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Application of Commensurability in Earthquake Prediction

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Abstract

This article introduces application of the expanding commensurability in earthquake prediction. The results show that most of the world's major earthquake occurred at their commensurable points of time axis. An EQ 7.0 occurred in Lushan of China on 2013-04-20 and an EQ 8.2 occurred in Iquique of northern Chile on 2014-04-01 all occurred at their commensurable points of time axis. This once again proves that the commensurability provides an important scientific basis for the prediction of major earthquakes, which will occur in the area in future.

Keywords

Commensurability, Orders in the Natural World, Earthquake Prediction

1. Introduction

Earthquake (EQ) research, especially EQ prediction, is accepted as a worldwide difficult scientific problem [1]. People have made arduous and unremitting efforts for searching for the effective methods of EQ prediction for a very long time. However, most of the basic concepts and systems of methods do not break away from the system of quantitative analysis of the inertial system so that the problem of prediction of serious natural disasters like EQs has not been solved. A Chinese famous geophysicist, Weng Wenbo (1912-1994) studies the Titius-Bode law [2] and firstly pointed out that the occurrence time of EQ has the commensurability and applied the principle of the commensurability which was firstly proposed in astronomy to the prediction of major natural disasters such as earthquakes, droughts and water-loggings, etc., thereby developed it into the theory of prediction which have been widely used in the prediction of disasters [3]-[7]. Based on this theory, the occurrence of a few EQs, droughts and water-loggings, and other natural disasters were successfully predicted.

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2. Commensurability and Its Expansion

Commensurability of the word was first proposed by the German famous astronomer Titius who found and proposed it in the study of the average distance between the planets within the solar system to the sun. Later, another famous German astronomer Bode made further studies. This is the famous Titius-Bode Law. From Titius-Bode law the distance of the planet n from the sun can be expressed as:

$$a_n = 0.4 + 0.32 \times 2^{n-2}, \tag{1}$$

It also can be written as the following form:

$$\beta = \frac{a_{n+1}}{a_n}, \tag{2}$$

where a_n is the distance of the planet n to the sun, reckoned in astronomical unit, and *n* is the number of the planets away from the sun to the far side. For Mercury, the number *n* is not 1, instead it is taken as $-\infty$. β is the commensurable value for the planets in the solar system [8].

Just as the famous geophysicist Weng Wenbo [9] pointed out that the commensurability is one of the orders in the natural world. The Equation (2) itself brings to light the distribution law of the matter in a space region, and for time domain the commensurability can be expressed as:

$$\Delta X = \frac{X_{i+\Delta i} - X_i}{K} \tag{3}$$

Here *k* is an integer. If the above relation is tenable, then the data set $\{X_i\}$ is commensurable. ΔX is the commensurable value of the data set $\{X_i\}$ and X_i and $X_{i+\Delta i} \in \{X_i\}$. If k is equal to 1, then ΔX is the period of $\{X_i\}$ [10].

3. Prediction Practice

3.1. Forecast by Weng Wenbo on the EQ Ms7.4 in California of United States on June 28, 1992

Before 1992 Weng Wenbo made a few forecasts of EQs occurring in United States, most of these forecasts corresponded quite well with the later occurred actual events [11]. As example, on January 17, 1992, according to a request from Prof. Cecil H. Green, Director of American Geophysical Unit, and upon obtaining ratification from senior authorities, Weng Wenbo presented his forecast report to Prof. Green [12];

Time: June 19 1992

Magnitude: 6.8

Place: Broad region of San Francisco

The predicted EQ occurred on June 28, 1992. Its magnitude Ms7.4, was only Ms0.6 greater in magnitude, and the occurrence date was only 9 days later than the date stated by the forecast report of Weng Wenbo [13].

3.2. Prediction on the Wenchuan EQ 8.0 and Lushan EQ 7.0 in China and the Iquique EQ 8.2 in Chile of 2014

The Wenchuan EQ Ms8.0 occurred in Sichuan province of China on May 12, 2008. It caused greatest heavy losses of the life and property in China in recent history. Before the EQ, Long Xiaoxia *et al*. based on the commensurability using the following commensurable equations with five elements rather precisely predicted that a strong EQ might occur in 2008 [14]:

$$\begin{aligned}
X_{23} + X_{15} + X_1 - X_3 - X_7 &= 2008 \\
X_{23} + X_{20} + X_{12} - X_{18} - X_7 &= 2008 \\
X_{24} + X_{21} + X_8 - X_{18} - X_6 &= 2008 \\
X_{25} + X_{15} + X_7 - X_{19} - X_3 &= 2008 \\
X_{22} + X_{15} + X_5 - X_{13} - X_3 &= 2008 \\
X_{21} + X_{11} + X_9 - X_{13} - X_1 &= 2008
\end{aligned} \tag{4}$$

The EQ catalogue used by Long Xiaoxia *et al*. is given in **Table 1**. From **Table 1** the commensurable value of the EQs occurrence is equal to 2.44 years. Taking $k = 5$ we obtain:

$$2008\text{-}05\text{-}12 = 1996.09 + 2.44 \times 5 = 2008^{y}\,4^{m}\,15^{d} + 27 \text{ days} \tag{5}$$

Its error which is the opposite of the occurrence date of the earthquake is 27 days. Its relative error is 0.03.

