Environmental Racism and Income Gap: Air Pollution Exposure Disparities in California

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Do Race and Income play a factor in Air Pollution Exposure?

- Which racial/ethnic group is most/least affected by air pollution?
- Which city has the most/least disparities in access to clean air, across racial groups?
- Is this disparity also present across income groups?

We answer these questions for 3 major cities in California:
- San Diego
- San Francisco
- Los Angeles

We select cities in California as no race constitutes a majority of it's population [2]

NON-HISPANIC WHITES   HISPANICS   BLACKS

POLLUTION INEQUITY

3

AIR QUALITY
CONTRIBUTION & EXPOSURE

3
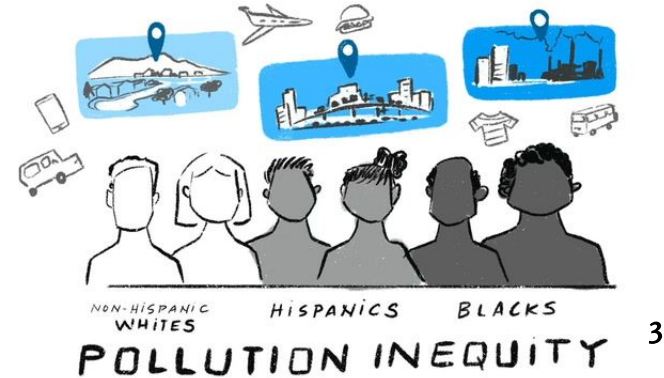
Quantizing the Relationship between Racial groups, Income, and Air Pollution

Census Tract	Median Household Income	Population						Mean Concentration			City
		White	Black	American Indian	Asian	Pacific Islander	Other Race	NO2	CO	Aerosol	
1											San Diego
2											Los Angeles
3											San Francisco

2019 ACS Data

Census Tract Level Zonal Statistics of Google Earth Engine Spatial Estimates (2019 average) *

- For each city, we calculate the correlation between the population of 6 different racial groups and the mean NO_2, CO, and Aerosol concentrations at the census tract level using the Pearson's r coefficient.
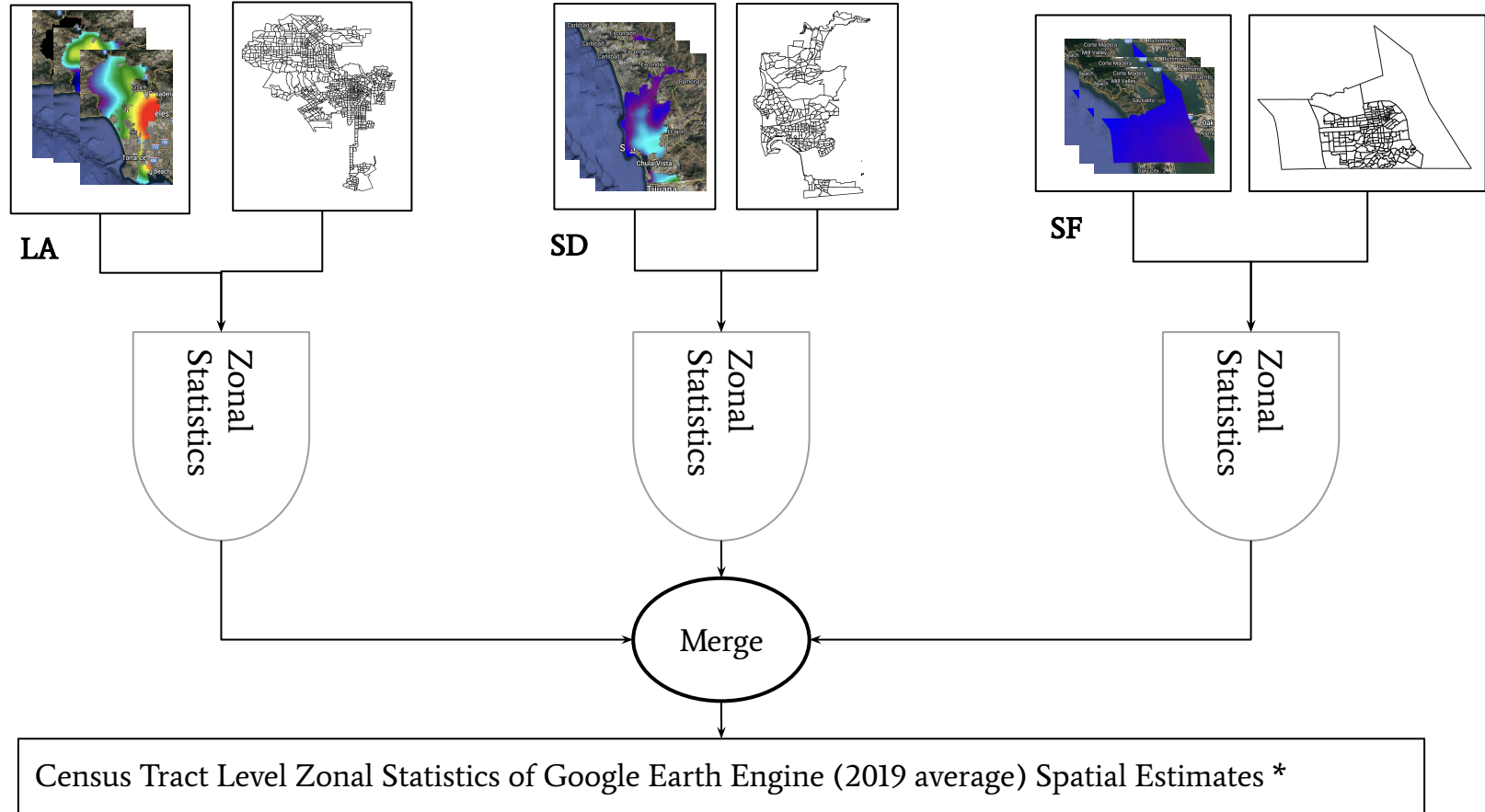
* Process of getting this data is described in next slide
https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S5P_OFFL_L3_NO2
 https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S5P_OFFL_L3_CO
 https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S5P_OFFL_L3_AER_AI

