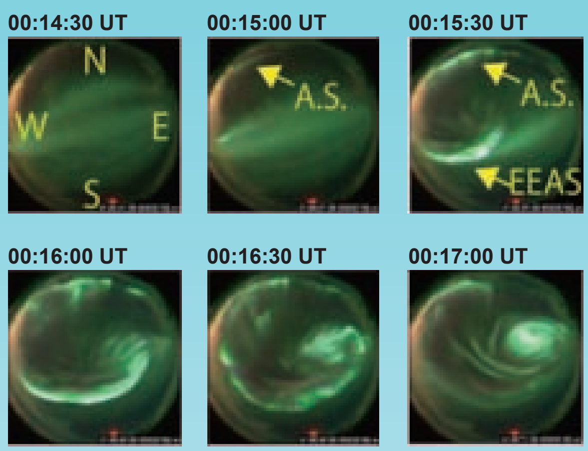
Earth, Planets and Space

The 12th International Conference on Substorms



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Earth, Planets and Space (EPS) is the official journal of the Society of Geomagnetism and Earth, Planetary and Space Sciences, The Seismological Society of Japan, The Volcanological Society of Japan, The Geodetic Society of Japan, and The Japanese Society for Planetary Sciences.
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Earth, Planets and Space

Shiokawa *et al. Earth, Planets and Space* (2016) 68:87
DOI 10.1186/s40623-016-0471-8

PREFACE **Open Access**

Special issue "The 12th International Conference on Substorms"

Kazuo Shiokawa[1*], Mei-Ching Fok[2] and Masaki Fujimoto[3]

The 12th International Conference on Substorms (ICS-12) was held at the Ise-Shima Royal Hotel in Shima, Japan, on November 10–14, 2014. There were 125 attendees including 68 from foreign countries. The ICS has been held every 2 years since 1992 to discuss substorms, which are fundamental global-scale disturbances in the Earth's magnetosphere. The year 2014 marked the 50th anniversary of the first publication about substorms (Akasofu 1964). The conference included three tutorial lecturers (Profs. S.-I. Akasofu, V. Angelopoulous, and D. Baker), as well as many international scientists, to discuss substorm processes in the tail, their interactions with the inner magnetosphere and the ionosphere, substorm currents and their dynamics and energetics, the role of MagnetoHydroDynamics (MHD) and kinetic instabilities, storm–substorm relationships, ULF/ELF/VLF waves, and non-Earth substorm-like features. Prof. Akasofu also gave an evening talk about the history of auroral research since the nineteenth century with photographs that inspired and intrigued the young scientists and students in attendance.

This special issue presents 16 papers from the ICS-12 presentations. The topics and related papers are: control of magnetospheric conditions by solar wind parameters (Kubyshkina et al. 2015; Sergeev et al. 2015; Troshichev and Sormakov 2015), modeling of reconnection and instabilities in the tail (Birn et al. 2015; Pritchett 2015; Uchino and Machida 2015), relationships between relativistic electrons and pulsations in the inner magnetosphere (Antonova and Stepanova 2015; Hajra et al. 2015; Teramoto et al. 2016), the effects of substorms on ionospheric irregularities and currents (Berngardt et al. 2015; Cherniak and Zakharenkova 2015; Connors and Rostoker 2015), auroral disturbances during substorms (Antonova et al. 2015; Connors et al. 2015; Tanaka et al. 2015), and ground magnetometer chains (Connors et al. 2016). In addition, a review paper by Akasofu (2015) based on his presentation at ICS-12 was published in *Progress in Earth and Planetary Science*. These papers provide a comprehensive overview of recent progress in research related to substorms from solar wind to the ionosphere. We hope that these publications provide resources for the understanding of the various physical processes that occur in the magnetosphere and ionosphere during substorms.

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Authors' contributions

All authors of this article served as the guest editors for this special issue. KS prepared this preface with the agreement of the other authors. All authors read and approved the final manuscript.

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Acknowledgements

We thank the members of the science organizing committee for ICS 12, the conference participants, and especially the authors of the papers in this special issue. We are grateful to the referees who served to evaluate the contributions and gave helpful comments and suggestions. We also express our sincere appreciation and deep sorrow for the demise of late Olaf Amm, who was initially a guest editor for this special issue, and made various helpful comments and suggestions as a member of the science organizing committee, but who passed away on December 16, 2014, 1 month after ICS-12.

Competing interests

The authors declare that they have no competing interests.

Received: 12 May 2016 Accepted: 12 May 2016
Published online: 24 May 2016

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Uchino H, Machida S (2015) Full-particle simulations of instabilities in a thin current sheet of the magnetospheric system prior to substorm onset. Earth Planets Space 67:165. doi:10.1186/s40623-015-0335-7

FULL PAPER **Open Access**

Relativistic electron acceleration during HILDCAA events: are precursor CIR magnetic storms important?

