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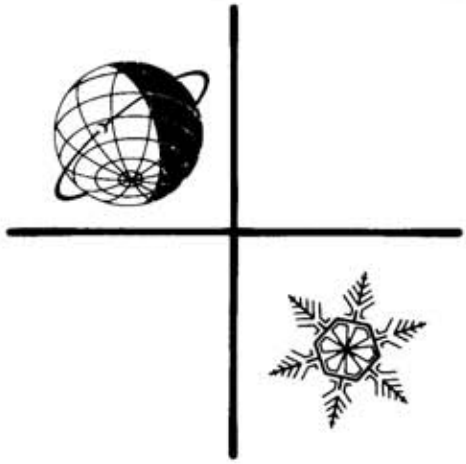
REPORT GD-7

GLACIOLOGICAL DATA

INVENTORY OF SNOW COVER AND SEA ICE DATA

World Data Center A
for
Glaciology
Snow and Ice



December 1979

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NOTES:

1. World Data Centers conduct international exchange of geophysical observations in accordance with the principles set forth by the International Council of Scientific Unions. WDC-A is established in the United States under the auspices of the National Academy of Sciences.
2. Communications regarding data interchange matters in general and World Data Center A as a whole should be addressed to: World Data Center A, Coordination Office (see address above).
3. Inquiries and communications concerning data in specific disciplines should be addressed to the appropriate subcenter listed above.

GLACIOLOGICAL DATA

REPORT GD-7

INVENTORY OF SNOW COVER AND SEA ICE DATA

Compiled by

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Published by:
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[SNOW AND ICE]

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Environmental Data and Information Service
Boulder, Colorado 80303 U.S.A.

DESCRIPTION OF WORLD DATA CENTERS[1]

WDC-A: Glaciology (Snow and Ice) is one of three international data centers serving the field of glaciology under the guidance of the International Council of Scientific Unions Panel of World Data Centers. It is part of the World Data Center System created by the scientific community in order to promote worldwide exchange and dissemination of geophysical information and data. WDC-A endeavors to be promptly responsive to inquiries from the scientific community, and to provide data and bibliographic services in exchange for copies of publications or data by the participating scientists.

1. The addresses of the three WDCs for Glaciology and of a related Permanent Service are:

World Data Center A
INSTAAR
University of Colorado
Boulder, Colorado, 80309 U.S.A.

World Data Centre C
Scott Polar Research Institute
Lensfield Road
Cambridge, CB2 1ER, England

World Data Center B
Molodezhnaya 3
Moscow 117 296, USSR

Permanent Service on the Fluctuations of Glaciers - Department of Geography
Swiss Federal Institute of Technology
Sonneggstrasse 5
CH-8092 Zurich, Switzerland

2. Subject Matter

WDCs will collect, store, and disseminate information and data on Glaciology as follows:

Studies of snow and ice, including seasonal snow; glaciers; sea, river, or lake ice; seasonal or perennial ice in the ground; extraterrestrial ice and frost.

Material dealing with the occurrence, properties, processes, and effects of snow and ice, and techniques of observing and analyzing these occurrences, processes, properties, and effects, and ice physics.

Material concerning the effects of present day and snow and ice should be limited to those in which the information on ice itself, or the effect of snow and ice on the physical environment, make up an appreciable portion of the material.

Treatment of snow and ice masses of the historic or geologic past, or paleoclimatic chronologies will be limited to those containing data or techniques which are applicable to existing snow and ice.

3. Description and Form of Data Presentation

3.1 General. WDCs collect, store and are prepared to disseminate raw+, analyzed, and published data, including photographs. WDC's can advise researchers and institutions on preferred formats for such data submissions. Data dealing with any subject matter listed in (2) above will be accepted. Researchers should be aware that the WDCs are prepared to organize and store data which may be too detailed or bulky for inclusion in published works. It is understood that such data which are submitted to the WDCs will be made available according to guidelines set down by the ICSU Panel on WDCs in this Guide to International Data Exchange. Such material will be available to researchers as copies from the WDC at cost, or if it is not practicable to copy the material, it can be consulted at the WDC. In all cases the person receiving the data will be expected to respect the usual rights, including acknowledgement, of the original investigator.

[1]International Council of Scientific Unions. Panal on World Data Centers. (1979) Guide to International Data Exchange Through the World Data Centres. 4th ed. Washington, D.C. 113 p.

+The lowest level of data useful to other prospective users.

This Guide for Glaciology was prepared by the International Commission on Snow and Ice (ICSI) and was approved by the International Association of Hydrological Sciences (IAHS) in 1978.

3.2 Fluctuations of Glaciers. The Permanent Service is responsible for receiving data on the fluctuations of glaciers. The types of data which should be sent to the Permanent Service are detailed in UNESCO/IASH (1969)*. These data should be sent through National Correspondents in time to be included in the regular reports of the Permanent Service every four years (1964-68, 1968-72, etc.). Publications of the Permanent Service are also available through the WDCs.

3.3 Inventory of Perennial Snow and Ice Masses. A Temporary Technical Secretariat (TTS) was recently established for the completion of this IHD project at the Swiss Federal Institute of Technology in Zurich. Relevant data, preferably in the desired format**, can be sent directly to the TTS or to the World Data Centers for forwarding to the TTS.

3.4 Other International Programs. The World Data Centers are equipped to expedite the exchange of data for ongoing projects such as those of the International Hydrological Project (especially the studies of combined heat, ice and water balances at selected glacier basins***), the International Antarctic Glaciological Project (IAGP), the Greenland Ice Sheet Project (GISP), etc., and for other developing projects in the field of snow and ice.

4. Transmission of Data to the Centers

In order that the WDCs may serve as data and information centers, researchers and institutions are encouraged:

4.1. To send WDCs raw+ or analyzed data in the form of tables, computer tapes, photographs, etc., and reprints of all published papers and public reports which contain glaciological data or data analysis as described under heading (2); one copy should be sent to each WDC or, alternatively, three copies to one WDC for distribution to the other WDCs.

4.2. To notify WDCs of changes in operations involving international glaciological projects, including termination of previously existing stations or major experiments, commencement of new experiments, and important changes in mode of operation.

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*UNESCO/IASH (1969) Variations of Existing Glaciers. A Guide to International Practices for their Measurement

**UNESCO/IASH (1970a) Perennial Ice and Snow Masses. A Guide for Compilation and Assemblage of Data for a World Inventory; and

Temporary Technical Secretariat for World Glacier Inventory. Instructions for Compilation and Assemblage of Data for a World Glacier Inventory.

***UNESCO/IASH (1970b) Combined Heat, Ice and Water Balances at Selected Glacier Basins. A Guide for Compilation and Assemblage of Data for Glacier Mass Balance Measurements; and

UNESCO/IASH (1973) Combined Heat, Ice and Water Balances at Selected Glacier Basins. Part II, Specifications, Standards and Data Exchange.

+The lowest level of data useful to other prospective users

FOREWORD

Under a NOAA/EDIS contract, the Data Center has recently undertaken an inventory of snow cover and sea ice data. The primary focus of this survey has been on map series or data sets which characterize these two cryospheric parameters on a regional to global scale. Such information is of broad relevance to problems of global climate, hydrology, and environmental monitoring, as well as for operational and planning purposes in conjunction with engineering projects, transportation, agriculture, and energy assessments. As a result of the wide-ranging significance of snow cover and sea ice, many agencies, organizations and individuals, world-wide, are involved in programs generating or requiring pertinent data. It is hoped that this survey, prepared and compiled by Robert Crane, a member of the Data Center's scientific staff, will provide greater awareness of the data sources and products that are potentially available and will also serve as a stimulus to further standardization and integration of the basic data. These steps are essential to the future preparation of digitized data bases. Recommendations relating to these matters are contained in the report of the Data Center's Workshop on Mapping and Archiving of Data on Snow Cover and Sea Ice Limits (Glaciological Data, Report GD-5). The current holdings of snow and ice charts in the WDC-A are listed in that same report (p. 22-23).

This issue introduces Ann Brennan of the staff to our scientific colleagues in her new capacity as Technical Editor. We anticipate publication of GD-8 dealing with our ice core inventory work in March 1980.

R. G. Barry
Director
World Data Center-A
for Glaciology (Snow and Ice)

PREFACE

We wish to thank all respondents for their efforts in completing and returning the snow cover and sea ice data questionnaire. We apologize to early respondents for the delay in publication of the results. We did this in order to ensure as complete a response as possible. For this reason, the material in some of the responses may be somewhat dated.

The responses have been edited and formatted by Data Center staff. A few descriptions have been prepared in the Data Center from available information. A copy of the original questionnaire is included for comparison.

We wish to thank Margaret Strauch for typing the bulk of the text and Annie Gensert for supplementary assistance.

Ann M. Brennan
Technical Editor

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Inventory of Data on Snow Cover and Sea Ice Extent

R.G. Barry and R.G. Crane

Introduction

Determination of the physical processes which control global climate and its variations is the second major objective of the Global Atmospheric Research Program (GARP). Observational studies are a vital component of GARP. Since the most pronounced and spatially extensive variations in the earth's surface properties are represented by the seasonal and long term changes in the global cryosphere, it is clear that an improved knowledge of snow cover and sea ice conditions is a key requirement to secure the GARP objectives. These cryospheric variables are of great significance for man's welfare and economic activity, yet data on their distribution and thickness are limited and are only readily available in the form of large-scale mean seasonal charts.

Records of sea ice limits and snow cover extent on land are obtained for most of the globe on a daily to weekly time scale by a combination of ground observations, aircraft reconnaissance, and satellite remote sensing, using a variety of measurement techniques. Since the mid-1960s, U.S. satellites have provided a good global view of, at least, the snow and ice boundaries. However, a standardized numeric data set based on these measurements has not yet been prepared.

As a first step in assessing the feasibility of assembling such numeric data sets, the World Data Center A for Glaciology {Snow and Ice} held a workshop on Mapping and Archiving of Data on Snow Cover and Sea Ice Limits in November 1978. The results of this meeting are published in Glaciological Data, Report GD-5 (World Data Center-A for Glaciology, 1979). At the same time, the Center began preparing an inventory of snow cover and sea ice data. The Commission of Atmospheric Sciences of the World Meteorological Organization (WMO 1977) had earlier suggested that the Data Center would be a suitable organization to carry out an inventory of existing sea ice data sets as an aid to studies of climate-ice interactions.

A questionnaire was circulated to producers of map series and cryospheric indices derived from primary and secondary sources. In view of the global focus of both the U.S. and the World Climate Programs, with respect to climate variability, the survey included data on global, hemispheric, and regional scales. The questionnaire dealt with the space and time coverage of the data, as well as the consistency and internal homogeneity of the various data sources and products. The format and availability of the data were also determined.

The Scope of the Survey

Snow Cover

For the United States, Colbeck, et al. (1979)* list 36 state governments, including universities, and 22 federal agencies involved in snow research. An added observation concluded that if this list were expanded to include those groups that use snow data in a direct application, it would include virtually all agencies within the federal government, most state governments, and numerous private organizations and companies. The fragmented nature of snow research has resulted in numerous agencies collecting a wide variety of information, with the type of data being determined mainly by the individual requirements of the organization involved. There has so far been little attempt to compile these data sets, or even to identify the scope of activities of all the agencies involved. Similarly, there has been no attempt to standardize current data collection and archiving procedures.

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*Colbeck, S.C. et al. (1979). Focus on U.S. snow research. World Data Center-A for Glaciology {Snow and Ice} Glaciological Data, Report GD-6, p. 41-51.

The Data Center is in the process of indentifying all of these agencies and documenting their data holdings. The present inventory is primarily concerned with sets of large-scale snow cover data, of most relevance to the GARP objective. A summary of data available from the State Snow Surveys and from a few of the regional-scale operational and experimental snow cover data sets is included, where information on these was available. Some national data sets from non-U.S. sources are also described. Reference to other data sets, for which detailed information was not available for this inventory, can be found in Glaciological Data, Report GD-6 (World Data Center-A for Glaciology, 1979). Reference to general publications on snow cover, snow cover extent, snow cover mapping, and remote sensing applications, are listed in the same report.

Sea Ice

The inventory of sea ice data sources focused on mapped information relating to the seasonal cycle. It is considered that most of the major sources have been described in this inventory with the exception of the Soviet data, for which little information is available. Continuing efforts are being made to include these data in the international exchanges routinely conducted through the World Data Centers.

Data on other sea ice parameters exist and although these sources may include information relating to ice extent, they are not included in the present inventory. Most notable of these are the data collected by the Arctic Ocean drifting stations, the AIDJEX data set, the Bering Sea Experiment, and the Outer Continental Shelf Environmental Assessment Program. Other on-going sea ice experiments and data collection projects are being carried out, for example, at the Center for Cold Ocean Resources Engineering (Memorial University of Newfoundland) and the Marine Meteorological Studies Group at the Pacific Marine Environmental Laboratory (3711 15th Avenue, N.E., Seattle, Washington 98105). Many of the results of these projects have appeared in the literature, and reference to these and other publications on sea ice can be found in Glaciological Data, Report GD-2 (World Data Center-A for Glaciology, 1977).

Response

Questionnaires were sent to 55 individuals, agencies, or institutions, from which 39 responses were obtained, according to the following breakdown:

	Number of Questionnaires Sent out	Number of Responses Obtained
North American universities or research institutes	7	6
U.S. Federal agencies	13	12
State agencies	12	9
Government agencies (Canada)	3	3
Private consultants	3	2
Oil companies	3	0
Agencies outside North America	14	7
Total	55	39

Of the 39 responses, 7 were from individual state Snow Surveys and are included as a single summary. Four were returned as being inapplicable to the work of the person or agency concerned. A number of questionnaires sent to non-U.S. institutions have not yet been returned. Should sufficient replies be received following this publication, they will appear in a future issue of Glaciological Data. Similarly, we would like to be informed of any other data sets that are not reported in this inventory.

WORLD DATA CENTER A

for

GLACIOLOGY

[SNOW AND ICE]

OPERATED FOR ENVIRONMENTAL DATA SERVICE, NOAA, BY

Institute of Arctic and Alpine Research
University of Colorado
Boulder, Colorado, U.S.A.

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TELEPHONE: (303) 492-5171 FTS: 323-4311
TELEX: 45897 SOLTERWARN BDR

IN REPLY REFER TO:

SNOW COVER
GLACIER FLUCTUATIONS
AVALANCHES
POLAR ICE MASSES
SEA ICE
PERMAFROST
PALEOGLACIOLOGY

14 September 1978

SNOW COVER AND SEA ICE EXTENT DATA INVENTORY

QUESTIONNAIRE

The questionnaire has been divided into 2 parts, one concerning data sources, and one concerning the finished products. If sufficient space is not available for comment, please use a separate sheet. If for some reason you are unable to supply a response, please indicate why (data not available, data will be available at a later date, etc.).

Please list all products concerned with snow cover or sea ice extent on table 1, and complete one copy of the questionnaire for each (several copies are enclosed for your convenience). If the same data sources and product formats are used for several products (e.g., Canadian AES Ice Summary and Analysis for Hudson Bay Approaches, Canadian Arctic, etc.), one questionnaire can be completed for the group.

CONTENTS

PART ONE: DATA SOURCES

For users of primary data (e.g., satellite, remote sensing, ship and ground observations)

I. General information I-1
II. Data sources and consistency for chart (or other) products I-3
III. Data consistency I-6
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PART TWO: PRODUCTS

I. Map or other products II-1
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III. Use and applications of products II-9
IV. Other comments II-9

PART ONE: DATA SOURCES

SUBJECT: Snow_____ Ice_____

I. GENERAL INFORMATION

Respondent
Name_____
Affiliation_____
_____
Address_____
_____
_____
_____
Phone (commercial)_____FTS(if available)_____

Project Director (if different from above)
Name_____
Address_____
_____
_____
_____
Phone (commercial)_____FTS(if available_____

Publications

(1) Please attach a compete list of references to your snow/ice work (include in-house and in-press reports, and student theses which you feel significantly contribute to a description of your work).

(2) If possible, please enclose examples of your products and the types of data used.

ADDITIONAL COPIES OF THIS FORM ARE ENCLOSED SEPARATELY

TABLE 1. DESCRIPTION OF PRODUCT

Name of product	Retention Period	Archive Location	Length of time product will be produced		Available to (please check)				Contact (Name, agency, address, phone)	Cost
			indefinitely	until	Interested scientists	A WDC data base	Upon specific request	Not available		

II. DATA SOURCES AND CONSISTENCY FOR CHART (OR OTHER) PRODUCTS

A. Data sources and originating agencies (indicate data used).

	Agency	Routine	Special
Satellite observations			
Aircraft observations			
Ship observations			
Ground observations			
Other (please specify)			

B. What methods were initially used to determine levels of accuracy/resolution of data (i.e., acceptance tests of system). Reference appropriate reports.

C. We wish to set up a record of the snow/ice data available over different time intervals, and to determine their consistency for archiving. Please divide the data used as your source(s) into time periods for which there is internal consistency and complete table 2 on the following page. If a particular question is better answered in some other manner, please do so.

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TABLE 2. TYPE OF DATA/METHOD OF COLLECTION FOR YOUR DATA SOURCE(S) [a,b]

Time period		Remote sensing system						Ground observation[c]		Other types of data (percentage of map covered, frequency of observations, etc.)	Resolution of data (km^2 or °lat/long)
from	to	Sensor platform	Sensor type	Spectral region	Number of images used at one point per time interval mapped			Approximate size of sample from which means are obtained for each map			
					Average	Range max.	Range min.	Number of observing points	Frequency (obs/day, week, etc.)		

[a] If observations are in the form of flight tracks, ship observations, etc., please supply statistics on area covered by observations, frequency of observations, etc. Include maps of usual tracks if appropriate.

[b] If empirical relationships (i.e.,between climatic variables) are used in part to determine snow/ice cover (e.g., AFGWC snow maps), please supply information on parameters used, percent of map area for which representative observations are available, or other relevant information.

[c] Attach maps of station sources if applicable.

D. For your current method of analysis, list in preferential order the data sources used. Indicate, for an average year, season, etc., the percentage time for which there are missing data. If the preferred order of data use changes through the year (i.e., on a seasonal basis), indicate accordingly.

season/months	
Preferential order of data used	% time missing data

season/months	
Preferential order of data used	% time missing data

season/months	
Perferential order of data used	% time missing data

E. Indicate the procedures used to differentiate between:

1. Cloud and snow/ice surfaces_____

2. Nilas and water_____

3. Open water and surface melt water_____

4. Different ages of snow/ice cover_____

5. Snow thickness_____

6. Other_____

F. Have these procedures changed over time? Describe_____

G. Give criteria/limitations used for the polar night cutoff_____

H. Have these criteria changed over time? Describe_____

I. Have methods of interpretation changed over time? Describe_____

J. Have the interpreters involved changed over time? Describe_____

K. Are there any changes planned in data sources? Describe and give dates____

L. Are any changes planned in methods of interpretation? Describe and give dates_____

III. DATA CONSISTENCY

A. Indicate the steps that are taken to assure consistency of interpretation among interpreters_____

B. What methods are routinely used to check for consistency in:

1. Source data_____

2. Interpretation_____

C. Are data sources cross-checked with other data sources? Describe_____

D. Give results of any consistency checks_____

E. List references on separate page.

F. Other comments on consistency_____

IV. GROUND DATA FOR REMOTE SENSING

A. What are the amount and type of ground data (include aircraft underflights, etc.):

1. For the initial test period_____

2. For routine measurements of:

a) Albedo or bidirectional reflectance_____

b) Snow depth_____

c) Moisture content of snow_____

d) Ice thickness_____

e) Ice concentration_____

f) Age of ice_____

g) Presence/absence of snow cover on ice_____

h) Melt water ponds on ice_____

i) Other_____

B. Supply any documentation of measurements.

C. Assess effectiveness and usefulness of ground data (e.g., problems such as time coincidence between ground and satellite/airborne observations).

V. AVAILABILITY OF DATA

A. Format

1. Listings: (please check)

___Original record sheets ___Computer lists
___Other (please specify)_____

2. ___Tape files: 7/9 track_____
b.p.i._____

3. ___Maps: indicate scale, material (e.g., paper, transparencies, film, etc.) and size of maps_____

4. Microform: Indicate ___Microfilm ___35mm ___16 mm roll
___16 mm cartridge

___Microfiche

___Microcard aperture

5. ___Other (please specify)_____

B. Are data digitized? ___yes ___no

C. Could it be digitized? ___yes ___no

D. Estimate the total data set (e.g., number of daily or monthly observations per number of years and per number of grid points)_____

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TABLE 3. AVAILABILITY OF DATA

Type of data	Retention Period	Archive Location	Available to (please check)				Contact (Name, agency, address, phone)	Cost
			Interested scientists	A WDC data base	Upon specific request	Not available		

PART TWO: PRODUCTS

I. MAP OR OTHER PRODUCTS

A. Area covered (please check)

1. __Global
2. ___Northern Hemisphere
3. ___Southern Hemisphere
4. ___Other (give coordinates _____
_____

Please attach sample map.

B. Mapping scale_____

C. Projection

1. ___UTM
2. ___Mercator
3. ___Polar stereographic
4. ___Other (please specify)_____
_____
_____

D. Divide your available snow/ice maps, etc. into time periods for which there is internal consistency in the finished product (i.e., in scale, format, accuracy, etc.), and complete the table on the next page.

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TABLE 4. MAP, DIGITAL, OR OTHER PRODUCTS.

Time period (also list intervals with no analyses)		3 Time interval between successive products	Smallest homogenous area that your mapping/digitizing system resolves		6 Km within which plotted snow/ice boundaries are accurate under typical conditions	Consistency between maps in the identification of the minimum resolvable areas indicated in columns 4 & 5 (please check)								9 How consistent between maps is the accuracy of the boundaries with the mean shown in column 6			
						7 under worst conditions				8 under typical conditions							
1 from	2 to		4 under worst conditions	5 under typical conditions		poor	fair	good	excellant	poor	fair	good	excellant	poor	fair	good	excellant

E. Charted Features

For each type of feature mapped, list the classes and state the minimum area that can be mapped in each category under typical and worst conditions.

FOR ICE (For SNOW, go to p.II-6)

classes of ice concentration (give units)	minimum area that can be recognized		accuracy (±1 class, order of magnitude, etc.)
	typical conditions	worst conditions	
classes of age and type of ice (e.g., fast ice, 1st yr, multi-yr)	(as above)		(as above)

classes of ice thickness (give units)	minimum area that can be recognized		accuracy (±1 class, order of magnitude, etc.)
	typical conditions	worst conditions	
classes of average size of floes (give units)			
classes of ridging			

classes of melt features	minimum area that can be recognized		accuracy (±1 class, order of magnitude, etc.)
	typical conditions	worst conditions	
other features mapped (give classes and units if applicable			

FOR SNOW

reflectivity, (e.g., presence/absence of snow reflectivity categories)	minimum area that can be recognized		accuracy (±1 class, order of magnitude, etc.)
	typical conditions	worst conditions	
snow depth classes (give units)			
age classes			

other features mapped (give classes and units if applicable)	minimum area that can be recognized		accuracy (±1 class, order of magnitude, etc.)
	typical conditions	worst conditions	

F. Attach information/documentation on any pilot tests of product.

G. List any changes in product format that have occurred (e.g., in scale, area covered, features/detail depicted); cross-refer to Table 4 time intervals

_____
_____
_____
_____
_____
_____
_____

H. Are any changes planned in format, scale or content of product? Please describe _____
_____
_____
_____
_____
_____
_____
_____

I. Additional information mapped, e.g., pressure patterns, wind flow, thawing degree days, etc. List the sources of the data_____

II. AVAILABILITY OF PRODUCTS

A. Format available: (please check)

1. Listings
   ___Original record sheets
   ___Computer lists
   ___Other (please specify)_____

2. Tape files: Indicate ___7/9 track_____
   ___b.p.i._____

3. Maps: indicate scale, the material (e.g., paper, transparencies, film, etc.) and size of maps_____

4. Microform: Indicate ___Microfilm ___35 mm ___16 mm roll ___16 mm cartridge
   ___Microfiche
   ___Microcard aperture

5. ___Other (please specify)_____

B. Are any of the products digitized? ___yes ___no

C. Could any of it be digitized? ___yes ___no

D. Estimate the total data set (e.g., number of daily or monthly observations per number of years and per number of grid points)_____

III. USE AND APPLICATION OF PRODUCT

A. Principal users:

Agency	Individual(s)	Applications

B. Is the product used internally? Please describe (e.g., for research, information service, forecasting, etc.)

IV. OTHER COMMENTS

Global Sea Ice Limits

Source: Fleet Weather Facility/Joint Ice Center[1]

Contact: Raymond H. Godin/Don G. Barnett
Fleet Weather Facility
4301 Suitland Road
Washington, D.C. 20390
(301) 763-5972/3 FTS 763-5972/3

I. Products

Table 1. Description and availability of products

Name of product	Retention Period	Archive Location	Contact
Weekly Southern Ice Limit (Eastern Arctic)*	January 1972 to present	F.W.F. ------ NTIS/DDC	Defense Documentation Center* Cameron Station Alexandria, VA 22314 or National Technical Information Service* Springfield, VA 22161 (703) 557-4650
Weekly Southern Ice Limit (Western Arctic)*	January 1972 to present	F.W.F. ------ NTIS/DDC	
Weekly Northern Ice Limit (Antarctic)*	January 1973 to present	F.W.F. ------ NTIS/DDC	
30 Day Western Arctic Sea Ice Forecast	June 1973 to present	F.W.F.	Commanding Office Fleet Weather Facility 4301 Suitland Road Washington, D.C. 20390
30 Day Eastern Arctic Sea Ice Forecast	May 1973 to present	F.W.F.	
30 Day Ross Sea, Sea Ice Forecast (Nov. - Feb.)	1970 to present	F.W.F.	
Eastern Arctic Seasonal Outlook	1976 to present	F.W.F.	*compilations of weekly analyses are listed in References, and are available from NTIS or DDC for reproduction cost. Weekly mailings are available at no cost from the Commanding Officer, Fleet Weather Facility.
Western Arctic Seasonal Outlook	1970 to present	F.W.F.	
Ross Sea Seasonal Outlook	1970 to present	F.W.F.	

[1] Now the Navy-NOAA Joint Ice Center
Naval Polar Oceanography Center
Suitland, Maryland

A. Description of products

The area covered is global with charts produced weekly on a scale of 1:11.6 million for the Arctic and 1:16 million for the Antarctic.* Charts are plotted on an azimuthal equidistant projection with the point of tangency at the poles. The smallest homogeneous area resolved by the mapping system is < 20km under typical conditions and 40km under the worst. Boundaries are accurate to <20km under typical conditions and the consistency between maps in their identification is excellent under typical conditions and good under the worst.

*Mailing and telefacsimile charts differ in scale from originals. Eastern Arctic Analysis, figure 1, is a 75 percent reduction of a work chart reduction of a work chart copy.

Western Arctic Analysis, figure 2, is a 62 percent reduction of a work chart copy.

Antarctic analysis is a 45 percent reduction of a work chart copy.

1. Charted features.

Classes of ice concentration (give units)		Classes of age and type of ice (e.g., fast ice, first year, multiyear
ice free open water 0-2 oktas 1-3 oktas 2-4 oktas 3-5 oktas 4-6 oktas 5-7 oktas 6-8 oktas 7-8 oktas 8 oktas	Generally accurate to within class limits. Minimum accuracy to within + 1 class, except less accuracy in first 4 classes (ice free to 1-3)	fast ice new young first year multiyear

Classes of ice thickness	Classes of average size of floes	Other features mapped
new young first year thin first year medium first year thick multiyear	new ice brash (<20m) small floe (20-100m) medium floe (100-500m) big floe (500m-2km) vast floe (2-10km) giant floe (>10km)	cracks icebergs bergy bits

Minimum areas that can be recognized vary greatly from season to season dependent on available data. The intent of analyses is to provide global ice coverage.. This precludes analyzing mesoscale features that the data provide.

2. Additional information mapped included theoretical ice thicknesses from October 1973 to July 1974 based on observed shore station frequency and thawing degree days, and +2°C sea surface and +0.0°C atmospheric weekly mean isotherm from fleet numerical data.

3. No changes are planned in format, scale or content of the product.

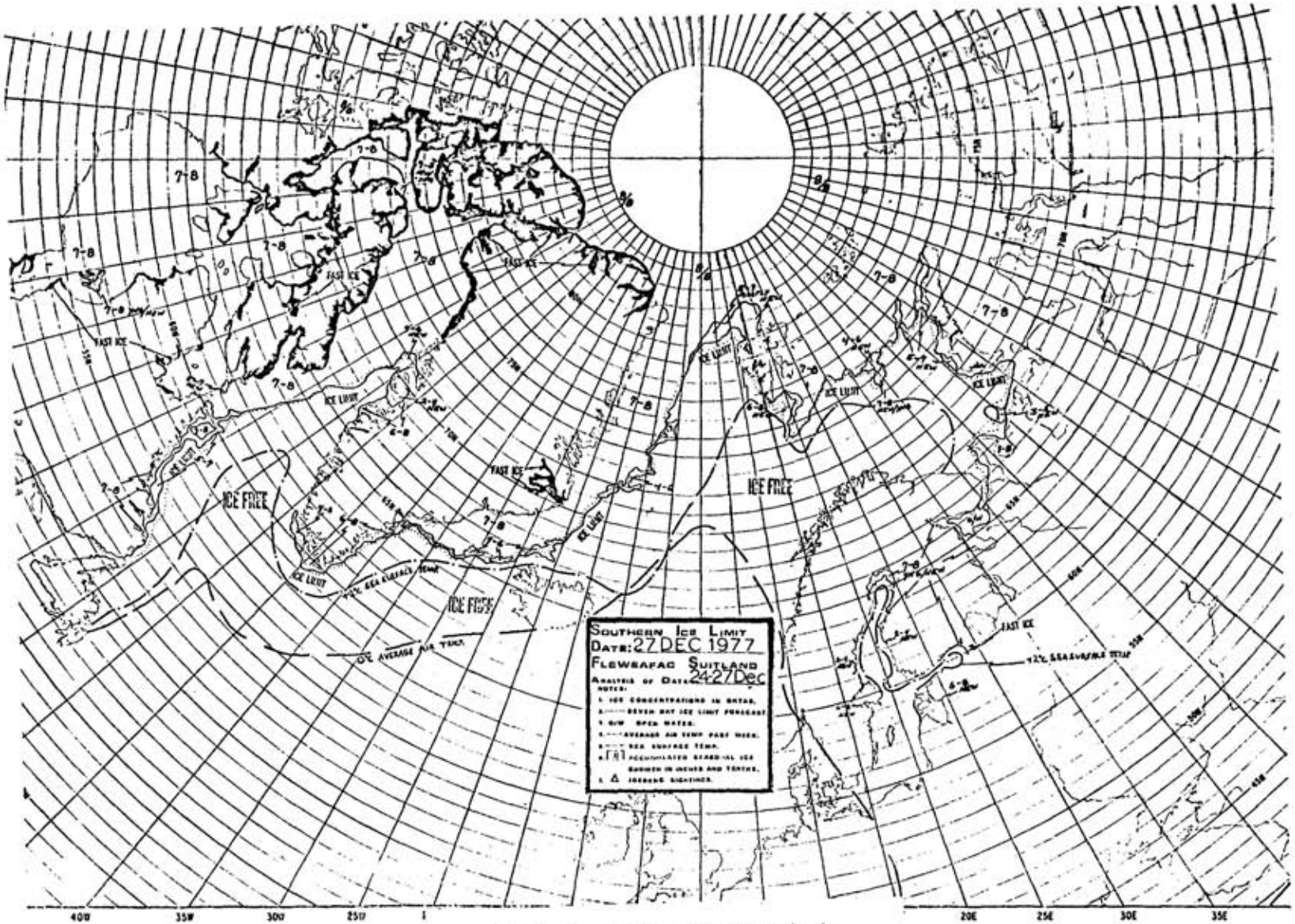

Figure 1, Eastern Arctic Analysis

Figure 2. Western Arctic Analysis

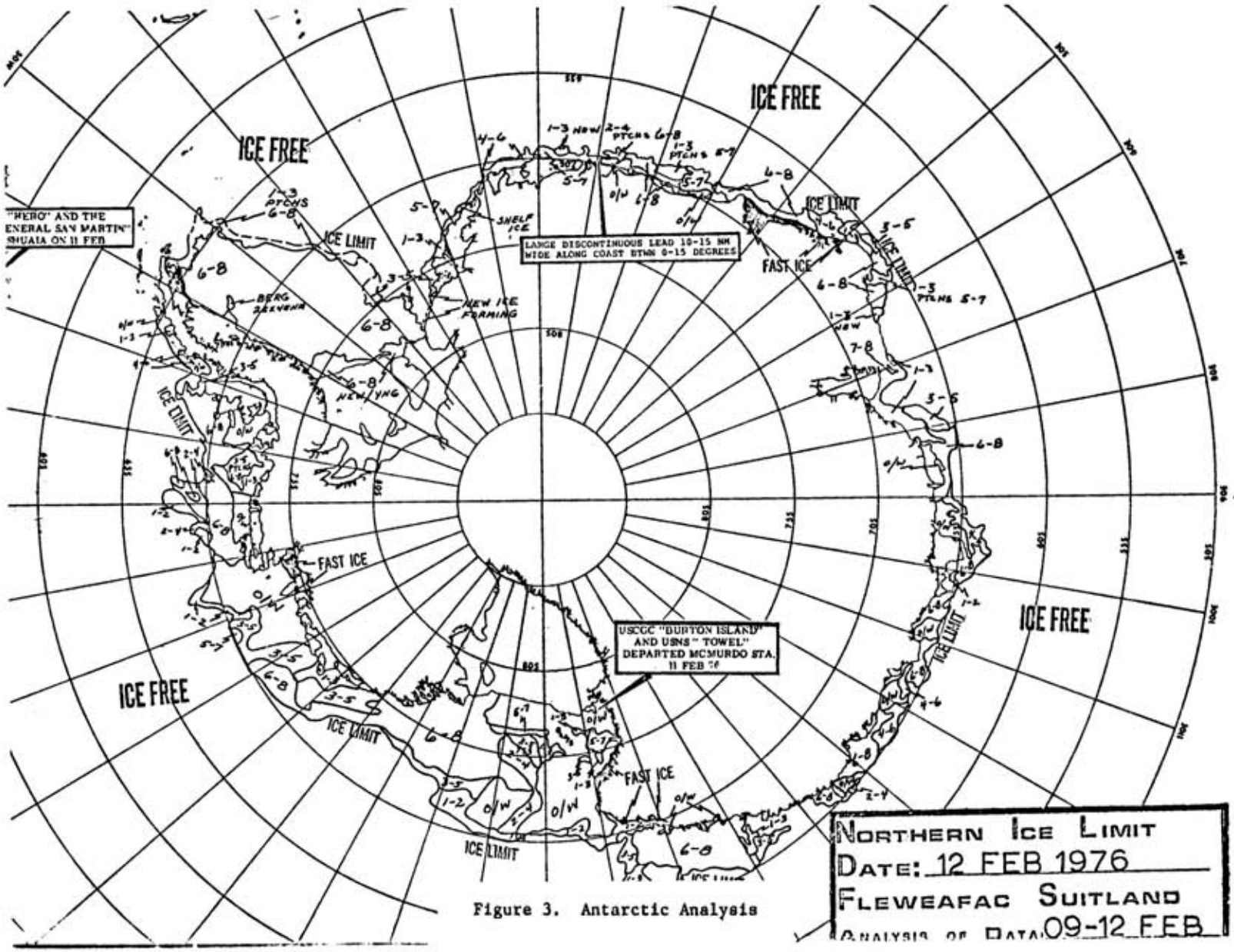

Figure 3. Antarctic Analysis

B. Availability of products

1. Formats available

a. Listings: original record sheets

b. Maps: map scales vary widely depending upon reduction procedures and individual reproduction machines for hard copy products.

c. Microform: microfiche

d. Other: facsimile, telecopier, message

2. The products currently are not digitized by Fleet Weather Facility, but they could be.

C. Use and application of products

1. The principal users are the U. S. Department of Defense and U. S. Coast Guard and numerous foreign governments.

2. The mailing list contains over 200 subscribers.

3. The principal applications of the product are planning/operational support and questions of ice transit.

The product is used internally in the routing of ships transiting ice infested waters, research, ice forecasting, and as an information service to the military and civilian communities.

