Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PEM28-01 会場:413 時間:4 月 29 日 11:00-11:15

地磁気急始に伴う中低緯度電離圏電場応答の磁気地方時依存性
MLT dependence in the response of ionospheric electric fields at mid-low latitude during geomagnetic sudden commencement

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The geomagnetic sudden commencement (SC) is one of the geomagnetic disturbance phenomena triggered by an enhancement of the magnetopause current associated with the compression of the magnetosphere due to solar wind disturbances [e.g., Araki, 1994]. Detailed evolution and propagating processes of the electromagnetic field associated with SCs are observed three-dimensionally in the entire geospace. Unlike magnetic storms and substorms which involve complex plasma physical processes, SCs can be identified as distinct magnetic variations that sharply change on a global scale. However, the characteristics of SCs have been extensively investigated mainly by means of the magnetic field variations obtained by ground-based observations, which could be affected by conductivities when deducing electric fields. Thus, investigating the electric field variations is needed to understand the transport of electromagnetic energy (Poynting fluxes, E$\times$B/μ) associated with SCs. In this study, we examined two critical subjects about the ionospheric electric field associated with SCs using the in-situ electric field data.

The in-situ ionospheric electric field was derived from the drift velocity observed by the Ionospheric Plasma and Electrodynamics Instrument (IPEI) onboard ROCSAT-1, which orbited at an ionospheric altitude (about 600 km), with magnetic field from the IGRF-10 model. We also used the geomagnetic field data from ground stations at the subauroral region, mid and low latitudes, and dip equator with a high time resolution of 1 second.

The first subject is the transmission time of the ionospheric electric field from the subauroral region to the dip equator. We found the simultaneous SC onset between the ionospheric electric field by the ROCSAT-1 observations and geomagnetic fields by ground-based observations, and the time delay in the peak amplitudes of the preliminary impulse (PI) and main impulse (MI) occur irrespective of the magnetic local time (MLT). In statistical analyses, we showed that peak signatures of the ionospheric electric field at the low latitude appeared simultaneously with that of the geomagnetic field at the subauroral region. We also found that the peak signature at the equatorial region was observed with the time delay, and its value is about 20-40 seconds in the PI peak and 80-140 seconds in the MI peak. The instantaneous onset can be explained by means of the TM_0 mode waves propagating at the speed of light in the Earth-ionosphere waveguide, while the time delay in the peaks is interpreted as the difference of the time constant L/R of an equivalent circuit. From these results, we demonstrated the transmission of the electric field from the subauroral region and the common energy transport process for both the PI and MI.

The second subject is the global structure of the ionospheric field. Ground-based observations are limited to mid and low latitudes, and provide only the horizontal component (E_{phi}) of the electric field. Thus, it is difficult to estimate the global electric field variation, especially at the terminator sector where SC signatures tend to appear in the radial component (E_r) of the electric field. We found the MLT dependence of the SC amplitude both the PI and MI signatures in the E_r and E_{phi} electric fields. In addition, the dayside characteristics of the PI signature extended to the evening terminator sector (18-21 h MLT) with an enhancement around 20 h MLT. This tendency is consistent with previous results obtained by the ground-based observations and model calculations. We consider that enhancements associated with SCs are influenced by the non-uniform ionospheric conductivity.

In the present study, we revealed the global instant response of the ionospheric electric field during SCs based on the in-situ ionospheric electric field observations. Our results can serve as a basis for understanding energy transmission paths during rapid reconfigurations of ionospheric convection.

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磁気急始に伴う電離圏の過渡的対流
Evolution of convection vortices associated with sudden impulses observed by SuperDARN

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Spatial evolution of transient ionospheric convection induced by sudden impulses (SIs) recorded by ground magnetometers is studied statistically by using SuperDARN (SD) data. An advantage of using SD data instead of ground magnetic fields is that ionospheric flows measured by the radars are not virtually biased by the spatially-varying ionospheric conductance or the magnetospheric currents. First we surveyed the Sym-H index for Jan., 2007 to Dec., 2012 to identify SI events with a peak amplitude |dSym-H|greater than 10 nT. Next we searched all SD data over the northern hemisphere during the SI events for ionospheric backscatters which give us the light-of-sight velocity of horizontal ionospheric flows. For each SI event, the collected ionospheric flow data were sorted into the four periods: the pre-SI period, the pre-Main Impulse (MI), middle-MI, and post-MI periods. In the present study, we examine the differences in flow velocity between the pre-SI period and the three MI periods to clarify how ionospheric flows change in association with SIs. As a result, the ionospheric flow shifts eastward on the dusk side and westward on the dawn side at the higher latitudes during positive SIs (SI+), while it shows a roughly westward/eastward shift on the dusk/dawn side, respectively, during negative SIs (SI-). These polarities of flow shifts are basically consistent with the higher latitude portions of the DP current for the MI phase as shown by Araki [1994] and Araki and Nagano [1988]. The high latitude flow shifts are basically larger for SI events with larger Sym-H variations, in the same fashion as ground magnetic field variations at high latitudes. In addition to the major dependence on SI amplitude, the flow shift magnitude shows a minor dawn-dusk asymmetry particularly under strong IMF-By conditions. We speculate that the interaction with pre-existing convection cells might cause the selective enhancement of either side of flow shifts.

