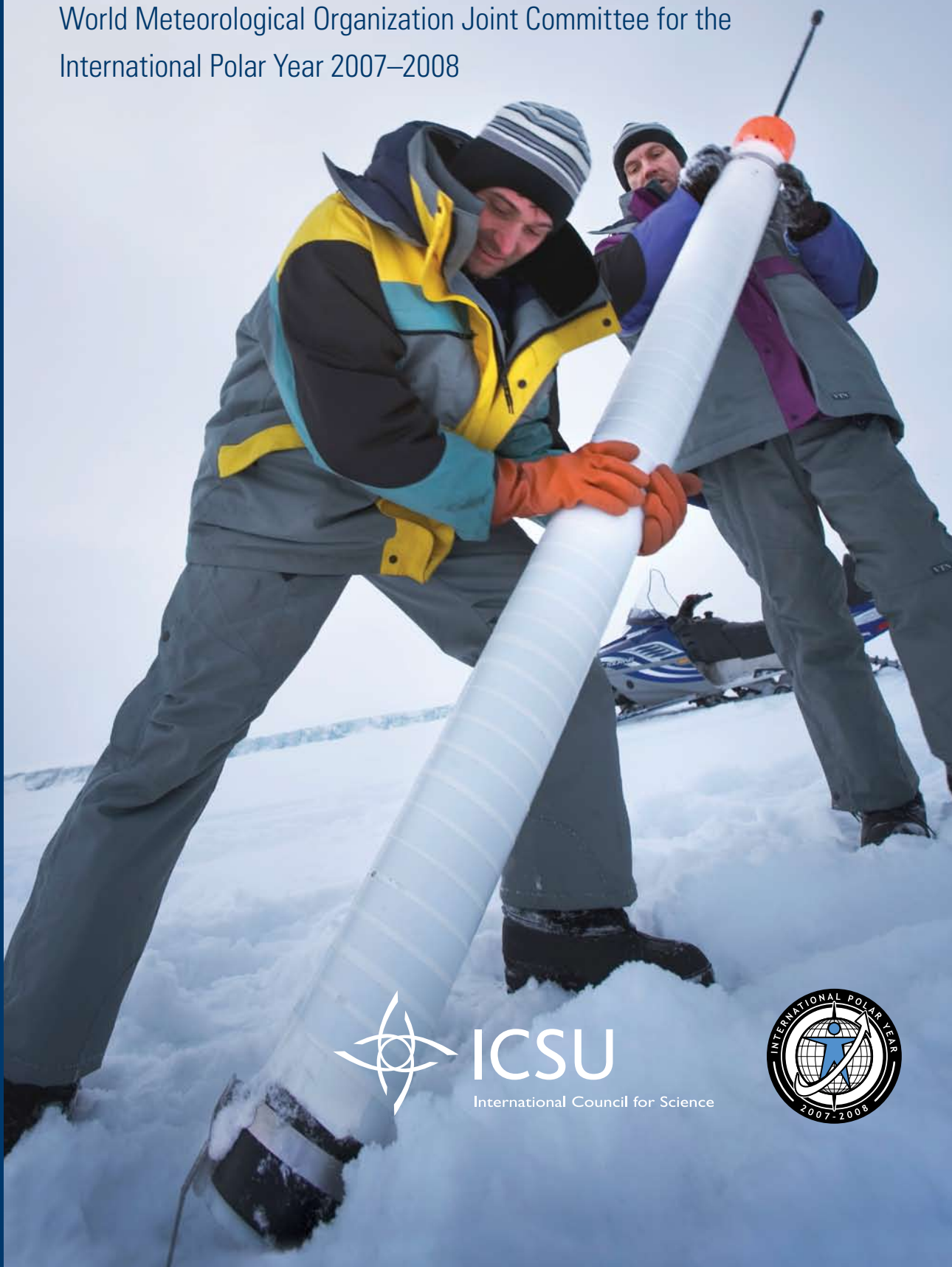


# The State of Polar Research

A Statement from the International Council for Science/  
World Meteorological Organization Joint Committee for the  
International Polar Year 2007–2008



