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

PEM27-01 Room:A01 Time:May 25 17:15-17:30

Development of wideband impedance probe system for observation of the ionosphric ion composition

KUMAMOTO, Atsushi[1]*

[1]Tohoku University

Concept and design of new wideband impedance probe system for observation of the ionospheric ion composition have been investigated. Impedance probe system for measurement of the electron number density, which is called NEI, were developed by Oya [1966], and successfully utilized for numerous sounding rockets and spacecraft such as Denpa, Taiyo, Jikiken, Hinotori, Ohzora, and Akebono [e.g. Wakabayashi et al., 2013]. NEI measures the equivalent capacitance of the probe immersed in the magnetized plasma. By applying RF signal to the probe, we can identify the minimum of equivalent capacitance due to upper hybrid resonance (UHR). The frequency of RF signal is swept from 100 kHz to 25 MHz, in order to cover the UHR frequency range in the Earth's ionosphere. The equivalent capacitance of the probe in the magnetized plasma shows minimum not only at UHR frequency but also at another resonance frequency: Lower hybrid resonance (LHR). If we can measure LHR frequency with UHR frequency and electron cyclotron frequency, we can derive effective mass of ionospheric plasma and determine the ionospheric ion compositions. Because LHR frequency is about several kHz in the ionosphere, we have to extend the lower limit frequency of the current impedance probe system to 100 Hz. We changed the design of NEI as follows: (a) Coupling capacitor between the circuits is changed in order to pass the low-frequency AC signals. (b) Because long time is needed for frequency sweep in a low frequency range, high-frequency signal with short sweep period and low-frequency signal with long sweep period are combined and impressed to the probe in order to keep the high time resolution in the measurement of UHR frequency. We have performed the chamber experiment with bread-board model (BBM) of wideband impedance probe system in 2014. We confirmed that the new impedance probe system could measure (1) UHR in high frequency range as well as the current NEI could, and (2) equivalent capacitance profile from 100 Hz to 100 kHz, which indicates sheath capacitance of 120 pF and sheath resistance of 30 kohm. Unfortunately, LHR could not be identified in the chamber experiment because of high collision frequency in the chamber. The detectability of LHR with the wideband impedance probe system have to be verified through the future sounding rocket experiments in the ionosphere, where the collision frequency is enough low.

Keywords: Impedance probe, Ion composition, Sounding rocket, Chamber experiment, Lower hybrid resonance (LHR), Electron number density

PEM27-02 Room:A01 Time:May 25 17:30-17:45

Study of the ionospheric plasma density structure observed by topside sounder on board the EXOS-D (Akebono) satellite

HOSHI, Yasuto[1*] ; KATOH, Yuto[1] ; KUMAMOTO, Atsushi[1]

[1]Dept. Geophys., Grad. Sch. Sci., Tohoku Univ.

The electron number density, electron and ion temperature of the ionospheric trough in the polar ionosphere has been investigated based on the analysis of data obtained by Plasma Wave detectors and Sounder (PWS) system onboard the EXOS-D (Akebono) satellite.

Stimulated Plasma Wave experiments (SPW), one of the subsystems of PWS, enables us to conduct topside sounding of the ionosphere and to measure the excitation of plasma resonances in the surrounding plasma [Oya et al., 1990]. In operation of SPW in H-band normal sweep mode, RF pulse is transmitted with a swept frequency ranging from 0.3 MHz to 11.4 MHz within 32 sec. We measure the frequency and delay time of each echo found in the ionograms. We then divide the topside ionosphere into multiple plasma layers, and determine group velocities in them, which are to be consistent with measured frequency and delay. Finally, we can obtain the plasma density distribution of the topside ionosphere.

First, we analyze ionograms obtained by SPW in the region nearby European Incoherent Scatter (EISCAT) radar at (69.58 N, 19.23 E) (Tromso, Norway). We identified two events of ionospheric trough, in which the plasma density is depleted. One is found at (65 N, 15 E) on Feb. 28, 1995 (hereafter called "Event 1"), and the other is found at (70 N, 35 E) on Mar. 1, 1995 (hereafter called "Event 2"). We also analyze simultaneous EISCAT UHF radar data with EXOS-D observations and find no density depletion in the radar data.

Next, we derive the vertical profile of the scale height inside and outside the inospheric trough from the vertical profile of the electron number density. The derived scale height at 500 km altitude inside the ionospheric trough of these 2 events is 20 % less than that outside the ionospheric trough. Assuming that the distribution of electrons and ions can be explained by the diffusive equilibrium of the bipolar diffusion, we estimate the sum of electron and ion temperature from the scale height. The estimated temperatures are 3730 K inside the trough and 5070 K outside the trough found in Event 1, and 3290 K outside the trough and 2940 K inside the trough in Event 2. These results indicate that the plasma temperature in the identified plasma depletion region is lower than that in the surrounding region. Based on the explanation that the frictional heating increase the plasma temperature, and cause the plasma density depletion by the enhanced dissociative recombination, the plasma temperature in the trough have to be higher than that outside the trough. The results do not agree with the expectation. However, in Event 1, the estimated plasma temperature in the trough is higher than the plasma temperature (about 3000 K) obtained from IRI-2012 model at the observed local time. So we can consider also that the plasma temperatures both inside and outside the trough was higher than normal background ionospheric temperature. We also discuss the dependence of the temperature inside the trough on other control factor such as composition of ionospheric plasma, and unsteady control factor such as the geomagnetic activities.

