Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

U06-01 Room:105 Time:May 24 09:00-09:15

Evolution of New Seamless Science From Space, Sun to the Earth Surface: Observational studies of greenhouse gas species

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In order to understand the earth system as well as to solve global environmental problems, it is necessary to develop and to promote a science dealing with ”earth-life interactive system” as a holistic interacting system of space-sun-magnetosphere-atmosphere-hydrosphere-geosphere-biosphere. Through the seamless research among those disciplines, continuous nature of the boundaries and interactions between the disciplines has to be elucidated. Our research on the measurements of greenhouse gases related climate change and atmospheric environment will be also presented and future direction of the research will be discussed.

Keywords: Global warming, Greenhouse gas, Balloon-borne measurement, Carbon dioxide, Methane, Laser isotope spectrometer

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U06-02 Room:105 Time:May 24 09:15-09:35

Importance of integrated research on the Sun-Earth-Life Interactive System (SELIS)

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In the 20th century, the understanding of our planet earth was promoted through segmentalization and/or disaggregation of the complex earth system. However, large negative aspects of scientific activity have also emerged, e.g., global environmental issues, such as global warming, the ozone depletion issue, desertification, and the destruction of tropical rainforests. In the 21st century we must have a holistic view of the earth and environment, where we live, by integrating the physical, chemical and biological earth, of course, including human beings. I believe that the items one and two listed above are important for understanding the integrated seamless system of the earth. Based upon these ideas, we conducted the 21 century COE program titled ”The Sun-Earth-Life Interactive System (SELIS)” in the right direction, and that the role of the program has become important for promoting a more holistic approach of geosciences both in research and education. Through the SELIS-COE program, we became convinced of a necessity of the new paradigm for integrated understanding our planet earth, including human beings and the life. It is my great pleasure to hear that the Nagoya University is now going to set up a new research institute for SELIS. I do hope and believe that this new institute would lead study on SELIS both national-wide and internationally.

Keywords: Sun, Earth, Biosphere, Interaction, Earth system, Integrated research

Japan Geoscience Union Meeting 2015
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U06-03 Room:105 Time:May 24 09:35-09:55

Atmospheric chemical response to the changes in biological and solar activities

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The temporal and spatial distributions of atmospheric constituents, especially trace species, are related to air quality and climate system. The distribution of trace species in the atmosphere is controlled by the chemical processes, the emission and deposition and the transport from one region to another. Vegetation is the largest sources of reactive volatile organic compounds (VOCs) which are the precursors of photochemical ozone and organic aerosol in the troposphere. The increase in ozone and aerosol concentrations at the surface level would affect agricultural productivity, biogenic activities, and local/regional climate. On the other hand, ozone and aerosol budgets would be strongly influenced by human activities, e.g., agricultural and industrial activities. Furthermore, climate change affects vegetation and the emission rates of biogenic VOCs and emission which leads to change in the type and strength of biogenic volatile organic compounds' emission. It is therefore important to accelerate the joint-studies between biological and atmospheric science communities in order to improve the knowledge of the interrelation among biogenic activity, chemistry in the atmosphere, human activity, and climate.

Solar radiation, the heat source of Earth, is an important external factor to control and trigger chemical reactions in the atmosphere. For example, the production rates of stratospheric ozone are basically given as a function of the flux of solar radiation shorter than 240nm, which is much more sensitive to solar activity than the radiation in visible and IR region. Solar activity may also perturb the circulation field in the middle atmosphere. Therefore, the distribution of ozone in the middle atmosphere would be given as a complex function against the variation of solar activity. Solar activity change also influences on the amount of energetic charged particles which penetrate into the Earth's atmosphere. Solar energetic particle event is one of the examples and triggers many neutral and ionic reactions which results in the large changes in trace atmospheric species, e.g., total reactive nitrogen (NOy) and ozone concentrations in the middle atmosphere. The enhanced NOy and/or depleted ozone could be used as a tracer of the atmospheric motion. Not only transient phenomena but also long term variability of solar activity has an influence on Earth's environment. For example, one of the ideas concerning the interrelation between solar activity and climate is that the changes in the production rates of fine particles in response to the variation of solar activity would affect the solar energy reaching at the Earth's surface. However, in order to estimate the impact of solar activity changes on aerosol concentration, atmospheric chemical feedback should be considered because both the emissions of VOCs and chemical processes would also be influenced by the change in the solar flux and temperature. Environmental changes induced by solar/cosmic transient phenomena and/or long term variation of solar activity would be mediated through atmospheric processes and their information might be recorded into the ice core, soil, and biosphere. Information on interaction among sun-atmosphere-biosphere should be shared in order to understand the mechanisms how the atmospheric chemical processes response the change in solar activities and cosmic events.

