

GOOGLE EARTH ENGINE
ENGINEERING ECONOMICS
CODING ASSIGNMENT

SO₂ & Its Role in
Climate Change

INTRODUCTION

In this problem-based assignment, we try to investigate the impact of sulfur dioxide on the environment. Sulfur dioxide comes from both human activities and natural sources. **Burning coal and other fossil fuels** is the largest source of sulfur dioxide from human activities, while **volcanic activity** is the prime natural cause of Sulfur Dioxide.

RECENT OVERVIEW

Power plant emissions of sulfur dioxide have increased across India in recent years. India passed the United States in 2010 to become **the world's second largest** emitter of sulfur dioxide, after China. NASA's Aura satellite found that emissions of sulfur dioxide from Indian power plants have **increased by more than 60 percent** between 2005 and 2012.

OUR OBJECTIVE

- 1 To develop **JavaScript** code for extracting zonal statistics from major cities in India using the **Google Earth Engine** Code Editor.
- 2 Extract the **Zonal Statistics** of the attribute 'Pollution levels' by using **Sulphur dioxide** as a proxy for pollution in cities as a CSV file.
- 3 Examine the cities - **Bengaluru, Delhi, Kolkata, Mumbai and Hyderabad** and use them as our frame of study.
- 4 Perform **Python analysis** on the extracted data with the help of Jupyter notebooks, Pandas library, etc. and draw inferences.
- 5 Conduct **Correlation analysis** and form **ML regression models** with other correlated datasets.

PROGRAMMING
LANGUAGES
USED

JavaScript
Python

TECHNICAL TOOLS

Google Earth Engine
Jupyter Notebook
Pandas library
Seaborn library

Sklearn library
NumPy library
SciPy library
Matplot library

DATASETS

For Data Extraction:

Sentinel-5P NRTI SO2: Near Real-Time Sulphur Dioxide (https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S5P_NRTI_L3_SO2)

For Analysis, Correlation and ML Regression Model:

Sentinel-5P NRTI SO2: Near Real-Time Sulphur Dioxide (https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S5P_NRTI_L3_SO2)

ERA5 Monthly aggregates - Latest climate reanalysis produced by ECMWF / Copernicus Climate Change Service (https://developers.google.com/earth-engine/datasets/catalog/ECMWF_ERA5_MONTHLY)

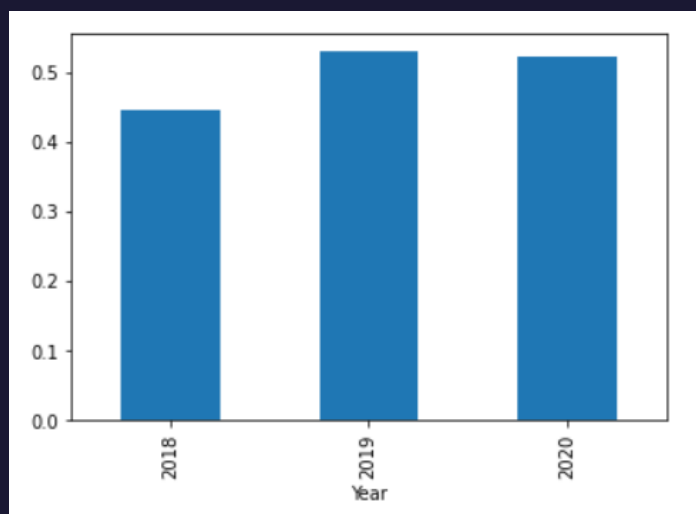
Sentinel-5P NRTI AER AI: Near Real-Time UV Aerosol Index (https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S5P_NRTI_L3_AER_AI)

LIMITATIONS & ASSUMPTIONS

Since the Sentinel-5P satellite was **only launched in the end of 2017**, data was only available from the year 2018 till 2020. As a result, it is impossible to perfectly predict yearly and monthly trends and projections.

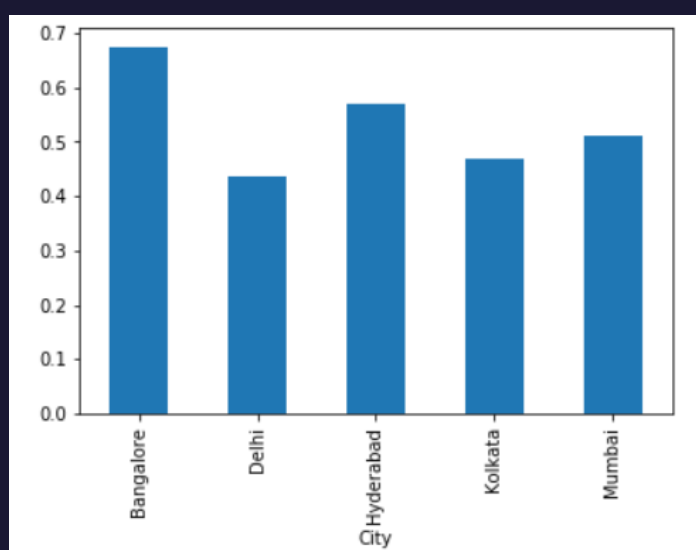
The data available for Temperature was extracted for monthly. Hence it was assumed the **temperature remains constant for a month**.

