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# The scope of science for the International Polar Year 2007–2008



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# PREFACE



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The International Polar Year (IPY) 2007–2008 represents one of the most ambitious coordinated international science programmes ever attempted. It will include research and observations in both the Arctic and Antarctic polar regions and explore the strong links these regions have with the rest of the globe. The poles are recognized as sensitive barometers of environmental change. Polar science is crucial to understanding our planet and our impact on it. The poles are also exceptional archives of what the Earth was like in the past, and offer a unique vantage point for many terrestrial and cosmic phenomena.

This IPY will initiate a new era in polar science and involve a wide range of research disciplines, from geophysics and ecology to social science and economics. It is a truly international endeavour with over 60 countries participating in more than 200 projects. IPY 2007–2008 also aims to educate and involve the public, and to help train the next generation of engineers, scientists and leaders. Therefore, over 50 of the projects deal with education and outreach.

IPY 2007–2008 is co-sponsored by the International Council for Science (ICSU) and the World Meteorological Organization (WMO). It builds on a 125-year history of internationally coordinated study of polar regions. This extends back to the first and second International Polar Years of 1882–1883 and 1932–1933, which were sponsored by the International Meteorological Organization — WMO's predecessor — and the International Geophysical Year of 1957–1958, backed by ICSU and WMO. IPY 2007–2008 marks the 50th anniversary of the International Geophysical Year.

## THE CO-SPONSORS

Founded in 1931, ICSU is a non-governmental organization representing a global membership that includes both national scientific bodies (111 members) and international scientific unions (29 members). ICSU's mission is to strengthen international science for the benefit of society. A key part of this is to plan and coordinate research, particularly for topics that require collaboration between scientists in different disciplines and in different parts of the world. The ICSU Executive Board in June 2003 established the IPY Planning Group, made up of leading polar scientists from across the world. ICSU and WMO then set up in October 2004 a Joint Committee for IPY responsible for the overall scientific planning, coordination, guidance and oversight of IPY 2007–2008.

In 1950, WMO succeeded IMO, founded in 1873, and became a United Nations specialized agency in 1951. WMO is the United Nations' authoritative voice on weather, climate and water. It facilitates cooperation in the establishment of networks for meteorological, climatological, hydrological and geophysical observations over the globe. It also facilitates data exchange, and assists technology transfer, training and research. WMO fosters cooperation between the National Meteorological and Hydrological Services of its 188 Members, and furthers the application of meteorology to aviation, shipping, agriculture, water issues and the mitigation of the impacts of natural disasters. In May 2003 the World Meteorological Congress adopted a resolution to sponsor the International Polar Year 2007–2008.

[www.icsu.org](http://www.icsu.org)

[www.wmo.int](http://www.wmo.int)



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# EXECUTIVE SUMMARY

The International Polar Year 2007–2008 will be the largest internationally coordinated research programme in 50 years. It will be an intensive period of interdisciplinary science focused on the Arctic and the Antarctic. The polar regions are especially important for the following reasons:

- They are presently changing faster than any other regions of the Earth, with regional and global implications for societies, economies and ecosystems. This change is particularly evident in widespread shrinking snow and ice.
- Processes in polar regions have a profound influence on the global environment, and particularly on the weather and climate system. At the same time, the polar environment is impacted by processes at lower latitudes. Examples include the formation of the ozone hole and the accumulation of pollutants in the Arctic environment.
- The Arctic is home to more than 4 million people, and these communities face changes in their natural environment and in their natural resources and food systems — changes that are, for the most part, of a rapidity and magnitude beyond recent experience or traditional knowledge.
- Within the polar regions lie important scientific challenges yet to be investigated and unique vantage points for science. The regions beneath the polar ice sheets and under the ice-covered oceans remain largely unknown. Many of the new scientific frontiers in the polar regions are at the intersection of traditional scientific disciplines.

Six scientific themes provide a framework for IPY 2007–2008.

1. **Status:** to determine the present environmental status of the polar regions;
2. **Change:** to quantify and understand past and present natural environmental and social change in the polar regions and to improve projections of future change;
3. **Global linkages:** to advance understanding on all scales of the links and interactions between polar regions and the rest of the globe, and of the processes controlling these;
4. **New frontiers:** to investigate the frontiers of science in the polar regions;
5. **Vantage point:** to use the unique vantage point of the polar regions to develop and enhance observatories from the interior of the Earth to the sun and the cosmos beyond;
6. **The human dimension:** to investigate the cultural, historical and social processes that shape the sustainability of circumpolar human societies and to identify their unique contributions to global cultural diversity and citizenship.

IPY 2007–2008 research activities were assembled from the ideas of researchers in more than 60 countries. A total of 228 projects have been endorsed by the ICSU/WMO Joint Committee for IPY 2007–2008. These projects have a strong interdisciplinary emphasis and address the six themes as well as education and outreach objectives. IPY projects will exploit new technological and logistical capabilities and strengthen international

coordination of research. They aim to attract, engage and develop a new generation of researchers and raise the awareness, interest and understanding of polar residents, educators, students, the general public and decision makers worldwide. IPY projects will collect a broad-ranging set of samples, data and information which will be made available to an unprecedented degree.

IPY 2007–2008 aims to leave a legacy of enhanced observational systems, facilities and infrastructure. The observational networks to be established during IPY include integrated ocean observing systems in both the Arctic and Southern Oceans, coordinated acquisition of satellite data products from multiple space agencies and observational systems for astronomy, sun–earth physics,

atmospheric chemistry, meteorology, ecosystems, permafrost, glaciers and geophysics. Many observing systems within IPY will be developed within the framework of existing international global observing systems.

The period from 1 March 2007 to 1 March 2009 will be exciting and historic. The International Polar Year 2007–2008 should significantly advance our ability to meet the major science challenges of the polar regions and generate a rich legacy, notably in a new understanding of polar processes and their global linkages at this critical time — for it is becoming ever clearer that we humans have to recognize and respond to the planetary limits of our behaviour. The polar regions provide a litmus test and the insight to help us do so.



# 1 INTRODUCTION

The polar regions are integral components of the Earth system, as illustrated in Figure 1. As the heat sinks of the climate system, they respond to and drive changes elsewhere on the planet. Today, the polar regions are changing faster than any other regions of Earth, with implications for local animals, plants, people and infrastructure, and for coastal populations everywhere. Within the polar regions lie frontiers of knowledge as well as unique vantage points for science, yet because of their remoteness and harsh nature, the poles remain poorly understood. With recent technological advances providing new scientific possibilities and humankind's urgent need for environmental knowledge and understanding, the time is ripe for a coordinated international initiative to achieve major advances in polar science.

Motivated by urgency and a need to understand the poles and their relation to the rest of the planet, scientists from 63 nations will launch a major multidisciplinary International Polar Year in 2007 co-sponsored by the International Council for Science (ICSU) and the World Meteorological Organization (WMO). The concept of the International Polar Year 2007–2008 is based on an intensive and internationally coordinated campaign of cutting-edge research activities and observations in the polar regions. The official IPY 2007–2008 observing period will be from 1 March 2007 to 1 March 2009, in order to include a complete annual cycle of seasons in the Arctic and in Antarctica. IPY 2007–2008 will build upon a 125-year history of internationally coordinated study of the polar regions. The current IPY is the successor of the first International Polar Year (1882–1883), the second International Polar Year (1932–1933) and the International Geophysical Year (1957–1958).

IPY 2007–2008 will have a strong interdisciplinary emphasis, with active participation of the social sciences. This international cooperative venture will lay the foundation for significant scientific advances in understanding the nature and behaviour of the polar regions and their role in the functioning of the planet. In addition, IPY 2007–2008

will leave a legacy of observing sites, facilities and systems to support ongoing polar research and monitoring as the basis for observing and forecasting change. The Polar Year will strengthen international coordination of research and enhance international cooperation in polar regions, particularly among scientists, local residents and their institutions in scholarship, education, health and environmental protection. IPY 2007–2008 projects will address both polar regions and their global interactions in order to improve understanding of the poles as key components of the global environment.

Since interdisciplinary work is fundamental to building a global understanding, IPY will link researchers to address questions and issues lying beyond the scope of individual disciplines. IPY 2007–2008 projects will collect a broad-ranging set of samples, and data and information regarding the state and behaviour of the polar regions and their relations to the rest of the world. These data will provide a reference for the future and the past. Data collected under IPY 2007–2008 will be made available in an open and timely manner. IPY will also provide a unique opportunity to intensify the recovery of relevant historical data and ensure that these also are made openly available.

IPY 2007–2008 projects will attract, engage and develop a new generation of researchers, and experts. Further, they will raise the awareness, interest and understanding of polar residents and their community institutions, as well as educators, students, the general public and decision makers worldwide with respect to the purpose and value of polar research and observations. Building on existing and potential new funding sources, projects developed as part of the Polar Year will optimize the use of available polar observing systems, logistical assets and infrastructure, and develop and embrace new technological and logistical capabilities.

This document provides an overview of the scope of the scientific research that will be undertaken during the International Polar

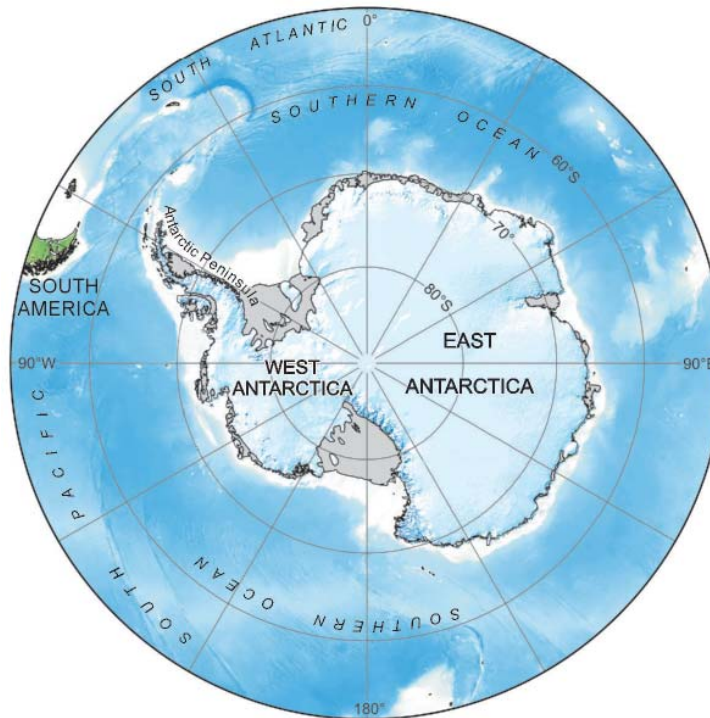
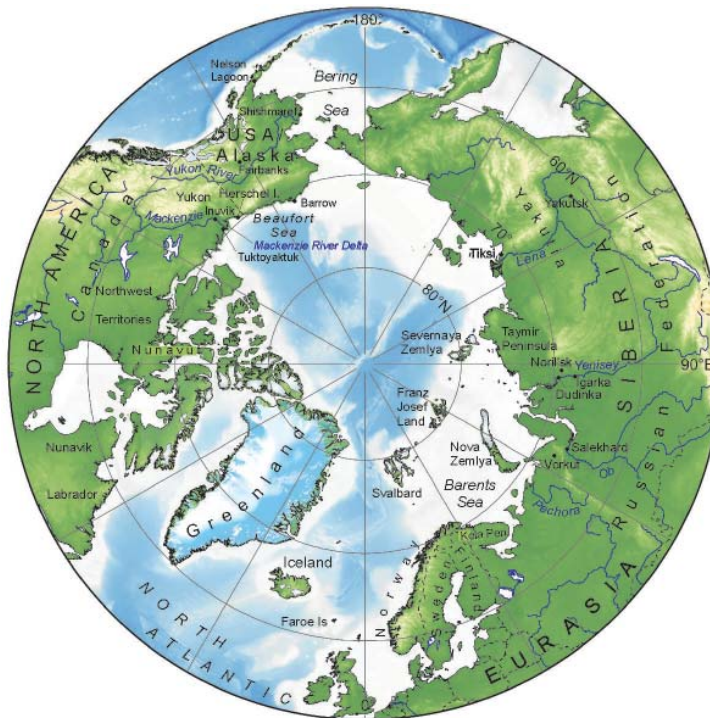


Figure 1. The two polar regions of the Earth will be the focus for research during the International Polar Year 2007–2008. As heat sinks of the climate system, they respond to and drive changes elsewhere on the planet.

[Source: British Antarctic Survey Mapping and Geographical Information Centre]

Year 2007–2008. The development of IPY 2007–2008 research activities has been driven as a bottom-up process by active researchers in many countries. A total of 228 projects, including 57 that focus on education and outreach, have been formally endorsed by the ICSU/WMO Joint Committee for IPY 2007–2008 as IPY activities (see Appendix III).

Details are available at <http://www.ipy.org/development/eoi/>. The IPY core participants are self-organizing groups of researchers, international organizations and consortia of national governmental and non-governmental agencies. The wide scope of IPY science presented here is based on the research plans and objectives of these endorsed projects.

## 2 AN URGENT NEED FOR POLAR RESEARCH

IPY science covers an enormous range of topics and specialties. All the IPY projects confront challenging science issues fuelled by the need to understand rapid changes in polar regions. IPY science goals will evolve as time and discovery refine and refresh our understanding. Four key issues however, require urgent attention.

### 2.1 SHRINKING SNOW AND ICE: RAPID CHANGE IN POLAR REGIONS

Global warming is not uniformly distributed. As a result of a positive feedback in which reduced snow and ice cover increases solar heat absorption, the atmosphere and the ocean are warming much faster in some areas of the polar regions than elsewhere on the planet. The results are plain for all to see: IPY occurs amidst abundant evidence of changes in snow and ice, with reductions in the extent and mass of glaciers and ice sheets, in area, timing and duration of snow cover, and in the extent and thickness of sea ice. There are clear indications that the reduction rate of many snow and ice masses has accelerated over the past decade.

On land the Arctic permafrost is melting, removing the stable foundations of buildings, roads and pipelines, and also having consequences for wildlife and the activities of native populations. Changes to the distribution of snow cover in the amount and timing of snow-melt runoff from snow packs and the shrinkage of glaciers impact the hydrological cycle locally and globally. Southern regions of the Greenland Ice Sheet are melting and thinning by collapse around the edge, though increased precipitation thickens the centre of the ice sheet on the high plateau. In the Antarctic the warming is more localized, but has been strong on the Antarctic Peninsula, where 87 per cent of glaciers are in retreat and large ice shelves have broken up. A major discharge of glacier ice is also occurring into the Amundsen Sea Embayment of the West Antarctic Ice Sheet, apparently as a result of ocean warming and

the loss of fringing ice shelves, since summer surface temperatures in the region remain well below the freezing point.

The Arctic sea ice cover is shrinking, opening the prospect of trans-Arctic sea routes. Polar bears, seals, walruses and other ice-associated marine species are at risk as their habitat disappears, with the unknown consequences to many polar residents and their subsistence-based economies. The Southern Ocean sea ice is also decreasing around the Antarctic Peninsula, but around East Antarctica the sea ice extent is stable. The shrimp-like krill that feed the whales, seals and birds of the Southern Ocean have declined tenfold near the Antarctic Peninsula where less sea ice means less cover to protect growing krill larvae. Declines in some penguin species are becoming apparent, but the picture is complicated by the tendency of some species to migrate south as the ocean warms and the sea ice retreats.

The observations and modelling studies of IPY will document and quantify the extent, rate and impact of the changing environment in both polar regions.

### 2.2 GLOBAL LINKAGES: INTERACTIONS BETWEEN THE POLES AND THE REST OF THE EARTH

Surface temperatures over large areas of the Arctic and on the Antarctic Peninsula have risen considerably faster than the global average, partly because of the ice–albedo feedback that amplifies climate change in polar regions and impacts our global climate. Above Antarctica, tropospheric temperatures have significantly warmed while the stratosphere has cooled. The latter has in turn enhanced the ozone hole. Global warming has also led to lower and higher pressures south and north of about 60°S, which is consistent with intensified and poleward-shifted westerlies in the region. The poleward-intensified westerlies are strengthening the Antarctic Circumpolar Current and contributing to Southern Ocean warming.



The changing polar environments are closely linked to changing environments globally. The ocean conveyor belt that transports heat and freshwater around the globe and connects ocean circulation between the Arctic and the Antarctic, known as the thermohaline circulation, is driven by sinking dense water produced at the surface in polar regions. As polar waters warm, and as sea ice production decreases, polar waters lose their tendency to sink, and there are concerns that the conveyor belt is slowing down as a response to ocean warming. As atmospheric carbon dioxide levels rise, the ocean surface waters are becoming more acid, with potentially deleterious effects on those plankton forming carbonate skeletons that form the base of the Southern Ocean food chain.

Changes in sea ice combined with enhanced river input of freshwater may alter the temperature and salinity of polar ocean waters, leading to substantial changes in the ocean circulation patterns that moderate climate. Changes in snow cover and sea ice have immediate local consequences for surface radiation budgets and for terrestrial and marine ecosystems. Warming of polar waters, coupled with changes in ice coverage and river run-off, will have consequences for several globally significant marine fisheries.

Changes in the large ice sheets will have a global impact on sea level, affecting large portions of human populations living in coastal and low-lying areas. Global sea level rose at a rate of some 1–2 mm/year over the 20th

In calm weather, frost flowers occur extensively on the surface of freshly formed sea ice. Research suggests that these exquisitely delicate structures may be involved in the production of reactive gasses that remove atmospheric ozone.



BRITISH ANTARCTIC SURVEY

century in response both to thermal expansion — a warmer ocean occupies more space — and to the melting of mountain glaciers and ice caps. In recent years the rate has risen to 3 mm/year, probably reflecting some addition from melting polar ice sheets.

Permafrost, an additional form of ice that influences nearly 24 per cent of the northern hemisphere landmass, also shows substantial change, mostly in the form of thermal decomposition, due to warming climate. Permafrost degradation affects local ecology and hydrology as well as coastal and soil stability. It may also mobilize vast reserves of frozen carbon, some of which, such as methane, will increase the global greenhouse effect.

IPY research will enhance understanding of these linkages and their impact for global human societies. It will also enhance our skill in predicting future Earth system changes.

### 2.3 NEIGHBOURS IN THE NORTH

Polar changes do not occur on a remote planet, but in the daily living environment of more than four million people in the Arctic. Those communities and societies face changes in their natural environment and in their natural resources and food systems. These changes are, for the most part, of a rapidity and magnitude beyond recent experience or traditional knowledge. Northern people are confronting unique health challenges from diverse pollutants transported to their regions from other parts of the globe. There are also new health risks and hazards associated with rapid climate change, transport and commercialism issues and accelerating pressures of industrial development due to the demand for polar energy and mineral resources.

IPY research, guided by and in partnership with polar residents, local communities and their institutions, will seek to understand the complex factors that determine individual well-being and community resiliency in the face of this extraordinary environmental and social change.

### 2.4 A SENSE OF DISCOVERY

For many people, polar regions represent places of wonder. The Russian poet Yuvan Shestalov, for example, refers to them as “temples of the planet”, but they can also be regarded as the “Earth’s sentinels”. The polar regions are characterized by a six-month polar night, an atmosphere largely free of local pollution sources, a small human population and a mostly undisturbed vegetation and wildlife. The poles act as amplifiers of anthropogenic and natural environmental global stresses. Hence, they offer an ideal and unique natural laboratory from which to observe and understand the changes we are making to our planet.

For science, the sense of visual, aural and emotional wonders includes a sense of discovery of polar regions as the home of unexplored places and the source of unexpected ideas. What secrets, what clues to the planet’s past, lie under the ice? Can ancient, solid, silent ice hold so much history and yet change so fast? What marvels of physics and chemistry occur when spring’s first light strikes winter snow? How does life survive extreme cold and long darkness? What structural and physiological adaptations evolved in cold waters and propagated throughout the oceans? How and why do microbial communities in the upper ocean influence cloudiness in the atmosphere above? What subtle richness of behaviour, language and knowledge has allowed human communities to survive in the Arctic for thousands of years? What will be the impacts of any future large-scale resource exploitation on polar biodiversity and societies?

These are some of the important and urgent scientific challenges to be investigated in both the Arctic and Antarctic, and IPY provides a unique opportunity to make exciting new discoveries, visit unseen places, develop new concepts and theories and set the stage for future scientific advances through new collaborative efforts and partnerships. Many scientific frontiers in the polar regions are at the intersection of disciplines, and progress will be achieved not only through the use of

new observational techniques, but also by the interdisciplinary cross-analysis of existing databases, taking advantage of outstanding strides made recently in computing capability and communication on the Internet. New polar scientific advances will occur on a tremendous range of spatial scales, from the previously inaccessible realms of the genome to vast areas of the Earth's crust beneath the ice and polar oceans.

### 3 SCIENTIFIC THEMES FOR IPY 2007–2008

On the basis of consultations held with the research community and of its own considerations, a framework for the International Polar Year 2007–2008 was developed by the ICSU/WMO Planning Group (see [www.ipy.org/development/framework/framework.pdf](http://www.ipy.org/development/framework/framework.pdf)). It contains a science framework; a data management plan; a strategy for education, outreach and communication; and a structure for the organization and implementation of IPY 2007–2008.

Six scientific themes were identified from the extensive input from the polar science community, providing a framework for IPY 2007–2008 activities:

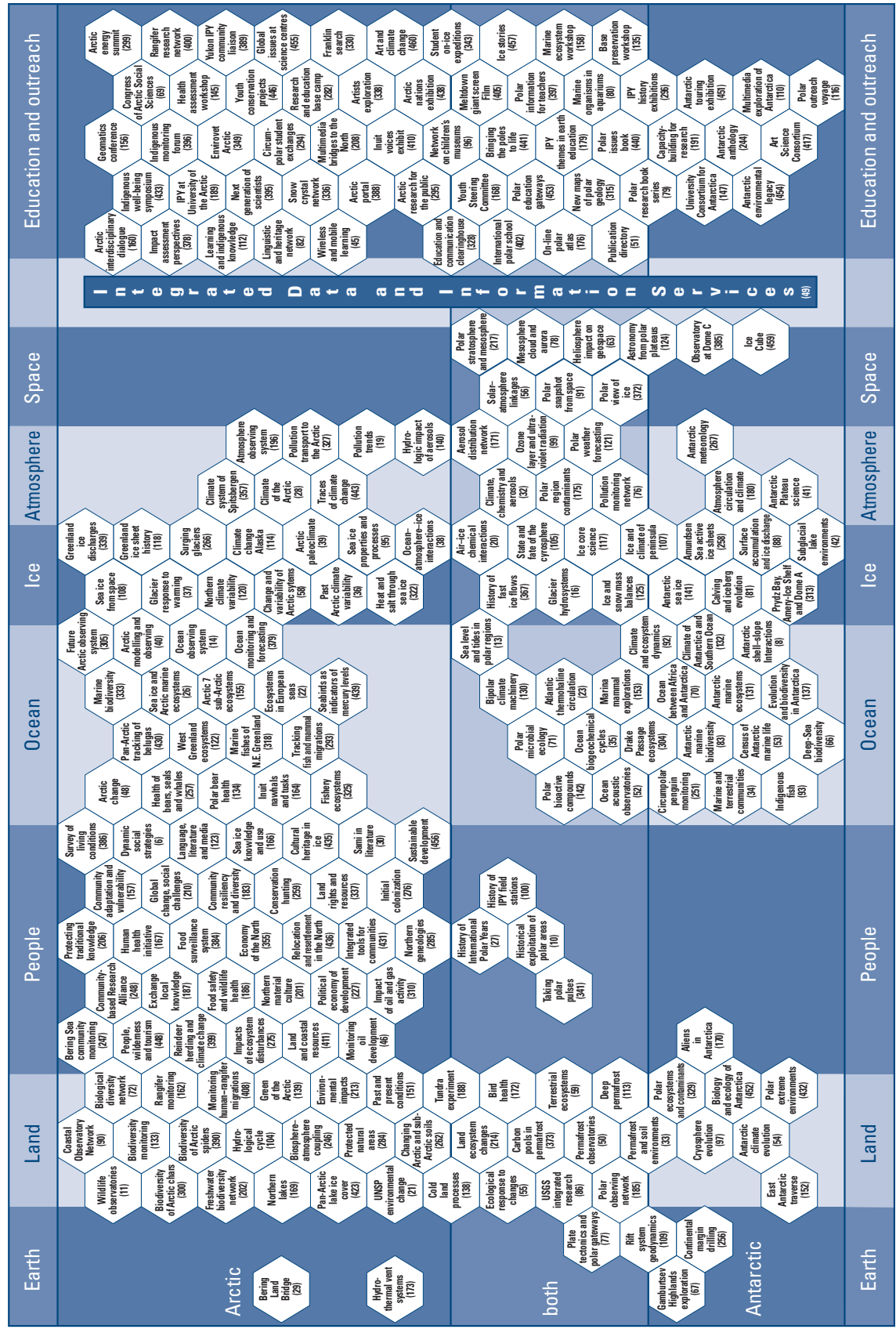
1. **Status:** to determine the present environmental status of the polar regions;
2. **Change:** to quantify and understand past and present natural environmental and social change in the polar regions and to improve projections of future change;
3. **Global linkages:** to advance understanding on all scales of the links and interactions between polar regions and the rest of the globe, and of the processes controlling these;
4. **New frontiers:** to investigate the frontiers of science in the polar regions;
5. **Vantage point:** to use the unique vantage point of the polar regions to develop and enhance observatories from the interior of the Earth to the sun and the cosmos beyond;
6. **The human dimension:** to investigate the cultural, historical, and social processes that shape the sustainability of circumpolar human societies and to identify their unique contributions to global cultural diversity and citizenship.

