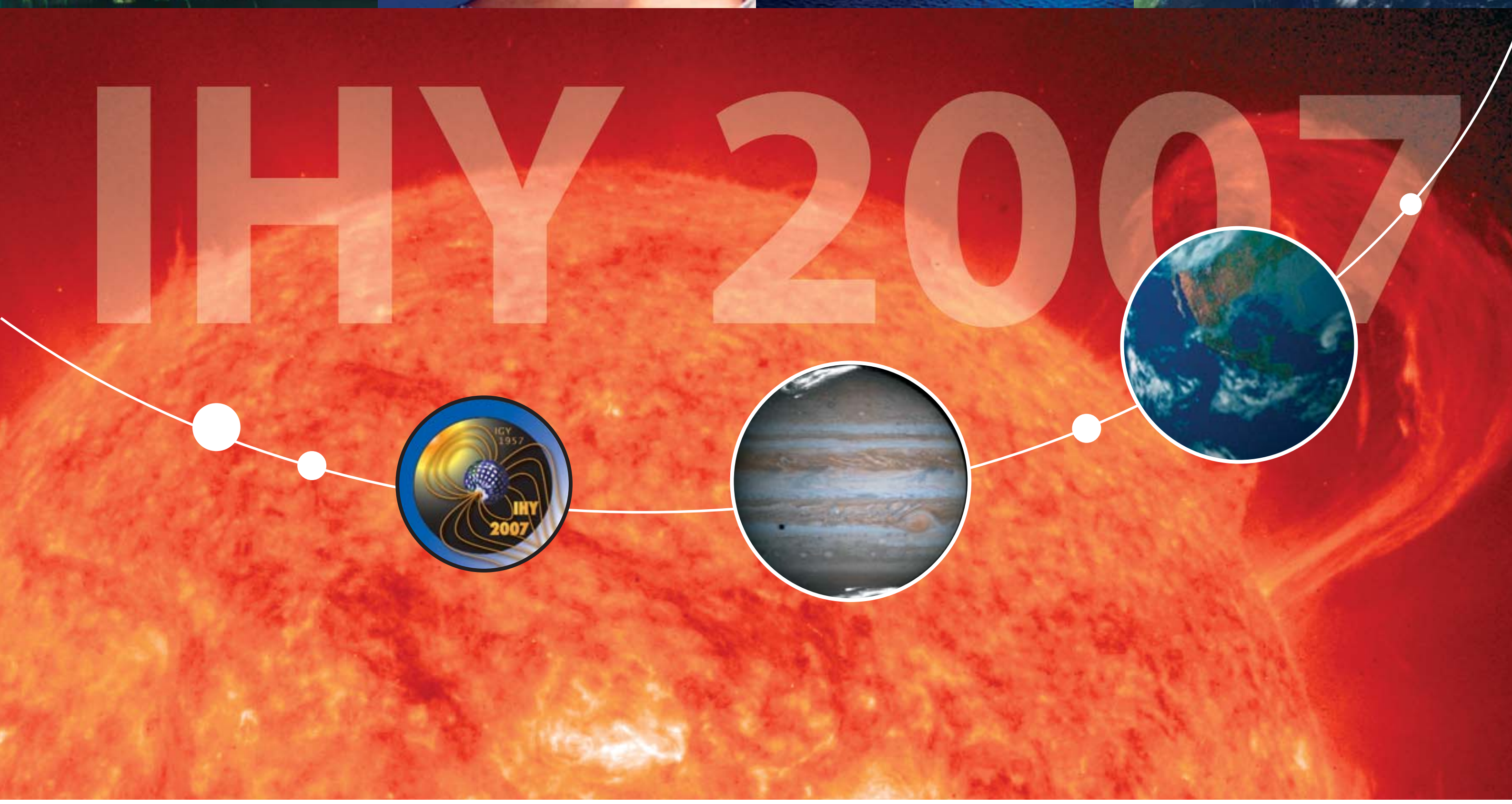
UNITED NATIONS
OFFICE FOR OUTER SPACE AFFAIRS

Putting the “I” in the IHY

Comprehensive overview on the worldwide organization of the International Heliophysical Year 2007







UNITED NATIONS

TABLE OF CONTENTS

I. IHY Overview

"Space is a part of the world's cultural heritage. It has inspired generations of artists, poets, scientists and musicians. Throughout history, societies have admired and searched for meaning in the same night sky.

"Indeed, space exploration can help bring cultures together. Manned space missions today are rarely top-secret national projects. Much more common are international crews, with members from a variety of backgrounds. Crews live together in cramped and challenging conditions for months, sharing experiences, customs and, above all, the enthusiasm for space that brought them together in the first place. Their missions capture the imaginations not only of their native lands, but of people around the world.

"Space is also helping us to address some of today's most urgent problems. Space technology has produced tools that are transforming weather forecasting, environmental protection, humanitarian assistance, education, medicine, agriculture and a wide range of other activities. And, of course, a fascination with space leads many young people to pursue careers in science and technology, helping developing countries in particular to build up their human resources, improve their technological base and enhance their prospects for development."

- UN Secretary-General Kofi Annan, on the occasion of World Space Week, 2001

A. Introduction, IHY Goals and Objectives

Heliophysical: A broadening of the concept "geophysical", extending the connections from the Earth to the Sun and interplanetary space. On the 50th anniversary of the International Geophysical Year, the 2007 International Heliophysical Year activities will build on the success of IGY 1957 by continuing its legacy of system-wide studies of the extended heliophysical domain.

In 1957 a programme of international research, inspired by the International Polar Years of 1882 and 1932, was organized as the International Geophysical Year (IGY) to study global phenomena of the Earth and geospace (Figure 1). IGY involved about 60,000 scientists from 67 countries, working at thousands of stations, from pole to pole to obtain simultaneous, global observations on Earth and in space. There had never been anything like it before.

2007 will mark the 50th Anniversary of IGY and 50 years of space exploration. An extensive suite of spacecraft and observatories was established, the "Great Observatory," which places us on the verge of a system-wide understanding of the entire interconnected heliophysical system. Fifty years after IGY, the world's science community will again come together for an international programme of scientific collaboration: the International Heliophysical Year (IHY) 2007.

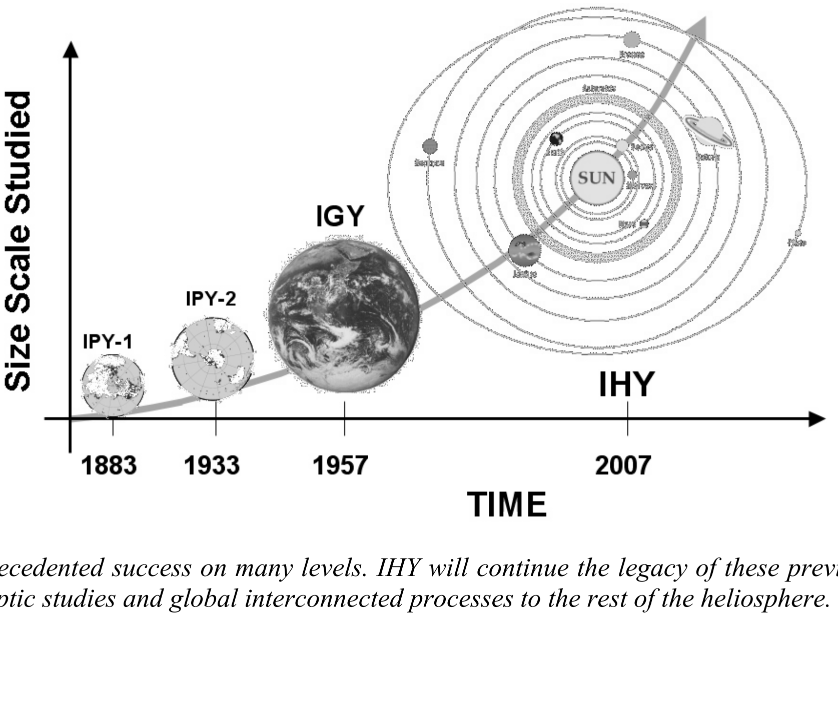


Figure 1. *The extension of the concept of "geophysical" into "heliophysical". The tradition of international science years began almost 125 years ago with the first international scientific studies of polar processes in 1882-3. A second International Polar Year (IPY) was organized in 1932, but a worldwide economic depression curtailed many of the planned activities. IGY in 1957 was an unprecedented success on many levels. IHY will continue the legacy of these previous events, extending global synoptic studies and global interconnected processes to the rest of the heliosphere.*

IHY has ***three primary objectives***:

- **Advancing the understanding of the fundamental heliophysical processes that govern the Sun, Earth and heliosphere;**
- **Continuing the tradition of international research and advancing the legacy of IGY on its 50th anniversary; and**
- **Demonstrating the beauty, relevance and significance of space and Earth science to the world.**

These objectives will be accomplished through an intensive programme of IHY activities, beginning with the "start" of IHY in March 2007, the "end" of the coordinated activities of IHY in late 2008, and concluding in a series of analysis and legacy activities in 2009 and 2010. From these objectives one can derive the **six goals of IHY**, each corresponding to a unique opportunity afforded by IHY:

1. **Develop the basic science of heliophysics through cross-disciplinary studies of universal processes;**
2. **Determine the response of terrestrial and planetary magnetospheres and atmospheres to external drivers;**
3. **Promote research on the Sun-heliosphere system outward to the local interstellar medium - the new frontier;**
4. **Foster international scientific cooperation in the study of heliophysical phenomena now and in the future;**
5. **Preserve the history and legacy of IGY on its 50th anniversary; and**
6. **Communicate unique IHY results to the scientific community and the general public.**

IHY is an integrated programme of many diverse activities working on an international level to achieve all of the above goals. Most of these activities fit in at least of one of the IHY's **programmatic thrusts: Science, observatory development, outreach and history**.

B. The Four IHY Programmatic Thrusts

The IHY programme has four main components, which are called programmatic thrusts:

1. **Science activities,** consisting primarily of Coordinated Investigation Programmes (CIPs) dedicated to the study of the extended heliophysical system and the universal processes common to all of heliophysics;
2. The **IHY/United Nations Basic Space Science Initiative (UNBSSI) programme,** dedicated to the establishment of observatories and instrument arrays to expand greatly our knowledge of global heliophysical processes, while increasing the viability of space science research and education in developing countries and regions that traditionally have not been active in space research;
3. **Education and public outreach,** increasing public awareness of heliophysics and educational activities for "students" of all ages; and
4. The **"IGY Gold" history initiative,** preserving the history and legacy of IGY 1957 by identifying and recognizing planners of and participants in the first IGY, preserving and making available items of historical significance from the IGY and organizing commemorative activities and events.

The four programmatic thrusts of IHY are (roughly) related to the goals of IHY (listed above) as follows:

Science activities	**Goals 1 - 4**
IHY/UNBSSI programme	**Goals 3 and 4**
Education and public outreach	**Goal 6**
IGY Gold history	**Goal 5**

Each of the four programmatic thrusts of IHY is planned as part of one integrated programme. The plans, progress and current state of these individual activities will be discussed throughout this publication.

C. Status, Schedule and Basic Plan

Major planning activities have taken place for all aspects of the IHY programme. Hundreds of national, regional and international planning conferences and meetings have occurred. Teams continue to form, implementing IHY activities in all the regions of the globe. The basis for the four main programmatic thrusts of IHY (science, IHY/UNBSSI programme, outreach and history), and a means by which all of these activities will be coordinated, are necessary to enable the individual organizations and institutions to develop unique IHY programmes that suit their own goals and challenges. It is the activities and programmes developed by these individual organizations and institutions that form the "building blocks" of IHY. Therefore, the IHY international planning activities have focused on the establishment of the four main components of IHY and on enabling the individual IHY regions to commence with their planning activities.

The numerous national and regional planning activities have consisted primarily of IHY team meetings and special sessions at scientific meetings. IHY team meetings have occurred in each of the seven IHY regions (described in Section VI) and national planning teams continue to develop and implement elements of their programme in coordination with the international effort. Numerous special sessions on IHY have taken place at a wide range of scientific meetings, addressing all four of the IHY programmatic thrusts. Those special sessions provide a venue for members of the community to learn about IHY activities and begin to contribute to the IHY effort.

As one would expect, the number of IHY events has increased exponentially in the past several years. The "Events" section of the IHY website (described in Appendix III) lists a representative number of these activities, especially those pertaining to the "science" and "IHY/UNBSSI programme" aspects of the programme.

In preparation for the "official launch" of IHY activities in 2007, many precursor activities are required for the 2005-2006 timeframe. For the s**cience** component of IHY, the regional coordinators have already established a list of several hundred observatories planning to participate in IHY science activities, and members of the international scientific community have begun proposing their CIPs (described in Section II) for implementation during IHY. Scientific sessions on IHY science activities at various meetings have focused on bringing discussions of IHY science to the forefront and identifying campaigns to be implemented as CIPs. The **IHY/UNBSSI programme** component has been the focus of intensive activities in concert with UNBSSI (described in Section III). In particular, the deployment of individual instruments at remote sites has already begun as an essential step towards the establishment of global arrays by 2007. New instrument programmes and new "host" sites for these activities continue to be identified on a regular basis. The **outreach** (Section IV) component has already launched several activities worldwide, emphasizing the linkage to national programmes, while the **IGY Gold history programme** (Section V) was implemented in 2004 with plans to continue through 2009.

A general description of the IHY timeline is as follows:

2001-3: Establishment of the IHY Secretariat; establishment of the main elements of the IHY programme; initialization of planning activities on all continents.
2004: National and regional coordination meetings begin to take place; the four essential components of IHY are defined; synergy/coordination discussions with professional organizations; establishment of CIP structure; launch of the IHY/UNBSSI programme and IGY Gold history programmes.
2005: Continuation of national and regional coordination meetings; synthesis and coordination from regional to international; precursor activities for each of the four main components continue to take place; instrument deployment begins and CIPs proposed by individual community members begin to form the fabric of the IHY science campaigns.
2006: Focus on the implementation of the four main IHY components and on the integration of national activities with the international IHY community; prototyping year; particularly for numerous CIPs and outreach activities that serve as trailblazers and/or test beds.
2007-8: IHY is launched as an integrated international programme. Science, IHY/UNBSSI programme, outreach and history activities occur around the globe, and the efforts of each national and regional component are multiplied in impact by their coordination with the worldwide effort.
2008-9: IHY activities continue. Results of the IHY CIPs and science campaigns are analyzed in a wide range of workshops and analysis activities; instrument and observatory development continues through the IHY/UNBSSI programme; outreach activities incorporate major scientific results and breakthroughs.

II. Science Activities & Coordinated Investigation Programmes (CIPs)

With the phenomenal improvement of ground-based and space-based observations since IGY in 1957, the opportunity to observe heliophysical processes has never been better. Today, ground-based instruments/observatories routinely observe the ionosphere with ground radars, energetic particles with chains of neutron monitors and changes in Earth's magnetic field with arrays of magnetometers. Observatories in space now provide data from locations and regimes that have only recently become accessible, with drastically improved resolution and range, and large-scale computer modelling has made it possible to assimilate and couple these diverse observational inputs, enabling cross-disciplinary studies that transcend traditional boundaries in space physics.

It is now widely recognized that evolution in the magnetized plasma portion of the solar system proceeds through a set of **universal processes**, i.e. reconnection, particle acceleration, plasma wave generation and propagation, etc. These processes occur in the atmosphere of the Sun, the Earth and other planets; in the interplanetary medium; and in the outer reaches of the heliosphere where the solar wind meets the interstellar medium. By facilitating research on these universal processes across the many heliophysical regimes that serve as independent sampling sites, we are able to gain insight on these driving forces at a fundamental level.

A. Scientific Disciplines and the Universal Processes

IHY will focus on the cross-disciplinary study of universal processes in the solar system, observed in a variety of settings. Studying these universal processes together, in diverse environments, and in a comparative way, will lead to new scientific insights.

This is perhaps best understood by citing a few examples: (1) Shocks are observed in situ in the interplanetary medium, and are believed to play a role in the acceleration of particles in the solar corona. Standing bow shocks and termination shocks separate the major regions in the heliosphere. Shock formation and particle acceleration are IHY targeted universal processes. (2) Auroras (Figure 2) are observed on Earth, Saturn and Jupiter, and Jovian auroral "footprints" have been observed on Io, Ganymede and Europa. The formation of auroras is observed to be the universal response of a magnetized body in the solar wind. The cross-disciplinary study of these processes will: (i) provide new insights that will lead to a better understanding of the universal processes in the solar system that affect the interplanetary and planetary environments; (ii) pave the way for safe human space travel to the Moon and planets in the future; and (iii) serve to inspire the next generation of space physicists.

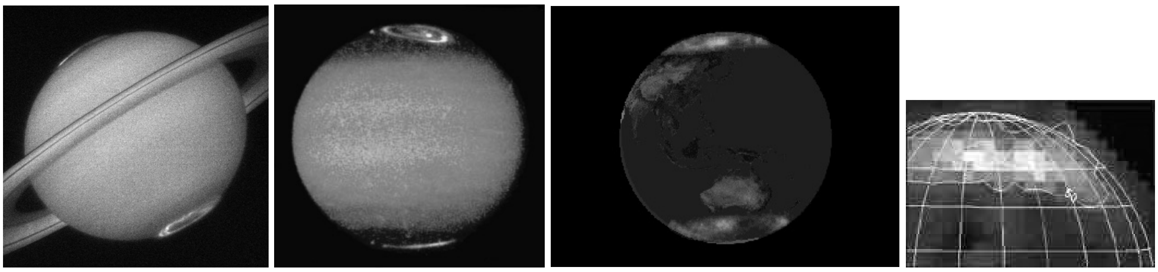


Figure 2. *Auroras on Saturn (left), Jupiter (center left), Earth (center right) and Ganymede (right) are examples of universal physical processes at work in the solar system.*

For the majority of scientific studies in heliophysics, comparison of processes at multiple sampling sites is either secondary or nonexistent. Most of the scientific organizations categorize research according to the regime in which the studies occur, e.g. solar, magnetospheric, atmospheric. To facilitate the transition from regime-dominated science to a focus on universal processes, the CIPs of IHY are integrated with respect to more "traditional" categories. The IHY disciplines are:

- **Solar physics;**
- **Planetary magnetospheres;**
- **Heliosphere and cosmic rays;**
- **Planetary ionospheres, thermospheres and mesospheres;**
- **Climate studies; and**
- **Heliobiology.**

Here, "heliobiology" refers to the space environment's influence on and interaction with biological systems and processes, ranging from energetic particle radiation effects to the influence of magnetic disturbances on animals relying on geomagnetic fields for navigation.

UNIVERSAL PROCESSES	Solar	Planetary Magnetospheres	Climate Studies	Heliosphere	Ionospheres, Thermospheres Mesospheres
Particle acceleration	X	X		X	
Plasma waves	X	X		X	X
Aurora		X			X
Energetic particle propagation	X	X	X	X	X
Shocks	X	X			
Climate	X	X	X	X	X

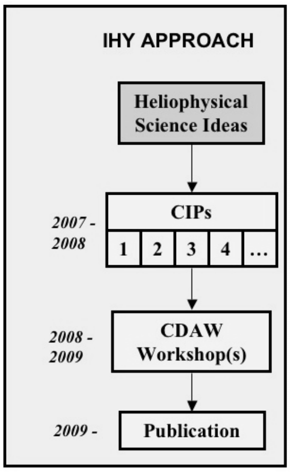


Figure 3. *The "IHY scientific approach." The table on the left shows the overlap of various universal processes with several scientific regimes. The schematic on the right illustrates the progression from a science idea, as proposed by individual scientists, to a CIP, and to the analysis and interpretation of the data via Coordinated Data Analysis Workshops (CDAWs), resulting in the publication and availability of the results.*

Each discipline has at least two discipline coordinators, who are responsible for organizing the CIPs, facilitating theory and modelling efforts, and coordinating analysis activities that emphasize the "universal process" approach. This process is illustrated in Figure 3. For example, the universal process of particle acceleration is present in at least three of the IHY disciplines. Therefore, CIPs and joint analysis activities spanning three different disciplines will be required to address the universal process of particle acceleration.

B. Science Campaigns and CIPs

CIPs are the *fundamental building blocks of IHY science.* During the IHY, CIPs utilizing space and ground-based observatories as well as theory and modelling capabilities will be organized to study universal processes at work throughout the solar system. The resulting data sets will be processed and assembled for easy access by the global science community. Coordinated data analysis will be performed during a series of workshops (CDAWs) and the results will be published and made available to the science community.

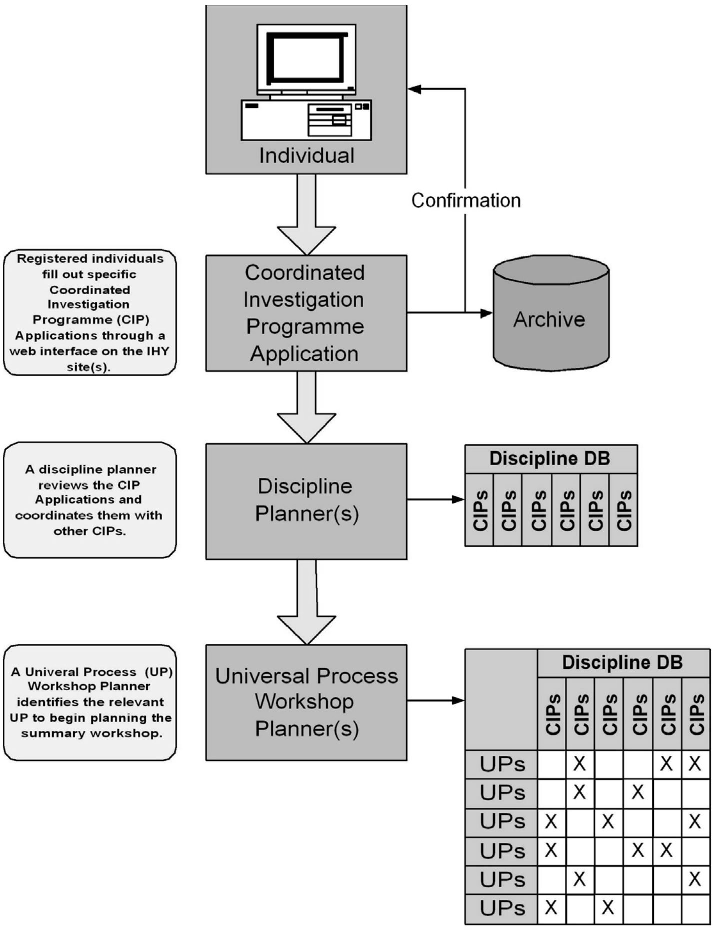


Figure 4. *"How CIPs work" schematic.*

For the scientific programme of IHY to be fully successful, the CIPs must include input from an unprecedented number of heliophysical researchers with a broad range of interests and expertise. The process by which the IHY community originates and proposes a wide range of investigations, which the discipline coordinators execute as CIPs, is illustrated in Figure 4. The top frame of the figure denotes an individual researcher, accessing the IHY CIP system via the Internet. Individuals lacking Internet access can send CIP proposals by mail to the IHY Secretariat or their respective national coordinator (http://ihy2007.org). Researchers should design the CIP applications to best address a scientific topic according to expertise and available resources. A current list of CIPs is maintained on the CIP application page to be used for reference in proposing a CIP.

