Visual Analysis on Global Carbon Emissions

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Carbon emissions is a driving factor of climate change, detrimentally impacting our environment and rocking the biosphere. I have been passionate about researching the topic and have chosen to take the opportunity with this final project to make informative visualizations while exploring certain questions I have. I began this project with two choropleth maps to display emissions for every country in the world from 2023. One displaying total emissions (Figure 1) and the other displaying emissions per capita (Figure 2).

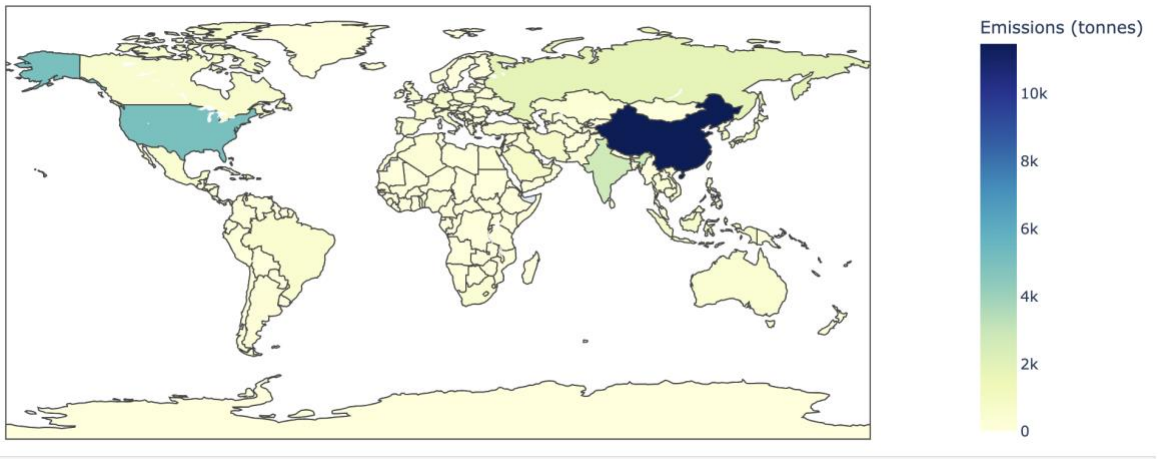

Figure 1: A map in Mercator projection. Displaying total emissions (tonnes) by country. Originally interactive, now static due to PDF format.

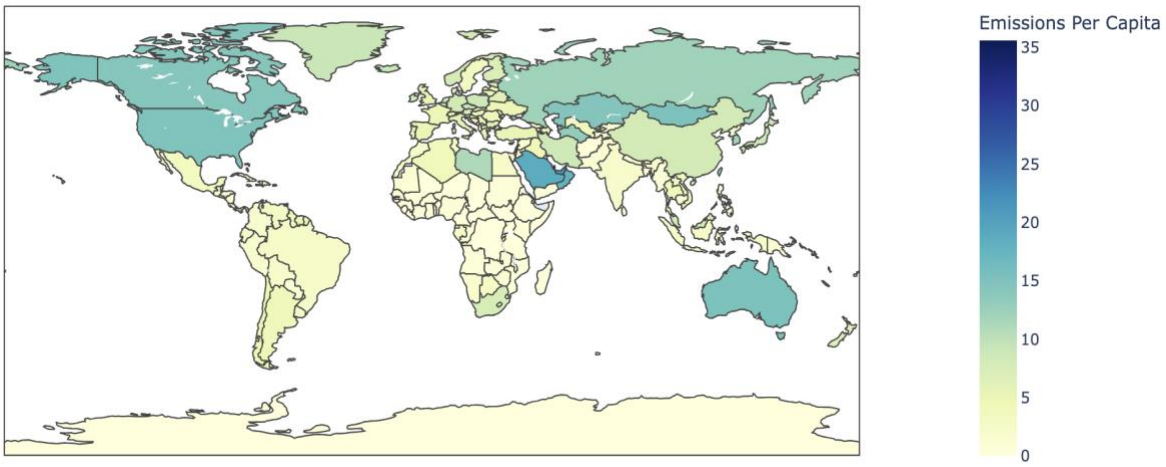

Figure 2: A map in Mercator projection. Displaying emissions per capita (tonnes) by country. An originally interactive map, now static due to PDF form.