Keywords: ionosphere, topside sounder, trough

Japan Geoscience Union Meeting 2015
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PEM27-03 Room:A01 Time:May 25 17:45-18:00

A study of equatorial plasma bubbles by 630-nm airglow imaging observations from the International Space Station

YAMADA, Takanori[1*] ; OTSUKA, Yuichi[1] ; SAKANOI, Takeshi[2] ; YAMAZAKI, Atsushi[3] ; KUBOTA, Minoru[4] ; JIN, Hidekatsu[4] ; SAITO, Akinori[5] ; AKIYA, Yusuke[5] ; HOZUMI, Yuta[5]

[1]Solar-Terrestrial Environmental Laboratory, Nagoya University, [2]Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, [3]Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency, [4]National Institute of Information and Communications Technology, [5]Department of Geophysics, Graduate School of Science, Kyoto University

In order to disclose global distribution of the upper atmosphere, Ionosphere, Mesosphere, upper Atmosphere, and Plasmasphere mapping mission (IMAP) on the International Space Station (ISS) started on October 2012. In this study, we analyzed 630-nm airglow images observed during a period from September 5, 2012 to August 28, 2013 by VISI (Visible and Infrared Spectral Imager), mounted on ISS to reveal the longitudinal characteristics of the equatorial ionosphere disturbances. We examined the seasonal and longitudinal characteristics of the occurrence of the plasma bubbles, and found occurrence rate of the plasma bubbles is high in spring and autumn equinoxes, especially at African longitudinal sector. This result is consistent with previous studies. Furthermore, we measured zonal interval between the plasma bubbles and examined its longitudinal characteristics. We found that plasma bubble intervals depend on longitude and that most of intervals are 100-200 km at 0-90o longitudinal sector and 200-300 km at 225-360o longitudinal sector. In this study, we also compare the observed 630-nm airglow intensity with that simulated by GAIA(Ground-to-topside model of Atmosphere and Ionosphere for Aeronomy) model to discuss day-to-day and longitudinal variations of equatorial ionization anomaly.

Keywords: plasma bubbles, ISS-IMAP

PEM27-04 Room:A01 Time:May 26 09:00-09:15

Comparison of neutral temperature with ion temperature in the polar lower thermosphere

TAKITA, Shintaro[1*] ; NOZAWA, Satonori[1] ; OGAWA, Yasunobu[2] ; KAWAHARA, Takuya[3] ; TSUDA, Takuo[4] ; SAITO, Norihito[5] ; WADA, Satoshi[5] ; TAKAHASHI, Toru[1] ; FUJIWARA, Hitoshi[6] ; HALL, Chris[7] ; BREKKE, Asgeir[8]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University, [2]National Institute of Polar Research, [3]Faculty of Engineering, Shinshu University, [4]The University of Electro-Communications, [5]Advanced Photonics Technology Development Group, RIKEN, [6]Faculty of Science and Technology, Seikei University, [7]Tromsoe Geophysical Observatory, The Arctic University of Tromsoe, [8]Faculty of Science, The Arctic University of Tromsoe

We will present results of comparison between the neutral temperature and the ion temperature at 100-110 km height above Tromsoe (69.6^{o}N, 19.2^{o}E), Norway. We have conducted observations of the neutral temperature and the sodium density between about 80 and 110 km with the sodium LIDAR at Tromsoe since October 2010. We have also obtained wind data by making five directional observations since October 2012. To date, we have obtained temperature and sodium density data for about 2800 hours in total and about 1800 hours of wind data. For five winter observational seasons between 2010 and 2015, simultaneous observations of the sodium LIDAR and the EISCAT UHF radar were conducted at altitudes between 100 and 110 km for 43 nights (about 250 hours).

Below 150 km in altitude at middle latitudes, due to collisions between the two species as well as absence of external heat sources, the ion temperature is thought to be almost the same as the neutral temperature. This is not the case in the polar lower thermosphere because of the energy input from the magnetosphere. Major heat sources are Joule heating, auroral particle heating, and the electron-ion heat exchange. Among them, Joule heating is the strongest component in the lower thermosphere. To evaluate contributions of these heat sources, as the first step, we have compared the neutral temperature obtained by the sodium LIDAR with the ion temperature by the EISCAT UHF radar at altitudes between 100 and 110 km. In general, at and below about 105 km there seems to be a reasonable agreement between the temperatures, and the ion temperature tends to be higher than the neutral temperature with increasing height above 105 km. We will present the comparison results and also discuss the effect of the Joule heating.

Keywords: sodium lidar, EISCAT radar, joule heating, atmosphere temperature, polar lower thermosphere

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PEM27-05 Room:A01 Time:May 26 09:15-09:30

A case study on generation mechanisms of a sporadic sodium layer during a night of high auroral activity

TAKAHASHI, Toru[1*] ; NOZAWA, Satonori[1] ; TSUDA, Takuo[2] ; OGAWA, Yasunobu[3] ; SAITO, Norihito[4] ; HIDEMORI, Takehiro[1] ; KAWAHARA, Takuya[5] ; HALL, Chris[6] ; FUJIWARA, Hitoshi[7] ; BREKKE, Asgeir[8] ; TSUTSUMI, Masaki[3] ; WADA, Satoshi[4] ; KAWABATA, Tetsuya[1] ; OYAMA, Shin-ichiro[1] ; FUJII, Ryoichi[1]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University, [2]The University of Electro-Communications, [3]National Institute of Polar Research, [4]RIKEN Center for Advanced Photonics, RIKEN, [5]Faculty of Engineering, Shinshu University, [6]Tromso Geophysical Observatory, The Arctic University of Tromso,, [7]Faculty of Science and Technology, Seikei University, [8]Faculty of Science, The Arctic University of Tromso, Tromso, Norway

Generation mechanisms of sporadic sodium layers (SSLs) have been discussed for more than three decade. Proposed mechanisms are as follows: *Es* layer, chemical reaction enhancement due to a background temperature variation, gravity waves, meteor deposition, and aurora particle spattering. However there are few studies that evaluate these mechanisms quantitatively based on observational data. In this study, we have quantitatively evaluated generation mechanisms of a SSL based on observational data obtained by multiple instruments at a high latitude station: Ramfjordmoen, Tromso, Norway (69.6^{o}N, 19.2^{o}E).

