

INTERNATIONAL HELIOPHYSICAL YEAR ACTIVITIES IN JAPAN

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ABSTRACT

The IHY Japanese National Steering Committee (STPP subcommittee of the Science Council of Japan) has been promoting and supporting (1) two satellite missions, (2) five ground-based networks, (3) public outreach, (4) international and domestic workshops, and (5) the nomination of IGY Gold Club members. In the present paper we introduce these IHY activities, briefly summarize them, and suggest several post-IHY activities.

Keywords: IHY, Hinode, QSAT, CHAIN, IPS, Muon, MAGDAS, OMTIs, Public Outreach, IGY Gold Club.

1 INTRODUCTION

In 1957–58, more than 66,000 scientists and engineers from 67 nations participated in the International Geophysical Year (IGY). Fifty years on, the International Heliophysical Year (IHY) will again draw scientists and engineers from around the globe in a coordinated campaign to observe the heliosphere and its effects on planet Earth. For the benefit of scientists and engineers from developing nations, the United Nations Office for Outer Space Affairs, through the United Nations Basic Space Science Initiative (UNBSSI), assisted scientists and engineers from all over the world in participating in the activities of IHY 2007–08 (United Nations, 2006).

The IHY was an extensive international program undertaken to study the universal physical processes in the heliospace in order to gain a better understanding of the Sun-heliosphere system. Particular attention was paid to the neutral and ionized matter in the heliospace from the Sun to the atmospheres of Earth and the other planets and throughout the interplanetary medium. The IHY continued the legacy of the IGY by extending the geophysical studies performed 50 years ago to the combined system of the Sun and the planets. IHY also extended the physical realm from geospace to heliospace, recognizing the enormous progress made over the past 50 years.

There were four key elements of IHY: 1) science (coordinated investigation programs conducted as campaigns to investigate specific scientific questions, 2) instrument development (the IHY/UNBSS program), 3) public outreach (to communicate the beauty, relevance and significance of space science to the general public and students), and 4) the IGY Gold Club program (to identify and honor the scientists who participated in the IGY program).

2 IHY ACTIVITIES IN JAPAN

In June of 2006, the Science Council of Japan formally recognized the STPP (Solar Terrestrial Physics Program) subcommittee for International Affairs, Committee on Earth and Planetary Sciences, as the *IHY National Steering Committee* for Japan. The committee was chaired by Kiyohumi Yumoto and promoted (1) satellite missions launched or to be launched by Japan (2) international network observations, (3) public outreach, (4) international and domestic workshops, and (5) the nomination of Japanese scientists

as IGY Gold Club members (<http://www2.nict.go.jp/y/y223/sept/IHY/IHY-e4.html>).

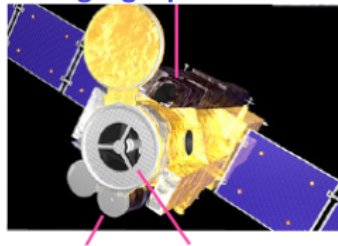
2.1 SATELLITE MISSIONS LAUNCHED/TO BE LAUNCHED BY JAPAN

2.1.1 Hinode Satellite Project

(Contact: Prof. T. Sakurai, National Astronomical Observatory of Japan)

The *Hinode* (Solar-B) satellite was launched to obtain data about the Sun. The mission is led by the Japan Aerospace Exploration Agency in collaboration with NASA, PPARC, and ESA. The *Hinode* is a highly sophisticated observation satellite equipped with three advanced solar telescopes (see Figure 1 and Web site of Hinode Science Center, NAOJ—http://solar-b.nao.ac.jp/index_e.shtml). It was launched on 22 September 2006 UT (23 September Japan time). Its solar optical telescope (SOT) has an unprecedented 0.2-arcsec resolution for the observation of solar magnetic fields (Tsuneta et al., 2008). It could resolve a feature of 50 cm if it observed the Earth. The x-ray telescope (XRT) has a resolution three times that of the *Yohkoh* satellite (Kano et al., 2008), and the EUV imaging spectrometer (EIS) has sensitivity ten times that of the ESA *SOHO* instrument (Culhane et al., 2007). These x-ray and EUV telescopes have been used to reveal the heating mechanism and dynamics of the active solar corona. *Hinode*'s one-year mission was to explore the magnetic field of the Sun and improve our understanding of the mechanisms that power the solar atmosphere and drive solar eruptions. A number of scientific reports based on the data gathered by *Hinode* have been published (http://solar-b.nao.ac.jp/publ/hsc_paper_e_main.shtml).

