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

SCG69-P01 Room:Convention Hall Time:May 24 17:15-18:30

IONOSPHERE-ATMOSPHERE-OCEAN-CRYOSPHERE-GEOSPHERE INTERACTION FROM MICROSEISMS AND MICROBAROMS IN ANTARCTICA

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Several characteristic waves detected by seismographs in Antarctica are originated from physical interaction between solid-earth and atmosphere - ocean - cryosphere, involving environmental changes. An infrasound sensor was planted at Syowa Station (SYO; 39E, 69S), Antarctica at the International Polar Year. Continuous data in 2008-2009 include background signals (microbaroms) with peak with few seconds of its intrinsic period. Signals with same period are recorded in broadband seismograph at SYO (microseisms). Continuous signals are identified as Double-Frequency Microseism-baroms (DFM) with peaks between 4 and 10 s in whole season. The peak amplitudes of DFM reflect the influence of winter cyclonic storms in Southern Ocean. The DFM has relatively lower amplitudes during winters, caused by sea-ice extent around the coast with decreasing oceanic loading effects. In contrast, Single-Frequency Microseism-baroms (SFM, between 12 and 30 s) are observable under storm conditions particularly in winter. On infrasound data, stationary signals are identified with harmonic over tones at a few Hz to lower most human audible band, which appear to be local effects, such as sea-ice cracking vibration. Microseism-baroms are useful proxy for characterizing ocean wave climate, and continuous monitoring by seismograph and infrasound contribute to FDSN and CTBT in southern high latitude.

Keywords: Antarctica, Microseismic Noise, Infrasound Microbaroms, ocean wave climate, earth system, physical interaction

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SCG69-P02 Room:Convention Hall Time:May 24 17:15-18:30

Radio wave emission from 1 MHz to 18 GHz due to rock fracture and the estimation of the emitted energy

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1. Introduction

Formerly, the microwave emission due to rock fracture was reported from 300 MHz to 22 GHz [1]. We started experiments adding the 1 MHz receiving system in order to gather more data and to study the relation with lower frequencies [2].

This paper describes the measurement results of the radio wave emission from 1 MHz to 18 GHz. The estimation of the emitted energy that may be difficult to understand will be carefully explained. Then, the estimated result is presented.

Lastly, it is shown that this research work may be effective as disaster measures through the detection of earthquakes and volcanic activities.

2. Measuring system

At 1 MHz, a loop antenna and a receiver of direct reception are adopted. The relation between the input power and the indication on an oscilloscope for the antenna and receiver was calibrated using the radio wave of a broadcasting station at 954 kHz (wavelength of 314 m). The distance R is 37.2 km. Therefore, the power density of the radiated radio wave from the station is obtained by geometrical calculation.

On the other hand, in a laboratory experiment, the distance between a rock sample and an antenna is only 1 m, which is much shorter than a wavelength. As a result, the emission from a destroyed rock is expressed as a near field rather than a far filed. We convert the near field value to the far field value, then verify the energy relation.

3. Received waveforms

Figure 1 show an example of the received waveforms. In the coarse time axis in the figure (a), the waveform looks like pulses. Most pulses occurred at the same time as the pulses in the other frequency bands. The expanded waveform at 1 MHz in the figure (b) includes sinusoidal change at the frequency of 1 MHz, and its envelope attenuates exponentially.

4. Estimation of the emitted energy

The procedure is as follows:

(1) With an input power to a receiver, calibrate the voltage value on an oscilloscope.
(2) In the rock destruction experiment, read the voltage of a signal on the oscilloscope.
(3) Assuming the received signal to be a continuous wave, obtain the equivalent received power.
(4) Using the values of free space loss and the receiving antenna gain, calculate the equivalent power of the emitted radio wave.
(5) Using the signal duration or a pulse width, convert the equivalent power of the emitted radio wave to the emitted energy.

In the lecture, the concrete procedure and results of the estimation will be given.

5. Applicability of the experimental results to earthquake detection

The earthquake prediction has been officially stated impossible. On the other hand, many technologies and knowledge appear in the surroundings of seismology. The radio wave emission phenomenon due to rock fracture is one of them.

