

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

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

西岡 未知^{1*}, 丸山 隆¹, 大塚 雄一², 津川 卓也¹, 塩川 和夫², 石橋 弘光¹, 石井 守¹

Michi Nishioka^{1*}, Takashi Maruyama¹, Yuichi Otsuka², Takuya Tsugawa¹, Kazuo Shiokawa², Hiromitsu Ishibashi¹, Mamoru Ishii¹

¹ (独) 情報通信研究機構, ² 名古屋大学太陽地球環境研究所

¹National Institute of Information and Communications Technology, ²Solar-Terrestrial Environment Laboratory, Nagoya University

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.

キーワード: 熱圏風, イオノゾンデ共役観測, ファブリ・ペロー干渉計

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

5チャンネルHRO電波干渉計の開発と流星軌道およびエコー絶対受信強度の計測の試み

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

山本 真行^{1*}, 大和 忠良¹

Masa-yuki Yamamoto^{1*}, Tadayoshi Yamato¹

¹ 高知工科大学

¹ Kochi University of Technology

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.

キーワード: 流星, 流星電波観測, 軌道, 絶対受信強度, 較正, 前方散乱

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

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

Ryo Deguchi^{1*}, Heikki Vanhamaki², Huixin Liu³, Olaf Amm²
Ryo Deguchi^{1*}, Heikki Vanhamaki², Huixin Liu³, Olaf Amm²

¹Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, ²Finnish Meteorological Institute, Helsinki, Finland, ³Earth and Planetary Science Division, Kyushu University

¹Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, ²Finnish Meteorological Institute, Helsinki, Finland, ³Earth and Planetary Science Division, Kyushu University

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.

キーワード: spherical elementary current system, Ionospheric currents

Keywords: spherical elementary current system, Ionospheric currents

Atmospheric Density Modeling Using Neural Networks Atmospheric Density Modeling Using Neural Networks

Hongru Chen^{1*}, Huixin Liu², Toshiya Hanada¹

Hongru Chen^{1*}, Huixin Liu², Toshiya Hanada¹

¹Department of Aeronautics and Astronautics, Kyushu University, ²Department of Earth and Planetary Science, Kyushu University

¹Department of Aeronautics and Astronautics, Kyushu University, ²Department of Earth and Planetary Science, Kyushu University

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.

キーワード: Atmospheric density, Neural networks modeling, Geomagnetic storm, Magnetic activity index

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

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

Run Shi^{1*}, Huixin Liu¹, Akimasa Yoshikawa¹, Zhang Beichen², Ni Binbin³
Run Shi^{1*}, Huixin Liu¹, Akimasa Yoshikawa¹, Zhang Beichen², Ni Binbin³

¹Department of Earth and Planetary Sciences, Kyushu University, ²SOA Key Laboratory for Polar Science, Polar Research Institute of China, ³Department of Atmospheric and Oceanic Sciences, UCLA

¹Department of Earth and Planetary Sciences, Kyushu University, ²SOA Key Laboratory for Polar Science, Polar Research Institute of China, ³Department of Atmospheric and Oceanic Sciences, UCLA

A one dimensional kinetic model is constructed to simulate the electron acceleration by inertial Alfvén 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 Alfvén 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 Alfvén velocity and electron inertial length. When Alfvén waves encounter this sharp gradient at lower altitudes, the electrons accelerated by the waves become super-Alfvénic, 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 Alfvén wave reflection is modified due to mirror force and wave particle interaction.

キーワード: inertial Alfvén waves, super-Alfvénic, bursts

Keywords: inertial Alfvén waves, super-Alfvénic, bursts

Adjustment of the ionospheric height for TEC derivation of GRBR network Adjustment of the ionospheric height for TEC derivation of GRBR network

Kornyanat Watthanasangmechai^{1*}, Mamoru Yamamoto¹, Akinori Saito²
Kornyanat Watthanasangmechai^{1*}, Mamoru Yamamoto¹, Akinori Saito²

¹Research Institute for Sustainable Humanosphere, Kyoto University, ²Department of Geophysics, Graduate School of Science, Kyoto University

¹Research Institute for Sustainable Humanosphere, Kyoto University, ²Department of Geophysics, Graduate School of Science, Kyoto University

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 ionosondes 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.

キーワード: GRBR-TEC, Ionospheric height, Equatorial region, EIA, Ionosonde, GPS

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

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

Wei-han Chen^{1*}, Charles Lin¹, Chia Hung Chen¹, Huixin Liu²
Wei-han Chen^{1*}, Charles Lin¹, Chia Hung Chen¹, Huixin Liu²

¹Department of Earth Sciences, National Cheng Kung University, ²Earth and Planetary Science Division, Kyushu University SERC, Kyushu University

¹Department of Earth Sciences, National Cheng Kung University, ²Earth and Planetary Science Division, Kyushu University SERC, Kyushu University

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.

キーワード: ionosphere, STID, tsunami

Keywords: ionosphere, STID, tsunami

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

Eswaraiiah Sunkara^{1*}, M. Venkat Ratnam², B.V. Krishna Murthy³, S.Vijaya Bhaskara Rao¹
Eswaraiiah Sunkara^{1*}, M. Venkat Ratnam², B.V. Krishna Murthy³, S.Vijaya Bhaskara Rao¹

¹Department of Physics, Sri Venkateswara University, Tirupati-517502, India, ²National Atmospheric Research Laboratory (NARL), Gadanki, Tirupati-517 502, India, ³B1, CEEBROS, Chennai-600020, India.

¹Department of Physics, Sri Venkateswara University, Tirupati-517502, India, ²National Atmospheric Research Laboratory (NARL), Gadanki, Tirupati-517 502, India, ³B1, CEEBROS, Chennai-600020, India.

Using long-term data (1998 to 2008) collected from Mesosphere-Stratosphere-Troposphere (MST) radar and Rayleigh Lidar located at a tropical station, Gadanki (13.5°N, 79.2°E), 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.

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

南極昭和基地の共鳴散乱ライダーシステム:カリウム層の国内試験観測 Resonance scattering lidar system at Syowa Station in Antarctica: Test observations of potassium layer in Japan

津田 卓雄^{1*}, 江尻 省¹, 阿保 真², 川原 琢也³, 中村 卓司¹
Takuo Tsuda^{1*}, Mitsumu Ejiri¹, Makoto Abo², Taku D Kawahara³, Takuji Nakamura¹

¹ 国立極地研究所, ² 首都大学東京大学院システムデザイン研究科, ³ 信州大学工学部

¹National Institute of Polar Research, ²Graduate School of System Design, Tokyo Metropolitan University, ³Faculty of Engineering, Shinshu University

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 (N₂⁺, 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