



**ANNUAL REPORT
1989**

**NATIONAL SNOW AND ICE DATA CENTER
WORLD DATA CENTER-A FOR GLACIOLOGY
(SNOW AND ICE)**

COVER: Patterson Glacier, Coast Mountains, Alaska. U.S. Geological Survey
photograph taken 23 August 1976.

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

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE
BOULDER, COLORADO 80303 U.S.A.

NSIDC ANNUAL REPORT FY 1989

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WDC/NSIDC ANNUAL REPORT FY 1989

I. INTRODUCTION

The role of the WDC/NSIDC is to acquire, archive and disseminate data relating to all forms of snow and ice, within the context of the ICSU guidelines for international data exchange (ICSU, 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, and weather-related economic impacts.

II. HIGHLIGHTS

A. ICE CORE BIBLIOGRAPHY AND INVENTORY

WDC's contribution to the National Geophysical Data Center's (NGDC) paleoclimate program for FY89 has been the updating of the ice core inventory and bibliography published in *Glaciological Data*, Report GD-8 in 1980. A total of 109 cores has been identified through a review of the literature. The inventory contains site name, year core taken, location, core depth, drill type, drilling and curating agency, and a bibliographic reference. All categories of information are not available for each core identified. The final draft of the inventory was sent for comment to seven scientists working in this field. We plan to publish the material in GD-23 early in FY90.

An update to the ice core bibliography has also been completed, covering the period 1980 to mid 1989. Approximately 700 references have been identified. The published bibliography will contain both an author and a categorized subject listing. This work will be augmented in FY90 from the NSF-funded GISP2 proposal (see p. 16).

B. POLAR SMMR BRIGHTNESS TEMPERATURE GRIDS ON CD-ROM

The National Snow and Ice Data Center is distributing the NIMBUS-7 Scanning Multichannel Microwave Radiometer (SMMR) brightness temperature grids for the North Polar region on CD-ROM. The first CD-ROM in the series contains grids for the period October 29, 1978 through January 31, 1980 (Figure 1). Approximately five subsequent CD-ROMs will contain the Northern Hemisphere grids for February 1, 1980 through mid-August 1987, when the SMMR became inoperative. Following completion of the North Polar region series, South Polar region grids will be mastered on CD-ROM as well.

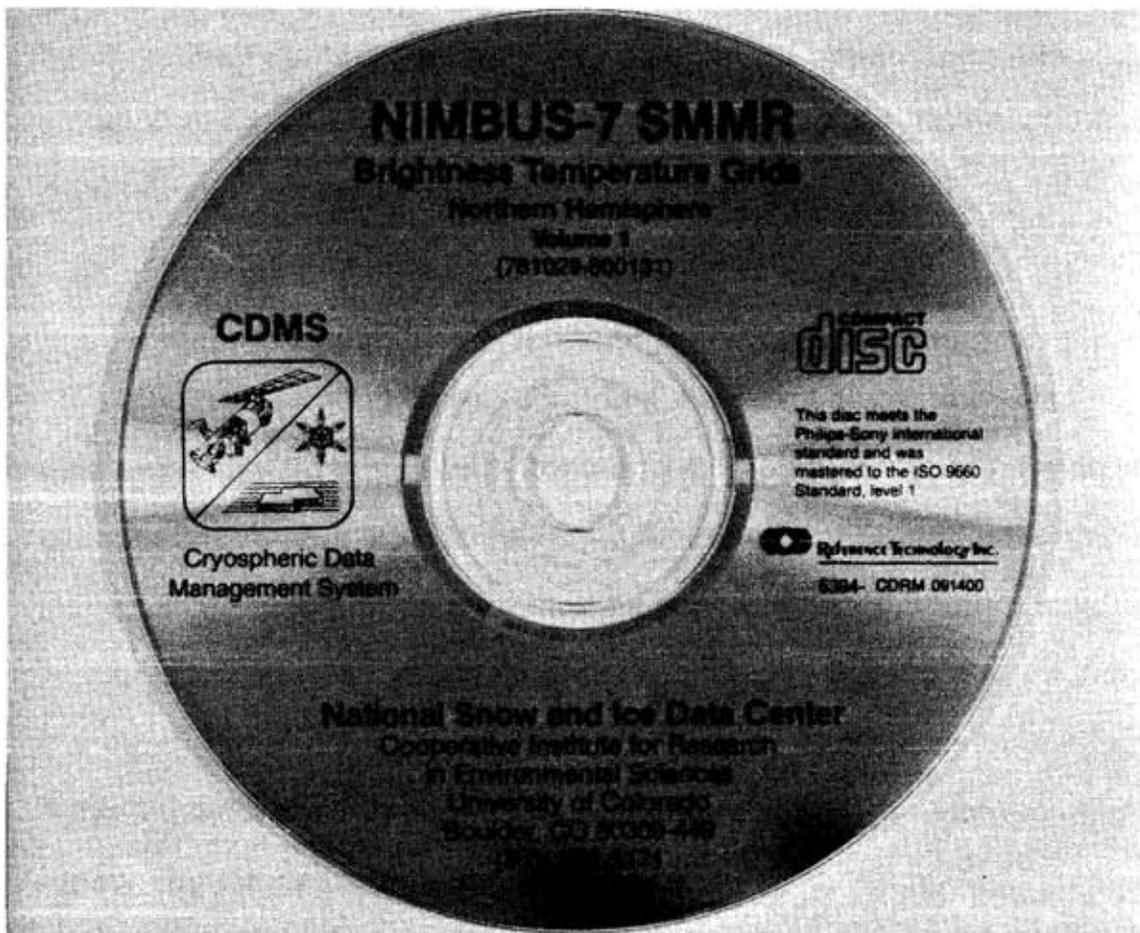


Figure 1.

In addition to the brightness temperatures from each of the five dual-polarized SMMR channels, the CD-ROM contains a landmask, a coastal outline map, latitude and longitude pairs georeferencing each SMMR grid cell, sensor and grid documentation, and bibliographic references. Two floppy diskettes accompany the CD-ROM distribution. The diskettes contain a suite of software designed to extract individual channels from the archive files residing on the CD-ROM and to derive daily ice concentration grids, and an image display package, IMDISP, designed by NASA's Planetary Data System. IMDISP is used in a PC-compatible environment and supports CGA, EGA, and VGA graphics adapters.

The first volume has been distributed without charge with first priority given to NASA and NASA-funded investigators. Feedback from the research community on this prototype volume has indicated that the basic format is acceptable. Further CD-ROMs are now being mastered for distribution in the coming year.

C. AIR FORCE SNOW COVER MODEL

Draft Functional Descriptions and a Technical Report describe the work undertaken by NSIDC to improve the accuracy of the operational daily global snow cover and snow depth analysis model currently used by the Air Force Global Weather Central (AFGWC). The current reports were approved at the most recent project meeting with Air Force representatives in Boulder on July 18, 1989. The overall goal of this project is to analyze weaknesses in the current version of the model, identify enhancements, and design and demonstrate the improved software system. Richard Armstrong and Molly Hardman are the responsible NSIDC staff persons.

