Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PEM29-01 Room:304 Time:May 22 14:15-14:30

HF propagation model reflected by frontal Es

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We have developed the method to derive precisely both direction and speed of the frontal Es by using the HF Doppler observation network with muti-reflection points. Based on the analysis of this method we have shown that the HF Doppler variation due to the frontal Es can be described by the mirror reflection model instead of the scattering model. It is therefore concluded that the frontal structure of Es should have both the thin cross-section less than the diameter of the first Fresnel zone and the horizontal straight-line shape much more than the same diameter.

Keywords: sporadic E, frontal structure, HF propagation model

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PEM29-02 Room:304 Time:May 22 14:30-14:45

Study of quantitative characteristics of ionospheric disturbances during solar flare with 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 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, 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, 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. In order to confirm this result and to study characteristics of ionospheric disturbance in more detail, we are working on the classification of solar flare events according to its intensity, local lime, season and solar zenith angle, and the investigation of their effects on the ionospheric disturbances. We estimated variation of electron densities at D-region ionosphere and will estimated that of F-region ionosphere. In addition, we are trying to estimate variation of ionospheric electron densities by chemical reaction model using X-ray / EUV irradiation data from GOES and SDO satellites. We will compare the variation of ionospheric electron densities obtained from SuperDARN Radar data and that obtained from chemical reaction model. More detailed analysis result will be reported.

Keywords: solar flare, SuperDARN hokkaido radar, lower ionospher, F-region ionospher, Doppler shift

Japan Geoscience Union Meeting 2013
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PEM29-03 Room:304 Time:May 22 14:45-15:00

The response of The 20 May 2012 solar ecliption the geomagnetic field

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The solar eclipse geomagnetic effect was studied ealier, but it was not clear so many.

We cannot distinguish geomagnetic effects due to an eclipse-induced from S_q variation, because S_q variation has irregularity depending on the day.

We need to evaluate the irregurality of S_q variation to detect a disturbance during annular solar eclipse,when the effect expected is most discernible.

The annulation belt of the solar eclipse on 21 May 2012 run from the southwest of Japan to northeast,where the precise obsertational data gained in.

Creating a mathmatical model through making reference to data of each observatory in Japan allow to presume the S_q variation in Katano (KTN).

Some observatory has geomagnetic effect due to a solar eclipse and others don’t have.Therefore,several mathmatical models generate the residual having various signature.

In this paper,the results are compared with each other to detect a of annual solar eclipse.

Keywords: Geomagnetic effects, solar eclipse, Kalman filter

Japan Geoscience Union Meeting 2013
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PEM29-04 Room:304 Time:May 22 15:00-15:15

Cause of long term variation of geomagnetic Sq field

Masahiko Takeda[1*]

[1]Masahiko Takeda

Variation of geomagnetic Sq field amplitudes in the Y component at some observatories was studied and effect of the solar activity in the variation was investigated. While solar activity dependence of ionosphere conductivity could explain most solar activity dependence of the time scale for more than a few years of Sq amplitude, the solar activity dependence of the dynamo electric field was small. Rather, the dynamo field tends to be small when solar activity is high. Although there was a difference by an observatory in the long-term change of the a dynamo electric field, the difference is mainly due to the secular variation of a geomagnetic main field, and variation of the neutral wind velocity was almost the same at all observatories.

Keywords: geomagnetism, daily variation, solar activity, electric conductivity, neutral wind, main field strength

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PEM29-05 Room:304 Time:May 22 15:15-15:30

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

Atsuki Shinbori[1*], Yukinobu Koyama[2], Masahito Nose[2], Akiyo Yatagai[1], Tomoaki Hori[3], Yuichi Otsuka[3]