Rajkumar Hajra*, Bruce T Tsurutani, Ezequiel Echer, Walter D Gonzalez, Christiano Garnett Marques Brum, Luis Eduardo Antunes Vieira and Ondrej Santolik

Earth, Planets and Space 2015, **67**:109 DOI: 10.1186/s40623-015-0280-5
Received: 21 June 2015, Accepted: 22 June 2015, Published: 7 July 2015

Abstract

We present a comparative study of high-intensity long-duration continuous AE activity (HILDCAA) events, both isolated and those occurring in the "recovery phase" of geomagnetic storms induced by corotating interaction regions (CIRs). The aim of this study is to determine the difference, if any, in relativistic electron acceleration and magnetospheric energy deposition. All HILDCAA events in solar cycle 23 (from 1995 through 2008) are used in this study. Isolated HILDCAA events are characterized by enhanced fluxes of relativistic electrons compared to the pre-event flux levels. CIR magnetic storms followed by HILDCAA events show almost the same relativistic electron signatures. Cluster 1 spacecraft showed the presence of intense whistler-mode chorus waves in the outer magnetosphere during all HILDCAA intervals (when Cluster data were available). The storm-related HILDCAA events are characterized by slightly lower solar wind input energy and larger magnetospheric/ionospheric dissipation energy compared with the isolated events. A quantitative assessment shows that the mean ring current dissipation is ~34 % higher for the storm-related events relative to the isolated events, whereas Joule heating and auroral precipitation display no (statistically) distinguishable differences. On the average, the isolated events are found to be comparatively weaker and shorter than the storm-related events, although the geomagnetic characteristics of both classes of events bear no statistically significant difference. It is concluded that the CIR storms preceding the HILDCAAs have little to do with the acceleration of relativistic electrons. Our hypothesis is that ~10–100-keV electrons are sporadically injected into the magnetosphere during HILDCAA events, the anisotropic electrons continuously generate electromagnetic chorus plasma waves, and the chorus then continuously accelerates the high-energy portion of this electron spectrum to MeV energies.

Keywords: HILDCAAs; High-speed streams; CIRs; Chorus plasma waves; Radiation belt; Magnetospheric relativistic electrons; Solar wind; Geomagnetic storms

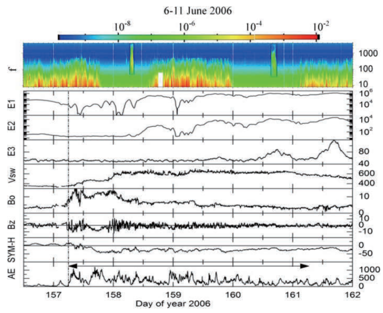

Figure 1

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Further evidence for the role of magnetotail current shape in substorm initiation

M. Kubyshkina*, N. Tsyganenko, V. Semenov, D. Kubyshkina, N. Partamies and E. Gordeev

Earth, Planets and Space 2015, **67**:139 DOI: 10.1186/s40623-015-0304-1
Received: 24 March 2015, Accepted: 11 August 2015, Published: 28 August 2015

Abstract

Substorm initiation still remains an unsolved problem, even though there is a consensus among most researchers that its main stages include dayside reconnection and substorm expansion. Dayside reconnection results in magnetotail flux buildup to a certain critical level, after which [or after the interplanetary magnetic field (IMF) Bz turns northward] the substorm expansion begins. One problem with the above scenario is that the critical amount of magnetic flux differs from one substorm to another, and not every northward turning of the IMF Bz triggers a substorm. We suggest that an important factor in substorm dynamics may be the variable shape and alignment of the magnetospheric tail current sheet, which bends and warps in response to diurnal/seasonal changes of the Earth's dipole tilt angle and also in response to more rapid changes of the solar wind flow direction. Both of these factors may be important, if one assumes that the deformed current sheet becomes unstable at lower values of the tail lobe magnetic flux/pressure than the planar sheet. To investigate this idea, we examined large multi-year sets of THEMIS, Cluster, and Geotail data and established a relationship between the tail lobe Bx and the dipole tilt angle. Further examinations of substorm events during 2005–2010 supported the hypothesis that their probability and intensity indeed depended on the concurrent values of the tilt angle.

Keywords: Magnetospheric substorm; Tail current sheet; Empirical modeling

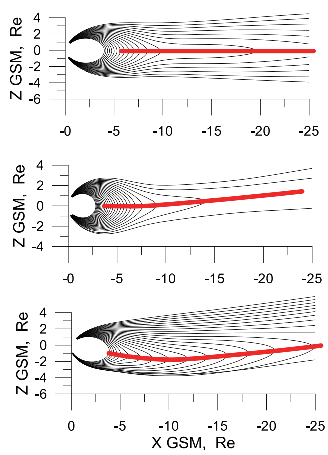

Figure 1

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Inverting magnetic meridian data using nonlinear optimization

Martin Connors* and Gordon Rostoker

Earth, Planets and Space 2015, **67**:155 DOI: 10.1186/s40623-015-0315-y
Received: 29 April 2015, Accepted: 27 August 2015, Published: 17 September 2015

Abstract

A nonlinear optimization algorithm coupled with a model of auroral current systems allows derivation of physical parameters from data and is the basis of a new inversion technique. We refer to this technique as automated forward modeling (AFM), with the variant used here being automated meridian modeling (AMM). AFM is applicable on scales from regional to global, yielding simple and easily understood output, and using only magnetic data with no assumptions about electrodynamic parameters. We have found the most useful output parameters to be the total current and the boundaries of the auroral electrojet on a meridian densely populated with magnetometers, as derived by AMM. Here, we describe application of AFM nonlinear optimization to magnetic data and then describe the use of AMM to study substorms with magnetic data from ground meridian chains as input. AMM inversion results are compared to optical data, results from other inversion methods, and field-aligned current data from AMPERE. AMM yields physical parameters meaningful in describing local electrodynamics and is suitable for ongoing monitoring of activity. The relation of AMM model parameters to equivalent currents is discussed, and the two are found to compare well if the field-aligned currents are far from the inversion meridian.

