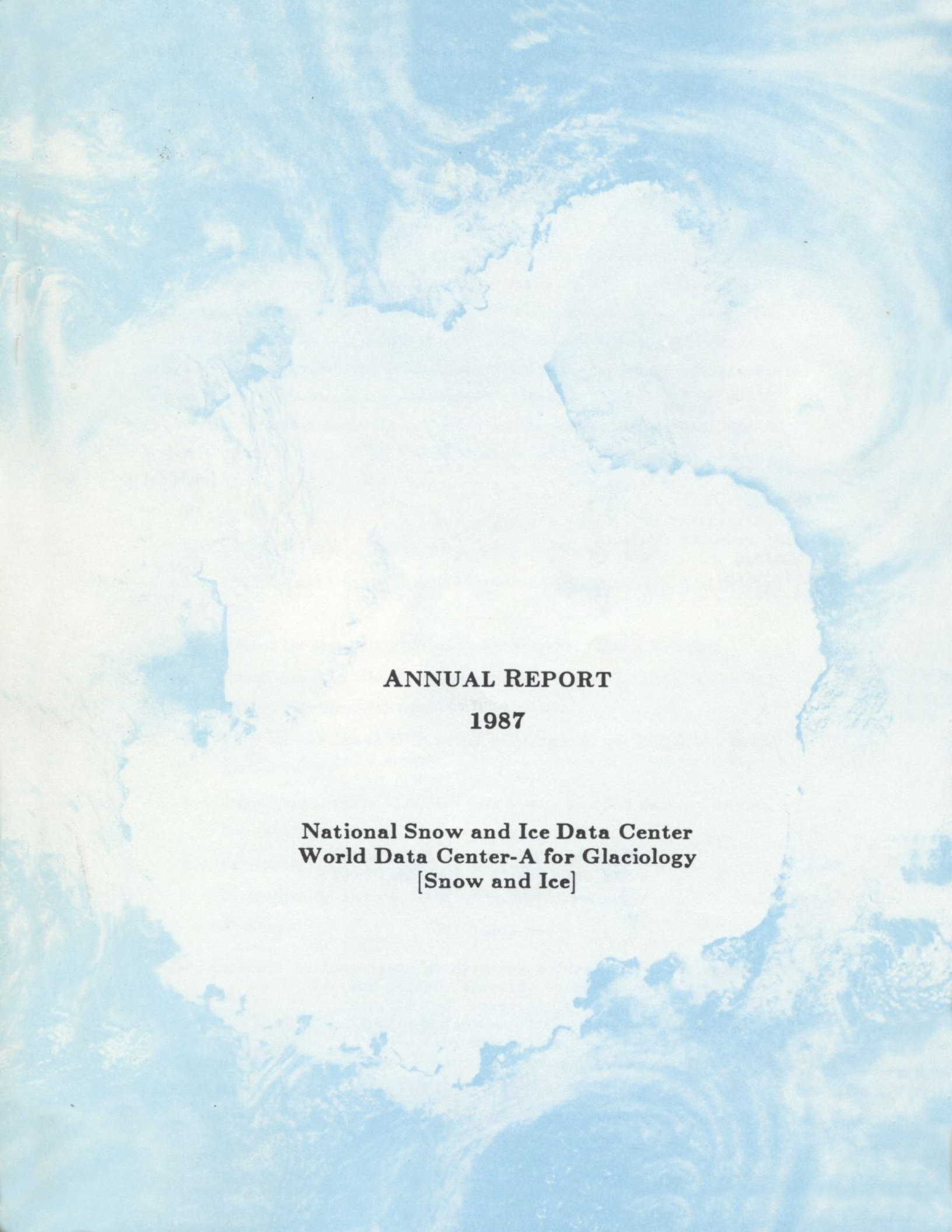

ANNUAL REPORT

1987

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

COVER: Antarctica, compiled from 5 images (with minor retouching), collected between 4 and 25 November 1986. DMSP Satellite F-7, visible-band, 2.7 km resolution. See page 10 for details.

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WORLD DATA CENTER-A FOR GLACIOLOGY
[SNOW AND ICE]

November 1987

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Operated for:

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WDC/NSIDC ANNUAL REPORT FY 1987

I. INTRODUCTION

A. Purpose

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.

B. FY87 Goals

MBOs identified in the FY87 proposal stated the following goals.

1. Organize and host the Passive Microwave User's Workshop, 8-10 October 1986.
2. Publish the proceedings of the Passive Microwave User's Workshop.
3. Install and test the Pilot Ocean Data System (PODS) version 3.1 software, specifically designed for SSM/I data.
4. Purchase and install ONR-funded photodigitizer on DIPIX Inc. image analysis system.
5. Study ways to offer CITATION data base to an online data and information service.
6. Participate in U.S. Canadian Ice Working Group.
7. Participate in preparation of a revised *International Guide to Data Exchange*.

II. HIGHLIGHTS

A. Passive Microwave User's Workshop

The Passive Microwave User's Workshop was attended by over 100 current and potential users of passive microwave satellite data from industry, academia, civilian and military government agencies. The attendance was about double our

preliminary estimates. This one and one-half day workshop was held in Boulder, October 8-10, 1986. Major agenda items included: plans for SSM/I (and also ESMR and SSMR) data distribution; current status of SMMR and SSM/I data distribution system. A summary and the recommendations generated at this meeting are published in *Glaciological Data, Report GD*-19.

B. WDC-A for Glaciology Tenth Anniversary

The Data Center celebrated its 10th anniversary of operations at the University of Colorado on November 14. The occasion was marked by guest lectures by the two previous center directors, William O. Field (1957-71) and Mark F. Meier (1971-76), as well as by Alan Shapley, former director NGDC, and the current WDC-A Glaciology director, Roger G. Barry. These presentations are published in *Glaciological Data, Report GD*-19. The meeting attendees included representatives from NOAA-NESDIS, Margaret Courain and Harold Yates, and from the National Academy of Sciences, Pembroke Hart (Geophysics Research Board) and Bruce Molnia (Polar Research Board). On behalf of NESDIS, M. Courain presented the Center with a national weather map for October 14, 1976, the day Glaciology began operations in Boulder.

