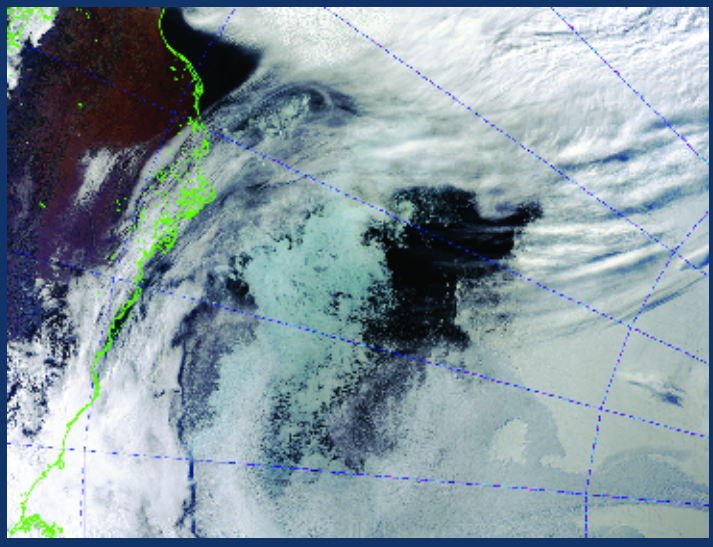
National Snow and Ice Data Center

World Data Center for Glaciology, Boulder



Annual Report 2006

Supporting Cryospheric Research Since 1976

National Snow and Ice Data Center
World Data Center for Glaciology, Boulder
Annual Report 2006

Cover image captions (clockwise from upper left)

During the IceTrek expedition, team members tow a sled with equipment to install on an Antarctic iceberg. (Courtesy Ted Scambos, NSIDC)

This image shows the Beaufort Sea Polynya. A polynya, or area of persistent open water surrounded by ice, appeared during the summer 2006 Arctic sea ice melt season. The polynya is the dark area of open water; to the left is the coastline of Alaska, showing fall foliage color, and to the bottom right is the North Pole. This image is from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor, which flies on the NASA Terra and Aqua satellites. (Courtesy NSIDC)

Toboggan Glacier, Alaska, in 1909. This image one of a pair of photographs available through the "Repeat Photography of Glaciers" portion of NSIDC's online Glacier Photograph Collection. These photograph pairs illustrate the dramatic changes that researchers have observed in glaciers worldwide over the past century. (Photograph courtesy of Sidney Paige/USGS Photo Library, available through NSIDC's online Glacier Photograph Collection).

Members of the IceTrek expedition practiced installing their meteorological equipment on this small Antarctic iceberg, nicknamed "Chip," before installing the equipment permanently on larger icebergs. (Courtesy Ted Scambos, NSIDC)

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In October 2006, the National Snow and Ice Data Center (NSIDC) celebrated the 30th year of operating the World Data Center (WDC) for Glaciology in Boulder. NSIDC hosted a one-day seminar on 25 October to mark the occasion and to acknowledge the contributions of Dr. Stan Wilson of the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite, Data, and Information Service. Wilson's efforts were instrumental to the NASA Polar Oceanography Program, the Distributed Active Archive Centers (DAACs), and their predecessor Pilot Data Systems. The seminar agenda consisted of four themes, with speakers and scientists involved in the development of the NASA Polar Oceans Program and the Boulder WDC:

- The introduction of satellite remote sensing to snow and ice monitoring
- Glacier monitoring from field photography to space sensors
- From the International Geophysical Year (1957) to the International Polar Year (2007)
- The evolution of Data Systems and future challenges: From paper collections to Pilot Ocean Data System/NASA Ocean Data System to DAACs

During 2006, NSIDC also engaged in a range of collaborative efforts to support the cryospheric community, discuss research findings, develop new data products, and utilize new data visualization techniques.

- In March, NSIDC and the International Polar Year (IPY) Programme Office hosted a data management workshop for the IPY at the British Antarctic Survey in Cambridge, England.
- In May, NSIDC, hosted a workshop, "Antarctic Peninsula Climate Variability: Observations, Models, and Plans for IPY Research."
- In May, scientist Mark Serreze participated in a Congressional Briefing to discuss "Recent Scientific Findings of Arctic Environmental Change."
- In May, NSIDC expanded data visualization capabilities, making a select set of data viewable through the popular interactive desktop application, Google Earth.
- In July, NSIDC supported the First Annual Virtual Globes Scientific Users Conference, which was held in Boulder, Colorado.
- In August, five NSIDC staff attended the first Asian Conference on Permafrost, held in Lanzhou, China.

NSIDC staff were also recognized for their contributions to cryospheric research. In February 2006, Mark Serreze and Roger Barry received the award for Best Book of 2005 from the Atmospheric Science Librarians International for *The Arctic Climate System*, published by Cambridge University Press. On October 13, Roger Barry presented the Goldthwait Lecture, "Arctic Ocean-Ice-Atmosphere Interactions," and received the Goldthwait Polar Medal from the Byrd Polar Institute at Ohio State University.

NSIDC/WDC will make fundamental contributions to cryospheric science and will excel in managing data and disseminating information in order to advance understanding of the Earth system.

Roger G. Barry
Director
NSIDC/World Data Center for Glaciology, Boulder

Highlights

NSIDC director receives Goldthwait Polar Medal

Roger Barry was awarded the 2006 Goldthwait Polar Medal, given in recognition of his outstanding contributions to polar research. Barry presented the Goldthwait Lecture, "Arctic Ocean-Ice-Atmosphere Interactions," on 13 October 2006 at the Byrd Polar Research Center in Columbus, Ohio.

NSIDC scientists receive award for textbook

Mark Serreze and Roger Barry received the award for Best Book of 2005 from the Atmospheric Science Librarians International (ASLI) for their book *The Arctic Climate System*. ASLI presented the award at the February American Meteorological Society meeting. *The Arctic Climate System* provides a comprehensive and accessible overview of Arctic exploration, research, physical characteristics, and climatic features.

NSIDC monitors declining winter and summer sea ice in the Arctic

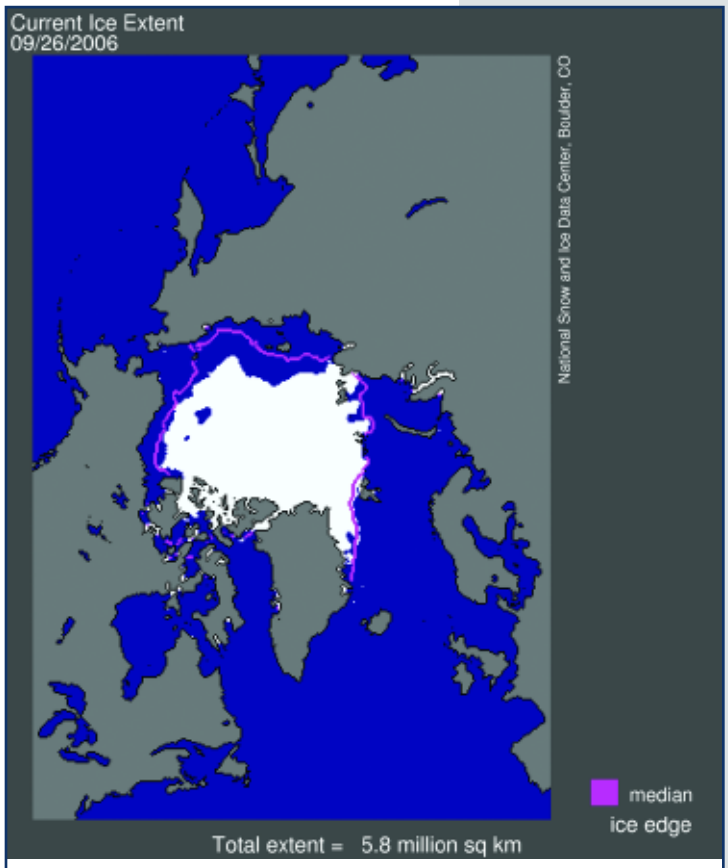
Scientists at NSIDC announced that March 2006 showed the lowest Arctic winter sea ice extent since the beginning of the satellite record in 1979. In October 2006, NSIDC reported that summer sea ice fell below normal for the fifth year, despite cool temperatures in August. This decline continues a trend of sharply decreasing Arctic sea ice, raising further concern that the Arctic is responding to greenhouse warming. The spring and fall sea ice announcements received international press attention, and several NSIDC scientists gave interviews that appeared in dozens of media outlets.

NSIDC scientists speak about the Arctic and Arctic sea ice decline

NSIDC scientists Walt Meier and Julienne Stroeve discussed Arctic sea ice decline during a presentation, "Melting Away? Views of Arctic Sea ice," given at the Denver Museum of Nature and Science in January 2006.

Senior scientist Mark Serreze was one of three speakers at a May 2006 Congressional briefing, "Recent Scientific Findings of Arctic Environmental Change." The briefing, sponsored by the non-profit Arctic Research Consortium of the United States, explained the science behind the recent news coverage of ongoing environmental change in the Arctic. Serreze specifically discussed Arctic climate change and interactions between the atmosphere, oceans, and sea ice.

Mark Serreze also participated in a press conference, "Arctic warming and its impacts," at the 2006 Fall American Geophysical Union Meeting to discuss recent changes in Arctic sea ice and the system as a whole.



Fall 2006 had the second-lowest average September Arctic sea ice extent on record. The white area indicates sea ice extent, gray areas indicate land, and the magenta line indicates the average September sea ice extent from 1979 to 2000. Note the polynya, or area of open water surrounded by sea ice, in the Beaufort Sea north of the Alaskan coast. (Courtesy NSIDC)

NSIDC staff members complete IceTrek

NSIDC lead scientist Ted Scambos and staff member Rob Bauer participated in IceTrek, a field mission to study the breakup of Antarctic icebergs. As part of an international team, they installed weather instruments, a video camera, and snow sensors on the surface of two large tabular icebergs: AMIGOSberg and A22A. These instruments and sensors are designed to transmit continuous, high-resolution observations that will supplement satellite data and help the research community understand the processes behind iceberg drift and breakup.

NSIDC hosts the Antarctic Peninsula Climate Variability workshop

NSIDC hosted a two-day international workshop, from 14 to 16 May 2006, on the ice and climate system of the Antarctic Peninsula. Participants discussed recent research results and possible logistical cooperation for future research during the International Polar Year (IPY). The meeting format included a series of invited keynote talks, contributed talks, and a poster session.

NSIDC prepares for the International Polar Year (IPY)

NSIDC released Glaciological Data Report 33, *International Polar Year Data Management Workshop, 3–4 March 2006*, a report that compiles recommendations from a data management workshop. Participants developed specific recommendations on engaging archives, data discovery and access methods, standards and interoperability, and ways to ensure that all International Polar Year (IPY) data are captured and readily available. NSIDC also released the Discovery, Access, and Delivery of Data for IPY (DADDI) Web site. DADDI is a NASA-supported project to improve the availability of arctic coastal data and develop a system that can be readily extended to support IPY.

NSIDC makes data available through Google Earth

NSIDC made a select set of data viewable through the popular interactive desktop application, Google Earth. Distributions of permafrost, snow, and ice are displayed as overlays on the Google Earth base map. Snow and ice information is updated daily. The glacier photographs are indicated by individual “push pins” that reveal the actual photograph when clicked.

IceTrek team members tow a sled with equipment to install on an Antarctic iceberg. (Courtesy Ted Scambos, NSIDC)

Data Management at NSIDC

NSIDC serves the scientific community by making cryospheric and other data accessible and useful to researchers around the world. We manage scientific data on behalf of our research communities, in turn supporting the quality, efficiency, and innovativeness of the research that depends on these data.

Our collaborative approach to data management supports an increasingly complex scientific enterprise and contributes to advances in scientific understanding of the frozen places of our Earth and their relationship to Earth systems as a whole. NSIDC involves teams of data managers and scientific programmers, plus researchers specializing in frozen ground, glaciers, ice sheets, sea ice, and snow. These experts work together to understand the evolving needs of our research communities and so to refine our data and information services.

NSIDC distributes hundreds of data sets, adds new data sets on a continual basis, extends temporal coverage of existing data sets, and publishes new data algorithms and versions using refined processing methods that represent the most current scientific methodologies for retrieving parameters from remote sensing data. Much more than physically housing and distributing data, we disseminate scientific data that is accessible, discoverable, understandable, reliable, and stable.

During the International Polar Year (IPY) 2007 to 2009 and beyond, NSIDC will continue its legacy of providing data management services to IPY researchers.

Data centers

NSIDC includes several data centers, each focusing on a particular objective defined by the sponsoring agency. These data centers allow NSIDC personnel to develop strong connections to data providers and to maintain expertise in their methods and topics, whether satellite or ground observations, Arctic or Antarctic, or specialized fields such as frozen ground research. In 2006, NSIDC contained these data centers, whose highlights are featured in the following section of this report.

Data Center	Focus
The Arctic System Science (ARCSS) Data Coordination Center (ADCC)	NSF-funded Arctic System Science Program data
U.S. Antarctic Data Coordination Center (USADCC)	U.S.-funded Antarctic scientific data
Antarctic Glaciological Data Center (AGDC)	Antarctic glaciological and cryospheric system data collected by the U.S. Antarctic Program
The Frozen Ground Data Center (FGDC)	Data related to permafrost and seasonally frozen ground
Global Land Ice Measurements from Space (GLIMS)	Inventory of critical information about the extent and rates of change of the world's estimated 160,000 glaciers
International Polar Year Data and Information Service (IPYDIS)	A coordination office for the IPYDIS, a global partnership of data centers, archives, and networks working to ensure proper stewardship of IPY and related data
NASA Distributed Active Archive Center (NSIDC DAAC)	Snow and ice data from NASA's past and current Earth science research satellites and field measurement programs
NOAA at NSIDC and the World Data Center for Glaciology, Boulder (WDC)	Snow and ice in situ data, data rescue, and data sets from operational communities such as the U.S. Navy

Product teams

Product teams at NSIDC focus on ingesting and processing data, assuring data quality, and publishing new data sets for access by researchers. Using well-defined processes, cross-functional teams of data operations specialists, scientists, scientific programmers, user support experts, technical writers, and Web designers manage quality control, documentation, accessibility, and scientific and technical aspects, such as adjustments to data processing. Data operations staff provide feedback to scientists and developers about problems observed during processing, which leads to improvement in the quality of the product. Product teams provide suggestions on organization of the data, which improves accessibility and ease of use.

NSIDC scientists and scientific programmers

Scientists at NSIDC serve on product teams, collaborate on special research topics such as sea ice measurement or frozen ground studies, perform research with the data, and create new data sets in response to research questions. Because they understand the research questions in these fields and how researchers want to use data, their contributions ensure that NSIDC data, documentation, discovery, and access meet the needs of the research community. NSIDC researchers specialize in numerous topics in snow, glaciers, sea ice, frozen ground, ice shelves, polar oceanography, and polar meteorology. Several researchers specialize in remote sensing methods for specific parameters.

