Earthquake: The Wrath of Mother Nature

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Msc. Data Analytics

Data Visualization

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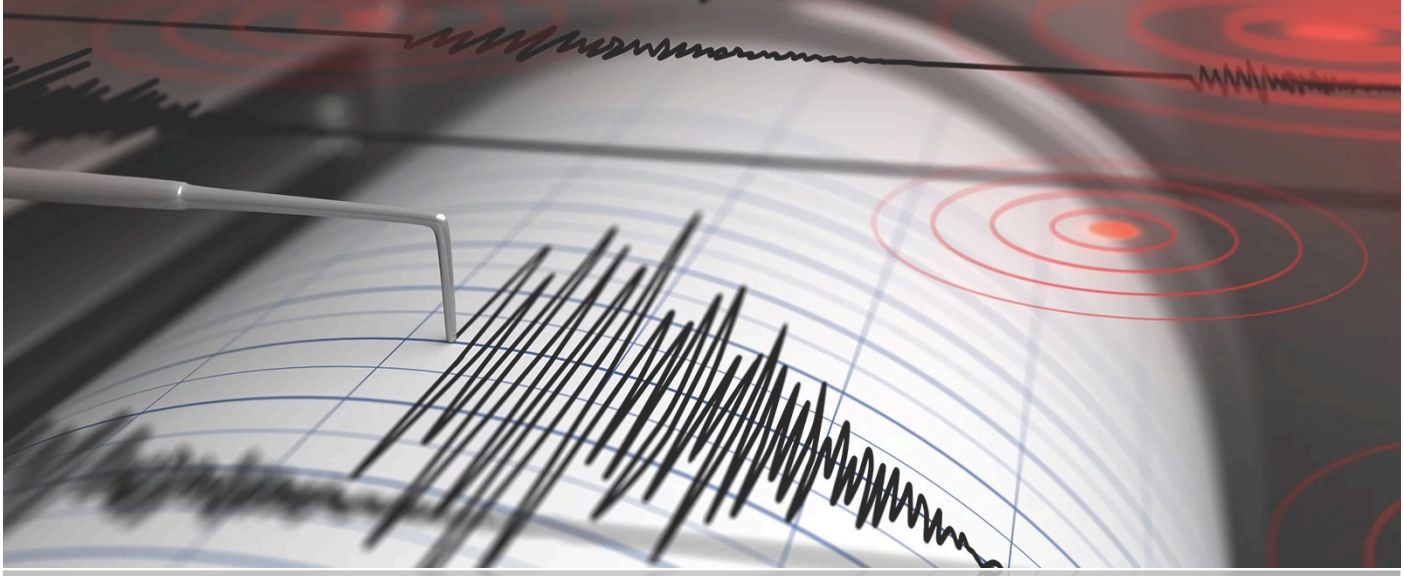

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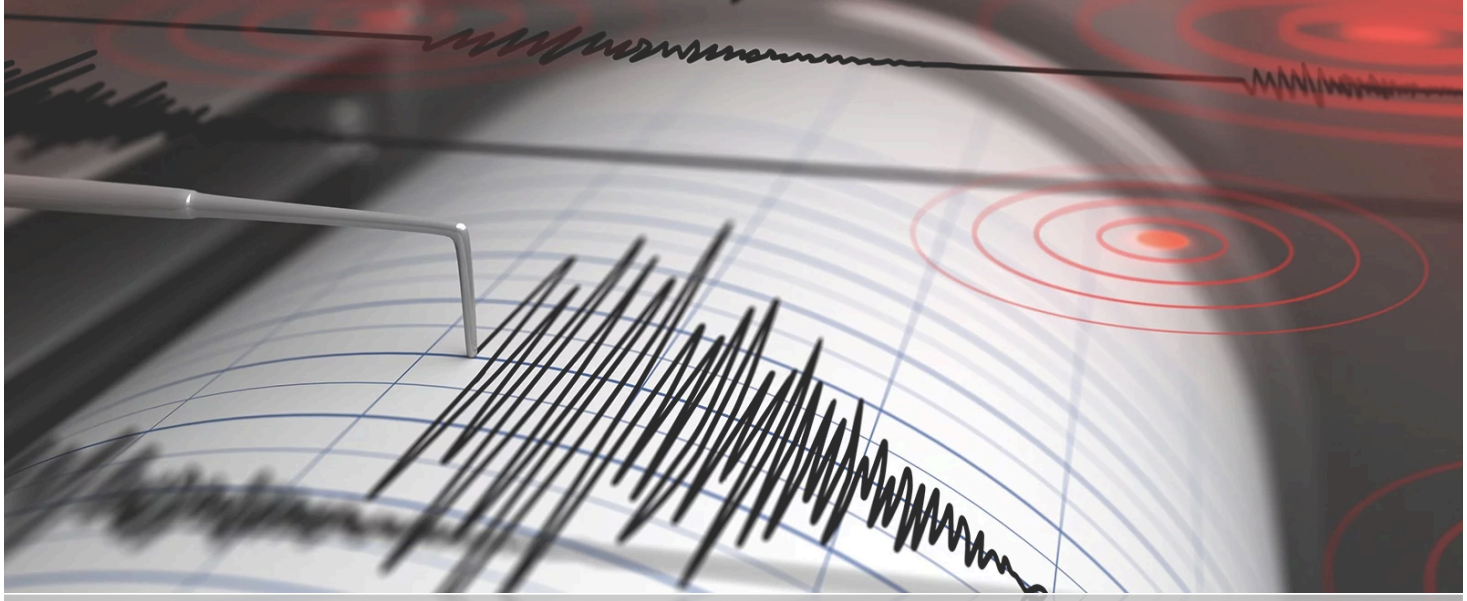

Earthquake: The Wrath of Mother Nature

- **500,000** earthquakes happen every year on average out of which near about 100 cause severe damage and only 100,000 can be felt by us.
- **9.5** magnitude is the highest recorded earthquake in 1960 in Chile.

