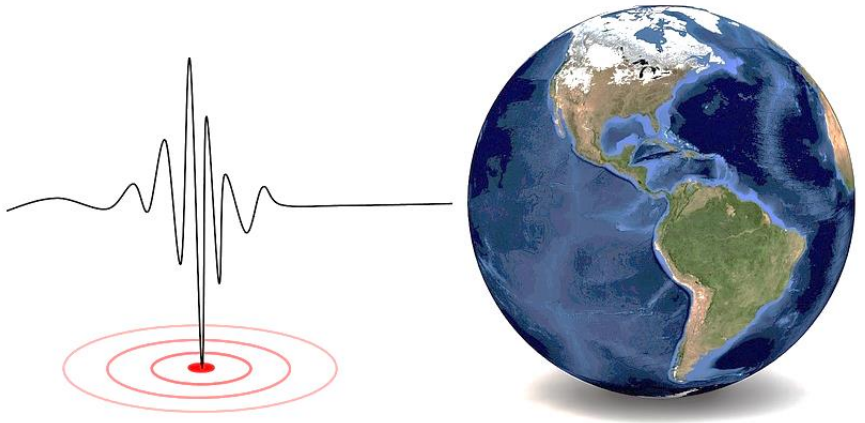
CSIR-Summer Research Training Program (SRTP)-2020

Frequency-Magnitude Relations & Hazard Estimation



By

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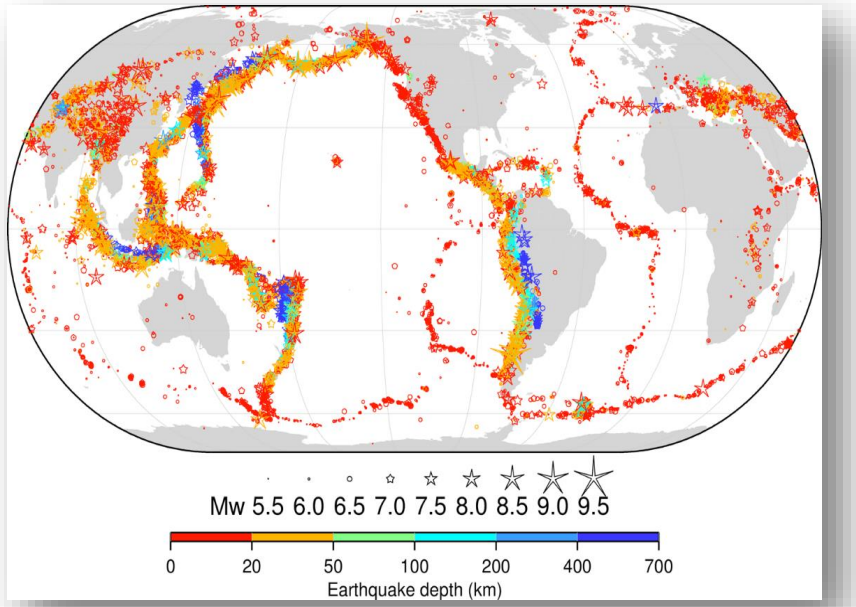
Frequency-Magnitude Distribution

The global distribution of earthquakes



Average number of earthquakes per year

Level	Richter Magnitude	Frequency/Year
Great	+8.0	1
Major	7.0-7.9	18
Destructive	6.0-6.9	120
Moderate	5.0-5.9	1000
Minor	4.0-4.9	6000
Generally Felt	3.0-3.9	49000
Potentially Perceptible	2.0-2.9	300,000
Imperceptible	<2.0	+600,000