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It has been well-known that geomagnetic solar quiet (Sq) daily variation is produced by the global ionospheric currents flowing in the E-region from middle latitudes to the magnetic equator. These currents are generated by dynamo process via interaction between the neutral wind and ionospheric plasma in a region of the lower thermosphere and ionosphere. The motion of the neutral particles is driven by heat convection due to solar irradiance and by tidal force of the sun and moon. According to the Ohm's equation, the ionospheric currents strongly depend on ionospheric conductivity, polarization electric field and neutral wind. Then, the long-term variations in the ionospheric conductivity and neutral wind in the lower thermosphere and ionosphere can be detected by investigating the long-term variation in the Sq amplitude. Recently, Elias et al. [2010] reported that the Sq amplitude tends to increase by 5.4-9.9 % in the middle latitudes in a period of 1961-2001. They mentioned that the long-term variation of ionospheric conductivity associated with geomagnetic secular variation mainly determines the Sq trend, but that the rest component is due to ionospheric conductivity enhancement associated with cooling effect in the thermosphere due to increasing greenhouse gas. In the present study, we try to clarify the characteristics of the long-term variation in the Sq amplitude using the long-term observation data of geomagnetic field and neutral wind. These observation data have been provided by Japanese institutes participating in the IUGONET (Inter-university Upper atmosphere Global Observation NETwork) project which started in FY 2009. In the present analysis, we used the F10.7 solar flux as a good indicator of the variation in the solar irradiance in the EUV and UV range as well as geomagnetic field data with time resolution of 1 hour observed at 184 geomagnetic stations. The definition of the Sq amplitude is the difference of the H-component between the maximum and minimum every day when the Kp index is less than 4. As a result, the long-term variation in the Sq amplitude at all the geomagnetic stations shows a strong correlation with the solar F10.7 flux which depends on 11-year solar activity. The relationship between the Sq amplitude and F10.7 flux 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 EUV and UV fluxes as already reported by Balan et al. [1993]. In order to minimize the solar activity dependence on the Sq amplitude, we calculated second orders of fitting curve between the F10.7 flux and Sq amplitude during 1950-2011, and examined the residual Sq amplitude defined as the deviation from the fitting curve. The residual Sq amplitude clearly shows increase and decrease trends with the periods of 20 years. It should be noted that the residual Sq amplitude around 2010 is almost the same level as that around 1970. On the other hand, the similar tendency can be seen in the diurnal variation of geomagnetic field in the auroral zone and polar cap (Sqp field) driven by the twin vortex of ionospheric currents associated with energy inputs from the solar wind into the ionosphere. Then, it seems that the trends in the residual Sq and Sqp fields are related to the long-term variation in the ionospheric conductivities associated with the secular variation of the ambient magnetic field and the upper atmosphere (for example, plasma and neutral densities). In order to verify qualitatively the above signatures, we need to investigate the long-term variation in the ionospheric conductivities using a calculation tool developed by the IUGONET project.

Keywords: Geomagnetic solar quiet (Sq) daily variation, Solar activity, Upper atmosphere, Neutral wind, Ionosphere, Thermosphere

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PEM29-06 Room:304 Time:May 22 16:15-16:30

Plasma wave turbulence induced by the wake of an ionospheric sounding rocket

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In the ionosphere, a rarefied plasma region called ‘plasma wake’ is formed behind a sounding rocket. For the past a few decades, many theoretical works, rocket experiments and numerical simulations have revealed the electron density depletion and the electron temperature enhancement in plasma wakes.

Several recent studies based on rocket observations have indicated that plasma waves are possibly excited in the rocket wake. They have discussed the observational results of the wave spectra in a frequency range around a few MHz based on the cold plasma theory and have suggested that the observed waves are the upper-hybrid resonance (UHR) mode waves. A wake turbulence model has been also proposed as a possible explanation for the waves where the two stream instability occurs in the wake center owing to the incident plasma flow from the both sides of the wake edges. However, there remains an issue that a part of the waves have not been explained by the dispersion relation of the UHR-mode waves calculated from the obtained electron density in the wake. In addition, these plasma waves have been investigated by using wave receivers with time resolutions worse than 500 msec, which is not enough for detailed investigations about their generations and propagations.

Plasma waves around the wake have been also reported in the region close to an artificial satellite and solar system bodies such as Moon. This suggests that the generation of plasma waves due to the rocket wake should be understood as a kind of universal phenomena in interactions between streaming plasma and a non-magnetic body.

