

NATIONAL SNOW AND ICE DATA CENTER

WORLD DATA CENTER-A FOR GLACIOLOGY



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Cover: During the spring breakup of the Great Lakes ice cover, ice floes drift into the northern inlet of the St. Clair River from the southern tip of Lake Huron. This photo, taken during a U.S. Air Force photographic reconnaissance training mission on 1 March 1971, shows the Blue Water Bridge between Port Huron, Michigan, and Sarnia, Ontario (lower left corner). Photograph from the NOAA/Great Lakes Environmental Research Laboratory lake ice data archive maintained by the National Snow and Ice Data Center.

National Snow and Ice Data Center
World Data Center-A for Glaciology (Snow and Ice)
CIRES, Box 449
University of Colorado
Boulder, Colorado 80309
U.S.A.
Telephone: (303) 492-5171
Telex: 7401426 WDCA UC
Telemail [NSIDC/OMNET]MAIL/USA
VAX Mail KRYOS::NSIDC via SPAN
FAX: (303) 492-2468

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World Data Center-A for Glaciology*

NSIDC/WDC ANNUAL REPORT

FY 1992

Table of Contents

INTRODUCTION	1
HIGHLIGHTS	2
Coordinated Eastern Arctic Experiment (CEAREX) Data Management	2
Arctic Multisensor Data Sampler	2
CURRENT PROGRAMS	3
Data Activities	3
Data Set Administration	3
Permafrost Inventory	6
Information Center and CITATION Data Base	6
Publication Program	7
Data Related Meetings	8
Project Activities	11
Distributed Active Archive Center (DAAC) at NSIDC ...	11
Defense Meteorological Satellite Program Data Management	13
Application of Special Sensor Microwave Imager (SSM/I) Data for Snow Cover and Climate Research	15
MIZEX/CEAREX	16
Greenland Ice Sheet Program (GISP2)	16
ESDIM	19
Arctic System Science (ARCSS) Program	20
Research Activities	20
Radiative Characteristics of Sea Ice	21
Arctic Radiation Flux Climatology	22
Remote Sensing of Sea Ice Leads	22
Sea Ice - Atmosphere Interaction	23
Greenland Ice Sheet Climate Programme	23
Buoyant Convection Above Leads	24
Atmospheric Forcings Related to the Great Salinity Anomaly	24
Structure of the Arctic Troposphere	25
Arctic Tropospheric Temperature Trends	25
Field Studies in the Canadian Arctic	26
Snow Melt Over Arctic Sea Ice	26
Artificial Intelligence Applications for Sea Ice Classification and Processes	27

Sensitivity of Arctic Sea Ice Regime to Varying Treatments of Surface Energy Budgets in Sea Ice Models	27
Characterization of Sea Ice and Clouds in the Arctic	28
Parameterization and Scaling of Arctic Ice Conditions in the Context of Ice-Atmosphere Processes	28
Cryospheric Indices	29
FUNDING	29
Funding Sources	29
Data Request Statistics	31
REFERENCES	32
NATIONAL AND INTERNATIONAL COLLABORATION	34
COMMITTEES	35
MEETINGS	35
PAPERS and REPORTS PUBLISHED DURING FY1992	39
ACRONYMS	43

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

ANNUAL REPORT FY1992

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. The World Data Center system is celebrating its 35th anniversary in 1992 and NSIDC/WDC is completing its sixteenth 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 directly relating to NSIDC/WDC include the acquisition and dissemination of global environmental satellite data, data on earth surface properties, including snow cover, on ocean variables, including sea ice extent and on paleoclimates, with ice core information (NOAA, 1992, Appendix, C, D). These data sets serve as cryospheric components in inter-disciplinary global change research.

This report discusses NSIDC/WDC activities for the 1992 fiscal year (October 1, 1991 - September 30, 1992).

HIGHLIGHTS

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 (Figure 1). 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), AIDJEX, LEADEX, 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, 89 copies of the "beta" version of the CD-ROM were distributed to CEAREX participants and other interested researchers. The CD-ROM master was produced by NSIDC using hardware and software at the National Geophysical Data Center (NGDC). The resulting "one off" disc was then sent to a commercial CD-ROM facility for replication.

CEAREX field experiments were carried out in the East Greenland Sea in the area west of Svalbard between 70 and 85°N 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.

Arctic Multisensor Data Sampler

NSIDC, with collaborative support from the University of Washington's Applied Physics Laboratory (UW/APL), the University of Colorado's Colorado Center for Astrodynamic Research (CCAR) and the Naval Oceanographic and Atmospheric Research Laboratory (NORAL), has published the Arctic Multisensor Data Sampler on CD-ROM.

NSIDC distributed the Arctic Multisensor Data Sampler on CD-ROM in March of 1992. The Data Sampler, alpha version, provides access to data which are nearly concurrent temporally and spatially, and useful for



algorithm intercomparisons. The driving force behind this CD-ROM was the desire to provide a set of data in a common format to participants of the AVHRR Data Workshop, held in conjunction with the International Glaciological Society's (IGS) Remote Sensing Symposium in May 1992. (See Data Related Meetings, p. 9.)

Data sets on the CD-ROM included calibrated AVHRR Local Area Coverage (LAC) and Global Area Coverage (GAC) data for the Svalbard and the Beaufort Sea areas from NORAL. NORAL also supplied land mask, coast outlines and grid line files. Calibrated AVHRR LAC data for two areas within the Arctic Basin region and land masks for both areas were supplied by UW/APL. Calibrated LAC data for the Fram Strait and the Greenland area and an OLS scene for the same area and time as the AVHRR Greenland data were supplied by CCAR. NSIDC supplied all of the SSM/I and SMMR brightness temperature data.

The Arctic Multisensor Data Sampler may serve as a model for distributing data sets that will be used for data intercomparison studies. The production of similarly packaged CD-ROMs will be guided by feedback from investigators who are working with this CD-ROM sampler.

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 activities 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 FY92 include:

- a. Weekly digitized sea ice charts produced by the Navy - NOAA Joint Ice Center (JIC) for 1991 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 20 years for the Arctic and 19 years for the Antarctic. Data sources include satellite observations (NOAA and DoD) as well as any airborne or surface reconnais-

sance available to the JIC as they produce the weekly operational product.

- b. University of Washington/Polar Science Center Arctic Ocean Buoy Program (AOBP) data for 1986-1990 were received. The data base of daily pressure, temperature, buoy position, and interpolated velocity now extends from 1979-1990. The data reports for 1986-1990 were printed with support from NSIDC/WDC.
- 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 1990 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 1953-1990.
- d. 1991 iceberg data from the International Ice Patrol were received on a PC diskette, extending this time series from 1960 - 1991.
- e. Water level gauge site observations of ice conditions around the Great Lakes were keyed for the 1990/91 season, and added to the 38-year time series archived on 9-track tape. The entire data set was checked for completeness and annual files were merged. This unique data set provides a relatively long-term record of the length of the ice season on the Great Lakes.
- f. Arctic historical rawinsonde data, 1947-1986, were received from J. Kahl (Univ. Wisconsin, Milwaukee) and M. Serreze (Univ. of Colorado, CIRES). Documentation for this archive of 1.2 million vertical soundings of temperature, pressure, humidity, and wind (all Arctic land stations north of 65°N) was published as *NSIDC Special Report no. 2*.
- g. Daily snow depth, air temperature, precipitation and humidity data from 223 stations in the former Soviet Union were received on seven 9-track tapes via NOAA/NCDC. The data are being re-formatted, inventoried, and documented as part of the NSIDC EOSDIS project. The original data source is the USSR State

Committee for Hydrometeorology, All-Union Research Institute of Hydrometeorological Information, Obninsk.

- h. Sea ice charts covering Alaskan and Greenland waters were received from the estate of William S. Dehn, a noted sea ice expert who supported the U.S. Navy Arctic operations throughout the 1950s-1980s. The 7000 hard-copy charts are being sorted in preparation for storage in map cabinets. John Walsh, University of Illinois, Department of Atmospheric Sciences, and Don Barnett, Navy - NOAA Joint Ice Center (retired), will digitize end-of-month Arctic ice charts at 100 kilometer resolution, and add the resulting data to the University of Illinois Northern Hemisphere monthly sea ice concentration data base (1953 to present). This work will begin in November 1992.

During the past year, revisions of nearly the entire Data Announcement series were completed, to reflect updated holdings, price changes or media availability. Twenty-three 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.
Eastern Arctic Ice, Ocean and Atmosphere Data, Volume 1:
CEAREX CD-ROM 91-GLA-59.1
Great Lakes Ice Data, 86-GLA-61
Nimbus-7 SMMR Polar Radiances on CD-ROM 89-GLA-81.2

Permafrost Inventory

Work has begun on a preliminary inventory of permafrost data sources. Because of permafrost's extreme sensitivity to changes in climate, the need for permafrost data input to support global change research is crucial. Working in cooperation with the International Permafrost Association Working Group on Data and Information, NSIDC is attempting to establish a permafrost data system. The first step in the process was a letter and brief questionnaire sent to approximately 300 scientists working in the field. Responses will be put into a data file with information on types of data, areas covered, availability, etc. We are also considering the publication on CD-ROM of some sample data sets along with our 15-year cumulative Permafrost Bibliography, 1978-1992.

