Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-01 Room:104 Time:May 25 09:00-09:15

Earthquake statistics and probabilistic forecasting for the southern Kanto after the 2011 Mw9.0 Tohoku-Oki earthquake

NANJO, Kazuyoshi[1*], SAKAI, Shin'ichi[1], KATO, Aitaro[1], HIRATA, Naoshi[1]

[1]ERI, Univ. of Tokyo

After the 11 March 2011 Mw9.0 Tohoku-Oki earthquake, seismicity in the southern Kanto became active immediately after this event and then started a gradual decrease with time. Here we show that the seismicity is well correlated with the two fundamental laws that are valid for aftershocks: the Gutenberg-Richter (GR) law for the frequency-magnitude distribution and the Omori-Utsu (OU) law for the temporal decay of aftershock activity. Our dataset is the earthquake catalog maintained by the Japan Meteorological Agency. We cut this catalog available on 25 January 2012 to use data until 31 December 2011 in the region 35.0-36.5N and 139.3-140.8E with a depth range of 0-150 km. We found that the behavior of the GR frequency-magnitude distribution for post-quake seismicity is similar to that for pre-quake one. Only the annual frequency of earthquakes is higher for the former than for the latter: for example, it is about 4 times higher if we consider magnitude M4 or larger. We also found that the decay obtained by fitting the OU law is slow, relative to the decay of typical aftershock sequences. Both the activated seismicity and OU-like decay allow us to use the method for evaluating aftershock probability constituted by the Earthquake Research Committee (1998) and to evaluate the probability of a M7-class (M6.7-7.2) event in the southern Kanto. We found that the range of the probability significantly varies if we take into account the standard errors of the optimized parameters for the post-quake seismicity. Comparing with a report by the Earthquake Research Committee, we conclude that our probabilities as of 25 January 2012 are equal to or larger than the probabilities of the long-term evaluation in the southern Kanto.

Keywords: Earthquake interaction, forecasting, and prediction, Probability distributions, Computational seismology, Statistical analysis, Time series analysis, Dynamics: seismotectonics

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-02 Room:104 Time:May 25 09:15-09:30

Earthquake forecasting using a smoothing Kernel and the rate-and-state friction law: Application to Taiwan

CHAN, Chung-Han[1*], Yih-Min Wu[1], Jui-Pin Wang[2]

[1]Department of Geosciences, National Taiwan University, Taipei, Taiwan, [2]Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technolog

In this work, two approaches were employed for estimating the spatio-temporal distribution of the seismicity density in Taiwan. A long-term forecasting model that involves a smoothing Kernel function is proposed. By way of the rate-and-state friction law, another model for short-term forecasting according to the fault-interaction-based rate disturbance due to seismicity was considered. The application of the models to Taiwan led to good agreement between the models forecast and actual observations. Using an integration of the two approaches, the integrated method was found to be capable of providing a seismicity forecast with a higher accuracy and reliability. The proposed methodology, with verified applicability for seismicity forecasts, could be useful for seismic hazard analyses.

Keywords: earthquake forecasting, smoothing Kernel function, Coulomb stress change, rate-and-state friction law, Taiwan

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-03 Room:104 Time:May 25 09:30-09:45

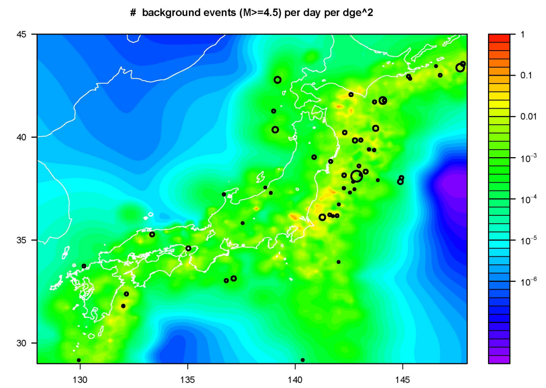
Long-term earthquake forecasts based on the ETAS model for short-term clustering

ZHUANG, Jiancang[1*]

