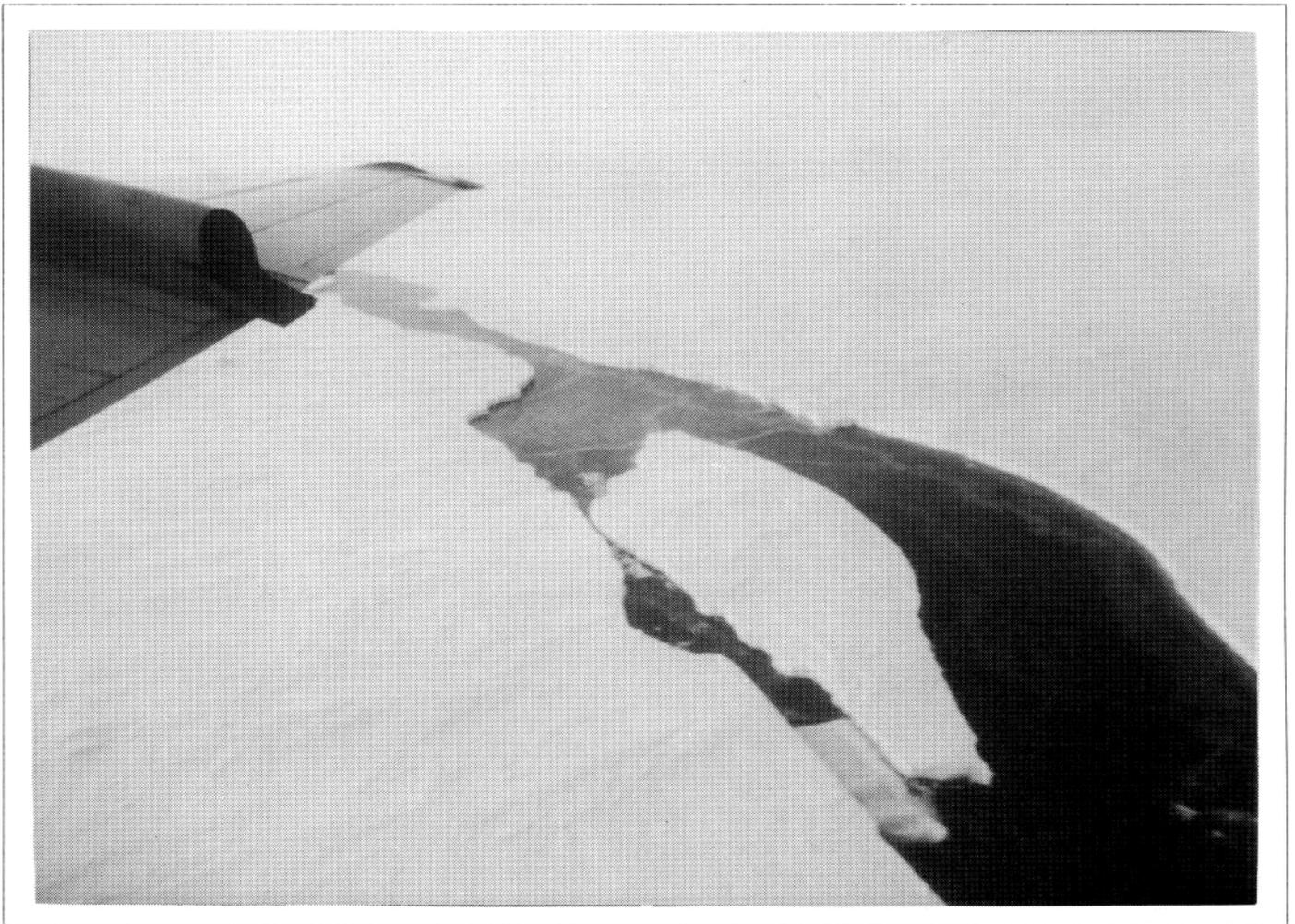


***NATIONAL SNOW AND ICE
DATA CENTER***

***WORLD DATA CENTER A-
FOR GLACIOLOGY***



***ANNUAL
REPORT***

1990

Cover: Photo taken from a NOAA P-3 aircraft at approximately 80°N 30°E during CEAREX, Spring, 1989.
Photo: Eric Ellefsen, University of Colorado/CIRES.

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ANNUAL REPORT

1990

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

NSIDC/WDC ANNUAL REPORT

FY 1990

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NSIDC/WDC ANNUAL REPORT FY1990

INTRODUCTION

The National Snow and Ice Data Center (NSIDC)/World Data Center A for Glaciology (WDC) is operated under a contractual agreement between the University of Colorado, Cooperative Institute for Research in Environmental Sciences (CIRES) and the National Environmental Satellite, Data, and Information Service (NESDIS) of NOAA. NSIDC/WDC is completing its fourteenth year of service to the snow and ice research community from its Boulder location.

NSIDC/WDC is funded by various federal agencies, including the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Office of Naval Research (ONR), the U.S. Air Force (USAF) and the National Science Foundation (NSF). The "core" data management and administrative functions are supported by NOAA, with additional project support from all the above mentioned agencies.

The role of the NSIDC/WDC 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, 1987) and NOAA's mission. 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 (Byrne, 1984). Examples of such activities include the acquisition and dissemination of global environmental satellite data, data on resources including water, on natural hazards, weather-related economic impacts, and data sets which can serve as cryospheric components in inter-disciplinary global change research.

This report discusses NSIDC/WDC activities for the 1990 fiscal year (October 1, 1989 - September 30, 1990).

HIGHLIGHTS

The following highlights provide information on programs which we feel are of particular interest to our user community. They represent efforts in all three of our focus areas – Data, Project, and Research Activities.

Passive Microwave Data on CD-ROM

Defense Meteorological Satellite Program Special Sensor Microwave Imager (DMSP/SSM/I) Brightness Temperature Grids for

the Polar Regions, 9 July 1987 - 31 March 1989, were distributed on seven CD-ROMs to 270 users. A looseleaf User's Guide containing complete documentation is part of the package, along with two PC diskettes of software to read and display the SSM/I grids.

Of the 270 copies distributed, 95 individuals (35%) have returned registration cards, and 68 (25%) have responded to the initial survey form sent with each package. Thirteen percent (36) of the copies were distributed to the NASA "SSM/I Algorithm Intercomparison Group", and another 13% (35) were sent as "courtesy" or promotional mailings. Twenty-four persons (9%) have requested the Macintosh custom display software developed for NSIDC by the Colorado Center for Astrodynamic Research (CCAR) at the University of Colorado. Updates and corrections to the User's Guide and the software are distributed as they occur. See p. 16 for more information.

Scanning Multichannel Microwave Radiometer (SMMR) data for 28 October 1979 - 31 January 1980 were mastered on one CD-ROM and distributed to 180 users. This product was developed by Dr. Per Gloersen, NASA Goddard Space Flight Center (GSFC). A decision on data format and production of further SMMR data on CD-ROM awaits the outcome of a poll of the passive microwave user community on preferred data formats.

Coordinated Eastern Arctic Experiment (CEAREX) Data Management

NSIDC, with support from the Office of Naval Research (ONR), is providing data management services for the international, interdisciplinary, Coordinated Eastern Arctic Experiment (CEAREX).

CEAREX field experiments were carried out in the East Greenland Sea in the area west of Svalbard between 70 and 85°N (Figure 1) between August 1988 and May 1989 to provide a better understanding of the structure and function of the meso- to small-scale processes in the exchange of momentum, heat, and biomass between the Arctic Ocean and the Nordic Seas. Ice process studies included intrafloe stress and deformation, floe failure, and algal habitat. Acoustics studies included coherence, scattering, and ambient noise fields. The experiment included two camps located on drifting ice floes and was supported by three ships, with remote sensing and support flights using both helicopter and fixed-wing aircraft.

