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Frequency - Magnitude Relations and Hazard Estimation

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1. Background

When the earthquakes generates it's have definite magnitude and frequency, Earthquake is sudden movement of tectonics plates on each other and to result ground surface displace, and other words earthquakes is results of sudden release of stored energy from earth crust that's create seismic wave, seismic wave detect by seismometer, And the study of earthquake is called seismology.

Distributions of earthquake of any region of the earth typically satisfy by the GUTENBERG – RICHTER'S relationship. This law expresses the relationship between the magnitude of earthquake and total number of earthquake in any region and time period of that magnitude.

$$\mathbf{Log_{10}N = a - b\,M}$$

Where N represent number of events having a magnitude ≥ M

And a, b are positive constant and a, b are same for all value of N and M

The frequency of a natural hazard events is the number of times it's occurs within a specified time interval and magnitude of a natural hazard events is related to the energy released by the events, the magnitude of natural hazard event varies in frequency of occurrence over time in an inverse power relationship, with an increase in earthquake magnitude the frequency is also decreased consequently, in Gutenberg-Richter relation two parameter are widely use a-value and b-value, the parameter " a " is known as seismic activity and the a-value represent the total seismic rate of the regions and the a-value depend on many parameter like – size of the area, time interval, total number of earthquake and magnitude of each earthquake and the value of " b ". The parameter " b " is known as the b-value or b-slop and it generally describe the slop of the cumulative number and magnitude trend line. A high b-value indicates the large number of smaller earthquakes compared to large once and a low b-value indicates the smaller number of larger earthquakes. The b – value is mainly use for quantifying seismicity and its show the relative number of ratio. Its value generally lies within 0.5 to 1.5 for wide variety of regions and different magnitude scale, depends on tectonics, structural heterogeneity and stress distribution in space. The relationship between magnitude and frequency of occurrence is remarkable common although the a-value and b-value many very significantly from region to region. The a-value represent the total Seismicity rate of the region, thus is more easily seen Gutenberg-Richter relation in terms of total number of events.

$$\mathbf{N = N_{total}10^{-bM},\ Where\ N_{total} = 10^{a}}$$

When the b-value close to 1 is seismically active region, and when the b-value becomes as high as 1.5 thus indicating a very high proportion of small magnitude earthquakes to large once. There is an apparent b-value decrease for smaller magnitude events range in all empirical catalogue of earthquakes, this effect is describe as ' Roll of b-value '.

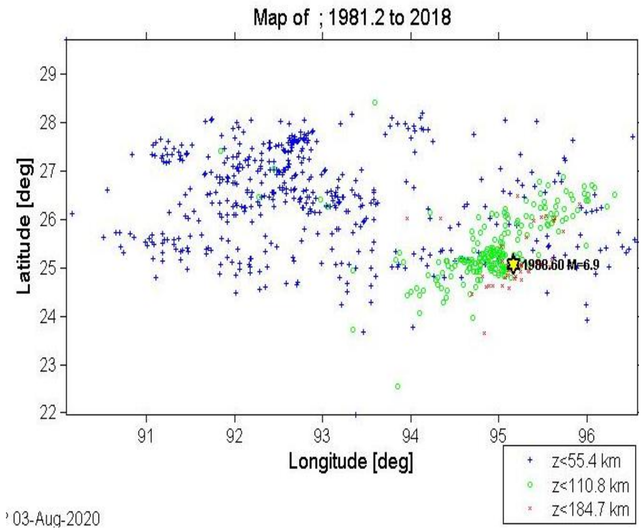
It is important to look at the magnitude frequency distribution of the earthquakes globally:

