Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PEM06-P01 会場:3 階ポスター会場 時間:4 月 30 日 18:15-19:30

Equatorial MU Radar project
Equatorial MU Radar project

山本 衛 [1*] ; 橋口 浩之 [1] ; 津田 敏隆 [1]
YAMAMOTO, Mamoru[1*] ; HASHIGUCHI, Hiroyuki[1] ; TSUDA, Toshitaka[1]

[1] 京都大学生存圏研究所
[1]RISH, Kyoto University

Research Institute for Sustainable Humanosphere, Kyoto University (RISH) has been studying the atmosphere 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 for more than 10 years. The MU radar and the EAR are both utilized for inter-university and international collaborative research program for long time. National Institute for Polar Research (NIPR) joined EISCAT Scientific Association together with Nagoya University, and developed the PANSY radar at Syowa base in Antarctica as a joint project with University of Tokyo. These are the efforts of radar study of the atmosphere/ionosphere in the polar region. Now we can find that Japan holds a global network of big atmospheric/ionospheric radars. The EAR has the limitation of lower sensitivity compared with the other big radars shown above. RISH now proposes a plan of Equatorial MU Radar (EMU) that is to establish the MU-radar class radar next to the EAR. The EMU will have an active phased array antenna with the 163m diameter and 1055 cross-element Yagis. Total output power of the EMU will be more than 500kW. The EMU can detect turbulent echoes from the mesosphere (60-80km). 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” for Master Plan 2014 of the Science Council of Japan (SCJ). We show the EMU project and its science in the presentation.
Keywords: Atmospheric radar, ionosphere observation, Indonesia, MST radar

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(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PEM06-P02 会場:3 階ポスター会場 時間:4 月 30 日 18:15-19:30

コンフィギュラブルな大気レーダー用デジタル受信機の開発
Development of a configurable digital receiver for atmospheric radars

山本 真之 [1*] ; Gan Tong[1] ; 藤田 俊之 [1] ; Noor Hafizah Binti Abdul Aziz[1] ; 岡谷 良和 [1] ; 橋口 浩之 [1] ; 山本 衛 [1]
YAMAMOTO, Masayuki[1*] ; GAN, Tong[1] ; FUJITA, Toshiyuki[1] ; NOOR HAFIZAH BINTI, Abdul aziz[1] ; OKATANI, Yoshikazu[1] ; HASHIGUCHI, Hiroyuki[1] ; YAMAMOTO, Mamoru[1]

[1] 京都大学生存圏研究所
[1]Research Institute for Sustainable Humanosphere, Kyoto University

鉛直分解能及び角度分解能を向上させるレーダーイメージング技術の発展により、大気レーダー観測による大気不安定波の微細構造・生成メカニズムの理解が進みつつある。レーダーイメージング技術の開発をさらに進め、大気レーダーへの標準的な実装につなげるためには、安価かつ多チャンネルの受信機が必要である。また、レーダーイメージング技術の開発・実証のためには、観測要求に応じてリアルタイム信号処理を柔軟に変更できる受信機が必要である。
講演者らが開発に取り組んでいる大気レーダー用デジタル受信機は、汎用のソフトウェア無線機である Ettus Research 社製の Universal Software Radio Peripheral (USRP) とパソコンから構成されている。そのため、安価であるのみならず柔軟な信号処理の構成が可能（コンフィギュラブル）である。講演では、デジタル受信機の開発状況と開発成果を述べる。

キーワード: 大気レーダー, ウィンドプロファイラー, デジタル受信機, ソフトウェア無線技術, USRP
Keywords: atmospheric radar, wind profiler radar, digital receiver, software-defined radio technique, Universal Software Radio Peripheral (USRP)

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Statistical study of F-region field-aligned irregularities based on Equatorial Atmosphere Radar in Indonesia
Statistical study of F-region field-aligned irregularities based on Equatorial Atmosphere Radar in Indonesia

Dao Tam[1*] ; 大塚 雄一 [1] ; 塩川 和夫 [1] ; 山本 衛 [2]
DAO, Tam[1*] ; OTSUKA, Yuichi[1] ; SHIOKAWA, Kazuo[1] ; YAMAMOTO, Mamoru[2]

[1]STEL, Graduate School of Science, Nagoya University, [2]Research Institute for Sustainable Humanosphere, Kyoto University
[1]STEL, Graduate School of Science, Nagoya University, [2]Research Institute for Sustainable Humanosphere, Kyoto University

