COMMISSION G: Ionospheric Radio and Propagation (November 2004 – October 2007)

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G1. Ionospheric Irregularities

G1.1. Equatorial Spread F and Plasma Bubble

Onset conditions and the evolution of plasma bubbles were studied in a multi-instrumental atmosphere observation program, CPEA (Coupling Processes in the Equatorial Atmosphere) [Fukao, 2006], including FAI (field-aligned irregularity) mode operation of the Equatorial Atmosphere Radar (EAR) at Kototabang in Sumatra Island, Indonesia [Yokoyama et al., 2004a, 2005a; Patra et al., 2005; Yokoyama and Fukao, 2006; Fukao et al., 2006; Ogawa et al., 2006a; Otsuka et al., 2006a]. EAR observations of FAI were compared with the plasma blobs detected by the ROCSAT-1 satellite [Yokoyama et al., 2007]. Ionospheric height variations were studied in connection with onset conditions of plasma bubbles [Saito and Maruyama, 2006, 2007] by using the ionospheric sounding data from the Southeast Asia Ionospheric Network (SEALION) [Maruyama et al., 2007]. Passive remote soundings of plasma bubbles and the related structure were conducted by receiving TV broadcasting signals at VHF from Southeast Asia countries [Nakata et al., 2004, 2005] and by receiving HF radio broadcasting signals from Australia [Maruyama and Kawamura, 2006]. A greatly developed plasma bubble extending over middle Japan, with an equatorial height of approximately 2500 km, was detected by a dense GPS receiver network over Japan, GEONET (GPS Earth Observation Network), [Ma and Maruyama, 2006]. A geomagnetically conjugate aspect of well-developed plasma bubbles was observed by all-sky imagers located in Japan and Australia and an OI 135.6-nm imager onboard the IMAGE satellite [Ogawa et al., 2005a].

G1.2. Sporadic E and Quasi-Periodic Echo

A multi-instrumental observation campaign, SEEK-2 (Sporadic E Experiment over Kyushu 2), for sporadic E study was conducted around Kyushu Island, southern Japan. This was a continuation of the SEEK campaign conducted in 1996. An outline of the observation is described by Yamamoto et al. [2005]. Two sounding rockets were launched on the night of 3 August 2002, which carried the Electric field Detector [Pfaff et al., 2005], the Impedance Probe [Wakabayashi et al., 2005; Wakabayashi and Ono, 2005], the Dual-Band Beacon transmitter [Bernhardt et al., 2005], Tri-Methyl Aluminum release experiment [Larsen et al., 2005], and other instruments. Ground-based facilities operated along with the rocket launches were two VHF coherent backscatter radars in Tanegashima close to the rocket launch site [Saito et al., 2005], the middle and upper atmosphere (MU) radar [Ogawa et al., 2005b], a rapid-run ionosonde [Maruyama et al., 2006], and an all sky imager [Onoma et al., 2005]. The observations obtained during the campaign were compared with numerical simulations [Yokoyama et al., 2005b].

Generation mechanisms responsible for E-region field-aligned irregularities and quasi-periodic (QP) echoes involved with neutral atmospheric dynamic were studied using

VHF radars, all sky imagers, and other experiments [Ogawa et al., 2006b; Saito et al., 2006, 2007; Patra et al., 2007; Otsuka et al., 2007], in numerical simulations [Yokoyama et al., 2004b], and through theoretical approaches [Tsunoda et al., 2004; Haldoupis et al., 2005]. Global and seasonal distribution of sporadic E was depicted by applying an occultation technique to radio propagation data from the GPS satellites to the CHAMP satellite [Garcia-Fernandez and Tsuda, 2006]. A correlation between the sporadic metal layers and the sporadic E layer was studied with simultaneous lidar and ionosonde observations over Kototabang in Sumatra Island, Indonesia [Shibata et al., 2006].

