赤道MUレーダー計画の現状２０１６
Status of Equatorial MU Radar project in 2016

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Research Institute for Sustainable Humanosphere, Kyoto University (RISH) has been studying the atmosphere and ionosphere by using radars. The first big facility was the MU (Middle and Upper atmosphere) radar installed in Shiga, Japan in 1984. This is one of the most powerful and multi-functional radar, and is successful of revealing importance of atmospheric waves for the dynamical vertical coupling processes. The next big radar was the Equatorial Atmosphere Radar (EAR) installed at Kototabang, West Sumatra, Indonesia in 2001. The EAR was operated under close collaboration with LAPAN (Indonesia National Institute for Aeronautics and Space), and conducted the long-term continuous observations of the equatorial atmosphere/ionosphere. The EAR, however, had a limited sensitivity to the MU radar as the total output power is just 1/10 to the MU radar. Our new project is to establish "Equatorial MU Radar (EMU)" just next to the EAR site in Indonesia. The EMU will have an active phased array antenna with the 163 m diameter and 1055 cross-element Yagis. Total output power of the EMU will be more than 500 kW. The EMU is the "MU radar class" facility, and can detect turbulent echoes from the mesosphere (60-80 km). In the ionosphere incoherent-scatter observations of plasma density, drift, and temperature would be possible. Multi-channel receivers will realizes radar-imaging observations. The EMU is one of the key element in the project "Study of coupling processes in the solar-terrestrial system" that is one of the important project in the Master Plan 2014 of the Science Council of Japan (SCJ). In 2015 the MU radar was awarded IEEE Milestone as the world first atmospheric radar with active phased array antenna system. For the EAR, preparation for construcion permission has almost completed. We will report current status of the EMU project together with stutus of the Master Plan 2017 of SCJ.

キーワード：大気レーダー、赤道大気、低緯度電離圏、インドネシア
Keywords: Atmospheric radar, Equatorial atmosphere, Low-latitude ionosphere, Indonesia

NASA Ionospheric Connection Explorer, Validation of Scientific Performance

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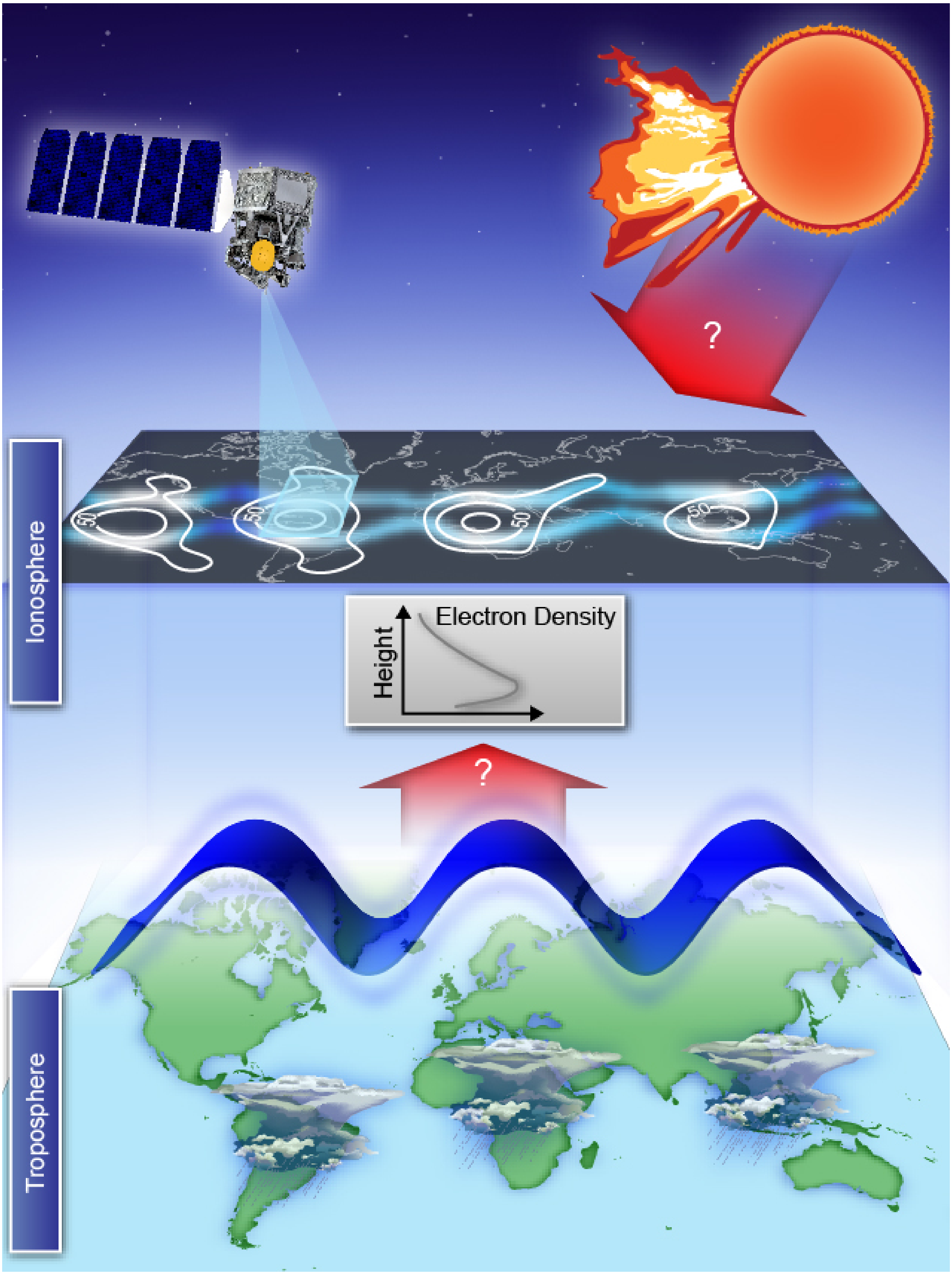
Earth's space environment is highly variable, changing in ways that we are currently unable to predict. Specifically, the ionosphere exhibits remarkable day-to-day changes that cannot be attributed to any known source, though forcing from the lower atmosphere is now considered of key importance. NASA's Ionospheric Connection Explorer, a mission designed to discover the causes of this variability, is in development for a June 2017 launch. Concurrent with the build of the instruments and spacecraft, a science validation effort has tracked the expected performance of the observatory. The predicted performance of the science retrieval algorithms developed for ICON will be reported. The current performance models show that ICON will have outstanding scientific capability and be able to address and resolve the open questions in space plasma physics that pertain to space weather. Here we will present the performance predictions and observational plans for the ICON mission, and discuss opportunities for collaborative measurements aligned with international research efforts.

Keywords: Thermosphere, Ionosphere, atmospheric physics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Electron Density
Height
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Troposphere

Pre-YMC2015キャンペーン速報
Early Results from pre-YMC 2015 Field Campaign in Sumatra

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The Years of the Maritime Continent (YMC) is designed to take place from mid-2017 to mid-2019 for improving our understanding and prediction of the weather-climate system over the Maritime Continent (MC) region and its global impact. During the campaign period, several intensive observations coordinated under the framework of YMC are planned in addition to the long-term monitoring by the MC local agencies. However, such coordination and conducting observations may encounter unforeseen difficulties. In addition, 2-year period is still insufficient to understand even local-scale phenomena as it may be affected by large/longer-scale phenomena such as El Nino. By considering these factors, we have conducted another field campaign as a pilot study for the YMC, and we call it as pre-YMC campaign. This campaign was conducted in Sumatra, Indonesia including Bengkulu (on and off the coast) and Kototabang from November through December 2015. While we deployed land-based radar/special radiosonde sites in Bengkulu and the R/V Mirai off Bengkulu to study precipitation mechanism, we also conducted water vapor/ozone-sonde observations at the EAR site in Kototabang to study upper troposphere/stratosphere interactions. Observations captured the atmospheric features in the transition phase from inactive to active for convection associated with the Madden-Julian oscillation. In this talk, some selected early results will be presented in addition to the basic information about the field campaign.