II. Data Sources

A. Data sources and originating agencies

	Agency	Routine	Special
1. Satellite observations	NASA: Nimbus 5 ESMR	X	
	NOAA: NOAA 5 VHRR	X	
	DOD/USAF: DMSP	X	
	NASA: Landsat		X
2. Aircraft observations	U.S. Navy, U.S. Coast Guard	X	
	National Weather Service	X	
	Private industry	X	
	Canada, Denmark, Norway	X	
	Japan	X	
3. Ship observations	U.S. Coast Guard	X	
	Military Sealift Command	X	
	Icelandic Coast Guard	X	
	Merchant and fishing vessels	X	
	Research vessels	X	
4. Ground observations	USSR, Finland, Sweden (Baltic and Gulf of Bothnia)	X	
	Norway (Jan Mayen, Hopen, Bear Island	X	
	Greenland, Alaska, Canada	X	

5. Diagnostic aids

a. 168-hr theoretical ice drift vectors located at 207 grid point locations in the Arctic — X

b. (+) and (-) degree day accumulations and theoretical ice thicknesses at 62 Arctic stations — X

c. 15-day observed temperature trends and daily average temperatures at 62 Arctic stations X

d. FNWC sea surface and surface temperature analyses X

B. Data accuracy

1. Comparisons between aerial ice reconnaissance and satellite data were initially used to determine levels of accuracy/resolution of data.

2. For the current method of analysis, the data sources used are listed in preferential order.

Arctic

Winter/ November - March	
Preferential order of data used	% time missing data
Ice reconnaissance	>99%
*NOAA 5 VHRR	<10%
NIMBUS 5 ESMR	<10%
DMSP IR	< 5%
Summer/ April - October	
Ice reconnaissance	>99%
*NOAA 5 VHRR	< 5%
NIMBUS 5 ESMR	<10%
DMSP VIS	< 5%

Antarctic

Summer/ October - March	
Preferential order of data used	% time missing data
Ice Reconnaissance	>99%
NOAA 5 VHRR	< 5%
DMSP VIS	< 5%
NIMBUS 5 ESMR	<100%
Winter/ April - September	
Ice Reconnaissance	100%
NIMBUS 5 ESMR	<10%
DMSP IR	< 5%
*NOAA 5 VHRR	>90%

*For limited area coverage.

3. The procedures used to differentiate between:

a. Cloud and ice surfaces: (1) comparison of coincident visual and IR imagery and associated thermal differences aids in discriminating clouds from ice (2) identification of clouds through shadow discrimination on visual imagery (3) discriminate clouds by texture

b. Nilas and water: "ground truth" from aerial ice observations, shore and ship station reports

c. Open water and surface melt water: "ground truth" from aerial ice observations, shore and ship station reports

d. Different ages of ice cover: (1) "ground truth" from aerial ice observations, shore and ship station reports (2) satellites during optimum conditions can indicate multiyear/first year boundaries as well as younger stages.

4. Criteria/limitations used for the polar night cutoff are:

DMSP change to visual in Southern Hemisphere	15 October
DMSP change to IR in Southern Hemisphere	15 April
DMSP change to visual in Northern Hemisphere	15 April
DMSP change to IR in Northern Hemisphere	15 October

5. The interpreters involved have changed over time. U.S. Navy personnel are now stationed at Suitland for three to four years. Previously, rotations often exceeded five years. Beginning in 1977, a National Weather Service meteorologist augmented the analysis staff.

Table 2. Type of data/method of collection for data source(s)

Time period		Remote sensing system						Ground observation		Other types of data	Resolution of data
from	to	Sensor platform	Sensor type	Spectral region	Number of images used at one point per time interval mapped			Approximate size of sample from which means are obtained for each map			
					Average	Range		Number of observing points	Frequency		
						max.	min.				
1-72	12-74	NOAA-3	SR IR VHRR			S I M I L A R TO N O A A 5					
12-74	8-76	NOAA-4	SR IR VHRR			S I M I L A R TO N O A A 5					
7-76	3-78	NOAA-5	SR IR	0.5-0.7μm	3	7	7	n/a	n/a	Global coverage	2nm/3.7km 4nm/7.4km
7-76	present		VHRR	0.5-0.7μm 10.5-12.5μm						Remote Area Coverage 4 remote area/ day	
			VIS	0.6-0.7	3	5	1	. . . . .	. . . . .	Seasonal/weekly variations	0.5nm/.9km
			IR	10.5-12.5	3			. . . . .	. . . . .	dependent also on NESS commitments	0.5nm/.9km
										Western Arctic Eastern Arctic Great Lakes Ross Sea Antarctic Peninsula Amery Ice Shelf	

Table 2. (Cont.)

Time period		Remote sensing system						Ground observation	Other types of data (percentage of map covered, frequency of observations, etc.)	Resolution of data
from	to	Sensor platform	Sensor type	Spectral region	Number of images used at one point per time interval mapped			Approximate size of sample from which means are obtained for each map		
					Average	Range				
						max.	min.	Number of observing points / Frequency		
12-72	present	NIMBUS 5	ESMR	1.55cm	2	2	1		Global	25km
6-75	9-76	NIMBUS 6	ESMR	0.8cm	2	2	1		Global	32km
10-77	present	DMSP	HR MI	0.4-1.1μm 8.0-13.μm	3	7	7		Global	1.5nm/2.8km* 1.5nm/2.8km*

* Hemispheric mosaics utilzed have resolution of approximately 2-3nm/3.7-5.5km. The larger scale, 1:15 million, Southern Hemispheric mosaics are the most useful.

6. A change is planned in data sources. As of October 1979, use of NIMBUS 5 ESMR All Weather/Day/Night Sensor data was terminated.

7. Currently, other methods of data interpretation are being explored. No definite dates for implementation have been planned.

C. Data consistency

1. To assure consistency of interpretation among interpreters, random sampling and weekly reviews of ice analyses and products are held prior to the weekly (Friday) Command ice briefings.

2. Methods used routinely to check for consistency in:

   a. Source data: continuity checks are used for ship and station reports. Stretching of VHRR imagery is checked in gridding procedure.

   b. Interpretation: comparison is made of lower resolution satellite imagery with higher resolution data, i.e., aerial reconnaissance, shore and station reports.

3. Cross-checks among data sources are systematically made. Aerial ice reports with ship/shore station reports are cross-checked against satellite data sources.

4. Generally, analyses agree to approximately 20nm/37km between data sources. The greatest differences occur in new ice/open water and lower concentration areas. New ice often is not discernible on satellite imagery.

D. Ground data for remote sensing

1. The amount and type of ground data used to assess the following parameters are:

   a. Ice thickness: aerial observation (indirect) relates approximate ice thickness program and ship and shore station reports.

   b. Ice concentration: aerial observations, ship and shore station reports are used.

   c. Age of ice: similar to a.

   d. Presence/absence of snow cover on ice: not observed.

   e. Melt water ponds on ice: aerial reconnaissance, ship and shore station reports are used.

2. Ground truth data are utilized to "calibrate" the analyst's eye to data from satellite sensor imagery. Questionable interpretations of satellite imagery are clarified when this ground truthing, such as aerial reconnaissance is available.

E. Availability of source data

1. Data are not currently digitized, but could be.

2. Data are generally not retained at Fleet Weather Facility (see table 3). Although hard copy satellite imagery is retained, the original source of these data, i.e., NESS and NASA, should be the point of contact for acquisition. Virtually all microwave (ESMR) and VHRR imagery used since 1972 is on local file. Ice reconnaissance and other station/ship reports have been and continue to be forwarded to:

   NAVOCEANO Code 34223
   NSTL
   Bay St. Louis, Mississippi 39522.

Table 3. Availability of source data

Type of Data	Retention Period	Archive Location	Available to				Contact
			Interested scientists	A WDC data base	Upon specific request	Not available	
Numbus 5 ESMR	1973-present	F.W.F.				X	
NOAA VHRR	1972-present	F.W.F.				X	
DMSP	1977-present	F.W.F.				X	
Navy aerial ice reconnaissance satellite information							
Antarctica Arctic	1969-1975 1971-1975		X	X	X		Naval Oceanographic Office Publication 17 (NOO RP 17)
	1976		X	X	X		NOO RP 17 (76)
	1977		X	X	X		NOO RP 17 (77)
							Gabriel Potocksy Naval Oceanographic Office NSTL Station Bay St. Louis, Mississippi 39522

References

Barnett, D. G. (1976) A practical method of long range ice forecasting for the north coast of Alaska, part 1. U. S. Navy. Fleet Weather Facility, Suitland, MD. Technical Report TR-1, 16 pp.

Godin, R. H. (1979) Data sources and sea ice products of Fleet Weather Facility/ Joint Ice Center, Suitland, MD. World Data Center A for Glaciology (Snow and Ice). Glaciological Data. Report GD-5, p. 29-35.

Potocsky, G. J. (1977 and 1978) Aerial ice reconnaissance and satellite ice information microfilm file - 1976/1977. U. S. Naval Oceanographic Office. Reference Publication NOO RP 17(76) and NOO RP 17(77).

Antarctic Ice Analyses 1973-1974. NTIS: AD-A 028 256.

Antarctic Ice Analyses 1975-1976. NTIS: AD-A 043 354.

Eastern Arctic Sea Ice Analyses 1972-1975. NTIS: AD-A 033 344.

Eastern-Western Sea Ice Analyses 1976. NTIS: AD-A 043 353.

Eastern-Western Sea Ice Analyses 1977. NTIS: AD-A 056 784.

Western Arctic Sea Ice Analyses 1972-1975. NTIS: AD-A 033 345.

Sea Ice Information from Satellite Derived Microwave Data

Source: U. S. National Aeronautics and Space Administration (NASA)

Contact: National Space Science Data Center
Goddard Space Flight Center
Code 601
Greenbelt, Maryland 20771 U.S.A.

I. Products

A. Description of products

NASA produce 3-day average maps of Northern and Southern Hemisphere brightness temperatures. The maps cover the area between the pole and 50° latitude, at about 50km resolution. They can be used to infer sea ice limits. For Antarctica, maps of sea ice concentration are also produced. Monthly averages of both the sea ice extent and the ice concentration maps have been prepared. Maps are available in the form of digital tape, dicomed color image tapes, 8 by 10 inch prints, color slides, and positive and negative film. The derived parameters available from the microwave data are summarized in tables 1 and 2 (Posey, 1978).

B. Availability of products

The 3-day average brightness charts and the monthly means are available from the National Space Data Center. The ice concentration maps for 1973-76 are being compiled for future publication in atlas form.

Requests from non-U.S. researchers should be addressed specifically to the Director, World Data Center-A for Rockets and Satellites at the above address.

II. Data Sources

A. Data sources and originating agencies

NASA: Electrically Scanning Microwave Radiometer (ESMR), on board the Nimbus-5 and Nimbus-6 satellites. Processed on a 293 by 293 grid, the original data resolution is 25km at nadir and 30 by 40km at 30.5° from nadir. Information on the ESMR instrument characteristics are summarized in table 3 (Posey, 1978).

NASA: Scanning Multichannel Microwave Radiometer (SMMR). Launched on Nimbus-7, this produces a multispectral passive microwave image. The parameter retrieval algorithms are still being developed and no data are available at this time. The instrument characteristics are summarized in table 4, and the derived parameters that are anticipated, in table 5 (Posey, 1978).

B. Availability of source data

The basic data are the 3-day average brightness temperature charts, referred to above, which are available from the National Space Science Data Center.

Table 1. ESMR instrument characteristics

	ESMR-5	ESMR-6
Nadir angle	Scans perpendicular to velocity vector	40°
Scan range	± 50°	± 35°
Earth incidence angle	Variable	~ 50°
Center frequency	19.35 GHz (1.55cm)	37.0 GHz (0.81cm)
Polarization	Horizontal	Horizontal and vertical
Bandwidth	250 MHz	250 MHz
Scan period	4 seconds	5 1/3 seconds
Samples per scan	78	71
Field of View (FOV)	25km by 25km at nadir, degrading to 40km cross-track by 30km downtrack at ± 30.5° and to 160km by 45km at scan extremes	Elliptical, approximately, parallel to satellite track, 20km crosstrack by 45 km downtrack
Swath width	Approximately 3000km (only 1360 km, ± 30.5° swath used, except near poles)	1270km
Raw data rate	200 bits per second	300 bits per second

Due to temperature calibration problems, no routine parameter extraction from the ESMR-6 data is being performed.

The accuracy, resolution, and coverage of the ESMR-5 and ESMR-6 parameter products are listed in tables 2 and 3.

Table 2. Derived snow and ice parameters - ESMR-5

Parameter	Medium	Accuracy	Spatial Resolution	Temporal Resolution	Coverage (after data fully processed)
Sea ice boundary maps (average brightness temperature) in °K	Digital tapes, Dicomed color image tapes, Dicomed color prints, Color slides, positive and negative film (Contour plots planned for the future)	Boundary position accurate to 50km	30km	3, 9, 27 days, 1 year	3-day, 9-day, 27-day, 1 year maps for approximately 85 percent of the time from 12/72 to 5/77 except for the following periods: March-May 1973 June-August 1975. Maps extend from 50° latitude to the poles and have negligible gaps (<5%) on the average.
Sea ice concentration (percent coverage)	Digital tapes Printout	10-15 percent	30km	3, 27 days; possibly 9 days and 1 year	Will produce concentration maps from existing sea ice boundary (average brightness temperature) maps in near future; will run 27-day and 3-day maps for 12/72-5/77.

Table 3. Derived snow and ice parameters - ESMR-6

Parameter	Medium	Accuracy	Spatial Resolution	Temporal Resolution	Coverage
Sea ice boundary maps (average brightness temperature in °K, horizontal and vertical channels mapped separately)	Same as ESMR-5	Boundary position to 50km	30km	3 days	36 3-day time periods processed from 8/75 to 7/76 (28 N. Pole, 8 S. Pole). Plans to process 24 3-day time periods from 7/75 to 7/77 (mid-month).
GARP sea ice maps (percent coverage)	Digital tapes		2-1/2° by 2-1/2°	1 week	Weekly average maps for January to February, 1976, and mid-August to mid-October, 1976. Maps extend from 50° to 85° latitude (N & S).
Soil moisture Polar ice Winds over oceans Rain over land	Snow cover and depth Snow water equivalent Atmospheric liquid water and water vapor		Research and development only		

Table 4. SMMR instrument characteristics

Nadir angle	42°
Scan-range	± 25°
Earth incidence angle	50.3°
Antenna aperture	79cm
Dynamic range	10-330° K
Absolute temperature accuracy	2° K
RF bandwidth	250 MHz
Scan period	4.096 seconds
Swath width	778km
Data rate	2 Kbits per second

Table 5. SMMR sampling characteristics

Frequency (GHz)	6.60	10.69	18.00	21.00	37.00
Wavelength (cm)	4.6	2.8	1.7	1.4	0.8
FOV (km)	144 by 92	88 by 57	53 by 40	45 by 29	26 by 17
Samples per full scan	30	60	60	60	240
	(15 vertical for right scan, 30 horizontal for left scan)	(30 vertical for right scan, 30 horizontal for left scan)			(60 vertical and 60 horizontal for both right and left scans)

Table 6. SMMR derived snow and ice parameters

	Level II Spatial Resolution	Level III Spatial Resolution	Level III Temporal Resolution	Date Algorithm Available	Expected Accuracy
Sea Ice Parameters					
Sea ice concentration (%)	30km + 60km	25km	3 & 30 days	Launch	2-10%
Sea ice surface temperature (°K)	156km	150km	3 & 30 days	*Launch	2° K
Multiyear ice fraction (%)	60km	50km	3 days	*Launch	10% (add.)
Thin first year ice fractions (%)	60km	50km	3 days	*Launch	10% (add.)
Land Snow Parameters					
Snow layer water equivalent	60km	50km	3 & 30 days	Unknown	-
Dry snow (yes/no)	60km	50km	3 days	Launch	$\leq$ 90% (depends on terrain)
Snow subsurface temperature (°K)	156km	150km	3 & 30 days	Unknown	-
Snow surface temperature (°K)	156km	150km	3 days	Unknown	-
Ice Sheet Parameters					
Ice sheet surface temperatures (°K)	60km	50km	3 & 30 days	Unknown	-
Snow subsurface temperature (°K)	156km	150km	3 & 30 days	Unknown	-
1.7cm $a_1T_v + b_1T_H$ (°K)	60km	50km	3 days	Ready	Exact
2.5cm $a_2T_v + b_2T_H$ (°K)	97.5km	100km	3 days	Ready	Exact

*By-product of improving accuracy of sea ice concentration model; availability date uncertain

References

Gloersen, P. et al. (1973) Microwave signatures of first-year and multi-year sea ice. Journal of Geophysical Research, v. 79(18), p. 3564-3572.

Gloersen, P. et al. (1976) Microwave maps of the polar ice on the Earth. American Meteorological Society, Bulletin, v. 55(12), p. 1442-1448.

Gloersen, P.; Salomonson, V.V. (1975) Satellites - new global observing techniques for ice and snow. Journal of Glaciology, v. 15(73), p. 373-389.

Gloersen, P.; Barath, F.T. (1977) A scanning multi-channel microwave radiometer for Nimbus-G and SEASAT-A. IEEE Journal of Oceanic Engineering, v. OE-2(2), p. 172-178.

Madrid, C.R., ed. (1978) The Nimbus-7 user's guide. U. S. National Aeronautics and Space Administration. Goddard Space Flight Center, p. 213-246.

Posey, K. (1978) Candidate NASA Data Sets Applicable to the Climate Program. Unpublished report. U.S. National Aeronautics and Space Administration. Goddard Space Flight Center.

Wilheit, T.T. (1972) The Electronically Scanning Microwave Radiometer (ESMR). (In: The Nimbus-5 Users Guide. U. S. Government Printing Office, p. 59-104.)

Wilheit, T.T. (1973) ESMR corrections to the user's guide. (In: Nimbus-5 Data Catalog, v. 3. Greenbelt, Maryland, Goddard Space Flight Center.)

Zwally, H.J. et al. (1976) Characteristics of Antarctic sea ice as determined by satellite-borne microwave imagers. (In: Symposium on Meteorological Observations from Space: Their Contribution to the First GARP Experiment, 1976.) Boulder, Colorado, National Center for Atmospheric Research, p. 94-97.

Zwally, H.J. (1977) Microwave emissivity and accumulation rate of polar firn. Journal of Glaciology v. 18(79), p. 195-216.

Zwally, H.J.; Gloersen, P. (1977) Passive microwave images of the Polar regions and research applications. Polar Record v. 18(116), p. 431-450.

Composite Minimum Brightness and Composite Maximum Temperature Images

Source: U.S. National Oceanic and Atmospheric Administration/National Environmental Satellite Service (NOAA/NESS)

Contact: Dr. E. Paul McClain
U.S. Department of Commerce
NOAA/NESS/S33
World Weather Building Rm. 810
Washington, D.C. 20233 U.S.A.
(301) 763-8036

I. Products

A. Description of products

Satellite multi-day composite images, composite minimum brightness (CMB) and composite maximum temperature (CMT), are produced for the Northern and Southern Hemispheres (Polar sectors) at a scale of 1:110,000,000 on a polar stereographic projection. These have been done since 1974. CMB images are available from 1968. For a list of products and product accuracy and resolution see table 1. Beginning in 1979, the North Polar sector was replaced by a Northern Hemispheric sector, covering a much enlarged area. The new composite will cover a 7-day period and will be updated daily, i.e., the product will be an overlapping 7-day composite. Visible and IR images for both hemispheres are archived on a single negative (25.4 by 25.4 cm).

B. Availability of products

Products are retained indefinitely at the Satellite Data Services Division, World Weather Building, Rm. 810. The cost is $3.25 each.

Contact: Eugene Hoppe
Satellite Data Services Branch
NOAA/National Climatic Center
World Weather Building, Room 606
Washington, D.C. 20233 U.S.A.

C. Use and application of products

Principal users are the U.S. Navy, operational backup at the Fleet Weather Facility, Suitland; and for research, G. Wendler (Geophysical Institute, University of Alaska); W. F. Budd (Arctic Division, Department of Science, Australia); A. L. Gordon (Lamont-Doherty Geological Observatory, Columbia University). The product is also used internally as an operational backup for the Northern Hemisphere Weekly Snow and Ice Boundary Chart as well as for research, particularly that related to climate.

Table 1. Description of product

Time period		Time interval between successive products	Smallest homogenous area that your mapping/digitizing system resolves		Consistency between maps in the identification of the minimum resolvable areas								How consistent between maps is the accuracy of the boundaries			
					under worst conditions				under typical conditions							
from	to		under worst conditions	under typical conditions	poor	fair	good	excellent	poor	fair	good	excellent	poor	fair	good	excellent
CMB 11/20/68	12/14/70	5 days	110 km	55 km		X					X				X	
CMB 2/3/71	11/6/72	5 days	110 km	55 km		X				X				X		
CMB/ CMT 12/1/74	3/19/78	10 days	110 km	55 km							X				X	
CMB/ CMT 1/1/79		7 days	110 km	55 km		?				?					?	

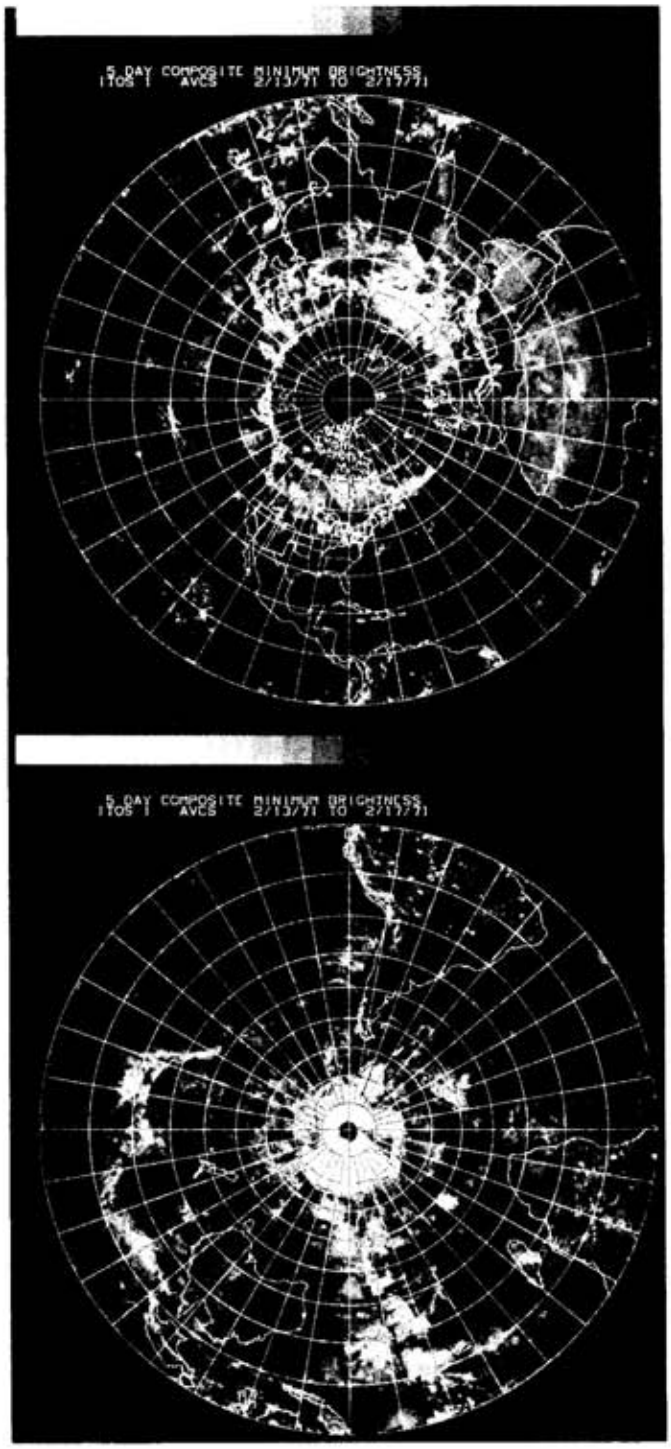

Figure 1. Northern and Southern Hemisphere Composite Minimum Brightness (CMB) images for the compositing period 13-17 February 1971.

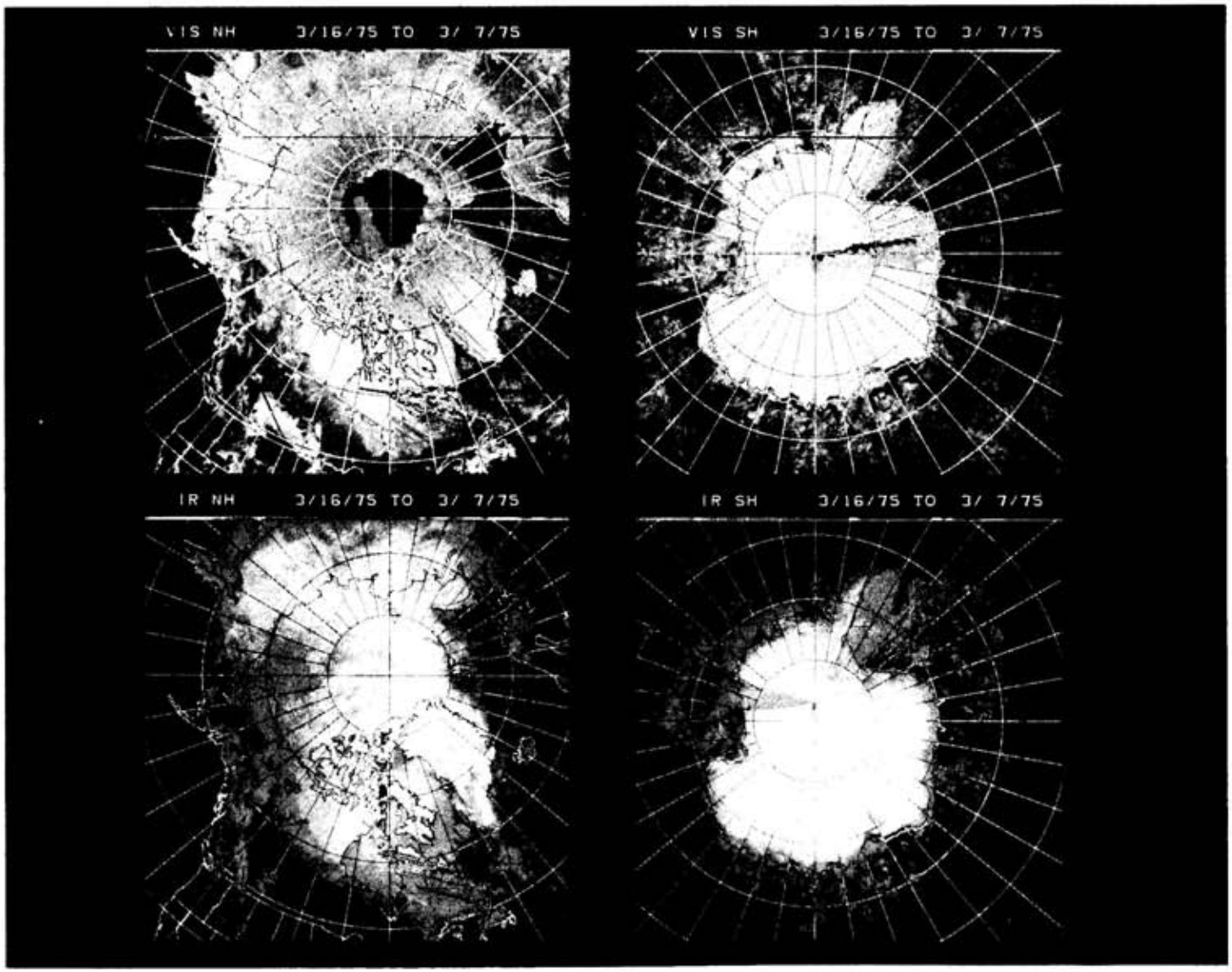

Figure 2. North and South Polar (CMB/CMT) sectors for the compositing period 7-16 March 1975.

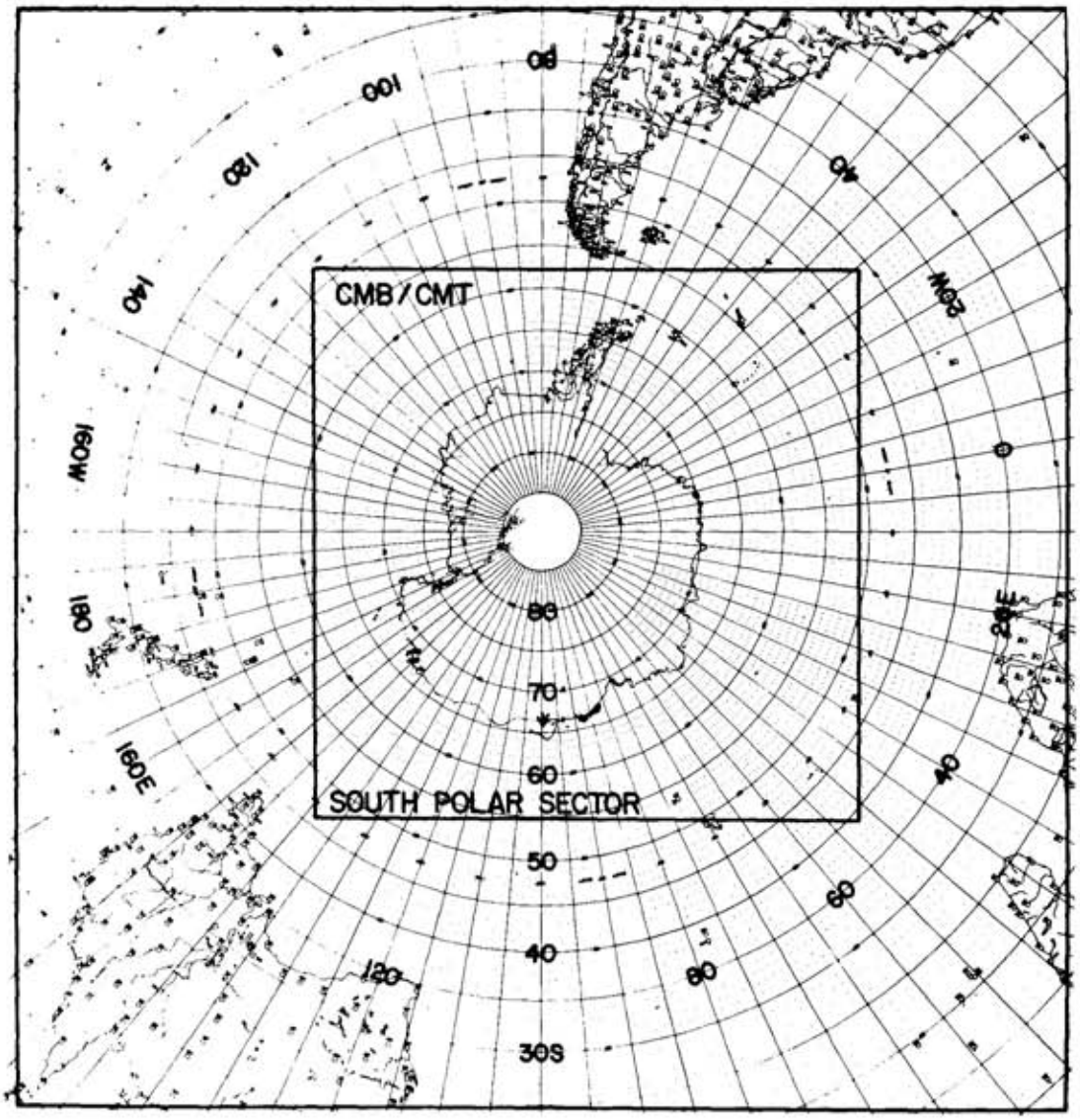

Figure 3. Geographic coverage of the South Polar sector CMB/CMT images from 1974 onwards.

