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Update on Japan's Contribution to the ISWI

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Abstract: We are conducting three initiatives in Japan, in order to accomplish the ISWI objectives. The first is an instrument array program to deploy new and existing observation networks. The second is data coordination to develop predictive models using ISWI data. And the third is training, education (that is capacity building), and public outreach programs, such as the ISWI Newsletter. An update on Japan's Contribution to the ISWI in 2010 will be summarized in the present paper.

1. Introduction

The aim of the International Space Weather Initiative (ISWI; 2010 - 2012), a new United Nations initiative involving developing and developed countries, is to contribute to the progress of basic space science, and to secure the safety of satellites concerned with daily life issues, such as communications and navigation systems. In Japan, the Solar Terrestrial Physics Program (STPP) subcommittee of the Science Council of Japan is participating in ISWI as a follow-on program of the International Heliophysical Year (IHY) 2007. The Chair of the STPP subcommittee (Kiyohumi Yumoto of Kyushu University) and other members of the subcommittee are moving forward with their instrument deployment plans and are constructing database systems for public access. The leading instrument programs (CHAIN, GMDN, MAGDAS, OMTIs, SEALION) have been actively expanding their operations since the beginning of 2010. The ISWI bureau members in Japan are K. Yumoto of Kyushu University and Hajime Hayakawa of JAXA. The ISWI Newsletter Office (on behalf of the United Nations) is led by K. Yumoto (Publisher) of Kyushu University, and George Maeda (Editor) of Kyushu University. The ISWI National Coordinator for Japan is Takahiro Obara of JAXA. Japan strongly supports such initiatives of the United Nations and contributes to the ISWI and related UN Basic Space Science Initiative activities.

The objectives of ISWI are intended to develop the scientific insight necessary to understand the solar-terrestrial physical relationships inherent in space weather, to reconstruct and forecast near-Earth space weather, and to communicate this knowledge to scientists and to the general public. In order to accomplish the ISWI objectives, we are conducting three initiatives in Japan. The first is an instrument array program to deploy new and existing observation networks. The second is data coordination to develop predictive models using ISWI data. And the third is training, education (that is capacity building), and public outreach programs, such as the ISWI Newsletter. In the present paper, we will provide an update on Japan's Contribution to the ISWI in 2010

1. Instrument Array Program of Japan

	INSTRUMENT	Lead Scientist	Objective
1	Continuous H-alpha Imaging Network (CHAIN)	Dr. Satoru Ueno, Prof. Kazunari Shibata (Kyoto U)	Time variation and 3D velocity field of solar activity, flares, filament eruptions and shock waves (Morton waves) by using multi-wavelength H-alpha images of the full-disk Sun.
2	Global Muon Detector Network (GMDN)	Prof. Kazuoki Munakata (Shinshu U)	To identify the precursory decrease of cosmic ray intensity that takes place more than one day prior to the Earth-arrival of the shock driven by an interplanetary coronal mass ejection
3	Magnetic Data Acquisition System (MAGDAS)	Prof. Kiyohumi Yumoto (Kyushu U)	Study of dynamics of geospace plasma changes during magnetic storms and auroral substorms, the electromagnetic response of iono-magnetosphere to various solar wind changes, and the penetration and propagation mechanisms of DP2-ULF range disturbances
4	Optical Mesosphere Thermosphere Imagers (OMTIs)	Prof. Kazuo Shiokawa (Nagoya U)	Dynamics of the upper atmosphere through nocturnal airglow emissions
5	South-East Asia Low - Latitude Ionospheric Network (SEALION)	Dr. Tsutomu Nagatsuma (NICT)	Monitoring and study of ionospheric disturbances occurring in the equatorial region by ionospheric and geomagnetic field observations.