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U06-04 Room:105 Time:May 24 09:55-10:15

Linkages in biogeochemical cycles between surface ocean and lower atmosphere

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Increase of the substances emitted to the atmosphere by human activities and global warming change the amount of land origin substances transporting to the ocean, and influence the marine ecosystems, such as the species and amount of marine organism. While carbon and nitrogen are taken up by marine organism, the amount of trace gases produced from marine organism may change. The release of marine biogenic gases into the atmosphere, the gases will be oxidized and converted to particles (aerosols). It is believed to modify the property and the amount of clouds and to change the lifetime of clouds and the reflection of the sunlight to the earth surface. I would like to introduce the research results revealed the seamless interaction between the atmosphere and the ocean through the marine biological activities.

Across these series of studies were carried out with the collaboration of the scientists from the various fields such as atmospheric chemistry, marine meteorology, marine chemistry, marine biology, and marine physics. As a study area, marine atmospheric boundary layer from the sea surface to the altitude of 2 km above and ocean surface water layer shallower than 200 m of euphotic zone were defined. The joint observation cruises by research vessels have been conducted in collaborative research issues, and it has been collaborated with the land-based atmospheric observations and satellite observations simultaneously.

In the subarctic region of the North Pacific Ocean, we were able to ascertain that atmospheric iron supply to the ocean as a natural phenomenon was observed during a Kosa event and enhanced marine biological activity by in-situ measurement of a research cruise. In addition the marine biological production increased by the supply of iron in the volcanic ash during the eruption in the Aleutian Islands and measured the increased trace gases productions caused by the marine organisms.

The measurement of volatile organic compounds in and over the Pacific Ocean, the gases released from the ocean was converted to organic aerosols in the marine atmosphere. In particular by the 2008 eruption of Kilauea volcano in the Hawaii Islands, production of aerosols over the central North Pacific increased the cloud coverage and the reduction of cloud droplet size by the observations. It strengthened the negative radiative forcing at sea, and the sea surface water temperature reduction was demonstrated. It clarified the possible presence of indirect effects on marine ecosystems.

By the development of direct measurement techniques on shipboard for aerosol generation and annihilation processes in marine atmosphere covering 70% of the Earth's surface, it becomes possible to obtain the important findings of the various processes of the air-sea interface.

On the other hand, by global warming, stratification of ocean surface water is enhanced and causes an increase in plankton to perform nitrogen fixation in the subtropical North Pacific. Atmospheric supply of substances is extremely important for control of plankton fate and species in this region. Based on the observation, vertical mixing of surface seawater by meteorological phenomena such as passage of low-pressure systems and typhoons enhanced the biological production, an incubation experiment of simulated mixing water by typhoon was carried out on shipboard. As a result, large size diatoms increased and it was suggested the possibility of efficient carbon transport into the deep ocean, and succeeded in quantification of its amounts by a model. These findings, changes in the marine structure due to climate change suggest that marine organism contributes for the change of the carbon cycle between the marine atmosphere and the marine ecosystem.

Keywords: biogeochemistry, material cycles between surface ocean and lower atmosphere, marine biogenic substances, atmospheric anthropogenic substances, marine ecosystem, IGBP/SOLAS

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U06-05 Room:105 Time:May 24 10:15-10:30

Observations and simulations of cloud ice and aerosol

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Cloud ice composing cirrus clouds and aerosol have large impacts on climate and weather by an interaction with radiation. They are one of the large uncertainties for the projections of the climate change. Upper layer cirrus clouds surrounding a typhoon strongly control the upper layer temperature around the typhoon. Consequently, their characteristics are related to typhoon intensity. So far, we have been using hydrometeor videozondes (HYVISs) to observe cloud particles in the upper troposphere. The HYVISs can observe cloud particles ranging from 10 micrometer to 1 mm. It shows size, shape and number concentration of cloud particles with high vertical resolution. We conducted field observations using HYVISs for various types of clouds associated with heavy rainfall systems and typhoons in Okinawa, Japan and Palau in the tropics. The observation results show characteristics of cloud particles and are used to improve the cloud processes in a cloud-resolving model.