In pursuing these themes, IPY 2007–2008 seeks to exploit new technological and logistical capabilities and to make major advances in knowledge and understanding. It aims to leave a legacy of new or enhanced observational systems, facilities, infrastructure, numerical Earth simulators and research networks, as well as an unprecedented degree of access to the data and information it will generate. Another critical legacy of IPY 2007–2008 will be the next generations of scientists and educated polar residents, trained in advanced research methodologies and an interdisciplinary approach.

This document provides an overview of planned IPY 2007–2008 activities against a backdrop of these themes. Not only are most endorsed IPY projects strongly internationally collaborative and interdisciplinary, they also are cross-thematic. Most proposals are targeted at more than one of the IPY science themes. For example, many endorsed projects that address theme 1 (status) involve establishing baseline observations and thus also address theme 2 (change). The IPY planning chart, Figure 2, categorizes endorsed projects by region (Arctic, Antarctic or bipolar) and topic (Earth, land, people, ocean, ice, atmosphere, space, data management, education and outreach). The full set of endorsed IPY proposals clearly demonstrates both the breadth and depth of the planned science for IPY.

Figure 2. IPY planning chart as of 4 January 2007: the framework of hexagons provides a visual impression of how all the endorsed IPY projects are related in terms of geography and topic and how they may be linked. An Adobe Acrobat form of the latest hexagon diagram can be accessed at [www.ipy.org](http://www.ipy.org).

[Source: David Carlson, IPY 2007–2008 International Programme Office]





## 4 ENHANCED POLAR OBSERVING SYSTEMS — AN IPY LEGACY

Intensive activity during IPY 2007–2008 will include linked physical, geological, biological and chemical observations of the atmosphere, oceans, ice and land. Multidisciplinary observations, including the observation of social and human systems, will improve spatial and temporal coverage of many data sets. The infrastructure and comprehensive polar observing systems developed during IPY 2007–2008 will provide long-term observing networks to support polar research for decades to come to enable determination of the present environmental status and establish a baseline for identifying and forecasting future change. This will be a particularly significant legacy of IPY 2007–2008, since change in the polar regions is a harbinger for change elsewhere. Additionally, many IPY projects aim at engaging and training polar residents as monitors, environmental experts and community-based observers.

New multidisciplinary observational systems will enhance existing networks and leave a substantial legacy of new facilities, technologies and ways of coordination and data access. The time-limited focus and elevated funding during the IPY years will encourage scientists and engineers from many nations to work together to master technological challenges — such as how to measure ocean changes beneath the sea ice that covers the high-latitude ocean surface for much of the year. At the same time, the high-intensity observing period of the IPY years will provide detailed observations that can, through the integration of observations and advanced numerical models, guide the design of cost-effective, feasible observing systems for the future.

Observing systems within IPY will be developed within the framework of and as contributions to the larger global observing systems, for example, the Global Earth Observation System of Systems, the WMO World Weather Watch and Global Atmosphere Watch Programmes and the Global Climate and Global Ocean Observing Systems.

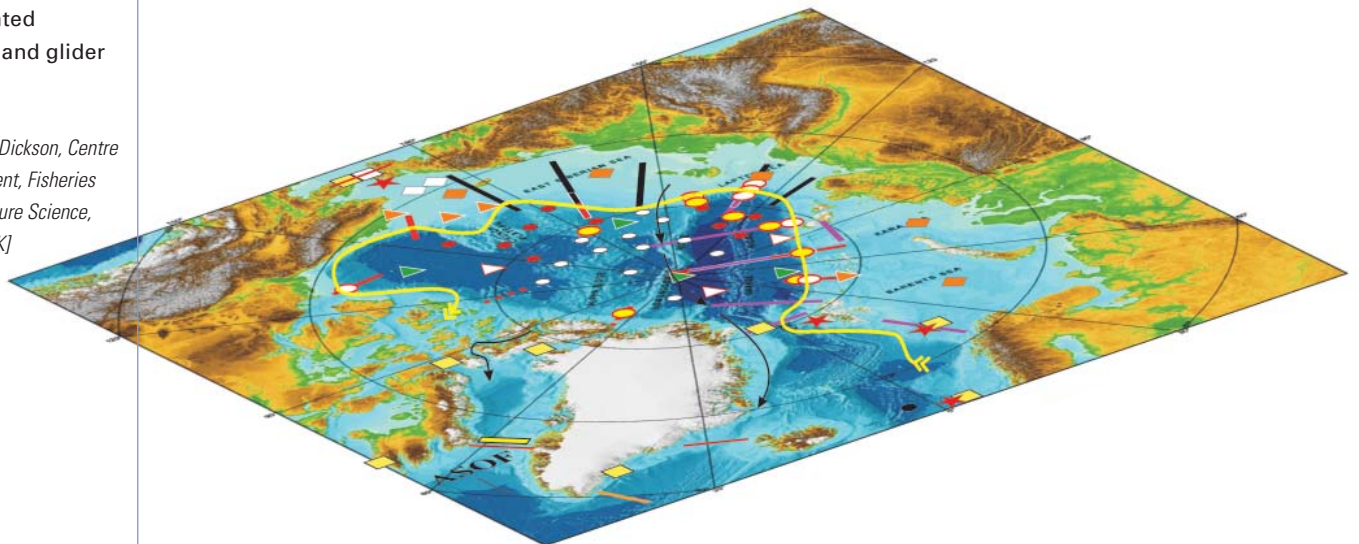
Enhanced observing systems endorsed as part of IPY include:

- An integrated Arctic Ocean observing system, based on proven technology and mobilizing both new and on-going activities during the IPY years to achieve an unprecedented level of observations of a region which is particularly sensitive to climate change, but inadequately covered by present observations (see Figure 3);
- Establishment of a southern hemisphere observing system, harnessing the resources of the global polar community, that will provide an early warning system for climate change and improved southern hemisphere meteorological analyses;
- A coordinated inter-agency effort linking space agencies and scientific institutions, aimed at planning, acquiring, archiving and distributing bipolar satellite data products essential to meeting IPY objectives;
- Establishment of acoustic networks to monitor the movement of marine mammals and fishes in both polar regions;
- A coordinated network of Arctic observatories measuring key physical and biological variables and processes at multiple sites in order to explore the diversity of climates and ecosystems at landscape scale;
- Observational systems for glaciology, oceanography, geology, geophysics, sun–earth physics, atmospheric science and astronomy installed along Antarctic transects extending from the summit of the ice sheet to the deep ocean;

Figure 3. A large number of planned research projects in the Arctic Ocean during IPY have been coordinated to form the basis for an international Arctic Ocean Observing System. This potentially provides the legacy of a regional contribution to the Global Ocean Observing System and Global Earth Observation System of Systems. The graphic illustrates ship cruise tracks and locations for instrumented moorings and glider surveys.

[Source: Bob Dickson, Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, UK]

- Coordination of activities at those year-round, intensive and permanent Arctic atmospheric observatories with sufficient infrastructure and staff to operate sophisticated atmospheric instruments, such as lidars and radars. These data will contribute to detailed studies of processes such as cloud–aerosol–atmospheric chemistry interaction and the relative role of tropospheric dynamics and stratospheric linkages in controlling Arctic surface variability;
- A coordinated network of local observation sites engaging Arctic residents, their knowledge and their methods of monitoring changes in sea ice cover, weather patterns, atmosphere, terrestrial environment and coastal processes;
- A comprehensive set of permafrost measurements in boreholes to provide a snapshot of permafrost temperatures in both polar regions, against which assessment can be made of present and future regional and global changes;
- A consortium, under the auspices of the Arctic Council, to increase effectiveness and efficiency in the use of infrastructure, personnel and funding, and to improve coordination for sustained long-term timeseries Arctic observations and for data handling.



## 5 THEME 1: STATUS

### Determination of the present environmental status of polar regions

Previous International Polar Years and the International Geophysical Year brought the international scientific community together to develop an integrated assessment of the polar regions and polar processes. Similarly, a key output of IPY 2007–2008 will be the documentation of the contemporary natural and human environments of the polar regions, quantifying their spatial and short-term variability and characterizing present-day processes. Well-planned synoptic observations of the environmental status of the polar regions will serve as a valuable benchmark for scientists and decision makers globally.

The depth of IPY programmes focused on the status of the polar regions reflects our lack of integrative knowledge and cross-disciplinary models of both natural and social environments in polar regions. These projects aim for integrated and interdisciplinary synoptic observations that will capture the modern environmental status of the poles and document current spatial variability. They include integrated physical, biological and social observational projects drawing on an expanded observational network, applying new technologies and enhancing the use of satellite observations.

In both polar regions, IPY will address the current composition and patterns of circulation of the high-latitude ocean–atmosphere–ice system and investigate the interactive processes that drive high-latitude circulation.

#### 5.1 THE POLAR ATMOSPHERE

Atmospheric research during IPY will aim to improve understanding of linkages between ice, oceanic and terrestrial systems and the representation of these in weather prediction and climate models. Researchers will investigate chemical exchanges and air–ice, air–ocean and air–land interactions; the impacts of these chemical, physical and biological exchange processes on tropospheric chemistry; and the complex feedback mechanisms among these processes in the context of changing climate. Understanding all these atmospheric linkages and processes will require observational and modelling studies of transports throughout the atmospheric column from near-surface layers to the lower stratosphere — in the case of polar vortices, even to the mesosphere — of teleconnections between polar and lower-latitude regions (see Figure 4) and of short- to medium-term weather events.

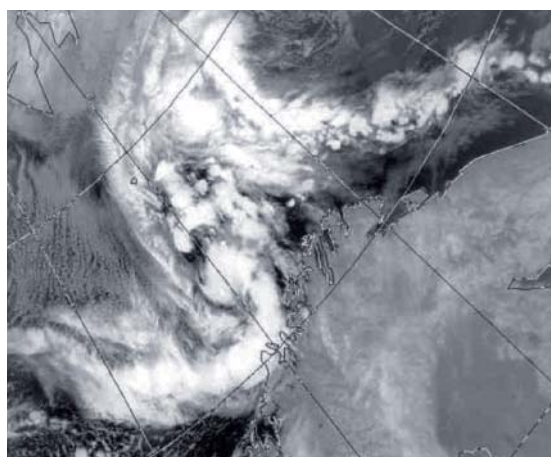
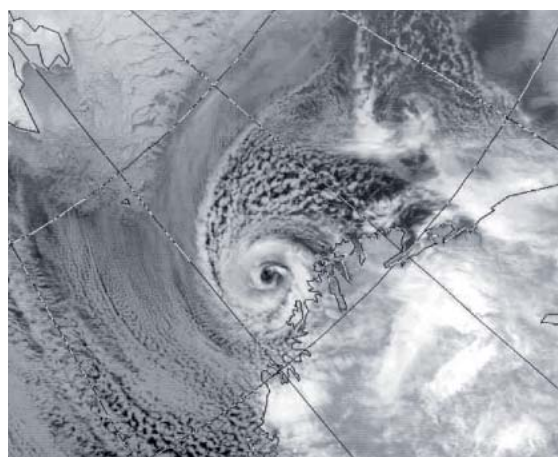


Figure 4. Infrared satellite images of a winter polar low (cyclone) situated between Greenland and the southern tip of Spitsbergen. New active and passive satellite technologies offer the potential for vastly improved numerical weather forecasting capabilities.

[Source: World Meteorological Organization]

Improved weather prediction skills will serve to benefit society, the environment and the economy. Meteorological research during IPY will include high-latitude contributions to The Observing System Research and Predictability Experiment (THORPEX), a WMO global atmospheric research programme that aims to accelerate improvements in weather prediction skills on a 1- to 14-day timescale. IPY THORPEX activities will include investigations of the two-way interactions between polar and sub-polar weather regimes; assessment and improvement of the quality of operational analyses and reanalysis products in the polar regions; measurements to develop, test and refine coupled modelling strategies designed to simulate and predict conditions in the polar earth system; and demonstration of the value of improved utilization of ensemble weather forecast products for events that are of high impact to polar societies and for IPY operations.

Aerosols have a large effect on radiation transmission in the polar troposphere directly and indirectly via clouds. IPY aerosol programmes will study transport — to the Arctic of aerosols and of air pollution more generally — from anthropogenic sources and boreal forest fires. These studies will use observations from aircraft, ship and surface stations, as well as satellite data and numerical models. Atmospheric chemists will determine the role that the transport of remote aerosols and local biochemical processes over open ocean leads within the sea ice zone play in polar cloud formation, polar precipitation, hydrological cycles and ice–albedo climate feedbacks.

Physical–chemical mechanisms that occur at the crucial interface between the atmosphere and the ocean in polar regions remain poorly understood. These processes impact on the nature of climate change and are influenced significantly by a change in climate. IPY scientists will establish comprehensive polar atmospheric monitoring programmes alongside existing long-term monitoring programmes, such as the Arctic Monitoring and Assessment Programme (AMAP). This will be coupled with research into the

processes of atmospheric transport, deposition and photochemistry and exchange between the atmosphere, ice and snow and the polar ocean.

Polar ozone losses in both hemispheres will be precisely quantified during IPY in concerted international campaigns of balloon soundings, satellite data and ground-based observations with lidar and other remote-sensing techniques. Polar stratospheric clouds play a key role in processes affecting the ozone layer. Chemical, microphysical and optical properties of polar cloud particles and gas-phase species will be obtained in situ and remotely from stratospheric balloons and aircraft, including high-altitude research aircraft.

## 5.2 ICE SHEETS AND GLACIERS

A better knowledge of the physical characteristics of the great ice sheets of both Greenland and Antarctica is necessary to improve understanding of their current and future contributions to sea level change. Large-scale surface and airborne ice sheet observational projects in conjunction with space observations will be a focus during IPY. Satellite-borne sensors will provide a unique snapshot of the polar ice sheets. New data on ice sheet characteristics will be incorporated into ice sheet models for investigating ice sheet formation, the response of ice sheets to climate change and the distribution of subglacial lakes. The new data will also be used to identify locations where the longest coherent climate records can be obtained from ice cores.

Quantification of ice sheet mass balance — the balance between snow accumulation over the ice sheets and ice loss, principally at the margins — is essential to understanding global sea level change. Improved estimates of this balance are a key goal of IPY. These improved estimates will be based on a variety of techniques. The grounding line of the Antarctic ice sheet will be identified by analysing interferometric synthetic aperture radar (InSAR) data. The total discharge of ice from



## Polar satellite missions

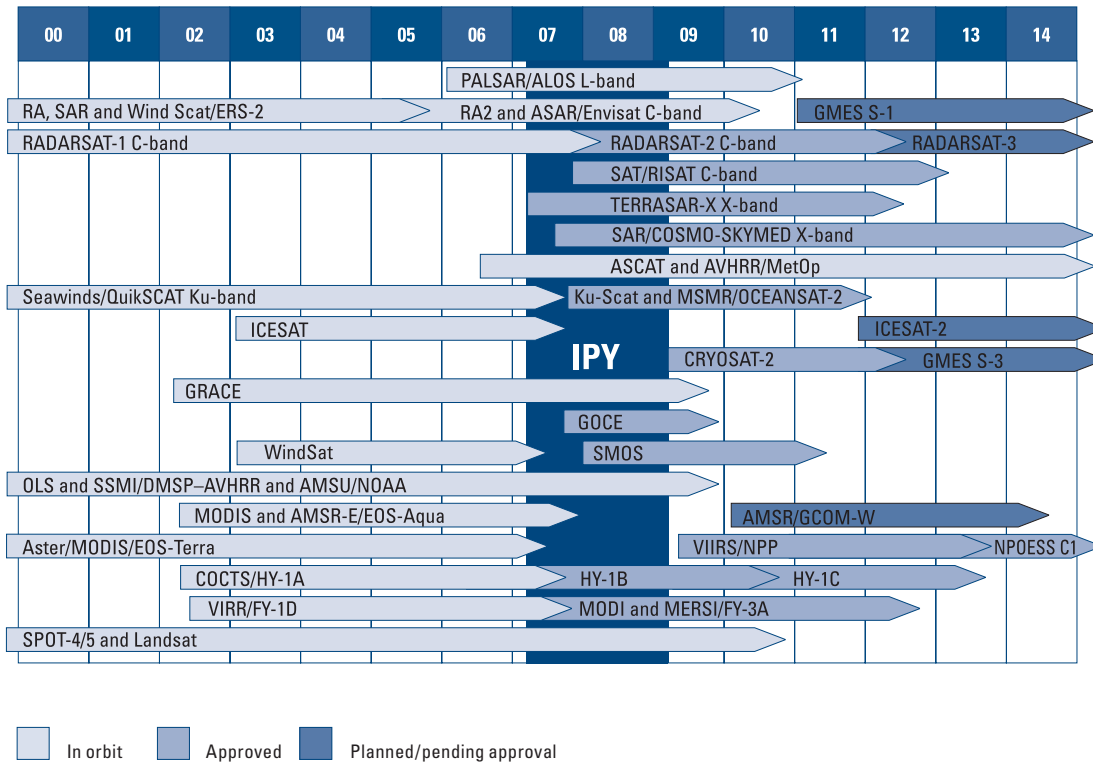


Figure 5. A large number of satellite missions will be addressing cryosphere issues during and after the IPY field period and international coordination of these missions will yield a vast range of data products for the polar regions.

[Source: Jezek, K. and M.R. Drinkwater, *Global Interagency IPY Polar Snapshot Year*, EOS, 87, 50, 566, 12 December 2006]

Antarctica will be derived from the surface ice velocity, also obtained from InSAR, and from dedicated airborne radar missions around the total grounding line. Iceberg calving is a major factor in loss of mass from the ice sheet, and the processes leading to the formation of rifts and subsequent iceberg calving from ice shelf edges will be studied using a combination of in-situ measurements, automatic observatories and satellite data. Ice sheet mass balance estimates from field surveys will be compared with results from other IPY studies of the variations in space and time of polar ice and snow mass estimated from satellite data, including the laser altimeter on the Ice, Cloud and land Elevation Satellite and the Gravity Recovery and Climate Experiment satellite mission. (See Figure 5).

New data showing the existence of large-scale water drainage systems beneath the polar ice sheets have renewed concern about ice sheet stability. Assessing this requires a fundamental understanding of both

surface accumulation and basal conditions. IPY provides an unprecedented opportunity to constrain these largely unknown parameters by coordinated and systematic airborne and surface surveys of the ice sheets. Geophysical data will contribute to mapping the heat flow and basal melt beneath the ice sheets, and comprehensive data sets on the spatial and temporal patterns of snow accumulation on the ice sheets will be acquired from high-frequency radar soundings along oversnow traverses tied to dated ice cores. Airborne and oversnow surveys will also image the ice sheet's internal features and, together with the ground measurements, will be used to link the data records from the main deep ice core sites on the ice sheets. New shallow and medium-depth ice cores will be obtained to extend the record of climate variability on timescales from years to millennia. Interior ice sheet locations first explored during the International Geophysical Year will be revisited to observe any changes. Automatic instruments will be deployed in remote regions during oversnow surveys.

In the polar regions, sunlight triggers the release of chemicals from surface snow into the lower atmosphere, a process that affects both air quality today and the interpretation of past climate using ice cores. IPY investigators will study how the presence of snow and ice affects the chemistry of air above the polar ice sheets.

On the Antarctic Peninsula and in the Arctic, where air temperature has risen faster than the global average in recent decades, baseline glaciological data on glacier extent and mass balance will be obtained. Glacier dynamics will be studied by means of field observations and remote sensing from satellites to facilitate more accurate computer modelling of glacier response to future climate changes. This will include investigation of modern surging glaciers in Alaska, Svalbard and high Asian mountains to develop improved projections of their cycle of evolution.

### 5.3 THE POLAR OCEANS

The role of the polar oceans and their processes remains a poorly understood facet of the global climate system. IPY projects will examine water mass transformations, ocean currents, ocean–atmospheric exchanges, ocean–ice interactions, physical–biogeochemical–ecological linkages and teleconnections between polar and lower latitudes. Improved understanding of modern polar ocean processes and their variability will feed through advanced numerical models into improved climate predictions. Many of the IPY projects that will research the physical and chemical processes of the polar oceans are linked to studies of the ecology and the biodiversity of the coupled ocean sea ice ecosystem.

A comprehensive synoptic understanding of both the nature and variability of the physical circulation of polar oceans, including ice-covered regions, is necessary to understand the observed environmental change and to develop accurate predictions of the future. IPY oceanographers will use a diverse array of in-situ instruments and

sampling strategies to obtain the first fully comprehensive synoptic picture of the nature and variability of the circulation and physical characteristics of water masses in the polar oceans, including ice-covered regions. Their strategies will include the use of remote sensing from space, novel technologies for observing the ocean beneath the winter ice cover and a fleet of polar research vessels. They will investigate the relationship between circulation, ocean biogeochemistry, ecology and biodiversity, both in the open ocean and around the margins, and the properties and circulation of the water masses beneath the sea ice. In the north, IPY research will focus on the large-scale circulation of the Arctic Ocean, including circulation influences on sea ice; on local and large-scale fluxes of heat, salt (freshwater) and mass; and on interactions between central basins, the Arctic shelves and the adjacent ocean areas. (See Figure 6).

Accurate bathymetric data constrain both ocean models and habitat studies. A number of IPY oceanographic projects will include sea-floor imaging using multibeam swath bathymetric techniques. In addition, investigators on all IPY oceanographic cruises will be encouraged to contribute echo-sounding data of the ocean floor to the presently sparse polar bathymetry archives. These data will provide a basis for construction of improved maps of ocean bathymetry needed as clues to interpreting underlying geological processes, guides to identifying biological habitats and inputs to advanced numerical models of ocean circulation.

Globally, sea ice is one of the most rapidly changing components of the cryosphere. In both polar regions scientists will obtain circumpolar data on sea ice thickness, extent, and physical properties. Ice thickness data will be obtained by a variety of methods including observations from vessels, buoy arrays, airborne inductive electromagnetic surveys, under-ice floats, autonomous underwater vehicles and satellite remote sensing. A quantitative baseline on sea ice thickness is essential for detection of change and validation of the next generation of

satellite altimeter observations, particularly for the Antarctic where the distribution of sea ice thickness is as yet only poorly known. A network of semi-automatic stations to monitor the land-fast ice around the coast of Antarctica will be established.

Shifts in the global freshwater cycle are powerful agents of global change. IPY will explore the broader ice–ocean connections that modulate global ocean circulation and which contribute to the global freshwater cycle. These include processes driving stratification, water mass modification, ice shelf–ocean interaction and ice shelf stability. Understanding of the sensitivity of the freshwater cycle to climate change and variability and the impact of changes in the high-latitude water cycle on the rest of the globe will be significantly improved during IPY.

