FGDC standard, several attributes are identified as mandatory fields (Tables 1 and 2). These attributes describe the data and the metadata.

3.1.1 Identification Information

Identification Information attributes describe some of the higher order information about the shapefile and the chart it represents. As Table 2 shows, Identification Information attributes provide information on the producer, location of the coverage, and date of origin. This list also includes the date, restrictions, region, and associated keyword attributes. Each center will assemble a suitable list of place keywords that must be consistent to all charts in a series.

3.1.2 Metadata Reference Information

Metadata reference information provides additional information about the creator of the SIGRID-3 shapefile. If this contact information is the same for every part of the shapefile, this is the only location where it needs to be provided.

3.2 *Mandatory if Applicable Elements*

Several attributes are identified as mandatory in the FGDC model if they are applicable to the data set. SIGRID-3 requires three of these: data quality information, spatial reference information, and entity and attribute information.

3.2.1 Data Quality Information

Data quality elements describe the overall quality of the data. Data source type and date of acquisition can be repeated for the total number of different sources used to include both in-situ observations and remote sensed data.

3.2.2 Spatial Reference Information

The spatial reference element contains projection information, beginning with the projection name followed by all information needed to define the projection. This will generally include longitudes, parallels, units, datum name, and ellipsoid. If the projection is not a common projection, the equations used to define the projection should be included in this section.

3.2.3 Entity and Attribute Information

This section is used to describe the contents of the individual dBase fields. It includes a subsection for all mandatory and any optional SIGRID variable identifiers. These must be in the same order as in the shapefile *.dbf file.

Table 3. The lower half of a FGDC standard SIGRID-3 metadata file, as it would appear displayed in a browser, and using a stylesheet (XML tags are not shown). Fields that should be filled in are indicated by **bold** text. Notes on usage that are not part of the metadata file are in brackets (“{...}”). Examples of metadata files from various ice centers are posted on the GDSIDB web sites (<http://nsidc.org/noaa/gdsidb/> and http://www.aari.nw.ru/gdsidb/gdsidb_2.html). Table 2 and Table 3 are only examples, different tools for creating or displaying FGDC compliant metadata may have slightly different fields in a different order.

Data_Quality_Information:

Logical_Consistency_Report: {quality-assurance comments}

Completeness_Report: {comments about unknown or land regions}

Lineage: {This section should be repeated for each data source that went into the chart}

Source_Information:

Source_Citation:

Citation_Information:

Originator:

Publication_Date:

Title:

Type_of_Source_Media: Type of First Source Media {electronic, observation}

Source_Time_Period_of_Content:

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date: {Begin Date of Source}

Ending_Date: {End Date of Source }

Source_Currentness_Reference: {ground conditions at time of Source}

Process_Step:

Process_Description:

Process_Date:

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:

Planar:

Map_Projection: {The items below are mandatory when needed to describe the projection. An example is shown.}

Map_Projection_Name: Polar Stereographic

Straight_Vertical_Longitude_from_Pole: 180.000000

Standard_Parallel: 60.000000

False_Easting: 0.000000

False_Northing: 0.000000

Planar_Coordinate_Information:

Planar_Coordinate_Encoding_Method: coordinate_pair

Coordinate_Representation:

Abscissa_Resolution: 0.061565

Ordinate_Resolution: 0.061565

Planar_Distance_Units: meters

Geodetic_Model:

Horizontal_Datum_Name: WGS 1984

Ellipsoid_Name: WGS 1984

Semi-major_Axis: 6378137.000000

Denominator_of_Flattening_Ratio: 298.257224

Entity_and_Attribute_Information:

Detailed_Description:

Entity_Type:

Entity_Type_Label:

Entity_Type_Definition:

Entity_Type_Definition_Source:

Attribute:

Attribute_Label: {FID}

Attribute_Definition: {ESRI created internal feature number. Sequential unique whole numbers that are automatically generated.}

Attribute_Definition_Source:

Attribute_Domain_Values:

Codeset Domain:

Codeset Name:

Codeset Source:

Attribute:

Attribute_Label: Shape

Attribute_Definition: Feature geometry. Coordinates defining the features.

Attribute_Definition_Source:

Attribute_Domain_Values:

Codeset Domain:

Codeset Name:

Codeset Source:

Attribute:

Attribute_Label: AREA

Attribute_Definition: Area of polygon.