I examined the statistical characteristics of Field-Aligned Irregularities (FAIs) echoes from the F-region of Ionosphere using Equatorial Atmosphere Radar (EAR) in Indonesia during three years from 2010 to 2012. We investigated the differences between post-sunset and post-midnight FAIs. Some results are analyzed in the daily and monthly average of echo power, spectral width, and Doppler velocity. We found that post-midnight FAIs occurred mostly in summer solstices from May to August in 2010 and 2011, and only in June and July in 2012. We realized some different characteristics between post-sunset and post-midnight FAIs observed from EAR as follow. (1) Echo intensity of the post-midnight FAIs is weaker than that of post-sunset FAIs. (2) The post-sunset FAIs often exceed an altitude of 450 km, whereas the post-midnight FAIs mostly occur in a range from 200 to 450 km in F-region. (3) Spectral width of the post-midnight FAIs is smaller than that of the post-sunset FAIs. These results suggest that plasma instability operates more actively at post-sunset than at post-midnight.

キーワード: F-region Ionosphere, Field-Aligned Irregularities (FAIs), VHF radar
Keywords: F-region Ionosphere, Field-Aligned Irregularities (FAIs), VHF radar

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PEM06-P04 会場:3 階ポスター会場 時間:4 月 30 日 18:15-19:30

Statistical study of ionospheric irregularities by using Equatorial Atmosphere Radar
Statistical study of ionospheric irregularities by using Equatorial Atmosphere Radar

Martiningrum Dyah Rahayu[1*] ; 山本 衛 [1]
MARTININGRUM, Dyah rahayu[1*] ; YAMAMOTO, Mamoru[1]

[1] 京都大学生存圏研究所
[1]RISH, Kyoto University

The equatorial region is the source of many unique atmospheric processes that couple the entire atmosphere vertically from bottom to top and horizontally from equator to pole. The dynamical, electrodynamical, and electrical process of lower and upper atmosphere of equatorial region contribute to ionospheric irregularities through propagation of atmospheric waves, and magnetosphere-ionosphere interaction. Those process are responsible for the large degree of variabilities observed in the low latitude ionosphere.

Study of ionospheric irregularities was made during 2008-2013 by using 47 MHz Equatorial Atmosphere Radar (EAR) in Kototabang, Indonesia (0.20S, 100.32E; 10.36S dip latitude). Characteristic of echoes from ionospheric Field Aligned Irregularities (FAI) classified based on structure of E and F backscattered echoes power of EAR radar both of spatially and temporally. The results base on intermittent observations (2008-2010) and continuous observations (2011-2013). During the observations were obtained percentage of Equatorial Spread F (ESF) occurrences, diurnal and seasonal characteristics of ionospheric irregularities from the E region and also from F region. Furthermore, occurrence correlation between E and F region irregularities are also observed.
Keywords: Ionospheric Irregularity, Equatorial Atmosphere Radar, Statistical Study

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赤道大気上下結合研究のためのライダー観測
Lidar observations for study of coupling processes over the equatorial region

阿保 真 [1*] ; 長澤 親生 [1] ; 柴田 泰邦 [1]
ABO, Makoto[1*] ; NAGASAWA, Chikao[1] ; SHIBATA, Yasukuni[1]

[1] 首都大学東京
[1]Tokyo Metropolitan University

Stratosphere-troposphere exchange is important for the budget of ozone in the lower stratosphere as well as in the troposphere. Upward transport occurs in the tropical region (Brewer-Dobson circulation), but the exact mechanism controlling the transport is not clear. We have constructed the lidar facility for survey of atmospheric structure over troposphere, stratosphere, mesosphere and low thermosphere over Kototabang (100.3E, 0.2S), Indonesia in the equatorial region [1]. The lidar system consists of the Mie and Raman lidars for tropospheric aerosol, water vapor and cirrus cloud measurements, the Rayleigh lidar for stratospheric and mesospheric temperature measurements and the Resonance lidar for metallic species such as Na, Fe, Ca ion measurements and temperature measurements in the mesopause region. The laser system included in this lidar facility consists of three pulsed Nd:YAG lasers, a pulsed Ti:Sapphire laser seeded by a ring Ti:Sapphire laser and a dye laser. The most parts of this lidar system are remotely controlled via the Internet from Japan. The full lidar observations started from 2004. The routine observations of clouds and aerosol in the troposphere and stratosphere are continued now.

We found the top height of the stratospheric aerosol layer descend with time, synchronized with the QBO in the zonal wind. The QBO signals of the aerosol layer are noticed in the altitude range from 30 to 40 km. In addition, the tropospheric aerosol amount observed around the tropopause over Kototabang is much more than at mid-latitudes. They suspect that this is an evidence of active material exchange between the troposphere and the stratosphere over the equatorial region.

