Pollution Racial Bias in South United State

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Abstract

This study purpose is to verify if PM2.5 pollution is racially biased and if we can predict counties black population ratio based on pollutant PM2.5 daily concentration data, next aim is to confirm the increasing pollution as consequence of Trump administration laws recalling. Study consists of 2016 year data from thirty PM2.5 pollutant monitoring stations from Texas, Louisiana, Mississippi, Alabama states. PCA was applied to investigate overall variability, BD depth and time-warping plus registration calculation to distinguish outliers in the data set and it was found out that Cameron and Nueces (Texas counties) behave differently from whole data. At the ending functional scalar response linear regression fit is checked and showed decent results, in consequence there is a log-relation between counties PM2.5 pollution and size of black community there. Finally 2016, 2019, 2020 are compared with ANOVA test using multiple test statistics and most of them helps us to reject null hypothesis of the same means, hence pollution mean is varying from year to year and Trump administration laws rollback might have a impact(further analysis can be applied).

Keywords

Functional Analysis — PM2.5 Pollution — Scalar functional regression — Redlining — PCA — FANOVA — BD — Time-warping

Contents

Introduction

Segregation After the United States abolished slavery, Black Americans continued to be marginalized through enforced segregated and diminished access to facilities, housing, education—and opportunities. The first steps toward official segregation came in the form of "Black Codes". These were laws passed throughout the South starting around 1865, that dictated most aspects of Black peoples' lives, including where they could work and live. The codes also ensured Black people's availability for cheap labor after slavery was abolished. Using loopholes in ruling in the 1920s, Secretary of Commerce Herbert Hoover created a federal zoning committee to persuade local boards to pass rules preventing lower-income families from moving into middle-income neighborhoods, an effort that targeted Black families.[1] The Federal Housing Administration, which was established in 1934, furthered the segregation efforts by refusing to insure mortgages in and near African-American neighborhoods — a policy known as "redlining". The areas marked in red as "hazardous" typically outlined Black neighborhoods. The Federal Housing Administration's justification was that if African-Americans bought homes in these suburbs, or even if they bought homes near these suburbs, the property values of the homes they were insuring,the white homes they were insuring, would decline. And therefore their loans would be at risk. However in 1968 the Fair Housing Act passed have been passed, in effect, but it's an empty promise because those homes are no longer affordable to the families that could have afforded them when whites were buying into those suburbs and gaining the equity and the wealth that followed from that. [2] The Home Mortgage Disclosure Act (HMDA) of 1975 and the Community Reinvestment Act (CRA) of 1977-designed to combat banks' redlining practices. HMDA required regulated lenders to disclose the location, by census tract, of their home mortgages and home improvement loans. In combination, HMDA and CRA provided tools to pressure banks to invest in low-income and minority neighborhoods.[3] Half a century since the death of America's most prominent civil-rights icon, race is no longer destiny. Overt housing discrimination, which kept black communities tightly packed into confined, cordoned-off neighbour-hoods, has been all but eliminated, though subtler forms still exist; Today,those who can afford to move to better neighbourhoods are able to, nevertheless it doesn't solve consequences. [4]

Pollution   Opposition to civil rights was led by elected officials, journalists, and community leaders who shared racist ideologies, shut down public schools and parks to prevent integration, and encouraged violence against civil rights activists. Segregation in America profiles segregationist leaders who were not shamed or banished but repeatedly won re-election to the highest political offices. Racist politicians enjoyed support from the majority of white voters, the Ku Klux Klan claimed many of the South's most prominent and powerful citizens as members and perpetrators of vicious attacks. One of those were The Underwriting Manual of the Federal Housing Administration that recommended that highways be a good way to separate African-American from white neighborhoods. So this was not a matter of law, it was a matter of government regulation. In this way pollution hotspots are created and those hot spots are the same, year after year,and every time they are in low-income communities – often communities of color. [5] Research has long concluded minority and poor communities are more likely to live near dangerous air pollution, a pattern activists call environmental racism. [6] This phenomena especially thrived in South: of 677 disproportionally Black counties ($>$ 13% Black American), 91% are concentrated in the southern U.S. [7] Another problem, Though many of the older, more-harmful plants have closed, others remain open and are often grandfathered into older regulatory standards that aren't as strict as those imposed on newer companies [8] Even with Previous research has shown that despite widespread reductions in air pollution, blacks are still experiencing twice the health risk from air pollution than whites. [8] and the situation doesn't see future prospects - The Trump administration is rolling back multiple transportation pollution standards.[10]

