Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

MIS29-01 Room:313 Time:April 29 14:15-14:30

Radiations of earthquake-excited electromagnetic waves from the ground

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We have been observing electromagnetic (EM) pluses excited by earthquakes, using tri-axial electromagnetic sensor system installed in a borehole of 100 m in depth in the campus of Kyoto Sangyo University. During the period of 13 months from December 20, 2011 to March 26, 2013, we had nineteen earthquakes with magnitude of M>2 occurred around our EM observation site. They were within a circle of radius of 40 km centered at the EM observation site. We have confirmed detections of clear EM pulses for thirteen earthquakes among them. Seismic intensities at the EM observation site by these earthquakes were mostly 1 or less. From March, 2013, we added EM measurement above the ground. Furthermore, we began to capture waveforms of EM pulses in the borehole and above the ground and of seismic waves installed near the borehole simultaneously. Then we have confirmed that the detected EM waves were co-seismic ones readily generated by piezo-electric effect in earth's crusts [1].

Figure 1(a) shows a waveform of seismic wave detected at the EM observation site when an earthquake of M3.0 occurred at 10 km depth and at 5.4 km north of the EM observation site at 03:57 Dec. 2013, and (b) shows a waveform of magnetic H_{ew} components of the EM pulse detected in the borehole. Figure 1(c) also shows a waveform of H_{ew} component of the EM pulses detected above the ground where is on a hill of 60 m at about 600 m south-east of the EM observation site, in which the waveform have delayed 0.257 sec from that measured in the borehole. Therefore, this result shows clear evidence that earthquake-excited EM pulse has been radiated from the ground. We had another evidence of EM pulse radiation out of the ground surface when a large earthquake (M6.3) occurred at 14.8 km depth and at 130 km south-west of the EM observation site, in which earthquake-excited EM pulse was detected above the ground of the EM observation site in the campus. In that case, EM pulse was detected above the ground at 13.063 sec prior the detection in the borehole.

Next step is to detect and confirm EM pulses radiated at the occurrence of earthquakes. The final destination is to detect EM pulses radiated before earthquakes. For these purposes, we need to accomplish measurements of EM pulses in deeper earth (at about 1 km depth) after improving the sensitivity of the EM sensors.

[1] M. Tsutsui, submitted to IEEE Geoscience, Letters, 2014.

Keywords: seismic wave, electromagnetic wave, observations above and under ground, EM wave radiation from the ground

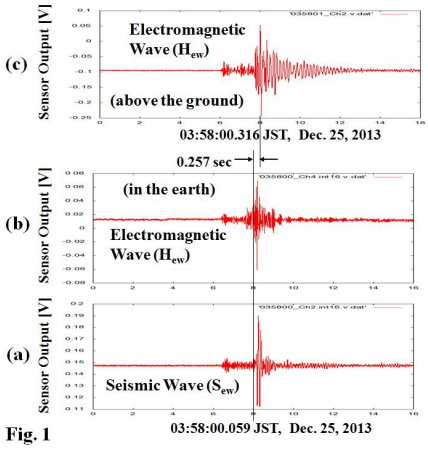

Fig. 1

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MIS29-02 Room:313 Time:April 29 14:30-14:45

A statistical study for relationship between anomalous transmission of VHF band radio waves and earthquakes at Hidaka

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Electromagnetic phenomena precursors to earthquakes, such as variations of geo-electric current, total electron contents in the ionosphere and anomalous transmission of radio waves, have been observed (ex. Hayakawa, 1996). The statistical relationship between such anomalies and an earthquake has investigated statistically (Liu et al., 2011; Orihara et al., 2012).

Anomalous transmission of VHF-band radio wave beyond the line-of-sight has been investigated by many researchers (Kushida and Kushida, 2002), and anomalous FM broadcasting wave (VHF range) has observed close to the epicenter of impending (Moriya et al., 2010). Radio waves transmitted from a given FM radio station are considered to be scattered, such that they could be received by an observation station beyond the line of sight. A quantitative correlation between total duration of scattered wave transmission and the magnitude, or maximum seismic intensity has been proposed (Moriya et al., 2010).

Nevertheless, a statistical relation between the anomalies transmission in VHF-band and impending earthquakes has not been investigated yet. We carried out statistical consideration by using the anomalous transmission data documented by Hokkaido University, and discuss the significance of this relation in this study.