My research questions revolve around the top carbon emitting countries. First, I want to look at the raw breakdown of emissions totals by country. There are 5 emitters that make up over 50% of total carbon emission world-wide: China, United States, European Union, India, and Russia. The following is a visualization of the total carbon emissions for each of these countries compared to the total emissions from every other country in the world (Figure 3).

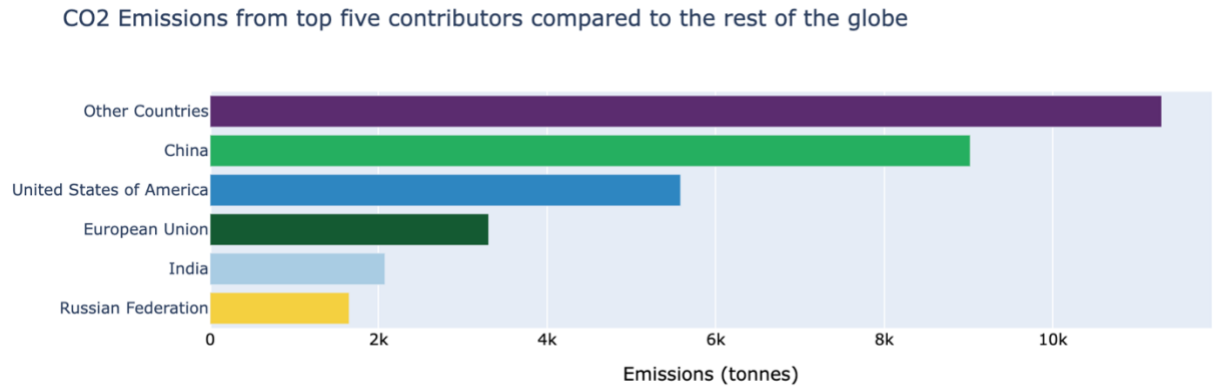

Figure 3: A comparison of emissions from the top five emitters against the total emissions from all other countries. All six of these bars add up to equal the total global carbon emissions.

From here, I focused solely on these top emitters. I wanted to explore what the major sources of emissions are per country. This led me to create a breakdown in the form of pie charts for the USA (Figure 4), China (Figure 5), the European Union (Figure 6), India (Figure 7), and Russia (Figure 8).

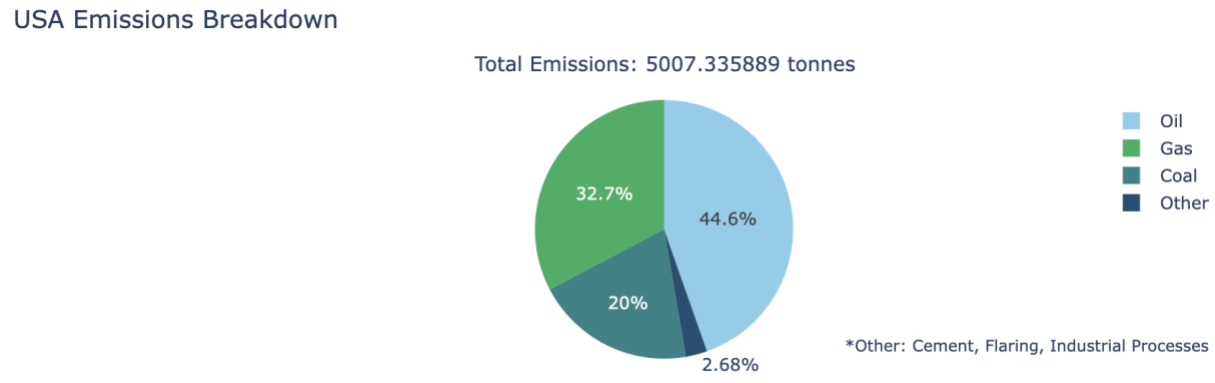

Figure 4: Percentage breakdown for sources of carbon emissions in the United States. Data from 2023

