Commission G: Ionospheric Radio and Propagation (November 2013 – October 2016)

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URSI Commission G takes care of radio propagation in the ionosphere and the study of the ionosphere and/or upper atmosphere. In this national report, we would like to summarize the research activities by showing major measurement instruments, observation network, related model/database projects, and future plans that are closely related to the Commission G. For results of the studies, please refer to papers that are listed below.

G.1 Major Instruments

G1.1 PANSY

PANSY (Program of the Antarctic Syowa MST/IS Radar) is a project which was started in 2000 to comprehensively study the polar atmosphere with a large aperture atmospheric radar as the main instrument combined with complementary observation techniques and also with numerical modeling and theoretical works. (PANSY project web page: http://pansy.eps.s.u-tokyo.ac.jp/en/)

The radar started research observation in 2012 with 1/4 of the full array system, and has collected almost continuous observational data in the troposphere, lower stratosphere and mesosphere for about three years. Although the full system operation has been postponed due to limited transportation in 2011/12 and 2012/13 seasons caused by a very thick sea-ice condition, full system observations have been successfully started in early 2015 with 520 kW transmitting power and 1045 array antennas.

1-year continuous full system observation of the PANSY radar started late September 2015. It enables us to capture various temporal- and spatial-scale phenomena in the Antarctic troposphere, stratosphere, mesosphere, and thermosphere/ionosphere with high temporal and vertical resolution throughout the year and to contribute to improving global climate models for better understanding of future climate change.

In addition, the first international campaign based on a combination of GCM (General Circulation Model) simulations and simultaneous observations by several MST/IS radars over the world including PANSY and some complementary instruments such as MF (Medium Frequency) and meteor radars, lidars, imagers, and so on was successfully conducted from January 22 to February 17, 2016. This campaign was named the Interhemispheric Coupling Study by Observations and Modeling (ICSOM: see details at http://pansy.eps.s.u-tokyo.ac.jp/icsom/), and approved as a project for ROSMIC (Role Of the Sun and the Middle atmosphere/thermosphere/ionosphere In Climate) of SCOSTEP (Scientific Committee on Solar-Terrestrial Physics) under ICSU (International Council for Science). It is expected that these international collaborations including the PANSY radar will promote a more accurate understanding of the Antarctic atmosphere and interhemispheric coupling processes.

G1.2 EISCAT radar

NIPR (National Institute of Polar Research) and Institute of Space-Earth Environmental Research, Nagoya University have joined the EISCAT (European Incoherent Scatter) Scientific Association since 1996 and conducted observations with three incoherent scatter radar systems, at 224 MHz, 931 MHz in Northern Scandinavia and one at 500 MHz on Svalbard. They kept high research activity in this period. Examples of research results are as follows. (EISCAT database in NIPR: http://pc115.seg20.nipr.ac.jp/www/eiscatdata/)

Ogawa et al (2014) studied data from the EISCAT radar above Tromsø for over 33 years, and estimated the first significant trends of ion temperature at altitudes between 200 and 450 km. The estimated trends indicate a cooling of 10–15 K/decade near the F region peak (220–380 km altitude), whereas above 400 km the trend is nearly zero or even warming. Miyoshi et al (2015) showed that pulsating auroras show quasi-periodic intensity modulations caused by the precipitation of energetic electrons of the order of tens of keV. It is expected theoretically that not only these electrons but also sub-relativistic/relativistic electrons precipitate simultaneously into the ionosphere owing to whistler-mode wave-particle interactions. Iyeda et al (2015) studied the solar zenith angle (SZA) dependence of the conductance, and obtained a simple theoretical form for the Hall-to-Pedersen conductance ratio, using the peak plasma production height based on observations with the EISCAT radar at Tromsø. Taguchi et al (2015) reported three-dimensional imaging of the plasma parameters of a moving cusp aurora from the all-sky imager at Longyearbyen, Svalbard. Also, Nozawa et al (2014) reported that a new solid-state sodium lidar installed at Ramfjordmoen, Tromsø (69.6°N, 19.2°E), started observations of neutral temperature together with sodium density in the mesosphere-lower thermosphere (MLT) region on 1 October 2010.