By receiving the emitted radio wave due to rock fracture and friction, we can detect an earthquake or volcanic activities. If the rock is destroyed before the ground quake, the radio wave indicates real prediction. Even if the rock destruction and the ground quake occur simultaneously, we can give an effective alarm against disaster because of a large delay time difference between the radio wave and seismic wave.

The relation between rock fracture and the ground quake is hardly clarified, and is rendered to seismologists and geologists for a future research. Seismology and seismo-electromagnetics should cooperate in this field.

6. References

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Keywords: radio wave emission, rock fracture, emitted energy, estimation, pulse waveform, earthquake detection

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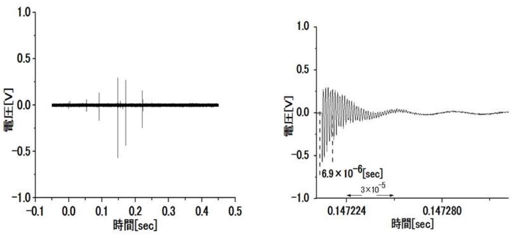

(a) Packed waveform (b) Expanded waveform

Fig. 1 Waveforms from quartzite at 1 MHz-band.

Japan Geoscience Union Meeting 2012
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SCG69-P03 Room:Convention Hall Time:May 24 17:15-18:30

ULF geomagnetic changes possibility associated with large earthquake.

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There are many reports on earthquake-related electromagnetic phenomena. Anomalous ULF geomagnetic field changes associated with earthquake is one of the most convincing and promising phenomena due to deeper skin depth. Since ULF signals associated with large earthquakes are weak, effective signal discrimination methods should be required. Several methods for the signal discrimination have been developed so far. In this study, we investigate ULF geomagnetic changes possibly associated with large earthquake during the 2001 and the 2008 in Boso Peninsula based on spectrum density ratio analysis, fractal analysis (Detrended Fluctuation analysis : DFA) and direction finding analysis. Geomagnetic data observed at Kiyosumi, Uchiura and Kakioka have been analyzed. Kiyosumi and Uchiura stations are set up within 5 km, so similar tendency results is expected to record at Kiyosumi, and Uchiura stations.

At 16:34(LT) on the Jul. 23, 2005, a large earthquake occurred in Boso Peninsula. The epicentral distance from Kiyosumi station is about 47 km. On the day, the variations of spectrum density ratio at Kiyosumi and Uchiura stations exhibit apparent changes from the average ones. On the same day, scaling index of vertical component decrease at the Kiyosumi and Uchiura stations based on DFA. On the contrary, there are no corresponding significant changes at a remote station of Kakioka. We only use the midnight time data (LT 01:30~03:30), so that signatures appear before the earthquake. And results of direction finding on that day indicate an increase of direction of arrive from the epicenter. These facts suggest the anomalous changes at the Kiyosumi, Uchiura station are a possible candidate ofearthquake-related ULF geomagnetic signals.

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SCG69-P04 Room:Convention Hall Time:May 24 17:15-18:30

interferometric detection of invisible VHF radio propagation possibly associated with earthquake

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Recently, earthquake-related electromagnetic phenomena have been reported in various frequency bands. In the VHF band, it is known that anomalous propagation (invisible propagation) precedes larger earthquakes. Temporal correlation between earthquake and anomalous propagation has gradually understood. However, spatial correlation hasn't been understood yet. Then, in this study, we develop a VHF band interferometer system and we have installed the system at Chiba and Numata to identify disturbed area related to earthquake. Accuracy of the develop system has an error of about a few degrees from direction of arrival, if received signal has enough intensity and there signal source locates within 40 degrees from the path.

In practical observation, FM Sendai [77.1MHz] has been selected as the target transmitter. The system is locked in direction of FM Sendai with the elevation of 15 degrees. Additionally, we tune the frequency which is not used for broadcast because of comparison with the natural emission.

We investigate propagation condition associated with (1) upper air profile and (2) earthquake. When a radioduct, which is an inversion layer of the refractive index of the atmosphere which arises by rapid changes of an atmospheric temperature or humidity, is generated, VHF wave is propagated to a distant place by ducted propagation. We found that intensity of a received signal increase and directional arrive of the VHF waves is tuned to be from Pacific coastline where the radioduct appear easily in summer.

As for the analysis on earthquakes, we found that the probability of direction of wave arrived from future focus seems to increase about the shallow earthquake (a maximum of M:5.7) which occurred near the Inawashiro Lake in September 29 and 30,2010.

