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Exploring the potential impacts of VMT induced $PM_{2.5}$ on the rate of COVID-19 infection

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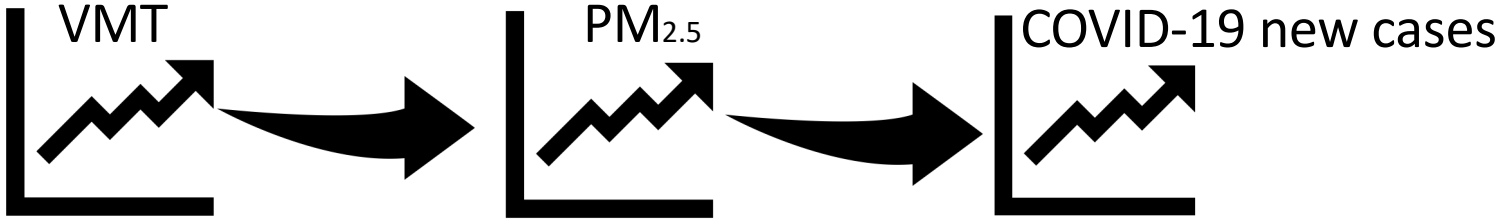
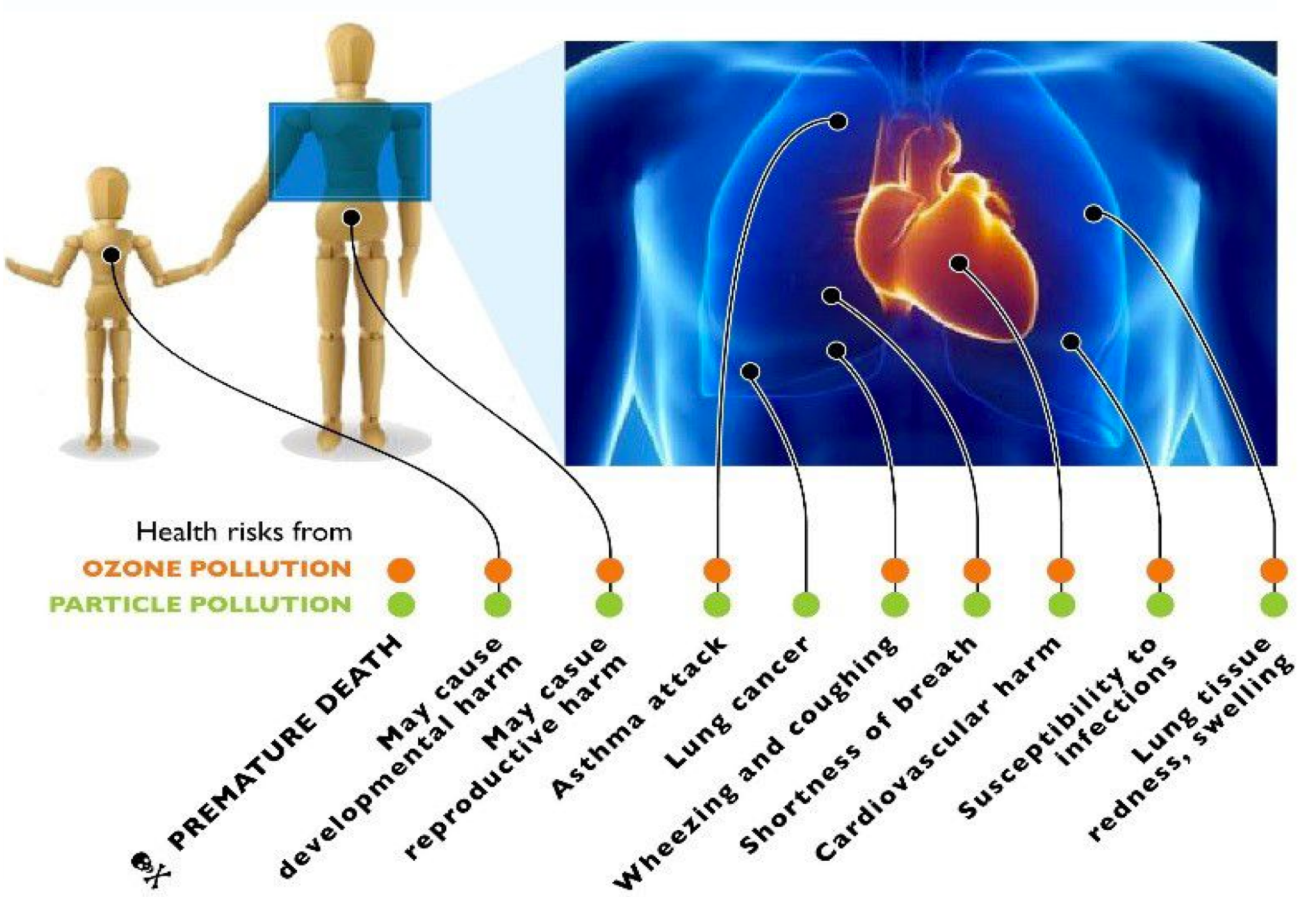
Motivation

