Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SSS25-01 Room:312 Time:May 2 14:15-14:30

Foreshock activity of the large-scale interplate earthquakes around Japan

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According to Bouchon et al. (Nature Geosci, 2013), they reported that the number of foreshocks increased towards the mainshock in the interplate earthquakes around North America and Japan. But, the foreshocks were much less frequent in the intraplate earthquakes. We investigate whether such a clear difference is really found between the interplate earthquakes and the intraplate earthquakes around Japan.

Keywords: Foreshocks, Interplate earthquakes, Accelerating seismicity

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Development of Acoustic Frequency Comb technology by ACROSS appropriate for active monitoring of the earthquake field

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Acoustic Frequency Comb technology by utilizing ACROSS (Accurately Controlled Routinely Operated Signal System) has been developed since 1994 at Nagoya Univ. and Earthquake Research Institute at Univ. of Tokyo for the active monitoring method of the subsurface structures. It is now being operated routinely in several locations in Gifu, Aichi, Shizuoka, Hyogo and Kagoshima prefectures.

A group of earthquake seismologists wrote in a book"Science of Earthquake Prediction"(UT Press, 2007) as follows: Whereas ACROSS is an indispensable element for earthquake prediction works, there are problems in stability of the instrumentations, methods of data analysis, etc. To resolve the problems raised by them, our own research works are demanded rather than to complain or to criticize.

1..In the current ACROSS transmitters, single force vector F as frequency-modulated signal is generated by centrifugal force by rotation of a rather small mass M ($\sim$ 100 kg) with a displacement amplitude u as constrained by equation of motion;

$F = M\, d^2u/dt^2 = -\omega^2 (Mu)$

The centrifugal force thus generated is transmitted towards the Earth's interiors through a transmitting antenna named 'ground coupler', which is a steel-reinforced concrete block of several meters in size and $\sim$ 100 tons in weight. As specified by the formula above, transmitted force amplitude is proportional to frequency squared, so that signal transmission is difficult in the useful low frequency range. The previous transmitters designed are practically limited for the use above 5Hz. To extend the frequency to the lower span, we propose the use of a linear motion of larger inertia mass M, 100 $\sim$ 100000 times larger the current transmitter to reduce the frequency by a factor of 10 $\sim$ 100. This could be simply realized by utilizing a large ground coupler as an inertia mass. Quantitative examination of this approach is found to be promising, and we have started the works on the technical realization of this observation system.

2. Low frequency acoustic signal below 1 Hz is useful for the stationary monitoring system covering everything in the whole Japanese Islands, once we build a transmitter array consisting of several tens transmitting statins, since the signal is easily detected up to 100 km distance without any environmental pollution. Local dense array of the signal sensors would provide us with the accurate data set on the swarm of local eigen-modes within the frequency range of the transmitted signals. This approach is the frequency comb interferometry much potential than the seismic daylight interferometry commonly applied nowadays. To make the structural inversion of the data by frequency comb interferometry, we have developed a new forward method named PANW, in which wave equation as a differential equation is converted to arithmetic equation in frequency and wavenumber domain on the basis of the theory of generalized functions.

3. The combined use of observation data by frequency comb ACROSS transmitter array and the data analysis method of frequency comb interferometry by PANW theory is expected to provide us with a potential tool for the practical active monitoring methodology. The contemporary application most relevant is the safety evaluation of artificial constructions such as buildings, tunnels and so on in contact with their subsurface structures.

The prediction and/or control of the earthquakes and volcanic activities will come to be our sound research target after the accumulation of data, our experiences on the 'evolving structural sensitivity' of the materials and its detailed nature at the target zone. Additional essential factor is the associated experimental and theoretical studies on the structural sensitivity of polycrystalline materials containing hydroxyl ions under stress.

We note that the developmental works of this method have been continued for a long period of time by collaboration of so many research workers of a variety of disciplines.

