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## Moving Beyond the IGY: The Electronic Geophysical Year (eGY) Concept

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The International Geophysical Year (1957–1958) was inspired by the realization that much better and more complete information was needed about the Earth and geospace to understand and manage the complete terrestrial environment on which we depend. So it was that the IGY member countries worked together to deploy a large number of geophysical observatories around the world. These nations were pursuing the major IGY objectives to collect geophysical data as widely as possible, and to provide free access to these data for all scientists around the globe. About 50 permanent stations were set up in the Arctic and Antarctic, and the World Data Center System was established to ensure that the data collected were properly archived and made available without restrictions for scientific research and practical applications.

IGY was an outstanding success. It elevated geophysical monitoring to a new level, and set new standards for international collaboration and data-sharing. Many successes of the geophysical sciences in recent times have origins that can be traced back to the IGY. A notable example is the modern era of space exploration. As we approach the 50-year anniversary of the IGY, it is appropriate to seek to build on the achievements through renewed global resolves as well as to review the outcomes of the IGY and celebrate its successes. This is the “IGY+50” concept.

At the 1999 International Union of Geodesy and Geophysics (IUGG) Assembly in Birmingham, in the United Kingdom, a resolution on “IGY+50” was introduced through the International Association of Geomagnetism and Aeronomy (IAGA). This resolution, which may be viewed at <http://www.ngdc.noaa.gov/stp/SCOSTEP/scostep.html>, does not stand alone, but is complemented by several earlier resolutions passed by the IUGG and its constituent associations urging international cooperation in the collection and sharing of geophysical data.

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Regions such as deep space and ocean bottoms are still challenging the worldwide scientific communities with their relative remoteness or inaccessibility. However, at the beginning of the 21st century, only a few places are left on the Earth's continents where geophysical instruments are not yet installed or that satellite-based remote systems cannot observe. The new frontiers that are the logical extension to the IGY now lie in the intelligent, efficient, and cooperative use of observational data that make full use of modern information management opportunities. With the tremendous growth of computing and networking technologies in the last decade of the 20th century, there are no longer serious barriers to establishing large, centralized or distributed geophysical data bases, or to ingesting worldwide geophysical data into high-performance global simulation models to advance our knowledge of planet Earth and its surrounding geospace. Furthermore, much scientific progress is occurring at the interface between traditional disciplines; thus, data have to be made even more widely available.

We are witnessing rapid progress in Earth and space science in the development of an integrated data environment. That integrated environment will offer easy, simultaneous access to multiple sources of high-quality observations, long-term geophysical information, model output, and data services across traditional discipline boundaries. The integrated data environment will also enable the use of tools that facilitate the full utilization of those data. The ready availability of inexpensive, capable microprocessors means that researchers can redefine the “data center” concept: we can now form “virtual observatories” that enable users to attain, in principle, many of their data requirements through one interface, or even to create user-owned, self-populating “data centers” that are interconnected through the Internet with other data bases distributed worldwide.

Within the geophysics community, there are many approaches to addressing all or part of

the Virtual Observatory concept. We envision that in a very short while, there will be “a Virtual Sun,” “a Virtual Magnetosphere,” “a Virtual Ionosphere,” and so on. For example, Figure 1 shows the present concept for a Virtual Solar Observatory.

The high-tech potential of the modern information era is powerful and exciting, but we should not lose sight of the value of exploiting the vast resources of data that already exist. A parallel exists in the mining industry, where efficient extraction of known deposits is considered to be at least as important as the discovery of new deposits. The barriers to this exploitation are familiar and daunting—restrictions placed by owners on release of their data, physical and electronic difficulties of access, and ignorance about what data holdings exist and where.

Members of a task force of the International Association of Geomagnetism and Aeronomy (IAGA) worked intensively at the International Union of Geodesy and Geophysics General (IUGG) Assembly in Sapporo, Japan, last summer to establish a conceptual basis for the IGY+50. It was proposed that IGY+50 be developed under three themes: International Year (I\*Y) initiatives, celebrations to commemorate the IGY, and an electronic Geophysical Year (eGY), which will provide a common thread throughout the geoscientific community.

### *Celebration of the IGY*

Celebrations can be used to review the outcomes of the IGY, help us capitalize on the lessons learned from the IGY, market geophysics as an enabling discipline for the future, and identify new directions. An IGY+50 symposium has already been proposed for the 2007 IUGG General Assembly in Perugia, Italy. This occasion, and other meetings held in 2007–2008, will be the natural foci for celebrations.