The above results suggest that effectiveness of the usage two or more VHF interferometers to estimate the earthquake-related scattered source of the VHF wave.

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Bostick 1-D Inversion of Magnetotelluric Sounding at Cimandiri Fault, Pelabuhan Ratu, West Java, Indonesia

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To verify the mechanism of earth currents as sources of Ultra Low Frequency (ULF) electromagnetic emissions associated with large earthquakes occurred close to Cimandiri fault, Pelabuhan Ratu, West Java, Indonesia, the subsurface structure near Cimandiri fault has been investigated by forty eight magnetotelluric (MT) sites. The MT exploration was carried out during two weeks, from July 27, 2009 to August 8, 2009. The data were distributed along 13.2 km x 9.4 km profile. One-dimensional modelling using 1-D Bostick inversion has been applied in this research. The data analysis is going on now and details will be given in our presentation.

Keywords: ULF electromagnetic anomalous change, 1-D Bostick inversion, magnetotelluric

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Coseismic ionospheric disturbances and preseismic TEC anomalies of 2005 Nias and 2007 Bengkulu earthquakes from GPS-TEC

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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 originating from phenomena in the solid earth, e.g. volcanic eruption [Heki,2006], launches of ballistic missiles [Ozeki and Heki, 2010], mineblasts [Calais et al., 1998]. The 2005 Niasearthquake (Mw 8.7)[Briggs et al., 2006]and the 2007 Bengkulu earthquake (Mw 8.6)[Gusman et al., 2010] occurred as mega-thrust earthquakes in the Sunda arc, Sumatra, as aftershocks of the 2004 great Sumatra-Andaman earthquake(Mw 9.2) [Banerjee et al., 2005].

In this study, we investigate the coseismic ionospheric disturbances (CID) and pre-seismic TEC anomalies of these two earthquakes, the largest earthquakes whose ionospheric disturbances have never been studied in spite of available GPS data.Continuous GPS data in Sumatra and nearby islands are taken by the SUGAR (Sumatra GPS Array) network,which is designed by members of the Tectonics Observatory at Caltech and the Indonesian Institute of Sciences (LIPI).The sampling rate of the network is 2 minutes, sparser than 30 second sampling usually employed in other GPS networks.

CIDs have relatively short time scales, and we model temporal changes in TEC with polynomials of time and subtract them to isolate short-term changes in TEC. To investigate spatial characteristics of CID,e.g. propagation speed of such disturbances, we calculated sub-ionospheric points (SPP), ground projections of theionospheric piercing point of line-of-sights assuming a thin layer of ionosphere at altitudes ˜300 km. CIDs are detected clearly in signals of three satellites 25, 27 and 28 in the Bengkulu earthquake. Satellite 25 and 27 was located in the western sky during this time interval and moving from north to south. Because of relatively high elevation, their SIPs are close to the GPS sites. Disturbance signals moved north-westward from the epicentre gradually changing their shapes. The signals showed that the disturbance started with a positive pulse (i.e. TEC increase), being consistent with the earthquake mechanism [Astafyeva and Heki, 2009]. Apparent velocity of CID was calculated from their arrival times at different point. They were estimated as 0.74, 0.77, and 0.82 km/s with satellites 25, 27 and 28, respectively, and the propagation started from the centre of uplift about 15 minutes after earthquake.These velocities are consistent with one another within their uncertainties, and suggest that they were acoustic waves excited near the epicentre and propagating in the ionospheric F layer (i.e. not by the Rayleigh surface wave).

CID of the largest aftershock (Mw7.9) of the 2007 Bengkulu earthquake was also studied. By analysing the phase dataofthe satellite 21, we found thatacoustic-wave-origin CID with amplitude of 0.04-0.35 TECU propagatedas fast as about 0.60 km/s.

Next we investigated if there are preseismic TEC anomalies similar to the 2011 Tohoku-oki earthquake [Heki, 2011] before the 2007 Bengkulu earthquake. The disturbances are sought by three satellites (25,27 and 28) following the procedure of Ozeki and Heki [2010] (modelling vertical TEC by cubic polynomials of time).We found that clear pre-seismic TEC enhancement occurred about 60 minutes before the earthquake just like other M9 class earthquakes reported by Heki [2011].

