An aerial photograph of a snowfield, likely a glacier or a large snowfield, showing a prominent meltwater stream or channel. The stream flows from the upper right towards the lower right, with several smaller tributaries branching off. The snow surface is textured with various ridges, depressions, and small-scale erosion features. The overall color is a pale, off-white to light blue-grey, typical of snow and ice under natural lighting.

**Annual Report
1988**

**National Snow and Ice Data Center
World Data Center-A for Glaciology
[Snow and Ice]**

**COVER: Sea Ice in the Arctic Ocean. Aerial photograph taken in 1971
during the Arctic Ice Dynamics Joint Experiment (AIDJEX).**

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[SNOW AND ICE]**

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WDC/NSIDC ANNUAL REPORT FY 1988

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WDC/NSIDC ANNUAL REPORT FY 1988

I. INTRODUCTION

The role of the WDC/NSIDC is to acquire, archive and disseminate data relating to all forms of snow and ice, within the context of the ICSU guidelines for international data exchange (ICSU, 1979) and NOAA's mission (Byrne, 1984). The latter mandate calls for information to assist policy formulation and decision-making regarding the oceans, atmosphere, and coasts, and to ensure related public health and safety and national resource development. Examples of such activities include the acquisition and dissemination of global environmental satellite data, data on resources including water, on natural hazards, and weather-related economic impacts.

II. HIGHLIGHTS

A. Twelfth Northern Libraries Colloquy

WDC-A for Glaciology and the Institute of Arctic and Alpine Research (INSTAAR) hosted the Twelfth Northern Libraries Colloquy in Boulder, 5-9 June 1988. Approximately 75 participants representing eleven countries took part in the meeting. The Colloquy, which began in 1971, meets biennially and provides an international forum for the exchange of information and ideas among the polar bibliographic community. The theme of this meeting, "Northern Information - The Global Connection," focused on the networking of northern information. A grant from the National Science Foundation Division of Polar Programs (\$46,000) provided support for invited speakers and participants, and to print and distribute the Colloquy proceedings.

B. Panel on Glaciological Data

The Panel on Glaciological Data of the National Academy of Sciences visited the WDC/NSIDC on 23-24 May 1988. Panel members, J. E. Walsh, University of Illinois, and W. Harrison, University of Alaska, heard presentations by the director and staff on operations and activities since their last visit in November 1986. The

Panel prepared a report on the WDC/NSIDC for the Committee on Geophysical Data.

C. Workshop on Permafrost Data, Trondheim

Approximately 300 scientists from 18 countries took part in the Fifth International Conference on Permafrost held in Trondheim, Norway, August 1988. R.G. Barry presented a paper entitled "Permafrost Data and Information: Status and Needs" and also organized a workshop on Permafrost Data. Fifty people attended the workshop and as a result of the discussions a proposal was submitted to the new Council of the International Permafrost Association to establish a Working Group on Permafrost Data. This has been approved and R.G. Barry will serve as Working Group Secretary.

D. U.S. Arctic Environmental Data Workshop

A workshop convened by T. Laughlin (NOAA) on Arctic Environmental Data Systems was held in Boulder, 21-24 March. The meeting was attended by representatives of U.S. and foreign agencies, and other research scientists involved in Arctic programs. Members of the NSIDC professional staff participated in this meeting. R.G. Barry gave a briefing on Snow and Ice Data and presented the plenary report for the subgroup that discussed "Next Steps". Ron Weaver, NSIDC Scientific Manager, led one of the meeting sub-groups considering how to establish an Arctic data directory. The data directory subgroup recommended that the Arctic data directory be merged with other on-going directory efforts related to the Interagency Data Management Working Group for Global Change. The directory format should follow that of the Catalog Interoperability effort which is a joint effort of the Geological Survey, NOAA, and NASA.

III. CURRENT PROGRAMS

A. NOAA/NESDIS/NGDC Funded Programs

1. Information Center and CITATION Data Base

One of the principal directives of the *Guide to the World Data Center System* is to "provide a mechanism for international exchange of data in all

disciplines related to the Earth, its environment, and the Sun." To fulfill this directive in the area of Glaciology and to meet the increasing interest in cryosphere/climate studies on a global scale, WDC/NSIDC maintains an active program to acquire published material in all areas of snow and ice research.

Currently the Information Center contains 4750 monographs and technical reports and approximately 10,000 reprints; 90 serials are regularly received. During 1988, approximately 1200 items were added to the collection.

All materials received are catalogued and assigned subject and geographic descriptors. Primary access to the collection is provided by CITATION, the in-house online catalog. At the end of 1988, there were almost 24,000 records in the data base. The file is updated quarterly and 400-500 records are added each time. The subject headings in CITATION are those used by the Cold Regions Research and Engineering Laboratory in their CRREL bibliography and COLD data base. Our collection holds materials on all aspects of snow and ice research, however our focus in recent years has concentrated on snow cover and sea ice data and information and the effects of the cryosphere on climate. Online searches of the collection are performed on request. Figure 1 details the subject areas of user interest during 1988.

2. Publication Program

Two series, *New Accessions List* and *Glaciological Data*, are published by WDC/NSIDC. *New Accessions List (NAL)*, a product of the CITATION data base, is a quarterly list of documents, categorized by subject, received and catalogued during a given period. This publication which fills much of the information exchange role stipulated by World Data Center System guidelines is mailed worldwide to about 350 scientists,

research institutions, and libraries. During FY88, 3 *NAL* issues were completed.

DATA REQUESTS BY SUBJECT - FY 1988

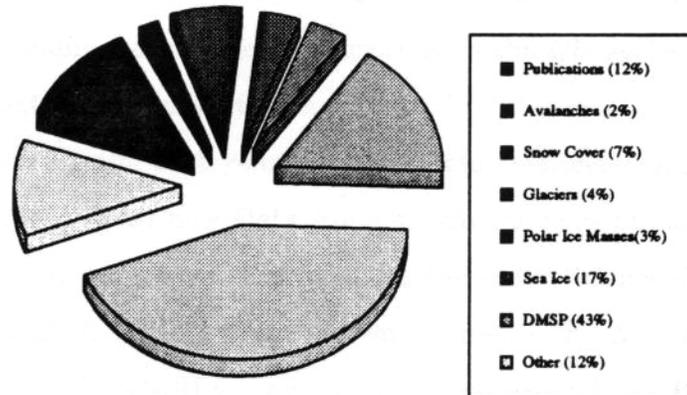


Figure 1. Data requests by subject, 1988.

Glaciological Data (GD) is the principal publication of WDC/NSIDC. Issues focus on a single topic and include specialized bibliographies, inventories, and survey reports relating to snow and ice data prepared by WDC/NSIDC staff, as well as invited or contributed articles on data sets, data collection and storage, methodology, and terminology in glaciology. Current circulation for *GD* is approximately 950 copies, 50 percent of which are mailed to addresses outside the United States in exchange for publications submitted to the WDC. Whenever possible, *GD* publication costs are obtained through specific agency or project support.

During FY88, three issues in this series were prepared. *GD-20* contains the proceedings of the NSF-funded Workshop on the U.S. Antarctic Meteorological Data Delivery System held in Boulder. *GD-21* updates the 1983 Permafrost Bibliography (*GD-14*) to cover references from 1983-1987.