キーワード：国際集中観測YMC、集中観測Pre-YMC、スマトラ島
Keywords: YMC, Pre-YMC, Sumatra

Cloud Propagation over Sumatera during Coupling Processes in the Equatorial Atmosphere Campaign I and II

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Cloud propagation determines the distribution of precipitation. Previous studies on cloud propagation over Sumatera are mostly focused on mean propagation. Marzuki et al. [1] investigated the propagation of individual cloud cluster using Hovmoller diagram of 10 years of brightness temperature data. However, cloud tracking through Hovmoller diagram has some disadvantages: 1) result significantly depends on the averaging window, 2) two or more cloud can be assumed as a single cloud if they lie at the same longitude at the same time, and 3) only possible to get one direction of propagation. Therefore, objectively identifying and tracking the cloud in latitude-longitude space is necessary. In this study, we present the result of cloud tracking based on three-dimensional brightness temperature (T_b) data during Coupling Processes in the Equatorial Atmosphere (CPEA) campaign I and II. The two campaigns have a different Madden-Julian Oscillation (MJO) phase in which active MJO was observed during the CPEA-I in contrast to the CPEA-II. Although during the CPEA-II strong actively convective due to the MJO was not observed, Sumatra received high daily rainfall during this period. Although mean outgoing longwave radiation (OLR) is much lower during CPEA-II than CPEA-I, the cloud size during the CPEA-I is larger than during CPEA-II. It was also found that the ratio of westward to eastward moving cloud during CPEA-I (II) is 7:1 (6:1). Both during CPEA-I and II, westward moving streaks generally have a longer span and faster speed than those of eastward-moving system.
[1] Marzuki, Hashiguchi, H., Yamamoto, M. K., Yamamoto, M., Mori, S., Yamanaka, M. D., Carbone, R. E., and Tuttle, J. D.: Cloud episode propagation over the Indonesian Maritime Continent from 10 years of infrared brightness temperature observations, Atmos. Res., 120–121, 268–286, 2013.

Keywords: Cloud propagation, Sumatra, CPEA-I and II

Coordinated observations of post-midnight irregularities and thermospheric neutral wind and temperature

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Field-aligned irregularities (FAIs) have been observed since last few decades by using UHF/VHF/HF radars. At equatorial F-region, FAIs are generated within plasma bubbles. The plasma bubbles are well-known to be initiated at evening terminator and occur frequently in equinoxes, especially during high solar activity conditions. On the other hand, recent observations show that the FAIs frequently occur at post-midnight around June solstice in low solar activity conditions. From the comparison of ionosonde data, it is found that uplift of the F layer could play an important role in generating the post-midnight plasma bubbles. However, mechanisms of uplift of the F layer has not been revealed yet.
In this study, we investigate an event of the post-midnight FAIs observed with the EAR (Equatorial Atmospheric Radar) at Kototabang in Indonesia. Two-dimensional map of rate of total electron content change index (ROTI) obtained from GPS receivers in Southeast Asia, thermospheric neutral winds and temperature observed at Kototabang by Fabri-Perot interferometer, and altitude of the bottomside of the F layer observed with ionosondes at Kototabang, Chumphon, and Chiang Mai, are compared. On the night of July 9, 2010, the post-midnight FAIs appeared within the field of view of the EAR. By estimating the vertical rise velocity of this FAI structure, we found that the FAIs could be accompanied by plasma bubble initiated at magnetic equator around 22:00 LT.
Two-dimensional ROTI map also showed an enhancement near magnetic equator around this time, then extended to the higher low latitudes and reached Kototabang at midnight. Thermospheric neutral wind was southward (magnetically poleward) from19:30 to 23:00 LT, and northward (magnetically equatorward) enhancement was observed from 22:30 LT. The altitude of the bottomside of F-layer increased at 15:30-16:00 LT. This altitude increase of the F layer could be caused by the enhancement of the equatorward thermospheric wind. Thermospheric neutral temperature was higher at north than at south from 22:30 to 01:00 LT on the subsequent day, indicating that Midnight Temperature Maximum (MTM) existed at the north of Kototabang. We discuss a role of MTM in the generation of post-midnight FAIs at low latitude region.

Keywords: Post-midnight F layer field-aligned irregularities (FAIs) , Plasma bubbles, Equatorial Ionospheric region

Coordinated Incoherent Scatter Radar and Fabry-Perot Interformeter observations of ionosphere-thermosphere
disturbances during the March 17-18, 2015 great solar storm

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With a tremendous drop of the Dst index to ~ -230 nT, the geomagnetic storm during March 17-18, 2015 has been the largest during the current solar cycle. This strom was caused by a combined effect of the arriving solar Coronal Mass Ejection materials with high-speed solar wind streams originated from a nearby coronal hole. It was very fortunate for us to have coordinated an international campaign monitoring geospace disturbances during this period using ground-based facilities. These include incoherent scatter radars and Fabry-Perot Interferometers in the America sectors and other instruments in East Asia sectors, forming an observational network along approximately the 60W/120E meridional circle. The presentation will highlight these ground-based observations along with simultaneous DMSP in situ measurements and TEC from a network of dense GPS receivers, with a focuses on (1) the ion-neutral coupling processes at subauroral and mid-latitudes; (2) periodic midlatitude ionospheric disturbances; and (3) topside ionospheric variations. In particular, one of the most striking features to be discussed is the unexpected pre-midnight northward neutral wind surge, observed over multiple subauroral and midlatitude sites, accompanying strong westward winds developed at earlier times. We ascribe these wind disturbances to Subauroal Polarization Stream (SAPS).

Keywords: geomagnetic storm, magnetosphere-ionosphere-thermosphere coupling, incoherent scatter radar, Fabry-Perot Interformeter

地球大気を制御する赤道域の海岸線
Equatorial coastlines controlling Earth's atmosphere

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Just half a century has passed since the theories of vertically evanescent tides (Kato, 1966) and equatorially ducting modes (Matsuno, 1966) as varieties of atmospheric gravity waves. Horizontal convections as superimpositions of upward/downward gravity waves are generated between dayside and nightside hemispheres and between land and sea surfaces by insolation with diurnal cycles. Importance of the latter category, so-called sea-land breeze circulation, has been emphasized by ground-based and space-borne observations over the equatorial troposphere. The cloud activity has diurnal and annual cycles dominantly on land, in contrast to intraseasonal and interannual variations mainly over oceans, and the tropical rainfall amount is expressed by functions of coastal distance and length (Ogino et al., 2016; Yamanaka, 2016). This explains the global cloud activity-rainfall maximum located over the Indonesian maritime continent (IMC) with the world’s longest coastlines.

