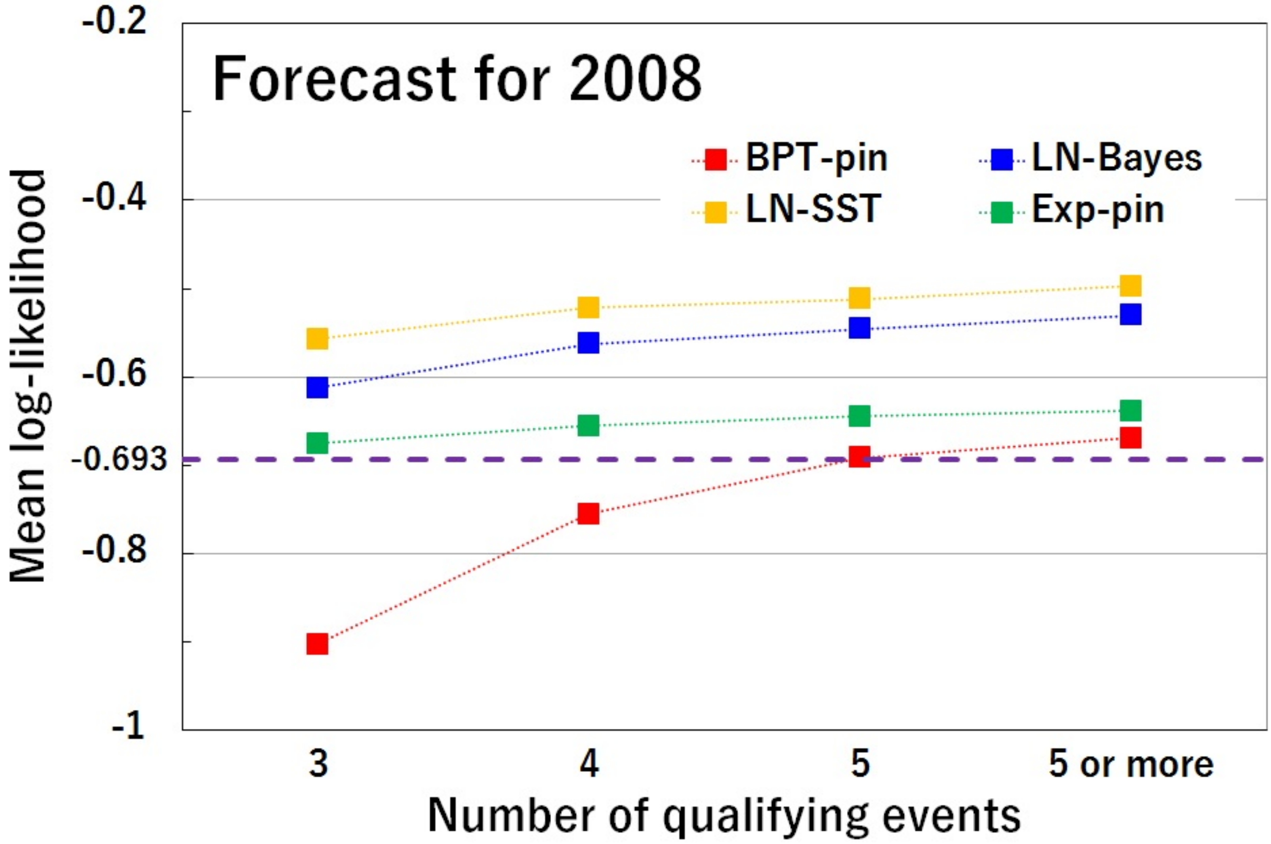
Long-term predictability for the repeating earthquake with a few times recurrence using the BPT model

*Masayuki Tanaka[1], Masami Okada[1]

