# How the COVID-19 pandemic has affected both air quality and single use plastic waste

**DS4A: Women's Summit 2020 - Team #21**

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## Introduction

The COVID-19 pandemic has had severe repercussions not only on how people lead their day-to-day life, but also on the environment. On the one hand, newspapers and the media stress the reduction in air pollution and how the pandemic benefitted urban areas, typically surrounded by clouds of smoke. On the other hand, the restrictions imposed and the days in lockdown increased the consumption of plastic exponentially: people order more groceries and deliveries and, mostly, make large use of disposable plastic-based personal protection equipment (PPE).

The UN Environment lists greenhouse gases (GHGs, and in particular CO2) and plastic pollution as two of the main environmental challenges we face as humanity. In this project we seek to understand the impact of the recent pandemic on these two aspects of environmental quality and to assess the truthfulness of media reporting around them. In fact, while several newspapers and sectorial magazines (e.g. the Economist, NewScientist, Wired and the BBC to name a few) have commented on the environmental consequences of the pandemic, many of these articles have failed to specify the data used to make their inference and/or the underlying assumptions. We hope to shed light on the two issues and quantify the impact of COVID-19 on these two key environmental issues.

To do so, we analyze the trends before and after the beginning of the pandemic to identify whether there was a significant gain in air quality and the impact of this new amount of plastic waste. To address these questions we started by using EDA, then studied the issues through geospatial analysis, time-series analysis, and significance testing.

## Data Analysis & Computation

### Datasets, Data Wrangling & Cleaning

#### *COVID and Plastic Use*

We found monthly data on plastic production spanning 1972 until July/August 2020 for 'plastic products', 'plastic and rubber products' and 'plastic material and resin' for the whole US from the Federal Reserve Bank of St. Louis. We used the data from 2019-01 up to present day for the analysis and used all three plastic types. We understand that plastic production in these three categories may not include all plastic used in the USA, as imports and exports might alter this slightly, and this also may not correspond exactly to plastic waste, as some plastic may be used, reused and recycled, so there may be a lag or reduction in the amount of waste in relation to this. With these caveats in mind, our assumptions are that production can be used as a proxy for waste in this analysis, understanding that this might impact the interpretation of the results.

#### *COVID and CO2 Emissions*

We were able to find monthly CO2 data at the country and the state level from the U.S. Energy Information Administration and NASA's Global Climate Change Research. We cleaned the country level data and prepped it for analysis because this dataset has monthly observations up through 2020, which will assist us in analyzing any anomalies in CO2 emissions since March of 2020. While this data set is convenient because it is at the month level, it was only observed in Hawaii, which we do not believe is representative of United States CO2 levels as a whole. Finally, to get a feel for the CO2 emissions of the country as a whole, we aggregated the state-level CO2 reports. After additional data cleaning to these aggregated counts, we were able to see the CO2 levels from 1990 to 2015 at the country level.

To assess some of the major producers of CO2 -- namely fuel usage for transportation -- we incorporated travel data into our analysis as well. We found datasets about bike, automobile, and airplane travel from the Bureau of Transportation Statistics and grouped them by year to analyze how their trends compare with the CO2 emissions.

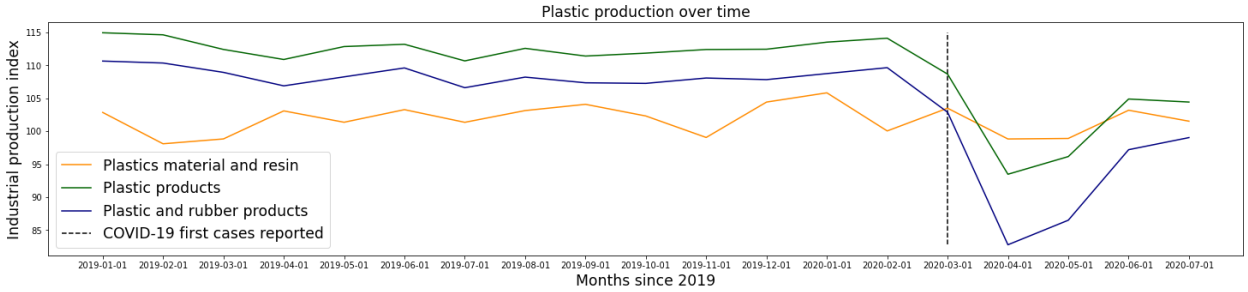
#### *COVID case counts and Air quality*