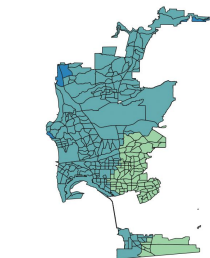# Average Air Pollution in each Census Tract

LA

SD

SF

Zonal Statistics

Zonal Statistics

Zonal Statistics

Merge

Census Tract Level Zonal Statistics of Google Earth Engine (2019 average) Spatial Estimates *
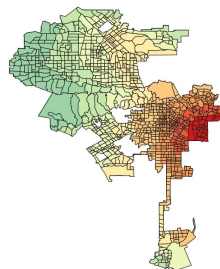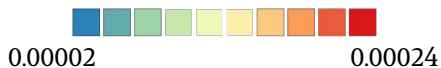
Air Pollution - Spatial Distribution

San Diego (372.4 mi²)

San Francisco (46.87 mi²)

Los Angeles (503 mi²)

NO$_2$ (mol/m²)

CO (mol/m²)
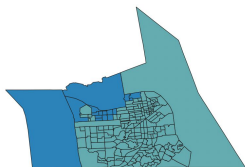
Aerosols (mol/m²)

Less disparities in SF because of smaller area

0.00002   0.00024

0.029   0.035
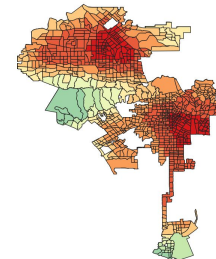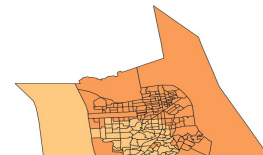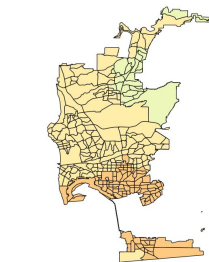
-1.11   -0.09

Elasticities between Income & Pollution

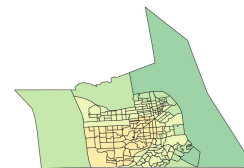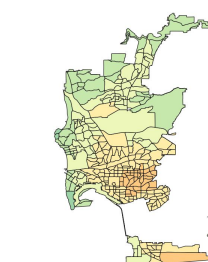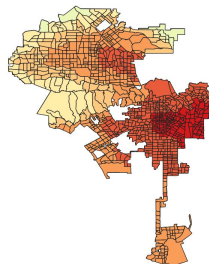|	Pollution		
	NO2	**CO**	**Aerosol**
San Diego	-0.4765	-0.4264	-0.5452
San Francisco	-0.0194	-0.0696	0.3145
Los Angeles	-0.4827	-0.4556	-0.5528

▢ Better in low income neighborhoods   ▢ Worse in low income neighborhoods

- Aerosol content is significantly higher in high income neighborhoods than low income neighborhoods, only in San Francisco.
- San Francisco doesn't show strong trends like Los Angeles and San Diego. This might be because it is much smaller in area, and thus has lesser variance in pollution content.