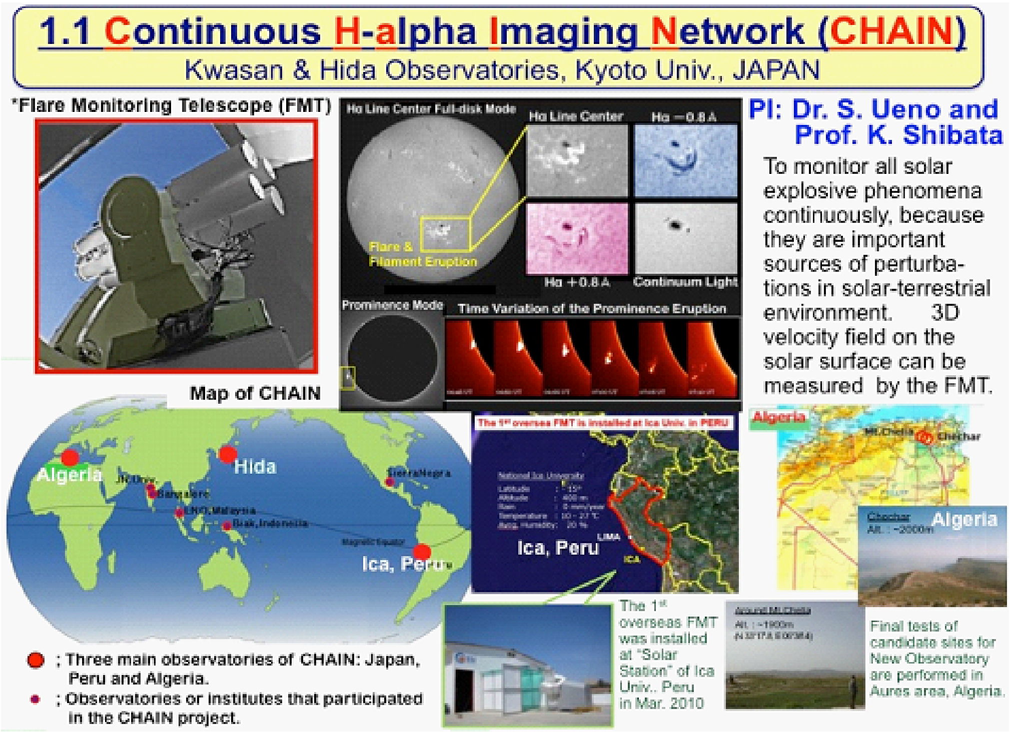

Fig. 1. Concepts, recent progress and future plan of the Continuous H-alpha Imaging Network (CHAIN) Project promoted by Kwasan & Hida Observatories, Kyoto University.

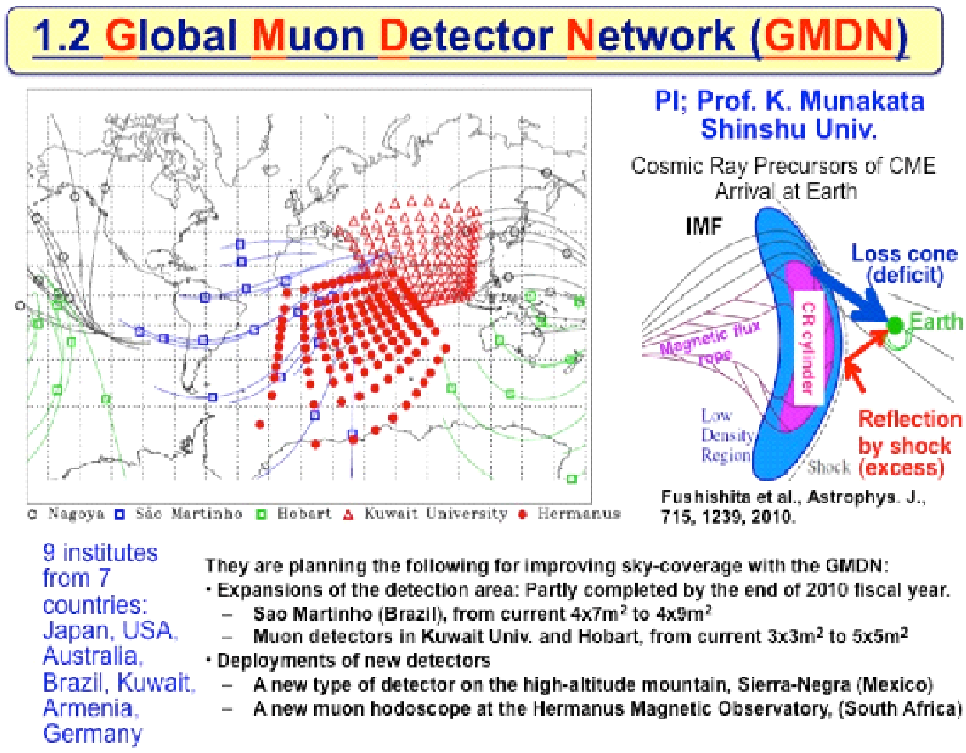

Fig. 2. Concepts, recent progress and future plan of the Global Muon Detector Network (GMDN) Project conducted by Shinshu University.