NSIDC is planning and organizing production of a CD-ROM containing data from the CEAREX field experiments. This project draws on the coordination and production expertise at NSIDC in

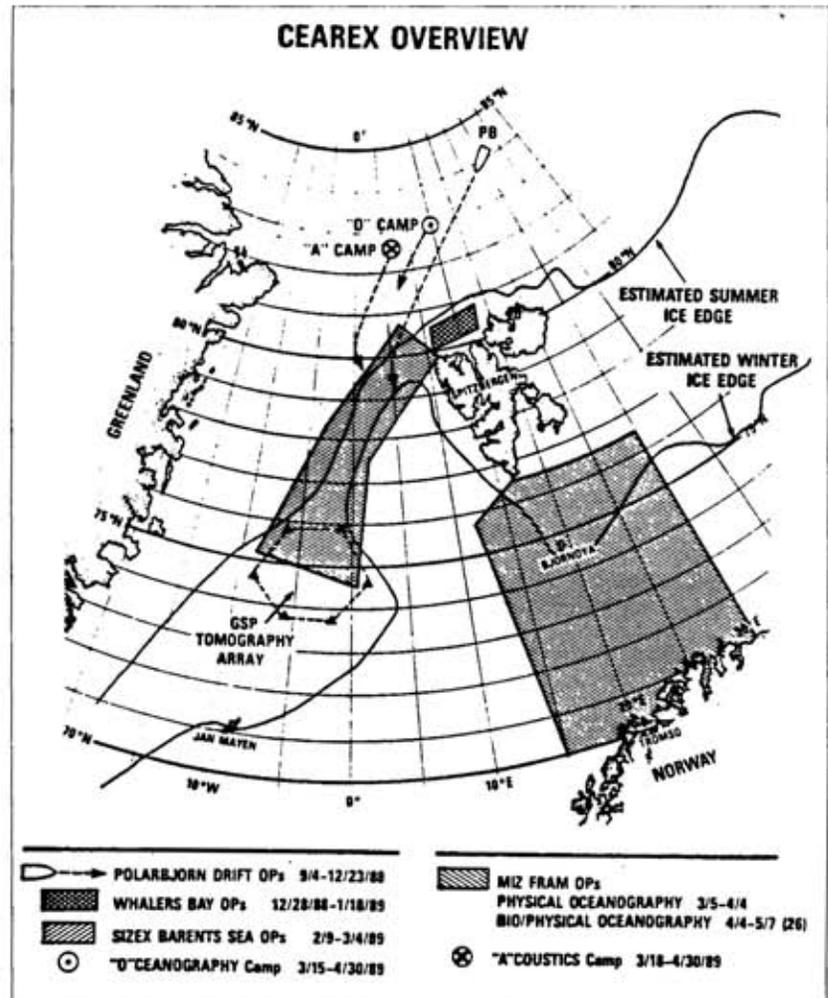


Figure 1. Location of CEAREX

combination with discipline-specific experience at the home institutions of the CEAREX investigators to produce a multi-discipline disc. Envisioned as the first in a series of CD-ROMs delivering Eastern Arctic data to the oceanography and sea ice user communities, the disc will present hydrography, bio-optics, meteorology, position, and bathymetry data bases compiled from the entire experiment, as well as ice stress and deformation, samples of ambient noise, and several other small data sets.

The CEAREX CD-ROM project at NSIDC is unique in that the quality control and formatting of the data are taking place at the home institutions of investigators who serve as data set managers (DSM) for their discipline. The role of NSIDC is to work with the DSMs in each discipline on format definition (to assist in determining whether standard formats for a data type already exist)

and documentation preparation. For example, at least seven investigators collected bio-optics data for their own research projects. These seven submitted their data to the designated DSM at Scripps Institution of Oceanography, who designed the combined bio-optics data base. When the data bases are complete, they will be collected at NSIDC for final checking and formatting to tape, before they are sent to the CD-ROM mastering facility. CEAREX data management at NSIDC is initially a two-year project, with production of one CD-ROM scheduled during each year.

Global Snow Depth Model

NSIDC is developing a new snow depth model to replace the current model used by the U.S. Air Force Global Weather Central (AFGWC). The overall goal of the project is to analyze weaknesses in the current version of the model, identify enhancements, and design and demonstrate improved algorithms. The prototype model will provide a state-of-the-art integration of all snow cover data available at AFGWC in order to provide a global snow cover product at a 40 km grid resolution. The basic data generated for each grid point include calculated average and maximum snow depth, age in days of the total snow cover and days elapsed since the last snowfall, along with appropriate data source flags and summary diagnostics. The model represents the integration of surface and satellite observations. Surface measurements used are from the World Meteorological Organization (WMO) synoptic data collection network. The model uses passive microwave satellite data (DMSP-SSM/I) which provide global, all-weather, day/night, information on snow cover extent. In addition, the potential to extract snow depth information from passive microwave data is fully exploited. Currently no single snow depth algorithm is suitable for global application and therefore NSIDC is evaluating individual algorithms to determine which are most accurate for a given surface-type region.

Special routines have been developed to eliminate certain problems found in the current model. An improved surface measurement point to grid point interpolation technique has been developed based on both distance and elevation weighting criteria as well as a spatial variance as defined by snow cover climatology. In addition, a method to extrapolate from high-confidence grid points into data-void mountainous regions based on generalized orographic precipitation gradients has been developed. While passive microwave satellite data provide an excellent means to evaluate snow cover in certain areas, in others, such as mountainous terrain and areas of dense coniferous vegetation, passive microwave does not represent an ideal data source. These areas are identified in the model output and appropriate confidence flags are applied. Routines have also been developed to identify dry

versus wet snow and to characterize snow grain size, two additional problem areas associated with passive microwave data. In cases where neither surface observations nor satellite data are available, the model checks against a surface temperature data set and computes melt when appropriate. In cases where no input data are available for a certain time, the model begins to move the most recent grid values towards climatology.

SSM/I Snow Cover Research

Snow cover is an important variable for climate and hydrologic models due to its effects on surface albedo, energy, and moisture budgets. Satellite passive microwave observations afford the best method to monitor temporal and spatial variations in snow cover on the hemispheric scale, avoiding the problems of cloud cover and polar night. NSIDC is currently funded by NASA's Interdisciplinary Research Program to develop a capability for the production of daily snow parameter products from the DMSP Special Sensor Microwave Imager (SSM/I). A data system is being developed which will produce, archive, and distribute validated snow cover products for community use. Initial emphasis is on Northern Hemisphere snow extent. We are also exploring the potential of the SSM/I for mapping other snow cover properties such as snow water equivalent, snow depth, and dry/wet snow boundary.

Within this project NSIDC coordinates the activities of the SSM/I Products Working Team (SPWT) which is a multi-agency and multi-disciplinary working group focusing on the problems associated with extracting land surface (primarily vegetation, soil, and snow cover) information from SSM/I. Currently, emphasis is on developing optimal binning and gridding routines as well as the selection of one or more snow cover algorithms for use in the distribution of standardized data sets by NSIDC. Snow cover algorithm comparison is being undertaken in a cooperative effort with scientists at the University of Innsbruck, Austria. Regional test areas selected are the western United States and central Europe. For the U.S., the relative accuracy of the algorithms will be tested by comparison with several validation data sets including snow depth measurements from the National Weather Service and the Soil Conservation Service, as well as output from the prototype Air Force Global Weather Central (AFGWC) snow depth model. In the final stage of this three year project we will explore the combined research potential of the SSM/I-derived snow cover and sea ice products for studies of climate dynamics and global/regional hydrology.

