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

PEM29-P01 Room:Convention Hall Time:May 21 10:45-12:15

Space weather usage in JAXA radiation exposure management for astronauts

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The International Space Station (ISS) is a habitable artificial satellite that orbits the Earth at an altitude of about 400 km. Six astronauts regularly remain onboard the ISS, and conduct many experiments. Given the high altitude of the ISS, however, astronauts face health risks from space radiation in the form of galactic cosmic radiation, solar particle radiation, trapped radiation, and that from secondary eruptions. Astronauts onboard the ISS receive radiation exposure in one day that is equivalent to what humans on the Earth receive in six months. As these high-energy rays have high potential to adversely affect the health of astronauts, the Japan Aerospace Exploration Agency (JAXA) employs radiation exposure management for JAXA astronauts to minimize the health damage caused by space radiation exposure.

The important aspects of radiation management are space environmental monitoring and space weather forecasts. When a solar particle event and increasing the trapped radiation electrons occurs, astronauts are exposed to radiation several times greater than normal. As such events often occur unexpectedly, we must therefore constantly monitor the space environment. Based on this approach, we have established a system that can steadily monitor solar activity data from satellites in geostationary orbit, in collaboration with pertinent organizations. By using this system, we can receive space environment alerts and take action to minimize space radiation exposure before space radiation increases in the ISS orbit. Because this countermeasure is different based on the type and level of space environment, space weather offers us valid information to analyze the progress of a given situation.

Our system allows us to take action after receiving a space environment alert. By improving the accuracy of predicting space weather and taking action prior to the onset of some activities, we can help make missions safer and more reliable.

In this report, we introduce space radiation exposure management and space weather usage by JAXA.

Keywords: Astronaut, Space radiation exposure

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Possibility of interference caused by solar radio bursts

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It is known that strong radio wave with wide frequency range is emitted associated with solar flares. It is called solar radio bursts. There are several reports that strong solar radio bursts affected reception of radio wave from GPS satellites. GPS satellites use radio wave of 1.57542 GHz (L1) and 1.2276 GHz (L2) for positioning and it is necessary for positioning to receive signals from more than four satellites. It is difficult to eliminate the effect of solar radio bursts by directivity of antenna.

We examined how strong solar radio burst affects positioning of GPS. We analyzed how frequently the solar radio bursts which affect GPS positioning occurs using past approximately twenty-five years data from the Nobeyama Solar Radio Observatory of the National Astronomical Observatory.

Keywords: solar radio burst, interference, space weather

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Relationship between geosynchronous satellite charging and space environment

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In the social life accompanying rapid social development what depends the improvement in the convenience on satellites are large, and many satellites are going around the near earth. The space weather is various, the thing especially about employment of satellites, solar flare, solar wind, magnetic storm, galactic cosmic ray, etc. are raised. Prediction of space weather and research of evasion of danger are advanced.

It is called a ”space weather forecast.” Moreover, the system of catching the space environment correctly and supervising it in order to perform activity in the universe safely is indispensable, and in order to employ safely the satellite which requires a large amount of expenses for development and employment, the space weather forecast for the satellite has been an important issue. The influence of the global environment on a solar activity changes greatly with kinds of satellites, it pays its attention about the obstacle of a geostationary orbit satellite in this research.

Relationship between space environment and surface charging of geosynchronous satellite was investigated using the Potential monitor (POM) onboard ETS-V. In analyzing, the orbit condition of ETS-V and changes of the operation mode changes the condition of spacecraft charging, we try to remove these effects before our data analysis. As a result, we found that the surface charging of satellite is frequently occurred during 00LT and 06LT. It is thought that it is based on the photoelectric effect discharged by hitting light on the satellite surface and extensive electron injection by a substorm.

Next, we assume that the extensive electron injection by the substorm can be measured by AL index. Therefore, we investigated about the relationship between surface charging phenomena and AL index.

Correlation between spacecraft charging and AL index is not good in general. However, weak correlation is seen only in the time zone between 00LT and 06LT. This result seems to be related to the partial ring current by a substorm. Moreover, we were investigated whether the start time of satellite charging and the rapid growth of AL index are correlated. A result, 120 events of satellite charging is identified. 66 events are well correlated. About half of the events do not show clear correspondence.