In order to observe any possible correlation between the severity and frequency of COVID cases and air quality, we used the US Census data, air quality data from the Environmental Protection Agency at the city and county level, and COVID data at the county level from USAFacts. To clean this data, we grouped the case count and death count datasets by state, joined it with the census data, and divided each state's case count by their population to calculate a standardized COVID report of cases per person and deaths per person.

For analysis of the Ozone and Air quality data, we grouped Ozone and AQI (Air Quality Index) observations by county and by state and took the average for each region. These values will allow us to observe air quality trends across the country and compare them with how the pandemic has affected citizens' health.

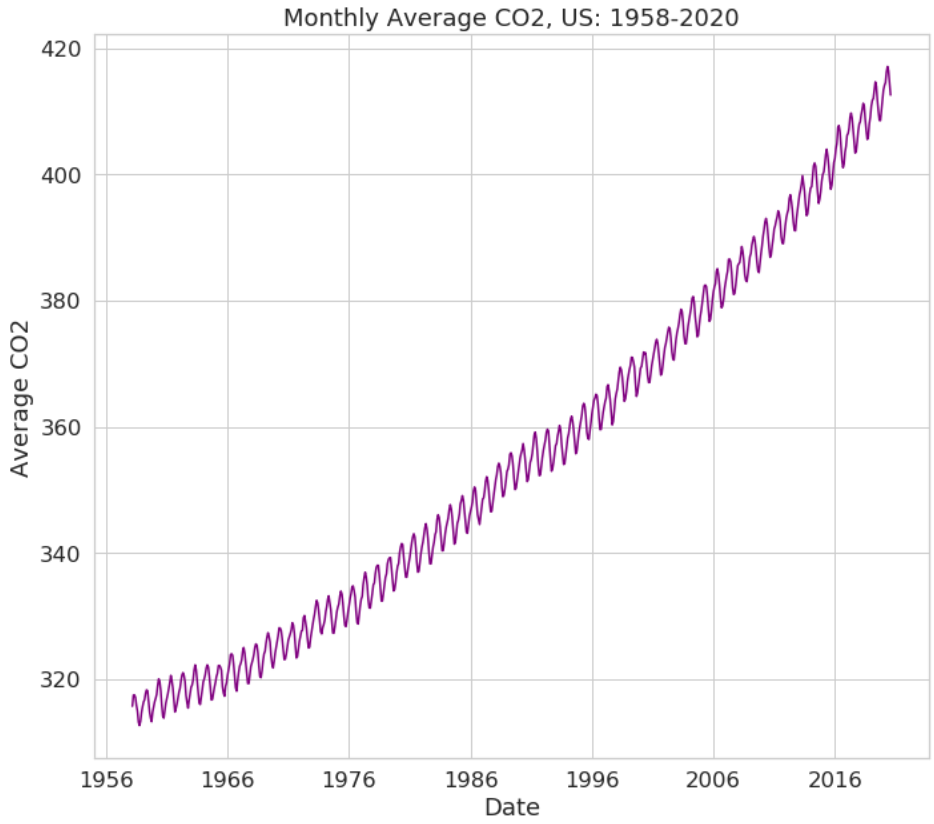
## Exploratory Data Analysis

### *COVID and Plastic Use*

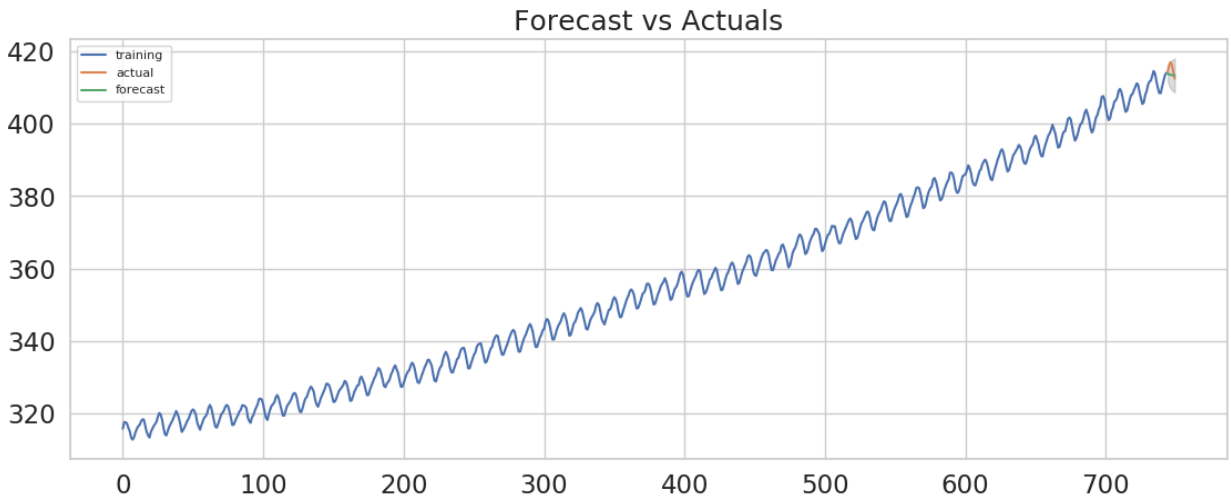



### *COVID and CO2 Emissions*

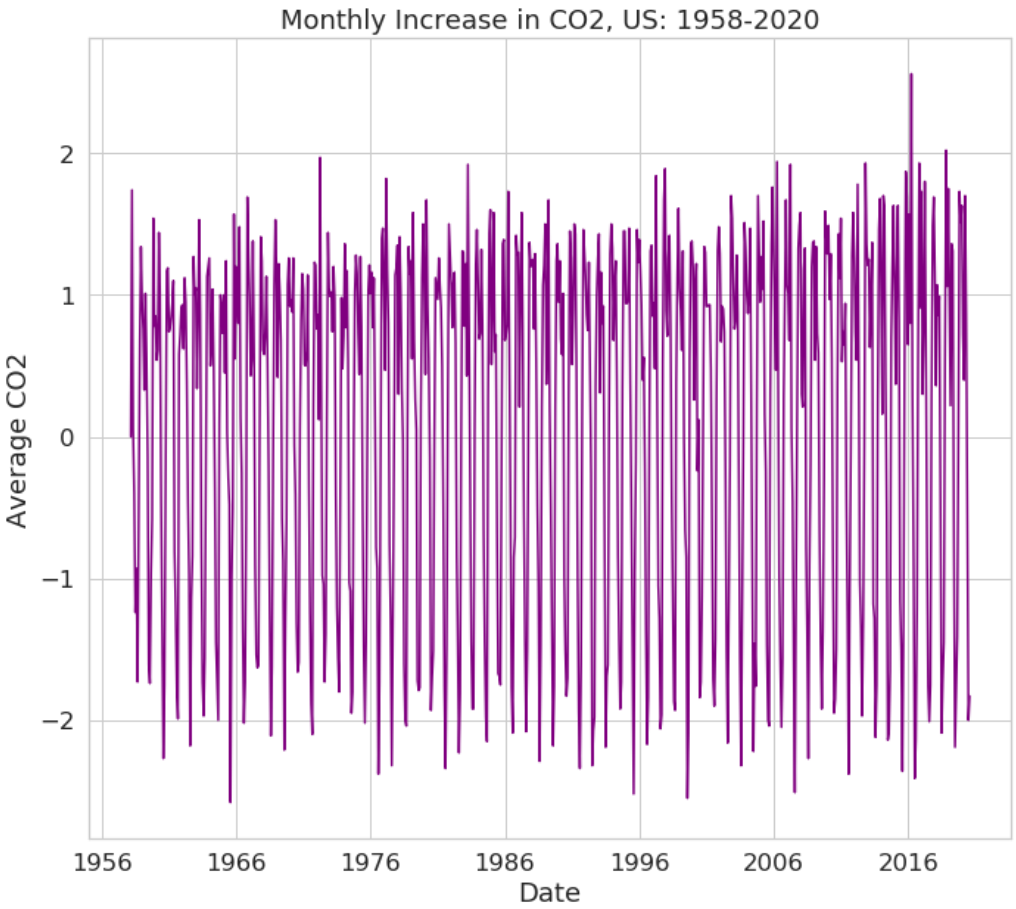
We observe a general linear increase in CO2 in the atmosphere, with some seasonality.