PM2.5 what is it?   A bit about Pm2.5 - which causes fine particles pollution - when exposes to human it can lodge deep in our lungs and bloodstream and can lead to health problems like earth disease asthma and lung cancer and after all it associated with increased risk of COVID-19 deaths whether long-term average exposure to fine particulate matter (PM2.5) is associated with an increased risk of COVID-19 death in the United States. A small increase in long-term exposure to PM2.5 leads to a large increase in the COVID-19 death rate. [18] This pollutant mostly emitted form road vehicles, petrochemical plats, fires and etc.

Motivation   Literature has shown that non-Whites and below-poverty individuals are more likely to reside near stationary sites of PM2.5 emissions. [9] Hence there should be some relation between racial distribution and pollution in counties, in this case we will associate cities monitoring data as counties data. To confirm this assumption, we studied the effects of a PM2.5 pollutant relation on new cancer numbers/racial distribution. To assess whether scarce pollution monitoring station data can explains phenomena of unequal toxic by race, refer to table 1. To get more acquaintances with the problem we display *Map 1, 2* in the Appendix.

Mean Absolute and Proportional Burdens From Facilities Emitting PM in the 2011 National Emissions Inventory, Selected Subgroups: American Community Survey, United States, 2009–2013

Variable	Proportion of Population, %	PM$_{2.5}$ Burden, Absolute (Proportional)	PM$_{10}$ Burden, Absolute (Proportional)	Facility Burden, Absolute (Proportional)
Overall population	1.00	22.4 (. . .)	29.2 (. . .)	5.7 (. . .)
Race/ethnicity[a]				
White	0.63	18.8 (0.84)	24.7 (0.85)	4.1 (0.72)
Non-White	0.37	28.6 (1.28)	37.0 (1.27)	8.5 (1.49)
Black	0.12	34.5 (1.54)	43.6 (1.49)	6.2 (1.09)
Hispanic	0.17	26.9 (1.20)	35.9 (1.23)	9.8 (1.70)
Poverty level				
Above poverty	0.85	20.9 (0.93)	27.2 (0.93)	5.5 (0.95)
Below poverty	0.15	30.3 (1.35)	39.3 (1.35)	7.2 (1.26)

Note. PM = particulate matter; PM2.5 = PM of ≤ 2.5 μm in diameter; PM10 = PM of ≤ 10 μm in diameter. Poverty level determined by the US Census Bureau in 2013. Burdens represent the PM emissions or the number of facilities in the 2011 National Emissions Inventory that are near the block group of residence for an average individual in the 2009–2013 American Community Survey population. Absolute burden units for PM emissions are tons/year; for facilities, they are the total number. Proportional burden is the ratio of subgroup burden to overall population burden.

[a]"White" refers to only non-Hispanic Whites; "non-White" refers to all others. Included in the latter group are Black (non-Hispanic) and Hispanic (any race).

Table 1. PM2.5 distribution by race
Note. Adapted from [11]

Also no functional analysis research were used to investigate the problem, only scarce papers use fda on pollution like.[12] To add up,

1. Methods and theory

Skipping it since a lot to cover.

2. Results and discussion

Most common functional analysis tools will be used to analyse racial bias in pollution.

2.1 Exploratory data analysis

Relaying on recent paper [13] that confirms seasonality of PM2.5 concentration suggested to use Fourier basis of *nbasis* = 7 to avoid redundant fluctuations, the smoothed data can be seen in *Figure 1*.
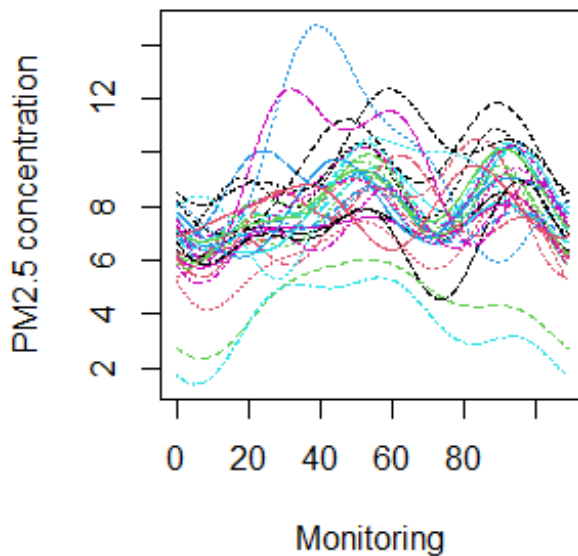
Figure 1. Smoothed PM2.5 concentration functional data