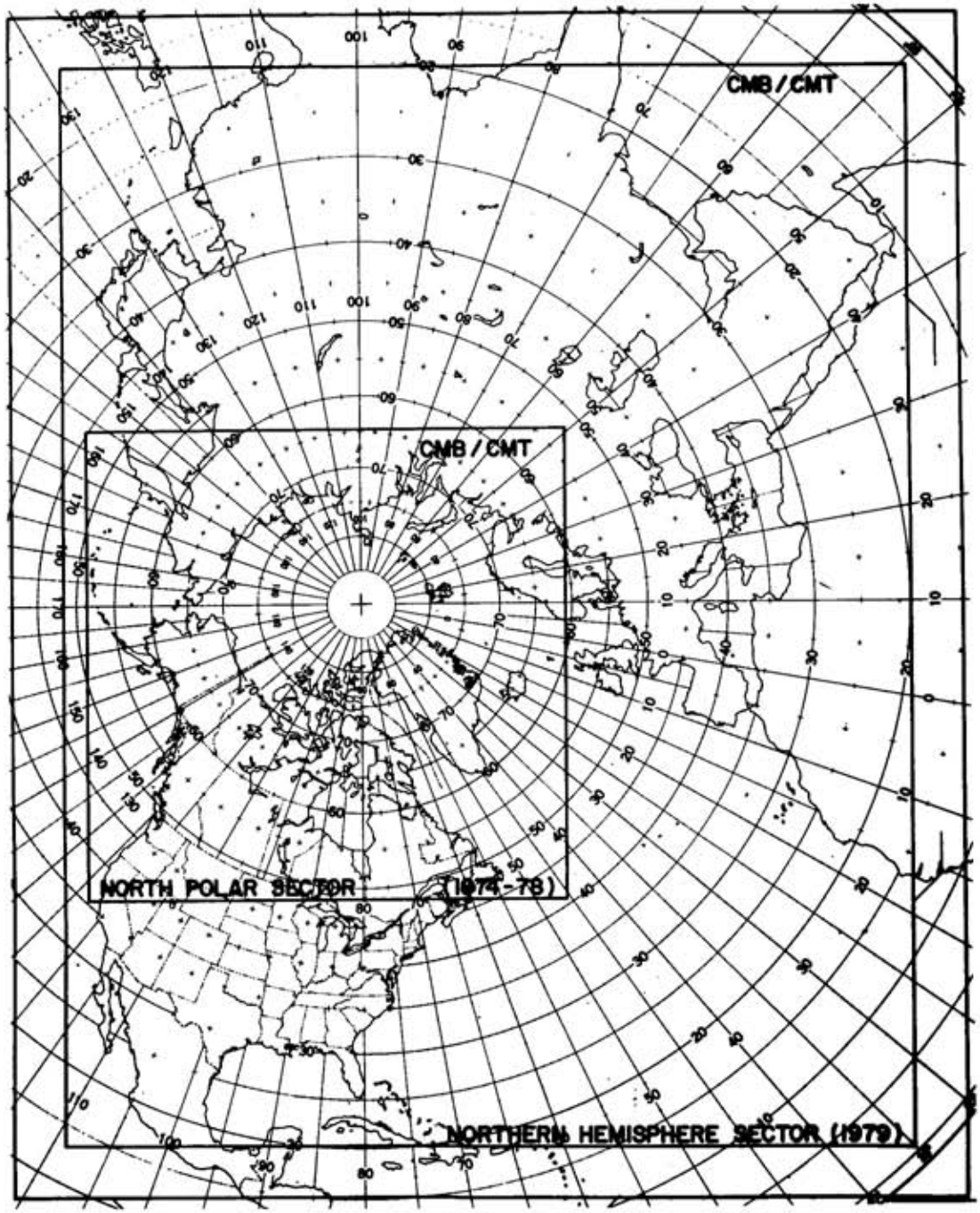

Figure 4. Geographic coverage of the North Polar sector.

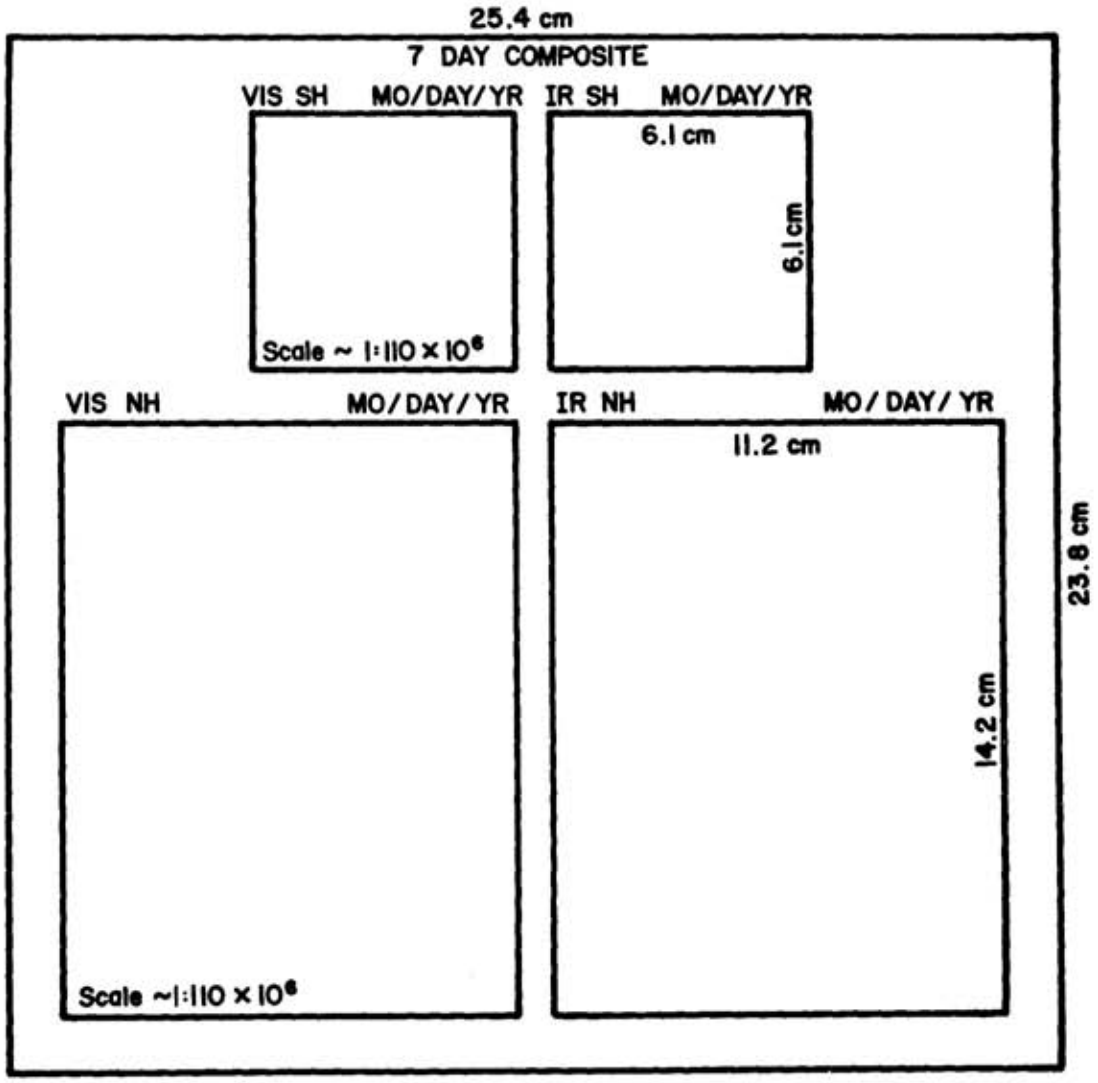

Figure 5. The archive negative format for the Northern Hemisphere.

II. Data Sources

A. Data sources and originating agencies

NOAA/NESS: Data used are digitized visible and thermal IR data from polar orbiting satellites.

B. Data accuracy

1. The percentage time of missing data is less than 5% during the indicated time periods in table 2, but there are some large time gaps.

2. Initial levels of accuracy/resolution of data, i.e., acceptance tests of the system are described in McClain and Baker (1969).

3. Use of minimum brightness (visible) and/or maximum temperature over 5 to 10-day compositing periods eliminates or suppresses all but the most persistent cloudiness.

4. There is no polar night cut-off for thermal data but images based on visibl data are limited to areas of adequate solar illumination. Maximum cut-off is at 52° latitude.

C. Data consistency

Data sources are occasionally cross-checked with NESS's Northern Hemisphere Weekly Snow and Ice Boundary Charts. The consistency in source data is checkec by visual inspection of images. Consistency checks are generally satisfactory.

D. Availability of source data

Products are available on 35mm microfilm and as paper prints from the 25.4cm archived negative.

Table 2. Type of data/method of collection for data source(s)

Time period		Remote sensing system				Resolution of data
from	to	Sensor platform	Sensor type	Spectral region µm	Other types of data	
11/69	12/70		AVCS(1)	visible	5-day compositing period	55km^2
2/71	11/72		AVCS	visible	5-day compositing period	55km^2
12/74	3/78	NOAA-3, 4, 5	SR(2)	0.5-0.7 10.5-12.5	10-day compositing period	55km^2
1/79	-	TIROS-N	AVHRR(3)	0.55-0.90 0.725-1.0 3.55-3.93 10.5-11.5	7-day compositing period	55km^2

(1) Advanced Vidicon Camera System
(2) Scanning Radiometer
(3) Advanced Very High Resolution Radiometer

References

McClain, E.P.; Baker, D.R. (1969) Experimental large-scale snow and ice mapping with composite minimum brightness charts. ESSA Technical Memorandum NESCTM 12. Washington, D.C., U. S. Dept. of Commerce, 19 p.

McClain, E.P. (1970) Quantitative use of satellite vidicon data for delimiting sea ice conditions. Arctic, v. 26, p. 44-57.

McClain, E.P. (1974) Some new satellite measurements and their application to sea ice analysis in the Arctic and Antarctic. (In: Advanced Concepts and Techniques in the Study of Snow and Ice Resources, Proceedings of a Symposium held 2-6 December 1973, Monterey, California.) Washington, D.C., National Academy of Sciences, p. 457-466.

McClain, E.P. (1978) Sea ice observations by NOAA's National Environmental Satellite Service. World Data Center-A for Glaciology (Snow and Ice), Glaciological Data, Report GD-2, p. 33-42.

McClain, E.P. (in press) A note on the form and availability of satellite multi-day composite images. Glaciological Data. This issue, p.

A Note on the Form and Availability of Satellite Multi-Day Composite Images

E. Paul McClain
National Environmental Satellite Service, NOAA
Washington, D.C., U.S.A.

Composite Minimum Brightness (CMB) and Composite Maximum Temperature (CMT) images have been generated from Earth satellite data for a period of about ten years. This is being done on an experimental basis as an aid to research into large-scale snow and ice mapping (Dismachek, 1977; McClain, 1973 and 1978). Since the coverage, format, and compositing period have changed over the years, and because there are gaps in the series as well, the purpose of this note is to provide information on these changes in order to aid a potential user of this information source. Table 1 lists the periods of availability and other information on the various types of composite images that are available.

Figure 1 is a sample Southern Hemisphere 5-day CMB from the 1968-70 period.This is an enlargement made from the 35mm archive negative roll which also contains a number of multi-day composites. Figure 2 is a sample of Northern and Southern Hemisphere 5-day CMB's from the period 1971-72. This is a contact print from the 25.4cm archive negative, which also contains 5-day average brightness images for the two hemispheres. Finally, figure 3 is a sample of 10-day North and South Polar CMB/CMT sectors from the 1974-78 period.

The geographic coverage of the composite images for the South Polar sector from 1974 to 1978, which is expected to continue with TIROS-N, is shown in figure 4. As seen in table 1, the latest time gap began in March of 1978 when the Scanning Radiometer on NOAA-5 failed. Composite images produced from the Advanced Very High Resolution Radiometer on TIROS-N began early in 1979. Figure 5 enables comparison of the corresponding CMB/CMT image coverages of the North Polar sector, for the period 1974-78 and the new enlarged Northern Hemisphere sector, beginning with TIROS-N. The format of the 10-inch archive negative for the new combined Northern Hemisphere and South Polar CMB/CMT sectors is illustrated in figure 6. The format of the 25.4 cm archive negative used between 1974 and 1978 differs from this new format in that the North and South Polar CMB and CMT sectors were all the same image size.

All composite images are archived in negative form by NOAA and are available through the group listed below:

Satellite Data Services Branch
NOAA/National Climatic Center
World Weather Building, Room 606
Washington, D.C. 20233, U.S.A.

Telephone: (301) 763-8111

Table 1. Availability of satellite composite images

Type	Dates	Area	Compositing Period	Frequency	Archive Medium
CMB	20 November 1968 to 14 December 1970	Northern and Southern Hemisphere	5 days*	5-day*	35mm negative*
CMB	3 February 1970 to 6 November 1972	Northern and Southern Hemisphere	5 days	5-day	25.4cm negative
CMB/CMT	1 December 1974 to 15 March 1978	North and South Polar Sectors	10 days	daily	25.4cm negative
CMB/CMT	1 January 1979 to date	Northern Hemisphere and South Polar sectors	7 days	daily	25.4cm negative

*Five-day, and a few ten-day, so-called "augmented resolution" composites were produced during the period from November 1969 through June 1970, and these are archived as 25.4cm negatives.

Snow Cover Analysis, Northern and Southern Hemispheres

Source: U.S. Air Force Global Weather Central (AFGWC)

Contact: Major R.C. Woronicz
U.S. Air Force Global Weather Central
Offut Air Force Base
Nebraska 68113
(308) 294-3477

I. Products

A. Description of products

AFGWC produces Northern and Southern Hemisphere snow cover analyses for 1975 to present. The smallest homogeneous area mapped is 37 by 37km, and the plotted boundaries are accurate to within 37km. The consistency in the identification of the minimum resolvable area between maps is fair under worst conditions and good under typical conditions. Consistency in terms of the accuracy of plotted boundaries is fair.

Maps are plotted on a gridded data base with a polar stereographic projection true at 60°. The product is digitized and is available on computer listings and tape.

Snow depth is given in tenths of inches to a maximum depth of about 100 inches (250cm). Daily snow cover is modeled on a 1/8 mesh grid system (25nmi{46.3km} between grid points at 60° latitude).

B. Availability of products

Snow cover analyses are retained indefinitely at the National Climatic Center in Asheville, North Carolina, and are available on request.

II. Data Sources

A. Data sources and originating agencies

1. AFGWC: DMSP satellite imagery, video sensor in the .4μm to 1.2μm band, with 23km resolution. At any one point, 64 images are obtained over the time interval mapped.

2. AFGWC: global data base (ground observations) with 5500 observation points in the Northern Hemisphere and 2200 points in the Southern Hemisphere. There are 4 observations per day, with variable resolution.

3. Fleet Weather Facility

B. Data accuracy

1. Preferential order of data used: surface observations, climatology, satellite, ice fields.

2. The procedures used to differentiate between:

   a. Cloud and snow surfaces: areas of clear skies and no snow cover are determined in the automated processing of the DMSP video data (3-dimensional nephanalysis program).

   b. Different ages of snow cover: distinguished mainly by surface observations. If the snow depth increases by more than one inch over 24 hours, the snow age is reset to zero.

   c. Snow thickness: climatological data on snow depth.

C. Data consistency

Manual quality control is carried out daily.

1. Gross error checks are made with snow analysis from the previous day and interpretation is checked by using satellite imagery. The analysis is derived from surface observations and climatology and is cross-checked with a no-snow flag from the processing of the video DMSP data.

2. There are plans to use a quantitative precipitation forecast (QPF) and high resolution temperature fields to determine snowfall at grid points not influenced by surface observations.

3. Subject to planned evaluation, a snow/cloud discriminator sensor on a future DMSP platform may be utilized. The spectral interval will be 1.46μm-1.6μm.

D. Availability of source data

Data are on tape files, 7 track, 800 bpi.

Reference

Luces, S.A.; Hall, S.J.; Martens, J.D. (1975). The Air Force Snow Cover Analysis Model. U.S. Air Force. Global Weather Central. Technical Memorandum 75-1. NTIS: AD-A017 942.

Northern Hemisphere Snow and Ice Conditions

Source: British Meteorological Office, Sea Ice Unit

Contact: R.M. Rowland
Sea Ice Unit, Room R215
Meteorological Office
London Road
Bracknell, Berkshire
U.K.

I. Products

A. Description of products

Ice and snow charts are produced for the Northern Hemisphere on a polar stereographic or BDTU projection at various scales. See tables 1 and 2.

1. Charted features

a. Ice

<table>
<tr><td>classes of ice concentration</td><td>classes of age and type of ice</td><td>classes of ice thickness</td></tr>
<tr><td><1 tenth
1-3 tenths
4-6 tenths
7-10 tenths
Landfast (10 tenths)
New ice (1-10 tenths)</td><td>new
young
first year
second year
multiyear</td><td>in cm from station observations</td></tr>
<tr><td colspan="3">(on occasions Nilas or pancake is reported from land station, ship or aircraft reconnaissance)</td></tr>
<tr><td colspan="2">classes of average size of floes</td><td>classes of ridging</td></tr>
<tr><td colspan="2" rowspan="2">small (20-100m)
medium (100-500m)
big (500-2000m)
vast (2-10km)
giant (>10km)</td><td>Ridged or not ridged</td></tr>
<tr><td>classes of melt features</td></tr>
<tr><td colspan="2"></td><td>occasional reports of rotten, flooded or puddled ice are received from land stations and/or aircraft reconnaissance</td></tr>
<tr><td colspan="3">other features mapped

information on ice of land origin is plotted from objective reports supplemented by climatological averages.</td></tr>
</table>

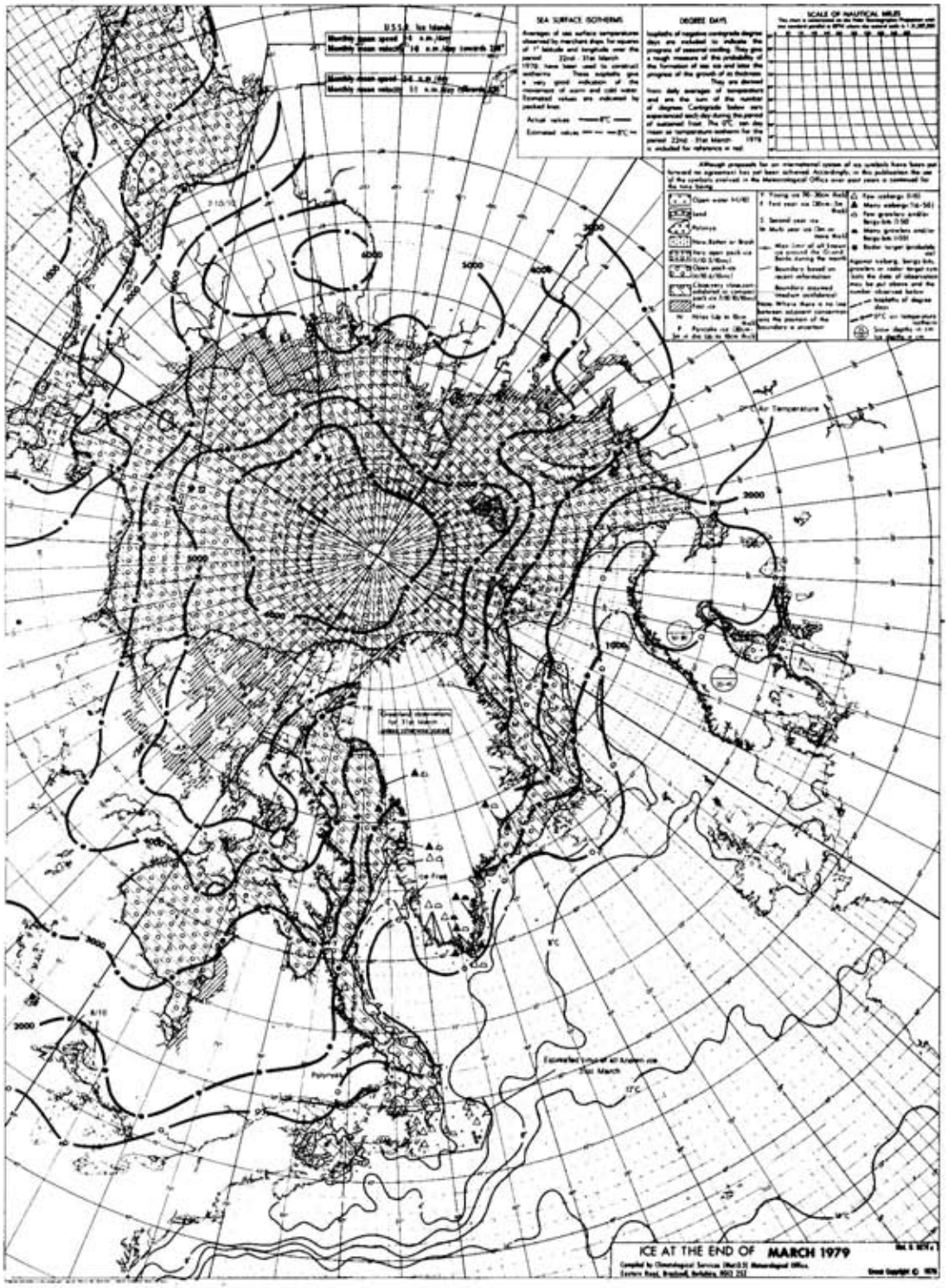

Figure 1. Meteorological Office chart of ice at the end of March 1979.

Table 1. United Kingdom Meteorological Office - sea ice data

Chart archives

Frequency	Period	Chart area	Scale	Content
Monthly (at the end of each month)	January 1960 - December 1961	Maps were prepared on a research and development basis for varying areas of the North Atlantic and adjacent seas		
	January 1962 - December 1964	47N 130W-60N 125E 35N 55W-45N 20E	1:22M	Sea ice, icebergs sea isotherms, degree days
	January 1965 - December 1967	53N 160W-60N 100E 35N 65W-35N 5W	1:22M	Sea ice, icebergs sea isotherms, degree days
	January 1968 - to date	45N 155W-40N 80E 35N 85W-30N 15W	1:21M	Sea ice, icebergs. sea isotherms, degree days
10-day	January 1962 - December 1964	47N 130W-60N 125E 35N 55W-45N 20E	1:10M	Sea ice, icebergs, sea isotherms, degree days
	January 1965 - February 1970	53N 160W-60N 100E 35N 65W-35N 5W	1:10M	Sea ice, icebergs sea isotherms, degree days
Daily (Monday, Wednesday, Friday)	January 1966 - January 1968	55N 95W-67N 13E 30N 65W-34N 24W	1:10M	Sea ice Icebergs
Daily (Tuesday, Thursday, Saturday)	January 1966 - January 1968	One chart for the following three areas 48N 95W-53N 69W 40N 87W-43N 68W 53N 67W-53N 41W 45N 67W-45N 45W 73N 40E-66N 52E 55N 8E-53N 19E	1:6M	Sea ice Icebergs
Daily (Wednesday, Sunday)		61N 168W-55N 90E 61N 81W-55N 20E	1:10M	Sea ice Icebergs
Daily	February 1969 - to date	57N 96W-71N 71E 38N 48W-54N 20E	1:10M	Sea ice Icebergs

Table 1. United Kingdom Meteorological Office - sea ice data (continued)

Computer archives

Frequency	Period	Chart area	Scale	Content
Monthly (at the end of each month)	March 1966 - February 1976	45N 155W-40N 80E 35N 85W-30N 15W	1:21M	Grid point concentrations of sea ice (1° lat. by 2° long.) for 1-3 tenths, 4-6 tenths, and 7-10 tenths.

Tabulated Data - Sea Ice Index (nmi^2)

Monthly (at the end of each month)	January 1966 - December 1977	80°W through Greenwich meridian to 140° E	1:21M	Area concentrations for 7-10 tenths and "all known ice" derived from equal areas of 10,000 nmi^2/18520km^2. By zonal bands ≃ 1.5° lat. and to a maximum of 40° long.

Table 2. United Kingdom Meteorological Office - snow cover data

Chart archives

Frequency	Period	Chart area	Scale	Content
5-day	1953 - 1961	70N 00E-70N 30E 40N 00E-70N 30E	1:30M	World Meteorological Organization (WMO) station snow depths (mm)
Semimonthly	1962 - 1970	30N 130W-30N 130E 30N 50W-20N 60E	1:30M	WMO station snow depths (mm) (excluding WMO blocks 41-59)
5-day	1971 - to date	30N 130W-30N 130E 30N 50W-20N 60E	1:30M	WMO station snow depths (mm) (excluding WMO blocks 41-59)
6-day	1975 - to date (temperature ceased March 1978)	40N 10W-40N 170W 20N 50E-20N 130W	1:20M	Snow cover analysis by visual satellite using minimum brightness

For the sea ice charts, there are also 10-day mean surface pressure maps, produced every 2 days, and daily positive and negative degree day totals.

b. Snow

reflectivity	snow depth classes
presence or absence of full cover	In cm: <2, <5 <10, <15 <25, <50 <100, <200 >200

Snow charts also describe the state of the ground adjacent to the snow edge, i.e., more than 50 percent snow cover, frost covered ground, moist, wet, or dry ground. Also shown are anomalous areas of snow cover, derived from 10-year mean snow lines for December, January, February, and March, and a 50 percent probability line for the September, October, November, and April snow lines.

A minimum brightness method is subjectively used to differentiate cloud from snow over 6-day runs of visible images.

NOAA 4 data were first used in 1975. NOAA 5 was used until March 1978. From September 1978, AFGWC satellite visible facsimile pictures have been used. Tiros "N" will be used when available.

2. Satellite charts have been compared with ground plots as well as with NOAA satellite chart production. The comparison was favorable.

B. Availability of products

1. Formats available

   a. Listings: original record sheets and computer lists

   b. Tape files: 7/9 track tape, 800 or 1600 bpi

   c. Maps: monthly sea ice maps are available on paper, 46 by 34cm on a scale of 1:21,597,000. Daily maps are available on paper, 63 by 54cm on a scale of 1:10,000,000.

2. Currently, only the sea ice normals are digitized, but other data sets could be.

C. Use and application of products

1. The products are used for forecasting by the U.K. Long Range Forecasting Unit; for research, by the University of East Anglia; for transport questions, by the U.K. Ship Routing Service.

2. Daily ice maps are distributed to about 50 agencies.

3. Monthly maps are distributed to about 60 agencies.

II. Data Sources

A. Data sources and originating agencies

		Agency	Routine	Special
1.	Satellite observations	U.S. Navy: Fleet Weather Facility, Suitland	X	
		U.S. - NOAA/NESS	X	
		Norway	X	
		Canada - Ice Central, Ottawa	X	
2.	Aircraft observations	Greenland		X
		Canada		X
		U.S. Navy flights originating at Keflavik		X
3.	Ship observations	Telecommunications	X	X
4.	Ground observations	Greenland	X	
		Shore stations bordering the Baltic Sea	X	
5.	In the critical season, use is made of radiofax charts transmitted by Sweden and Finland.			

B. Data consistency

Data consistency is considered adequate for areas west of Greenland, but poor east of Greenland, and in the Barents and Kara Seas.

C. Availability of source data

In general, the sea ice products are based primarily on information derived from international agencies, particularly Ice Central, Ottawa, Canada, and the U.S. Navy Fleet Weather Facility, Suitland, Maryland.

Reference

Tunnell, G.A. (1968) Synoptic ice maps of the Meteorological Office. Institute of Navigation. Journal, v. 21(4), p. 439-447.

Northern Hemisphere Snow and Ice Boundary Charts and Monthly Mean Snow Cover Chart

Source: U. S. National Oceanic and Atmospheric Administration/National Environmental Satellite Service

Contact: Mr. M. Matson
U.S. Department of Commerce
NOAA/NESS
World Weather Building, Room 810
Washington, D.C. 20223
(301) 763-8036

I. Products

A. Description of products

NOAA/NESS produces Northern Hemisphere snow and ice boundary charts and Northern Hemisphere monthly mean snow cover charts on a polar stereographic projection at 1:50,000,000. Charts show areal extent of snow cover. It is possible that in the future, a change will be made to an equal area projection of the Northern Hemisphere from the the current polar stereographic. See table 1 for information on time periods, accuracy, and resolution of available products.

Table 1. Description of products

Time period		Time interval between successive products	Smallest homogenous area that your mapping/ digitizing system resolves		Km within which plotted snow/ice boundaries are accurate under typical conditions
from	to		under worst conditions	under typical conditions	
11/66	12/70	1 month	$0.1 \times 10^6 km^2$	$0.1 \times 10^6 km^2$	± 50 km
1/71	12/73	1 month	$0.1 \times 10^6 km^2$	$0.1 \times 10^6 km^2$	± 50 km
1/74	present	1 month	$0.1 \times 10^6 km^2$	$0.1 \times 10^6 km^2$	± 50 km

B. Availability of products

The products are all on 8 1/2 by 11 inch transparent paper overlaid on a polar stereographic projection base map. Products are retained indefinitely and are available from NOAA/NESS at above address. There is currently no charge.

C. Use and application of products

The products are used for climate and snow cover studies at NOAA/NESS (by M. Matson, C. Berg, D.R. Wiesnet); for climate and snow cover studies by G. Kukla (Lamont-Doherty Geological Observatory); and for climate modeling by A. Robock (University of Maryland, Meteorological Department).

II. Data Sources

A. Data sources and originating agencies

The weekly Northern Hemisphere Snow and Ice Boundary Chart is compiled from NOAA/NESS visible band images from polar-orbiting satellites. Photo-interpretation methods are used. Data are missing only 1 percent of the time. See table 2.

B. Data accuracy

1. Three reflectivity classes are mapped, least, moderately, and most reflective. The snow and ice boundaries are predetermined and the weekly charts are averaged to produce the monthly means of these boundaries.

Table 2. Satellites and sensors used in mapping Northern Hemisphere snow and ice cover

Satellite	Sensor*	Spectral band	Subpoint resolution	Period of operations
		(μm)	(km)	
ESSA 3	AVCS	0.5-0.75	3.7	October 2, 1966 - October 9, 1968
ESSA 4	APT	0.5-0.75	3.7	January 26, 1967 - December 6, 1967
ESSA 7	AVCS	0.5-0.75	3.7	August 15, 1968 - July 19, 1969
ESSA 8	APT	0.5-0.75	3.7	December 15, 1968 - March 12, 1976
ESSA 9	AVCS	0.5-0.75	3.7	February 26, 1969 - December 15, 1973
ITOS 1	AVCS	0.5-0.75	3.7	January 23, 1970 - June 17, 1971
	APT	0.5-0.75	3.7	
	SR	0.52-0.73	3.7	
		10.5-12.5	7.4	
NOAA 2	VHRR	0.6-0.75	1-1.9	October 15, 1972 - January 30, 1975
		10.5-12.5	1-1.9	
	SR	0.52-0.73	3.7	
		0.50-0.94**	3.7	
		10.5-12.5	7.4	
NOAA 3	VHRR	0.6-0.75	1-1.9	October 6, 1973 - present
	SR	0.52-0.73	3.7	
		10.5-12.5	7.4	
NOAA 4	VHRR	Same as NOAA 3		November 15, 1974 - present
	SR	Same as NOAA 3		
NOAA 5	VHRR	0.6-0.75	1-1.9	July 29, 1976 - present
		10.5-12.5	1-1.9	
	SR***	0.52-0.73	3.7	
		0.50-0.94	3.7	
		10.5-12.5	7.4	
SMS-1 (GOES)	VISSR	0.55-0.70	1-7.4	May 17, 1974 - present
		10.5-12.5	7.4-14.8	

*Camera and sensors: AVCS=Advanced Vidicon Camera System; APT=Automatic Picture Transmissions; SR=Scanning Radiometer; VHHR=Very High Resolution Radiometer; VISSR=Visible and Infrared Spin Scan Radiometer.

**SR - Failed 3/3/74.

***SR - Failed 3/16/78.

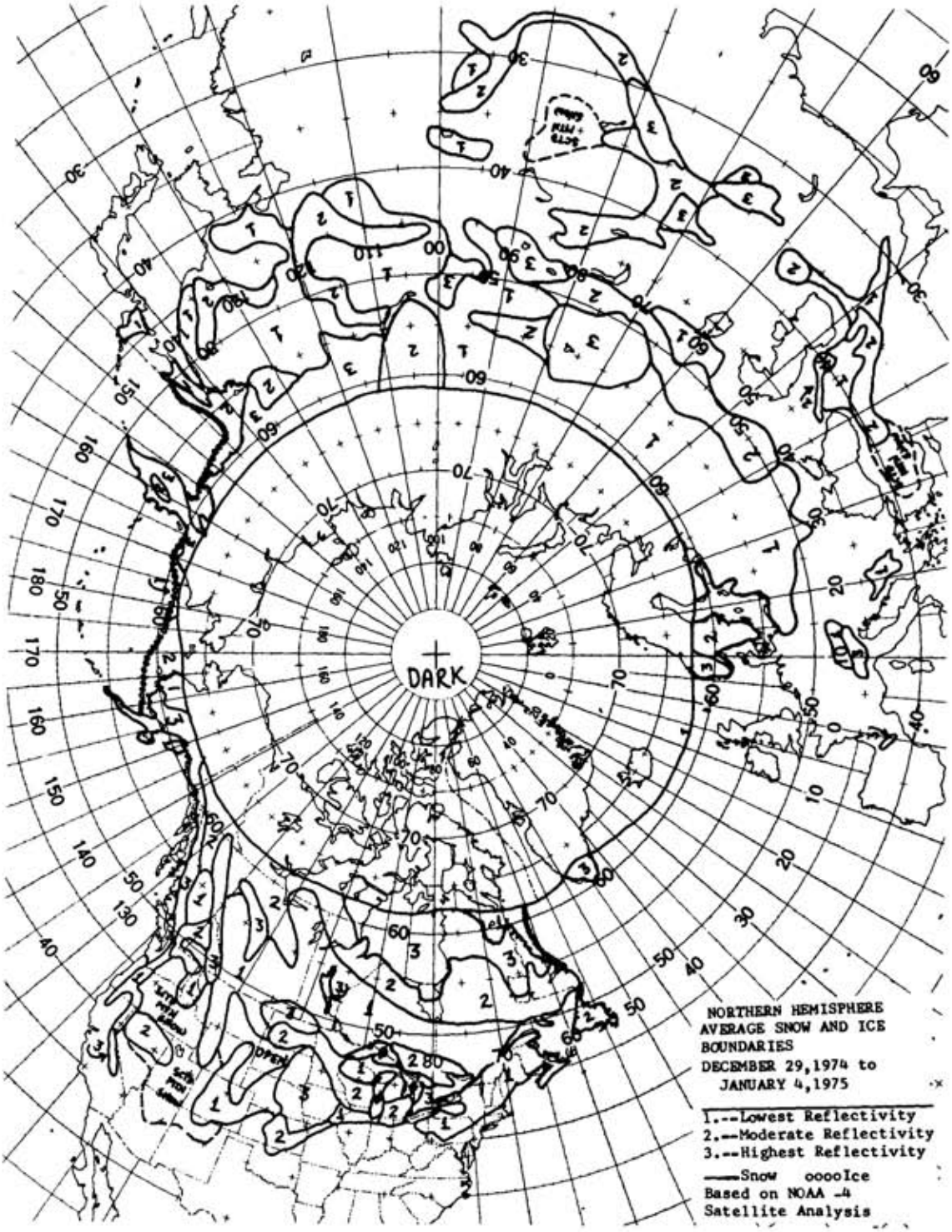

Figure 1. Weekly Snow and Ice Cover Chart for the period December 29, 1974 to January 4, 1975. Note the various classes of reflectivity and the "dark" area north of 60°N where lack of solar illumination prevents the collection of satellite visible data.