Introduction

We all are very well aware of the movie “2012”. Those who haven’t seen the move, it is a depiction of ultimate destruction and a visual display of apocalypses. There are many natural phenomenas which can bring some serious amount of destruction but the most commonly observed among these is earthquake. The earthquake is a natural phenomena which takes place due to sudden disturbance in the tectonic plates of the earth near to the crust. Basically, it is caused due the vibration in the crust. They standout as the most sensitive and critical phenomena as it effects the human life in many ways. Earthquakes not only cause human casualties but also bring a mass destruction which results in great economic losses to the state.

Very well known Ring of Fire, which is shown in Figure 1, is the area in Pacific Ocean which considered as the home of many earthquakes and active volcanoes. The purpose of this report is to study the trend of the occurrence of earthquake in one of the regions from this Ring of Fire, the Indian subcontinent which is at a certain distance from Ring of Fire and the Middle East countries and Russia which are far from the Ring of Fire. So let us being with the studies noted for Japan.

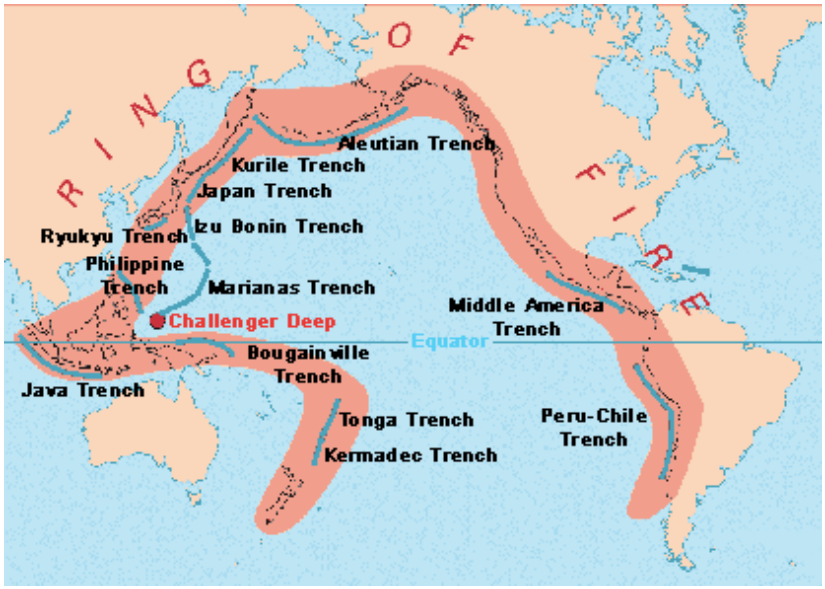

Figure 1 - Ring of Fire

The Japan Case Study

Japan is considered to be the most prominent region for occurrence of the earthquake and volcanoes. The major reason for this is the location of Japan. Japan lies on the hot spring.

The Figure 2 shows the earthquake with highest magnitude(mb) in past one decade recorded in Japan. From this figure we can interpret that in 2011 the largest earthquake has been recorded. Whereas, less severe earthquake is observed in year 2017 with magnitude of 6.30 mb(body-wave magnitude).

The maximum magnitude of the earthquake cannot indicate the frequent occurrence of the earthquake with the same intensity.

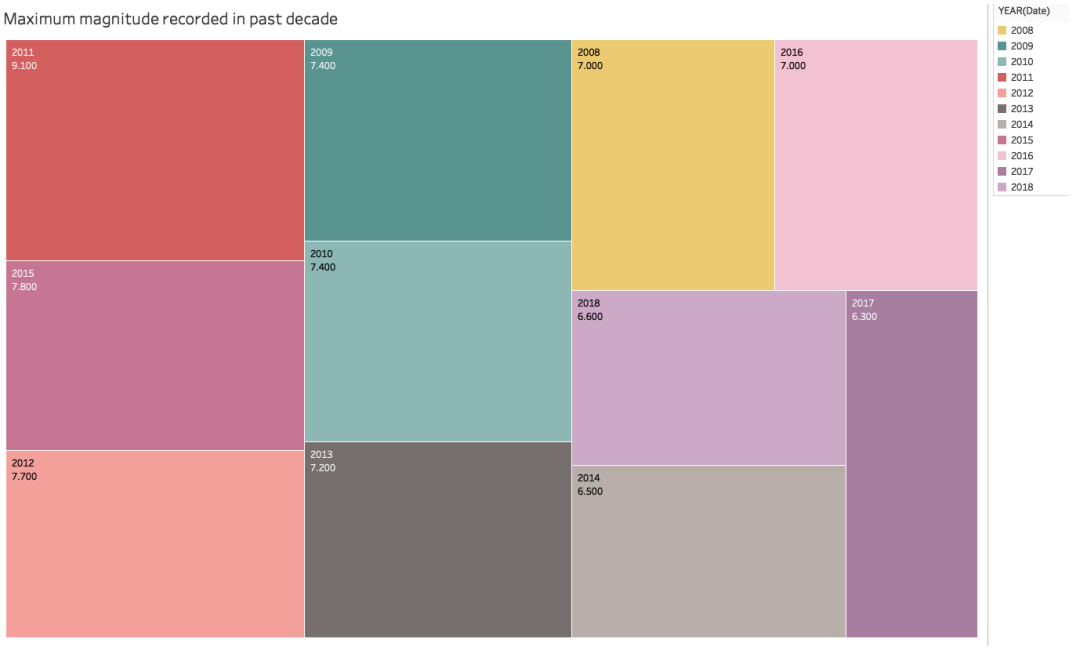

Figure 2 - Maximum Magnitude Per Year(2008-2018)

