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Time:May 26 08:30-08:45

Seasonal dependence of magnetic field variations from high latitude to the magnetic equator during geomagnetic sudden co

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Seasonal dependence of diurnal variation of the main impulse (MI) of geomagnetic sudden commencements (SCs) has been investigated using the long-tern geomagnetic field data with high time resolution of 1 sec within a period from 1996 to 2008 provided from the NSWM [Kikuchi et al., 2008] and CPMN [Yumoto and the CPMN group, 2001] chains and the WDC for Geomagnetism, Kyoto. In the present analysis, we used the geomagnetic field data obtained from the 12 stations: Pohnpei (geomagnetic latitude, MLAT = 0.27 degree), Yap (MLAT = 0.38 degree), Cebu (MLAT = 0.85 degree), Guam (MLAT = 5.22 degree), Okinawa (MLAT = 16.54 degree), Kakioka (MLAT = 27.18 degree), Memanbetsu (MLAT = 35.16 degree), St. Paratunka (MLAT =45.58 degree), Magadan (MLAT = 53.62 degree), Zyryanka (MLAT =59.74 degree), Chokurdakh (CHD, 70.62N, 147.89E GR, 64.81N, 212.53E GM), Kotel'nyy (KTN, 75.94N, 137.71E, 70.08N, 201.39E), and King Salmon (KSM, 58.68N, 203.35E GR, 58.09N, 258.39E, GM). In this study, the SC events have been defined as a rapid increase with its amplitude of more than 5 nT within 10 minutes in the SYM-H index. In this case, 3535 events of the magnetic field disturbance are found in a long period from January 1996 to October 2010, which has no Pi 2 signature around 10 minutes at the SC onset. Details of the analysis method have been described in the paper of Shinbori et al. [2009]. Moreover, the SC amplitude obtained at the above 12 stations has been normalized by that in the SYM-H index with latitude correction in order to minimize the different contribution of the rapid change in solar wind dynamic pressure. We also used solar wind data obtained from the IMP-8, Geotail, Wind and ACE satellites within the same period. As a result, the diurnal variation of SC amplitude in a region from the high latitude (KTN) to the middle latitude (MMB) shows a remarkable DP-2 type magnetic signature in the daytime (6-18 h) produced by the ionospheric currents. The ionospheric currents are driven by a dawn-to-dusk polar electric field carried by a pair of field-aligned currents (FACs). In the nighttime (18-06 h), the SC amplitude in the sub-auroral latitude (ZYK) to low latitude (KAK) tends to increase significantly and increases with increase of magnetic latitude. This tendency indicates that the nighttime enhancement of SC amplitude is caused by the magnetic effect of FACs. The size of the diurnal variation of SC amplitude tends to be more enhanced in the summer, compared with that in the winter. This result implies that ionospheric currents (ICs) and field-aligned currents (FACs) generated during the MI phase of SC are intensified due to the increase of ionospheric conductivity in the summer. This feature of SC current system shows the voltage generator rather than the current generator. On the other hand, the diurnal variation of SC amplitude near the equatorial region shows a remarkable equatorial enhancement in the daytime (6-18 h) with its maximum around 11 h produced by the enhanced eastward ionospheric currents due to the Cowling effect. The seasonal variation of the daytime SC amplitude showed quite a different signature from that in the middle latitudes. The remarkable feature is that the equatorial enhancement of SC amplitude tends to become relatively smaller in the summer than in the equinox or winter. This tendency suggests that the intensity of the equatorial electrojet current does not depend on only the solar zenith angle. One of the implications of the equatorial seasonal dependence is that the penetration polar electric field tends to become weak in the summer, compared with that in the winter. In future, in order to verify this feature, we will need to investigate the response of the penetration polar electric field to equatorial conductivity variation by solving the global ionospheric potential solver which uses three-dimensional ionospheric conductivity model.

Keywords: geomagnetic sudden commencement, high latitude, magnetic equator, seasonal dependence, ionospheric conductivity, voltage generator



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Magnetospheric Substorm Observed by QZS, ETS-VIII and MAGDAS on October 25, 2010 - Preliminary result-

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In this study, we analyzed magnetic field variations observed by the quasi-zenith satellite QZS [Matsumoto et al., 2011] and the geostationary satellite ETS-VIII [Koga and Obara, 2008] during magnetospheric substorms. The field configuration quickly changes from tail-like to dipole-like after expansion phase of magnetospheric substorms. The magnetic data from MAGDAS (MAGnetic Data Acquisition System) [Yumoto et al., 2006] low- latitude station were used to identify the onset of magnetospheric substorms. At the onset of the magnetospheric substorms, Pi 2 magnetic pulsations occur globally in the magnetosphere. We focus on the October 25, 2010 substorm event. On the day, the isolated substorm occurred around 13:30UT. The azimuthal distance between QZS and ETS-VIII is about 2Re. They moved eastward at the speed of about 1.7Re/hour.

The following results are obtained;

(1) X-component (azimuthal) variation observed by QZS and ETS-VIII changed from negative to positive (Westward is positive sense) within 10 minutes. It means the QZS and ETS-VIII crossed the very thin plasma sheet.

(2) Y-component (compressional) variation observed by QZS changed from positive to negative (Northward is positive sense) after substorm onset. It means that QZS was located inside Substorm Current Wedge (SCW) at 13:33-13:38UT and then QZS moved outside SCW.

On the other hand, Y-component variation observed by ETS-VIII increased except 13:38-13:43UT period. ETS-VIII was located outside SCW in this period due to traveling of ETS-VIII. After that ETS-VIII was located inside SCW again. It indicates that SCW expanded eastward.

The difference of Y-component variation between QZS and ETS-VIII indicates that a transition region of the SCW is about 0.3 Re.



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Correlation of Pi 2s Observed by ETS-VIII and MAGDAS/YAP

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Pi 2 is an impulsive geomagnetic pulsation with the period range from 40 to 150 seconds. Pi 2 is believed to be globally detectable with aurora breakup. Propagation modes of Pi 2 depend on geomagnetic latitude, local time and so on[cf. Yumoto et al., 2001].

In this study, we analyzed similarity and time lag of Pi 2s observed by ETS-VIII (Engineering Test Stellite-VIII; M.Lat=-7.88, M.Lon=218.56, Hight=36000km)[Koga and Obara, 2008] and by MAGDAS(MAGnetic Data Acquisition System)[Yumoto et al., 2006] station located at the magnetic equator, YAP(M.Lat=1.49, M.Lon=209.09), using cross-correlation. For the analysis, we selected 88 Pi 2 events which showed clear Pi 2 pulsation (p-p more than 0.3nT) during 19:00-03:00LT. The analysis period covered a year from 16 September 2008 to 31 August 2009.

From the analysis, the following results are obtained;

(1)The correlation coefficient between Y-component(compressional) of ETS-VIII and H-component(compressional) of YAP is the highest for combinations of each components, X-, Y-, Z- components of ETS-VIII and H-, D-, Z- components of YAP.

(2)The correlation coefficient between Y-component of ETS-VIII and H-component of YAP depend on local time. In the sector 19:00-21:00LT, 45% of Pi 2s shows positive correlation. In the sector 21:00-03:00LT, 68% of Pi 2s shows positive correlation.

(3)Time lag of Pi 2s from Y-component of ETS-VIII to H-component of YAP also depends on local time. In the sector 19:00-21:00LT, 19% of Pi 2s shows good coherency and time delays of at ETS-VIII 20-75 sec earlier than at YAP. In the sector 21:00-01:00LT, 67% of Pi 2s shows good coherency and time delays of at ETS-VIII 25-50 sec earlier than at YAP.



