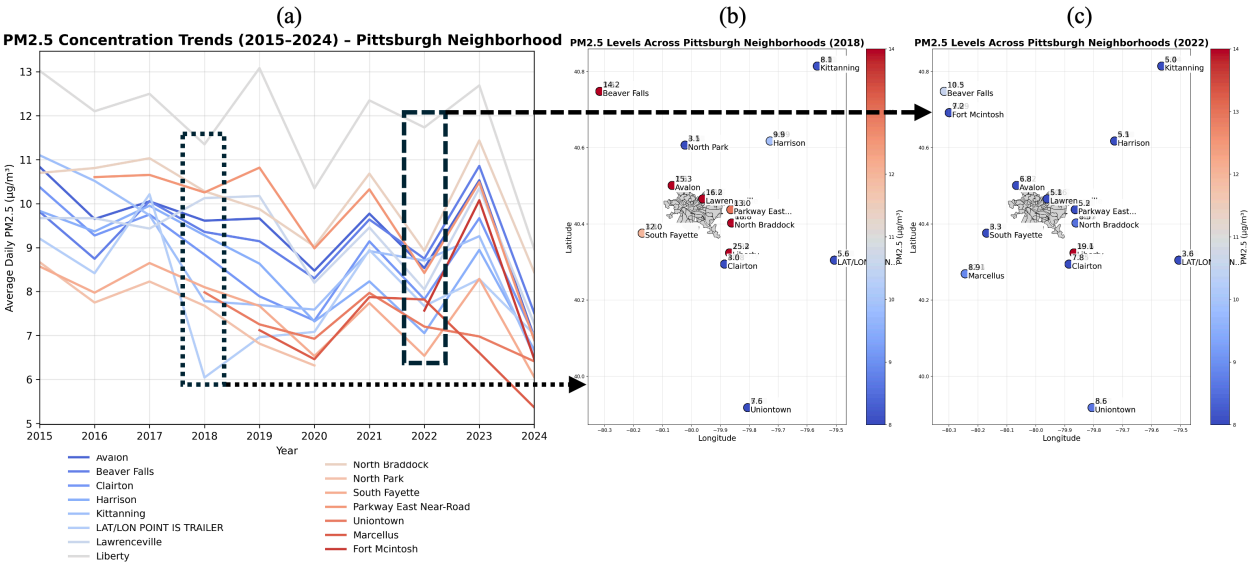
Final Report By Hui Ji (huj16@pitt.edu)

(i) Title: PM2.5 Concentration Trends in Pittsburgh Neighborhoods (2015–2024)

(ii) Main Figure: (ideally an integrated version comprising both the main one and small panels on the side)



- **Panel (a):** Year-to-year PM2.5 concentration trends across Pittsburgh Neighborhoods.
- **Panel (b):** Geographical PM2.5 distribution in **2018**.
- **Panel (c):** Geographical PM2.5 distribution in **2022**.

(iii) Legend Explanation:

- **Colored Lines (Panel a):**Panel (a) visualizes **year-to-year PM2.5 concentration trends** for all monitoring neighborhoods across the Pittsburgh region from **2015 to 2024**. The following elements appear in the plot:

- Each line represents the **annual average PM2.5 concentration** measured at one monitoring neighborhood.
- X-Axis (Year), Y-Axis (Average Daily PM2.5 ($\mu g/m^3$)).
- Colors are **assigned uniquely to each neighborhood** for visual distinction *only*; the color does **not** encode magnitude or category.

- Line shapes and directions reveal:
  - **Long-term trends** (decline, increase, or plateau)
  - **Year-to-year variability**
  - **Neighborhoods with consistently high or low PM2.5 levels**

This allows comparison of pollution trajectories across different areas.

- **Solid Points in Panels (b) and (c):**
  Each point represents a monitoring site.
  - **Color scale:** PM2.5 concentration (blue = low, red = high).
  - **Numeric label:** Actual PM2.5 value measured at that location.
  - **Text label:** Neighborhood name.
- **Gray Polygons (b) and (c):**
  Pittsburgh administrative neighborhood boundaries from GIS shapefile.
- **Color Bar:**
  Quantitative mapping of PM2.5 concentration ($\mu g/m^3$) to a blue–red color gradient.
- **Dashed Boxes and Arrows (Panel a → b → c):**
  Highlight selected years (2018 and 2022) used for detailed spatial visualization.

(v) data and method:

Data Sources (https://www.epa.gov/outdoor-air-quality-data/download-daily-data)

- **EPA Air Quality Monitoring Dataset (2015–2024)**
  Files: ad_viz_plotval_data_2015.csv, ..., ad_viz_plotval_data_2024.csv
  Includes:
  - Latitude & longitude of monitoring sites
  - Local Site Name (interpreted as neighborhood)
  - Daily Mean PM2.5 Concentration
- **Pittsburgh Neighborhood Boundary Shapefile**
  Files: Neighborhoods_.shp, .dbf, .shx, .prj, .cpg
  Used for accurate geographic boundary overlays.

Method Summary

1. **Data Cleaning & Standardization**

    - Harmonized column names.
    - Filtered valid PM2.5 measurements.
    - Converted geographic coordinates into a GeoDataFrame.
2. **Trend Analysis (Panel a)**
    - Aggregated daily PM2.5 to **yearly averages** per neighborhood.
    - Produced multi-line time-series visualization using Matplotlib/Seaborn.
3. **Spatial Analysis (Panels b & c)**
    - **Spatial join**: matched PM2.5 monitoring points to neighborhood polygons.
    - Overlayed point measurements on geographic neighborhoods.
    - Labeled points with PM2.5 value + Local Site Name.
    - Used a **controlled color range** for consistent visual comparison.
4. **Visualization Integration**
    - Combined trend plot and two spatial panels into a single multi-panel figure.
    - Added annotations linking temporal trends to spatial snapshots.

(vi) significance statement:

Understanding neighborhood-level PM2.5 pollution is essential for:

- **Environmental justice:** identifies communities disproportionately exposed to harmful air pollution.
- **Public health planning:** PM2.5 is linked to cardiovascular disease, asthma, and premature mortality.
- **Urban policy:** supports targeted interventions such as emission controls, zoning changes, or traffic redirection.
- **Long-term monitoring:** reveals persistent hotspots and evaluates effectiveness of clean-air initiatives.

The integrated figure (trends + spatial maps) provides a **comprehensive picture** of how pollution evolves over time and how it is distributed across the Pittsburgh metropolitan area—insights not visible from either temporal or spatial analysis alone.

Github:

https://github.com/HuiJi-1024/Final-Project-for-INFSCI-2415-huj16-pitt.edu-