C. Panel on Glaciological Data

The Panel on Glaciological Data of the National Academy of Sciences visited the WDC/NSIDC on November 13. Panel members J.E. Walsh, University of Illinois, and A. Gow, CRREL, heard presentations by the director and staff on operations and activities since their last visit in August 1984. These meetings were also attended by participants in Boulder for the 10th Anniversary meeting on the following day, including former panel members C.E. Bull and M.F. Meier, and representatives of NOAA/PMEL and the Arctic Environmental Information and Data Center. The Panel will prepare a report on the WDC/NSIDC for the Committee on Geophysical Data.

D. *CDMS Notes*

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

E. U.S. Antarctic Meteorological Data Delivery System Workshop

On September 10-11, 1987, NSIDC convened a Workshop on the U.S. Antarctic Meteorological Data Delivery System. The project goal was to assure U.S. Antarctic meteorological data are easily accessible for research. The overall objective of the workshop was to prepare recommendations for a system to deliver U.S. Antarctic meteorological data to the user.

Funded by the Polar Coordination and Information Section of the National Science Foundation/Division of Polar Programs (NSF/DPP), the Workshop brought together twenty-five representatives from organizations that collect, process, archive, and use meteorological data (standard synoptic surface and upper air) from U.S. Antarctic stations.

NSF participants were G. Guthridge, and E. Chiang. C. Stearns, University of Wisconsin, chaired the meeting. Working groups prepared recommendations in the following broad areas of concern:

1. Data collection, entry, and display at observing stations.
2. Transmission of real-time U.S. data from Antarctica.
3. Flow of data from U.S. stations into permanent archives.
4. Special types of data: drifting buoy data, numerical analyses, satellite data, and unique historical data sets.
5. Data access for users.
6. Proposed follow-up oversight committee.

Draft recommendations have been delivered to NSF/DPP. Following incorporation of comments from attendees and other interested parties, the proceedings of the workshop, including text of the final recommendations, will be published in a forthcoming issue of *Glaciological Data*. Text of the recommendations will be disseminated as widely as possible in the community. NSF/DPP plans to implement the final recommendations in an effort to protect its thirty-year investment in Antarctic data collection and research.

In conjunction with the Workshop, demonstrations of two climate data management systems were presented to workshop attendees, as well as to NGDC, Geophysical Monitoring for Climatic Change (GMCC), and ERL Climate Research Group personnel. CLICOM was demonstrated by Richard Cram, Primary Data Branch Chief, National Climatic Data Center. CLICOM is a PC-based, menu-driven system for managing climate data, developed by NCDC and WMO for use in

developing countries. CLICOM is also being used by several State Climatologists, and by the Western Regional Climate Center in Reno. CLICOM could be adapted for the management of snow and ice, oceanography, or other types of data.

The NASA Pilot Climate Data System (PCDS) (soon to be the NASA Climate Data System) was demonstrated by Lola Olson of the National Space Sciences Data Center at NASA/Goddard Space Flight Center. PCDS is an online menu-driven system that provides descriptive catalog information about data sets available online in PCDS, as well as providing the data themselves according to user-selected time and space parameters.

III. CURRENT PROGRAMS

A. NOAA/NESDIS/NGDC Funded Programs

1. Information Center and CITATION Data Base

One of the principal directives of the Glaciology section of the *Guide to International Data Exchange through the World Data Centres* is to "collect, store and disseminate information and data on Glaciology ... ." To fulfill this directive 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 1987, approximately 1300 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 1986, there were almost 22,000 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 since 1978.

Remote access to CITATION is not yet available, but we are still pursuing the possibility. Discussions with Systems Development Corporation (SDC),

the online supplier of the COLD data base, had begun when the company was sold. We are beginning to work with Pergamon-Infoline (the new supplier), and hope to complete these discussions and initiate the transfer of the data base during FY88. Also, by utilizing Pergamon's online ordering feature, WDC/NSIDC could supply materials in its collection to remote users very quickly. A document delivery service is especially important to the researcher in glaciology because of the interdisciplinary nature of the research (covering geology, geography, geophysics, engineering, and climatology) and the diversity of sources which publish snow and ice material. Preparing CITATION for online access will continue to be a priority activity until accomplished. Microfiche indexes also offer user access to the collection. Author, title, subject, and geographic indexes are available for material received and catalogued through 1985.

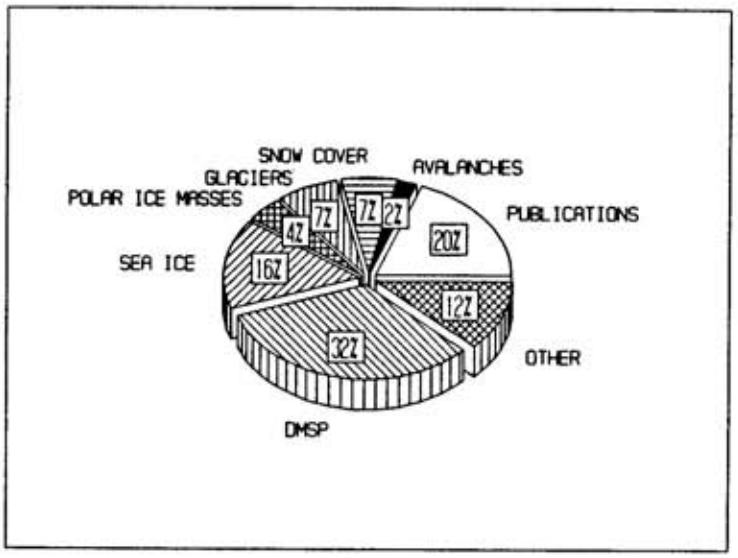

Figure 1. Data request by subject, 1978-1987.

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 FY87, 3 NAL issues were completed.

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 FY87, one issue in this series was prepared. *GD*-19 contains the papers presented at WDC's Tenth Anniversary Seminar in Boulder, in addition to the report on the Passive Microwave User's Workshop and the updated Microwave Radiometry bibliography. The issue was sent to the printer in early October 1987.