It was distributed to the participants of the Fifth International Conference on Permafrost held in Trondheim, Norway, in August, 1988. Printing of *GD-21* was supported by the U.S. Army Cold Regions Research and Engineering Laboratory. *GD-22* comprises the proceedings and recommendations of the Twelfth Northern Libraries Colloquy. Funding for printing and distribution of this issue came from NSF Division of Polar Programs. The three issues published this year reflect the trend toward outside funding support for publications in the *GD* series.

3. Data Set Administration

During the past year, two new data sets were received, six were updated, and three new Data Announcements were produced. Chukchi Sea drifting buoy data were received from the Polar Science Center, University of Washington. This 2-year data set augments the Arctic ice motion data archived at WDC/NSIDC, some dating from as early as 1893.

Radio echo sounding data reports for the Variegated Glacier (located west of the juncture of Russell Fiord and Disenchantment Bay near Yakutat, Alaska) were received from the Geophysical Institute, University of Alaska. This data set and the Variegated Glacier time lapse photo data, also from the Geophysical Institute, are the subject of a new Data Announcement currently in production.

Data sets updated this year include the 28-year North Atlantic iceberg data base from the International Ice Patrol, the 33-year daily Great Lakes visual ice observation data set, the 14-year National Weather Service/Navy - NOAA Joint Ice Center Great Lakes hard copy ice chart set, 15 years of weekly digitized Arctic and Antarctic ice charts from the Navy NOAA Joint Ice Center, and the six-year NOAA/PMEL Bering Sea Argos buoy ice motion data set.

NSIDC continues to archive, jointly with NOAA/NGDC, the Geosat altimeter data over land and ice areas of the globe. A Data Announcement was prepared by NGDC to explain availability and distribution policies.

Data Announcement 88-GLA-80 was prepared, describing data products NSIDC will produce from the Special Sensor Microwave/Imager (SSM/I) data using the Cryospheric Data Management System (CDMS) on the NSIDC computer system.

Two additional Announcements were compiled, listing all data sets relevant to the Antarctic and to the Arctic. 88-GLA-ANT and 88-GLA-ARC are given to requesters seeking general information about WDC/NSIDC activities.

B. Contractually Supported Data Sets

1. DMSP

NSIDC is in the sixth year of service as the national archive for data from the U.S. Air Force Defense Meteorological Satellite Program (DMSP). During FY88, approximately 75,000 images were sorted, catalogued, and archived into the collection, now amounting to about 1.3 million pieces of imagery. More than 50,000 entries, referring to single orbit strips, were added to the searchable computer data base. One hundred and ninety eight data and information requests were processed this year (almost identical to FY87) resulting in data sales of \$10,445 (up 15 percent from FY87).

University of Colorado students continue to be the primary source of personnel to staff the archive. Participation in the work/study and Boulder County Private Industry Partnership programs resulted in salary savings of \$17K to the archive activity.

DMSP data continue to be used in a variety of notable projects. A mosaic depicting Europe at night was compiled by NSIDC staff in conjunction with a data request from the Geospace Company of Austria. The mosaic was compiled from four passes collected by the visible-band

sensor of the DMSP F7 satellite during the fall months of 1985, 1986 and 1987.

DMSP images were used in support of the National Center for Atmospheric Research (NCAR) High Altitude Observatory (HAO) expedition to study the solar eclipse in the Southern Hemisphere during March 1988. HAO used imagery from several years covering the Philippines to determine typical cloud conditions and to select the best areas for viewing the eclipse. Clear-sky conditions at General Santos City, Mindanao Island, resulted in a successful expedition, including sophisticated measurements of the white light corona, the emission line corona, and the inner corona. HAO sent NSIDC a formal thank you and a photograph taken at the height of the eclipse.

Satellite coverage of the 'B-9' iceberg in the Antarctic has been well documented by NSIDC staff using DMSP imagery (see Figure 2.). Images showing the calving of the iceberg appeared in the AVHRR column of the May issue of *Photogrammetric Engineering and Remote Sensing*. The column, which regularly features noteworthy images from polar-orbiting satellites, demonstrated the capabilities of satellite imagery for monitoring icebergs. G. Scharfen contributed the section on DMSP which includes a sequence of three images showing the iceberg as it broke off the Ross Ice Shelf and moved away. A brief description of the DMSP system and how to obtain data from the archive follows.

DMSP images are also being used in a large exhibit at the Denver Museum of Natural History this summer and fall. The exhibit, 'New Visions of Earth: The Technology of Reading Our Planet' covers all aspects of remote sensing from theory and the electromagnetic spectrum to examples and applications of the various types of remote sensing data. NSIDC contributed several images to the exhibit including the Antarctic Mosaic and the sequence of images of the 'B-9' iceberg.