EXPLORATORY DATA ANALYSIS



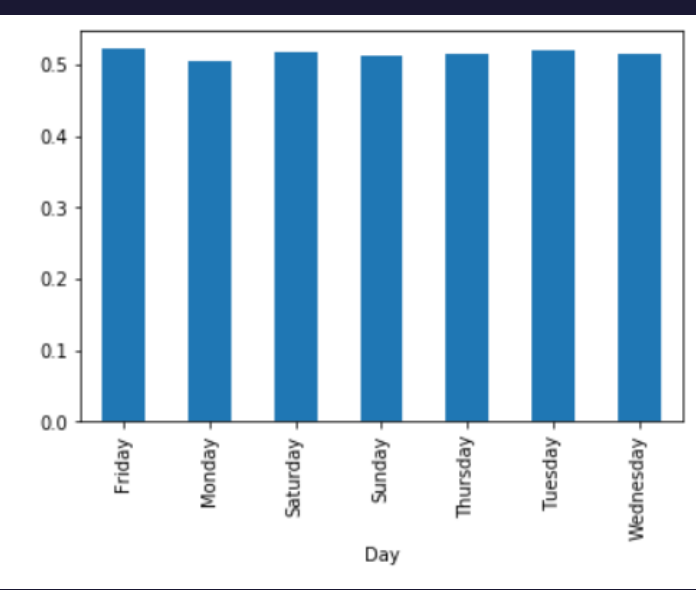
Bar plot showing mean SO2 value (in mol/m^2) in years 2018 to 2020.

The maximum mean SO2 value was observed at 2019 in the graph while the minimum was in 2018.



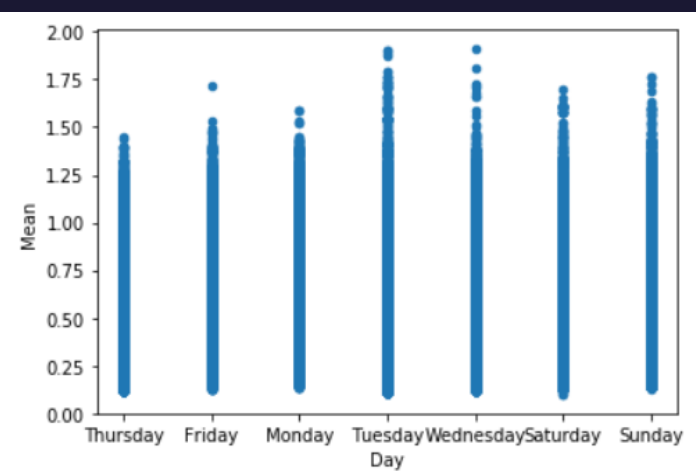
Bar plot showing mean SO2 level (in mol/m^2) in each city.

Bangalore has the highest mean SO2 value among all the cities studied, while Delhi has the lowest.



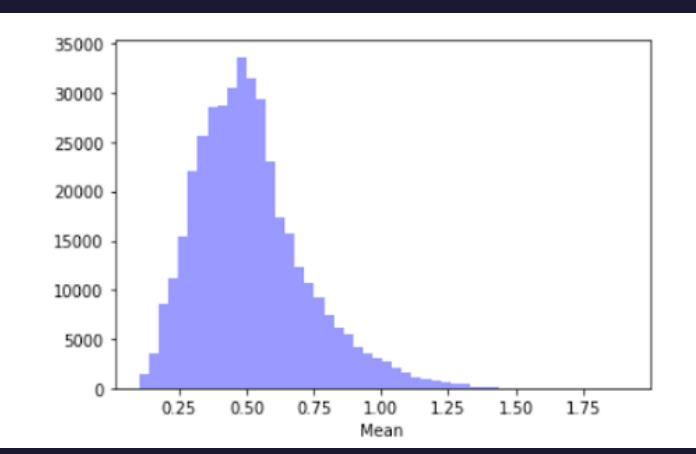
Bar plot showing variation of mean SO2 level (in mol/m^2) according to the days in a week.