2. Instrument array program

The first Table shows five instrument array programs from Japan, which include CHAIN, GMDN, MAGDAS, OMTIs, and SEALION. The second column shows the lead scientists, and the third column shows their scientific objectives. In the following figures, we will present further details of the 2010 updates to these instrument array programs.

The first instrument array program is the Continuous H-alpha Imaging Network (CHAIN) project as shown in Fig. 1, which is promoted by Prof. K. Shibata and Dr. S. Ueno, Kyoto University (UeNo et al., 2007, 2009, and 2010). They are planning to install several Flare Monitoring Telescopes throughout the world in order to monitor all explosive solar phenomena continuously. These phenomena are important sources of perturbations in the solar-terrestrial environment. This telescope can obtain solar images in several kinds of modes, enabling it to effectively measure important physical parameters of solar phenomena, such as velocity, density and temperature. In March 2010, the first overseas telescope was installed at Ica University in Peru, and preparations are now underway for the installation of the second overseas telescope in Algeria. Through the distribution of flare monitoring telescopes, they have performed various international personnel training and academic exchanges. For example, technical training of Peruvian young staff in Japan, guidance of the solar observation method in Peru, some lectures in Peru and Algeria, scientific data-analysis training and a scientific workshop for students and young researchers in Peru. Such capacity- building activities are surely promoting and spreading solar physics and space weather research efforts throughout the world.

The second instrument array program is the Global Muon Detector Network (GMDN) project, organized by Prof. K. Munakata, Shinshu University as shown in Fig. 2. The primary scientific purpose of GMDN is the seamless monitoring of precursory signatures in cosmic-ray intensity prior to the shock arrival at Earth, and the real-time monitoring of the large-scale interplanetary magnetic structure of CME, by using the three dimensional spatial gradient of cosmic-ray density deduced from observations with the nwtwork of these ground-based stations (Munakata et al., 2000, Fushishita et al., 2010). During ISWI, they are improving sky-coverage with the GMDN through the expansion of detection area at Sao Martinho, Brazil, and Muon detectors at Kuwait University and in Hobart, Australia. They also have plans to deploy a new type of detector on a high-altitude mountain in Mexico, and a new Muon detector at the Hermanus Magnetic Observatory in South Africa.

The third program is the MAGDAS (MAGnetic Data Acquisition System) network deployed by the Space Environment Research Center, SERC, Kyushu University (PI: Prof. K. Yumoto). The scientific target of the MAGDAS project is real-time monitoring and modeling of the global ionospheric current system and the ambient plasma mass density in geo-space to understand the Sun-Earth coupling system (Yumoto et al., 2007). They constructed three linear arrays along the 210 magnetic meridian (MM), 96 MM, and magnetic dip equator during IHY (Yumoto et al., 2010). In 2010, they visited MAGDAS stations in the red circle regions in Asia and Africa as shown in Fig. 3, to maintain 210 MM and 96 MM arrays, and to install a new type of magnetometer in the magnetic equatorial region. The bottom right shows the new type magnetometer with 10 Hz data sampling to measure the geomagnetic field variations, and the bottom left shows the FM-CW radar system to measure the ionospheric electric field variation. At present, they have 54 real-time MAGDAS stations and more than 20 non-real time stations world-wide. However, it is not easy for one institute to maintain the MAGDAS stations on a truly global scale, so they are now constructing a MAGDAS regional support center. The first MAGDAS Subcenter is now operating at the Manila Observatory in the Philippines. Six MAGDAS magnetometers and a FM-CW radar system were installed in the Philippines to observe the equatorial electrojet current and its anomaly for space weather study. These data in Philippines are collected at the Subcenter, and then transferred to SERC, Kyushu University. These collected data are also analyzed by the host scientists in Philippines. Dr. Sugon and Fr. McNamara (both with Manila Observatory) are operating the SERC sub-center at the Manila Observatory. This is one way to create an “Equal Partnership” between “instrument provider” and “instrument host”.

