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INTRODUCTION TO A NEW SEA-ICE DATABASE

by

Richard W. Knight

(National Climatic Data Center, Federal Building, Asheville, North Carolina 28801, U.S.A.)

ABSTRACT

An important new sea-ice database is presently being created at the National Climatic Data Center in Asheville, North Carolina, USA. The data are digitized from weekly charts prepared at the US Navy/National Oceanic and Atmospheric Administration (NOAA) Joint Polar Ice Center and converted into a digital format prescribed by the World Meteorological Organization. The data cover both the Arctic and Antarctic for a ten-year period of record. The grid points are identified by earth coordinates and have a resolution of 15 nm or better.

This paper is intended to inform potential users of sea-ice data about the availability of the new data set. Topics covered are (1) data source, (2) brief description of the processing procedures, (3) the SIGRID output format, and (4) future plans.

1. INTRODUCTION

Since the arrival of high-resolution satellite imagery, it has been possible to map accurately sea ice in both polar regions. Weekly analyses have been prepared and published since 1972 by the US Navy and National Oceanic and Atmospheric Administration (NOAA) Joint Ice Center located in Suitland, Maryland.

A number of other ice data sets exist (Walsh 1981), but the Joint Ice Center (JIC) charts appear to have the most beneficial combination of length of record along with spatial and temporal resolution, at least from the standpoint of creation of a digital database to be used for climatological summaries.

During the summer of 1981, the JIC initiated plans to digitize all of the charts dating from 1972 (1973 for Antarctic) to the present. At about the same time, Dr T Thompson, in the capacity of World Meteorological Organization (WMO) consultant on sea ice, coordinated the writing of a proposed format for gridded sea-ice data. The timing of these two events was fortunate since having an output format greatly simplified the design of the digitizing system. This format is known as SIGRID (Thompson unpublished) and has generally been accepted as the new WMO standard, although the final version has not yet been approved at this writing.

The sea-ice digitization system is now operational; a technician feeds analog data into a minicomputer and, a few hours later, a magnetic tape emerges containing gridded data in the SIGRID format. The primary purpose of this paper is to let the user community know that this database exists, so that climate modelers and ice researchers can begin to plan applications using the new data set.

2. DATA SOURCES

The weekly analyses (Fig.1) produced at the JIC result from the syntheses of four general classes of data. The sources of these data are (1) shore station reports, (2) ship reports, (3) aerial reconnaissance, and (4) satellite imagery (Godin 1981). The last group, however, dominates. Satellites provide between 90 and 98% of the data, depending on the season.

There are two categories of satellites used (Table I). One is the visible/infrared type. The other is the scanning microwave type (Scanning Multi-frequency Microwave Radiometer (SMMR)/Electrically Scanning Microwave Radiometer (ESMR)). D G Barnett and R H Godin (1983 personal communication) have made some estimates as to the percent of utilization of each. During the summer, visible/infrared provides about 60% of the data, microwave 30%, and direct observations the remaining 10%. During the winter, the figures are approximately 33%, 65% and 2% respectively.

Satellite microwave data were used in the Arctic and Antarctic analyses for the first time in January 1973. This allowed complete dark-season surveillance of the Antarctic. Infrared data were available for the Arctic in 1972 which allowed wintertime analysis there a year earlier (Barnett 1983 personal communication). The accuracy of the depiction of ice extent and ice concentration for the post-1972 Navy charts is considered quite good (Kukla and Robinson 1979). Since 1973, there has been little change in the reliability of the data sources over time. Occasionally the most current data may arrive too late for inclusion in the week's analysis. When this happens, ice coverages are estimated using data up to several days old in conjunction with the previous analysis and continuity considerations. Therefore, the database resulting from digitization of the Navy charts will be complete with no gaps caused by missing data.

3. PROCESSING PROGRAMS AND PROCEDURES

The task of digitizing ice charts is straightforward. After a chart is mounted on the digitizing tablet and header information is entered into the keyboard terminal, digitizing begins. The digitizer operator follows the ice "contours" with a cross-hair cursor, and x-y coordinate pairs are generated and recorded at a rate of five points per second. The digitizer program invokes a dialog which prompts the operator for all of the required input. This approach to digitizing allows all of the salient information on a chart to be saved. If grid point resolution requirements were to change, one could modify the gridding programs and rerun the raw contour data from the digitizer program with no loss of information. Therefore, the contour digitization approach has a clear advantage over the more commonly used and more labor-intensive method of reading values at each grid point.

