The International Polar Year: A legacy of Sydney Chapman

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The importance of the polar regions to solving many of the fundamental problems in geophysics, including climatology and meteorology, was recognized by Austrian explorer Lt. Karl Weyprecht, scientist and co-commander with Lt. Julius von Payer of the Austro-Hungarian Polar Expedition of 1872–1874. He realized that the many private expeditions conducted previously would not suffice to provide the data needed to understand nature on a larger scale. During his long overwintering while stranded on the sea ice of the Barents Sea, Weyprecht contemplated the self-serving folly of frivolous polar nations and their generally unproductive scientific pursuits. The key to success in achieving a greater understanding of geophysical phenomena, he envisioned, was to be found in an effort of international science cooperation, working together at greater efficiency.

Weyprecht believed that gathering scientific data was the only justification for costly expeditions in the high arctic regions, a process which could be best carried out by nations working in collaboration with each other. He began to advocate the scientific exploitation of newly discovered regions by setting up a chain of circumpolar stations for observations of magnetism, meteorology, and geodesy. Weyprecht's ideas were presented to the 1873 meeting of the Association of German Naturalists and Physicists, which impressed Prince Otto von Bismarck sufficiently to appoint a commission to study the prospect. Success was not immediate due to other international political agendas, but at the 54th International Meteorological Congress in Rome in 1879, Weyprecht's vision for an International Polar Year took form. IPY-1 was not an easy birth, and the sought-after participation of the United States failed. However, at the second International Polar Conference held at Berne in 1880, the first International Polar Year was designated as 1881–1883. Twelve nations shared in the establishment of 15 sites, including two in the antarctic. The United States, though not a participant in the organizational conferences, nevertheless established two stations—one at Barrow, Alaska, under the command of Lt. P. H. Ray and the other in northern Greenland under the command of Lt. Adolphus W. Greely. Greely's post (at latitude 81° 44") was the northernmost of all IPY-1 stations. Unfortunately, Karl Weyprecht died in 1880, one year before the commencement of the first International Polar Year.

The first IPY occurred at a time of considerable sunspot activity, offereing a unique opportunity to observe its effects around the circumpolar world. Although the IPY sites were established with some difficulty, all of the stations maintained operations to about the same time in early August 1883. This provided an excellent composite baseline record of various geophysical variables. Shortly after the conclusion of IPY field activities, Krakatoa erupted on 26–27 August 1883, sending atmospheric waves twice around the Earth and setting up immense pyroclastic flows and tsunamis. The finest fragments of tephra resulted in acidic aerosols and volcanic dust, which traveled around the world, generating exotic optical effects for several years, including a temperature drop of several degrees. Thus the fulfillment of Karl Weyprecht's vision established the value of international cooperation in geophysical observations. Although 12 nations agreed to Weyprecht's grand idea of collaboration,

Figure 1: Sydney Chapman and son Cecil, at the Fairbanks Geophysical Institute at the University of Alaska building named in his honor in 1968. (Geophysical Institute archive photo).

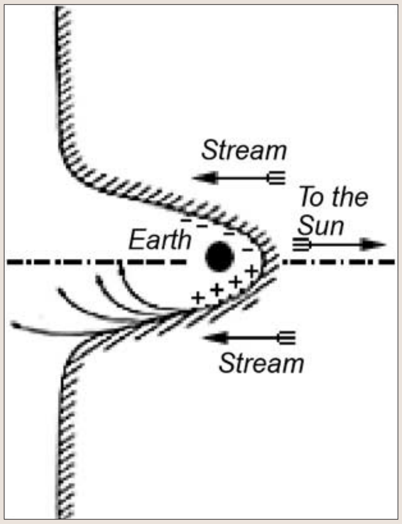

Figure 2. *Determining the shape of the magnetosphere is one of the oldest problems in space physics. Chapman and Ferraro, 1931, were the first to recognize that the Earth's magnetic field carves out a cavity in the oncoming solar wind (Chapman and Ferraro, 1931).*

it was a scheme that still lacked coordination and synthesis.

Participants published their observations primarily in independent reports and the *Bulletin of the International Polar Commission*. These reports contained not only geophysical observation time series but often natural history and ethnographic information of considerable value today.

The success of the IPY-1 coincided with rapid advances in technology, scientific exploration and discovery. The heroic age of polar exploration took on new meaning with the dawn of the 20th century. The quest to reach the poles was a major goal finally attained in Antarctica by Norway's Roald Amundsen and Britain's Robert Scott in 1911. Although these expeditions were tied to national pride, scientific observations played a significant part of the expedition activity.