Figure 4 shows a recent scientific result of MAGDAS project, i.e., space weather map of Sq ionospheric current obtained from MAGDAS data, indicating a strong coupling of the Sun-Earth system. The figure at the top right shows global Sq ionospheric current driven by solar radiation, and this Sq ionospheric current produces magnetic field variations on the ground as shown on the bottom right. From the obtained MAGDAS network magnetic field data we can estimate the global Sq ionospheric current pattern and its intensity as a function of solar activity and day of year (Yamazaki et al., 2011). The animation shows seasonal and day-to-day variations of global Sq ionospheric current from 2001. The white line indicates the terminator between daytime and night-time hemisphere. It is found that the strong Sq current is flowing in the summer hemisphere and there is a rapid change in day-to-day Sq current intensity. The rapid change of Sq ionosphereic current may be explained by the strong coupling with atmospheric neutral wind. This is a new scientific target of the MAGDAS Project.

The fourth instrument array is the Optical Mesosphere Thermosphere Imagers (OMTIs), which is organized by Prof. K. Shiokawa, Solar-Terrestrial Environment Laboratory (STEL), Nagoya University. The STEL is operating OMTIs equipment at 12 ground- based stations in the world [Shiokawa et al., 1999 and 2009]. Figure 5 schematically shows latitudinal distribution of the airglow imagers and physical phenomena in the upper atmosphere that can be observed by the imagers. The top-right panel shows current stations of the airglow imagers of OMTIs. The OMTIs can obtain two-dimensional images, Doppler winds, and temperatures of the upper atmosphere at altitudes of 80-300 km to investigate propagation of thermospheric waves and disturbances over high to low latitudes and from low to high altitudes. The upper atmosphere is the region where most of the artificial satellites and space stations exist. Thus the measurements of OMTIs significantly contribute to the utilization of space by human beings by enhancing our understanding of the "geospace" environment. In May 2010, an all-sky airglow imager and a Fabry-Perot interferometer were installed at Kototabang, Indonesia, in collaboration with LAPAN.

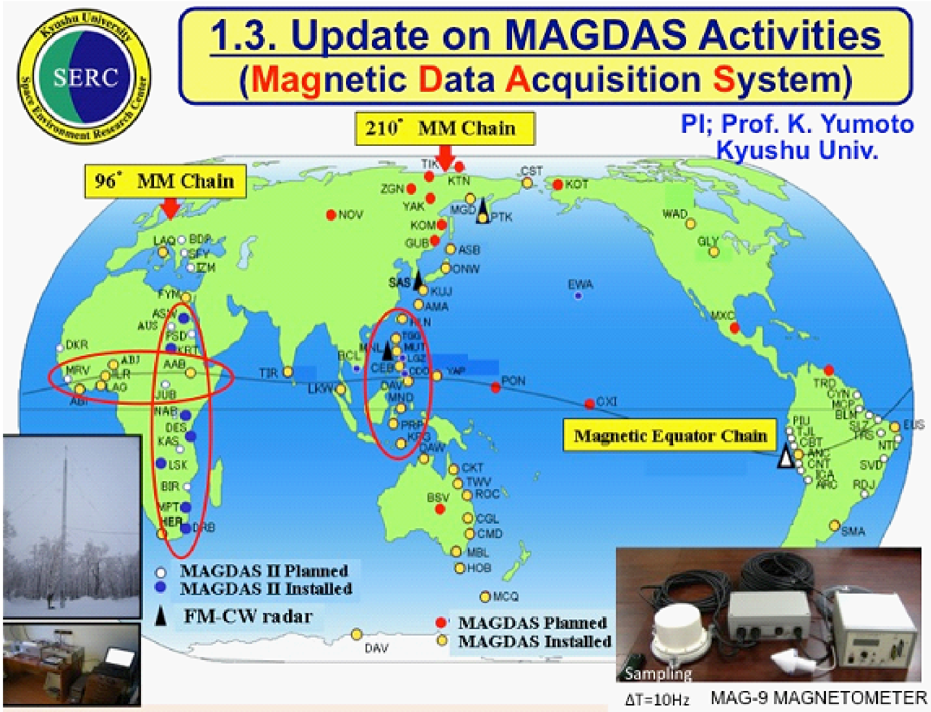

Fig. 3. Recent progress and future plan of the MAGnetic Data Acquisition System (MAGDAS) Project conducted by the Space Environment Research Center (SERC), Kyushu University.

