Commission G Report

November 26, 2013

1. Research Report

1.1. EISCAT activities (Takuji Nakamura, National Insititute of Polar Research)

(1) Using a simultaneous and common-volume observation by a European incoherent scatter (EISCAT) VHF radar and a sodium lidar at Tromso, Norway (69.6 deg N, 19.2 deg E), the effect of pure particle precipitation, excluding that of the electric field, on sodium density variations has been observed for the first time (Tsuda et al., 2013). The observation on 24-25 January 2012 showed that sodium atom density decreased when there was no ion temperature enhancement (indicating a weak electric field) and the electron density increased (indicating strong particle precipitation). From the results we have concluded that auroral particle precipitation induced sodium atom density decrease in this event. Furthermore, a discussion is provided regarding the time response of the decrease in sodium density.

(2) Ionospheric ion upflow during an auroral substorm has been investigated using simultaneous EISCAT radar and IMAGE satellite data (Ogawa et al., 2013). Approximately 6 minutes after an initial brightening identified with data from the IMAGE WIC instrument, ion upflow was seen and the electron temperature became enhanced, too. The ion upflow, with a velocity of about 150 m/s, and the electron temperature enhancement lasted for about 25 minutes. During the poleward expansion phase surges of large upward ion velocity and flux, and high ion and electron temperatures occurred over Longyearbyen. The upward ion flux reached 2×10^14 m-2s-1. Naturally enhanced ion-acoustic lines (NEIALs) were seen near the poleward edge of the expanded auroral oval both near the end of expansion phase 17 minutes after onset and also later in the recovery phase. The NEIALs seemed to be accompanied by another type of enhanced echoes, obliquely to the local geomagnetic field. Data from the LENA instrument on the IMAGE satellite show that energetic neutral oxygen reaches the IMAGE satellite about 40 minutes after the initial brightening, and oxygen continues to get detected during the recovery phase. Ion upflow at the poleward edge of the auroral oval during the expansion phase was proved to be related to ion/neutral outflow with energy below 18-27 eV, whereas during the recovery phase of a substorm upward ions are accelerated up to about 60 eV and flow out in the entire polar region.

(3) Updates on EISCAT results are found at

http://polaris.nipr.ac.jp/~eiscat/results.html

References

Ogawa, Y., M. Sawatsubashi, S. C. Buchert, K. Hosokawa, S. Taguchi, S. Nozawa, S. Oyama, T. T. Tsuda, and R. Fujii, Relationship between auroral substorm and ion upflow in the nightside polar ionosphere, J. Geophys. Res., in press, 2013. (Accepted in October)

Tanaka, Y., A. Shinbori, T. Hori, Y. Koyama, S. Abe, N. Umemura, Y. Sato, M. Yagi, S. UeNo, Satoru, A. Yatagai, Y. Ogawa, and Y. Miyoshi, Analysis software for upper atmospheric data developed by the IUGONET project and its application to polar science, Advances in Polar Science, in press, 2013.

Tsuda, T. T., S. Nozawa, T. D. Kawahara, T. Kawabata, N. Saito, S. Wada, Y. Ogawa, S. Oyama, C. M. Hall, M. Tsutsumi, M. K. Ejiri, S. Suzuki, T. Takahashi, and T. Nakamura, Decrease in sodium density observed during auroral particle precipitation over Tromso, Norway, Geophys. Res. Lett., in press, 2013. (Accepted in August)

1.2. PANSY: Program of the Antarctic Syowa MST/IS Radar
(Takuji Nakamura, National Insititute of Polar Research)

PANSY (Program of the Antarctic Syowa MST/IS Radar) is a project which was started in 2000 to comprehensively study the polar atmosphere with a large aperture atmospheric radar as the main instrument combined with complementary observation techniques and also with numerical modeling and theoretical works.

The PANSY project has been supported internationally by resolutions from international scientific bodies such as IUGG, URSI, SPARC, SCOSTEP, and SCAR. The scientific research objectives and technical developments have been frequently discussed at international and domestic conferences. The project was authorized in 2008 as one of the main observation plans for the 6 year period of Japanese Antarctic Research Expedition program (2011-2016), and funded by Japanese government in 2009.

The PANSY radar is the first Mesosphere-Stratosphere-Troposphere/Incoherent Scatter (MST/IS) radar in the Antarctic region. It is a large VHF monostatic pulse Doppler radar operating at 47 MHz, consisting of an active phased array of 1,045 Yagi antennas and an equivalent number of transmit-receive modules with a total peak output power of 500 kW. Its first stage has been installed at Syowa Station (69°00’S, 39°35’E) in early 2011, and is currently operating with 228 antennas and modules.