The second frame of Figure 4 illustrates the CIP application and archival process. Researchers registered in the IHY science coordination database (described below) are able to submit CIPs directly to the archive. When a CIP application is submitted, it is logged and the researcher receives confirmation that the CIP has been placed in the digital archive.

Discipline coordinators will review all suggestions and organize similar CIPs into observing programmes that can actually be implemented, as shown in the third frame of Figure 4. For example, it is anticipated that a number of CIPs will be proposed to investigate ionospheric disturbances and structure at equatorial latitudes. Many of these proposed ionospheric CIPs will have similar requests for instrument/observatory data. Coordinating the CIPs provides access to a wider range of data that can be assembled and analyzed more efficiently. The discipline coordinators will optimize the schedule of these CIPs to maximize scientific benefit and minimize the strain on needed resources. Observatory coordinators, representing each of the instruments participating in the IHY, will assist in this process.

The final stage of the CIP process occurs months to years later, as the researchers involved in various CIPs are invited to participate in one of many CDAWs. These are cross-disciplinary topical universal process workshops, some of which will be "virtual" through Internet communication, to present and discuss the scientific results of the IHY campaigns.

Joint campaigns among organizations with similar goals minimize the resources required for IHY. For example, IHY will seek to identify areas where it can support programmes like the International Polar Year (IPY), the Electronic Geophysical Year (eGY) and the International Year of Planet Earth (IYPE), perhaps by providing the web-based campaign planning database software developed to support IHY to these groups. Discussions on areas of support will continue throughout 2006, leading to specific cooperative activities. Many IHY workshops and coordination meetings will be held in conjunction with topical research groups such as Solar Heliospheric and Interplanetary Environment (SHINE), Geospace Environment Modeling (GEM), Coupling, Energetics and Dynamics of Atmospheric Regions (CEDAR), Climate and Weather of the Sun-Earth System (CAWSES), and in conjunction with major society meetings whenever possible to minimize travel time and expenses.

C. The IHY Science Coordination Database and Coordination Tools

The IHY science coordination database is a central resource developed for the many IHY coordinators and team members, to facilitate communication and coordination. The database includes people, their scientific interests, geographical location, scientific facilities, instruments/observatories, scientific organizations and events. As IHY working groups, CIPs and other teams form, they will also be added to the database.

The primary function of the database is to serve as a central information resource for the people and activities of IHY, to maximize the potential of the activities and minimize the efforts of the many national and regional coordinators, working groups, CIP leaders, discipline planners, meeting organizers, etc. For example, an IHY team member from Cameroon may want to update personal contact information and email address. This team member is also part of the IHY-Africa initiative, the international body of IHY scientists and working groups as well. Rather than expecting the leaders of all of these teams to keep up-to-date information separately, the science coordination database serves as a single contact point saving team members unnecessary effort.

The database software currently used by IHY is MySQL, which allows rapid retrieval of information and easy synchronization with other databases. The database is used to generate most of the IHY website, so that the events page and coordination pages contain the most accurate information. Additionally, some of the national coordinators or working group leaders have chosen to establish databases to store their team’s information and develop additional tools for their scientific activities. Because the databases can be synchronized via the Internet, this virtual database allows the IHY team members flexibility if they choose to develop database applications and tools for their own websites. Additionally, the IHY CIPs are hosted by the IHY-United Kingdom programme, but a simple XML interface synchronizes the CIP database with the science coordination database.

The database generates the events calendar and many of the IHY websites and resources, which are described in Appendix III below. The science coordination database can be accessed via the “science” section of the IHY website.

D. Coordination with other Scientific Activities and International Years

In order to have the optimal scientific impact, IHY coordinates its activities and efforts in conjunction with a wide variety of organizations. These organizations include scientific unions and bodies such as the International Astronomical Union (IAU), outreach activities such as Sun-Earth Day and Yuri’s Night World Space Party, scientific activities such as CEDAR, and other initiatives and events.

IHY Coordination with Other International Years

With the approach of the 50th anniversary of IGY in 1957-1958, a number of IGY legacies still pervade the astrophysical and geophysical sciences. These include global geoscientific cooperation, continuation of the IPYs begun in 1882, global data initiatives such as the world data centres, space-based flight and observations beginning with the launch of the Sputnik 1 and an unprecedented global awareness of geoscience issues and activities. In addition to 50th anniversary commemorative events (such as the International Union of Geophysics and Geodesy’s IGY+50 programme), several other major scientific initiatives are planned.

IHY team members have already initiated a wide variety of activities in conjunction with other “International Years,” i.e. activities occurring on the 50th Anniversary of the IGY. There are three primary activities fitting this description: eGY, IPY and IYPE. The IHY activities overlap with the other international years in each of the primary activities of IHY: science, IHY/UNBSSI programme, “IGY Gold” history and outreach.

A large number of the IHY CIPs will be executed in coordination with other international years. Additionally, IHY team members are participating in and coordinating research activities for the other international years, such as the joint "Interhemispheric Conjugacy in Geospace Phenomena and their Heliospheric Drivers" (ICESTAR)/IHY activity for IPY. The IHY/UNBSSI programme has identified a fundamental need to address the infrastructure issues facing scientists in the participating countries, which is a joint eGY activity described in Section III.D. Some of the IHY working groups will also be exploring overlapping activities with other international years, and joint activities called "supergroups," such as the eGY-hosted education portal, describe initiatives spanning more than one of the international years.

Because there are so many natural overlaps between these initiatives, there are too many items to describe in a single publication. The facilitation of these coordinated activities has arisen from the large number of IHY team members whose involvements span more than one international year. Recently, the cooperation was formalized at a joint meeting of the leaders of the international years in September 2005. The "Celimontana Declaration" is included as Appendix II, along with brief statements describing the associated activities. The IHY International Advisory Committee now includes positions reserved for leaders of each of those initiatives, and IHY team members serve as organizers or advisors for the other international years.

Support from International Scientific Unions and other Scientific Activities

The programmes of IHY are being implemented with support from a number of major scientific unions. The global IHY initiative is neither hosted nor sponsored by a single agency or organization; instead, support for national activities and for the four programmatic thrusts are provided by a wide range of cooperating organizations.

The United Nations Office for Outer Space Affairs serves as the home for the IHY/UNBSSI programme, described in Section III below. Major support for the workshops is provided by the European Space Agency (ESA), while the individual experimenters are supported by several national funding agencies. Co-organization support was provided in 2005 by the National Aeronautics and Space Administration (NASA) of the United States, the National Astronomical Observatory of Japan (NAOJ), IAU and the Committee on Space Research (COSPAR). The working group on infrastructure and sustainability issues in global space sciences is a joint activity of IAU and the African Scientific Network (see Section III.D below).

IHY planning discussions have been hosted by a number of major geophysical and astrophysical organizations throughout the world. Additionally, there have been nearly 100 scientific sessions and discussions on IHY, which have played a fundamental role in the development of the national activities and CIPs. IAU hosts a special subgroup on IHY and is providing leadership in support of the IHY-US programme.

The American Geophysical Union (AGU) has provided support by hosting the IHY Secretariat and the IHY website (http://ihy2007.org). The International Union of Geophysics and Geodesy (IUGG) is planning a special "IGY+50" history celebration in 2007, and is the primary sponsor of the IGY Gold history programme described in Section V below. The AGU and International Association of Geomagnetism and Aeronomy (IAGA) history committees are playing a significant role in the development of the IGY Gold history programme.

Finally, hundreds of scientific instruments/observatories in space and on the ground are participating in IHY through the science and outreach activities. This extensive suite of instrumentation, the "Great Observatory," spans all the heliophysical subdisciplines; without their participation, IHY would not be possible.

III. IHY/UNBSSI Programme

A. Introduction

The purpose of the IHY/UNBSSI programmatic thrust of IHY is to develop activities and facilitate partnerships that stimulate space and Earth science activities throughout the developing countries of the world, such as the establishment of ground-based instrument arrays and research programmes. This includes the deployment of small, inexpensive instruments such as magnetometers, radio antennas, Global Positioning Service (GPS) receivers, all-sky cameras, etc. around the world to provide global measurements of ionospheric and heliospheric phenomena. This joint programme, a collaboration between the IHY and UNBSSI, centres around a series of annual workshops hosted in Member States of the United Nations (starting with the 2005 UN/ESA/NASA Workshop on the IHY in Al-Ain, United Arab Emirates).

The IHY/UNBSSI programme facilitates partnerships between instrument providers and instrument host institutions. The lead scientist, or principle investigator (PI) will provide instrumentation (or fabrication plans for instruments) for the array; the host country provides human resources, facilities and operational support to obtain data with the instrument, typically at a local university.

Exemplary Science on a Global Scale: Connecting Local Ionospheric Disturbances to Global Processes

Figure 5 shows the effects on the naturally occurring ionospheric emissions caused by an instability process generated at the magnetic equator in addition to a geomagnetic storm. The local structures, seen in the data as depletions in the airglow intensity, are caused by an instability process generated at the magnetic equator. The turbulence within these local structures can disrupt transionospheric communication and navigation signals. The local structure typically drifts from west to east. In this example, simultaneous with the development of this equatorial instability process, a travelling ionospheric disturbance (TID) propagates equatorward from the polar region, launched by energy input in the auroral region due to the onset of a geomagnetic storm.

Within this TID are electric fields and neutral winds that can differ significantly from their respective quiet-time values. As the TID passes over Hawaii, the perturbed electric fields and neutral winds affect the observed local structure by both reversing the drift direction to the west and initiating the development of secondary instabilities on the eastern edge of the primary local structure.

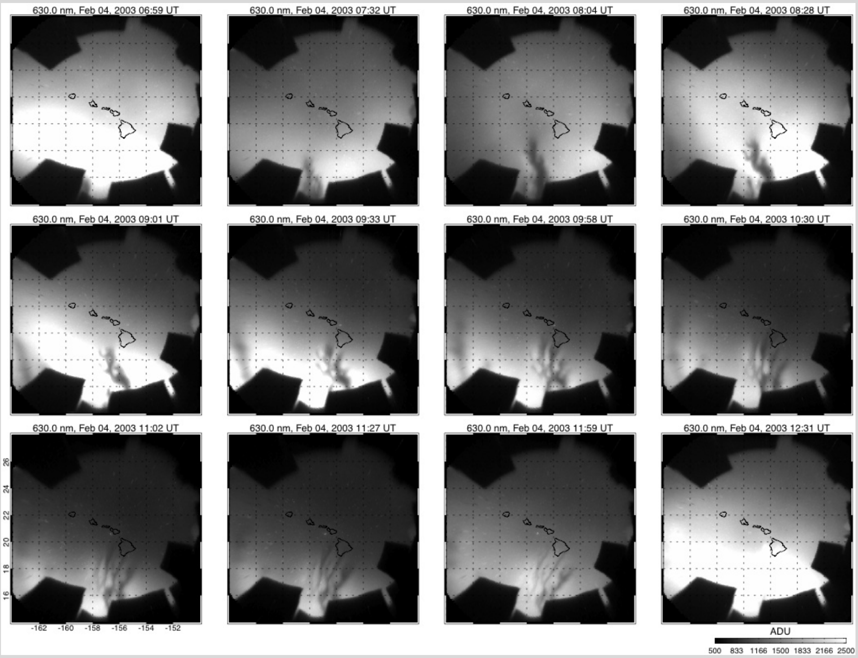


Figure 5. *A series of images capturing the development of structures, seen as dark regions, associated with an equatorial instability process. These structures are further modified by the passage of a TID, seen as an enhancement travelling from northeast to southwest, associated with energy input in the auroral region. The images are of the 630.0-nm emission that occurs naturally in the Earth's ionosphere/ thermosphere system and were recorded from the site of the Haleakala Volcano on Maui, Hawaii, USA.*

The instabilities introduced by TIDs and other ionospheric phenomena impact our ability to communicate through the ionosphere (e.g. GPS, satellite communications). The lack of ability to predict such phenomena leads to unanticipated transionospheric communications outages that negatively impact everyday aspects of life in the 21st Century. In order to mitigate those outages, we need a global predictive capability. A global capability requires comprehensive and extended observations that can resolve both the fine scale structures as well as the global coupling effects that influence the development, structure and impact of ionospheric disturbances on transionospheric radio signals.

B. The UN/ESA Workshops on Basic Space Science

The United Nations, through its Office for Outer Space Affairs, and in cooperation with the European Space Agency (ESA), initiated in 1990 the organization of annual Workshops on Basic Space Science within the framework of the United Nations Programme on Space Applications. Those workshops, focusing on astrophysics and space science, have been held in a number of countries, balancing the geographical representation of the programme activities.

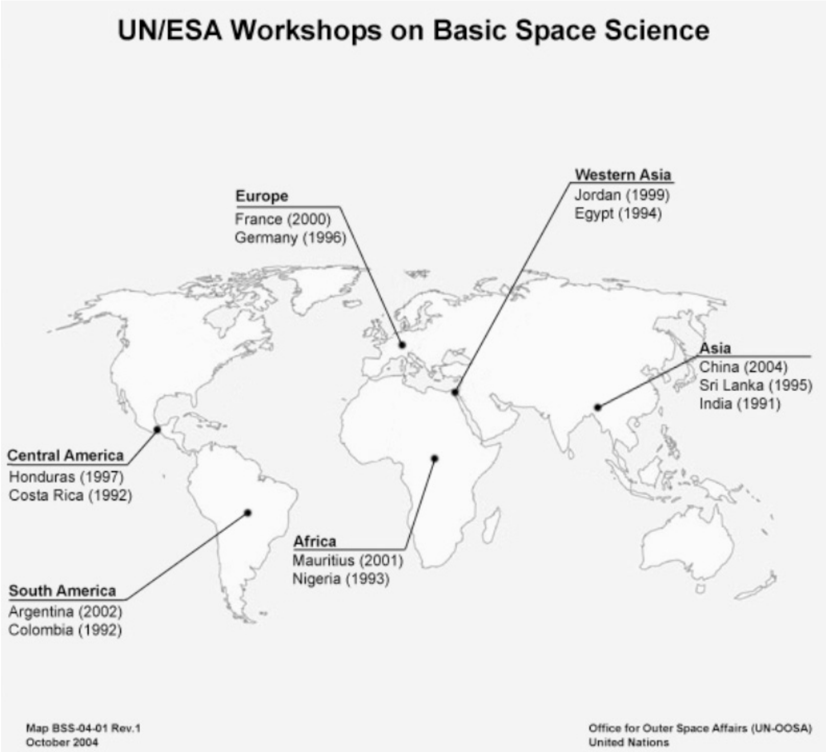


Figure 6. *Locations of previous UN/ESA Basic Space Science Workshops*

The 2005 UN/ESA/NASA Workshop was held in Abu Dhabi and Al-Ain, United Arab Emirates, from 20 to 23 November. Highlights of this activity included the first instrumentation deployed as a part of the IHY/UNBSSI programme (see the description of the Atmospheric Weather Educational System for Observation and Modeling of Effects programme in Appendix IV), the establishment of the IHY-Western Asia initiative (described in Section VI.D.7) and the establishment of a special activity targeting sustainability and infrastructural issues facing space scientists in developing countries (described in Section III.D).

Brief Summary of the UN/ESA/NASA Workshop on IHY

The four-day workshop was hosted by the United Arab Emirates University (UAEU), under the patronage of H.H. Sheikh Nahayan Mabarak Al-Nahayan, Minister of Education of UAE and Chancellor of UAEU, and on behalf of the United Arab Emirates Government. The meeting was co-organized by COSPAR, IAU, NAOJ and the Department of Physics at the UAEU. The local organization was also provided by the Department of Physics at UAEU.

Workshop participants represented 39 United Nations Member States, including a significant portion of North Africa, the IHY-West Asia region, as well as leadership from the remaining six IHY international regions. There were special sessions on IHY instruments and host institutions, as well as IHY science, global scientific initiatives, education programmes, astrophysical research in Arab countries and the 2005 World Year of Physics. Special discussions also included planning for the IHY-Africa initiative, education and outreach activities and the establishment of a working group on infrastructure and sustainability issues in global space sciences.

The following are recommendations that emanated from the workshop:

The Workshop observed with satisfaction that the regional centres for space science and technology education, affiliated to the United Nations, which have been established in India, Morocco, Nigeria, and Brazil/Mexico, were operational. The Workshop emphasized that the establishment of such a regional centre in Western Asia would be beneficial.

The Workshop noted with satisfaction the continued installation of telescopes and planetariums in developing countries through the official development assistance programme of the Government of Japan, in particular its continuing support for Bolivia, Ethiopia and Pakistan (astronomical telescopes), and Cuba, El Salvador and Romania (planetariums).

The Workshop noted with satisfaction that the published report “Developing Basic Space Science World-Wide: A Decade of UN/ESA Workshops” has been widely distributed and served as a guide for space science related activities in developing countries.

The Workshop noted with appreciation that the Office for Outer Space Affairs had received indications of interest from India, Japan and the Republic of Korea to host future workshops.

The Workshop strongly recommended the support of the scientific activities related to IHY 2007. The following concepts and projects were discussed and endorsed during the Workshop:

- *The TRIPOD concept, which was developed and implemented by previous UN/ESA Workshops on Basic Space Science should be adopted for IHY 2007: installation and operation of scientific instruments, taking data with the scientific instruments and using scientific instruments and data for university education should be considered equally important in each of the scientific instrument activities;*
- *Scientific instrument host groups, which will provide sites in locations where measurements are desirable, were identified. Potential scientific instrument host groups that showed interest came from various parts of Africa, Western Asia, India, Malaysia, Indonesia and countries in Latin America;*
- *Potential providers of scientific instruments discussed their interactions with potential scientific instrument hosts during the course of the Workshop, and expressed overall satisfaction with the amount of interest shown by Workshop participants;*
- *All scientific instrument providers discussed the development status of their instruments and the degree of readiness to deploy those instruments. It was noted that the installations will remain quasi-permanent throughout the period of IHY 2007 activities and thus there was no time pressure on the scientific instrument providers; and*
- *Workshop participants were ready to provide voluntary support to the preparations and coordination of the above-mentioned scientific instrument activities as part of IHY 2007 activities.*

The Workshop strongly supported the proposed collaboration of scientists from Georgia and Ukraine within the framework of IHY 2007, with the aim of creating a complex electromagnetic polygon at the base of the Abastumani Astrophysical Observatory as well as a student-developed microsatellite, to be launched in 2007.

The Workshop noted that the IHY 2007 collaborations will require the exchange of personnel and scientific instruments between participating scientific organizations from different countries. Governments should be encouraged to facilitate such exchanges as much as possible.

The Workshop observed that Internet access was now available in almost all countries, and encouraged support for the increased use of the Internet as a tool for education and research, in view of the fact that many educational resources were now available online and could be accessed in a cost-effective manner. In this context, note was taken of a discussion group on the "Digital Divide", which was established by IAU. Developing countries were encouraged to participate in this discussion group.

The Workshop noted that the mirror sites of the NASA-funded Astrophysics Data System (ADS) in Brazil, Chile, China, France, Germany, India, Japan, Republic of Korea, Russian Federation and the United Kingdom have been enthusiastically accepted by the scientific community, and have become important assets for developing countries to improve access to the astronomical literature. The Workshop commended ADS for this work.

The Workshop appreciated the ongoing development of virtual observatories (VOs) on the part of major scientific organizations. The Workshop strongly recommended that every effort be made to allow usage of these research tools, as well as access to the data and to the analysis software, by scientists from developing countries.

The Workshop observed that the scanning of historical observatory publications by ADS now provided easy access to a part of the astronomical literature that so far has been difficult to obtain in developing countries.

The Workshop encouraged close cooperation between the VO community and ADS, with the goal of allowing scientists from developing countries to compete on the highest level of scientific research.

The Workshop appreciated the increased availability of hands-on educational websites produced by major research organizations, which greatly facilitate science education in developing countries. Space science professionals in all countries should be encouraged to support such efforts.

C. Instrument Programmes and Status

Drawing on 15 years of experience, UNBSSI developed the “Tripod” concept, an implementation model for the accelerated establishment of basic space science associated activities in developing countries. The Tripod concept, identified in the first UN/ESA Workshop on Basic Space Science in India (1991), is described as follows:

1. The availability of research tools of a level where meaningful science can be made, but at a level where the national socio-economical infrastructure can maintain functionality in the university/research laboratory environment, e.g. a small telescope facility or instrument array;
2. Teaching materials allowing basic space science to be introduced at the teaching level of fundamental mathematics, physics and chemistry courses in middle and higher education; and
3. Application materials for original research in basic space science such as observing programmes for variable stars.

Using this approach, small astronomical telescope facilities in Colombia, Egypt, Honduras, Jordan, Morocco, Paraguay, Peru, Philippines, Sri Lanka and Uruguay have been established and continue to be in operation. The introduction of astronomy in the context of basic space science in university curricula in countries such as Honduras as a regional activity is a result of the Tripod approach.

Several initiatives have reached a mature stage of development and have been selected for the first phase (2005-2006) of the IHY/UNBSSI programme. Instrumentation is prioritized based on suitability to accomplish the goals of the IHY/UNBSSI programme:

- **The projects must produce scientifically significant and publishable results pertaining to the objectives of the IHY activities;**
- **To identify activities that can be performed in developing countries (many of which are near the equator); and**
- **The costs and technical requirements must be compatible with the resources available in the participating countries.**

Additionally, the following factors are desirable:

- **Legacy potential: leading to a beneficial relationship for the participants in developing countries;**
- **"Tiered" technology: instruments with several designs corresponding to increasing design complexity; and**
- **Educational components, including university level (see Section IV.B).**

The efforts of the IHY activity will focus on finding host sites for the observatories and instruments and assisting in the identification of technical and financial resources.

A description of the instrumentation targeted for deployment at the 2005 UN/ESA/NASA workshop is included in Appendix IV. There will be at least one workshop held annually through 2009, and additional instrumentation will be selected each year for implementation. Prospective experimenters or instrument hosts should review the "observatory development" section of the IHY website.

D. Working Group on Infrastructure and Sustainability Issues in Global Space Sciences

During the 2005 UN/ESA/NASA workshop in the UAE, a group of participants from IAU and the African Scientific Network (among others) founded the working group on infrastructure and sustainability issues in global space sciences. This group will be co-sponsored by eGY, IAU, regional centres for space science and technology education affiliated to the United Nations and possibly other organizations. Precursors to the founding of this group include an IAU discussion on global astrophysical research viability in 2004 in St. Petersburg, Russian Federation, and a discussion of instrument deployment and maintenance issues at the 2005 IAGA General Assembly in Toulouse, France.