The Nias earthquake occurred to the west of the Sumatra Island at 16:09:36 UTC, 28 March, 2005. We found that the TEC time series over a few hours period before and after the earthquake have been disrupted by severe plasma density luctuation known as plasma bubbles. This event is commonly seen in low latitude regions after sunsets [Li et al, 2009; Chu, 2005].

Figure a. (Left) SIP trajectories of the satellites and its error time series after the Bengkulu earthquake (right). B. (left) TEC disturbances by satellite 25 and its SIP trajectories (right)

Keywords: GPS, TEC, Ionosphere, Coseismic, Preseismic

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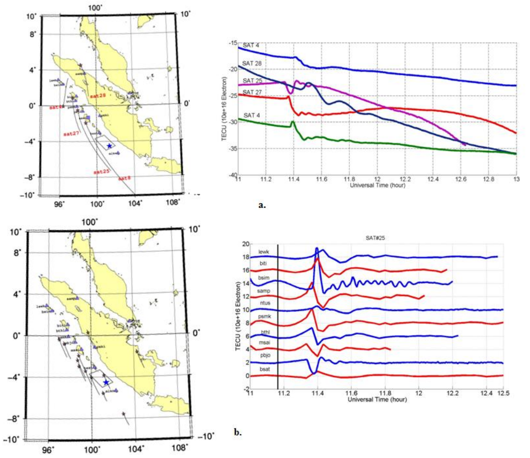

SCG69-P07 Room:Convention Hall Time:May 24 17:15-18:30

Key parameters for definite detections of earth-origin electromagnetic pulses

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In order to find electromagnetic (EM) pulses which might be generated by strong stress impacts to the earth crust when the earthquakes occurred, we have been conducting following observation methods for the sake of surefire detections of EM pluses in the earth. They are as follows:

1. Frequency spectra in a range up to 6.4 kHz are continuously obtained every 2.6 minute from signals of EM fields detected by sensors installed in a borehole and are displayed for monitoring electromagnetic environment in the earth [1].

2. We developed an analysis method of obtaining real-time frequency-time (f-t) diagram of EM pulses detected in the earth for obtaining information on the pulse behavior in detail, because dynamical energy collapse generally starts with impulsive movement and would be followed by radiations of heat, sound and electromagnetic waves including light. Using the information, we have developed a basic analysis method for obtaining horizontally arrival directions of detected EM pulses [2].

3. We have clarified propagating properties of EM pulses simultaneously detected on the ground and at the bottom of bore-hole, and have classified their propagation modes and their possible sources from analysis of their amplitudes and phases, their three dimensional polarization loci at the different detecting points, and local time dependences of their detections [3].

4. We have found observation sites in electromagnetically quiet environment for identifying source locations of EM pulses in the earth. Furthermore, we have developed a new EM sensor system which make it possible to detect tri-axial electric and magnetic field components sensitively in boreholes. We have also developed an analysis method for calculating strict Poynting vector of the EM pulse using the data of tri-axial (six) field components and for obtaining accurate arrival directions of an EM pulse at one point in the earth [4].

Since we have never confirmed earth-origin EM pulses yet, we have to employ key measure to detect them whose intensity would be extremely weaker than the environmental noise level. Now we are improving the system for the sake of detecting the weak earth-origin EM pulses in the earth.

References

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Keywords: earth-origin electromagnetic pulses, detection in boreholes, accurate measurements of 3-D arrival direction, identification of source locations in the earth, relation with earthquakes

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VHF radio wave transmission anomaly associated with 2011 off Urakawa EQ (Mw6.2) observed at multiple sites

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We have observed VHF band radio-wave propagation anomaly beyond the line of sight prior to earthquakes (EQ echo) since September 2003 at Erimo area in Hokkaido, northern Japan. EQ echoes have documented more than 40 times at the Erimo Observatory (ERM) prior to earthquakes that occurred in the Hidaka mountains since then. To confirm a region where the EQ-echo simultaneously observed for each earthquake, we have installed four observation sites with approximately 8 km spacing in the Erimo area since September 2011. Four way antennas were installed at every 90 degrees to detect an arrival direction of EQ echoes at RSK (8km away from ERM in NW) and TYO (8km away from ERM in SE) site and six way antennas (every 60 degrees) were installed at FYS (16km away from ERM in NW). We also installed the electric field mill to monitor a static electric field of atmosphere at FYS and TYO.

