



# Arctic Sea Ice Charts from Danish Meteorological Institute, 1893 - 1956, Version 1

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## USER GUIDE

### How to Cite These Data

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

Danish Meteorological Institute and National Snow and Ice Data Center. Compiled by V. Underhill and F. Fetterer. 2012. *Arctic Sea Ice Charts from Danish Meteorological Institute, 1893 - 1956*, Version 1. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. <https://doi.org/10.7265/N56D5QXC>. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT [NSIDC@NSIDC.ORG](mailto:NSIDC@NSIDC.ORG)

FOR CURRENT INFORMATION, VISIT <https://nsidc.org/data/G02203>



National Snow and Ice Data Center

# TABLE OF CONTENTS

|       |   |    |
|-------|---|----|
| 1     | DETAILED DATA DESCRIPTION .....           | 2  |
| 1.1   | Format .....                              | 3  |
| 1.2   | File and Directory Structure .....        | 5  |
| 1.3   | Spatial and Temporal Coverage.....        | 5  |
| 1.3.1 | Sample Data Record .....                  | 6  |
| 2     | SOFTWARE AND TOOLS.....                   | 10 |
| 2.1   | Quality Assessment .....                  | 10 |
| 3     | DATA ACQUISITION AND PROCESSING .....     | 10 |
| 3.1.1 | Processing Steps.....                     | 10 |
| 4     | REFERENCES AND RELATED PUBLICATIONS ..... | 11 |
| 4.1   | Related Data Collections.....             | 12 |
| 4.2   | Related Websites .....                    | 12 |
| 5     | CONTACTS AND ACKNOWLEDGMENTS.....         | 12 |
| 6     | DOCUMENT INFORMATION.....                 | 13 |
| 6.1   | Publication Date .....                    | 13 |
| 6.2   | Date Last Updated .....                   | 13 |

# 1 DETAILED DATA DESCRIPTION

These charts, created by the Danish Meteorological Institute (DMI), provide observed and inferred sea ice extent for each summer month from 1893 to 1956. From 1893 to 1956, the Danish Meteorological Institute (DMI) created charts of observed and inferred sea ice extent for each summer month. These charts are based on compiled observations of ice conditions reported by a variable network of national organizations, shore-based observers, scientific expeditions, and ships as detailed in each report; in cases where no observations were available, the lead mapmakers extrapolated further ice cover using their knowledge of ice movement. Except for where direct observations are indicated, caution is advised in using the charts' ice edge because there is no way to quantify the assumptions used in extrapolating ice edge or the error involved in this method. See the note on reliability for further discussion of potential error. The charts were scanned at the Icelandic Meteorological Office (IMO) and are being made available here as a service and in cooperation with DMI and other contributors. In all, there are 266 image files containing 291 images.

The early history of this collection is described in Thomsen (1947). In 1885, the Danish Meteorological Institute began systematically collecting information on sea ice in the Davis Strait. Ship captains sailing to west Greenland settlements, and people living in Greenland, were asked to record the occurrence of ice. This sea ice observation program quickly grew to include observers on ships from other nations, and to cover a wider geographic area. Beginning in 1900, these observations were collated and published annually in reports entitled "The State of the Ice in the Arctic Seas." The reports have a summary with detailed information for particular regions where ship traffic was concentrated, and charts showing ice conditions as observed, or, when observations were not available, inferred ice extent.

All charts are plotted on a polar stereographic projection. Beginning in 1901, the charts are pan-Arctic; prior to that, they cover a smaller region. Monthly coverage varies slightly from year to year, though for most of the record, charts cover April through August. From 1939 to 1946, World War II prevented the collection of international data, and no charts were published. The DMI later attempted to retroactively publish information from these years (Kelly 1979), but we do not possess scans of those charts and have no further information. For a complete list of chart availability, see the [DMI Chart Inventory by Month and Year \(1893-1956\)](#) (PDF 35 KB). Note: The September ice is often depicted for some regions on the same chart as August.

