Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PEM029-01 Room:203 Time:May 24 14:15-14:30

A Conceptual Design on Incorporation of WASAVIES to the Aviation Route Dose Calculation System

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The main task in the management of cosmic radiation exposure for aircraft crew is calculation of the aviation route doses based on the flight information. Since the source of exposure at aviation altitude normally comes from galactic cosmic rays (GCR) of which the dose level gradually changes along the 11-year solar cycle, it is possible to calculate the aviation dose using a monthly average value of solar magnetic potential and a flight plan given for each month. Whereas, in case that a short, significant increase of atmospheric radiation happened by the solar energetic particles (SEP) emitted with a large eruption on the solar surface, in-flight exposure should be evaluated with minute intervals according to the precise actual information on flight time and route, separated from the GCR exposure. More concretely, it is necessary to develop a software that can estimate the minute-interval change of global atmospheric dose rates for 0 to 13 km in altitude for 24 h after a GLE detection and can calculate automatically the aviation route dose for any flight operated during the respective time. As a step to achieve it, we are presenting the conceptual design of an application to calculate a short-term, precise aviation route dose by utilizing the Warning System of AVIation Exposure to SEP (WASAVIES).

Keywords: cosmic, radiation, aircraft, exposure, GLE, SPE

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PEM029-02 Room:203 Time:May 24 14:30-14:45

Cosmic-ray exposure during aircraft operation

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Effects of exposure to cosmic-ray during aircraft operation, are divided into the exposure of the crew and operational impact. International Commision on Radiological Protection(ICRP) issued a recommendation to include occupational exposure of aircrew with a jet operated exposure from natural radiation source in 1990.Radiation Council consists of the Ministry of Education, Culture, Sports, Science and Technology, the Ministry of Health,Labour and Welfare, the Ministry of Land, Infrastructure, Transport and Tourism estabilised "Guidelines for management of aircrew exposure to cosmic radiation" in 2006. In response to this, airlines manage doses on each aircrew using Japanese Internet System for Calculation of Aviation Route Doses(JISCARD) developed by National Institute of Radiological Sciences(NIRS). Examples of operational impacts are, communication difficulty on short wave due to Dellinger Phenomenon during international flight, and rewrite the data in memory known as soft error on electronic equipment onboard aircrafts. Use of Space Weather forecast for major solar flare, how to provide the information to aircrew and how to make decisions are urgent consideration.

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PEM029-03 Room:203 Time:May 24 14:45-15:00

Development of WASAVIES: WArning System of AVIation Exposure to SEP

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The prediction of solar energetic particles (SEP) is important to mitigate the space weather hazard toward increasing solar activities, and is also an ultimate problem for physics-based modelers because of the hybrid nature of MHD fluid and particles. We are developing a two-step forecast system called Warning System of AVIation Exposure to SEP (WASAVIES) as follows: 1) Detect ground level enhancement (GLE) onset by multiple ground-based neutron monitors [Kuwabara et al., Space Weather, 2006] and obtain the GLE, solar wind, and flare parameters to publish the preliminary forecast within one hour after X-ray flare detection. At this stage we have only a small number of necessary parameters, and available forecast may be limited about the anisotropic GLE dose map and the maximum level of SEP fluence during coming 7 days. 2) Within 6 hours after the flare onset, automatically obtain the CME parameters such as speed and direction parameter to predict the CME driven SEP profiles during the 7 days in the energy range from 10 MeV to 10 GeV. The modified MHD Cube model [Kataoka et al., J. Geophys. Res., 2009] calculates the time-varying CME shock strength and the magnetic field connectivity to Earth for a particle model to estimate the SEP spectra, and also estimate the weekly profiles of solar wind parameters which are necessary inputs for T05 storm model to estimate the cutoff latitudes. Using the SEP energy spectra and cutoff latitudes, the aviation dose map are evaluated by modified PARMA model [Sato et al., Radiat. Res., 2008]. The real-time data of SEP, solar wind, and geomagnetic activities are also utilized properly. In the presentation, we report the initial results of WASAVIES and discuss some other important real-time observations of Type II burst and EIT waves etc.