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Comparison of ionospheric Pc5 oscillations with geomagnetic pulsations observed on the ground and in geostationary orbit

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Pc5 pulsations are electromagnetic wave at periods of 150-600 s in the ultra-low frequency (ULF) range, which are frequently observed and have been studied well by ground and satellite magnetometers. The most common generation process of Pc5 pulsations is the field line resonance (FLR) of shear Alfven waves standing along Earth's magnetic field lines, which are coupled with fast compressional mode propagating from the flank side of magnetopause. The ionosphere in both hemisphere acts the reflection boundary of FLR and the ionospheric current generated by waves results in Pc5 geomagnetic pulsations on the ground. In the magnetosphere, magnetometers and electric field instruments onboard satellites observe directly in situ amplitude of Pc5 pulsations. Previous studies identified Pc5 pulsations as one of the key mechanisms of transport and acceleration of energetic electrons in Earth's outer radiation belt; wave power of Pc5 band is well correlated with radiation belt electron fluxes. In particular, waves in global mode (low-m) are likely more effective than localized mode (high-m). However, it is difficult to know correct wave numbers from satellite nor ground observations, because satellites are in situ and ground magnetometers integrate all neighbor signals. Thus, we investigated Pc5 pulsations using data from King Salmon HF radar (KSR), which observe twodimensionally the doppler velocity of ionospheric plasma (E x B drift) due to electric-field components of Pc5 pulsation. First of all, we searched Pc5 oscillation observed by KSR beam 3 (westward beam) in 2007. Secondly, we investigate the similarity and difference of ionospheric Pc5 oscillations with geomagnetic variations simultaneously observed on the ground (Pebek and King Salmon) and in geostationary orbit (ETS-8); these align the almost same meridian. In this presentation, we show the local time distribution of ionospheric Pc5 oscillations, their relations with solar wind parameters, and event and statistical analyses of Pc5 events on the ground, in the ionosphere and in geostationary orbit.

Keywords: Pc5 pulsation, HF radar



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Observations of escaping and reflected photoelectrons by the FAST satellite in the polar cap magnetosphere

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The polar wind process is strongly controlled by solar radiation. Modeling studies suggested that escaping photoelectrons, which are produced by solar extreme ultraviolet radiation, originating from the polar cap ionosphere drive the polar wind which includes heavy ions. A photoelectron driven polar wind models described by Wilson et al. [1997] indicated that a potential drop (about 60 V), which reflects most of the escaping photoelectrons, exists at high-altitudes (about 7 R_E) to achieve zero field-aligned current. Although presence of such a potential drop was reported for some cases [Winningham and Gurgiolo, 1982; Horwitz et al., 1992], the statistical characteristics of the potential drop (e.g., potential difference, and occurrence frequency) have not been studied in detail.

We have statistically examined the photoelectron spectra obtained by the electron spectrometer aboard the Fast Auroral Snapshot (FAST) satellite at about 3800 km altitude during geomagnetically quiet periods near solar maximum. The data obtained from 2 to 16 July 2002 (quiet-time: about 50 orbit passes) are used for the statistical study. In this period, the apogee of the FAST satellite located at high latitudes in the Northern (summer) Hemisphere. Magnetic field data are used to estimate field-aligned currents. The reflected photoelectrons, which were likely reflected by a potential drop, were almost always (about 90%) observed in the region of a weak field-aligned current ($-1.6*10^{-7}-1.6*10^{-7}$ A/m² mapped to 1000 km altitude). The typical potential difference estimated in the present study is about 20 V, which is about a half of that predicted by photoelectron driven polar wind models [Wilson et al., 1997; Su et al., 1998]. When the potential difference are above 20 V, the typical number flux of the reflected photoelectrons with energy below the potential difference is about 90% of that of the escaping photoelectrons in the same energy range. The high reflection rate supports the presence of field-aligned electric fields.

Keywords: ion outflow, polar wind, potential drop



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On the origin of low-energy downward electrons in the polar cap ionosphere

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It is known that the thermal ions are accelerated by ambipolar electric field due to ambipolar diffusion caused by plasma pressure gradient along field lines in the polar cap where the geomagnetic field lines are basically open.

There is an idea that the strong potential difference may be generated to keep current continuity between the magnetosphere and the ionosphere approximately above 2 Re altitude in the polar cap. Upward moving ions are further accelerated by such a potential difference because such a potential difference is upwardly directed. This idea may suggest that the potential difference plays an important role in transporting ions from the ionosphere to the magnetosphere. On the other hand, since this potential difference can accelerate electrons downwardly, it is possible that low energy component of upward photoelectrons with energy of about 10-50 eV originated from the ionosphere is reflected by the potential gap. Therefore it is possible that a part of low energy (about 10-50[eV]) downward electrons observed in the polar cap ionosphere is attributed to the potential difference above 2 Re altitude. In fact, such low energy downward electrons are observed by Low Energy Particle (LEP) instrument on Akebono satellite below 2 Re altitude in the polar cap. Thus, we believe that such a potential difference actually exists and plays a role in reflecting upward photoelectrons above 2 Re altitude.

A statistical analysis of long-term observations of the photoelectron flux with the LEP on Akebono in the polar cap region suggests that even when the upward photoelectron flux is in the same level the downward flux of electrons with the same energy changes. Such downward electrons may be originated from the deep magnetosphere. However, a fact the energy spectra are similar between upward and downward electrons implies that the downward electrons are originated from the ionosphere and reflected by the upward electric fields. The observational result of variable downward flux may indicate that the flux is controlled by the magnitude of the potential difference existing in the high altitude polar cap. The purpose of our study is to elucidate what the dominant process or condition is for determining the size of the potential difference. It is suggested from our statistical analysis that the potential difference is about 30 V on the average but the actual magnitude changes from 10 to 50 V in some cases.

In this presentation, we show the detailed result of our analysis and discuss the dependence of the potential difference in the high-altitude polar cap on the solar activity, the geomagnetic activity, and the ionospheric plasma condition.

Keywords: polar cap, polar wind, photoelectron



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Development of 0.1-100eV ion energy mass spectrometer

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Measurements of ions with energies lower than several eV are not easy in the terrestrial magnetosphere, since spacecraft potential is positive in many cases. However, it is indicated that there are significant amount of ions in this energy range, based on, for example, ion observations under eclipse.

On the other hand, applied voltages on electrodes in an electrostatic analyzer should not be so low (i.e., near zero), since it becomes difficult to keep stable enough. This is one of problems on the ion measurements with energies lower than several eV. In order to avoid this, we have tried following points: (1) to apply wider gap between curved electrodes, (2) to apply small inlet and exit, and (3) adjustment of inlet and exit positions. Using numerical calculations, we got a sensor design with energy, angle, and mass resolving capability. Noise level due to EUV photons can be reduced to low enough. Note that an active control of spacecraft potential will be necessary, especially in a low-density region.

The sensor can be used for observations of ions upflowing from the polar ionosphere.

