Analysing the Impact of Air Pollution on Urban Climate in London

Introduction:

Main Question

How do variations in air pollution levels impact weather conditions in London from 2008 to 2018?

Description

This project examines the relationship between London's air pollution levels and weather from 2008 to 2018. The goal is to examine how changes in the weather might affect air quality by using historical weather data along with pollution measurements. The project integrates data from the London Datastore and Kaggle to investigate relationships between weather patterns and pollution indices, including its impact of temperature on gasses and particle matter. Our goal is to get a deeper understanding of the environmental dynamics in metropolitan London through this study.

Used Data:

London Weather Data

- **Source**: Kaggle
- **URL**: [London Weather Data on Kaggle]
- **Period**: 1979 - 2021
- **Description**: This dataset includes historical weather data from London, collected from a weather station near Heathrow Airport. It features daily measurements such as temperature, humidity, and precipitation.
- **License**: Public Domain (CC0)

London Air Quality Levels

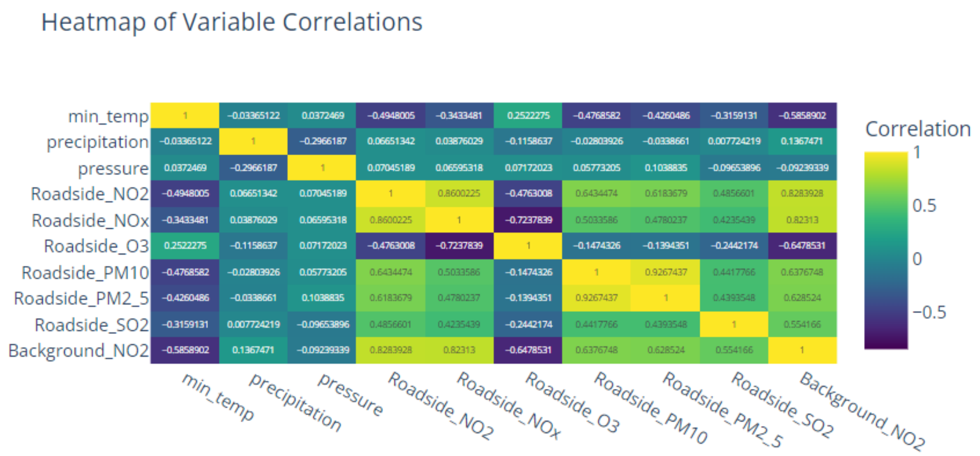
- **Source**: London Datastore
- **URL**: [London Average Air Quality Levels]
- **Period**: Data available till 2019
- **Description**: This dataset provides readings of air pollutants including Nitric Oxide, Nitrogen Dioxide, Particulate Matter (PM10 and PM2.5), and Ozone. Measurements are collected from various monitoring sites across Greater London.
- **License**: UK Open Government Licence (OGL v2) (allowing use with attribution. Obligations include acknowledging the data source and maintaining a link to the license.)

The analysis utilizes two primary datasets: London Weather Data from Kaggle and Air Quality Levels from the London Datastore. The weather dataset includes daily measurements of temperature, humidity, and precipitation from a station near Heathrow Airport. The air quality dataset provides readings on pollutants like Nitric Oxide, Nitrogen Dioxide, and Particulate Matter from various monitoring sites across London. Both datasets are integrated using their common temporal features, enabling a detailed analysis of the correlations between air quality and weather conditions.

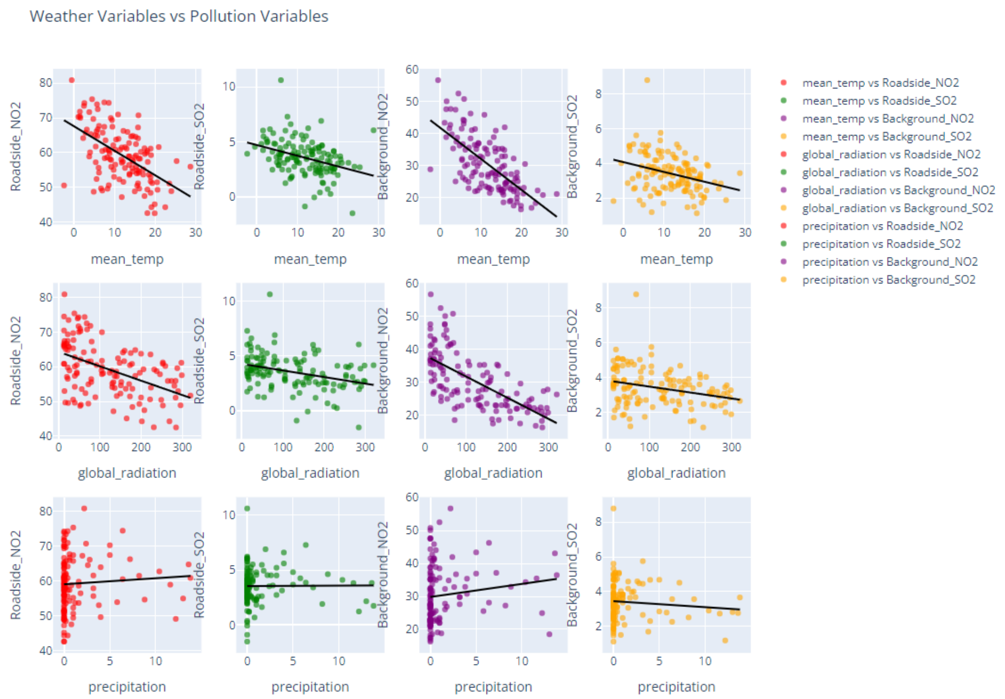
London Weather Data Fields: date: Date of recording, **mean_temp:** Average temperature, **max_temp:** Highest temperature, **min_temp:** Lowest temperature, **precipitation:** Total rainfall, **pressure**, **global_radiation**, **cloud_cover, sun_shine**

