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

PEM36-01 Room:312 Time:April 28 09:00-09:15

Effect of Surface BRDF on the Geostationary and Low Orbit Observations of Tropospheric NO_2

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We investigated the effect of surface reflectance anisotropy, Bidirectional Reflectance Distribution Function (BRDF), on geostationary and low orbit satellites' retrievals of tropospheric NO_2. We first develop an empirical model of the three BRDF coefficients for each land cover type over Tokyo, and then apply the model to the calculation of land cover type dependent AMFs and BAMFs. Results show that the variability of AMF among the land types is up to several tens percent, and if we neglect the reflectance anisotropy, the difference from BRDF's AMF reaches 10% or more. The evaluation of the BAMFs calculated shows that not to consider variations in BRDF will cause large errors if the concentration of NO_2 is high close to the surface, although the importance of BRDF for AMFs decreases for large AOD.

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PEM36-02 Room:312 Time:April 28 09:15-09:30

R&D of passive radar -Water vapor estimation with digital terrestrial broadcasting wave-

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In general, radars retrieve some information by transmitting radio waves and by receiving their scatted echoes. On the other hand, passive radars never transmit radio waves. They retrieve some information by receiving radio waves which are transmitted by others for other purposes. Passive radars do not need new radio wave frequencies, and just consist of rather simple and low cost receivers because they do not transmit radio waves. We, National Institute of Information and Communications Technology (NICT), are developing passive radar measurement systems whose targets are environmental monitoring.

In this study, we are developing a water vapor measurement system using digital terrestrial broadcasting wave as one of passive radars. Localized heavy rain in the urban area is a social issue in these days. Water vapor is an essential parameter for weather forecast because it is a state before rain drop. And it is one of the most difficult physical quantity to measure with remote sensing technique. If we can monitor water vapor around the ground surface with precise time and spacial resolutions, the weather forecast might be able to predict the localized heavy rain.

Radio waves are delayed due to water vapor through propagation. If we can measure this time delay, water vapor can be retrieved from it. Since delay doe to water vapor is quite small, very precise (sub-nano second order) measurements are needed. Radio waves used for digital terrestrial broadcasting are modulated with OFDM, and known signals are embedded. Complex delay profiles are calculated using these known signals. Using the phase of delay profile, we can measure propagation delay with precise accuracy (pico-second order).

When we consider the accuracy with order of sub-nano seconds, phase fluctuations of local oscillators at radio tower and receivers are essential error factors. We have developed a real-time delay (phase of delay profiles) measurement system with software-defined radio technique. Using this system, we can also measure phase fluctuations of local oscillator at each TV station by just receiving radio waves. With these systems at two receiving points on the same line including the radio tower, and with synchronization between their local oscillators, we can measure water vapor between two receiving points. After proving test of estimation of water vapor, we will distribute many small receivers and develop water vapor monitoring system in collaboration with many observations and data assimilations.

Keywords: passive radar, digital terrestrial broadcasting wave, water vapor, propagation delay

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PEM36-03 Room:312 Time:April 28 09:30-09:45

Observation of local circulation in north area of Fukui prefecture by using two adjoining 1.3-GHz wind profiler radars

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Global impact of our lifestyle to our own has been pointed out previously. In the field of atmospheric environment, it has been considered that heavy rainfall, of which occurrence and damages are increasing in recent years, to be related with global warming. In addition to influence of yellow dust and PM 2.5 on our health, it has been known that photochemical oxidant tends to increase again since 1980's. Furthermore, the severe accident of Fukushima Daiichi Nuclear Power Station has caused us the interest about diffusion of radioactivity.

Above atmospheric problems are not only global but also local because they are strongly affected by local circulation. Local circulation occurs in atmospheric boundary layer (ABL) which has different characteristics in each local area, therefore, it is essential to reveal the detailed characteristics of ABL for resolution of the atmospheric problems.

Under such a situation, Fukui University of Technology started a project named as "Formation of research base for measurement and conservation of environment in Hokuriku area" (H23 - H27) supported by MEXT. In the project, a 1.3-GHz wind profiler radar (FUT-WPR), which is same type atmospheric radar as that of JMA WINDAS network, was installed in the coastal area of northern part of Fukui prefecture in 2012. In Fukui prefecture, a WPR of WINDAS has worked at Fukui local meteorological observatory (WINDAS-FUKUI), and the distance between FUT-WPR and WINDAS-FUKUI is only 24 km. There is no area in Japan where two WPRs are located within such a short distance, which enables more detailed study of the local circulation in Fukui plain than previous studies.

The observation results of FUT-WPR have revealed the detailed characteristics of see and land breeze (SLB) which is well known local circulation in coastal areas; its temporal variation, structure in altitude, relation with ABL, occurrence probability, and effect on generating area of clouds. Especially, the comparison with WINDAS-FUKUI not only confirms the observation results by FUT-WPR but also shows the SLB reaches from the seashore to a few 10 km inland. Although the observation results are fundamental in meteorology, this is the first time that the real picture of SLB in Fukui plain was revealed in detail so far. The comparison with WINDAS-FUKUI also shows the horizontal winds under about 1 km in altitude often differs between FUT-WPR and WINDAS-FUKUI, which indicates the importance of measurement of ABL.

We also carried out the data analyses in the case of heavy rain. On September 3 in 2013, passage of the stationary front accompanying the typhoon No. 17 brought about the heavy rain reaching to 10 mm/10min in Fukui prefecture from 14:00 to 16:00 (JST). FUT-WPR observed not only a typical structure and temporal variation of horizontal wind followed by the passage of stationary front but also intermittent upward flow, of which velocity reaches 1 m/s in the altitude from 200 m to about 4 km, from 7 hours before the passage of front. Especially, a strong upward flow with the velocity of 4 m/s was observed around 12:00 in the altitude from 3.5 to 5 km although the duration was relatively short. The observations of MTSAT from 10:00 to 14:00 have shown that optically thick clouds, of which top altitude was estimated to reach about 10 km, had arrived over Fukui prefecture. Therefore, the upward flows observed by FUT-WPR should be a part of cumulonimbi system which brought about the heavy rain. On the other hand, upward flows observed by WINDAS-FUKUI was weaker than that of FUT-WPR, which indicates the horizontal scale of upward flow accompanying the cumulonimbi system was under 24 km at least.

The results of observations and data analyses obtained so far indicates the observation of ABL by adjoining WPRs will be useful in early detection of arriving cumulonimbi system or local weather prediction.