EUV Imaging Spectrometer (EIS)



X-Ray Telescope (XRT) , Solar Optical Telescope(SOT)

Figure 1. Hinode (Sunrise) satellite

2.1.2 QSAT Satellite Project

(PI: Dr. T. Hanada, Kyushu University)

The QSAT satellite project for polar plasma observation began in 2006 as an initiative by graduate students at Kyushu University (Tsuruda et al., 2009). It has the potential to contribute greatly to IHY by showing to the world the beauty, importance, and relevance of space science. The primary objectives of the QSAT project are (1) to investigate plasma physics in the Earth's auroral latitudes in order to better understand spacecraft charging and (2) to compare the field-aligned current observed in orbit with ground-based observations (Figure 2). It is providing education and research opportunities for students in both space sciences and satellite engineering. The *QSAT* satellite was designed to be launched in a piggyback fashion with the Japanese H-IIA launch vehicle. The spacecraft bus is being developed by the Department of Aeronautics and Astronautics of Kyushu University in collaboration with the Fukuoka Institute of Technology. Regarding the payload instruments, the Space Environment Research Center of Kyushu University is developing the magnetometers, and the Laboratory of Spacecraft Environment Interaction Engineering of the Kyushu Institute of Technology is developing the plasma probes. An opportunity for its launch is expected in 2011 (<http://directory.eoportal.org/presentations/10000718/10000719.html>).

Data related to the first primary objective will be gathered using an onboard magnetometer, a high-frequency probe (HP), and a Langmuir probe (LP). The magnetometer (Fujimoto et al., 2009) measures the magnetic field variations caused by field-aligned currents (FACs) in the polar and equatorial

regions. Polar FACs are well understood while equatorial FACs are not. The scientific goals are (1) to better understand FACs in the polar region, (2) to compare the FACs observed in orbit with those observed using ground-based MAGDAS (magnetic data acquisition systems), and (3) to better understand the spatial distribution of FACs in the equatorial region. FACs play a crucial role in the coupling between the solar wind, the magnetosphere, and the ionosphere/between the solar wind and the magnetosphere and between the solar wind and the ionosphere in terms of energy transfer. Clarification of the relationship between the space-based and ground-based FAC data should enable long-term study of the solar wind–magnetosphere–ionosphere couplings by using data mainly from ground-based magnetometer arrays, which is discussed in 2.2.4, MAGDAS network.

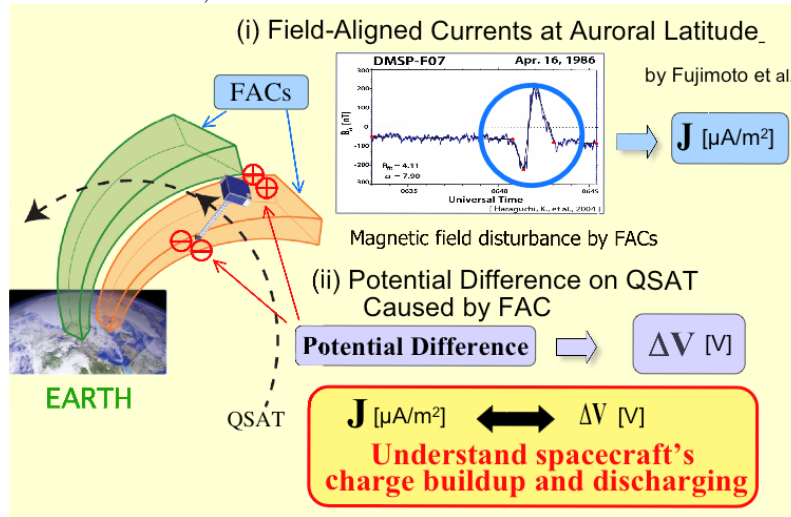


Figure 2. Main scientific mission of the QSAT satellite project

2.2 INTERNATIONAL NETWORK OBSERVATIONS

2.2.1 CHAIN network

(PIs: Dr. S. Ueno and Prof. K. Shibata, Kwasan and Hida Observatories, Kyoto University)

