METEORITE LANDINGS ON THE EARTH (1700 – 2013)

Vishnu Lasya Marthala

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Abstract

Meteorite Landings is an interesting research topic because there are many mysteries of meteorites about where they come from, how they got here, where actually they are landing, and what they tell us about the solar system and the life that existed so far. Meteorites are nothing but the rocks (both tiny and large) from space that land on Earth's surface by surviving the atmosphere along its way. This domain is interesting because Meteorites can tell how actually we all landed here, from their chemical, mineral properties and the impacts they created. Investigating the impact of Meteorite mass (weight) on different parts of Earth can help us find how big and large the craters are formed in different parts of the Earth based on the weight of the Meteorite and know if there are is any actual loss/ trouble to the people because of the craters. Analysing what kind of meteorite origin and their mineral classification (if they are from Mars/ Moon/ Asteroid belt between Jupiter and Mars/ Comets) can help the scientists find the history behind the building blocks of planets and life. The powerfulness of knowing what factors are influencing meteorites occurrence in particular areas and exploring if there is any trend on the fall of the Meteorite in different years can help scientists to see if most meteorites are falling in any specific year, any pattern recognition and find reasons behind this occurrence through research. This research uses Data Analytics, Statistical Summaries, and Visualizations with the help of Python, R and Standard Query Programming Languages to find out the concealed trends in the Meteorite Landings data from the year 1700 – 2013.

I. Introduction

The chance of viewing the meteorite fall is very rare. Very few people can have that chance. Meteorites can be classified based on its fall type, namely Fell and Found. When the meteorite fall is watched by someone, then it comes under the Fell type. When the meteorite fall is not watched by anyone, then it comes under the Found type. Large meteorites fall with a very high noise like that of a fireball. For example, a large crater with 1.2 km width and 150 m

depth formed at Arizona was by an iron meteorite. Many parts of the world have just missed from destructions as meteorites fell few kilometres away from the livelihood. Meteorites are generally made up of minerals. These minerals can be mostly seen in the rocks that are available on the Earth, but only a few minerals are exception. This is what differs the meteorites from the earthen rocks. Meteorite classification is very complex as they are made up of different minerals and compositions from the solar system. However, Meteorites are classified in a simple way based on the amount of iron and silicate minerals, namely, Stony-Iron, Stony and Iron Meteorites. Chondrites and Achondrites are the two types of Stony meteorites that are classified based on the silicates named as chondrules. Mostly all the Chondrites are considered the oldest meteorites from the solar family as they are 5 billion years old. With the help of chondrites, scientists found that solar family is formed 5 billion years. Carbon contained chondrites have minerals such as diamonds and scientists think that these are formed before the sun existed in the solar family. Meteorites come from the solar family but from different sources namely Asteroid belt, Moon, Mars and also other planets.

This research paper focuses on the analysis of Meteorite Landings in different parts of the world and their impacts from the year 1700 to 2013. This study will investigate the following research questions:

- *In which part of the world most Meteorites Fell/Found and what factors influence their occurrence in particular areas? Is there any trend on the fall of the Meteorites in different years?*
- *On what kind of meteorite origin (if they are from Mars/ Moon/ Asteroid belt between Jupiter and Mars/ Comets) the scientists must focus on to find the history behind the building blocks of planets and life?*
- *What will be the impact of Meteorite mass (weight) on different parts of Earth?*

By exploring and analysing the above research questions, we can find if there are any patterns in the fall of Meteorites from 1700 to 2013 and their impacts on the Earth geological formation.

II. Literature Review

There are many analysis and Research going on in the field of Meteorites Landings but mostly limited to particular country or continent. For example, One research report on Meteorite Landings particularly focused to analyse the fell and found meteorites and to investigate if there is any actual relationship between world population and Meteorite Landings.

This research is valuable to find out which parts of the world had most fell or found meteorites and why only particular parts of the world receive more meteorites than other. Also, by finding the relationship between the population and meteorite landings, we can help people from any destructions in the future.

Another research paper (published in New York times), found that 2 -billion year old meteorite from Mars had 6000 parts per million in water content. Their major contribution to study 2-billion year old meteorite is to find water content (parts per million) in a meteorite from Mars found in Sahara desert and to investigate the age of the meteorite based on the metric 'parts per million'. Their research also focused on to find if life existed in Mars if water content measured in parts per million is very high. This research is valuable because theoretically it is proved from this research that life existed on Mars at some point. But there is no exact evidence that life actually existed in Mars.