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Chairperson, Publications Board  
World Meteorological Organization (WMO)  
7 bis, avenue de la Paix  
P.O. Box 2300  
CH-1211 Geneva 2, Switzerland

Tel.: +41 (0) 22 730 84 03  
Fax: +41 (0) 22 730 80 40  
E-mail: [publications@wmo.int](mailto:publications@wmo.int)

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# The State of Polar Research

A Statement from the International Council for Science/  
World Meteorological Organization Joint Committee for the  
International Polar Year 2007–2008

By: Ian Allison and Michel Béland (Co-Chairs), Keith Alverson, Robin Bell, David Carlson,  
Paul Cutler, Kjell Danell, Cynan Ellis-Evans, Eberhard Fahrbach, Grete Hovelsrud,  
Johannes Huber, Vladimir Kotlyakov, Igor Krupnik, Jerónimo Lopez-Martinez, Tillmann Mohr,  
Helena Odmark, Dahe Qin, Volker Rachold, Chris Rapley, Odd Rogne, Eduard Sarukhanian,  
Colin Summerhayes, Takashi Yamanouchi

February 2009



## Overview

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The International Polar Year 2007–2008 (IPY) was an intensive, internationally coordinated scientific research campaign in the Arctic and the Antarctic sponsored by the International Council for Science (ICSU) and the World Meteorological Organization (WMO).

In two action-packed years, IPY researchers observed exciting new phenomena, made fundamental scientific discoveries, developed new methods and tools, advanced interdisciplinary and international links in polar science and, most importantly, gained new understanding of the role of the polar regions in the total Earth system.

IPY 2007–2008 took place during a time when our planet was changing faster than ever in recorded human history, especially in the polar regions. Polar changes are critical because of various feedbacks involving the ocean, the cryosphere and/or the biosphere, each of which has the potential to accelerate the rates of global changes. The need for polar research has never been greater.

## International Polar Year 2007–2008

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IPY highlighted the global importance of polar processes and the urgent need to understand and track the extremely rapid changes occurring at high latitudes. It resulted in a plethora of research activities and observations that would not have otherwise occurred, all underpinned by a mutual appreciation of the value of shared logistical facilities, research capabilities and data. The planners of IPY<sup>1</sup> set four major goals:

- Make major advances in polar knowledge and understanding;
- Leave a legacy of new or enhanced observational systems, facilities and infrastructure;
- Inspire a new generation of polar scientists and engineers;
- Elicit keen interest and participation from polar residents, schoolchildren, the general public and decision-makers worldwide.

IPY has emerged as the largest internationally coordinated planetary research effort in the past 50 years. It has engaged the intellectual resources of thousands of scientists – many more than expected and often from non-polar countries – representing an unprecedented breadth of specialties, from geophysical to biological to social sciences. IPY has been a truly international, interdisciplinary endeavour with over 160 endorsed science projects assembled from the ideas of researchers in more than 60 countries. Substantial new funding – more than US\$ 400 million – was pledged for IPY, which coordinated with and supplemented ongoing polar research and monitoring programmes. In addition, novel system-level approaches, and observational and analysis technologies, including in situ and remote-sensing, were fundamental features of IPY science.

Many IPY projects and their offspring will continue beyond the formal observational period, which ends in March 2009.