1.Meteorological Research Institute

Event numbers of sequential recurrent large/medium earthquakes listed in seismic catalog are not so many, because they occur at long intervals. So, the probability of the next earthquakes must be calculated with a small number of data. We are studying the predictability by the BPT model using the 126 sequence of small interplate repeating earthquakes along the Japan Trench, which were used for the experiment of prospective forecast in 2008. Calculation was carried out with a small number of events. Events data was taken out in order of proximity from the last earthquake, by three, four, five and five or more.
We use BPT model to calculate the probabilities and three other models for comparison,
(1) BPT-pin: BPT distribution model. The parameters: the mean recurrence intervals, the average value of each series; the coefficient of variation, the median (α=0.367) of the values calculated in five events for each series.
(2) LN-Bayes: Lognormal distribution model with Bayesian approach. Probability distribution of recurrence interval is given with inverse gamma prior distribution. The parameters of inverse gamma are shape, φ=0.25 and scale, ζ=0.44.
(3) LN-SST: Lognormal distribution model base on the small sample theory.
(4) EXP-pin: Exponential distribution model. The parameter plugged is the sample mean.
The "Mean log-likelihood" mentioned below are used to score the forecast results.
Mean log-likelihood (MLL): Average of Ev*ln (P) + (1-Ev)* ln (1-P)
Here P means forecast probability for event and Ev means presence (Ev=1) or absence (Ev=0) of the event. If the Mean log-likelihood is larger than those of the alternative, the model is considered to be superior to the alternative one.
In Figure 1 the forecasts by four models become worse surely as the number of preceding events is smaller. The BPT-pin model is inferior to the other three of the statistical model. When the three qualifying events, the score is poor in the Exp-pin model, and it is below the results of the probability of 0.5 (MLL=-0.693).

Keywords: Repeating earthquakes, forecast, BPT model, Mean log-likelihood


Forecast for 2008
BPT-pin
LN-Bayes
LN-SST
Exp-pin
Mean log-likelihood
-0.2
-0.4
-0.6
-0.693
-0.8
-1
3
4
5
5 or more
Number of qualifying events

How often do the abnormal phenomena witnessed just before 1946 Nankai earthquake appear (1)

*Yasuhiro Umeda[1], Satoshi Itaba[1]

1.Advanced Industrial Science and Technology

Abnormal phenomena such as well water decreases or sea level changes has been witnessed just before the 1946 Nankai earthquake. In the Pacific Ocean coastal area of Shikoku from Kii peninsula, such phenomena have been witnessed in 24 locations. It has been witnessed that about 2m decrease of well water, maximum 3m lowering of sea level and about 0.5m of secondary undulation. It has been stable weather before the main shock. Do the witnessed abnormal phenomena has appeared only just before the main shock? Or do they occasionally appear? Based on the recent observation data, we examined the frequency with that the same phenomena as witnessed just before the main shock. The water level of three wells which have been reported the decreased water before the main shock have been observed continuously by AIST. In recent two years data, it was not found that the well water steeply decreases by more than 2m. We have searched the sea level departure at Kushimoto, Muroto cape and Kochi, on the JMA website. In 2003 - 2014, we could not find the sea level departure of more than -2m. The secondary undulations at Muroto cape were checked on the JMA website. In 2006-2014, there were 17 times of the secondary undulations more than 0.5m. All cases were caused by the weather. Within this survey, we could not find the similar abnormal phenomena which were witnessed just before the main shock.

Keywords: 1946 Nankai earthquake, witness

Empirical forecast of mainshocks based on foreshock activities - Applied to the specific three regions and inland area of Japan -

*Kenji Maeda[1], Fuyuki Hirose[1]

1.Meteorological Research Institute

1. Introduction

Generally it is quite difficult to distinguish foreshocks from background seismicity before a mainshock occurs. However, it is known that some activities like swarms tend to be followed by large earthquakes. We have investigated statistical features of swarm-like activity and searched for the best parameters to define foreshocks. So far, we have found that such defined foreshock activities are particularly effective for specific three regions in Japan: regions along the Japan trench, off the Izu peninsula region, and in the north-central Nagano prefecture, and proposed best parameters for each regions to define foreshocks. In this study we report the current status of prediction performance for three regions basing on the latest data. Besides, we also demonstrate the preliminary results of prediction performance for the inland area of Japan using the same parameters estimated for the north-central Nagano prefecture.