Another case study on the impact of Craters on geological formation had their major contribution to study impact of Craters in Africa. This research focuses on finding if there are any changes in the geological formation because of the craters and also if there is any economic importance for Africa because some craters contains oil or mineral deposits. This research is valuable because one can find how the geological formation of Africa changed over a period of time because of Craters. Also, craters have economic value if they contain mineral deposits.

III. Materials and Methods

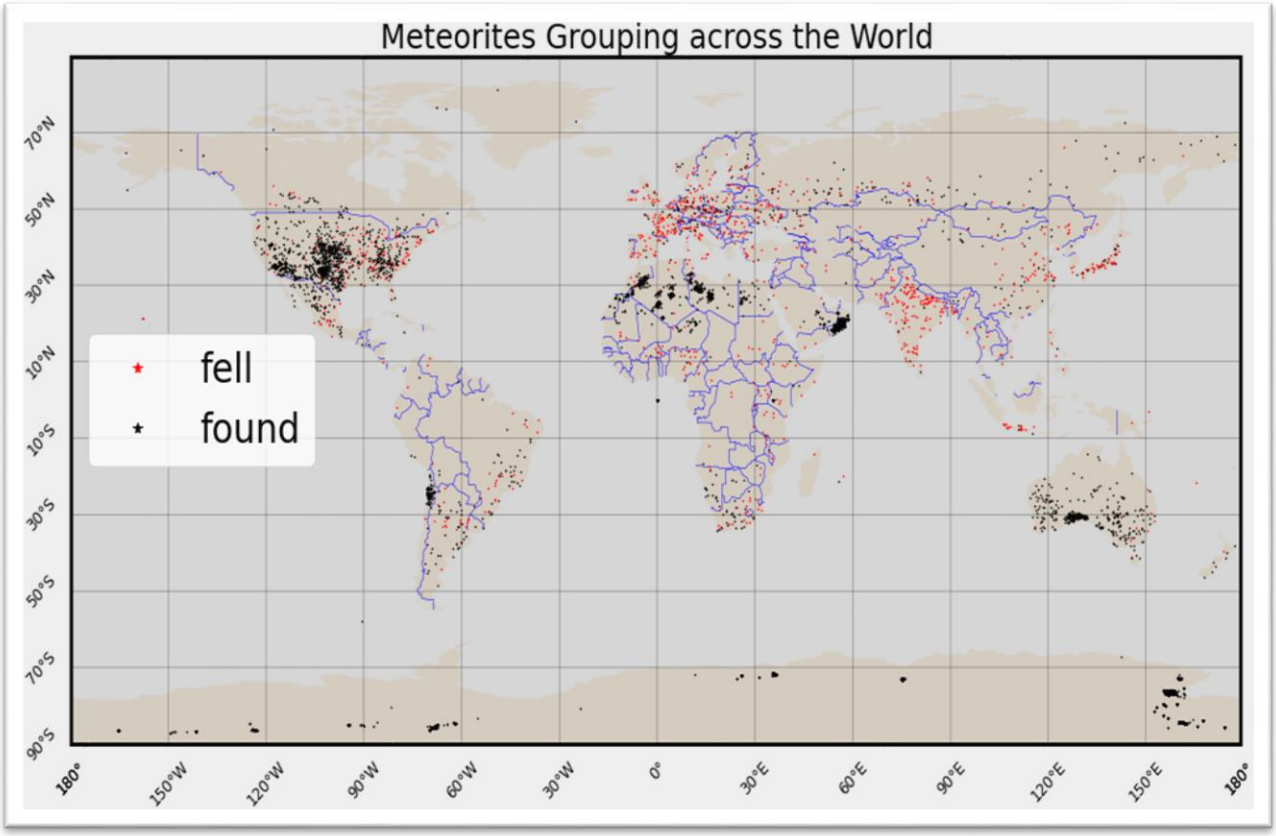
This dataset was restored from a public portal named NASA's open data portal which was available online. Meteorite Landings Dataset consisted of many attributes namely, the name of the meteorite, id of the meteorite to uniquely identify the meteorites, nametype of a meteorite which says whether the meteorite's quality is disturbed by Earth's atmosphere (Relict) or not (Valid), recclass of a meteorite which is nothing but the recommended Classification of a meteorite, mass of the meteorite in grams, fall of the meteorite which is classified based on whether the meteorite is seen during its landing (Fell) or not seen during its landing(Found) , recommended latitude of the meteorite, recommended longitude of the meteorite, Geolocation which is the combined latitude and longitude columns separated by

