

Observation of Ozone concentration relation to meteors echo duration distributions by a forward scattering radar

MADKOUR, Waleed^{1*} ; YAMAMOTO, Masa-yuki¹ ; MIZUMOTO, Satoshi¹

¹Kochi University of Tech.

Several studies have concluded the existence of secondary maxima of ozone concentration at the mesospheric level of 85-90 km. At this level in atmosphere, meteor radio observations shows a consistent lack of long overdense echoes with certain durations where the number of meteor echoes drops for what is known as the 'knee' position. As the lack of long meteor echoes was significantly greater than being only a result of ambipolar diffusion, some studies linked this drop to ozone concentration in the meteor region. Baggeley and Cummack (1974) suggested the drop to be the result of oxidation of meteors ions by the secondary maxima of ozone layer which causes the removal of ionization and consequently unreflected radio signals. Jones et. al (1990) and Cevolani and Pupillo (2003) supported this conclusion by analyzing meteor echoes duration distributions and determining approximately the height of meteor echoes at the knee point based on visual magnitude levels.

At Kochi University of Technology (KUT) we attempted to observe the knee position in selected meteor showers. The 5 channel HRO interferometer radar developed at KUT utilizes forward scattering of 53.75 MHz continuous radio signals emitted from Sabae station, Fukui prefecture, Japan (Fukui National College of Technology: FNCT) at a distance of 340 km from Kochi prefecture. The software HROFFT (Ham-band Radio meteor Observation Fast Fourier Transform) generates spectrogram images for meteor echoes in 10 minute intervals. These images are used by the developed auto counting software Meteor echo counter through image processing to automatically count meteor echoes and their durations. The critical duration T at which the drop occurs in long echoes counts can be indicative about the Ozone concentration by the relation derived by McIntosh and Hajduk (1977): $O_3 = (\alpha T)^{-1}$. As currently there is no developed mechanism for meteor height determination at KUT, the scope is focused on the analysis of meteor echoes duration, detection of the knee point and then finally comparing the ozone concentration measurements to the results of similar studies.

References:

- BAGGLEY, W.J. and CUMMACK, C.H., (1974): Meteor train ion chemistry. *J. Atmos. Terr. Phys.* 36, 1759
- CEVOLANI, G and PUPILLO, G (2003): Ground-based radio observations to probe the ozone content in the meteor region, *Annals of Geophysics*, 46. 247-258
- JONES, J.MCINTOSH, B.A & SIMEK, M. (1990): Ozone and the duration of overdense radio meteors. *J. atmos. terr. Phys.* 52, 253.
- MCINTOSH, B.A. and A.HAJDUK (1977): Sunrise effect on persistent radar echoes from sporadic meteors, *Bull. Astron. Inst.Czechosl.*, 28, 280-285.

Keywords: Ozone concentration, meteors, forward scattering, radar, mesosphere

Simultaneous observations of polar mesosphere winter echoes (PMWE) and Cosmic Noise Absorption (CNA) by the PANSY radar

NISHIYAMA, Takanori^{1*} ; SATO, Kaoru² ; NAKAMURA, Takuji¹ ; TSUTSUMI, Masaki¹ ; SATO, Toru³ ; KOHMA, Masashi² ; NISHIMURA, Koji¹ ; TOMIKAWA, Yoshihiro¹ ; EJIRI, Mitsumu K.¹ ; TSUDA, Takuo⁴

¹National Institute of Polar Research, ²Department of Earth and Planetary Science, The University of Tokyo, ³Department of Communications and Computer Engineering, Kyoto University, ⁴Department of Communication Engineering and Informatics, University of Electro-Communications