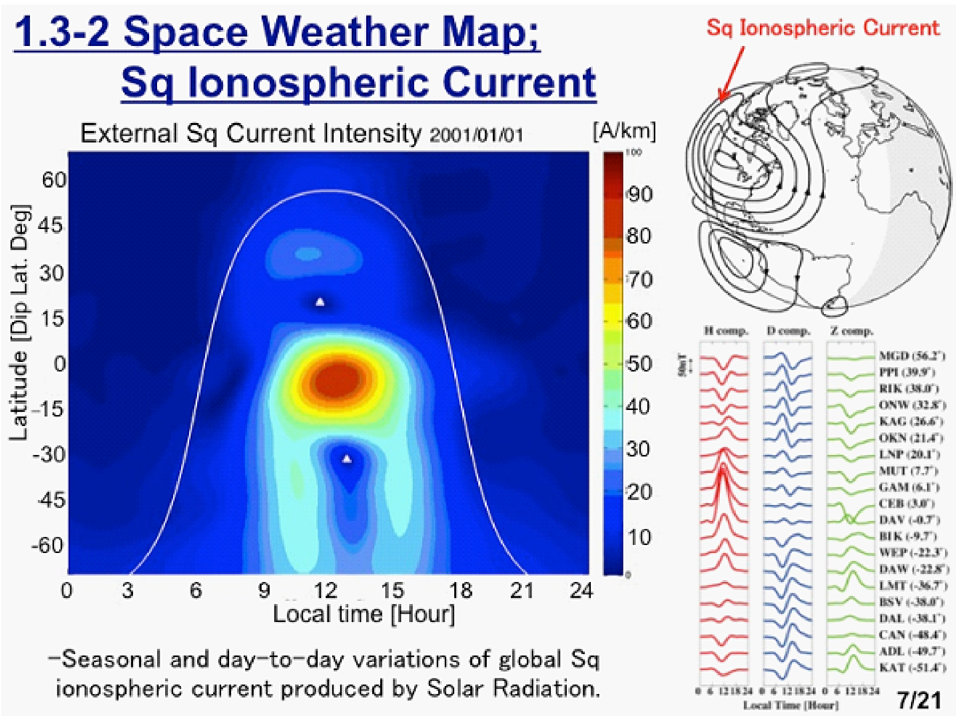

Fig. 4. Space weather map of Sq ionospheric current obtained from MAGDAS data during 2001, indicating a strong coupling of the Sun-Earth system.

