CIS4020 Report

1) A short description of the problem, including the questions that your dashboard will answer

With this dashboard we will be illustrating the effect that the COVID-19 pandemic has had on climate change in North America (Canada & America) in response to the restrictions on mobility. Our interactable dashboard illustrates a map of either Canada or the United States (depending on selection) and will illustrate the relative amount of mobility in each region. Further, we illustrate climate change impacts through correlation calculations and graphs at the bottom of this document to illustrate the impact of mobility restrictions throughout the pandemic.

Some main questions we wanted to answer with this dashboard are:

1) How have businesses been affected by the COVID-19 pandemic and how has that impacted carbon emissions?

   This is not directly viewable within our map (due to lack of data), however, data and calculations can be found at the bottom of this document to illustrate the effect that business closures have had on emission rates throughout the pandemic.

2) What has been the effect on climate change with respect to mobility and transportation?

   The relative amount of mobility & transportation throughout the pandemic is viewable with the visualization map, however, the effect on climate change (e.g., co2 emissions) is found at the bottom of this document through the correlation graphs and calculations.

3) Can we make any assumptions about the future of climate change after the pandemic is over?

   To answer this question we interpreted results in relation to the graphs for the correlation between values from question one and two. You can find a summary including an explanation at the bottom of this document that will illustrate some of our findings.

2) A short literature review that outlines the problem. The literature review should be accessible by non-academic community members, and properly cited.

Below is a short list of some of the references we take inspiration from and some quick details about each. Note we take inspiration from more references but we limited the list, in order to make this list easier to scan through, while not being daunting to even novice users.

1) Current and future global climate impacts resulting from COVID-19: https://www.nature.com/articles/s41558-020-0883-0

- Due to the pandemic and enforced/voluntary social distancing (including remote work), there has been a reduction of both GHG and air pollutants
- Mobility data has shown that mobility reduced by 10% in most of 125 tracted nations and by 80% in 5+ nations (during April 2020).
- Estimate of emission changes in GHG and air pollutants since the pandemic and how the this could affect the future
- Expect that changes in surface-transport have contributed the most to the decrease in GHG and air pollutants
- Bottom-up analysis of 123 countries and covering >99% of global fossil fuel CO2 emissions
- Emission reductions peaked in mid-April 2020, further global fossil fuel CO2 emissions & total NOX emissions could have decreased by as much as 30% (in April 2020) -- Likely a result of a reduction in transportation
- Observing CO2 concentrations due to COVID-19 is challenging as CO2 has a long atmospheric lifetime, making any slight changes very hard to see
- However, changes in the amount of air pollutants can tested, and an overall decline in NO2 has been observed globally, further NO2 reductions are expected to be well correlated with CO2 changes
- Develop machine learning model to derive meteorology and chemistry changes in NO2 and then aggregate the changes for 32 nations to show how the observation of NO2 changes compare to the mobility estimate of NOX changes
- Project a long term cooling of 0.01+/- 0.005C if emission decrease stays at the 66% through June 2020 to the end of 2021
- Estimate that declines in NOX of ~30% will lead to short-term cooling of ~0.01C from 2020-2025

2) Reduction in greenhouse gas emissions from national climate legislation: Eskander, S.M.S.U., Fankhauser, S. Reduction in greenhouse gas emissions from national climate legislation. Nat.

- Countries are taking action against climate change, the climate change laws of the world database has records of 1800 climate change laws and policies and very importantly, there is no country in the world that does not have at least one climate change law
- They estimate statically what these laws have actually achieved
- In previous material the climate change laws of the world database has been used to:
    i) Assess global progress in adopting climate policies
    ii) Understand the political economy of passing climate laws
    iii) Identify good practice in climate change laws
- Most climate change laws were passed in the last 20 years and at the end of 1999 there were only 145 laws worldwide
- Hypothesis is that climate change laws will identify a countries ambitions with respect to GHG emissions and after the law is passed an affect should be seen in the national emissions
- Paper looks at the annual effects of the laws in two ways
    i) 1- the short term impact
    ii) 2- the long term impact
- Passing a new climate law reduces annual CO_2 emission per GDP in that country by 0.78% in the short term and 1.79% in the long term (after 3 years)
- By 2016 the difference between the observed CO_2 emission and the predicted (with no legislation) was 15%

3) Le Quéré, C., Jackson, R.B., Jones, M.W., Smith, A.J., Abernethy, S., Andrew, R.M., DeGol, A.J., Willis, D.R., Shan, Y., Canadell, J.G. and Friedlingstein, P., 2020. Temporary reduction in daily global CO 2 emissions during the COVID-19 forced confinement. Nature Climate Change, pp.1-7. https://www.nature.com/articles/s41558-020-0797-x (2020).

