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

MIS30-01 Room:301B Time:May 21 14:15-14:30

Examination of statistical significance of earthquake-related precursory phenomena -Izu Islands Kozu case, as an example

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We published the paper entitled ”Preseismic anomalous telluric current signals observed in Kozu-shima Island, Japan, Proceedings of National Academy of Sciences of the United States of America (PNAS), Vol. 109, no. 47, 19125-19128, doi: 10.1073/pnas.1215669109, 2012, by Yoshiaki Orihara, Masashi Kamogawa, Toshiyasu Nagao and Seiya Uyeda”. The authors believe that this paper is the first example of the proof of the existence of precursory electric signals by using the well-considered statistical approach in the ground observation. For the next step, to persuade suspicious general scientists, we have to present the effectiveness of this kind of precursory phenomena. Because some seismologists claim that the ETAS model performs very good prediction in comparison with random prediction with probability gain of 100. The most important issue is to introduce the concept of ”probability gain”. Actually, this argument is somehow nonessential. However we have to overcome this kind of argument. In the presentation, we would like to propose the minimum step of necessary statistical evaluation items.

Keywords: precursor, statistics

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MIS30-02 Room:301B Time:May 21 14:30-14:45

An estimation of electromagnetic field variations due to the thermoelectric effect accompanying a point heat source gene

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Thermoelectric effect which couples both the temperature gradient and the electric field to both the heat flow and the electric current density can cause, in principle, coseismic electromagnetic field variations due to fault motions with frictions. The present study attempts to estimate the field variations.

Assuming a point heat source with spherical symmetry which is regarded to be generated by a point dislocation with friction in a homogeneous whole space, the equation of the temperature is separated. The magnetic field variation is not excited.

Expanding the self-consistent system of the equations with spherical symmetry, the temperature satisfies a non-linear diffusion equation, for the coupling between the heat flow and the electric field depends on the temperature.

By a kinematic approach which considers the contribution of the temperature gradient to the electric current density and neglects the contribution of the electric field to the heat flow, the resultant electric field and the temperature variations with respect to time both show increase, maximum and decay. However, order estimations with realistic quantities of physical properties suggest that the arrival time of the maximum amplitude at kilometers away from the heat source amounts to years. The maximum amplitude of the electric field does not exceed the observable level in realistic situations.

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MIS30-03 Room:301B Time:May 21 14:45-15:00

Numerical simulation of co-seismic electromagnetic signals in porous media

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Field observations indicated the existence of the electromagnetic signals accompanying with natural earthquakes. Such co-seismic electromagnetic signals may provide some useful information of earthquake process. So it is becoming an interesting topic in geophysical community. Unfortunately, the generation mechanisms of co-seismic electromagnetic signals are not well understood at the current stage. In this study, we simulate numerically the co-seismic electromagnetic signals in layered porous media by using the generalized reflection and transmission coefficients method. We focus on the characteristics of electromagnetic signals generated by a double couple point source or a finite fault source in different models. The effects of source time function type and center frequency have been investigated. The numerical results show that the co-seismic electromagnetic signals depend on the model structures and the rupture sources. The simulation results also indicate that seismic waves and electromagnetic signals have good correlations in both the waveform and the dominant frequency.

This study is supported by the China-Korea-Japan (CKJ) Joint Research Collaboration Program by the Ministry of Science and Technology of China (2010DFA21570).

Keywords: Seismo-electromagnetic signals, Finite fault, Source time function

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MIS30-04 Room:301B Time:May 21 15:00-15:15

Locating earthquakes using magnetic data via the magnetic transfer function in Taiwan

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Magnetic data have been widely utilized to survey direction of high-conductivity materials via the magnetic transfer function. Many studies have reported that conductivity of rocks close to epicenters is increased before earthquakes due to stress accumulation. Here, magnetic data are utilized to investigate location in which conductivity is enhanced during earthquakes in Taiwan. Analytical results show that anomaly increased conductivity appears about 30 days prior to M5 earthquakes in Taiwan. Directions determined through the anomalous increased conductivity via the magnetic transfer function well agree with earthquake azimuths to one magnetic station when effects of tectonic structure and sea water on magnetic data are mitigated. Earthquake epicenters can be further determined by using an intersection of anomalous directions determined by two or more magnetic stations. Meanwhile, depths of forthcoming earthquakes can be roughly estimated when the skin effect is conducted into the magnetic transfer function.