Keywords: suprathermal ion, ion upflow, magnetosphere, instrument



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Multiple enhancements of the electron density in the cusp for brief southward excursions of IMF

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A brief southward excursion of IMF is thought to cause a short-period enhancement of the magnetosheath plasma precipitation along the reconnected magnetic field lines, and of the electron density at F2 peak altitudes in the cusp. Our survey for the high time resolution data from EISCAT Svalbard Radar found events in which multiple enhancements of the electron density in the cusp were detected during a brief southward excursion of IMF. One of the clear events shows that three enhancements occurred within about 2 minutes of each other. This time interval is much shorter than the mean time between successive auroral events in the cusp, i.e., 6 min. Simultaneous observations of the plasma precipitation by DMSP spacecraft show that the cusp electron precipitation region has a few spatial boundaries in terms of the energy and energy flux of the precipitating electrons. We consider how these spatial boundaries can be incorporated in the multiple enhancements of the electron density detected by the radar, and present a picture for the phenomenon triggered in the ionospheric cusp by a brief southward excursion of IMF.

Keywords: cusp, electron density, plasma flow, IMF



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A comparative study on the types and dynamics of auroras and the fine properties of auroral particles using Reimei

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The dynamic variations and numerous types of spatial distributions found in the auroral emissions have been well-known as one of the most remarkable and exciting phenomena in the Earth's polar magnetosphere. The Reimei satellite mission, starting the scientific observations at 650-km altitudes in the late 2005, has been providing us with the high-time/spatial resolution auroral data with the novel observation function realizing simultaneous conjunction measurements of the auroral emissions at the ionospheric altitudes and the auroral plasma particles in the topside ionosphere. The multi-spectral auroral camera (MAC) with 1.1-km resolution over a 70-km x 70-km area at the auroral altitudes (110 km) are imaging a number of spatial distributions and time variations of auroras simultaneously with energy spectra of the energetic (10 eV - 12 keV) plasma over the full-pitch angle range by auroral electron/ion energy spectrum analyzers (ESA/ISA). The geomagnetic field data are also investigated for elucidating the correlation of the transversely accelerated ions (TAIs) with the field-aligned currents carried by invisible thermal electron flows which could not be detected by the electrostatic plasma analyzer on Reimei due to the lowermost energy limitation. These features of the Reimei mission imply that the satellite observation dataset could reveal the closed correlation between the structures and variations of auroral arcs/bands and the precipitating electron components accelerated mainly by quasi-static fieldaligned potential structures and kinetic (dispersive) Alfven waves above the Reimei orbit. We could also investigate the fine-scale relations among the auroral electron signatures, field-aligned current properties, and TAIs, by being mapped on the auroral emissions. The detailed comparisons based on these high-quality auroral image/particle data would derive the newest comprehensive knowledge which has not been obtained for several decades. For instance, Reimei firstly showed that rapidly varying inverted-V electron components are highly correlated with small-size active auroras like rotating auroral vortices, high-speed streaming shear-type arcs, flushing ray-type auroras, etc. It is also common that the downward electron conics and the associated upward wide-energy electron bursts are observed in association with dynamically changing auroras at the lower energy range than the inverted-V electrons. In this paper, we report several characteristic observational results from the comparative study on the types and dynamics of auroras and the fine properties of auroral particles using Reimei.

Keywords: auroral emission, auroral particle, fine structure, satellite observation, particle acceleration, auroral dyanamics



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High-speed imaging of auroral microstructures

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We have been conducting high-speed (100 Hz) imaging observations of auroral microstructures since January 2010 at Poker Flat Research Range (PFRR), Alaska. For example, from the observations in the last winter season, we showed evidence that auroral folds were periodically formed in a breakup arc and the luminosity is exponentially increased for about 10 sec before an auroral breakup onset. The evolution of turbulent microstructures and the formation of folds may be interpreted by the nonlinear evolution of inertial Alfven wave (IAW) turbulence in the thin current sheet. In this presentation we report the development and initial results of a new optical instrument system installed at PFRR since November 2010. Using a Hamamatsu EMCCD camera, we are conducting 180 Hz and 250 Hz imaging of the breakup aurora for the first time to search unexpectedly fast auroral phenomena, and to understand the electron acceleration mechanisms associated with dispersive Alfven waves in collaborations with Tohoku University and University of Alaska, Fairbanks. We use a telephoto lens of 300mm/F2.8 to resolve the finest scale of aurora with attaching a BG3 filter to see only the prompt emissions from molecular nitrogen.



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Fine-scale structure of aurora in the sub-auroral region

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Auroras sometimes appear in the equatorward of the main auroral oval. The "sub-auroral" aurora has been observed since 1970's, and known to consist of faint patches. The Reimei satellite revealed its complicated, fine-scale structures of the sub-auroral aurora. The observation was made by optical and particle instruments on board the Reimei satellite near the equatorward edge of the main auroral oval. The aurora has the following characteristics: (1) A full width at half maximum (FWHM) value is as low as only ~1.8 km from optical measurements, and ~0.6 km from particle measurements at the ionospheric altitude, which is much smaller than previously determined. (2) Using the IGRF model, the FWHM value of 0.6 km corresponds to 9 km in the equatorial plane (L^{-5}), which is ~10 times smaller than the gyroradius of typical protons in the inner magnetosphere. (3) The velocity distribution function of precipitating electrons is comparable to that of the trapped ones and does not demonstrate any plateau or positive gradient in the distribution at high energies greater than ~1 keV. (4) The aurora was observed in geomagnetically quiet condition. (5) A geosynchronous satellite observed a significant increase in the plasma pressure of hot electrons as was previously suggested. If the structured aurora is a visual manifestation of the cold plasma that determines the growth of the waves scattering the hot electrons, an issue will be the extremely small scale of the cold plasma. Possible mechanisms leading to the extremely small scale structure of the cold plasma will be discussed.

Keywords: Inner magnetosphere, aurora, fine-scale structure, Reimei satellite, precipitating electrons



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Relation between drift oscillations of auroral patches in the morning sector and ULF pulsations

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In this study, we investigate a relation among oscillations in drift of auroral patches, ULF pulsations, and propagating auroral arcs simultaneously observed in the morning sector and discuss the physical processes of these phenomena. We have studied Quasi-Stationary Auroral Patches (QSAPs) observed at the South Pole Station (-74.3CGLAT) in the interval 9-14 MLT on July 8, 2004, that were characterized as stable auroral form, location, and luminosity for up to several hours (Ebihara et al., 2007). In this interval, the QSAPs showed oscillations in their eastward drift velocity and the oscillations were accompanied by Poleward Moving Auroral Arcs (PMAAs) and Pc 5 pulsations. It was further demonstrated from the detailed anaysis that all the three phenomena had the same period as Pc 5 pulsations and regular phase relation among them.

There are a few previous studies on the correlation between the drift oscillations of the auroral patches and ULF pulsations, in which the oscillations were deduced to be the ionospheric perturbations due to the coupling between the propagating compressional waves and the shear Alfven waves in the magnetosphere. Furthermore, we calculated the magnetosphere-ionopshere coupling process by the numerical simulation assuming that the field-line resonance (FLR) occurred in the magnetosphere. As a result, the oscillations of QSAPs, PMAAs, and Pc 5 pulsations can be interpreted as the various aspects of the FLR phenomena.

Such drift oscillations of auroral patches can be observed occasionally by the color digital camera at Tromso (66.7CGLAT), Norway, in the early morning and are coincident with ULF pulsations. In the presentation, we will also report the characteristics of the auroral patches observed at Tromso comparing with ULF pulsations from the IMAGE magnetometer network.

References:

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Oguti T., R. Nakamura, and T. Yamamoto, Oscillations in drifts of auroral patches, J. Geomagn. Geoelectr., 39, 609-624, 1987.