In the lower thermosphere at the altitude of around 100 km, both neutral turbulence and ionization of atmosphere due to solar radiations cause irregularities of refractive index, and as a result back scatter echoes from that altitude are frequently observed by radars on the ground. In the mesosphere, Polar Mesosphere Summer Echo (PMSE) is reported to be a strong echo associated with ice particles, which are produced around the coldest mesopause region in the polar summer, by a number of past radar observations [Cho and Röttger, 1997; Rapp and Luebken, 2004]. It should be also noted that occurrence rate of PMSE is very high (80-90%) [Bremer et al., 2003]. On the other hand, Polar Mesosphere Winter Echo (PMWE) is also known as back scatter echo from 55 to 85 km in the mesosphere, and it has been observed by MST and IS radar in polar region during winter [e.g., Ecklund and Balsley, 1981; Czechowsky et al., 1989; Luebken et al., 2006; Strelnikova and Rapp, 2013]. Due to the lack of free electrons and ice particles in the dark and warm mesosphere during winter, it is suggested that PMWE requires strong ionization of neutral atmosphere associated with precipitations of Solar Energetic Particles (SEPs) during geomagnetically disturbed periods [Kirkwood et al., 2002; Zeller et al., 2006]. However, the detailed generation process of PMWE has not been identified yet, partly because the reported PMWE occurrence rate was quite low (2.9%) [Zeller et al., 2006].

We present occurrence characteristics of PMWE from June 2012 to October 2013 and its relation to Solar Energetic Particles. When PMWE was detected by the PANSY (Program of the Antarctic Syowa MST/IS) radar, highly energetic particle precipitations, either protons or electrons, were frequently observed by NOAA satellite particle measurements above Syowa Station. During the SPE that occurred in May 23, 2013 PMWE and a significant Cosmic Noise Absorption (CNA) of about 1 dB were simultaneously detected by the PANSY radar. MF radar also showed Isolated Lower Mesosphere Echo (ILME) at the same time [Morris et al., 2011], suggesting enhancement of electron density in ionospheric D-regions. Moreover, occurrence of PMWE was likely related to the flux of precipitating electrons in the medium energy range (30-300 keV) during recovery phase of geomagnetic storms. We would like to show correlations between PMWE and CNA using dataset for mesospheric observation mode.

Keywords: Polar Mesosphere Winter Echo, Energetic Particle Precipitation, Ionospheric D-region, Turbulence, Cosmic Noise Absorption, the PANSY radar

Gravity wave activity in a wide height range of 65-110km over Syowa st. (69S), Antarctica

TSUTSUMI, Masaki^{1*}

¹National Institute of Polar Research

There are very small number of ground-based observation techniques in the lower thermosphere, especially above around 100 km, although the region is a pronounced transition region in terms of the thermal structure, chemistry and dynamics. Radio meteor echo measurement in a low radio frequency such as MF is a possibility of atmosphere observation above 100 km. We have applied a meteor wind measurement technique, which is widely used in VHF, to MF radar systems, and have successfully obtained meteor winds up to 120 km altitude [Tsutsumi et al, 1999; Tsutsumi and Aso, 2005]. The technique was applied to the MF radar at Syowa station, Antarctica and meteor winds have been continuously obtained since May 1999, simultaneously with conventional correlation based wind measurements in the mesosphere.

In this study we try to estimate seasonal behavior of gravity wave activity over Syowa in a wide height range from 65 to 110km using the accumulated 16 years of data. Gravity wave activity is estimated in two ways. One is a commonly used wave variance estimation technique based on time series of wind velocities [e.g., Vincent, 1994]. Hourly mean winds are used for the purpose in the present study. The other is a recently developed technique by Mitchel and Beldon [2009], where residuals after the hourly mean wind estimation are used as a proxy of short period wave activity. The former and the latter correspond to wave periods longer and shorter than about two hours, respectively. Obtained wave activities show a broad winter time maximum and summer time minimum in both wave periods, which is consistent with previous results in the mesosphere over Antarctica [Dowdy et al.,2007]. We further found that wave activities above 100 km are enhanced in late summer to early winter in both wave periods, which has not been known so far. Details of these features are discussed in the presentation.