キーワード: 磁気急始, SuperDARN, 電離圏対流
Keywords: sudden impulse, SuperDARN, ionospheric convection

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磁気嵐時の地磁気変動に見られるグローバルな電離圏電流分布について
Global distributions of storm-time ionospheric currents as seen in geomagnetic field variations

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To investigate temporal and spatial evolution of global geomagnetic field variations from high-latitude to the equator during geomagnetic storms, we analyzed ground geomagnetic field disturbances from high latitudes to the magnetic equator. The daytime ionospheric equivalent current during the storm main phase showed that twin-vortex ionospheric currents driven by the Region 1 field-aligned currents (R1 FACs) are intensified significantly and expand to the low-latitude region of ˜30 degrees magnetic latitude. Centers of the currents were located around 70 and 65 degrees in the morning and afternoon, respectively. Corresponding to intensification of the R1 FACs, an enhancement of the eastward/westward equatorial electrojet occurred at the daytime/nighttime dip equator. This signature suggests that the enhanced convection electric field penetrates to both the daytime and nighttime equator. During the recovery phase, the daytime equivalent current showed that two new pairs of twin vortices, which are different from two-cell ionospheric currents driven by the R1 FACs, appear in the polar cap and mid latitude. The former led to enhanced northward Bz (NBZ) FACs driven by lobe reconnection tailward of the cusps, owing to the northward interplanetary magnetic field (IMF). The latter was generated by enhanced Region 2 field-aligned currents (R2 FACs). Associated with these magnetic field variations in the mid-latitudes and polar cap, the equatorial magnetic field variation showed a strongly negative signature, produced by the westward equatorial electrojet current caused by the dusk-to-dawn electric field.

キーワード: 磁気嵐, 対流電場, 遮蔽電場, 電離圏擾乱ダイナモ, 惑星空間磁場, 太陽風
Keywords: geomagnetic storm, convection electric field, shielding electric field, ionospheric disturbance dynamo, interplanetary magnetic field, solar wind

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磁気赤道における DP2 侵入電場の午前・午後非対称性について
The forenoon-afternoon asymmetry of DP2 electric field penetrated to the dip equator

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DP2 変動は、数十分から数時間の周期を持つ準周期的な変動で、太陽風擾乱と同期していること [Nishida, 1968]、地上でグローバルに観測される特徴を持つ [Nishida, 1968], [Kikuchi et al., 1996] ことがよく知られている。この２つの特徴は太陽風擾乱に伴う電磁場擾乱が極域電離圏に入り込み、中低緯度領域をまたいで、磁気赤道領まで侵入する様な磁気圏-電離圏結合電流系を励起していることを示唆しているが、極域から磁気赤道域への侵入経路・メカニズムは未だ明らかになっていない。

本研究では、磁気圏-電離圏結合の終着点でもある磁気赤道域において、DP2 変動時における電磁場構造の空間構造を調べることで、極域の電場がどのようなメカニズムで磁気赤道にまで侵入して来ているかを明らかにし、DP2 電流系を推定することを目標とした。電場は磁場と電気伝導度からオームの法則に基づいて計算し、磁場データは、MAGDAS/CPMN [K. Yumoto et al., 2006 and 2007] の地上観測点のうち、ILR, AAB, TIR, LKW, DAV, CEB, YAP の磁気赤道観測点群を、電気伝導度は京都大学 WDC の電気伝導度モデルを用いて、得られたカウリング伝導度をそれぞれ使用した。これらのデータを用いて、2007 年~2008 年の 2 年間にわたって解析を行い、電場の LT 分布を導出した。

解析の結果、DP2 変動に対応する電場が磁気赤道域において、午前・午後の間に明瞭な非対称構造を持つことが明らかになった。この非対称構造は南北半球における極域の電場のみから作り出されるポテンシャル構造では説明が難しく、極域から磁気赤道に電場が侵入する間にこの構造を作り出す何かしらのメカニズムが存在することを示唆している。我々はこのメカニズムとして、Cowling channel model [Yoshikawa et al., 2012, AGU] での、昼夜境界領域や磁気赤道域で生成された分極電場が全球的なポテンシャル構造を歪曲させたと考えており、このモデルに基づいたポテンシャル分布の計算結果と今回の結果は矛盾しない。

キーワード: DP2 変動, 磁気赤道, 電離圏電流
Keywords: DP2 oscillation, dip equator, ionospheric current

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サブストーム時の夜側低緯度の電離圏電場
Substorm electric fields at nightside low latitude

