COSC3000 Visualisation Report

Analysis of the State of Degradation of the Amazon Rainforest

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Introduction

Background

The Amazon rainforest is the world's largest rainforest spanning over 526 million hectacres[1]. Not only is this great forest home to 10% of the world's known biodiversity including more than 24 million people that live there but it also plays a vital role in regulating the world's oxygen and carbon levels [2]. The Amazon rainforest is a natural wonder, to say the least, in all its beauty and awe, but it has been facing one constant threat over the past couple of decades: degradation.

Deforestation, fires and climate change all attribute to the degradation of the Amazon rainforest. Countless habitats and natural artifacts have been destroyed and erased from history following this calamity. It was only rightly so that the world has woken up to action to protect our sacred rainforest from endangerment, with the recent Paris Agreement showcasing humanity's unity to overcome this difficulty [3]. Petitions, movements and laws have taken measures to prohibit and cut down on deforestation and climate change. But have these efforts been worthwhile?

Project Goals

The main goal of this project is to analyse the statet of degradation on the Amazon rainforest over the years and determine whether counter-degradation efforts have been working.

In addition to this, further sub-goals will be established such as:

1. Discovering which Brazillian state comes out on top of firespot occurrences through visualisation
2. Finding out which month/parts of the year do firespots most occur
3. Figuring out if there is a correlation between climate phenomenon El Nino & La Nina and occurrences of firespots

Dataset

Data Source

The data provided for analysis was collected from an online repository[4], where it showed the occurrences of firespots in 9 states of Brazil over the years 1999 - 2019 as well as the effect of climate phenomena El Nino & El Nina over those years.
The 9 Brazillian States represented in the data were - Tocantins (TO), Amazonas (AM), Acre (AC), Roraima (RR), Amapa (AP), Para (PA), Mato Grosso (MT), Rondonia (RO), and Maranhao (MA).

Two .csv files were downloaded :

1. The Amazon forest fires csv file contained columns of years, months, locations (state and coordinates) and occurrences of firespots.
2. El Nino & La Nina csv file which contained columns of years, location(state) and severity rating. The severity was rated in 4 ranks - weak, moderate, strong and very strong

Data Handling

For this report, the programming language Python was used to analyse and visualise the data with the help of the libraries Matplot and Seaborn.
In order to ensure the veracity of the data, the data was combed for any syntax or logging errors such as negative values, improper locations or false severity ratings.
The data was read via the Pandas library using the *read_csv()* function. Subsequently, the columns of the csv file were converted into NumPy arrays and lists to easily access the data.
Then the total and average occurrences of firespots were calculated and placed into separate data sets. 2D arrays linking these values to the years and months they occurred were also created.
Finally, the data was visualised using the plot functions of MatPlot such as plot(), bar(), graph(), scatter3d() and bar3d(). A heat map was created using Seaborn's heatmap() function.

Visualisations

Colour blind appropriate colours were used wherever applicable for visualisations so that it maybe be accessible for everyone.

Occurrences of firespots

To start off the project, it is important to highlight the range of values of the occurrences of firespots over the years.
In *Figure 1* below, the occurrences are represented via a scatter plot, representing the values reported between the years 1999 and 2019.

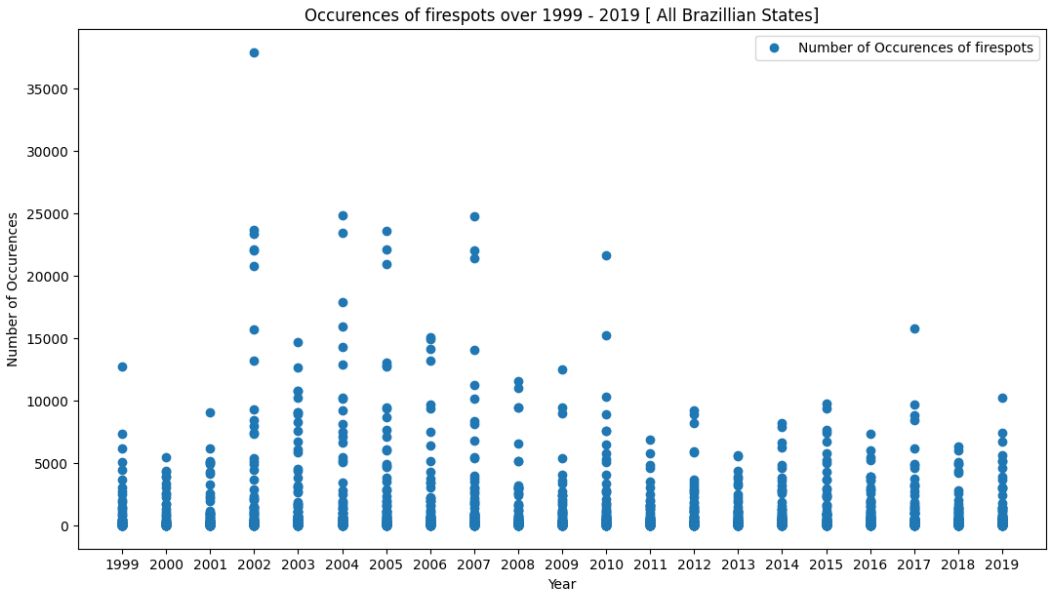

Figure 1: Scatter plot of Occurences of firespots over the years 1999 - 2019 in all the 9 Brazillian states

From the figure, we can deduce that most of the reported values are concentrated in the 0 - 5000 range. We can also see that the highest reported value was about 37,500, with the next closest value being 25,000 in 2004 and 2007.

