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Article 1

The 13th International Symposium on Equatorial Aeronomy

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Jorge L. Chau

The 13th **International Symposium on Equatorial Aeronomy** (ISEA13) was held on March 12-16, 2012 in Paracas Peru. ISEA's meet every three to four years. They are a major gathering of scientists around the world interested in the low-latitude atmosphere and ionosphere, and their coupling to other latitudes and altitudes. Each ISEA meeting represents an opportunity for researchers to share their most recent results and discuss possibilities for future campaigns and experiments.

The objective of the symposium is to bring together the leaders in the field of equatorial, low-, and mid-latitude aeronomy to advance our knowledge of these

Figure 1. ISEA13 group picture.

regions of the Earth’s atmosphere. Topics for the workshops cover a wide range of research areas, reflecting the need to study the Earth’s ionosphere/atmosphere system in a coupled sense. ISEA13 participants joined the celebration of two important events: the 50th Anniversary of the Jicamarca Radio Observatory (JRO) and also the *first* ISEA meeting --- ISEA1 --- which took place in Huaychulo, Peru, in 1962. The celebration day for JRO's 50th anniversary was held on Saturday March 17th 2012 at the observatory grounds. The celebration program included a detailed tour of the facilities with the Jicamarca scientists and technicians and frequent users participating as “tour guides”.

The celebration program was attended by approximately 150 guests, partially overlapping the 150 participants of ISEA-13. The participants of ISEA-13 included 25 students and representatives from 23 countries. Also, 120 oral talks were presented and 95 posters were displayed during two poster sessions. The oral and poster presentations were aligned with the following eight topical sessions: (1) Irregularity Physics, (2) E and F region coupling (low and mid latitude coupling), (3) Wave propagation between low/middle atmosphere and ionosphere, (4) Plasma neutral coupling, (5) Low and mid latitude Aeronomy and Electrodynamics, (6) Ionospheric storms and Space weather effects at low and mid latitudes, (7) New techniques, experiments, campaigns, and results, and (8) Future trends and challenges. More information about ISEA13, including an access to the program and abstracts, can be found at http://jro.igp.gob.pe/isea13.

ISEA13 was supported by the US National Science Foundation (**NSF**), the US Air Force Office of Scientific Research (**AFOSR**) and the Southern Office of Aerospace Research and Development (**SOARD**), Scientific Committee On Solar-Terresrial Physics (**SCOSTEP**) and Climate And Weather of the Sun-Earth System (**CAWSES**), the International Association of Geomagnetism and Aeronomy (**IAGA**), the International Union of Radio Science (**URSI**), the Consejo Nacional De Ciencia Y Tecnología del Perú (**CONCYTEC**). In addition, ISEA received support from private companies in Peru. Most of this was devoted to support the participation of young scientists and researchers from developing countries.

The results of the workshop will be published in a special issue in the Journal for Atmospheric and Solar Terrestrial Physics. The deadline for submission of papers is July 31st, 2012.

Ethiopia was chosen as the site of the next ISEA meeting to be held in 2015/2016 time window.

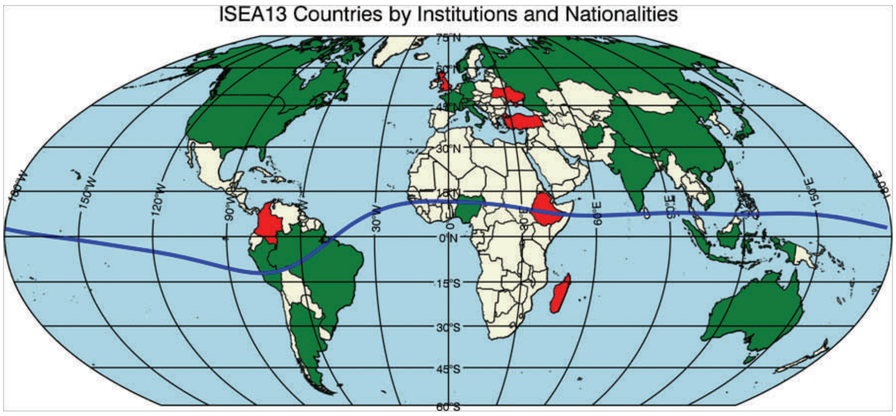

Figure 2. ISEA13 countries: Institutions (Green), Nationalities not represented by Institutions (red).