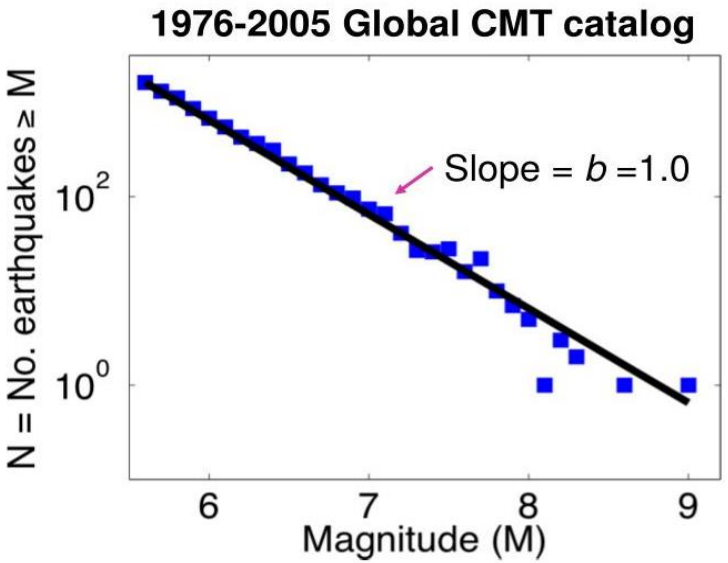
Basics of Frequency-Magnitude Distribution

- The Gutenberg–Richter relation (Gutenberg and Richter, 1944) is one of the well known empirical relations in seismology.

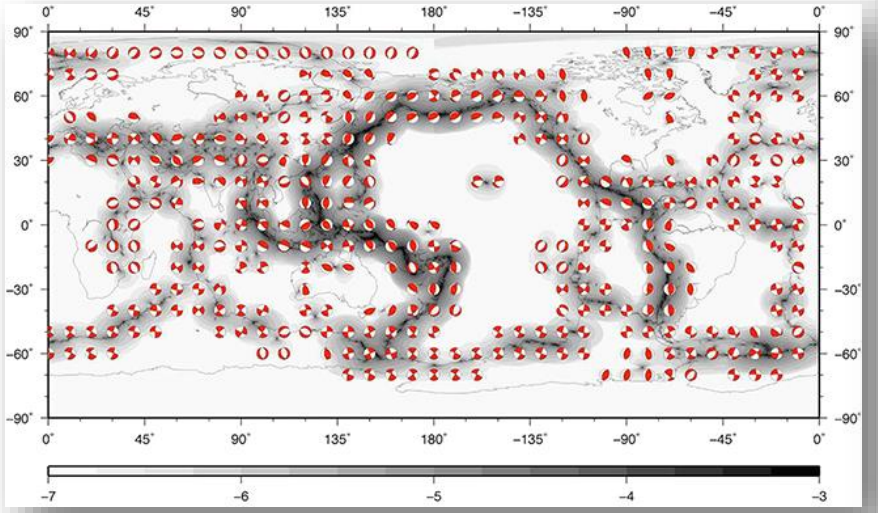
$$\log_{10} N = a - bM$$

- It is the robust method in understanding the plate dynamics and assessing the earthquake hazard analyses.

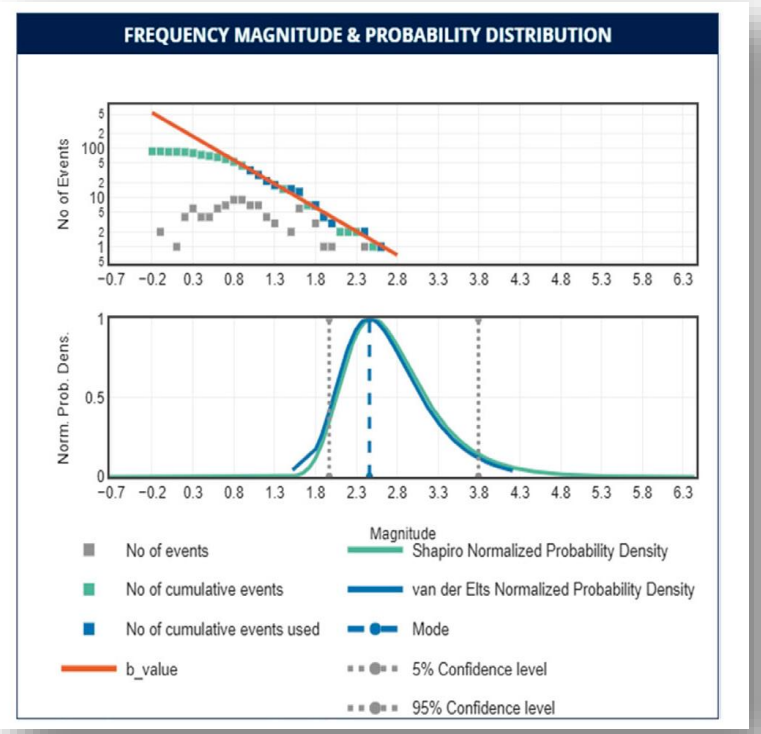
The global Gutenber-Ritcher Frequency-Magnitude distribution



