

PEM005-01

Room:303

Time:May 26 14:15-14:35

## Structural Growth of Magnetic Flux Systems and Solar Eruption

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Erupting magnetic structures seen in coronal mass ejections are of grand scales. There have been speculations that such structures are formed in the solar interior before their emergence out of the solar surface. However, the structures observed to emerge into the solar photosphere are usually of a much smaller scale than the coronal structures observed before eruption. In this paper, we examine the evolution of a group of small scale flux tubes into stepwisely larger scale flux systems while magnetic helicity is continuously injected into the corona. As magnetic helicity increases, individual flux tubes expand and reconnect with each other to create new field line connections between magnetic patches separated farther than the footpoint distance of the original connection. Thus created are new flux systems of larger scales, which are entwined with mutual magnetic helicity. When the system reaches a critical state, in which it can no more increase the footpoint distances by magnetic reconnection, the system must eject excessive magnetic helicity and energy away from the boundary. This process arises as an eruptive phenomenon in the solar corona. A relevant observation is presented and compared with the simulation. It is also found that a localized eruptive behavior may take place with a smaller helicity input through a ballooning instability when the plasma beta is relatively high (though still lower than unity).

Keywords: coronal mass ejections, magnetic reconnection, magnetic helicity, ballooning instability

PEM005-02

Room:303

Time:May 26 14:35-14:50

## Loss of storm-time ring current

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The development of the ring current is the manifestation of magnetic storms. Decay of the ring current occurs when loss of particles trapped in the inner magnetosphere exceeds injection of particles. It had been thought that the charge exchange with geocoronal neutral hydrogen is the dominant loss process for the storm-time ring current. Recently, we have shown that pitch angle scattering due to violation of the 1st adiabatic invariant in a curved field line plays an important role in the rapid decay of the ring current by means of a numerical simulation. Hereinafter, we refer this to field line curvature (FLC) scattering. Some of the scattered particles are entered into the loss cone, and precipitated into the upper atmosphere, resulting in proton aurora. The power of precipitating protons is consistent with that obtained from the proton auroral observation for the large magnetic storm of August 12, 2000. However, a few issues remain to be solved with regard to the followings: When does the FLC scattering dominates the charge exchange? Why was the observed proton aurora expanded largely in comparison with the simulation? Is an inclination of the magnetic field at geosynchronous altitude good proxy for the equatorward boundary of the proton precipitation as was previously suggested? We will discuss these issues and role of the FLC scattering in the recovery of magnetic storms in detail.

Keywords: ring current, decay, magnetic storms

PEM005-03

Room:303

Time:May 26 14:50-15:05

## Coronal disturbances unveiled with recent observations

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Solar flares are very spectacular, and they are accompanied by various kinds of active phenomena. We also observe waves and wave-like coronal disturbances associated with flares. Moreton waves, which are seen traveling with the speed of about 1000 km/s in H-alpha images, are an example of flare-associated wave phenomena. They are thought to be the intersections of MHD fast shock front traveling in the corona with the chromosphere. As the coronal counterpart of Moreton waves, X-ray waves have also been studied. EIT waves (or EUV waves) are another major player in coronal disturbance studies. They are also expected to be the coronal counterpart of MHD fast shock, while the traveling speed is much slower of about 300 km/s than those for Moreton waves/X-ray waves. There have been, therefore, many discussions on the nature of EUV waves. I overview recent observations of flare-associated waves and wave-like coronal disturbances especially done by Hinode, STEREO, and SDO.

Keywords: solar flare, corona, chromosphere, MHD shock

PEM005-04

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Time:May 26 15:05-15:20

## Solar wind-radiation belt coupling via wave-particle interactions

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We investigate the solar wind-radiation belt coupling process, focusing on the large flux enhancement of outer belt electrons associated with high speed coronal hole streams. The flux enhancement tends to occur during the high-speed streams with predominantly southward interplanetary magnetic field (IMF). The IMF dependence can be understood as a result of the internal acceleration of relativistic electrons by wave-particle interactions as follows: The internal acceleration by wave-particle interactions is especially effective when a continuous source of hot electrons is maintained to produce chorus waves for several days. The continuous injection is enhanced during a prolonged period of intense convection and/or substorms associated with southward IMF in high-speed streams. Here we show evidence that the activities of hot electrons, whistler mode chorus waves, and convection/substorms during southward IMF events are clearly different from that during northward IMF events. Based on these results, we propose a model of solar-wind radiation belt coupling in which wave-particle interactions driven by continuous hot electron injections play an important role for the flux enhancement of outer belt electrons.

Keywords: radiation belts, solar wind, relativistic electron acceleration

PEM005-05

Room:303

Time:May 26 15:20-15:35

## Hinode observations of activities in emerging flux regions

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After a long silent period in the solar minimum phase, the Sun is gradually increasing its magnetic activities and produces sunspots and active regions on the surface, although slow increase. Sunspots are formed with successive emergences of magnetic flux from below the surface, Emergences trigger microflares and jets frequently, and occasionally flares. A large-scale emergence activity may cause large flares, which give influences to the geo-space environment. Thus, understanding natures of magnetic emergences and their associated activities is one of important topics in space weather researches. The solar observing satellite "Hinode" has been performing continuous observations of photospheric magnetic fields, chromospheric features and X-ray corona with the unpreceding high spatial resolution and it is an observatory suitable for investigating the relations between emerging activities and dynamics in the atmosphere. This presentation will present a continuous observation of the emerging flux region in 29-31 December 2009, which successfully captures the temporal evolution from before the emergence to the formation of a large sunspot, and discuss the magnetic field configuration responsible for activities such as microflares and jets (plasma ejections). A remarkable finding is that microflares and jets are produced with high frequency in the magnetic channel formed in the developing sunspot, and the magnetic field configuration observed there is never discussed so far.

Keywords: Sun, Emerging Flux, Flares, Jets

PEM005-06

Room:303

Time:May 26 15:35-15:50

## Asia-Oceania Space Weather Alliance

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It is often said that, for human being, the 21st century is a century of space. Our daily lives will be more dependent on space and the practical use of the space is getting more important: satellite communication systems, satellite broadcasting systems, satellite navigation systems, international space station and so on. Space vehicles, such as spacecraft and space station, are always in severe environment with energetic particles and strong electromagnetic fields. For safety operations of these vehicles in the space, predictions of the severe conditions, e.g., when it comes, how large it is and how much the estimated damage is, are indispensable. These predictions are often called Space Weather information, which is named after general weather forecasting.

In these days, a lot of countries and organizations have been promoting researches and also practical space weather services, aiming at providing information of space environment. In order to provide more accurate and valuable space weather information, data exchange between countries and organizations are important. We should note that a launch of spacecraft costs at least \$1 million. Every country cannot afford to launch such expensive vehicle to the space.

With the backgrounds mentioned above, the United States and Europe countries have had annual meetings for space weather operations and researches: the Space Weather Workshop in the US and the Space Weather Week in EU. These regional meetings have helped their collaboration, information exchange, and operation of space weather activities in both regions. Through these face-to-face meetings, space weather forecast activities have been still in progress.

We need to point out that we have no such regional cooperative relationship among Asia and Oceania countries. However, the cooperation of each country is also indispensable to offer information that supports Space Activity of the 21st century in these countries. Here we propose our international space weather alliance: the Asia-Oceania Space Weather Alliance (AOSWA). The AOSWA is a regional forum for the development of collaboration and promotion of the space weather activities in the Asia and Oceania region. The major objectives of the AOSWA are (i) regional exchanges of both real-time and archived data between Asia and Oceania countries, including sun and solar, geomagnetic and ionospheric observation and computer simulation data, (ii) research collaborations between Asia Oceania countries on space weather, and (iii) communication and information exchange for space weather operation, research and education (outreach).

We had two kick-off meetings of the AOSWA at Indonesia and Thailand. More than 10 countries were involved in the discussion and most of the attendees gave their approbation. In the present talk, we introduce the concept of the AOSWA and discuss our future plan to progress our space weather operations and researches in the Asia and Oceania regions.