The distribution and abundance of marine biodiversity in the polar regions and how polar biodiversity will be affected by climate change remain largely unknown. IPY researchers will undertake multi-ship surveys of polar marine ecosystems (see Figure 7) in both polar regions to determine the distribution and abundance of marine biodiversity and to investigate how biodiversity and overall ecosystems will be affected by climate change. Discovery and census activities will include surveys of ecosystems in and on sea ice. These will be strongly affected by a shrinking sea ice cover. Biodiversity surveys will cover pelagic microbial communities, phytoplankton, larger organisms such as krill, benthic and sub-ice communities, fish and shellfish, sea birds and marine mammals. In quantitative terms microorganisms, including algae, protozoa, bacteria, fungi and viruses, form by far the most important

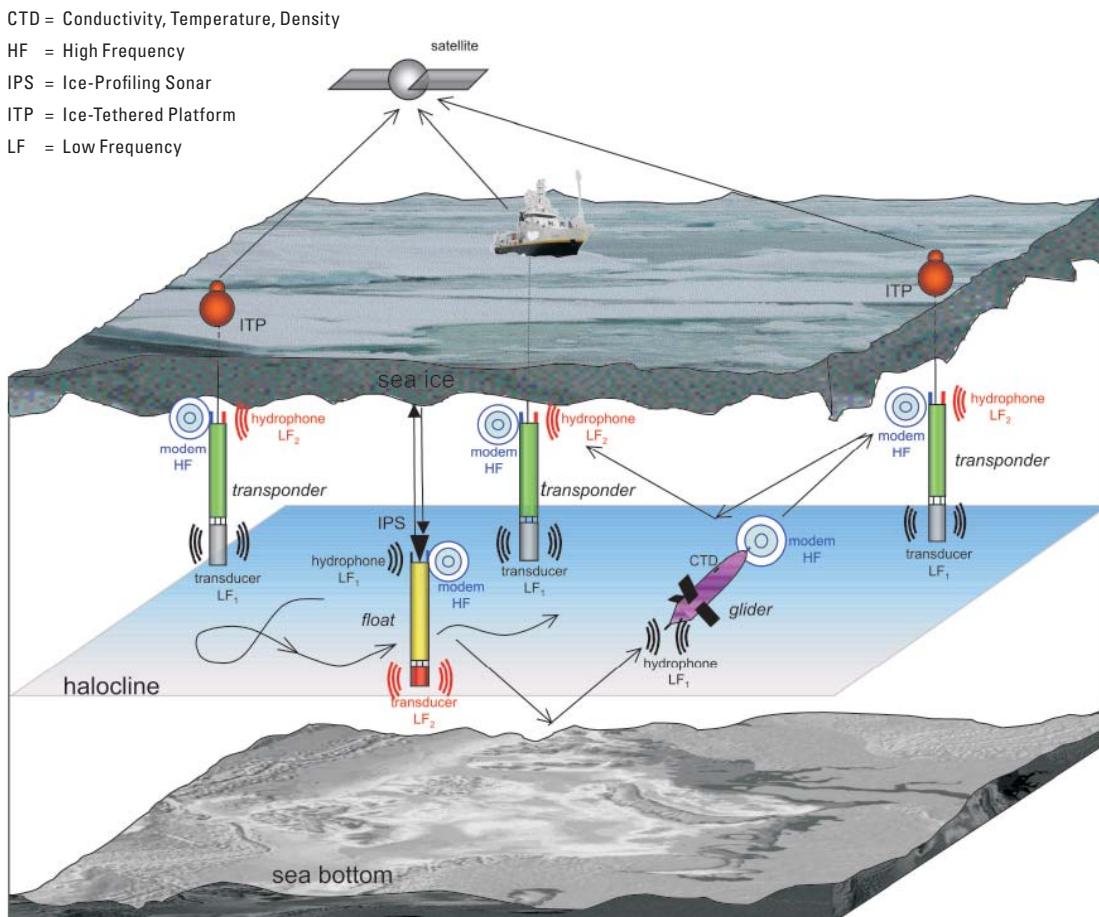
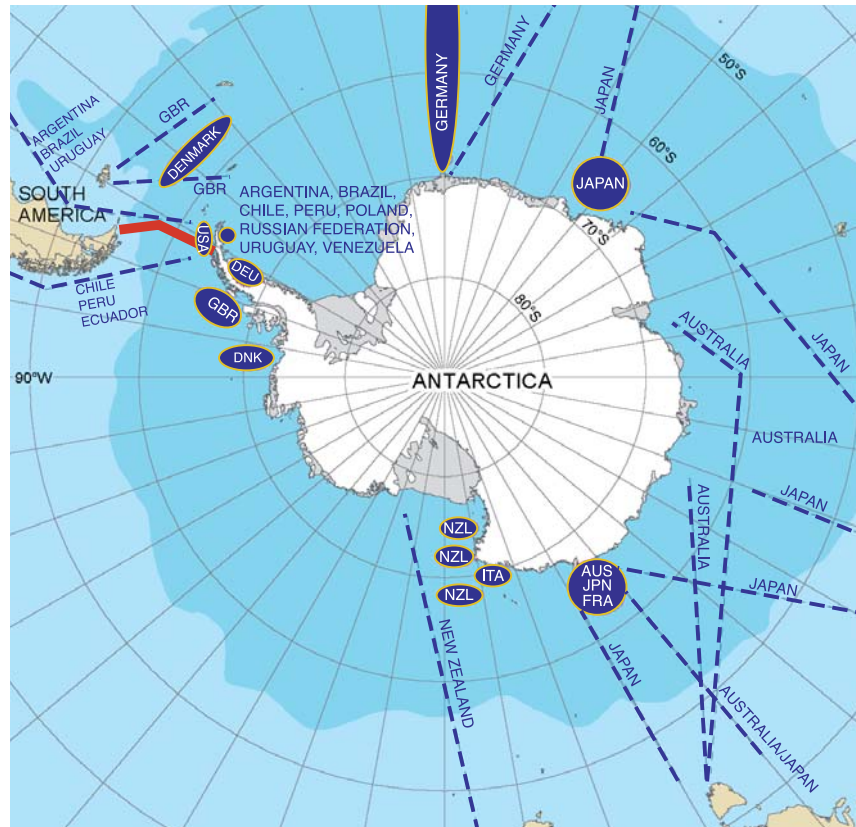


Figure 6. A full range of advanced sensor technology will be deployed during IPY in the Arctic region through satellite, aircraft, ship, submarine and sea ice platforms as well as fixed ocean moorings and autonomous ocean profiling packages.

[Source: DAMOCLES Consortium]

Figure 7. Ship-based sampling plans for the Census of Antarctic Marine Life during IPY: dark blue areas denote bottom sampling activities while the dashed lines are transects using the Continuous Plankton Recorder. The red band near the Antarctic Peninsula will be sampled by tourist vessels. The darker of the two ocean colours indicates waters south of the Subantarctic Front. The fieldwork is being undertaken by Argentina, Australia, Brazil, Chile, Denmark, Ecuador, France, Germany, Italy, Japan, Peru, Poland, New Zealand, Uruguay, the United Kingdom and Venezuela.

[Source: Census of Antarctic Marine Life Consortium]



- AUS = Australia
- DEU = Germany
- DNK = Denmark
- FRA = France
- GBR = United Kingdom of Great Britain and Northern Ireland
- ITA = Italy
- JPN = Japan
- NZL = New Zealand
- USA = United States of America

group of organisms in polar aquatic ecosystems, and the diversity and activity of these organisms will receive particular attention. These ecological studies will include the development and application of state-of-the-art molecular methods to detect, enumerate and monitor sentinel, or indicator microbial genes, determine molecular biodiversity and assess polar waters as source regions for marine speciation.

The Arctic marine ecosystem is diverse and highly productive and has many connections to other latitudes. Arctic marginal seas are vitally important breeding areas for mammals, birds and fish and provide substantial fisheries for Eurasia and North America. Changes in the Arctic exert profound effects elsewhere. Existing monitoring programmes of Arctic marine ecosystems will be supplemented by more detailed studies during IPY. The deepest parts of the Arctic Basin remain poorly studied owing to year-round

ice cover; therefore, a concerted IPY effort is planned to document its biodiversity and study extreme environments for life, such as the hydrothermal environments of the Gakkel Ridge.

Polar influences on global biogeochemical cycles will be addressed through a combination of models and observations. Researchers will investigate population dynamics, trophic interactions and flows of energy and matter in polar marine ecosystems to understand polar influences on global biogeochemical cycles. IPY researchers will conduct comprehensive studies of cooling and freezing processes in key ocean shelf regions to identify mixing processes in downward cascading waters, obtain production rates of bottom water and investigate relationships among deep-water formation, carbon dioxide uptake rates and large-scale climate forcing. The role of oceanic microbial processes in regulating the efficiency





In both polar regions marine mammals will be used as oceanographic monitoring platforms to complement and supplement conventional oceanographic monitoring systems. A Southern Elephant Seal has been fitted with instrumentation to measure global position, water depth, temperature and salinity. (See Figure 8.)

of the removal of carbon from the upper ocean and sequestering it on the ocean floor, the “biological pump” — thus regulating atmospheric carbon dioxide — will be investigated and assessed. Studies will be carried out to understand how high-nutrient-low-chlorophyll polar areas may act as carbon dioxide sinks during glacial periods when increased inputs of iron stimulate primary production. A coordinated investigation of ocean chemistry will help elucidate the crucial role that trace elements such as iron play in regulating and recording polar biogeochemical and physical processes.

Integrated analyses of climate–ocean–ecosystem interactions will be made across a range of spatial and temporal scales. Marine mammals will be recruited as instrumented partners to investigate oceanic “hot-spot” regions of high productivity and biogeochemical complexity. Hierarchical sets of models of the operation of ocean ecosystems

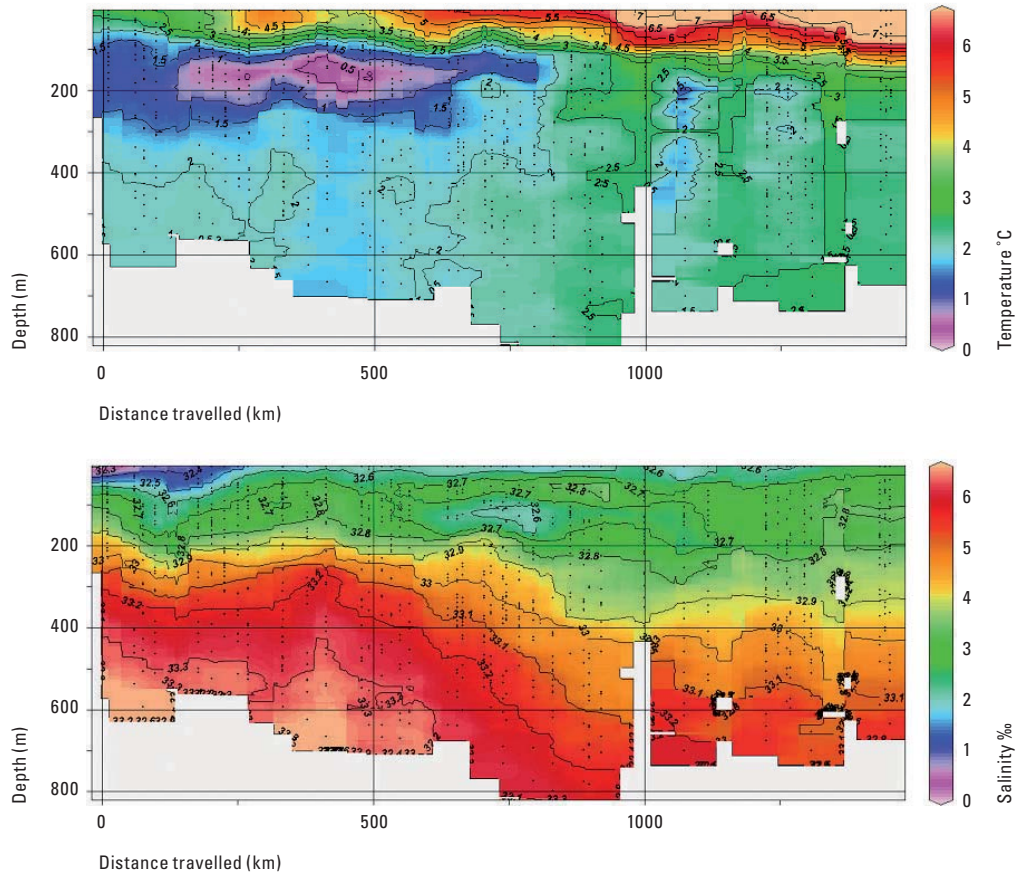
will be developed to quantify their response to variability and projected change. In both polar regions, researchers will also explore sources, sinks and transports of contaminants in marine ecosystems and linkages among contaminant levels and changes in physical or biological systems. They will integrate ecological and economic models to develop strategies for sustainable use of polar marine resources.

#### 5.4 PEOPLE OF THE POLAR REGIONS

Humans are a key component of the polar regions and, for the first time, IPY 2007–2008 will have a strong research programme focused on assessing the cultural, historical and social processes that shape the sustainability of circumpolar human societies and identifying their contributions to global diversity and citizenship. Thus, IPY 2007–2008 will become the key reference point for prior

Figure 8.  
Typical examples  
of temperature  
and salinity  
obtained along a  
1500-km track by  
oceanographic  
instrumentation  
fitted to a Southern  
Elephant Seal

[Source: Mike Fedak,  
Sea Mammal Research Unit,  
St. Andrews, Scotland]



and future interdisciplinary studies involving polar residents and societal institutions. Interactions between social and natural actors that would occur with the expected changes in the sea ice, water temperatures and land vegetation are an important component of this theme, owing to the significant role of subsistence hunting and the economically important fishing and reindeer herding industries to Arctic residents' well-being. IPY projects focused on economic development and strategies for community sustainability will also determine adaptation and mitigation policies that will enhance the value of IPY research to local agencies and stakeholders.

IPY studies will also address many critical issues concerning the health and well-being of polar residents, particularly the impacts of industrial pollutants, contaminants and parasites in traditional foods; existing and

emerging infectious diseases; chronic diseases; new health risks brought by rapid climate change, particularly in the Arctic; challenges to community well-being stemming from current living conditions, existing community services and social behaviour patterns. Many IPY projects addressing the health status of polar residents require a network of new social observations, comparative case studies and extensive data sets or databanks of health, community and occupational records. Researchers collecting new physiological, public and occupational health and psycho-social data during IPY and beyond can utilize efficient and innovative health and telemedicine technologies to provide a snapshot of human health in the northern and southern polar regions. These health issues are inextricably linked to many local and global factors affecting climate, environment, economies and cultures across polar regions.





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The economically and culturally important Arctic activities of hunting, fishing and herding are being challenged and stressed by climate and geopolitical changes. IPY projects are addressing a wide range of traditional human activities in the context of a changing Arctic.

## 5.5 TERRESTRIAL PROCESSES AND SYSTEMS

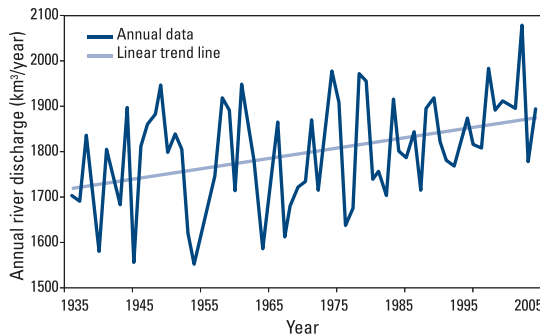
Assessing the current status and biodiversity of polar terrestrial ecosystems in order to understand acclimation and adaptation to dehydration, low temperature and darkness, and to discern variations induced by temperature or precipitation changes or by enhanced UV-B radiation, is a prime goal of the International Polar Year. IPY researchers will also study key polar species as bio-monitors of the distribution, fate and potential impact of man-made contaminants in polar environments.

A new level of ecological monitoring of the anthropogenic pressures on the Arctic, Subarctic and northern taiga ecosystems is required because of their low stability in the face of change. Arctic researchers will focus on changes in hydrological systems, green biomass, wildlife populations and in

the overall habitability of the Arctic. They will use integrated geophysical, ecological and economic models to determine thresholds of critical change. In many cases the Arctic terrestrial and marine ecosystem studies will be linked to study of the social impacts for Arctic peoples. For example, human–caribou/reindeer systems across the Arctic will be monitored and assessed, and new practices will be investigated to enhance the sustainability and adaptive capacity of those systems.

In polar terrestrial regions, the hydrological connections between ice, freshwater systems and continental discharge to the ocean are profoundly relevant to broader environmental issues. During IPY, an enhanced network of hydrological observatories in the Arctic will provide an important benchmark for assessing future change (see Figure 9). Scientists will monitor the impacts of freshwater and

Figure 9. Rapid climate change is manifested in steadily increasing discharge rates from the major Arctic rivers over recent decades. This influx of freshwater and organic carbon has a marked impact on the Arctic Ocean and its ecosystems. Total annual discharge from the six largest Arctic rivers are shown with a linear trend line fitted.

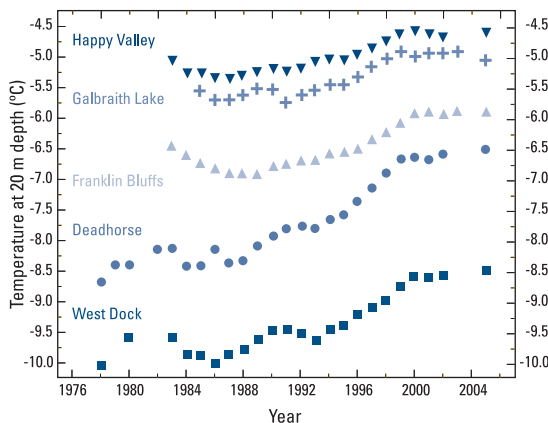


[Source: Richter-Menge, J. et al. (2006) *State of the Arctic Report*. NOAA OAR Special Report, NOAA/OAR/PMEL, Seattle, WA, 36 pp.]

other changes on ecosystems and biodiversity, and will study the hydro-systems linked to glaciers, lakes, the surface and underground flows.

Although permafrost covers 24 per cent of the continental surface of the northern hemisphere, a comprehensive understanding of the permafrost region is lacking. IPY researchers will produce retrospective and contemporary global data sets of permafrost distribution and temperatures (see Figure 10), active layer thicknesses and temperatures, soil processes in polar regions and coastal erosion rates. They will develop new estimates of sub-surface carbon and of a variety of greenhouse gases in permafrost regions and explore microbial processes that may either stimulate or mediate carbon fluxes to the atmosphere. Where glaciers retreat, IPY researchers will determine the consequences of deglaciation on geochemical processes, development of soil substrates and environmental potential for colonization.

Figure 10. Permafrost is sensitive to climate, and data from boreholes in five separate sites along an Alaskan transect indicate significant warming at depth.



[Source: Richter-Menge, J. et al. (2006) *State of the Arctic Report*. NOAA OAR Special Report, NOAA/OAR/PMEL, Seattle, WA, 36 pp.]

Diverse contaminants from increasing global industrialization have been detected in Arctic and Antarctic ecosystems. Concentrations of certain semi-volatile contaminants may become elevated owing to cold-condensation effects in those regions. IPY scientists will be studying the path and fate of contaminants in Arctic and Antarctic ecosystems, particularly through higher organisms such as polar bears and their major food species, ringed seals and seabirds. The influence of toxic compounds on higher organisms also impacts the ecosystem as a whole through disruption of community dynamics. The effect of contaminants will also be a significant component of extensive Arctic human health monitoring programmes during IPY. Ice, tree rings and sediments provide a detailed archive of historical deposition of contaminants and will be studied during IPY to identify contamination patterns and the diversity of contaminants. A number of projects will address issues such as oil spill remediation and the application of microorganisms.

## 5.6 GEOSCIENCES

The Earth's surface and sub-surface contain many clues to understanding the geological history of oceanic basins and gateways, and thus of past ocean current systems. The vertical motion of the Earth's surface provides key insights into the history of continental glaciation. The Earth's deep interior contains important clues to deciphering global scale processes and the geological history of the polar regions. The study of climatic evolution on a geological timescale will provide a framework to compare and evaluate recent and current climate changes.

Connections between the northern and southern hemispheres during past periods of large or abrupt climate change will be investigated from the records in ocean sediments and ice cores. During IPY, detailed tectonic, geodynamic, sedimentary and palaeogeographic histories of strategic oceanic basins and gateways (see Figure 11) will be constructed to assess, through the use of modelling studies, how changes to large-scale oceanic

circulation have influenced climate change. The opening of marine passages between Antarctica, South America and Australia has been of major global significance owing to the connection of the southern hemisphere oceans and the establishment of the Antarctic Circumpolar Current. Similarly, the alternating role of the Bering Strait region, owing to tectonic changes, as either a marine gateway or a terrestrial migration corridor, is also a focus of IPY research.

Vertical motions of the Earth's crust can result from tectonic forces or ice sheet loading. Today the polar regions are characterized by vertical motions produced by changing ice volumes at timescales ranging from the disappearance of the Fennoscandian Ice Sheet in northern Europe to any current change in mass of the West Antarctic and Greenland ice sheets. Previously these vertical movements could only be extrapolated from distinct geomorphological features such as raised beaches. Today the vertical motion can be directly observed with

geodetic Global Positioning System (GPS) instruments and absolute gravity measurements. Determining the status of vertical crustal dynamics in the polar regions is a powerful tool to understanding the history of glaciation. During IPY, the network of GPS instruments that can observe these important, but very small, vertical motions, will be expanded. Coordinated geological, geophysical and GPS observations during IPY will contribute to a more accurate overview of current plate motion and crustal geodynamics.

Recent imaging techniques such as seismic tomography now allow important details of the Earth's interior to be resolved for the first time, providing a window to understanding the complicated history of the polar regions as shown in Figure 12. The height of parts of the East Antarctic bedrock has been a key factor in localizing glaciations there. The cause of this anomalous elevation is as yet unknown, but it could be due to mantle buoyancy, composition

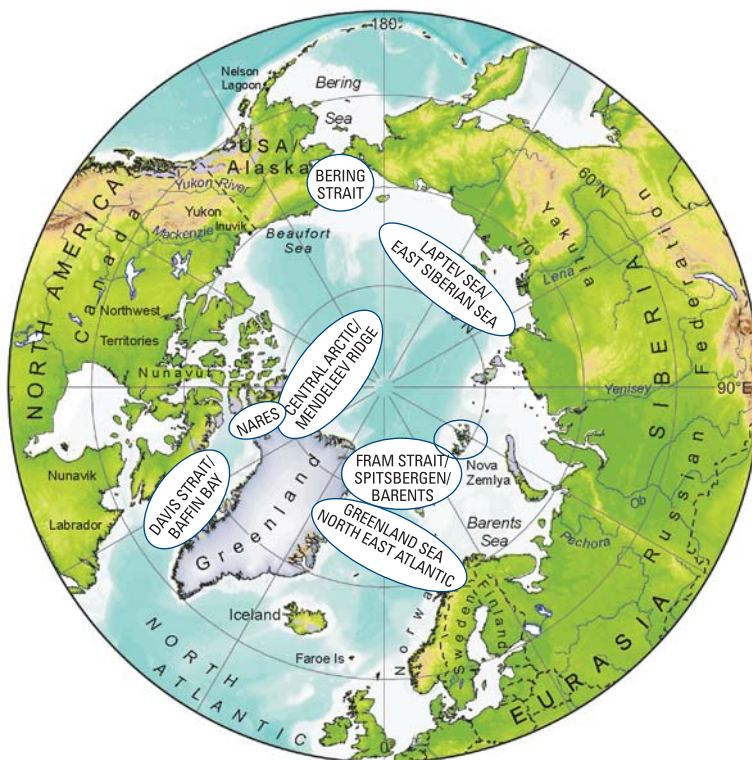


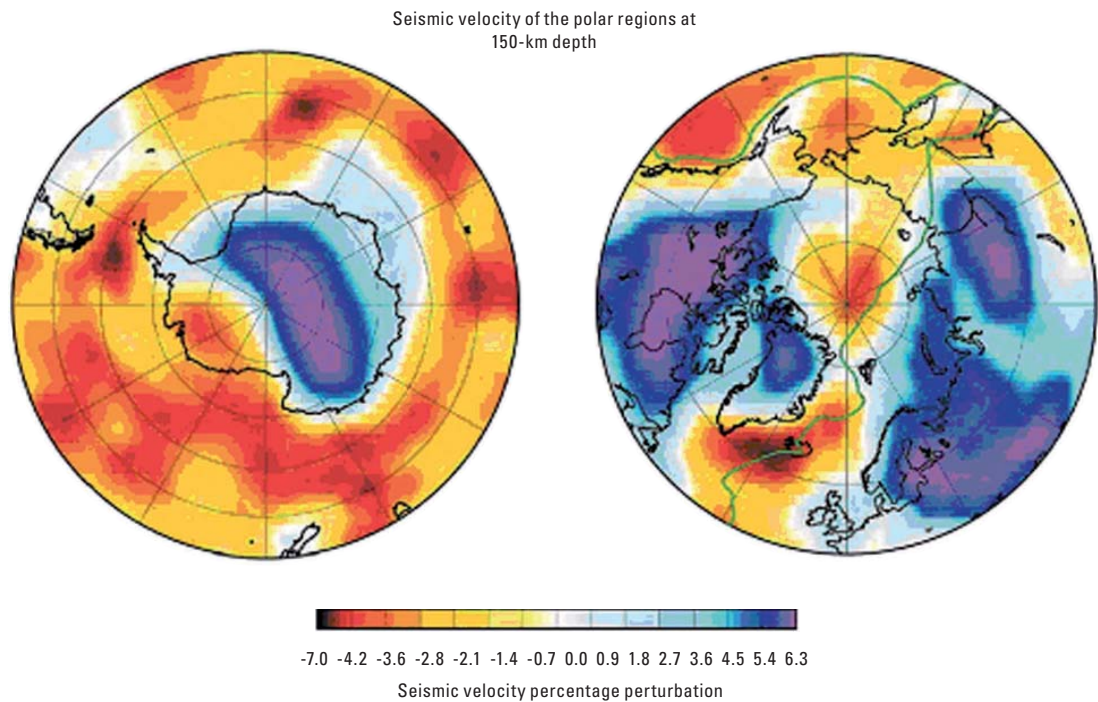
Figure 11. Target areas in the Arctic region for surveying and coring: the modern polar environments are the result of tectonic processes opening and closing ocean gateways around the globe that change patterns of ocean circulation and global heat transfer. A number of sites have been selected for geophysical surveying and marine coring to investigate the timing and patterns of polar gateway opening.