Keywords: atmospheric boundary layer, local circulation, see and land breeze, heavy rain, wind profiler radar

Japan Geoscience Union Meeting 2014
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PEM36-04 Room:312 Time:April 28 09:45-10:00

Relationship between solar activity and disturbance in the middle atmosphere during Arctic winter

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Purpose of this research is to clarify relationship between solar activity and disturbance in the middle atmosphere during Arctic winter. In this research we consider stratospheric sudden warming (SSW), which is typical phenomenon in Arctic winter, as disturbance in the middle atmosphere including the mesosphere. Previous research reported effect of 11-year solar cycle on thermal structure only in the Stratosphere.

To get thing started, we selected daily bottom altitude of easterly wind area, which corresponds to SSW, in the zonal mean horizontal wind. Averaged value of those during one SSW event is used for quantitative comparison with solar activity and QBO index. No clear relationship was found between the selected new value (ZEW index) and two indexes. However we confirm that the ZEW index represents well the degree of disturbance. Next, we calculate AO index in the altitude range from 1000 hPa to 0.1 hPa (65km alt). AO index also represents the degree of disturbance.

In this presentation, we will examine and discuss in more detail about ZEW and AO index as those which indicate the degree of disturbance in the middle atmosphere for quantitative comparison with solar activity.

Keywords: Middle atmosphere disturbance, Solar activity, Arctic Oscillation, QBO, Arctic region, Stratospheric sudden warming

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PEM36-05 Room:312 Time:April 28 10:00-10:15

Temporal variations of O3 and NO in the middle atmosphere above Syowa Station observed by a millimeter-wave radiometer

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Precipitation of energetic particle into the atmosphere impacts abundances of atmospheric constituents in the middle atmosphere. Highly energetic solar protons, which directly enter the middle atmosphere, cause increase of HOx and NOx species. Energetic electrons also increase NOx in the thermosphere, and the downward transport in the polar vortex moves the produced NOx to lower altitudes. These NOx species cause a decrease of O_3 in the middle atmosphere through catalytic reactions [Seppälä et al. 2006; Daae et al., 2012]. To investigate the effect of NOx on O_3 variation in the polar region, a ground-based millimeter-wave spectroscopic radiometer was installed at Syowa Station, Antarctica in March 2011. The instrument has recorded brightness temperature spectra of rotational emission from the atmospheric O_3 and NO molecules. From the NO spectra, both multiple short-term enhancements and seasonal variation of NO column are observed [Isono et al., 2014]. The short-term enhancements are correlated with the energetic particle precipitation. In the present study, O_3 profiles are retrieved from the brightness temperature spectra between 238.94-239.24 GHz, whose spectral range has sensitivity to the O_3 abundance between 20 and 70 km. The optimal estimation scheme is used for the O_3 profile retrieval, along with radiative transfer calculation through the use of the NCEP reanalysis data and spectroscopic parameters. Since the O_3 spectra are integrated over 1 hour every 6 hours, we usually derive four O_3 profiles in a day. We present the result of O_3 retrieval and discuss how the O_3 mixing ratios at given altitudes response to the short-term NO column enhancement.

Keywords: ozone, nitric oxide, remote sensing

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

PEM36-06 Room:312 Time:April 28 10:15-10:30

Current status of Syowa lidar project in the prioritized observation project for VIII-th term JARE

EJIRI, Mitsumu K.[1*] ; TSUDA, Takuo[1] ; NISHIYAMA, Takanori[1] ; ABO, Makoto[2] ; TOMIKAWA, Yoshihiro[1] ; SUZUKI, Hidehiko[3] ; KAWAHARA, Takuya[4] ; TSUTSUMI, Masaki[1] ; NAKAMURA, Takuji[1]

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The National Institute of Polar Research (NIPR) is leading a six year prioritized project of the Antarctic research observations since 2010. One of the sub-project is entitled ”the global environmental change revealed through the Antarctic middle and upper atmosphere”. Profiling dynamical parameters such as temperature and wind, as well as minor constituents is the key component of observations in this project, together with a long term observations using existent various instruments in Syowa, Antarctica (69S, 39E). As a part of the sub-project, Rayleigh/Raman lidar was installed at Syowa Station in January, 2011 and has been operated at more than 350 nights (>3000 hours clear sky) by February, 2014. The Rayleigh/Raman lidar observes temperature and clouds in the mesosphere, the stratosphere and part of the troposphere, and providing seasonal and yearly variations of temperature profiles and data of gravity wave characteristics in the middle atmosphere, as well as high altitude clouds of PMC (polar mesospheric clouds) and PSC (polar stratospheric clouds). In order to extend the height coverage to include mesosphere and lower thermosphere region, and also to extend the parameters observed, a new resonance scattering lidar system with tunable wavelengths is developed at NIPR in Tachikawa (36N, 139E). The lidar transmitter is based on injection-seeded, pulsed alexandrite laser for 768-788 nm (fundamental wavelengths) and a second-harmonic generation (SHG) unit for 384-394 nm (second harmonic wavelengths). The laser wavelengths are tuned in to the resonance wavelengths by a wavemeter that is well calibrated using a wavelength-stabilized He-Ne laser. The new lidar has capabilities to measure density variations of minor constituents such as atomic iron (Fe, 386 nm), atomic potassium (K, 770 nm), calcium ion (Ca^+, 393 nm), and aurorally excited nitrogen ion ($N_2{}^+$, 390-391 nm) and temperature profiles in the mesosphere and lower thermosphere (MLT) region using resonance scatter of K. Currently, the fundamental laser pulses are transmitted with 120-160 mJ/pulse at approximately 25 Hz (i.e., $\sim$3-4 W) and the backscattered signal is received with a 35 cm diameter telescope. The new lidar system will be installed two years later at Syowa Station and provide information on the mesosphere and lower thermosphere as well as the ionosphere. This unique observation is expected to make important contribution to studies on the atmospheric vertical coupling process and the neutral and charged particle interaction. In this talk, current status of the research, observations, and system developments, as well as future plans will be presented.