Comparison between average magnitude and maximum magnitude per year has been shown in figure. In this side-by-side graph the top horizontal axis is representing the years ranging from 2001 to 2018 and the bottom horizontal axis is representing the average and maximum magnitude recorded for the years. As it is

- **1923** is the year when Japan recorded the most deadliest earthquake in the country's history which caused causality of 100,000

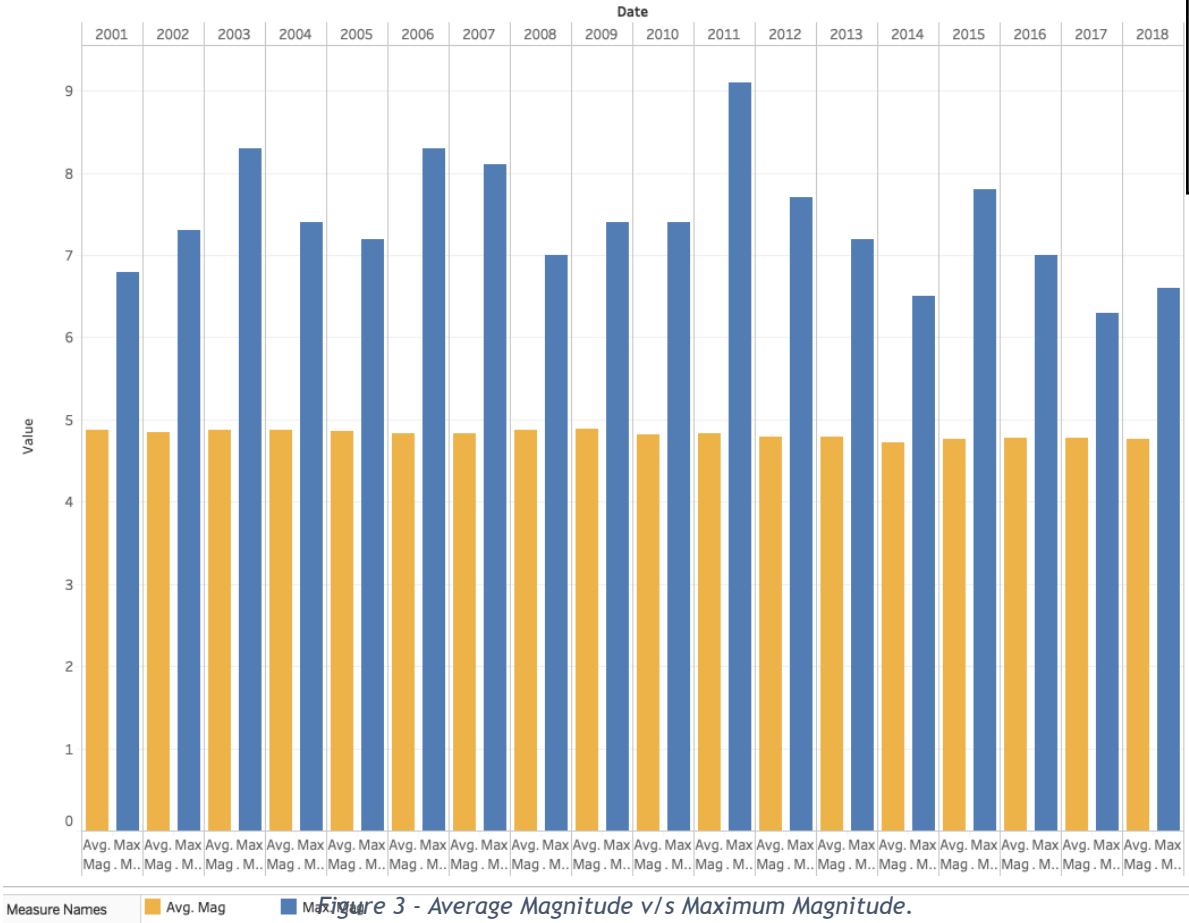

Figure 3 - Average Magnitude v/s Maximum Magnitude.

clearly shown, the average magnitude of earthquake in Japan from 2001 to 2018 is almost constant and varies between 4.6 mb to 4.9 mb. Whereas, the average magnitude over the years is not constant and is fluctuating. The maximum difference between the average and the maximum magnitude of the earthquake is observed in the year 2011 where the maximum magnitude of the earthquake is recorded above 9 mb. The least difference between average and maximum magnitude for the earthquake is observed in the year 2017. Through this we can conclude that in the year 2017, Japan witnessed less number of earthquakes as the difference between the average and the maximum magnitude is less.

The movement or the vibration in the tectonic plates are not necessarily cause to natural phenomena but also because of the human activities. In past few decades there is an exponential growth in the nuclear related activities. Nuclear explosions can generate a severe disturbance in the earth's crust resulting in movement of the tectonic plates which can lead to major earthquake. The below shown bar graph(Figure 4) gives us a glimpse of difference between the magnitude of naturally caused earthquake and the nuclear explosion disturbance. Here we can clearly see that in past few years the highest average magnitude of the disturbance in Japan is recorded due the nuclear explosion. This really is a serious concern as the growing powers of world are focusing more on strengthening their nuclear power. Though, there are many studies and recommendations have been made by several scholars in terms of the gigantic future consequences of these activities, but still the political and administrative group is ignorant towards them.

- **9.1** Magnitude earthquake was recorded in Japan in year 2011 which was the cause for the biggest Tsunami in the history.