We have installed DIAL (differential absorption lidar) system for high-resolution measurements of vertical ozone profiles in the equatorial tropopause region over Kototabang, Indonesia. We will contribute to the elucidation of the climate change by getting observational information about high-resolution ozone density profiles, and the wave-propagation and material transportation using ozone as a tracer from the troposphere to the lower stratosphere over the equator.

There were many ozone DIAL systems in the world, but almost systems are optimized for stratospheric ozone layer measurement [2] or tropospheric ozone measurement [3]. Because of deep ozone absorption in the UV region, the wavelength selection is important. Simulation results show that we can measure above 20km with height resolution of 500m within 5% random error.

Acknowledgments

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キーワード: 大気上下結合, 赤道, ライダー
Keywords: coupling process, equatorial region, lidar

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Microstructure of Precipitation over Indonesia from a Network of Parsivel disdrometers

Microstructure of Precipitation over Indonesia from a Network of Parsivel disdrometers

MARZUKI, Marzuki[1*] ; HASHIGUCHI, Hiroyuki[2] ; YAMAMOTO, Masayuki[2] ; MORI, Shuichi[3] ; TAKAHASHI, Yukihiro[4]
MARZUKI, Marzuki[1*] ; HASHIGUCHI, Hiroyuki[2] ; YAMAMOTO, Masayuki[2] ; MORI, Shuichi[3] ; TAKAHASHI, Yukihiro[4]

[1]Department of Physics, Andalas University, Padang, Indonesia, [2]Research Institute for Sustainable Humanosphere (RISH) Kyoto University, Gokasho, Uji, Kyoto 611-001, [3]Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Japan, [4]Hokkaido University, Sapporo, Japan
[1]Department of Physics, Andalas University, Padang, Indonesia, [2]Research Institute for Sustainable Humanosphere (RISH) Kyoto University, Gokasho, Uji, Kyoto 611-001, [3]Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Japan, [4]Hokkaido University, Sapporo, Japan

Insight into the regional variability of raindrop size distribution (DSD), is of primary importance for estimation of rainfall using remote sensing techniques, cloud/precipitation microphysical processes and numerical weather modeling. In order to quantify the regional variability of the DSD over Indonesia, a network of 4 Parsivel disdrometers along equatorial Indonesia has been designed. The disdrometers were installed at Kototabang (KT; 100.32E, 0.20S), Pontianak (PT; 109.37E, 0.00S), Manado (MN; 124.92E, 1.55N) and Biak (BK; 136.10E, 1.18S). It was found that the DSD at PT has more large drops than at the other three sites. The DSDs at the four sites are influenced by both oceanic and continental systems, and majority of the data matched the maritime-like DSD that was reported in a previous study. Continental-like DSDs were somewhat dominant at PT and KT. The combination of World Wide Lightning Location Network, wind profiler and the Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) allows a discussion on physical basis behind the regional variability of DSD over Indonesia.

キーワード: Indonesia, Parsivel, Raindrop
Keywords: Indonesia, Parsivel, Raindrop

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EISCAT_3D による極域下部熱圏大気の研究
Feature studies of the polar lower thermosphere by EISCAT_3D

野澤 悟徳 [1*]
NOZAWA, Satonori[1*]

[1] 名古屋大学太陽地球環境研究所
[1]STEL, Nagoya University

The new EISCAT_3D radar will give us with great opportunities. Its 3D volumetric observations of ion velocity will provide high quality neutral wind data in the lower thermosphere. Furthermore, its continuous observations will make it possible to study planetary waves in the lower thermosphere in more detail as well as day-to-day variabilities of tides. In this talk, we will describe our future study targets.

The lower thermospheric wind dynamics has been paid great attention for several decades to understand the Magnetosphere-Ionosphere-Thermosphere coupling, since the neutral atmosphere plays a key role. In particular, it has been an issue how the lower thermosphere will response to the solar wind energy input. IS radar measurements of the polar lower thermosphere begun about 40 years ago by a pioneer work of Brekke et al. [JGR, 78, 8235, 1973], and significant number of studies have been conducted since then. However, our understanding of the lower thermosphere is still limited. One of reasons is that the lower thermosphere is significantly influenced by atmospheric waves propagating from below. Thus, the day-to-day variability is very prominent. Owing to high running cost, long term datasets are hard to be obtained by IS radar a decade ago. In 2007-2008, EISCAT Svalbard radar was operated almost continuously for 1 year. However, only about 20% of the data sets can be used for deriving the ion velocity vector. If we have wind velocity datasets on daily basis like meteor and MF radars usually made for the mesospheric wind measurements (70-100 km), our understanding of the lower thermosphere wind dynamics will be much more progressed. EISCAT_3D will make it possible.

