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

SSS01-01 会場:104 時間:5 月 25 日 09:00-09:15

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

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

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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.

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

SSS01-02 会場:104 時間:5 月 25 日 09:15-09:30

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

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

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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.

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

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SSS01-03 会場:104 時間:5 月 25 日 09:30-09:45

短期クラスタリングの ETAS モデルに基づく長期地震予測
Long-term earthquake forecasts based on the ETAS model for short-term clustering

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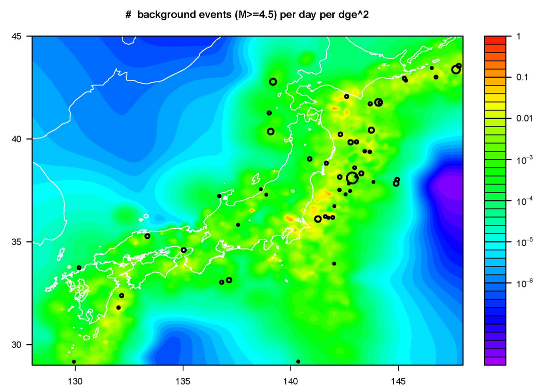
Based on the ETAS (epidemic-type aftershock sequence) model, which is used for describing the features of short term clustering of earthquake occurrence, this paper presents some theories and techniques related to evaluating the probability distribution of the maximum magnitude in a given space-time 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.

キーワード: ETAS モデル, 常時地震活動, 長期地震予測, 地震確率
Keywords: ETAS model, background seismicity, long term earthquake forecast, earthquake probability



SSS01-04 会場:104 時間:5 月 25 日 09:45-10:00

Inter-event Time Maps to Predict Earthquakes
Inter-event Time Maps to Predict Earthquakes

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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.

キーワード: Earthquake prediction, Inter-event times, Alarm function, Molchan error diagrams
Keywords: Earthquake prediction, Inter-event times, Alarm function, Molchan error diagrams

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SSS01-05 会場:104 時間:5 月 25 日 10:00-10:15

Predictability of the 2011 Tohoku M9.0 Earthquake
Predictability of the 2011 Tohoku M9.0 Earthquake

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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.

キーワード: 2011 Tohoku M9.0 earthquake, earthquake prediction, quiescence area, earthquake strip, foreshock
Keywords: 2011 Tohoku M9.0 earthquake, earthquake prediction, quiescence area, earthquake strip, foreshock

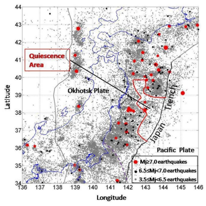

Fig.1 The Mj≥7.0 earthquake quiescence area in the interplate seismic zone between 1925 and 2002

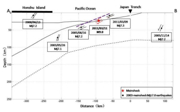

Fig.3 The depth profile of the earthquake strip perpendicular to the Japan Trench

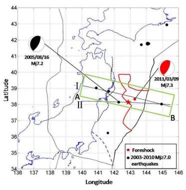

Fig.4 2011/03/09 Mj7.3 foreshock

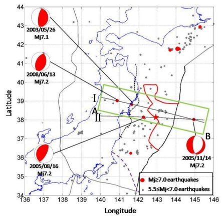

Fig.2 The Mj≥7.0 intraplate earthquake strip perpendicular to the Japan Trench between 2003 and 2010

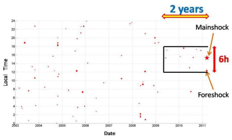

Fig.5 Closeness in local time of Mj≥5.6 generalized foreshocks two years before the foreshock

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地震検知率の日変化が completeness magnitude に与える影響
The influence of the daily variation of the detection capability on the completeness magnitude

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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.

キーワード: completeness magnitude, 地震カタログ, ベイズ統計, 統計地震学
Keywords: completeness magnitude, earthquake catalogue, Bayesian statistics, statistical seismology

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

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

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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.

キーワード: earthquake predictability, Collaboratory for the Study of Earthquake Predictability, CSEP, global testing
Keywords: earthquake predictability, Collaboratory for the Study of Earthquake Predictability, CSEP, global testing

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SSS01-08 会場:104 時間:5 月 25 日 11:00-11:15

日本における地震発生予測検証実験概要
Overview of the CSEP-Japan: The Japanese node of the collaboratory for the study of earthquake predictability

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

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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.