Keywords: auroral patches, ULF pulsations, poleward moving auroral arcs, field line resonance, magnetosphere-ionosphere coupling



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Nonlinear simulation of ionospheric feedback instability with nonuniform Alfven velocity distribution

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The ionospheric feedback instability has been presented for the model that describes the dynamics of auroral arcs developed in convection electric fields [e.g. Sato, 1978; Lysak, 1991]. Destabilization of shear Alfven waves, propagating along the ambient magnetic field, is induced by the resonant coupling with the electric drift propagating on the ionosphere. Recently, formations of small-scale arc dynamics and ionospheric cavity modes were investigated by numerical simulations including non-uniformity in the background plasma density and the two-fluid effects in dipole magnetic field geometry [Streltsov and Lotko, 2004; Lu et al., 2008]. However, these simulations were performed only in a two-dimensional coordinate (along the magnetic field and perpendicular to the auroral arcs) and did not necessarily treat the nonlinear terms in a sufficient manner. Watanabe [2010] performed a three-dimensional simulation in slab magnetic field geometry with the reduced-MHD model that treats the nonlinear terms appropriately. The nonlinear behaviors indicate that the Kelvin-Helmholtz type vortex structures are spontaneously excited in the magnetosphere. We make a linear eigenmode analysis of shear Alfven waves in dipole field geometry to understand the characteristics of the cavity modes excited by non-uniformity in the Alfven velocity [Hiraki and Watanabe, 2011]. A realistic Alfven velocity profile is known such that it increases with height from the ionosphere, peaks around 1 Re, and decreases toward the magnetic equator. We find that the growth rate of cavity modes is considerably reduced by a large gradient of the Alfven velocity in the magnetospheric side, without any collisional effects at the ionosphere. For a realistic velocity distribution, the growth rate is a factor of 10 or much smaller than the rate for fundamental field-line resonances. It means that the field fine resonances are well developed when the cavity modes begin to grow up. Based on these results, we start to perform a nonlinear simulation considering non-uniformity in the Alfven velocity in dipole field geometry. We will present some new results of the analysis on the dynamics of arcs and cavity modes.

Keywords: feedback instability, Alfven wave, ionospheric cavity, nonlinear simulation, magnetosphere-ionosphere coupling



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Auroral conductance estimated from Polar and FAST satellites

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We estimated auroral conductance using Polar satellite global auroral images. We then compared the estimated conductance with FAST satellite observations of electrons at 3500 km altitude. Polar satellite observed a westward traveling surge at 21 MLT at 0301UT on February 23, 1997, when FAST satellite travelled across the northern auroral oval to the north at 20 MLT from 0255-0305 UT. Intense auroras concentrated in the poleward half (65-68 deg LAT) of the oval, where FAST observed the inverted-V signatures. In the inverted-V regions, the average energy of precipitating electrons was estimated as 7 and 8 keV from Polar auroral images and from FAST particle observations, respectively. The ionospheric conductance was estimated as Pedersen=12 and 15 (Z) and Hall=30 and 35 (Z) from images and particles, respectively. These results indicate that the estimation of conductance from auroral images agreed with particle observations better than the typical instrumental ambiguity (30 %) in spatial scales larger than 3 degree in latitudes. On the other hand, FAST observed localized (0.5 deg in LAT) enhancements in the conductance at the both edges of the inverted-V structure. These localized enhancements were not reproduced from auroral images, presumably because of the wider spatial resolution of images (0.5-2 deg in LAT).

Keywords: aurora, substorm, conductance, conductivity, geomagnetic field



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A statistical study of auroral upward field-aligned current using THEMIS electron data

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Using plasma sheet electron density and temperature obtained from the electrostatic analyzer (ESA) onboard the THEMIS-D satellite from Nov. 2007 to Jan. 2010, we have statistically investigated thermal current and conductivity to find where and when the field-aligned potential difference is formed. The thermal current (j_{th}) represents the field-aligned current carried by magnetospheric electrons without field-aligned potential difference, and can be estimated from the field-aligned current (j|) which was introduced by Knight (Planet. Space Sci., 1973). The Knight relation for the field-aligned current assumes a Maxwellian distribution of magnetospheric electrons in the plasma sheet, while the THEMIS electron data do not show a single Maxwellian. Therefore, we have also examined thermal current by integrating the downward electron flux without the Maxwellian assumption. Through a comparison of the thermal current with the typical auroral current, which is shown by Iijima and Potemra (JGR, 1976), we can roughly estimate the magnitude of the field-aligned potential difference. We found that in the dawn side inner magnetosphere (source of the region 2 upward field-aligned current), both of the thermal currents with/without the Maxwellian assumption are comparable to or higher than the typical auroral current, particularly during active time (AE > 100 nT). On the other hand, in the dusk side outer magnetosphere (source of the region 1 upward field-aligned current), both thermal currents are smaller than or comparable to the typical auroral current. It means that the potential difference may be necessary in the dusk region 1 current. In case of the field-aligned potential difference is formed, the field-aligned current is on the relation j|=KV||, where K is the conductivity that represents the efficiency of the upward field-aligned current. This relation was shown by Lyons (JGR, 1980). From the relation between the typical auroral current and the conductivity estimated by our study with Maxwellian assumption, we conclude that 1-10 kV of the filed-aligned potential difference is necessary on the dusk side region 1 upward field-aligned current.

Keywords: Field-Aligned Current, Plasma Sheet, Field-Aligned Potential Difference



Room:103

Time:May 26 12:30-12:45

Study of temporal / spatial changes of SAID/SAPS structures by the SuperDARN Hokkaido radar

Nozomu Nishitani^{1*}, Tadahiko Ogawa², Takashi Kikuchi¹, Yusuke Ebihara³, Tomoaki Hori¹

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Possible causes of variations of SAID / SAPS structures, both external and internal, will be discussed using the 4-year data from the SuperDARN Hokkaido radar.

Keywords: SuperDARN, Hokkaido HF radar, SAPS/SAID, inner magnetosphere, sub-auroral ionosphere, plasma instability



Room:Convention Hall

Time:May 26 14:00-16:30

Relationship between Solar and Seismic Activities

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Solar activities play significant roles in electromagnetic coupling of the Sun-Earth system. By comparing the 11-year sunspot cycles and earthquake events during 1963 to 2010 period, it is possible to reveal the correlation of solar and seismic activities. In the present paper, the monthly values of sunspot cycles number 20 to 23 and earthquake events at different magnitude scales were analyzed to examine the relationship of these values and to understand the coupling mechanisms in solar and geomagnetic activities. The sunspot numbers are obtained from Marshall Space Flight Center, NASA database, and earthquake events are extracted from Advanced National Seismic System (ANSS) database. We found a significant correlation between high speed solar wind (velocity greater or equal to 500 km/s) and great earthquake events (magnitude greater or equal to 8.0 Richter scale). We will discuss the statistical results in details.

Keywords: 11-year sunspot cycle, Earthquake event, High speed solar wind



Room:Convention Hall

Time:May 26 14:00-16:30

Spatiotemporal variations of flickering aurora obtained from imaging observations with a high-speed EMCCD camera

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We conducted high-speed imaging observations of flickering aurora at 100 Hz sampling rate using electron multiplying chargecoupled device (EMCCD) in Alaska during 2009-2010 winter season. We detected various types of flickering aurora, including drifting and rotating features at a frequency below 15 Hz. We identified, for the first time, flickering stripes and some other unusual flickering events at frequency of higher than 20 Hz on the imaging observations. A dispersion relation derived from a statistical analysis of observed images is compared with the theoretical dispersion curve of O+ electromagnetic ion cyclotron (EMIC) waves. The frequencies and spatial scales calculated from a coherence/phase analysis based on an interference theory are consistent with the wave dispersion relation derived from the statistical analysis, suggesting that the obtained results are essentially consistent with the scenario that the interference of EMIC waves produces the observed dispersion relation of flickering aurora. Furthermore, flickering frequencies higher than 20 Hz are confirmed from our observations, which are higher than expected frequency of O+ EMIC waves at altitudes of several thousands km. We therefore suggest that high frequency waves such as He+ and H+ EMIC waves may also contribute to produce a significant fraction of flickering aurora.