An EQ 7.0 occurred in Lushan of Sichuan province, China on 2013-04-20. Similar, on the basis of the **Table 1** we obtain:

$$2013\text{-}04\text{-}20 = 2008.36 + 2.44 \times 2 = 2013^{y}\,3^{m}\,29^{d} + 22 \text{ days} \tag{6}$$

It occurred just at the commensurable point equal to 2 times of its time axis. Its absolute error is 22 days. Its relative error also is 0.03.

An EQ 8.2 in Iquique, northern Chile, occurred on 2014-04-01. By the research of Engdahl and Villasenor [15] the catalogues of EQs of $M \geq 7.0$ have been complete and reliable since 1900. Therefore we have analyzed the EQs of $M \geq 7.0$ in Chile since 1900.0, and found its commensurable value is 0.59 years (see **Table 2**). So,

$$2004\text{-}04\text{-}01 = 2010.15 + 0.59 \times 7 = 2014^{y}\,04^{m}\,12^{d} - 11 \text{ days} \tag{7}$$

It occurred just at the commensurable point equal to 7 times of its time axis. Its absolute error is 11 days. Its relative error is 0.05.

On the basis of many years' research for commensurability according to the commensurable principle, we compiled a Fortran program for commensurable analyses of the data. By means of the Fortran program our analyzed results have been all given in the tables. The two tables all are directly output results by computer.

Table 1. Commensurability of earthquakes in Sichuan-Yunnan region since 1900.0.

	Earthquakes date	$X_i - X_{i-1}$			$K\Delta X$	$X_i - K\Delta X$
No.	YMD	(year)	(year)	K	(year)	(year)
1	19131221	1913.97				
2	19170731	1917.57	3.60	1	2.44	1.16
3	19230324	1923.22	5.65	2	4.88	0.77
4	19250316	1925.20	1.98	1	2.44	−0.46
5	19330825	1933.64	8.44	3	7.32	1.12
6	19360427	1936.32	2.68	1	2.44	0.24
7	19410516	1941.37	5.05	2	4.88	0.17
8	19420201	1942.08	0.71	0	0.00	0.71
9	19480525	1948.40	6.32	3	7.32	−1.00
10	19500203	1950.09	1.69	1	2.44	−0.75
11	19520930	1952.75	2.66	1	2.44	0.22
12	19550414	1955.28	2.53	1	2.44	0.09
13	19601109	1960.85	5.57	2	4.88	0.69
14	19670830	1967.66	6.81	3	7.32	−0.51
15	19700105	1970.01	2.35	1	2.44	−0.09
16	19710428	1971.32	1.31	1	2.44	−1.13
17	19730206	1973.09	1.77	1	2.44	−0.67
18	19740511	1974.35	1.26	1	2.44	−1.18
19	19760823	1976.64	2.29	1	2.44	−0.15
20	19790315	1979.20	2.56	1	2.44	0.12
21	19810124	1981.06	1.86	1	2.44	−0.58
22	19881106	1988.84	7.78	3	7.32	0.46
23	19890425	1989.31	0.47	0	0.00	0.47
24	19950712	1995.52	6.21	3	7.32	−1.11
25	19960203	1996.09	0.57	0	0.00	0.57
26	20080512	2008.36	12.27	5	12.20	0.07
Commensurable value					2.44	
Mean					−0.031	
Standard deviation (σ_{n-1})					0.717	

Table 2. Commensurability of EQs in Chile since 1900.0.

