LECTURE NOTES: EMGT 234

SOURCE:

Polat Gulkan, Mustafa Erdik, 1988. "Probabilistic Tools in Earthquake Hazard Forecast: A Case Study for Turkey", Seismic Hazard in Mediterranean Regions, 229-253.

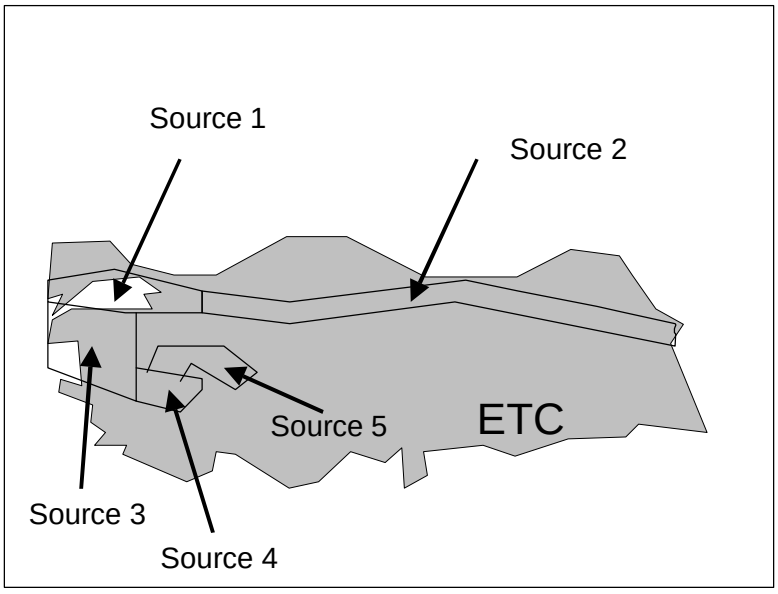
Question 1: How often do Earth Quakes Occur?

The Region in question has a finite number of sources that could produce measurable earthquakes: j=1,. . . ,N

Definition:
An Earthquake is measurable when its intensity falls between intensity levels $[i_{min}, i_{max}]$

A single source generates Earth Quakes following the Poissonian Law:

- Let ν_j be the annual rate of number of earthquakes from source j.



- Let $[0, t]$ be a time period under consideration. For example, the next 10 years.

- Let $N_j(t)$ be the total number of earth quakes from Source j in the period $[0, t]$.

$$Pr(N_j(t) \quad n) \quad \frac{(\nu_j \quad t)^n}{n!} e^{-(\nu_j \, t)}$$

- Let T_j the time between two consequtive earthquakes from source j

$$Pr(T_j \quad t) \quad 1 - e^{-(\nu_j \, t)}$$

Question 2: Given that an Earth Quake occurs what is the likelihood of its intenstiy level

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Assessing Conditional Probability Distribution for Intensity Levels in from a particular source

Assumption:
Intensity level of interest ranges from $[i_{min}, i_{max}$

For example:

i_{min} = 2.0 on Richter Scale

Notation: EQ = Earthquake

Definition:

$n(i)$:= the number of EQ's with intensity level more than i in a geographic region

Past studies have shown that:

$$n(i) = exp(a + b(i - i_{min})),\ b < 0$$

n_{min} the number of EQ's with intensity level more than i_{min}

n_{max} the number of EQ's with an intensity level more than i_{max}

STEP 1:
Determine total number of EQ's of interest (those that caused some level of damage) for a particular geographic region and set this equal to n_0. Assume that there is one Earth Quake of level higher than i_{max}. Set

$$n_{min} \quad n_0 + 1$$

Solve for the constant a, via

$$n_{min} \quad exp(a)$$

STEP 2:
Go back into your historical data set and determine the EQ with the highest intensity level. Set i_{max} equal to this intensity level. Assumption, n_{max} = 1.