CITATION on CD-ROM

The information holdings of NSIDC/WDC are now available on CD-ROM. The bibliographic data base is included on the *Arctic and Antarctic Regions* disc produced by the National Information Services Corporation (NISC) for the Library of Congress, Cold Regions Bibliography Project. Currently, the disc holds over a quarter of a million references on various aspects of polar regions science and technology. Data have been contributed by the Cold Regions Bibliography Project and NSIDC/WDC (U.S.), the Arctic Science and Technology Information System and the Centre for Cold Ocean Resources Engineering (Canada) and the Scott Polar Research Institute (U.K.). This disc provides access to the most comprehensive polar regions science bibliographic collections in the world.

CURRENT PROGRAMS

The activities of NSIDC/WDC fall into three broad and overlapping areas: 1) data – archiving, managing, disseminating; 2) projects – limited-scope or defined-period duties relating to specific data sets; 3) research – scientific study which expands our knowledge of the role of the cryosphere in the global climate system. Staff members may be involved in a variety of activities at any given time.

Data Activities

Publication Program

Two series, *New Accessions List* and *Glaciological Data*, are published by NSIDC/WDC. *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 FY90, 4 *NAL* issues were completed. We have now published listings through 1989.

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

possible, *GD* publication costs are obtained through specific agency or project support.

One issue in this series was published this year, *GD-23, Ice Core Update, 1980-1989; Permafrost Data Workshop*. This volume updates our first ice core publication, *GD-8*, published in 1980. It contains an inventory, based on the literature, of cores drilled since 1980 along with a categorized bibliography of published ice core research. Compilation of the inventory and bibliography was funded by NGDC for the NOAA Climate and Global Change Program. *GD-23* also contains the summaries and recommendations of a Permafrost Data Workshop conducted by R.G. Barry in conjunction with the Fifth International Conference on Permafrost in Trondheim, Norway, August 1988.

An ice core publication combining the information published in *GDs* 8 and 23 is in preparation for the NGDC Paleoclimate Program. It will include an inventory documenting all the ice cores reported in the literature since the first French core drilling in Greenland in 1949 and a comprehensive categorized bibliography. It will be published as a volume in the NGDC *Paleoclimate* series.

Data Set Administration

New and updated data sets received during FY90 include:

- a. Extent of Antarctic sea ice, mean monthly surface temperatures for a selection of Antarctic research stations, and mean monthly sea level adjusted air pressure for the same stations, 1901 - 1989. Provided by T.H. Jacka, Department of Meteorology, University of Melbourne. 1 each IBM and Macintosh diskette.
- b. The complete set of 10-minute meteorological data from the Coordinated Eastern Arctic Experiment (CEAREX) was provided to the MIZEX/CEAREX archive by Ken Davidson and Peter Guest, Naval Postgraduate School. These data will be included on the CEAREX CD-ROM being prepared under contract to the Office of Naval Research, but are also available for distribution on one reel of magnetic tape while CD-ROM preparation continues.
- c. Dr. Ken Jezek, Byrd Polar Research Center, and Nancy H. Greeley, U.S. Army CRREL, sent their data analysis software package "DATEX" on a floppy disk. This package was developed to provide more efficient use of the Antarctic surface and bedrock elevation/ice thickness data set from Dr. U. Radok of CIRES. The data set was transferred to

four floppies and provided to NSIDC/WDC by Jezek and Greeley.

- d. Sea ice concentration data covering 1953 - 1977 were updated by Dr. John Walsh, University of Illinois Department of Atmospheric Sciences, and now include data through 1988. The data base brings together various satellite and surface data sources, and is useful for hemispheric-scale studies of sea ice fluctuations.
- e. Navy - NOAA Joint Ice Center (JIC) sea ice concentration data for 1988 were received and added to the digital data archive spanning 1972 to the present for the Arctic and 1973 to the present for the Antarctic. The SIGRID format for sea ice data exchange, an interim standard since 1980, was adopted formally by WMO in September 1989 (see also p. 10).

Fifty-eight IBM PC diskettes holding about 35 discrete data sets from the NSIDC/WDC archive were inventoried in a dBaseIII file, backed up, and the duplicate set stored in the NOAA/NGDC tape library room. This offsite backup increases our data security while the inventory provides information for disaster recovery. Some of the data sets stored on diskettes have been copied from 9-track tape, and are also stored on the original and backup tape reels.

One new Data Announcement was prepared during FY90: Marginal Ice Zone Experiment (MIZEX) Data, 90-GLA-57.

Data Announcements updated during the year include:

List of Snow and Ice Data Announcements, 85-GLA-00
Price List for Snow and Ice Data Sets, 90-GLA-05
Glaciological Data Series, 90-GLA-04
WDC/NSIDC Arctic Data Sets, 88-GLA-ARC
WDC/NSIDC Antarctic Data Sets, 88-GLA-ANT
General Description of WDC/NSIDC, 90-GLA-01
Arctic Ocean Buoy Data, 81-GLA-02
Cumulative Index to Information Center Document Collection, 90-GLA-03
Snow Cover Data, 83-GLA-10
Glacier Photo Collection, 83-GLA-21
Ice Core Data, 87-GLA-41
Joint Ice Center Data, 83-GLA-54
Digital Sea Ice Data, 83-GLA-55
Scanning Multichannel Microwave Radiometer, 83-GLA-56
Arctic Ice Dynamics Joint Experiment Data, 83-GLA-58
Great Lakes Ice Data (complete description), 86-GLA-61

Great Lakes Ice Data (general description), 86-GLA-61G
SSM/I Brightness Temperature Grids for the Polar Regions,
89-GLA-80.1

Information Center and CITATION Data Base

The role of the Information Center is to support the research activities of the Data Center's scientific staff and to document the data holdings. To accomplish this and to meet the increasing demands for information on cryosphere/climate studies on a global scale, NSIDC/WDC maintains an active program to acquire published materials in all areas of snow and ice research.

Currently, the Information Center contains 5500 monographs and technical reports and 11,500 reprints; 90 serial publications are regularly received. During 1990, over 1000 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 FY90, there were over 27,000 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.

Data Related Meetings

CEAREX Workshop and Publications Planning Meeting, 8-10 February 1990, Long Beach, MS

Fifty-eight CEAREX investigators, and five Office of Naval Research program managers convened at the University of Southern Mississippi Gulf Park Conference Center for a three-day workshop to review preliminary results of CEAREX, develop a publications plan, and initiate discussions leading to a plan to create a CD-ROM data base for CEAREX and related Arctic data. The NSIDC/WDC Data Base Manager (C. Hanson) was invited to lead the CD-ROM discussions.

As described in Highlights, p. 2, the CD-ROM production plan relies on the investigators to supply data to a discipline Data Set Manager for production of a discipline data base. The NSIDC/WDC Data Base Manager is responsible for designing the CD-ROM,

working with Data Set Managers to determine data formats, finalizing documentation, and final formatting of data files for CD-ROM mastering.

At the workshop, several discipline Data Set Managers were identified, and several working groups held discussions on applicable standard or commonly-used data formats. It was agreed that the data would be presented as ASCII files to simplify use of the data and minimize the need for software development or support.

The workshop provided an excellent opportunity for the Data Base Manager to renew contacts and meet CEAREX participants from disciplines outside the normal purview of NSIDC. The CEAREX group was afforded an opportunity to provide direction and guidance at the inception of the CD-ROM plan.

