

SPARC and the International Polar Year (IPY) 2007–2008

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What is IPY?

Nearly 150 years ago, 13 nations joined forces for the first internationally co-ordinated programme of scientific exploration in the polar regions during the International Polar Year 1882-1883. Beyond the advances in science and geographical exploration, a principal legacy of the first IPY was that it set a precedent for international science co-operation. In 1904 the first permanent Antarctic station was established by the government of Argentina at Orcadas/South Orkneys to carry out research (including weather monitoring) and other activities in the region. This base still continues its scientific activities.

Following the successful IPY, the International Meteorological Organization promoted the second IPY in 1932–1933 to investigate the global implications of the newly discovered jet stream. Some 40 nations participated in the second IPY, which heralded advances in meteorology, atmospheric sciences, geomagnetism, and the “mapping” of ionospheric phenomena. In the years following World War II, many nations increased the number of permanent and semi-permanent stations and bases in both polar regions, thus providing many of the long term weather datasets that are crucial to our understanding of polar weather and climate processes and their relationship with the rest of the world.

Scientists again decided that an international science year was warranted to utilize the new technologies of the era. This time, the scope of the effort was global, and 67 nations participated in the International Geophysical Year (IGY) in 1957-1958. The IGY led to an increased level of research in many disciplines, and the scientific, institutional, and political legacies of the IGY endured for decades, in many cases to the present day. IGY helped consolidate the engagement of many countries in sustained Antarctic research.

Today, nations around the world are planning for a new International Polar Year in 2007-2008. This IPY will be far more than an anniversary celebration of the IGY or previous IPYs; it will be a watershed event and will use today’s powerful research tools to better understand the polar regions. Automatic observatories, satellite-based remote sensing, autonomous vehicles, the Internet, and genomics are just a few of the innovative approaches for studying previously inaccessible realms. IPY 2007–2008 will be fundamentally broader than the IGY and past IPYs

because it will explicitly incorporate multidisciplinary and interdisciplinary studies, including biological, ecological, and social science elements. Such a program will not only add to our scientific understanding, but will also assemble a world community of participants with shared ownership in the results.

IPY 2007–2008 will provide a framework and impetus to undertake projects that normally could not be achieved by any single nation. It will allow us to think beyond traditional borders — whether national borders or disciplinary constraints — toward a new level of integrated, cooperative science. A coordinated international approach maximizes both impact and cost effectiveness, and the international collaborations begun today will build relationships and understanding that will bring long-term benefits. Within this context, IPY 2007–2008 will seek to galvanize new and innovative observations and research while at the same time building on and enhancing existing relevant initiatives, many of which have been subject to dwindling budgets and cancellations in recent years despite their relevance for long term monitoring. In addition, there is clearly an opportunity to organize an exciting range of educational and outreach activities designed to excite and engage the public, with a presence in classrooms around the world and in the media in varied and innovative formats.

IPY 2007–2008 Organization

IPY 2007–2008 is organized around six themes. Its broad goals are:

- § To determine the present environmental status of the polar regions by quantifying their spatial and temporal variability;
- § To quantify, and understand, past and present environmental and human change in the polar regions in order to improve predictions;
- § To advance our understanding of polar–global interactions by studying teleconnections on all scales;
- § To investigate the unknowns at the frontiers of science in the polar regions;
- § To use the unique vantage point of the polar regions to develop and enhance observatories studying the Earth's inner core, the Earth's magnetic field, geospace, the Sun and beyond; and
- § To investigate the cultural, historical, and social processes that shape the resilience and sustainability of circumpolar human societies, and to identify their unique contributions to global cultural diversity and citizenship.

The IPY International Programme Office is hosted by the British Antarctic Survey in Cambridge, UK. The office provides planning, coordination, and guidance to 25 international organizations that support IPY, as well as 28 national IPY committees. In January 2005 the office received over 900 “Expressions of Intent” from the international research community, including one EoI from SPARC. SPARC-IPY was recognized by the IPY Joint Committee as having the “potential to

make a major contribution to the IPY," and is expected to "clearly contribute to significant international collaboration." SPARC was invited to submit a full proposal, due in June 2005. While the IPY office will coordinate the research efforts, it does not fund the research. Funding is left to national and international funding agencies.

Although IPY 2007–2008 is oriented toward the polar surface environment, it also emphasizes connections to other regions as well as the solid Earth below and the atmosphere above.

Connection Between Polar Climate and the Stratosphere

There is a strong dynamical connection between the circulation of the high-latitude stratosphere, and surface weather and climate. In particular, stratospheric wind anomalies tend to progress downward to the lowermost stratosphere (near 10 km), and then induce changes to the Arctic Oscillation (AO) pattern, which is similar to the NAO (North Atlantic Oscillation). Our understanding of the mechanisms is advancing, but it is still incomplete. Over the Arctic, the phase of the AO affects surface winds, temperature, sea-ice motion, and ice extent. There appears to be a memory in summer sea-ice of the previous winter's AO, and part of the observed thinning of sea-ice can be attributed to long-term changes in the AO.

In the Southern Hemisphere (SH), observations and models show that the springtime stratospheric ozone hole has not only been linked to cooling of the lower stratosphere and strengthening of the circumpolar winds within the stratospheric polar vortex, but that these changes have induced surface circulation and temperature changes over Antarctica — changes lasting well into the summer. During spring and summer, the lower stratosphere at southern mid latitudes has in turn undergone changes linked to the changes over Antarctica. Although chlorofluorocarbons (CFCs, now banned by international agreement) are largely responsible for current ozone depletion, increasing concentrations of greenhouse gases like carbon dioxide and methane may delay future ozone recovery.