The first in a new series of specialized bibliographies which cover specific snow and ice subtopics, "Microwave Radiometry", was distributed in October 1986. A second was prepared with support from the Natural Hazards Research and Applications Information Center (NHRAIC) of the University of Colorado. A *Bibliography of Snow and Ice Hazards on Highways* was compiled by A. Schweiger, CIRES graduate student. This 900-item bibliography is intended to provide a guide to the diverse literature on this topic from the standpoints of forecasting and detection, prevention and removal techniques, management, and economic, environmental and social impacts. A separate author listing is also provided. This publication is being distributed jointly by NSIDC and NHRAIC.

A project to update the Permafrost Bibliography was begun this year. It is scheduled for completion in mid-FY88. A listing of Soviet permafrost literature from 1982 to the present was prepared and sent to P.I. Melnikov, Director of the USSR Academy of Sciences Permafrost Institute. After discussions with us, Dr. J. Brown, NSF and the U.S. Committee for the International Permafrost Association, Dr. Melnikov has reviewed our list and added references which were not included. This Soviet material will be included in the permafrost bibliography update which we are preparing for the Fifth International Conference on Permafrost to be held in Trondheim, Norway in August 1988.

3. Public Relations

WDC/NSIDC is an active participant in the Northern Libraries Colloquy. The Colloquy is an international group of libraries and information centers in the North or with collections of Northern interest. It meets biannually, alternating between Europe and North America, to discuss various aspects of information service and policy. The Colloquy met in Lulea, Sweden in 1986. An invitation for the 1988 Colloquy to meet in Boulder was extended jointly by WDC/NSIDC and INSTAAR. The invitation was accepted and the group will meet here in June, 1988. The National Science Foundation has funded a proposal ($46,000) to support the Colloquy, provide for invited speakers, and publish and widely distribute the proceedings.

4. Data Set Administration

During the past year, nine new data sets were received, three were updated, and one new Data Announcement was produced.

Geosat Land/Ice Data. Monthly tapes containing altimeter data over land and ice, from the Geosat Exact Repeat Mission, are now being archived jointly by NSIDC and NGDC/Solid Earth Geophysics. D. Hastings, R. Buhmann and C. Hanson comprise the "Geosat Task Group," which is preparing a joint Data Announcement as well as determining future plans for archiving, dissemination, and use of this portion of the Geosat data.

Seasat Ice Sheet Elevation, Greenland and Antarctica. Two reels of magnetic tape were received from the Ice Branch at NASA/Goddard Space Flight Center, containing ice sheet elevation products for Greenland and Antarctica. The gridded, geo-reference products were derived from Seasat altimetry.

Synthetic aperture radar (SAR) data from the experimental airborne STAR-1 system were received from the Jet Propulsion Laboratory. Eight reels of magnetic tape contain data from two flights over the Greenland ice sheet in March and April 1986. The data set includes imagery (transparencies) from the SAR as well. The STAR-1 (Sea Ice and Terrain Assessment Radar) instrument was developed by the Environmental Research Institute of Michigan and Intera Technologies, Ltd.

Nimbus-5 ESMR (Electrically Scanning Microwave Radiometer) data, comprising monthly averaged, multi-year monthly averaged, and yearly averaged sea ice concentrations and brightness temperatures for 1973-1976, and

monthly averaged climatological surface temperatures and sea level pressures, were received from NASA/Goddard Space Flight Center. These data are presented in the atlas, *Arctic Sea Ice, 1973-1976: Satellite Passive-Microwave Observations*, by C.L. Parkinson, J.C. Comiso, H.J. Zwally, D.J. Cavalieri, P. Gloersen and W.J. Campbell. (NASA, 1987) This data set is contained on one 6250 bpi magnetic tape, and complements the Antarctic averaged data received from NASA/Goddard in 1982.

Nimbus-5 ESMR three-day average brightness temperatures were also received from NASA/Goddard for both Northern and Southern Hemisphere, 1973-1976. Contained on four reels of 6250 bpi tape, these data complete the Nimbus-5 ESMR data products set from NASA/Goddard.

Time-lapse photography studies of the Variegated Glacier in Alaska, were carried out during 1979-1984 by the Geophysical Institute at the University of Alaska. Velocity data were used to analyze short period motion events. One reel of magnetic tape contains the motion data; the data report has been added to the Information Center Library Collection.

Snowfall data spanning 1931-1980 were received from the Swiss Meteorological Institute, for approximately forty stations. Parameters included are new snow and depth of snow on the ground. The data are contained on one reel of 6250 bpi tape.

Baltic Sea ice extent estimates for 1719-1982 were received from the Institute of Marine Research, Helsinki. This small data set, useful for climate research, is contained on one diskette.

The archive of AIDJEX (Arctic Ice Dynamics Joint Experiment) data was expanded with the addition of six cartons of aerial photos of Arctic sea ice, received from the Polar Science Center, University of Washington. The photos, taken by NASA and U.S. Navy aircraft in 1972, 1975 and 1976, will be used for sea ice studies. The remainder of this collection, will be shipped to WDC/NSIDC by the U.S. Geological Survey in Tacoma, where the photos have been on loan from the Polar Science Center for about ten years.

Data sets updated this year included the 27-year North Atlantic iceberg data base from the International Ice Patrol, the 32-year daily Great Lakes visual ice observation data set, and the 13-year National Weather Service Great Lakes hard copy ice chart set.

A new Data Announcement, 87-GLA-41, was prepared to describe the ice core data sets available from WDC/NSIDC. "Ice Core Data" discusses the oxygen isotope studies on the 2000-meter core from South Greenland, work done by the Geophysical Institute at the University of Copenhagen. The data set is available on one diskette.

Announcement 86-GLA-61, "Great Lakes Ice Data," was revised to consolidate its contents and reduce the number of pages. More complete information was included for several of the data sets described therein.

B. Contractually Supported Data Sets

1. DMSP

NSIDC is in the fifth year of service as the national archive for data from the U.S. Air Force Defense Meteorological Satellite Program (DMSP). During FY87, approximately 78,500 images were sorted, catalogued, and archived into the collection, now amounting to about 1.25 million pieces of imagery. More than 55,500 entires, referring to single orbit strips, were added to the searchable computer database. Two hundred and seven data and information requests were processed this year (up 6.7 percent from FY86) resulting in data sales of $9,050 (down 48.8 percent from FY86). The stability in numbers of requests reflects the popularity of the USA at Night mosaic, and the recently completed Antarctic mosaic (see below), both of which are available in a variety of low cost photographic formats.

