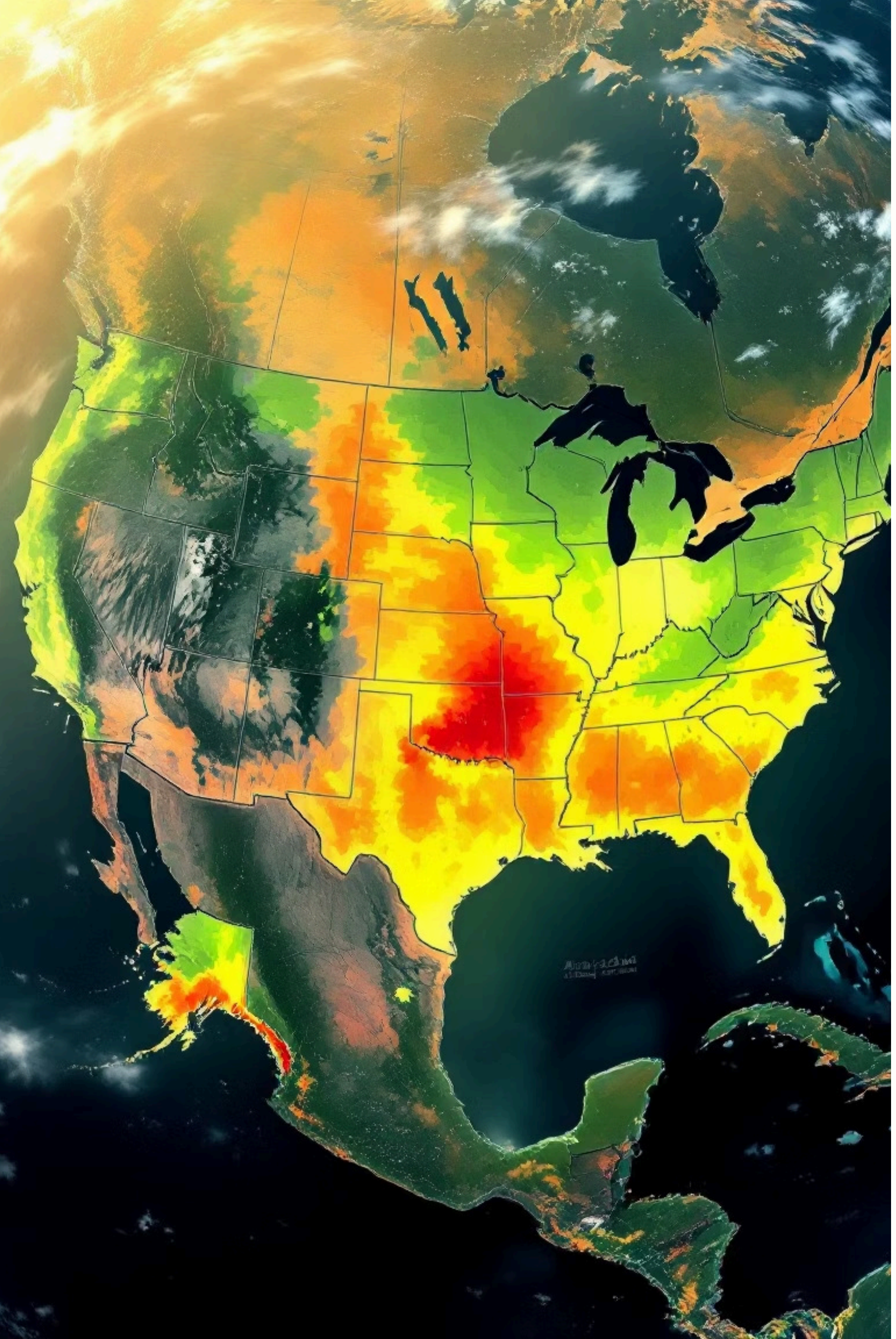


Tracking Air Quality Trends Across the United States: A Focused Analysis of Ozone and PM2.5 Levels

Air pollution remains a significant public health concern, with pollutants like ozone (O_3) and fine particulate matter (PM2.5) posing ongoing challenges. This project delves into long-term air quality trends across the U.S., leveraging the EPA's comprehensive outdoor monitoring dataset. Our study aims to decipher the evolution of pollution levels over time and across different regions, assess compliance with national air quality standards, and pinpoint critical pollution hotspots for targeted interventions.

Data Preparation and Methodology

Our analysis commenced with meticulous data preparation, loading and parsing 59,175 records from the EPA's 2024 dataset. We focused on ozone (O_3) and PM2.5 levels across various states and counties, extracting key parameters such as annual arithmetic mean, maximum values, and geographic coordinates. Data cleaning involved handling null values and removing outliers using Z-score thresholding.