Current work focusses on three basic areas. First, NSIDC is developing an improved interpolation method for station reports based on a nearest-neighbor weighting

scheme which considers both the distance of the measurement point from the grid point as well as their relative elevations. Precipitation/elevation gradients and digital topography will be used to extrapolate into mountain zones where no surface observations are available. The second task is to incorporate the all-weather capability of passive microwave satellite remote sensing into the model. The specific sensor will be the SSM/I on the DMSP satellite which has a cell resolution of 25 km, a resolution compatible with that required for the model (45 km). The third task is to optimize application of the global snow cover climatology recently compiled by the Air Force. The climatology will be stored as a cross-correlation matrix such that whenever a reporting station is missing the model can search not only for its nearest spatial neighbor but also for its nearest climatological neighbor.

D. SSM/I SNOW COVER STUDIES

NSIDC has been awarded three years funding for research on SSM/I snow cover-climate data products under the NASA Program for Interdisciplinary Research in the Earth Sciences. The study has two main objectives: the development of a data system for production, archiving and distribution of validated snow cover products from the DMSP-SSM/I for community use; the preparation of a prototype snow cover climatology from the first three years of SSM/I data; an assessment of its utility as a climate system index in a conjunction with SSM/I-derived sea ice products. Richard Armstrong and Greg Scharfen will be the lead NSIDC staff on this project. In connection with this activity Dr. S. Tilford, NASA, has established a SSM/I Products Working Team (SPWT) chaired by Dr. J. Dozier, Univ. of California, Santa Barbara. The SPWT met in Boulder on August 2-3, 1989, to formulate recommendations for SSM/I products, including snowcover.

III. CURRENT PROGRAMS

A. NOAA/NESDIS/NGDC FUNDED PROGRAMS

1. Information Center and CITATION Data Base

"World Data Centers operate under the auspices of the International Council of Scientific Unions for the benefit of the international scientific community and provide a mechanism for international exchange of data in all disciplines related to the Earth, its environment, and the Sun" (ICSU, 1987). To fulfill this directive in the area of Glaciology and to meet the increasing interest in cryosphere/climate studies on a global scale, WDC/NSIDC maintains an active program to acquire published material in all areas of snow and ice research.

Currently the Information Center contains 5000 monographs and technical reports and approximately 11,000 reprints; 90 serials are regularly received. During 1989, approximately 1200 items were added to the collection.

All materials received are catalogued and assigned subject and geographic descriptors. Primary access to the collection is provided by CITATION, the in-house online catalog. At the end of FY89, there were almost 26,000 records in the data base. The file is updated quarterly and 400-500 records are added each time. The subject headings in CITATION are those used by the Cold Regions Research and Engineering Laboratory in their CRREL bibliography and COLD data base. Our collection holds materials on all aspects of snow and ice research, however our focus in recent years has concentrated on snow cover and sea ice data and information and the effects of the cryosphere on climate. Online searches of the collection are performed on request. Figure 2 details the subject areas of user interest during 1989.

The 1983-1987 index to the WDC/NSIDC Information Center Library Collection was updated to include items catalogued during 1988. Following a reformat of the

NSIDC/WDC DATA REQUEST STATISTICS

REQUESTS BY SUBJECT AREA
FISCAL YEAR 1989

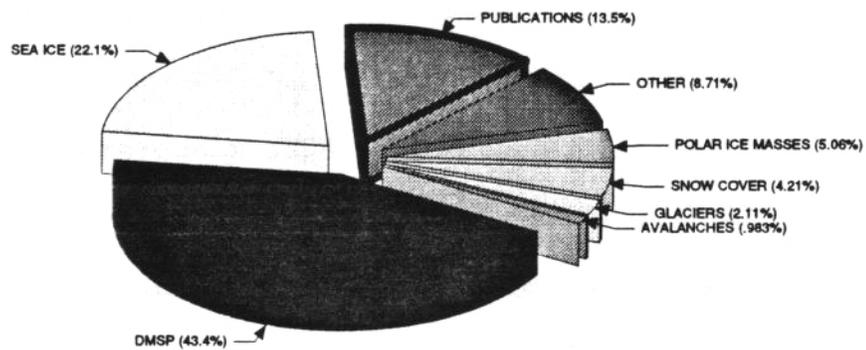


Figure 2.

1978-1982 System 2000 data base, a new, cumulative index was produced for the 5-year period. Information Center users can now search for items by author, title, subject or geographic location in two sets of microfiche indexes rather than four sets, as was previously required.

Currently the Guide to the World Data Center System is being revised and expanded. WDC-A is preparing the section on Glaciology in consultation with Centers B (USSR), C (UK) and D (China).

2. Publication Program

Two series, *New Accessions List* and *Glaciological Data*, are published by WDC/NSIDC. *New Accessions List (NAL)*, a product of the CITATION data base, is a quarterly list of documents, categorized by subject, received and catalogued during a given period. This publication which fills much of the information exchange role stipulated by World Data Center System guidelines is mailed worldwide to about 350 scientists, research institutions, and libraries. During FY89, 5 *NAL* issues were completed. We have now published listings through 1988.

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

One issue in this series has been in preparation this year. We expect to publish *GD-23* early in FY90. This issue will contain the reports and recommendations of the

Workshop on Permafrost Data held in Trondheim, Norway, in August 1988 in conjunction with the Fifth International Conference on Permafrost. It will also include an Ice Core Bibliography and Inventory of Cores, 1980-1989, updating the material published in GD-8 (May 1980).

3. Data Set Administration

Daily pressure, temperature and velocity (uninterpolated) from buoys deployed in the Arctic Ocean during 1981-1986 were received on 1 reel of tape from the Polar Science Center (PSC), University of Washington. This supplements the 1979 - present interpolated data set distributed for the PSC by WDC/NSIDC since 1980.

Dr. U. Radok, CIRES, provided copies of two data sets for distribution by the WDC/NSIDC. The first is Appendix 2.1 of *Climate and Physical Characteristics of the Greenland Ice Sheet*, Radok, et al., 1982, containing data and programs to plot the data given in the published report. The second is a digitized data base of Antarctic ice sheet and bedrock elevations, prepared from the atlas *Antarctica: Glaciological and Geophysical Folio* (D.J. Drewry, ed., Scott Polar Research Institute, 1983.) Each data set is contained on one reel of 6250 bpi tape.

Dr. Carol Pease, NOAA/PMEL, provided the 1988 update to the Bering Sea Argos buoy ice drift data set, extending the archive from 1981 to the present. Sea ice concentration data for the Sea of Okhotsk, 1978-1987, were provided by the Japan Meteorological Agency. These data, in the WMO standard SIGRID format, will be updated annually and were provided in exchange for a copy of the Navy - NOAA Joint Ice Center sea ice concentration data, also in SIGRID format.

New/Updated Products

Scanning Multichannel Microwave Radiometer (SMMR) Brightness Temperature Grids for the North Polar Region, October 1978 - January 1980, were released on

NSIDC's first CD-ROM. This is the first in a series of approximately 10 CD-ROMs to contain the entire Nimbus-7 SMMR brightness temperature data set, 1978-1987.