Article 2

Concentric waves observed in the ionosphere after the 2011 Tohoku earthquake

Takuya Tsugawa[1](*), Akinori Saito[2], Yuichi Otsuka[3], Michi Nishioka[1], Takashi Maruyama[1], Hisao Kato[1], Tsutomu Nagatsuma[1], and Ken T. Murata[1]

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Takuya Tsugawa

14:50 (JST=Japan Standard Time) [**~3 min. after EQ**] **15:00** (JST) [**~13 min. after EQ**] **15:55** (JST) [**~68 min. after EQ**]

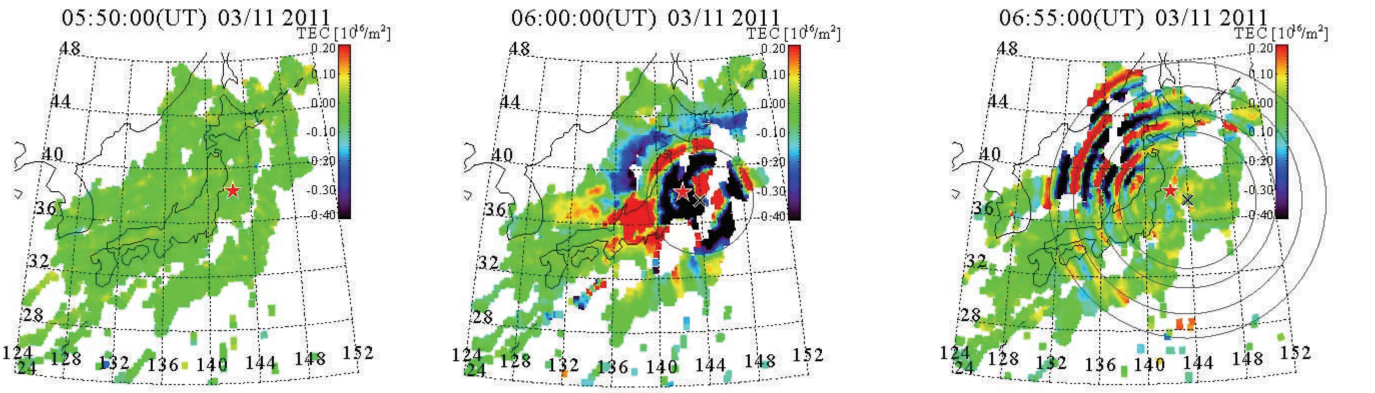

Figure 1. Two-dimensional maps of total electron content (TEC) variation derived using the data of GEONET, a dense GPS receiver network operated by GSI. The TEC data are detrended values derived by subtracting 10-minute running average of the data. The star and cross marks represent the epicenter and "ionospheric epicenter", respectively. Gray circles represent concentric circles with the ionospheric epicenter. The animation of TEC maps is available on the NICT website (http://www.seg.nict.go.jp/2011TohokuEarthquake).

Ionospheric disturbances were observed by GPS total electron content (TEC) and ionosonde observations in Japan after the 2011 Tohoku earthquake off the Pacific coast of northern Honshu on March 11. High-resolution TEC maps were derived using the Japanese GPS receiver network, GEONET, consisting of about 1,240 stations operated by the Geospatial Information Authority of Japan. In these ionospheric observations, concentric waves propagating away from the vicinity of epicenter were detected from about 7 minutes to several hours after the earthquake.

According to the GPS-TEC observation, concentric waves in the ionosphere began to appear about 7 minutes after the earthquake onset at 14:46:23 JST (05:46:23 UT) near the epicenter (38.322 deg N, 142.369 deg E, according to the U.S. Geological Survey) (See Figure 1). The center of these ionospheric concentric structures, termed the "ionospheric epicenter", was located about 170 km from the epicenter in the southeast direction. The ionospheric epicenter was closer to the Japan trench than the epicenter and consistent with estimated areas of the tsunami source. These concentric waves appeared in the western part of Japan until around 18:00 JST (09:00 UT).

According to the observation of ionospheric electron density altitude profiles using ionosondes, swept-frequency vertical sounding radars, the irregular distortion of ionospheric echo trace was observed at virtual height of 200-300 km in Japan after the earthquake (See Figure 2). These irregular echo traces would be caused by the modulation of ionospheric height at the real height of 150-250 km due to the atmospheric waves associated with the earthquake.