Polar Libraries Colloquy, 10-14 June 1990, Rovaniemi, Finland

The 13th Polar Libraries Colloquy met this year in Rovaniemi, Finland, on the Arctic Circle. The group meets biennially and provides an international forum for the exchange of information and ideas among the polar bibliographic community. This year's meeting titled "Man's Future in Arctic Areas" was attended by 140 participants representing 15 countries. Ann Brennan represented NSIDC/WDC. Discussion focused on ways information scientists can support research on the environmental protection of fragile areas. In-depth discussions were held with representatives of the University of Alaska relating to the inclusion of NSIDC/WDC's CITATION data base in the PolarPac CD-ROM and with Scott Polar Research Institute (U.K.) and British Antarctic Survey participants relating to active cooperation on acquisition and cataloging of polar materials.

Global Sea Ice Data Bank Meeting, 24-27 September 1990, Leningrad, USSR

A consultative meeting on the establishment of a Global Sea Ice Data Bank was held in Leningrad, 24-27 September 1990, among representatives of the Arctic and Antarctic Research Institute (AARI) (I. Frolov, A. Turchin), NSIDC/WDC-A for Glaciology (R.G. Barry, V. Troisi) and the World Meteorological Organization (M. Krasnoperov).

The participants reviewed existing U.S. and Soviet sea ice data, proposals for data exchange, current and planned data activities at AARI and NSIDC/WDC-A for Glaciology, the WMO sea ice test data for 1982 in SIGRID format, and plans for future processing and quality control of the SIGRID data. It was conclud-

ed that some modification of the SIGRID format may be required; a WMO-appointed group will review this issue. Barry and Troisi saw a demonstration of the AARI Ice Center data management system and were shown examples of the various ice chart products. An agreement between AARI and NSIDC for future exchanges of data and personnel, and for research collaboration was signed by Dr. B.A. Krutskikh and Dr. R.G. Barry. A report of the meeting will be issued by WMO.

During the visit Barry gave a lecture on "Arctic ice climate interactions" (in Russian) to some 20 AARI scientists.

Project Activities

DMSP

NSIDC is in the eighth year of service as the national archive for Operational Linescan System (OLS) data from the U.S. Air Force Defense Meteorological Satellite Program (DMSP). During FY90, approximately 10,000 images were sorted, catalogued, and archived into the collection, now amounting to about 1.4 million pieces of imagery. About 2500 entries, referring to single-orbit strips, were added to the searchable computer data base. Two hundred and twenty two requests for data and information were processed this year (down 26% from FY89) resulting in data sales of \$10,983 (down 8% from FY89). The decrease in contacts may be due in part to the dramatic decrease in receipts of new imagery, a result of the implementation of the digital Satellite Data Handling System (SDHS), at Air Force Global Weather Central. Receipts of new imagery are about 15% of the level one year ago. Some 284 prints, 422 35-mm slides, 331 original images on loan, 123 information letters and 823 data flyers were shipped during the course of the year. There were at least 115 visitors to the archive.

University of Colorado students continue to be the primary source of personnel to staff the archive. Participation in the work/study program resulted in a salary savings of \$4K to the archive activity.

The scientific community continues to use DMSP data in a variety of interesting projects. An unusual use of visible-band satellite images from the DMSP system is for the monitoring of internal waves. These waves form in the ocean between subsurface layers having differing densities, typically along thermoclines. The waves are often generated by tides and by flow around topographical obstacles like islands and continental shelves. Surface manifestations of the waves may be visible if the waves occur in the area of the sun's reflection off the ocean (sunglint), and the sea state is relatively calm. The waves can disrupt underwater

sound propagation, and have caused problems to oil and gas operations. Dr. Curt Ebbesmeyer, a consultant working for Occidental Petroleum Corporation, purchased copies of the images showing the waves in the Sulu Sea near the Philippines. Figure 2 shows an example of waves and their refractions in the Sulu Sea.



Figure 2. DMSP F7 visible-band image on 23 August 1987, over the Sulu Sea in Indonesia. Surface manifestations of internal ocean waves near the center of the image are apparent due to sun glint on the ocean surface.

Nighttime visible-band images are being used to study possible urban heat-island effects on long-term temperature records in the U.S. Kevin Gallo, a NOAA/NESDIS researcher at the USGS/EROS Data Center in Sioux Falls, is using digital DMSP data from NSIDC to create a data base indicating proximity to major urban areas. This will then be used in statistical comparisons of urban vs. rural stations. NSIDC provided digital data by digitizing the original images used in our *USA at Night* mosaic on the Eikonix photo-digitizer.

The Australian Antarctic Division is using DMSP images to study the dependency of emperor penguins on wintertime open leads and polynyas. Dr. Graham Robertson measured the distance from known penguin rookeries to open water as identified on

thermal-infrared images. The IR imagery permits the detection of open water even in the polar night because of the large contrast in temperatures between open water and pack ice.

A major use of the DMSP collection that began this year, and is not included in the user statistics reported above, is the extraction of lightning information from the nighttime visible-band images. NASA Marshall Space Flight Center and NSIDC have embarked on a joint project to create a digital data base containing information about lightning events on a global basis through the length of the film archive. Lightning strikes are recorded on the imagery with a characteristic horizontal signature. See Figure 3.

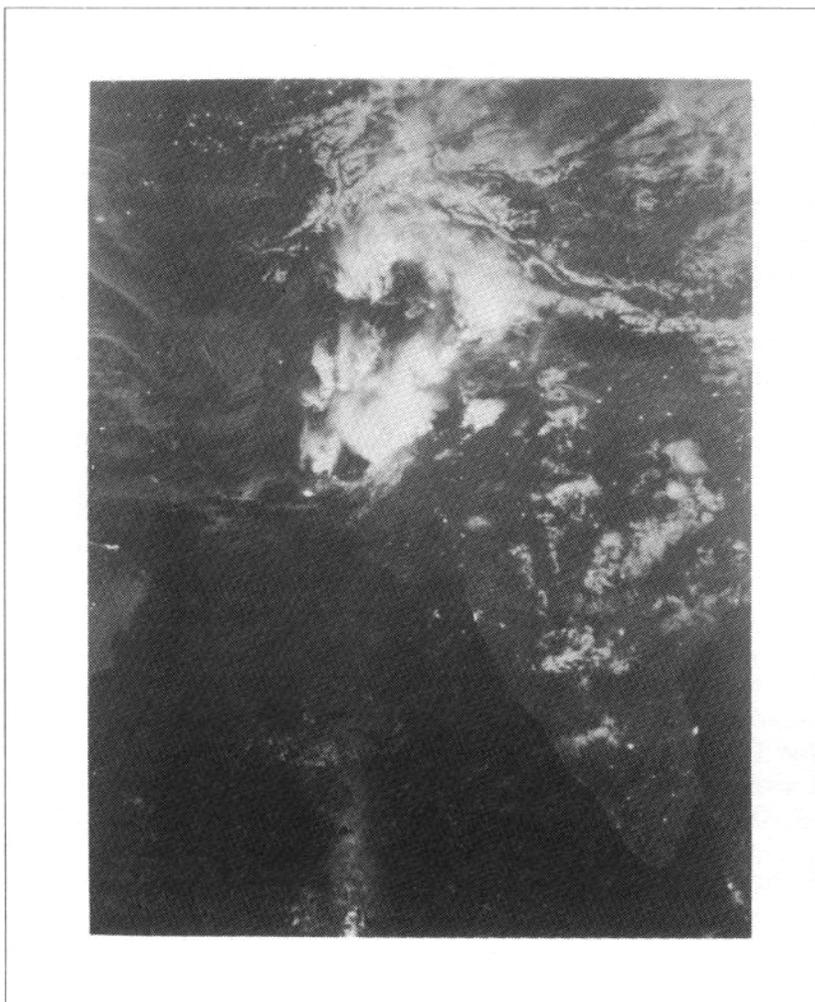


Figure 3. DMSP F7 visible-band image on 8 May 1987, over India and Pakistan showing storm clouds and lightning signatures. The horizontal white streaks in the center of the image are lightning signatures.