Keywords: Flickering aurora, EMCCD, alfven waves, EMIC waves, magnetosphere, ionosphere



Room:Convention Hall

Time:May 26 14:00-16:30

Analyses of aurora images observed from a cockpit of jet airliner

Yoshiyuki Sakai^{1*}, Yutaka Tonegawa¹, Katsuya Kokubun²

¹School of Engineering, Tokai Univ., ²ANA (retired)

We present a possibility of optical observations of aurora from a jet airliner flying along polar routes with an altitude of 12km. The aircraft-based optical observation from such a high altitude has several advantages comparing ground observations. The visibility above the tropopause is extremely high because of the clear and rarefied air. It is possible to detect the light of aurora down to an elevation of -2 degrees below the horizon. It means that very clear images of aurora in wide area can be observed from the aircraft.

Thousands of pictures were taken by a still camera installed just inside of a cockpit rear window of the jet airliner in the period of September 1999 to March 2005. The pictures were taken automatically every 20 seconds during night flights over the polar region. We select a number of pictures in which aurora and stars are clearly taken. Assuming an altitude of 100 km for the bottom of aurora, positions of aurora can be calculated from azimuth and elevation angles obtained from stars in the picture. We present very interesting aurora images from the cockpit, and compare them with conjugate data observed by the FAST satellite.

Keywords: aircrft observation, aurora, the FAST satellite



Room:Convention Hall

Time:May 26 14:00-16:30

Observations of large flow shears around small-scale auroral beads observed at substorm onset

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¹University of Electro-Communications, ²National Institute of Polar Research

We present, for the first time, a fine-scale electrodynamic structure behind the auroral beads observed at substorm onset, as inferred from high spatial and temporal resolution measurements of substorm aurora with an all-sky TV camera (ATV) and a coherent HF radar of SuperDARN in Iceland. On the night of September 24, 2006, the ATV observed eastward propagating auroral beads in the initial brightening arc of a substorm just prior to the poleward expansion. During the sequential passage of the beads across the radar beams, the radar detected large velocity flow shears whose magnitude was in excess of 1.5 km/s. The observations suggest that flow shears were located very close to the center of the beads; thus, they corresponded to the horizontal electric fields converging toward the beads, which is consistent with the existence of upward field-aligned currents (FACs) flowing out of the beads. The temporal and spatial resolutions of the current radar measurement were still insufficient for fully resolving the detailed electrodynamic structure behind the fast moving auroral beads. At least, however, we can suggest the existence of localized filamentary FAC structures behind the beads, which played a very important role in connecting the auroral beads in the ionosphere and their source perturbation in the magnetosphere.

Keywords: Substorm, Radar Observations



Room:Convention Hall

Time:May 26 14:00-16:30

Event and statistical studies on energy and pitch angle distribution properties of electrons in Inverted-V structures

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Inverted-V electrons are accelerated by field-aligned potential difference. It is thought that these fine structures of their energy and pitch angle distribution are due to electrostatic structures and their variations. Lin and Hoffman(1979) investigated the time variations of flux ratio of downward electron component to perpendicular electron component in the Inverted-V region. There are, however, also the results which are inconsistent with the acceleration process due to field-aligned potential difference. For example, Whalen and Daly(1979) showed that the pitch angle distributions of precipitating electrons are field-aligned near the edge of an auroral arc, while they are isotropic pitch angle distributions at the center of the arc. These variations of pitch angle distributions are very interesting in terms of the existence of an additional acceleration mechanism but there are few data focused on the fine scale pitch angle distributions of Inverted-V electrons. It is also important to compare auroral emissions to pitch angle distributions for more advanced understandings of auroral acceleration region. We used the data based on Reimei simultaneous observations for auroral particles and emissions with high spatial and time resolutions in our study.

In this presentation, we will summarize statistically the variation patterns of the energy and pitch angle distribution in the Inverted-V region. We found the characteristic variations of pitch angle distribution. Energy fluxes of downward electrons are distinguished at the edges of Inverted-V structures. It is difficult to understand that electrons are accelerated along the magnetic field at these regions because the electric field is perpendicular to the magnetic field. As REIMEI moves toward the center of Inverted-V region, perpendicular energy fluxes of electrons increase and their characteristics energies increase at the same time. These signatures also exist even when field-aligned electrons by the inertial Alfven wave acceleration are not observed.

We estimated the origin of collimated electrons at the edges of Inverted-V structures and find that it is the ambient electrons existing at the altitudes of the acceleration region. These electrons are continuously supplied in the acceleration region. We analyzed the relations of these electrons and type of auroras at the edges of Inverted-V structures considering the effect of the electrostatic field-aligned potential drop. The statistical studies show that collimated electrons are observed despite types of discrete auroras. If we only think the effect of electrostatic field-aligned potential drops, we consider that the electrostatic field-aligned potential drop exists in the polar magnetosphere.



Room:Convention Hall

Time:May 26 14:00-16:30

Study of the aurora and precipitation particles before the aurora breakup: Reimei observations

Takahisa Yano¹, Taku Takada^{1*}, Kazushi Asamura², Takeshi Sakanoi³, Atsushi Yamazaki²

¹Kochi National College of Technology, ²ISAS/JAXA, ³PPARC, Tohoku University

In this study, we investigated the characteristics of aurora and precipitation particles during the steady condition before auroral breakup. The statistical analysis was made, using the optical aurora, precipitation electron and ions, field-aligned currents observed by REIMEI satellite and AU/AL indices. Then we find that even in the steady condition the aurora appears depending on the global magnetospheric conditions and discuss it in detail.



Room:Convention Hall

Time:May 26 14:00-16:30

Coordinated ground and multi-satellite observations of eastward drifting auroral forms in the post-midnight sector

Tetsuo Motoba^{1*}, Keisuke Hosokawa², Yasunobu Ogawa¹, Akira Kadokura¹, Natsuo Sato¹

¹NIPR, ²UEC

We present eastward drifting auroral forms in the post-midnight sector on 21 September 2009 and the associated in-situ signatures in the near-Earth tail. All-sky cameras (ASC) at the Iceland-Syowa geomagnetic conjugate stations observed successive eastward passage of optical auroral forms similar to omega bands. The auroral forms had dimensions of 100-200 km in longitude and less than 100 km in latitude, and an eastward propagation speed of ~1.5 km/s. The ground magnetometer measured magnetic field fluctuation with period of ~2 minutes and amplitude of ~10-20 nT, which were generated by the passage of brighter auroral forms. During this interval, the Cluster satellites were located in the central near-Earth tail (X= -11⁻-14 Re) conjugate to the ground-based ASCs. The Cluster 2 and 4, which were longitudinally separated by ~7700 km in Ygsm (Cluster 2 was closer to the midnight), detected similar local magnetic field variations with a time delay comparable to the eastward propagation time of the observed auroral forms. The in-situ magnetic field variations are probably attributed to a series of oppositely directed field-aligned currents responsible for the auroral forms. In addition to the above-mentioned features, we will discuss more detailed relationship between the eastward drifting auroral forms and the counterparts in the near-Earth tail.