comma and the last attribute is Year in which the meteorite fell/found. This dataset was easy to use in many platforms like RStudio, Oracle SQL Developer, Jupyter Notebook as this data set was in the form of Comma Separated Values File. The dataset consisted of 45,716 meteorite Landings on to Earth between the years 1700 and 2013 respectively. This was a huge dataset and analysing the data lead to find many hidden trends and perspectives regarding the landings of Meteorite.

The research started by cleaning the dataset which was done in Python (Jupyter Notebook). There were more than 7000 null values for reclat and reclong columns and around 130 null values for mass column in the dataset. The data points consisting these null values are removed as the location of meteorites is important for the research questions to be discussed in this paper and also meteorites without any weight is meaningless. Besides this, mass column name has spaces and this created an issue while creating a table in SQL Developer. So, 'mass (g)' column is replaced with 'mass'. Also, in the given dataset the mass column is in grams, but for Visualization friendly, mass in grams is converted to kilograms. Furthermore, the values in the GeoLocation column are enclosed in '( )' which can create a disturbance while working with this column in Python or R. So, these enclosed braces were removed using String's inbuilt strip function.

In addition, year attribute in the data set has timestamp values. As the research questions need only the year in which meteorites landed, extraction of year from the timestamp was done. Few column values had weight of meteorites as 0.0 which was inappropriate, so had to remove meteorites id's with mass 0.0. Exploratory Data Analysis was the next step after cleaning the data. This Analysis was done by using Python and R where data frames and visualizations were created. Finally, Oracle SQL Developer was used to crosscheck the summarized values and frequencies obtained from the plots in R and Python.