Metadata and catalog

For each data set, NSIDC generates metadata records. Metadata, which are data about the data, provide documentary and descriptive information about each data set. These metadata, in turn, enable data discovery, support understandability and stability of data, and support its long-term preservation and access. NSIDC staff maintain knowledge of evolving metadata standards, including FGDC and ISO standards. Metadata is increasingly used on the World Wide Web to share information about data holdings and enable discovery through multiple search portals. NSIDC provides metadata to the NASA Global Change Master Directory (GCMD) on an ongoing basis to enable discovery of our data and has engaged in discussions with other search portals to enhance the dissemination and value of our data.

Data discovery

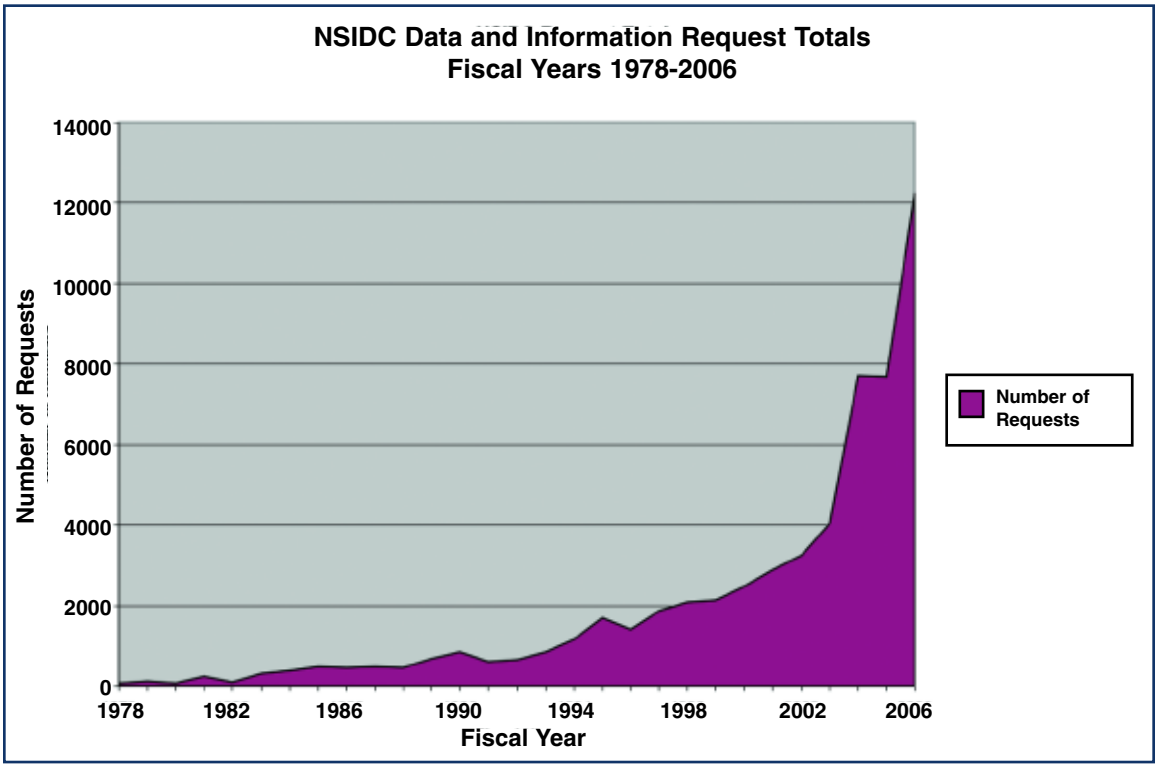
NSIDC offers multiple data search, access, and distribution capabilities, based on the demands of particular data sets and projects. Satellite remote-sensing data, for example, require sophisticated search, subsetting, and ordering tools, while in situ data sets may be easily searched by science parameter and downloaded through FTP. Programming staff at NSIDC work continuously with NSIDC scientists and User Services to develop search mechanisms that more closely match the needs of data users. Data Operations specialists and User Services staff work one-on-one with users who have unique issues with access to data, to help them get data as efficiently as possible (for example, users who need long time-series data and have no easy way to identify the thousands of granules they want).

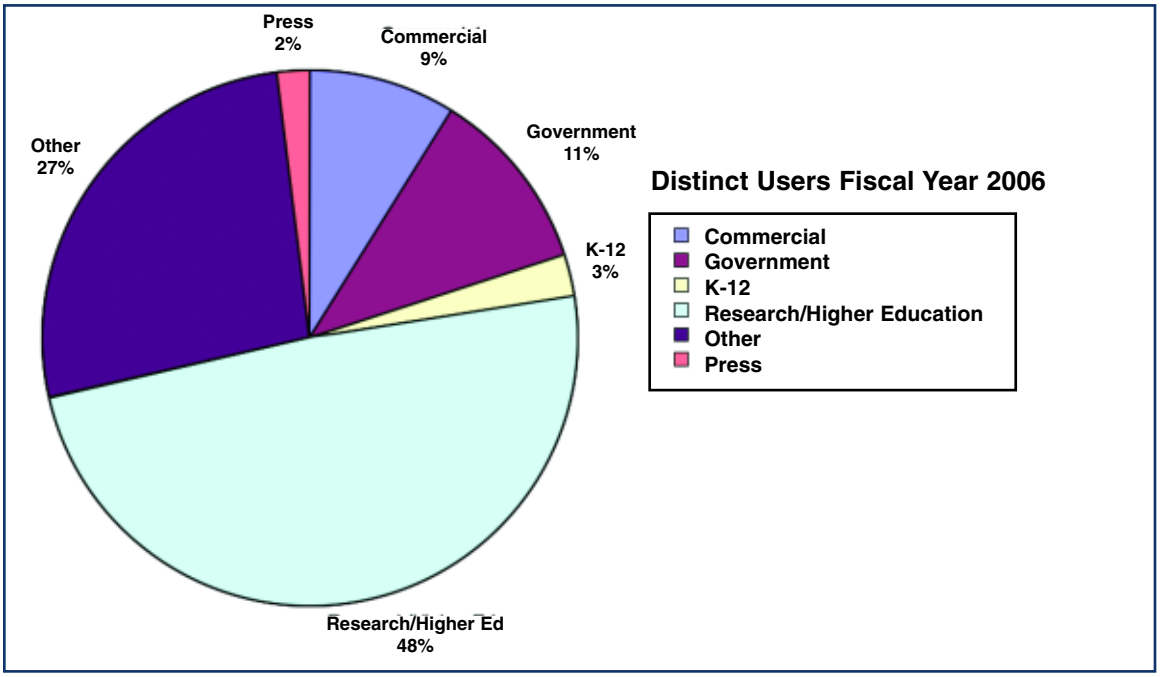
Data quality

NSIDC product teams strive to ensure that data are of the highest possible quality for scientific research. Data quality activities may range from statistical checks of data integrity and completeness, to researching and assimilating techniques for development of data sets, design, analysis, software development, production, user interface, scientific interpretation, and data delivery. Operations team members monitor data production to detect processing errors quickly. We maintain close ties with external and internal developers to expedite problem identification and resolution, and identify “beta testers” who get early access to the data to provide additional feedback on technical issues about the data.

User services

NSIDC's User Services Office (USO) consists of specialists who maintain scientific and technical knowledge about the data we distribute. These specialists are also experts in user needs and represent those needs on product teams, helping to ensure data and documentation usability. They are the first point of contact for all user inquiries; they provide prompt responses to requests, solve problems, and research user questions about data. USO also helps educate data users on our holdings through e-mail broadcasts, development of cryospheric parameter brochures, scientific conferences, and our quarterly data newsletter, *NSIDC Notes*. To ensure prompt response and resolution, USO tracks user requests. The following charts depict historical growth in user requests, broken down by type of request and by type of user.





Information Center

NSIDC data include a unique, specialized research collection focusing on the cryosphere. This collection is open to researchers who visit NSIDC and includes published and unpublished analog materials on snow cover, land and sea ice, cold climates, and frozen ground, as well as digital data such as CD-ROMs and Web resources. Our Information Center contains more than 44,000 monographs, serials, journal articles, reprints, videos, maps, atlases, and CD-ROMs. It currently receives more than 100 periodicals and newsletters relating to the cryosphere and to remote sensing of ice and snow. The Center's collection also includes many hard-to-locate international journals dating back well into the mid-twentieth century, as well as many foreign-language materials. Our Information Center catalog can be searched on site or through the Web, as part of the Arctic and Antarctic Regions Database published by the National Information Services Corporation (NISC). Our analog data archives include rare field notebooks, photographs, ice charts, and other research materials.

NSIDC on the Web

NSIDC's primary interface to the world is through our Web site (http://nsidc.org). Users may obtain general information about data offerings, search the data catalog, use our search and ordering tools, obtain data, and obtain data set documentation. Our site also provides general information about the cryosphere and research developments to the public, press, educators, and students. The NSIDC Web site receives several million visitors each year. Many of these visitors are seeking general information about the cryosphere, such as about glaciers, snow, or ice. See the Outreach section below for more information about the Web content we host for these visitors.

Scientific data users can obtain information on all of our data holdings using our Web site, and can download many products directly from the Web using FTP. Users can also search for and create distribution requests for larger data sets, in particular remote sensing data and data subsets. NSIDC product teams include technology experts, user interface design specialists, and professional designers and writers who focus on making interactions with our site efficient, intuitive, and productive. During 2006, we enhanced several content areas to improve content and ease of use, and completed a new Web page and navigation design to enhance site usability, for implementation during 2007.

Outreach

NSIDC scientists and writers research, create, and maintain "The Cryosphere" section of NSIDC's Web site (http://nsidc.org/cryosphere/), which contains educational materials about snow, ice, glaciers, sea ice, Arctic meteorology, and other cryospheric topics of interest to K–12 students and the public. We developed a new Cryosphere Glossary, providing a unique resource for people to learn this specialized terminology. The glossary is searchable, and the terms can also be linked from pages throughout the site. Many definitions include photographs, and some have Russian translations.

During 2006, outreach and user services staff once again helped scientists explain the continued strong decline of Arctic sea ice at the end of summer 2006, which barely missed setting a new record low. To help respond to the barrage of inquiries and provide a more in-depth analysis of current ice conditions, we posted a sea ice blog throughout the melt season. The blog, updated when changes in conditions warranted, provided much-requested scientific analysis and images to the scientific community and the public and was followed by many in the news media as a trusted source of information on sea ice decline. In addition, we produced a QuickTime animation of sea ice decline from 1979 to 2006, presented on Google Earth, which was easily accessed through the Web. The animation was featured in the International Polar Year (IPY) international opening ceremonies in Paris and became a popular visual resource for both scientists and news media.

Also during 2006, we issued the twelfth annual science feature publication on behalf of the NASA EOSDIS data centers (of which the NSIDC DAAC is one), *NASA: Supporting Earth System Science 2006*. This 56-page print publication and accompanying Web site cover intriguing research uses of NASA's remote sensing data, in feature-story format with color data images. The complete publication is available online, and stories are republished on the EOSDIS data centers Web site, "NASA Earth System Science Data and Services" (http://nasadaacs.eos.nasa.gov/). NSIDC publications staff research and write ten to twelve articles each year and design and produce the print publication and Web site to help the centers promote interest in their data products. This publication continues to be a popular educational piece for NASA audiences and also generates interest among potential data users.

In 2006, NSIDC updated "The Cryosphere" Web page (http://nsidc.org/cryosphere) to provide easier access to educational material. (Courtesy NSIDC)

The Distributed Active Archive Center (DAAC)

The NSIDC Distributed Active Archive Center (DAAC) serves scientists, educational communities, and the general public by providing cryospheric, land, and ocean data and information. The primary goal is to provide easy and reliable access to Earth Observing System (EOS) satellite data, ancillary in situ measurements, relevant baseline data, model results, and algorithms relating to cryospheric and polar processes. The NSIDC DAAC, in its fourteenth year of operation, is an integral part of the multiagency-funded efforts at NSIDC to provide snow and ice data and information management services.

The DAAC manages products from the following instruments:

- Moderate Resolution Imaging Spectroradiometer (MODIS)
- Advanced Microwave Scanning Radiometer–EOS (AMSR-E)
- Geoscience Laser Altimeter System (GLAS)
- Special Sensor Microwave/Imager (SSM/I) and the follow-on Special Sensor Microwave Imager/Sounder (SSMI/S)
- National Oceanic and Atmospheric Administration (NOAA) Advanced Very High-Resolution Radiometer (AVHRR)
- RADARSAT Antarctic Mapping Mission (RAMP) mosaic data

Ron Weaver is the DAAC manager, Marilyn Kaminski is the deputy DAAC manager and senior systems engineer, and Roger Barry is the senior DAAC scientist.

The Year in Summary

All data product sets from MODIS on Aqua and Terra, AMSR-E on Aqua, and GLAS on ICESat continue to be ingested, archived, and distributed. Operations during the year were routine. By the end of 2006, the NSIDC DAAC held 98 terrabytes (TB) of data and 6.1 million data granules. Throughout 2006, NSIDC distributed 53 TB of data, an average of 4,419 gigabytes (GB) of data per month, up from 2,368 GB per month in 2005. This increase in distribution is encouraging and indicates wider use of all types of products and data sets.

In January 2006, the NSIDC DAAC became the first NASA data center to undergo a science products review. The NSIDC DAAC Data Priority Workshop was the first of several sessions to assess the data holdings of the DAACs and related data activities within the NASA Earth Observing System Data and Information System (EOSDIS). NASA Headquarters sponsored and chaired the workshop at NASA Goddard Space Flight Center. Representatives of the DAAC and NASA's EOSDIS Project Office presented information about product histories and usage by the community. Product developers were asked to attend to provide information on product theoretical basis, quality and accuracy, usage, and science value. The seven invited participants examined the science data products and were asked to provide recommendations for each specific product or product suite. The PDF version of the workshop report may be downloaded from the NSIDC extranet (http://extranet.nsidc.org/nasa/daac/podag/prod_rev/report_ver06.pdf).

Science Data Operations

GLAS Data from ICESat

(http://nsidc.org/daac/glas/)

The Geoscience Laser Altimeter System (GLAS) is the sole instrument on the Ice, Cloud, and land Elevation Satellite (ICESat), which was launched in January 2003. The GLAS instrument provides high-resolution elevation data that will improve understanding of ice sheet mass balance in the Polar Regions. NSIDC archives and distributes 15 products, including Level-1A, -1B, and -2 laser altimetry and atmospheric LIDAR data. The initial data stream was approximately 20 GB per day, but was not sustained due to problems with the instrument. These problems have been ameliorated by not running the lasers continuously, but intermittently instead.

Thus far, there have been three campaigns each year, most of them lasting about 33 days each. Details about the mission, science algorithms, and products are available at the NSIDC GLAS Web site.