The sodium LIDAR observed an SSL at 2118 UT on 22 January 2012. The SSL was observed for 18 min with a maximum sodium density of about 1.9x10^{10} m^{-3} at 93 km with a 1.1 km thickness. The EISCAT UHF radar observed a sporadic *E* layer (*Es* layer) above 90 km from 2000 to 2300 UT. After 2000 UT, the Es layer gradually descended and reached 94 km at 2118 UT when the SSL appeared at the same altitude. In this event, considering the abundance of sodium ions (10% or less), the Es layer could provide only about 21% or less of the sodium atoms to the SSL. We have investigated a temporal development of the normal sodium ion layer with consideration of chemical reactions and the effect of the (south-westward) electric field using observational values of the neutral temperature, electron density, horizontal neutral wind, and electric field. This calculation has shown that those processes, including contributions of the *Es* layer, would provide about 88% sodium atoms of the SSL. Effects of meteor absorption and auroral particle spattering appear to be less important. Therefore, we have concluded that the major source of the SSL was sodium ions in a normal sodium ion layer. Two processes-namely the downward transportation of sodium ions from a normal sodium ion layer due to the electric field, and the additional supply of sodium ions from the *Es* layer under relatively high electron density conditions (i.e., in the *Es* layer)-played a major role in generating the SSL in this event. Furthermore, we have found that the SSL was located in a lower temperature region, and that the temperature inside the SSL did not show any remarkable temperature enhancements.

Keywords: Sporadic sodium layer, sodium lidar, polar region, aurora, MLT

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PEM27-06 Room:A01 Time:May 26 09:30-09:45

Derivation of the stratospheric temperature with the sodium lidar

HIBINO, Tatsuya[1*] ; NOZAWA, Satonori[1] ; TSUDA, Takuo[2] ; KAWAHARA, Takuya[3] ; SAITO, Norihito[4] ; WADA, Satoshi[4] ; TAKAHASHI, Toru[1] ; FUJIWARA, Hitoshi[5] ; HALL, Chris[6]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University, [2]The University of Electro-Communications, [3]Faculty of Engineering, Shinshu University, [4]The RIKEN Center forAdvanced Photonics Technology Development Group, RIKEN, [5]Faculty of Science and Technology, Seikei University, [6]Tromso Geophysical Observatory, The Arctic University of Tromso, Tromso, Norway

We have derived the temperature in the upper stratosphere between 30 and 50 km by using Rayleigh scatter data obtained by the sodium LIDAR at Tromsoe (69.6N, 19.2E), Norway. We have carried out observations of the neutral temperature and sodium density between 80 and 110 km in the polar upper mesosphere and lower thermosphere for five winter seasons (October-March) starting in October 2010 by using the sodium LIDAR. To date, about 2800 hours of data are obtained. Together with datasets obtained by EISCAT radars, MF radar and meteor radar operated at the same observational field, we have studied the vertical coupling of the atmosphere as well as the magnetosphere-ionosphere-thermosphere coupling. To facilitate these activities, a millimeter wave receiver for measuring minor constituent in the stratosphere/mesosphere/lower thermosphere will be installed at the same observational field in the near future. In this talk, we will present results of the derivation of the neutral temperature in the upper stratosphere (30-50 km) by using the sodium LIDAR.

A sodium LIDAR observations use the resonance scattering from sodium atoms in the sodium layer between 80 and 110 km. We also successfully receive Rayleigh scattering light from the atmosphere between about 30 and 60 km. The upper height depends on the background noise level, while the lower height limit is determined by contamination of Mie scatter light. We calculated the temperatures between November 2011 and February 2012 with a 1 km resolution and compared them with the calculated atmospheric temperatures with the ECMWF (The European Centre for Medium-Range Weather Forecasts) data. The comparison shows a reasonable agreement.

This new addition of the datasets will make it possible to investigate the correlation of the temperature variation between the upper stratosphere (30-50 km) and the upper mesosphere/lower thermosphere (80-110 km). Furthermore, the observed stratospheric temperature will improve the accuracy of the millimeter wave observations.

Keywords: Sodium Lidar, Rayleigh scattering

PEM27-07 Room:A01 Time:May 26 09:45-10:00

Statistical study of probability of instabilities in the polar upper mesosphere/lower thermosphere

ASATO, Saki[1*] ; NOZAWA, Satonori[1] ; FUJIWARA, Hitoshi[2] ; KAWAHARA, Takuya[3] ; TSUDA, Takuo[4] ; TSUTUMI, Masaki[5] ; SAITO, Norihito[6] ; WADA, Satoshi[6] ; KAWABATA, Tetsuya[1] ; TAKAHASHI, Toru[1] ; HALL, Chris[7] ; BREKKE, Asgeir[8]

[1]STEL, Nagoya University, [2]Faculty of Science and Technology, Seikei University, [3]Faculty of Engineering, Shinshu University, [4]The University of Electro-Communications, [5]National Institute of Polar Research, [6]Advanced Photonics Technology Development Group, RIKEN, [7]Tromsoe Geophysical Observatory, The Arctic University of Tromsoe, [8]Faculty of Science, The Arctic University of Tromsoe