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 subsidies of $15K to the archive activity.

DMSP data were used in a variety of notable projects this year. A poster depicting the earth's lighting at night was compiled by W.T. Sullivan of the University of Washington, using visible-band imagery from the DMSP archive. The annotated poster, titled *The Earth at Night*, is being distributed by the Hansen Planetarium in Salt Lake City. Nighttime images were also used as part of a Public Broadcasting System 6-hour series called *The Ring of Truth*. Images showing the Eastern U.S. and Europe in daylight and at night were used in the segment titled *Mapping*, which was aired on November 3, 1987. The series is being produced by the creators of *NOVA* and *Odyssey*. DMSP data played a role in the state of New Mexico's 75th anniversary celebration

when the Air Force turned on the visible-band sensor to cover the event. Participating citizens held lamps toward the sky, burned fires and lit candles so a poster could be produced showing the state that night. We received a letter of appreciation from U.S. Senator Jeff Bingamen in response to our efforts at coordinating the event.

In conjunction with another request, NSIDC produced a mosaic of the Antarctic from DMSP data. (See Cover.) The daytime mosaic was compiled from images collected at near local noon during five passes of the F7 satellite in November 1986. The selection of data minimized lighting differences, but an airbrush artist touched up the remaining discontinuities and gaps in the cloud systems around the periphery of the continent. The mosaic is to be used in an exhibit at Sea World in Florida, and has become a popular product at NSIDC. It is available in a variety of photographic formats.

DMSP imagery continue to be used in a variety of important research projects. Images of the Antarctic were used extensively in support of the Antarctic Ozone Hole Experiment, a joint effort, conducted this August and September by NOAA, NSF, NASA and NCAR, to study depletion of ozone. DMSP visible- and infrared-band data were used to document meteorological conditions and help analyze measurements taken during flights of DC-8 and ER-2 aircraft flying over the Antarctic from Punta Arenas, Chile. Dr. Adrian Tuck of NOAA/ERL reported that the DMSP images are making a significant contribution to the effort. DMSP images are being used in the analysis of conditions surrounding the Chernobyl nuclear accident. The U.S. Information Agency and Belgian Public Television station requested copies of an image appearing in an article in *Aviation Week & Space Technology*, March 23, 1987, concerning the event. The photograph shows the effect the nuclear distrail (escaping radiation) from the power plant had on clouds in the area (Figure 2). Other images show the absence of manmade lighting in the city of Chernobyl following the accident. DMSP data are also being used in an in-house research project at NSIDC to study variations in summer snowmelt (and related albedo) on arctic sea ice. (See VI. Associated CIRES Research Projects.)

NSIDC has been archiving U.S. Air Force DMSP data for NOAA/NESDIS since 1983 (DMSP mosaics since 1979) when the collection left the University of Wisconsin. During the last few years, funding for the archive from NESDIS has become increasingly uncertain, a reflection of much broader funding problems for similar data sets. However, FY88 funding was assured on

28 August 1987. The archive is a cost-effective way to disseminate DMSP data to a diverse user community, and user response and support has been good.

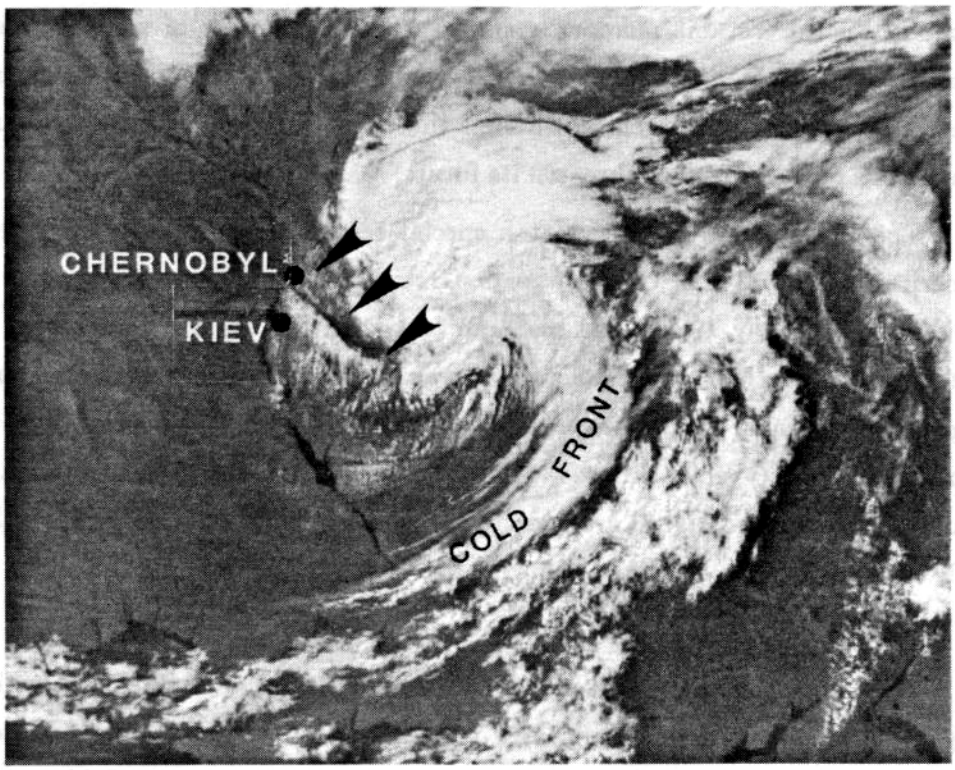

Figure 2. DMSP visible-band image showing meteorological effect of radioactive ions cutting a 150 mile long path through the clouds (white arrows) southeast of Chernobyl on May 2, 1986, six days after the accident. This so-called "nuclear distrail" had been predicted but never seen before. Apparently, ionized radioactive gases pouring from the ruptured reactor chemically reacted with water vapor to dissipate clouds along the 30 mile wide strip.