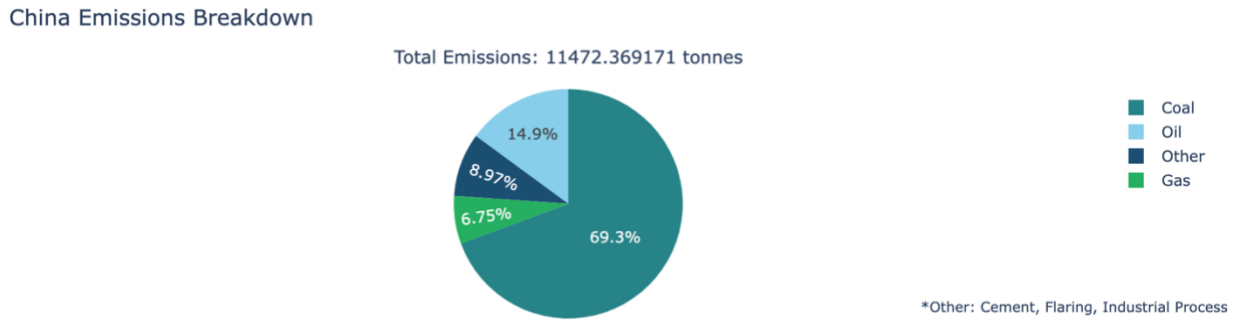

Figure 5: Percentage breakdown for sources of carbon emissions in China. Data from 2023.

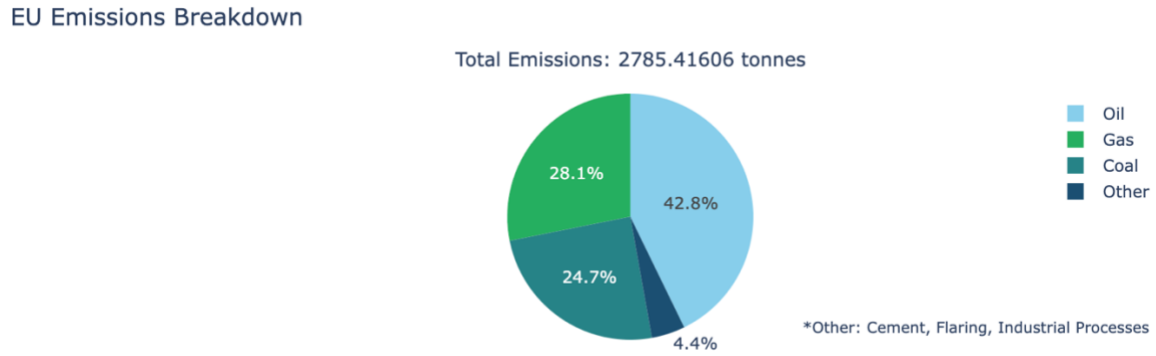

Figure 6: Percentage breakdown for sources of carbon emissions in the European Union. Data from 2023

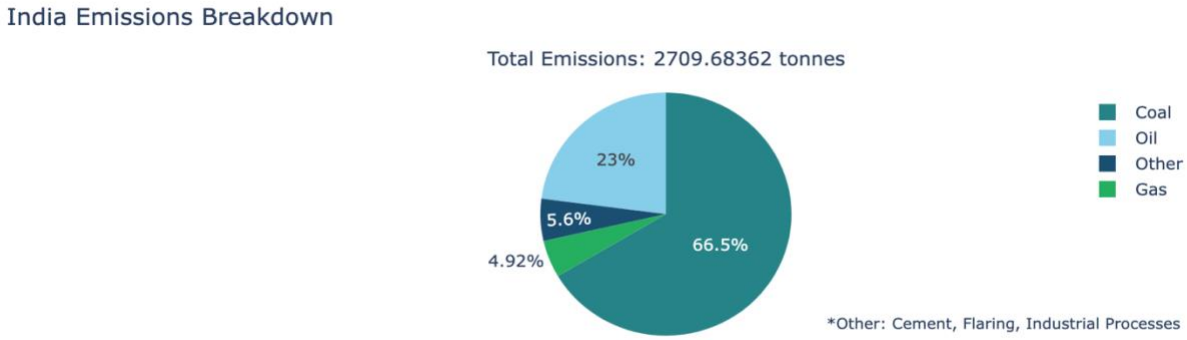

Figure 7: Percentage breakdown for sources of carbon emissions in India. Data from 2023.