Attribute_Definition_Source:

Attribute_Domain_Values:

Codeset Domain:

Codeset Name:

Codeset Source:

Attribute:

Attribute_Label: PERIMETER

Attribute_Definition: Perimeter of polygon.

Attribute_Definition_Source:

Attribute_Domain_Values:

Codeset Domain:
Codeset Name:
Codeset Source:

Attribute:

Attribute_Label: CT
Attribute_Definition: Total Concentration.
Attribute_Definition Source:
Attribute Domain Values:
Codeset Domain:
Codeset Name:
Codeset Source:

Attribute element repeated for CA, SA, FA, CB, SB, FB, CC, SC, FC, CN, CD, and CF

.
.
.

Attribute:

Attribute_Label: POLY_TYPE
Attribute_Definition: Surface type (L,W,...).
Attribute_Definition Source:
Attribute Domain Values:
Codeset Domain:
Codeset Name:
Codeset Source:

Attribute element repeated for additional SIGRID-3 variable identifiers, if any

4 General Information

4.1 File Naming Conventions

All ice centers should follow the same guidelines when naming their files. File names are divided into five parts containing information on issuing organization, region covered, date of the chart, feature type and version, as follows:

organization-code_region-name_yyyymmdd_feature-type_version.ext

An underscore separates each division. Organization Code is a unique identifier adopted by each issuing organization (for example, CIS, DMI, AARI, NIC). Region Name is a descriptive name assigned by the issuing organization to identify the geographic region contained in the file (for example, Baffin, Baltic, Chukcha, Hudson Bay, Arctic, and Antarctic). Date is the date for which the information in the file is valid, in the format yyyymmdd. If the information in the file is valid for more than one date, the issuing organization should assign the date that is most representative. The next division describes the one feature type contained in the shapefile set. Two characters are used to identify the feature type as polygons (pl), lines (ln), or points (pt). The final division is used to distinguish between charts that would otherwise have the same name or to facilitate versioning. The first or only chart will use ‘_a’, additional charts, if any, will use ‘b’, ‘c’, and so on. The extension, represented by “ext” above, is .xml, .dbf, .shx, or .shp, depending on the file type.

Example:

nic_antarc_20030210_pl_a.dbf

4.2 Stylesheets

Stylesheets are XML documents that make other XML documents, such as SIGRID-3 metadata, displayable using an XML/Java capable browser. Stylesheets have the extension “.xsl”. To use a stylesheet with an XML document, include a reference to the stylesheet in the XML document. The stylesheet need not be kept with the XML file. For example, the XML file shown in

Figure 2 references a stylesheet from the FGDC web site. The stylesheet may, however, be included with the XML file to ensure that the XML file is always viewable.

SIGRID-3 does not require a stylesheet. However, the GDSIDB plans to develop a stylesheet that may be used for SIGRID-3 metadata.

Figure 2. The first few lines of an XML metadata file from the National Ice Center, showing a reference to an FGDC stylesheet. The first line of an XML file is called the “XML declaration.”

```
<?xml version="1.0"?>
<?xml-stylesheet type="text/xsl" href="http://www.fgdc.gov/FGDC_V2.xsl"?>
<metadata>
  <idinfo>
    <citation>
      <citeinfo>
        <origin>National Ice Center Naval Ice Center</origin>
        <pubdate>20030207</pubdate>
        <title>arctic030203</title>
      </citeinfo>
    </citation>
  </idinfo>
</metadata>
```


Appendix 1. SIGRID-3, earlier SIGRID versions, discrepancies in use and references

The first version of SIGRID is described in a white paper by Thomas Thompson (1981). Minor changes were made to this version before it was adopted by WMO in 1989. A simplified version, SIGRID-2, was adopted by WMO in 1994. The full text for the proposed SIGRID (Thompson, 1981), the official SIGRID (WMO, 1989), and SIGRID-2 (WMO, 1994) can be obtained from the U.S. National Snow and Ice Data Center GDSIDB web sites sites (<http://nsidc.org/noaa/gdsidb/> and http://www.aari.nw.ru/gdsidb/gdsidb_2.html). SIGRID-3 follows SIGRID (WMO, 1989) to the fullest extent possible.