Keywords: Acoustic Frequency Comb, ACROSS, Structure Estimation

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SSS25-03 Room:312 Time:May 2 14:45-15:00

Earthquakes are directed to diversity: An arithmetic seismic activity model

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Seismic activity is diverse. If we use the methodology in which an earthquake generation process is decomposed into individual fundamental processes and they are integrated by assembling a detailed physical model in each process, initial conditions and boundary conditions to be determined become an enormous amount.Therefore, it is difficult to describe the earthquake generation process by finding the solution of one deterministic equation system. In the prediction of seismic activity that has been attempted in recent years, stochastic or statistical techniques have been used. In approaches of stochastic processes theory, characteristics of seismic activities are modeled as probability distributions which are estimated theoretically or empirically. One of the sample path of a stochastic process that is modeled corresponds to the value to be observed. Such an approach is effective to represent the statistical properties of the entire seismic activity, but it cannot be applied to analyze a depth nature of the individual sample path. In this study, we mathematically construct a specific sample path corresponding to the observed value. By showing that they satisfy the statistical nature of seismic activity, we propose seismic activity model based on the idea that different from the stochastic processes approach. A model is proposed for seismic activity due to ”number”.

We consider a correspondence between earthquakes and prime numbers. We parameterize occurrence time of earthquakes as the prime numbers and magnitude of earthquakes as the interval of prime numbers. Then we obtain a relationship similar to Gutenberg-Richter law. We call the model obtained by this correspondence as ”arithmetic seismic activity model”. In the ” arithmetic seismic activity model”, earthquake is equivalent to prime number of prime numbers distribution theory. Earthquake prediction is something equivalent to prediction of emergence of prime numbers. Earthquake is captured as a phenomenon that corresponds to changes in the energy level of the field. Using certain quantum system, we consider to model a field of earthquake occurrence. Considering the Hamiltonian of the field of earthquake occurrence, we set earthquake occurrence as an eigenvalue problem for the Hamiltonian. If we can show that the eigenvalue problem is associated with the zeta function, we can expect to explain the similarity between the distribution of the prime and seismic activity. At present, dynamical system can explain seismic field based on this concept is not known. On the other hand, trying to capture the zero distribution of the zeta function of Riemann in the relationship equivalent to the prime number distribution as an eigenvalue problem of the quantum dynamical system, research on the distribution of prime numbers is progressing. Distribution of prime numbers is related to limits of diversity of ”number”. Distribution of prime numbers is likely to be associated with critical phenomena. Earthquake can be interpreted as an critical phenomena. For this reason, it is considered that there is a similarity between the prime numbers and earthquakes.

Keywords: Number theory, Prime number, Gutenberg-Richter relation, Earthquake

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SSS25-04 Room:312 Time:May 2 15:00-15:15

Comments on a Bayesian approach to earthquake probabilities of the Poisson model

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In making national seismic hazard maps for Japan, earthquake probabilities are estimated based on past seismicity with the Brownian passage time model and the Poisson process model. With a small number of past earthquakes, unreliable model parameters produce large uncertainties of estimated values. In the present paper, we discuss a Bayesian approach to the problem for the Poisson model. When n earthquakes were observed in period T_0, a Bayesian approach gives the probability that m earthquakes are observed in period T_1 in the form of a binomial distribution. We compared Bayesian probabilities with those obtained by the maximum likelihood estimate (MLE) for n less than 5 and found the following significant differences between them. 1) When T_1 is the average interval of the past earthquakes, Bayesian probabilities of at least one earthquake increase 3 to 12% over those of MLE. 2) For a somewhat smaller T_1 than that in 1), the differences become larger. The Bayesian approach presented here could be tested by a simulation study.

Keywords: Earthquake probability, Poisson model, Bayesian statistics, Seismic hazard maps for Japan, Kanto

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SSS25-05 Room:312 Time:May 2 15:15-15:30

Long-term probability for large earthquake along the Nankai trough estimated from an incomplete catalog

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The Earthquake Research Committee of Japan published a report (the second edition) on the long-term evaluation for great recurrent earthquake along the Nankai trough in May, 2013 and newly forecasted the probability for such event in coming 30 years to be 60 - 70%. The giant earthquake may be possible, and the report was socially paid attention to very much. In the calculation of probability the BPT, Brownian Passage Time, distribution model is used in which the distribution parameters estimated with the maximum likelihood method or the time predictable model are plug in directly to the formula of conditional probability. Those are estimated from a few data, but not considered about the bias and uncertainty in them.