Keywords: Lidar, Antarctic observation, middle and upper atmosphere, Resonance scattering, Rayleigh scattering, Raman scattering

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PEM36-07 Room:312 Time:April 28 10:30-10:45

A daytime observation of polar mesospheric clouds with Syowa Rayleigh Raman lidar system equipped with a new etalon unit

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A Rayleigh/Raman lidar system has been operated by the Japanese Antarctic Research Expedition (JARE) since February, 2011 (JARE 52nd) in Syowa Station Antarctica (69.0S, 39.5E). Polar Mesospheric Cloud (PMC) was detected by the lidar at 22:30UT (+3hr for LT) on Feb 4th, 2011, the first day of a routine operation. This event is the first time to detect PMC over Syowa Station by a lidar [Suzuki et al., 2013]. However, signal to noise ratio (SNR) of the PMC event was not so good due to a large shot noise from a daytime background signal. Moreover, a receiver system was mainly designed for nighttime observations. Therefore, observation of PMC during the midnight Sun, which also corresponds to PMC most active period, was difficult. Thus, to improve SNR of the PMC observation with Syowa Rayleigh/Raman lidar during daytime, a narrow bandpass Fabry-Perot etalon system has been developed and installed in the receiver system on Dec 2013 by JARE 55th. In this paper, Prompt report of a PMC observation with Syowa Rayleigh Raman lidar system equipped with the new etalon unit is presented.

Keywords: polar mesospheric cloud, noctilucent cloud, lidar, Antarctic

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PEM36-08 Room:312 Time:April 28 11:00-11:15

Study on generation and sustaining mechanism for an SSL during a night of high auroral activity above Tromsoe

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We will report observational results about an SSL (Sporadic Sodium Layer) that appeared on 22 January 2012 above Tromso, Norway (69.6deg N, 19.2deg E). An SSL is sudden formation (more precisely, from observer's viewpoint) of a dense thin sodium layer superposed on a normal sodium layer. Characteristic of an SSL is suitable for investigating, in particular, fine structures in the atmosphere such as small scale waves and turbulences. For example, Tsuda et al., GRL, 2011GL048685 [2011] found out a short-period wavelike structure on an SSL with sodium lidar operated Tromso, Norway.

Some generation mechanisms for SSLs have been proposed and discussed. A high correlation between an SSL and a sporadic E (Es) layer occurrences has been reported, and several authors proposed mechanisms how SSLs are generated by association of the Es layers [e.g., von Zahn and Hansen, JATP, 50, 93-104, 1988]. Kirkwood and von Zahn, JAP, 53, 389-407 [1991] have suggested that a strong electric field that generates an Es layer plays an important role for generation of an SSL as well in the auroral region. Recently, Matuura et al. JGR, 118, 1-12, jgra.50414 [2013] have proposed another mechanism that an electric current loop plays an important role for the convergence of positive ions including metallic ions.

Altitudinal temperature gradients have been also discussed as a candidate for an SSL generation. Clemesha et al., JASTP, j.jastp.2010.03.017 [2010] showed that an SSL tended to be located in the region where the temperature gradient is negative. A sodium lidar measurement exhibited a 40 K temperature increase on the topside of the SSL [Gardner et al., JGR, 98, 16,865-16,873, 1993].

We like to point out two concerns to be improved for the previous studies. First, although an SSL is complex phenomenon resulting from the confluence of various mechanisms, most studies focused on one mechanism alone. Second is a temporal resolution to calculate the neural temperature and sodium density. Since the sodium density inside an SSL varies largely and quickly in an order of seconds, data with insufficient resolution mislead our understanding. The temporal resolutions of five minutes used in previous studies are insufficient. In this study, we have derived neutral temperature and sodium density with a 15 second. Furthermore, we have used data obtained with the EISCAT UHF radar, meteor radar and photometer together with the sodium LIDAR at Tromso.

On 22 January 2012, an SSL was observed by the sodium lidar at about 94 km about 19 minutes after hard auroral precipitations. From 2118 UT to 2142 UT, the sodium density inside the SSL was from 2 and 6 times greater than the background sodium density. After 2142 UT the peak of the SSL went up to 96 km and the SSL became thinner than it was. The peak sodium density decreased, but it was still a few times higher than the background sodium density from 2142 UT to 2400 UT. We have calculated the temperature with a 15 second resolution, and have found that there are no remarkable enhancements in temperature profiles inside the SSL from 2118 to 2142 UT. It would be worth to point out that from 2200 to 2400 UT the SSL stayed in the local temperature minimum of the background atmosphere. Gardner et al. JGR. 2004JD005670 [2005] argued that the sodium density has a negative correlation with temperature at topside of the sodium layer. Therefore, our result is likely to indicate that the temperature profile contributes sustention of the SSL in this event. To investigate other candidate mechanisms for the SSL generation, we have analyzed the EISCAT radar data. The EISCAT radar detected an Es layer simultaneously with the SSL. The Es layer was located on about 94 km altitude where the SSL was located from 2118 UT to 2200 UT. However, after 2200 UT the Es layer was located on 2 km below the SSL. This result is likely to indicate that the Es layer contributes the SSL generation.

Keywords: Sporadic sodium layer, sodium lidar, aurora, EISCAT radar, meteor radar

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

PEM36-09 Room:312 Time:April 28 11:15-11:30

Seasonal variation of Polar Mesosphere Winter Echo (PMWE) observed by PANSY radar

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In the lower thermosphere at the altitude of around 100 km, both neutral turbulence and ionization of atmosphere due to solar radiations cause irregularities of reflective index, and as a result back scatter echoes from that altitude are frequently observed by radars on the ground. In the mesosphere, Polar Mesosphere Summer Echo (PMSE) is reported to be a strong echo associated with ice particles, which are produced around the coldest mesopause region in the polar summer, by a number of past radar observations [*Cho and Rottger*, 1997; *Rapp and Lūbken*, 2004]. It should be also noted that occurrence rate of PMSE is very high (80-90%) [*Bremer et al*., 2003]. On the other hand, Polar Mesosphere Winter Echo (PMWE) is also 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 winter [e.g., *Ecklund and Balsley*, 1981; *Czechowsky et al*., 1989; *Lūbken et al*., 2006; *Strelnikova and Rapp*, 2013]. Due to the lack of of free electrons and ice particles in the dark and warm mesosphere during winter, it is suggested that PMWE requires strong ionization of neutral atmosphere associated with precipitations of Solar Energetic Particles (SEPs) during geomagnetically disturbed periods [*Kirkwood et al*., 2002; *Zeller et al*., 2006]. However, the detailed generation process of PMWE has not been identified yet, partly because the reported PMWE occurrence rate was quite low (2.9%) [*Zeller et al*., 2006].

In the Ⅷ-th six-year project of the Japanese Antarctic Research Expedition (JARE) from 2010, the middle and upper atmosphere research is one of the sub-projects of the prioritized research project entitled 'Global warming revealed from the Antarctic', and comprehensive ground based observations with various remote sensing instruments for the middle and upper atmosphere have been operating continuously in Syowa station. We analyzed data obtained by PANSY (Program of the Antarctic Syowa MST/IS) radar, which is the core instrument of the project, focusing on PMWE in the context of neutral-plasma atmospheric coupling process between the middle and upper atmosphere. PANSY radar is a 47 MHz VHF radar with 125 kW (full system 500 kW) output power, and it is the largest MST radar composed 5,000 m^2 (full system 20,000 m^2) antenna array in Antarctica at the moment. PANSY has already identified a number of PMWE near local noon since operation of mesosphere observation mode was started in June 2012.

