Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

MIS30-P01 Room:Convention Hall Time:May 21 18:15-19:30

Statistical Changes in the 3-component Geomagnetic Fields at Okutama site in Central Japan before and after the 2011 off

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We have observed the 3-component geomagnetic fields with a fluxgate magnetometer at the Okutama site in Central Japan, at 1 Hz sampling since December 2003 and at 32 Hz sampling in and after May 2008. This site is located just outside the area where the seismic activity increased after the 2011 off the Pacific coast of Tohoku Earthquake. In this study, we checked whether or not there are statistical changes in the observed data before and after the earthquake. However, the daytime data included noises mainly from trains driven by DC electric power. Therefore, we used only the nighttime data from 2:30:00 to 3:04:08 JST. The power spectrum densities, especially of the period range from 1/16 s to 45 s, had seasonal variations. The annual median, 1st quartile, and 3rd quartile were calculated for the differences between the power spectrum densities and their seasonal variations. As a result, we found (1) the variations of the annual interquartile range, especially for short period spectrum ranges, were in harmony with those of geomagnetic indices and the solar activity and (2) the annular medians for all period spectrum ranges decreased after the earthquake though the declined levels were within the annual interquartile ranges just before the earthquake. One of the possible reasons of the decreases may be the change of the local groundwater condition after the earthquake though we could not ignore the effect of saving electricity due to a power shortage in Japan after the earthquake.

Keywords: geomagnetic field, Tohoku earthquake

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Fundamental measurements of Radon concentration in a cave and the atmosphere for earthquake prediction II

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An increase of the radon in underground water at Nishinomiya City[1] and an increase of the radon in atmosphere[2] at the southern part of Hyogo Prefecture earthquake in 1995 were reported. Moreover, in the case of Tohoku Region Pacific Coast Earthquake, the data of the exhaust air monitor in the radiation facility of Fukushima Medical College (Fukushima) has been reported that the peak duration was long, and the peak decreased rapidly before the earthquake[3].

We had started to measure radon concentration in a pit of Kurashiki mine, Okayama from the beginning of November, 2009, and started to measure radon concentration in the atmosphere from the end of May, 2011 at Chiba Institute of Science in Choshi, Chiba. We used a Radon Monitor of SUN NUCLEAR Corporation, Model 1028 in the Kurashiki, and a Pylon Trace Environmental Level Radon Gas Detector in Choshi.

In relation to the Southern Hyogo Prefecture Earthquake, seasonal variation in the radon concentration of the air was removed by using the exponential smoothing method[4, 5]. This time we also try to analyze radon concentration variations at the above 2 area using the exponential smoothing method.

In the variation of radon concentration in the pit of the Kurashiki mine, there were twice cases which were over 3 residual error. The 1st case was that earthquake of magnitude 3.3 had happened at eastern Shimane after three weeks. The 2nd case was that no earthquake had happened for four weeks. Then we could not get clear correlation between increase of residual error and the earthquake.

The exponential smoothing method was applied to variation of radon concentration, although the observation period at the Chiba Institute of Science has not passed for two years. However,we could get no date which exceeded 3 residual error. In earthquakes at Choshi, Chiba, their epicenters were almost in the sea.

Since the data of Kobe Pharmaceutical University and Fukushima Medical U niversity are a prolonged measurement over ten years, it is necessary to continue radon concentration observation for a long period at Kurashiki and Choshi.

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Keywords: radon, cave, atmosphere, earthquake, prediction

MIS30-P03 Room:Convention Hall Time:May 21 18:15-19:30

Observation and detection of ULF geomagnetic changes before earthquake in Kanto

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1. Research Purpose / Background
Many electromagnetic phenomena relevant to an earthquake have been reported in recent years.
Since it precedes with an earthquake and, it is thought that these electromagnetic phenomena are very important for earthquake prediction.
In observation of an earthquake electromagnetism phenomenon
1-1. The technique of observing directly the electromagnetic waves emitted from the focus on the ground
1-2. The technique of detecting the ionospheric perturbation relevant to an earthquake using the terrestrial existing electric wave
1-3. The technique of detection of ionospheric perturbation using a satellite, etc.
Its attention was paid to ULF magnetic field change considered to precede with an earthquake and to generate also in this research.
In ULF, a frequency band of 10 Hz or less is put, and it is a detectable range.
From the epicenter to observation station show that
Magnitude 6 -> radius 60 km
Magnitude 7 -> radius 100 km
It is experientially calculated from the past observations.
That is, it is shown that it is very effective in pinpointing a position in advance to a big earthquake.
It aims at contributing to future seismic activity prediction in building a ULF network of observation and analyzing observational data.