G1.3 SuperDARN Hokkaido East / West Radars

SuperDARN (Super Dual Auroral Radar Network) is an international collaboration project by eleven countries in the world. Most SuperDARN radars have observed the polar regions higher than 60 geomagnetic latitude for more than a decade. The mid-latitude SuperDARN radars began operation recently (since 2005), and new discoveries have been made using newly constructed SuperDARN radars by several countries in the world such as Japan, USA and UK. The Hokkaido East / West radars were constructed by Nagoya University in 2006 / 2014, and are located in the lowest latitude of the recently constructed radars. Detailed information of this radar is found from: http://cicr.isee.nagoya-u.ac.jp/hokkaido/index.html

The radars are used for variety of studies of the magnetosphere and the ionosphere. In the ionospheric region, the study of the traveling ionospheric disturbance (TID) is the important topic. During the period of 2014-2016, medium-scale TIDs (MSTIDs) were intensively studied. For example, Koustov et al. (2014) investigated 117 of periodic E region echoes that propagate, for 2008-2012. The wave structures, which are actually MSTIDs, are shown to occur at nighttime, preferentially during summer, although significant number for events was found for winter. They interpreted the onset of these MSTIDs in terms of gravity waves. Oinats et al (2016) further conducted statistical study of MSTIDs using the Hokkaido East (2007 to 2014) and Ekaterinburg (2013 to 2014) high-frequency (HF) radar data, and compared their propagation directions with that of the ambient neutral wind.

G1.4 MU radar

The MU radar is the 46.5-MHz atmospheric radar located in Shigaraki, Shiga, Japan. The radar can measure atmospheric winds from near the surface to about 20km, and is also useful to measure coherent and incoherent scatters from the ionosphere. Multi-beam capability with the active-phased array antenna is the most power feature of the system, and the various interesting observations were conducted so far. (MU radar and EAR web: http://www.rish.kyoto-u.ac.jp/mu+ear/english/index.html)

IEEE, an association dedicated to advancing innovation and technological excellence for the benefit of humanity, is the world's largest technical professional society. IEEE established the Milestones Program in 1983 to recognize the achievements of the Century of Giants who formed the profession and technologies represented by IEEE. Each milestone recognizes a significant technical achievement that occurred at least 25 years ago in an area of technology and having at least regional impact. In December 2014, IEEE decided to award Milestone to the MU (Middle and Upper atmosphere) radar as the first large-scale MST (Mesosphere, Stratosphere, and Troposphere) radar with a two-dimensional active phased array antenna system. The MU radar was established in 1984 by Kyoto University with collaboration of Mitsubishi Electric Corporation, and enabled continuous and flexible observation of the atmosphere, and has contributed to the progress of atmospheric science and radar engineering. Its dedication ceremony was successfully held on May 13, 2015 at Shirankaikan, Kyoto University.

Recent topic of the MU radar is the combination of its radar range-imaging observations of the turbulence and the direct measurement of the atmospheric parameters by using UAV. Scientists from USA and France conducted the observation campaign in 2015 and 2016.

G1.5 Equatorial Atmosphere Radar

Equatorial Atmosphere Radar (EAR) is a big atmospheric radar located in West Sumatra, Indonesia. The EAR was established in June 2001, and has continued long-term observations since June 2001. Research Institute for Sustainable Humanosphere (RISH), Kyoto University and National Institute of Aeronautics and Space (LAPAN) of Indonesia hold the 15th anniversary ceremony and symposium on August 3, 2016, at

Jakarta. The ceremony was attended by the Director General for Research and Development, Ministry of Research, Technology and Higher Education of Indonesia, and Minister/Deputy, Chief of Mission, the Embassy of Japan in Indonesia and the Minister of the Embassy of Japan. From Kyoto University, Executive Vice-President for Gender Equality, International Affairs attended. Total number of participants reached 222.