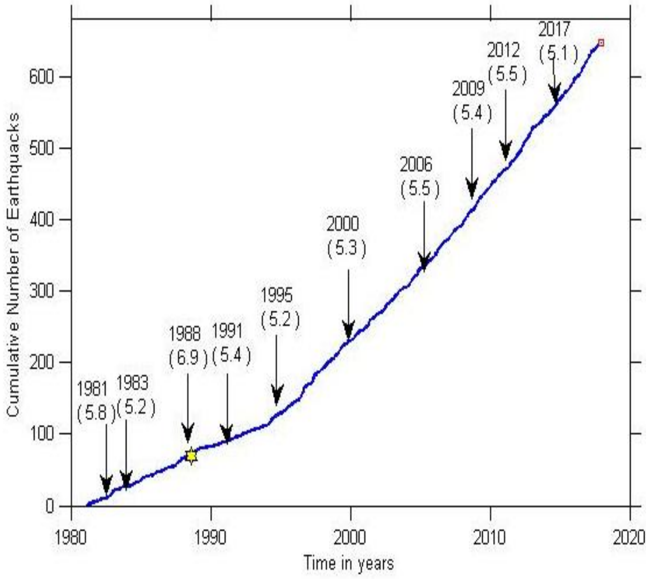
Descriptor	Magnitude	Annual global frequency
Great	8 and higher	1
Major	7 to 7.9	18
Strong	6 to 6.9	120
Moderate	5 to 5.9	800
Light	4 to 4.9	6200
Minor	3 to 3.9	49000
Very minor (micro)	2 to 2.9 1 to 1.9	Around1000 per day Around 2000 per day

And some other important terminology such as, main shock, foreshock, and after shock., Main shock is highest magnitude earthquakes in particular seismicity region, a foreshock are earthquakes that occurs before a larger seismic event (main shock) and is related to it in both time and space. The designation of earthquakes as foreshock. Main shock or after shock is only possible after the full sequence of events has happened.

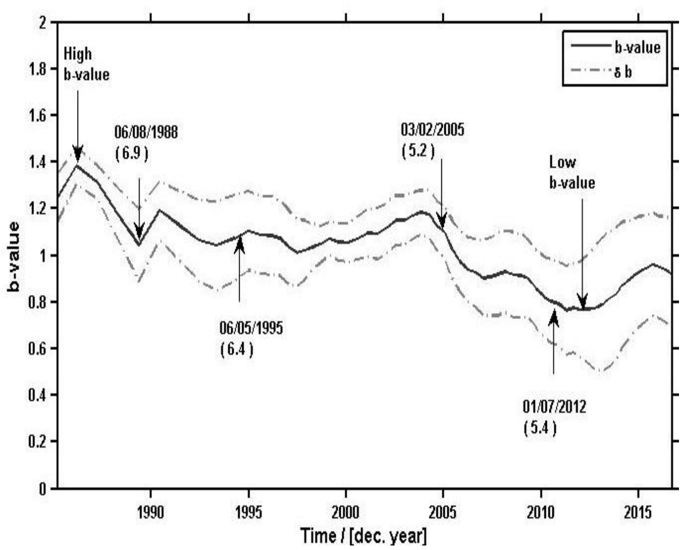
There are some important graphical figures that define variation of b-value, frequency-magnitude distribution curve and some other important parameters.

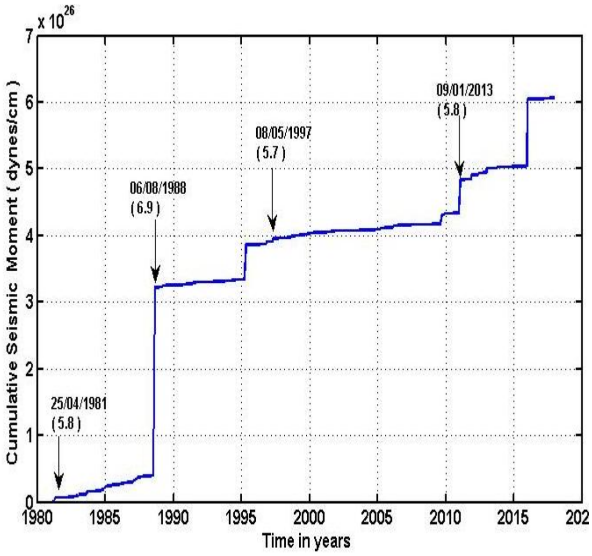
Graphical illustration of **seismicity map** and **cumulative number of earthquake with time** at latitude 23 to 30 and longitude 90 to 97 in time period 1981 to 2017, data based on ISC