2. Method

The method to search for parameters for foreshocks that present high prediction performance consists of four steps. 1) To eliminate small aftershocks from the original data. 2) To define foreshock candidates satisfying the condition that earthquakes of count Nf with magnitude >= Mf_0 occur in the segment of the size of D x D degree (latitude x longitude) during the period of Tf days. 3) To set the alarm period of Ta days during which a mainshock is expected to occur after a foreshock candidate is found. 4) To search for the values of D, Mf_0, Tf, Nf and Ta which give high prediction performance for mainshocks with M >= Mm_0 by the grid search method. The prediction performance is measured mainly by dAIC that is defined as the difference of AIC for a stationary Poisson model and a model based on a foreshock activity, and additionally by alarm rate (AR: the fraction of mainshocks alarmed), truth rate (TR: the fraction of foreshock candidates followed by a mainshock), and probability gain (PG: the ratio of mainshock occurrence rate in the predicted space-time to background occurrence rate).

3. Data and Results

1) Along the Japan Trench

By applying the above method to the earthquakes with M >= 4.0 and depth <= 100 km in three regions along the Japan trench, i.e., off Iwate, off Miyagi and off Ibaraki, cataloged by JMA during the period from 1961 through 2010, we obtained the best parameters for foreshocks as D=0.5 degree, Mf_0 =5.0, Tf=10 day, Nf=3, and Ta=4 days to predict mainshocks with M>=6.0. The prediction performance for the latest period from 1961 to 1/31/2016 is expressed as AR=27% (=13/48) and TR=22% (=17/77).

2) Off the Izu Peninsula

Using earthquakes with M >= 3.0 and depth <= 50 km off the Izu peninsula regions during the period from 1977 to 6/31/2013, we obtained the best parameters for foreshocks as D=0.2 degree, Mf_0=3.0, Tf=3 day, Nf=3, and Ta=5 days to predict mainshocks with M>=5.0. The prediction performance from 1977 to 1/31/2016 using the above parameters is expressed as AR=68% (=44/65) and TR=22% (=43/195).

3) In the North-central Nagano Prefecture

Using earthquakes with M >= 2.0 and depth <= 30 km in the north-central Nagano prefecture during the period from 1998 through 2014, we obtained the best parameters for foreshocks as D=0.1 degree, Mf_0=2.0, Tf=1 day, Nf=5, and Ta=5 days to predict mainshocks with M>=5.0. The prediction performance from 1998 to 1/31/2016 using the above parameters is expressed as AR=45% (=5/11) and

TR=12% (=8/69).

4) Inland of Japan

As a preliminary calculation, we apply the parameters obtained for the north-central Nagano prefecture, i.e., D=0.1 degree, Mf_0=2.0, Tf=1 day, Nf=5, and Ta=5 days for mainshocks with M>=5.0, to the inland area of Japan except for Izu. The prediction performance obtained for the period from 1977 to 1/31/2016 is expressed as AR=11% (=9/79) and TR=1.8% (=11/607).

Keywords: earthquake prediction, performance, foreshocks, statistics, empirical relation, Japanese inland area

The Predicting earthquakes/estimation and the historical tsunami.

*Masaru Nishizawa[1]

1.none

1. The historical tsunami in the wilderness researcher has predict the 2011 TOHOKU Great Earthquake. At present it is difficult to make an accurate prediction on the occurrence of earthquake. But these historical tsunami is effective method to a rough prediction.
2. I believe that the electromagnetic wave is most effective method to an accurate prediction on the occurrence of earthquake.

Reference.
(1)YUUGI IINUMA: Historical Tsunami of Sendai Plain. 1995

Keywords: IINUMA YUUGI, Historical tsunami of Sendai plain, Predicting earthquakes, Petition, TOHOKU district great earthquake, Public office

Fig-1 宮城県沖二つの空白域

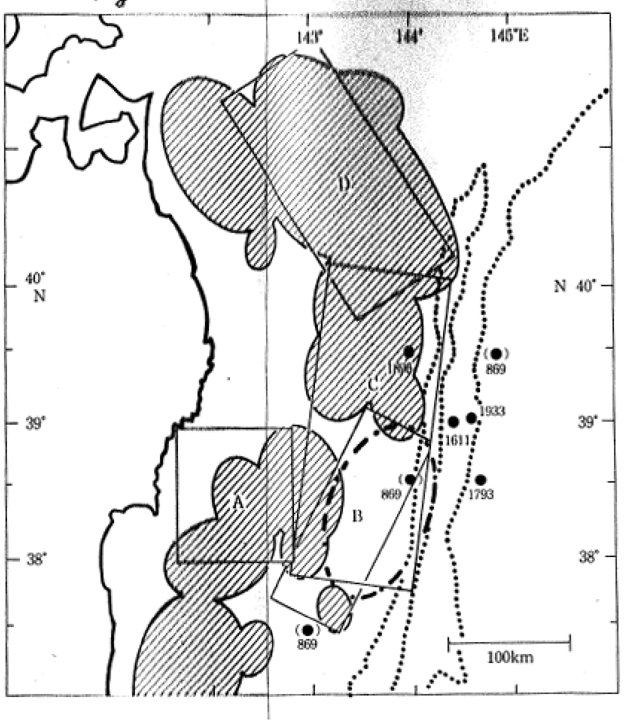
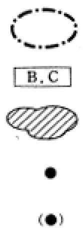