キーワード: 地震発生予測, 検証, 地震活動モデル
Keywords: Earthquake Predictability, test, Earthquake Model

SSS01-09　会場:104　時間:5 月 25 日 11:15-11:30

地震発生予測検証実験の現状
CSEP-Japan: Report on prospective evaluation of earthquake forecasts in Japan

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

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国際的な研究計画 CSEP （Collaboratory for the Study of Earthquake Predictability）と関連した、第 1 回地震発生予測検証実験が 2009 年 11 月に開始された。これは、単に地震活動に基づく地震発生予測の実施だけでなく、客観的で統計学的に厳密な手法を用いた予測結果の評価を目指している。実際に評価を行うのは、東京大学地震研究所内に設けられた予測実験検証センターであり、世界中の研究者から地震発生予測モデルがエントリーされている。予測領域は、海域を含む日本、陸域のみの日本、海域を含む関東である。

2012 年 2 月現在での実験終了回数 (ラウンド) と地震発生予測期間はそれぞれ、1 日予測・92 ラウンド、3ヶ月予測・7 ラウンド、1 年予測・4 ラウンドである。実験の結果を要約すると以下のようになる。2011 年東北地方太平洋沖地震より前の 1 日予測については参加している全てのモデルが 90%以上のラウンドの検証をクリアした。3ヶ月予測と 1 年予測では、規模は予測率が高く、場所は予測率が低い、関東地域は、海域を含む日本より予測率が高い、ほとんどのモデルが地震数を多く見積もるなどの傾向がみられた。

本発表では、実際に得られた結果と考察を中心に議論する。CSEP の実験概要については、鶴岡らが発表を行う。日本での CSEP の活動の詳細は、http://wwweic.eri.u-tokyo.ac.jp/ZISINyosoku/wiki.en/wiki.cgi　を参照されたい。

キーワード: 地震発生予測, テストセンター, 事前予測, 統計モデル, 検証実験
Keywords: earthquake forecasting, statistical models, evaluation, CSEP

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地震間の相関を考慮した地震活動予測の評価手法について
Proposal of correlation-based evaluation methods for earthquake forecasts

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地震活動を事前に予測し，その予測手法がどのくらい有効であったかを検証しようという試みが進められている（CSEP 地震活動予測検証実験）．このとき，各予測モデルを評価する方法のほとんどは，発生する地震の間に相関が無く，互いに独立な事象であることを前提にしている．そこで，どのくらい相関を考える必要があるか，あるいは無視しても差し支えない程度か，実際のデータセットで確かめることにした．

例えば，CSEP の予測テストで設定されている日本全域の領域を取り上げる．領域を 0.1 °四方の 20062 区画（深さ 100km 以浅）に細分し，それぞれの区画で１年間に何回地震が起きたかを数える．こうして，１年間に１回だけ地震が起きた区画，２回，３回，…，ｘ回起きた区画をそれぞれ明らかにする．これを，2001 年から 2010 年まで 10 年分について積算した．ただし，ここではマグニチュード４以上の地震に注目し，マグニチュードの違いについては考慮しない．このとき，常時活発な場所とめったに起きない場所では，次の１年に期待される地震の発生数にかなりの違いが生じるであろう．そこで，前年まで１回も地震が起きていない区画，前年までに１回だけ地震が起きている区画，…，をそれぞれ区別して数えることにした．

1965 年から前年までの間に１回だけ地震が起きたことのある区画（10 年分の合計 21561）を例として取り上げると，次の１年に１回地震が起きた区画は 498，２回，３回起きた区画はそれぞれ 59 回と 10 回であった．このデータセットの平均的な地震発生数の期待値は 0.03627 であるが，これに対応するポアソン分布は，１，２，３回の順に 754，14，0.17 区画になり，地震発生が独立な事象であると仮定したとき，実際の分布とはかけ離れていることがわかる．このような実態を無視して，ポアソン分布，あるいはポアソン過程を前提にして予測モデルの予測結果を検証するとしたら，その判断はあまり意味のないものになってしまうかもしれない．