The goal for this group is to discuss issues affecting the ability of space scientists in all regions of the world to perform research, stay connected with the research community and sustain student programmes at universities. Participants in the group will address the use of VOs (as referred to in Section III.B) to improve global access to data, access to scientific journals (see ADS as referred to in Section III.B) and analysis tools, difficulties and obstacles in sharing scientific information and technology between countries, access to financial and technical resources, and socio-political issues affecting a researcher's ability to develop and sustain a research programme at a university.

The topics will also include the "digital divide," i.e. gaps that exist between groups regarding their ability to use information and communications technologies effectively, due to differing levels of literacy and technical skills, as well as the gap between those groups that have access to good quality and useful digital content and those that do not. There is currently an IAU discussion group on that topic, as well as several global groups working to understand and address these issues. Therefore, the group's goals include a clear assessment of similar and related activities to determine an appropriate role for IHY to make progress in resolving these fundamental issues.

E. UN Publications & Resources

The United Nations Office for Outer Space Affairs and the IHY/UNBSSI programme have produced a series of publications including the results of previous workshops, curricula for education in space science and technology, a planetarium guidebook and the present booklet on IHY. These publications are a valuable resource because their topics focus on the development of space science research and education worldwide and a number of them have been translated into the six official languages of the United Nations: Arabic, Chinese, English, French, Russian and Spanish. Because many international scientific meetings are conducted in English, a language barrier may exist that affects the viability of space scientists in certain regions of the world. Since most of the UNBSSI publications and curricula are available in multiple languages, their impact can easily extend beyond English-speaking countries.

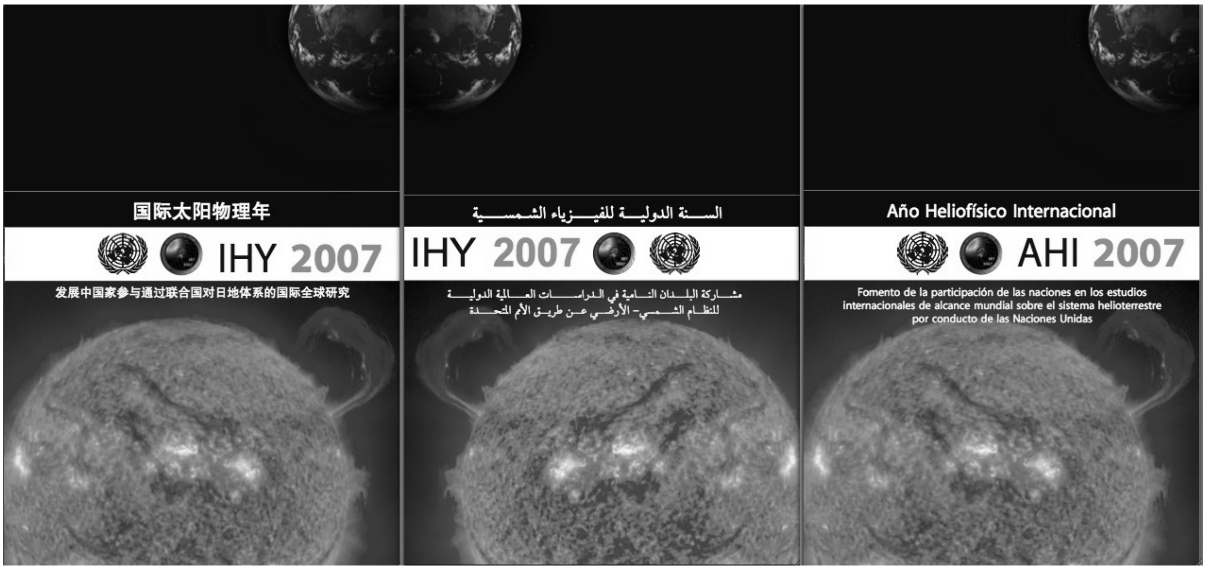


Figure 7. *The 2005 version of the IHY brochure, shown (left to right) in Chinese, Arabic and Spanish.*

Several IHY products are available in multiple languages. The most recent version of the IHY brochure, shown in Figure 7, was published in all six official languages of the United Nations. A number of outreach products (see next section) and websites have also been developed in multiple languages, in keeping with the goal of the United Nations to improve the availability of these resources to the world.

IV. Education and Public Outreach

IHY presents unique opportunities for expanding the education and awareness of space and Earth sciences. As a result, the education programme forms a cornerstone of IHY. As hundreds of observatories and institutions are preparing for the scientific activities of IHY, the associated educational programmes are being linked into an unprecedented network of schools, institutes, programmes and activities in developing countries.

Although each of the four programmatic thrusts has a unique function, it is clear that the coordination of these activities allows the successful implementation and maximization of the impact of each of the components. For example, if the education and public outreach (E/PO) component is integrated with the science campaigns, instrument/observatory development and history initiatives, it will be able to reach a greater audience and have a larger impact.

As IHY establishes a greater presence for space and Earth sciences in developing countries, it will assist the local researchers in establishing education and outreach initiatives through IHY international educational programmes. Stronger research programmes mean stronger universities, which will foster the development of graduate and undergraduate programmes, which are in turn key factors in encouraging youth to become interested in the exciting field of heliophysics.

Similarly, there are hundreds of observatories planning to participate in IHY scientific activities. As many of these observatories have education and outreach programmes and relationships with local schools, IHY will use science activities to form a focus and coordination point for education programmes.

The E/PO programme of the IHY has many components:

- Increasing public awareness of the "great heliophysical observatory" and the exciting process of scientific exploration;
- Generating interest in space science, Earth science and space exploration, particularly in regions that do not have strong educational programmes;
- Coordinating E/PO activities between programmes at participating IHY observatories (200 and growing!);
- Leveraging international activities, such as the IHY/UNBSSI programme and the CIPs, to tap into new educational arenas;
- Activities with amateur astronomy clubs, planetariums, science centres, museums and other established programmes;
- Development of tools and resources for educators;
- "Moving exhibitions" or kiosks that can be deployed to reach a wider audience;
- Educational activities with the IHY/UNBSSI programme that provide students with a deeper challenge and connection to global space science;
- Summer schools on heliophysical topics for college undergraduate and graduate students.
- Historical commemorations and anniversary events; and
- Helping great ideas become reality: many activities are still in the planning stage.

A. Organizational Structure

The organizational structure of the IHY E/PO programme closely mirrors the overall organization of the IHY programme: a central coordinator, an advisory committee, E/PO leaders for each region and participating country and working groups targeting particular aspects or components (Figure 8). There will also be IHY educational leaders or contact points for institutions, towns or programmes that are interested in participating regularly in IHY E/PO activities. Many of the E/PO activities are coordinated on a "grass roots" basis, and the working groups and an advisory committee coordinate the various local activities while developing unique outreach activities to take place on a global scale. The IHY E/PO coordinator is part of the IHY Secretariat, serves as the chair of the E/PO advisory committee and is a contact point and facilitator for the IHY team members and their E/PO activities. The E/PO advisory committee is chosen to represent a wide range of expertise while ensuring geographical balance and strong connections with other E/PO programmes.

Most of the IHY E/PO activities will be developed as partnerships with other programmes or institutions. Chief among these collaborative opportunities are the regional centres for space science and technology education affiliated to the United Nations, eGY, IPY, IYPE, the European Planetarium Network, participating IHY institutions and observatories, scientific organizations, educational programmes of government agencies, planetariums, museums and science centres. In some cases, the function of IHY will be to expand participation and awareness of an activity, such as the "NASA Cosmos" website and the Yuri's Night World Space Parties. In other cases, IHY will assist a programme or institution with the development of a new component or activity, such as new exhibits for museums and science centres, or events hosted by amateur astronomy clubs. There will also be activities unique to IHY, like many of the educational components of the IHY/UNBSSI programme.

Figure 8. *IHY E/PO team members will rely on their experience with travelling exhibits such as the SpaceUK Exhibition of the Inter-University Centre for Astronomy and Astrophysics (commissioned by the British Council), which toured India in 2004. The exhibit took just a few hours to put up (left), had a lot of information about the planets and the solar system (middle) and even included high-resolution pictures and models (right).*

The following sections give a brief "sampling" of IHY E/PO activities.

B. IHY/UNBSSI Joint Activities

Many of the instruments/observatories in the IHY/UNBSSI programme also contain educational components. The AWESOME Space Weather Monitors (described in Appendix IV) that are being deployed are sophisticated instruments and generally require support from a university. However, the PI team has developed an inexpensive version, known as a Sudden Ionospheric Disturbance (SID) monitor. Stanford's Solar Center, in conjunction with the Electrical Engineering Department's Very Low Frequency (VLF) group and local educators, have developed inexpensive SID monitors (Figure 9) that students can install and use at their local high schools. Students can join the project by building their own antenna, a simple structure costing less than \$10 and taking only a few hours to assemble. Data collection and analysis is handled by a local PC, which need not be fast or elaborate. Stanford University will be providing a centralized data repository and blog site where students can exchange and discuss the data.

Figure 9. *Front (left) and back (right) of the Stanford Solar Center SID monitor. Students assemble an antenna and provide an Internet connection to become part of a growing network of space weather monitors.*

C. Educator Resource Development

As mentioned in Section III.E, the IHY/UNBSSI programme has been developing curricula and educator resources to improve the quality of space science education worldwide. Many of the IHY E/PO team members have been involved in educator resource development, such as the NASA Cosmos website, which provides direct access to tutorials and images of new space science discoveries. The "outreach" section of the IHY website already contains a great deal of teacher and educator resources; the section will be expanded to include information about events, new programmes and activities, and provide links to hundreds of international educational sites.

D. Sun-Earth Day and the Total Solar Eclipse of 2006

Solar eclipses provide excellent educational opportunities, and the annual "Sun-Earth Day" event for 2006 will be held on the day of a total solar eclipse on 29 March. The eclipse path begins in Brazil, traverses the Atlantic, Northern Africa, Central Asia, ending at sunset in western Mongolia. Both educators and researchers will be attending the eclipse event, which has also been targeted by the African Scientific Network. IHY outreach activities have already begun with the October 2005 deployment of the AWESOME space weather monitor in Tunisia; a poster on the solar eclipse featuring the eclipse path, solar facts, space weather information and tips on eclipse viewing safety has been developed and translated into four languages commonly spoken along the eclipse path: Arabic, English, French and Spanish. The poster (shown in Figure 10) and special eclipse-viewing glasses will continue to be distributed in anticipation of the eclipse.

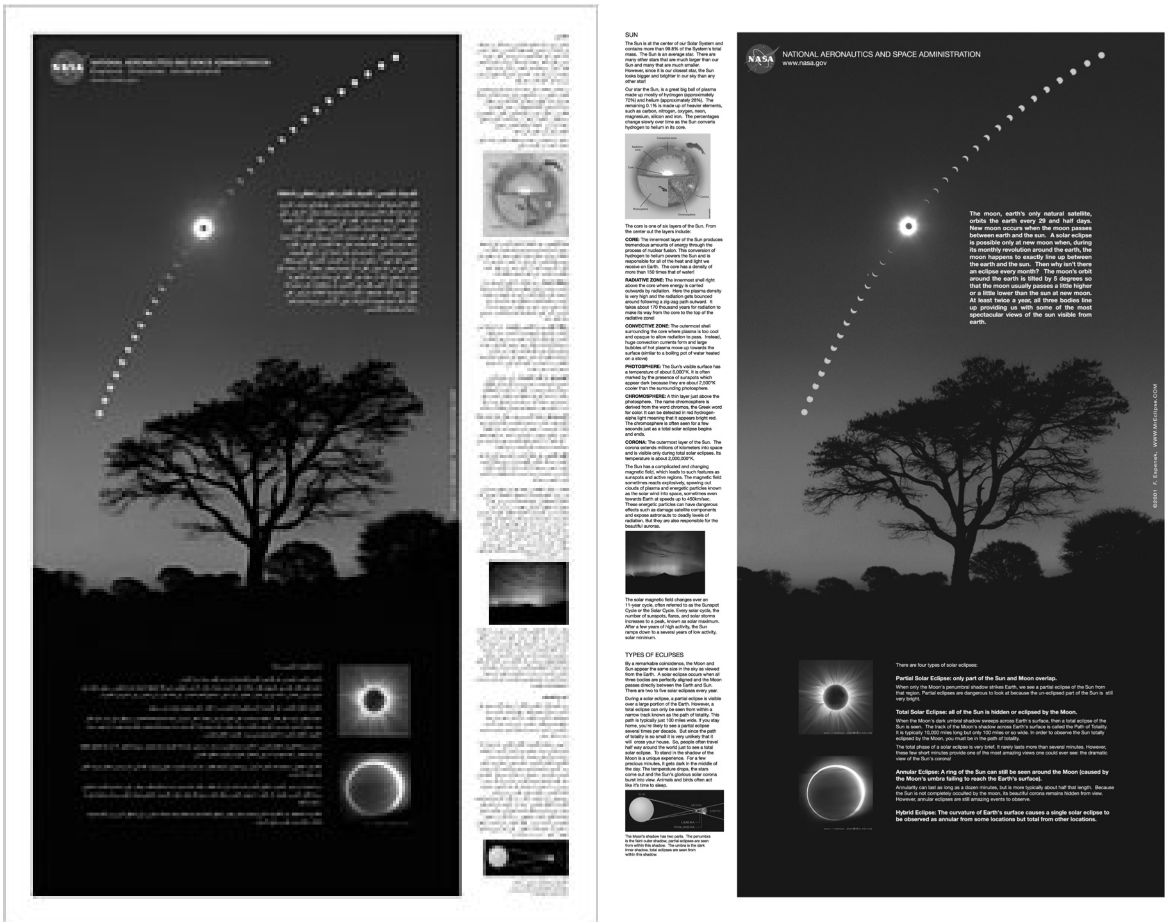


Figure 10. *A poster describing the total solar eclipse path and geometry and containing facts about the Sun, space weather effects and eclipse viewing safety was developed in four languages commonly spoken along the eclipse path. Shown are Arabic (left) and English (right).*

E. Yuri's Night World Space Party

Yuri's Night is an international celebration held on 12 April every year to commemorate the flight of the first human in space, Yuri Gagarin, on 12 April 1961, and the first Space Shuttle launch on 12 April 1981. Locations have included all seven continents and the International Space Station.

The goal of Yuri's Night is to increase public interest in space exploration and to inspire a new generation of explorers. Driven by space-inspired artistic expression and culminating in a worldwide network of annual celebrations and educational events, Yuri's Night creates a global community of young people committed to shaping the future of space exploration while developing responsible leaders and innovators with a global perspective. These global events are a showcase for elements of culture that embrace space including music, dance, fashion and art. Everyone is welcome to organize Yuri's Night events. Some have hundreds of participants while others are more small and informal. Those who are interested in Yuri's Night activities can find more information through the "Outreach" section of the IHY website or go to the Yuri's Night website at http://www.yurisnight.net.

Through the IHY outreach and history programmes, IHY team members around the globe are partnering with Yuri's Night to bring greater awareness to past and current events in space. This annual event is particularly significant to IHY in that it is one of the activities that reaches beyond space science and focuses on the development and exploration of space in general.

V. “IGY Gold” History Initiative

A. Goals

IGY 1957-8 was one of the greatest scientific events in the 20th century. Although a great deal of historical effort has been dedicated to IGY, there is still a great deal of historical information in danger of being lost in time. Therefore, an important part of the IHY 2007 activities will be preserving the history and memory of IGY (for a brief history of IGY and the other international science years, please see Appendix I below). "IGY Gold" history initiative (Gold symbolizing the 50th anniversary) has several goals:

- Identifying and recognizing planners of and participants in the first IGY;
- Preserving memoirs, articles, photographs and all items of historical significance for the IGY;
- Making these items available to historians, researchers, etc.;
- Serving as a contact service for these activities;
- Spreading awareness of the history of geophysics; and
- Planning special events and "reunions".

The IGY Gold programme, launched in 2004, is accomplishing those goals by creating a network that identifies participants in the first IGY, awards them a special certificate and commemorative pin and encourages them to collect items of historical interest and make them available to historical archives. Support for this programme is provided by IUGG, while organizations such as the AGU and IAGA history committees have played a significant leadership role in the development of this activity.

B. The IGY "Gold" Club

The IGY "Gold" club identifies and recognizes the exceptional accomplishment of participants from the first IGY. To be inducted into the IGY Gold Club, individuals ***must meet three requirements:***

- Have been a participant in the first IGY;
- Contributed an item of historical significance to the initiative. It can be a letter, a recollection, an article, a photograph, etc. Unusual items are often the most significant to historians; and
- Willing to have that item made publicly available to historians, librarians and other people interested in investigating and preserving the history of geophysics.

Gold club participants will be rewarded with a special commemorative "IGY Gold" lapel pin. They also receive a special "IGY Gold Anniversary" certificate of recognition from one of the IGY legacy sponsors (IHY, IYPE, eGY or IPY) and one of the associated geophysical organizations (currently IUGG, AGU and IAGA; other organizations are welcome to join). ***The "IGY Gold" commemorative lapel pin has been specially designed for the 50th anniversary of IGY, and only members of the IGY Gold club will be issued this pin.***

Figure 11. *All members of the IGY Gold club receive a special certificate (left) and IGY Gold commemorative pin (right).*

There have already been hundreds of people, from all continents, inducted into the IGY Gold club, and a great deal of valuable historical information has been obtained and preserved for posterity. The first award was presented at a special IHY ceremony to Alan Shapley, who served as Co-chair of the US IGY Committee. Additionally, the University of Iowa had a special presentation for James Van Allen, Explorer I project scientist and one of the people who originally proposed IGY. The IGY Gold history initiative proudly continues to award certificates and pins worldwide.

VI. Science Coordination & International Organization

A. Organizational Structure

The IHY programme's organizational structure was devised to balance the priorities and influence of the international coordination team, the working groups, the individual national IHY programmes and the supporting international scientific bodies and consortia.

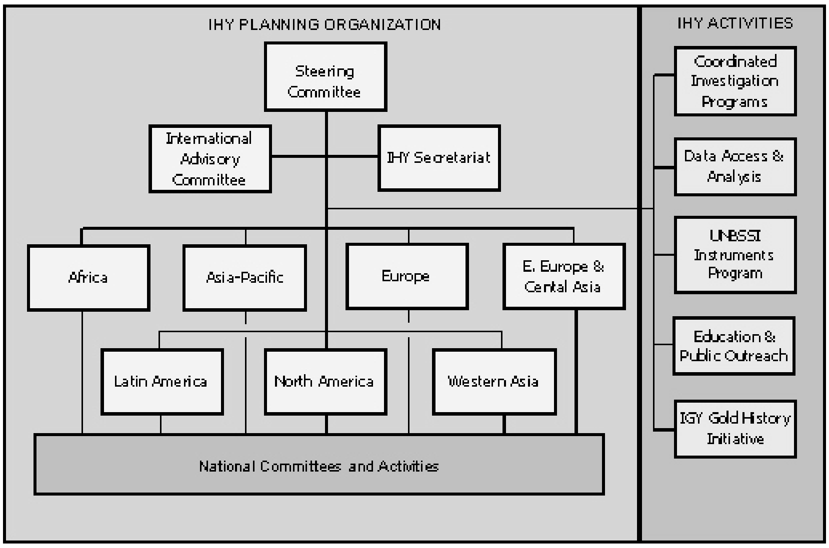


Figure 12. *IHY organizational structure.*

Figure 12 illustrates how these facets are related; the **Steering Committee, International Advisory Committee** and **Secretariat,** respectively, are charged with the guidance, execution and coordination of the international activities of IHY. Local IHY activities – that is, activities and coordination within a particular region or country – are represented in the lower portion of the organizational chart in Figure 12. Each of the (currently 191) United Nations Member States belongs to one of the IHY international regions: **Africa, Asia-Pacific, Eastern Europe and Central Asia, Western Europe, Latin America, North America** and **Western Asia**. The internationally coordinated activities, represented on the right side of the organizational chart, are facilitated via the IHY working groups. Current IHY working groups focus on **CIPs, data access and analysis**, the **IHY/UNBSSI programme, education and public outreach,** and **the "IGY Gold" history initiative.**

The remainder of this section is devoted to describing the responsibilities and current status of each of the IHY organizational components.

B. IHY Secretariat

The IHY Secretariat is responsible for the support of IHY committees and international activities. The Secretariat also maintains the IHY website and coordination system, provides resources for IHY activities and is responsible for communication within and outside the participating community. Currently, the IHY Secretariat has the following membership:

- Chair of the IHY Steering Committee, who also functions as the Executive Director of the IHY Secretariat;
- International Coordinator;
- Director of Operations;
- Coordinator of the IHY/UNBSSI Programme;
- International Advisory Committee Chair;
- CIP Coordination Committee Chair;

- Education and Outreach Committee Chair;
- Publications Committee Chair;
- "IGY Gold" History Committee Chair;
- Newsletter Editor;
- Press and Media Relations Secretary; and
- Website and Web-based Applications Designers and Editors

The individuals filling these many roles are located at various locations, drawing support from a wide range of international bodies; however, the central coordination and contact point is at a single site, hosted by AGU. It is important to note that the IHY Secretariat is not hosted by a governmental body; this allows all countries to participate and contribute on an equal basis. AGU is an international scientific organization hosting meetings throughout the world, and welcoming contributions from all countries. The address of the IHY Secretariat is:

International Heliophysical Year Secretariat
American Geophysical Union
2000 Florida Avenue NW
Washington, DC 20009, USA

The list of people currently serving in these IHY positions is provided in the "contact" section of the IHY website. Individuals filling these roles may change, and the reader is referred to the IHY Secretariat and website for the most accurate and recent information.

C. Advisory Committees, Steering Committees and Working Groups

As mentioned previously, the guidance, execution and coordination of IHY international activities are performed by the International Advisory Committee, Steering Committee and Secretariat, respectively. The membership of the **International Advisory Committee** is chosen to balance geographical distribution, scientific disciplines and representation from organizations and supporting programmes. The International Advisory Committee advises the IHY team on issues of international coordination, planning and connectivity with international scientific organizations, national bodies and related activities. This group serves as a consultant body to help optimize the relationship between the goals and efforts of IHY and other international groups and activities.

The IHY **Steering Committee** has the responsibility of ensuring the implementation of the recommendations of the International Advisory Committee, as well as overseeing the operations within IHY. The IHY International Steering Committee is comprised of representatives from each of the seven IHY geographical regions and scientists spanning all of the sub-disciplines of heliophysics. The responsibilities of the International Steering Committee include the prioritization of IHY resources and activities, providing guidance and monitoring the progress of the IHY working groups and ensuring clear communication among the IHY teams, scientific organizations and constituent bodies.

