# Analyzing The Seismic Behaviour of Central Himalayan Region Using Frequency Magnitude Distribution and Fractal Dimension

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# Introduction

- The Himalayan region is a seismically active belt of arc length 2400 km extends spatially from Indus river valley (western region) to Brahmaputra river valley (eastern region) India.

- The seismicity in Himalaya is heterogeneous due to well defined geological structures.

- Meanwhile, the Central Himalayan region, along with its neighbouring area is known to be the part of the Alpine-Himalayan global seismic belt, a seismically active area of the world.

- In the past (1897, 1905, 1934, and 1950) four great earthquakes have triggered in this region with a magnitude higher than M =8.0.

- The 2015 (M = 7.8) Gorkha Nepal earthquakes call attention to the need for a more accurate understanding of seismic characteristics in the Central Himalayan region.

# Scope of this study

To analyze the spatial variation of seismic activity in the Central Himalayas covering the Indian state of Himachal Pradesh, Uttarakhand and Western part of Nepal is done by analyzing the variation of seismic parameters and fractal dimension (Dc) using the updated and homogeneous earthquake catalogue of the study area.

# Methodology

- Considering the earthquake distribution and tectonic features, the central Himalayas is divided into 12 seismic source zones.

- For the comparison of the seismicity between each seismic source zone, seismic parameters such as seismic activity rate (λ), maximum possible earthquake magnitude (Mmax), and `b-value' are calculated.

- The fractal dimension (Dc) is used as a quantitative measure of the degree of heterogeneity of seismic activity in seismotectonic elements of a region and expressed in following steps:

$$D_C = \lim_{r \to 0} \left[ \log C(r) / \log r \right] \quad \text{... ... ... (1)}$$

$$C(r) = 2\, N_{R\langle r} / N(N-1) \quad \text{... ... ... (2)}$$

$$\boldsymbol{C(r) \sim r^{Dc}} \quad \text{... ... ... (3)}$$

C(r) - Correlation function

r- Distance between two epicenters

N- Number of event pairs separated by a distance R<r

For epicenter distribution with fractal structure

# Methodology

- For a seismic source zone frequency magnitude distribution (FMD) of earthquakes is assumed to be in accordance with the Gutenberg–Richter (G–R) relation (Gutenberg and Richter 1944) given by.

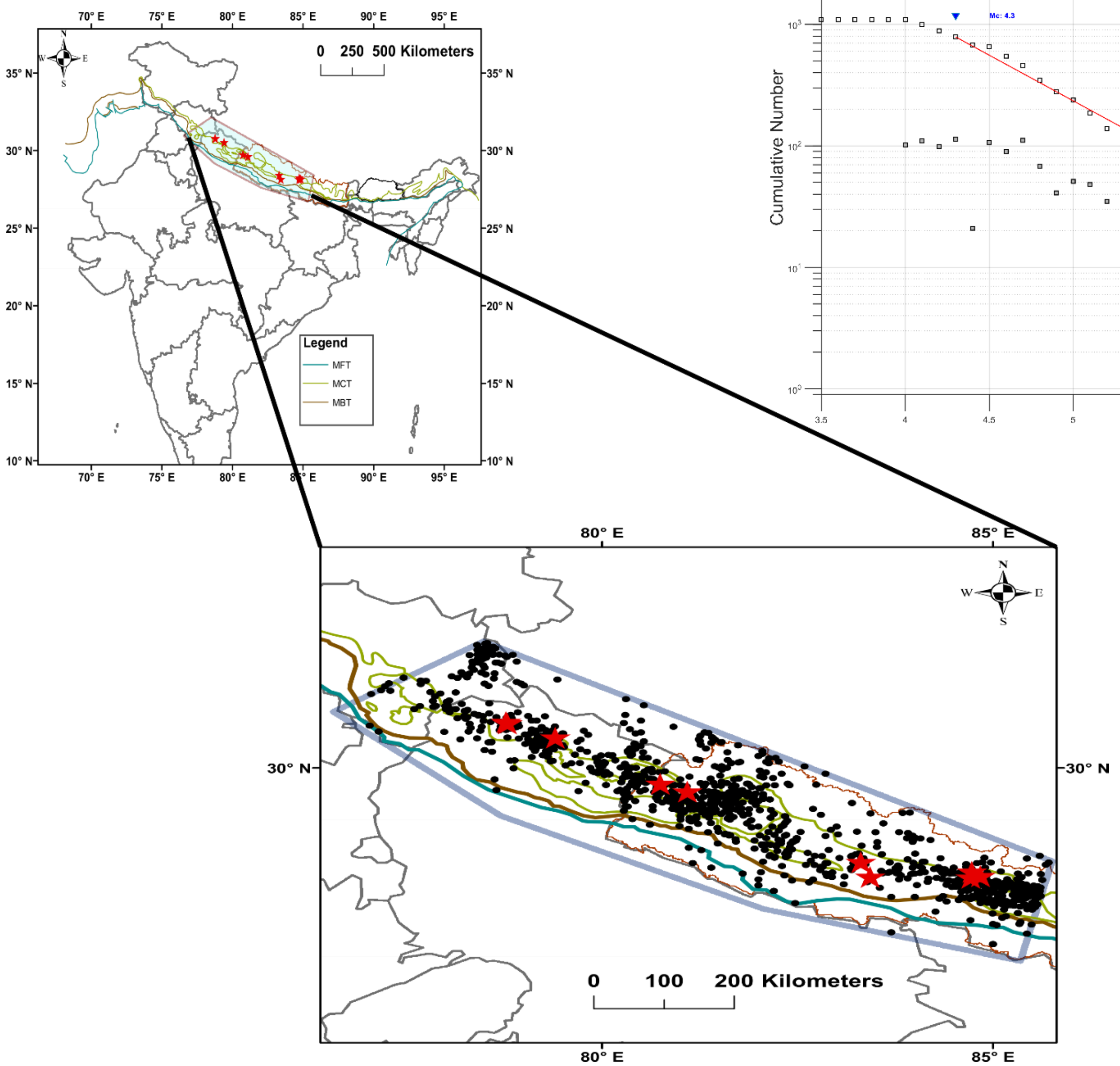
$$\log(N) = a - b(M) \quad \text{… … … (4)}$$

