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

PEM12-01 Room:301B Time:May 21 09:00-09:15

Global Lightning and Sprite Measurements from International Space Station (GLIMS)

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The Global Lightning and sprIte MeasurementS mission (GLIMS) to observe lightning and sprites from the International Space Station (ISS) are introduced in this presentation. Lightning is an electrical discharge which neutralizes the charge inside thunderstorm. In the early 1990s, optical transient luminous events (TLEs) occurring just above the thunderstorm were firstly reported by the US scientists and are associated with positive cloud-to-ground discharges with a large amount of charge. Though the luminous events so-called sprite, elves and jets have been investigated by numerous researchers all over the world based mainly on the ground observations, some important problems have not been fully understood yet such as generation mechanisms of columniform fine structure and horizontal offset of some sprites from the parent lightning discharges. In the JEM-GLIMS mission, observations from our synchronized sensors are going to shed light on above-mentioned unsolved problems regarding TLEs as well as causative lighting discharges. Our goals are (1) to detect and locate lightning and sprite within storm scale resolution over a large region of the Earth's surface along the orbital track of the ISS without any bias, (2) to clarify the generation mechanism of sprite, and (3) to identify the occurrence conditions of TLEs.

Keywords: Lightning, TLE, ISS

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PEM12-02 Room:301B Time:May 21 09:15-09:30

Science Instruments Onboard JEM-GLIMS

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In order to study the occurrence characteristics, spatial distributions, and occurrence conditions of Transient Luminous Events (TLEs), lightning and TLE observations named JEM-GLIMS (Global Lightning and sprIte MeasurementS on JEM-EF), which will be carried out at Exposed Facility of Japanese Experiment Module (JEM-EF) of International Space Station (ISS), will start this year. In this mission two kinds of optical instruments and two sets of radio receivers are employed and installed into the Multi mission Consolidated Equipment (MCE), which is the bus system and will be installed at JEM-EF. The optical instruments consist of two wide FOV CMOS cameras (LSI) and six-channel spectrophotometer (PH). These optical instruments are pointed to the nadir direction. LSI uses a STAR-250 CMOS device as a detector, which has 512x512 pixels and 25x25 um pixel size, and has 28.3x28.3 deg. FOV. LSI-1 equips a wide band optical filter (766-832 nm) and mainly measures lightning emission, while LSI-2 equips a narrowband optical filter (762+/-7 nm) and mainly measures TLE emission. Five of six PH channels have 42.7 deg. FOV and use photomultiplier tube (PMT) as a photon detector. They equip band-pass filters (150-280 nm, 316+/-5 nm, 337+/-5 nm, 392+/-5 nm, and 762+/-5 nm) for the absolute intensity measurement of the TLE emission. One of six photometers equips a wide-band filter (600-900 nm) to detect lightning occurring within 86.8 deg. FOV. These output signals will be recorded with the sampling frequency of 20 kHz with a 12-bit resolution. In order to detect whistler wave in the VLF range excited by lightning discharges, one VLF receiver (VLFR) is installed. VLFR consists of a 15cm monopole antenna directing nadir direction and attached at the base plate of MCE and consists of a VLF receiver that records waveform data with a sampling frequency of 100kHz with 14-bit resolution. VHF interferometer (VITF) that measures VHF pulses emitted by lightning discharges is installed. VITF consists of two patch-type antennas installed at the base plate of MCE and separated by 1.5m and of one receiver which records pulse data with a sampling frequency of 200MHz with 8-bit resolution. JEM-GIMS will be launched this year by HTV carrier cargo for ISS. In 2010 all the fabrications of GLIMS instruments and the environmental tests were completed. In 2011 all the function check tests and system environment tests were also finished. Now, MCE was delivered to the launch site in order to install MCE into HTV and to construct the rocket system. We will present the detailed specification and functions of JEM-GLISM instruments and discuss the expected science outputs derived from this mission.

Keywords: lightning, TLEs, JEM-GLIMS mission, ISS

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

PEM12-03 Room:301B Time:May 21 09:30-09:45

VHF Lightning Observations on JEM-GLIMS Mission

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Global Lightning and sprIte MeaSuremints (GLIMS) mission is scheduled on Exposed Facility of Japanese Experiment Module (JEM-EF) of the International Space Station (ISS). This paper introduced an electromagnetic (EM) payload of JEM-GLIMS mission, VHF broadband digital InTerFerometer (VITF) as well as our gradual approach to realize space-borne lightning monitoring by means of EM observations.