To discuss the properties of the plasma waves caused around the rocket wake in more detail, we have measured the electron number density and electric fields of plasma waves in the mid-latitude ionosphere by an impedance probe and a plasma wave receiver, which were installed on the sounding rocket S-520-26. The time resolutions of the two instruments are about 260 msec, which corresponds to one fourth or one fifth of a spin period. The rocket was launched at Uchinoura in Kagoshima Prefecture, Japan, on January 12, 2012, and reached at an altitude of 298 km, approximately. We have observed plasma waves in the frequency range of 1.3-2.4 MHz (MF range) as well as in the frequency range below 0.9 MHz (LF range). The MF emissions are similar to the observed waves in the previous studies. Although the frequency range of the MF emissions is around the UHR frequency, we reveal that a component of the emissions are not explained by the dispersion relation of UHR-mode waves in the wake condition, which is deduced from the IGRF magnetic model and the data obtained by the impedance probe.

In this study, we discuss the mode of the observed plasma waves based the dispersion relation in a hot plasma. Assuming that the waves are generated around the wake near the rocket, we clarify that the MF emissions are explained by electrostatic cyclotron harmonics (ESCH) waves as well as the UHR-mode waves and that the LF emissions are electrostatic whistler-mode waves, because the wave length should be shorter than the size of the disturbed region. Besides, the analysis of the rocket attitude tells us that the both emissions are strongly observed only when the dipole antenna is in a certain direction. Moreover, we perform calculations of plasma dispersion relations numerically by assuming anisotropic velocity distribution functions including an electron beam or temperature anisotropy. As a result, positive linear growth rates are obtained in the wave number and frequency ranges of the electrostatic UHR-mode waves, ESCH waves and whistler-mode waves.

In this presentation, we compare the observational results with the obtained dispersion relations and discuss the properties of the observed plasma waves.

Keywords: wake, plasma wave, sounding rocket, ionosphere

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PEM29-07 Room:304 Time:May 22 16:30-16:45

Observation of ionospheric disturbance using GPS, and evaluation of their impact on air navigation augmentation system

Naoki Omatsu[1*], Yuichi Otsuka[1], Susumu Saito[2], Kazuo Shiokawa[1]

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In recent years, GPS has been utilized for navigation system for airplanes. Propagation delays in the ionosphere due to total electron content (TEC) between GPS satellite and receiver cause large positioning errors. In precision measurement using GPS, the ionospheric delay correction is generally conducted using both GPS L1 and L2 frequencies. However, L2 frequency is not internationally accepted as air navigation band, so it is not available for positioning directly in air navigation. In air navigation, not only positioning accuracy but safety is important, so augmentation systems are required to ensure the safety. Augmentation systems such as the satellite-based augmentation system (SBAS) or the ground-based augmentation system (GBAS) are being developed and some of them are already in operation.

GBAS is available in a relatively narrow area around airports. In general, it corrects for the combined effects of multiple sources of positioning errors simultaneously, including satellite clock and orbital information errors, ionospheric delay errors, and tropospheric delay errors, using the differential corrections broadcast by GBAS ground station. However, if the spatial ionospheric delay gradient exists in the area, correction errors remain even after correction by GBAS. It must be a threat to GBAS.

In this study, we use the GPS data provided by the Geographical Survey Institute in Japan. From the GPS data, TEC is obtained every 30 seconds. We select 6 observation points from 26.4 to 35.6 degrees north latitude in Japan, and analyze TEC data of these points from 2001 to 2011. Then we reveal dependences of Rate of TEC change Index (ROTI) on latitude, season, and solar activity statistically. ROTI is the root-mean-square deviation of time subtraction of TEC within 5 minutes. In the result, it is the midnight of the spring and the summer of the solar maximum in the point of 26.4 degrees north latitude that the value of ROTI becomes the largest. We think it is caused by plasma bubbles, and the maximum value of ROTI is about 6 TECU/min. Since it is thought that ROTI is an index representing the spatial ionospheric delay gradient, we can evaluate the effect of spatial ionospheric delay gradient to GBAS. More detailed results will be reported in this presentation.