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PEM029-04 Room:203 Time:May 24 15:00-15:15

Development of Automated Flare-CME Event Recognition System for WASAVIES

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Solar Energetic Particles (SEPs) are accelerated by interplanetary shocks driven by coronal mass ejections (CMEs). The intensity of the SEP events is closely related to the CME speed, width, and source location. SEPs pose significant radiation hazard to space systems and aviation, so it is important to predict the SEP events. The WArning System of AVIation Exposure to SEPs (WASAVIES) is a new initiative to forcast the expected exposure to SEP events at the latitude of commercial aircraft. The aim of this work is to obtain the CME parameters in real-time for better prediction of SEP events. The work involves the identification of CME source regions using soft X-ray flares and CME kinematics using automatic recognition of CMEs.

Solar flares are a good indicator of the source location of the CMEs, since the two phenomena are closely related in time and space. X-ray intensity from the Sun routinely monitored in the 0.1?0.8 nm wavelength band by GOES is used to determine the flare onsets, peak intensities, and durations. Normally the GOES data become available within a few minutes. Flare locations are determined by the Atmospheric Imaging Assembly (AIA) on the Solar Dynamic Observatory (SDO). Fe XVIII (9.4 nm) images are used because they have a good response to high temperature plasmas (˜7 MK). AIA observes the Sun with 0.6 arcsec (4k x 4k pixels) spatial resolution and 12 second cadence, but we use the synoptic data (1k x 1k, 2.4 arcsec pixels and 3 min, cadence) to minimize the network traffic. Since January 2011, the flare module has operated without problems. Typical latency to correct the required flare information is 1-3 hours.

Automated CME recognition system has been investigated by several researchers. The well-maintained programs are CACTus (Berghmans et al.) and SEEDS (Olmedo et al.) Both systems attempt to identify CMEs as human eyes do. They work well except for identifications of fast CMEs. This is because only a few images are taken for those CMEs. We are planning to optimize these programs for detecting fast CMEs or develop our own software if necessary. The preliminary result will be presented in the meeting.

Keywords: WASAVIES, SEP, CME, Flare

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PEM029-05 Room:203 Time:May 24 15:15-15:30

Studies on solar flares and shocks based on solar EUV images taken by STEREO

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Space weather researches have been actively discussed in the world. Solar flares and related CMEs are especially important as a generator of SEPs and strong radiations in X-rays and in EUVs. STEREO satellites, which was launched in 2006, are observing the sun from different points on the orbital path of the earth at 1AU. STEREO aims to derive 3-dimensional structure of solar corona, eruption, and so on. By STEREO data, therefore, we can study the structure of flare-related ejections and shocks in more detail. Moreover, we can know the ”invisible” solar surface from the earth. In this presentation, we show recent observations on solar eruptions and shocks by STEREO. We also discuss how much we can predict flare radiations/SEPs by using only solar full-disk images in EUVs.

Keywords: solar flare, MHD shock, corona, particle acceleration, SEP

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PEM029-06 Room:203 Time:May 24 15:30-15:45

Particle acceleration in solar flares and propagation of high energy particles to the Earth

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Large amount of particles are accelerated to relativistic energy in association with solar flares, and sometimes these penetrate to the Earth's atmosphere. These particles are observed by the ground based detectors (neutron monitor etc.). Such phenomena are called Ground Level Enhancements (GLEs).

Solar flares are observed by using electromagnetic radiations. Hard X-ray, radio and line gamma-ray observations give information of accelerated electrons and ions, respectively. High energy particles which reached to the Earth and penetrated to ground are observed by neutron monitors. We can predict energy spectrum of high energy particles penetrating to the Earth's atmosphere, by comparing with electromagnetic radiations. This is beneficial for the quantitative prediction of radiation dose.

There are two possible candidates for high energy particle production: the solar flare itself; and/or the CME-driven shocks - the flare producing 'seed' particles that enter to the CME-driven shocks and then they are re-accelerated there. However detailed acceleration mechanisms are still not understood that should be modeled. For predicting the energy spectrum of energetic particles at the Earth, it is important to understand quantitatively the population of accelerated particles during the flare.