A matter requiring attention and interagency planning is related to a technology change at Air Force Global Weather Central (AFGWC), Offutt Air Force Base, NE, where the images are produced. AFGWC is in the process of implementing 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 14-year global 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 (eg. 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 apparent changes in format and limitations on funding that threaten its future.

These subjects were raised at a special session on DMSP at the North American NOAA Polar Orbiter Users Group (NANPOUG) meeting held n Boulder, 14-16 July 1987. The response to the DMSP system as a source of data and the continuation of its archive was positive. Participants noted that high temporal and spatial frequency and resolution, coincident coverage by multiple sensors (visible, infrared, SSM/I, SSM/T), and the possibility that it could be a calibrated digital archive in the future make DMSP imagery as valuable as that from the NOAA satellites.

2. MIZEX

Data management for the Marginal Ice Zone Experiment (MIZEX), which began during 1983, continued during FY87. Data from the study of the mesoscale interaction of air-sea-ice processes during the 1983 and 1984 field experiments in the Fram Strait between Greenland and Svalbard have been archived at NSIDC. Additional data from the winter 1987 field experiment have also begun to arrive. A mapped overview of the MIZEX '87 program is shown in Figure 3 (Johnson and Hawkins, 1987). The 1983 and 1984 experiments took place in the same general geographic 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.

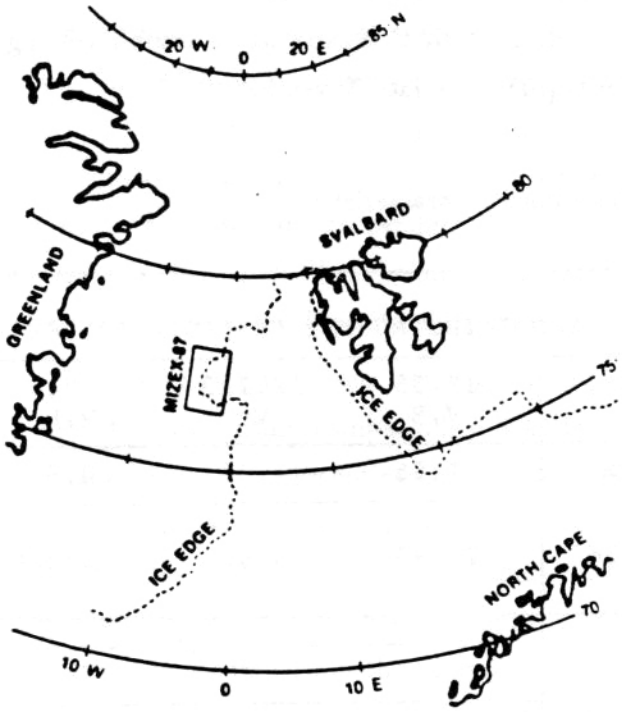

Figure 3. Location of the MIZEX-87 field experiment during March and April 1987. An ice edge analysis for 24 March 1987 is superimposed.

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 (km) of the SSM/I sensor footprint ranges from a coarse 70 x 45 km for the 19.3 GHz channel to a high resolution of 16 x 14 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. See Table 1. NSIDC is expected to begin receiving the SSM/I orbital Sensor Data Records (SDRs) in late-November 1987.

Table 1. SSM/I instrument characteristics.

SSM/I INSTRUMENT CHARACTERISTICS				
FREQUENCY (GHz)	19.35 V,H	22.235 V	37.0 V,H	85.5 V,H
WAVELENGTH (cm)	1.55	1.35	0.81	0.35
FOOTPRINT (km) Effective Field of View	70x45	60x40	38x30	16x14
TEMPERATURE ACCURACY (K)	<——— 1.5 ———>			
BANDWIDTH (MHz)	500	500	2000	3000

NSIDC will receive SSM/I data from FNOC through Satellite Data Services Division (SDSD) of the National Environmental Satellite, Data, and Information Service (NESDIS). Data will be received from SDSD via magnetic tape and then archived into the CDMS.

The SSM/I orbital brightness temperatures will be reformatted into a rapid access archive and stored on optical disk. Daily brightness temperature grids will be 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 will be available for each of the archived grids providing a mechanism for perusal of the SSM/I inventory.

FY87 accomplishments are detailed below.

1. Hardware and Software Acquisitions

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.

An optical disk subsystem has 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 occurs 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.

Installation of the NODS Version 3.1 Software onto the VAX-11/750 was completed in 1987. Simulated SSM/I data tapes were supplied by the JPL NODS group for testing of the load and extract procedures in the CDMS environment. Although not all of the product tests were successful in the prelaunch version of the NODS software, NSIDC is hopeful that the system will be 'bug-free' by mid-November.

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 will be the standard word processing software. TeX/LaTex will add additional typesetting capabilities.

Wordperfect word processing software has been installed on the VAXstation and on all PCs at NSIDC.

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 VAX-11/70 and the VAXstation-II/GPX were connected to the University of Colorado's Campus Fiber-optic/Ethernet network. In preparation for this event, the VAX-11/750 was disconnected as a direct SPAN node. SPAN access to and from the CDMS is now possible indirectly over the campus network and through the University's Laboratory for Atmospheric and Space Physics (LASP) DEC Router.

The inaugural volume of *CDMS Notes* was published in August 1987. *CDMS Notes* is a newsletter reporting useful information to the research community about current events at NSIDC. The focus of *CDMS Notes* will be CDMS, new acquisitions of snow and ice data products, and the status of applications using NSIDC products.

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. See Figure 4.

