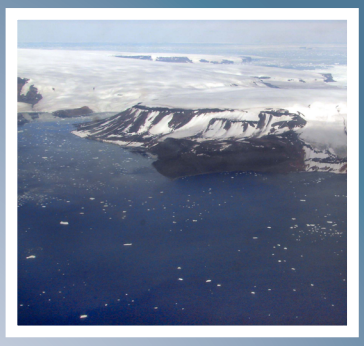
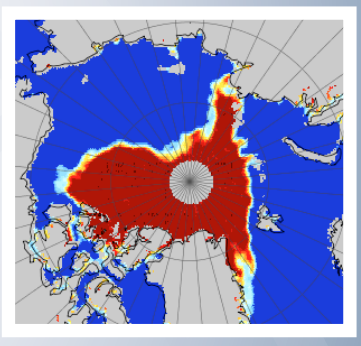




National Snow and Ice Data Center

2011 Annual Report

National Snow and Ice Data Center
2011 Annual Report

National Snow and Ice Data Center
University of Colorado Boulder

http://nsidc.org/pubs/annual/

Cover image captions

Top (left to right)

The Norwegian-U.S. Traverse team disembarks from the LC-139 Hercules at the South Pole, on their way to a ten-week over land traverse of Dronning Maud Land in East Antarctica. The joint campaign, an International Polar Year (IPY) project, studied how climate variability relates to ice sheet mass and global sea level rise. Credit: Ted Scambos, NSIDC

Artist's conception of a polar-orbiting operational environmental (POES) satellite carrying the AVHRR instrument. Many POES satellites are managed and maintained by NOAA.

This in-flight photo shows James Ross Island. Credit: Ted Scambos and Rob Bauer, NSIDC

Middle (left to right)

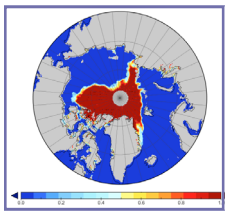
While navigating the Ross Sea, the ARISE project team came across this unusual cluster of icebergs and pancake ice. This is one of several photos taken. Credit: Ted Scambos, NSIDC

NSIDC technical services manager David Gallaher points out features of the new cooling units during the construction of NSIDC's Green Data Center. A key element of the redesign, these new evaporative units reduce cooling energy by more than 90%, compared to the traditional air conditioning units that they replaced. Credit: Ron Weaver/National Snow and Ice Data Center

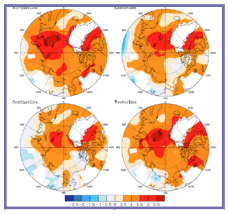
Bottom

This image of sea ice concentration was derived from Nimbus-7 SMMR and DMSP SSM/I passive microwave data, using the NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration.









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Director's Overview

Our Mission

The mission of the National Snow and Ice Data Center (NSIDC) is to improve our understanding of the Earth's frozen realms. This includes our planet's floating sea ice cover, lake ice, glaciers, ice sheets, snow cover and frozen ground, collectively known as the cryosphere. NSIDC advances its mission through:

- Managing, distributing and stewarding cryospheric and related climate data collected from Earth orbiting satellites, aircraft missions, and surface observations.
- Facilitating the collection, preservation, exchange, and use of local observations and knowledge of the Arctic.
- Conducting research addressing all major elements of the cryosphere. This research has increasingly focused on understanding how and why the cryosphere is changing and the implications of these changes.
- Conducting informatics research aimed at finding better ways to discover, integrate, and distill the vast and growing volume of cryospheric and climate data.
- Educating the public about the cryosphere, the changes that are being observed, and their implications.

The National Snow and Ice Data Center is part of the Cooperative Institute for Research in Environmental Sciences, at the University of Colorado Boulder.

Background

NSIDC traces its roots to 1976 when Roger G. Barry took over the Directorship of the transferred World Data Center-A for Glaciology, to archive analog data and information from the 1957–1958 International Geophysical Year. NSIDC got its name in 1982 from the National Oceanic and Atmospheric Association (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) as a result of funding to serve as a national information and referral center for polar research. Dr. Roger G. Barry was the director of NSIDC from its inception until spring of 2009, when the torch was passed to Dr. Mark C. Serreze.

Today, NSIDC makes hundreds of scientific data sets accessible to researchers around the world, ranging from small text files to terabytes of remote sensing data from the National Aeronautics and Space Administration (NASA) Earth Observing System satellite program and other sources. Our data managers, technical writers and scientific programmers operate in teams to create or publish data sets, working closely with data providers and users to understand their needs and to offer documentation, tools, and formats that support scientific research. NSIDC also works to ensure that data and metadata (data describing the data) are continually preserved and will be accessible for the longer term, so that researchers can study climate change over long periods. Together, these practices ensure the physical and scientific integrity of the data we manage and disseminate. We manage data under sponsorship from NASA, the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF).

Major areas of research at NSIDC include:

- Processes driving the observed downward trend in Arctic sea ice extent and the environmental and societal consequences of this ice loss both within and beyond the Arctic.
- The behavior of the Greenland and Antarctic ice sheets and Himalayan glaciers, along with their contributions to sea level rise.
- Forecasting stream flow in the American west.
- Changes in Earth's permafrost and their implications.

In response to an increasingly challenging funding environment, NSIDC is finding more efficient ways of conducting its work, including capitalizing on synergies between different projects and embracing a more flexible and responsive team-oriented approach to software development.

- Alternative database structures to enable investigators to more efficiently search through vast data volumes to answer science questions.
- Data casting services to make NSIDC data more visible to more researchers.
- New directions in data stewardship involving the university library system.
- Enhancing data discovery through semantic interoperability.

A continued strength of NSIDC is synergy between its environmental and informatics research and data management. Our in-house scientists consult in creating data products, answer questions from data users, and in some cases produce new data sets distributed by NSIDC. NSIDC's education and outreach efforts are wide ranging. NSIDC scientists are in high demand by the media to lend their expertise on environmental issues involving cryospheric change. Arctic Sea ice News and Analysis (ASINA, http://nsidc.org/arcticseaicenews/), the most popular web page at NSIDC, provides daily updates of Arctic sea ice extent along with scientific analysis of evolving conditions that that is both accurate but accessible to a wide audience. Icelights (http://nsidc.org/icelights/) provides detailed information on ice and climate topics to complement ASINA. The NSIDC Education Center (http://nsidc.org/cryosphere/) provides a range of information about Earth's snow and ice, from comprehensive "All About" sections to quick facts on popular snow and ice topics.

Highlights of 2011

The assembled collection of NSIDC Monthly Highlights (http://nsidc.org/monthlyhighlights/) that follows serves to illustrate the breadth of work at the Center, including how we address challenges in data management, research on the cryosphere and the changes that are taking place, and how we are developing innovative ways to add value for our data and information users.

However, words and pictures are ineffective in conveying the pride, spirit of teamwork, and willingness to adapt to change that characterizes the employees of NSIDC. In response to an increasingly challenging funding environment, NSIDC is finding more efficient ways of conducting its work, including capitalizing on synergies between different projects, embracing a more flexible and responsive team-oriented approach to software development, and reorganizing working space to promote better coordination and communication between the different functional groups of the center. While we have made great strides in the past year, as a living, evolving organization NSIDC is always learning, constantly trying to improve itself to better serve the global community. ❄

Looking Back on the International Polar Year

The Norwegian-U.S. Traverse team disembarks from the LC-139 Hercules at the South Pole, on their way to a ten-week over land traverse of Dronning Maud Land in East Antarctica. The joint campaign, an International Polar Year (IPY) project, studied how climate variability relates to ice sheet mass and global sea level rise. *Credit: Ted Scambos, NSIDC*

"In fifty years time, the data resulting from IPY 2007-2008 may be seen as the most important single outcome of the programme." —A Framework for the International Polar Year 2007-2008 (ICSU, 2004)

Past International Polar Years left exciting legacies for generations of scientists: the first synoptic polar observations, confirmation of the continental drift, unprecedented international cooperation, and even the foundations for the Antarctic Treaty. What will be the legacies of the 2007-2008 IPY?

Among those legacies are lessons on collaborative data management and data sharing for today's highly interdisciplinary, data-intensive science. Whether data are images captured by satellites in space or the deep knowledge of indigenous hunters on the ground, IPY highlighted the need for changes in data management, and the potential to in turn support scientific progress. As a result, practices have evolved at data centers like NSIDC, and IPY continues to shape how the scientific community thinks about and plans for data management.

Open data and data policy

During a time of rapid polar change, IPY called for open data release on the shortest feasible timescale, to support the interdisciplinary collaboration that can lead to richer insights during an IPY. This data policy pushed the bounds of established practice, while recognizing ethical restrictions of data sharing, such as concerns about human subjects and fair attribution for data creators.

To maximize their value and reuse, public data should be made freely available in the public domain. This is a major focus of the Polar Information Commons, an ICSU project following on from IPY to establish an improved framework for polar data sharing and preservation. A central tenant of the PIC is that data should be as unrestricted as possible, but scientists need to establish norms of behavior that ensure proper, informed, and equitable data use.

From these concepts of timely data release and ethical data sharing, many nations imposed new, open-data conditions as part of IPY project funding requirements. The U.S. Arctic Observing Network (AON) was a leading example, requiring annual data deposit in a collaborative archive at NSIDC and the National Center for Atmospheric Research. IPY also encouraged fair attribution for data creators by promoting formal data citation and providing data citation guidelines. NSIDC has continued this effort, and an evolved version of the

IPY Guidelines has been adopted by both the Group on Earth Observations (GEO) and the Federation of Earth Science Information Partners (ESIP).