表2 仙台地方の巨大津波の発生海域の震央

巨大津波名	日本年号	西暦	震央	
			東経	北緯
(仮称) 仙台沿岸津波	?	700頃	?	?
貞観津波	貞観11年	869	143°～145°	37.5°～39.5°
慶長津波	慶長16年	1611	144.4°	39°
寛政津波	寛政 5年	1793	144.5°	38.5°
明治三陸津波	明治29年	1896	144°	39.5°
昭和三陸津波	昭和 8年	1933	144°.7°	39.1°



飯沼 勇義著「仙台平野の歴史津波」1995
YUUGI IINUMA P. 53, 54
「Historical Tunami of Sendai Plain」 1995. P53, 54

The To-Nankai E.q. is previous and the Nankai E.q. occurs after it or with it, Elucidation of that mechanism

*Hirofumi Mase[1]

1.none

I explained that the right-turn of slab under Kii Peninsula is the To-Nankai Earthquake, and that the big earthquake which neighbors on it isn't also a simple plate boundary earthquake(1)(2)(3). I studied details around the turn-center this time. That was the drive part of the first half of the Nankai Earthquake, and of the mechanism that that can't explode first than the To-Nankai. (Please refer to the Fig.)(I call the subducting plate or slave the Lower, and call the part upper than it the Upper.)

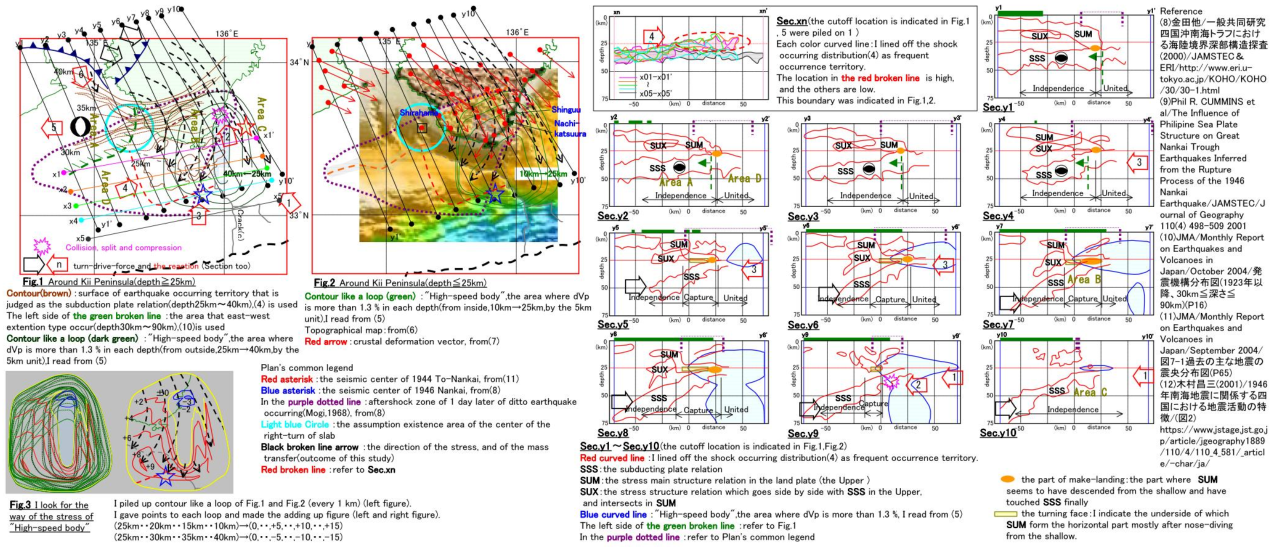
The power that the mantle which flows to the east relatively pushes the edge of the Lower directly and makes the Lower turn to the right is the turn-drive-force(1). The reactions of it occur widely, but symbolic 6 are representation of all(Fig.1). The west(Area A) from the turn axis(fulcrum) is east-west extension area certainly by the reaction. At the east(Area B) from the fulcrum, doing a nose-dive from the shallow place and after forming the almost horizontal part, shocks will approach the Lower and be the part of make-landing(Sec.y5-Sec.y8). The Lower crawling up with turning rubbs, involves and assimilates the Upper that is rotated in advance. The horizontal part of preparations (turning face) will be formed so. I indicated the turning face at yellow coloring territory and indicated the part of make-landing at gray coloring territory (an orange broken line, centerline) (Fig.2). At the more east(Area C) I can't check the part of make-landing(Sec.y9-Sec.y10). Because the turn in the Lower is moderate (radius large) here, I think the Upper isn't captured.