G2. Ionospheric Disturbances

G2.1. Ionospheric Storm

Ionospheric disturbances caused by the prompt penetration of magnetospheric electric fields during major magnetic storms were demonstrated. [Mannucci et al., 2005; Tsurutani et al., 2006] and model calculations were compared with the observations [Pavlov et al., 2006; Pavlov and Fukao, 2007; Tsurutani et al., 2007]. Observations including magnetometer data from the Pacific sector were used to study the equatorial ionospheric electric field during a geomagnetic storm [Fejer et al., 2007]. GEONET and an ionosonde network along the Japan's meridian were used to study geomagnetic storm effects on the ionosphere disturbances [Unnikrishnan et al., 2005; Kutiev et al., 2005, 2006, 2007; Maruyama, 2006; Maruyama and Nakamura, 2007], while observations in the East Asian and Brazilian sectors were compared for studying global characteristics of ionospheric storms [Sahai et al., 2005; Abdu et al., 2007]. Responses of the D-region electron density to geomagnetic storms were studied by analyzing tweek atmospherics in the ELF/VLF bands [Ohya et al., 2006].

G2.2 Direct Effect of Energetic Radiations

Increases in EUV and soft X-ray radiations associated with solar flares cause ionospheric disturbances. Characteristics of the ionospheric response to solar flares were studied from sudden increases in the total electron content (SITEC) [Tsugawa et al., 2006b, 2007], rapid thermospheric responses observed by the CHAMP satellite [Liu, H. et al., 2007b], and changes in the amplitude of VLF signals with short and long propagation distances [Todoroki et al., 2007]. An ionospheric disturbance caused by another energetic event, a cosmic gamma-ray burst, was detected by a riometer and other instruments [Maeda et al., 2005].

G2.3. Traveling Ionospheric Disturbances

Geomagnetic conjugate characteristics of traveling ionospheric disturbances were studied with simultaneous observations in Japan and Australia by using an all-sky airglow imager network [Shiokawa et al., 2005a] and GPS receiver networks over Japan (GEONET) and Australia [Tsugawa et al., 2006a]. Midlatitude ionospheric irregularities over Japan were statistically investigated in connection with medium scale TIDs (MSTIDs) detected by GEONET [Otsuka et al., 2006c]. Characteristics of MSTIDs were analyzed by using TEC data derived from the International GNSS Service (IGS) dataset [Kotake et al., 2006], GPS networks in Southern California [Kotake et al., 2007], and MU radar observations [Liu, J. -Y. et al., 2007]. A general circulation model was applied to studying TIDs [Fujiwara and Miyoshi, 2006], and a TID propagating southward during a major magnetic storm was compared with NCAR-TIEGCM calculations incorporated with the assimilative mapping of ionospheric electrodynamics (AMIE) [Shiokawa et al., 2007].

G2.4. Other Disturbances Associated with Magnetic Storm

Low-latitude aurora events in the northern sky of Japan associated with magnetic storms were compiled and 20 events were identified in the high solar activity period from 1999 to 2004 [Shiokawa et al., 2005b]. In the historical literature written in the 12–19th centuries, low-latitude aurora events were picked up and interpreted in the eyes of the modern science [Nakazawa et al., 2004]. Significant nocturnal enhancements in electron temperature in the topside ionosphere were found by the HINOTORI satellite measurements [Oyama, K. -I. et al., 2005]. An ionospheric radio absorption event associated with a great geomagnetic storm on 15-16 July 2000 was observed in the Brazilian geomagnetic anomaly region using an imaging riometer [Nishino et al., 2006].

G3. GPS Application to Ionosphere Study

Several new techniques were developed for ionospheric application of GPS signals. A technique for determination of GPS differential biases and an ionospheric tomography based on the artificial neural network technique was developed [Ma et al., 2005a, b]. A combined use of limb sounding data with that from ground-based GPS receiver and ionosonde networks improved the accuracy of an ionospheric tomography [Garcia-Fernandez et al., 2005]. For the purpose of space weather monitoring, a near real-time estimation procedure of TEC was developed based on the GEONET data service [Miyake, 2007]. An improvement of the accuracy of vertical TEC estimates was discussed for the oblate earth's gravitational equipotential surface model [Hobigar et al., 2007].