[1]Institute of Statistical Mathmematics

Based on the ETAS (epidemic-type aftershock sequence) model, which is used for describing the features of short term clustering of earthquake occurrence, this paper presents some theories and techniques related to evaluating the probability distribution of the maximum magnitude in a given space-time window, where the Gutenberg-Richter law for earthquake magnitude distribution cannot be applied directly. It is shown that the distribution of the maximum magnitude in a given space-time volume in long term is determined by the background seismicity rate, the magnitude distribution for all earthquakes, and the structure of earthquake clusters. The introduced techniques were applied to the seismicity in the Japan region in the period from 1926 to 2009. It is found that the regions most likely to have great earthquakes are along the Tohoku (Northeastern Japan) Arc and the Kuril Arc, both much higher probabilities than the offshore Nankai and Tokai regions.

Keywords: ETAS model, background seismicity, long term earthquake forecast, earthquake probability



SSS01-04 Room:104 Time:May 25 09:45-10:00

Inter-event Time Maps to Predict Earthquakes

TALBI, Abdelhak[1*], NANJO, Kazuyoshi[1], SATAKE, Kenji[1], ZHUANG, Jiancang[3], Mohamed Hamdache[2]

[1]Earthquake Research Institute, University of Tokyo, [2]Centre de Recherche en Astronomie Astrophysique et Geophysique (CRAAG), [3]Institute of Statistical Mathematics (ISM)

Abstract. This study discusses the use of inter-event time spatial mapping as a tool to provide forecast for large earthquakes. The ratio of the mean inter-event time over the variance, called moments ratio (MR), is used as a precursory alarm function. The statistic MR has been proved to be an approximation of the percentage of background events present in the whole catalog. As a result, MR is supposed to depict long term changes in the background seismicity with a potential to detect precursory signals before the occurrence of large events. In order to test the forecasting performance of MR, a composite catalog covering all Japan within the period 679-2011, was compiled using the Japan Meteorological Agency (JMA) catalog for the period 1923-2011 and the Utsu historical seismicity records for the period 679-1922. Our study selects the time period by taking into account the completeness of the magnitude. For example, for target earthquakes with magnitude $M >= 7$, we test the forecasting within the longest time period for which all target events are completely reported. In a retrospective test of $M >= 7$ target earthquakes, MR is spatially mapped for different learning time periods before the occurrence of target earthquakes. The start of the learning period is defined for each target earthquake depending on the magnitude of learning events and the catalog completeness, whereas it ends a short time before the occurrence of the target event. The forecasting ability of MR is discussed using the relative operating characteristic (ROC) error diagrams which plot successful hits against false alarms. In addition, Molchan error and area skill score diagrams are used to evaluate the quality of forecasting in space and time. The preliminary results show good performance when the relative intensity (RI) forecasting method is used as a reference model.

Keywords: Earthquake prediction, Inter-event times, Alarm function, Molchan error diagrams

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-05 Room:104 Time:May 25 10:00-10:15

Predictability of the 2011 Tohoku M9.0 Earthquake

ZHAO, Shuxian[1*], Li MA[1], Yongqing ZHANG[1]

[1]ICD, CEA, CHINA

On 11 March 2011, a M9.0 interplate earthquake occurred off the Pacific Coast of Tohoku, Japan. Before this earthquake, the seismicity patterns in the Japan Trench subduction zone(shorted for JTSZ) indicate long-term, middle-term and short-term predictability.

1 Mj>=7.0 earthquake quiescence area in the interplate seismic zone between 1925 and 2002

Fig.1 displays Mj>=3.5 earthquakes in the JTSZ and its vicinity during 1925-2002. The Mj>=7.0 earthquakes are denoted by red dots, the 6.5<=Mj<7.0 earthquakes by black dots, and the 3.5<=Mj<6.5 earthquakes by small gray dots.

An abnormal quiescence area of Mj>=7.0 earthquakes in the interplate earthquake zone can be found. Only one Mj7.0 earthquake occurred, and 6.5<=Mj<7.0 and 3.5<=Mj<6.5 earthquakes are also quiescent. The mainshock is located in the margin of the quiescence area.