The five major IHY **Working Groups** are CIPs, data access & analysis, IHY/UNBSSI programme, E/PO and the "IGY Gold" history initiative. These denote the working groups only at a top level, as most of the groups contain sub-groups that focus on a particular aspect of the activity. Each of the groups, except for the data access & analysis working group, was described in the previous sections. The data access & analysis working group is in the early stages of formation, and is forming as a result of a joint activity with eGY in partnership with IAU.

Other working groups will be formed depending on the need for additional coordination. Additionally, the structure of each working group may change in response to the demands and needs of IHY activities.

D. Regional and National Leadership and Coordination

Currently there are IHY contacts in all 191 United Nations Member States, and there is progress in approaching the goal of having national organizers and planning teams identified for each country and IHY region (**Africa, Asia-Pacific, Eastern Europe and Central Asia, Western Europe, Latin America, North America** and **Western Asia**). Following are brief summaries of the IHY science planning activities for each of the seven IHY regions. Because the space in this publication is limited, it is not possible to provide information on individual activities or events. Each region will be pursuing a conduit to publish the results of their planning efforts, and an update of these activities will always be available on the IHY website. Please note that the IHY activities described throughout this publication have components in multiple regions, therefore many of the activities occurring in a particular region may instead be described in one of the previous activity sections.

1. Africa

Several individual countries within Africa have been organizing IHY initiatives, in anticipation of continent-wide coordination activities in 2006. National coordinators have been identified for many African countries, and planning activities are underway. IHY-Nigeria has been particularly active, having recently held a national coordination meeting in October 2005 attended by research scientists, students, engineers and educators. The region-wide IHY-Africa planning committee is planning a workshop in early 2006, inviting international and national delegates consisting of space science researchers and students to discuss the state of Sun-Earth connection education and research in Africa, particularly, the theoretical and experimental understanding of the Sun-Earth connection. The workshop will refine and articulate research areas and pave the way for effective integration of space research and education in "K-life" (Kindergarten and beyond) learning.

Following are the objectives of the IHY-Africa planning team. These objectives clearly interweave educational priorities with scientific priorities:

1. Provide education and training in satellite and ground based instrumentation;
2. Offer topical lectures on advances in heliophysical phenomena;
3. Identify common priorities in space science research and education in participating countries that may lead to the development of regional space science centres;
4. Become a conduit for future generations of African space scientists and educators to gain professional experience;
    (a) Adoption and development of Kindergarten to 12th Grade (K-12) space science curricula.
    (b) Conduct informal education to bring about public awareness of the field of space science.
    (c) Develop a comprehensive space education strategy for K-12.
    (d) Contribute to the improvement of science education in K-12.
    (e) Encourage the participation of women in space science education and research.
    (f) Stimulate quantity and quality of space research and education at the undergraduate and graduate levels at African institutions.
5. Enable African scientists and institutions to build rewarding partnerships with the global space science community.

In the near term, the team will be pursuing the establishment of an African space scientists network in conjunction with the African scientific network, and will begin the discussion of region-wide scientific teams such as an African astronomical union. The deployment of the first IHY/UNBSSI programme instrument, completed in October 2005 (see Section VII.A), also included the initiation of an outreach activity to accompany the total solar eclipse traversing northern Africa in March 2006 (see Section IV below).

2. Asia-Pacific

The Asia-Pacific region started the planning activities in 2004, beginning with a planning meeting from 10 to 12 July in India. This was followed by the Japanese meeting in Kiyosato from 26 to 29 October 2004. The Asia-Pacific region consists of a large number of countries, with primary activities concentrated in Australia, China, India and Japan. The Asia and Oceanic Geophysical Society (AOGS) meeting in Singapore in July 2005 was the first instance many countries came together and presented their activities. Three important activities have been identified, which are likely to contribute to the campaign activities in 2007: (1) Solar observations from the Nobeyama Radioheliograph and H-alpha observations from China participating in the Big Bear Solar Observatory's network; (2) Japan, India and China have radio observatories that can link up to observe the Sun continuously, with additional participation from other countries; (3) The Interplanetary Scintillation (IPS) network for studying the solar wind and coronal mass ejections (CMEs) using radio telescopes in Japan and India collaborating with other instruments in Mexico and the UK; and (4) The MAGDAS network lead by Japan is a facility for studying magnetospheric phenomena (see Annex IV for detail).

In addition to the CIP activities, a large number of countries from South and Southeast Asia are participating in the IHY/UNBSSI programme. The recent UN/ESA/NASA workshop in the United Arab Emirates had a significant participation from Indonesia, Malaysia, India and Pakistan. Many of these countries are planning to host IHY/UNBSSI instruments. Negotiations are underway to begin deployment. Japan has a long tradition of supporting the IHY/UNBSSI programme, which is likely to be extended because of the MAGDAS network. Finally, educational innovators from the Asia-Pacific region are providing leadership for a number of IHY E/PO activities and are also assisting in the formation of the international E/PO advisory committee.

3. Western Europe

The IHY-Western Europe initiative is comprised of a number of extremely active subgroups, many of which are also involved in the international planning of IHY. IHY-Europe team members are active in all four of the IHY programmatic thrusts, including serving as PIs for the IHY/UNBSSI programme. Several new missions to be launched, plus a rich network of ground-based observatories, provide the basis for many of the IHY science campaigns. IHY planning discussions and special scientific sessions have taken place at several scientific meetings with the first IHY European General Assembly to be held in Paris, France, from 10 to 13 January 2006. Reference is made to the IHY-Europe website at http://calys.obspm.fr/IHY/ for news, updates and an interactive map of IHY national coordination activities in Europe.

IHY-UK

The IHY-UK activity is led by a small committee formed after the first UK IHY meeting, held in London in December 2003, and supported by a wider interest group. A second UK meeting dedicated to IHY was held in London in November 2005, to present the status of planning and preparations for work in IHY science involving the UK for 2007, and to review the next steps for 2006. The science planning has been driven in large part by preparation of the joint ICESTAR/IHY proposal to IPY, in which the UK took a leading role, and for which a number of UK groups are planning specific programmes of work. Summaries of the presentations and discussions at both meetings can be found on the UK IHY website (http://ihy2007.org.uk).

UK groups have contributed to several CIPs already, and more will appear in late 2005/early 2006, further stimulated by the national community meetings for solar physics (UKSP) and solar-terrestrial physics (Magnetosphere Ionosphere and Solar-Terrestrial or MIST). In 2006 these will be held jointly at the University of Wales, Aberystwyth, with IHY as a major focus and the likely subject of an all-day combined session.

The UK has also been playing a significant role in supporting the international effort for IHY. In addition to the role, already mentioned, in producing the ICESTAR/IHY proposal to IPY, the UK has taken on responsibility for running the CIP process; the online facilities to support CIP submission and review are hosted on the UK website and from early 2006 the UK will coordinate the CIP review process.

IHY Balkan, Black Sea and Caspian Sea Regional Network

An active IHY regional network has been established for the Balkan, Black Sea and Caspian Sea region. The group's website is at http://www.stil.bas.bg/. From 6 to 8 June 2005, IHY representatives of Armenia, Azerbaijan, Bulgaria, Croatia, Georgia, Greece, Poland, Romania, Russian Federation, Serbia and Montenegro and Ukraine participated in the IHY Balkan and Black Sea regional planning meeting held in Sozopol, Bulgaria. Scientists from the Czech Republic, Slovakia and Turkey who were unable to attend the meeting, expressed their wish to be included in the planned activities. Special guests of the meeting were Jean-Pierre Rozelot, former director of the Cote d'Azur Astronomical Observatory, Centre de Recherche en Géodynamique et Astrométrie (CERGA), and deputy director at the Centre National de la Recherche Scientifique (CNRS) of France, who presented the introductory lecture "*What can we learn from the Sun's interior useful for an understanding of Solar-Terrestrial links?*" and Michael Milligan from the European Office of Aerospace Research and Development (EOARD). This meeting was made possible by sponsorship from EOARD and the Bulgarian Academy of Sciences. Following are the results from the meeting:

- A number of scientific problems to be addressed within the framework of IHY were identified and observational networks supporting them were proposed;
- The participants decided to create a "Black Sea and Caspian Sea Regional Network on Space Weather Studies" consisting of all above-listed countries and open to other countries willing to participate in its activities;
- The regional network decided to have a special website – http://www.stil.bas.bg/IHY. The website will contain information about current and proposed regional and worldwide activities, and a scientific database as well as a database on each member country's activities and participants;
- The regional network will publish an international refereed scientific journal "Sun and Geosphere", with an international editorial board. The proceedings of the meeting will be published in the first issue of this Journal;
- Bilateral and multilateral joint projects and collaborations among member countries will be promoted. The first possible collaborations were identified during the meeting;
- The possibility of training young scientists from member countries in different participating institutions will be provided;
- Annual regional summer/winter schools on solar terrestrial physics will be organized in different member countries. The opportunities provided by big scientific events, such as the total solar eclipse,

will be used to dedicate those schools to observational expeditions;

- To coordinate the activities on popularization of knowledge on solar terrestrial physics, popular scientific articles will be written by the members of the regional network and will be published monthly on the website of the regional network and in domestic periodicals of the member countries; and
- School competitions will be organized in the member countries for observational proposals, and the regional network participants will formulate problems for astronomy olympiads.

4. Eastern Europe and Central Asia

18 institutes, observatories and solar stations in the Russian Federation are involved in coordinating the IHY-Eastern Europe/Central Asia initiative. Additionally, a wide range of ground-based observation programmes and solar-terrestrial space missions are prepared for (or anticipated to be ready for) participation in the 2007 activities. Fortunately, the solar eclipse (29 March 2006) presents a very good opportunity for the upgrading of the observatories and station. There is a special programme at the Russian Academy of Sciences just for this event, and a large number of solar telescopes in the Russian Federation (Kislovods Mountain Solar Station, Russian-Ukrainian Observatory at Terskol-Peak and Niznnyi Arkhyz) will be upgraded due to the eclipse. Many of these observations will be newly available for the IHY, and an extensive theoretical and modelling effort will be available to aid the interpretation of these new data sets.

A number of national and international meetings concerning solar activity and solar-terrestrial relations were held in the Russian Federation and Ukraine in 2005, including IX International Annual Pulkovo Workshop "Solar Activity as the Factor of Space Weather" in St. Petersburg, Russian Federation (4-9 July), Workshop "Physics of Celestial Bodies", devoted to the 60th anniversary of the Crimean Astrophysical Observatory (Nauchny, Crimea, Ukraine, 12-18 September), Annual Baikal School in astrophysics, space physics and geophysics (Irkutsk, Russian Federation, 12-19 September), Workshop "Experimental and Theoretical Studies of Forecast of Helio-Geophysical Activity", (Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation (IZMIRAN), Troitsk, Russian Federation, 10-15 October). In 2006 the 10th Annual Pulkovo Workshop (St-Petersburg) and Solar Meeting in the Special Astrophysical Observatory (Radio Telescope of the Academy of Science (RATAN-600), Caucasus, Russian Federation) are planned, a special workshop devoted to the solar eclipse will be held in Kislovodsk Mountain Solar Station at the end of March 2006, and an international meeting on small satellites will be held in July 2006 at the Moscow State University. These meetings involve numerous participants from the Russian Federation, Eastern Europe, Central Asia and beyond, and serve as an excellent coordination point for upcoming IHY activities and the preparation of science campaigns.

The IHY team in Eastern Europe and Central Asia is also involved in a number of educational activities. To improve education in astronomy in Russian secondary schools, observatories, planetariums and astronomical institutes in the Russian Federation have been organizing events for youth via lectures and excursions. For example, about 15,000 school children from St. Petersburg visit Pulkovo Observatory annually, and Pulkovo Observatory plans to launch a special website for astronomical education by IHY in 2007.

The IHY is a direct legacy of IGY, which involved the dedicated efforts of many Russian scientists. It will continue to identify numerous scientists in the Russian Federation who took part in IGY 1957 so that they may participate in the IGY Gold History Programme. The identification of IGY alumni will also provide a focus for historically commemorative activities, such as the 50th anniversary of the launch of Sputnik 1.

The Space Solar Patrol (SSP) Mission Project

PI: Sergei Avakyan (Vavilov State Optical Institute & Central Astronomical Observatory at Pulkovo, Russian Federation)

The SSP Mission is being deployed for space weather studies during 2008 and beyond, overlapping heavily with the IHY/ "Developing the scientific basis for monitoring, modelling and predicting space weather" (COST724) action programme of the European Cooperation in the field of Scientific and Technical Research (COST). The goal of SSP is to be the first in the world to obtain the possibility of permanent patrol of variations for the flux of ionizing radiation of the Sun. Such a patrol is currently absent, and it is most important for science, technology and practical applications in the spectral range of solar radiation. This occurs solely because of technical and methodological difficulties in performing the measurements and calibration on this spacecraft.

Areas of SSP:

- Prediction of space weather;
- Study of solar-terrestrial relationships;
- Investigation of radiocommunication, radionavigation, radiolocation;
- Space technology, manned astronautics:
  - failures in work and degradation of solar batteries
  - slowing down of spacecrafts at low orbits
  - irradiation of aircraft crews
- Cellular telephony (through satellite communication);
- Large systems of electricity transmissions, pipelines and cable networks;
- Global climatic changes, meteorology;
- Seismology; and
- Medicine (the crisis phenomena, epidemiology, professional pathology).

The creation of SSP is a significant step in modern science and space weather, and represents an important scientific contribution to IHY.

5. Latin America

In 2005, the IHY planning team in the region of Latin America was composed of about 50 researchers from four countries: Argentina, Brazil, Mexico and Peru. Among the 16 centres involved, the main institutions are the Instituto Nacional de Pesquisas Espaciais (INPE) of Brazil, the Centro Regional Sul de Pesquisas Espaciais (CRSPE/INPE) of Brazil, the Centro de Radioastronomia e Astrofísica Mackenzie (CRAAM) of Brazil, the Instituto de Astronomia e Física del Espacio (IAFE) of Argentina, the Complejo Astronômico El Leoncito (CASLEO) of Argentina and the Universidade Nacional Autônoma de México (UNAM) of Mexico.

Most of the scientific activities in the region are related to the IHY themes: solar drivers and magnetospheres/ionospheres, with some participation in the two remaining themes: heliosphere and Earth atmosphere.

The activities and the instrumental facilities were presented during meetings and workshops in 2005: the AGU Chapman Conference in Manaus, Brazil (February 2005) and the IAGA 2005 in Toulouse, France (July 2005). A regional planning reunion was held at Mackenzie University, Brazil on 8 and 9 December 2005, where the following points were discussed:

- Latin-American instrumental facilities on the IHY/NASA website;
- Including the Latin-American-IHY website within that of the Latin American Conference on Space Geophysics (COLAGE);
- CIPs
- IHY/UNBSSI programme: future proposals;
- Working group activities; and
- Latin American participation in the IPY/IHY activities within IPY.

In 2005 two CIPs were proposed by Latin America-IHY participants:

- **High energy processes and dynamics of the low solar atmosphere during explosive events**

This CIP is devoted to obtaining observational clues on the total number of accelerated particles during the impulsive phase of solar flares, in order to better constrain existing particle acceleration models. Using the gradual development of solar flares, the dynamics of the low solar atmosphere will also be studied. Finally the proposed CIP will be exploring the relationship between the launch of CMEs and the solar activity close to the disk as observed at high radio frequencies.

- **Ionospheric effects of the solar activity variations, solar flares, lightning and energetic particle precipitation**

This project is concerned with the physical sources of the disturbances in the Earth's ionosphere at different time and space scales and their influence on the characteristics of VLF wave propagation.

The main points of analysis are as follows: (i) Long-term variations in the ionosphere using characteristics of VLF propagation obtained at ground-based receivers at Itapetinga Radio Observatory and at the Brazilian Antarctic Comandante Ferraz (EACF) research station; (ii) Influence of electromagnetic radiation from solar flares and energetic solar flare particles on the VLF propagation; (iii) Effect of lightning and charged particle precipitation (energetic electrons and protons) during geomagnetic disturbances on the VLF amplitude and phase records; and (iv) Efforts are made to estimate the relative effects of solar flare particles, energetic precipitation of magnetospheric particles and lightning on the VLF propagation characteristics.

A proposal for a small instrument deployment has been proposed within the IHY/UNBSSI programme, during the UN/ESA/NASA workshop in Al-Ain, United Arab Emirates in November 2005.

The **South Atlantic VLF Network (SAVN)** will be a network of seven VLF receivers located in the region (Peru, Argentina, Brazil, Antarctica), with the following objectives:

- Monitoring the long-term solar activity using properties of VLF wave propagation; and
- Detecting and studying the precipitation of particles in the South Atlantic Geomagnetic Anomaly (SAGA).

Other institutions have expressed their interest in hosting VLF receivers, increasing the SAVN coverage toward the west coast of Africa and Cape Verde. This project is discussed in greater detail in Appendix IV below.

Another programme being developed for the IHY/UNBSSI programme in 2006 is the **Southern hemisphere magnetic variations improved coverage and South Atlantic Magnetic Anomaly (SAMA; Figure 13) monitoring by the installation of a small magnetometer network on the Brazilian territory.** The main scientific goals of this programme are:

- To increase the magnetic measurements in the southern hemisphere for a better determination of the planetary indices;
- Local and continuous monitoring of SAGA - magnetosphere/atmosphere interaction; and
- Equilibrium mechanisms of the Van Allen radiation belts (Trimpi events versus geomagnetic activity).

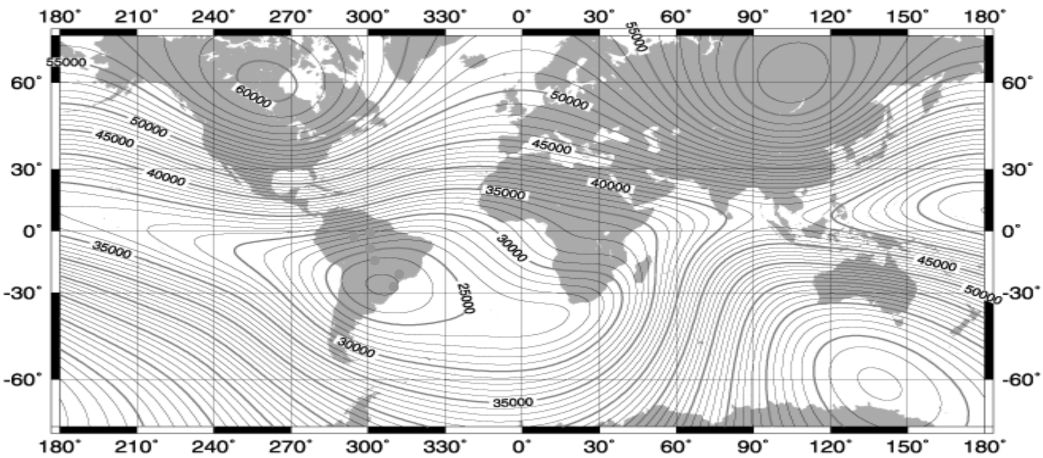


Figure 13. *Map of SAMA sites*

6. North America

The IHY-North America activity consists of a planning team for the entire region working to synthesize the activities of the region's two constituent countries: Canada and the United States of America. Both Canada and the US have established national planning teams, and have also launched activities for each of the four major programmatic thrusts of IHY. Several community workshops and town hall meetings have been held with the intention of defining the region's science priorities for the IHY timeframe. The most recent has been the IHY North American Community Science Planning Workshop, held from 16 to 18 February 2005 in Boulder, Colorado, USA. Post-meeting summaries along with hundreds of presentations made in this capacity are available in the "events" section of the IHY website.

In addition to the development of scientific priorities, the generation of numerous CIPs and the convening of numerous special sessions on IHY at scientific meetings, the process of gathering information on participating North American IHY observatories has also reached a mature stage. A current list of participating observatories is available in the Science Coordination Database (described in Section II.C below). Individual institutions and observatories anchor the science campaigns as well as the education and public outreach components of the North American initiative.

The launch of the IGY Gold History Programme in North America coincided with the launch of the international programme. Additionally, there are several PIs and team leaders from the US and Canada who are playing major roles in the IHY/UNBSSI programme. Many key components of the IHY-North America activities were described in the previous sections.

7. Western Asia

The IHY-Western Asia initiative has played a fundamental role in each of the four programmatic thrusts of IHY. The UN/ESA/NASA Workshop on IHY was held in Abu Dhabi and Al-Ain, United Arab Emirates, from 20 to 23 November 2005. Representatives from 39 UN member States were present, representing a large portion of the Western Asian region as well as Northern Africa. This allowed extensive discussions of the state of heliophysical research in this region and facilitated planning for IHY nationally and regionally. A more complete description of the workshop activities and recommendations are included in Section III.B of this publication.

IHY has coordinators in place for many of the countries in the Western Asian region, with the goal of establishing a coordination team in each country in early 2006. In addition to hosting the UN/ESA/NASA Workshop on IHY, IHY-Western Asia team members are active in coordinating scientific activities that will lead to many scientific campaigns. The region's extensive activities for the World Year of Physics 2005 (http://www.physics2005.org) have resulted in experience and a foundation for the continued development of educational programmes, summer schools and historical events.

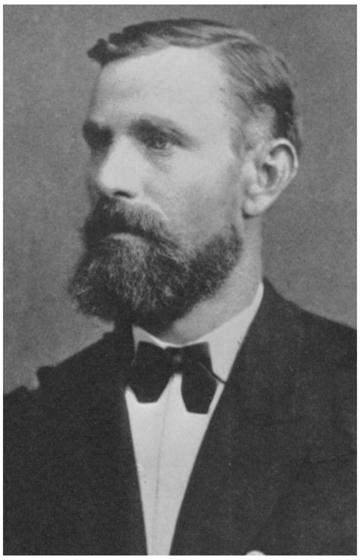
VII. Acknowledgements

We thank the IHY team members whose efforts made this publication possible. Contributors to this publication include: *R. Albrecht, H. M. K. Al-Naimiy, S. Avakyan, K.S. Balasubramaniam, J.-P. Barriot, C. Barton, A. Benz, V. Bothmer, J.-L. Bougeret, J. Bradford, A. Breen, C. Briand, B. Bromage, R. Calfas, D. Carlson, A. Chilingarian, E. Christian, E. W. Cliver, N. U. Crooker, J. M. Davila, C. Davis, C .E. DeForest, E. DeMulder, E. Drobnes, G. Eichhorn, E. O. Famutimi, N. J. Fox, T. Fuller-Rowell, P. T. Gallagher, L. Gentile, K. Georgieva, N. Gopalswamy, K. Groves, S. Gurubaran, G. Haines-Stiles, R. A. Harrison, A. Hashish, D.M. Hassler, H. Haubold, L. Hidalgo, U. Inan, Y. Kamide, J. Kasper, A. Kebede, T. W. Kraupe, J. Makela, C. Mandrini, I. Mann, C. Mazaudier-Amory, P. K. Manoharan, D. Milling, K. Munakata, I. S. Nurgaliev, K. O. Obrou, A. Paranjpye, W. Peterson, M. Petitdidier, S. Petty, M. Potgieter, M. C. Rabello-Soares, B. A. Rabiu, J.-P. Raulin, N. Rodrigues, T. Sakurai, D. Scherrer, R. Senseney, K. M. Sigsbee, G. Siscoe, R. Smith, R. Stamper, A. V. Stepanov, L. Strachan, Q. Sultan, B. J. Thompson, I. S. Veselovsky, J. Wang, D. F. Webb, R. Wesenberg, R. Wickramatunga and K. Yumoto.*

Appendix I. Brief History of International Science Years

The IHY proposal follows a tradition of international cooperation in scientific research begun in the 19th century, which consisted of the First and Second IPYs, followed by IGY in 1957.