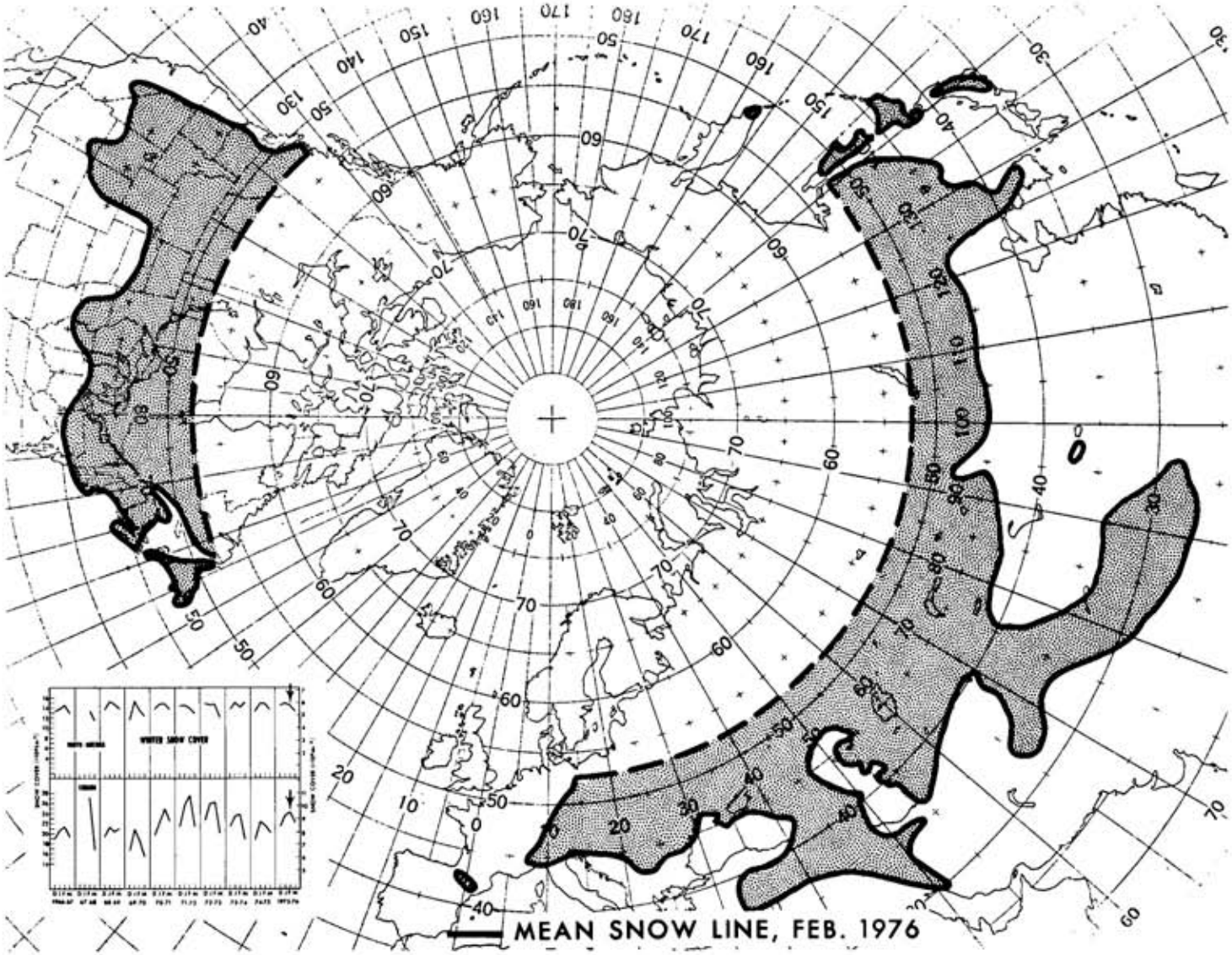

Figure 2. Mean snowline, February 1976.

2. There has been some problem in standardizing the reflectivity classes as they are subjectively determined by different analysts. The best consistency in the reflectivities dates from 1974 to the present.

3. Between the fall and the spring equinoxes, varying portions of the Northern Hemisphere are not analyzed. The maximum extent analyzed, during the period about the winter solstice, reaches 52°N. During the period of restricted analysis, areas in the "dark" portion are considered completely snow and/or ice covered.

C. Data consistency

1. The chart is generally prepared by only one (and usually the same) analyst. The analyst did change for the period June 1978 to June 1979.

2. The data are indirectly checked by Dr. G. Kukla at Lamont-Doherty Geological Observatory, Columbia University. (Kukla and Gavin, 1979.)

D. Availability of source data

Data are available as copies of the original analyses. Reproduction costs are charged.

Contact: Mr. Frank Smigielski
NOAA/NESS
World Weather Building
Room 401
Washington, D.C. 20233

References

Kukla, G.J.; Gavin, J. (1979). Snow and pack ice indices. World Data Center A for Glaciology {Snow and Ice}. Glaciological Data. Report GD-6, p. 9-14.

Matson, M. (1977). Winter snow cover maps of North America and Eurasia from satellite records, 1966-1976. U.S. National Oceanic and Atmospheric Administration. NOAA Technical Memorandum. NESS 84, 28 p.

Matson, M. (1978). The satellite snow cover record: status, trends, and relationships. (In: NOAA Climate Diagnostics Workshop, 2nd, Proceedings. Held at La Jolla, California, 31 October-2 November 1978. Washington, D.C. U.S. Department of Commerce, p. 10-1 - 10-16.

Wiesnet, D.R.; Matson, M. (1976). A possible forecasting technique for winter snow cover in the Northern Hemisphere and Eurasia. Monthly Weather Review, v. 104(7), p. 828-835.

Danish Ice Reconnaissance

ırce: Danske Meteorologiske Institut

ıtact: J. Fabricius
Meteorologiske Institut
Lyngbyvej 100
2106 København Ø
Denmark

he information included in this report was summarized from published information od interviews.

I. Products

. Description of products

1. Sea ice conditions have been reported by the Danish Meteorological Institute since 1885. Records of the ice conditions in the Davis Strait during the years 1890 to 1894 were published in the reports of the Institute for 1892 and 1894. In 1895 the work was extended to include ice conditions between Greenland and Novaya Zemlya.

2. Sea ice charts were published from 1900-1956 for the Arctic Seas: Isforholdene i de Arktiske Have (The State of the Ice in the Arctic Seas) and from 1957-1964 for the area around Greenland: Isforholdene i de Grønlandske Farvande (The Ice Conditions in the Greenland Waters). Information on the ice charts is summarized from Fabricius (1961) and Danske Meteorologiske Institut (1971).

3. Data since 1900 have been published in chart form. A summary is first given of the ice conditions in the various sections of the waters navigated, followed by detailed information on the ice conditions in the following waters:

   1) The waters around Novaya Zemlya and Spitsbergen.

   2) The Greenland Sea and Denmark Strait.

   3) The North Atlantic.

   4) Davis Strait, Baffin Bay, Hudson Bay and Strait.

   5) Siberian Sea, Bering Sea and Strait, Beaufort Sea.

4. The text is in English, accompanied by multicolored charts depicting the ice conditions for the months of April, May, June, July, and August. The later reports in the 1900-1956 series give information for areas north of Alaska, the Canadian Arctic Islands, north of Greenland, and in Baffin Bay, based mainly on American air-reconnaissance. Part of the information on Denmark Strait was also made available by the U.S. Navy Hydrographic Office. The later maps do not show information for the Barents Sea, previously provided by Norwegian sealers and Soviet naval vessels.

5. Charted features

   The series of charts for 1957-1964 was prepared on similar lines to the U.S. Naval Oceanographic Office ice reconnaissance reports. Wherever possible, the sizes of the ice floes are indicated by a fraction. The numerator states the total ice-belt in tenths, while the 3 or 4 ciphers of the denominator denote (in tenths) the core of (a) slush, brash and blocks (floes smaller than 10m), (b) small and medium floes (10-1000m diameter) and (c) giant flces and fields (greater than 1000m). A relative assessment of the number of bergs is given, although icebergs are often omitted from the published charts. Place name charts are provided.

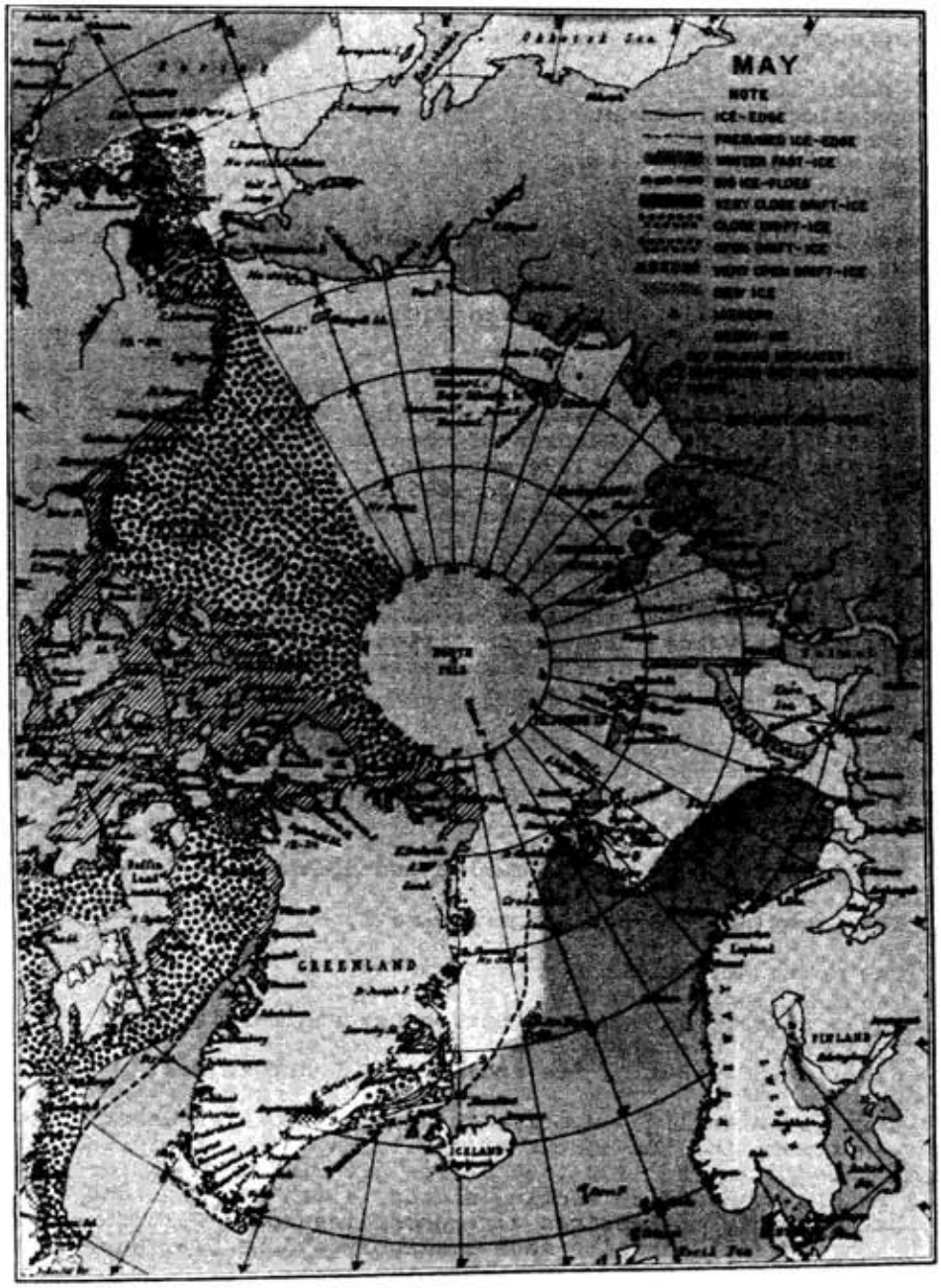

Figure 1. Ice chart for the Arctic produced by the Danske Meteorologiske Institut.

6. There have been no serial publications since 1965. Several reports have been prepared for publication for the period 1966 to 1975, and these should be available in 1980.

   A major study prepared for commerical interests will be made public in 1982. This is titled Western Ice Investigations. A portion of this report will consist of a comprehensive tabulation of ice condition histograms for the period 1959 to 1974.

B. Availability of products

Many of the earlier publications are out of print. For further information, contact the Dankse Meteorologiske Institut at the above address.

II. Data Sources

Information for the earlier reports was from vessels sailing to the West Greenland settlements and also from settlement inhabitants. After 1895, information was collected from all shipping in the North Atlantic. Up to 1917, the Danske Meteorologiske Institut served as an international center for sea ice data.

Currently ice observers conduct visual surveys using a Twin Otter aircraft. The aircraft is equipped with Omega navigation, search radar, and a photo port for SLAR. The southern waters off Greenland are flown twice weekly and the east and west coasts twice monthly in spring and autumn. A helicopter is used for ship piloting and near shore surveys. Sea ice conditions are also reported by passing ships.

Routine maps of sea ice conditions are prepared from the various sources discussed, as well as the ice charts from Great Britain. The maps are issued in Faxcom format from Simiutaq, South Greenland.

References

Danske Meteorologiske Institut. (1967-1971) Isforholdene i de Gronlandske Farvande, 1957-1964. (Ice Conditions in the Greenland Waters, 1957-1964.) Charlottenlund, Danske Meteorologiske Institut, 8v.

Fabricius, J.S. (1961) Danish ice reconnaissance. (In: Fristrup, B., ed. Physical Geography of Greenland. XIX International Geographical Congress, Held at Norden, 1960. Symposium S.D. 2. University of Copenhagen, Geographical Institute.

Hansen, G.J.A.; Sveistrup, P.P. (1943) Arctic fluctuations in Julianehaab Bay 1901-1937. Meddelelser om Grønland, Bd. 131(13).

Koch, L. (1945) The East Greenland ice. Meddelelser om Grønland, Bd. 130(3).

Speerschneider, C.I.H. (1931) The State of the Ice in Davis Strait 1820-1930. Danske Meteorologiske Institut. Publication No. 8.

Arctic Sea Ice Data from the Soviet Union

Source: World Meteorological Organization

Contact: Arctic and Antarctic Research Institute
Fontanka 34
Leningrad, USSR

I. Products

A. Description of products

Ice charts for the Soviet Arctic have been prepared since 1937. Current sea ice charts are issued on a Mercator projection at scales of 1:500,000 to 1:13,000,000. Composite charts are produced every 5 to 10 days on a regular basis, and 1 to 3 days for areas of intensive navigation.

Charts are transmitted to users by facsimile and mail. The coded sea ice information concerning navigation in the Baltic Sea is transmitted to users by radiotelegraph.

One to ten-day forecasts of the ice edge position and ice concentration are produced by Area Centers (see table 1). Thirty-day forecasts are also made of: dates of ice formation, freeze-over, break-up, and disappearance in bays, harbors, and in the vicinity of other important sites on the coast.

B. Availability of products

The 10-day and monthly ice charts are not published. Some sea ice observations are published as tables in marine hydrological yearbooks. Atlases of sea ice maps are published as monographs. No further information is available on these publications at present.

C. Use and application of products

The main users of the data are:

1. Sea-going cargo vessels, river boats, and fishing boats.
2. Ports and shipbuilding works.
3. Various economic institutions and services responsible for operational activities at sea.

II. Data Sources

A. Data sources and originating agencies

Data collection, processing, and dissemination are carried out by Area Centers for Hydrometeorology and Control of Natural Environment through hydrometeorological observations and local weather services.

Table 1. Area centers and their coverage.

Location	Sector
Tallinn	Baltic Sea
Archangel	White Sea and south-eastern Barents Sea
Murmansk	Barents Sea, Greenland Sea and North Atlantic
Amderma	South-western Kara Sea
Dixon	North-eastern Kara Sea
Tiksi	Laptev Sea
Pevek	East Siberian and Chukchi Seas
Yuzhno-Sakhalinsk	South-western Okhotsk Sea, Gulf of Tatary and Kuril Islands
Petropavlovsk-Kamchatski	Eastern Kamchatka Peninsula
Odessa	Azov Sea and north-western Black Sea

B. Ground data

1. All shore stations make daily observations of the following parameters:
   a. ice concentration (visual)
   b. ice age (visual)
   c. number of ridges (hummocks) (visual)
   d. degree of sea ice disintegration (visual)
   e. drift direction and velocity (measured)
   f. fast ice extent (measured)
   g. thickness (measured in fast ice)
   h. depth and density of snow on the ice (measured on fast ice)
2. Ships in the area make 4-hourly observations.
3. Since 1945, aerial reconnaissance has been used. Currently, visual air reconnaissance flights are made every 5 to 10 days. Airborne radar is used in the Barents, Bering and other arctic sea ice areas.
4. The above data are supplemented by satellite imagery received at the Area Centers.
5. Automatic drifting stations have been deployed in the Arctic since 1953. Originally only radio beacons sending out position data were in use. Drifting Automatic Radio-Meteorological Stations (DARMS), transmitting meteorological data in addition, were introduced in 1957. A description of the deployment of stations, the DARMS data and their accuracy is given in Olenicoff (1971).

Reference

Olenicoff, S.M., (1971). The Soviet DARMS. AIDJEX Bulletin, no. 7, p. 5-24.

Spatial and Temporal Variation of Ice in Antarctica

Source: Department of Geography, Ohio State University

Contact: J.N. Rayner
103 Administration Building
190 N. Oval Mall
Ohio State University
Columbus, Ohio 43210
(614) 422-2515

I. Products

Spatial and temporal variations of ice in Antarctica have been mapped for the period December 1972 to June 1975. Two hundred and nineteen 3-day arrays are used out of a possible 299 for the period. Material is published in 2 volumes:

> Rayner, J.N.: Howarth, D.A. (1977) Analysis of the Spatial and Temporal variation of the Ice in Antarctica, December 1972 - June 1975. Greenbelt, Maryland, Goddard Space Flight Center.

Volume 1 covers the analysis, and volume 2 the maps and the meridian time series. The mapping scale is 1:48,000,000 using 293 by 293 cells with a cell side varying from 28-31.5km on a polar stereographic projection.

II. Data Sources

The chief data source was NASA Nimbus 5, 15.5mm band. This uses 3-day averages for a 293 by 293 rectangular array, tangent at 50°S on a stereographic projection. Tapes include the number of observations per cell, as well as the average radiation level, brightness temperature, of each cell.

See also Sea Ice Information from Satellite Derived Microwave Data, p. 37, this issue.

Ice Summary and Analysis, Canadian Arctic and Sub-Arctic

Source: Atmospheric Environment Service

Contact: W.E. Markham
Atmospheric Environmental Service
4905 Dufferin Street
Downsview, Ontario M3H 5T4
Canada
(416) 667-4727

I. Products

A. Description of products

Table 1. Description and availability of products

Name of product	Retention Period	Archive Location	Contact	Cost
Historical ice chart Series A Series B	Indefinite	Ottawa	W.J. Sowden[1] Ice Climatology Office Trebla Building Ottawa, Ontairo K1A OH3 Canada (613) 795-6730	
Composite ice charts (present ice situation) A) Eastern seaboard B) Hudson Bay and approaches C) Eastern Arctic and approaches D) Western Arctic and approaches		Ottawa Ottawa Ottawa Ottawa	A.P. Beaton[2] Ice Forecasting Central DFE Trebla Building Ottawa, Ontario K1A OH3 Canada (613) 795-6730 For past records: W.J. Sowden	about $20 per year
Current ice charts. All areas of Canadian coastal waters	Indefinite	Ottawa	As above	
Ice observers' charts. All areas of Canadian coastal waters	Indefinte	Ottawa	As above	about $1 per year

[1]This product is available for use by interested scientists, but is not suitable for copying.
[2]These products are available upon request.

1. Historical ice charts have been produced weekly since 1960 at a scale of 1:6 million. Series A covers the Gulf of St. Lawrence and the Eastern Seaboard, with Hudson Bay added in the period May - November. Series B covers the Arctic waters, May - October only. Preparation is done several months after the fact.

2. Composite ice charts (present ice situation) have been produced since 1970 and are done on a scale of 1:4 million.

   a. The Eastern Seaboard is mapped, 1 to 3 times weekly, late December - June.

   b. Hudson Bay and Approaches is produced weekly, late June - late November.

   c. Eastern Arctic and Approaches is produced weekly, late June - late October.

   d. Western Arctic and Approaches is produced weekly, late June - late October.

3. Current ice charts, produced since 1958, and done on a scale of 1:2 million (earlier data are on microfilm), cover all areas of Canadian coastal water, and are prepared daily in support of shipping. These charts combine shipboard, aerial, and satellite data. They include the Eastern Seaboard in winter and northern areas in summer.

4. Ice observers charts, produced since 1958 on a scale of 1:2 million and 1.1 million, cover all Canadian coastal waters, mainly the Eastern seaboard in winter and northern areas in summer.

5. Charted features

classes of ice concentration	classes of age and type	classes of average size of floes
Tenths is normal occasionally broken only to Very open 1-3 Open 4-6 Close 7-9/10	multi-year second year first year grey white grey Niles new	Division between small floe and loss vs medium floe and greater (this unit changed about 1968)
classes of ridging	classes of melt features	other features mapped
By light, medium, heavy to 1965 then by tenths	Same as ridging (also separate puddles, thaw holes, and frozen puddles	Rafting, hummocks, numbers of icebergs sighted

6. Basic map scale for observations changed in 1978 from 1:2 million to 1:1 million.

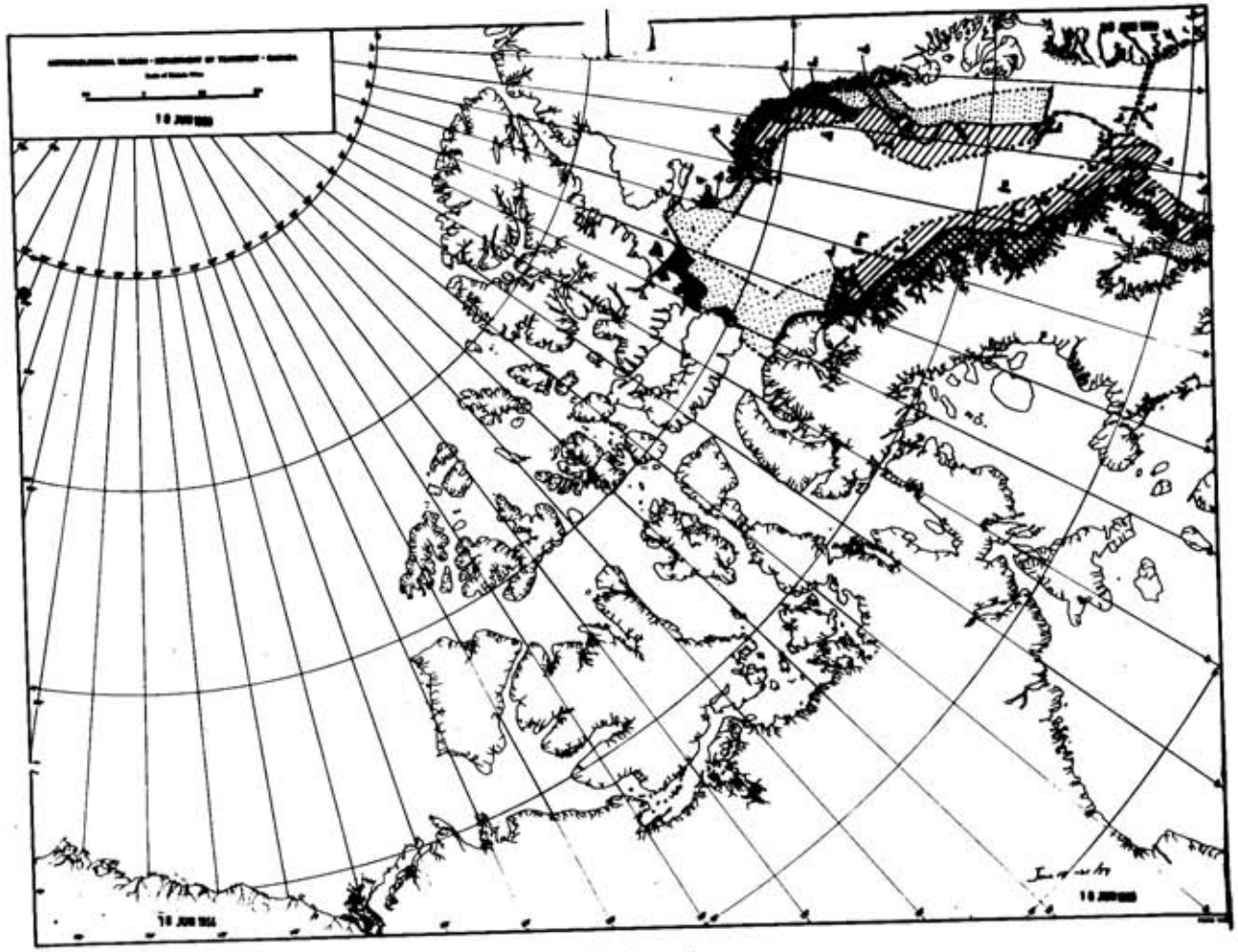

Figure 1. Ice chart from the Northern Historical series.

B. Availability of products

1. Formats available

a. Listings: ozalid copy

b. Maps: map scales vary from 1:1,000,000 to 1:6,000,000. Composite charts measure 15 by 19 inches; other charts are 18 by 22 inches.

c. Microform: 35 mm microfilm.

2. Some of the products are digitized and all could be.

II. Data Sources

A. Data sources and originating agencies

	Agency	Routine	Special
1. Satellite observations	NOAA-VHRR from NESS	X	
	NOAA-VHRR from AES	X	X
	LANDSAT from ISIS	X	X
2. Aircraft observations	Ice Branch, AES	X	X
3. Ship observations	Canadian Coast Guard, Ice Branch, observers	X	X
4. Ground observations	Coastal network, mainly government agencies	X	
5. Other	Armed Forces Aerial Northern Patrols	X	
	Canadian Coast Guard helicopter surveys - St. Lawrence River	X	

ata accuracy

1. Direct operational use by vessels in ice was employed to determine levels of accuracy/resolution of data.

2. Type of data/method of collection for data source(s).

period		Remote sensing system			Area covered
	to	Sensor platform	Sensor type	Spectral region	
8	1971	Aircraft	Visual	Observation	Eastern Seaboard and Great Lakes in winter
2	1977	Aircraft Aircraft Aircraft Aircraft	Visual Laser Camera ART	Observation -visual IR	
978	-	Aircraft Aircraft	Visual SLAR added above	Observation to X-band	Eastern Seaboard and Great Lakes in winter

Note: Data relay was by teletype message prior to 1965 but then it was changed to relay from field to Ottawa by telephone facsimile.

2. For the current method of analysis, the data sources used are listed in preferential order:

season/months		season/months		season/months	
Dec. - June		July - Sept.		Oct. - Nov.	
Preferential order of data used	% time missing data	Preferential order of data used	% time missing data	Preferential order of data used	% time missing data
Aerial Observations	30	Aerial Observations	40	Aerial Observations	50
Ship reports		Ship reports			
Satellite (NOAA)	40	Satellite (NOAA)	40	Satellite (NOAA)	50
Shore report(s)		Shore reports			

3. The procedures used to differentiate between:

   a. Cloud and ice surfaces: pattern recognition on satellite imagery and comparison with earlier images and aerial data.

   b. Nilas and water: (1) easily visible from ship and aircraft; (2) LANDSAT Channel 5 and NOAA IR VHRR at decreasing resolution.

   c. Open water and surface melt water: reliance is on aerial and shipboard data.

   d. Different ages of ice cover: (1) SLAR in cold conditions; (2) visual detection by color and topography.

   e. Snow thickness: visual description; drifted or percent cover; no thickness reported.

4. Because of the prevalence of clouds, snow flurries, and the short day, the last week of October was arbitrarily chosen for the polar night cutoff.

5. No changes are currently planned in data sources except for expanded use of SLAR.

6. Automated satellite interpretation is planned for the future.

C. Data consistency

1. To assure consistency of interpretation among interpreters, correlation is made from satellite data to aerial and ship data and vice versa.

2. Methods used routinely to check for consistency in:

   (a) Source data: inspection flights and contact training of new personnel.

   (b) Interpretation: discussion among personnel.

3. Cross-checks among data sources are always made. Aerial, shipboard, and satellite data are integrated at Ice Central.

Northwatch, Snow and Ice Cover in the Canadian Arctic North of 60°

Source: Gregory Geoscience Ltd.

Contact: Dr. B. Dey
Gregory Geoscience Ltd.
1750 Courtwood Crescent
Ottawa, Ontario K2C 2B5
Canada
(613) 224-9565

I. Products

A. Description of products

Gregory Geoscience produced weekly snow and ice maps of the Canadian Arctic, excluding Quebec and Labrador, from 1974-1977. The maps are on paper (8½ by 14 inches) on a Mercator projection at 1:9,000,000 scale.

The smallest homogenous area resolved by the mapping system is not determined but is estimated to be about $1km^2$ under typical conditions and $10km^2$ under worst conditions.

Emphasis is on the rate of change of boundaries. Boundaries are thought to be accurate to within several kilometers under typical conditions. The consistency between maps in terms of the minimum resolvable area is fair under typical conditions and poor under worst conditions. The consistency between maps in the accuracy of the plotted boundaries is fair.

1. Charted features

Classes of ice concentration	Reflectivity
open water	>75 percent snow cover
light pack ice	0-25 percent snow cover
heavy pack ice	
fast ice/solid pack	bare ground

2. Additional information mapped includes thawing degree days from Atmospheric Environment Service (Canada) meteorological data.

B. Availability of products

1. Northwatch, on 8½ by 14 inch paper copy, is available upon request for the cost of reproduction and mailing.

2. The products are not currently digitized, but with difficulty could be.

C. Use and application of products

The maps are used by several Canadian government departments, as well as mining companies and local air services for field operations, planning and logistics.

II. Data Sources

A. Data sources and originating agencies

1. Satellite observations

   a. NOAA data from Atmospheric Environment Service and Integrated Satellite Imaging Systems, Ltd. (ISIS).

   b. Landsat data from ISIS.

2. Ground observations - standard meteorological observations from AES.

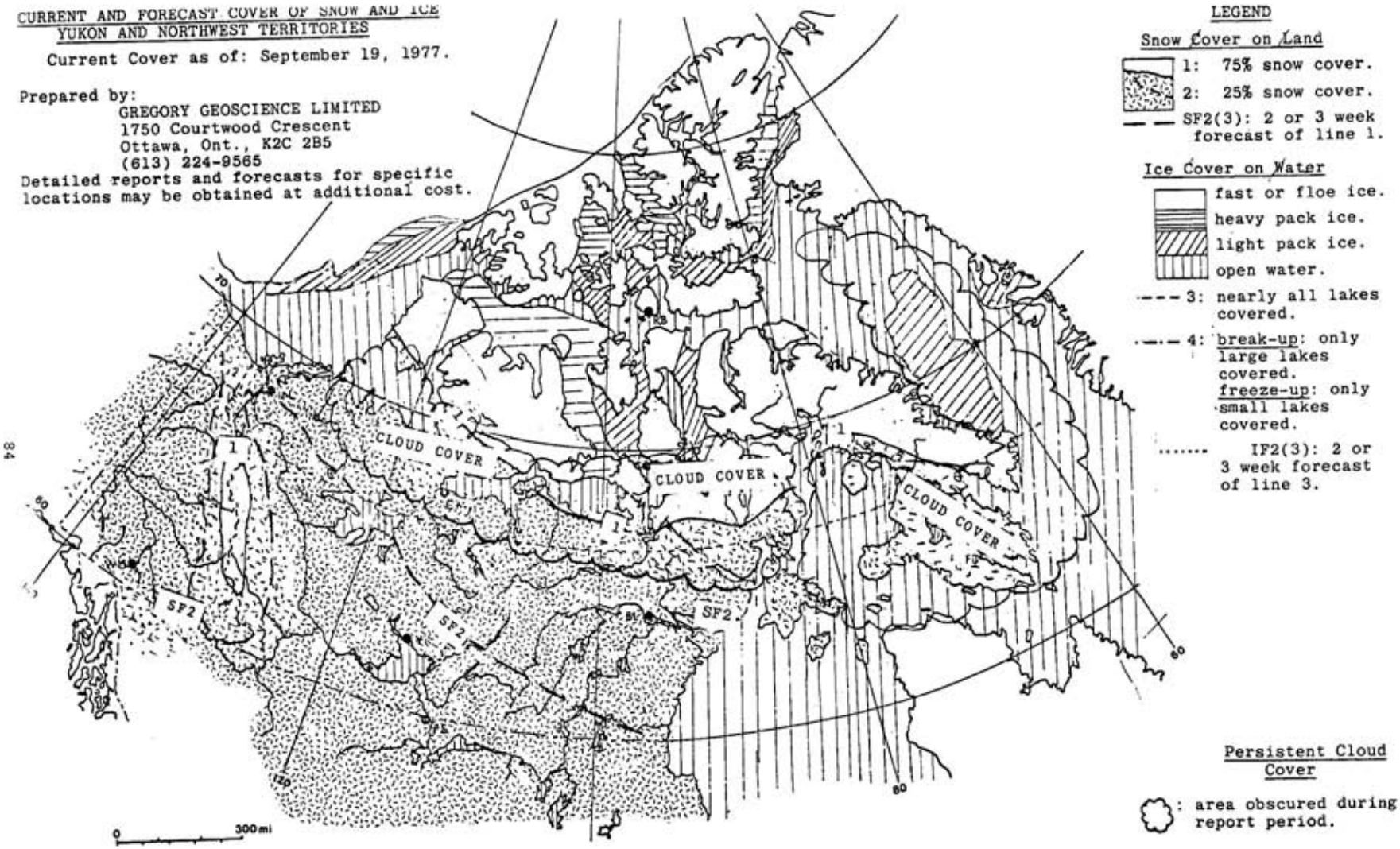

Figure 1. Sample of Gregory Geoscience Limited chart.

Data accuracy

Levels of accuracy and resolution were tested with reference to weekly ice charts published by Ice Central (AES) and by isolated field reports from independent observers.

References

, B.; Moore, H.; Gregory, A. F. (1977) The use of satellite imagery for itoring ice break-up along the Mackenzie River, N.W.T.. Arctic, v. 30(4), 234-242.

y, B. (1978) Use of Landsat and NOAA imagery for mapping deformation d movement of Baffin Bay ice. (In: Canadian Symposium on Remote Sensing h, Proceedings. Held at Victoria, B.C., August 1978, p. 200-208.)

ay, B.; Moore, H.; Gregory, A. F. (1979) Applications of satellite imagery or monitoring snowline in the Yukon and Northwest Territories. Polar Record, . 19(122), p. 473-483.

ey, B.; Moore, H.; Gregory, A.F. (1979) Monitoring and mapping sea ice breakup nd freezeup of Arctic Canada from satellite imagery. Arctic and Alpine Research, . 11(2), p. 229-242.

Physical Properties of the Seasonal Snow Cover and Surface Ice Conditions and Ice Thickness on Lakes, Rivers, and Fast Sea Ice for the North American Arctic and Sub-Arctic

Source: U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)

Contact: M.A. Bilello
U.S. Army, CRREL
Hanover, NH 03755
(603) 643-4105; FTS 834-7585

I. Products

A. Description of products

1. Ice data have been collected during winter seasons from 1946 to the present, on a weekly basis, from about 65 ground observing stations. The length of record for each station varies from five to thirty years. Surface ice conditions and ice thickness are recorded. The final maps are produced with a resolution of about 2500 mi^2/6475km^2.

2. Snow data have been collected during winter seasons from 1952 to the present for about 30 ground observing points at weekly intervals. The length of record for each station varies from three to twenty years. The physical properties and characteristics of the snow cover are recorded. The resolution of the final maps is about 10,000 mi^2/25,900km^2.

