

Notes and Comments

A review of catalogues of Chinese Earthquakes

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Abstract: In the past a decade, Catalogues of Chinese earthquakes with higher authority and being used widely by seismologists in China are:

1. Gu Gong-xu, 1983, Catalogue of Chinese earthquakes;
2. Min Zi-qun, 1988, Simple catalogue of Chinese earthquakes;
3. Xie Yu-suou, 1989, Catalogue of Chinese earthquakes (M 4.7) from 1900-1980 with uniform magnitudes;
4. Min Zi-qun, 1995, Catalogue of Chinese historical strong earthquakes.

Earthquakes occurred pre-1900 are mainly from historical materials.

Since 1950's, two major compilings of historical materials finished in 1956 and 1983-1987 separately resulted in two chronicles, two volumes for the first and five volumes for the second. The magnitudes are converted from the max. intensity. These magnitudes, by convention, are connected with surface wave magnitudes to be used. But it is clear that they have no any strict seismological conception yet.

The period 1900-1962 is early instrumental record era. Magnitudes of all earthquakes occurred in this period, in principle, are determined by Chinese own magnitude scale. It seems that further detail description about this in the explanatory remarks of early catalogue is less. In fact, perhaps, it is complicated, because just a few seismic stations existed at that time in China.

The period after-1963 is modern instrumental era. All surface wave magnitudes are determined by Beijing Baijiatan-seismic station magnitude formula, which is different from that LASPEL recommended to global. Beijing Baijiatan magnitudes have a systematic over-estimation of 0.2 magnitude unit.

Catalogues of Chinese earthquakes need to be connected with global seismic data, to unify seismic parameters in these catalogues becomes a urgent task, which will be considered in our research plan of GSHAP.

1. Introduction

Natural hazard and hazard prevention are global problems. More and more seismologists must use and treat basic seismic data from different regions and countries in the world comprehensively. So, the uniformity of parameters is going to be a very important research project. It is necessary to have a review before these special researches have been made. Among these parameters, magnitude is the first one to be considered, because its accuracy could affect results of seismic hazard assessment directly.

China is a country with high seismicity and long historical culture. The historical records of earthquakes for two thousand year must be stamped with branks of eras, regions, races, populations and developed degrees. Even the instrumental data are also affected by scaling functions of magnitudes, type of

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instruments, distribution of seismic stations, number of stations and so on. Thus, for catalogues of Chinese earthquakes, it is also necessary to unify parameters themselves, in particular, the magnitudes.

In this paper, we review the methods of magnitude determination and the materials used in the compiling catalogues of Chinese earthquakes. It could provide a reference for using these catalogues of both seismologists of domestic and foreign.

2. Available catalogues of Chinese earthquakes

Since 1950's Chinese seismologists have paid a large efforts on both respects of finding historical materials of earthquakes and developing seismic network, so that the compiling a national catalogue with relative completeness become real.

Some major catalogues are listed in Table 1. Following four catalogues with higher authority are just

Keywords: China, earthquake catalogue, magnitude scale

Table 1 List of catalogues of Chinese earthquakes.
LIST OF CATALOGUES OF CHINESE EARTHQUAKES