The EQ-echoes have been observed simultaneously in these sites associated with off Urakawa EQ (Mw 6.2) that occurred at 19:25, 24 Nov. 2011. Larger EQ echoes were documented on 21 and 22 November, which were 2 or 3 days before the earthquake, at FYS, ERM and TYO in every direction. Although some of EQ echoes were observed in same time at these sites, but some of them were appeared with time rag of duration in each EQ echo among these sites. We discussed what these time rags mean by considering possibilities of generation and moving of scattering objects.

Keywords: Radio wave transmission, earthquake forcasting, seismo-electromagnetics

SCG69-P09 Room:Convention Hall Time:May 24 17:15-18:30

Preseismic TEC changes for Tohoku-Oki earthquake in comparisons between simulations and observations

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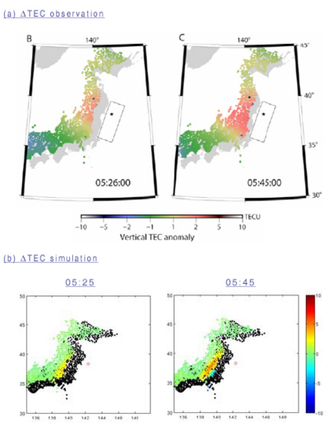
Earthquake precursors can be used for earthquake prediction to reduce the loss of resources and human lives. Pre-earthquake ionospheric signatures have been reported by many scientists. Among those, Zhao et al., [2008] and Liu et al., [2009] reported that the total electron content (TEC) may anomalously decrease or increase up to 5 - 20% several days before 2008 Wenchuan earthquake (Mw7.9). Recently, Heki [2011] found that, ˜40 minutes before the Tohoku-Oki earthquake (Mw9.0), the Japanese GPS dense network detected clear precursory positive anomaly of TEC. Similar preseismic TEC anomalies were also observed in the 2010 Chile earthquake (Mw 8.8), 2004 Sumatra-Andaman (Mw 9.2) and the 1994 hokkaido-Toho-Oki (Mw 8.3) [Heki, 2011]. The finding of TEC variations near epicenter lacks the physical mechanism to explain those pre-earthquake ionospheric signatures.

In this presentation, we propose a mechanism to couple the pre-earthquake activity with the TEC anomalies. Before the break of rocks in the main shock of earthquake, rocks are continuously subjected to stress. The stressed rocks can activate positive holes as charge carriers and generate electric currents along the stress-gradient direction with current density [Freund, 2010]. The outflow of positive charge carriers from the stressed rock sets up a potential difference, which causes the unstressed rock to become positively charged relative to the stressed rock. The mobile positive charge carriers inside the unstressed rock repel each other electrostatically and will be pushed toward the surface. The positive charges carriers are accumulated over Earth surface, and associated electric field can drive current upwardly through atmosphere into ionosphere. We formulate an electrical coupling model for the stressed rock-Earth surface charges-atmosphere-ionosphere system [Kuo et al., 2011]. A three-dimensional atmospheric current system and a NRL ionosphere simulation code [Huba, 2008] are used to study the ionospheric dynamics based on the atmospheric electric fields and currents.

For the simulations of Tohoku-Oki earthquake, we assume that the stressed associated current started ˜ 40 minutes before the earthquake, linearly increased, and reached its maximum magnitude at the time of rocks breaks in the main shock of earthquake. Provided by geolocations of GPS stations in Japanese dense network and corresponding flight tracks of GPS satellites, TEC variations calculation uses the ray tracing method for our ionospheric simulations. The simulation results are compared to the observed TEC anomalies for available nearby GPS satellites. We will demonstrate simulations with different sizes of fault region and stressed current density over Earth surface. One of simulations is shown in figure. The panel (a) show the dTEC observation [Heki, 2011], while panel (b) for our simulations. The similarity and differences between TEC observations and simulations will be discussed in this presentation.