Keywords: ionosphere, GPS, satellite navigation, GBAS, ROTI

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PEM29-08 Room:304 Time:May 22 16:45-17:00

Effect of IMF-By on variations of ionospheric total electron content at mid-latitudes

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The primary factor that controls ionospheric total electron content (TEC) variation is solar UV/EUV radiations through direct and indirect processes. The direct effect is the ionization of the thermospheric neutral particles by EUV radiations with wavelengths (*lambda*) shorter than 102.5 nm. Virtually all photons of *lambda*<102.5 nm are absorbed by photoionization and the absorbed energy splits into the photo-electron channel and the chemical energy channel (ion-electron pair) with the ratio that depends on the wavelength. Indirect effects of solar irradiance on the ionosphere are through the modification of the thermosphere. The recombination of ion-electron pair and the dissociation process of molecular oxygen (O_2) by the Schumann-Runge continuum radiation (*lambda* = 130-175 nm) are the primary heat source of the thermosphere. Changes in temperature and composition of the neutral atmosphere, and the atmospheric circulation greatly affect the ionospheric electron density.

Because the relationship between the solar spectral irradiance and ionospheric TEC is highly complex, we applied an artificial neural network (ANN) technique that has a great capability of function approximation of complex systems to model solar irradiance effects on TEC. Three solar proxies, $F_{10.7}$, SOHO-SEM$_{26-34}$ EUV emission index, and MgII$_{c-w-r}$ were the input parameters to the ANN representing activities at various heights and regions of the solar atmosphere (Maruyama, JGR 2010). Although the trained ANN prediction model was confirmed to work well to predict TEC variations, there remained some errors as easily expected from the fact that another channel of energy flow from the sun to the earth's ionosphere in the form of solar wind was not considered in the model. Thus, in the next step, we have examined effects of magnetic disturbance, which is a manifestation of solar wind magnetosphere energy coupling. For this purpose, the K_p index and several solar wind magnetosphere coupling functions were chosen as an additional input parameter to the ANN-TEC model and we obtained a substantial improvement in the TEC prediction when the preprocessed K_p index was used.

Somewhat minor but interesting effects on TEC variations are expected to emerge when major effects of solar irradiance and magnetic disturbance have been removed. We analyzed the time series of residual error by using a wavelet transformation, which revealed an error characterized by a period of approximately 27-30 days in the summer. Possible origins of the error having such a period are (1) insufficient modeling of solar activity effect, (2) lunar tidal forcing, (3) coupling with planetary waves in the lower atmosphere, and (4) solar wind effect other than geomagnetic disturbances. Regarding the first and second possibilities, the time series of the error amplitude did not synchronize with the solar rotational modulation of the activity or the lunar age. The third possibility may not be probable because the penetration of planetary waves up to ionospheric heights is suppressed during the summer. We examined solar wind effects in detail.

A various solar wind parameters and their combinations were examined. The best result was obtained when the IMF-By component and the solar wind velocity were included in the input space of the ANN and the residual error showing the 27-30 day period during the summer was removed. Parallel use of the solar wind magnetosphere coupling function further improved the model. Possible explanation of the IMF-By effect is discussed in terms of changes in the thermospheric general circulation pattern.

Keywords: TEC, IMF-By, artificial neural network

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PEM29-09 Room:304 Time:May 22 17:00-17:15

Study of gravity waves generated from strong tropospheric convection over Brazil by using multi-point GPS-TEC data

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It has been suggested that gravity waves causing the ionospheric disturbances were secondary waves generated by dissipation of primary gravity waves in the mesopause region or lower thermosphere. Vadas and Liu (submitted to JGR, 2013) simulated primary gravity waves generated from deep convection over Brazil after 18 UT on 1 October, 2005. They showed that the primary gravity waves generated secondary gravity waves through their dissipation in the thermosphere. The horizontal phase velocity, period, and horizontal wavelength of the secondary gravity waves were 500-600 m/s, 2-3 hours, and 4000-5000 km, respectively. They propagated even to Antarctica, Africa, and Europe.

