MIS29-P01 Room:Convention Hall Time:May 22 18:15-19:30

Importance of estimating the extremely large GIC in Japan

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The geomagnetically induced currents (GICs) happen to cause power line failure in the high-latitude countries. Meanwhile, there are no researches about extremes of GICs in Japan with heterogeneous profiles of the underground conductivity. Therefore, to evaluate extremes of the GIC in Japan is not only important for Japanese society but also significant for the scientists. Namely, estimation of extremes of the GIC is a challenging interdisciplinary research from the magnetosphere-ionosphere physics for estimation of the extremely large storms and related phenomena to the solid Earth geomagnetism for electromagnetic response under three-dimensionally heterogeneous conductivity profiles. We also need information from the solar physics for extremely large flares and the interplanetary physics for propagation of the disturbances from the sun to the Earth. This session is a kick-off meeting for investigating the extremely large GIC expected in Japan. By sharing present status of the researches related to evaluation of the extreme GIC, we will discuss future collaborating research among scientists from space science, solid-earth geomagnetism, and related fields toward evaluation of the extremes of GICs.

Keywords: Geomagnetically Induced Current, Extreme space waether condition, nonuniform ground electric conductivity, modelling, statistical analysis

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Science and Operational Activity of Space Weather in NICT

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We, NICT has been providing space weather forecast information for keeping secure and safe operation of telecommunication, broadcast and satellite positioning, etc. We need to study very wide area, from the sun to the earth's ionosphere and/or ground for studying space weather. In addition we still have unknown mechanism in this field. We are now constructing forecasting system with observation network, empirical model and numerical simulation in such limited condition. And we use informatics technique for high-performance observation and building large computing field. GIC is one of the big topics in space weather and we will discuss how to collaborate their expert community to improve this scientific field.

Keywords: Space Weather, satellite positioning, solar flare

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Numerical solver of EM induction equation in 3-D anomalous sphere by using integral equation method

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We developed a forward modeling solver of EM induction equation in 3-D anomalous Earth by using the integral equation method. The integral equation method use a semi-analytic Green's function for 1-D background structure so that the numerical solution can be more accurate, but Green's function requires a lot of computational memory and time.

To reduce them, we performed a spherical harmonics expansion in lateral direction and variable separation in vertical direction. Further, we adapted a modified IDM to accelerate the solver, which is well known that the condition number of discrete integral equation is drastically reduced.

We introduce the details of this method.

Keywords: 3-D forward modeling, integral equation method, modified IDM, Green's function, spherical harmonic expansion, variable separation

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Development of the ionospheric conductivity model

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To estimate the ionospheric current quantitatively, we implemented the ionospheric conductivity model on Interactive Data Language (IDL) by using IRI-2012, NRMSISE-00, and IGRF-11. In this presentation, we don't mention about Geomagnetically induced current itself which is the theme of this session. We explain about the ionospheric conductivity model implementation, the calculation example, and the current situation of the software distribution preparation.

Keywords: ionosphere, conductivity, numerical model, IDL, IUGONET

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Estimation of the extreme geomagnetic storm level by utilizing extreme value statistics

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Extreme GIC events, hazardous to some technological systems in our current society, must be associated closely with a large disturbance in the geomagnetic field. The typical prominent phenomenon is the geomagnetic storm, which is defined by the time variation of the Dst-index. The interest of the present study is the statistical assessment of the occurrence of severe storms, characterized by the large negative depression of Dst less than -100 nT. The largest storm in the recorded history is known as the Carrington event of 1859, whose Dst was estimated to be -1750 nT. In the published Dst since 1957, the largest value is -589 nT on March 1989. Using the whole Dst database is inadequate for drawing the precise statistics of the occurrence of such "superstorms" due to its rareness. In the present study, we utilize extreme value statistics, which focuses on the statistical behavior only in the tail of the distribution. We extract the Dst data less than -280 nT and determine the form of the generalized Pareto distribution by fitting this subset to it. This enables us to estimate the imaginable largest storm level, as well as the occurrence probability for the specific level in several decades ˜ centurial scale.

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Seafloor electromagnetic observation and recent application for imaging sub-seafloor structure

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Abrupt changes of geomagnetic field can yield damages to pipelines, cables and other architectures. For understanding the phenomena and future risks, geomagnetic observations and exploration of sub-surface resistivity structure are necessary. Here, I introduce the seafloor electromagnetic observations: the observation techniques and recent examples of the application for evaluating sub-seafloor resistivity structure.

Mainly, the seafloor observation was conducted by using OBEMs: ocean-bottom electromagnetometers. OBEM can records the fluctuations of geomagnetic and induced electric field on the seafloor. Although the high frequency components could not be recorded due to high attenuation in the conductive sea layer, the low frequency components (e.g., less than 0.1 Hz typically) can be observed on the seafloor with water depth of several thousand meters. The obtained electromagnetic field can be analyzed for imaging sub-seafloor resistivity structure. In addition to the natural electromagnetic field, a controlled artificial electromagnetic signal can be used for imaging shallow sub-seafloor structures. The survey is now expanded to various fields: for finding energy and mineral resources, imaging active faults and submarine magmatic activities, etc.

In my talk, I review the techniques to observe electromagnetic field on seafloor, and recent topics related to sub-seafloor resistivity explorations briefly.

Keywords: ocean bottom, sub-seafloor structure, electromagnetic observation

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A statistical study of geomagnetic events in Japan

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Japan Meteorological Agency has reported geomagnetic events at Kakioka, Memambetsu and Kanoya. Lists of geomagnetic events at Kakioka and Memambetsu are since July 1957, and the list of Kanoya is since January 1958. Furthermore, lists of older events at Kakioka are in preparation to publish.