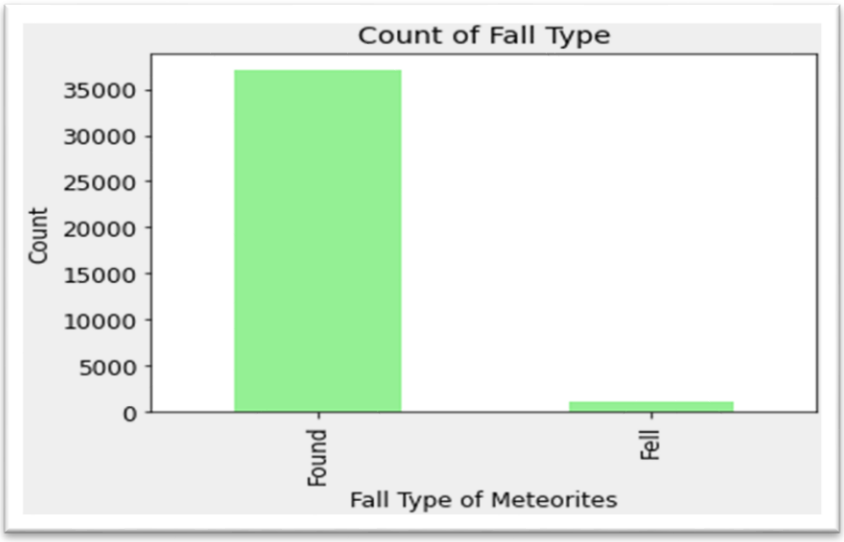
IV. Results



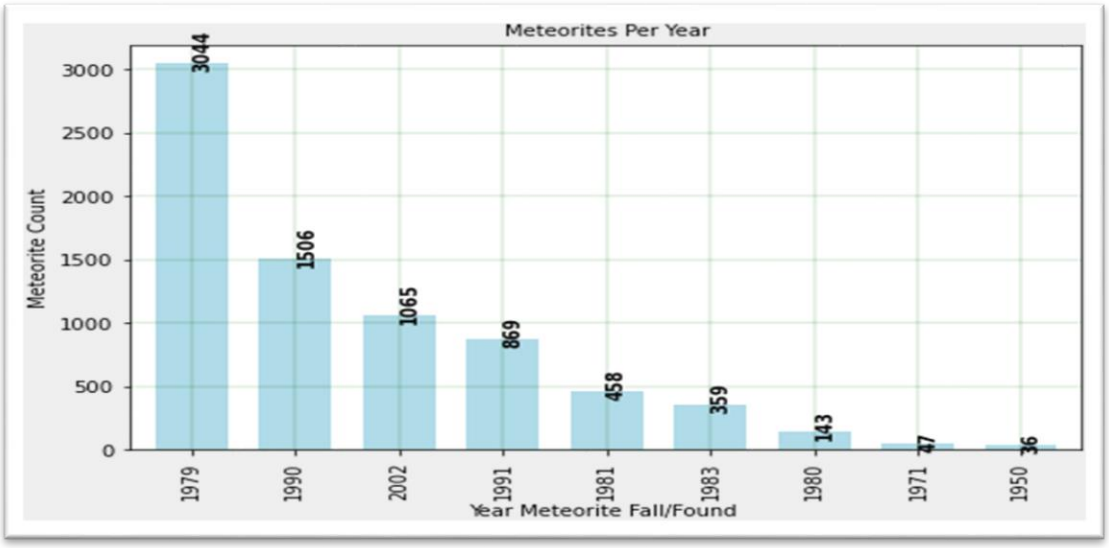
The above world map is plotted using Basemap Package in Python. This visualization displayed the fell/found meteorites at different locations in the world. We observed that most of the meteorites are recovered after they landed on the earth because the 'found' (black dots) one's can be seen more like a blob than the fell one's marked as red. We observe that India and Europe has most of the fell types compared to other parts of the world i.e., people living there are able to observe the meteorite landings in an increased number compared compared to other locations. Antarctica had a major portion of found meteorites.

	FALL	COUNT(FALL)
1	Found	37028
2	Fell	1052

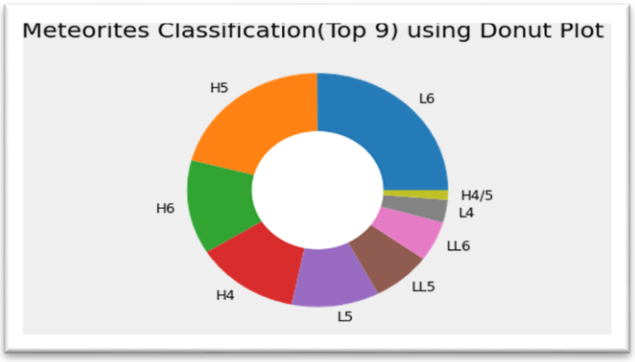
We observed that Found count is far more higher than the Fell count from the summary table in SQL. From the frequency observed, people have less chance of viewing the fall of meteorites.



This plot in Python also supported the above discussion of the count of fall type of Meteorites.