SO2 level on all days in a week is roughly the same. Mean value on each day is approximately 0.5



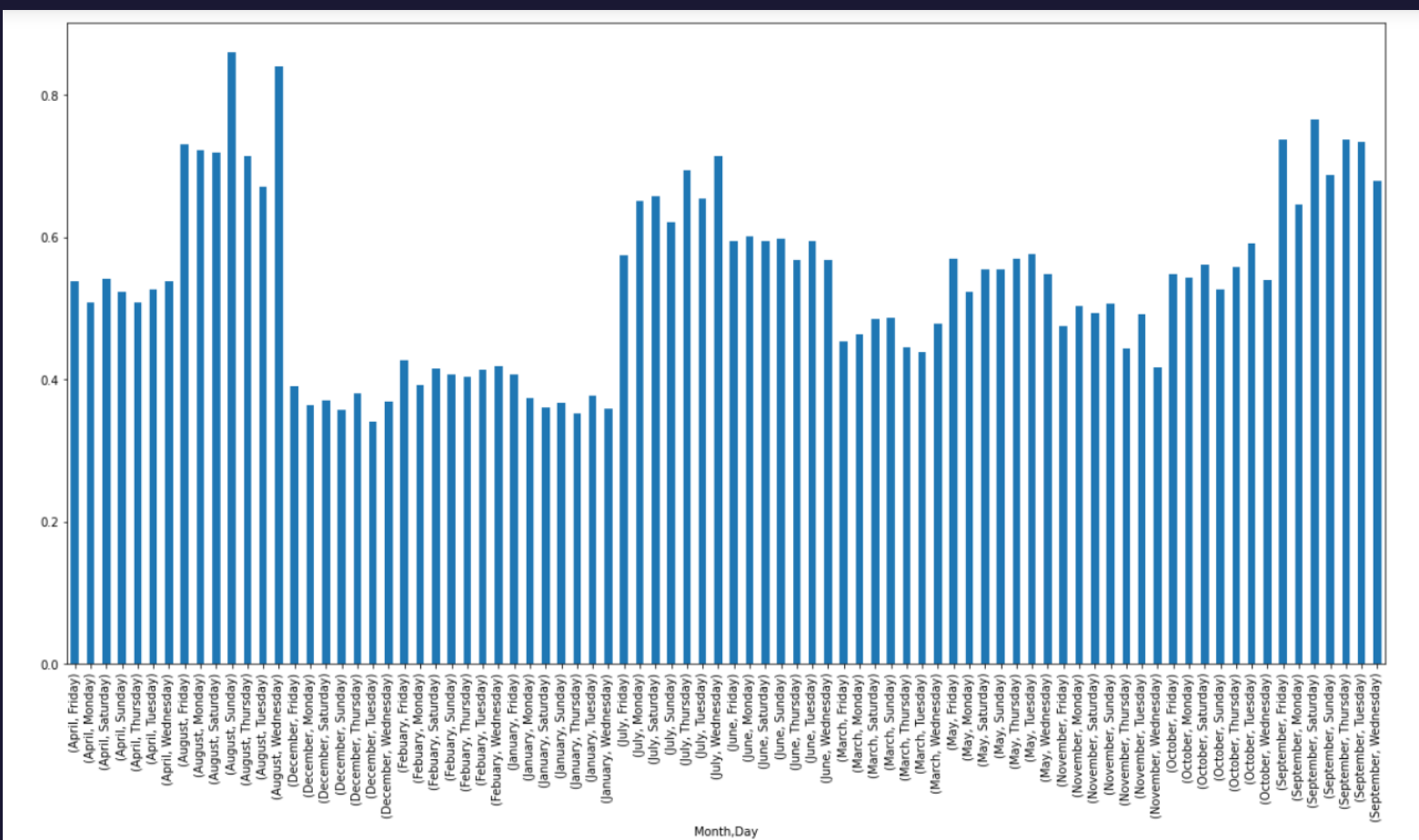
Scatter plot showing the distribution of SO2 level (in mol per m2) on each day of week.