The anomalous VHF-band radio wave data used in this research was observed at the Erimo observatory in Hidakra area from June 1st 2012 to December 31th, 2013. To judge anomalous data, we refer to the statistical method proposed by Liu et al. (2011) that they had used to detect abnormal signals of GPS TEC (total electron content) variations. We adopt a certain standard from median of observed data, and we identified anomalies if data beyond the standard value over 10 minutes.

As a result, some earthquakes were observed precursory anomalous radio propagation, but others are not observed a precursory anomaly. If we set the standard values strictly, the numbers of misdetections are decreased.

Big noises are found because of the appearance of a sporadic E layer in the ionosphere and so on especially in summer. We have to overcome the problem that how to remove such noises.

The earthquakes that we have cheese as targets were magnitude is more than 4.0 and the distance from Erimo observatory is less than 50km as the first trial.

We will investigate the statistical method in many conditions such as duration time, threshold of anomaly, magnitude, hypocenter distance etc and also discuss reasonable method to remove big noise. After that, we need to discuss probability of prediction using the relation between the occurrence of earthquake and anomalous transmission of radio wave propagation.

Keywords: ionosphere, anomalous transmission, relation with earthquakes

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MIS29-03 Room:313 Time:April 29 14:45-15:00

Preseismic geomagnetic deflection synchronized with GPS-TEC enhancement 2011 Tohoku-Oki earthquake

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The GPS-TEC enhancement stating ?40 minutes before the 2011 Tohoku-Oki earthquake has been observed (Heki, GRL, 2011). The geomagnetic declination change was confirmed nearby the fracture zone, at Easashi (ESA), Mizusawa (MIZ) by GSI and at Kakioka (KAK), Kanozan (KNZ) by JMA in respect to Kanoya (KNY) in synchronization with the GPS-TEC anomaly(Heki & Enomoto, JGR, 2013).These anomalies satisfy the criteria of earthquake precursor candidate (Wyss, AGU, 1991).

The magnetic declination; the difference between the direction of the horizontal components H of the Earth's magnetic field and the magnetic north is normally ?6.9 degree westward (=-415.7 arc min) from true north at the ESA site, but, as seen in the Figure, Δ D ([ESA]-[KNY]) gradually changes to the positive direction (eastward) starting from 40 minutes to the maximum Δ D value of Δ D? +0.32 arc min (= 9.31×10^{-5} rad) just before the main shock. This change should be affected by generation of preseismic magnetic field ?Δ B?. As Δ D is small, we can approximate the relationship between Δ H, Δ D and ?Δ B? as shown in an insert of the Figure; i.e.

?Δ B?[nT] ? ?**H**? [nT]?Δ D[rad]

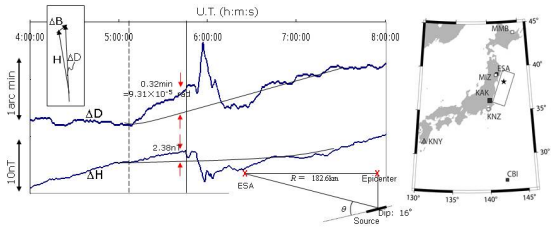
The amount of H is normally 29037nT at ESA. The ?Δ **B**? is then 29037 nTx9.31×10^{-5} rad = 2.70 nT, which is in agreement with the observed preseismic variation of Δ H (?2.38 nT) as seen in the Figure.

The preseismic geomagnetic field | Δ **B**|, resulting from the time-varying current at the earthquake nucleus zone by Biot-Savalt's law, is expressed, by assuming the time-varying source current element of the length w_c t∗, as:

?Δ **B**?=μ0 ?**I**? sinθ w_ct∗/4πR^2,

where μ_0 is the permittivity of free space, ?**I**? is the pressure-impressed current, which is 170kA in the Tohoku-Oki earthquake (Enomoto & Heki, GJI, submitted), is an angle shown in the Figure, w_c is the earthquake nucleation size, t∗is the normalized preseismic time duration, R is the distance between observation site from the epicenter. The present model of the above equation at t∗=1 gives ?Δ B?=1.78 nT with R=181km: distance between the ESA and the epicenter of which the agreement with the observed value of 2.38nT is rather well.