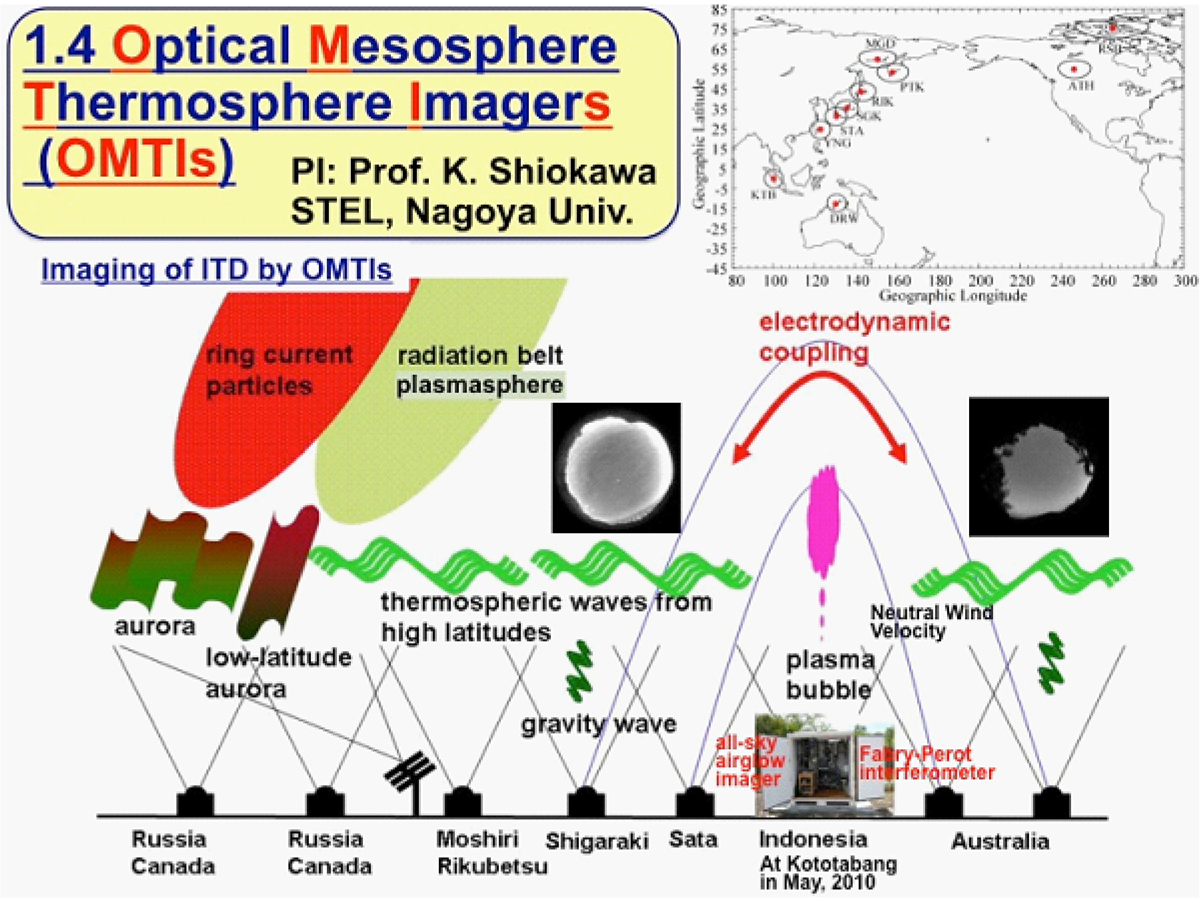

Fig. 5. Airglow imagers of OMTIs that measure various waves and turbulences in the upper atmosphere.

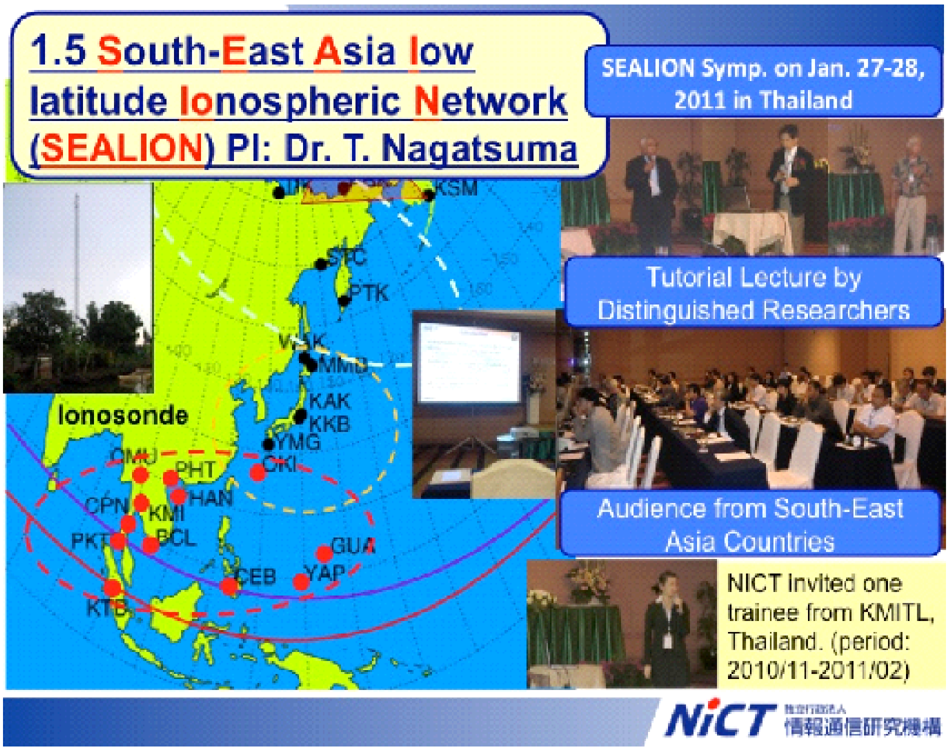

Fig. 6. Recent progress of the South-East Asia Low latitude IOnospheric Network, SEALION by the NICT.

