Analysis Report: Temperature Change and Air Emission Levels in European Countries

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1 Introduction

Climate change presents profound challenges to global ecosystems and human health, with air quality becoming a critical concern. This report analyzes the trends in temperature change and air pollution levels, focusing on particulate matter (PM10 and PM2.5) and nitrogen dioxide (NO2), across selected European countries. These pollutants were chosen due to their significant health impacts and their influential role in climate dynamics. The primary objective of this analysis is to address the following key questions:

- How have temperature and air pollution levels (PM10, PM2.5, NO2) changed over the years in European countries?
- Is there a correlation between key air pollutant levels and temperature changes in these countries?

2 Used Data

The analysis in this report utilizes two primary datasets sourced from open data repositories, focusing on temperature variations and air pollution levels. The implemented data pipeline downloads FAO's Climate Change dataset and WHO's Air Quality dataset, processes them to ensure consistency and data integrity by standardizing column names, filtering for selected European countries, aggregating air quality data on a country level, and addressing missing values. Subsequently, the cleaned and transformed datasets are stored in separate tables within an SQLite database, forming the foundation for the analytical insights presented in this study.

2.1 Temperature Change Table

Source: Food and Agriculture Organization (FAO)
Structure: This table provides monthly average temperature changes for European countries from 2000-2022. Each record includes the country name, year, average temperature change value in degrees Celsius.

2.2 Air Pollution Table

Source: World Health Organization (WHO)
Structure: This table presents ground measurements of annual mean concentrations of nitrogen dioxide (NO2) and particulate matter (PM10, PM2.5) across the same European countries from 2010-2022. These pollutants primarily originate from human activities related to fossil fuel combustion. Records are organized by country code, country name, year, and pollutant concentrations measured in micrograms per cubic meter ($\mu g/m^3$).

2.3 Data License Compliance

Both datasets are licensed under "CC BY-NC-SA 3.0 IGO", allowing for use, sharing, and adaptation for non-commercial purposes with appropriate credit. In compliance with this license, proper attribution of the data sources is included in this report. The data will be used exclusively for educational purposes, aligning with the licensing terms set forth by FAO and WHO.

3 Analysis

3.1 Trends

In order to answer the first question we used line plots to show trends of temeparture changes and air pollutant concentrations over the years.

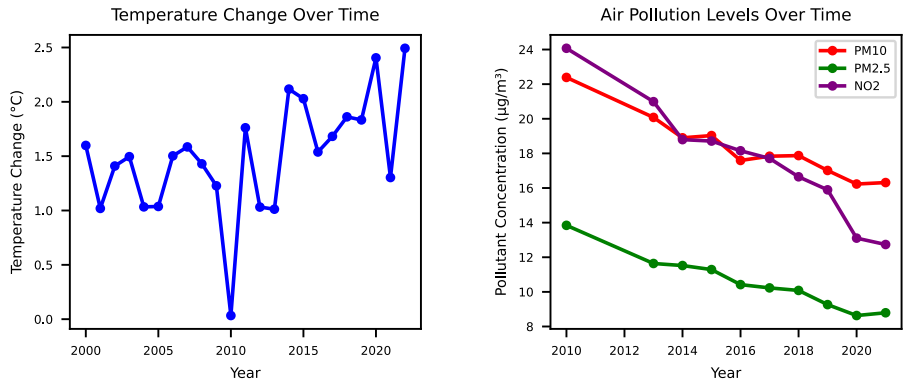


Figure 1: Trends in average Temperature Change and average Air Pollution Levels Across all European Countries