In this paper, we present two topics regarding solar flares, for the sake of the prediction of radiation dose in the Earth's atmosphere. The first is the population of accelerated particles in solar flares, and the second is the prediction of the energy spectrum of high energy particles (especially solar neutrons) in the Earth's atmosphere during the GLE event.

Keywords: solar flare, particle acceleration

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PEM029-07 Room:203 Time:May 24 15:45-16:00

Shock propagation model for Solar Energetic particles flux prediction

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Solar energetic particles (SEPs) are one of the most significant part of the space weather forecast. The most widely accepted acceleration mechanism is diffusive shock acceleration (Axford et al 1977, Bell 1978, Blandford & Ostriker 1978, Krymskii 1977) in a shock wave driven by a coronal mass ejection (CME).

Largest events associated with high energy SEPs are called as ground level enhancements (GLEs) in which high energy particles are detected in ground-based neutron monitors. In those events, protons whose energy exceed 1 GeV are accelerated very rapidly just after the associated flare/CME beginning. The fact means the GeV protons may be accelerated in a shock propagating in the corona near the Sun. Recently some studies show that particles can be rapidly accelerated by the shock with the time varying shock parameters (Tilka & Lee 2006; Sandroos & Vainio 2007; 2009; Ng & Reames 2008). The variation of the shock parameters along a field line during the propagation can be very important information for the forecast of proton fluxes.

We are developing a new model to trace the time variation of the shock parameters along a field line near the Earth. We first calculated three dimensional coronal magnetic field using a high resolution potential source surface model with SOHO/MDI synoptic maps. Next we assumed a virtual shock source near an active region, and then a spherically propagating shock wave. As the shock propagates, the cross point between the shock and the field line moves and then shock parameters change.

Keywords: solar energetic particle, solar corona, shock, coronal mass ejection, solar wind

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PEM029-08 Room:203 Time:May 24 16:00-16:15

Maximum Energy of Solar Energetic Particles

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The standard diffusive shock acceleration (DSA) model is often invoked for the mechanism accelerating energetic particles around collisionless shocks. We will discuss the maximum attainable energy for solar energetic particles in the context of shock acceleration theory. While the maximum energy can easily be estimated by DSA in the most simplified (i.e., ideal) condition, there are number of effects (e.g., time-dependence, geometry, nonlinear effects, anomalous diffusion) which may alter the acceleration efficiency. In this report, we discuss these effects in the context of solar energetic particle acceleration around strong shocks propagating in the inner heliosphere.

Keywords: collisionless shock, particle acceleration, solar energetic particles

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PEM029-09 Room:203 Time:May 24 16:30-16:45

Solar energetic particles entering into the terrestrial magnetosphere

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We investigate the solar energetic particles (SEPs) entering into the terrestrial magnetosphere associated with coronal mass ejections (CMEs), using the POES satellite data at low-earth orbit. The POES satellites have ion detectors, measuring the energetic ions ranging from 30 keV to 7 MeV. We demonstrate the superposed epoch analysis of the MeV ions associated with CME-driven intense storms during solar cycle 23. The zero epoch time corresponds to the interplanetary shock arrival detected by the ACE satellite. The initial results indicate that a significant SEP enhancement is observed for a few hours just before the shock arrival, possibly associated with the energetic storm particles accelerated at CME shocks. The enhancement appeared at the invariant latitudes of larger than 60 deg with a different appearance at dawn and dusk. The significant dawn/dusk asymmetry of the SEP flux entering in the magnetosphere is probably due to so called east-west effect of the gyrating protons at the low altitude. We report further statistical results to contribute for a robust forecast of SEP flux entering into the terrestrial magnetosphere.

