Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PEM29-01 Room:304 Time:May 21 13:45-14:05

Recent Hinode Observations of Solar Flares

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With starting the new solar cycle, large flares, i.e., X-class and M-class flares, began to occur on the solar disk in 2011. "Hinode" successfully captured an X2.2 flare in 15 February 2011, followed by other successful observations of some large flares. X-Ray Telescope (XRT) performs high-cadence soft X-ray imaging observations not only during the flares but also in pre-flare phase, by using its flare automatic trigger function. Solar Optical Telescope (SOT) monitors an active region with medium-cadence photospheric magnetic-field and chromospheric Ca II H observations and, in response to the XRT flare trigger, switches to high-cadence observations for white-light flares and chromospheric dynamics. EUV Imaging Spectrometer (EIS) performs so-called flare hunting study, in which an active region is repeatedly and sparsely scanned but with fairly high (about 6 minutes) cadence. The Hinode team is optimizing our flare observations for better observations, although severe limitation of the telemetry volume and narrow telescopes' field of view make it difficult to hunt large flares. Regions with the potential to produce flares will be given the highest observing priority. The target for the observations may utilize the Maximum Millennium Flare Watch target designation. In addition, Hinode began instituting a Hinode Flare Watch that may be called by the representatives in the Hinode team. In this presentation, we will show some observing data from recent large flares and discuss how Hinode observations are important for flare investigations.

Keywords: solar flare, Hinode, Soft X-ray, UV, Optical

PEM29-02 Room:304 Time:May 21 14:05-14:25

A prospective vision of future space weather research and operation

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Main methodologies of Space Weather so far are theoretical, experimental and observational, and computer simulation approaches. Recently ”informatics” is expected as a new (fourth) approach to the STP studies. Informatics is a methodology to analyze large-scale data (observation data and computer simulation data) to obtain new findings using a variety of data processing techniques.

At NICT (National Institute of Information and Communications Technology) we are now developing a new research environment named OneSpaceNet. The OneSpaceNet is a cloud-computing environment, which connects many researchers with high-speed network (JGN: Japan Gigabit Network). It also provides the researchers rich resources for research studies, such as super-computer, large-scale disk area, licensed applications, database and communication devices. What is amazing is that a user simply prepares a terminal (low-cost PC). After connecting the PC to JGN, the user can make full use of the rich resources via L2 network. Using communication devices, such as video-conference system, streaming and reflector servers, and media-players, the users on the OneSpaceNet can make research communications as if they belong to a same (one) laboratory: they are members of a virtual laboratory.

We present two initial results using the OneSpaceNet for large-scale computer simulation data transfer and virtual observation data transfer system.

Keywords: Informatics, Space Weather, Science Cloud

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PEM29-03 Room:304 Time:May 21 14:25-14:40

Confined Solar Flares observed by the Solar Dynamic Observatory

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Since coronal mass ejections (CMEs) are main cause of solar energetic particle events and geomagnetic storms, the CME forecasting is essentially important for the space weather. During 2011 February ? 2012 January, 21 major flares (>= M5 level) occurred. We examined their association of coronal mass ejections (CMEs) by viewing the white light images obtained by the LASCO C2 and STEREO COR1 coronagraphs. We found that, out of the 21 major flares, four lacked the associated CMEs. The four confined flares were an M6.6 flare on 2011 February 18, an X1.5 flare on 2011 March 9, an M5.8 flare on 2011 September 24, and an X1.9 flare on 2011 November 3. We examined flare locations in the active region using the SDO/AIA and SDO/HMI data and found that each flare occurred at the center of the AR. We confirmed that the confinement by the overlying magnetic field is responsible for the confined major flares.

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PEM29-04 Room:304 Time:May 21 14:40-14:55

Dynamic behavior of the radiation belt electrons during the big magnetic storm

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Outer radiation belt electrons vary largely at the commencement of the magnetic storm. According to the JAXA satellite observations, followings have been identified; i.e. i) MeV electrons in the outer radiation belt disappear, ii) 300keV electrons disappear largely, iii) 30˜100keV electrons increase intensity, and iv) demarcation energy between increase and decrease may be in between 100keV and 300keV, depending on the individual magnetic storm.