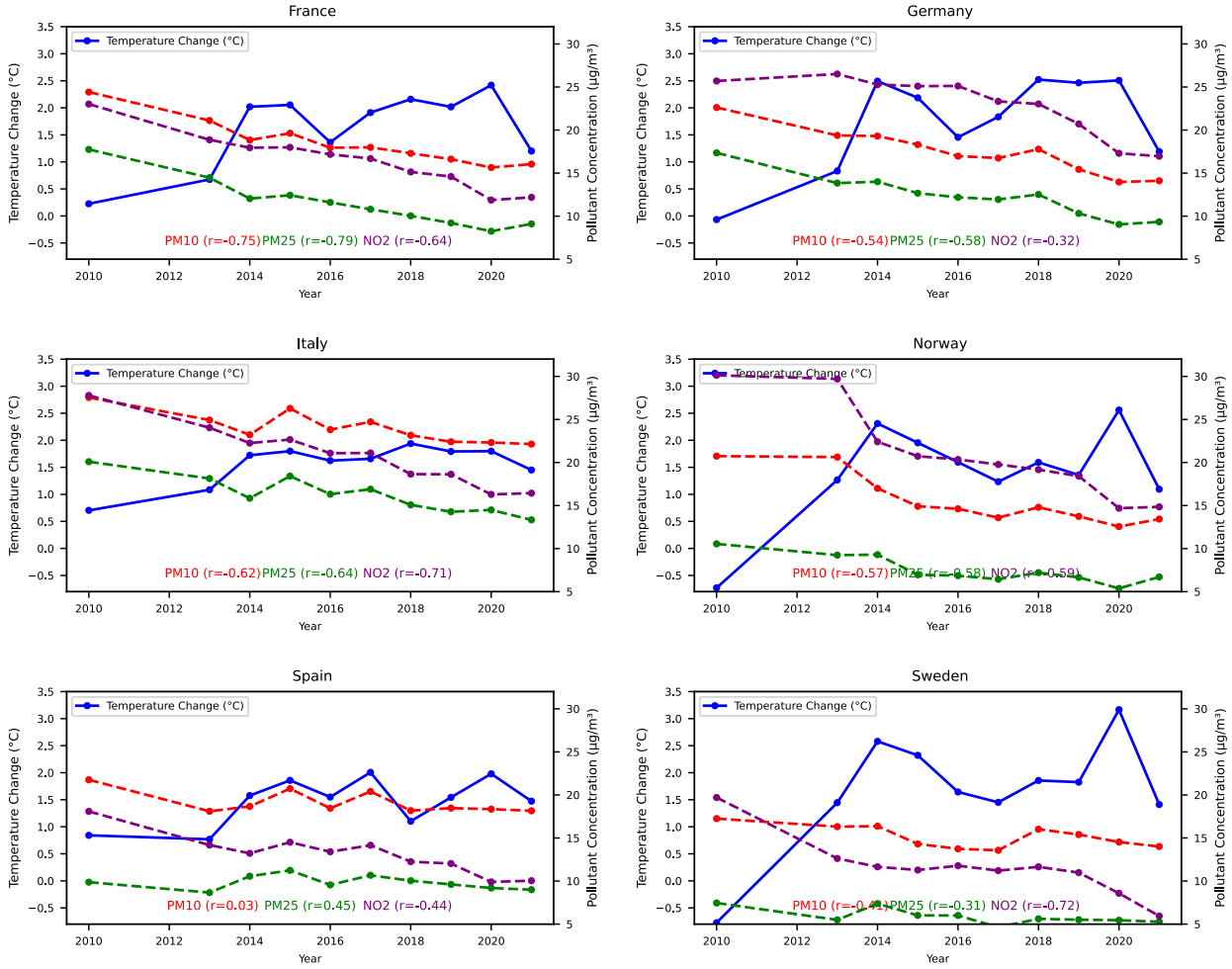
Result: The plots depict two distinct trends over time. The first plot on the left, titled "Temperature Change Over Time," shows the variation in temperature change (°C) from the year 2000 to 2020. The blue line represents the temperature change, revealing an overall upward trend. Initially, from 2000 to 2010, there were notable fluctuations with periods of decrease in temperature change. However, from 2010 to 2020, there is a significant and consistent increase in temperature, indicating a warming climate, which aligns with the ongoing impact of human activities
The second plot on the right, titled "Air Pollution Levels Over Time," illustrates the concentration levels (µg/m^3) of three pollutants: PM10, PM2.5, and NO2, from 2010 to 2020. All three pollutants show a clear decreasing trend over the decade, indicating improving air quality. The steepest decline is observed in NO2 levels, while PM10 and PM2.5 also exhibit significant reductions.

Interpretation: The visualization shows a consistent increasing trend for temperature changes and a decreasing trend for air pollutants (PM10, PM2.5, NO2) from 2010-2020.

3.2 Correlation

To address the second question, we integrated two datasets by year and country, then utilized line plots to visually compare trends in temperature change and air pollution concentration.

Result: The figure shows trends in temperature change (in °C) and pollutant concentrations (in µg/m^3) for six European countries from 2010 to 2022. Each subplot represents a different country and displays temperature change, PM10, PM2.5, and NO2 concentrations. Pearson correlation coefficients (r) indicating the strength of the association between temperature change and each pollutant concentration.



Interpretation: The figure illustrates trends in temperature changes and pollutant concentrations (PM10, PM2.5, NO2) across six European countries from 2010 to 2022. In all countries, temperatures show a general increasing trend with noticeable fluctuations and peaks, particularly around 2018.
France, Germany, and Italy exhibit strong negative correlations between temperature changes and pollutant levels, suggesting that decreases in pollution are associated with rising temperatures. Norway and Sweden also show significant temperature increases, with sharp peaks in temperature and noticeable drops in NO2 concentrations. Spain presents a

unique case with a very weak correlation between PM10 levels and temperature changes, indicating different influencing factors compared to other countries.
Across all subplots, the consistent reduction in pollutant levels alongside rising temperatures highlights the effectiveness of pollution control measures and the complexity of climate dynamics, suggesting that while pollutants may have had a cooling effect, other factors are driving the temperature increases. Further research is needed to fully understand these interactions and their broader environmental implications.

4 Conclusions

- The analysis reveals that all countries exhibit an increasing trend in temperature over the years, with occasional fluctuations. In contrast, all monitored pollutants generally demonstrate decreasing trends, suggesting effective pollution reduction efforts over the study period.
- Negative correlations between temperature and pollutant levels suggest that as air quality improves, temperatures tend to rise. This could imply that pollutants might have had a cooling effect or that other factors are driving the temperature increases.

4.1 Critical Reflection

- The air pollution dataset spans from 2010 to 2022, which, while substantial, may not fully capture longer-term trends and variations that could help in better understanding the correlations.
- The focus on PM10, PM2.5, and NO2 pollutants does not cover all potential contributors to air emissions and climate change, indicating the need for further research into other relevant pollutants.
- The exclusive focus on temperature change does not encompass all aspects of climate change, underscoring the necessity for further research into correlations with other climate variables such as precipitation or extreme weather events.