Using a modified digitizing tablet and in-house programming support, NSIDC designed a system to calculate the latitude, longitude and time of each lightning signature on the imagery. NASA is using the data base to study relationships between the global distribution of lightning and large-scale general circulation features, including El Niño and the Southern Oscillation. Until dedicated lightning mappers are launched in the EOS era, the DMSP system is a unique source of this information. A seven month pilot study which included the software development has been completed, and a three year follow-on proposal to analyze the entire collection is expected to be funded in FY 91.

A plan for the long-term disposition of the film archive has been funded by NOAA/NESDIS. Following its decision to locate the AVHRR film archive in the Federal Records Center (FRC), NESDIS has decided to do the same with the DMSP collection. The plan calls for the eventual transfer of all DMSP film images to the FRC in Denver, however, specific arrangements for this transfer have just begun. NESDIS has provided \$60K for the task, part of which has been used to complete a detailed inventory of the data that will be transferred first. The transition will begin with the parts of the collection that are rarely used; most frequently used data will be retained for an indefinite period. NSIDC will do everything possible to ensure easy access to the data transferred to the FRC.

Our long-standing concern about the archiving of future digital data from the DMSP/OLS system is also nearing resolution, but on a more positive note. After years of debate between agencies and users, a multi-agency effort appears to be moving forward. NSIDC has been funded by the NOAA Climate and Global Change Program for two years to set up an archive system for the digital OLS data now being generated by AFGWC. NASA has informally agreed to fund the hardware modifications at AFGWC. The solar physics research community together with NOAA/NESDIS/NGDC, who have used DMSP data to study aurorae for many years, will contribute to both the start-up and continuing costs. NASA will also be a contributor to the long-term costs, through the continuation of the lightning analysis from digital data. A schedule for work at AFGWC is being prepared and we expect digital data to be arriving at NSIDC on high density storage cassettes by about mid-1991. There will be an unavoidable gap between receipts of film images and the digital data. NSIDC will process and geolocate the data, generate browse products, and subsets for the meteorological and auroral users. Data will be available in several formats. We are seeking input from the user community at this time to ensure that all requirements for the data are met. Interest from potential users attending the recent 'OPSAT 90' conference in Washington D.C. was high. A mailing list is being compiled for periodic announcements as the system is implemented.

MIZEX/CEAREX

NSIDC continues to provide data management services for the Marginal Ice Zone Experiment (MIZEX). Data sets in the categories of Physical Oceanography, Ice, Acoustics, Biology, Remote Sensing, and Meteorology are available from the 1983, 1984, and 1987 field experiments in the East Greenland and Bering seas.

Plans for the Coordinated Eastern Arctic Experiment (CEAREX) are discussed in Highlights, p. 2.

Greenland Ice Sheet Program (GISP2)

GISP2 represents the renewal of the seven-year GISP1 which began in 1976 and produced a 2037 m deep core at the Dye 3 location in southeastern Greenland. The GISP2 site is located on the ice divide in central Greenland where the depth to bedrock is anticipated to be 3100 m which equates to a stratigraphic record of at least 200,000 years. Such a length of record includes two glacial/interglacial cycles. GISP2 is a five-year program (1989-1994), involves 25-30 scientists, and is funded by NSF Division of Polar Programs.

NSIDC has been funded by NSF to provide data management services for GISP2. This includes the development of a data management plan specific to the needs of the GISP2 scientists undertaken in cooperation with the GISP2 Executive Committee and the GISP Science Management Office. This plan assures efficient and timely access to ice core data as they are released by the GISP2 PIs and provides for the safe, long-term, archival of key data. Because of the widespread and growing interest in paleoclimate and global change, GISP2 data sets will receive ever increasing attention from fields outside glaciology.

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. 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 provides near real-time microwave data on sea ice, atmospheric moisture and precipitation, soil moisture, snow cover over land 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.

SSM/I orbital swath data are being gridded into brightness temperature (TB) grids for the polar regions. NSIDC receives compact antenna temperature tapes from Remote Sensing Systems. These data are converted to brightness temperature values using an antenna pattern correction algorithm. The orbital brightness temperature data are stored on Write-Once-Read-Only (WORM) optical platters in the Rapid Access Archive (RAA), an internal format accessible by the CDMS. Data are extracted from the RAA and are mapped onto daily polar stereographic grids for the north and south polar regions. The gridded data are stored in an optical jukebox sub-system for access by users of the CDMS.

A new geolocation correction algorithm has been implemented in the software that maps the SSM/I brightness temperature grids. Remote Sensing Systems discovered large location errors in the SSM/I data. The cause of these errors is thought to be due to 1) orbit prediction errors coincident with increases in solar activity and 2) errors in the location software implemented at Fleet Numerical Oceanography Center (FNOC) in June 1989. Beginning with the 1989 SSM/I data, Remote Sensing Systems began deriving different latitudes and longitudes from those computed by FNOC. Code that produces the SSM/I brightness temperature grids was modified in order to disable the geolocation correction algorithm used for gridding data for the period prior to 1989. New software was added to the CDMS in order to correct a residual 0.5 degree yaw-angle error.

CD-ROM

In January 1990, NSIDC began distributing SSM/I brightness temperature grids for the polar regions on CD-ROM. Three months of SSM/I polar grids are extracted to tape from the CDMS gridded archive. The tapes are shipped to Disk Manufacturing Incorporated (DMI), a CD-ROM mastering facility in California. Eight CD-ROM volumes of daily polar grids, covering the period July 1987 through June 1989, have been distributed to over two hundred users.

In addition to the brightness temperature grids, the CD-ROM contains a landmask and a coastal outline map in the same projection used for mapping the SSM/I data. A comprehensive user's

CD Volume No.	Time Period
1	July - September 1987
* 2	October - December 1987
** 3	January - April 1988
4	May - July 25, 1988
5	July 26 - October 15, 1988
6	October 16 - December 1988
7	January - March 1989
8	April - June 1989

* 85V GHz channel begins demonstrating dramatic increase in noise. By April 1988, data from this channel were considered unuseable.

** Sensor turned off from 3 December 1987 through 12 January 1988

guide and software accompany each CD-ROM shipment. The user's guide, *DMSP SSM/I Brightness Temperature Grids for the Polar Regions User's Guide*, includes a history of the SSM/I sensor, a description of the structure and formats of the data residing on the CD-ROMs, and FORTRAN listings of the code supplied with the distribution. The suite of software includes 1) code to extract individual images from the channel-interleaved grids, 2) an ice concentration algorithm designed by the NASA Polar Oceans Branch at GSFC, and 3) a program to convert between cell position in the grid (I,J) and the geographic coordinates of the centroid of the grid cell (latitude and longitude).

Hardware and Software Environment

VMS 5.2 was installed on the MicroVAX 3600. The MicroVAX 3600 was configured as the boot node for the NSIDC Local Area VAXcluster (LAVC). Client members of the LAVC include a MicroVAX 3500 dedicated to the processing of SSM/I data and two VAXstation-II/GPXs configured for image analysis and algorithm development.

