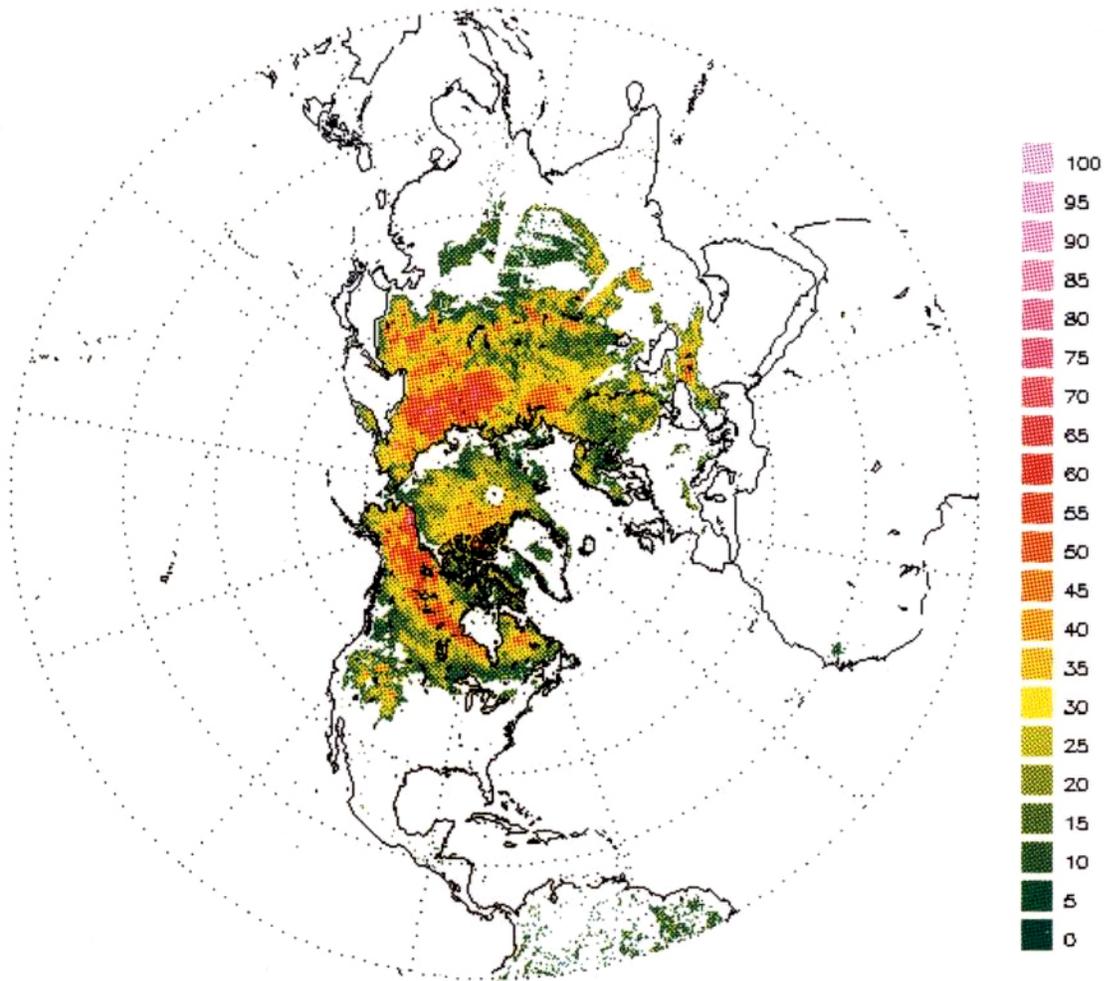


*NATIONAL SNOW AND ICE
DATA CENTER*

*WORLD DATA CENTER A-
FOR GLACIOLOGY*



*ANNUAL
REPORT 1991*

*The Data Center
for Glaciology*

ANNUAL REPORT

1991

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

Cover: The cover image shows snow cover derived from 3-day averaged SSM/I brightness temperatures using the algorithm of Chang *et al.* (1987). The scale on the image is in centimeters. The image was created in postscript format using PV-WAVE on a MicroVax II and printed on a QMS ColorScript 100 Model 30 printer.

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NSIDC/WDC ANNUAL REPORT

FY 1991

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NATIONAL SNOW AND ICE DATA CENTER/ WORLD DATA CENTER-A FOR GLACIOLOGY

ANNUAL REPORT FY1991

INTRODUCTION

The National Snow and Ice Data Center (NSIDC)/World Data Center A for Glaciology (WDC) is operated under a cooperative 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. Within CIRES, NSIDC/WDC is a part of the Cryospheric and Polar Processes division. NSIDC/WDC is completing its fifteenth 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 1991 fiscal year (October 1, 1990 - September 30, 1991). R.G. Barry was on leave as Visiting Professor at the Institute of Geography, ETH, Zurich, during 1 April - 14 August 1991. During this period, R.L. Weaver served as Acting Director.

HIGHLIGHTS

The following highlights provide information on major programs which we feel are of particular interest to our user community.

Coordinated Eastern Arctic Experiment (CEAREX) Data Management

Under contract to the Office of Naval Research, NSIDC has prepared a CD-ROM containing data from the CEAREX field experiments. The disc is seen as the first in a potential series entitled "Eastern Arctic Ice, Ocean and Atmosphere Data", containing data from CEAREX, MIZEX, Eurasian Basin Experiment (EUBEX) and other Arctic campaigns as well as other pertinent or related data sets of potential use to scientists involved in Arctic research. The disc includes hydrography, bio-optics, meteorology, sampling positions, and bathymetry data bases compiled from the entire CEAREX experiment, as well as ice acceleration, stress and deformation, samples of ambient noise and acoustics data, and several EUBEX and MIZEX hydrography data sets.

In November 1991, the "beta" version of the CD-ROM is being distributed to CEAREX participants and other interested researchers. Comments received from this distribution will assist NSIDC in designing possible future versions of this disc as well as in planning subsequent CEAREX CD-ROMs. The CD-ROM master was produced by NSIDC using hardware and software at NGDC. The resulting "one off" disc was then sent to a commercial CD-ROM facility for replication.

CEAREX field experiments were carried out 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 within the ocean/atmosphere boundary layer. 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. Figure 1 shows two of the ships involved in the experiment. CEAREX data management at NSIDC is initially a two-year project, with production of one CD-ROM scheduled during each year.

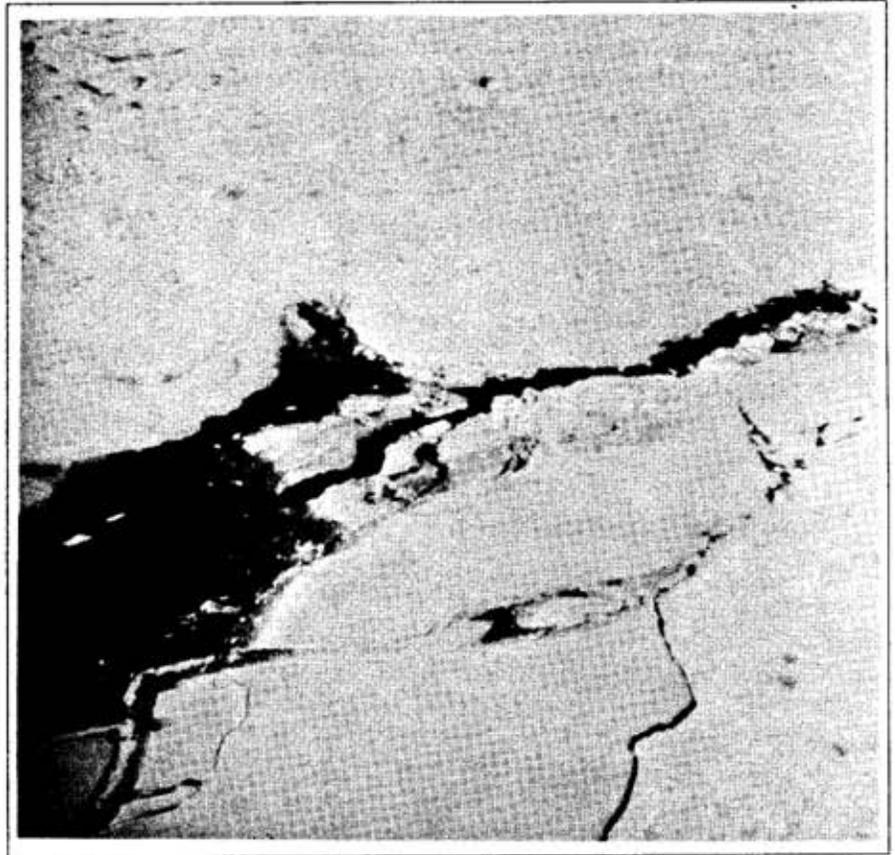


Figure 1. USCGC *Northwind* and Norwegian ship *Polarbjorn* at 82° 41'N, 32° 26'E on 16 September 1988. Photo courtesy of D.L. Bell, U.S. Army CRREL.

SSM/I Snow Cover Research

Snow cover is important to the study of global change with respect to surface energy budgets and the hydrologic cycle. 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 daily snow parameter products from the DMSP Special Sensor Microwave Imager (SSM/I) (see cover). A data system is being developed which will produce, archive, and distribute Northern Hemisphere snow extent products. 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, gridding and projection techniques as well as the selection of one or more snow cover algorithms for use in the distribution of standardized data sets. Snow cover algorithm comparison is being undertaken in a cooperative effort with scientists at the University of Innsbruck, Austria, and the Canadian Climate Center. The accuracy of the algorithms is being 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 which was developed by NSIDC. 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.

