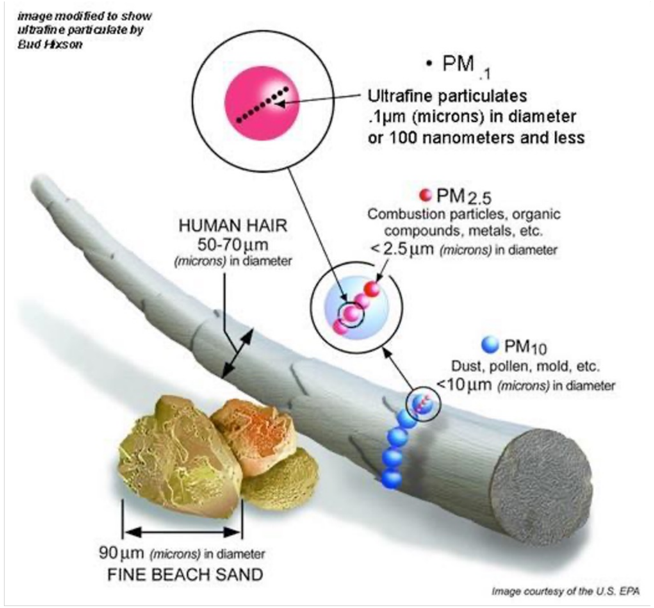
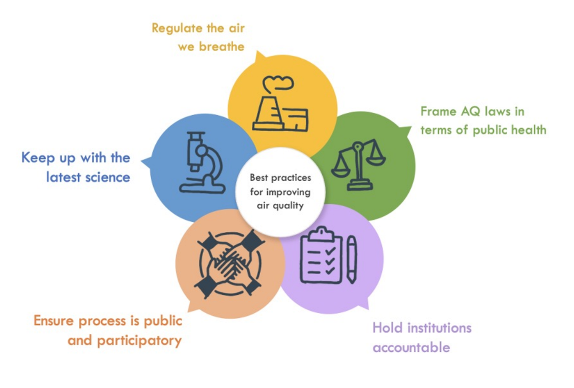
Introduction:

- Humans need Oxygen to Survive.
- Pollutants like particulate matter, NO_2, SO_2 increase risk of respiratory diseases.
- Some air pollutants like particulate matter have been classified by the World Health Organization as a Group 1 carcinogen. https://www.who.int/news/item/02-11-2023-climate-change-and-noncommunicable-diseases-connections.
- Vulnerabilities: Male, Female, Childrens & Elderly people.



Significance:

- Understanding health impacts.
- Informed Policymaking - Air quality research informs policy and regulations at local to national levels.
- Guide Mitigation Strategies.
- Track Trend Over time.
- Prepared for future challenges.



Community Tour of an Air Quality Monitoring Station

Calculation Process

File Structure

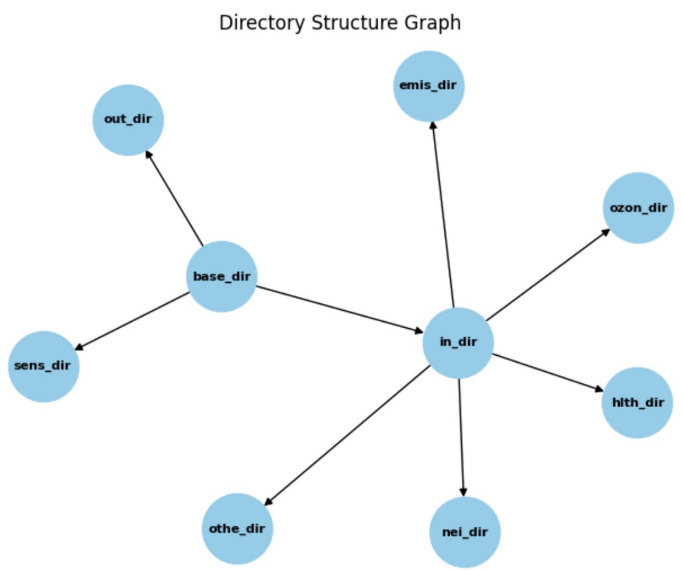
base_dir = '/UMBC IS/IS777/Project/input_folder/'

#City Initials: INIT = 'LOS'

#City Name: NAME = 'Los Angeles'

#State city is in: STATE = 'California'

#Directories
out_dir = base_dir+'outputs/'
in_dir = base_dir+'static/'
sens_dir = base_dir+'inputs/'+INIT+'/'
emis_dir = in_dir+'emissions/'
othe_dir = in_dir+'other/'
ozon_dir = in_dir+'ozone/'
nei_dir = in_dir+'nei/'
hlth_dir = in_dir+'health/'



Data Files

`V5GL02.HybridPM25.Global.201101-201112.nc`: Contains monthly PM (Particulate Matter) data for the specified time period.
`gpw_v4_population_count_rev11_2010_30_sec.tif`: Contains global population data
`cities_13k_largerext.tif`: Provides a mask for cities, possibly indicating regions of interest.
`GC_M2_US_05x0667.nc`: Holds information about the area of each grid in the specified region.
`IHME_GBD_2019_POP_SYA_2011_Y2021M01D28.CSV`: Contains global disease burden population data for states.
`USCITIES_07212022_Data.csv`: Includes population data for cities and kids, possibly related to health analysis.
`IHME-GBD_2019_DATA.csv`Contains mortality data, possibly categorized by age groups.
`IHME-GBD_2019_DATA_ASTHMA.csv` Contains asthma-related data, possibly categorized by age groups.

