Japan Geoscience Union Meeting 2015
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MIS02-01 Room:201A Time:May 26 09:00-09:15

Earthquake Prediction with Satellite Cloud Image

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Russian scientists has found some linear clouds in tectonic active area in 1980s, while few papers about this topic were published in the following 30 years except Russian scientists. One of the reason may be that clouds are difficult to be described with numbers or formulas, it is qualitative, and qualitative researches are difficult to be published. After years observation, we found that clouds related with seismic activity have three features, first their shape are linear, second they are often over fault systems, third they often stay over fault systems for hours and do not move with winds. Such clouds are found in Japan, Italy, Bulgaria and New Zealand. With the help of satellite, we have made several successful predictions about these countries earthquakes. We think that clouds are reliable earthquake precursors, while if you want to make an accurate prediction, satellite clouds images are not enough, and it is better to combine other geophysical data to get an accurate result.

Keywords: Earthquake Prediction, Clouds, Satellite

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MIS02-02 Room:201A Time:May 26 09:15-09:30

Discriminating satellite IR anomalies associated with the Ms 7.1 Yushu earthquake in China

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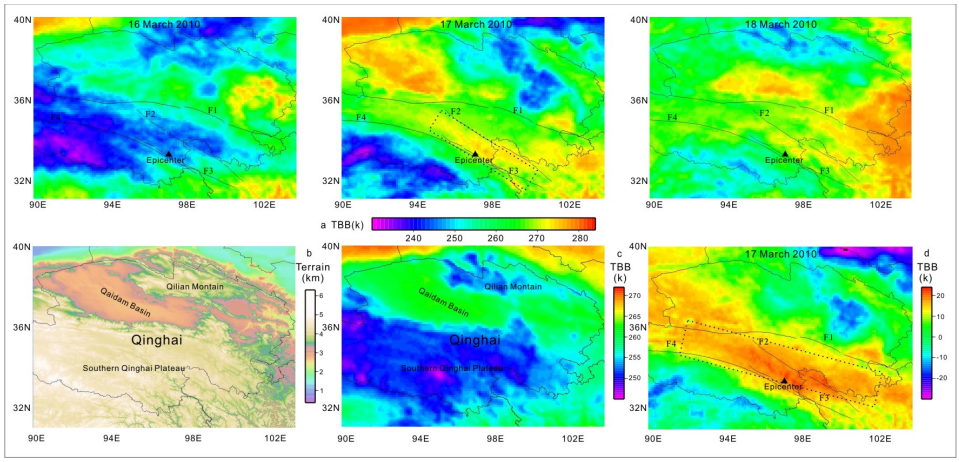
In the process of exploring pre-earthquake thermal anomalies using satellite data, Blackett et al. (2011) found that the reported anomalies before the 2001 Mw 7.7 Gujarat earthquake, in India, were related to positive biases caused by data gaps. They supposed that such effects could also be responsible for other cases. We noted a strip-shaped TIR anomaly on 17 March 2010, 28 days before the Ms 7.1 Yushu earthquake (below figure). Here we again investigate multi-year infrared satellite data in different bands to discriminate whether the anomaly is associated with the earthquake, or is only normal bias caused by the data gaps. From the water vapor images, we find lots of clouds that have TIR anomalies. However, on the cloudiness background, there is an obvious strip-shaped gap matching the tectonic faults almost perfectly. In particular, the animation loops of hourly water vapor images show that the cloud kept moving from west to east, while they never covered the strip-shaped gap. We consider that the cloud with this special spatial pattern should have implied the abnormal signals associated with the seismogenic process. Based on current physical models, the satellite IR anomalies both on TIR and water vapor bands can be explained using synthetic mechanisms.