The radar aims to clarify the role of atmospheric gravity waves at high latitudes in the momentum budget of the global circulation in the troposphere, stratosphere and mesosphere and the dynamical aspects of unique polar phenomena such as polar mesospheric clouds (PMC) and polar stratospheric clouds (PSC). The katabatic winds as a branch of Antarctic tropospheric circulation and as an important source of gravity waves are also of special interest. Moreover, strong and sporadic energy inputs from the magnetosphere by energetic particles and field-aligned currents can be quantitatively assessed by the broad height coverage of the radar extending from the lower troposphere to the upper ionosphere.

Currently the radar is operating with about a quarter of the full system. Nevertheless, we have already obtained interesting results on the Antarctic troposphere, stratosphere and mesosphere, such as observation of gravity waves and multiple tropopauses associated with a severe snow storm in the troposphere and stratosphere, and polar mesosphere summer echoes. The first paper of these initial results was recently accepted and is now online [Sato et al., JASTP, 2013].

Reference

Sato, K., M. Tsutsumi, T. Sato, T. Nakamura, A. Saito, Y. Tomikawa, K. Nishimura, H. Yamagishi, T. Yamanouchi, Program of the Antarctic Syowa MST/IS radar (PANSY), J. Atmos. Solar-Terr., Physics, doi:10.1016/j.jastp.2013.08.022 , in print, 2013.

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

Statistical characteristics of occurrence rate, direction of motion, and wave parameters of high-latitude nighttime medium-scale traveling ionospheric disturbances (MSTIDs) were reported based on observations by all-sky airglow imagers at Tromsoe (magnetic latitude: 67.1N), Norway and at Athabasca (61.7N), Canada. The MSTIDs were observed mostly before midnight with an occurrence rate of more than 30-50% of clear observation hours. The average wavelengths, phase velocities, and periods of the observed MSTIDs were 150-200 km, 50-80 m/s, and 30-60 min, respectively. Some MSTIDs at Tromsoe tend to show eastward motion in addition to the typical westward and southwestward motion at middle latitudes. At both stations, some MSTIDs showed characteristic changes of their phase velocity and directions in association with auroral activity, suggesting that they are plasma structures affected by auroral electric field.

Reference

Shiokawa, K., M. Mori, Y. Otsuka, S. Oyama, S. Nozawa, S. Suzuki, and M. Connors, Observation of nighttime medium-scale travelling ionospheric disturbances by two 630-nm airglow imagers near the auroral zone, J. Atmos. Solar-Terr. Phys., 103, 184-194, 2013. (published on September 7, 2013)

1.4. Remote-sensing of ionosphere and thermosphere with IMAP/VISI an ground-based all-sky imager (Takeshi Sakanoi, Tohoku University)

Airglow emissions at the lower-thermosphere (O2 762 nm, 95km alt.) and the upper-thermosphere (O 630 nm, 250 km alt.) are measured with IMAP/VISI on the international space station. We find many concentric gravity wave event in the O2 emission, and equatorial anomaly and plasma bubbles in O630 nm emission. We are also conducting the ground-based all-sky imaging measurement at the summit of Haleakala, Maui, Hawaii to carry out simultaneous measurement of airglow emissions with IMAP/VISI.

1.5. Auroral polarization measurement (Takeshi Sakanoi, Tohoku University)

We will carry out the auroral polarization measurement at Pokar Flat, Alaska throughout this winter, and are now developing a new instrument for auroral meridional polarization spectrograph.

1.6. Planetary ionosphere and magnetosphere (Takeshi Sakanoi, Tohoku University)

We examine the faint emissions of sodium and sulfur ion around the Jupiter's satellite Io, and oxygen atom emission around the Saturn's satellite Enceradas. We are also planning the Sprint-A/EXCEED and ground-based telescope campaign this winter, of which targets are Jupiter's aurora and volcanoes on Io, etc.

1.7. Simulation of medium-scale Traveling Ionospheric Disturbances
(Takuya Tsugawa, National Institute of Information and Communications Technology)

(1) Hemisphere-coupled modeling

An intriguing aspect of nighttime medium-scale traveling ionospheric disturbances (MSTIDs) is that they were simultaneously observed at magnetic conjugate locations in the Northern and Southern Hemispheres. In order to study the hemisphere-coupled electrodynamics, the numerical model has been upgraded to consist of two simulation domains for both hemispheres in which the electrostatic potential is solved by considering electrodynamics in both hemispheres. The simultaneous occurrence of MSTIDs at the magnetic conjugate stations has clearly been reproduced when the F-region neutral wind satisfies the unstable condition in both hemispheres and a sporadic-E layer is given only at the Northern (summer) Hemisphere.