The committee explained that an earthquake, the Keicho event (1605) may not occur along the Nankai trough and some qualifying earthquakes are probably missed from the current catalog. In this presentation I will introduce a Bayesian new method with non-informative prior distribution to the parameters in a lognormal distribution for calculating the probability for the coming event from an incomplete catalog, and show the result of about 23 % for the event in the forthcoming 30 years along the Nankai trough

Keywords: Nankai trough, recurrent earthquake, forecast, Bayesian approach, incompleteness of catalog

Japan Geoscience Union Meeting 2014
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SSS25-06 Room:312 Time:May 2 15:30-15:45

Space- temporal stability of the seismic quiescence (4) -Relation of seismic quiescence area and the main shock

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We have been continuing investigation of seismic quiescence phenomena for the purpose of application to earthquake prediction. As a result of re-investigation of the cases for the earthquakes of M7 class in Japan, we found that the distance between the hypocenter of the main shock and the center of seismic quiescence area becomes large with the earthquake magnitude to occur in the detected cases. Based on this scaling law, detectable cases could be newly found in the non-detected ones in the previous investigation.

We applied the method of 'eMAP' which was developed by Aketagawa and Ito (2008) and Hayashimoto and Aketagawa (2010) for detection of the seismic quiescence. For the study we picked up 26 earthquakes that occurred from 1987 to 2011 with the magnitude larger than or equal to 6.7 and the intensity larger than or equal to five in Japan. There were 11 detected cases and 15 non-detected cases in the past investigation (Ota et al.(2009) and Yoshikawa (2012)). In the case of the 1995 Kobe earthquake, where seismic quiescence could not be detected by 'eMAP' in the past investigation, a clear seismic quiescence has been reported by the DPRI of Kyoto University (1995) and the Japan Meteorological Agency (1995). As a result of re-investigation of this case, it became possible to treat it as a detectable case if the following things were considered. Though we have considered as the necessary condition for the precursor that the phenomenon appears in and around the focal area before occurrence of the main shock, we could not recognize as a phenomenon to be connected directly with the main shock because a seismic quiescence appeared in Tamba region approximately 30km distant from the epicenter near the Akashi Channel. And any remarkable quiescence was not detected in the epicenter, since the average seismic activity before the earthquake was too low. It is necessary to make clear the condition to treat the quiescence as a precursor. Then as we re-examined the detected cases, we found that the distance between the epicenter of the main shock and the center of the quiescence area became large with the magnitude of the earthquake to occur. We have reported that there are scaling laws in the size of the quiescence area and the duration of quiescence against the magnitude (Yoshikawa et al., 2013). As the quiescence is supposed to occur in the stress reduction area caused by aseismic slip, the main shock should occur in the periphery of the quiescence area and it is quite natural that the distance between the epicenter and the center of the quiescent area becomes larger obeying the scaling law.

We re-examined other non-detection cases and found that the precursory seismic quiescence can be detected also in the 1987 eastern off Chiba earthquake, the 1994 far-off Sanriku earthquake, the 2000 western Tottori earthquake, and the 2004 south-east off Kii peninsula earthquakes. As a result of this, 16 cases can be considered as detected and 10 cases as not- detected for 26 cases in total.

Keywords: earthquake, quiescence, hypocenter

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Recent anomalous groundwater temperature and water level changes and impending great earthquakes at the Nankai trough

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Earthquakes are generated by the anisotropic principal stress regime in the rock medium. In the preparing process of a large earthquake, the medium would be deformed generating regions of contraction and dilatation around the nucleus of the shearing stresses. According to a hydraulic model, pore fluid flow is driven upward to the ground surface through crack systems serving as flowing pipes by high pressure pumps at a deep spot. The change in the quantity of the upwelling hot water from deep underground causes a change of groundwater temperature(Tsukuda et al., 2005).

We have groundwater observation stations for temperature at 12 sites, and for water level at two in the Tokai and Nanki regions, central and southwest Japan, respectively, where are close to the so-called Tokai and Nakai earthquakes. High precision quartz thermometers are installed at Otomi (OT) in Yaizu City and Nakajima (NK) in Shizuoka City. At other stations, platinum resistance thermometers are installed. We use semiconductor pressure sensors for water level. At OT(Yaizu) in the Tokai region, the temperature has been monotonously increasing since the measurement started in 2003. The rate of increase has clearly fallen down since the end of 2012, suggesting weekning of the contraction in the rock medium. At NK(Shizuoka), 14km northeast of OT, the temperature data presented a precursory change from increasing to decreasing trend, one year before the 2009 Suruga-bay earthquake of M6.5 (Tsukuda, 2012). The decreasing rate after the earthquake became much higher than before and had continued till 2012. The temperature changed suddenly into increasing trend since May, 2013. The dilatation of the rock medium under Shizuoka recently changed into contraction. At stations HA and WA in Shionomisaki, Nanki region, Wakayama Prefecture. The long-term trend of the water level is rising, corresponding to the ground subsidence found by levelling and GNSS data (Kobayashi, 2013). The trend of temperature is similarly rising, suggesting contraction of the rock medium under Shionomisaki, the southernmost end of Honshu. At KZ(Kozagawa) in the Nanki region, the temperature is monotonously falling since the observation started in 2002. The decreasing rate is growing during recent two years, suggesting the dilatation turned to be intensified recently.