Before discussing the gridding programs, it is necessary to digress for a moment to examine the grid

TABLE I. SATELLITE DATA UTILIZED DURING 1981

Time period		Satellite remote sensing			Resolution	Coverage
From	To	Sensor platform	Sensor type*	Spectral region	(km)	
1-81	12-81	NOAA-6	AVHRR			
			HRPT/LAC			
			VIS	0.55-0.68 μm	1	Regional
			NIR	0.73-1.10 μm		
			IR	3.55-3.93 μm		
			IR	10.5-11.5 μm		
			GAC			
			VIS	0.55-0.68 μm	4	Global
			IR	10.5-11.5 μm		
7-81	12-81	NOAA-7	AVHRR			
			HRPT/LAC			
			VIS	0.58-0.68 μm	1	Regional
			NIR	0.73-1.10 μm		
			IR	3.55-3.93 μm		
			IR	10.3-11.3 μm		
			GAC			
			VIS	0.58-0.68 μm	4	Global
			IR	10.3-11.3 μm		
1-81	12-81	NIMBUS-5	ESMR	1.55 cm	25	Global
1-81	12-81	NIMBUS-7	SMMR	0.81 cm 1.66 cm	50	Global

*Acronyms:

AVHRR Advanced Very High Resolution Radiometer
ESMR Electrically Scanning Microwave Radiometer
GAC Global Area Coverage
HRPT High Resolution Picture Transmission
IR Infrared
LAC Local Area Coverage
NIR Near Infrared
SMMR Scanning Multifrequency Microwave Radiometer
VIS Visual

point resolution requirements. Two constraints were imposed upon the chosen coordinate grid system: (i) the grid point resolution must always be ≤15 nm, (ii) the quotient obtained by dividing 180° by the longitudinal grid point spacing must be an integer. These constraints have led to the choice of the longitudinal grid point spacing shown in Table II. The latitudinal grid point spacing is 0.25° over the entire map.

Now, knowing the locations of the required grid points allows the raw contour data to be transformed into an ice type and concentration at a grid point. Heuristically speaking, the gridding program goes through the Master Grid point Table (MGT) and asks the question "Is this point inside or outside of the contour?" If the point is inside, it receives an appropriate value for ice type and concentration. If outside, no action is taken. Since there are approximately 146 000 grid points covering the Arctic region, this would be an inordinately lengthy procedure if it were not for the fact that only small parts of the MGT need be accessed for each contour. This is true because the MGT is arranged as a direct access file whose record numbers are based on geographic location. Therefore, the program only queries those grid points whose locations are in the vicinity of those encompassed by the raw contour. This substantially reduces the number of computations and allows the gridding to proceed quickly.

When this program has completed, the MGT contains a latitude, longitude, and an 18-digit grid point value which may identify ice, open water, or land. Each of these grid point records is then written to another file which is sorted first by latitude (equator to pole) and then by longitude (west to east). The sorted file then becomes input to the final programs which produce the SIGRID format.

TABLE II. GRID POINT SPACING ALONG PARALLELS CHOSEN TO SATISFY RESOLUTON REQUIREMENTS

Latitude range (°)	Grid point spacing (°)
45.00 - 59.75	.25
60.00 - 75.75	.50
76.00 - 82.75	1.00
83.00 - 85.75	2.00
86.00 - 86.75	3.00
87.00 - 87.75	4.00
88.00 - 88.75	5.00
89.00 - 89.25	10.00
89.50 - 89.50	20.00
89.75 - 90.00	30.00

4. THE SIGRID FORMAT

The vast majority of sea-ice data in the world today is stored in the form of ice charts prepared by the various ice services of different countries. It has long been recognized that data in this form have limited use for statistical and climatological summaries. Efforts are now being made to construct digital representations of these ice charts. SIGRID was designed to provide a versatile, yet comprehensive archival format for digital data. Having one uniform standard for all of the cooperating ice services should greatly facilitate information interchange.

The SIGRID format is tremendously flexible, allowing for the inclusion of many combinations of parameters from a total list of 53. All of the data received from the JIC can be coded using 12 parameters. When all 12 parameters are used, the corresponding data group will be 38 characters long.

