Commission G Report

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Archived by Mamoru Yamamoto, Kyoto Univ.

1. Research Report

1.1. Ionospheric disturbances after the intense earthquake and tsunami (Takuya Tsugawa, NICT)

Ionospheric disturbances following the intense earthquake and tsunami such as the 2011 off the Pacific coast of Tohoku Earthquake (2011 Tohoku EQ) were studied by GPS-TEC and ionosonde observations in Japan and numerical simulations. All the details of post-seismic ionospheric disturbances were first observed by a high-resolution two-dimensional GPS-TEC observation in Japan (Tsugawa et al., 2011). The initial ionospheric disturbance appeared as sudden TEC depletion about seven minutes after the earthquake onset near the epicenter (Saito et al., 2011; Kakinami et al., 2012). In the vicinity of the epicenter, short-period oscillations with a period of about 4 minutes were also observed (Saito et al., 2011). Off the epicenter, zonally-extended band-like structures and concentric wave trains appeared in the detrended TEC maps about 15 minutes after the earthquake onset. The former band-like structure traveled equatorward and also appeared in Taiwan (Chen et al., 2011). The latter concentric waves with longer wavelengths and larger propagation velocities appeared earlier (Tsugawa et al., 2011). The center of the TEC depletion and concentric waves, termed "ionospheric epicenter", was located about 170 km from the epicenter in the southeast direction and consistent with estimated areas of the tsunami source. These ionospheric disturbances were reproduced by numerical simulation with a time-dependent, two-dimensional, nonlinear, non-hydrostatic, compressible and neutral numerical model (Matsumura et al., 2011). Based on these observation and simulation results, it is considered that the first fast-propagating 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 (AGWs) propagating in the ionosphere. These AGWs are considered to be generated at the tsunami wavefronts and at the lower ionosphere above the tsunami source. Unusual multiple-cusp signature (MCS) was observed in ionograms obtained by four ionosonde stations in Japan about 15 minutes after the earthquake onset (Maruyama et al., 2011). The real height analysis of the MCS showed a vertical ionospheric structure with a scale size of 20~30 km, indicating acoustic wave generated from the propagating Rayleigh wave. The specific conditions of MCS appearance were statistically studied based on MCS events observed in 8 or 43 earthquakes with a seismic magnitude of 8.0 or greater during the period 1957 to 2011 (Maruyama et al., 2012).

1.2. Sounding rocket experiment (Keigo Ishisaka, Toyama Pref. Univ.)

Ionospheric Radio Wave: S-310-40 sounding rocket experiment was carried out at Uchinoura Space Center (USC) at 23:48 JST on 19 December, 2011. The purpose of this experiment is the investigation of characteristics of radio wave propagation in the ionosphere and the estimation of electron density structure in the lower ionosphere, when the intensity of radio wave measured on the ground was attenuate at nighttime. In order to measure the radio waves, a LF/MF band radio receiver (LMR) is installed on the sounding rocket. The LMR measured the propagation characteristics of four radio waves at frequencies of 60 kHz, 405 kHz, 666 kHz and 873 kHz in the region from the ground to the lower ionosphere. The LMR could measure the relative attenuation of radio waves from the ground up to the ionosphere. Furthermore the loop antenna consists of three loop antennas in order to measure three components of four radio waves.

Although the attenuation of intensity is seen near an altitude of 100 km, the amount of attenuation is less than usual. 100 dB or more is decreased in usual. Such observations are not obtained by past rocket experiments. We investigate the unusual propagation characteristic of radio waves in the ionosphere at winter nighttime. Then we will obtain the 3-dimensional structure of electron density in the lower ionosphere by measuring the intensity of radio waves that propagate from the three different directions.