London Air Quality Data Fields: **date**: Date of recording, **Roadside_NO2:** Roadside nitrogen dioxide, **Roadside_NOx:** Roadside nitrogen oxides, **Roadside_O3:** Roadside ozone, **Roadside_PM10:** Roadside particulate matter (PM10), **Roadside_PM2_5:** Roadside particulate matter (PM2.5), **Roadside_SO2:** Roadside sulfur dioxide, **Background_NO2:** Background nitrogen dioxide, **Background_NOx:** Background nitrogen oxides, **Background_O3:** Background ozone, **Background_PM10:** Background particulate matter (PM10), **Background_PM2_5:** Background particulate matter (PM2.5), **Background_SO2:** Background sulfur dioxide

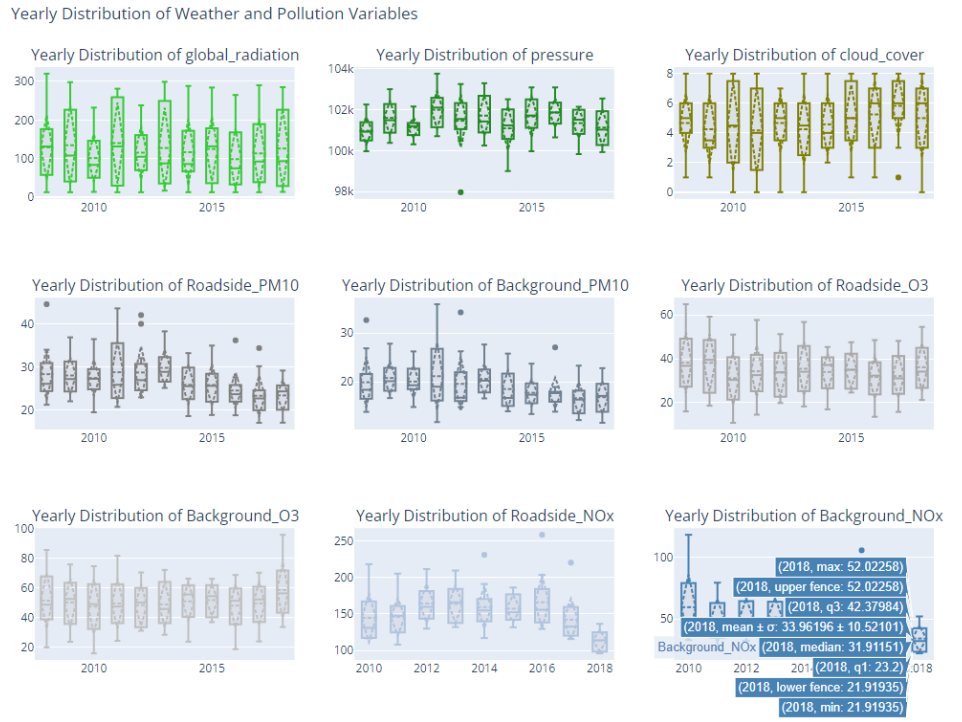
Analysis:



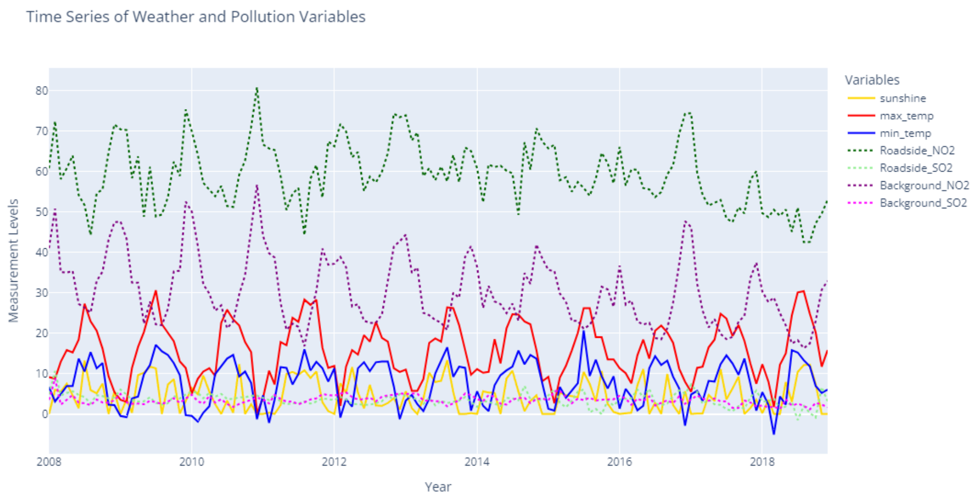
The heatmap of variable correlations visualizes that mean temperature negatively correlates with NO2 levels, suggesting warmer temperatures help reduce NO2 due to atmospheric dispersion. Positive correlations between mean temperature and global radiation confirm expected trends that higher temperatures coincide with clearer skies and more solar radiation. Meanwhile, precipitation and cloud cover display mixed effects on pollutants, with precipitation often negatively correlating with pollutants like SO2, indicating rain may help remove these from the air.



The visualized scatter plots demonstrate the relationship between various weather conditions and pollution levels. There's a clear negative correlation between mean temperature and both NO2 and SO2 across different contexts, suggesting that higher temperatures may facilitate the reduction of these pollutants due to enhanced atmospheric dispersion and possibly chemical degradation. Similarly, global radiation shows a strong negative correlation with NO2 and SO2, reinforcing that increased solar radiation may contribute to the breakdown of these pollutants. In contrast, precipitation displays a variable relationship with pollutants: while it generally shows a negative correlation with SO2, indicating rain's effectiveness in washing out soluble pollutants from the atmosphere, its impact on NO2 is less pronounced, suggesting that NO2's atmospheric behaviour is less influenced by precipitation.



The provided boxplots illustrate the annual variations in weather and pollution variables in London from 2008 to 2018. Weather metrics such as global radiation and pressure show distinct yearly patterns with some fluctuations, indicating typical seasonal variations. For pollution variables, PM10 and ozone (O3) levels display consistency over the years but with notable spikes, highlighting episodic pollution events possibly triggered by specific weather conditions or human activities. Additionally, the NOx levels in both roadside and background locations show similar trends, reflecting persistent exposure to nitrogen oxides amidst urban traffic emissions.



This time series graph presents the variations in weather and pollution in London over a span from 2008 to 2018. It displays distinct seasonal patterns in weather variables such as sunshine, maximum temperature, and minimum temperature, with noticeable peaks during the summer months each year. The temperatures are tracked through max and min values, where maximum temperatures are consistently higher, underscoring the typical warmth of summer compared to cooler winter periods. In contrast, pollution variables like NO_2 and SO_2, measured at both roadside and background levels, show variations that don't follow a clear seasonal trend and seem to respond more to changes in urban activity and traffic.

Conclusions:

This study has provided a comprehensive analysis of the relationship between air pollution and weather conditions in London from 2008 to 2018. Our findings confirm that weather patterns significantly influence pollution levels; higher temperatures are generally associated with lower concentrations of NO_2 and SO_2, suggesting that warmer weather could help to reduce air pollutants more effectively, likely due to increased atmospheric mixing.

Additionally, the study explores the impact of solar radiation on air quality. Increased levels of global radiation correlated with reduced pollutant concentrations, reinforcing the idea that sunlight not only chemically breaks down certain pollutants but also contributes to atmospheric conditions conducive to dispersing pollutants. While some pollutants like NO_2 showed clear correlations with temperature changes, others such as PM_{10} exhibited more variable patterns that did not consistently align with specific weather conditions.

In conclusion, this study highlights the significant yet complex role that weather conditions play in influencing air pollution levels, underscoring the importance of understanding these dynamics for developing effective environmental policies in urban settings. Despite these insights, the study faces limitations due to the exclusion of real-time traffic data and specific emission sources, which are critical factors in urban pollution dynamics. Continued research is essential to fully mitigate the complicated relationships between weather, human activities, and urban air quality, thereby enhancing our ability to effectively manage and resolve pollution.