3. For both snow and ice, maps are produced for northern North America at approximately 1 in=850 miles/1368km. The smallest homogeneous area resolved by the mapping system is about 500 miles/805km on a side, under worst conditions, and about 200 miles on a side under typical conditions. Plotted snow and ice boundaries are accurate to approximately 50-100 miles/80-161km. The consistency between maps in the identification of the minimum resolvable areas is good under worst conditions and fair under typical conditions. The consistency between maps in the accuracy of boundaries is fair.

4. Charted features.

   a. Ice

classes of ice concentration	classes of age and type of ice	classes of ice thickness
first ice freeze-over ice thickness ice breakup body of water free of ice	first year ice only for: rivers lakes fast sea ice	every inch from 6 inches to 8 feet accurate to ± 3 inches
classes of melt features	other features mapped	
visual description of surface ice conditions during melt period - generally over 3-4 day intervals	rate of ice thickness, ablation accurate to ± 6 inches amount and date of maximum ice thickness	

b. Snow

(1) Presence or absence of snow.

(2) Snow depth at 1 to 2 inch intervals - accurate to ± 6 inches.

(3) Age classes - ± 30 day intervals.

(4) Snow density - accurate to ± 6 inches.

(5) Several reports relating climate to changes in the seasonal characteristics of the snow or ice cover have been produced. Climate data for this purpose are taken from NOAA and Canadian Meteorological Summaries.

B. Availability of products

1. Products will be retained indefinitely and are currently being archived at the WDC-A for Glaciology. When archiving is completed, the data will be available to interested scientists.

2. Only a small portion of the available ice data and none of the snow data has been digitized.

C. Use and application of products

1. The principal users are:

Agency	Applications
a. NOAA	Hydrology, snow runoff, dam construction
b. U.S. Army and Navy	Military activities, construction, mobility
c. U.S. Department of the Interior; Bureau of Land Management; Environment Canada	Flood forecasting, agricultural, fish and wildlife studies

II. Data Sources

A. Data sources and originating agencies

1. Ice

a. Environment Canada - Ice Summary and Analysis (Hudson Bay and Approaches, Eastern Canadian Seaboard, Canadian Arctic); Historical Ice Charts; weekly ice conditions.

b. U.S. National Weather Service - station reports.

c. Alaska National Guard.

d. U.S. Geological Survey, Water Division, Alaska (USGS/WD).

2. Snow

a. U.S. National Weather Service (NWS) - station reports.

b. U.S. Soil Conservation Service (SCS) - snow surveys.

c. U.S. Air Force, Air Weather Service (AWS) - snow cover property observations.

d. Environment Canada - weekly ice conditions.

B. Data accuracy

1. All of the agencies supplying snow data have data missing less than 10 percent of the time.

2. Ice data from NWS and Environment Canada are missing less than 5 percent of the time. USGS/WD data is missing less than 20 percent of the time.

3. For both snow and ice, methods of interpretation have changed over time only to the extent that computer analysis of the data has been incorporated. Many of the field observing programs that have been in progress for five to thirty years are either being phased out or supported by new or other agencies.

4. Where possible, data sources are cross-checked with other data sources, although locations where data are collected are often too isolated to make cross-checking possible. Data are checked for quality control since observations have obvious limits and detectable errors. Errors are either omitted or corrected, and apparent consistent mistakes are passed on to the observers for awareness and correction.

References

Bilello, M.A. (1961) Formation, growth and decay of sea ice in the Canadian Arctic Archipelago. Arctic v. 14(1), p. 3-24.

Bilello, M.A.; Bates, R.E. (1966) Ice thickness observations, North American Arctic and Subarctic 1962-63; 1963-64. CRREL Special Report No. 43, Part III, 103 p.

Bilello, M.A. (1969) Surface measurements of snow and ice for correlation with aircraft and satellite observations. CRREL Special Report No. 127, 9 p.

Bilello, M.A. et al. (1970) Physical characteristics of the snow cover, Fort Greely, Alaska 1966-67. CRREL Technical Report No. 230, 33 p.

Bilello, M.A.; Bates, R.E. (1975) Ice thickness observations, North American Arctic and Subarctic 1970-71, 1971-72. CRREL Special Report No. 43, Part VII. 103 p.

U. S. Army. Cold Regions Research and Engineering Laboratory. (1962) Instructions for making and recording snow observations. CRREL Instruction Manual No. 1.

Sea Ice Atlas of Arctic Canada

Source: Canada. Department of Energy, Mines and Resources

Contact: G.D. Hobson
Director, Polar Continental Shelf Project
Department of Energy, Mines and Resources
City Centre Tower
880 Wellington Street
Ottawa, Ontario K1A OE4
Canada
(613) 996-3388

I. Products

A. Description of products

Two atlases are available, one covering the period 1961-1968 and one for 1969-1974. A third atlas for 1975-1978 is in preparation. A seasonal summary outlining the general ice regime for each year is given. Aerial observations were made at various intervals between March and November. Each map is accompanied by a written description and a figure showing the flight tracks. The maps are in color, 28 by 38 cm, at a scale of 1:5,317,000. The maps cover the area of the Canadian Arctic Archipelago and adjacent waters. They give information on ice concentration-flow categories and open water, ice type, 3 classes based on age, floe size, and some surface morphological features.

B. Availability of products

Atlases are available from:

Printing and Publishing
Supply and Services Canada
Ottawa, Canada K1A OS9

The price is $20.00 (Canada) and $24,00 (other countries).

II. Data Sources

Data are from aerial observations. Each flight consisted of a number of reconnaissance surveys or tracks and many include data collected from between two and twenty tracks. The number of tracks per flight varies depending on weather, available flying time, and the schedule of flying required to observe as much as possible of the entire area without duplicating similar surveys conducted by other government agencies. Ice conditions inferred or known to exist in nearby regions, but not observed directly, are also indicated on the descriptions.

References

Lindsay, D. G. (1976) Sea Ice Atlas of Arctic Canada 1961-1968. Ottawa, Canada, Department of Energy, Mines and Resources, 213 p.

Lindsay, D. G. (1977) Sea Ice Atlas of Arctic Canada 1969-1974. Ottawa, Canada, Department of Energy, Mines and Resources, 219 p.

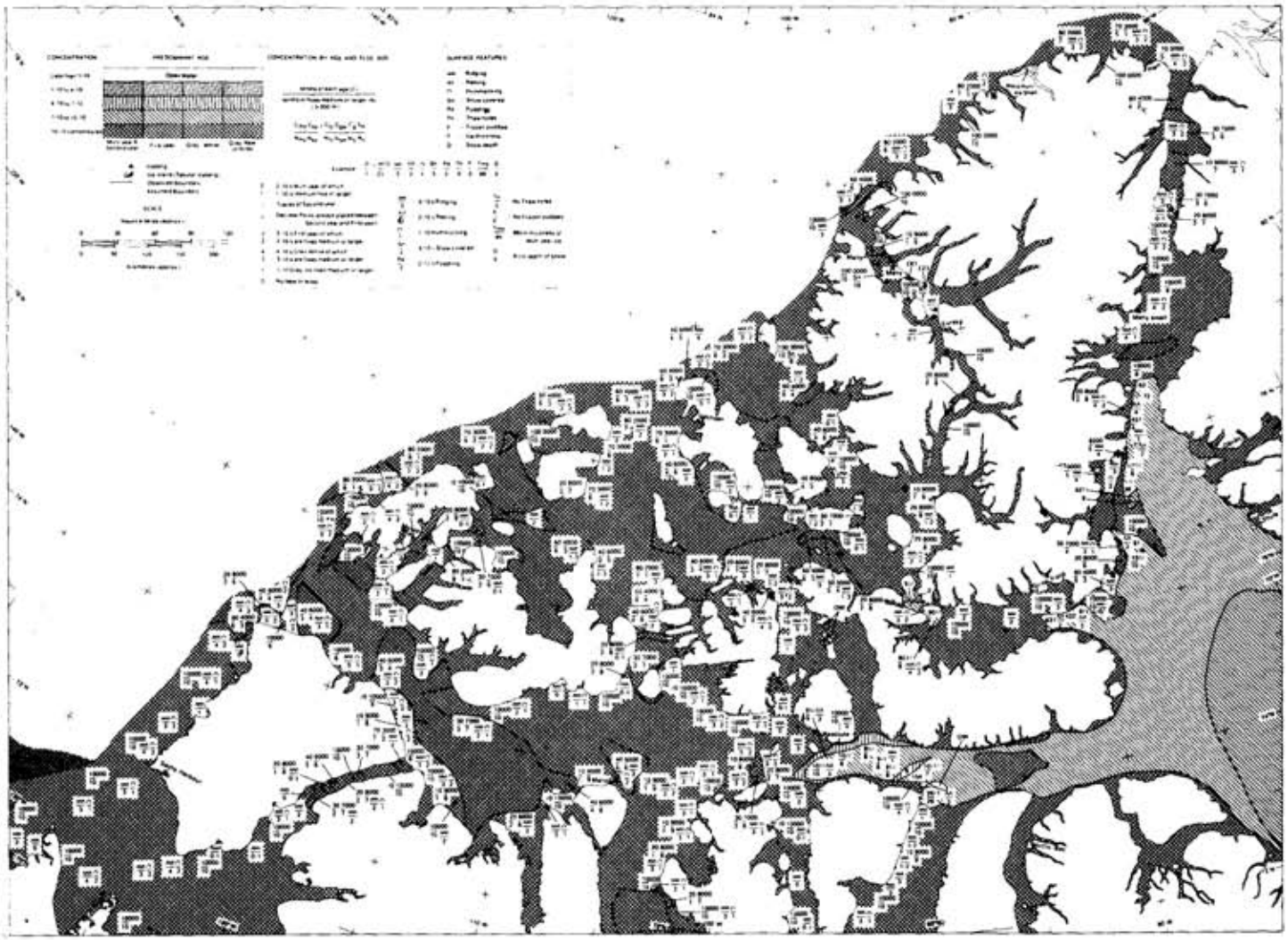

Figure 1. Eastern Canada ice chart 1-4 April 1974.

Alaskan Sea Ice Analyses

Source: U.S. National Oceanic and Atmospheric Administration/
National Environmental Satellite Service

Contact: Franklin Kniskern
World Weather Building
Room 510
Washington, DC 20233
(301) 763-8142;

I. Products

NOAA/NESS is cooperating with the U.S. Navy Fleet Weather Facility in what is now the Joint Ice Center. The Navy has taken over the production of the maps. The Alaskan Sea Ice Analyses are now included in the regular Navy sea ice charts.

A. Description of products

1. NOAA/NESS produced weekly maps of the Bering, Chukchi, and Beaufort Seas on a polar stereographic projection from 1973 to early 1979.

2. Charted features

classes of ice concentration	minimum area that can be recognized		accuracy
	typical conditions	worst conditions	
0-3 oktas 3-5 oktas 5-7 oktas 7-8 oktas	1 km 1 km 1 km 1 km	tens of km tens of km tens of km 1 km.	when clouds are present, it is often difficult to differentiate concentrations of ice. Under typical conditions, accuracy usually within 1 or 2 oktas.
classes of age and type of ice			
fast ice young ice first-year ice multi-year ice	1 km 1 km 1 km 1 km	1 km tens of km tens of km 1 km	Differentiating age of ice is very subjective. Generally it is based on the experience of the climatology of the area. Fast ice, young ice and multi-year ice can usually be recognized, but differentiating between young ice and first-year ice and first-year ice and multi-year ice is often difficult.

classes of ice thickness	accuracy	classes of average size of floes
See previous table and our enclosed maps. We differentiate our thickness of ice by age of ice.		Not able to distinguish. Areas of giant floes or floes that are well broken are often analyzed.
Breakdown of first year ice. FL (30-70 cm) FM (70-120 cm) FT >120 cm	The breakdown of first year ice based strictly on experience and climatology. We are able to determine by satellite, and usually combine categories.	

Other features mapped	
Leads and Polynyas	Leads may be ice free or we attempt to distinguish age of ice within lead if not ice free.
Ice edge	During good or typical conditions, ice edge should be accurate to within 5 km.

3. On October 1, 1976, we changed base charts. We now use two base charts: one chart covers the Chukchi and Bering Seas, and the other covers the Chukchi and Beaufort Seas. Only one chart is used depending on ice cover. We feel our ice analyses have become more detailed as we have gained experience utilizing the VHRR imagery.

B. Availability of products

The Alaskan Sea Ice Analyses are available as page size charts from F. Kniskern at the above address.

C. Use and application of products

The charts are used by the National Weather Service in preparation of ice advisories and forecasts to aid in navigation during the resupply of Alaskan ports. They are also used as a research tool in ice modeling, especially in the Beaufort Sea.

II. Data Sources

A. Data sources and originating agencies

VHRR imagery from the NOAA satellites is the only data source used to produce the analyses. Occasionally, some ground observations are used to confirm freeze-up.

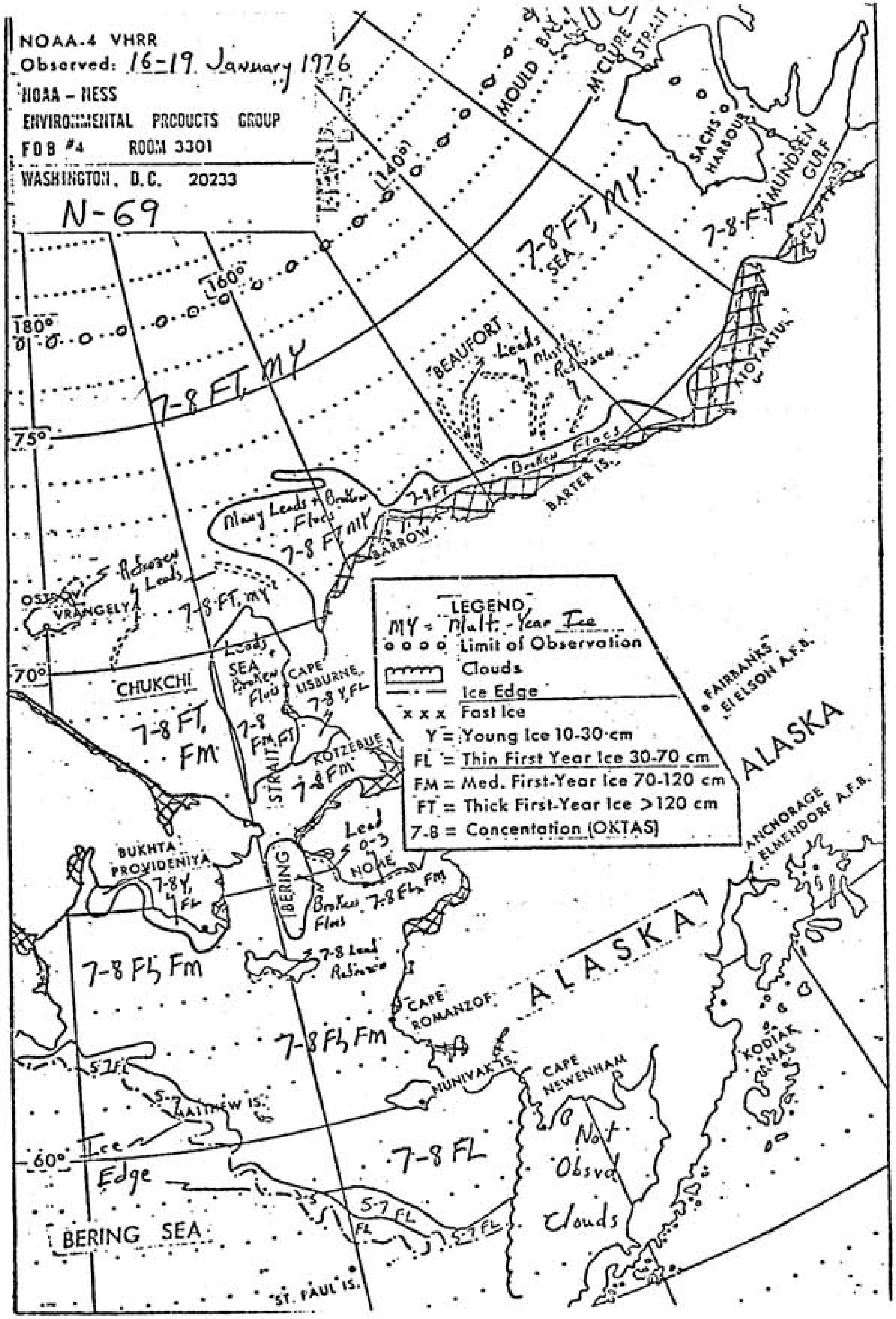

Figure 1. Experimental ice analysis.

Figure 2. Alaska ice analysis - North Slope.

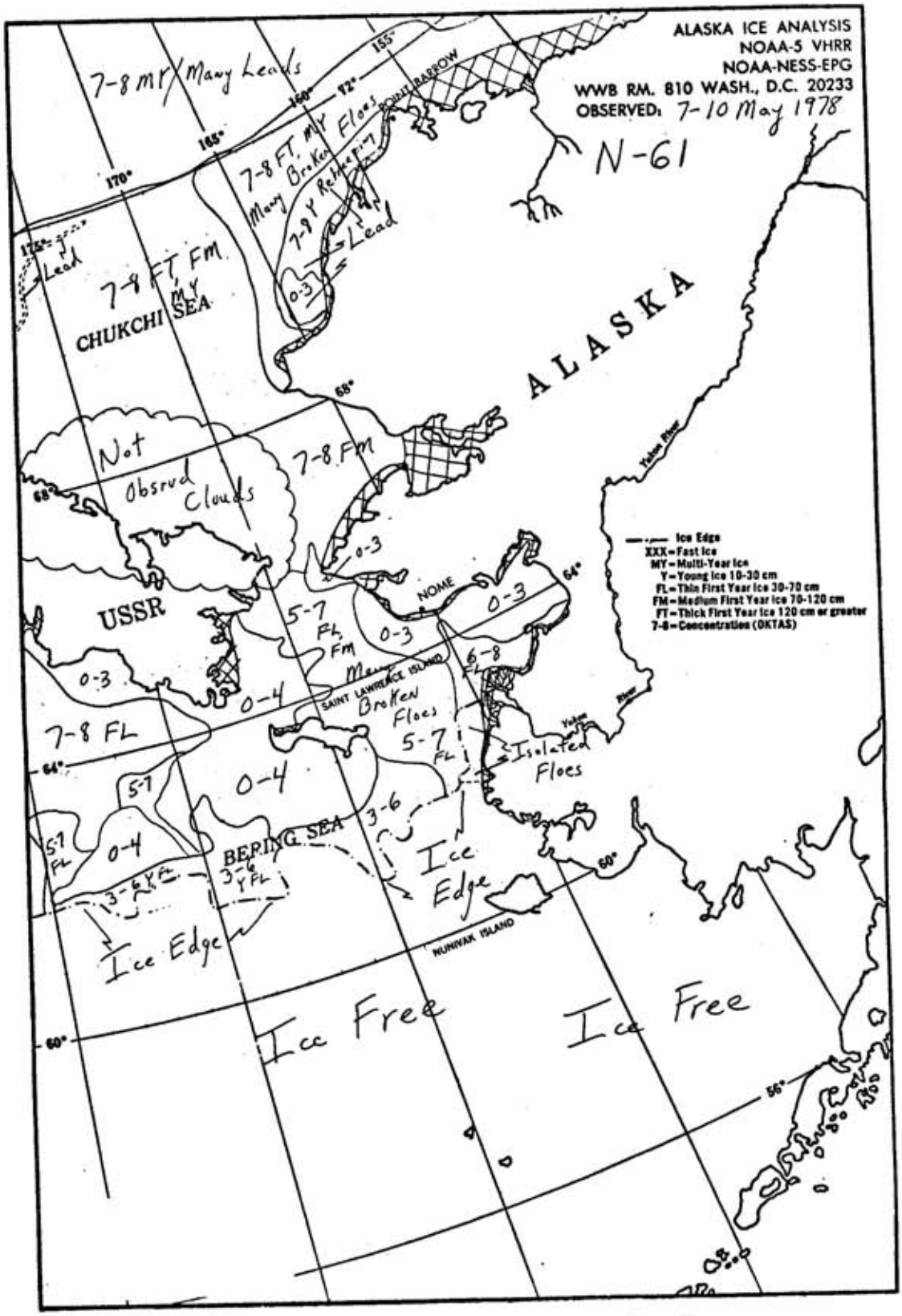

Figure 3. Alaska ice analysis - Chukchi and Bering Seas.

B. Data accuracy

Table 1. Type of data/method of collection of data source

Time period		Remote sensing system					Resolution of data	% time missing data
from	to	Sensor platform	Sensor type	Spectral region	Number of images used at one point per time interval mapped			
					Average	Range max.	Range min.	
October-March		NOAA VHRR	IR	10.5 - 12.5 μm	3	7	1	1 km	1-2 percent
March-October		NOAA VHRR	Visible	0.6-0.7	3	7	1	1 km	1-2 percent

1. The procedures used to differentiate between:

   a. Cloud and ice surfaces: Persistence is probably the best procedure to differentiate between cloud and ice. Clouds move quite rapidly, while ice tends to remain or persist in a given area relative to clouds. Also clouds are often oriented in perpendicular line relative to an ice surface.

   b. Nilas and water: Nilas, or ice slightly thicker, appears lighter (gray) in both the visible and IR than water which appears black.

   c. Open water and surface melt water: Surface melt water is very difficult to differentiate with the present sensors on NOAA satellites.

   d. Different ages of ice cover: The thicker or older the ice, the lighter or whiter it appears in both the visible and IR. Snow cover on ice often creates a problem.

   e. It is often possible to differentiate between the multi-year ice and first-year ice in the Beaufort Sea using the visible channel during the summer.

2. Infrared (IR) imagery using a special cold "look-up" table is used during the polar night.

3. Generally, a grid overlay is put over the image and the ice is analyzed on a base chart. Lately, a Zoom Transfer Scope has been used in an optical device that stretches and magnifies the image to fit the base chart.

4. AVHRR data began to be used with the launch of TIROS-N.

C. Data consistency

1. Generally, the same individual interprets the satellite imagery for the Alaskan chart. However, instruction is provided for a new interpreter by having him practice on old analyses and having him become familiar with the "ice climatology" of the area.

2. Since a composite chart is being analyzed, several satellite images are utilized. A consistency of break-up or freeze-up or general ice movement therefore can be followed by examining each day's imagery.

3. The previous week's ice analysis is used as a guide for the present analysis. Since ice and clouds can often look similar, the interpreter must know where the ice is located. This helps assure consistency or continuity.

4. The Alaskan ice analysis utilizes high resolution satellite imagery only. The original purpose of the chart was to determine if high resolution satellite imagery would be useful to solve some of the environmental problems of Alaska. Since ice is a problem, an ice analysis was initiated. We still hold to this philosophy, although aerial reconniassance data and frost degree day data are sometimes used, if available.

D. Ground data for remote sensing

Frost degree data have been utilized from stations such as Point Barrow, Nome, and Kotzebue to give a theoretical ice thickness which is then compared with the gray shade of the ice in the satellite image.

Some aerial ice reconnaissances are used to compare the ice concentration derived from satellite.

The degree-day data help us to determine the age of the ice and aerial reconnaissance data aid us in determining the ice edge and ice concentration. However, ground data are used only sparingly.

E. Availability of source data

Type of data	Retention period	Archive location	Contact	Cost
Negatives 9-Track Magnetic Tape -	1-1973 to the present Available on 90-day recall	World Weather Building Room 606	Eugene Hoppe NOAA/EDIS/SDSD World Weather Building Room 606 Washington, DC 20233 (301) 763-8111 or FTS - 763-8111	$3.25 per duplicate negative or print
Prints	1-1974 to the present	World Weather Building	Franklin E. Kniskern World Weather Building Room 510 NOAA/NESS/EPB Washington, DC 20233 (301) 763-8142 or FTS - 763-8142	$3.25 per frame

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Sea Ice Advisory for the Western Alaskan and/or Arctic Alaskan Coastal Waters

Source: U.S. National Weather Service (NWS)

Contact: Bruce D. Webster
U.S. National Weather Service
101 12th Avenue, Box 21
Fairbanks, Alaska 99701
(907) 456-7596

I. Products

A. Description of products

The Sea Ice Advisory covers the Alaskan area, the Bering, Chukchi, and Beaufort Seas out to 180°W in the Bering and Chukchi Seas, and to within 200nmi/371 km of the Arctic Coast of Alaska. The mapping scale is 1:2,500,000m on a Mercator projection. The sea ice advisory began in 1976.

The smallest homogeneous area resolved by the mapping scheme is $\geq .81 km^2$ under typical conditions. No area observed under cloudy conditions. Ice boundaries are accurate to within .9km. The consistency between maps in the identification of the minimum resolvable area is poor under worst conditions and good under typical conditions. The consistency between maps in the accuracy of the plotted boundaries is good.

B. Availability of products

Products are retained indefinitely at the above address and are available at no cost. This is an operational product used on a daily basis and is also disseminated on NWS teletype circuit service C.

C. Use and application of products

1. The principal users are:

Agency	Applications
a. National Weather Service	Wave forecasting, briefing marine interests on sea ice conditions
b. Bering Sea Fisheries	Keeping fishermen apprised of the position of the pack ice edge and short range movement
c. Sea Use Foundation	Ice conditions for Arctic resupply
d. Canada. Ice Forecasting Central	Arctic ice conditions in relation to ice breaker movement

2. The product is also used internally by NWS to monitor the status of near shore pack ice so that the nature of coastal flooding, ice overflow, ice push, etc. will be dealt with more accurately.

   Requests for ice information from the public are also satisfied by the Sea Ice Advisory.

II. Data Sources

A. Data sources and originating agencies

	Agency	Routine	Special
1. Satellite observations	NOAA 5 VHRR Infrared and Visual imagery (available in real time in Fairbanks	X	
	NOAA: Nimbus 6 ESMR data interpreted at the U.S. Navy Fleet Weather Facility, Suitland, Md. Chart arrives in Fairbanks via facsimile	X	
2. Aircraft observations	U.S. National Weather Service		X
	U.S. Navy		X
	Private enterprise		X
	Canadian Government flights		X
3. Ship observations	U.S. Coast Guard	X	
	Various research vessels (National Oceanic and Atmospheric Administration, U.S. Geological Survey, National Marine Fisheries Service	X	
4. Ground observations	U.S. National Weather Service	X	
	Private enterprise contracted to operate Distant Early Warning (DEW) line sites		X

B. Data accuracy

1. Preferential order of data used:

Summer/June-September	Winter-Spring/October-May
Aircraft - amount of data collected depends on cloud cover	Aircraft - preferred but not routine as yet
Satellite - about 50 percent time missing data*	Satellite - about 30 percent time missing data*
Ship - about 20 percent time missing data**	Ship - about 20 percent time missing data**
Coastal	Coastal

* An estimate of the fraction of time cloud cover precludes ice mapping.

** Estimate of the percentage of reporting ships that do not get into the communications system.

2. The procedures used to differentiate between:

   a. Cloud and ice surfaces:

      (1) Comparison of satellite observations from one day to the next to determine changes in cloud patterns; thus, identifying the more stable pattern of sea ice.

      (2) Recognizing the surface features of sea ice as opposed to the character of cloud tops. The former identified by the existence of fractures, leads and, in general, a more uniform appearance than the mottled and puffy appearance of the latter.

      (3) When the sun angle is low, clouds will often project shadows on the underlying ice cover and aid in distinguishing between the two.

      (4) When attempting to discern ice cover through a cloud layer, the features discussed in (2) may be perceptible, or there may be a sharp line delineating an ice edge contrary to the fuzzy borders of a cloud bank.

      (5) Comparing the visual imagery with its infrared counterpart may elucidate the presence of high clouds due to their brighter temperature signature in the infrared display.

      (6) "Blowing up" the visual or infrared imagery to two, three or four times its original size can facilitate the detection of sea ice particularly when trying to analyze ice conditions through the clouds.

      (7) Examining the clarity of the outline of the coast where sea ice lies in close proximity and corroborating surface weather observations, if any, to determine the presence of clouds or fog.

   b. Nilas and water:

      (1) If the nilas are snow covered, there should be little difficulty in distinguishing them from water on the visual imagery. In the case of no snow cover, the presence of nilas is imperceptible. However, a clue to their existence may lie in the presence of streaming bands of stratus or stratocumulus clouds emanating from a point removed from the ice edge during periods of strong cold air advection. Their point of origin could possibly mark the leading edge of nilas or lesser stages of new ice development to the lee of the pack ice edge.

      (2) If the temperature difference between the nilas and water is great enough, then this disparity will be indicated by the contrast in gray shadings on the infrared imagery, The shading of the nilas being a bit brighter than that of the water.

      (3) If the contrast in shadings discussed in (2) is too subtle to be discerned by the human eye, then increasing the number of gray shades over a certain temperature range will increase the contrast. This infrared enhancement could show all ice to appear white (the lowest level of shading) and water to appear black (the highest level of shading).

   c. Open water and surface melt water: differentiable from the NOAA VHRR visual display; open water will appear dark while surface melt water will have a lighter gray shading.

   d. Different ages of sea ice:

      (1) Enhancements of the gray shading on the NOAA VHRR infrared display will delineate the new ice boundary. The new ice will show a much lighter shading than the ice-free water which will appear black.

New ice in its later stages of development, i.e., slush, shuga, light nilas, can be detected on the visual display of the NOAA imagery. New ice in these forms will have a slightly lighter gray shading than the ice-free water, but will show less gray than young ice.

(2) From both the visual and infrared displays of the VHRR imagery, young ice will appear in one form as a dull gray homogeneous mass. This is particularly noticeable on the lee side of islands in the Bering Sea, Nunivak, St. Matthews, and St. Lawrence Islands, during midwinter when strong northerlies create shore polynyas and there is a continuous process of refreezing within them. During these same periods of strong northerly flow, the southern pack ice edge in the Bering Sea will have fingers of ice pointing southward. These appendages, normal to the ice edge, are young pack ice and will have slightly darker gray shading than the main pack. Young ice will also take the form of belts and strips and will have a darker gray shading on both the visual and infrared in contrast to brightness of the older ice.

(3) First year ice in the Bering Sea is discernible by the presence of ice floes and their bright thermal signature in the infrared. Differentiation between first and multiyear ice in the Beaufort Sea has not been attempted during midwinter. However, during the melt season on the Arctic Slope, first-year ice appears much darker than the polar pack.

3. The identification of different ice forms along the Alaskan Arctic coast has improved due to the corroboration of satellite data with aerial reconnaissance (visual). Procedures have remained static in the Bering Sea due to the lack of ground truth.

4. The polar night cutoff occurs when ice can no longer be seen on visual imagery; IR imagery is then used.

5. Some changes in data sources are possible. One is the use of TIROS N AVHRR imagery. The other is proposed routine SLAR reconnaissance of the Bering Sea pack ice edge in support of winter-time fishing and crabbing.

C. Data consistency

Consistency in interpretation is checked by occasional comparison with ice analyses prepared by the Fleet Weather Facility. Significant differences are discussed. The satellite imagery is compared with aerial reconnaissance, ship, and shore reports. Taking into account the resolution of the satellite, there is agreement between ground truth data, including aerial observations, and the satellite imagery. During cloudy periods, ice analyses based only on ESMR data are not representative of the ice conditions due to the coarse resolution of the data.

Beaufort and Chukchi Near-Shore Sea Ice Conditions

Source: Institute of Arctic and Alpine Research (INSTAAR)

Contact: Dr. R.G. Barry
Institute of Arctic and Alpine Research
University of Colorado
Boulder, Colorado 80309
(303) 492-6387

I. Products

A. Description of products

1. Maps depicting ice conditions in the Beaufort and Chukchi Seas have been prepared from satellite data for the period 1973-1977. The maps are on a universal transverse Mercator projection at a scale of 1:1,000,000 and cover the Beaufort and Chukchi Seas, 142°W to 168°W and 64°N-72°N. Boundaries are accurate to less than 1km under typical conditions. The consistency between maps in the accuracy of the boundaries and the identification of the maximum resolvable area, 10,000m^2, is good.

2. Charted features

classes of ice concentration	classes of age and type of ice	minimum area that can be recognized		accuracy
		typical conditions	worst conditions	
0/10-1/10 open	pack ice	1-2km across	1km across	
2/10-3/10 open w/floes	ridges	1-2km across	1km across	
4/10-6/10	grounded features	none	1-2km	Difficult to discern without ground truth
7/10-8/10	multiyear ice	none	1-2km across	
9/10-10/10 consolidated ice	fast ice	<80m	<80m	
	puddled ice	1-2km	1-2km	
Accuracy is ± 1/10	open water	<80m	<80m	

classes of melt features	minimum area that can be recognized		accuracy
	typical conditions	worst conditions	
flooded ice	2-3 km^2	several km^2	± 1/2 - 1 km^2
puddled ice	<1 km^2	1-2 km^2	
rotten ice	<1 km^2	1 km^2	
open water	$10^4 m^2$	<1 km^2	

B. Availability of products

Ice maps and associated research reports are available from Dr. R.G. Barry at the above address.

C. Use and application of products

The maps have been used internally for research conducted under the NOAA/Bureau of Land Management Offshore Continental Shelf Environmental Assessment Program.

II. Data Sources

A. Data sources and originating agencies

1. U.S. Geological Survey, EROS Data Center: Landsat data. Generally, one frame per month for each grid area.

2. INSTAAR: aircraft observation, six flights per month in June 1976 and 1977.

B. Data accuracy

1. A comparison of different bands was used to discriminate between clouds and snow/ice surface and between open water and surface meltwater.

2. A comparison of bands 4 and 7 was used to differentiate between nilas and open water.

3. Different ages of ice could only be differentiated with ground truth data.

4. Mapping of the stationary fast ice was the primary concern. Ground truth from mid-June could be used to check Landsat data for May, June, and sometimes July.

C. Data consistency

Interpreters changed over time but with sufficient overlap to enable techniques to be passed on from one interpreter to another.

D. Availability of source data

Landsat frames are available from EROS Data Center, U.S. Geological Survey, Sioux Falls, South Dakota, 57198, USA.