We would like to show seasonal variations of occurrence characteristics of PMWE between June 2012 and July 2013. Taking full advantage of PANSY radar's detectability, we calculated monthly-averaged height-time section of backscatter echo power in austral winter between 2012 and 2013. The result demonstrated that durations of PMWE strongly depended on hours of sunlight, although occurrence heights of PMWE, which range from 60 to 80 km, were fixed on every month and year. These statistical characteristics of PMWE were consistent with previous studies suggesting ionization at the PMWE height due to solar radiation play a dominant role in generation of PMWE [*Zeller et al*., 2006; *Lūbken et al*., 2006]. However, the mean occurrence rate of PMWE estimated by our study was 20-30%, which was considerably higher than that of previous studies. It implies that atmospheric turbulence in the mesosphere would be driven by breakings of atmospheric gravity waves more frequently than past observations, especially in Antarctica, and the role of atmospheric gravity waves cannot be ignored when considering the long-termed climate changes.

Keywords: Polar Mesosphere Winter Echo, PANSY radar, Atmospheric gravity wave, Neutral-plasma interaction

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PEM36-10 Room:312 Time:April 28 11:30-11:45

Analysis of atmospheric gravity waves observed by airglow imaging at Syowa Station (69S,39E), Antarctica

MATSUDA, Takashi S.[1*] ; NAKAMURA, Takuji[2] ; EJIRI, Mitsumu K.[2] ; TSUTSUMI, Masaki[2] ; SHIOKAWA, Kazuo[3] ; TAGUCHI, Makoto[4] ; SUZUKI, Hidehiko[4]

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Atmospheric gravity waves (AGWs), which are generated in the lower atmosphere, transport significant amount of energy and momentum into the mesosphere and lower thermosphere and cause the mean wind accelerations in the mesosphere. This momentum deposit drives the general circulation and affects the temperature structure. Among many parameters to characterize AGWs, horizontal phase velocity is very important to discuss the vertical propagation. Airglow imaging is a useful technique for investigating the horizontal structures of AGWs at around 90 km altitude. Recently, there are many reports about statistical characteristics of AGWs observed by airglow imaging. However, it is difficult to compare these results obtained at various locations because each research group uses its own method for extracting and analyzing AGW events. In order to deal with huge amounts of imaging data obtained on different years and at various observation sites, without bias caused by different event extraction criteria for the observer, we have developed a new statistical analysis method for obtaining the power spectrum in the horizontal phase velocity domain from airglow image data. This method was applied to the data obtained at Syowa Station, Antarctica, in 2011 and compared with a conventional event analysis in which the phase fronts were traced manually in order to estimate horizontal characteristics. This comparison shows that our new method is suitable for deriving the horizontal phase velocity characteristics of AGWs observed by airglow imaging technique.

We plan to apply this method to airglow imaging data observed at Syowa Station in 2002 and between 2008 and 2013, and also to the data observed at other stations in Antarctica (e.g. Rothera Station (67S, 68W) and Halley Station (75S, 26W)), in order to investigate the behavior of AGWs propagation direction and source distribution in the MLT region over Antarctica. In this presentation, we will report interim analysis result of the data at Syowa Station.

Keywords: atmospheric gravity wave, airglow imaging

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PEM36-11 Room:312 Time:April 28 11:45-12:00

First detection of daytime tweek atmospherics observed at Moshiri and Kagoshima, Japan

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It is well known that tweek atmospherics can be observed only at night except for solar eclipse days, because daytime attenuation rate of the tweeks is much larger (˜70 dB/1000 km) than that in nighttime (˜3 dB/1000 km). In this presentation, we firstly report detection of daytime tweeks at Moshiri (Geographic coordinate: 44.37^{o}N, 142.27^{o}E) and Kagoshima (31.48^{o}N, 130.72^{o}E), Japan, on non-solar eclipse days in December, 1980. The daytime tweeks were observed both before and during a large magnetic storm during 16-20 December, 1980. The minimum Dst value was -240 nT at 04:00 UT on 20 December. The average occurrence numbers of the daytime tweeks at Moshiri and Kagoshima were 2.7 and 0.3 tweeks per minute, respectively. The local times (LT) when the daytime tweeks occurred were through 07:00 - 17:00 LT at Moshiri, while they were 07:00 - 09:00 LT and 15:00 - 17:00 LT at Kagoshima. All the daytime tweeks show clear frequency dispersion. The average duration was 18.94 ms, while that of nighttime tweeks is ˜50 ms. The average reflection heights of daytime tweeks at Moshiri and Kagoshima were 86.2 km and 94.7 km, respectively. The average reflection heights of nighttime tweeks at Moshiri and Kagoshima in same period were 87.1 km and 92.1 km, respectively. The variation of the daytime tweek reflection height was higher than that of nighttime tweeks. The horizontal propagation distance in daytime cannot be estimated from the dispersion, because the duration was too short to estimate the distance.

We found through a theoretical consideration that the VLF/ELF attenuation on the D-region ionosphere depends not only on the ionospheric height, but also the sharpness of electron density profiles, β. The β is a conventional parameter proposed by Wait and Spies [1964]. When the β increases, the attenuation decreases. Even daytime, when the β is occasionally large, the attenuation would become less down to be able to observe the tweeks. In this talk, we will show the results of the daytime tweeks and discuss their occurrence mechanism.

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PEM36-12 Room:312 Time:April 28 12:00-12:15

Long term variation of geomagnetic Sq field over 100 years

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The long-term variation of the geomagnetic Sq field over 100 years at several observatories was studied in the Y-component as well as the ionospheric conductivity estimated by the IRI model. The amplitude of the geomagnetic Y-component (Sq(Y)) depended strongly on solar activity, and showed features similar to those in the solar activity even when 11-years running averages were employed. The solar activity dependence of Sq(Y) can be fully explained by that of the ionospheric electrical conductivity, and wind velocity tends to be large for low solar activity; and slower in the middle of the 1900s in response to higher long-term solar activity. On the other hand, other long-term variations were not clear in the wind velocity. Although the dynamo theory predicts that the Sq current is enhanced when geomagnetic main field intensity decreases, the result of the present analysis does not necessarily support this prediction.

