Mega Earthquake Prediction in Asia using a Yearly Unit Cycle

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Abstract
The objective of this research is to develop earthquake prediction in Asia using the yearly unit cycle of past mega earthquakes for supporting clearly targeting preparedness against earthquake disaster. Hereinafter mega earthquake means large earthquakes causing human casualties. The method is based on newly developed multiple year interval analyses between combinations of past mega earthquakes in each region derived from historical records. In this paper the new method is named Yearly Unit Cycle (YUC) method. Four case studies shown in the paper include East Japan Area, Myanmar, Indian Region and Indonesia where seriously damaging mega earthquakes have occurred in the past. The results demonstrate, based on long-term prediction of yearly units, that the year of 2026 for East Japan Area, the year of 2022 for both Myanmar and Indian Region and the year of 2023 for Indonesia, are the most likely repeatable years for mega earthquakes with magnitudes similar to those occurred in the past. In order to validate the reliability of the YUC method, four successful examples are demonstrated.
Key Words:Yearly Unit Cycle, mega earthquake prediction, Asia

1.Introduction
Earthquake prediction is an extremely difficult task, some scientists consider that reliable earthquake prediction is impossible (Geller et al., 1997), while others consider that we should not stop earthquake prediction research though it is very difficult (Wyss et al., 1997). The Headquarters for Earthquake Research Promotion of the Japanese government has presented the 2020 version of seismic hazard map for the public, which includes color coded probability percentages indicating the risk of M7 class earthquake occurrence in the next 30 years (HERP). However, it is difficult to understand how to promote preparedness against upcoming mega earthquakes in the next 30 years from this hazard map. It would be unclear how to understand for example, 70% probability risk over the next 30 years in the Tokyo Metropolitan Area. The Asian nations expect to receive long-term predictions with clear targets on when the most serious earthquakes are likely to occur, regardless of the correctness. Moreover, another problem is that the Japanese committee has not shown how to compute the probability percentage based on scientific

rigor. No one can verify the hazard map with the corresponding probabilities for individual residential areas.

One of the largest worries for the Japanese nation are future occurrences of mega earthquakes together with Tsunami in the Tohoku, East Japan Area which caused an estimated about 22,000 casualties in 2011, if a similar mega earthquake occurs on cycles of several tens of years. Many people living in the East Japan Area would be anxious about their future, but not able to prepare specific emergency measures when the probability for the next 30 years is only 70 to 80%. In the same way, many Asian people are afraid that mega earthquakes such as the 2004 Sumatra M9.1 earthquake, together with the Tsunami that caused more than 300,000 casualties, may occur in the near future.

The paper in "Nature' by the American scientist Bakun and his colleagues predicted that a M6 class earthquake may occur ±5 years from 1988 with 90% probability, derived from the average cycle between the past earthquakes along San Andreas Faults in California, USA in 1857, 1881, 1901, 1922, 1934 and 1966 (Bakun et al., 2005). However, the prediction was not correct as the M6.0 earthquake occurred in 2004.

The authors of this paper have re-considered the existing earthquake probability analysis methods using the mean and standard deviation based on normal distribution of earthquake occurrences. As a result of this re-consideration, a new prediction method based on yearly unit cycle analysis with multiple combinations between past mega earthquakes has been developed and described in this paper.

2. Long-term Prediction Method Using a Yearly Unit Cycle Analysis

Step 1: Select past records of mega earthquakes from United States Geological Survey website (USGS). Let n be the number of the earthquakes selected.

Step 2: Prepare a matrix table with i line and j column (i=1, n; j=1, n). Let the years of mega earthquakes be Y(i) and Y(j).

Step 3: Calculate the multiple intervals T(i, j) between the years of mega earthquakes as follows.

$$T(i, j)=Y(i)-Y(i-j) \quad (i>j: i=1,n+1; j=1,n)$$

Step 4: The year for the next predicted mega earthquake is Y(n + 1).

Step 5: Apply a similar procedure as Step 3 and search the most likely risky year with maximum number of multiple yearly intervals.

Step 6: Check the same or multiple year intervals of more than 10 years at the Y(n+1) line and change the number to red color. Change the common periodical year number to blue color for years other than Y(n+1).

We set up the following two rules on which year to adopt in the yearly cycles.

1) The year of the first column which is the yearly interval between neighboring mega earthquakes should not be adopted, because the number will be so small in some cases which may cause some confusion. Another reason is to discriminate the YUC method from the existing statistical studies using yearly intervals of neighboring mega earthquakes.
2) A yearly unit of less than 10 should not be adopted in order to emphasize that the YUC method is based on long term prediction.

