National Science Foundation
WHERE DISCOVERIES BEGIN

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Overview

NPEO
SBI
SEARCH
SNOWSTAR

Scientists at the top of the world are picturing what the future holds for Arctic climate. On a given day, they may snowmobile across the Alaska tundra, deploy buoys to the deep bottom of the Arctic Ocean, collect and study microscopic animals from the frigid Arctic seas or sample Siberian peat bogs to figure out how a warming trend might release greenhouse gasses. The complex factors that influence climate change demand a multi-faceted approach—from ships at sea to snowmobiles in Alaska—to study the process.

Researchers go to such literal extremes because they suspect a long-range global climate shift will first show itself in the polar regions. In fact, over the past 30 years or so, scientists and the Arctic peoples, who depend on a delicately balanced environment for their livelihoods, have observed dramatic reductions in the extent and thickness of Arctic sea ice, as well as other rapid and, as yet, unexplained environmental changes.

Testifying in 2001 at an Alaska field hearing of the Senate Appropriations Committee in Fairbanks, Alaska, former NSF Director Dr. Rita Colwell stressed the importance of expanding research efforts in the Arctic to understand the region's complex ecological relationships and the potential effects of a change in its climate.

"The evidence for climate change in the Arctic is mounting and serious, but our picture is not yet comprehensive," she said. "We do not yet know for certain whether this change is part of a cycle, or is following a long-term, possibly irreversible trend. Understanding the causes, however, is critical to making good policy decisions.

She noted, for example, that at the NSF's Long-term Ecological Research Station at Toolik Lake, Alaska, over a quarter-century of observations have shown that the lake has warmed by 2 degrees centigrade and that the alkalinity of the water has increased. The change in the water chemistry may be due to thawing permafrost" and added that "measurements over longer time-scales are absolutely crucial to tracking climate change."

She also pointed out very clearly that unlike in other, more accessible areas of the globe, it is only at the beginning of the 21st century and, to a lesser extent, in the closing days of the 20th, that science has been able to begin to comprehensively measure and sample the Arctic environment with a broad array of tools, from nuclear submarines to icebreakers equipped for science to satellite measurements.

"We need copious and accurate observations over time to improve computer models that help us to predict environmental change, but—compared to much of the globe—the Arctic is data-poor. It is difficult to reach much of the region, especially in the winter, and there are very few research stations. NSF is committed to gathering the information—oceanic, terrestrial, aquatic, atmospheric and cultural—that will help us refine our models and help us interpret these changes."

Whether such changes are permanent or are part of a larger and poorly understood long-term climate cycle—or some manner of both—is what NSF-funded scientists working above the Arctic Circle hope to discover.

NSF plays many roles in Arctic climate research. The foundation chairs the Federal Government's Interagency Arctic Research Policy Committee (IARPC), and NSF's Office of Polar Programs (OPP) supports a wide range of scientific disciplines to carry out research in the Arctic. OPP's Arctic Natural Sciences program, for example, supports research in the atmospheric sciences, biological sciences, earth sciences, glaciology and oceanography.

NSF's Arctic System Science (ARCSS) program is an interdisciplinary effort to understand the physical, geological, chemical, biological, and social and cultural processes of the Arctic system; how they interact with natural systems elsewhere; and how they may contribute to or be influenced by global changes. The program's goal is to advance the scientific basis for predicting environmental change—from seasonal to centuries—and to help to formulate policy options to deal with anticipated impacts of global change on humans and society brought about by climate change.

The ARCSS program emphasizes

- understanding the global and regional impacts of the Arctic climate system and its variability
- determining the Arctic’s role in global biogeochemical cycling
- identifying global change effects on the structure and stability of Arctic ecosystems
- establishing links between environmental change and human activity

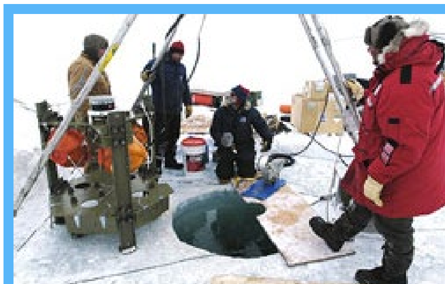
OPP’s Arctic Social Sciences program supports studies in anthropology, archeology, economics, geography, linguistics, political science, psychology and sociology. Scientists supported by this program also are examining what science linked with native knowledge and tradition can teach us about environmental change. They are also studying how these two approaches overlap to synthesize new knowledge.