Electric field measurement with double probe: S-520-26 sounding rocket experiment was carried out at Uchinoura Space Center (USC) in Japan at 5:51 JST on 12 January, 2012. The purpose of this experiment is the investigation of the bonding process between the atmospheres and the plasma in the thermosphere. S-520-26 sounding rocket reached to an altitude of 298 km at 278 seconds after the launch. The S-520-26 payload was equipped with Electric Field Detector (EFD) with a two set of orthogonal double probes to measure both DC and AC less than 200 Hz electric fields in the spin plane of the payload by using the double probe method. Results of DC electric fields measured by the EFD have the large sine waves that result from the payload rotation at the spin period. The largest contribution to the electric field measurements by double probes moving through the ionosphere at mid-latitudes is that due to the $\boldsymbol{v}\mathrm{x}\boldsymbol{B}$ fields created by their motion across the ambient magnetic field, where $\boldsymbol{v}$ is the rocket velocity in the Earth-fixed reference frame and $\boldsymbol{B}$ is the ambient magnetic field. The sum of the squares of the two components represents the magnitude of the DC electric field in the spin plane of the payload. These data reveal abrupt, large-scale variations which can immediately be attributed to changes in the geophysical electric field since the $\boldsymbol{v}\mathrm{x}\boldsymbol{B}$ fields are slowly varying. The sum of the squares data also reveals contributions at the spin frequency and its harmonics. These contributions result primarily from distortions of the waveforms in the raw data.

1.3. Airglow imaging and tweak experiment (Kazuo Shiokawa, Nagoya Univ.)

Shiokawa et al. (2012) reported the rapid oscillating motion of nighttime medium-scale traveling ionospheric disturbances (MSTIDs) associated with an auroral brightening, based on airglow imaging observations at Tromso (magnetic latitude: 67.1N), Norway. This observation indicates that the MSTID oscillation was linked to auroral electric field in the ionosphere, implying that the observed MSTIDs are ionospheric plasma structures. They suggest that the observed MSTIDs were created by atmospheric gravity waves at the beginning, left as fossil plasma structures even after the gravity wave packet dissipated in the thermosphere.

Ohya et al. (2012) reported multi-point observations of daytime tweek atmospherics during the solar eclipse of 22 July 2009 at Moshiri and Kagoshima, Japan, where the magnitudes of the solar eclipse were only 0.458 and 0.966, respectively. The wide range of estimated tweek reflection heights at Kagoshima also suggests a difference in electron density in the D- and lower E-regions between total and partial solar eclipses.

1.4. Polar cap studies (Keisuke Hosokawa, Univ. of Electro-Communications)

Several studies on various phenomena in the polar cap ionosphere have been conducted by using an all-sky airglow imager (ASI) of OMTIs (Optical Mesosphere Thermosphere Imagers; operated by Nagoya University) at Resolute Bay (74.73N, 265.07E). Hosokawa et al. (2011a) observed an unusual event in which a polar cap ionization patch stopped its anti-sunward motion and stayed within the field-of-view for more than one hour. When the patch stagnated, its luminosity decreased gradually, which allows them to investigate how the patch plasma decayed in a quantitative manner. The decay of the patch can be quantitatively explained by the loss through recombinations of O^+ with ambient N_2 and O_2 molecules, if we assume the altitude of the optical patch to be around 295 km. The derived altitude of the patch around 295 km is much higher than the nominal value at 235 km obtained from the MSIS-E90/IRI2007 models, which suggests that we should employ higher emission altitude when we investigate optical patches transported deep into the nightside polar cap. Hosokawa et al. (2011b) carried out a statistics of motion of polar cap arcs (i.e., auroral arcs in the polar cap latitudes) by using 5 years of optical data from Resolute Bay. They identified 743 arcs by using an automated arc detection algorithm, and statistically examined their moving velocities. They showed that polar cap arcs fall into two distinct categories, the IMF-dependent and IMF-independent (IMF: Interplanetary Magnetic Field) arcs. This implies that the mechanism causing the arc motion is fundamentally different between these two types of arc. Thus, their magnetospheric source could also be different.