The Continuous H-alpha Imaging Network (CHAIN) project will continuously monitor solar flares and erupting filaments by using several flare-monitoring telescopes (FMTs) (see Figure 3) to be installed at locations around the world in addition to the one at Hida Observatory in Japan (http://www.kwasan.kyoto-u.ac.jp/index_en.html). The first overseas FMT to be installed as part of the CHAIN project will be in Peru. Several factors are currently being investigated, and the aim is to start operation of the FMT in Peru by the end of 2009. These factors include the observation conditions (such

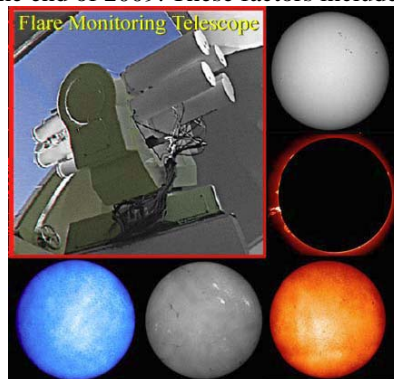


Figure 3. FMT of CHAIN network

as atmospheric turbulence due to heat haze), the best structure for housing the telescope, the telescope modifications needed given the latitude at which it will be installed, the best combination of observation wavelengths, the appropriate software for data processing given the computer environment at Ica University, and the human environment and the training needed for the local staff.

2.2.2 Interplanetary scintillation (IPS) network

(PIs: Prof. M. Kojima and Prof. M. Tokumaru, Solar-Terrestrial Environment Laboratory, Nagoya University)

The interplanetary scintillation (IPS) remote sensing technique is used to observe the solar wind. It has two advantages in particular over in situ spacecraft measurement: it can be used to observe three-dimensional solar wind, and the observations can be carried out over a solar cycle (Kojima et al., 2004). The plan is to coordinate IPS observations among IPS facilities so that the solar wind can be observed over the full distance from the near-Sun region to the Earth's orbit and be monitored 24 hours a day. The IPS network synergistically collaborates with the Solar Mass Ejection Imager (SMEI), which gives measurements of bulk density changes in the solar wind with much higher spatial resolution than the IPS technique. Already underway is a complementary collaborative project using both the muon network and the IPS network, both of which can image 3D coronal mass ejection (CME) structures. The IPS network is used to observe the density compressed and pile-up regions prior to an ejection while the muon network is used to observe the magnetic flux rope structure of the ejection. A loop-shaped density structure, which is closely associated with magnetic flux ropes, was identified from this collaboration for the CME event of 28 October 2003 (Tokumaru et al., 2007). A global campaign called the "Whole Heliosphere Interval (WHI)" was carried out during Carrington Rotation 2068 (March 20 to April 16, 2008, <http://ihy2007.org/WHI/>). The participants provided the IPS data they collected, and this data was used to reconstruct the 3D features of the solar wind that occurred during the WHI observation campaign.