Keywords: Tohoku-Oki earthquake, Precursor phenomena, Geomgnetic, Declination, GPS-TEC, Modelling



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Japan Geoscience Union Meeting 2014
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MIS29-04 Room:313 Time:April 29 15:00-15:15

Preseismic ionospheric electron enhancements, revisited : Discrimination from TID and interfrequency receiver bias estim

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Possible enhancement of ionospheric Total Electron Content (TEC) immediately before the 2011 Tohoku-oki earthquake (Mw9.0) has been reported by Heki [2011]. Later, Kamogawa and Kakinami [2013] attributed the enhancement to an artifact falsely detected by the combined effect of the highly variable TEC under active geomagnetic condition and the occurrence of a tsunamigenic ionospheric hole [Kakinami et al., 2012]. Recently, Heki and Enomoto [2013] showed that preseismic TEC increase did occur by studying vertical TEC (VTEC) rather than slant TEC (STEC) before and after the 2011 Tohoku-oki earthquake and by comparing them with other geophysical data including the electron density profile from radio occultation, foEs at the Kokubunji ionosonde, and geomagnetic declination changes. In this paper, I focus on a few remaining problems in preseismic TEC enhancement, i.e. (1) possibility to discriminate preseismic TEC anomalies from space-weather origin TEC changes represented by the large-scale traveling ionospheric disturbances (LSTID), (2) estimation of site-specific inter-frequency biases for stations outside Japan, (3) possible difference of amplitudes of preseismic TEC anomalies between mid-latitude and equatorial regions, and (4) comparison between the TEC drops occurring ~10 minutes after earthquakes with preseismic enhancements.

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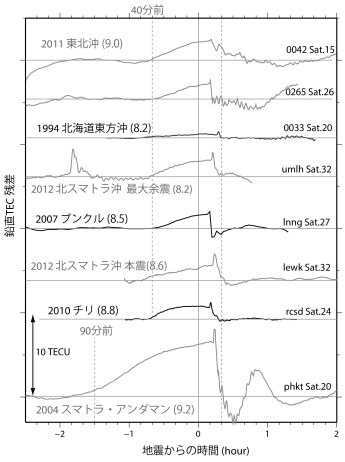
(Figure caption) Residual vertical TEC time series for seven large earthquakes for which precursory TEC enhancements have been observed. Below the two examples of the 2011 Tohoku-oki earthquake, the rest (six) of the events are arranged by their moment magnitudes. Distinct trend changes seem to occur about 40 minutes before the earthquake. In some cases, they are cancelled by sudden drops 10 minutes after the earthquakes (e.g. 2007 Bengkulu, 2004 Sumatra-Andaman). In other cases, they decay gradually with a timescale of 20 minutes or so (e.g. 2012 North Sumatra earthquakes). Site names and satellite PRN numbers are given at the right end of the time series.

Keywords: GNSS, GPS, ionosphere, earthquake, precursor, TEC

MIS29-04 Room:313 Time:April 29 15:00-15:15



Japan Geoscience Union Meeting 2014
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MIS29-05 Room:313 Time:April 29 15:15-15:30

A Decision Process of the Observation and Research Program of Earthquakes and Volcanoes

KODAMA, Tetsuya[1*]

[1]Tetsuya KODAMA

A Decision Process of the Observation and Research Program of Earthquakes and Volcanoes for Contribution to the Reduction of Disaster will be presented.

Keywords: Subdivision on Geodesy and Geophysics, Earthquake and Volcanoes Subcommittee, Next Research Program Review Committee

Japan Geoscience Union Meeting 2014
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MIS29-06 Room:313 Time:April 29 15:30-15:45

New coordination program of next ”earthquake prediction research” based on the electromagnetic methods

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[1]Earthquake Prediction Research Center, Tokai University, [2]JAXA

FY 2013 is the final year of the currentfive years program called the University’s earthquake prediction research study. During the current program, devastating Tohoku earthquake occurred in 2011. Therefore extensive revision is requested by the evaluation committee. Unfortunately, the short-term prediction research is not on the map among the current program. We believe that the most important issue in the prediction is the short-term prediction. Therefore, for the next five years’ program we proposed and adopted the unified project based on the electromagnetic methods, which includes Tokai University, Hokkaido University, Earthquake Research Institute, Kyushu University and so on. This really needs close coordination of the SEMS community. In the presentation, we would like to present the outline of impending research plan and tactics.