Directory Activities

WDC/NSIDC has provided descriptive entries for 16 Arctic data sets to the U.S. Geological Survey Arctic Environmental Data Directory (AEDD). All WDC/NSIDC holdings (35 entries) are now described in the NASA Master Directory, an online source for information about content and access to data sets. The NASA Master Directory is a multi-disciplinary computer directory of space and earth science data sets that are of potential interest to space, ocean, land, and atmosphere scientists. The Master Directory contains descriptions of data sets and provides mechanisms for searching for data by criteria such as geophysical parameter, time and spatial coverage, or investigator.

Five new Data Announcements were prepared this year:

88-GLA-11A	DMSP Mosaics
89-GLA-52	ESMR Sea Ice Concentration
89-GLA-71	Geosat Land/Ice Altimetry
89-GLA-80.1	NSIDC's SSM/I CD-ROM
89-GLA-81.1	SMMR Brightness Temperature Grids for the Northern Hemisphere.

The Data Announcements which were updated during FY89 include:

85-GLA-00	Snow and Ice Data Announcements
88-GLA-ANT	WDC/NSIDC Antarctic Data Sets
88-GLA-ARC	WDC/NSIDC Arctic Data Sets
83-GLA-10	Snow Cover Data
83-GLA-11	DMSP Visible and Infrared Imagery Collection
88-GLA-21	Glacier Photo Collection
83-GLA-53	International Ice Patrol Iceberg Data
83-GLA-54	Joint Ice Center Digital Data

4. Data-Related Meetings

The Arctic Environmental Data Directory Working Group (AEDDWG) met in Boulder, 13-14 June 1989 hosted by NSIDC. The group reviewed progress on the Directory over the past year; over 200 data references have been identified

and entered. Plans were made to develop a CD-ROM as a prototype digital data journal for the Arctic, to distribute AEDD, along with bibliographic information and selected Arctic data sets for desktop use by researchers. A segment of NSIDC's Arctic buoy data will be included on this prototype. Future editions may include our complete Permafrost Bibliography, 1978-1987, with a current update.

At the International Association of Meteorology and Atmospheric Physics meeting, IAMAP '89, in Reading, England, 8-13 August 1989, Roger Barry convened a one-day Workshop on Global Data Sets for Climate Research. The 40 participants heard reports on available data for key areas of the climate system, on major climate programs generating satellite products, and on needs and opportunities for product distribution.

B. CONTRACTUALLY SUPPORTED DATA SETS

1. DMSP

NSIDC is in the seventh year of service as the national archive for data from the U.S. Air Force Defense Meteorological Satellite Program (DMSP). During FY89, approximately 60,000 images were sorted, catalogued, and archived into the collection, now amounting to about 1.36 million pieces of imagery. More than 40,000 entries, referring to single-orbit strips, were added to the searchable computer data base. Two hundred and ninety nine requests for data and information were processed this year (up 51% from FY88) resulting in data sales of \$11,900 (up 14% from FY88). Some 376 prints, 330 35-mm slides, 1679 original images on loan, and 669 data flyers were shipped during the course of the year. There were at least 87 visitors to the archive.

University of Colorado students continue to be the primary source of personnel to staff the archive. Participation in the work/study program resulted in a salary saving of

\$9K to the archive activity. Professional staffing underwent a major change in July when Mr. Rob Bauer was hired as DMSP Data Services Supervisor succeeding Mr. Donald Van Metre who left professional status to pursue academic interests. Mr. Bauer is a former student employee.

One of the major achievements this year was the reorganization of the collection in RL2. A long-standing concern has been the vulnerability of parts of the collection which were physically situated within the limits of the 100 year flood plain of Boulder Creek as defined by the City of Boulder and the University. Successful negotiation with CIRES and the University led to a major move during the summer months. Prior to the move the collection occupied eight rooms on the basement, first and second floors of RL2. The entire collection is now above the floodplain and resides in two large rooms on the second and third floors. Though a cumbersome move (taking 10 students 5 weeks to move 225,000 lbs. of data and cabinets), the added benefits of a much more efficient layout are already apparent.

The scientific community continues to use DMSP data in a variety of notable projects. Thermal infrared imagery of Antarctica is being used to study katabatic drainage from the ice cap. Persistent strong downslope winds from the perimeter of the ice cap to the coast have been well documented by a number of researchers and visitors to the area. A study by Ohio State and Indiana University researchers, D. Bromwich and A. Carleton, using DMSP imagery is showing these winds to be more extensive than previously recognized. The winds show up on infrared imagery since they are relatively warm compared to the surrounding environment. The researchers suspect the winds play a role in cyclogenesis in the Ross and Weddell Seas. In another Indiana University study, graduate student J. DeGrand is developing a climatology of jet contrails as seen on high resolution DMSP data. Exhaust from jet aircraft introduce millions of condensation nuclei

into the atmosphere and the cumulative effect on total cloud cover is unknown. The 0.6 km resolution direct readout images are especially useful for mapping the contrails since they have considerably higher resolution than any other daily satellite product. DeGrand spent three weeks in the DMSP archive, and will eventually complete a masters thesis on the subject.

In preparation for the upcoming 1992 solar eclipse, the National Center for Atmospheric Research (NCAR) High Altitude Observatory (HAO) used DMSP imagery to study prevailing cloud conditions in Baja California so that optimum observation sites can be determined. Much of the cloud cover in the area is low level stratus which tends to be influenced by local topography, and again the high resolution coverage of the DMSP sensors was especially useful for getting repetitive detailed views of the area.

The role of DMSP in the numerous planned global change programs has been one of our major thrusts this year. Renowned spokesperson for the climate community, Dr. Steven Schneider of NCAR, is making good use of the nighttime visible-band images from DMSP in his presentations to scientific and legislative audiences. Schneider uses our USA at Night and Europe at Night mosaics to illustrate the obvious presence of man on the planet, and nighttime images of Africa and South America to show the number of fires (and their spatial extent) which are coming under increasing attention as concern rises over the destruction of the tropical rainforests. Figure 3 is an example of the use of DMSP imagery for global change studies.

The future of the DMSP collection is still unresolved. In the short term, funding from NOAA/NESDIS is increasingly hard to obtain and at years' end, funding for FY90 was doubtful. Funding for FY89 came in two separate six month increments totalling \$40K, considerably less than NESDIS provided in previous years. NSIDC subsidizes the DMSP activity with help from the work/study program, the University and other sources.