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The convection electric field penetrates from the polar ionosphere to low latitude and drives the DP2 currents in the global ionosphere with an intensified equatorial electrojet (EEJ). The electric field often reverses its direction, that is, the overshielding occurs and causes the equatorial counterelectrojet (CEJ) during storm and substorms. In this paper we report that the overshielding electric field is detected by the HF Doppler sounders at low latitude on the nightside. We analyzed the Doppler frequency of the HF radio signals propagated over 120 km in Japan at frequencies of 5 and 8 MHz and compared with the equatorial EEJ/CEJ during the substorm expansion phase. We found that the overshielding electric field reaches around 2 mV/m during major substorms (AL <-1800 nT). Taking the geometrical attenuation into account, we estimate the equatorial electric field to be about 1.5 mV/m. We also found that the electric field drives the eastward electrojets in the equatorial ionosphere on the night side. It is to be noted that the overshielding electric field is observed on the nightside at low latitude during the major substorms, while the convection electric field is dominant during smaller size substorms, as the CEJ flows on the dayside. These results suggest that the overshielding electric field associated with the Region-2 field-aligned currents becomes dominant during substorms at low latitude on the nightside as well as on the dayside. On the other hand, we found strong seasonal dependence of the overshielding in the sub-auroral latitudes. Although the substorm CEJs at Huancayo do not depend on season, the overshielding frequently occurs at subauroral latitudes during the winter period from November to February. In contrast, the convection electric field is dominant at the subauroral and low-latitudes during the summer period from April to August. The strong seasonal dependence may suggest that the Region-1 field aligned currents (FACs) have a constant voltage source, while the Region-2 FACs have a constant current source, which results in the convection and overshielding electric fields being dominant in summer and winter, respectively.

キーワード: サブストーム, 中緯度電離圏, 対流電場, 過遮蔽, 赤道カウンタージェット電流
Keywords: subsotm, midlatitude ionosphere, convection electric field, overshielding, equatorial counter electrojet

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プラズマ対流速度の磁気圏電離圏結合シミュレーションから得られる計算値と SuperDARNHF レーダーデータから得られる観測値の比較
Comparing the ionospheric plasma drift obtained from the global MHD simulation and that measured by SuperDARN radars

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グローバル電磁流体力学的（MHD）シミュレーション（*Tanaka et al.*, 2010）による太陽風の変動に対する地球磁気圏や電離圏の応答を調べる研究は発展を続けており、太陽風から取り込まれた磁気圏のエネルギーが突然開放されるサブストームと呼ばれる現象を再現し、そのときの地球磁気圏のダイナミクスを議論できる程度にまで成長してきた。

磁気圏-電離圏相互作用過程は現在も十分に解明されていないために、シミュレーションモデルにおける磁気圏と電離圏の境界における関係式にはいくつか任意に決定されている係数がある。これらの係数の値によって、オーロラ発生時の磁気圏や電離圏における物理量分布は変化する。

本研究の最終的な目的はデータ同化手法を用いて最適な組み合わせの係数を推定することである。磁気圏モデルの内部境界における関係式から、磁気圏から入力される沿磁力線電流や、プラズマ圧などの電離圏電気伝導度への寄与を変えると、磁気圏にフィードバックされる沿磁力線電流やポテンシャルが変化し、最終的には磁気圏・電離圏の対流構造も大きく変わってくることが予想される。

本発表では衛星 ACE によって観測された太陽風パラメータを入力してシミュレーションを実行して得た電離圏のプラズマ対流速度と SuperDARN レーダーで観測されたプラズマ対流速度の比較を行う。また、シミュレーションでは再現されなかったプラズマ対流構造を紹介し、太陽風中の磁場が南を向いて磁気圏・電離圏対流が活発な状態における磁気圏-電離圏結合過程におけるシミュレーションモデルの関係式の改良とモデルパラメータの最適値推定について考察する。

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Tanaka, T., A. Nakamizo, A. Yoshikawa, S. Fujita, H. Shinagawa, H. Shimazu, T. Kikuchi, and K. K. Hashimoto (2010), Substorm convection and current system deduced from the global simulation, J. Geophys. Res., 115, A05220, doi:10.1029/2009JA014676.

キーワード: 電離圏対流, SuperDARN, シミュレーション
Keywords: the ionospheric convection, SuperDARN, simulation

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プロトンオーロラ・電子オーロラサブストーム総合モデルの構築に向けて： 昭和基地地上観測

Toward construction of comprehensive proton and electron auroral substorm model: Ground-based observation at Syowa

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極地研では、南極地域観測第Ⅷ期 6 ヵ年計画の下、昭和基地でのオーロラ光学観測システムの整備を進めている。「モニタリング観測」機器としては、(1) 全天単色デジタル CCD イメージャ 4 式（427.8, 557.7, 485.0, 481.0nm）と (2) 全天カラーデジタルカメラ、「一般研究観測」機器としては、(1) 全天 TV カメラと (2)8 色掃天フォトメータ、の導入を進めてきた。2014 年のシーズンには、電子オーロラ 2 波長（427.8, 557.7nm）とプロトンオーロラ 2 波長（481.0, 485.0nm）の全天 CCD イメージャ 4 式による同時観測が実現出来ているので、その初期結果を中心に報告する。上記 4 式のイメージャの撮像間隔は 15 秒で共通にし、同じ時間分解能で電子オーロラとプロトンオーロラの空間分布を観測することを目的としている。微弱なプロトンオーロラを観測するため、プロトンイメージャについては、元々 512x512 の画素数の CCD 出力に対し 8x8 のビンニングを行い、空間解像度を 64x64 に落としている。