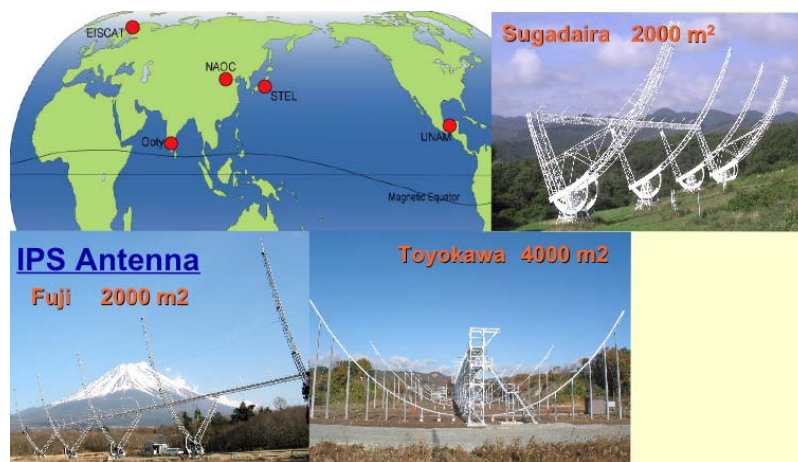


Figure 4. IPS observation network

2.2.3 Muon detection network

(PI: Prof. K. Munakata, Shinshu University)

The Muon detection network consists of detectors at nine institutes in seven counties (Figure 5) and monitors cosmic rays for space weather study. It obtains the directional intensity of high-energy cosmic rays. In March 2006, this worldwide network of muon detectors was upgraded with both an enlargement of the detector in Brazil and the installation of a new detector in Kuwait City, Kuwait. This upgrade greatly improved the coverage of the cosmic ray pitch angle. The participating institutes are (1) the Physics Department at Shinshu University, (2) the Bartol Research Institute at the University of Delaware, (3) the STE Laboratory at Nagoya University, (4) the Australian Antarctic Division, (5) the School of

Mathematics and Physics at the University of Tasmania, (6) the Southern Regional Space Research Center of the National Institute for Space Research, and (7) the Physics Department at Kuwait University. The precursory decrease in cosmic ray intensity one day prior to the sudden commencement of a magnetic storm is globally investigated (Munakata et al., 2000, <http://www.supaa.com/080623munakata/index.html>).

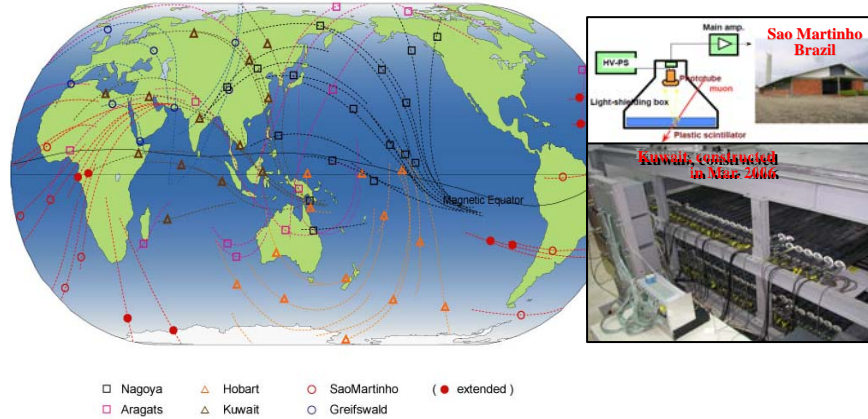


Figure 5. The location of each detector and the asymptotic viewing of a particle incident on each telescope with the meridian primary rigidity.

2.2.4 MAGDAS network

(PI: Prof. K. Yumoto, Space Environment Research Center, Kyushu University)

As Japan's leading contributor to the IHY, the *Space Environment Research Center* (SERC) of Kyushu University, Fukuoka, Japan, is in the process of globally deploying 50 state-of-the-art magnetometers (Figure 6, <http://magdas.serc.kyushu-u.ac.jp/>). The *Magnetic Data Acquisition System* (MAGDAS) Group seeks to deploy around the world in a strategic fashion a new generation of tri-axial fluxgate magnetometers (called MAGDAS) that transfer digitized data to a central SERC server in real time for space weather study and application during the IHY period (2007–2009). The MAGDAS stations are deployed along the 210° and 96° magnetic meridians and the magnetic dip equator, as shown in Figure 6. The installed MAGDAS units are listed in Annex V of the official UN report on the IHY Tokyo