Between 1925 and 2002, eight Mj>=7.0 intraplate earthquakes occurred in the JTSZ. Seven of them occurred in the overriding Okhotsk plate, and one in the outer rise region of the subducting Pacific plate. These eight events scatter along the Japan Trench.

2 Mj>=7.0 intraplate earthquake strip perpendicular to the Japan Trench during 2003-2010

Fig.2 displays Mj>=5.5 earthquakes in the JTSZ and its vicinity between 2003 and 2010. The Mj>=7.0 earthquakes are denoted by red dots, and the 5.5<=Mj<7.0 earthquakes by gray dots.

Three Mj>=7.0 intraplate earthquakes occurred in a great circle on the earth's surface perpendicular to the Japan Trench and a perpendicular intraplate earthquake strip formed (shorted for PIES, as shown in Fig.2). The first one (2003/05/26 Mj7.1) occurred in the intermediate depth region of the Pacific plate, the second one (2005/11/14 Mj7.2) in the outer rise region of the Pacific plate, and the last one (2008/06/13 Mj7.2) in the Okhotsk plate. Seven 5.5<=Mj<7.0 interplate earthquakes occurred along the great circle I in the quiescence area. Three (Mj5.9, Mj6.3, Mj6.3) occurred in August 2005, and four (Mj6.1, Mj5.5, Mj5.5, Mj5.5) in December 2008.

Two Mj>=7.0 interplate earthquakes occurred, and one of them (2005/08/16 Mj7.2) occurred in the PIES.

The mainshock is located in PIES, and also in the great circle II passing through the 2005/08/16 and 2005/11/14 earthquakes. The mainshock is located on the upper surface of the subducting Pacific plate, and the faults of the mainshock and 2005/08/16 earthquake are almost coplanar, as shown in Fig.3.

3 2011/03/09 Mj7.3 foreshock

On 9 March 2011, two days before the mainshock, a Mj7.3 foreshock occurred in the quiescence area, as shown in Fig.4. The foreshock is located between the great circle I and II, close to the great circle I. The faults of the mainshock and the foreshock are almost coplanar, as shown in Fig.3.

4 Closeness in local time of Mj>=5.6 generalized foreshocks two years before the foreshock

From March 2009 to the foreshock (after PIES appeared), 10 Mj>=5.6 earthquakes occurred in the JTSZ, and 9 of them occurred in only 6 hours (12-18 local time), as shown in Fig.5.

Mainshock occurred in the middle of this period.

5 Preliminary physical interpretations

An earthquake is caused by a sudden slip on a fault, and the slip needs enough stress and space. The seismicity, before the 2011 Tohoku M9.0 earthquake, indicates the formation process of the two conditions clearly.

The continual stress accumulation in the PIES, indicated by the long-term interplate seismic quiescence area during 1925 - 2002, and the stress transfer to the mainshock fault, indicated by the events in the PIES between 2003 and 2010, provide the stress condition for the mainshock slip.

The slips of the 2005/08/16 earthquake and the foreshock, weakened the deep and shallow portion of the mainshock fault respectively, provide the space condition for the mainshock slip.

The significant closeness in local time of the generalized foreshocks for two years prior to the foreshock might be a critical phenomenon correlated with the movement of the Sun.

Keywords: 2011 Tohoku M9.0 earthquake, earthquake prediction, quiescence area, earthquake strip, foreshock

SSS01-05 Room:104 Time:May 25 10:00-10:15

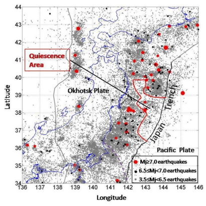


Fig.1 The Mj≥7.0 earthquake quiescence area in the interplate seismic zone between 1925 and 2002

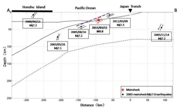


Fig.3 The depth profile of the earthquake strip perpendicular to the Japan Trench

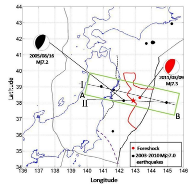


Fig.4 2011/03/09 Mj7.3 foreshock

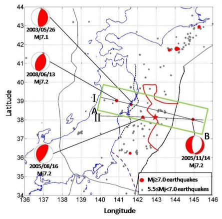


Fig.2 The Mj≥7.0 intraplate earthquake strip perpendicular to the Japan Trench between 2003 and 2010

