Predict the 2016 Kumamoto M7.3 earthquake with satellite clouds data

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Clouds are usually considered as weather phenomenon, while in recent years some reports were published that unusual clouds appeared before strong quakes, and they could be used to predict earthquake. In March 2016, we observed some anomalous clouds over Japan and predict that a M5.8-M6.8 quake will hit east Japan, and the possible date is April 14. This information was published on Researchgate in advance. On April 14 a M6.5 quake hit west Japan and on April 16 a M7.3 quake happened. These facts proved our prediction, and in this paper why the predicted location is wrong is discussed. The predictions about Afghanistan quake and Myanmar quakes which happened in April 2016 are also introduced. Our analysis show that the three consecutive successful predictions are not by coincidence.

Keywords: Kumamoto Earthquake, Satellite Clouds Data

Statistical analysis of ULF geomagnetic changes related to earthquake activity using transfer function around Kakioka,Japan, during 1997-2015

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Recently, ultra low frequency(ULF, less than 1 Hz) has been considered one of the most prospective bands to detect earthquake precursory signatures because of its larger skin depth. Han et,al., 2014 have performed statistical studies at Kakioka(KAK) station, it is proved that ULF geomagnetic changes preceding earthquake at KAK station has statistical significances. However, we can use only the remote station as a reference which shows a high correlation with KAK station. Therefore, to study use any remote station for investigation the ULF geomagnetic changes related to earthquake, we have performed statistical studies using the geomagnetic transfer function approach using the KAK station, Japan, during 1997-2015. We investigated the energy of ULF geomagnetic signals of the frequency around 0.01 Hz using wavelet transform analysis. To minimize the influences of artificial noisesand to remove global geomagnetic perturbations, we used only the geomagnetic data observed at nighttime (LT01:30 A.M. to 04:30 A.M.) and utilized observations from a remote station, Memambetsu, as a reference. We have computed geomagnetic Z component at KAK station using transfer function, and defined P value (the ratio observed Z component and computed). We have determined threshold for geomagnetic anomaly from P value. Earthquake as Es>10^8 at KAK station have chosen for this study. Statistical results of superposed epoch analysis have indicated that significant correlation between ULF geomagnetic changes and earthquake 21-25 days before the events. Further, we have evaluated the precursory information of ULF geomagnetic changes related to earthquake using Molchan’ s error diagram. The probability Gain(PG) is around 1.3 against a Poisson model. The above results have indicated that it is possible to use any remote station using transfer function. Details will be given in the presentation.

Spatiotemporal Characteristics of b-value and TEC Variations before the 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 2003Tokachi-oki EQ, we investigated temporal variation for the b-value with interval of 1day. We found decrease of b-value occurred 16 days and 2-3days 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 2011Tohoku-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

Development of Radon Detector and Observation at Okayama

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An increase of the radon in underground water at Nishinomiya City[1] and an increase of the radon in atmosphere[2] at the southern part of Hyogo Prefecture earthquake in 1995 were reported. Moreover, in the case of Tohoku Region Pacific Coast Earthquake, the data of the exhaust air monitor in the radiation facility of Fukushima Medical College (Fukushima) has been reported that the peak duration was long, and the peak decreased rapidly before the earthquake[3].
We had measured radon in a pit of Kurashiki mine, and in the atmosphere in Chiba Prefecture, Chiba. We used a Radon Monitor of SUN NUCLEAR Corporation, Model 1028 in the Kurashiki, and Pylon Trace Environmental Level Radon Gas Detectors (abbreviated to TEL) in Chiba. The TEL is composed of ZnS(Ag) scintillator and a Photomultiplier. However, its count rate decreased due to unknown causes, and stopped in the end.
On the other hand PIN photodiode have been developed for high sensitive radon detector, and used in Super-Kamiokande[4]. Last year we made a detector to measure atmospheric radon, using PIN photodiode. We use a Si PIN photodiode as detector, S3204-09 (Unsealed), supplied by Hamamatsu Photonics K.K. We constructed a radon detection system, using a stainless pot as air container, H4083 as charge amplifier, C4900-01 as High voltage power supply module, a pulse shape amplifier, a Multi-Channel Analyzer, and a Personal computer as data analysis. Output of the multi-channel analyzer showed clear alpha peaks of ^{218}Po and ^{214}Po of radon daughters from Uranite.
This time we have measured the radon in the atmosphere by the system, for one year at Okayama University of Science, and observed daily variation. We also measured the radon by the system in the pit of Kurashiki mine for about 1 week, and got sensitive data comparing with those by the Radon Monitor, Model 1028. We also plan to substitute the system for the TEL to measure the radon density in the atmosphere in Chiba Prefecture, Chiba.

