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

PEM06-P01 Room:Convention Hall Time:May 21 18:15-19:30

Meridional thermospheric winds observed by Fabry-Perot iterferometers and ionosondes at low latitudes

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It is important to know the thermospheric wind system in order to understand ionosphere-thermosphere coupling system. Observation of thermospheric wind is traditionally done by Fabry-Perot interferometers (FPIs). It is not easy to observe thermospheric wind every night, because FPI observation depends on weather condition and moon phase, and not many FPI observation has been conducted. Instead of FPI observation, some researchers have estimated meridional wind velocities using data from a pair of ionosondes near geomagnetic conjugate points, assuming that the meridional wind is uniform between the two ionosonde stations (transequatorial wind). However, the comparison between meridional wind velocities estimated by ionosondes and those directly measured by FPIs has not been reported. In this presentation, we show the comparison of meridional winds estimated by ionosondes and those observed by FPIs for the first time. We analyzed data of ionosondes and FPIs installed at Chiang Mai [98.9E, 13.0Mlat] in Thailand and Kototabang [100.3E, -10.0Mlat] in Indonesia. They are located approximately at the geomagnetic conjugate points. Although the estimated and observed wind velocities were generally in good agreement on many nights, we found that they were not in good agreement on some nights. In these nights, the assumption that the meridional wind is uniform between the two ionosonde stations would not be valid. We also investigated seasonal dependence of the correlation between the estimated and observed meridional winds. They were in good agreement from February to April while they were not in good agreement from May to July. This result suggests that meridional wind have more convergence / divergence components from May to July.

Keywords: thermospheric wind, ionosonde conjugate observation, Fabry-Perot Intereferometer

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Development of a 5ch HRO-IF and a trial of measureing trajectory and absolute reception power of each meteor echo

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Ham-band Radio meteor Observation (HRO) has an advantage of 24-hour continuous data-detection. In Kochi University of Technology (KUT), a 5ch HRO-IF was developed in 2009 and has been observing the meteor appearance position of every meteor echo, with operating an automatic meteor observation system that automatically publishes observational results on web in quasi-real time (Noguchi, 2009). Meteor parameters acquired by the observation system are: time of detection, elevation and azimuth of the echo, and relative intensity. During 2010-2012, we developed a system of meteor trajectory measurement by multiple-sites observation with precise GPS timing and the 5ch HRO-IF. Then, during 2011-2013, we developed a calibration device for measuring absolute reception power of each meteor echo. Since high time resolution is needed for the determinations of meteor trajectories by the multiple-sites simultaneous observation, a program to analyze the reception power trend with tracking a peak frequency of every 0.001 s by quick repetition of FFT was developed by using the IDL. For the determination of absolute reception power of each meteor echo, we developed a signal generator of observation frequency of 53.75 MHz by applying PLL (Phase Locked Loop) circuit with switching attenuator devices from -80 dBm to -120 dBm per 10 dB in every 5 s. The calibration signal is supplied into a receiver once per 10 minutes, then the artificially supplied stepped function is analyzed automatically and determine each meteor echo reception power in dBm by developed software.

In order to verify the observation system of meteor trajectory measurement, we observed meteor echoes during 4-nights active period of Geminids 2011. We tried a simultaneous observation by high sensitivity video instruments (Watec, WAT-100N) and by a combination of the 5ch HRO-IF and multiple-sites HRO. In the period, 71 meteor echoes were detected, however, only 1 simultaneously observed meteor echo at 3 radio sites as well as the camera site was obtained. Though it was only 1 case, the azimuth angles of the meteor trajectory obtained by the both methods were nearly consistent with each other, within an error range of about 5 degrees for direction-determination by the 5ch HRO-IF. For the confirmation of absolute reception power measurement of each meteor echo, we observed meteor echoes in a peak night of Geminids 2012 with multiple-site optical observations, resulting in 101 absolute reception power of echoes of determined in -80 dBm to -125 dBm. In a region between -100 dBm and -120 dBm, within 1 dB accuracy was confirmed by using test calibration signal supplied by a signal generator (Agilent N9342C).

We improved the KUT radio meteor observation system by adding the measurement of each meteor trajectory and reception power, yielding meteor velocity and its plasma line density for each meteor echo, in case all of the parameter can be fixed. In order to verify the system performance we need more dataset to make a statistical approach, however, here we successfully built a forward-scattering meteor radar system with a capability of meteor trajectory and reception power measurement for obtaining physical parameters. In this paper, we will introduce current status of the KUT radio meteor observation system, that all of the instruments/software were developed by students in this decade.