Keywords: geomagnetic daily variation, long-term variation, solar activity, main field strength, elecric conductivity, wind velocity

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

PEM36-13 Room:312 Time:April 28 12:15-12:30

Long-term variation in the upper atmosphere as seen in the geomagnetic solar quiet (Sq) daily variation

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It has been well-known that the geomagnetic field on the ground shows a regular variation with a fundamental period of 24 hours during a solar quiet day. This daily variation depends on local time, latitude, season and solar cycle and has been called solar quiet (Sq) geomagnetic field daily variation. The Sq variation is mainly produced by magnetic effects due to ionospheric currents flowing in the E region of the ionosphere around 105 km. The global pattern of the Sq variation of the H-component shows positive and negative changes in the equatorial and middle-latitude regions around noon, respectively. The Sq current system expected from the geomagnetic field perturbations consists of two large current vortices: one is an anticlockwise current in the northern hemisphere and the other is a clockwise current in the southern hemisphere. The Sq current is dominant in the daytime ionosphere where ionospheric conductivity is relatively large, and is driven by electric fields originating from the ionospheric dynamo via the interaction between ionized and neutral particles. According to the Ohm's law, the main variables in the Sq amplitude are the ionospheric conductivity, the polarization electric field, the solar diurnal tide, and the intensity of the ambient magnetic field at the E-region height. Then, to investigate the long-term variation in the Sq amplitude is important for understanding the physical mechanism of long-term variation in the upper atmosphere related to solar activity and lower atmospheric change such as global warming. In this study, we investigated long-term variation in the Sq amplitude using 1-hour geomagnetic field data obtained from 184 geomagnetic observation stations within a period of 1947-2012 in order to clarify the physical mechanism of long-term variation in the upper atmosphere. For the analysis of long-term observation data obtained from a lot of geomagnetic stations, we took advantage of the IUGONET data analysis system (metadata database search system and data analysis software). The Sq amplitude is defined as a difference of the H-component of geomagnetic field between the maximum and minimum values each solar quiet day. We identified the solar quiet day as the day when the maximum Kp value is less than 4 for each day. As a result, the Sq amplitude observed at all the geomagnetic stations showed a clear dependence on the 11-year solar activity and it tended to be enhanced significantly during solar maximum. The Sq amplitude became the smallest around the minimum of 23/24 solar cycle in 2008-2009. The relationship between the Sq amplitude and F10.7 solar activity index was not linear but nonlinear. This nonlinearity could be interpreted as the decrease of production rate of electrons and ions in the ionosphere for the strong extreme ultraviolet (EUV) and ultraviolet (UV) fluxes. In order to minimize an effect of solar activity including the long-term variation in the Sq amplitude, we calculated second orders of fitting curve between the F10.7 solar index and Sq amplitude during 1947-2012, and examined the residual Sq amplitude defined as the deviation from the fitting curve. As a result, majority of the residual Sq trends passed through the trend test showed a negative value without dependence on geographical latitude and longitude. The tendency was strong in India, the southern part of Africa, and the northern part of America and Europe. In a region of northern part of America and Europe, the secular variation of magnetic inclination becomes relatively large, compared with other regions. Therefore, the long-term trend in the residual Sq amplitude could be linked to a change in the ionospheric conductivities associated with the secular variation of the ambient magnetic field and the upper atmosphere and electro motive force (UxB) via the interaction between ionized and neutral particles.

Keywords: Geomagnetic solar quiet daily variation, Solar activity, Long-term variation, Geomagnetic secular variation, Ionospheric conductivity, Global warming

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

PEM36-14 Room:312 Time:April 28 12:30-12:45

Temporal increases of horizontal speed of frontal Es observed by HFD

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In the yearly analysis of the horizontal speed of frontal Es by using the HFD observation data of the year 2012, we found some events which showed temporal increase and then decrease within the time scale from 40 to 270 minutes. The rate of the temporal speed enhancements were only 2.4 % in all frontal Es events in 2012, and the enhances were mainly observed aroun 21h JST in summer. The rate of the speed enhancement were less than 30 %, but some peak speeds increased up to more than 200 m/s. The duration times varied from 40 to 300 min, but most of the events terminated within 150 min. The average leading and trailing times were 35 and 50 min, respectively, so the trailing part took long time. The cause of temporal speed variation can be related to time variation of horizontal electric field or of horizontal wind speed of neutral atmosphere in the E layer. The former should show coincidence over the wide area but the latter would show some time difference. Analyzing pair data over 100 km separation, we obtained time delay less than 20 min. It is therefore interpreted that the temporal speed increase is caused by the change of the horizontal wind speed. Because the distance between successive Es front shows the minimum of less than 50 km around the speed peak, and increases upto 200 km both to the start and to the end, it can be attributed to the inequally spaced Es front. Combining all separation distances for each event, we get the outer size of the temporal variation as 400 km for 65 %, and as the maximum of 1400 km. On the otherhand, it can be related to a non-isotropic structure because the peak speed did show different values for the separate stations. Based on those observational results, it is concluded that the temporal speed increase may be introdued by a spiral-like, instead of linear, structure.

Keywords: frontal Es, horizontal speed, temporal increase, HF Doppler observation

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

PEM36-15 Room:312 Time:April 28 14:15-14:30

Study of medium-scale traveling ionospheric disturbances (MSTID) with sounding rockets and ground observations

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Medium-scale traveling ionospheric disturbance (MSTID) is an interesting phenomenon in the F-region. The MSTID is frequent in summer nighttime over Japan, showing wave structures with wavelengths of 100-200 km, periodicity of about 1 hour, and propagation toward the southwest. The phenomena are observed by the total electron content (TEC) from GEONET, Japanese dense network of GPS receivers, and 630 nm airglow imagers as horizontal pattern. It was also measured as Spread-F events of ionograms or as field-aligned echoes of the MU radar. MSTID was, in the past, explained by Perkins instability (Perkins, 1973) while its low growth rate was a problem. Recently 3D simulation study by Yokoyama et al (2009) hypothesized a generation mechanism of the MSTID, which stands on electromagnetic E/F-region coupling of the ionosphere. The hypothesis is that the MSTID first grows with polarization electric fields from sporadic-E, then show spatial structures resembling to the Perkins instability. We recently conducted a observation campaign to check this hypothesis. We launched JASA ISAS sounding rockets S-310-42 and S-520-27 at 23:00 JST and 23:57JST on July 20, 2013 while an MSTID event was monitored in real-time by the GPS-TEC from GEONET. We found 1-5mV/m northeastward/eastward electric fields during the flight. Variation of electric fileds were associated with horizontal distribution of plasma density. Wind velocity was measured by the TME and Lithium releases from S-310-42 and S-520-27 rockets, respectively, showing southward wind near the sporadic-E layer heights. These results are consistent to the expected generation mechanism shown above. In the presentation we will discuss electric-field results and its relationship with plasma density variability together with preliminary results from the neutral-wind observations.