MU radar and EAR web: http://www.rish.kyoto-u.ac.jp/mu+ear/english/index.html

G1.6 Ground-based network observations

MAGDAS

MAGDAS is the world network of magnetometer developed and maintained by International Center for Space Weather Science and Education (ICSWSE), Kyushu University. MAGDAS network and its observations are well maintained during this period. Many studies of atmospheric tides, sudden stratospheric warming, various ionospheric phenomena, and thermosphere-ionosphere coupling are published in international journals. For example, quasi-biennial oscillation is analyzed from Sq current system from the dense magnetometer network over Japan. Also, peak time of equatorial electrojet was deeply investigated based on data from the MAGDAS network.

MAGDAS related database web: http://data.icswse.kyushu-u.ac.jp/

VLF/ELF

Institute for Space-Earth Environmental Research (ISEE), Nagoya University reports a campaign observation of auroras and VLF/ELF waves was carried out from January 28 to February 5, 2014 at Poker Flat, Alaska, in collaboration with an auroral rocket launch. Dual cameras were used to determine the height of auroras. A loop antenna with a 20 kHz-sampling portable recorder was tested for VLF/ELF wave measurement at remote site without power line. They also showed that the first statistical analysis of ELF/VLF emissions based on 1-year 100 kHz continuous observations at Athabasca, Canada (L = 4.3), in collaboration with Athabasca University and Kanazawa University. Characteristics of the ELF/VLF emissions, such as chorus, hiss, and QP emissions, and their dependence on local time, geomagnetic activity, and solar wind parameters are clarified.

ISEE VLF/ELF web: http://stdb2.stelab.nagoya-u.ac.jp/vlf/

AVON (Asia VLF Observation Network) group has been making continuous measurements of LF/VLF/ELF waves at Tainan (Taiwan), Saraburi (Thailand), Pontianak (Indonesia), Los Banos (Philippines), and Hanoi (Vietnam) since December 2007. 14 Universities/institutes including Chiba, Hokkaido, Tohoku Universities and Ashikaga Institute of Technology participate in the AVON project. The antennas consist of a monopole antenna, a dipole antenna, and an orthogonal loop antenna. The sampling frequency of LF/VLF transmitter signals is 200 kHz, while that of VLF/ELF waves radiated from lightning discharges is 100 kHz. Recently, the first observation of about 100-s periodic oscillations of intensity and phase in two LF transmitter signals over Japan at 05:52-05:56 UT on March 11, 2011 (about 5' 42" after the main shock onset the M9.0 earthquake) was reported. The 100-s LF periodic oscillation was caused by the vertical propagation of the acoustic waves excited by the seismic Rayleigh waves. Tohoku University group is also operating LF/VLF transmitter observation at Ny-Alesund (Norway), Poker Flat (Alaska), Athabasca (Canada), Zhigansk (Russia) to detect energetic electron precipitation from inner magnetosphere. These observations are a part of the ground-based observation networks for the ERG satellite launched on December 20, 2016.

Airglow imagers

ISEE, Nagoya University is conducting the Optical Mesosphere Thermosphere Imagers (OMTI) in order to investigate the dynamics of the upper atmosphere through nocturnal airglow emissions. The network is expanding now and reaches more than 20 stations from the equatorial to the polar regions. Installation of new instruments during this period was, an imager at Haleakala, Hawaii (March 2013), an imager at Ishigaki (later Yonaguni) (April 2014), an imager at Abuja, Nigeriea (June 2015) and an imager at Eureka, Canada (October 2015). Just recently they also expand the network in northern subauroral region.

OMTI web: http://stdb2.isee.nagoya-u.ac.jp/omti/

SEALION

SEALION is an ionospheric observation network in Southeast Asia. It has been conducted by National Institute of Information and Communications Technology (NICT) since 2003 for the purpose of monitoring and forecasting equatorial ionospheric disturbances, especially plasma bubbles. SEALION is a unique ionospheric observation network in having the conjugate observational points in the northern and southern hemispheres and around the magnetic equator. The network consists 7 stations in five countries, which are, Chiang Mai (CMU), Bangkok (KMI), Chumphon (CPN), and Phuket (PKT) in Thailand, Kototabang (KTB) in Indonesia, Bac Lieu (BCL) in Vietnam, and Cebu (CEB) in Philippines. Observations are FMCW ionosonde, GPS-TEC, GPS-Scintillation, and Magnetometer.