The aim of this study is to clarify probabilities of convective and dynamical instabilities and their variations in altitude/time in the polar upper mesosphere and lower thermosphere (80-110 km). In this study, we have used temperature data obtained with the sodium LIDAR operated at the EISCAT Tromsoe (69.6N, 19.2E) site. Between October 2010 and January 2015, there are 287 nights when their temporal data lengths are equal to or longer than 4 hours on a night. Based on the temperature data, we have calculated square of Brunt-Vaisala frequency (N^2). The time and height resolution of the temperature data used are 10 min and 1 km, respectively. Together with wind data obtained by the sodium LIDAR (after October 2012) or the co-located meteor radar (before March 2012), we have also calculated Richardson numbers (R_i) for the 287 nights. The instability probability on one night is calculated as the percentage of the number of points whose N^2 is negative for convective instability, and whose Ri falls in the range of $0 < R_i < 0.25$ for dynamical instability to the total data set over the height region for the entire night.

Studies of probabilities of instabilities around the mesopause region were made at middle/low latitudes. Zhao et al. (JASTP, 65, 219-232, 2003) analyzed 32 nights (195 hours) of data sets over 1 year between June 1998 and May 1999 obtained at Starfire Optical Range, near Albuquerque, NM (35N, 106.5W) and showed that the probabilities of static and dynamic instabilities were maximum in mid-winter. Li et al. (JGR, 110, 2004JD005097, 2005) analyzed 19 nights of data sets obtained between January 2002 and November 2003 at Maui, Hawaii (20.7N, 156.3W), and pointed out that at any given time the probability that an unstable condition was found at some altitudes in the 85-100 km range was about 90%. To the best of our knowledge, no such a study has been made for the polar upper mesosphere/lower thermosphere.

We will show probabilities of instabilities in the polar upper mesosphere and lower thermosphere, and difference of the probabilities in terms of year, month, and altitude. Furthermore, we will discuss correlations between the probabilities and amplitudes of tides/gravity waves and between the probabilities and auroral activity.

Keywords: polar upper mesosphere and lower thermosphere, convective instability, dynamical instability, sodium LIDAR, Tromsoe

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PEM27-08 Room:A01 Time:May 26 10:00-10:15

Comparison of horizontal phase velocity distributions of gravity waves observed by ANGWIN, using a 3D spectral technique

MATSUDA, Takashi S.[1*] ; NAKAMURA, Takuji[2] ; EJIRI, Mitsumu K.[2] ; TSUTSUMI, Masaki[2] ; TAYLOR, Michael J.[3] ; ZHAO, Yucheng[3] ; PAUTET, P.-dominique[3] ; MURPHY, Damian[4] ; MOFFAT-GRIFFIN, Tracy[5]

[1]SOKENDAI (The Graduate University for Advanced Studies), [2]National Institute of Polar Research, [3]Utah State University, [4]Australian Antarctic Division, [5]British Antarctic Survey

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 their vertical propagation. Airglow imaging is a useful technique for investigating the horizontal structures of AGWs around mesopause. An international airglow imager (and other instruments) network in the Antarctic, named ANGWIN (Antarctic Gravity Wave Imaging/Instrument Network) was started in 2011. Its purpose is to understand characteristics of mesospheric gravity waves and their impacts on the Mesosphere and Lower Thermosphere (MLT) environment over Antarctica.

In this study, we compared distributions of horizontal phase velocities of gravity waves at around 90 km altitude over different locations using our new statistical analysis method based on 3-D Fourier transform, developed by Matsuda et al. (2014). The comparison has been carried out for airglow imagers at four stations, that are, Syowa (69S, 40E), Halley (76S, 27W), Davis (69S, 78E) and McMurdo (78S, 156E), out of the ANGWIN imagers, for the observation period between April 6 and May 21 in 2013. Not only horizontal propagation characteristics, gravity wave energies can also be quantitatively compared, indicating a smaller GW activity in higher latitudes. The presentation will be focused on showing the performance of the new statistical technique for studying gravity waves.

Keywords: atmospheric gravity wave, airglow imaging

PEM27-09 Room:A01 Time:May 26 10:15-10:30

A revisit to critical level blocking diagram

TOMIKAWA, Yoshihiro[1*]

[1]National Institute of Polar Research, [2]SOKENDAI

Matsuda et al. (2014) have proposed a new method to obtain a power spectral distribution of gravity waves in a horizontal phase velocity domain from airglow observations. The obtained power spectral distribution can be interpreted as a product of gravity wave source spectrum and wave transmissivity distributions under an assumption without wave dissipation/reflection and wave horizontal propagation. The gravity wave transmissivity depends on the existence of a critical level for the wave, which is determined by background horizontal wind distributions. Taylor et al. (1993) have proposed a critical level blocking diagram which represents a gravity wave transmissivity in a horizontal phase velocity domain. In this talk, the critical level blocking diagram proposed by Taylor et al. (1993) will be revisited, and its amendment will be discussed. In addition, examples of the critical level blocking diagram in some given background horizontal wind distributions will be shown.

Keywords: critical level, gravity wave, mountain wave

PEM27-10 Room:A01 Time:May 26 10:30-10:45

Gravity Waves in the Martian Atmosphere detected by the Radio Science Experiment MaRS on Mars Express

TELLMANN, Silvia[1*] ; PATZOLD, Martin[1]

[1]University of Cologne, Germany

Gravity waves are a ubiquitous feature in all stably stratified planetary atmospheres. They are known to play a significant role in the energy and momentum budget of the Earth and they are assumed to be of importance for the redistribution of energy. This high vertical resolution of the radio occultation profiles from the MaRS experiment on Mars Express provides the unique opportunity to study small scale vertical wave structures in the Martian lower atmosphere. These small scale temperature perturbations are most probably caused by gravity waves (buoyancy waves) produced by the displacement of air masses flowing over elevated topographical features or other atmospheric sources like convection in the surface boundary layer or wind shear. A study of the global distribution of gravity waves provides insight into possible source mechanisms, local time dependencies, seasonal dependencies and/or topographical dependencies.