Furthermore, the EISCAT_3D radar will give us higher temporal resolution data sets of neutral winds in the lower thermosphere with multi volumes. The observations will allow us to distinguish the temporal and spatial variations of winds. One of scientific targets is to investigate wind variations nearby the auroral arc in the E-region. By combining sodium and Rayleigh LIDARs as well as meteor and MF radars, which provide neutral temperature and wind velocity, respectively, we expect we can investigate dissipation process of gravity waves in more details as well as effects of auroral precipitation on the middle atmosphere.

キーワード: EISCAT_3D, 極域電離圏, 下部熱圏, プラネタリー波, 大気潮汐波, 大気重力波
Keywords: EISCAT_3D, polar ionosphere, lower thermosphere, planetary wave, tidal wave, gravity wave

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EISCAT 3D による惑星非熱的電波観測
Observation of non-thermal planetary radio emissions with EISCAT 3D

土屋 史紀 [1*] ; 三澤 浩昭 [1]
TSUCHIYA, Fuminori[1*] ; MISAWA, Hiroaki[1]

[1] 東北大学
[1]Tohoku University

EISCAT 3D is developing as incoherent scatter radar to study the terrestrial ionosphere and atmosphere. Due to large aperture area and low noise temperature of the receiving system of EISCAT 3D and the uniqueness of the receiving frequency of 233 MHz, it can also be a useful tool to study non-thermal radio emissions from the solar system planets. In this paper, feasibility and advantage of EISCAT 3D for observing non-thermal planetary radio emissions are presented. Following topics will be discussed. (1) Time variability of Jovian synchrotron radiation, (2) Radio emissions from lightning discharges occurred in the atmospheres of Mars and Saturn, and (3) Recent trials to detect incoherent radio emissions from extra-solar planets.

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PEM06-P09 会場:3 階ポスター会場 時間:4 月 30 日 18:15-19:30

EISCAT_3D プロジェクトへの応用に向けた一般化オーロラトモグラフィの数値シミュレーション
Numerical simulation of Generalized Auroral Computed Tomography toward its application to the EISCAT_3D project

田中 良昌[1*] ; 小川 泰信[1] ; 門倉 昭[1] ; Gustavsson Bjorn[2] ; 麻生 武彦[3] ; Brandstrom Urban[4] ; 宮岡 宏[1] ; 上野 玄太[5] ; 才田 聡子[6]
TANAKA, Yoshimasa[1*] ; OGAWA, Yasunobu[1] ; KADOKURA, Akira[1] ; GUSTAVSSON, Bjorn[2] ; ASO, Takehiko[3] ; BRANDSTROM, Urban[4] ; MIYAOKA, Hiroshi[1] ; UENO, Genta[5] ; SAITA, Satoko[6]

[1] 国立極地研究所, [2] トロムソ大学, [3] 総合研究大学院大学, [4] スウェーデン宇宙物理研究所, [5] 統計数理研究所, [6] 情報・システム研究機構
[1]National Institute of Polar Research, [2]University of Tromso, [3]The Graduate University for Advanced Studies (Sokendai), [4]Swedish Institute of Space Physics, [5]The Institute of Statistical Mathematics, [6]Research Organization of Information and Systems

The EISCAT_3D is a next-generation phased-array incoherent scatter radar, which is capable of measuring three-dimensional (3D) ionospheric plasma parameters at ten-times higher temporal and spatial resolution. Thus, it is expected that the EISCAT_3D will provide new insights into auroral physics. On the other hand, optical imaging observation will be still useful for studying the auroral dynamics, because high-sensitivity camera can generally measure horizontal 2D distribution of the aurora at higher temporal resolution than the radars. We demonstrate by numerical simulation how useful monochromatic auroral images taken at multi-point camera network are for the study of aurora dynamics in the EISCAT_3D project. We apply the generalized - aurora computed tomography (G-ACT) to simulated observational data from real instruments, that is, the Auroral Large Imaging System (ALIS) and the EISCAT_3D radar. The G-ACT is a method to reconstruct three dimensional (3D) distribution of auroral emission and ionospheric electron density (corresponding to horizontal 2D distribution of energy spectra of precipitating electrons) from multi-instrument data. It is assumed that a core site of the EISCAT_3D radar is located at Skibotn (69.35N, 20.37E), Norway, and scans an area of 0.8 degrees in geographic latitude and 3 degrees in longitude at 130km altitude with 21x21 beams. Two neighboring discrete arcs are assumed to appear in the observation region of the EISCAT_3D radar. The reconstruction results from the G-ACT are compared with those from the normal ACT as well as those from only the electron density observed by the EISCAT_3D radar. It is found that the G-ACT can interpolate the ionospheric electron density at much higher spatial resolution than the original one observed by the EISCAT_3D radar. Furthermore, the multiple arcs reconstructed by the G-ACT are more precise than those by the normal ACT. Even for the case that the reconstruction by the ACT is difficult due to unsuitable location of the camera sites relative to the discrete arcs and/or a small number of available images, the G-ACT allows us to achieve the reconstruction.