Global Snow Depth Model

NSIDC has completed the development of a prototype snow depth model to replace the operational model used by the U.S. Air Force Global Weather Central (AFGWC). The prototype model provides a state-of-the-art integration of all snow cover data available at AFGWC in order to generate a global snow cover product at a 40 km grid resolution. Improved interpolation techniques have been developed based on both distance and elevation weighting criteria as well as a spatial variance as defined by snow cover climatology. 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 WMO synoptic surface and satellite observations. The latter are passive microwave Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I) data 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. 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.

Snow and Ice Distributed Active Archive Center

In 1989 NSIDC was invited to participate as one of the seven Distributed Active Archive Centers (DAACs) in the Earth Observing System Data and Information System (EOSDIS) Project. The Earth Observing System (EOS) is a long-term, interdisciplinary and multidisciplinary research mission to study global-scale processes that shape and influence the Earth as a system. The EOSDIS will provide the distributed ground system for the collection, production, archival, distribution and analysis of EOS and other Earth science data. A

proposal for support of the Snow and Ice DAAC (SIDAAC) was approved by NASA in January 1991.

Between 1991 and 1994 the EOSDIS Project Office is building a prototype of the EOSDIS that will provide a smooth transition from the existing DAAC systems to the operational EOSDIS configuration. Version 0 (V0) is defined as an evolutionary build of the EOSDIS and is being developed upon existing DAAC systems and capabilities. The primary goal of the V0 systems engineering effort is to develop transparent interoperability among the participating DAACs. The early phase of V0 will focus on the elements that provide the interface between the user and the DAAC services: user interface, catalogs and inventories, network efficiency and reliability, and data format standards.

Passive Microwave Data on CD-ROM

DMSP SSM/I Brightness Temperature Grids for the Polar Regions, 9 July 1987 - 31 March 1990, have been distributed on eleven CD-ROMs to over 320 users. A looseleaf User's Guide containing complete documentation is part of the package, along with two PC diskettes of software. Software to read and display the SSM/I grids on an Apple Macintosh II is available, as well as two user-submitted "shareware" programs for Macintosh II applications. An average of two new requests per week are received for this popular CD-ROM data product. Further details are provided on page 16-17.

Nimbus-7 SMMR Northern Hemisphere data for 28 October 1979 - 31 December 1982 have been mastered on three CD-ROM discs by NASA/Goddard Space Flight Center, Oceans and Ice Branch. NSIDC was asked to distribute these data for NASA, and a mailing list is now being developed while documentation and access software are being written and tested. Distribution began in October 1991. The complete Northern and Southern Hemisphere data set for 1978 - 1987 is expected to require twelve discs and should be completed during 1992.

DMSP Global Lightning Detection

NSIDC has begun analysis of the USAF Defense Meteorological Satellite Program (DMSP) global imagery collection for the detection of lightning occurrence. This project, which is an outcome of NSIDC's data management of the DMSP collection, has been funded by NASA's Marshall Space Flight Center for three years. Lightning signatures appear as horizontal streaks on the nighttime visible-band images. DMSP data provide unique information about lightning since no other satellite system operates a visible-band sensor at night, and no other global-coverage lightning detectors are operational. A preliminary data base of the seasonal location and time of nighttime lightning signatures has been prepared for 1986-87.

NSIDC is incorporating the use of GIS technology to improve quality control and editing of the lightning data base. In a cooperative effort with LORAL Aerosys of Seabrook, Maryland, custom software using 'Arc Info', a commercial GIS package, is being developed for the new Data General workstation which will eventually support the lightning analysis. We expect that the analysis tools and GIS development will benefit our polar interests and promote more effective management of the DMSP collection.

CURRENT PROGRAMS

The ongoing activities of NSIDC/WDC fall into three broad inter-related 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 are often involved in a variety of complementary activities.

Data Activities

Data Set Administration

New and updated data sets received during FY91 include:

- a. Weekly digitized sea ice charts produced by the Navy - NOAA Joint Ice Center (JIC) for 1989 were received on 9-track tape and added to the archive. This data set covers areas where sea ice can be expected to occur in both the Arctic and Antarctic regions, and now spans 18 years for the Arctic and 17 years for the Antarctic. Data sources include satellite observations (NOAA and DoD) as well as any airborne or surface reconnaissance available to the JIC as they produce the weekly operational product.
- b. Dr. Carol Pease of NOAA/Pacific Marine Environmental Laboratory provided a 9-track tape containing data from her Bering Sea ice buoys, extending the data base to cover 1981-82 and 1985-89.
- c. The historical "Northern Hemisphere Sea Ice" data base produced by Dr. John E. Walsh at the University of Illinois/Department of Atmospheric Sciences, has been updated to include 1989 data. The older data were digitized from published reports and hard copy ice charts, while newer data sources include satellite imagery and satellite passive microwave observations from the Special Sensor Microwave/Imager now flying on the DMSP platforms. Data in this time series now extend from 1953 - 1989.

- d. Ice observations from ship and shore stations around the Great Lakes for 1988-1990 were filmed on 16mm microfilm for the Great Lakes ice-related archive. Water level gauge-site observations of ice conditions around the Great Lakes were keyed for the 1990/91 season, and added to the 37-year time series archived on 9-track tape. This unique data set provides a relatively long-term record of the length of the ice season on the Great Lakes.

Twenty-one data sets were received during FY91 for the CEAREX CD-ROM (See Highlights, p. 2). They will also be archived at NSIDC on magnetic media.

During the past year, revisions of nearly the entire Data Announcement series were completed, to reflect updated holdings, price changes or media availability. Twenty fliers were revised:

List of Snow and Ice Data Announcements, 85-GLA-00
Information Center and Bibliographic Collection, 91-GLA-02
Glaciological Data Series, 90-GLA-04
Guidelines for Transfer of Data, 91-GLA-06
WDC/NSIDC Arctic Data Sets, 88-GLA-ARC
Snow Cover Data, 83-GLA-10
DMSP Visible and Infrared Imagery, 83-GLA-11
DMSP Mosaic Products, 83-GLA-11A
Glacier Photo Collection, 83-GLA-21
Ice Core Data, 87-GLA-41
Airborne Polar Ice Sounding and Geomagnetism Data, 80-GLA-43
ESMR Sea Ice Data, 89-GLA-52
International Ice Patrol Iceberg Data, 83-GLA-53
Joint Ice Center Digital Sea Ice Data, 83-GLA-54
Digital Sea Ice Data, 83-GLA-55
MIZEX Data, 90-GLA-57
Arctic Ice Dynamics Joint Experiment Data, 83-GLA-58
Great Lakes Ice Data (general description), 86-GLA-61-G
Geosat Land/Ice Data, 89-GLA-71
SSM/I Brightness Temperature Grids for the Polar Regions,
89-GLA-80.1.

Antarctic Data Questionnaire

In May 1991 a survey form was sent to each of the twenty-four National Committees of the Scientific Committee on Antarctic Research (SCAR) on behalf of the SCAR ad hoc Committee on the Coordination of Antarctic Data, requesting preliminary information on Antarctic data sets and data collections within each of the participating countries. Responses received from nine countries were forwarded to S. Abbott of the Polar Research Board for compilation into a report to the XVth

Antarctic Treaty Consultative Meeting, October 1991. WDC/NSIDC continues to seek funding to compile a directory of Antarctic data using the survey responses, following up with individual data holding institutions, where necessary, to complete the directory entries. This effort may eventually result in the expansion of the Arctic Environmental Data Directory to include Antarctic entries, if agency support can be obtained.

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 user requests for information on global scale cryosphere/climate studies, NSIDC/WDC maintains an active program to acquire published materials in all areas of snow and ice research.

Currently, the Information Center contains 5800 monographs and technical reports and 12,000 reprints; 90 serial publications are regularly received. During 1991, over 1200 items were added to the collection.

All materials received are catalogued and assigned subject and geographic descriptors. Primary access to the collection is provided by CITATION, the in-house online catalog. At the end of FY91, there were almost 29,000 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.

The information holdings of NSIDC/WDC are now also 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.

INMAGIC and SearchMAGIC bibliographic software have recently been purchased. This will allow the CITATION data base to be implemented at NSIDC rather than operating on the Unysis computer at

Asheville, North Carolina. Through a networked SearchMAGIC, CITATION will be available on every PC at NSIDC.

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 FY91, 4 NAL issues were completed. We have now published listings through 1990.

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, *GD-24*, is in preparation. This volume, due in November 1991, will focus on NSIDC involvement with passive microwave data, from processing the data to research using it. It will also contain a bibliography updating that published in *GD-19*, 1987. The bibliography comprises references on passive microwave theory, instruments, research and applications, from 1987 to date.

Data Related Meetings

Arctic Environmental Data Directory Working Group, 12 February 1991, Reston, VA

The Arctic Environmental Data Directory Working Group (AEDDWG) met in Reston, Virginia, on 12 February 1991, to put in motion plans for quality control of existing entries in the AEDD and input of new entries. C. Hanson was appointed a member of the AEDD Input Form Subcommittee, and subsequently worked with D. Irvine of the Global Change Master Directory and A.C. Brown and F. Rowland of the USGS to compile a new document, *AEDD Input Form Manual*, that provides instructions for preparing entries for the AEDD. The manual is based on the Master Directory's Directory Interchange Format Manual, Version 3.0, 12/1990.

Arctic System Science Program Planning Meeting, 8-9 March 1991, Amherst, MA; 23-24 August, Boulder, CO

The Arctic System Science (ARCSS) program of the National Science Foundation (NSF) held a planning meeting in Amherst, Massachusetts, on 8-9 March 1991. The focus of the working session was to write the implementation plan for the Land-Atmosphere-Ice Interactions (LAI) portion of ARCSS. C. Hanson represented NSIDC in Amherst. A second meeting in Boulder on 23-24 August 1991, attended by R.G. Barry and C. Hanson, completed the implementation plan for presentation to NSF.

