

Correlation between deep-sea fish sighting and earthquakes around Japan

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One often believes that deep-sea fish washing-up on shore is one of unusual animal behavior before earthquakes (EQs) in Japan. Suehiro (1968) reported that oarfish (ryugu-no-tsukai) was caught in the shallows of Niijima a few days before 1957 Izu-Niijima-Kinkai EQ (M6.3). They substantially assumed that deep-sea fish floated on the shallows was regarded as an EQ precursor, because they are seldom events. On the other hand, some people have claimed that they are not the EQ precursor. In this presentation, we will discuss correlation between deep-sea fish washing-up on shore and earthquake occurrences around Japan or geomagnetic disturbances.

Keywords: deep-sea fish, earthquake, geomagnetic disturbance

Source mechanism for seismo-EMs- Coupled interaction of rock rupture with deep Earth gases

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None

Keywords: seismo-electromagnetics, rock rupture, exo-electron

2D and 3D structures of Ionospheric anomalies preceding the large earthquake

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Many papers on ionospheric anomalies possibly associated with large earthquakes have been reported. As for the ionospheric approach, it is important to reduce the effect of geomagnetic storms. The influences of a magnetic storm on TEC variations depend on the intensity and onset time of the storm. In this study, to clarify such dependences, we applied classification analysis method to the storm data (Dst) and discussed the response of TEC variation to each type of storm. We picked out all the 294 geomagnetic storms during 1998-2013, and classified them into 3 types in magnitude and 4 types in the onset time (local time). A bootstrap method is used to calculate the average variation of the TEC for each type of storm. Then, we could find the accurate period affected by each type of storm. Next we performed statistical analysis of the TEC anomalies possibly associated with large earthquakes in Japan area during 1998-2013. There are statistical significance of positive TEC anomalies 1-5 days before and 16-20 days after $M \geq 6.0$ earthquakes. The significance of 16-20 days after earthquakes may be due to aftershock effects of the Tohoku earthquake. Then, we used the Molchan's error diagram to evaluate the efficiency of TEC anomalies for short-term earthquake forecasts. The result indicates that the predictions based on TEC anomalies are better than random guess, which suggests that the TEC anomalies contain certain precursory information of earthquakes. As for the tomographic approach, we investigate the spatial and temporal distribution of ionospheric electron density prior to the 2011 Tohoku earthquake (Mw9.0) and additional large earthquakes in Japan. We found the common TEC increase on 1-5 days prior to the earthquakes was remarkable and the electron density was decreased around the east-region of reconstructed area above the epicenter around 250 km altitude and increased the wide area around 3-400 km, respectively. We also analyzed several cases for ionospheric storms using the tomography. The detailed results will be presented in my talk.

Keywords: TEC, Ionospheric Tomography, Ionospheric anomalies preceding the large earthquake

Spatiotemporal Variations of the b-value and Total Electron Content Prior to Large Earthquakes in Japan

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In recent years, there are many reports on electromagnetic phenomenon preceding large earthquakes. Anomaly of the total electron content (TEC) is one of the most promising anomalies for the short-term earthquake forecast. On the other hand, it is reported that the b-value around the epicenter region decreases prior to the large earthquake. The b-value can compute using the Gutenberg Richter law. The lead time is around few or tens of years. We can't discriminate anomalous changes on earthquakes and solar activities easily at the moment. In this paper, we try to develop a method for the earthquake short-term forecast using the b-value and the TEC analysis. We investigate the effectiveness of the integrated analyses on the b-value for the middle-term forecast and TEC analysis for the short-term forecast.