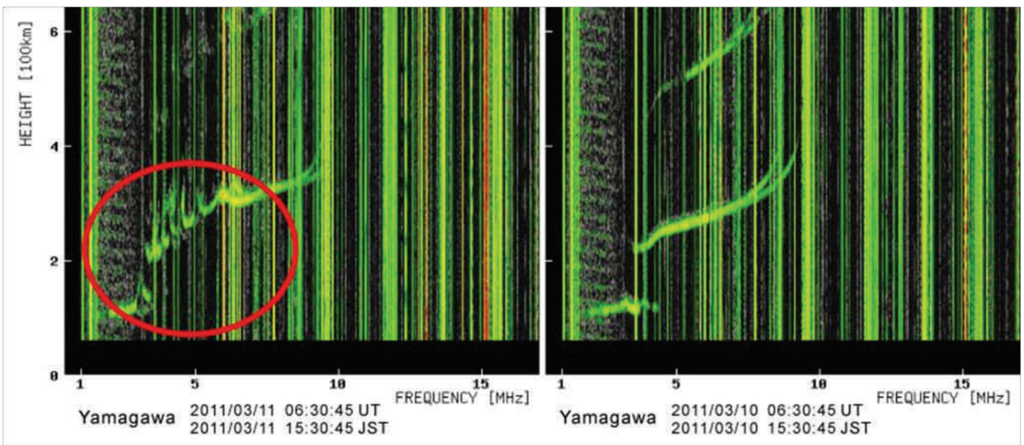

Figure 2. Ionograms from ionosonde observations at Yamagawa (31.20 deg N, 130.62 deg E) about 44 minutes after the earthquake (left) and at the same time one day before (right). As indicated by the red circle, irregular distortion of echo trace was observed after the earthquake at virtual height of 200-300 km which corresponds to the real height of 150-250 km.

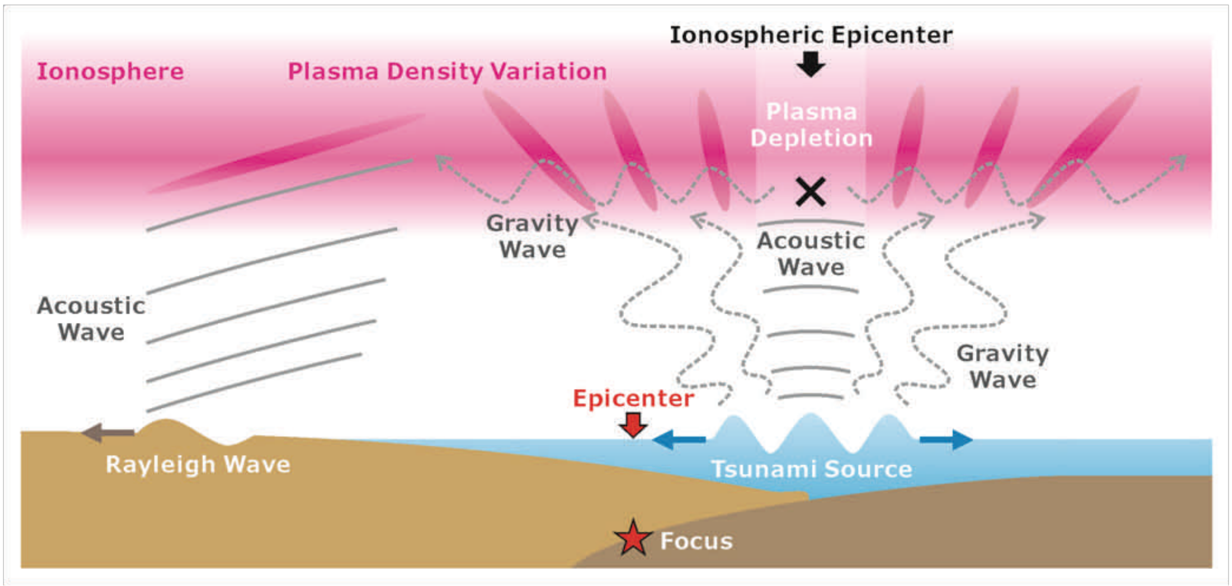

Figure 3. Schematic picture of the generation mechanism of atmospheric waves and ionospheric variations after the earthquake. It is considered that the first ionospheric concentric wave with the propagation velocity of about 3.5 km/s was caused by the acoustic wave generated from the propagating Rayleigh wave. The second and following concentric waves would correspond to the atmospheric gravity waves (AGW) propagating in the ionosphere. These AGWs are considered to be generated at the tsunami wavefronts and at the lower ionosphere above the tsunami source.