キーワード: オーロラトモグラフィ, EISCAT_3D, シミュレーション, 多点カメラ観測
Keywords: aurora computed tomography, EISCAT_3D, simulation, multi-point camera observation

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Na ライダー/EISCAT レーダー連携観測によって検出したオーロラ起因の Na 層変動
Aurora-induced sodium layer variation detected by coordinated observation with sodium lidar and EISCAT radar

津田 卓雄 [1*] ; 野澤 悟徳 [2] ; 川原 琢也 [3] ; 川端 哲也 [2] ; 斎藤 徳人 [4] ; 和田 智之 [4] ; 小川 泰信 [1] ; 大山 伸一郎 [2] ; Hall Chris[5] ; 堤 雅基 [1] ; 江尻 省 [1] ; 鈴木 臣 [2] ; 高橋 透 [2] ; 中村 卓司 [1]
TSUDA, Takuo[1*] ; NOZAWA, Satonori[2] ; KAWAHARA, Takuya[3] ; KAWABATA, Tetsuya[2] ; SAITO, Norihito[4] ; WADA, Satoshi[4] ; OGAWA, Yasunobu[1] ; OYAMA, Shin-ichiro[2] ; HALL, Chris[5] ; TSUTSUMI, Masaki[1] ; EJIRI, Mitsumu K.[1] ; SUZUKI, Shin[2] ; TAKAHASHI, Toru[2] ; NAKAMURA, Takuji[1]

[1] 国立極地研究所, [2] 名古屋大学太陽地球環境研究所, [3] 信州大学工学部, [4] 理化学研究所, [5] トロムソ大学
[1]National Institute of Polar Research, [2]Solar-Terrestrial Environment Laboratory, Nagoya University, [3]Faculty of Engineering, Shinshu University, [4]RIKEN, [5]University of Tromsoe

Sodium atom layer is generally distributed at 80-100 km. One of mysterious subjects on high-latitude sodium layers is relationship between auroral particle precipitation and sodium atom layer variation. A previous study suggested a sodium column density decrease during a geomagnetic active period due to that the particle precipitation accompanied by electron density enhancement could induce ionization of sodium atom through their ion-molecule chemistry. Another study pointed a possibility of sodium density increase. For this reason, it is suggested that auroral precipitating particle bombardment on meteoric smoke particles can sputter sodium atoms from the smoke particles. On the other hand, ionospheric electric field, which may become more significant near auroral precipitating regions, could induce ion motions (i.e. can generate sodium ion convergence and/or divergence), and then also could affect generation and/or loss processes of sodium atoms through their ion-molecule chemistry. Thus, for the examination of the causality, it is vitally important to distinguish the effects of auroral particle precipitation and ionospheric electric field. Using a sodium lidar (which was installed in early 2010) and European incoherent scatter (EISCAT) radar at Tromsoe, Norway (69.6N, 19.2E), we have investigated, for the first time, that the actual effect of the particle precipitation to the sodium density variations without electric filed injection. In the nighttime observation on 24-25 January 2012, we detected a significant decrease of sodium atom density coincied with electron density enhancements (implying strong particle precipitations) and low ion temperatures (implying no electric field injections). These results strongly suggested that auroral particle precipitations induced sodium atom density decrease. Furthermore we discuss observed time response in the sodium density decrease.

キーワード: Na ライダー, EISCAT レーダー, Na 層, オーロラ降下粒子, 電離圏電場
Keywords: Na lidar, EISCAT radar, Na layer, Auroral particle precipitation, Ionospheric electric field

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The spatial and temporal evolution of equatorial plasma bubble observed using ground based GPS TEC measurement.

The spatial and temporal evolution of equatorial plasma bubble observed using ground based GPS TEC measurement.