To analyze these trends better we first look at an ARIMA model to forecast the last 6 months (from March 2020) and see that the model would forecast lower CO2 than the one we see.




As newspapers claim that COVID caused a reduction in emissions we study whether this is the case by considering differences from the average concentration of CO2 from the month before. To do so we create a new variable differencing the n-th month's CO2 average and the n-1-th.



We see no obvious pattern. If the pandemic had caused a decrease in emissions we should observe all 6 last observations below zero, but to confirm this we also consider an ARIMA model applied to this difference.

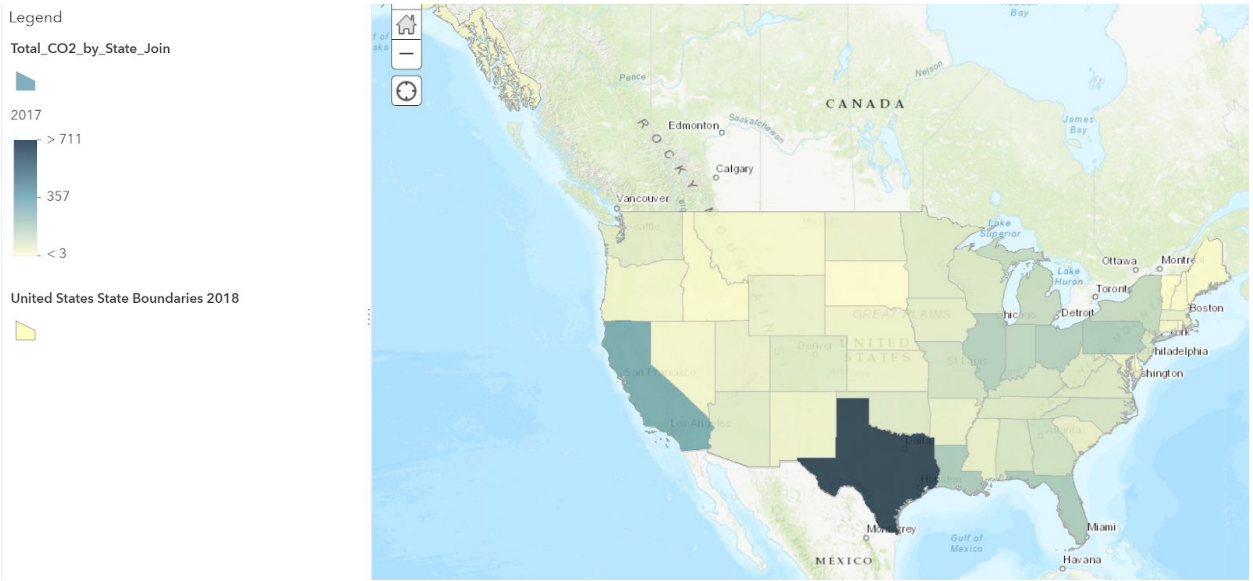
### *COVID and Transport*

Looking back to 1990 - 2011, we do see that air travel and CO2 emissions are correlated. Because of this, we expected the CO2 emissions to drop when COVID hit because there were fewer planes in the sky.