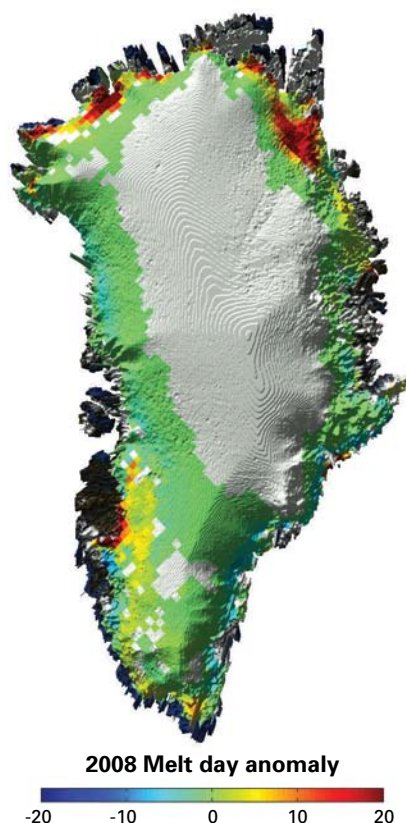
## IPY scientific advances

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IPY has laid the foundation for major scientific advances in knowledge and understanding

<sup>1</sup> Rapley, C., R. Bell and the ICSU IPY 2007–2008 Planning Group, 2004: *A Framework for the International Polar Year 2007–2008*. ICSU, Paris.

Figure 1. Extreme snowmelt during summer 2008 over the northern part of the Greenland ice sheet, based on the analysis of microwave data recorded by the Special Sensor Microwave Imager (SSM/I) on board the F13 satellite of the United States of America Defense Meteorological Satellite Program. Colours indicate the 2008 melt day anomaly for Greenland, that is, the number of days in 2008 with surface melt minus the average melt number for 1979–2007. Red areas in northern Greenland indicate where extreme melting occurred and new records were set. Green colours represent areas where melt days were close to the seasonal average, with no large anomalies.



of the polar regions and their role in the functioning of our planet. The full scientific legacy of IPY will evolve in the years and decades following the completion of the observational programme described in the IPY Science Plan.<sup>2</sup> Already however, significant advances in scientific knowledge and understanding have begun to emerge. Just a few of the early discoveries and achievements are summarized here.

New assessments of the state of the Greenland and Antarctic ice sheets have been made using novel techniques. These include

satellite measurements of changes to the elevation and the gravitational fields of the ice sheets, and estimates of the difference between snow input (from high-resolution meteorological models) and ice discharge (from satellite measurements of ice-sheet velocities and thickness at the coast). These assessments continue to be refined, but it now appears certain that both the Greenland and the Antarctic ice sheets are losing mass and thus raising sea level, and that the rate of ice loss from Greenland is growing. (See Figure 1.) Part of the loss is due to increased ice outflow, and the potential for these ice sheets to undergo further rapid ice discharge remains the largest unknown in projections of the rate of sea-level rise by the Intergovernmental Panel on Climate Change. New data also confirm that warming in the Antarctic is much more widespread than was thought prior to IPY.

During international traverses across Antarctica, scientists have resurveyed regions unvisited for 50 years and gathered numerous shallow ice cores and snow samples to better understand accumulation and ablation processes and recent variability in the surface net mass balance of the central Antarctic ice sheet. They have also investigated processes of aerosol and gas exchange between the atmosphere and the snow surface to better interpret how signals of regional and global environmental variability are locked into the ice core record. Airborne surveys, using sophisticated ice-penetrating radar and other geophysical systems, have been used on a scale not seen since the International Geophysical Year (IGY) 1957–1958 to map characteristics of the ice and underlying bedrock over vast areas of Antarctica and Greenland. For the first time, these collaborative surveys have reached places that no single nation could reach alone. Most importantly, the new images of the ice sheet and the underlying terrain resulting from these programmes will help produce

(Source: Tedesco, M., X. Fettweis, M. Van Den Broeke, R. Van De Wal and P. Smeets, 2008: Extreme snowmelt in northern Greenland during summer 2008. *Eos*, 89(41): 391, 7 October 2008. Available at <http://forum.sci.cuny.cuny.edu/Members/mtedesco/cryosenslab/greenland2008melting>.)