Moderate Resolution Imaging Spectroradiometer (MODIS) Products
(http://nsidc.org/data/modis/)
The Moderate Resolution Imaging Spectroradiometer (MODIS) is an optical 36-spectral-band instrument, aboard the NASA Earth Observing System (EOS) Terra and Aqua satellites, that provides daily global coverage at spatial resolutions of 250, 500, and 1,000 meters. NSIDC archives and distributes MODIS snow and sea ice products, and helps guide the development of these products through close interaction with the NASA development team. On 18 December 2006, NSIDC released Version 5 (V005) of the Terra MODIS snow and sea ice data products. This version contains the following improvements:

- Monthly snow products are available in a Climate Modeling Grid (CMG) format.
- Fractional snow cover was added to MOD10_L2 and MOD10A1 products.
- Browse images are available for all products.
- All products use HDF compression making the file size much smaller.

Once reprocessing is complete in mid-2008, MODIS V005 data will extend from 24 February 2000 to present. The NSIDC DAAC continued its outreach to the MODIS user community through numerous avenues in 2006.

AMSR-E data from AQUA
(http://nsidc.org/daac/amsre/)
The Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) is a mission instrument launched on NASA's Aqua Satellite on 4 May 2002. The Aqua mission provides data for multidisciplinary studies of the Earth with a special emphasis on oceans. NSIDC has been archiving the Level-0 data since the Aqua launch and will continue to do so for the life of the mission. NSIDC will archive and distribute all 16 standard data products, including Level-1A, -2A, -2B, and -3 data. During 2006, NSIDC made Release-26 and Release-28 data available. NSIDC also released two related products: AMSR-E Daily Ease-Grid Brightness Temperatures and AMSR-E/Aqua Daily Global Quarter-Degree Gridded Brightness Temperatures. Details about the mission, science algorithms, and products are available at the NSIDC AMSR Web site.

AMSR-E Validation Data Management
(http://nsidc.org/data/amsr_validation/)
NSIDC is supporting the AMSR-E product validation activities by hosting a Web site portal to all AMSR-E validation experiments, including soil moisture, rainfall, and cryospheric validation campaigns. NSIDC provides documentation (user guides) as well as metadata (GCMD DIFs) for AMSR-E validation experiments and collaborates with the AMSR-E Science Investigator-Led Processing Systems (SIPS) to provide scientists in the field (Arctic and Antarctic ship and flight campaigns) with quick, easy access to subsetted and reformatted data for their experiments.

Non-EOS Passive Microwave Data Products and EASE-Grid Products

Polar Stereographic Products

Bootstrap Sea Ice Concentrations
(http://nsidc.org/data/nsidc-0079.html)

NASA Team Sea Ice Concentrations
(http://nsidc.org/data/nsidc-0051.html)

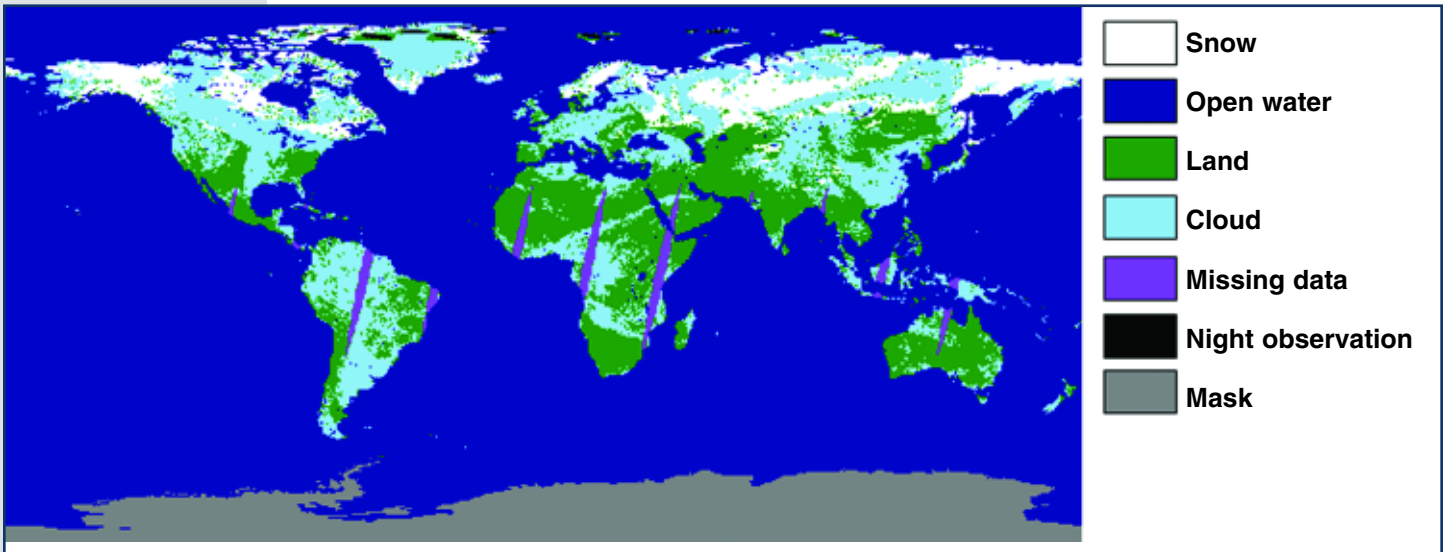
The NSIDC polar stereographic standard sea ice products were routinely updated, and Goddard sea ice time series products were updated through 2006 for both Bootstrap and NASA Team data sets. Accompanying ancillary products of ice area/extent, monthly climatologies, and GIS files were also updated. The distribution method of the NASA Team product was changed from CD-ROM to FTP. The complete archive of both products is also available online.

DMSP SSM/I Daily Polar Gridded Brightness Temperatures
(http://nsidc.org/data/nsidc-0001.html)
NSIDC is now distributing Version 2 of this data set. Changes included correcting an error in the 1987 to 1999 data, fully distributing the data through FTP, converting the data files from HDF to binary, and creating a new file naming convention.

Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I Passive Microwave Data
(http://nsidc.org/data/nsidc-0051.html)
This product was updated in 2006 to include new, preliminary data for users who need more current data, a new file naming convention, a new FTP directory structure, and updated documentation.

Near Real-Time DMSP SSM/I Daily Polar Gridded Sea Ice Concentrations
(http://nsidc.org/data/nsidc-0081.html)
This product was updated in 2006 to include a new binary data format, a new file naming convention, a new FTP directory structure, and updated documentation.

EASE-Grid products
(http://nsidc.org/data/ease/)
Regular processing continued for the products in all three Equal-Area Scalable Earth Grid (EASE-Grid) projections. The processing maintained pace with ingest from Remote Sensing Systems. CD-ROM production was discontinued and replaced with online FTP access to the complete SSM/I time series of all three Equal-Area Scalable Earth Grid (EASE-Grid) projections. FTP files are now available to users immediately upon production, with no delays for CD-ROM production.



This Moderate Resolution Imaging Spectroradiometer (MODIS) image shows global daily snow extent on 3 April 2003. The image is derived from MODIS/Terra Snow Cover Daily L3 Global 0.05 degree Climate Modelers Grid data, and is part of NSIDC's MODIS Image Gallery. (Courtesy NSIDC)

Outreach and Collaboration

NSIDC staff completed several improvements to the NSIDC Web site, and the Web team analyzed the site in preparation for revisions to the content organization and usability. The science communications group also updated the following sections of the NSIDC Web site.

- Education Center: The Cryosphere (http://nsidc.org/cryosphere/index.html)
  NSIDC reorganized this section of the Web site, and it is now more suited for the general public. The science communications group also added "All About the Cryosphere," a collection of general information about Earth's cold regions.
- State of the Cryosphere (http://nsidc.org/sotc/)
  The Ice Shelves section was updated to highlight ice shelf responses to climate change.
- All About Snow (http://nsidc.org/snow/)
  NSIDC staff developed a collection of Web sites focused on snow data.
- Image Gallery of MODIS Snow and Sea Ice Products
  (http://nsidc.org/data/modis/gallery/index.html)
  NSIDC staff developed this site to provide several representative MODIS snow and sea ice images, accompanied by explanatory text, as well as links to other MODIS imagery sources.

Arctic sea ice decline press coverage

NSIDC's outreach coordinator developed a Web page to provide information to the media about the 2006 Arctic sea ice minimum. Regular updates provided sea ice conditions throughout the end of the Arctic summer melt season and included images, links to NSIDC's Sea Ice Index, and related press releases. The outreach coordinator also fielded press inquiries and helped coordinate interviews with NSIDC scientists.

DAAC Alliance Annual

(http://nasadaacs.eos.nasa.gov/).

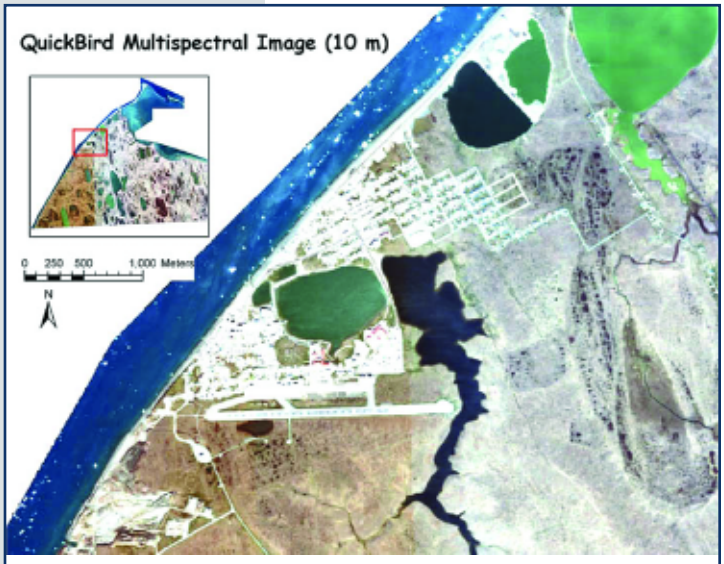
As a member of NASA's DAAC Alliance, the NSIDC DAAC published the 12th edition of the DAAC Alliance Annual, *NASA: Supporting Earth System Science 2006*, a multidisciplinary publication that highlights applications and research uses of data from NASA's Earth Observing System satellites. Articles from the 2006 DAAC Alliance Annual are also available electronically on the DAAC Alliance Web site.

For more information, visit the DAAC Web site (http://nsidc.org/daac/)

Arctic System Science (ARCSS) Data Coordination Center (ADCC)

The Arctic System Science (ARCSS) Data Coordination Center (ADCC) at NSIDC is the data archive for the ARCSS Program. Since 1991, the National Science Foundation has continuously funded the ADCC at NSIDC. The purpose of the ADCC is to present and archive ARCSS related research data on the ADCC Web site, to prepare metadata for submission to the Global Change Master Directory (GCMD), and to provide long-term storage of data within its archive. The ADCC Web site provides tools for data discovery using the name of the Principal Investigator (PI), the project title, the measured parameter, geographical location, or keywords. An online Metadata Submission Form is a part of the data submission process and is the starting point for all PIs who wish to submit their data sets to the ADCC.

Chris McNeave is the data coordinator and Lindsay Husted is the technical writer, in addition to several other staff members who work on this project as required. Rudolph Dichtl is the ADCC manager and PI and Dr. Roger Barry is Co-PI. They both lead the ADCC activities at NSIDC. During 2006, ADCC received and processed 30 data sets, each indicating a submission of a new or updated ARCSS data set for publication.



This image shows a sample of the ARCSS data product, High-Resolution Quickbird Imagery and Related GIS Layers for Barrow, Alaska. (Courtesy NSIDC)

Featured Data Products

High-Resolution QuickBird Imagery and Related GIS Layers for Barrow, Alaska, USA
(http://nsidc.org/data/arcss304.html)
This data set contains QuickBird satellite imagery and related Geographic Information Systems (GIS) layers. These products share a common projection, spatial extent, and data format. The primary QuickBird data were acquired by DigitalGlobe from 1 to 2 August 2002, and consist of orthorectified satellite imagery. This product is distributed as a four-DVD set for the restricted high resolution product and through FTP for the unrestricted reduced resolution version.

North Pole Environmental Observatory PMEL/CRREL 2000–2003 Ice Temperature and Mass Balance Buoy Data
(http://nsidc.org/data/arcss128.html)
This data set contains ice temperature and mass balance data from drifting ice buoys near the North Pole in the Central Basin of the Arctic Ocean. Buoys were deployed each April by the Pacific Marine Environmental Laboratory (PMEL) and the Cold Regions Research and Engineering Laboratory (CRREL). Data are available through FTP.

Cloud-Radiation Feedback: Boundary Layer Cloud Microphysical Properties and Processes
(http://nsidc.org/data/arcss140.html)
This data set includes Surface Heat Budget of the Arctic (SHEBA) cloud microphysical data collected onboard the National Center for Atmospheric Research (NCAR) C-130 aircraft. This work focused on improving the quality of algorithms used to process in situ measurements collected during the First International Satellite Cloud Climatology Project Regional Experiment/ Arctic Cloud Experiment project, and then applying the results to the analysis of five case studies. Data are distributed on CD-ROM.

Resource Allocation and Allometry of Plant Growth at Selected Sites in the Arctic: 2003–2005 Growing Seasons

(http://nsidc.org/data/arcss164.html)

This data set consists of measurements from Arctic field sites during the summer months from 5 July 2003 to 5 August 2005 as part of the Land-Atmosphere-Ice Interactions (LAII) International Tundra Experiment (ITEX). Investigators designed this research, which compares an extensive range of vegetation types that exists in widely-separated sites, to help identify the relative vulnerability of different vegetation types, plant functional types, and species to climate change and other forms of disturbances. Data are distributed by FTP.

Estimating Sea Ice Floe Velocities to Characterize Whaling Seasons Using Satellite Imagery of the Chukchi and Beaufort Seas, Spring 2000 and 2001

(http://nsidc.org/data/arcss149.html)

Containing SAR images from the RADARSAT and the ERS-2 satellites along with broadband visible and infrared images from the AVHRR satellite, these data cover two spring whaling seasons in the Chukchi and Beaufort Seas from March to June in 2000 and 2001.

Time Series of Seasonally Frozen Ground Depth in the Russian Arctic, 1930–1990

(http://nsidc.org/data/arcss166.html)

This product consists of seasonally frozen ground depth measurements based on soil temperatures in the Russian Arctic. Investigators constructed a record that extends from 1930 to 1990 using data from 211 ground-based stations.

SHEBA Upper Ocean CTD and Thermal Microstructure, Western Arctic Ocean

(http://nsidc.org/data/arcss151.html)

This data set includes conductivity, temperature, and depth (CTD) measurements along with turbulent thermal variance, turbulent kinetic energy, and vertical temperature gradient data collected from 12 October 1997 to 30 September 1998 in the Western Arctic Ocean.

Coring Data from Drained Thaw-Lake Basins of the Arctic Coastal Plain, Alaska

(http://nsidc.org/data/arcss143.html)

This product includes measurements and observations from drained thaw-lake basin (DTLB) cores retrieved from Barrow and Atqasuk, Alaska, in April and August of 2001 through 2003.