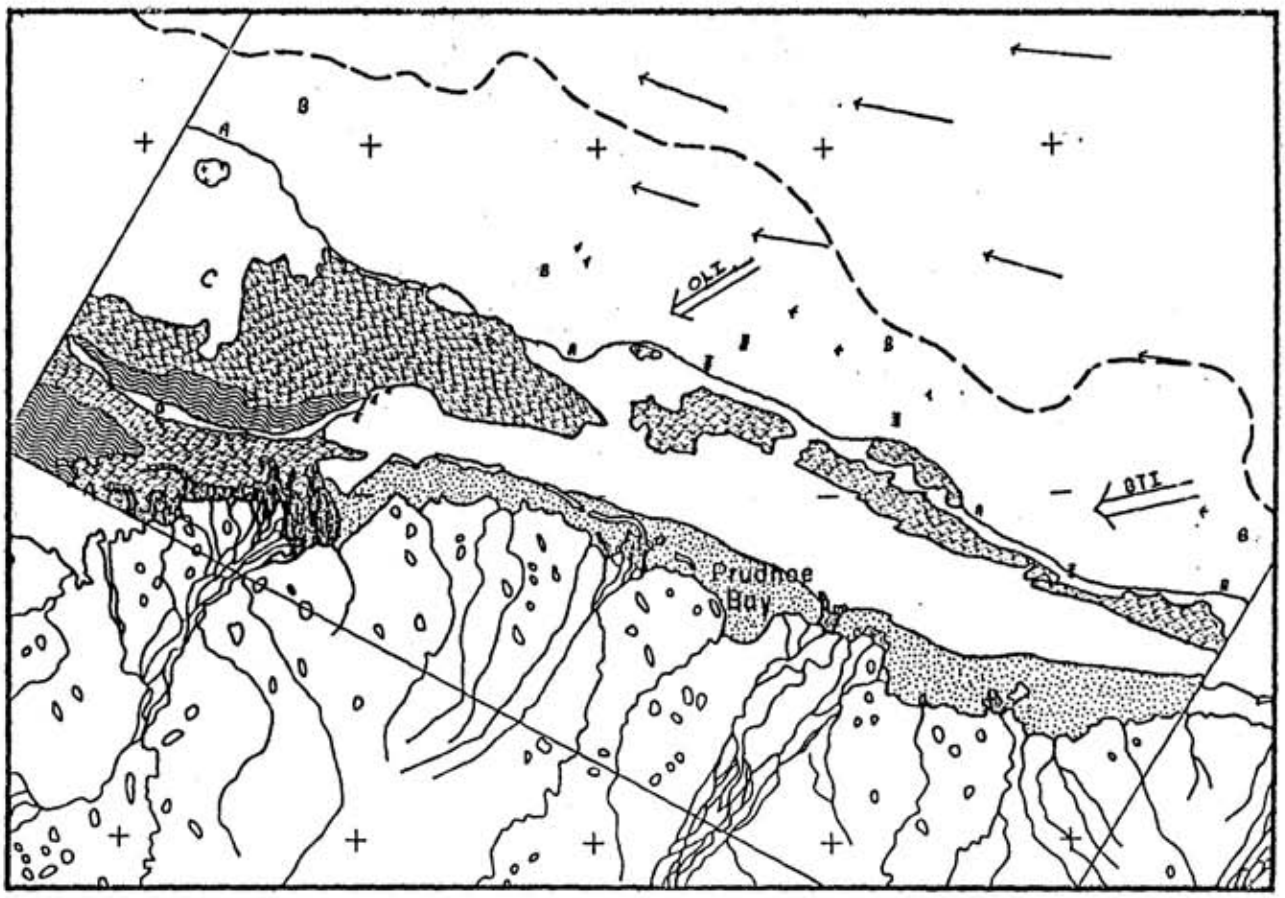

Figure 1. Shorefast sea ice surface morphological characteristics, Beaufort Sea coast, Prudhoe sector, 26 June 1974.

26 JUNE, 1974: SCENE 1703-21151

THE CONTINUOUS ICE LIMIT (A) HAS BEEN EXTENDED WEST INTO OUTER HARRISON BAY. NO MOTIONS COULD BE DETECTED WITHIN THE 25 JUNE CONTINUOUS ICE LIMIT. PACK ICE (B) REMAINED COMPACTED AGAINST THE CONTINUOUS ICE EDGE. PACK ICE DISPLACEMENTS IN THE TIME INTERVAL 25-26 JUNE ARE SHOWN ON THE MAP AS SOLID ARROWS. THE "≠ " SYMBOL DENOTES A "NO MOTION" CONDITION AT A PARTICULAR POINT. THE SHEAR ZONE IS CLEARLY NOT LOCATED AT THE EDGE OF CONTINUOUS ICE BUT RATHER SOME 15-20 KM SEAWARD OF IT. THE PREVAILING WIND DIRECTIONS FOR 25 JUNE AT BARTER ISLAND AND OLIKTOK ARE SHOWN AS DOUBLE ARROWS (BTI AND OLI, RESPECTIVELY). THEIR RESPECTIVE MAGNITUDES WERE 5.7 and 6.2 M/SEC. THE ICE DRIFT BEYOND THE SHEAR ZONE AGREED VERY WELL WITH EXPECTATIONS BASED ON ZUBOV'S RULE (ICE DRIFTS AT 1/30TH TO 1/50TH THE WIND SPEED AND AT AN ANGLE OF ABOUT 30° TO THE RIGHT OF THE WIND). THE PLOTTED VECTORS BEYOND THE SHEAR ZONE ARE BETWEEN 1/35TH AND 1/50TH OF THE WIND SPEED AND 30 TO 40° TO THE RIGHT. NEAR-SHORE ICE BETWEEN OLIKTOK AND THE EASTERN EDGE OF THE MAP REMAINED SIMILAR TO THE PREVIOUS DAY EXCEPT THAT THE ICE BETWEEN PRUDHOE BAY AND THE KUPARUK RIVER DELTA APPEARS TO HAVE DRAINED. THIS IS INDICATED ON THE LANDSAT DATA BY THE DISAPPEARANCE OF THE DRAINAGE CRACKS AS WELL AS BY A RELATIVE LIGHTENING IN TONE. THE NEWLY-IMAGED AREAS IN HARRISON BAY EXHIBIT SEVERAL INTERESTING CHARACTERISTICS. FOREMOST IS THE PRESENCE OF A LARGE GROUNDED ICE MASS AT N70°58', W150°42'. THE SEAWARD "PUDDLING 3" BELT OF 25 JUNE TERMINATES IN EASTERN HARRISON BAY AT A BOUNDARY WITH MUCH LIGHTER ICE, SSE OF THE LARGE GROUNDED MASS. THE LIGHTER ICE HERE HAS A TEXTURE ON LANDSAT INDICATING A GREAT NUMBER OF LIGHT-TONED FLOE-LIKE ICE PIECES EMBEDDED IN A SLIGHTLY DARKER MATRIX OF ICE. ANALYSIS OF THE COLOR INFRARED PHOTOGRAPHY FROM 21 JUNE AND APRIL SLAR IMAGERY IN THIS REGION LEADS US TO CONCLUDE THAT THE EASTERN PORTION OF THIS ICE ("C") CONSISTS OF 2ND- AND/OR MULTI-YEAR ICE FLOES, VARYING FROM SMALL TO VAST FLOE SIZE, AND EMBEDDED IN A 1ST-YEAR ICE MATRIX. SHOREWARD OF THIS ICE, A CRESCENT-SHAPED BELT OF VERY DARK TONE EXTENDS ACROSS THE BAY (DESIGNATED "PUDDLING 4" ON MAP). THE SLAR IMAGERY SHOWS THIS TO BE RELATIVELY FLAT, UNDEFORMED ICE. SHOREWARD OF THIS BELT IS A SECOND ARCUATE ICE AREA OF LIGHTER TONE("D"), WHICH HAS MODERATELY DEFORMED ICE WITH POORER PUDDLING DEVELOPMENT ON 26 JUNE. THE BOUNDARY AREA ("E") TO THE EAST OF THESE BELTS CONTAINS SEVERAL PROMINENT RIDGES AND A NUMBER OF HEAVILY-HUMMOCKED AREAS. MODERATE TO HEAVY PUDDLING CONDITIONS EXIST ON THE REMAINING HARRISON BAY ICE, UP TO THE COLVILLE MOUTH AREA, WHERE OPEN WATER HAS EXTENDED OUT FROM THE DELTA.

Description of figure 1.

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Snow and Ice Project Research Reports

Source: Environmental Research and Technology, Inc.

Contact: James C. Barnes
Environmental Research and Technology, Inc.
696 Virginia Road
Concord, Massachusetts 01742
(617) 369-8910

I. Products

A. Description of products

The products are research reports produced under contract to the government or private industry. Snow and ice maps described below are produced for inclusion in these reports but are not generated on a routine basis.

1. Snow

   a. Maps, usually at 1:1,000,000, some at 1:250,000, on universal transverse Mercator or Mercator projection are produced for various test sites within the United States, for example, the Sierras in California.

   b. The time interval between successive products varies with the type of satellite data used. Under typical conditions, the smallest homogeneous area that the mapping system resolves, using Landsat, is ≈80 meters. The plotted snow boundaries are accurate to within 1km using VHRR, and somewhat better using Landsat. The consistency between maps in the identification of the minimum resolvable area, and the accuracy of the boundaries, is excellent under typical conditions.

   c. Charted features.

      Snow features charted include: snow reflectivity; snow depth - some definition up to about 10cm depth depending on vegetation. Depths greater than 10cm cannot be broken down into further categories; melting snow contrasted with dry snow in near IR; snow surface temperature in thermal IR.

2. Ice

   a. For various Arctic regions, sea ice is mapped at scales from 1:5,000,000 to 1:1,000,000 on a polar stereographic projection.

   b. Charted features.

      Ice features charted include:

      1. Ice concentration, all WMO classes, from Landsat. The minimum area recognised is about 80 meters with an accuracy of ±80 meters.

      2. Various categories of first-year ice. Multiyear ice can only be distinguished with a knowledge of the past history and other information.

      3. Ice thickness, 0-10cm, 10-20cm, 20-50cm, >70cm, estimated qualitatively, based on brightness and knowledge of the ice climatology.

      4. Size of floes--down to 20-100 meters.

      5. Other features - puddled and flooded ice, shore fast ice, icebergs, leads and fracture patterns, polynyas, ice edge characteristics.

B. Availability of products

Reports to private industry are not generally available to the public, although provision can be made to purchase these in certain circumstances. Reports produced under contract to the government are available. For further information contact J.C. Barnes at the above address.

C. Use and application of products

Principal users include NOAA/NESS and NASA.

The oil industry is also a significant user of the ice reports. Much of the recent ice work has involved the development of sea ice climatologies in various Arctic regions, using satellite data. These reports are confidential to the sponsoring companies, so are not available in the public domain. Products are also used internally for research.

II. Data Sources

A. Data sources and originating agencies

1. Snow

   a. Weekly Weather and Crop Bulletin. Snow Chart

   b. U.S. National Weather Service. Station reports

   c. U.S. National Weather Service. Snow surveys

   d. California Department of Water Resources. California Cooperative Snow Survey reports

   e. Salt River Project Office. Arizona Aerial Survey Maps for Salt-Verde Watershed

   f. NOAA. EDIS. NOAA state climate summaries

   g. NOAA. Satellite Data Service. Various types of satellite data

   Preferential order of data used: satellite, aerial, surface (truth).

2. Ice

   a. NOAA/NESS. Northern Hemisphere Average Snow and Ice Boundaries

   b. U.S. Navy. Fleet Weather Facility. Southern Ice Limit in Arctic and Northern Ice Limit in Antarctic

   c. British Meteorological Office. Monthly ice charts

   d. Environment Canada. Ice Summary and Analysis

   e. Environment Canada. Historical Ice Charts

   f. Environment Canada. Ice Conditions (weekly)

   g. Danske Meteorologiske Institut. Ice Conditions in Greenland Waters

   (Some of the above are acquired for specific projects and are not used routinely.)

   h. NOAA. Satellite Data Services. Various types of satellite data

   Preferential order of data used: satellite, other.

B. Data accuracy

For both snow and ice projects, methods and reliability of interpretation have increased with newer types of satellite data. The satellite data are correlated with both aerial survey and ground truth.

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Northeast Atlantic Ice Charts

Source: Det Norske Meteorologiske Institutt

Contact: Eilert Theisen
Det Norske Meteorologiske Institutt
Postboks 320
Blindern, Oslo 3
Norway

I. Products

A. Description of products

1. Since 1970, the Norske Meteorologiske Institutt has produced ice charts of the Arctic between 30°W and 60°E. These charts are produced every three to four days on a polar stereographic projection at a scale of 1:10,000,000.

2. Charted features

   a. classes of ice concentration in oktas
   b. fast ice
   c. sea surface temperature in the area not covered by ice
   d. sea surface temperatures from ship and land stations.

B. Availability of products

The charts are available on 22 by 33cm paper from the Norske Meteorologiske Institutt.

C. Use and application of products

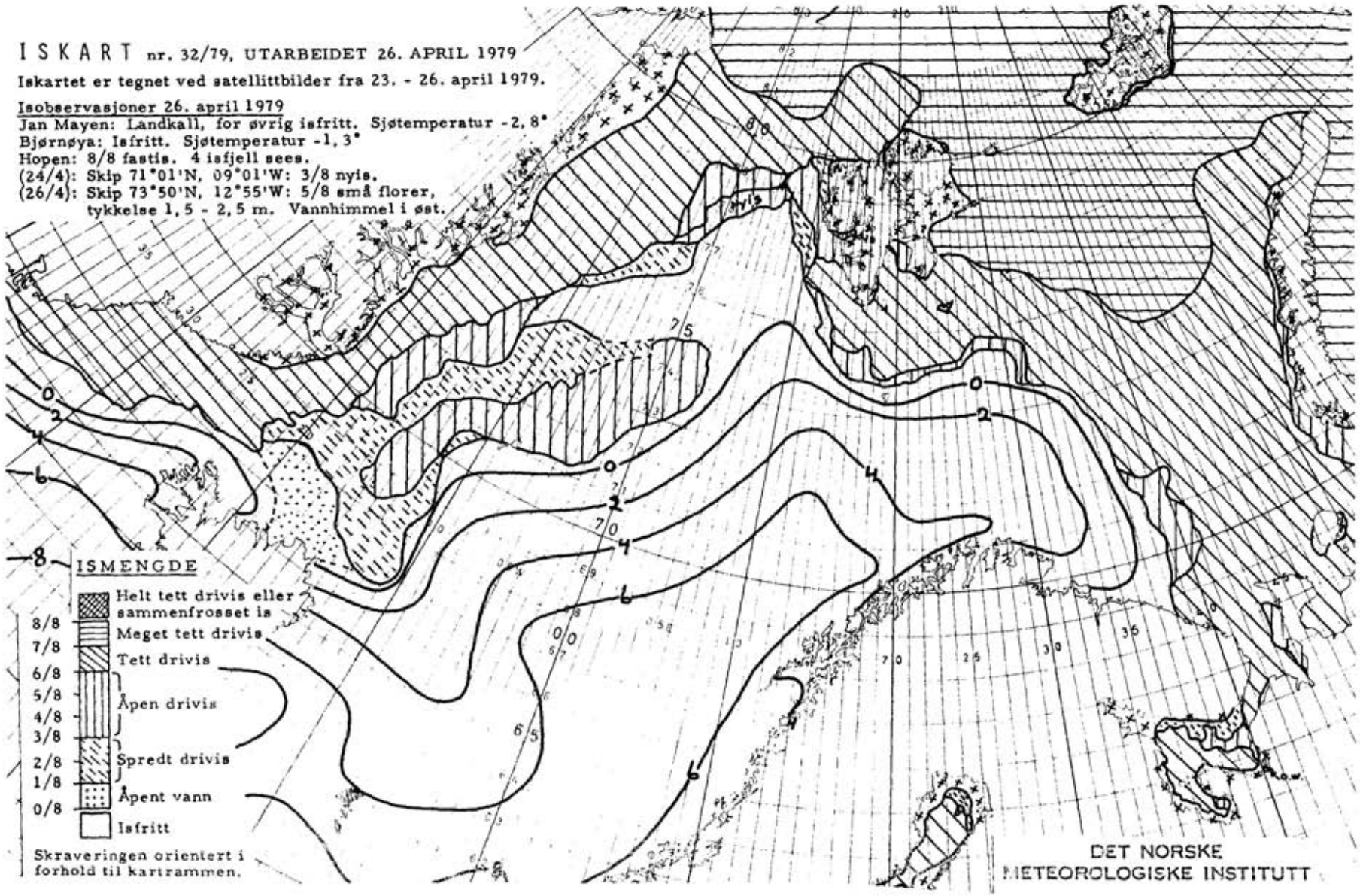
1. The charts are used principally to answer questions concerning ice navigation by a variety of commercial operations as well as by the Navy.

2. Internally, the charts are used for weather forecasting and research.

II. Data Sources

A. Data sources and originating agencies

	Agency	Routine	Special
1. Satellite observations	U.S.A. Satellites ESSA, later NOAA, TIROS. The images are received from satellites at Det Norske Meteorologiske Institutt	X	
2. Aircraft observations	1) Reconnaissance flights in the Svalbard area and Barents Sea		Approximately one monthly
	2) Reports from commercial airplanes	X	
3. Ship observations	Norwegian and other ships		X
4. Ground observations	Jan Mayen (70°56'N, 08°40'W)	X daily	
	Bjørnøya (74°31'N, 19°01'E)	X daily	
	Hopen (76°30'N, 25°04'E)	X daily	


ISKART nr. 32/79, UTARBEIDET 26. APRIL 1979
Iskartet er tegnet ved satellittbilder fra 23. - 26. april 1979.
Isobservasjoner 26. april 1979
Jan Mayen: Landkall, for øvrig isfritt. Sjøtemperatur -2,8°
Bjørnøya: Isfritt. Sjøtemperatur -1,3°
Hopen: 8/8 fastis. 4 isfjell sees.
(24/4): Skip 71°01'N, 09°01'W: 3/8 nyis.
(26/4): Skip 73°50'N, 12°55'W: 5/8 små florer,
tykkelse 1,5 - 2,5 m. Vannhimmel i øst.
ISMENGDE
8/8
7/8
6/8
5/8
4/8
3/8
2/8
1/8
0/8
Helt tett drivis eller sammenfrosset is
Meget tett drivis
Tett drivis
Åpen drivis
Spredt drivis
Åpent vann
Isfritt
Skraveringen orientert i forhold til kartrammen.
DET NORSKE METEOROLOGISKE INSTITUTT

Data accuracy

1. The ice charts are mean charts for 3 or 4 days, drawn mainly from satellite pictures. As a comparison test, we used observations from land stations, reconnaissance flights, and observations from commercial airplanes and ships.

2. The procedures used to differentiate between:

   a. Cloud and ice surfaces: Structure and temperature.

   b. Nilas and water: This is very difficult as we have no microwave pictures. If there is a good possibility, based on our meteorological and oceanographical charts, we look for a window. If we see from our meteorological charts that there has been snow, it is rather easy to differentiate.

   c. Open water and surface melt water: Melt water occurs mainly in the summer when visual pictures are used. Then it is not difficult to differentiate.

   d. Different ages of ice cover: Impossible from satellite pictures. We only have observations from 3 ground stations and a few ships.

C. Data consistency

Instruction in ice observation at our ground stations is given each summer when a new crew comes to the arctic stations. The observations are sent in the "Working Group on Sea Ice Ice-Observations Code" which gives possibilities for cross-checking. No other direct check is made.

D. Ground data for remote sensing

1. Observations are made at three ground stations and from ship and aircraft of: (1) snow depth on the ice (2) ice thickness (3) ice concentration (4) presence/absence of snow cover on ice.

2. The main purposes of our ice charts is to give ice boundaries and the ice edge on the open sea. An error of a few nautical miles is not very important. We find our ground data effective and useful.

E. Availability of source data

Ice observations from the three land stations and occasionally from ships are available from the Norske Meteorologiske Institutt to interested scientists.

Table 1. Type of data method of collection for data source(s)

Time Period		Remote Sensing System						Ground Observations		Other types of data	Resolution of data
from	to	Sensor platform	Sensor type	Spectral region	Number of images used at one point per time interval mapped			Approximate size of sample from which means are obtained for each map			
					Average	Range max.	Range min.	Number of observing points	Frequency		
1970	1973	ESSA 7-8									APT
	1978	NOAA 3-5	APT since 1977 VHRR	visual summer IR winter	9	12	6				APT since 1977, also VHRR
1978	now	TIROS 1		"	16						
1970	indef-inite	commercial aircraft visually or by radar						a 180° sector from station so far as the observer can see. 3	each station each day		
1970	indef-inite	commercial aircraft visually or by radar								between Iceland and Jan Mayen twice weekly	
1970	indef-inite	reconnaissance flights, visually or by radar								Iceland area and in the Svalbard-Barents Sea area sporadic	

Sea Ice and Drift Speed Observations (Svalbard Area)

Norsk Polarinstitutt

Torgny G. Vinje
Norsk Polarinstitutt
Rolfstangveien 12
1330 Oslo Lufthavn
Norway
(02) 123650

I. Products

Description of products

Maps are produced showing ice concentration in oktas at the end of each month, for the area between longitude 30°W and 60° to 70°E. The maps, and a brief description of ice conditions for each year, are published in the Norsk Polarinstitutt. Årbok.

Availability of products

Annual sea ice reviews and special reports for the period 1969 - present are available on request to Dr. T. Vinje at the above address.

II. Data Sources

Principal data sources are NASA (NIMBUS) satellite observations, satellite tracked buoys, and Landsat data. Satellite-derived data are checked against ship observations where available.

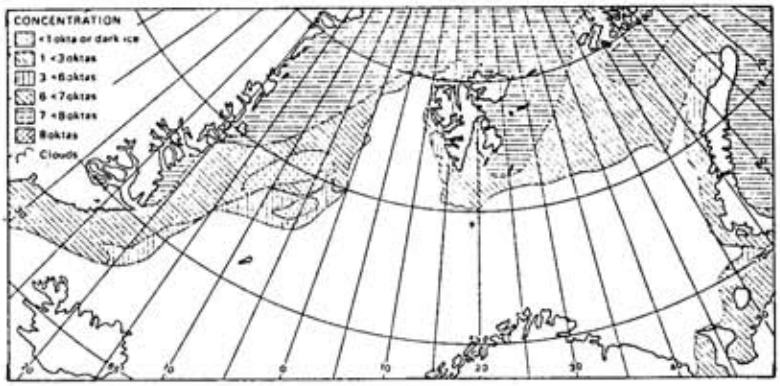


Figure 1. Sea ice distribution at the end of January.

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Baltic Ice Bulletin and Ice Chart

Source: Institute of Marine Research

Contact: Hannu Grönvall
Institute of Marine Research
PB 166 00141
Helsinki 14, Finland

I. Products

A. Description of products

Table 1. Products

Name of product	Retention period	Contact
Ice bulletin	November 1 to May 31	Hannu Grönvall Institute of Marine Research PB 166 00141 Helsinki 14, Finland Phone 651 566
Ice chart	October 15 to May 31	
including water temperatures	Since 1920	
Ice chart in digitized form in gridpoints on magnetic tape	1963-64 1965-66 1967-68 1971-72 1972-73 1973-74 1975-76 1977-78	Matti Leppäranta Institute of Marine Research PB 166 00141 Helsinki 14, Finland Phone 651 566

1. The ice charts cover the Baltic Sea on a polar stereographic projection.

2. The smallest homogeneous area resolved by the mapping system is $10nm^2$/ $18.52km^2$ under worst conditions and $5nm^2/9.26km^2$ under typical conditions.

3. Charted features

classes of ice concentration	mimimum area that can be recognized		accuracy
	typical conditions	worst conditions	
in tenths	$10nm^2/18.52km^2$	$15nm^2/27.78km^2$	$\pm$ 1
classes of ice thickness	classes of ridging		
0-5cm 5-10cm 10-15cm	heavy light no		

B. Availability of products

The products are available as charts and also on magnetic tape. Digital data are available for the winters of 1963/1964 to the present.

C. Use and application of products

The ice charts are used by the Finnish Board of Navigation and the Institute of Marine Research to direct winter sea traffic. The data are also used in research to develop methods for sea ice forecasting.

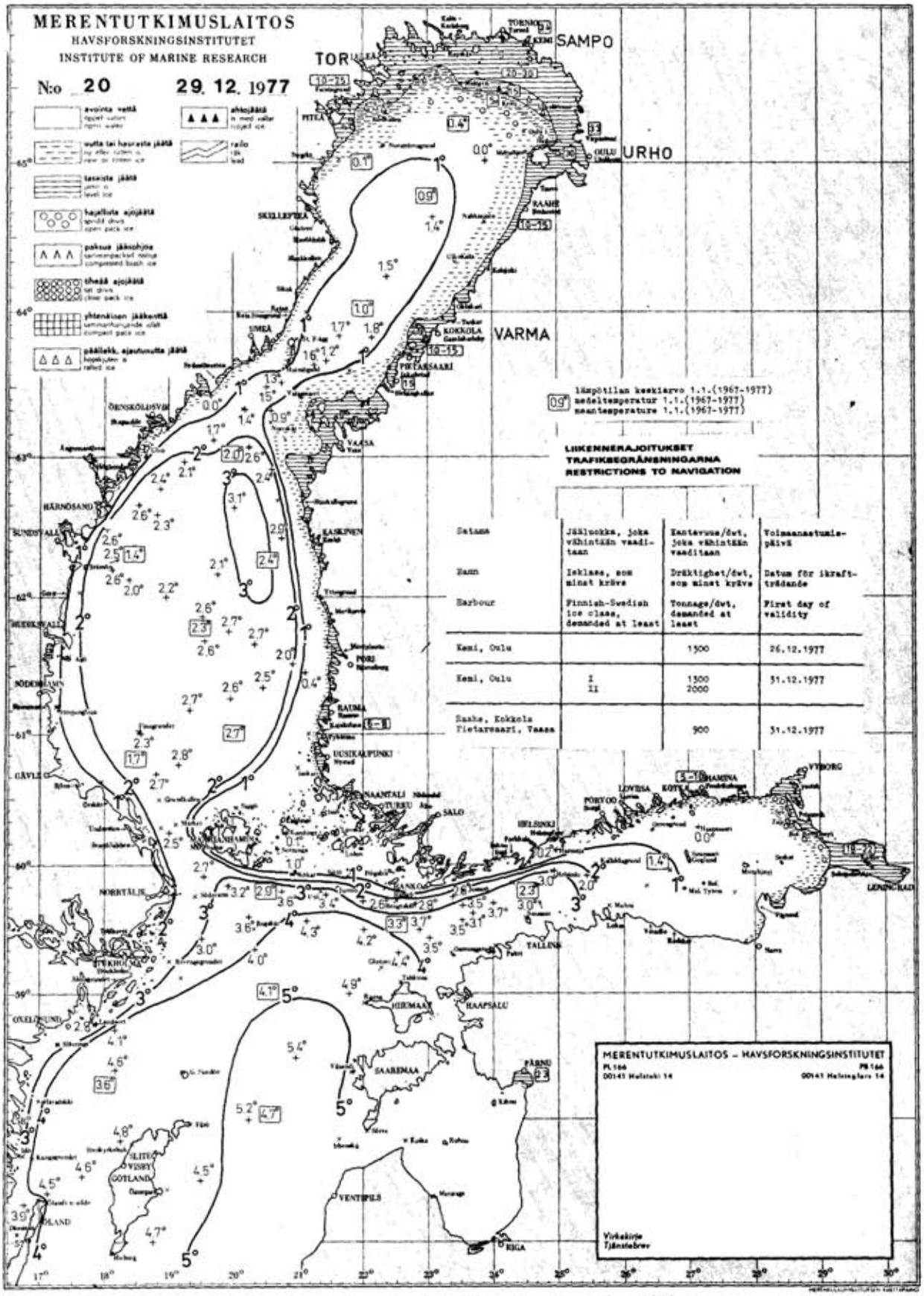

Figure 1. Finnish Institute of Marine Research ice report for 29 December 1979.

II. Data Sources

A. Data sources and originating agencies

1. Data from both U.S. and USSR satellites are used when available, as well as aircraft observations in all Finnish sea areas.

2. Data are also reported from icebreakers and some merchant ships and from a network of 40 stations along the coast.

B. Data consistency

To insure consistency in reporting on ice conditions in the Baltic, Finnish data are checked with data from Sweden and other Baltic countries.

C. Availability of source data

Data are available on 35mm microfilm from about 1880. They are not yet digitized, but could be. They are available from the Institute of Marine Research.

Reference

Uusitalo, S. et al. (In press). Data bank for sea ice conditions and sea surface temperature in the Baltic Sea. Finland. Navigation Research Board. Research Report Series.

Great Lakes Ice Cover Charts

Source: U.S. National Oceanic and Atmospheric Administration. Great Lakes Environmental Research Laboratory.

Contact: R.A. Assel
Great Lakes Environmental Research Laboratory
NOAA, ERL
2300 Washtenaw Avenue
Ann Arbor, Michigan 48104
U.S.A.
(313) 668-2264; FTS 378-2264

I. Products

A. Description of products

1. Great Lakes Environmental Research Laboratory (GLERL) produces ice charts of the Great Lakes, 41°-49°N, 76°-92°W, at varying scales from 1:400,000 to 1:3,000,000 published in the NOAA Technical Memorandum series (table 1.) A polyconic projection is normally used, except for charts from the Atmospheric Environment Service of Canada which use a Lambert conformal projection.

Table 1. Great Lakes ice cover series

		NTIS Number
1.	Great Lakes Ice Cover 1962-63 and 1963-64	AD-695 639
2.	Great Lakes Ice Cover 1964-65	
3.	Great Lakes Ice Cover 1965-66	AD-658 227
4.	Great Lakes Ice Cover 1966-67	AD-666 223
5.	Great Lakes Ice Cover 1967-68	AD-685 846
6.	Great Lakes Ice Cover 1968-69	COM-72-10197
7.	Great Lakes Ice Cover 1969-70	COM-72-10917
8.	Great Lakes Ice Cover 1970-71	COM-73-11023
9.	Great Lakes Ice Cover 1971-72	COM-73-11746/7
10.	Great Lakes Ice Cover 1972-73	COM-74-11822
11.	Great Lakes Ice Cover 1973-74	COM-75-10981
12.	Great Lakes Ice Cover 1974-75	PB-261 833
13.	Great Lakes Ice Cover Winter 1975-76	PB-271 255
14.	Summary of Great Lakes Weather and Ice Conditions 1976-77	
15.	Summary of Great Lakes Weather and Ice Conditions 1977-78 (in press)	
16.	Summary of Great Lakes Weather and Ice Conditions 1978-79 (planned)	

2. GLERL also produces reports containing information on Great Lakes ice cover (see References).

3. Charted features

classes of ice concentration	minimum area that can be recognized		accuracy
0 - 10 in tenths	typical conditions	worst conditions	± 1 class
	≤ 4km²	≥ 25km²	
classes of age + and type of ice			
thin (0-15cm) medium (15-30cm) thick (30-70cm) very thick (70cm)	≤ 4km²	≥ 25km²	± 2 classes
+ currently being used			

4. Floe size and ridges are plotted; the classes vary with the data source.

5. All historical Great Lakes ice charts are being digitized by lake. When complete, the data base will include ice charts for 1960 through 1977. The digital data will have a resolution of 5km and will include ice age and ice concentration, to the nearest 10 percent. It is anticipated that digitization will be completed by the end of 1980.

B. Availability of products

GLERL publications are available from NTIS[+] as indicated, GLERL, or the World Data Center-A for Glaciology (Snow and Ice).

C. Use and application of products

The products are used to describe and document the annual ice cycle on the Great Lakes and will be used to revise the current Great Lakes ice cover climatology.

II. Data Sources

A. Data sources and originating agencies

1. Satellite observations: NOAA/NESS

2. Aircraft observations: a. visual - U.S. Coast Guard, Environment Canada; b. SLAR - U.S. Coast Guard.

Table 2. Type of data method of collection for your data source(s)

Time period		Remote sensing system			Resolution of data
from	to	Sensor platform	Sensor type	Spectral region	
1972	1976	ERTS-LANDSAT	MSS	VIS & IR	80 m
1972	1976	NOAA-2, NOAA-3, NOAA-4, NOAA-5, NOAA-6	HRR	VIS & IR	1 km
1963	1976	Visual reconnaissance made by Lake Survey Center and/or Great Lakes Environmental Research Laboratory			
1959	present	Canadian visual reconnaissance			
1970	present	U.S. Coast Guard visual reconnaissance			
1973	present	Side Looking Airborne Radar - U.S. Coast Guard			

B. Data accuracy

Differentiation between snow and ice surfaces on the satellite data is checked by comparison with other data sources; i.e., visual reconnaissance and SLAR. Differentiation between nilas and water, open water and surface meltwater, and between different ages of ice is made by visual reconnaissance.

[+]NTIS
National Technical Information Service
U.S. Department of Commerce
Springfield, VA 22161

C. Data consistency

Consistency in the source data is verified by cross-checking with other data sources. Visual observations are considered to be the most reliable and are used to check other data sources for consistency and accuracy. SLAR is also used as a cross-check on the satellite data.

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Depth of Snow on the Ground for the United States

Source: Weekly Weather and Crop Bulletin

Contact: D. Haddock
Agricultural Weather Facility
USDA South Building, Room 1248
Washington, DC 20250
(202) 447-7917

I. Products

A. Description of products

The Environmental Data and Information Service of NOAA and the Economics, Statistics and Cooperatives Service of the U.S. Department of Agriculture provide data on depth of snow on the ground in the United States on a weekly basis during the months of December through March. The data, in inches, are given for each Monday during this period at 12 Noon G.m.t.

The chart has appeared in the Weekly Weather and Crop Bulletin since 1935.

B. Availability of product

The Weekly Weather and Crop Bulletin is retained permenantly at the above address and is available on request. The annual subscription cost is $13.

II. Data Sources

Data displayed on the chart are derived surface observations from a network of 10,000 stations comprised of the National Weather Service and cooperative stations.

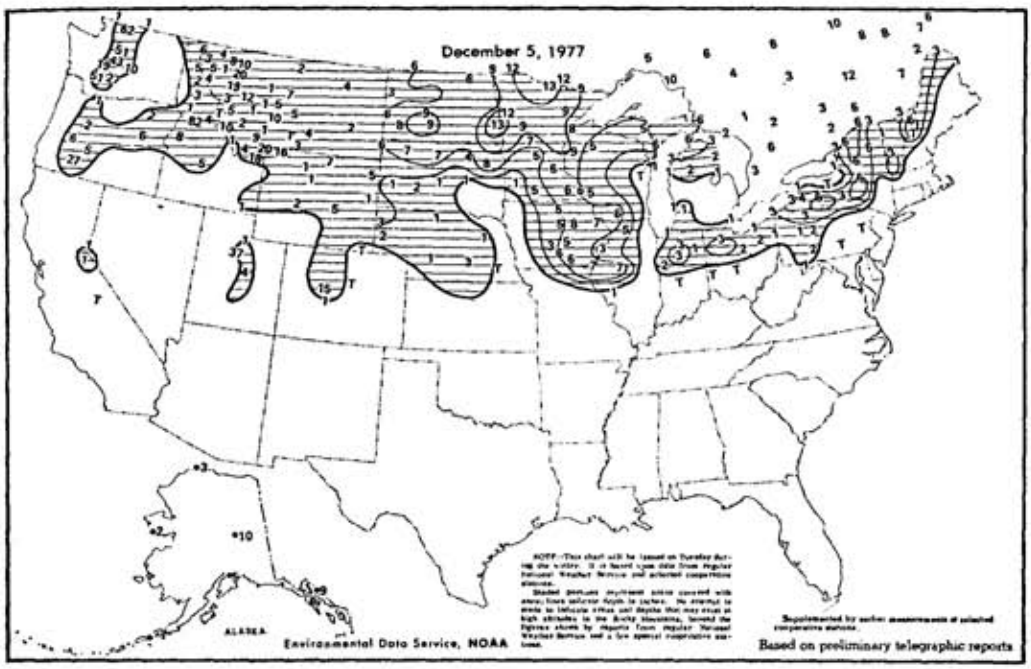

Figure 1. Depth of snow on the ground (inches).