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 6000 monographs and technical reports and 12,750 reprints; 90 serial publications are regularly received. During 1992, over 1500 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. We are now using INMAGIC and SearchMAGIC software at NSIDC. This allows CITATION to be implemented in-house rather than operating on the Unysis computer at NCDC, Asheville, North Carolina. SearchMAGIC, a user-friendly system for searching the data base and outputting reports, has been installed in the Information Center. We plan to network SearchMAGIC soon so that CITATION will be available to each PC at NSIDC.

At the end of FY92, there were almost 30,000 records in the data base. The file is updated regularly. 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 600,000 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 and two data bases from the Canadian Circumpolar Institute (Canada) and the Scott Polar Research Institute (U.K.). This disc provides access to the most comprehensive bibliographic collections of polar regions science in the world.

Publication Program

Two series, *New Accessions List* and *Glaciological Data*, have been published by NSIDC/WDC since 1977. *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 FY92, 4 NAL issues were completed. We have now published listings through 1991.

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 in 1992. GD-24, *Passive Microwave Research, Microwave Bibliography Update, 1988-1991*, was printed in January 1992. This report provides an update of the bibliography on passive microwave research relating primarily to snow and ice, meteorology, oceanography and the land surface published in

GD-19 in 1987. Short contributions are also included from the staff of the Data Center and colleagues in the Division of Cryospheric and Polar Processes, CIRES.

In FY92, NSIDC began publication of a new series of reports. The *NSIDC Special Report* series will include publication of information of topics which are not large enough for inclusion in the *GD* series and those which might be of interest to a limited segment of the research community. With this series, significant material can be published quickly with a limited printing and distributed to a targeted audience. Two reports were published in FY92. *Special Report-1, DMSP SSM/I Brightness Temperatures and Sea Ice Concentration Grids for Polar Regions on CD-ROM - User's Guide* was distributed to researchers using NSIDC-distributed passive microwave data on CD-ROM (approximately 380).

The Historical Arctic Rawinsonde Archive Documentation Manual (Serreze et al., 1992) was the second report in this series. This document describes a data set compiled with support from NOAA's Climate and Global Change Program.

NSIDC/WDC has begun publication of a quarterly newsletter. Two issues of *NSIDC Notes*, superseding *CDMS Notes*, were distributed to a mailing list of 650 names in FY92. *NSIDC Notes* provides information about activities at NSIDC relating to Arctic System Science (ARCSS) Ocean-Atmosphere Ice-Interactions (OAI) data management, DMSP OLS digital data distribution, passive microwave data distribution, Greenland Ice Sheet Program 2 (GISP 2) data management, and research projects underway. This newsletter is part of NSIDC's commitment to foster communication with the cryospheric research community.

Data Related Meetings

Arctic Environmental Data Directory Working Group, 12 December 1991, San Francisco

The Arctic Environmental Data Directory Working Group (AEDDWG) met during the Fall AGU meeting, 12 December 1991, to review plans for quality control of existing entries in the AEDD and input of new entries; Roger Barry and Claire Hanson attended these discussions. Other topics included joint activities with the library community, plans for approaching agencies for new data descriptions, and enhancements to the USGS Earth Science Data Directory, the host system for AEDD.

NSF Workshop on Antarctic Operations Environmental Impact Monitoring and Assessment, 29-31 January 1992, Washington, DC

C.S. Hanson represented WDC/NSIDC at the NSF Workshop on Antarctic Operations Environmental Impact Monitoring and Assessment, 29-31 January, in Washington, DC. A report based on the workshop recommendations, prepared by Dr. Sidney Draggan, NSF Environmental Officer, has been circulated for comment to the 32 workshop participants and to other experts. The report was for the June 1992 Buenos Aires meeting of an international Group of Experts charged with preparing a position paper for the implementation of the Protocol on Environmental Protection to the Antarctic Treaty.

WDC/NSIDC was invited to the workshop to provide expertise on data management. Travel support for WDC/NSIDC attendance was provided by the NOAA Office of International Interests.

International Symposium on Remote Sensing of Snow and Ice, 17-22 May 1992, Boulder, CO

Several NSIDC staff members participated in the International Glaciological Society's (IGS) International Symposium on Remote Sensing of Snow and Ice, held in Boulder, May 17-22. NSIDC operated an information booth which fielded over 30 requests for information and data. At least seven papers at the symposium used NSIDC data sets, primarily SSM/I gridded brightness temperatures, in their studies. Dr. Konrad Steffen, CIRES, CPP, is an editor of the proceedings of this symposium which will be published in the *Annals of Glaciology* series in 1993. On May 20, NSIDC coordinated an AVHRR data users workshop. (See below.)

AVHRR Data Workshop, 20 May 1992, Boulder Colorado

The IGS AVHRR Data Workshop, held during the Symposium on Remote Sensing of Snow and Ice addressed the following questions:

- 1) What are the most important parameters that can be derived from the AVHRR data in the polar regions, and how accurately can they be derived using current techniques?
- 2) What are the science validation requirements before the AVHRR data can be used routinely for polar research?

- 3) How much temporal and spatial coverage is required from the polar regions?
- 4) What are the optimal resolutions and gridding required for each of the parameters?
- 5) Are there other concerns and issues associated with utilizing these data?

With these goals in mind, some of the AVHRR data were gridded and aligned into the same projection as that used by (NSIDC) for Arctic SSM/I data to facilitate comparisons between SSM/I and AVHRR data. Approximately 500 megabytes of data, stored in directories organized by region, are on the CD-ROM (See Highlights, p. 2). There are five regions included in this data set: Arctic Basin, Greenland, Fram Strait, Svalbard and Beaufort Sea; directories for each region are further grouped by sensor, i.e., SSM/I, SMMR, OLS and AVHRR. Some of the data files contained on this CD-ROM incorporate the NASA Planetary System (PDS) formatting system. PDS labels are ASCII text "keyword = value" labels containing file format and descriptive information.

Global Digital Sea Ice Data Bank, 20-24 July 1992, St. Petersburg, Russia

Roger Barry and Vince Troisi attended the Third Consultative Meeting on the Establishment of a Global Digital Sea Ice Data Bank. The meeting, sponsored by the World Meteorological Organization, was held at the Arctic and Antarctic Research Institute (AARI) located in St. Petersburg, Russia, 20-24 July.

Roger Barry reported on the development and organization of NSIDC/WDC-A for Glaciology which included relationships between NSIDC and U.S. agencies such as NOAA and NASA. Dr. Barry's discussion included descriptions of both the data management and research activities being conducted at NSIDC.

Vince Troisi described the Earth Observing System Data and Information System (EOSDIS) Version 0 Project and the role of NSIDC as an EOSDIS Distributed Active Archive Center (DAAC). Mr. Troisi's discussion included an overview of the Write-Once CD-ROM technology.

AARI is developing an ice analysis system that will be applied to digital satellite imagery. The PC-based system is reminiscent of the DIFAS

system that was developed for the Joint Ice Center. The prototype system was demonstrated by AARI data analysts and system developers.

The 1992-93 work plan for completion of the data bank between AARI and NSIDC was reviewed and an agreement was signed by Dr. Ivan Frolov, Project Leader of the Global Digital Sea Ice Data Bank and Dr. Roger Barry.

Project Activities

Distributed Active Archive Center (DAAC) at NSIDC

In 1989 NSIDC was invited to submit a proposal to participate as one of eight Distributed Active Archive Center (DAACs) in the Earth Observing System Data and Information System Project (EOSDIS). The Earth Observing System (EOS) is a long-term interdisciplinary and multidisciplinary research effort to study global-scale processes that shape and influence the Earth as a system. EOSDIS will manage the data resulting from NASA's research satellites and field measurement programs, and other data essential for the interpretation of these measurements. It will also provide access to data held in the archives of other government agencies, organizations, and countries.

Science Objectives

Polar regions have the following unique features that influence macro-scale climate processes. Support of research responding to the following attributes comprises the primary objective of the NSIDC DAAC:

The dramatic changes in energy fluxes associated with the annual cycle of snow cover on land and sea ice on the ocean.

The decoupling of the atmosphere from the ocean provided by the sea ice cover, especially in terms of turbulent fluxes of heat and moisture.

The effects of the melting and freezing of sea ice on ocean-density structure that controls the formation of the deep waters which cool and ventilate the deep oceans.

The vast ice sheets in Greenland and Antarctica, whose fluctuations in mass can significantly raise or lower sea level.

Data Products

Between 1991 and 1994 the EOSDIS Project Office is building a working prototype of the EOSDIS that will provide a smooth transition from the existing DAAC native data systems to the operational EOSDIS configuration. The DAAC staff at NSIDC are participating in the Version 0 (V0) prototype efforts to create a unified, across-DAAC information management system. In addition we are working on browse generation issues specific to polar regions.

One of the NSIDC DAAC's on-going products includes the distribution of the DMSP Special Sensor Microwave Imager (SSM/I) Brightness Temperature Grids for the Polar Regions (to date covering 9 July 1987 - 30 June 1991), and associated sea ice concentration products. A loose leaf *User's Guide* containing complete documentation is part of the package, along with display software for both PC and Macintosh platforms.

We have also completed distribution of SMMR gridded brightness temperature data for the period October 25, 1978 to August 20, 1987. These data are in the same format as the SSM/I products.

Gridded sea ice concentration estimates from both the SMMR and SSM/I data have been issued on CD-ROM, covering 1978 to 1990. This combined data set is one of the longest satellite-era measurements of a cryospheric parameter.