SEALION data web: http://seg-web.nict.go.jp/sealion/

Planetary atmospheres

Tohoku University and other groups carried out campaign-based large telescope observations of planetary atmosphere and ionosphere. Using Subaru/COMICS and IRCS and NASA IRTF/CSHELL, they reported Jupiter's infrared aurora and Venus's cloud characteristics measured by mid-infrared wavelengths (Kasaba et al., 2014, Uno et al., 2014; Sato et al, 2014). They are also operating a 40-cm telescope facility and a sodium monochromatic imager at the summit of Haleakala, Hawaii to monitor variations in planetary atmosphere, its surrounding faint gas and its satellite, such as Jupiter's Io torus and Io's volcanism, for more than ten years since 2006 (Yoneda et al., 2014, 2015). They are also operating the large radio telescope (IPRT) at Iitate, Fukushima, and some HF antennas to measure planetary and solar radio emission (Kaneda et al., 2015; Morioka et al., 2015). Spacecraft data were also used to understand Martian atmosphere, for example, MGS (Noguchi et al., 2014), Mars Express (Aoki et al., 2014, 2015a, 2015b), and MAVEN (Yigit et al., 2015, Medvedev et al., 2016). Modeling study was used to understand Jupiter's atmosphere (Kuroda et al. 2014) and gravity waves in Martian atmosphere (Haider et al., 2015; Kuroda et al., 2015, 2016).

Haleakala long-term monitoring data web: http://pparc.gp.tohoku.ac.jp/data/hal

IPRT data center web: http://pparc.gp.tohoku.ac.jp/data/iprt/

HF antenna system web: http://ariel.gp.tohoku.ac.jp/jupiter/

G1.7 GNSS receiver network

GEONET (GNSS Earth Observation Network System) is the GPS receiver network over Japan that is operated by Geospatial Information Authority of Japan (GSI). GEONET consists of 1,300 GPS or more stations. This is one of the largest GNSS network of the world, and the data of every 30s is opened to the public. GENET web page (in Japanese) is, http://terras.gsi.go.jp/geo_info/geonet_top.html

GEONET is used for the ionospheric study very much. It is well known that Tohoku Earthquake on March 11, 2011 induced intense ionospheric disturbances, and were clearly observed as fluctuation of GPS total electron content (TEC). Two-dimensional TEC maps over Japan have been provided routinely by NICT (http://seg-web.nict.go.jp/GPS/DRAWING-TEC/). One of the prominent research topic related to GEONET is the real-time three-dimensional ionospheric tomography. This tomography technique uses the constrained least-squares fitting to reconstruct the electron density distributions. Recently Saito et al. (2016) further development of the software system enabled to conduct the tomography analysis in the near real-time basis. They show results of the 3D tomography reconstruction of the ionosphere every 15 minutes with 6 minutes latency at the following web page: http://www.enri.go.jp/cnspub/tomo3/

More application-oriented study is also important with the GNSS use for the ionosphere. ENRI is leading activities to characterize the spatial gradient in ionospheric TEC for aviation use of GNSS in a framework of ICAO (International Civil Aviation Organization) Asia-Pacific region. Ionospheric TEC gradient data from States/Administrations in the Asia-Pacific region are being consolidated to develop a “threat model” for the ground-based augmentation system (GBAS) to enable precise approach guidance for airplanes.

G1.8 Satellite missions

During the period of 2014-2016, there are several satellite missions conducted by JAXA, and used for the studies of the ionosphere, magnetosphere and planetary sciences.

IMAP/VISI

Airglow emissions at the lower-thermosphere (O2 762 nm, 95km alt.) and the upper-thermosphere (O 630 nm, 250 km alt.) are measured with IMAP/VISI on the international space station (ISS) (Akiya et al., 2014). Many concentric gravity wave events in the O2 emission, and equatorial anomaly and plasma bubbles in O630 nm emission (Perwitasari et al., 2015; Perwitasari et al., 2016). Unfortunately, operation of ISS IMAP/VISI was terminated by August 2015. Researchers continue analyzing the data from the facility.