Another all-sky airglow imager has been operational in Longyeabyen, Norway (78.2N, 15.6E; AACGM latitude 75.3) since October 2011 by University of Electro-Communications. The ASI is equipped with an EMCCD camera whose imaging part has 512x512 pixels. The imager has two different passband interference filters for airglow measurements, one at 630.0 nm and the other at 557.7 nm, which enables us to study various phenomena in the polar cap ionosphere, such as cusp aurora, polar cap aurora and polar cap patches. The exposure time for 630.0 nm emissions is 4.0 s. Every 56 s (= 14 x 4 s) 557.7 nm emissions are observed with an exposure time of 1.0 s by rotating the filter turret. Background continuum emission from the sky is sampled every 10 min at a wavelength of 572.5 nm and is used to derive the absolute intensity of the airglow lines. Optical images obtained by this ASI will be used for better understanding the dynamic nature of polar cap ionospheric phenomena such as polar cap patches and polar cap arcs in near future.

1.5. EISCAT radar experiment and related studies (Satonori Nozawa, Nagoya Univ.)

By using EISCAT radars as well as instruments operated in northern Scandinavia, we have conducted following studies: (1) Lower thermosphere/Mesosphere wind was investigated by the new meteor radar at Bear Island (74.5ºN, 19.0ºE) that started operation on November 2007. Seasonal variations of mean wind, diurnal and semidiurnal tides, and quasi-two day wave are found to be similar to those at Tromsø (69.6ºN, 19.2ºN). (2) First observations of auroral roar emissions near 4 times f_{ce} (electron cyclotron frequency) were conducted at Longyearbyen (78.2ºN, 16.0ºE). 4 f_{ce} roar emissions were detected from 5.27 to 5.70 MHz during moderate geomagnetic disturbances in 22 days between May and September 2011 only from noon to evening, while no event occurred during the winter season. The observations support the idea expanded from the most commonly accepted generation mechanism of 2 f_{ce} and 3 f_{ce} roar: the origin of 4 f_{ce} roar is upper hybrid waves favorably generated under the condition of f_{UH} (upper hybrid resonance frequency) equal to 4 f_{ce} in the auroral F-region. (3) Variations of ion temperatures at Longyearbyen were investigated using IPY long-run data obtained by EISCAT Svalbard radar and predictions by GCM. The ion temperatures show significant seasonal variations. The amplitudes of the local time and seasonal variations observed are much larger than the ones predicted by the IRI-2007 model. This study suggested significant heat sources in the polar cap region even under solar minimum and geomagnetically quiet conditions. (4) Fine structure of a sporadic sodium layer (SSL) was observed by a new sodium LIDAR, which started operation on October 1, 2010, at Tromsø on January 11, 2011. The sodium lidar measurement with 5-sec time resolution revealed the details of dramatic sodium-density increase as well as short-period wavelike structure in the SSL. The calculated power spectral densities are well represented by power laws, implying the presence of the short-period waves and turbulence in the frequency range of $10^{-4} – 10^{-1}$ Hz.

1.6. Equatorial Atmosphere Radar (Mamoru Yamamoto, Kyoto Univ.)

Equatorial Atmosphere Radar (EAR) is a big atmospheric radar located in West Sumatra, Indonesia. The EAR was established in June 2001, and has continued long-term observations. Research Institute for Sustainable Humanosphere (RISH), Kyoto University and National Institute of Aeronautics and Space (LAPAN) of Indonesia hold the 10th anniversary ceremony and symposium on September 22-23, 2011, at Jakarta. The ceremony was attended by the Minister of Research and Technology of Indonesia, the Minister of the Embassy of Japan, and the representative from the Ministry of Education, Culture, Sports, Science Technology (MEXT), and the Vice President of Kyoto University.