Data Acquisition

EPA's outdoor monitoring dataset

Pollutant Focus

Ozone and PM2.5

Cleaning & Imputation

Null value handling, outlier removal

Temporal Trends in Air Quality

Our temporal analysis revealed distinct seasonal patterns. Ozone levels peaked in summer, likely due to photochemical reactions, while PM2.5 showed winter spikes in colder states, correlating with increased heating activities. Notably, we observed a general downward trend in average ozone levels since 2010. PM2.5 trends varied more significantly by region, suggesting localized factors influencing particulate matter concentrations.

Ozone

Summer peaks, declining since 2010.

PM2.5

Winter spikes in colder states, variability by region.

Outliers and Regional Patterns

We identified several extreme outliers in the dataset, particularly for ozone levels exceeding 1.5 ppm. These were flagged as likely logging errors and removed before further analysis. States like California and Texas exhibited higher pollution variability, likely due to a combination of natural and industrial activities. Heatmaps highlighted persistent high PM2.5 concentrations in Southern California, the Midwest, and the Southeast.

Data Anomalies

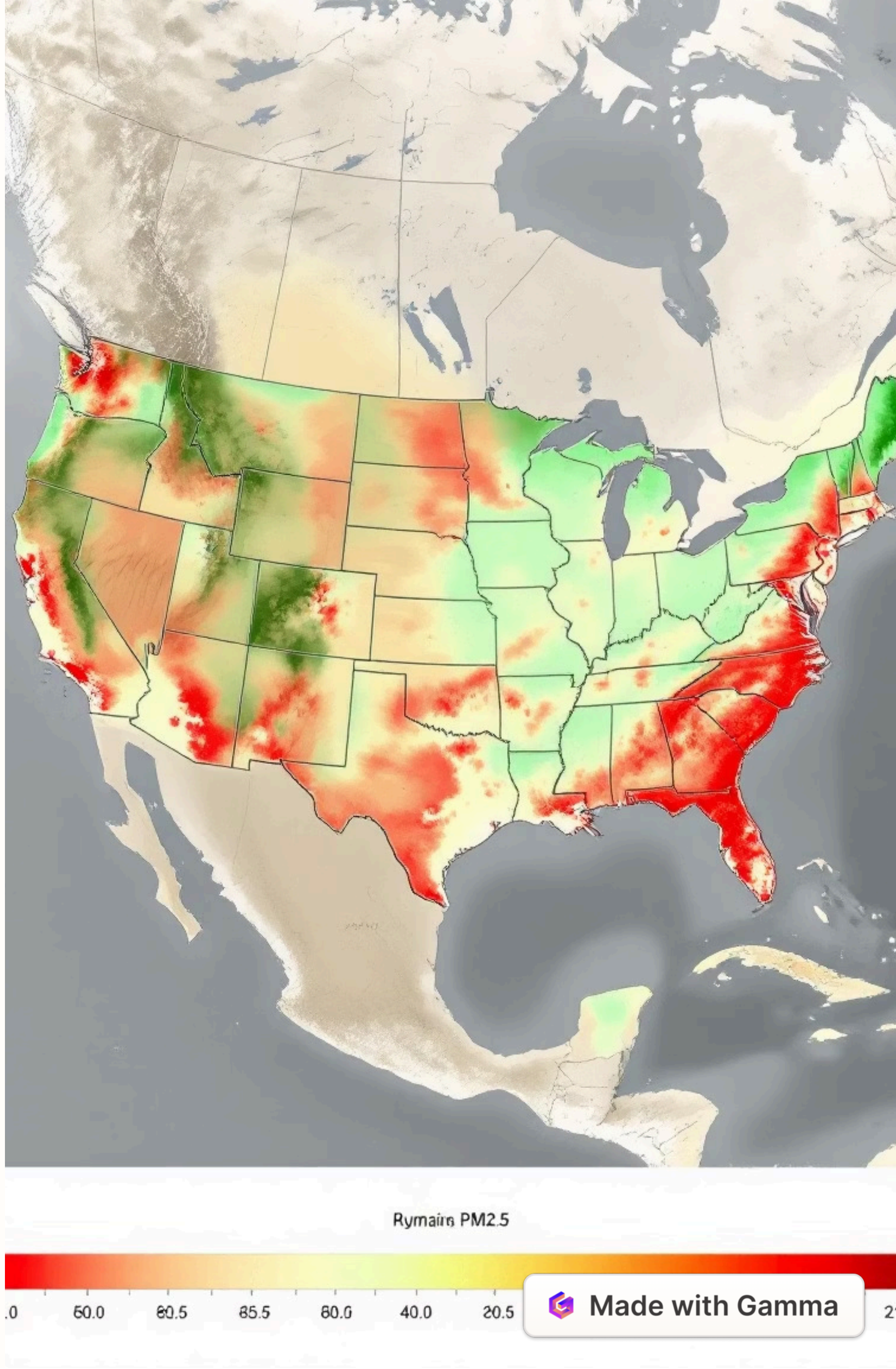
Extreme ozone values flagged as errors.