[Source: Plates and Gates Consortium Steering Committee]



Figure 12. IPY projects will investigate heat flow from the Earth's interior and its affect on overlying ice sheets. Seismic velocity measurements illustrate substantial temperature differences between East and West Antarctica.

[Source: Redrawn from Ritzwoller, M.H. et al. (2002) Journal of Geophysical Research 106 (B12), 30645-30670, (2001) and Shapiro, N.M. and M.H. Ritzwoller, Geophysical Journal International, 151, 88-105.]



or thermal/dynamic processes. Detailed seismic imaging of the mantle should resolve this question. At present, owing to the ice sheet coverage, Antarctica has the highest average elevation of any continent. Exploring the earth's interior will also help constrain coupled climate-ice-sheet models that require knowledge of basal heat flow and mantle viscosity. Heat flow from the interior of the earth to the base of the ice sheet affects the ice flow, through the strong temperature dependence of ice viscosity, and the terrestrial response to ice loading, through mantle viscosity. Seismic velocity measurements suggest that there is a temperature difference of about 600°C

between East and West Antarctica at a depth of 100 km, markedly influencing the results of ice sheet models. During IPY 2007–2008, researchers will install new seismic station networks on a broad regional scale encompassing the entire Antarctic continent, and on a limited regional scale, focusing on key tectonic targets such as the Gamburtsev Subglacial Mountains. New information on sub-ice geology to be obtained during IPY will improve knowledge of the subglacial environments and associated processes, contribute to new discoveries related to subglacial streams and lakes and aid the location of future ice-coring sites where ice older than one million years could exist.

## 6 THEME 2: CHANGE

### Quantifying and understanding past and present natural environmental and social change in polar regions; improving projections of future change

Rapid environmental change occurring in the polar regions today has increasingly significant global ramifications. This change is occurring over a wide range of timescales. Instrumental records enable assessment of timescale variations from inter-annual to decadal periodicities, while proxy records from sediment and ice cores provide information on the longer timescales. IPY scientists will combine these by collecting new data from direct measurements and proxies to extend the available timeseries, evaluating available timeseries data and further developing models to understand the changes and how they are being transferred into the proxy records.

Projection of future changes will be derived from a variety of models. These will be calibrated and initialized with comprehensive data sets obtained from synoptic surveys of the present state. Providing the means to monitor future changes is one of IPY's major goals. For this purpose IPY observations will be designed to establish optimal observing systems in the Arctic and Southern Oceans to keep track of the ongoing changes, and to provide data streams for assimilation into models. In this way, a more reliable prediction of future states of the coupled atmosphere–ocean–cryosphere systems in the polar regions will be achieved.

#### 6.1 THE POLAR ATMOSPHERE

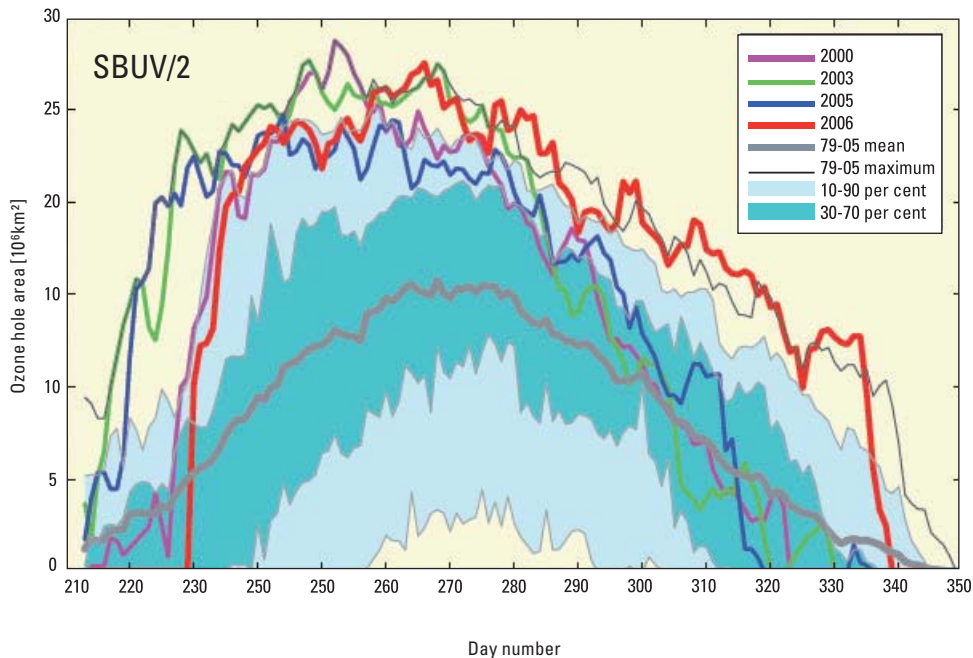
The physical state and chemical composition of the polar atmospheres will undergo major changes in the coming decades. Moreover, these changes will appear throughout the whole atmospheric column, from the surface up to the mesosphere. The major driver of change is the increase in carbon dioxide and other greenhouse gases. Through enhanced monitoring and observational capacity, and

improved data assimilation and modelling, this increase and its impacts will be further described.

Changes in the dynamical structure of the polar atmospheres will be manifested through changes in traditional weather patterns and hazards. THORPEX-IPY is the polar component of a major WMO experiment that aims to better understand the impacts of this warming on severe and extreme weather events, such as snow storms and blizzards, polar lows and fog. In the upper atmosphere, increasing greenhouse gases bring about a cooling of the stratosphere; this cooling in turn changes the strength and character of the polar vortices and that of the meridional circulation cell by which ozone-rich low-latitude air is transported to the polar regions (the Brewer–Dobson circulation). An integrated research programme will explore these processes.

Coupled atmosphere–ocean patterns of variability such as the Northern and Southern Hemisphere annular modes are important processes of longer-term variability. The Northern Hemisphere annular mode is also called the Arctic Oscillation or the North Atlantic Oscillation, and the Southern Hemisphere annular mode has been referred to as the Antarctic Oscillation. Natural variability has to be determined before anthropogenic changes can be diagnosed. Coupled models are indispensable tools for this purpose. Longer-term changes may occur in an abrupt and irreversible manner, and it is important to try and quantify the probability of these happening. Another important link between atmosphere and ocean change is the freshwater cycle fed through local precipitation, river runoff, differential freeze and melt of sea ice and melt of continental ice. IPY projects investigate the feedbacks between these, and their impacts

Figure 13. Existing measurements of ozone over Antarctica derived from the Solar Backscatter Ultraviolet Radiometer 2 (SBUV/2) illustrate the seasonal appearance of an ozone hole which has resulted in markedly enhanced ultraviolet radiation exposure for many life forms in the polar regions.



[Source: NOAA]

on the local and overall ocean circulation patterns.

Another set of polar changes relates to the chemical state of the atmosphere. The ozone hole recovery process (see Figure 13), a result of the Montreal Protocol, which came into force in 1987, will be impacted by the cooling of the lower stratosphere, and changes in the Brewer-Dobson circulation. Many complex interactions between the chemistry and the dynamics of this recovery process will be observed, monitored and modelled during IPY. In the lower atmosphere, the different pathways through which man-produced air pollutants are transported into the Arctic, and their disposition and fate, will be closely studied through a number of IPY projects. Any eventual melting of Arctic Ocean sea ice will have a significant impact on the exchanges between the lower atmosphere and the surface, and on complex chemical processes. Changes are particularly important given the risks of contamination of the food web, and eventually of living animal and human populations. Changes in precipitation and thermal regimes will impact the chemical exchanges between the cryosphere and the lower atmosphere, which control in part the ozone and mercury chemistry.

## 6.2 ICE SHEETS AND GLACIERS

Changes in ice on land have the potential to impact populations globally through changing sea level and changing climatic conditions. IPY seeks to understand variability and change of snow and ice on many time and space scales, particularly in large ice reservoirs whose changes in mass greatly influence ocean circulation and sea level. Full assessment of change in global ice mass will require accurate and comprehensive measurements of accumulation, surface and basal melting of land and shelf ice, glacier and ice shelf motions, fracturing, melt percolation, related changes in surface albedo and seasonal changes in ice flow.

Melting glaciers in polar and mountain regions will raise the sea level and the supply of sediment and freshwater to embayments and fjords. IPY projects will monitor changes to mountain glaciers and small ice caps using ground and space observations. The variations in space and time of the mass of ice and snow over polar and mountain regions will be linked to water supply, global climate change, the global hydrological cycle and sea level change.



Changes in ice sheets will be monitored and assessed, with specific emphasis on the margin of Greenland, on West Antarctica and the Antarctic Peninsula where ice is melting quickest. Recent changes in surface elevation and discharge speed in outlet glacier systems along the margins of the Greenland Ice Sheet show dramatic local shifts in the balance of ice discharge, surface melt and accumulation. These rapid changes are in sharp contrast to relatively slow variations in surface elevation in the interior, which have been tied to variations in accumulation and firn compaction on decadal timescales. IPY research will address these changes by using a range of observational and modelling techniques and by exploiting evolving capabilities in atmospheric modelling, remote sensing for measurement of ice motion and surface conditions and surface-based and aircraft-based measurement techniques.

Melting of the West Antarctic Ice Sheet, especially where it discharges into the Amundsen Sea, is already contributing to sea level rise, and holds the potential to dwarf most other sea level contributions in the long term. IPY activities in this region will include studies of ice dynamics from surface measurements of motion, conditions at the base of the ice from seismic studies at critical sites, sub-ice shelf oceanic interactions using moorings both through the ice shelf and in the surrounding seas, atmospheric transport of incoming snow using automatic weather stations and historical records of ice extent from geological sampling, marine studies and deep ice coring. This new knowledge will contribute to the construction, initialization and validation of improved full-stress tensor models of ice flow.

Changes on the Antarctic Peninsula include a mix of enhanced precipitation at high elevation; enhanced melting at low elevation; enhanced surface and basal melting of land and shelf ice; glacier and ice shelf fracturing; melt percolation down through the ice sheet; seasonal changes in ice flow; and rapid acceleration of glaciers that had been buttressed by ice shelves which subsequently collapsed. Recent regional warming was

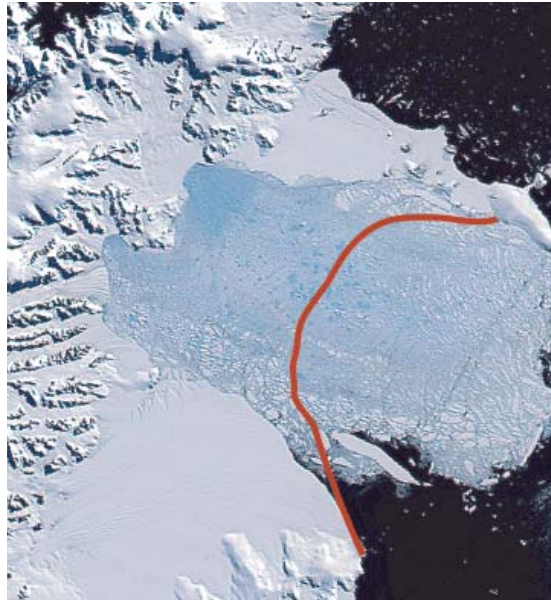


Figure 14. Temperatures on the Antarctic Peninsula have risen rapidly over the past 50 years, and some ice shelves in this region have thinned and collapsed. The breakup of the Larsen B ice shelf, about 35 days, was captured by the MODIS satellite. The red solid line shows the position of the ice shelf front edge in November 2001 and the image shows the collapsed ice sheet (~3250 sq km) in March 2002.

[Source: National Snow and Ice Data Centre and Ted Scambos, Boulder, Colorado, USA]

responsible for the collapse of the Larsen A ice shelf in 1995 and Larsen B in 2002, as illustrated in Figure 14. Further south, Larsen C has thinned, and continued warming could lead to its break-up within the next decade. IPY will investigate the complex and rapid changes in this sensitive region.

The processes by which the polar ice masses nucleated are not well known, but are important for understanding the present-day stability of the ice sheets and interpreting the ice core paleoclimate records. Field observations and numerical modelling will be used in IPY projects to address the evolution and stability of both the Greenland Ice Sheet and the modern East Antarctic Ice Sheet, which is thought to have nucleated in the region of the Gamburtsev Subglacial Mountains.

### 6.3 THE POLAR OCEANS

The oceans are experiencing dramatic changes in both polar regions. The Arctic Ocean environment has undergone tremendous changes over the past decades, with shrinking sea ice cover, increased freshwater run-off and accelerated coastal erosion. In the Southern Ocean changes in the salinity

and temperature of intermediate waters and properties of deep water advected into the Southern Ocean have taken place. Changes have also been observed in the characteristics of bottom water masses, but these are in opposite directions in different regions. The contradictory behaviour of the Arctic and Antarctic sea ice cover with a strong decrease in the Arctic and an almost constant ice cover, except for the area of the Antarctic Peninsula, is still not understood. The collection of new comprehensive ocean data sets during IPY will allow comparison with historic observations and provide baselines for the assessment of future change. Global environmental change is modulated by both inter-annual and local variability, and it is important to have adequate data to distinguish this variability from secular change. Comprehensive IPY analyses of how the polar oceans work will facilitate the design of viable,

cost-effective, sustained observing systems for the ocean–ice–atmosphere system in both polar regions, enabling inter-annual and seasonal variability to be documented for the first time in many locations.

International collaborative efforts to inventory marine biodiversity in the sea ice, water column and sea floor, from the shallow shelves to the deep basins of both polar oceans, will contribute to understanding and evaluation of the impact of physical change on the ocean ecosystem. High-latitude ecosystems are characterized by significant inter-annual variability, and polar organisms have developed coping strategies. The Arctic region has been subject to marked changes in environmental drivers in recent decades, largely as a result of climate warming. The ocean is warming in the marginal areas and experiencing substantial freshwater influxes from rivers and meltwater

The Arctic marine food chain has proved highly susceptible to organic and inorganic atmospheric pollution drawn into the Arctic region. Polar bears and their main seal prey are top predators in this food chain, suffering reproductive and physiological damage from toxic accumulation in body tissues.



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as well as anthropogenic influences from pollutants transported by the atmosphere, and through growing exploitation of marine resources. Retreat of the Arctic sea ice is impacting the life cycle of marine organisms on, in and under the ice. It is also influencing exploitation of these resources, and thus the lifestyles of the indigenous Northern peoples.

The Southern Ocean ecosystems are complex and diverse, sustaining large populations of higher predators such as birds, whales and seals. These ecosystems are highly responsive to changes in the Southern Ocean food chain. The relative isolation of this ocean around 30 million years ago with the development of the Antarctic Circumpolar Current, which acts as a barrier to exchange between northern and southern ecosystems, has resulted in the preservation of a pre-Quaternary marine environment whose ecosystems have evolved differently from those in the other major oceans. The permanent cold of this environment has resulted in unique physiological adaptations and life strategies as well as a striking diversity of organisms, even greater than the diversity of rain forests. This diverse environment is as yet largely unstudied. Ocean warming will have deleterious effects on Southern Ocean organisms adapted to uniquely cold conditions, and may encourage the influx of alien species from the north. Ocean acidification is an additional threat that could potentially have an even greater impact on biota. IPY projects include studies on the diversity of life in the Southern Ocean, the physiological adaptations of marine organisms, their response to environmental change and the impact on fisheries in these waters.

#### 6.4 POLAR PEOPLES

Environmental changes and subsequent alterations to the polar ecosystems have a major effect on local human communities in the Arctic and the economy of human populations, both directly and indirectly. Direct effects can be seen in the availability of food and shifts in traditionally used resources

and feeding practices. These lead to differences in growth, development, health and well-being. Security is also affected because of the new disease vectors and the invasion of organisms that are not common in the region. For the human economy in general, it is expected that ecosystem changes will affect both marine and terrestrial food chains, particularly in the Arctic, with possibly deleterious consequences on the availability of living resources and small-scale local economies. Such changes can be predicted with numerical models developed during IPY and data obtained from IPY surveys across the polar regions.

IPY 2007–2008 will be the first major interdisciplinary venture in the history of polar studies that will specifically feature social and human aspects of change on its research agenda. Many IPY projects will address the impacts of those new cultural and societal agents in the polar regions that are triggered by larger global processes. Such processes include advances in the global economy, transportation systems and the rising demand for polar mineral and energy resources; cultural and language globalization; new forms of governance; and progress in global communications that give new and greater accessibility to the polar regions, through physical and electronic networks. These communication networks also provide polar inhabitants with much more open access to the rest of the world. Unlike some International Geophysical Year activities, no research efforts in IPY 2007–2008 are propelled by military interests in the polar regions.

Social and human actors will also be a critical part of many concerted interdisciplinary efforts during IPY 2007–2008. For the first time, social and human scientists will be tasked with addressing the interactions and linkages among the environment, governance and socio-economic development across polar regions. All three areas are currently undergoing rapid change. This has helped transform our former vision of the polar zones as relatively stable and low-key regions at the periphery of global



The rapid economic development of the Arctic region brings industrialization into conflict with ecosystems and traditional ways of life.



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processes. The new vision will be tested by various projects focused on coupled human–environmental systems and adaptive mechanisms, vulnerabilities, or resilience of polar societies to change. It will also help bring new understanding of the role of polar regions and their residents in changing global systems — in the environment, economy, politics, values, education and culture.

## 6.5 TERRESTRIAL PROCESSES AND SYSTEMS

The physical environment of polar regions, particularly the Arctic, is changing markedly. Temperature is increasing, permafrost is melting and spring snow cover has decreased in many regions. These changes in turn affect other elements of the physical environment. For example, changes in precipitation and snow cover impact river discharge. In addition, permafrost retreat is resulting in significant changes in Arctic terrestrial ecosystems, including summer flooding, instability of the tundra and the northerly advance of the tree line.

Changes in the amount and timing of snow accumulation and subsequent melt from mountain snow packs and glaciers will have significant impacts on water resources, and in turn, on the peoples and the economy in the alpine regions and major polar river basins. Changes in continental and alpine snow cover will directly impact the timing of spring runoff and the characteristics of the annual runoff hydrograph affecting the nature and occurrence of floods and droughts, reservoir regulation, hydropower production, irrigation needs for agriculture, community water supply, wetland recharge and moisture supply for spring planting. Most melt water from glaciers is released during the hot summer months, when the discharge from snowmelt has decreased and when the water is mostly needed for agriculture and domestic/industrial water supply. Reduced winter snowfall and increased winter rains will change the amount and distribution of water available to the economies of these regions. In addition to the socio-economic impact, there will be direct effects on the functioning of the ecosystems in these regions and on permafrost degradation that

in turn will affect the biogeochemical cycle of these regions, as well as the developing economies.

Such changes in the physical environment have consequent impacts on the ecosystem. Land-use changes and climate-related changes will favour some species, while others will be disadvantaged. Warming increases the presence of invading sub-polar species that compete with indigenous polar plants and animals (see Figure 15). In the extreme case, temperature and other physical changes may be so rapid that ecosystems might not have the capacity to adapt, and organisms will disappear or move away from these regions. We may also see new plant and animal communities develop in the polar regions.

Arctic terrestrial ecosystems are trophically complex, but species-poor relative to those at lower latitudes. Substantial population fluctuations in herbivore and predator populations, such as lemmings, caribou/reindeer and snowy owl are features of Arctic terrestrial ecosystems. The Arctic is an important area for migratory breeding birds, and environmental changes exert profound effects on the annual cycle and the spatial distribution of these species. A rich wildlife is crucial for Arctic residents and for attracting tourists.

IPY projects will study community stability in polar ecosystems and their sensitivity to environmental change. Existing monitoring projects of both the physical and biological terrestrial environments will be supplemented and expanded. Processes that shape polar ecosystems will be investigated, and IPY scientists will seek to predict the likely impacts of projected 21st century climate warming on such diverse elements as Arctic lake ice cover, polar snow cover characteristics, plant communities and bird and mammal populations and breeding success.

During IPY, scientists will describe the adaptive capacity of polar terrestrial and marine organisms, from the molecular level, up to the functional level of whole organisms. In

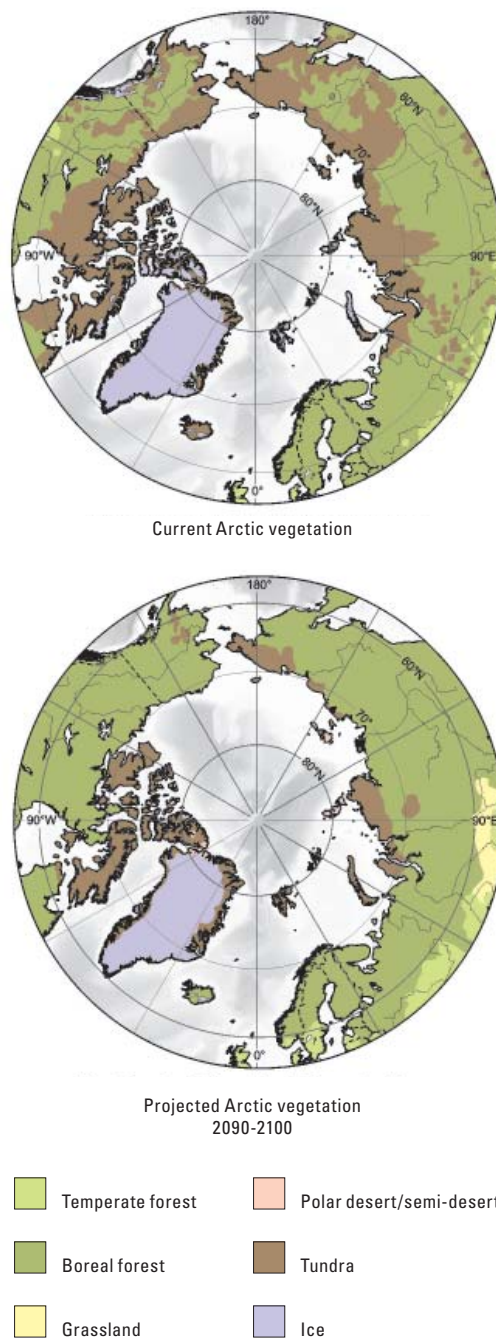


Figure 15. Warming of the Arctic region is predicted to impact particularly on tundra environments which will largely give way to boreal forest by the end of this century, fundamentally changing the nature of large swathes of Arctic terrestrial ecosystems.

[Source: modified from Arctic Climate Impact Assessment 2004]

Antarctica, the short food chains and relatively simple environments with a strong seasonality provide ideal natural systems for those IPY projects planning experimental manipulation to study the evolutionary adaptation of organisms to the polar environment. Another source of Antarctic change that will be evaluated during IPY is the introduction of propagules (seeds, spores, eggs) of alien species carried by human visitors. In the Arctic, IPY projects will accept the challenging task of developing new strategies for managing the resources of plants, fish and wildlife in a sustainable way — despite changes and threats. Many IPY projects will

Vast numbers of birds, such as the geese pictured here, migrate between the polar regions and the lower latitudes. In the Arctic, climate change, coupled with vegetation changes, will allow southern bird species to move further north, changing the Arctic ecosystem structure.



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make substantial contributions to facilitate the sustainable and adaptive management of the vulnerable Arctic ecosystems.