The positions of direct observations are marked on each chart with red dots Figure 2. The chart from August 1932 showing both direct observations (marked in red) and the presumed but not observed ice edge (the white edge). Observed regions also often show the type of ice present, with

the standard legend in the top right corner. Each chart shows the map makers' inferred ice edge as well as the type of ice present, for example large ice fields or new ice, in certain locations. These ice types have been converted into approximate percent-coverage values (See Table 1 and Table 2). The process for defining these percentages is described in the [Arctic Sea Ice Concentration and Extent from Danish Meteorological Institute Sea Ice Charts, 1901-1956](#) data set.

Coverage is considerably better over Greenland, Iceland, and Spitzbergen than for the rest of the Arctic, and direct observations over the Western Arctic are particularly sparse over the entire period of record. From 1946 to 1956, the ice edge in this region solely reflects annual climatology; the DMI probably did not have access to any data in this region because of the Cold War.

## 1.1 Format

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There are a total of 266 image files containing 291 scanned monthly charts. They are in JPEG (.jpg) format. Each image is approximately 5000 by 7000 pixels and 4.5 MB in size.

Each file is named according to the following convention:

YYYY\_MM.jpg

Where YYYY is the 4-digit year and MM is a 2-digit month of the chart.

Note: For charts from 1895 - 1900, a single JPEG image contains multiple monthly charts in one file. The months included in the image are listed sequentially in the filename. For example, the file 1897\_07\_08\_09.jpg contains the monthly charts for July, August, and September for 1897. For the 1893 and 1894 charts, a composite chart was created from all of the summer months. The months included in the composite are listed in the filename. For example, the file 1893\_04-09.jpg contains a composite of the data from April through September of 1893.

The first two columns of Table 1 list the legend text from the charts from 1893 through 1950. Note: The charts after 1935 do not contain the Danish language column of the legend. The last three columns give our interpretation of what corresponding concentration ranges or values are for these text descriptions. The DMI Tenths column contains the fraction of sea ice cover in ranges, as used by DMI. The % Concentration column contains the central value of concentration in percent of the associated ranges in DMI Tenths. The % Uncertainty column contains the assumed uncertainty in these concentrations in percent. The process for defining the concentration and uncertainty percentages in Tables 1 and 2 is described in the [Arctic Sea Ice Concentration and Extent from Danish Meteorological Institute Sea Ice Charts, 1901-1956](#) data set.

Table 1. Mapping of ice concentration descriptions to ice concentration values and assumed uncertainty for the 1893 - 1950 charts

| Danish                 | English                                  | DMI Tenths   | % Concentration | % Uncertainty |
|------------------------|--|--------------|-----------------|---------------|
| ubruds Polar           | unbroken polar ice                       | 10/10        | 100             | 10            |
| store Ismarker         | great ice fields                         | 8/10 - 10/10 | 90              | 10            |
| taet Drivis            | tight pack-ice                           | 7/10 - 9/10  | 80              | 10            |
| landfast vinteris      | landfloe                                 | 6/10 - 8/10  | 70              | 10            |
| spredd Drivis          | open ice                                 | 4/10 - 6/10  | 50              | 10            |
| Nyis og Sjapis         | bay-ice (young-ice after 1930) and brash | 1/10 - 3/10  | 20              | 10            |
| Isforholdene ubekendte | state of ice unknown                     | n/a          | n/a             | n/a           |
| Isfjeld                | iceberg                                  | n/a          | 0               | 0             |

Beginning in 1951, the DMI charts began using a standard terminology as set forth by the World Meteorological Organization (WMO). Charts from 1951 to 1956 contain a legend with these WMO terms for describing ice listed in the first column of Table 2. The WMO assigns a specific range in fractional ice cover to each of these standard terms. The WMO equivalent ranges are listed in the second column, and the corresponding ranges used by DMI are in the third column.

If a single corresponding ice concentration number is needed, one may use the number in the % Concentration column. That is what was done for the related [Arctic Sea Ice Concentration and Extent from Danish Meteorological Institute Sea Ice Charts, 1901-1956](#) data set. However, the choice of a single number to represent a range is somewhat arbitrary. The % Uncertainty column contains the assumed uncertainty in these concentrations in percent.