To perform simulations and numerical experiments of high-impact weather systems such as heavy rainfall systems and typhoons, and convective/stratiform clouds, we have been developing a cloud-resolving numerical model named the Cloud Resolving Storm Simulator (CReSS) since 1998. The cloud processes are important part of the CReSS model. Typhoons bring about strong wind and heavy rainfall occasionally and cause severe disasters in East Asia. The recent studies projected future increase of typhoon intensity with the climate change (Tsuboki et al. 2015). Accurate predictions of typhoon intensity and the associated rainfall are important for disaster prevention. A recent statistics of the typhoon prediction accuracy showed that typhoon track prediction has been significantly improved, while intensity prediction has not for the last 20 years. Since the inner core of typhoon is composed of intense convective clouds, cloud-resolving simulation at a high-resolution (less than 2 km in a horizontal direction) is essentially required for accurate prediction of typhoon intensity. We apply CReSS for simulations of observed typhoons and for projection experiments of future change of typhoons associated with the climate change.

The CReSS model was designed for a large parallel computer and performed simulation experiments at the Earth Simulator and the Kei Computer. It is a non-hydrostatic and compressible equation model using terrain-following coordinates. Prognostic variables are 3-dimensional velocity components, perturbations of pressure and potential temperature, water vapor mixing ratio, sub-grid scale turbulent kinetic energy (TKE), and cloud physical variables. Cloud physical processes are formulated by a bulk method of cold rain. The bulk parameterization of cold rain includes mixing ratio of water vapor, rain, cloud, ice, snow, and graupel and number concentrations of solid hydrometeors. Parallel processing is performed using the Massage Passing Interface (MPI). The OpenMP is also available for intra-node communications. More detailed explanations are found in Tsuboki and Sakakiara (2002) and Tsuboki (2008). To investigate the interaction of aerosol and cloud particles, it is necessary to install more detailed nucleation processes for liquid cloud and ice crystals. These are future subjects in this field.

Keywords: cloud ice, aerosol, cloud resolving model, typhoon, hydrometeor videosondes (HYVISs)

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U06-06 Room:105 Time:May 24 10:30-10:45

Prospects of Interdisciplinary Research for Solar Influence on Climate

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Solar magnetic (sunspot) activity is one of the factors that vary the climate of the Earth. The variation of solar magnetic activity consists of the so-called 11-year cycle (solar cycle) and the long-term variation, which is recorded in cosmogenic isotopes (14C and 10Be) contained in tree-rings and the ice core in Antarctica and Greenland. The long-term variations of the Sun are believed to be caused by the dynamo mechanism, which periodically reverses the magnetic polarity of polar regions and sunspots in each solar cycle. On the other hand, it has also been observed that there is a certain correlation between the long-term variation of the solar activity and global climate change. In particular, the medieval warm period that lasted from approximately the 10th century to the 14th century, and the Little Ice Age, which lasted until the mid-19th century from the 14th century, respectively correspond to the active age and the quiet era (Grand Minima) of solar activity. It suggests that the global climate is likely to have received some influence from the Sun. Several different mechanisms of solar influence on climate have been proposed; for instance, the variability of solar irradiance, the impact on clouds of galactic cosmic rays, and the chemical influence of high-energy particle precipitated into upper atmosphere. However, the detail mechanism is not elucidated yet. The current solar cycle (cycle 24) is likely to be the quietest cycle in the past 100 years. Some possibility is pointed out that the solar activity is further reduced, and a new ground minimum will start during the 21 century. Therefore, the understanding of solar influence on climate is an extremely important issue in order to improve the predictive reliability of global climate change in future. In order to solve this important issue, the point of view of seamless science, which holistically investigates the Space-Sun-Earth system, is needed. To establish that, the interdisciplinary study of astrophysics, solar physics, geo-space science, meteorology, climatology, and paleoclimatology plays an important role. In this presentation, we discuss about the important issues for the solar influence on climate, and introduce the new project planned in Nagoya University to solve them by the collaboration of Solar-Terrestrial Environment Laboratory, Hydrospheric Atmospheric Research Center, and Center for Chronological Research.

Keywords: climate change, solar activity, dynamo, interdisciplinary research, the Little Ice Age

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U06-07 Room:105 Time:May 24 11:00-11:20

Toward a new seamless science for a detection of terrestrial ecosystem responses under changing climate

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Global warming caused by human-induced greenhouse gas emissions has impacts on atmospheric, oceanic, and terrestrial carbon cycles, and on ecosystem processes in various time scales. If the earth's ecosystem has a global effect of negative feedback to climate change, it means that the ecosystem has a function to stabilize the earth system by providing increasing sinks. If there is a positive feedback that accelerate global warming, such process should be monitored, evaluated, and mitigated. Examples of negative feedback in terrestrial ecosystems are a fertilization effect of plants under higher atmospheric CO_2 concentration, and an increased productivity and reproductive success under warmer environment and longer growing season length. A potential positive feedbacks is an accelerating greenhouse gas emission from permafrost.