### *Electronic Geophysical Year (eGY)*

Discussing various research programs and initiatives proposed for 2004–2008, we note, first of all, that a key achievement of the IGY was to provide ready access to data through the installation of a worldwide system of physical observatories and the establishment of data centers. Great progress was achieved in this area, although access has never been as easy as one would like, and archival and indexing of data are seldom given high priority. Second, there is the great potential, widespread acceptance, and rapid growth of “e-science” using Internet-based methodologies for

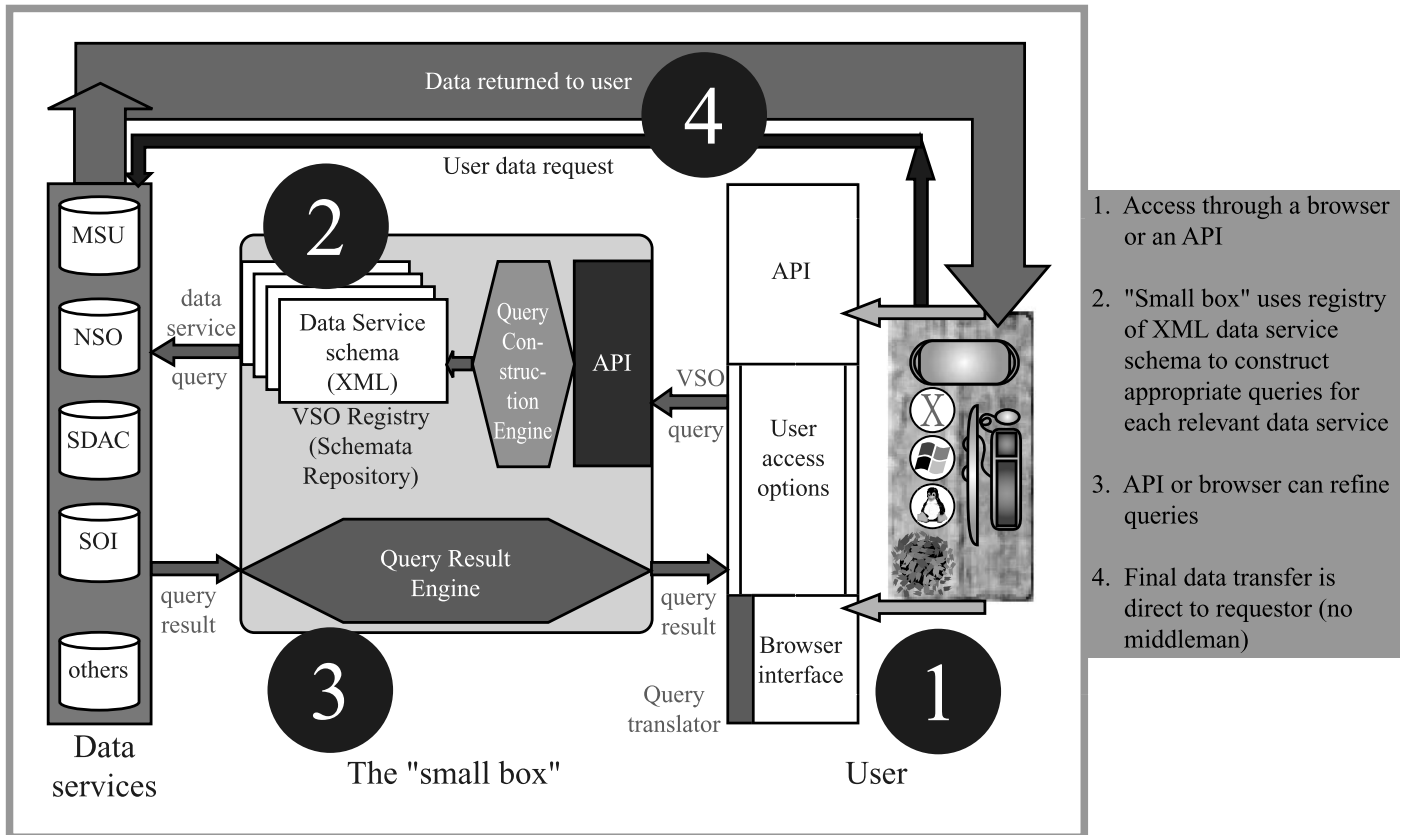


Fig. 1. The NASA Office of Space Science concept for a "Virtual Solar Observatory" is shown. (Courtesy of J. Gurman and C. Holmes, NASA).

accessing globally distributed computing power, software, and data/information in a manner analogous to the way personal computers deliver those capabilities within the confines of a box on our desk (see Figure 1).

We conceive an electronic Geophysical Year as an internationally endorsed means of marshalling a worldwide effort to address the issues of:

- Data discovery – improving records of what data holdings exist and where;
- Permission – encouraging the owners of data to make them available to the international scientific community and to provide descriptive (meta-data) information; and
- Access and sharing – enabling users to obtain and share data, often from distributed sources, in an appropriate, machine-readable form.

