

The Study of Environmental Arctic Change

An Interagency Program to Understand Change in the Arctic and How it Connects to Global Climate and Society

International Collaboration Nets Results

The widespread collaboration that distinguishes SEARCH will also ensure that the program is effective and influential. The SEARCH Interagency Working Group oversees high-level coordination among the cooperating U.S. agencies. The broader scientific community is developing the SEARCH science plan, with leadership from the SEARCH Science Steering Committee, chaired by Jamie Morison of the Polar Science Center, Applied Physics Laboratory, University of Washington.



Researchers on the Arctic sea ice, photo © James H. Barker.

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To be most effective, SEARCH must be active on an interna-

tional level. The hypotheses guiding SEARCH are implicitly global in scope – the data won't be useful without a global perspective, including input from the other arctic nations. Since 1999, the U.S. has led efforts to involve SEARCH in appropriate international research programs. SEARCH has formal ties to two components of the International Research Programme on Climate Variability and Predictability (CLIVAR) and the Arctic Climate System Study (ACSYS).

Direct interface between governments, guided by the National Science Foundation's Arctic System Science Program and SEARCH, has already increased our access to data, equipment, and opportunities for field work in Russia. Data and other resources that result from continued cooperation with Japan and the European Union are critical to developing a complete picture of the many elements found in the diverse regions of the Arctic.

A Letter from Dr. Rita Colwell—Chair, IARPC

Our global climate is changing, especially in the Arctic. The average winter temperature in the Arctic has increased by six degrees Celsius over the past 30 years. As sea ice cover diminishes, stronger storms are eroding coastlands across the Arctic.

Some debate whether this is a naturally occurring change or caused by humans. The federal agencies participating in SEARCH are contributing to a long-term program that will help us answer this and other key questions. As envisioned in the science plan, SEARCH will document environmental trends in the Arctic and conduct additional studies, in order to gain a solid understanding of their causes and impacts. The information will help us better predict weather, design better roads and buildings, better manage and use natural resources, and safely explore new ocean routes.

This program is critical—the potential impacts to people described in the SEARCH science plan could cost the United States and the world enormously as we adapt to or try to mitigate the environmental changes that are possible. An effort must begin to document and understand changes in biocomplexity associated with changing climate.

International collaboration is an important element of this work. U.S. federal agencies will work with international partners and share expensive research platforms and access to each other's territorial waters.

The hard work that has already gone into shaping and

Interagency Leadership

The Interagency Arctic Research Policy Committee (IARPC) is composed of senior officials from U.S. government agencies that conduct arctic science activities. The Committee is chaired by Rita Colwell, Director, National Science Foundation.

In March 2000, the IARPC reviewed its FY2000-04 plan for arctic research. The striking evidence of recent changes in the arctic environment prompted the IARPC to initiate an ambitious, multi-agency approach for addressing this topic. The Interagency Working Group for SEARCH was created in March 2000.