Reference

Yokoyama, T., Hemisphere-coupled modeling of nighttime medium-scale traveling ionospheric disturbances, Adv. Space Res., doi:10.1016/j.asr.2013.07.048, 2013.

(2) Scale dependence

Scale dependence of nighttime medium-scale traveling ionospheric disturbances (MSTIDs) is studied with the midlatitude ionosphere electrodynamics coupling model by changing initial perturbation scales. It is shown that both sporadic E (Es)-layer and Perkins instabilities have the scale dependence that a shorter wavelength mode tends to stop growing within a shorter period, whereas a very long wavelength mode grows so slowly in the E region that it does not effectively seed the Perkins instability in the F region. As a result, the typical wavelength of MSTIDs (100-200 km) can be spontaneously generated without scale-dependent forcing. It is also shown that long frontal structures of MSTIDs can be formed by the Pedersen polarization process along the wavefront of MSTIDs by which the wavefront is forced to be uniformly distributed.

Reference

Yokoyama, T., Scale dependence and frontal formation of nighttime medium-scale traveling ionospheric disturbances, Geophys. Res. Lett., 40, doi:10.1002/grl.50905, 2013.

1.8. Earthquake-induced ionospheric variations
(Takuya Tsugawa, National Institute of Information and Communications Technology)

(1) Sudden TEC depletion near the epicenter

Unusual ionospheric variations were observed in the M9.0 Tohoku-oki earthquake on 11 March 2011. Among various kinds of features in the ionosphere, significant depletion of TEC near the epicenter was observed after the earthquake. Although previous studies have suggested that the coseismic ionospheric variations are associated with atmospheric perturbation caused by vertical displacement of the sea surface, the mechanism of the TEC depletion has not been fully understood. In this paper, a two-dimensional nonlinear nonhydrostatic compressible atmosphere-ionosphere model is employed to investigate the ionospheric variations in the vicinity of the epicenter. The simulation results reveal that an impulsive pressure pulse produced by a sudden uplift of the sea surface leads to local atmospheric expansion in the thermosphere and that the expansion of the thermosphere combined with the effect of inclined magnetic field lines in the ionosphere causes the sudden TEC depletion above the epicenter region.

Reference

Shinagawa, H., T. Tsugawa, M. Matsumura, T. Iyemori, A. Saito, T. Maruyama, H. Jin, M. Nishioka, and Y. Otsuka, A simulation study of ionospheric variations in the vicinity of the epicenter of the Tohoku-oki earthquake on 11 March 2011, Geophys. Res. Lett., 40, 5009–5013, doi:10.1002/2013GL057627, 2013.

(2) Acoustic resonance

Three rare occasions are introduced, where the excitation of vertical acoustic resonance between the ground and the ionosphere, and the resultant generation of a field-aligned current, just after earthquakes are observationally confirmed. In the case of two inland earthquakes, barometric observations very close to the epicenters (i.e., only 30 km apart) were available, and they showed a sharp spectral peak which appeared within one hour after the origin time and lasted a few hours. The observed periods of the spectral peaks around 260 seconds are close to the period of the theoretically-expected fundamental mode of the resonance. On the other hand, magnetic observations on the ground showed a dominant period at 220–230 seconds which corresponds to the first overtone among theoretically-expected major resonance peaks. In the third case, i.e., during the 2010 Chile earthquake, a long-period magnetic oscillation in the east-west direction, which has two major resonance periods at 265 and 190–195 seconds, was observed on the night-side magnetic dip equator in Peru, where the distance is more than 2600 km from the epicenter, under a very quiet geomagnetic condition. The oscillation was interpreted as the effect of field-aligned current generated through a dynamo process in the ionosphere over the epicenter caused by the resonance.

Reference

Iyemori, T., Y. Tanaka, Y. Odagi, Y. Sano, M. Takeda, M. Nose, M. Utsugi, D. Rosales, E. Choque, J. Ishitsuka, S. Yamanaka, K. Nakanishi, M. Matsumura, and H. Shinagawa, Barometric and magnetic observations of vertical acoustic resonance and resultant generation of field-aligned current associated with earthquakes, Earth Planets Space, 65, 901–909, doi:10.5047/eps.2013.02.002, 2013.