### *COVID case counts and Air quality*

Using basic geospatial analysis of CO2 levels by state, we see that California and Texas far outpace the other states in both transportation and total energy-related CO2 emissions, with Texas at 711 million metric tons of total CO2 emitted in 2017 alone.

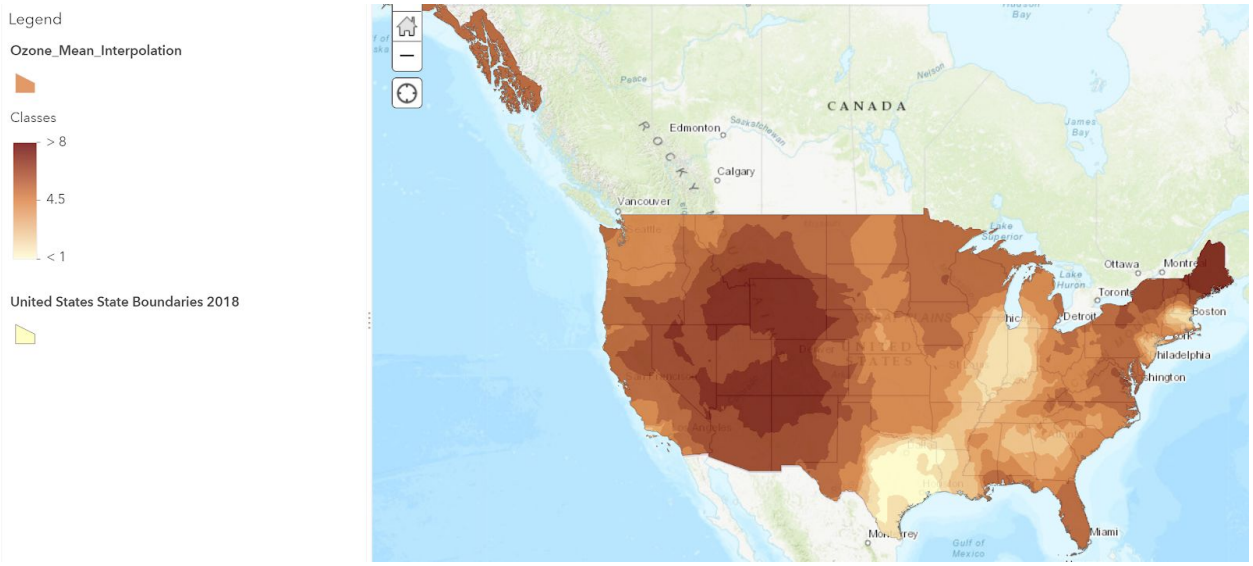
Total CO2 Emissions (million metric tons) :




Interestingly, we see that these trends are not consistent with the Ozone measurements - the average ozone measurements are much higher in the west and in Maine than in big cities, which came as a surprise.