In 1989 a test of SIGRID format was performed, with Argentina, Canada, Japan, U.S., and USSR ice services submitting data in SIGRID format to the GDSIDB. Over subsequent years, use of SIGRID among the centers diverged somewhat. One example of this is the use of variable identifier "CF" for identifying the form of ice. SIGRID (WMO, 1989) specifies that this variable identifier be expressed in two variables consisting of two digits each: FpFpFsFs (FpFp, for the predominant form of ice, and FsFs for the secondary form of ice). However, variable identifiers CA, CB, and CC, for identifying the partial concentration, stage of development, and form of the first thickest ice (CA), second thickest ice (CB), and third thickest ice (CC), also allow for the form of ice to be identified. When form is specified with these variable identifiers, it is expressed in three variables of two digits each: FaFaFbFbFcFc (FaFa for the form of ice corresponding to the stage of development of the first thickest ice, FbFb for the second thickest, and FcFc for the third thickest). Having two options for reporting form may have lead to different interpretations among the services in how to use CF. At present, DMI uses FaFaFbFbFcFc, but also uses FpFp occasionally for reporting the form of strips and patches of ice, while filling FsFs with the "missing" or "dummy" variable. CIS consistently uses FaFaFbFbFcFc, but never uses FpFpFsFs. NIC never uses FaFaFbFbFcFc, filling the spaces with the "missing" or "dummy" variable, and sometimes uses FpFp for reporting the form of strips and patches of ice, while filling FsFs with the "missing" or "dummy" variable.

In SIGRID-3, CF is required. Therefore those services that do not use CF will fill the CF column in the SIGRID-3 dBase file with the dummy variable. Those services that use CF are urged to include notes on how it is used in their metadata.

SIGRID References

Thompson. 1981. Proposed Format for Gridded Sea Ice Information (SIGRID). Unpublished report prepared for the World Climate Programme. This report is available at:

http://nsidc.org/data/docs/daac/nsidc0050_aari_seaice/sigrid.html
<http://www.aari.nw.ru/gdsidb/format/sigrid-1.pdf>

World Meteorological Organization. 1989. Annex to Recommendation II (CMM-X) of the Final Report of the Tenth Session of the WMO Commission for Marine Meteorology, Paris, February 1989. World Meteorological Organization. Available by request from [NSIDC User Services](#).

World Meteorological Organization. 1994. Format to Provide Sea Ice Data for the World Climate Program (SIGRID-2). World Meteorological Organization. This publication is available at <http://www.aari.nw.ru/gdsidb/format/sigrid-2.html>
<http://www.aari.nw.ru/gdsidb/format/sigrid-2.pdf>

Appendix 2. Link to Information on Shapefiles from ESRI

ESRI Shapefile Technical Description, An ESRI White Paper—July 1998, can be found on the ESRI web site (<http://www.esri.com/software/opengis/openpdf.html>) and at <http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf>.

Appendix 3. Database (dBase) File Structure

The database file used in the SIGRID-3 Archive Format is an amalgamation of the Borland Inc. dBase III and dBase IV file types with a few additional nonstandard ESRI features. It is created by the GIS software package when a shapefile is created. The file (which has the same name as the other files making up the shapefile set for a given chart, with the extension *.dbf) can be read following the file structure of dBase version III. The dBase III file is accessed as two lines of input. The first line is the header. The second line will contain every polygon record without field separators or record terminators. The header describes how to parse the second line.

The header line structure consists of a file header structure and a structure for describing each field. The file header portion occurs once while the description is repeated for each field included. Below are the file structures for SIGRID-3 dBase files.

To learn more about dBase files in general please consult: <http://www.cs.cornell.edu/Courses/cs212/2001fa/Project/Part1/dbf.htm>

Table 2.1 File header

Byte	Contents	Description
0	1 byte	'3' indicating valid dBase III Plus file.
1-3	3 bytes	Date of last update in YYYYMMDD format; YYYY plus 1900 equals current year
4-7	32-bit number	Number of records in the table
8-9	16-bit number	Number of bytes in the header
10-11	16-bit number	Number of bytes in the record
12-31	20 bytes	Reserved bytes
32-n	32 bytes each	Field descriptor array (table 2.2)
n+1	1 byte	0Dh stored as the field terminator