In this study, we investigated whether these simulated gravity waves were actually observed or not, by using the total electron content (TEC) observed by the multi-point GPS receivers in South America. TEC perturbations which are likely to be caused by the gravity waves were seen around 4 UT on 2 October, 2005 in the TEC data at Brasilia, Brazil. The period of the observed TEC perturbation is slightly different from the original gravity-wave period since the observed period contains the effect of the GPS satellite motion, which varies depending on satellites. Based on multi-satellite analysis, we infer that the phase front of the observed gravity wave is east-west direction. The horizontal phase velocity, period, and horizontal wavelength of the gravity wave calculated by using the difference of the apparent periods were 660 m/s, 2 hours, and 4600 km, respectively. These parameters are similar to those of simulated secondary gravity waves described above. In the presentation, we discuss the comparison between the observed and simulated gravity waves.

Keywords: gravity wave, GPS-TEC, tropospheric convection

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PEM29-10 Room:304 Time:May 22 17:15-17:30

Observational results with the Tromsoe sodium LIDAR from October 2012 to March 2013

Satonori Nozawa[1*], Taku D Kawahara[2], Norihito Saito[3], Takuo Tsuda[4], Testuya Kawabata[1], Masaki Tsutsumi[4], Shin-ichiro Oyama[1], Toru Takahashi[1], Hitoshi Fujiwara[5], Satoshi Wada[3], Yasunobu Ogawa[4], Ryoichi Fujii[1]

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We have made observations of the neutral temperature as well as wind velocity in the polar MLT region (80-110 km) from October 2012 to now (probably March) using the sodium LIDAR installed at Ramjordmoen, Tromsoe (69.6N, 19.2E), where the EISCAT radars, MF radar, meteor radar (NIPR), FPI, aurora imagers have been operated. This season is our 3rd season of observations using the sodium LIDAR at Tromsoe. In late September and early October 2012, we made further improvements of the LIDAR system such as (1) achievement of higher laser power output (about 4W), (2) replacement of a dome with a glass window, (3) use of narrower iris-mask, and (4) PC monitoring of temperature of laser devices.

This talk will give an overview of results obtained with the sodium LIDAR over about 6 months (October 2012 - March 2013) during the 3rd season. We mainly operated the sodium LIDAR with a five-beam mode where the laser beam was transmitted simultaneously toward five directions (vertical, north, east, south, west). In addition to the five-beam operation, we operated the sodium LIDAR with a vertical (1-beam) mode, where the laser beam was transmitted vertically only, for about 1 hour each in the beginning and ending, since the noise level of the vertical receiver was significantly lower than the others due to sharpness of receiving backscatter laser echo. We will present variations of atmospheric waves, horizontal structure of the neutral temperature, comparison of wind velocity obtained with the LIDAR and the meteor radar, and simultaneous observational results with the EISCAT radars.

Keywords: Sodium LIDAR, Temperature variation, lower thermosphere, mesosphere, polar upper atmosphere, EISCAT

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PEM29-11 Room:304 Time:May 23 09:00-09:15

Progress of the middle and upper atmosphere observations over Syowa station in the Antarctic

Takuji Nakamura[1*], Kaoru Sato[2], Masaki Tsutsumi[1], Takashi Yamanouchi[1]

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The Japanese Antarctic Research Expedition (JARE) has started the VIII-th six-year mid-term project in 2010, and the 52nd JARE departed in November 2010 commenced observations of the six-year project. The middle and upper atmosphere study in the VIII-th term, named as 'Global environmental change revealed by observing the Antarctic middle and upper atmosphere', is one of the sub-projects of the prioritized research project entitled 'Global warming revealed from the Antarctic'. PANSY (Program of the Antarctic Syowa MST/IS) radar, and a Rayleigh/Raman lidar system have been newly installed besides the existing radio and optical instruments such as an MF radar, HF radar (Super DARN radar), ionosondes, an OH spectrometer and an all-sky airglow imager in Syowa station, in order to clarify variabilities on the atmosphere from the ground to the upper atmosphere. Also installed was a millimeter wave spectrometer for profiling minor constituents.