Maximum 'Mean' values were observed on Tuesday and Wednesday



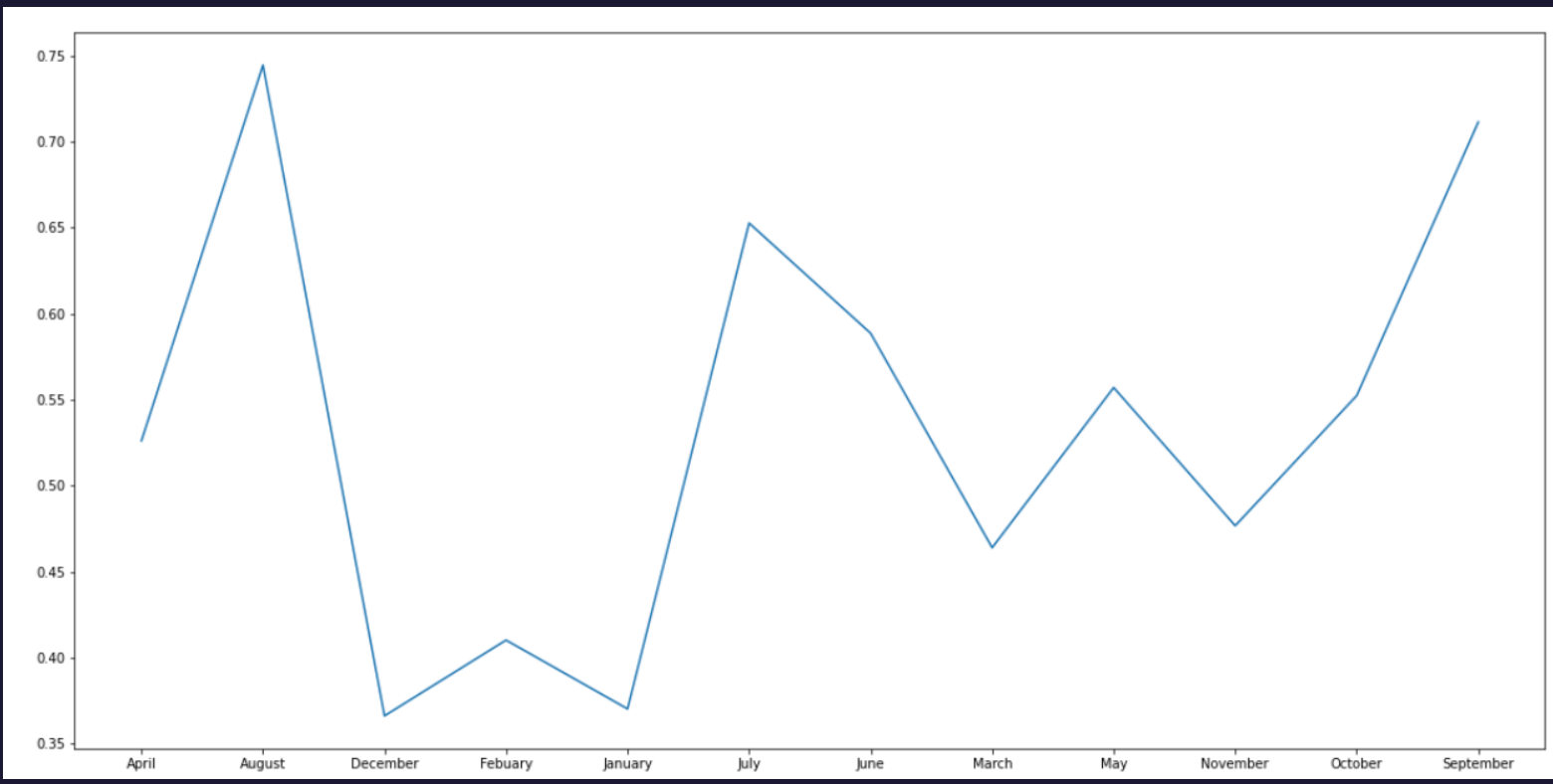
Seaborn distplot showing the distribution of SO2 level (in mol/m^2) of all entries in the database.

The graph resembles bell curve of normal distribution with mean 0.50. Distribution curve of 'Mean' peaked at about 0.50.



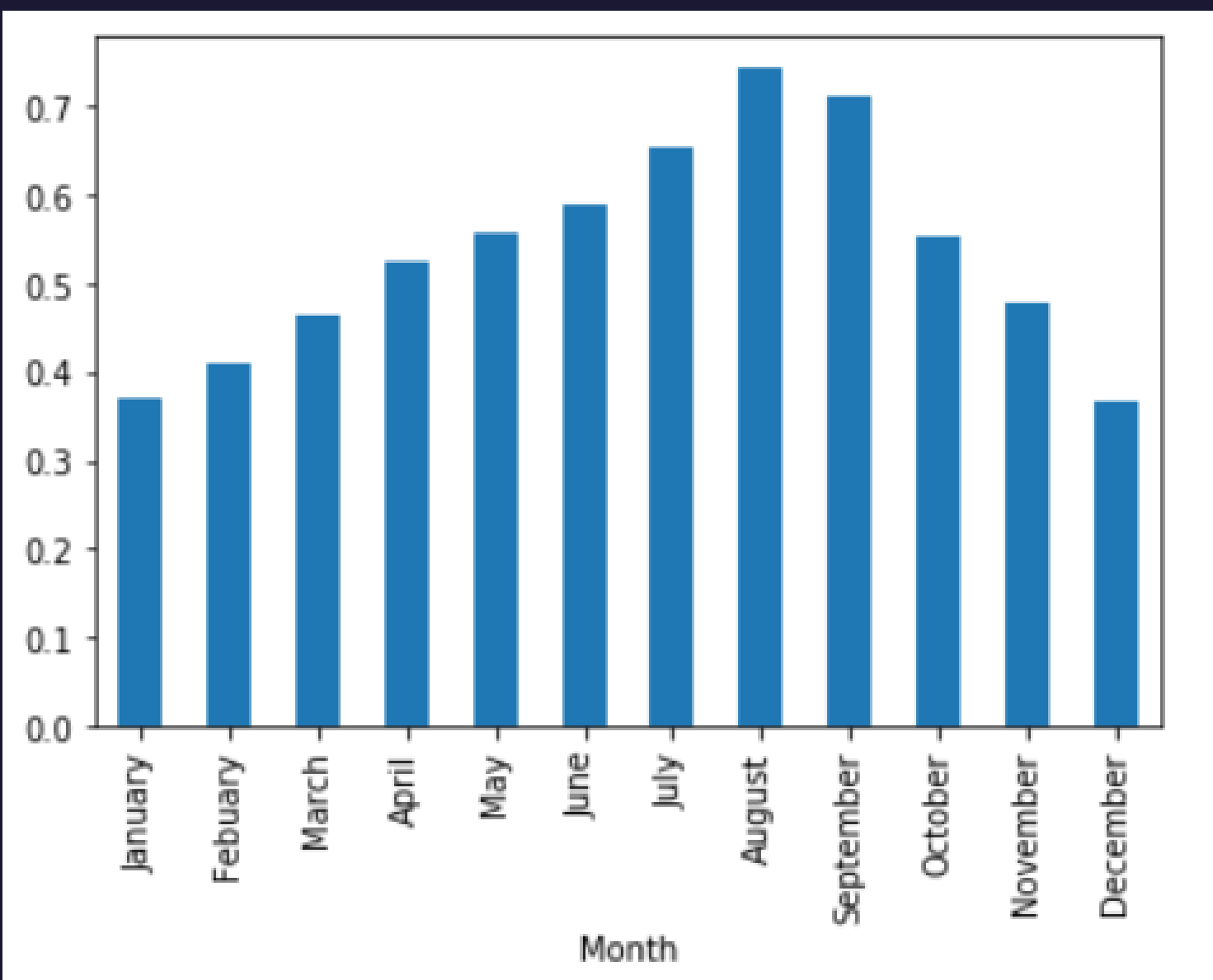
Bar plot showing variation of mean SO2 level (in mol per m2) according to the days in a week monthwise.