Keywords: Seismo-electromagnetic anomaly, Magnetic transfer function

Japan Geoscience Union Meeting 2013
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MIS30-05 Room:301B Time:May 21 15:15-15:30

Study for earthquake prediction by detections of electromagnetic pulses in the earth

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So far we could not find electromagnetic (EM) pulses generated by earthquakes. However, we have found that high frequency (a few kHz) components of EM waves would decay due to high electrical conductivity during their propagations in the earth medium, and that EM waves in the extremely low frequency range (0-25HHz) could be detect.

In the observation at Kyoto Sangyo University, during the period of 13 months from December 20, 2011 to January 25, 2013, we found EM pulses clearly for ten earthquakes among thirteen ones with magnitude of >M2 occurred within a circle region of radius of 40 km centered at the EM observation site. In this case, EM pulse detection is affected by the electrical conductivity of the land.

On the other hand, we found, from the data of EM pulses related earthquakes, that we detected these EM pulses which might be excited by the wave front of the propagating seismic wave in the crust near the EM observation site. Therefore, a waveform of detected EM pulse might include multi-EM waves radiated from various place along the propagation path of the seismic wave.

For earthquake prediction, we need to clarify the mechanism of the waveform formation of the detect EM pulses. For this purpose, we need to observer EM pulses in deeper earth (at about 1 km depth).

Keywords: electromagnetic pulses in the earth, detections in boreholes, relation with earthquakes, earthquake prediction

Japan Geoscience Union Meeting 2013
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MIS30-06 Room:301B Time:May 21 15:30-15:45

Comparative study of ULF depression and ELF radiation associated with seismic activity

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Magnetic anomalies in the ULF and ELF ranges in association with major seismic activities are investigated. Previously depression of the magnetic intensity in the ULF range and the radiation in the ELF range were separately studied for different seismic events. In this paper we report first time the comparison of the results between the ULF and ELF anomalies based on the several common seismic events occurred in the vicinity of Japan. The ULF magnetic depressions are observed by two fluxgate magnetometers in Hokkaido and Kyushu while ELF radiations are identified by two induction type magnetometers in Hokkaido and central Japan. Initial result indicates that both ELF and ULF anomalies are observed nearly simultaneously with local seismic events.

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MIS30-07 Room:301B Time:May 21 16:15-16:30

INTEGRATED STUDIES OF EARTHQUAKE PRECURSORS IN INDONESIA

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Integrated studies of earthquake precursors have been done by the research and development center of BMKG since 2010. Studies of earthquake precursors carried out in stages and sustainable that is focused on geophysical, geo-atmospheric and geochemical parameter. This studies are to develop test methods that have been developed with field data in Pelabuhan Ratu, West Java. The target for third year is to studies of vp/vs ratio, magnetic, impedance of EM wave, temperature, humidity and radon consentration as well as verify the predictability of earthquake precursors based on information that has been done.

Research focused on identifying the physical parameters of the character as an earthquake anomaly precursor in the Pelabuhan Ratu, West Java, Indonesia along 2012. The analysis of vp/vs ratio using earthquake catalog and phase report sheet from BMKG. Electromagnetic parameter data used is the magnetotelluric data that observed at geophysical observatories of Pelabuhan Ratu which was collaboration with Chiba University (Japan). Observation data of the radon gas concentration, air temperature and humidity in the soil obtained from RAD7 that installed with sensor of soil gas probe is planted in the ground as deep as 1.2 meters. And surface temperature data is the maximum temperature (Tmax) and minimum temperature (Tmin) were recorded using a mercury thermometer.