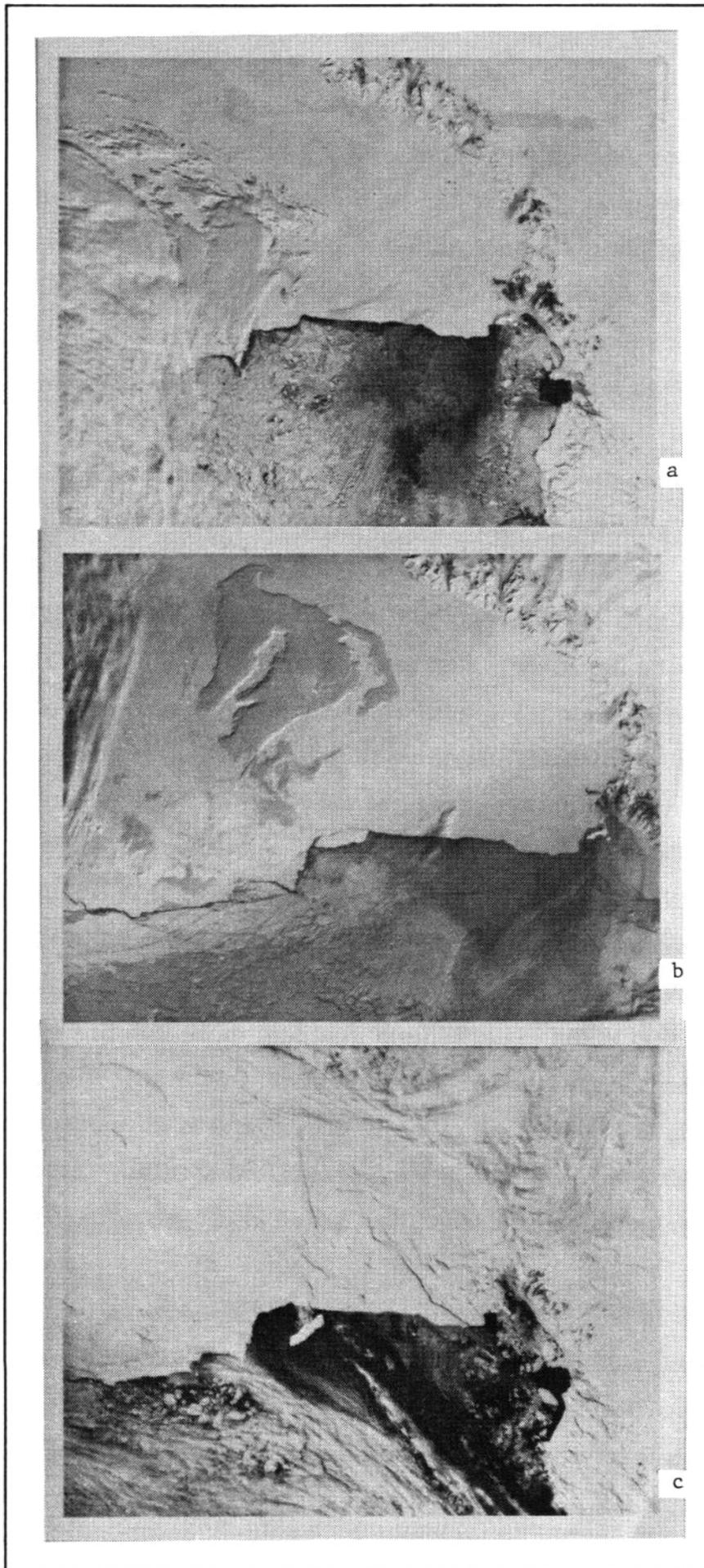


Figure 2. DMSP images of the B-9 iceberg: a. The Bay of Whales Regions, 20 November 1986; b. 14 October 1987; c. 27 December 1987.

Imagery from the DMSP collection was used more often than any other satellite data in papers presented at the 2nd Conference on Polar Meteorology sponsored by the American Meteorological Society, 28-31 March 1988, Madison, WI. The papers used DMSP data both as a data source, and for illustrative purposes. Authors cited the accessibility of the data, its coverage in space and time, and its suitability for use in the polar regions as the main reasons for using DMSP.

The future of the DMSP collection and the effects that changes at the Air Force Global Weather Central (AFGWC) will have on the archival of DMSP data is being considered by a number of concerned agencies. The AFGWC is in the process of installing their Satellite Data Handling System (SDHS), a state of the art computer facility which will allow the digital integration of several satellite data streams and conventional meteorological observations for DOD forecasting purposes. The SDHS will drastically reduce AFGWC's needs for hard-copy image products - the medium archived at NSIDC. Continuation of the 15-year archive may therefore be in jeopardy. The DMSP archive represents the single longest-running global, daily archive of conventional meteorological satellite observations, making it invaluable for global climate and environmental studies. The short-term budget considerations that have resulted in the loss of other long-term data sets (e.g. NOAA GAC coverage formerly on the Terabit memory system at SDSD) may be of serious consequence to the feasibility of global change studies. NSIDC is working to ensure the continuation of the archive through the changes in format and limitations on funding that threaten its future.

These subjects are being addressed by the Office of the Federal Coordinator, and the National Academy of Sciences Committee on Geophysical Data. The Federal Coordinator's Working Group on Meteorological Information Management has considered the problem over

Meteorological Information Management has considered the problem over the past year and has recommended that the present archive be continued. It recognizes the importance of DMSP for global change programs in the future. These recommendations were forwarded to the Interdepartmental Committee for Meteorological Services and Supporting Research, the next level committee at the Federal Coordinator's office. The Committee on Geophysical Data (CGD) is considering the DMSP issue. The CGD is comprised of government and non-government scientists representing a broad range of interests related to global change. Meanwhile, NSIDC is again awaiting approval for next year's funding as FY88 draws to an end. Thus far, only six months' funding for FY89 is assured. NSIDC has submitted informal proposals to NESDIS headquarters and a formal proposal in response to an RFP for the archive solicited by NCDC. We hope that recommendations from the above committees will help to secure continued funding for the years ahead, and provide guidelines for the continued archival of DMSP data beyond the technology change at AFGWC.

2. MIZEX

Data management for the Marginal Ice Zone Experiment (MIZEX), begun in 1983, continued during FY88. Data from the study of the mesoscale interaction of air-sea-ice processes during the 1983, 1984 and 1987 field experiments in the Fram Strait between Greenland and Svalbard have been archived at NSIDC. NSIDC will also manage the data resulting from the latest field experiment taking place in the East Greenland Sea. This new program, Coordinated Eastern Arctic Experiment (CEAREX) is being designed to provide a better understanding of meso- and small-scale processes in the exchange of momentum, heat, and biomass within ocean eddies, internal waves, and within the ocean/atmosphere boundary layer. This experiment will take place in approximately the same location as the

MIZEX experiments (Figure 3) and will operate from September 1988 until June 1989.

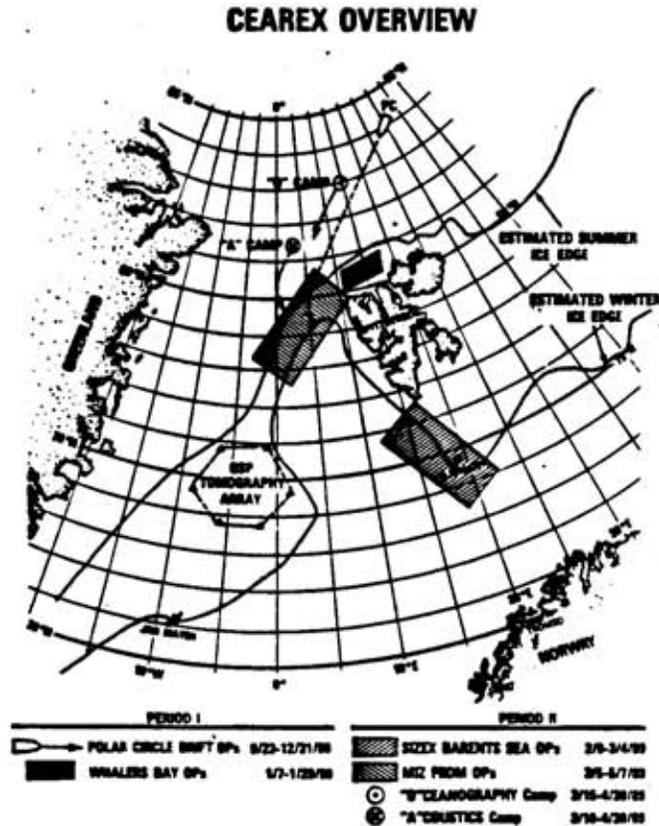


Figure 3. Location of the CEAREX study area.

The data management plan established by NSIDC not only provides for long term data archival and storage but also maintains a centralized access point for the data as soon as it becomes available. The plan is an example of the effort to address the task of data management at an early stage in a large research project with a multi-year duration. Additional management responsibilities include the establishment of data exchange standards for the flow of data among principal investigators and other data centers. Initially data services are restricted to the project personnel, some 200 in all representing eleven nations, but data become unrestricted and available to the scientific community-at-large two years after collection. The collection currently contains 225 individual data sets ranging from listings

of raw data to technical reports with many of the larger data sets available on magnetic tape. A regularly updated computer listing of the complete data catalog is available through an electronic mail system. Funding for this work is provided by the Office of Naval Research.

C. Cryospheric Data Management System

NSIDC is funded by NASA Polar Oceans Program to develop a computer-based Cryospheric Data Management System (CDMS). The CDMS design aims to provide a single focal point for snow and ice data sets, improved access to a subset of the currently produced digital data sets (e.g., SMMR), and software tools to aid data analysis. The CDMS is an enhanced version of the NASA Jet Propulsion Laboratory's NASA Ocean Data System (NODS) designed for the archival of SSM/I data and production of cryospheric data sets.