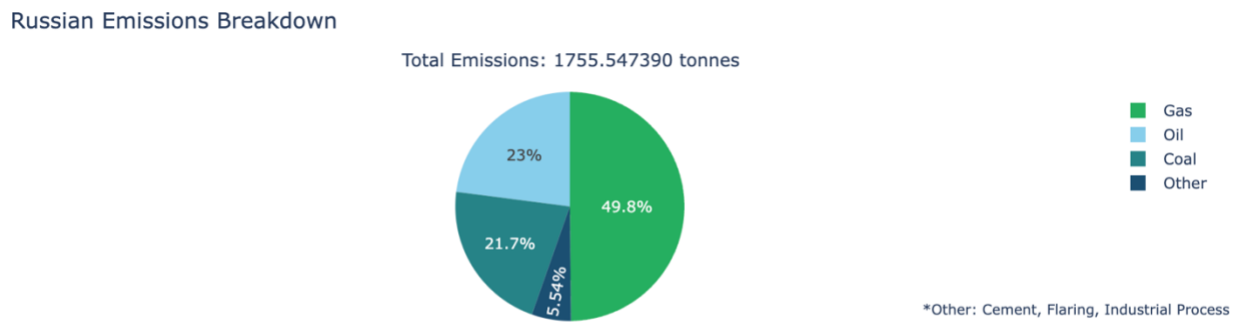

Figure 8: A percentage breakdown of sources of carbon emissions in Russia. Data from 2023.

Now with a visual breakdown of carbon emission sources, I have discerned that a common major source is the burning of coal. However, this is not consistent across all the top emitters. So, it is to be concluded that there is no standout in terms of carbon emission sources within these top countries. Furthermore, this shows that it is not likely for the source of carbon emissions to indicate higher total emissions.

Still looking specifically at the top emitting countries/regions, I wanted to see how the level of emissions has changed over time (Figure 9).

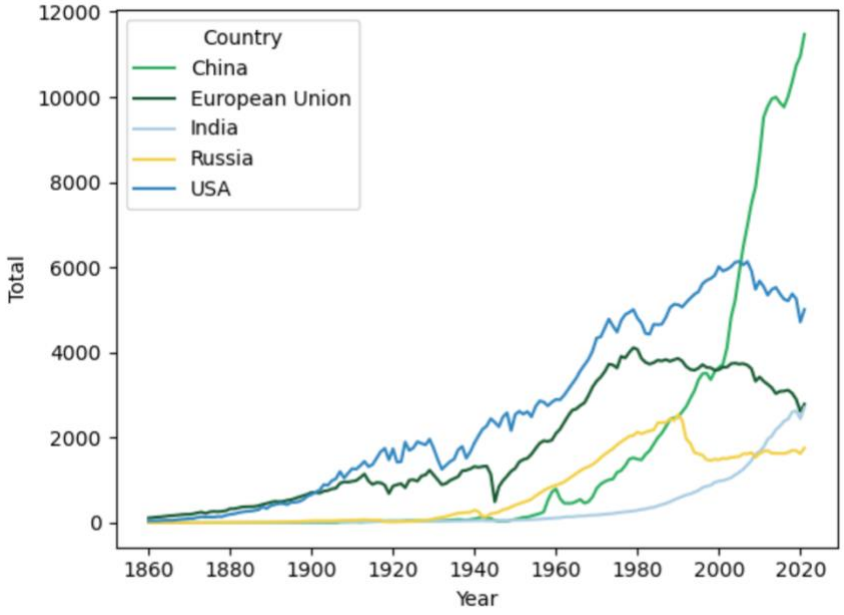

Figure 9: A change of carbon emissions over time. Countries are chosen as they are the top emitters of carbon. Total refers to total carbon emissions measured in tonnes.