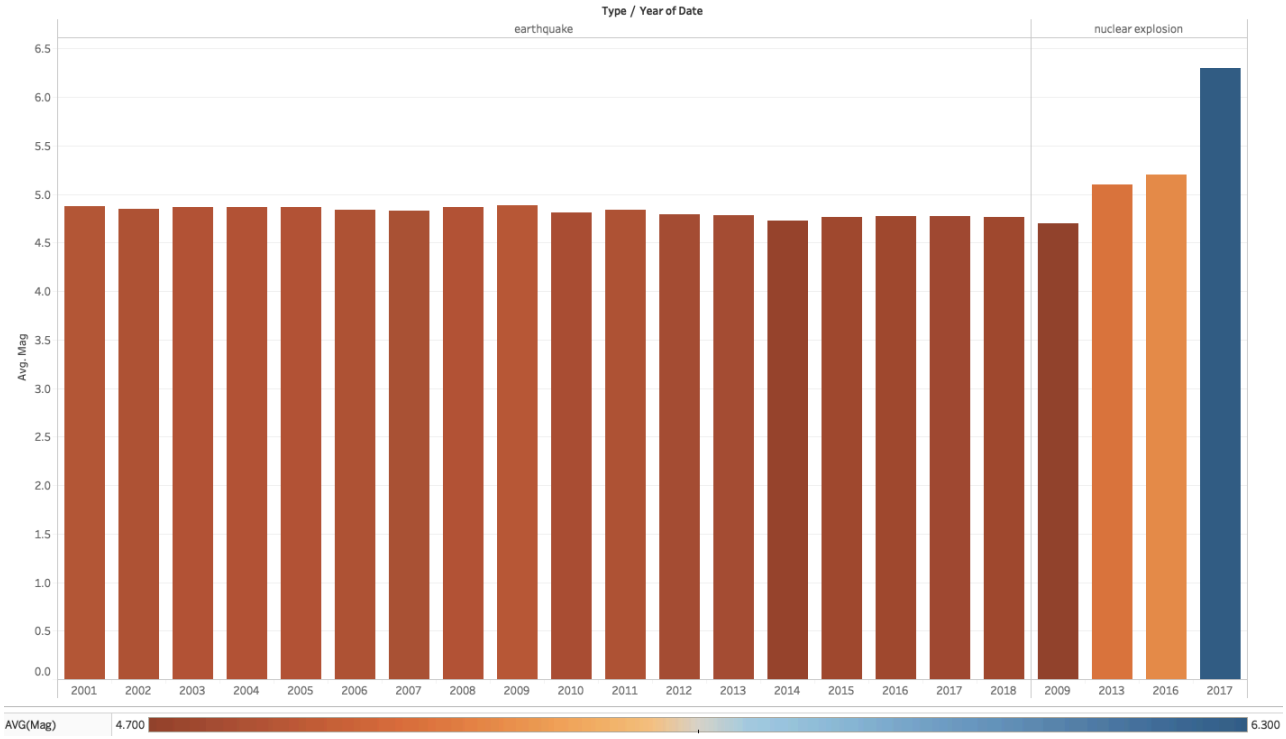

Figure 4 - Earthquake v/s Nuclear Explosion over the years

The Indian Subcontinent Case Study

The geographical area which we focused in this section of the report is the Indian Subcontinent which includes countries like India, Sri Lanka, Myanmar, Bhutan, Bangladesh, Nepal, Pakistan and Afghanistan and also the parts of eastern cost of India and Bay of Bengal. The occurrence of earthquake in this region is mainly along the Himalayan Belt. The main cause of this region being high sensitive earthquake zone is the Indian plates which are in subduction with the Sunda and Eurasia plates.

Now lets us look at the map shown in Fig. In the Indian-subcontinent, Hindu Kush region, that is located in Afghanistan, is considered as the region with maximum intensity .i.e VII, of the earthquake. Year 2015 was the year in which two major earthquakes were observed in the region. The first one was in Nepal which has the magnitude of 7.8 Mw. This was a huge calamity and according to BBC News there were more than 2000 casualties. The other one took place in Hindu Kush on October 15, 2015. The magnitude recorded of this earthquake was 7.3 Mw and more than 500 people died. In the Map we can observe that the in past 18 years the maximum disturbance in the earth's crust is observed in Hindu Kush region of the Indian-Subcontinent. It can also be seen that the south-east region of Indian subcontinent is also effected highly by the tremors.