In June 1987, the Defense Meteorological Satellite Program (DMSP) successfully launched the Special Sensor Microwave Imager (SSM/I). The SSM/I is a high resolution microwave imager which will provide near real-time microwave data on sea ice, atmospheric moisture and precipitation, soil moisture, and ocean parameters. The instrument operates at four frequencies: 19.3, 22.2, 37.0, and 85.5 GHz. Vertical and horizontal polarizations are provided for each frequency, except the 22.2 GHz channel which has only vertical polarization. The resolution of the SSM/I sensor footprint ranges from a coarse 70 x 45 km for the 19.3 GHz channel to a high of 16 x 14 km for the 85.5 GHz channel. The satellite orbital characteristics permit daily global coverage with repeat coverage possible every 12 hours due to the orbital overlap. Table 1 presents the area coverage of the SSM/I grids. NSIDC began receiving the SSM/I orbital Sensor Data Records (SDRs) in late November 1987.

Table 1. Area Coverage of the SSM/I Grids.

<u>X</u>	<u>Y</u>	<u>Latitude</u>	<u>Longitude</u>
<u>Northern Hemisphere</u>			
-3850	5850	30.98	168.35
0	5850	39.43	135.00
3750	5850	31.37	102.34
3750	0	56.35	45.00
3750	-5350	34.35	350.03
0	-5350	43.28	315.00
-3850	-5350	33.92	279.26
-3850	0	55.50	225.00
<u>Southern Hemisphere</u>			
-3850	4350	-39.23	317.76
0	4350	-51.32	0.00
-3950	4350	-39.23	42.24
3950	0	-54.66	90.00
3950	-3950	-41.45	135.00
0	-3950	-54.66	180.00
-3950	-3950	-41.45	225.00
-3950	0	-54.66	270.00

NSIDC is receiving SSM/I data from FNOC through Satellite Data Services Division (SDSD) of the National Environmental Satellite, Data, and Information Service (NESDIS). Data are received from SDSD via magnetic tape and then archived into the CDMS. The tapes are purchased by NASA on behalf of NSIDC.

The SSM/I orbital brightness temperatures are formatted into a rapid access archive and stored on optical disk. Daily brightness temperature grids are produced for both the northern and southern hemispheres. Three-day ice concentration grids will be calculated from the brightness temperature grids using the Nimbus Team Algorithm as specified by the NASA Sea Ice Algorithm Working Group. Six-day metafile images binned at 100 kilometer resolution are available for each of the archived grids providing a mechanism for perusal of the SSM/I inventory.

The second issue of *CDMS Notes* was printed in April 1988. This newsletter is published to provide information to the research community about current activities at NSIDC. The focus is the Cryospheric Data Management System, current ice and snow data products available at NSIDC, and the status of applications using NSIDC products. *CDMS Notes* is published on an irregular basis as "Noteworthy" events occur.

FY88 accomplishments are detailed below.

1. **Hardware and Software Acquisitions**

The VAX-11/750 has been replaced by a Micro VAX 3600 and a VAXstation 3500. The Micro VAX 3600 will serve end user requests and processes. The VAXstation 3500 will be dedicated to SSM/I data processing.

SSM/I processing has begun at the JPL/NODS facility. After software validation and data integrity verification at the JPL site, the operational version of the NODS software will be transferred to NSIDC. NSIDC is expected to begin processing of SSM/I data during November 1988.

A stand-alone optical disk subsystem and an optical jukebox system have been integrated into the CDMS hardware configuration. In order to maintain compatibility with the JPL NODS specifications, NSIDC has acquired the Perceptics LaserSystem. The Perceptics subsystem is an OEM product which is configured with an Optical Storage International (OSI) Laser Drive 1200, SCSI interface, Emulex Unibus Host Adapter, and the Perceptics Laserware Software. The OSI optical drive is unique in that write and read operations occur within the same pass. Hence, revectorization of located bad blocks is immediate. The two-sided 12-inch optical platters provide 1 Gigabyte of formatted write-once media per side. The Laserware emulates the DEC Files-11 ODS-2 disk structure, the standard VMS file structure. The LaserStar Jukebox has the capacity to provide 32 Gigabytes of random access data.

The DIPIX Image Analysis System was upgraded to an ARIES-III. A VAXstation-II/GPX color graphics workstation was purchased to replace the PDP-11/73 microprocessor as the host processor for the ARIES Kernel Software System. The ARIES-III system is configured as a 1024 kb display system with 8 mb of video memory. The upgrade included the acquisition of an Eikonix photodigitizer camera. The camera provides users of the image analysis system with the capability to produce raster images from products such as satellite imagery (e.g., DMSP) and charts. In addition, a Polaroid film module was acquired to provide quick onsite photographs.

Hardware/software for a PC-based LAN to upgrade the word processing environment at NSIDC has been purchased. PCs and VAXstation will communicate with each other via Ethernet using the DECnet protocol. Sharing and transfer of documents will be by any of the workstations. VAXstation disks will be the repository for all documents. Archival of documents will be performed easily through the VMS backup utility. WordPerfect is the standard word processing software; it has been installed on the VAXstation and on all PCs at NSIDC. TeX/LaTeX will add additional typesetting capabilities.

2. Systems Management

David Hendrix was hired in July 1987 as a computer programmer for NSIDC. Mr. Hendrix has been instrumental in the modification of the load, extract, and display functions used to incorporate the SMMR data sets into CDMS.

An operations guide has been written to describe the techniques for loading, approving, and copying the SMMR data from tape to the optical disk archive.

The MicroVAX 3500 and 2 VAXstation-II/GPX were connected to the University of Colorado's Campus Fiber-optic/Ethernet network. SPAN access to and from the CDMS is now available over the campus network

and through the University's Laboratory for Atmospheric and Space Physics (LASP) DEC Router.

3. SMMR Acquisition and Archival

NSIDC has received almost eight years of Nimbus 7 SMMR data from the Polar Oceans Branch of NASA Goddard Space Flight Center (GFSC). Software has been developed to convert the SMMR southern hemisphere microwave brightness temperature grids onto a 25 kilometer SSM/I grid plane. Loader and extractor functions have also been developed for integrating the SMMR brightness temperature data sets into the CDMS.

IV. FUNDING

A. Funding Sources

The combined total of Data Center and related research dollars nearly reached \$1 million, down slightly from FY87. Continuing support from NASA, the ONR-University Research Initiative "Arctic Interactions" grant, and NOAA remain the principal funding sources. The slight downturn in FY88 was due to termination of the NASA-CDMS buildup stage and startup of operational phase of SSM/I data processing. The ONR-URI funding also sustained a 10% budget reduction in the second project year, as it did in the first year.

The proportion of Data Center funding from NOAA sources has remained stable, although the relative proportion of total funding (18%) is two percent less than in FY87. Figure 4 displays the WDC/NSIDC funding by source for FY88. As in past years salaries and benefits account for more than 80% of the total available funds.