Keywords: Earthquake Prediction, Electromagnetics, VLF, VHF

Japan Geoscience Union Meeting 2014
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MIS29-07 Room:313 Time:April 29 15:45-16:00

Review of seismo-electromagnetics and earthquake predictology

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[1]University of Electro-Communications

This paper consists of a few parts. The 1st part deals with the review of electromagnetic precursors to the 2011 Japan earthquake (EQ). The 2nd part is based on the general review of seismo-electromagnetics, and the 3rd, the proposal of a new science field of EQ predictology. In the 1st paper we present our own results on electromagnetic precursors to the 2011 EQ, including (1) subionospheric VLF/LF propagation anomaly, (2) ULF (ultra-low-frequency) magnetic field depression, and (3) atmospheric VLF/ELF radiation. The 2nd part deals with the present situation of seismo-electromagnetics (DC geoelectric measurement, ULF emissions, atmospheric effect and ionospheric effects), in which the ionospheric precursor has already been found to be statistically correlated with EQs based on long-term data. Finally, by using such EQ precursors we are ready to perform the short-term EQ prediction and to propose a new science field of EQ predictology.

Keywords: Earthquake precursors, Earthquake predictology

Japan Geoscience Union Meeting 2014
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MIS29-08 Room:313 Time:April 29 16:15-16:30

Let’s make use of foretelling an earthquake information.

KUNIHIRO, Hidemitsu[1*]

[1]JYAN meeting for the study

The observation information of 1 JYAN meeting for the study (a foretelling an earthquake amateur net = volunteer group)
(1) Our society for the study performs the NET observation of the FM broadcasting electric-wave, but recorded a decisive harbinger by Awajishima earthquake in last April, and elsewhere much observation records are accumulated, and act for high-reliability as a law learned by experience of the earthquakes.When I could go ahead through the high-reliability in three kinds of observation networks such as the low inside, all frequency to the short wave zone, FM broadcast 100, observation of the ground electromagnetism, and the (2)JYAN meeting for the study collated each observation result, I understood a correlative thing.(3) A great variety of seismometry is carried out, and we demand the collection and feedback of the information there, and can go ahead through the preparations for an exhibition of the observation information nationwide.**I announce the electromagnetism observation to contribute to the mechanism elucidation of 2 earthquakes**.(1) The electric wave propagation change (3) others which appear for several months of the electromagnetism change (2) earthquake that appeared before an earthquakeThe cause that **3 ”foretelling an earthquake information” is not valid**?(1) When ”the foretelling an earthquake is very difficult”, the Japanese Seismological Society of Japan announced it, but do not progress before can announce the foresight information of the earthquake, and therefore cannot start the yet most recent ”foretelling an earthquake information”.(2) If earthquake information is accompanied with a panic and information responsibility, and the information of the major earthquake is announced, a panic is worried about ahead of an earthquake, and if earthquake information is wrong again, is asked the responsibility, and, therefore, cannot be involved in administration and the media either.**4 problems and good solution**?(1) It is necessary let the advancement of the observation technology is necessary, and the promising field of the foretelling an earthquake observe it with enough studies with the earthquake study that the accuracy of the earthquake forecast is necessary for foretelling an earthquake to becoming it there, and to plan the advancement of the foresight technology, and knowledge and the cooperation of the field of extensive arts and sciences let all integrates scientific study or observation information because necessary, and visualize it, and the earthquake study plans the development of the new technology again.(2) Is a panic and information responsibility, but if wake up a large panic in little information, and the warning information of the earthquake cooperates with the media there, and the commuter rush of the city just announces the observation information of the earthquake in the same way as typhoon information because daily life is an abnormal situation, and change it to use earthquake information by a self-judgment anytime, the panic is controlled, and do not have the responsibility problem besides now. **To convey the earthquake forecast that 5 is ideal for** If it is with more right seismometry information if it establishes a seismometry center (a tentative name) to make environment let unify all observation information, and to be able to give synthetic judgment to to do earthquake information precisely because necessary, and let unify a study and observation information, and feed back information again necessary for each observation spot., and may start the earthquake forecast that the nation can rely on, and there are administration and cooperation of the media, may change in the country more reliable safely.

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MIS29-09 Room:313 Time:April 29 16:30-16:45

3-D visualization of the preseismic ionospheric anomalies

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The ionospheric anomalies possibly associated with large earthquakes have been reported by many researchers. However, a physical mechanism of pre-seismic 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 prior to large earthquake, the Neural Network based tomographic approach is adapted to GEONET and ionosonde data. In the case of the 2011 Off the Pacific Coast of Tohoku Earthquake (Mw9.0), the significant enhancements are found in Total Electron Content (TEC) investigation, 1, 3-4 days prior to the earthquake. Especially, TEC increase of 3 days prior to the earthquake was remarkable. As a result of tomographic analysis, the reconstructed distribution of electron density was decreased above the epicenter around 250 km altitude (below the hmF2 altitude) in comparison with 15 days backward median distribution. Meanwhile, we found the electron density enhancement above hmF2 altitude. Moreover, the similar structures were found in many other earthquake occurred in Japan. Especially, in the case of long-term GIM-TEC anomalies (10 hours per day and over) were found, the similar structure was detected at a high rate (85%). Details will be shown in the presentation.