Keywords: meteor, radio meteor observation, trajectory, absolute reception power, calibration, forward scattering

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Modification of one-dimensional spherical elementary current systems for applying at low/mid latitude

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The technique of 1-dimensional spherical elementary current systems (1D SECS) is one way of determining real ionospheric and field-aligned currents (FAC) from magnetic field measurements observed at a low-orbit satellite. The SECS consist of two sets of basis functions that are either divergence-free (DF) or curl-free (CF), and cause poloidal and toroidal magnetic fields, respectively. In previous studies the full 1D SECS method has been applied only at high latitudes, where we can make the simplifying assumption of radial FAC. This way the full ionospheric current distribution (i.e. both DF and CF horizontal currents and field-aligned currents) can be determined. At low/mid latitudes, on the other hand, only DF equivalent current owing in the ionosphere has been determined from ground magnetic field measurements. In this study, the 1D SECS is applied at low/mid latitudes by including dipole geometry for the FAC associated with the CF elementary systems. The modified 1D SECS is tested to determine both DF and CF ionospheric currents and FAC using both synthetic and real data from the CHAMP satellite and comparing these results with the equivalent current obtained from MAGDAS/CPMN ground magnetic data in 210 MM.

Keywords: spherical elementary current system, Ionospheric currents

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Atmospheric Density Modeling Using Neural Networks

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Atmospheric density during geomagnetic storms is usually poorly predicted due to the lack of clear understanding of the coupling mechanism between thermosphere and magnetosphere in such circumstances. Consequently, the orbit prediction in severe geomagnetic condition is affected. Neural networks are the technique of identifying nonlinear system without exactly knowing its physical model. In the present study, an attempt has been made to model the atmospheric density using neural networks. In developing such models, we use both the ring current index Dst and the geomagnetic index ap as model inputs. The ap index is commonly used in density models such as the MSIS and the Jacchia series to represent geomagnetic activity. On the other hand, Dst has been reported to have better correlation with the storm-time density, and to represent additional heating source to that represented by ap. The density data used for modeling is derived from satellites CHAMP and GRACE's accelerometer measurements. The performance of the neural network models (NNMs) is compared with that of the NRLMSISE-00 at different geomagnetic activity level, which reveals the advantages of the neural network technique and the Dst index.

Keywords: Atmospheric density, Neural networks modeling, Geomagnetic storm, Magnetic activity index

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Coupling of electrons and inertial Alfven waves in the top-side ionosphere

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A one dimensional kinetic model is constructed to simulate the electron acceleration by inertial Alfven waves. The electrons are divided into cold and hot electrons and treated separately. Cold components are described by the fluid equation and hot ones by the Vlasov equation, both carrying field-aligned currents. Intense variation of Alfven speed has been introduced by inclusion of cold electrons. The model results show that the exponential decrease of the plasma density plays a key role, which leads to the sharp gradient of both Alfven velocity and electron inertial length. When Alfven waves encounter this sharp gradient at lower altitudes, the electrons accelerated by the waves become super-Alfvenic, and the width of burst structures becomes much wider than the electron inertial length. Consequently, the background electrons carry the oppositely field-aligned current due to plasma oscillation. It is demonstrated that the current carried by the electrons exceeding the wave front is balanced by the reverse current carried by background electrons. This mechanism can be used to reasonably explain observations of the electron bursts accompanied by little net field-aligned current. Furthermore, our simulation indicates that Alfven wave reflection is modified due to mirror force and wave particle interaction.

Keywords: inertial Alfven waves, super-Alfvenic, bursts

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Adjustment of the ionospheric height for TEC derivation of GRBR network

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To derive Total Electron Content (TEC) of GNU Radio Beacon Receiver (GRBR) network in low latitude region, the ionospheric height was adjusted to reduce a TEC estimation error. GRBR is a simple digital receiver developed to measure the ionospheric total electron content (TEC) from Low-Earth-Orbit (LEO) satellites. GRBR network is used to capture the small-scale structure of the ionosphere. It is known that fixed altitude of the ionosphere leads to large error of TEC in low latitude sector. In order to reveal a low latitude meridional TEC distribution, we thus developed the method with adjustable ionospheric height to derive GRBR-TEC.

This method employs data from 5 GRBRs, 3 ionosondes and 17 GPS receivers in March 2012. The GRBR receivers are located at Kototabang (0.20S, 100.32E), Phuket (7.89N, 98.38E), Chumphon (10.72N, 99.37E), Bangkok (13.73N, 100.77E), and Chiang Mai (18.76N, 98.93E). The ionsondes are located at Kototabang (0.20S, 100.32E), Chumphon (10.72N, 99.37E) and Chiang Mai (18.76N, 98.93E). The GPS stations distribute from 25N to 10S and 98E to 108E in the geographic coordinate. Assuming that mean ionospheric height variation is a function of latitude, the ionospheric height at each position was adjusted based on an ionosonde-hmF2. Consequently, GPS-TEC was employed as a zero-guess to estimate the bias for the GRBR-TEC calculation. As a result, meridional TEC of the low-latitude ionosphere over equatorial region was obtained with high accuracy for both cases with and without plasma bubble occurrence. In addition, an asymmetry of EIA enhancement was captured as well, which will be discussed in the presentation. The proposed method with adjustable ionospheric height was successful to derived multi-station GRBR-TEC from polar orbit satellite.

