Frequency-Magnitude Relations

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1 Basics of Frequency-Magnitude Distributions

- Sir introduced the global distribution of earthquakes
- Majority of earthquakes occur due to collision of tectonic plates
- Some earthquakes are shallow-depth, mid-depth, deep-depth earthquakes
- the earthquakes which happen in the deeper parts and ones which happen in the shallow parts, both have many differences as far as hazard estimation is concerned.
- The earthquakes which occurs less than 15 km is less hazardous than the one that occurs at a depth of 100 km. As a result shallow depth earthquakes are generally more hazardous than deep-depth earthquakes. This is because, Shallow quakes generally tend to be more damaging than deeper quakes. Seismic waves from deep quakes have to travel farther to the surface, losing energy along the way. Shaking is more intense from quakes that hit close to the surface like setting off "a bomb directly under a city.
- Surface waves cause the most damage to things like highways, bridges and buildings. Surface waves are one of four types of seismic waves generated during an earthquake. The four types of seismic waves present during an earthquake are primary waves, secondary waves, Rayleigh waves and Love waves. Rayleigh and Love waves are the two types of surface waves. Rayleigh waves are the surface waves responsible for the rolling or heaving during an earthquake. Love waves are responsible for sideways movements. The other, less destructive types of waves present during an earthquake are primary and secondary waves. Primary waves travel quickly through liquid and solid matter. Secondary waves travel through solids and move more slowly.
- Seismic waves (generally surface waves) are more destructive in water or liquids rather than solids or rocks. This is because, in rocks, the waves dissipate easily as the energy is not transferred due to the relatively lower atomic density in liquefied objects.
- The difference in the magnitude of earthquake can give difference in the energy in an exponential manner.
- The energy increases by x times when the magnitude difference is m such that

$$x = 10^{1.5\times m}$$

- So for magnitude difference of 1, for eg., from 3.0 to 4.0 on the m_b scale, the energy increases by $10^{1.5}$ i.e almost 32 fold increase. But for magnitude difference of 2, for eg., from 3.0 to 5.0 on the m_b scale, the energy increases by $10^{3.0}$ i.e. 1000 fold increase
- We will use the Guttenberg-Richter relation to determine hazard,

$$\log_{10} N = a - b \cdot M$$

Where N is the frequency or number of events having a magnitude $\geq$ M and a is the coefficient of seismicity and b is the coefficient used for hazard estimation.

2 Spatio-temporal variation of b-value

2.1 b-value Estimation (Check this section once)

- The Least Square Fit Method - used generally in areas where seismicity is small
- The Maximum Likelihood Method - used generally for areas where seismity is large

2.2 b-value variation (Check this section)