

# Technical Report:

## PM2.5 & Health Forecasting Shiny App

**APP:** [https://q5m0v0-v0clav-mikulec.shinyapps.io/SEMPR\\_VMikulec\\_PED/](https://q5m0v0-v0clav-mikulec.shinyapps.io/SEMPR_VMikulec_PED/)

### 1. Introduction

The **PM2.5 & Health Forecasting Shiny App** is an interactive dashboard designed to analyze and forecast particulate matter (PM2.5) concentrations and correlate them with weather conditions and health outcomes. The app is intended for researchers, environmental scientists, and public health analysts who require a flexible tool to explore how seasonal weather extremes (heatwaves and cold spells) affect PM2.5 levels and related health metrics (respiratory and cardiovascular death cases, as well as overall mortality). App is currently using dataset for London, United Kingdom.

### 2. Key Features

#### 2.1 Data Upload and Filtering

- **File Upload:**  
Users can upload a CSV file containing relevant data. The expected dataset includes, at a minimum, columns such as date, year, pm25, tmean (mean temperature), resp (respiratory cases), cvd (cardiovascular cases), and all (total deaths).
- **Dynamic Year Range Slider:**  
Based on the year column in the data, a dynamic slider allows users to filter the dataset by selecting a specific year range.

#### 2.2 User Inputs for Analysis

- **Health Condition Selector:**  
A dropdown menu lets users choose between "Respiratory" and "Cardiovascular" health outcomes.
- **Forecast Input:**  
A numeric input field lets users specify the number of years into the future for which forecasting should be performed.
- **Temperature Threshold Sliders:**  
Two sliders are provided to set thresholds for weather extremes:
  - **Cold Spell Threshold:** Defines the maximum temperature considered as a cold spell.
  - **Heatwave Threshold:** Defines the minimum temperature for a heatwave.
- **Mirror Weather Extremes Checkbox:**  
A checkbox option ("Mirror Weather Extremes") allows users to enable or disable the projection of extreme weather markers (heatwaves and cold spells) onto the PM2.5 and Mortality time series plots. When enabled, the app overlays markers on the PM2.5 and Mortality plots:
  - **Cold Spell events** are projected with a **10-day lag** (displayed as blue markers).
  - **Heatwave events** are projected with a **3-day lag** (displayed as red markers).

#### 2.3 Interactive Visualizations

The app is divided into multiple tabs, each offering a different perspective on the data:

- **Data Table Tab:**  
Displays the uploaded data in an interactive table (using the DT package).

- **Time Series Plot Tab:**

Shows three vertically stacked panels:

1. **PM2.5 Panel:** Displays the PM2.5 time series as a blue line. When "Mirror Weather Extremes" is enabled, days classified as extreme (heatwaves or cold spells) are marked with neon-colored points.
2. **Temperature (tmean) Panel:** Displays the temperature series as an orange line with extreme events always marked.
3. **Mortality Panel:** Displays three mortality time series (for all deaths, respiratory, and cardiovascular cases). Extreme events (if mirroring is enabled) are projected on this panel with a lag (blue markers for cold spells with a 10-day lag; red markers for heatwaves with a 3-day lag).

A text summary below the plot outlines the date range, number of observations, the thresholds used, and the fixed lag times.

- **Temp & Mortality Trends Tab:**

Provides additional visualizations that show:

- **Monthly Trends:** Line plots of the monthly mean temperature and monthly mean mortality (using overall deaths), with LOESS smoothing.
- **Annual Trends:** Line plots of the annual mean temperature and annual mean mortality, again with LOESS smoothing.

A summary text below the trends indicates the monthly and annual data ranges.

- **Seasonal Trends Tab:**

Displays monthly averages for PM2.5 and the selected health condition. Both plots include fitted linear regression lines with annotated slope values.

- **Summary Tab:**

Shows a PM2.5 histogram (to visualize the distribution of PM2.5 values) along with a table of summary statistics (mean, median, standard deviation, minimum, and maximum) for all numeric variables (excluding non-essential fields like year, month, etc.).

- **Forecast Tab:**

Uses STL (Seasonal and Trend decomposition using Loess) forecasting to predict future PM2.5 concentrations. A linear regression model then predicts the corresponding health outcome based on the forecasted PM2.5 values. Two forecast plots (one for PM2.5 and one for the health outcome) are displayed, and a summary text shows the forecasting method, the forecast horizon (in days), and the start date for the forecast.

## 2.4 Download Options

- **Data Report Download:**

Users can download the filtered dataset as a CSV file.

- **Plots Download:**

The app provides a download button that creates a multi-page PDF file containing the following:

- Time Series Plot (all three panels)
- Seasonal Trends Plot
- PM2.5 Histogram (from the Summary tab)
- Forecast Plot