Studies on ecosystem change in the global and continental scales have been conducted using satellite remote sensing and ecosystem process models to bring meaningful predictions and suggestions. Now more reliable verification of such predictions and direct detections of actual changes in ecosystems are required based on long-term ground observations. A major difficulty is that it needs a very long-term, highly comprehensive, and consistent monitoring that covers productivity, decomposition, nutrient cycle, plant invasion, changes in species composition, succession, etc.

In this presentation, recent studies on global warming effects in terrestrial ecosystems will be reviewed, and progress on carbon budget estimations based on integrated observing and analysis systems are introduced. In particular, such projects as "The US National Ecological Observatory Network" (NEON; http://www.neoninc.org/) and "Integrated Carbon Observation System" (ICOS; http://www.icos-infrastructure.eu/) in Europe are introduced to discuss future needs of long-term, consistent, and operational ecosystem monitoring to detect changes in ecosystems and biogeochemical cycles due to climate change.

Keywords: Carbon cycle, Global warming, Terrestrial ecosystem, Global monitoring

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U06-08 Room:105 Time:May 24 11:20-11:40

Recent achievements and future perspectives of paleoenvironmental studies

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Recent progress in geochemical analysis enables reconstruction of a variety of environments using sediment as well as biogenic skeleton/shells. The reconstructed environments range from local conditions such as temperature, salinity and pH to global phenomena including frequency and intensity of El Nino and southern oscillation (ENSO), Indian Ocean Dipole (IOD), and Pacific Decadal Oscillation (PDO). An extraterrestrial effect (solar activity) to earth's climate and ecosystem can be delineated as well. It is possible to detect artificial environmental changes such as the shifts in carbon isotope composition in oceans owing to anthropogenic activities and the spreading of radioactive elements created atmospheric nuclear weapons testing. These indicate that the paleoenvironmental studies using biogenic skeleton/shells and sediment is typical of seamless science. This presentation overviews recent achievements and future perspectives of the paleoenvironmental studies.

Keywords: Paleoenvironment, sediment, skeleton, shell

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U06-09 Room:105 Time:May 24 11:40-12:00

Potential of luminescence dating

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Many kinds of natural phenomena such as radioactive decay and fission of nuclei, solid surface phenomena and chemical changes of organic compounds etc. are applied to radiometric dating and the other various dating methods. Luminescence dating is a technique using light emission from quartz when it is excited by heat or radiant energy. The phenomena applied in CHIME and C14 methods are not influenced by the change of environmental condition, but luminescence and ESR (electron spin resonance) which are surface phenomenon of solids and racemization of amino acid method which measures the rate of chemical reaction are sometimes affected by the changes of circumstances such as temperature and moisture. Under the circumstance at normal temperature under normal pressure, luminescence dating covers the age from several tens years to several hundred thousands years ago and even a million yeas ago in an ideal condition.

The phenomenon of quartz luminescence is the result of the radiation acting on its lattice defects formed by radiation or impurity elements. Meta-stable hole and electron pairs in crystal defects are stimulated by heat or light energy and recombined resulting light emission or luminescence. The crystal defects are created by secondary cosmic rays and radiations from natural radioactive nuclides, thus the number of them and the intensity of luminescence have increased for a function of time from the quartz crystallization. It is the same in the luminescence from the crystal defects caused by impurity elements.

When quartz is heated by volcanic eruption or artificial heating or exposed to light, the holes and electrons in its lattice defects recombine and result in light emission, and the number of them reduces to the initial state (zeroing). The luminescence age give the time elapsed from the zeroing. The luminescence dating technique covers the latter half of quaternary period or human period, and determines the natural events such as volcanic eruption, tsunami and dune formation which influence the human life, and artificial one such as open-air fire and pottery making.

The luminescence ages of several palaeolothic sites and the comparison of them with ages obtained by the other dating techniques will be shown at the session.

Keywords: luminescence, dating, radiation, quartz, human period, artificial event

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U06-10 Room:105 Time:May 24 12:00-12:20

Reconstruction of global electric circuit model and investigation of solar-climate connection

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Global electric circuit, GEC, model was proposed log time ago, around 1930s, in which thunderstorm plays a role of generator, and the ground and the ionosphere work as a spherical capacitor. However, the both qualitative and quantitative understanding of GEC is not sufficient only with oversimplified model. Recently the research on the solar-climate connection is becoming the significant issue in the climate study. The GEC is one of the important concept that potentially could take a role in modulating the Earth climate. We insist on the reconstruct of GEC from two points of views: 1) taking into account the nonuniformities both of ionospheric conductivity and of the distribution of the generators, and 2) establishing the observational methodology, excluding the effect of cloud existing just above the observation sites.