We select the 2003, 2008 Tokachi-oki EQ (M8.0) and the 2011 Tohoku-oki EQ. As results, we found the variation of b-value has a tendency to decrease for M7class EQs in the analyzed regions and the neighbor's area. For the 2003 Tokachi-oki EQ, we investigated temporal variation for the b-value with interval of 1 day. We found decrease of b-value occurred 16 days and 2-3 days before the main shock. On the other hand, for anomaly of the TEC in the Hokkaido-region, we found significant increase of TEC 2 days before the EQ ($M > 6.0$, $D < 40$ km) using the statistical analysis during 1998-2015. That is, the positive anomaly is dominant. In the case of the 2003 Tokachi-oki EQ, TEC anomaly occurred 2 days before main shock. However, immediately after this TEC anomaly, solar activity becomes active, and after that, positive anomaly may be masked from solar activity. From these results, in the 2003 Tokachi-oki EQ, we found that anomaly of b-value occurred 16 days before main shock after that, TEC anomaly occurred. The results for the 2011 Tohoku-oki EQ show the similar tendency in b-value and TEC variations. From above results, we can conclude that simultaneous use of the b-value and the TEC analysis is suggestive of the effectiveness in short-term earthquake forecast for the M7 or higher earthquakes. Details will be given in the presentation.

Keywords: Earthquake, Electromagnetics, b-value

Ionospheric perturbations due to earthquakes observed simultaneously by subionospheric VLF/LF wave and GPS TEC measurements

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The Gravity Waves (GWs) produced by an earthquake propagate upward from the epicenter to the ionosphere. The GWs interact with the ionospheric plasma and generate the density perturbations which can be detected by different radio remote sensing techniques. In this paper, we study the vertical coupling between the lithosphere-atmosphere-ionosphere (LAI) coupling through signature of IGW waves generated from major seismic activities observed in different altitudes (D and F layers) by subionospheric VLF/LF waves and GPS TEC measurements. We will demonstrate the Travelling ionospheric disturbances (TIDs) induced by major earthquakes observed in the both ionospheric altitudes and deduce their propagation characteristics.

Keywords: VLF subionospheric waves, GPS TEC, very low frequency, earthquake, gravity wave, travelling ionospheric disturbance

Correlation between earthquake occurrence and the anomalous propagation of VHF radio waves indicated by the gain and the p-value of prediction maps produced by a simple objective algorithm in the Shimabara area, Kyushu, Japan

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Electromagnetic precursors associated with the impending earthquake, such as variations of geoelectric current, total electron contents in the ionosphere, and anomalous transmission of radio waves in the VLF or VHF band, have been observed (e.g. Hayakawa, 1996). Recently, some researchers have discussed how these precursory phenomena relate statistically to the impending earthquake (Le et al., 2010, Orihara et al., 2012, Hattori et al., 2013, Han et al. 2014). Anomalous (i.e., beyond the line of sight) VHF-band radio-wave propagation is one such claimed short-term precursor; physical preparatory processes of earthquakes may produce/attract electromagnetic scatterers in the area over the source of the impending earthquake (Kushida and Kushida, 2002, Moriya et al., 2010). Hokkaido University has been monitoring this anomalous propagation in several regions in Japan. On April 14th 2016, an Mw 6.5 earthquake occurred in Kumamoto, which was followed by a nearby greater Mw 7.3 event on April 16th. Just before these events, anomalous propagation of the VHF radio wave from an FM station in Miyazaki was observed at Shimabara receiving station. Epicenters of these Kumamoto events were between the broadcast and receiving stations. To evaluate the statistical significance of the tendency that such anomalies precede impending earthquakes in this region, we made a spatio-temporal map of earthquake alarm (though for only one spatial grid, which is the region between the Miyazaki broadcast and the Shimabara receiving stations) based on the data for 2015 to 2016; after anomaly appears, we turn ON the alarm for a certain period of time L , and thus divide the whole observation period into “Alarm ON”, “Alarm OFF”, and “Undecided (due to missing data)” periods. The alarm map was compared with the occurrence of local earthquakes with $M > 4.5$ after declustering. The result, the associated p-value was not low enough to suggest the statistical significance.

Keywords: Earthquake prediction map, objective algorithm

Evaluation of electromagnetic wave measurement system for pre-seismic VLF signals

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We develop the VLF electromagnetic wave location system to study lightning,, transient luminous events, and pre-seismic electromagnetic emission. In this presentation, we introduce our evaluation of this system, comparing other lightning location systems. Our final goal of this study is to verify and understand the pre-seismic VLF emission.