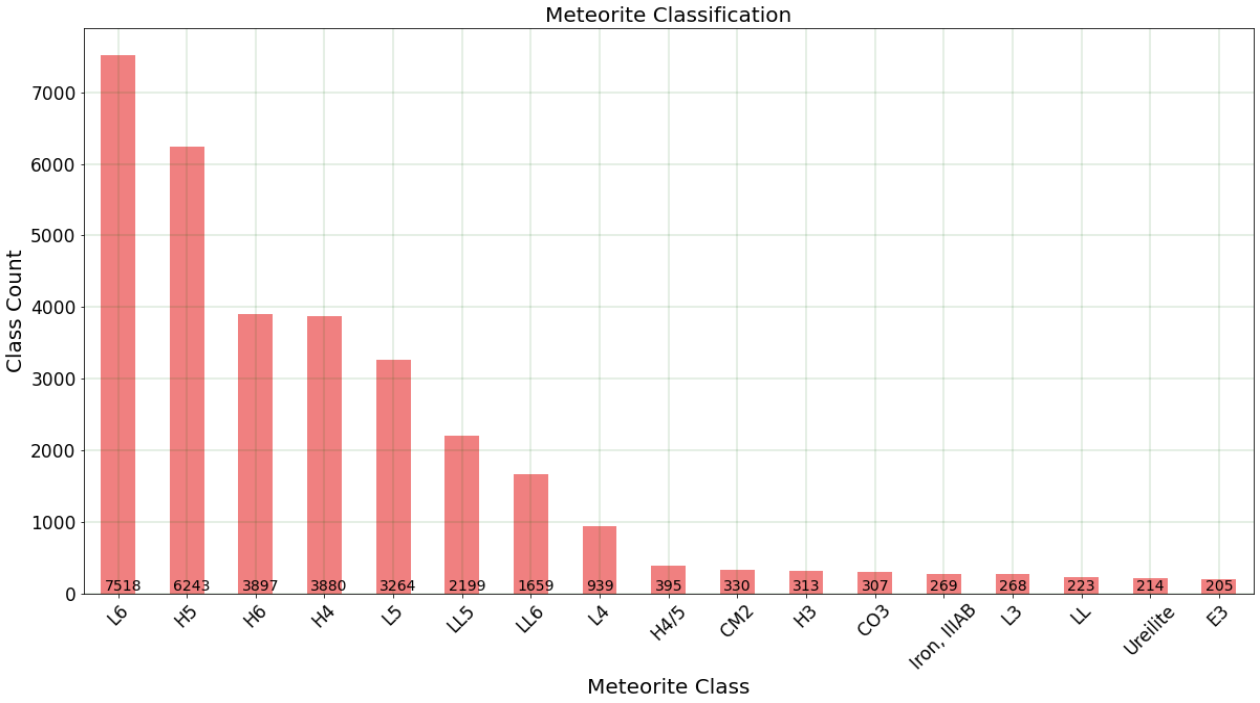


This barplot was plotted in python which showed that 3044 number of meteorites have occurred in 1979 alone. Till 2013 there were never such huge number of meteorites in a single year.