Global Sea Ice Data Bank Planning, 6-10 September 1991, Boulder, CO

A return visit to NSIDC by Dr. Ivan Frolov, Alexi Turchin and Andrei Yazev of the Arctic and Antarctic Research Institute (AARI), St. Petersburg, was made on 6-10 September 1991, to discuss progress on the cooperative development of a global sea ice data bank in WMO SIGRID format. This was a follow-up to the visit to AARI by R.G. Barry and V. Troisi in September 1990. Dr. Frolov's visit was sponsored by WMO and the other visitors by WDC-A. AARI wishes to see the activity recognized as a component of WDC-B. Recommendations on the SIGRID format were prepared for submission to WMO by Dr. Frolov. AARI provided an inventory of AARI sea ice data holdings as a basis for future data exchanges and also brought copies of several of their software programs for processing sea ice data.

NSIDC and AARI exchanged data, digitized from respective national sea ice charts, in the SIGRID format for 1972. The work plan for 1992 includes target dates for exchange of several specific data sets.

Project Activities

DMSP

NSIDC is in the ninth 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 FY91, approximately 3,000 images were sorted, catalogued, and archived into the collection, now amounting to about 1.4 million pieces of imagery. Approximately two hundred requests for data and information were processed this year (about the same as in FY90) resulting in data sales of just over \$19,000 (almost double that of FY90, and the most ever for the DMSP activity). The stable number of user contacts reflects continuing usage of the collection even though receipts of new imagery have decreased dramatically. The increase in data sales income is due to a higher percentage of large data requests. Receipts of new imagery are about 10% of the level two years ago. Some 395 prints, 156 35-mm

slides, 1492 original images on loan, 35 information letters and 403 data flyers were shipped during the course of the year. There were at least 95 visitors to the archive.

Scheduling for the transfer of the OLS analog image collection to the Federal Records Center, as decided in 1990 by NOAA, is in progress. NSIDC has submitted the required information to NOAA, which is negotiating with the National Archives and Records Administration. Staff from NSIDC and NGDC attended a training course at the Federal Records Center in Denver, the site where the data will most likely be transferred.

DMSP data from the analog image collection continue to be used in noteworthy projects. Two separate research efforts aimed at a better understanding of South American snow cover made use of the seventeen-year record of imagery. Dr. Ken Dewey, of the Department of Geography at the University of Nebraska, Lincoln, used historical images to update the satellite-derived snow cover record that has been used by many researchers to identify possible long-term trends in the global extent of snow and ice cover on the earth's surface. Gaps and inconsistencies in the AVHRR imagery, which was the source for most of the record, and its analysis, especially in South America, account for significant errors in interpretation of the record. Dewey will fill in these gaps with his own analysis of the DMSP imagery.

Andrew Fox, a graduate student at Cornell University, digitized approximately eight hundred images during a working visit at NSIDC. The images were digitized using NSIDC's Eikonix digitizing camera and related image analysis equipment. Fox is correlating the areal extent of snow cover of present day conditions with that of paleoclimate proxy snow cover records.

Renewed vigor in the oil and gas industry resulted in a request from Fred Kloepper, of Questa Engineering, Golden, Colorado. Questa Engineering is participating in a study that will assess the feasibility of an over-land pipeline from the Soviet Arctic coastal city of Varandey, inland. The images that Questa obtained highlighted fast ice boundaries, river ice extent and topography. Figure 2 shows one of these images. It was collected by a DMSP satellite at night and shows city lights and the regional snow-covered landscape under full moon conditions. Novaya Zemlya is the island in the top center of the photograph.

Another request, from Commander Lawson Brigham of the U.S. Coast Guard Strategic Planning Office, involving a study of sea ice conditions in the Soviet Arctic, is using the DMSP images to determine variations in seasonal ice conditions in the Barents, Kara and Laptev seas. The joint project with the Russians is aimed at lengthening the shipping season with an improved knowledge of sea ice conditions.

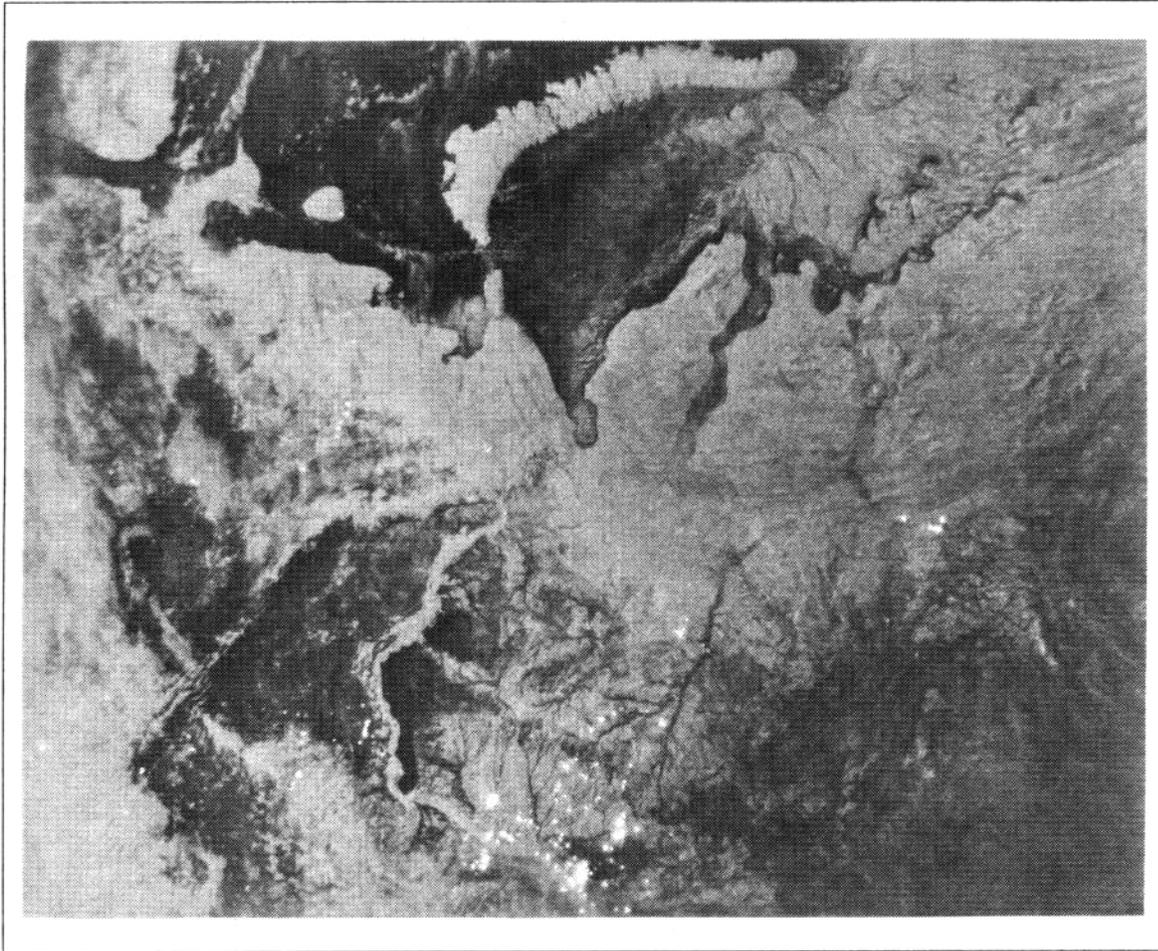


Figure 2. The Kara and Barents seas at night in a DMSP F8 visible-band image, 5 December 1987.

Dave Lindberg of the 'CD-ROM Atlas Project', a private company, plans to use both analog and digital data from the DMSP collection as part of a digital atlas aimed at education audiences. Lindberg wants to use DMSP/OLS data for this purpose since it has a higher spatial resolution than any of the other global coverage satellites. DMSP data will be used as the global coverage data set, and higher resolution data from the Landsat and Spot systems will be used where available. Users will be able to 'roam' around the globe and then 'zoom' in to examine interesting features with the use of a mouse and a personal computer/CD-ROM reader. Selected analog images are being used in the prototype version, since the digital data are not yet available.

The National Geographic Society plans to include a list of DMSP images that show Kuwaiti oil fires and the Persian Gulf in their soon to be published 'Environmental Data Set Directory of the Persian Gulf'. The images show the fires and the extensive smoke plumes in the region from December 1990 through June 1991. Figure 3 is an example of one of the nighttime images.