Keywords: VLF, Lightning location system, Earthquake

Ionospheric disturbance in D region possibly related to pre-earthquake activities observed by the DEMETER

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A decrease of electric field at the 1.7 kHz, i.e., VLF electromagnetic waves, within 4 hours before neighboring earthquake (EQ) with the magnitude of more than 4.8 was statistically shown through the data set of in-situ satellite measurement according to French groups. We found that the intensity originating from the whistler waves in the frequency of more than cutoff decreased in the orbit near the epicenter. The interpretation of the intensity decrease is due to the electron density increase in D region over the epicenter.

Keywords: Earthquake, Ionosphere, DEMETER

Study of ionospheric precursor using the DEMETER ELF data

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A decrease of electric field at the 1.7 kHz, i.e., VLF electromagnetic waves, within 4 hours before neighboring earthquake (EQ) with the magnitude of more than 4.8 was statistically shown through the data set of in-situ satellite measurement according to French groups. In this study, we apply the DEMETER ELF data to our previous analysis for VLF data. We apply this method to ELF data. Our preliminary analysis showed that the intensity of electromagnetic wave was enhanced around 700 Hz near the epicenter 40 hours before the earthquake.

Keywords: Earthquake, Ionosphere, DEMETER

Precursory electric field observation cubesat demonstrator: Prelude

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Small satellites have already been used for earthquake precursory phenomena observation in other countries, but CubeSat-class satellite has not existed yet. The French seismo-electromagnetic satellite DEMETER reported statistically the reduction of the radio wave intensity 4 hours before earthquakes, but its mechanism and dependence on local time is unknown.

The 3U CubeSat "Prelude" under development is aimed at verifying the reduction of radio wave intensity 4 hours before earthquakes by installing only one pair of electric field probes which is already proven by DEMETER in the vertical direction, constructing the satellite constellation in a low cost.

Keywords: Prelude, CubeSat, DEMETER

We were able to predict a foreshock and a main shock in an FM observation network by Kumamoto earthquake.

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JGU No 018707 The Japanese Seismological Society of Japan A Japanese foretelling an earthquake society

JYAN society for the study's chairperson Hidemitsu Kunihiro

We were doing an earthquake study while expanding an observation network including construction of a direct radio observation point of FM broadcasting into the whole country from 8 years before, targeting the earthquake prediction. A big abnormal change showed in the FM broadcasting radio wave which has propagated the sky around the seismic center on April 6 and April 9 because of the Kumamoto earthquake in April of last year. And a main shock occurred on April 14 of about 1 week later (a foreshock) and April 16. Our observation network is a FM broadcasting radio wave, an observation was always continued, but a big change was for the first time like this except for E-SUPO phenomena. Our research council is doing a study and data analysis/analyses of an electromagnetic observation and is piling up the empirical rule which becomes earthquake prediction. When there was a big abnormal change, an earthquake occurred about 1 week later, but an earthquake also occurred on April 14 and April 16 on the empirical rule street this time. A route and the suburb from a sender of an FM radio wave (Kumamoto-City Kinpousan) to a reception point (Taketa-City) were an epicenter from these presage on April 6 and empirical rule, and the scale of the earthquake could expect a big earthquake from the abnormal level of the radio wave. You could expect to continue twice because big unusualness also showed on the 9th. I shook in an earthquake on the prediction street in Taketa-City of a reception point at night on the 14th with that, and an observation and an empirical rule confirmed the right thing, and an epicenter found out Mashiki-Town near the route. But, the Meteorological Agency was announcing "Please be careful about an aftershock for 1 week from now on.", so for me who predicted the 2nd time of big earthquake to tell "A big earthquake came again.", I ran to Kumamoto-Pri Mashiki-Town next early morning. But while an aftershock continued at a disaster area, I fully realized that almost earthquake prediction information which also has no agreements with media is of no avail. So electromagnetic observational data of our workshop is developed at this JGU academic meeting, and it's announced that an electromagnetic observation is very effective in earthquake prediction. (For an observation chart, the transverse = hour and vertical axis= the electric field strength and the color = observation radio wave)

Keywords: Foretelling earthquake, Electric wave observation , FM electric wave, Kumamoto earthquake

熊本地震でのJYAN研電磁観測は「余震」まで判りました。