Keywords: atmospheric gravity waves, mesosphere and lower thermosphere, Antarctica, MF radar, Syowa station

Variability of the Equatorial Ionization Anomaly on seasonal and day to day time scales

CHIEN, Shin han^{1*} ; CHANG, Loren¹ ; LIU, Huixin²

¹Institute of Space Science, National Central University, Jhongli City, Taiwan, ²Earth and Planetary Science Division, Kyushu University SERC, Kyushu University

The Equatorial Ionization Anomaly (EIA) is a persistent feature of the F layer, around 300 km altitude in the thermosphere, generated by the E-region dynamo driven equatorial fountain. When the EIA is present, electron densities on either side of the magnetic equator will become much higher during the local afternoon times. In our study we want to quantify short term EIA variability due to atmospheric, solar, and geophysical sources. Short-term anomalies in EIA region total electron content (TEC) from GPS-derived global ionosphere maps (GIM) at 105 degree West longitude are compared to anomalies in three different geophysical sources: solar flux (F10.7 solar flux proxy), geomagnetic storms (Kp index), and atmospheric zonal winds near the semidiurnal tidal peak at northern mid-latitudes (GAIA assimilative general circulation model). We present spectral and coherence analysis of EIA TECs and the aforementioned geophysical indices in 2008 and 2012, to illustrate the variability on seasonal and day to day time scales. The variability of the F10.7 solar flux proxy is dominated by 23-27 day periodicities. The Kp index indicates significant 9 day periodicities in 2008 for entire year, though 2012 is dominated by significant variations with 9-13 day periods during equinox and 5-7 day periods during boreal summer. F10.7 and Kp index both demonstrate good coherence with EIA TECs during specific seasons. With regard to the neutral zonal winds, TECs at the equator show good coherence with 100 km mid-latitude zonal winds in the same longitude region at specific planetary wave periods during the certain local times, suggesting modulation of the E-region dynamo.

Keywords: Equatorial Ionization Anomaly, ionosphere, mid-latitude, planetary wave, Kp index, E-region dynamo

Topside Ionospheric Plasma Temperatures Retrieved From FORMOSAT-3/COSMIC Observations

WANG, Jack C.^{1*} ; CHANG, Loren C.¹ ; LIU, Jann-yenq¹

¹Graduate Institute of Space Science, National Central University, Taiwan

Bottom-side ionospheric electron profiles now can be well-determined thanks to mature development of ground-based instruments, such as ionosonde, or incoherent radar. However, the topside ionosphere, located above the F2 layer peak to the exobase (from 200~400 km to 600~1000km, depending on solar activity) is still not well understood. Previously, the electron density distribution and plasma temperatures in the topside ionosphere could only be measured by incoherent scatter radar, in-situ sounding rocket, or certain satellite instruments, making it hard to draw a global map of electron density and plasma temperatures in the topside ionosphere. FORMOSAT-3/ Constellation Observing System for Meteorology, Ionosphere, and Climate (F3/C) using the GPS radio occultation method (GPS-RO) now can give us great opportunities to determine the global electron density profiles above the F2 layer peak. We also present results showing how the plasma temperatures may be estimated from such GPS-RO observations.

This study first examines the structure and variability of electron densities in topside ionosphere. Seasonal F3/C observations will first be assimilated into a gridded model in latitude, longitude, altitude, and local time. The resulting vertical profiles at each gridpoint will then be used to infer the vertical scale height of the topside ionosphere. Next, we retrieved the seasonal and local-time variabilities of topside plasma temperature from the scale height of topside ionospheric electron densities. This is one of the first times that topside plasma temperatures can be globally determined using remote sensing techniques.

Keywords: Ionosphere, Topside ionosphere, Plasma temperature, Formosa-3/COSMIC

Development of real-time three-dimensional GPS-TEC tomography

SUZUKI, Shota^{1*} ; YAMAMOTO, Mamoru¹ ; CHEN, Chieh-hung⁴ ; SAITO, Susumu² ; SEEMALA, Gopi¹ ; SAITO, Akinori³

¹Research Institute for Sustainable Humanosphere, Kyoto University, ²Department of Geophysics, Graduate School of Science, Kyoto University, ³Navigation Systems Department, Electronic Navigation Research Institute, ⁴Department of Earth and Environmental Sciences, National Chung Cheng University, Taiwan