For the years 1951 through 1953, there is an additional item called polar fast-ice. We believe that this is the same as winter fast-ice, but we do not have any documentation proving this. The years 1954 through 1956 do not contain the additional legend item. Figures below provide examples of the charts from the early, mid, and late parts of the program and illustrates differences in the legends.

Table 2. Mapping of ice concentration descriptions to ice concentration values and assumed uncertainty for the 1951 - 1956 charts

| English                             | WMO Tenths                   | DMI Tenths   | % Concentration | % Uncertainty |
|-------------------------------------|------------------------------|--------------|-----------------|---------------|
| winter fast-ice<br>(polar fast-ice) | n/a                          | n/a          | 100             | 5             |
| big ice-floes                       | n/a                          | n/a          | 70              | 10            |
| very close drift-ice                | 9/10 and greater but < 10/10 | 9/10 - 10/10 | 95              | 5             |
| close drift-ice                     | 7/10-8/10                    | 7/10 - 9/10  | 80              | 10            |
| open drift-ice                      | 4/10-6/10                    | 4/10 - 6/10  | 50              | 10            |
| very open drift-ice                 | 1/10-3/10                    | 1/10 - 3/10  | 20              | 10            |
| new ice                             | n/a                          | n/a          | 50              | 25            |
| bergy-bit                           | <1/10                        | n/a          | 0               | 0             |

## 1.2 File and Directory Structure

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All 291 charts in the 266 .jpg files reside in a single directory on the NSIDC HTTPS site: <https://noaadata.apps.nsidc.org/NOAA/G02203/>

## 1.3 Spatial and Temporal Coverage

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These charts provide a pan-Arctic view of sea ice extent covering the Arctic Ocean from approximately 55° N to 90° N. The charts span 1893 - 1939 and 1946 - 1956. The number of charts ranges from 1 to 6 per year depending on the year. For a complete list of chart availability, see the following DMI inventory table:

[DMI Chart Inventory by Month and Year \(1893-1956\)](#) (PDF 35 KB). Note: The September ice is often depicted for some regions on the same chart as August.