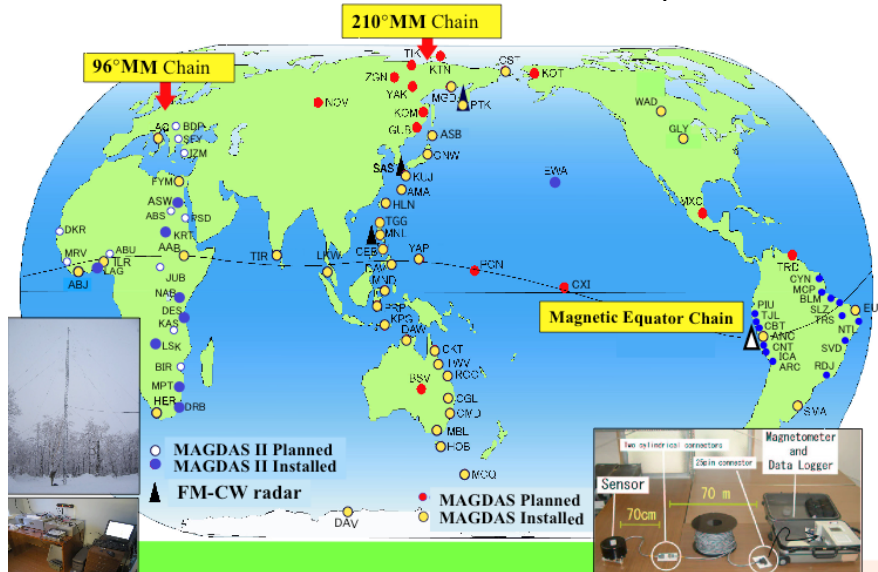


Figure 6. Map of 50 MAGDAS stations along the 210° and 96° magnetic meridians and the magnetic dip equator

Workshop of June 2007. The data collected will aid in the study of the dynamics of geospace plasma changes during magnetic storms and auroral substorms, the electromagnetic response of the iono-magnetosphere to various solar wind changes, and the penetration and propagation mechanisms of DP2–ULF range disturbances from the solar wind region into the equatorial ionosphere. It will also help with real-time monitoring and modeling of (1) the global three-dimensional current system, (2) the ambient plasma mass density for understanding the electromagnetic and plasma changes in geospace, and (3) the ionospheric electric fields for understanding how they penetrate the equatorial region (Yumoto et al., 2006, 2007; Maeda et al., 2009).

2.2.5 OMTIs network

(PI: Prof. K. Shiokawa, Solar-Terrestrial Environment Laboratory, Nagoya University)

Optical Mesosphere Thermosphere Imagers (OMTIs) were developed at the Solar-Terrestrial Environment Laboratory of Nagoya University for use in investigating the dynamics of the upper atmosphere through nocturnal airglow emissions (<http://stdb2.stelab.nagoya-u.ac.jp/omti/index.html>). They consist of an imaging Fabry-Perot interferometer, three all-sky cooled CCD cameras, three tilting photometers, and a spectral airglow temperature imager (SATI), all housed in two containers. These instruments simultaneously measure wind speed, temperature, and two-dimensional airglow patterns in the upper atmosphere at multiple wavelengths of OI (557.7 and 630.0 nm), OH (6-2) bands, O₂ (0, 1) bands, and Na (589.3 nm). Shiokawa et al. (1999) showed examples of the data for the cameras, the photometers, and the SATI captured from an airglow observation at a mid-latitude station in Japan. Good correlation between the photometer and SATI observations and a comparison were shown for small- and large-scale wave structures in airglow images at four wavelengths around the mesopause region taken using four cooled CCD cameras. An event was found during which large-scale bands, small-scale row-like structures, and a large-scale front passage occurred simultaneously.