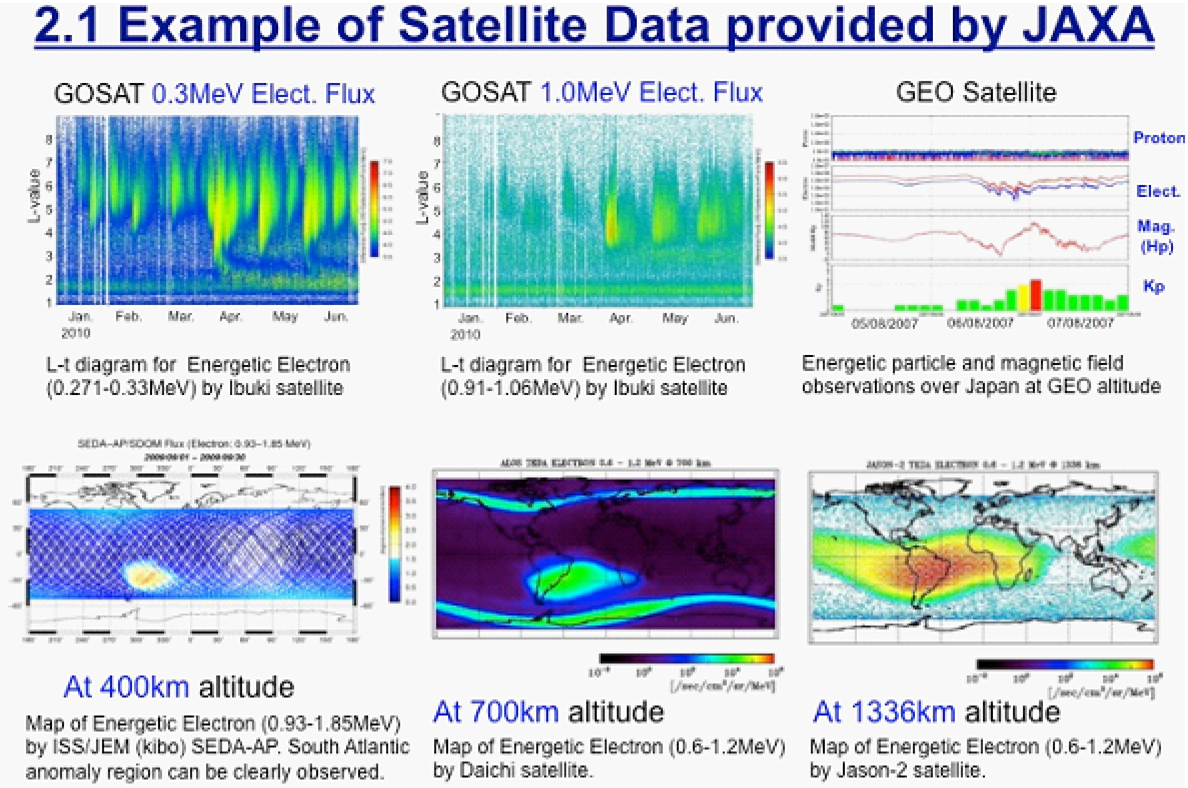

Fig. 7. The upper left and middle panels show energetic electron flux variations as a function of L value and time. Sporadic enhancements of intermediate and high energy electrons are due to commencement of magnetic storms. Top right panel shows magnetic variation and energetic particle variations at the Japanese geosynchronous satellites. Lower three panels show maps of energetic electron fluxes at different altitudes of JAXA satellites. We can clearly identify significant widening of South Atlantic Anomaly (SAA) region with an increment of satellite altitude.

Fig. 8. Activity of ISWI Newsletter Office at SERC, Kyushu University.