Model Output of Active Layer Depth in the Arctic Drainage Basin, 1979–2001

(http://nsidc.org/data/arcss158.html)

To create this data set, the Frozen Ground Model was applied to the entire Arctic Drainage Basin to produce active layer depth measurements. The model is driven by 2-meter air temperatures from the ERA-40 European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis.

SHEBA Ocean Turbulence Mast Data Archive

(http://nsidc.org/data/arcss142.html)

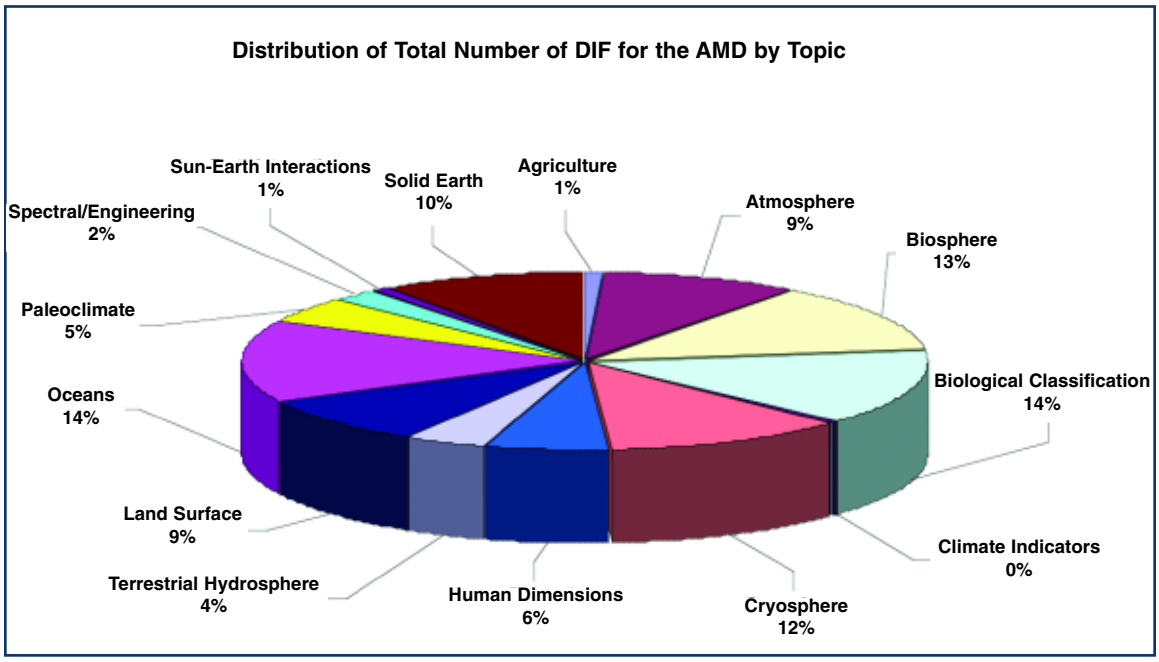
This data set includes a time series of temperature, conductivity, salinity, three-dimensional velocity, pressure, and magnetic heading at multiple levels in the boundary layer under the drifting ice floe in the western Arctic Ocean.

For more information, visit the ADCC Web site (http://nsidc.org/arcss/)

U.S. Antarctic Data Coordination Center (USADCC)

Since 1996, the National Science Foundation (NSF) has funded the U.S. Antarctic Data Coordination Center (USADCC) at the National Snow and Ice Data Center (NSIDC) to facilitate the development of U.S. data set descriptions for inclusion in the Antarctic Master Directory (AMD), a node of the Global Change Master Directory (GCMD). The AMD contains metadata for multidisciplinary Antarctic scientific data collected by 26 countries, under the auspices of the Scientific Committee on Antarctic Research (SCAR) and the Council of Managers of the National Antarctic Programs (COMNAP). Internal to the United States, USADCC provides a national focal point for this activity, by assisting scientists with metadata directory tools, formats, and requirements, and by providing assistance to researchers with a host of related data management issues.

Internationally, USADCC represents the United States in the continuing international collaborative effort to develop, implement, and maintain the AMD. United States-contributed metadata records in the AMD numbered 930 in July 2006. AMD use represents a considerable fraction of total GCMD usage. The USADCC Web site provides information to contributing scientists and users of the AMD, including access to tools, tutorials, and NSF data policies. Rob Bauer and Clark Judy lead the USADCC activities at NSIDC.



For more information, visit the USADCC Web site (http://nsidc.org/usadcc/)

Antarctic Glaciological Data Center (AGDC)

The National Science Foundation's Office of Polar Programs (OPP) funds the Antarctic Glaciological Data Center (AGDC) at NSIDC to provide Antarctic data management and to archive and distribute Antarctic glaciological and cryospheric system data obtained by the U.S. Antarctic Program.

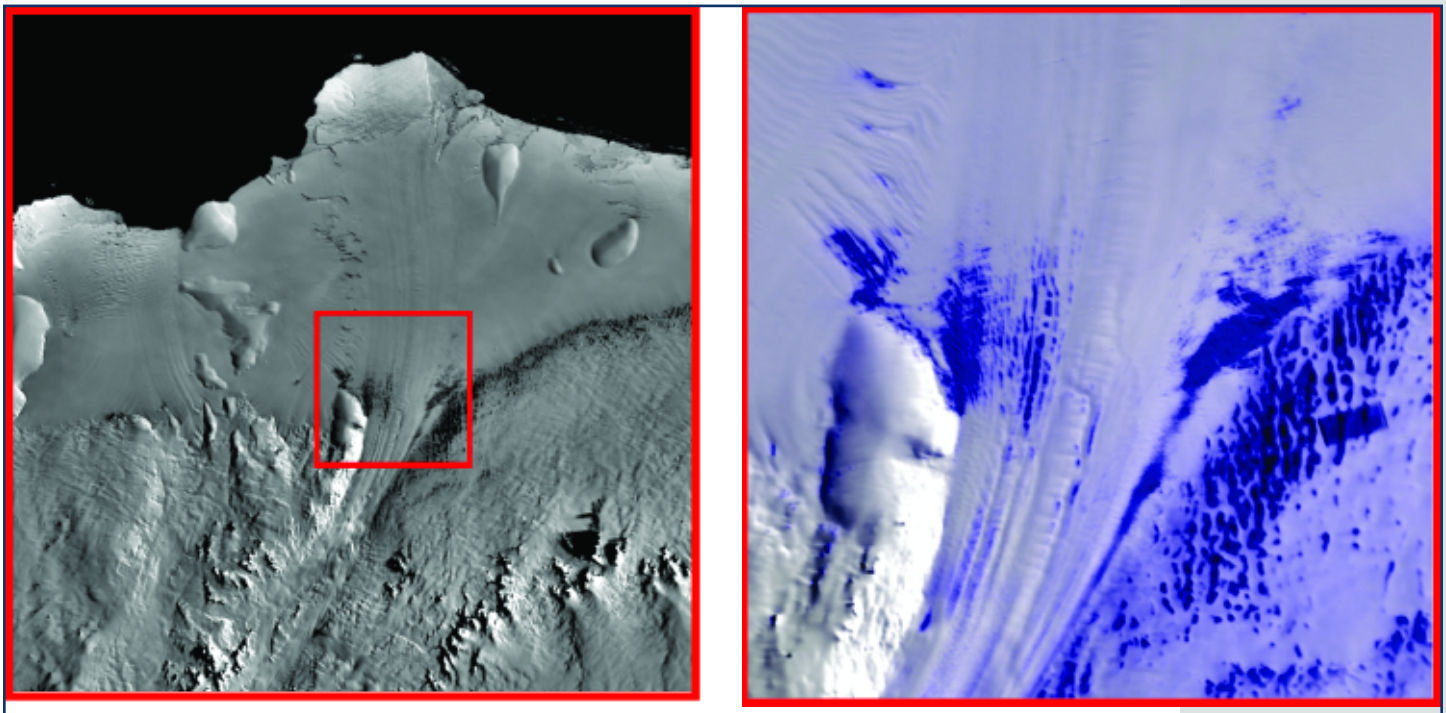
AGDC has two guiding objectives: to accumulate the data record of NSF-funded Antarctic Glaciology grants and to provide glaciology researchers with basic geophysical parameters useful for field planning, modeling, and research.

AGDC provides two types of data: Principal Investigator data sets that hold data acquired by specific grants and compiled products that offer collections of important glaciological parameters. Compiled data archived at AGDC include ice velocity, firn temperature, shallow ice core measurements, geochemical composition of ice cores, snow pit data, and satellite images of ice shelves. AGDC now contains data contributed by 120 Principal Investigators, whose research spans a broad variety of glaciological topics.

Featured Data Products

MODIS Mosaic of Antarctica (MOA) Image Map
(http://nsidc.org/data/nsidc-0280.html)

The Mosaic of Antarctica (MOA), released in 2005, was updated in 2006. Maps are derived from composites of 260 Moderate-resolution Imaging Spectroradiometer (MODIS) orbit swaths acquired between 20 November 2003 and 29 February 2004. The MOA provides a cloud-free view of ice sheets, ice shelves, and land surfaces, and a quantitative measure of optical snow grain size for snow- or ice-covered areas. All land areas larger than a few hundred meters that are south of 60 degrees South are included in the mosaic, as well as persistent fast ice regions and some grounded icebergs present near the coast in the 2003 to 2004 austral summer.



Sub scenes from the MODIS Mosaic of Antarctica (MOA) show Siple Coast at 750 meter resolution (left), and a close-up of Jutulstraumen at a grain size of 125 meters (right). (Courtesy NSIDC)

Atmospheric Nitrate Isotopic Analysis at Amundsen-Scott South Pole Station, A Twenty-Five Year Record

(http://nsidc.org/data/nsidc-0281.html)

This data set contains snow pit measurements of oxygen isotopes in nitrate and ion concentrations, along with supplementary surface measurements of oxygen isotopes in nitrate and in nitrate aerosols from the Amundsen-Scott South Pole Station, Antarctica.

GPR and GPS Data: Characteristics of Snow Megadunes and their Potential Effects on Ice Core Interpretation

(http://nsidc.org/data/nsidc-0282.html)

This data set contains ground penetrating radar (GPR) data showing surface morphology and internal layering structure along with global positioning system (GPS) data collected within an area of 60 square kilometers on the East Antarctic Plateau.

AWS Data: Characteristics of Snow Megadunes and Their Potential Effect on Ice Core Interpretation

(http://nsidc.org/data/nsidc-0283.html)

This data set contains automated weather station (AWS) data from two sites on the East Antarctic Plateau where investigators conducted field research on the Antarctic megadunes. The stations collected snow/firn temperature, air temperature, air pressure, and wind data from 16 January 2004 to 17 November 2004.

Firn Air Chemistry Observations from Siple Dome, 1996, and the South Pole, 2001

(http://nsidc.org/data/nsidc-0290.html)

This data set includes gas ratios in polar firn air. Investigators sampled air from bubbles in the firn-ice transition region to observe and model the processes of gravitational settling, thermal fractionation, and preferential exclusion within the Antarctic snowpack.

Subglacial Topography: Airborne Geophysical Survey of the Amundsen Sea Embayment, Antarctica

(http://nsidc.org/data/nsidc-0292.html)

This data set includes 5 kilometer gridded data from the Airborne Geophysical Survey of the Amundsen Sea Embayment, Antarctica (AGASEA) conducted during the 2004–2005 austral summer. Investigators derived maps of the ice sheet surface and subglacial topography, which covers the entire catchments of both the Thwaites Glacier and the Pine Island Glacier, from airborne survey systems mounted on a Twin Otter aircraft.

Compilation of Antarctic Radar Data, Siple Coast, 2000–2002

(http://nsidc.org/data/nsidc-0274.html)

This data set contains ground-based, ice-penetrating radar profiles across satellite-detected lineations and terrains that were taken in the lower reaches of Ross Ice Stream C, also known as the Kamb Ice Stream (KIS); on Roosevelt Island; on the Siple Dome; and on the Shabtaie Ice Ridge.

For more information, visit the AGDC Web site (http://nsidc.org/agdc/).

Frozen Ground Data Center (FGDC)

The Frozen Ground Data Center (FGDC) continues to support and maintain significant permafrost and related data. Each month, at least 150 to 300 different users download FGDC data. We provide basic user support and updates and corrections to data and documentation, but the lack of funds prohibits further development of the data center. We are working with the International Permafrost Association (IPA) to develop a sustainable data preservation and access strategy. At the Ninth International Conference on Permafrost in Fairbanks in June, we convened a meeting to develop the format and outline for a snapshot of IPY permafrost data as a step toward a new Circumpolar Active Layer Permafrost System compilation and a new and sustainable IPA data strategy.

Featured Data Products

Arctic EASE-Grid Freeze and Thaw Depths, 1901–2002
(http://nsidc.org/data/ggd651.html)
This FGDC data set contains mean, median, minimum, and maximum freeze and thaw depths for each year from 1901 to 2002 on the 25 kilometer EASE-Grid for areas north of 50 degrees. Freeze and thaw depths are estimated using a variant of the Stefan solution that uses an edaphic factor and freezing or thawing indices as inputs.

Northern Hemisphere Seasonal and Intermittent Frozen Ground Areas 1901–2000
(http://nsidc.org/data/ggd650.html)
This FGDC data set contains monthly values of the total exposed land area of seasonally frozen ground and annual values for intermittently frozen ground in the Northern Hemisphere. Seasonally frozen ground is defined as the near-surface soil that experiences freeze for more than 15 days per year, while intermittently frozen ground experiences fewer than 15 days of freeze per year.

For more information, visit the FGDC Web site (http://nsidc.org/fgdc/).

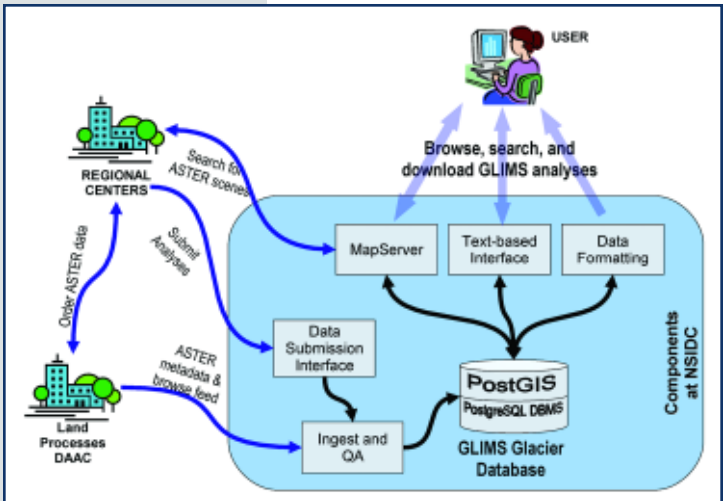
Global Land Ice Measurements from Space (GLIMS)

GLIMS Data Products at NSIDC

The Global Land Ice Measurements from Space (GLIMS) database project represents a fundamental baseline study that will enable scientists to quantify the areal extent of existing glaciers in order to accurately assess the magnitude of glacier change that is occurring worldwide. The GLIMS project is creating an inventory of the majority of the world's estimated 160,000 glaciers and mapping their extent and rate of change. GLIMS is an international project with participation from more than 60 institutions in 28 nations worldwide. Each institution, called a Regional Center (RC) oversees the creation and analysis of data for a particular region appropriate to their expertise. These data are submitted to the GLIMS database at the National Snow and Ice Data Center (NSIDC), and are accessible through the GLIMS Web site (http://nsidc.org/glims/). This Web site provides an overview of the GLIMS Glacier Database and describes the GLIMS Web Mapping Service (WMS). It provides links to the GLIMS WMS, the data submissions page, descriptions of analyses performed with data in the GLIMS database and related research, and the main GLIMS project home page. This work is being undertaken in direct collaboration with the World Glacier Monitoring Service (WGMS) in Zurich, Switzerland, and is a logical extension of the WGMS World Glacier Inventory (WGI). The NSIDC GLIMS project is funded through research grants from the National Aeronautics and Space Administration (NASA).