Funding for the DMSP collection is still in doubt. NESDIS was able to level fund the activity in FY88, but has only provided reduced support for the first six months of FY89. The AFGWC has started the transition from hardcopy to fully digital data use. At this point no plans have been made to retain the digital data stream from the OLS sensor systems. As we have stated in the past, the

NSIDC/WDC FUNDING BY SOURCE

FISCAL YEAR 1988

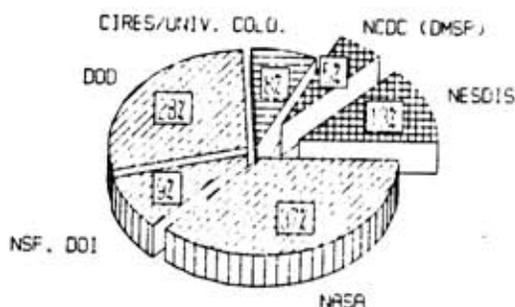


Figure 4. NSIDC/WDC funding by source.

completeness and length of record provided by the collection make it an invaluable resource for studies of global change parameters under the developing national and international programs in this area. Equipping the Center for processing of digital DMSP visible and IR data would be costly, but the potential value of such archives, at least for selected regions covered by the 600 m resolution direct readout data, makes the question of importance in our forward planning. The fact that SSM/I products from DMSP satellites will be archived at the Center is a further reason for having available digital OLS data.

The ONR-URI funding sustained a 10% budget cut in this fiscal year and it is likely that a 13-15% cut will occur in FY89. This cut was the smallest of any of the URI programs and demonstrates the strength of our research efforts. NASA-CDMS funding has remained stable, despite cuts in other NASA science programs. We are pleased that NASA Polar Oceans program remains strongly committed to our data management and product generation efforts.

B. Data Request Statistics

Data sales income recovered slightly from the FY87 downturn. The total number of requests was essentially stable (see Figures 5 and 6). It appears that research or industrial programs which purchased large blocks of data in the past once again did not do so in 1988. The total FY88 sales were \$17,776. The largest percentage user group is U.S. academia (29%) followed by industry and the U.S. government.

NSIDC/WDC DATA REQUEST STATISTICS

BY FISCAL YEAR

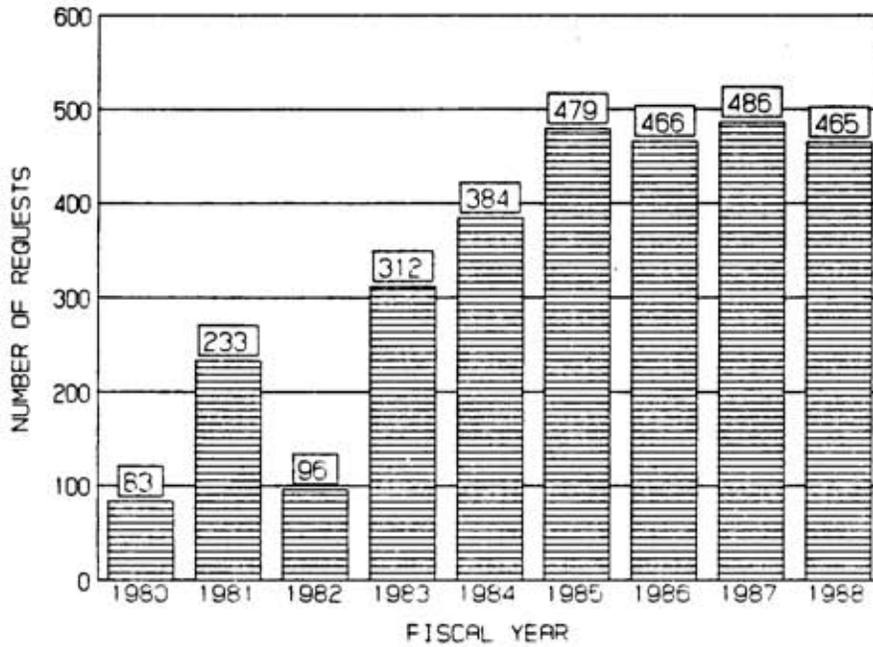


Figure 5. NSIDC/WDC data requests.

NSIDC/WDC DATA REQUEST STATISTICS

BY FISCAL YEAR

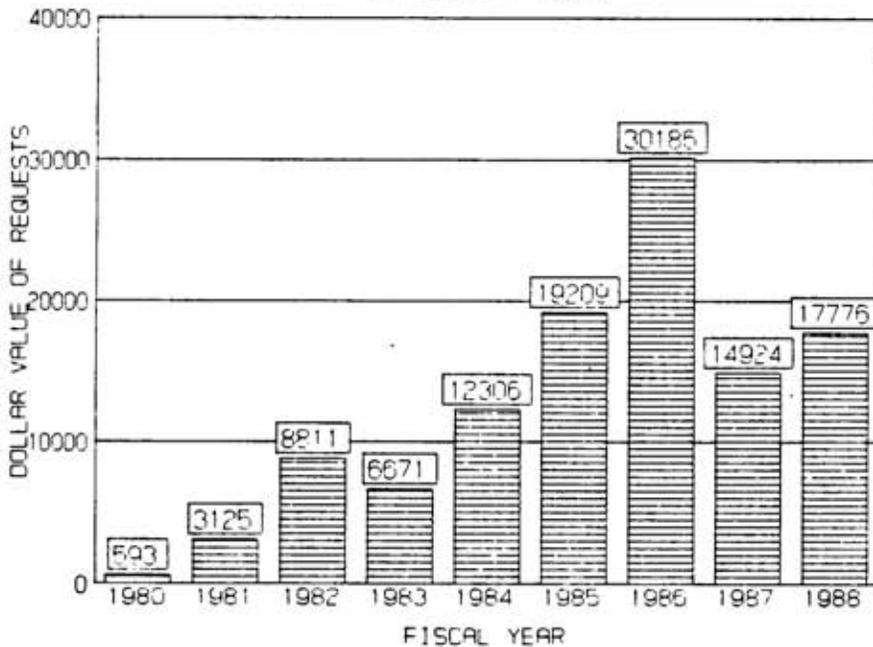


Figure 6. NSIDC/WDC data sales.

V. NEW INITIATIVES

Since June 1987, NSIDC has been involved in a joint planning effort with NGDC to develop a new paleoclimatology program. We are happy to announce that NGDC has provided \$10K of startup funding for this program in FY89. The initial goals of the program to be addressed in FY89 are to assess the trends and opportunities in paleoclimate data management and research; and to identify those data compilations or modeling initiatives which are data-intensive or would require multidisciplinary data input. The second phase would involve the acquisition of all appropriate data sets making them available to the general research community as well as provide a basis for research activities within NGDC and NSIDC. These goals will be pursued in terms of four major paleoclimate data sources: tree rings, ocean sediments, lake and bog sediments, ice core/glacier fluctuations. The latter category is the responsibility of NSIDC and is managed by Richard L. Armstrong.

Funding has been received for a two-year study of the AFGWC Snow Depth Model. A planning meeting at Offut AFB, was held on 6 October. R.L. Armstrong, R.G. Barry and G. Scharfen of NSIDC, Dr. D. Meyer (AWS), Lt. Col. Ed Nimmo (AFGWC) and other key Air Force personnel met.