Many IPY data in some countries and disciplines remain unavailable, and much in the culture of science resists open and timely access. Nevertheless, IPY has fundamentally changed the conversation in polar science. No longer is it a question of whether to share data but rather when and how. Furthermore, it is clear that funding agencies have the ability to steer that conversation.

Developing infrastructure

One of the greatest lessons from IPY is that data management must be funded and planned in advance. Important developments in polar data infrastructure have occurred, but we are still playing catch up. Significant differences remain between Arctic and Antarctic data management, at both national and international levels. While the situation has improved, new polar research programs are still designed today without considering data sharing and archiving needs and their support. As a result, some of these data are at risk for becoming inaccessible, or lost to future researchers.

We also learned that different disciplines have different attitudes and norms of behavior around data sharing. They also have highly variable data infrastructures. Much more flexible and collaborative systems are needed, and science communities also need to recognize that the groundwork for sharing data between systems is laid at the time of data collection. It starts with using consistent protocols and measurement techniques within disciplines, which can, in turn, drive data formats. Designated data coordinators at the project and national level greatly facilitate this process.

On a more positive note, IPY led to the creation of many new national and discipline-based data centers. The U.S. National Science Foundation (NSF) funded a new system to handle all the data from NSF-funded Arctic investigators, as a collaborative effort between NSIDC and the National Center for Atmospheric Research (NCAR). Increasingly, data centers such as these are networked and share metadata and data through automated systems.

While IPY visions of integrated data systems are still a long ways off, some of the building blocks are coming into place. Furthermore, there is greater emphasis on data management in disciplines where it was previously lacking, such as Arctic biodiversity and local and traditional knowledge.

New collaborations

Perhaps the greatest outcome of IPY was the increase in international and interdisciplinary collaboration around data management. Repeatedly, data managers found how a pragmatic, flexible, and especially a collaborative approach can encourage change in science that enhances data flow and usefulness. NSIDC has increased its collaboration with data creators and data centers around the world as a result of IPY, helping to create more robust and useful data and to identify and spread best practices. We look forward to maintaining these collaborations with our new friends to ensure IPY data survive as the lasting legacy of IPY. ❄

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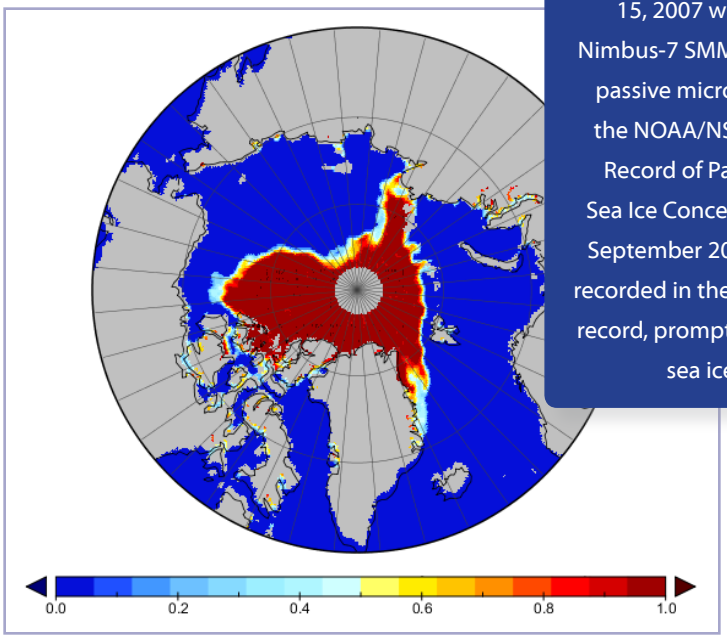
A Climate Data Record for Sea Ice

The rising interest in Arctic sea ice is the inverse of its decline: less ice equates to more demand for reliable data on sea ice conditions. But with decades of data from multiple satellite sensors and multiple research groups, where do researchers turn for the most reliable long-term view? In answer, NSIDC has produced a Climate Data Record for sea ice concentration, an important indicator of sea ice health and Arctic climate.

The demand for data

The National Research Council (NRC) defines a Climate Data Record (CDR) as a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change. Because of the strong decline in Arctic sea ice, a signal of climate warming, some of NSIDC's most used products are sea ice records from passive microwave remote sensing instruments on U.S. Defense Meteorological Satellite Program (DMSP) satellites. These products provide ice concentration and extent information since late 1978, based on two algorithms developed by scientists at the NASA Goddard Space Flight Center (GSFC). Each algorithm utilizes scientific expertise to manually pull out spurious areas of ice, and the resulting data products have different strengths and weaknesses. For example, the NASA Team data product is more accurate where surface temperatures are very cold; the Bootstrap data product does a better job where ice is melting.



This image of percent sea ice concentration for September 15, 2007 was derived from Nimbus-7 SMMR and DMSP SSM/I passive microwave data, using the NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration. Sea ice in September 2007 was the lowest recorded in the thirty-year satellite record, prompting high interest in sea ice data sets.

Like many climate data sets, the sea ice concentration products were developed and processed by individual researchers or research groups for use within the scientific community studying sea ice. These expert users knew how to appropriately use the data, and understood the limitations of the data. However, as interest in sea ice data (and climate data in general) has increased, there is a much broader community of users: researchers in other areas of climate, modelers, biologists, ecologists, sociologists, civilian and military government planners, educators, students, journalists, bloggers, and the general public. These users are not familiar with the science behind the data or the subtleties of different data sets. As a result, they may not understand the limitations of the data, and can easily misuse the data.

Setting the record straight

When NSIDC set out to produce a CDR for sea ice concentration under NOAA's CDR program, the intent was to blend the current NASA GSFC products into the combined CDR. As NSIDC examined the blended product, it became clear that it would not meet NOAA's requirement to be transparent and reproducible. So NSIDC created a new data product by reprocessing the original satellite data with both the NASA Team and Bootstrap algorithms, adding several features to meet CDR criteria. First, the processing is fully automated and documented, with processing code

available from the NOAA CDR program. Second, the data are provided in a self-describing file format (NetCDF4) that contains complete Climate and Forecasting (CF1.5) metadata. Finally, the data include fields that indicate data quality or uncertainty for each concentration measurement.

The new sea ice CDR was recently made available to users. The CDR provides a consistent, daily time series of sea ice concentrations from 09 July 1987 through 31 December 2007. Data are in the same polar projection and grid size as the previous NSIDC and NASA data sets. The original NASA data sets are also provided for reference. Additional years of data will be released as processing permits. ❄

Access the NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration.

This work was supported by the NOAA Climate Data Record program, grant #NA08OAR4320914. The NASA Distributed Active Archive Center (DAAC) at NSIDC provided input data sets to the CDR effort under NASA contract NNG08HZ07C.

Broken sea ice north of Greenland.
Credit: Courtesy Andy Mahoney, NSIDC

Greening Snow and Ice

Snow and ice by definition need to stay cold, and so do scientific data about snow and ice. While computer room air conditioning is not the kind of cold that NSIDC normally specializes in, NSIDC has figured out how to keep its computers and data cool with a lower carbon footprint. The NSIDC Green Data Center, a first-of-its-kind system, has cut the energy required to cool its data center by more than 90%, and stands as a model for others to reduce energy consumption.

The NSIDC Green Data Center, a first-of-its-kind system, stands as a model for others to reduce energy consumption.

The impossible dream

At NSIDC, a roomful of computers and storage devices serve up its data archive containing more than 500 terabytes of data on the world's frozen regions, to researchers around the globe. Keeping these machines cool so that they can operate safely used to consume more than 300,000 kilowatt-hours of electricity per year, enough to cool 34 average U.S. homes. "There was a certain irony that here we are working on climate research and our data center was consuming an awful lot of power," NSIDC technical services manager David Gallaher said.

He had a vision of massively cutting the energy used to run the data center on a combination of advanced cooling and solar arrays. Many people told him it could not be done, but he found enthusiastic partners at the National Renewable Energy Laboratory and at Colorado companies Coolerado Corporation and RMH Group. Together they designed a new data center, using energy-sipping indirect evaporative units that cool by blowing air over water. The NSIDC team was awarded a grant from the National Science Foundation under its Academic Research Infrastructure Program to renovate the computing facility.

The design takes advantage of Boulder, Colorado's dry climate. Evaporative cooling works best in low-humidity conditions; plus, during cool weather, the new system shuts off the cooling units, and draws in the cool outside air and filters it. The Coolerados function as chillers in the summer and humidifiers in the winter. Humidity and temperature are controlled within a few percent. The system has smart software controls to automatically swing between the evaporative coolers and outdoor air.

Powered by the sun

Soon, the dream of a solar-powered data center will be a reality. In late 2011, 720 solar panels will be mounted on NSIDC's roof. The panels will generate enough energy to cool the data center, operate the computers, charge backup batteries, and feed energy back to the grid, when the sun is shining. Since Boulder averages more than 330 days of sunshine per year, Gallaher expects the solar array to provide about 70% of the retrofitted computing facility's power needs.

Gallaher and NSIDC want to share what they learned with others, in hopes of helping to reduce the energy demands and carbon emissions of data and computing centers around the U.S. According to the EPA, data centers in the U.S. consume as much energy as 5.8 million average U.S. households, which is similar to the amount of electricity used by the entire U.S transportation manufacturing industry.

"The technology works, and it shows that others can do this too," Gallaher said.

Gallaher and his team received the Colorado Governor's Award for High-Impact Research for the project. ❄

For more information and to view a near-real-time monitor of energy consumption, cooling, and energy savings, visit NSIDC's Green Data Center page (http://nsidc.org/about/green-data-center/).