It was observed that the SO2 emission on all days in a week in each month was roughly uniform except for a couple of peaks at (August,Sunday) and (August,Wednesday). We could also confirm the conclusion drawn before that the SO2 emission in August and September is high and the same in December and January is low.



Line graph showing variation of mean SO2 level (in mol/m^2) according to the months of the year.

SO2 level is the usually highest during August-September, and lowest during December-February.



Bar plot showing variation of mean SO2 level (in mol/m^2) according to the months of the year.

The SO2 level is the highest in August and September. The SO2 level is the lowest in December and January.

MACHINE LEARNING MODEL

The top Model Performance for the test set:

R2 score of **Gradient Boosting regression** model of SO2_Pollution : 0.670

R2 score of **K-Neighbour regression** model of SO2_Pollution : 0.669

R2 score of **Random Forest regression** model of SO2_Temperature : 0.625

R2 score of **Gradient Boosting regression** model of SO2_Temperature : 0.605

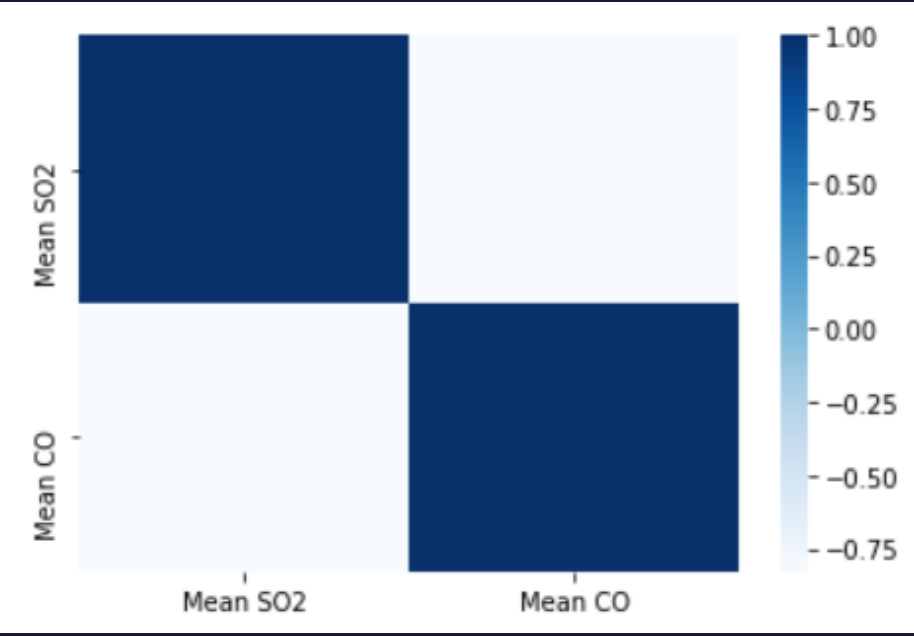
R2 score of **Gradient Boosting regression** model of SO2_CO : 0.756