For the past two years we have attempted, so far without success, to acquire funding for development of a Northern Hemisphere snow cover grid for SSM/I data. Our previous submission to NSF Division of Polar Programs was unfunded despite its high marks by the reviewers. We have since incorporated the comments from the NSF reviewers and from other members of the research community and submitted the proposal to the Innovative Research Program of NASA. This proposal is now pending action.

A proposal for study of Climate - Cryosphere Processes and Interactions involving the University of Colorado, Dartmouth College and ETH Zurich was submitted to the EOS program of NASA in June 1988 and is in review. Our scientific goals are to improve understanding of the unique properties of high-latitude snow and sea ice and their role in the global climate system and its temporal evolution. The spatial and temporal characteristics of atmosphere-ice-ocean system interactions need to be

comprehensively determined as a basis for modeling and prediction of the sensitivity of polar regions to climate perturbations.

We have also submitted two proposals to the NOAA Global Change Initiative (for FY89). The first was to fund the development of a digital DMSP data archive when the Air Force finally stops production of the hardcopy products (see section B.1. above). The second is for development of a archival capability for the Digital Ice Forecast and Analysis System (DIFAS) of the Navy-NOAA Joint Ice Center. We assume that both of these proposals will require re-submission in February 1989 for the "second tier" of Global Change proposals.

VI. ASSOCIATED CIRES RESEARCH PROJECTS

A. Arctic Ocean-Atmosphere-Ice System Studies Program

Funding: Office of Naval Research. University Research Initiative.

R.G. Barry, A.S. McLaren, R. Schnell.

The objectives of this program are to improve the understanding and prediction of ice-atmosphere interactions in the Arctic on synoptic to interannual time scales through:

1. studies of the mechanisms of changes in sea ice extent, concentration, thickness and distribution;
2. determination of the space-time characteristics of snow cover melt, leads and polynyas, and ice thickness distribution;
3. analysis of arctic cloud regimes and synoptic activity and their interactions with the ocean/ice surfaces.

Ice conditions are being determined from analysis of satellite imagery and passive microwave data and submarine under-ice sonar measurements. Work during the first two years has concentrated on three topics: international variations in ice motion of the Beaufort Gyre in the Canada Basin; climatology of Arctic cyclones and anticyclones; and analysis of lead response to changing synoptic conditions. Results from these analyses will be utilized as model input and

validation data by our associates at Dartmouth College and by scientists at NORDA seeking to improve our prediction capabilities for Arctic sea ice.

The highlights of work to date include our identification, from the ice velocity data provided by the Arctic drifting buoys (1979-85), of a recurring reversal of ice motion in late summer in the Canada Basin (McLaren *et al.* 1987). This previously unrecognized phenomenon occurs in response to changes in atmospheric forcing as the mean anticyclone which persists over the area from October through early summer is replaced by quasi-stationary cyclones (Serreze and Barry, in press). The cyclonic motion of the ice in summer leads to divergence of the ice in the Beaufort Sea in late summer causing reduced ice concentrations (Maslanik and Barry, 1988). Analysis of DMSP images has enabled mapping of the occurrence of major leads; their relationship to synoptic forcing is being determined. Also, it has been demonstrated that open leads in winter can be detected using lidar backscatter which records plumes of ice crystals (Barry and Miles, 1988). These may penetrate to several kilometers altitude and can persist for several hundred kilometers downwind.

B. Mass Balance History and Modeling of Blue Glacier

Funding: NSF through a subcontract with the University of Washington.

R.L. Armstrong

This study has three related goals: first, the uniform reduction and presentation of climatological and mass balance data which have been collected for Blue Glacier since 1956. Second, the development of a method, based on the analysis of these data, to model or indirectly compute the mass balance, and third, to develop simplified measurement techniques which will allow the future collection of data necessary to support the model. In addition, we are evaluating all systematic and random errors potentially effecting the computation of mass balance values. These data, along with the 50-year record of glacier terminus location, represent one of the two longest data sets in the United States and will provide a valuable data source for future study of the interactions between climate and

glacier dynamics. The mass balance record indicates that Blue Glacier has been in approximate equilibrium with local climate conditions for the past several decades. This is in contrast with most other glaciers being monitored in both North America and Europe, which have experienced an average mass loss during the same period. Two indices which distinguish Blue Glacier from those in almost continuous retreat are an Accumulation Area Ratio (AAR) of 0.5 and a consistently linear relationship between net balance and elevation from the terminus through the accumulation zone. The complete data set will be archived at NSIDC.

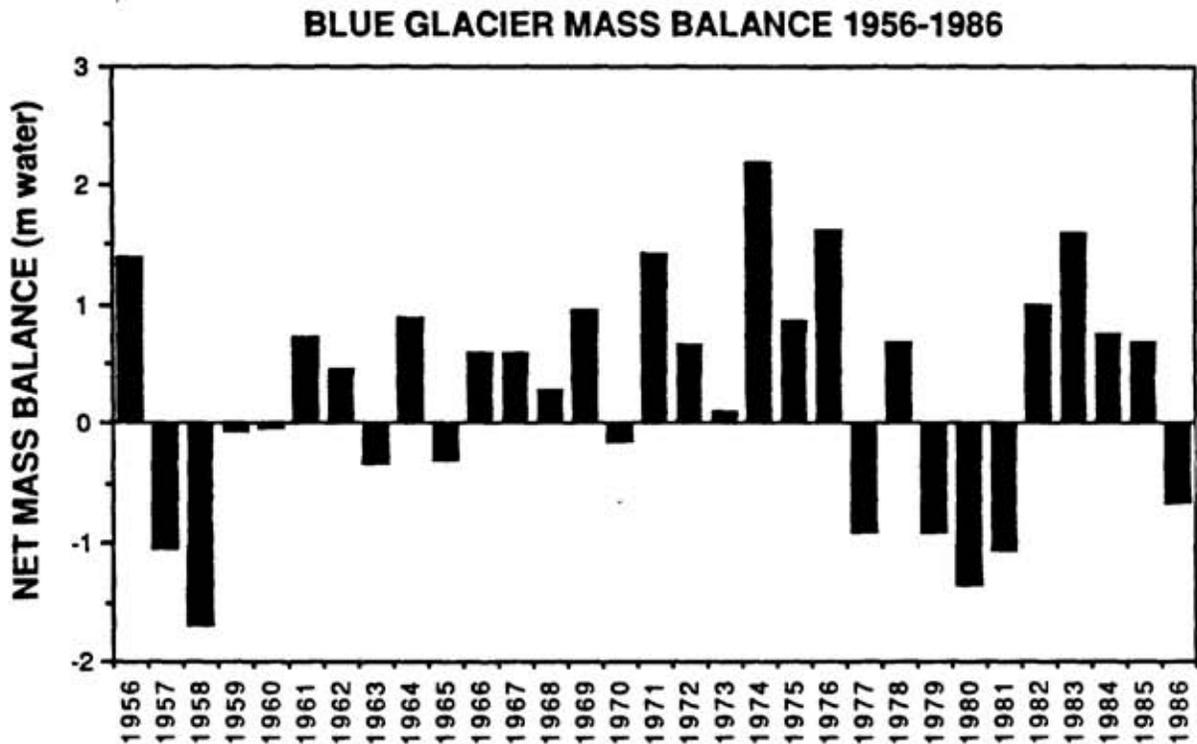


Figure 7. Blue Glacier mass balance, 1956-1986.