These observational results indicate that this great earthquake caused not only underground waves (seismic wave) and sea waves (tsunami) but also atmospheric waves which propagated upward in the atmosphere and reached the ionosphere (See Figure 3). Although some aspects of coseismic ionospheric waves were observed after great earthquakes such as the 2004 Sumatra earthquake and the 2010 Chile earthquake, it is the first time to detect all the details of post-seismic ionospheric disturbances by high-resolution and wide-coverage ionospheric observations. This study is important not only to reveal the relationship between the ionosphere and the lower atmosphere, but also to apply the ionospheric observations to monitor tsunami in a wide area. The details of post-seismic ionospheric disturbances are reported in Tsugawa et al. [Earth Planets Space (EPS), 2011] and accompanying papers [Maruyama et al., EPS, 2011; Saito et al., EPS, 2011; Matsumura et al., EPS, 2011; Chen et al., EPS, 2011].

Article 3

Optical aeronomy studies at the Physical Research Laboratory, India

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D. Pallamraju

Physical Research Laboratory (PRL) at Ahmedabad is known as the cradle of space research in India. Studies on optical aeronomy were initiated by PRL as early as in the 1960s wherein a high-altitude station, Mt. Abu, was established for enabling airglow observations. It was also during those times that optical photometers were flown on rockets to determine the altitude profiles of various airglow emissions. Optical photography of vapor clouds released by rockets was also initiated by PRL during the late 60s to derive the neutral winds in the upper atmosphere.

Initially, the studies focused on broad-bandwidth photometry of redline (OI 630.0nm) airglow emissions. Later, PRL established another high-altitude (1700 m above MSL) observatory at Gurushikhar which serves as one of the main locations for optical aeronomy studies. It is at PRL that several optical photometric, spectral imaging, and interferometric techniques were developed in India. The in-house built techniques which yielded most exciting results were the nighttime Fabry-Perot spectrometer, Doppler imaging Fabry-Perot interferometer, dayglow photometer and narrow-bandwidth nighttime photometer. These instruments have been used to investigate phenomena over low- and equatorial -latitudes, such as, equatorial electrojet, Equatorial Ionization Anomaly (EIA), equatorial spread F, and equatorial temperature and wind anomaly. These phenomena are intricately coupled to one another and leave their signatures in optical airglow emissions. Optical measurements have been carried out by PRL researchers in campaign mode from several magnetic-latitudes in India (e.g., Thumba, Gadanki-Tirupati, Waltair, Hyderabad, Kolhapur, Ahmedabad, Gurushikhar) and the Indian station in Antarctica (Maitri) to investigate the upper atmospheric dynamics. As different emissions originate at different altitudes, in addition to redline, measurements were carried out at OI 297.2nm, 557.7nm, 777.4nm, and Na 589.6nm to investigate the dynamics at those altitudes. The 297.2nm UV emissions were measured on-board a high-altitude balloon from Hyderabad as a PRL-Boston University collaborative experiment.

A few important results are mentioned below to provide a flavor of work at PRL. Temperature and winds from Gurushikhar showed the height of the ionosphere over low-latitudes follows the Servo model, although proposed for mid-latitudes. The retrieval of the EIA in the nighttime was captured by the Doppler Imaging Fabry-Perot Interferometer wherein the redline intensity pattern clearly moved from the crest of EIA towards equatorial region. Narrow-bandwidth and photometric measurements revealed several finer features such as the impact of interplanetary electric field on the low-latitude redline emissions. These features are otherwise submerged in the conventional broad-bandwidth all-sky imaging measurements. Sodium nightglow emission measurements at Gadanki-Tirupati, in conjunction with the lidar derived sodium concentrations provided experimental evidence to the importance of collisions in the mesospheric sodium nightglow emissions as suggested by earlier workers. Several other results, such as, presence of solar flux effect on the day-to-day variations on redline dayglow intensities, its response to EIA, and to storms & sub-storms, are available in literature.

Figure 1. (Top) Optical aeronomy observatory at Gurushikhar (24.6°N, 72.7°E). PRL's Infrared telescope building can be seen in the background. The airglow photometers and Fabry-Perot spectrometer located in this optical aeronomy observatory can be seen in the figure at the bottom.