Keywords: MSTID, Sounding rocket, Electric field, GPS-TEC, Observation campaign

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

PEM36-16 Room:312 Time:April 28 14:30-14:45

Characteristics of O630nm emission associated with equatorial ionization anomaly obtained with IMAP/VISI

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The Equatorial Ionization Anomaly (EIA) is occurred by plasma upwelling due to eastward electric field in the dayside magnetic equator, and descends to both northern and southern hemispheres along the field line. Density maximum appears around geomagnetic latitudes of +/-15 degree at both hemispheres. Since most of the past studies carried out with ground experiments, it is difficult to observe a wide area and study the variability of the northern and southern O630nm emission associated with EIA.

IMAP/VISI on the International Space Station(ISS) measures O630 nm airglow emission in the nightside hemisphere at an altitude of 400km. It covers the latitudinal range between +/-52 degrees with a typical spatial resolution of 1x14 km. Because of the wide observation coverage, it is possible to observe the variability of O630nm airglow associated with the EIA.

In this study, we carried out a statistical analysis using IMAP/VISI data from September 2012 to December 2013 to understand the variability of O630nm airglow associated with the EIA, particularly on its local time dependence, seasonal variation and geomagnetic activity. We derived the integrated intensity of O630nm emission along latitude with the four criteria as follows: (1) The O630nm emission in the EIA is greater than the background airglow that was determined by emission intensity in the middle latitude. (2) Latitudinal distribution of O630nm emission in the EIA is fully measured. (3) The northern and southern O630nm emission in the EIA is clearly separated. (4) The moon phase is smaller than 0.5. In case that the moon phase is bigger than 0.5 then we used the data when the moon did not appear.

We find that the time dependence of O630nm emission which is decreased from the evening toward the post mid-night. But there is a large variance in the intensity at the same local time. This fact suggests that other process, such as the longitude and/or seasonal variation, may affect the O630nm emission associated with the EIA in addition to the local time dependence.

On the seasonal dependence, we find that O630nm emission in the EIA in the winter hemisphere is greater than that in the summer hemisphere. This is consistent with the model that the thermospheric tidal wind affects the 630 nm intensity, namely, the tidal wind decreases the altitude of O630 nm emission layer and finally gain the O630 nm intensity.

To examine the longitudinal dependence, we used the data in equinox (September and October, 2013) and find that O630nm emission in the EIA in the northern hemisphere is greater than that in the southern hemisphere where the dip equator is the south of geographic equator (longitude is between 200 degree ? 310 degree). This is also consistent with the model that the thermospheric tidal wind controls the O630 nm intensity by making a vertical motion of emission layer.

Finally, we investigate the magnetic storm dependence on O630 nm intensity and find that significant decrease of O630nm intensity in the EIA happens during the period when the Dst index is larger than 90. From this fact, it is plausible that westward electric field in Region 2 current system penetrates to the low latitude region during the main phase of magnetic storm and reduce the formation of EIA.

Keywords: ISS, airglow, thermosphere, ionosphere, equatorial ionization anomarly, IMAP

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

PEM36-17 Room:312 Time:April 28 14:45-15:00

Analysis of the airglow structures using the simultaneous observations by ISS-IMAP and all-sky imagers

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The spatial structure of the atmospheric gravity waves in the mesosphere was analyzed using the simultaneous observational data of ISS-IMAP and the all-sky imager at Hawaii. There are a plenty of ground-based observations of the atmospheric gravity waves in the mesosphere and the thermosphere. The problem of the ground-based observation is that it cannot distinguish spatial variations from temporal variations for the structures whose scale size is larger than its field-of-view. ISS-IMAP was launched on July 21, 2012 to observe the atmospheric gravity waves whose scale size is larger than 100 km. The altitude of the International Space Station (ISS) flies around 400 km altitude, and its orbital inclination angle is 51.6 degrees. ISS-IMAP/VISI (Visible-light and infrared Spectrum Imager) observes the airglow in the mesosphere and the ionosphere. The spatial resolution of the VISI imaging observation is from 10 km to 25 km. The airglow wavelengths observed by VISI are 630 nm, 730 nm, and 762 nm and by the ground-based all-sky image of Hawaii (20.48 N, 156.2 W) are 630 nm and 557.7-nm with 5.5 minutes interval. The observational data of ISS-IMAP/VISI and an all-sky imager in Hawaii were investigated for the nights when VISI made the observation over Hawaii, and the sky over the imager was clear. The night when the plasma bubble was detected by the ground-based all-sky imager, the plasma bubble was detected by the 630nm airglow observation of ISS-IMAP/VISI. The spatial and vertical structures of the airglow that were observed by the ground-based imager and the ISS-IMAP/VISI were analyzed. The sensitivity of the observation of ISS-IMAP/VISI will also be discussed in the comparison of the ground-based observation.

Keywords: airglow, plasma bubble, ISS-IMAP

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

PEM36-18 Room:312 Time:April 28 15:00-15:15

Horizontal structures of ionized Helium in the topside ionosphere of dusk side observed by ISS-IMAP/EUVI

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Horizontal structures of ionized Helium in the topside ionosphere of dusk side were obtained with the Extreme Ultra Violet Imager (EUVI) of the ISS-IMAP (Ionosphere, Mesosphere, upper Atmosphere and Plasmasphere mapping) mission. EUVI has taken image of He He II radiation (30.4 nm) from the International Space Station (ISS) since October 2012. In this work, images taken in 2013 were analyzed. North-south asymmetry and longitudinal structure of ionized Helium were found. Seasonal dependence of these horizontal structures will be discussed.

Keywords: Topside ionosphere, ISS-IMAP, Ionoized Helium

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

PEM36-19 Room:312 Time:April 28 15:15-15:30

Study of ionospheric disturbance characteristics during solar flare events using the SuperDARN Hokkaido radar

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Ionospheric disturbances during solar flare events have been studied by various kinds of observation instrument in the last few decades. Kikuchi et al. (1985) reported on the positive Doppler shift in the HF Doppler system data during solar flare events, and indicated that there are two possible factors of Doppler shift, i.e., (1) apparent ray path decrease by changing refraction index due to increasing electron densities in the D-region ionosphere, and (2) ray path decrease due to descending reflection point associated with increasing electron density in the F-region ionosphere.