The second International Polar Year (1932–1933), proposed by J. Georgi at the Deutsche Seewarte in 1927, came at an unfortunate time with the world plunged into economic depression. Nevertheless, the International Meteorological Organization promoted IPY-2 to investigate the global implications of the newly discovered "jet stream," and 40 nations responded. IPY-2 emphasized observations in meteorology, magnetism, atmospheric science, and ionospheric mapping, in support of increasing knowledge of radioscience. Participants in IPY-2 now had access to improved instrumentation for probing the land, sea, and atmosphere, and the airplane offered the opportunity for extending their surveys and explorations more effectively. Forty observation stations were established in the arctic. The U.S. contribution in Antarctica was the second Byrd antarctic expedition, which wintered on the Ross Ice Shelf. Although the logistics of living conditions in the extreme environments of the polar regions consumed most of the participants' time, the spirit of the polar year legacy prevailed. Weyprecht's vision of nations collaborating in the pursuit of scientific goals in the polar regions would take form during IPY-2 with greater emphasis on internationally coordinated projects.

In 1950, a group of eminent physicists, including Sydney Chapman (Figure 1), James Van Allen, and Lloyd Berkner, met informally at Van Allen's home in Washington, D.C., to discuss applying new post-WWII technologies, such as rockets and radar, to studies of the Earth's geophysics, particularly in the upper atmosphere. Berkner proposed a third and more comprehensive IPY, a goal which Chapman and Berkner pursued steadfastly. Chapman was intimately familiar with the first and second polar years. He used the data from the first IPY as the basis for his hypothesis on the flow of currents in the upper atmosphere (Figure 2). He was also involved in the planning and implementation of the second IPY. This led him to broaden and shape the concept of a third IPY an International Geophysical Year (IGY), which took root and occurred 1 July 1957 to 31 December 1958. Chapman was president of the Special Committee for the IGY (CSAGY).

Sixty-seven nations conducted research during the third IPY/IGY, with 12 nations maintaining 65 stations in Antarctica. The IGY was extended for an additional year, called the International Geophysical Cooperation (IGC), until 31 December 1959. Both the IGY and IGC attempted simultaneous measurements in 11 fields of Earth, near-Earth and solar physics: aurora and airglow, cosmic rays, geomagnetism, glaciology, gravity, ionospheric physics, latitude and longitude determination, meteorology, oceanography, seismology, and solar activity. There were many accomplishments. Most notable was the confirmation of continental drift, the discovery of the Van Allen belts encircling the Earth, the shape of the Earth and a greatly increased knowledge of the size of the antarctic ice mass. Another event that would change the course of space science was the launch of Sputnik on 4 October 1957. The U.S. followed with Explorer 1 on 31 January 1958, launched under the U.S. Army's Jupiter Project. The launch of these two satellites is considered the start of the "space race" as an aspect of the Cold War, but it actually inaugurated the age of space exploration.

Chapman's leadership during this time was characterized by the scientific confidence he engendered by virtue of his own extensive investigations and a strong commitment to the IGY. The International Council for Science (ICSU) published a monumental series of reports, Annals of the IGY, from 1959 until 1970. Chapman was a frequent contributor. The IGY was a great success and served as a model for other cooperative research programs, including the Year of the Quiet Sun (1964–1965), the International Hydrological Decade (1965–1975), and the International Decade of Ocean Exploration (1970–1980). Many other multidisciplinary environmental research programs followed the IGY model. Public interest in the IGY was very high because of the forum it presented for discussion of geophysical influences on the Earth.

Nearly 50 years have now passed since the IGY. Environmental changes in the polar regions have in many cases been more pronounced than at midlatitude or tropical locations. The arctic ice cover is decreasing in extent and area; some ice shelves in Antarctica are retreating and thinning; glaciers are shrinking; ecosystems are changing; arctic coastal villages are losing ground due to increased coastal erosion; and permafrost is disappearing. Such phenomena engendered world-wide enthusiasm for organizing another international science campaign, which took on several forms before culminating in an International Polar Year (IPY-4).

The International Council for Science (ICSU) formed an IPY-4 planning group in 2003 to develop the IPY-4 2007–2008 science plan and implementation strategy. The fundamental concept of IPY-4 is of an intensive burst of internationally coordinated, interdisciplinary scientific research and observations focused on the Earth's polar regions. The IPY aims to exploit the intellectual resources and science assets of nations world wide to make major advances in polar knowledge and understanding, while leaving a legacy of new or enhanced observational systems, facilities, and infrastructure. The six research themes represent diverse dimensions of scope, such as assessing present status of the polar regions environment and change related to past and present natural environmental and social change, with related global linkages. New frontiers look at science in the polar regions, and vantage point considers enhanced observatories from the interior of the Earth to the sun and beyond. Finally, the theme of human dimensions describes influences that help shape the sustainability of circumpolar human societies. To coordinate the U.S. scientific community's efforts in identifying potential contributions to the IPY and to provide a means for interaction with the ICSU IPY Planning Group, The Polar Research Board of the National Academies formed a U.S. National Committee for the International Polar Year in the summer of 2003. IPY-4 was organized with the goal of expanding the boundaries of our understanding of the polar regions and their key roles in the Earth's linked systems. IPY-4 is a joint initiative of the World Meteorological Organization (WMO) and the International Council for Science (ICSU). Thirty-eight national and regional committees have been formed to participate in IPY-4.