The diurnal cycle is generated directly by land-sea temperature contrast along a coastline: solid land becomes hotter than liquid sea by solar heating through clear sky before noontime, and opposite contrast appears before the sunrise by evening rainfall-induced sprinkler-like land cooling in tropics (different from infrared cooling at clear night in extratropics). This is why the diurnal cycle is dominant in the rainy season, and also why the rainy season appears exactly in the summer-side hemisphere, because land heating in the clear morning and water-vapor transport by afternoon sea-wind are strongest in the season of maximum insolation. El Niño causes less rainfall, because lower sea surface temperature makes morning maritime convection weaker.

Those lower-atmospheric features are reflected in the middle- and upper atmospheric dynamics. As suggested so far (e.g., Ogino et al., 1995; Tsuda et al., 2000), the stratospheric gravity-wave activity takes maximum near the equator and in particular near IMC as does the convective activity. Here it is suggested from the latter that these activities are generated with diurnal cycles and horizontal scales of about 300 km along coastlines, which are fixed with the major islands and the whole IMC with zonal scales of 1,000 and 5,000 km, respectively. 14-year hourly 25 km-resolution cloud-top height data are analyzed to show spectral slopes of around -2 for frequency and -5/3 and -3 for higher and lower zonal wavenumbers (with a border of about 300 km in zonal wavelength), as have shown already for tropopausal gravity waves or quasi-two dimensional turbulence (e.g., Nastrom and Gage, 1985). A part of the insolation over equatorial lands sequentially with Earth’s rotation may contribute (through infrared absorption) to generation of migrating tides. All the features mentioned here appear on a land-sea coexistent planet like Earth, and differences in other planets are also discussed briefly.

キーワード：赤道域、大気・海洋・陸面相互作用、地球自転・公転
Keywords: equatorial region, air-sea-land interaction, Earth's rotation and revolution

太陽地球系結合過程の研究のための名古屋大学宇宙地球環境研究所の地上ネットワーク観測
Ground network observation of ISEE, Nagoya University, for the study of coupling processes in solar-terrestrial system

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The Solar-Terrestrial Environment Laboratory, Nagoya University has been combined with Hydrospheric Atmospheric Research Center and Center for Chronological Research to become the Institute for Space-Earth Environment Research (ISEE) of Nagoya University since October 2015. Under the new institution, ground-based observation network has been kept operating to study coupling processes in solar-terrestrial system, particularly at ground stations in Asia and Africa from high to low latitudes. A new collaborative research system will be launched from April 2016 particularly to extend this ground network observations in collaboration with various Japanese and foreign institutions. The Center for International Collaborative Research (CICR) and Center for Integrated Data Science (CIDAS) are newly established under ISEE to promote international collaborative researches and to promote integrated analyses using various kinds of observation data and advanced computer simulations, respectively. These centers also contribute to the operation and database construction of the ground-based network observation by ISEE. In this presentation, we show ground-based network observations and domestic and international collaboration system newly developed under ISEE and its two centers.

キーワード：地上ネットワーク観測、宇宙地球環境研究所、共同利用・共同研究
Keywords: Ground network observation , Institute for Space-Earth Environment Research (ISEE), Nagoya University, cooperative research

MAGDASプロジェクトの進展：国際協力の戦略
Recent development of MAGDAS project: Strategy for international alliance of geomagnetic field network observation

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For space environment monitoring, Kyushu University has developed a real time magnetic data acquisition system (the MAGDAS project) around the world. The number of observational sites is increasing every year with the collaboration of host countries. Now at this time, the MAGDAS Project has installed 77 real time magnetometers -so it is the largest magnetometer array in the world. The history of global observation at Kyushu Univ is over 30 years and number of developed observational sites is over 140.
In this talk, we will introduce recent development of MGADAS project and stradegy for international alliance of geomagnetic field network observation based on the project "Study of coupling processes in solar-terrestrial system" that was approved by the Master Plan 2014 of Science Council of Japan and the Roadmap 2014 of MEXT.
Topics for open policy for MAGDAS data, development of Space weather index, and extension of Equatorial network will be also discussed.

キーワード：国際協力、磁場ネットワーク観測、マスタープラン
Keywords: International aliance, geomagnetic field network, master plan

CHAMP衛星やSWARM衛星などの低高度衛星で観測される磁気リップル現象
Magnetic ripples as observed by low altitude satellites, CHAMP and SWARM

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The low altitude satellites such as the CHAMP or the SWARM satellites have been observing the small amplitude (typically 0.5 –5nT on the dayside) magnetic fluctuations with period of a couple of ten seconds. They exist almost all the time and at any local time (LT) in middle and low latitudes. They were named as “magnetic ripples” because the magnetic fluctuations like ripples exist globally.
They have the following characteristics: (1) They are perpendicular to the geomagnetic main field. (2) Their amplitude has the magnetic conjugacy. (3) The amplitude and the period along the orbit have latitudinal dependence, and they depend also on the geographic longitude. (4) The amplitude is larger on the day side than on the night side. (5) The amplitude doesn’t have dependence on the solar wind parameters nor the magnetic disturbance. (6) The amplitude has the following seasonal and topographical characteristics. That is, the amplitude during the northern summer and northern winter is larger than those during the equinoxes. In the northern summer, the amplitude over South America, Eurasia, North Africa and Australia continents, and their magnetic conjugate regions is larger than those in the other regions. In the northern winter, the amplitude over the eastern Pacific Ocean is larger.
We assume that they are generated through the E-region dynamo driven by the acoustic mode of the gravity waves propagated from lower atmosphere. We discuss the consistency of the above mentioned characteristics and suggested mechanism of generation of the magnetic ripples with ground based observations such as the GPS-TEC, micro-barometric observation, etc..

キーワード：磁気リップル、微細沿磁力線電流、重力音波、低高度磁場観測衛星
Keywords: magnetic ripples, small-scale field-aligned currents, acoustic gravity waves, low-altitude magnetic satellite

Observations of medium-scale traveling ionospheric disturbances using FORMOSAT-2 / ISUAL 630.0 nm airglow

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We reports observation results of space based imaging of medium-scale travelling ionospheric disturbances (MSTID) in 630.0 nm emission by Imager of Sprites and Upper Atmospheric Lightnings (ISUAL), onboard FORMOSAT-2 satellite. The limb integrated measurements, after removing background, reveal multiple bands of intensity perturbation when projected to a horizontal plane corresponding to the altitude of peak emission, with distinct southwest to northeast orientation in the southern hemisphere. The ISUAL observations in the year 2007 are further used to investigate the MSTID features as well as occurrence characteristics in the southern hemisphere, most of which are over the ocean where no ground based observations are available. The preliminary statistics shows more MSTID occurrence in solstices with peak in June-July months. Majority of the MSTID perturbations have wavelength in the range 150-300 km, and are aligned at about 30°-50° from the east-west plane. The orientation of the wave fronts indicate that Es-layer instability might be important in the MSTID generation.