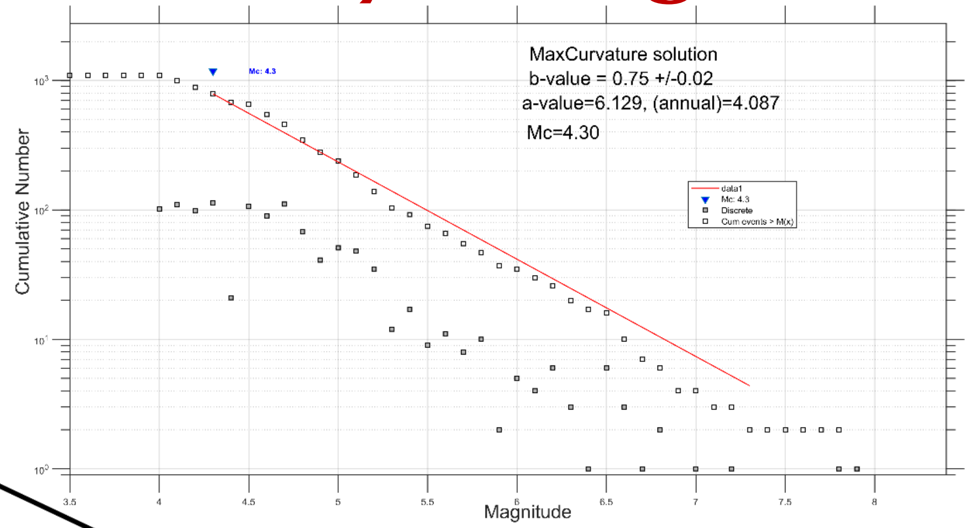
- A Modified Gutenberg–Richter (MGR)–Poisson model is chosen as a seismicity model. (Cornell and Van Marke 1969)

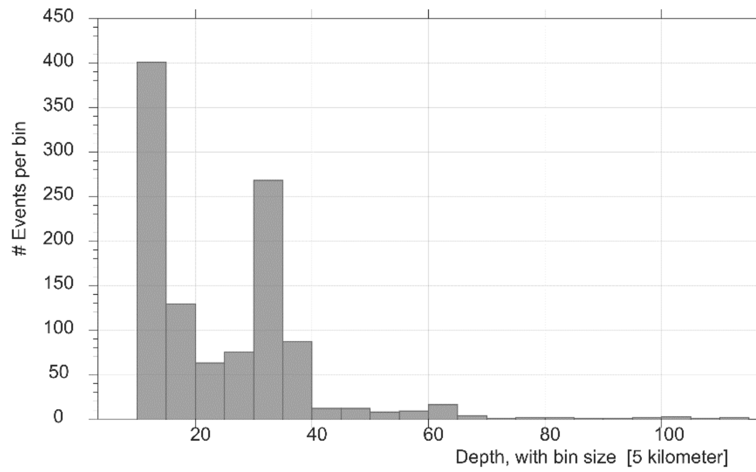
$$(\mathbf{M}) = \mathbf{o}\,\frac{\exp(-\mathbf{M}) - \exp(-\mathbf{Mmax})}{\exp(-\mathbf{Mo}) - \exp(-\mathbf{Mmax})} \qquad \textit{where}\ \mathbf{Mo} \le \mathbf{M} \le \mathbf{Mmax} \quad \text{… … … (5)}$$

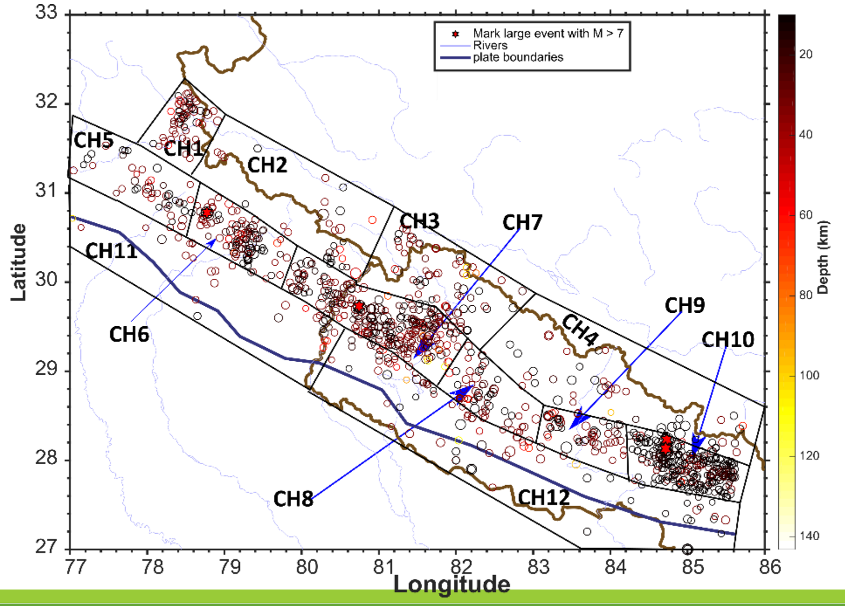
- The detailed procedure of homogenization of catalogue, duplicate earthquakes removal is further explained in Kumar et al., 2022.