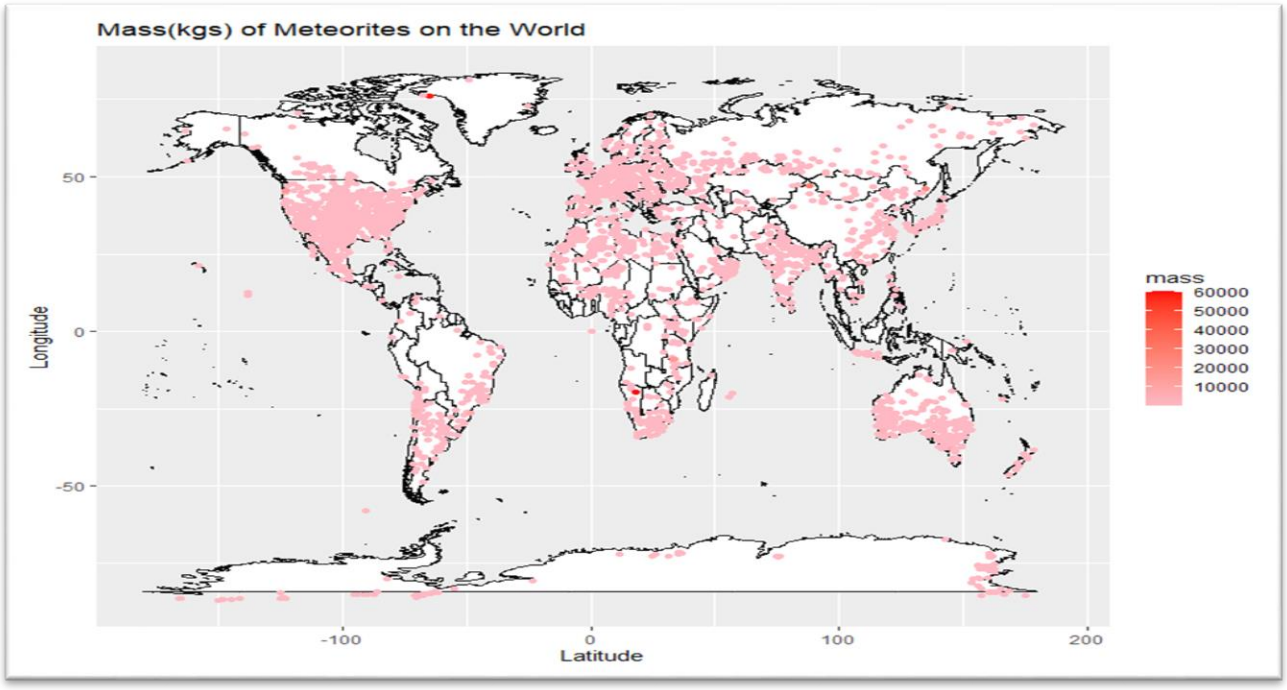


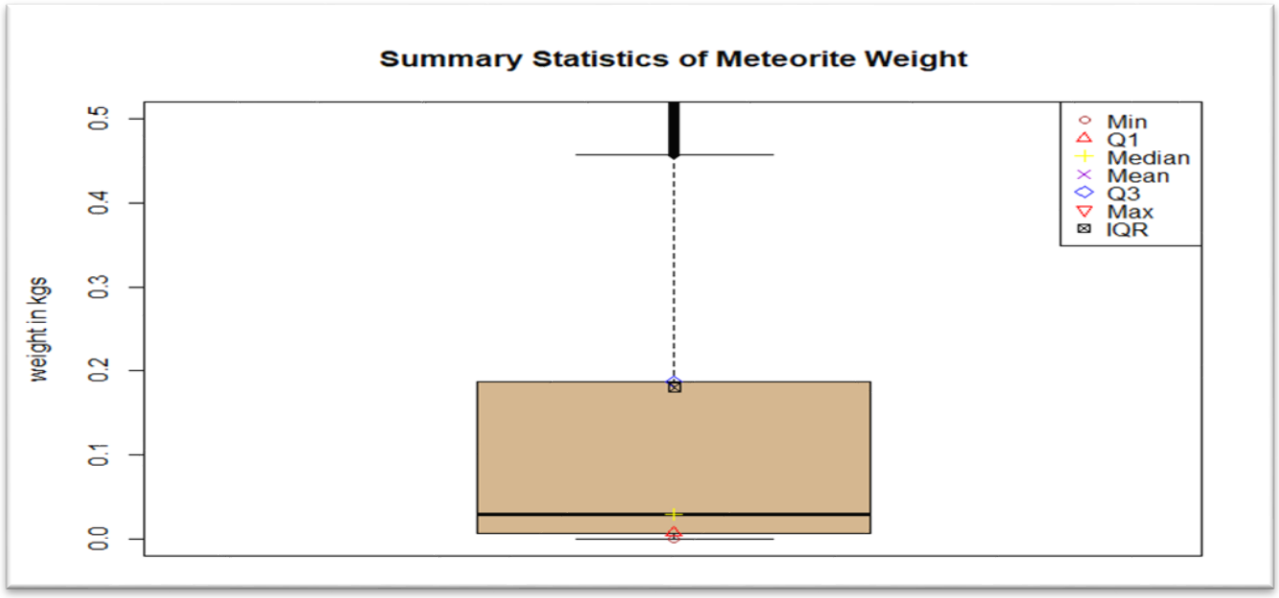
	RECCLASS	COUNT
1	L6	7518
2	H5	6243
3	H6	3897
4	H4	3880
5	L5	3264
6	LL5	2199
7	LL6	1659
8	L4	939
9	H4/5	395

Donut plot above represented how meteorites are classified based on their chemical and mineral composition. We observed that L6 class had the highest occurrence followed by H5 class. L6 Class is a subclass of Chondrite which is a stony meteorite.



This plot represented the visual representation of Meteorites Class along with its frequency.