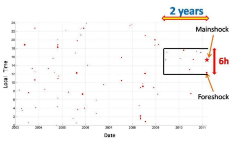


Fig.5 Closeness in local time of Mj≥5.6 generalized foreshocks two years before the foreshock

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-06 Room:104 Time:May 25 10:15-10:30

The influence of the daily variation of the detection capability on the completeness magnitude

IWATA, Takaki[1*]

[1]The Institute of Statistical Mathematics

Evaluating the detection capability of earthquakes in an earthquake catalogue is the first step of statistical seismicity analysis. Conventionally the completeness magnitude M_c, the minimum magnitude of complete recording, is estimated for a catalogue ranging over several weeks, months or years [e.g., Wiemer and Wyss, 2000, BSSA]. It is well known, however, that the detection capability of earthquakes is lower in daytime than in nighttime because of human activity [e.g., Rydelek and Sacks, 1989, BSSA; Atef et al. 2009, BSSA];, and hence an estimated M_c for a catalogue ranging over more than one day would be smaller than Mc in daytime. Therefore, a quantitative analysis of daily variation of detection capability is necessary to discuss the completeness of an earthquake catalogue.

In this study, we used a statistical model representing a magnitude-frequency distribution of all observed earthquakes [e.g., Ringdal, 1975, BSSA; Ogata and Katsura 1993, GJI]. The distribution was assumed to be the product of the Gutenberg-Richter (GR) law and a detection rate function $q(M)$. Following the previous studies, the cumulative distribution of the normal function was used as $q(M)$. Hence, $q(M)$ has two parameters m and s. In the evaluation of the detection capability, the parameter m is fundamental, and it indicates the magnitude where the detection rate of earthquake is 50%. By combination of and m and s, we can compute the magnitude where the detection rate is equal to a particular probability.

Data used in this study was taken from the JMA catalogue from 2008 to 2010. Subareas covering whole of the inland of Japan with a size of 1 x 1 degree were considered, and sequences of shallow (depth <= 30 km) were constructed for each of the subareas. The earthquake sequences were divided into one-day increments, and divided sequences were stacked in each of the subareas. Then, a Bayesian approach with a piecewise linear function and smoothness constraint [Iwata, 2008, GJI; 2011, Research in Geophysics] was applied to these stacked data to estimate the daily variation of m in each of the subareas. The value of s and the b-value of the GR law were also estimated through the framework of the maximum likelihood method.

In this study, the value of $m+3s$, corresponding to the magnitude where the detection rate is approximately equal to 99.9%, was regarded as the completeness magnitude. In most of the subareas, the value of $m+3s$ is close to 1 or less than 2, which is consistent with Nanjo et al. [2010, BSSA] investigating Mc in Japan using the 1-year JMA catalogue. In a few subareas, however, the value of $m+3s$ exceeds 2, suggesting that, to ensure the completeness of an earthquake catalogue, it is important to consider the daily variation of the detection capability.

Keywords: completeness magnitude, earthquake catalogue, Bayesian statistics, statistical seismology

SSS01-07 Room:104 Time:May 25 10:45-11:00

Current developments and results of the Collaboratory for the Study of Earthquake Predictability (CSEP)

LIUKIS, Maria[1*], SCHORLEMMER, Danijel[1], John Yu[1], Philip Maechling[1], Jeremy Zechar[2], Thomas H. Jordan[1]

[1]Southern California Earthquake Center/University of Southern California, [2]Swiss Seismological Service, ETH Zurich

The Southern California Earthquake Center (SCEC) began development of the Collaboratory for the Study of Earthquake Predictability (CSEP) in January 2006 with funding provided by the W. M. Keck Foundation. Since that time, scientists and software engineers have developed the CSEP software for earthquake forecast testing. This development was guided by four design goals as proposed by the Regional Earthquake Likelihood Models (RELM) working group: controlled environment, transparency, comparability, and reproducibility. The W. M. Keck Foundation Testing Center at SCEC, designed to conduct computational earthquake forecast experiments in California, began operations on September 1, 2007 and has been improved, optimized, and extended over the past five years. As of February 2012, there are several testing centers established around the globe, with more than 200 forecasts being evaluated. We describe how the CSEP Testing Center software has been constructed to meet the design goals for rigorous testing and its current and future developments. We also present the ongoing forecast experiments and their results.