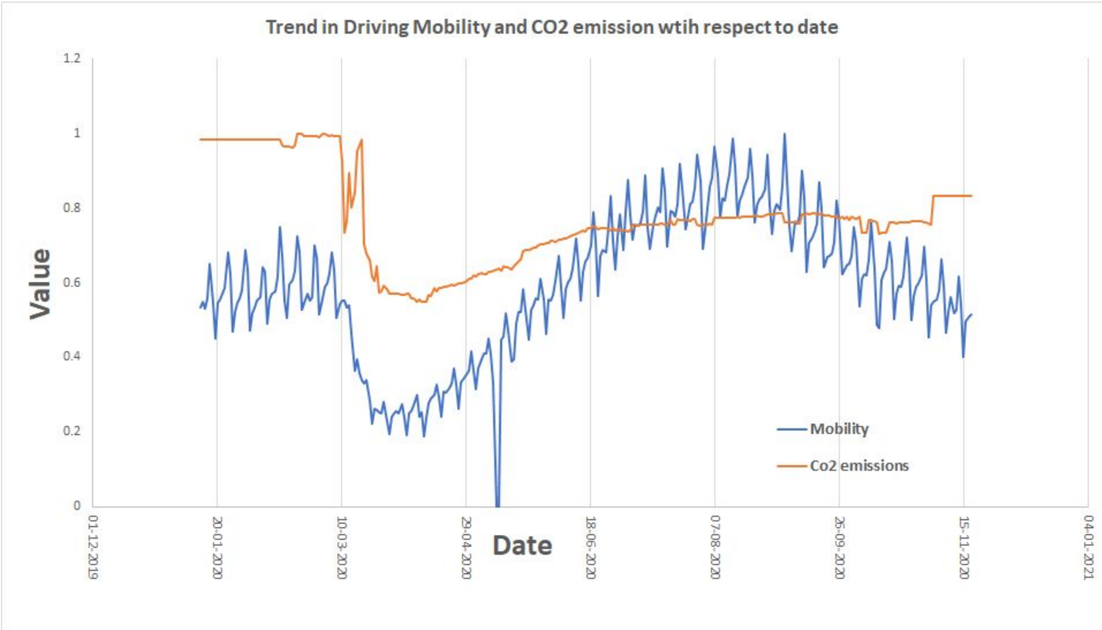
- Compiled government policies and activity data to estimate the decrease in CO_2 emissions during forced confinements
- Daily CO_2 levels dropped by 17% (compared to 2019), and about half of the changes is from surface transport
- Due to a lack of a real-time CO_2 emissions data, propose a new approach to estimate country level emissions based on confinement index, in order to capture the extent to which different policies affect emissions
- During past crisis such as the 2008-2009 financial crisis saw global co_2 emissions decline by 1.4% in 2009, but this was followed by a rapid increase of 5.1% in 2010
- However, COVID-19 is very different as individual behaviour is far more important
- Changes in co_2 emissions done for over 69 countries, 50 us states and 30 chinese provinces (represents 85% of the population and 97% of the co_2 emissions)
- Decrease in daily activity of 75%, surface transport decrease of 50%, industry and public sectors saw a reduction in activity of 35%
- The confinement resulted in a reduction in daily global CO_2 emissions of 17% (daily emissions comparable to 2006)

    - Global emissions from surface transport fell by 36% and made the largest contribution to the total emissions changes
    - An estimated reduction in CO_2 emissions of 5.7% overall for 2020 (considering several factors which could affect the current levels of decrease which are possibilities that exist when confinement levels are lightened)
    - However, International Energy Agency (IEA) predicts a decrease of -8% over 2020 (aligning with the high end scenario proposed)
    - Further, it is forecasted that emissions will rebound by +5.8 and +3.5% in 2021 as predicted by the international monetary fund and IEA
4) Climate Action Tracker Update: A Government Roadmap for Addressing the Climate and Post COVID-19 Economic Crises *Summary and Conclusions (Climate Action Tracker, 2020).*
    - CO_2 emissions declining during COVID-19 are nothing to celebrate, accordingly if strategies and policies are not developed, emissions will once again rise and potentially overshoot projected levels at 2030 (due to economic stimulus packages)
    - Strategies that invest in green energy have the strongest effect in reducing emissions post COVID-19
    - If there is a rebound to fossil fuel emissions at a significant scale, then emission rates will rebound to be worse than precovid-19 estimates for 2030
    - COVID-19 will do little to decrease emissions and will actually delay increases