8 色掃天フォトメータの波長構成（中心波長（半値幅））は、482.5(0.6), 483.5(0.6), 484.5(0.6), 485.5(0.6), 486.5(0.6), 487.5(0.6),670.5(5.0), 844.6(0.6) nm で、プロトンオーロラ（H β）のスペクトル用 6 波長と電子オーロラ用 2 波長からなる。掃天速度は 180 度/10 秒で、サンプリング速度は 20Hz である。

こうした全天イメージャと掃天フォトメータの電子オーロラ、プロトンオーロラ同時観測データにより、降下電子や降下プロトンのエネルギー情報も含んだ、オーロラサブストーム発達過程の総合的なモデルを構築するすることが 1 つの目標となる。目標としているモデルの概要についても紹介する予定である。

キーワード: オーロラ, サブストーム, 地上光学観測, 昭和基地
Keywords: aurora, substorm, ground-based observation, Syowa Station

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朝夕昼夜境界付近で観測される Pi 2 型地磁気脈動の性質
Characteristics of Pi 2 pulsations around the dawn and dusk terminator

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We statistically investigate low-latitude Pi 2 pulsations observed around the dawn and dusk terminator. The main observational results of this study are: (1) Pi 2 pulsations tended to have east-west polarity in the sunlit side of the dawn terminator, while these in the sunlit side of the dusk terminator tended to have north-south polarity. (2) Phase reversals of D-component oscillations occurred near the dawn terminator and 2-3 hours before the dusk terminator. (3) Peaks of D/H (maximum amplitude ratio between D and H component) appear 3 hours after the dawn terminator and near the dusk terminator.

We suggest that there is the dawn-dusk asymmetry of meridional ionospheric currents connecting between equatorial Cowling current and oscillating nightside FACs; meridional currents around dawn is more intense than around dusk. This asymmetry current system can be qualitatively explained by the deformation of potential pattern caused by polarization charges at the terminator.

キーワード: Pi 2 型地磁気脈動, 朝夕昼夜境界, 電離層電流, 沿磁力線電流
Keywords: Pi 2 pulsations, The dawn and dusk terminator, Ionospheric currents, FACs

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北海道‐陸別 HF レーダーの RBSP モードを用いた Pc5 波動自動検出
Automatic identification of Pc5 waves using RBSP mode data from the SuperDARN Hokkaido HF radar

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Ultra-low-frequency Pc5 waves have been observed by many methods such as ground-based magnetometers, HF radars and satellites. It has been demonstrated by numerical experiments that magnetospheric Pc5 waves are globally and directly generated on the dayside by solar wind dynamic pressure variations and/or on the dawn/dusk flank by Kelvin-Helmholtz surface waves. In addition, there are storm-time Pc5 waves on the dusk side magnetosphere that are associated with instabilities in the storm time ring current caused by the particle injection. The Pc5 waves can play an important role in mass and energy transport within the inner magnetosphere such as the radial diffusion of outer radiation belt electrons, as suggested by previous studies. Outstanding problems in Pc5 studies include clarification of their global characteristics and distribution, generation mechanisms, and especially their dependence on the solar wind parameters.

In this study, we try to develop a new automatic identification method of Pc5 waves using ˜20-sec time resolution data obtained by the SuperDARN Hokkaido HF radar operated in the RBSP mode. In this method, we use the Doppler velocity data and the power spectrum density calculated by the wavelet transformation. We set criteria which can detect Pc5 waves even when harmonic oscillations coexist. We show an example for the identification method using the Doppler velocity data obtained by the SuperDARN Hokkaido HF radar in details. Then, the candidates of Pc5 event are verified by inspection. From the rate of error identification, we evaluate the accuracy of the automatic identification method statistically. In the presentation we will also report on the preliminary results of mid-latitude Pc5 characteristics such as frequency distribution and MLT dependence.

キーワード: SuperDARN, Pc5 波動
Keywords: SuperDARN, Pc5 waves

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PEM28-10 会場:413 時間:4 月 29 日 15:00-15:15

北海道 HF レーダーと地上磁場における Pc 4 脈動の同時観測研究
A Simultaneous Observation of Pc 4 pulsation by Hokkaido HF Radar and Ground-Based Magnetometers

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We studied a Pc 4 (6.7-22.2 mHz) oscillation of ionospheric Doppler plasma velocity observed around the dawn terminator on 16 Jul 2013 on an east-northeast pointing beam 14 of SuperDARN Hokkaido HF radar in Japan. We compared this ionospheric Pc 4 oscillation with magnetic field variation at St. Paratunka (PTK) in Russia, Kakioka (KAK) in Japan, Guam (GUA), Middlemarch (MDM) and Te Wharau (TEW) in New Zealand. PTK and conjugate points of MDM and TEW are located almost under the radar beam. The waveforms showed high similarity among the HF Doppler, the D (east-west) component of magnetic field at stations in the middle latitude of northern hemisphere (PTK and KAK). While, at the other stations (MDM, TEW, and GUA) the H (north-south) component of magnetic field showed high similarity to the HF Doppler. Using the value of the peak-to-peak amplitude of the HF Doppler velocity, we estimated amplitude of magnetic field variation with assuming a horizontal current sheet infinitely extended in the ionosphere. The estimated amplitude was comparable to the observed amplitude at PTK. We also studied longitudinal variation in amplitude using magnetic field data at Amsterdam Isl. (AMS) in South Indian Ocean and Fredericksburg (FRD) in the United States. The maximum amplitude was found at AMS which located around the midnight.