The access issue is the most challenging and exciting, given the capabilities of the modern information management era. It also holds the greatest potential for a revolution in the way we use geoscientific data. Activities would range from digitization of analogue records, to the establishment of a system of Virtual Observatories embracing all available and upcoming geophysical data (e.g., atmospheric, geomagnetic, gravity, ionospheric, magnetospheric, etc.) into a series of virtual geophysical observatories now being "deployed" in cyberspace. This concept implies free access to all available data through the Internet and World Wide Web. That is, all data providers and data users will exchange the data directly, establishing a worldwide fabric (or grid) of geophysical data. At the same time, the existing World Data Center system would become a part of that

distributed worldwide data source, dipping into the "data fabric" and extracting newly available data for the permanent archives. The data providers (or the Data Centers) may digitally "sign" produced (or archived) data sets, so the data users would know the quality of data spread through the worldwide data fabric.

The eGY concept is modern, global, and timely. The eGY concept is based on the existing and continually developing computing and networking hardware and software technologies (for example, Internet, XML, Semantic Web, etc.) and can be smoothly incorporated into various planned "International Year" initiatives in the near future, for example, by the IGY+50 anniversary in 2007–2008. The eGY initiative is pragmatic and affordable. The U.S. and European funding agencies are currently defining the status and future development of various aspects of the national and international cyber infrastructure.

The eGY has many desirable characteristics common to all of the IUGG associations and the wider geoscientific community:

- **Timeliness:** Many nations and agencies are moving toward the "Virtual Observatory" concept.
- **Scope:** The proposed approach is global in scope and character.
- **Interdisciplinarity:** Issues of data-sharing and data accessibility are common to all the associations of IUGG.
- **Affordability:** The computing and networking technologies are already being developed and IUGG would incur no significant expense.

**Cost-effectiveness:** Organizing on a worldwide basis will be more efficient, thus allowing more science for less money.

- **Appeal:** Governments are interested in geophysical science as an application of technology to societal problems.

- **Inclusiveness:** The program offers important research opportunities for developed and developing countries.

- **Capacity-building:** Developing countries can use the infrastructure in ways most appropriate to their needs.

- **Attractiveness:** These programs provide exciting, relevant research that will engage younger scientists.

The eGY initiative has been proposed for consideration by all seven associations of the IUGG, the IUGG's Committee for IGY+50 (chaired by Michael Kuhn, Austria), as well as the existing I\*Y initiatives listed above. The IUGG associations have warmly embraced the eGY concept. The eGY will provide a forward impetus to geoscience in this century similar to that provided by the IGY 50 years ago. The task group felt that this concept would both commemorate the IGY and would move forward aggressively toward 2007–2008 and beyond.

A natural question concerns funding for the eGY. The eGY initiative may not need a lot of dedicated funding. The eGY concept underlines a philosophical change from the storing of scientific data at certain locations, such as World Data Centers, to more distributed data bases located elsewhere on the Internet. The funding of such activities should still continue to come from governments to support the transfer of scientific data to the data centers, but these repositories should become integral parts of the worldwide distributed data storage system and lead the effort to create virtual

observatories. Nothing, of course, is free. However, we note today how everyone wants to place "data content" on the Web, spending their own money to allow the whole world to see important data.

We envision that eGY could have a central steering committee under the IUGG umbrella to drive the initiative. However, the scale of the eGY enterprise will probably grow beyond what can be handled in what is essentially people's spare time. Therefore, either some benevolent institutions will have to allow their staff to spend time on eGY and fund some travel, or the effort must have its own funding. We consider that the most likely source of funding for eGY would seem to be from the International Council for Science (<http://www.icsu.org>) through either dedicated or proposal-based funding requests. Some national funding agencies and institutions might decide to support nationwide committees to coordinate deployment of "national virtual observatories" in cyberspace. Nevertheless, even with such support, eGY would have to run on a relatively small budget, mainly serving a promotional role and providing a lever for eGY-related projects.

The Task Force welcomes feedback on the eGY concept. We look forward to continuing development of the ideas presented here.

**Table 1. International Year Initiatives.**

<i>I*Y Years</i>	<i>Name</i>	<i>Main sponsor</i>	<i>Further Information</i>
IYPE 2004-2007	International Year of Planet Earth	IUGS	<a href="http://www.iugs.org/iugs/news/iype_01.htm">http://www.iugs.org/iugs/news/iype_01.htm</a>
IPY 2007-2008	International Polar Year	ICSU	C.G.Rapley@bas.ac.uk
IHY 2007-2008	International Heliophysical Year	NASA	<a href="http://ihy.gsfc.nasa.gov">http://ihy.gsfc.nasa.gov</a>
CAWSES 2004-2008	Climate and Weather in the Sun-Earth System	SCOSTEP	<a href="http://www.ngdc.noaa.gov/stp/SCOSTEP/scostep.html">http://www.ngdc.noaa.gov/stp/SCOSTEP/scostep.html</a>