1.9. Ionospheric variations observed after a massive tornado

(Takuya Tsugawa, National Institute of Information and Communications Technology)

We detected clear concentric waves and short-period oscillations in the ionosphere after the EF5 tornado hit Moore, Oklahoma, USA, on 20 May 2013 using a dense wide-coverage ionospheric total electron content (TEC) observation in North America. These concentric waves were non-dispersive waves with a horizontal wavelength of ~120 km and a period of ~13 minutes. They were observed for more than seven hours throughout North America. TEC oscillations with a period of ~4 minutes were also observed in the south of Moore for more than eight hours. Comparison between the TEC observation and the infrared cloud image from the GOES satellite indicates that the concentric waves and the short-period oscillations are caused by supercell-induced atmospheric gravity waves and acoustic resonances, respectively. This observational result provides the first clear evidence of a severe meteorological event causing atmospheric waves propagating upward in the upper atmosphere and reaching the ionosphere.

Reference

Nishioka, M., T. Tsugawa, M. Kubota, and M. Ishii, Concentric waves and short-period oscillations observed in the ionosphere after the 2013 Moore EF5 tornado, Geophys. Res. Lett., 40, doi:10.1002/2013GL057963, 2013.

1.10. Storm-induced plasma stream in the low-to-mid latitude

(Takuya Tsugawa, National Institute of Information and Communications Technology)

Geomagnetic disturbances from 7 to 12 November 2004 were quite intense, and the maximum excursion of Dst reached –374 nT. Unusual ionospheric phenomena have been observed around the world that have been associated with successive magnetic storms during this period. The ionospheric total electron content (TEC) was increased at the longitudes of Japan within a short time after sunset on 8 November, from 20 TEC units at 1830 JST to 97 TEC units at 2015 JST (JST = UT + 9 h). The enhanced TEC was significant over Hokkaido (43 deg N), and the center of the enhanced region was well within the plasmasphere as an L value of approximately 1.5. The drift velocity of the plasma in the density-enhanced region measured by the Defense Meteorological Satellite Program (DMSP) satellite was westward with a peak value of 250 m/s in the Earth’s frame, demonstrating a positive correlation between density and drift velocity. A similar TEC event was observed after sunset on 10 November: TEC was enhanced, from 15 TEC units at 1830 JST to 45 TEC units at 2030 JST. During the second event, the ionosphere was highly structured and the rate of the TEC index (ROTI) increased. The two-dimensional map of a ROTI-enhanced region exhibited the west to northwest transportation of plasma in which density irregularities were entrained. A physical mechanism is proposed to explain these disturbances, i.e., storm-induced plasma stream, which is different from a phenomenon called storm-enhanced density at midlatitudes.

Reference

Maruyama, T., G. Ma, and T. Tsugawa, Storm-induced plasma stream in the low-latitude to midlatitude ionosphere, J. Geophys. Res. Space Physics, 118, doi:10.1002/jgra.50541, 2013.

1.11. A new format to promote international sharing of GNSS-TEC data
(Takuya Tsugawa, National Institute of Information and Communications Technology)

NICT, a delegate of Japan, proposed “GNSS-TEC exchange format (GTEX)” as a format to promote international exchange and sharing of GNSS-TEC data in an input document to the meeting of Working Group 3L-3 (trans-ionospheric propagation) of ITU-R held in Geneva from 19 to 26 June 2013. The document was discussed in the larger context of the need to incorporate new digital products and SG3DB databanks. As a result, the GTEX was included in a Chairman’s report towards the definition of new digital products for transionospheric propagation.

1.12. Development of SDR (software-defined radio) based radar receiver
(Mamoru Yamamoto, Research Institute for Sustainable Humanosphere, Kyoto University)