Keywords: Mars, Mars Express, Gravity Waves, Atmosphere, Radio Occultation Experiment, Radio Science

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PEM27-11 Room:A01 Time:May 26 11:00-11:15

Imaging of polar cap patches with small airglow cameras

HOSOKAWA, Keisuke[1*] ; OGAWA, Yasunobu[2] ; TAGUCHI, Satoshi[3]

[1]University of Electro-Communications, [2]National Institute of Polar Research, [3]Graduate School of Science, Kyoto University

In the last two decades, 630.0 nm airglow measurements with cooled CCD cameras have been widely used to observe various kinds of ionospheric phenomena such as plasma bubble and MSTID. Recently, similar airglow observations at high-latitudes have enabled us to visualize the dynamical behavior of polar cap patches, which are regions of high density plasma propagating in the central polar cap region. In this sense, now the all-sky airglow measurement is one of the essential tools for monitoring ionospheric phenomena at all the latitude regions. However, it is still very difficult to make a dense network of airglow imagers and capture the large-scale structure in the ionosphere because the system is relatively large and high cost.

In this paper, we have employed a cheap and small CCD camera (Watec Co.Ltd.: WAT-910HX) to observe airglow in the polar cap region and check if such a camera can be used for observations of polar cap patches. We prepared two sets of small airglow camera, one with a fish-eye lens and the other with a wide field-of-view lens. They are combined with an optical filter whose central wavelength is 632.0 nm, FWHM is 10 nm and transmittance is 85%. The two airglow cameras were installed in Longyearbyen (78.1N, 15.5E), Norway in October 2013 and operated continuously during the 2013/2014 winter season. In Longyearbyen, airglow measurements with an EMCCD all-sky airglow imager (ASI) and the auroral spectrograph (ASG) have been carried out; thus, we were able to compare the images from the small airglow cameras with those from the conventional airglow observation systems.

On the night of December 4, 2013, a series of polar cap patches was observed by the EMCCD all-sky imager in Longyearbyen. The optical intensity of the patches was as large as 500 R. At the same time, the small airglow cameras also detected regions of enhanced airglow intensity passing through their fields-of-view. The quality of the images was slightly lower than those from the EMCCD-ASI, but it was high enough for capturing the 2D structure of the patches. This indicates that the small CCD camera of Watec Co.Ltd. can be used for observations of ionospheric phenomena such as polar cap patches. However, there is some sort of difference in the optical intensity between the EMCCD-ASI and the small airglow camera. We suppose that this is due to the difference in the FWHM of the optical filters. In the presentation, we will discuss this difference in a quantitative manner by using airglow spectra from ASG.

Keywords: Polar cap region, Polar cap patches, Airglow measurements

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PEM27-12 Room:A01 Time:May 26 11:15-11:30

Measurements of neutral wind and plasma drift with chemical release in the cusp region - preliminary results

KAKINAMI, Yoshihiro[1*] ; KIHARA, Daiki[1] ; WATANABE, Shigeto[2] ; YAMAMOTO, Masa-yuki[1] ; CONDE, Mark[3] ; LARSEN, Miguel[4]

[1]Kochi University of Technology, [2]Hokkaido Information University, [3]University of Alaska, Fairbanks, [4]Clemson University

A chemical release experiment was taken place on 24 November 2014 to measure neutral wind and plasma drift in the cusp region, which was named the Cusp Region Experiment (C-REX). We set up 2 cameras (one for neutral Barium (Ba) and the other for ionized Barium (Ba+)) at Longyerben and Ny-Alsund for each site. In addition, one video camera at Ny-Alsund and one camera with a grating at Longyerben were set up. The rocket was launched from Andoya at 08:05 UT and first chemical release was observed at 08:14:19 UT from Longyerben, Ny-Alsund and an airplane. Ten of 24 canisters were successfully ignited between 200 and 400 km altitude at about 600 km away from Svalbard islands. Each canister contains barium (Ba) and strontium (Sr). Evaporated gasses reflect sunshine and green and blue “space fireworks” were observed by digital cameras with filter and video as well as human eyes. The filters were developed to observe resonance scattering of neutral Ba (552.5 nm) and ionized Ba (454.5 nm), and evaluated with an integrating sphere in National Institute of Polar Research. We also observed space fireworks with a grating and successfully obtained spectrums. In this paper, we introduce our observation and show preliminary results of the experiment.

Keywords: cusp, neutral wind, plasma drift, space firework, chemical release exeprimet, neutral density anomaly

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PEM27-13 Room:A01 Time:May 26 11:30-11:45

Detecting mid-latitude Es by InSAR

SUZUKI, Takato[1*] ; MAEDA, Jun[1]

[1]Department of Natural History Sciences, Hokkaido University

Maeda and Heki. (2014) succeeded in capturing sporadic-E (Es) over Japan two-dimensionally, using the observation of Global Positioning System – Total Electron Content (GPS-TEC). While the GPS is originally used for the crustal deformation monitoring, Interferometric Synthetic Aperture Radar (InSAR) is another space geodetic technique that allows us to detect crustal movements. SAR transmits a microwave pulse and receives the reflected pulse while a target on the ground is in the beam by using an antenna on the platform like aircrafts and satellites, so that it can implement virtually a large aperture antenna and can create high-resolution images. InSAR can detect crustal deformation signals between the two acquisition dates as a two-dimensional image by taking the difference of the phase data of the SAR images. Like GPS carrier phases, ionospheric effect sometimes appears on the InSAR images. The lower the used microwave frequency, the more notably the ionospheric effect appears. Hence, a satellite using L-band microwave like Advanced Land Observing Satellite (ALOS) is advantageous to detect ionospheric phenomena. If Es can be detected by InSAR whose spatial resolution is higher than GPS, we can understand its spatial structure in more detail and help to clarify the generation mechanism of the Es. In this study, we aimed to detect Es over Japan by InSAR.