<sup>2</sup> Allison, I., M. Béland and the ICSU/WMO Joint Committee for IPY 2007–2008, 2007: *The Scope of Science for the International Polar Year 2007–2008*. WMO/TD-No. 1364, World Meteorological Organization, Geneva.

accurate models to predict future changes to the ice sheets.

During IPY, the summer minimum extent of Arctic perennial sea ice decreased by roughly one million square kilometres to its minimum extent since satellite records began. In addition, the North Pole region was covered only in relatively thin first-year ice in mid-winter for the first time in the observational record. IPY expeditions recorded an unprecedented rate of ice drift across the Arctic basin, providing compelling evidence of changes in the Arctic ice–ocean–atmosphere system.

Intensive multi-ship surveys of the Southern Ocean have uncovered a remarkably rich, colourful and complex range of life, greatly extending our knowledge of polar biodiversity. As a result of these surveys, two areas, each around 400 square kilometres, have been recognized as vulnerable marine ecosystems under the Convention on the Conservation of Antarctic Marine Living Resources, and placed on an international register for protection. Interdisciplinary studies of Antarctic sea ice have revealed that the physical characteristics of the ice and the adjacent ocean play an important role in controlling primary productivity in marine ecosystems.

Marine and terrestrial ecologists have continued to unravel the fascinating and complex patterns of geographical distribution of polar organisms and their interaction with their environment. Some microbial species occur in nearly identical form in both Arctic and Antarctic ecosystems, while other species have developed very differently in these two environments. Some polar organisms have evolved and expanded their ranges to distant latitudes: for example, new evidence from IPY shows that many present-day deep-sea octopuses originated from common ancestor species that still survive in the Southern Ocean. (See Figure 2.) IPY studies of present-day

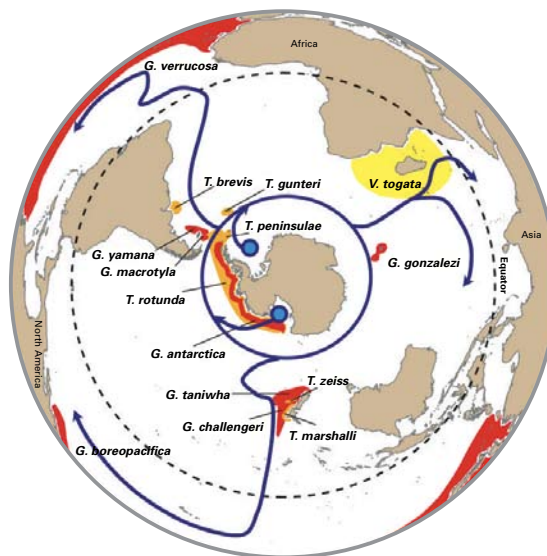


Figure 2. Distribution of deep-sea octopus species showing the southern focus of their distribution. This includes all species of *Graneledone* (red), *Thaumelodone* (orange) and *Velodona* (yellow), according to the most recent taxonomic revisions of each group. The deep-sea octopus lineage had its evolutionary origins in Antarctica around 33 million years ago (Ma), coincident with the development of an Antarctic Circumpolar Current and a continent-wide ice sheet on Antarctica. The deep-sea octopus lineage then radiated northward into other ocean basins starting at 15 Ma, a time of increased deep-water production near Antarctica and enhanced global thermohaline circulation. Blue lines indicate schematic pathways of the Antarctic Bottom Water flows of the thermohaline circulation using the Lambert azimuthal equal-area projection.

(Source: Strugnell, J., A. Rogers, P. Prodhöhl, M. Collins and A. Allcock, 2008: *The thermohaline expressway: the Southern Ocean as a centre of origin for deep-sea octopuses*. Cladistics 24: 1–8.)

ecosystems have also documented recent poleward migrations of terrestrial and marine species in response to global warming.