Keywords: Current systems; Substorms; Geophysical inversion techniques; Nonlinear optimization; Geomagnetism; Equivalent current

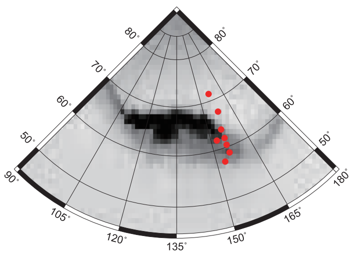

Figure 1

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Full-particle simulations of instabilities in a thin current sheet of the magnetospheric system prior to substorm onset

Hirotoshi Uchino* and Shinobu Machida

Earth, Planets and Space 2015, **67**:165 DOI: 10.1186/s40623-015-0335-7
Received: 29 April 2015, Accepted: 23 September 2015, Published: 8 October 2015

Abstract

Substorm triggering was the focus of recent two-dimensional superposed-epoch analyses based on Geotail and THEMIS data. The results indicate that magnetic-field dipolarization at $X \sim -8$ Re and magnetic reconnection at $X \sim -20$ Re occur simultaneously at the onset. These results imply that there are physical mechanisms that widely affect both the dipole and current-sheet regions. The analyses also have found that a local B_z enhancement appears before the substorm onset and magnetic reconnection occurs at its tailward edge. We performed four 2.5-dimensional full-particle simulations with a new initial magnetic-field structure to focus on instabilities in the magnetosphere. The structure is similar to the Earth's dipole magnetic field combined with a stretched field and current sheet on the tailward side. The simulation with the initial magnetic-field configuration shows that nodes of the magnetic field appear in the current sheet where the growth condition of tearing instability is satisfied. The features of the instability are close to those of the electron tearing mode reported in previous simulation results. Another three simulations with a local B_z enhancement, as seen in the observational results, at various locations in the current sheet were performed to explore its impacts on the evolution of the instability. A relaxation process around the enhancement generates a new node at its tailward edge if its location satisfies the growth condition. The wavelength and dominant mode of the instability can be changed by the coupling between the process and tearing mode depending on the location of the enhancement. Our simulations reveal new features associated with tearing instabilities in the magnetospheric-field configuration.

Keywords: Tearing instability; Magnetospheric substorm; Magnetic reconnection

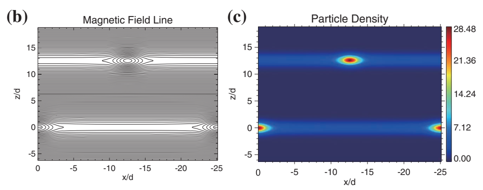

Figure 1

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PC index as a proxy of the solar wind energy that entered into the magnetosphere: 2. Relation to the interplanetary electric field E_{KL} before substorm onset

OA Troshichev* and DA Sormakov

Earth, Planets and Space 2015, **67**:170 DOI: 10.1186/s40623-015-0338-4
Received: 2 April 2015, Accepted: 6 October 2015, Published: 21 October 2015

Abstract

This paper (the second of a series) presents the results of statistical investigation of relationship between the interplanetary electric field E_{KL} and the Polar Cap (PC) index in case of magnetic substorms (1998–2001), which have been analyzed in Troshichev et al. (J. Geophys. Res. Space Physics, 119, 2014). The PC index is directly related to the E_{KL} field variations on interval preceding the substorm sudden onset (SO): correlation $R > 0.5$ is typical of more than 90 % of isolated substorms, 80 % of expanded substorms, and 99 % of events with coordinated E_{KL} and PC jumps. The low or negative correlation observing in ~10 % of examined substorms suggests that the solar wind flow measured by the Advanced Composition Explorer (ACE) spacecraft in the Lagrange point L1 did not encounter the magnetosphere in these cases. Examination of the delay times ΔT in the response of PC index to E_{KL} variations provides the following results: (1) delay times do not depend on separate solar wind parameters, such as solar wind speed V_X and interplanetary magnetic field (IMF) B_Z component, contrary to general conviction, (2) the ΔT value is best controlled by the E_{KL} field growth rate (dE_{KL}/dt), (3) the lower ΔT limit (5–7 min is attained under conditions of the higher E_{KL} growth rate, and (4) the PC index provides the possibility to verify the solar wind flow transportation time from ACE position (where the solar wind speed is estimated) to magnetosphere. These results, in combination with data testifying that the substorm onsets are related to the PC precursors, demonstrate that the PC index is an adequate ground-based indicator of the solar wind energy incoming into the magnetosphere.