Keywords: MSTID, FORMOSAT-2/ISUAL, airglow

国際共同観測およびモデルに基づく南北両半球結合過程の研究（ICSOM）
Interhemispheric Coupling Study by Observations and Modelling (ICSOM)

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Recent observational and modelling studies suggest that the Northern and Southern Hemispheres of the earth atmosphere are potentially coupled by the Lagrangian mean flow in the mesosphere modulated by waves interacting with the mean flow. However, observations of modulated wave and flow fields which are needed for quantitative understanding of the interhemispheric coupling are not sufficient. Simultaneous observations of gravity waves at various locations are most important because they are a main driver of the Lagrangian mean flow in the mesosphere.
With the start of full system observation by the PANSY radar in the Antarctic in March 2015, a global mesosphere-stratosphere-troposphere (MST) radar network extending from the Arctic to the Antarctic has been realized. The MST radars are able to observe wind vectors with fine temporal and vertical resolutions including vertical wind components in the troposphere, stratosphere and mesosphere, although an observational gap of the middle and upper stratosphere remains. Thus, the characteristics of small-scale or short-period wave motions including gravity waves and the momentum fluxes associated with these waves can be estimated with a good accuracy.
In addition, recent high-resolution general circulation models enable an explicit simulation of gravity waves under ideal and/or climatological boundary conditions and allow us to examine the momentum budget in the MST region including gravity waves, although their resolution is currently not sufficient to resolve the entire gravity wave spectrum. Real atmosphere simulations utilizing such high-resolution models are still a challenge for the MST region. However, if such real atmosphere simulations are successful, they will help quantitative interpretation of the dynamical fields observed by the MST radar network, and the observations will provide invaluable validation data for the model improvement.
Therefore we will examine the interhemispheric coupling of the earth atmosphere through a combination of simultaneous observations by networking the MST radars over the world and high-resolution model simulations of the observed atmosphere. The first international campaign was performed in 22 January-17 February 2016. Two minor stratospheric warmings occurred in the Arctic. The second one was a minor warming by its definition but the temperature at the north pole increased by about 70 K in two days at 10 hPa. Seven MST radars over the world and a lot of complementary observations were performed by more than 30 participants in eight countries. Preliminary results from this campaign will be reported.

キーワード：南北半球結合、中層大気、成層圏突然昇温、MSTレーダー、大気大循環、重力波
Keywords: interhemispheric coupling, middle atmospehre, sudden stratospheric warming, mesosphere-stratosphere-troposphere radars, general circulation, gravity waves

EISCAT_3D計画の現状と日本の貢献
Current Status of EISCAT_3D and Japan's Contribution

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The European Incoherent Scatter(EISCAT) Scientific Association with associate members from Sweden, Norway, Finland, UK, China and Japan, including affiliated member organizations from South Korea, France and EC, is planning for the construction of the next generation near-earth space and upper atmosphere radar system in northern Feno-Scandinavia, called EISCAT_3D. The technical design work is currently being almost finalized and the project has now entered the new phase of production engineering. The Swedish Research Council, the Academy of Finland, the Research Council of Norway and the European Commission have now granted funds for the development, construction and operation of EISCAT_3D, which covers approximately 70% of the total costs of establishing the first stage of the system. EISCAT_3D is the major upgrade of the existing EISCAT mainlamd radars, with a multi-static phased array system composed of one central active (transmit-receive) site and 4 receive-only sites to provide us 50-100 times higher temporal resolution than the present system. The construction of EISCAT_3D is planned to implement by 4-staged approach, starting from the core site with half transmitting power about 5MW at Skibotn (Norway) and 2 receiving sites at Bergfors (Sweden) and Karesuvanto (Finland) at the 1st stage. The Japanese EISCAT user community has been pursuing the opportunity to contribute in-kind to the construction of EISCAT_3D. Our proposal is to supply the power amplifiers for the radar as a joint venture with EISCAT in cooperation with Japanese industry. The EISCAT_3D program in Japan has been successfully granted as as one of 27 high-priority programs of Master Plan 2014 and 10 new Roadmap 2014 programs as a part of ’Study of Coupling Processes in the Solar-Terrestrial System’ (PI: Prof. Tsuda, Kyoto Univ.). Supported by this decision, National Institute of Polar Research has made a funding proposal to MEXT for EISCAT_3D, collaborating with Institute for Space-Earth Environmental Research, Nagoya University. In parallel to the funding proposal, we started a development for a high energy-efficient power amplifier collaborating with the EISCAT headquarter and Japanese industry. In this paper, we will overview the current status and outlook on Japan’s national contribution to the EISCAT_3D project.
Figure. Location of existing EISCAT radar and planned EISCAT_3D radar sites.

キーワード：非干渉散乱、レーダー、北極、ジオスペース
Keywords: incoherent scatter, radar, arctic, geospace


トロムソ
アンドーヤ
(Andøya)
シーボトン
(Skibotn)
カレスバント
(Karesuvanto)
ベルグフォース
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Significance of the D-region ion chemistry in the atmospheric forcing from above by precipitating high-energy particles

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Although the ionisation degree of middle atmosphere -lowere thermosphere region is low, it surprisingly turns out that ion chemistry plays a significant role in causing variations in concentrations of neutral chemically active minor constituents during events of excess ionisation, such as auroral particle precipitation. Here we first give an overview of the D-region ion chemistry, pointing out the relevant processes, which can be both direct and indirect via first generating chemically active minor constituents of the atmosphere, such as odd nitrogen and odd hydrogen, which in turn can affect for example atmospheric ozone via catalytic reactions either directly in-situ, or after transport in atmosphere to lower altitudes and lower latitudes. We show recent results using the detailed coupled neutral and ion chemistry model, the Sodankyla Ion Chemistry model. We also show how the upcoming new incoherent scatter radar facility EISCAT_3D, together with coordinated other currently planned measurements, will enhance the research opportunity in studying the coupling between geospace environment and atmosphere of Earth during high energy particle precipitation into the atmosphere.

Keywords: Ion chemistry, D region, aurora

EISCAT、MF、流星レーダー、およびナトリウムライダーデータを用いた2016年2月における北極域下部熱圏・中間圏変動の研究

Variations of the polar lower thermosphere and mesosphere in February 2016 using EISCAT radar, meteor radar, MF radar, and sodium LIDAR observations

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We made an EISCAT special program (SP) experiment, under collaborations of Japan, Sweden, and Norway, to study variations of a quasi-two day wave (Q2DW) and tidal waves in the polar lower thermosphere using the EISCAT UHF radar at Tromsoe (69.6N, 19.2E) and the EISCAT Svalbard radar at Longyearbyen (78.2N, 16.0E) for 45 hours. The SP started at 23 UT on February 10, 2016, just after EISCAT CP2 (Common program 2) run made for 135 hrs, and ended at 20 UT on February 12, 2016. By combining the EISCAT CP2 run and our SP run, we have, in total, made a data set of 7.5 day length. Unfortunately, there was a data gap from about 01 UT to 07 UT on February 7 due to a problem of data recording at the Tromsoe site. Except for the gap, the operations went well without no seirouous problems at both the EISCAT radars. Sodium LIDAR observations of wind, temperature, and sodium density collocated at the Tromsoe site were also made during dark time intervals together with meteor and MF radar contiunual observations. We have analyzed the data sets, and derived Q2DW and 24h/12h tides. An SSW occurred in this time interval, so we focus on changes of the waves around time interval of the SSW.

