Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PEM09-P01 Room:Convention Hall Time:May 27 18:15-19:30

The properties of ionosphere during extreme low solar activity over the equatorial ionization anomaly crest area

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The solar activity during 2008-2009 is extremely unusually long lower, which offers us an opportunity to study the properties of ionosphere over the equatorial ionization anomaly crest area. This study collected ionospheric data from ground-based observation of Chung-Li and GPS data of TWTF receiver during 2008-2009. In this investigation, we show the seasonal, monthly, and daily variations during the prolonged low solar activity. Meanwhile, the result also compared with the ionospheric properties during high solar activity period. Furthermore, a comprehensive discussion of the physics processes for the variation of ionosphere during the prolonged low solar activity period.

Keywords: ionosphere, EIA, ionospheric dynamics, ionospheric physics

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Advanced Ionospheric Probe onboard the FORMOSAT-5 Satellite

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Advanced Ionospheric Probe (AIP) designed by National Central University is recently accepted by National Space Organization to built for the FORMOSAT-5 (FS-5) satellite as a piggyback science payload in early 2012. The FS-5 satellite is scheduled to launch in 2016 and anticipated to flight in a 98.28^o inclination sun-synchronous circular orbit at 720 km altitude in the 1030/2230 LT sectors. The orbital coverage provides a great opportunity to survey the Earth globally from equatorial to polar region. The AIP is an all-in-one plasma sensor under constraints in power (5 W), weight (5 kg), and form factor (100 mm L x 100 mm W x 100 mm H) in sensor size but with sampling rate up to 8,192 Hz to measure ionospheric plasma concentrations, velocities, and temperatures over a wide range of spatial scales. Once comprehensive dataset available from the AIP, a systematic examination of longitudinal and seasonal variations of the ionospheric parameters in the topside F region can be conducted for all latitudinal coverage. The transient and long-term variations of ionospheric plasma can be monitored in the upcoming solar maximum period and are benefit to public and scientists who are interested in space weather and seismic precursors associated with strong earthquakes.

Keywords: Science payload, Ionosphere, FORMOSAT-5, Advanced Ionospheric Probe

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Observation and IRI-2012 comparison of F1-layer parameters at the geomagnetic equator during solar minimum

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This study is to assess the predictability of IRI-2012 on the equatorial F1 layer during solar minimum. The observed characteristics of F1 layer by the Jicamarca digisonde are compared with the model outputs. The results show that the time range for F1-layer appearance of observation is longer than that of IRI-2012, by at least 1 hour in the early morning and later afternoon. In IRI-2012, there are three options for the occurrence probability of F1 layer: IRI-95, Scotto-97 no L, and Scotto-97 with L options. The first option predicts the probability well, but the last two underestimate the probability. The peak density of F1 layer (NmF1) of observation is very close to that of IRI-2012. For the F1 peak height (hmF1), the modeled values are smaller than the observed ones. The observed seasonal variation of hmF1 is not found in the modeled results. Nevertheless, the observed diurnal variation of hmF1 is similar to the modeled results with the B0 choices of Bil-2000 and ABT-2009. Regarding the shape parameter, the values of D1 (the shape parameter of F1 layer in observation) are much greater than the values of C1 (the shape parameter of F1 layer in IRI-2012). The D1 values are 3-6 time of the C1 values. The diurnal variation of D1 is similar to that of C1, but the seasonal variation of D1 is not.

Keywords: F1-layer, IRI-2012

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Numerical simulation on electrodynamics of the pre-earthquake ionospheric anomalies

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Over the last few decades, ionospheric observations indicate that the total electron content (TEC) often significantly decreases in afternoon on 3-5 days before the M>6.0 earthquakes. It is generally considered that electric currents driven by stressed rock flow into ionosphere. We use NRL 3D ionosphere model, SAMI3 to simulate this phenomenon, and add external current terms into current continuity equation. The range of external current distribution is 120±20oE, 30±20oN, 85~170km, and the maximum current density is 500nA/m2. Our simulation result indicates that the upward current on the bottom of ionosphere produces the maximum (minimum) variation of increasing (decreasing) ~30% (~10%) △TEC. The increasing △TEC is mainly located in west region of external current; however, the decreasing △TEC is mainly located on both sides of increasing region.