Based on the analysis of vp/vs ratio, the accumulation of stress in rocks began to be detected around 1-3 months before the earthquake occurred. Results of electromagnetic parameters analysis using polarization of magnetic data and impedance of EM wave obtained precursor anomaly approximately 14-56 days before the earthquake occurred, so these parameters are included in short-term precursors are likely due to the electrokinetic and microcrack before the accumulation of energy released as earthquakes. Parameters of temperature and humidity as well as radon gas precursor patterns detected about 9-30 days before the earthquake happened so that the parameters are included in short-term precursors. Radon gas and temperature anomalies associated with the deformation in the region of observation before the earthquake occurred.

Keywords: EARTHQUAKE PRECURSORS, INTEGRATED STUDIES, INDONESIA

Japan Geoscience Union Meeting 2013
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MIS30-08 Room:301B Time:May 21 16:30-16:45

Investigation of ULF seismo-magnetic phenomena in Kanto, Japan during 2000-2010

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In this study we have conducted an investigation of ULF seismo-magnetic phenomena in Izu and Boso Peninsulas, Japan, based on the data observed from 2000-2010.

First, case studies of major events have been applied. Energy of ULF geomagnetic signals at the frequency around 0.01 Hz has been investigated by wavelet transform analysis. In order to minimize the influences of artificial noises, only the midnight time data (LT 1:00 ~ 4:00) have been utilized. To indentify anomalous changes from ionospheric disturbances, the standard station Memabutsu has been chosen as a reference station. (1) Case studies of the 2000 Izu Islands earthquake swarm have indicated that there are unusual geomagnetic energy enhancements in vertical component before and during the earthquake swarm. (2) Case studies of the 2005 Boso M 6.1 earthquake have also shown clear geomagnetic energy enhancements in vertical component before the earthquake. (3) Case studies of the 2002 and 2007 slow slip events have demonstrated that there are geomagnetic energy enhancements in both vertical and horizontal components during the slip events.

Then, to verify and clarify the relation between ULF geomagnetic anomalies and seismicity, statistical studies by superposed epoch analysis (SEA) have been carried out. The results have indicated that before a sizeable earthquake there are clearly higher probabilities of ULF anomalies than after the earthquake: for Seikoshi (SKS) station in Izu, about 20~30 days before, one week and few days before, and one day after the event statistical results of daily counts are significant; for Kiyosumi (KYS) station in Boso around two weeks before, few days before, and one day after the event.

Finally, to find out the detailed waveform of anomalous magnetic signals, waveform analysis has been performed. The results show that there are mainly two kinds of seismo-magnetic signature. (1) Noise-like signals: Compared with the background, the signals exhibit small increases of amplitudes at a wide frequency range. (2) Transient/quasi-rectangular signals: the signals have transient/quasi-rectangular waveforms with amplitudes of several nT (~ nT). The noise-like signals usually persist for several days or even a few weeks, and are mainly associated with large earthquakes; the transient/quasi-rectangular signals have durations of few seconds to few ten seconds, and are registered mainly during slow slip events.

Based on the results obtained above, we conclude that: (1) there is a correlation between ULF geomagnetic anomalies and local sizeable earthquakes in Izu and Boso Peninsulas, Japan, and the common period of significant results is few days before and one day after a sizeable earthquake; (2) there are mainly two kinds of seismo-magnetic signature registered in Izu and Boso Peninsulas: noise-like signals and transient/quasi-rectangular signals. The mechanisms of the anomalous geomagnetic signals are still unclear and need further studies.

Keywords: ULF seismo-magnetic phenomena, earthquake, wavelet transform analysis, statistical study, geomagnetic field, superposed epoch analysis (SEA)

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MIS30-09 Room:301B Time:May 21 16:45-17:00

Is an ionospheric electron enhancement preceding the earthquakes a precursor?