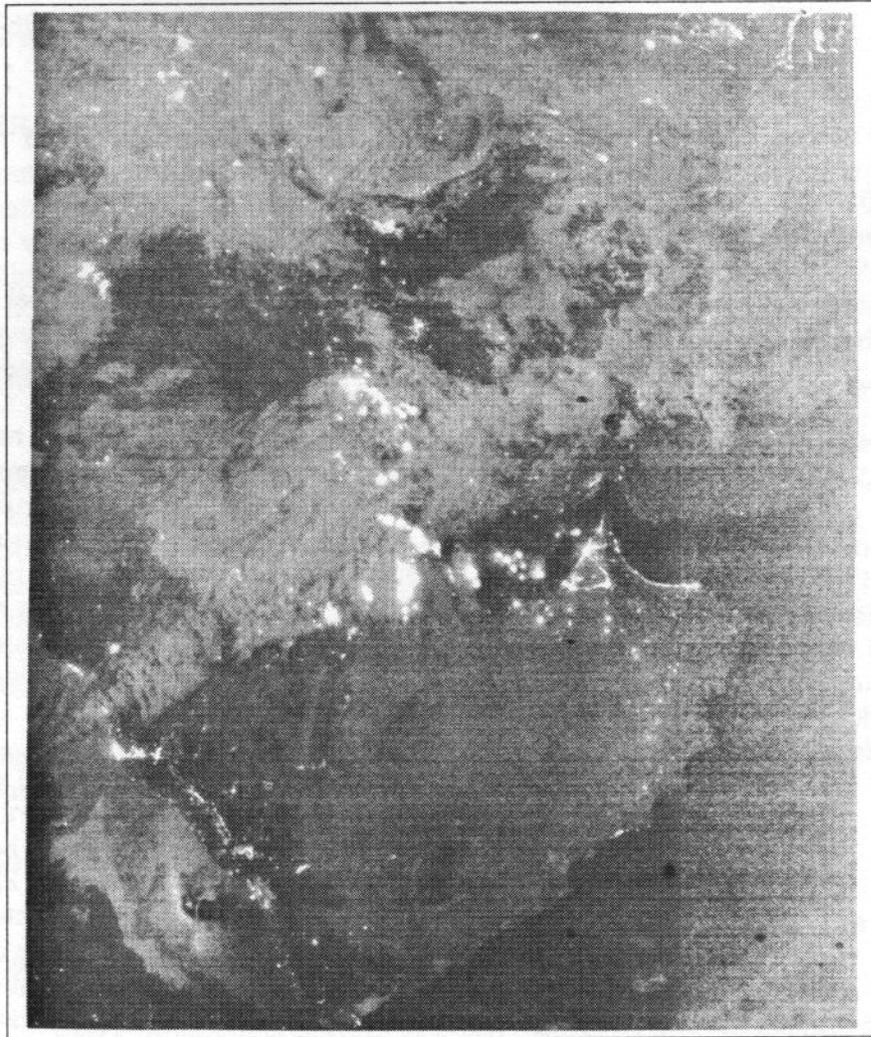


Figure 3. DMSP F-9 visible band image of the Persian Gulf region showing extensive oil fires in Kuwait, 22 January 1991.

Nighttime images from the collection appeared in IMAX movie theaters all over the U.S. and Canada this year in the movie 'Blue Planet'. The images show city lights and fires on dark nights, simulating the view from the space shuttle. The scenes in the film were also used in the 'World at Night' poster compiled from DMSP images at NSIDC by Dr. Woodruff T. Sullivan of the University of Washington, Seattle. NSIDC is listed among the many credits at the end of the film.

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.

Digital Ice Forecasting and Analysis System (DIFAS)

Year two of the joint effort between NSIDC and the National Ocean Service (NOS) to archive and analyze data from the NOAA/Navy Joint Ice Center (JIC) underwent changes associated with the evolution of the DIFAS system at the JIC. This project, funded by the NOAA Climate and Global Change Program, has both data management and research objectives. The DIFAS system is being redesigned, forcing delays in its integration into JIC operations. JIC management has also ruled out transfer of most data sets used in DIFAS analyses, though an opportunity to archive DIFAS products remains a future possibility. Our research objectives have been met by utilizing other sources and data sets to simulate the assemblage of data collected by the JIC. Research has focused on a better understanding of the relationships between the atmosphere-ice-ocean system in the polar regions.

Specific research objectives of the DIFAS project are to: 1) identify seasonal and decadal variations in ice formation, concentration, advection, and melt with primary focus on the North Atlantic (in keeping with the goals of the Atlantic Climate Change Program [ACCP]; 2) relate these variations to atmospheric forcing mechanisms; and 3) determine whether these relationships can serve as indicators of larger-scale climate processes. The methodology to meet these objectives includes statistical analyses of meteorological fields and sea ice data, intercomparisons of remotely-sensed data, in-situ observations and model output, and diagnostic multiyear runs of a dynamic-thermodynamic sea ice model. The modeling efforts were designed to test specific hypotheses developed from the empirical analyses as well as to provide new information (ice thickness, compactness, motion, etc.) to study climatic changes and interrelationships. Results to date include: 1) generation of basic statistics for meteorological variables for regions in the Arctic spanning a minimum of 6 years; 2) estimated open-water turbulent heat fluxes for the Arctic by region (as a means of assimilating the observed variations in temperature and wind speed); 3) case-study comparison of the response of ice concentration to atmospheric forcings; 4) detection of a possible atmospheric mechanism to contribute to the Great Salinity Anomaly in the northern North Atlantic; 5) testing of this hypothesis using daily winds driving a sea ice model; and 6) analyses of interannual variability of a 21 year record of modeled ice conditions in relation to atmospheric forcings.

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. During the 1991 field season the GISP2 core reached a depth of 1510 m.

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. Beginning in late 1991, data will be available to GISP2 PIs by electronic file transfer (Internet, FTP). Because of the widespread and growing interest in paleoclimate and global change, GISP2 data sets will receive ever increasing attention from fields outside glaciology.

Snow and Ice Distributed Active Archive Center

NSIDC is funded by NASA EOSDIS V0 to provide data services to the snow and ice user community (see Highlights, p. 4-5).

Major prototyping activities in which NSIDC is participating include:

- 1) Development of level 3 interoperability between the seven DAAC sites and the V0 Project Information Management System (IMS). An EOSDIS V0 IMS development team retreat is scheduled for November 1991. A set of science scenarios will be used for evaluating the IMS. The scenarios, defined by representatives of the EOS Data Panel, reflect the type of queries investigators may pose to determine what data exist suitable for their research. Feedback on the current prototype will be solicited from the meeting attendees. If feasible, recommended changes will be made to the prototype.
- 2) Evaluation of existing data formats for application to EOS data. A subset of the Marginal Ice Zone Experiment (MIZEX) data set archived at NSIDC will be placed into the Planetary Data System (PDS) format and distributed on CD-ROM to investigators studying the polar regions. Recipients of the 'sampler' CD-ROM will be asked to evaluate the utility of the PDS data format system by responding to a data formats requirements survey. Results will be gathered from all seven DAACs and evaluated to determine which of the data formatting systems will be

recommended as suitable for packaging EOS data sets. Primary among our tasks is the continued distribution of SSM/I derived sea ice products.

SSM/I orbital swath data continue to be binned into brightness temperature (TB) grids for the polar regions. DMSP F8 (launched in June 1987) continues to be our primary data source. DMSP F10, carrying the second SSM/I instrument, was launched on 1 December 1990. The orbit of the DMSP is nominally circular. However, the F10 was launched into an elliptical orbit varying in altitude from 736 to 851 kilometers. The SSM/I data are of marginal use due to varying incidence angles. NSIDC does not plan to use any of the F10 SSM/I data.

Gridded Brightness Temperatures

NSIDC has published eleven volumes of SSM/I brightness temperature grids for the polar regions on CD-ROM.

| 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 |
| 9 | July - September 1989 |
| 10 | October - December 1989 |
| 11 | January - March 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

From our experience with the CD-ROM production cycle it has become evident that a pre-mastering environment is a requirement if NSIDC is to continue distributing data sets in this medium. NSIDC will acquire the hardware and software required to pre-master data sets intended for CD-ROM. In-house pre-mastering has three advantages: 1) reduces the costs associated with the production of a CD-ROM volume, 2) simulates access to the data on the volume prior to shipment to a mastering facility, and 3) retains more control over the quality of the CD-ROM production process.

SSM/I Sea Ice Concentration Grids

In addition to the SSM/I products currently being distributed we are nearing completion of a sea ice concentration CD-ROM. Two algorithms

that derive sea ice concentration parameters from the polar grids of SSM/I radiances have been gridded. One of the algorithms known as the NASA Team Algorithm (Cavalieri *et al.*, 1990) employs a polarization ratio of the 19 GHz frequency for determination of the ice/open water boundary and the spectral gradient ratio between the 19 GHz and 37 GHz vertical polarizations. The NASA Team Algorithm also employs 'tie-points' that can be adjusted, depending on the season or location being investigated, in order to calculate accurately ice concentration parameters. The second algorithm, developed by J. Comiso, simulates a scatterplot analysis of the brightness temperatures of the 37 GHz channels to determine slope of consolidated ice in a region. Ice concentrations are then calculated by determining the ratio of the difference between the observed brightness temperature and the brightness temperature of open water to the difference of the representative brightness temperature of consolidated ice and open water in the region.

Ice concentration grids are being computed from the SSM/I brightness temperature grids for the polar regions for the period July 1987 through December 1989. Two sets of ice concentration grids will be produced; one the NASA Team Algorithm, the other using the Comiso algorithm. Both sets of grids will be distributed on one CD-ROM volume by the end of calendar 1991.

Cryospheric Information Management System

The concept of the SIDAAC includes the ability to provide on-line information to the user community about the digital data sets archived at NSIDC. The Cryospheric Information Management System (CIMS) will provide an interface between the research community and the information and services that are provided by NSIDC. In addition to providing users with metadata of NSIDC holdings through the data set catalog and inventory, the CIMS will be interoperative with the EOSDIS V0 IMS facilitating access to information of data products held by other DAAC centers.

NSIDC and the Laboratory for Atmospheric and Space Physics (LASP), University of Colorado, have agreed to collaborate in the development of the CIMS as well as participate in the V0 IMS Level 3 (minus) interoperability development activities. The following activities were completed:

- A memorandum of agreement was prepared and signed by both parties.
- A functional requirements document was prepared by NSIDC and delivered to LASP.
- An interface design specification was prepared by LASP using an object-oriented design approach.

- Data set descriptions have been defined for the initial data sets that will populate the CIMS:

- 1) SSM/I calibrated orbital Brightness Temperatures (Sensor Data Records)
- 2) SSM/I Brightness Temperature Grids for the Polar Regions
- 3) Arctic Rawinsonde Soundings Data Set

- Inventory table definitions have been defined for the data sets listed above.