Cryospheric Information Management System Development

National Snow Ice Data Center (NSIDC) and Laboratory for Atmospheric and Space Physics (LASP) are collaborating on the development of the Cryospheric Information Management System (CIMS) and in the V0 IMS interoperability development activities.

The following data sets have been populated into the CIMS:

- SSM/I Orbital Brightness Temperatures
- SSM/I Brightness Temperature Grids for the Polar Regions
- SSM/I Sea Ice Concentration Grids
- SMMR Brightness Temperature Grids for the Polar Regions
- SMMR Sea Ice Concentration Grids
- Historical Arctic Sounding Data
- AOBP Buoy Position Data
- AOBP Ice Velocity Grids
- AOBP Pressure and Temperature Grids

Requirements have been determined for migrating the Data Request Tracking System from a stand-alone PC environment into the CIMS. Preliminary data base tables for the tracking system have been redefined; a prototype rolodex function has been implemented; and product codes are being defined.

Defense Meteorological Satellite Program Data Management

Analog Collection

NSIDC is in the tenth year of service as the national archive for Operational Linescan System (OLS) data from the U.S. Air Force Defense Meteorological Satellite Program (DMSP). Approximately 1,000 images were added to the collection this year, now amounting to about 1.4 million pieces of imagery. Approximately 175 requests for data and information were processed in FY92 resulting in data sales of about \$17,000. The continuing usage of this data in light of the decrease in receipts of new images reflects the scientific value of this project.

DMSP data from the analog collection continue to be used in some notable requests. DMSP data are being used in support of an International Geosphere-Biosphere Program (IGBP) field campaign in Africa called the South African Fire-Atmosphere Research Initiative. SAFARI is designed to monitor and model the effects of slash and burn agricultural practices. Dr. Donald Cahoon of NASA Langley Research Center is using OLS visible-band images at night to detect numerous small fires. Dr. Cahoon has also requested digital OLS data for the same purpose. This forms the first official request for data from the joint NSIDC/NGDC effort to archive digital DMSP data (discussed below).

In another request, researchers from Norland Science and Engineering in Ottawa, Canada, visited NSIDC to study seasonal and interannual variability of sea ice in shipping areas of the Canadian Arctic using historical DMSP/OLS satellite imagery (Figure 2). The images were used to determine ice stage development at a coarse scale and to look at synoptic dynamics in response to atmospheric and oceanographic forcing. The study also includes Canadian ice charts, NOAA AVHRR satellite imagery, airborne SAR and selected Landsat images.

DMSP visible and infrared images from the NSIDC DMSP archive appeared in the newly released Smithsonian Institution Air and Space Museum book, *Looking at Earth*. The book is designed as a 'coffee table' picture book covering many aspects of remote sensing of the earth. Several nighttime visible-band images showing city lights and agricultural

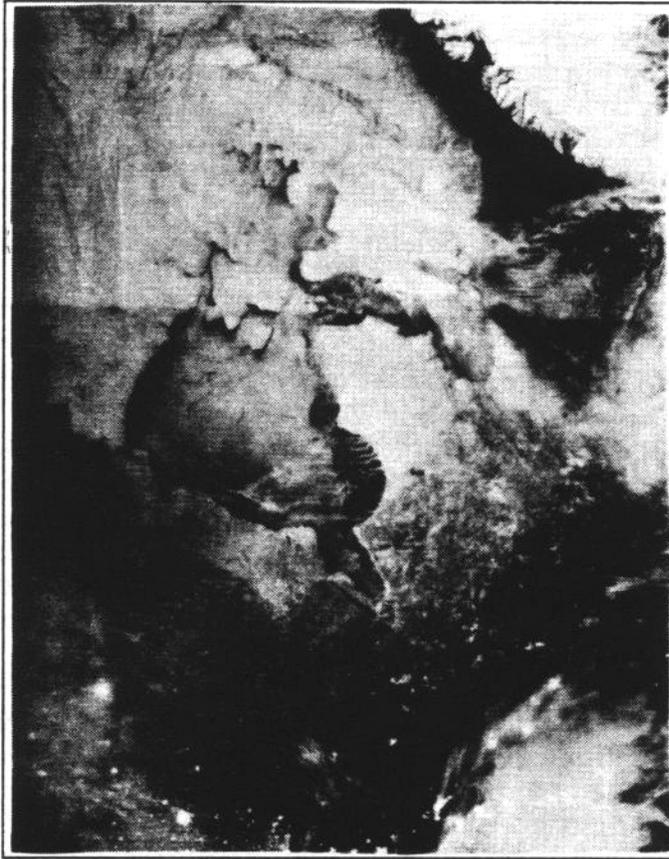


Figure 2. DMSP OLS visible band image on 19 November 1986. This moonlit image shows sea ice in the Davis Strait and Baffin Bay area, Hudson's Bay sea ice, snow cover and Great Lakes city lights.

burning, and daytime images showing icebergs near Antarctica were used. A description of the DMSP system and image archive is included.

NSIDC will attempt to smooth the transition of the DMSP collection to the Federal Records Center (FRC), which is scheduled to begin this year. The most widely used data sets will be retained at NSIDC the longest (for several more years). NSIDC, NGDC and the FRC are

discussing the logistics and procedures for user services for data that will be transferred to the FRC.

DMSP Digital Data

NSIDC and the National Geophysical Data Center (NGDC) are involved in a joint project to archive digital data collected by USAF DMSP satellites and copied to 8 mm tapes by Air Force Global Weather Central. This effort will make the complete DMSP data stream available for the first time. While the national archive for DMSP data will officially be at NGDC, NSIDC will provide user services to cryospheric and climate researchers for data collected by the Operational Linescan System (OLS) sensor (visible and infrared), SSM/I passive microwave data, SSM/T and SSM/T-2 temperature and water vapor sounders.

Funding for the program is being provided by NOAA, NASA and the Department of Defense. NSIDC's involvement is a result of our past activities with the analog DMSP/OLS collection and SSM/I sea ice concentration products.

Tape recorder problems have so far prevented continuous production of archive tapes, but NGDC and NSIDC have made good progress in system design, software development and hardware procurement. In the next few months we will form a scientific advisory committee, composed primarily of members of the user community, which will meet on a regular basis to provide guidance. We also will convene a users conference in 1993.

Application of Special Sensor Microwave Imager (SSM/I) Data for Snow Cover and Climate 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 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. These tasks will contribute towards the production of a

prototype snow cover climatology based on the first five years of SSM/I data.

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 global map projection methods, as well as the selection of one or more snow cover algorithms for use in the distribution of standardized data sets by NSIDC. A prototype version of the Equal Area SSM/I Earth (EASE) Grid was distributed on CD-ROM for community evaluation in October 1992. The basic purpose of the EASE-Grid is to provide a standard earth-located grid and an optimal technique to interpolate from the data in swath format to the appropriate earth-located grid cell. Figure 3 shows an example of the 3 equal-area projections distributed on the prototype CD-ROM. The EASE-Grid is intended to provide the general user with a data structure which is easier to use than swath format, while maximizing the radiometric, spatial, and temporal integrity of the original swath data. Snow cover algorithm comparison and validation is being undertaken in cooperation with several SPWT scientists. Regional test areas selected are the western United States, Prairie Provinces of Canada, and central Europe.

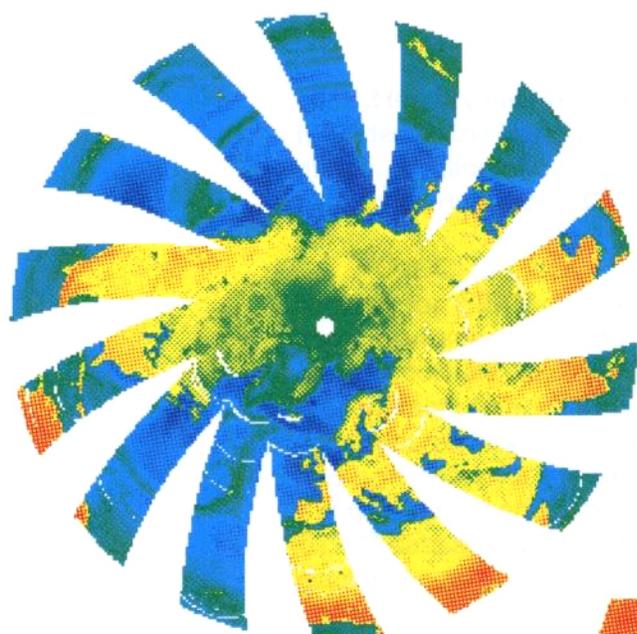
MIZEX/CEAREX

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.

The Coordinated Eastern Arctic Experiment (CEAREX) CD-ROM is discussed in Highlights, p. 2.

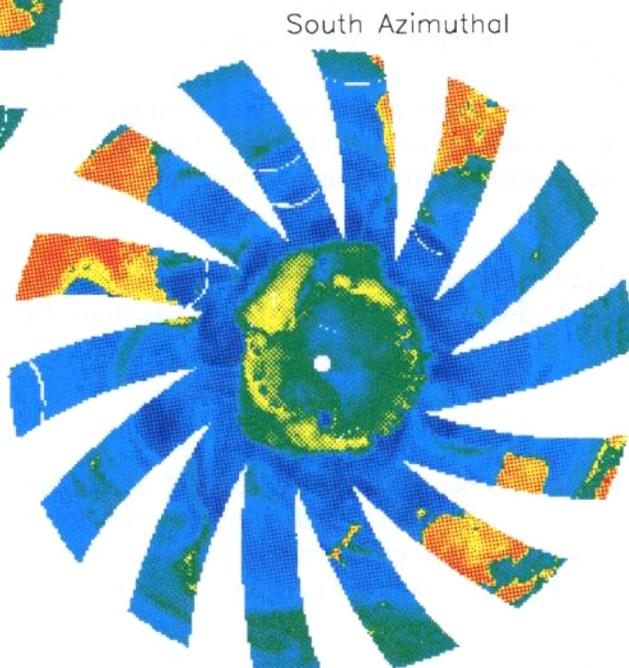
Greenland Ice Sheet Program (GISP2)

GISP2 represents the renewal of the seven year GISP1 Program which began in 1976 and produced a 2037 m deep core at the location Dye 3 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.