First, we chose the dates whose critical frequencies of Es (foEs) were more than 15MHz at ionosonde in Wakkanai, Kokubunji and Yamagawa in the morning in 2006 through 2010 from May to August. Second, we chose the data of ALOS/PALSAR whose observing areas and dates are as close as possible, and generated interferometric images. An interesting phase shift appeared on one of the images, the pair of March 28, 2009 (Master) and Jun 28, 2009 (Slave), and it had northeast direction slope. Although the entire shape could not be imaged due to the sea surface, we could observe four patches; the spatial scale of each patch is about 20km. Converting this phase shift into TEC variation (△TEC), it turns out that △TEC=0.44TECU, which is close to when Es appears. However, we could not identify the altitude in the InSAR image, and thus we used GPS-TEC. As a result, a similar signal was detected near the place where the phase shift appeared on the InSAR image. We could identify the altitude of the signals to be 100km. Therefore, it turns out that the phase shift on the InSAR image is caused by mid-latitude Es.

Keywords: InSAR, sporadic-E, GPS-TEC

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PEM27-14 Room:A01 Time:May 26 11:45-12:00

Tidal effect of the neutral atmosphere in the lower thermosphere on the movement of sporadic E at midlatitude

MAEDA, Jun[1*] ; HEKI, Kosuke[1]

[1]Hokkaido University

Introduction

Sporadic *E* is a highly ionized plasma patch unpredictably appears at an altitude of ˜100 km in the *E*-region of the ionosphere. At midlatitudes, occurrences maximize in local summer (Whitehead, 1989 and references there in), and in the Far East region including Japan (Wu et al., 2005; Arras et al., 2008). Ground-based radar observations and rocket experiments have been the two primary methods of sporadic *E* observations. Since their spatial and temporal resolutions are restricted, two-dimensional (2-D) and/or continuous observations of sporadic *E* plasma patches and their movements have been difficult. Maeda and Heki [2014] have performed 2-D observations of midlatitude sporadic *E* by using dual-frequency Global Navigation Satellite System (GNSS) satellites and a dense array of GNSS receivers in Japan (GEONET) composed of ˜1200 GNSS staions. Sporadic *E* can be observed as positive total electron content (TEC) anomaly in the GNSS-TEC observations. Mapping these anomalies revealed 2-D horizontal structure of sporadic *E* plasma patches and time sequences of TEC maps showed temporal evolution of the plasma structure, including their movements.

Analyses

In the present study, we use GNSS-TEC observations with GEONET receivers. We focus on the movement of sporadic *E* patches. Typically sporadic *E* plasma patches form frontal structure that elongates 50-500 km in the east-west (E-W) direction [Maeda and Heki, 2014]. Since the movements in the E-W direction cannot be distinguished from the development of elongation, here we only study movements in the N-S directions. 5 min TEC maps are generated to study temporal evolution of plasma patches. Direction and speed of movements are manually read by 20-30 min interval. In total, 27 cases of sporadic *E* movements over Kanto region are analyzed.

Results and Discussion

We counted the number of northward and southward movements, respectively, and plotted in the local time (LT) order. The histogram shows LT dependence of N-S movements, i.e., northward and southward movements concentrates in the 10-12 LT and 18 LT, respectively. In between the two peaks, there is a silent period, i.e., the minimum of the number of movements at 15 LT. These results are consistent with those reported by Tanaka [1979] who conducted backscatter radar observations in Kanto region (the same study area as ours). Tanaka [1979] showed that the westward movement peaks around 15 LT. Since we ignored the E-W movements, the silent period in the N-S movements can be interpreted as the results of rotation of movement directions of plasma patches possibly governed by atmospheric tide. Thus, GNSS-TEC observations of sporadic *E* plasma patches may be useful to infer the dynamics of the neutral atmosphere in the lower thermosphere.

Keywords: sporadic-E, GPS, TEC, atmospheric tide

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

PEM27-15 Room:A01 Time:May 26 12:00-12:15

Imaging observation of spatial structure of sporadic E layer by Magnesium Ion Imager on the sounding rocket S-520-29

KURIHARA, Junichi[1*] ; IWAGAMI, Naomoto[2] ; KOIZUMI-KURIHARA, Yoshiko[3] ; TANAKA, Makoto[4] ; TAKAHASHI, Takao[4] ; ABE, Takumi[3]

[1]Faculty of Science, Hokkaido University, [2]Graduate School of Science, The University of Tokyo, [3]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, [4]ICT Education Center, Tokai University

To study the spatial structure of midlatitude sporadic E (Es) layers, the vacuum ultraviolet resonant scattering by magnesium ions (Mg^+) in an Es layer was observed with the Magnesium Ion Imager (MII) on the sounding rocket S-520-29. Since the Es layers is formed by the convergence of metallic ions that have slow ion-electron recombination rates, the distribution of Mg^+, which is one of the dominant species among the metallic ions, is thought to reflect the spatial structure of the Es layer. It is suggested that the spatial structure of the Es layer is closely related to various ionospheric phenomena such as the field aligned irregularity and the E-F coupling. Therefore, it is expected that imaging observations of the Mg^+ distribution will provide new knowledge in the spatial structure of the Es layer.