NSIDC Computing System

The NSIDC computing environment is principally for support of EOS-related activities. However, all systems are treated as a whole for administrative purposes.

VMS 5.4 was installed on the MicroVAX 3600 in early 1991. 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.

DEC's UCX was installed on the MicroVAX 3600. UCX provides a VMS environment with a subset of TCP/IP functions such as the BIND name service, FTP, TELNET, and NFS.

The NSIDC LAN was removed from the University of Colorado Ethernet-Fiber network backbone. The NSIDC LAN now operates as a subnet under the Class "B" campus network. A CISCO router with gateway software was installed between the campus backbone and the NSIDC LAN.

A CISCO router was installed between the NSIDC LAN and the EOSDIS V0 network. The EOSDIS V0 network is a Class "C" network that will support the network activity among the seven nodes participating in the EOSDIS V0 Systems development. Systems that will be participating in V0 activities at each of the V0 nodes are connected to the V0 network.

A 1.2 Gigabyte SCSI disk drive was acquired for the SUN Microsystems SPARCstation-1 that is being used to support research of artificial intelligence methods for polar science applications.

The Interactive Display Language (IDL) visualization software package was acquired to support algorithm and product development activities in the UNIX environments. Analysis tools using IDL were developed to support both the Air Force Snowcover Model development

activities and the NASA SSM/I snowcover algorithm comparison project. These software tools were modified to support quality assurance activities associated with the integration of ice concentration algorithms ported into the SIDAAC environment.

A Data General Avilion workstation was acquired by NSIDC to support a collaborative GIS toolkit development project between NSIDC and Loral Aerosys Incorporated. ESRI ARC/INFO GIS software came bundled with the Data General workstation.

A DECstation 5000 was acquired by NSIDC to support both the Cryospheric Information Management System (CIMS) and EOSDIS V0 IMS development activities. The DECstation 5000 was chosen because it is bundled with DECNET networking protocol providing access to the system by nodes on the SPAN network. LASP developers are using the DECNET protocol to access remotely the DECstation during the early phases of the CIMS development.

INGRES Data Base Management System (DBMS) was installed on the DECstation 5000. The CIMS is being developed using INGRES, a relational DBMS that supports the Standard Query Language (SQL).

Silicon Graphics Incorporated (SGI) loaned two workstations to NSIDC for performance evaluation. Gridding software that is currently running on the VAXstations was ported to these platforms. The gridding algorithm took over an hour to complete on a VAXstation, while the algorithm required less than two minutes to complete on the SGI platforms. The SGI systems operate faster than comparably configured RISC or MIPS workstations from other vendors, especially the 2-dimensional and 3-dimensional graphics subsystem. Hence, the SGI systems are more expensive than comparably configured systems from other vendors. Whether NSIDC purchases either of these systems is unknown at this time. However, it is apparent from this exercise that NSIDC should continue to migrate its current processing and analysis environment toward the RISC/MIPS technologies.

Research Activities

Polar Climate Processes

Funding: NSF, NASA, NOAA, Navy
J.A. Maslanik; M.C. Serreze; J. Key; R.G. Barry

A physical process model was developed to test the sensitivity of surface energy flux in the ice pack to variations in wind speed, air temperature, ice thickness and dimensions of open water area. Since these sensible and latent fluxes are critical to determining the transfer of heat to the polar atmosphere and the resulting ice growth and modification of the ocean's salinity structure, proper treatment of these turbulent fluxes in ice and climate models is particularly important. Further work will incorporate this process model into more comprehensive ice models.

Analysis of the existing time series of remotely-sensed and field-collected observations for high latitudes has continued. The basic statistics for the Arctic show no significant trends in wind speed, but a noticeable upward trend in minimum air temperatures during winter. Intercomparisons of meteorological measurements from drifting buoys and Soviet ice stations, statistical correlations of pressure patterns and ice outflow in the East Greenland Sea, and calculation of basic meteorological and ice statistics for the entire Arctic as well as subregions have been performed. A strong and significant correlation has been found between high pressure systems in the Canadian Archipelago and ice outflow in the East Greenland Sea, which suggests a strong atmospheric connection to "Great Salinity Anomaly" events in the North Atlantic. We are investigating this further using 2-D ice models.

Means to improve techniques for analyzing of data sets have been examined by applying artificial intelligence (AI) techniques (expert systems and neural networks) to satellite imagery and field observations. Image analysis techniques for extracting pattern information from different satellite image types have been refined and an expert-system-based ice classification is being developed.

J. Maslanik and M.C. Serreze received NSF-DPP funding for participation in the cruise of the *Sovetskiy Soyuz*, a Soviet icebreaker scheduled to cross the Arctic from Murmansk to the Bering Strait via the pole in August 1991. The research plans were to collect atmospheric measurements and to sample ice conditions throughout this cruise track. The Soviet government denied permission for the science portion of this cruise at short notice; NSF will attempt to reschedule a similar cruise in the summer of 1992.

Summer Snow Melt and Albedo Over Arctic Sea Ice

Funding: National Science Foundation - Division of Polar Programs
M.C. Serreze; R.G. Barry; G. Scharfen

Under support of NSF/DPP, work is progressing on analysis of variability in large-scale patterns of snow melt and parameterized surface albedo over Arctic sea ice, based on a ten-year data set compiled from manual analysis of Defense Meteorological Satellite Program (DMSP) visible-band satellite imagery. Variations in the timing of snow melt are being examined in relation to synoptic-scale forcings of winds, surface pressure, temperature and cloud cover.

Variability and Trends in Arctic Tropospheric Temperatures

Funding: NOAA, NSF, Electric Power Research Institute
J.D. Kahl; M.C. Serreze; R. Schnell

Over the last year, all available historical Arctic sounding data above 65°N, including observations from land stations, drifting ice stations and ships, have been compiled into a single format, quality-controlled archive. The data base contains over 1.3 million soundings. These data are being analyzed to examine long-term variability and possible trends in Arctic tropospheric temperatures. Climatological characteristics, pressure and upper-air height analyses are also being examined in conjunction with a synoptic typing scheme to address relationships between temperature fluctuations and regional atmospheric variability.

Retrieval of Ice Surface Temperature from Thermal Sensors

Funding: NASA
J. Key; M. Haefliger

The retrieval of ice surface temperatures (IST) from the AVHRR sensor is important for monitoring long-term climate changes. Coefficients that account for the effects of atmospheric attenuation (water vapor, aerosols) of upwelling longwave radiation have been developed. These coefficients are based on simulated satellite radiances modeled using temperature and humidity profiles from Soviet ice islands and directional emissivities of snow determined through Mie calculations and a 2-stream approximation to the radiative transfer equation. Because the detection of polar clouds in satellite data is a research topic in itself, we assume that a cloud-clearing procedure is available, so that only clear sky radiances are examined. A paper has been submitted for publication on this topic.

Arctic Radiation Flux Climatology

Funding: NASA

A. Schweiger; J. Key; M. Haefliger

A radiation flux climatology for the arctic is being developed based on the cloud product of the International Satellite Cloud Climatology Project (ISCCP) monthly (C2) data for the years 1983-86. This data set contains information on cloud fraction, cloud top temperature and pressure, optical thickness (visible), surface temperature, and surface spectral reflectance. There are a number of difficulties in computing radiative fluxes from these quantities, such as the unknown geometrical thicknesses of the clouds, the conversion of narrow-band surface reflectances to broadband albedos, and the potential errors in the cloud amounts. Directional surface albedos for snow are being modeled so that a small number of spectral reflectance curves can be used to represent the snow/ice surface at various times of the year. Concerning the accuracy of cloud amounts, the ISCCP data have been compared to a 30 year record of surface observations and also to another satellite cloud climatology (C-MATRIX based on Nimbus-7 THIR data). A paper on this comparison has been submitted for publication.

Remote Sensing of Leads as a Function of Measurement Scale and Atmospheric Properties

Funding: Office of Naval Research

J. Key; J. Maslanik; R. Stone; M. Miles; R.G. Barry

A systematic, theoretical approach to the effect of sensor resolution on the retrieved fractional area coverage of geophysical parameters has not previously been undertaken. The AVHRR sensor radiances are being simulated under varying atmospheric conditions to determine the detectability of sea ice leads in satellite data. The simulated radiances and a statistical-geometric model of a lead network are used to generate synthetic images with known atmospheric characteristics, and the changes in retrieved lead statistics (e.g., lead width distributions) are being examined. The effect of measurement scale - i.e., pixel size - is modeled as a function of the autocovariance function describing in some sense the spatial configuration of a lead network or cloud field.

Related work concerns the establishment of a climatology of large leads and polynyas using satellite imagery, primarily DMSP imagery, and examination of synoptic-scale forcings on lead patterns via a statistical analysis of lead orientations and surface pressure gradients. Another investigation involved the use of airborne lidar backscatter data to detect open and refrozen leads, and associated atmospheric phenomena.

Sea Ice - Atmosphere Interaction

Funding: NASA
K. Steffen; A. Schweiger

The objective of the sea ice - atmospheric interaction project is to test the feasibility of the application of multispectral satellite data in polar surface energy flux estimates. Recent work has concentrated on energy flux sensitivity studies, ice surface temperature retrievals, corrections to AVHRR thermal infrared data, modelling of cloud fraction retrievals, and radiation climatologies. We tentatively conclude that the passive microwave satellite data (DMSP-SSM/I) may not provide accurate enough estimates of ice concentration and type to improve short term energy flux estimates. SSM/I-derived parameters may still be applicable in longer term climatological flux characterization. Further, we have found considerable variation in modelled energy flux estimates when bulk transfer coefficients are modulated by lead fetch.