Keywords: arurora, ground-satellite observations, magnetotail configuration



Room:Convention Hall

Time:May 26 14:00-16:30

Intervals of pulsations of diminishing periods (IPDP) and related aurora observed at Athabasca

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Intervals of pulsations of diminishing periods (IPDP) is the geomagnetic pulsation with varying their frequency from ~100mHz to ~1Hz for about a half an hour. The mechanism of IPDP is that electromagnetic ion cyclotron (EMIC) waves excited at the equatorial region in the magnetosphere by the ion cyclotron instability propagate along the magnetic field to the Earth. Proton particles resonated with these waves also propagate to the Earth and are observed as proton auroras [e.g., Yahnin et al., 2009]. The cause to make the variation of IPDP frequency has been considered that the magnetospheric source region moves earthward by the dawn-to-dusk electric field with the enhancement of the magnetospheric convection [Kangas et al., 1998].

However, Yahnin et al. [2009] pointed out using data from ground magnetometers and the IMAGE satellite that the frequency variation calculated from the latitudinal variation of proton aurora as a projection of magnetospheric source region for IPDP is much smaller than the frequency variation of IPDP observed on the ground.

In order to investigate in more detail of the relation between the frequency variation of IPDP and the motions of proton aurora, we compared IPDP observed by a 64-Hz sampling induction magnetometer and proton auroras observed by an all-sky imager at Athabasca (ATH, 54.7N, 246.7E, magnetic latitude: 61.7N), for 6 events identified from January 2009 to December 2010. We found that proton auroras associated with IPDP appeared within less than 1 degree apart from the equatorward boundary of aurora oval and that southward motion of aurora oval is correlated with southward motion of proton aurora. In the presentation, we will discuss the variation of proton of proton aurora, and the IPDP frequency in relation with the plasma sheet dynamics.



Room:Convention Hall

Time:May 26 14:00-16:30

Conjugate observations of field-aligned current evolution with Space Technology 5 and Greenland magnetometer chain

Atsushi Tawara^{1*}, Satoshi Taguchi¹, James A Slavin², Guan Le², Juergen Matzka³, Claudia Stolle³

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It is believed the field-aligned current in the cusp and polar cap responds quickly to the change in IMF, and that a new fieldaligned current state is established within several minutes. The purpose of this paper to understand what kind of a transitional state occurs during such a relatively short period of time using the magnetic field measurements from Space Technology 5 mission and the Greenland west magnetometer chain. ST5 mission is a three microsatellite constellation [e.g., Slavin et al. 2008]. Taking advantage of this constellation, we have taken several events in which the cusp/polar cap field-aligned current pattern changes above the Greenland magnetometer chain within approximately 10 min. The ground magnetometer data for these simultaneous events show that gradual variations occur beneath the change of the field-aligned current. These variations are caused by temporal change of the Hall currents, suggesting that a transitional state exists in which the electric field, which is related to the closure of the field-aligned current, evolves. We present results about the detail of the electrodynamics in this state.

Keywords: field-aligned current, ground magnetic perturbations, cusp, polar cap, IMF



Room:Convention Hall

Time:May 26 14:00-16:30

A statistical survey of terrestrial hectometric radiation generated in the topside auroral ionosphere

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The terrestrial auroral ionosphere emits electromagnetic waves in the MF and HF bands (about 1-5 MHz), some of which can reach to the ground level or escape to space. Ground-based observations indentified two types of MF/HF auroral radio emissions: auroral roar and MF burst. Both auroral roar and MF burst are usually attributed to mode-conversion radiation from upper hybrid waves generated by interaction with auroral electrons in the bottomside ionosphere. Several papers reported satellite observations of MF/HF auroral radio emissions radiating from the topside ionosphere to space: 2-MHz, 4-MHz noise [*James et al.*, 1974], terrestrial hectometric radiation (THR) [*Oya et al.*, 1985, 1990], and topside ionospheric MF/HF radio emission [*Bale*, 1999]. Recently, *Sato et al.* [2010] showed typical spectrum and polarization features of THR emissions by case studies using the Akebono satellite data. However, there is no consensus regarding their statistical characteristics and relations with auroral roar and MF burst, both of which are observable from the ground.

We analyze long-term data of the Akebono satellite, which has been operated since its launch on February 1989, for the statistical characteristics of THR emissions. The initial result is as follows: The frequency distribution shows a bimodal pattern which has a dip near 2.3-3.0 MHz and broad peaks near 1.4 MHz and 3.6 MHz. While the lower-band THR (< 2.5 MHz) has a higher occurrence rate than the upper-band THR (> 2.5 MHz), both have a similar distribution pattern of magnetic local time (MLT) and invariant latitude (ILAT). THR emissions are detected at any hour in MLT, and the higher occurrence is concentrated to the afternoon and nightside sectors between 12 and 01 MLT. The ILAT distribution is concentrated to the auroral latitude between 45 and 90 deg with a peak near 70-75 deg. THR emissions are detected over the entire altitude range of the Akebono satellite pass (275-10500 km). This result suggests that THR emissions are generated in the topside auroral ionosphere in the nightside sector. We will show the statistical characteristics of THR emissions, such as polarization and distributions in altitude, frequency spectrum, bandwidth, MLT, and ILAT, to examine the source region and propagation features of the THR emissions.

Keywords: auroral ionosphere, auroral radio emissions, radio propagation, plasma instability



Room:Convention Hall

Time:May 26 14:00-16:30

On the relation between particle precipitation and heat flux in the polar ionopshere

Yasunobu Ogawa^{1*}, Yoshimasa Tanaka¹, Tetsuo Motoba¹, Hiroshi Miyaoka¹, Akira Kadokura¹

¹National Institute of Polar Research

We have investigated characteristics of particle precipitation and heat flux based on the European Incoherent Scatter (EISCAT) radar data. The soft particle precipitation is often accompanied by electron heating due to the heat flux from the magnetosphere, and both can be a trigger of ionospheric ion upflow. However, little is known about the relation between the particle precipitation and heat flux (for example, relative locations between them). In this paper, we show their characteristics and relations to auroras using data obtained with EISCAT and optical measurements in November 2008 and February 2011, and discuss the plausible mechanisms determining the relative locations between electron heating and auroras in the polar ionosphere.

Keywords: polar ionopshere, particle precipitation, heat flux, EISCAT



Room:Convention Hall

Time:May 26 14:00-16:30

Low energy electron observation by LEP-ESA on Norwegian sounding rocket ICI-3

Toshihiro Irie^{1*}, Yoshifumi Saito¹, Shoichiro Yokota¹

¹Earth and Planetary Science University o

There exists large-scale plasma convection in the high latitude ionosphere such as two-cell pattern. Moen's group in Norway found the existence of Reverse Flow Events (RFEs) where plasma flow is opposite to the background convection pattern by EISCAT Svalbard Radar. RFEs are ~100-200 km wide east-west elongated channels that have an average life time of ~18 minutes. On the other hand, coherent HF radars obtain backscatter echoes from field-aligned plasma irregularities of decametre scale length. The strong coherent HF backscatter echoes are a well-known characteristic of the polar cusp. Although there exist several candidate processes including gradient drift instability, the generation mechanism of backscatter targets has not yet been agreed upon. The RFE phenomenon may be a very important facilitator of HF backscatter irregularities in the cusp ionosphere. Since the Reversed Flow Events (RFEs) are relatively long lived and do not move much in latitude during their lifetime, they are ideal as target for a rocket investigation. In order to prove the hypothesis that the RFE phenomenon plays an important role in plasma irregularity formation, ICI-3 sounding rocket experiment was proposed. ICI-3 will be launched in December 2011 from Ny Alesund, Svalbard, Norway. The main objective of ICI-3 is to obtain a better physical description of instabilities and wave phenomena driven by the RFEs in the winter cusp ionosphere. We are now preparing low energy electron energy spectrometer LEP-ESA for ICI-3 sounding rocket. LEP-ESA measures the electron distribution function in the energy range between 10eV and 10keV with time resolution as high as 11msec. We will report the design of LEP-ESA and its performance based on the results obtained by calibration experiment. We will also report the observation results obtained by the similar low energy electron analyzer on ICI-2 sounding rocket that was launched into cusp region in December 2008.