We can make out a pattern of decreasing the highest value of firespot occurrences from 2002 onwards. To better understand this, let us visualise a graph of the total occurrences of firespots over the years 1999 - 2019.

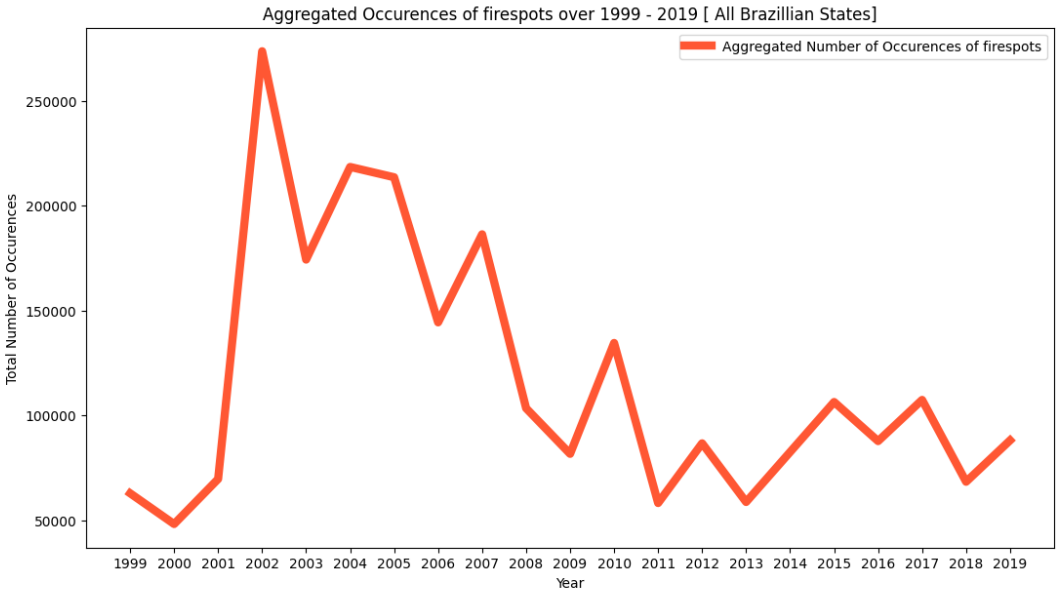

Figure 2: Plotted line of Aggregated Occurences of firespots over the years 1999 - 2019 in all the 9 Brazillian states

The figure above shows a significant drop in reported firespots in the 9 states reported since 2002. We can thus summarise from the two figures that both the highest value and total firespot occurrences follow a decreasing trend from 2002 onwards.

Throughout this report, we will prefer to use the total occurrences of firespot to analyse the data rather than the average. The reason is that a lot of the reported values in all the years are similar to each other, as we noticed in *Figure 1*. With the figure below, we can see that the average occurrences of firespots appear to be virtually the same while the total occurrences represent a better understanding of variability. Another reason is that there are no proper metrics available to compare and examine average occurrences of firespots, so the results obtained would be on the basis of a lot of assumptions