Keywords: earthquake predictability, Collaboratory for the Study of Earthquake Predictability, CSEP, global testing

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-08 Room:104 Time:May 25 11:00-11:15

Overview of the CSEP-Japan: The Japanese node of the collaboratory for the study of earthquake predictability

TSURUOKA, Hiroshi[1*], NANJO, Kazuyoshi[1], YOKOI, Sayoko[1], HIRATA, Naoshi[1]

[1]ERI, Univ. Tokyo

Collaboratory for the Study of Earthquake Predictability (CSEP) is a global project of earthquake predictability research. The primary purposes of the CSEP is to develop a virtual, distributed laboratory ? a collaborator ? that can support a wide range of scientifically objective and transparent prediction experiments in multiple natural laboratories. The final goal of this project is to investigate, through experiments, the intrinsic predictability of earthquake rupture mechanisms. The experiments have to be fully specified and conducted in controlled environments, called testing centers.

One major focus of the Japanese earthquake prediction research plan 2009-2013 is testable earthquake forecast models. So, the Earthquake Research Institute joined the CSEP and installed in an international collaboration a testing center as CSEP-Japan for rigorous evaluation of earthquake forecast models.

A total of 91 models were submitted from USA, Switzerland, Italy, New Zealand and Japan. And CSEP-Japan started the prospective experiments from 1 November 2009. The models are currently under test in 12 categories, with 3 testing regions (so-called All Japan, Mainland and Kanto) and 4 testing classes of different time spans (1day, 3 month, 1 year and 3 years). We evaluate the performance of the models in the official suite of tests defined by the CSEP (L, M, N, S, R, T and W tests) against authorized catalogue compiled by Japan Meteorological Agency of time delay of 6 months.

CSEP-Japan testing center has conducted 92, 7 and 3 rounds tests for 1 day, 3 month and 1-year testing classes, respectively. Yokoi et al. will report the test results in detail in this session. An outline of the experiments and activities of the CSEP-Japan are accessible on our Web site: http://wwweic.eri.u-tokyo.ac.jp/ZISINyosoku/wiki.en/wiki.cgi.

Keywords: Earthquake Predictability, test, Earthquake Model

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-09 Room:104 Time:May 25 11:15-11:30

CSEP-Japan: Report on prospective evaluation of earthquake forecasts in Japan

YOKOI, Sayoko[1*], NANJO, Kazuyoshi[1], TSURUOKA, Hiroshi[1], HIRATA, Naoshi[1]

[1]ERI, Univ Tokyo

Collaboratory for the Study of Earthquake Predictability (CSEP) is a global project of earthquake predictability research. The final goal of this project is to look for the intrinsic predictability of the earthquake rupture process through forecast testing experiments. The Earthquake Research Institute, the University of Tokyo joined the CSEP and started the Japanese testing center called as CSEP-Japan. This testing center constitutes an open access to researchers contributing earthquake forecast models for applied to Japan. A total of 105 earthquake forecast models were submitted on the prospective experiment starting from 1 November 2009. The models are separated into 4 testing classes (1 day, 3 months, 1 year and 3 years) and 3 testing regions covering an area of Japan including sea area, Japanese mainland and Kanto district. We evaluate the performance of the models in the official suite of tests defined by the CSEP.

The experiments of 1-day, 3-month and 1-year forecasting classes were implemented for 92, 7 and 4 rounds, respectively. The results of the respective classes are summarized as follows. Before the 2011 Tohoku off earthquake, on the 1-day testing class, all models passed all the CSEP's evaluation tests at more than 90% rounds. The results of the 3-month and 1-year classes gave us new knowledge concerning statistical forecasting models. All models showed a good performance for magnitude forecasting. On the other hand, observation is hardly consistent in space-distribution with most models in some cases where many earthquakes occurred at the same spot.