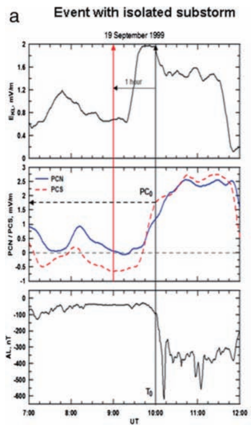

Figure 1

Keywords: Interplanetary electric field E_{KL}; PC index; Magnetic substorms; Delay time; Solar wind parameters growth rate; Solar wind energy input

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Eastward-expanding auroral surges observed in the post-midnight sector during a multiple-onset substorm

Yoshimasa Tanaka*, Yasunobu Ogawa, Akira Kadokura, Noora Partamies, Daniel Whiter, Carl-Fredrik Enell, Urban Brändström, Tima Sergienko, Björn Gustavsson, Alexander Kozlovsky, Hiroshi Miyaoka and Akimasa Yoshikawa

Earth, Planets and Space 2015, **67**:182 DOI: 10.1186/s40623-015-0350-8
Received: 30 April 2015, Accepted: 28 October 2015, Published: 9 November 2015

Abstract

We present three eastward-expanding auroral surge (EEAS) events that were observed intermittently at intervals of about 15 min in the post-midnight sector (01:55–02:40 MLT) by all-sky imagers and magnetometers in northern Europe. It was deduced that each surge occurred just after each onset of a multiple-onset substorm, which was small-scale and did not clearly expand westward, because they were observed almost simultaneously with Pi 2 pulsations at the magnetic equator and magnetic bay variations at middle-to-high latitudes associated with the DP-1 current system. The EEASs showed similar properties to omega bands or torches reported in previous studies, such as recurrence intervals of about 15 min, concurrence with magnetic pulsations with amplitudes of several tens of nanotesla, horizontal scales of 300–400 km, and occurrence of a pulsating aurora in a diffuse aurora after the passage of the EEASs. Furthermore, the EEASs showed similar temporal evolution to the omega bands, during which eastward-propagating auroral streamers occurred simultaneously in the poleward region, followed by the formation of north-south-aligned auroras, which eventually connected with the EEASs. Thus, we speculate that EEASs may be related to the generation process of omega bands. On the other hand, the EEASs we observed had several properties that were different from those of omega bands, such as greater eastward propagation speed (3–4 km/s), shorter associated magnetic pulsation periods (4–6 min), and a different ionospheric equivalent current direction. The fast eastward propagation speed of the EEASs is consistent with the speed of eastward expansion fronts of the substorm current wedge reported in previous studies. The difference in the ionospheric current between the EEASs and omega bands may be caused by a large temporal variation of the surge structure, compared with the more stable wavy structure of omega bands.

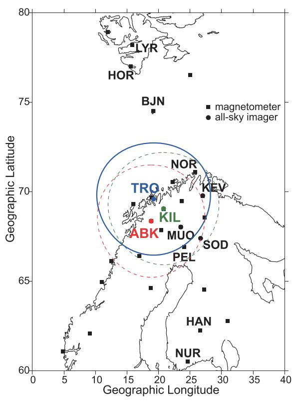

Figure 1

Keywords: Eastward-expanding auroral surges; Auroral streamers; Post-midnight sector; Substorm expansion phase; Omega bands; Magnetic pulsations; Ionospheric equivalent current

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The February 24, 2010 substorm: a refined view involving a pseudobreakup/expansive phase/poleward boundary intensification sequence

Martin Connors*, Christopher T. Russell, Xiangning Chu and Robert L. McPherron

Earth, Planets and Space 2015, **67**:195 DOI: 10.1186/s40623-015-0363-3
Received: 1 May 2015, Accepted: 9 November 2015, Published: 3 December 2015

Abstract

A substorm on February 24, 2010 was chosen for study by Connors et al. (Geophys. Res. Lett. 41:4449–4455, 2014) due to simple symmetric subauroral magnetic perturbations observed in North America. It was shown that a substorm current wedge (SCW) three-dimensional current model could represent these perturbations well, gave a reasonable representation of auroral zone perturbations, and matched field-aligned currents determined in space from the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE) project. The conclusion was that substorm onset was at approximately 4:30 UT and that the substorm current wedge (SCW) formed in the region 1 (more poleward) current system.

Here, we examine the substorm in more detail, using ground optical data, more ground magnetic measurements, and in-situ measurements in the region of the substorm downward current by three Time History of Events and Macroscale Interactions During Substorms (THEMIS) spacecrafts. We apply magnetic inversion techniques and find that they agree with and complement optical data. We find that a sequence involving three previously categorized types of substorm-related response took place, that is, a pseudobreakup or weak expansive phase, followed by the full onset of a substorm expansive phase (EP), and in turn by a poleward boundary intensification (PBI) carrying the bulk of the SCW current. The initial activity was equatorward of that described by Connors et al. (Geophys. Res. Lett. 41:4449–4455, 2014) and began at 4:11 UT. The THEMIS spacecraft in the early morning sector detected magnetic field changes associated with the EP and PBI, aiding in differentiating them. The fuller picture suggests involvement of regions both relatively near the Earth and deeper in the magnetotail, in the overall substorm process.