NSIDC technical services manager David Gallaher points out features of the new cooling units during the construction of NSIDC's Green Data Center. A key element of the redesign, these new evaporative units reduce cooling energy by more than 90%, compared to the traditional air conditioning units that they replaced. *Credit: Ron Weaver/National Snow and Ice Data Center*

Working the West Antarctic Ice Sheet

On September 21-23 2011, more than 90 Antarctic scientists, data experts, writers, and students gathered at Sylvan Dale Ranch, nestled in the rolling plains near Loveland, Colorado. This three-day retreat brought diverse research disciplines from around the world to focus on rapid changes in the West Antarctic Ice Sheet (WAIS) and related areas of other ice caps.

Unlike most of the ice in Antarctica, the West Antarctic Ice Sheet rests on bedrock below sea level. In the 1970s, theoretical research suggested this made it vulnerable to a rapid collapse, potentially as quickly as two centuries, that could add several meters to sea level. NASA researcher Bob Bindschadler said, "This research suggested that ice sheets were not stable if they sat on a bed below sea level." Once the ice sheet began to retreat, water would flow under it, lifting the ice and floating it off its resting place.

Research on the WAIS started off with glacier studies, but researchers soon realized that there were more factors involved. "As the science evolved, we realized it wasn't just a glaciological problem. There were additional aspects of the science that involved meteorology and oceanography and ice coring subglacial geology," said Bindschadler. The researchers needed to measure and monitor such things as whether the ice sheet was gaining or losing mass, whether glaciers were speeding up their flows, and how much these changes were adding to sea level.

Resources to do fieldwork in Antarctica are limited. The WAIS workshop helps bring researchers together to decide where to focus these limited efforts, and to share the results of their fieldwork. In this photo, clouds pepper the sky over a research camp on the West Antarctic Ice Sheet. *Credit: Spruce Schoenemann, University of Washington*

An interdisciplinary community

Each year, scientists meet at the workshop to share the latest WAIS research, and mull over difficult questions like how the valleys and lakes underneath the ice sheet affect how it moves, or what happens to glaciers when the ice shelves in front of them collapse. NSIDC Lead Scientist Ted Scambos organized the workshop along with NSIDC and CIRES staff. He said, "The WAIS meeting is the key meeting of the year for ice sheet dynamics, remote sensing, and the net growth or shrinkage—mass balance—of the WAIS and other major ice sheets."

In 2011, researchers presented new data that helps better quantify just how much ice is trapped in the giant ice sheet, how fast it is moving, and where it is going. Researchers from UC Irvine presented a new, virtually complete map of ice velocity across Antarctica, showing where the ice is flowing fastest. Scientists also discussed how to best harness data from the NASA Gravity Recovery and

The WAIS Workshop is organized as a retreat, getting researchers together in a remote, quiet setting, where they can focus on talking to each other about science. This year the attendees also had the chance to get out and explore the 5,000 acres of Sylvan Dale Ranch, either on foot or horse. *Credit: Ted Scambos, NSIDC*

Climate Experiment (GRACE) satellite to measure the mass of the ice sheet, and determine how that data might fit together with new data from the European Cryosat mission and the upcoming Ice, Cloud, and Land Elevation Satellite–2 (ICESat–2). New radar studies presented detailed maps of the lakes and rivers that flow beneath the ice sheet.

Christine LeDoux, a researcher at Portland State University, attended the workshop for the first time this year. She said, "The length of the meeting and social opportunities made it possible to talk with many people, working on different parts of problems similar to mine, or interesting in different ways." LeDoux presented details of the history of ice flow and fracturing on the Ross Ice Shelf using MODIS mosaic images.

As observations of West Antarctica improve, the scientists are realizing that it is more important than ever to continue the meeting. Bindschadler said, "We have been astonished at how rapidly changes can occur. We are no longer talking about hypothetical dynamics of the ice sheets, but we are perhaps witnessing the early stages of this." ❄

Arctic Sea Ice News & Analysis: Near-real-time Data for All

As Arctic sea ice declined towards its lowest extent for the 2011, people around the world were watching. Would the ice extent break another record this year? What would it mean if it does break a record? If it doesn't break a record, does that mean the sea ice is recovering?

Many people will find their answers to these questions on the NSIDC Arctic Sea Ice News & Analysis Web site. Interested readers can follow the ups and downs of sea ice extent in near-real time, checking back daily for data updates. Once or twice a month, NSIDC scientists weigh in with their analysis of current conditions and highlights of related data and research, including from the broader science community. Scientists work with NSIDC communications staff to write clear, concise articles. The result is a unique source of scientific information that provides valuable real-time input for researchers around the world studying sea ice and the Arctic environment, but written in a way that is accessible to everyone, including the general public.

Updated images of sea ice extent are published daily on the Arctic Sea Ice News & Analysis Web site, providing current analysis of conditions in the Arctic. Arctic sea ice extent on September 9, 2011 was 4.33 million square kilometers (1.67 million square miles). The orange line shows the 1979 to 2000 median extent for that day. *Credit: NSIDC*

Arctic Sea Ice News & Analysis grew out of an effort to share information with journalists, during the record-low sea ice levels in 2007. But the site drew millions of visits, reaching a far broader audience than originally intended.

Making data available and understandable

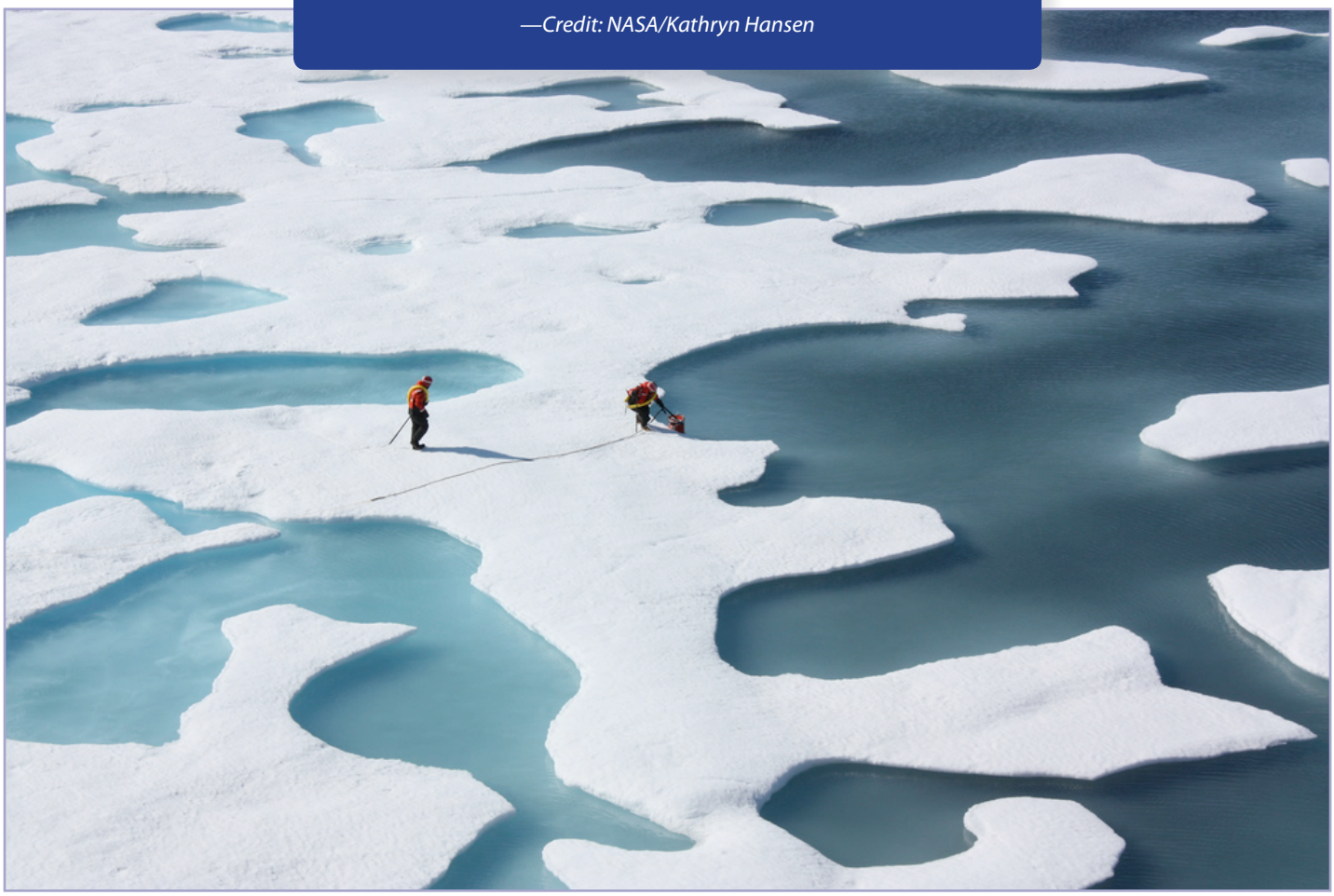
Arctic Sea Ice News & Analysis grew out of an effort to share information with journalists, during the record-low sea ice levels in 2007. But the site drew millions of visits, reaching a far broader audience than originally intended. Regular readers now include scientists, journalists, teachers, students, and the interested public. These readers have different views about science and the changing climate, but all are interested in sea ice data.