High-density "High-speed body" touches the peninsula and goes through the Upper and Lower(each Fig. referring)(5). That's a man-shaped who consists of head and body, and depth 40km is neck. There will be time when movement and pressure in Area B shaves or improve, conversely, the "High-speed body" in existence. I regard the neck(Fig.1,depth 40km blue coloring) as the core which stays while thinning. Because the Lower is divided into a inside turn(Area B) and a outside turn(Area C) by collision with the core, and the outside turn is making a wide turn(Fig.1, black broken line arrow), the Lower separate inevitably in east and west at the south from the core. I think the rub of two boards causes pressure and increases density like an rubbing face of a stone-hand-mill and I think the discoid head is formed by it. But the head isn't plane symmetry in depth 25km(Fig.1,2,loop contour). Material partiality to the south and west is seen more in the upper part of the head.

Red arrows of Fig.2 are the observational data(7) by which the inside turn and the outside turn are surely indicated. The To-Nankai Earthquake was a right turn in the large-scale area which has started in the red asterisk from crushing in the Lower(1)(Fig.1). This is the outside turn. The real inside turn that mostly depends on interference of the rubbing face of the stone-hand-mill requires facts that the Lower can turn and advance to a shallow part. In other words, pressing-force-reduction from the outside-turn-part and preceding-destruction in the shallow part are wished for. Is there something equivalent to this inside turn besides The Nankai Earthquake which has started from the blue asterisk 2 years later of the To-Nankai(8)(9)?

(1)MASE/JpGU2014/SSS29-P10(2)MASE/SSJ2014FALL/S08-P11(3)MASE/JpGU2015/SSS31-P15(4)AIST/Visualization system for subsurface structures/all-Japan hypocenter catalog by the JMA/1995-2015/above M1(5)AIST/same to(4)/tomography data by Abdelwahed and Zhao (2007)dVp (6)JHOD,JCG/Seafloor Topography of the Plate Boundaries (7)GSI Home Page/ GEODETIC SURVEY/Crustal Movement in Japan/Long-term Information/Horizontal2005/10-2015/10fixed stn.NAKAMURA (8)(9)indicated on the

drawing



Reference
(8)金田他/一般共同研究 四国沖南海トラフにおける海陸境界深部構造探査(2000)/JAMSTEC＆ERI/http://www.eri.u-tokyo.ac.jp/KOHO/KOHO/30/30-1.html
(9)Phil R. CUMMINS et al/The Influence of Philipine Sea Plate Structure on Great Nankai Trough Earthquakes Inferred from the Rupture Process of the 1946 Nankai Earthquake/JAMSTEC/Journal of Geography 110(4) 498-509 2001
(10)JMA/Monthly Report on Earthquakes and Volcanoes in Japan/October 2004/発震機構分布図(1923年以降、30km≦深さ≦90km)(P16)
(11)JMA/Monthly Report on Earthquakes and Volcanoes in Japan/September 2004/図7-1過去の主な地震の震央分布図(P65)
(12)木村昌三(2001)/1946年南海地震に関係する四国における地震活動の特徴/(図2) https://www.jstage.jst.go.jp/article/jgeography1889/110/4/110_4_581/_article/-char/ja/