Read a speech by former NSF director Rita Colwell on
"The Arctic as a Biocomplex System":
http://www.nsf.gov/od/lpa/forum/colwell/rc020516arcticforum.htm

By Peter West

OVERVIEW
NPEO
SBI
SEARCH
SNOWSTAR

North Pole Environmental Observatory



James Morison of the University of Washington—principal investigator for the North Pole Environmental Observatory—takes samples from a hole drilled through the Arctic sea ice.

Credit: National Science Foundation

Sitting atop one axis of the Earth, the North Pole is located at the junction of ocean and atmospheric currents that affect global climate. Observations in recent years have shown a rapid thinning of sea ice in the Arctic Ocean and shifts in ocean circulation around the world that are related to a pattern of change in the atmospheric circulation of the Northern Hemisphere—known as the Arctic Oscillation—which is roughly centered at the North Pole.

Arctic Ocean circulation and the water flowing from the Arctic into the Greenland Sea affect the deep circulation of the Atlantic Ocean and thus play an important role in regulating climate. To more closely observe and understand such changes, an international scientific team supported by NSF has established a polar research camp known as the North Pole Environmental Observatory (NPEO).

Led by oceanographer James Morison of the University of Washington, NSF-supported scientists from Oregon State University, as well as others supported by the National Oceanic and Atmospheric Administration (NOAA), the Naval post-graduate school, and the Japan Marine Science and Technology Center, are conducting an array of experiments at the North Pole to understand this little known, but extremely important region.

Video

NSF's North Pole Researchers study climate change in the Arctic.

Credit: Peter West, National Science Foundation

Video no longer availbe

In addition to the logistical challenges of establishing a world-class observatory in such harsh conditions, the scientific and logistical teams regularly contend with the challenges of scuba diving in the icy Arctic Ocean and keeping an ever-watchful eye out for polar bears. Since there is no land mass directly over the North Pole, scientists must constantly gauge shifting conditions of the sea ice beneath them. A frozen-solid ice pack one day may give way to open water the next.

To collect year-long information about ice thickness and movement, water temperature and salinity, and the speed and direction of underwater polar currents, the team deploys a system of floating buoys on a mooring line that stretches more than two-and-a-half miles from the bottom of the Arctic Ocean, to within feet of the constantly shifting polar ice pack. That's longer than Mt. Rainier is high.

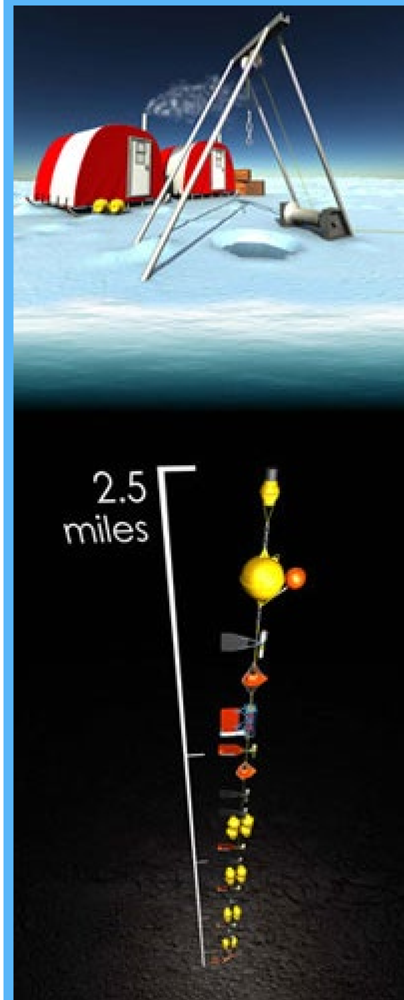
Teams of scientists also drill through ice—often more than 12-feet thick—to install buoys that measure air temperature through the ice cover. Imbedded in the ice automated sensors that send detectors on hundred-mile treks—from the North Pole to Greenland, for example—to measure heat fluctuations in the upper ocean. Even subtle changes in air and water temperature can mean large variations in the thickness of ocean ice.

