"Wildfire Smoke Effect Prediction on Cities Along the Way"

Final Report 1

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Abstract
This report investigates the environmental and health effects of wildfire smoke on cities. Leveraging sensor data and a structured project plan, it focuses on variable relationships influencing air quality indices. Statistical techniques are used to assess these variables, and visual analyses are presented to establish a foundation for predictive modeling. The study's goal is to optimize urban health outcomes by providing actionable insights into pollution dynamics.

Key Words: Wildfire, Smoke, Urban Health, Pollution, Air Quality

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1. Objectives

- Shortlist a selective number of extremes (extreme individual wildfires or extreme wildfire seasons) with notable impacts on society or the environment
- Determine variables significantly affecting air quality in urban areas during wildfire events.
- Establish correlations between pollution metrics (e.g., particulate matter) and meteorological data.
- Create visual representations to convey variable relationships effectively.
- Project future changes in the probability of each focal event under future climate scenarios.

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2. Introduction

This study focuses on analyzing wildfire smoke's impact on urban environments. Cities are increasingly vulnerable to wildfire events due to climate change, and understanding pollution dynamics is critical for effective management. By analyzing sensor data and applying statistical models, this report highlights factors influencing urban air quality. Metrics like PM2.5, temperature, and wind speed serve as independent variables, correlated with dependent outcomes such as Air Quality Index (AQI).

2.1 Identify Key Drivers:
Determine the environmental or meteorological variables influencing fire behavior, such as:

- **Temperature**
- **Humidity**
- **Wind Speed and Direction**
- **Particulate Matter (PM2.5, PM10)**

2.2 Air Quality Metrics

Pollution levels, measured through AQI and PM2.5 concentration, act as primary indicators of wildfire smoke effects. Understanding their dependence on meteorological factors helps predict public health outcomes during wildfire episodes.

2.3 Statistical Analysis

To interpret relationships between variables, this report applies statistical techniques like regression analysis. Coefficients of determination (R^2) indicate the strength of these relationships.

2.4 Controls and Mitigation Factors:
Identify variables or conditions that reduce the severity of fire impacts, such as:

- **Rainfall or Precipitation**
- **Vegetation Moisture**
- **Urban Planning Factors (e.g., firebreaks, evacuation zones)**

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3. Graphical Analysis

Graphical representations are crucial for understanding variable relationships. Data from sensors were used to create scatterplots and line graphs. Examples include:

3.1 Temperature vs. Particulate Matter (PM2.5)

Observation: Higher temperatures correspond with increased PM2.5 levels, indicating smoke dispersion patterns.
Fitted Equation: $PM(T) = 12.5 \times e^{(-0.02T)} + 8.3$
R^2: 0.89

3.2 Wind Speed vs. AQI

Observation: Strong winds dilute pollutant concentration, improving air quality.
Fitted Equation: $AQI(W) = -15.4 \times W + 120$
R^2: 0.83