G4. Ionospheric Structure and Models

G4.1. Ionospheric Structure

A far ultraviolet (FUV) imager onboard the IMAGE satellite revealed nighttime zonal structure of the low latitude ionosphere with the wave-number-4 feature [Sagawa et al., 2005; England et al., 2006; Immel et al., 2006]. An electron density discontinuity or additional layering of the low latitude F region, sometimes referred to as the F3 layer in the bottomside or to as an ionospheric ledge in the topside, were studied by using topside soundings by the EXOS-C and ISIS-2 satellites [Uemoto et al., 2004, 2006] and bottomside soundings from a meridional ionosonde network over Southeast Asia [Uemoto et al., 2007]. Chaotic behavior of ionospheric fluctuations was studied in various geophysical conditions using GPS TEC data [Unnikrishnan et al., 2006a, b].

A D-region electron density profile was obtained at a noon high-latitude by using an LF/MF radio receiver and a DC probe onboard a sounding rocket [Ishisaka et al., 2005].

G4.2. Ionospheric Models

Long-term databases of incoherent scatter radars including the MU radar at Shigaraki, Japan were used to create local empirical models to complement global models such as the International Reference Ionosphere (IRI) [Zhang et al., 2005, 2007]. Electron densities and temperatures obtained by satellite in-situ measurements [Liu, H. et al., 2007c; Bilitza et al., 2007] and vertical electron density profiles [Uemoto et al., 2007] were compared with IRI predictions for improvements of the model.

G5. Coupling with Atmosphere/Lithosphere

G5.1. Neutral Atmosphere-Ionosphere System

Airglow measurements near the equator over Kototabang in Sumatra Island, Indonesia revealed quasi-periodic southward moving waves in the thermosphere [Shiokawa et al., 2006a] and northward propagating front-like structure aligned in the east-west direction in the mesosphere [Shiokawa et al., 2006b]. Thermospheric winds at midlatitudes observed by the MU radar at Shigaraki, Japan were compared with numerical simulations [Balan et al., 2006; Lei et al., 2007]. Equatorial thermospheric zonal winds as measured by the CHAMP satellite were investigated and compared with theoretical and empirical models [Liu, H. et al., 2006]. Climatology of the equatorial mass anomaly (EMA) in the thermosphere was investigated using CHAMP measurements and a strong variation of the EMA with the season and solar flux level was found [Liu, H. et al., 2007a].

G5.2. Effect of Thunder Storm and Meteorological Phenomenon

Coordinated optical and electromagnetic (VLF/ELF/VHF) measurements of sprites, optical emissions in the mesosphere associated with thunderstorm activities, were conducted [Adachi et al., 2005; Matsudo et al., 2007]. Electrical properties of lightning discharges that play an essential role in the initiation and development of sprites were investigated [Ohkubo et al., 2005]. The ISUAL payload, space-based measurement of sprites for the first time, onboard the FORMOSAT-2 satellite was launched [Mende et al., 2005]. The electron energy and electric field were estimated from the spectral data, and kinetic processes involved with sprites were studied [Adachi et al., 2006]. It was numerically demonstrated that the time scale of charge removal by lighting is an essential parameter for the initiation of sprites [Hiraki and Fukunishi, 2006]. Numerical simulations were made to study the behavior of positive charges causing sprite halos using a particle model combined with a quasi-electrostatic model [Tong et al., 2005]. Midlatitude ionospheric Alfvén resonator (IAR) excitation due to electromagnetic waves radiated from lightning discharges was studied analytically and numerically [Surkov et al., 2005, 2006]. The intensity of the Schumann resonance, global electromagnetic oscillations, has been monitored at Moshiri, Japan and a good correlation was found between the global ground temperature and the Schumann resonance intensity [Sekiguchi et al., 2006]. Ionospheric DC electric fields and plasma density variations associated with meteorological phenomena such as tropical storms and typhoons were investigated [Sorokin et al., 2005].

G5.3. Earthquake Effect on the Ionosphere

Upper atmospheric perturbations stimulated by the great Sumatra earthquake on 26 December 2004 were detected as changes in the ionospheric total electron content by GPS receiver networks [Otsuka et al., 2006b; Heki et al., 2006; Liu, J.-Y. et al., 2006] and as geomagnetic pulsations generated through the dynamo action of an atmospheric pressure pulse [Iyemori et al., 2005]. The observed TEC disturbances were numerically modeled [Shinagawa et al., 2007]. A similar TEC disturbance generated by a volcano eruption in central Japan was detected by GEONET [Heki 2006].