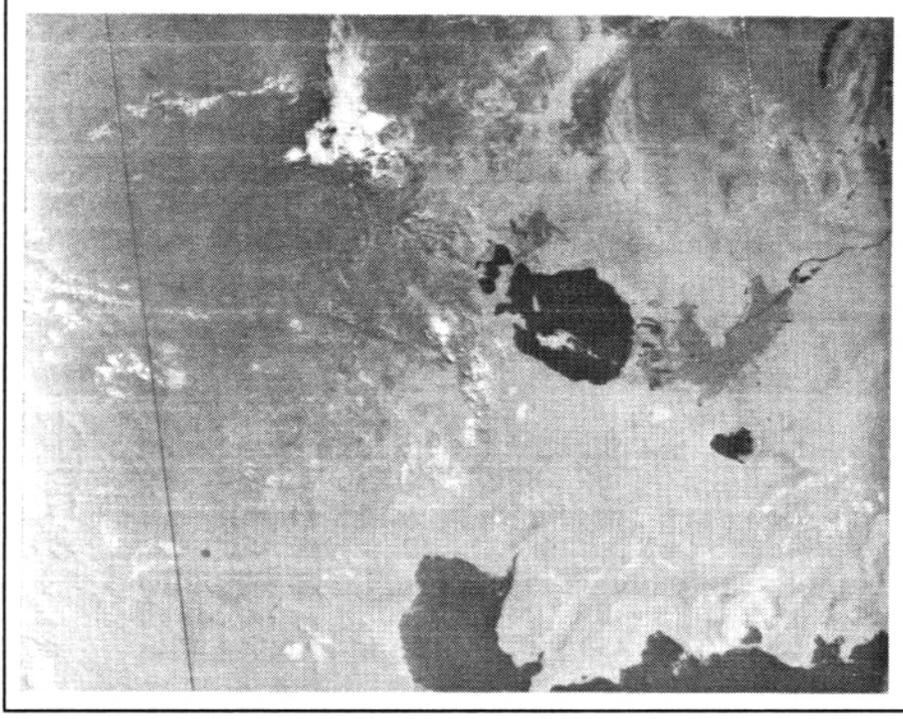
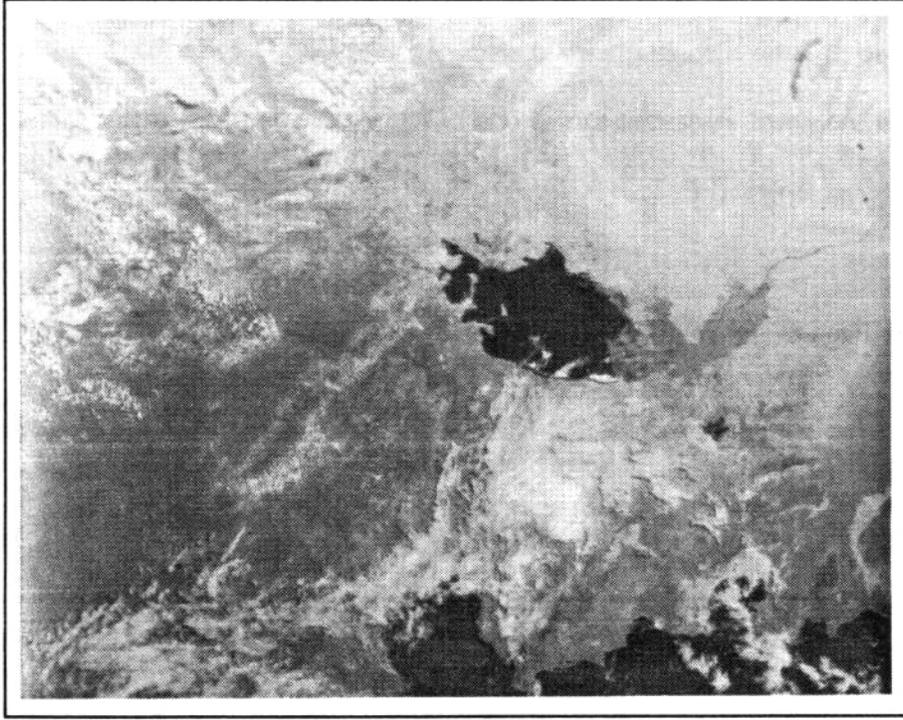


Figure 3. This pair of visible band DMSP satellite images collected 14 years apart shows the dramatic decrease in size of the Aral Sea in the central Soviet Union. The image on the left (DMSP-Q-V-7128) shows the Aral Sea as it appeared on 10 August 1973. The image on the right (DMSP-F7-H-19113) shows the same area on 26 July 1987. The Caspian Sea is on the left margin of both images. The demise of the Aral Sea is being called a major ecological disaster. Irrigation for the region's growing agricultural economy has upset the gentle balance between precipitation and evaporation. The inland sea is being drained at an unprecedented rate, and fishing ports and boats are now stranded inland. The demands to produce high yields from crops in an arid region have led to the overuse of chemical pesticides and fertilizers which have polluted ground water tables to the extent that drinking water must be brought in from outside. Large areas formerly underwater have been exposed creating salt flats. The salt is being carried by windstorms to distant locations, threatening the economy and environment of an even larger area.

Our long term plans to archive the digital data which the Air Force will begin producing in FY90 have drawn considerable attention and have been the focus of much debate among a number of agencies and concerned parties. Support from the user community and governmental agencies has been excellent. The Federal Coordinator's Office for Meteorological Services and Supporting Research has recommended that "the agencies involved – DOC, DOD, NASA, and NSF – should devise a cooperative program to acquire the imagery from AFGWC in digital form, store it, and make it available to users" (Evans, 1988). The National Academy of Sciences' Committee on Geophysical Data also discussed support of DMSP, and is considering the development of an interagency data disaster fund with DMSP as a test case. Though support remains high, funding for these ideas has not been identified. The Air Force has already cut back the production of hard-copy images by 50-60% and further cuts will occur in the next few months. Recently, a team of scientists and data managers from NSIDC, NGDC and NCDC visited Air Force Global Weather Central (AFGWC) to explore the feasibility of tapping into their digital data stream. The Air Force appears to be cooperative although unwilling to incur any costs. The solar/terrestrial research community, perhaps the most cohesive DMSP user group, is planning its own drive to obtain funding for the procurement of part of the hardware necessary to record and transfer digital data for archival purposes. Though NOAA/NESDIS has arranged the archival of DMSP data for many years, they are so far unwilling to commit to any support of the proposed effort. Further, NESDIS has not identified NSIDC as the logical place for the future archive, despite the existence of the now sixteen-year-long DMSP data set at NSIDC, our working relationship with the user community, and our long standing efforts to secure the future digital data. A recent proposal we submitted to NOAA Climate and Global Change Program for the development of a digital archive capability was unsuccessful. We will

continue to explore other sources of funding. However, the present indecision will make a gap in the record of observations inevitable.

2. MIZEX/CEAREX

Since 1983 NSIDC has provided data management services for the International, Interdisciplinary, Marginal Ice Zone Experiment (MIZEX). Data sets are available from field experiments in the East Greenland Sea and the Bering Sea. As a continuation of the management of the MIZEX data, NSIDC has been asked by the Office of Naval Research (ONR) to manage data which will result from the Coordinated Eastern Arctic Experiment (CEAREX). This experiment took place in the East Greenland Sea in the area west of Svalbard between 70 and 85 degrees north latitude from September 1988 until June 1989 (Figure 4).