A SUN Microsystems SPARCstation-1 was acquired with funding by NASA to support research of artificial intelligence methods for polar science applications.

A QMS 100/Model 30 color Postscript printer was added to the VAXcluster configuration.

Two Alphatronix erasable optical disk subsystems were acquired with support from the NOAA Climate and Global Change Program in cooperation with the Joint Ice Center (Suitland, MD). One of these systems has been added to the VAXcluster environment; the other Alphatronix device has been added to the SPARCstation-1 configuration.

The Precision Visual Incorporated visualization package PV-Wave was acquired to support algorithm development and product development activities in both the VMS and UNIX environments.

Research Activities

Arctic Ocean Ice - Climate Interactions

Funding: Office of Naval Research, University Research Initiative
R.G. Barry, A.S. McLaren and R.C. Schnell

Under a 5-year Office of Naval Research Program, CIRES researchers, in collaboration with Dartmouth College, are studying ice-atmosphere interactions in the Arctic. Research at CIRES is concerned with: (1) the mechanisms of changes in sea ice extent, concentration and thickness using remote sensing, buoy and sonar data; (2) the space time characteristics of snow cover melt, lead occurrence, and ice thickness distributions; and (3) arctic atmospheric circulation, synoptic activity, cloud regimes and vertical atmospheric structure and their interactions with ice/ocean surfaces. Highlights of this work include identification of a recurring late summer reversal of ice drift in the Canada Basin, related to persistent cyclonic weather systems; a tendency in late summer for reduced ice concentrations (70-80 percent concentration) in the southern Canada Basin near 150° - 160°W due to ice divergence; and the existence of plumes of ice crystal condensate emanating from major leads in winter that can penetrate up to 4 km into the troposphere. Annual reports and a publication list are available.

Arctic Snow Melt

Funding: NSF/Climate Dynamics.
M.C. Serreze, G. Scharfen and R.G. Barry.

The analysis of DMSP visible-band imagery for the seasonal progression of snow melt on Arctic Basin sea ice for ten summer seasons has been completed. Snow melt brightness classes, mapped at 3-day intervals from May to mid-August of each year, were digitized and converted to approximate surface albedos resulting in the first basin-wide data of this kind. Results of the analysis of seven of the ten summer seasons show substantial differences in

timing, duration and extent of the melt regime, especially May-June. Further analysis of the ten year set is forthcoming. Follow-on funding has been received from NSF/ATM. A paper has been submitted to *Journal of Climate*.

Retrieval of Ice Surface Temperature, OLR, and Cloud Cover From Thermal Sensors

Funding: Office of Naval Research
J. Key and M. Haeffliger

Methods of retrieving ice surface temperature (IST) and outgoing longwave radiation (OLR) from narrow band thermal sensors are being investigated. Radiative transfer modeling with a new set of arctic radiosonde data are used to simulate the advanced very high resolution radiometer (AVHRR) thermal bands, and empirical relationships between radiances measured in these channels and IST or OLR are developed. As expected, atmospheric attenuation from the water vapor column is small. As in lower latitude studies, the complicating factor is cloud contamination. The problem is even more complex in the polar regions, where clouds can be warmer than the surface and can also be more reflective. For this reason cloud detection algorithms are being investigated, and it appears that a multispectral, multisensor approach will be needed to retrieve cloud top height, optical thickness, and cloud fraction. Data sets consisting of AVHRR, TOVS (Tiros Operational Vertical Sounder), and passive microwave data are now assembled.

Remote Sensing of Leads with Reference to Relationships of Scale

Funding: Office of Naval Research
J. Key, J. Maslanik and A.S. McLaren

Our ability to retrieve statistics of sea ice leads (*e.g.*, width, orientation, spacing) from satellite data is being examined. Sensor responses are simulated with a radiative transfer model under a variety of atmospheric, surface, and viewing geometry conditions. This approach aids in the determination of what the satellite is actually measuring. The way in which lead statistics change with the satellite field-of-view is an important issue if comparisons between high-, medium-, and low-resolution sensors are to be of any value. Our approach to this problem uses multisensor data sets as well as methods for successively degrading high resolution data. Lead width distributions sampled along a transect and the "true" width distribution are being related in a probabilistic sense.

Sensitivity Studies of Turbulent Fluxes in the Ice Pack

Funding: NASA

K. Steffen, J. Maslanik, A. Schweiger, J. Key, M. Haeffliger.

Design and application of remote sensing methods to large-scale surface energy budget calculations require an understanding of the sensitivity of flux estimates to uncertainties in measurements of surface conditions. A radiative transfer model, a zero-dimensional ice growth model, and equations for bulk transfer coefficients adjusted for fetch and stability are being used to calculate the change in turbulent fluxes due to variations in ice thickness, ice surface temperature, snow cover, lead width, and atmospheric conditions. These sensitivities will be combined with the expected errors in remotely-sensed observations to estimate the effectiveness of remote sensing methods for measuring some of the variables that contribute to the surface energy budget.

Assimilation of Observations and Two-Dimensional Ice Models

Funding: Colorado Commission on Higher Education (CCHE)

M. Cavanaugh, J. Maslanik, M. Serreze.

Satellite-derived surface reflectances and ice concentrations are being combined with a two-dimensional dynamic-thermodynamic ice model to study how surface parameterizations compare to remotely-sensed surface conditions, and to investigate the effect on modeled ice growth and transport by including the satellite-derived surface conditions directly in the ice model. This project is part of a CCHE program to support interaction between undergraduate and CU professors and research associates.

Artificial Intelligence Applications for Sea Ice Processes

Funding: NASA

J. Maslanik and J. Key

The rule-based system methodology has been applied to the analysis of Landsat imagery for the retrieval of sea ice lead statistics, primarily widths, orientations, and densities. Rule-based systems are also being examined for their application to the retrieval of sea ice concentration from passive microwave and ancillary data. Neural networks were used to classify polar clouds and surface in AVHRR imagery, but were less successful in describing cloud morphologies. We have also developed a neural network to detect melt effects and the "false" multiyear ice signature in passive microwave data and a simple sea ice model,

and to estimate concentrations of first-year, second-year, and multiyear ice.

Re-analysis of Meteorological Fields, Ice Motion, and Ice Concentration for the Arctic

Funding: NOAA - Climate and Global Change
M. Serreze, J. Maslanik and R.G. Barry.

Gridded meteorological data from NMC and the Arctic Drifting Buoy Program, together with ice concentration and ice type estimated using passive microwave data are being processed to generate basic statistics for a time series of surface pressures, internal buoy temperatures, geostrophic winds, and ice conditions for regions in the Arctic. Dominant patterns within these fields, as well as relationships between the different variables, will be defined using discriminant forcing fields, changes in ice concentration, and variations in ice export into the North Atlantic through the Transpolar Drift Stream.

Variability in the Low-Level Arctic Temperature Inversion

Funding: NOAA-Climate Global Change
M.C. Serreze, J.D. Kahl and R.C. Schnell

An Arctic temperature sounding data base, consisting of all available historical Arctic rawinsonde data above 60°N, is being compiled to examine long-term variability and possible trends in Arctic temperatures at the surface and aloft. Current research is focusing on spatial and temporal variability in the low-level Arctic temperature inversion. Recent results for the Eurasian Arctic will be combined with data for Alaska, Canada and from drifting ice island stations. Synoptic-scale controls on variability of the inversion layer are also being addressed.