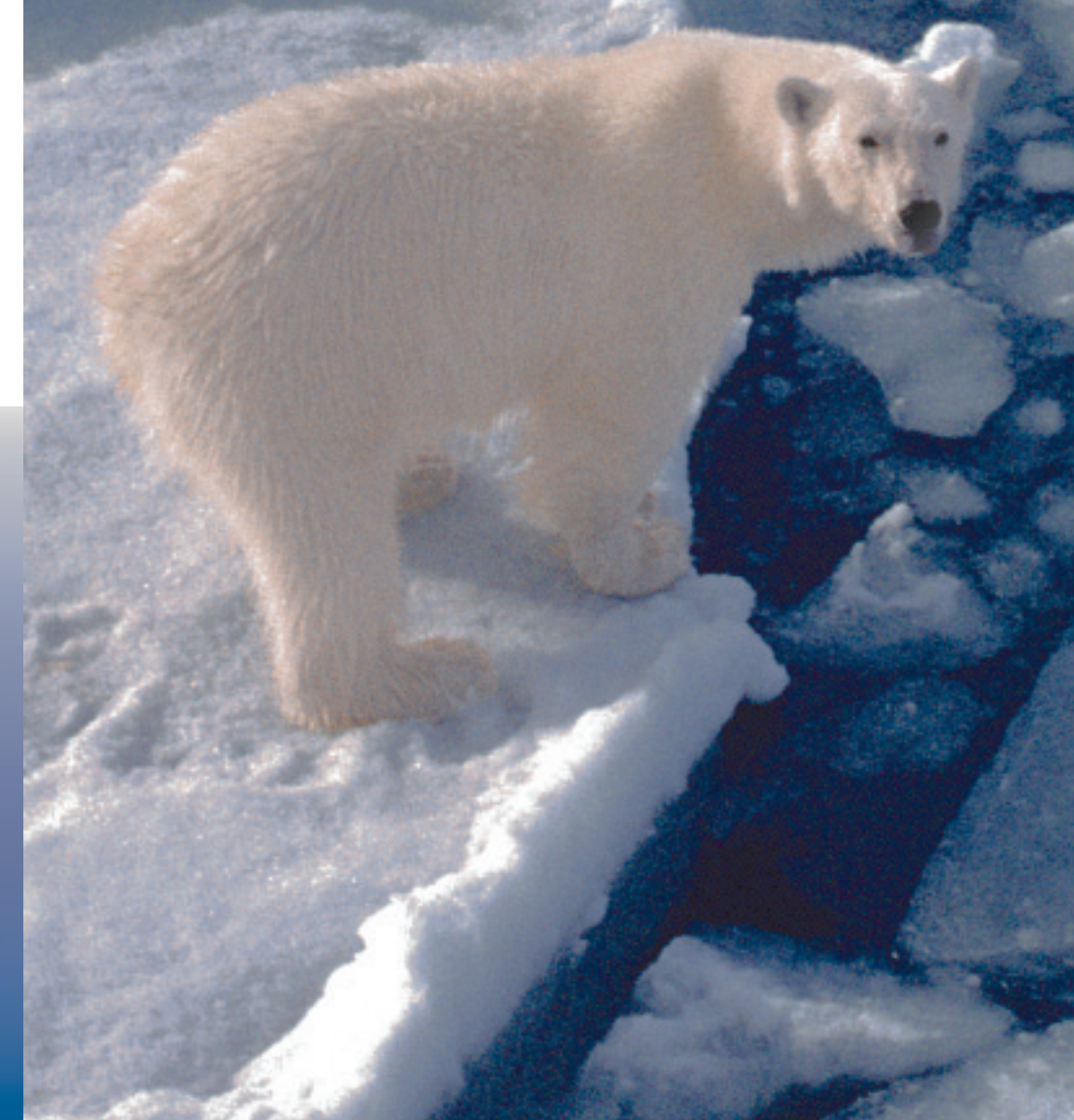
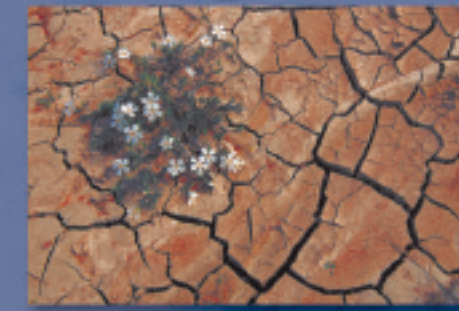
setting the scientific goals for interagency cooperation in SEARCH is commendable. Nine federal agencies and organizations, with support from a tenth, the Coast Guard, are working together in an unprecedented collaborative effort, and will soon request funds for joint work. This makes the best use of the resources available, but it is more important than that. Scientists and agencies are sharing their information with each other and sharing the decisions about what must happen next.

SEARCH can't prevent the environmental changes that may come, but armed with the knowledge that SEARCH will provide, our government and industry can make better-informed decisions about our future.