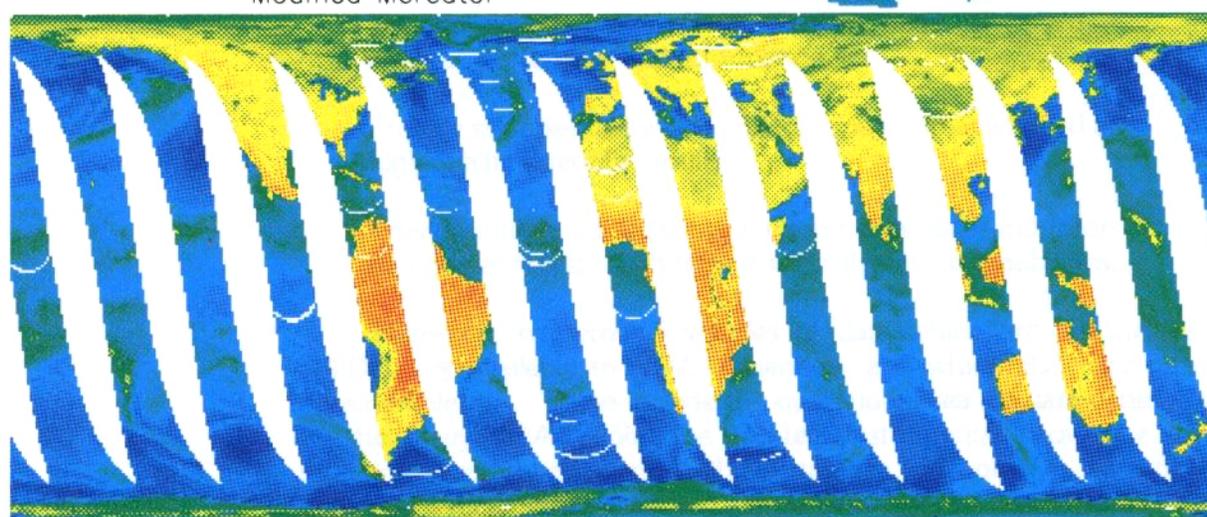


North Azimuthal

3 December 1989
19 GHz horizontal
Ascending passes



South Azimuthal



Modified Mercator

Figure 3

GISP2 is a five year program (1989-1994), involves 25-30 scientists, and is funded by the National Science Foundation (NSF) Division of Polar Programs. Drilling efforts during the 1992 field season resulted in the core reaching a depth of 2253 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 GISP2 Science Management Office. This plan assures efficient and timely access to ice core data as they are released by the GISP2 Principal Investigators (PIs) and it 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.

Following release of the data by the Executive Committee, NSIDC will consolidate all GISP2 and associated data on to a CD-ROM for general distribution.

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 is 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, e.g., snow cover ground observations from Russian and data on the fluctuation of glaciers in the Caucasus.

Arctic Radiation Flux Climatology

Funding: NASA

J. Key; A. Schweiger

A radiation flux climatology for the arctic has been developed from 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 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. To evaluate 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).

Remote Sensing of Sea Ice Leads

Funding: ONR, NASA, CSES/CIRES

J. Key; J. Maslanik; R. Stone; E. Ellefsen

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 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.

Can the information contained in submarine sonar ice draft distribution data be used to estimate the two-dimensional properties of sea ice leads? The degree of error expected in the measurement of widths of sea ice leads along a single transect were examined in a probabilistic sense under assumed orientation and width distributions where both isotropic and anisotropic lead orientations are examined. Methods are developed for estimating the distribution of "actual" widths (measured perpendicular to the local lead orientation) knowing the

"apparent" width distribution (measured along the transect), and vice versa. The distribution of errors, defined as the difference between the actual and apparent lead width, can be estimated when the two width distributions are known, and all moments of this distribution can be determined. The problem has been applied to Landsat imagery and a submarine sonar transect. Results are determined for a range of geometries, and indicate the importance of orientation information if data sampled along a transect are to be used for the description of lead geometries. While the application here is to sea ice leads, the methodology can be applied to measurements of any linear feature.

Sea Ice - Atmosphere Interaction

Funding: NASA, Swiss Federal Institute of Technology
K. Steffen; J. Key; J. Maslanik; A. Schweiger; M. Haefliger

The objective of the sea ice - atmosphere interaction project is to test the feasibility of multispectral satellite data application for polar surface flux estimates. In the past year, work has been concentrated on snow - and ice-surface temperature retrieval from thermal and passive microwave satellite data and on a monthly climatology of Arctic radiative fluxes modeled from the International Satellite Cloud Climatology Project (ISCCP) data set.

In the future, the main emphasis will be on the parameterization of broadband surface albedo from visible satellite data and the validation of satellite-derived albedo values with *in situ* measurements from the Greenland ice sheet. Further, the application of the parameterization schemes to basin-wide energy balance estimates using remote sensing data will be tested.

This research aims to derive, from satellite data, Arctic climate parameters which are essential for large scale climate modeling.

Greenland Ice Sheet Climate Programme

Funding: NASA, Swiss Federal Institute of Technology
K. Steffen; A. Ohmura; K. Jezek

The objectives of the program are the study of the atmospheric boundary layer above the ice sheet, the study of the physical processes of the energy and mass fluxes in the snow layer and at the surface, the study of the climatology of the entire Greenland ice sheet, and the use of satellite and aircraft data for the interpretation of the ice surface. The

interannual and seasonal variations of different surface parameters and energy fluxes will be analyzed for the entire Greenland ice sheet for the past 10 years. This data set will be used in the future as baseline data to detect deviations from the climate norm.

The entire logistics of Greenland field station, which was established by the Swiss Federal Institute of Technology in 1990, have been signed over officially to the University of Colorado, CIRES, at no cost. Therefore, field expeditions are planned for 1993 and 1994 to continue the climate recording and the experimental field measurements for satellite calibration.

Buoyant Convection Above Leads

Funding: NOAA, NSF

M. Serreze; E.L. Andreas; J.A. Maslanik; J.D. Kahl; M.C. Rehder; R.C. Schnell

A simple fetch-dependent boundary-layer model was used to examine theoretical heights of buoyant convection above open leads in the winter Arctic pack ice cover. The model was applied to a suite of sounding data from Soviet drifting stations, assuming open-water leads of 100 m, 1000 m and 10,000 m. The depth of convection increases with increasing lead width. While the depth of convection shows large variability, events of convection up to 4 km, as observed from lidar backscatter data, are likely to be uncommon. First, these events require an open water lead of least 10,000 m. Second, while the conditions most conducive to deep convection are a combination of large air-sea temperature differences, low wind speeds and a weak low-level temperature inversion, this combination appears to be atypical of Arctic conditions. Finally, the conditions most suitable for deep convection are also those in which any newly formed leads will quickly ice over.

Atmospheric Forcings Related to the Great Salinity Anomaly

Funding: NSF

M. Serreze; R.G. Barry; J.A. Maslanik; T. deMaria

Variations in synoptic activity were assessed in terms of their potential influences of sea ice transport and as indicators of shifts in the Arctic atmospheric circulation related to the "Great Salinity Anomaly" of the North Atlantic. This extreme ice/ocean event, characterized by reductions in surface salinities in the North Atlantic of 0.5 to 1.0 ppt, coupled with negative water temperature anomalies and positive sea ice

anomalies in the Greenland Sea, may be analogous to past climatic regimes in which deep water production in the subpolar gyres is suppressed by surface freshening.

Analysis of winter atmospheric pressure anomalies suggests an increased contribution to the Fram Strait ice flux by multiyear ice from along the northern coasts of Greenland and Ellesmere Island. This may be related to a teleconnection involving changes in anticyclonic activity over the central Arctic Ocean and Canadian Arctic Archipelago.

Structure of the Arctic Troposphere

Funding: NOAA, NSF, EPRI
M. Serreze; J.D. Kahl; R.C. Schnell; R.S Schnell

The Historical Arctic Rawinsonde Archive (HARA), a collection of Arctic rawinsonde ascents above 65°N, is now available for distribution. HARA contains over 1.2 million individual soundings, comprising records for over 50 stations. The archive currently extends through 1987. Data for most stations begin in the mid 1950s, but go back to 1948 for some Canadian and Alaskan stations. A separate data base, containing soundings from the Ptarmigan aircraft overflights (1950-61), has also been assembled. Efforts are underway to compile a third data base of drifting station data for the Arctic ocean.

Low-Level Arctic Temperature Inversions. Variability in the low level Arctic temperature inversion may influence the transport and mixing of Arctic pollution gases and aerosols, alter the magnitude of heat and moisture fluxes escaping from Arctic leads and polynyas. Nevertheless, remarkably little is known regarding spatial and temporal variability in the Arctic inversion layer.