Keywords: Asia, Oceania, Space Weather, Alliance, Observation, Simulation

PEM005-07

Room:303

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## CME-driven Interplanetary Shocks and associated Sudden Commencement signatures observed at low latitudes

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Interplanetary (IP) shocks driven by coronal mass ejections (CMEs) are indicative of powerful eruptions on the sun that accelerate to very high energies. Recently, it is reported that the radio-emission characteristics of 222 interplanetary (IP) shocks detected by spacecraft at Sun-Earth L1 during solar cycle 23 (1996 to 2006, inclusive) (Gopalswamy et al., 2009). A surprisingly large fraction of the IP shocks (~34%) was radio quiet (i.e., the shocks lacked type II radio bursts) compared to radio-loud (RL) shocks. These CME driven shocks arriving at Earth also compress the magnetosphere causing storm sudden commencement (SSC), which may be followed by a geomagnetic storm if the shock sheath and /or the driving IP CME (ICME) contains south-pointing magnetic field. We examined the properties of SSCs amplitude which observed at low latitude stations Alibag (ABG, 10. 17 N Geo.mag.Lat.) related to the IP/ICME/ CME shock speeds. We further analysed the categories of RL and RQ shocks and associated characteristics of SSCs. It is interesting to observe that the RL shocks have produced high amplitude SCs than RQ shocks and also investigated associated phenomena such as Ejecta and Magnetic cloud type and related shocks. The important results will be presented and discussed.

### References

N. Gopalswamy et al., American Astronomical Society, 2009.

**Keywords:** Interplanetary shocks, sudden commencements, magnetic storms

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PEM005-08

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## Observation and Physical Mechanism of Substorms

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We present key features of substorm observation and their physical mechanism. In particular, we emphasize the fine structure in the breakup arcs and the associated magnetic fluctuations in Pi1 and Pi2 frequency ranges and their exponential growing behaviors before the arc breakup. We will discuss the possible physical mechanism of substorm onset in the magnetosphere and the formation of auroral breakup arc in the ionosphere. We will also discuss the turbulent states, the current disruption and magnetic field dipolarization processes and the dispersionless particle injection during the expansion phase.

Keywords: substorms



PEM005-09

Room:303

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## Response of ring current ion dynamics during the storm recovery phase to different solar wind drivers

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Geomagnetic storms, which are represented by the Dst index, show time profiles different between solar wind drivers such as Coronal Mass Ejections (CME) and Corotating Interaction Regions (CIR). A super-posed epoch analysis of Dst [Miyoshi and Kataoka, 2005, GRL] shows a distinct difference during the late recovery phase; Dst for CIR-driven storms is smaller than that for CME-driven storms. In addition, the flux of radiation belt electrons is higher for CIR-driven storms than for CME-driven storms.

It is well known that Dst development is strongly coupled with the evolution of the ring current which is mainly governed by ion pressure in the inner magnetosphere. The ring current spatial-temporal evolution results in distortion of the magnetic field configuration in the inner magnetosphere and accordingly can affect the dynamics of radiation belt electrons. In this study, we investigate the response of ring current ion dynamics during the storm recovery phase to different solar wind drivers, by comparing the temporal variations of energy spectra of energetic neutral atoms (ENAs) between CIR- and CME-driven storms.

We use ENA data obtained with the High Energy Neutral Atom (HENA) imager onboard the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) satellite. The ENA energy used in the present study ranges from 10 keV to 198 keV for hydrogen and from 29 keV to 222 keV for oxygen. We use ENA data integrated over image pixels; ENAs generated within HENA line-of-sights passing by close to the Earth are excluded in order to distinguish high-altitude emissions from low-altitude emissions. The ENA imaging enables continuous monitoring of spatial distributions and energy spectra of ring current ions.

Case studies of the temporal evolution of ENA energy spectra for three CME-driven storms [Keika et al., 2011, JGR, in press] suggested that the contribution from >60 keV H<sup>+</sup> to the ring current intensity increases as a storm recovers. The ring current intensity was dominated by higher energy (>60 keV) H<sup>+</sup> during the late recovery phase. This paper extends the study toward comparison between different solar wind drivers. We study possible differences in the dominant loss process and energy ranges that contribute most to the ring current energy. We also discuss the role played by the ring current in the difference in radiation belt electron flux between CIR- and CME-driven storms.

**Keywords:** Magnetic storms, ring current, CME, CIR

PEM005-10

Room:303

Time:May 26 17:05-17:20

## A Possible Mechanism of Flux Cancellation via U-loop Emergence on the Sun

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We use a 3-dimensional MHD simulation to investigate a dynamic process producing flux cancellation on the solar surface. Our calculations are fully self-consistent in that any prescribed dynamic process is not applied on the surface, which is self-consistently generated via the emergence of a twisted flux tube. Most of the flux that emerges below the surface is in the form of  $\Omega$ -loops (concave down geometry), so that dense photospheric plasma can drain down along the legs of the loop as it rises into the corona. We find, however, that some U-loops (concave up geometry) can also emerge. A U-loop geometry implies that a field line has a dip below the surface and a local peak somewhere above the surface on either side of the dip. Although the emergence of U-loops can produce flux cancellation on the surface, loops with such a geometry are not expected to emerge easily, due to the trapping of dense plasma in the dipped portion of the loops. Our results indicate that if one of the peaks is sufficiently low, of the order of the photospheric gravitational scale height above the surface, plasma can drain out of the dipped portion by a siphon-like mechanism, allowing the U-part of loops to emerge and resulting in the cancellation of magnetic flux on the surface. But if both peaks of a U-loop are high compared to the photospheric scale height, dense plasma simply settles in the dip of the loop, preventing the U-part from emerging, rather producing reconnection which is another possible mechanism of flux cancellation. We also discuss the implications of our results for observations.

Keywords: Coronal mass ejections, Prominence eruption, Flux emergence

PEM005-11

Room:303

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## Flux dependence of magnetic cancellation on the solar photosphere

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We report the flux dependence of magnetic cancellations on the photosphere by using the long-term observation and automatic detection. Various solar energetic activities, such as X-ray bright points and solar jets, are caused by magnetic field. It is very important to know the flux distribution for understanding of statistical characters of such solar activities. Parnell et al.(2009) reports the power law distribution of magnetic flux content on solar photosphere, which continues from large active regions to network field in quiet Sun. This flux distribution is thought to be achieved and maintained by four magnetic activities, namely emergence, splitting, merging, and cancellation. There are few statistical investigation of these activities so far. We reported the flux dependence of splitting and merging in the PEM029-P08 of the JpGU meeting 2010. We discussed that emergence and cancellation in the investigated range do not take large roles in flux balance from the result that they are much less frequent than splitting and merging. However, there is a possibility that tiny cancellations below the observational threshold take a large part of flux balance. We can evaluate cancellations below the observational from the flux dependence of cancellation frequency.

Line of sight magnetograms obtained by Solar Optical Telescope(SOT)/ Narrowband Filter Imager(NFI) on board Hinode satellite is used in this study. The data period of this data set is from 2008 December 30th 10:29UT to 2009 January 5th 5:37UT. The time interval of data is 5 minutes and full field of view is 121"x121". The observation period is long enough to investigate the statistical property of cancellations. Same algorithm for detection and tracking of magnetic patches is employed as the previous study (see JpGU meeting 2010 PEM029-P08). 18000 positive patches and 13000 negative patches are detected in this data set. The flux dependence of cancellations are a power-law distribution with an index of -2.5. The power-law index steeper than -2 means cancellations between smaller patches take larger part of magnetic flux content. We will also discuss the relationship between a power-law index of flux content and that of cancellation.