# Study area: Central Himalayan Region

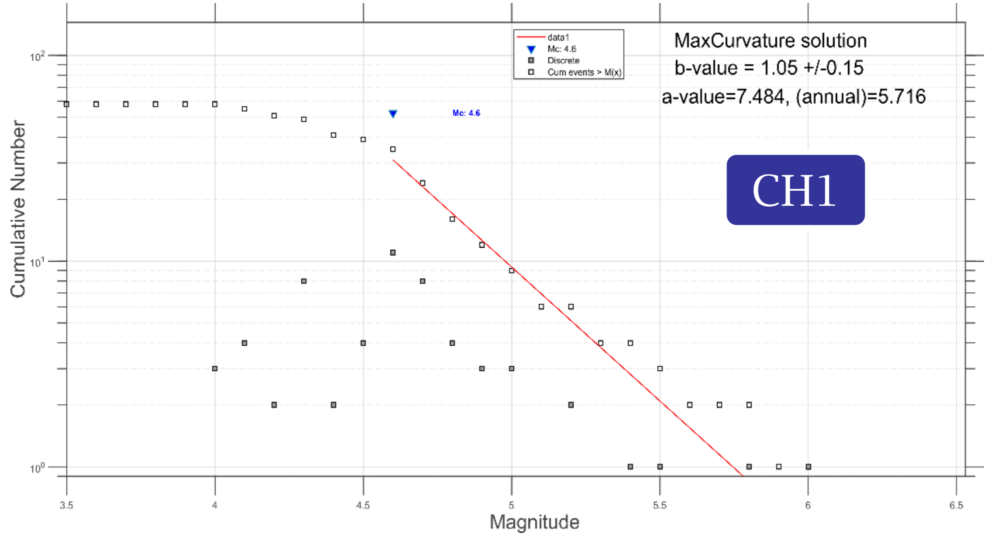


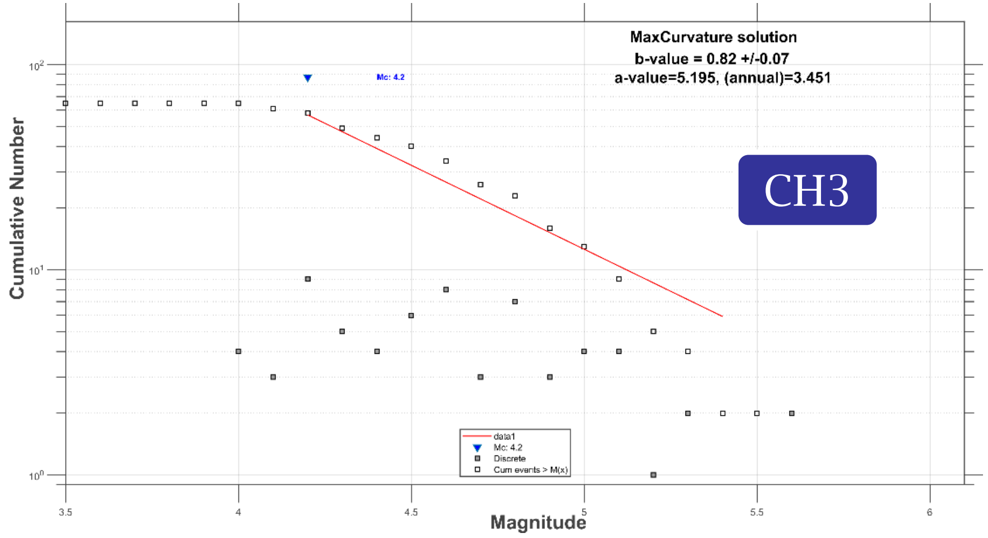



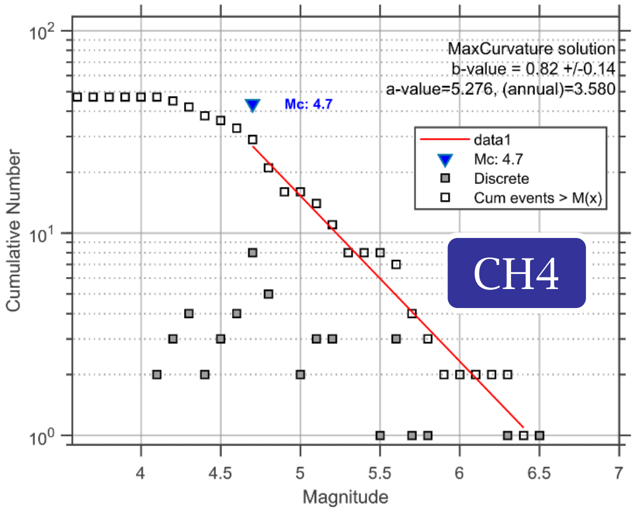



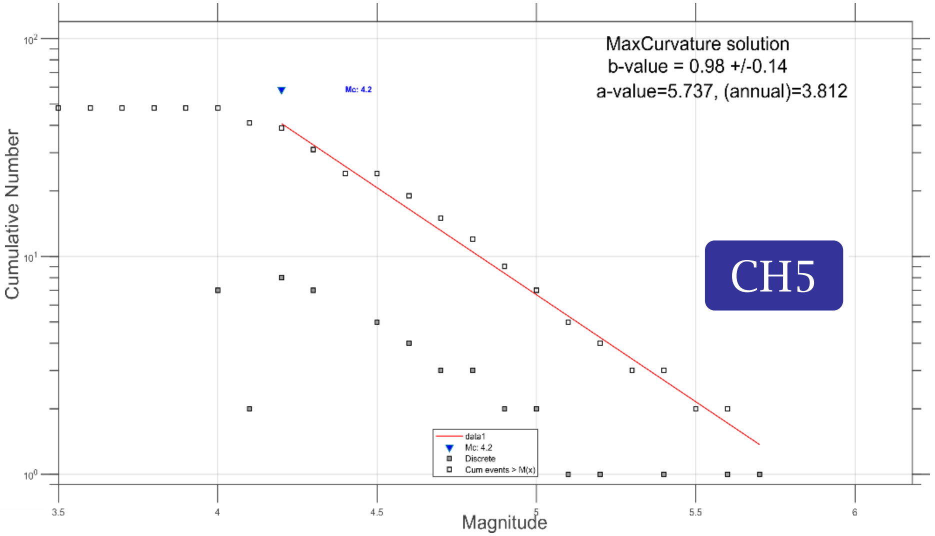



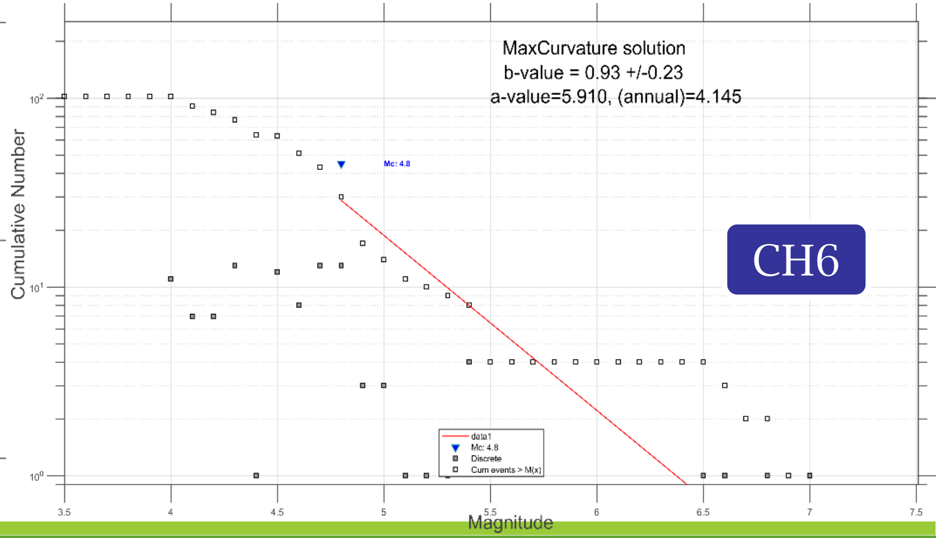