Validation of the NASA Team Algorithm for the determination of sea ice concentrations from the DMSP SSM/I has been completed. A total of 28 cloud-free Landsat scenes were selected in order to permit validation of the passive microwave ice concentration algorithm for a range of ice concentrations and ice types. Mean absolute differences between SSM/I and Landsat ice concentrations are within one percent during fall using local and global tie points. Standard deviations of the difference are 13.1%, and 16.2% respectively. The overall accuracy of the NASA Team Algorithm is lower in spring than fall. The Landsat - SSM/I ice concentrations comparison have a correlation of 0.968 for all spring and fall case studies with a standard deviation of 16.6% using global tie points. The NASA Team Algorithm tends to underestimate ice concentrations in areas of close pack ice, and to overestimate ice concentrations in areas of open pack ice. In summer, mean differences between SSM/I and Landsat ice concentrations are 3.8% for local tie points and 11.0% for global tie points for Arctic areas, 7.2% for local tie points and 11.7% for global tie points for Antarctic areas. These large differences are attributable to surface melt during summer, and comparison problems arising from a time lag of up to eight hours between the DMSP and Landsat satellites.

Greenland Ice Sheet Climate Programme

Funding: Swiss National Science Foundation
K. Steffen

The Greenland Expedition is a major part of the longer term "Greenland Ice Sheet Climate Programme", a collaborative project among the Swiss Federal Institute of Technology (ETH), Zurich, Switzerland, Ohio State University, Byrd Polar Research Center, and CIRES. The objectives of the programme are to study: 1) the atmospheric boundary

layer above the ice sheet; 2) the physical processes of the energy and mass fluxes in the snow layer and at the surface; 3) the climatology of the entire Greenland Ice Sheet; and 4) the use of satellite and aircraft data for the interpretation of the ice surface.

FUNDING

Funding Sources

The Fiscal Year 91 funding continued the moderate rise of the last few years. Total funding is approximately \$1300 K, up \$200 K from FY90. The largest increase was from NOAA and NASA sources. FY91 marks the first year in several that NOAA-NGDC has been able to increase NSIDC funds, by augmenting our core funding (\$10K) and funding Earth System Data and Information Management (ESDIM) projects in snow and ice. NASA remains our largest contributor (62%), with NOAA second (22%) from combined NGDC, NGDC-ESDIM, and NOAA Climate and Global Change Program sources. NSF and ONR (8%) constitute the third block of federally funded projects. University of Colorado and Data Sales offer a small but important addition to the total funding picture. See Figures 4 and 5.

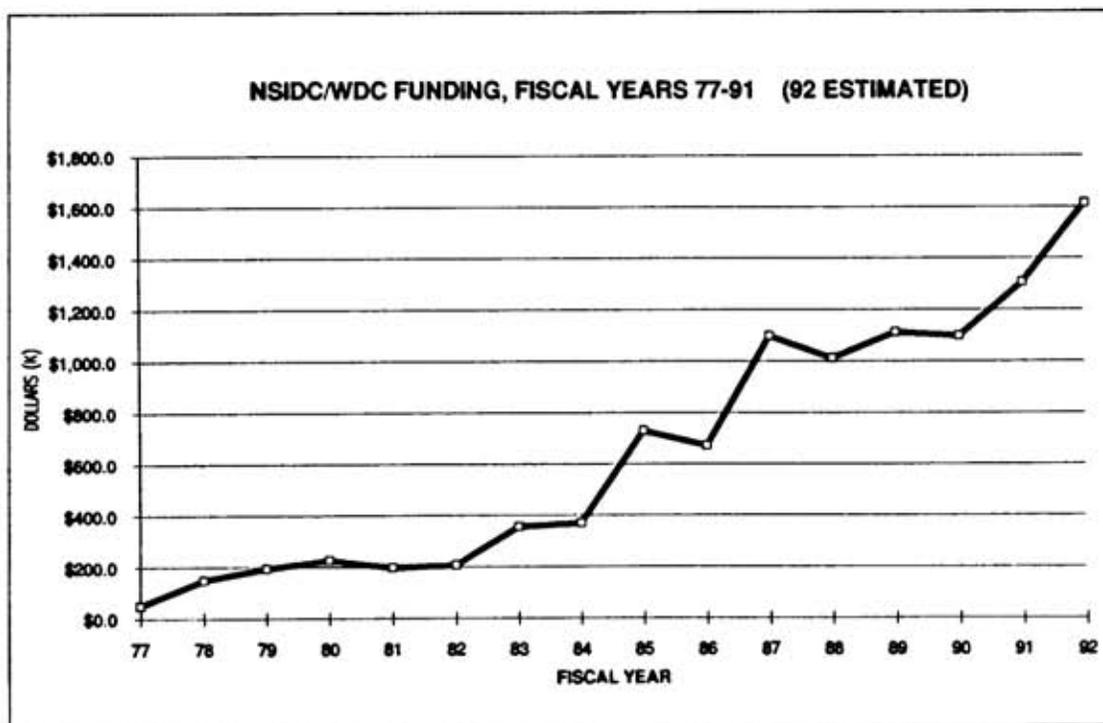


Figure 4.

NSIDC/WDC FUNDING BY SOURCE

FISCAL YEAR 1991

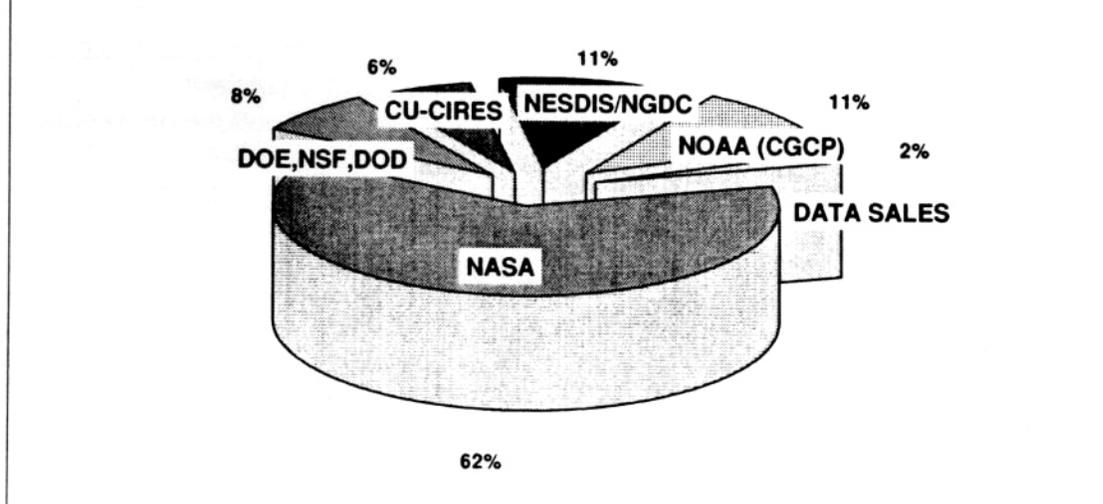


Figure 5.

Data Request Statistics

Twenty-six percent of total requests for the period January 1978 - September 1991 were from U.S. academic users, 20 percent from U.S. government (including 4 percent from NOAA), 24 percent from foreign users, and 19 percent from U.S. industry or commercial users. During the 14-year period the distribution of user types has remained relatively stable. However, during FY91, U.S. academic users increased by 7 percent compared to the 14-year total, with U.S. industry and U.S. government counts falling by 3 percent each, and the foreign count off by 2 percent. The increase in U.S. academic users can be attributed to the large number of requests for the SSM/I brightness temperature data on CD-ROMs. See Figure 6.

DMSP OLS hard-copy imagery continues to lead the list of income-producing data sets, with a total of \$110,747 received since 1978. This is 58 percent of NSIDC/WDC data sales income, and 34 percent of total requests for the period. The Navy - NOAA Joint Ice Center digital weekly sea ice data continues in second place, bringing in \$14,456, level at 8 percent of income and 3 percent of total requests.

Requests for copies of materials in the library ranks next, with income of \$12,344, about 7 percent of income and 25 percent of total requests. These requests for reference service, copies, literature searches, interlibrary loans, or the microfiche index product are over one quarter of our total request traffic, reflecting a large (or small but active) group of library users. Many of these requesters are from Boulder, experienced users who do not require assistance and thus are not formally counted, making library usage difficult to quantify. Figure 7 tracks the number of requests and the dollars earned since 1978.

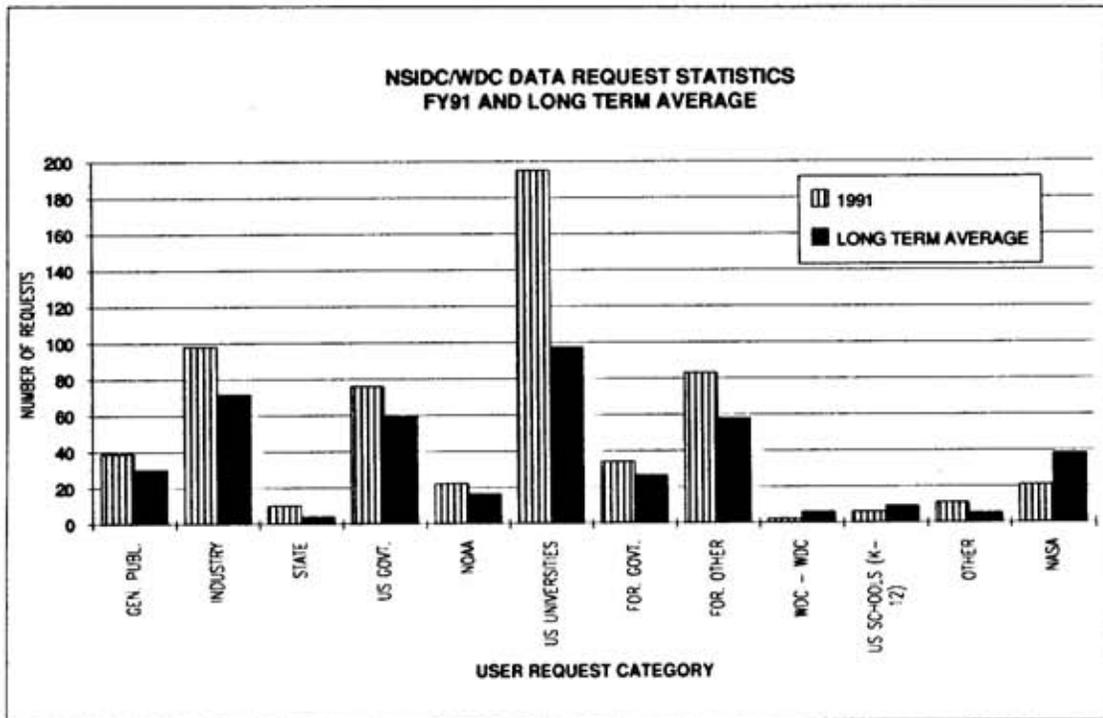


Figure 6.