Keywords: the Sun, photosphere, magnetic field, magnetic flux cancellation, quiet Sun

PEM005-12

Room:303

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## Whistler-mode and EMIC triggered emissions

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We develop a nonlinear wave growth theory of VLF whistler-mode emissions, taking into account the spatial inhomogeneity of the static magnetic field and the plasma density variation along the magnetic field line. We also derive theoretical expressions for the nonlinear growth rate and the amplitude threshold for the generation of self-sustaining rising tone emissions like chorus emissions. The theory is extended for electromagnetic ion cyclotron (EMIC) triggered emissions observed by Cluster spacecraft. We performed a self-consistent particle simulation, in which we inject triggering whistler-mode waves with a constant frequency. The resonant electrons are organized at the resonance velocity in the velocity phase space, and they are released from the triggering wave near the equator. Because of the organized phase structures, the electrons radiate a coherent wave with an increasing frequency that undergoes the nonlinear wave growth due to formation of an electromagnetic electron hole. Self-sustaining emissions become possible when the wave propagates away from the equator. The self-sustaining mechanism can result in rising tone emissions covering the frequency range below the equatorial electron cyclotron frequency. We also performed a hybrid-code simulation injecting EMIC waves as triggering waves. We found the nonlinear wave growth of EMIC triggered emissions below the proton cyclotron frequency. We obtain a pair of coupled differential equations for the wave amplitude and frequency. Solving the equations numerically, we can reproduce characteristics of whistler-mode chorus emissions and EMIC rising tone emissions observed in the inner magnetosphere.

Keywords: wave-particle interaction, whistler-mode wave, chorus, EMIC, nonlinear, radiation belts

PEM005-13

Room:303

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## Study of the inner magnetospheric response to pressure pulses in the solar wind based on the GEMSIS-RC model

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Geospace storms are the largest electromagnetic disturbance in near-Earth space and facilitate extensive particle acceleration in the inner magnetosphere, which causes development of the ring current and a drastic increase of relativistic electrons in the radiation belt. GEMSIS (Geospace Environment Modeling System for Integrated Studies) of STEL, Nagoya University, is the observation-based modeling project for understanding energy and mass transportation from the Sun to the Earth in the geospace environment. Aiming at understanding the dynamics of the inner magnetosphere during the geospace storms, the GEMSIS-Magnetosphere working team has addressed the development of new physics-based models for the global dynamics of the ring current (GEMSIS-RC model) and radiation belt (GEMSIS-RB model).

The GEMSIS-RC model is a self-consistent and kinetic numerical simulation code solving the five-dimensional collisionless drift-kinetic equation for the ring-current ions in the inner-magnetosphere coupled with Maxwell equations. It is demonstrated that the propagation of magnetohydrodynamic waves can successfully be described by the present model. It is also found that the self-consistent coupling could affect the transport of energetic particles especially at low energies as well as the intensity and spatial distribution of field-aligned currents. Our approach is unique in the sense that it includes MHD wave modes as well as deformation of magnetic field configuration due to the ring current self-consistently. In order to investigate responses of the inner magnetosphere to pressure pulses in the solar wind, time variation of magnetic and electric fields as well as the ring current ion distributions is simulated based on the GEMSIS-RC model with simple boundary conditions to mimic an abrupt compression of the inner magnetosphere. The effects of the pressure pulses on excitation of ULF waves, generation of FAC, and change in the pitch angle distribution of ring current ions will be discussed for several cases.

Keywords: inner magnetosphere, ULF waves, ring current, radiation belt, SC, solar wind dynamic pressure

PEM005-14

Room:303

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## Theoretical and statistical studies of the magnetic storm effects to ionosphere

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Magnetic storm affects the ionospheric electron density structure through modifications of the ionospheric electric field, thermospheric neutral winds and compositions. The electric field disturbances are produced by prompt penetration electric field, shielding electric field and neutral wind disturbance dynamo, while the neutral wind and composition disturbances are produced by global circulation changes as a result of energy deposition at the high latitude/aurora region. The electric field disturbances modulate the equatorial plasma fountain and ionospheric height leading to ionospheric electron density disturbance. On the other hand, the neutral wind disturbance affects the plasma transport, and the composition change by reducing the [O]/[N<sub>2</sub>] ratio speeds up the recombination loss process of the ionospheric plasma. As the electric field, neutral wind and composition effects are often mixed during the storm period, the resulting ionospheric plasma structure becomes complex. In this study, we first review theoretical simulations of these combined ionospheric storm effects by using the NCAR thermosphere ionosphere electrodynamics general circulation model (TIEGCM) and the Sheffield University Plasmasphere Ionosphere Model (SUPIM). From theoretical modeling tasks, relative importance of these disturbed ionospheric drivers and their combined effects are evaluated and studied. Based on the model results, we further examine the GPS-TEC observations of magnetic storms occurred during ten-year period of 1999-2009 to study the ionospheric disturbances under various storm conditions.

Keywords: Ionospheric storm effect

PEM005-15

Room:303

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## RECENT ICME ANALYSIS USING SOLAR MASS EJECTION IMAGER DATA

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The Air Force/NASA Solar Mass Ejection Imager (SMEI) placed in orbit on 6 January 2003 records whole-sky images over each 102-minute orbit. Once a large background from zodiacal light, starlight, and aurora is removed, these precise photometric images allow a nearly continuous measurement of the electron Thomson-scattering density component of the inner heliosphere. A tomographic technique then yields a 3-D analysis of this brightness allowing the measurement of the solar wind bulk density. We have refined our tomography program to analyze both corotating heliospheric structures and more time-dependent phenomena such as Interplanetary Coronal Mass Ejections (ICMEs). A portion of these observations and data access to the volumetric-analysis results are available on the UCSD Website at <http://smei.ucsd.edu>, and also at the Community Coordinated Modeling Center (CCMC) at the NASA Goddard Spaceflight Center. Here we highlight a study of two recent events that were measured by this instrumentation. The first event arrived at the STEREO-B spacecraft late in 20 January, 2010. A flux rope present at STEREO-B has an associated increase in density at its center that is reproduced well by the SMEI analysis, which in turn allows its orientation to be determined. The second event began to arrive at Earth on 3 August 2010: here the SMEI analyses map various portions of this complex ICME structure produced by multiple CME eruptions from the solar surface a few days earlier.

**Keywords:** Coronal Mass Ejections (CMEs), Interplanetary CMEs, Magnetic Flux Ropes, The Solar Mass Ejection Imager - SMEI, Space Weather, Solar Wind

PEM005-16

Room:303

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## Large-scale three-dimensional MHD numerical experiment on the solar flux emergence and the formation of active region

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To study the formation of solar active regions, we perform three-dimensional magnetohydrodynamic (MHD) experiment on the flux emergence from a depth of 20,000 km.

It is widely thought that the flux generated at the bottom of the convection zone rises through the interior and appears at the surface to form an active region. Previous studies on flux emergence have been separated into two groups: one is the study on the emergence in the interior and the other on that above the surface. Thus, as a next step, we aim to research the flux emergence from the deep interior to the corona in a consistent manner.

In our preceding studies, we have carried out two-dimensional calculations on the flux emergence from -20,000 km and found the condition of the flux tube as field strength  $10^4$  G, total flux  $10^{21}$ - $10^{22}$  Mx, and the sufficient twist  $> 5.0 \times 10^{-4} \text{ km}^{-1}$ . Using these values, we simulate the three-dimensional calculation and find the features as follows. (1) The emerging flux becomes flat beneath the surface. (2) Secondary evolutions to the corona occurs due to the interchange-mode instability. (3) The evolution is consistent with the AR observation by Strous and Zwaan (1999). On the basis of the results above, we newly suggest the model for the flux emergence and the formation of active region.