Database

The NSIDC GLIMS project has created a geospatial and temporal database composed of glacier outlines and various scalar attributes. These data are derived from high resolution optical satellite imagery, primarily from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument aboard the NASA EOS Terra satellite and the Landsat Enhanced Thematic Mapper Plus (ETM+). Historic data, maps, and photographs are used to document changes from earlier periods. Each glacier snapshot is from a specific time, and the database is designed to store multiple snapshots representative of different times. The GLIMS glacier database currently contains outlines for more than 58,000 glaciers. The database also includes metadata for more than 160,000 ASTER images acquired over glacierized terrain. The ASTER footprints can be spatially viewed, temporally constrained, and queried to help GLIMS collaborators quickly find suitable cloud-free ASTER imagery. Once found, a simple "one click" order feature is used to request scenes from the EROS/USGS/LP DAAC archive.



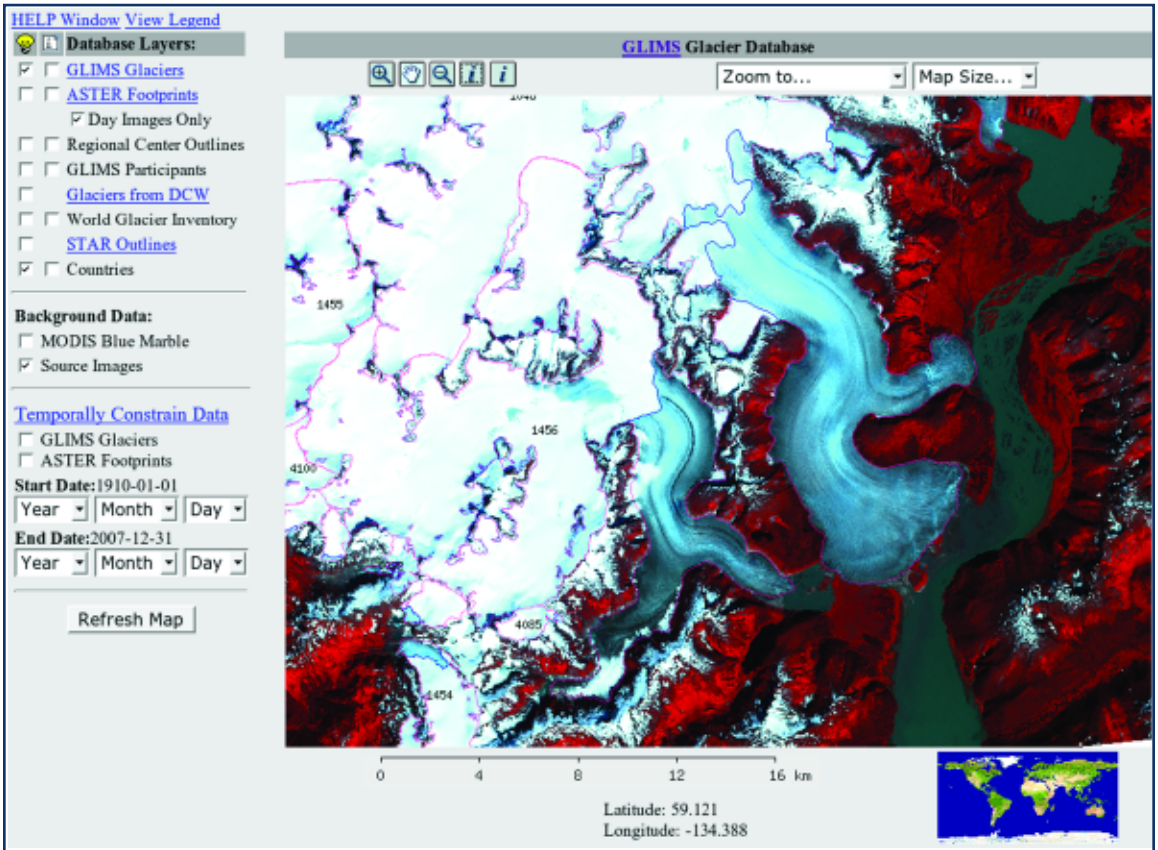
Components of the GLIMS Glacier Database, its public interfaces, and links to GLIMS Regional Centers (RCs). RCs use the GLIMS MapServer to search for appropriate ASTER scenes, which can then be ordered from the LP DAAC. RCs produce analyses using GLIMSView and transfer the results to NSIDC. Using a Web browser, anyone can search GLIMS data graphically or using text-based constraints and can download GLIMS data in a variety of formats. (Courtesy NSIDC)

We have also implemented a Google Earth interface to our database of ASTER imagery. By loading a small file into Google Earth, users can view ASTER browse images (~150 meter pixels) and GLIMS glacier outlines overlaid on the terrain in Google Earth, and constrain which images appear by acquisition date. Clicking on the push-pin of an image displays metadata and a link that places the granule into a "shopping cart" for order, thus providing an additional feature for quick and easy access to both GLIMS glacier data and ASTER imagery. For more information, see http://glims.colorado.edu/glacierdata/asterinfo.php.

MapServer

(http://glims.colorado.edu/glacierdata/)

The GLIMS MapServer Web site (http://glims.colorado.edu/glacierdata/) allows users to view and query several thematic layers, including glacier outlines, ASTER footprints, selected high resolution source imagery, MODIS Blue Marble imagery, GLIMS Regional Center locations, the World Glacier Inventory, and glaciers from the Digital Chart of the World. Query results for glacier outlines can be downloaded into a number of GIS-compatible formats, including Keyhole Markup Language (KML) for viewing files in Google Earth, Environmental Systems Research Institute (ESRI) Shapefiles, MapInfo tables, Generic Mapping Tools (GMT), and Geographic Mark-up Language (GML). Glacier outlines can be selected visually using the interactive map or by using the text search interface to specify values (for example, glacier name, area, etc.). The data are stored in a spatially enabled database (PostGIS), which has sophisticated functions for spatial data analysis and query. The MapServer application provides data from the GLIMS Glacier Database to other Open Geospatial Consortium (OGC) compliant services through OGC-standard protocols, thereby increasing the utility of this glacier data set.



Screenshot of GLIMS MapServer showing database layers and options for constraining data. (Courtesy NSIDC)

For more information, visit the GLIMS Web site (http://nsidc.org/glims/).

NOAA@NSIDC and the World Data Center for Glaciology, Boulder

The National Oceanic and Atmospheric Administration (NOAA) program at NSIDC operates in cooperation with the NOAA National Geophysical Data Center (NGDC) to produce data sets relevant to polar and climate research. We manage approximately 65 data sets, with an emphasis on developing products for tracking long-term climate change in the Arctic, data rescue, and data sets from operational communities.

In 2006, NOAA@NSIDC built momentum toward our goal of making data sets available in geospatial formats and exposing our data to new user communities. Planning for IPY data management with NOAA's National Data Centers began in 2005, but efforts were reduced in 2006 because of a lack of funding for this activity. One way to make data management less costly in the future is to work toward interoperability in the present. This means bringing data and metadata into compliance with standard formats so that there is less of a need for special readers for data, and so that data sets are discoverable through many different online pathways.

NOAA@NSIDC activities are supported primarily by NOAA's National Environmental Satellite, Data and Information Service, National Geophysical Data Center. In 2006, the NOAA team included Florence Fetterer (NOAA liaison and program manager), Lisa Ballagh (project manager), Jonathan Kovarik (operations), Allaina Howard (analog archivist and librarian) and Molly McAllister (user services). The Glacier Photograph project is being carried out in partnership with database administrator I-Pin Wang. Web/database applications engineer John Mauer translated DIF to FGDC metadata records.

2006 Accomplishments

Accomplishments in this area included making the online Glacier Photograph Collection, permafrost maps, global ice and snow extent, and the Sea Ice Index available in Google Earth Keyhole Markup Language (KML) files.

Two of our products are especially popular with the general public. First, the Glacier Photograph Collection's dramatic Glacier Pairs are often in the news. For instance, photo pairs helped illustrate the following articles:

- ABC News online, "World's glaciers rapidly melting, causing quakelike disruptions," 23 March 2006. The "Glacier Pairs" are linked under *Related Stories: Glacier fields, massive melting* on left side of the page (http://abcnews.go.com/Technology/GlobalWarming/story?id=1760048&page=1).
- The New York Times, "As the World Warms: A Glacier Archive that Documents a Melting Landscape," 13 June 2006

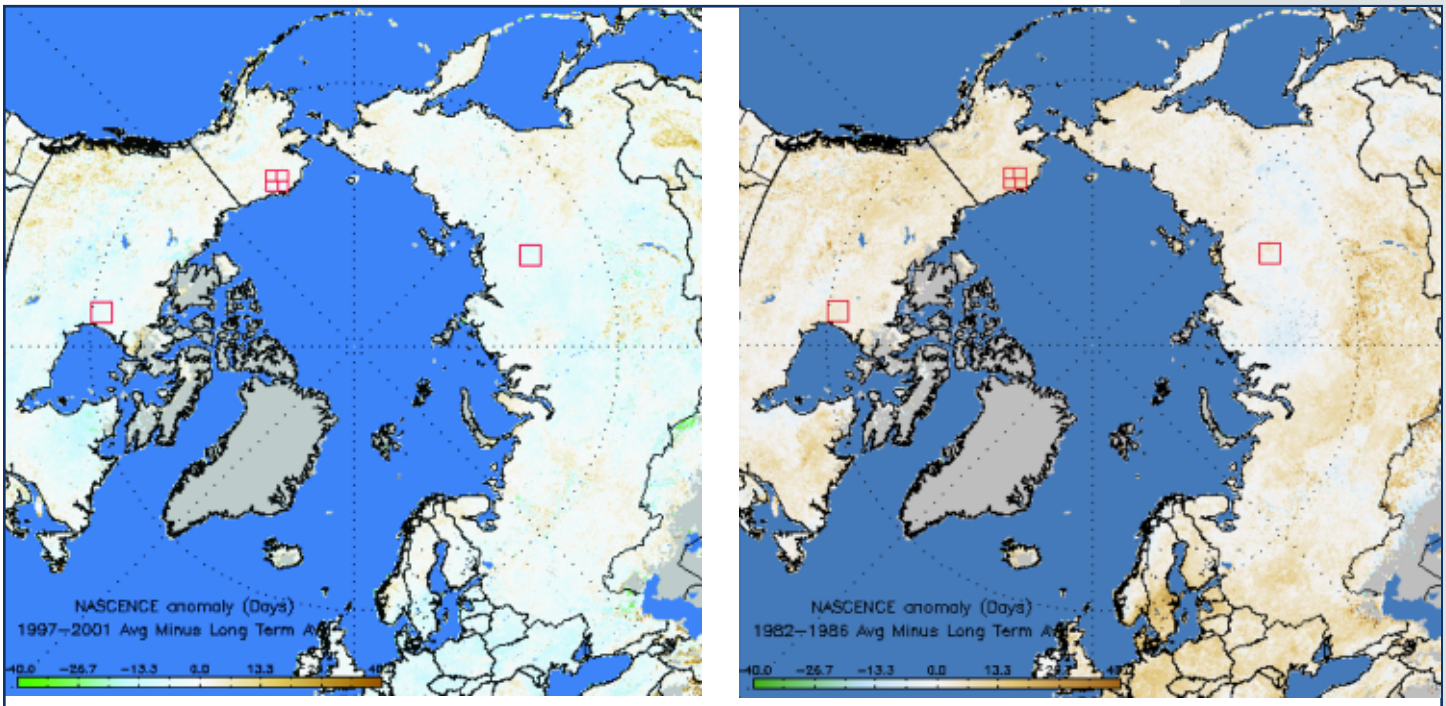
Second, the Sea Ice Index makes it easy for newcomers to polar science to grasp how sea ice is changing. Images from the index were included in *The Arctic: A Friend Acting Strangely* exhibition at the Smithsonian's National Museum of Natural History, on display April through November 2006. The Arctic Sea Ice News 2006 Web page (http://nsidc.org/news/press/2006_seaiceminimum/20060816_arcticseaicenews.html), created and maintained by NSIDC's Outreach group, used Sea Ice Index information to keep the public informed about conditions as they developed.

The NOAA@NSIDC team published the Cryospheric Climate Indicators Web site (http://nsidc.org/noaa/search/indicators/). The site presents Arctic soil temperature, snow cover, sea ice, and greenness as time series with trends and anomalies. These are displayed with

interpretive text and information about processing algorithms and uncertainties. The images characterize, at a glance, some of the changes that are occurring. We developed the site with the intent of updating the series yearly, but funding is not available for the project's continuation.

We also expanded the Glacier Photograph Collection digital subset and added a Special Collection section for unique collections, such as repeat photography of glaciers showing change over time (http://nsidc.org/data/g00472.html). In all, 422 glacier photographs were added. The project is in its fourth year with the NOAA Climate Database Modernization Program (CDMP). CDMP scans the photographs that are held by the NSIDC/World Data Center for Glaciology archive.

In 2006, NOAA@NSIDC metadata records were translated from their native Directory Interchange Format (DIF) to Federal Geographic Data Committee (FGDC) compliant records in XML. As a result, our data sets have been harvested by external data catalogs such as Geospatial One Stop.