IMAP/VISI project web: https://www.iss-imap.org/

AKATSUKI

AKATSUKI, also known as the Venus Climate Orbiter (VCO) and Planet-C, is a Japanese (JAXA) space probe tasked to study the atmosphere of Venus (Sato et al., 2014, 2015). It was launched aboard an H-IIA 202 rocket on 20 May 2010. The spacecraft was successfully inserted into the Venus’ orbit by the thrust ejection operation on December 7, 2015 (Nakamura et al., 2016). After checking condition of the on-board instruments, scientific observations started in April 2016, and data analyses are now underway (Ando et al, 2016; Sato et al, 2016).

AKATSUKI mission web: http://www.isas.ac.jp/en/missions/spacecraft/current/akatsuki.html

HISAKI

HISAKI, also known as the Spectroscopic Planet Observatory for Recognition of Interaction of Atmosphere (SPRINT-A), is a Japanese ultraviolet astronomy satellite operated by JAXA (Yamazaki et al., 2014). The first mission of the JAXA’s Small Scientific Satellite program was launched in September 2013 on the maiden flight of the Epsilon rocket. HISAKI carries an extreme ultraviolet spectrometer which will be used to study the composition of the atmospheres and the behavior of the magnetospheres of the planets of the Solar System, such as Jupiter (Yoshioka et al., 2014; Yoshikawa et al., 2014, Tao et al., 2016a, 2016b; Kita et al., 2016; Tsuchiya et al., 2015; Murakami et al., 2016) and Venus (Masunaga et al., 2015). Campaign-based collaboration with coordinated satellite measurements between Hisaki and Chandra, XMM-newton, and Hubble Space Telescope were carried out (Kimura et al, 2015, 2016; Badman et al., 2016; Gray et al., 2016; Tao et al., 2016a, 2016b).

HISAKI mission web: http://www.isas.ac.jp/en/missions/spacecraft/current/hisaki.html

ARASE

ARASE, also known as Exploration of energization and Radiation in Geospace (ERG), is a scientific satellite to study the Van Allen belts. It was developed by the Institute of Space and Astronautical Science of JAXA. ARASE was launched aboard Epsilon launch vehicle at 11:00:00, 20 December 2016 UTC into apogee height 32250 km, perigee 214 km orbit. Subsequent perigee-up operation moved its orbit to apogee 32110 km, perigee 460 km of 565 minutes period (Kasahara et al., 2016). After initial checking for satellite and on-board instruments, JAXA confirmed that every function is working well. Nominal operation has been started in March 2017, and data analyses and opening are now underway (Kitahara, 2016).

ARASE mission web: http://www.isas.ac.jp/en/missions/spacecraft/current/erg.html

G1.9 Sounding rocket experiments

Japanese sounding rockets have been used to achieve in-situ measurements in the thermosphere and ionosphere as well as other objectives such as microgravity experiment, demonstration of various instrument and technique, and advanced engineering experiments. In the years of 2014-2016, two rocket experiments aiming at the ionospheric study were conducted in Japan.

JAXA Sounding Rockets web: http://global.jaxa.jp/projects/rockets/s_rockets/

In August 2014, "S-520-29" sounding rocket experiment was conducted to elucidate three-dimensional plasma density structure of the sporadic E (Es) layer by using three complemental instruments; optical imager, radio-wave receiver, and probe for in-situ measurement. Among the onboard instruments, Fast Langmuir Probe (FLP) successfully measured the electron density and temperature with high time resolution along the rocket trajectory, and those data were used to understand the detailed structure of electron temperature inside the Es layer. The result shows that the electron temperature gradually decreases by about 200 K from the outside boundary to the center. Numerical study on the cause of the temperature decrease was made to find the responsible process.