I chose to begin this time-series analysis at the year 1860 due to this being the start of global industrialization and the catalyst for an increase in carbon emissions. In my initial visualization the carbon emission levels were near 0-20 tonnes per country from 1750-1860. So, I narrowed in on our range of years to draw more impactful conclusions. A dip is prominent for the USA between 1920 and 1940. This is very likely due to the Great Depression and decline in production. Another dip in shown for the European Union in the 1940s, which is more than likely due to World War II and the toll it had on the continent as a whole. Russia saw a dip around 1990, which is likely around the fall of the Soviet Union and the formation of the Russian Federation (as we now know it). Otherwise, we see a steady climb in emissions for most countries over the last 100 years. China has seen a boom in emissions as the exponential industrialization and production has grown in more recent years, surpassing the USA and all other leading emitters. The European Union has seen a steady decline since the 1980s as they have been heavily focused on reaching net-zero carbon emissions.

For my final visualization for analysis. I noticed very highly populated and economically powerful countries have high carbon emissions. I wanted to see if there was any correlation between GDP (Gross Domestic Product) and emissions (Figure 10). To do this I created a scatter plot with data combined from my found datasets and gapminder data containing data for GDP by country.

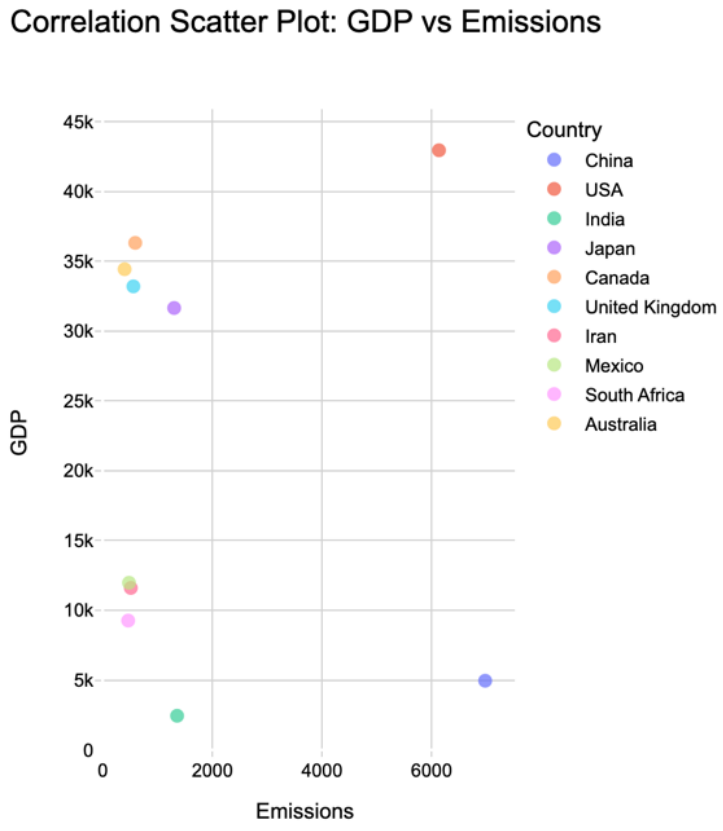

Figure 10: A scatterplot correlation chart depicting the top ten emitting countries with total emissions (tonnes) on the x-axis and GDP on the y-axis. Data is from 2007.

In order to complete this correlation plot, I had to omit Russia as gapminder had no GDP data pertaining to them. This did not make a major impact on my analysis however, as it is clear there is no strong correlation between the two factors. I was surprised by this result as I instinctively predicted that a higher GDP would correlate with higher levels of carbon emissions.

Conclusion

I have many ideas for where to go from here with this exploration of my questions regarding emissions data. I made all my plots via Plotly to be interactive with the intention of creating a Dash app to host my visualizations. However, in a crunch for time, I was not successful in producing a visually pleasing final product with Dash, and had to resort to creating a PDF for the sake of turning my assignment in. I would like to take the time throughout the summer to create a detailed finished product that allows interactivity with my plots. I would like to introduce new research questions as a result of this project. Where are these top emitting countries at in their process of reaching a goal of net-zero emissions. This would take quite a bit more work as I would have to gather data around the negative emission factors for each country to discern what level of emissions need to be accomplished in order for total emissions to cancel out to zero. I would like to see if I can find more correlating factors with these top emitting countries. I would have to explore more short-term effects of emissions to be able to find correlation more easily between the two. Overall, my questions regarding the generation of carbon emissions, sources, change over time, and correlation with GDP were answered through visualizing the data I found, whether it supported or rejected my hypotheses.