The research project "Research Enhancement and System Establishment for Space Weather in Indonesia" is conducted during FY 2010-2012 under the framework of "Strategic Funds for the Promotion of Science and Technology" by MEXT (operation by Japan Science and Technology Agency (JST)). This is a joint project with RISH, Solar-Terrestrial Environmental Laboratory (STEL), Nagoya University, and National Insititute for Information and Communications Technology (NICT). The counterpart in Indonesia is LAPAN. Space weather is a program to observe, assess, and forecast the space environment, and regional observations and studies of the ionosphere are very important. Experiments for the project is not limited in Indonesia, but spread over southeast Asian countries. RISH and LAPAN started the EAR long-duration observation of the equatorial Spread-F (ESF) since July 2010 and archived huge amount of data for ESF occurrence and their spatial-time structures. They also expand observation network of dual-band satellite beacon receivers for the study of ionospheric structures. STEL started the Fabry-Perot interferometry experiment at the EAR site and Chiang Mai (Thailand) to measure thermospheric winds at the geomagnetically conjugate points. NICT keeps operation of SEALION ionosonde network, and collecting GPS-TEC data from the region of southeast Asia.

1.7. Magnetic Data Acquisition System (MAGDAS) and related studies (Huixin Liu, Kyushu Univ.)

MAGDAS is the world network of magnetometer developed and maintained by International Center for Space Weather Science and Education (ICSWSE), Kyushu University. MAGDAS network and its observations are well maintained during this period. New installation of fluxgate magnetometer (MAGDAS 9) in 2012 is listed as follows.

- Jayapura, Indonesia. - Sicincin, Sumatra, Indonesia
- Bengkulu, Sumatra, Indonesia
- Liwa, Sumatra, Indonesia
  (Above three are for earthquake investigations in Sumatra).
- Jerusalem, Ecuador.

Many studies of atmospheric tides, sudden stratospheric warming, various ionospheric phenomena, and thermosphere-ionosphere coupling are published in international journals.

2. Meetings

39th COSPAR Scientific Assembly, Mysore, India, July 14-22, 2012

2012 ISWI and MAGDAS School on Space Sciences, Puncak, Indonesia, September 17-26, 2012

3. Publication list

Ionospheric disturbances after the intense earthquake and tsunami (related to 1.1)

Chen, C. H., A. Saito, C. H. Lin, J. Y. Liu, H. F. Tsai, T. Tsugawa, Y. Otsuka, M. Nishioka, and M. Matsumura, Long-distance propagation of ionospheric disturbance generated by the 2011 off the Pacific coast of Tohoku Earthquake, Earth, Planets, and Space, 63, 881-884, 2011.

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Maruyama, T., M. Ishii, T. Tsugawa, H. Kato, and M. Nishioka, Rayleigh wave signature in ionograms induced by strong earthquakes, J. Geophys. Res., 117, A08306, doi:10.1029/2012JA017952, 2012.

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Airglow imaging and tweak experiment (Related 1.3)

Shiokawa, K., M. Mori, Y. Otsuka, S. Oyama, and S. Nozawa, Motion of high-latitude nighttime medium-scale traveling ionospheric disturbances associated with auroral brightening, J. Geophys. Res., 117, A10316, doi:10.1029/2012JA017928, 2012.

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Polar cap studies (Related to 1.4)

Hosokawa, K., J. I. Moen, K. Shiokawa, and Y. Otsuka, Decay of polar cap patch, Journal of Geophysical Research, 116, doi:10.1029/2010JA016297, 2011a.

Hosokawa, K., J. I. Moen, K. Shiokawa, and Y. Otsuka, Motion of polar cap arcs, Journal of Geophysical Research, 116, doi:10.1029/2010JA015906, 2011b.

EISCAT radar experiment and related studies (Related to 1.5)

Nozawa et al., *JASTP*, 10.1016/j.jastp.2012.05.002, 2012. [Referred as (1) in Subsection 1.5]

Sato et al., *Geophys. Res. Lett.*, vol 39, L07101, doi:10.1029/2012GL051205, 2012. [(2) in Subsection 1.5]

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Equatorial Atmosphere Radar (Related 1.6)

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Magnetic Data Acquisition System (MAGDAS) (Related 1.7)

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