As mentioned above, the deformations of the rock medium are accelerated under the regions close to the source regions of the great erthquakes at the Nankai trough. For prediction studies for the impending great erthquakes, we should start to conduct detailed and multidisciplinary observations.

Keywords: dailatation, contraction, groundwater temperature, water level, precursor, earthquake prediction

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Two questions related to short- and long-term prediction of the so-called Tokai earthquake

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In the 1970s there was widespread discussion suggesting that a large subduction zone earthquake was imminent in the Tokai district (the so-called ”Tokai earthquake”), but the ”Tokai earthquake hypothesis” was not stated in a testable form. About 40 years have passed, but no such event has occurred in Tokai. Under those circumstances it seems justifiable to conclude that the hypothesis has been falsified. That does not mean that Tokai is not at risk, just that the risk is not greater than other tectonically similar regions.

Under the Large Scale Earthquake Countermeasures Act (LECA), which was enacted in 1978, an organization for monitoring possible ”precursors” and issuing short-term alarms was established. But no reliable precursors have ever been found. LECA should therefore be repealed and the monitoring organization abolished.

Reference:
Geller, R.J., 1997, Earthquake prediction: a critical review, GJI, 131, 425-450.

Keywords: earthquake prediction, Tokai earthquake

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On the sea level changes before the 1946 Nankai earthquake on the Pacific coast of Shikoku, Japan

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1. Introduction

The abnormal sea level changes before the 1946 Nankai earthquake (M8.0) were witnessed by the inhabitants, on the Pacific coast of Shikoku, Japan. From a few days before the main shock, irregular tides were witnessed. The fishing boats could not arrive at the ports, because of the low sea level. On the contrary, some boats could arrive at ports. We considered that the abnormal sea level changes were caused by the small tsunamis from a few days before the main shock. The period and amplitude of the small tsunamis seem to have been larger and shorter closer to main shock.

2. Period and amplitude of the sea level changes

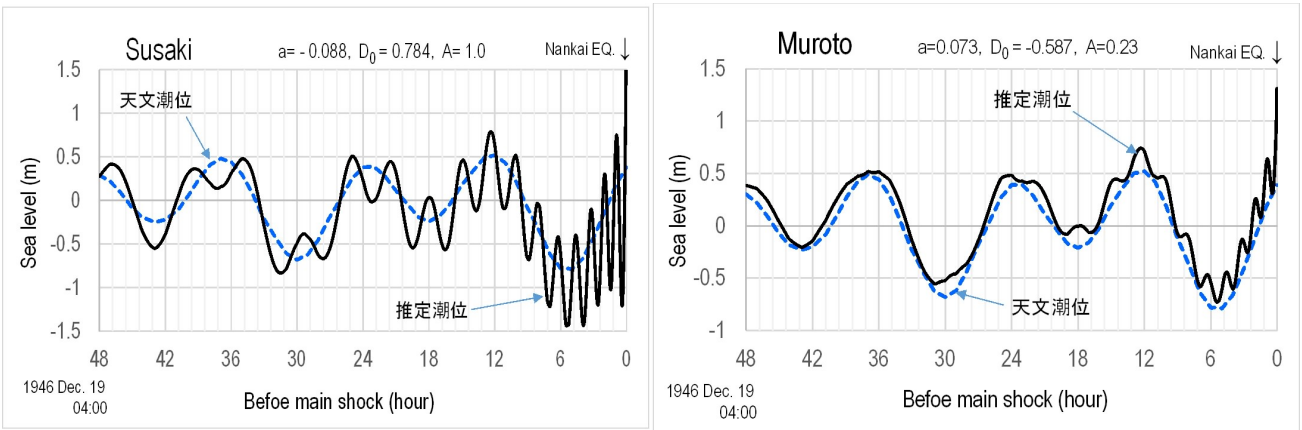
At seven points in the Susaki bay, the sea level changes were observed from

2010 to 2011. The height of tsunami by the 2011 off the Pacific coast Tohoku earthquake was amplified 20 and 8 times compared to that of the Nankai trough of 2300m depth (JAMSTEC) and 100m depth, respectively. The periods of 30-40, 50 and 80 minutes of sea level changes were observed in either case of tsunami, storm or mild weather. The periods of 50 and 80 minutes would be characteristic periods of Tosa bay. We considered that the small tsunamis were generated in the Tosa bay before the 1946 Nankai earthquake.