Systematic measurements of daytime atomic emissions at 557.7nm, 630.0nm, and 777.4nm initiated at PRL continue to lead investigations on neutral dynamics of upper atmosphere in daytime. Currently, plan is underway to network the optical measurements being carried out from different locations to obtain a detailed picture of this region which encompasses both the crest and trough of the EIA. Further, several measurements with improved instrumentation, such as, nighttime OH mesospheric temperatures, thermospheric temperatures and winds, and Na concentrations by Lidar from Gurushikhar will become operational enabling a comprehensive dataset for critical investigations of different aspects of vertical coupling of atmospheric regions.

Acknowledgements: Inputs and suggestions from R. Sekar are duly acknowledged.

Article 4

Dynamical coupling during the 2006 stratospheric sudden warming as simulated by TIME-GCM

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A. Maute

We examine the 2006 Stratospheric Sudden Warming (SSW) event using the NCAR Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Model (TIME-GCM). The TIME-GCM lower boundary is forced with daily averaged European Center for Medium-Range Weather Forecasting (ECMWF) reanalysis data to account for planetary wave activity, plus monthly climatologies of migrating and nonmigrating tides from the Global Scale Wave Model (GSWM). Figure 1 shows the TIME-GCM zonal mean neutral temperature at 71^{o} latitude for January-March 2006. The initial phase of the major SSW is evident between days 20-25. Comparison with SABER observations [*Smith et al., 2009, GRL*] shows that TIME-GCM reproduces the global features of the disturbed middle atmosphere. To quantify the SSW planetary wave effects we conduct a control simulation without planetary wave forcing. Figure 2 shows the longitudinal variation of the noontime vertical ExB drift at the geomagnetic equator without (left plot) and with (right plot) planetary wave forcing. The latter exhibits a strong wave-4 variation with longitude throughout the January-March period. However, the wave-4 feature is disturbed in January when planetary waves are included. The wave-4 feature at a fixed local time can be associated with the diurnal eastward propagating tide with zonal wavenumber 3 (DE3), but also with a zonal wavenumber 4 stationary planetary

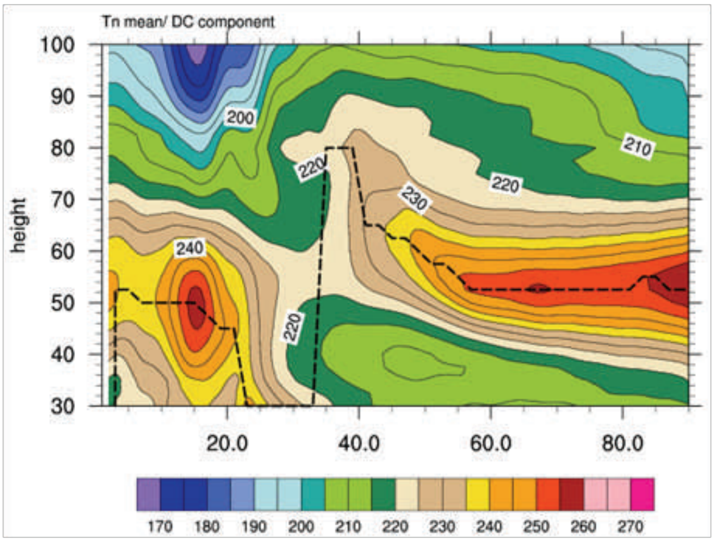

Figure 1. Zonal mean temperature [K] at 71^{o} latitude as simulated by TIME-GCM for 2006 day numbers 1-90.