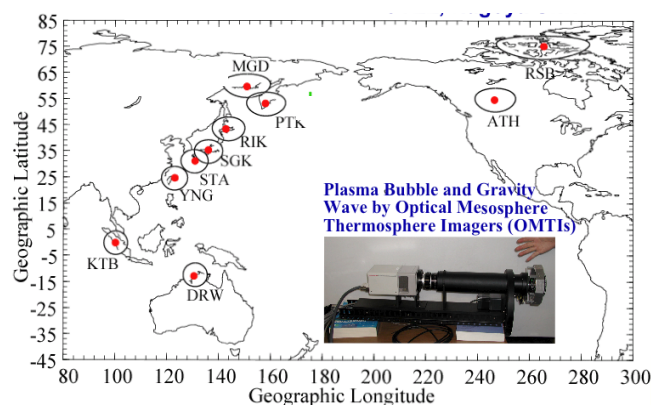


Figure 7. OMTIs network

2.3 PUBLIC OUTREACH

Public outreach is carried out through the Network of International Space Environment Services (ISES) of the National Institute of Information and Communication Technology (NICT, Contact: Dr. S. Watari). The International Space Environment Service (ISES) forecasts space weather and its effects on the Earth. The focal points for this work are the national space weather forecast centers, which are ISES Regional Warning Centers (RWCs). In recent years RWCs have been located in Boulder (USA), Ottawa, (Canada), Brussels (Belgium), Lund (Sweden), Warsaw (Poland), Prague (Czech Republic), Moscow (Russia), New Delhi (India), Beijing (China), Tokyo (Japan), Sydney (Australia), with an associate RWC in Toulouse (France) and the European Space Agency acting as a collaborative expert center for space weather activities in Europe. The most advanced was at the Hermanus Magnetic Observatory (South Africa), which in 2007 became ISES' newest RWC. Similar developments are underway in Sao Jose dos Campos

(Brazil). The National Institute of Space Research (INPE) plans to establish an RWC in South America. The NICT Space Weather Information Center of the International Space Environment Services (Watari and Boteler, 2009) takes real-time data from satellites and ground observatories and issues a space weather forecast everyday at 6:00 UT (Figure 8). The exploitation of space requires that we have a better understanding of space weather. A link to a summary of related IHY activities in Japan can be found on the home page of IHY in Japan: <http://www2.nict.go.jp/y/y223/sept/IHY/IHY-e.html>.



Figure 8. Space weather now- and fore-casting at NICT

2.4 IHY WORKSHOPS

The STPP subcommittee organized six international and domestic workshops: CAWSES/IHY Workshop, Nagoya University, March 14–16, 2007; IGY+50 Special Session, Japan Geoscience Union (JGU) Meeting 2007, May 19–25, 2007; IHY 2007, National Astronomical Observatory of Japan (NAOJ), June 18–22, 2007; Exhibition of Japanese I*Y Projects, Asia Oceania Geosciences Society 2007, July 30–August 4, 2007; IGY+50 Special Session, JGU Meeting 2008, May 25–30, 2008; and International IGY+50 Symposium, Tsukuba, November 10–13, 2008.

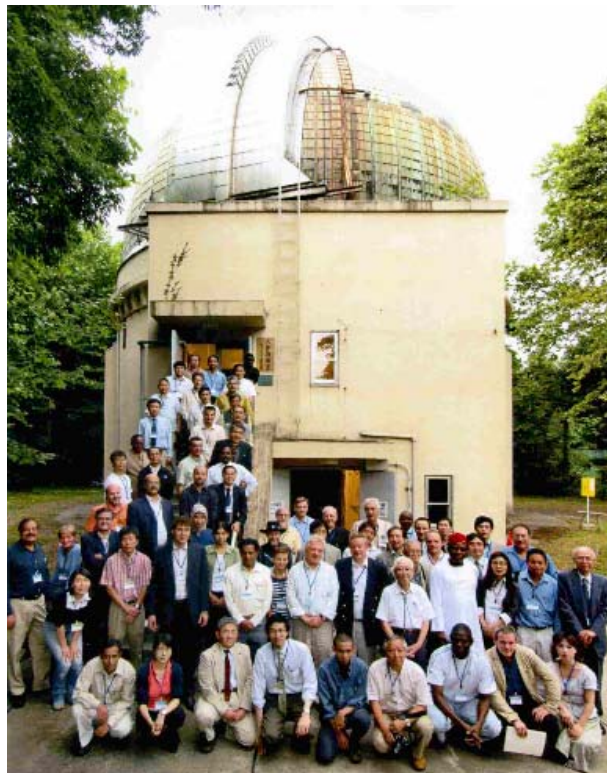


Figure 9. UN/ESA/NASA Workshop on Basic Space Science and IHY 2007 at NAOJ

Japan hosted a UN/ESA/NASA Workshop on Basic Space Science and IHY 2007 at the NAOJ (Figure 9), Mitaka, Tokyo, June 18–22, 2007 (Chair of Local Organizing Committee: Prof. T. Sakurai, NAOJ). Many workshops are being held in various countries in conjunction with IHY, aimed at helping scientists and engineers from developing nations. Information on the IHY workshops is available at <http://ihy2007.org/events/events.shtml>.