The First IPY was the idea of an Austro-Hungarian Naval lieutenant, Karl Weyprecht. Weyprecht (Figure 14) had just returned from a polar expedition where he commanded one of the research vessels. In January 1875 at the Academy of Sciences in Vienna, Weyprecht expressed his ideas to establish an international collaboration to obtain a set of simultaneous observations, extending over a considerable time period, at various locations around the Arctic. The concept was presented again in September 1875 at the 4th Meeting of the Association of German Naturalists and Physicists in Graz. In 1877 a detailed programme was prepared and submitted to the International Meteorological Congress. In 1879 the International Meteorological Congress met in Rome and recognized the importance of the proposal. The 1st International Polar Conference (IPC) met in Hamburg, Germany from 1 to 5 October 1879. It was determined that a minimum of eight Arctic stations was needed, to obtain observations of at least one-year duration. The Conference also established the IPC with representatives from Austria, Hungary, Denmark, France, Germany, the Netherlands, Norway, Russian Federation and Sweden. G. Neumayer of Hamburg was the first Commission president. In July 1880 the 2nd IPC met in Berne, Switzerland. There, an Italian representative joined the existing representatives, and H. Wild became the second president. On 1 August 1881 the 3rd IPC met in St Petersburg. The United States joined the group, and a programme of observations was adopted. The First IPY began on 1 August 1882 and continued for 13 months to 1 September 1883. Scientific results and observational data were published in the Bulletin of IPC. In 1884 and 1891 the 4th and 5th Polar Conferences were convened. Weyprecht did not live to see the culmination of his grand concept. He died on 29 March 1881.



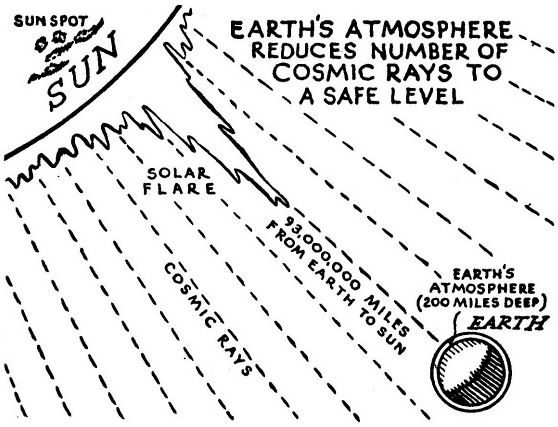


Figure 14. LEFT: *Lieutenant Karl Weyprecht first proposed IPY in 1875 after returning from an Arctic expedition. RIGHT: During IGY, it was known that events on the Sun influence the Earth, but the exact mechanism was unknown. The discovery of the solar wind was a big step.*

In 1927 J. Georgi at Deutsche Seewarte in Hamburg suggested that a **Second IPY** be conducted on the fiftieth anniversary of the first. A proposal was submitted to the International Meteorological Committee, and then forwarded to Reseau Mondial and Polar Meteorology. In June 1928 an informal organizational meeting was held in London to discuss plans for the event. Finally, in 1929 the Meteorological Conference of Directors in Copenhagen endorsed the plan for the cooperative study of magnetic, auroral and meteorological phenomena. Also in 1929 the International Cloud Commission passed a resolution for an international year for clouds coinciding with IPY. The Commission for IPY 1932-1933 was appointed to prepare detailed plans for the observations to be made and the methods for making them. A collaboration was established between the Commission for IPY and IUGG. In August 1930 the first meeting of the Commission for IPY took place in Leningrad, to further refine proposals for IPY. In December 1930, at a meeting in London, the Commission prepared a detailed report containing proposals, for research programmes in meteorology, terrestrial magnetism, atmospheric electricity, aurora and aerology. At a subsequent meeting in September 1931 the Commission for IPY, despite being urged to delay due to poor economic conditions worldwide, decided to go ahead with the IPY programme. On 1 August 1932 the Second IPY began. It continued until 1 September 1933.

The Commission introduced the concept of “International Days”. The scientific objective was to study phenomena on the largest possible scale with simultaneous observations, the same as in the previous IPY. The most significant new development that affected how the programme was conducted was the advent of radio communication.

In 1950, a proposal for IGY, 25 years after the Second IPY, was brought before the Mixed Commission on the Ionosphere, which endorsed it. The Mixed Commission on the Ionosphere was formed by the International Council of Scientific Unions (ICSU), under the sponsorship of the International Union of Radio Science (URSI) with the cooperation of IAU and IUGG. IUGG drew up a tentative programme and adopted a resolution to transmit it to ICSU, which sponsored the event. All bodies endorsed the proposal by 1951.

During times when the Sun was especially active (Figure 14), on a day not designated as a World Day (Figure 15), alerts were issued. These could be followed by the declaration of special world intervals that followed alerts. These could be called with an eight-hour notice. Rocket and balloon launches might take place, and other programmes of study might be intensified. World Meteorological Intervals consisted of 10 consecutive days, four times a year, usually near the beginning of seasons, for intensive study, rocket campaigns, etc. Data were collected at three centres (US, Europe and the former Soviet Union) and made available to all countries.

IGY was a tremendous success. The newly developed space-flight capability was used to discover and explore Earth’s radiation belts, to study the magnetosphere and to provide the first observations of the emission from the Sun’s corona. Public interest in the scientific results of IGY was high. IGY provided a forum and a backdrop for discussing the importance of geospace influences on Earth. Space physics, and many of its current institutions, were born during IGY.

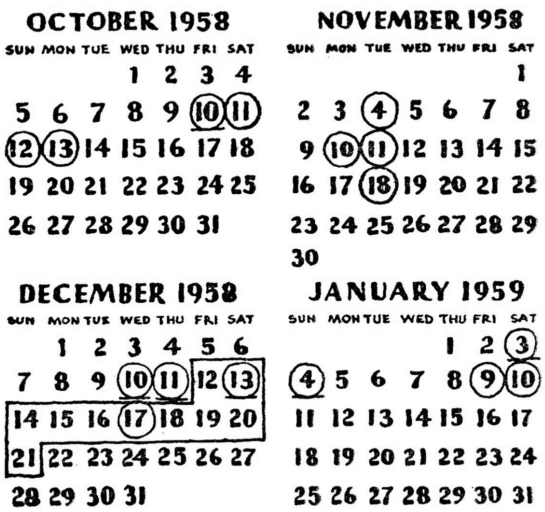


Figure 15. *IGY calendars were marked to indicate World Days (circles) and World Meteorological Intervals (box) where more intensive observational campaigns were carried out.*

Appendix II. The Celimontana Declaration: IHY and the other International Science Years

The following declaration was authored by the leaders of the four international years that will take place on the 50th anniversary of the IGY, who gathered in September 2005 to establish formal cooperation between the four international years as well as the many associated programmes and activities. Individual statements from IYPE, IPY and eGY follow.

The leaders of the Electronic Geophysical Year, the International Heliophysical Year, the International Polar Year, and the International Year of Planet Earth, meeting with representatives of international science bodies at the Home of Geography, Villa Celimontana, Rome, on 7 September 2005,

note that we

- share a fundamental motivation to understand, in a descriptive and predictive sense, many facets of our planet,
- share a common recognition that understanding our planet requires not only an understanding of linked systems and processes that interact on many time and space scales, but also an understanding of this planet as home to inhabitants of wondrous variety and complexity,
- share the goal of extending to all citizens a sense of substantial human influence and dependence on many systems of planet earth and a view of shared knowledge of the planet as a fundamental right and responsibility,
- recognise the 50th anniversary of the International Geophysical Year (2007-2008) as a unique opportunity to raise public awareness and increase scientific capability,
- recognise a mutual interest and benefit in sustaining cooperation among our programmes, and

declare that we will

- maintain vigorous and open communication to realise such benefit,
- define and implement joint activities in areas of common scientific interest, as well as in education, outreach, capacity building, and development of data and information systems, and
- communicate our collective efforts, results and products to the scientific community, governments, and the public.

Signed:

(Eduardo F. J. de Mulder) for the International Year of Planet Earth

(David J. Carlson) for the International Polar Year

(Joseph M. Davila) for the International Heliophysical Year

(Daniel N. Baker) for the Electronic Geophysical Year

planetearth®
International Year

The International Year of Planet Earth (2007-2009) aims to contribute to the improvement of everyday life, especially in the developing countries, by uncovering the underused societal potential of the world's Earth scientists, as expressed in the Year's subtitle Earth sciences for Society. Ambitious outreach and science programmes constitute the backbone of the International Year, politically endorsed by all 191 Member States of the United Nations Organization when it proclaimed 2008, the central year of the triennium, as a UN Year of Planet Earth.

Its desired outcomes are raising public awareness and enhancing research. The project was jointly initiated in 2001 by the International Union of Geological Sciences (IUGS) and the United Nations Educational, Scientific and Cultural Organization's (UNESCO) Earth Science Division. Since initiation, the project has attracted 12 Founding Partners that actively support the initiative either in-kind or in-cash, 23 Associate Partners and collected support by the geo-scientific communities in most countries.

The Outreach Programme lies close to the heart of the International Year because of its prime aim to generate interest and greater awareness among the general public, decision makers and politicians about the effective application, for the betterment of human society, of the widely available wealth of information in the hands of the Earth science community. The publication of the Year's first brochure: Planet Earth in our hands was a step in that direction, quickly followed by the brochure on Outreach, bringing Earth sciences to everyone.

The scientific themes selected for IYPE were all determined on the basis of their relevance to Society. The selected themes are: *Groundwater, Hazards, Earth and Health, Climate change, Resources, Megacities, Deep Earth, Ocean, Soil* and *Earth and Life*. Brochures addressing each of these themes are available as hard copy or can be downloaded from the website (see below).

Success or failure of the International Year's ambitions will depend to some considerable extent on how these are realized at national and local levels. For that reason, the Year's national committees are perhaps the most important structural components of IYPE because their activities will be most clearly visible to the public. Every country is encouraged to create such a committee.

For more information, please check http://www.yearofplanetearth.org

International Polar Year (IPY)

The International Polar Year 2007 – 2008 (IPY), jointly and officially sponsored by the International Council of Science (ICSU) and the World Meteorological Organization (WMO), has generated enormous scientific interest and enthusiasm. More than 1,000 teams of investigators from more than 50 countries submitted preliminary plans for IPY research. The initial expressions of interest have evolved into coordinated international proposals, each proposal gathering the interests and efforts of hundreds of researchers to focus on a crucial area of polar science. The ICSU – WMO IPY Joint Committee, charged with oversight and guidance of the IPY, recently endorsed 139 of these coordinated efforts covering research, data and information services, and education and outreach as the basis for a full rich IPY programme. The IPY development process remains open to additional expressions of interest and coordinated proposals, up to a final submission date of 31 January 2006.

An IPY planning chart (available at http://www.ipy.org) based on coordination proposals endorsed so far shows the breadth and variety of proposed IPY research by geographic region and science topic. IPY research will cover all aspects of the past, current and future state of the cryosphere and of linkages between the cryosphere and global processes. IPY research will build on IGY history, and on its obvious partnership with IHY, by exploring space from polar regions and by using space-based tools to monitor polar regions. IPY will build connections among geophysical, biological and social sciences as it focuses on biogeochemical systems and processes and as it embraces human perspectives to address all facets of social dynamics and cultural resiliency.

Many national and international planning and funding processes have responded to IPY activities. Many countries have announced substantial new IPY funds, have allocated substantial resources such as ships, and have solicited new proposals based on IPY themes and plans. It already seems certain that IPY will represent the largest coordinated international research programme focused on this planet in the last 50 years. The vast IPY research effort will present a new set of challenges and opportunities in data exchange and data services, requiring close collaboration with eGY, and will represent a timely opportunity to engage public attention through formal and informal education and a wide range of outreach activities. A recent IPY leaflet published in several languages, available on the IPY website, represents the first of many IPY outreach products.

Electronic Geophysical Year (eGY)

The following eGY declaration continues to be endorsed by a wide range of scientific organizations and institutions. The elements in the declaration form the basis for the 2007-2008 eGY activities. Please refer to the eGY website for a complete description of eGY programmes, plans and opportunities: http://www.egy.org

Declaration for a Geoscience Information Commons

"Knowledge is the common wealth of humanity" - *Adama Samassekou, Convener of the UN World Summit on the Information Society (WSIS)*

Preamble The electronic Geophysical Year (*e*GY) joins ICSU, WSIS and many other bodies in recognizing that knowledge is the common wealth of humanity. We have a shared responsibility to create and implement strategies to realize the full potential of digital information for present and future generations. In the 21st century and beyond, access to digital information and new technologies for information integration and knowledge discovery will influence the free and productive development of societies around the world. Providing ready and open access to the vast and growing collections of cross-disciplinary digital information is the key to understanding and responding to complex Earth system phenomena that influence human survival. In the geosciences, as elsewhere, the issues of concern are as follows.

Article 1: Data access Earth system data and information should be made available electronically with interoperable approaches that facilitate open access.

Article 2: Data release Owners, custodians and creators of Earth system data should work together to share their digital information with the world community, though in a manner that respects propriety requirements and security constraints.

Article 3: Data description Providers and users of Earth system data and information should share descriptions of structure, content, and contexts to facilitate interoperability and the discovery of relationships within and between information resources.

Article 4: Data persistence Data and information about the Earth system should be preserved and sustained in forms that are both software and hardware independent so as to be openly accessible today and in the future.

Article 5: Data rescue An effort should be made to identify and rescue critical Earth system data and ensure persistent access to them.

Article 6: Common standards and cooperation Standards for interoperability should be identified, created and implemented through international collaboration.

Article 7: Capability building Communities with advanced information technology and communications capabilities should contribute to developing such capabilities elsewhere to reduce the digital divide.

Article 8: Education and public outreach Students, scientists, decision makers and the public should be informed about and be enabled to contribute to our understanding and management of Earth system phenomena that impact human survival.

Appendix III. IHY Web Resources

The IHY Secretariat maintains the ihy2007.org website, science coordination database (described in Section II.C), events calendar and email lists. A number of coordination tools are also being developed, which will be launched and tested in 2006.

To sign up for the ihyinfo mailing list and receive updates on IHY events, activities and progress, please go to http://ihy2007.org/mail_list.shtml or go to the "get involved" section of the IHY website.

To enter the science coordination database, go to http://ihy2007.org/scd.shtml or go to the "science" or "get involved" section of the IHY website.

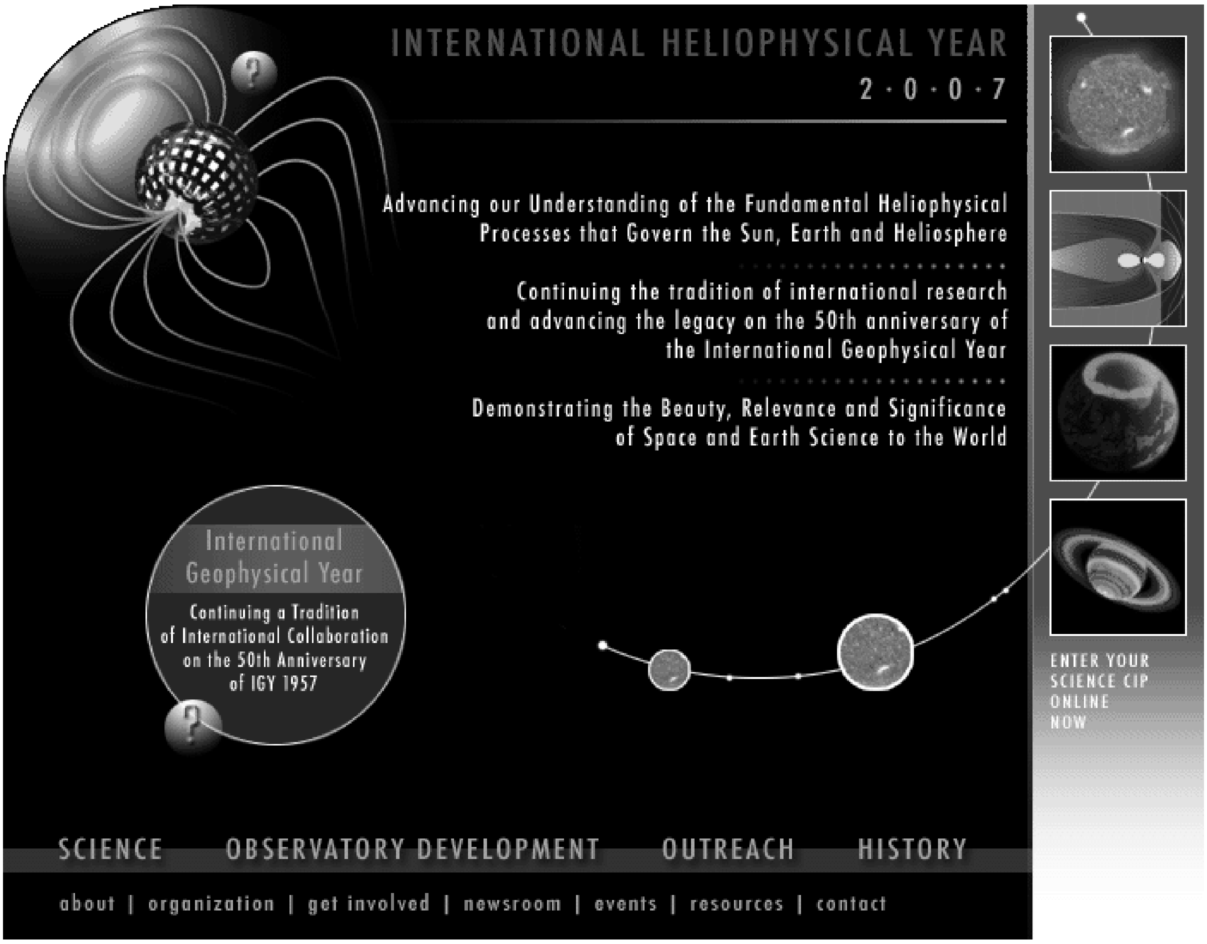


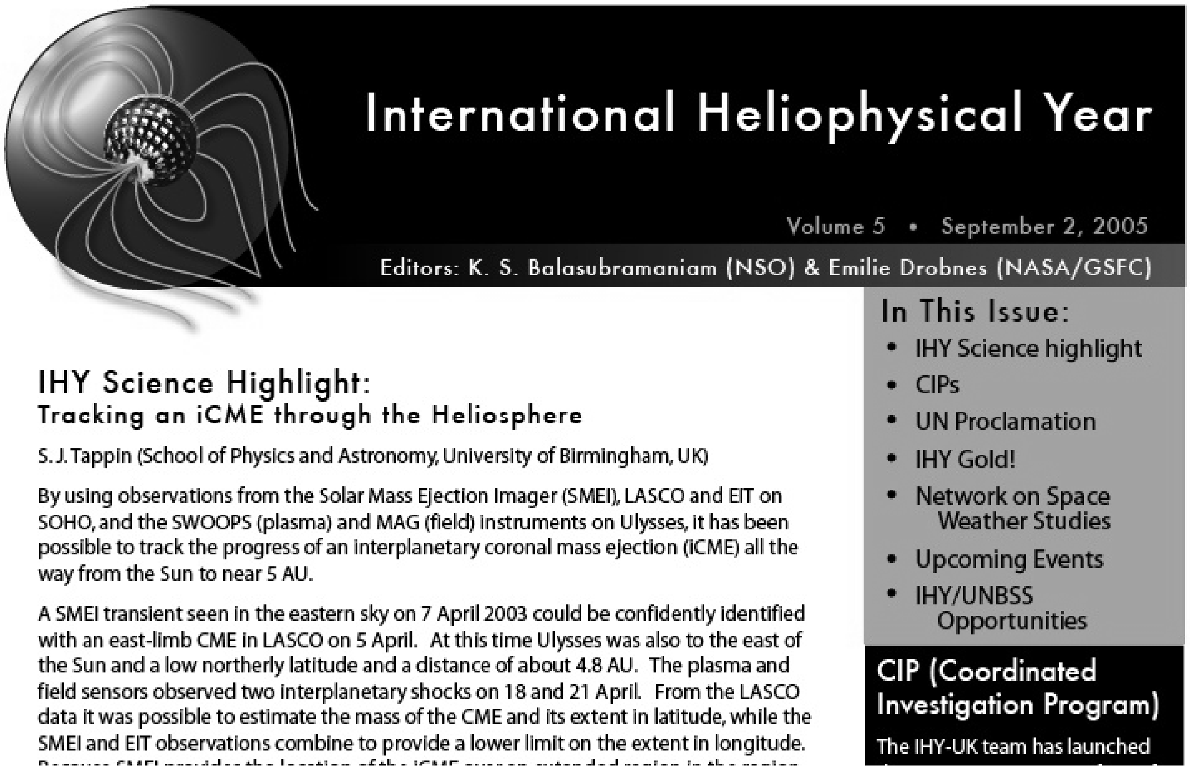
Figure 16. *The current design of the ihy2007.org website provides a great deal of information as well as direct access to the four programmatic thrusts. Multilingual access points are also being developed.*

The website has entry points to the four main programmatic thrusts: **science, observatory development, outreach** and **history**. Additionally, the site provides information in seven additional sections:

- **"About"** contains the goals of IHY, the IHY vision statement, the history of IGY and IHY, a section on "how IHY works" and a description of the four IHY programmatic thrusts and how they relate to the goals. The section also contains the "frequently asked questions" (FAQs);
- **"Organization"** contains a description of the organizational structure, including the Secretariat, International Advisory Committee, Steering Committee, working groups and IHY regions. Contact information for the leaders of all the IHY regions and participating countries is available here, along with links to national websites and organizing committees;
- **"Get Involved"** provides a link to IHY activities and email lists, and contains a special tutorial "getting started in four easy steps." The section also connects to the science coordination database and links to contact information for national and regional coordinators;
- The **"Newsroom"** is provided as a resource for team members to post announcements and stay up-to-date on IHY events. The section also has past IHY "news notes," which are a series of email updates

provided to the ihyinfo mailing list, and the IHY newsletter, which is published several times a year, containing science articles, highlights, meeting reports and summaries, announcements of opportunity and other news and events;

- **"Events"** is a searchable interface of all activities within the heliophysical community, including scientific meetings, IHY planning meetings and information sessions, special sessions and seminars;
- **"Resources"** contains publications, brochures, handbooks and guides and useful links. The section also provides links to educational resources, such as curriculum materials, travelling exhibits, posters, CDs and other items.
- **"Contact"** provides information on the IHY Secretariat, working groups and national and regional leaders. Photos of team members are featured, so interested community members can identify the IHY team leaders at major meetings.