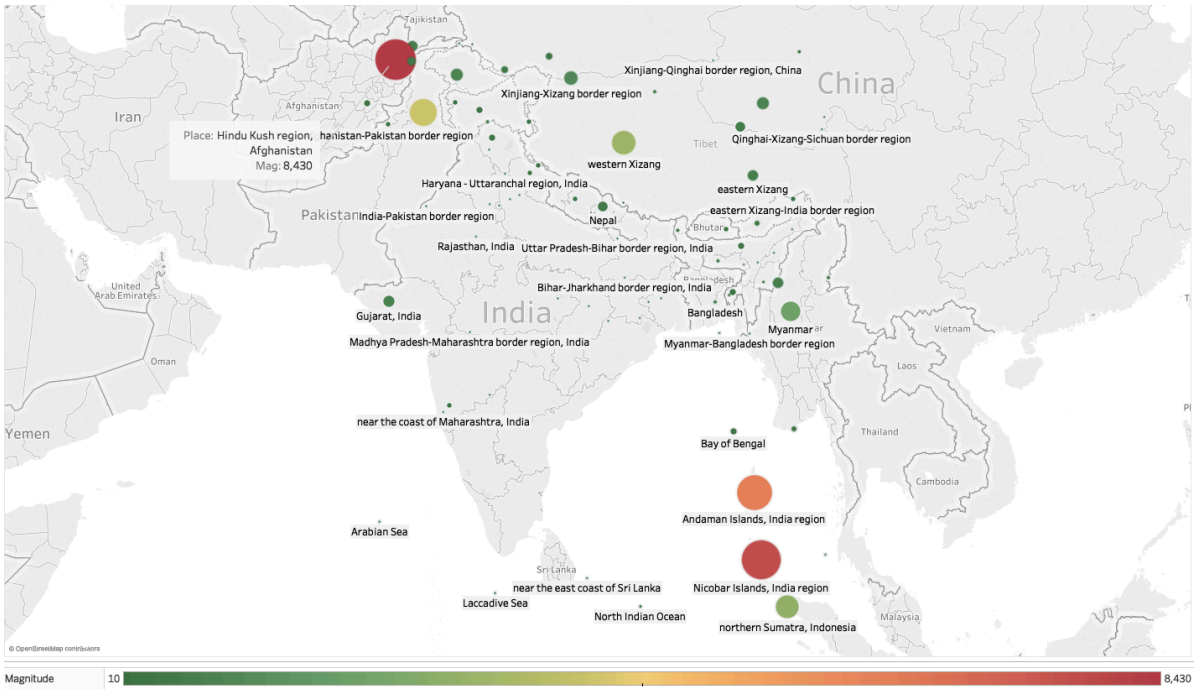

Figure 5 - Earthquake Prone Regions in Indian Subcontinent

We can observe

That the Andaman and Nicobar Island are the prominent zones where the earthquake occurrence was very frequent.

- **Depth of Earthquake**

There are few concepts related to earthquake which we need to look for, one being, the depth of the earthquake. The earthquake can take place near about 700 km below the earth surface. Based on this, depth of the earthquake is divided into three zones: Shallow,

- **4** earthquake zones are observed in India, mainly denoted as II, III, IV and V. 'V' being the most sensitive zone.

which ranges from first 0-70 km from the earth surface. Next is Intermediate, which is measured from 70-300 km from the earth's

from 2007 to 2017 in Indian subcontinent. The highest average depth due to earthquake is observed in year 2007 which is

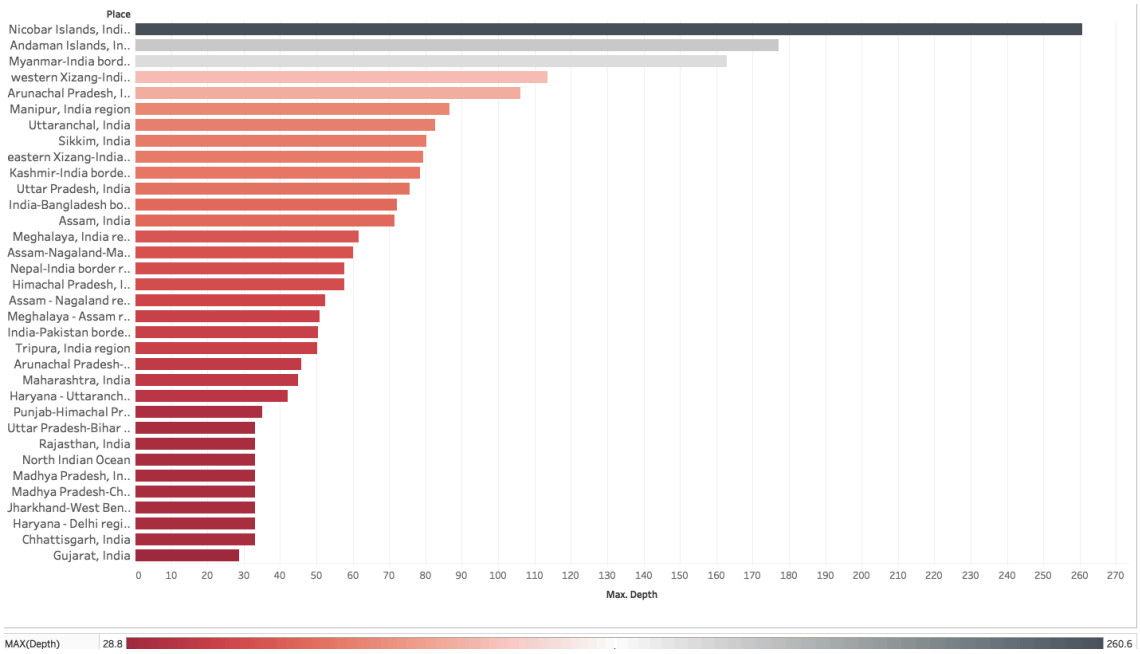

Figure 7 - Maximum depth(in km) Recorded in Various Regions of India

approaching about 85 Km and the Surface and the last on is deep, which is from 300 km onwards. The above shown horizontal bar chart is the representation of the depth of the earthquake observed in the Indian-subcontinent. The period of the records is from 2000-20176. From the first look of the chart we can clearly state that since 2000 to 2017, the observed earthquakes fall in the second zone i.e. intermediate, as the maximum depth recorded is 260 Km.

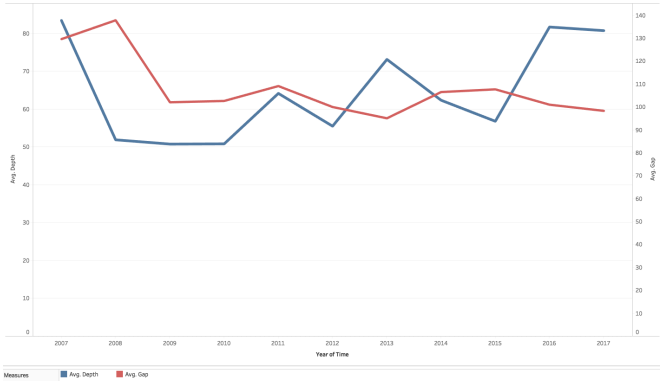

Figure 7 - Depth v/s Gap pattern

The next thing we need to know about the earthquake is 'gap'. Tremors of less intensity and magnitude create fault across the earth's crust. These faults are called as gap and assumed to hold potential of cause of next big earthquake in that particular region. The line chart shown is the comparison of the average depth and average gap caused by earthquakes in the years ranging highest average gap is recorded in year 2008. From this we can say that the depth of the earthquake is not correlated to the gap caused because of it.