C. Sea Ice Responses to Synoptic Conditions

Funding: NSF/Division of Polar Programs. R.G. Barry

This project used SMMR passive microwave data, in conjunction with atmospheric data and ice motion determined from the Arctic drifting buoys (1) to describe modes of variability of ice concentration and extent in the Canada Basin and (2) to determine the nature and role of atmospheric forcing on synoptic time

scales. The analysis shows that the pack ice in this area is more variable than expected with substantial (20% or more) reductions in ice concentration occurring in late summer associated with episodes of persistent cyclonic activity (Maslanik and Barry, 1988). These ice reductions are substantiated by visible band imagery. They can persist for up to 2 weeks after the responsible pressure system has dissipated and there are longer-term effects on the ice. These areas could have significant effects on the regional heat and salinity budgets.

D. Arctic Snow Melt

Funding: NSF/Climate Dynamics. R.G. Barry and G. Scharfen (with D.A. Robinson and G. Kukla). Supplemental funding has come through the URI grant. See VI.A

Results from the analysis of the seasonal progression of snow melt on Arctic pack ice, mapped at 3-day intervals for 4 seasons from DMSP visible images, have been published (Robinson *et al.*, 1987; Robinson and Scharfen, 1988). The geographical and temporal patterns of melt and surface albedo changes have been determined. Substantial differences are found in the timing, duration and extent of the melt regime, especially May - June. The analysis is being extended to provide a 10-year digital data set on snow melt and surface albedo.

E. SSM/I Sea Ice Algorithm Validation Efforts

Funding: NASA/Polar Oceans. R.G. Barry, K. Steffen, R. Weaver.

The approach to the DMSP SSM/I sea ice validation effort is to demonstrate a quantitative relationship between the SSM/I-derived sea ice parameters and those same parameters derived from other data sets including visible and infrared satellite imagery, aerial photographic and high-resolution microwave imagery from aircraft. The main question addressed is, to what accuracy (relative to these other observations) can we determine the following sea ice parameters:

- (1) position of the sea ice boundary;
- (2) total sea ice concentration; (see Figure 8 for example.)
- (3) multiyear sea ice concentration.

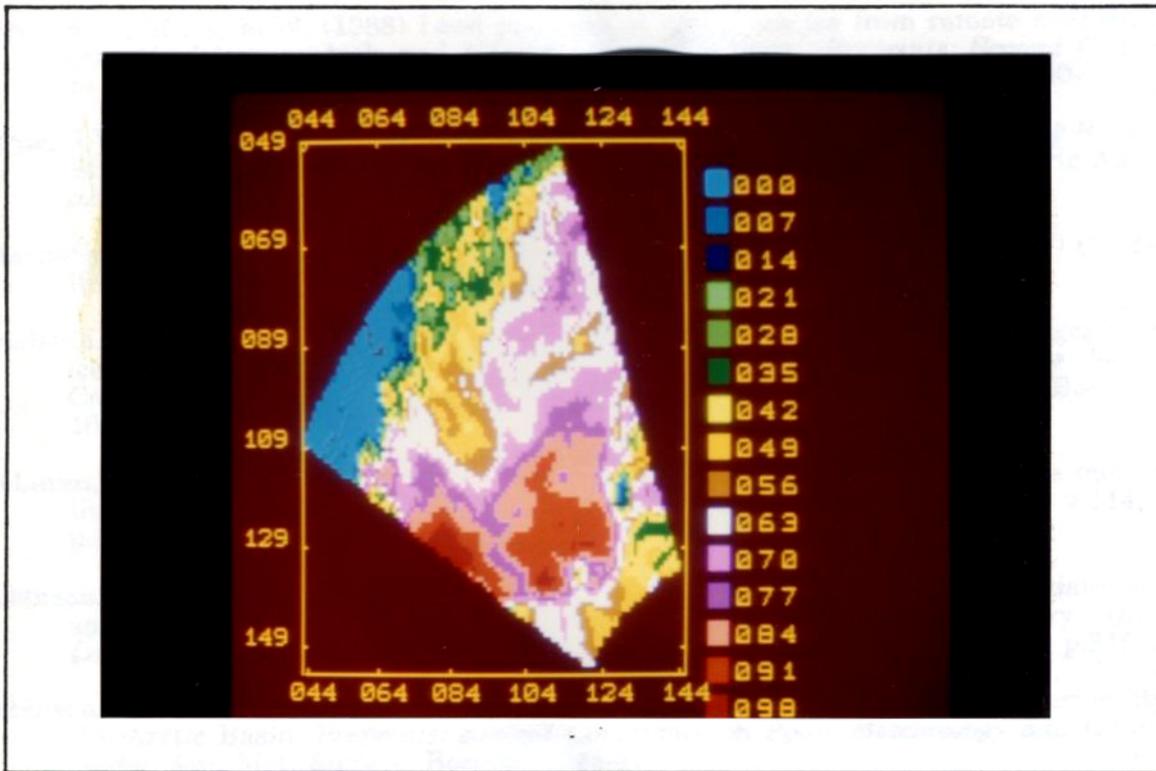


Figure 8. SSM/I-derived sea ice concentration data for the Weddell Sea, 29 November 1987.

Specific tasks include (1) a study of the interrelationship of surface information content and sensor spatial and spectral resolution in order to establish relationships between ice surface features and the manner in which they are expressed in the satellite observations; and (2) apply these relationships to map the sea ice features which can be used to evaluate NASA's proposed SSM/I sea ice algorithms.

Other key points to be addressed include: the accuracy to which these parameters can be determined in different regions (e.g. marginal ice zone, such as the Bering Sea, Arctic Ocean such as the Beaufort Sea); the accuracy of these parameters for different seasons; the accuracy of the algorithms weather filter under different weather conditions; and the effectiveness of the 85.5 GHz channels to locate the ice edge.

REFERENCES

- Barry, R.G.; Miles, M.W. (1988) Lead patterns in Arctic sea ice from remote sensing data: characteristics, controls and atmospheric interactions. *Preprints: Second Conference on Polar Meteorology and Oceanography*, Am. Met. Society, Boston, p. 40-43.
- Byrne, J.V. (1984) Letter from the administrator. In: *NOAA 1985-2000. A Long-Range Strategy for Agency Development*. U.S. National Oceanic and Atmospheric Administration. Unpublished report, 21 p.
- International Council of Scientific Unions. Panel on World Data Centres (1987) *Guide to World Data Center System*. Vol. 1, Boulder, CO, 91p.
- Maslanik, J.A.; Barry, R.G. (1988) Interannual variability of short-period changes in sea ice and atmospheric synoptic conditions in the Canada Basin. *Preprints: Second Conference on Polar Meteorology and Oceanography*, Am. Met. Society, Boston, p. 40-43.
- McLaren, A.S.; Serreze, M.C.; Barry, R.G. (1987) Seasonal variations of sea ice motion in the Canada Basin and their implications. *Geophysical Research Letters*, v.114, p.1123-1126.
- Robinson, D.A.; Scharfen, G.R.; Barry, R.G. (1987) Analysis of interannual variations of snowmelt on Arctic sea ice mapped from meteorological satellite imagery. (In: *Large Scale Effects of Seasonal Snow Cover*. IAHS Publication no. 166, p.315-327.)
- Robinson, D.A.; Scharfen, G.R. (1988) Summer cryospheric and atmospheric variability in the Arctic Basin. *Preprints: Second Conference on Polar Meteorology and Oceanography*, Am. Met. Society, Boston, p. 44-47.
- Serreze, M.C.; Barry, R.G. (1988) Synoptic activity in the Arctic Basin, 1975-1985. *Journal of Climate*, in press.