Log_{10} probability of earthquake occurrence, $M_W > 5.8$ eq/day (100km)^2



Kagan and Jackson (2014)



Sepideh Karimi and Dario Baturan, 2018

- ✓ a is the productivity
- ✓ b is the b-value
- ✓ N is the number of earthquakes per year of magnitude M

Spatio-temporal variation of b-value

b-Value Estimation

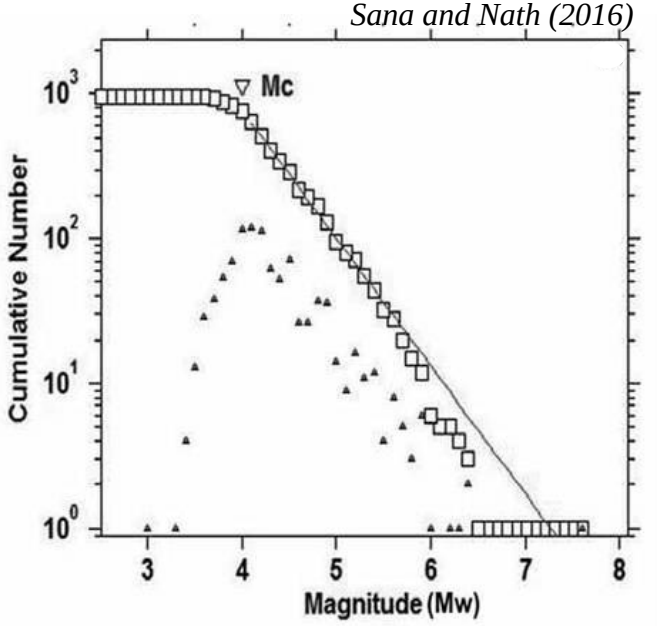
✓ **The Least-Square Fit Method:**

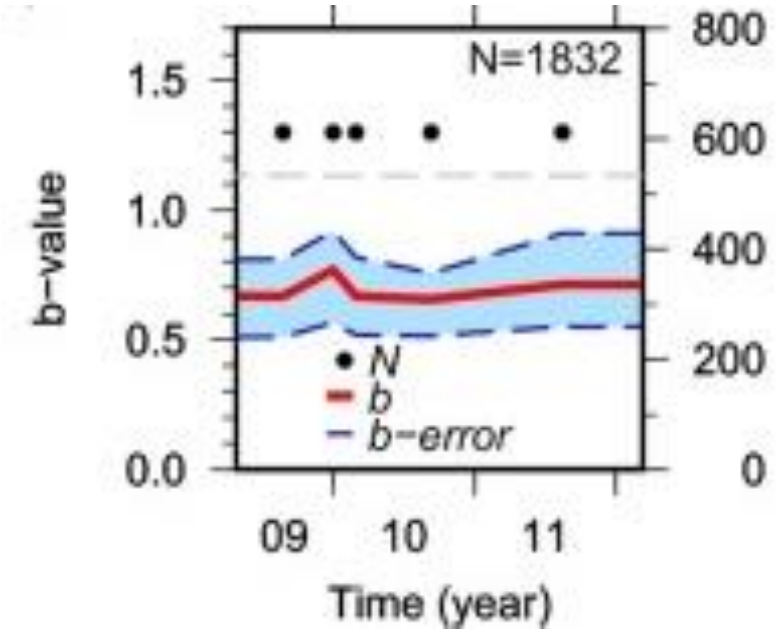
The log values of the cumulative number of earthquakes (N) are plotted against magnitude (M).