The Turkey Case Study

Turkey is really vulnerable to the earthquakes. The major reason for this is its geographical location. Eurasia and Arabia are the two huge tectonic plates between

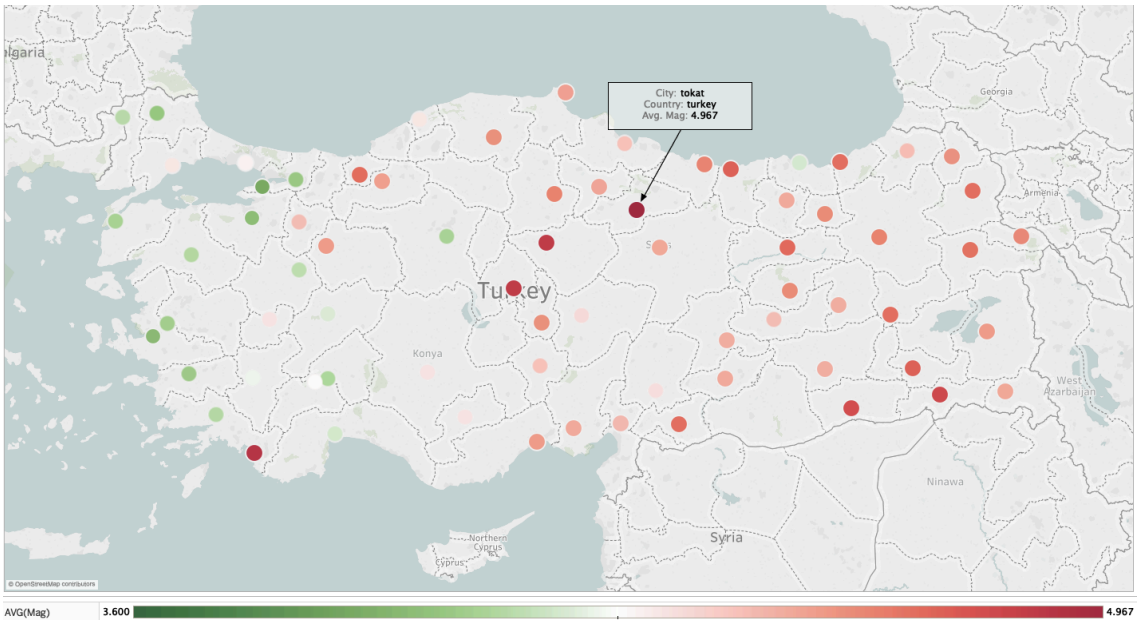

Figure 8 - Cities of Turkey and The Recorded Avg. Magnitude

which Turkey lies. These two plates are converging into each other rapidly and that is why it is causing disturbance in the earth's crust in the region. Basically, Turkey's huge land mass is situated on Anatolian plate which is continuously been pushed towards Aegean Sea in west. So due to this faults are created and the movement is observed. The map(*Figure8)* shown above clearly depicts that the entire country observes earthquake. If we observe the earthquakes with high average magnitude is recorded mostly towards the eastern part of the country and earthquakes with less average magnitude is recorded on the western part of the country. As we discussed above, the Anatolian plate is been pushed towards the West, this may the

•7.1
Is the highest magnitude earthquake recorded for Turkey in the year 1999.

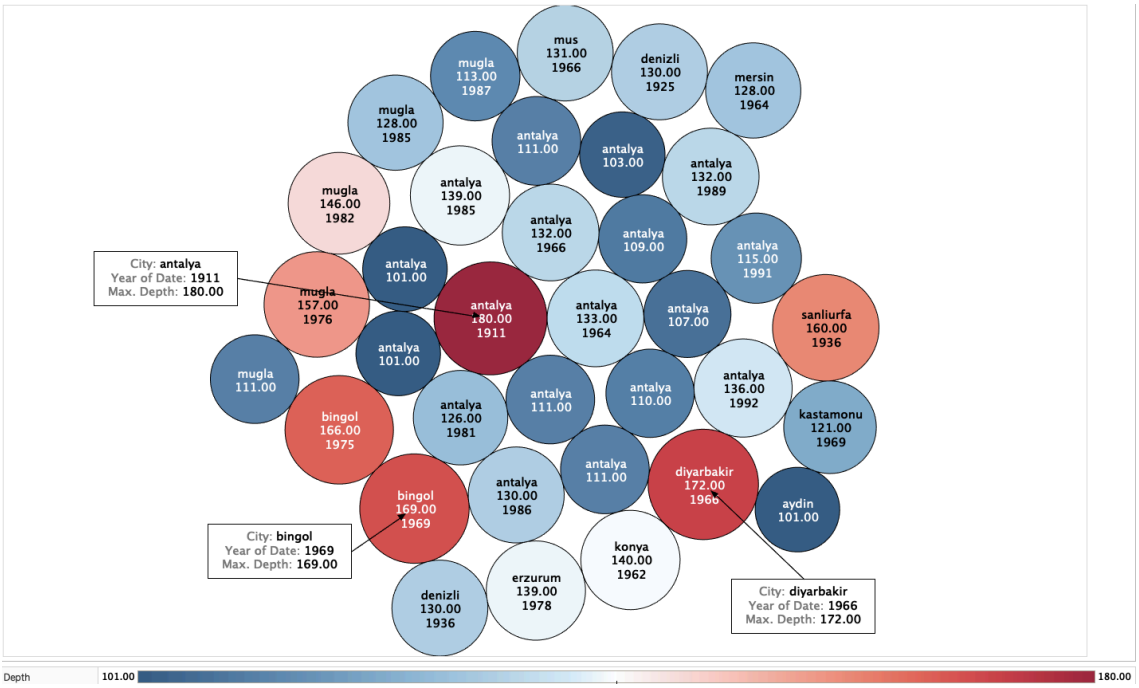

Figure 9 - Maximum Depth Recorded in Last Century

reason as the epicenter happens to be mostly on the eastern part of the country. The period covered in the study is from 1910 to 2015. So, from the above map we can say that the highest average magnitude observed in last century is of 4.96 mb and is concentrated at the city called Tokat which is situated in the center zone of the country. The bubble chart(*Figure 9)* shown observes the maximum depth caused by any earthquake in last century in the cities of Turkey. The range selected for the depth in this study is from 100 km to 180 km, which is maximum. We can clearly see that the maximum depth is observed in year 1911 in the city of Antalya with depth of 180 km followed by Diyarbakir(172 km) in year 1966 and Bingol(169 km) in year 1969. One this stands out from the bubble chart is that the city of Antalya received most of the earthquakes with very high depths i.e. over 101 km.