PANSY radar is the core instrument of this project, and is a 47 MHz VHF radar with 500 kW output power and 20,000 m2 antenna array. The radar observes wind velocities from the troposphere to the mesosphere, as well as plasma parameters in the ionosphere. Three groups of antena (1/18 of full system) was installed during summer operation of the 52nd JARE, and started observation of troposphere. Scientific observation with 12 groups of antenna (about 1/4) started since April 2012 and the tropospheric and lower stratospheric winds has been measured continuously. PMSE (Polar mesosphere summer echo) and PMWE (Polar mesosphere winter echo) have been monitored in detail by continuous observations. The Rayleigh/Raman lidar observes temperature and clouds in the mesosphere, the stratosphere and part of the troposphere, and providing 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, an external laser system for multi-wavelength resonance scatter lidar measurement is being developed. The millimeter spectrometer measures density profiles of O3 and other species. Since January 2012, NO density has been measured in order to observe day-to-day variation, in order to investigate NO variations due to high energy particles and electrons. Current status of the research and observations, as well as future plans will be presented in the presentation.

Keywords: Antarctic, Middle atmosphere, Upper atmosphere, radar observation, lidar observation, millimeter wave spectrometer

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PEM29-12 Room:304 Time:May 23 09:15-09:30

Program of the Antarctic Syowa MST/IS Radar (PANSY) – after one year continuous operation since 2012 –

Kaoru Sato[1*], Masaki Tsutsumi[2], Toru Sato[3], Takuji Nakamura[2], Akinori Saito[3], Yoshihiro Tomikawa[2], Koji Nishimura[2], Masashi Kohma[1], Hisao Yamagishi[2], Takashi Yamanouchi[2]

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The PANSY radar is the first Mesosphere-Stratosphere-Troposphere/Incoherent Scatter (MST/IS) radar in the Antarctic region. It is a large VHF monostatic pulse Doppler radar operating at 47 MHz, consisting of an active phased array of 1,045 Yagi antennas and equivalent number of transmit-receive modules with total peak output power of 500 kW. Its first stage has been installed at Syowa Station (69ˆo00'S, 40ˆo35'E) in early 2011, and is currently operating with 228 antennas and modules. This paper reports its scientific objects, technical descriptions, and preliminary results of observations made so far. The radar aims to clarify the role of atmospheric gravity waves in important polar events such as polar mesospheric clouds (PMC) and polar stratospheric clouds (PSC). The generation mechanism of gravity waves from katabatic winds is also of special interest. Moreover, strong and sporadic energy inputs from the magnetosphere by energetic particles and field-aligned currents can be quantitatively assessed by the broad height coverage of the radar extending from the lower troposphere to the upper ionosphere. From engineering points of view, the radar had to overcome restrictions due to severe environments of Antarctic research, such as very strong winds, limited power availability, and short period of construction with small manpower. We cleared these problems with specially designed class-E amplifier, light-weight and tough antenna elements, and versatile antenna arrangements. Although the radar is operating with only about a quarter of the full system, we have already obtained interesting results on the Antarctic troposphere, stratosphere and mesosphere, such as observation of gravity waves and multiple tropopauses associated with a severe snow storm in the troposphere and stratosphere, and polar mesosphere summer echo.

Keywords: MST/IS radar, Antarctic atmosphere, Troposphere, Stratosphere, Mesosphere, Ionosphere

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PEM29-13 Room:304 Time:May 23 09:30-09:45

Study on thermospheric sodium layer using Na lidar data from Syowa Station in Antarctica

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The neutral metallic atom layers (such as sodium, iron, potassium layers) are normally distributed at a height range of 80-110 km (in the upper mesosphere and lower thermosphere). Resonance scattering lidar observations of these metallic layers have been used as an important tool for investigation of the upper mesosphere and lower thermosphere. On the other hand, ground-based observations of the neutral atmosphere at higher altitude (above 110 km) are quite limited. Recently, observations of iron layers above 110 km up to 155 km have been reported from an iron Boltzmann lidar at McMurdo Station (77.8S, 166.7E) in Antarctica. Such high-altitude metallic layers (so-called thermospheric metallic layers) is currently well-unknown phenomenon, and has possibility to greatly improve our understanding of the lower thermosphere.