Keywords: earthquake, satellite, anomaly, thermal, remote sensing



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MIS02-03 Room:201A Time:May 26 09:30-09:45

Onsite earthquake early warning techniques and its applications at schools in Taiwan

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[1]NCREE

Regional earthquake early warning (EEW) system is not suitable for Taiwan due to most of the destructive seismic hazard comes from in-land earthquakes, thus makes the lead-time before destructive earthquake wave arrives provided by the regional EEW system can be null. On the other hand, on-site EEW system can provide more lead-time at the region close to an epicenter since only the seismic information on the target site is required. Instead of leveraging the information of several stations, the on-site system extracts some P-wave features from the first few seconds of vertical ground acceleration of a single station and performs the prediction of the coming earthquake intensity at the same station according to these features. Recently, a new method of estimating seismic intensity using the support vector regression (SVR) has been developed. However, till now, most popular on-site algorithms are TauC-Pd-Attenuation (TPA) method and Pd-Threshold method (PdT). The objective of this study is to evaluate the performance of these three methods using earthquake data of the Taiwan Strong Motion Instrumentation Program and the earthquake data of EEW stations of National Center for Research on Earthquake Engineering in Taiwan. The results show that SVR method can provide more reliable and accurate EEW among these three methods.

Keywords: earthquake early warning, on site, single station

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MIS02-04 Room:201A Time:May 26 09:45-10:00

Earth observation using the GAIA-1 and GAIA-2 satellite platforms

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[1]Chiba University

Earth observation from space provides a vantage point unlike any other. Global Navigation Satellite System (GNSS) and GPS satellites orbiting the planet are all emitting microwave signals. These signals can be exploited using the radio occultation (RO) technique which can be used to sense minute changes in the atmosphere. By studying these changes it is hoped that natural phenomenon such as earthquakes can be predicted before they occur. With that in mind we have a long term plan to launch a satellite with a GNSS-RO sensor called GAIA-1 to seek out the possibility of this potential prediction. Lessons learnt from GAIA-1 will be applied to it's next generation GAIA-2, where the primary payload will be a synthetic aperture radar (SAR) system. This presentation will introduce both satellites and their respective payloads, mission plan, and system architecture.

Keywords: radio occultation, GPS, GNSS, synthetic aperture radar, satellite

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MIS02-05 Room:201A Time:May 26 10:00-10:15

Statistical study on short-term earthquake forecast using TEC anomalies over Japan area

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To reduce the effect of strong geomagnetic activities such as geomagnetic storms, the TEC data of 2 days after Dst index exceed -60 nT were excluded in previous statistical studies of earthquake related TEC anomalies. Actually, 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 according to its magnitude and 4 types according to the onset time (local time). We checked the TEC data from 2 days before till 5 days after the onset of each geomagnetic storm. A bootstrap method (10000 times extraction) is used to calculate the average variation of the TEC for each type of storm. The average variation can be regarded as an average response of TEC to the related type of storm. If the average value of TEC exceeds the mean$\pm 2\sigma$ threshold, we consider it being affected by the storm. By this mean, we could find the accurate period affected by each type of storm.

We employed the results obtained above to remove the TEC data associated with geomagnetic storms. Next we performed statistical analysis of the TEC anomalies possibly associated with large earthquakes in Japan area during 1998/05-2013/12. There are statistical significance of TEC anomalies 1-5 days before and 16-20 days after M>=6.0 earthquakes. The significance of pre-earthquake anomalies is consistent with the results reported by Kon et al., 2011. The significance of 16-20 days after earthquakes may be due to aftershock effects of the Tohoku earthquake. To remove the influences of any per- and after- shock effects, we proposed a new method which considers 'isolate EQs' only. 'Isolate EQs' are earthquakes which is unique in a 61 days window centered by the day of the EQ. The result shows there are clear high possibilities of TEC anomalies 1-5 days prior to M>=6 earthquakes.

Finally, we used the Molchan's error diagram to evaluate the efficiency of TEC anomalies for short-term earthquake forecasts. The results indicates that the predictions based on TEC anomalies are better than random guess (Poisson model), which suggests that the TEC anomalies contain certain precursory information of M>=6.0 earthquakes.