Regional Hotspots

PM2.5 concentrations in specific regions.

State Variability

Higher pollution variance in CA and TX.



Exceedance of Air Quality Standards

In several states and years, we found notable exceedances of national air quality standards, indicating potential risks to public health. These violations underscore the importance of continued monitoring and targeted interventions to mitigate pollution levels. Further investigation into the specific causes of these exceedances is warranted to inform effective policy decisions.

Monitoring

Continuous data collection

Targeted Interventions

Focused pollution mitigation strategies

Effective Policy

Data-driven decision making

Discussion and Implications

Our analysis both confirms existing understanding and reveals data quality challenges affecting policy interpretation. The observed downward trends in ozone levels suggest some success from regulatory efforts. However, spatial disparities in PM2.5 concentrations emphasize the need for localized interventions. This information can empower environmental policymakers, city planners, and public health agencies to implement focused mitigation strategies.

1. ## Policy Validation

   Trends confirm regulation effectiveness.

2. ## Spatial Targeting

   Localized interventions for PM2.5.

3. ## Empowered Stakeholders

   Informed decision-making for agencies.

Limitations and Future Research

Our study was limited by gaps in city-level data and inconsistencies in Pollutant Standard fields. The reliance on Arithmetic Mean also simplifies potential health risks better modeled by short-term pollution peaks. Future work should incorporate meteorological data for causality analysis, expand to include more pollutants (e.g., NO_2, CO), and develop forecasting models using seasonal autoregressive or LSTM methods.

Forecasting Models

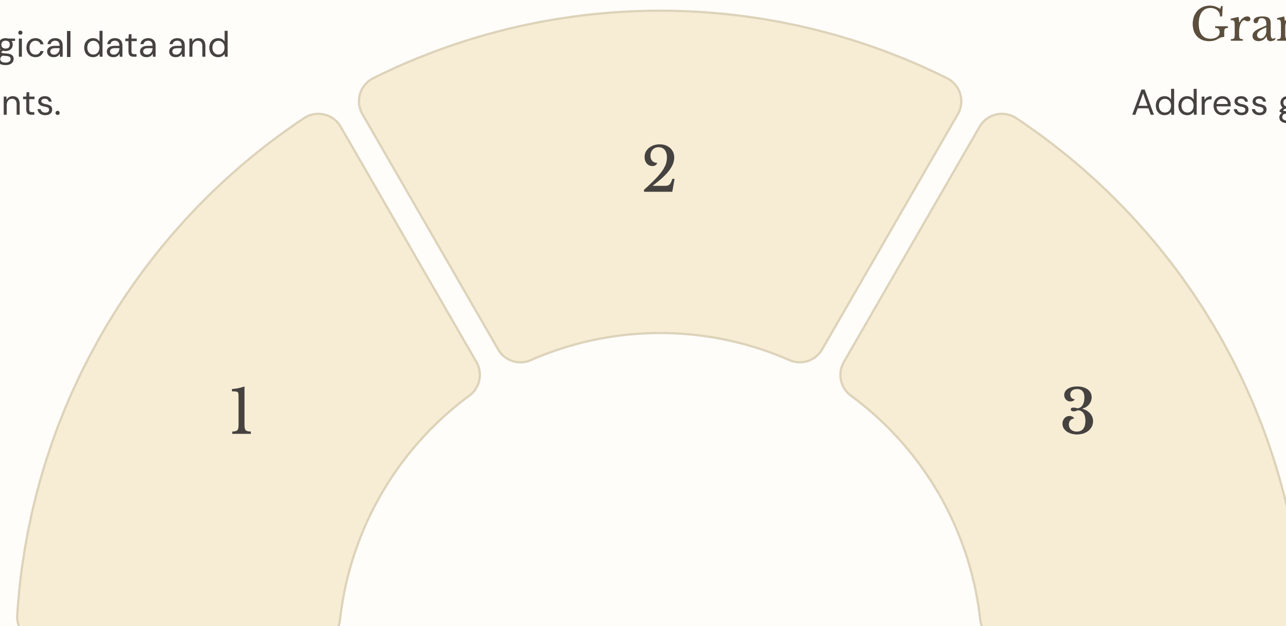
Predict future pollution levels with AI.