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Keywords: Radon detection, atmosphere, earthquake prediction

Experimental Study for Lithosphere-Atmosphere-Ionosphere Coupling : Observation of Atmospheric Parameters at Asahi Station, Chiba, Japan

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The Ionospheric anomaly is one of the most promising precursory phenomena for large earthquakes. Lithosphere-Atmosphere-Ionosphere Coupling (LAIC) model has been proposed to explain these phenomena. To examine the possibility of chemical channel of LAIC through the monitoring of atmospheric electricity parameters, we have installed sensors for the atmospheric electric field (AEF), atmospheric ion concentration (AIC), radon concentration, radon exhalation quantity (REQ), and weather elements. We will report the properties of variation in atmospheric electricity parameters observed at Asahi station (ASA), Japan to identify earthquake-related signals in these parameters.
We found that the variation of radon exhalation quantity shows a clear negative correlation with 3 hours delay to the air pressure variation in clear days. Each season differs in daily pattern. AIC and AEF variations show lag correlation with radon exhalation quantity variation. To extract anomalous radon variation related to earthquakes, we should set a network of Radon monitoring and establish a model of radon variation for the future detailed analysis. We also observed cases that AEF has showed a spike-like increase at the same time as the time when AIC has largely increased. It must be going to be checked whether AEF data was taken in fair-weather period, however, it is suggested that change in local charge distribution may have influenced AEF.

Keywords: Lithosphere-Atmosphere-Ionosphere Coupling, atmospheric ion concentration, atmospheric elctric field, radon exhalation quantity

Co-seismic signatures observed by QuakeFinder systems during the 6 February 2016 M6.6 Meinong Earthquake in Taiwan

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At 03:57 local time (19:57 UTC) on 6 February 2016, an earthquake with a moment magnitude of 6.6 struck in the Meinong District of Kaohsiung in Taiwan. The earthquake struck at a depth of around 23 km. This comparatively shallow depth caused more intense reverberations on the surface, and resulted in widespread damage and 117 deaths. The earthquake is the deadliest earthquake in Taiwan since the 921 earthquake in 1999. In this paper, seismograms of the free field strong earthquake observation network published by Center Weather Bureau are used as a reference. Concurrent/co-located measurements of seismometer and QuakeFinder systems together with infrasound systems are employed to study seismic waves and disturbances in the neutral atmosphere near the Earth’ s surface of the Meinong Earthquake. Each QuakeFinder system consists of a 3-axes induction magnetometer, an air conductivity sensor, a geophone, and temperature/relative humidity sensors. There are no obvious charges in the positive/negative ions, the temperature, and the humidity, while the magnetometer, the geophone, and infrasound data show clear co-seismic signatures, similar to seismic waves recorded by seismograms. The magnetometers register high-frequency pulsations, like seismic waves and superimpose with low-frequency variations, which could be caused by the magnetometer tilting and the underground water level change, respectively, during the arrival of seismic waves. The overall power spectrum of the geophones is similar to that of the seismometers, and however, the geophone (also magnetometer) power yields an exponential decay to the distance to the epicenter, while the seismic wave power is inversely proportional to the square of the distance. This suggests that the mechanisms detecting seismic waves of the QuakeFinder system and seismometers are different. In general, the geophone and magnetometer/infrasound system are useful to record high- and low-frequency seismic waves, respectively. Finally, some latest progresses in pre-earthquake signals probed by QuakeFinder systems in Taiwan are reported.