キーワード：下部熱圏、中間圏、大気潮汐波、準２日波、EISCATレーダー、ナトリウムライダー
Keywords: Lower thermosphere, Mesosphere, tidal waves, quasi-two data wave, EISCAT radar, sodium LIDAR

MUレーダー実時間アダプティブクラッター抑圧システムの開発

Development of MU radar real-time processing system with adaptive clutter rejection

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大気レーダー観測において、しばしば強いクラッターエコー(山や建物からのエコー)が問題になることがある。そのクラッター抑圧法としてNC-DCMP (Norm Constrained-Directionally Constrained Minimum Power)法が提案され、MUレーダーによる実観測データに適用し、効果があることが実証されている[Nishimura et al., JTech., 2012]。この処理は、これまではオフラインで実施されていた。そこで本研究では、NC-DCMP法によるクラッター抑圧処理をMUレーダーのオンライン処理システムとして実装することを目的とする。これにより、観測データの記録容量を数百分の１に削減でき、外部記憶装置などの制約の少ない標準観測を行うことが可能になる。NC-DCMP法では、所望信号方向を固定した上で、ウエイトベクトルのノルムをある値以下に制約して、信号電力を最小化するように制約条件付最適化問題を解く。
MUレーダーでは30年以上に渡って、毎月100時間程度の対流圏・成層圏標準観測モードによる観測を継続している。まず、この標準観測モードにNC-DCMP処理を実装した。このモードでの観測データは8秒に1回取得される。そのため、実時間でクラッター抑圧を行うためには全ての信号処理を8秒以内に行う必要があるが、処理方法の工夫により、NC-DCMP法の処理時間を平均1.0秒にまで高速化した。山や建物からのエコーは時間的に大きく変化しないため、インコヒーレント積分7回分(約1分間)の受信信号を用いて最適ウエイトベクトルを求めるようにしたところ、良好な結果を得た。2015年11月の標準観測からNC-DCMP処理を適用しているが、安定運用できている。完全ではないが、航空機からのエコーについても、抑圧する効果が得られている。
インドネシア共和国の西スマトラに建設が計画されている赤道MUレーダーは、八木アンテナ19本を1群とする55群構成で、各群からの受信信号を独立に取得可能なシステムが提案されている。本研究の成果は、この赤道MUレーダーにも適用可能である。

キーワード：大気レーダー、クラッター抑圧、ウエイトノルム拘束付DCMP法、MUレーダー
Keywords: Atmospheric radar, Clutter rejection, NC-DCMP method, MU radar

Variability of Rain Microstructure over Sumatra from Micro Rain Radar Observation

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The vertical profile of rain microstructure such as raindrop size distribution (DSD) is important for understanding rain formation processes and to improve the accuracy of radar-derived rainfall estimates. The variability in the DSD substantially limits the accuracy of the DSD application. The aim of the present study is to investigate the natural variability of vertical profile of DSDs as a function of large-scale atmospheric conditions and storm characteristics using measurements from the Equatorial Atmospheric Radar (EAR) facility at Kototabang, west Sumatra, Indonesia. This study is a follow-up of our previous work on the DSD variability over Sumatra [1,2]. The vertical profile of DSD is obtained from a Micro Rain Radar (MRR) with a near continuous record of operation over four consecutive years (2011–2014). The DSDs from the radar are compared with those from an optical disdrometer. The data are partitioned according to diurnal, convective and stratiform precipitation classifications, monsoonal regime, and MJO phase. Findings support previous Sumatra studies suggesting a significant diurnal and DSD parameter signal associated with both convective–stratiform and MJO phase regime classification. Negligible monsoonal phase influence is determined for the DSD over the Kototabang location. The natural variability of vertical profile of DSDs leads to variability of Z-R relationships in rain column.

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Keywords: Raindrop size distribution, Micro Rain Radar, Sumatra

DIURNAL VARIABILITIES ANALYSIS OF METEOROLOGICAL PARAMETER OF CCAM-NWP OUTPUTS AND OBSERVATION AT KOTOTABANG

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The diurnal varibilities of some meteorological parameter (rainfall, temperature, relative humidity, and pressure) study, needed a model that can predict the behavior of the weather in the future by following the data history in the past. As a validation stage, outcomes such dynamic model of spatial and temporal very necessary compared with surface observational data from Automatic Weather Station (AWS) and u-v wind data from Equatorial Atmosphere Radar (EAR). The purpose of this study is analyzing the diurnal varibilities of meteorological parameter of dynamic model outputs Conformal Cubic Atmospheric Model-Numerical Weather Prediction (CCAM-NWP), and the surface observational data. The data used is the hourly output CCAM-NWP models in (12-15) February, (12-15) June 2014, and (2-14) January 2015, and surface observational data in (2-4) January 2015 as validation. The method on analyzing the output CCAM-NWP from the input models Global Forecast System (GFS-NOAA) with a resolution of the model 0.25^o x 0.25^o, and statistical analysis with method of T-test and F-test. Based on the results shown the diurnal variabilities and dinamic process of meteorological parameter for the model output and surface observation. Furthermore, we obtained a weak correlation between the temporal model output with surface observations from statistical analysis which mean that there are significant differences of the results found from the CCAM-NWP output and surface observations. Additionally, we compared spatial distribution of hourly output CCAM-NWP with satellite observation data such as MTSAT.
Keywords: rainfall, temperature, relative humidity, pressure, CCAM-NWP, T-test, MTSAT.

Solar-Terrestrial Interaction as Studied from Total Solar Eclipse of 9 March 2016

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Total Solar Eclipse of 9 March 2016 provides a great opportunity to study the interaction between the Sun and Earth as a complex system. Several team of observers and scientists from National Institute of Aeronautics and Space will be dispatched to some observing points along the track of Lunar shadow and its proximity. The main missions are: (1) to study the physical nature of lower part of Solar corona, (2) to understand the ionospheric disturbance caused by a sudden drop of Solar radiation to the Earth, and (3) to measure the dynamics of local magnetic field that is influenced by the ionospheric disturbance. Preliminary result of those observations/experiments will be discussed in this paper.

Keywords: Solar Eclipse, Corona, Ionosphere, Geomagnet

RELATIONSHIP OF F LAYER HEIGHT RISE, ESF ONSET TIME, AND AMPLITUDE OF LARGE SCALE WAVE STRUCTURE

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Under favourable conditions ionospheric plasma at the bottomside of the F-region can become unstable. Plasma irregularities in several scales produced by Rayleigh-Taylor Instability mechanism. The recombination process at the E-region after sunset causing the bottom side F-region electron density gradient become steep. At the same time the eastward electric field intensified just before it reverses to the westward electric field causing the peak of the F region rise known as evening prereversal enhancement. The relationship between onset time of field aligned irregularities related to ESF observed by Equatorial Atmosphere Radar during 2010-2012 with F layer height rise observed by ionosondes near geomagnetic equator, Chumphon (10.7 N; 99.4 E; 0.86 N) and Bac Lieu (9.3 N; 105.7 E; 0.62 N) is discussed in correspondence with growth rate of Rayleigh Taylor instability development. The field aligned irregularities onset time associated with equatorial spread F observed into two different cases, first case where the EPB/ESF onset time concurrent with the peak of virtual height of F region - (h’F) time. Second case where the EPB/ESF onset time happened with delay of more than 30 minutes, with reference to the peak of virtual height of F region - (h’F) time. The possibility that the amplitude of Large Scale Wave Structure obtained from GRBR data effects the height of plasma instability development also discussed.

Keywords: F layer height rise, Large Scale Wave Structure, onset time of Equatorial Spread F

EIA structure and its relation to plasma bubble occurrence along longitude 100° E in 2012

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To reveal a relationship between EIA structure and plasma bubble occurrence along longitude 100° E in 2012, the ground-based observations i.e., GNU Radio Beacon Receivers (GRBR), GPS, ionosonde, and Equatorial Atmospheric Radar (EAR), are employed. GRBR is used to capture the precise structure of EIA. The Rate Of TEC change Index (ROTI) of GPS is used to monitor the plasma bubble occurrence. Temporal variation of the bottom side of the F layer is measured by the ionosonde. The EAR is for detecting Field Aligned Irregularities (FAI). In this paper, we will answer the following questions:
(1) What does the EIA structure look like on the plasma bubble on and off day?
(2) Is it necessary that plasma bubble will occur only when EIA is symmetric?
(3) How does the plasma bubble structure look like on the GRBR TEC?