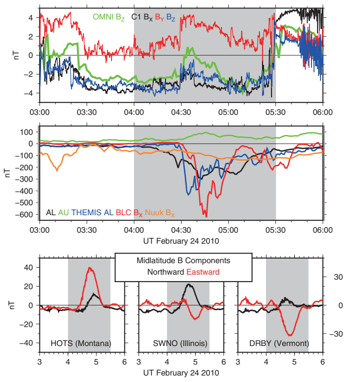

Figure 1

Keywords: Substorms; Pseudobreakups; Expansive phase; Poleward boundary intensifications; Data inversion

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FULL PAPER Open Access

The AUTUMNX magnetometer meridian chain in Québec, Canada

Martin Connors*, Ian Schofield, Kyle Reiter, Peter J. Chi, Kathryn M. Rowe and Christopher T. Russell

Earth, Planets and Space 2016, **68**:2 DOI: 10.1186/s40623-015-0354-4
Received: 6 May 2015, Accepted: 4 November 2015, Published: 7 January 2016

Abstract

The AUTUMNX magnetometer array consists of 10 THEMIS-class ground-based magnetometers deployed to form a meridian chain on the eastern coast of Hudson Bay in eastern Canada, a second partial chain one hour of magnetic local time further east, and one magnetometer at an intermediate midlatitude site. These instruments, augmented by those of other arrays, permit good latitudinal coverage through the auroral zone on two meridians, some midlatitude coverage, and detection of magnetic field changes near the sensitive infrastructure of the Hydro-Québec power grid. Further, they offer the possibility for conjugate studies with Antarctica and the GOES East geosynchronous satellite, and complement the Chinese International Space Weather Meridian Circle Program. We examine current world distribution of magnetometers to show the need for AUTUMNX, and describe the instrumentation which allows near-real-time monitoring. We present magnetic inversion results for the disturbed day February 17, 2015, which showed classic signatures of the substorm current wedge, and developed into steady magnetospheric convection (SMC). For a separate event later that day, we examine a large and rapid magnetic field change event associated with an unusual near-Earth transient. We show GOES East conjugacy for these events.

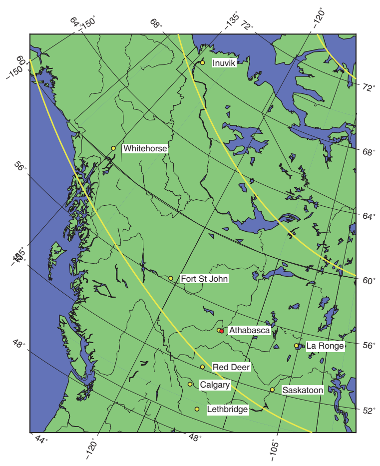

Figure 1

Keywords: Geomagnetism; Geophysical instrumentation; Geomagnetically induced currents; Substorm; Electrojet; Data inversion

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Latitudinal dependence on the frequency of Pi2 pulsations near the plasmapause using THEMIS satellites and Asian-Oceanian SuperDARN radars

Mariko Teramoto*, Nozomu Nishitani, Yukitoshi Nishimura and Tsutomu Nagatsuma

Earth, Planets and Space 2016, **68**:22 DOI: 10.1186/s40623-016-0397-1
Received: 13 May 2015, Accepted: 10 January 2016, Published: 17 February 2016

Abstract

We herein describe a harmonic Pi2 wave that started at 09:12 UT on August 19, 2010, with data that were obtained simultaneously at 19:00–20:00 MLT by three mid-latitude Asian-Oceanian Super Dual Auroral Radar Network (SuperDARN) radars (Unwin, Tiger, and Hokkaido radars), three Time History of Events and Macroscale Interactions during Substorms (THEMIS) satellites (THEMIS A, THEMIS D, and THEMIS E), and ground-based magnetometers at low and high latitudes. All THEMIS satellites, which were located in the plasmasphere, observed Pi2 pulsations dominantly in the magnetic compressional ($B_{//}$) and electric azimuthal (E_A) components, i.e., the fast-mode component. The spectrum of Pi2 pulsations in the $B_{//}$ and E_A components contained two spectral peaks at approximately 12 to 14 mHz (f_1, fundamental) and 23 to 25 mHz (f_2, second harmonic). The Poynting flux derived from the electric and magnetic fields indicated that these pulsations were waves propagating earthward and duskward. Doppler variations (V) from the 6-s or 8-s resolution camping beams of the Tiger and Unwin SuperDARN radars, which are associated with Pi2 pulsations in the eastward electric field component in the ionosphere, observed Pi2 pulsations within and near the footprint of the plasmapause, whose location was estimated by the THEMIS satellites. The latitudinal profile of f_2 power normalized by f_1 power for Doppler velocities indicated that the enhancement of the normalized f_2 power was the largest near the plasmapause at an altitude-adjusted corrected geomagnetic (AACGM) latitude of 60° to 65°. Based on these features, we suggest that compressional waves propagate duskward away from the midnight sector, where the harmonic cavity mode is generated.