2.The special feature of this research
Now, prepare for the earthquake in the metropolitan area.
2-1. The south Kanto network of a ULF magnetic field observation exists, and it is storing the data for about ten years.
2-2. The result which suggests significance statistical about an earthquake and the abnormalities in ULF has been obtained.
2-3. It is necessary to reinforce the present network.
2-4. We are anxious about the earthquake of magnitude 8 classes off Boso, and it is necessary to collect the basic data immediately after the earthquake on March 11, 2011.
Furthermore, I would like to tie to generating mechanism pursuit of an earthquake electromagnetism phenomenon by also doing many researches of other techniques (change of the radon concentration in the atmosphere, etc.), and conducting synthetic analysis in combination with ULF.

3. Research Program and Method
After 3.11, the ULF observation station which targeted the offing of Choshi distortion is not released completely offshore. And we are anxious about the occurrence of a big earthquake, so observation station was newly established in Asahi-city, Chiba, and observation was started.
Next, synthetic analysis is conducted by combining acquisition data with the ULF data of other observation pstation, and the other technique observational data (radon concentration observation in the atmosphere, etc.).

4. Result Expected
It was difficult to catch ULF magnetic field change preceded with the earthquake off shore from Choshi in the once network of observation.
Since there are comparatively many occurrences of an earthquake also before that the distortion after 3.11 remains, and 3.11 in this area, a possibility that ULF electromagnetic radiation is caught in advance and can be detected by establishing an observation station in this area newly becomes very high as stated previously.
A possibility that a big earthquake will occur can greatly contribute to the elucidation of the generating mechanism of a precursor in the detection accuracy of an earthquake ULF signal analyzing increase and its data by observing in high area.
Furthermore, an earthquake precursor is detected, and the research to solve is useful for future disaster reduction, and is a field also with great expectation from society.

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Focal Mechanism Dependence of Coseismic Ionospheric Disturbance Waveforms Revisited:Strik Slip,Normal,and Reverse Fault

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Ionospheric Total Electron Content (TEC) is easily derived from the phase differences of the two L band carrier waves of the Global Positioning System (GPS) satellites. Past GPS-TEC studies revealed various kinds of ionospheric disturbances including those by large earthquakes. Here we study coseismic ionospheric disturbances (CID) of earthquakes with three different kinds of focal mechanisms, i.e. reverse, strike-slip, and normal faulting. The first category earthquakes include the 2004 Sumatra-Andaman (Mw 9.2) and the 2007 Bengkulu (Mw 8.5) earthquakes. Their CIDs have already been reported in past studies [Heki et al., 2006; Cahyadi and Heki, 2013], but here we present some new data from GPS points in Malaysia. The second category includes the 2012 April northern Sumatra earthquake (Mw 8.6), one of the largest strike-slip earthquakes ever observed. Normal fault earthquakes large enough to disturb the ionosphere are rare. Astafyeva and Heki [2009], by analyzing the 2007 January outer rise earthquake off the central Kuril Islands, suggested that coseismic crustal subsidence in normal-fault earthquakes excite atmospheric waves led by a rarefaction pulse, and hence will cause CID starting with the negative polarity. However, theoretical considerations predict that such waves may not be stable enough to reach the F layer. In December 2012, we experienced a normal fault earthquake in the outer rise region of the Japan Trench (Mw 7.3), which would offer the second opportunity to study the CID waveform of normal-fault earthquakes.

We use GPS data from SUGAR (Sumatra GPS Array), the Malaysian GPS network, and GEONET (GPS earth observation network) in Japan. CIDs are detected clearly in signals of two satellites 13, and 20 in the 2004 Sumatra Andaman earthquake (Fig.1b). Satellite 32 and 20 in the 2012 April Sumatra earthquake detected clear CID in the western sky (Fig.1c). These CID started with only positive changes, possibly originating from the uplift region of the sea floor. Clear CIDs were also detected by satellite 8 in the 2012 NE Japan earthquake. An interesting result from the 2012 normal fault earthquake in Japan is that its CID signals initiated with positive pulses (Fig.1e). After all, we could not find any correlation of the CID signal waveforms with the focal mechanisms of earthquakes

In addition to the initial change polarities, we study various aspects of the CIDs including propagation speeds, atmospheric resonances, directivity, etc. To investigate spatial characteristics of CID, e.g. propagation speed of such disturbances, we calculated sub-ionospheric points (SPP), ground projections of the ionospheric piercing point of line-of-sights assuming a thin layer of ionosphere at altitudes ˜300 km. We also briefly mention pre-seismic TEC anomalies of the 2012 north Sumatra earthquake because its moment magnitude suggests the existence of small preseismic TEC anomalies as found before M9 class earthquakes [Heki, 2011; Cayadi and Heki, 2013].