Keywords: sun, magnetic field, solar interior, photosphere, chromosphere, corona



PEM005-17

Room:303

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## Energy release between the tail magnetic reconnection and dipolarization regions and its role in the substorm onset

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The triggering mechanism of a substorm expansion onset is continually a major controversial issue in magnetospheric research. Various models, such as the near-Earth neutral line model and the current disruption model, have been proposed. These models "predict" different observational features in the initial process, its location, and the propagation direction of the resultant flows or waves. The critical issues for understanding the substorm onset mechanism include the relative timing and causal relationship between the magnetic reconnection and the current disruption as well as the processes midway between the regions of the two processes, such as fast earthward flows and waves. To solve these issues, we have performed statistical analyses and showed an overall picture of substorm-associated evolution of the near-Earth magnetotail. Namely, the magnetic reconnection occurs at  $X \sim -16$  to  $-20$  Re at least 2 min before onset to create a plasmoid tailward of  $X \sim -20$  Re. Almost simultaneously with the magnetic reconnection, i.e., within 2 min, the dipolarization begins at  $X \sim -7$  to  $-10$  Re. Furthermore, we showed that the energy release occurs in the magnetic reconnection region and its surrounding regions, associated with substorm expansion onsets. Interestingly, the energy release is more significant between the regions of the magnetic reconnection and the initial dipolarization, rather than in the magnetic reconnection region, and is more widely seen than localized fast earthward flows. On the other hand, the energy increases in the initial dipolarization region at  $X > -12$  Re. In the present study, we discuss what a large amount of the released energy in the midway region is spent in, where it is transported, and what is its role in the substorm onset.

Keywords: substorm, magnetotail, energy release, energy transport, magnetic reconnection, dipolarization

PEM005-18

Room:303

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## Global ionospheric currents driven by Region-2 field-aligned currents during substorms

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The dawn-to-dusk convection electric field increases during the growth phase of substorms, driving DP2 currents composed of two-cell current vortices in high latitude and leading to an increase in the eastward electrojet (EEJ) at the dayside dip equator. During the expansion phase, electric field and currents are reversed in direction to the normal DP2 currents at subauroral to equatorial latitudes when the convection electric field reduces abruptly. The reversed current at the dayside dip equator appears as a counter-electrojet (CEJ) and causes an equatorial enhancement of the negative bay in the afternoon sector [Kikuchi et al., 2000]. In this study, by using magnetometer array data and SuperDARN (Super Dual Auroral Radar Network) convection maps, we deduce that the reversed electric field and currents often develop at the onset of substorms when the convection electric field increases and the auroral electrojet (AEJ) continues to move equatorward. These observations imply that the Region-1 and Region-2 field aligned currents (R1 and R2 FACs) increase in the afternoon sector concurrently with the current wedge responsible for the positive bay at midnight. The substorm-associated R2 FACs are strong enough to cause the reversed current at the subauroral latitude and the CEJ at the equator. We also deduce that the dayside equatorial CEJ begins simultaneously with the midnight positive bay while the positive bay onset is delayed by several minutes as the station departs from the midnight meridian. These observations suggest that the unloading process begins in the near-Earth magnetotail with the intensification of the asymmetric ring current that is responsible for the equatorial CEJ and R2 FACs on the dayside.

Keywords: substorm, Region-2 field-aligned current, Overshielding electric field, equatorial counter electrojet, substorm current

PEM005-19

Room:303

Time:May 27 09:35-09:50

## Magnethydrodynamic simulation of solar chromospheric evaporation jets in the oblique coronal magnetic field

Yuki Matsui<sup>1\*</sup>, Takaaki Yokoyama<sup>1</sup>, Hideyuki Hotta<sup>1</sup>

<sup>1</sup>Univ. of Tokyo

We reproduce solar chromospheric evaporation jets in the oblique coronal magnetic field by two-dimensional MHD simulation with heat conduction effect. The solar chromospheric evaporation jets are caused by the heat of the magnetic reconnection between the emerging flux and the preexisting coronal magnetic field. Miyagoshi & Yokoyama (2004) performed two-dimensional MHD simulation based on this scenario and succeeded in reproducing the evaporation jet. In this simulation, the preexisting coronal magnetic field was parallel to the convection zone to keep the initial condition. On the other hand, most of the observed chromospheric evaporation jets are thought to occur in the oblique coronal magnetic field. In our simulations, we assume the energy damping in the heat conduction and succeed in keeping the initial condition of the oblique coronal magnetic field and reproducing more realistic evaporation jets.

In the recently observation, EUV imaging spectrometer aboard Hinode observed hot jets and cool jets simultaneously and revealed the detailed structures of the velocity of the jets. Our simulations succeed in reproducing the high density jets and also show that hot jets and cool jets are exist simultaneously. We will compare the characteristics of the observation to our simulations and discuss the acceleration of the jets.

Keywords: MHD simulation, solar jet, chromospheric evaporation

PEM005-20

Room:303

Time:May 27 09:50-10:05

## Simulation Study on the Trigger Process of Solar Flares

Kanya Kusano<sup>1\*</sup>, Satoshi Inoue<sup>2</sup>, Daikou Shiota<sup>3</sup>, Tetsuya Yamamoto<sup>1</sup>

<sup>1</sup>STEL, Nagoya University, <sup>2</sup>NiCT, <sup>3</sup>RIKEN

Solar flare is one of the most catastrophic phenomena in our solar system, and it is widely believe that magnetic reconnection plays a main role for the liberation of magnetic energy driving solar flare. However, what triggers magnetic reconnection in solar flares is still an open question to be solved. It is important to reveal the trigger mechanism of solar flares not only for the understanding of solar coronal activity but also for the advancing predictability of space weather. In this study, first, we analyze the initiation process of the X3.4 class solar flare on December 13, 2006, based on the observation by the Hinode satellite, and propose a new scenario that the feedback of two different reconnections, which can be initiated by the emerging of magnetic flux sheared oppositely to the preexisting magnetic arcade, should trigger solar flare. Second, we carry out the numerical experiments to verify this hypothesis in terms of the two different types of three-dimensional magnetohydrodynamic simulations, in which the linear force-free model field and the realistic nonlinear force-free field are used for the preexisting magnetic arcade, respectively. Both the simulations clearly demonstrate the proposed scenario can work to abruptly commence magnetic reconnection in the realistic geometry of solar active regions. Finally, we like to discuss about the possibility to predict the onset of solar flares in terms of the combination of high resolution observation of solar magnetic field and the data-driven numerical simulation.

Keywords: solar flares, trigger, simulation, reconnection, MHD, Hinode

PEM005-21

Room:303

Time:May 27 10:05-10:20

## The Incipient Stages of Solar Eruptions

Alphonse Sterling<sup>1\*</sup>

<sup>1</sup>NASA/MSFC

Solar eruptions are the starting point of large, transient disturbances to the Heliosphere in the form of Coronal Mass Ejections (CMEs). Understanding the onset of solar eruptions therefore is vital to long-term Space Weather interests. Solar eruptions originate from locations on the Sun where magnetic polarity reverses across magnetic inversion lines. Filaments of cooler chromospheric material suspended in the hot corona frequently demarcate these inversion lines, with the onset of eruption of the filament itself being among the earliest indicators of the start of the overall solar eruption. In recent years we have been investigating the onset of solar eruptions by studying the dynamics of solar filaments just prior to and during eruption. In this talk we briefly review work by us and others on filament eruptions, mainly based on observational data from the SoHO, Yohkoh, TRACE, Hinode, and SDO satellites among other sources.

Keywords: Solar Eruptions, Solar Filaments, Solar Magnetic Fields, Solar Flares, CMEs

PEM005-22

Room:303

Time:May 27 10:45-11:05

## On the geo-effective CME and flare parameters

Yong-Jae Moon<sup>1\*</sup>

<sup>1</sup>NASA/GSFC (CUA), <sup>2</sup>School of Space Research, Kyung Hee Univ

In this study we discuss geoeffective CME and flare parameters for the purpose of developing empirical space weather (geomagnetic storms, solar proton events, and solar flares) forecast models based on solar information. These models have been set up with the concept of probabilistic forecast using historical events. Our recent progress is as follows. First, we presented a concept of storm probability map depending on CME parameters (speed, location, and earthward direction parameter). Second, we demonstrate that the earthward direction parameter is important for the forecast of geomagnetic storms. Third, the importance of solar magnetic field orientation for storm occurrence was examined. Fourth, the importance of cone model parameters for geomagnetic storms and proton events was discussed. Fifth, a new proton event forecast method depending on flare parameters (flare strength, duration, and longitude) as well as CME parameters (speed and angular width) has been suggested. Sixth, we are examining the probability of solar flares depending on sunspot McIntosh classification and its area change (as a proxy of flux change). In addition, future prospect on this issue will be discussed.