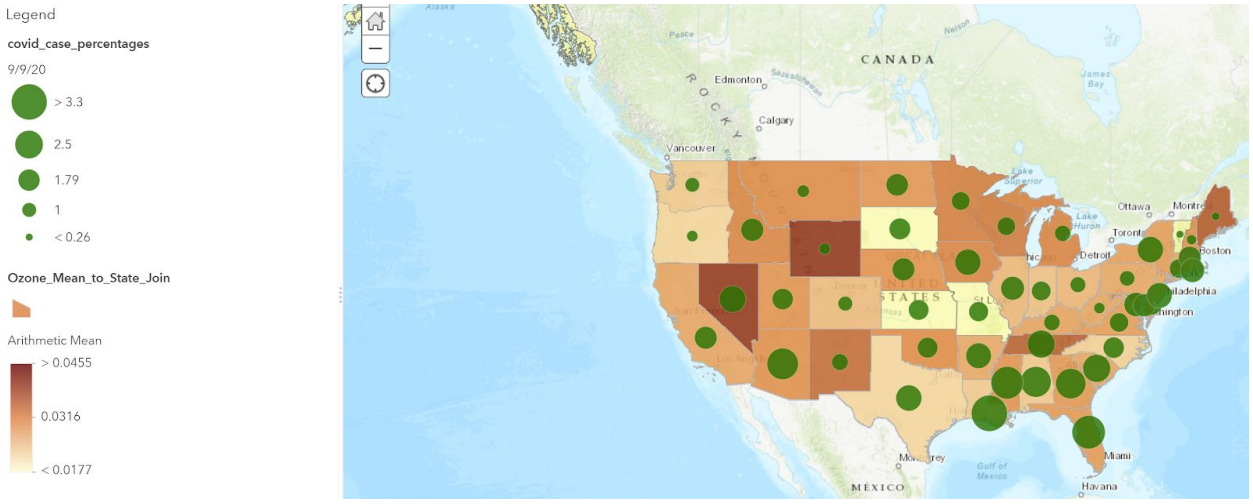
We know that high ozone levels can worsen respiratory issues including asthma, bronchitis, and emphysema, we wondered if it may affect COVID severity as well. We were curious about how the air quality in each region may be correlated with the percent of the population that caught or even died from COVID.

Here are the Interpolated Ozone values based on the 165 testing sites:

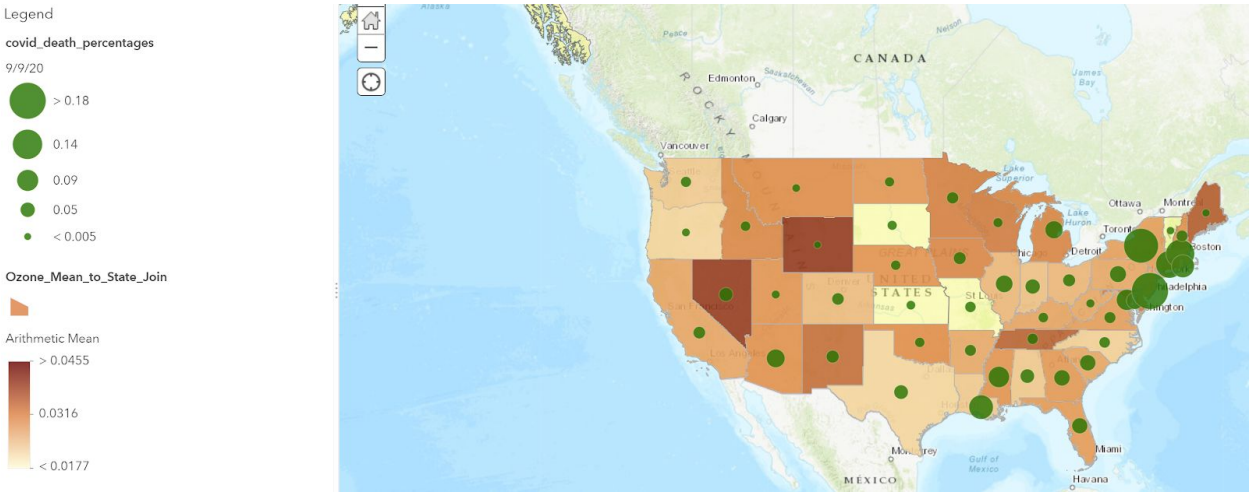


If there were a correlation between COVID severity and air quality, we would expect to see the percentages of deaths or percentages of cases rising in the areas with poor air quality such as Wyoming, Nevada, and Maine.

Here, we have the mean Ozone levels (ppm) aggregated to the state level shown by color. The layer on top of the ozone data is COVID case percentages shown by size of the green circles.