# FMD of Central Himalayan seismic zones:



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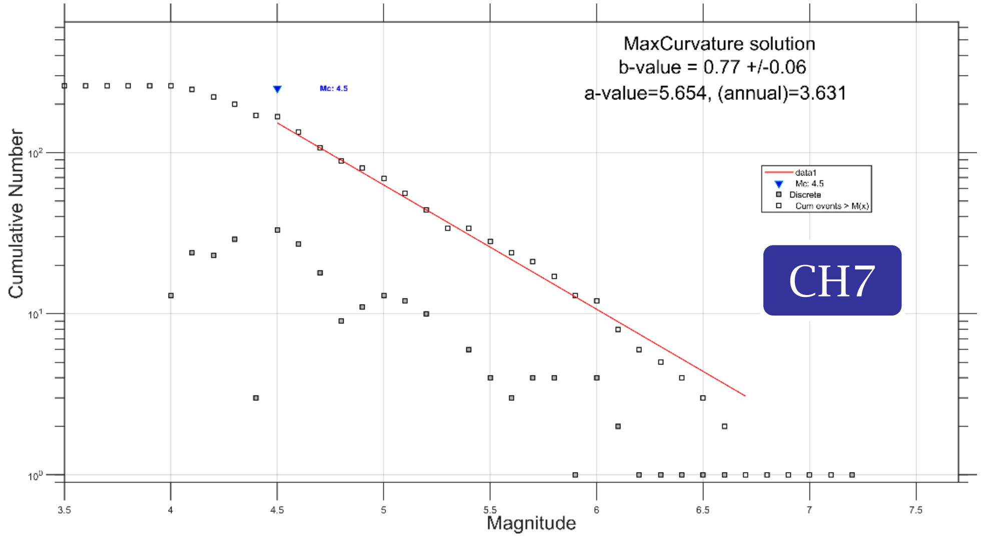
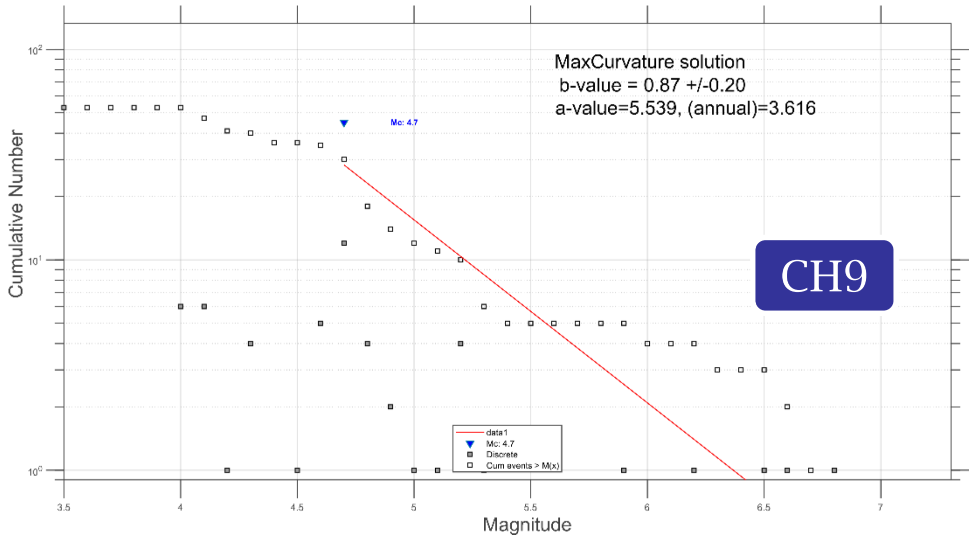
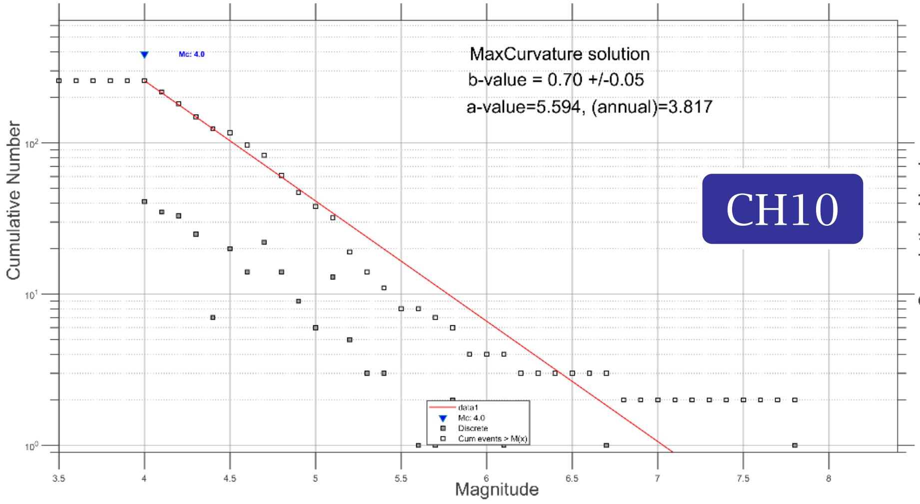
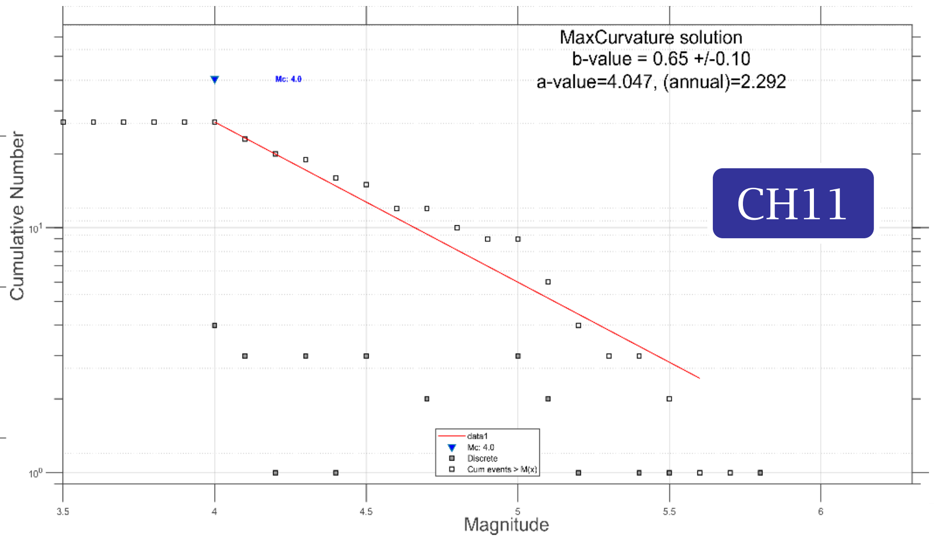
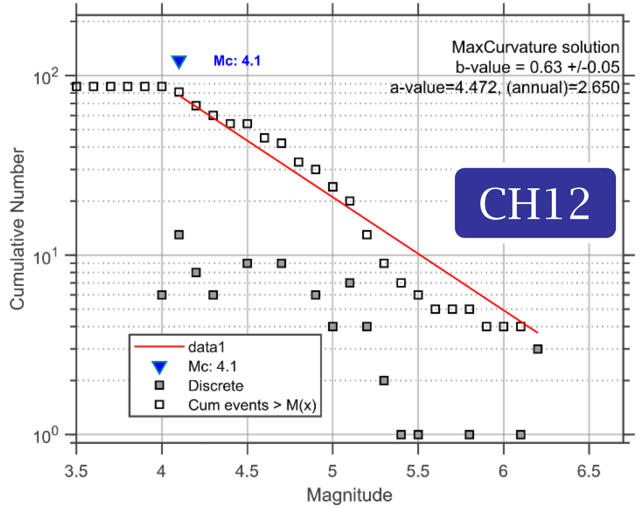