FUNDING

Funding Sources

The FY90 funding picture was much the same as the last three years. Total funding has been approximately \$1.1 million from four major sources. NASA (44%) continues to be the largest supporter of NSIDC projects, through the CDMS-SSM/I and Snow Cover gridding efforts. NOAA is a close second, with "core" funding (13%) and Climate and Global Change Program funding (15%). DoD, ONR and NSF were the third largest contributors, at 20%. University of Colorado and Data Sales offer a small but important addition to the total funding picture. See Figures 4 and 5.

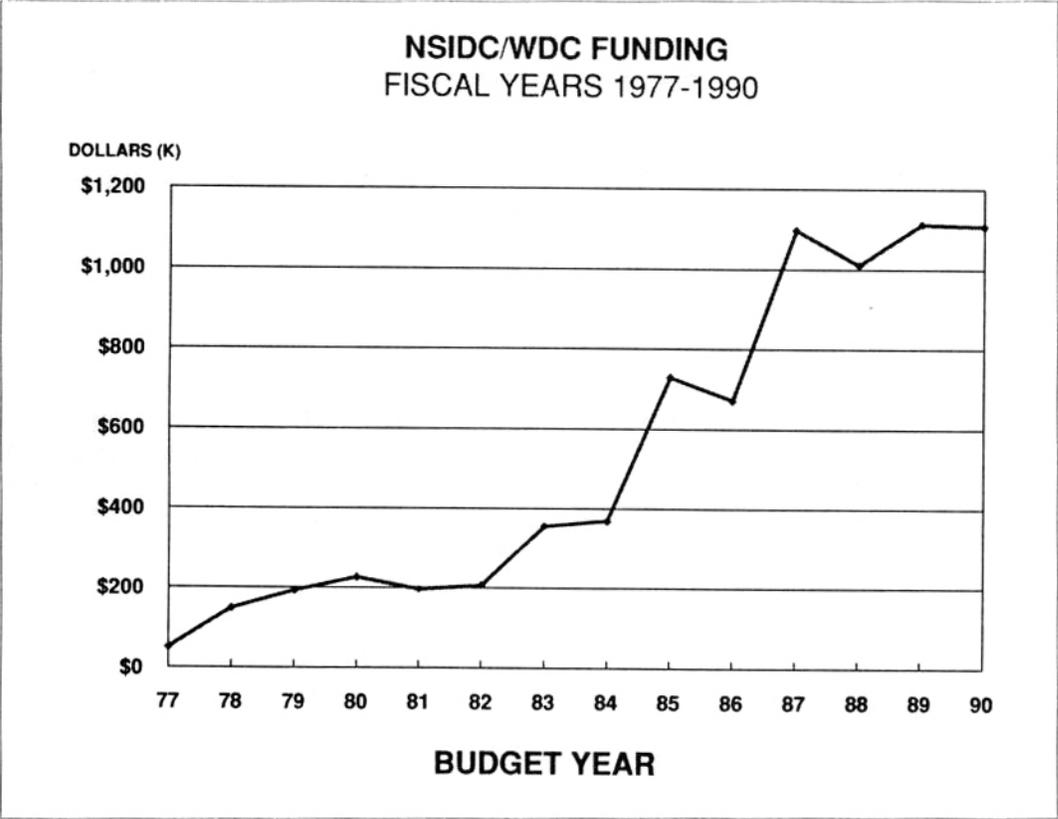


Figure 4.

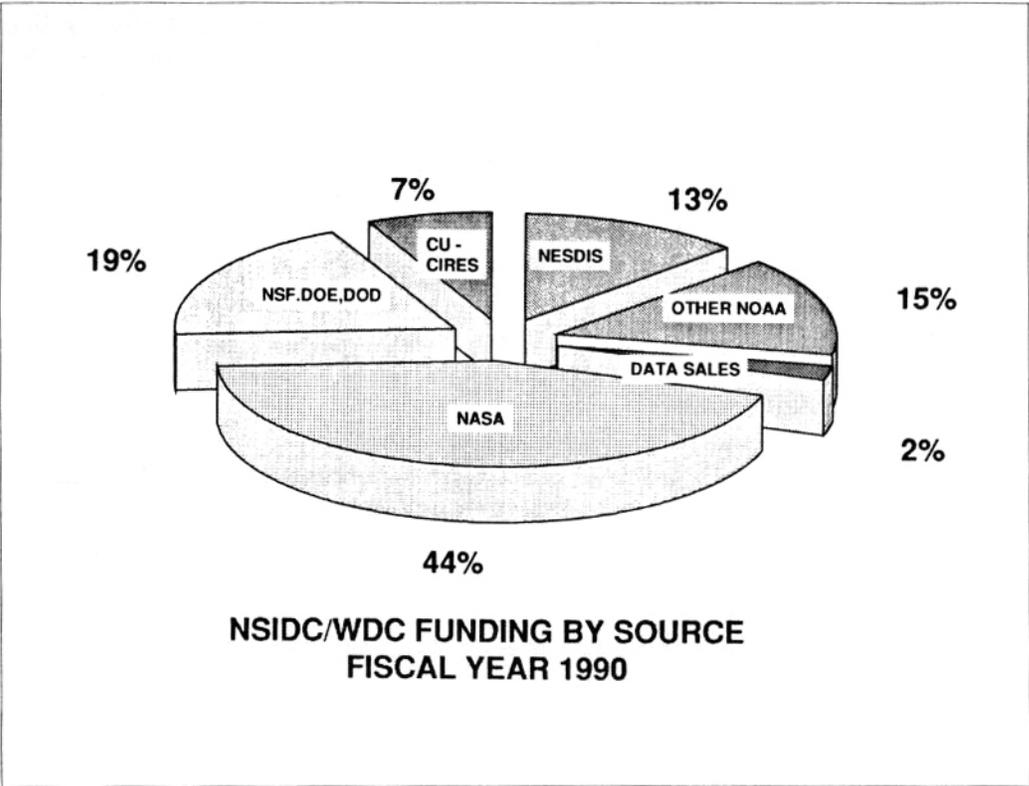


Figure 5.

Data Request Statistics

Twenty-five percent of total requests for the period January 1978 - September 1990 were from U.S. academic users, 22 percent from U.S. government users (including 5 percent from NOAA), 22 percent from foreign users, and 19 percent from US industry or commercial users. During this 13-year period the relative distribution of user types has remained fairly stable. See Figure 6.

DMSP OLS imagery leads the list of income-producing data sets, with a total of \$91,262 received since 1978. This is 56 percent of NSIDC/WDC data sales income, and 35 percent of total requests for the period. The next most profitable data set is the Navy - NOAA Joint Ice Center digital weekly sea ice data, bringing in \$12,628, or 8 percent of income and 3 percent of total requests. Antarctic and Greenland ice sheet echo sounding data raised the next-largest amount of income, \$10,072 (6 percent, for 0.7 percent of total requests).

The amount of income generated by requests for copies of materials in the library (\$12,102; 7 percent of income, nearly 27 percent of requests), and for Great Lakes ice-related data (\$2550; 1.5 percent of income, 1.7 percent of requests) is somewhat surprising. Library usage is difficult to quantify because many of those who use the collection are from Boulder and are experienced users who do not require assistance, and thus are not counted. The number of requests logged, for copies, literature searches, the microfiche index product, or interlibrary loans, is over one quarter of our total, indicating a large (or small but active) group of library users. The Great Lakes data requests have been a slow but steady source of income during the 13-year period, despite our general impression that this area is of limited interest in the research community. Most of the requests for Great Lakes data have been from U.S. federal and state government entities. Figure 7 tracks the number of users and the dollars earned since 1979.