In this presentation, we will discuss the results of the experiments, and discuss direction of our activity. See also Tsuruoka et al. who overview the CSEP-Japan in this meeting. An outline of the experiment and activities of the CSEP-Japan is published on our WEB site; http://wwweic.eri.u-tokyo.ac.jp/ZISINyosoku/wiki.en/wiki.cgi

Keywords: earthquake forecasting, statistical models, evaluation, CSEP

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-10 Room:104 Time:May 25 11:30-11:45

Proposal of correlation-based evaluation methods for earthquake forecasts

YAMASHINA, Ken'ichiro[1*], HIMENO, Tetsuto[2], TSURUOKA, Hiroshi[1]

[1]Earthquake Reserch Institute, University of Tokyo, [2]National Institute of Polar Research

Earthquake forecasting experiments are currently being conducted at CSEP regional centers. In these programs, many methods evaluating the performance of various forecasting models are based on the assumption that earthquakes will occur independently of each other. Therefore, the degree of correlation has been examined to confirm the validity of those methods.

Here, we consider the all-Japan area designated by the Japanese center of CSEP and earthquakes with a magnitude 4 or greater. The area consists of 20062 rectangular cells, each with a size of 0.1 by 0.1 degrees in latitude and longitude, and depths from the surface to 100km. The numbers of cells indicating a specific frequency of earthquakes in a year are then counted from 2001 to 2010. Differences from previous activities are also considered, because the expected activity in the next year will be considerably affected.

For example, among the cells in which only one earthquake occurred from 1965 through the previous year (i.e., 21561 cells for ten years), there were 498 cells with one event in the next year, 59 cells with two events, and 10 cells with three events. Considering that the average expectation of earthquakes for this data set was 0.03627, the expected number of cells will be 754, 14, and 0.17, if the process follows a Poisson distribution. This result suggests that evaluation tests essentially based on the Poisson distribution or the Poisson process are questionable.

The CSEP experiments examine both various forecasting models and various evaluation methods. The marked correlation between earthquakes makes it desirable to adopt and examine, if possible, methods that do not assume the Poisson process. A summation of squares of residuals between observed and forecasted numbers of events, or rather the logarithm of its inverse or root mean square, will be a simple measure for representing the distance from a perfect forecast.

In order to advance a probabilistic analysis, it is necessary to prove a reasonable correlation-based distribution function that replaces the Poisson distribution. For example, a function such as N(x)/N(x-1)=exp(-C/x^D) may be a candidate for this purpose. Here, N(x) is the number of cells in which events occur x times or more, C is a constant defined by C=-ln(N(1)/N(0)), and D is an additional parameter. Further studies will be valuable for a significant evaluation.

Keywords: earthquake forecast, CSEP, evaluation method, Poisson process, Poisson distribution, root mean square

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-11 Room:104 Time:May 25 11:45-12:00

The Testability of Estimates of Maximum Magnitude

SCHORLEMMER, Danijel[1*], Robert Clements[1], Alvaro Gonzalez[1], Gert Zoeller[2]

[1]GFZ German Research Centre for Geosciences, [2]University of Potsdam

Recent disasters caused by earthquakes of unexpectedly large magnitude (such as those of Tohoku and Christchurch) illustrate the need for reliable estimates of the maximum possible magnitude, M_{max}, at a given fault or in a particular zone. Such estimates are essential parameters in seismic hazard assessment, but their accuracy remains untested. In fact, the testability, or lack thereof, of M_{max} estimates, even over short periods, is still uncertain. In this study, we discuss the testability of long-term and short-term M_{max} estimates and the limitations that arise from testing such rare events. Of considerable importance is whether or not those limitations imply a lack of testability of a useful maximum magnitude estimate, and whether this should have any influence on current hazard assessment methodology.