Keywords: Solar Proton, low-altitude satellite, interplanetary shock, CME

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PEM029-10 Room:203 Time:May 24 16:45-17:00

Simulation of Air Shower Induced by Solar Energetic Particle

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When solar energetic particles (SEP) or galactic cosmic-rays (GCR) are incident to the atmosphere, they can induce air showers by generating varieties of secondary particles. Such secondary particles can reach conventional flight altitudes (~12 km), and hence, aircrews are exposed to enhanced level of radiations. In order to precisely estimate the aircrew doses, the Monte Carlo simulation for air shower is indispensable. We had therefore simulated air showers induced by GCR, using a general-purpose Monte Carlo particle and heavy ion transport simulation code system PHITS, and established a model for calculating the aircrew doses anywhere in the world at the solar quiet time [Sato et al. Radiat. Res. 2008, http://phits.jaea.go.jp/expacs/]. In this study, we applied our simulation technique to the analysis of air shower induced by SEP, and established a model for estimating the aircrew doses from a given SEP energy spectrum and cutoff latitude. The model is to be incorporated into our developing Warning System of AVIation Exposure to SEP called WASAVIES. The procedures for the air shower simulation together with some initial results of the aircrew dose calculations for past GLE events will be presented at the meeting.

Keywords: SEP, air shower, radiation dose, Monte Carlo simulation, GLE, WASAVIES

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PEM029-11 Room:203 Time:May 24 17:00-17:15

Development of a GLE alarm system based upon neutron monitors for early warning of radiation hazard

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We have developed a system that watches for count rate increases recorded in real time by eight neutron monitors, which triggers an alarm if a ground level enhancement (GLE) is detected. In this work, we determine optimal strategies for detecting the GLE event at a very early stage, while still keeping the false alarm rate at a very low level. We study past events to optimize appropriate intensity threshold values and a baseline to determine the intensity increase. The highest-level alarm, which we term an ALERT, is generated when a 4% increase is recorded at three stations in 3 min averaged data. At this level, the false alarm rate obtained by back testing over the past 4.4 years is zero. Ten GLEs occurred in this period, and our system produced GLE alarms for nine events. Alarm times for these nine events are compared with satellite proton data. The GLE alert precedes the earliest alert from GOES (100 MeV or 10 MeV protons) by 10-30 min. Real-time GLE data may be viewed at http://neutronm.bartol.udel.edu/spaceweather. An automated e-mail alert system is now under beta testing at http://www.bartol.udel.edu/˜takao/neutronm/glealarm/index.html.

Keywords: GLE, Neutron Monitor, Cosmic Ray

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PEM029-12 Room:203 Time:May 24 17:15-17:30

Probability forecast of the SEP event occurrence in a long-term range

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[1]NICT

The SEP events are one of the space weather effects most hazardous to the space environment of mankind. Due to the rareness of its occurrence, the long-term, a monthly-to-yearly range, probability assessment can also provide useful information to operations, as well as the accurate prediction of its arrival. We have already developed the forecast scheme of one-month occurrence probability for the geomagnetic storm [Tsubouchi and Kubo, 2010], in which the probability is derived as a function of the elapsed time after the latest event from the cumulative distribution function for the time interval between successive events. In the present study, we apply this scheme to the SEP case and compare with the corresponding observations to verify the forecast validity. The most appropriate parameters, such as the event criterion and lead time, will be explored.

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PEM029-13 Room:203 Time:May 24 17:30-17:45

A Modeling of the Solar Energy Particles in NICT

Satoshi Inoue[1*], Shinichi Watari[1], Mitsue Den[1], Yuki Kubo[1], Ryuho Kataoka[2]

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Solar energy particles (SEP) are one of the most important problems for the space weather research because these phenomena cause the obstacles of the satellites and the radiation exposure to astronauts. However these generation and propagation processes mainly depend on the occurrence of the solar flares, shock wave derived from coronal mass ejections (CMEs) propagating in the interplanetary and the magnetic field in the solar wind. Therefore, it is very difficult to perform a numerical modeling to need the cover region from the sun to earth. Recently, Kataoka et al. are developing a unified model from an occurrence of the CME in the solar corona and the particle acceleration derived from shock wave in the interplanetary to a calculation of the radiation upper atmosphere. This goal is to develop a prediction system for GeV particles.