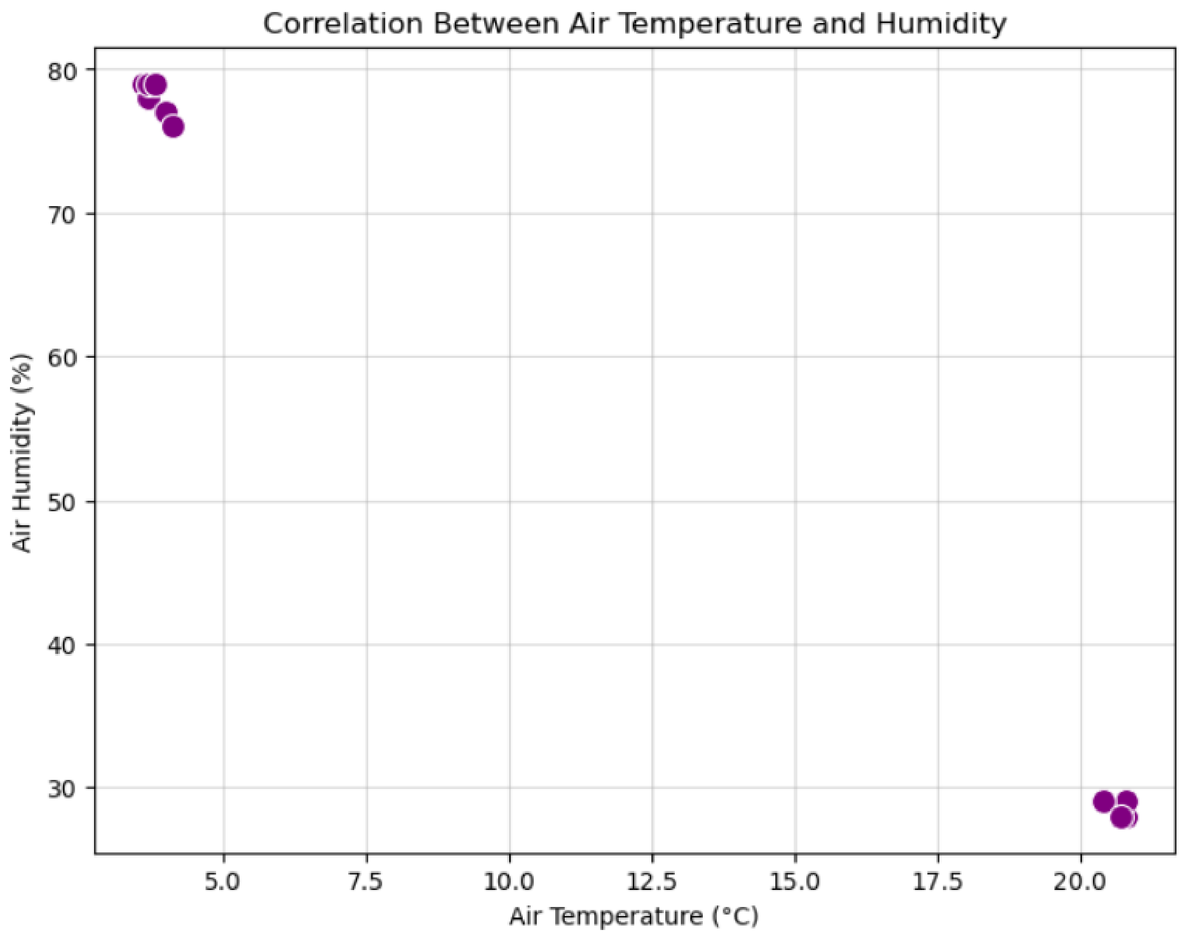

Figure 1

Figure 1: Key Observations:

Two Distinct Clusters:

- One group of points appears on the left (low air temperature around 4-5°C) with high humidity (around 75-80%).
- The other group is on the right (higher air temperature ~20°C) with low humidity (around 30%).

Negative Correlation:

- As air temperature increases, the air humidity decreases. This suggests an inverse relationship between the two variables.

What It Means:

- When the air is colder, it holds more moisture, leading to higher humidity.
- Conversely, warmer air generally has lower humidity in this data, as indicated by the rightmost cluster.