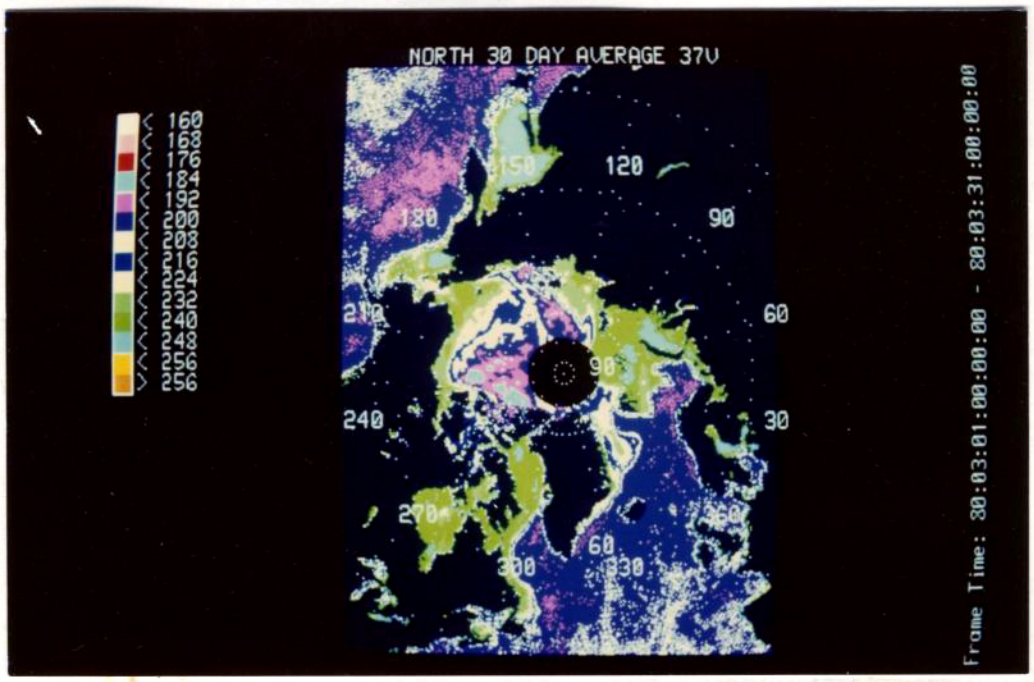

Figure 4. Example of SMMR data for the Northern Hemisphere. The figure shows 30-day average brightness temperatures, 37 GHz, for the period 1 March — 31 March 1980.

IV. FUNDING

A. Funding Sources

The combined total of Data Center and related research dollars topped $1 million in FY87. A year ago we expected our funding to return closer to the FY85 level. However, award of the ONR-University Research Initiative Arctic Interactions Grant instead pushed the total funding upward. We do not expect to see this trend continue in FY88. In fact, funding levels should drop because the NASA-CDMS buildup stage is nearly complete and we are moving into the operational phase of SSM/I data processing.

The proportion of Data Center funding from NOAA sources continues to shrink. In FY87 it was 20%, down from 31% in the previous year. This is more a reflection of increased funding from other sources than a reduction in NOAA funding. Figure 5 displays WDC/NSIDC funding by source.

As we have stated in previous years, the percent of the Data Center budget expended on salaries and benefits continues to rise In FY87 roughly $600K was devoted to staff and student salaries and benefits. When permanent equipment and university overhead costs are removed from the $1.2 million

FY87 budget, salaries and benefits represent about 85% of the remaining budget.

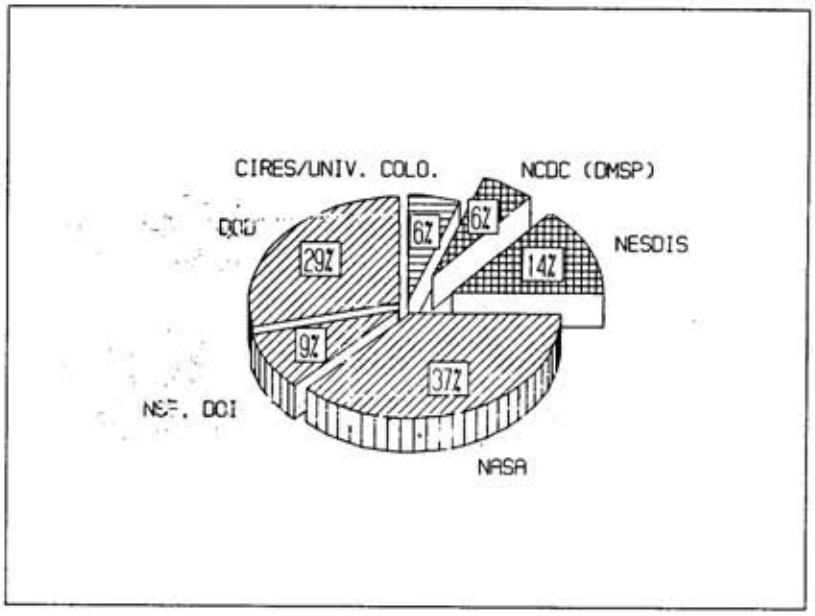

Figure 5. NSIDC/WDC funding by source.

Despite the FY87 budget increase, the Center faces serious problems in FY88. The DMSP collection required considerable effort this past year to secure FY88 funds, without which it could not be maintained. As the DMSP program moves toward a completely digital system, smaller quantities of the photographic products will be produced. Nevertheless, the completeness and length of record provided by the collection makes 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 for, at least, selected regions covered by 600 m-resolution direct readout data makes the question of importance in our forward planning, especialy in view of the SSM/I products that will be archived at the Center.

The ONR-URI funding sustained a budget cut in its first year and it is likely that additional cuts will occur in FY88. It is extremely difficult to budget and, therefore, plan Data Center activities for periods longer than one year.

B. Data Request Statistics

Data sales income sustained a significant downturn in FY87, despite an increase in total number of data requests (see figures 6 and 7). Review of data