To make the IHY Tokyo Workshop a reality, considerable financial support was provided by NAOJ and SERC. For example, SERC paid for the travel expenses of five Japanese and about ten foreign scientists. At the opening of the workshop, statements were made by the Director General of NAOJ on behalf of the Government of Japan and by representatives of the International Heliophysical Year secretariat, NASA, and the Office for Outer Space Affairs. The workshop was divided into plenary sessions, each focusing on a specific issue. Presentations by invited speakers, describing their achievements with regard to organizing events, and carrying out research, education, and outreach activities related to basic space science and the International Heliophysical Year, were followed by brief discussions. Eighty papers and posters were presented by the invited speakers, some of whom came from developing countries. Poster presentation sessions and working groups provided participants with an opportunity to focus on specific problems and projects related to basic space science and the International Heliophysical Year (Kitamura et al., 2008).

The Workshop focused on the following topics: (a) the development of telescopes; (b) the space program of Japan (e.g., Hinode); (c) the development of instruments, data analysis software, and teaching materials to be used as part of the “Tripod” concept for the promotion of the International Heliophysical Year in developing countries; (d) data acquisition systems; (e) virtual observatories; (f) statistical mechanics and astrophysics; and (g) deployment of ground-based instruments for global network-type scientific observations.

2.5 IGY GOLD CLUB

One aim of IHY is to recognize and celebrate the accomplishments of the International Geophysical Year of 1957. With this in mind, in 2006, the “IGY Gold Club” was initiated. Membership is limited to those individuals who participated in IGY. To date, 13 Japanese have been selected as Gold Club Members (all nominated by SERC).

- ◇ Dr. Kaichi Maeda
- ◇ Dr. Hiroshi Maeda
- ◇ Dr. Masahisa Sugiura
- ◇ Dr. Noboru Wakai
- ◇ Dr. Mutsumi Ishitsuka
- ◇ Dr. Hiroyoshi Tanabe
- ◇ Dr. Keizou Nishi
- ◇ Dr. Eijiro Hiei
- ◇ Dr. Masami Wada
- ◇ Dr. Tai-ichi Kitamura
- ◇ Dr. Takashi Oguti
- ◇ Dr. Ichiro Kondo
- ◇ Dr. Toru Ogawa

More details and images of their IGY Gold Club certificates can be found at <http://www2.nict.go.jp/y/y223/sept/IHY/IHY-e4.html>. More members from Japan are expected as additional nominations are currently being considered.

3 CONCLUSION

By using newly established observation systems (such as orbiting satellites and ground-based networks), we can now study the universal physical processes in the “heliospace” – from the Sun to the atmospheres of Earth and the other planets, and throughout the interplanetary medium.

During IHY, many developing nations were invited to join the space science community by attending IHY workshops (such as the IHY Tokyo Workshop in 2007), hosting ground instrumentation (such as MAGDAS), and hosting regional IHY schools (such as the IHY Africa School in Nigeria in 2008). But this was only the first step. The next logical step is to continue the nurturing of young scientists in these countries by (1) training them how to do scientific observations and how to use the results, (2) internationally exchanging students and young researchers, and (3) organizing international scientific workshops on their behalf.

However, to effectively achieve these goals, we believe there must be regular international scientific conferences that (1) cover the entire region from the Sun to the Earth and the other planets and (2) bring into this discussion the scientists and engineers working in developing countries (who have been neglected in the past).

Because of the international scope of this agenda, we suggest that the United Nations coordinate these important plans by initiating an appropriate “post-IHY” program.

4 ACKNOWLEDGEMENTS

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