In this study, we use the SuperDARN Hokkaido Radar to investigate the detailed characteristics of solar flare effects on ionospheric disturbances. We focus on the positive Doppler shift of ground / sea scatter echoes just before sudden fade-out of echoes. Davies et al. (1962) showed that if the factor (1) is dominant, the Doppler shift should have positive correlation with slant range and negative correlation with elevation angle and frequency. On the other hand, if the factor (2) is dominant, the Doppler shift should have negative correlation with slant range and positive correlation with elevation angle and frequency. While Kikuchi et al. (1985) studied solar flare events and mainly discussed frequency dependence of Doppler shift, we study mainly slant range and elevation angle dependence, for the first time to the best of our knowledge. We found that the factor (1), in other words, increase of electron densities at D-region ionosphere, is dominant during solar flare events. This result is consistent with that of Kikuchi et al. (1985). In order to study characteristics of ionospheric disturbance in more detail, we are studying relationship between timing / amplitude of ionospheric disturbance and that of the solar irradiation changes, by comparing the HF radar data with high wavelength resolution irradiation data for X-ray and EUV from RHESSI and SDO satellites. Generally, X-ray radiation becomes more important for the changes in the D-region during solar flare events. Therefore we investigate relationship between X-ray flux changes and electron density variation in the D-region ionosphere intensively. Furthermore, we estimated electron density changes in the ionsosphere by analyzing elevation angle dependence of Doppler shift in radar echoes quantitatively. We are estimating electron density by considering chemical reaction and photoreaction caused by solar radiation. We will compare the two electron density changes deduced from different two ways and evaluate the amplitude of ionospheric disturbance observed by the HF radar. More detailed analysis result will be reported.

Keywords: SuperDARN, Hokkaido radar, solar flares, ionospheric disturbances, photochemical reaction, range dependence

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

PEM36-20 Room:312 Time:April 28 15:30-15:45

Thermospheric tidal effects on the ionospheric midlatitude summer nighttime anomaly

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This study use a 3D physics-based ionospheric model, SAMI3, coupled with the National Center for Atmospheric Research Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM) and Global Scale Wave Model (GSWM) to simulate the mesospheric and lower thermosphreic tidal effects on the development of midlatitude summer nighttime anomaly (MSNA). Using this coupled model, the diurnal variation of MSNA electron densities at 300 km altitude is simulated on both June solstice (day of year (DOY) 167) and December solstice (DOY 350) in 2007. Simulation results show successful reproduction of the southern hemisphere MSNA structure including the eastward drift feature of the southern MSNA, which is not reproduced by the default SAMI3 runs using the neutral winds provided by the empirical Horizontal Wind Model 93 (HWM93) neutral wind model. A linear least squares algorithm for extracting tidal components is utilized to examine the major tidal component affecting the variation of southern MSNA. Results show that the standing diurnal oscillation component dominates the vertical neutral wind manifesting as a diurnal eastward wave-1 drift of the southern MSNA in the local time frame. We also find that the stationary planetary wave-1 component of vertical neutral wind can cause diurnal variation of the summer nighttime electron density enhancement around the midlatitude ionosphere.

Keywords: Midlatitude Summer Nighttime Anomaly, thermospheric tidal effect

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

PEM36-21 Room:312 Time:April 28 15:45-16:00

Horizontal ion drag effect on the thermospheric mass density anomaly in the cusp

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CHAMP satellite observations have revealed that the thermospheric mass density in the cusp region is statistically larger by a factor of about 1.3 than that in its adjacent region. Many studies have pointed out that the upward mass transport due to heating is important for the generation of the mass density anomaly, but what confines the heating rate to the cusp is controversial. We have paid attention to the effect of the horizontal mass transport. Our reasoning on this point is as follows. Ionospheric convection gives momentum to the neutral air through ion drag, and the ion drag can modify the distribution of the neutral mass density. Our recent results from numerical simulations have indicated that the ion drag enhances the neutral mass density in the cusp that the terminator overlaps. In this paper, we report on the result about more general situations including cases when the terminator is located away from the cusp. Our results show that the mass density anomaly is confined to the cusp by ion drag, irrespective of the location of the terminator. We show detailed relations between the ion drag distribution and the mass density enhancement or depletion.

Keywords: thermosphere, mass density, cusp, CHAMP satellite

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

PEM36-22 Room:312 Time:April 28 16:15-16:30

Edge of polar cap patches

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A highly sensitive all-sky EMCCD airglow imager (ASI) has been operative in Longyearbyen, Norway (78.1N, 15.5E) since October 2011. One of the primary targets of this optical observation is a polar cap patch which is defined as an island of enhanced plasma density in the F region drifting anti-sunward across the central polar cap. Since the electron density within patches is often increased by a factor of 2?10 above that in the surrounding region, all-sky airglow measurements at 630.0 nm wavelength are capable of visualizing their spatial distribution in 2D fashion.

During a 4-h interval on the night of December 4, 2013, a series of polar cap patches was observed by the ASI in Longyearbyen. By using the high-quality ASI images, we estimated the gradients in the leading/trailing edges of the patches and found that the gradient in the leading edge is 2-3 times steeper than that in the trailing edge. We also identified finger-like undulating structures growing along the trailing edge of the patches. Generation of these fingers is probably governed by a structuring through the gradient-drift instability which is known to occur only along one side of patches.

From these observations, we suggest that such a structuring process can transport and mix the patch plasma across their trailing edges so that the scale size of the edges get extended. This means that the structuring through the plasma instability can strongly influence the large-scale shape of patches. Such a knowledge is of particular importance for better understanding the space weather effects of patches on the trans-ionospheric satellite communications in the polar cap region.

Keywords: Polar cap ionosphere, Airglow, Polar patches, Plasma instability

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

PEM36-23 Room:312 Time:April 28 16:30-16:45

Correlation analysis between equatorial electrojet,pre-reversal enhancement and equatorial spread F in Southeast Asia

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At the equatorial latitudes, the reversal of dayside eastward electric field to westward around sunset is often accompanied by a strengthened eastward electric field. The strengthened eastward electric field is called as the pre-reversal enhancement (PRE). PRE is considered to be the primary process acting on the equatorial spread F (ESF) onsets. Relationships between PRE strength, ESF onsets, and equatorial electrojet (EEJ) strength have been investigated by using ionosonde observation and magnetometer observation. Uemoto et al. (2010) found that PRE strength and ESF onsets are suppressed when pre-sunset integrated EEJ from 2 hours to 1 hour prior to sunset is negative owing to the evening counter electrojet, by statistical analysis of observations in the Southeast Asia low-latitude ionospheric network (SEALION). Their analyzing period is from November 2007 to October 2008. The period is in solar minimum phase.