✓ **The Maximum Likelihood Method:**

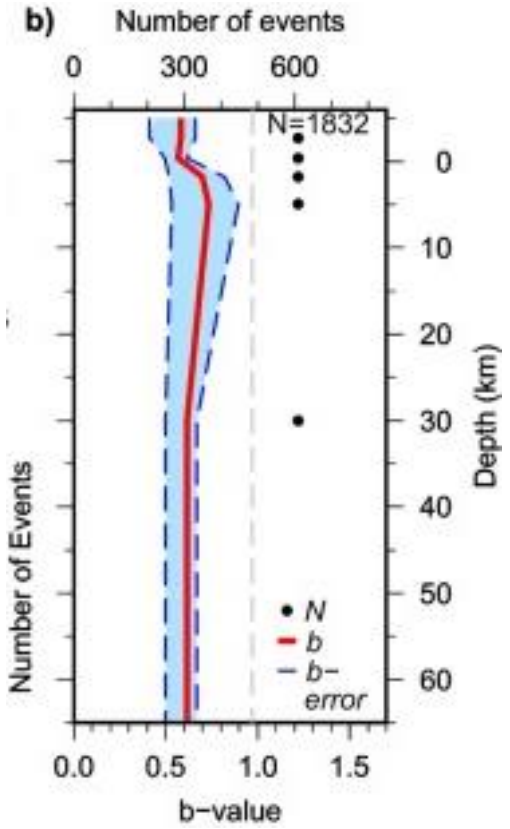
The maximum likelihood estimate of b-value is given by Aki (1965) – $b = \log_{10}e/M\text{-}M_0$

Sana and Nath (2016)



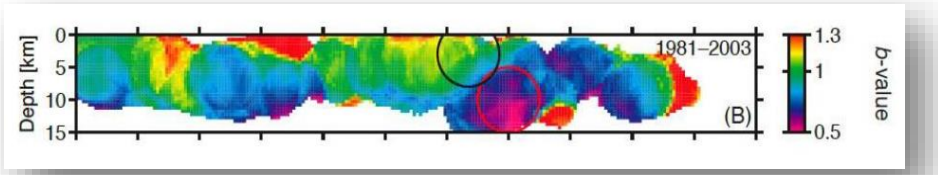


Maher and Kendall (2018)



b-value Variation	Faulting Style
b < 1	Thrust Fault
b = 1	Strike-slip Fault
b > 1	Normal Fault

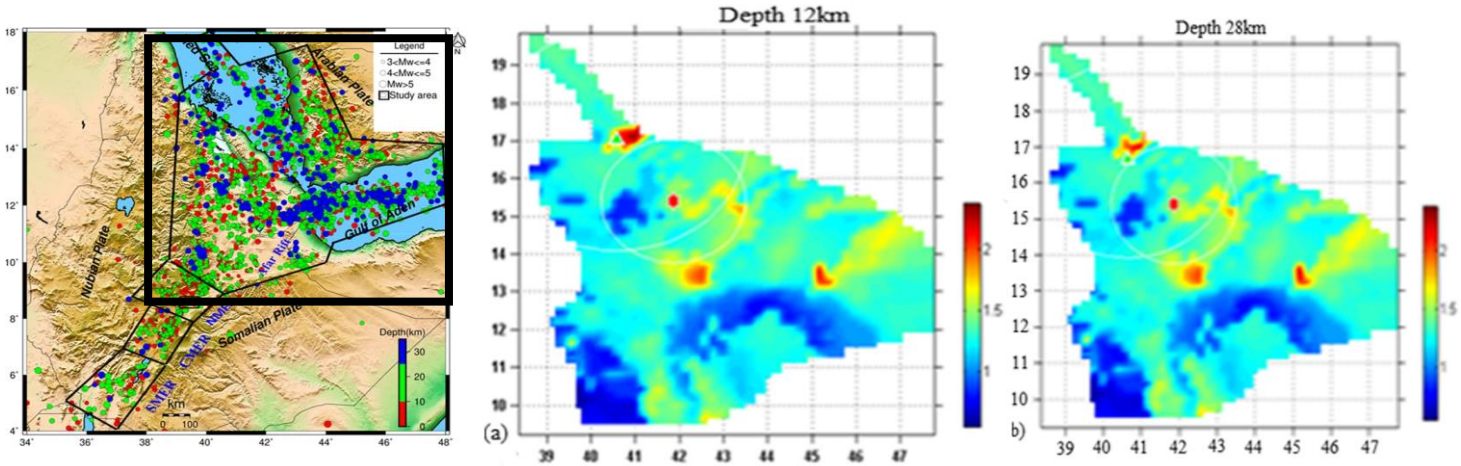
Case study of variability of b-value with location



Wiemer and Schorlemmer (2007)