CSEP の予測検証実験は，いろいろな予測モデルの有効性を比較検証すると同時に，いろいろな検証方法そのものの有効性を比較検討する場にもなっている．上記のような問題点を考慮すると，ポアソン分布やポアソン過程を仮定しない検証方法を積極的に採用して検討に加えることが望まれる．例えば,「発生した地震の数－予測した数」の自乗和，あるいは実用上はその逆数の対数や二乗平均平方根は，理想的な予測からの距離の近さを示す素朴な指標として，有用ではないかと思われる．

一方，確率的な議論を進展させるには，ポアソン分布に代わる，もっと実態を反映する分布関数を明らかにする必要がある．例えば，Ｎ(ｘ)／Ｎ(ｘ-1)＝exp(－Ｃ／ｘ^Ｄ)という関数を与えると，実際の分布をある程度表すことがわかった．ここで，Ｎ(ｘ)はｘ回以上の地震が起きた区画の数，ＣとＤは定数で，Ｃ＝－ln(Ｎ(1)／Ｎ(0))の関係がある．有意義な検証のために，このような検討がさらに進むことが望まれる．

キーワード: 地震活動予測, CSEP, 評価手法, ポアソン過程, ポアソン分布, 二乗平均平方根
Keywords: earthquake forecast, CSEP, evaluation method, Poisson process, Poisson distribution, root mean square

SSS01-11 会場:104 時間:5 月 25 日 11:45-12:00

The Testability of Estimates of Maximum Magnitude
The Testability of Estimates of Maximum Magnitude

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

キーワード: Earthquake forecasting, Testing and Evaluation, Earthquake hazard, Maximum magnitude
Keywords: Earthquake forecasting, Testing and Evaluation, Earthquake hazard, Maximum magnitude

Japan Geoscience Union Meeting 2012
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SSS01-12 会場:104 時間:5 月 25 日 12:00-12:15

Temporal Clustering of Mega Subduction Earthquakes
Temporal Clustering of Mega Subduction Earthquakes

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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

キーワード: earthquakes, statistics, clustering, Poissonian processes
Keywords: earthquakes, statistics, clustering, Poissonian processes

SSS01-13 会場:104 時間:5 月 25 日 13:45-14:10

地震活動変化に基づくプレート境界すべり過程モニタリングの可能性
Possibility of the use of seismicity data for monitoring spatiotemporal slip variation on a plate interface

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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.

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キーワード: 地震サイクル, 地震活動静穏化, 摩擦, 非地震性すべり
Keywords: earthquake cycle, seismic quiescence, friction, aseismic sliding

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SSS01-14 会場:104 時間:5 月 25 日 14:10-14:25

地震及び火山噴火予知のための観測研究計画における地震活動予測実験
A forecast experiment of earthquake activity under Japanese Research Program for Prediction of Earthquakes

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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

キーワード: 地震予知研究, 予測実験, CSEP
Keywords: Earthquake Prediction Research, Forecast experiment, CSEP

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

SSS01-15 会場:104 時間:5 月 25 日 14:25-14:40

地震の確率予測における頻度・時間・空間・マグニチュードの総合及び各因子の評価
Comprehensive and topical evaluations of earthquake forecasts in number, time, space and magnitude

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予測性能の評価スコアのうち対数尤度が最も自然で重要である。我々は、確率予測の性能を比較するために、予測の総合力を対数尤度スコアで推定誤差つきで評価するが、さらに地震の頻度、発生時間、空間、大きさの局所予測力を評価する。このために、観測された地震に基づいて、条件付や周辺尤度関数を使用する。これらの各スコアは、提案された予測モデルの中の優れた部分と弱点を明らかにし、どの成分を改善すべきかを示唆する。 マグニチュード 9.0 の東北沖地震が含まれている 2011 年 3 月の期間において、CSEP の確率予測を評価実験に対する提言として、これらのスコアを適用し、その結果の意味するところを議論する。

キーワード: 日別確率予測, 対数尤度スコア, CSEP
Keywords: One-day probability forecast, log likelihood score, CSEP

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SSS01-P01 会場:コンベンションホール 時間:5 月 25 日 15:20-16:00

Seismic quiescence and natural time analysis
Seismic quiescence and natural time analysis

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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