3.The Results of Cases Studies in Asia

3.1 Case study 1: East Japan

Table 1 shows the results of YUC method which is applied to the past records of thirteen mega earthquakes from 1703 to 2011 in Tohoku, East Japan Area including Sendai and Fukushima. The 14th line of 2026 in Table 1 shows eight periodical yearly cycles including multiple year cycles which are listed in red color. They are 15, 32, 58, 73, 74, 88 and 95, which correspond to the years 2011, 1994, 1968, 1960, 1953, 1952, 1938 and 1931. It is concluded that the year of 2026 should be the most likely risky year for the next mega earthquake in East Japan Area, as the number of common periodical cycle years is a maximum.

3.2 Case study 2: Myanmar

Table 2 shows the results of YUC method which is applied to the past record of fourteen mega earthquakes from 1908 to 2015 in Myanmar. In the 15th line of 2022 in Table 2, ten periodical yearly cycles including multiple yearly cycles are listed in red color. They are 34, 52, 72, 75, 84, 88, 104, 110 and 114, which correspond to the years 1988, 1870, 1950, 1947, 1946, 1908, 1912 and 1908. It is concluded that the year of 2022 should be the most likely risky year for the next mega earthquake in Myanmar, as the number of common periodical cycle years is the maximum. The second most likely risky year for the next mega earthquake in Myanmar is 2026, which is the same as for East Japan.

If we compare the years of occurrence of mega earthquakes over M6.5 in East Japan and Myanmar, five such mega earthquakes occurred in the same years, namely 1923, 1931, 1938, 2003 and 2011 (in case of Myanmar mega earthquakes are over M6.5). This might have been a strange coincidence, but it is an interesting fact.

3.3 Case study 3: Indian Region

Table 3 shows the results of YUC method which is applied to the past records of eleven mega earthquakes from 1908 to 2015 in the Indian Region including India, Pakistan, Nepal, Afghanistan, Kyrgyzstan, Tajikistan and Assam Tibet. In the 12th line of 2022 in Table 3, eight periodical yearly cycles including multiple yearly cycles are listed in red color. They are 16, 20, 21, 71, 75, 92, 100 and 116, which correspond to the years 2005, 2001, 1950, 1906, 1921, 1911 and 1905. It is concluded that the year of 2022 should be the most likely risky year for the next mega earthquake in the Indian Region, as the number of common periodical cycle years is the maximum. The second most likely risky year for the next mega earthquake in the Indian Region is 2025.

3.4 Case study 4: Indonesia

Table 4 shows the results of YUC method which is applied to the past record of fourteen mega earthquakes from 1907 to 2016 in Indonesia. In the 15th line of 2023 in Table 4, six periodical yearly cycles including multiple yearly cycles are listed in red color. They are 16, 18, 80, 90, 109 and 116, which correspond to the years 2007, 2005, 1943, 1933, 1914, and 1907. It is concluded that the year of 2023 should be the most likely risky year for the next mega earthquake in Indonesia, as the number of common periodical cycle years is a maximum. The yearly unit number of 18 is derived from the yearly unit number of 9. In Table 4, many mega earthquakes occurred in very short yearly intervals such as 1, 2 and 4 as shown in the first column. Therefore, the yearly unit of 9 was exceptionally adopted. The second most likely risky year for the next mega earthquake in Indonesia is 2025.

4. The Reliability and Verification of YUC Method

Although the long-term prediction method introduced in this paper is not verified on a scientific basis, this approach could persuade the Asian people to prepare for mega earthquake disasters, because the method can show the risky years. It is much better and clearer than the Japanese Government's long-term prediction in the form of xx% in 30 years in the future, for example. Another benefit is that the proposed method will be available for anybody to calculate simply, if the past mega earthquake record in the relevant area can be searched.

At least it can be said that the results obtained from four case studies in this paper seem reasonable for individuals to execute preparedness for their own risk of mega earthquakes. Otherwise, people have no other options than to believe the Government's probability prediction without scientific evidence.

It may be surprising to know that there is a yearly periodicity for mega earthquakes as shown in this paper, which seems to be a strange coincidence. However, the cyclic anomalies occurring on Earth, including earthquakes, volcano eruptions and climate change such as global warming, may have been strongly influenced by the solar cycle for sunspots of 11years, as well as planetary orbital cycles of 12 years for Jupiter and 29 years for Saturn. In Table 1, the cycle of 66 and 88 corresponds to multiple solar cycles and 58 corresponds to multiples of Saturn's planetary cycle (Gribbin, 1971).

4.1 Successful example No.1: East Japan

In 2011 the maximum mega earthquake namely Great East Japan Earthquake with M9.1 occurred in Japan, causing about 22,000 casualties, mainly by the resulting Tsunami. If you look at the 13th line of Table 1 for the case of 2011, it is estimated to have several periodical yearly cycles including multiple yearly cycles. Table 5 shows the result of YUC method in advance of 2011. It will be surprising to know that eight periodical yearly cycles including multiple yearly cycles are listed in red color. It would have been possible to predict a mega earthquake in advance of 2011 by applying the YUC method. It might have contributed to preparedness of the Japanese people to reduce the number of casualties.