Using data from the HARA data set for Arctic land stations above 65°N for 1976-87, and available data for the central Arctic Ocean from Soviet drifting stations, a climatology of Arctic temperature inversions has been developed.

Arctic Tropospheric Temperature Trends

Funding: NSF, NOAA, EPRI
M. Serreze; J.D. Kahl; R.C. Schnell

Soundings from the HARA have been used in a detailed analysis of Arctic tropospheric temperature trends for the period 1958-1986. Time

series of seasonally averaged thickness temperatures for the 850-700 mb, 700-500 mb, 500-400 mb and 400-300 mb layers have been examined for approximately 50 stations. While the results indicate regionally coherent temperature trends for all layers, particularly during winter, no general warming has occurred during the study period that can be attributed to increasing concentrations of greenhouse gases. Results from this study were reported during the 1992 Annual Meeting of the Association of American Geographers, San Diego, on 19 April 1992.

Field Studies in the Canadian Arctic

Funding: NSF

M.C. Serreze; J. Maslanik; J.R. Key; A. Schweiger

During May and June of 1992, Drs. M.C. Serreze, J.A. Maslanik and J.R. Key, as well as A. Schweiger (PhD. candidate) conducted field studies in the Canadian Arctic as part of the Canadian Seasonal Ice Monitoring and Modeling (SIMMS) program. Studies were primarily directed at collecting surface validation data for remote sensing of surface temperature, albedo and other sea ice properties. Transects of surface temperature and albedo were collected during clear sky periods near AVHRR overpasses over transects at a first-year site near Griffith Island, N.W.T., Canada. An extensive set of sun photometer measurements was collected, as well as information on snow depth and hummock/meltpond coverage as a large multiyear flow in Lancaster Sound. Efforts are underway to acquire funding to perform additional measurements during the spring of 1993.

Snow Melt Over Arctic Sea Ice

Funding: NSF

M. Serreze; D.A. Robinson; R.G. Barry, G. Scharfen

Patterns of spring and summer snow melt and parameterized albedo over Arctic sea ice have been examined for 10 spring-summer seasons. These data sets are based primarily on manual charting of surface brightness changes observed in visible-band DMSP imagery. Comparisons between parameterized albedo values from the Robinson et al. [1992] data set (RO92) and albedos determined from the ISCCP algorithm show good agreement between spatial patterns [Schweiger et al., 1992]. Systematic differences of up to 0.10 occur, however, and may be due to simplification of the RO92 parameterization scheme, as well as inadequacies in the ISCCP cloud-clearing algorithm.

In a related study, the timing of spring snow melt over the Beaufort and East Siberian seas, determined from the RO92 data set is compared to snow melt inferred from SMMR brightness temperatures, and surface air temperature data for the years 1979, 1980 and 1984-1986. Three years (1980, 1984 and 1985) are chosen as case studies to examine relationships between snow melt and atmospheric forcings.

Artificial Intelligence Applications for Sea Ice Classification and Processes

Funding: NASA
J.A. Maslanik; J. Key

Rule-based systems and neural networks are being combined with remotely-sensed data and physical models to improve our ability to map sea ice conditions and to detect subtle changes in physical processes in the ice-atmosphere system. Work has focused on using networks and other AI methods to identify spatial patterns associated with ice leads and as a "fusion" tool to combine passive microwave data and output from ice models.

Sensitivity of Arctic Sea Ice Regime to Varying Treatments of Surface Energy Budgets in Sea Ice Models

Funding: NSF
J.A. Maslanik; M.C. Serreze; J. Key

The goal of this work is to define the responses of the Arctic ice pack to changes in atmospheric radiative forcings and to compare short-period and averaged contributions of thermodynamic versus dynamic ice processes. Through comparisons of model results, satellite imagery and other observations, we are working to define the relative importance of radiative forcings (such as cloud cover) on changes in ice thickness and concentration versus changes caused by disruption of the ice pack by transient synoptic systems and larger-scale shifts in wind patterns. Our principal objectives are to enhance radiation components in a dynamic-thermodynamic ice model, define first-order sensitivity of ice thickness, concentration, and extent to changes in radiative forcings, and make comparisons between modeled and observed ice conditions.

A two-dimensional dynamic-thermodynamic model has been modified to include more detailed treatment of ice types in order to examine the spatial and temporal sensitivity of the ice pack (thickness, area, and ice type distribution) to changes in atmospheric forcings,

addition of a snowpack, and to facilitate tracking of the history of ice flow into and out of individual grid cells. The sensitivity to radiative forcings includes tests of ice response to different parameterizations of radiation, and to parameterized and modeled radiation estimated using climatologies versus satellite-observed cloud cover. Work is underway to couple this 2-D ice model to radiation parameterizations with the coupling occurring through albedo and surface temperature. Downwelling longwave and shortwave radiation fields have been generated from cloud fraction climatologies and from International Satellite Cloud Climatology Program cloud fractions using a simple radiation parameterization scheme and a radiative transfer model. Monthly varying and spatially varying radiation fields were produced using forcings for the three-year period from 1984-1986. In addition, fields were calculated using fixed scalings of cloud fraction and radiation.

In addition to these sensitivity studies, we are exploring the relationships between interannual changes in atmospheric pressure patterns and ice transport using a 33-year simulation of ice conditions. We are focusing on the "Great Salinity Anomaly" period in the late 1960's, when it appears that a shift in atmospheric circulation may have led to changes in sea ice source regions that would inject more thick, multiyear ice into Fram Strait than is typical.

Characterization of Sea Ice and Clouds in the Arctic

Funding: National Space Development Agency of Japan (NASDA)
J.A. Maslanik

This effort is part of the NASDA validation program for the recently-launched JERS-1 remote sensing satellite. Imagery representing different ice, water, and cloud conditions for the Arctic will be analyzed to determine sensor characteristics and potential applications. Our particular focus is the combination of JERS-1 data with other types of imagery and observations to retrieve new types of ice and cloud information.

Parameterization and Scaling of Arctic Ice Conditions in the Context of Ice-Atmosphere Processes

Funding: NASA
R.G. Barry; J.A. Maslanik; J.R. Key; K. Steffen

This project focuses on the use of synthetic aperture radar, in conjunction with other remotely-sensed data and field observations, to

determine how sea ice conditions change under different atmospheric forcings, and to study how these changes are represented in different types of observations. Radar imagery from the European remote sensing satellite (ERS-1) for the western Arctic and Baffin Bay have been acquired and are being analyzed in conjunction with Landsat satellite imagery, NOAA imagery, and model simulations. Activities to date have centered on 1) the ice response during the passage of a strong storm system in the Beaufort Sea; 2) analysis of the differences in how open water and different ice types appear in different parts of the spectrum; and 3) the effect of different fields-of-view on identification and mapping of features in the ice pack using the radar data.

Cryospheric Indices

Funding: NSF
R.G. Barry; R.L. Armstrong

A collaborate study with Drs. A.N. Krenke and T. Kadomtseva of the Institute of Geography, Academy of Sciences, Moscow, is examining the usefulness of data on snow cover and mountain glaciers as indices of global change in annual to decadal time scales. Ground observations of snow cover from Russia are being intercompared with satellite passive microwave measurements. Fluctuations of glaciers in the Caucasus have been analyzed by graduate student Dan Bedford.

Barry, Armstrong and Bedford visited Moscow and the Caucasus in summer 1992 to continue this collaboration. Joint papers on the use of snow cover and mountain glaciers as indicators of changes in climatic variables are planned.

FUNDING

Funding Sources

The trend of the past several years continues in that NASA remains our largest funder of Data Center programs. (See Figure 4.) The EOSDIS DAAC effort is the central focus of the NASA work. NOAA is a strong second at 22 % of overall funding. The longer term trend in total funding took a downward dip in FY92. This was caused by the closeout of several Data Center programs, and the delay in some DAAC funding. The 3-4 year average level which is more representative of Data Center performance remains strongly growth oriented. We have expected our funding to level out for several years now and it appears that this has happened in FY92. See Figure 5.