Keywords: EIA, Plasma bubble

TBExおよびFORMOSAT-7/COSMIC-3衛星を用いた赤道電離圏研究用の新ディジタルビーコン受信機

New digital beacon receiver for the study of equatorial ionosphere with satellites TBEx and FORMOSAT-7/COSMIC-2

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We have successfully conducted observations of total-electron content (TEC) of the ionosphere using a satellite-to-ground beacon experiment. A unique dual-band (150/400MHz) digital receiver GRBR (GNU Radio Beacon Receiver) was developed for this purpose, which is based on the recent digital-signal processing technologies. The GRBR network was deployed into the southeast Asian and Pacific regions. By using beacon signals from the low-inclination satellite C/NOFS, we studied longitudinal “large-scale wave structures (LSWS)” in detail as a possible source of equatorial Spread-F (ESF) events. Now there are 2 new beacon-satellite plans. One is TBEx (Tandem Beacon Explorer), a project by SRI International, to fly a constellation of two 3U cubesats with triband beacon transmitters. Another one is a constellation of FORMOSAT-7/COSMIC-2 satellites, also with triband (or quad-band) beacon transmitters. All of these satellites will be placed into low-inclination orbits by the same launch vehicle in late 2016. This launch will provide great opportunities to enhance studies of the low-latitude ionosphere. Kyoto University, Ehime University and Hsing Wu University are now developing the new GRBR system that is expected to be used for the TBEx and FORMOSAT-7/COSMIC-2 beacon experiments. In the presentation we will show development of the new beacon receiver together with plan of observations.

キーワード：衛星—地上ビーコン観測、電離圏全電子数、COSMIC-2、cubesat、赤道電離圏
Keywords: Satellite-ground beacon experiment, Ionospheric TEC, COSMIC-2, cubesat, equatorial ionosphere

太陽地球結合系研究のためのIUGONETデータ解析システム
IUGONET data analysis system for a study of coupling processes in the solar-terrestrial system

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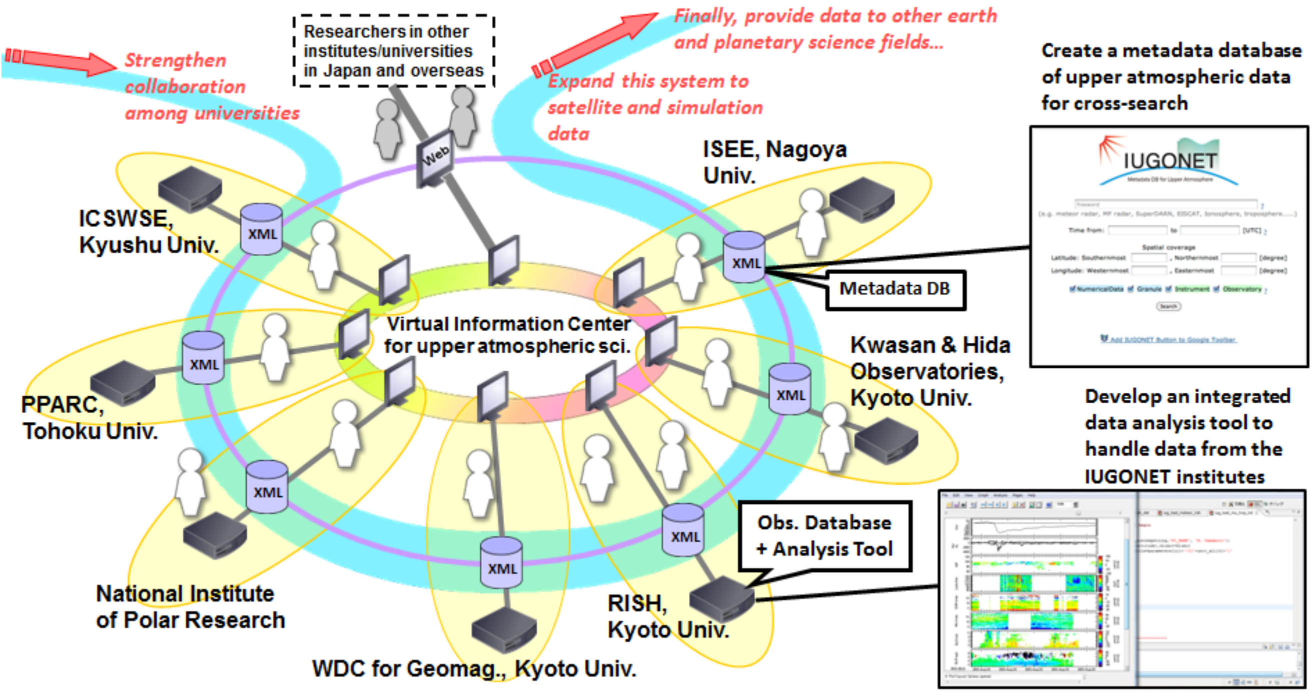
Various kinds of disturbance phenomenon and long-term variation in the upper atmosphere above 100 km are caused by energy input from solar radiation, solar wind, momenta and energies from the lower atmosphere via atmospheric waves, and chemical reaction. Such a disturbance phenomenon and long-term variation observed by various kinds of ground-based and satellite instruments are the result of such complicated processes. Therefore, in order to understand the mechanisms of these phenomena detected in this region, researchers need to conduct comprehensive analyses with various kinds of long-term observation data that have been continued by means of a global network of radars, magnetometers, optical sensors, helioscopes, etc. The IUGONET (Inter-university Upper atmosphere Global Observation NETwork) project initiated in 2009 is proposed to establish a cross-reference system for various kinds of ground-based observation data obtained from different techniques. The IUGONET participants consist of five universities/institutes: the National Institute of Polar Research (NIPR), Tohoku University, Nagoya University, Kyoto University, and Kyushu University. We have developed a metadata database (MDDB) and IUGONET data analysis software (UDAS) of ground-based observation data managed by these IUGONET universities/institutes with an international collaboration in order to promote a comprehensive study on coupling processes in the Sun-Earth system. MDDB provides researchers in a wide range of disciplines with a seamless data environment to link observation databases spread across the IUGONET universities/institutes. Researchers can find basic information of observation data (for example, observation period, data format, data use policy, instrument, observed region, observation site etc.) from the metadata for each observation data they are interested in. Recently, the metadata for several satellite observation data (for example, Akebono, GPS) have been registered to MDDB, and researcher can easily find the satellite database. UDAS will also be of great help in conducting integrated analyses and visualization of various kinds of solar-terrestrial observation data to investigate the long-term variation in the upper atmosphere throughout the Sun-Earth system. UDAS deals with 29 kinds of ground-based observation data provided by the IUGONET universities/institutes. Moreover, the executable file of SPEDAS/UDAS working on Interactive Data Language (IDL)-VM without IDL license has been released on the SPEDAS website. Owing to the executable file, anybody can use UDAS and conduct a comprehensive analysis of various kinds of solar and Earth’s atmospheric observation data. Moreover, in the IUGONET project, in order to enhance an international use of these IUGONET products, we held a mini-training workshop of how to use the IUGONET MDDB and UDAS at several developing countries (India, Indonesia, Nigeria, Peru etc). Now, the IUGONET products became an

essential tool to study a mechanism of the solar-terrestrial environmental change. In this talk, we introduce a brief overview of the IUGONET project, and an application of the IUGONET products to typical examples of upper atmospheric researches.