Keywords: Coronal Mass Ejections, Flares, Geomagnetic Storms, Solar Proton Events

PEM005-23

Room:303

Time:May 27 11:05-11:20

## Response of the magnetosphere-ionosphere compound system to periodic variation of the solar wind

Shigeru Fujita<sup>1\*</sup>, Takashi Tanaka<sup>2</sup>

<sup>1</sup>Meteorological College, <sup>2</sup>Kyushu University

Recently, typical magnetospheric phenomena such as a substorm [Tanaka et al., 2010], a sudden commencement [Fujita et al., 2003], a theta aurora [Tanaka et al., 2004] have been investigated intensively by using a realistic global MHD model. These studies revealed the magnetospheric and ionospheric plasma processes occurred during these events in a self-consistent manner. In particular, global current circuits including the current generators are clearly presented at the first time in these studies. By investigating in detail generation mechanisms of the field-aligned current and related shear flow in the magnetosphere, we completely interpret the physical processes of these events. In this sense, generation of a new Region 2 current in the dayside magnetosphere associated with northward turn of the interplanetary magnetic field is a kind of a tutorial phenomenon for comprehension of the magnetosphere-ionosphere compound system. The current generator of this new R2 FAC is driven by plasma convection flow across pressure enhancement in the dayside cleft region. The pressure enhancement in the cleft is also supported by sunward return flow after northward turn of the IMF.

In the talk, we will present deformation of the magnetosphere-ionosphere compound system associated with periodic variations of solar wind IMF based on the concept of the magnetosphere-ionosphere compound system as explained above.

**Keywords:** magnetosphere-ionosphere compound system, global simulation, periodic solar wind variation, magnetospheric topology

PEM005-24

Room:303

Time:May 27 11:20-11:35

## Global geomagnetic field variations during a geomagnetic storm

Atsuki Shinbori<sup>1\*</sup>, Yukitoshi Nishimura<sup>2</sup>, Yuji Tsuji<sup>2</sup>, Takashi Kikuchi<sup>2</sup>, Tsutomu Nagatsuma<sup>3</sup>, Shinichi Watari<sup>3</sup>

<sup>1</sup>RISH, Kyoto Univ., <sup>2</sup>STEL, Nagoya Univ., <sup>3</sup>NICT

It has been well-known that two-cell ionospheric convection in the polar ionosphere driven by a dawn-to-dusk electric field which carries the region-1 (R-1) field-aligned currents (FACs) are significantly intensified and expand to middle-low latitudes during the main phase of geomagnetic storms. The two-cell ionospheric currents produce negative and positive disturbances of the H-component of geomagnetic field in the morning and afternoon sectors, respectively. The dawn-to-dusk polar electric field penetrates to the magnetic equator, and drives the eastward equatorial electrojet current (eEJ) due to the Cowling effect in the daytime sector. During the recovery phase which is caused by the weakness of southward interplanetary magnetic field (IMF) or northward turning of the IMF, the two-cell ionospheric currents in the polar ionosphere are abruptly reduced and the equatorward boundary of auroral electrojet currents (AEJ) move to high latitude. In this case, the magnetic field at the magnetic equator show a significant enhancement of negative variations of the H-component in the daytime sector produced by the westward equatorial electrojet current (wEJ) driven by the dusk-to-dawn electric field originating from the R-2 FACs. However, due to the lack of geomagnetic field data in the middle-low latitudes, detail relationship between the magnetic field variations of high-middle latitudes and at the equator during geomagnetic storms has not been clarified yet. In this paper, we investigated time and spatial evolution of global geomagnetic field variations from high-latitude to the magnetic equator during the geomagnetic storm occurred on May 23-24, 2002, using geomagnetic field data with time resolution of 1 minute obtained from the CARISMA, GIMA, IMAGE, MACCS, and NSWMC networks, and provided from WDC geomagnetism in Kyoto. In the present analysis, we first subtracted geomagnetic field variations during a magnetically quiet day (May, 31, 2002) from the disturbed field during the geomagnetic storm for each station. As a next step, we excluded the magnetic effects produced by magnetospheric currents (for example, ring current) by subtracting the low-latitude (10-20 degrees, GMLAT) geomagnetic field variation of the northward component. As a result, the equivalent current system showed that two-cell ionospheric currents are significantly enhanced in the daytime sector together with a strong enhancement of the eEJ at the daytime equator during the main phase of the geomagnetic storm. The centers of these vortices were located at 70 degrees and 65 degrees in the morning and afternoon sector, respectively. The two-cell ionospheric currents expanded to the low-latitude region of less than 30 degrees (GMLAT). In the nighttime sector of middle-low latitudes, the arrows of the equivalent current were directed in the northward direction. This signature indicates that the nighttime magnetic field signatures are produced by the magnetic effect of the R-1 FACs. On the other hand, during the recovery phase associated with strong northward turning of the IMF, the equivalent current system showed that the two new vortices different from two-cell ionospheric currents driven by the R-1 FACs system appear in the polar cap and middle latitude. The former led to the enhanced NBz current driven by the lobe reconnection due to the strong northward IMF, while the latter was generated by the enhanced R-2 FACs produced by the strongly asymmetric ring current flowing westward in the inner magnetosphere. In this case, the equatorial magnetic field variation showed a strongly negative signature produced by the wEJ current due to the dusk-to-dawn electric field. Therefore, it seems that the enhanced NBz current system plays an important role in the intensification of the dusk-to-dawn electric field from the middle-latitudes to the magnetic equator.

**Keywords:** geomagnetic storm, convection electric field, shielding electric field, field aligned currents, geomagnetic field variations, interplanetary magnetic field



PEM005-25

Room:303

Time:May 27 11:35-11:50

## Pi2 current system at polar to equatorial latitudes

Takashi Kikuchi<sup>1\*</sup>, Kumiko Hashimoto<sup>2</sup>, Yukitoshi Nishimura<sup>1</sup>, Atsuki Shinbori<sup>3</sup>, Tsutomu Nagatsuma<sup>4</sup>, Akira Kadokura<sup>5</sup>, Natsuo Sato<sup>5</sup>

<sup>1</sup>Solar-Terrestrial Environment Laboratory, <sup>2</sup>Kyushu University of Health and Welfare, <sup>3</sup>Res Inst for Sustainable Humanosphere, <sup>4</sup>Nat Inst of Inform and Comm Tech, <sup>5</sup>National Institute of Polar Research

It has been reported that the Pi2 appears at the dayside geomagnetic equator with an enhancement in amplitude (Shinohara et al. GRL 1997; Tokunaga et al., GRL 2007). The Pi2 at the dayside equator is explained by means of electrojets driven by an electric field transmitted from the polar ionosphere (Shinohara et al. GRL 1997). Simultaneous ground and spacecraft observations show that the relationship between the Pi2 on the ground and above the ionosphere is in phase on the nightside and out of phase on the dayside (Han et al., JGR 2004). These observations indicate that the dayside Pi2 is caused by ionospheric currents extending from high latitude to the equator, while the nightside Pi2 is attributed to cavity resonance of MHD waves in the plasmasphere. On the other hand, the period of the Pi2 does not depend on the latitude at around the plasmapause, which may not match the cavity resonance model (Tokunaga et al., GRL 2007). In this paper, we show that the equatorial Pi2 is well correlated with the nightside Pi2 with no time shift greater than several seconds and that the amplitude of the nightside Pi2 is larger at higher latitude. This local time and latitudinal features are similar to those of the main impulse (MI) of sudden commencement (SC), which is explained by means of Region-1 type field-aligned currents generated during the compression of the magnetosphere (Araki et al., EPS 2006; Shinbori et al., JGR 2009). We also show that the Pi2 at nightside auroral latitude is out of phase with the equatorial Pi2. We suggest that the Pi2 is explained by means of Region-1 type field-aligned currents which flow into the auroral ionosphere and further to the dayside equatorial ionosphere. The relationship of the equatorial Pi2 and substorm current wedge should be clarified to identify the source of the Pi2 currents.