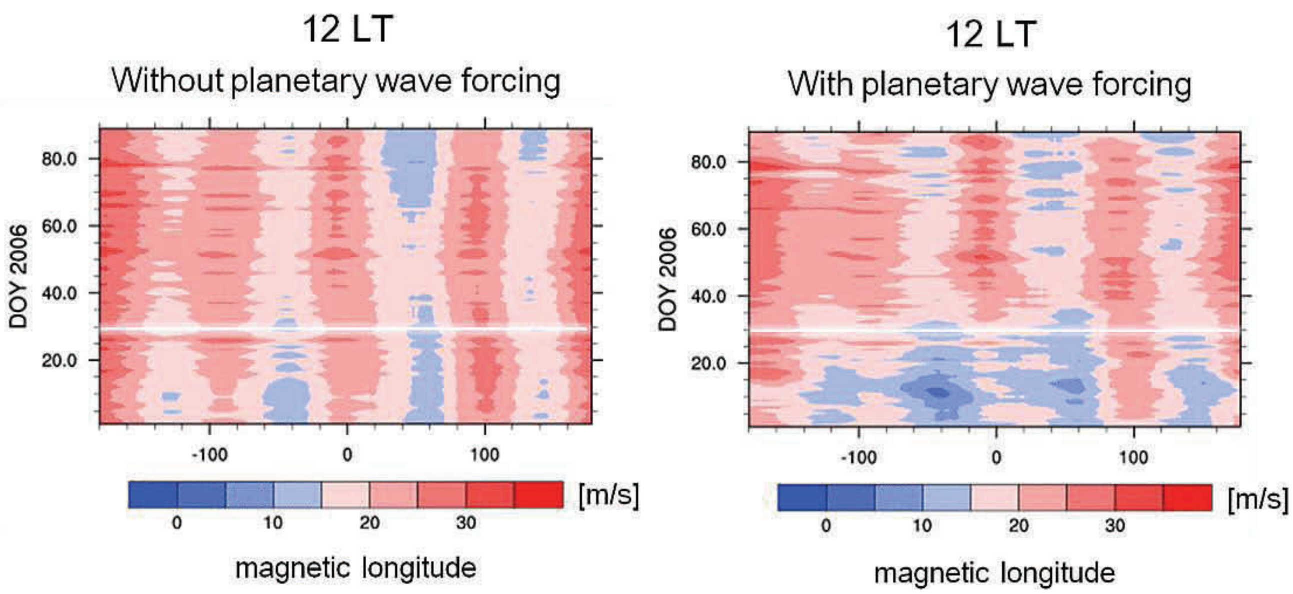

Figure 2. Noontime vertical ExB drift [m/s] at magnetic equator over magnetic longitude and day number as simulated by TIME-GCM: without planetary wave forcing (left), with planetary wave forcing (right); end of January is indicated by the white line.

wave (PW4) or a semidiurnal eastward propagating tide with zonal wavenumber 2 (SE2). Figure 3 depicts the height variation of the equatorial zonal wind amplitude of the dominant zonal wavenumber 1 planetary wave (PW1) associated with the SSW (middle), and the latitudinal variation of the zonal wind amplitude of the DE3 (bottom) and the diurnal eastward propagating tide with zonal wavenumber 2 (DE2; top) at 110 km. This figure provides evidence that a nonlinear interaction between PW1 and DE3 generates a secondary DE2 component. The PW1 amplitude decreases with altitude and exhibits strong temporal variability. This PW1 variability is similar to the variability in both the DE3 and DE2 amplitudes at 110 km. The DE3-PW1 nonlinear interaction associated with the SSW results in a reduction of up to 15 m/s in the DE3 zonal wind amplitude at 110 km during January, while the DE2 amplitudes are comparable to the control simulation (not shown), indicating that the secondary DE2 component is out of phase with the ubiquitous DE2 component excited in the troposphere. Although this mechanism is plausible, we need to move beyond examining similar signals in different quantities to examining mechanisms in a quantitative way. The DE3 zonal neutral wind amplitude decreases up to 15 m/s, but the amplitude of the wave-4 feature in the vertical ExB drift is reduced by just 1 m/s. Additional factors which could offset the DE3 zonal wind effect on the vertical drift could be the modest increase of 2-3 m/s in the PW4 and SE2 zonal and meridional wind amplitudes in the E-region. However, we have yet to fully understand their interplay. Understanding the impact of dynamical disturbances excited in the lower atmosphere on electric fields is a critical first step towards understanding the SSW effects on the ionosphere.