Keywords: Space Weather Forecast, Satellite Charging, Substorm, Geosynchronous Satellite

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PEM29-P04 Room:Convention Hall Time:May 21 10:45-12:15

Influence Evaluation of Solar Activity to Seismic Activity by Statistical Models

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Detection of statistical connection between solar activity and seismic/volcanic activities was discussed in the literature. In this talk, statistical models are used to predict seismic energy by the measurements of the solar activity. We used daily data opened to the public.

Auto-regressive models with exogenous variables (ARX models) were used for prediction of the seismic energy. The target variables are the total energy of earthquakes (EQ) of the day after present day, with respective magnitudes 3-3.9, 4-4.9,..., 7-7.9 and 8+. The explanatory variables are solar/space measurements; sunspot numbers, solar wind velocity, Interplanetary Magnetic Field temperature, proton density, solar wind dynamic pressure and energy of solar wind, magnetic field; Dst and polar cap index. Data observed up to present day are used for prediction. The explanatory variables are selected by Bayesian Information Criterion so as to get parsimonious models. The optimal models have the following features:

1) The ARX models are useful for predicting small EQ, whereas poor for big EQ.
2) The most relevant explanatory variable is solar wind velocity.
3) The coefficient of determination for EQ4-4.9 was 53%.

Thus, it is statistically shown that solar activity affects small EQ.

Acknowledgments on data sources
Solar activity: Goddard Space Flight Center, NASA via the OMNIWeb Data Explorer and the Space Physics Data Facility.
Earthquake events: Advanced National Seismic System (ANSS) database.

Keywords: solar activity, seismic activity, solar wind, interplanetary magnetic field, auto-regressive models with exogenous variables

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Temporal behavior of the coronal hard X-ray source in solar flares

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In Sui & Holman 2003 and Sui et al. 2004, they analyzed a few flares occurred on the northwest limb (NOAA Active Region 9011) from April 14 to April 16, 2002, which were well observed with Reuven Ramaty High- Energy Solar Spectroscopic Imager (RHESSI). When the impulsive rise in hard X-rays began, the cusp part of the coronal source separated from the underlying flare loop and remained stationary for about 2 minutes. During this period, the underlying flare loops shrank. This phenomenon is very important to understand the energy-release process in solar flares since it might be closely related with magnetic reconnection. This has been reported for the first time by using the RHESSI data, even though Yohkoh observed more than 3,000 flares during its operational period (1991-2001). The purpose of this research is to verify quantitatively this phenomenon by using Yohkoh data.

The hard X-ray telescope (HXT) on board Yohkoh has an advantage to achieve it. This source motion takes place at the early phase of a flare. This means the number of photons is not enough to synthesize a hard X-ray image with a high quality. HXT has so-called fan-beam type sub-collimators. Using them, information on the source location can be derived without image-synthesis process. Also Yohkoh is not a spinning satellite and the time resolution is 0.5 second. Thanks to these characteristics, Yohkoh/HXT enables us to reveal the behavior of the coronal hard X-ray source in the early phase of a flare. First, we checked how this method worked for a well-known flare which has a moving hard X-ray source. In this presentation, we show the result of this test and discuss the limitation of this method.

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PEM29-P06 Room:Convention Hall Time:May 21 10:45-12:15

The evolution of magnetic structure of NOAA AR11158 and M-class flare on February 13, 2011

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We investigate the evolution of magnetic structure of NOAA AR 11158 and the corresponding M6.6 flare occurred on February 13, 2011.

Solar flare, a large energy release in the solar outer atmosphere, has a great influence on the geosphere. Spatially- and temporally-resolved observational data have been obtained by the recently-launched satellites Hinode and Solar Dynamics Observatory (SDO). The solar activity started to rise again in 2011 and a lot of flare data are now going to be accumulated.