Keywords: global circuit, solar-climate connection

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U06-11 Room:105 Time:May 24 12:20-12:40

The importance of tropospheric water vapor in space weather

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Space weather events are the electro-magnetic disturbance on the vicinity of the Earth mainly originated by the solar activity. Recently the influence of space weather events has been discussed in various fields. Many scientists have been discussing the mechanism of space weather phenomena, and in addition that, some industry people started the discussion of the influences of space weather to social infrastructure, for example telecommunication, broadcast, satellite positioning, air navigation, and electric supply.

On the view of users, the scale and duration of influence is more important than the mechanism of the influence. To reply these user's requirement, the scientists should consider whole system from the Sun to the Earth's ground. For example, the largest error factor of satellite positioning is the delay in the ionosphere, however, the effect of water vapor in the troposphere is not negligible. This effect is applied to "GPS meteorology" to discuss the global distribution of water vapor. The information is useful to improve our developing atmosphere-ionosphere coupling model "GAIA".

In addition, the millimeter wave frequency has been frequently used recently, which is influenced by water vapor in the air. When we consider the total use of radio wave, it is important to consider the tropospheric condition.

It is expected to discuss the merit of consideration of the effect of water vapor in the troposphere in this talk.

Keywords: space weather

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U06-12 Room:105 Time:May 24 14:15-14:35

SCOSTEP Activities toward a Better Understanding of Sun-Earth Connection

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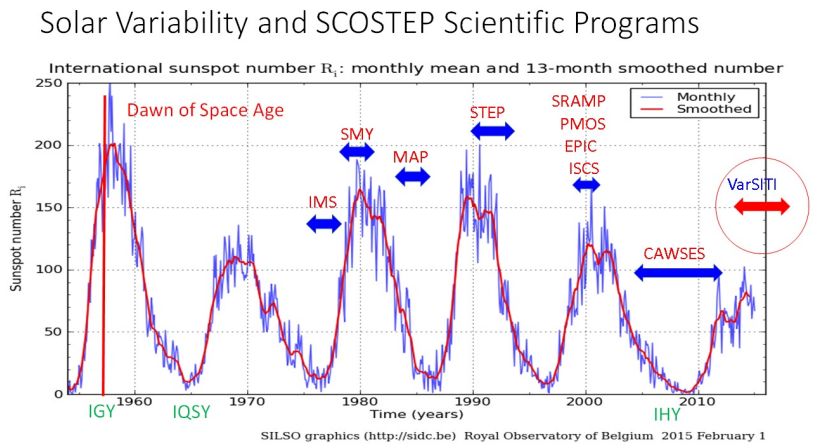
The Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) was established in 1966 as an interdisciplinary body of ICSU, the International Council for Science. SCOSTEP is tasked with running long-term scientific programs in Solar Terrestrial Physics, a topic closely related to life on Earth. In addition to running the scientific programs, SCOSTEP is heavily invested in Capacity Building and in Public Outreach. During the quadrennial solar terrestrial physics symposia, scientific highlights from the ongoing scientific programs are presented and plans are made to publish scientific results to the world scientific community. SCOSTEP collaborates with other efforts such as the International Space Weather Initiative (ISWI) in running Space Science Schools. SCOSTEP is a Permanent Observer to the United Nations Committee on Peaceful Uses of Outer Space (UNCOPUOS), which is used as a forum to disseminate SCOSTEP activities to the member countries. In particular, SCOSTEP participates in the deliberations of the Science and Technology Subcommittee of UNCOPUOS under the Space Weather Agenda. This talk will focus on some of the recent SCOSTEP scientific programs and the associated activities that have helped spur research in solar terrestrial physics.

Keywords: SCOSTEP, Solar Terrestrial Physics, International Cooperation, Capacity Building, Public Outreach, Sun-Earth Connection



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U06-13 Room:105 Time:May 24 14:35-14:55

Coupling processes in the Solar-Terrestrial System

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Coupling process in the solar-terrestrial system" aims to study the solar energy inputs into the Earth, and the response of Geospace (magnetosphere, ionosphere and middle atmosphere) to the energy input. The solar energy can mainly be divided into two parts - the solar radiation involving infra-red, visible, ultra-violet and X-ray, and solar wind which is a high-speed flow of plasma particles. The solar radiation becomes maximum at the equator; and atmospheric disturbances are actively generated near the Earth's surface. They further excite various types of atmospheric waves which propagate upward carrying energy and momentum. On the other hand, the energy associated with the solar wind converges into the polar regions where disturbances are generated. A part of the energy is transported toward lower latitudes and lower atmospheric regions. We propose to establish large atmospheric radars with active phased array antenna at the equator and the Arctic region. Among the equatorial regions, we focus on the Indonesian region where atmospheric disturbances are most intense. We will establish a comprehensive observatory in Indonesia with the Equatorial MU (EMU) radar as its main facility. Alongside, we will take part in the construction of the state-of-the-art radar, called EISCAT_3D, in northern Scandinavia under international collaborations. We will also develop the global observation network of portable equipment from the equator to both polar regions, and study the flow of the energy and materials in the whole atmosphere.