Solve for the constant b, via

$$n_{max} = exp(a) \quad exp(i_{max} - i_{min})),\ b < 0$$

$$1 \quad n_{min} \quad exp(b \quad (i_{max} - i_{min}))$$

$$\Rightarrow b \quad \frac{Ln \ \frac{1}{n_{min}}}{i_{max} - i_{min}}$$

Note:

- **Constant a** depends on the length of the time period over which Earth Quakes have been recorded and the number of Earth Quakes recorded in this period.

- **Constant b** depends on the maximum intensity level observed over the time period and the lowest intensity level of interest.

STEP 3:

$$Pr(EQ\ of\ intensity\ [i_{min}, i_{max}\ ) \qquad \frac{n_{min}-1}{n_{min}}$$

STEP 4:

$$Pr(EQ of\ intensity\ [i_{min}, i\ ) \qquad \frac{n_{min} - n(i)}{n_{min}}$$

STEP 5:

$$Pr(EQ\,of\,intensity\,[i_{low}, i\ \,|EQ\,of\ \,intensity[i_{min}, i_{max}\ )$$

$$\frac{Pr(EQ\,of\,intensity\,[i_{low}, i\ \,)}{Pr(EQ\,of\ \,intensity\,[i_{min}, i_{max}\ )}$$

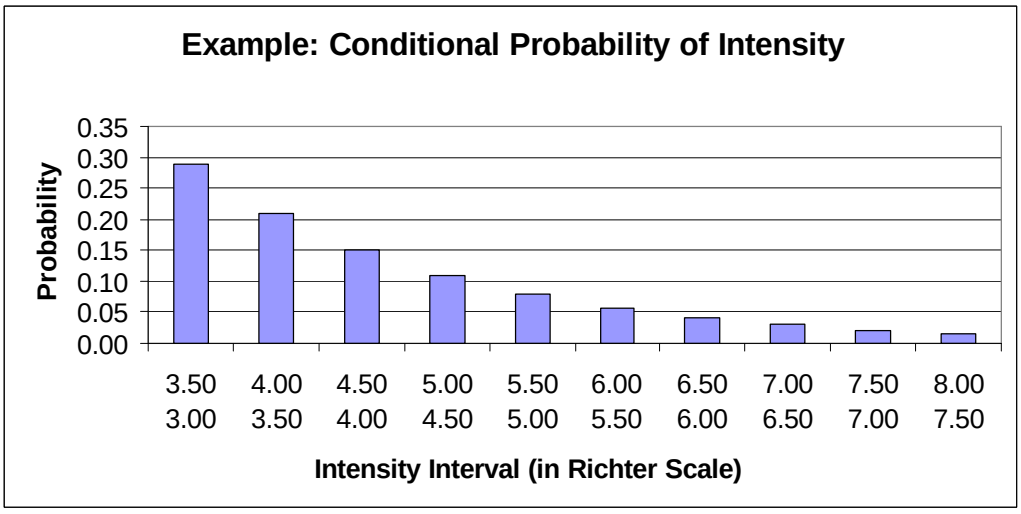
$$\frac{n_{min} - n(i)}{n_{min}} \quad \frac{n_{min}}{n_{min} - 1} \quad \frac{n_{min} - n(i)}{n_{min} - 1}$$

or using

$$n = exp(a + b(i - i_{min}))$$

$$Pr(EQ\,of\,intensity i_{low}, i\ \,|EQ\,of\ \,intensity\,[i_{min}, i_{max}\ )$$

$$\frac{exp(a) - exp(a + b(i - i_{min}))}{exp(a) - 1}$$



Question 3: Given that an Earth Quake occurs at a source with intensity i what is the intenstiy at a certain site a particula distance away from the source

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Let:

i_s : $Intensity\, at\, the\, site$
i : $Intensity\, at\, the\, source$
R : $Distance\, away\, from\, the\, source.$

$$i_s \quad i - w(R) + \epsilon$$

where

$w(R)$: $Some\, function\, of\, R$
ϵ : $Some\, random\, error\, term$