JAXA Press Release: http://global.jaxa.jp/press/2014/08/20140817_s-520-29.html

In Jan 2016, sounding rocket "S-310-44" equipped with five science instruments was launched from Uchinoura Space Center to elucidate a mechanism of the ionospheric electron heating in the Sq current focus. Data from the FLP onboard the rocket suggest that the electron temperature increased by about 200 K with respect to the background in the altitude range from 100 to 110 km. It is also significant that the observed energy distribution unlikely seems Maxwellian distribution and sometimes exhibits a possible existence of non-Maxwellian component in the high electron temperature region. Electron current measured by the fixed bias probe and power spectrum from HF plasma wave receiver indicate that the amplitude in the frequency range of several hundred Hz significantly increased at the E region altitude. It is remarkable that the strong electron density perturbation was observed in the broad frequency range from several 100 Hz to 2 kHz at altitudes from 95 to 110 km.

JAXA Press Release: http://global.jaxa.jp/press/2016/01/20160115_s-310-44.html

G1.10 Instruments for planetary sciences

One of the important research trend during the period 2014-2016 is the enhancement of planetary sciences. Now Japan operates two spacecrafts HISAKI and AKATSUKI for this purpose. Also, researchers are using number of telescopes on the ground. JAXA recently started the future Mars Moon exploration project (MMX), which is going to observe Phobos, Deimos and Martian atmosphere, and some groups are joining in the core teams for science and instruments. Hokkaido University operates 1.6m Pirka Telescope that is dedicated for observations of planets (http://sana.ep.sci.hokudai.ac.jp/nayoro/index-en.html) (Nakao et al., 2014). This telescope joins "Optical and Infrared Synergetic Telescope for Education and Research (OISTER)" that networks telescopes of seven universities and National Astronomical Observatory of Japan (NAOJ) (Project web page: http://oister.oao.nao.ac.jp/ (in Japanese)). Tohoku University also plays an important role to study planets from the ground-based telescope. They were operating a 60-cm telescope dedicated for planetary observations at Iitate, Fukushima. Unfortunately, the site use was largely limited because of the nuclear power-plant accident caused by the Tohoku Earthquake in 2011. The facility was then relocated to Haleakala in Hawaii in 2014(http://pparc.gp.tohoku.ac.jp/index-en.html). Visible chronagpraph imager, mid- and high-resolusion Echellle spectrograph (Visp), and super-high resolution heterodyne spectrograph are installed on T60 (Sakanoi et al., 2014). They are also developing a near-infrared imager and Echelle spectrograph. Nakagawa et al. (2016) reports results for Venus atmosphere from this facility after relocation. As shown in the later section (G3.2), the research group is developing a larger facility in the same location. The study of the planetary atmosphere is a hot topic in the research field. More data from Japanese satellites and ground-based telescopes are now expected.

G2. Model and database

G2.1 GAIA

The demand for quantitative predictions of the situation in the upper atmospheric region has increased, along with brisker human activities in space in recent years. And in conjunction with the effects stemming from human activities, it has become more important to understand the long-term process of atmospheric variations. Thus, the development of a global atmospheric model is considered beneficial for such demand in the future. In the field of academic research on the upper atmosphere, however, the coupling to the lower atmosphere has been an essential issue. Evidence regarding the interrelationship between ionospheric and tropospheric variations has been consistently reported based on recent observations using satellites and ground-based radars. A model applicable to the entire atmospheric region is thus needed to understand such vertical coupling from the troposphere through the ionosphere, as variations propagating across regions with different characteristics and complex dynamics must be handled.

The GAIA project combines atmospheric and ionospheric models (developed separately thus far), and targets the development of a simulation model for the whole global atmosphere. Upon being realized, this model will provide a powerful means of studying and solving such upper atmosphere issues as the vertical coupling in the Earth's atmosphere. This project is also aimed at reproducing actual upper atmospheric variations by assimilating observation data into the GAIA model.

Recent achievements with the GAIA model are studies of the sudden stratospheric warming (Pedatella et al., 2014; 2016; Liu et al, 2014; Miyoshi et al, 2015), global distribution of gravity waves in the thermosphere (Miyoshi et al, 2014), and Weddell Sea Anomaly simulations (Chang et al, 2015).