### 1.3.1 Sample Data Record

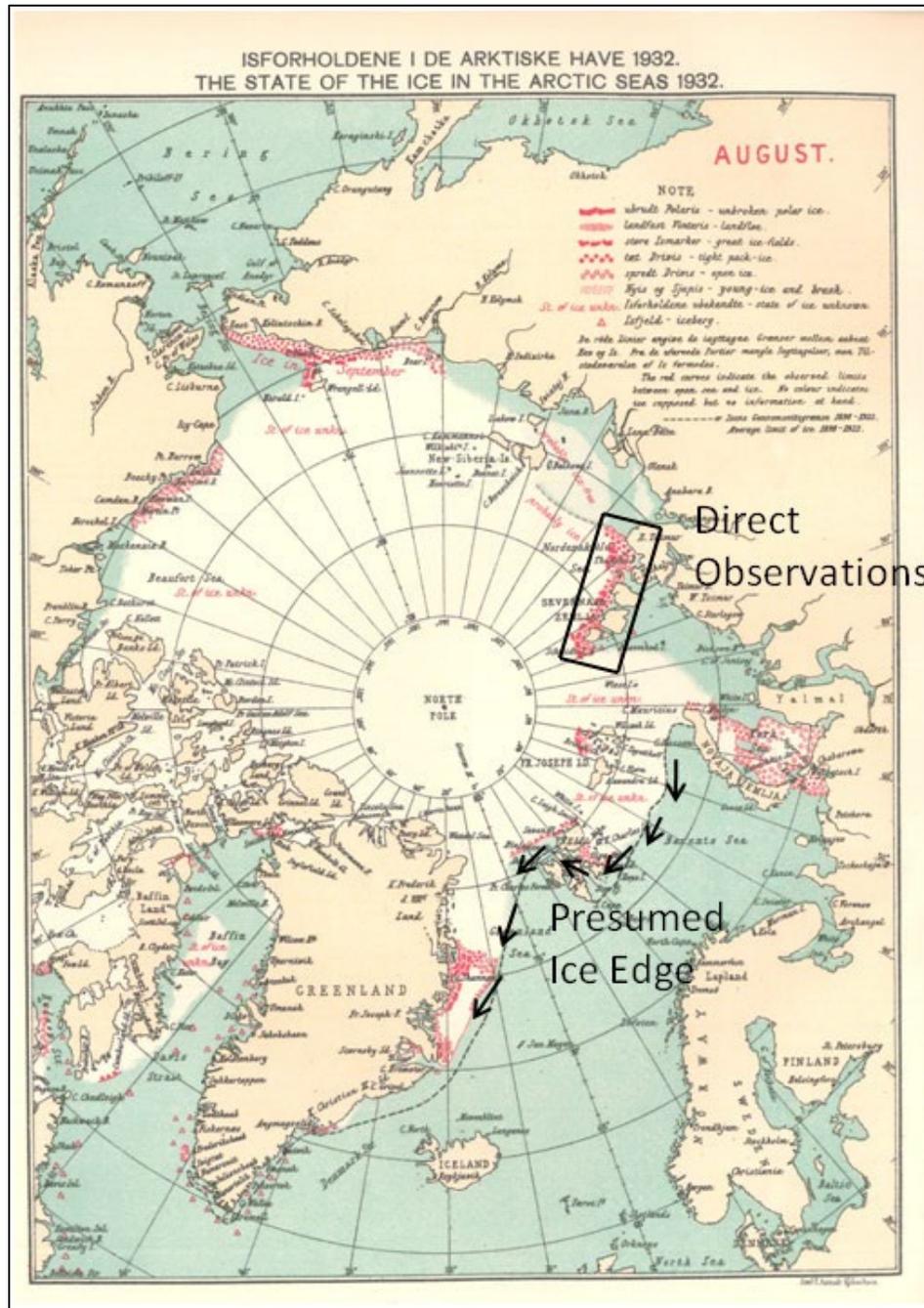


Figure 1. The chart from August 1932 showing both direct observations (marked in red) and the presumed but not observed ice edge (the white edge). Observed regions also often show the type of ice present, with the standard legend in the top right corner.