In this presentation, we will show characteristics of geomagnetic events at these three observatories with those databases of events. And we will predict scales of "once in 1,000 years event" boldly.

Keywords: geomagnetic, database, magnetic storm, si, ssc

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Responses of Geomagnetic Storm and Magnetosperic convection to the extreme solar wind conditions

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[1]NICT

To estimate the extreme value of the geomagnetically induced current (GIC), estimation for the extreme value of geomagenetic disturbances and its time variations are essential. It is well known that geomagnetic disturbances are produced from the magnetospheric current systems driven by the interaction between the solar wind and the magnetosphere. So, it is important to understand the response of the magnetospheric current systems to the extreme solar wind conditions. Magnetospheric convection and geomagnetic storm are parts of the important elements for the magnetospheric current systems. The geomagnetic storm is believed to be developed by the enhancement of the magnetospheric convection. However, both phenomenon show different behavior to the extreme conditions of the solar wind electric field. In the case of magnetospheric convection, its development is saturated by the extreme conditions of the solar wind. On the contrary, in the case of geomagnetic storm, its development is linearly growth depending on the intensity of the solar wind electric field. Based on the data analysis of the previous great geomagnetic storm events, we will show the difference for the responses of magnetospheric convection and geomagnetic storm, and will discuss about the responses of geomagnetic disturbances to the various kinds of extreme solar wind conditions.

Keywords: Geomagnetic Disturbances, Magnetospheric Convection, Geomagnetic Storm, Magnetospheric Current System, Solar wind - Magnetosphere Interaction

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Geoelectric Potential difference observation conducted by Kakioka Magnetic Observatory

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Kakioka Magnetic Observatory, Japan Meteorological Agency, has measured the geoelectric potential difference continuously since 1930's at Kakioka amd 1950's at Memambetsu and Kanoya. The measurement is sometimes addressed as an Earth current measurement, however what has been measured is a voltage difference between two electrodes at the Earth's surface. The electrodes and their locations were changed several times. At present, we use a pair of cupper plates or carbon rods as the electrodes and separate them 100 - 300m each other. Two pairs of electrodes are placed in the north-south and east-west directions at each observatory and the two horizontal components of the voltage difference are measured every 0.1 second.

The geoelectric potential difference measurement for a long term is rather rare. In addition, the geomagnetic field is simultaneously measured in our case, which makes investigations of conductivity structures, geomagnetic sudden changes, and crustal activity possible. Use of the geoelecric potential difference data is expected to be boomed because a data download service through the observatory HP started in the end of 2012 and data accessibility has been improved.

I will introduce observation systems and characteristics of our geoelectric potential difference measurement in my presentation. Site differences among Kakioka, Memambetsu, and Kanoya will be focused and the relationship with the local conductivity structure will be speculated. For instance, a heterogeneity of the voltage difference at Kakioka, which has been known for years, will be considered if a modern spectral analysis technique and a modeling method may add new information.

Keywords: geoelectric potential difference, long term observation, Kakioka Magnetic Observatory

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Evaluation of the earth-induced current contribution for a precise prediction of the Dst index

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A precise prediction of the Dst index is one of the important issues in space weather forecasting. The Dst index was developed by Sugiura [1964] to measure the magnitude of the axially symmetric geomagnetic field variations. The field variations during geomagnetic storms are produced by various currents in the magnetosphere, such as, the ring current, the tail current, the magnetopause current, and the field-aligned current. Since the Earth can be considered as a conductor, these magnetospheric currents generate the induced currents inside the Earth, which also contribute to the Dst index. Previous studies have reported that the magnetic field variations due to the induced currents are about 20-30% of the Dst index [Rikitake and Sato, 1957; Anderssen and Seneta, 1969; Langel and Estes, 1985; Hakkinen et al., 2002].

In order to predict the Dst index precisely, we need a more proper evaluation of the contribution of the Earth-induced current. From the property of induction, we expect that the percentage of the Earth-induced current contribution may depend on the rate of change of the disturbance field. Thus, using the magnetic field data obtained at 70-80 ground observatories, we examine how the Earth-induced current contribution changes during magnetic storms. The magnetic field variations are decomposed into portions of the external (i.e., magnetospheric current) origin and the internal (i.e., Earth-induced current) origin by using the spherical harmonic expansion. It is found that the Earth-induced current contribution varies between ~30% and ~50%. We will derive an empirical equation relating the Earth-induced current contribution to the rate of change of the disturbance field.

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A modeling of Geomagnetically Induced Currents in Midlatitude Regions

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We have simulated an electromagnetic field to reproduce Geomagnetically Induced Currents (GIC). GIC are induced along an electrical conductor on the ground from electric fields generated by an ionospheric current, and are serious threat to a power grid system. The generation of GIC depends on the geomagnetic latitude, the current system, and the structure of a stratum and the topology of the electrical conductor. We usethe exact method offered by Hakkinen et al., which can take into accountthe above-mentioned factors, for the sake of reproducing GIC at a transmission network.By this method, the intensity of GIC is calculated as a function of the parametersof the ionospheric currents and the earth, i.e. height, density, frequency of theionospheric currents, as well as magnetic inclination, magnetic declination and itsdistribution. We calculate an electromagnetic field for GIC by various parametersof the ionospheric current, and clarify which parameters affect the intensity of GIC.As a result, we find that the height and the frequency of the ionospheric currentsgreatly influence the intensity of the electromagnetic field and GIC. We also find that the magnetic declinationand the magnetic inclination and declination because of the field aligned currents.In the presentation, we discuss the factors that affect GIC and adversely affect infrastructure systems at mid-latitudes including Japan.