Keywords: Pi2 pulsation, substorm, magnetic equator, ionospheric currents, field-aligned currents

PEM005-26

Room:303

Time:May 27 11:50-12:05

## A study of ionospheric storms using an atmosphere-ionosphere coupled model (GAIA)

Hiroyuki Shinagawa<sup>1\*</sup>, Hidekatsu Jin<sup>1</sup>, Yasunobu Miyoshi<sup>2</sup>, Hitoshi Fujiwara<sup>3</sup>, Shigeru Fujita<sup>4</sup>, Takashi Tanaka<sup>2</sup>, Kaori Terada<sup>3</sup>, Naoki Terada<sup>3</sup>, Ken T. Murata<sup>1</sup>

<sup>1</sup>NICT, <sup>2</sup>Kyushu University, <sup>3</sup>Tohoku University, <sup>4</sup>Meteorological College

The ionosphere is controlled by the solar EUV and X-rays, and energy influx from the solar wind and the magnetosphere. In addition to the energy inputs from space, recent observations suggest that atmospheric waves from the lower atmosphere significantly affect the ionosphere. During magnetic storms, ionospheric disturbances are generated by electromagnetic energy and particle precipitation from the magnetosphere. Even if the same magnetospheric input is given to the ionosphere, the response of the ionosphere depends on ionospheric and thermospheric conditions. In the mid-latitude region, thermospheric winds driven by energy inputs from the magnetosphere might interact with atmospheric waves propagated from the lower atmosphere. Penetration electric fields from the polar region and dynamo electric fields generated by thermospheric winds might also overlap. In order to self-consistently include the effects of the magnetosphere as well as the lower atmosphere on the ionosphere, we developed an atmosphere-ionosphere coupled model "GAIA" (Ground-to-topside model of Atmosphere and Ionosphere for Aeronomy), which includes the whole atmosphere and ionospheric dynamo processes. We will present simulation results of ionospheric storms using GAIA.

Keywords: ionosphere, thermosphere, atmosphere, disturbance, model, simulation

PEM005-27

Room:303

Time:May 27 12:05-12:20

## Numerical simulation of a coronal loop: response to impulsive heating with a power-law energy distribution

Naomasa Kitagawa<sup>1\*</sup>, Takaaki Yokoyama<sup>1</sup>

<sup>1</sup>The Univ. of Tokyo

We conducted one-dimensional numerical simulations of a 40 Mm length coronal loop heated by impulsive heating events (nanoflares) with a power-law energy distribution. The solar flares have a very wide energy range of about 10 orders of magnitude. There are a number of statistical studies on the occurrence frequency of solar flares so far, from which it has been concluded that the energy distribution of solar flares obeys to a power-law distribution (Lin et al. 1984, Shimizu 1995, Parnell & Jupp 2000). If the power-law index has a value which exceeds 2, numerous smaller flares, often called "nanoflares", contribute to the coronal heating instead of large, violent flares (Hudson 1991). Focusing on this point related to the longstanding enigma of coronal heating (see the review: Klimchuk 2006), many authors have investigated the power-law index of the energy distribution of solar flares. When putting it all together, their results indicate an index of 1.5-1.8 (Aschwanden & Parnell 2002). Therefore, in consideration of this result from previous studies, so called "nanoflares" cannot contribute to the heating of the solar corona. However, previous studies have implicitly assumed that the increment of thermal energy derived from observational data is same as the input energy to the solar corona. If this assumption is not correct, that is, there are discrepancies between the power-law index of input and that of observations, we must re-examine the interpretation of previous studies. In this study, synthetic observational data of a coronal loop heated by numerous impulsive heating events (nanoflares) with a power-law energy distribution are made by taking account of the filter response of Transition Region And Coronal Explorer (TRACE) satellite. We have analyzed synthetic data by the same method as previous studies and concluded that energy distribution derived from synthetic data differs from input power-law energy distribution in its shape, that is, convex upward distribution. This result is similar to the result of Antolin et al. (2008). The derived energy distribution can be fitted better by a double-power law than a single-power law. When the intervals of time between nanoflares are sufficiently long, the derived energy distribution appears similar to the input energy distribution.

Keywords: sun, corona, nanoflares

PEM005-28

Room:303

Time:May 27 12:20-12:35

## Active region outflows as a source of the slow speed solar wind: elemental abundance measurements by Hinode/EIS.

David Brooks<sup>1\*</sup>

<sup>1</sup>George Mason University

The solar wind impacts the terrestrial environment and influences the propagation of disturbances such as coronal mass ejections towards Earth. Hydrodynamic models of the solar wind are very sensitive to the boundary conditions at the formation site. Locating the source region of the slow speed wind, however, is still an outstanding problem in solar physics. Recently, Hinode X-ray Telescope (XRT) and EUV Imaging Spectrometer (EIS) observations have shown that there are areas of high speed outflow at the edges of many active regions. It has been suggested that these outflows may line on open field lines that extend out to the heliosphere, and that they therefore could be a significant source of the slow speed wind. We present new direct evidence of a connection between these outflows and the solar wind from EIS elemental abundance measurements of AR 10978. We show that the enhancement factor of low first ionization potential elements is always 3-4. This is consistent with measurements made in situ in the solar wind. Furthermore, when the outflows were favorably oriented towards the Earth, the EIS measurements made on the Sun were found to match those made a few days later by the ACE Solar Wind Ion Composition Spectrometer at Earth. The agreement between spectroscopic and ion composition measurements, from two different instruments on two different spacecraft, suggests that the plasma in the outflows really contributes to the solar wind.

Keywords: Sun: corona, Sun: abundances, Sun: solar wind

PEM005-29

Room:303

Time:May 27 14:15-14:30

## Simulation of thermosphere and ionosphere variations using meteorological reanalysis data

Hidekatsu Jin<sup>1\*</sup>, Yasunobu Miyoshi<sup>2</sup>, Hitoshi Fujiwara<sup>3</sup>, Hiroyuki Shinagawa<sup>1</sup>, Kaori Terada<sup>3</sup>

<sup>1</sup>NICT, <sup>2</sup>Kyushu University, <sup>3</sup>Tohoku University

The upper atmosphere is the region where space weather phenomena have direct impacts on human activities as we increasingly utilize this region through radio propagation from satellites. On the other hand, the ionosphere and thermosphere are observed to change on various temporal and spatial scales, so understanding and providing the information on these changes are important as a part of space weather research. Recent studies of the upper atmosphere have suggested that not only magnetospheric effects, but the lower atmospheric activities could also have large impacts on the upper atmosphere and cause both short and long-term scale changes. Recently, we have developed a whole Earth's atmospheric model (GAIA: Ground-to-topside model of Atmosphere and Ionosphere for Aeronomy) by integrating several global models for different atmospheric regions, a whole atmospheric general circulation model, an ionospheric model and an electrodynamics model. We have shown the usefulness of the model, by reproducing the ionospheric longitudinal structure and day-to-day variations similar to the observations, which can be considered as lower atmospheric effects. Recently, we also started the simulation in which lower atmospheric reanalysis data is assimilated in order to reproduce realistic upper atmospheric variations. In this presentation, we will report recent upgrades of GAIA, and initial results of data-assimilated GAIA simulation.

Keywords: ionosphere, lower atmosphere, thermosphere, simulation, data assimilation, space weather

PEM005-30

Room:303

Time:May 27 14:30-14:50

## Propagation and evolution of nonlinear MHD disturbances in space

Dong-Hun Lee<sup>1\*</sup>, Kyung-Im Kim<sup>1</sup>, Khan-Hyuk Kim<sup>1</sup>, Kihong Kim<sup>2</sup>

<sup>1</sup>Kyung Hee Univ, <sup>2</sup>Ajou Univ

Propagation of nonlinear MHD waves is studied in the magnetosphere and the interplanetary space. As realistic variations of MHD disturbances in space become often nonlinear, it is important to examine time-dependent evolution of these fluctuations. We have examined how the fluctuations are changed by steepening processes and/or shock formation in both analytical and numerical approaches. Our results suggest that the pattern of disturbances tends to significantly change during the travel path between L1 and the Earth's magnetosphere unless the amplitude is extremely low or the disturbance time-scale is relatively long. It is shown how the initial profiles in the solar wind can be different from those observed near the near-Earth space owing to the nonlinear properties. Our theoretical model provides the time-dependent solutions at different locations, which can be useful in interpreting observations at the multiple locations.