NSIDC/WDC DATA REQUEST STATISTICS

FY90 AND LONG TERM AVERAGE

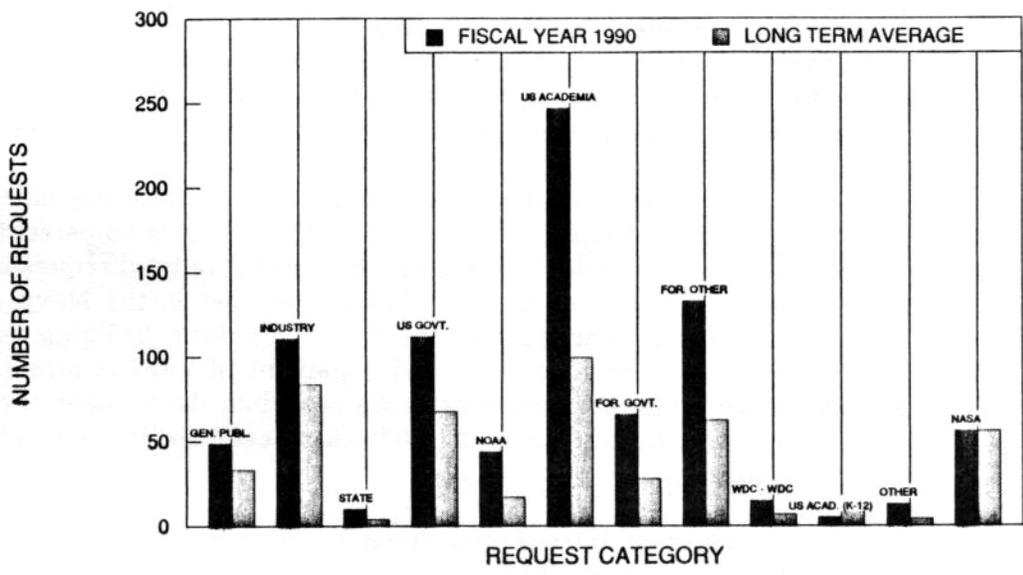


Figure 6.

NSIDC/WDC DATA REQUEST STATISTICS

DOLLAR AND USER REQUEST TOTALS BY YEAR

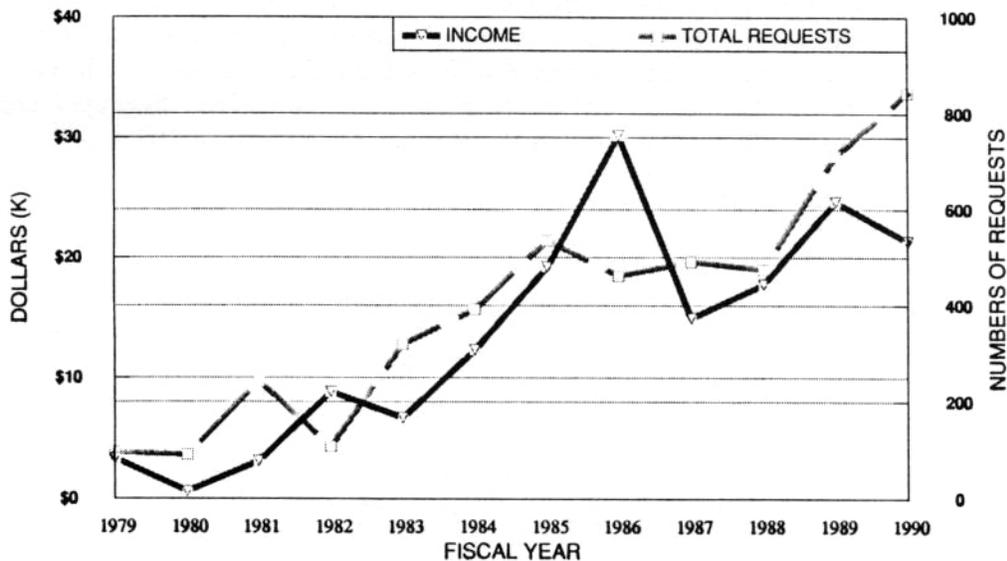


Figure 7.

NEW INITIATIVES

Earth Observing System Data and Information System (EOSDIS)

NSIDC has been invited to participate in the NASA-coordinated evolutionary design of the EOSDIS for the pre-EOS era. The early activities of EOSDIS will be to:

- Improve access to current data;
- Produce and use new data sets derived from both currently available and newly acquired data;
- Integrate and migrate existing data systems towards an integrated Earth science data system;
- Improve the infrastructure for obtaining information required for research activities by developing a Global Change Master Directory and interoperability between distributed catalog systems;
- Adopt standards and protocols to facilitate the accomplishment of the above activities.

To meet these goals, the EOSDIS Project with guidance from NASA Headquarters has defined seven sites as primary Distributed Active Archive Centers (DAACs). NSIDC has been selected as the primary DAAC for Snow and Ice (Non-SAR) to participate in the system engineering of the pre-EOSDIS prototype.

NSIDC will continue to process, archive and distribute SSM/I data during the 1991-1994 years. In early 1991, NSIDC will develop plans to migrate the CDMS to a UNIX environment and convert the existing catalog and inventory systems to a relational DBMS supporting the SQL interface.

In addition to the above activities, NSIDC has proposed to participate in three system engineering tasks during fiscal year 1991: 1) develop a model for catalog interoperability, 2) select a data format standard (BUFR, HDF, netCDF, SDFU, etc.) and convert an existing or new data set to this format, and 3) investigate existing systems for more broadly shareable software that can be implemented in the DAAC operational environment.

Digital Ice Forecasting and Analysis System (DIFAS)

A joint effort between NSIDC and the National Ocean Survey (NOS) to archive data from the Navy/NOAA Joint Ice Center's (JIC) Digital Ice Forecasting and Analysis System (DIFAS) has been funded by NOAA's Climate and Global Change Program. The two-year project entitled "Analysis and Assessment of Sea Ice Fluctuations in Relation to Atmosphere-Ocean Processes" has both

research and data management components. Ingest data streams and output products will be transferred to NSIDC and archived digitally for the retrospective sea ice research community. NOAA has funded the development of DIFAS, a state of the art workstation for forecasting sea ice for JIC customers. The same software and a similar hardware configuration will be located at NSIDC allowing the manipulation of satellite data with conventional meteorological observations and ship reports. The research goals of the project are aimed at better understanding the relationships between the atmosphere-ice-ocean system in the polar regions.

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COMMITTEES

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

SSM/I Products Working Team (SPWT), NASA - R.L. Armstrong

Western Snow Conference Executive Committee - R.L. Armstrong

Arctic Environmental Data Directory Working Group - R.G. Barry, C.S. Hanson

EosDIS Science Advisory Panel, NASA - R.G. Barry

Polar Research Board, National Academy of Sciences (1987-1991) - R.G. Barry

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

Committee on Human Dimensions of Global Change, National Academy of Sciences (1989-1991) - R.G. Barry

U.S. Polar Bibliographic Information Working Group - A.M. Brennan

U.S. - Canadian Great Lakes Ice Information Working Group -
C.S. Hanson

U.S. Canada Joint Ice Working Group - G.R. Scharfen

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

Colorado Governor's Consortium on Global Climate Change -
R.L. Weaver (affiliate member)

MEETINGS

EOSDIS Phase B Preliminary System Design Review - V.J. Troisi,
30 October - 3 November 1989 (GSFC, Greenbelt, MD)

EOSDIS Data Panel - V.J. Troisi, 1-3 November 1989, 23 February
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Polar Libraries Colloquy - A. Brennan, 10-14 June 1990 (Rovaniemi, Finland)

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Richard L. Armstrong

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