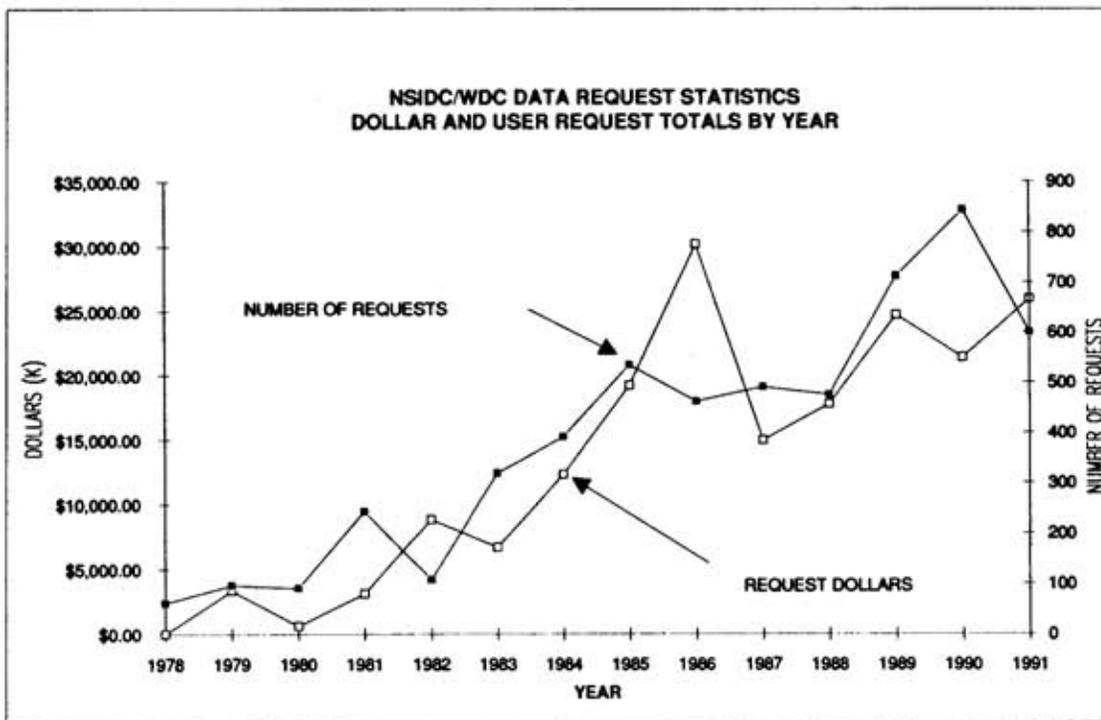


Figure 7.

NEW INITIATIVES

ESDIM

NSIDC has been funded by NGDC to start work on critical data rescue and access needs for snow and ice data. This effort has been funded by the NOAA Earth Science System Data and Information Management (ESDIM) Initiative. The stated objectives of the ESDIM program are to:

Provide an integrated Earth System view of NOAA's environmental data and information;

Provide science-quality data and information that will lead to high-quality scientific results;

Provide integrated efficient environmental data and information services through NOAA-wide distributed capabilities.

There are numerous examples of data which are not held by NSIDC, not available to NOAA scientists, and which also may be at considerable risk. These include the operational sea ice data generated by the Navy/NOAA Joint Ice Center, instrumental snow, ice and meteorological observations in the Antarctic, and non-U.S. data from both the Arctic and Antarctic.

During FY91, a review of the entire data holdings at NSIDC was carried out. Data sets that are NOAA responsibility have been identified and are in the process of being included in the NGDC archive maintenance program. Equipment is being procured so that NSIDC can use archival 3480 tape cartridges. An Earth Science Data Technician has been hired to manage the archival of NOAA data at NSIDC. During FY92, the archive management of NOAA data at NSIDC will become operational. A NOAA staff person will be assigned to NSIDC to improve coordination between NOAA/NGDC and NSIDC programs. A workshop is planned, possibly in conjunction with the NSF, to identify critical ice and snow data sets to be rescued.

Arctic System Science (ARCSS) Program

NSIDC has been funded by the National Science Foundation to formulate a pilot data management project for the Ocean - Air - Ice Interactions (OAI) component of the Arctic System Science (ARCSS) program. The fundamental requirement will be to identify data sets, including existing historical time series, present and planned satellite data streams, data from international programs and from other research programs (such as WOCE, TOGA, JGOFS and EOSDIS, for example) that are needed for OAI research, and to determine methods of making these data easily accessible to all OAI investigators. In addition, a plan

to archive and make accessible the data collected during OAI will be developed. NSIDC intends to foster and maintain a close linkage with the ARCSS OAI Steering Committee and the Arctic Research Consortium of the U.S. (ARCUS) in order to involve the science community in the design of the data management plan.

DMSP Digital Data

NSIDC is proceeding with plans to develop an archive capability for all of the digital data being generated from the DMSP system. This effort, funded by NOAA, NASA and the Air Force, will address a major data access problem faced by the science community since the dramatic reduction in the production of analog images in the last two years. While implementation of the digital Satellite Data Handling System (SDHS) at Air Force Global Weather Central (AFGWC) has resulted in decreased Air Force requirements for the expensive hard-copy images (and thus the source for archival data), it will enable outside access to digital DMSP Operational Linescan System (OLS) data for the first time. Recently, NASA and the Air Force Space Systems Division have provided funds for the Harris Corporation, the primary contractor for the DMSP ground segment, to modify the processing system at AFGWC to begin the production of digital data tapes for archival. The flow of digital data is scheduled to begin in February 1992. It will include data collected by the full suite of meteorological and space environment sensors on DMSP satellites. The total volume of this data stream could be as much as 9 Gbytes per day if DMSP continues a three-satellite system.

This project is being undertaken jointly by NSIDC and NOAA's National Geophysical Data Center (NGDC) in Boulder. NGDC has a long record of providing user services for auroral subscenes from the OLS sensor, and has been involved in model development for the DMSP space environment sensors. Archival of DMSP data for researchers has historically been a provision of various memoranda of agreement (MOA) between the USAF and NOAA, and this arrangement will continue in the future. NOAA/NESDIS and the Satellite Data Services Division will continue their active programs related to the processing and dissemination of DMSP SSM/I and SSM/T data for the general research community. NGDC has been designated as the NESDIS agency responsible for data from the OLS and space environment sensors. NSIDC will provide most user services for these data under contract to NOAA/NGDC. NSIDC will also continue to produce SSM/I grids for the polar regions under separate NASA funding. (See Highlights, p. 4-5.)

Modifications to the processing system at AFGWC have been funded and NSIDC has received some startup funding from NOAA's Climate and Global Change Program, but funding for the routine data processing remains to be provided. NSIDC is working with all of the involved agencies to secure continuing financial support for the program. NOAA/NESDIS has stated that this program will proceed on a trial basis (2-3 years) given the uncertainty of funding.

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- Chang, A.T.C., J.L. Foster and D.K. Hall (1987) Nimbus-7 SMMR derived global snow cover parameters, *Annals of Glaciology*, **9**, 39-44.
- International Council of Scientific Unions, Panel on World Data Centres. (1987) *Guide to the World Data Center System. Part 1. The World Data Centers*. Boulder, CO, 91 p.

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
- International Association of Hydrological Sciences, Snow Classification Working Group - 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. Brennan Thomas

SCAR Ad hoc Committee on Coordination of Antarctic Data -
R.G. Barry (Chairman)

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

WMO World Sea Ice Data Bank Project: Arctic and Antarctic Research
Institute, Leningrad - R.G. Barry and V. Troisi, 21-26 September, 1990
(Leningrad, USSR)

6th Catalog Interoperability Workshop (CI-6) - C.S. Hanson, 1-3 October
1990 (NOAA Metro Center, Silver Spring, MD)

NOAA Conference on Operational Satellite Data for Climate and Global
Change Research - R.G. Barry, 16-19 October 1990 (Washington, DC)

EOS IWG Meeting and DAAC Managers Meeting - R.L. Weaver, 2-5
November 1990 (Hampton, VA)

American Geophysical Union - R.L. Armstrong, 7 December 1990 (San
Francisco, CA)

American Geophysical Union. Session on IPCC Report. Paper on
Changes in Global Snow and Ice - R.G. Barry, 7 December 1990 (San
Francisco, CA)

Arctic Environmental Data Directory Working Group - C.S. Hanson, 12-
13 February 1991 (US Geological Survey, Reston, VA)

DAAC Managers Meeting. EOSDIS V0 Briefing to Industry - R.L.
Weaver, February 1991

International Space Year/Space Agency Forum/Panel of Experts on
Space Science and Technology - G.R. Scharfen, 17-21 February 1991
(Montreal, Canada)

SSM/I Land Products Working Team - R.L. Armstrong, 18-19 February
1991 (Boulder, CO)

Polar Research Board - R.G. Barry, 2-3 March 1991 (Dallas, TX)

Arctic System Science (ARCSS) Land/Atmosphere/Ice Interactions Science Planning Meeting - C.S. Hanson, 8-9 March 1991 (Amherst, MA)

Air Force Global Weather Central DMSP Digital Archive Meetings - G.R. Scharfen, 28 November 1990 and 20 March 1991 (Omaha, NE.)