New evidence of the global warming rate also comes from other IPY projects. Data from robotic ocean-profiling floats, instrumented marine mammals and IPY research vessels confirm that the Southern Ocean, particularly the southern flank of the Antarctic Circumpolar Current, has warmed more rapidly than the global ocean average. In addition, the dense bottom water formed near Antarctica has freshened in some locations and warmed in others. The freshening is consistent with increased melt from the Antarctic ice shelves and ice sheet. These changes are signs that global warming is affecting the Antarctic in ways not previously suspected.

Studies of stratospheric ozone in both hemispheres have shown the impact of enhanced exposure to ultraviolet irradiation on marine and terrestrial ecosystems. In addition, a complicated picture has emerged of the interconnections between ozone concentrations above Antarctica, the size and intensity

of the polar vortex and the wind conditions and storm frequencies at the surface over the Southern Ocean and around the Antarctic perimeter. This knowledge will enable us to refine models associating global warming and ozone depletion, and to predict future change more accurately. In the North Atlantic, subtle changes in ocean conditions and in the fluxes of heat and momentum between the atmosphere and the ocean have been shown to play a strong role in the eventual strength and trajectories of major storms. Observations and modelling by IPY researchers have revealed that these storm systems represent the major atmospheric inputs of heat and moisture to the Arctic. This knowledge will improve forecasting the paths and intensities of storms. Other teams have made progress in understanding the role of Arctic stratus clouds and aerosols, recognized as the largest source of uncertainty in current

climate models. IPY researchers have also investigated the fate and transport of persistent organic pollutants into the Arctic, where they play a major role in contaminating the food chain.

Over 30 IPY projects addressed Arctic social and human science issues. These included studies of the well-being of local communities, use of natural resources, economic and social development, local ecological knowledge and preservation of natural, historical and cultural heritage. Many involved indigenous and local groups and organizations as partners or leaders, particularly those looking at community responses and adaptations to rapid climate and socio-economic changes. Several local communities have joined IPY monitoring networks to collect, exchange and document observations of changes in sea ice, biota, weather and climate. IPY researchers

Collecting samples of young ice and seawater from a crane cage of the Canadian research icebreaker *Amundsen* to investigate the behaviour and transport of mercury in the Arctic Ocean



also studied Arctic human health issues, including diseases such as tuberculosis; food security; traditional food sources; the impact of global contaminants and new risks to Arctic residents. (See Figure 3.)

IPY has documented substantial changes caused by global warming in the type and extent of vegetation in the Arctic. These included transitions from grasses to shrubs, changes in the types of wetlands, shifts in treelines related to alteration in patterns and timing of snowfall, modification of soil structure and increases in infestation by insects and fungi. These landscape changes affect grazing animals and hunting. The change in timing of the type and in the amount of winter precipitation (rain or snow) presents a major new challenge to traditional reindeer herders in north-western Europe, whereas reindeer herds farther east are increasingly experiencing stress from loss of pasture and blockage of migration routes due to land-use change and infrastructure developments.

Pools of carbon stored in permafrost, which are larger than previously estimated, have been identified during broad-scale IPY observations. These are perhaps more likely to reach the atmosphere as additional greenhouse gases as warming continues, although the patterns of vegetation and permafrost change vary widely across the Arctic. Modelling studies completed during IPY suggest that terrestrial permafrost degrades much faster than expected when sea ice disappears. IPY research cruises along the Siberian coast observed substantial out-gassing of methane from ocean sediments.

The rapid pace of scientific advance and our increasing awareness of humankind's impact on the Earth system as a whole suggest that research and data from IPY 2007–2008 will leave a lasting legacy in many fields of science, particularly in providing a clearer