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Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
0.00     0.01     0.03    14.03     0.19 60000.00
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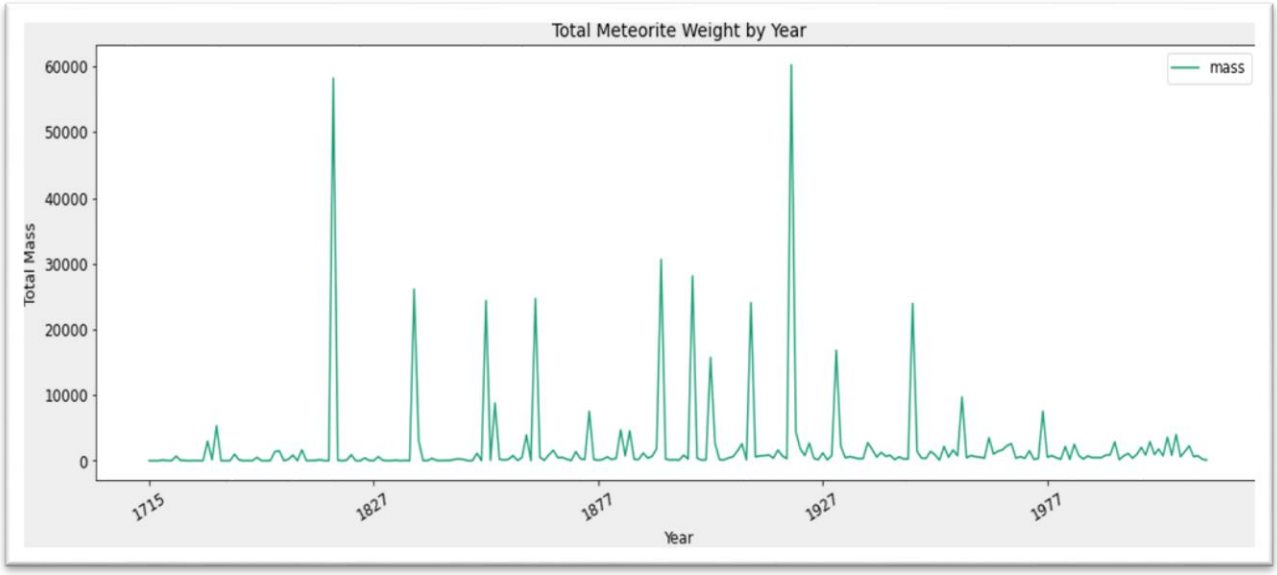
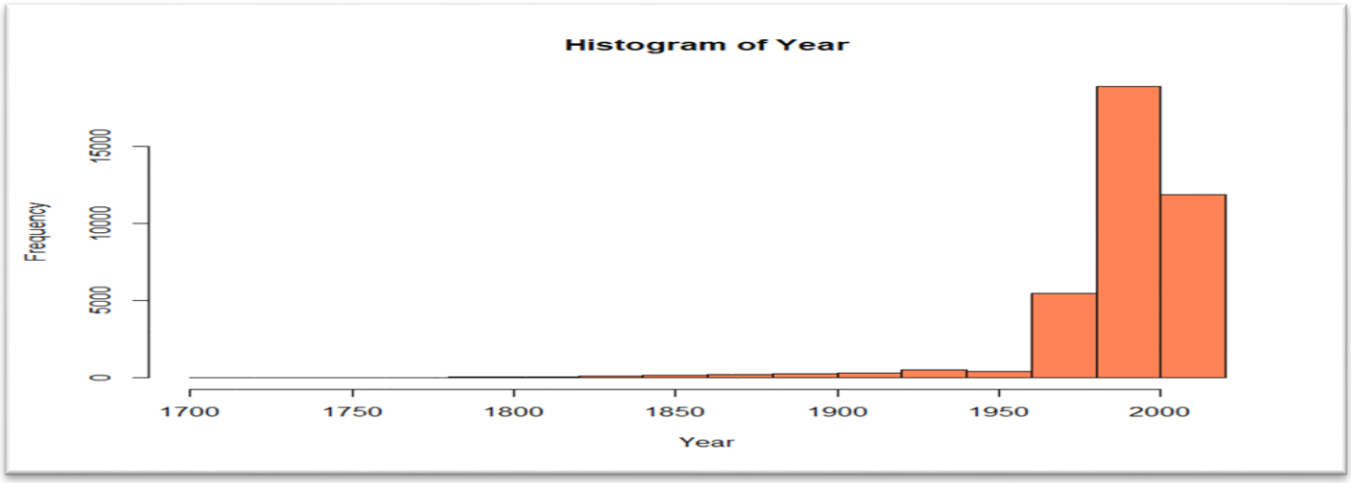
The World Map above was plotted using R where it represents the mass of the meteorites in different parts of the world. We observed red dots which conveyed the highest weighted meteorite of around 60,000 kgs in Africa and GreenLand. This huge mass on these places would have changed their geographical shape. Also from the summary statistics, we

observed that half of the meteorites were of below 0.03 kg and the average weight was 14.03 but this would have been affected by the highest mass which were just 1-2 in count.