Keywords: statistical analysis, geomagnetic storm, TEC anomalies, earthquake, SEA, Molchan's Error Diagram

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MIS02-06 Room:201A Time:May 26 10:15-10:45

Seismo-ionospheric precursors of the 11 March 2011 M9.0 Tohoku Earthquake

LIU, Jann-yenq[2*] ; LEE, I. T.[3] ; CHEN, C. H.[4] ; HATTORI, K.[5] ; CHEN, Y. I.[6] ; HUANG, C. S.[1] ; SU, Y. Z.[1]

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In this paper, the total electron content (TEC) of the global ionosphere map (GIM) is used to observe seismo-ionospheric anomalies associated the 11 March 2011 M9.0 Tohoku earthquake, while the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM) is applied to simulate and understand the observed anomalies. The GIM TEC associated with M>=6.0 earthquakes in Japan are statistically examined during 1998-2011. It is found that the GIM TEC significantly enhance day 3 before the earthquakes. On the other hand, the TEC over the epicenter also significantly and continuously enhances on 6-8 March 2011, 4-2 days before the Tohoku earthquake. The agreement between the statistical result and the event anomaly implies that seismo-ionospheric precursor related to the Tohoku earthquake might be observed. The spatial analysis further is further conducted to find that the enhancement anomaly specifically and persistently appears in the northern epicenter area. Simulation results well agree with the observations, which suggest that the electric potential around the epicenter has been distorted and significantly affects the TEC during the earthquake preparation period.

Keywords: Seismo-ionospheric precursors, Tohoku Earthqauke

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MIS02-07 Room:201A Time:May 26 11:00-11:30

Validation of pre-earthquake atmospheric signals and their connection with major seismicity

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We are presenting a new approach of utilizing multi-parameters space and ground observations to study pre-earthquake processes related to major earthquakes. In this study we are exploring the potential of atmospheric and ionospheric signals to alert for large earthquakes. To achieve this, we start validating retrospectively and prospectively anomalous ionospheric /atmospheric signals. Our method for validation is based on a joint analysis of several physical and environmental parameters (Satellite thermal infrared radiation (STIR), electron concentration in the ionosphere (GPS/TEC), VHF-bands radio waves, radon/ion activities, air temperature and seismicity patterns) that were found to be associated with earthquakes. The science rationale for this methodology is based on the concept of Lithosphere-Atmosphere-Ionosphere Coupling (LAIC) [Pulinets and Ouzounov, 2011], which explains the synergy of different physical processes, usually named short-term pre-earthquake anomalies.

Our validation include continuous retrospective analysis performed over two different regions with high seismicity- Taiwan and Japan for 2003-2011 .The retrospective tests show STIR and GPS/TEC anomalous behavior in advance for most of these events with false positives less than 25%. The prospective tests for Honshu and Hokkaido (Japan) started in 2014. Our initial test results suggest systematic appearance of STIR anomalies, one to several days in advance to major events, including the two largest earthquakes for that period - M7 of July 12, 2014 and M6.9 of Feb17, 2015 in Eastern Honshu. The proposed is multi-parameters approach and new observations could be further integrated into and the synergy of these parameters implying their connection with the earthquake preparation processes.

Keywords: earthquake forecasting, pre-earthquake signals, Thermal amomaly, GPS/TEC, radon, LAIC

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MIS02-08 Room:201A Time:May 26 11:30-11:45