In order to measure changes in seawater chemistry, Morison and coworker, Kelly Falkner of Oregon State

University, sampled water nearly a mile below the ocean surface—from an aircraft.

Even using submarines and icebreakers, it is difficult to obtain long-term measurements of temperature and other important climate variables at the North Pole. NEPO’s drifting research stations are designed to provide a mix of coverage over time and in a wide geographic area.

"The observatory really fills a hole in our scientific observations," says Morison. "The station, and others like it, will provide a set of data taken reliably over a long period as a benchmark for the study of climate change."



For the past five years, NSF has supported an international and interagency team of researchers led by investigators at the University of Washington, who are studying the physical properties of the Arctic Ocean and the potential effects of changes in the Arctic on global climate.

Credit: Trent Schindler, National Science Foundation

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Western Shelf-Basins Interactions Project

Frozen carbon dioxide, or dry ice, has found many uses in science experiments as well as popular culture, including as a special effect at rock concerts, magic shows and ice-skating spectacles. As it warms, the unique substance transforms directly from solid ice to a smoky gas, without ever becoming a watery liquid in between.

Sea ice covering the Arctic Ocean near Alaska breaks up as spring approaches.

Credit: Peter West, National Science Foundation

Severely cold Arctic temperatures have locked enormous amounts of carbon dioxide in the frozen northern permafrost for thousands or years. In a multi-pronged effort, NSF-funded scientists are studying whether a well-documented Arctic warming trend will release more of the gas from the permafrost and what may happen as a result. Any change in the current carbon-dioxide balance could affect air temperatures and the amount of sea ice covering the Arctic Ocean. For example, changes in that balance might cause some species to flourish that currently cannot and sufficiently change the habitat of others to make it impossible for them to survive in their present ecological niche.

Currently, the ocean basins act as carbon-dioxide reservoirs, or sinks, locking up some of the gas and preventing it from escaping into the atmosphere. The Arctic Ocean, for example, receives some 28 million tons of dissolved carbon each year, released from far-northern bogs and other soils. As part of the Western Shelf-Basin Interactions (SBI) project, scientists are carrying out a series of research cruises to study how Arctic warming may already be changing the carbon balance, how it may affect the plants and animals that live there—as well as the people who depend upon them—and what measures might be taken to compensate for any change.

During SBI research cruises aboard the U.S. Coast Guard icebreaker Healy, scientists will deploy water- and sediment-sampling devices and gather and study samples of microscopic life as well as larger organisms. Scientists aboard the research vessel, Nathaniel B. Palmer, are conducting surveys of the deep-ocean basins to map the distribution of salinity, temperature, nutrients and other characteristics over the outer shelf to the deep- basin region of the Chukchi and Beaufort seas off northern Alaska.

Jackie Grebmeier of the University of Tennessee, co-

According to James Swift, the Scripps Institution chief scientist for the Palmer summer cruise, mapping the various characteristics of the waters in the SBI will provide a reference grid for other SBI cruises in this three-year field program. "We hope, once the cruise is over, to be able to produce a very good map of the physical, chemical, pigment and other variables in the SBI study region," Swift said. "When we’re finished we will know where exactly this property or that is highest or lowest."

Meanwhile, SBI scientists have already

Video

In July and August 2002, more than 30 NSF-funded scientists conducted research aboard the United States Coast Guard cutler (USCGC) Healy, a specially-equipped Coast Guard icebreaker, as part of the Western Shelf-Basins Interactions cruise. The research program is designed to understand how the shallow and deep areas of the Arctic Ocean work together to support life, whether there are indicators of earlier climate change and what predictions might be made about the future of the Arctic shelves.

Credit: Peter West, National Science Foundation

Video no longer available

chief scientist for the SBI project, carefully prepares samples fresh from the ocean bottom for transport to the ship's lab.