Elasticities between Population of a Race and Pollution

White Population

	NO2	CO	Aerosol
San Diego	-0.0495	-0.1192	-0.1258
San Francisco	-0.0598	0.1369	0.2644
Los Angeles	-0.39835	-0.3806	-0.31886

Asian Population

	NO2	CO	Aerosol
San Diego	-0.0966	-0.1991	-0.1161
San Francisco	-0.0235	-0.0985	0.1184
Los Angeles	-0.0566	0.0017	0.0329

Black or African American Population

	NO2	CO	Aerosol
San Diego	0.5245	0.3137	0.4267
San Francisco	0.2973	0.01806	-0.1056
Los Angeles	0.1759	0.1523	0.0604

Native Hawaiian & Other Pacific Islander Population

	NO2	CO	Aerosol
San Diego	0.1117	0.0075	0.0521
San Francisco	0.1081	-0.0742	-0.1423
Los Angeles	0.0041	-0.0164	0.0035

American Indian & Alaska Native Population

	NO2	CO	Aerosol
San Diego	0.0603	-0.1596	0.0089
San Francisco	0.1507	0.1153	0.0456
Los Angeles	0.2144	0.1386	0.1069

Other Race Population

	NO2	CO	Aerosol
San Diego	0.4356	0.2235	0.3481
San Francisco	0.3506	-0.2342	0.0849
Los Angeles	0.3718	0.3357	0.5115

Why do these disparities exist?

- Groups may face greater exposure to pollution because of factors like:
  - Systemic racism
  - Class bias
  - Housing market dynamics and land costs.
- Redlining: Residents in neighborhoods historically plagued by redlining are more than twice as likely to go to the emergency room for asthma.
- Existing health conditions or traits may predispose racial/income groups to greater health risk.

Modern air pollution disparities in historically redlined areas

Philadelphia, PA   Chicago, IL

202 redlining maps drawn in the 1930s

Los Angeles, CA   Detroit, MI

Population wtd NO$_2$ (ppb)

Air pollution in 2010 increases with 1930s redlining grade
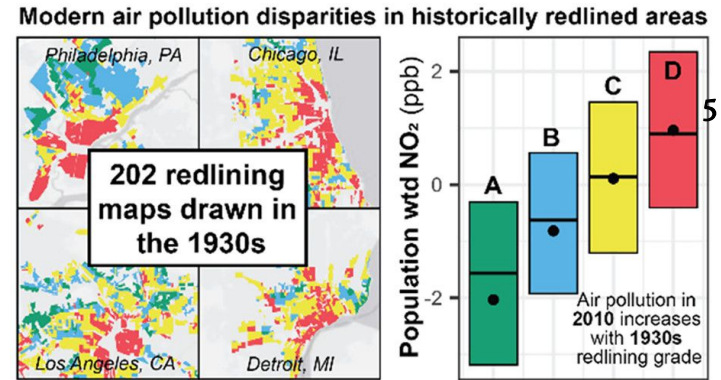
Key Findings

- Black, American Indian and Other race populations have a positive relationship with pollution while white and asian population contrastingly have a negative one.
- There could be a strong positive correlation between NO_2 emissions and Income as their primary source is through burning of fossil fuels.
- Aerosol content is significantly higher in high income neighborhoods than low income neighborhoods, only in San Francisco.
- San Francisco doesn't show strong trends like Los Angeles and San Diego. This might be because it is much smaller in area, and thus has lesser variance in pollution content.