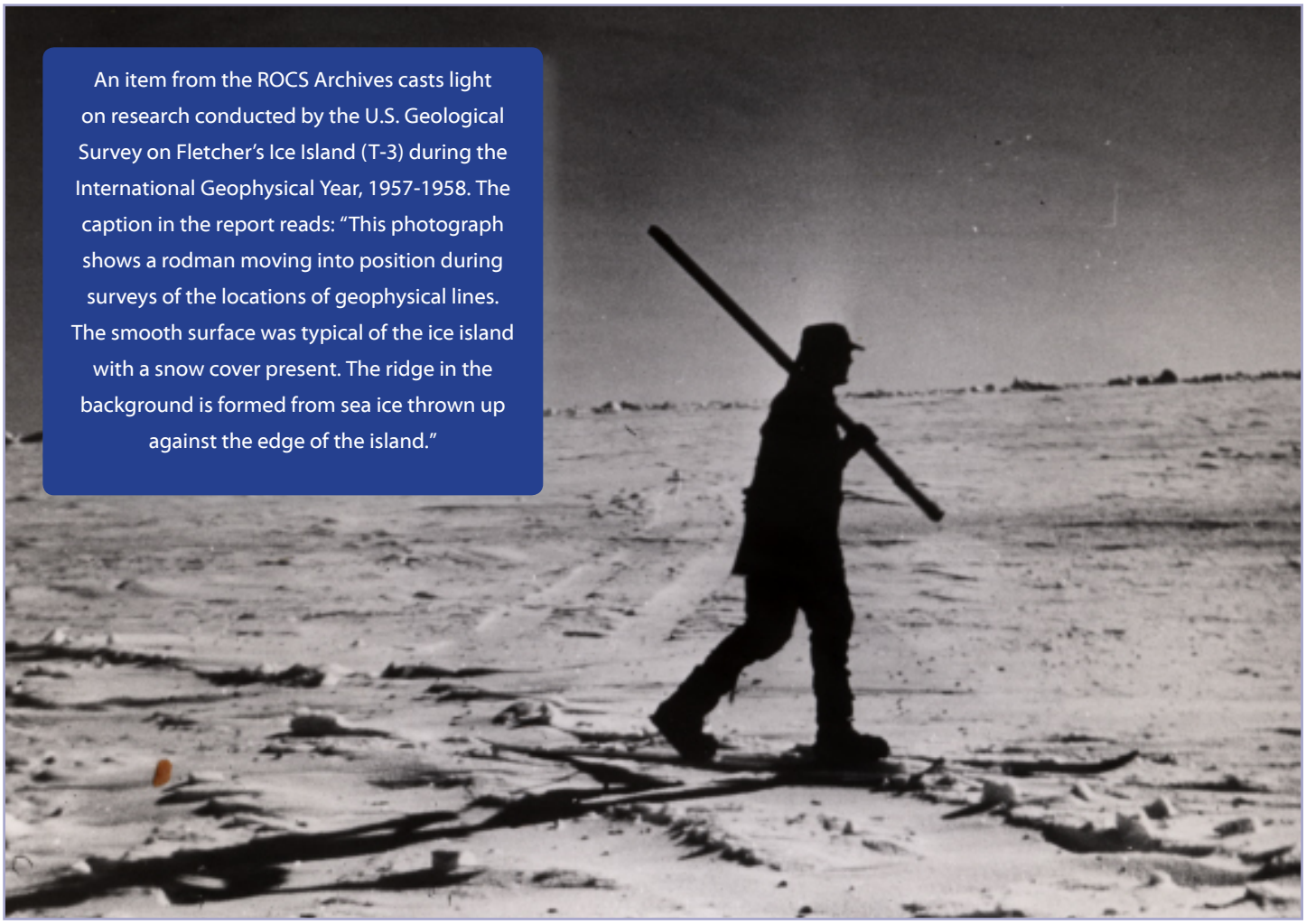
NSIDC primarily functions as a data center, archiving scientific data and making it available to scientists. But more and more, people are calling for transparency and openness in scientific data. Arctic Sea Ice News & Analysis shows one way to do that. Making data available is of little use unless people can understand where it comes from and what it means. ❄

Arctic Sea Ice News & Analysis is partially funded by NASA.

This photograph from the NASA ICESCAPE mission in July shows melt ponds on the surface of the Arctic sea ice cover. Surface melt has now stopped as air temperatures have cooled. But relatively warm water will continue to melt the ice from below for another couple of weeks.

—Credit: NASA/Kathryn Hansen





An item from the ROCS Archives casts light on research conducted by the U.S. Geological Survey on Fletcher's Ice Island (T-3) during the International Geophysical Year, 1957-1958. The caption in the report reads: "This photograph shows a rodman moving into position during surveys of the locations of geophysical lines. The smooth surface was typical of the ice island with a snow cover present. The ridge in the background is formed from sea ice thrown up against the edge of the island."

A Catalog of the Cryosphere

Today, scientists study the Earth with satellites and computers, but their interest in past climate precedes these digital tools. So while NSIDC is best known for its massive archives of digital Earth science data, it also holds an archive of non-digital, or analog, materials. Journals, photographs, films, and publications help document the state of Earth's frozen regions stretching more than 100 years in the past, as well as the history of science and exploration in cold regions. NSIDC has been organizing these materials into distinct collections and just released the first catalog records for one of these collections. Scientists and historians can now go online to peer into the International Polar Year Data and Literature collection, at the Roger G. Barry Resource Office for Cryospheric Studies (ROCS) at NSIDC. More than 800 digital items—photographs, data charts, publications, audio files, and even a video—relating to the first two International

Polar Years (IPY) 1882-83 and 1932-33 and the International Geophysical Year (IGY) 1957-58 reside in this public, searchable catalog, most of which are available for download. To search and access the collection, see the International Polar Year Historical Data and Literature Web page (http://nsidc.org/data/g02201.html).

Searching the archives

The ROCS Archives specializes in historical science materials related to Earth's frozen regions. Its holdings include thousands of maps, photographs, prints, expedition journals, and more.

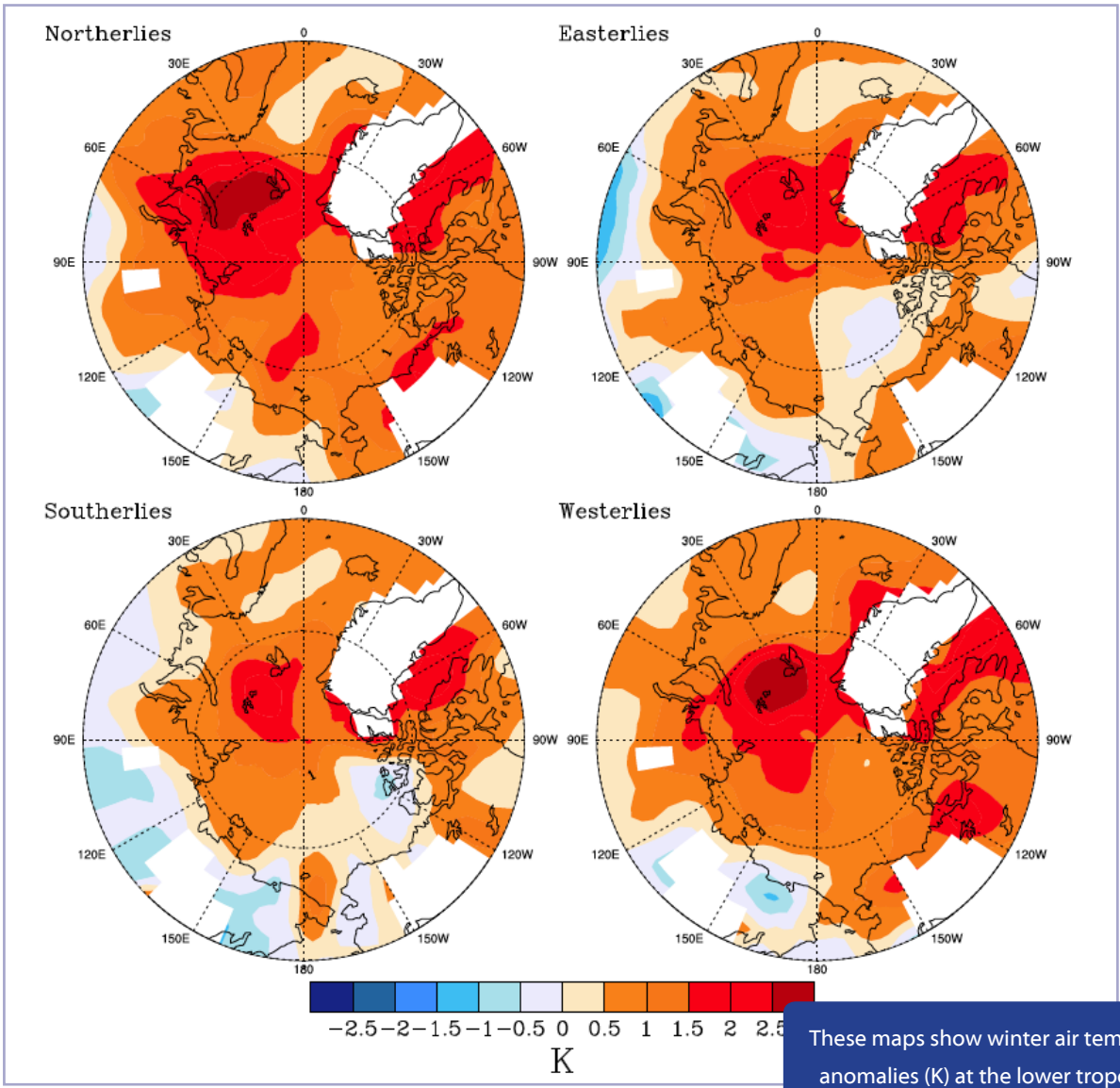
Included are materials from early expeditions to Alaska, the Alps, South and Central America, and Greenland, as well as historical records of the National Snow and Ice Data Center. These materials include approximately 1,400 maps, 8,000 photographic prints, 1,400 glass plate negatives, 1,600 color slides, more than 7,000 ice charts, and 38 cubic feet of manuscript materials. In addition, NSIDC holds 144 cubic feet of film and 34 cubic feet of the records of the history of NSIDC. All of these materials, garnered since the late 1800s, document the birth of glaciology as a field of study and more recently the history of the National Snow and Ice Data Center.