Keywords: solar-terrestrial system, coupling process, Equatorial MU radar, EISCAT_3D radar, Global network, IUGONET

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U06-14 Room:105 Time:May 24 14:55-15:15

Importance of water vapor in vertical coupling of atmosphere

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Water and water vapor in the earth’s atmosphere is mostly confined in the troposphere. Furthermore, the scale height of water vapor density in the troposphere is much smaller than the scale height of the atmosphere and the major part is existent around the ground level. However, the water vapor is raised to near the tropopause easily by convections and releases latent heat there. This acts as a very important heat source to derive large scale atmospheric waves and induces strong vertical coupling in the earth’s atmosphere from the ground to the upper atmosphere and the ionosphere. This paper will describe the importance of such latent heat transfer by the water in the atmospheric dynamics.

Keywords: Nagoya, Sun, Earth, environment, water vapor, coupling

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U06-15 Room:105 Time:May 24 15:15-15:35

ICSWSE and the New STEL: collaboration and cooperation in the future

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Over the years, ICSWSE (=International Center for Space Weather Science and Education) has been successfully collaborating with STEL in building and operating the world largest ground magnetometer network, MAGDAS/CPMN (MAGnetic Data Acquisition System/Circum-pan Pacific Magnetometer Network). Furthermore, ICSWSE and STEL have been working together to play the leading role for capacity building activities in Asia and African regions. In this presentation we will discuss how we can continue and what we can expect from the collaborating and cooperating efforts by the ICSWSE and the new STEL.

Keywords: space weather, capacity building

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U06-16 Room:105 Time:May 24 15:35-15:55

High-latitude ionospheric phenomena requiring a better understanding of the coupling to the magnetosphere/thermosphere

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Various phenomena in the high-latitude ionosphere are coupled to the dynamics in the magnetosphere or thermosphere, and for some of those phenomena the coupling process has been well understood. However, there are still phenomena that require a much better understanding of the coupling. Those phenomena are discussed on the basis of the recent observations from a high-sensitivity all-sky imager at Svalbard, the EISCAT radar, and multi-spacecraft.

Keywords: high-latitude ionosphere, magnetosphere, thermosphere

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U06-17 Room:105 Time:May 24 16:15-16:35

Interdisciplinary study of space plasma waves in solar terrestrial environments

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Waves in space plasmas play important roles in dynamics variation of the Earth's radiation belts. Whistler-mode chorus emissions excited by several tens of keV electrons can acceleration a small fraction of the energetic electrons to MeV energy range, contributing to formation of radiation belts. Electromagnetic ion cyclotron (EMIC) rising-tone emissions, on the other hand, can scatter relativistic electrons effectively, and induce precipitation into the polar atmosphere. The precipitated MeV electrons can penetrate deep into the middle atmosphere, and they may affect the atmospheric chemistry. Thus these nonlinear plasma wave emissions in the magnetosphere connect the variation of solar activity and that of the atmospheric compositions. The variations in the past could also be detected in ice core samples. The ERG satellite for observation of wave-particle interactions in geospace is being developed under close collaboration of the STE laboratory and other research institutes and universities. Through the reorganization of the related research institute at Nagoya University, we expect promotion of the interdisciplinary studies related to the radiation belts and relativistic electron precipitation into the atmosphere.

Keywords: plasma waves, magnetosphere, radiation belts, relativistic electrons, middle atmosphere, nonlinear process

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U06-18 Room:105 Time:May 24 16:35-16:55

Future Perspective on Solar-Terrestrial Science

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In the field of solar-terrestrial science, the forefront researches and education of the structure and dynamics of Sun, Earth, and their interplanetary space are being conducted by the Solar-Terrestrial Environment Laboratory (STEL), Nagoya University, as well as other research universities and institutes. These researches and education, in general, include two aspects in science: one is the applied science to solve the environment problems in our life, and the other is the fundamental science to reveal the mechanism of the system of the solar-terrestrial relationship. The final goal of the former science pursuing the environment problem and of the latter science focusing on the fundamental physics would be same, but their approaches toward the goal do not seem to be necessarily same. The different approaches may bear a subtle difference of science strategy and philosophy. After summarizing the accomplishment of STEL in the research area of the solar-terrestrial science, a future perspective of the solar-terrestrial science will be stated.