Keywords: earthquake precursor, ionospheric dynamics, total electron content

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Reconnection electric fields in the "2 null - 2 separator" magnetosphere simulated by a global magnetohydrodynamic model

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It is known that the magnetic reconnection rate is proportional to the field-aligned electric field along the so-called X line. It represents the rate of the magnetic field vanishing in the diffusion region. In global magnetohydrodynamic (MHD) modeling of the magnetosphere, the field-aligned electric field can be used to identify the reconnection mode occurring in the simulated magnetosphere. This is particularly useful when antiparallel field line geometry are not formed. One example is the magnetosphere for northward interplanetary magnetic field (IMF). Global MHD simulations generally reproduces the magnetospheric structure characterized by two magnetic nulls and two separators (which we call here the "2 null - 2 separator" structure, or "null-separator" structure for short). In this configuration, antiparallel magnetic fields do not exist. In addition, the field line geometry for northward IMF is often too complicated to grasp intuitively. In this study, in order to identify the reconnection mode clearly, we explicitly calculate the reconnection electric fields in the simulated magnetosphere during northward IMF periods. We apply this approach to the modeling of the interchange cycle proposed by Watanabe and Sofko [2009, doi:10.1029/2008JA013426]. Although Watanabe et al. [2010, doi:10.1029/2009JA015041] reported observations showing ionospheric signatures of the interchange cycle, there seem to be some debates on the interpretation of the observational data. We aim to support Watanabe et al. [2010] from the modeling point of view. We also discuss the partial collapse of the null-separator structure when the IMF clock angle (measured from due north) is around 45 degrees. In this case, unconnected IMF lines tangle in the closed field lines on the nightside, showing a collapse of the null-separator structure. We argue how such a topology is created by analyzing the field-aligned electric field on separatrices.

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Features of long period geomagnetic pulsations caused by the inclined front of the solar wind discontinuity

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We study long-period geomagnetic pulsations caused by the solar wind discontinuity impact during the July 14, 2012 magnetic storm onset from data of satellite observations in the solar wind and magnetosphere, as well as of ground stations located at low, middle and high latitudes. The character of pulsations propagation is shown to correspond to their excitation mechanism by the discontinuity front at the magnetopause. Location relative to the noon of the sector, from which the waves propagate to both magnetosphere flanks, is determined by the front azimuthal angle inclination. We discuss a change of polarization both by longitude and latitude directions. The frequency of spectral maximum of the pulsations does not coincide with one of the solar wind oscillations.

Keywords: geomagnetic pulsations, ULF waves, solar wind discontinuity, wave propagation

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Evolution and propagation of electric fields during magnetic impulses based on multiple observations

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Magnetic impulses triggered by the input from the solar wind lead to the variation of the particle and electromagnetic field. Sudden commencements (SCs), known as one of the most distinct magnetospheric disturbance phenomena, are triggered by the compression of the magnetosphere due to solar wind disturbances. Unlike magnetic storms and substorms, SCs can be identified as sharp magnetic variations on the global scale. Since SCs are isolated phenomena, their onset time and driver are relatively easy to identify. Several spacecraft observations of the electric field have indicated that the Alfven wave launching from the ionosphere toward the magnetosphere plays a crucial role in inducing the transient response of the electric field in the magnetosphere. However, this suggestion has not been tested sufficiently due to lack of the electric field observation in the ionosphere. Therefore, the interaction in the magnetosphere?ionosphere coupled system, such as the electric field propagation and energy transport process, is still an open issue.

Motivated by these issues, we try to investigate electric field characteristics associated with SCs by simultaneous multiple ground-based and spacecraft observations that can recently be utilized. We investigate the evolution and propagation of electric fields during SCs using in situ electric field data obtained by five THEMIS spacecraft and two Van Allen Probes (VAPs) spacecraft. We also investigate the propagation of electric fields to/in/from ionosphere with SuperDARN radar, HF Doppler radar, and ground magnetometer data. SC events are identified by the SYM-H index provided in OMNI database and geomagnetic field data. The event criteria were set as follows: (1) SCs occur from January 2013 to December 2014. (2) The amplitude of the SYM-H is more than 10 nT, and its rise time is less than 5 min. (3) Preliminary Impulse (PI) is recorded on high-latitude geomagnetic field (FSIM and FSMI stations).