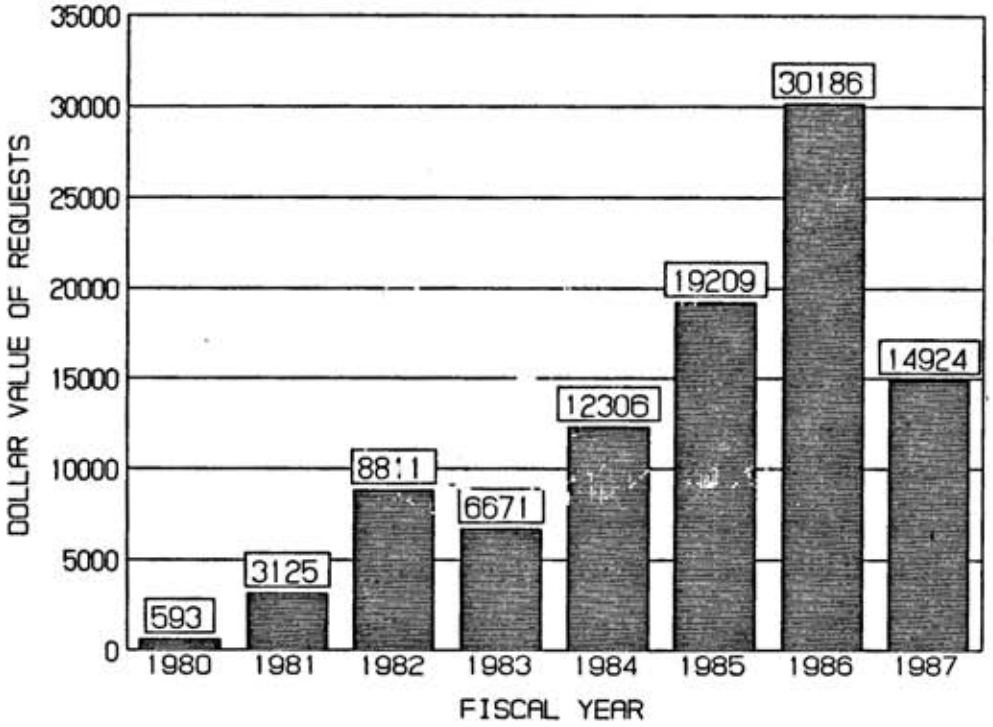

Figure 6. NSIDC/WDC data sales.

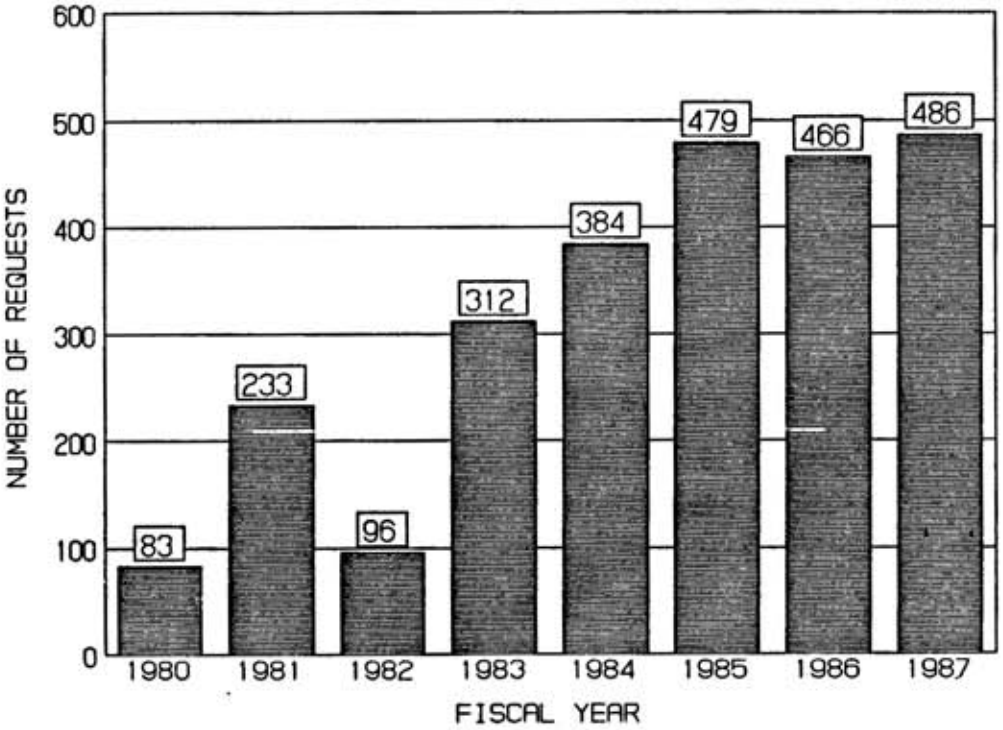

Figure 7. NSIDC/WDC data requests.

request records suggest reduced purchases in all categories and especially for large dollar orders. It appears that research programs which purchased large blocks of data in the past did not do so in 1987. It is important to note that the total *number* of requests has not fallen. FY87 total sales — $14,924.

The largest percentage user group is U.S. academia (27%) followed by industry and the U.S. government.

V. New Initiatives

Since June 1987, NSIDC has been involved in a joint planning effort with NGDC to develop a new paleoclimatology program. The initial goals of this program to be addressed in FY88 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 research community in general 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, and ice core/glacier fluctuations. The latter category will be the responsibility of NSIDC and will be managed by Richard L. Armstrong.

A proposal to design and implement a Northern Hemisphere snow cover grid for SSM/I data has been written and submitted to NSF Division of Polar Programs. The 24-month proposal aims to improve access to the SSM/I data for the snow cover climate research community. The northern hemisphere snow cover grids will be accessible through CDMS at NSIDC.

VI. Associated CIRES Research Projects

A. University Research Initiative

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 year (FY1987) has concentrated on four projects: interannual variations in ice motion of the Beaufort Gyre in the Canada Basin; climatology of Arctic cyclones and anti-cyclones; 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 production capabilities for Arctic sea ice.

The highlight of Year 1 has been 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. 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. This finding is reported in a publication to appear in *Geophysical Research Letters* (McLaren *et al.*, 1987).

A paper which presented a comparison of the under-ice thickness distribution in the Arctic Basin as recorded in 1950 and 1970 was presented at the POAC '87 Conference in Anchorage in August 1987. It will be published in the refereed proceedings (McLaren, 1987).

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 complete data set will be archived at NSIDC.

C. Avalanche Prediction, San Juan Mountains, Colorado

Funding: USDI Bureau of Reclamation, Division of Atmospheric Resources Research. R.L. Armstrong.

This study, which monitors the nature and causes of snow avalanches in the San Juan Mountains of southwestern Colorado, has produced a comprehensive data set of weather, snow cover, and avalanche information at a high altitude site. The data from Red Mountain Pass (3400 m) include air temperature, precipitation, wind speed and direction, snow depth and snow stratigraphy for the months of November through April, 1971 to 1987. These data support the development of a regional avalanche prediction technique. Current work focuses on incorporation of a general snow structure component into the prediction model.