Recently, a new three-dimensional GPS ionospheric tomography technique is developed which uses total electron content (TEC) data from the dense GPS receiver network, GPS Earth Observation Network (GEONET) in Japan. It uses the least squares fitting method constrained by the spatial gradient, and does not require an ionospheric model as the initial guess that could bias the reconstruction of electron density. But it refers to the NeQuick model to determine constrained parameters. The purpose of this study is to develop this technique and incorporate into the real-time GPS-TEC monitoring system. First we increase the computation speed by using a sparse matrix algorithm when solving the least squares fitting method. Programmed with Python, it takes less than 5 minutes to calculate a tomography by using 1.7GHz Intel Core i7. We could also improve the stability of the calculation. Furthermore we try to find a new method for determining the constrained parameters by analyzing a large amount data. As the tomography uses absolute TEC, it is necessarily to estimate instrumental delay bias which is originated in the hardware of the GPS satellite and receiver. We develop the bias estimation procedure that uses RINEX-OBS data of the previous day. Organizing these parts, we develop a system to conduct three-dimensional tomography analysis in the real-time basis.

Keywords: GEONET, TEC, tomography, sparse matrix, real-time system

Performance evaluation of low-cost airglow camera for mesospheric gravity wave measurements

SUZUKI, Shin^{1*} ; SHIOKAWA, Kazuo¹

¹Solar-Terrestrial Environment Laboratory, Nagoya University

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 behavior of the waves. Recent studies with simultaneous/multiple airglow cameras have derived spatial extent of the MLT waves. Such network imaging observations are advantageous to ever better understanding of coupling between the lower and upper atmosphere via gravity waves.

In this study, we newly developed a low-cost airglow camera to enlarge the airglow imaging network (Optical Mesosphere and Thermosphere Imagers: OMTIs) operated by the Solar-Terrestrial Environment Laboratory, Nagoya University. This camera has a fish-eye lens with a 185-deg field-of-view and equipped with a CCD video camera (WATEC WAT-910HX) ; the camera is small (W35.5 x H36.0 x D63.5 mm) and inexpensive, much more than the OMTI cameras, but has a highly sensitive CCD sensor with 768 x 494 pixels. OH airglow emissions are imaged at intervals of 4 sec with 4-sec exposure.

In this presentation, we will report some results of performance evaluation of this camera based on test observations at Shigaraki (35-deg N, 136-deg E), Japan, where is one of the OMTI station. By summing 15-images (i.e., 1-min composition of the images) we recognized clear gravity wave patterns in the images with comparable quality to the OMTI's image.

The FORMOSAT-3/COSMIC Radio Occultation Data Assimilated to NCAR/TIE-GCM to study the horizontal winds in the ionosphere

CHEN, Ming-quey^{1*} ; SU, Yung-chih¹ ; CHAO, Shih-hao¹

¹Grad. Inst. of Space Science, National Central Univ., Taiwan

The NCAR Thermosphere-Ionosphere Electrodynamics General Circulation Model (TIE-GCM) is a self-consistently electrodynamic-coupled thermosphere and ionosphere model subjected by a few parameters and boundary conditions. The migrating tidal waves are parameterized with the amplitudes and phases of the diurnal and semidiurnal tidal waves (Hough modes) as the forcing sources to modulate the TIE-GCM at the lower boundary. We constructed a data assimilation method to assimilate the FORMOSAT-3/COSMIC (F3/C) occultation total electron content (OTEC) observations to the Model with the optimal parameters of the TIE-GCM. The assimilated OTEC of the F3/C data could modulate the ionospheric electron densities, the neutral winds and the temperatures in the TIE-GCM due to the optimal parameters of the Hough modes. The horizontal wind in the assimilated model will be compared with the observations with ground based and the space-borne instruments (TIDI data).

Keywords: ionosphere, thermosphere, FORMOSAT-3/COSMIC radio occultation data, data assimilation

Periodic variations in the thermospheric density

LIU, Huixin^{1*} ; TSUBOSAKI, Hiroyuki¹

¹Kyushu University, Japan

We examined the periodic variation of thermosphere in this study using the thermospheric total mass density at 400km altitude derived from more than 5000 flying objects during 1967-2013, and also those measured by the accelerometer aboard the CHAMP satellite during 2001-2010. Among the periodic variations, we found a prominent 2-3 year period. Correlation of this density variation with QBO and ENSO indices are carried out to investigate possible lower atmosphere driver of this thermosphere variability.