Room:Convention Hall

Time:May 26 14:00-16:30

Visualization model of the 3D electron density distribution and its application to remote sensing observations

Yuuki Sagawa^{1*}, Satoshi Taguchi¹, Yasutomo Morii¹, Kei Sasaki¹, Yuuki Harano¹, Satoshi Suzuki¹

¹University of Electro-communications

We have constructed a visualization model of the 3D electron density distribution in the polar ionosphere. This model is based on the empirical model of the auroral oval we have developed, and several established models regarding the precipitation energy/energy flux of the auroral particles, and the production rate, which is dependent on the altitude, have been utilized. Our visualization model shows that variable "islands" exist in the 3D distribution. We assume that the line of sight direction of the radar passes through the island, and discuss how the island can be detected by the assumed radar.

Keywords: ionospheric electron density, auroral particles, modeling, visualization

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PEM031-P14

Room:Convention Hall

Time:May 26 14:00-16:30

Interhemispheric comparison of cross-polar cap potentials

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¹ROIS/NIPR

Cross polar cap potentials in the polar ionospheres are important physical parameters showing magnetospheric conditions depending on solar wind energy input, energy dissipation in the magnetosphere and strength of plasma convection in the magnetosphere, etc. The potential drop at northern hemisphere and one at southern hemisphere is thought to be identical in the zero's order approximation. However, it is not clear whether they are always completely the same values or not because of the existence of difference in ionospheric conductivity in both hemisphere due to seasonal difference, the effect of dipole tilt angle, and asymmetries in phenomena in a variety of spatial scales between both hemispheres. In the past, some possible seasonal differences have been discussed with statistical analyses mainly using satellite data, and a recent study using SuperDARN data pointed out that an effect of dipole tilt angle on the differences, but no comprehensive physical understanding has been made yet. We here use SuperDARN data simultaneously obtained at both hemispheres from 1999 to 2006 and try to obtain essential physical understanding of this potential differences especially on dependencies on interplanetary magnetic fields, geomagnetic activities, seasons, dipole tilt angle, and substorm phases, and so on. We first show the initial results of this interhemispheric comparison this time particularly on whether the two simultaneous values show any statistical differences, and whether there exist any examples where large differences exist and discuss the possible reasons if any in detail.

Keywords: SuperDARN, Cross polar cap potential, interhemispheric, symmetry, asymmetry, polar ionosphere



Room:Convention Hall

Time:May 26 14:00-16:30

Saturation effects incorporated in the modeling of the high-latitude potential distribution

Satoru Nakashima¹, Yasutomo Morii¹, Satoshi Taguchi^{1*}

¹Univ. of Electro-Communications

We have developed an empirical model of the electric potentials in the high-latitude ionosphere which can express the distribution for superstorms. Our model is the numerical solution of the Laplace's equation with the boundary conditions obtained from the statistical analysis of the DE 2 electric field data, and the use of nonlinear functions for data fitting. For the determination of the boundary condition, we also used the data of the location of the precipitation particle boundary detected by DMSP spacecraft during several superstorms. The method used in our modeling can include the potential saturation effect. The model shows that polar cap potential reaches about 250 kV, which is in agreement with previous observations. Another advantage of our model is the ability to produce the distribution of the auroral oval corresponding to the potential distribution. By comparing between the potential distribution and the equatorward boundary of the modeled auroral oval, we can define the subauroral region. Our result shows that subauroral potential is large in the dusk sector, and saturated approximately at 70 kV. This is consistent with recent radar observations.

Keywords: potential, plasma convection, saturation effect, superstorms, solar wind

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PEM031-P16

Room:Convention Hall

Time:May 26 14:00-16:30

Variation of Sq focus latitudes for the active sun year 2001

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Variations of Sq focus latitudes for the northern and southern hemispheres have been broadly investigated by utilizing magnetic observation networks. The relation of the Sq focus latitude and the equatorial electrojet strength has also been discussed because the electrojet results from the Sq current in the equatorial day side of the ionosphere. The day-to-day variation of the Sq focus latitude has been evaluated during the quiet days or weak disturbance days. In order to evaluate the seasonal variation of the Sq focus, the contribution of the magnetic disturbance must be as little as possible through the year. For example, Stening et al. [2007] used the data corrected for the magnetic disturbance by subtracting the Dst index for the quiet sun year 1997. The similar method using the Dst index had been applied in a study of the Japan Meteorological Agency (JMA) for the active sun year 1958 and for the quiet sun year 1964; The results, however, might have been entangled with the errors. In the previous work, we examined the characteristics of the variability in the Sq focus latitudes on data from the JMA observatories for 17 active sun years, using a wavelet analysis which retrieves the Sq variation approximately. In this study, we examine the relation between the northern and southern Sq foci during the active sun year 2001 on data from both the JMA and the INTERMAGNET: MMB, KAK, KNY, CBI, GUA, KDU, CTA, ASP, and CNB.

Our results are as follows:

1. We found the approximate-synchronization in the poleward and equatorward movements of the northern and southern Sq foci during spring and during autumn.

2. We found the out-of-phase synchronization in the poleward and equatorward movements of the Sq foci during February and during December. This result overlaps that of Stening et al. [2007].

3. We found various poleward and equatorward shifts in the Sq focus latitudes, showing a poleward shift of the northern focus in February and an equatorward shift of the southern focus in November (Stening et al., 2007).

4. The strength of the equatorial electrojet was obtained representatively from data at the Huancayo observatory. On the occasional cases that the Sq focus moves equatorward, the strength of the electrojet increases. These agree with the previous works. The poleward and equatorward shifts of the Sq foci might be correlated with the enhancements of the electrojet strength during spring and during autumn.

5. The periodicity of about 10 days (or about 30 days) in the variation of Sq focus latitudes can be directly attributed to that of the Sq variation retrieved by the wavelet analysis.

Keywords: Sq current system, Sq focus latitude, seasonal variation, equatorial electrojet, wavelet analysis



Room:Convention Hall

Time:May 26 14:00-16:30

Identification of full-substorm onset from ground-magnetometer data by singular value transformation

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Pi 2 magnetic pulsations are defined as impulsive hydromagnetic oscillations with a period of 40-150s. It is well-known that Pi 2 pulsations has one-to-one correspondence with auroral breakups (Jacobs et al., 1964; Saito, 1969; Li et al., 1998). Although Pi 2 pulsations have been accepted as a good indicator of auroral breakups, they correspond to not only full-substorm onsets but also most pseudobreakups. Hsu and MacPherron (2007) examined statistical properties of Pi 2 pulsations. They reported that the most probable number of Pi 2 bursts per substorm is 2. In the previous substorm researches, geophysical differences between pseudobreakups and full substorms have been studied. However, the physical difference in the magnetosphere and on the ground has not been clarified yet. In other words, to figure out the physical difference is a key subject for understanding the substorm onset mechanism. From this viewpoint, it is important to detect Pi 2 pulsations that correspond to full-substorm onset.