We also tried to study the pattern of the frequent occurrence of the earthquake with average magnitude in the Middle East countries and Russia. *Table 1* Contains data for Iran, Iraq, Russia, Syria and Turkey. The shade of blue color depicts the range of the average magnitude. The darker the blue, the highest is the average. From this we can say that for years 2005 to 2015 the highest average magnitude is observed in Iraq in year 2009 .i.e 5.3 mb and the least average magnitude is also recorded for Iraq(4.00 mb) in year 2008 and for

Country	Year of Date							
	2005	2006	2007	2008	2009	2010	2011	2015
iran	4.525	4.483	4.250	4.433	4.620	4.600	4.275	
iraq		4.300	4.400	4.000	5.300		4.250	
russia	4.225	4.400	4.260	4.014	4.225	4.467	4.217	
syria				4.400				
turkey	4.406	4.311	4.276	4.234	4.605	4.458	4.433	4.000

Table 1 - Average Magnitude Recorded for Middle East and Russia

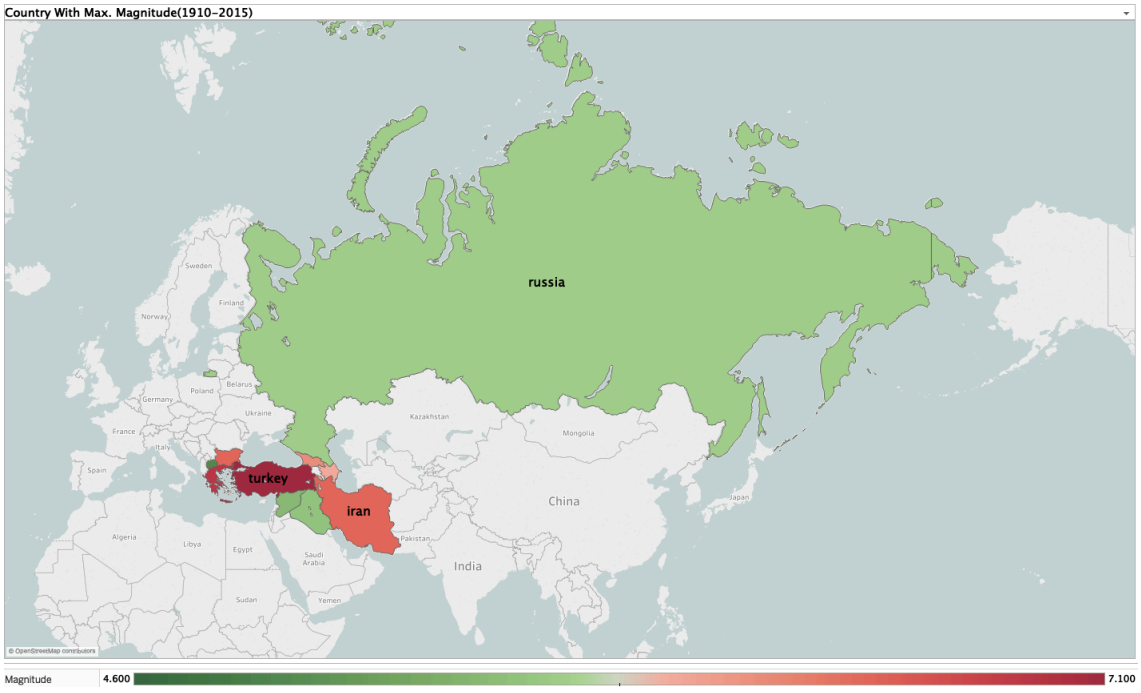

Figure 11 - Country With Highest Magnitude(1910-2015)

Turkey(4.00mb) in 2015. The frequency of occurrence of the earthquake can also be observed. Turkey has received the earthquake in year of the decade, wherein, there was only one earthquake observed for Syria in year 2008. It is the year 2008 which observed earthquake in the every given country, wherein, in 2015 the phenomena id observed only inTurkey. This gives us an estimation that the phenomena is constant for Turkey.

Finally let us take a look at the country which has recorded highest magnitude earthquake in last century. The map(*Figure 11*) here indicates the countries that has received the earthquake with maximum magnitude in last century. Over here the color ranges from green to red, red being the maximum recorded magnitude. It can be observed that in last century Turkey have experienced the earthquake with maximum magnitude of 7.1 mb and the country with the lightest green i.e. Syria has experienced the earthquake with minimum magnitude of 4.6 mb.

Conclusion

The report covers the trend of the earthquake moving from the Ring of Fire, which lies in Pacific Ocean region, to the Indian Subcontinent which lies in the west of the Ring of Fire and finally to the Middles East and Russia. In this study it can be observed that as we move further to the Ring of Fire the average magnitude of the earthquakes tends to go down. It is a known fact that studied phenomena is more active and frequent in the South East Asia region and mainly near the Ring of Fire, which cause mass destruction across the countries like Indonesia, Japan and China. And from our gathered data as well we were able to justify the facts.