3. Assumed sea level changes

The assumed sea level changes(f(t)) before the main shock were obtained by the summation of the sea level changes by long term crustal movements(Fl(t)), small tsunami(F0(t)) with the period of 50-80 minutes and astronomical tide(Ft(t)). That is, f(t) = Fl(t) + F0(t) + Ft(t). Fl(t) = a • ln(t) + D0 was adopted by Umeda and Itaba(2013). In view of the summaries by the testimony for the abnormal sea level changes, F0(t) was assumed as F0(t)= A • B(t)m[cos{ωln(t-tc) +ϕ}]. ω and ϕ is frequency and phase angle, respectively. A is the amplitude ratio at each fishing port when the amplitude of Susaki bay is 1.0. Assumed sea level f(t) is shown by solid line in figure. f(t) of Susaki bay is expressed well the witness testimonies, but that of Muroto is not expressed them. f(t) of Muroto will be improved by considering the short -term and small-scale crustal deformations just before the main shock in the Muroto region.

Keywords: 1946 Nankai earthquake, sea level change, witness testimony,



1946年南海地震の前に小規模な津波が発生していたとして，各地で推定される海水位の変化（黒の実線）と比較のための天文潮位（青の点線）

Japan Geoscience Union Meeting 2014
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Mechanism of generating electric fields just before earthquakes

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[1]none

1. Precursory seismic electric fields

We consider that precursory seismic electric fields are generated by the mechanism as follows:(Refer to attached Figure):

(1) Before earthquakes, micro-cracks run in the source regions (Assumption), and into these cracks pore water pours.

(2) Uranium compounds, radium compounds and radon, which exist in crystal boundaries, dissolve into the pore water.

(3) The cracks connect the pore water and spring water, and the radio active materials appear on the surface of source regions.

(4) The radio active materials ionize the lower atmosphere above the source regions, and the electric conductivity increases there locally and temporarily.

(5) The ionization increases the current along the trace of cosmic shower between the surface and the ionosphere.

(6) As the current is pulsating, it radiates wide band radio-waves, which are observed as precursory seismic waves.

For the above mechanism the precursory micro-cracks are indispensable.

2. Mechanism generating the current between the surface and the ionosphere

The top of thunderclouds has the voltage up to about 100MV, so the electrons and negative ions flow into the clouds from the ionosphere. As a result, the ionosphere has a few MV. The mechanism, which increases the voltage at the cloud top, will be as follows:

(I) At middle latitudes, in the cloud lower than -10 deg. waterdrops become crystals, and they collide with each other. Then the water film on the smaller crystal, which is negatively charged, moves to the larger crystal, and makes the smaller crystal charged positive. The smaller crystals blow up to the cloud top and make it high voltage.(1)

(II) At low latitude, in the cloud no crystal will exist, but electric fields of about 1 kv/m exist, as other areas. So, waterdrops are polarized such as the top is negative and bottom is positive. When they collide, the negative part of smaller waterdrops, which have higher speed than the larger ones, neutralizes the positive charge of the larger waterdrops, and the smaller ones become positively charged and blow up to the cloud top, resulting the high voltage.

In the smoke billowing from volcanos, the lightning is observed. The tephra collide with each, other, and are charged by frictional electricity. By the same reason shown in (II), the charge is polarized and high voltage in the upper part of the cloud is generated. If this high voltage is observed, the explanation mentioned above will be considered to be valid.

References

(1) Kozo Takahashi: Mechanism of generating electromagnetic fields just before great earthquakes, Japan Geoscience Union Meeting 2011, S-SS024-13

(2) Kozo Takahashi: Mechanism of Generating The Earthquake Cloud just before Shallow Great Earthquakes, Japan Geoscience Union Meeting 2010, S-SS012-08

Keywords: precursory seismic electric fields, mechanism of generating thunder, thunder in middle-latitude, thunder in low-latitude, thunder in smoke of volcano