Age Code File: `IHME_GBD_2019_CONTEXTS_BY_AGE_Y2020M12D18.csv`
Location Code File: `IHME_GBD_2019_ALL_LOCATIONS_HIERARCHIES_Y2022M01D20.csv`
Cause Code File: `IHME_GBD_2019_CAUSE_HIERARCHY_Y2020M11D25.csv`
These files contain codes related to age, location, and causes, providing a context for health-related data.

Additional files for Pollutants are also there.

Data

Input Files: Data related to Pollutants, Population, Mask, City, Area, Health etc.

Assignment: Grid Dimension, Max Days

Emission Factors: SPD, CM2M, MW, KGCONV, E-Factor

Health Information: Age and corresponding

Mortality Rate Outcome Names: Identifiers are provided

Pollutant: : 'PM' (Particulate Matter), 'O3' (Ozone), and 'NO2' (Nitrogen Dioxide)

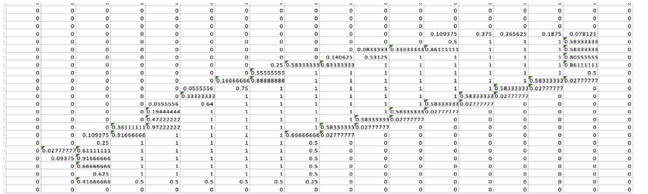
Read in adjoint sensitivities and aggregate to annual time-scale

For each pollutant,

For each month,

File paths are constructed for sensitivity and month

base_dir+'inputs/'+INIT+'/'+'ems.adj.'+mon+'.'+INIT+'.'+pollutant[p]+'.nc'



Get cost-function data

Read Mask Data, O3, PM, NO2, Population Data.
Calculate city and state mask

Calculate cost-function values

Checks if the pollutant data is not NaN.

If conditions are met, the numerator (NUM) is incremented by the product of Pollutant concentration, city mask value, and population.

The denominator (DEN) is incremented by the product of the city mask value and population.

Cost Function is calculated as the ratio of the total numerator to the total denominator.

Emission scaling

Emissions are scaled by multiplying with the emission factor (efactor) and grid cell area (GCM2).

Normalize the sensitivities for PM, O3, and NO2 by dividing with the scaled emissions, avoiding division by zero.

Emissions are scaled based on the type of VOC and grid cell area.

Normalize the sensitivities by dividing with the scaled emissions and apply a threshold using the correction factor.

Apply cost-function scaling

Cost-function scaling is applied to the normalized sensitivities of PM2.5 (Particulate Matter), O3 (Ozone), and NO2 (Nitrogen Dioxide).

Calculate contributions

Contributions of individual species to the total emissions of PM2.5, O3, and NO2 are calculated based on the National Emissions Inventory (NEI) data.