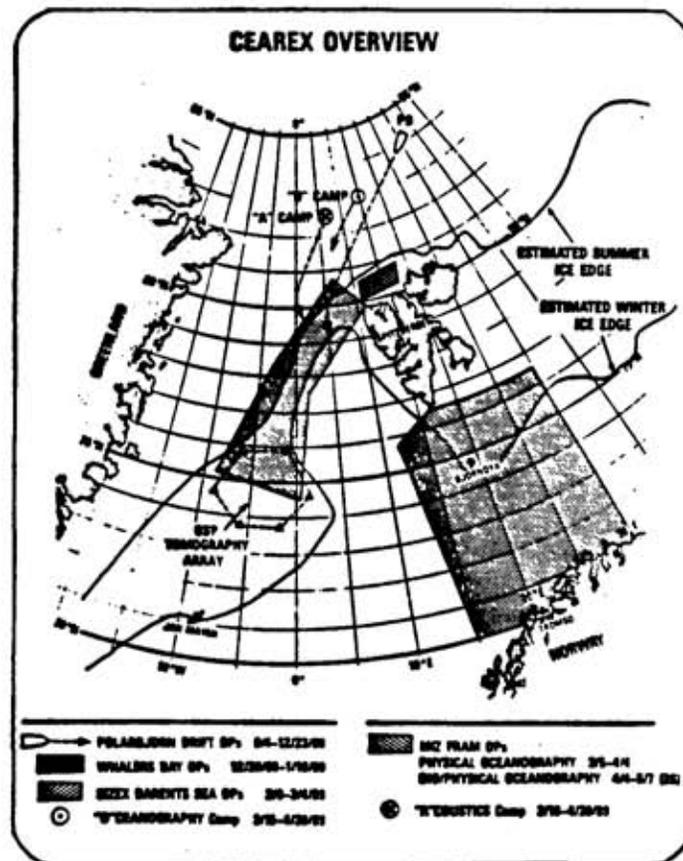


Figure 4.

CEAREX will provide a better understanding of the structure and function of the meso-small scale processes in the exchange of momentum, heat, and biomass within ocean eddies, internal waves, and within the ocean/atmosphere boundary layer. Studies of ice processes will include intrafloe stress and deformation, floe failure, and algal habitat. Acoustics studies will focus on coherence, scattering, and ambient noise fields. The same data categories used in the MIZEX management project will again be used in conjunction with CEAREX. These are: Physical Oceanography, Ice, Acoustics, Biology, Remote Sensing, and Meteorology.

3. GISP2

NSIDC has received a small grant from the National Science Foundation Division of Polar Programs to provide data management services for the Greenland Ice Sheet Project (GISP2). GISP2 represents the renewal of the seven year GISP1 program which ended in 1983 and produced a 2037 m deep ice core (70,000 year record) at the location Dye 3 in southeastern Greenland. The GISP2 drill site is located in central Greenland where the depth to bedrock is estimated to be 3100 m which could provide a stratigraphic record of 200,000 or more years. The first field season for GISP2 was successfully completed during the summer of 1989.

C. CRYOSPHERIC DATA MANAGEMENT SYSTEM

NSIDC is funded by NASA Polar Oceans Program to develop a computerized-based Cryospheric Data Management System (CDMS). The CDMS design aims to provide a single focal point for snow and ice data sets. The CDMS is an enhanced version of the NASA Jet Propulsion Laboratory's NASA Ocean Data System (NODS) designed for the archival of SSM/I data and production of cryospheric data sets. This project is led by Ron Weaver and Vince Troisi.

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

SSM/I orbital swath data are being gridded into brightness temperature (TB) grids for the polar regions. NODS has processed SSM/I data for the period June 20, 1987 through May 15, 1988. NSIDC has assumed responsibility for the archival and production of the gridded data for the polar regions for the period extending past May 15, 1988. The two archives were merged into a single archive at NSIDC in September, 1989. In addition to delivering the processed SSM/I data, NODS representatives delivered the final version of the NODS software (Version 3.6). During their visit, operational procedures which were developed at JPL during the archiving of the first year of SSM/I data were conveyed to CDMS operations personnel.

Quality control became an important component to the SSM/I archival operations at NSIDC in 1989. Geolocation has been an enigma to users of SSM/I passive microwave data. The NASA SSM/I Sea Ice Algorithm Working Group (SSIAWT) agreed to accept the corrections proposed by the Dr. Cal Swift at University of Massachusetts. The corrections assume the geolocation error is a function of the attitude of the DMSP spacecraft. Coefficients, which are latitude and time dependent, are derived using fifteen

islands located at various latitudes to locate the SSM/I pixels. The derived coefficients are then used to derive the small angle approximations for both cross-scan and along-scan shifts due to pitch, roll, and yaw of the spacecraft. These adjustments are applied to the SSM/I prior to gridding the orbital data for the polar regions. Another quality control measure is to filter data from the archive where values are determined to be unrealistic. SSM/I TB values have been found as low as 0 (degrees Kelvin) and as high as 650 (degrees Kelvin).

Hardware and Software Acquisitions

VMS 5.0 was installed on the VAXstation 3500. The VAXstation 3500 is dedicated to SSM/I data processing. The installation of VMS 5.0 was required in order to support the NODS Version 3.6 software. An Apple Macintosh-II has been integrated into the NSIDC LAN.

Management

Nick Sandoval was hired in August 1989 as operations support and computer programmer for the CDMS. Mr. Sandoval has acquired training from the NODS data archiving team during their visits to NSIDC. Nick will be responsible for the integrity of the SSM/I archive.

Two Summer Minority Access to Research Training (SMART) students were introduced to image analysis techniques using the DIPIX Image Analysis System at NSIDC. SMART is sponsored by the Graduate School at the University of Colorado at Boulder. DMSP Optical Line Scanner orbital swath imagery was photo digitized with an Eikonix photodigitizer. Color enhancements of the digital images were used to examine structural differences in clouds that occur off the coasts of NW Africa and California.

IV. FUNDING

A. FUNDING SOURCES

The combined total of Data Center and related research dollars broke \$1 million for the third year in a row. Continuing support from NASA, the ONR-University Research Initiative "Arctic Interactions" grant, and NOAA remain the principal funding sources. It is encouraging to note that NOAA support increased in FY89, due principally to NOAA Climate and Global Change Program resources. Our base funds remained stable. The ONR-URI funding sustained an 18% budget reduction in the third project year, as it did in the first two years.

The proportion of Data Center funding from NOAA sources has increased to roughly 28% of the total. Figure 5 displays the WDC/NSIDC funding by source for FY89. Figure 6 shows the data center funding the for past 12 years. Estimated salary expenses are also graphed for FY88-90 (FY90 estimated).