4.2 Successful example No.2: Myanmar

Similar settings were derived for the case of Myanmar mega M6.8 earthquake that occurred in 2015 as shown in Table 6. Seven periodical yearly cycles including multiple yearly cycles are listed in red color. It would have been possible to predict the occurrence of mega earthquake in 2015 if the YUC method was applied.

4.3 Successful example No.3: Haiti

On the 14th August 2021, a mega M7.2 earthquake occurred in Haiti, Central America which caused more than 2,000 casualties as of the 19th August 2021, according to UNICEF. In addition, Haiti experienced a tropical cyclone at nearly the same time. The YUC method was applied to check whether the earthquake could be predicted based on the past twelve mega earthquakes larger than M6.5 from 1918 to 2010.

Table 7 shows the result of YUC method, which predicts the possibility of a mega earthquake in 2021. Five periodical yearly cycles, including multiple yearly cycles, are listed in 2021 as shown in red. This prediction might have contributed to improve preparedness against the risky mega earthquake for Haitian people and thus reduced the number of casualties.

4.4 Successful example No.4: California, USA

The San Andreas Fault, California, USA is well known for frequent occurrence of mega earthquakes in the past. In 2018 the first author predicted that 2019 would be the most likely risky year for a mega earthquake. He sent a email to US Government as an early warning, but his prediction was completely neglected and with no response. Table 8 shows the result of YUC method where the year of 2019 is the most likely risky year, with eleven periodical yearly cycles, including multiple yearly cycles, as listed in red. Fortunately the earthquake did not cause serious damages but it would have been beneficial for the residents to be prepared for the expected danger in advance, because this earthquake was said to have been the maximum magnitude for 20 years in the region.

5. Conclusions

Here a new mega earthquake prediction method using a yearly unit cycle has been developed by the authors. The validation results for the four successful examples as shown in Tables 5 to 8 in Asia and North/Central America reveal that the most likely risky years for the upcoming mega earthquakes are correct based on a yearly unit prediction, which would have been helpful for preparedness against earthquake disasters in Asia as well as North/Central America.

The advantage of the long-term prediction method developed by the authors is that it is very clear and simple for anybody to calculate the most likely risky years from past earthquake records. It would give individuals a free hand to believe or not in their own risk. Moreover, the second most likely risky year can be searched by the YUC method as the next candidate. The selection of historical Mega earthquakes are recommended not too short cycle and not too long cycle. It would be better to select mega earthquakes with larger than M7.0 for example. If the historical data cycle is not long enough, and some new cycles appear in the next tens of years, then the prediction based on history data will not be reliable. The new method will be verified in future when case studies together with successful examples are accumulated in various areas.

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Year	M	Table 1 Yearly unit cycle in East Japan												
1703	8.2													
1855	7.8	152												
1923	7.9	68	220											
1931	7.2	8	76	228			T(i,j)=Y(i)-Y(i-j i>j; i=1,...n+1, j=1,....n							
1933	8.4	2	10	78	230									
1938	7.5	5	7	15	83	235								
1952	8.1	14	19	21	29	97	249							
1953	7.9	1	15	20	22	30	98	250						
1960	7.2	7	8	22	27	29	37	105	257					
1968	7.9	8	15	16	30	35	37	45	113	265				
1994	7.8	26	34	41	42	56	61	63	71	139	291			
2003	8.2	9	35	43	50	51	65	70	72	80	148	300		
2011	9.1	8	17	43	51	58	59	73	78	80	88	156	308	
2026	?	15	23	32	58	66	73	74	88	93	95	103	171	323

Year	M>7.0	Table 2 Yearly unit cycle in Myanmar													
1908	7.0														
1912	7.5	4													
1918	7.2	6	10												
1930	7.5	12	18	22											
1934	8.0	4	16	22	26										
1938	7.0	4	8	20	26	30									
1943	7.2	5	9	13	25	31	35								
1946	8.0	3	8	12	16	28	34	38							
1947	7.3	1	4	9	13	17	29	35	39						
1950	8.6	3	4	7	12	16	20	32	38	42					
1970	7.0	20	23	24	27	32	36	40	52	58	62				
1988	7.3	18	38	41	42	45	50	54	58	70	76	80			
1991	7.0	3	21	41	44	45	48	53	57	61	73	79	83		
2015	7.8	24	27	45	65	68	69	72	77	81	85	97	103	107	
2022	?	7	31	34	52	72	75	76	79	84	88	92	104	110	114