Rita Colwell
Director, National Science Foundation
Chair, Interagency Arctic Research Policy Committee

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SEARCH



“About fifteen years ago, it started getting warmer. The snow melts faster and faster. Even this year I was surprised how fast the ice broke up. A lot of the senior captains were saying the ice conditions weren't really good for the little baby walrus and seals.”

—Benjamin Pungowiyi, Savoonga

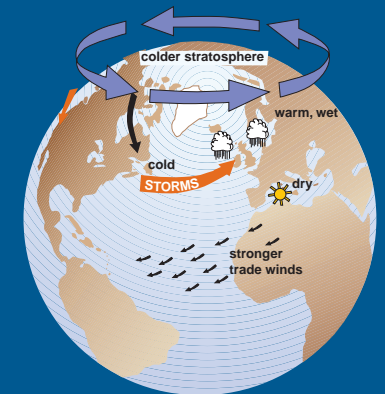
“The thing that I notice when I walk out the tundra—now I can hear it crackle when I walk on it, and it's dry. Whatever is out there is dried up. We didn't get blueberries this year, last year, and the year before. I used to be able to find blackberries in abundance, and now I have to really search.”

—Hannah Mendenhall, Kotzebue

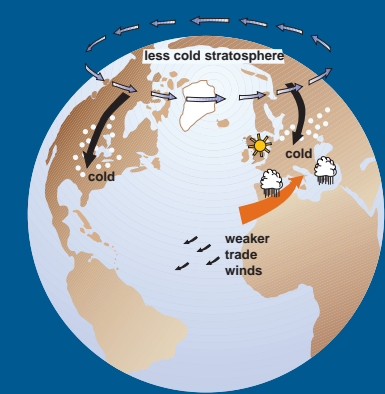
Polar bear near Spitsbergen, photo © B&C Alexander.
Cushion phlox in South Dakota, photo © Daniel J. Cox/naturalexposures.com.
Oil field on Alaska's North Slope, photo © James H. Barker.

The Arctic Oscillation: The Northern Hemisphere's El Niño?

In the early 1990s, researchers reported that their observations of the Arctic were dominated by a surprising set of rapid changes that appeared to be interrelated. They also seem to be connected to a cyclic pattern in the atmosphere of the Northern Hemisphere called the Arctic Oscillation (AO). Mounting evidence indicates that the AO is a primary driver of North American and northern European weather, with impacts comparable to the effects of El Niño beyond the tropical Pacific. How the Arctic Oscillation interacts with climate change is a key research issue in SEARCH.



Top: The Arctic Oscillation flips back and forth between low and high pressure over the Arctic many times each winter. Low pressure over the Arctic causes strong westerly winds in the upper atmosphere that keep cold arctic air in the North and push warmth and precipitation toward northern Europe. The Arctic Oscillation has shown a trend in the past few decades toward low pressure over the Arctic. This trend has resulted in record warm winters in Europe and the eastern U.S. and allowed warm salty water from the Atlantic Ocean to push 20% further into the Arctic Ocean than usual.

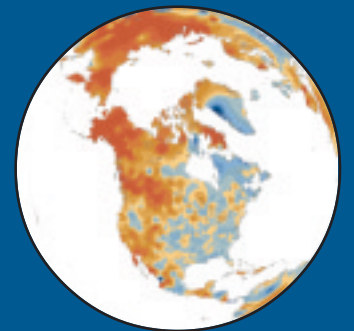


Bottom: During the opposite phase, high atmospheric pressure over the Arctic enables cold air to reach further south.

Figures courtesy of D. Thompson, Colorado State University, and M. Wallace and K. Dewar, University of Washington.

Why Do We Need New Research in the Arctic?

Research by several federal agencies has confirmed what most global climate models predict: early and striking evidence of climate warming in the Arctic. The red areas of the top map indicate wintertime warming of over 3^o Celsius observed in the last two decades in Alaska, northwestern Canada, Scandinavia, and Siberia. At the same time cooling has occurred in northeastern Canada and Greenland.