M BUHARI, Suhaila[1*] ; ABDULLAH, Mardina[2] ; HASBI, Alina marie[3] ; OTSUKA, Yuichi[4] ; NISHIOKA, Michi[5] ; TSUGAWA, Takuya[5]
M BUHARI, Suhaila[1*] ; ABDULLAH, Mardina[2] ; HASBI, Alina marie[3] ; OTSUKA, Yuichi[4] ; NISHIOKA, Michi[5] ; TSUGAWA, Takuya[5]

[1]Physics Department, Universiti Teknologi Malaysia, [2]Space Science Centre, Universiti Kebangsaan Malaysia, [3]Department of Electrical, Electronics & Systems Engineering, Universiti Kebangsaan Malaysia, [4]Solar-Terrestrial Environment Laboratory, Nagoya University, [5]National Institute of Information and Communications Technology
[1]Physics Department, Universiti Teknologi Malaysia, [2]Space Science Centre, Universiti Kebangsaan Malaysia, [3]Department of Electrical, Electronics & Systems Engineering, Universiti Kebangsaan Malaysia, [4]Solar-Terrestrial Environment Laboratory, Nagoya University, [5]National Institute of Information and Communications Technology

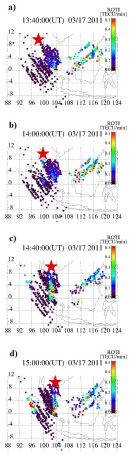
The equatorial plasma bubble (EPB) commonly occurs near the equatorial region after post sunset period. The generation process of EPB has been well understood where it is commonly developed near the magnetic equator and elongated along magnetic field lines through Rayleigh-Taylor instability mechanism. However, the source of seeding perturbation leads to the generation of Rayleigh-Taylor instability is still unknown. The temporal and spatial properties of EPB have been well studied using airglow imager. However, the observation using airglow imager is impossible during sunset time where the EPB starts to develop due to light from the sun while the observation during night time is always interfered by moon and clouds.

In this study, we obtain the GPS data from Malaysia Real-Time Kinematics GNSS Network (MyRTKnet), International Ground Station (IGS) network and Sumatera GPS Array (SUGAR) network. The networks contains 127 receivers in South East Asia (SEA) region covers 8^{o}N to -8^{o}S latitude and 92^{o}E to 120^{o}E longitude geographic coordinates. In this study, we detected the structure of EPB using two-dimensional map of rate of TEC index (ROTI) calculated from ground based GPS TEC measurement in. The average ROTI value for all visible satellites at 300 km altitude is binned into 0.45^{o} x 0.45^{o} grid in geographic latitude and longitude. The advantage of this technique is the GPS data is always available and we are able to observe the spatial and temporal properties of EPBs continuously without distracted by light.

On the 17th March 2011, we observed the appearance of EPB structure pass through the SEA territory for 5 hours from 1300 UT (2100 LT) - 1900 UT (0200 LT). The initial ROTI-enhancement region is at 1300 UT is propagating to eastward direction and the information of the structure is lost due to the limited coverage of GPS receiver. At 1340 UT, a new ROTI-enhancement region appeared as a point source at geographic coordinate 2^{o}N and 98^{o}E as shown in Figure (a). After 20 minutes, the point source of ROTI-enhancement region expand to ˜600 km in the North and ˜200 km South direction as shown in Figure (b) while the zonal size ˜50 km remains the same. The perturbation region is expanding faster towards dip magnetic equator might associated with field-aligned irregularities. The structure travelled in eastward direction with velocity ˜133 ms^{-1} until the development process stopped. After 60 minutes, we assumed the structure is fully developed as illustrated in Figure (c) when no development in zonal size and ROTI value is observed anymore. The developed structure has 200 km zonal size continuously moves to eastward directions with slower velocity ˜111 ms^{-1}. The slower velocity incidentally with no development in zonal size and ROTI value might indicates the ”fossil” bubble where the plasma density is equal with background density and the structure velocity following the background plasma density. At 1440 UT the second structure is coming ˜600 km away from the first structure with velocity ˜111 ms^{-1} and zonal size 200 km same as the previous structure as shown in Figure (d). The first and second structure has the same zonal sizes and velocities might due to the same temporal and spatial evolution during the generation process.

The two-dimensional structure of EPB has been presented using GPS networks in SEA region is an alternative tool to observe the temporal and spatial properties of EPB structure from the initial perturbation until the decaying process without being distracted by light. The temporal and spatial properties of EPB can contribute towards understanding the generation mechanism of the Rayleigh-Taylor instability process.