R2 score of **Random Forest regression** model of SO2_CO : 0.746

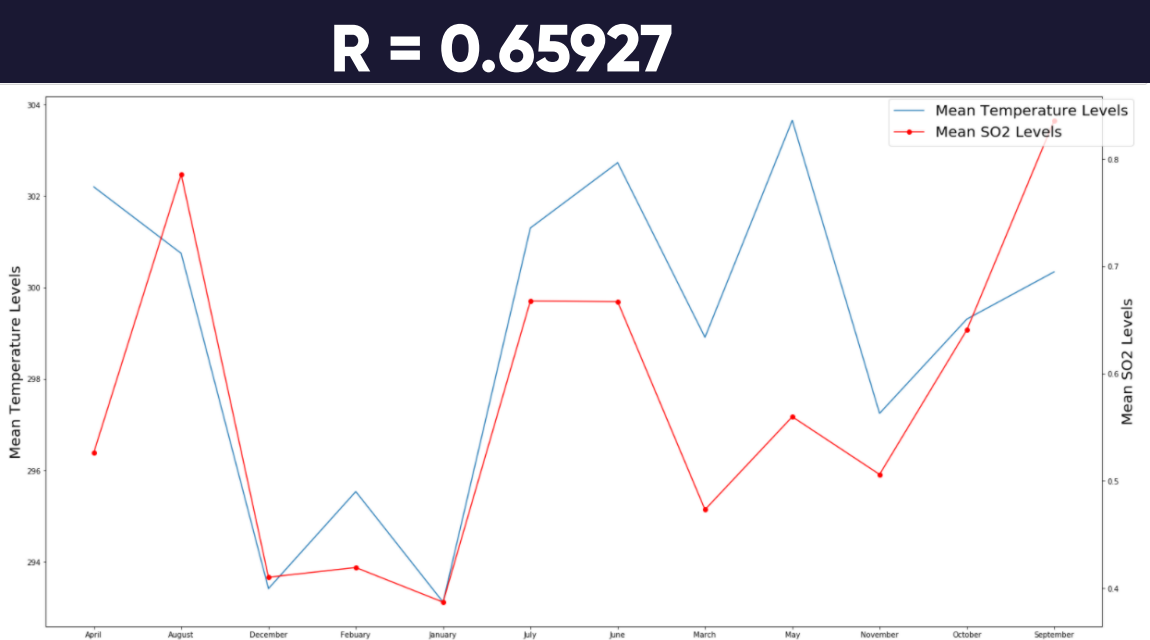
CORRELATION ANALYSIS



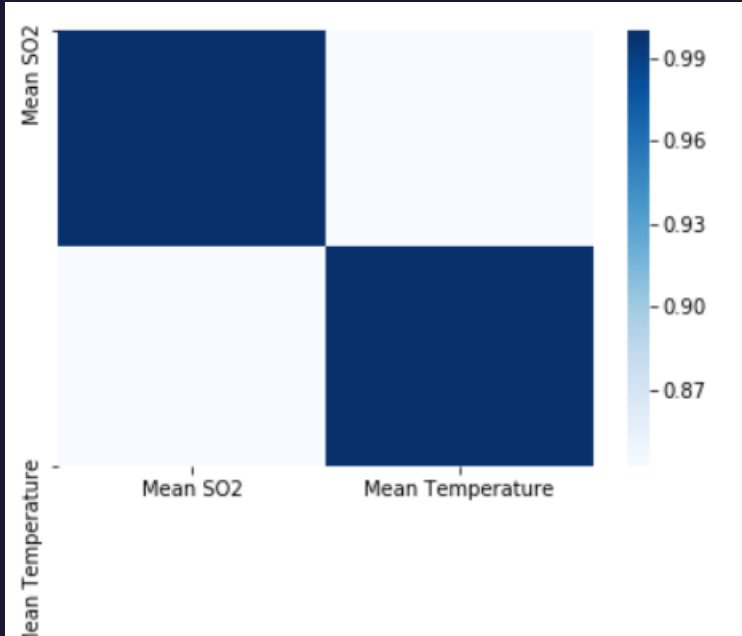
R = -0.826897



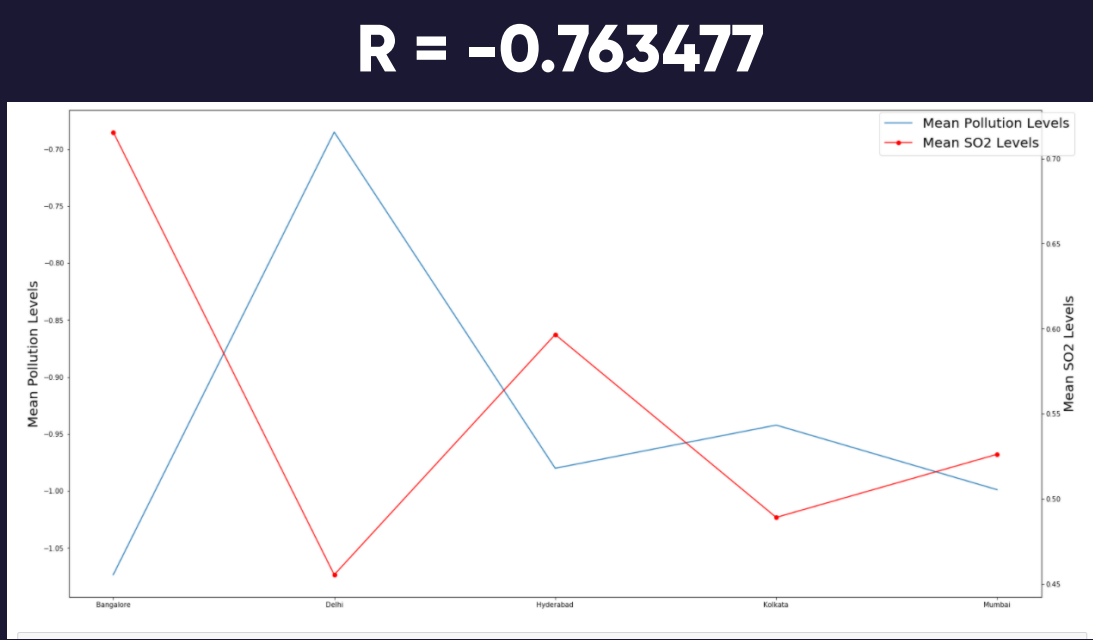