The lower map shows that the low pressure mode of the Arctic Oscillation (AO), considered alone, could be responsible for these trends. If the AO mode of the past 20 years continues, the unusual wintertime warmth in the central and eastern U.S. and Europe is likely to continue as well. The situation in eastern Siberia and western North



America is more complex, as the Pacific Ocean's influence may override that of the AO. Unraveling the interactions between the Pacific Ocean and the AO is a major research issue of great importance to the U.S.

Figures courtesy T. Mitchell, University of Washington.

What is SEARCH?

SEARCH, the Study of Environmental Arctic Change, is a new research program on the changes occurring in the Arctic and their potential impacts on the Earth, including human social and economic well being. Nine U.S. government agencies and organizations, with support from a tenth, the Coast Guard, are collaborating to launch SEARCH, which extends across scientific disciplines and agency boundaries.

Through SEARCH, agencies will cooperate to understand the full scope of the changes going on in the Arctic—to learn exactly how the observed changes relate to the Arctic's natural variability and if the changes indicate the start of a major climate shift in the North. This information will enable the agencies to predict how the changes will interact with one another and how they are likely to affect ecosystems and societies. SEARCH agencies will combine their financial and intellectual resources to accomplish SEARCH in three stages:

- FY2001, coordinate activities already planned by individual agencies.
- FY2002, identify new efforts by individual agencies that relate directly to SEARCH.
- FY2003, jointly plan and manage their activities that support SEARCH.

SEARCH reports and science plan can be found at: <http://psc.apl.washington.edu/search/>

Scientists investigating the arctic environment have been able to collect significant new data in recent years because of improved access to the central Arctic Ocean, new technologies, and better agency and international cooperation. With these new data, researchers sponsored by several federal agencies have noted a number of unexpected changes in the Arctic. These include:

- Lower sea-level atmospheric pressure
- Increased air temperature over most of the Arctic, but lower temperatures over eastern North America and Greenland
- Changed ocean circulation and rising coastal sea level
- Warmer Atlantic waters penetrating farther in the Arctic Ocean
- Reduced sea ice cover
- Altered precipitation and terrestrial vegetation
- Thawing permafrost

These changes are unlike anything measured in the past 100 years, and the observations indicate that they are related to each other and to the continuing lower pressure mode of the Arctic Oscillation (AO). The unexpected changes in the arctic environment, which began around three decades ago, seem to be linked to the trend in the AO over the same period towards lower sea-level atmospheric pressure.

These changes may be due to natural environmental variability. A number of studies predict, however, that the lower pressure mode of the AO will accompany greenhouse warming, suggesting that the recent changes may indicate a long-term, human-driven shift in climate. An innovative research effort, aimed at understanding this complex of arctic environmental changes, is needed to complement existing agency research programs.

We know very little about how the AO and climate change will interact, but these changes have considerable potential regional and global impacts, including:

- accelerating already rising sea level through warming of oceans and melting of land ice. Estimates of the cumulative impacts of a 50 cm sea-level rise by 2100 on U.S. coastal property range from \$20-150 billion.
- easing marine shipping in Canada as arctic sea ice decreases. If current trends continue, use of the Northern Sea Route along the coast of Russia may expand access to oil, gas, and other arctic natural resources.
- affecting the demand for, as well as the supply of, water, influencing a wide range of water-system components, including reservoir operations, water quality, hydroelectric generation, and navigation.
- shifting ecosystem distributions in the U.S. As temperatures continue to rise, scientists predict that forests will replace much of the arctic tundra, the breeding habitat for millions of migratory birds. Some populations of north Pacific salmon crashed as ocean temperatures in the region soared in 1997 and 1998.

Climate change in the Arctic could cause major perturbations in the global environment. At the same time, many important long-term observational programs in the Arctic are being lost or reduced in size. Therefore, nine federal agencies have agreed that an intensive interagency effort of observations and analysis is needed to understand the changes in the Arctic, their relation to the rest of the globe, and their impact on society.

This effort is the Study of Environmental Arctic Change or SEARCH.