International Heliophysical Year

Volume 5 • September 2, 2005

Editors: K. S. Balasubramaniam (NSO) & Emilie Drobnes (NASA/GSFC)

In This Issue:

- IHY Science highlight
- CIPs
- UN Proclamation
- IHY Gold!
- Network on Space Weather Studies
- Upcoming Events
- IHY/UNBSS Opportunities

IHY Science Highlight:
Tracking an iCME through the Heliosphere

S. J. Tappin (School of Physics and Astronomy, University of Birmingham, UK)

By using observations from the Solar Mass Ejection Imager (SMEI), LASCO and EIT on SOHO, and the SWOOPS (plasma) and MAG (field) instruments on Ulysses, it has been possible to track the progress of an interplanetary coronal mass ejection (ICME) all the way from the Sun to near 5 AU.

A SMEI transient seen in the eastern sky on 7 April 2003 could be confidently identified with an east-limb CME in LASCO on 5 April. At this time Ulysses was also to the east of the Sun and a low northerly latitude and a distance of about 4.8 AU. The plasma and field sensors observed two interplanetary shocks on 18 and 21 April. From the LASCO data it was possible to estimate the mass of the CME and its extent in latitude, while the SMEI and EIT observations combine to provide a lower limit on the extent in longitude.

CIP (Coordinated Investigation Program)

The IHY-UK team has launched

Figure 17. *The IHY newsletter is published several times annually, containing science highlights, major announcements, meeting reports and news on IHY activities.*

Appendix IV. IHY/UNBSSI Programme: Participants in the 2005 Cycle

A. GPS/Ionospheric Networks

Atmospheric Weather Educational System for Observation and Modeling of Effects (AWESOME)

PI: Umran Inan (Stanford University, USA)

AWESOME is an ionospheric monitor that can be operated by students around the world. The monitors detect solar flares and other ionospheric disturbances.

About 60 km above the ground lies the Earth's ionosphere, where continual blasts of particles and energy from the Sun hit the Earth's atmosphere so strongly that electrons are stripped away from their nuclei. The free electrons in the ionosphere have a strong influence on the propagation of radio signals. Radio frequencies of very long wavelength (very low frequency or VLF) bounce back off the ionosphere allowing radio communication over the horizon and around the curved Earth. The ionosphere reacts strongly to the intense x-ray and ultraviolet radiation released by the Sun during a solar flare, solar storm or CME. By monitoring the signal strength from distant VLF transmitters and noting unusual changes as the waves bounce off the ionosphere, these disturbances can be monitored and tracked. To monitor a VLF signal, a radio receiver is needed that can tune to VLF stations, an antenna to pick up those VLF signals and a computer to keep track of the data. Since most consumer radios cannot pick up the VLF signals, a radio receiver and an antenna need to be built. This combination of receiver and antenna is called a VLF receiver.

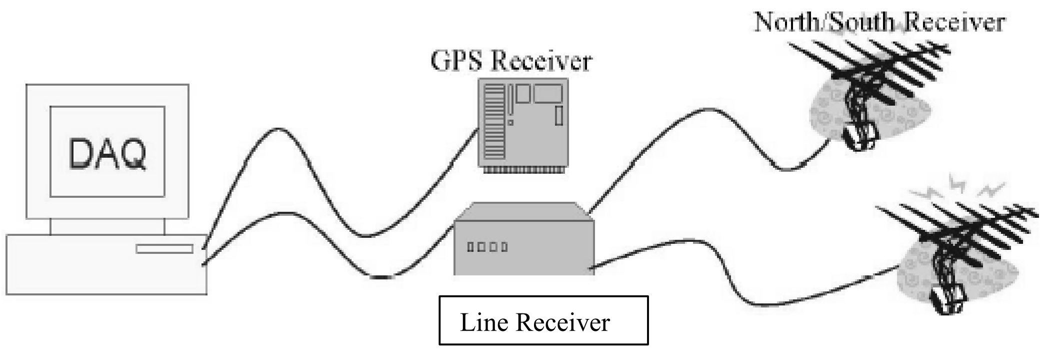


Figure 18. *VLF Data Acquisition (DAQ) system, which works in conjunction with a TrueTime GPS receiver, the line receiver and the North/South and East/West receivers.*

The key elements of AWESOME are the computer, the Stanford Monitor and the antenna. Internet link is important; otherwise a good quality DVD burner could be used. The setup is illustrated in Figure I. The line receiver gets VLF signals from two antennas. There is usually one antenna in the North/South orientation and another in the East/West orientation. These signals are sent to a 200kHz analogue-to-digital converter (ADC) card attached to the Peripheral Component Interconnect (PCI) slot of the computer. The ADC will capture data from the two antennas at 100kHz each. The timing signal from the GPS is also fed into the ADC card, allowing for very precise acquisition of data. Now in development is a Universal Serial Bus (USB) interface to replace the ADC card, which will enhance the ease of use and substantially reduce the cost.

There are two types of data saved by the receiver. Narrowband data involves monitoring the amplitude and phase of a single frequency, corresponding to a VLF transmitter. Broadband data involves saving the entire waveform from the antenna, thus enabling studies of many more ionospheric phenomena. The VLF DAQ software controls precisely when the system should acquire broadband and narrowband data. Upon data acquisition, various user-specified signal processing can be performed on the data. The data may be sent to another computer at Stanford University, via the Internet, where it will be made available to anyone through a web interface, so that interested parties at different sites can share their data and collaborate. The data produced by AWESOME is the same quality being used by researchers at Stanford University; the receiver sensitivity has exceeded the point where any detectable signal above the ambient noise floor will be recorded.

Deployment of one of the AWESOME monitors has recently been completed in Tunisia. Umran Inan (Stanford University) and Zohra Ben Lakhdar (University of Tunis) have started this collaboration under the IHY/UNBSSI programme. This project will provide a basis for quantitative comparison of lightning-induced disturbances of the ionosphere and the radiation belts in the American and European sectors. Most of the current data on such phenomena have so far been obtained in the western hemisphere, and the weight of scientific information indicates that lightning-induced effects at high altitudes and in the radiation belts may dominate other processes on a global scale.

Coherent Ionospheric Doppler Receiver (CIDR)

PI: Gary Bust, (University of Texas at Austin, USA) with Trevor Garner, Tom Gaussiran and Roy Calfas

CIDR is a radio receiver developed at the Applied Research Laboratories at the University of Texas at Austin designed to measure the line-of-sight relative total electron content (TEC) using the 150 and 400 MHz radio beacons on board low Earth orbit (LEO) satellites. The CIDR system is capable of tracking up to three different beacon satellites with different offsets in frequency at one time including the Navy Ionospheric Monitoring System (NIMS), the Radar Calibration Satellite (RadCal) and Geodetic Satellite Follow-On (GFO). In the near future, more radio beacons at these frequencies will be launched on the Communication/Navigation Outage Forecasting System (C/NOFS) and the Constellation Observing System for Meteorology (COSMIC) spacecraft.

CIDR is unique in its ability to monitor three simultaneous satellite passes at data rates up to 1 kHz with an instrument error of less than 0.1 radians of phase. CIDR system chains are currently in operation in Alaska, the eastern United States and Greenland. These chains are all oriented latitudinally. A new CIDR system chain is planned to be placed in South America in a longitudinal orientation near the magnetic equator to study equatorial phenomena in association with the C/NOFS satellite.

A CIDR system installation consists of the CIDR receiver, a control computer (which is provided with the system, typically a laptop) and two antennas (one for CIDR, one GPS). The antenna installation requires a good all-sky view with minimal or no obstructions. 100-metre cables are provided as well. An Internet connection allows each individual CIDR system to be accessed by the science team remotely. The Internet connection will also be used to download satellite track information (so that the system may plan which satellite passes it can observe and record), and the collected data is uploaded to archives for use by the science team. If there is a broadband connection, individual satellite passes can be remotely monitored via a web interface.

The data produced by a chain of CIDR systems can be used in a tomographic reconstruction of the ionosphere along the satellite track. Depending on the number of ground installations (no less than four) and baseline, the tomography can reveal the large scale structure of the ionosphere, medium sized structures such as plumes, patches, etc., and very fine structures using a short baseline configuration. In addition, the CIDR data can be used as an input to data assimilation models for reconstructing the ionosphere on a global or local scale.

In association with the IHY/UNBSSI, the CIDR team seeks new science team members in eastern Africa in order to place a CIDR chain in a line from Asmara, Eritrea to Addis Ababa, Ethiopia. This would permit the team to observe in great detail the unique phenomena of the ionosphere in this area. The CIDR team is also exploring the possibility of forming an association with scientists in the Asia-Pacific region to place a CIDR chain to gather data in an area that is virtually unexplored in terms of ionospheric science.

GPS in Africa

PIs: Tim Fuller-Rowell (University of Colorado and National Oceanic and Atmospheric Administration (NOAA) Space Environment Center, USA),
Christine Mazaudier, Monique Petitdidier, and Paul Vila (Centre national d'études spatiales (CNES), France)

Introduction: Much attention in space weather has been devoted recently to the large changes in TEC over the American sector during geomagnetic storms. The attention has been fuelled by the ability to map the electron content using networks of ground-based, dual-frequency GPS receivers. Figure 19 shows a large gradient in TEC stretching across the eastern United States during an ionospheric storm, driven by electrodynamics. Steep gradients in TEC can disrupt operational systems such as the Wide Area Augmentation System (WAAS), which is utilized by the Federal Aviation Administration (FAA) for aircraft positioning. This gradient severely disrupted the FAA use of WAAS over its service volume for periods totalling 26 hours, navigation errors sometimes exceeded 50 m, more than 10 times the typical uncertainties of 2-3 m.

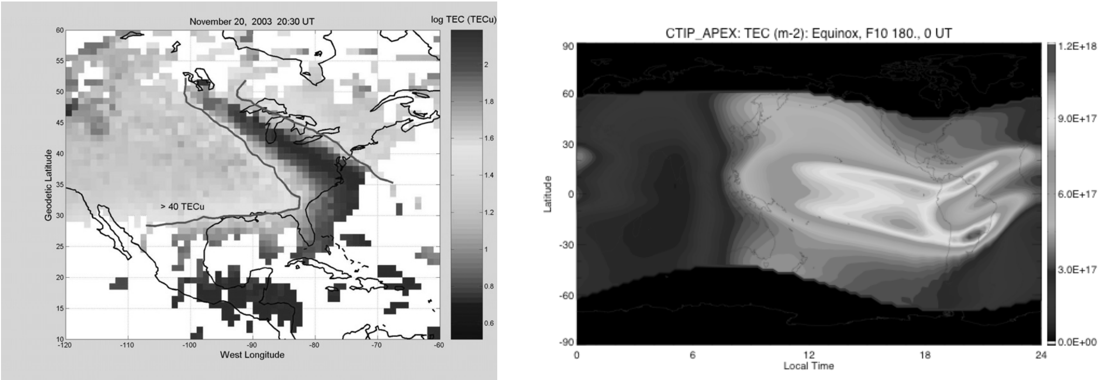


Figure 19. *LEFT: Example of a plume of storm enhanced density derived from GPS "imaging". RIGHT: Illustration of the distortion of the geomagnetic field between the American and African sectors.*

The Geomagnetic Field: There has been speculation that the large change in plasma density and electrodynamics in the American sector is related to the unusual configuration of the geomagnetic field, including the South Atlantic Anomaly (SAA) and large values of declination (see Figure 19). The speculation has spurred the need to target other geographic regions with significantly different geomagnetic field configurations. In contrast, over Africa the magnetic equator is parallel to the geographic equator and more uniform in magnitude. This region, however, does not have a dense network of ground-based GPS receivers available to perform a complementary study, nor does it have sufficient magnetometer chains to monitor the dayside plasma drift.

Objective: The space science community is therefore exploring ways to increase the observational infrastructure at mid and low latitudes in the Sub-Saharan African sector. The **GPS in Africa** project would like to collaborate with other activities in the region, such as the African Monsoon Multidisciplinary Analysis (AMMA), the IHYMAG project and the SCINDA project. In particular, the GPS in Africa project would like to encourage scientists in African universities to become interested in the science objectives and be willing to host a dual-frequency GPS system at their universities. The availability of real-time maps of the ionosphere over Africa will hopefully spark interest in the local schools and encourage the next generation to become interested in space sciences. This Africa GPS activity is a focused part of a broader initiative to try to coordinate the number of real-time GPS stations worldwide. Models are available at University of Colorado/NOAA Space Environment Center for processing the GPS data into TEC maps for use by all the scientists involved. The codes would be available for the African scientists to use if requested. Coordination with the International GPS Service real-time (IGS-rt) network is encouraged.

Low Cost Ionosonde for the IHY/UNBSSI programme

PI: John Bradford, Chris Davis, Richard Stamper (Rutherford Appleton Laboratory, UK)

During IGY in 1957, a number of ionosonde stations were opened, but in subsequent years, most of those stations have ceased operation and the remaining stations are largely at mid and high latitudes. There are scientific and operational reasons for studying the equatorial ionosphere and the IHY provides an opportunity to do this; the Rutherford Appleton Laboratory (RAL) is proposing to develop a new ionosonde for this purpose as part of the IHY/UNBSSI programme.

An important design driver is cost and it is anticipated that this can be an order of magnitude lower than that of commercially available ionosondes. This will be achieved by using commercial components wherever possible; for example by using standard PCs rather than dedicated digital signal processing (DSP) devices and radio frequency (RF) components originally designed for ham radio applications.

The instrument design will be based on meteorological radars recently designed by RAL; these are now operational instruments and a good deal of the signal processing system design and software will be directly applicable to the proposed ionosonde.

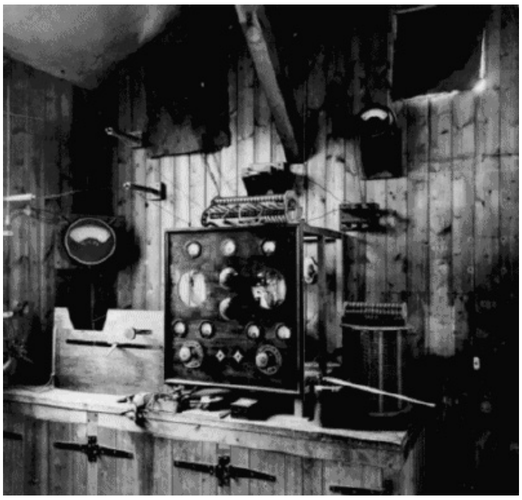


Figure 20. *Previous ionosonde design; design studies have shown that a lower-cost version can perform with little or no loss of data quality.*

The design will be upgradeable by, for example, adding receiver channels to provide directional information or by using GPS time and frequency references to operate a pair of ionosondes in a bistatic mode. It is proposed that when the design and prototyping have been completed, the construction and installation of the instruments would to a large extent be carried out by the host organizations themselves.

Remote Equatorial Nighttime Observatory for Ionospheric Regions (RENOIR)

PI: Jonathan J. Makela (University of Illinois at Urbana-Champaign, USA)

RENOIR is a suite of instruments dedicated to studying the equatorial/low-latitude ionosphere/thermosphere system, its response to storms and the irregularities that can be present on a daily basis. The occurrence of equatorial plasma instabilities, commonly referred to as equatorial spread-F, equatorial plasma bubbles or depletions, can cause radio signals propagating through the disturbed region to scintillate. This results in a fade in received signal power translating to a loss of the signal. Scintillations on frequencies from several GHz and below are known to occur and are a concern to many sectors. Through the construction and deployment of a RENOIR station, it is possible to achieve a better understanding of the variability in the nighttime ionosphere and the effects this variability has on critical satellite navigation and communication systems.

A typical RENOIR station involves the following: (1) an array of single frequency GPS scintillation monitors. These provide measurements of the irregularities present, their size, orientation and speed; (2) a dual-frequency GPS receiver. This provides measurements of ionosphere TEC. If a site that already fields a dual-frequency GPS receiver could be located, this would not be needed; (3) an all-sky imaging system. This measures two different thermosphere/ionosphere emissions from which the two-dimensional structure/motion of irregularities can be observed. The data can also be used to calculate the density and height of the ionosphere; and (4) two miniaturized Fabry-Perot interferometers (MiniME). These provide measurements of the thermospheric neutral winds and temperatures. The two interferometers are separated by approximately 300km or so, allowing bistatic, common-volume measurements.

Deployment of RENOIR stations is being planned in collaboration with the IHY/UNBSSI programme. Ideally, the RENOIR stations would be fielded in Africa at a longitude of approximately 7 degrees from the magnetic equator. The instrumentation that make up a RENOIR station have all been used in the field in previous experiments and are at a moderately mature level of development. The optical systems can be housed in individual, self-contained housing units, requiring very little infrastructure. If an optical facility is available at a host institution, the optical equipment could easily be modified to interface with available optical domes. The facility should be located in a region with relatively dark skies (away from any major cities) and away from any tall structures (buildings and trees). If two Fabry-Perot interferometers are to be fielded, the second system should be located approximately 300 km away from the main site.

The dual-frequency GPS receiver is quite rugged and simply requires a location to mount the antenna and minimal space to locate the control computer. The array of single-frequency GPS scintillation monitors requires a space of approximately 100m x 100m over which to space the five antennas in a cross formation. Again, minimal space is needed to locate the control computers for each receiver. The facility should be located away from any tall structures (buildings and trees).

Scintillation Network Decision Aid (SCINDA)

PI: Keith Groves (Hanscom Air Force Research Laboratory, USA)

SCINDA is a real-time, data driven, communication outage forecast and alert system. Its purpose is to aid in the specification and prediction of communications degradation due to ionospheric scintillation in the equatorial region of Earth. Ultra high frequency (UHF) and L-band scintillation parameters are measured, modelled and propagated in time to provide a regional specification of the scintillation environment in an effort to mitigate the impacts on the satellite communications community.

Equipment at the remote sites record scintillation parameters from available UHF Fleet Satellite Communication System (FLTSAT) and L-band (Geostationary Operational Environmental Satellite (GOES), GPS) satellite links and measure ionospheric drift velocities. The data drives a semi-empirical model that produces simple three-colour graphical representations of large-scale equatorial scintillation structures and associated communication impact regions.

Ionospheric disturbances can cause rapid phase and amplitude fluctuations of satellite signals observed at or near the Earth's surface; these fluctuations are known as scintillation. Scintillation affects radio signals up to a few GHz frequency and seriously degrades and disrupts satellite-based navigation and communication systems. SCINDA consists of a set of ground-based sensors and quasi-empirical models, developed to provide real-time alerts and short-term (< 1 hour) forecasts of scintillation impacts on UHF satellite communication and L-Band GPS signals in the Earth's equatorial regions.

The SCINDA system (see Figure 21) concept is presently being demonstrated using eight equatorial stations in South America, Southwest Asia and Southeast Asia (

Figure 22). Scintillation parameters from available UHF (FLTSAT) and L-band (GOES, GPS) satellite links and ionospheric drift velocities are measured and recorded at the remote sites. The scintillation maps are available to users for proto-type operational support via a secure network. Analysis of data collected during the recent solar maximum period (2000-2002) indicates that both single and dual-frequency GPS receivers are subject to significant errors during severe scintillation events. All SCINDA sites are now equipped with GPS scintillation monitors and model development is in progress. Following the solar cycle, L-band scintillation activity will decline over the next few years and should remain relatively benign until around 2008. The goal is to have accurate GPS navigation error products available to support the operations before the next solar maximum.

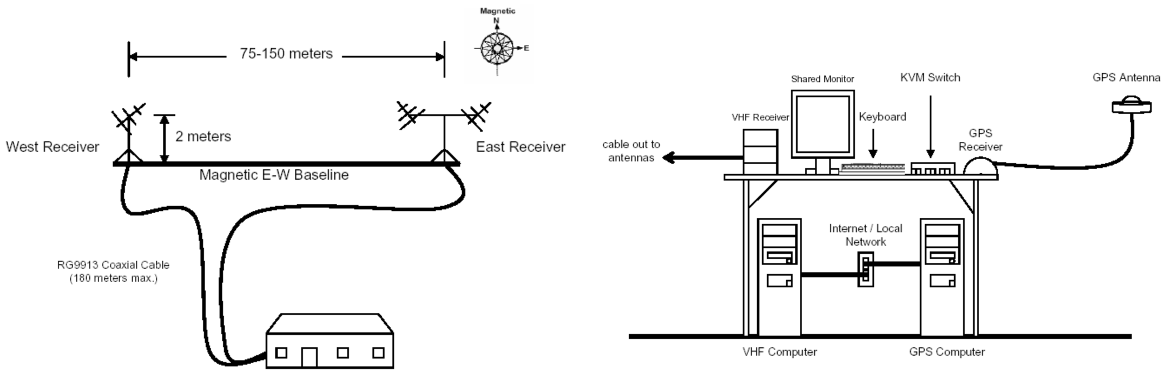


Figure 21. *VHF Antenna Set-Up (left) and VHF Receiver Chain and Data Acquisition System (right)*

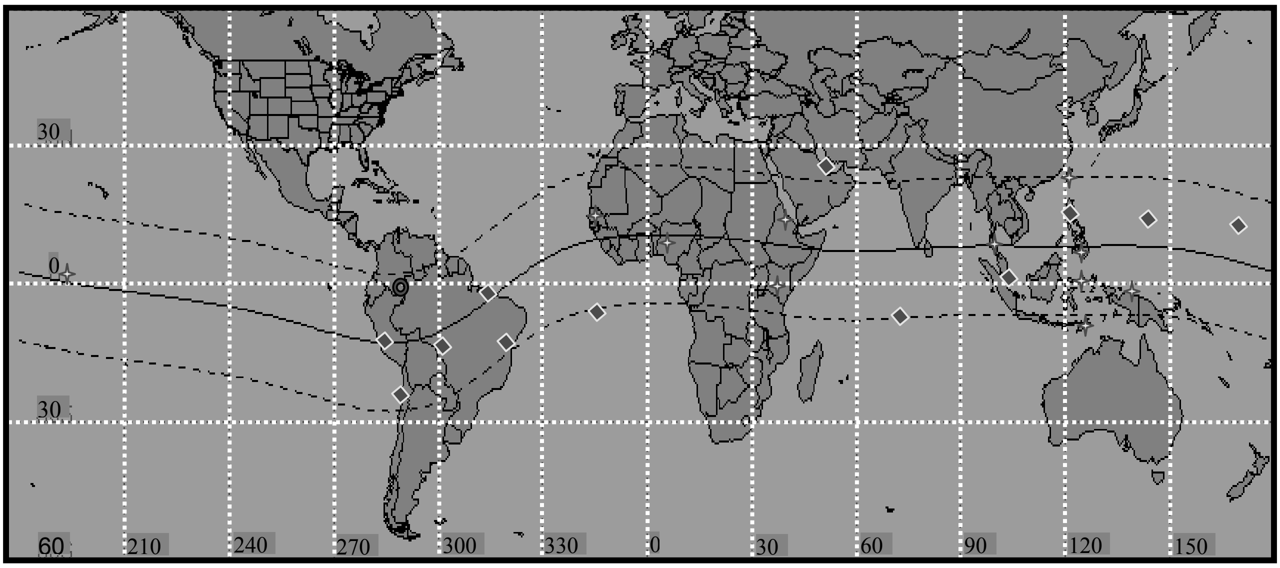


Figure 22. *Existing and proposed SCINDA stations. The magnetic equator and northern and southern magnetic latitudes at 20° are shown by dashed lines. The most intense natural scintillation events occur during nighttime hours within 20° of the Earth's magnetic equator. SCINDA observations in this 20° belt on either side of the magnetic equator are sought. Current plans include expansion of the network to new geographic regions.*

B. Magnetometer Networks

IHYMag

PI: Ian Mann; Programme Manager: David Milling (Space Physics Group, University of Alberta, Canada)

Introduction: IHYMag is a network of ground-based magnetometers in the African continent filling a significant gap in worldwide magnetometer coverage. The IHYMag team plans to utilize not only the coordination and committee structure available through the North American IHY Coordination Committee, but also that available from the IHY/UNBSSI programme, to facilitate the cost-effective deployment of IHYMag.