Keywords: Tohoku-Oki earthquake, Pre-earthquake ionospheric signatures, anomaly of TEC



SCG69-P10 Room:Convention Hall Time:May 24 17:15-18:30

Geoelectric potential difference measurements at the Nii-jima and Kozu-shima Islands

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We re-started geoelectric potential difference measurements at the Kozu-shima and the Nii-jima Islands since February 2010 under the research program of "Observation and Research Program for Prediction of Earthquakes and Volcanic Eruptions". During our previous observations of the geoelectric potential difference at the Kozu-shima Island in Japan under the RIKEN research program (International Earthquake Frontier Research program). 19 anomalous changes (ACs) were detected. Their possible relations with nearby earthquakes were statistically significant.

In the presentation, we would like to introduce our current observation systems and characteristic records before and after the M9 Tohoku EQ. At this moment, any earthquake with $M>3.0$ did not occur near the islands except induced seismic activities which occurred just after the M9 Tohoku EQ. We have never detected any clear AC as of January 2012.

Keywords: Geoelectric Potential, Kozu Island

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Precursor observed by MF Band 2 Freq Simultaneous Measurement prior to The 2011 off the Pacific coast of Tohoku EQ

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1. Abstract

This paper is to report detail about anomalous phenomena on the MF Band Electric Magnetic(EM herein after) wave dual frequency simultaneous measuring method observed at Kyoto EM observation post about 700km from the epicenter prior to the 2011 off the Pacific coast of Tohoku Earthquake(EQ herein after).

The EM anomaly has been detected since about 2 month and half before the EQ and continued till about 1 month after the EQ.

We tryed this measuring method from a paper of Teruaki YOSHIDA, June Heisei 17.

2. Observation System

This system contains a BOOSTER with Antenna, an EM WAVE SENSOR and a DATA PROCESSOR and observes EM as EQ precursor at MF band 2 frequency 505 kHz and 525 kHz simultaneously. Those 2 frequencies are out of band from MF broadcasting band and vacant frequency are chosen. Received and detected MF EM is transferred to observation center automatically through Internet.

Received MF EM is amplified at the BOOSTER located out door and cabled in door EM WAVE SENSOR in which EM is changed into DC logarithm potential in order to be displayed in dBm scale. This potential is sampled once in 20mSec (50 times/Sec.) picked up maximum and average value in 20 second at the DATA PROCESSOR then output in CSV format to PC. Sensitivity of the system is -110dBm in band width +-1kHz/3dB.

The reason why maximum value is observed is to be intended to measure impulsive noise, however, thunder noise may not be cached as it seems to be shorter than 20 mSec.

If only one of two frequencies receives some signal, this will not be regarded as seismic, and if signal strength goes up at both channel simultaneously, this will be judged as seismic, as seismic EM has wide frequency.

3. What's observed

This observation is performed at calm residential area with little EM interference in Kyoto since January 2010. Attached figure shows 2 input signal strength variation from 2010/9/1 to 2011/5/31 and daily average graph of maximum and average value sampled in 20m sec.

Calm status has been continued since January 2010 of observation start up to middle of December 2010, after that, receiving signal strength at both channel raise up gradually and reached at peak in the middle of February 2011. Then anomalous condition continued till early April and returned to calm condition after middle of April.

On 2011/03/11 14:46:18 prior to the 2011 off the Pacific coast of Tohoku Earthquake M9.0 D=24km occurred. As the signal strength has raised up by more than 10dB comparing with calm period at Kyoto observation post, and anomaly timing was just before the Earthquake almost co-seismic in some meaning, this EM in MF band could be regarded as precursor of the huge EQ.

4. Conclusions

In usual observation, row data is only displayed in daily, weekly, and monthly graph, we could know that another world is shown by making long span graph in different way. It may be possible if we develop another analysis data processing way in real time.

If MF band EM is observed at many places, exact place of epicenter may be pointed out and be lead magnitude by calculating distance between epicenter and each observation post and signal strength. Proceeding period of EQ occurring of bigger magnitude of 7 may be 1 to 2 months from our experience of this time, and smaller scale EQ may occur within 1 week from our past experience.

Our aim by using this method is not academic EQ prediction, our aim and purpose is practical EQ prediction as disaster prevention information. Important thing as practical disaster prevention information is to predict huge (M>6, brings human damage), middle (M5 Class, brings people big surprise) or small scale (M4 Class, brings small surprise) EQ occurrence.