MEETINGS

- Polar Research Board, Washington, DC 28-30 April - R.G.Barry.
- SODSSWG, December 10, 1987, March 26, 1988 - R.Weaver.
- Digital Equipment Corporation User Society (DECUS) Symposium, Cincinnati, OH 16-20 May 1988 - V.Troisi.
- Second Conference on Polar Meteorology and Oceanography, Madison, WI, 29-31 March 1988 - R.G. Barry, R.L. Weaver, G. Scharfen, A.S. McLaren.
- Fifth International Conference on Permafrost, Trondheim, Norway, 2-5 August 1988 - R.G. Barry
- Study Conference on Data Management for the IGBP, Moscow, 9-12 August 1988 - R.G. Barry
- AGU, San Francisco, 9-11 December 1987 - R.G.Barry, R.L. Weaver, R.L. Armstrong
- Altimetry Science Working Group, JOI, 12-13 April 1988 - V.J.Troisi, C.S.Hanson
- U.S. Ice Core Research Workshop, 14-17 June 1988, Durham, NH, R.L. Armstrong

U.S./Canada Joint Ice Working Group, 4-7 October 1987, Woods Resort, West Virginia - G. Scharfen; U.S. members pre-meeting 26 May 1988 - R.Weaver.

Great Lakes Ice Information Working Group, Ottawa, 28 October 1987 - C.S. Hanson

Northern Libraries Colloquy, 6-10 June 1988 - A.M. Brennan

Symposium on Ice Dynamics, Hobart, Australia, 14-20 February - R.G. Barry

COMMITTEES

Member, Polar Research Board (September 1, 1987-1991) - R.G. Barry

SCAR representative to ICSU Panel on World Data Centers - R.G. Barry

Ad Hoc Panel on Remote Sensing of Snow and Ice, Committee on Glaciology, Polar Research Board, National Academy of Sciences - R.G. Barry

NASA SSM/I Validation Team - R.L. Weaver.

Satellite Ocean Data System Science Working Group (SODSSWG) - R.L. Weaver

SSMI Sea Ice Archive Working Team (SSIAWT) - R.L. Weaver (interim chairman)

Panel on Snow Avalanches, Committee on Ground Failure Hazards, National Research Council, National Academy of Sciences - R.L. Armstrong

Working Group on Snow Classification, International Commission on Snow and Ice, International Association of Hydrological Sciences - R.L. Armstrong

NOAA-NGDC Paleoclimate Study Committee - R.L. Armstrong

PAPERS SUBMITTED/PUBLISHED DURING FY88

World Data Center for Glaciology (Snow and Ice), 10th Anniv. Seminar, Passive Microwave Users Workshop, Microwave Radiometry Bibliography, *Glaciological Data, GD-19*: 1-132, October 1987.

Richard Armstrong

Melting Snow. *Weather* 43(2): 59-60, 1988.

Response of Blue Glacier to recent climate conditions. American Geophysical Union, Fall Meeting, 7-11 December 1987, San Francisco, CA.

Roger G. Barry

Intercomparison of satellite-derived cloud analyses for the Arctic Ocean in spring and summer, *Int. J. Rem. Sens.*, 9(3): 447-467, March 1988; with K. McGuffie, A. Schweiger, D.A. Robinson, J. Newell.

World Data Center A for Glaciology, National Snow and Ice Data Center. (R.G.Barry and A.M.Brennan) *Arctic Research of the United States*, v.2:32-38, 1988.

Seasonal variations of atmospheric circulation and sea ice motion in the arctic, In: *2d Conf. on Polar Meteorology and Oceanography*, Madison, WI, 29-31 March 1988: 20-23; (with A.S.McLaren and M.C.Serreze).

Interannual variability of short-period changes in sea ice atmospheric synoptic conditions in the Canada basin, In: *2d Conf. on Polar Meteorology and Oceanography*, Madison, WI, 29-31 March 1988: 28-31; (with J.A.Maslanik).

Lead patterns in arctic sea ice from remote sensing data: characteristics, controls and atmospheric interactions, In: *2d Conf. on Polar Meteorology and Oceanography*, Madison, WI, 29-31 March 1988: 40-43; (with M.W. Miles)

Synoptic activity in the arctic basin in summer, 1979-1985, In: *2d Conf. on Polar Meteorology and Oceanography*, Madison, WI, 29-31 March 1988: 52-55; (with M.C. Serreze)

Comparison of atmospheric circulation indices for Shelikof Strait, Gulf of Alaska, In: *2d Conf. on Polar Meteorology and Oceanography*, Madison, WI, 29-31 March 1988: 57-60; (with C.W. Ziskin)

Permafrost data and information: Status and prospects. In: *Proceedings, Fifth International Conference on Permafrost*, Vol. 1, Tapir Publishers, Trondheim 1988, pp. 119-122.

Melting of polar ice caps. *Weather*, 1988, 43: 60-61.

Ann Brennan

World Data Center A for Glaciology, National Snow and Ice Data Center. (R.G.Barry and A.M.Brennan) *Arctic Research of the United States*, v.2:32-38, 1988.

Twelfth Northern Libraries Colloquy, 5-9 June 1988. Proceedings (A.M.Brennan and M.Andrews, eds.) *Glaciological Data, Report GD-22*, 331p.

Permafrost Bibliography Update, 1983-1987 (A.M.Brennan, comp.) *Glaciological Data, Report GD-21*, 225p.

Claire Hanson

World Data Center for Glaciology (Snow and Ice), Workshop on the U.S. Antarctic meteorological data delivery system, (eds. C.S. Hanson, C.R. Stearns), *Glaciological Data, GD-20*, 76 p.

Workshop on the U.S. Antarctic Meteorological Data Delivery System, *Bulletin American Meteorological Society*, v.69(6): 627, 1988. (C.S. Hanson, R.G. Barry, C.R. Stearns)

A. S. McLaren

Analysis of the under-ice topography in the Arctic Basin as recorded by the *USS Nautilus* during August 1958, *Arctic*, 41(2): 117-126, June 1988.

Greg Scharfen

Summer cryospheric and atmospheric variability in the arctic basin. *2d Conf. on Polar Meteorology and Oceanography*, Madison, WI, 29-31 March 1988: 44-47; (with D.A. Robinson)

Konrad Steffen

Surface temperatures and sea ice typing for northern Baffin Bay, *Int. J. Rem. Sens.*, 9(3): 409-422, March 1988.

Ronald L. Weaver

Passive microwave data for snow and ice research: planned products from the DMSP SSM/I system, *2d Conf. on Polar Meteorology and Oceanography*, Madison, WI. 29-31 March 1988: 129-132.