In order to monitor solar activities, and their related equatorial disturbances for space weather forecasting, the National Institute of Information and Communications Technology, NICT (PI: Dr. T. Nagatsuma) is also deploying the South-East Asia Low latitude IOnospheric Network, SEALION as shown in Fig. 6 (Nagatsuma et al., 2011). They are now constructing a dense ionospheric and geomagnetic field observation network in the equatorial region. NICT organized a SEALION symposium from January 27-28, 2011 in Thailand, including tutorial lectures by distinguished researchers, student presentations on south-east Asia countries, and one invited talk by a trainee from Thailand for capacity building in this region.

3. Data coordination in Japan

Another contribution to ISWI is "Data Coordination in Japan." To create awareness of ISWI in Japan, the STPP sub-committee organized an ISWI-Japan Kick-Off Meeting at *Kyushu Universit*y in March of 2010, and the ISWI-Japan International Symposium at Makuhari in May of 2010 with the help of the *Japan Geophysical Unio*n (JpGU). This symposium will be held every year in Japan during ISWI (2010 through 2012). The existing databases of *Solar Wind*, *Space Environment* (satellite measurements), and *Geomagnetic Field* will be provided by Prof. M. Tokumaru (STEL, Nagoya University), Dr. T. Obara (JAXA), and Prof. T. Iyemori (WDC for Geomagnetism, Kyoto University), respectively, and a new database from 5 instrument arrays will contribute to the data coordination and analysis programs of ISWI in Japan.

One example of satellite data obtained by the JAXA space environment group (PI: T. Obara) is shown in Fig. 7. The upper panels show energetic electron fluxes and magnetic variation at Japanese geosynchronous satellites, and the bottom panels show maps of energetic electron flux at different altitudes of JAXA satellites. We can observe a dynamic spatial change of the radiation belt and the altitude dependence of penetration of energetic electron flux. This data will help to understand the energetic particle environment for space weather study. We will organize a data coordination workshop in which all the data will be used to advance our understanding of space weather phenomena.

4. Public outreach and ISWI Newsletter

The next figure illustrates the Public outreach service of the ISWI Newsletter. At the request of the United Nations Office for Outer Space Affairs, SERC of Kyushu University, became the publisher of the *ISWI Newsletter* as shown in Fig. 8. The main mission of the newsletter is to deliver timely news and information to all participants of the ISWI. Already, 148 issues of the newsletter have been distributed via email. All issues are archived at the ISWI website (www.iswi-secretariat.org) so that a formal record is kept of this publication. In this way, coordination is improved for ISWI and greater awareness of activities is created.

Japan's most noteworthy contribution to ISWI is through Capacity Building to promote knowledge of space weather study and its application. In order to build capacity through the MAGDAS project, the first MAGDAS Session was organized from November 8-9, 2010, during the first UN/NASA/JAXA workshop in Egypt. Thirty-one persons (mostly from Africa) delivered 20-minute talks. We had 16 instrument-related talks from these countries, three data-related talks, and 11 science-related talks on various magnetic variation phenomena

Also, the National Institute of Information and Communications Technology (NICT) has actively expanded space weather outreach activities, which are carried out through the Network of International Space Environment Services (ISES; Dr. S. Watari) of NICT. They operate one of thirteen ISES centers. Each center makes forecasts of flares, geomagnetic storms, and high-energy proton events every day.

5. Summary

Outside Japan, three major International Space Weather Initiative workshops are scheduled: in Egypt in 2010, in Nigeria in 2011 and in Ecuador in 2012. The 2010 International Space Weather Initiative United Nations/NASA/JAXA workshop was held on the campus of Helwan University, Egypt, from 6 to 10 November 2010. Several instrument array sessions were scheduled. One of those was the Magnetic Data Acquisition System (MAGDAS) session, where 31 persons (mainly MAGDAS hosts from all over the world, but mostly from Africa) delivered 20-minute talks. The general theme of the MAGDAS session was capacity building, which consists of three phases: (a) development of instrument capacity, (b) development of data analysis capacity and (c) development of science capacity (see Yumoto, 2011). Capacity-building is one of the major goals of the International Heliophysical Year and the International Space Weather Initiative, as specified by the organizers of those initiatives. Thanks to MAGDAS hosts, the Space Environment Research Center is able to successfully operate ground observatories all over the world. This is a good example of the International Space Weather Initiative in action. Japan continues to contribute to International Space Weather Initiative through these five Instrument Array programs, Data Coordination, Capacity Building and the ISWI Newsletter.

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