	Earthquakes date	$X_i - X_{i-1}$			$K\Delta X$	$X_i - K\Delta X$
No.	YMD	(year)	(year)	K	(year)	(year)
1	19040319	1904.21				
2	19060817	1906.62	2.41	4.	2.36	0.05
3	19060830	1906.66	0.04	0.	0.00	0.04
4	19061226	1906.98	0.32	1.	0.59	−0.27
5	19090608	1909.43	2.45	4.	2.36	0.09
6	19100906	1910.67	1.24	2.	1.18	0.06
7	19110915	1911.70	1.03	2.	1.18	−0.15
8	19140130	1914.07	2.37	4.	2.36	0.01
9	19180520	1918.38	4.31	7.	4.13	0.18
10	19181204	1918.92	0.54	1.	0.59	−0.05
11	19221107	1922.85	3.93	7.	4.13	−0.20
12	19221111	1922.86	0.01	0.	0.00	0.01
13	19250515	1925.36	2.50	4.	2.36	0.14
14	19270414	1927.28	1.92	3.	1.77	0.15
15	19281201	1928.92	1.64	3.	1.77	−0.13
16	19310318	1931.20	2.28	4.	2.36	−0.08
17	19330223	1933.14	1.94	3.	1.77	0.17
18	19360713	1936.53	3.39	6.	3.54	−0.15
19	19390125	1939.06	2.53	4.	2.36	0.17
20	19390418	1939.29	0.23	0.	0.00	0.23
21	19401004	1940.76	1.4	2.	1.18	0.29
22	19420708	1942.51	1.75	3.	1.77	−0.02
23	19430314	1943.20	0.69	1.	0.59	0.10
24	19430406	1943.26	0.06	0.	0.00	0.06
25	19450913	1945.70	2.44	4.	2.36	0.08
26	19460802	1946.58	0.88	1.	0.59	0.29
27	19490420	1949.29	2.71	5.	2.95	−0.24
28	19490425	1949.31	0.02	0.	0.00	0.02
29	19530506	1953.34	4.03	7.	4.13	−0.10
30	19600521	1960.38	7.04	12.	7.08	−0.04
31	19600522	1960.39	0.01	0.	0.00	0.01
32	19600522	1960.39	0.00	0.	0.00	0.00
33	19600620	1960.46	0.07	0.	0.00	0.07
34	19601202	1960.92	0.46	1.	0.59	−0.13
35	19620214	1962.12	1.20	2.	1.18	0.02
36	19650328	1965.23	3.11	5.	2.95	0.16
37	19661228	1966.98	1.75	3.	1.77	−0.02
38	19671221	1967.97	0.99	2.	1.18	−0.19
39	19710709	1971.51	3.54	6.	3.54	0.00
40	19740818	1974.62	3.11	5.	2.95	0.16
41	19750510	1975.35	0.73	1.	0.59	0.14
42	19811016	1981.79	6.44	11.	6.49	−0.05
43	19811107	1981.85	0.06	0.	0.00	0.06
44	19831004	1983.75	1.90	3.	1.77	0.13
45	19850303	1985.16	1.41	2.	1.18	0.23
46	19850304	1985.17	0.01	0.	0.00	0.01
47	19850409	1985.26	0.09	0.	0.00	0.09
48	19870305	1987.17	1.91	3.	1.77	0.14
49	19870305	1987.17	0.00	0.	0.00	0.00
50	19870808	1987.60	0.43	1.	0.59	−0.16
51	19880119	1988.05	0.45	1.	0.59	−0.14
52	19880205	1988.09	0.04	0.	0.00	0.04
53	19950730	1995.57	7.48	13.	7.67	−0.19
54	19971015	1997.78	2.21	4.	2.36	−0.15
55	19980130	1998.07	0.29	0.	0.00	0.29
56	20050613	2005.44	7.37	12.	7.08	0.29
57	20100227	2010.15	4.71	8.	4.72	−0.01
Commensurable value					0.590	
Mean					−0.027	
Standard deviation (σ_{n-1})					0.142	

From **Table 1** and **Table 2** the results show that the EQs basically all occur at the commensurable point of its time axis, respectively. It also shows that the EQs occurrence is not accidental, and there is its pattern and inevitability, only the commensurable value is different for EQs occurred in different areas.

In the Tables, ΔX is the commensurable value of the studied region. K means that the EQ lies on K times of the commensurable value ΔX behind the latest recent EQ occurred in the area in its time axis. In the Tables, $X_i - X_{i-1}$ is the time interval between major EQs occurring in the same area. For example, EQ No. 3 in **Table 1**, X_3 = 1923.22, X_2 = 1917.57, the time interval between the 3rd and 2nd EQ is 5.65 year (unit: years). The corresponding K value under EQ No. 3 is $K_3 = 2$, *i.e*. the 3rd EQ occurred on the second commensurable point in its time axis after the 2nd EQ. According to K_3 and the commensurable value, the predicting point equals to 1917.57 adding the product of 2 and the commensurable value (*i.e*. 1917.57 + 2ΔX = 1917.57 + 4.88). Its prediction error (*i.e*. the difference between the predicted point and actual time of occurrence of the third EQ) is 0.77 years.

4. Discussion and Conclusion

1) The commensurability revealed by Titius-Bode itself brings to light the distribution law of the matter in a space region, and the expanding commensurable theory proposed by Weng Wenbo reveals the time law of the occurrence of the events in a specified space region. It can be seen that the commensurability is present in various natural phenomena and has universality. It is helpful to study the complicated relationships among various matters, and thus merits further in-depth research.

2) The occurrence of the events seems to be a random accident. In fact, that is not the case. It is in the accident that the necessity resides. Therefore, the commensurability can provide a scientific basis for the prediction of events which may occur.

3) After commensurable value can be determined, K values should be used in order of K = 1, 2, 3, ⋯, *i.e*. when $K = 1$ is used but earthquake does not occur, then use K = 2, ⋯. The predicted point extrapolated in the time axis by the commensurable value is only a necessary condition, and therefore certain false forecasts are also inevitable, because the exact occurrence time is determined by multiple complex factors. In order to obtain precise prediction, this method must be used in collaboration with other relevant methods, taking the approach of comprehensive analysis.

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