We use SEALION data from 2007 to 2013. Therefore, our analyzing period covers not only solar minimum phase but also solar maximum phase. Statistical analyses for each year are conducted. Further, detailed case study is conducted. Significant day-to-day variations of EEJ strength, PRE strength, and ESF onsets are picked up from these seven years data. Then, we investigate how and to what extent day-to-day variations of EEJ strength relate to the day-to-day variations of PRE strength and ESF onsets. The magnetometer data in our study were obtained at Phuket (geographic lat. 8.09N, geographic long. 98.32E, dip lat. -0.2) and Kototabang (0.20S, 100.32E, dip lat. -10.1). The ionosonde data in our study were obtained at Chumphon (10.72N, 99.37E, dip lat. 3.0), Chiang Mai (18.76N, 98.93E, dip lat. 12.7), and Kototabang (0.20S, 100.32E, dip lat. -10.1).

Reference

Uemoto J., T. Maruyama, S. Saito, M. Ishii, and R. Yoshimura, Relationships between pre-sunset electrojet strength, pre-reversal enhancement and equatorial spread-F onset, Ann. Geophys., vol. 28, pp. 449-454, 2010.

Acknowledgements

The ionosonde at Chiang Mai is operated under agreements between NICT, Japan and Chiang Mai University (CMU), Thailand. The ionosonde at Chumphon and the magnetometer at Phuket are operated under agreements between NICT and King Mongkut ′ s Institute of Technology Ladkrabang (KMITL), Thailand. The magnetometer at Kototabang has been operated in collaboration among the Solar-Terrestrial Environment Laboratory (STEL), Nagoya University, Japan, the Research Institute for Sustainable Humanosphere (RISH), Kyoto University, Japan, and the National Institute of Aeronautics and Space (LAPAN), Indonesia. The ionosonde at Kototabang has been operated in collaboration among NICT, RISH and LAPAN. We thank Mr. Yamazaki for manual scaling of ionosonde data.

Keywords: electrojet, equatorial spread F, day-to-day variation, SEALION

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

PEM36-24 Room:312 Time:April 28 16:45-17:00

Low-latitude ionosphere dynamics as deduced from meridional ionosonde chain: Ionospheric ceiling

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Peculiar ionospheric features at low latitudes originate in the earth's magnetic field configuration that has a shape of arch. Near the magnetic equator, the daytime eastward electric field raises the ionosphere to high altitudes where the ion-neutral collision frequency reduces. The ionospheric plasma slips down over off-equatorial latitudes along the arch-shaped magnetic field line by the earth's gravity acceleration and the reduced ion-neutral drag, which is called the fountain effect. As a consequence, the latitudinal distribution of ionospheric critical frequency (foF2) forms two crests at low latitudes and a trough above the magnetic equator, which is well-known equatorial anomaly in foF2 distribution. As for the diurnal variation of the ionosphere above the magnetic equator, foF2 once increases in the morning and decreases before noon along with the development of the equatorial anomaly, which is called noon bite-out. Another feature at the magnetic equator, associated with the fountain effect, is the relatively steady ionospheric peak height (hmF2) around noon, even though the EXB drift is upward throughout the daytime. However, not much attention has been paid to hmF2 except for the time rate of change of it in connection with the vertical plasma drift velocity.

Interest in the equatorial anomaly has been focused mostly on foF2 (or NmF2), and there have been a few studies on hmF2 variations associated with equatorial anomaly development. In this paper, we revisit the equatorial anomaly in terms of height variations. For this purpose, we analyzed scaled ionogram parameters from three stations located along the magnetic meridian that is a primary component of Southeast Asia low-latitude ionospheric network (SEALION); one at the magnetic equator and the others at conjugate off-equatorial latitudes near 10 degrees magnetic latitude.

The daytime hmF2 was investigated for each season during the solar minimum period, 2006-2007 and 2009. The peak height increased for approximately 3 hr after sunrise at all locations, as expected from the daytime upward EXB drift. The apparent upward drift ceased before noon at the magnetic equator, while the layer continued to increase at the off-equatorial latitudes, reaching altitudes higher than the equatorial height around noon. The noon time restricted layer height at the magnetic equator did not depend on the season, while the maximum peak height at the off-equatorial latitudes largely varied with season. The daytime specific limiting height of the equatorial ionosphere was termed ionospheric ceiling. Numerical modeling using the SAMI2 code reproduced the features of the ionospheric ceiling quite well. Dynamic parameters provided by the SAMI2 modeling were investigated and it was shown that the ionospheric ceiling is another aspect of the fountain effect, in which increased diffusion of plasma at higher altitudes has a leading role.

Keywords: equatorial anomaly, fountain effect, ionospheric ceiling, EXB drift, SEALION

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

PEM36-25 Room:312 Time:April 28 17:00-17:15

Three-dimensional high-resolution plasma bubble modeling

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Equatorial plasma bubble (EPB) is a well-known phenomenon in the equatorial ionospheric F region. As it causes severe scintillation in the amplitude and phase of radio signals, it is important to understand and forecast the occurrence of EPB from a space weather point of view. The development of EPB is known as a evolution of the generalized Rayleigh-Taylor instability. Numerical modelings of the instability on the equatorial two-dimensional plane have been conducted since the late 1970's, and the nonlinear evolution of the instability has been clearly presented. Recently, three-dimensional (3D) modelings became popular tools for further understanding of the development of EPB such as 3D structure of EPB, meridional wind effects and gravity wave seeding. One of the biggest advantages of the 3D model is that the off-equatorial E region which is coupled with the equatorial F region can be included in the model. It is known from observations that the conductance of the off-equatorial E region controls the growth rate of the Rayleigh-Taylor instability, that is, sudden decrease of the E-region conductance around the sunset accelerates the evolution of the instability. We have developed a new 3D high-resolution model for EPB, and studied internal structure of EPB and the contribution of the off-equatorial E region. As it is necessary to use high-order numerical schemes to capture sharp plasma density gradient of EPB, we adopted the CIP scheme which can keep the third-order accuracy in time and space. The simulated EPB has asymmetrical density gradients at east and west walls, and the growth rate changes significantly depending on the condition of the off-equatorial E region. In the future, we will integrate the high-resolution model into whole atmosphere-ionosphere coupled model (GAIA) to study the growth of EPB under the realistic background conditions.

Keywords: plasma bubble, equatorial spread F, equatorial ionosphere, numerical simulation