Intensive sodium temperature lidar observations were carried out at Syowa Station (69.0S, 39.6E) in Antarctica between 2000 and 2002 as a part of JARE observations. From the observational data, we investigate thermospheric sodium layer (above 110 km). In this presentation, we will report a thermospheric sodium layer event (up to 130 km) observed on 23 September 2000. In this event, the lidar detected significant signals not only from 80-110 km but also from 110-130 km. More detailed analysis has provided the temperature and the sodium-density measurements at this height range up to 130 km. The estimated sodium density reached about tens of cm^{-3} at around 120 km. The temperature profile in the thermospheric sodium layer was fairly comparable to that from the NRLMSISE-00 model. Furthermore we will discuss relationship between the thermospheric sodium layer and background ionospheric condition during the event.

Keywords: Sodium layer, Thermosphere, Syowa Station, Antarctica

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PEM29-14 Room:304 Time:May 23 09:45-10:00

Variation of Nitric Oxide in MLT region associated with energetic particle precipitation

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Energetic particle precipitation (EPP) due to large solar proton events or geomagnetic storms induces ion-molecule reactions and changes abundances of some minor molecules in the lower thermosphere, the mesosphere and the upper stratosphere. Energetic solar protons directly enter the middle atmosphere, causing increase of HO_x and NO_x radicals and decrease of ozone (e.g., *Lopez-Puertas et al. 2005*). Energetic electrons also increase NO_x in the thermosphere, and the NO_x-rich air is transported downward in the polar vortex during the polar winter (e.g., *Seppala et al. 2007*). To understand the variation mechanism of those molecules related to the solar activities and the polar vortex in the MLT region, we newly installed a microwave spectroscopic radiometer at Syowa Station in Antarctica (69.00S, 39.85E). We have been carrying out the ground-based continuous monitoring of microwave NO (250.796 GHz) spectral lines since January 2012, and 189 daily averaged NO spectra have been obtained.

Typical rms noise of the NO spectra is estimated 21 mK. Most of the spectra have been fitted by a single Gaussian with a half-power band width (HPBW) of 0.5 MHz, suggesting that the NO-line emitting region is lower thermosphere or mesosphere. The total intensity of NO emission shows a long-term or seasonal variation that increases more than a factor of two during a period from autumn to winter. The period of NO enhancement roughly corresponds to the polar vortex activity that are observed by CO downward descend obtained by MLS, but there is no significant increase of the line width of NO, suggesting that NO enhanced air mass does not reached down below ˜60km. On the other hand, energetic electron precipitation events observed by GOES occurred more frequently during the NO long-term enhancement. The temperature below 100 km did not show significant variation throughout the observed period based on the SABER data, suggesting that the temperature variation did not affect on the NO total intensity. Thus, the enhancement of the NO total intensity reflects actual enhancement of NO column density. In addition to the long-term variation, we have detected short-term variations with a timescale of several days directly related with the energetic electron precipitation caused by large geomagnetic storms. The NO total intensity peaks during the recovery phase of the geomagnetic storms about 2-7 days after the main phase.

In this presentation, we will discuss about possible cause of the NO enhancement by comparing with satellite data such as SABER, GOSE, POES and MLS.

Keywords: microwave spectroscopy, Nitric Oxide, MLT region, Energetic Particle Precipitation

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PEM29-15 Room:304 Time:May 23 10:00-10:15

Concentric rings of gravity waves in the mesosphere observed by the OMTI network in Japan

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Atmospheric gravity waves significantly contribute to the wind/thermal balances in the mesosphere and lower thermosphere (MLT) through their vertical transport of horizontal momentum. It has been reported that the gravity wave momentum flux preferentially associated with the scale of the waves; the momentum fluxes of the waves with a horizontal scale of 10-100 km are particularly significant.

Airglow imaging is a useful technique to observe two-dimensional structure of small-scale (<100 km) gravity waves in the MLT region and has been used to investigate global behaviour of the waves. Solar-Terrestrial Environment Laboratory, Nagoya University has made long-term airglow imaging observations in the world using the Optical Mesosphere and Thermosphere Imager (OMTI) system. On 10 December 2002, concentric rings of gravity waves were observed simultaneously by all-sky imagers of OMTI in Japan located at Shigaraki (34.9N, 136.1E), and Rikubetsu (43.5N, 143.8E). The airglow structures, which were well-defined and formed a coherent wave pattern expanding from the southeast, were identified over 8 hours (1235-2047 UT or 2135-2947 LT). This unique event will give us new insight into the lower and upper atmosphere coupling.