From *Figure 2* it is easy to notice two outliers, Breuser and Cameron, below the clustered cloud of functions, both values are from Texas counties that are far away from petrochemical industry, follow *Map 2*; Other two, Culberson and Nueces, outstanding functions are also from Texas counties that are heavy on industry as well as with massive highways that can be considered few of the biggest in the world. [14] The explosive growth of PM2.5 around late winter can be explained by many chemical pollutants accumulation, read [15] for more in-depth explanation.
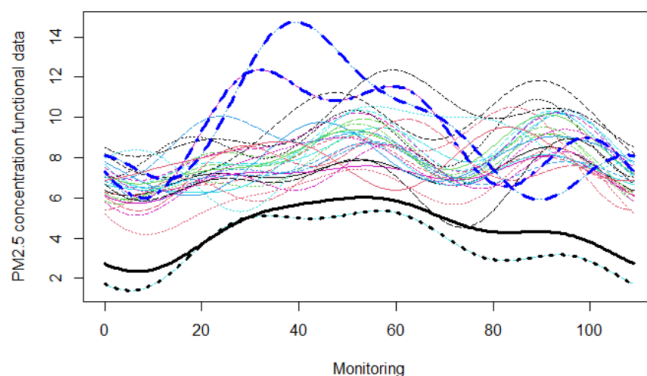
Figure 2. Outliers

2.2 Time-warping and registration
Outliers can be analysed by its acceleration, more specifically if its dynamics are similar to the other PM2.5 monitoring

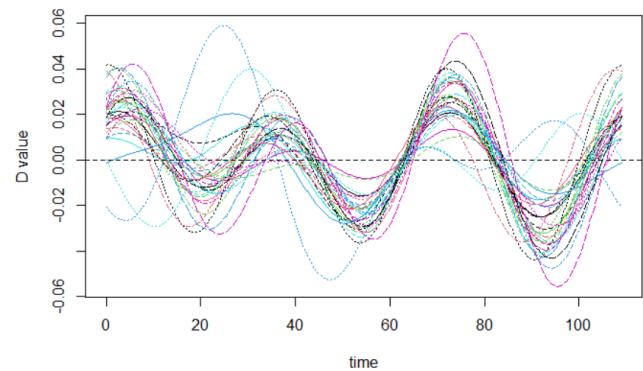stations data patterns pollution acceleration is displayed in *figure 3*.

Figure 3. Functional PM2.5 concentration after time-warping and registration

Figure 4 confirms abnormality of mentioned counties Cameron and Nueces data, hence we will call those to true outliers of the dataset.
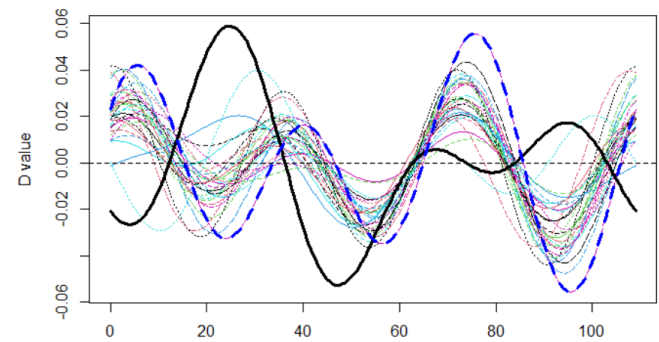

Figure 4. Acceleration of functions and anomalies

2.3 Principal Component Analysis
First PC explains $66,9\%$ of variability and its multiples have strong positive over all period of time, mostly those multiple are functions above the mean, for instance Texas states, *Figure 5*.
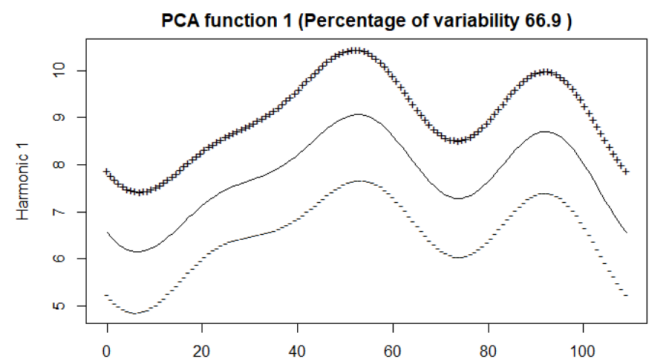