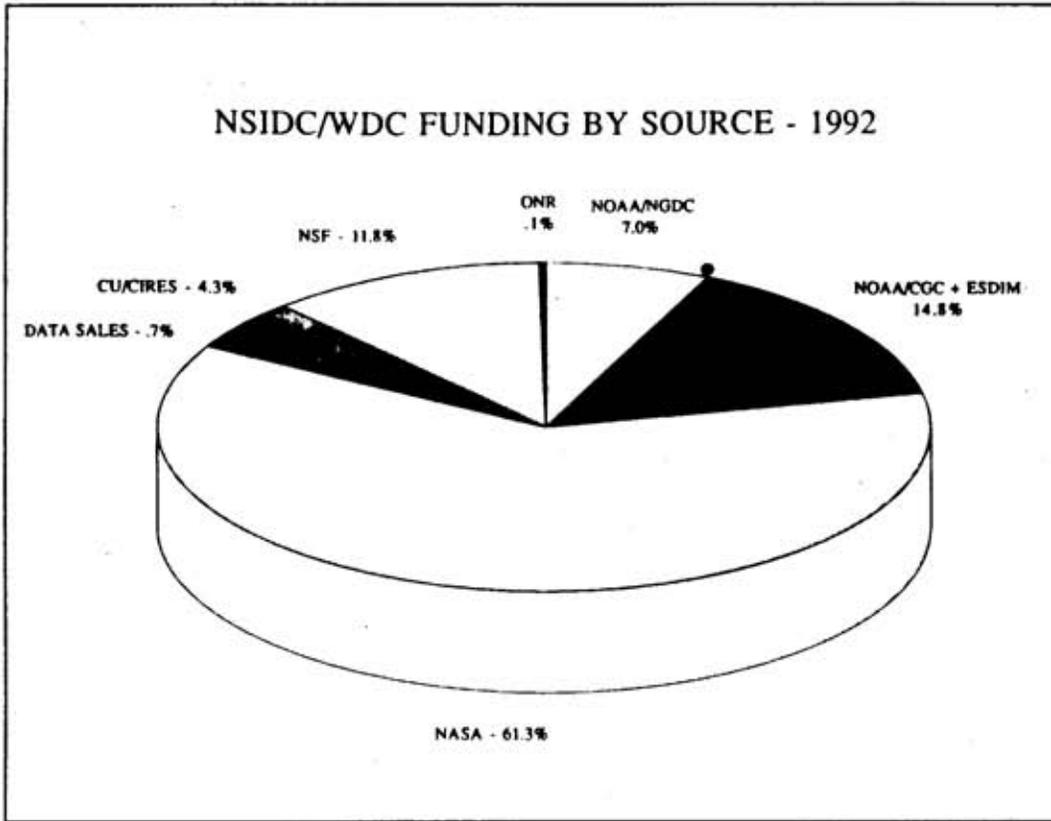


Figure 4.

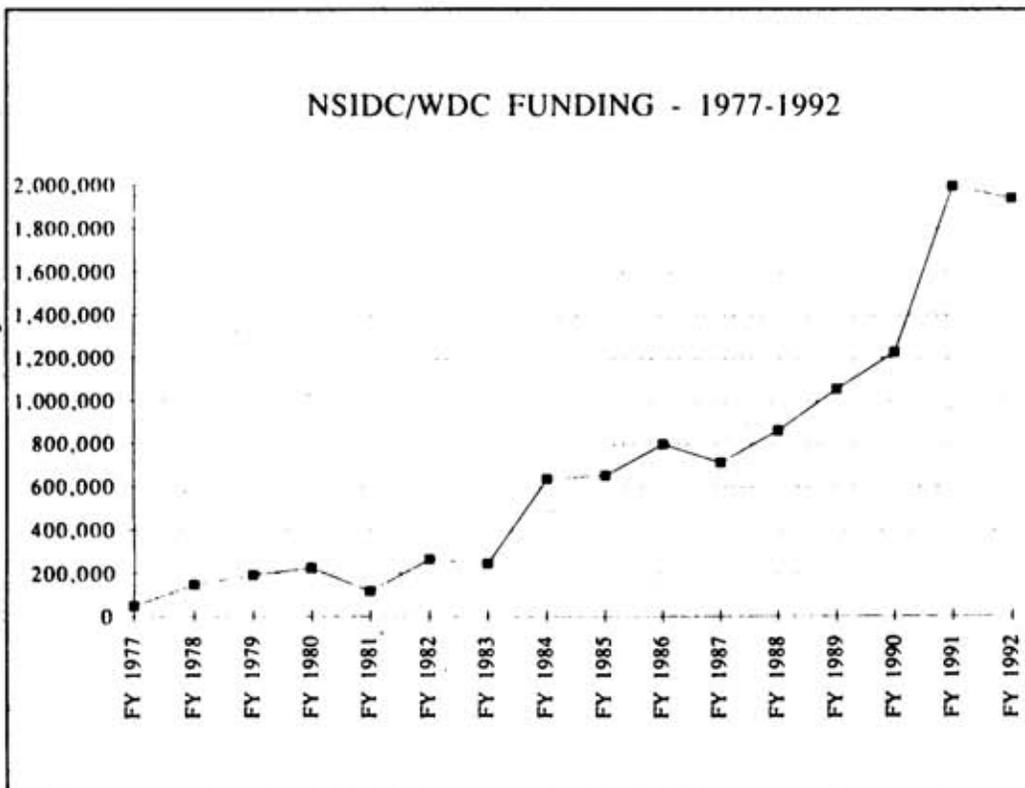


Figure 5.

Data Request Statistics

User Categories

One of the variables by which NSIDC tracks users is by type of organization. Over the 15-year period of record, 1978 - September 1992, the distribution of user types has remained relatively stable. The most frequent users represent U.S. academia, this year 27% of the total requests. Twenty-five percent of the requests were from outside the U.S. and 16% represented industry. (See Figure 6.)

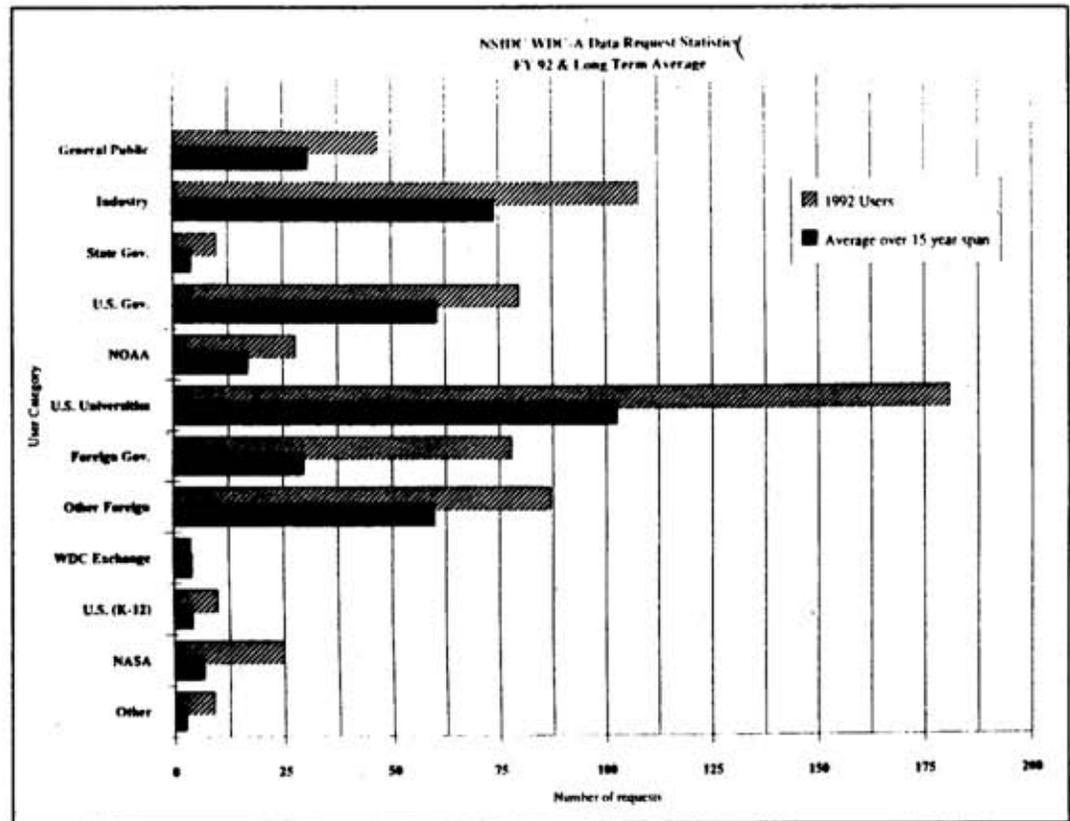


Figure 6.

Data Categories

DMSP OLS hard-copy imagery continues to lead data statistics, both in terms of numbers of users and income. FY92 saw 203 requests (30%) for DMSP data and information and about \$14K in income. Requests for our CD-ROM products generated the next largest number of requests. Passive microwave data (SSM/I and SMMR) accounted for approximately 20% of all requests. Shipments of our newest CD-ROM product "Eastern

Arctic Ice, Ocean and Atmosphere Data" brought CEAREX/MIZEX data management activities into third place in number of requests (15%).

Usage of the Information Center continues steady. Official requests for information account for 15% of our total requests. However, since the collection is used extensively by associates in CIRES and the Institute of Arctic and Alpine Research (INSTAAR) who are experienced patrons and not officially counted, we think this percentage may not truly reflect the Information Center's impact.

Figure 7 shows the number of requests and income earned since 1978.