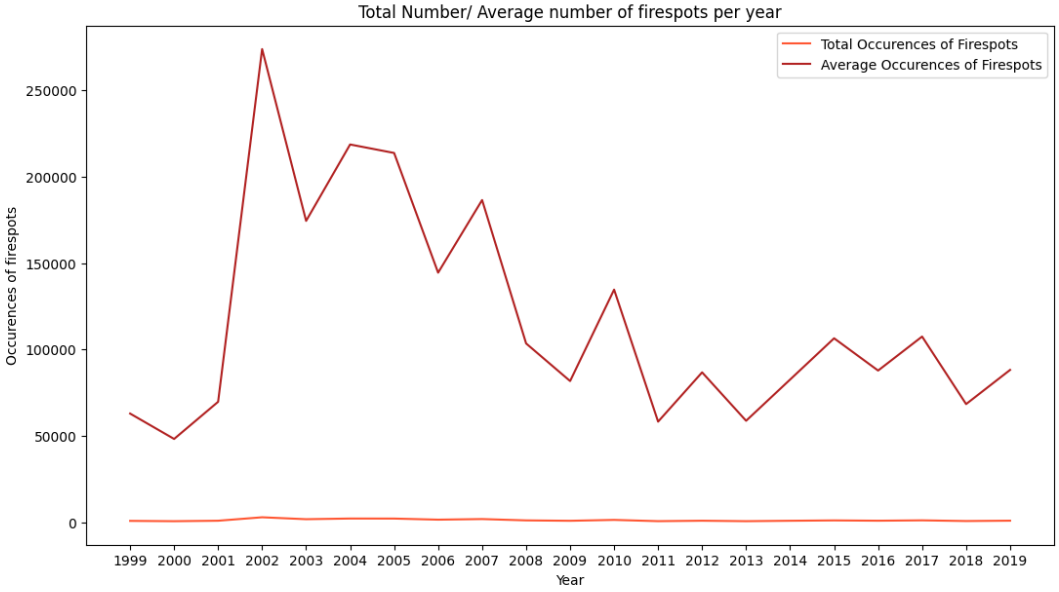

Figure 3: Comparisons of the Total Occurences of firespots to the average occurrences of firespots over the years 1999 - 2019 in the 9 Brazillian states

Finally, to understand at which parts of the year do these firespots occur, a bar graph was made with the months of the year against the total firespot occurrences as seen in *Figure 4.*

From the figure, we can reason that the firespots most occur during the late winter (August to September) to the early spring season (September to October) of the southern hemisphere[5], with September coming out with the most recorded firespots in all the years.

In fact, the summer season (December to March) shows very few occurrences of fire spots, despite being the hottest season of the year.

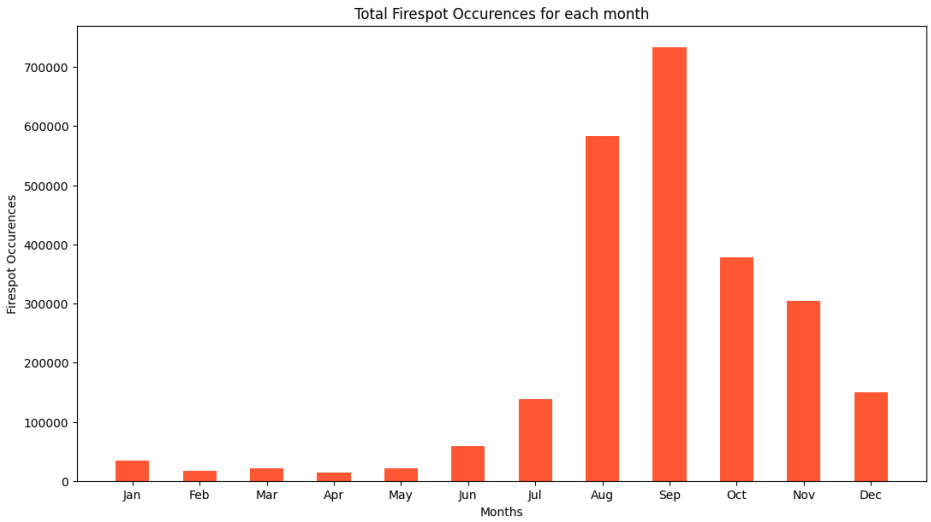

Figure 4: Bar graph of Total Occurences of firespots over all the months the in the 9 Brazillian states between the years 1999-2019

Firespot locations

To figure out in which states these firespots occur, the total firespot occurrences of each state were mapped and graphed using a bar plot as shown in *Figure 5.*
The state of Para (PA) reported the most occurrences of firespots over the years 1999 - 2019, coming out with about 900,000 of the accounted firespots. The next state with the second-highest reported occurrences was Mato Grosso (MT) with only about 600,000 reports.
Despite Para being only the second-largest state in Brazil, sharing 14% of the total area, with Mata Grosso and Amazonia securing 18% and 10% respectively[6], they top the chart by a wide margin with firespot occurrences.