SO2 vs Carbon Monoxide (High Correlation)



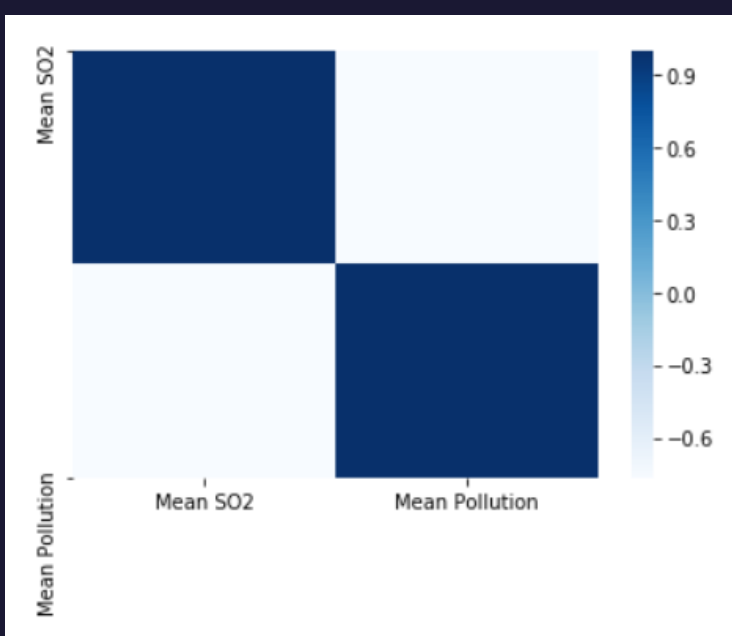
R = 0.65927



SO2 vs Temperature (High Correlation)



R = -0.763477

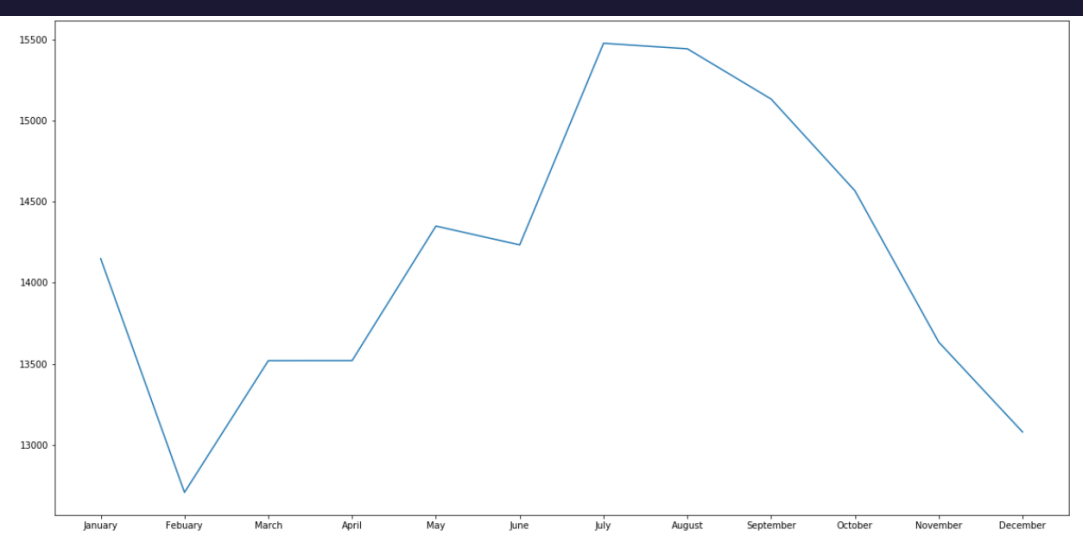


SO2 vs Pollution (High Correlation)