Keywords: co-seismic signature, earthquake

Characteristics of Ionospheric Electron Density Anomalies related to Geomagnetic Storms and large Earthquakes

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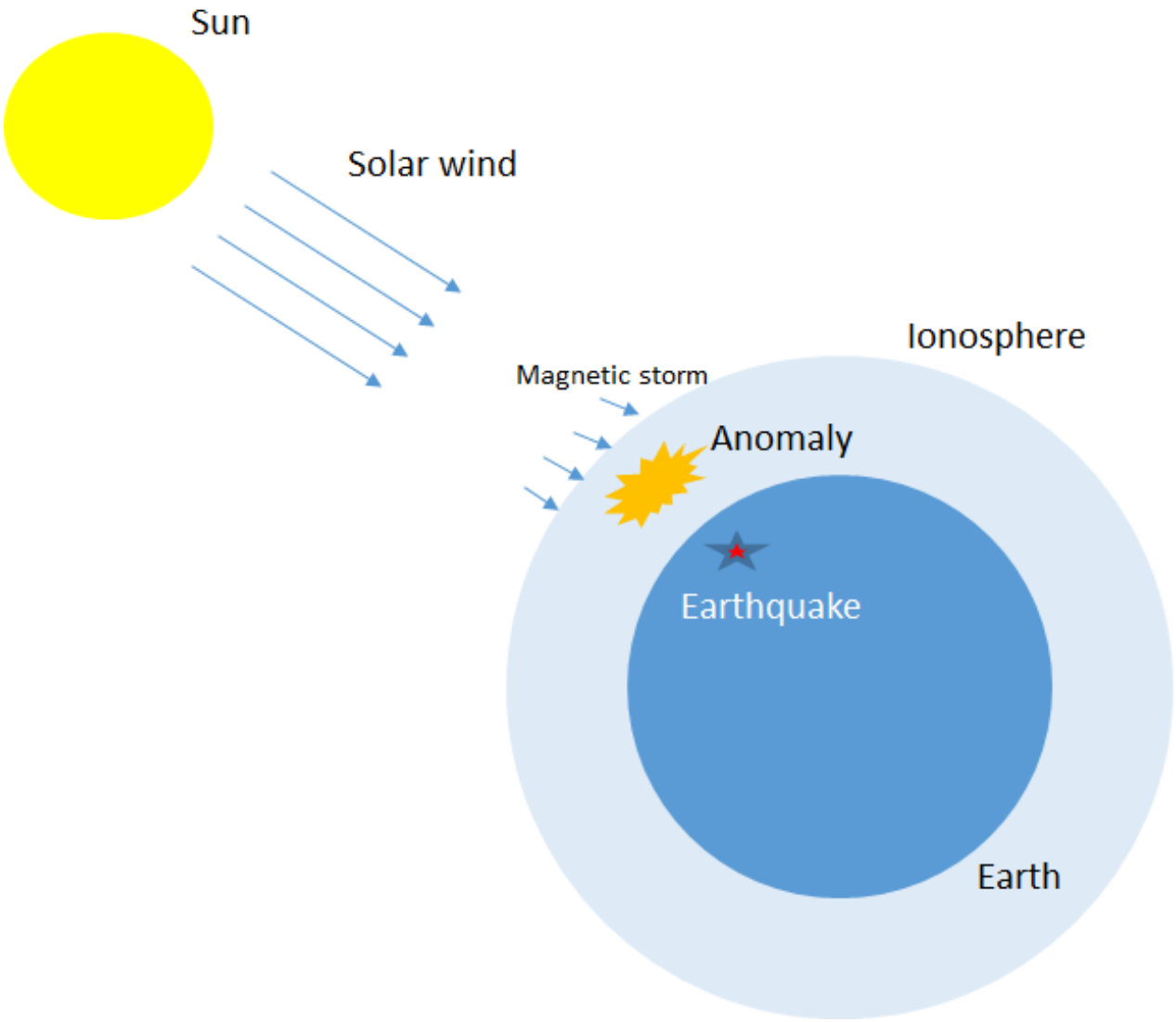
Pre-seismic electron density anomalies have been a widely discussed phenomena in ionospheric studies. However, it is not well-known what causes these anomalies and what is the possible source mechanisms. These are still having not been elucidated questions and more investigations are needed to make clear that phenomena. The another question is how to distinguish ionospheric anomalies from other disturbances such as geomagnetic storms. In many cases, simultaneous geomagnetic activities make it difficult to detect an earthquake precursor effect in the ionosphere. Therefore, a characterization and classification of magnetic storm and earthquake signatures is necessary to make reliable forecasting. For this purpose, in this study, we investigated the similar and differing effects of magnetic storms and earthquakes on the ionospheric composition.
Int this study, the time period after magnetic storms and before earthquakes were mainly investigated. The selection of earthquakes was carried out between 1998 to 2013 with M>6 and depth<30 km. Following this, to detect the anomalous behaviour, we examined the temporal and spatial distribution of TEC values of those cases by using GIM-TEC data. Thus, we found that 28 earthquakes had caused anomalous changes in the ionosphere. We further examined these earthquakes with tomography method to investigate their 3D distributions. There we found that 13 of them had also shown the similar anomalous effect. Meanwhile, magnetic storm cases were chosen between 1998 to 2013 within the intense storm category in which Dst < -100 nT. And the onset time was selected in daytime hours from 6 am to 6 pm. By applying this criteria, 42 magnetic storms were extracted. Among them, we selected arbitrarily 10 different storm cases and same analysis steps was followed to determine the anomalous changes. For TEC analysis, we mainly made use of TEC data from both local receivers (GPS-TEC) and global receivers (GIM-TEC). The GPS-TEC data sets were inverted to electron density form (Ne) in the tomography process with neural networks to examine the 3D electron density distribution of the ionosphere. On the other hand, since the TEC is sometimes slower to respond to compositional changes in the ionosphere, we further employed the ionospheric foEs, NmF2 and hmF2 quantities as complementary data. There, we prepared time series figures of these parameters and compared their responses against storm and earthquake effects. Results will be presented in the presentation.