キーワード：大学間連携プロジェクト(IUGONET)、超高層大気、メタデータデータベース、解析ソフト、長期変動、地上観測
Keywords: Inter-university Upper atmosphere Global Observation NETwork, Upper atmosphere, Metadata database, IUGONET data analysis software (UDAS), Long-term variation, Ground-based observation



Ionospheric weather in the dayside polar cap region

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Using European incoherent scatter radar (EISCAT) and EISCAT Svalbard radar (ESR), we have made simultaneous obserbations of the dayside polar cap ionosphere at Longyearbyen and Tromso. Five year observation data show significant disturbances in the polar cap region northward the ESR site even during geomagnetically quiet periods. This suggests that the energy input from the magnetosphere would play a fundamental role for dynamics and energetics in the region all the time. In addition, some researchers suggest effects from the lower atmosphere on the thermospheric variations in the polar region. In order to understand variations of the polar ionosphere/thermosphere from hour to hour, we should understand energy flows from the above (magnetosphere) and below (lower atmosphere). Numerical simulations with a GCM are also essential to do so. In particular, GCM simulations would reveal physical and chemical processes/mechanisms to produce the thermoshperic variations while the thermospheric observations are very few in the dayside.
In the present study, we overview the EISCAT and ESR observations during 2011-2016. The recent progress of our understandings from comprehensive observations and GCM simulations are also shown.

Keywords: ionosphere, thermosphere, EISCAT, GCM, simulation

Using Vondrak smoothing method to improve the prediction of Sunspot Maximum

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About 11-year cycle of solar activity is the most significant quasi-periodic component, which largely represents the strength of solar activity and is the basis for dividing solar cycle. Many studies have proven that solar activity can affect the developing process of many phenomena on the Earth, such as climate, geophysical and marine changes etc. In order to meet the demands of heliophysics and solar activity variation characteristics studies, especially, for the demand of Solar Terrestrial Relations studies and space science development, studies of solar activity characteristics and prediction are getting more attention. Some authors summerized a variety of methods for the maximum predictions of 22nd, 23rd, 24th solar cycles, the incomplete statistics are 63, 54 and 75 cases respectively, results of the methods, which the difference between forecasting and observed values within the range of ±15%, are 27.0%, 25.9% and 24.3% respectively. Using the 13 points smoothed value of monthly sunspot numbers, we studied correlation between sunspot number rising rate of the first 24 months of the solar cycle and the coming cycle maximum, published forecasting result that the maximum value was 139.2 ±18.8 for 23rd solar cycle (Han et al., 2000), and the observed value is 120.8, the error is about 15.2%. The present paper introduces our improved forecasting methods. Vondrak smoothing method is used to deal with the monthly sunspot numbers. It is studied that the relationship between the rise rate of earlier months of sunspot numbers of this smoothed sequence and the coming maximum value in each solar cycles. The results show that the first 22, 23, 24 months rise rate of sunspot numbers are highly related with the coming maximum values, and simulated prediction of maximum for 22~24 cycles show that using the 22-month rise rate of three solar cycles, the maximum forecasting error is about 13.2%, using 23-month rise rate, the maximum error is about 11.2%, while using 24-month rise rate, the maximum error is only about 9.3%. The new method can make the forecasting time in advance at least half a year than the common method using 13 points monthly smoothed value, which the difference between prediction and observed values within the range of ±15%. The results also show that the maximum error is about 20% if we use 18-month rise rate, and it can make the forecasting time in advance at least one year than the common method using 13 points monthly smoothed value.

Keywords: Sunspot Maximum, Prediction

D- and E-region ISR spectra measured with the EISCAT radars

D- and E-region ISR spectra measured with EISCAT radars

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The energy from the solar wind is mainly transported to the polar upper atmosphere and causes various phenomena such as auroras characterized by their rapid variability in time and space. Incoherent scatter radar (ISR) located in high latitude is one of the most powerful tools to investigate generation mechanisms of such phenomena and their effects on the atmosphere. The ISR basically gives information of plasma parameters between the bottom-side and topside ionospheres. However, the ISR has several unavoidable limitations to derive ionospheric parameters in the E- and D-region ionospheres, due to limited information of the ISR spectra.
We have investigated ISR spectra in the D- and E-region using the latest techniques of the EISCAT UHF and VHF radars located in Tromsø. Previous studies indicate that the EISCAT UHF and VHF radars have limitations of plasma parameter derivation below 90 and 100 km altitudes, respectively. We show lower limits of reliable plasma parameter derivation using the latest pulse coding techniques of the EISCAT radars. Based on the knowledge and experience of the current EISCAT radar observations, we will discuss possibility and limitation of future E- and D-region observations of the EISCAT_3D radar.

キーワード：ionosphere、Incoherent scatter radar、plasma
Keywords: ionosphere, Incoherent scatter radar, plasma

トロムソOMTIを用いた極域超高層大気の国内・国際共同研究
National/International joint studies with the Tromsø OMTI for studying the polar upper atmosphere

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Institute for Space-Earth Environmental Research (ISEE) has been operating various kinds of optical instruments for more than 15 years at the Tromsø European Incoherent Scatter (EISCAT) radar site in Norway (Geographic: 69.6N, 19.2E, Geomagnetic: 66.7N, 102.2E, L=6.4), which is one of the state-of-art observatories at high latitudes. In January 2009, we began operation of a Fabry-Perot interferometer (FPI) and an all-sky type cooled CCD camera (ASC) at dark nights of the winter months (from middle of September to early April in most years). The FPI (#01 of the Optical Mesosphere Thermosphere Imagers (OMTIs)) measures airglow and aurora by rotationally changing optical wavelengths of 557.7 and 630.0 nm for most of the nights in order to derive the thermospheric wind and temperature. Four cardinal points with zenith angle of 45 or 15 and the geographic vertical (i.e. five directions) are measured sequentially. The combination of data from the four cardinal positions provides the horizontal components of the neutral wind velocity. The all-sky camera (camera #12 of OMTIs) includes a filter wheel used to select one of the six optical filters (channel 1: 557.7 nm, channel 2: 630.0 nm, channel 3: OH band (720 ~1000 nm), channel 4: 589.3 nm, channel 5: 572.5 nm, and channel 6: 732.0 nm). While the exposure time for FPI and ASC measurements is tuned as good for individual scientific objectives, in the case of FPI typical values are 1 minute or 15 seconds for airglow and auroral measurements, respectively, and in the case of ASC those are about 30 and 10 seconds for the individual targets, respectively. However, shorter exposure times have been applied for measuring fine structures of aurora. Other optical instruments such as photometer, digital camera, and all-sky camera (486.1 nm) are collocated with the OMTI FPI and ASC. Data from these instruments have been provided to national and international researching activities. For example, the FPI was operated together with the EISCAT radars as a key diagnostic instrument for providing thermospheric parameters during periods of geomagnetic disturbances. Integrated studies of the FPI-measured wind and the EISCAT-measured ionospheric parameters (including full vector of the electric field) improve our understanding of the energy dissipation and momentum transfer processes and of polar ionospheric/thermospheric responses to the solar-wind change. Effects of energetic electron precipitation (EEP) on the atmosphere are also analyzed using data from our optical instruments and EISCAT radars. This topic is proceeded under collaboration with Chemical Aeronomy in the Mesosphere and Ozone in the Stratosphere (CHAMOS) group. Sodankylä Ion Chemistry (SIC) model, which is used in the group, is a powerful tool for estimating atmospheric responses to EEP, in particular variations in the atmospheric minor components such as NO_x, HO_x, and O_3. Ionospheric and atmospheric variations associated with EEP will be one of the important scientific objectives in the ERG project. This presentation will make a brief introduction of a few results from the national/international join studies.