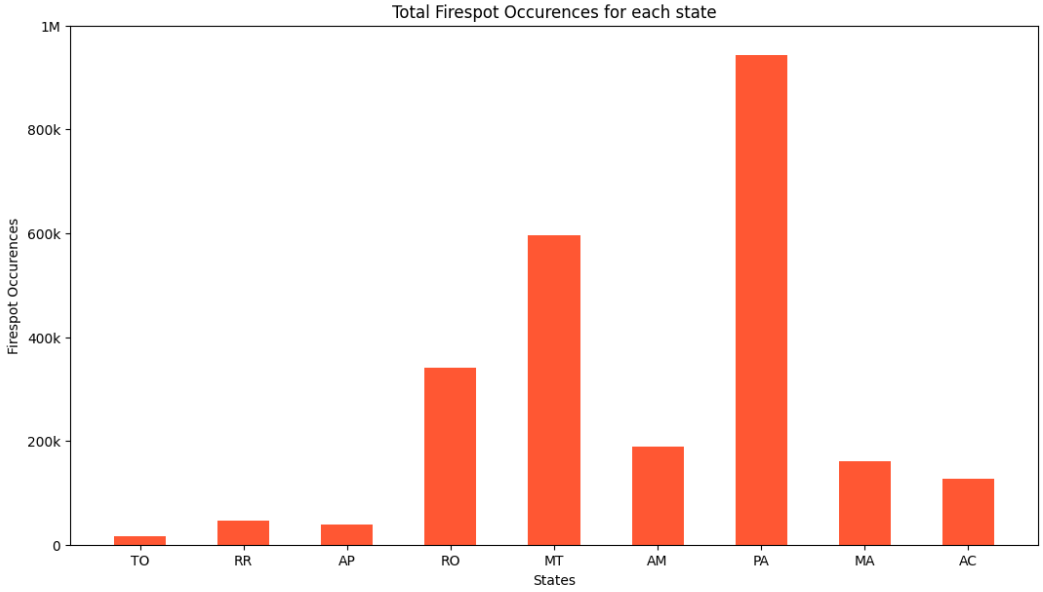

Figure 5: Bar graph of Total Occurences of firespots for each of the 9 Brazillian states over the years 1999 - 2019

To visualise this better, a scatter plot of the location of the firespots was created with the geographic coordinates as shown in *Figure 6.* Two separate colours were used to distinguish the locations with reported firespots well below or equal to the average occurrences and locations with reported firespots above the average occurrences.

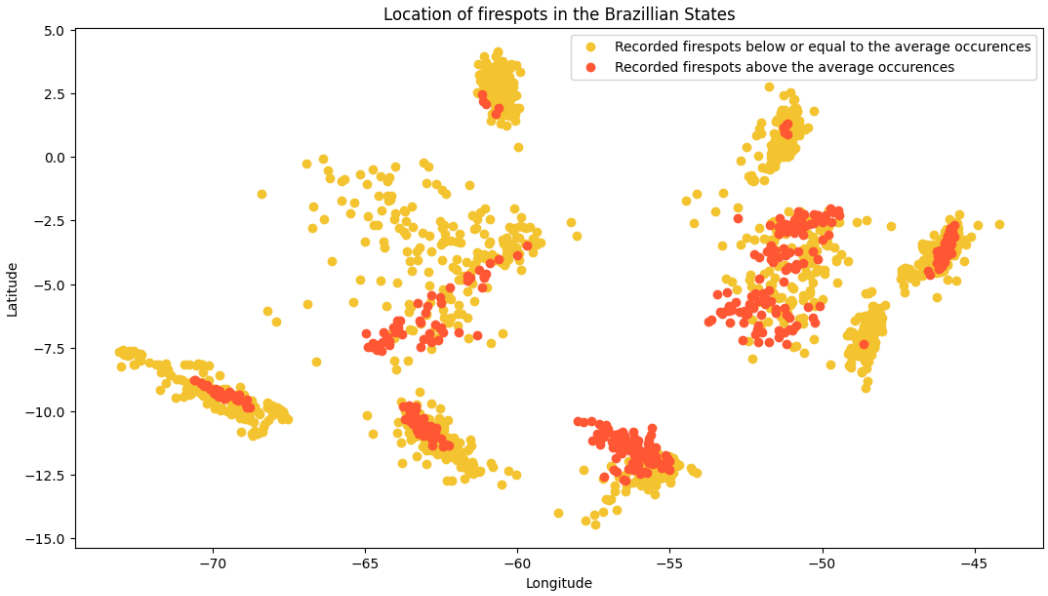

Figure 6: Plot showing the location of firespots via geographic coordinates over the years 1999-2019

To more accurately visualise this data, a map of Brazil was overlaid over the figure below. We can observe from the figure that Para (PA) mostly reports firespots that are above the average occurrences. Amazonia (AM) despite being the largest state only represents a few of the firespot locations, more than half of them being less than or equal to the average occurrences.