キーワード: equatorial plasma bubble, rate of TEC index, GPS TEC measurement
Keywords: equatorial plasma bubble, rate of TEC index, GPS TEC measurement



Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PEM06-P12 会場:3 階ポスター会場 時間:4 月 30 日 18:15-19:30

Relationship between Latitudinal Extension of Scintillation and Pre-reversal Enhancement in the Southeast Asian Region

Relationship between Latitudinal Extension of Scintillation and Pre-reversal Enhancement in the Southeast Asian Region

Abadi Prayitno[1*] ; 大塚 雄一 [2] ; Husin Asnawi[1] ; Jiyo Jiyo[1] ; 山本 衛 [3] ; 津田 敏隆 [3]
ABADI, Prayitno[1*] ; OTSUKA, Yuichi[2] ; HUSIN, Asnawi[1] ; JIYO, Jiyo[1] ; YAMAMOTO, Mamoru[3] ; TSUDA, Toshitaka[3]

[1] インドネシア航空宇宙庁, [2] 名古屋大学太陽地球環境研究所, [3] 京都大学生存圏研究所
[1]National Institute of Aeronautics and Space (LAPAN), [2]STEL, Ngoya University, [3]RISH, Kyoto University

We have investigated the relationship between the maximum latitude extension of observed scintillations (Lmax) and the maximum altitude of the equatorial F-region bottomside (h'Fmax), peak of eastward electric field (Emax), and time duration of eastward electric field (TE) during PRE period in the equatorial region. We used three GPS receivers installed in Kototabang (0.2S, 100.3E; 10.0N magnetic latitude), Pontianak (0.02S, 109.3E; 8.9S magnetic latitude), and Bandung (6.9S, 107.6E; 17.5S magnetic latitude), Indonesia for observing scintillation activity in period 18.00-22.00 LT (LT=UT+7h) and two frequency modulated-continues wave (FM-CW) ionosondes installed near equator magnetic, Chumphon (10.7N, 99.4E; 3.3N magnetic latitude), Thailand and Bac Lieu (9.3N, 105.7E; 1.7N magnetic latitude), Vietnam for measuring PRE parameters, such as h'F, vertical drift (dh'F/dt) which indicates eastward electric field, and TE. Our observation period is during equinox months (March, April, September, and October) in 2010, 2011, and 2012. We divide the relationships into two groups; 1) the relationships between PRE parameters obtained from Chumphon ionosonde and Lmax observed by Kototabang and Bandung GPS receivers and 2) PRE parameters obtained from Bac Lieu ionosonde and Lmax observed by Pontianak and Bandung GPS receivers. The following table is to show the coefficient correlation (R) of the relationships for each group. The results indicate that duration of eastward electric field does not play an important role for extension of the plasma bubble or latitudinal extension of scintillation, and that the peak of h'F and magnitude of E at the initial phase of plasma bubble generation (PRE period) is a primary factor for the plasma bubble extension. Therefore, the maximum latitude of scintillation is determined at the initial phase of plasma bubble generation (PRE period) in the equatorial region.

Relationship	R (group 1)	R (group 2)
h'Fmax vs Lmax	0.596	0.471
Emax vs Lmax	0.489	0.270
TE vs Lmax	0.054	0.090

Keywords: Ionosphere, Scintillation, Pre-reversal enhancement

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0.1-40kHz 帯電磁波観測に基づいた海洋大陸における落雷の位置推定
Geolocation of lightning discharge in the Maritime Continent based on radio observation in 0.1-40 kHz band

山下 幸三 [1*] ; 大矢 浩代 [2] ; 高橋 幸弘 [3] ; 土屋 史紀 [4] ; 松本 淳 [5]
YAMASHITA, Kozo[1*] ; OHYA, Hiroyo[2] ; TAKAHASHI, Yukihiro[3] ; TSUCHIYA, Fuminori[4] ; MATSUMOTO, Jun[5]

[1] サレジオ工業高等専門学校, [2] 千葉大学, [3] 北海道大学, [4] 東北大学, [5] 首都大学東京
[1]Salesian Polytechnic, [2]Chiba University, [3]Hokkaido University, [4]Tohoku University, [5]Tokyo Metropolitan University

Recent researches based on observation and data assimilation of lightning discharge indicate a possibility of now-cast and forecast of severe weather such as torrential rain. In these works, lightning data is focused on as a proxy for the presence or absence of deep convection which generates thunderstorm.

In previous works, occurrence of cloud-to-ground (CG) lightning discharges has been mainly used due to the ease of data availability. However, lighting observation based on electromagnetic measurement shows that there is extremely huge scale lightning whose scale is more than hundreds times bigger than that of averaged event. Lightning data including ″ occurrence ″ and ″ scale ″ enable us to evaluate not only existence but also intensity of atmospheric convection. Quantitative evaluation of atmospheric convection would make it possible to make a now-cast and forecast for intensity distribution of precipitation.

The Maritime Continent (MC) is one of the most important regions for lightning observation in the world. Thunderstorm activity causes enormous human and economic damage to countries in MC. However, until now, only few statistical studies on the lightning activity with scale information of lightning discharge have been done.