Cataloging items like these is a long and painstaking project. Unlike a book in a library, which often comes with a ready-made catalog entry, each collection in an archive must be evaluated, classified, described, and indexed individually before it can be entered into the catalog. NSIDC and ROCS continue the long-term project of cataloging the many collections in the archives. Some holdings have been partially digitized for online viewing, including the Glacier Photograph Collection and the Dehn Collection of Arctic Sea Ice Charts, 1953-1986, and these items can be found in NSIDC's data catalog. However, many more analog resources remain to be described and cataloged.

Items in the ROCS Archives can be viewed on site at NSIDC. Contact the ROCS Archivist with more specific questions about holdings or to arrange a visit to NSIDC. ❄

Learn more about the ROCS Archives holdings (http://nsidc.org/rocs/analog_archives/holdings.html).

Search the ROCS Archives online catalog (http://nsidc.org/rocs/archives-catalog/index.php).



These maps show winter air temperature anomalies (K) at the lower troposphere (925 hPa level) for the decade 2000–2009 for northerly, southerly, easterly, and westerly winds, calculated with respect to mean temperatures for each wind direction over the base period 1979–2009. The predominance of reds indicates that temperatures tend to be warmer than they used to be for all wind directions. The changes are especially large over the Kara and Barents seas. Part of what is happening is that the loss of sea ice is allowing for ocean heat to be readily pumped into the atmosphere, and this heat is then carried downwind to affect the surrounding region.

Winds of Change

Scientists look at changes in the extent of Arctic sea ice at summer's end—the seasonal minimum—as an indicator of climate change. Since 1979, that low mark is averaging 11 percent lower each decade. Will that downward slide continue? Scientists think yes, so the next question is how fast: will it be at a steady rate, will it slow down, or will it speed up?

In any one year, the Arctic´s sea ice cover can get a nudge from unusually warm or cool weather patterns. But could Arctic weather patterns also be getting nudged by the loss of sea ice? NSIDC scientists Mark Serreze and Andy Barrett, and colleague John Cassano took a closer look at this question.

Changes amplified

The loss of Arctic sea ice is not just a response to a warming planet—it also contributes to the warming. With less of the bright, white ice, more of the sun's energy is absorbed at the ocean surface in spring and summer, causing even more ice to melt. Scientists call this a feedback, and it is one of the ways that warming gets amplified in the Arctic.

The sea ice cover is also influenced by weather patterns. Winds may push ice together and expose more open water. Warm winds from the south can promote more melt in summer or less ice growth in winter. At other times, weather patterns will slow summer melt or foster more winter ice growth. What Serreze and colleagues are seeing is that temperatures associated with different Arctic weather patterns are starting to change, and that some of this change is itself due to the loss of sea ice.

Circulating the heat

The researchers compared temperature patterns for the period from 1979 to 2009 with the period from 2000 to 2009, to look for anomalies during this most recent decade of strong sea ice decline and Arctic warming. They then looked at how these temperature anomalies relate to changes in heat transfer from ocean surface to the air, changes in snow cover on land, and changes in the character of the winds.

They found that while, in general, winds from all directions now tend to be warmer they used to be, the warming in winter months is especially strong in areas that were formerly ice-covered but are now free of ice, particularly in the Kara and Barents seas. As winds blow over these open water areas, they pick up heat being released by the underlying ocean. This heat is then carried downwind to warm surrounding regions.

However, they also found that part of the reason why there is less winter ice in the Kara and Barents seas regions in the first place is that warm winds from the south have also have become more frequent. Changing ocean currents have likely also played a role. This complex interplay of processes documents some of the challenges that scientists face in trying to predict both the pace of Arctic warming and the pace of sea ice decline. ❄

References

Serreze, Mark C., Andrew P. Barrett, and John J. Cassano. 2011. Circulation and surface controls on the lower tropospheric air temperature field of the Arctic. Journal of Geophysical Research 116, D07104, doi:10.1029/2010JD015127.

A New Twist on Climate Communication

When the general public reads news about the changing climate, shrinking glaciers, and declining sea ice, they often have questions about what they see. How do scientists get these data? How do we know that climate change is a real phenomenon? How much can scientists do to predict the future of the climate? In January 2011, NSIDC launched a new Web site to help answer those questions: Icelights: Your Burning Questions About Ice and Climate.

The idea for Icelights grew out of NSIDC's interactions with the public on satellite sea ice observations. In 2007, when Arctic sea ice hit record lows, journalists and other readers came to NSIDC looking for answers. With our near-real-time data and in-house scientists, we saw an opportunity to offer more than just bare facts. NSIDC communicators and scientists launched the Arctic Sea Ice News & Analysis Web site to offer up-to-date information on fast-changing conditions.

Since then, changing Arctic sea ice conditions have sparked further questions from our readers. Some people have specific questions: How do you determine ice extent numbers? What is the standard error for this data? Others question the conclusions of our scientists, or want to know more about the implications of Arctic sea ice decline or climate change in the Arctic. We have even received suggestions for potential fixes to ice loss and climate change: one reader suggested covering the Arctic Ocean with Styrofoam to replace dwindling sea ice. Icelights was conceived as a way to respond to these questions, to correct misconceptions, and to give readers a behind-the-scenes view of how scientists work.

For example, the unusually cold weather during winter 2011 in Europe and the eastern United States prompted some people to ask whether there was a connection between declining sea ice and the unusual weather. Scientists have been exploring this connection, but much of the research was preliminary. An Icelights article looked at the state of the research and helped explain how a correlation between low ice extent and odd weather may or may not indicate a causative relationship.

With traditional science journalism experiencing challenging times, Icelights provides a new model for communicating science with the general public. The site not only announces new findings and studies, but unpacks these topics to explain how science works. Icelights readers are also invited to send in their questions, making it a true dialogue between NSIDC and the people who follow our research. ❄

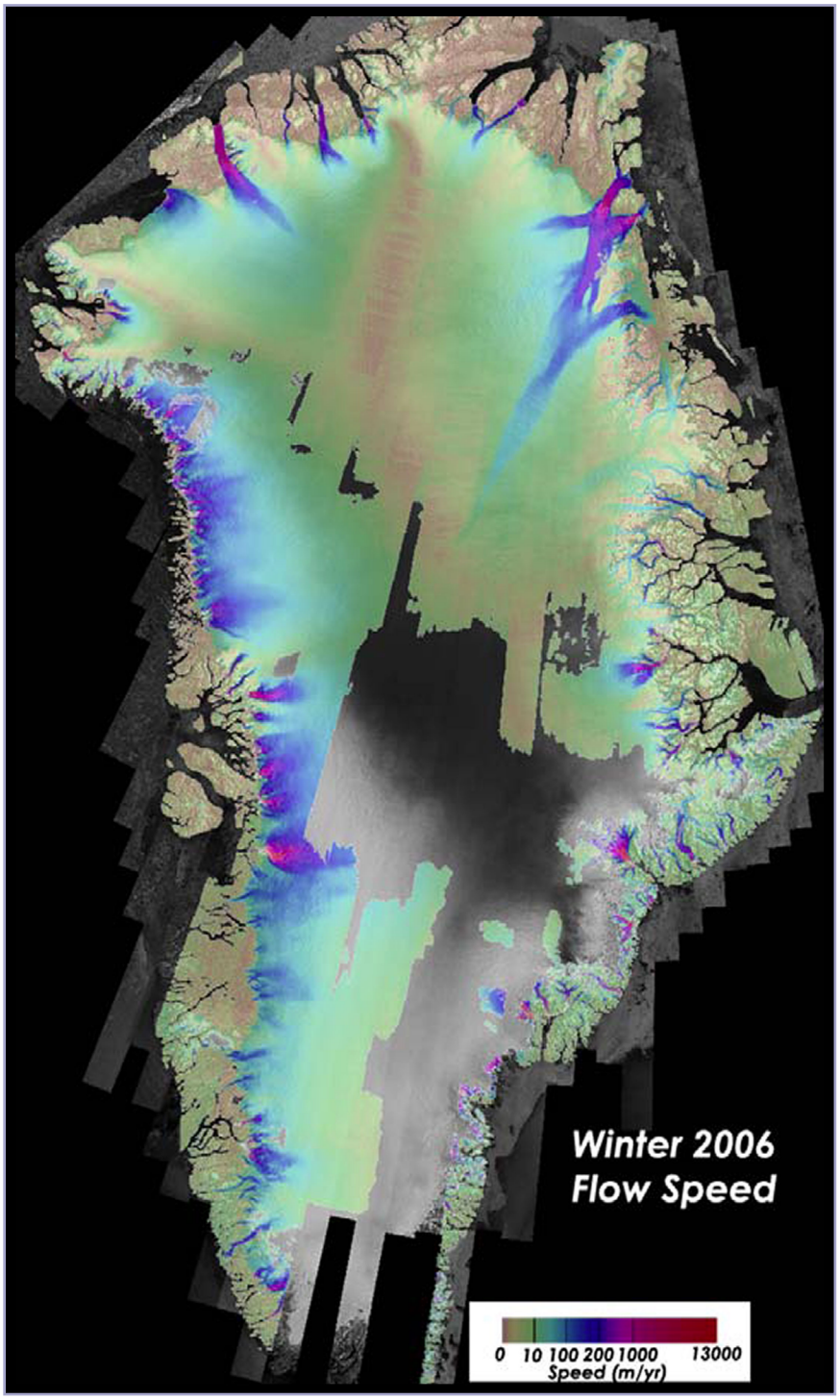
For more information and to read new articles from Icelights, visit the Web site at at http://nsidc.org/icelights/

Arctic Sea Ice News & Analysis is produced with support from NASA; Icelights is supported by the National Science Foundation (NSF).