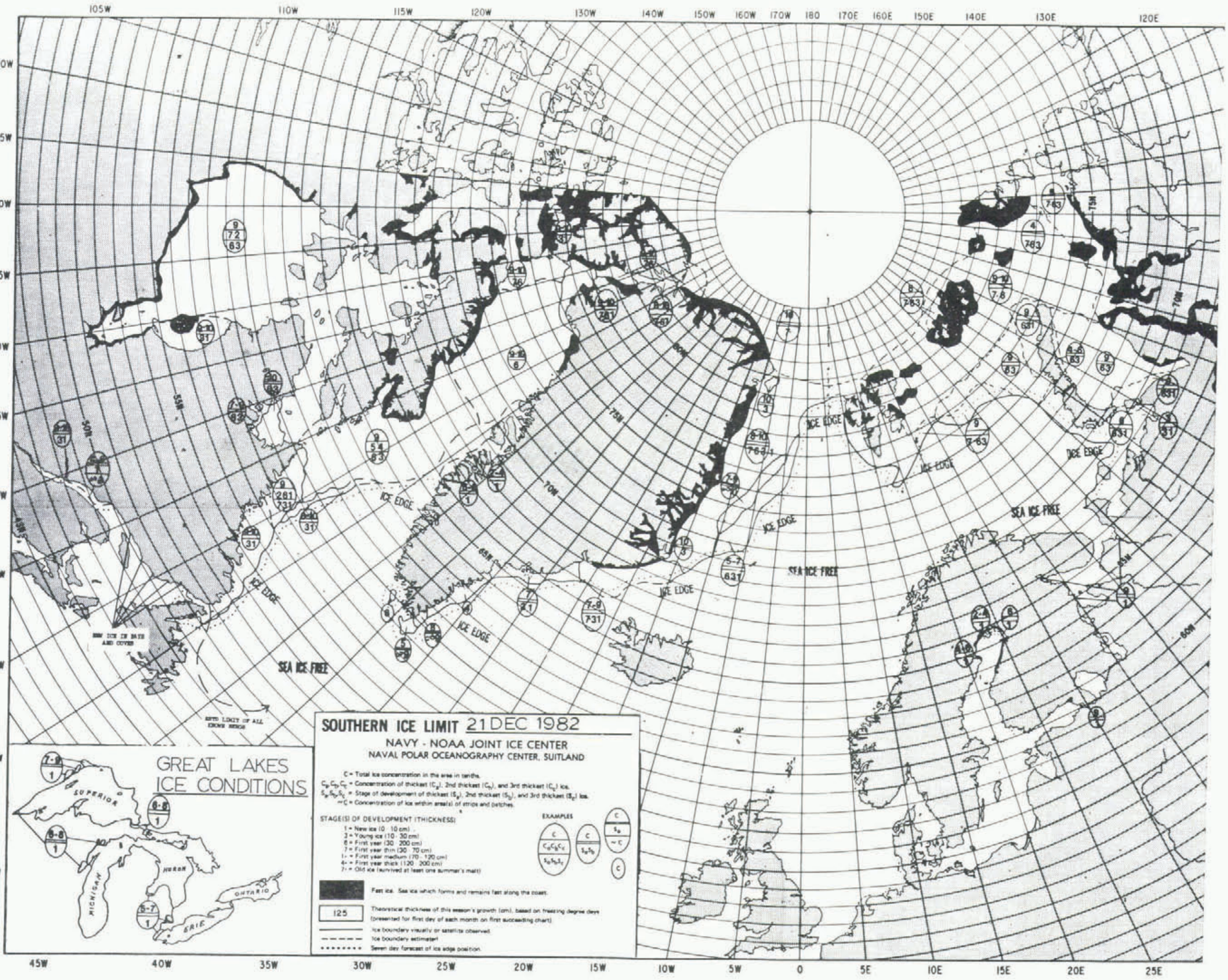

Fig.1. An example of a weekly analysis of sea ice produced at the US Navy-NOAA Joint Ice Center.

However, data groups of the order of 2 parameters and 16 characters are far more typical. A fully expanded grid point record from a Navy chart would contain the following 12 parameters, although in practice, some would be designated as unknown. First, the total ice concentration (coverage) in tenths is listed. This is followed by three groups of three parameters each which describe the partial concentration, stage of development, and form of ice respectively for the thickest, second thickest, and third thickest ice. The last two parameters describe the predominant and secondary form of ice and are only coded from Navy charts when ice occurs in strips and patches.

SIGRID requires two header records which contain all of the information needed to identify the analysis from which the data were taken. In addition, there is information which will allow the data records which follow to be completely reconstructed as individual grid points with a latitude, longitude, and an ice concentration/type identifier. The data are ordered in strips of latitude running equatorward to poleward, and, within the strips, from west to east. The format allows for compaction by use of a repeater constant, which enables one data group to describe from 1 to 99 adjacent grid points.

Shown below, is an example of part of a grid line record having three data groups:

:R05LL:R12CT92CA929908:R03CT00

Data groups always begin with :R followed by the repeat constant. The LL in the first data group signifies land, so the first data group represents five land grid points. The second data group describes the next 12 grid points as having an ice concentration CT of ten-tenths (92). The partial concentration of the thickest ice CA is also ten-tenths and its stage of development is unknown (99). The form of this ice (08) is fast ice. The final data group depicts three grid points of zero concentration which translates to open water.

5. FUTURE PLANS

We, at the National Climatic Data Center (NCDC), have begun work on some sea-ice climatological summaries. In general these summaries will be graphical products depicting some feature composited on a semi-monthly basis for a 10-year period of record. Some examples are (i) mean, maximum, and minimum ice edge, (ii) mean ice concentration in tenths, (iii) mean ice age, (iv) mean extent of 5/10ths or more concentration, and (v) mean extent of old ice. The summary charts will ultimately be published under the aegis of the Joint Ice Center.

The complete database should be available on two or three magnetic tapes in the SIGRID format by late summer of 1984. In addition, the data will be available in a more compacted format used for the production of the climatological summaries mentioned above.

REFERENCES

Godin R H 1981 Sea ice charts of the Navy/NOAA Joint Ice Centre. *Glaciological Data Report* GD-11: 71-77

Kukla G, Robinson D 1979 Accuracy of snow and ice monitoring. *Glaciological Data Report* GD-5: 91-97

Thompson T Unpublished Proposed format for gridded sea ice information (SIGRID). (Report prepared for the World Climate Programme, 1981)

Walsh J E 1981 Snow and ice data sets. *Glaciological Data Report* GD-11: 139-144