GAIA project web: http://seg-web.nict.go.jp/GAIA/index_e.html

G2.2 IUGONET

Global phenomena observed in the Earth's upper atmosphere are the results of many complex processes, such as the energy and momentum input from the Sun (e.g., solar radiation and solar wind), the energy and momentum transport by atmospheric waves from the lower atmosphere, and various internal phenomena (e.g., electromagnetic energy transport, plasma convection, chemical reaction). To understand the mechanism of the long-term variation in the upper atmosphere, therefore, it is important to analyze various data (e.g., wind velocity and temperature in the atmosphere, auroral images, geomagnetic field, solar activity index, etc.) obtained by the global ground-based network observation.

The Inter-university Upper atmosphere Global Observation NETwork (IUGONET) project started in 2009 (Abe et al., 2014; Yatagai et al., 2014, 2015). The objective of the project is to establish a metadata database of various ground-based observation data covering a wide region from the Sun to the Earth; this will encourage more studies on the mechanisms of long-term variations in the upper atmosphere. Also, they developped a software to ease comparison between various types of systems. IUGONET would be important for future study of complicated nature of the ionosphere.

Project web: http://www.iugonet.org/?lang=en.

G3. On-going and future plans

G3.1 Masterplan / Roadmap 2014 and 2017

Research Institute for Sustainable Humanosphere (RISH), Kyoto University, National Institute of Polar Research (NIPR), Institute for Space-Earth Environmental Research (ISEE), Nagoya University, and International Center for Space Weather Science and Education (ICSWSE), Kyushu University proposed the research project "Coupling process in the solar-terrestrial system" to Masterplan 2017 of Science Council of Japan. This is a project to study the solar energy inputs into the Earth, and the response of Geospace (magnetosphere, ionosphere and atmosphere) to the energy input. We plan to install large atmospheric radars with active phased array antenna at the equator and the Arctic regions. One is Equatorial MU (EMU) radar by RISH in Sumatera Island, Indonesia, and the other is EISCAT_3D by NIPR in northern Scandinavia under international collaborations. We develop the global observation network (ISEE, ICSWSE with other institutions). The participating institutions have already started budget request of their facilities. The same project was once proposed to Masterplan 2014, and was approved as one of 27 high-priority projects, and further approved as one of 11 new plans in the Roadmap 2014 of Ministry of Education, Culture, Sports, Science and Technology (MEXT). We continue to pursue realization of this research project.

Project web: http://www.rish.kyoto-u.ac.jp/masterplan2017/index-e.html

G3.2 Telescope PLANETS

"PLANETS" is a project to develop a new telescope dedicated to the planetary science by the international collaboration by University of Hawai'i Institute for Astronomy (IfA), Tohoku University, and the Kiepenheuer Institute for Solar Physics (KIS) and the National Autonomous Univesity of Mexico (UNAM). The telescope has a low-scattering optical system with a 1.8m-diameter off-axis main mirror to observe faint emission near a bright object, such as resonant/Rayleigh/Mie scattering surrounding a planet/satellite. Off-axis telescopes can have far superior contrast because there are no obstructions in the beam such as secondary mirror supports. This limits the diffraction as well as scattered light from obstructions. The telescope would also be highly polished to minimize diffuse scatter from mirror roughness - a major source of scattering at large angles. The project is now underway, and expects the first light in early 2018.

Project web: https://www.planets.life/planets-telescope/

G3.3 SMILES-2

The Effectiveness of highly sensitive submillimeter-wave limb sounder in vertical-distribution measurements of atmospheric chemical compositions, temperature, and wind over a wide altitude range has been demonstrated by the Superconducting Submillimeter-wave Limb-Emission Sounder (SMILES), which was operated in 2009-2010 winter on the International Space Station. A new proposal is being put out as SMILES-2, which is a satellite mission carrying submillimeter-wave limb sounder inherited from SMILES. When realized, SMILES-2 will provide precise measurement of vertical distribution of compositions, temperature, and wind, in an extend altitude by implementing multi-frequency band receiver including THz channel (Baron et al, 2015; Suzuki et al., 2015).

SMILES web: http://smiles.tksc.jaxa.jp/about/index_e.html

SMILES-2 conceptual design: https://repository.exst.jaxa.jp/dspace/handle/a-is/609876?locale=en

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