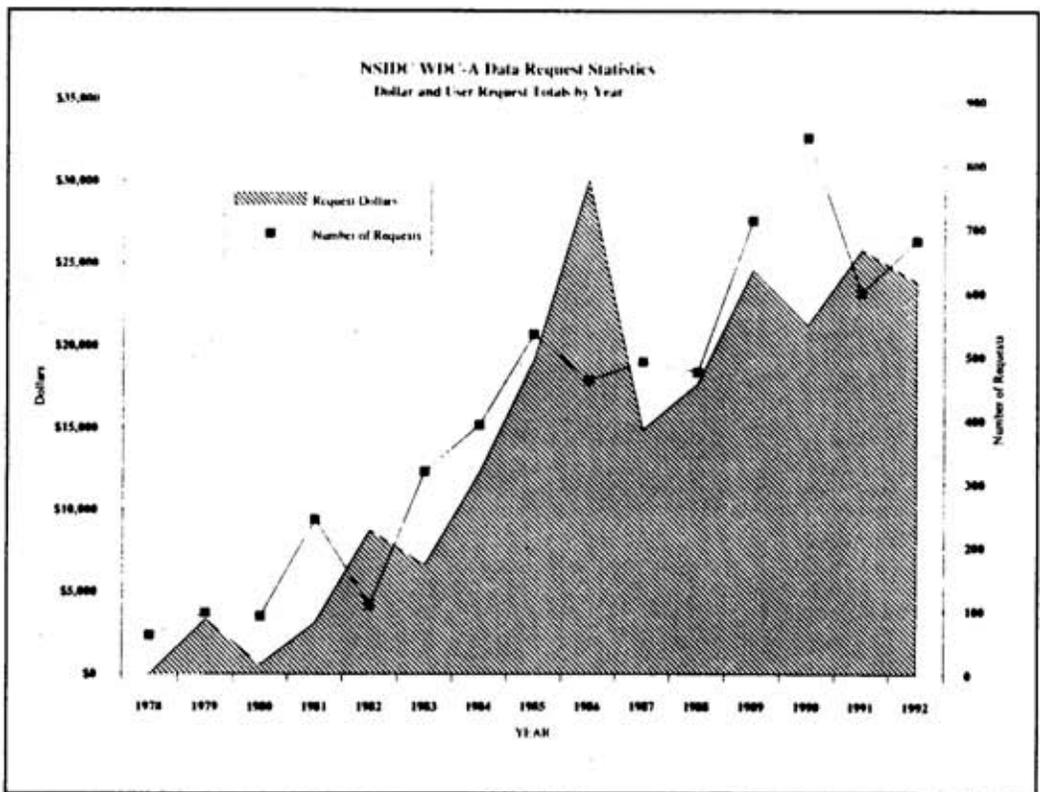


Figure 7.

REFERENCES

Byrne, J.V. (1984) Letter from the administrator. In: NOAA 1985-2000. *A Long Range Strategy for Agency Development*, U.S. National Oceanic and Atmospheric Administration. Unpublished report, 21 p.

International Council of Scientific Unions, Panel on World Data Centres. (1987) *Guide to the World Data Center System. Part 1. The World Data Centers*. Boulder, CO, 91 p.

NOAA (Earth System Data and Information Management Program)
(1992) *NOAAs Data and Information Management Strategy: A vision for the 1990s and beyond*. U.S. Dept. of Commerce, NOAA.

Robinson, D.A., Serreze, M.C., Barry, R.G., Scharfen, G., Kukla, G.
(1992) Large-scale patterns and variability of snowmelt and parameterized surface albedo in the Arctic Basin. *Journal of Climate* 5(10): 1109-1119.

Schweiger, A.J., Serreze, M.C., Key, J.R. (1992) Arctic sea ice albedo: a comparison of two satellite-derived data sets. *Geophysical Research Letters*, in press.

Serreze, M.C., Kahl, J.D., Shiotani, S. (1992) *Historical Arctic Rawinsonde Archive Documentation Manual*. National Snow and Ice Data Center. Special Report-2, 26 p.

NATIONAL AND INTERNATIONAL COLLABORATION

CANADA

Atmospheric Environment Service, Downsview
University of Waterloo

CHINA

Institute of Glaciology and Cryopedology, Lanzhou
(World Data Center-D for Glaciology)

RUSSIA

Arctic and Antarctic Research Institute, St. Petersburg.
Institute of Geography, Moscow.
Central Asian Hydrometeorological Center, Tashkent.
World Data Center-B (State Hydrometeorological Service), Obninsk.

SWITZERLAND

Institute of Geography, ETH, Zurich.
World Meteorological Organization, Geneva.
Swiss Federal Institute for Snow and Avalanche Research.

U.K.

Scott Polar Research Institute, Cambridge.
World Data Center-C for Glaciology, Cambridge.

U.S.A.

Cold Regions Research and Engineering Laboratory, Hanover, NH.
Library of Congress
NASA - Goddard; JPL, Marshall
NOAA - NESDIS
- Joint Ice Center, Suitland, MD.
Ohio State University, Byrd Polar Research Center, Columbus, OH
U.S. Air Force, Offhut, NB
University of Alaska, Geophysical Institute.
University of Washington, Seattle.
International Mountain Society (Univ. of California, Davis).

COMMITTEES

International Commission on Snow and Ice, Representative to International Association of Hydrological Sciences - R.L. Armstrong

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 Snow Science Workshop 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, A.M. Brennan

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

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

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

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

ARCUS Data and Information Resources Working Group - C.S. Hanson, Co-Chair

MEETINGS

U.S. - Canadian Great Lakes - St. Lawrence Ice Information Working Group, C.S. Hanson, 16 October 1991 (Hanover, NH)

Conference on Climate Variations, American Meteorological Society - R.G. Barry, 17 October 1991 (Denver, CO)

GISP 2 1991 Field Season Workshop - R.L. Armstrong, 16-18 October 1991 (Miami, FL)

Polar Research Board - R.G. Barry, 21-22 October 1991 (Washington, DC)

SSM/I Products Working Team Meeting - R.L. Armstrong, N. Sandoval, R. Weaver, 29-30 October 1991 (Greenbelt, MD)

EOSDIS DAAC Managers Meetings - V. Troisi, R.L. Weaver, N. Sandoval, 29-31 October 1991 (Greenbelt, MD)

EOSDIS Version 0 (V0) Information System (IMS) Retreat - V. Troisi, 12-15 November 1991 (Bethesda, MD)

American Geophysical Union - R.G. Barry, R.L. Armstrong, C.S. Hanson, 9-11 December 1991 (San Francisco, CA)

AEDD Working Group - C.S. Hanson, R.G. Barry, 9 December 1991 (San Francisco, CA)

NOAA: Science lecture and briefing - R.G. Barry, 14 January 1992 (Silver Spring, MD)

NSF Workshop on Antarctic Operations Environmental Impact Monitoring and Assessment - C.S. Hanson, 29-31 January 1992 (Washington, DC)

DMSP Planning Meeting - G. Scharfen, K. Knowles, 30-31 January 1992 (Offutt AFB, NE)

LEADEX - R.G. Barry, R.L. Weaver, 12-13 February 1992 (Boulder, CO)

EOSDIS DAAC Managers' Workshop - R. Weaver, V. Troisi, 26 February 1992 (Keystone, CO)

Snow Watch '92 - R.G. Barry, R.L. Armstrong, March 1992 (Niagara-on-the-Lake, Ontario)

Polar DAAC Advisory Group - R.G. Barry, R.L. Weaver, 9-10 March 1992 (Annapolis, MD)

DMSP Mission Sensor Working Group - G. Scharfen, 17-19 March 1992 (Los Cruces, NM)

ARCUS Data and Information Working Group - C. Hanson, 23-24 March 1992 (Washington, DC)

DMSP Technical Working Group - G. Scharfen, 23-24 March 1992 (Washington, DC)

NMC/NESDIS/DOD Conference on DMSP Retrievals - G. Scharfen, 14-15 April 1992 (Washington, DC)

Western Snow Conference - R. Armstrong, 13-15 April 1992 (Jackson, WY)

EOSDIS Information Management System Working Group - C.S. Hanson, V. Troisi, N. Sandoval, 14-16 April 1992 (Boulder, CO)

Association of American Geographers - R.G. Barry, 19-22 April 1992 (San Diego, CA)

SSM/I Pathfinder Science Working Group - R.L. Armstrong, 20-21 April 1992 (Tallahassee, FL)

WetNet PI Workshop - R.L. Armstrong, 22-23 April, 1992 (Tallahassee, FL)

Polar Libraries Colloquy - A.M. Brennan, 3-7 May 1992 (Columbus, OH)

U.S./Canada Joint Ice Working Group - G. Scharfen, 4-7 May 1992 (Easton, MD)

International Symposium on Remote Sensing of Snow and Ice - R.G. Barry, R.L. Weaver, R.L. Armstrong, G. Scharfen, 17-22 May 1992 (Boulder, CO)

IGARSS'92 - M. Hardman, 26-28 May, 1992 (Houston, TX)

NOAA Operational Measurements Science Review of the Climate and Global Change Program - R.G. Barry, 27-28 May 1992 (Greenbelt, MD)

URSI Terrestrial Remote Sensing Microwave Signature Conference - R.L. Armstrong, 1-4 July 1992 (Igls, Austria)

Arctic System Science OAI Modelling Workshop - C.S. Hanson, 13-14 July 1992 (Monterey, CA)

NASA/NOAA Combined Pathfinder Workshop - R.L. Armstrong, M. Hardman, July 29-30, 1992 (Washington, DC)

EOSDIS Data Advisory Panel - R. Weaver, 23 July 1992 (Keystone, CO)

Joint Session. Steering Group of the "WMO Project Global Sea Ice Data Bank" - R.G. Barry, V. Troisi, 20-24 July 1992 (St. Petersburg, Russia)

Aspen Global Change Institute on the Coupled Climate System and Global Change - R.G. Barry, 2-14 August 1992 (Aspen, CO)

Satellite Remote Sensing for Resource Management, Environmental Assessment, and Global Change Studies: Needs and Applications of Developing Countries - G. Scharfen, N. Sandoval, 17-20 August 1992 (Boulder, CO)

NOAA Satellite/ In Situ Global Climate Data Workshop - R.L. Armstrong, 8-10 September 1992 (Camp Springs, MD)

Pathfinder/HDF Workshop - N. Sandoval, 22-23 September 1992
(Champaign, IL)

The SCAR - COMNAP ad hoc Planning Group on Antarctic Data Management - C.S. Hanson, 28 September - 2 October, 1992
(Washington, DC)

International Snow Science Workshop - R.L. Armstrong, 5-7 October 1992 (Breckenridge, CO)

NASA/NOAA SSM/I Pathfinder Science Working Group - R.L. Armstrong, 20-23 October 1992 (Annapolis, MD)

PAPERS and REPORTS PUBLISHED DURING FY1992

Richard L. Armstrong

- 1991 Monitoring global snow cover. **R.L. Armstrong and M. Hardman.** *Proceedings of IGARSS'91*, Helsinki, Finland, Volume IV: 1947-1949.