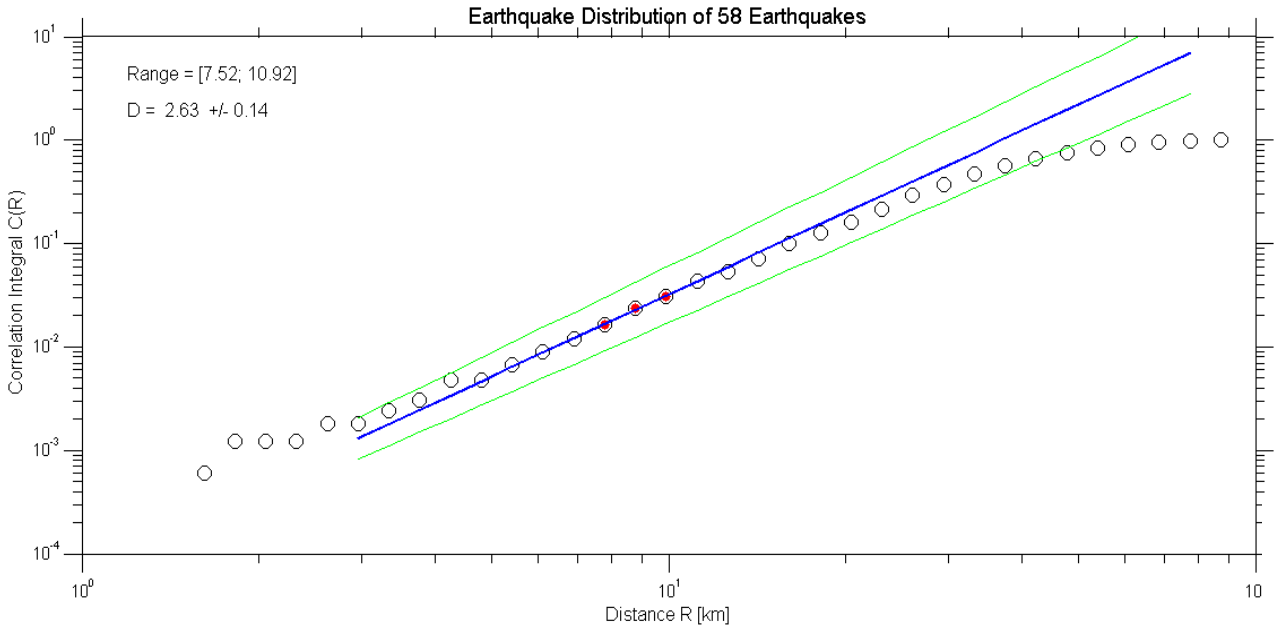



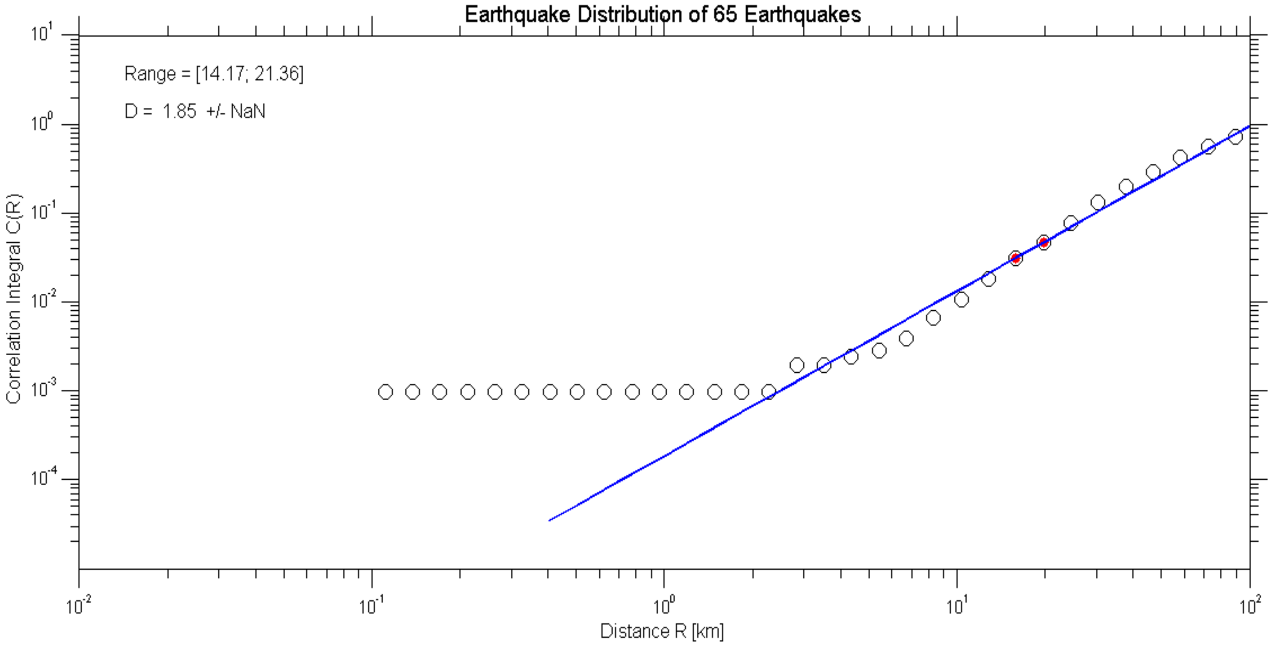



# Fractal Dimension (Dc) of Central Himalaya:




CH1
DC Value= 2.63