Figure 5. First Principal Component

In the second PC case only 16,8 % variability is explained, PC multiples have a strong positive effect between 20th monitoring and 70th - that comes from already discussed high Texas counties values and chemical accumulation effect in the late winter the negative impact in the rest observations might indicated us that Texas suffers a lot from transportation pollution and this concentration plunges in the hotter days.
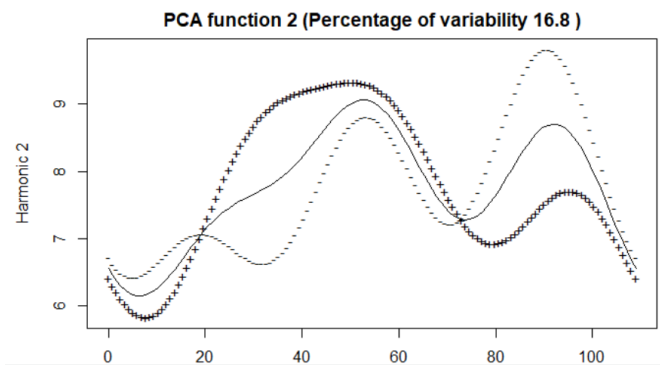

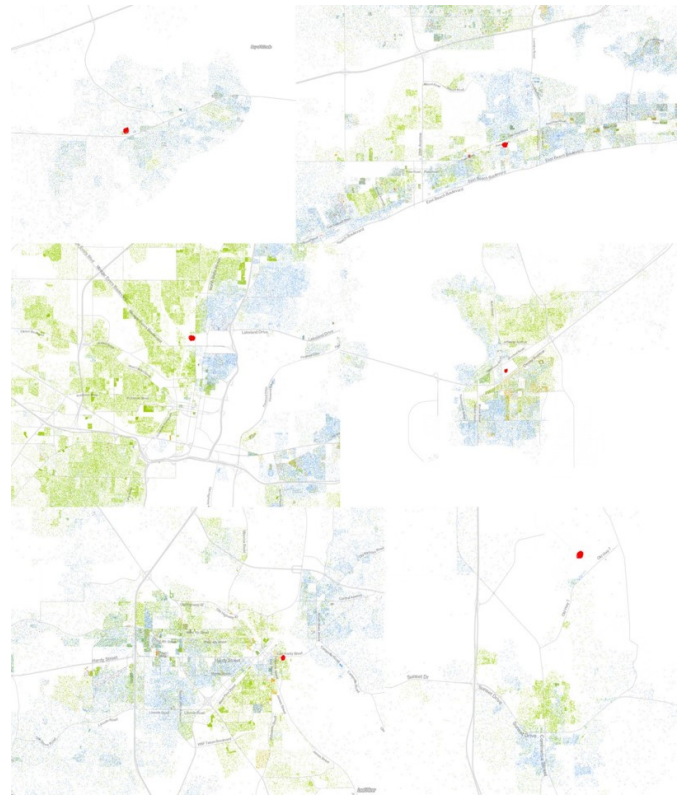**Figure 6.** Second Principal Component

Figure 8. Neighborhood by race
Note. Adapted from [15]

Everything can be generalized from *Figure 7* and *Map 1*, Culberson and Brewster are responsible for such high first PC values in the first half of the year.Cameron and Nueces are again opposite of the former. The cluster cannot be separated uniquely, mostly it will depend on the neighborhood of a monitoring station, county place or some regulatory things. To conclude, we can not cluster neat groups together, more data is needed to confirm the hypothesis of pollution difference if it is measured in black/white neighborhood.
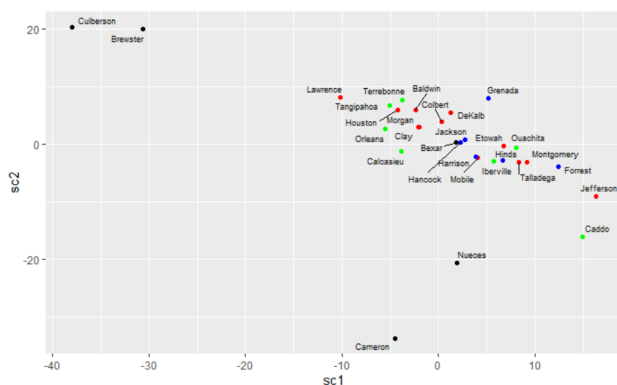
2.4 Functional linear scalar response regression