Name	Chief Editor	Publishing House	Publishing Date	Material Sources Reference Documents	Determination of Magnitude	Note
Catalogue of Chinese earthquakes	Li Shan-Bang	Science	1960			From B.C.1189-A.D. 1955: total 1180 events (No aftershock), two volumes.
Catalogue of Chinese earthquakes	Working group of centre earthquake office	Science	1971		Pre-1900, Derived From Io After 1900: Determined by Chinese measure function Accuracy 0.1 for good reliability Accuracy 1/2 for poor reliability	From B.C.1177-A.D.1969: total 4 volumes, 2257 events (include aftershocks)
Catalogue of Chinese earthquakes (B.C.1831-A.D. 1969)	Gu Gong-Xu	Science	1983	<ul style="list-style-type: none"> ● Pre-1900: Chronicle (Vol.1 and Vol.2) of materials of Chinese earthquakes, earthquake working group of Chinese academy of sciences, Dec. 1956. ● After 1900: By macro-investigation and equipment-observation Data. 	<ul style="list-style-type: none"> ● Pre-1900: $M=0.58 I_0 + 1.5$ Reference to effected area of this event (Error: 0.5 magnitude unit) ● 1900-1962: Modified Gutenberg's formula (1945): $M_s = \log A + 1.656 \log \Delta + 1.818 + S_c$ Station correct value S_c is corresponded to standard Gutenberg magnitude. ● After 1963: new surface magnitude formula of china $M_s = \log(A/T) + 1.66 \log \Delta + 3.5$ A and T are the amplitude and period of the surface waves respectively. 	Total 3187 events
(1970-1979)	Gu Gong-Xu	Science	1983	<ul style="list-style-type: none"> ● Bulletin of seismological observations of Chinese stations, 1970-1979, Inst. of Geophysics, SSB. ● Catalogues of earthquakes of various provincial seismological bureaus and macroscopic reports of seismological survey etc. ● Regional catalogue of earthquakes, 1970-1979, International Seismological Center. 	<ul style="list-style-type: none"> Take M_s Determined by Chinese Seismological Stations ● Main source: Bulletin of seismological observation of Chinese stations, 1970-1979, Inst. of Geophysics, SSB. Formula is: $M_s = \log(A/T) + 1.66 \log \Delta + 3.5$ ● For some events: take the M_s Determined by various provincial stations (Derived from M_l) or by data of a single standard $M_s = 1.13 M_l - 1.08$ and $M_l = \log(A) + R(\Delta)$ 	Total 896 events
Simple catalogue of Chinese earthquake (B.C.780-A.D. 1986) ($M \geq 4.7$)	Compiling group of simple catalogue of Chinese earthquakes, (Chief: Min Zi-Qun)		1988	<ul style="list-style-type: none"> ● Compilation of historical materials of Chinese earthquakes (total 5 volumes, 7 books), Xie Yu-Shou and Cai Mei-Biao, Science Publishing House, 1983-1987. ● Compilations of local historical earthquake materials of various provinces. 	<ul style="list-style-type: none"> ● Pre-1900: $M = F(I_0)$ East of China $M_s = 0.579 I_0 + 1.403$ West of China $M_s = 0.605 I_0 + 1.376$ Taiwan of China $M_s = 0.507 I_0 + 2.108$ ● 1901-1979 or $M \geq 6$: Take the magnitude of Gu Gong-Xu's catalogue 	Total 5142 events
				<ul style="list-style-type: none"> ● Bulletin of seismological observations of Chinese stations, Institute of Geophysics, SSB. 	<ul style="list-style-type: none"> ● After 1979 or $M \geq 6$: ● Bulletin of seismological observations of Chinese stations, Inst. of Geophysics, SSB. ● Reports (or catalogue) of seismological observations of regional and local stations. 	
Catalogue of Chinese earthquakes ($M \geq 4.7$) from 1900-1980 with uniform magnitudes	Xie Yu-Shou	Seismological Press	1989	<ul style="list-style-type: none"> ● Take data of seismological station network of global and China, redetermine magnitude for every event, in order to obtain successive data and uniform magnitude. ● Time of occurrence and epicenter location are from compilation of historical materials of Chinese earthquakes, vol.4, Sec.book and vol.5, Xie Yu-Shou and Cai Mei-Biao, Science Publishing House, 1983 and 1986. 	<ul style="list-style-type: none"> ● Gutenberg's formula of 1945 for surface magnitude: $M_s = \log A + 1.656 \log \Delta + 1.818 + S_c$ ($T=20=3$ Sec) Station correction S_c: Pre-1949, Take Gutenberg's value of 1945. After-1949, Calculate one by editor. ● If the surface wave period is less than 17 Sec: $M_v = \log(A/T) + 1.66 \log \Delta + 3.3 + S_v$ S_v is station correction calculated by editors. ● Gutenberg's formula of 1956 for body magnitude: $M_b = \log(A/T) + Q(H, \Delta) + C$ Calculate M_b for various components and various body waves (Pz, Ph, Sh, pPz, pPh etc.) Separately, then take an average value as the body magnitude. 	Total 3133 events Editors extrapolate the table $Q(h, \Delta)$ From $\Delta \geq 18-20^\circ$ To $\Delta \geq 4^\circ$
Catalogue of Chinese historical strong earthquakes	Min Zi-Qun Department of Seismic Hazard Prevention, SSB.	Seismological Press	1995	<ul style="list-style-type: none"> ● Compilation of Historical Materials of Chinese earthquakes (Total 5 volumes, 7 books), Xie Yu-shou and Cai Mei-Biao, Science Publishing House, 1983-1986. ● Local historical materials of earthquakes and chronicles of various provinces. 	Same as that of 'Simple Catalogue of Chinese Earthquakes, 1688'	<ul style="list-style-type: none"> ● Total 1034 ev. ● For some historical earthquake without destroy of building or fracture of surface, determine magnitude by: $M = 1.60 L_g(R) + 2.12$ (East of China) $M = 1.68 L_g(R) + 2.24$ (West of China) ● R: Equivalent radius of intensity IV.
Catalogue of Chinese historical strong earthquakes (1912-199?)	Department of Seismic Hazard Prevention, SSB, China.		will be published in 1996			