Taken from the Cryospheric Climate Indicators Web site, the anomaly images above show a trend toward earlier nascence (blue colors) over much of the Arctic in the last five years of our data record when compared with the first five years. In contrast to anomalies in seasonally integrated NDVI, however, there is considerable spatial variation. Nascence, or spring greenup, is marked by the day of year (plus or minus about five days) on which the normalized difference vegetation index (NDVI) exceeds, for the first time, a threshold of 0.3. north of 55 degrees North. This is usually between late May (DOY=140) and the end of June (DOY=180). The grey areas in the images above show where the threshold of 0.3 was not exceeded. Shield, bare rock, ice sheets, and areas largely covered by water have low or zero NDVI. (Courtesy NSIDC)

Featured Data Products

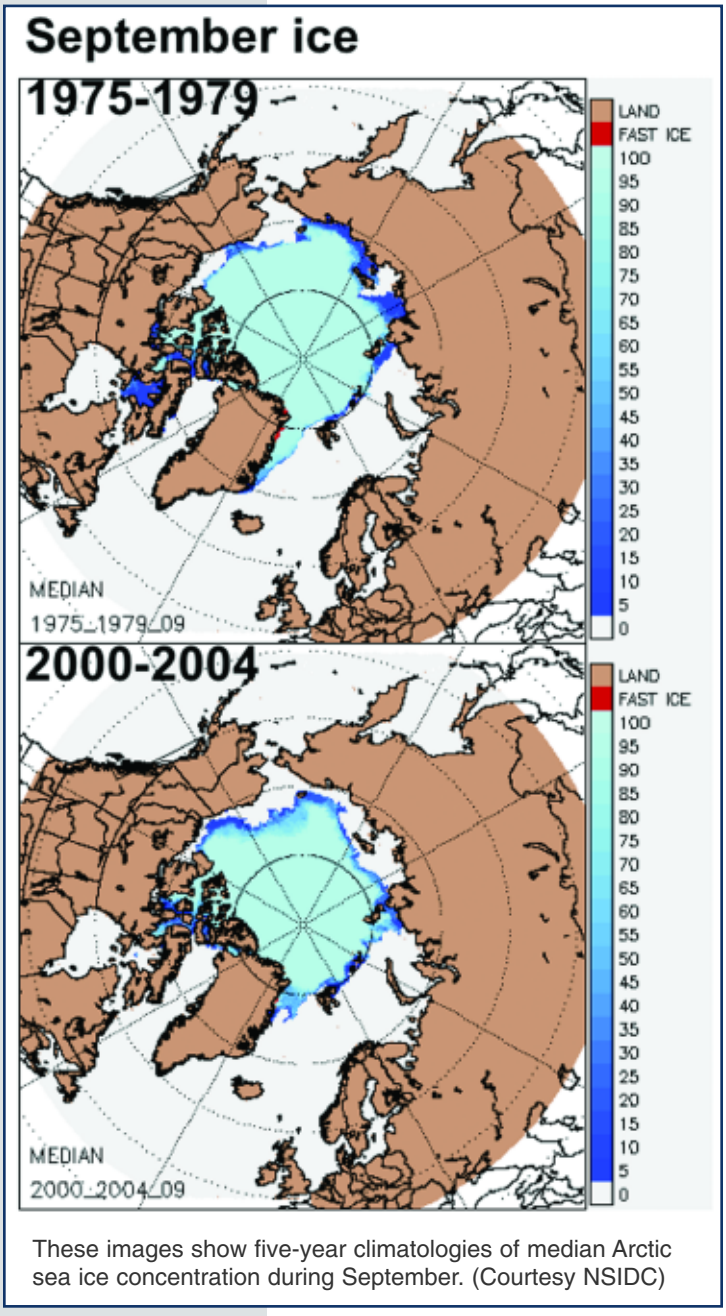
Submarine Upward Looking Sonar Ice Draft Profile Data and Statistics
(http://nsidc.org/data/g01360.html)

Sea ice draft is used to estimate ice thickness, without which ice volume cannot be estimated. Ice thickness cannot be directly measured by satellite, and there are relatively few in situ thickness observations. Recent work by investigators at the University of Washington's Polar Science Center adds 15 cruises to the existing data collection of draft measurements from submarines. These data were originally recorded on paper rolls. The University of Washington investigators devised a way to scan and digitize the analog data. In all, the data cover almost

122,000 kilometers of cruise tracks. Researchers making use of these data owe a debt of gratitude to the Arctic Submarine Laboratory (ASL), San Diego, California, for their stewardship of the data. ASL holds raw data from all U.S. submarine cruises, beginning with the first cruise under the ice in 1958.

Monthly Mean Precipitation Sums at Russian Arctic Stations, 1966–1990
(http://nsidc.org/data/g02170.html)

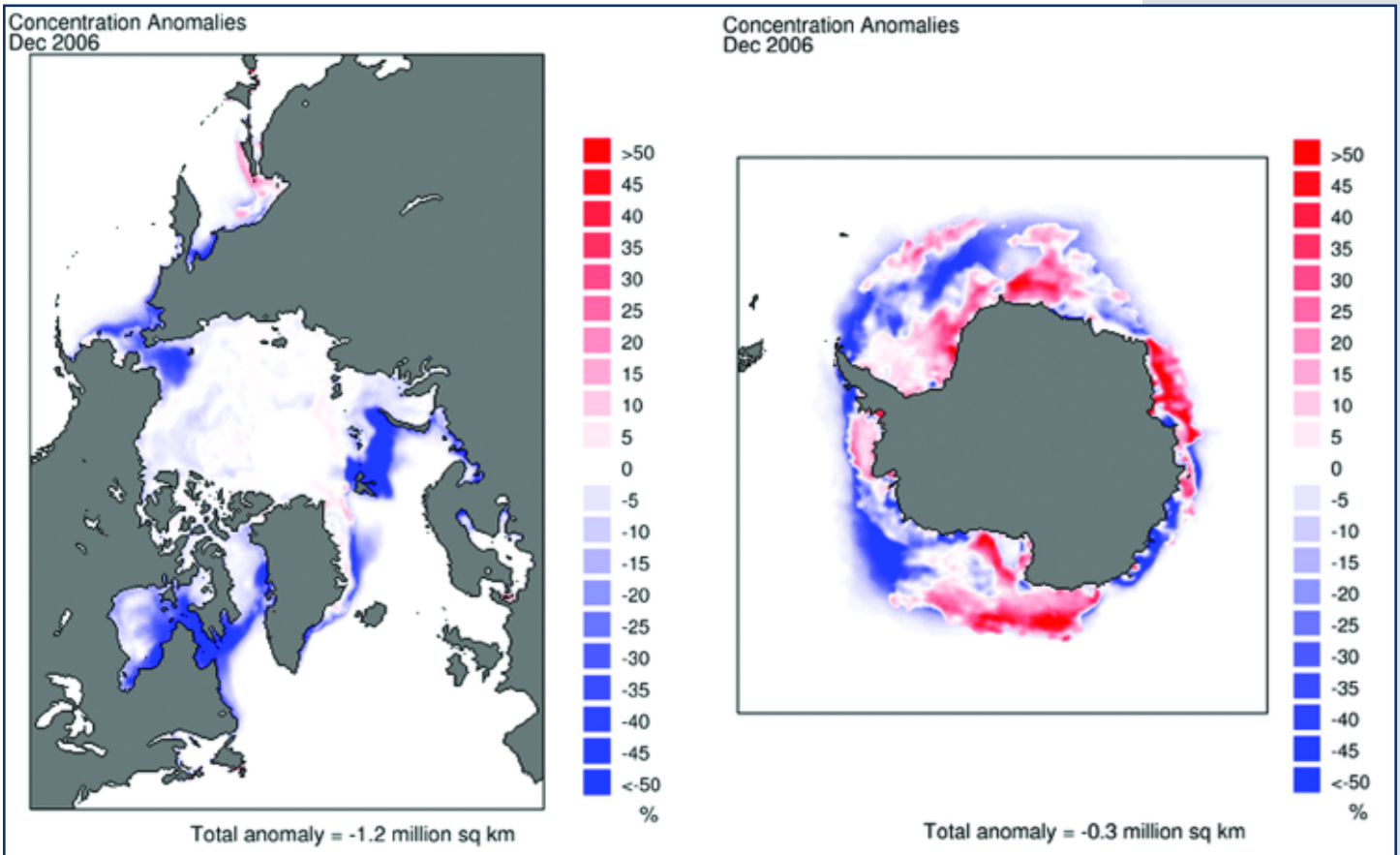
Data from 216 Russian stations fill gaps in the historical precipitation record that are needed for applications including reanalysis validation and climate change studies. Documentation includes a section describing the relationship between this data set and other commonly used precipitation data sets: an important addition because the number and variety of sometimes overlapping precipitation data sets often makes it difficult to use them for climate studies. The NOAA Arctic Research Program funded this effort as a contribution to the interagency Study of Environmental Arctic Change (SEARCH) program.



These images show five-year climatologies of median Arctic sea ice concentration during September. (Courtesy NSIDC)

National Ice Center Arctic Sea Ice Charts and Climatologies in Gridded Format
(http://nsidc.org/data/g02172.html)

We worked with the U.S. National Ice Center (NIC) an interagency NOAA, Navy, and Coast Guard facility, to produce this data set. Since 1972, NIC has constructed weekly or biweekly Arctic and Antarctic sea ice charts. These analyses are produced using available in situ, remotely sensed, and model data sources. They are generated primarily for mission planning and safety of navigation. Overall, the record of sea ice concentration from the NIC series is believed to be more accurate than that from passive microwave sensors, especially from the mid-1990s on. The ice edge in particular is more accurate and precise in the chart series. NSIDC and other researchers are using the charts to compare with and adjust other sea ice data sets for better long-term climate records. The climatology includes median, maximum, and minimum concentrations as well as frequency of occurrence of ice at any concentration for 33 year, 10 year, and 5 year periods. The charts from which the climatologies were derived are included as well. All products are available in EASE-Grid (binary) format, with GIF browse files. The climatology products are available in GIS compatible format as well. The data cover 1972 through 2004.



The above images show Arctic (left) and Antarctic (right) sea ice concentration anomalies for December 2006 from the Sea Ice Index, which is produced by NOAA@NSIDC as part of the Cryospheric Climate Indicators Web site. To produce concentration anomaly images, monthly concentration images are subtracted from an image of the mean for the month in question from the 1979 to 2000 portion of the data set. The color bar shows, in percent, how much the ice concentration for the month differs from the mean calculated for that month over the 1979 to 2000 portion of the data set. (Courtesy NSIDC)

For more information, visit the NOAA@NSIDC Web site (http://nsidc.org/noaa/).

Research

NSIDC scientists are known internationally for their expertise in a range of fields related to the cryosphere. In-house scientists investigate the dynamics of Antarctic ice shelves, monitor the links between Arctic sea ice and climate, study new techniques for the remote sensing of snow and freeze/thaw cycles of soil, account for snow in hydrologic modeling, research large-scale shifts in polar climate, investigate seasonally and permanently frozen ground, and work to improve understanding of river and lake ice. Scientists pursue their work as part of the Cooperative Institute for Research in Environmental Sciences (CIRES) Cryospheric and Polar Processes Division, at the University of Colorado at Boulder. National agencies fund research through the peer review proposal process.

NSIDC scientists are involved in a variety of cryospheric projects and collaborations. To better communicate these scientific contributions, NSIDC added a new Science section to its Web site to provide instant access to information about NSIDC scientists and their research. In this new section, biography pages list each scientist's education, areas of expertise, professional affiliations, activities, funded projects, and publications. NSIDC also created pages for each funded project that include summaries, collaborators, and funding source. For more information about NSIDC scientists, please visit the Scientists at NSIDC Web page (http://nsidc.org/research/). To view a listing of research projects at NSIDC, please visit the Research Projects at NSIDC Web page (http://nsidc.org/research/projects.html).

During 2006, several NSIDC scientists received awards for their research. In January, Oliver Frauenfeld received the Climate Specialty Group 2006 John Russell Mather Paper of the Year award from the Association of American Geographers for "A Distinctly Interdecadal Signal of Pacific Ocean-Atmosphere Interaction," published in *Journal of Climate* in 2005. In February,

NSIDC scientist Ted Scambos standing on AMIGOSberg, as part of the IceTrek expedition.The iceberg edge is sloped over Ted's left shoulder, but the waterline is flat in the other small iceberg in the distance. This reveals that the iceberg is being flexed by the forces around it. (Courtesy Ted Scambos, NSIDC)

NSIDC director Roger Barry and senior scientist Mark Serreze received the award for Best Book of 2005 from the Atmospheric Science Librarians International (ASLI) for their textbook, *The Arctic Climate System*. In October, Barry received the Goldthwait Polar Medal in recognition of his contributions to polar research. Barry also presented the Goldthwait lecture, "Arctic Ocean-Ice-Atmosphere Interactions," at the Byrd Polar Research Center in Columbus, Ohio.

NSIDC scientists made progress on many of their funded research grants, conducting international studies, and collaborating with colleagues worldwide. Through their research, NSIDC scientists help further understanding of the many changes that Earth is undergoing.

Arctic Peoples

There is an urgent need for scientists, decision makers, and others to better understand the human and social dynamics surrounding Arctic sea ice change, what is at stake for coastal communities, and what the responses might be. Scientists at NSIDC have been using remotely-sensed data to monitor the Arctic environment and to regularly report on the declining Arctic sea ice. NSIDC also continued to distribute the data product, *When the Weather is Uggianaqtuq: Inuit Observations of the Environment*, a compilation of knowledge from an indigenous community in Nunavut.

Inuit often use dogsleds to travel over land and sea ice. Long-term changes in sea ice concentration and extent have impacted many of the coastal Inuit communities that depend on the ice cover for their livelihoods. (Courtesy Photos.com)

NSIDC scientists Shari Gearheard, Andy Mahoney, Julienne Stroeve, Walt Meier, and Roger Barry were involved in a variety of interdisciplinary projects that unite observations from remote sensing with indigenous knowledge and observations, including communities in Barrow, Alaska; Clyde River, Nunavut; and Qaanaaq, Greenland. Their research will provide important insights into present and anticipated changes to Arctic ecosystems at scales most significant to coastal inhabitants and ecosystems.

To see related research projects, visit the NSIDC Research Projects Web page (http://nsidc.org/research/project.html#arctic_peoples).

Arctic Hydrology and Climate

Change is a dominant theme in Arctic research. How much of this change is due to natural variability versus the impacts of greenhouse gases? A synthesis of observational records, paleoclimate information, and model results already suggest that the terrestrial Arctic is experiencing the largest change of any world region in terms of temperature, and modeling studies and current trends suggest that this change will continue. While natural variability has and will always be large in the Arctic, greenhouse gas loading is now becoming an important factor.

NSIDC scientists Mark Serreze, Roger Barry, Julienne Stroeve, Walt Meier, Andrew Slater, Tingjun Zhang, Andrew Barrett, and Richard Armstrong participated in international research projects to study the Arctic freshwater cycle, heat budget, ocean-ice-atmosphere system, and to observe interconnections between Arctic hydrology and global climate.

In 2006, Mark Serreze was one of three speakers at a 23 May 2006 Congressional Briefing, "Recent scientific findings of Arctic environmental change." The session briefed legislators about significant findings concerning temperature, sea ice, permafrost, tundra, and the

freshwater cycle, providing a foundation for policy discussions. Serreze specifically discussed Arctic climate change and interactions between the atmosphere, oceans, and sea ice. Serreze also participated in a press conference, "Arctic warming and its impacts," at the Fall 2006 American Geophysical Union meeting to present recent changes in the Arctic.