The sounding rocket S-310-38 was launched from the Uchinoura Space Center in Kagoshima, Japan, on 6 February 2008 for the same purpose and the two-dimensional horizontal structure of Mg^+ in an Es layer was observed for the first time. While this result demonstrates the usefulness of Mg^+ imaging for understanding the spatial structure of Es layers, the attitude of the sounding rocket, especially the zenith angle of the rocket axis was unusually tilted and the area of meaningful observation was limited.

In the sounding rocket S-520-29 experiment conducted on 17 August 2014, the MII was improved since the S-310-38 experiment and an attitude control system by gas jet was implemented. Unfortunately, the attitude control did not work as expected, but the Mg^+ distribution was successfully observed and important information on the spatial structure of the Es layer was obtained.

Japan Geoscience Union Meeting 2015
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PEM27-16 Room:A01 Time:May 26 12:15-12:30

Ampere force exerted by geomagnetic Sq currents and thermospheric pressure difference

TAKEDA, Masahiko[1*]

[1]Data Analysis Center for Geomagnetism and Space Magnetism., Kyoto Univ.

Relationship between Ampere force exerted by geomagnetic Sq currents and neutral pressure was examined. It was shown that the Ampere force around the Sq current vortex center is almost equal to the pressure difference between its maximum and minimum, and this balance is kept through the solar cycle. The lowest height of the pressure integration for best fit is 120km, which is reasonable considering the height profile. There was a seasonal variation that the pressure difference is smaller and larger in local summer and winter, respectively. This is consistent with the effects of magnetic field by inter-hemispheric field-aligned currents on geomagnetic Sq field.

Keywords: geomagnetic daily variation, total current, Ampere force, thermospheric pressure difference, solar acivity

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

PEM27-17 Room:A01 Time:May 26 12:30-12:45

Study of ionospheric disturbances using the remote HF wave receiver of the SuperDARN Hokkaido East radar

NISHITANI, Nozomu[1*] ; KIGAWA, Ryusuke[1] ; HORI, Tomoaki[1] ; HAMAGUCHI, Yoshiyuki[1]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University

We have been operating the remote HF wave receiver of the SuperDARN Hokkaido East radar in Nagoya and Rikubetsu (in the vicinity of the HF radar) since 2014 to monitor the ionospheric disturbances. Using the remote receiver data it is possible to monitor the upward / downward motion of the ionosphere at the ionospheric reflection point of the HF radar backlobe beams emitted torward Nagoya areas. Initital result of the observation of ionospheric perturbations using the remote HF wave receiver of the SuperDARN Hokkaido East radar will be presented.

Keywords: SuperDARN, remote HF wave receiver, ionospheric disturbance

PEM27-18 Room:A01 Time:May 26 14:15-14:30

Seismo-traveling ionospheric disturbance observed by HF Doppler sounding system

CHOU, Min-yang[1*] ; TSAI, Ho-fang[1] ; LIU, Jann-yenq[2] ; LIN, Charles[1]

[1]National Cheng-Kung University, [2]2Institute of Space Science, National Central University,

In this paper, networks and concurrent/co-located measurements of seismometers (BATS, K-net, KiK-net), HF Doppler Sounding Systems in Taiwan and Japan are used to study Seismo-traveling ionospheric disturbance (STIDs). It's shown that these infrasound wave packets triggered by seismic surface waves that was generated by strong earthquake. The infrasound wave packets were detected in the ionosphere at heights ˜200 km about 9 min after the detection of corresponding wave packets on the ground. The individual wave packets recorded on the HF Doppler have different observed horizontal velocities and correspond to different type of seismic waves.

The Hilbert-Huang Transform (HHT) is applied to analyze Doppler frequency shifts (DFSs) detecting STIDs and estimated the amplification factor in vertical displacement of the ionosphere relative to the ground surface motion, while the time delay, circle, ray-tracing, and beam-forming methods are used to compute the origin of the detected STIDs.

Keywords: STIDs, Ionosphere

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

PEM27-19 Room:A01 Time:May 26 14:30-14:45

Propagation Characteristics of Neutral Atmospheric Waves Associated with Earthquakes Using a Numerical Simulation

YOSHIKAWA, Kouhei[1*] ; SHIMIZU, Yuki[1] ; NAKATA, Hiroyuki[1] ; TAKANO, Toshiaki[1] ; MATSUMURA, Mitsuru[2]

[1]Graduate School of Engineering, Chiba University, [2]National Institute of Polar Research

By using HF Doppler and GPS ionospheric total electron content (TEC) observations, it is found that atmospheric waves excited by earthquakes cause ionospheric disturbances. In this study, we examined the relationship between seismic ground perturbations and ionospheric disturbances in order to mechanism of the propagations of atmospheric waves using a numerical simulation. In this simulation, we calculated temporal evolutions of neutral atmospheric waves by solving basic equations of neutral atmosphere.