These results can be interpreted as follows. This event had its source from night side and the Doppler velocity oscillation was caused by an oscillating electric field in the east-west direction. In the northern hemisphere (PTK and KAK), the ionosphere above the observatory was sunlit, thus the ionospheric Hall current induced by the electric field makes D component of magnetic filed oscillation on the ground. On the other hand, in the southern hemisphere (MDM and TEW) and GUA, the ionosphere above the stations was still in the darkness, thus effective ionospheric current could not be induced due to low conductivity. The H component of magnetic field oscillation may reflect direct incidence of magnetic field oscillation from the magnetosphere to the ground.

キーワード: ULF, HF レーダー, 磁気圏電離圏結合, 地磁気脈動
Keywords: ULF, HF radar, M-I coupling, magnetic pulsation

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PEM28-11 会場:413 時間:4 月 29 日 15:15-15:30

電離圏へのエネルギー流入と酸素及び水素イオン流出との関係の太陽天頂角依存性
Solar zenith angle dependence of relationships between energy inputs to the ionosphere and O+ and H+ ion outflows

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Recent satellite observations and simulations have clarified that plasma outflows play an important role in abrupt changes in the ion composition in the plasmasheet and ring current during geomagnetic storms. Statistical studies by Strangeway et al. [2005] and Brambles et al. [2011] indicated that the flux of ion outflows is correlated well with soft electron precipitation (precipitating electron density and electron density in the loss cone), and DC and Alfvenic Poynting fluxes using the data obtained by the FAST satellite near the cusp region in the dayside during the 24-25 September 1998 geomagnetic storm. To distinguish between O^+ and H^+ ion outflows, we performed statistical studies using the ion composition data in addition to the ion and electron data obtained by the FAST satellite at 3000-4150 km altitude during January 1998 and January 1999. The long-term dataset enables us to identify empirical formulas between the outflowing O^+ and H^+ ion fluxes and the precipitating electron density, the electron density in the loss cone, the net electron number flux, and the DC and Alfvenic Poynting fluxes in a wide solar zenith angle (SZA) range (for dayside, 50-110 degree; and for nightside, 90-150 degree). In the SZA range of 90-110 degrees, the above formulas in the dayside are almost similar to those in the nightside. While SZA dependence of the relationshps between the outflowing O^+ and H^+ ion fluxes and the DC and Alfvenic Poynting fluxes are weak, the empirical formulas between the outflowing O^+ and H^+ ion fluxes and soft electron precipitation, especially the precipitating electron density and the electron density in the loss cone, depend on SZA. Although the precipitating electron density and the electron density in the loss cone that correspond to the outflowing O^+ ion flux of about 10^7 /cm^2/s increase with decreasing SZA, the outflowing O^+ and H^+ ion fluxes become more sensitive to an increase in soft electron precipitation with decreasing SZA.

キーワード: イオン流出, 極域電離圏
Keywords: ion outflow, polar ionosphere

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PEM28-12 会場:413 時間:4 月 29 日 15:30-15:45

Inversion method for estimating the helium ion density distribution in the plasmasphere based on IMAGE/EUV data

Inversion method for estimating the helium ion density distribution in the plasmasphere based on IMAGE/EUV data

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The plasmasphere exhibits a variety of shapes as a result of the variation in the electric field in the inner magnetosphere due to the coupling processes between the solar wind, the magnetosphere, and the ionosphere. Global imaging observations from outside the plasmasphere provide striking evidence of the variability of the plasmasphere. In particular, the EUV imager on board the IMAGE satellite obtained global EUV images of the plasmasphere, which have provided important insights into the variation of the plasmasphere. Our aim is to obtain the information on the ion density distribution for individual events rather than simply the averaged distribution from IMAGE/EUV data. For this purpose, we propose a linear inversion technique by which to estimate the helium ion density distribution. We applied this technique to a synthetic EUV image generated from a numerical model. This technique was confirmed to successfully reproduce the helium ion density that generated the synthetic EUV data. We also demonstrate how the proposed technique works for real data using real EUV images.