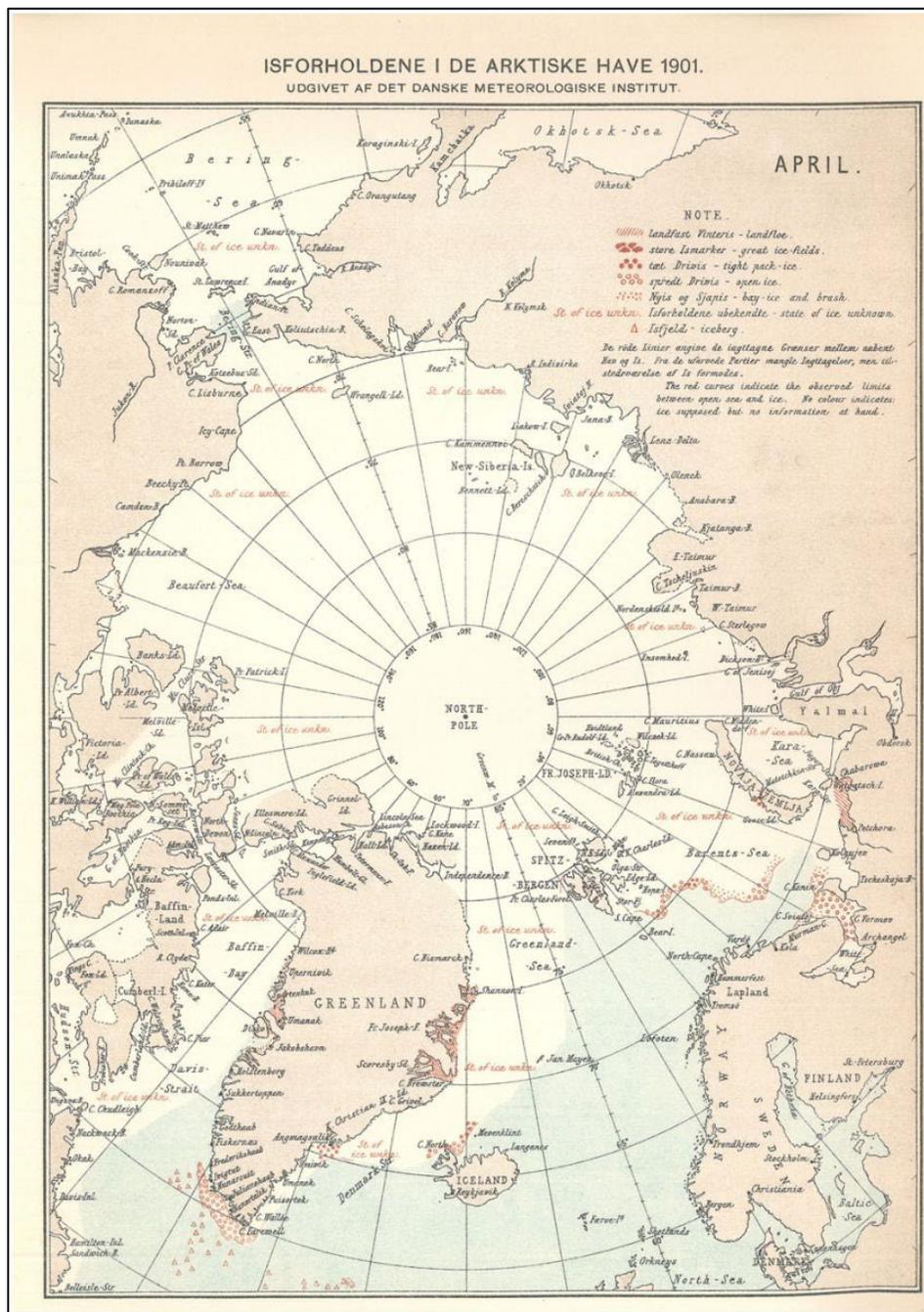


Figure 2. Example of an early chart from 1901

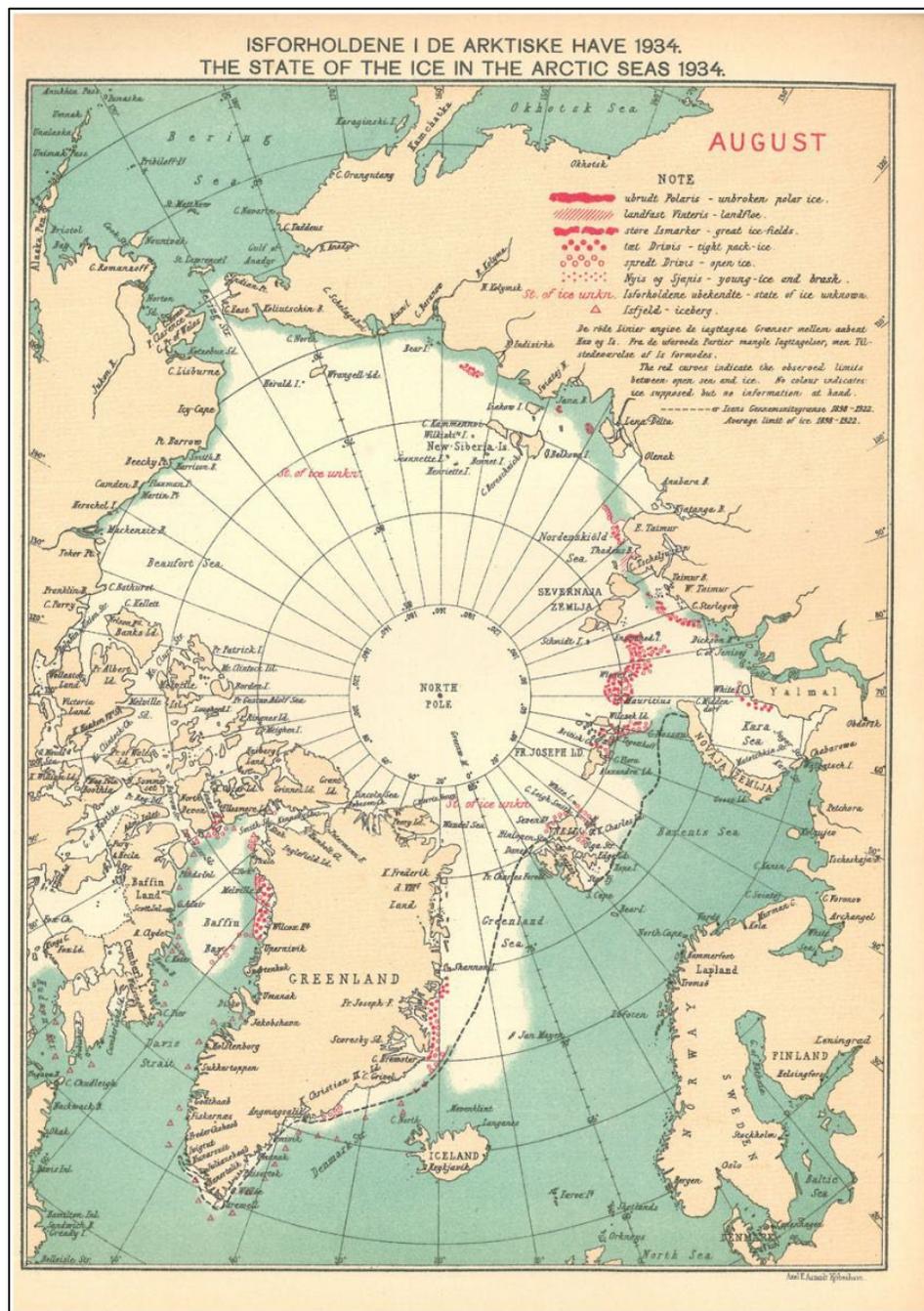


Figure 3. A mid-program chart from 1934

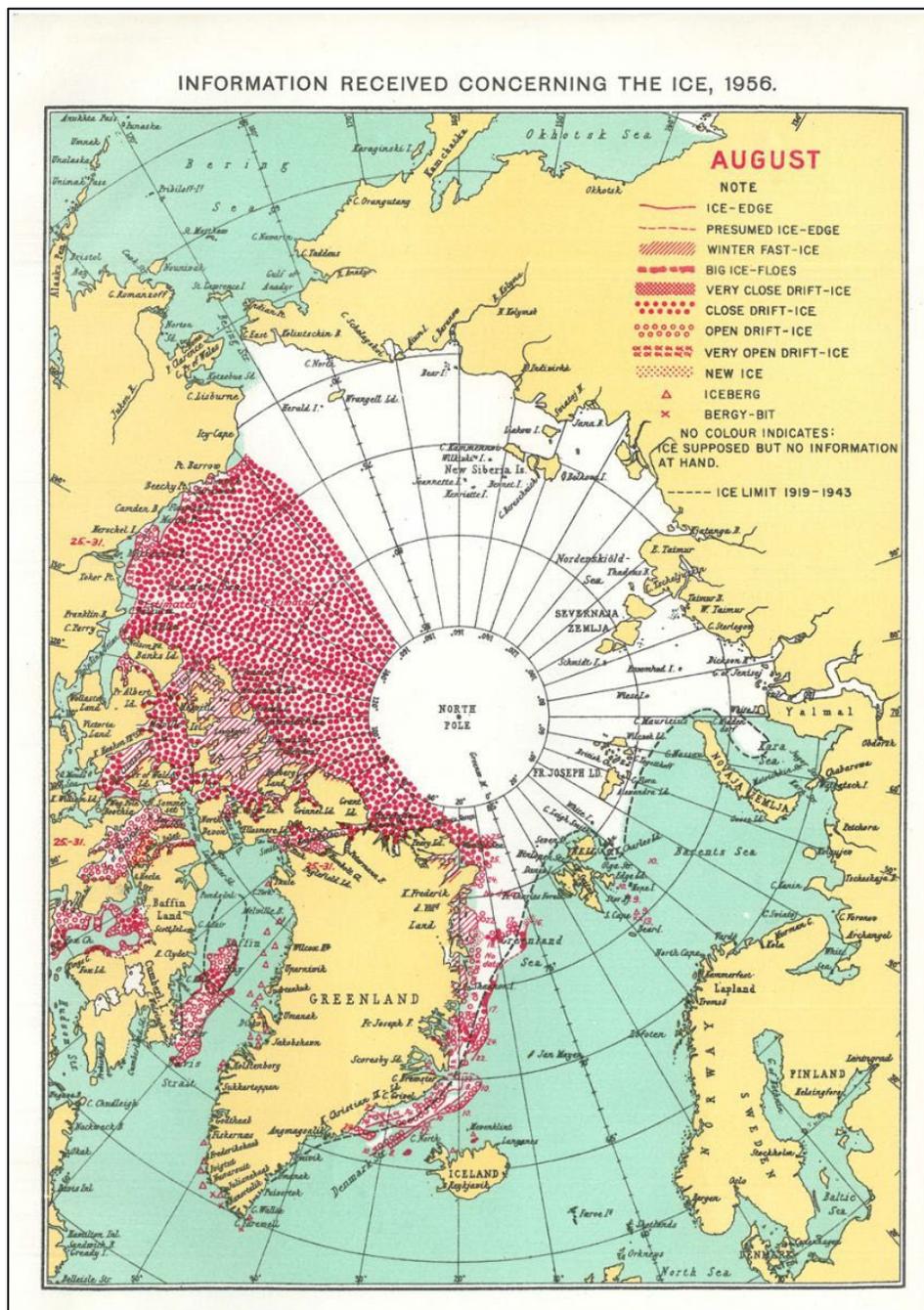


Figure 4. A late chart from 1956 showing the differences in the legends over the program's history

## 2 SOFTWARE AND TOOLS

### 2.1 Quality Assessment

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Especially early in the century, these charts are based on relatively sparse data and rely to a large degree on the inference and extrapolation of the lead map makers: V. Garde, C. Speerschneider, and H. Thomsen and M.V.L. Lorck (Thomsen, 1947). Direct observations are always clearly marked, but white space denotes the assumed ice edge. Directly observed open water is not shown differently than assumed open water. Details on areas of open water can be found in the notes that accompany the charts. In most cases, this