Figure 7. First PC versus second PC scores

The main problem of this paper is to confirm if it is plausible to predict counties black population ratio from PM2.5 pollutant concentration though-out a year period.*Figure 8* describes pollutant beta coefficient significance in year perspective, hence it is more likely county has bigger black community if pollution peaks in any of those three spikes in a year: around February, mid summer and November. To add up, beta coefficient varies around zero in the most of the time, consequently it can be considered insignificant except mentioned periods.
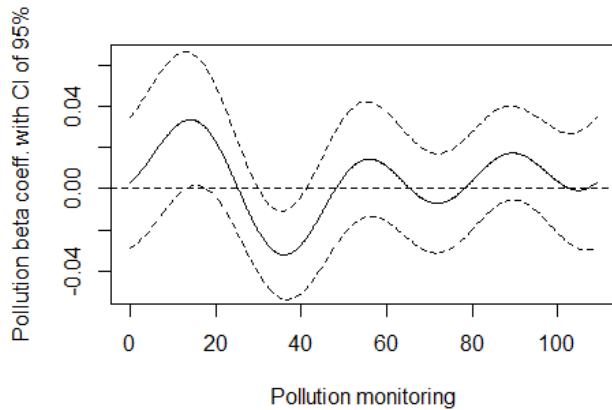
Figure 9. Beta coefficient for pollution function with CI of 95 %

In the first steps of modelling it was noticed that we have pseudo-log relation between pollution and racial distribution, hence percentage of black population values were transformed by log function. Next, functional scalar response regression R^2 estimate has value of 65% and $F - statistics = 4.8$ which is higher that critical value and confirms of model goodness. From the *Figure 10* we can observe one leverage point at value $(3.1, 0.5)$ it might indicate model is fit only if we consider counties that are in range of plants, heavy transportation networks.
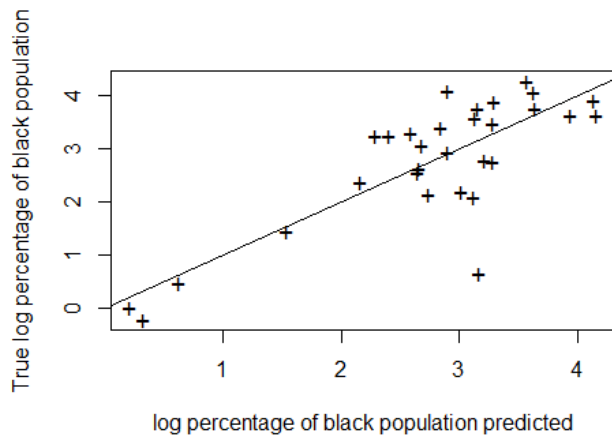

Figure 10. True versus predicted values

2.5 Trump administration's environmental rollbacks
Trump administration rollback of over 100 Environmental rules might have crucial impact for black community especially in the South where pollution is already close to the limit of 10 PM2.5 per observation, from [17] estimates every year at least additional 1000 people will die because of air pollution.

ANOVA test confirms pollutant PM2.5 mean change, however we can not statistically prove that 2020 data from April to December has significant higher mean that 2016, 2019 year cases, refer *Figure 11*.
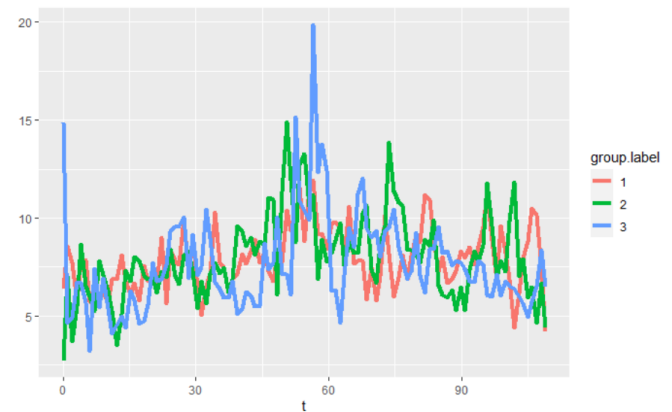

Figure 11. ANOVA test results to compare means between 2016, 2019, 2020

3. Conclusion

The main object of this study to predict counties black community proportion related to monitored pollutant PM2.5 numbers was successful, model is fit and validates 65% of variability, however to create a more robust model we need more data, hourly data, more stations in counties or combine more pollutants in the equation.