Keywords: GRBR-TEC, Ionospheric height, Equatorial region, EIA, Ionosonde, GPS

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Observations of seismo-traveling ionospheric disturbance triggered by earthquake and tsunami

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In this study, the seismo-traveling ionospheric disturbances (STIDs) of total electron content (TEC) generated by the 2011 Mw9.0 Tohoku earthquake at 05:46:23 UT on March 11, 2011, are investigated by using ground-based Global Positioning System (GPS) receiver networks. The STIDs are not only triggered by seismic surface waves but also by tsunami waves of the Tohoku earthquake. A method of wavelet analysis is used to investigate the spectral characters of STIDs induced by seismic surface waves and tsunami waves. Results find that the spectrum of STID by surface waves shows a single short period enhancement, while the spectrum of STID by tsunami waves shows multiple long-period responses. Multiple events, including 1999 Chi-chi, 2003 Hokkaido, 2004 Sumatra, and 2010 Chile earthquakes, are employed to investigate the general spectral characteristics of seismic surface and tsunami waves. This study also find that the arrival time of STID by surface waves is earlier than that by tsunami waves, which could be applied for the short-term tsunami warnings.

Keywords: ionosphere, STID, tsunami

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Variability of the gravity wave forcing from troposphere to mesosphere: By momentum flux estimation

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Using long-term data (1998 to 2008) collected from Mesosphere-Stratosphere-Troposphere (MST) radar and Rayleigh Lidar located at a tropical station, Gadanki (13.5oN, 79.2oE), India, variability of the gravity wave forcing from troposphere to mesosphere is investigated by estimating the momentum flux associated with the gravity waves of periods 20 min. to 2 h, for the first time. The emphasis is on seasonal variability of mean zonal and meridional momentum fluxes in mesosphere and troposphere and vertical flux of zonal momentum in the stratosphere. An effort is made to examine the variations in momentum flux for different cases, viz., during the occurrence of mesospheric temperature inversion and convection events. At tropospheric altitudes of 11-16 km large enhancement in flux is noticed during equinoxes. In the stratosphere the maximum values of flux (~2.8 m2/s2) are pragmatic in winter and spring at the altitude region 58-62 km. Interestingly, the vertical flux of zonal momentum estimated from lidar is in the range of those estimated from radar data in the overlap altitude region, though the estimates are from two different techniques. In the mesosphere, in summer large variations with altitude in zonal momentum flux are noticed with a magnitude ~0- 4 m2/s2. The meridional fluxes in the mesosphere are higher in equinoxes (~10-12 m2/s2). The two case studies showed that during mesospheric temperature inversion due to large wave breaking at mesosphere, momentum fluxes are raised up to ~7-10 m2/s2 and during deep convection, large variations in troposphere momentum fluxes are noticed than in mesosphere and the variations in mesospheric momentum fluxes due to tropospheric convection are noticed at earlier times than overhead convection period in troposphere, the possible reasons are discussed.

Keywords: Mesosphere-Stratosphere-Troposphere, short-period gravity waves, Momentum flux, MST radar, Rayleigh lidar

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Resonance scattering lidar system at Syowa Station in Antarctica: Test observations of potassium layer in Japan

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We are developing a new resonance scattering lidar system to be installed at Syowa Station (69S, 39E) in Antarctica. For the new lidar system, we have employed a tunable alexandrite laser covering the resonance scattering wavelengths of two neutral species, which are atomic potassium (K, 770.11 nm) and atomic iron (Fe, 386.10 nm), and two ion species, which are calcium ion (Ca^+, 393.48 nm) and aurorally excited nitrogen ion ($N_2{}^+$, 390.30 nm, 391.08 nm). Thus the new lidar system will provide information on the mesosphere and lower thermosphere as well as the ionosphere. Using the new resonance scattering lidar and other instruments, we will conduct a comprehensive ground-based observation of the low, middle, and upper atmosphere above Syowa Station. 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 presentation, we introduce the new resonance scattering lidar system and report current status of its development. In particular, our presentation focus on test observations of potassium layer at National Institute of Polar Research in Tachikawa, Japan.

Keywords: Resonance scattering lidar, Potassium layer, Syowa Station, Antarctica