Funding for the DMSP collection is still in doubt and it is highly likely that NESDIS support will be terminated in FY90. NESDIS was able to level fund the activity in FY88-89. The AFGWC has started the transition from hardcopy to fully digital data use. Our incoming data has been reduced to about 40% of past years. As we have stated in the past, the completeness and length of the existing 16-year record provided by the imagery collection make it an invaluable resource for studies of global change parameters under the developing national and international programs in this area. Equipping the Center for processing of digital DMSP visible and IR data would be relatively costly, but the potential value of such archives, at least for selected regions covered by the 600 m resolution direct readout data, makes the question of importance in our forward planning. The fact that SSM/I products from DMSP satellites will be archived at the Center is a further reason for

NSIDC/WDC FUNDING BY SOURCE

FISCAL YEAR 1989

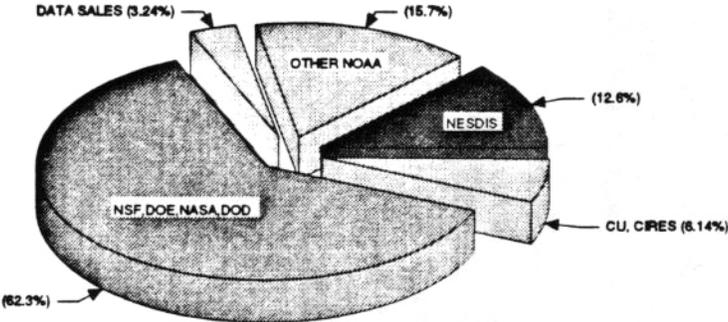


Figure 5.

NSIDC/WDC FUNDING BY SOURCE

FISCAL YEARS 1977-1990 (1990 ESTIMATED)

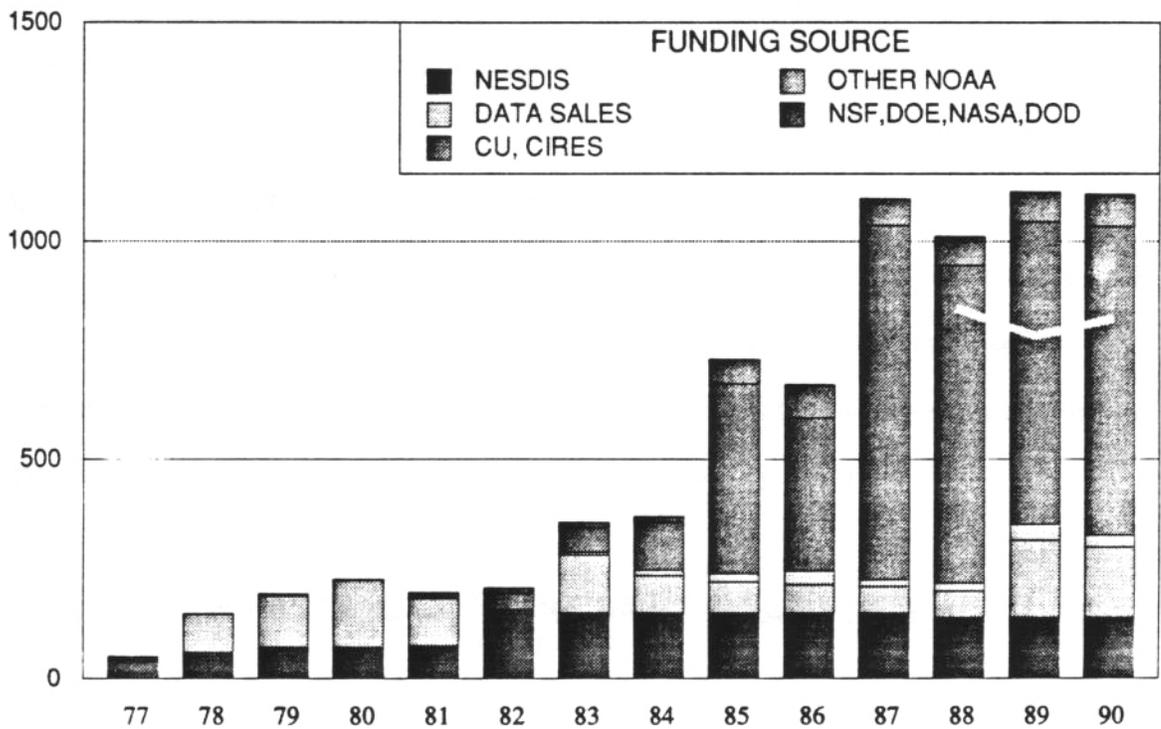


Figure 6.

having available digital OLS data. We continue to explore ways to obtain and archive digital OLS data.

The ONR-URI funding sustained an 18% budget cut in this fiscal year and it is likely that a 10-15% cut will occur in FY90. This cut was one of the smallest of any of the URI programs and demonstrates the strength of our research efforts. NASA-CDMS funding has remained stable, despite cuts in other NASA science programs. We are pleased that NASA Polar Oceans program remains strongly committed to our data management and product generation efforts. We have great hopes that our NASA support will continue on into the EOS era.

B. DATA REQUEST STATISTICS

Both data sales income and data request numbers were up significantly over FY88 levels (See Figures 7 and 8). Total FY89 sales were \$24,664, a 38% increase over the previous year. A total of 712 requests for data and information were processed this year. That represents more than a 50% increase over requests for FY88.

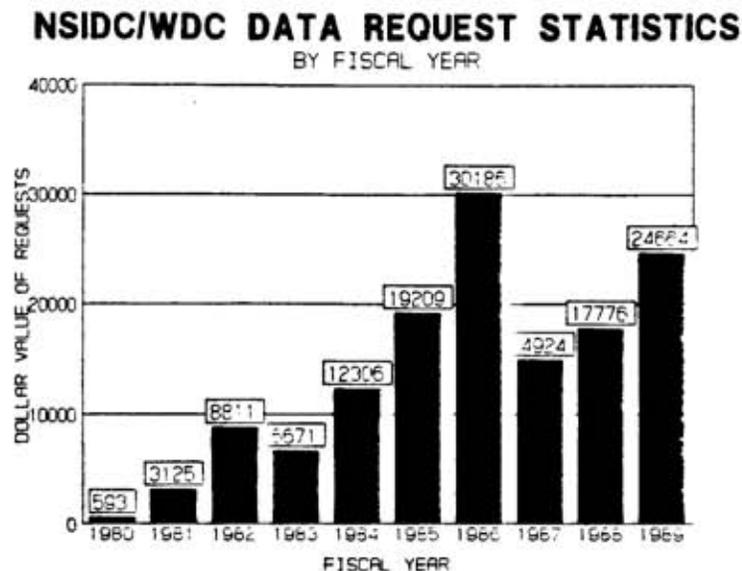


Figure 7.

NSIDC/WDC DATA REQUEST STATISTICS BY FISCAL YEAR

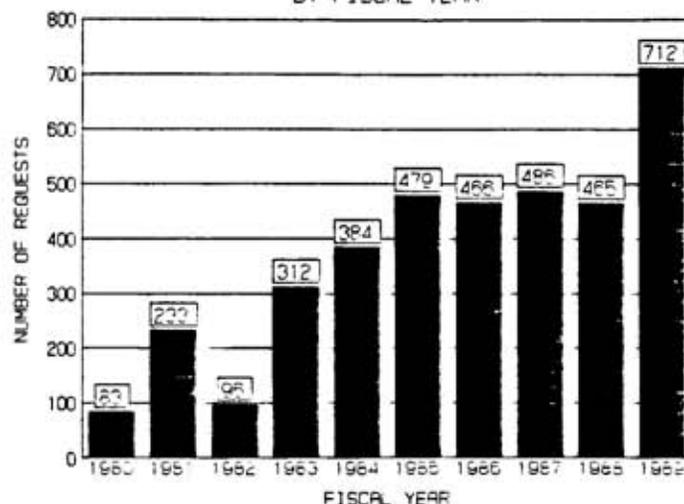


Figure 8.