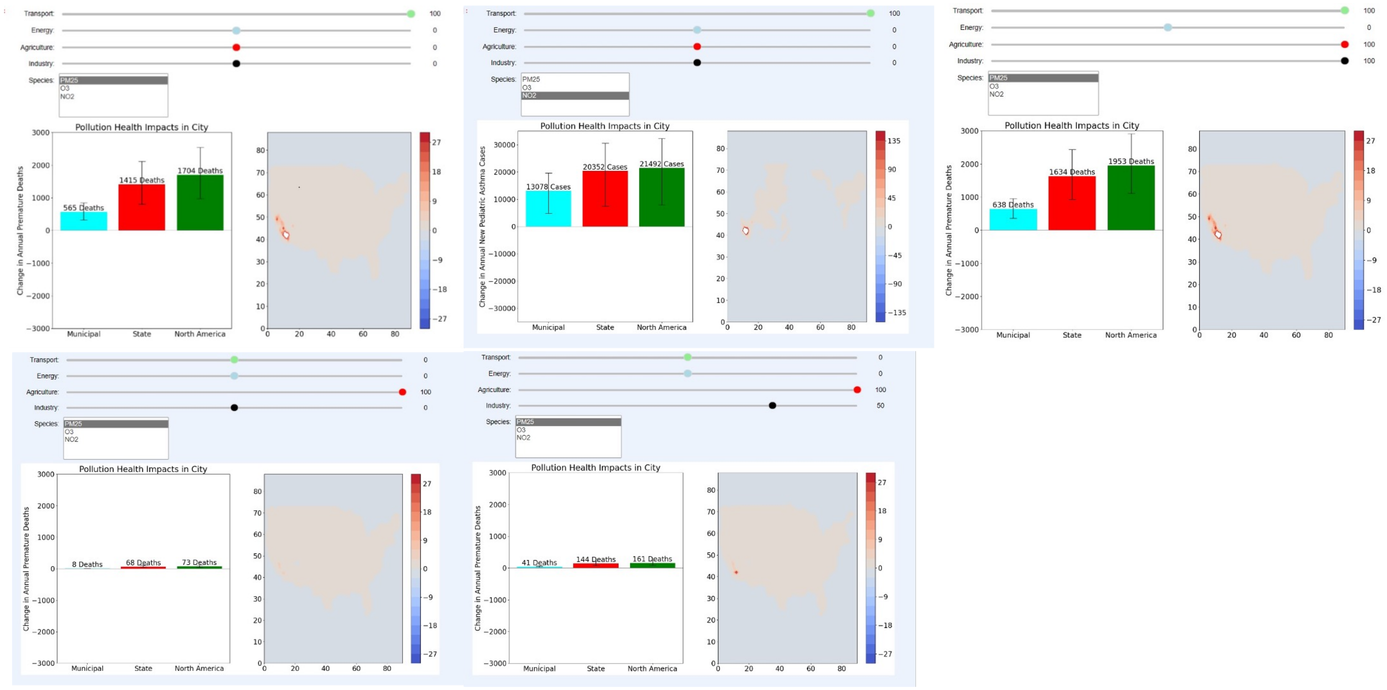
Preprocess health data

- Load and extract population information.
- Load and process mortality rates, focusing on State i.e. California.
- Calculate Population in Age Brackets
- Calculate Mortality Rate for Asthma

Health Impact Contribution

- Get relative risk from log-linear exposure response equation
- Calculate the baseline health impact
- Calculate the perturbed health impact
- Calculate health scaling factors for exposure from each pollutant

Widgets



Transport:
100
Energy:
0
Agriculture:
0
Industry:
0
Species:
PM25
O3
NO2
Pollution Health Impacts in City
Change in Annual Premature Deaths
565 Deaths
1415 Deaths
1704 Deaths
Municipal
State
North America
Transport:
100
Energy:
0
Agriculture:
0
Industry:
0
Species:
PM25
O3
NO2
Pollution Health Impacts in City
Change in Annual New Pediatric Asthma Cases
13078 Cases
20352 Cases
21492 Cases
Municipal
State
North America
Transport:
100
Energy:
0
Agriculture:
100
Industry:
100
Species:
PM25
O3
NO2
Pollution Health Impacts in City
Change in Annual Premature Deaths
638 Deaths
1634 Deaths
1953 Deaths
Municipal
State
North America
Transport:
0
Energy:
0
Agriculture:
100
Industry:
0
Species:
PM25
O3
NO2
Pollution Health Impacts in City
Change in Annual Premature Deaths
8 Deaths
68 Deaths
73 Deaths
Municipal
State
North America
Transport:
0
Energy:
0
Agriculture:
100
Industry:
50
Species:
PM25
O3
NO2
Pollution Health Impacts in City
Change in Annual Premature Deaths
41 Deaths
144 Deaths
161 Deaths
Municipal
State
North America

Related Works

Project-Level Air Quality Analysis - The information and tools described below comprise of materials developed by Caltrans, as well as materials developed by external agencies including the U.S. Environmental Protection Agency (EPA), the Air Resources Board (ARB), and local air districts. https://dot.ca.gov/programs/environmental-analysis/air-quality/project-level-air-quality-analysis

Data-Driven Framework for Understanding and Predicting Air Quality in Urban Areas - https://www.frontiersin.org/articles/10.3389/fdata.2022.822573/full

Ambient Air Methods and Measurement Development Research - https://www.epa.gov/air-research/ambient-air-methods-and-measurement-development-research

Future Work

1. Long-term cohort studies tracking health outcomes in populations exposed to different levels of air pollution over decades. This can definitively confirm links between air pollutants and diseases.
2. Research into impacts of early-life exposures and prenatal exposures on childhood development and disease risk later in life. This can reveal especially vulnerable windows.
3. Investigations into synergistic effects of co-exposures to air pollution mixtures, heat waves, allergens etc. that reflect real-world exposures. Multi-factor studies can detect amplified responses.
4. Enhanced pollution speciation and exposure assessments using satellites, sensors, personal monitors and more to enable “big data” epidemiological analyses with machine learning algorithms. This can provide unprecedented insight.
5. Evaluations of positive health co-benefits accrued by climate change mitigation strategies which also reduce co-emitted air pollutants. This can motivate adoption of win-win approaches.

Conclusion

In conclusion, clean air is utterly essential for human health and longevity. However, air pollution remains the largest environmental health risk globally, responsible for millions of deaths annually. The composition and impacts of air pollution are incredibly complex and require dedicated research to unravel. Such research is invaluable for connecting specific pollutants to tangible health outcomes. This informs better policies, guidelines, and mitigation efforts aimed at preserving our wellbeing.