Keywords: Pi2 pulsations near the plasmapause; Multipoint observations; Mid-latitude SuperDARN radars; THEMIS satellites

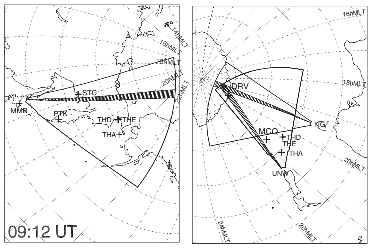

Figure 1

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LETTER Open Access

Reconnection flow jets in 3D as a source of structured dipolarization fronts

Philip L. Pritchett

Earth, Planets and Space 2015, **67**:103 DOI: 10.1186/s40623-015-0264-5
Received: 18 March 2015, Accepted: 5 June 2015, Published: 27 June 2015

Abstract

Three-dimensional electromagnetic particle-in-cell simulations are used to investigate the propagation and breakup of a reconnection flow jet of initial cross-tail extent $24d_i$ ($\sim 1.5R_E$; d_i is the ion inertial length). Such a front is found to separate into two segments, with the dawnward portion propagating ahead of the duskward one. Both segments expand duskward, reaching separate lengths of $18–25d_i$, and both segments develop internal structures on east–west scales of $1–2d_i$. The currents responsible for the ramp up of B_z at the fronts are confined to narrow ($\lesssim d_i$) ribbons whose localization is primarily associated with the electron U_{ey} flow. The incoming ion flow is slowed down and deflected duskward at the front, and ambient ions are reflected back from the moving front. These processes create regions of enhanced T_{ixx} both downstream and upstream of the front, while there is a local minimum at the front itself. These results help to explain the prevalence of $\sim 1R_E$ flow jets in the plasma sheet.

Keywords: Localized magnetic reconnection; Dipolarization front; Reconnection jet breakup; Ballooning/interchange mode; 3D PIC simulation; Ion temperature asymmetries

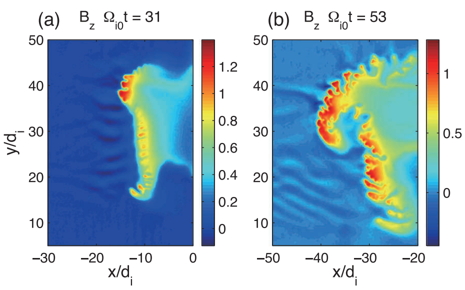

Figure 1

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LETTER Open Access

Reconnection and interchange instability in the near magnetotail

Joachim Birn*, Yi-Hsin Liu, William Daughton, Michael Hesse and Karl Schindler

Earth, Planets and Space 2015, **67**:110 DOI: 10.1186/s40623-015-0282-3
Received: 1 May 2015, Accepted: 25 June 2015, Published: 16 July 2015

Abstract

This paper provides insights into the possible coupling between reconnection and interchange/ballooning in the magnetotail related to substorms and flow bursts. The results presented are largely based on recent simulations of magnetotail dynamics, exploring onset and progression of reconnection. 2.5-dimensional particle-in-cell (PIC) simulations with different tail deformation demonstrate a clear boundary between stable and unstable cases depending on the amount of deformation, explored up to the real proton/electron mass ratio. The evolution prior to onset, as well as the evolution of stable cases, are governed by the conservation of integral flux tube entropy *S* as imposed in ideal MHD, maintaining a monotonic increase with distance downtail. This suggests that ballooning instability in the tail should not be expected prior to the onset of tearing and reconnection. 3-D MHD simulations confirm this conclusion, showing no indication of ballooning prior to reconnection, if the initial state is ballooning stable. The simulation also shows that, after imposing resistivity necessary to initiate reconnection, the reconnection rate and energy release initially remain slow. However, when *S* becomes reduced from plasmoid ejection and lobe reconnection, forming a negative slope in *S* as a function of distance from Earth, the reconnection rate and energy release increase drastically. The latter condition has been shown to be necessary for ballooning/interchange instability, and the cross-tail structures that develop subsequently in the MHD simulation are consistent with such modes. The simulations support a concept in which tail activity is initiated by tearing instability but significantly enhanced by the interaction with ballooning/interchange enabled by plasmoid loss and lobe reconnection.

Keywords: Reconnection; Interchange; Magnetotail dynamics; Substorms

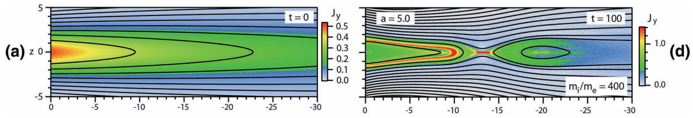

Figure 1

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LETTER Open Access

On the plasma sheet dependence on solar wind and substorms and its role in magnetosphere-ionosphere coupling

V A Sergeev*, N P Dmitrieva, N A Stepanov, D A Sormakov, V Angelopoulos and A V Runov

Earth, Planets and Space 2015, **67**:133 DOI: 10.1186/s40623-015-0296-x
Received: 26 March 2015, Accepted: 24 July 2015, Published: 19 August 2015