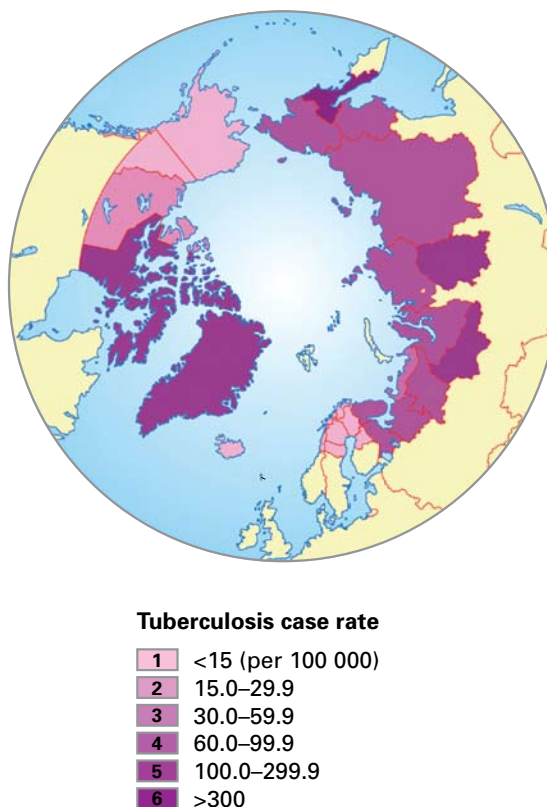


Figure 3. Variation in incidence rates of active tuberculosis cases among northern regions. For comparison, much lower rates for the same period (2000–2004) were recorded for the full populations of Sweden (4.9 per 100 000), the USA (5.3) and Canada (5.4).

(Source: Young, T. K. and W. Dallmann, 2008: *Circumpolar health indicators: sources, data and maps*. Circumpolar Health Supplements 2008; 3. International Association of Circumpolar Health Publishers.)

picture of what future changes may occur and what effects they may have.

### Creating an IPY legacy

The planners of IPY 2007–2008 intended that it would pave the way for a new era of scientific progress in knowledge and understanding of the polar regions, and leave a vital legacy of sustained observing systems, increased international research coordination and collaboration, stronger links between researchers across different disciplinary fields, reference datasets for comparison with the future and the past, the development of a new generation of enthused polar researchers, and full engagement and understanding of the public

Helicopter mission to study the dynamic processes of the Arctic marine ecosystem affecting the habitats of ringed seals and polar bears. The craft is equipped with an electromagnetic induction system that measures the thickness and roughness of sea ice.



and decision-makers worldwide in the purpose and value of polar research.<sup>3</sup>

In addition, IPY 2007–2008 has advanced the participation of Arctic residents, including indigenous peoples, in polar science at all levels. These developments will enable future research to make maximum use of indigenous knowledge and for indigenous communities to benefit from scientific advances.

#### **Observational systems, facilities and infrastructure**

Observing systems for monitoring change are essential for validating and improving predictions, especially of future global warming

and its impacts. An unprecedented expansion of ice, ocean, atmosphere, coastal and land observations was made in the Arctic region during IPY. A similar enhancement of ocean and ice observations also took place in the Antarctic. Many national and international organizations are making plans to sustain improved polar observing systems. Ongoing work on the Sustaining Arctic Observing Networks and the Southern Ocean Observing System is closely integrated with global observational initiatives. New national and international data systems and increased coordination across systems are helping lay a foundation of data sharing, access and preservation as more IPY data come online.

#### **Scientific and political cooperation**

Owing to the common interest in polar science during IPY, the links between science and the

<sup>3</sup> Rapley, C., R. Bell and the ICSU IPY 2007–2008 Planning Group, 2004: *A Framework for the International Polar Year 2007–2008*. ICSU, Paris.

political frameworks provided by the Antarctic Treaty System and the Arctic Council have been strengthened. The heightened level of political attention and financial support has enhanced opportunities for direct international scientific collaboration, facilitated polar access and effective international sharing of polar logistical assets and infrastructure, accelerated the exchange of technological information and improved reporting from nationally supported operational networks. It has also increased connections and collaboration among polar science organizations, such as the Scientific Committee on Antarctic Research and the International Arctic Science Committee, as well as with non-polar science organizations. As a result, the findings of IPY science have attracted the interest of the Antarctic Treaty System and the Arctic Council.