The last point, it would be interesting to investigate Trumps administrations rollback rules and how it amended existing pollution concentrations in near future 2021 and on.

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Appendix
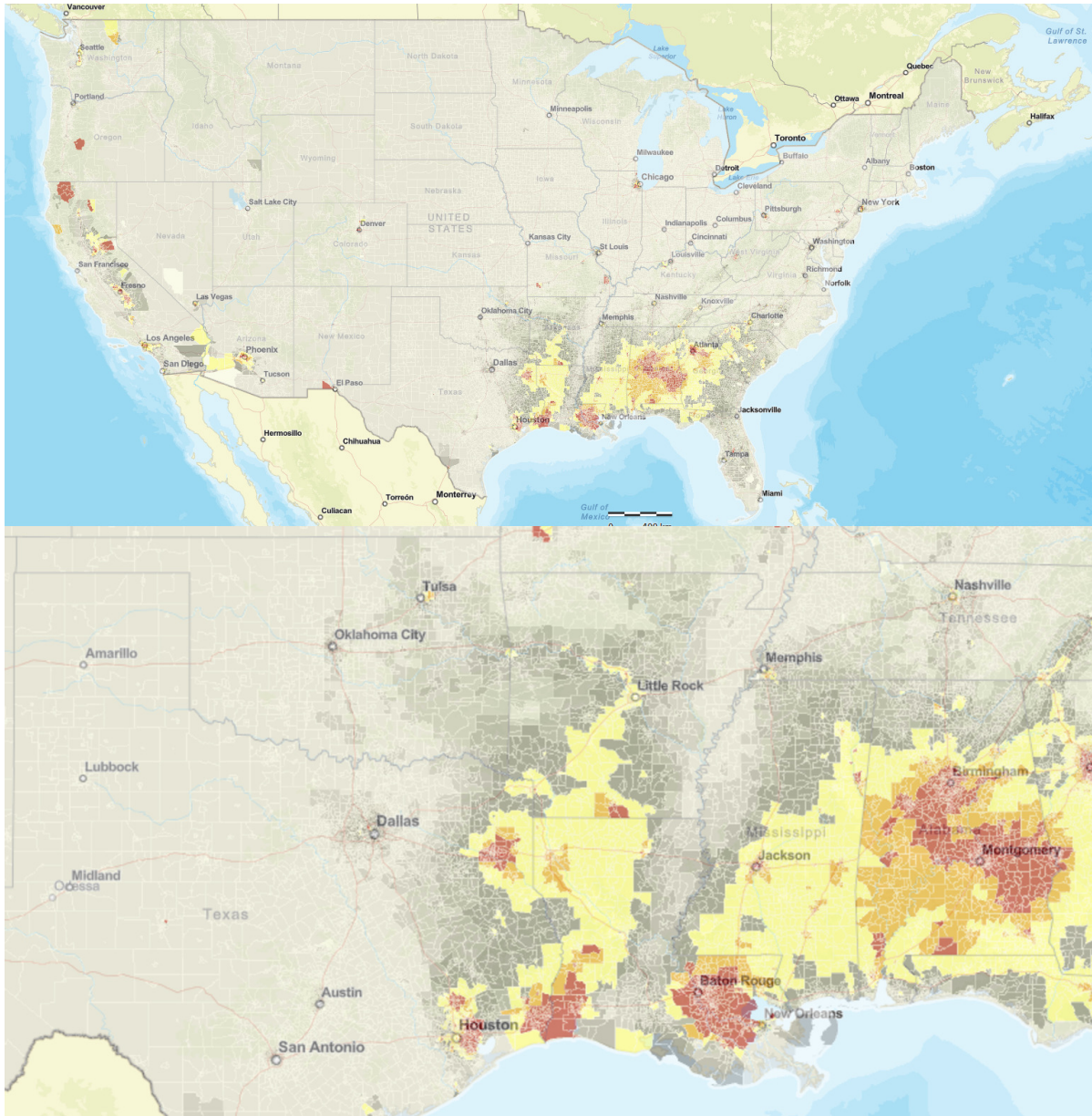
Note. Adapted from [12]