キーワード: プラズマ圏, 逆問題, 磁気圏
Keywords: plasmasphere, inverse problem, magnetosphere

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PEM28-13 会場:413 時間:4 月 29 日 15:45-16:00

雷ホイスラ解析を主眼としたあけぼの搭載 VLF/WBA データ解析の現状と今後の利活用について
Current availability and utilization prospect of data obtained by AKEBONO for the research on lightning whistler

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The AKEBONO spacecraft (EXOS-D) was launched in 1989 to observe particles and plasma waves in the auroral region and the plasmasphere of the Earth. It covers the altitude region from 300 km to about 10,000 km with an orbital inclination of 75 degree, and has been operated for more than 25 years which exceed 2 cycles of solar activity or 1 cycle of solar magnetic polarity reversal. Therefore analyses of the data obtained by AKEBONO enable us to study how the magnetosphere varies comprehensively.

The WBA (Wide Band Analyzer) is one of subsystems of the VLF instruments onboard AKEBONO. It measures 1 component of electric or magnetic analogue waveform in the frequency band of 50 Hz - 15 kHz. Typical waves such as chorus, hiss and whistler were frequently observed by the WBA. Huge amounts of data obtained by the WBA for more than 25 years are originally recorded as analogue waveform format in the magnetic audio tapes. Data conversion from analogue to digital is now carried out and the converted data are stored in our computer storage as digital WAVE format. Total number of the data files of digital WAVE format is more than 6,000, the total file size exceeds 10 terabytes and the processable data amount corresponds to more than 5,000 hours observation.

An automatic detection system to detect lightning whistlers from spectrograms of the WBA was developed. The spectrum intensity is automatically calibrated inside the system referring to the status of automatic gain controller of the receiver before detecting lightning whistlers. The system can output observed time, frequency band and dispersion of each detected lightning whistler. Some statistics of the lightning whistlers such as spatial and local time dependence of the occurrence frequency were already performed and the comparison with lightning activities are now under study. Because the dispersion of lightning whistler strongly depends on the electron density profile along the propagation path of the wave so that global electron density profile can be estimated using trend of dispersions of lightning whistlers. It is also pointed out that the propagation behavior of lightning whistlers is important clue to understand the wave-particle interaction. Thus these data and statistics have potential to achieve more valuable knowledge of the plasma physics in the magnetosphere.

In this presentation, we introduce the current status of data availability of the WBA and the derived results so far. We also discuss prospect of the data utilization.

キーワード: あけぼの, VLF, 広帯域受信機, 雷ホイスラ
Keywords: AKEBONO (EXOS-D), VLF, wide band receiver, lightning whistler

Japan Geoscience Union Meeting 2014
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PEM28-14 会場:413 時間:4 月 29 日 16:15-16:30

MF/HF 帯オーロラ電波の地上・衛星同時観測
Simultaneous ground-based and satellite observations of MF/HF auroral radio emissions

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Ground-based and satellite observations have revealed that the Earth is a distinct radio source. The terrestrial auroral ionosphere emits electromagnetic waves in the MF/HF ranges (about 1-6 MHz) as well as well-known intense auroral kilometric radiation (AKR) and auroral hiss in the VLF/LF ranges. Terrestrial Hectometric Radiation (THR) is observed by satellite observations in a frequency range of 1-4.5 MHz at high latitudes during geomagnetic disturbances and is regarded as a counterpart of auroral roar which is one type of MF/HF auroral radio emissions observable from the ground. Both THR and auroral roar are attributed to mode conversions of upper hybrid waves favorably generated under the matching condition, $f_{UH} \sim nf_{ce}$, where previous studies confirmed n = 2,3,4 and 5 for auroral roar, and n = 2 for THR. However, no previous studies have tested the simultaneous appearance. In this study, we survey long-term observation data obtained by the ground-based passive receivers installed at the Husafell station, Iceland (after September 2005, latitude 64.67^{o}N, longitude -21.03^{o}E, 65.3^o magnetic latitude) and the Kjell Henriksen Observatory (KHO), Svalbard (after August 2008, latitude 78.15^{o}N, longitude 16.04^{o}E, 75.2^o magnetic latitude) and by the Plasma Waves and Sounder experiment (PWS) mounted on the Akebono satellite. This data set includes several simultaneous appearance events, while the frequency of aurora roar is different from that of THR observed by the Akebono satellite passing over the ground-based stations. This frequency difference supports the previously proposed idea that auroral roar and THR are generated at different altitudes near 250 km and 1000 km, respectively. There is hardly any possibility that simultaneous observations indicate the identical generation region of auroral roar and THR. We also find that auroral roar appearing during the time when the Akebono satellite passes over the ground-based stations tends to be accompanied by THR. However, when the Akebono satellite passing over the stations detects THR, auroral roar does not always appear. This tendency is explained in terms of the fact that the Akebono satellite can detect THR emissions coming from a wider region, and a considerable portion of auroral roar emissions generated in the F region is absorbed in the D/E regions.