#### **Cross-disciplinary collaboration, synthesis and integration**

The very complexity of the Earth system, in which physics, biology, chemistry and geology all interact, demands an interdisciplinary approach to advance understanding and improve predictions of the future. The science scope of this IPY was remarkably different from that of its predecessors and other large-scale science programmes in polar research. Dedicated efforts were made to include synthetic cross-disciplinary studies and projects exploring the human dimension, ecological diversity, and community and ecosystem health. For the first time in IPY-IGY history, physical, natural, social and humanistic scientists and local community-based experts worked together under a common multidisciplinary science programme. This new form of cross-disciplinary collaboration is widely perceived as a lasting achievement of IPY. It marks an extraordinary advance in our perception of the complexities of the polar regions and of the importance of synthesis, knowledge integration and data sharing in

the understanding of processes that affect our planet.

#### **Reference data**

In both hemispheres, and throughout the IPY period, enhanced international coordination and cooperation among space agencies have produced an extraordinary quantity and quality of satellite observations of polar regions. These, and many other broad-ranging and easily accessible reference data on the status of the polar regions that IPY provides, will be crucial for comparisons with the future and the past.

#### **A new generation of polar scientists and engineers**

IPY has offered an opportunity to hundreds of graduate students and post-doctoral researchers in many specialties to be trained to meet new polar challenges. In many countries this surge represents the largest ever recruitment of new polar scientists. An international group of motivated and energetic young researchers has established the interdisciplinary Association of Polar Early Career Scientists, which offers and promotes career development, collaboration, leadership, and education and outreach tools and opportunities. The leading Antarctic and Arctic polar science organizations, the Scientific Committee on Antarctic Research and the International Arctic Science Committee, respectively, have formally recognized the Association as a vital long-term partner.

#### **Broad public interest and participation**

Enhancing investment in polar research for the benefit of all can only be achieved through the political will that comes from greater public understanding. IPY outreach efforts have contributed to increased public attention on climate and environmental

Woods Hole Research Center scientist Max Holmes with students from Zhigansk, Siberia, a predominately Evenki community along the Lena River. Students and teachers from Zhigansk, as well as additional participants from communities located along other large Arctic rivers in the Russian Federation, Canada and Alaska, work with IPY scientists to investigate the impact of climate change on Arctic rivers and their watersheds as part of the Student Partners Project.



issues and improved public awareness of the connections between polar regions and the rest of the planet.

IPY has attracted extensive media coverage. Explicit education and outreach components embedded in IPY science projects – coupled with dedicated funding for education, outreach and communication activities in several nations – have produced new, high-quality educational, outreach and communication initiatives and networks. Through many publications, exhibitions, films, web pages and lectures, the scientists participating in IPY have enlightened a broad audience around the world about the importance of the polar regions.

International outreach networks have been established largely through IPY Polar Science Days and other internationally coordinated IPY events. These networks include many

links to northern communities and play an important role in involving them in the continuing analysis and assessment of IPY outcomes and impacts.

### **Engagement of Arctic residents, including indigenous peoples**

IPY has advanced the participation of Arctic residents, including indigenous peoples, in large-scale interdisciplinary science in their own region. For the first time, Arctic residents and their organizations have acted as full partners and leaders in international projects involving scholars from many nations and disciplines, research planning, data collection, management, analysis and outreach. The contributions, observations and knowledge of Arctic residents have proven key to the success of several IPY studies on the dynamics of sea ice, weather, changes in habitat and wildlife distribution, the sustainability of local economies, public health and community well-being. This legacy of partnership has built a solid foundation for the engagement of Arctic residents and indigenous peoples in future large-scale science projects.

### **An urgent need for further polar research**

IPY has demonstrated the benefits of an enhanced level of support for polar research into the future, as well as the absolute necessity to establish comprehensive and sustainable long-term polar observing systems.