V. NEW INITIATIVES

Two year funding has been awarded by the NOAA Climate and Global Change Program for research on sea ice data and analyses to be acquired in cooperation with the Digital Ice Forecasting and Analysis System (DIFAS) at the Joint Ice Center, Suitland, MD. The DIFAS will provide the only digital data stream for both polar regions combining satellite, NWS-NMC surface and upper air analyses, and ice model prediction output. This data stream will be acquired by NSIDC/WDC for the proposed global change research tasks as well as for re-distribution to the polar research community. The project will be lead by Greg Scharfen with support from Mark Serreze and Richard Armstrong.

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

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

Funding has been awarded by NASA's Interdisciplinary Program in Earth Sciences for development of snow cover products from SSM/I passive microwave data and related research on snow cover and climate.

The study has two main objectives: (1) to develop a data system for production, archiving and distribution of validated snow cover products from the DMSP SSM/I for community use; (2) the preparation of a prototype snow cover climatology from the first three years of SSM/I data, and an assessment of its utility as a climate system index in conjunction with SSM/I derived sea ice products.

VI. ASSOCIATED CIRES RESEARCH PROJECTS

A. ARCTIC OCEAN-ATMOSPHERE-ICE SYSTEMS STUDIES PROGRAM

Funding: Office of Naval Research. University Research Initiative.

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

Studies on Arctic Ocean ice-climate interactions supported through the ONR University Research Initiative Program to CIRES (jointly with Drs. E. Schulson and W.D. Hibler of Dartmouth College) have continued through the third year of this 5-year program. Further analyses of drifting buoy data and earlier pressure data reveal that the tendency for the normal clockwise ice drift in the Beaufort Gyre to be reversed in late summer (Serreze et al., 1989A), under the forcing of persistent synoptic cyclone systems

(Serreze and Barry, 1988), occurs in approximately two-thirds of the summers. In addition, there are also short-term reversals of ice drift in the Transpolar Drift Stream (Serreze et al., 1989B). The reversals in the Canada Basin favor ice divergence and therefore reduced ice concentrations of up to 20 percent identified in SMMR data by J. Maslanik under NSF Division of Polar Programs support (Barry and Maslanik, 1989; Maslanik and Barry, 1989). Statistical analyses have been carried out on sonar data of under-ice draft distributions and keel spacings in the Arctic basin in summer; further work is planned for other areas and seasons. The demonstrated variability of the central Arctic pack ice suggests that climate models used to take account of ice dynamics.

Related work supported by the ONR-URI and by U.S. Army Corps of Engineers involves the use of aircraft lidar data, collected during AGASP in 1986 and by NASA in 1984, to analyze leads (open water) in Arctic sea ice (Schnell *et al.*, 1989). The 1.06 micrometer lidar permits detection of open leads due to plumes of condensate emanating from them. These plumes may persist for hundreds of kilometers downwind and may penetrate the Arctic inversion to altitudes of 3-4 km (Schnell *et al.*, 1989). Their presence is significant for studies of arctic cloudiness and occurrence and for polar energy budgets.

B. NASA ARTIFICIAL INTELLIGENCE APPLICATION TO SEA ICE STUDIES

A grant has been received from NASA's Polar Oceans Division to investigate artificial intelligence applications for sea ice studies. J. Key and J. Maslanik are testing the utility of knowledge-base systems and neural networks (Key *et al.*, in press) for sea ice classification, lead detection, and surface melt identification.

This variability in ice concentration also has implications for heat transfer and brine production. Calculations are underway to assess the effects of such open water

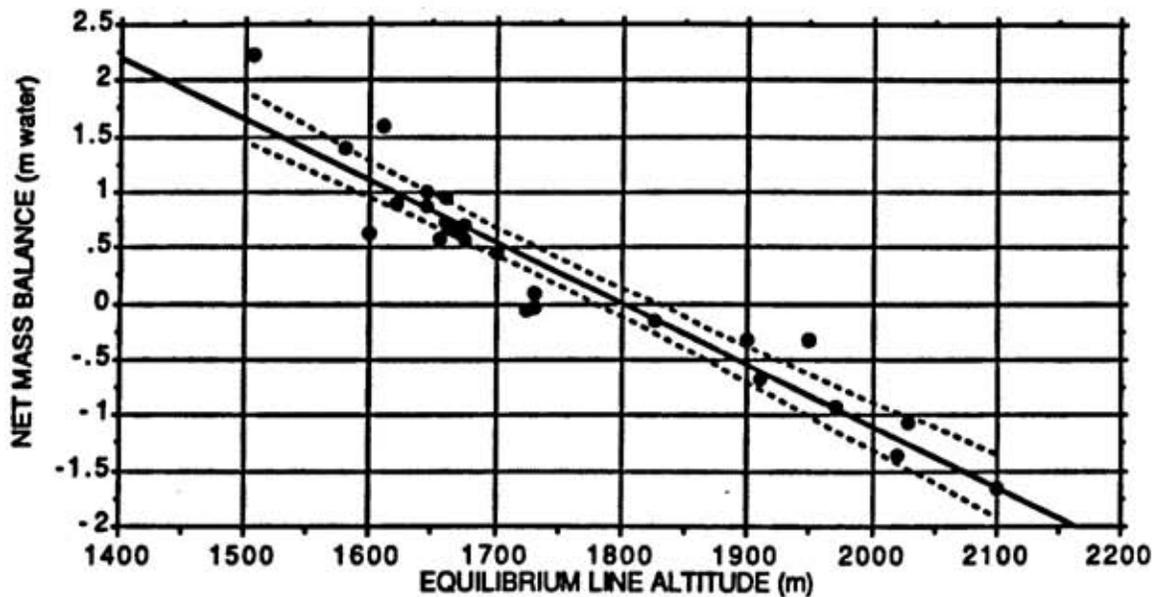
areas by combining SMMR and SSM/I-derived ice concentrations with Arctic Drifting Buoy Program gridded temperatures, pressures, and wind speeds. Work is continuing along these lines to determine basin-wide and regional trends in potential turbulent fluxes in the Arctic.

C. MASS BALANCE HISTORY AND MODELING OF BLUE GLACIER

Funding: NSF through a subcontract with the University of Washington. (Project to be completed during 1989). R.L. Armstrong

Mass balance data for Blue Glacier have been compiled for the 31-year period 1956-1986 (Armstrong, 1989). The glacier location is strongly maritime with annual precipitation of 3500 to 5000 mm, most of which falls as snow during the winter season. The low elevation of the glacier contributes to large amounts of summer ablation resulting in significant annual mass exchange. Blue Glacier has been in approximate equilibrium with climate conditions during the past 30 years with a slightly positive mean annual net mass balance of 0.3 m and a terminus advance of 150 m. Comparison with other glaciers in western North America for the same time period indicates that this pattern of mass increase is not typical and may be specific to a maritime location.