A key science goal of IHYMag is to discover the importance of Pc5 Ultra Low Frequency (ULF) waves for the generation and acceleration of mega electron-volts (MeV) energy “killer” electrons in the radiation belts. Recent theoretical and observational developments have highlighted the possibility that ULF waves might accelerate electrons to MeV energies in the outer radiation belt, which then can penetrate to inner magnetospheric regions. Since MeV energy electron flux enhancements are believed to have been responsible for a number of satellite failures and anomalies, this has very important consequences for space weather. Global magnetometer coverage is necessary to study the dynamics of the outer belts and the role and reaction of the inner belts during these crucial periods. Additionally, ULF pulsations have also been observed from the ground to increase in amplitude towards the geomagnetic equator, believed to be an equatorial electrojet phenomena. Therefore, measurements around multiple meridians at latitudes corresponding to the magnetic footpoints of these crucial coupling regions are needed.

Another major science goal is to monitor and understand the fundamental processes governing electrodynamics and cold plasma mass injection and loss in the low/mid-latitude stormtime plasmasphere-ionosphere system. The action of solar wind convection and other dynamic magnetospheric and wave electric fields results in the re-organization, injection and loss of cold plasma populations. The Space Physics Group at the University of Alberta, in collaboration with the University of Newcastle, Australia, have been instrumental in developing cross-phase and related techniques for remote-sensing the distribution and dynamics of cold plasma using networks of ground-based magnetometers. In particular, the results show how mass distributions in the plasmatrough and plasmasphere can be monitored, the density diagnosis technique having been validated by comparison with in-situ Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) satellite electron density measurements, with ground-based VLF wave inferred electron densities and to results from the ab-initio Sheffield University Plasmasphere Ionosphere Model (SUPIM). Inner-magnetospheric shielding from the convection electric field due to tail dynamics, loss due to wave-particle interaction with ring current ions through electromagnetic ion cyclotron (EMIC) waves, as well as particle injection from the ionosphere may all introduce complex height and azimuthally asymmetric variations in mass density profiles. At mid- and low-latitudes, the altitude profile of ionospheric density has an increasing influence on natural Alfvén eigen-frequencies and the effects of vertically-crossed electric and magnetic field (E-cross-B) drifts begin to strongly influence ionospheric structure. IHYMag will be deployed in partnership with parallel US funded efforts to establish a dual-frequency GPS receiver network in Africa during IHY. The GPS network will also monitor stormtime TEC plasma dynamics in the coupled ionosphere-plasmasphere system. Using the TEC measurements together with the Alfvén eigen-frequency dynamics as a function of latitude across IHYMag, and using established inversion techniques, the IHYMag team will be able to monitor mass injection, loss and field-aligned density dynamics of the coupled ionosphere-plasmasphere system, leading to understanding of the fundamental processes driving plasma dynamics. Also of importance are the forthcoming launch of the Canadian Cascade SmallSat and Ionospheric Polar Explorer/enhanced polar outflow probe (CASSIOPE/e-POP) satellite in 2007 and its subsequent operation during IHY. e-POP is charged with determining the processes responsible for cold/thermal ion outflow from the ionosphere into the magnetosphere. Combining e-POP with IHYMag will allow important ion outflow studies at mid- and low-latitude regions in the African local time sector, the e-POP orbit being ideal for in-situ monitoring of the field line apex regions. Finally, the other major forthcoming Canadian space environment satellite mission involvement will be the flight of the Canadian Electric Fields Instrument (c-EFI) on the ESA Swarm mission around 2007-8. Swarm will make in-situ electrodynamics measurements at the lowest noise and highest ever accuracy of any satellite mission. Using IHYMag conjunctions to Swarm at low- and mid-latitudes will provide a unique capability to address the spatiotemporal behaviour of equatorial electrodynamic coupling during geomagnetic storms.

Proposed IHYMag Instrumentation: Using coordination support from the IHY/UNBSSI programme, eight magnetometers are planned to be deployed at mid- and low latitudes in the African continent for operation during IHY between 2007-9 and beyond. Whilst polar-cap to equatorial coverage will exist in the American meridian with the deployment of the Mid-continent Magnetoseismic Chain (McMAC) array funded by the National Science Foundation (NSF) of the US, linking the expanded Canadian Array for Realtime Investigations of Magnetic Activity (CARISMA) (formerly the Canadian Auroral Network for the OPEN Program Unified Study (CANOPUS)) and the South American Meridional B-field Array (SAMBA), in Europe the coverage essentially ends with the South European Geomagnetic Array (SEGMA). The IHYMag magnetometers will fill a worldwide gap in global coverage in Africa. IHYMag will hence allow the global study of solar-terrestrial coupling phenomena. Specifically, this will extend the current IMAGE-Sub-Auroral Magnetometer Network (SAMNET)-SEGMA coverage to low and dip-equator latitudes, and link up with South African Intermagnet and Antarctic magnetometers in the southern hemisphere. A map of proposed magnetometer locations is shown in Figure 23.

The location of the magnetometer sites is intended to complement the European sector coverage and utilize the existing Intermagnet Observatories in Africa to obtain station pairings intended to target the science goals of IHYMag.

(1) Algeria: Three site locations. Initial contact has been made with the Centre de Recherche en Astronomie, Astrophysique et Géophysique (CRAAG), which operates the Tamanrasset Intermagnet site.
(2) Nigeria: Two site locations have been offered by the Heads of Physics Departments at the Universities of Kaduna and Nsukka.
(3) Ethiopia: One site location. The IHYMag team proposes to utilize contacts already made by Keith Groves for the deployment of GPS receivers.
(4) South Africa: One site location. Contact will be made with staff at Hermanus Observatory.
(5) Zambia: One site location. So far no contacts have been established there.

The two magnetometer pairs close to the dip equator will allow determination of equatorial electrojet strength and determination of the vertical component of E-cross-B dynamics, which is known to exert a significant influence at these latitudes (e.g., Anderson et al., 2002). The magnetic measurements of the IHYMag team are critical for the magnetospheric-ionospheric coupling studies described above, including the relation to GPS/TEC network measurements to be made during IHY. Indeed, the IHYMag programme is being developed in parallel with the SCINDA network and GPS for Africa network, described above. IHYMag will provide low- and mid- latitude meridional coverage to meet up with the SEGMA and SAMNET arrays in the north, through the equator to the South African Intermagnet site at Hermanus, and will be an excellent scientific complement to the MAGDAS network described below.

Hardware and data return: Existing hardware designs will be used in IHYMag. Fluxgate magnetometers will be obtained either from the University of California, Los Angeles (UCLA) or the Lviv Centre of Institute of Space Research (LCISR), Ukraine. Additional African magnetometer coverage may also be available from a partner proposal to be submitted by UCLA to NSF. The data logger unit will be the same as the one developed by the University of Alberta for the CARISMA array.

Data will be returned from IHYMag stations using Internet connectivity through African universities, wherever this is available, using software developed at the University of Alberta for the CARISMA project. Magnetically quiet sites will be selected at these universities; cable, telephone or radio modem infrastructure being used to connect to a local data centre where possible. One uncompressed 3-component 1Hz magnetometer data day-file is less than 2MB, hence daily transfer of compressed files should be easily achievable. This will be done in real-time using Internet connectivity, or by daily modem upload where necessary. Another option (or for use during periods of long-lasting Internet interruption), would be for a local operator to collect data on a USB flash device for mailing to the nearest data centre.

Data from the combined IHYMag array will be made openly available on the Canadian Space Science Data Portal (SSDP, http://www.ssdp.ca), together with data visualization and analysis tools. Combined data sets could also be published on CD/DVD for sending to participating African institutions that have poor or non-existent Internet connectivity.

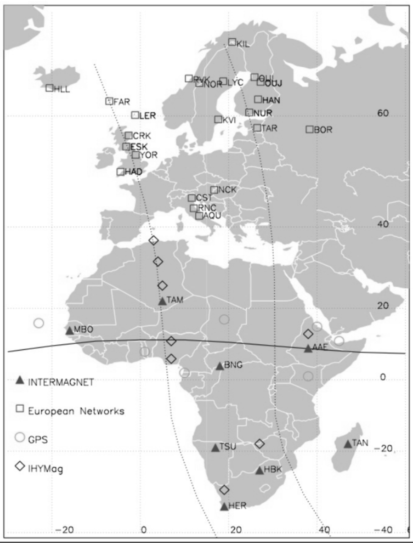


Figure 23. *Map of proposed IHYMag site locations.*

Magnetic Data Acquisition System (MAGDAS) Project

PI: Kiyohumi Yumoto (Space Environment Research Center, Kyushu University, Japan)

MAGDAS is being deployed for space weather studies during 2005 to 2008, overlapping heavily with the IHY/UNBSSI programme. The project will aid the study of dynamics of geospace plasma changes during magnetic storms and auroral substorms, the electro-magnetic response of the iono-magnetosphere to various solar wind changes and the penetration and propagation mechanisms of DP2 channel-ULF range disturbances from the solar wind region into the equatorial ionosphere. With the help of MAGDAS data, one can conduct real-time monitoring and modelling of: (1) the global three-dimensional current system; and (2) the ambient plasma density for understanding the electromagnetic and plasma environment changes in the geospace.

Global 3-D current system: The MAGDAS data will be used to map the ionospheric equivalent current pattern every day. The current and electric fields at all latitudes are coupled, although those at high, and middle and low latitudes are often considered separately. By using the MAGDAS ionospheric current pattern, the global electromagnetic coupling processes at all latitudes will be clarified.

Ambient plasma density: New MAGDAS magnetometers will be deployed at several pairs of stations along the 210° magnetic meridian to observe the magnetic field line resonance (FLR) pulsations. Each pair will be separated in latitude by approximately 100 km. The FLR oscillations are useful for monitoring temporal and spatial variations in the magnetospheric plasma density. The MAGDAS data will be analyzed by the amplitude-ratio and cross-phase methods to identify the FLR events and measure their eigen-frequencies, providing the plasma density varying with time. Those measurements will be highly valuable in understanding the variations of the ambient plasma density and the location of the plasmapause during magnetic storms and auroral substorms.

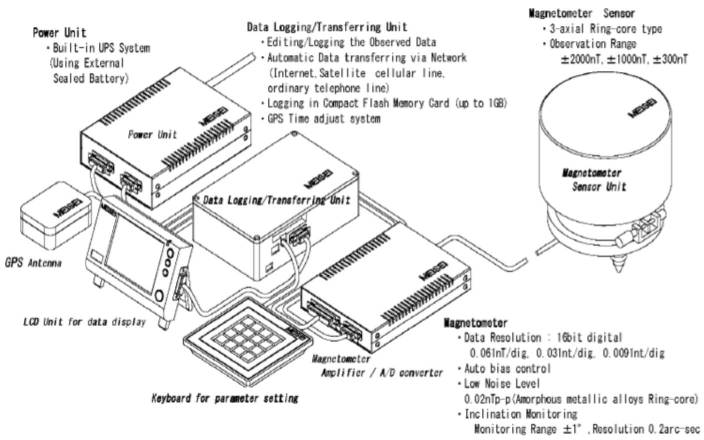


Figure 24. *Details of the MAGDAS/CPMN magnetometer system for real-time data acquisition*

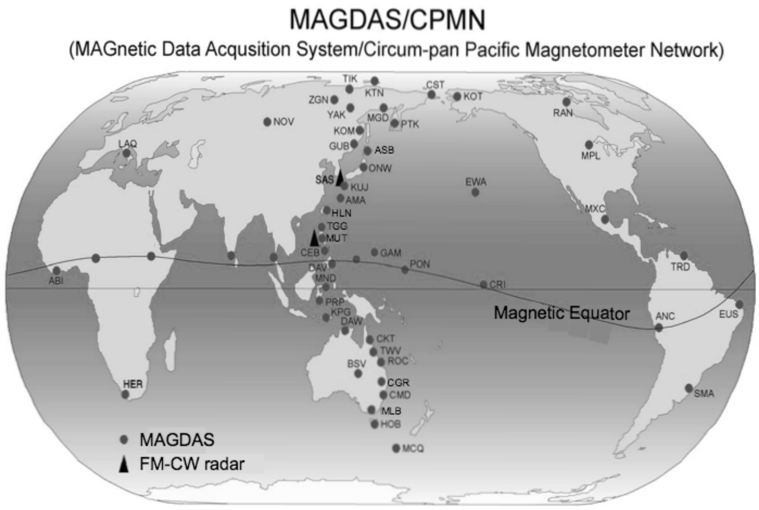


Figure 25. *Stations of CPMN.*

MAGDAS will utilize the Circum-Pan Pacific Magnetometer Network (CPMN) involving several countries around the globe (Australia, Indonesia, Japan, Philippines, Russian Federation, United States and Taiwan Province of China). Additional locations where the magnetometers can be deployed are: Brazil, Canada, Côte d'Ivoire, Ethiopia, Federated States of Micronesia, India, Mexico, Peru, South Africa and Trinidad and Tobago.

C. Radio Observatories

Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO) Frequency Agile Solar Spectrometers

PI: Arnold Benz (Institute of Astronomy, ETH-Zentrum in Zurich, Switzerland)

CALLISTO is a dual-channel frequency-agile receiver based on commercially available consumer electronics. The low cost for hardware and software, and the short assembly time make this an ideal instrument for the IHY/UNBSSI programme. The total bandwidth of CALLISTO is 825 MHz, and the width of individual channels is 300 kHz. A total of 1,000 measurements can be made per second. The spectrometer is well suited for solar low-frequency radio observations pertinent for space weather research and applications. Space weather has become a topic of interest to the society that increasingly depends on satellites for day-to-day activities. One prime example is cell phones, which can be seriously affected by space weather. Space weather refers to the variable conditions in Earth's space environment primarily caused by changing conditions on the Sun. Radio observations are simple means of detecting the solar disturbances when they are still near the Sun. The early detection of solar disturbances such as shock waves is possible from the ground using radio spectrometers such as CALLISTO. The Sun produces various types of radio emissions, so spectrometers such as CALLISTO are necessary to identify the nature of coherent solar radio emissions from solar eruptions, relevant to space weather. One of the important types of radio emissions occurring in the CALLISTO spectral range are the shock related radio bursts known as type II radio bursts. These bursts are caused by shocks driven by CMEs. Occurrence of these bursts marks the formation of shocks near the Sun, which might arrive at Earth after a few days and mark the start of geomagnetic storms.

It is important to have continuous monitoring of the Sun, which requires a network of spectrometers at several locations in the world. Five CALLISTO instruments have been constructed until now and put into operation at several sites, including Bleien in Zurich, Switzerland and the National Radio Astronomy Observatory (NRAO) in the United States. Arrangements are being made to deploy one in India at the Radio Astronomy Center in Ooty. This network, in addition to the existing spectrometers at Hiraiso in Japan, ARTEMIS in Greece and Culgoora in Australia will form an excellent radio network for IHY science and for achieving the goals of the IHY/UNBSSI programme.

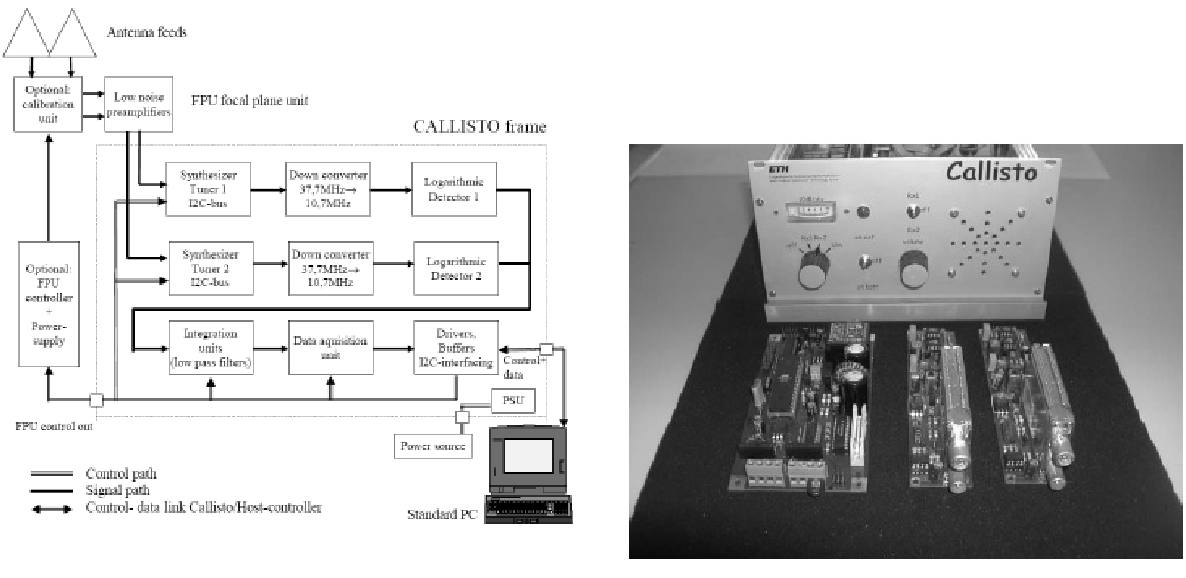


Figure 26. *Basic design of CALLISTO (left) and the hardware (right). The main board for data acquisition and interface with a RISC processor ATmega16 and of two synchronous receivers are shown in the foreground of the right panel. The complete spectrometer is shown in the background. Its physical size (width) is 24 cm. It is a very cheap instrument suitable for copying easily and deploying in many locations.*

The software is distributed on a Reduced Instruction Set Computer (RISC) processor ATmega16 and a standard PC or laptop. On the RISC, the driver, buffer and interfacing software is programmed in C++, using an interrupt-driven state machine concept. The host software on the PC is also in C++ and operates under Windows 2000 and XP. The relevant parameters are locally stored in a text file, which can be easily adapted to other observing configurations. Additional RS232 ports are pre-configured to communicate with an extended GPS system and external temperature and humidity sensors. It is also possible to control CALLISTO via the Internet, using an RS232 network adapter. A file-controlled scheduler starts and stops measurements in relation to local PC time (Universal Time or UT). The scheduler is repeated every day automatically and can be changed online and remotely.

Low-Frequency Radio Antenna Arrays

PIs: Justin Kasper (Massachusetts Institute of Technology, USA), Robert MacDowall (NASA Goddard Space Flight Center, USA)

This network employs a new, expensive radio receiver technology to conduct low-frequency radio observations. A single unit consists of an antenna, receiver, computer and processing board. The receiver unit could either produce 10-100 MHz power spectra of the total power incident on the receiver, or whole imaging arrays distributed at locations around the globe can be assembled to provide spatial resolution to act as all-sky monitors and provide 24-hour low-frequency coverage of the Sun. This investigation could also be used to track Jovian radio emissions and could provide prompt afterglow observations from gamma ray bursts.

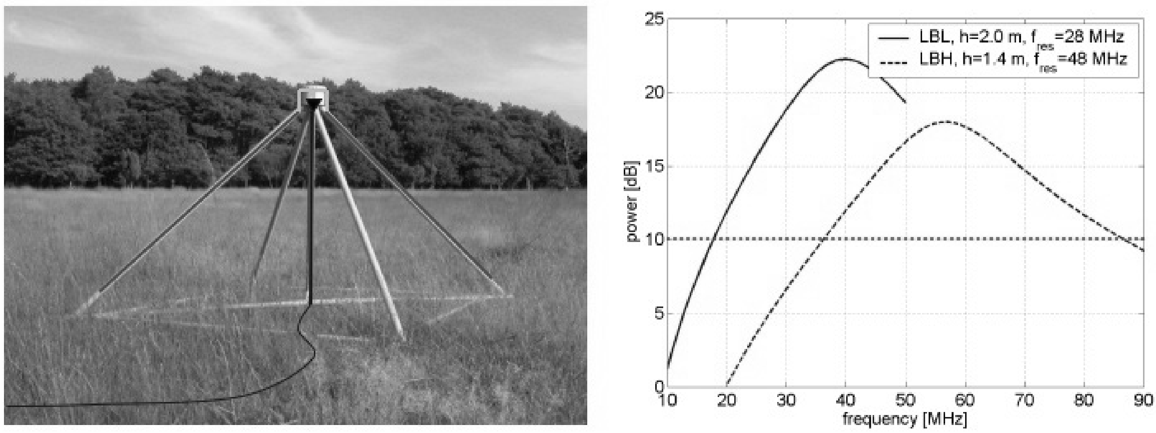


Figure 27. *A single low-frequency radio antenna and sample power spectrum*

Low frequency radio arrays can be deployed at two levels: Option (1) low-frequency monitoring of solar radio bursts with single dipoles; and Option (2) 8-16 element arrays for all sky monitoring.

Opportunities are being explored to install a low frequency radio telescope at the Gauribidanur radio telescope site in India to work in conjunction with CALLISTO in Ooty.

SAVN

PI: Jean-Pierre Raulin (Universidade Presbiteriana Mackenzie, Brazil)

This programme has three main goals: monitoring the solar activity on long and short time scales; monitoring ionospheric perturbations over SAMA; and atmospheric studies.