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PEM28-15 会場:413 時間:4 月 29 日 16:30-16:45

カスプにおけるオーロラ増光の時間空間分布
Spatiotemporal distribution of auroral brightening in the cusp

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Previous studies have shown that mesoscale auroral forms occur near the equatorward edge of the background, stable cusp aurora, and that they move in a direction that is consistent with the motion of the magnetic field line after reconnection on the dayside magnetopause. In this study we pay attention to its initial brightening using data from a high-sensitivity all-sky imager at Longyearbyen, Svalbard. The imager has a field-of-view that spans more than 4 hours in MLT, and can observe auroral brightenings that are widely separated in MLT. We determined the position of dayside auroral brightening using the 630-nm auroral images, and examined how these positions are distributed in the cusp, focusing on intervals when IMF was extremely stable. Results of analyses show that brightening occurs over a wide dayside MLT range. We show detailed spatiotemporal patterns for successive brightening events, and discuss the patterns in terms of the formation of intermittent reconnection on the dayside magnetopause.

キーワード: オーロラ, カスプ, 粒子降下, 磁気リコネクション, 全天イメージャ
Keywords: aurora, cusp, particle precipitation, magnetic reconnection, all-sky imager

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PEM28-16 会場:413 時間:4 月 29 日 16:45-17:00

立体視によるオーロラの高度測定
Height measurement from stereo imaging of aurora

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A new stereoscopic measurement technique is developed (Kataoka+2013) to obtain an all-sky altitude map of aurora using two ground-based digital single-lens reflex (DSLR) cameras. Two identical full-color all-sky cameras were set with an 8 km separation across the Chatanika area in Alaska (Poker Flat Research Range and Aurora Borealis Lodge) to find localized emission height with the maximum correlation of the apparent patterns in the localized pixels applying a method of the geographical coordinate transform. It is successfully estimated that a typical ray structure of discrete aurora shows the broad altitude distribution above 100 km, while a typical patchy structure of pulsating aurora shows the narrow altitude distribution of less than 100 km. Recent new findings about the time variation of the emission height and further new challenges of February/March 2014 will also be reported.

Reference: Kataoka, R., Y. Miyoshi, K. Shigematsu, D. Hampton, Y. Mori, T. Kubo, A. Yamashita, M. Tanaka, T. Takahei, T. Nakai, H. Miyahara, and K. Shiokawa (2013), Stereoscopic determination of all-sky altitude map of aurora using two ground-based Nikon DSLR cameras, Ann. Geophys, 31, 1543-1548.

キーワード: オーロラ, 地上光学観測, デジタル一眼レフカメラ
Keywords: aurora, ground-based imaging, digital single-lens reflex camera

Japan Geoscience Union Meeting 2014
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PEM28-17 会場:413 時間:4 月 29 日 17:00-17:15

トロムソでの地上光学観測に基づく圧力駆動型プラズマ不安定を示唆するオーロラ構造の統計解析
Statistical analysis of auroral structures related to the plasma instability based on ground optical observations

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HASHIMOTO, Ayumi[1*] ; SHIOKAWA, Kazuo[1] ; OTSUKA, Yuichi[1] ; OYAMA, Shin-ichiro[1] ; NOZAWA, Satonori[1]

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オーロラの形状は、地球磁力線による磁気圏・電離圏結合により、磁気圏の擾乱が磁力線沿いに降り込むオーロラ粒子を通じて電離圏へ投影されることで形成されると考えられている。このため磁気圏の状態を説明する上でオーロラの形状を詳しく調べることは重要な手掛かりとなる。 Shiokawa et al. [JGR, 2010] では、カナダのギラム（磁気緯度：65.5° N）での高分解能狭視野 CCD カメラを用いた観測で、オーロラパッチの西側に小さいスケールの指状のオーロラ構造が発見された。この構造は夜側のサブストームの回復相に、東へ動くパッチの速度が遅くなったときに現れ、成因は尾部の磁気圏の巨視的なレイリー・テイラー型不安定性と推測されている。しかしこの現象の統計解析はまだなされていない。本研究ではノルウェーのトロムソ（磁気緯度：67.1° N）に設置された全天カメラで 2009 年 1 月から 2012 年 11 月の冬の期間に観測された、圧力駆動型不安定性に起因すると思われるオーロラ現象の発生条件についての統計解析を行った。この期間のオーロラ画像を調べた結果、オーロラアークから発達する「大きい」構造は 14 例、パッチの中に現れる「小さい」構造は 6 例見つけることができた。本研究では、それぞれの発生した時間帯の MLT 依存性、サブストームとの関連性、スケール、東向き伝播速度、発達速度等について解析を行った。その結果、「大きい」構造は真夜中から朝側に見られ、「小さい」構造は朝側に良く見られた。開始時刻は、「大きい」構造はサブストームの回復層の始まりに、「小さい」構造はサブストームの終わり頃に対応していると考えられる。スケールはどちらも磁気圏におけるイオンのジャイロ半径よりも大きく、MHD 不安定を示唆している。伝播速度は典型的な真夜中のオーロラのドリフト速度より遅く、低エネルギープラズマがソースとなっていると考えられるが、このことは高エネルギー粒子が圧力駆動型不安定を引き起こすことに矛盾するため、より詳細に調べる必要がある。

キーワード: オーロラ, 圧力駆動型プラズマ不安定, 地上光学観測
Keywords: aurora, pressure-driven plasma instability, ground optical observation

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オーロラ渦列形成とアルヴェン波のキャビティ捕捉
Auroral vortex street formation and cavity trapping of Alfven waves