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Heki [2011] reported that the TEC gradually enhanced from 40 minutes before the 2011 M9.0 off the Pacific coast of Tohoku earthquake (Tohoku EQ) to the time when the co-seismic acoustic wave reached the ionosphere and the TEC immediately recovered at the normal state. This paper shows an alternative interpretation of total electron content (TEC) variation in the ionosphere associated with the Tohoku EQ. Our interpretation is that a tsunamigenic ionospheric hole, a wide depletion of the TEC, occurred after the co-seismic acoustic wave reached the ionosphere and gradually recovered at the normal state with several tens of minutes [Kakinami et al., 2012]. The difference between Heki [2011] and Kakinami et al. [2012] is attributed to the reference curves of the TEC to extract the ionospheric variations. The former is given by the least-squares fitting curve of the EQ day data excluding an expected precursor period, while the latter is given by the data of the similar orbit of global positioning system (GPS) satellite on another day. The results strongly suggest that variation of slant TEC is explained by the depletion of TEC due to tsunami rather than the precursory enhancement.

Keywords: Seismo Electromagnetics, precursor, ionospheric disturbance, total electron content, Tohoku earthauake

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MIS30-10 Room:301B Time:May 21 17:00-17:15

Seismo-ionospheric precursors of the total electron content associated with M?6.0 earthquakes in Japan

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This paper reports statistical results of seismo-ionospheric precursors (SIPs) of the total electron content (TEC) in the global ionosphere map (GIM) associated with 132 earthquakes with magnitude 6 and/or greater in Japan during 1 May 1998 ? 10 March 2011. To detect SIP, a quartile-based (i.e. median-based) process is performed. The earthquakes without being led by magnetic storms are further isolated and investigated to confirm the SIP existence. Results show that the SIP mainly is the TEC significantly increase in the afternoon period 1-5 days before the earthquakes in Japan. Finally, the SIP of the GPS TEC associated with the 11 March 2011 M9.0 Tohoku earthquake is presented and discussed.

Keywords: seismo-ionospheric precursors, GPS, total electron content, M9.0 Tohoku earthquake

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MIS30-11 Room:301B Time:May 21 17:15-17:30

Three-dimensional structure analysis of ionospheric anomalies associated with large 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-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 enhanced in sub-ionosphere to over F-region in comparison with 15 days backward median distribution. Moreover the enhanced area was seems to be developed to upper ionosphere from sub-ionosphere with time. The rise velocity along magnetic field line was approximately 70 m/s. The tomographic results suggest the existence of some energy influx from the surface associated with seismic activity. Then, in order to understand the relationship of detected phenomenon and earthquake, we performed the tomographic analysis for other earthquakes occurred in Japan. Details will be shown in the presentation.

Keywords: Pre-seismic ionospheric anomaly, Ionospheric tomography, GPS

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MIS30-12 Room:301B Time:May 21 17:30-17:45

Multi-parameter observations of pre-earthquake atmospheric signals and their validation. The LAIC concept.

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We are carrying out a scientific framework involving multi-sensor observations in our investigation of phenomena preceding major earthquakes. The recent catastrophic earthquake in Japan in March 2011 has provided a renewed interest in the important question of the existence of precursory signals preceding strong earthquakes and their physical validation. We describe a possible physical link between atmospheric observations with earthquake precursors using the latest Lithosphere-Atmosphere-Ionosphere Coupling model, the physical concept that we are validating. LAIC model explains the synergy of different ground surface, atmosphere and ionosphere processes and anomalous variations, which are usually named as short-term earthquake precursors.

We demonstrate our approach based on integration and analysis of several atmospheric and environmental parameters that were found associated with earthquakes. The newly developed approach named as Interdisciplinary Space ? Terrestrial Framework (ISTF) permits to identify the precursory phenomena in seismically active areas. The observations included in ISTF are: thermal infrared radiation, radon/ ion activities; air temperature and humidity and a concentration of electrons in the ionosphere. We present our findings of the retrospective thermal radiation precursory detection for more then 100 earthquakes (M>6) occurring in 2004-2011 over Taiwan and Japan including the latest M9.0 great Tohoku earthquakes of March 11, 2011. The cause-effect relationship between different types of precursors united by physical basis of the LAIC model is the main advantage of the presented ISTF approach

Keywords: LAIC, earthquake, earthquake precursor, thermal anomaly, GPS/TEC

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MIS30-13 Room:301B Time:May 21 17:45-18:00

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

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FY 2013 is the final year of the current five 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 (if it’s exist), we have to propose unified project based on the electromagnetic methods. 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