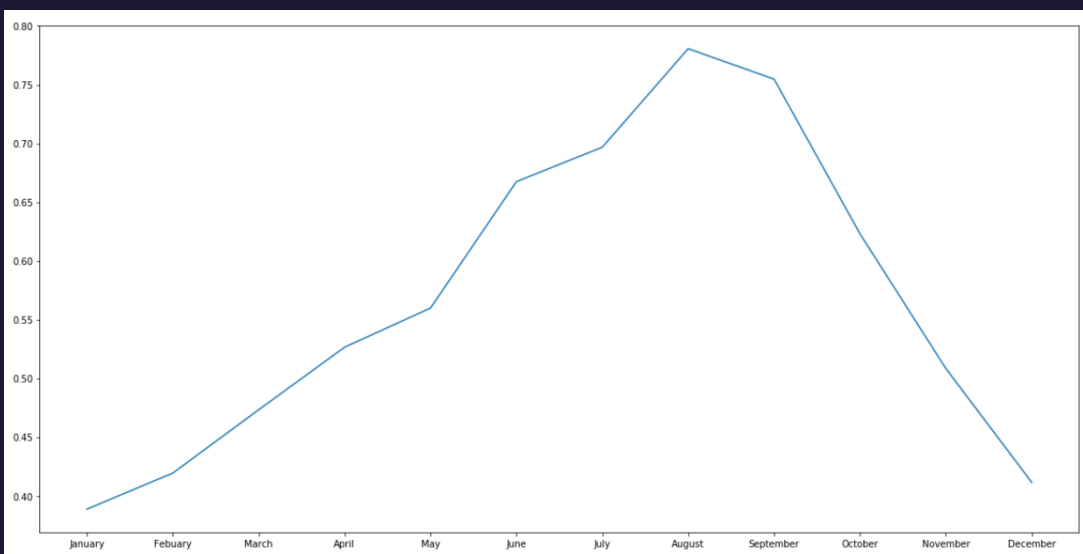
SPURIOUS RELATIONS

The Data shows that there is high positive correlation between the **concentration levels of SO2** in the five cities of Bangalore, Kolkata, Mumbai, Delhi, Hyderabad and **the number of children born in the country of Netherlands during the time period of October 2018 to May 2020**.

We know there are a lot of young couples in urban cities. When they saw our statistic of how Levels of SO2 is very strongly related to Pollution, Temperature and greenhouse gases like Carbon Monoxide they knew it will be impossible to live in these conditions. So they decided to move to Netherlands being a clean and safe country. But the weather of Netherlands was so cold that they spent most of their time inside and it has been shown that the chance of having a baby are more. Hence we can find a relation between the two statistics.



Number of children born in the Netherlands



Concentration level of SO2 in the cities

Correlation = 82.93%

The Data record of the number of Children born was collected from http://data.un.org/Data.aspx?d=POPS&f=tableCode%3A55#f_1

IS CLIMATE CHANGE A MYTH?
SHOULD THE GOVERNMENT BE CONCERNED?
CLIMATE CHANGE: HOW DO WE KNOW?

Scientific evidence for warming of the climate system is unequivocal. Earth's climate has changed throughout history. Just in the last 650,000 years, there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 11,700 years ago marking the beginning of the modern climate era — and of human civilization. The study of whether climate change is a myth by studying the pollution levels considering SO2 as a proxy has **opened our eyes to the truth**.

It was drawn to our attention that the SO2 levels are increasing at an alarming rate and this has its peak during the later part of August in the summer. SO2 is the component of greatest concern and is used as the indicator for the larger group of gaseous sulfur oxides (SOx). SO2 can affect both health and the environment. Short-term exposures to SO2 can harm the human respiratory system and make breathing difficult. People with asthma, particularly children, are sensitive to these effects of SO2. At high concentrations, gaseous SOx can harm trees and plants by damaging foliage and decreasing growth. SO2 and other sulfur oxides can contribute to acid rain which can harm sensitive ecosystems. With our study we have been able to draw **strong correlations between Temperature and SO2, CO and SO2 and also between Pollution and SO2**. We were able to visualise the effect and the impact each of these attributes has on SO2 levels.

We believe that **Climate Change is not a myth** and is and is a reality that will hit us hard if we don't react immediately.

Should the government start considering the effects of climate change now? We think, 'NO'. The government should have been concerned **decades ago** about Climate Change. But it's better late than never. **Lets act now!**

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