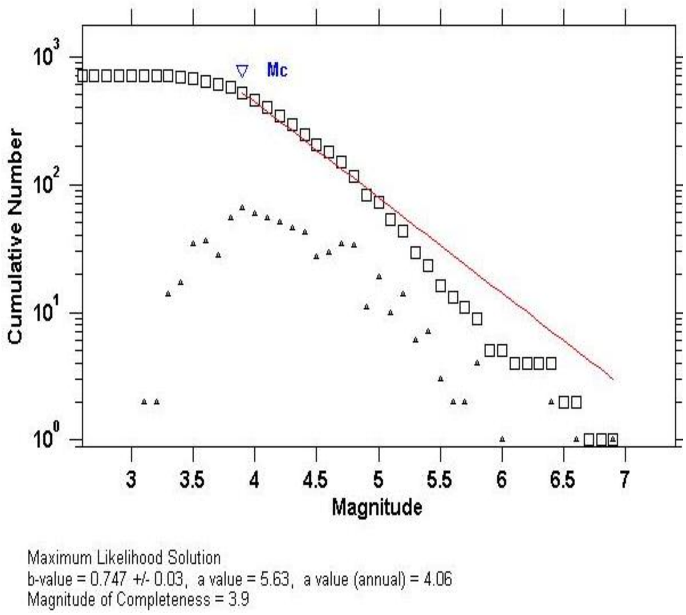


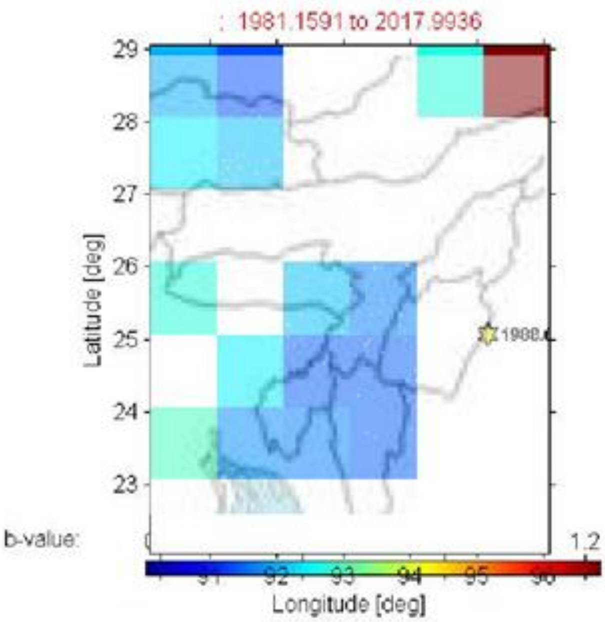
Graphical illustration of temporal variation of b-value and cumulative seismic moment with time at same time period and same coordinate.





Graphical illustration of Frequency-Magnitude distribution and b-value map at same time and same coordinate.





2. Conclusion

Studies of database and graph have concluded the following point, which are as follows

- b-value a parameter in seismology which give information about magnitude of earthquack and hazard estimation. Zhang and song (1981) have pointed out that the following equation which gives a biased estimate of the b-value

$$\mathbf{b = \log_{10}e/ (M_1 - M_{0)}}$$

- b-value generally lies within 0.5 to 1.5 for wide variety of regions and different magnitude scale,
- Depends on tectonics, structural heterogeneity and stress distribution in space.
- A high b-value indicates the large number of smaller earthquakes compared to large once and a low b-value indicates the smaller number of larger earthquakes.
- In any seismic active region the aftershock are more dangerous compared to main shock and foreshock, because aftershock usually unpredictable, can be of a large magnitude, and can collapse buildings that are damaged from the main shock
- The frequency-magnitude distribution curve shows relation between frequency and magnitude.
- The relation between frequency and magnitude are invertible
- When increase in earthquake magnitude the frequency is also decreased consequently.

3. Future Perspectives

Improved understanding of fault behavior, responsible urban planning, and advances in building construction have greatly reduced the threat to life from earthquakes, yet more could be done to reduce our exposure to their hazards. Generally, prediction can be completed by stochastic way (statistical) /and deterministic (subjective) way. Former includes the anomalies in seismic waves (abnormality in stress drop and shear stress,) while, latter includes anomalies in seismic images (increment and decrement of regional seismicity, appearance of seismic gaps, seismic belts, seismic swarms and anomalies in special value such as b-value). Earthquake Predictability can be defined as Brick by Brick seismic hazard assessment. In order to improve the accuracy of the earthquake prediction, the earthquake prediction mode should be transferred from the statistical mode to the physical mode. The seismic activity method analyses the time, space, and magnitude of the small to medium-size earthquakes that occurred before past strong earthquakes and can be use to predict the future medium-size or strong earthquakes. In this paper, results emphasize based on these methodologies and several predictions for Indian region However, the study highlight that space-time distribution of the earthquakes has enabled to locate potential area where future earthquake may be seated and recommend monitoring of multi-parameter short term precursory

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