Reference;

"Observation of VHF Band EQ EM measured by dual frequancy measurement method" in paper-C of Institute of Electrical Engineers of Japan issued on June Heisei 17 year by Teruaki YOSHIDA, Hiroshima City University.

Keywords: earthquake, precursor, MF Band, EM, electro magnetic wave, EM wave

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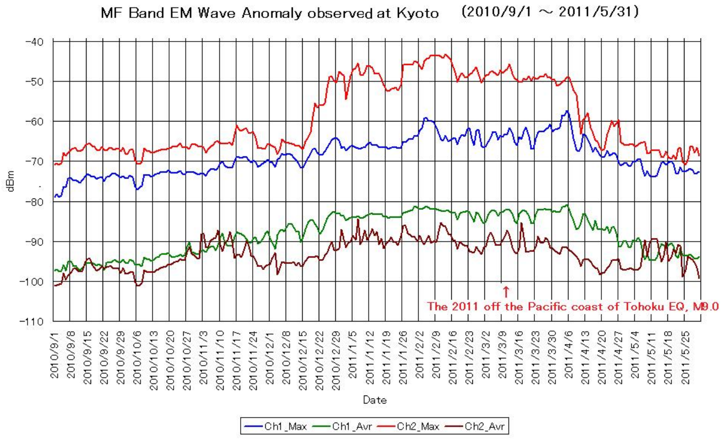

SCG69-P12 Room:Convention Hall Time:May 24 17:15-18:30

3-D structure analysis of ionospheric anomalies associated with the 2011 Off the Pacific Coast of Tohoku Earthquake

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The ionospheric anomalies possibly associated with large earthquakes have been reported by many researchers. However, a physical mechanism of pre-earthquake ionospheric anomalies has not been clarified. To understand the mechanism, monitoring of three-dimensional distributions of ionospheric electron density is considered to be effective.

In this study, to investigate the three-dimensional structure of ionospheric electron density associated with the 2011 Off the Pacific Coast of Tohoku Earthquake (Mw9.0), the Neural Network based tomographic approach is adopted to GEONET and ionosonde data.

At first, we investigate the Total Electron Content (TEC) anomaly associated with the earthquake using the Global Ionosphere Maps (GIM) published by the Center for Orbit Determination in Europe (CODE). To detect the anomalous TEC change, the normalized GIM-TEC, which is computed based on 15 days backward running mean of GIM-TEC, have been investigated. Then, in order to investigate the structure of electron density in ionosphere, tomographic method is performed.

As for the 2011 Off the Pacific Coast of Tohoku earthquake, the significant enhancements are found in GIM-TEC investigation, 3 days prior to the earthquake. As a result, the reconstructed distribution of electron density was enhanced around F-layer and lower ionosphere. In our presentation, not only the electron density distribution of before the earthquake but also those on the other periods will be shown.

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SCG69-P13 Room:Convention Hall Time:May 24 17:15-18:30

Hypocenter Depth Evaluations of Earthquakes Using Geomagnetic Data in Taiwan

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When earthquakes with similar magnitudes occur at different depths, severe seismic hazards are generally in response to shallow ones. Although many studies report that timing, location and magnitude of forthcoming earthquakes could be forecasted, estimation of hypocenter depth should also be taken into account to achieve complete perception against seismic hazards. In this study, the Parkinson vectors, which tend to orient along materials with relatively-high conductivity, are computed by using 3-component geomagnetic data recorded in central Taiwan via the magnetic transfer function. The "skin effect" is further incorporated into the analytical process to understand associated depths of the Parkinson vectors when they are computed by data filtering at distinct frequency bands. Orientations and magnitudes of the Parkinson vectors are compared with epicenter azimuths and hypocenter depths of 16 earthquakes ($M >= 5.5$) between 2002 and 2005, respectively. When effects of sea water and tectonic structure are removed, the results show that the azimuth distribution of the Parkinson vectors is mainly concentrated at directions of epicenter azimuths 15 days before earthquakes. Projection depths, which are determined by using the depth with the largest difference between the magnitude distribution of the Parkinson vectors 10 days before earthquakes and within an entire study period, generally yield a difference $<$ 30 km with hypocenter depths. This would be used to roughly evaluate hypocenter depths of forthcoming earthquakes.