Abstract

Recently, it was argued that Hall conductivity and peak intensity of equivalent ionospheric currents are sensitive to the amount of field-aligned acceleration of plasma sheet (PS) electrons, which in turn depends on the plasma sheet parameters T_e and N_e (electron temperature and density) proportionally to the quantity eTN = $(T_e)^{1/2}/N_e$. Here we extend these studies using data from six tail seasons of THEMIS observations to show statistically that the behavior of these PS electron parameters, measured in the middle of the nightside plasma sheet at ~10 R_E distance, depends in a very different way on two basic processes: the solar wind state and substorms. We confirm previous work that slow/dense (fast/tenuous) solar wind provides cold/dense (hot/tenuous) plasma sheet conditions. However, we find that electron temperature and pressure parameters (T_e and P_e) behave differently from the proton ones (T_p and P_p), indicating a strong decoupling between temperature variations of auroral protons and electrons in the central plasma sheet (CPS): electrons are more sensitive to the substorm-related acceleration in the magnetotail than protons. Our superposed epoch study of plasma sheet parameter variations during substorms as well as our analysis of plasma acceleration at dipolarization fronts shows that during the substorm expansion phase a new (accelerated and plasma-depleted) population comes into the inner CPS with the flow bursts, showing an average increase of electron temperature and eTN parameter roughly by a factor of 2 above its background values for both cold/dense and hot/tenuous plasma sheet states. Preferential electron heating in the flow bursts is also statistically confirmed.

Keywords: Plasma sheet; Particle acceleration; Solar wind driver; Substorms; Flow burst

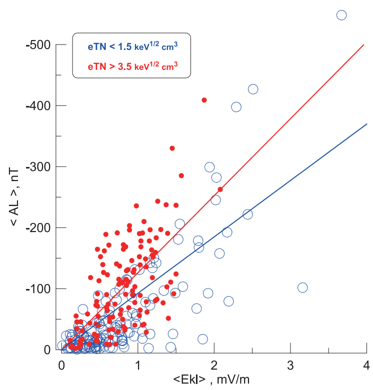

Figure 1

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LETTER Open Access

Observations of field-aligned ionospheric irregularities during quiet and disturbed conditions with EKB radar: first results

Oleg I. Berngardt*, Nina A. Zolotukhina and Alexey V. Oinats

Earth, Planets and Space 2015, **67**:143 DOI: 10.1186/s40623-015-0302-3
Received: 30 April 2015, Accepted: 10 August 2015, Published: 3 September 2015

Abstract

This paper presents the first results of statistical analysis of 2-year data series obtained with the first midlatitude decameter coherent radar of Russian segment of SuperDARN network. Based on individual events observed on 13–15 December 2013 and 1–4 January 2014, we also demonstrate the possibility of using the radar data for monitoring of magnetosphere-ionosphere dynamics in quiet and disturbed geomagnetic conditions.

Keywords: Midlatitude SuperDARN radar; Dynamics of field-aligned ionospheric irregularities; Substorm-like events

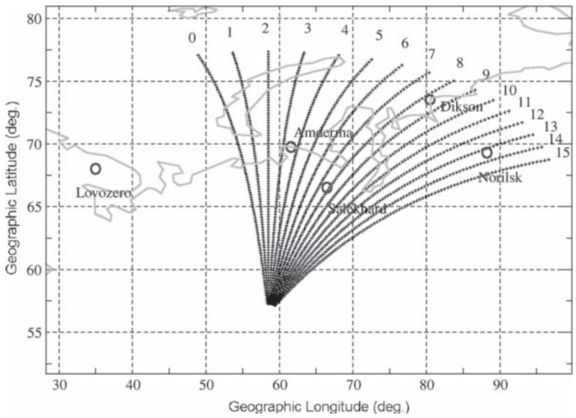

Figure 1

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LETTER Open Access

The problem of the acceleration of electrons of the outer radiation belt and magnetospheric substorms

E. E. Antonova* and M. V. Stepanova

Earth, Planets and Space 2015, **67**:148 DOI: 10.1186/s40623-015-0319-7
Received: 1 May 2015, Accepted: 28 August 2015, Published: 15 September 2015

Abstract

Predicting of the location of the maximum in high-energy electron fluxes filling a new radiation belt is an endeavor being carried out by physicists studying the magnetosphere. We analyzed the data from the Defense Meteorological Satellite Program (DMSP) satellites and ground-based magnetometers obtained during geomagnetic storm on 8–9 October 2012. The minimum value of the disturbance storm time (Dst) was −111 nT, and the maximum in high-energy electron fluxes that appeared during the recovery phase was observed at $L = 4\,Re$. At the same time, we analyzed the motion of the auroral oval toward lower latitudes and related substorm activity using the data of the low-orbiting DMSP satellites and the IMAGE magnetic meridian network. It was found from the DMSP satellites' measurements that the maximum of the energy density of precipitating ions, the maximum of the plasma pressure, and the most equatorial part of the westward auroral electrojet are all located at the 60° geomagnetic latitude. This value corresponds to $L = 4\,Re$, i.e., it coincides with the location of the maximum in high-energy electron fluxes. This L-value also agrees with the predictions of the Tverskaya relation between the minimum in Dst variation and the location of the maximum of the energetic electron fluxes, filling a new radiation belt. The obtained results show that the location of this maximum could be predicted solely from the data of the auroral particle precipitations and/or ground-based magnetic observations.