Air Force Global Weather Central snow analysis development - phase 1. **R.L. Armstrong and M. Hardman.** *Technical Report NSIDC*, University of Colorado: 30 p.

Passive microwave remote sensing of snow cover. **R.L. Armstrong.** *EOS*, Transactions American Geophysical Union, Vol. 72, No. 44: 190 (abstract).

- 1992 URAD '92. **R.L. Armstrong and M.A. Hardman.** *Proceedings of Specialist Meeting on Microwave Radiometry and Remote Sensing Applications* (E.R. Westwater, editor): 99-103.

Monitoring snow and grain size for passive microwave studies. **R.L. Armstrong** and A. Rango. *Proceedings of the Western Snow Conference*, 60th annual meeting, Jackson, Wyoming: 46-55.

Snow depths and grain size relationships with relevance for passive microwave studies. **R.L. Armstrong**, A. Chang, A. Rango and E. Josberger. *Proceedings of International Symposium on Remote Sensing of Snow and Ice*, Boulder, CO (in press).

Comparison and validation of passive microwave snow cover algorithms for hemispheric - scale application. **R.L. Armstrong and M.A. Hardman**, *Proceedings of U.R.S.I. Microwave Signature Conference - 92*, Igls, Austria, 1-3 July, 1992.

Roger G. Barry

- 1990 Climate. J. Jäger and **R.G. Barry.** In: B.L. Turner *et al.*, (eds.). *The Earth Transformed by Human Action*. Cambridge Univ. Press: 335-351.

- 1991 Atmospheric circulation anomalies in the Arctic Basin and their relationship to the Great Salinity Anomaly in the northern North Atlantic. M.C. Serreze, J.A. Maslanik, **R.G. Barry** and T.L. Demaria. *Preprints Volume. 5th Conference on Climate Variations*, Amer. Met. Soc., Boston, MA: 350-353.

Atmospheric forcings on large scale patterns of parameterized albedo over Arctic sea ice: case studies for June 1975 and 1978. M.C. Serreze, T.L. Demaria, **R.G. Barry** and D.A. Robinson. *Preprints Volume. 5th Conference on Climate Variations*, Amer. Met. Soc., Boston, MA: 396-399.

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: 329-345.

Working Group I: Observations. K. Trenbarth, J. Angell, **R. Barry** and 14 others. M.E. Schlesinger (ed.) *Greenhouse Gas-Induced Climatic Change: A Critical Appraisal of Simulations and Observations*. Elsevier, Amsterdam: 571-582.

Cryospheric products from DMSP SSM/I: status and research applications. *Global and Planetary Change* 4: 231-234.

Global Change: Geographical Approaches. Contributing author to chapters 2.2 and 2.3 on Landscape Dynamics, pp. 22-63. In: J.R. Mather and G.B. Sdasyuk (eds.), Univ. of Arizona Press, Tucson.

Climate - Ice Interactions. In: W.A. Nierenberg (ed.), *Encyclopedia of Earth System Science*, Vol. 1, Academic Press, Orlando, FL: 517-524.

Arctic ice-climate interactions. In: *Ocean Technology*. OCNR 112191-16, Office of Naval Research, Arlington, VA: 120-124.

1992 *Global Environmental Change. Understanding the Human Dimensions*. **R.G. Barry**, Member of the Committee. C. Stern, O.R. Young and D. Druckman, eds., National Research Council, Committee on the Human Dimensions of Global Change, National Academy Press, Washington, DC: 308 p.

Mountain Weather and Climate. 2nd revised edn., Routledge, London, 402 p.

Mountain climatology and past and potential future climatic changes in mountain regions: a review. *Mountain Res. Devel.* 12: 71-86.

Arctic Ocean atmosphere - ice system studies. **R.G. Barry**, A.S. McLaren, R.C. Schnell. Final Summary Report, Office of Naval Research, URI. CIRES, Univ. of Colorado, Boulder, CO, 24 p.

Analysis and assessment of sea ice fluctuations in relation to atmosphere-ocean processes. **R.G. Barry, J.A. Maslanik, M.C. Serreze, G.R. Scharfen and R.L. Weaver.** Final Report NOAA/CGCP, CIRES, Univ. of Colorado, Boulder, CO, 50 p. and Appendices.

Snow cover conditions in European Russia and Georgia. A comparison of station data and passive microwave values. **R.G. Barry, R.L. Armstrong and J.A. Maslanik.** *Abstracts. 88th Annual Meeting Assoc. Amer. Geographers*, Washington, DC: 13-14.

Winter atmospheric circulation patterns in the Arctic Basin and possible relationships in the Great Salinity Anomaly in the northern North Atlantic. **M.C. Serreze, J.A. Maslanik, R.G. Barry and T.L. Demaria.** *Geophys. Res. Lett.*, **19(3)**: 293-296.

A.M. Brennan

1992 National Snow and Ice Data Center. *Earth System Monitor*, 2(3), p. 7-8.

Passive microwave research. Microwave bibliography update, 1988-1991. *Glaciological Data. Report GD-24*, 138 p.

C.S. Hanson

1991 National Snow and Ice Data Center (1991) *Eastern Arctic Ice, Ocean, and Atmosphere Data, Volume 1, CEAREX-1*. CD-ROM.

1992 "CEAREX data available on CD-ROM." *EOS, Transactions of the American Geophysical Union*, 73(12), p. 130.

Eastern Arctic Ice, Ocean and Atmosphere Data: A Pilot CD-ROM Project for the Office of Naval Research. *Arctic Research of the United States*, volume 6: 120-121.

Recent Great Lakes ice trends. **H.P. Hanson, C.S. Hanson and B.H. Yoo.** *Bulletin of the American Meteorological Society*, **73(5)**: 577-584.

M.A. Hardman

1992 Validation of passive microwave snow cover algorithms using spatially interpolated surface point measurements. **M.A. Hardman and R.L. Armstrong.** *IGARSS '92*, Houston, TX, Volume 1, p. 818.

R.L. Weaver

- 1992 Development of Sea Ice Data Sets from Passive Microwave Satellite Data: Preliminary Lessons. **R.L. Weaver, V.J. Troisi and C.S. Hanson.** In: *International Conference on the Role of the Polar Regions in Global Change, June 1990, Fairbanks, AK. Proceedings*, volume 1, 120-125.

ACRONYMS

AARI - Arctic and Antarctic Research Institute (Russia)
AEDD - Arctic Environmental Data Directory
AEDDWG - AEDD Working Group
AFGWC - Air Force Global Weather Central
AIDJEX - Arctic Ice Dynamics Joint Experiment
ARCSS - Arctic System Science
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
COMNAP - Council of Managers of National Antarctic Programs
CRREL - Cold Regions Research and Engineering Laboratory
CSES - Center for the Study of Earth from Space
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
EASE - Equal Area SSM/I Earth Grids
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
ESDIM - Earth Science System Data and Information Management
ESMR - Electrically Scanning Microwave Radiometer
ETH - Eidgenössische Technische Hochschule (Switzerland)
EUBEX - Eurasian Basin Experiment
FRC - Federal Records Center
GD - Glaciological Data
GIS - Geographic Information System

GISP - Greenland Ice Sheet Program
HARA - Historical Arctic Rawinsonde Archive
ICSU - International Council of Scientific Unions
IGBP - International Geosphere Biosphere Program
IGS - International Glaciological Society
IMS - Information Management System
ISCCP - International Satellite Cloud Climatology Project
IST - Ice Surface Temperature
JIC - Joint Ice Center
LASP - Laboratory for Atmospheric and Space Physics
LAVC - Local Area Vax Cluster
LEADEX - Leads Experiment
MIZEX - Marginal Ice Zone Experiment
NAL - New Accessions List
NASA - National Aeronautics and Space Administration
NASDA - National Space Development Agency (Japan)
NCDC - National Climatic Data Center
NESDIS - National Environmental Satellite, Data and Information Service
NGDC - National Geophysical Data Center
NISC - National Information Services Corporation
NMC - National Meteorological Center
NOAA - National Oceanic and Atmospheric Administration
NODS - NASA Ocean Data System
NORAL - Naval Oceanographic and Atmospheric Research Laboratory.
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
SAFARI - South African Fire – Atmosphere Research Initiative
SCAR - Scientific Committee on Antarctic Research

SIG - Silicon Graphics Incorporated
SIMMS - Seasonal Ice Monitoring and Modeling Program (Canada)
SMR - Scanning Multichannel Microwave Radiometer
SPWT - SSM/I Products Working Team
SSM/I - Special Sensor Microwave Imager
SSM/T - Special Sensor Microwave Temperature
SQL - Standard Query Language
THIR - Temperature Humidity Infrared Radiometer
TOGA - Tropical Oceans and Global Atmosphere Project (WMO)
USAF - United States Air Force
USGS - United States Geological Survey
V0 - Version 0
WDC - World Data Center
WMO - World Meteorological Organization
WOCE - World Ocean Circulation Experiment