Keywords: Ionospheric tomography, GPS-TEC, Preseismic ionospheric anomaly

Japan Geoscience Union Meeting 2014
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MIS29-10 Room:313 Time:April 29 16:45-17:00

Study on lithosphere-atmosphere-ionosphere coupling inferred from the data of GPS surface displacement and ionopheric pe

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Various scenarios of coupling mechanisms between the major seismic activities on the ground and overlaying ionosphere have been proposed, experimental evidence has not been observed clearly. In this paper we analyze long-term data from ground movement and ionospheric anomalies in relation with major earthquakes occurred around Japan. In association with major earthquakes, anomalous surface displacements are observed by dens GPS network whilst lower ionospheric perturbations are identified by continuous measurement of VLF/LF transmitter signals. As a result, we found that the ionospheric anomalies are observed preferably associated with the thrust type earthquakes. GPS surface displacements tend to occur in association with any types of earthquakes.

Keywords: ionopheric perturbations, GPS surface displacement, lithosphere-atmosphere-ionosphere coupling, earthquake

Japan Geoscience Union Meeting 2014
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MIS29-11 Room:313 Time:April 29 17:00-17:15

Precursor Ionization Anomaly (PIA) caused by earthquake electric field- with and without natural eastward electric field

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In the low/midlatitude ionosphere, feature which is similar to Equator Ionization anomaly (EIA) is produced about 5 days before large earthquake (Oyama et al., 2010). The phenomenon was found by using the data obtained by US satellite DE-2, which was in orbit during 1981-1982. We named this phenomenon Precursor Ionization Anomaly (PIA). To find the PIA, satellite altitude should be below 400 Km. PIA seems to show different feature depending on the magnitude of electric field associated with earthquake, distance from the magnetic equator, and the height of the ionosphere to be studied. Depending on the magnitude of the earthquake electric field, and the height to be measured, the electron density shows the minimum or the peak. PIA is also influenced by natural electric field. When EIA exists, two minima of the electron density appear; one is caused by natural eastward E filed, another by earthquake electric field. sometimes three minima appear. Here we present two cases: 1.PIA under the existence of natural eastward electric field. 2. PIA without/or weak natural eastward electric field. We stress here that constellation of small satellites will provide a breakthrough for precursor study of large earthquake.

Keywords: Earthquake, electric field, plasma density, fountain effect

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MIS29-12 Room:313 Time:April 29 17:15-17:30

Mission Analysis of Micro-Satellite for Earthquake Precursor Study

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[1]Dpt. of Phys., Tokyo Gakugei Univ.

A mitigation of the disasters attributed to mega-earthquake should be prioritized for saving human lives. In order to promote earthquake prediction, we take particular notice of one of plausible ionospheric precursors, the decrease of VLF electromagnetic wave intensity. Then we statistically verify such a precursor associated with world-wide large earthquakes, and finally conclude whether earthquakes are predicable or not. For this purpose, a dedicated satellite with 2.5- year operation is proposed.

Keywords: Earthquake, Ionospheric Precursors, Micro-Satellite

Japan Geoscience Union Meeting 2014
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MIS29-13 Room:313 Time:April 29 17:30-17:45

Satelite orbit of detecting Ionospheric Earthquake Precursor

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[1]Dpt. of Phys., Tokyo Gakugei Univ.

In general, it is difficult to show a statistical correlation between the precursor and the large earthquake, because of infrequent occurrences of the large earthquake. In particular, to prove the causation required by the identification criteria 5 needs a number of much larger earthquakes, which are further less number according to Gutenberg- Richter relation. In addition, the events of earthquakes in the ocean and far from the ground observation site might be undetectable. Supposing that a number of precursors are detectable on the ground-based station, it might take the long term of thousand years. Theses plausible atmospheric-ionospheric precursors last for a few hours to a few days before the mainshock. Therefore, some of precursors are detectable by satellites because the orbit sampling of satellite is less than the duration of the precursors. Moreover, the satellite observation can cover the whole of a region of active seismicity, when the inclination of satellite is more than 60 degrees. In this presentation, we propose ideal orbits of dedicated satellite for this study.

Keywords: Earthquake, Ionosphere, Satellite