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PolarVision 2010

Earth's Arctic and Antarctic polar regions present unique opportunities for discovery in social science, biology, Earth processes, climate, atmosphere and ocean science and Earth and space physics. The need for research at the poles has never been more pressing — the polar regions are poised at the brink of major changes as a result of human activity and climate change. These regions are uniquely sensitive and will undoubtedly exert a major influence on the course of global climate change, with far-reaching implications for the natural world and for society. Polar research presents challenges that often require specialized and highly coordinated approaches. The Office of Polar Programs leads the National Science Foundation's support of innovative polar research and provides the academic community and researchers from other US federal agencies critical access to the polar regions. Activities of the Office of Polar Programs promote the National Science Foundation's objective to "*empower the nation through discovery and innovation*".

The US Antarctic Program

Under Presidential Memorandum 6646, NSF is designated as the single point manager of the U.S. Antarctic Program (USAP) on behalf of the U. S. Government and has overall management for planning, funding and implementing USAP activities. The fundamental objective of the USAP is to maintain an active and influential U.S. presence in Antarctica by maintaining a substantial program of scientific research on the continent and the Southern Ocean consistent with the terms of the Antarctic Treaty and reflecting the needs of other U. S. federal agencies. The NSF Office of Polar Program's Division of Antarctic Sciences (ANT) supports a wide range of scientific research by NSF-funded investigators including projects co-sponsored with other units within NSF, other U.S. agencies and/or international partners. The Division of Antarctic Infrastructure & Logistics (AIL) maintains three permanent research stations at South Pole, McMurdo, and Palmer Station, operates two ice-capable research vessels and supports science projects distributed throughout the Antarctic as driven primarily by merit review.

The ice-covered continent of Antarctica and the surrounding Southern Ocean are critical, but poorly understood components of the Earth System, containing Earth's largest reservoir of fresh water, and a significant portion of Earth's biological activity. Antarctica offers many opportunities for research related to a broad array of earth, biological, space and astrophysical sciences including, but not limited to, climate change and records of past climate and environmental conditions in the high southern latitudes, adaptation on both the organism and ecosystem levels to extreme cold and long periods of darkness, oceanographic and atmospheric processes related to energy and mass flux in the Southern Ocean and overlying atmosphere, clues to evolution of the solid and living earth from Precambrian through recent times, ice sheet dynamics and the contribution of ice sheet changes to sea level rise, interactions of the solar wind with earth's upper atmosphere and magnetosphere, and astrophysical investigations of high energy phenomena and the early history of the universe.

Together, ANT & AIL support, within the framework of the Foundation's Strategic Plan and Goals, grants for both on-ice and off-ice research with the goals of: 1) expanding fundamental knowledge of the Antarctic in the geo- and bio-sciences; 2) fostering research on global and regional problems in which Antarctica has a role through connected atmospheric, oceanographic, or solid earth systems and processes; and 3) using Antarctica as a platform from which to make important observations of the cosmos, our solar system, or other regions of the Earth. At the same time, ANT & AIL endeavor to ensure diversity of the science and education community active in the USAP and to foster U.S. leadership in Antarctic scientific activities. ANT & AIL work with PEHS to assure that research is carried out responsibly with respect to environment, safety and health.

Arctic Program:

In the Arctic, NSF plays a lead role coordinating and implementing U.S. research activity; the director of NSF chairs the Interagency Arctic Research Policy Committee under the President's National Science and Technology Council (as designated in the Arctic Research and Policy Act of 1984 and amended by the July 22, 2010 Presidential Memorandum). The NSF Office of Polar Program's Division of Arctic Sciences (ARC) supports a wide range of scientific research by NSF-funded investigators including projects co-sponsored with other units within NSF, other U.S. agencies and/or international partners. The Division of Arctic Sciences encompasses science and infrastructure and logistics support to gain a better understanding of the Arctic's physical, biological, geological, chemical, social and cultural processes; the interactions of oceanic, terrestrial, atmospheric, biological, social, cultural, and economic systems; and the connections that define the Arctic.

The rapid rate of Arctic environmental change has attracted considerable national and international attention. Air temperatures in much of the Arctic have significantly warmed, sea ice extent and thickness are clearly trending downward, land ice loss that is accelerating, permafrost is warming and eroding, and atmosphere and ocean circulation patterns are changing, ecology both on the land in in the sea is being altered and human systems traditionally dependent on ecological "services" are being disturbed. These changes in the Arctic are stimulating societal interest in resource development, shipping and tourism. As such human activities ramp up in the Arctic, the need to understand the Arctic environment as a system has never been more compelling. The changes in Arctic conditions are also likely to have global implications for weather, climate, and biological systems that are not yet fully understood.

The Division of Arctic Sciences hosts science research funding programs that foster advancement of natural, social and system science as well as an observing network. The Research Support and Logistics Program supports field work of priority merit reviewed projects funded by ARC science programs. In addition, ARC and other NSF programs support projects that contribute to the development of the next generation of researchers and scientific literacy for all ages through education, outreach, and broadening participation in science, technology, engineering, and mathematics and foster U.S. leadership in Arctic scientific activities. ARC works with PEHS to assure that research is carried out responsibly with respect to environment, safety and health.

Office of Polar Environment, Health and Safety

The NSF Act of 1950 (Public Law 81-507) set forth missions to promote the progress of science and to advance the national health, prosperity and welfare. In promoting the progress of polar science, the Office of Polar Programs must assure that the science is conducted responsibly from the standpoints of environmental impact, human health and safety. The OPP Office of Polar Environment, Health and Safety (PEHS) manages and oversees the environmental, safety, and health aspects of research and operations conducted in both polar regions. Protection of the environment has high priority for nations that operate in the Antarctic. The Antarctic Treaty System, with its Agreed Measures for the Conservation of Fauna and Flora (1964) and its Protocol on Environmental Protection (1991), prescribes comprehensive protective measures. The U.S. Government is pledged to uphold these principles. PEHS assures that NSF operates the U.S. Antarctic Program in accordance with U.S. and international requirements regarding protection of the environment. PEHS is engaged in extending appropriate protocols to research conducted in the Arctic.