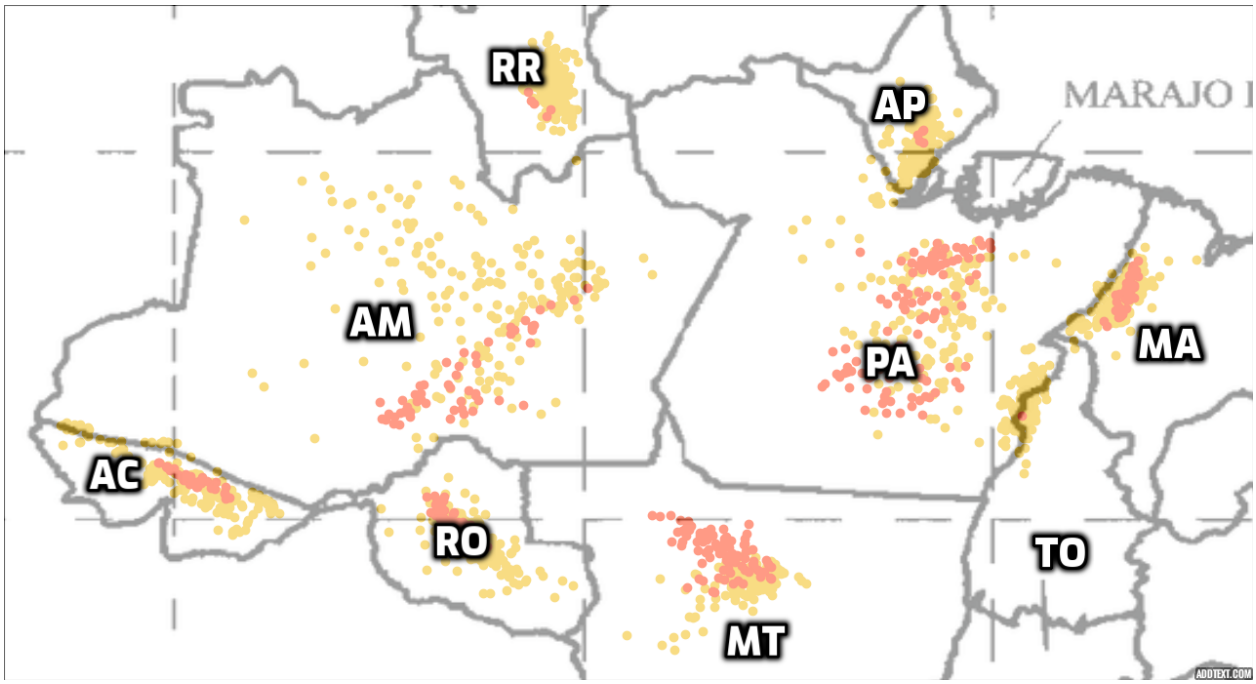

Figure 7: Map of the 9 Brazillian states and the location of firespots over the years 1999 - 2019

Heat Map

In conjunction with the firespot location figures, a heat map for the 9 states was created, showing the total occurrences of firespot per year and per month. This will help determine which states contribute the most to the reported firespot occurrences

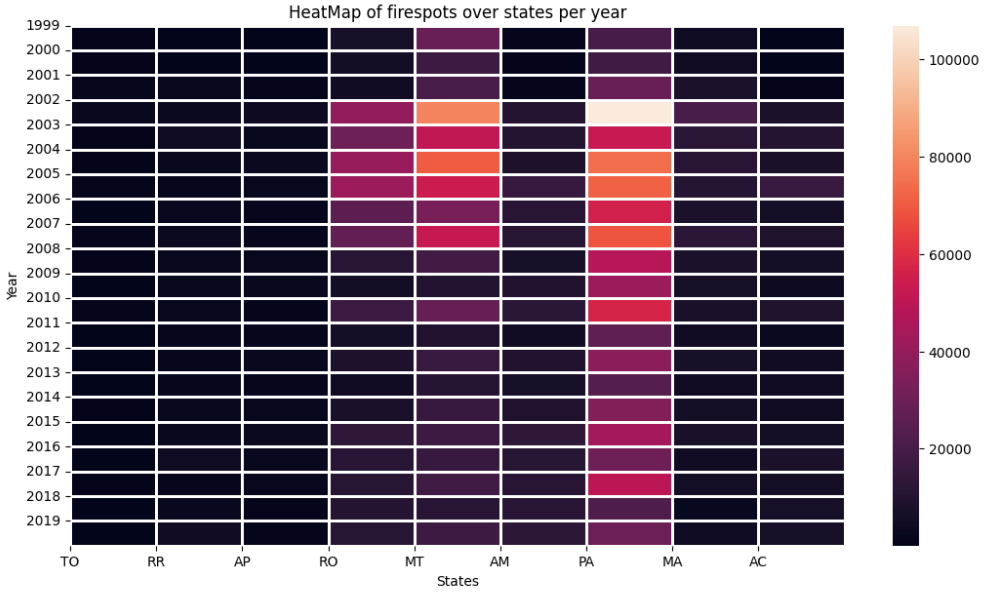

Figure 8: Heat Map showcasing the Occurrences of firespots over the years 1999 - 2019 in the 9 Brazillian states

From the above figure, we can observe that most of the firespots occur in the state of Para(PA), Mato Grosso (MT) and Rondonia (RO) when compared to the other states. In 2002, the previously mentioned states came out with the highest recorded firespots, with Para recording the most. However, since 2002, the firespots appear to decrease, with Mata Grosso and Rondonia reporting virtually the same number of fire spot occurrences as the other states from 2008 onwards. Although Para still appears to top the heat map with most occurrences, they have significantly dropped in their firespot occurrences from 2002, with them reporting almost the same number of firespot occurrences in 2018 and 2019 as other states.