In this works, lightning observation network in the MC based on electromagnetic measurement in 0.1-40 kHz band is summarized. This network is developed to estimate not only spatial distribution but also scale one of lightning discharges. We have already constructed observation stations at Tainan in Taiwan (23.1N, 121.1E), Saraburi in Thailand (14.5N, 101.0E), Pontianak in Indonesia (0.0N, 109.4E), Los Banos in Philippines (14.2N, 121.25E) and Son Tay in Viet Nam (21.1N, 105.5E). Data obtained by multipoint observation is synchronized by GPS receiver installed at each station.

At the presentation, we show evaluation of accuracy for geolocation and detection efficiency of signal radiated from lightning discharge based on comparisons with World Wide Lightning Location Network (WWLLN) data.

Keywords: lightning discharge, thunderstorm, severe weather, VLF, the Maritime Continent

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衛星電波の大気伝搬特性を利用 した小型低軌道衛星ミッション に関する研究
A study on a low Earth orbit (LEO) satellite mission using radio propagation characteristics

竹田 悠二 [1*] ; 津田 敏隆 [1]
TAKEDA, Yuji[1*] ; TSUDA, Toshitaka[1]

[1] 京都大学生存圏研究所
[1]Research Institute for Sustainable Humanosphere, Kyoto University

本研究では、L バンドと Ka バンドの電波による大気伝搬特性を利用した、新たな小型低軌道 (LEO: Low Earth orbit) 衛星ミッションの検討を行う。特に、GPS 電波掩蔽法を用いることにより気温・水蒸気・電子密度等の高度プロファイルをラジオゾンデと同程度の高い分解能で観測することを考える。また Ka バンドを利用によって、雲の含水量、及び水蒸気量を測定する放射計計測についても検討を行う。

GPS 電波掩蔽法では、受信機を搭載した LEO 衛星から見て電波の発信源となる衛星が、地球によって掩蔽される際、地球大気を掠めて伝播してくる電波を LEO 衛星で受信する。この時、伝播経路の屈折による遅延が起こるが時間とともに衛星同士の幾何学的配置が変化し、電波が通過する大気層の厚さが変わるにしたがい、遅延量が変化する。この遅延量を正確に測ることにより大気情報を測定する。しかし、従来は GPS 衛星のみが、電波掩蔽観測に用いられてきたが、GPS 衛星のみではなく他の GNSS(GLONASS、Galileo、北斗、QZSS) および通信衛星である O3b をこの電波掩蔽観測に用いることにより掩蔽観測によるデータ取得の空間密度、および時間密度の増加を図る。

本研究で LEO 衛星による大気観測手法の提案をおこなうにあたり GNSS による掩蔽観測のデータ分布について検討する。このデータ分布は、LEO 衛星、各 GNSS 衛星の相対的な位置によって決まるので、時間的にも空間的にも非常に広範囲にちらばる。よって効率の良いミッションを提案するために、数値モデルによってデータ分布を調査し、LEO 衛星の軌道決定、アンテナ設計等を行った。数値モデルによると、GPS のみを使った電波掩蔽に比べ、他の GNSS および O3b 衛星を電波掩蔽観測に用いれば、データ数は約 3 倍になり、非常に有用であることがわかった。経度に対するデータ分布は、LEO 衛星の軌道に影響を受けず一様になるのに対し、緯度に対するデータ分布は LEO 衛星の軌道傾斜角に影響を受けることがわかった。ローカルタイムに対するデータ分布は、LEO 衛星の軌道傾斜角および昇交点赤経によって決められることも示した。

また本研究では Ka バンドの電波を用いる O3b 衛星を利用するのだが、Ka バンドは L バンドの約 10 倍周波数が高い。GPS 電波掩蔽では、L バンドの電離層における遅延により、温度を測定することが出来る高度限界は約 50km となっているが、周波数が高いほど電離層での影響を受けにくいため Ka バンドによる電波掩蔽では高度限界の上昇が期待できる。さらに、電波が大気中を伝搬す際、その経路上で酸素や水蒸気、雲によって電界強度が減衰するのだが O3b で用いられる Ka バンドのダウンリンク付近では水蒸気および雲による減衰は L バンドと違い大きく、酸素による減衰ではなく水蒸気、雲による減衰が支配的になる。よって、LEO 衛星によって O3b の電波を受信する際、ダウンリンク内の異なる周波数の電波の、雲と水蒸気の減衰よって生じる信号強度の差の測定から雲の含水量、および水蒸気量を求めることが期待できる。

キーワード: GPS 電波掩蔽, 小型低軌道衛星, 全地球航法衛星システム, Ka バンド
Keywords: GPS radio occultation, Low Earth orbit satellite, Global Navigation Satellite System, Ka-band