The IPY 2007–2008 builds on the historic achievements of the three previous polar years and a vision shared by Weyprecht, Georgi and Chapman, as well as others. New technologies since the IGY have made it possible to travel to and make observations in extreme environments on Earth and in deep space. It is impressive to read the published reports of expeditions in years before the advent of computers and modern electronics and to note the difficulty in obtaining data. Our ability to collect geophysical information from the interior of the Earth and in space has increased dramatically. Modern computers and methodologies for information management have provided us with an unprecedented ability to access and share this information and processing ability. An Electronic Geophysical Year (*e*GY) has been formed to coincide with the 50th anniversary of the IGY. By exploiting the power of modern communications and information management capabilities, *e*GY set out to accomplish in the 21st century what the IGY sought 50 years ago. Providing ready and open access to the vast and growing collections of cross-disciplinary digital information is the *e*GY philosophy and key to understanding and responding to complex Earth system phenomena that influence human survival.

The 50th anniversary of the IGY gave rise to a proposal from the Goddard Space Flight Center in the U.S. and the Rutherford Appleton Laboratory in the U.K. in 2001 to organize an International Heliospherical Year. The IHY idea grew out of the success of the IGY and Chapman's strong interests and would focus on solar variation effects on Earth. The IHY could provide a unique opportunity to coordinate observations from the current list of international space missions, with data from solar ground based observations. The objective of the IHY is to discover the physical mechanisms at work which couple the Earth's atmosphere to events that drive them from the heliosphere. It is now possible with modern technologies to provide the simultaneous observations over a broad area desired by the organizers of past polar year programs. It will also require the handling of enormous amounts of data as advised by the framers of the *e*GY.

Public interest was high during the IGY and is even higher in recent years as geoscientists, decision makers and the general public express concern about how the Earth's scientific knowledge can be used for sustainable development. The 60th United Nations General Assembly declared 2008 as the International Year of Planet Earth (IYPE). The year's activities will span 2007–2009. The United Nations Educational, Scientific and Cultural Organization (UNESCO) was designated to organize activities during the year in collaboration with the International Union of Geological Sciences and other geosciences societies throughout the world. The General Assembly's desire was to increase awareness of the importance of earth sciences in achieving sustainable development and promoting local, national, regional, and international action.

One of the major drivers at the beginning of the IGY was the launch of Sputnik in Russia and Explorer 1 in the United States. Two weeks after the Sputnik launch, members of the National Science Board met to discuss how they would ensure that the National Science Foundation (NSF) would be able to produce an adequate supply of scientists and engineers as the space race began to unfold. By 1959, NSF's budget was greatly increased to meet the challenge. NSF began to sponsor research using the new technologies involving rockets, balloons and satellites. In recognition of the launch of Sputnik, Europe will launch 50 ultrasmall satellites (nanosats) by Arianspace in a single payload. Each nanosat weighs about 1 kg and will stay in orbit about two years. The satellites will perform experiments chosen and designed by each individual country. Fifty different countries will have the opportunity to do space research. Other celebrations and recognitions are bound to follow especially during the IHY.

Many scientists have contributed to the development of collaborative international scientific research since the first IPY. However, it was Sydney Chapman, whose impressive research background in mathematics and geophysics (more than 450 papers) and prestigious honors, made it possible for him to guide the course of the IGY and beyond. He wrote in the introduction to the first edition of the Annals of the International Geophysical Year that the main aim of the IGY was to "learn more about the fluid envelope of our planet—the atmosphere and oceans—over all the Earth and at all heights and depths." He emphasized that "these researches demand widespread and simultaneous observation." The ideas of Sydney Chapman and the success of the IGY provide a lasting legacy for the development of the IPY 2007–2008 and other international Earth and space science programs to follow.

Suggested reading. *Sydney Chapman Eighty* (sponsored by University of Alaska, University of Colorado, and University Corporation for Atmospheric Research. The Publications Department of the University of Colorado coordinated final review of this volume. Library of Congress No. 68-15590. 1968). *Annals of the International Geophysical Year*, Volume 1 (Pergamon Press, 1959). *A Vision for the International Polar Year 2007–2008* (National Academies Press, 2004). *Assault on the Unknown: The International Geophysical Year* by Sullivan (McGraw-Hill, 1961). "A new theory of magnetic storms by Chapman and Ferraro (*Terrestrial Magnetism and Atmospheric Electricity*, 1931). TLE

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