Keywords: Geomagnetic Storm, Earthquake,TEC(Total Electron Content), Tomography, foEs, NmF2, hmF2



Inner and external geomagnetic Sq current system associated with the 2011 Tohoku earthquake (Mw 9.0)

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Han et al. (2016) have reported unusual behaviors of geomagnetic diurnal variation (GDV) in the vertical component prior to the 2011 off the Pacific coast of Tohoku earthquake (Mw 9.0). Spatiotemporal characteristics of the GDV anomalies and the possible coupling of multiple pre-earthquake phenomena have been demonstrated. To make a further understanding of the reported geomagnetic anomalies, spherical cap harmonic analysis method is applied to reveal the inner and external geomagnetic Sq current system. The inner Sq current, which is an induced field, may reflect possible conductivity structure changes related to the Tohoku earthquake. We calculate three-component Sq variations of 17 geomagnetic observatories. The detailed results will be shown in our presentation.

Keywords: Sq variation, Inner and external geomagnetic field, Tohoku earhquake

VLF radio signal propagation anomaly associated with strong earthquakes from joint observations from the ground and space based observations

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The VLF radio signals recorded both from the ground based VLF radio wave monitoring network and the DEMETER is investigated during the 2010 Ms 7.1 Yushu earthquake. The ground-based observations show that the disturbance intensity of VLF wave’ s amplitude relative to the background gets an enhancement over 22% at 11.9 kHz, 27% at 12.6 kHz and 62% at 14.9 kHz VLF radio wave along the path from Novosibirsk - TH one day before the main shock, as compared to the maximum 20% observed during non-earthquake events. The space based observations indicate that there is a decrease of the signal to noise ratio (SNR) for the power spectral density data of 14.9 kHz VLF radio signal at electric field four days before the main shock, with disturbance intensity exceeding the background by over 5% as compared to the maximum 3% observed during non-earthquake events. The geoelectric field observations in the epicenter region also show that a sharp enhancement from ~ 340 to 430 mV/km simultaneously appeared at two monitors 14 days before main shock. The comparative analysis from the ground and space based observations during the earthquake and non-earthquake time provides us convincible evidences that there are seismic anomalies from the VLF radio wave propagation before the 2010 Ms 7.1 Yushu earthquake. The possible mechanism for VLF radio signal propagation anomaly during 2010 Yushu earthquake maybe related to the change of the geoelectric field nearby the earthquake zone.