Keywords: Solar-Terrestrial Science, Future Perspective

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U06-19 Room:105 Time:May 24 16:55-17:15

The direction of planetary environment sciences: Current and future activities of observational and modeling studies

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Study of planetary environment aims the comparative and systematic understanding of PLANETARY ATMOSPHERE, covering from terrestrial planets and satellites (Earth, Mars, Venus, Mercury, Europa/Ganymede, Enceladus/Titan, ...), outer planets (Jupiter, Saturn, ...), interplanetary space, to exoplanets.

All planets have their ATMOSPHERE. Here, the word ATMOSPHERE covers all altitude range from tropospheres, stratspheres, mesospheres, thermospheres, exospheres, to magnetospheres, which are physically and chemically connected to the planets. In lower altitude, neutral is major component, and affeted by the phenomena occured at the planetary surface and interior. In upper altitude, plasma is major, connecting to sun and interplanetary space and affected by them. Planetary gravity, temperature, history, sea/crustal activity, etc. produce different atomspheres. The various physics and chemical processes decide the planetary environment. It is like 'the major terrestrial environment problems are our atmospheric issues.'

Our studies are systematically promoted by the pioneering tool and method. The former includes new instruments and own groundbased facilities. The latter covers state of art numerical codes and analytical tools. Based on these activities, we can realize new space missions by JAXA and contribute to world-wide planetary explorations by other space agencies. It is the basis of long-standing research and education capabilities of our field with active international collaborations.

In last Feb, JAXA requested space science communities to submit the future target, strategy, and process document. Related to the planetary environment sciences, two visions are shown: One is Solar-Terrestrial-Planetary Environment Field (from Upper atmospheric science group of Society of Geomagnetism and Earth, Planetary and Space Sciences [SGEPSS]). The other is Planetary and Solar System Field (from Japanese Society of Planetary Sciences). Both documents are based on their recent long-term vision formed by long discussions, and include the reality of JAXA space missions in next two decades. It is the first version, and expected the revisions year by year.

This paper will discuss the parts related to the planetary environment sciences involved in both visions, and also involve the possible directions of ground-based and modeling activities. It is not realistic that our domestic community can cover whole related fields by our resources and limited launch and human resource capabilities. We need to find 'a better way' (it might not be the best, but), to enhance the strong core points and to enlarge the wings to wider fields. It means a kind of 'selection and concentration', but we should create the ambitious ships which can convey larger number of multi-field scientists and enhance the interaction between them. We try to draw an additional line for the discussion in the community.

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Solar Activity Cycles, Their Long-Term Variations, and the Earth's Environment

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The Sun affects the environment of the Earth in several ways, through electromagnetic radiation of diverse wavelengths, high energy particles, the solar wind and its variations including CMEs (coronal mass ejections), and so on. How short timescale events like solar flares and CMEs disturb the Earth environment is the topic of space weather research. Although detailed processes are complex and yet to be studied further, our understanding has advanced significantly in these decades, particularly by in situ observations with satellite-borne instruments. On the other hand, longer timescale variations in the Sun and their influence on the Earth environment are less well understood, partly because of longer timescales involved and smaller amplitudes in such variations. This paper considers such space climate research.

The idea of possible variations in total solar irradiance (TSI) and their relationship with climate change dates back to the 19th century. The Smithsonian Institution conducted an extensive program of measuring TSI from the ground (from high mountains) for more than 60 years starting at the beginning of the 20th century. They claimed solar cycle related change in TSI, but nowadays it is considered as due to incomplete compensation of atmospheric changes. The first conclusive evidence of solar cycle changes in TSI came from satellite-borne radiometers in the 1980s. The TSI changes in phase with the sunspot number, which was not a naive outcome from the darkness of sunspots. Now the enhancement in TSI during the sunspot cycle maximum is understood as due to numerous bright points (faculae), whose positive contributions to TSI overwhelm the negative contributions from sunspots.

Shorter wavelength radiations (UV and X-rays) change in larger amplitudes with the solar cycle; a few tens of percent in the UV and more than ten times in X-rays. Changes in UV are important in the photo-chemistry of the upper atmosphere of the Earth. Spectral irradiance in the UV was measured with satellite-borne radiometers since 1990s, but the measurements are difficult in maintaining the accuracy due to instrumental degradation.