Problems encountered and Limitations towards completion

Through this project we faced some major problems and limitations through the development of this dashboard. Specifically, with finding data and this managed to really limit our ability to do everything we wanted to with this dashboard. A Lot of data needed for the completion was either 1) not accessible (locked by researchers), and they never responded, or 2) simply unavailable. In the first case for instance we wanted data from University of Maryland as they had mobility and co2 data for America and more specifically for each state. However, they required researchers to email them for access to the data they publicly made available in their dashboard and unfortunately we never got any responses. Next, some data was simply unavailable, for instance a lot of co2 data was published for 2 years prior, for instance with 2020's publications by EPA and Statistics Canada we could get data from around the 1990's to 2018 (but nothing more recent than that). To overcome this, we found data from Priestly for national and sector co2 emissions, however, the data had a major flaw in that the regions were never specified, which meant we could not calculate the average co2 emission per day in a specific state or province like we originally intended. We attempted to find further data but were unsuccessful and this is especially relevant as the pandemic is very recent. It seems a couple major consequences of the pandemic being recent are that most research groups want to hide their data away in an effort to capitalize on publishing in as many high impact journals as possible, well, disuating others from doing so by putting major restrictions on the access of their data. To, at the very least have some illustration of our main goals we related the calculations to the overall data we found for Canada and the US, and while this eliminated our analysis and comparison by region, at the very least we could explore and interpret results nationally.

Graphs and Results

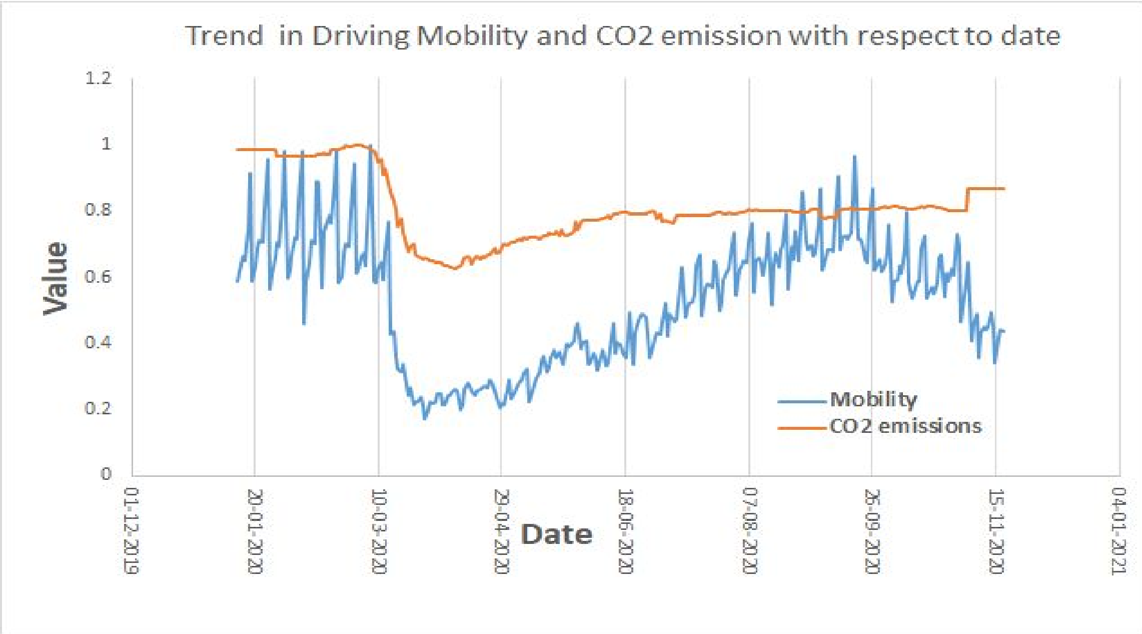



```
> cor.test(canCo2Data, canDriveData,method="spearman")

        Spearman's rank correlation rho

data:  canCo2Data and canDriveData
S = 3832001, p-value = 7.459e-06
alternative hypothesis: true rho is not equal to 0
sample estimates:
      rho
0.2501952
```

For emissions in Canada, we found that there was a sudden drop in mobility and emissions around the start of the pandemic. We can note that there is a clear correlation between mobility and CO2 emissions during that time frame. We can also see a gradual increase in CO2 as mobility increases. Since we have a positive correlation value from spearman's correlation formula, we can state that there is a positive correlation between emissions and mobility in Canada.