Keywords: Earthquake forecasting, Testing and Evaluation, Earthquake hazard, Maximum magnitude

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-12 Room:104 Time:May 25 12:00-12:15

Temporal Clustering of Mega Subduction Earthquakes

Felipe Dimer de Oliveira[1*]

[1]Risk Frontiers Macquarie University

In this presentation we show that a statistical test is not guaranteed to determine whether a stochastic process is Poissonian when it is applied to a single data series of limited duration, as is the case with the global earthquake catalogue. In particular, we are interested to know whether these tests can determine if the earthquake clusters that appear in the historical record have ocurred by chance or not. We do this by providing a counter-example in the form of a stochastic process that is clustered by construction. We simulate the detection of Poissonian properties by generating many 110 years event catalogues which are clustered - this is comparable to the duration of the best available historical records. To each one of these series we apply a Kolmogorov-Smirnov test. We show that under certain circumstances this test is not capable of rejecting the hypothesis that inter-event times follows an exponential distribution, which is characteristic of a Poisson process - not when applied to a single trajectory. We show that longer time series are necessary to determine with greater certitude whether or not the global earthquake catalogue is Poissonian

Keywords: earthquakes, statistics, clustering, Poissonian processes

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-13 Room:104 Time:May 25 13:45-14:10

Possibility of the use of seismicity data for monitoring spatiotemporal slip variation on a plate interface

KATO, Naoyuki[1*], KATSUMATA, Kei[2]

[1]Earthquake Research Institute, University of Tokyo, [2]Institute of Seismology and Volcanology, Hokkaido University

During an interseismic period of large interplate earthquakes, stresses on and around the plate interface are expected to be varied by evolution of aseismic sliding. Numerical simulations on the basis of a rate- and state-dependent friction law indicate that aseismic sliding gradually propagates updip on the seismogenic plate interface due to stress concentration generated by deep continuous stable sliding. The characteristics of propagating aseismic sliding such as the amplitude and propagation speed depend on frictional properties (Kato and Seno, 2003). Since a large earthquake that breaks the entire seismogenic plate interface nucleates near the front of the aseismic sliding zone, monitoring of aseismic sliding may be useful for forecasting the earthquake. The propagating aseismic sliding increases shear stress ahead of the aseismic sliding zone and relaxes stress around the slipped zone. This stress variation may affect seismic activity. For example, the numerical simulations suggest that seismic quiescence precedes the occurrence of a large interplate earthquake a few months to a few years (Kato et al., 1997). Propagating aseismic sliding also influences crustal deformation, which can be monitored by geodetic observations such as Global Positioning System and strainmeters. However, the simulation results suggest that the amplitudes of abnormal crustal deformation are small except for that caused by possible preseismic sliding immediately before earthquake occurrence. In contrast, the amplitudes of stress changes may be larger than 0.01 MPa, which is thought to be large enough to affect seismic activity. The simulation results also suggest that seismic activity may be affected by episodic aseismic slip events, which may be useful for detecting aseismic slip events (Kato and Hirasawa, 1999). Using a homogeneous earthquake catalog, Katsumata (2011) found that seismic quiescence appeared for about five years before the 2003 Tokachi-oki earthquake (Mw=8.3), along the Kuril trench. He evaluated stress changes due to aseismic sliding on a deeper part of plate boundary to compare them with the focal mechanisms of earthquakes in the quiescent regions. This observation is consistent with the numerical simulation. We will report some other examples of changes in seismic activity, which may be caused by stress variation due to aseismic sliding. We emphasize the importance of homogeneous earthquake catalogs and focal mechanisms of affected earthquakes for detecting stress changes and comparison between observations and model predictions.

References

Kato, N., and T. Hirasawa (1999), Pure Appl. Geophys., 155, 425-442.
Kato, N., and T. Seno (2003), Earth Planet. Sci. Lett., 210, 53-63.
Kato, N., M. Ohtake, and T. Hirasawa (1997), Pure Appl. Geophys., 150, 249-267.
Katsumata, K. (2011), J. Geophys. Res., 116, B10307.