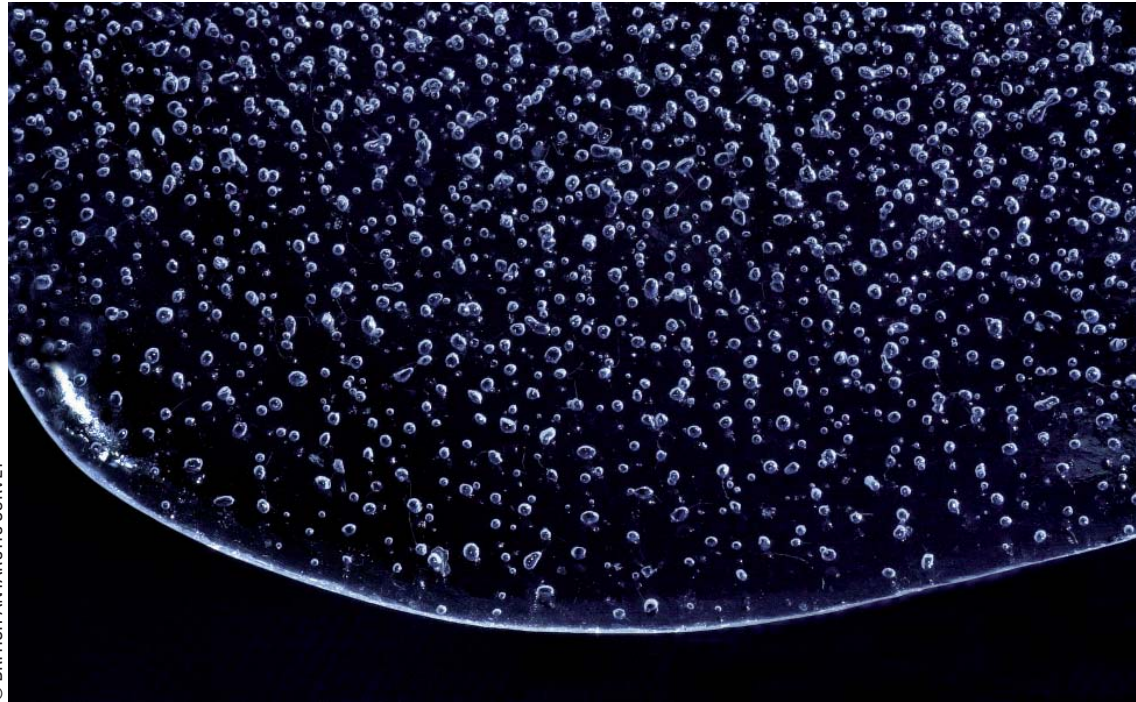
## 6.6 PALAEOENVIRONMENTS

Our planet has undergone major shifts in climatic conditions in the past, changes that provide an important framework for understanding current environmental changes. IPY projects will use proxy records from ice cores, sediment cores and other sources to determine how the Earth's past climate and environment have changed over a number of different timescales. Ice cores from regions with high snow accumulation rates, along with studies of tree rings from polar regions and varved polar lake sediments can provide annually resolved records. These can be used to extend the quantitative instrumental record of ecosystem feedbacks and climate change back through time for many centuries. Many potentially valuable records are being destroyed through melting of the ice, hence a pressing need to extract the information now, during IPY 2007–2008.

Proxy records from marine sediments and ice cores will be used to determine the natural modes of climate variability on timescales from years to millennia and to improve our understanding of the mechanisms of abrupt climate change in the past, including the role of northern versus southern hemisphere. Drilling programmes in ice sheets and the polar oceans will target these climate change mechanisms, contributing to a more effective representation of natural processes in climate models.

Ice cores provide unique records of change in atmospheric composition from the trapped air in bubbles in the ice, enabling precise and quantitative links to be established between temperature and atmospheric gases. During IPY, new records of glacial to interglacial change during the Quaternary and since the Last Glacial Maximum will be recovered through both sediment cores and ice cores. During IPY major new cores will be drilled in Greenland and Antarctica. Reconstructing the history of climate change for the past 30 000 years will improve understanding of the movements of animals, plants and early





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Glacial ice contains air trapped as minute bubbles. Analysis of the gas composition provides a sensitive historical record of past greenhouse gas composition, while isotopic analysis of the ice provides a temperature record.

humans into the polar regions. In conjunction with glaciological models, palaeohistories will improve understanding of the advance and retreat of glaciers and ice sheets. An improved quantitative appreciation of how the Earth system has changed in the past will improve confidence in our ability to predict future change.

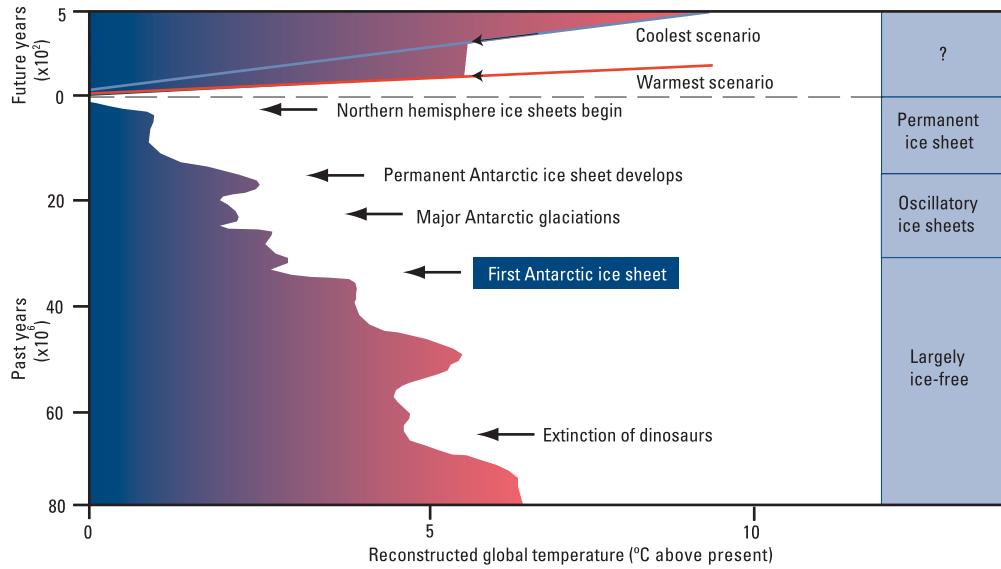
The last interglacial period was warmer than the Holocene, providing an analogy for an anthropogenically warmed world. A deep ice core from Greenland reaching back into the penultimate glacial period will provide a North Atlantic record enabling comparison with the 800 000 year-old record of changing climate from Dome C, Antarctica. This new North Atlantic record will also provide a greatly improved record of recent Holocene climate history.

Studies of longer timescale records to determine the critical factors that triggered the cooling of the polar regions are also part of IPY. Planetary cooling began following the late Cretaceous 65 million years ago (see Figure 16). Two significant decreases in

temperature and associated increases in ice volume occurred around 34 and 15 million years ago, prior to the establishment of the cold conditions of the Quaternary Ice Age around two million years ago. Continental-scale glaciation of Antarctica seems to have begun at the first of these steps, 34 million years ago. IPY projects will investigate the history of glaciation and the consequent change in sea level at the global cooling step 34 million years ago, and at key times since then, using unique sedimentary records from the margins of polar landmasses. These records and numerical ice sheet models will provide insights into the glaciation processes in both polar regions, the variability modes in the Earth system and the history of sea level change.

The separation of continental fragments as a result of tectonic plate motion and the progressive opening of seaways like Fram Strait between Svalbard and Greenland, Drake Passage between Tierra del Fuego and the Antarctic Peninsula, and the Southern Ocean between Tasmania and Antarctica, may have played a role in cooling and glaciation in both

Figure 16. This diagram shows variations in global temperature over the past 80 million years and projected future changes based on Intergovernmental Panel on Climate Change (IPCC) 2001 scenarios. The historical record has been derived from oxygen isotope proxies in calcareous marine microfossils.



[Source: Barrett, P., *Cooling a continent*, Nature, 421, 221-223 (2003)]

polar regions. The opening and closing of the Bering Strait in response to changing sea levels affected the circulation of the Arctic and North Pacific Oceans and their associated climates, as well as the exchange of flora and

fauna between North America and Asia, and in the ocean, between the Pacific and Arctic Oceans. Drilling, coring and geophysical studies in these key gateways during IPY will help document these changes.



# 7 THEME 3: GLOBAL LINKAGES

Advancing our understanding on all scales of the links and interactions between polar regions and the rest of the globe and of processes controlling these

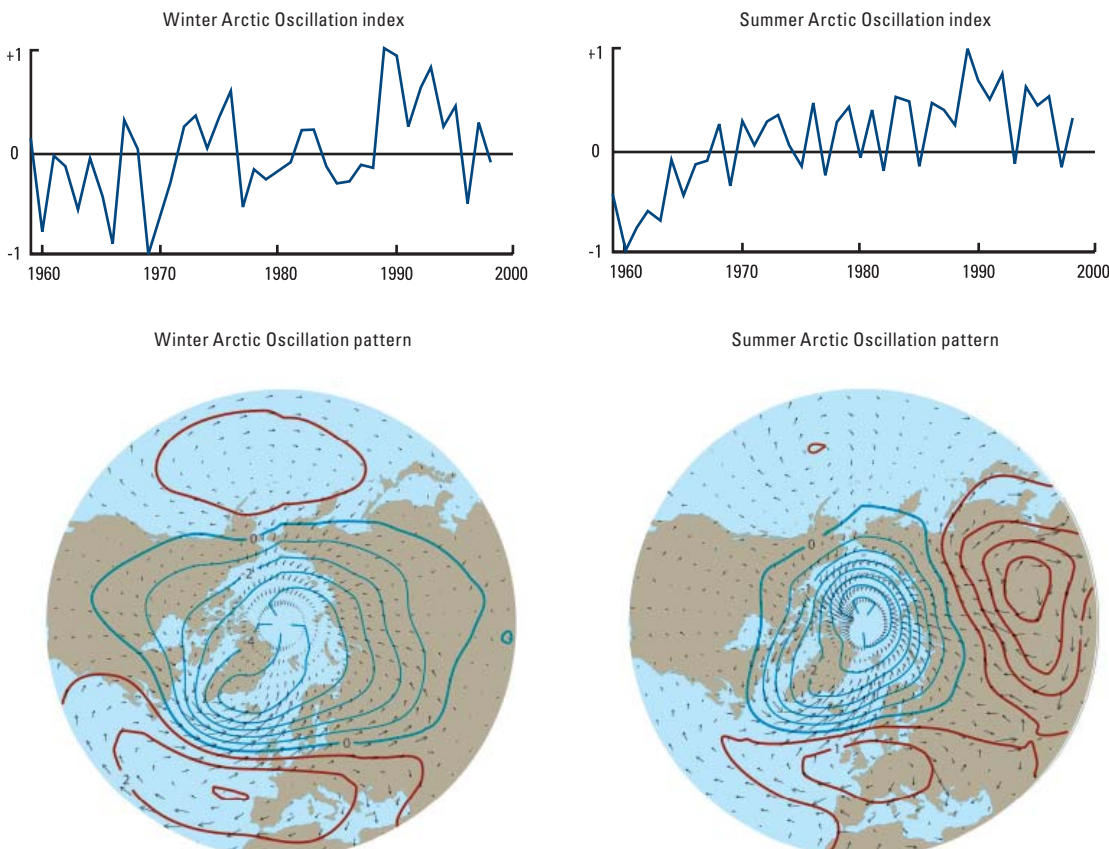
The global influence of polar regions, especially in the climate system, is profound and far reaching. They contain some of the world's major resources such as fisheries and minerals, hold massive stores of ice capable of causing significant global sea level rise under global warming, represent large carbon sinks that may ameliorate anthropogenic carbon dioxide production and are home to peoples that contribute to global cultural diversity. Just as the polar regions influence global processes, global processes also have an impact on the poles. Examples of polar impacts from global processes include the formation of the ozone hole, the accumulation of pollutants in the Arctic, the influence of

global satellite communication connectivity on polar residents and the impacts of world price variations on resource exploitation.

## 7.1 GLOBAL CLIMATE PROCESSES

The state of the polar atmospheres and the changes they undergo owing to natural or anthropogenic causes have global repercussions. The atmosphere has no barriers and the atmospheric circulation patterns interconnect all regions of the globe within a timescale of a few weeks. Moreover, through its interactions with the oceans and the cryosphere, any significant perturbation

Figure 17. The Arctic Oscillation, or Northern Hemisphere annular mode, refers to opposing atmospheric pressure patterns in northern middle and high latitudes. In positive phase the Oscillation results in low pressure over the polar region and high pressure at mid-latitudes, whilst the reverse occurs in negative phase. In recent times the positive phase has occurred more frequently bringing wetter weather to Alaska and Scandinavia and drier conditions in the USA and Mediterranean.



[Source: AMAP (2003) AMAP Assessment 2002: The Influence of Global Change on Contaminant Pathways to, within, and from the Arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway, xi+65 pp.]

to present circulation patterns will be felt globally. This is true for atmospheric chemical composition and its physical state.

IPY projects will address many aspects of these linkages. The intense IPY monitoring of the upper atmospheric circulation and chemical composition will allow us to better understand the impact that stratospheric cooling and circulation changes caused by increasing green house gases are having on the ozone layer and its progress to recovery. IPY atmospheric monitoring will also give us new insights into the causes of global teleconnections and observed patterns of variability, such as the Northern Hemisphere annular mode (see Figure 17) which have a major impact on temperate latitude weather patterns.

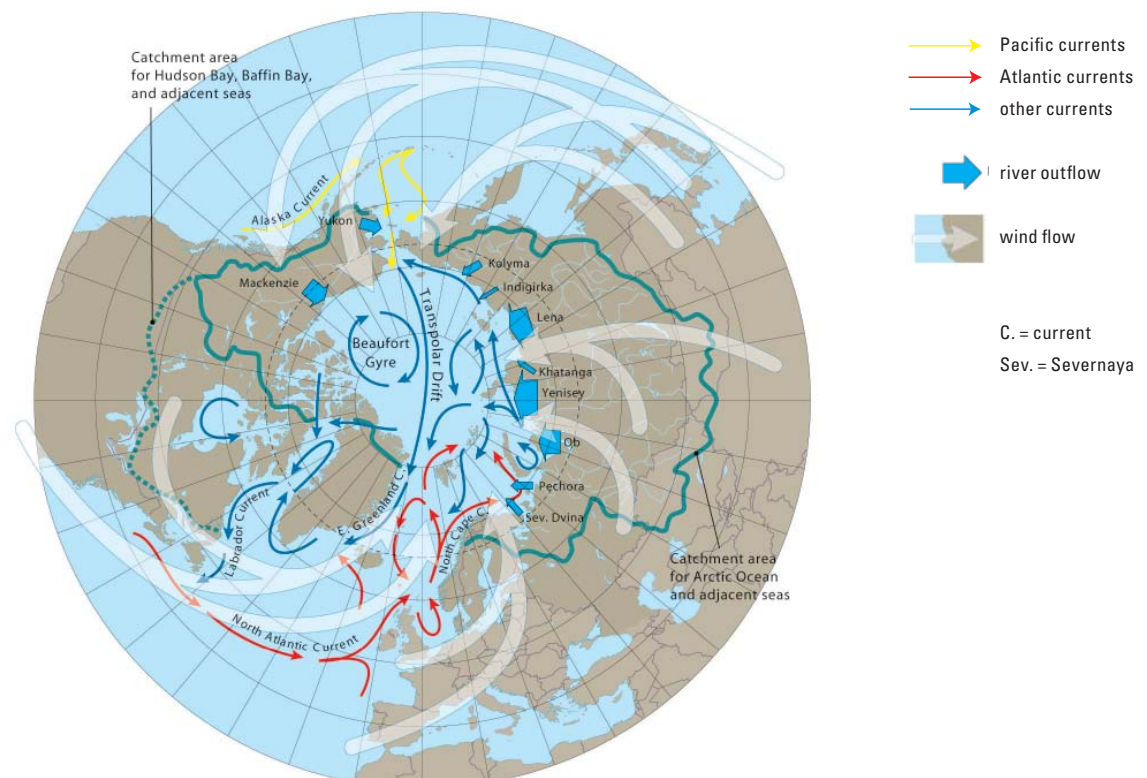
Owing to their very cold temperatures, the lack of solar radiation during the polar night and the lack of local sources of industrial pollution, the polar atmospheres also act as sentinels. Through meridional atmospheric

circulation patterns many pollutants eventually penetrate the polar environments where they impact on the local chemistry of the atmosphere and, through deposition processes at the surface, the local ecosystems (see Figure 18). These processes will be studied closely through many IPY projects. As the polar weather and climate regime changes, the influx and ultimate fate of these pollutants will evolve, and may affect much larger areas of the temperate latitudes. It is therefore important to understand the processes that will govern this evolution. Through radiative effects, it impacts directly on the thermal structure of the troposphere and the circulation; through deposition at the surface and contamination of the food chain, it affects the local inhabitants of the polar regions.

The warming of the lower atmosphere will of course impact directly on many climate-related processes at the surface. In the Arctic, as the ice cover shrinks and larger open ocean areas appear, the fluxes of heat and moisture

Figure 18. Main atmospheric pathways from the industrialized regions of eastern USA, Europe and South-East Asia to the Arctic.

[Source: AMAP (2003) AMAP Assessment 2002: The Influence of Global Change on Contaminant Pathways to, within, and from the Arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway, xi+65 pp.]



will bring major changes to the local weather and climate. In turn, through the interactions with mid-latitude circulation patterns, there could be significant modifications of the atmospheric wave regimes. There is also an indirect effect linked with atmosphere ocean interactions: changing polar wind regimes will modify the heat exchange between the polar oceans and the atmosphere, and thus have an impact on the so-called ocean conveyor belt circulation.

Polar precipitation regimes determine the nourishment of Antarctic and Arctic glaciers, hence influencing their dynamics and ultimately, through changes in glacier extent, producing global impacts through sea level rise. Another indirect link is through the water discharge from circumpolar river systems, changing the salinity and density of the Arctic Ocean, and thus its circulation patterns. Heating will accelerate the melting of vast permafrost areas, which will not only have local impacts on transport and structures, but will also release greenhouse

gases such as methane contained within the melting layers. Any significant local increases in such surface emissions will rapidly disperse and mix globally, accelerating global warming.

Many IPY projects will focus on better understanding these complex interactions and processes. Results from this research will contribute to more accurate ocean-ice-atmosphere circulation models, and eventually result in improved weather forecasting and climate change projections.

## 7.2 THERMOHALINE CIRCULATION IN THE GLOBAL OCEAN

The large-scale oceanic thermohaline circulation plays a major role in the global climate system by transferring heat and freshwater around the globe, as shown in Figure 19. Abrupt changes in past climate have been attributed to changes in the thermohaline circulation, which is related to the production

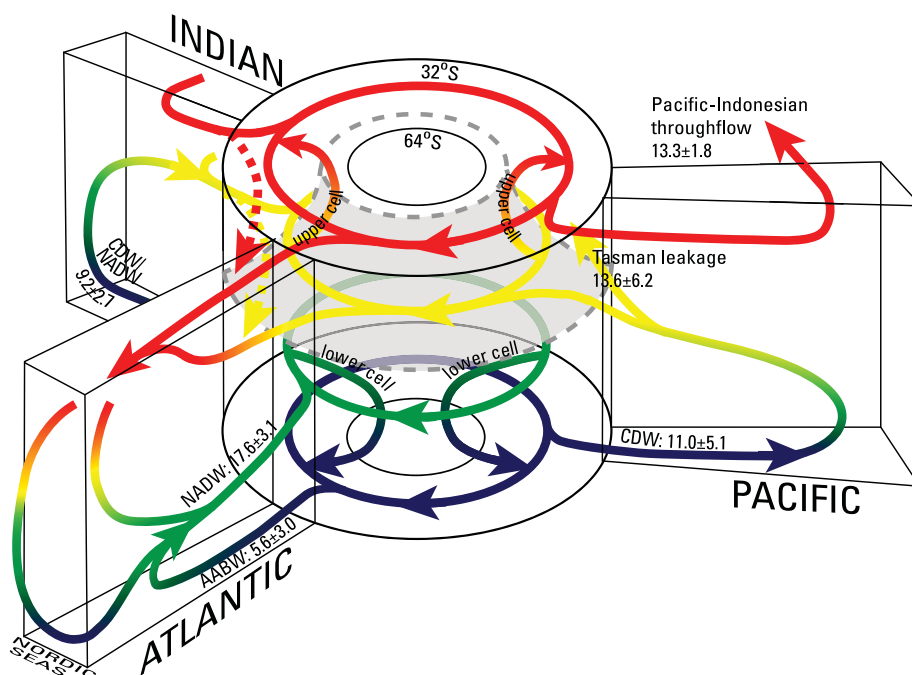


Figure 19. This 3-D global overturning diagram illustrates some of the key roles of the Southern Ocean in the climate system. The Southern Ocean buffers the rest of the world from the frigid conditions of the Antarctic continent, while meridional overturning across the Antarctic Circumpolar Current is the mechanism for the exchange of heat, carbon dioxide and other climate anomalies from the surface to the deep World Ocean. Water temperature is illustrated as warm (red) surface water and cold (blue) bottom water.

[Source: Lumpkin, R., and K. Speer (2007) *Global meridional overturning*. *Journal of Physical Oceanography* (in press)]

of cold dense water masses, particularly in the high-latitude North Atlantic Ocean. In the North Atlantic, upper ocean water cools and becomes denser as it flows northward until it is subjected to deep convection, subduction and mixing in the Labrador Sea and Nordic Seas and becomes dense enough to sink to the abyssal depths of the ocean. From there it spreads back south across the equator. The southern limb of the thermohaline circulation is driven by the production of Antarctic Bottom Water, initiated by brine release into the upper ocean column in regions of intense sea ice production – typically coastal polynyas. In the Antarctic Circumpolar Current, deep water from the adjacent ocean basins ascends and feeds into the surface and intermediate waters to close the global meridional overturning circulation. The intermediate waters spread back towards the equator supplying the source waters for subtropical and equatorial upwelling areas.

Both the warming of the ocean surface and the enhanced run-off from land caused by ice melt are likely to reduce the density of ocean water in the Norwegian-Greenland Sea, thereby reducing the sinking of dense ocean surface water that drives this global overturning circulation. Similarly, freshening of Antarctic coastal waters by ice melt may reduce the production of Antarctic Bottom Water. Within IPY, researchers will investigate bipolar characteristics of the thermohaline circulation. Observational and modelling studies will identify key regions of bottom water formation, estimate production rates of dense water and quantify the cascading of dense water towards the deep ocean. Relationships between variability in intermediate, deep and bottom-water formation, carbon dioxide uptake rates and large-scale natural or anthropogenic climate forcing will also be investigated.

Changes in the thermohaline circulation will ripple through the ocean, with knock-on effects on ocean chemistry and biota. Since the thermohaline conveyor belt transports both heat and freshwater, such changes are expected to have widespread effects on global climate. IPY studies will

help climate scientists better understand the climate connections between low and high latitudes. The climate system exhibits a substantial degree of natural variability in polar regions, for example, the Southern Hemisphere annular mode, which may be related to non-polar modes of variability such as the El Niño-Southern Oscillation. The IPY data will help assess the sensitivity of these natural variability modes to forcing by global warming.

### 7.3 MARINE BIOGEOCHEMICAL CYCLING

The Southern Ocean is both a primary source of and a major sink for atmospheric carbon dioxide. Deep water upwelling along the Antarctic margin brings carbon dioxide to the surface and releases it into the atmosphere. Further north, at the frontal systems within the Antarctic Circumpolar Current, Antarctic surface waters sink and move towards the equator, carrying carbon dioxide absorbed from the atmosphere. This dissolution of carbon dioxide is making the Southern Ocean gradually more acid, posing a potential threat to those organisms that manufacture calcium carbonate skeletons, especially when they are in the form of the mineral aragonite. Studies of the rates and amounts of dissolution are key to comprehending not only the role of the oceans in global warming, but also the rate and extent of acidification of the ocean.

The dissolution of carbon dioxide is but one aspect of the biogeochemical cycling of the elements by the ocean. The trace elements and isotopes dissolved in the ocean also play a crucial role as regulators and recorders of important biogeochemical and physical processes that control the structure and productivity of marine ecosystems and the dispersion of contaminants in the marine environment. Within IPY, multidisciplinary studies will be conducted in the Arctic and Southern Oceans of the processes affecting marine biogeochemical cycling, particularly those controlling the distribution of key trace elements and isotopes, and their sensitivity to changing environmental conditions. These





Aurora are the most obvious visual indication in the polar regions of the interaction of the Earth's magnetosphere and upper atmosphere. The polar regions offer unique platforms for studies of the atmosphere; the image illustrates the Super-DARN (Dual Auroral Radar Network) radar in Antarctica used for global ionospheric studies in conjunction with similar radar facilities in the Arctic.

studies will determine the distributions of selected trace elements and isotopes; evaluate the oceanic sources, sinks and internal cycling of these; and provide a baseline distribution as a reference for assessing past and future changes. Knowledge of the processes controlling the distribution of trace elements and isotopes in marine organisms, especially in the skeletons of planktonic organisms, will help unravel the history of environmental change, through studies of the fossil remains of these and related organisms in ocean sediments.

#### 7.4 TERRESTRIAL ENERGY, HYDROLOGICAL AND BIOGEOCHEMICAL CYCLES

Realistic estimates of future climate and sea level change and of the impacts of high-latitude environmental changes on ecosystems and human populations are required to enable society to adapt. Several IPY projects will investigate coupled systems to establish how changes in polar regions will affect regional and global biogeochemical, surface energy and water cycles, as well as human

societies. Palaeoclimate archives will be used to determine the interplay of northern and southern polar processes in driving and amplifying global climate. Improved Earth system models, with full inclusion of those components of the system that are important in polar regions, such as snow cover, permafrost and glaciers, and with societal feedback, will be developed.