CH3
DC Value= 1.85



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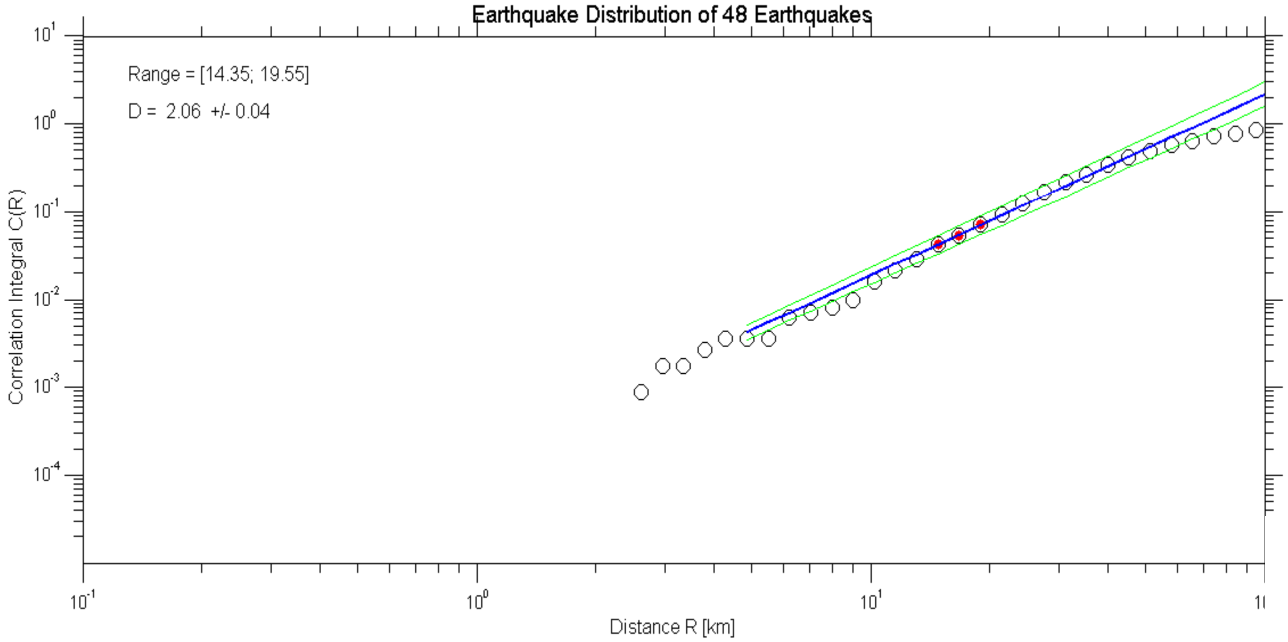
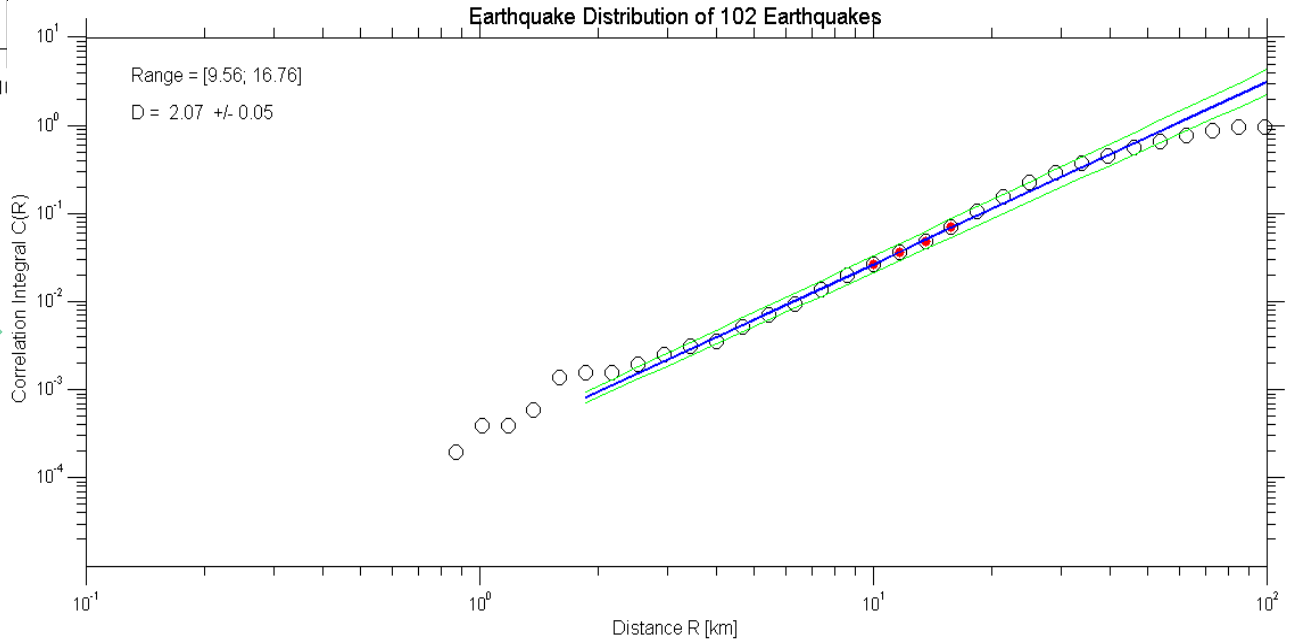