Keywords: space weather, MHD waves, nonlinear waves

PEM005-31

Room:303

Time:May 27 14:50-15:05

## Catapult current sheet relaxation model for substorm onset

Shinobu Machida<sup>1\*</sup>, Yukinaga Miyashita<sup>2</sup>, Akimasa Ieda<sup>2</sup>

<sup>1</sup>Graduate School of Science, Kyoto Univ., <sup>2</sup>Solar-Terrestrial Environment Laboratory

Based on the results of our superposed epoch analysis of Geotail data, we have proposed a catapult (slingshot) current sheet relaxation model in which earthward flows are produced in the central plasma sheet (CPS) due to the catapult current sheet relaxation, together with the rapid enhancement of Poynting flux toward the CPS in the lobe around  $X \sim -15$  Re about 4 min before the substorm onset. These earthward flows are characterized by plasma pressure decrease and large amplitude magnetic field fluctuations. When these flows reach  $X \sim 12$  Re in the magnetotail, they give significant disturbances to the inner magnetosphere to initiate some instability such as a ballooning instability, and the substorm starts. The occurrence of the magnetic reconnection is a natural consequence of the initial convective earthward flows, because the relaxation of a highly stretched catapult current sheet produces a very thin current at its tailward edge. Recently, Nishimura et al. [2010] reported that the substorm onset begins when a North-South (N-S) arc reaches equatorward quiet arcs. The region of earthward convective flows correlatively moves earthward prior to the onset. Thus, this region of the earthward convective flows seems to correspond to the N-S arc.

Keywords: magnetosphere, substorm, magnetic reconnection, current disruption, aurora, plasma sheet

PEM005-32

Room:303

Time:May 27 15:05-15:20

## Substorm ignition in the M-I coupling region

Akira Morioka<sup>1\*</sup>, Yoshizumi Miyoshi<sup>2</sup>, Yukinaga Miyashita<sup>2</sup>, Yasumasa Kasaba<sup>3</sup>, Hiroaki Misawa<sup>1</sup>, Fuminori Tsuchiya<sup>1</sup>, Ryuhō Kataoka<sup>4</sup>, Akira Kadokura<sup>5</sup>, Kiyohumi Yumoto<sup>6</sup>, Toshifumi Mukai<sup>7</sup>

<sup>1</sup>PPARC, Tohoku IUniversity, <sup>2</sup>STEL, Nagoya University, <sup>3</sup>Graduate School of Science, Tohoku Univ., <sup>4</sup>IRC, Tokyo Institute of Technology, <sup>5</sup>National Institute of Polar Research, <sup>6</sup>SERC, Kyushu University, <sup>7</sup>JAXA

The sudden formation of parallel electric fields in the magnetosphere-ionosphere (M-I) coupling system is essential to complete substorm onset. From this standpoint, we focus substorm ignition on field-aligned acceleration, by studying the dynamical behavior of auroral kilometric radiation (AKR). Field-aligned auroral acceleration shows distinct two-step evolution at substorm onset: the activation of low-altitude acceleration ( $h \sim 4000-5000$  km) which corresponds to auroral initial brightening, and subsequent abrupt breakout of high-altitude acceleration ( $h \sim 6000-12000$  km) which corresponds to auroral breakup. Cases when only low-altitude acceleration (first step evolution) is activated are pseudo-substorms. This indicates that the second evolution of field-aligned acceleration divides full-substorm from pseudo-substorm. The statistical relationship between the plasma-flow burst in the plasma sheet and its response to the M-I coupling region shows that about 65 % of flow bursts cause pseudo-breakup/initial-brightening and one third of them develops into full-substorm, while the magnitude of flow velocity does not necessarily determine the substorm intensity. This suggests that some plasma flow bursts originate field-aligned current (FAC) which first enhance low-altitude acceleration, and the increasing field-aligned current induces second acceleration above the pre-existing low-altitude acceleration as a consequence of current/current-driven instabilities. In this sense, substorm is finally ignited in the auroral M-I coupling region.

Keywords: substorm, auroral acceleration, M-I coupling region



PEM005-33

Room:303

Time:May 27 15:20-15:40

## Effects of nonlinear wave growth on radiation belt particle fluxes

Danny Summers<sup>1\*</sup>

<sup>1</sup>MUN / KHU

In parallel with the emergence of the new science of space weather, there has been a resurgence of interest in radiation belt research in the last decade. Highly energetic electrons, which are typically generated in the outer radiation zone during geomagnetic storms, can cause serious malfunctions of orbiting satellites. Consequently, understanding the generation and dynamics of radiation belt particle fluxes has become a key feature of current space physics research. In this study we derive new relativistic formulae for the limiting electron flux for a general planetary radiation belt at a given L-shell. We compare the theoretical results on the trapped flux with observed energetic electron fluxes at Earth. We then incorporate the effects of nonlinear wave growth into the calculation of the limiting flux. Using model wave equations, we estimate nonlinear wave growth rates for a range of input parameters. We find that inclusion of nonlinear wave growth effects in specifying the wave power gain can significantly modify the limiting flux. Exact quantification of the effects of nonlinear wave growth on the limiting particle flux requires accurate information on the length scales for both linear and nonlinear convective wave growth. Unfortunately such data are not currently available from either experimental observations or computer simulations.

Keywords: radiation belts, nonlinear wave growth, stably trapped particle flux

PEM005-34

Room:303

Time:May 27 15:40-15:55

## Scientific Results Obtained from MAGDAS/CPMN Data

Kiyohumi Yumoto<sup>1\*</sup>, MAGDAS/CPMN Group<sup>1</sup>

<sup>1</sup>SERC, Kyushu University

The Space Environment Research Center (SERC), Kyushu University has deployed the MAGnetic Data Acquisition System (MAGDAS) at 54 stations along the 210- and 96-degree magnetic meridians (MM) and the magnetic Dip equator, and three FM-CW radars along the 210o MM during the International Heliophysical Year (IHY; 2005-2009) and the International Space Weather Initiative (ISWI; 2010-2012) (see <http://magdas.serc.kyushu-u.ac.jp/> and <http://magdas2.serc.kyushu-u.ac.jp/>). The goal of MAGDAS project is to become the most comprehensive ground-based monitoring system of the earth's magnetic field. It does not compete with space-based observation. Rather, this ground-based network complements observation from space. To properly study solar-terrestrial events, data from both are required.

This project intends to get the MAGDAS network fully operational and provide data for studies on Litho-space Weather. By analyzing these new MAGDAS data, we can perform a real-time monitoring and modeling of the ambient plasma mass density and the global current system (e.g. Sq, EEJ) for understanding the plasma and electromagnetic environment changes in geospace and lithosphere during helio-magnetospheric storms. In order to examine the propagation mechanisms of transient disturbances, i.e., sc/si, Pi 2, and DP2, relations of ionospheric electric and magnetic fields are also investigated by analyzing the Doppler data of our FM-CW ionospheric radar and the MAGDAS magnetic data.

A new EE-index (EDst, EU, and EL) was proposed by SERC for real-time and long-term geospace monitoring. The basic algorithm to obtain EE-index was constructed by Uozumi et al. (2008). EU and EL mainly represent the range of the EEJ (equatorial electrojet) and CEJ (equatorial counter electrojet) components, respectively. H-component magnetic variations observed at the MAGDAS/CPMN (Circum-pan Pacific Magnetometer Network) stations along the magnetic equator during each nighttime sector (LT = 18-06) were used as the baseline of EU and EL. The baseline value is defined as EDst and its variations are found to be similar to those of Dst. An empirical model of the quiet daily geomagnetic field variation has been constructed by Yamazaki et al. (2010), based on geomagnetic data obtained from 21 stations along the 210 Magnetic Meridian of the CPMN from 1996 to 2007 (Kp? 2+). Using the least-square fitting method, the quiet daily geomagnetic field variation at each station was described as functions of (1) solar activity SA, (2) day of year DOY, (3) lunar age LA and (4) local time LT. After interpolation in latitude, the model can describe solar-cycle and seasonal variations of both solar (S) and lunar (L) fields.