To realize a space-borne VHF broadband Digital InTerFerometer (DITF), Lightning Research Group of Osaka University (LRG-OU) intends to have gradual approach for the development. As the first step, LRG-OU has installed Broadband Measurement of Waveform for VHF Lightning Impulses (VHF sensor) on Maido-1 satellite to examine the feasibility of the space-borne DITF receiving VHF lightning impulses in space. VHF sensor comprises a system to record VHF broadband EM signals. Maido-1 satellite had been launched successfully and operated for 9 months in 2009. VHF sensor conducts 153 sets of lighting observations around the world, and provides its function in space. The results show the clear distinction between over land and ocean as well as the regional dependency in the feature of obtained VHF waveforms.

As the next step JEM-GLIMS mission is ongoing to observe global distributions of lightning and lightning-associated transient luminous events (TLEs) by combining radio and optical sensors. The simplest DITF, witch consists of a pair of VHF broadband antennas and electronics to record EM waveforms from lightning discharges is installed. It is designed to estimate the direction-of-arrival with about 10 km resolution that is equivalent to the scale of a thundercloud. It means that VITF is able to monitor thunderclouds with lightning activities globally. Comprehensive observations with the optical payloads of JEM-GLIMS for lightning activities and related TLEs are expected to give us many scientific impacts. The developments of VITF are based on the heritage of VHF sensor on Maido-1 satellite.

After the designing and manufacturing, various environmental tests such as vibration, impact and thermal vacuum tests were conducted as well as electrical tests. It is developed on the heritage of VHF sensor on Maido-1 satellite and is scheduled to start observations in 2012. It is the first platform to realize the simplest DITF and synchronous observations with optical sensors.

Keywords: lightning observations, electromagnetic wave, transient luminous event, the International Space Station

Japan Geoscience Union Meeting 2012
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PEM12-04 Room:301B Time:May 21 09:45-10:00

Measurement of Sprites and Elves from JEM-GLIMS and mountain-based observations

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We introduce our plan to investigate Sprites and Elves observed from JEM-GLIMS and two mountains in Japan. Our target is to observe the sprites and other related phenomena such as blue jet during the summer thunderstorm. In the ground observation, we will install several instruments at the top of the Mt. Fuji and Mt. Norikura. In addition, we compare the data of the ground-based observation with that of the JEM-GLIMS.

Keywords: Splite, Elves, JEM-GLIMS, Mountain observation

Japan Geoscience Union Meeting 2012
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PEM12-05 Room:301B Time:May 21 10:00-10:15

TARANIS: a satellite project for the study of transient energy transfers between atmosphere ionosphere and magnetosphere

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Sprites, jets and elves called Transient Luminous Events (TLE), observed in the middle and upper atmosphere above thunderstorms, are the manifestation of intense energy exchanges between the troposphere, stratosphere and mesosphere. Different types of luminous emissions have been identified by ground based observations, showing the complexity of these phenomena. Other, possibly related, transient emissions in the Earth atmosphere include high energy electrons, radio emissions in a broad frequency range from ELF up to VHF, luminous emissions in FUV, X-gamma ray emissions called Terrestrial Gamma-ray Flashes (TGF) with energies which could reach 100 Mev. The purpose of the satellite TARANIS (Tool for the Analysis of RAdiations from lightNIngs and Sprites) is to study simultaneously these emissions above the thunderstorm areas with complementary instruments including: micro cameras and photometers, X-ray and gamma-ray detectors, high energetic electrons spectrometers, electric and magnetic sensors. The orbit will be quasi-polar sun-synchronous at 700 km altitude. Data of ”event” and ”survey” modes will be stored on a mass memory of 16 Gbits and transmitted to the ground by X band telemetry link. TARANIS, presently in construction phase, is scheduled to be launched by the end of 2015.The presentation will describe the instrumentation and review the new challenges opened by the most recent observations related to these phenomena. It will also discuss the possibilities opened by the synergy with the other space missions GLIMS and ASIM.