CH5
DC Value= 2.06

CH6
DC Value= 2.07



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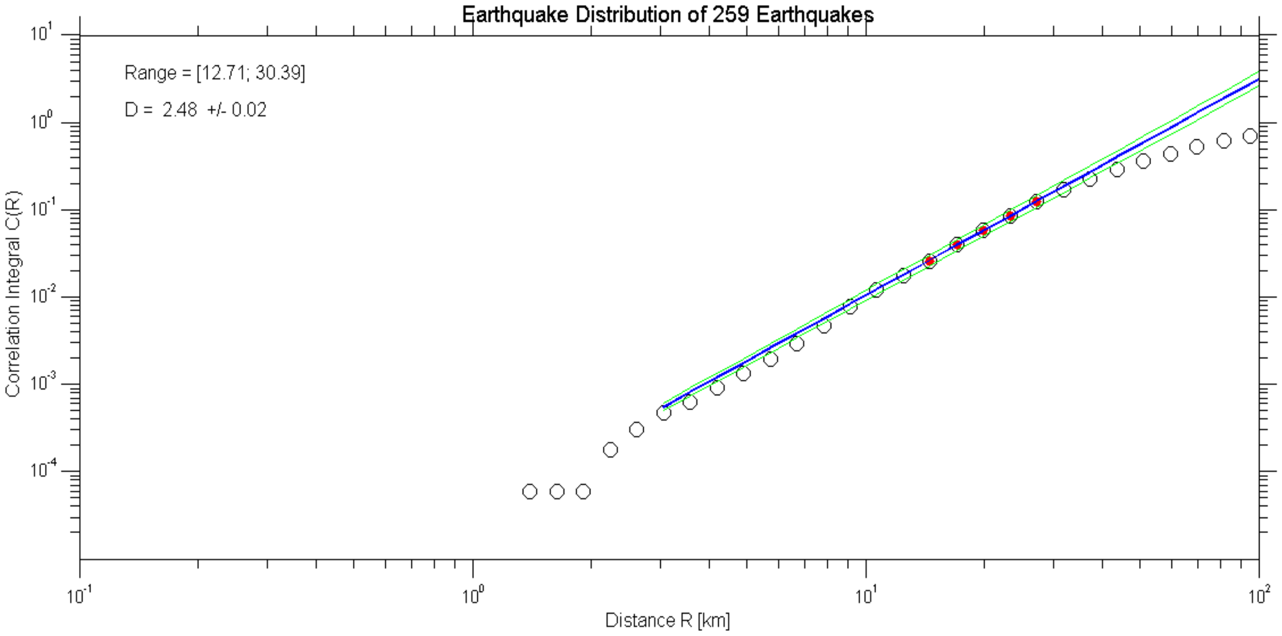
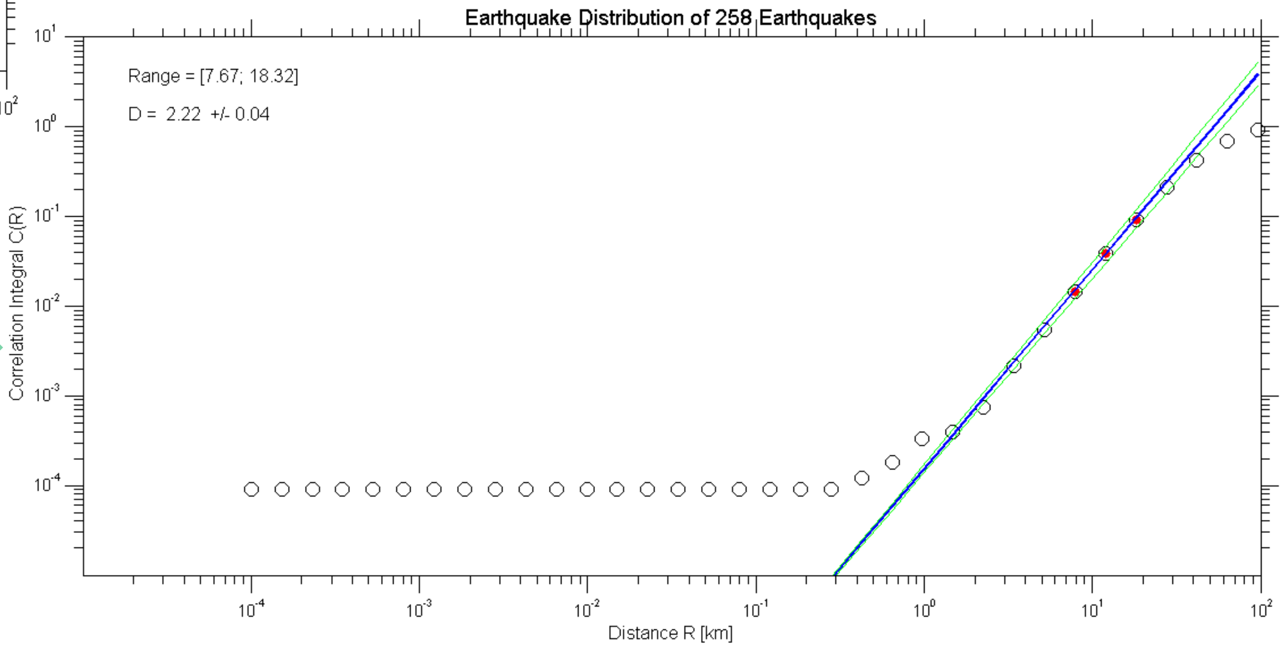