By using the MAGDAS/CPMN system and FM-CW radar array, we could obtain the following results; (1) Imaging of global 3-D current system, (2) Annual and semi-annual Sq and EEJ current variations, (3) A new EE-index and its long-term variation, (4) Estimation of plasma mass density, (5) Latitudinal dependence of Pc 3-4 amplitudes along 96o MM and Pi 2 along 210o MM, (6) Ionospheric electric fields of DP-2, sc, Pi2, and Pc 5 observations by FM-CW radar, and (7) anomalous magnetic daily and ULF variations associated with the great earthquakes observed near the MAGDAS/CPMN stations. In this paper, we will present the several scientific results obtained by the MAGDAS project.

**Keywords:** MAGnetic Data Acquisition System (MAGDAS), FM-CW radar, the International Heliophysical Year, the International Space Weather Initiative, MAGDAS/CPMN system

PEM005-35

Room:303

Time:May 27 15:55-16:10

## Morning-afternoon asymmetry of geosynchronous magnetic field

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The present study examines the morning-afternoon asymmetry of the geosynchronous magnetic field strength on the dayside (MLT = 06-18 hours) using observations by the GOES satellites over a period of 9 years from February 1998 to January 2007. During geomagnetically quiet intervals ( $K_p < 3$ ), we observed that a peak of the magnetic field strength is skewed toward the earlier local times (MLT =  $\sim 11.1$ -11.6) with respect to local noon and that the geosynchronous field strength is larger in the morning sector than in the afternoon sector. That is, there is the morning-afternoon asymmetry of the geosynchronous magnetic field strength. We found that the peak location of the magnetic field strength is shifted toward the earlier local times as the ratio of the magnetic field strength at MLT = 18 (B-dusk) to the magnetic field strength at MLT = 06 (B-dawn) is decreasing. It is also found that the dusk to dawn B field ratio, B-dusk/B-dawn, is decreasing as increasing solar wind dynamic pressure. The morning-afternoon asymmetry of the magnetic field strength appears in Tsyganenko geomagnetic field model (TS-04 model) when the partial ring current is included in TS-04 model. Unlike our observations, however, TS-04 model shows that the peak location of the magnetic field strength is shifted toward the noon as the solar wind dynamic pressure grows in magnitude. This may be due to that the symmetric magnetic field associated with the magnetopause current, strongly affected by the solar wind dynamic pressure, increases. However, the partial ring current is not affected as much as the magnetopause current by the solar wind dynamic pressure in TS-04 model. Thus, our observations suggest that the contribution of the partial ring current at geosynchronous orbit is much larger than that expected from TS-04 model as the solar wind dynamic pressure increases.

Keywords: morning-afternoon asymmetry, geosynchronous magnetic field, partial ring current

PEM005-P01

Room:Convention Hall

Time:May 26 10:30-13:00

## Geomagnetic sudden commencement(SC) seen from the solar wind

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It is well known that geomagnetic sudden commencements (SCs) are caused by dynamic pressure( $P_d$ ) increase associated with interplanetary shock/discontinuities(IPS/DISCONs). It has not been known yet, however, if all of IPS/DISCONs produce SCs. There is no analysis which studied statistically ground geomagnetic signatures starting from the list of IPS/DISCONs. Here we first list up interplanetary IPS/DISCONs and then investigate corresponding geomagnetic ground responses.

Takeuchi et al. [2002] found that two IPSs with similar  $P_d$  increase produce different type of geomagnetic variations and that it depends upon difference in inclination of the shock front. When the inclination is large, interaction time of the shock with the magnetosphere becomes longer and the shock produces a slower geomagnetic variation which is not identified as SC.

We first check if this is applied to other many IPS/DISCONs.

**Keywords:** Geomagnetic sudden commencement (SC), solar wind, interplanetary shock/discontinuity, magnetosphere, ionosphere

PEM005-P02

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## Analysis of real-time magnetosphere simulation data using location of magnetopause

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It is possible to study responses of magnetosphere to various solar wind conditions using the large data set of the real-time magnetosphere simulation, which runs routinely in the National Institute of Information and Communications Technology (NICT).

There are several previous works using the data of the real-time simulation such as comparison between observed and calculated AE-index (Kitamura et al., 2008), analysis of geomagnetic fields at geostational orbit (Watari et al, 2010 SGEPS meeting), and so on.

Here, we analyzed location of magnetopause obtained by the result of the real-time magnetosphere simulation. There is an empirical model called the Shue model on the location of magnetopause. This model takes account of dynamic pressure and south-ward IMF of solar wind. Locations of magnetopause obtained by the result of the real-time simulation were compared with those calculated using the Shue model. It is found that magnetopause location obtained by the simulation shows good agreement with that calculated by the Shue model.

Keywords: magnetopause, magnetosphere, simulation

PEM005-P03

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## Global ionospheric currents driven by storm-time electric fields

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During the strong southward interplanetary magnetic field (IMF), the convection electric field originating from the region-1 field-aligned currents (R1 FACs) causes a two-cell ionospheric current at high latitudes [Nishida, 1968]. The convection electric field penetrates to the magnetic equator, and drives the eastward equatorial electrojet (EEJ) [Kikuchi et al., 1996]. This condition is called an undershielding. Subsequently, when the southward IMF weakens, the reversed ionospheric current, equatorial counter electrojet (CEJ), is driven by the developed shielding electric field originating from the region-2 field-aligned currents (R2 FACs). Its condition is called an overshielding because the shielding electric field relatively overcomes the reduced convection field in lower latitudes of the R2 FACs [e.g., Kelley et al., 1979]. However, the temporal and spatial development of global ionospheric current has not been yet established in middle latitudes during storms. So, we have investigated global ionospheric current deduced by magnetic field variations in high-low latitudes in the 21 storm events. During the periods of EEJ, the influence of the Hall current expanded into the middle latitudes (around 40 degrees in corrected geomagnetic latitude) driven by the intensified convection electric field. While, during the periods of CEJ, the reversed Hall currents appeared in the middle latitudes due to the overshielding electric field. Based on the above results, we reconstructed a picture of the 3-D current system depending on undershielding/overshielding condition corresponding to the storm main/early recovery phase, including the middle latitudes. Moreover, it is found the observed life time of CEJ was longer than that of the overshielding current at the middle latitudes. This fact implies that the CEJ at the equator is driven by the ionospheric disturbance dynamo. We will talk about global ionospheric currents driven by the convection, shielding, and disturbance dynamo electric fields.

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## Space Weather: The International Journal of Research and Applications

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Since the era of development of the initial electrical telegraph systems in the early 19th century, the solar-terrestrial environment has influenced the design and operations of ever-increasing and sophisticated technical systems. James Van Allen reported in 1958 that the space environment around the Earth was not benign, but rather composed of high-intensity radiation. Engineers and scientists immediately recognized from this discovery that technical systems such as the communications satellites envisioned by Arthur Clark and John Pierce would require design and operations procedures (and therefore costs) that had not been otherwise anticipated. Space Weather: The International Journal of Research and Applications is an online publication devoted to the emerging field of space weather and its impact on technical systems, including telecommunications, electric power, and satellite navigation. The journal publishes (a) peer-reviewed articles presenting the latest engineering and science research in the field, including studies of the response of technical systems to specific space weather events, predictions of detrimental space weather impacts, and effects of natural radiation on aerospace systems; (b) news and feature articles providing up-to-date coverage of government agency initiatives worldwide and space weather activities of the commercial sector; (c) letters and opinion articles offering an exchange of ideas; and (d) editorial comments on current issues facing the community. The journal is published by the American Geophysical Union (AGU).

Keywords: Space weather impacts, Applications, Predictions