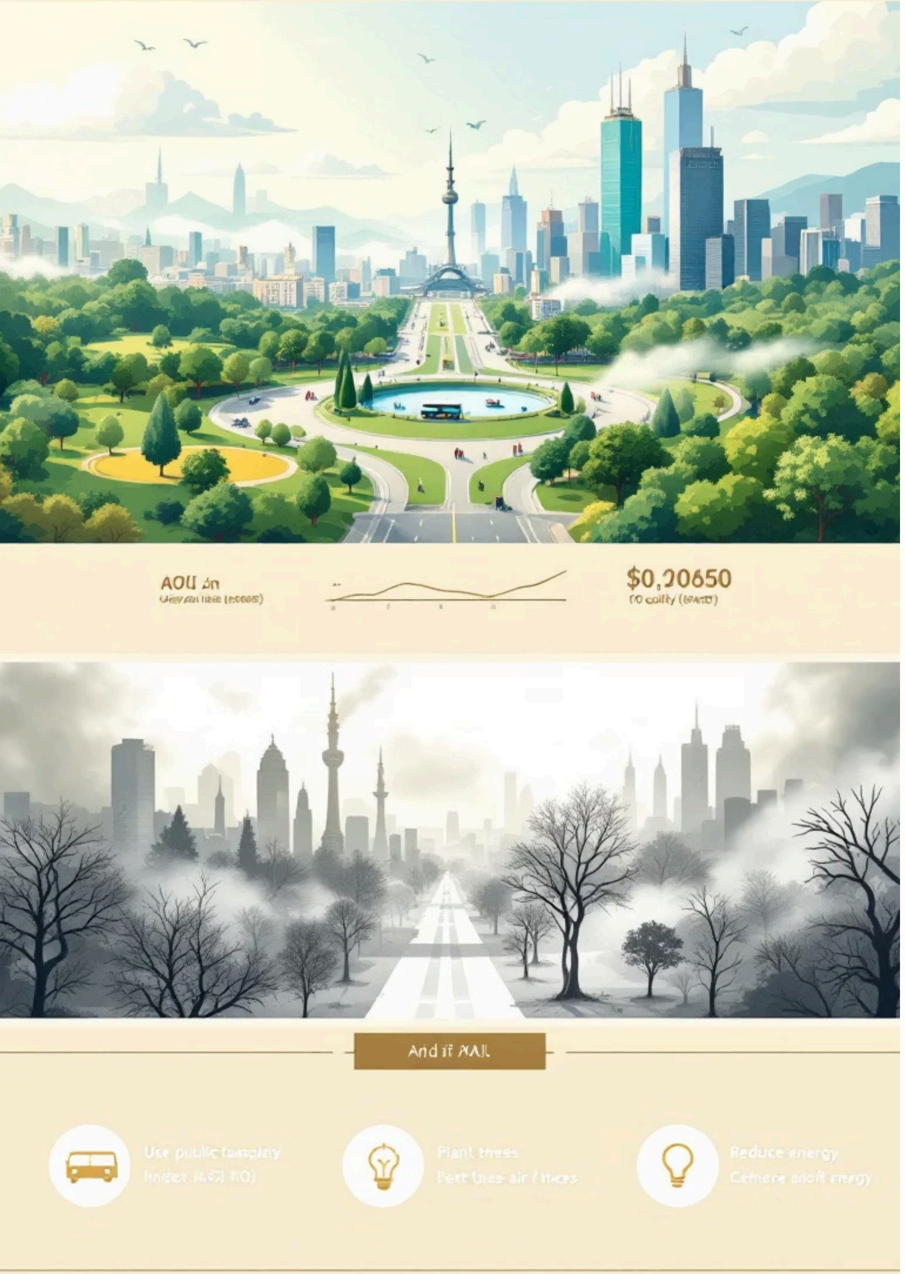
Data Expansion

Incorporate meteorological data and more pollutants.

Granular Analysis

Address gaps in city-level data.





Key Takeaways and Next Steps

This analysis highlights both progress and persistent challenges in U.S. air quality. Downward ozone trends signal success in regulatory efforts, but spatial disparities in PM2.5 demand targeted interventions. Our next steps involve incorporating meteorological data, expanding pollutant analysis, and developing forecasting models to provide more actionable insights for policymakers.

1. **Regulatory Success**

   Ozone reduction shows promise.

2. **Localized Focus**

   PM2.5 needs regional interventions.

3. **Actionable Insights**

   Informed policy decisions.