The VLF network will be deployed in a region where the coverage at similar frequencies is currently very poor. This will allow the study of the SAMA region at low ionospheric altitudes and its structure and dynamics during geomagnetic perturbations. The monitoring of transient solar phenomena will improve scientific knowledge of the low ionosphere and of the chemical processes occurring there. On longer time scales, the SAVN team will be able to define an ionospheric index of the solar activity characteristic of the ionizing agent of the low ionosphere (extreme ultraviolet and Ly-alpha). Currently these are poorly monitored and only accessible through models. The proposed instrument will also permit the study of the VLF counterpart of newly discovered atmospheric phenomena related to lightning and thunderclouds. The proposed science is relevant to the following IHY themes: impact of space weather phenomena on the Earth's climate; and the ionosphere/magnetosphere.

Ideally, the VLF receivers should be able to measure amplitude perturbations of 1 dB (relative to the unperturbed level) and phase changes as low as 0.5 μs, corresponding to changes observed for example during very small solar flares. The basic data output is composed of these phase and amplitude measurements. There are no strong requirements on the location of the receivers, except for minimal man-made interferences. Some potential sites with existing infrastructure are: Piura in the north of Peru (05°12’ S; 80°38′ W); Punta Lobos near Lima, Peru (12°30’ S; 76°48′ W); Palmas, Tocantins, Brazil (10°10’ S; 49°20′ W); Santa Maria, Rio Grande do Sul, Brazil (29°43′ S; 53°43′ W); and CASLEO, San Juan, Argentina (31°32′ S; 68°31′ W).

These new sites will complement the existing VLF sites at Atibaia, São Paolo, Brazil (23°11′ S; 46°36′ W), and EACF (62°05′ S; 58°24′ W). It will be possible to compare the VLF propagation characteristics from paths that completely cross SAMA, paths for which the receivers are located at the border or outside the SAMA and paths that end at the SAMA centre location (see Figure 6). The estimated cost of the instrumentation is $5,000 per unit (there are five units) and an additional cost of $10,000 for travel between stations for installation, testing and maintenance.

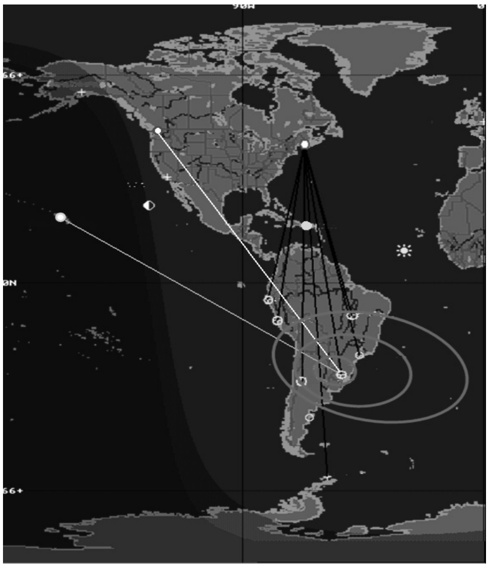


Figure 28. *SAMA locations and the nearly north-south oriented paths from the NAA transmitter in the US (44°39′ N; 67°17′ W) will enable a comparison of examples of simultaneous measurements from totally sunlit path NLK (48°12′ N; 121°55′ W) and partially sunlit path NPM (38°59′ N; 76°27′ W), which are also shown. They will allow scientists to obtain a two-dimensional view of the SAMA region. In the case of NAA transmission, note also the path over Puerto Rico where ionospheric radio measurements are made at the Arecibo (18°30′ N; 68°31′ W) radio facilities in association with the sprites phenomena.*

D. Particle Detectors and Muon Networks

Middle-to-Low Latitude Particle Detector Network for Space Weather Forecasting

PI: Ashot Chilingarian (Aragat Space Environmental Center (ASEC) of the Cosmic Ray Division (CRD) of Alikhanian Physics Institute, Armenia)

A network of middle to low latitude particle detectors is planned within the framework of IHY, to improve space weather forecasting research and alerts. The network will be flexible to detect more than one species of particles and provide directional data.

Particle beams accelerated at the Sun are superimposed on the uniform and isotropic cosmic ray background from galactic and extragalactic sources. Space-borne spectrometers measure the time series of the changing fluxes with excellent energy and charge resolution. Surface detectors measure the time series of secondary particles, born in cascades originated in the atmosphere by primary ions. Studies of these particles shed light on the high-energy particle acceleration by flares and shocks driven by CMEs.

Table 1: Characteristics of ASEC Monitors (see also Figure 29)

Detector	Altitude m	Surface m^2	Threshold(s) MeV	Operation	Count rate (min^{-1})
NANM (18NM64)	2000	18		1996	2×10^4
ANM (18NM64)	3200	18		2000	4.5×10^4
SNT-4 thresholds +	3200	4 (60 cm thick)	120, 200, 300, 500	1998	5.2×10^4 [a]
veto		4 (5cm thick)	10		1.3×10^5
NAMMM	2000	5 + 5	10 + 350 [c]	2002	2.5×10^4
AMMM	3200	45	5000	2002	1.2×10^5 [b]
MAKET-ANI	3200	6 x 16 groups	10	1996	1.5×10^5

[a] Count rate for the first threshold; near vertical charged particles are excluded
[b] Total count rate for 45 muon detectors from 100
[c] First number – energy threshold for the upper detector, second number – bottom detector

Time series of intensities of high-energy particles can provide highly cost-effective information on the key characteristics of the interplanetary disturbances. Because cosmic rays are fast and have large scattering mean free paths in the solar wind, this information travels rapidly and may prove useful for space weather forecasting. Size and occurrence of southward magnetic field component in interplanetary coronal mass ejections (ICMEs) is correlated with modulation effects the ICME poses on the ambient population of the galactic cosmic rays (GCRs) during its propagation up to 1 astronomical unit (AU). On the way to Earth (15 – 50 hours), the magnetic cloud and shock modulate the GCR flux, making it anisotropic. Surface monitors located at Aragats Space Environmental Center (ASEC) on Mt. Aragats, Armenia, at 2,000 and 3,200 m altitude (40˚30′N, 44˚10′E. Cutoff rigidity: 7.6 GV) detect charged and neutral components of the secondary cosmic rays with different energy thresholds and various angles of incidence (see Figure 9 for a schematic view of the new detector at ASEC). This richness of information (see Table 1) coupled with the simulation of the physical phenomena, can be used to estimate the shock size and the magnetic field "frozen" in the ICME. Consequently, one can predict the upcoming geomagnetic storms hours before the ICME arrival at the magnetometers on the Advanced Composition Explorer (ACE) and the Solar and Heliospheric Observatory (SOHO). The half-hour lead time provided by the L1 monitors is a bit short to take effective mitigation actions and protect surface industries from harm of major geomagnetic storms. To identify the major sources of error in the predictions, we need to measure, simulate and compare: (1) the time series of neutrons, low energy charged component (mostly electrons and muons) and high-energy muons; (2) the correlation between changing fluxes of various secondary particles; and (3) directional information.

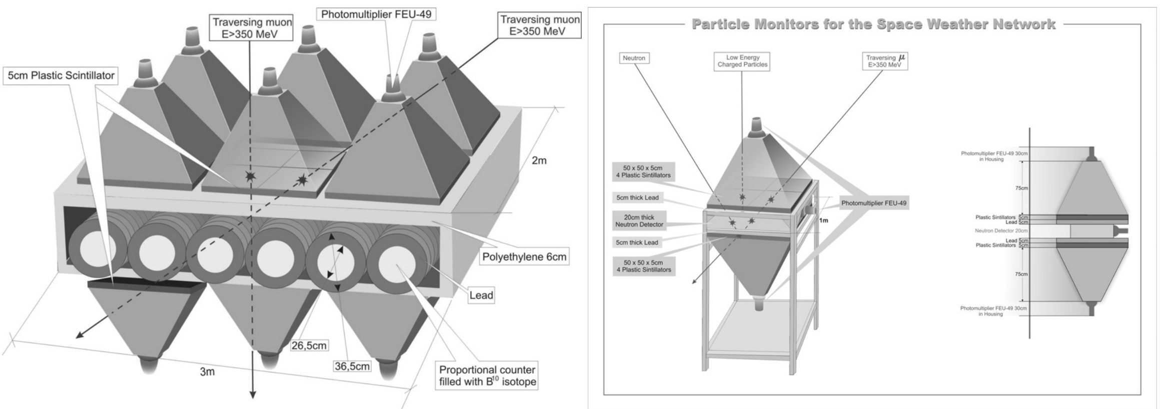


Figure 29. *Schematic diagram of the basic detector for muons and neutrons installed at ASEC, Armenia and two modules of prototype detectors for the space weather network. LEFT: One section of the Nor Amberd Multidirection Muon Monitor (NAMMM). RIGHT: Compact prototype detector for the space weather network.*

Based on experience with correlation analysis of multivariate time-series from ASEC monitors, several new types of particle detectors were designed and fabricated to meet the above goals. In order to keep the instrument inexpensive, the options are kept flexible by using modular designs. The price of a fully autonomous single unit (See Figure 29), with facility to send data to the Internet, will not exceed $20,000, so that the network of countries involved in space research can be significantly expanded to enable them to participate in IHY. Like the world network of neutron monitors, the new monitors will measure the neutron fluxes and in addition they will measure charged particle fluxes with different energy thresholds, thus allowing the investigation of additional populations of primary ions.

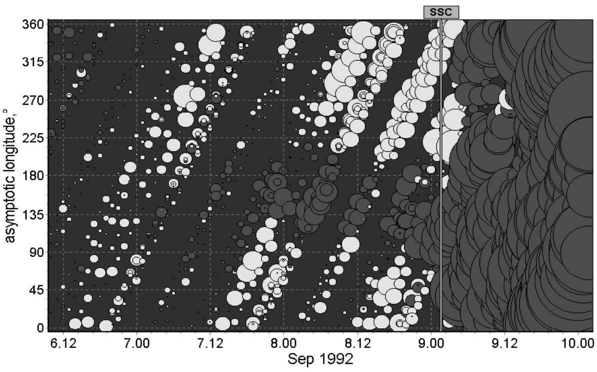
The network is planned to be installed at middle and low latitudes and will be compatible with the currently operating high latitude particle detector network *Spaceship Earth*, coordinated by the group from Bartol Research Institute of University of Delaware in the USA and with the Muon network coordinated by the group from Shinshu University in Japan.

The potential recipients of particle detectors in this new initiative are Bulgaria, Croatia, Costa Rica, Egypt, Georgia, Indonesia and Kazakhstan. It is expected that particle fluxes measured at the medium to low latitudes with the new network, combined with information from satellites and detector networks at high latitudes, will reduce the number of “false alarms” in alerting on severe radiation and geomagnetic storms.

Muon Network

PI: Kazuoki Munakata (Shinshu University, Japan)

Muon detector network collaboration consists of nine institutes from seven countries (Armenia, Australia, Brazil, Germany, Japan, Kuwait and the United States). Many of the countries are already operating muon detectors and some have recently installed them.



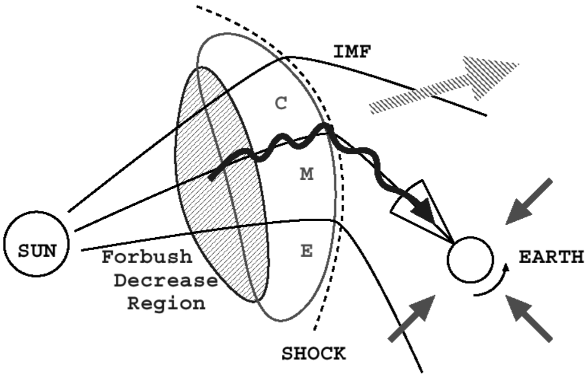


Figure 30. *LEFT: The “loss-cone” precursor observed prior to the arrival of a CME at Earth on 9 September 1992. RIGHT: The physical mechanism causing the loss-cone precursor. CME from the Sun (large oval region marked CME), and the depletion region (Forbush decrease region) are also shown. The CME drives a shock shown by the dashed curve. Particles entering the detector are denoted by the central helical arrow. Three interplanetary field lines are also shown.*

The utility of the muon detector for detecting ICMEs is shown in Figure 30. Each circle represents an hourly measurement by a single telescope as a function of time (day of year on the abscissa) and the asymptotic longitude of the viewing direction (in degree on the ordinate). The light and dark circles represent, respectively, an excess and deficit of cosmic ray intensity relative to the average, and the size of each circle is proportional to the magnitude of excess or deficit. The precursory decrease (dark circles) of cosmic ray intensity from ~135 deg longitude (sunward direction along the nominal interplanetary magnetic field (IMF)) is clearly seen more than one day prior to the sudden commencement of the storm (arrival of shock driven by CME at Earth). The physical mechanism for the precursory decrease is illustrated in Figure 30 (right). A CME propagating away from the Sun with a shock ahead of it, affects the pre-existing population of GCR in a number of ways. Most well-known is the Forbush decrease, a region of suppressed cosmic ray density located downstream of a CME shock. Some particles from this region of suppressed density leak into the upstream region and, travelling nearly at the speed of light, they race ahead of the approaching shock and are observed as precursory loss-cone anisotropy far into the upstream region. Loss-cones are typically observed four to eight hours ahead of shock arrival for shocks associated with major geomagnetic storms. (Munakata et al., JGR, 105, 2000).

The current network (see Fig. 31) is almost complete except for a desired one in the United States (Hawaii or the West Coast) and the other in South Africa.

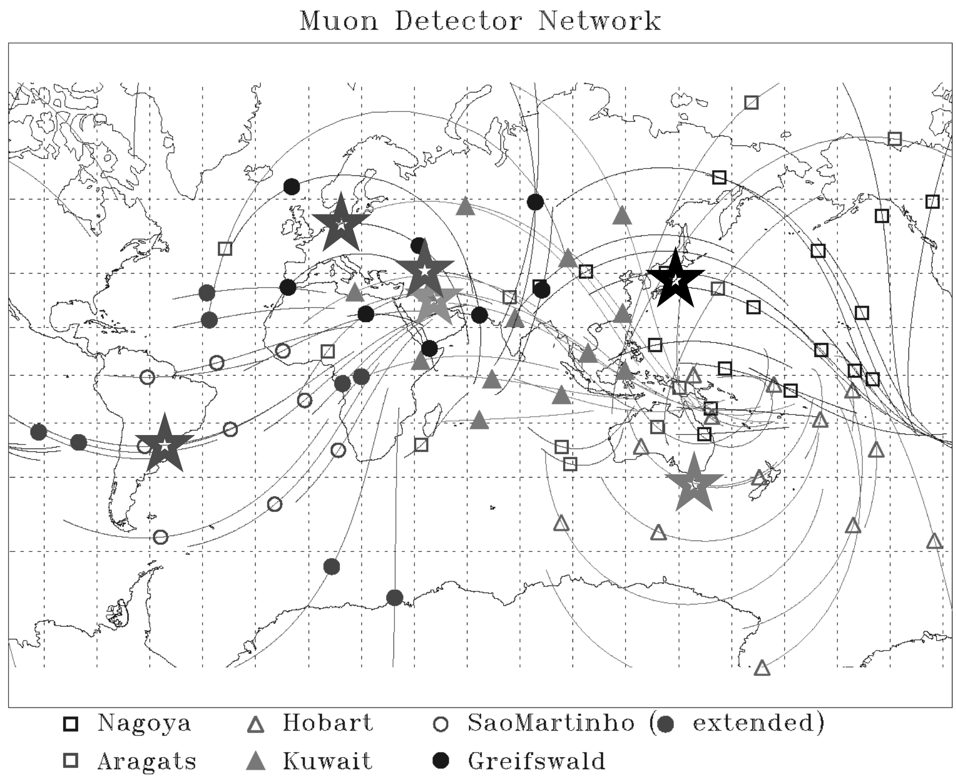


Figure 31. *The geographic location of each detector is indicated by a big star and distinguished by shape coding. Each of the symbols (squares, triangles and circles) shows the asymptotic viewing of a particle incident on each telescope with the median primary rigidity. Open symbols display the existing viewing directions, while full symbols represent the directions to be added by the planned installation and extension of detectors. The track through each symbol represents the spread of viewing directions corresponding to the central 80% of each telescope's energy response.*

Appendix V: Glossary

ACE: Advanced Composition Explorer

ADC: analogue-to-digital converter

ADS: Astrophysical Data System

AGU: American Geophysical Union

AMMA: African Monsoon Multidisciplinary Analysis

AOGS: Asia and Oceanic Geophysical Society

ASEC: Aragats Space Environmental Center

AU : astronomical unit

AWESOME: Atmospheric Weather Educational System for Observation and Modeling of Effects

CALLISTO: Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory

CANOPUS: Canadian Auroral Network for the OPEN Program Unified Study

CARISMA: Canadian Array for Realtime Investigations of Magnetic Activity

CASLEO: Complejo Astronómico El Leoncita, Argentina

CASSIOPE/e-POP: Canadian Cascade SmallSat and Ionospheric Polar Explorer/enhanced polar outflow probe

CAWSES: Climate and Weather of the Sun-Earth System

CDAW: Coordinated Data Analysis Workshop

CEDAR: Coupling, Energetics and Dynamics of Atmospheric Regions

c-EFI: Canadian Electric Fields Instrument

CERGA: Centre de Recherche en Géodynamique et Astrométrie (France)

CIDR: Coherent Ionospheric Doppler Receiver

CIP: Coordinated Investigation Program

CME: coronal mass ejection

C/NOFS: Communication/Navigation Outage Forecasting System

CNES: Centre national d’études spatiales (France)

CNRS: Centre National de la Recherche Scientifique (France)

COLAGE: Latin American Conference on Space Geophysics

COSMIC: Constellation Observing System for Meteorology

COSPAR: Committee on Space Research

COST: European Cooperation in the field of Scientific and Technical Research

COST724: “Developing the scientific basis for monitoring, modelling and predicting space weather” action programme of COST

CPMN: Circum-Pan Pacific Magnetometer Network

CRD: Cosmic Ray Division of ASEC (Armenia)

CRAAG: Centre de Recherche en Astronomie, Astrophysique et Géophysique (Algeria)

CRAAM: Centro de Radioastronomia e Astrofisica Mackenzie (Brazil)

CRSPE: Centro Regional Sul de Pesquisas Espaciais, INPE (Brazil)

DAQ: Data Acquisition

DSP: digital signal processing

E-cross-B: crossed electric and magnetic fields

EACF: Brazilian Antartic Comandante Ferraz research station

eGY: electronic Geophysical Year

EMIC: electromagnetic ion cyclotron

EOARD: European Office of Aerospace Research and Development

E/PO: education and public outreach

ESA: European Space Agency

FAA: Federal Aviation Administration (USA)

FAQ: Frequently Asked Question

FLR: Field Line Resonance

FLTSAT: Fleet Satellite Communication System

GCR: Galactic Cosmic Ray

GEM: Geospace Environment Modeling

GFO: Geodetic Satellite Follow-On

GOES: Geostationary Operational Environmental Satellite

GPS: Global Positioning System

IAFE: Instituto de Astronomia e Fisica del Espacio (Argentina)

IAGA: International Association of Geomagnetism and Aeronomy

IAU: International Astronomical Union

ICESTAR: Interhemispheric Conjugacy in Geospace Phenomena and their Heliospheric Drivers

ICMEs: interplanetary CMEs

ICSU: International Council of Science (formerly International Council of Scientific Unions)

IGS-rt: International GPS Service real-time

IGY: International Geophysical Year

IHY: International Heliophysical Year

IHYMag: network of ground-based magnetometers in Africa

IMAGE: Imager for Magnetopause-to-Aurora Global Exploration

IMF: interplanetary magnetic field

INPE: Instituto Nacional de Pesquisas Espaciais (Brazil)

IPC: International Polar Conference

IPS: Interplanetary Scintillation

IPY: International Polar Year

IUGG: International Union of Geophysics and Geodesy

IUGS: International Union of Geological Sciences

IYPE: International Year of Planet Earth

IZMIRAN: Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation (Russian Federation)

K-12: Kindergarten to 12^{th} Grade

LCISR: Lviv Centre of Institute of Space Research (Ukraine)

LEO: Low Earth Orbit

MAGDAS: Magnetic Data Acquisition System

McMAC: Mid-continent Magnetoseismic Chain

MiniME: two miniaturized Fabry-Perot interferometers

MIST: Magnetosphere Ionosphere and Solar-Terrestrial (UK)

MySQL: database software used for IHY coordination

NAMMMM: Nor Amberd Multidirection Muon Monitor

NASA: National Aeronautics and Space Administration (USA)

NAOJ: National Astronomical Observatory of Japan

NIMS: Navy Ionospheric Monitoring System

NOAA: National Oceanic and Atmospheric Administration (USA)

NRAO: National Radio Astronomy Observatory (USA)

NSF: National Science Foundation (USA)

PCI: Peripheral Component Interconnect

PC: Personal Computers

PI: Principle Investigator

RadCal: Radar Calibration Satellite

RAL: Rutherford Appleton Laboratory (UK)

RATAN-600: Radio Telescope of the Academy of Science (Russian Federation)

RENOIR: Remote Equatorial Nighttime Observatory for Ionospheric Regions

RF: radio frequency

RISC: Reduced Instruction Set Computer

SAA: South Atlantic Anomaly

SAGA: South Atlantic Geomagnetic Anomaly

SAMA: South Atlantic Magnetic Anomaly

SAMBA: South American Meridional B-field Array

SAMNET: Sub-Auroral Magnetometer Network

SAVN: South Atlantic VLF Network

SCINDA: Scintillation Network Decision Aid

SEGMA: South European Geomagnetic Array

SHINE: Solar Heliospheric and Interplanetary Environment

SID: Sudden Ionospheric Disturbance

SOHO: Solar and Heliospheric Observatory

SSDP: Canadian Space Science Data Portal

SUPIM: Sheffield University Plasmasphere Ionosphere Model

TEC: total electron content

TID: travelling ionospheric disturbance

Tripod: concept of basic space science development through three elements: telescope, teaching and observation

UAE: United Arab Emirates

UAEU: United Arab Emirates University

UCLA: University of California, Los Angeles

UHF: Ultra High Frequency

UK: United Kingdom of Great Britain and Northern Ireland

UKSP: UK solar physics community

ULF: ultra low frequency

UN: United Nations

UNAM: Universidade Nacional Autonoma de Mexico (Mexico)

UNBSSI: United Nations Basic Space Science Initiative

UNESCO: United Nations Educational, Scientific and Cultural Organization

URSI: International Union of Radio Science

US or USA: United States of America

USB: Universal Serial Bus

UT: Universal Time

VLF: very low frequency

VO: virtual observatory

WAAS: Wide Area Augmentation System (FAA, USA)

WMO: World Meteorological Organization

WSIS: World Summit on the Information Society

XML: interface synchronizing the CIP database

The United Nations Office for Outer Space Affairs (OOSA) is responsible for promoting international cooperation in the peaceful uses of outer space and assisting developing countries in using space science and technology.

United Nations Office for Outer Space Affairs
P.O. Box 500, 1400 Vienna, Austria
Tel: (+43-1) 26060-4950, Fax: (+43-1) 26060-5830
E-mail: oosa@unvienna.org
Website: www.unoosa.org