Credit: Peter West, National Science Foundation

produced findings about the Arctic carbon balance. An international team of U.S. and German scientists last spring reported that they used carbon-14 dating techniques to determine that most carbon transported to the Arctic Ocean by northern rivers is fairly new in global time scales, and not likely to affect the balance of the Earth's climate. Nevertheless, they caution that a warming trend could result in a reservoir of ancient carbon—currently locked into peat bogs—to be released and contribute to the well-documented Arctic warming trend.

Previously, scientists had not known the age of the carbon that reaches the ocean. Was it recently derived from contemporary plant material, or had it been sequestered in soils for hundreds or thousands of years and therefore not part of Earth's recent carbon cycle?

The new findings complement work by Laurence C. Smith, an NSF-funded researcher at the University of California, Los Angeles, indicating that massive Siberian peat bogs, widely known as the permanently frozen home of countless square miles of moss and untold hordes of mosquitoes, also are huge repositories for gases thought to play an important role in the Earth's climate balance.

Even though the incriminating gases, carbon dioxide and carbon-containing methane, are known to trap heat in the Earth's atmosphere, scientists have not yet calculated the impact of large amounts of these gases in climate change models.

"Traditionally, we had thought these areas were simply a gradually varying source of methane and an important sink for atmospheric carbon," Smith said. "They've been viewed as a stable thing that we always count on. The bottom line is Siberian peat lands may be a bigger player in climate change than we knew."

Stephane Plourde, right, of Woods Hole Oceanographic Institution, fends off ice flows with the help of Coast Guard personnel in order to retrieve a sampling net. Long hours and hard work are elements of any scientific research cruise.

Credit: Peter West, National Science Foundation

Scientists have debated the origin of the methane spike, variously attributing it to sources in tropical wetlands and offshore sediments. New research conclusively points for the first time, to Siberia as a likely methane source, where bogs arose suddenly between 11,500 to 9,000 years ago—much earlier than previously thought. The appearance of the bogs coincides with an abrupt and well documented spike in atmospheric methane recorded in ancient climate records. The finding counters previously held views that the bogs were largely unchanged—and unchanging—over millennia.

But researchers also point out that the bogs, which collectively cover an area of roughly 233,000 square miles, have long absorbed and held vast amounts of carbon dioxide while they released large amounts of methane.

"There are natural sources of greenhouse gases out there that are potentially enormous that we need to know about," Smith said. "One of the concerns is that up until now, the bogs have been more or less a sink for CO_2, absorbing carbon dioxide from the atmosphere. In an extreme scenario, not only would they stop taking up CO_2, they would release a lot of the carbon they have taken up for centuries."

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ARCTIC CLIMATE RESEARCH::::::::: A SPECIAL REPORT

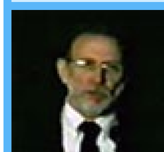
Study of Environmental Change in the Arctic (SEARCH)

Besides warmer air temperatures and melting permafrost, sea ice, and glaciers, other substantial changes have taken place in the Arctic. Out-of-place plant communities are appearing in the high latitudes, subsurface ocean currents are warmer and precipitation patterns have changed, all of which affect animal habitats and migration routes.

Human populations in the Arctic have also felt the changes, which some have dubbed *Unaami*, the Yu'pik word for tomorrow, because the rapidly changing environment makes it difficult for native residents to predict their future living conditions.

NSF's Office of Polar Programs leads the Study of Arctic Environmental Change, a multi-agency initiative known as SEARCH, to understand the nature of these changes. Primary objectives of the program include determining whether these changes are permanent or part of a long-term cycle, what they might mean for the people and creatures who depend on the Arctic ecosystem and what steps might be taken to mitigate these changes.

Video



James Morison, an NSF-funded researcher at the University of Washington and former head of the SEARCH science steering committee, addresses the first SEARCH open science meeting on the challenges facing Arctic climate researchers.