The pressing need for further polar research provides the motivation for a sustained high level of public awareness of the polar regions, significant national and international commitments to funding and operational support, ongoing global data stewardship, and recruitment and training of promising young researchers who are needed to carry the work forward.

The following research challenges will have great societal relevance and urgency beyond IPY:

- Rapid climate change in the Arctic and in parts of the Antarctic;
- Diminishing snow and ice worldwide (sea ice, glaciers, ice sheets, snow cover, permafrost);
- The contribution of the great ice sheets to sea-level rise and the role of subglacial environments in controlling ice-sheet dynamics;
- Global climate impacts of changes to ocean circulation;
- Loss of biodiversity and changing ecosystem patterns and ranges;
- Methane release to the atmosphere from melting permafrost;
- Improved projections and forecasts from integrated coupled climate and weather models;
- Global transport of pollution and contamination to the polar regions and consequent impacts on environments, humans and ecosystems;
- Health and well-being of Arctic residents and Arctic communities.

### Recommendations for the way forward

The next two to four years will be a crucial time for polar research. IPY projects must produce individual and integrated results in a timely and high-impact manner. A key objective should be to maximize the input of

IPY research to the upcoming assessments of the Intergovernmental Panel on Climate Change and the deliberations of the United Nations Framework Convention on Climate Change. These include the thirtieth session of the Subsidiary Body for Scientific and Technological Advice to be held in Bonn in June 2009, when the adequacy of the existing terrestrial, atmospheric and oceanographic observing systems for climate will be assessed, and the fifteenth Conference of the Parties to take place in Copenhagen in December 2009, when an agreement on commitments for the post-Kyoto Protocol period after 2012 should be concluded. Major IPY conferences in 2010 (Norway) and 2012 (Canada) will provide additional milestones in assessing and reporting IPY accomplishments and shaping future directions for polar research.

Integrating the initial IPY results among projects and across disciplines to achieve system-level understanding and ensuring accessible archiving of IPY data remain substantial tasks for the immediate post-IPY period.

Increasing operational costs and global economic pressure on national research and development budgets will compound the challenge for politicians and science-funding organizations of maintaining and expanding polar research programmes. Nevertheless, the urgent need to understand the global impact of polar changes will remain, not least because climate change is affecting the polar regions more and faster than the rest of the globe.

Far-reaching scientific, public and political enthusiasm for IPY offers an excellent and unique basis for developing polar research in support of better understanding of the role of polar systems in the sustainable development, not only of those regions, but of the whole planet.

Starting now, and within the next decade, which could well be designated the International Polar Decade, internationally coordinated action is needed to achieve the following goals:

- Rapidly provide IPY data and outcomes as contributions to global and polar-specific integrated assessments;
- Preserve, store and exchange reliable, accessible, long-term IPY data;
- Identify stable long-term locations for the many networks and programmes established during IPY;
- Set up or enhance multidisciplinary sustained long-term observing systems in polar regions;
- Develop integrated climate–ecosystem–economic prediction capabilities

for polar regions and regional prediction capabilities for specific areas of the Arctic and Antarctic;

- Continue to focus attention on polar research and polar issues at the highest levels of international science organizations.

All of these will, of course, require sustained and expanded support and funding for polar research, particularly to ensure maximum exploitation and impact of IPY efforts.

The polar regions are an integral and rapidly changing part of the Earth system. Humankind's future environment, well-being and sustainable development require that we comprehensively understand and observe polar systems and processes and the changes that are already upon us. The message of IPY is loud and clear: what happens in the polar regions affects the rest of the world and concerns us all.





For more information, please contact:

**World Meteorological Organization**

7 bis, avenue de la Paix – P.O. Box 2300 – CH-1211 Geneva 2 – Switzerland

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

**Communications and Public Affairs Office**

Tel.: +41 (0) 22 730 83 14 – Fax: +41 (0) 22 730 80 27

E-mail: [cpa@wmo.int](mailto:cpa@wmo.int)