	TOTAL_METEORITE_WEIGHT	YEAR
1	60255.072	1920
2	58231.417	1818
3	30655.725	1891
4	28147.2935	1898
5	26148.3	1836

The above plot represented the total weight of meteorites across different years. This was plotted in order to find any trends across different years. We observed that the total weight of the meteorites in 1818 is around 59000 kgs and the total weight of the meteorites in 1920 is around 60000 kgs. This happened for 102 years and this much weight of different / one meteorites may land on the earth in the future(2022 – 1920 + 102). Such patterns help scientists to help the mankind from destruction.



The above histogram for Years was plotted in R, to get a quick view of which years received most meteorites. The plot showed that it's around 1970.

V. Limitations and further research needed

There were not many limitations while writing the paper and analysing the data set. Firstly, Meteorite Landings Dataset was not up-to-date, i.e, it only had landings data till 2013. This may lead to the missing of any patterns and hidden trends of meteorite landings till date. Also, this data set could have come with another columns namely 'Impact' which can say how large / small the impact was, 'Destruction' which say if the meteorite caused any serious damages or destructions to the people and 'Economical Profit' which can say that so and so meteorite has brought economic importance in the area it fell/found.

Moreover, there were few limitations when trying to find the location of meteorite landed from the GeoLocation column in the dataset. As the dataset is huge with around 38000 data points after cleaning, python was able fetch locations for around 260 data points and reaches a limit. Due to time constraint, I haven't divided the 38000 data points into separate files and find out the locations of each file separately. Even separating the data into files may not solve the issue because the processing time is too long to just find 260 locations from the GeoLocation column.

Further research is needed in finding out the location names from the geolocation with less processing time and finding out a way without dividng the data into multiple files. Also,

the year column has the timestamp values with day and month of the all meteorites as almost same. This may lead to inability to find the landings pattern across different months.

VI. Discussion and Conclusion

The exploratory data analysis conducted during this entire research process is showing few factual data along with few patterns in the meteorite landings. The research questions stated earlier when applied from the analysis point of view are discussed here.

1) In which part of the world most Meteorites Fell/Found and what factors influence their occurrence in particular areas? Is there any trend on the fall of the Meteorites in different years?

We observe that India and Europe has most of the fell types of meteorites compared to other parts of the world i.e., people living there are able to observe the meteorite landings frequently compared to other locations. Antarctica is having a major portion of found meteorites and this is because it is the coldest place and always covered with ice and the meteorites can be easily visible on white surface compared to other black road or soil or vegetation surfaces in the other parts of the world. These are the factors that are influencing more meteorites to be found in Antarctica compared to other areas of the world. Coming to the visualization of the trend on the fall of the meteorites, it is leading to an interesting analysis of why 1979 alone received such huge number of meteorites. This can help scientists to analyse various aspects leading to such big count and find if such huge count of meteorites occur in a future years and take necessary steps to save the living from any destructions.

2) On what kind of meteorite origin (if they are from Mars/ Moon/ Asteroid belt between Jupiter and Mars/ Comets) the scientists must focus on to find the history behind the building blocks of planets and life?

We observe that L6 class meteorites are the most common meteorites followed by H5 class according to this dataset. It is observed from research that these meteorite class are mostly from Asteroid Belt in the space. Astrophysical Journal provided a new view into origin of H Chondrites. They observed 2 source regions of H chondrites one is in the Asteroid belt and the other is outside of the Asteroid Belt. Such many interesting analysis of different

kinds of Meteorites can lead to find the age of solar family, age of Earth, Moon and other planets.

3) What will be the impact of Meteorite mass (weight) on different parts of Earth?

From the world map plotted with meteorite mass, it is seen that Africa and Greenland are having the highest meteorite weight of around 60,000 kgs. This huge weighted meteorite could be one of the factors of Africa and Greenland's geographical location. This could also have lead to economical profits for Africa and Greenland.

In conclusion, the entire study helped in finding the insights of the meteorite landings on how big the craters are formed in different parts of the Earth based on the weight of the Meteorite and know if there are is any actual loss/trouble to the people because of the craters formed and also if there are any patterns in these landings.

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