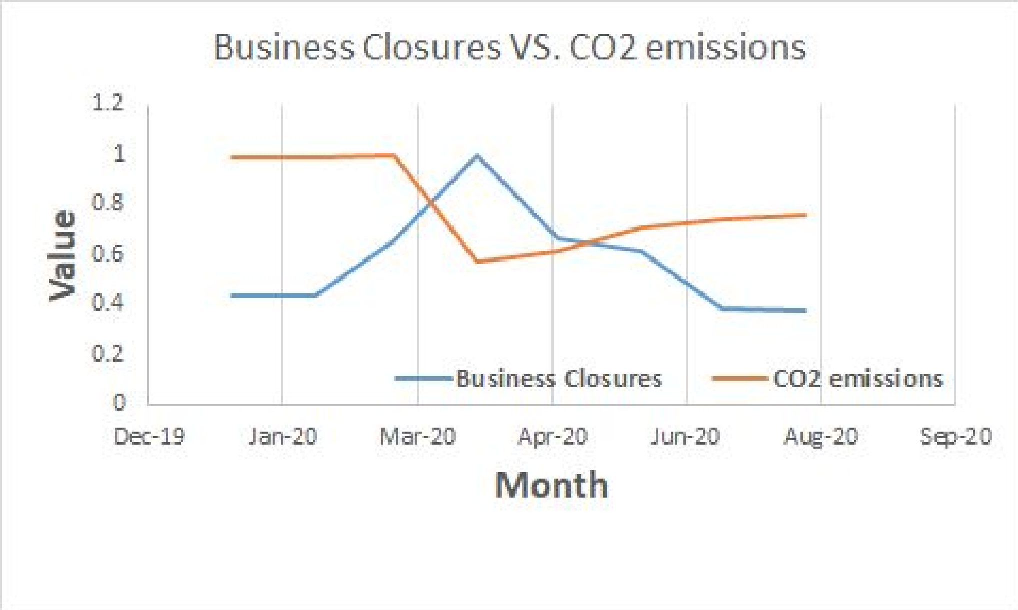



```
> cor.test(co2Data,driveData,method="spearman")

        Spearman's rank correlation rho

data:  co2Data and driveData
S = 3772256, p-value = 2.641e-06
alternative hypothesis: true rho is not equal to 0
sample estimates:
      rho
0.2618854
```

Similar to the emissions in Canada. There is a direct correlation between mobility and emissions in the USA. We can see that both dropped significantly around the start of the pandemic. Conversely we can see a gradual increase in CO2 as mobility increases. Since the rho returned by the spearman correlation formula is positive, we can see that there is a positive correlation between emissions and mobility.




```
> cor.test(busCo2Data,busData,method="spearman")

	Spearman's rank correlation rho

data:  busCo2Data and busData
S = 121.22, p-value = 0.2715
alternative hypothesis: true rho is not equal to 0
sample estimates:
       rho
-0.4431217
```

We can also see that there were numerous business closures in Canada as reported by Statistics Canada during the pandemic. These closures have an inverse correlation with emissions as shown in the graph above. Using both metrics in spearman's correlation formula, we can see that there is a negative correlation between the two values.

<u>Reflections for the project:</u>

As a group we acknowledge we chose a difficult and highly volatile set of questions to answer given how recent the data we would need is. We reflect on this with the knowledge that in the future limiting ourselves to a simpler problem and perhaps a lighter set of questions, with more readily available data would make this alot more doable. Despite the problems we encountered we are collectively all proud of the work we accomplished and we are captivated and impressed by our own visualization.

References

Smith, C., Forster, P., Allen, M., Leach, N., Millar, R., Passerello, G., & Regayre, L. (2018). FAIR v1.3: a simple emissions-based impulse response and carbon cycle model*Geoscientific Model Development, 11*(6), 2273–2297.

"COVID‑19 - Mobility Trends Reports." *Apple*, covid19.apple.com/mobility.

Lafrance-Cooke, Amelie, et al. "Monthly Business Openings and Closures: Experimental Series for Canada, the Provinces and Territories, and Census Metropolitan Areas ." *Monthly Business Openings and Closures: Experimental Series for Canada, the Provinces and Territories, and Census Metropolitan Areas*, Government of Canada, Statistics Canada, 5 Aug. 2020, www150.statcan.gc.ca/n1/pub/11-626-x/11-626-x2020014-eng.htm.

Priestley-Centre. "Priestley-Centre/COVID19_emissions." *GitHub*, github.com/Priestley-Centre/COVID19_emissions.