Keywords: earthquake cycle, seismic quiescence, friction, aseismic sliding

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-14 Room:104 Time:May 25 14:10-14:25

A forecast experiment of earthquake activity under Japanese Research Program for Prediction of Earthquakes

HIRATA, Naoshi[1*]

[1]Earthquake Research Institute, The University of Tokyo

The Japanese national earthquake prediction program started in 1962 with a blue print for the scope and direction of research to follow. Substantial time and efforts were subsequently devoted to the construction of new observation networks and the study on the earthquake generation mechanisms. An important result has been the recognition of the great difficulty in identifying creditable precursors due to a diversity of earthquake generation process. After the 1995 Kobe earthquake, a new age of near real time observations of Earth's crustal processes by dense arrays of seismic and the GPS (Global Positioning System) stations has arrived. The results of the real time monitoring may lead to a new approach in the earthquake prediction research, i.e., the quantitative forecasting of the crustal activities. The new national program, which inherits its essential observational network from all the previous programs, emphasizes the importance of modeling as well as monitoring for a sound scientific development of earthquake prediction research (Hirata, 2004). The current prediction research program is integrated with that of volcanic eruptions since 2009.

One major focus of the current Japanese earthquake prediction research program (2009-2013) is to move toward creating testable earthquake forecast models. For this purpose we started an experiment of forecasting earthquake activity in Japan under the framework of the Collaboratory for the Study of Earthquake Predictability (CSEP) through an international collaboration. We established the CSEP Testing Centre, an infrastructure to encourage researchers to develop testable models for Japan, and to conduct verifiable prospective tests of their model performance.

I will discuss the recent results and achievement of the current prediction research program, which has been seriously reviewed since the 2011 M9 Off-Tohoku earthquake. I will review results by statistical seismology, including CSEP activity, which should be correctly integrated with a physics-based forecasting model.

References

N. Hirata , Past, current and future of Japanese national program for earthquake prediction research, Earth Planets Space, 56, xliii?l, 2004

Keywords: Earthquake Prediction Research, Forecast experiment, CSEP

SSS01-15 Room:104 Time:May 25 14:25-14:40

Comprehensive and topical evaluations of earthquake forecasts in number, time, space and magnitude

OGATA, Yosihiko[1*], Kouichi Katsura[2], Giuseppe Falcone[3], NANJO, Kazuyoshi[4], ZHUANG, Jiancang[5]

[1]The Institute of Statistical Mathematics, [2]The Institute of Statistical Mathematics, [3]INGV, Italy, [4]Earthquake Research Institute, [5]The Institute of Statistical Mathematics

Among evaluation scores of prediction performance, the log-likelihood is the most natural and important. We will use this score naively to compare performances of probability forecasts. Estimation error of the log-likelihood value is given for the uncertainty of the score. Although the log-likelihood score evaluates a comprehensive power of forecasts, we further need to evaluate topical predictive powers of respective components of number of earthquakes; namely, occurrence time, space, magnitude. For these purpose, we will use conditional or marginal likelihood function based on the observed events. Such topical scores reveal strong and weak parts of a forecasting model, and suggest which components of the model should be improved. We will illustrate the use of these scores to evaluate probability forecasts for CSEP Japan experiments during the period 1 - 31 March 2011, in which the Tohoku-Oki earthquake of magnitude 9.0 is included.

Keywords: One-day probability forecast, log likelihood score, CSEP

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS01-P01 Room:Convention Hall Time:May 25 15:20-16:00

Seismic quiescence and natural time analysis

NAKATANI, Yuta[1*], UENO, Masahiro[1], Nakatani Masao[2], KAMOGAWA, Masashi[1]

[1]Dpt. of Phys., Tokyo Gakugei Univ., [2]Earthquake Research Institute, University of Tokyo

A critical point of seismicity may be evaluated by means of the natural time analysis (Varotsos et al., Sprinter, 2011). In the concept of natural time, the time proceeds when the event occurs. The time in some of phenomena proceeds consequently with obeying their internal time. In our interpretation of natural time analysis, "weighted time" plays a key role to find the critical point. The previous study of seismicity in the natural time analysis does not consider the spatial parameters in the weighted factor. When we consider the spatial parameters, we obtain the result that shows seismic quiescence.

Keywords: Seismicity, Quiescence, Natural time