With traditional science journalism experiencing challenging times, Icelights provides a new model for communicating science with the general public.

Some news reports last winter connected heavy snow over the Northeastern U.S. to decreasing Arctic sea ice. A March Icelights post explored the research on the topic, providing background and context for our readers. *Credit: NASA Earth Observatory.*

Spanning the Satellite Generations



High above the clouds, some twenty NASA satellites circle Earth each day, measuring an astounding range of phenomena, from the minute soot particles that make up the plume of a forest fire, to the movement of massive plates of the Earth's crust. Put together, the data are an impressive long-term record of observations on Earth's environment and climate for the last fifty years.

NASA is making sure these data, called Earth science data records (ESDRs), remain valid across old and new satellite missions and a myriad of sensors. The NASA Making Earth Science Data Records for Use in Research Environments (MEaSUREs) program supports scientists who make these long-term ESDRs in their area of speciality. Researchers will soon be able to access several cryospheric MEaSUREs data sets via NSIDC. Ted Scambos, NSIDC's Lead Scientist, is coordinating two of the efforts at the data center. "These are critical data products that NASA-funded scientists have been generating at high precision for the past several years," he said. "Now they will be transferred to a data center and made available to everyone."

This map shows the different speeds at which ice was flowing from the Greenland ice sheet toward the ocean during the winter of 2005 to 2006. The fastest velocities can be found in the outlet glaciers (magenta), seen near the western, northern, and eastern coasts. *Image courtesy Ian Joughin/APL.*

Tapping the expertise

For example, Ian Joughin at the Applied Physics Laboratory at the University of Washington has been producing ice velocity maps of the Greenland Ice Sheet for nearly a decade. The data show how rapidly the ice is moving, from the ice sheet summit towards the ocean; in recent years, many areas have seen increased velocity as a result of warmer ocean water and more surface melt.

Scambos said the new data will be a huge help to researchers interested in ice sheet dynamics. "The data will tell us how well models of ice sheets are doing in predicting ice flow and their net contribution to the oceans," he said. "The main result will be better models of ice sheet dynamics and glacier processes." Ultimately, these data will help in understanding climate warming and its impacts, such as the potential for sea level rise.

Data for better models

Joughin's data are now available online, while pending review by the MEaSUREs program. Researchers can also access a global record of daily freeze and thaw from 1988 to 2007, produced by John Kimball at the University of Montana Flathead Lake Biological Station, and Kyle McDonald, at the NASA Jet Prolusion Laboratory in California. This big-picture, daily look of frozen and thawing land informs research on the interactions of water, heat, and carbon on Earth's oceans and land masses. These data are also pending review.

NSIDC expects to offer data sets from two other MEaSUREs projects: ice velocities in Antarctica from Eric J. Rignot at the University of California at Irvine, and snow extent in the Northern Hemisphere, from David A. Robinson at Rutgers University. ❄

For more information and to access the data, see NASA MEaSUREs Data at NSIDC (http://nsidc.org/data/measures/).

For more information about the NASA MEaSUREs Program, see the NASA MEaSUREs Program (http://earthdata.nasa.gov/our-community/community-data-system-programs/measures-projects).

> ***"These are critical data products that NASA-funded scientists have been generating at high precision for the past several years. Now they will be transferred to a data center and made available to everyone."***
>
> ***—Ted Scambos, NSIDC's Lead Scientist***

From Satellites to Scientists

Snow and ice at the remote poles, the Earth's oceans, the air we breathe, a world of plants: these are just some of the things that satellites can observe. With this wealth of data, sometimes locating specific data for research can feel like hunting for a needle in a haystack. NSIDC alone has 100 terabytes of NASA Earth science data on snow and ice, in more than 27 million files.

Starting in March 2011, NSIDC users can try NASA's newest tool for data search and access, Reverb. Reverb promises a faster, easier experience for discovering and accessing NSIDC's NASA data holdings, as well as data at other NASA centers.

Spanning vast archives

Reverb speeds the process of locating and retrieving just the data a researcher needs. Like NASA's previous search interface, the Warehouse Inventory Search Tool (WIST), Reverb searches metadata at both a high level and a detailed level. Users can limit searches to particular geographic coordinates or search for global data. Users who know the satellite instrument they are interested in can zero in on just that, while other users can discover data on a particular topic across multiple satellites and instruments.

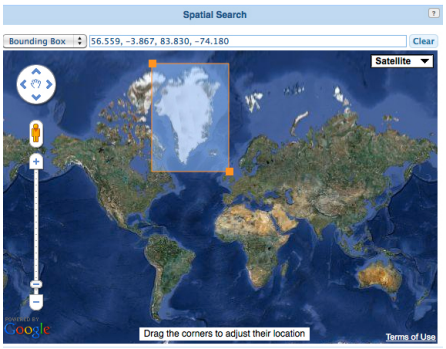
What distinguishes Reverb is its evolution of the user experience. Reverb offers many improvements, small and large, that can help reduce the time users spend figuring out how to use the interface, or understanding what types of data sets are offered.

Discovering and browsing

A redesigned page layout brings important search controls to the top of the Reverb page. Context-sensitive help is available without leaving the main page, by rolling the cursor over marked topics. Controls for manipulating a map for spatial searches match the types of controls that Web users have become familiar with on many other Web sites.

The initial Reverb view immediately offers a list of data set titles, giving users instant results and then allowing them to further filter and refine this list on the fly. Users can browse the data listings, opening an information window to get more detail without leaving the main search interfaces.

Features like these result in a faster, easier-to-understand search experience, leaving NSIDC's research communities more time to focus on science. The current beta release of Reverb is only a starting point for more advanced Web features planned in the near future.



In the Reverb Earth science data discovery tool, users can focus their search by drawing a bounding box on a map. In this example, Greenland is highlighted, so search results will only include data for these geographic coordinates. Compared to previous user interfaces, this map in Reverb is easy to manipulate, and the controls for drawing the bounding box are intuitive. Features like these save users time and cut down on the frustration often associated with learning how to use a tool.

Reverb is currently offered to users for beta testing, with a selection of data sets directly available in the system. Other data sets can be accessed via links to the data archives. ❄

For more information about Reverb, and to access the beta version to search data holdings at the NSIDC NASA Distributed Active Archive Center (DAAC), go to http://www.echo.nasa.gov/reverb/about_reverb.htm. For questions about Reverb, contact NSIDC User Services.

Plotting the Big Thaw

The decline of summer sea ice in the Arctic punctuates a long warming trend that is amplified in the north. While some scientists study the loss of sea ice and its effect on climate patterns, other scientists have been monitoring ground that was once permanently frozen. It is also thawing, with both local and global consequences. NSIDC scientist Kevin Schaefer and colleagues studied the trend to see how much carbon this thawing ground would add to the atmosphere in the future—in the form of greenhouse gases that will accelerate the warming of Earth's climate.

In cold storage

Permafrost covers 25 percent of the ground in the Northern Hemisphere, mostly above the Arctic Circle. Permafrost is ground that has stayed frozen for at least two years in a row, and often for many hundreds or even thousands of years. Harder to monitor than snow and ice on the surface, it also hides many secrets. The permafrost contains a large amount of vegetation, primarily partially decayed plant roots, that has remained frozen in a thick layer near the surface since the last ice age.

Locked in this layer are some 1,672 gigatons of carbon from the decayed vegetation, more than twice the amount of carbon currently in the atmosphere. Like broccoli in the freezer, it is stable as long as it remains frozen, but when removed from the freezer, will quickly thaw and break down. As it decays, some of the carbon is released to the atmosphere as carbon dioxide and methane, adding to the increasing carbon from man-made sources that are causing climate to warm.

Kevin Schaefer's research team drills permafrost cores on Alaska's North Slope. New findings by the researchers indicate permafrost in Earth's frozen regions is readying to release vast quantities of carbon into the atmosphere, increasing carbon dioxide levels. *Image courtesy Kevin Schaefer, NSIDC/University of Colorado at Boulder*

Coming soon to a latitude near you

Scientists have long been watching and measuring permafrost, which is difficult because of its extent and remoteness. Satellites do not easily detect frozen ground, so laborious field studies have been used to study and inventory permafrost. Scientists do not expect permafrost to thaw steadily, but instead to thaw and periodically refreeze, making it harder to plot out how it would release its carbon over time. Based on what they had learned about permafrost thawing, Schaefer and team were able to set up a computer model that combined temperature trends and other data to estimate how permafrost would thaw and release carbon in the future.