Health and safety must be of foremost concern in conducting research in remote polar regions to which ready access can be quite limited. PEHS endeavors to set in place policies and systems that assure that science is conducted in a safe and healthy manner taking into account risks inherent to remote deployments to regions of harsh climate.

The *vision* of the Office of Polar Programs is:

A scientific understanding of the physical, biogeochemical, ecological and human systems in the polar regions, and their role in the global climate system.

A scientific basis for assessing human impacts on the polar regions, and for developing sustainable policies.

Advances across the Earth, Life, and Space sciences enabled by the use of the polar regions as a natural observatory for research and discovery

An informed public, aware of the unique importance, sensitivity, and beauty of the polar regions and the need for responsible stewardship of these regions.

The OPP mission is to achieve this vision by enabling polar research at the frontiers of glaciological, oceanographic, atmospheric, biological and space sciences.

This involves:

- *Building a broadly based, interdisciplinary community of researchers, committed to a systems-level understanding of the polar regions, and integrated with the Earth System Science communities.*
- *Enabling intensive and sustained observations of the polar regions in ways that minimize the environmental footprint of research activities.*
- *Promoting the availability and utility of scientific data from the polar regions and ensuring that data will be preserved for future generations.*
- *Communicating the excitement and importance of polar science to K-12 students and the general public*
- *Making polar research accessible to policy-makers and other stakeholders.*
- *Building international partnerships critical to accessing and observing the polar regions, advancing scientific knowledge, promoting a common understanding of the scientific basis for stewardship.*

Discovery

Polar science has generated extraordinary new insights across a wide range of disciplines, from cryobiology to space physics. A few of the many extraordinary scientific discoveries of recent years are highlighted here. Behind every one is a unique logistical support organization making it possible for scientists to work in these harsh, remote, and inaccessible polar regions.

Case studies: [suggested topics]

1. Polar ice cores and abrupt climate change
2. Arctic sea ice
3. Glacial dynamics and sea level rise
4. Ecosystem changes in the Antarctic peninsula
5. Biological adaptation
6. IceCube

The challenges ahead

1. Polar System Science – Achieving a systems-level understanding of how the polar regions function requires a multidimensional research agenda combining physical, biogeochemical, ecological scientists. This requires integration and coordination of research that challenges the traditional disciplinary structure of NSF programs, and the funding of individual research projects. In response, the OPP has pioneered the development of "Integrated System Science" programs. The OPP will continue to seek innovative ways to facilitate the self-organization of polar research, and to build communities of scientists focused on broad system science issues while preserving the flexibility for individual researchers to innovate.

2. Connecting the polar regions to the Earth System – the polar regions are a critical part of the global Earth climate system. Understanding the teleconnections and interdependences between the tropics, midlatitudes, and polar regions is a challenge to the global Earth Science community. The OPP will seek to integrate polar science into the broader framework of Earth System Science by promoting integrative activities and partnering with ….

3. Strong core disciplinary science –OPP will support to use of the polar regions as natural laboratories for discovery in the physical, chemical, and life sciences. This will be done in partnership with disciplinary programs within NSF and across the Federal government.

4. Education/outreach/educate policy-makers

3. Data management: The challenge…The OPP is committed to the curation, accessibility, and preservation of data generated by polar researchers. This involves establishing and establishing protocols and policies that promote open access to data and interoperability of data sets [data repositories if needed]. OPP is also committed to improving the ease of access of data to investigators across the various disciplines of Earth and Space sciences and across the globe. This will be done by actively pursuing partnerships across the US and international research and monitoring communities.[availability to the public]

4. Research infrastructure and logistics: The remote and harsh environmental conditions in the polar world make access to this environment the single most challenging aspect of the OPP enterprise. The OPP recognizes the need for continual investment in new and improved capabilities to bring scientists and instrumentation into the field, and to bring remotely sensed information to scientists at their home institutions. This involves fixed and distributed assets, such as permanent and seasonal bases, aircraft, ice breakers and ice strengthened research vessels, overland traverse capabilities. Advances in remote sensing, robotics, and communication make it increasingly possible to carry out environmental observations without

human presence with range and resolution never before possible. At the same time, such systems bring increased logistical requirements for deployment, calibration, maintenance, and ground-truthing. Current trends in polar research suggest increasing demand on scientific logistics infrastructure both in terms of size and complexity of field operations, and to geographic range of the activities. The polar research infrastructure must continuously evolve in order to take advantage of new technologies, requiring a continual process of assessment and prioritization, in close consultation with the scientific community.

5. Relationship between OPP and other entities: intraNSF, Federal agencies, private sector, other nations

6. Sustainability – OPP is dedicated to responsible stewardship of the polar environment. This means utilizing the best available technologies to carry out polar operations while minimizing the impact on the unique polar environment.

7. Leadership – which areas will OPP lead on? What are its unique roles? Climate change, earth system processes, ice sheet processes

8. Policy relevance – OPP is committed to providing the scientific understanding needed as the basis for sound public policy. This is particularly pressing in the area of climate change because the polar regions are both highly sensitive to climate change and because uncertainties in the behavior of polar systems is a major uncertainty in the prediction of the extent and nature of future climate change.

11. Long-term observations — in support of scientific discovery