The effects of the artificial viscosity used in the numerical simulation are evaluated. In compressible fluids, shock waves occur when advection velocity is faster than the sound velocity. Although shock waves correspond to discontinuous planes mathematically, they have the thickness of the mean free path of air molecules approximately. When we run the simulation without artificial viscosity, the simulation is diverged. Thus, we add Von-Neumann-type artificial viscosity. In adding the artificial viscosity, it is necessary to determine an adequate artificial viscosity coefficient. Therefore we compared the simulation results with the theoretical equations (*Chum et al*., 2012) obtained by subtracting attenuation from law of the conservation of energy flux. The simulation results were determined with the various artificial viscosities. As the artificial viscosity becomes larger, the amplitude of simulation results become small and the amplitude depend on the period of input disturbance as compared to the theoretical equations. This result means that the adequate artificial viscosity coefficient must be determined owing to the period of input disturbances. At the wave front, the waveform is elongated, the amplitude is larger than theoretical equation. We discussed temporal waveforms to find the cause of this waveform. It is found that the waveform includes the lower frequency component than input disturbance. The theoretical equation shows that the atmosphere works as low pass filter, and that the cut-off frequency become lower with the higher altitude because high frequency components are attenuated due to viscosity and heat conduction. Due to these characteristics, low-frequency component is dominant at higher altitude.

Keywords: Earthquake, Neutral atmospheric wave, Numerical simulation, Ionospheric disturbance

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

PEM27-20 Room:A01 Time:May 26 14:45-15:00

Ca+ density perturbations observed by a resonance scattering lidar during MSTIDs

EJIRI, Mitsumu K.[1*] ; TSUDA, Takuo[2] ; NISHIYAMA, Takanori[1] ; ABO, Makoto[3] ; NISHIOKA, Michi[4] ; MARUYAMA, Takashi[4] ; SAITO, Akinori[5] ; NAKAMURA, Takuji[1]

[1]National Institute of Polar Research, [2]The University of Electro-Communications, [3]Graduate School of System Design, Tokyo Metropolitan University, [4]National Institute of Information and Communications Technology, [5]Department of Geophysics, Graduate School of Science, Kyoto University

In the mesosphere and lower thermosphere region, there are permanent layers of metal atoms and ions, the source of which is vaporization of cosmic dust and meteoroids during their entry into the Earth's atmosphere. Some metal atom layers e.g. Na, K, Ca, and Fe layers, and only Ca^+ (Calcium ion) can be observed by ground-based resonance scattering lidars. The National Institute of Polar Research (NIPR) is developing a new resonance scattering lidar system with a frequency-tunable laser. The lidar transmitter is based on injection-seeded, pulsed alexandrite laser for 768-788 nm and a second-harmonic generation (SHG) unit for 384-394 nm. The new lidar is able to measure density variations of minor constituents including Ca^+ (393 nm). As a part of the development, observation tests are carried out at NIPR (35.7N, 139.4E) since 2013, and we got the first light from Ca^+ on 21 August, 2014. The Ca+ density profiles were obtained for $\sim$5 hours (23:13 LT-28:28 LT) with time and height resolutions of 1 min and 15 m, respectively. At the same night, sporadic E (E_s) layer was observed with an ionosonde at Kokubunji by National Institute of Information and Communications Technology (NICT) (35.7N, 139.5E), also medium scale traveling ionospheric disturbances (MSTIDs) were observed with the dense GPS receiver network (GEONET). In this presentation, we compare these data in detail and discuss relationships between observed Ca^+ density perturbations, E_s layer and MSTIDs.

Keywords: resonance scattering lidar, Ca+, medium scale traveling ionospheric disturbances, GPS-TEC, sporadic E layer

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

PEM27-21 Room:A01 Time:May 26 15:00-15:15

Characteristics of spatial gradient of ionospheric TEC assoicated with plasma bubbles and its impact on GNSS

SAITO, Susumu[1*] ; YOSHIHARA, Takayuki[1]

[1]Electronic Navigation Research Institute

The plasma bubble is a sharp depletion in the ionospheric plasma density. Spatial gradient of the ionospheric TEC (total electron content) associated with the sharp depletion of the plasma density makes it difficult for GNSS augmentation systems to work properly. To mitigate the ionospheric threats associated with the spatial TEC gradient, it is important to know the characteristics of the TEC gradient.

Data used are obtained in Ishigaki (24.3N, 124.2E) with five GNSS receivers with mutual distances from 86 to 1557 m. TEC differences and thus the gradients between a pair of GNSS receivers are precisely derived with the single-frequency carrier-based and code-aided (SF-CBCA) technique. Directions of the TEC gradients are estimated with the TEC gradients between three of the five stations. The derived TEC gradients are compared with those derived with the dual-frequency TEC estimation with the assumption that the TEC gradient in quiet time would be zero. The velocity and propagation directions of the gradients are estimated with the correlation analysis of TEC variation of three of the five stations.

Associated with the plasma bubble events on 3 April 2008, the TEC gradients derived with the SF-CBCA method was amounted to be 3.2 TECU/km, which is equivalent to the gradients in the ionospheric delay at L1 frequency of 518 mm/km. It exceeds the upper bound of the ionospheric threat space (maximum assumed values in the safety design) of ground-based augmentation system (GBAS). The result is proved to be realistic with the dual frequency measurements, though there seems to be cycle-slip effects in TEC estimation. The velocity was estimated to be 118 m/s, and the propagation direction was estimated to be 75 degrees. The propagation direction is consistent with the direction of the TEC gradient of 74 degrees (clockwise from the North). The spatial scale of the TEC gradient is estimated to be 7 km.

These parameters derived in this study are all relevant to the ionospheric threat space of GBAS, and the threat space is shown to be modified so that this extreme TEC gradient is bounded. Thus, studying the characteristics of the TEC gradient with the parameters shown above are very important to the safety design of GNSS augmentation systems, and have to be investigated extensively. Further analysis of the data obtained in the periods of higher solar activity than that of the event analyzed here is necessary and is now going on.

Keywords: plasma bubble, ionospheric irregularity, TEC gradient, irregularity velocity, irregularity scale size, GNSS augmentation system