Table 2.2 Field description

Byte	Contents	Description
0-10	11 bytes	Field name in ASCII (Zero-filled)
11	1 byte	Field type in ASCII (C (character) D (date), N (numeric), L (logical), M (memo))
12-15	4 bytes	Field data address (set in memory; not useful on disk)
16	1 byte	Field length in binary
17	1 byte	Field decimal count in binary
18-19	2 bytes	Reserved
20	1 byte	Work area ID
21-22	2 bytes	Reserved
23-31	9 bytes	Reserved bytes

Appendix 4. SIGRID-3 Optional Variable Identifiers

Table 3.3 SIGRID-3 optional variable identifiers (from SIGRID (WMO, 1989))

Identifier	Description
Dynamic Processes	
DP	Dynamic processes
DD	Direction of dynamic processes
DR	Rate of ice drift in tenths of knots
DO	Source of information
Water Openings	
WF	Form of water openings
WN	Number of water openings
WD	Orientation (direction) of water openings
WW	Width of water openings
WO	Source of information
Topography Features	
RN	Nature of topography feature
RA	Age of topography feature
RD	Orientation of topography feature
RC	Concentration of topography feature
RF	Frequency of topography feature
RH	Height (mean) of topography feature
RO	Source of information
RX	Maximum height of topography feature
Thickness of Ice	
EM	Mean thickness of level ice in cm
EX	Maximum thickness of level ice in cm
EI	Thickness interval
EO	Source of information
Surface features and melting forms	
SC	Concentration of snow
SN	Snow depth
SD	Orientation (direction) of sastrugies
SM	Melting forms
SA	Area coverage of water on ice in tenths
SO	Source of information
Icebergs or ice of land origin	
BL	Type of iceberg
BD	Direction of drift of iceberg
BE	Rate of drift in tenths of knots
BN	Number of icebergs
BY	Day of month
BO	Source of information
Sea surface temperature	
TT	Sea surface temperature in tenths of degrees
TO	Source of information
Source of information	
OP	Primary source of information on which the chart is based
OS	Secondary source of information on which the chart is based
OT	Tertiary source of information on which the chart is based

Appendix 5. Code Tables for SIGRID-3 Variables

Tables 4.1 – 4.4 are for mandatory variables. The remainder is for optional variables.

Table 4.1 Concentration codes for variable identifiers CT, CA, CB, and CC.

Definition	Code Figure
Ice Free	00
Less than 1/10 (open water)	01
Bergy Water	02
1/10	10
2/10	20
3/10	30
4/10	40
5/10	50
6/10	60
7/10	70
8/10	80
9/10	90
10/10	92
Concentration intervals (lowest concentration in interval followed by highest concentration in interval)	
9/10 – 10/10	91
8/10 – 9/10	89
8/10 – 10/10	81
7/10 – 9/10	79
7/10 – 8 /10	78
6/10 – 8/10	68
6/10 – 7/10	67
5/10 – 7/10	57
5/10 – 6/10	56
4/10 – 6/10	46
4/10 – 5/10	45
3/10 – 5/10	35
3/10 – 4/10	34
2/10 – 4/10	24
2/10 – 3/10	23
1/10 – 3/10	13
1/10 – 2/10	12
Unknown	99

Table 4.2 Thickness of ice or stage of development codes for variable identifiers SA, SB, SC, CN, and CD.

Stage of Development	Thickness	Code Figure
Ice Free		00
No Stage of Development		80
New Ice		81
Nilas, Ice Rind	< 10 cm	82
Young Ice	10 - 30 cm	83
Grey Ice	10 - 15 cm	84
Grey - White Ice	15 - 30 cm	85
First Year Ice	30 - 200 cm	86
Thin First Year Ice	30 - 70 cm	87
Thin First Year Stage 1	30 - 50 cm	88
Thin First Year Stage 2	50 - 70 cm	89
For Later Use		90
Medium First Year Ice	70 - 120 cm	91
For Later Use		92
Thick First Year Ice	> 120 cm	93
For Later Use		94
Old Ice		95
Second Year Ice		96
Multi-Year Ice		97
Glacier Ice		98
Undetermined/Unknown		99

Table 4.3 Form of ice codes for variable identifiers FA, FB, FC, and CF.