A receiver system for radars were developed based on the general-purpose software-defined radio receiver referred to as Universal Software Radio Peripheral 2 (USRP2) under control of a PC. The receiver is able to collect received signals at intermediate frequency (IF) of 130 MHz with a sample rate of 10 MHz. USRP2 digitizes IF received signals, produces IQ time series, and then transfers the IQ time series to PC through the Gigabit Ethernet. PC receives the IQ time series, executes range sampling, carries out filtering in the range direction, decodes phase-modulated received signals, integrates the received signals in time, and finally stores processed data to the hard disk drive (HDD). Because only sequential data transfer from USRP2 to PC is available, the range sampling is triggered by transmitted pulse leaked to the receiver. In order to perform range imaging with multiple frequencies, the digital receiver executes real-time signal processing for each of the time series collected at different frequencies. Further, in order to implement oversampling, the receiver is able to decode phase-modulated oversampled signals by interleaving oversampled signals in the range direction. Because program codes for real-time signal processing at PC is written in C++ language, the signal processing executed by the digital receiver is easy to be implemented, reconfigured, and reused. Using the measurement result from a 1.3-GHz range imaging atmospheric radar, we demonstrate that the digital receiver, which is capable of executing real-time signal processing for range imaging and oversampling, is useful for resolving fine-scale structure of atmospheric turbulence with a vertical scale as small as 100 m.

Reference

Yamamoto, M. K., T. Fujita, Noor Hafizah Binti Abdul Aziz, T. Gan, H. Hashiguchi, T.-Y. Yu, and M. Yamamoto, Development of a digital receiver for range imaging atmospheric radar, J. Atmos. Sol.-Terr. Phys., doi:10.1016/j.jastp.2013.08.023, in press, 2013.

1.13. Sounding rocket/ground-based observations of the ionosphere in July 2013
(Mamoru Yamamoto, Research Insitute for Sustainable Humanosphere, Kyoto University;
Keigo Ishisaka, Toyama Prefectural University)

There are number of waves in the mid-latitude ionosphere. One interesting phenomenon is medium-scale traveling ionospheric disturbance (MSTID) in the F-region. The MSTID is the wave structure with a wavelength of 100-200 km. These horizontal structures can be observed by using the total electron content (TEC) from GEONET, Japanese dense network of GPS receivers. We conducted an intensive experiment to study generation mechanism of the MSTID by the combination of sounding rockets and ground observations. We monitored horizontal structures of the MSTID by using GPS-TEC real-time monitor system. While active MSTID region appeared over south Kyushu, Institute of Space and Aeronautical Science of JAXA (JAXA/ISAS) launched sounding rockets S-310-42 and S-520-27 from Uchinoura Space Center (USC) at 23:00 JST and 23:57 JST, respectively. Ionospheric parameters, i.e., plasma density, electric field, density fluctuations, were measured by in-situ instruments on board of the S-520-27 rocket. TMA (Tri-Methyl Aluminum) and Lithium were released from the S-31-42 and S-520-27 rockets, respectively, for measurement of the neutral winds. Their luminescent clouds were imaged from the JAXA experimental jet "Hisho" and from three ground sites. The Lithium experiment under the moonlight was the world first trial, and was successful. Both rockets transmitted dual-band beacon signal which was received at five ground sites. Preliminary analysis of from the experiment show that strong wind shear and sporadic-E layers co-existed at around 100 km. Also the results infer large horizontal inhomogeneity of F-region plasma density as well. Electric-field detector (EFD) on board of the rocket S-520-27 measured a waveform of electric field at the frequency less than 6.4 kHz. Intensity from 4 kHz to 6 kHz are increased at the apex region during the period from 210 sec to 350 s. In the low frequency components, we sound enhanced intensity of 40 Hz or less is clearly seen during the time of most of rocket flight.

2. Meetings

Meetings scheduled in relation to URSI Commission-G were conducted as listed below.

IAGA the XIIth Scientific General Assembly, Merida Yucatan, Mexico, August 26-31, 2013
Symposium web-page: http://www.iaga2013.org.mx/

Mesosphere, Thermosphere, Ionosphere Research Meeting,
National Institute of Information and Communications Technology, Koganei, Japan,
September 16-17, 2013

International CAWSES-II Symposium, Nagoya, Japan, November 18-22, 2013
Symposium web-page: http://www.stelab.nagoya-u.ac.jp/cawses2013/
NOTE: There were more than 250 participants from 32 countries.
Number of presentations reached 393.

Future meetings related to URSI Commission-G are as follows,

Japan Geoscience Union (JpGU) Meeting 2014
Pacifico Yokohama, Yokohama, Japan, April 28-May 2, 2014.
http://www.jpgu.org/meeting_e/

Asia Oceania Geosciences Society 11th Annual Meeting,
Royton Sapporo Hotel, Sapporo, Japan, July 28-August 1, 2014.
http://www.asiaoceania.org/aogs2014/

The 40th COSPAR Scientific Assembly
Moscow, Russia, August 2-10, 2014.
http://cospar2014moscow.com/

3. Publication list

Publications were listed in each section of research report.