These observation results suggest that loss of highly energetic electrons occurs in a wide energy range together with a transportation of the intermediate energy electrons to the outer radiation belt zone.

We have paid a particular attention to the very big magnetic storms to investigate a dynamical behavior of so-called slot region (L˜2.5). For the very large magnetic storm, 300keV electrons moved to the slot region and the injection of 30˜100keV electrons was also identified till the slot region. The movement of the electrons is likely caused by the terrible large electric field, which appears during the big magnetic storm.

The electrons in the slot region, then, decrease their intensities, and some of them drifted inward to the inner radiation belt region. The inward motion is caused by the radial diffusion and we are trying to estimate time constant by investigating the electron pitch angle characteristics obtained by the JAXA satellite. Outer belt electrons, on the contrary, increase their intensities, which is very common during the normal magnetic storm.

Keywords: Radiation Belt Electron, Magnetic Storm, Slot Region, Electron Accerelation, Doffusion

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PEM29-05 Room:304 Time:May 21 14:55-15:10

Long-term variation in the upper atmosphere as seen in the geomagnetic solar quiet (Sq) daily variation

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It has been well-known that geomagnetic solar quiet (Sq) daily variation is produced by the global ionospheric currents flowing in the E-region from middle latitudes to the magnetic equator. These currents are generated by dynamo process via interaction between the neutral wind and ionospheric plasma in a region of the thermosphere and ionosphere. The motion of the neutral particles is driven by heat convection due to solar irradiance and by tidal force of the sun and moon. From the Ohm's equation, the ionospheric currents strongly depend on ionospheric conductivity, polarization electric field and neutral wind. Then, to investigate the Sq amplitude is essential for understanding the long-term variations in the ionospheric conductivity and neutral wind of the thermosphere and ionosphere. Recently, Elias et al. [2010] found that the Sq amplitude tends to increase by 5.4-9.9 % in the middle latitudes (Apia, Fredericksburg and Hermanus) in a period of 1961-2001. They mentioned that the long-term variation of ionospheric conductivity associated with geomagnetic secular variation mainly determines the Sq trend, but that the rest component is ionospheric conductivity enhancement associated with cooling effect in the thermosphere due to increasing greenhouse gas. In this talk, we try to clarify the characteristics of the long-term variation in the Sq amplitude using the long-term observation data of geomagnetic field and neutral wind. These observation data have been provided from the IUGONET (Inter-university Upper atmosphere Global Observation NETwork) project which stated in facial 2009. In the present analysis, we used the F10.7 solar flux as a good indicator of the variation in the solar irradiance in the EUV and UV range, geomagnetic field data with time resolution of 1 hour observed at 184 geomagnetic stations. The definition of the Sq amplitude is the difference of the H-component between the maximum and minimum every day when the Kp index is less than 4. As a result, the Sq amplitude at all the geomagnetic stations is closely correlated with the solar F10.7 index, and tends to be more enhanced during the high activities (19- and 22- solar cycles) than during the relatively low activity (20-solar cycle). The Fourier spectrum of the Sq amplitude shows one peak in the high latitude around 1 year and two peaks in the low latitude and at the equator except for solar activity periods (5.5, 7,5 and 10.5 years). The coherence value between the F10.7 index and Sq amplitude gives more than 0.8 around 5.5, 7,5 and 10.5 years. Therefore, it can be concluded that the semi-annual and annual variations of the Sq amplitude is a cause of the upper atmosphere variation. In order to minimize the solar activity dependence on the Sq amplitude, we calculated second orders of fitting curve between the F10.7 and Sq amplitude during 1950-2011, and examined the residual Sq field defined as the deviation from the fitting curve. The residual Sq amplitude clearly showed increase and decrease trends with the periods of 20 years. It should be noted that the residual Sq amplitude around 2010 is almost the same level as that around 1970. On the other hand, the similar tendency can be seen in the diurnal variation of geomagnetic field in the auroral zone and polar cap (Sqp field) driven by the twin vortex of ionospheric currents associated with energy input of solar wind into the ionosphere. Then, it seems that the trends in the residual Sq and Sqp fields are related to the long-term variation in the ionospheric conductivities associated with the secular variation of the ambient magnetic field and the upper atmosphere (for example, plasma and neutral densities). In order to verify qualitatively the above signatures, we need to investigate the long-term variation in the ionospheric conductivities calculated using the IRI-2007 and MSIS-00 models.

