The Environmental Impacts of COVID-19 in Texas: an Integrative, Multivariate Geospatial Analysis and Mapping Software

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Introduction - COVID19, Air Quality and Greenhouse Gases

At present, there are no comprehensive efforts to monitor and synthesize the environmental impacts of the abrupt, COVID19 lockdown-induced reductions in transportation and industry in Texas (Brookings). Incremental closures facilitate partitioning individual contributions of various societal and economic functions to environmental pollution; such attribution is normally impossible. Understanding how air quality and greenhouse gas emissions are affected by these changes in behavior provides a direct analog for characterizing the effectiveness of extreme, short-term environmental mitigation. Recent studies looking at these impacts across the United States have found reductions of up to 25.5% in NO_2 concentrations and 4.5% in PM2.5 concentrations during the federal lockdown period in comparison to previous years (Berman, Jesse D., and Keita Ebisu), as well as an estimated 25% drop in GHG emissions in China (Wang and Su 2020) and a 7.8% (Liu et al. 2020) to 17% (Le Quéré et al. 2020) reduction in global CO2 levels compared to the same months in previous years.

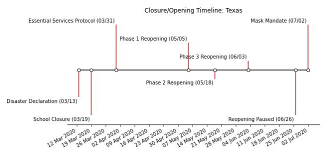


Figure 1. Texas State-wide Key Closure and Reopening Timeline.
(National Association of Governors - Coronavirus State Actions)

Results 1: Greenhouse Gases and Air Quality

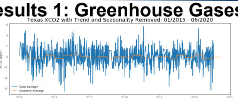


Figure 2.1: Quarterly 2015- 2020 Texas CO2 Levels, Tre[nd and Seasonality] Removed (NA[SA OCO, GOSAT])

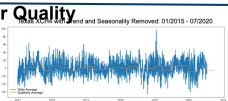


Figure 2.2: Quarterly 2015- 2020 [Tex]as CH4 Levels, Trend and [Seaso]nality Removed (NASA GES)

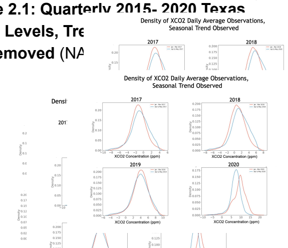
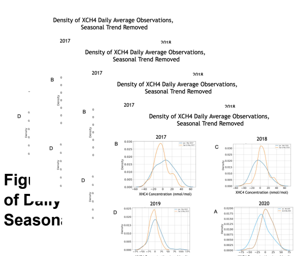


Figure 3.1: Gaussian Kernel Density of Daily Texas CO2 Levels, Seasonality Removed (NASA OCO, GOSAT)



Fig[ure 3.2 ...] of Daily [...] Season[ality Removed]

Greenhouse Gas Results:

Overall, neither CO2 nor CH4 emissions significantly changed during the months of the lockdown.

- Both exhibit significant differences between Jan - Mar 2020 and April - May 2020
- However, analysis of 2015-2019 data unveil similar monthly changes within previous years.
- Comparisons of April - May 2020 to April - May for 2015-2019 demonstrate no significant change.

Texas Weekly Averages 2020 vs. 2015-2019

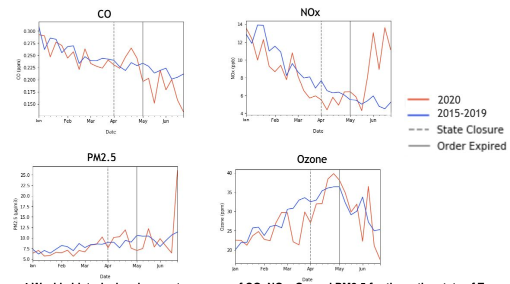


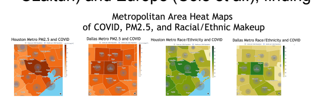
Figure 4 Weekly historical and current averages of CO, NOx, O_3, and PM2.5 for the entire state of Texas. The grey lines represent the state-wide stay-at-home order enforcement and relaxation. (TCEQ TAMIS)

Air Quality Results:

- Each line graph shows some variation between 2020 and historical pollutant values
- Statistical analyses comparing average values April - May 2020 to values April - May 2015-2019 suggest:
    - NOx concentrations dropped roughly 17% in 2020
    - No other pollutants demonstrated significant changes
- Spikes in PM2.5 during June - July may be explained by the June 2020 Saharan dust storm

Ties between CV19, Socioeconomic Impacts, and Air Quality

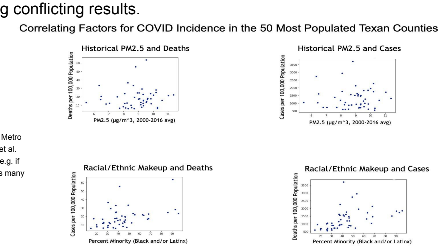
Low-income and people of color are experiencing a disproportionate burden from COVID-19 (APM Research Lab, McLaren, Price-Haywood et al.). Several papers have investigated correlations between PM2.5 and COVID incidence rates across the US (Wu et al., Liang et al., Knittel and Ozaltun) and Europe (Cole et al.), finding conflicting results.