assumed ice edge follows a 30-year climatological average over a period of years that shifts over the record. We do not have a reference or any more information on the 30-year climatology. However, the assumed ice edge moves independent of the climatological average line. This suggests that the map makers incorporated more factors than just an average estimate. As suggested by Kelly (1979), the map makers probably extrapolated the annual ice edge in three ways: they probably used their knowledge of ice movement, growth, and melt to project ice conditions from given data points further in both time and space. They also may have used auxiliary data that are not included in the DMI publications themselves; these sources may have included annual climatic or atmospheric circulation data present at the time. The DMI map makers were experienced climatologists, so while their inferences are subjective, they are also probably the most reliable of the time.

## 3 DATA ACQUISITION AND PROCESSING

### 3.1.1 Processing Steps

The first use of these charts in digitized format was in the late 1970s when P.M. Kelly, at the University of East Anglia, digitized the ice edge in a set of the charts (Kelly 1979). This was done at a resolution of 100 km, beginning with the 1901 chart. Kelly originally planned flagging areas of potential error. However, a lack of funding limited his work to digitizing the ice edge only. Kelly's digitized version was later incorporated into larger data sets, notably Chapman and Walsh (1991), but also see Walsh (1978) and Sear (1988).

The entire chart set was scanned for use in sea ice research by K. Wood, NOAA, and T. Jonsson, Icelandic Meteorological Office. They have been re-compiled by V. Underhill and F. Fetterer at NSIDC and made available as this data set, in cooperation with Dr. Wood, Dr. Jonsson, and the Danish Meteorological Institute library.