Keywords: IUGONET, metadata database, Integrated data analysis software, geomagneitc solar quiet daily variation, ionospheric conductivity, upper atmosphere

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PEM29-06 Room:304 Time:May 21 15:30-15:45

Chromospheric evaporation observed with Hinode/EIS: temperature dependent upflow in the impulsive phase

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The analysis of a chromospheric evaporation in a M-class flare observed with the EUV Imaging Spectrometer (EIS) onboard *Hinode* was conducted. We report for the first time the dependence on temperature of the chromospheric evaporation in the growing flare loops.

The solar flares are the most energetic phenomena in the solar atmosphere, which release the magnetic energy through magnetic reconnection. The coronal plasma is heated up to a few tens of MK in the slow shocks extended from the reconnection point. In that regime, thermal conduction becomes dominant, and the chromosphere at reconnected flare loops, dense and cool ($T\tilde{}10^4$K) plasma experiences impulsive heating by reaching thermal conduction front. The gas pressure of the heated chromosphere suddenly raises to around 10MK, which results in so called *chromospheric evaporation*, fast upflow along the flare loop with the sound speed (~500 km s^{-1} at 10MK). This phenomenon has been firstly reported by Antonucci et al. (1982), in which the chromospheric evaporation was detected as the blueshifted component in the emission lines of highly ionized Ca XIX (mainly radiated by a few tens of MK). Although their data has very low spatial resolution, they revealed that the evaporation had occurred at the footpoints of flare loops by using other instruments. In the late 1990's, Czaykowska et al. (1999) firstly reported spatially resolved observation of chromospheric evaporation in the gradual phase observed with the Coronal Diagnostic Spectrometer (CDS) onboard the *Solar and Heliospheric Observatory* (*SOHO*), from which the authors reported relatively strong blueshift (~100 km s^{-1}) of Fe XIX line profiles and the gradient in the Doppler velocity indicating the continuous reconnection. The chromospheric evaporation in the impulsive phase was also observed with *SOHO*/CDS as reported by Teriaca et al. (2003, 2006). They estimated the momentum balance of upflow in the corona and downflow in the transition region, resulting in the good agreement (in the order) which supports the evaporation scenario. Recent observation by *Hinode*/EIS has shown the existence of fast upflow up to 400 km s^{-1} in the Fe XXIII (~10MK) line profiles at the footpoints of flare loops during the early phase of a flare (Watanabe et al. 2010). Fast upflows in the warm line (Fe XVI; 2-3MK) was also discovered in a small B class flare observed with *Hinode*/EIS (Del Zanna et al. 2011). However, the dependence of upflow velocity on temperature has not intensively studied yet.

In this study, we analyzed the ongoing chromospheric evaporation which occurred in the impulsive phase of a M1.2 class flare observed with *Hinode*/EIS on 2011 September 9. This flare had started soon after the filament erupted, followed by the formation of compact flare loops (L~10,000km). Investigating the line profiles carefully, we found the enhanced blue wings in hot emission lines (Fe XXIII and Fe XXIV; a few tens of MK) which indicate the upflow from the solar surface of around 400 km s^{-1}. This value is slightly smaller than the sound speed at the temperature of 10MK (~500 km s^{-1}), which supports the chromospheric evaporation scenario when considering the projection effect. Not only those hot emission lines, other coronal lines at the evaporation site also show the velocities near the sound speed in each formation temperature. The upflow is switched into downflow at several MK, and intriguingly, cooler lines ($\log T<6.2$) show the downflow near the sound speed as same as the upflow. As a collateral evidence, the density derived by Fe XIV line ratio indicated the density of 10^{11} cm^{-3}, which also supports the evaporation from the dense chromosphere. Fortunately, the EIS spectroscopic slit cut across old and new flare loops simultaneously, which enables us to discuss the temporal evolution of the evaporation flow.