Statistical Analysis of ULF Seismo-Magnetic Phenomena in Kanto, Japan

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In order to clarify and verify the ultra-low frequency (ULF) seismo-magnetic phenomena, we have performed statistical studies on the geomagnetic data observed at several stations, in Japan, during 2001-2010. They are Kiyosumi (KYS), Uchiura (UCU), Fudago (FDG), Seikoshi (SKS), Mochikoshi (MCK), Kamo (KAM), and Kakioka (KAK). KAK is a standard geomagnetic station operated by JMA (Japan Meteorological Agency) and the others are operated by us. We investigated the energy of ULF geomagnetic signals of the frequency around 0.01Hz using wavelet transform analysis. To minimize the influences of artificial noises and global geomagnetic perturbations, we used only the geomagnetic data observed at nighttime (LT 2:30am-4:00 am). In this abstract, we describe the results of KAK as an example. As for KAK data, we utilized observations from a remote station, Kanoya (KNY), as a reference. Statistical results of superposed epoch analysis have indicated that ULF magnetic anomalies are more likely to appear before sizeable earthquake events rather than after them, especially 6-15 days before the events. Further statistical investigations show clearly that the ULF geomagnetic anomalies at KAK are more sensitive to larger and closer events. Finally, we have evaluated the precursory information of ULF geomagnetic signals for local sizeable earthquakes using Molchan error diagram. The probability gain is around 1.6 against a Poisson model. The above results have indicated that the ULF seismo-magnetic phenomena at KAK clearly contain precursory information and have a possibility of improving the forecasting of large earthquakes. The statistical results for the other stations also show similar tendency. These facts suggest that ULF magnetic anomalies have a significant correlation and precursory information on a sizable earthquake.

Keywords: ULF seismo-magnetic phenomena, statistical test, short-term earthquake forecast

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MIS02-09 Room:201A Time:May 26 11:45-12:00

Detectability of seismic network: an approach of the probability-based magnitude of completeness method

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The magnitude of completeness is a key quantitative index to assess the detectability of regional seismic network. This paper deals with the detectability of the Capital-circle Seismic Network in China by adopting the probability-based magnitude of completeness (PMC) method which can reveal the detailed spatio-temporal characteristics of regional seismic network detectability. The earthquake data (2002-2009) and station information are from China Earthquake Administration (CEA). We estimated the network detectability and discussed the possibility of improving the network detectability according to the spatio-temporal distribution of completeness magnitudes and the simulation results. The results show that the detectability of the Capital-circle Seismic Network is high in most regions, although the detectability in a few regions needs to be enhanced. Simulation results suggest that increasing stations may further enhance the detectability of the seismic network. This study may be helpful for the optimization of the regional seismic network.

This study is supported partially by the National Natural Science Foundation of China (41025014).

Keywords: Probability-based magnitude of completeness (PMC), seismic network, detectability

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MIS02-10 Room:201A Time:May 26 12:00-12:30

Earthquake Monitoring and case study by using Multi-parameters Remote Sensing information in China

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In the last ten years, a few national research plans and scientific projects on remote sensing application in Earthquake monitoring research are implemented in China and some progress were achieved on EQ-related ionospheric and RS precursors extracting and distinguishing by statistical research, case study and real-time monitoring experiments on historical or recent earthquakes. The LAI coupling models were computed and checked also, which laid the foundation for gradually promoting the practical use.

Focusing to advance earthquake monitoring capability and to search for the way of earthquake prediction, the prototype data processing and application platform of satellite-based EQ monitoring system, which integrate mainly GNSS, electromagnetism, infrared RS and D-InSAR technologies were developed systematically. and integrated earthquake remote sensing application system has been designed comprehensively.

On the basis of these works, the first space-based platform in earthquake stereoscope observation system in China, which named as China Seismo-Electromagnetic Satellite (CSES) now is on his phase of electrical model and qualifying model. According to the schedule, the 1st CSES will be launched before the end of 2016 and 2nd CSES will come into review soon.