A precursor of ionospheric perturbations to the Sumatra earthquake was found in subionospheric VLF propagation signals [Horie et al., 2007]. An anomalous effect on the Schumann resonance was detected associated with other large earthquakes. For one of those earthquakes, an anomaly appeared one week to a few days before the main shock [Hayakawa et al., 2005], and this anomaly was numerically modeled [Nickolaenko et al., 2006]. A subionospheric LF and VLF propagation anomaly caused by ionospheric disturbances [Maekawa et al., 2006; Yamauchi et al., 2007] and anomalous sporadic E layers [Sorokin et al., 2006a] were observed in prior to earthquakes; the effect was numerically modeled [Soloviev et al., 2006]. Various applications of the Schumann resonance to ionospheric studies including an earthquake effect were reviewed [Nickolaenko and Hayakawa, 2007]. An electrodynamic model was developed for strong DC electric-field formation in the ionosphere above typhoon and earthquake regions [Sorokin et al., 2006b].

G6. Polar Atmosphere-Ionosphere

The cosmic radio noise absorption (CNA) was measured at Poker Flat Research Range, Alaska and results were compared with the precipitating electron flux observed by the NOAA12 satellite [Tanaka et al., 2005]. An all-sky airglow imager at Resolute Bay, Canada revealed polar cap patches that drift anti-sunward during a period of the southward IMF condition [Hosokawa et al., 2006]. The ratio of the Lorentz force to the Joule heating rate terms in generating atmospheric gravity waves in the auroral electrojets was investigated using data from the European Incoherent Scatter (EISCAT) radar [Yuan et al., 2005]. Using observations by the EISCAT Svalbard radar at Longyearbyen and the EISCAT UHF radar at Tromsø, it was shown that the ion drag plays an important role in wind dynamics in the lower thermosphere [Tsuda et al., 2007]. The ion and neutral temperatures in the auroral region and in the polar cap were compared using two EISCAT radars, and agreement/disagreement with the MSISE-90 empirical model was studied [Maeda et al., 2005]. Vertical ion velocities in the lower ionosphere were investigated using data from the EISCAT Tromsø UHF radar under geomagnetically quiet conditions [Oyama, S. et al., 2005a]. A new beam configuration for monostatic incoherent scatter radar observation at high latitudes was developed to estimate the vertical component of the neutral wind velocity in the lower thermosphere and it was applied to the Sonderstrom IS radar, Greenland [Oyama, S. et al., 2005b]. Vertical winds in the thermosphere were measured with Fabry-Perot interferometers at Poker Flat Research Range and Eagle Observatory, Alaska during the Horizontal E region experiment campaign (HEX) [Ishii et al., 2004]. A numerical simulation of atmospheric dynamics near an auroral arc was conducted and it was found that interaction of local heating and strong horizontal flow could play an important role in generating vertical motion [Shinagawa and Oyama, 2006].

Among the backscattering from ionospheric irregularities, distinctive polar mesosphere summer echoes (PMSEs) were detected by the oblique incidence SuperDARN radars in the Arctic and Antarctic regions [Hosokawa et al., 2004, 2005; Ogawa et al., 2004]

A sounding rocket was launched from Andøya Rocket Range, Norway in the Dynamics and Energetics of the Lower Thermosphere in Aurora (DELTA) campaign [Abe et al., 2006a], being coordinated with ground-based instruments. Atmospheric parameters were obtained along the rocket trajectory in a diffuse aurora; the electron density was increased by the auroral precipitation [Wakabayashi and Ono, 2006]; the electron temperature was remarkably high at 106-114 km altitudes [Abe et al., 2006b]; observed energy spectra of energetic electrons were compared with auroral images taken from the ground [Ogasawara et al., 2006]; the rotational temperature and the density of molecular nitrogen were measured and compared with the MSIS empirical model [Kurihara et al., 2006]; the neutral and electron temperatures measured by the DELTA rocket were compared with neutral/ion and electron temperatures observed by the EISCAT UHF radar [Nozawa et al., 2006].

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