In conjunction with this study, NSIDC has acquired the U.S. Forest Service mountain weather and avalanche data set for the western United States. These data are on magnetic tape and are a compilation of all weather and avalanche data from approximately 30 high altitude sites throughout the western U.S. The period of record averages between 15 and 25 years.

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 in two papers (*Annals of Glaciology*, v. 9, 1987, and *Proceedings of the International Association of Hydrological Sciences*, 1987). 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.

Additional funding has been obtained from NSF for completing another six years of analysis. The total of ten years of digitized melt data will be made available as a data set following completion of the research.

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Scharfen, G.R.; Barry, R.G.; Robinson, D.A.; Kukla, G.; Serreze, M.C. (1987) Large-scale patterns of snow melt on Arctic sea ice mapped from meteorological satellite imagery. *Annals of Glaciology*, v. 9, p. 200-205.

Meetings

VXIX General Assembly IUGG, Vancouver, BC, 9-22 August 1987 — R.G. Barry, R.L. Armstrong, G.R. Scharfen.

IAHS Symposium on Large-Scale Effects of Seasonal Snow Cover, XIX General Assembly IUGG, Vancouver, BC, 17-19 August 1987 — R.G. Barry, R.L. Armstrong, G.R. Scharfen.

Polar Research Board, U. of Alaska, 21-23 September — R.G. Barry.

Antarctic Research Center dedication, Scripps, 23 July — C. Hanson.

Symposium on Glacier Fluctuations and Climatic Change, Amsterdam, The Netherlands, 1-5 June — R.L. Armstrong.

Conference on Passive Microwave Observing from Environmental Satellites, Williamsburg, VA, 1-4 June — V. Troisi.

SODDSWG, June 16-17, 18-21 November, 1986 — R. Weaver.

Digital Equipment Corporation User Society (DECUS) Symposium, Nashville, TN, 26 April-1 May — V. Troisi.

Workshop on Arctic Interactions, UCAR, 5-6 January — R.G. Barry.

AGU, San Francisco, 8-10 December 1986 — R.G. Barry.

Workshop on Remote Sensing of Snow Cover, Tacoma, WA, 4-7 November 1986 — R.L. Armstrong.

SPOT Image Corporation User's Meeting, Denver, 18 November 1986 — G.R. Scharfen.

Snow Avalanche Panel of the Land Failure Hazards Committee (NRC), Lake Tahoe, CA, 21, October — R.L. Armstrong.

International Snow Science Workshop, Lake Tahoe, 22-24 October — R.L. Armstrong.

Joint Oceanographic Institute Workshop on Data Cataloging, Washington, DC, 20-21 October — V. Troisi.

U.S./Canada Ice Working Group, Ottawa, 30 October 1986 — G.R. Scharfen.

Great Lakes Ice Information Working Group, Ottawa, 30 October — G.R. Scharfen.

Workshop on Remote Sensing of Snow Cover, Tacoma, WA, 4-7 November — R.L. Armstrong.

Northwest Glaciologists, Annual Meeting, Seattle, WA, 3-5 December — R.L. Armstrong.

Colorado Hydrometeorological Committee, Denver, Colorado, 14 January and 6 May, 1987 — R.L. Armstrong.

Committees

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

SCAR representatives 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.

SODDSWG — R.L. Weaver.

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.

Papers Submitted/Published During FY87

Richard Armstrong

Mass budget history of Blue Glacier, 1957-1987. Proceedings of the International Symposium on Glacier Fluctuations and Climatic Change. *Glaciology and Quaternary Geology*, D. Reidel, Dordrecht, Holland.

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

Snow cover parameters retrieved from various data sources in the Federal Republic of Germany. (A.J. Schweiger, R.L. Armstrong and R.G. Barry) In: *Large Scale Effects of Seasonal Snow Cover*, IAHS Publications no. 166, pp. 353-364.

Mode of formation of "ablation hollows" controlled by dirt content of snow. (with S. Warren and J. Rhodes) *Journal of Glaciology*, Cambridge, U.K.

The mountain snowpack. In: *The Avalanche Book*, Chapter 13, B.R. Armstrong and K. Williams, eds. Fulcrum Inc., Golden, Colorado, 1986, 231 p.

Snow and avalanche climates of the western United States. International Symposium on Avalanche Formation, Movement, and Effects. Davos, Switzerland. 14-19 September 1986. International Association of Hydrological Sciences and International Glaciological Society.

Snow cover data management: The role of WDC-A for Glaciology. (R.G. Barry and R.L. Armstrong) *Hydrological Sciences Journal* 32: 281-295, 1987.

Roger Barry

The cryosphere — neglected component of the climate system. In: U. Radok, ed., *Towards Understanding Climate Change. (The J.O. Fletcher lectures on climate analysis and forecasting)*, Westview Press, Boulder, pp. 35-67, 1987.

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Large Scale Effects of Seasonal Snow Cover, eds. B. Goodison, R.G. Barry and J. Dozier, IAHS Publication no. 166, Wallingford, UK, 1987, 425 pp.

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Lake ice formation and breakup as an indicator of climate change: Potential for monitoring using remote sensing techniques. In: *The Influence of Climate Change and Climatic Variability on the Hydrologic Regime and Water Resources.* IAHS Publication no. 168, 1987, 153-161.

Greg Scharfen

Analysis of interannual variations of snow melt on Arctic sea ice mapped from meteorological satellite imagery. (D.A. Robinson, G. Scharfen, R.G. Barry and G. Kukla) In: *Large Scale Effects of Seasonal Snow Cover.* IAHS Publication no. 166: 315-327, 1987.

Large-scale patterns of snow melt on Arctic sea ice mapped from meteorological satellite imagery. (G.R. Scharfen, R.G. Barry, D.A. Robinson, G. Kukla, M.C. Serreze) *Annals of Glaciology*, v. 9: 200-205, 1987.

Ronald L. Weaver

Passive microwave data for snow and ice research: planned products from the DMSP SSM/I System. (R. Weaver, C. Morris and R.G. Barry) *EOS* 68(39): 769-777, 1987.