Year	M>7.5	Table 3 Yearly unit cycle in Indian Region									
1905	7.9										
1911	7.7	6									
1921	7.8	10	16								
1931	7.6	10	20	26							
1934	8.0	3	13	23	29						
1946	7.5	12	15	25	35	41					
1949	7.5	3	15	18	28	38	44				
1950	8.6	1	4	16	19	29	39	45			
2001	7.7	51	52	55	67	70	80	90	96		
2005	7.6	4	55	56	59	71	74	84	94	100	
2015	7.8	10	14	65	66	69	81	84	94	104	110
2021	?	6	16	20	71	72	75	87	92	100	116

Year	M>7.5	Table 4 Yearly uniti cycle in Indonesian Region													
1907	7.8														
1914	7.6	7													
1933	7.6	19	26												
1935	7.6	2	21	28											
1943	7.8	8	10	29	36										
1969	7.6	26	34	36	55	62									
2000	7.9	31	57	65	67	86	93								
2004	9.1	4	35	61	69	71	90	97							
2005	8.6	1	5	36	62	70	72	91	98						
2007	8.4	2	3	7	38	64	72	74	93	100					
2009	7.6	2	4	5	9	40	66	74	76	95	102				
2010	7.8	1	3	5	6	10	41	67	75	77	96	103			
2012	8.6	2	3	5	7	8	12	43	69	77	79	98	105		
2016	7.8	4	6	7	9	11	12	16	47	73	81	83	102	109	
2023	?	7	11	13	14	16	18	19	23	54	80	88	90	109	116

Year	M	Table 5 Sucessful prediction example of YUC method in East Japan											
1703	8.2												
1855	7.8	152											
1923	7.9	68	220										
1931	7.2	8	76	228									
1933	8.4	2	10	78	230								
1938	7.5	5	7	15	83	235							
1952	8.1	14	19	21	29	97	249						
1953	7.9	1	15	20	22	30	98	250					
1960	7.2	7	8	22	27	29	37	105	257				
1968	7.9	8	15	16	30	35	37	45	113	265			
1994	7.8	26	34	41	42	56	61	63	71	139	291		
2003	8.2	9	35	43	50	51	65	70	72	80	148	300	
2011	?	8	17	43	51	58	59	73	78	80	88	156	308

Year	M>7.0	Table 6 Sucessful prediction eample of YUC method in Myanmar												
1908	7.0													
1912	7.5	4												
1918	7.2	6	10											
1930	7.5	12	18	22										
1934	8.0	4	16	22	26									
1938	7.0	4	8	20	26	30								
1943	7.2	5	9	13	25	31	35							
1946	8.0	3	8	12	16	28	34	38						
1947	7.3	1	4	9	13	17	29	35	39					
1950	8.6	3	4	7	12	16	20	32	38	42				
1970	7.0	20	23	24	27	32	36	40	52	58	62			
1988	7.3	18	38	41	42	45	50	54	58	70	76	80		
1991	7.0	3	21	41	44	45	48	53	57	61	73	79	83	
2015	7.8	24	27	45	65	68	69	72	77	81	85	97	103	107

Year	M>6.5	Table 7 Suceesful prediction example of YUC method in Haiti											
1918	7.1												
1932	6.7	14											
1943	7.7	11	25										
1946	7.5	3	14	28									
1947	6.6	1	4	15	29								
1948	6.9	1	2	5	16	30							
1953	6.6	5	6	7	10	21	35						
1962	6.6	9	14	15	16	19	30	44					
1971	6.5	9	18	23	24	25	28	39	53				
1984	6.9	13	22	31	36	37	38	41	52	66			
2004	6.8	20	33	42	51	56	57	58	61	72	86		
2010	7.0	6	26	39	48	57	62	63	64	67	78	82	
2021	7.2	9	17	37	50	59	68	73	74	75	78	89	103

Year	M	Table 8 Sucessful prediction example of YUC method in Calfornia, US													
1906	7.9														
1915	7.0	9													
1918	6.8	3	12												
1925	6.8	7	10	19											
1927	7.1	2	9	12	21										
1940	6.9	13	15	22	25	34									
1952	7.5	12	25	27	34	37	46								
1956	6.8	4	16	29	31	38	41	50							
1983	6.7	27	31	43	56	58	65	68	77						
1989	6.9	6	33	37	49	62	64	71	74	83					
1992	7.3	3	9	36	40	52	65	67	74	77	86				
1994	7.1	2	5	11	38	42	54	67	69	76	79	88			
1999	7.1	5	7	10	16	43	47	59	72	74	81	84	93		
2010	7.2	11	16	18	21	27	54	58	70	83	85	92	95	104	
2019	7.1	9	20	25	27	30	36	63	67	79	92	94	101	104	113