Keywords: VLF radio signal, ground based observation, space based observation, earthquake

Geomagnetic Diurnal Variations Analysis in Space and Time Associated with the 2011 off the Pacific Coast of Tohoku Earthquake (Mw9.0)

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Recent studies have reported unusual behaviors of geomagnetic diurnal variation (GDV) in the vertical component prior to the 2011 off the Pacific coast of Tohoku earthquake (Mw 9.0). To make a better understanding of this phenomenon, time-spatial analysis of GDV has been applied in this study. Geomagnetic data of long term observations at 17 stations in Japan have been analyzed using the same method in Han et al. 2015. Ratios of diurnal variation range between the target station and the reference station KAK have been computed. After removing seasonal variations revealed by wavelet transform analysis, the 15-day mean values of the ratios in the vertical component shows a clear anomaly exceeding the statistical threshold about 2 months before the mega event in both ESA and MIZ stations in the Tohoku Region. Similar results could not be found in other regions of Japan. Spatial distributions of the ratios show a good agreement between the location of the anomalies and the epicenter of Mw 9.0 earthquake. These time-spatial results seem to be consistent with independent results obtained from other observations such as radon density, seismicity, and GPS displacements, which suggest the geomagnetic data might be useful in earthquake monitoring and disaster mitigation.

Keywords: Geomagnetic Diurnal Variation, the 2011 off the Pacific Coast of Tohoku Earthquake, earthquake monitoring and disaster mitigation

TIR anomaly possibly related to the large earthquake

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MT Survey and its preliminary result at Boso Peninsula, Japan (3)

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A magnetotelluric (MT) survey is one of the methods to understand the underground electric properties. In Boso area, Japan, there are three main topics to perform the MT survey; (1) to estimate underground resistivity structures related to the plate boundaries, seamount, asperities, and slow slip events; (2) to obtain a regional realistic resistivity structure for the numerical simulation in generation and propagation mechanisms of electromagnetic precursors, and (3) to develop a new MT technique to reduce the cultivated noises such as DC-driven train system and factories. For challenges to solve them, we decided to carry out the MT survey in Boso area, Japan during 2014 - 2016. Due to sensing down to 100 km depth, we used induction and fluxgate magnetometers. We set 41 and 12 sites for induction and fluxgate type magnetometers, respectively.

To remove noises from MT data, we attempted remote reference method that is conventional MT method in frequency domain. Hereupon, MT impedance at southern Boso area is improved to a certain degree. In other hand, the one at northern Boso are is not very improved. Therefore, we attempted MSSA (Multi-channel Singular Spectrum Analysis) for MT data in time domain to improve MT impedance. We performed SVD (Singular Value Decomposition) of original time series in MSSA, and reconstructed time series by using the principal components that indicate relatively high correlation in horizontal geomagnetic field between observation site and remote reference site. Then, unexpected MT impedance seen after remote reference method is tend to be restrained. It supposedly indicates that preprocessing MT data in time domain is effective and promise.

We calculated underground resistivity structure from southwest to northeast by using long period sites' data, there is low resistivity region (0.1 −10 ohm-m) around 1 - 2 km depth. This region possibly indicates fluid in sediment layers overlying large amount of surface at Boso area. There is low resistivity region (0.1 −10 ohm-m) under about 3 −10 km depth at southwest site, which possibly indicates ultramafic rock or accretionary prism pushed up by subducting seamount.

Magnetotelluric data progressing with U-43 data beneath the Boso Peninsula

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In Boso Peninsula, we have several stations to study seismo-electromagnetics. Among of them we had very interesting phenomena to show the fluid flows under the ground related to slow slip event. In addition, we have observed geomagnetic anomalies before sizeable earthquakes. In order to understand generation and propagation mechanisms of earthquake-related ULF electromagnetic signatures, we need the computer simulation on electromagnetic waves using FDTD or FEM. Due to this aim, we carried out the MT survey in BOSO area, Japan during 2014-2016.

Keywords: MT data processing