Keywords: Earthquake monitoring, China Seismo-Electromagnetic Satellite, LAI coupling, remote sensing application

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MIS02-11 Room:201A Time:May 26 14:15-14:30

Multiple seismo-anomalies associated with three major earthquakes in China, Japan and Taiwan

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Seismo-crustal deformation, groundwater (containing levels, temperature and radon), geomagnetic and ionospheric anomalies are integrated together to investigate pre-earthquake anomalous phenomena associated with the M6.1 Ludian earthquake, China, the M9.0 Tohoku-Oki earthquake, Japan and the M7.6 Chi-Chi earthquake, Taiwan. Seismo-crustal deformation and groundwater anomalies generally lead the other promising parameters because stress accumulation in crust is one of the major driving forces of earthquakes. Uplift and depression groundwater levels are exactly related with compression and tension stress loading in the crust, respectively. Decreases of groundwater temperature and radon concentration are resulted from uplift groundwater levels. Meanwhile, groundwater would infuse into fracture zones of faults once cracks are developed before earthquakes that can enhance conductivity near hypocenters and/or faults affecting electromagnetic fields and electron total electron contents in the ionosphere. Those aforementioned relationships can be utilized to eliminate anomalies which are unrelated with earthquakes to further increase of the accuracy and understand causal mechanisms of pre-earthquake anomalous phenomena in seismogenic processes.

Keywords: Groundwater, Electromagnetic field, Total electron content, Crustal deformation, Earthquake forecast

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MIS02-12 Room:201A Time:May 26 14:30-14:45

Space-borne observations of pre-earthquake atmospheric signals associated with major seismicity in Xinjiang, China

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We are presenting the latest development in multi-sensor observations of short-term phenomena preceding major earthquakes. The purpose of this study is to verify if satellite thermal infrared radiation (STIR) anomalous can be found retrospectively in association with three major earthquakes in XinJiang province China (M6.9 of 02.12.14; M6.2 of 08.12.2012; M7.2 of 03.20.08) by systematically analyzing multi-sensor satellite and ground temperature/ humidity observations for the period of 2008-2014. Meteorological satellite data include NOAA polar orbit POES and Chinese geostationary satellite FY2D. In the case of M6.9 of 02.12.14, NOAA STIR data for January ?February shows building an atmospheric anomaly 10-20 days before the main shock. FY2D STIR data show similar trend by revealing anomalous value with persistency of more then 9 hours on Jan 31, 2014. The 2012 (M 6.2) and 2008 (M7.2) event shows similar STIR anomalies over the major Altyn Tagh fault lines within 10-15 days before the seismic event. This probably is connected with the geochemistry gas increase, which can provide additional source for flux emission near major faults in the area. The hourly in-situ atmospheric observation show similarly in the air temperature increases and drop in the relative humidity, probably as result of additional atmospheric ionization observed before the three earthquake events. Our initial results suggest that systematic use of multi-parameter observations can be used for additional physical validation of pre-seismic processes associated with the major earthquake events.

Keywords: short-term earthquake forecasting, pre-earthquake signals, Thermal amomaly, GPS/TEC, radon, LAIC

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MIS02-13 Room:201A Time:May 26 14:45-15:00

Multi-sensor monitoring network for earthquake precursors and preparation process near subduction zone at Boso, Japan

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New observations from ground and space have provided multiple evidences of pre-earthquake signals and the latest studies show their statistical significance, repeatability, and universality. In this project, to understand the preparation process of large earthquakes and slow-slip events in subduction zone, especially to clarify the nucleation stage of the earthquake cycle, we plan to establish a dense observation network in Boso, Japan, where large subduction earthquakes are expected soon.

Since the subsurface fluid flow may play an important role in the preparation process of subduction activities, we intend to employ electromagnetic approaches including oceanic and continental MT survey to monitor the underground resistivity structure which is sensitive to the dynamics of fluid. Other geophysical monitoring such as ULF geomagnetic and geoelectrical observations, radon measurements, and inland GPS movements, will be incorporated to help to understand the preparation process and evaluate the applicability of various pre-earthquake signals towards short term earthquake forecasting.

Keywords: multi-sensor monitoring network, earthquake precursors, earthquake preparation process, short-term earthquake forecast