used by Chinese seismologists widely in China today.

1. Gu Gong-xu, 1983, Catalogue of Chinese earthquakes;
2. Min Zi-qun, 1988, Simple catalogue of Chinese earthquakes;
3. Xie Yu-shou, 1989, Catalogue of Chinese earthquakes (M 4.7) from 1900-1980 with uniform magnitudes;
4. Min Zi-qun, 1995, Catalogue of Chinese historical strong earthquakes.

The last one in Table 1 is compiled by Institute of Geophysics, SSB. It is said its contents and forms are as same as the 1995's catalogue roughly.

3. Pre-1900's earthquakes

3.1 Historical materials

It is an era without instrumental data before 1900. All sources of earthquakes occurred in this period in the catalogues are historical documents. According to 'New Intensity Table of Chinese Earthquakes', after evaluating the intensity values of every affected sited, seismologists take the location with highest intensity as epicentre and corresponding magnitude was converted then.

Since 1950's, two major compilings of historical materials have been finished in 1956 and 1983-1987 separately. The first compiling made by a working group of Chinese Academy of Sciences resulted in publishing of a chronicle (two volumes). The second finished under guide from Professor Xie Yu-shou resulted in publishing of 'compilation of historical materials of Chinese earthquakes' (five volumes, total seven books) (see Table 2).

Also many local chronicles of earthquakes were

Table 2 Compilation of historical materials of Chinese earthquakes.

VOLUME	NO.	PERIOD	CHINESE DYNASTY	EDITORS	PUBLISHING DATE
1		-2300-1367	REMOTE-YUAN	MAIN: INST. MODERN HISTORY, CHINESE ACADEMY OF SOCIOLOGY	1983
2		1368-1644	MING	SAME AS VOL.1	1986
3	1	1644-1736	QING	SAME AS VOL.1	1987
	2	1736-1911	QING	SAME AS VOL.1	
4	1	1912-1949 DOCUMENT MATERIALS		SECOND HISTORICAL ARCHIVES OF CHINA, SEISMOLOGICAL BUREAU OF JIANGSU PROVINCE	1985
	2	1912-1949 INSTRUMENT DATA		SAME AS ABOVE	1986
5		1949-1980		SEISMOLOGISTS	1983

published in succession. For example, 'compilation of earthquake materials in Tibet' added 8 earthquakes with magnitude 6.3-4.8 in the period from 14 century to the beginning of this century. Some new earthquakes were found in Sichuan and Xinjiang Provinces.

All materials above are basic sources of earthquakes occurred pre-1900.

3.2 Magnitude

The magnitude values converted from historical materials, strictly speaking, have not a clear conception from seismology. But they are used to be connected with surface wave magnitudes in the past, just as we have known, that is a conventional use only.

Converted formula from historical materials to magnitude in 1988's simple catalogue and 1995's catalogue are different from the one in 1983's catalogue. For some earthquakes occurred in a region with higher seismicity, determination of its magnitude is also based on local empirical relationship.

Major improvements of simple catalogue (1988) and 1995's catalogue are:

(1) 221 Earthquakes with wide felt (refer to intensity IV) and without obvious ground fractures or destroy of buildings were added into these catalogues. The used empirical relationship is listed in Tab.3.

These medium earthquakes, which can change the annual rate of occurrence and b value of a seismic belt in the probabilistic seismic risk analysis, could directly affect the results of seismic hazard assessment. Thus, this relative large contribution from relative low magnitude events must not be ignored.