We found 70 SC events satisfying these conditions. For all of them, both THEMIS and VAPs detect the enhancements of the electric field. The direction of the electric field is westward, which is consistent with that of the magnetospheric electric field observed by the Akebono satellite [Shinbori et al., 2004]. We found that the nightside magnetospheric electric field follows the dayside one within 5 s delay from the PI onset, despite the large distance between them (~5-10 R_E). In the ionosphere, SuperDARN and HF Doppler radars detected the westward electric field during the PI phase. The PI onset time of ionospheric electric field is almost same (within 5 s) with the magnetospheric electric field detected by THEMIS and VAPs regardless of local time, which indicates the simultaneous response between magnetospheric and ionospheric electric fields. These results suggest that the electric field propagates from dayside to nightside magnetospheres via the ionosphere. That is, the dayside magnetospheric electric field propagates into the polar ionosphere along the magnetic field line, and then from polar toward low-latitude ionospheres at the speed of light between the ionosphere and ground propagation path. On the other hand, the ionospheric electric field propagates within 5 s toward the plasmasphere and inner magnetosphere (~5-10 R_E). Although previous results have shown that the electric field associated with SCs is propagated into the magnetosphere by the Alfven wave along the magnetic field lines, the propagation velocity estimated by our observational results may be faster than the velocity of the Alfven wave.

In this paper, we report the validity of these data interpretation. We will also present the statistical results (i.e., the superposed epoch analysis) and the Poynting fluxes that play a crucial part in the energy transmission associated with the PI onset of electric fields, which is expected to clarify the propagation path of the electric field.

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The feature of global current circuit in the ionosphere from polar to dip equator during Dp2 event

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In the ionosphere, it is well known that the electromagnetic coupling is formed globally from polar region to dip equator region in daytime seen as penetration of electric field during Dp2 events. Yoshikawa et al., [2012, AGU] suggests the formation of the current system by Cowling channel model as the explanation of this coupling. The highly gradient of electric conductivity at the terminator between sunlit region and shaded region at dawn and dusk sides is assumed in this paper, which produces positive polarization electric field there and this electric field forms the connection between polar and dip equator.

In our previous study, the asymmetry of the ionospheric electric field, which is calculated from observed magnetic field variation and the model of conductivity, is found between morning side and afternoon side in the dip equator region, and we concluded that the positive electric charge at both dawn side and dusk side by Cowling channel formation enhances and weakens at dawn side and dusk side, which are primary positive and negative electric fields respectively. However, it was still not clear that there is actually such asymmetry in not only dip equator region but also in global.

To clarify this existence of global asymmetric feature of the electric field and the possibility of the formation of global Dp2 current system by Cowling channel model, we investigated global feature of Dp2 variation on simultaneous and multipoint observations. More than 200 stations data are used in this study, and their spatial distributions are from approximately -85 to 85 degree of geomagnetic latitude. The result shows that there is obvious asymmetry on the polarity of horizontal component of Dp2 variation in low and mid latitude region between morning side and afternoon side, but not obvious asymmetry in polar region. This unclear asymmetry in polar region might be because of the complexity of primary electric field which is penetrated from magnetosphere.

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Study on Omega signals detected by Poynting Flux analyzer onboard Akebono