Annually there are 4.2 million deaths around the globe due to air pollution emissions (World Health Organization)

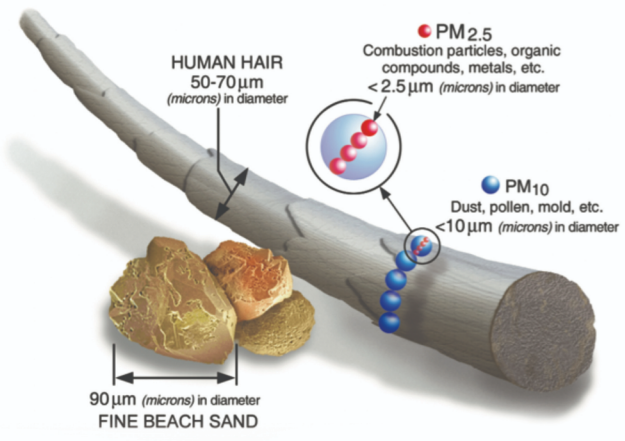


Not all pollutants are equally harmful



Emissions of fine particulate matter, ammonia, sulfur dioxide and VOC make up only half of all emissions by weights, but cause almost 80 percent of total damages.

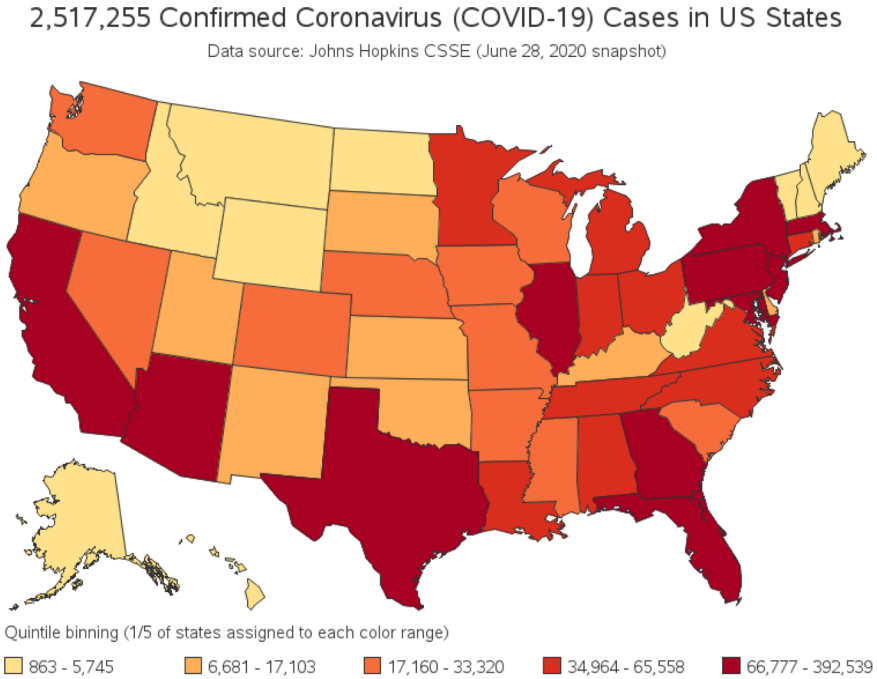
$PM_{2.5}$ account for only 6 percent of total emissions by weight but cause **<u>23 percent of total damages</u>**.