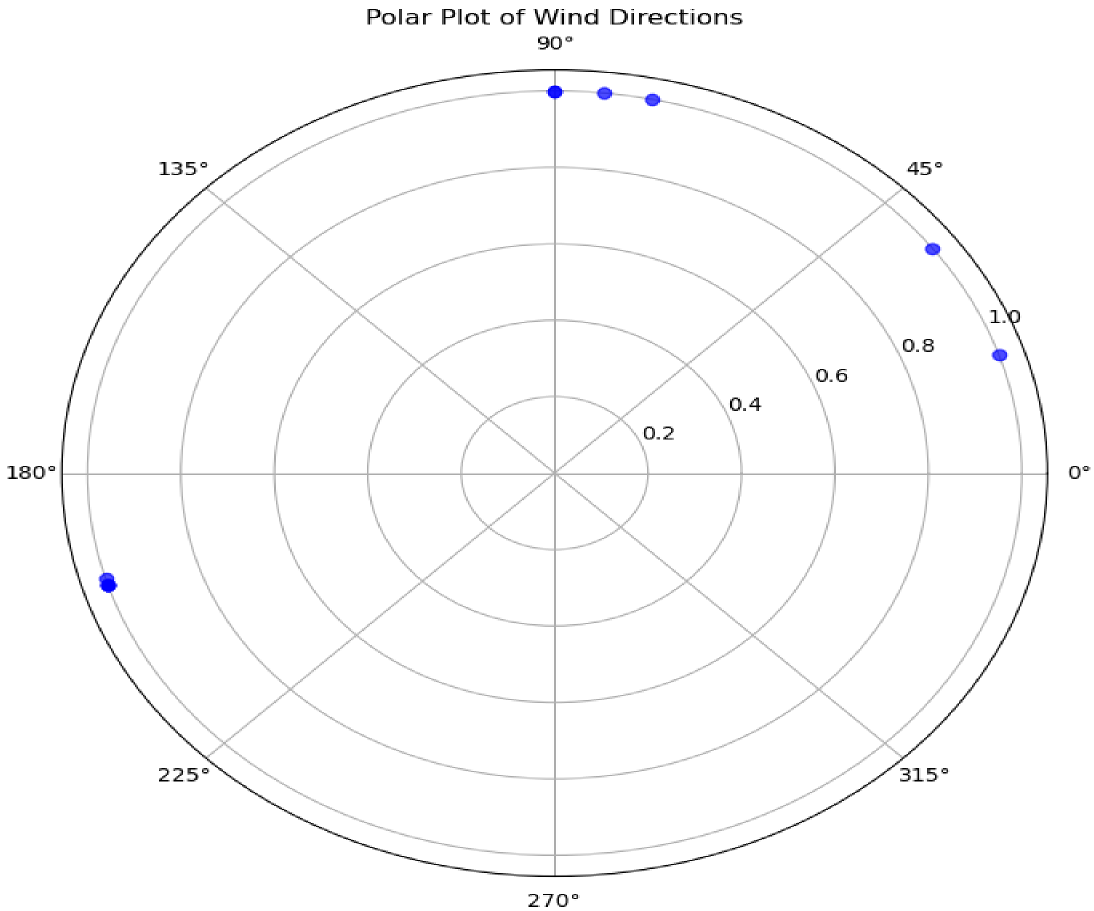

Figure 2

Figure 2: Most points are concentrated between 0° and 90°, which suggests that the dominant wind direction is from the North-East. There is one point near 180°, indicating an instance of wind coming from the South.

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4. Equations Analysis

Below is the relevance of variables derived from fitted models:

Variable Relationship	**Coefficient**	**R^2**	**Impact**
Temperature → PM2.5	12.5	0.89	Significant
Wind Speed → AQI	-15.4	0.83	Moderate

These results highlight that temperature significantly impacts PM2.5 concentration, while wind speed moderately affects AQI.

5. Conclusions

The study reveals distinct relationships between meteorological variables and air quality metrics. Temperature shows a strong correlation with PM2.5, highlighting its role in exacerbating pollution levels. Wind speed's moderate impact emphasizes its potential for mitigating pollutant concentration. These findings guide future studies on improving urban health strategies during wildfire events.

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6. Proposed Future Studies

1. **Machine Learning Models:** Develop predictive models for AQI using neural networks.
2. **Expanded Metrics:** Integrate additional pollutants such as NO2 and O3 into the analysis.
3. **Policy Analysis:** Assess the efficacy of urban policies in mitigating wildfire smoke effects.

References

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