NASA - WETNET PI Workshop - R.L. Armstrong, 20-22 March 1991 (Santa Barbara, CA)

U.S. Polar Bibliographic Information Working Group - A. Brennan Thomas, 5-6 April 1991 (Hanover, NH)

USGS/NASA/USDA Satellite Passive Microwave Remote Sensing of the Snowpack Workshop - R.L. Armstrong, 9-11 April 1991 (Tacoma, WA)

Western Snow Conference - R.L. Armstrong, 13-15 April 1991 (Juneau, AK)

SAR Facility dedication - R.G. Barry, R.L. Weaver, and V. Troisi, 23-24 April 1991 (Fairbanks, AK)

National Academy of Sciences/National Research Council/Climate Research Committee - G.R. Scharfen for R.G. Barry, 29-30 April 1991 (Irvine, CA.)

WDC-A Directors - C.S. Hanson (representing R.G. Barry), 8-9 May 1991 (Carbon Dioxide Information and Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN)

CEES Planning Meeting on Modelling Climate Variability, NCAR - R.G. Barry, 20-21 May 1991 (Boulder, CO)

EOS DAAC V.O User Services Workshop - C.S. Hanson, R.J. Bauer, G.R. Scharfen, 29-30 May 1991 (Pasadena, CA.)

IGARSS'91 Global Monitoring for Earth Management - R.L. Armstrong, 3-6 June 1991 (Helsinki, Finland)

LEADEX Remote Sensing Group Workshop - R.G. Barry, R.L. Weaver, J. Key, 24-25 June, 1991 (Estes Park, CO)

USAF OLS Digital Data Access Meeting - G.R. Scharfen, 25 June 1991 (Washington, D.C.)

Earth System Science Workshop: Keynote lecture - R.G. Barry, 24-25 July 1991 (College Park, PA)

SAR Science Team and Polar DAAC Advisory meetings - R.G. Barry and R.L. Weaver, 29-July - 1 August 1991 (Fairbanks, AK)

DAAC Managers Meetings, Data Panel Meeting - R. Weaver and V. Troisi, 29-30 July 1991 (Boulder, CO)

Cyrospheric Research for NOAA's CGCP: Planning meeting - R.G. Barry, 5-6 August 1991 (Boulder, CO)

XX General Assembly of the International Union of Geodesy and Geophysics - G.R. Scharfen, R.L. Armstrong, 11-24 August 1991 (Vienna, Austria)

IUGG 1991, IAHS Workshop on Intercomparisons of Remote Sensing Algorithms in Hydrology - R.L. Armstrong, 16 August 1991 (Vienna, Austria)

ARCSS Implementation Planning Meeting - R.G. Barry, C. Hanson, 23-24 August, 1991 (Boulder, CO)

EOS IWG and DAAC Managers Meeting - R.L. Weaver, August 1991 (Seattle, WA)

WMO World Sea Ice Data Bank Project: Arctic and Antarctic Research Institute, St. Petersburg - R.G. Barry and V. Troisi, 6-7 September, 1991 (Boulder, CO)

2nd WMO Workshop on Operational Remote Sensing of Sea Ice - R.G. Barry, 10-11 September 1991 (Ottawa, Canada)

First International Conference/Workshop on Integrating Geographic Information Systems and Environmental Monitoring - G.R. Scharfen, R.J. Bauer, K. Knowles, 15-19 September 1991 (Boulder, CO.)

SCAR Planning Meeting: An Antarctic Component for IGBP - R.G. Barry, 18-20 September 1991 (Bremerhaven, Germany)

Panel on Glaciological Data: Review of WDC-A Glaciology - R.G. Barry and staff, 26-27 September 1991 (Boulder, CO)

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Richard L. Armstrong

1990 The mass balance of Blue Glacier, Washington, U.S.A., 1956-1986. *Annals of Glaciology* 14: 329. (Abstract)

Snow Avalanche Hazards and Mitigation in the United States. (With Panel on Snow Avalanches [B. Voight, Chair].) Committee on Ground Failure Hazards, National Research Council, National Academy Press. Washington, DC: 89 p.

Snow avalanches. (With D.C. Trabant and D.M. McClung.) In: *Cold Region Hydrology and Hydraulics Monograph*. W.L. Ryan and R.D. Crissman (eds.), American Society of Civil Engineers. New York: 147-168.

- 1991 Monitoring Global Snow Cover. (With M. Hardman.) *Proceedings of IGARSS'91, Helsinki, Finland IV: 1947-1949*.

Roger G. Barry

- 1990 Arctic sea ice and its variability. R.G. Barry. In: V.M. Kotlyakov and V.E. Sokolov (eds.) *Arctic Research. Advances and Prospects. Part 1* (Proceedings of the Conference on Arctic and Nordic Countries on Coordination of Research in the Arctic). Nauka, Moscow: 91-101.

Climate. J. Jäger and R.G. Barry. In: B.L. Turner *et al.*, eds. *The Earth as Transformed by Human Action*, Cambridge Univ. Press: 335-351.

Observed climate variations and change. C.K. Folland, T.R. Karl and K. Ya. Vinnikov (eds.) (R.G. Barry: contributor). In: J.T. Houghton, G.J. Jenkins and J.J. Ephraums (eds.) *Climate Change: The IPCC Scientific Assessment*. Intergovernmental Panel on Climate Change. World Meteorological Organization/United Nations Environment Programme. Cambridge University Press, Cambridge: 194-238.

Remote sensing in Antarctica and the Southern Ocean: Applications and developments. J.A. Maslanik and R.G. Barry. *Antarctic Science* **2(2)**: 105-121.

The record of recent changes in global snow and ice cover. *EOS* **71(43)**: 1252 (Abstract).

Sea ice concentration in the Canada Basin during 1988: Comparisons with other years and evidence of multiple forcing mechanisms. M.C. Serreze, J.A. Maslanik, R. Preller and R.G. Barry. *J. Geophys. Res.* **95(C12)**: 22,253-22,267.

- 1991 Cryospheric products from the DMSP/SSM/I: Status and Research Applications. *Global and Planetary Change* **4**: 231-234.

Observational evidence of changes in global snow and ice cover. In: M.E. Schlesinger (ed.), *Greenhouse gas-induced Climatic Change: A Critical Appraisal of Simulations and Observations*, Elsevier, Amsterdam: 339-345.

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Gregory R. Scharfen

- 1991 Global nighttime lightning detection from DMSP satellite imagery. G.R. Scharfen and S.J. Goodman. In: *IUGGIAMAP XX General Assembly*: 5.

ACRONYMS

AARI - Arctic and Antarctic Research Institute (USSR)
AEDD - Arctic Environmental Data Directory
AEDDWG - AEDD Working Group
ACCP - Atlantic Climate Change Program
AFGWC - Air Force Global Weather Central
ARCUS - Arctic Research Consortium of the U.S.
AVHRR - Advanced Very High Resolution Radiometer
CDMS - Cryospheric Data Management System
CEAREX - Coordinated Eastern Arctic Experiment
CIMS - Cryospheric Information Management System
CIRES - Cooperative Institute for Research in Environmental Sciences
CRREL - Cold Regions Research and Engineering Laboratory
DAAC - Distributed Active Archive Center
DIFAS - Digital Ice Forecasting and Analysis System
DMSP - Defense Meteorological Satellite Program
DOD - Department of Defense
DPP - Division of Polar Programs
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
ETH - Eidgenössische Technische Hochschule (Switzerland)
EUBEX - Eurasian Basin Experiment
GD - Glaciological Data
GIS - Geographic Information System
ICSU - International Council of Scientific Unions
IDL - Interactive Display Language
IMS - Information Management System
ISCCP - International Satellite Cloud Climatology Project
JIC - Joint Ice Center
LASP - Laboratory for Atmospheric and Space Physics
LAVC - Local Area Vax Cluster
MIZEX - Marginal Ice Zone Experiment
NAL - New Accessions List

NASA - National Aeronautics and Space Administration
NESDIS - National Environmental Satellite, Data and Information Service
NGDC - National Geophysical Data Center
NISC - National Information Services Corporation
NOAA - National Oceanic and Atmospheric Administration
NODS - NASA Ocean Data System
NOS - National Ocean Survey
NSF - National Science Foundation
NSIDC - National Snow and Ice Data Center
OLS - Operational Linescan System
ONR - Office of Naval Research
PDS - Planetary Data System
SCAR - Scientific Committee on Antarctic Research
SGI - Silicon Graphics Incorporated
SIDAAC - Snow and Ice Distributed Active Archive Center
SMR - Scanning Multichannel Microwave Radiometer
SPWT - SSM/I Products Working Team
SSM/I - Special Sensor Microwave Imager
SQL - Standard Query Language
THIR - Temperature Humidity Infrared Radiometer
TOGA - Tropical Oceans and Global Atmosphere Project (WMO)
USAF - United States Air Force
V0 - Version 0
WDC - World Data Center
WMO - World Meteorological Organization
WOCE - World Ocean Circulation Experiment