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我々はこれまで、オーロラアークの構造化を磁気圏-電離圏 (MI) 結合系における磁気流体 (MHD) 不安定性とその非線型発展という観点で理解する試みを精力的に行ってきた。双極子磁場、対流電場中において、アルヴェン速度 (v_A) 不均一を考慮した線型固有モード解析を行い、磁力線共鳴モード、電離圏アルヴェン共鳴モードがフィードバック不安定を起こすことを示した [Hiraki and Watanabe, 2011; 2012, Hiraki, 2013]。MI 結合系の３次元 Reduced-MHD シミュレーション（v_A は磁力線上一定）により、初期条件としてアーク構造を与えた場合に対して、その後の非線型発展の様子を調べた。その結果、i) アークがスプリットした直後に、増光しながら渦列へと変形すること、さらに、ii) 対流電場 20-40 mV/m 間に、その成長パターンの遷移があることがわかった。次に、v_A 不均一を考慮した３次元シミュレーション（アーク構造はなし）を行い、電離圏・磁気圏キャビティによるオーロラ構造とアルヴェン波特性の変化を調べた。電離圏キャビティを深くしていくと、磁気赤道側での二次的不安定 [Watanabe, 2010] が抑制され、電離圏側で大振幅の波がトラップされる様子がみられた。本発表では、上記二つのシミュレーションの初期成果について報告する。さらに、電離圏キャビティ領域における二流体効果と平行電場を加えたモデル拡張と解析を進めており、オーロラ電子加速についても議論したい。

キーワード: オーロラ渦列, アルヴェン波, 電離圏キャビティ, 電子加速, MHD シミュレーション
Keywords: Auroral vortex street, Alfven wave, Ionospheric Alfven resonator, Electron acceleration, MHD simulation

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サブストームに伴う磁気圏尾部の磁気リコネクションとオーロラオンセットアークの形成のタイミング
Relative timing of substorm-associated magnetic reconnection in the magnetotail and formation of auroral onset arc

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本研究では、サブストーム開始時に磁気圏近尾部で発生する磁気リコネクションとオーロラオンセットアークの形成のタイミングについて、THEMIS 衛星と地上全天カメラのデータを用いて事例解析を行った。THEMIS 地上全天カメラは、オーロラを広範囲にわたって、これまでの衛星搭載のカメラよりも高い時間空間分解能で観測している。そのため、従来よりも詳細にオーロラの発展のタイミングを調べることができる。オーロラオンセットアークは、出現し、増光し始めてから数分後に大きく渦巻き始める。さらに数分後に極方向に拡大する。磁気圏近尾部のプラズモイドの観測から磁気リコネクションがどの時点で発生するかを調べたところ、磁気リコネクションは、X~-20 Re 付近で、オーロラオンセットアークの出現の少なくとも 1-3 分前に始まることがわかった。この結果から、磁気リコネクションがオーロラオンセットアークの形成に何らかの役割を果たしていることが示唆される。

キーワード: サブストーム, オーロラオンセットアーク, 磁気圏尾部, 磁気リコネクション, プラズモイド, GEMSIS
Keywords: substorm, auroral onset arc, magnetotail, magnetic reconnection, plasmoid, GEMSIS

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オーロラトモグラフィで得られた東向き伝搬するオーロラ渦構造の特性
Characteristics of eastward propagating aurora vortices obtained by aurora tomography

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We investigate characteristics of three mesoscale aurora vortices observed in the Northern Scandinavia by aurora campaign observation in March, 2013, which was conducted in collaboration with the Swedish Institute of Space Physics (IRF) and the Finnish Meteorological Institute (FMI). The aurora vortices propagated eastward intermittently at about 15-minute intervals in the post-midnight sector (0:00-0:40 UT; 2:30-3:10 magnetic local time) after the substorm onset. They were simultaneously observed by three monochromatic (427.8nm wave length) all-sky EMCCD imagers at Tromso (69.6N, 19.2E), Norway, Kilpisjarvi (69.0N, 20.9E), Finland, and Abisko (68.4N, 18.8E), Sweden, with an exposure time of about 2 seconds and a sampling rate of about 10 seconds. In addition to these optical data, geomagnetic field data from the IMAGE magnetometer chain were also available.

The propagation speed of these vortices was approximately 3 to 10 km/s at 100 km altitude. The ionospheric equivalent current system accompanied by the aurora vortices indicated a two-vortex structure. By applying tomographic inversion analysis to the events, we also obtained 3D distributions of volume emission rate and ionospheric electron density, as well as horizontal distribution of auroral precipitating electrons. It is also possible to estimate horizontal distribution of the ionospheric conductivity from the electron density distribution at every 10-second interval. In the presentation we will discuss the magnetosphere - ionosphere coupling process of the aurora vortices and the relationship with the omega bands that are generally observed in the post-midnight sector.

キーワード: オーロラ, トモグラフィ, サブストーム, 渦構造, イメージャ, 電離圏電流系
Keywords: aurora, tomography, substorm, vortex structure, imager, ionospheric current