Form	Size/Concentration	Code Figure
Pancake Ice	30 cm - 3 m	00
Shuga/Small Ice Cake, Brash Ice	< 2 m across	01
Ice Cake	< 20 m across	02
Small Floe	20 m - 100 m across	03
Medium Floe	100 m - 500 m across	04
Big Floe	500 m - 2 km across	05
Vast Floe	2 km - 10 km across	06
Giant Floe	> 10 km across	07
Fast Ice		08
Growlers, Floebergs or Floebiits		09
Icebergs		10
Strips and Patches	concentrations 1/10	11
Strips and Patches	concentrations 2/10	12
Strips and Patches	concentrations 3/10	13
Strips and Patches	concentrations 4/10	14
Strips and Patches	concentrations 5/10	15
Strips and Patches	concentrations 6/10	16
Strips and Patches	concentrations 7/10	17
Strips and Patches	concentrations 8/10	18
Strips and Patches	concentrations 9/10	19
Strips and Patches	concentrations 10/10	20
Level Ice		21
Undetermined/Unknown		99

Table 4.4 List of Poly_type character variables

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

Table 4.5 Dynamic processes

Compacting ice, no intensity given	0
Compacting ice, slight	1
Compacting ice, considerable	2
Compacting ice, strong	3
Diverging ice	4
Shearing ice	5
Ice drift, rate 0,1 - 0,9 knots	6
Ice drift, rate 1,0 - 1,9 knots	7
Ice drift, rate 2,0 - 2,9 knots	7
Ice drift, rate 3,0 knots or more	9

Table 4.6 Direction indicator

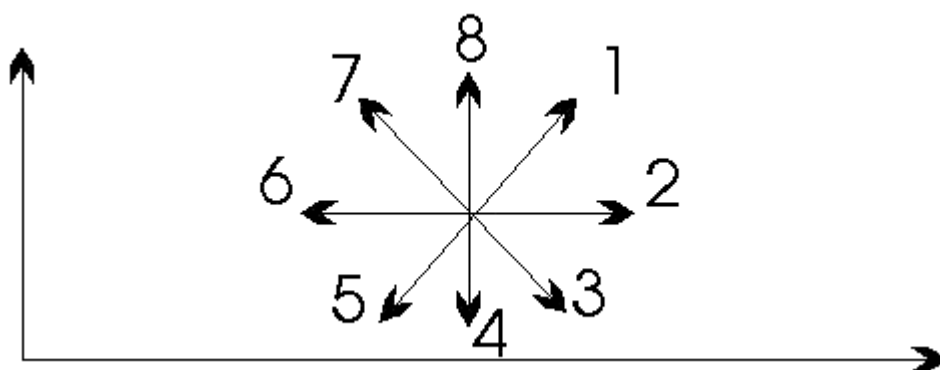


Table 4.7 Form of water opening

Cracks	1
Crack at specific location	2
Lead	3
Frozen lead	4
Polynia	5
Ice edge	6

Table 4.8 Number of water openings

1	1
2	2
3-5	3
5-10	4
> 10	5

Table 4.9 Nature of topographic feature (deformation)

Rafting	1
Hummocks	2
Ridges	3
Jammed brash barrier	4

Table 4.10 Age of topographic feature

New	1
Weathered	2
very weathered	3
Aged	4
Consolidated	5

Table 4.11 Melting forms

No melt	0
Few puddles	1
Flooded ice	3
Few thaw holes	4
Many thaw holes	5
Dried ice	6
Rotten ice	7
Few frozen puddles	8
All frozen puddles	9

Table 4.12 Snow depth

WMO code

Table 4.13 Ice of land origin (type of iceberg)

Form		Size	
Growler and or bergy bit	1	unspecified	0
Iceberg, unspecified	2	small	1
Iceberg, glacier berg	3	medium	2
Iceberg, dome	4	large	3
Iceberg, pinnacled	5	very large	4
Iceberg, tabular	6		
Ice island	7		
Floeberg	8		
Radar target	9		

Table 4.14 Number of icebergs

WMO code 2877

Table 4.15 Observational method

Visual surface observation	1
Visual aircraft observation	2
Visual and infrared satellite observation	3
Passive microwave satellite observation	4
Radar satellite surface or airborne observation	5
Radar satellite observation (SAR)	6
Laser/scatterometer/sonar	7
Data buoys	8
Estimated (temporal and/or spatial)	9
Unknown	0