The SEARCH program focuses on the longer-term dynamic aspects of the arctic environment, rather than encompassing all arctic research. Developing a predictive understanding of this complex and vital science problem will require a diverse set of research activities as well as an integrative perspective.

The agencies cooperating in SEARCH will track and quantify changes in the Arctic, identify their causes, assess their impacts, predict changes expected in the future, and inform policy makers and the public. This unprecedented interagency approach will develop a more complete understanding of the arctic environment through:


- **Long-term Observations** will describe and track the changes. A revitalized effort is required as many long-term observation programs have been reduced or eliminated.
- **Modeling and Analysis** will explain the observed changes and estimate critical variables that are difficult to determine by direct observation. Ultimately modeling will lead to prediction of future conditions.
- **Process Studies** will combine observations and experiments to determine


cause-and-effect relationships and important feedbacks in the arctic environment.


- **Products and Services** will provide useful information to the public and decision makers about mitigating, coping with, or capitalizing on environmental variability and change.
- **Public Outreach** will connect the implications of scientific results for social and economic systems with the priorities and needs of the public and industry.


Cooperating Agencies


The nine SEARCH agencies agree that a large-scale, long-term perspective on the arctic environment is needed to evaluate the potentially grave regional and global impacts of the continuing changes. Each agency is contributing to that perspective in keeping with its particular mandate, relevant research strategies, and specific scientific capabilities.


 Consistent with its stewardship principles and mandates, the **Department of the Interior** conducts research on environmental changes that may impact people, lands, and ecosystems so that informed management decisions can be made.


 The **Environmental Protection Agency** conducts research needed to protect human health and to safeguard the natural environment. The EPA supports improved scientific understanding and open dialogue with stakeholders on the serious environmental risks facing the Arctic and Bering Sea regions.


 Scientists at the Arctic Studies Center of the National Museum of Natural History of the **Smithsonian Institution** are helping to decipher the history of environmental and resource fluctuations from ancient archaeological sites and relating these to modern problems of today's arctic peoples.


 Because of the link between climate change and fossil fuel emissions, the **Department of Energy** supports physical and biological research related to energy development and to the understanding of global change. These investigations are important to the overall DOE mandate to provide solutions to the nation's energy needs.

 The **Department of Agriculture** conducts and fosters research to aid understanding, use, and management of agricultural, forestry, and environmental resources at high latitudes. This work will help ensure sustainability of food and timber resources, despite changes in northern ecosystems.

 The **Department of Defense** funds research on high-latitude oceanic and terrestrial processes to understand how the extreme arctic environment impacts the operational capabilities of military personnel, weapon systems and sensors.

 The **National Oceanic and Atmospheric Administration** (NOAA) of the Department of Commerce, which forecasts the Nation's weather, is evaluating the recent evidence that the Arctic Oscillation is a major factor affecting the weather of the U.S. mainland. NOAA is also concerned about ocean regime shifts and changes in atmospheric patterns that can affect marine ecosystems.

 The perspective from space made possible by the **National Aeronautics and Space Administration** enables researchers to examine phenomena over a wide range of spatial and temporal scales. This unique perspective is essential for the large-scale investigations needed to understand changes in the physical environment and consequences for life on Earth.

 The **National Science Foundation** supports basic scientific research into the arctic environment's complex feedbacks and how they affect and are affected by the global climate system. NSF will expand support for research into the biocomplexity of the region, particularly the processes driving and responding to the decade-long warming in the Arctic.

Many significant changes have occurred in the Arctic in the past decades, on land, in the sea, and in the air. These changes affect how people live in the Arctic and throughout the world.

Scientists do not know if the changes are part of the Arctic's normal variability or are caused by humans. They are uncertain if they are part of a natural cyclical pattern or reflect the beginning of a long-term shift in the environment.

The U.S. federal agencies responsible for scientific research in the Arctic have agreed to work together to investigate arctic environmental processes, emphasizing their interactions with global climate change and potential impacts on the biosphere, including human social and economic well being.



Blizzard in New York City, 1996, photo © Matthew J. Atanian.