In 2011, the ice edge position was traced on scanned charts in order to obtain the ice edge position at a higher resolution than has previously been possible. Gridded ice concentration was estimated as well. V. Underhill and F. Fetterer did this work. These gridded files will be published online as a data set when resources allow.

The yearbooks also contain narrative ship reports of sea ice for the winter months. About half of these were scanned by V. Underhill and will be made available at a later date.

## 4 REFERENCES AND RELATED PUBLICATIONS

Barry, R. 2000. [Data on the Geographical Distribution of Sea Ice](#). EWG Sea Ice Atlas on CD - ROM data set. Rpt. in NSIDC Special Report 15. 2013. Ed. A. Windnagel and F. Fetterer. NSIDC, Boulder, CO.

Chapman, W.L., and J.E. Walsh. 1991, updated 1996. [Arctic and Southern Ocean sea ice concentrations](#). Boulder, CO: National Snow and Ice Data Center.

Dehn, W. S. 1979. [Inadequacies in Archive Sea Ice Data](#). Glaciological Data Report: Workshop on Snow Cover and Sea Ice Data. GD-5 p 101-106. World Data Center A for Glaciology (Snow and Ice). Boulder, CO.

Kelly, P. M. 1979. [An Arctic Sea Ice Data Set: 1901-1956](#). Glaciological Data Report: Workshop on Snow Cover and Sea Ice Data. GD-5 p 101-106. World Data Center A for Glaciology (Snow and Ice). Boulder, CO.

Walsh, J.E. (1978) A data set on Northern Hemisphere sea ice extent. National Snow and Ice Data Center, "[Glaciological Data, Report GD-2](#)", part 1, pp. 49 - 51.

Sear, C. B. 1988. An Index of Sea Ice Variations in the Nordic Seas. *Int. J. Climatology* 8(4): 339-55.

Thomsen, H. 1939. The state of the ice in the Arctic seas and the surface temperature of the sea in the northern Atlantic-Ocean and in Davis-Strait 1938. Copenhagen: Danish Meteorological Institute.

Thomsen, H. 1947. The Annual Reports on the Arctic Sea Ice issued by the Danish Meteorological Institute. *J. of Glaciology* 1(3): 140-141.

## 4.1 Related Data Collections

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- [Arctic Sea Ice Concentration and Extent from Danish Meteorological Institute Sea Ice Charts, 1901-1956](#)
- [The Dehn Collection of Arctic Sea Ice Charts, 1953-1986](#)
- [National Ice Center Arctic Sea Ice Charts and Climatologies in Gridded Format](#)
- [Sea Ice Charts of the Russian Arctic in Gridded Format, 1933-2006](#)
- [Sea Ice Edge Location and Extent in the Russian Arctic, 1933-2006](#)
- [Morphometric Characteristics of Ice and Snow in the Arctic Basin: Aircraft Landing Observations from the Former Soviet Union, 1928-1989](#)

## 4.2 Related Websites

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- [Danish Meteorological Institute](#)

# 5 CONTACTS AND ACKNOWLEDGMENTS

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### **Acknowledgments:**

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Kevin Wood, Joint Institute for the Study of the Atmosphere and Ocean (JIASO) at University of Washington, and John Walsh, University of Illinois at Urbana-Champaign (UIUC), were instrumental in bringing the collection to our attention, providing links to references, and advising on its use. Trausti Jonsson, IMO, encouraged us to use the collection he had scanned.

We consulted members of the [International Ice Charting Working Group](#) (IICWG) when building the table of inferences concerning ice concentration nomenclature (Table 2).

Finally, we thank the Danish Meteorological Institute and its library for recognizing the importance of systematic collection of sea ice information very early on, organizing the effort internationally, and freely sharing the published reports that resulted.

## 6 DOCUMENT INFORMATION

### 6.1 Publication Date

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November 2012

### 6.2 Date Last Updated

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26 November 2020