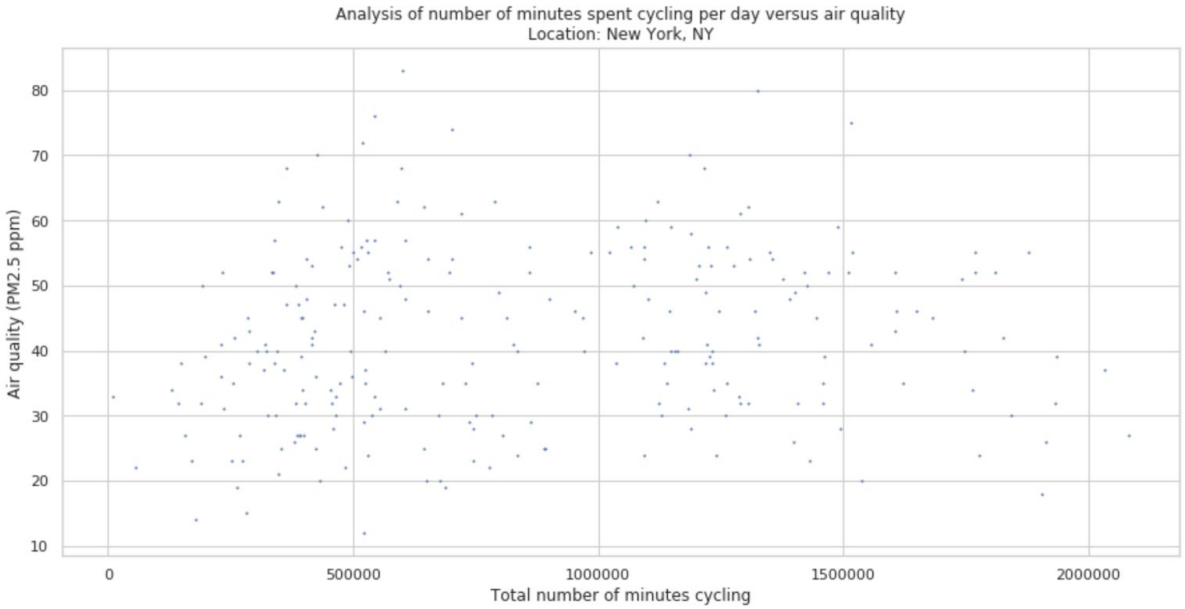



And the Ozone levels compared with COVID death percentages:

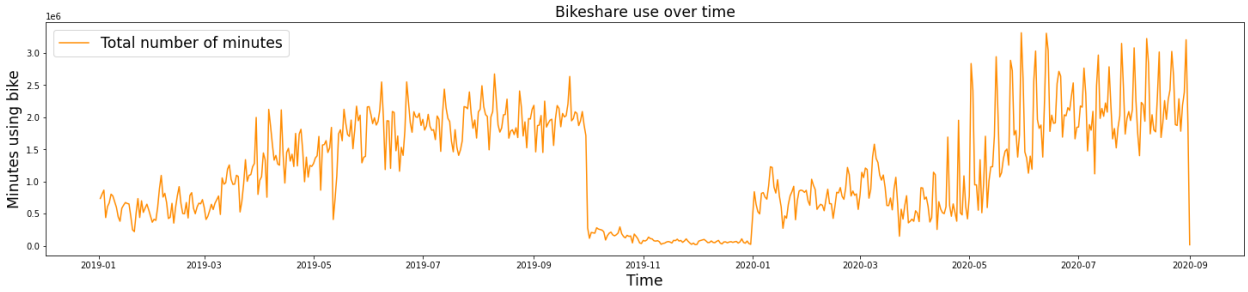



From these two maps, it does not appear that ozone levels and effects of COVID are correlated. Future analysis steps include observing the case : death ratio and whether or not that correlates with air quality.

*COVID and Bike Ridership*




The following chart shows the aggregated sum of minutes used bike share systems across centres per day, over time:




## Statistical Analysis & Machine Learning

## Conclusions and Future Work