Snow Cover Data for Canada

Source: Atmospheric Environment Service (AES)

Contact: B. Findlay/T.R. Allsopp/B.E. Goodison
4905 Dufferin Street
Downsview
Ontario M3M 5T4 Canada
(416) 667-4625 (B.F.)
667-4825 (T.R.A.)
667-4954 (B.E.G.)

I. Products

A. Description of products

1. Snow Cover Data for Canada is published monthly with information on snow depth and water equivalent from river basin and snow course data.

2. Subjective mapping is carried out based on station reports. Maps are produced weekly for the Dominion of Canada. Mapping is at a scale of 1:5,000,000; published at 1:10,000,000 or smaller, on a modified equal-area projection based in part on a Lambert conic conformal or a pure Lambert conic conformal with standard parallels at 49°N and 77°N.

3. Charted features

snow depth classes	minimum area that can be recognized		accuracy
	typical conditions	worst conditions	
30 cm (60 cm in mountains) standard deviations 20 cm time of occurrence 30 days	100 km^2	2500 km^2 (mountains)	estimate within 1 class interval
other features mapped			
dates of formation and loss of snow cover			
20 day interval standard deviation 5 day	100 km^2	2500 km^2 (mountains)	$\pm$ 1 class $\pm$ 1 class
snow cover measurement networks	100 km^2		$\pm$ 100 km^2
snowfall (precipitation) networks	100 km^2		$\pm$ 100 km^2

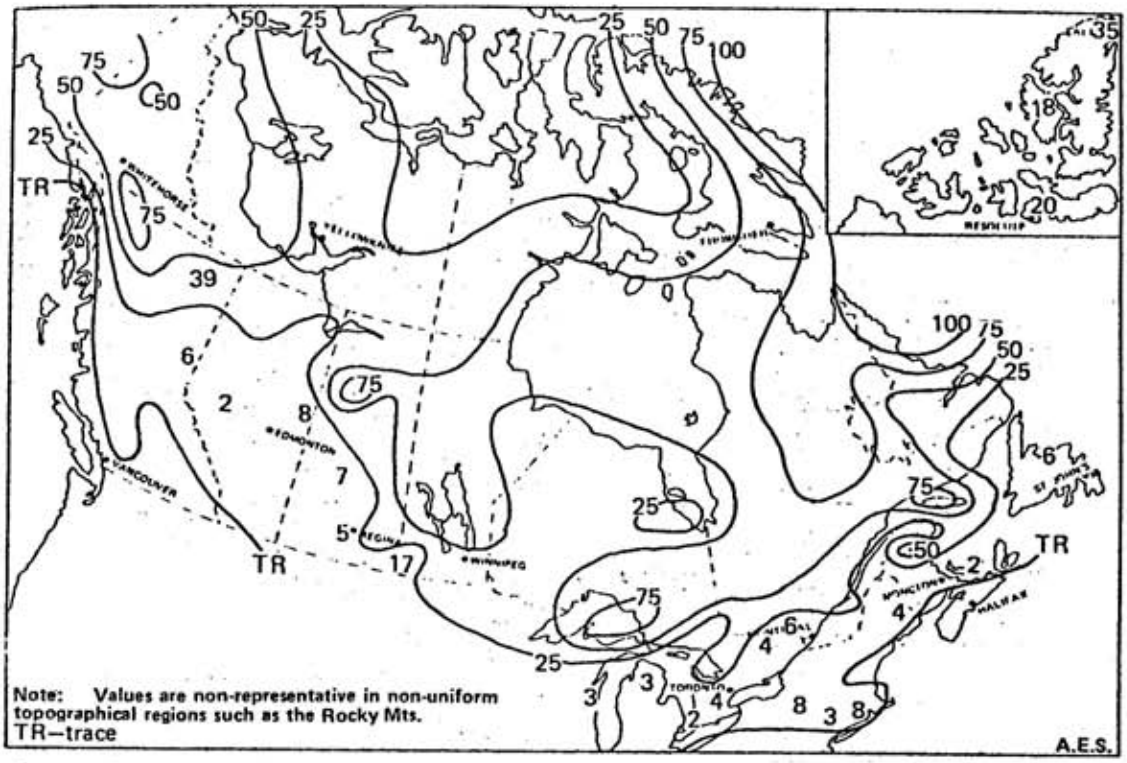

Figure 1. Snow depth on the ground (cm) on 9 April 1979.

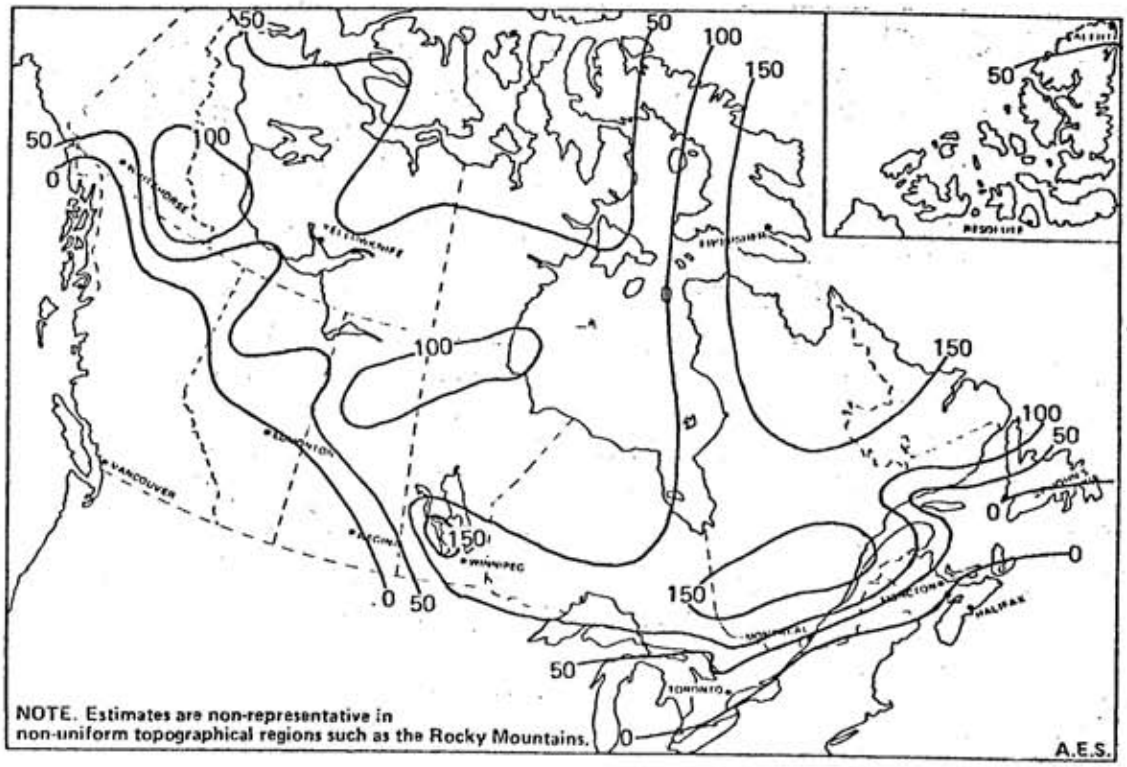

Figure 2. Estimate of the water equivalent (mm) of the snow pack on 9 April 1979.

4. A new publication, Climatic Perspectives, has been introduced. This includes a map of snow on the ground and the water equivalent of the snowpack, plus maps of temperature, precipitation, and heating degree days. This is published weekly. The first issue appeared in February 1979.

5. AES also plans to produce a 10-year atlas based on archived charts and to produce maps similar to the Hydrological Atlas collection on a provincial scale, (scale 1:2,000,000). This has been started for Newfoundland and British Columbia.

B. Availability of products

Name of product	Retention period	Archive location	Contact	Cost
1. Snow Cover Data Canada (publication)	indefinite	Toronto	AES Climate Information (416) 667-4614	$1.00
Raw data				
2. Snowfall	"	"	"	
3. Snow on ground at meteorological stations	"	"	"	
4. Snow course data - AES courses	"	"	"	
other agencies	"	various	see publication Snow Cover Data Canada for names	
5. NOAA 5 and GOES satellite data	"	Toronto	AES Satellite Laboratory (416) 667-4813	
6. Paper/Publications - misc.			contact author	
7. Climatic Perspectives			AES Climate Monitoring and Prediction Division T.R. Allsopp (416-667-4825)	

Data are also available on original record sheets, computer lists, 16mm microfilm, microfiche, and 9 track tape.

These products will be produced indefinitely and are available to interested scientists.

C. Use and application of products

Principal users are the Water Survey of Canada for flood forecasting. Products are also used internally for research.

II. Data Sources

A. Data sources and originating agencies

1. U.S. Department of Agriculture/ NOAA	Weekly Weather and Crop Bulletin Snow Chart
2. NOAA/NESS	Northern Hemisphere Average Snow and Ice Boundaries
3. Environment Canada	Ice Summary and Analysis - Great Lakes
4. AES/U.S. Weather Bureau	Station reports, snow depth at meteorological stations
5. U.S. Soil Conservation Service	Snow surveys

6. There are plans to create a snow cover archive in 1979-1980.

B. Data accuracy

In accuracy tests for snowfall and other meteorological parameters, a computer check is made on the basic logic. Alterations are done by hand. For snow cover, subjective decisions to cross-check may occur. There have also been several experiments regarding snow gauge and sampler accuracy. (Contact Dr. B. Goodison.)

References

Environment Canada (1974). Snow Survey Network. Environment Canada, Atmospheric Environment Service, Report No. DS 13-74.

Findlay, B.F. (1975). Snow maps for the Canadian Hydrological Atlas. (In: Western Snow Conference, 43rd, Proceedings, p. 49-86.)

State Snow Surveys

Source: U.S. Department of Agriculture. Soil Conservation Service

Contact: M. Barton
Head, Water Supply Forecasting Staff
West Technical Service Center
511 NW Broadway, Room 510
Portland, Oregon 97209
(503) 221-2843

I. Products

A. Description of products

Snow survey and water supply outlook reports are produced monthly by individual state snow surveys (see table 1). The reports contain water supply outlooks for the major watershed areas. Snow depths and water content are tabulated for drainage basins and snow courses.

Table 1. State snow surveys and supervisors

Alaska	G.P. Clagett Soil Conservation Service 2221 E. Northern Lights Blvd. Anchorage, Alaska 99504 (907) 276-4246	Nevada	R.E. Moreland P.O. Box 4850 Reno, Nevada 89505 (702) 784-5479
Arizona	R.W. Enz 3008 Federal Building 230 N. 1st Avenue Phoenix, Arizona 85025 (602) 261-6711	Oregon	T.A. George Soil Conservation Service 1220 S.W. Third Avenue Portland, Oregon 97204 (503) 221-2757
Colorado	B. Shafer P.O. Box 17107 Denver, Colorado 80217 (303) 837-3258	Utah	B.L. Whaley 4420 Federal Building 125 South State Street Salt Lake City, Utah 84138 (801) 524-5213
Idaho	J.A. Wilson Soil Conservation Service 304 N. 8th Street, Rm. 345 Boise, Idaho 83702 (208) 384-1613	Washington	R.T. Davis 360 U.S. Court House Spokane, Washington 99201 (509) 456-3716
Montana	P.E. Farnes Room 469, Federal Building P.O. Box 98 Bozeman, Montana 59715 (406) 587-5271	Wyoming	J.W. Haglund 100 East "B" Street P.O. Box 2440 Casper, Wyoming 82601 (307) 265-5550

Summaries of the snow survey measurements are published for each state in single volumes covering the period of record, see table 2. These volumes tabulate snow depth and water equivalent at each site for the 1st and 15th of each month from January through June. Some information for October 15 - December 21 may also be included. Maps showing the locations of snow courses are included.

Table 2. Number of snow courses by state

State	Number of snow courses	Period of record
Alaska	114	1951 to date
Arizona	52	1938 to date
Colorado	149	1936 to date
Idaho	206	1921 to date
Montana	217	1922 to date
Nevada	129[1]	1910 to date
New Mexico	34	1937 to date
Oregon	202[2]	1926 to date
Utah	173	1924 to date
Washington	177[3]	1915 to date
Wyoming	148	1919 to date
Total	1601	

[1]Includes 45 snow courses in California measured by Nevada
[2]Includes 5 snow courses in California measued by Oregon
[3]Includes 94 snow courses in western Washington measured by U.S. Geological Survey

A volume entitled Water Supply Outlook for the Western United States, Including the Columbia River Drainage in Canada, is published each month providing a summary of snow equivalent measurements for the major basins and sub-watersheds and selected streamflow forecasts. A brief state-by-state summary of snowfall and the water supply outlook is also included.

B. Availability of products

The products are available at no cost either from the individual state surveys listed in table 1 or from:

Water Supply Forecasting Office
West Technical Service Center
511 N.W. Broadway, Room 510
Portland, Oregon 97209

II. Data Sources

Snow data are derived primarily from aerial markers and snow course measurements. The number of snow courses monitored by each state is included in table 2. Usually about 10 samples are taken at each location. Surveys are carried out monthly or semi-monthly from January 1 through June 1 in most states. Surveys are conducted by the Soil Convervation Service and cooperating agencies, including the Bureau of Reclamation, Corps of Engineers, Forest Service, National Park Service, NOAA, National Weather Service, Geological Survey, and other federal agencies, departments of state government, irrigation districts, power companies, and others.

The Soil Conservation Service is presently developing a data collection, transmission, and processing system, designated SNOTEL. This system collects data on remote sites and which are then transmitted to Ogden, Utah and Boise, Idaho by reflecting the signals from the sites off meteor-ionization trails. The data are then transferred to a central office in Portland, Oregon. There are 160 stations in operation at present, with a planned expansion to 511 sites throughout the 10 western states. These data will also be incorporated into individual state snow survey reports.

Reference

Barton, M; Burke, M. (1979). SNOTEL: An operational data acquisition system using meteor burst technology. World Data Center A for Glaciology {Snow and Ice} Glaciological Data. Report GD-6, p. 59-69.

Snow Survey for California

Source: California Department of Water Resources

Contact: A.J. Brown
California Department of Water Resources
Snow Surveys Branch
P.O. Box 388
Sacramento, California 95802
(916) 445-2196

I. Products

A. Description of products

A series of reports, entitled Water Conditions in California, is produced on a monthly basis for February through May. The reports include a map of the seasonal precipitation between the date of publication and the preceeding October, and a map showing monthly forecasts of unimpaired snowmelt runoff. Summaries are also given of water conditions for individual hydrographic areas, including information on snowpack measurements, precipitation, resevoir storage, and runoff.

A data supplement documenting the data used in the preparation of these reports is also published at the end of each season.

B. Availability of products

Reports are available at no cost from the above address.

II. Data Sources

A. Data sources and originating agencies

1. California Department of Water Resources: ground observations of snow depth, water content, and density collected at 325 observing points on a monthly basis, published four times per year, from 1930 to the present. A snow sensor network is planned which will decrease the need for ground observations.

2. California Department of Water Resources: aircraft observations of snow depth from aerial marker data at 160 sites calibrated since 1955.

3. NASA: snow covered area data derived from satellite imagery, intermittently from January to June since 1975.

B. Data accuracy

1. The preferential order of data used is that given above. There is generally 5 percent missing data for the ground observations, and 25 percent for the aircraft and satellite data.

2. The snow data are compared with precipitation data. The results of checks on the accuracy and consistency of the data are good.

C. Availability of data

The data used are published in the annual data supplements referred to above and are available from the Department of Water Resources. Data are also available on computer cards.

Snow Cover Maps of Six Colorado Watersheds

Source: U.S. Soil Conservation Service

Contact: B. Shafer
U.S. Soil Conservation Service. Snow Survey Unit.
P.O. Box 17107
Denver, Colorado 80217
(303) 837-3258

I. Products

A. Description of products

Snow cover maps of six Colorado drainage basins have been prepared for the period 1973-1978. The six watersheds are: Upper Rio Grande; South Fork of the Rio Grande; Alamosa Creek;Conejos River; Culebra Creek; and the Arkansas River.[1] Maps are on paper at a scale of 1:250,000.

B. Availability of products

The maps are available from B. Shafer at the above address.

II. Data Sources

A. Data sources and originating agencies

1. NASA: Landsat imagery. On average, five images are used at each point per time interval mapped.

2. Some aerial reconnaissance flights were also conducted in 1975 and 1978.

B. Data accuracy

Snow course data, aerial flights and ground reconnaissance were initially used to determine levels of accuracy and resolution. Data were missing 40 percent of the time between March and June.

C. Availability of source data

1. Landsat data are available from:

   EROS Data Center
   U.S. Geological Survey
   Sioux Falls, South Dakota 57198

2. Snow course measurements can be obtained from:

   B. Shafer
   U.S. Soil Conservation Service
   P.O. Box 17107
   Denver, Colorado 80217

[1]These maps have been produced as part of an assessment of an Applications Systems Verification Test (ASVT) Program (see Rango, 1975a). Within this program, satellite snow cover data have been analyzed for river basins in Arizona (Schumann, 1975; Warskow, et al., 1975; and Kirdar, et al., 1977), California (Brown and Hannaford, 1975), Colorado (Washichek and Mikesell, 1975), and the Northwest states (Limpert, 1975). Preliminary results were documented (Rango, 1975b) and proceedings of the final workshop held in April 1979 are in press.

References

Brown, A.J.; Hannaford, J.F. (1975) Interpretation of snowcover from satellite imagery for use in water supply forecasts in the Sierra Nevada. (In: Rango, A. (ed.) Operational Applications of Satellite Snowcover Observations, NASA SP-391, Washington, DC, p. 39-51.)

Kirdar, E.H.H., et al. (1977) The application of aerial and satellite snow-mapping techniques for multi-purpose reservoir operations in Arizona. Western Snow Conference, 45th, Proceedings, p. 95-101.

Limpert, F.A. (1975) Operational application of satellite snow cover observations, Northwest United States. (In: Rango, A. (ed.) Operational Applications of Satellite Snowcover Observations, NASA SP-391, Washington, DC, p. 71-85.)

Rango, A. (1975a) Operational applications of satellite snowcover observations project. (In: International Symposium on Remote Sensing of Environment, 10th, Proceedings, Ann Arbor, Center for Remote Sensing Information and Analysis, Environmental Research Institute of Michigan, v. 2, p. 1367-1376.)

Rango, A., ed. (1975b) Operational Applications of Satellite Snowcover Observations, NASA SP 391, Washington, DC, 430 p.

Schumann, H.H. (1975) Operational applications of satellite snowcover observations and LANDSAT data collection systems operations in central Arizona. (In: Rango, A. (ed.) Operational Applications of Satellite Snowcover Observations, NASA SP-391, Washington, DC, p. 13-28.)

Warskow, W.L., et al. (1975) Application of hydrometeorological data obtained by remote sensing techniques for multi-purpose reservoir operations. (In: Rango, A. (ed.) Operational Applications of Satellite Snowcover Observations, NASA SP-391, Washington, DC, p. 29-37).

Washichek, J.N.; Mikesell, T. (1975) Operational applications of satellite snowcover observations in Rio Grande drainage of Colorado. (In: Rango, A. (ed.) Operational Applications of Satellite Snowcover Observations, NASA SP-391, Washington, DC, p. 53-69).

River Basin Snow Mapping

Source: National Oceanic and Atmospheric Administration/National Environmental Satellite Service

Contact: Stanley R. Schneider
NOAA/NESS
Environmental Products Branch
World Weather Building, Room 510
Washington, DC 20233
(301) 763-8142;

I. Products

A. Description of products

1. NOAA/NESS produces snow extent maps of scattered river basins on a Lambert conformal conic projection generally on a scale of 1:2,500,000.

Table 1. Basins being mapped as of 1978

River Basin	Drainage Area in km^2	Primary Users
American above Fair Oaks (15)	5,601	Sacramento RFC
Boise above Lucky Peak (11)	6,941	Portland RFC, Columbia Basin Network
Carson (18)	8,864	Soil Conservation Service, Sacramento RFC
Clearwater above Peck (7)	20,824	Portland RFC, Columbia Basin Network
Columbia River above Mica Dam (1)	21,290	Portland RFC, Columbia Basin Network, B.C. Hydro & Power Authority, Environment Canada
Deschutes (4)	27,195	California State Department of Water Resources
Feather above Oroville (14)	9,386	California State Department of Water Resources
Humboldt above Comus (20)	31,339	Salt Lake City RFC, Soil Conservation Service
John Day (5)	19,632	Portland RFC, Columbia River Network
Kootenay above Libby (2)	23,277	Portland RFC, Columbia River Network
North Platte between Alcova and Guernsey (22)	12,198	Bureau of Reclamation, Kansas City RFC
North Platte above Seminoe (23)	15,274	Bureau of Reclamation, Kansas City RFC
Northeast U.S. Snow Map		NE Regional Hydrologist NWS
Payette above Emmett (10)	6,941	Portland RFC, Columbia Basin Network
Rio Grande above Colorado-New Mexico State Line (26)	19,900	Soil Conservation Service, Fort Worth RFC
Rio Grande above Del Norte (25)	3,419	Soil Conservation Service, Fort Worth RFC
Sacramento above Shasta (13)	16,630	California State Department of Water Resources
Salmon above Whitebird (8)	35,095	Portland RFC, Columbia Basin Network

Table 1. (continued)

Salt (28)	16,141	Salt Lake City RFC, Phoenix RDO, Salt River Project, U.S. Geological Survey
San Juan (24)	65,273	Salt Lake City RFC
Snake above Palisades (12)	13,340	Portland RFC, Columbia Basin Network
St. John	55,167	Maine Bureau of Civil Emergency Preparedness, New Brunswick Department of Environment, Environment Canada, St. John Basin Task Force
Sweetwater above Pathfinder (21)	6,027	Bureau of Reclamation, Kansas City RFC
Tahoe-Truckee (16, 17)	7,665	Soil Conservation Service, Sacramento RFC
Umatilla (6)	5,931	Portland RFC, Columbia Basin Network
Verde (27)	17,094	Salt Lake City RFC, Phoenix RDO, Salt River Project, U.S. Geological Survey
Walker (19)	9,241	Soil Conservation Service, Sacramento RFC
Weiser (9)	3,781	Portland RFC, Columbia Basin Network
Willamette (3)	26,159	Portland RFC, Columbia Basin Network

Notes on Users:

1. The Columbia Basin Network includes the Soil Conservation Service, Bureau of Reclamation, U.S. Geological Survey, U.S. Army Corps of Engineers, National Weather Service, Bonneville Power Administration, B.C. Hydro and Power Authority, as well as other state and local agencies.
2. Basins being done for the Bureau of Reclamation in Denver, Colorado, are retransmitted from the site to field offices in Casper, Laramie and Cheyenne, Wyoming.
3. The St. John Basin Task Force includes the National Weather Service, U.S. Army Corps of Engineers, U.S. Geological Survey, Environment Canada, and other states and provincial agencies.

Figure 1. River basins for NESS operational snow mapping.

Figure 2. VHRR imagery of the U.S. Pacific coast.

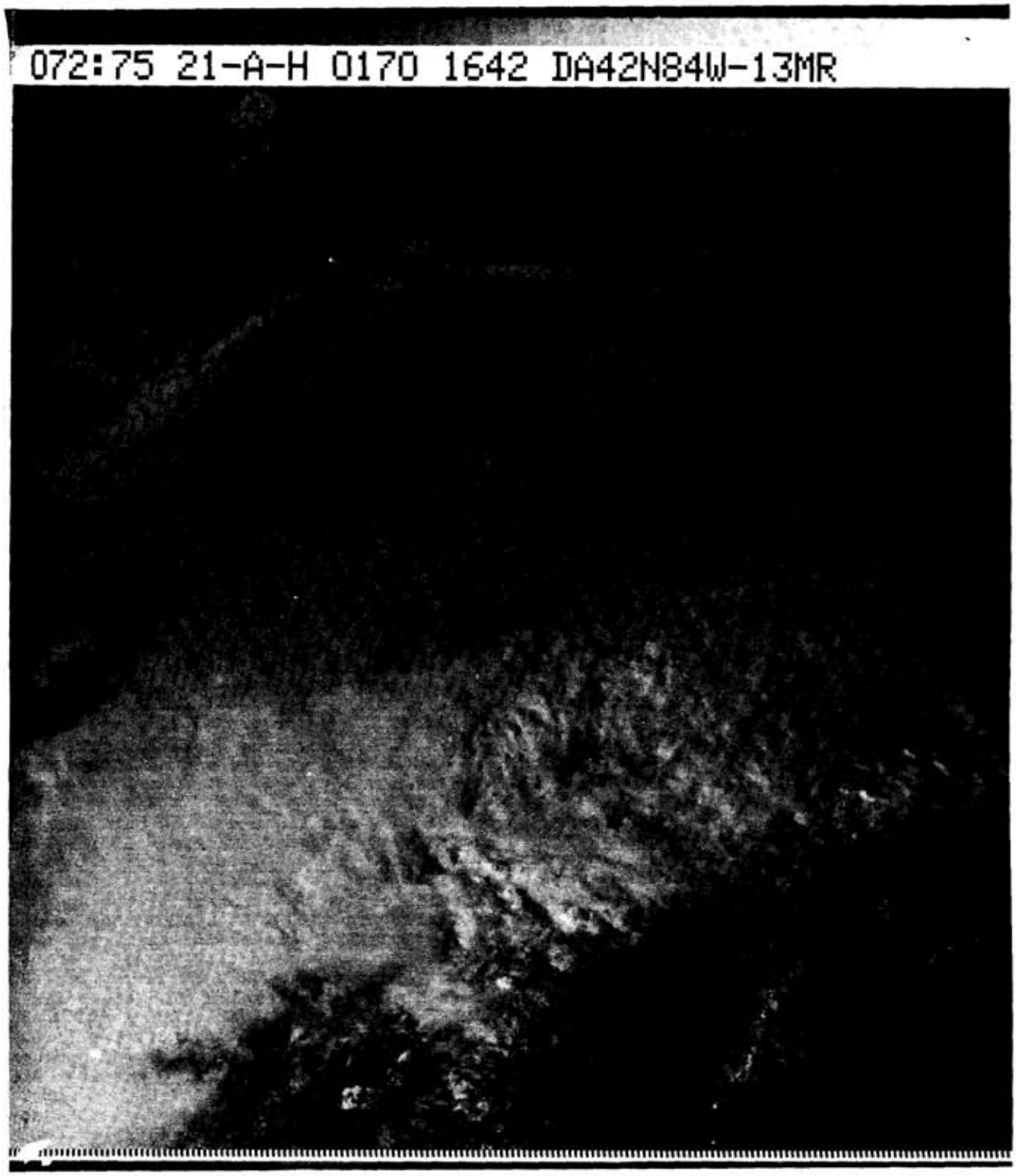

Figure 3. SMS/GOES imagery of the Great Lakes.

2. The maps are produced from November to July. Some basins have been mapped since 1973. Depending on the basin, snow conditions, and the weather, mapping is done on a weekly basis. In areas of rapid snowmelt, for example, Arizona, maps are done daily.

3. There is a possibility that digital, computer-generated snow maps will be produced in the future. With the addition of TIROS-N near infrared channel melting snow zones may be delineated.

B. Availability of products

The maps are transmitted to users operationally by mail, by teletype and by telecopier. They are available to interested scientists upon request to S.R. Schneider at the address given above.

C. Use and application of products

The maps are used primarily in water resource planning, runoff monitoring, and river forecasting. They are also used by the U.S. Soil Conservation Service as a Snow Survey check.

II. Data Sources

A. Data sources and originating agencies

Data used for mapping are derived from the NOAA polar-orbiting satellite, VHRR sensor in a daily basis and on a half-hourly basis from SMS/GOES, VISSR sensor. The resolution of the data is 1 km.

B. Data accuracy

1. The procedures used to differentiate between:

   a. Cloud and snow surfaces: (1) comparison of visible and thermal infrared imagery; (2) study of sequential half-hour GOES imagery for detection of cloud movement; (3) detection of cloud shadow; (4) location of terrain features in snow.

   b. Different ages of snow cover: This is not now done operationally. It maybe done operationally by comparison of visible and near infrared imagery when TIROS-N satellite is launched.

   c. Snow thickness: differentiation of snow and light-colored bare rock is done by comparing visible and thermal infrared imagery. It involves knowledge of terrain.

2. Differentiation procedures become more effective as more satellites and more multispectral data become available. The SMS/GOES system increased our temporal coverage. The TIROS-N system will increase our spectral coverage.

3. Since river basins are mapped with visible data, no basins with the polar night cutoff can be done operationally.

4. The method of interpretation has remained photointerpretation. Planimetry work is now done by an electronic density slicer. Originally, the work was done by a compensating polar planimeter.

5. A change is planned in interpretation methods. Interactive and all digital techniques are under active investigation. No fixed date for transfer has been set. Transfer will depend upon proven effectiveness of these other methods.

C. Data consistency

1. River basins are always mapped by same team of individuals. Each analyst has a unique geographic area of responsibility.

2. In-house calibration checks of the satellite data are routinely made.

3. All snow maps are examined by an experienced hydrologist for consistency with previous analyses and satellite data.

4. Satellite snow maps are spot-checked with ground surveys, aerial surveys, and other satellite data.

5. Both the Salt River Project in Arizona and U.S. Army Corps of Engineers, Walla Walla, Washington, believe satellite data to be accurate and consistent enough to allow reduction of aerial surveys.

D. Ground data for remote sensing

For routine measurements of snow depths, the project uses:

1. (a) Monthly Climatological Data published for each state by NOAA and stored at National Climatic Center, Asheville, North Carolina.

   (b) Water Supply Outlook published monthly for each Western state by the Soil Conservation Service.

   (c) miscellaneous regional surveys.

2. The network of ground snow depth stations is not dense enough to check snow extent, particularly in mountainous basins. Aerial data are very good for comparison when available.

References

McGinnis, D.F., Jr.; Schneider, S.R. (1978) Satellite detection of an extremely light snowfall in Arizona. Monthly Weather Review, v. 106(9), p. 1380-1383.

Schneider, S.R. (1975) The operational program of satellite snowcover observations at NOAA/NESS. (In: Workshop on Operational Applications of Satellite Snowcover Observations, South Lake Tahoe, California, 18-20 August 1975. U. S. National Aeronautics and Space Administration. NASA Special Publication SP-391, p. 87-101.)

Schneider, S.R.; Wiesnet, D.R.; McMillan, M.C. (1976) River basin snow mapping at the National Environmental Satellite Service. U. S. National Oceanic and Atmospheric Administration. NOAA Technical Memorandum NESS 83, 19 p.

Schneider, S.R. (1976) Satellite Snowcover Monitoring of Selected Watersheds in North America, with Emphasis on the Columbia River Basin. U. S. National Oceanic and Atmospheric Administration. National Environmental Satellite Service, 17 p.

Schneider, S.R. (1977) Operational satellite assessment of snowcover and river ice in the Saint John Basin. World Meteorological Organization. Saint John River Basin Task Force. Report 6.2. U. S. National Oceanic and Atmospheric Administration/National Environmental Satellite Service, 26 p.

Schneider, S.R.; Matson, M. (1977) Satellite observations of snowcover in the Sierra Nevadas during the great California drought. Remote Sensing of Environment, v. 4, p. 327-334.

Schneider, S.R. (1979) Satellite-derived river basin snowcover percentages: a new data base for hydrologists. World Data Center-A for Glaciology (Snow and Ice). Glaciological Data, Report GD-5, p. 57-60.

Schneider, S.R. (in press) Application Systems Verification Test (ASVT)/Operational Applications of Satellite Snowcover Observations. Final Report: Contract No. S-53772. U. S. National Aeronautics and Space Administration. Goddard Space Flight Center.

Wiesnet, D.R.; Schneider, S.R. (1975) The use of NOAA's environmental satellites for snow studies. (In: Remote Sensing of Snow Cover Workshop, Proceedings, 13-15 January 1975. Ottawa, Canada Centre for Remote Sensing, 4 p.

Snow Survey of Great Britain

Source: United Kingdom Meteorological Office.

Contact: The Director-General
Meteorological Office
London Road
Bracknell
Berkshire RG12 2SZ
England

I. Products

A. Description of products

The Meteorological Office has prepared reports on snow conditions in Great Britain since 1953/1954. Each Annual Report provides a map of contributing stations (figure 1), a summary of snow observations in mountainous areas during June through September, and a summary, for Britain as a whole, for October through May. These summaries include mean temperature, total precipitation, snow depth, and frequencies of days of snow falling and snow lying.

The reports include tables listing:

1. the total annual number of days of snowfall and of snow lying at 10 representative stations or station pairs since 1946/47
2. daily depths of snow at a selection of stations
3. the number of days of snowfall and snow lying, and the maximum depth of undrifted snow with the earliest date that this depth occurred at each station
4. the number of days each month and during the season when snow was seen lying at three stated altitudes, observed from a selection of stations.

B. Availability of products

Table 1. Accessibility of snow survey reports

Snow season	Published in
1938/39 and 1939/40	Royal Meteorological Society. Quarterly Journal, January 1941.
1946/47 to 1952/53	Journal of Glaciology, no. 3, 5, 7, 9, 11, 13, and 15.
1953/54 to 1955/56	Meteorological Magazine, December 1954, December 1955, and December 1956.
1956/57 to 1967/68	British Rainfall, 1957 to 1968.
1968/69 to 1975/76	Not published; limited number of copies available from the Meteorological Office* at £1 per copy.
1976/77 onwards	Published by the Meteorological Office* from whom they may be obtained at £2 per copy or £5 for a 3-year subscription.

*Meteorological Office (Met O 3b), London Road, Bracknell, Berkshire RG12 2SZ, England.