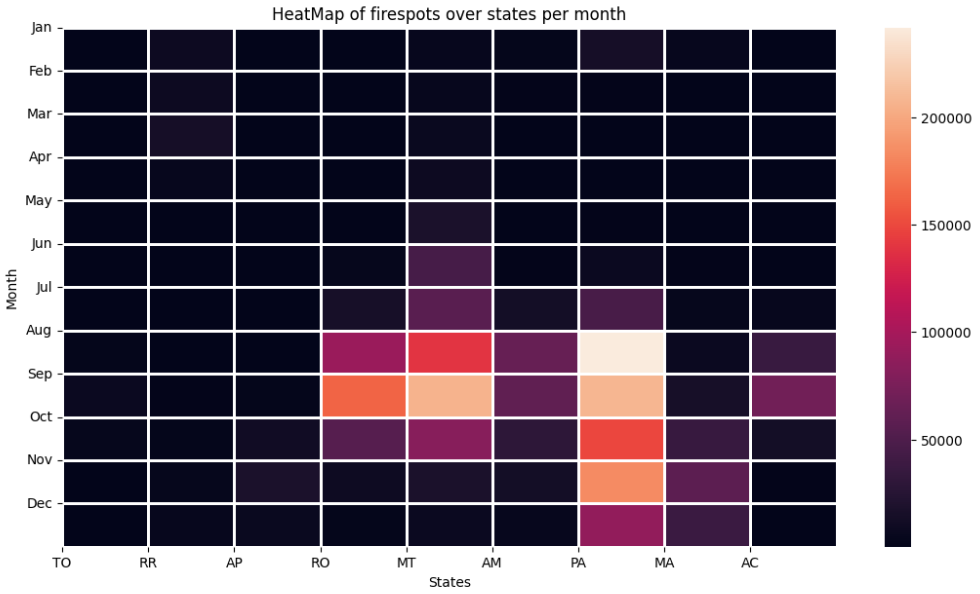

Figure 9: Heat Map showcasing the Occurrences of firespots over all the months in the 9 Brazillian states

Following a similar style to the previous heat map, the states of Para (PA), Mato Grosso (MT) and Rondonia (RO) reported the most firespot occurrences during the months, as seen in *Figure 9*. These mostly occurred between the late winter to early spring season (August and September), with Para extending the duration all the way to early summer (December). It appears that the early half of the year was virtually no reports of fire occurrences.

3D Plot

To visualise the firespot occurrences per state per year from a different perspective, a 3D plot was created. A 3D scatter plot and a 3D bar plot were generated to represent the data. However, the 3D plots obtained were too difficult to read and make out, on account of the large variable range. The figures below represent the failed attempts at visualising the data via a 3D plot.

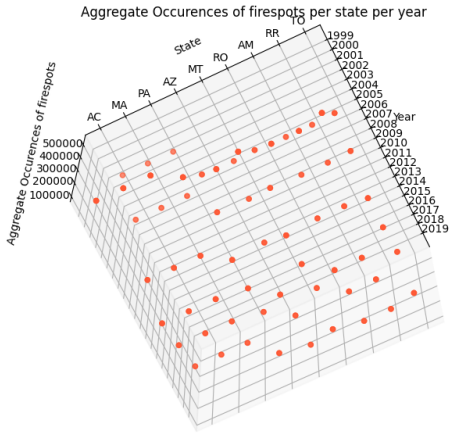

Figure 10: 3D scatter plot showcasing the Occurrences of firespots over the years 1999 - 2019 in the 9 Brazillian states

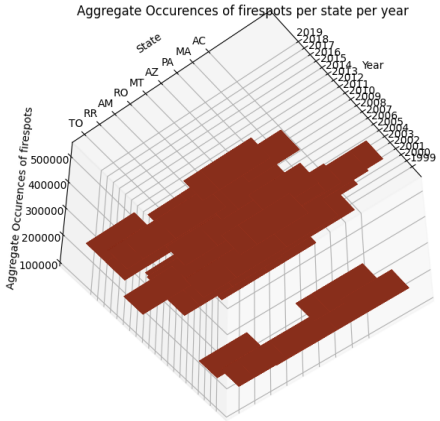

Figure 11(a): 3D bar plot showcasing the Occurrences of firespots over the years 1999 - 2019 in the 9 Brazillian states

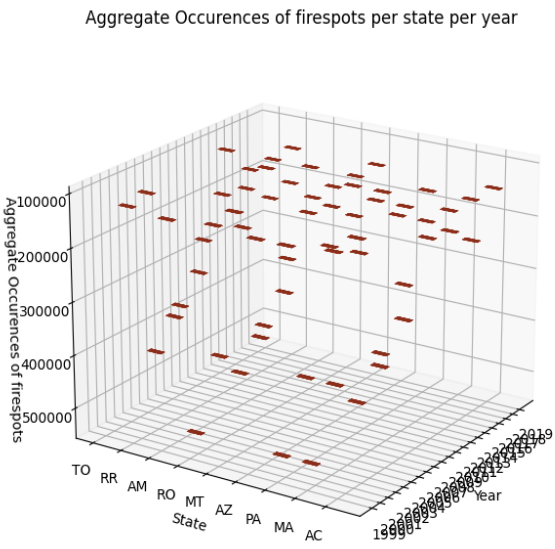

Figure 11(b): 3D bar plot showcasing the Occurrences of firespots over the years 1999 - 2019 in the 9 Brazillian states

In light of the failed 3D plots, a better way to represent the data might have been to make multiple subplots, occupying a different range, but it would be hard to combine and analyse the data altogether. Another method would have been to create a 3D model or simulation of the plot so that it would be easier to view, compare and analyse the data.