Figures 5.1-5.4 Race and COVID-19 deaths and cases by County. Houston and Dallas Metro Areas (US Census Bureau ACS 2019, TXDSHS COVID-19 Dashboard, Van Donkelaar et al. 2019). Note:: the scale of the deaths to cases circles is 1:10 for the sake of readability,, e.g. if a death marker and case marker had the same radius, they would represent 10 times as many cases as deaths.

Table 4. Harris County Economic Cost COVID Deaths (in $ millions)	**Up to date to July 28, 2020 Note: Acutal Percentage assumes uniform distribution within each age group. Expected Percentage assumes uniform deaths across races and age groups.		
Race; Age	Actual Percentage of Total Cost	Expected Percentage Total Cost	Percent of Expected Percentage
American Indian/Alaska Native	0.21%	0.34%	63.04%
Asian American/Pacific Islander	5.59%	5.54%	100.84%
Black	24.58%	14.43%	170.37%
Hispanic/Latinx	45.34%	32.79%	138.27%
White	24.05%	45.21%	53.20%
Multi-racial	0.22%	1.69%	13.23%
Total	100.00%	100.00%	100.00%

Figure 7. Harris County race/ethnicity-based estimates of cost of COVID-19 death. (Harris County/Houston COVID-19 Dashboard, Aldy and Viscusi 2007)



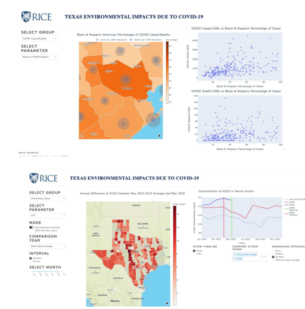
Figures 6.1-6.4 Scatterplots of COVID cases and deaths against county demographics and historical county PM2.5 levels. (US Census Bureau ACS 2019, TXDSHS COVID-19 Dashboard, Van Donkelaar et al. 2019)

Results 2: Socioeconomic Indicators and CV19

- Race/Ethnicity:
    - Scatterplots suggest a positive correlation between percent minority and COVID cases and deaths per 100,000 population.
    - Multivariate linear regressions corroborate scatterplot results, displaying a 0.28 incident increase in deaths per 100,000 population and 16 incident increase in cases for 100,00 population for every 1% increase in minority representation.
    - In Harris County, the estimated costs of COVID death fall disproportionately on Black and Latinx communities
- PM2.5:
    - Scatterplots suggest little correlation between historical PM2.5 levels and COVID cases and deaths.
    - Multivariate regressions corroborate, with a statistically insignificant correlation

Mapping Dashboard

Our new mapping software updates environmental changes based on the real-time evolution of human behavior in response to COVID19 policies. Users are able to click on a county and interactively plot trends in environmental indicators for the region of interest, and to view state-level trends in COVID and socioeconomics.

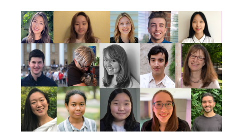


Conclusion

Satellite and ground-level real-time data suggest that of major air pollutants and greenhouse gases, only NOx concentrations changed over the course of Texas's March-April 2020 COVID-19 lockdown. Historical PM2.5 data does not correlate with COVID19 incidence at the county-level, but racial composition does, with an additional higher level of cost from COVID for minorities in Harris County

Team

This project was completed by a team of students and faculty from Rice and Princeton during summer 2020, funded by a generous grant from Rice U.



Data
National Governors Association - https://www.nga.org/coronavirus-state-actions-all/
TCEQ TAMIS - https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome
NASA OCO, GOSAT, and GES - https://earthdata.nasa.gov/
US Census Bureau ACS 2019 - https://data.census.gov/cedsci/
TXDSHS COVID-19 Dashboard - https://dshs.texas.gov/coronavirus/AdditionalData.aspx
Harris County/Houston COVID-19 Dashboard - https://harriscounty.maps.arcgis.com/apps/opsdashboard/index.html#/9280d2e195b440d5ac29dfc819048550
Van Donkelaar et al. 2019 / Harvard -
Aldy and Viscusi 2007 -
MORE PAPERS
Wang and Su

Works Cited
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APM Research Lab -
McLaren, John. “Racial Disparity in COVID-19-19 Deaths: Seeking Economic Roots with Census Data.” *National Bureau of Economic Research Working Paper Series*, 2020, doi:10.3386/w27407.
Price-Haywood, Eboni G., Jeffrey Burton, Daniel Fort, and Leonardo Seoane. 2020. “Hospitalization and Mortality among Black Patients and White Patients with Covid-19.” *The New England Journal of Medicine* 382 (26): 2534–43.
Wu, X., Braun, D., Schwartz, J., Kioumourtzoglou, M.A. and Dominici, F., 2020. Air pollution and COVID-19 mortality in the United States: Strengths and limitations of an ecological regression analysis. *Science advances*, *6*, p.eabd4049.
Liang, Donghai et al. “Urban Air Pollution May Enhance COVID-19 Case-Fatality and Mortality Rates in the United.” *medRxiv : the preprint server for health sciences* 2020.05.04.20090746. 7 May. 2020, doi:10.1101/2020.05.04.20090746. Preprint.
Knittel, C.R., and B. Ozaltun (2020): “What Does and Does Not Correlate with COVID-19-19 Death Rates,” NBER Working Paper No. 27391, DOI: 10.3386/w27391.
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World Population Review - https://worldpopulationreview.com/us-cities
McKinsey -