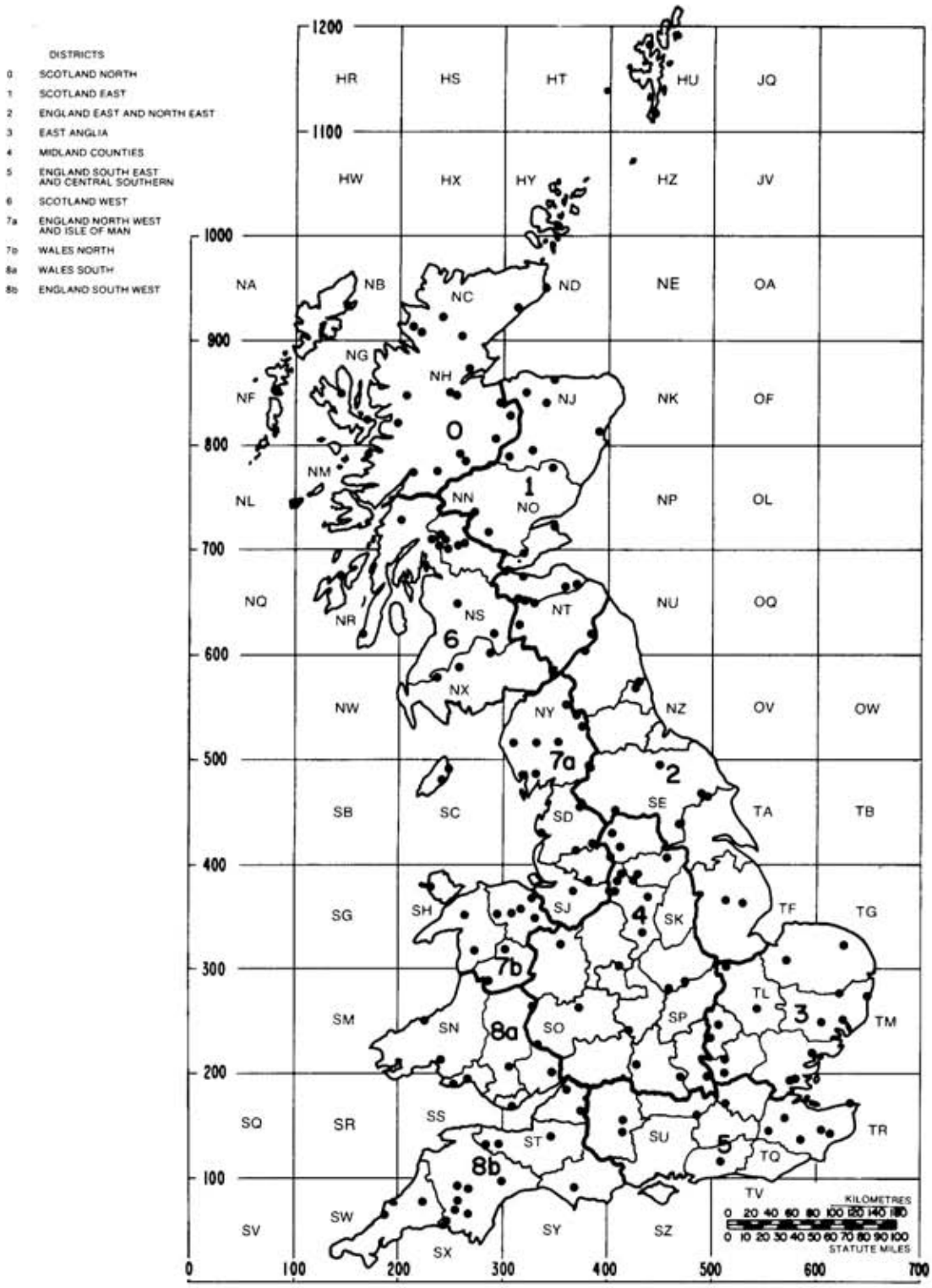

Figure 1. Snow survey stations in Great Britain.

Note: This map grid is based on the National Grid of Great Britain. It is a reference system that has a point of origin southwest of Land's End. The coordinates are parallel and at right angles to an approximate north-south line through the point of origin so as to form a grid square 100 km on a side

II. Data Sources

teorological Office data were available from over 300 observers in 1951, but e number has now declined to 160. The material is currently compiled largely om daily records of snow observers, supplemented by snow data from routine limatological returns. Certain snow data for these stations are given in the nthly Weather Report of the Meterological Office, published by Her Majesty's tationery Office, 49 High Holborn, London WC1, England.

Reference

gden, R.J. (1979). Snow Survey of Great Britain. World Data Center-A for laciology {Snow and Ice}. Glaciological Data, Report GD-6, p. 27-37.

Snow Observations in Norway

Source: Norwegian Snow Research Council (Utvalget for Snøforsking)

Contact: Utvalget for Snøforsking
Norwegian Snow Research Council
P.O. Box 5091
Oslo, Norway

I. Products

A. Description of products

For the winters of 1965/1966 - 1967/1968, the Norwegian Snow Research Council compiled and published in Snøobservasjoner i Norge (Snow observations in Norway) daily and periodic observations of snow cover. A summary was given of weather conditions and the development of the snow pack. Tables of daily snow temperature, snow density, monthly means, and maximum values of the snow depth were presented. Also included were comments on traffic problems and accidents caused by snow.

B. Availability of products

Three volumes of Snøobservasjoner i Norge were published, Winter 1965/1966, 1966/1967, and 1967/1968. Copies remaining are available at the above address.

II. Data Sources

A. Data sources and originating agencies

1. Daily observations - Norwegian Snow Research Council
   a. air temperature (read in the morning)
   b. maximum and minimum temperature
   c. type of precipitation
   d. wind direction and force
   e. snow depth
   f. snowfall during the preceding 24 hours
   g. snow temperature at the surface and 10cm and 30cm depths
   h. penetrability of the surface layer.
2. Periodic observations - Norwegian Snow Research Council
   a. snow thickness
   b. snow density
   c. free water content of snow
   d. strength of the snow layer structure
   e. snow temperature at every 10cm of depth
   f. complete ramsonde profile.

B. Availability of products

For the winters of 1965/1966 - 1967/1968, data were published by the Norwegian Snow Research Council as described above. Since 1971, the responsibility for snow investigations relating to avalanche activity has been taken over by the Norwegian Geotechnical Institute. The Norwegian Water Resources and Electricity Board became responsible for collecting information on the hydrology of snow. Requests for information on snow cover since 1971 should be made to the appropriate organization.

Norwegian Geotechnical Insitute
Avalanche Group
Box 40
Taasen, Oslo 8
Norway

Norwegian Water Resources and Electricity Board
Vassdragsvesenet - Box 5091-MJ
Oslo 3
Norway

References

Østrem, G. (1979). Snow investigations in Norway, World Data Center A for Glaciology (Snow and Ice). Glaciological Data, Report GD-6, p. 39-40.

Utvalget for Snøforsking (1968-1971). Snøobservasjoner i Norge. (Snow observations in Norway.) Vinteren 1965/1966 - 1967/1968. Utvalget for Snøforsking, Oslo, 3 v.

Soviet Snow Cover Data

Source: Dr. V. Suslov

Dr. V. Gracovich

Contact: Dr. V. Suslov
Central Asian Regional Research Hydrometeorological Institute (SARNIGMI)
Observatorskaja, 72
Tashkent, 700000
U.S.S.R.

Dr. V. Gracovich
Central Aerological Observatory
State Committee of the U.S.S.R. for Hydrometeorology and Control of the Environment
123376. Moscow, D-376
Per. Pavilik Morozov 12, U.S.S.R.

I. Products

A. Description of products

A snow cover data base on magnetic tape files is being developed for the USSR, on the basis of the regional division used in the Water Cadaster. Measurements included are:

1. Mean snow depth and water equivalent (snow mapping on the lowlands and along survey lines in the mountains)
2. Characteristics of the snow cover and proportion of snow-covered area
3. Thickness of ice crust beneath the snow and on the soil surface and the percent of ice crust covering the soil
4. State of the soil surface(frozen, thawed)
5. Height of snow line on mountains
6. Depth of snow cover, determined by stake survey
7. Atmospheric precipitation total (totalizing gauge)
8. Dates of formation and disappearance of snow cover.

Older processed snow cover data exist on punched cards in the format of the Minsk-model computer.

B. Availability of products

Not known.

II. Data Sources

Original archives are held by various institutes and agencies. Records are regularly sent to SARNIGMI for checking and returned to the observers for corrections. SARNIGMI also develops recommendations on methods and standards.

Mountain snow cover data are collected by helicopter survey of stakes. Three to five meter stakes are placed in summer and observed from helicopter by binoculars, telephoto survey, and gamma ray measurements.

Arctic and Antarctic Ice Concentrations and Northern Hemisphere Snow Cover

Source: Lamont-Doherty Geological Observatory

Contact: Dr. G. Kukla
Lamont-Doherty Geological Observatory
Columbia University
Palisades, New York 10964
(914) 735-4155

I. Products

A. Description of products

Various indices of snow cover and sea ice extent have been prepared. The indices generated, their frequency, and the length of record are presented in table 1. The ice concentration and snow reflectivity classes used are shown in table 2. The data are analyzed within geographic segments, shown in figures 1, 2, and 3. A more detailed description of these products is given in Kukla and Gavin (1979).

Table 1. Currently generated series of indices

Length of record	Indices	Interval	Method	Number of recognized classes	Principal chart source	Area
						Northern Hemisphere
1967-present	S	Biweekly	Planimeter	0	NOAA	Snow and pack ice
1967-1971	S	Weekly	Grid count	0*	NOAA	Snow and pack ice
1972-1973	S	Weekly	Grid count	6**	NOAA	Snow
1974-present	S	Weekly	Grid count	6	NOAA	Snow
1972-present	S,W	Weekly	Grid count	7	U.S. Navy	Arctic ice
1960-present	S,W	Monthly	Grid count	5	British	Arctic ice
1973-present	S,W	Weekly	Grid count	7	U.S. Navy	Antarctic ice
1967-1972	S	Monthly	Grid count	0	NOAA satellite photos	Antarctic ice†

Note: S = Area of snow or ice in km^2
W = Percent of open water within the pack ice boundary

* Reflectivity classes unreliable
** Reflectivity classes of poor quality
† Summer only

Table 2. Ice concentration and snow reflectivity classes.

Recognized Ice Classes	Corresponding U.S. Navy Chart Classes	Corresponding British and Canadian Chart Classes
00	Open water outside pack ice boundary	Open water outside pack ice boundary, new, rotten or brash ice
0	Open water within pack ice boundary	Open water within pack ice boundary, new, rotten or brash ice
1	0-2, 1-2, 1-3, 2-4 oktas	1-3 tenths
2	3-4, 3-5, 4-5, 4-6 oktas	4-6 tenths
3	5-6, 5-7, 6-7 oktas	4-6 tenths
4	6-8 oktas	7-9+ tenths (Canadian) 7-10 tenths (British)
5	7-8, 8-8 oktas, fast ice	7-10 tenths, fast ice

Recognized Snow Classes	NOAA Chart Classes
0	(Snow-free)
1	1 : Least reflective
2	2 : Moderate reflectivity
3	3 : Highest reflectivity
4	Scattered mountain snow
5	Snow in areas of poor illumination, indistinguished reflectivity as reconstructed

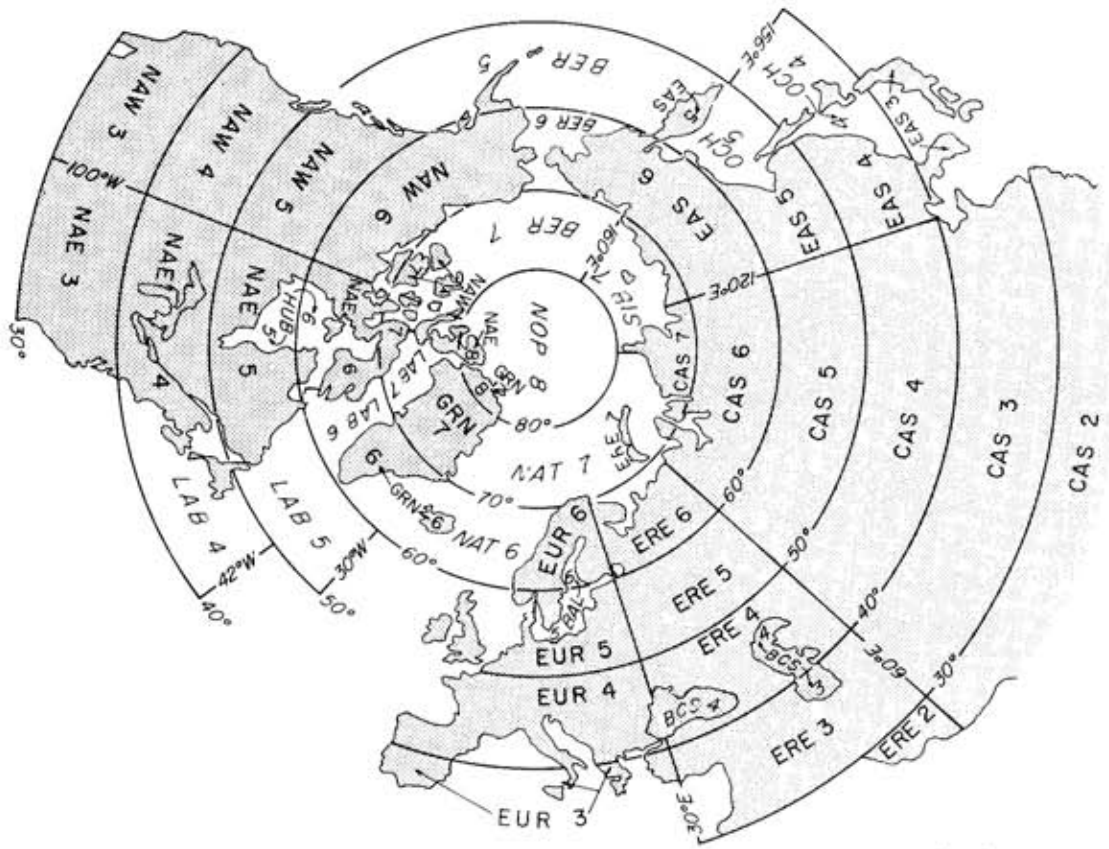

Figure 1. Geographic segments for the Northern Hemisphere.

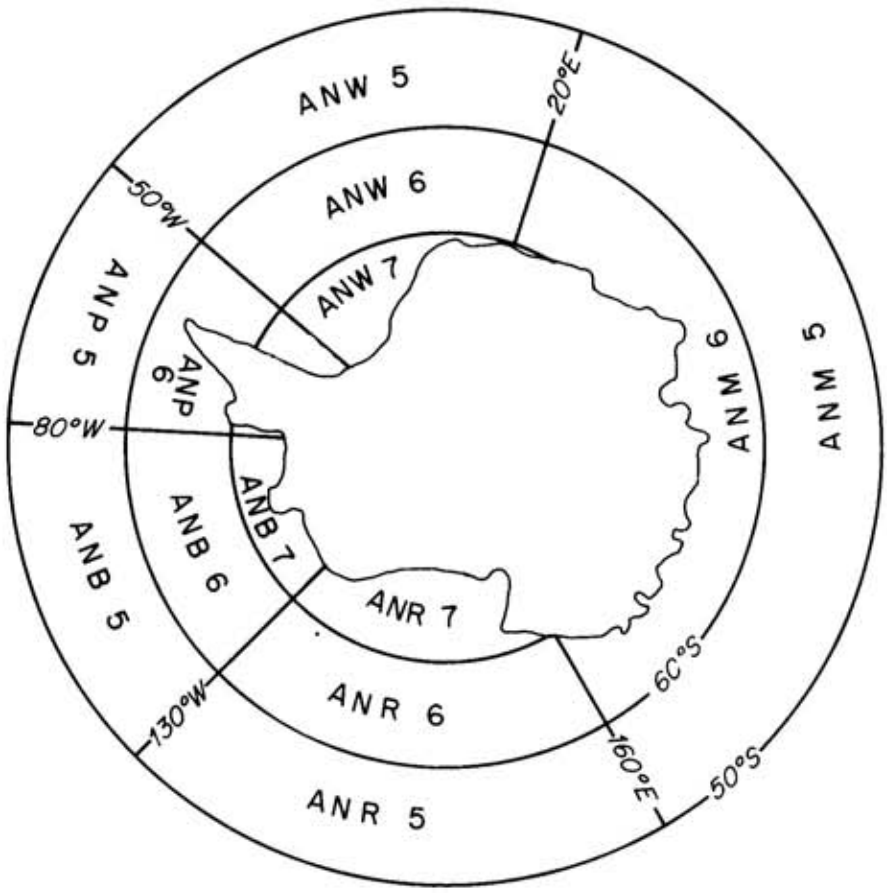

Figure 2. Geographic segments for the Southern Hemisphere.

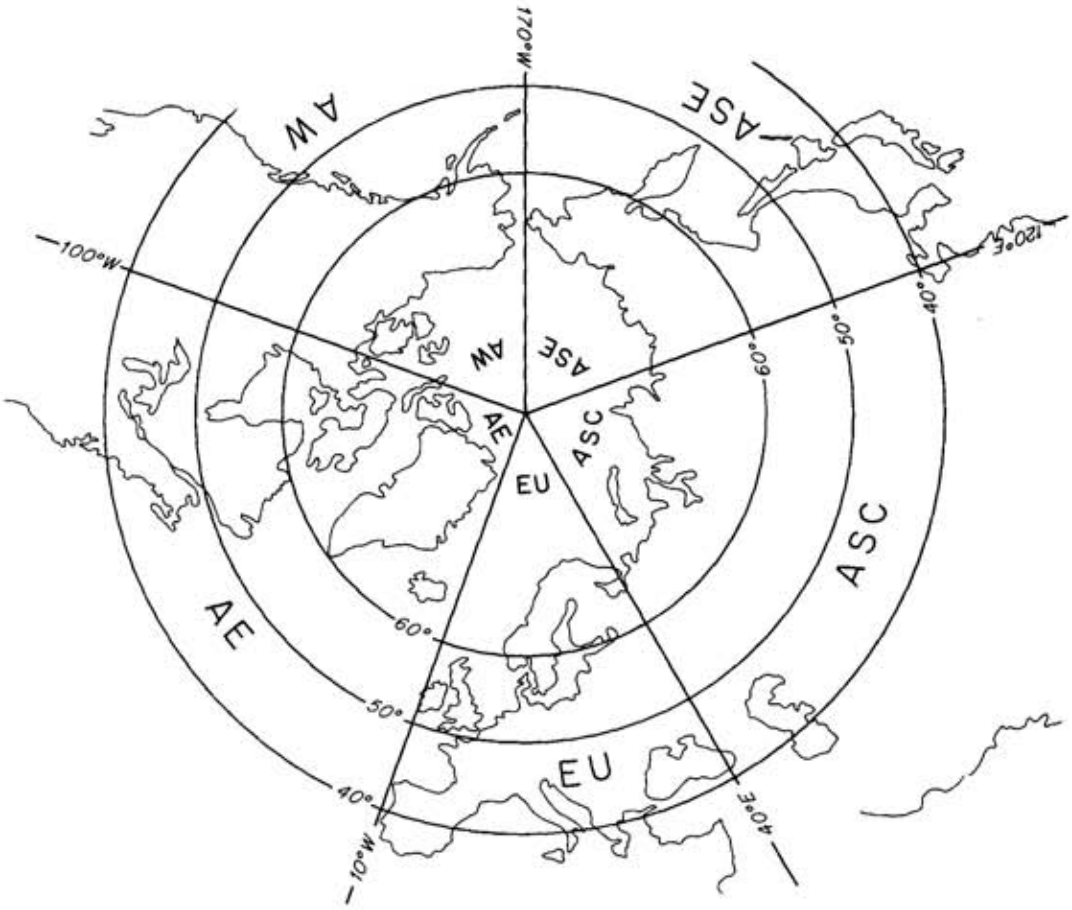

Figure 3. Planimetered segments of the Northern Hemisphere. Measurements are separately done for 60°-90°, 50°-60°, 40°-50°and south of 40°N latitudes.

B. Availability of products

Requests for further information should be made to Dr. G. Kukla at the above address. The data tapes are also archived at the World Data Center A for Glaciology and copies are available upon request.

II. Data Sources

A. Data sources and originating agencies

1. Department of Agriculture: Weekly Weather and Crop Bulletin.
2. NOAA/NESS: Northern Hemisphere Average Snow and Ice Boundaries.
3. U.S. Navy. Fleet Weather Facility: Southern Ice Limit in Arctic and Northern Ice Limit in Antarctic.
4. U.S. Air Force. Global Weather Central: Current Snow and Ice Depth, and Age of Surface Snow.
5. Environment Canada: Ice Summary and Analyses.
6. U.S. National Weather Service: station reports.

The principal chart source for each of the indices produced is indicated on table 1.

B. Data accuracy

The preferential order of data used:

1. U.S. Navy. Fleet Weather Facility - <1 percent missing data.

2. NOAA - <4 percent missing data.

3. British Meteorological Office - <1 percent missing data.

An independent re-analysis of the Arctic and Antarctic pack ice for several intervals shows the Navy assessment to be reliable. The U.S. Navy Arctic charts and the British series appear to be closely comparable, at least in terms of the total area of ice depicted. A comparison of NOAA's charts with ground station and satellite data shows that the information most closely corresponds to the last and next to last days of the week for which the analyses are produced. For these charts, some discrepancy exists for the pack ice boundary as compared to the U.S. Navy charts.

C. Data consistency

Several breaks in the quality of the charts are apparent, partly resulting from improvements in satellite hardware, and scale changes.

Limits are therefore placed on individual time series to assure sufficient uniformity of differentiated features.

D. Availability of source data

The source data for these indices are described elsewhere in this volume. The data are available from the individual agencies concerned.

References

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Kukla, G.J. (1977). New data on climatic trends. Nature, v. 270 (5638), p. 573-580.

Kukla, G.J. (1977). The role of snow and ice in climatic change (Abstract). (In: INQUA Congress, 10th, Proceedings, p. 258).

Kukla, G.J.; Gavin, J. (1978). Snow and sea ice cover fluctuations in 1977-78. (In: NOAA Climate Diagnostic Workshop, Proceedings, 31 October - 2 November, 1978, U.S. Department of Commerce.)

Kukla, G.J.; Robinson, D. (in press). Annual cycle of surface albedo. Monthly Weather Review.

Kukla, G.J.; Dehn, W.; Zwally, H.J. (in preparation). Open water in Antarctic winter pack.

Kukla, G.J.; Otterman, J. (in preparation). Problems with realistic surface albedo for heat budget studies.

Kukla, G.J.; Gavin, J. (in press). Recent secular variations of snow and sea ice covers. (presented at the World Glacier Inventory Workshop, Riederalp, Switzerland, 17-22 September 1978.)

Arctic Ice Cover and Northern Ice Limit Antarctica

Source: Max-Planck-Institut für Meteorologie

Contact: Professor Dr. K. Hasselmann
Max-Planck-Institut für Meteorologie
Bundesstrasse 55
2000 Hamburg 13
040-412951

I. Products

A. Description of products

Digital data sets are derived from monthly ice charts of the British Meteorological Office for the Arctic from January 1966 to December 1976. The sea ice-covered area is determined within 36 10°-longitudinal sectors. The ocean was regarded as being ice covered if the chart indicated at least 70 percent ice cover.

The Antarctic data set is derived from weekly charts of the U.S. Navy Fleet Weather Facility with the ice limit determined at 5°-longitude intervals. The data set runs from January 1973 to June 1978.

B. Availability of products

The data sets are available on 9 track tape, 800 bpi from the above address.

C. Use and application of products

The ice grids produced are used internally to investigate the interaction between sea ice and the atmosphere for input to a global climate model.

II. Data Sources

A. Data sources and originating agencies

1. Meteorological Office, United Kingdom: Ice at the End of the Month (for the Arctic).

2. U.S. Navy. Fleet Weather Facility: Northern Ice Limit, Antarctica.

B. Availability of source data

The data are available from the Meteorological Office (see this issue, p.57) and the U.S. Navy Fleet Weather Facility (see this issue p.25). These data sets are also archived at the World Data Center A for Glaciology.

Northern Hemisphere Sea Ice Concentration Grid

Source: University of Illinois, Laboratory for Atmospheric Research

Contact: John Walsh
Laboratory for Atmospheric Research
6-109 C.S.L. Building
University of Illinois
Urgana, Illinois 61801
(217) 333-7521; FTS 957-7521

I. Products

A. Description of products

1. Sea ice concentration grids for the Northern Hemisphere have been produced for the period January 1953 through December 1977.

   These data are displayed on a 1° latitude grid centered on pole (x,y) axes - 20°W, 70°E.

2. Classes of ice concentration are mapped in tenths. The minimum area that can be recognized is $60nmi^2/111km^2$ under any conditions. Accuracy is generally between ± 1 or ± 2 classes.

3. Additional information mapped included:

   a. Monthly sea level pressure grids, 1953-77
   b. Monthly surface temperature grids, 1953-77
   c. Monthly 700 mb height grids, 1953-77
   d. Monthly 700 mb temperature grid, 1953-77

B. Availability of products

The grids are available on 7 or 9 track magnetic tape at a cost of $40. Contact John Walsh at the above address.

II. Data Sources

A. Data sources and originating agencies

1. Southern Ice Limit in Arctic and Northern Ice Limit in Antarctic (U.S. Navy. Fleet Weather Facility).

2. Monthly Ice Charts (British Meteorological Office, Climatological Services).

3. Ice Summary and Analysis (Environment Canada)

   a. Hudson Bay and Approaches

   b. Canadian Arctic.

4. Ice Conditions in Greenland Waters (Danske Meteorologiske Institut).

5. Report of the Arctic Ice Observing and Forecasting Program, U.S. Naval Oceanographic Office, 1953-71.

6. The State of the Ice in the Arctic Seas, Danske Meteorologiske Institut, 1953-56.

7. Jökull (Icelandic Journal), Annual Ice Summaries, 1953-67.

8. Norsk Polarinstitut. Årbok. (Norwegian Yearbook), 1963-71.

B. Data accuracy

1. For the ice concentration grids, the data sources used are listed in preferential order:

	season/months summer (June-October)		season/months winter (November-May)	
	Preferential order of data used	% time missing data	Preferential order of data used	% time missing data
1972-77	U.S. Navy-F.W.F.	--	U.S. Navy-F.W.F.	--
1964-69	Canadian	0(Jun-Oct.)	U.S. Navoceano	30-40
1953-71	U.S. Navoceano	20	Icelandic	25
1953-67	Icelandic	--	Norwegian	40
1957-64	Norwegian	40	Danish-Greenland	30
1959-67	British Met. O.	10-20	British Met. O.	30-40
1953-56	Danish-Arctic Seas	0(Jun-Oct.)		

2. Data sources are cross checked:

   a. U.S. Navy vs. Canadian vs. British Meteorological Office.

   b. Norwegian, Icelandic, Danish vs. British Meteorological Office.

   c. Icelandic vs. Danish.

3. British Meteorological Office generally fared poorly in consistency checks with other, relatively consistent, data sources noted in above.

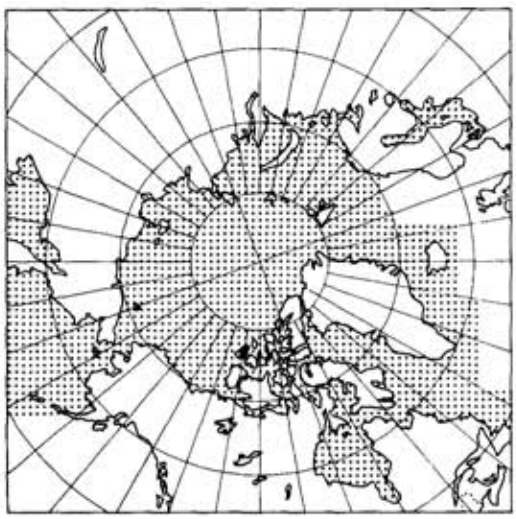

Figure 1. The ice concentration grid.

Table 1. Description of data sources

Source	Time Period		Time interval between successive products	Smallest homogenous area that data source's mapping/ digitizing system resolves[1]		Km within which plotted snow/ice boundaries are accurate under typical conditions	Consistency between maps in the identification of the minimum resolvable areas								How consistent between maps is the accuracy of the boundaries			
							under worst conditions				under typical conditions							
	from	to		under worst conditions	under typical conditions		poor	fair	good	excellent	poor	fair	good	excellent	poor	fair	good	excellent
U.S.Navy F.W.F.	1/72	12/77	1 week	(200 mi)^2	(~30 mi)^2	20-30		X					X				X	
U.S. Navoceano	1/53	12/71	1 week to several months	(300 mi)^2	(~40 mi)^2	20-30 (when not estimated)	X						X				X	
British Met. Off.	6/59	12/77	1 month	(300 mi)^2	(~50 mi)^2	50-75	X					X				X		
Danish-Greenland Waters	1/57	12/64	1 week to several months	(300 mi)^2	(~30 mi)^2	20-30 (when not estimated)	X						X				X	
Danish-Arctic Seas	4/53	12/56	1 month (summer only)	(400 mi)^2	(~60 mi)^2	50-75	X					X				X		
Canadian	5/64	11/69	1-2 weeks (summer only)	(100 mi)^2	(~30 mi)^2	10-20			X				X				X	
Icelandic	1/53	12/67	~1$^+$ months	(100 mi)^2	(~40 mi)^2	~50		X					X			X		
Norwegian	1/63	12/71	1 to several months	(100 mi)^2	(~40 mi)^2	~40	X						X			X		

[1]The mapping/digitizing system has a resolution of (60 n mi)^2/111 km^2. In many cases, resolution of the data source is considerably poorer; the final product often has misleadingly fine resolution.

References

Johnson, C.M. (In press). Some preliminary results relating Arctic sea ice to Northern Hemisphere sea-level pressure. (In: The General Circulation; Notes from a Colloquium: Summer 1977. National Center for Atmospheric Research publication).

Walsh, J.E. (1978). A data set on Northern Hemisphere sea ice extent, 1953-77. World Data Center A for Glaciology (Snow and Ice). Glaciological Data, Report GD-2, p. 49-51.

Walsh, J.E.; Johnson, C.M. (1979). An analysis of Arctic sea ice fluctuations, 1953-1977. Journal of Physical Oceanography, v. 9 (3), p. 580-591.

Walsh, J.E. (1979). Empirical orthogonal functions and the statistical predictability of sea ice extent. (In: Symposium on Sea Ice Processes and Models, Proceedings, Seattle, University of Washington Press, 2 v.)

Northern Hemisphere Ice Limits: 1901-1956

Source: Climatic Research Unit, University of East Anglia

Contact: Dr. P.M. Kelly
Climatic Research Unit
School of Environmental Sciences
University of East Anglia
Norwich, United Kingdom
0603-56161

I. Products

A. Description of products

The presence or absence of ice (greater than 4/10 concentration) is plotted on a monthly basis using the same grid as that used by Walsh (see this issue p.). The grids are still being prepared and little further information is available at the present time. See also Kelly (1978, 1979).

B. Availability of products

When the preparation of these grids has been completed, they will be available from Dr. Kelly at the above address, or from the World Data Center A for Glaciology.

II. Data Sources

A. Data sources and originating agencies

Danske Meteorologiske Institut: The State of the Ice in Arctic Seas, published yearly from 1901-1956. Reliability checks on the data are still in progress and will be available when the analysis is complete.

B. Availability of source data

The source data used are available from the Danske Meteorologiske Institute (see this issue p. 69).

References

Kelly, P.M. (1978) An Arctic Sea ice data set: 1901-1956. Climate Monitor, v. 7(5), p. 161-163.

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ACRONYMS

Because of the large number of acronyms present in this issue, the following list is included to assist the reader:

AES	- Atmospheric Environment Service (Canada)
AFGWC	- Air Force Global Weather Central (U.S.)
APT	- Automatic Picture Transmission
ASVT	- Applications Systems Verification and Transfer
AVCS	- Advanced Vidicon Camera System
AWS	- Air Weather Service (U.S.)
bpi	- bits per inch
CMB	- Composite Minimum Brightness
CMT	- Composite Maximum Temperature
CRREL	- Cold Regions Research and Engineering Laboratory (U.S.)
DARMS	- Drifting Automatic Radio - Meteorological Stations (USSR)
DDC	- Defense Documentation Center (U.S.)
DEW-Line	- Distant Early Warning Line
DMSP	- Defense Meteorological Satellite Program (U.S.)
DOD	- Department of Defense (U.S.)
EDIS	- Environmental Data and Information Service (U.S.)
ESMR	- Electrically Scanning Microwave Radiometer
ESSA	- Environmental Sciences Services Administration (U.S.) (now NOAA)
FNWC	- Fleet Numerical Weather Center (U.S.)
FOV	- Field of view
FWF	- Fleet Weather Facility (U.S.)
GARP	- Global Atmospheric Research Program (WMO)
GATE	- GARP Atlantic Tropical Experiment
GHz	- gigahertz - 10^9 hertz
GOES	- Geostationary Operational Environmental Satellite
HRR	- High Resolution Radiometer
IFYGL	- International Field Year for the Great Lakes
INSTAAR	- Institute of Arctic and Alpine Research (University of Colorado)

IR	- Infrared
ISIS	- Integrated Satellite Imaging Systems
MSS	- Multispectral Scanners Subsystem
NASA	- National Aeronautics and Space Administration (U.S.)
NAVOCEANO	- Naval Oceanographic Office (U.S.)
NCC	- National Climatic Center (U.S.)
NESS	- National Environmental Satellite Service (U.S.)
NMFS	- National Marine Fisheries Service (U.S.)
nmi	- nautical miles
NOAA	- National Oceanic and Atmospheric Administration (U.S.)
NTIS	- National Technical Information Service (U.S.)
NWS	- National Weather Service (U.S.)
RFC	- River Forecast Center
SARNIGMI	- Sredneaziatskii Nauchno-Issledovatel'skii Gidrometeorologicheskii Institut. (Central Asian Hydrometeorological Institute) (USSR)
SCS	- Soil Conservation Service (U.S.)
SLAR	- Side Looking Airborne Radar
SMMR	- Scanning Multichannel Microwave Radiometer
SMS	- Synchronous Meteorological Satellite
SNOTEL	- Snow Telemetry
USGS/WD	- U.S. Geological Survey/Water Division
VHRR	- Very High Resolution Radiometer
VIS	- Visual
VISSR	- Visible and Infrared Spin Scan Radiometer
WMO	- World Meteorological Organization

ERRATUM

Glaciological Data, Report GD-5, May 1979

p. 22, line 6. "30 Day Ice Forecast for Northern Canadian Waters" is a product of Environment Canada. Atmospheric Environment Service.

GLACIOLOGICAL DATA SERIES

Glaciological Data, which supercedes *Glaciological Notes*, is published by the World Data Center A for Glaciology (Snow and Ice) several times per year. It contains bibliographies, inventories, and survey reports relating to snow and ice data, specially prepared by the Center, as well as invited articles and brief, unsolicited statements on data sets, data collection and storage, methodology, and terminology in glaciology. Contributions are edited, but not refereed or copyrighted. WDC publications are distributed without charge to interested individuals and institutions.

Scientific Editor: Roger G. Barry
Technical Editor: Ann M. Brennan
Technical Staff: Margaret Strauch and Anne Gensert

The following issues have been published to data:

GD-1, *Avalanches*, 1977

GD-2, Parts 1 and 2, *Arctic Sea Ice*, 1978

GD-3, *World Data Center Activities*, 1978

GD-4, Parts 1 and 2, *Glaciological Field Stations*, 1979

GD-5, *Workshop on Snow Cover and Sea Ice Data*, 1979

GD-6, *Snow Cover*, 1979

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