Due to heavy amounts of winter snowfall, an accumulation area ratio (AAR) of only 0.5 is sufficient to maintain a zero balance on Blue Glacier. A strong gradient of increasing snowfall with elevation contributes to a linear relationship between net balance and elevation throughout the total altitude range. This pattern is consistent over the period of record and is not simply a response to the long-term mean positive balance as the pattern persists even during periods of strongly negative balance. The relationship between measured mass balance and equilibrium line altitude (ELA) provides a reasonable method to compute mass balance. (Figure 9.)



Correlation between equilibrium line altitude and net mass balance for selected years during the period 1956-1986 (dashed line is 95% confidence interval).

Figure 9.

D. ARCTIC SNOW MELT

Funding: NSF/Climate Dynamics. R.G. Barry and G. Scharfen (with D.A.

Robinson and G. Kukla). Supplemental funding has come through the URI grant.

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

E. SSM/I SEA ICE ALGORITHM VALIDATION EFFORTS

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

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

- (1) position of the sea ice boundary;
- (2) total sea ice concentration;
- (3) multiyear sea ice concentration.

Our results indicate that the use of regional tie points greatly increases the accuracy of sea ice concentration and ice type retrievals. We have developed techniques to overlay SSM/I, Landsat, and to a limited degree, NOAA AVHRR data. In the final months of the project we expect to compare the passive microwave data from SSM/I with radar and airborne passive microwave data. This intercomparison should better define the multiyear ice fraction algorithm.

F. CIRCULATION INDICES FOR THE ALASKAN SECTOR OF THE NORTH PACIFIC OCEAN

Funding: Pacific Marine Environmental Laboratory (NOAA). R. G. Barry and C. W. Ziskin

Walleye pollock (*Theragra Chalcogramma*) spawning at Shelikof Strait in the western Gulf of Alaska constitute a valuable international fishery resource with a total catch in 1984 of 306,700 tons (Alton et al., 1987). Under the direction of the Northwest Marine Fisheries Service (NMFS) and the National Oceanographic and Atmospheric Administration's (NOAA) Pacific Marine Environmental Laboratory (PMEL)

the Fisheries Oceanography Coordinated Investigations (FOCI) were initiated in 1986 to study the population dynamics of Shelikof Strait pollock and to assess environmental factors that may influence the recruitment of larval and juvenile pollock into the stock.

Under contract (NOAA-ERL/CIRES Task No. 3) with FOCI, several large-scale indices of atmospheric circulation have been developed for Shelikof Strait in the western Gulf of Alaska. The indices were developed to represent atmospheric variability at different levels and time scales in an attempt to characterize atmospheric forcing of the Alaska Coastal Current system during the three month period April through June, when walleye pollock (*Theragra Chalcogramma*) larvae may be vulnerable to transport, with a resulting impact on mortality. The data used in this study are available on diskette from the authors. (See Barry and Ziskin, 1989.)

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VIII. COMMITTEES

- U.S.-Canadian Great Lakes Ice Information Working Group — C. S. Hanson
- SSM/I Sea Ice Archive Working Team — R. L. Weaver
- Arctic Environmental Data Directory Working Group — R. G. Barry
- EosDIS Science Advisory Panel — R. G. Barry
- SSM/I Products Working Team (SPWT) — R. G. Barry
- Member, Polar Research Board (September 1, 1987-1991) — R. G. Barry
- SCAR representative to ICSU Panel on World Data Centers — R. G. Barry
- NASA SSM/I Validation Team — R. L. Weaver
- Satellite Ocean Data System Science Working Group (SODSSWG) — R. L. Weaver
- SSM/I Sea Ice Archive Working Team (SSIAWT) — R. L. Weaver (interim chairman)
- Panel on Snow Avalanches, Committee on Ground Failure Hazards, National Research Council, National Academy of Sciences — R. L. Armstrong

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

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

IX. MEETINGS

17th Annual International Great Lakes-St. Lawrence Ice Information Working Group — Claire S. Hanson, Cornwall, Ontario, 17 October 1988

NASA Climate Data System Workshop — Claire S. Hanson, 20-22 September 1989, Goddard Space Flight Center. Presentation on WDC/NSIDC activities, passive microwave archiving and quality control issues.

The Oceanography Society (TOS) Inaugural Meeting — Claire S. Hanson, Monterey, 27-30 August 1989. Exhibitor booth shared with JPL/NODS, demonstrating SMMR CD-ROM.

Arctic Environmental Data Directory Working Group — Claire S. Hanson, 13-14 June 1989, NSIDC, Boulder. Local arrangements by C. Hanson.

Polar Research Board — Roger G. Barry, Columbus, 24-27 October, 1988; Washington, DC, 4-5 May 1989

US-Canada Great Lakes Ice Working Group — Claire S. Hanson, Waterloo, Ontario, 11-13 October 1989

International Snow Science Workshop — Richard L. Armstrong, Whistler, B.C., 11-14 October 1989

Conference of Arctic and Nordic Countries on Coordination of Research in the Arctic — Roger G. Barry, Leningrad 12-15 December 1989

AGU — Roger G. Barry, Ronald L. Weaver, Vince J. Troisi, San Francisco, 6-8 December 1988

ONR Advanced Research Initiative Workshop on Arctic Leads — Ronald L. Weaver, Martin W. Miles, Russell C. Schnell, Seattle, 12-14 December 1989

PRB, Permafrost Committee — Roger G. Barry, St. Paul, MN, 5 February 1989

Silverton Avalanche School — Richard L. Armstrong, Silverton, CO, 20-22 January 1989

NASA Information System Strategic Planning Project Workshop — Ronald L. Weaver, Boulder, February 1989

Association of American Geographers — Roger G. Barry, Baltimore, 20-22 March 1989

NASA-SSM/I Validation Team — Ronald L. Weaver, Vincent J. Troisi, Goddard, 11-13 April 1989

US-Canada Joint Ice Working Group — Greg Scharfen, Montbello, Quebec, 2-4 May

URI Science Advisory Meeting — Roger G. Barry, Ronald L. Weaver, Dartmouth, 22-23 June

DOE Workshop on Greenhouse Gas Induced Climate Change — Roger G. Barry, U. of Massachusetts, 8-12 May

DEC Users Society Symposium — Vince J. Troisi, Atlanta, 8-12 May

WDC-A Directors Meeting — Roger G. Barry, Boulder, 6-7 June

WetNet — Richard L. Armstrong, Vince J. Troisi, Madison, 13-15 June

X. PAPERS PUBLISHED DURING FY89

Richard Armstrong

1989 Mass balance history of Blue Glacier, Washington, USA. In: *Glacier Fluctuations and Climatic Change*. J. Oerlemans (ed.), Kluwer Academic Publishers: 183-192.

Roger G. Barry

1988 Comparison of the MSL synoptic pressure patterns of the Arctic as observed and simulated the GISS general circulation model. R. G. Crane, R. G. Barry. *Met. Atmos. Phys.* 39:169-183.

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Ann M. Brennan

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Gregory R. Scharfen

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