El Nino & La Nina Severity

The climate Phenomenon El Nino and La Nina are part of a natural global climate system that plays an important role in regulating global temperature[7]. They particularly affect the South American countries, controlling the temperature in the region almost every year. El Nino events are associated with bringing warm currents of atmospheric air to regions while La Nina is the opposite, providing sustained cooling of areas and they never occur in the same year. Each year they can affect the severely, with a severity ranking of - Weak. Moderate, Strong and Very Strong.

Figure 12 below showcases the presence of El Nino and La Nina over the years 1999 - 2019 and their severity rating.

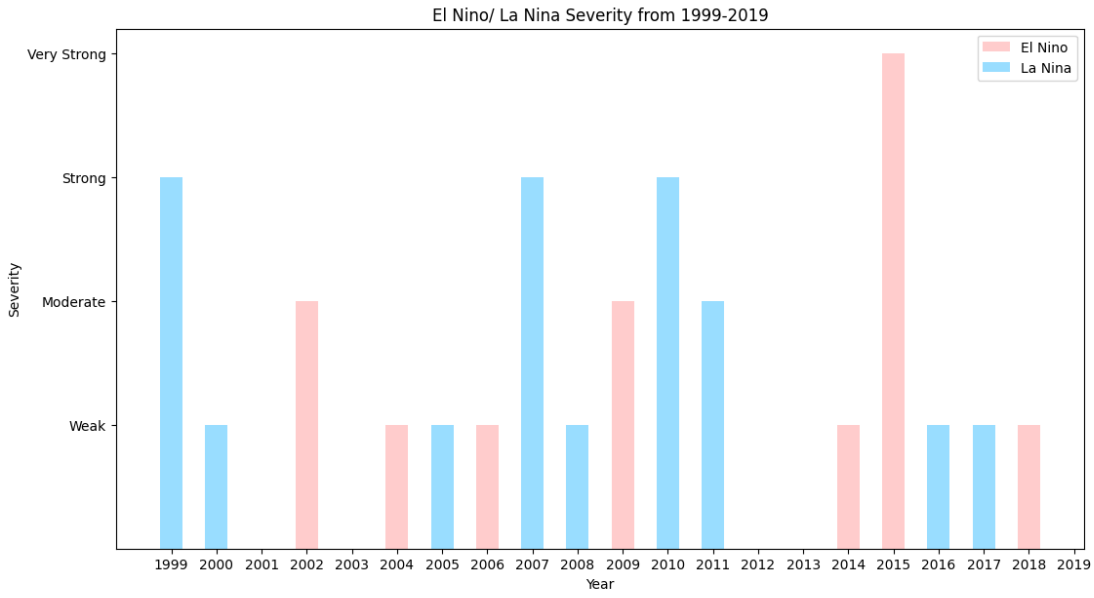

Figure 12: Graph representing the severity of El Nino and La Nina over the years 1999 - 2019

From the figure, we can observe that La Nina had a mostly strong presence between the years 1999 to 2011 while having a weak to being almost absent from 2012 to 2019. El Nino on the other hand has had a relatively weak presence all-round, but peaking with a ‘Very Strong’ severity rating in 2015

Firespots and El Nino & La Nina Correlation

To understand if there is a correlation between occurrences of firespots and El Nino & La Nina, a figure has been created which overlays the Aggregate Occurences of firespots graph (*Figure 2)* with the El Nino & La Nina Severity graph (*Figure 12*) across the years 1999 - 2019. At each of the critical points of the Aggregate Occurences of firespots graph, a marker has been placed which represents the colour of the climate phenomenon that occurred that year:

El Nino: Rose Pink La Nina: Sky Blue No Phenomenon: White

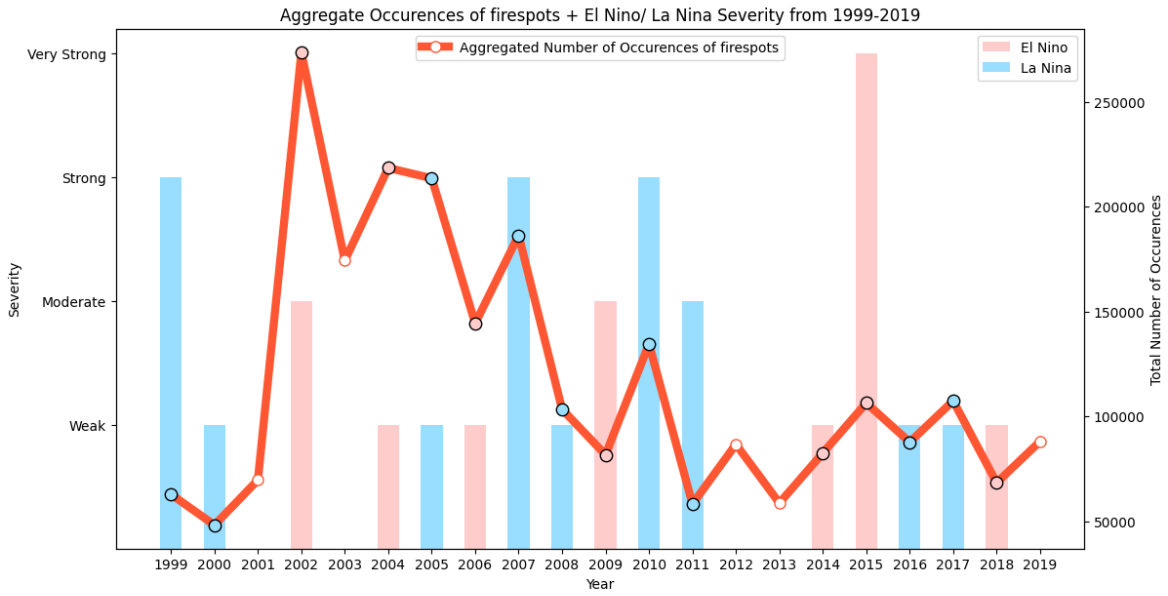

Figure 13: Comparison of Total Occurences of firespots to the severity of El Nino and La Nina over the years 1999 - 2019

Observing the colour of the critical points, we noticed that during the climate phenomenon of La Nina, the occurrences of firespots generally decrease over time. This may point to a loose negative correlation between Occurences of firespots and La Nina. This would make sense logically, as La Nina is associated with bringing cool currents to regions, thus possibly reducing fire spots.
On the other hand, it is difficult to make out a pattern between El Nino and the Occurrences of firespots. There appears to be no correlation between El Nino and the occurrences of firespots

Conclusion

With the data and visualisations provided in this report we can come to the following conclusions :

- ➔ The state of degradation on the Amazon Rainforest has decreased over the years, as seen in *Figure 2*, which may point to counter-degradation methods working

- ➔ The state of Paras accounts for the most occurrences in firespots over the years, as seen in *Figure 5, Figure 7* and *Figure 8*

- ➔ Almost all occurrences of firespots happen during Late Winter and Early Spring Season (August - September) as seen in *Figure 4* and *Figure 9*

- ➔ There appears to be weak evidence to believe that there is a negative correlations between Occurences of firespots and La Nina, while there is no conclusive evidence to show a correlation between Occurences of firespots and El Nino, as seen in *Figure 13*

Self Assessment

For this report, I believe I did a good job in hitting all the criteria points.

- I presented the report in a manner that people not familiar with data analytics would be able to understand.
- I explained how I obtained the data, as well as mentioned the values in the data and steps taken to process the data. I laid out all the methods and programming tools I used to explore the data and create visualisation graphs and plots.
- All my figures were labelled properly, with special consideration to use colour-blind friendly colours so that they may be accessible to everyone.
- I presented a variety of visualisations from scatter plots and bar graphs to heat maps as well as attempted to utilise 3D plots. I even mapped the location points to an actual map, which would greatly help anyone understand where the firespots occur.
- I included figure captions and report text to describe how the purpose of the visualisation and what conclusions can be read from it.
- I explained the importance of El Nino and La Nina briefly and made it easier to read the visualisation by including markers of critical points of the same colour as the climate phenomenon
- I decided not to use further quantitative data analysis on the dataset as I believe that it would require making a lot of assumptions and creating inconclusive results, alongside which the visualisations would become confusing and messy. Simple visualisations like the ones provided are apt to drive the goals of the project home without baffling the reader. I also briefly explained my point on why I chose not to use further data analysis in my report with regards to Average firespot occurrences.
- I also believe the conclusions I arrived at in this report would greatly help in future planning. Knowing which state is susceptible to firespots and when they are most vulnerable, as well as natural conditions that can help ease the workload on combatting firespots, would be useful in an ecological and financial manner.

In regards to aspects I would improve :

- I would have liked to present the data in a 3D model as mentioned in the report, for better visualisation
- I would have liked to make the graph look a bit more professional and elegant in regards to labelling and axis ticks

- I would have liked to present a visualisation of fire spots in all the individual states collectively in a clear but succinct manner

With the above points mentioned, I would grade myself with a P + 12

References

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