As greenhouse gases increase, the circulation of the stratosphere will likely be affected. But we are not able to predict whether high-latitude stratospheric winds will become stronger or weaker a few decades from now. Such a trend — positive or negative — is expected to affect the AO at the Earth's surface. On climate-change timescales, stratospheric effects are potentially large, and understanding how the stratosphere will change, as well as how the stratosphere and troposphere are coupled, will contribute to reducing that uncertainty.

Trends and variability in the AO — including changes in the stratospheric circulation — would affect the lifetimes of natural greenhouse gases such as methane and N₂O, as well as of anthropogenic greenhouse gases such as CFCs or

their replacements, since the removal of all of these gases requires, at least in part, transport through the stratosphere. Changes in lifetimes of greenhouse gases could themselves result in a forcing of the stratospheric circulation. It is uncertain to what degree ozone would be affected, since ozone acts not only as an ultra-violet filter but in a multifaceted manner as a greenhouse gas. Global, and in particular, polar ozone concentrations might respond sensitively to the circulation changes as well as to changes in ozone destroying trace gases resulting from the degradation of CFCs, N₂O and methane.

Trends and variability in the AO are further reflected in ecosystem changes, and feedback from ecosystem changes could be manifested in the stratosphere as well as the troposphere. Here one research topic would be to study whether changes in permafrost and wetlands are consistent with AO signals, investigating the effects of temperature and precipitation changes on methane fluxes and then estimating how these fluxes will change with time based on AO trends, including the possibility of enhanced production of water vapor in the stratosphere due to methane oxidation.

This question of changes in stratospheric water vapour by any mechanism is extremely important because it has been posited that increased stratospheric water vapor due to either large methane releases or decreased latitudinal temperature gradients may have led to an increase in the frequency and thickness of polar stratospheric clouds and drastically changed the radiative balance in the Arctic during the Eocene (55–40 million years ago), with large feedbacks on high-latitude temperatures. Since both of these mechanisms for increasing stratospheric water vapour may be present in the climate of the near-future, it is essential to try to determine the magnitude of the changes that may take place.

Weather in southern-most countries like Australia, New Zealand, Chile, and Argentina is strongly influenced by Antarctic atmospheric processes. Even South Africa and Brazil occasionally suffer cold spells of Antarctic origin in winter. The future evolution of climate in those countries and over the southern oceans is thus strongly linked to the changes that will take place in the Antarctic troposphere and stratosphere. Some of the richest fisheries and marine ecosystems in the world could suffer major impacts from changes in Antarctic climate, affecting the current state of biogeochemical cycles, marine food chains and fishing activities.

SPARC's Contribution to IPY

Because IPY will occur over a short time period, SPARC will focus on details of the polar stratosphere in a program called "The structure and evolution of the stratospheric polar vortices during IPY and its links to the troposphere."

The Antarctic ozone hole is one of the most recognized environmental issues of the 20th century. Ozone changes in the Arctic, though lesser in magnitude, are

equally important. Recent research has shown that the evolution of stratospheric ozone is tightly coupled to a wide range of processes acting within and outside the winter polar vortices. Much of this understanding has been achieved within the SPARC programme. The IPY programme offers a unique opportunity for SPARC to assemble a range of scientific expertise to study the Antarctic and Arctic Polar Vortices, the loci of key processes associated with ozone depletion and its eventual recovery, as well as contribute towards a better understanding of the coupling mechanisms between the troposphere and the stratosphere.

SPARC-IPY will co-ordinate the activities of the international SPARC community in relation to IPY. This co-ordination will be directed toward both satellite and ground-based experimental campaigns, as well as specific initiatives promoted by SPARC to increase understanding of the polar atmosphere. The services of the SPARC Data Center will be made available to facilitate acquisition and archiving of key data that will be used for projects or generated by them during the IPY period.

In addition to coordinating and facilitating IPY projects within the SPARC community, SPARC-IPY will promote specific initiatives directed toward the understanding of major features and processes in the polar middle atmosphere during the IPY period. These initiatives will include a range of research activities involving modelling, observations, and analysis, and will include workshops and meetings as needed or desirable to facilitate research and dissemination of results. These efforts will be carried out in context of the SPARC Project core thematic programmes of Stratospheric Chemistry and Climate, Stratosphere-Troposphere Coupling, and Detection, Attribution, and Prediction of Stratospheric Changes.

The dynamics, transport and chemistry of the polar vortices, as well as of properties relevant to microphysical processes, such as the formation of polar stratospheric clouds, will be documented as completely as possible. To achieve this detailed picture, SPARC-IPY will bring together available research and operational satellite data, as well as ground-based and aircraft data. SPARC-IPY will promote co-ordinated field campaigns to enhance the database, and encourage work on data assimilation and intercomparison of assimilated datasets to yield a unique synthesis of data on the polar vortices. Weather services carrying out routine radiosonde and ozonesonde measurements would be encouraged to increase the frequency of the observations and to store the data with full resolution.

Observations of a range of variables within the stratospheric polar vortex will be used, together with data assimilation, models and other analysis techniques to create a coherent and comprehensive picture of the current state of the stratosphere in the Arctic and Antarctic, and to elucidate further the interaction of the polar stratosphere with the underlying troposphere.

The project will involve the multi-national SPARC community and its affiliates, e.g. other WCRP research projects. SPARC-IPY will co-ordinate relevant field campaigns supported by national and international research programmes, and will seek, where possible, to promote additional campaigns where there are data gaps that need to be filled. As a core project within the WCRP, the SPARC Project relies on coordinated activities by agencies and groups within the affiliated community for the resources needed to carry out observational campaigns and research within its thematic programmes. SPARC-IPY will function within this general SPARC framework of coordination and collaboration with related and linked national and institutional IPY projects.