#### 7.5 SOLAR–TERRESTRIAL LINKAGES

Solar flares and mass ejections affect the composition and dynamics of the Earth's upper atmosphere through their gamma-ray, X-ray and ultraviolet emissions and through their influence on the solar wind, the stream of electrified particles from the sun. To explore the processes involved and their impacts, IPY scientists will bring together two complementary research programmes, the International Heliophysical Year and Interhemispheric Conjugacy Effects in Solar–Terrestrial and Aeronomy Research (ICESTAR). The International Heliophysical Year is an international programme



coordinating the use of current and forthcoming spacecraft missions with ground-based observatory instruments to study the sun's influence on the heliosphere. ICESTAR is an international initiative of the Scientific Committee on Antarctic Research (SCAR) to coordinate research on magnetospheric and ionospheric responses to solar inputs, with emphases on the study of inter-hemispheric relationships.

The coupling processes between different atmospheric layers; their connection with solar activity, energy and mass exchange between the ionosphere and the magnetosphere; and inter-hemispheric similarities and asymmetries in geospace phenomena have far-reaching scientific impacts. They are of importance to society at large because space-weather phenomena adversely affect spacecraft operations and communications, humans in space and satellite-based positioning systems. During IPY, bipolar observations of the movement and energetics of the near-Earth space environment's charged and

neutral constituents, their ionization density, magnetic signature and radio absorption characteristics will be made. The resulting observations and value-added data products will be used together with state-of-the-art models and simulations to improve our quantitative understanding of the near-Earth space environment.

The link between solar activity, electrical currents in the outer atmosphere and weather remains poorly known. Does the global electrical circuit merely respond passively to both meteorological and solar variations, or is there an active input to weather and climate via electrically induced changes in cloud microphysics? Present research indicates that the best place to measure the global electrical circuit is the high, dry, relatively meteorologically stable Antarctic plateau. The Greenland plateau provides an ideal northern hemisphere site. IPY programmes will address the link between electrical currents in the outer atmosphere, weather and solar activity.

# 8 THEME 4: NEW FRONTIERS

## Investigating the frontiers of science in polar regions

There are many important scientific challenges yet to be investigated in the polar regions. The regions beneath the polar ice sheets and under the ice-covered oceans remain largely unknown. Similarly, the pattern and structure of polar ecosystems still need to be mapped in detail. Today the new scientific frontiers in the polar regions are at the intersection of disciplines. Frontiers are both physical and intellectual, ranging in scale from the continental to the microscopic. Frontiers are accessible by ski-equipped aircraft and genomic imaging. Exploration and discovery in IPY 2007–2008 will be very different from in previous Polar Years. Progress will be made not only using new observational techniques, but also by interdisciplinary cross-analysis of existing databases, utilizing the overwhelming recent advances in computing capability. Although exploration is usually associated with discovering new physical features, exploration in IPY is defined in a broader sense.

### 8.1 ADAPTATION AND BIODIVERSITY IN POLAR ORGANISMS

The extreme cold and marked seasonal variation in length of daylight and temperature in polar regions confront organisms with a uniquely challenging set of conditions. Yet, the hostility of polar environments has not precluded the development of complex ecosystems whose constituent species have found novel ways to adapt to extreme physical conditions. Although considerable progress has been made in understanding the adaptations of polar animals and plants, we remain largely ignorant about the numerically dominant species in polar environments, the microbes, which provide the very foundation of these ecosystems. Until we explore the microbial world at the poles, we will lack the basis for a comprehensive understanding of the functions of polar ecosystems and their susceptibility to climate change. During IPY, scientists will explore the polar

environment in a way never done before. Using genomic techniques, often similar to those used by law enforcement agencies in molecular forensics, these teams will characterize the identity of microbial populations. They will explore the characteristics of the most extreme environments on the surface of the Earth, such as subglacial environments, the dry cold Antarctic valleys and the high plateaus of the Greenland and Antarctic ice sheets. The pattern and structure of polar ecosystems, including microbial organisms, will be mapped in detail for the first time, and variations in genetic and functional diversity will be probed in the largely unknown environments of the deep ocean, near sea-floor hydrothermal vents and beneath the ice sheets. The ecology of rapidly changing terrestrial environments and the impacts of invasive species in both marine and terrestrial environments will be assessed. Potential new applications of the bio-active properties of polar organisms will also be studied.

### 8.2 BENEATH THE ICE SHEETS

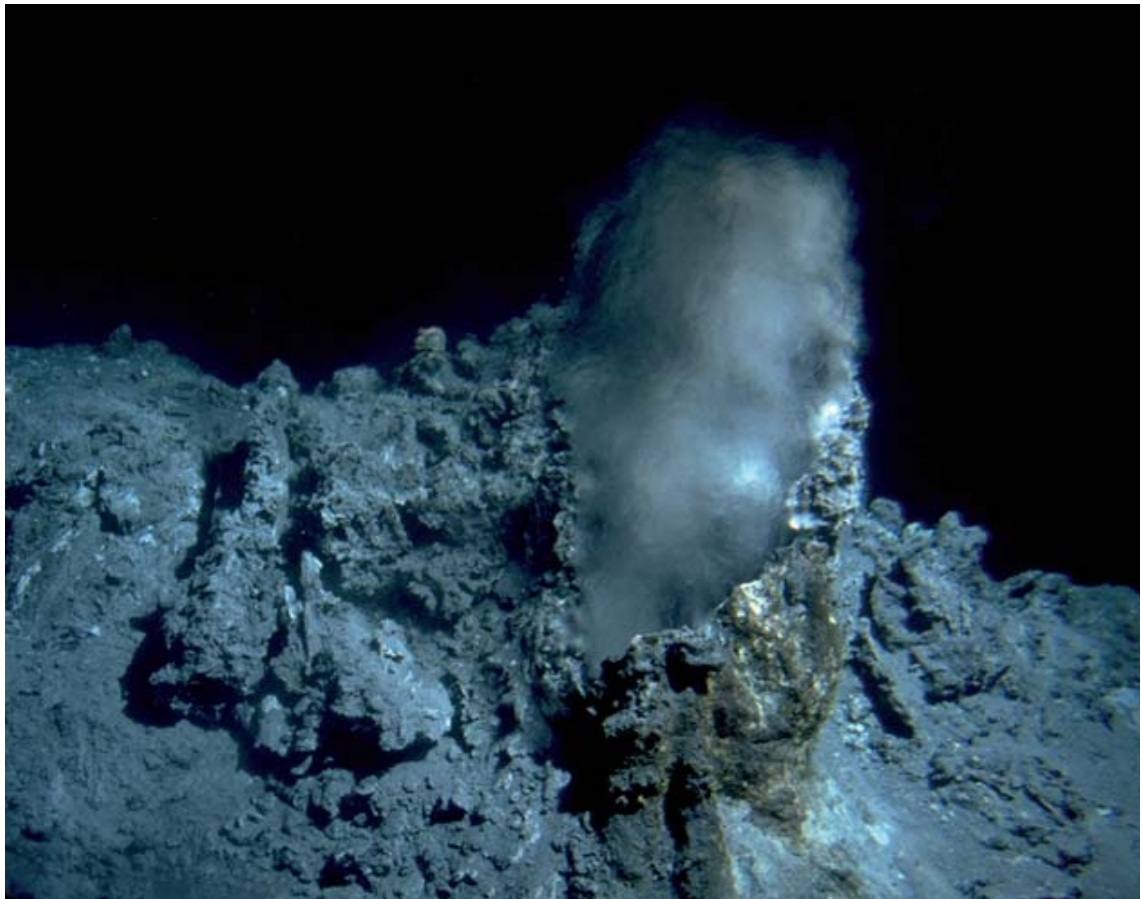
While vast continental terranes beneath the ice sheets of Antarctica and Greenland have not been fully investigated, these subglacial regions are vital for understanding ice sheet development. The nature of the underlying bedrock is a crucial boundary condition for the stability of the ice sheet. Since the distribution of highlands strongly defines both how and when glaciation initiates, the nature of subglacial topography is key to ice sheet modelling. With much of subglacial Antarctica and Greenland yet to be explored, the mind boggles as to how these regions became ice-bound. Major regions of Antarctica that are crucial to deciphering the intertwined geodynamic/climatic history puzzle remain to be examined. For example, the Gamburtsev Subglacial Mountains in East Antarctica cover an immense region larger than the European Alps, but are virtually unknown. Climate models show that the high elevation

of these mountains may have been crucial in localizing the first Cenozoic ice sheets that formed 34 million years ago. This onset of glaciation affected the entire earth, as global climate changed from the hothouse world of the early Cenozoic era to the more recent world in which whole continents are covered in ice. International teams of IPY scientists will use surface, airborne and satellite techniques to decode the origin of the Gamburtsev Subglacial Mountains in Antarctica and the underlying tectonics of the Greenland lithosphere in the Arctic.

Beneath the Antarctic Ice sheet are over 150 recently discovered subglacial lakes (see Figure 20) that range in size from Lake Vostok, a body the size of Lake Ontario, to shallow frozen swamp-like features the size of Manhattan. High-resolution imaging of the ice sheet surface has enabled scientists

to capture the movement of water through a previously unrecognized immense and interconnected hydrologic system that includes large lakes and rivers. The tremendous impact of water on ice sheet dynamics indicates that these are crucial components of the ice sheet system. While the extent and degree of interconnection are unknown, the potential drainage system is larger than that of the Mississippi River Basin. These subglacial environments have formed in response to the complex interplay of tectonics and topography with climate and ice sheet flow over millions of years. Tantalizing evidence from studies of the overlying ice sheet indicate that unique life-supporting ecosystems may be locked within these environments. Such life forms must be adapted to the temperatures and pressures akin to the deep ocean, as well as to the extremely slow delivery of nutrients from the overriding ice sheet. These

The microbial diversity of polar environments is proving far more substantial than previously assumed but is still very poorly documented. A significant target will be to study the biodiversity of hydrothermal vents and cold methane seeps recently identified in both the Arctic and Southern Oceans. The image shows a black smoker vent from which novel microorganisms tolerant of very high temperatures can be isolated.



JIM CHILDRRESS, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

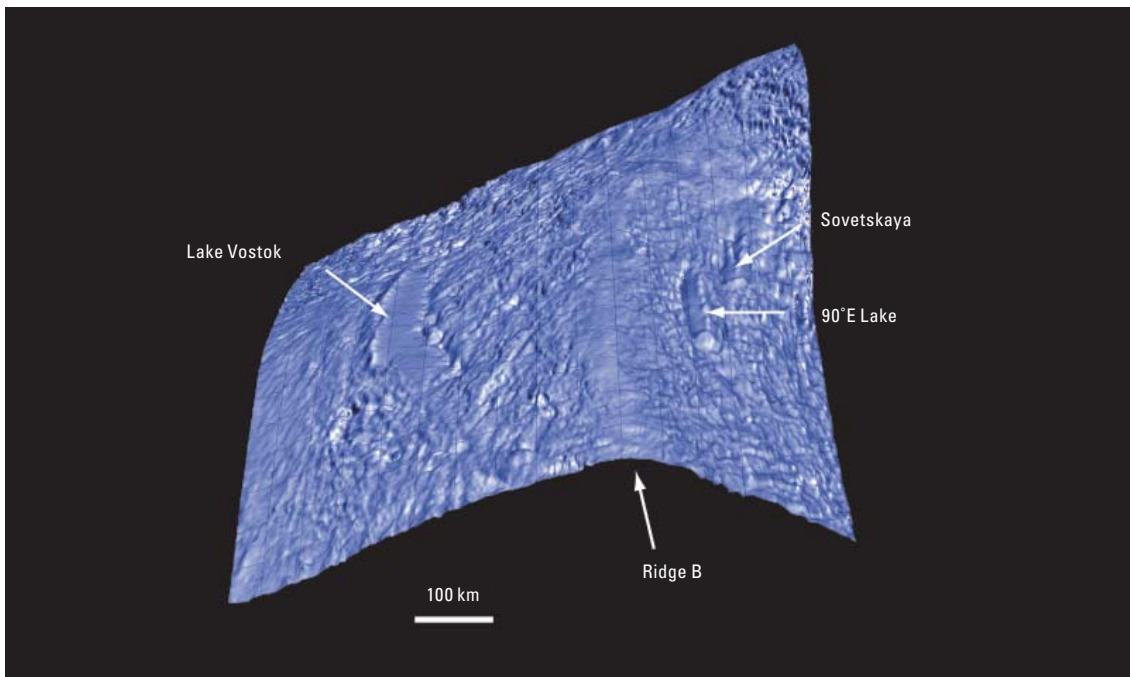


Figure 20. A computer generated image of the Antarctic Ice sheet showing the location of subglacial Lake Vostok and two further large lakes. The imagery indicates how the underlying lakes influence ice sheet morphometry.

[Source: Michael Studinger (2006), Lamont-Doherty Earth Observatory of Columbia University, New York, USA]

unique, subglacial environments provide an unparalleled opportunity to advance our understanding of how climatic and geological factors have combined to produce a unique and isolated biome that maybe occupied by yet unknown microbial communities. Subglacial lake exploration poses one of the most challenging scientific, environmental and technological issues facing polar science today. Exploration of these environments is only possible through concerted well-coordinated international efforts. During IPY, remote-sensing tools and novel sampling techniques will be used to explore subglacial lake systems in East and West Antarctica.

### 8.3 WITHIN THE POLAR OCEANS

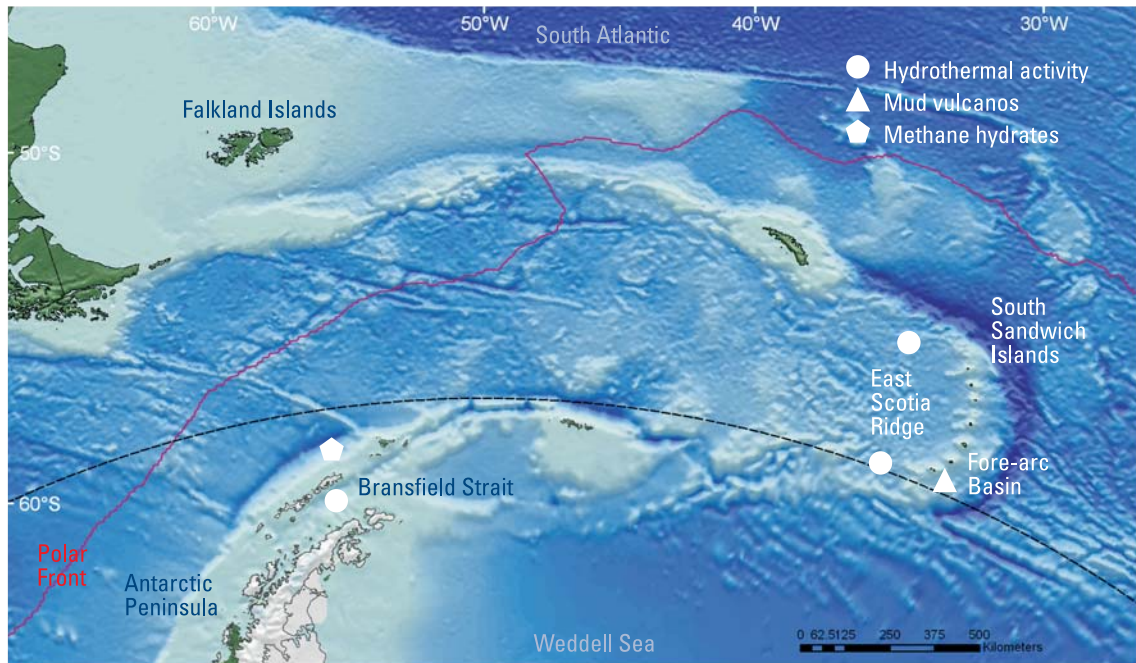
The Gakkel Ridge, in the centre of the Arctic Basin, is the slowest spreading mid-ocean ridge on earth, yet study of this feature has been limited to only a few submarine and icebreaker expeditions. In addition, it displays abundant hydrothermal and volcanic activity. The long-lived Gakkel Ridge hydrothermal ecosystems may have been cut off from the rest of the oceanic ecosystem for millions of

years, since the ridge segments are isolated and water exchange between the Arctic Basin and the global oceans is limited to shallow depths. Therefore, the fauna ecosystems of these deep water vent environments may contain a large number of endemic species and provide constraints on the genetics and evolution of sea-floor organisms. Evidence of hydrothermal activity in the Scotia Sea and Bransfield Strait suggests similarly isolated vent ecosystems may also be present in the Southern Ocean, as shown in Figure 21. During IPY the Arctic Basin and the Scotia Sea will be studied with modern technology, such as remotely operated vehicles and autonomous underwater vehicles.

The intriguing and surprisingly diverse ecosystems found deep beneath some floating Antarctic ice shelves, and the glacial history in sea-floor sediments now accessible following the collapse of Antarctic Peninsula ice shelves are other areas of discovery to be probed during IPY. Marine biologists will use new tools to investigate variations in ecosystems between the ice edge and regions deep within the ice pack and the types of seasonality found beneath the ice shelves.



Figure 21. Hydrothermal vent sites occur in both polar regions and are important IPY targets as they provide insight to the geological processes in the regions. These and cold methane seeps are likely to harbour a diverse flora and fauna physiologically adapted to extreme environments. The map shows the position of the Polar Front (red line) and locations in the Southern Ocean of both hydrothermal activity and methane hydrate accumulation.



[Source: Katrin Linse, CHaSS Consortium]



## 9 THEME 5: VANTAGE POINT

Using the unique vantage point of polar regions to develop and enhance observatories from the interior of the Earth to the sun and the cosmos beyond

The unique position of the poles on the planet makes them an ideal site for observation of diverse processes. Improved understanding of many processes and phenomena, such as solar–terrestrial interactions, the rotation of the Earth’s inner core and the strength of its magnetic dipole, cosmic ray detection, and astronomy and astrophysics, are uniquely benefited by observations from both northern and southern polar regions.

### 9.1 ASTRONOMY FROM POLAR REGIONS

Owing to extremely cold, dry and stable polar air, the polar plateaus provide the best sites on the Earth’s surface for the conduct of a wide range of astronomical observations at wavelengths from optical to millimetre. These exceptional site conditions enable observations to be made of the cosmos with greater sensitivity and clarity and across a wider part of the electromagnetic spectrum than from any other ground-based site. The extended winter night facilitates long time-series observations across broad areas of the sky. Similarly, the polar summer facilitates long timeseries solar observations.

IPY scientists will obtain the baseline data necessary to quantitatively assess planned astronomical facilities at sites such as Dome A, the 4084-metre summit of the Antarctic Ice Sheet. Potentially the pre-eminent location on the Earth for observational astronomy, this site was visited by Chinese scientists in 2005. Testing at Dome C, the site of the new Concordia station operated by France and Italy, has already demonstrated excellent astronomical observing conditions. Summit Station in Greenland (Denmark/United States of America) and Ellesmere Island (Canada) are also extremely cold and dry, and are prospective astronomical observing sites in

the Arctic, although observing conditions at these sites have not yet been quantified.

Fundamental questions remain as to the nature of the Big Bang, the earliest moments of the universe and the formation of galaxies and stars. These can only be addressed with new high-sensitivity observatories. Programmes envisioned for the next generation of polar observatories include measurements of the cosmic microwave radiation background resulting from the Big Bang, the use of optical and infrared telescopes to examine the formation of galaxies, sub-millimetre/far-infrared telescopes and interferometers to probe the dense molecular clouds where stars are born, the search for other Earth-like planets in the Galaxy using interferometric and micro-lensing techniques and the measurement of the earthshine from the moon to probe the variations in the Earth’s reflectivity associated with changing cloud cover. During IPY the suitability of new polar sites for astronomy will be assessed. Measurements will be made of the sky brightness from both auroral activity at optical wavelengths and thermal emission in the infrared, the optical “seeing” — a measure of the “twinkling” of stars — and of the transparency, precipitable water vapour content and microturbulence levels in the atmosphere. These astronomical data, along with meteorological data, will advance the design of the new generation polar astronomical science programmes.

The nature of the fascinating multi-TeV photons originating in the Crab supernova remnant and near the super-massive black holes of active galaxies highlights the unknown energy band that can only be explored with a large neutrino observatory. A new observatory will enable measurements in

The Ice Cube neutrino detector at the South Pole, over one kilometre in diameter and extending hundreds of metres into the ice sheet, is an example of the polar regions offering a valuable platform for space research. Proposals to establish the feasibility of locating a large optical observatory in East Antarctica are a further example.

*[Source: Derived from work supported by the National Science Foundation under Grant Nos. OPP-9980474 (AMANDA) and OPP-0236449 (IceCube), University of Wisconsin-Madison, USA]*



the PeV (10<sup>15</sup> eV) energy region, where the universe is opaque to high-energy gamma rays originating from beyond the edge of our own galaxy, and where cosmic rays do not carry directional information because of their deflection by magnetic fields. During IPY an international one-cubic-kilometre high-energy neutrino observatory will be installed in the ice below the South Pole

Station, opening these unexplored energy bands for astrophysics.

Although costs of making observations in the Antarctic are potentially higher than from observatories in dry temperate locations, the developing scientific air transport networks are making access to remote Antarctic locations increasingly easy.

## 10 THEME 6: THE HUMAN DIMENSION

Investigation of cultural, historical and social processes that shape the sustainability of circumpolar human societies and identification of their unique contributions to global cultural diversity and citizenship

Previous Polar Years had no socio-cultural studies within their official research programme. Historically, social and human-oriented polar research was advanced independently of IPY initiatives and has been focused on the key role played by such social factors as the economy, industrial development, politics, demography and health in the overall increase of scientific knowledge of polar regions. A very strong social and human component was integrated into IPY 2007–2008 programme planning from the outset, unlike previous Polar Years. The social and human component programmes will expand well beyond the former range of topics. These will include new fields such as the interactions between the world economy, large-scale societies and small polar communities; the new global role of polar resources in many critical fields, from energy supplies to the preservation of earth ecosystems; strategies for economic and cultural sustainability for polar residents; studies of local knowledge of the polar environment, or local ecological knowledge and the application of polar residents' observations to the study of Arctic climate change.

Two years of concerted IPY 2007–2008 research will leave a lasting legacy in polar studies. Major contributions will be an unprecedented level of interdisciplinary collaboration among polar scientists from various disciplines and a new understanding of the key role that human and societal factors play in the scientific grasp of the Earth's polar regions.

### 10.1 INTEGRATION OF THE KNOWLEDGE AND OBSERVATIONS OF POLAR RESIDENTS

IPY 2007–2008 will become a true milestone in polar studies because of the unprecedented level of engagement of polar residents, including polar indigenous people, in research planning, observation, processing and interpretation of the various data sets created through IPY projects. Such engagement of polar residents — genuine, constructive and respectful — will play a dual role in IPY efforts. Firstly, it is an integral part of most projects that involve local communities and is recognized as a vital component of the data collection, monitoring, data analysis and data management processes. This refers primarily to social and human-oriented studies but also, increasingly, to many projects undertaken by scientists from physical and biological disciplines: research in sea ice dynamics, climate variability, marine and terrestrial ecosystem health and broad environmental change. Secondly, and at least as important, are the projects that are initiated and conducted by polar communities and regional organizations, involving their own knowledge and observations of local processes and phenomena. The scope of such efforts will greatly increase through IPY 2007–2008 to include the sustainable use of local resources, for example, in fisheries, exploitation of reindeer/caribou populations and environmental-friendly tourism; indigenous cultural and language sustainability; increased resilience of local economic and social systems through co-management,

local self-governance and information exchange among local stakeholders; and interactions with the ongoing industrial development of the polar regions, including monitoring of local environmental and social impacts, primarily in oil and gas, and other mineral exploitation.

## 10.2 SOCIETAL AND HUMAN ASPECTS OF INTERDISCIPLINARY STUDIES

Projects in IPY 2007–2008 present unique opportunities to the various polar science disciplines as they seek to answer questions that require genuine interdisciplinary cooperation and input. Interdisciplinary work in IPY will take place at many different levels. The first level is collaboration among social scientists from various sub-fields of social research, such as political science, anthropology, economics, and between scientists and polar residents and their communal institutions or organizations. The second level will address the cooperation between social and natural/physical science disciplines, such as biology, meteorology and oceanography, along with their very different methods and approaches. For all of these disciplines, collaboration with social scientists and polar residents will help set the research agenda with regard to local scaling and articulating the study focus so that it becomes relevant to local stakeholders. This will be a huge step forward in making polar research relevant to broad societal needs.

Many large-scale IPY projects are also fundamentally interdisciplinary in that they seek to understand the coupling mechanisms of human and natural processes and phenomena. Also, the new interdisciplinary approach aims at bringing the specific disciplinary visions and understanding to larger questions of ecosystem change such as sea ice and lower atmospheric interactions, the role of different factors in maintaining environmental sustainability and the impact of contaminants and industrial development in polar regions. The opportunities of such an interdisciplinary approach reside in the

way many phenomena can be better understood through multi-disciplinary lenses, such as the impact of climate change on polar ecosystems, wildlife and plant species, ocean and atmospheric circulation, soil and coastal processes, polar communities and societal transitions. The challenges IPY researchers will address lie in the yet uncharted efforts to be made to accommodate other disciplines' methods of data collection and interpretation. For example, sea ice and weather/climate data series have to be calibrated and scaled to the level applicable to multi-disciplinary interpretation, so they can be useful in other fields as well as to the local stakeholders.