In this study, we will introduce an overview of a modeling for the solar energy particles (SEP) developed by NICT. This model will be co-development with warning system of aviation exposure to SEP (WASAVIES) developed by Kataoka et al. Our goal is to develop a unified numerical model that is able to reproduce not only GeV particles but also MeV particles and then to operate on the Science Cloud developed by NICT.The developments by NICT are as follows. (1) Developing an automatic detection of Type II burst from HiRAS data to determine the CME parameters. (2) Developing a numerical code for MeV particles that are not yet applied to WASAVIES. (3) Developing the global coronal magnetic field. In this study, we will introduce the method and current results for a modeling of the coronal magnetic field including the solar active region as well as an overview of our project, and also the relationships between the coronal magnetic field and SEP.

Keywords: solar Energy Particles, Numerical Modeling, Solar Coronal Magnetic Field

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PEM029-14 Room:203 Time:May 24 17:45-18:00

Simulations of Diffusive Shock Accerelation with Adaptive Mesh Refinement Scheme and Stochastic Differential Eq. Method

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It is beleieved that coronal mass ejcetion driven shock waves can produce energetic particles by diffusive shock acceleration. We model this mechanism by the following 2 steps: a study of the shock propagation and a study of acceleration at the shock. We show the spectra of particles obtained by using the results for the simulation in which the simulation box covers the orbit of 2.3AU and discuss contribution of the shock wave which has passed.

Keywords: high energy particles, shock acceleration, coronal mass ejections

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PEM029-15 Room:203 Time:May 24 18:00-18:15

Estimate of coronal shock speed by solar radio observation and solar energetic particle transport

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Ground level enhancement (GLE) is caused by extremely energetic particles from the Sun. The origin of these extremely energetic particles are thought to solar flares or solar coronal shock waves although origins of solar energetic particles are still controversial. If energetic particles accelerated at a coronal shock wave cause GLE, a speed of the coronal shock wave will be an elementary parameter for predicting the energetic particle intensity and also GLE level.

The coronal shock waves have been detected by various observations, such as solar radio spectra, H-alpha images, EUV images, and X-ray images. The speed of coronal shock waves can be estimated by these observation data although it is not sure if these observations are counterparts of the same coronal shock waves. We will introduce a method to estimate a speed of coronal shock wave by using solar type 2 radio burst data obtained with HiRAS system at Hiraiso Solar Observatory, NICT. Moreover, a method for automatic detection of type 2 radio burst will be introduced briefly.

After particles were accelerated at solar flare or coronal shock waves, the particles are propagating from the Sun to the Earth. Particle transport is one of the most important topic for predicting particle intensity time evolution on the Earth. We will also introduce current status of solar energetic particle transport study briefly.

Keywords: Solar Energetic Particles, Solar Radio Bursts

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PEM029-16 Room:203 Time:May 24 18:15-18:30

Paradigm on solar energetic particle events

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High-energy particles accelerated by solar activity are called solar energetic particles (SEPs). It found that there are two distinct types of SEP events by satellite observations of SEP composition and charge states. One is electron-rich SEP event called impulsive SEP event. Another is proton-rich SEP event called gradual SEP event.

Electron-rich SEP events are observed associated with impulsive flares, which occur in solar longitude around 55 degrees in the west and contains more heavy ions.On the other hand, proton-rich SEP events are observed associated with long duration events (LDEs): long-duration flares. Source regions of the events widely distribute in solar longitude. These observations suggest that SEPs of impulsive events are accelerated near flare regions and SEPs of gradual events are accelerated by shock waves of coronal mass ejections (CMEs).

It is found that some gradual SPE events have characteristics of impulsive SEP events according to long-term observation of SEP composition and charge states by the ACE spacecraft. As a result of this observation, acceleration of flare seed particles by quasi-perpendicular shocks is proposed on acceleration of high-energy SEPs.

Keywords: solar energetic particle, solar flare, coronal mass ejection, shock wave