In the presentation, we will report initial results on the concentric gravity waves on 10 December 2002 and discuss their possible source in the lower atmosphere.

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PEM29-16 Room:304 Time:May 23 10:15-10:30

A study of the tidal periodicity of gravity wave energy in the mesosphere observed with MF radar at Poker Flat, Alaska

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The neutral wind velocity data from mesosphere to lower thermosphere observed by Poker Flat MF radar has been observed since October 1999. The National Institute of Information and Communications Technology (NICT) is developing science application software and database systems associated with remote sensing experiments, which include Poker Flat MF radar, and has been conducting scientific studies. A number of observational and theoretical studies have shown that a mesospheric meridional circulation which flows from the summer hemisphere to the winter hemisphere is mainly driven by gravity waves. On the other hand, the interaction between gravity waves and tidal waves has been studied by using observation and modeling data. However, the time and spatial variation of middle atmosphere general circulation has not been fully understood when the interaction processes are incorporated.

The purpose of this study is to improve the understanding of three dimensional (3D) structure of mesospheric circulation modified by gravity waves and tidal waves from observation and modeling data. First, we extracted tidal waves and gravity waves from the MF radar observation data. In this study, harmonic analysis was carried out for periods of 48, 24, 12, and 8 hours, which are extracted from the 5 day time series of wind velocity using. Gravity waves are defined as the 1 ~ 12 hour period component of difference between observed wind velocity and these harmonic components. The method is applied to 30-minit-average data to calculate the 5 day running mean amplitude and phase of tidal waves. We made 1-day composite plots of kinetic energy of gravity waves for periods of 1 ~ 4 hours and harmonic components. The results show that the kinetic energy of gravity waves has two peaks in 3 ~ 6 LT and 12 ~ 15 LT respectively, which tend to coincide with the time when easterly wind of the 12 hour component is switched westerly. This feature commonly recognized in April to August. We plan to discuss more detail of underlying physical processes, applying the three dimensional transformed Eulerian mean series formulated by Kinoshita and Sato (2013a, b) and Sato et al. (2013) to the output data of a gravity wave resolving general circulation model.

Keywords: gravity waves, tidal waves, mesosphere

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PEM29-17 Room:304 Time:May 23 10:30-10:45

A study on a humidity estimation method using the side-lobe emission from a wind profiling radar

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This study aims to develop a new method to observe water vapor horizontal distribution using a side-lobe emission of the 1.3 GHz-band wind profiling radar (WPR). The phase delay of the received side-lobe emission is mainly due to the refractive index fluctuation along the propagation path. In the atmospheric boundary layer, the temporal and spatial non-uniformity of water vapor determines the refractive index fluctuation. Main scope of the study is to extract humidity information from the atmospheric phase delay of side-lobe emission from a WPR. Horizontal humidity distribution can be derived by the data assimilation into numerical prediction model.

The receiver system and data analysis algorithm were developed. A software radio, USRP N200 with an RX daughter board was employed to detect side-lobe emission received by an antenna. A Rubidium frequency standard and a 1 pps signal source of GPS receiver were used for accurate estimation of phase delay variation. The frequency stability of a crystal oscillator, which is generally employed for a reference frequency source of WPR, is insufficient for the accurate estimation. We proposed a new method to compensate the frequency uncertainty of WPR by using data of the additional receiver nearby the WPR site.

IQ data detected by USRP N200 are transferred to the control PC via Ethernet. The program written in IDL language extracts the temporal variation of the phase delay from the received IQ signal. In order to achieve good performance even in low SNR conditions, we developed an algorithm using STFT (Short-term Fourier transformation) aiming to remove noise in undesired frequency range.

The developed system is promising to derive humidity information from side-lobe emission from various WPRs such as the operational WPR network in Japan (WINDAS (WInd profiler Network and Data Acquisition System)).

Keywords: Wind Profiling Radar, estimation of horizontal humidity distribution, non-hydrostatic forecast model, software radio, side-lobe, water vapor