NOAA 11158 emerged on the solar surface on February, 2011. It produced a lot of flares including X-class one. Hinode and SDO observed this region in detail from its emergence. Spectro-polarimetric data on the photosphere was obtained by Solar Optical Telescope (SOT) on board Hinode in the vicinity of M6.6 flare. We analyze the time-evolution of the magnetic structure of this region, especially the trigger region of M6.6 flare, and compare the structure with the numerical calculation by Kusano. First we investigate the magnetic field data obtained by Hinode/SOT and SDO/HMI. It is found that this region is formed by a collision of the two emerging fluxes, and that they make a strongly sheared polarity inversion line (PIL), on which a lot of flares occurred. We also found a discriminating magnetic structure on the PIL before the M-class flare. The horizontal field, which has the same direction as the potential field, is formed after the flare. We interpret this relaxation as a result of the magnetic energy release through the flare. Next we investigate Ca images, and find a continuous Ca brightening just above the discriminating magnetic structure. This is similar to the character of pre-flare brightening, which is seen in the ”reverse shear type” flare model suggested by Kusano. Further we make comparison of this brightening with current density in the numerical calculation by Kusano. The spatial distributions of the Ca brightening in the observation and the current density in the simulation are coincided with each other. The relaxed horizontal field continues to be sheared again by the motion of the whole region. We consider this sheared field as a pre-flare coronal arcade of the following X-class flare.

We present a brief summary of the flare observations in 2011 and show detailed results of the comparison between the M6.6-flare observation and the numerical results by Kusano.

Keywords: Sun, Solar Flare, Active Region, Magnetic Field

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Hard X-ray and Microwave Emissions from Solar Flares with Hard Spectral Indices

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We analyze ten flare events that radiate intense hard X-ray emission with significant photons over 300 keV to verify that the electrons that have a common origin of acceleration mechanism and energy power-law distribution from solar flares emit hard X-rays and microwaves. Most of these events have the following characteristics. Hard X-rays emanates from footpoints of flare loops, while microwaves from tops of flare loops.

The time profiles of the microwave emission show delays of peak with respect to that of the corresponding hard X-ray emission. The spectral indices of microwave emissions show gradual hardening in all events, while the spectral indices of the corresponding hard X-ray emissions are roughly constant in most of the events, though rather rapid hardening is simultaneously observed in both indices during the onset time and the peak time in some of them. These characteristics suggest that the microwave emission emanates from the trapped electrons. Then, taking account of a role of the trapping of electrons for the microwave emission, we compare the observed microwave spectra with the model spectra calculated by a gyrosynchrotron code. As a result, we successfully reproduce the eight microwave spectra. From this result, we conclude that the electrons that have a common acceleration and a common energy distribution from solar flares emit the both hard X-ray and microwave emissions in the eight events, though microwave emission is contributed by electrons with much higher energy than hard X-ray emission.

Keywords: the Sun, microwave, hard X-ray, particle acceleration

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Longitudinal phase structures of Pc5 on the ground during Relativistic Electron Flux Enhancement at the Radiation Belt

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In this study, the magnetic data observed at H057 (MLat.=-66.42, MLong.=72.29) and Skallen (MLat.=-66.42, MLong.=70.53) in Antarctica are used to estimate the azimuthal wave number(m) of the Pc5 pulsations with the period of 150-600s. These two stations are located at the same latitude and spread in longitudes of 1.7 degrees. In general, the estimation of the azimuthal wave number of the Pc5 pulsations is difficult due to a strong latitudinal dependence of the field line resonance of the Pc5. The pair of the stations used in this analysis is quite suitable to estimate the azimuthal wave number.

In order to compare the temporal variations of Relativistic Electron flux Enhancement (REE) observed by GOES 10 satellite, the superposed epoch analysis for 24 CIR (Corotating Interaction Region) events is conducted for the horizontal component of the magnetic field data. As a result, although the Pc5 power increases corresponding to the increase of the solarwind velocity, the power of the H component becomes predominant after 0.5 days from enhancement of the Pc5 power, which corresponds to the apparent start time of relativistic electron flux enhancement (REE). This indicates that the toroidal oscillation of PC5 becomes predominant in the inner magnetosphere at the start time of the REE. Second, although the phase difference between two stations largely fluctuates before the start of REE, it shows certain values with small variances during the REE events. The estimated azimuthal wave numbers (m) of the H and D components are 1.62+/-0.99 and -2.25+/-2.86, respectively. The eastward propagation of the toroidal Pc5 with the low m number of 1.62 suggests that the relativistic electrons at the inner magnetosphere are accelerated by the drift resonance with the toroidal Pc5 pulsations.