Global Scenario of b-value

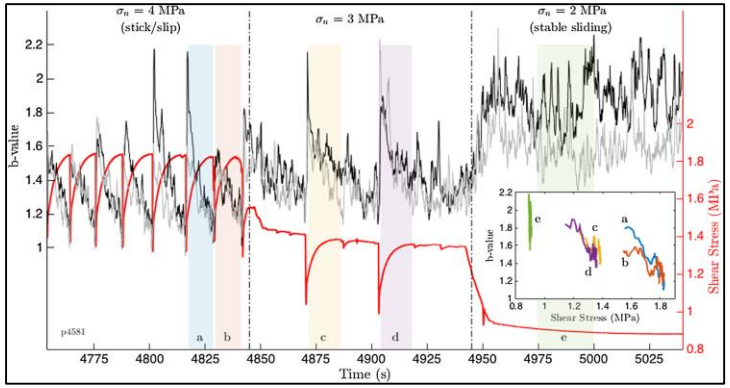
Continental Rift- b-value is related to the state of stress of a region



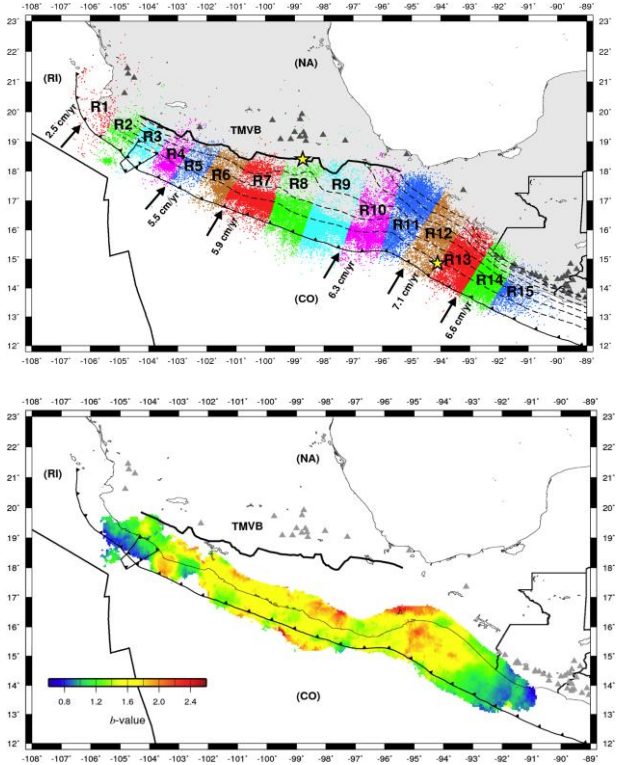
Depth slices of b-value for Afar Rifts (Including Red Sea and Gulf of Aden);at depth of (**a**) 12 km (**b**) 28kM. *(Lamessa et al., 2019)*

Evolution of b-value with seismic cycle on a simulated fault

Shear stress and b-value evolution as a function of time during the transition between stick–slip, at 4 MPa, irregular stick–slip, at 3 MPa and stable sliding at 2 MPa. (*Rivière et al., 2017*).