## 10.3 HUMAN HEALTH AND WELL-BEING IN POLAR REGIONS

Human health and well-being, primarily in the Arctic but also in the Antarctic, is a priority of IPY 2007–2008. Targeted issues include the human health impact of regional and intercontinental transport of anthropogenic pollution to Arctic regions; the effect of contaminants and infectious diseases on the traditional food supply; the spread of infectious diseases, including tuberculosis, HIV/AIDS, hepatitis and new emerging infectious diseases, such as severe acute respiratory syndrome (SARS); the status of chronic diseases, both old and new, such as cancer, obesity and diabetes; and behavioural health issues, such as suicide, interpersonal violence and substance abuse.

The effects of the changing Arctic environment on the evolution, ecology, and emergence of new health risks will also be considered. Although the polar regions are considered to have relatively low levels of pathogens, parasites and pollution, birds migrating between temperate regions and the Arctic are potential vectors of diseases, as are some migrating animal and fish species. The growing impact of polar flyways on global ecosystems is shown by the recent rapid spread of the West Nile virus (see Figure 22) and avian influenza which are now threatening domestic animals and humans. IPY



projects will address how animals cope with attacks on their health in an Arctic subject to climate change and pollution.

A key element of IPY initiatives on human health will be the development of new, and the expansion of existing, health surveillance, monitoring and research networks that are necessary to identify risk factors and develop control strategies. These circumpolar networks will enhance monitoring through the development of standardized protocols, data collection, laboratory methods and data analysis. Once established, these networks will facilitate the monitoring of disease prevalence over time, the determination of risk factors and implementation of disease prevention and control strategies. Networks will also provide opportunities for sustainable partnerships between communities and researchers through the community-based monitoring activities created during IPY.

#### 10.4 STUDIES IN POLAR HISTORY AND HUMAN EXPLORATION OF POLAR REGIONS

In the fields of polar history and archaeology, IPY 2007–2008 research will provide new insight into a wide range of subjects from the initial peopling of polar regions, to cultural artefacts and origins of the indigenous peoples of the North, to the early industrial exploitations of both polar regions.

Research in the history of polar explorations has always been an integral part of polar scholarship. For long, it was the only field of the humanities in an otherwise strictly polar natural and physical sciences effort. The new IPY projects in the history of polar explorations will increase that humanities component by applying new approaches developed in historical and societal research and by looking at the issues that did not exist or were not addressed during previous IPY ventures. Aside from the history of the IPY ventures themselves — the oldest and largest international scientific cooperative endeavours in science history — today’s researchers will explore such topics as the

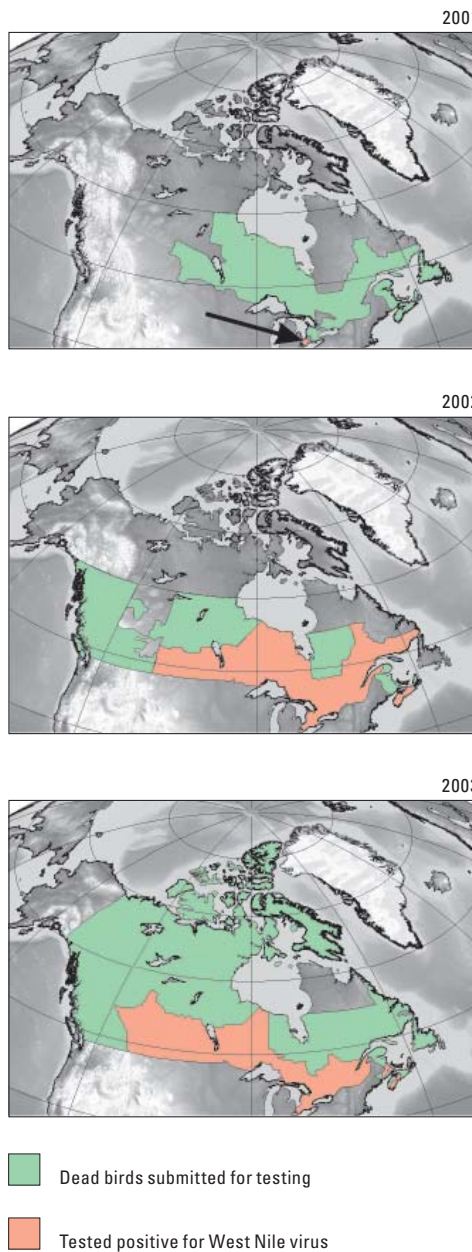


Figure 22. West Nile virus is an example of an infectious disease that will benefit from climate change in its dispersal. There is clear evidence of its rapid spread from an original small focus (see arrow in the top diagram) into the Arctic regions.

[Source: modified from Antarctic Climate Impact Assessment]

impact of polar studies on the overall development of science, public education and societal concern for the sustainable planet; on the interplay of culture, history and politics in the ways polar programmes have been launched and run; on the development of the new regimes for intergovernmental cooperation in the politically fragmented world; and on the preservation of the artefacts of the human advance to the poles as a part of the global cultural heritage.



# 11 EDUCATION, OUTREACH AND COMMUNICATION DURING IPY 2007–2008

The polar regions provide a powerful context for teaching and learning, attracting a wide, diverse audience. IPY thus represents a substantial education and outreach opportunity. The education, outreach and communication strategy for IPY addresses the question, “Why are the polar regions and polar research important to all people on Earth?”. They do this through a series of nationally and internationally coordinated programmes providing a better understanding of the importance of the poles globally. Implementing this strategy requires interaction between all parties promoting and involved in IPY, including IPY National Committees, polar organizations and foundations, the polar science communities and people living in the polar regions. Education and outreach will make a major contribution to the IPY

objective of attracting and developing the next generation of polar scientists, experts and leaders.

The projects endorsed as part of IPY include 57 which focus on education and outreach initiatives. These aim at heightening public awareness of polar regions and the scientific communities research activities there. They feature new films, exhibits, books and atlases; university courses and educational materials; and projects involving youth and polar communities in IPY through workshops and a range of other activities. In addition to these education and outreach projects, all other IPY-endorsed projects include a programme of educative and outreach activities for communicating their research objectives and results to the general public.





# 12 IPY DATA AND INFORMATION MANAGEMENT

Building an integrated data set from the broad range of IPY research activities represents one of IPY's most daunting challenges. An enduring data set, accessible to scientists and the public during IPY and for many decades into the future, will represent one of IPY's strongest legacies.

IPY starts from a strong and clear data policy, as stated in *A framework for the International Year 2007–2008*, a 2004 ICSU publication: "IPY data, including operational data delivered in real time, are made available fully, freely, openly and on the shortest feasible timescale". Exceptions will only apply to protect confidentiality of information about human subjects, respect needs and rights of holders of local and traditional knowledge and ensure that data release does not lead to harm of endangered or protected resources.

An IPY Data and Information Service (DIS) will build on ICSU and WMO strategies for future data systems. Planning and implementation of IPY-DIS will be carried out in partnership with the concurrent Electronic Geophysical Year. The technical solutions necessary to implement IPY-DIS will comply with advanced

international standards for interoperability and for metadata. A successful IPY-DIS will engage and connect many national and international data centres and promote the development of common formats, improved reference systems and geographic browsers. In partnership with the Electronic Geophysical Year, IPY promotes behaviours and systems that ensure consistent and accurate acknowledgement of data sources by all data users. Ensuring proper attribution across the IPY disciplines and data sets will highlight the need within science for a system of review and citation of all data sets.

IPY-DIS and the long-term IPY data legacy will involve many innovative solutions driven by the need to integrate and preserve a vast array of data combined with advances in storage and communication technologies in real-time data assimilation and in conceptual systems for integrating and exchanging information. In addition to these technical and infrastructural solutions, IPY will set a new standard in scientific cooperation as rapid and unrestricted data exchange becomes an accepted and enabling factor in daily research.



## 13 CONCLUSION

The International Polar Year 2007–2008 — a short period of a concentrated and internationally coordinated multidisciplinary science in both the Arctic and Antarctic — has received enthusiastic support from the research community and the general public. The response to calls for projects contributing to the IPY 2007–2008 objectives has been almost overwhelming, and in the short period that these IPY projects have had to develop, they have grown to be increasingly integrated and interdisciplinary and to involve the widest international representation. Endorsed IPY projects involve participation from scientists from more than 60 nations, including those not traditionally involved in polar research. They also include widespread participation of polar residents, including indigenous peoples.

The endorsed IPY projects address major issues in each of the six IPY themes, include a strong emphasis on social science and have many cross-thematic links. IPY projects will tackle the most challenging and urgent issues of the polar regions: issues that include rapid change to climate and ecosystems, critical links between polar processes and the rest of the globe, the impacts of societal and environmental change on polar residents and new scientific advances on the threshold of discovery. IPY 2007–2008 will see major new projects initiated addressing these challenges, significant enhancement of many existing large-scale international programmes and the development of improved space, land and ocean-based observing systems to provide

polar data for monitoring and process studies into the future. Some of these activities are already fully funded; many more are supported by significant funding that covers their core activities. An increasing appreciation by many national governments of the global importance of polar regions and of the threat of anthropogenic change should ensure additional funding and logistic support for further activities during IPY 2007–2008. Indeed, a major success of IPY 2007–2008 has been the allocation of significant new funds by many national agencies, over and above the established levels of support for polar research.

March 2007 to March 2009 will be an exciting and productive period of concentrated and coordinated research activity in the Arctic and Antarctic. The International Polar Year 2007–2008 will significantly advance our ability to meet the major science challenges of the polar regions — and it will leave a rich legacy in a new understanding of processes there and of their global linkages, large-scale baseline data sets against which future change can be assessed, novel and enhanced observing systems and a new generation of scientists and leaders trained and determined to carry this legacy into the future. The broad international effort of the International Polar Year promoted by ICSU and WMO aims to contribute to a future of increased cooperation between scientists, organizations and nations in the knowledge and rational use of our planet.





# 14 APPENDICES



## IPY structure and organization

From the outset, IPY has mainly been a bottom-up process driven by the research community. The numerous proposals were initially sorted by the ICSU/WMO Joint Committee for IPY 2007–2008 into clusters based on discipline. These clusters were then encouraged to develop large international projects and those meeting the criteria developed by the Joint Committee were subsequently endorsed. The endorsed projects are shown in the honeycomb chart in Figure 2 on page 14, and are also listed in Appendix III. National Committees were formed by many countries to coordinate national contributions to IPY, and these are listed in Appendix II.

The management structure outlined in the IPY framework document was implemented by the Joint Committee, which the sponsors, ICSU and WMO, created in 2004 to succeed the original Planning Group. The Joint Committee (see Appendix I) includes ex-officio membership from ICSU and WMO, as well as the Intergovernmental Oceanographic Commission, the Scientific Committee on Antarctic Research and the International Arctic Science Committee. Arctic Council and Antarctic Treaty Consultative Meeting (ATCM) representatives attend Joint Committee meetings as observers. A structure diagram of IPY created around the Joint Committee is shown in Figure 23.

An International Programme Office (IPO) (see Appendix I) was established by ICSU and WMO in Cambridge to support the Joint Committee and implement its decisions. Three subcommittees (see Appendix I) were also created to provide specialist advice to the Joint Committee. These dealt with

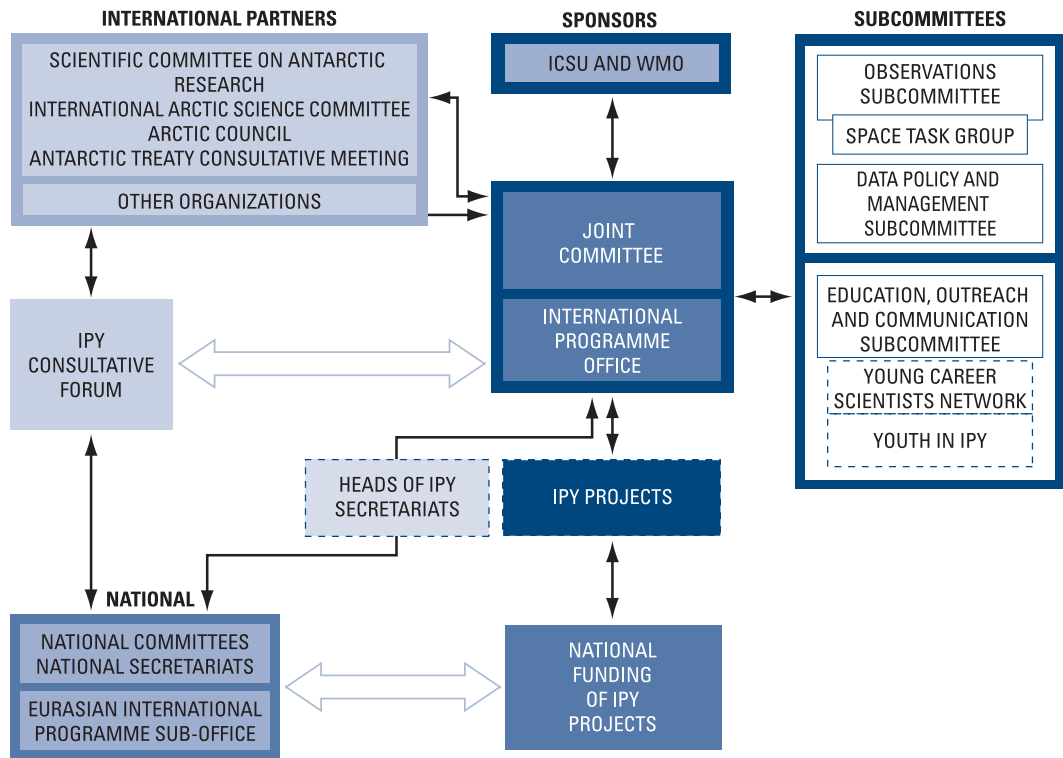
observations, data policy and management, and education, outreach and communication. An open consultative forum has been held at least once a year to provide a mechanism for national committees and various national and international organizations (Appendix I) to communicate with the Joint Committee.

As IPY has developed, additional management elements have been created. To provide advice and assistance for projects in the Eurasian Arctic, an IPY International Programme Sub-Office has been set up in St. Petersburg, Russian Federation (see Appendix I). Canada and Norway have also set up IPY offices to support Arctic research and, with the St. Petersburg Sub-Office, offer circum-Arctic coverage. The Observations Subcommittee established a Space Task Group (see Appendix I) to provide greater focus on satellite remote-sensing plans.

Developing the next generation of polar researchers is a priority of IPY and two groups have emerged from the projects: Youth in IPY and the Young Career Scientist Network. Both of these are informally overseen by the Education, Outreach and Communication Subcommittee rather than formally established by the Joint Committee. Similarly a committee called the Heads of IPY Secretariats, which is open to all National Committees, has recently been formed and managed by the International Programme Office to provide a more focused forum for detailed discussion of key issues which can then be reported to the Joint Committee via the International Programme Office. These unofficial groups are shown as dashed boxes in the management structure diagram in Figure 23.

Figure 23. This diagram outlines the management structure of IPY. The Polar Year has been largely a bottom-up process with a light management touch. Formally approved components are shown in solid boxes and more recent informally established components are shown in dashed line boxes.

[Source: Cynan Ellis-Evans, IPY 2007-2008 International Programme Office]



#### IPY 2007–2008 JOINT COMMITTEE MEMBERSHIP (as of January 2007)

##### Invited members

- Ian Allison, Co-Chair, Australian Antarctic Division and Antarctic Climate Ecosystems Cooperative Research Centre, Hobart, Australia
- Michel Béland, Co-Chair, Science and Technology Branch, Environment Canada, Montreal, Canada
- Robin Bell, Lamont-Doherty Earth Observatory, Columbia University, New York, USA
- Qin Dahe, China Meteorological Administration, Beijing, China
- Kjell Danell, Swedish University of Agricultural Sciences, Umeå, Sweden
- Edith Fanta, Universidade Federal do Paraná, Curitiba, Brazil
- Eberhard Fahrbach, Alfred Wegener Institute, Bremerhaven, Germany
- Yoshiyuki Fujii, National Institute of Polar Research, Tokyo, Japan
- Grete Hovelsrud, Centre for International Climate and Environmental Research, Oslo, Norway
- Vladimir Kotlyakov, Russian Academy of Science Institute of Geography, Moscow, Russian Federation
- Igor Krupnik, Smithsonian Institution National Museum of Natural History, Washington, USA



- Jeronimo Lopez-Martinez, Universidad Autónoma de Madrid, Spain
- Tillmann Mohr, European Organisation for the Exploitation of Meteorological Satellites (retired)
- Chris Rapley, British Antarctic Survey, Cambridge, UK

#### Ex-officio members

- Carthage Smith/Leah Goldfarb, International Council for Science
- Eduard Sarukhanian, World Meteorological Organization
- Colin Summerhayes, Scientific Committee on Antarctic Research
- Volker Rachold/Odd Rogne, International Arctic Science Committee Secretariat
- Keith Alverson, Intergovernmental Oceanographic Commission, UNESCO

#### IPY 2007–2008 INTERNATIONAL PROGRAMME OFFICE STAFF

- David Carlson, Director
- Cynan Ellis-Evans, Senior Advisor
- Odd Rogne, Senior Advisor
- Nicola Munro, Administrator
- Rhian Salmon, Education, Outreach and Communication Coordinator
- Camilla Hansen, Events Coordinator

#### Eurasian International Programme Sub-Office, St. Petersburg, Russian Federation

- Sergey Priamikov, Head of Office
- Victoria Razina, Web Design and News
- Roman Vlasenkov, Database Manager
- Oleg Golovanov, Mapping
- Elena Berezina, Administration

#### IPY 2007–2008 SUBCOMMITTEES MEMBERSHIP (as of January 2007)

##### Observations Subcommittee

- Wenjian Zhang, Chair, China Meteorological Administration, China
- David Williams, Co-Chair, Space Task Group, British National Space Centre, UK
- Mark Drinkwater, Co-Chair, Space Task Group, European Space Agency
- Jan Bottenheim, Science and Technology Branch, Environment Canada, Montreal, Canada
- Peter Dexter, Australian Government Bureau of Meteorology, Australia
- Lene Kielsen Holm, Inuit Circumpolar Council, Nuuk, Greenland
- Kenneth Jezek, Ohio State University, Columbus, USA
- Mark Majodina, South African Weather Service, South Africa
- Antoni Meloni, Istituto Nazionale di Geofisica e Vulcanologia, Italy
- Árni Snorrason, Hydrological Service, National Energy Authority, Iceland

- Craig Tweedie, University of Texas at El Paso, USA
- Tatiana Vlassova, Russian Academy of Science Institute of Geography, Russian Federation

#### Space Task Group

- David Williams, Co-Chair, British National Space Centre, UK
- Mark Drinkwater, Co-Chair, European Space Agency
- Vasilii Asmus, Russian Federal Service for Hydrometeorology and Environmental Monitoring, Russian Federation
- Jean-Marc Chouinard, Canadian Space Agency, Canada
- Craig Dobson, National Aeronautics and Space Administration, USA
- Manfred Gottwald, German Aerospace Centre, Germany
- Kenneth Holmlund, European Organisation for the Exploitation of Meteorological Satellites
- Chu Ishida, Japan Aerospace Exploration Agency, Japan
- Seelye Martin, National Aeronautics and Space Administration, USA
- Eric Thouvenot, Centre National d'Études Spatiales, France
- Licheng Zhao, China Meteorological Administration, China

#### Data Policy and Management Subcommittee

- Mark Parsons, Co-Chair, National Snow and Ice Data Center, USA
- Taco de Bruin, Co-Chair, Royal Netherlands Institute for Sea Research, Netherlands
- Nathan Bindoff, Antarctic Climate and Ecosystems Cooperative Research Centre, Australia
- Joan Eamer, GRID-Arendal, Norway
- Hannes Grobe, World Data Center for Marine Environmental Sciences, Alfred Wegener Institute, Germany
- Ray Harris, University College London, UK
- Ellsworth LeDrew, University of Waterloo, Canada
- Vladimir Papitashvili, University of Michigan, USA
- Hakan Olsson, Swedish University of Agricultural Sciences, Umeå, Sweden
- Birger Poppel, University of Greenland, Nuuk, Greenland
- Alexander Sterin, All-Russian Research Institute of Hydrometeorological Information, World Data Centre, Russian Federation
- Li Xin, World Data Centre for Glaciology and Geocryology, Chinese Academy of Sciences, China

#### Education and Outreach Subcommittee

- Sandra Zicus, Co-Chair, Antarctic Climate and Ecosystems Cooperative Research Centre, Tasmania, Australia
- Margarete Pauls, Co-Chair, Alfred Wegener Institute, Bremerhaven, Germany
- Linda Capper, British Antarctic Survey, Cambridge, UK

- Lars Kullerud, University of the Arctic, Norway
- Louise Huffman, Teachers Experiencing Antarctica and the Arctic, USA
- Tove Kolset, Centre for International Climate and Environmental Research, Oslo, Norway
- Rachel Hazell, shared seat, Hazell Designs Books, Edinburgh, Scotland, UK
- Linda Mackey, shared seat, Polar Artists Group
- Mark McCaffrey, Cooperative Institute for Research in Environmental Sciences Education Outreach Program, University of Colorado at Boulder, USA
- Birgit Kleist Pedersen, University of Greenland, Nuuk, Greenland
- Jean de Pomereu, International Polar Foundation, Cambridge, UK
- Rodion Sulyandziga, Center for Support of Indigenous Peoples of the North, Moscow, Russian Federation
- Patricia Virtue, University of Tasmania, Australia

#### Ex-officio members

- Representatives from the International Programme Office, IPY Youth Steering Committee, International Council for Science, World Meteorological Organization

#### INTERNATIONAL AND NATIONAL ORGANIZATIONS ENDORSING OR SUPPORTING IPY 2007–2008

- Antarctic Treaty Consultative Meeting
- Arctic Climate Impacts Assessment
- Arctic Council
- Arctic Ocean Sciences Board
- Australian Government Bureau of Meteorology
- British National Space Centre
- Canadian Space Agency
- Census of Marine Life
- Centre for International Climate and Environmental Research
- Centre for Support of Indigenous Peoples of the North, Russian Federation
- Centre National d'Etudes Spatiales
- China Meteorological Administration
- Chinese Academy of Sciences
- Climate and Weather of the Sun-Earth System
- Climate of the Arctic and its Role for Europe
- Commission for the Geological Map of the World
- Council of Managers of National Antarctic Programs
- Electronic Geophysical Year
- European Organisation for the Exploitation of Meteorological Satellites
- European Science Foundation Polar Board
- European Space Agency

- Forum of Arctic Research Operators
- German Aerospace Center
- Intergovernmental Oceanographic Commission, UNESCO
- International Arctic Science Committee
- International Arctic Social Scientists Association
- International Geosphere-Biosphere Programme
- International Heliophysical Year
- International Hydrographic Bureau
- International Permafrost Association
- International Polar Foundation
- International Science Initiative in the Russian Arctic
- International Society for Photogrammetry and Remote Sensing
- International Union of Geodesy and Geophysics
- International Union of Geological Sciences
- International Union of Radio Science
- International Year of Planet Earth
- Japan Aerospace Exploration Agency
- Meteorological Service of Canada
- National Aeronautics and Space Administration
- National Energy Authority, Iceland
- National Oceanographic and Atmospheric Administration
- National Snow and Ice Data Center
- Royal Netherlands Academies of Arts and Sciences
- Royal Netherlands Institute for Sea Research
- Russian Academy of Science Institute of Geography
- Russian Federal Service of Hydrometeorology and Environmental Monitoring
- Scientific Committee on Antarctic Research
- Scientific Committee on Oceanographic Research
- Scientific Committee on Solar–Terrestrial Physics
- Surface Ocean-Lower Atmosphere Study Programme
- The National Academies, USA
- The Norwegian Academy of Science and Letters
- The Royal Academies for Science and the Arts of Belgium
- The Royal Society, London
- The Royal Swedish Academy of Sciences
- United Nations Environment Programme
- University of the Arctic
- World Climate Research Programme (WCRP)
- WCRP Climate and Cryosphere Project
- WCRP International Programme for Antarctic Buoys
- WCRP Southern Ocean Climate Variability and Predictability Project



## Nations involved in IPY (63)

Argentina • Australia • Austria • Belgium • Bermuda • Brazil • Bulgaria • Canada • Chile • China • Colombia • Czech Republic • Denmark • Egypt • Estonia • Finland • France • Germany • Greece • Hungary • Iceland • India • Indonesia • Ireland • Israel • Italy • Japan • Kazakhstan • Kenya • Kyrgyzstan • Latvia • Lithuania • Luxembourg • Malaysia • Mexico • Monaco • Mongolia • Morocco • Netherlands • New Zealand • Norway • Peru • Philippines • Poland • Portugal • Romania • Russian Federation • Slovakia • Slovenia • Spain • South Africa • Republic of Korea • Sweden • Switzerland • United Republic of Tanzania • Turkey • United Kingdom of Great Britain and Northern Ireland • Ukraine • Uruguay • United States of America • Uzbekistan • Venezuela • Vietnam

### Nations with National Committees (31)

Argentina • Australia • Belgium • Brazil • Canada • Chile • China • Denmark • Greenland (local committee) • Finland • France • Germany • Iceland • India • Italy • Japan • Malaysia • Netherlands • New Zealand • Norway • Poland • Portugal • Russian Federation • South Africa • Republic of Korea • Spain • Sweden • Ukraine • United Kingdom of Great Britain and Northern Ireland • United States of America • Uruguay

### IPY National Points of Contact (3)

Austria • Czech Republic • Switzerland



## Endorsed IPY projects (as of February 2007)

The table below lists the 228 projects endorsed by the IPY Joint Committee. It contains the project number, full project title, information on the project's geographical focus (Arctic, Antarctic or both poles) and the broad category (Earth, land, people, ocean, ice, atmosphere, space, data or education and outreach) under which the project is placed in the honeycomb diagram (see Figure 2).