CH7
DC Value= 2.48

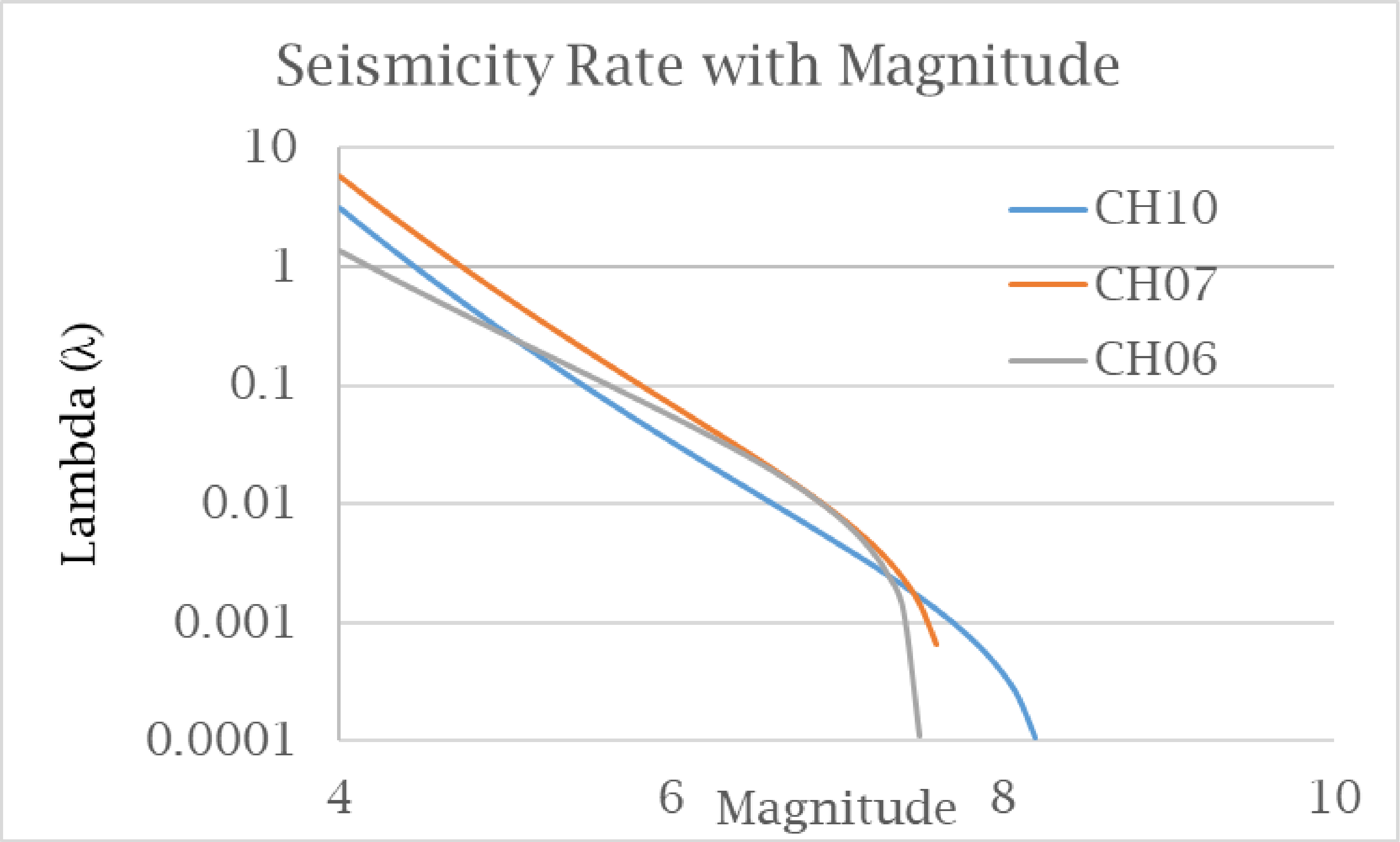
CH10
DC Value= 2.22



# Seismic parameters of Central Himalaya:

| Name of source zone | No of earthquake | Mmax_obs | b value | DC value |
|---|---|---|---|---|
| CH1 | 58 | 6.00 | 1.05 | 2.63 |
| CH2 | 30 | 6.50 | - | - |
| CH3 | 65 | 5.60 | 0.82 | 1.85 |
| CH4 | 47 | 6.50 | 0.82 | - |
| CH5 | 48 | 5.70 | 0.98 | 2.06 |
| CH6 | 102 | 7.00 | 0.93 | 2.07 |
| CH7 | 259 | 7.20 | 0.77 | 2.48 |
| CH8 | 62 | 5.60 | - | - |
| CH9 | 53 | 6.80 | 0.87 | - |
| CH10 | 258 | 7.80 | 0.70 | 2.22 |
| CH11 | 28 | 5.80 | - | - |
| CH12 | 87 | 6.20 | 0.65 | - |

# Seismic parameters of Seismic source (CH06,CH07&CH10)



# Conclusion

- ($\lambda_M$=4) is maximum for Zone CH7 (6.60).

- The calculated value of fractal correlation dimension Dc varies from 1.85 to 2.63, which shows that this region has high Dc value.

- The b-value changes between 0.65 and 1.05. Lowest b value (0.65) is calculated for Seismic Zone CH12 and seismic zone CH01 exhibited highest b value (1.05).

- The seismic Zone CH7 showed comparatively low b and high DC values. Conversely, seismic zone CH5 exhibited high b and low DC values.

- The clustering of seismic event is prominent in western part of Nepal (CH7 and CH10).

- The clustering of events are observed in seismic source near the Himachal Pradesh (CH1).

- The calculated seismic parameters will be useful for seismic hazard analysis of the study area.

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http://www.isc.ac.uk/iscbulletin/search/catalogue/

# THANK YOU