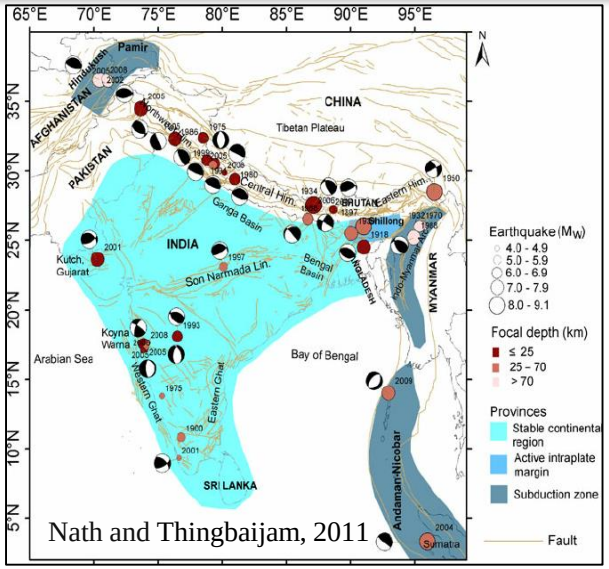


Subduction Zone-b-value depends on state of stress and faulting style

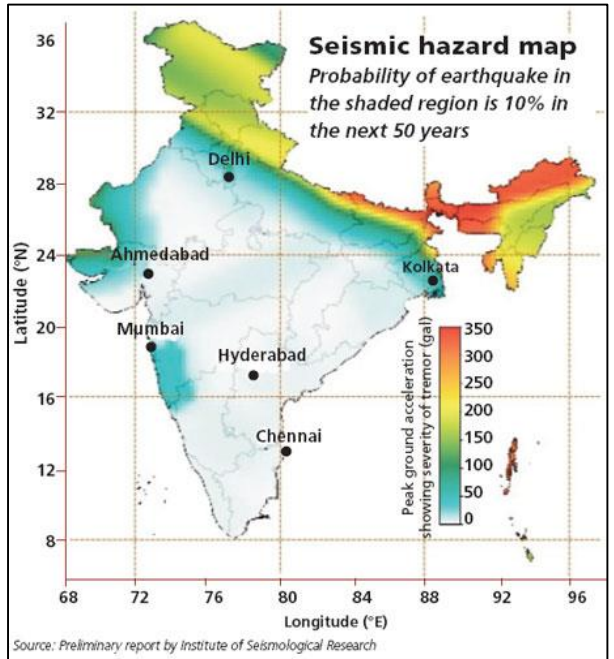


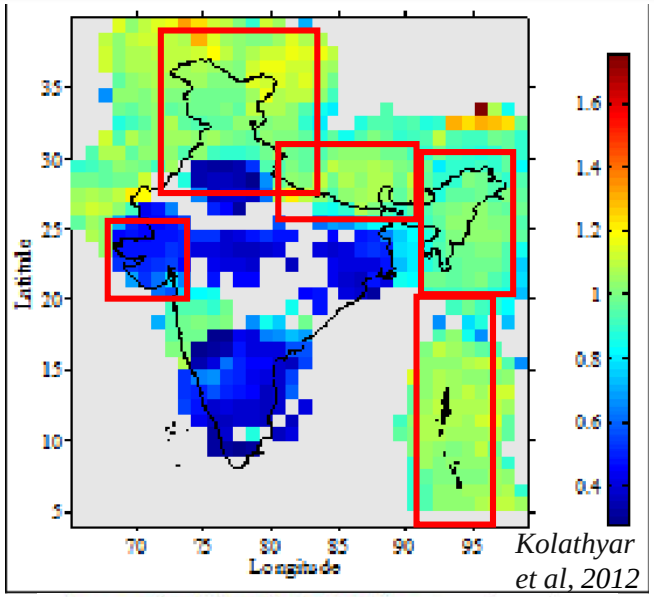
Mexico Subduction zone. Color indicates the segmentation (R1 to R15) used to study spatial *b*-value depth variations. Stars show the epicentral location of the 8 and 19 September 2017 normal-faulting intraplate events. (*Pérez and Zuñiga, 2018*)