Before 1980s there were no direct records of total or spectral irradiance variations. Therefore one makes use of proxies to investigate such changes. Optical imaging observations of the solar chromosphere in the H-alpha and Ca K lines might be utilized for this purpose. The longest data samples are those of Greenwich and Kodaikanal (India) since 1904. NAOJ has data from 1917 and they are all digitized. Radio emissions (F10.7 of Ottawa since 1947, four frequency radiometers of Toyokawa since 1951) and airglow data (since IGY) can also be utilized.

The solar cycle is believed to be maintained by the so-called MHD dynamo process. Solar internal rotation derived from helioseismology, and numerical simulation of fluid motions in the Sun's convection zone have greatly advanced our understanding of the dynamo process. Observationally the data available were limited to sunspots (since 1610) and magnetic flux distributions measured with magnetographs (since 1950s). Starting 1980s the magnetic field vectors in active regions have been measured and led to the hemispheric sign rule of magnetic helicity; negative helicity in the northern hemisphere and positive helicity in the southern hemisphere (although with large dispersion). This property gives a crucial constraint on the so-called alpha-mechanism in the dynamo. Recently we claimed (Hagino and Sakurai, 2005) that the hemispheric sign rule of helicity tends to be violated near sunspot activity minimum, and its implication on the dynamo process and on the amplitude of the forthcoming activity cycles will be discussed.

Keywords: Sun, sunspots, solar cycle, total solar irradiance, dynamo mechanism, magnetic field observation

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On the new solar-terrestrial institute

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Without the Sun, it is impossible for the Earth to harbor present life-friendly environment. A highly-developed civilization occasionally suffers from large solar flares. With Kepler data, Shibata et al. indicated that Sun-like stars are prone to produce super flares, significantly affecting our life and civilization on Earth, and estimated the non-negligible probability of such events. For the purpose of flare forecast, multiple countries including Japan are committed to space weather forecast. Indeed, Japan has launched 3 excellent solar observation satellites Hinotori, Yohkoh and Hinode, and contributed to develop a forecast algorithm as represented in the research by Kusano et al.

On another front, in a longer time scale, recent studies show that solar variation, typified by increase and decrease of sunspots, can impact the Earth's climate in significant ways. There is a record of global cooling during the Maunder Minimum occurred between 1645 and 1715 when very few sunspots were observed. Furthermore, measuring the captured isotopes in tree rings and ice cores from the polar zone can presume the number of sunspots in pre-telescopic era. This shows that Maunder Minimum-like episodes have occurred more than several times in past 10,000 years, and it is certain that there was decrease in the ocean temperature during the period. Today, it is established that solar variation has a significant effect on terrestrial climate.

It was as early as 1970's when solar observations in space revealed the surprising fact that the solar constant (the total radiation energy received from the Sun per unit of time per unit of area), which was considered to be unchanging, is actually changing by 0.15%. The Sun is slightly brighter at the time of solar maximum where large number of sunspots appears, and it is slightly darker at solar minimum where sunspots diminish. This variance in irradiance is caused by subtle balance between dark sunspots and accompanying bright faculae which consist of flux tube. Overall, the faculae brighten the Sun more than sunspots darken it, therefore the Sun is brighter when large number of sunspots appear. Variance in solar constant significantly correlate with terrestrial average temperature, and 0.1 % variance in irradiance induce approximately 0.12 degrees Celsius of change in temperature. Was the Sun darker during Maunder Minimum? If that is not the case, another mechanism is necessary to link solar variation and terrestrial climate.

Solar magnetic field is filled into interplanetary space, and it shields the Earth from cosmic radiation. When such shield is significant, the amount of cosmic radiation reaching the Earth decreases, and when the Sun is inactive the cosmic radiation increases. Some researches argue that the amount of cosmic radiation give impact on global environment.

It is has been discussed that the cause of the global warming accelerated in past 50 years is to be ascribed to the greenhouse effect, while the Sun is secondary element. Timely, the observation by the Japanese solar physics satellite Hinode shows that both polar regions are in homo-polarity, and there is a sign of significant and rapid decrease in magnetic flux of the Sun.

These facts clearly show that the comprehensive multidisciplinary research institute focusing on solar dynamo to geo-space and terrestrial environment is urgently required. Integrating the Solar-Terrestrial Environment Laboratory, Hydrospheric Atmospheric Research Center, and Center for Chronological Research of Nagoya University into one research institute, and making systematic and comprehensive approach to solar-earth-planetary science that is becoming more and more important is very timely also from the international perspective. I would like to express high degree of respect for the decision made by those who are concerned.

Keywords: solar terrestrial environment