Credit: National Science Foundation

Video no longer available

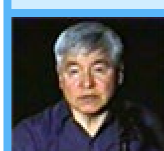
NASA, NOAA, the Smithsonian Institution, USDA, DOI, DOE, and DOD all contribute to SEARCH, as is the non-governmental organization International Arctic Science Committee. SEARCH is an interdisciplinary study of the interrelated atmospheric, oceanic and terrestrial changes in the Arctic and their potential impacts on the environment, regional societies and economies.
Four large-scale concepts underlie all of the SEARCH investigations:

1. Arctic environmental change is related to change in the atmospheric polar vortex, a large-scale cyclonic circulation in the atmosphere centered generally in the polar regions.
2. Arctic environmental change is a component of a more widespread change in climate.
3. Feedback between the ocean, the land and the atmosphere are critical to the change process. The amount of ice, for example, or the lack of it, directly affects the amount of energy reflected back into atmosphere or absorbed by the ocean.
4. Such physical changes have large impacts on the Arctic ecosystems and society.

Last fall, more than 400 scientists and others attended the first SEARCH open science in Seattle, Washington. The meeting was the largest scientific gathering ever held. Scientists who attended had the opportunity to discuss the research strategies needed to understand change in the Arctic environment.

"We don't know the full extent or future course of Arctic environmental change," said James Morison, an NSF-funded researcher from the University of Washington who headed the SEARCH science steering committee at the time. "But we think we can understand it because the recent observations of the changing environment have given us new insight into how the Arctic system functions."

Video



In a presentation at the first SEARCH Open Science Meeting, Caleb Pungowiyi of the Robert Aqqaluk Newlin Sr. Memorial Trust, discusses the concerns of the indigenous Arctic population about climate change.

Credit: National Science Foundation

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OVERVIEW
NPEO
SBI
SEARCH
SNOWSTAR
CLASSROOM RESOURCES

SnowSTAR

The Snow Science Traverse—Alaska Region team and their snowmobiles and sleds. The covered sled is heated and houses the computers that are used in a number of tests performed on the snow at each station.

Credit: National Science Foundation

The words “snow” and “Arctic” are almost interchangeable. But the white stuff that blankets the frozen north is incredibly complex and may hold several clues to what lies in store for a warmer tundra, scientists say.

In the Arctic, snow lasts eight to 10 months of the year and is one of the most important elements of the climate system. It insulates the ground, preserves the permafrost and reduces winter temperatures because it is such a good reflector of heat from the Sun. If scientists can understand the patterns of snow distribution and properties in the current climate, they will be in a much better position to model how this critical element in the Arctic landscape may change along with changes in climate.

For 35 days, the six-member Snow Science Traverse—Alaska Region (SnowSTAR 2002) crossed the state on snowmobiles to analyze the chemistry and composition of snow along the route and to determine the snow’s source. The traverse was part of an ongoing larger project to understand Arctic climate change, called ATLAS (Arctic Transitions in Land Atmosphere System), and sponsored by NSF's Office of Polar Programs.

Chemical sampling of snow layers. Two classes of samples were taken along the route of the traverse. Here, ultra-clean procedures are in use because these samples will be analyzed for trace elements and metals.

Credit: National Science Foundation

Beginning in March 2002, the expedition covered roughly 700 miles—from Nome, northeast through the Brooks mountain range to Barrow—sampling snow at more than 75 locations. According to Matthew Sturm of the U.S. Army's Cold Regions Research and Engineering Laboratory at Fort Wainwright, Alaska, and team leader, snow is so elemental to the Arctic ecosystem that such painstaking detail is easily justified.

By tracing the sources of the snow’s chemical constituents, such as calcium, magnesium and various isotopes like boron and deuterium, the team hoped to pinpoint where the snow originated and its atmospheric history. The data gathered during the traverse will help show how key meteorological events determine snow characteristics.

Matthew Sturm, principal investigator of the SnowSTAR expedition.

Credit: National Science Foundation

At journey’s end, the team had produced 33,000 snow-depth measurements, recorded the layering of snow from 415 snow pits and made more than 800 measurements of the water content of the snow. They also conducted several hundred experiments on snow density and its reflective properties.

The data is the most comprehensive ever collected on snow properties, and scientists are continuing their analysis.