Seismo-tectonics and b-value study in Indian context



Nath and Thingbaijam, 2011

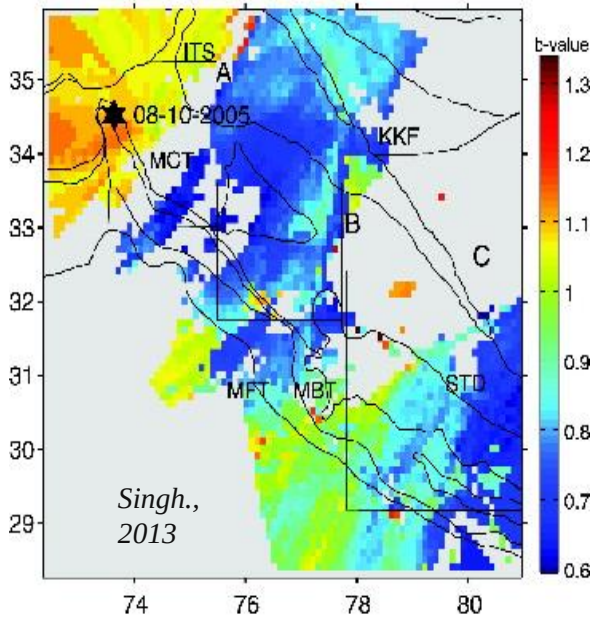




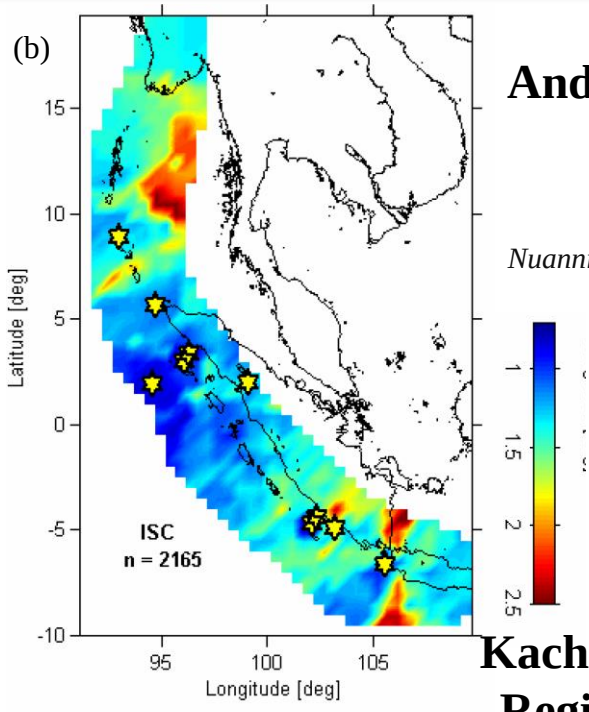
Kolathyar et al, 2012

North-West Himalaya

(a)



(b)