Keywords: radiation belt, relativistic electron, ULF wave

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Relativistic electron flux prediction at geostationary orbit based on multi-variate autoregressive model

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The flux of relativistic electrons at energies of a few to ten MeV in the outer radiation belt often largely increase at geostationary orbit a few days following high speed solar wind approach to the Earth. The enhancement of the relativistic electrons cause the anomalies on numerous geostationary spacecrafts due to deep- dielectric charging. Recent papers reported that solar wind dynamic pressure and north-south component of interplanetary magnetic field also control the amplitude of geostationary relativistic electron flux variation. We developed multi-variate autoregressive model for the prediction of its one-day average flux using time-series of the solar wind speed, dynamic pressure, and north-south component magnetic field observed by the ACE spacecraft and the geostationary electron flux at energies higher than 2 MeV observed by the GOES spacecraft for five years in 1999-2003. The comparison analysis showed that the multi-variate autoregressive model provides more accurate prediction values than commonly-used linear prediction filter which uses solar wind speed only as an input.

Keywords: Outer radiation belt, relativistic electron, prediction model

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Electron precipitation environment in low earth orbit observed by the GOSAT satellite

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The GOSAT satellite was launched on January 2009 into sun-synchronous sub-recurrent orbit with an altitude of 666km and an inclination of 98 deg. The LPT (Light Particle Telescope) installed on the GOSAT measure electrons from tens of keV to MeV and can observe precipitation into the atmosphere. The precipitating electrons are steadily observed in the inner and the outer radiation belt. In the outer radiation belt, the energy of the flux reaches to a few hundreds keV. The flux increases drastically during the magnetic disturbance. We will introduce a global behavior of the electron precipitations.

Keywords: Electron precipitation, Radiation belt electron, wave-particle interaction

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Pc1 band pulsation newly observed by induction magnetometer at magnetic low latitude

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Kyushu University Space Environmental Research Center has been observing geomagnetic data at Kuju(MLat=26.13) with induction magnetometer since 2003.We found some impulsive pulsation(We call this I-type event) during magnetic storm. The characteristic of I-type event similar to that of Intervals of Pulsations of Diminishing Period(IPDP) which observed at high latitude. The goal of this study is to investigate the characteristic of I-type event.

We analyzed data of year 2003,2004,2010 and 2011. The data were characterized based on ”Magnetic storm day data(S-data)” and ”Quiet day data(Q-data)”. There were 21 S-data in the analyzed period.

We found 7 I-type event from 21 S-data. During I-type event frequency increases with time. (delta f=0.8˜5[Hz],t= 10˜30[min])I-type event is only observed from S-data(not from Q-data) and occurred after 5 to 30 minutes from sub-storm onset. Considering these facts, it is clear that I-type event associates with magnetosphere disturbances.

We will discuss the details of I-type event at the presentation.

Keywords: Pc1, Induction magnetometer, magnetic low-latitude, IPDP

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Improvement of time resolution of equivalent ionospheric current system deduced from grand magnetic observation

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In the present study, the equivalent ionospheric current system is estimated by using the geomagnetic data observed at the multi-point grand observatories. As a preparation of the analysis, two kinds of interpolation are taken to the original data. First the observed points are virtually expanded in the longitude by taking the current vectors at every each one hour for six hours. Then the vector field of the ionospheric current system is calculated on the coordinated mesh grid with interval of 5 degrees in both latitude and longitude, by using the trigonometric interpolation.

The electric potential is obtained from the interpolated ionospheric current system by spherical harmonic analysis. As a result, the ionospheric current pattern estimated from 12-orderd spherical harmonic analysis well corresponds with that from the row current vector data which shows the snap shot of the ionospheric current system. It is confirmed that the reduction of the time resolution is not so critical, whereas more careful validation should be required in the future study.

Keywords: Equivalent ionosheric current system, geomagnetic observation