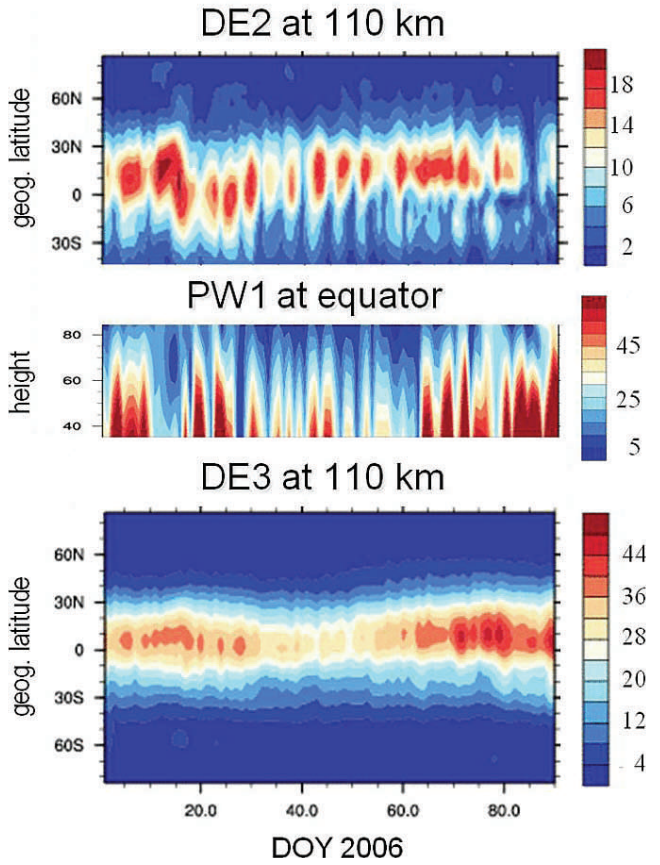

Figure 3. Zonal neutral wind amplitudes [m/s] as simulated by TIME-GCM for 2006 day number 1 to 90 for: PW1 at geographic equator over height (middle); DE2 (top) and DE3 (bottom) at 110 km over latitude.

Highlights on young scientists

Gravity wave seeding of the equatorial spread F irregularities

V. Sreeja
Nottingham Geospatial Institute, University of Nottingham, United Kingdom

V. Sreeja

As a post doctoral research fellow at the Nottingham Geospatial Institute, University of Nottingham, I have been working on the CIGALA (Concept for Ionospheric Scintillation Mitigation for Professional GNSS in Latin America) project, co-funded by the European Commission (EC) 7th Framework Program (FP7) and supervised by the GNSS Supervisory Authority (GSA). This project aims to understand the cause and implications of scintillation over low latitudes, model their effects and develop novel countermeasures to be implemented in multi-frequency, multi-constellation GNSS receiver. My research work in this project involves developing/ improving a GNSS receiver tracking error prediction model to counter ionospheric scintillation effects.

Equatorial Spread F (ESF), a nighttime phenomenon that manifests itself in the form of diffuse echoes in the

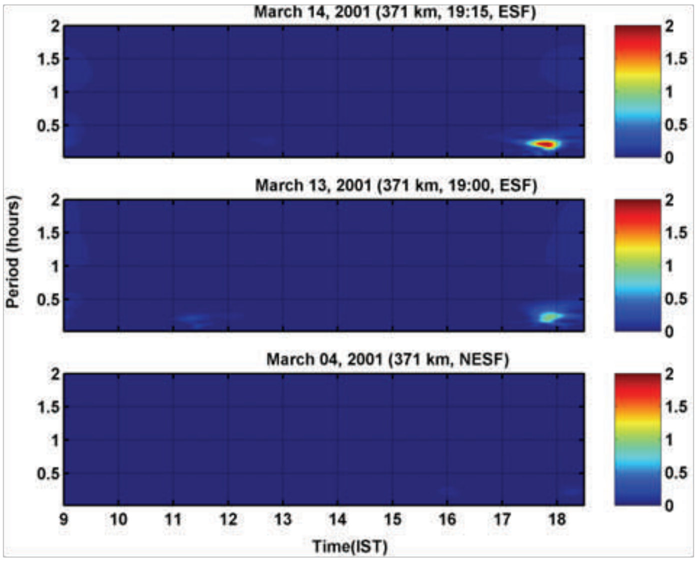

Figure 1. Wavelet periodiogram of the thermospheric 630.0 nm airglow emissions on ESF days (top and middle panels) and a non-ESF day (bottom panel) during the solar maximum year of 2001. The numbers in the parenthesis indicates the maximum post sunset h'F and the onset time of ESF. The colorbar indicate the amplitude of the periodicities in arbitrary units. (After Sreeja et al. [2009, Ann.Geophys., 27, 313–318])