The study concluded that one- to two-thirds of Earth's permafrost will disappear by the year 2200, releasing an amount of carbon equivalent to half the amount of carbon that has been released into the atmosphere since the dawn of the industrial age. Even at the lower end of the estimates, the amount of carbon released is expected to produce significant additional atmospheric warming. While not good news for the Earth, this knowledge helps more accurately gauge where global climate is headed. ❄

References:

Schaefer, K., T. Zhang, L. Bruhwiler, A. P. Barrett. 2011. Amount and timing of permafrost carbon release in response to climate warming. Tellus, doi:10.1111/j.1600-0889.2011.00527.x

For more information about permafrost, see All About Frozen Ground (http://nsidc.org/cryosphere/frozenground/).

Pressure on the Arctic

The winter storms of 2009-2010 snuffed out everyday routines in cities in the northeastern U.S. and Europe. That December and January, El Niño and the Arctic Oscillation (AO) joined itineraries to route moisture and extreme cold into record-setting snowfalls. While people living in the northeastern U.S. and Europe were caught off guard by the snow, the effects of the AO on the Arctic were also unexpected.

The AO is an index that marks variations in atmospheric pressure patterns, which in turn lead to changes in weather patterns in the Arctic and in middle latitudes. Data back to 1951 show that the winter of 2009-2010 experienced the most negative AO on record. Past negative phases of the Arctic Oscillation helped keep Arctic sea ice extents higher through the end of the following summer. But not this season: Arctic sea ice reached its third-lowest level in the satellite record during September 2010. NSIDC scientist Julienne Stroeve and colleagues investigated to understand why.

In this photograph of Washington, D.C., picnic tables wait for spring, with the Capitol Building in the background. During the winter of 2009-2010, an extremely negative phase of the Arctic Oscillation brought a series of major snowstorms to the northeastern U.S., with unexpected effects in the Arctic as well. *Image courtesy Carrie Smith, NOAA Central Library*

Patterns of variability

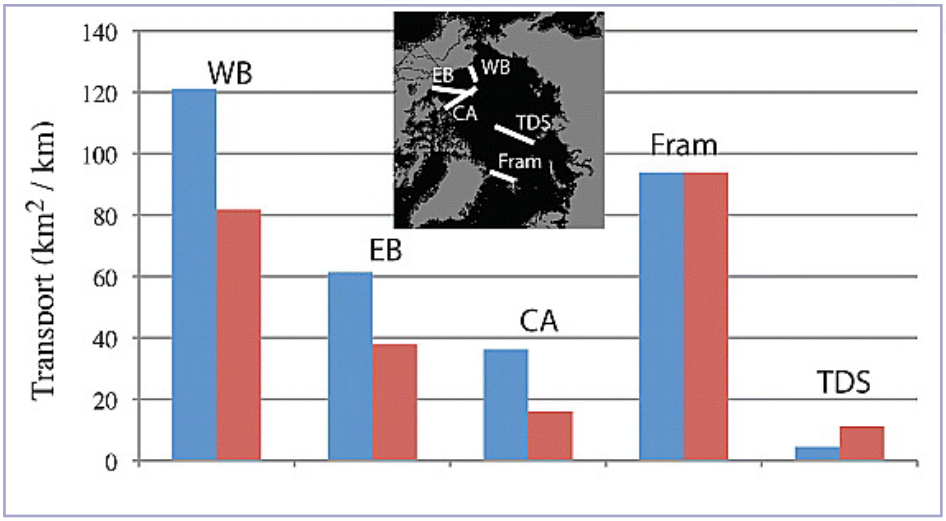
In an average year, a low-pressure air mass sits over the Arctic in winter, creating frigid conditions there, while higher pressures and relatively warmer temperatures occur in lower latitudes. When the AO is in a negative phase, the typical low-pressure pattern over Iceland is not as low; the typical high pressure system over the Beaufort Sea is stronger; and the mid-latitudes experience lower than average pressures. These shifts translate into changes in weather patterns that bring extremely cold air down to lower latitudes and send warmer air north.

The changes in pressure patterns associated with a negative AO also affect the winds and ocean currents that cause sea ice to circulate around the Arctic. Arctic sea ice does not remain stuck in place all winter, and how the ice moves can be key to its survival later in the season. A positive AO tends to flush ice out of the Arctic through the Fram Strait, where it melts in the North Atlantic. This process leaves open water areas in the Arctic that refreeze, but the new ice is thin and vulnerable to melt later in the summer. During a negative AO winter, less sea ice exits through the Fram Strait, and more ice piles up against the Siberian coast and collects in the Canadian Basin, where

it persists and thickens. This thicker ice resists melt during summer.

A change in character

So why did the negative phase of the AO in 2009/2010 fail to help retain ice the following summer? The researchers studied sea ice concentration data, sea ice motion fields, sea level pressures, and air temperatures to understand what happened. Comparing ice transport and the AO for each month, they found that during some periods, the negative AO indeed helped to keep sea ice in the Arctic. But they also noted that the high- and low- pressure systems formed in different areas than during other negative AO winters.



The graph shows the total area of ice transported through key locations in the Arctic for October 2009 through March 2010 (blue), compared to averages for 1979 to 2009 (red). More ice than average was transported westward across gates (see inset map) in the western Beaufort (WB), eastern Beaufort (EB), the western end of the region north of the Canadian Archipelago (CA). Although not higher than average, ice also left the Arctic via the Fram Strait (Fram) and the Transpolar Drift Stream (TDS), further reducing the volume of sea ice. *Image courtesy Stroeve et al.*

Typically, low pressure sits over Iceland during a negative AO, but that winter the AO center of action shifted towards the Barents and Kara seas. This caused enhanced transport of old, thick ice from the coast of the Canadian Archipelago southward and westward into the Beaufort and Chukchi seas; less ice was transported towards Siberia. Since this old, thick ice ended up in the southerly reaches of the Beaufort and Chukchi seas, it was more vulnerable to summer melt. After years of steady decline in the ice cover, this ice was also likely to be thinner than in past years.

The combination of transport of the Arctic's remaining store of old, thick ice into the southerly reaches of the Beaufort and Chukchi seas, together with an overall thinning of the ice over the past several decades, helped lead to the low extent observed in September 2010. Researchers expect to see continued declines in ice volume and extent. And as the ice thins, atmospheric patterns known to help stabilize ice loss are becoming less effective at doing so. ❄

Reference

Stroeve, Julienne C., Mark C. Serreze, Ignatius Rigor, Walter Meier, and Charles Fowler. 2011. Sea ice response to an extreme negative phase of the Arctic Oscillation during winter 2009/2010. *Geophysical Research Letters* 38, L02502, doi:10.1029/2010GL045662.

NSIDC Grants & Contracts

In 2011, NSIDC had 48 active contracts and grants, with a total value (over the anticipated lifetime of each award) of $51,062,167. New awards received totaled $10,710,314.

Approximately 60% of NSIDC's funding is from a NASA contract for operation of the Snow and Ice Distributed Active Archive Center (DAAC). Remaining funding is in the form of grants from NASA, NSF and NOAA. In 2011, NSIDC had 17 active data management grants and contracts and 31 active research grants. Current major data management projects follow below.

Distributed Active Archive Center (DAAC)

NASA

http://nsidc.org/daac/index.html

The NSIDC DAAC is one of NASA's Earth Observing System Data and Information System (EOSDIS) data centers. The NASA data centers process, archive, document, and distribute data from NASA's past and current Earth Observing System (EOS) satellites and field measurement programs. Each data center serves one or more specific Earth science disciplines and provides its user community with data products, data information, user services, and tools unique to its particular science. Each data center is also guided by a User Working Group in identifying and generating these needed data products. The NASA data centers serve as the operational data management and user services arm of EOSDIS, performing such tasks as data ingest and storage, filling user orders, answering inquiries, monitoring user comments, and providing referrals to other data centers.

Advanced Cooperative Arctic Data and Information Service (ACADIS)

NSF

http://www.aoncadis.org

ACADIS manages the diverse data needs of the Arctic research community supported by the NSF Office of Polar Programs (OPP) Division of Arctic Sciences (ARC). ACADIS provides data ingest and access services to scientists, decision-makers and other Arctic stakeholders, as well as archival services to ensure data accessibility through the coming years and decades. By allowing scientists an easier path to archive, access, integrate and work with data spanning multiple disciplines, the project enables scientific discovery.

ACADIS is a collaborative effort between the National Snow and Ice Data Center (NSIDC), the University Corporation for Atmospheric Research (UCAR), and the National Center for Atmospheric Research (NCAR). ACADIS expands the Cooperative

Approximately 60% of NSIDC's funding is from a NASA contract for operation of the Snow and Ice Distributed Active Archive Center (DAAC). Remaining funding is in the form of grants from NASA, NSF and NOAA.

Arctic Data and Information System (CADIS) system originally developed by NCAR, NSIDC, and UCAR. For nearly four years, CADIS provided data management support and archival services for the Arctic Observing Network (AON), one of the programs within the Division of Arctic Sciences (ARC) at the NSF Office of Polar Programs (OPP). ACADIS continues to support AON and broadens support to include other ARC programs: Arctic System Sciences (ARCSS), Arctic Natural Sciences (ANS), and the Arctic Social Sciences Program (ASSP).

NSIDC is focused on improving the discoverability, accessibility, and usability of NSF data in conjunction with broader Arctic data holdings from other agencies and countries. NSIDC also works with UCAR/NCAR on data stewardship, integration and (as is necessary), customized services, and activities for a broad user community. For each potential value-added product or activity, NSIDC scopes the level of effort required and meets the need based on recommendations by the ACADIS Data Advisory Committee (ADAC) and NSF management.