(Figure caption) Figure 1. (a). SIP (sub-ionospheric point) trajectories by four satellites before/after the three earthquakes in Sumatra (left), i.e. the 2004 Sumatra-Andaman (black), the 2007 Bengkulu earthquake (light grey), the 2012 North Sumatra earthquake (dashed line), and the 2012 outer rise earthquake in NE Japan (right). On the trajectories small black stars are SIP at the time when earthquakes occurred, and beach balls indicate mechanisms of earthquake. (b), (c), (d) and (e) show time series of slant TEC changes in these earthquakes. The black vertical lines in the time series (b, c,d,e) indicate the earthquake occurrence times (for the 2012 event, the largest aftershock ˜2 hours after the mainshock also generated CID).

Keywords: reverse fault, normal fault, strike-slip, GPS-TEC, earthquake

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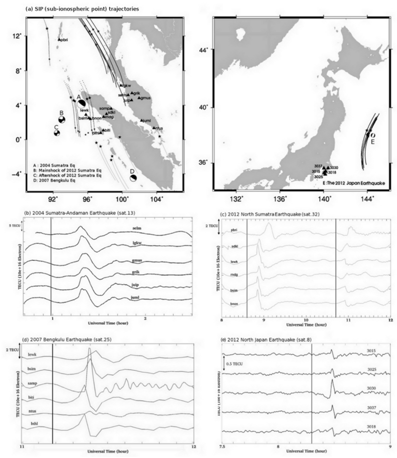

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Ionospheric Anomalies Associated with Large Earthquakes during 1998-2011

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Many anomalous electromagnetic phenomena possibly associated with large earthquakes have been reported. TEC (Total Electron Contents) anomaly is one of the most promising phenomena preceding large earthquakes. Recently, some case and statistical studies have revealed that negative TEC anomalies significantly appear a few days before large earthquakes occurred in low geomagnetic latitude areas such as Indonesia, Taiwan, and China. On the contrary, in middle geomagnetic latitude areas such as Japan, Mexico, and Chile, positive TEC anomalies significantly appear a few days before large earthquakes. In this study, we investigate TEC anomalies before large earthquakes whether there is a geomagnetic dependence.

TEC values are computed by using the GEONET and GIM (Global Ionosphere Maps). In order to remove a daily variation of TEC, 15 days backward running average (TECmean(t)) and its standard deviation sigma(t) at a specific time are taken for the normalization. The normalized TEC, GPS-TEC$*$, (t) is defined as follows: TEC$*$ (t) = (TEC(t)-TECmean(t))/sigma(t).

We investigate TEC anomalous variations in time and space for the 2011 off the Pacific coast of Tohoku Earthquake. GIM-TEC$*$ anomalies exceeding +2 sigma appear 3-4 days before the earthquake. The duration is more than 20 hours. This result is consistent with the previous statistical results that positive anomalies significantly appear 1-5 days before M$>$=6.0 earthquakes in Japan area.

SEA (Superposed Epoch Analysis) have been performed for the statistical analysis of TEC anomalies associated with M$>$=6.0 earthquakes occurred in low geomagnetic latitude(+15 to -15 degree) and middle geomagnetic latitude(+40 to +25 degree,-25 to -40 degree). For the low-latitude area, negative anomalies significantly appear 6-10 days before the earthquakes. For the mid-latitude area, positive anomalies significantly appear 1-5 days before the earthquakes. Furthermore, those anomalies depend on the magnitude of earthquakes. These results suggest that TEC anomalies before large earthquakes have geomagnetic dependences.

Keywords: Ionosphere, Earthquake

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Statistical analysis on relation between ULF geomagnetic anomaly at Kakioka and local seismicity

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There are many reports on earthquake-related ULF geomagnetic anomalies but there are active debates on the reliability about the anomalies and on the generation mechanism. Therefore, we investigated relation between local seismic activity and magnetic activity statistically in this study. The vertical intensities of the geomagnetic fields at 1 Hz sampling are examined at Kakioka and Kanoya (as a reference station) from 2000 to 2010. The wavelet filter is performed and the data around 0.01 Hz are focused. Nighttime data from 2:30 to 4:00 are used in the analysis to reduce contamination of artificial effects. The daily energy over the nighttime period analyzed is computed and correlation between Kakioka and Kanoya is investigated. It is found that the correlation between them is high (0.94). This is highly suggestive of the relative similarity of the underground electrical structures between Kakioka and Kanoya and enables to model computation using the Kanoya (reference station) data. The ratio between the original data at Kakioka and the idealized data at Kakioka derived from those at Kanoya is computed. An invalid assumption on the electrical structures beneath both stations gives a constant value of the ratio and it is possible to remove global changes such as magnetic storms due to upper atmospheric sources. An anomalous change in the ratio expects a local change of the underground structure or additional noise. We investigate the relationship between the anomalous changes and local seismicity. We define the criterion on the anomaly of the ratio as median+1.5IQR (IQR: inter-quantile range). Earthquakes which satisfy Es>10^8 are selected within 100 km of epicentral distance from Kakioka and within 60 km depth from earth surface. Then we perform Superposed Epoch Analysis. The results show that 5-15 days before the earthquake, geomagnetic anomaly appears significantly and there is the Es dependence. These epidemiological results show the relation between local seismicity and geomagnetic anomaly.