Strategies for Climate Justice

Identifying racially segregated communities and sources of air pollution in them

Offer programs to Black and other racial communities for respiratory diseases

Low carbon energy alternatives can decrease racial disparity of exposure to $PM_{2.5}$ by 20% and $PM_{0.1}$ by 40%

References

1. https://www.hsph.harvard.edu/news/press-releases/racial-ethnic-minorities-low-income-groups-u-s-air-pollution/
2. https://www.ppic.org/publication/californias-population/
3. https://www.usatoday.com/story/news/nation/2019/03/11/air-pollution-inequality-minorities-breathe-air-polluted-whites/3130783002/
4. Li, Yiting, et al. "Adoption of low-carbon fuels reduces race/ethnicity disparities in air pollution exposure in California." *Science of The Total Environment* (2022): 155230.
5. Lane, Haley M., et al. "Historical Redlining Is Associated with Present-Day Air Pollution Disparities in US Cities." *Environmental Science & Technology Letters* 9.4 (2022): 345-350.
6. Masri, Shahir, et al. "Disproportionate impacts of wildfires among elderly and low-income communities in California from 2000–2020." *International journal of environmental research and public health* 18.8 (2021): 3921.
7. Bell ML, Ebisu K. Environmental inequality in exposures to airborne particulate matter component in the United States. Environ Health Perspect. 2012; 120: 1699–1704.
8. https://www.unep.org/resources/report/actions-air-quality-global-summary-policies-and-programmes-reduce-air-pollution

APPENDIX

Code

```python
cities=["Los Angeles", "San Diego", "San Francisco"]

for i,df in enumerate([LA, SD, SF]):

    print(cities[i], " : Income \n")
    print("NO2: ", pearsonr(list(df['B19049e1']), list(df['NO2_mean']))[0])
    print("CO: ", pearsonr(list(df['B19049e1']), list(df['CO_mean']))[0])
    print("Aerosol: ", pearsonr(list(df['B19049e1']), list(df['AE_mean']))[0])
    print()

    print(cities[i], " : Race - White \n")
    print("NO2: ", pearsonr(list(df['B02001e2']), list(df['NO2_mean']))[0])
    print("CO: ", pearsonr(list(df['B02001e2']), list(df['CO_mean']))[0])
    print("Aerosol: ", pearsonr(list(df['B02001e2']), list(df['AE_mean']))[0])
    print()

    print(cities[i], " : Race - Black or African American \n")
    print("NO2: ", pearsonr(list(df['B02001e3']), list(df['NO2_mean']))[0])
    print("CO: ", pearsonr(list(df['B02001e3']), list(df['CO_mean']))[0])
    print("Aerosol: ", pearsonr(list(df['B02001e3']), list(df['AE_mean']))[0])
    print()

    print(cities[i], " : Race - American Indian and Alaska Native")
    print("NO2: ", pearsonr(list(df['B02001e4']), list(df['NO2_mean']))[0])
    print("CO: ", pearsonr(list(df['B02001e4']), list(df['CO_mean']))[0])
    print("Aerosol: ", pearsonr(list(df['B02001e4']), list(df['AE_mean']))[0])
    print()

    print(cities[i], " : Race - Asian \n")
    print("NO2: ", pearsonr(list(df['B02001e5']), list(df['NO2_mean']))[0])
    print("CO: ", pearsonr(list(df['B02001e5']), list(df['CO_mean']))[0])
    print("Aerosol: ", pearsonr(list(df['B02001e5']), list(df['AE_mean']))[0])
    print()

    print(cities[i], " : Race - Native Hawaiian and other Pacific Islander Alone \n")
    print("NO2: ", pearsonr(list(df['B02001e6']), list(df['NO2_mean']))[0])
    print("CO: ", pearsonr(list(df['B02001e6']), list(df['CO_mean']))[0])
    print("Aerosol: ", pearsonr(list(df['B02001e6']), list(df['AE_mean']))[0])
    print()
```

```javascript
var co = ee.ImageCollection('COPERNICUS/S5P/OFFL/L3_CO')
    .filterBounds(ROI)
    .select('CO_column_number_density')
    .filterDate(t1_1, t1_2)
    .mean()
    .clip(ROI);

var aerosol = ee.ImageCollection('COPERNICUS/S5P/NRTI/L3_AER_AI')
    .filterBounds(ROI)
    .select('absorbing_aerosol_index')
    .filterDate(t1_1, t1_2)
    .mean()
    .clip(ROI);

var no2 = ee.ImageCollection('COPERNICUS/S5P/OFFL/L3_NO2')
    .filterBounds(ROI)
    .filterDate(t1_1, t1_2)
    .select('tropospheric_NO2_column_number_density')
    .mean()
    .clip(ROI);
```