Keywords: Sun, flares, chromospheric evaporation, Hinode, emission line, Doppler velocity

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PEM29-07 Room:304 Time:May 21 15:45-16:00

Formation of Cowling channel from Polar to Equatorial Ionosphere

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Possible mechanism for formation of global Cowling channel from polar to equatorial ionosphere along the dawn and dusk terminator line is discussed. In our model, the global (primary) Hall current accompanied by the two-cell type convection has divergent component when they across the conductivity gradient region at the terminator-line and resultant polarization charge are induced along it. The secondary electric field accompanied by this induced charge generates the secondary Hall current, which flows along the terminator line and also diverges when they across it. The induced secondary charges at the end of equator side produces the electric filed along the magnetic dip equator line and becomes the driver of the equatorial electrojet or counter-electrojet components according to the sign of their polarization charge. Resultantly, the global Cowling channel connecting between polar to equatorial ionosphere via the terminator-line and magnetic-dip equator could be formed. This mechanism can be applied to the equatorial electrojet disturbances accompanied by the solar wind variations such as DP2-type magnetic field disturbances and many phenomena associate the equatorial enhancement and depression of the geomagnetic field disturbances.

Keywords: solar wind, poloar ionosphere, equatorial ionosphere, Cowling channel, Global coupling

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PEM29-08 Room:304 Time:May 21 16:00-16:15

A High-Velocity Motion of Active Region Loops Triggered by a 2011 Feb 18 Flare

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We report a high-velocity plasma motion near the lop-top region of large-scale active-region loops after the occurrence of the M-class flare at the solar active region NOAA 11158 on 2011 Feb 18.

The motion was detected during the impulsive phase of the M-class flare by the Doppler-shift measurement in Fe XXIV line at 192A with the Hinode EUV imaging spectrometer (EIS). Hinode/EIS continuously observed this region with a raster scanning mode and a strongly blue-shifted Fe XXIV line was observed in a period of 10:11 to 10:16 UT. We performed a spectral fitting using double Gaussian functions to estimate Doppler velocity and have found that the Doppler velocity near the loop-top region reaches 200-400 km/s.

In order to identify the high-velocity component from the temporal evolution of the coronal structures, we use high-cadence EUV images from Atmospheric Imaging Assembly (AIA) on Solar Dynamics Observatory (SDO), which provides high-resolution full-disk images taken at nine EUV wavelengths bands. The high-velocity motion was clearly recorded in the sequence of images at the AIA 131A band. Before the appearance of the high-speed plasma, we have found that one of the loops that rose vertically up to ~300 km/s interacted with other loop structures located above it. The configuration between these loops allows the occurrence of a magnetic reconnection in the loop-top region.

We interpreted the high velocity motion in the loop-top region, detected with EIS and AIA, as a bulk motion of reconnected loops toward a relaxed state.

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PEM29-09 Room:304 Time:May 21 16:15-16:30

Whole atmosphere-ionosphere coupled model (GAIA) for space weather research

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Space near the Earth, called geospace, is a highly complex system, consisting of the solar wind, the magnetosphere, the ionosphere, and the neutral atmosphere. Those regions have different physical characteristics with different temporal and spatial scales. In particular, the magnetosphere, the ionosphere, and the neutral atmosphere are strongly coupled with each other, and interaction between the regions is nonlinear and extremely complicated. Even within each region, there are strong interactions between physical processes with different temporal and spatial scales. The geospace environment significantly varies as electromagnetic energy and particles from the sun vary. Furthermore, recent observations have revealed that atmospheric waves generated in the lower atmosphere and variations of the lower and middle atmosphere significantly influence the thermosphere and the ionosphere. In order to quantitatively understand such a complicated system, it is necessary to model the entire geospace region self-consistently. We have developed an atmosphere-ionosphere coupled model, which includes the whole neutral atmosphere and the ionosphere. The model is called GAIA (Ground-to-topside model of Atmosphere and Ionosphere for Aeronomy). Some unsolved phenomena in the upper atmosphere have been already reproduced and studied. The model will be a useful tool for space weather research and forecast. We will report some recent results using GAIA, such as (1) upper atmosphere variation during the annular solar eclipse on May 21, 2012, (2) effects of lower atmospheric phenomena on the ionosphere, and (3) ionospheric variation associated with magnetic storms including effects of disturbances from the lower atmosphere. We will also report our future plans for the development of GAIA.

Keywords: atmosphere, ionosphere, coupling, model, simulation, space weather