Operation IceBridge

NASA

http://nsidc.org/data/icebridge/index.html

NASA's Operation IceBridge, initiated in 2009, collects airborne remote sensing measurements to bridge the gap between NASA's Ice, Cloud and Land Elevation Satellite (ICESat) mission and the upcoming ICESat-2 mission. IceBridge mission observations and measurements include coastal Greenland, coastal Antarctica, the Antarctic Peninsula, interior Antarctica, the southeast Alaskan glaciers, and Antarctic and Arctic sea ice. IceBridge combines multiple instruments to map ice surface topography, bedrock topography beneath the ice sheets, grounding line position, ice and snow thickness, and sea ice distribution and freeboard. Data from laser altimeters and radar sounders are paired with gravitometer, magnetometer, mapping camera, and other data to provide dynamic, high-value, repeat measurements of rapidly-changing portions of land and sea ice.

Exchange for Local Observations and Knowledge of the Arctic (ELOKA)

NSF

http://eloka-arctic.org/

ELOKA facilitates the collection, preservation, exchange, and use of local observations and knowledge of the Arctic. ELOKA provides data management and user support, and fosters collaboration between resident Arctic experts and visiting researchers. By working together, Arctic residents and researchers can make significant contributions to understanding the Arctic and recent changes.

Antarctic Glaciological Data Center (AGDC)

NSF

http://nsidc.org/agdc/

The AGDC archives and distributes Antarctic glaciological and cryospheric system data collected by the U.S. Antarctic Program. It contains data sets collected by individual investigators and products assembled from many different PI data sets, published literature, and other sources. The catalog provides useful compilations of important geophysical parameters, such as accumulation rate or ice velocity.

NOAA@NSIDC

http://nsidc.org/noaa/

The National Oceanic and Atmospheric Administration (NOAA) team at NSIDC manages, archives, and publishes data sets with an emphasis on in situ data and data sets from operational communities such as the U.S. Navy. It also digitizes old and sometimes forgotten but valuable analog data. We also help develop educational pages, contribute to larger center-wide projects, and support the Roger G. Barry Resource Office for Cryospheric Studies (ROCS) at NSIDC. ❄

New Funding

Advanced Cooperative Arctic Data and Information Service (ACADIS)

PIs: M. Serreze and J. Moore, UCAR

ACADIS manages the diverse data needs of the Arctic research community supported by the NSF Office of Polar Programs (OPP) Division of Arctic Sciences (ARC). ACADIS provides data ingest and access services to scientists, decision-makers and other Arctic stakeholders, as well as archival services to ensure data accessibility through the coming years. ACADIS enables scientific discovery by allowing scientists an easier path to archive, access, integrate, and work with data spanning multiple disciplines.

NSF has recently mandated that investigators develop a viable management plan for data collected or generated by their projects. By accepting metadata and data collected by Arctic investigators, ACADIS will facilitate the development of data management plans for their projects.

The project is a collaborative effort among the National Snow and Ice Data Center (NSIDC), the University Corporation for Atmospheric Research (UCAR), and the National Center for Atmospheric Research (NCAR). ACADIS expands the Cooperative Arctic Data and Information System (CADIS) system originally developed by NCAR, NSIDC, and UCAR. For nearly four years, CADIS provided data management support and archival services for the Arctic Observing Network (AON), one of the programs within the Division of Arctic Sciences (ARC) at the NSF Office of Polar Programs (OPP). ACADIS continues to support AON and broadens support to include other ARC programs: Arctic System Sciences (ARCSS), Arctic Natural Sciences (ANS), and Arctic Social Sciences Program (ASSP).

MODIS Persistent Ice Algorithm (MODICE Glacier Mapping)

PI: R. Armstrong

The end product of MODICE will be a consistently derived global map of permanent snow and ice. The project leverages the time series of the high precision retrievals of snow and ice fractional cover from the MODIS Snow Covered Area and Grain size (MODSCAG) algorithm. The MODICE glacier mapping sub-contract with NASA JPL supported the continued development of the MODIS Persistent Ice (MODICE) algorithm. Earlier stages of the project produced prototype maps for the Himalaya, Cordillera Blanca and the Juneau Ice Cap of Alaska.

Contributions to High Asia Runoff from Ice and Snow (CHARIS)

PI: R. Armstrong

CHARIS received funding from the United States Agency for International Development (USAID) to assess the mountain hydrology of High Asia. Water security in such high-altitude regions is particularly sensitive to climate change because of the significant role of snow and glaciers. The amount, timing, and spatial patterns of snow and ice melt play key roles in providing water for downstream irrigation, hydropower generation, and general consumption. The fundamental objective of this collaborative study is to develop a systematic assessment of the contribution of both seasonal snow and glaciers to the water resources originating from High Asia, which comprises the Himalaya, Karakoram, Hindu Kush, Pamir, and Tien Shan mountain ranges. University of Colorado scientists work directly with researchers at institutions in nine different nations where these ice and snow resources are located (Bhutan, Nepal, India, Pakistan, Afghanistan, Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan).

Submarine Arctic Science Program (SCICEX)

PI: F. Fetterer

The Submarine Arctic Science Program (SCICEX) is a federal interagency collaboration among the operational Navy, research agencies, and the marine research community. SCICEX uses nuclear-powered submarines for scientific studies of the Arctic Ocean. The grant allowed us to to facilitate the discovery and archiving of historic SCICEX data, locate approximately 90% of the data from the dedicated missions, work with NOAA NGDC to archive bathymetry data, and create a Web page with an overview of the project and a data inventory table with links to the locations of the data. See http://nsidc.org/scicex/.

Improving seasonal drought predictions in the western USA: Developing and evaluating an ensemble snow modeling framework in the Community Hydrologic Prediction System (CHPS)

PIs: A. Slater in collaboration with M. Clark (lead PI, UCAR) and A. Wood (National Weather Service)

This collaboration with NCAR's Research Applications Laboratory (RAL) and the National Weather Service (NWS) aims to improve drought predictions in the western USA. Drought forecasting in large part depends on simulations of seasonal evolution of snow and soil moisture. Thus, prediction accuracy is intimately linked to the validity of the hydrologic and land-surface models used to produce these predictions.

The goals of this project are to improve models of snow processes and quantify uncertainty in snow simulations. We focus on snow because much of seasonal streamflow predictability comes from knowledge of accumulated snowpack. The NWS's current framework for hydrologic forecasting lacks representation of some key processes, resulting in difficulty providing robust streamflow forecasts. We hope to improve this situation by more effectively quantifying the differences among various hydrologic modeling approaches, allowing research at a more granular level that in turn will support more accurate hydrologic forecasting.

Dust on Snow Monitoring

PI: J. Deems

This project supplements an existing NASA Interdisciplinary Studies award that supports deployment of four high-resolution time-lapse cameras to monitor dust emission from desert sites and snow accumulation, melt, and dust-induced melt enhancement at two mountain sites. Equipment installed during winter 2011 will be completed by spring of 2012. Image acquisition, image processing, and video production are ongoing.

Improved Cold Region Hydrology Process Representation as a Cornerstone of Arctic Biogeochemical Modeling

PIs: A. Slater, in collaboration with D. Lawrence, S. Swenson and H. Lee (NCAR GCD)

The Arctic environment is changing rapidly, as evidenced by widespread permafrost thaw, changes in lake distribution, shifts in vegetation, and alterations in other ecosystem processes. Threshold and non-linear responses associated with phase change between ice and water leave the Arctic particularly susceptible to swift and disruptive change. Observing the scope and pace of change, scientists are concerned that the massive soil carbon pools stored in permafrost and peatland may be more vulnerable than previously thought.

The fate of the Arctic carbon cycle is fundamentally governed by soil hydrology. The scientific community urgently needs the ability to assess and quantify whether this carbon is an "Arctic carbon time bomb" or if other biogeophysical and biogeochemical processes will slow carbon release as permafrost thaws. Comprehensive Earth System Models

(ESMs) like the Community Earth System Model (CESM) are required to assess the global response to terrestrial Arctic change. Despite recent advances in CESM's land model for permafrost, biogeochemical cycles, and Arctic vegetation succession, current modeling of cold region hydrology is inadequate for holistic permafrost-carbon study. To address this limitation, we propose improving CESM's Arctic terrestrial hydrological modeling to assess recent and future change. Ultimately, this will support thorough evaluation of the Arctic terrestrial biogeochemical feedbacks.

Arctic Sea Ice News and Analysis (ASINA)

PI: W. Meier

Arctic Sea Ice News and Analysis Web site received another year of funding in 2011. ASINA is a NASA-funded project to provide timely data and scientific analysis of the Arctic sea ice cover through the year. Data and imagery are updated daily and analyses are posted at least monthly, more frequently during the summer melt season. The foundation of the site uses passive microwave imagery archived at the NSIDC DAAC, while other satellite, airborne, and field data and imagery are used to highlight specific issues. In addition, guest contributions are made by fellow scientists from outside NSIDC to discuss recent research results. ASINA's Web site (http://nsidc.org/arcticseaicenews/) has continually been (or continues to be) NSIDC's most popular Web site and is widely cited by the scientific community, the media, and the general public.

The 18th Annual WAIS (West Antarctic Ice Sheet) workshop; September 21-23, 2011

PI: T. Scambos

This NASA-funded workshop was held at Sylvan Dale Ranch in northern Colorado. A total of 85 scientists attended, several from international research groups. The focus of this multidisciplinary, Earth system science workshop was the unique glaciological, geological, oceanographic, and climatic aspects of the West Antarctic Ice Sheet and related cryospheric regions. The workshop underscored the need to look across disciplines (atmospheric, cryospheric, biospheric, hydrospheric) to understand this system. ❄

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