キーワード：オーロラ、大気光、光学装置、電離圏、熱圏、高緯度

Keywords: Aurora, Airglow, Optical instrument, Ionosphere, Thermosphere, High latitude

脈動オーロラが起こすナトリウム密度変動の研究: 高速ナトリウムライダー観測
Study on pulsating aurora-induced sodium density variation: high-speed sodium lidar observation

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トロムソナトリウムライダーは2010年10月に観測を開始し，2016年2月現在までの冬季に計6シーズンの観測を行っている。これまで、EISCAT観測所に設置された観測機器との同時観測データを用いて、大気重力波の上方伝搬、イオン温度と中性大気温度の比較、スポラディックナトリウム層の生成機構など数分から数時間の時間スケールの現象を取り扱ってきた。

近年、高エネルギー電子を振り込ませる脈動オーロラが注目されつつある。脈動オーロラを起こす高エネルギー電子は高度100 km以下まで侵入し、衝突を介して中性大気にエネルギーを受け渡す。このエネルギーの授受に伴う中性大気の応答過程は未だに明らかになっていない。これは、明滅周期が10秒前後である脈動オーロラに対して、十分な時間分解能で中性大気を計測するような観測が行われていないことに大きな問題があるためである.

本研究では、高出力・高感度のトロムソナトリウムライダーのデータ取得系及び、レーザー制御系に改良を加え、現システムの時間分解能を１桁以上向上させることに挑戦した。国内で開発した改良データ記録システムを2016年１月にトロムソのライダーシステムに導入し、試験的な観測をすでに開始，現在では秒/サブ秒オーダーでのナトリウム密度計測に成功している。本発表では、2015年1月～3月の試験的観測により得られたナトリウム密度の高時間分解能データの紹介を行う予定である。

キーワード：ナトリウムライダー、脈動オーロラ
Keywords: sodium lidar, pulsating aurora

南極昭和基地大型大気レーダーで得られた中間圏エコーと下部電離圏における電子密度モデルとの比較研究

Comparison study between coherent radar echo and empirically-modeled electron density in the mesosphere based on the PANSY radar

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Polar Mesosphere Winter Echo (PMWE) is known as back scatter echo from 55 to 85 km in the mesosphere, and it has been observed by MST and IS radar in polar region during non-summer period. Since density of free electrons as scatterer is low in the dark mesosphere during winter, it is suggested that PMWE requires strong ionization of neutral atmosphere associated with Energetic Particles Precipitations (EPPs) during Solar Proton Events [*Kirkwood et al*., 2002] or during geomagnetically disturbed periods [*Nishiyama et al*., 2015]. However, studies on relationship between occurrence of PMWE and background electron density has been limited yet [*Lübken et al*., 2006], partly because the PMWE occurrence rate is known to be quite low (2.9%) [*Zeller* et al., 2006].
The PANSY (Program of the Antarctic Syowa MST/IS) radar, which is the largest MST radar in Antarctica, observed many PMWE events since it has started mesosphere observations in June 2012. We established an application method of the PANSY radar as riometer, which makes it possible to estimate Cosmic Noise Absorptions (CNA) as proxy of relative variations on background electron density. In addition, electron density profiles from 60 to 150 km altitude are calculated by Ionospheric Model for the Auroral Zone (IMAZ) [*McKinnell and Friedrich*, 2007] and CNA estimated by the PANSY radar.
In this presentation, we would like to focus on strong PMWE during two big geomagnetic storm events, St. Patrick’s Day and the Summer Solstice 2015 Event, in oreder to compare observed PMWE characteristics to model background electron density. On March 19 and 22, recovery phase of St. Patrick’s Day Storm, sudden PMWE intensification was detected near 60 km by the PANSY radar. At the same time, strong Cosmic Noise Absorptions (CNA) of ~ 0.8 dB and 1.0 dB were measured, respectively. However, calculated elctron density profiles did not necessarily demonstrate high elecetron density at the altitude where the PMWE intensifications were observed. On June 22, the Summer Solstice 2015 Event, strong nighttime PMWE near 80 km was detected around 16 UT, which is equal to 19 LT at Syowa station. Since PMWE observations are primarily confined to daytime because of relatively abundant free electrons in the illuminated mesosphere, this strong and long-lived nighttime PMWE implies that EPPs related to the storm caused the sporadic ionization sufficient for PMWE even in dark mesosphere. The modeled electron density profile agreed with the occurrence of the PMWE, showing density enehancement of 10^9 - 10^{10} cm^{-3} from 60 to 80 km altitude. The difference between the above two events is thought to be caused by overestimations of CNA in St. Patrick’s Day Storm, which leads to underestimation of modeled electron density. We are going to validate CNA estimated by the PANSY radar and discuss about discrepansy between modeled elecron density and PMWE in detail.

キーワード：大型大気レーダー、中間圏、冬季極域中間圏エコー、電離圏D領域
Keywords: MST radar, Mesosphere, Polar Mesosphere Winter Echo, Ionopheric D-region

南極昭和基地SENSU SuperDARNレーダーの第IX期南極研究観測計画(2016-2023)

Antarctic Syowa station SENSU SuperDARN radars in the 9th phase of JARE Atarctic project (2016-2023)

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Syowa SENSU SuperDARN HF radars are important components of SuperDARN, the international HF radars network since 1995 and have significantly contributed to understanding not only magnetosphere-ionosphere coupling system but also MLT region dynamics. As SuperDARN radars were originally designed to reveal global polar ionospheric plasma convection patterns in both hemispheres in real time, its spatial resolution has been relatively low. As the number of new scientific targets like comparison with mid and small scale aurora phenomena, meso scale transient phenomena, elementary generation and decay process of field aligned irregularities, PMSEs and fine height profile of neutral wind has been increasing, higher spatial and temporal resolution observations have been essentially desired and of great importance. Imaging radar technique has been tried to be applied and developed to overcome these issues. We show the current status of the SENSU imaging radar system, and will discuss particularly on the scientific targets including coming JARE (Japanese Antarctic Research Expedition) project phase IX (2016-2023) and the future perspectives which can be revealed by this new technique using SuperDARN. In the phase IX JARE project. Our research group has proposed a research program to JARE project focused especially on possible grand minimum influences on geospace environment and inner magnetospheric dynamics and the detail plans including collaboration with other satellite and ground-based observation and its contribution to the project "Study of coupling processes in solar-terrestrial system" as well as the international VarSITI program will be discussed.

キーワード：SuperDARN、南極昭和基地、第IX期南極観測計画、グランドミニマム、内部磁気圏、VarSITI
Keywords: SuperDARN, Antarctic Syowa Station, Japanese Antarctic Research Expedition project phase 9, Grand minimum, inner magnetosphere, VarSITI