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Volcanic and lava activity detecting using MODIS data

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There are a lot of active volcanoes in the world. But it is difficult to monitor all volcanoes because of costs. However, we can monitor efficiently a lot of volcanoes using satellite remote sensing technologies, because a volcanic activity will cause the increase in surface temperature and satellite (whose sensor can observe the surface temperature) remote sensing can cover a large area on surface. Therefore, our purpose of this study is to create an adequate algorithm detecting thermal anomalies related to volcanic activities (especially lava activity witch causes serious damages involve human lives) using satellite data. The developed algorithm investigates the difference temperature behavior between a target point and reference points. Therefore, removing cloud is essential in our algorithm.

The developed algorithm has been applied to Mt. Merapi (Indonesia), Mt. Shinmoe-dake (Japan) and so on and we found the effectiveness of it and reduction of faint changes due to clouds.

In addition, we examined the cloud removal method that we used in this study by comparing with continuous observation lidar data conducted by Institute for Environmental Studies at Tsukuba.

The details will be shown in our presentation.

Keywords: volcanic activity, satellite data, MODIS, Shinmoe-dake, lidar

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Present Status of the ELMOS Small Satellite Constellation

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Present status of the ELMOS small satellite constellation will be presented.

Keywords: ELMOS, Small satellite constellation, GPS occultation, Electron density, Electron temperature, Lithosphere-Atmosphere-Ionosphere Coupling

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Seismo-electromagnetic data observed by Chubu University before and after 2011 Tohoku Earthquake

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Chubu University has established electromagnetic observation network in order to study seismo-electromagnetics.

We have observed ULF/ELF electromagnetic waves at three observation stations (Nakatsugawa, Shinojima and Minami Izu) in order to catch the emissions from the focal region of earthquakes. And also we have observed VLF electromagnetic waves at Kasugai in order to measure the change of the propagation characteristic in the ionosphere and atmosphere disturbed by the energy from the epicentral region.

In this study, we talk about the result of the observation before and after the 2011 Tohoku Earthquake.

In our past studies, we had observed anomalous excitations of Schumann resonances before the 2004 Mid-Niigata Prefecture earthquake and the 2007 Noto Hantou earthquake at Nakatsugawa. However, we cannot found any anomalous Schumann resonances before the 2011 Tohoku Earthquake.

We found strong ULF emissions possibly propagated from the direction of the focal region of the 2011 Tohoku Earthquake on March 2, 2011, 9 day before the earthquake. And also we found propagation anomalies of VLF electromagnetic waves several days before and after the 2011 Tohoku Earthquake. But there was large foreshock on March 9. So we cannot point out that these anomalies were precursors of the 2011 Tohoku Earthquake, and even cannot point out that they were precursors of earthquakes in this stage.

The observed ULF/ELF/VLF anomalies possibly associated with earthquakes were not so convincing enough to predict the earthquakes. And so we need more case studies, further research, and trying to make a probabilistic forecast.

This multi-point observation network is now supported by Academic Frontier Project for Private Universities: matching fund subsidy from MEXT, 2006-2010.

Keywords: Seismo-electromagnetics, 2011 Tohoku Earthquake, ULF/ELF/VLF

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Geomagnetic anomalies possibly associated with the 2011 off the Pacific coast of Tohoku earthquake (Mw9.0)

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In this paper we have reported unusual changes of geomagnetic fields observed in the vicinity of the epicenter of the 2011 Tohoku earthquake (Mw9.0).

Firstly, we have investigated geomagnetic diurnal variations observed at ESA and KAK. Usually, the diurnal variations at the two stations are quite similar, because the inter station distance is not so large. In this study, the ratios of diurnal variation ranges of KAK to ESA have been monitored. The results indicate that about two month before the Mw9.0 earthquake, the ratio of Z component has increased significantly. This unique change was derived from more than one year data. After checking the original data, it is confirmed that the diurnal variations at ESA station in early January, 2011 have clearly unusual behaviors compared with other reference stations which are far from the epicenter.

And then, we have monitored underground apparent resistivity at ESA station. The mega Mw9.0 earthquake is located in the seismically active area. Actually, this place is also magnetic anomaly region. The short term variations of vertical geomagnetic fields at stations to the north and south of this region exhibit opposite phases. Preliminary results show that the energy of geomagnetic fields at short periods of ESA station is much smaller than that of KAK station, which suggests that the underground conductivity in ESA area may be different from other place. Analyzing MT data observed at ESA is now on-going.

Keywords: ULF seismo-magnetic phenomena, earthquake, geomagnetic field