*Several global "I\*Y" initiatives, each with its own special focus, are already under development by various Unions and agencies. Other I\*Y initiatives may come into being, although there is not much time between now and 2007 to set up any major new initiatives. The I\*Y initiatives are where the new science is most prominent.*

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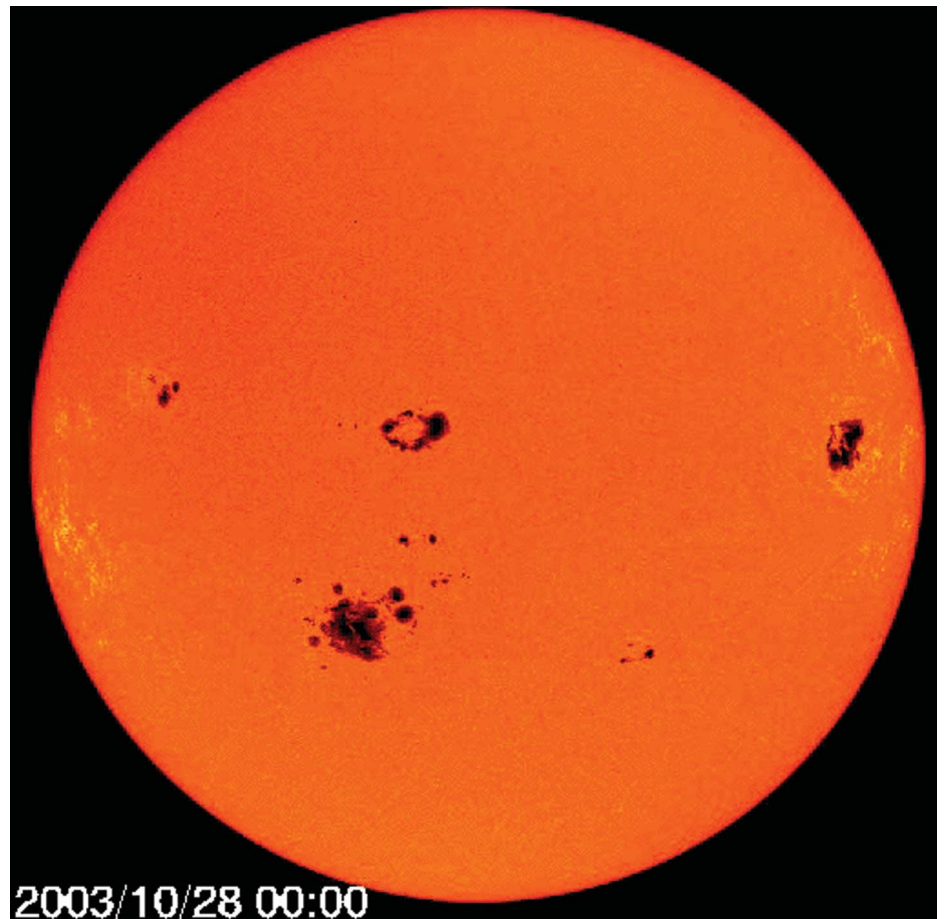
## Sun Unleashes Halloween Storm

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It is supposed to be a quiet time on the Sun, as we head toward solar minimum. At the beginning of October, it looked that way, as only a few small sunspots were visible. Then, sunspot group 484 came around the limb of the Sun on 18 October. By 23 October, when 484 was located right on the Earth-Sun line, this huge group covered 1.7% of the solar disk. At the far edge of the Sun, another massive sunspot group, 486, was just coming into the field of view. And late on the 26th, a third group, 488, emerged from the interior of the Sun just to the north of 486 (Figure 1).

With this sudden increase in sunspots came a series of solar flares. The most powerful, X-class, have an integrated power (1.0–8.0 Angstroms) greater than 0.0001 W/m<sup>2</sup>. They can produce radio blackouts and damage space-based systems due to energetic protons. The first of the X-class flares occurred on 19 October, producing a category R3 radio blackout on the National Oceanographic and Atmospheric Administration (NOAA) space weather scale. On the 23rd, another flare registering between X4 and X5 was observed. This was followed by a series of smaller M- and X-class flares.

On 28 October, 486 faced directly toward Earth, and it unleashed a huge X-17.2 solar flare (Figure 2). At the time, it was the third largest on record since 1976. The Space Environment Center (SEC) in Boulder, Colorado, issued a severe space weather alert and noted that a coronal mass ejection (CME) was headed for Earth.



*Fig. 1. This white light image of the Sun on 28 October shows large sunspot groups 484 (to the right), 486 (lower center), and 488 (center). Image courtesy of the Solar and Heliospheric Observatory Web site.*