Keywords: Hypocenter depth, Magnetic transform function, Skin effect, Parkinson vectors

SCG69-P14 Room:Convention Hall Time:May 24 17:15-18:30

The electromagnetism change just before the earthquake and the cause

KUNIHIRO, Hidemitsu[1*]

[1]JYAN meeting fore the study

The electromagnetism change just before the earthquake and the cause (the recommendation of the earthquake forecast experiment)

1, A change of electromagnetism environment affecting an earthquake

(1) The outbreak of the noise to disturb the sound of the radio

By Great Hanshin Earthquake that was an inland earthquake, a lot of obstacles of a radio and TV were reported, and there were many obstacle of wireless communication and the cell-phone and reports such as the eyewink light. A noise disorder of the radio is reported by the aftershock of the East Japan great earthquake disaster again (collection of testimony 1519). Therefore I work for abnormally electromagnetic grasp while always recording a broadband electromagnetic wave.

(2) Seismic center electromagnetic gravitation and harbinger phenomenon

The observation study of the FM electric wave is conducted till now in Hokkaido in the vicinity of observation and 60Mhz of the ionosphere reflection using FM broadcast. Therefore our meeting for the study receives 64 FM broadcast by 16 observation station in West Japan area around Kyushu Oita and I cross an observation net with a the BIC graph on the Internet at the same time and observe it. A harbinger (electromagnetic wave strength rises, and rolling begins) appears by the earthquake of seismic intensity three classes by the past observation, and a main shock occurs after an end in 6-3 days. The attention point seems to draw the electromagnetic wave which I should pass out of a prospect by some kind of gravitation from the usually reverse phenomenon "that an electromagnetic wave comes to resist" by a harbinger on the ground of the seismic center. I decided to call this electromagnetic gravitation "seismic center electromagnetic gravitation" as one of the earthquake harbinger phenomena. In addition, because I understand abnormal direction and strength by this observation network, I become able to estimate a position and the size of the seismic center and think that I can make three elements of the foretelling an earthquake clear more because an observation network is filled up.

(3) Underground propagation of ULF

The underground propagation of the electromagnetic wave was impossible by the insulators such as rocks, and the opinion which said that it was not possible for the spread to the ground even if an electromagnetism signal occurred at the epicenter was common till now. However, because the ULF obi in the electromagnetic wave is unique propagation, a certain study group challenges the communication that used a ground, and there is the report that succeeded in communication of approximately 3km. In addition, the result that a signal from the underground was largely stronger in than sky wave appeared when I received an electric wave signal of 50Kw in 60Khz of Saga in the approximately 150km west. I push forward a study whether I cannot catch an electromagnetic signal rising from this phenomenon at the epicenter of the earthquake as a harbinger signal of the earthquakes.

2, The need of the earthquake information generalization

I occasionally affect normal duties, and the earthquake information can cause the panic. Therefore, it is a common view to say that the handling of the earthquake information is careful, and the foresight information is kept in each place after Great Hanshin Earthquake, and there is not the announcement of the thing named the earthquake forecast.

Keywords: The outbreak of the noise to disturb the sound of the radio, Seismic center electromagnetic gravitation and harbinger phe, Underground propagation of ULF, The need of the earthquake information generalization

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Ionospheric Variations Associated with the Great East Japan Earthquake Disaster

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Recently, there are many reports on earthquake-related electromagnetic phenomena. Anomalous TEC (Total Electron Content) changes preceding large earthquakes are one of the most promising phenomena among of them. In this study, we investigate TEC anomalous variations in time and space for the 2011 off the Pacific coast of Tohoku Earthquake and after the accident at Fukushima Daiichi Nuclear Power Station.

In this study, TECs are computed with 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$*$ (t) is defined as follows: TEC $*$ (t) = (TEC(t) - TECmean(t))/sigma(t).

For the Pacific coast of Tohoku Earthquake, GPS-TEC$*$ anomalies exceeding +2 sigma appear 4 and 5 days before the earthquake. Their total durations are 13 and 14 hours, respectively. GIM-TEC$*$ anomalies exceeding +2 sigma appear 4 days before the earthquake. The duration is more than 20 hours. In space, the region of GIM-TEC$*$ anomalies 4 days before the earthquake appears over northern Japan and remains more than 24 hours.

These results are consistent with the previous statistical analysis around Japan. The detailes will be given in the presentation.