(2) Changes of earthquakes with magnitude 8 and more than 8

4. 1900-1962 early instrumental record earthquakes

Magnitudes of most earthquakes occurred in this period in all available catalogues of Chinese earthquakes, 1983's, 1988's, and 1995's, are followed from that of 1970's (Table 4). However, further detailed description about magnitude scaling seems to be less in the explanatory remarks of the book.

In principle, a Chinese own magnitude scale was used. But, in fact, perhaps, foreign data still are main sources, because there were just a few seismic stations at that time in China.

Table 3 The empirical relationship between radius of IV and magnitude.

M		4.3/4 -5	5.1/4-5.1/2	5.3/4 -6	6.1/4-6.1/2	> 6.1/2
B k m	EAST	40-70	90-150	200-300	350-500	> 500
	WEST	30-50	60-100	120-200	250-350	> 350

5. After 1963-modern instrumental record earthquakes

For all earthquakes occurred in this period, determination of magnitude is made by a new Chinese surface wave magnitude formula:

$$M_s = \text{Log} (A/T) + 1.66 \text{Log} (\Delta) + 3.5$$

Obviously, it is different from that recommended to global by IASPEL:

$$M_s = \text{Log} (A/T) + 1.656 \text{Log} (\Delta) + 3.3$$

The systematic over-estimation by using Chinese formula is about 0.2 unit of magnitude.

6. Catalogue of Chinese earthquakes (M 4.7) from 1900-1980 with uniform magnitude

This catalogue was compiled by Professor Xie Yu-shou who is a chief editor of 'compilation of historical materials of Chinese earthquakes' in 1989. The main purpose of compiling this catalogue is to unify the magnitude scale. For all earthquakes with amplitude data, the magnitude were recalculated by ourselves. For those without original data, the magnitudes were regressed from values given in other catalogues. Time of occurrence and location of focus were generally adopted from volume 4, part B and volume 5 of the 'compilation of historical materials of Chinese earthquakes'. Only a small number were redetermined or adjusted with reference to other catalogues. (from the explanatory remarks of Catalogue of Chinese earthquakes (M 4.7) from 1900-1980 with uniform magnitude).

The formulas of magnitude can be found in Table 1.

7. Un-uniformity of magnitude in catalogues of Chinese earthquakes

As mentioned above, the major un-uniformity of

Table 4 Changes of earthquakes with magnitude 8 and more than 8.

EARTHQUAKE IN 1996'S CATALOGUE			1988'S	1983'S
1556.2.2	SHANXI HUAXIAN	81/4	8	8
1604.12.29	FUJIAN QUANZHOU	71/2	8	8
1668.7.26	SHANDONG TANCHENG	34.8 118.5	34.8 118.5	35.3 118.6
1695.5.18	SHANXI LINFEN	71/4	71/2	73/4
1812.3.8	XINJIANG NELKA	8	8	7-8
1906.12.23	XINJIANG SILAWAN	7.7	7.7	8
1411.9.29	TIBET DANGXONG	8	NO	NO
1833.8.26	TIBET NYALAM	8	NO	NO

magnitude are:

- (1) For the earthquakes occurred in period pre-1900, there is no a strict seismological concept for the magnitude converted from historic materials. There is no special researches of relationship between the converted magnitude and the instrumental one too.
- (2) Magnitude scales are not unique for earthquakes occurred in different periods.
- (3) Two formulas of Beijing-Baijiatan's and Xie Yu-shou's are not as same as that recommended by IASPEL.
- (4) Absolutely, it is not a good treatment that list the M_s converted from M_l determined by local seismological bureau into any national catalogue of Chinese earthquakes.

These problems are just a project to be investigated and solved in our research plan of GSHAP.

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中国の地震カタログ

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中国の地震カタログの現状についてレビューする。最近のカタログは次のようである。

- 1) Gu Gong-xu(1983) Catalogue of Chinese earthquakes
- 2) Min Zi-qun(1988) Simple catalogue of Chinese earthquakes
- 3) Xie Yu-suou(1989) Catalogue of Chinese earthquakes from 1900-1980
- 4) Min Zi-qun(1995) Catalogue of Chinese historical strong earthquake