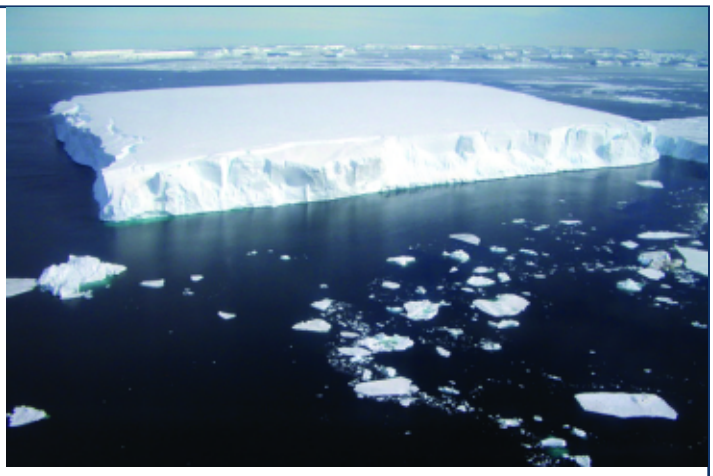
To see related research projects, visit the NSIDC Research Projects Web page (http://nsidc.org/research/project.html#arctic_hydrology).

Antarctic Glaciology and Climate

Antarctica, at Earth's South Pole, is an icy continent. A huge ice sheet covers the landmass of Antarctica and, in some places, shelves of floating ice extend into the ocean. The outer sections of ice break off or calve from these shelves and form icebergs. The icebergs float in the oceans, melting and falling apart as they drift into warmer waters.

Scientists recognize that the final stages of iceberg break up imitate the rapid disintegration of ice shelves caused by climate warming. Floating shelves of ice on the Antarctic Peninsula are experiencing temperatures and melt rates that they can no longer withstand. Ice shelves are important because they help control glacier flow; removal of ice shelves causes rapid glacier acceleration and calving. Ice shelf break up is usually caused by surface pond melting and fracturing. Scientists believe that melting at the base of ice shelves also contributes to disintegration. However, they are not sure how these processes interrelate. Waiting for a major ice shelf breakup could take decades—a long time to wait for important data.

However, examining an iceberg as it drifts into warmer climates provided a perfect opportunity for scientists to study an accelerated breakup. During January through April 2006, NSIDC lead scientist Ted Scambos participated in the IceTrek expedition, which involved landing on an Antarctic iceberg to set up observational instruments for detecting changes as the iceberg drifts north and begins to melt. The work was in collaboration with the Argentine Antarctic Institute. Scambos is analyzing the continuing results of iceberg changes during drift and decay, using data and images transmitted by the AMIGOS sites on icebergs AMIGOSberg and A22A. NSIDC staff member Rob Bauer also participated, applying his mountaineering skills to ensure the team's safety. Graduate student Atsuhiro Muto helped prepare equipment and instruments at NSIDC prior to the expedition. NSIDC followed the progress of the team, providing research updates and photographs on the IceTrek section of the NSIDC Web site (http://nsidc.org/icetrek/).
In May 2006, NSIDC also hosted a workshop, "The Antarctic Peninsula Climate Variability: Observations, Models, and Plans for IPY Research," that included presentations of recent



The IceTrek team tests setting up the 25-Mhz radar instrument (left) on a small Antarctic iceberg, nicknamed "Chip" (right), before installing their equipment on the larger AMIGOSberg and A22A icebergs. (Courtesy Ted Scambos, NSIDC)

climatological, oceanographic, and glaciological research in the Antarctic Peninsula. The workshop included a series of keynote talks, contributed talks, poster sessions, and breakout sessions for collaborative field research planning. One of the primary objectives of the meeting was to develop a coordinated science plan for the International Polar Year period (March 2007 through March 2009).

To see related research projects, visit the NSIDC Research Projects Web page (http://nsidc.org/research/project.html#antarctic).

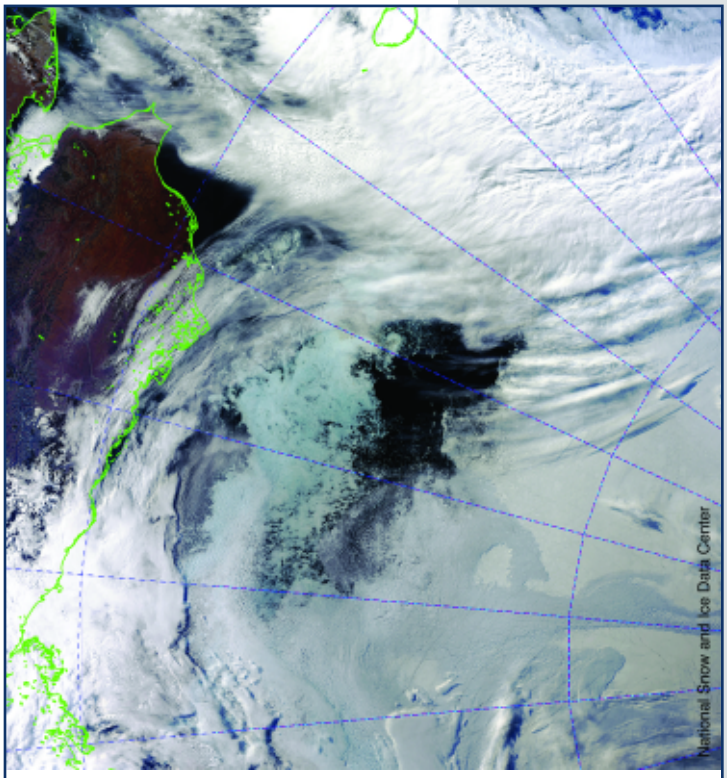
Sea Ice

Sea ice is frozen seawater that floats on the ocean surface. Blanketing millions of square kilometers, sea ice forms and melts with the polar seasons, affecting both human activity and biological habitat. In the Arctic, some sea ice persists year after year, whereas almost all Southern Ocean or Antarctic sea ice is seasonal ice, meaning that it melts away and reforms annually. While both Arctic and Antarctic ice are of vital importance to the marine mammals and birds for which they are habitats, sea ice in the Arctic appears to play a more crucial role in regulating climate.

The past five summers, 2002 to 2006, have exhibited particularly reduced Arctic sea ice extent and have reinforced a downward trend. Even the winter periods have now shown decreasing trends. In fact, NSIDC scientists announced a record low winter ice extent in April 2006. The following October, they announced that for the fifth straight year, the summer sea ice extent fell below normal.

A notable feature of the 2006 melt season was the development of a large polynya, or area of persistent open water surrounded by sea ice, north of Alaska. NSIDC Scientist Walt Meier determined that near its largest, in early September, the polynya was the size of the state of Indiana. How the polynya formed is still not clear. Unusual wind patterns may have forced the ice cover to spread apart. Scientists also speculate that thin ice moved into the area over the winter, melting out over the summer and creating the polynya. Another possibility is that warm waters rose to the surface, helping melt the ice. The team at NSIDC felt it would be speculative to attribute the polynya to greenhouse warming.

To communicate the summer ice decline, NSIDC maintained an Arctic sea ice news Web page from August to October, featuring regular updates and high-resolution images. In October 2006, Walt Meier, Mark Serreze, Julienne Stroeve, and Ted Scambos issued a press release discussing continuing Arctic summer sea ice decline, leading to press coverage from around the globe. NSIDC also held a joint press teleconference with NASA about the state of the Arctic sea ice. Mark Serreze of NSIDC, together with Josefino Comiso and Claire Parkinson of NASA, discussed the latest news on the declining Arctic sea ice and its impact on polar bear populations. The scientists fielded questions from reporters representing *The New York Times*, *The Washington Post*, and other news media. NSIDC plans to continue to watch the sea ice and report on milestones in the coming years.



This image shows the Beaufort Sea Polynya. A polynya, or area of persistent open water surrounded by ice, appeared during the summer 2006 Arctic sea ice melt season. The polynya is the dark area of open water; to the left is the coastline of Alaska, showing fall foliage color, and to the bottom right is the North Pole. This image is from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor, which flies on the NASA Terra and Aqua satellites. (Courtesy NSIDC)

Remote sensing is crucial for obtaining a year-round time series of data for studying ice conditions in the Arctic. However, satellite data often requires fieldwork to verify accuracy. To obtain more ground data about the rapidly changing Arctic sea ice, Walt Meier and Thomas Painter collaborated with Arctic explorers Lonnie Dupre and Eric Larsen, as part of Greenpeace's Project Thin Ice. During the project, Dupre and Larsen attempted the first-ever summer crossing of the North Pole, taking measurements of sea ice, snow depth, and collecting snow samples. The measurements will help scientists make satellite data more accurate by providing ground-truth data and help account for the effects of snow atop sea ice, which can cause noise in the data. Julienne Stroeve and Jim Maslanik also participated in a field campaign in Barrow, Alaska, to validate sea ice products from the Advanced Microwave Scanning Radiometer-EOS (AMSR-E) instrument aboard NASA's Aqua satellite.

To see related research projects, visit the NSIDC Research Projects Web page (http://nsidc.org/research/project.html#sea_ice).

Sea ice off the coast of Cape Churchill. NSIDC scientists have been using satellite data, ice charts, and field work to observe changes in Arctic sea ice concentration and extent. (Courtesy Photos.com)

Glaciers and Ice Sheets

Because glaciers are so sensitive to temperature fluctuations, they provide clues about the effects of global warming. With few exceptions, glaciers around the world have retreated at unprecedented rates over the last century. Some ice caps, glaciers, and even an ice shelf have disappeared altogether. Many more are retreating so rapidly that they may vanish within decades. Some scientists attribute this retreat to the Industrial Revolution; burning fossil fuels releases greenhouse gases into the atmosphere and affects the environment in ways not previously understood.

Glaciers differ from snow cover and sea ice extent in that scientists cannot use short-term changes in the areal extent of small glaciers as an index of current climatic conditions. Glaciers continually move, transporting mass from higher to lower elevations, somewhat like a conveyer belt. If the combination of climate and ice dynamics determines that the glacier is also advancing, the effect of the advance of the terminus is to increase the overall glacier area. However, because glaciers move slowly, a significant time lag occurs between the climatic conditions that caused the advance or retreat and the actual advance or retreat. This time lag may last several years or longer and is determined by the complicated and sometimes uncertain processes that control how fast the glacier moves.

To understand how glaciers are responding to climate change, researchers rely on a combination of fieldwork, remotely-sensed data, and photographic documentation. During 2006, several NSIDC scientists and staff members engaged in research and projects that increased the amount of glacier data and imagery available to the cryospheric community. NSIDC post-doctoral researcher Ian Howat participated in an expedition to the Jakobshavn Glacier in western Greenland to study the effects of meltwater drainage on the rate of flow. Scientist Richard Armstrong and programmer Bruce Raup continued to participate in the Global Land Ice Measurements from Space (GLIMS), a collaborative project to create a worldwide inventory of glacier extents and rates of change. Ted Scambos continued to lead the Antarctic Glaciological Data Center (AGDC), which collects and manages data for Antarctic Glaciology, and the NOAA@NSIDC team added 422 photos to the online Glacier Photograph Collection.

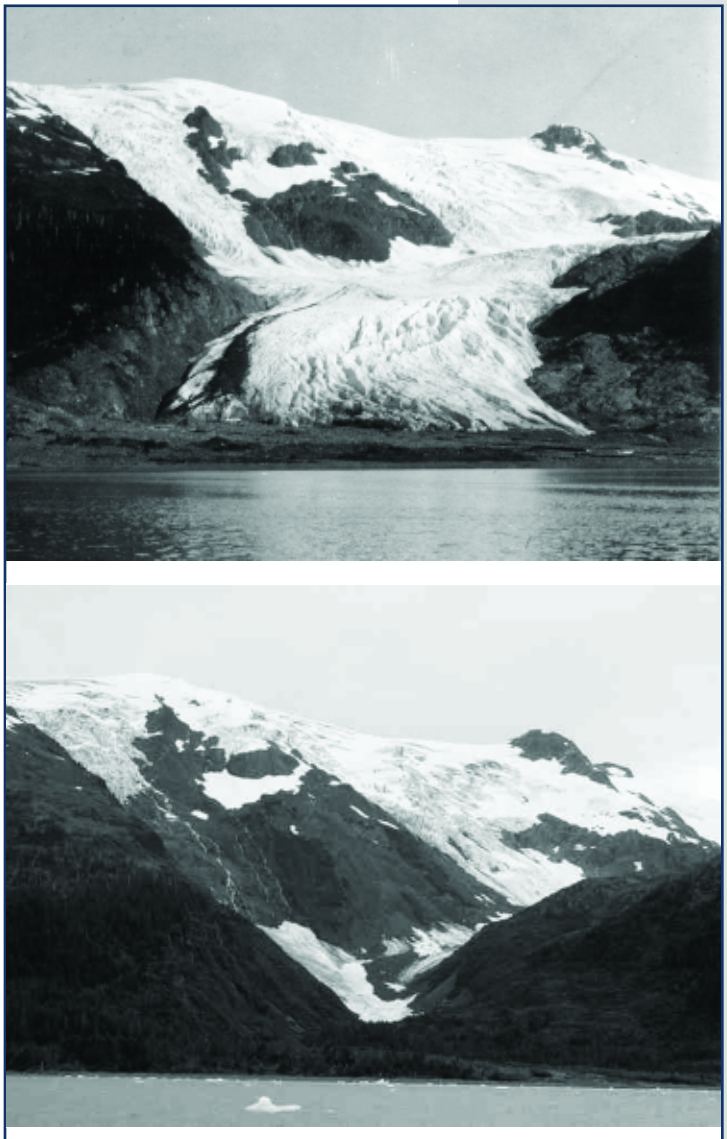
To see related research projects, visit the NSIDC Research Projects Web page (http://nsidc.org/research/project.html#glaciers).

Climate Change and the Cryosphere

The cryospheric regions, or regions where water is found in solid form, provide scientists with direct visual evidence of temperature changes. Unlike other substances found on Earth, ice and snow exist relatively close to their melting point and may frequently change phase from solid to liquid and back again. Consequently, consistent and prolonged warming trends should result in observable changes to the Earth's cryosphere.

To help document warming trends and the global effects of climate change, the Intergovernmental Panel on Climate Change (IPCC) has published several reports since 1990, drawing on global scientific expertise. Throughout 2006, NSIDC scientists contributed cryospheric expertise to the International Panel on Climate Change (IPCC) fourth assessment. For the Working Group I Report, *Climate Change 2007: The Physical Science Basis*, Roger Barry served as review editor. Tingjun Zhang served as lead author and Oliver Frauenfeld as co-author for Chapter 4, "Observations: Changes in snow, ice and frozen ground." Drew Slater served as co-author for Chapter 8, "Climate models and their evaluation." Roger Barry was also review editor for Chapter 15, "The polar regions," in the Working Group II Report, *Climate Change 2007: Impacts, Adaptation and Vulnerability*.

In addition, several NSIDC scientists and programmers contributed imagery to publications, exhibits, and educational products. Julienne Stroeve contributed to an exhibit at the Smithsonian National Museum of Natural History, *The Arctic: A Friend Acting Strangely*, providing a graphic and text illustrating the decline in Arctic sea ice extent 1978 through 2004. The exhibit ran from April through November 2006. Excerpts from the exhibit, including Stroeve's contribution, are viewable online at the Smithsonian Web site (http://forces.si.edu/arctic/index.html).