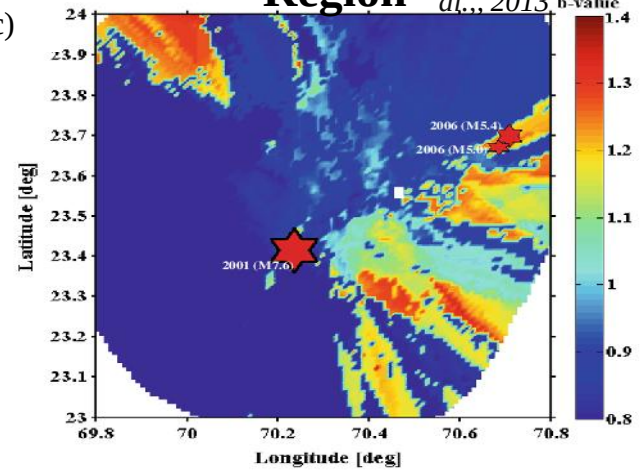
Andaman-Sumatra Trench

Nuannin, 2006

Kachchh Region

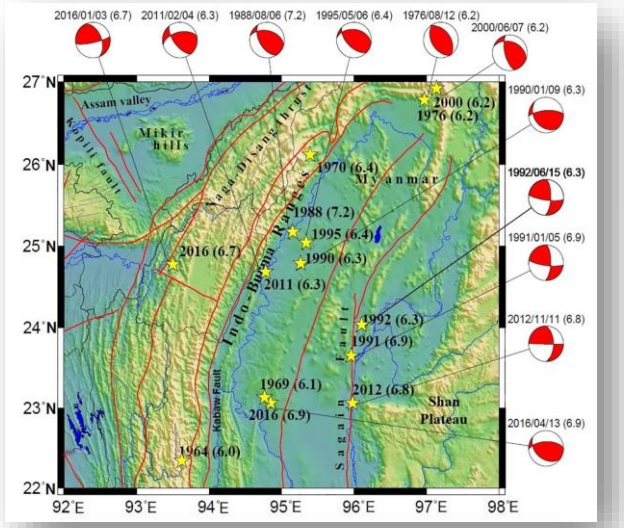
Singh et al., 2013

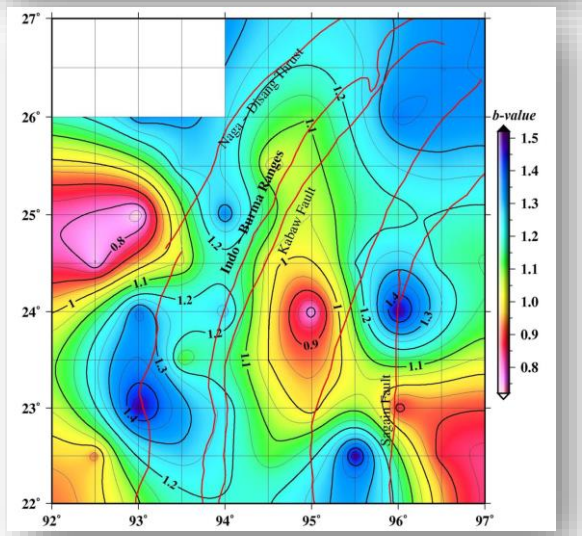
(c)



Indo-Burmese Wedge

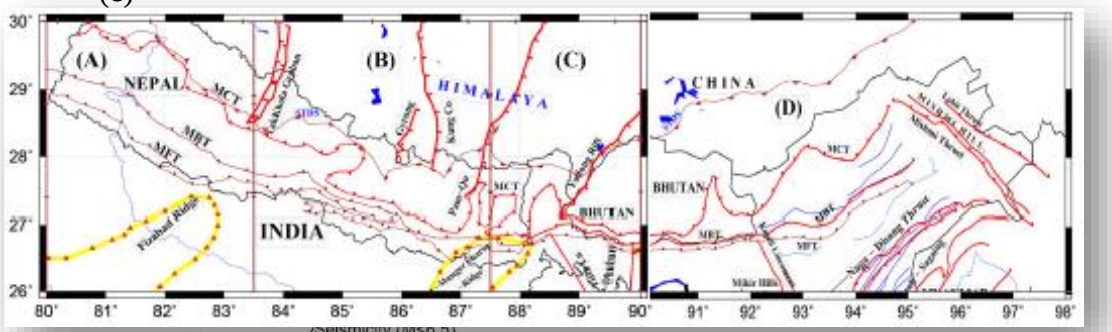
(d)

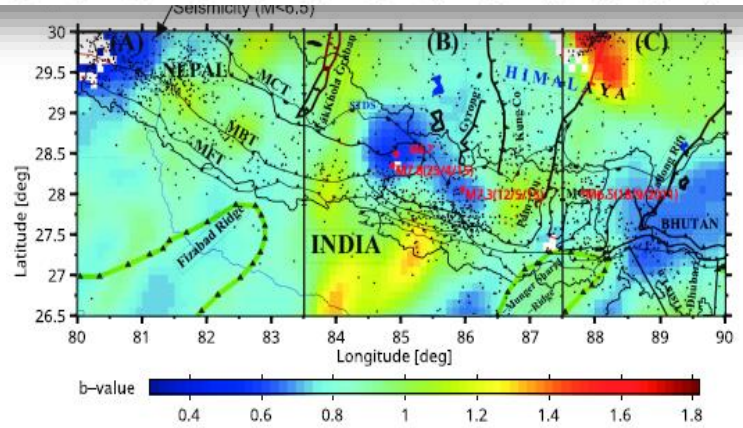


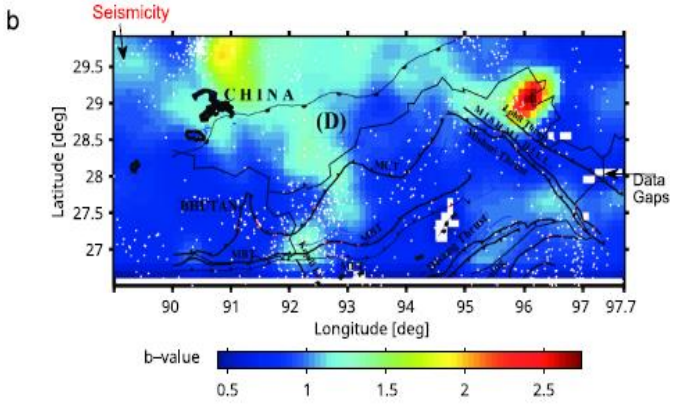


Bora et al., 2018

(e)







Kumar and Sharma, 2019

Central and North-East India

- **High b-value-** low stressed region; small to moderate earthquakes.
- **Low b-value-** high stressed; moderate to large earthquakes

Continuous fall of b-value for over a decade just before the Nepal earthquake

THANK YOU