References

[1] https://www.kaggle.com/caganseval/earthquake

[2] https://www.kaggle.com/nksingh673/earthquake-indian-subcontinent

[3] https://www.kaggle.com/aerodinamicc/earthquakes-in-japan/home

[4] https://pubs.usgs.gov/of/2007/1137/downloads/pdf/OF07-1137_508.pdf

[5] https://www.bbc.com/news/world-asia-32479909

[6] https://earthquake.usgs.gov/learn/topics/determining_depth.php

[7] http://science.sciencemag.org/content/341/6147/724

[8] http://news.bbc.co.uk/2/hi/europe/2992311.stm

[9] https://www.thoughtco.com/seismic-hazard-maps-of-the-world-1441205

[10] https://earthquake.usgs.gov/learn/glossary/?term=seismic%20gap

[11] http://www.sciencekids.co.nz/sciencefacts/earth/earthquakes.html

[12] https://www.livescience.com/6187-13-crazy-earthquake-facts.html

Appendix

List of Figures:

FIGURE	DESCRIPTION	VISUALIZATION
1	Ring of Fire	Source: https://www.nationalgeographic.org/encyclopedia/ring-fire/
2	Maximum Magnitude Per Year(2008-2018).	Tree map is used to show the maximum magnitude of earthquake experienced in each year. This visualization is chosen because the box size gives us clear indication of higher magnitude.
3	Average Magnitude v/s Maximum Magnitude.	A side-by-side bar graph is used in this because it compares two measures for all the given years.
4	Earthquake v/s Nuclear Explosions over the year.	Again a side-by-side bar graph is used as it is comparing two measures over the given period of time in data.
5	Earthquake Prone Regions in Indian Subcontinent.	Symbol map is used as it symoblizes the region which experienced most earthquakes in terms of total magnitude.
6	Maximum depth(in km) Recorded in Various Regions of India.	Horizontal bar graph is used as it is comparing one measure for all the given regions. It is best way to show the maximum mature for one dimension.
7	Depth v/s Gap Pattern.	Dual line chart is used as it shows us the patterns for the two measures over a certain period of time.
8	Cities of Turkey and The Recorded Avg. Magnitude.	Symbol map is used as it symoblizes the area accurately with a solid circle.

FIGURE	DESCRIPTION	VISUALIZATION
9	**Maximum Depth Recorded in Last Century.**	**Bubble chart is used as it clearly defines the measure with the size of the bubble and the color.**
10	**Average Magnitude Recorded for Middle East and Russia.**	**The highlight table is used as it clearly highlights the measures with the highest number is color(dark blue) and also shows if the value for the year is recoded or not.**
11	**Country With Highest Magnitude(1910-2015)**	**Map is used at it shows the selected measure for the countries with the color code.**

R Codes:

R studio is used to clean and process the data as per the requirement of the study.

1. For the Japan Case Study the data has been collected from https://www.kaggle.com/aerodinamicc/earthquakes-in-japan/home. The data consisted of 22 columns. As not all the columns were needed for the study we have reduced the columns. Null values are removed.

Following is the code used to clean this data:

```
setwd("/Users/varun/Documents/DATA VISUALISATION/earthquake/“)

EQ_Japan <- read.csv("/Users/varun/Documents/DATA VISUALISATION/earthquake/
Japan earthquakes 2001 - 2018.csv”)

library(lubridate)

EQ_Japan$time <- format(as.POSIXct(EQ_Japan,format=‘%Y-%m-%dT%H:%M:
%S'),format='%Y-%m-%d')

typeof(b)

b <- as.character(EQ_Japan$time)
a <- strtrim(b,19)
EQ_Japan$time <- a
```

```
EQ_Japan$time <- as.Date(EQ_Japan$time)
EQ_Japan$nst <- NULL
EQ_Japan$net <- NULL
EQ_Japan$updated <- NULL
EQ_Japan$horizontalError <- NULL
EQ_Japan$depthError <- NULL
EQ_Japan$magError <- NULL
EQ_Japan$magNst <- NULL
EQ_Japan$magSource <- NULL
EQ_Japan$locationSource <- NULL

colnames(EQ_Japan)[1] <- "Date"

write.csv(EQ_Japan,'/Users/varun/Documents/DATA VISUALISATION/earthquake/Japan earthquakes 2001 - 2018.csv', row.names = FALSE)
```

2. For the Indian Subcontinent Case study the data is collected from https://www.kaggle.com/nksingh673/earthquake-indian-subcontinent . This data too contained 22 columns.
Following is the code used to clean this data:

```
setwd("/Users/varun/Documents/DATA VISUALISATION/earthquake/“)

EQ_Indiasub <- read.csv("/Users/varun/Documents/DATA VISUALISATION/earthquake/Earthquake.csv”)

b <- as.character(EQ_Indiasub$time)
typeof(b)
a <- strtrim(b,19)
EQ_Indiasub$time <- a

EQ_Indiasub$time <- as.Date(EQ_Indiasub$time)
library(lubridate)
EQ_Indiasub$time <- format(as.POSIXct(EQ_Indiasub,format='%Y-%m-%dT%H:%M:%S'),format='%Y-%m-%d')
write.csv(EQ_Indiasub,'/Users/varun/Documents/DATA VISUALISATION/earthquake/Earthquake.csv', row.names = FALSE)
```

3. For the Turkey case study is data is taken from https://www.kaggle.com/caganseval/earthquake.
Following is the code used to clean this data:

```
setwd("/Users/varun/Documents/DATA VISUALISATION/earthquake/")

EQ_turkey <- read.csv("/Users/varun/Documents/DATA VISUALISATION/earthquake/earthquake_turkey.csv")
```

```
colnames(EQ_turkey)[1] <- "Date"
colnames(EQ_turkey)[3] <- "latitude"
colnames(EQ_turkey)[4] <- "longitude"
colnames(EQ_turkey)[15] <- “mag"

write.csv(EQ_turkey,'/Users/varun/Documents/DATA VISUALISATION/earthquake/
earthquake_turkey.csv', row.names = FALSE)
```