Keywords: thunderstorm, lightning, sprite, satellite, TLE, TGF

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

PEM12-06 Room:301B Time:May 21 10:15-10:30

Forecasting thunderstorms for global sprite observations from the ISS

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The global rate of sprites occurring in the mesosphere following positive cloud-to-ground lightning flashes was estimated from the ISUAL satellite data to be ˜0.5 per minute (Chen et al., 2008). During the summer 2011, in the framework of the "Cosmic Shore" project, we conducted a concentrated attempt to image sprites from the ISS, by directing the astronaut on-board. The methodology for target selection was based on that developed for the space shuttle MEIDEX sprite during the Columbia mission STS-107 (Ziv et al., 2004). Different types of convective systems generate thunderstorms which differ in their effectiveness for sprite production (Lyons et al., 2009); thus, we had to evaluate the ability of the predicted storms to produce sprites. We used the Aviation Weather Center (http://aviationweather.gov) daily significant weather forecast maps (SIGWX) to select regions with high probability for convective storms and lightning such that they were within the camera filed-of-view as deduced from the ISS trajectory and distance to the limb. In order to enhance the chance for success, only storms with predicted "Frequent Cb" and cloud tops above 45 Kft (˜14 km) were selected. Additionally, we targeted tropical storms and hurricanes over the oceans. The accuracy of the forecast method enabled obtaining the first-ever HDTV color images of sprites from space. We will report the observations showing various types of sprites in many different geographical locations, and correlated parent lightning properties derived from ELF and global and local lightning location networks (WWLLN).

Chen, A. B., et al. (2008), Global distributions and occurrence rates of transient luminous events, J. Geophys. Res., 113,A08306, doi:10.1029/2008JA013101

Lyons, W. A., et al. (2009), The meteorological and electrical structure of TLE-producing convective storms. In: Betz et al. (eds.): Lighting: principles instruments and applications, Springer-Science + Business Media B.V..

Ziv, B., Y. Yair, K. Pressman and M. Fullekrug, (2004), Verification of the Aviation Center global forecasts of Mesoscale Convective Systems. Jour. App. Meteor., 43, 720-726.

Keywords: Thunderstorms, Forecast, Sprites, ISS, Lightning, TLE

Japan Geoscience Union Meeting 2012
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PEM12-07 Room:301B Time:May 21 10:45-11:00

Multi-color photometric observation of cloud-to-ground and intra-cloud lightning from space

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This study aims at evaluating the effectiveness of spectrophotometric measurement from space in characterizing the properties of lightning flash. The multicolor photometric data obtained by FORMOSAT-2/ISUAL were analyzed in both of cloud-to-ground (CG) and intra-cloud (IC) lightning events identified by Duke RF measurement, National Lightning Detection Network (NLDN), North Alabama Lightning Mapping Array (LMA). The ISUAL data suggested that, while the optical color of CG strokes tends to be red, the color of IC pulses tends to be unchanged or blue. These tendencies were found consistently in about 90 % of 51 lightning events analyzed so far. Furthermore, in one event which was simultaneously observed by ISUAL and LMA, the color of lightning was found to slowly change to red as the source altitude gradually decreased. These results consistently suggest that the color of CG component is more red than that of IC component, and we explain this as a result of more effective Rayleigh scattering in blue light emission coming from lower-altitude light source. This finding suggests that spaceborne spectral measurement could be a new useful technique to for the first time discriminate CG and IC flashes on a global level.

Keywords: Atmospheric electricity, Lightning, Satellite measurement, Spectral observation

Japan Geoscience Union Meeting 2012
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PEM12-08 Room:301B Time:May 21 11:00-11:15

Observation of sprite events with the Reimei satellite

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The sprite emission is characterized by a vertically extending fine structure (called as carrot and column) in the altitude range from 40 to 90 km. The sprite has been measured by ground-based instruments, and there is no monochromatic imaging data from space. A satellite observation is useful to investigate the global distributions of sprite since an optical instrument on a satellite can measure the sprite in the wide range without atmospheric absorption.

The multi-spectral camera (MAC) on Reimei has taken the monochromatic images at 428 nm, 558 nm, and 670 nm with an exposure time of 957 ms in the limb direction at middle and low-latitudes from March 2008. The spatial resolution at a tangential point is ?4 km. According to the noon-midnight sun-synchronous orbit of Reimei at an altitude of ?640 km, the observation is made around the midnight sector.