Map 1. Cancer risk in USA
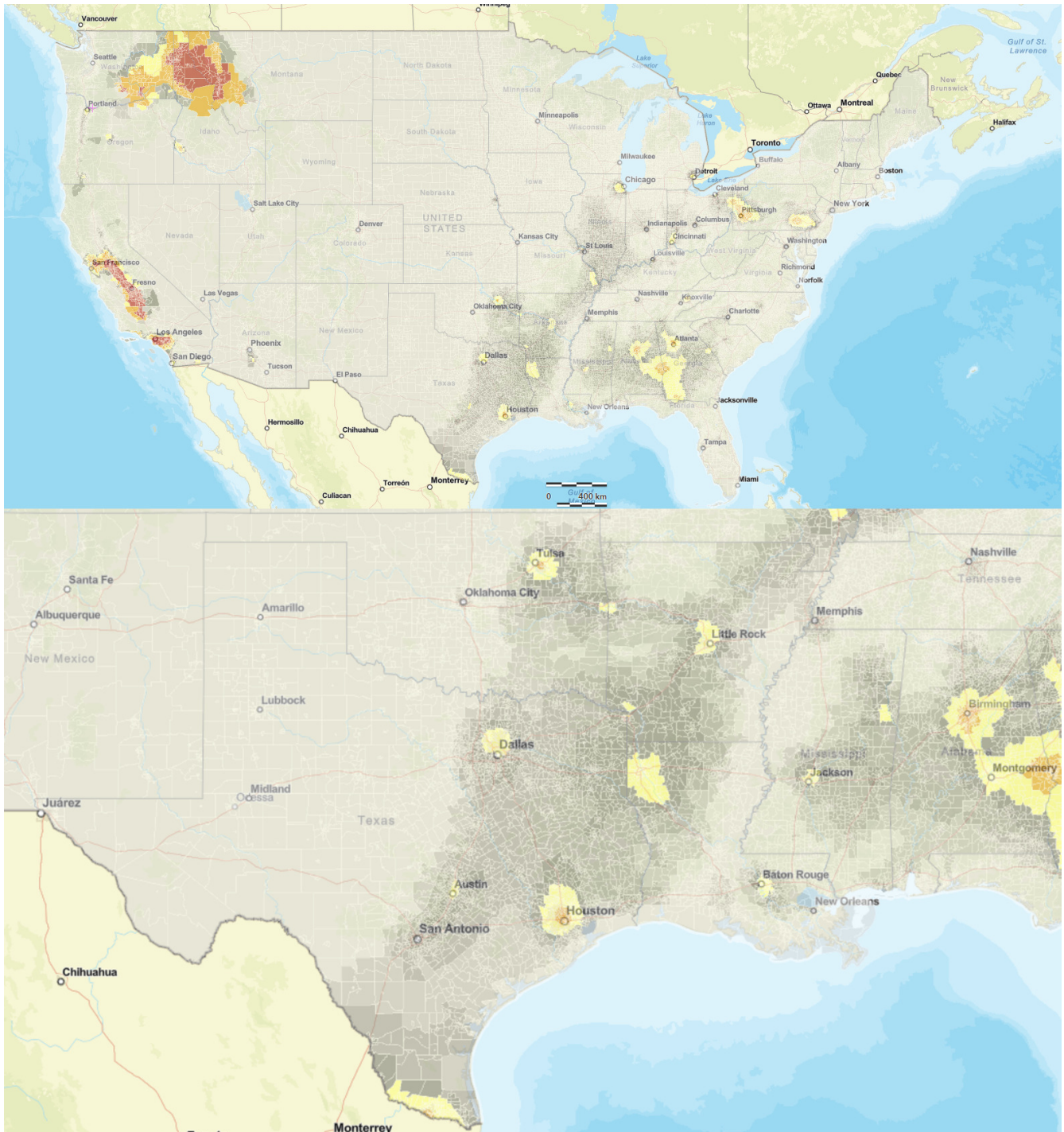
Note. Adapted from [12]

Map 2. PM2.5 pollution map in USA