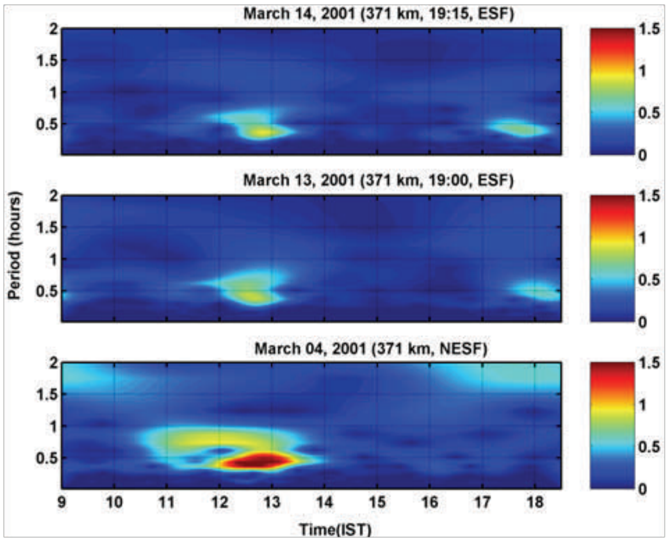

Figure 2. Wavelet periodiogram of the mesopause temperature for the same days as shown in Figure 1. The colorbar indicate the amplitude of the periodicities in degree Kelvin. (After Sreeja et al. [2009, Ann.Geophys., 27, 313–318])

ionograms has got considerable attention because of its impact on satellite communication and navigation systems. In all the previous studies attempted at solving the day-to-day variability of ESF, the seed perturbation (widely believed to be gravity waves) for ESF irregularities was assumed to be omnipresent.

In this context, my research has focused on identifying the seed perturbations for ESF using the daytime airglow intensity measurements made with the Multi Wavelength Dayglow PhotoMeter (MWDPM) located at the magnetic equatorial location of Trivandrum (8.5° N; 77°E; dip lat ~ 0.5°N) in India. Figure 1 presents the 'Morlet' wavelet periodiogram of the thermospheric O (1D) 630.0 nm emissions, clearly showing a dominant periodicity of 20-30 minutes in the late evening hours for the ESF days.

To ascertain the source region of the perturbations, the mesopause temperature data derived from the MWDPM was also subjected to a similar analysis and the results are shown in Figure 2. A dominant periodicity of 20-30 minutes is observed to get enhanced during the evening hours on the ESF days.

The most critical piece of the observations is that the gravity wavelike perturbations in the mesopause temperature occur at almost the same time as in the 630 nm intensity. This suggests that the waves could have originated lower below and propagated to the thermosphere. The present study takes us one step ahead towards solving the enigmatic problem of the day-to-day variability of ESF occurrence.

Short News

CAWSES-II/TG4 Business Meeting at COSPAR in Mysore, India

Jens Oberheide
Clemson University, SC, USA

TG4 will held a Business Meeting at the next COSPAR meeting in Mysore, India, on 20 July from 19:00-20:30, Room G071, right after the end of Session C2.2 (same room). The meeting is open to all participants. The purpose of the Business Meeting to give an update of recent CAWSES-II activities in general and TG4 in particular, including status reports of campaign activities and future plans. An open discussion about the plans until the end of CAWSES-II in 2013 is encouraged. The Business Meeting will be chaired by the two TG4 co-leaders, Jens Oberheide of Clemson University and Kazuo Shiokawa of Nagoya University.

Upcoming meetings related to CAWSES-II TG4

Conference	Date	Location	Contact Information
39th COSPAR Scientific Assembly	Jul. 14-22, 2012	Mysore, India	http://www.cospar-assembly.org
International Symposium on Solar-Terrestrial Physics	Nov. 6 - 9, 2012	Indian Institute of Science Education and Research, Pune	http://www.iiserpune.ac.in/~isstp2012/
AGU Chapman Conference on Longitude and Hemispheric Dependence of Space Weather	Nov. 12-16, 2012	Addis Ababa, Ethiopia	http://www.agu.org/meetings/chapman/2012/fcall/
CAWSES-II2013 Symposium	Nov. 18-22, 2013	Nagoya, Japan	http://www.stelab.nagoya-u.ac.jp/cawses2013/.

The purpose of this newsletter is to make more communications among scientists related to the CAWSES-II Task Group 4 (particularly between those of the atmosphere and the ionosphere). **The editors would like to invite you to submit the following articles to the TG4 newsletter.**

Our newsletter has four categories of the articles:

1. Articles— ~500 words and four figures (maximum)
   on campaign, ground observations, satellite observations, modeling, workshop/conference/symposium report, etc
2. Highlights on young scientists— ~200 words and two figures
   on the young scientist's own work related to CAWSES-TG4
3. Short news— ~100 words
   announcements of campaign, workshop, etc
4. List of planned workshop

Category 2 (Highlights on young scientists) helps both young scientists and TG4 members to know each other. Please contact the editors for recommendation of young scientists who are willing to write an article on this category.

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This newsletter is also available on the web at http://www.cawses.org/wiki/index.php/Task_4