We found several sprites events at a wavelength of N2 1P (670 nm). For three events among them, the simultaneous observations between N2+ 1N (428nm) and N2 1P were performed. The electron temperature associated with a sprite can be estimated from the intensity ratio between emission of N2+ 1N and that of N2 1P. However, it is rather difficult to identify the N2+ 1N for these three events due to the low sensitivity of 428 nm channel of MAC. The N2+ 1N intensities of sprites are estimated to be less than 92 - 188 R, while N2 1P intensities of sprites are 10 ? 12.5 kR. Therefore, we estimated the upper limit of electron temperature from these data. As a result, the upper limits of the electron temperatures are 5.5 ? 6.7 eV, and the upper limits of the electric field intensities are 141 ? 209 Td. The altitude of sprite emission is accurately determined with the satellite attitude data and the field-of-view of MAC. In this presentation, we will report precise estimation result of the temperatures and electric fields associated with sprites using the MSIS model.

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

PEM12-09 Room:301B Time:May 21 11:15-11:30

WWLLN Absolute Detection Efficiencies and the Global Lightning Source Function

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The World Wide Lightning Location Network (WWLLN) has been enhanced to allow for the measurement of the waveguide propagated very low frequency power radiated for each detected stroke. This allows for the 60 station network to measure the stroke power to a 17% uncertainty alongside the location and timing accuracies of ˜10 km and <30 micro-s. The Earth Networks Total Lightning Network (ENTLN) is a total lightning network utilizing 550 wide-band sensors (1 Hz to 12 MHz) in North America (in 2011) allowing for a nearly 95% detection efficiency over the continental United States of CG strokes and 66% for IC strokes. ENTLN also determines the peak current of the detected strokes. The WWLLN is compared to the ENTLN to determine the absolute detection efficiency over the continental United States as well as investigate the relation between the ENTLN peak current and the WWLLN radiated power per stroke measurements over several spatial and temporal scales.

The comparison between the two networks is utilized as a validation of a recently developed relative detection efficiency model of WWLLN. Through investigating the relationship between stroke power, peak current, and relative detection efficiency the model is expanded to provide estimates of absolute detection efficiency outside the bounds of the direct comparison. The expansion of the new model allows for WWLLN to correct for both uneven global coverage and undetected strokes, the corrected data enables an estimation of the global lightning source function over several time scales ranging from hourly to monthly. The longer time scale results are compared to previous seasonal and yearly estimates of the source function and with yearly satellite averages.

Keywords: Global lightning detection, detection of powerful lightning, transient luminous events

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PEM12-10 Room:301B Time:May 21 11:30-11:45

Relationship between the charge moment change of parent CG and the duration of sprites' light emission

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In the period of a combined aircraft and ground-based campaign supported by NHK Cosmic Shore project, June 27 to July 10, 2011, an airborne high-speed camera captured over 60 TLE events at a frame rate of 8000 /sec or 10000 /sec. In addition, we make use of waveform data recorded by the global ELF observation network, (GEON), operated continuously by Hokkaido University. Based on ELF waveform data, we can estimate charge moment changes (CMCs). Using GEON and NLDN data, relationship between the charge moment change / the peak current and the duration of sprites light emission was examined in detail. It is found that there exists a good correlation between the charge moment change of parent CG and the decay time of the sprites light-curve with R2˜0.72.

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

PEM12-11 Room:301B Time:May 21 11:45-12:00

Relationship between structures of sprite streamers and inhomogeneity of preceding halos

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Transient Luminous Events (TLEs) in the stratosphere, mesosphere and lower thermosphere is phenomena of high time resolution associated with lightning. The diffuse glows such as elves and sprite halos progresses first and discrete structure of sprite streamers progresses next. Elves and sprite halos are considered to have a relationship with structure of sprite streamers. Therefore, spatial distribution and time evolution of these phenomena is key parameters of the condition of generation and mechanism of TLEs.

In the period of June 27 - July 10, 2011, aircraft and ground-based campaign in support of NHK Cosmic Shore project was carried out under collaboration between NHK, Japan Broadcasting Corporation, and universities. Two aircrafts carried the high-speed camera, and observed the TLEs.

The observation from an aircraft makes it possible to capture TLEs without influence of atmospheric absorption, and detailed structures of TLEs over 40 events was able to observe with the high-speed camera with frame rate of 8300 /sec.

In the TLEs observed by the campaign, sprite streamers and sprite halos are always showing some inhomogeneity, and it seemed that sprite streamers is clearly related to inhomogeneity of sprite halos. At this presentation, we will show the relationship between inhomogeneity of halo and sprite streamers with these velocities of progress estimated from the high-speed images.

Keywords: sprite, halo, streamer, high-speed camera