Keywords: Magnetospheric storm and substorm; Outer radiation belt; Auroral oval

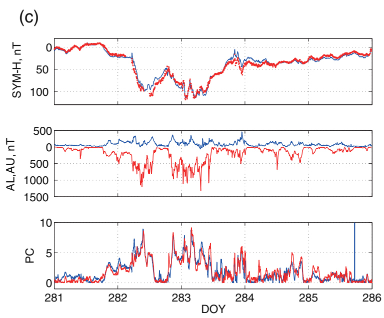

Figure 1

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LETTER **Open Access**

Dependence of the high-latitude plasma irregularities on the auroral activity indices: a case study of 17 March 2015 geomagnetic storm

Iurii Cherniak* and Irina Zakharenkova

Earth, Planets and Space 2015, **67**:151 DOI: 10.1186/s40623-015-0316-x
Received: 2 May 2015, Accepted: 27 August 2015, Published: 15 September 2015

Abstract

The magnetosphere substorm plays a crucial role in the solar wind energy dissipation into the ionosphere. We report on the intensity of the high-latitude ionospheric irregularities during one of the largest storms of the current solar cycle—the St. Patrick's Day storm of 17 March 2015. The database of more than 2500 ground-based Global Positioning System (GPS) receivers was used to estimate the irregularities occurrence and dynamics over the auroral region of the Northern Hemisphere. We analyze the dependence of the GPS-detected ionospheric irregularities on the auroral activity. The development and intensity of the high-latitude irregularities during this geomagnetic storm reveal a high correlation with the auroral hemispheric power and auroral electrojet indices (0.84 and 0.79, respectively). Besides the ionospheric irregularities caused by particle precipitation inside the polar cap region, evidences of other irregularities related to the storm enhanced density (SED), formed at mid-latitudes and its further transportation in the form of tongue of ionization (TOI) towards and across the polar cap, are presented. We highlight the importance accounting contribution of ionospheric irregularities not directly related with particle precipitation in overall irregularities distribution and intensity.

Keywords: Ionosphere irregularities; Geomagnetic storm; Auroral hemispheric power index; Auroral precipitation; GPS; ROTI

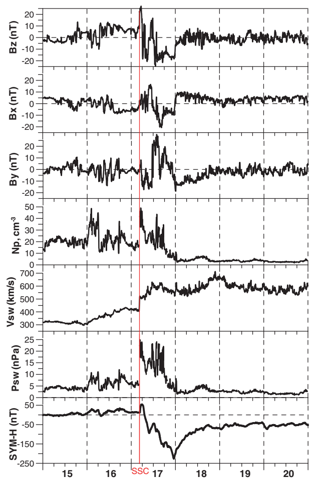

Figure 1

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LETTER **Open Access**

Problems with mapping the auroral oval and magnetospheric substorms

E. E. Antonova*, V. G. Vorobjev, I. P. Kirpichev, O. I. Yagodkina and M. V. Stepanova

Earth, Planets and Space 2015, **67**:166 DOI: 10.1186/s40623-015-0336-6
Received: 30 April 2015, Accepted: 1 October 2015, Published: 12 October 2015

Abstract

Accurate mapping of the auroral oval into the equatorial plane is critical for the analysis of aurora and substorm dynamics. Comparison of ion pressure values measured at low altitudes by Defense Meteorological Satellite Program (DMSP) satellites during their crossings of the auroral oval, with plasma pressure values obtained at the equatorial plane from Time History of Events and Macroscale Interactions during Substorms (THEMIS) satellite measurements, indicates that the main part of the auroral oval maps into the equatorial plane at distances between 6 and 12 Earth radii. On the nightside, this region is generally considered to be a part of the plasma sheet. However, our studies suggest that this region could form part of the plasma ring surrounding the Earth. We discuss the possibility of using the results found here to explain the ring-like shape of the auroral oval, the location of the injection boundary inside the magnetosphere near the geostationary orbit, presence of quiet auroral arcs in the auroral oval despite the constantly high level of turbulence observed in the plasma sheet, and some features of the onset of substorm expansion.

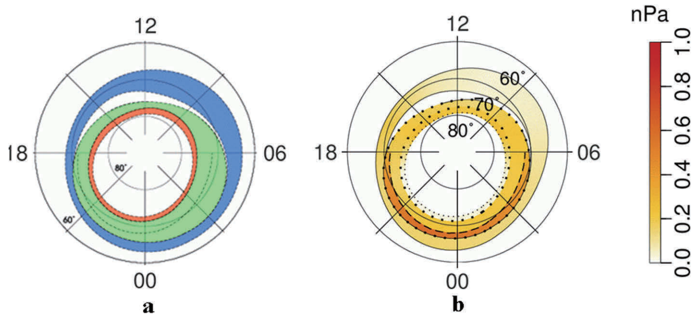

Figure 1

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A Grant-in-Aid for Publication of Scientific Research Results (251001) from Japan Society for the Promotion of Science is used for printing.

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Cover image: Tanaka, Y. *et al.*, *Earth, Planets and Space* 2015, **67**:182 DOI: 10.1186/s40623-015-0350-8