The top photograph of Toboggan Glacier, Alaska, was taken in 1909; the bottom photograph was taken in 2000. This pair of photographs illustrates the dramatic changes that researchers are observing in glaciers worldwide. (Top photograph courtesy of Sidney Paige/USGS Photo Library; bottom photograph courtesy Bruce Molnia/USGS; both are available through NSIDC's online Glacier Photograph Collection).

Walt Meier consulted for the NASA Scientific Visualization Studio to produce the educational DVD, *A Tour of the Cryosphere, Earth's Frozen Assets*. Scientist Richard Armstrong and scientific programmer Mary Jo Brodzik also contributed to the DVD. To view the material or order the DVD, visit the NASA Life on Earth Web site (http://www.nasa.gov/vision/earth/environment/cryosphere.html).

Senor scientist Mark Serreze was one of three speakers at a Congressional Briefing, "Recent Scientific Findings of Arctic Environmental Change," held to inform policy makers. Serreze discussed Arctic climate change and interactions between the atmosphere, oceans and sea ice.

A truck travels the Alaskan Highway through the Canadian Rockies. Permafrost affects buildings, roads, and infrastructure in a variety of Arctic and alpine regions, including communities in Alaska, Canada, Russia, and China. (Courtesy Photos.com)

To see related research projects, visit the NSIDC Research Projects Web page (http://nsidc.org/research/project.html#climate_change).

Permafrost and Frozen Ground

Permafrost, or permanently frozen ground, is soil, sediment, or rock that remains at or below 0 degrees Celsius for at least two years. Permafrost is not defined by soil moisture content, overlying snow cover, or location; it is defined solely by temperature. Seasonally frozen ground is near-surface soil that freezes for more than fifteen days per year. Intermittently frozen ground is near-surface soil that freezes from one to fifteen days per year. Permafrost underlies 12 to 18 percent of the exposed land surface in the Northern Hemisphere, and seasonally frozen ground regions may cover as much as 55 percent.

Understanding permafrost is not only important to civil engineering and architecture, it is also a crucial part of studying global change and protecting the environment in cold regions. Frozen ground data are critical to understanding environmental change, validating models, and building and maintaining structures in seasonal frost and permafrost regions. Frozen ground's widespread distribution makes it a substantial component of the cryosphere. Likewise, its role in the storage and release of carbon make it a major factor in future global change.

In August 2006, scientists Tingjun Zhang, Richard Armstrong, and Oliver Frauenfeld participated in the first Asian Conference on Permafrost in Lanzhou, China. They subsequently traveled across the Tibetan Plateau on the new Qinghai-Xizang (Tibet) Railroad, surveying the effects of the railroad's construction on the underlying permafrost. Frauenfeld also visited meteorological stations on the plateau to assess the site characteristics and establish the suitability and quality of the station observations for climate research.

To see related research projects, visit the NSIDC Research Projects Web page (http://nsidc.org/research/project.html#permafrost).

International Collaboration

Global Terrestrial Observing System (GTOS)

Roger Barry and Wilfried Haeberli contributed an article, "Global Terrestrial Network for Glaciers (GTN-G)," to the Global Terrestrial Observing System (GTOS) report, *GTOS Biennial Report 2004–2005*. Barry also attended the ninth session of the Terrestrial Observation Panel on Climate (TOPC) meeting in Ispra, Italy.

Intergovernmental Panel on Climate Change (IPCC)

Several NSIDC staff and scientists contributed to the IPCC Fourth Assessment Report, *Climate Change 2007: The Physical Science Basis*. NSIDC director Roger Barry served as review editor for Chapter 4, "The cryosphere." Senior research scientist Tingjun Zhang was lead author for Chapter 4, "Observations: Changes in snow, ice and frozen ground." Oliver Frauenfeld was co-author for Chapter 4, "Observations: Changes in snow, ice and frozen ground." Drew Slater served as co-author for Chapter 8, "Climate models and their evaluation."

Barry was also review editor for Chapter 15, "The polar regions," in the Working Group II Report, *Climate Change 2007: Impacts, Adaptation and Vulnerability*. He attended Lead Authors meetings in Christchurch, New Zealand, and Merida, Mexico.

NSIDC scientists Richard Armstrong, Walt Meier, Ted Scambos, and Mark Serreze, along with programmers Bruce Raup and James McCreight, also contributed to the IPCC report.

IceTrek

NSIDC participated in an international field project in the Antarctic Peninsula with Argentine scientists in the first half of 2006. Funded by a National Science Foundation Special Grant for Exploratory Research, and supported by the Argentine Antarctic, the study focused on using northward-drifting icebergs as tools for understanding the evolution and break up of ice shelves undergoing climate warming. Participating NSIDC personnel were lead scientist Ted Scambos and staff member Rob Bauer, working in collaboration with Argentine scientists Pedro Skvarca, Rudy DelValle, and Yevgeny Yermolin. Field activities included an aerial survey of ice shelves and glaciers in the northern peninsula region, and installation of two automated in situ sensing stations, called Automated Met-Ice-Geophysics Observing Stations (AMIGOS). AMIGOS units use steerable cameras, weather instruments, GPS, and other geophysical tools to collect data on snow accumulation, ablation, surface melting, bending or flexing of the iceberg plate, position data, and ice thickness. During the nine-week project (26 January through 30 March), the team successfully installed two AMIGOS units, which subsequently reported on iceberg surface conditions for ten months. The expedition was documented on the NSIDC Web site (http://nsidc.org/icetrek/).

NSIDC Prepares for IPY

International Polar Year (IPY) Data Management Planning Workshop

Mark Parsons and Roger Barry, in conjunction with the IPY Programme Office, hosted an IPY Data Management Planning Workshop at the British Antarctic Survey in Cambridge on 4 and 5 March 2006. The workshop immediately followed the inaugural meeting of the IPY Data Policy and Management Subcommittee, co-chaired by Parsons and Taco de Bruin of the Netherlands. More than forty people from thirteen nations attended the workshop to begin developing an implementation plan for the IPY Data and Information Service (DIS) described in the IPY Framework Document. Several working groups developed specific recommendations on entraining archives, data discovery and access methods, standards and interoperability, and methods to ensure all IPY data is captured and available. A guiding principle was that data

management needs to serve the objectives of IPY, especially the objectives of interdisciplinary science, international exchange, and the creation of a lasting legacy. The group recognized that while the community must act now to build pragmatic data management systems, IPY also provides an opportunity to push data management into a new era to better enable fully integrative science. A full report of the workshop is available on the NSIDC Web site (http://nsidc.org/events/ipydis/index.html), but the approach to developing IPYDIS will continue to evolve.

IPY Data Management and International Cooperation
Mark Parsons also conducted a town hall meeting at the European Geosciences Union General Assembly on 5 April 2006 to solicit input about IPY data management from the scientific community. Parsons and Taco de Bruin also convened a session at the 20th International Committee on Data for Science and Technology (CODATA) conference to discuss IPY as an opportunity for international data exchange and interdisciplinary science.

Antarctic Peninsula Climate Variability: Observations, Models, and Plans for IPY Research
NSIDC convened an international workshop from 15 to 16 May 2006 to review recent scientific results for the Antarctic Peninsula region. The meeting was the third Antarctic Peninsula Climate Variability (APCV) meeting, this one focusing on observations, models, and plans for IPY research. Approximately 80 scientists and students attended, with half of them from outside the United States, representing 14 countries. The meeting had a highly interdisciplinary focus, including discussions of climate and climate change, oceanography, glaciology, biology, and marine geology.

Data product development and visualization

20th Century Sea Ice Conditions in the Eurasian Arctic from a Comprehensive Reconstitution and Synthesis of Russian Data Sources with Modern Satellite Data
Roger Barry, Florence Fetterer, and Andy Mahoney are collaborating with Vasily Smolyanisky of the Arctic and Antarctic Research Institute (AARI) in St. Petersburg, Russia, on this product. The primary objective of this work is to fill specific gaps in the sea ice data record by extending the record back and forward in time. A secondary objective is to analyze the acquired data in order to provide summary statistics, and to assess the evidence for climate change in the Russian Arctic from the 1930s to the year 2000. The team acquired digitized historical ice charts of the Eurasian Arctic from AARI for the periods 1933 to 1992 and 1997 to 2006. They also have ice index data for the periods 1924 to 1933 and 1993 to 1996, creating an observational ice record that spans over 80 years. From ice chart data, they have located the ice edge where possible in every chart and calculated seasonal ice extent anomalies for the marginal seas of the eastern Arctic. These results indicate that although there was also a retreat in autumn (annual minimum) sea ice extent in the early part of the 20th century, there was no apparent retreat in springtime (annual maximum). In recent years however, there has been a year-round retreat of eastern Arctic sea ice extent. The team is currently examining historical meteorological station data and atmospheric indices (such as the Arctic oscillation) to seek correlations between Arctic climate and the observed variability in sea ice. They are also comparing the AARI ice chart data set with other digital sea ice data with the aim of producing an optimized data set of Arctic sea ice.

Permafrost data collaboration
With support from the National Science Foundation, Tingjun Zhang and colleagues at NSIDC continued to work with Russian colleagues to digitize and transfer soil temperature data from across the Russia Arctic and subarctic.

First Asian Conference on Permafrost

Tingjun Zhang, Richard Armstrong, and Oliver Frauenfeld attended the First Asian Conference on Permafrost held in Lanzhou, China, from 6 to 9 August 2006. Zhang presented an invited talk. Prior to the meeting, Zhang also attended the High Asian Permafrost Mapping workshop on 4 to 5 August. After the Asian permafrost conference, Zhang participated a field trip with International Permafrost Association president Dr. Jerry Brown and colleagues from the United States, Canada, Russia, Mongolia, and China. In addition, Zhang obtained funding from the National Science Foundation to bring about 20 graduate students, young scientists, and senior faculty members to attend the First Asian Conference on Permafrost and field trips after the conference.

Visiting scientists

Dahe Qin, head of the China Meteorological Administration and Academician of the Chinese Academy of Sciences, and his colleagues visited NSIDC in May 2006. Qin gave a brief introduction about glaciology study in China and spent a half-day with NSIDC scientists to discuss a variety of related issues. Qin also worked closely with Tingjun Zhang on future cooperative projects and plan.

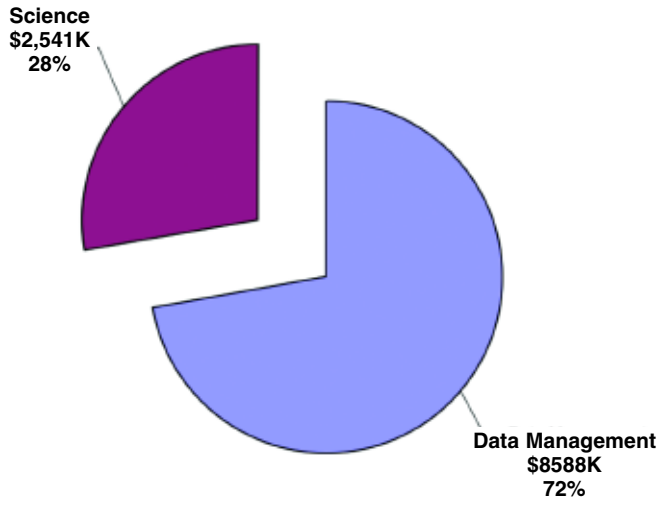
Qinbai Wu from the Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI) of the Chinese Academy of Sciences (CAS) joined NSIDC and the Cooperative Institute for Research in Environmental Sciences from October 2006 through May 2007. Wu worked closely with Tingjun Zhang on recent permafrost warming on the Qinghai Tibetan Plateau based on long-term measurements.

International scholarship

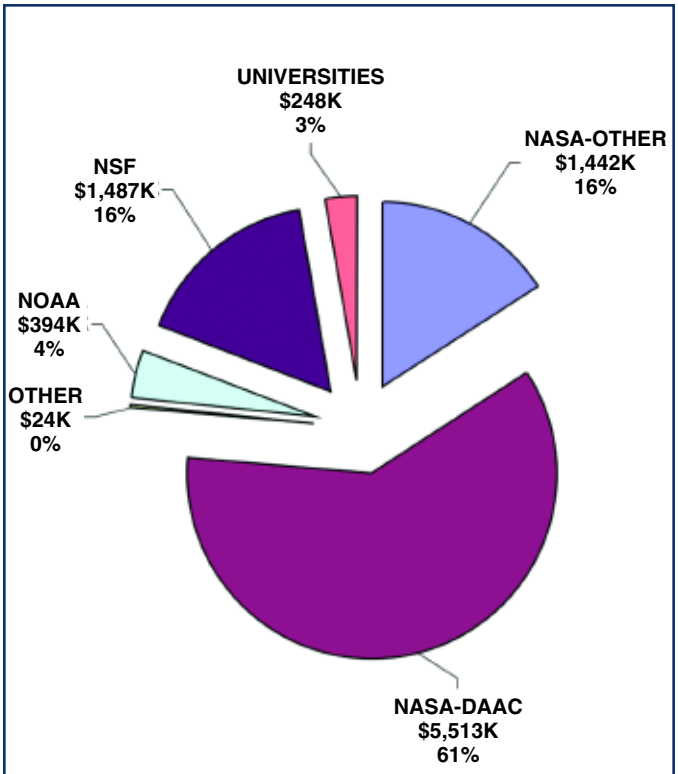
Tingjun Zhang was invited as an Overseas Guest Scientist at the Chinese Academy of Meteorological Sciences, in Beijing, China, from March 2005 through February 2008. He is working closely with colleagues on meteorological records in western China.

Financial Support

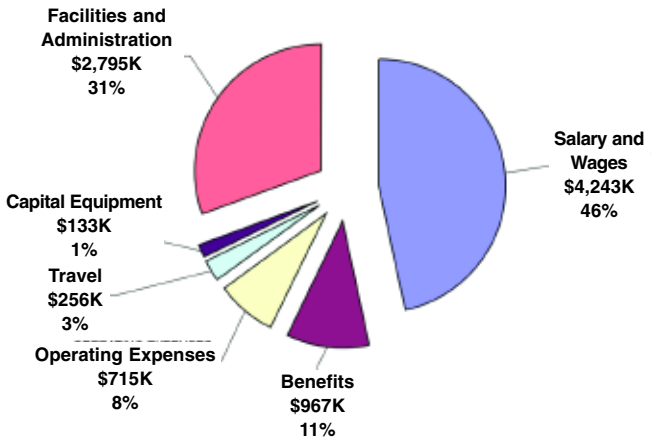
NSIDC's annual budget for calendar year 2006 was 9.1 million dollars, with funding from national agencies such as NASA, NOAA, and NSF, as well as from various universities.



Calendar year 2006 comparison of scientific research versus data management.



Calendar year 2006 total expenditures by funding source.



Calendar year 2006 actual expenses by category.

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