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The Akebono satellite was launched 1989 to observe the Earth's magnetosphere and plasmasphere. Wave normal and Poynting flux Analyzer (PFX) subsystem is equipped on the spacecraft. It measures two components of electric field (Ex and Ey) and three components of magnetic field (B1, B2, and B3) with band-width of 50 Hz in a frequency range from 100 Hz to 12.75 kHz. The center frequency of the PFX can be changed by command. By using the PFX, we measure the signals at 10.2 kHz transmitted from the omega stations which were operated until 1997. This omega signal was intended to be used as navigation signal similar to GPS nowadays. By automatically detecting the omega signals included in the PFX data, we study propagation patterns of VLF waves across the plasmasphere, because the propagation characteristics are strongly affected by plasma density and ambient magnetic field. First we developed a method to detect the omega signals automatically and accurately, especially for the delay time and signal existence within specific earth coordinate and time span observed by the Akebono satellite. The PFX data measures 5 channels which correspond to 3 axis of magnetic field (B1, B2, B3) and 2 axis of electric field (Ex, Ey) in satellite coordinate. The waveform data with band-width of 50 Hz centered at 10.2 kHz are sampled at rate of 320 Hz and sent to the ground by PCM telemetry. As for the omega signal, the omega station was transmitting its signal with transmission pattern every 10 s. Each station transmitted a different pattern of frequency but has common frequency at 10.2 kHz. By using this 10.2 kHz signal and the detection time represented by UTC on the satellite, we can determine when and which station was transmitting the signal. As for the detection algorithm, we first estimate the delay time of each signal by comparing average intensity of specific time frame then expecting sudden increase of intensity based on specific threshold on the expected omega signal's time and duration. Second, we detect the signal existence by comparing the intensity of expected omega signal's time and duration with the surrounding intensity based on specific threshold. In this study we used advanced detection algorithm to process huge amounts of several years' data. The algorithm enables us to distinguish noises and real omega signal and also handle the error detection to produce more accurate result. Currently we have analyzed data sets from 1989 to 1990. We found that the magnetic field intensity of the signal become weaker and the electric field intensity become higher on the other part of earth hemisphere far from the original transmission station. We will analyze further data sets from 1991 to 1997 for more credible analysis and discovery.

Keywords: VLF wave, Omega signal, Plasmasphere, Akebono satellite, Signal processing

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Ground-based observation of fine structures of MF/HF auroral radio emissions

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The terrestrial auroral ionosphere is a natural source of electromagnetic waves in the MF/HF ranges (up to 6 MHz) as well as well-known intense VLF/LF emissions (auroral kilometric radiation and auroral hiss). In the MF/HF ranges, three types have been identified at ground level: auroral hiss, medium frequency burst (MFB), and auroral roar. In addition, recent studies have resulted in ground-level detection of auroral kilometric radiation [LaBelle and Anderson, 2011] and discovery of a natural radio emission between f_{ce} and $2f_{ce}$ [Broughton et al., 2014]. Previous studies have also shown that observation of fine structures open new frontiers for these auroral radio emissions [e.g., LaBelle et al., 1995; Shepherd et al., 1997; Ye et al., 2006; Bunch and LaBelle, 2009]. In August 2008, we installed new instrumentation referred to as Auroral Radio Spectrograph (ARS) at Kjell Henriksen Observatory (KHO) in Svalbard (latitude 78.15^{o}N, longitude 16.04^{o}E, 75.2^o magnetic latitude). ARS consists of magnetic loop antennas whose size is 2.7 m $\times$ 6.0 m and two types of receivers: ARS-S and ARS-WF. The former is designed for the continuous measurement of wave spectra with a time resolution of 1 sec, and the latter is designed to obtain waveform data digitalized by an A/D converter with a sampling rate of 10 M samples/s (Nyquist frequency 5 MHz). Using ARS-WF, we succeeded in the first simultaneous measurements of structured $2f_{ce}$ auroral roar and optical aurora during 1710-1750 UT on February 1, 2011. In this event, the structured $2f_{ce}$ auroral roar showed temporal evolutions in frequency band width (300 Hz at minimum) and frequency drift rate (15 kHz/s at maximum). However, because ARS-WF recorded a series of 8 M samples (i.e., only 800-msec data) once every 40 sec, it was difficult to capture the entire temporal evolution of the structured auroral roar. In order to solve this problem, we carry out development and trial manufacture of a new receiver using USRP^{TM} (Universal Software Radio Peripheral). Such software-defined radio (SDR) receiver can implement high-speed, flexible digital signal processing of RF signals. This new receiver is designed to obtain higher-resolution spectra of RF signals pauselessly throughout the night in a wide frequency range up to 6 MHz. It is installed at KHO in Svalbard in March 2015. In this presentation, we also show detailed design of this receiver and some initial results.