Another well-known substorm related phenomenon measured on the ground is positive bays. At the onset of the substorm expansion phase, the crosstail current is diverted down the magnetic filed lines. The current then flows in the ionosphere as the westward electrojet and returns to the tail along the magnetic field line. The perturbation of tail current can be represented by an equivalent eastward current, which completes the three- dimensional current wedge. The mid-latitude and low-latitude signature of this wedge is a positive perturbation in the north-south component. It is widely accepted that the sudden formation of the current wedge is essential to complete substorm onset. Hence, positive bays at mid and low latitudes could be an evidence for the occurrence of full substorms. From these arguments, we can say that Pi 2 pulsations accompanied by positive bays are one of the most reliable indicators of full-substorm onsets.

In order to identify full-substorm onsets from ground-magnetometer data, we propose a new algorithm to screen Pi 2 pulsations that accompanied by positive bays. As mentioned earlier, there are some works about automatic detections of Pi 2 pulsations. However, these methods are limited only to detecting wave packets. To screen Pi 2 pulsations that accompanied by positive bays, we should detect wave packets and changes of slopes simultaneously in ground-magnetometer data. Recently, singular spectrum analysis (SSA) has been used for change-point detections in time series (Moskvina and Zhigljavsky, 2003). Ide and Inoue (2005) developed the SSA-based change-point detection method, named singular spectrum transformations (SST), and showed that it was useful in knowledge discovery of causal relationships from a set of heterogeneous time series. Recently, the SST has been applied to determine the onset of positive bays (Tokunaga et al., 2010a, b). Unlike other conventional approaches, the SSA is data adaptive and does not employ any specific generative models. Further, SSA can extract simultaneously complex trends and periodic components. Hence, SSA-based change-point detection method likely fills our purpose, that is, to detect wave packets and changes of slopes simultaneously. In this paper, we introduce a new SSA-based change-point detection method, named Singular Value Transformation (SVT), to screen Pi 2 pulsations that accompanied by positive bays.

The outline of this paper is as follows. First, we describe the basic concept of SSA. Further, we introduce bay-score that provides information to determine whether the Pi 2 pulsation accompanied by the positive bay is present or not. Then, we define the framework of SVT. Next, we apply our algorithm to the ground-magnetometer data and compare the result with auroral images obtained by Polar Ultra Violet Imager (Polar/UVI). Furthermore, we evaluated the practical performance of the algorithm in a statistical study.

Keywords: substorm, positive bay, Pi 2 pulsations, SVT



Room:Convention Hall

Time:May 26 14:00-16:30

Plasma mass density profile of the inner magnetosphere estimated from the frequency of standing Alfven waves

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The study of plasma density profile in the inner magnetosphere has been based on electron and H^+ density, and the contribution of heavy ions was mostly neglected. Observations by the retarding ion mass spectrometer (RIMS) onboard Dynamic Explore (DE-1) in 1981-1982 showed that there is heavy ion enhancement near the plasmapause identified by electron or H^+ . In recent years, these cold heavy ions have attracted attention of researchers as the cause of the ring current ion composition change during magnetic storms. Unfortunately, however, there are no direct observations of the ion composition profile of the plasmasphere, since the DE-1 observations in 1980s. In this study, we intend to estimate the heavy ion composition profile in an indirect method. We determined the plasma mass density profile from the fundamental frequency of the harmonic of toroidal standing Alfven waves, using magnetic field data obtained by the magnetometer on the TSUBASA satellite (MDS-1, Mission Demonstration Test Satellite-1) which had the geo-stationary transfer orbit. We obtained the plasma mass density profile over L=3-6 from around 40 orbital passes on the noon side to the dusk side. We will show statistical results and discuss the existence of the cold heavy ions.



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Simultaneous ground-geosynchronous observation of Pi 2 pulsations associated with the substorm current wedge

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The formation of a substorm current wedge (SCW) is one of the fundamental processes in the expansion phase of the magnetospheric substorm [e.g. *McPherron et al.*, 1973]. A Pi 2 magnetic pulsation always occurs at the expansion onset [*Saito*, 1969]. High- and mid-latitude Pi 2s in the *D* (east-west) component, which are observed away from the auroral breakup region, have been understood as an oscillation of the field-aligned currents (FAC) associated with SCW [*Lester et al.*, 1983; *Uozumi et al.*, 2009]. *Sakurai and McPherron* [1983] examined Pi 2s that observed at the geosynchronous orbit, and presented that the initial perturbation in the azimuthal component of a Pi 2 is in the same sense as the perturbations caused by the SCW. *Uozumi et al.* [2010] found that the ground Pi 2 timeseries had high coherencies with simultaneously observed AKR timeseries, regardless of whether the Pi 2 timeseries were associated with upward FAC or downward FAC; this fact suggests that the upward SCW and the downward SCW oscillated in a synchronized manner. This aspect was deduced from ground observations, and should be verified by a simultaneous observation on the ground and in the magnetosphere. In order to clarify the timing relation of Pi 2s that are associated with SCW oscillations, we made a comparative study by combining the ground and satellite data.

We analyzed simultaneous ground-satellite observation of Pi 2 pulsations at the ETS-VIII geosynchronous orbit (GGLon=146.0E) [*Koga and Obara*, 2008] and at MAGDAS/CPMN [*Yumoto and the MAGDAS Group*, 2006] high-, mid- and low-latitude stations, CST (GGLat.=68.5N, GGLon.=179.2E), ZYK (65.8N, 150.8E) and KUJ (33.1N, 131.2E). ETS-VIII was located in the geomagnetic southern hemisphere (GMLat = $^{-1}$ 12S), and a foot point of the magnetic field line is estimated as GGLat = 70.5N, GGLon = 152.9E by using Tsyganenko 96 model. The nearest ground station to the foot point was ZYK. We picked up Pi 2 events that exhibited a high coherency in the waveform among the ground and satellite Pi 2s. Pi 2s occurred around 1250 and 1300UT on May 5, 2008. MLT of each ground station and ETS-VIII at the occurrence of the first Pi 2 was as follows: KUJ: 21.4h, ZYK: 22.4h, ETS-VIII: 22.5h and CST: 23.6h. ETS-VIII was located at almost the same magnetic meridian as ZYK. The first Pi 2 occurred without any significant magnetic bay. The second Pi 2 was accompanied with magnetic bay signature. Characteristics of the Pi 2s are summarized as follows: (1) the initial deflection of the ground Pi 2s at ZYK and CST indicate the signature of the upward and downward FAC of the SCW, respectively. (2) Pi 2 oscillated in- or 180deg out-of-phase among the *D* (eastward) on the ground and *N* (eastward) components at the geosynchronous altitude. (3) Pi 2 oscillations in the *H* (northward) and *P* (parallel to the earth rotation axis) components exhibited phase (time) difference among them (d*T* = 10~30s). We found other Pi 2 events that have the same characteristics.

By taking into account that the polarity of the D and N components Pi 2 oscillations were demarcated by the direction of the SCW FAC (upward or downward) and the sign of the geomagnetic latitude (northern- or southern-hemisphere), the present results suggest that the entire part of the SCW system oscillated in a synchronized manner. On the other hand, the time differences in the H and P components Pi 2 can be explained by a characteristic of Pi 2 propagation in the magnetosphere, which was examined by *Uozumi et al.* [2000 and 2009].

Keywords: Pi 2, substorm current wedge, simultaneous ground-geosynchronous observation, substorm, MAGDAS/CPMN, ETS-VIII