Project No.	Title	Geographical focus	Category
6	Dynamic social strategies in Arctic environments: long-term perspectives on movement and communication	Arctic	people
8	Synoptic Antarctic shelf-slope interactions study	Antarctic	ocean
10	Large-scale historical industrial exploitation of polar areas	Bipolar	people
11	Arctic wildlife observatories linking vulnerable ecosystems	Arctic	land
13	Sea level and tidal science in the polar oceans	Bipolar	ocean
14	Integrated Arctic Ocean Observing System	Arctic	ocean
16	Hydro-sensor-FLOWS — Arctic and Antarctic glacier hydrosystems as natural sensors for recent climatic variations	Bipolar	ice
19	Metal pollution in the Canadian High Arctic: pollution trend reconstruction of noble metals (Pd and Pt)	Arctic	atmosphere
20	Air-ice chemical interactions – IPY coordinated studies	Bipolar	ice
21	U.S. National Park Service. Understanding environmental change and its biological, physical, social, subsistence and cultural effects in national parks and protected areas of Alaska, Chukotka and the Yukon through research, monitoring, education and outreach	Arctic	land
22	POLARSTERN expedition "HERMES — the Nordic margin" in the framework of the EU-funded integrated project HERMES (Hotspot Ecosystem Research on the Margins of European Seas)	Arctic	ocean
23	Bipolar Atlantic thermohaline circulation	Bipolar	ocean
26	The Pan-Arctic cluster for climate forcing of the Arctic marine ecosystem	Arctic	ocean
27	Changing trends in polar research as reflected in the history of the International Polar Years	Bipolar	people
28	Climate of the Arctic and its role for Europe/Arctic system reanalysis	Arctic	atmosphere
29	The Bering Strait, rapid change and land bridge paleoecology	Arctic	Earth
30	Representations of Sami in nineteenth-century polar literature: the Arctic 'other'	Arctic	people
32	Polar study using aircraft, remote sensing, surface measurements and modelling of climate, chemistry, aerosols and transport (POLARCAT)	Arctic	atmosphere
33	Antarctic and sub-Antarctic permafrost, periglacial and soil environments	Antarctic	land
34	Impact of climate-induced glacial melting on marine and terrestrial coastal communities on a gradient along the western Antarctic Peninsula	Antarctic	ocean
35	International Polar Year GEOTRACES: an international study of the biogeochemical cycles of trace elements and isotopes in the Arctic and Southern Oceans	Bipolar	ocean
36	Arctic Ocean warming in the past	Arctic	ice
37	The dynamic response of Arctic glaciers to global warming	Arctic	ice

Project No.	Title	Geographical focus	Category
38	Ocean–atmosphere–sea ice–snow pack interactions affecting atmospheric biogeochemistry and ecosystems in the Arctic	Arctic	ice
39	Arctic palaeoclimate and its extremes	Arctic	ice
40	Developing Arctic modelling and observing capabilities for long-term environmental studies	Arctic	ocean
41	Concordia, a new French-Italian facility for international and long-term scientific activities on the Antarctic Plateau	Antarctic	atmosphere
42	Subglacial Antarctic lake environments — unified international team for exploration and discovery	Antarctic	ice
45	POLAR: WMT — Paving the way for online learning in Arctic regions using wireless and mobile technologies	Arctic	education
46	Monitoring of oil development in traditional indigenous lands of the Nenets, Autonomous Okrug, northwestern Russia	Arctic	people
48	International study of Arctic change	Arctic	ocean
49	International Polar Year (IPY) Data and Information Service (DIS) for distributed data management	Bipolar	data
50	Permafrost Observatory Project: a contribution to the thermal state of permafrost (TSP-125)	Bipolar	land
51	International Polar Year publications database	Bipolar	education
52	Antarctic Biological and Earthquake Science (ABES): Southern Ocean broadband seismo/acoustic observatories	Antarctic	ocean
53	A census of Antarctic marine life	Antarctic	ocean
54	Antarctic climate evolution	Antarctic	land
55	Microbiological and ecological responses to global environmental changes in polar regions	Bipolar	land
56	Quantifying the relationship of solar variability with the atmosphere, weather and climate (particularly via the global electric circuit and ozone variability associated with solar activity)	Bipolar	space
58	Change and variability of the Arctic systems — Nordaustlandet, Svalbard	Arctic	ice
59	Terrestrial ecosystems in Arctic and Antarctic: effects of UV light, liquefying ice and ascending temperatures	Bipolar	land
63	ICESTAR/IHY — Inter-hemispheric conjugacy in geospace phenomena and their heliospheric drivers	Bipolar	space
66	ANDEEP – SYSTCO (Antarctic benthic deep-sea biodiversity: colonization history and recent community patterns — system coupling)	Bipolar	ocean
67	Origin, evolution and setting of the Gamburtsev Subglacial Highlands: exploring an unknown Antarctic territory	Antarctic	Earth
69	International Congress of Arctic Social Sciences VI in Nuuk, 2007–2008.	Arctic	education
70	Monitoring of the upper ocean circulation, transport and water masses between Africa and Antarctica.	Antarctic	ocean
71	Polar aquatic microbial ecology	Bipolar	ocean
72	Network for Arctic climate and biological diversity studies	Arctic	land
76	Atmospheric monitoring network for anthropogenic pollution in polar regions	Bipolar	atmosphere
77	Plate tectonics and polar gateways in earth history	Bipolar	Earth
78	Synchronized observations of polar mesospheric clouds (PMC), aurora and other large-scale polar phenomena from the International Space Station (ISS) and ground sites	Bipolar	space
79	IPY book series on environmental research	Bipolar	education



Project No.	Title	Geographical focus	Category
80	Determining breeding and exposition conditions for selected Arctic and Antarctic marine organisms at the Gdynia Aquarium in Gdynia, Poland.	Bipolar	education
81	Collaborative research into Antarctic calving and iceberg evolution	Antarctic	ice
82	LICHEN: the Linguistic and Cultural Heritage Electronic Network	Arctic	education
83	SCAR-MarBIN: the information dimension of Antarctic marine biodiversity	Antarctic	ocean
86	US Geological Survey participation in the International Polar Year	Bipolar	land
88	Antarctic surface accumulation and ice discharge (ASAID)	Antarctic	ice
90	Arctic Circumpolar Coastal Observatory Network	Arctic	land
91	Global Inter-agency IPY Polar Snapshot Year (GIIPSY)	Bipolar	space
92	Integrated analyses of circumpolar climate interactions and ecosystem dynamics in the Southern Ocean — International Polar Year	Antarctic	ocean
93	International collaborative expedition to collect and study fish indigenous to sub-Antarctic habitats, 2007	Antarctic	ocean
95	The state of the Arctic sea ice cover: physical and biological properties and processes in a changing environment	Arctic	ice
96	Go Polar!: an international network of children's museums to bring polar science to children and families	Bipolar	education
97	Investigating the cryospheric evolution of the Central Antarctic Plate (ICECAP): internationally coordinated long-range aero-geophysics over Dome A, Dome C and the Aurora Subglacial Basin of East Antarctica	Antarctic	land
99	Ozone layer and UV radiation in a changing climate evaluated during IPY	Bipolar	atmosphere
100	Polar field stations and IPY history: culture, heritage, governance (1882–present)	Bipolar	people
104	The Arctic Hydrological Cycle Monitoring, Modelling and Assessment Program	Arctic	land
105	The state and fate of the cryosphere	Bipolar	ice
107	IPY on the Antarctic Peninsula — ice and climate	Antarctic	ice
108	Sea ice from space for IPY	Arctic	ice
109	Geodynamics of the West Antarctic Rift System (WARS) in remote Ellsworth Land and its implications for the stability of the West Antarctic Ice Sheet	Antarctic	Earth
110	Antarctic mission: multi-media exploration of the science of climate change in Antarctica	Antarctic	education
112	Circumpolar Center for Learning and Indigenous Knowledge Systems	Arctic	education
113	Understanding deep permafrost: interdisciplinary studies related to understanding the structure, geology, microbiology, thermal state, physical properties and fluid fluxes in thick permafrost leading to a long-term observatory.	Arctic	land
114	Climate change in the Arctic with special emphasis on Alaska	Arctic	ice
116	The Royal Society of Victoria's two international research expedition polar inter-disciplinary voyages	Antarctic	education
117	International Partnerships in Ice Core Science (IPICS) — International Polar Year Initiative	Bipolar	ice
118	The Greenland Ice Sheet: stability, history and evolution	Arctic	ice
120	Northern high-altitude climate variability during the past 2000 years: implications for human settlement	Arctic	ice
121	Improved numerical weather forecasting and climate simulations by exploitation of in-situ, airborne remote-sensing and satellite data, advanced modelling systems and basic research into polar processes and into polar–global interactions	Bipolar	atmosphere
122	Ecosystem West Greenland	Arctic	ocean

Project No.	Title	Geographical focus	Category
123	Globalization — Language, Literature and Media among Inuit and Sami people 1. Language planning, 2. Computer-assisted linguistics, 3. From oral tradition to rap, 4. Citizenship, consumerism and media	Arctic	people
124	Astronomy from the Polar Plateaus	Bipolar	space
125	Ice and snow mass change of Arctic and Antarctic polar regions using GRACE satellite gravimetry	Bipolar	ice
130	Bipolar climate machinery — A study of the interplay of northern and southern polar processes in driving and amplifying global climate as recorded in paleoclimate archives and their significance for the generation of realistic estimates of future climate	Bipolar	ocean
131	Integrated circumpolar studies of Antarctic marine ecosystems to the conservation of living resources	Antarctic	ocean
132	Climate of Antarctica and the Southern Ocean — ocean circulation cluster	Bipolar	ocean
133	Circumpolar Biodiversity Monitoring Program	Arctic	land
134	Polar bear ( <i>Ursus maritimus</i> ) circumpolar health assessment in relation to toxicants and climate change	Arctic	ocean
135	A multidisciplinary and international conference with presentations focussed on technical and administrative issues associated with the protection and preservation of historic scientific bases and in particular earlier IPY stations in polar regions and taking the form of a series of presentations and discussions that will ultimately be published for distribution in book and electronic form	Bipolar	education
137	Evolution and biodiversity in the Antarctic: the response of life to change	Antarctic	ocean
138	Cold land processes in the northern hemisphere continents and their coastal zone: regional and global climate and societal-ecosystem linkages and interactions	Arctic	land
139	Greening of the Arctic: circumpolar biomass	Arctic	land
140	Hydrological impact of Arctic aerosols	Arctic	atmosphere
141	Antarctic sea ice in the International Polar Year	Antarctic	ice
142	The development of a polar-based photo-bioreactor for the production of bioactive compounds by indigenous micro-algae and cyanobacteria	Bipolar	ocean
145	Workshop/Conference summarizing the results of the Arctic Monitoring and Assessment Program's Human Health Assessment Group (AMAP HHAG) Research Program (2002–2008)	Arctic	education
147	International Antarctic Institute	Antarctic	education
151	Present-day processes, past changes and spatiotemporal variability of biotic, abiotic and socio-environmental conditions and resource components along and across the Arctic delimitation zone	Arctic	land
152	Trans-Antarctic scientific traverses expeditions — Ice divide of East Antarctica	Antarctic	land
153	Marine mammal exploration of the oceans pole to pole	Bipolar	ocean
155	Ecosystem studies of sub-arctic and Arctic regions	Arctic	ocean
156	Geomatics for the North — Circumpolar conference on basic geospatial information for northern development	Arctic	education
157	Community adaptation and vulnerability in Arctic regions	Arctic	people
158	Comparative studies of marine Arctic and Antarctic ecosystems and the potential consequences of climate change	Bipolar	education
160	Arctic change: an interdisciplinary dialog between the Academy, northern peoples and policy makers	Arctic	education
162	Starting the clock for the CARMA network: impacts on human–rangifer systems in the Circum-Arctic	Arctic	land
164	Inuit and scientific descriptions of the narwhal, connecting parallel perceptions: interdisciplinary studies of the narwhal with a focus on tusk function	Arctic	ocean

Project No.	Title	Geographical focus	Category
166	Sea ice knowledge and use: assessing Arctic environmental and social change	Arctic	people
167	Arctic Human Health Initiative	Arctic	people
168	International Polar Year Youth Steering Committee (IPY YSC)	Bipolar	education
169	Network for present and future circumpolar freshwater lake research and data management	Arctic	land
170	Aliens in Antarctica	Antarctic	land
171	POLAR-AOD: a network to characterize the means, variability and trends of the climate-forcing properties of aerosols in polar regions	Bipolar	atmosphere
172	Health of Arctic and Antarctic bird populations	Bipolar	land
173	Biogeography and geological diversity of hydrothermal venting on the ultra-slow spreading Arctic Mid-Ocean Ridge	Arctic	Earth
175	Fate, uptake and effects of contaminants in the Arctic and Antarctic ecosystem	Bipolar	atmosphere
176	A polar atlas for education and outreach based on a spatial data infrastructure framework	Bipolar	education
179	Extending IPY themes to the undergraduate Earth system science education community	Bipolar	education
180	Antarctic climate and atmospheric circulation	Antarctic	atmosphere
183	Arctic resiliency and diversity: community response to change	Arctic	people
185	Polar Earth-observing network	Bipolar	land
186	Engaging communities in the monitoring of zoonoses, country food safety and wildlife health	Arctic	people
187	Exchange for local observations and knowledge of the Arctic	Arctic	people
188	International Tundra Experiment (ITEX): impacts of long-term experimental warming and climate variability on tundra ecosystems	Arctic	land
189	The University of the Arctic: providing higher education and outreach programmes for the International Polar Year	Arctic	education
191	The Sixth Continent Initiative — Capacity-Building in Antarctic Scientific Research	Antarctic	education
196	International Arctic systems for observing the atmosphere	Arctic	atmosphere
201	Northern material culture through International Polar Year collections, then and now: in the footsteps of Murdoch and Turner	Arctic	people
202	Arctic Freshwater Biodiversity Monitoring and Research Network	Arctic	land
206	Legal and constitutional frameworks for protecting traditional ecological knowledge in northern Canada	Arctic	people
208	Remote sensibility — a multimedia project exploring and reflecting the immaterial relationship global industrial culture has with the circumpolar North	Arctic	education
210	Global change — social challenges processes of socio-economic changes in the circumpolar North, with focus on gender and inter- and intra-generational relations	Arctic	people
213	Environmental baselines, processes, changes and impacts on people in sub-arctic Sweden and the Nordic Arctic regions	Arctic	land
214	Retrospective and prospective vegetation change in the polar regions: back to the future	Bipolar	land
217	The structure and evolution of the polar stratosphere and mesosphere and links to the troposphere during IPY	Bipolar	space
227	The political economy of northern development	Arctic	people
244	Antarctic anthology, a collaborative book incorporating literary, visual and scientific representations of the continent, to commemorate this IPY	Antarctic	education
246	Arctic biosphere–atmosphere coupling across multiple scales	Arctic	land

Project No.	Title	Geographical focus	Category
247	Bering Sea sub-network of community-based environmental monitoring, observation and information stations	Arctic	people
248	Arctic Indigenous Community-based Monitoring and Information Stations Network: Arctic Community-based Research Alliance	Arctic	people
251	Circumpolar monitoring of the biology of key-species in relation to environmental changes	Antarctic	ocean
256	Antarctic continental margin drilling to investigate Antarctica's role in global environmental change	Antarctic	Earth
257	Wildlife health: assessing the cumulative impacts of multiple stressors	Arctic	ocean
258	Multidisciplinary study of the Amundsen Sea Embayment	Antarctic	ice
259	Conservation hunting in the Arctic: an analysis of constraints and opportunities	Arctic	people
262	Response of Arctic and sub-Arctic soils in a changing Earth: dynamic and frontier studies	Arctic	land
266	Remote-sensing monitoring and forecast of surging glaciers' evolution with the investigation of modern fluctuations of surging glaciers of the Alaska, Svalbard and high elevated Asian glaciers	Arctic	ice
267	Comprehensive meteorological data set of active IPY Antarctic measurement phase for scientific and applied studies	Antarctic	atmosphere
275	Polar disturbance and ecosystem services: links between climate and human well-being	Arctic	people
276	Initial human colonization of the Arctic in changing palaeoenvironments	Arctic	people
282	The Nunavut Arctic Research and Educational Base Camp	Arctic	education
284	Development of a system of complex monitoring and elaboration of information-analytical system on protected natural areas of the polar zone	Arctic	land
285	Northern genealogies: development of an ethno-demographic informational system on the peoples of Siberia and the Russian North	Arctic	people
293	Arctic shelf tracking and physics array	Arctic	ocean
294	International Polar Year Circumpolar Exchanges — proposed exchanges of students and young northern professionals from Canada and other circumpolar countries during International Polar Year 2007–2008	Arctic	education
295	Popularization of northern scholarly articles for public interest	Bipolar	education
296	IPY histories: International Polar Year activities past and present, museum and virtual exhibitions	Bipolar	education
299	International summit and working group conference on the development and deployment of energy resources in the Arctic, including remote and rural villages	Arctic	education
300	Arctic biodiversity of chars — network for monitoring and research (revised)	Arctic	land
304	Seasonality of the Drake Passage pelagic ecosystem: biodiversity, food webs, environmental change and human impact, present and past	Antarctic	ocean
305	Consortium for coordination of observation and monitoring of the Arctic for assessment and research	Arctic	ocean
310	The impacts of oil and gas activity on peoples in the Arctic using a multiple securities perspective	Arctic	people
313	The Prydz Bay, Amery Ice Shelf and Dome A Observatories — a Chinese key international programme for IPY	Antarctic	ice
315	Tectonic map of the Earth's polar regions	Bipolar	education
318	TUNU-Programme: marine fishes of northeast Greenland — diversity and adaptation	Arctic	ocean
322	International Polar Year — a multi-tracer approach to study heat and salt fluxes through sea ice, pollutant transport and surface ocean hydrography	Arctic	ice

Project No.	Title	Geographical focus	Category
325	Marine and estuarine ecosystems in the eastern, central and western Canadian Arctic	Arctic	ocean
327	Intercontinental atmospheric transport of anthropogenic pollutants to the Arctic	Arctic	atmosphere
328	Integrated communication, education and evaluation	Bipolar	education
329	The Canadian Antarctic Research Program	Antarctic	land
330	International Polar Year: the search for the Franklin expedition: a new perspective based on Inuit oral tradition	Arctic	education
333	Arctic ocean diversity (ArcOD)	Arctic	ocean
336	IPY Global Snowflake Network (GSN)	Bipolar	education
337	Dynamics of circumpolar land use and ethnicity	Arctic	people
338	Arctic quest — Northwest Passage 100-year celebration	Antarctic	education
339	Measurement and attribution of recent Greenland Ice Sheet changes (MARGINS)	Arctic	ice
341	Taking the Antarctic Arctic polar pulse — IPY 2007–8 human biology and medicine research	Antarctic	people
343	Students on ice — IPY Youth expeditions to the Arctic and Antarctic	Bipolar	education
349	Course in Arctic wildlife medicine and welfare	Arctic	education
355	The economy of the North	Arctic	people
357	Spitsbergen Climate System Current Status — SCSCS	Arctic	atmosphere
367	Neogene ice streams and sedimentary processes on high-latitude continental margins	Bipolar	ice
372	Polar View: The Polar Information Centre	Bipolar	space
373	Carbon pools in permafrost regions	Bipolar	land
378	Impact assessment with indigenous perspectives	Arctic	education
379	IPY operational oceanography for the Arctic Ocean and adjacent seas	Arctic	ocean
384	Integrity of the traditional food system and environmental health in the circumpolar North	Arctic	people
385	Towards an international astronomical observatory at Dome C in Antarctica	Antarctic	space
386	Survey of living conditions in the Arctic — remote access analysis system	Arctic	people
388	Arctic Portal developed by Arctic Council and affiliates	Arctic	education
389	Yukon IPY Community Liaison	Arctic	education
390	Biodiversity and climate-induced lifecycle changes of Arctic spiders	Arctic	land
395	Building the next generation of polar scientists, engineers and logisticians by engaging youth from Nunavut and the Northwest Territories in International Polar Year activities	Arctic	education
396	Indigenous Peoples' Forum on Environmental Monitoring in the Arctic	Arctic	education
397	International Polar Year 2007–2008 @ Grand Valley State University	Bipolar	education
399	Reindeer herders vulnerability network study: reindeer pastoralism in a changing climate	Arctic	people
400	ANTLER Network secretariat and workshop series	Arctic	education
402	International school education on polar issues	Bipolar	education
405	Meltdown 3D/2D, a National Geographic giant screen film	Bipolar	education
408	Social-science migrating field station: monitoring the human–rangifer link by following herd migration	Arctic	land
410	Inuit voices: observations of environmental change	Arctic	education
411	Norwegian and Russian Arctic resources: prospects for social and economic development	Arctic	people



Project No.	Title	Geographical focus	Category
417	INTERPOLAR Trans-national Art Science Consortium	Bipolar	education
423	Pan-Arctic lake ice cover under contemporary and future climate conditions	Arctic	land
430	Pan-Arctic tracking of belugas	Arctic	ocean
431	ARCTEC: a cumulative effects toolbox for northern ecological and social systems	Arctic	people
432	The Phoenix Mars polar lander and Antarctic analog studies	Antarctic	land
433	Pressures and impacts on the health and well-being of indigenous people of the Arctic: invitational international symposium and symposium publication	Arctic	education
435	Culturally and scientifically significant materials recovered from melting ice and cryosols: recovery, research, stabilization and community education	Arctic	people
436	Moved by the State: perspectives on relocation and resettlement in the circumpolar North	Arctic	people
438	International Polar Year Arctic nations exhibition and activities including symposia, seminars, workshops, residencies, documentation and event coordination	Arctic	education
439	Temporal and spatial distribution of mercury and methyl-mercury source types, transfer and impact in the North American Arctic and sub-Arctic food web using seabird eggs and feathers	Arctic	ocean
440	Top, bottom and middle Earth: a popular book about the importance of the poles to the global environment, economy and society	Bipolar	education
441	Bringing the poles to life	Bipolar	education
443	The use of radionuclides and other contaminants as tracers of climate change effects in the North	Bipolar	atmosphere
446	Circumpolar Indigenous Youth Conservation Project	Arctic	education
448	People and wilderness resources in arctic. Is local subsistence harvest and exclusive wilderness tourism a road to sustainable well-being or a source of conflict?	Arctic	people
451	Antarctic touring exhibition	Antarctic	education
452	Internationally coordinated studies on Antarctic environmental status, biodiversity and ecosystems	Antarctic	land
453	IPY Polar gateways: IPY education and outreach centres in polar communities	Bipolar	education
454	Enhancing the environmental legacy of IPY in Antarctica	Antarctic	education
455	IGLO (International action on global warming)	Bipolar	education
456	Practical applications for sustainable development in Arctic communities	Arctic	people
457	Ice stories: educational resources for the International Polar Year	Bipolar	education
459	Ice Cube South Pole Neutrino Observatory	Antarctic	space
460	Cape Farewell, the science, education and culture of climate change	Arctic	education

# Acronyms

AMAP	Arctic Monitoring and Assessment Programme
DIS	Data and Information Service
GPS	Global Positioning System
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
ICESTAR	Interhemispheric Conjugacy Effects in Solar–Terrestrial and Aeronomy Research
ICSU	International Council for Science
InSAR	Interferometric analysis of satellite synthetic aperture radar data
IOC	Intergovernmental Oceanographic Commission
IPY	International Polar Year
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
OAR	Office of Oceanic and Atmospheric Research
PMEL	Pacific Marine Environmental Laboratory
SCAR	Scientific Committee on Antarctic Research
THORPEX	The Observing System Research and Predictability Experiment
WCRP	World Climate Research Programme
WMO	World Meteorological Organization