Keywords: thermosphere

Evaluation of EEJ variation due to Ultra Fast Kelvin Waves using the Kyushu-GCM and the Quasi-3D dynamo model

GOYA, Kenshi^{1*} ; MIYAHARA, Saburo² ; CHEN, Ying-wen³

¹Dept. of Earth and Planetary Sci., Kyushu University, ²Kyushu University, ³JAMSTEC

The quasi-3dimensional dynamo-model using the neutral wind data of the Kyushu-GCM(Yoshikawa and Miyahara 2003, 2005) proves that Sq current system and Equatorial Electro Jet (EEJ) can be almost consistent with their day to day variations of the observation values (Kawano-Sasaki and Miyahara 2008, Aramaki 2012:Master Degree thesis).

And then analysis of Kelvin Waves in the Kyushu-GCM (Chen and Miyahara 2012) shows that Ultra Fast Kelvin (UFK) waves (zonal wavenumber =1, Period 2.5-4 days) originated in the troposphere are dominant in the MLT region above the equator (at around 100 km height) and contribute to the dynamical field of atmosphere. And the amplitudes of UFK waves fluctuate periodically at almost 10 days time scale.

Therefore this research shows that the contribution to EEJ variation due to UFK wind fluctuation has been quantitatively evaluated using the quasi-3dimensional dynamo-model that can express Sq current system and EEJ in asymmetric about the equator (Aramaki 2012 : Master Degree thesis) with UFK neutral wind data derived from the Kyushu-GCM (Yoshikawa and Miyahara 2003, 2005). This evaluation proves that UFK winds fluctuation contribute to EEJ day to day variation. Particularly it is evaluated that UFK winds day to day fluctuation contributes to about 25 percent of the strong Eastward EEJ current values day to day variation above around the Equator comparing the standard deviations of the simulated EEJ current values between the case of the UFK winds data at one month and the case of the Kyushu-GCM original neutral winds data at the same month. More comprehensive analysis and its evaluations in detail will be shown at the conference hall.

(Acknowledgement)

The Quasi-3D Dynamo equatorially symmetric model (2008) that Dr.Keiko Kawano-Sasaki (Kyushu University) had developed and M.Sc. Yui Aramaki (Kyushu University) had extended it to the asymmetric model (2012). We used the model for this research. We gratefully acknowledge for them.

Keywords: Equatorial Electro Jet, Ultra Fast Kelvin wave, the Kyushu-GCM, the quasi-3D dynamo model

The relationship between the electric field in the lower atmosphere and Sq variations

IKEDA, Akihiro^{1*} ; CARDINAL, G. maria²

¹Kagoshima National College of Technology, ²International Center for Space Weather Science and Education

The vertical atmospheric electric field (Ez) variations depend on the state of the global electric circuit. Geomagnetic phenomena can influence Ez through ionospheric disturbances [e.g. Kleimenova, 2008]. The daily quiet geomagnetic field variations (Sq variations) are mainly caused by electric field currents flowing in the E region of the ionosphere. It is likely that Sq variations are relevant to Ez variations. In this study, we aim to investigate the relationship between Ez and Sq variations at a low-latitude station. We analyzed the Ez and ground magnetic field data (H) at KAK (G.G. Lat.: 36.2 N, G.G. Lon.: 140.2 E) station during 2006 - 2014. The data was provided by the Kakioka Magnetic Observatory of the Japan Meteorological Agency. In here, we adopt the same definition for Sq amplitudes as defined by Yamazaki et al. [2010]. The daily amplitude of the Sq variation is derived by subtracting nighttime (22-24 LT and 00-02 LT) H values from daytime H (peak) values. Similarly, we calculated the daily Ez variation. The daytime Ez values were selected at the time when daytime H values show their peaks. The obtained Sq and Ez variations show annual and semi-annual variations. The annual variations are clearly seen every year, becoming the smaller values in winter. The semi-annual variations in Ez are clear in 2011 and 2014. As just described, we found similarities between Sq and Ez variations in several respects and ,therefore, conclude that the Ez variations depend on the condition of the ionosphere.

Keywords: atomospheric electric field, Sq