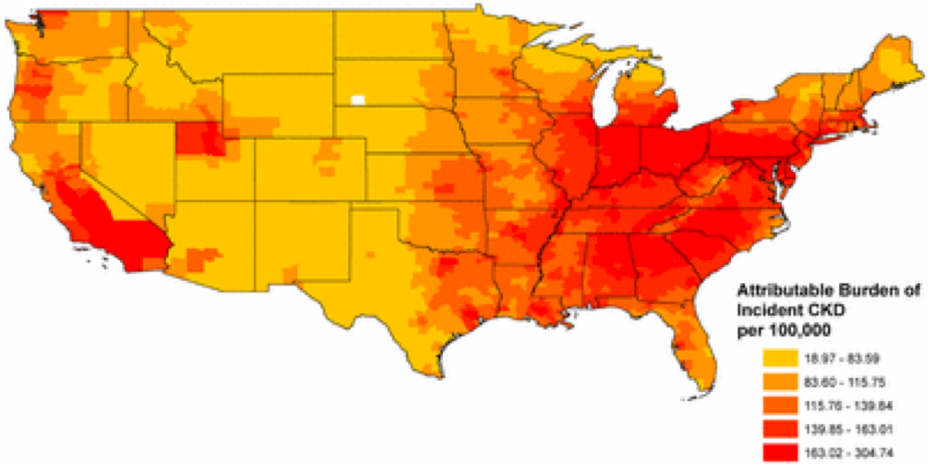


Source: "Particulate Matter (PM) Basics," U.S. Environmental Protection Agency, available at https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

Source: Mikael Häggström, "Medical gallery of Mikael Häggström 2014". WikiJournal of Medicine 1 (2). Public Domain. Available at https://en.wikipedia.org/wiki/Pollution#/media/File:Health_effects_of_pollution.png

$PM_{2.5}$ – COVID-19 – Risks





Source: John Hopkins – Github

Source: Particulate Matter Air Pollution and the Risk of Incident CKD and Progression to ESRD
Benjamin Bowe, Yan Xie, Tingting Li, Yan Yan, Hong Xian and Ziyad Al-Aly
JASN January 2018, 29 (1) 218-230; DOI: https://doi.org/10.1681/ASN.2017030253

What the scientific world tells us …

Viruses & $PM_{2.5}$

- $PM_{2.5}$ boosts respiratory virus infection.
- Particles inhalation increases virus penetration into the deepest parts of the respiratory system.
- A virus is a respiratory influential disease factor that has a synergistic effect together with $PM_{2.5}$.

$PM_{2.5}$ & VMT

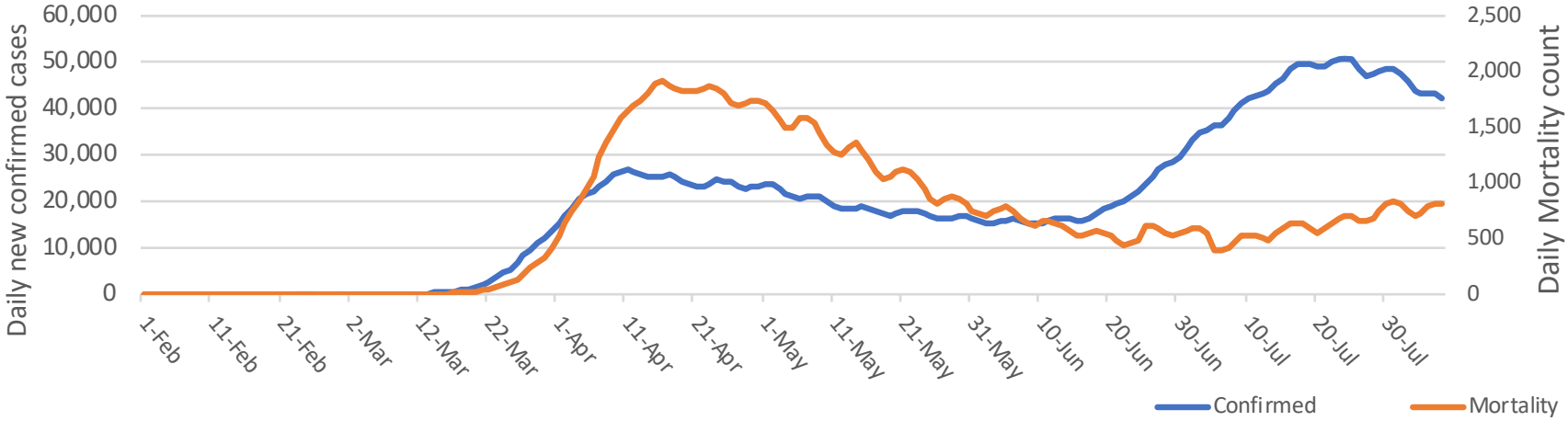
- VMT is responsible for 10% of the total $PM_{2.5}$ in the US.
- Incremental $PM_{2.5}$ decreases by 75% from 5 m to 30 m of a given roadway.
- Average transportation air pollution cost across the US is 1.3 cents/VMT.

COVID-19

- Research shows that COVID-19 could be airborne.
- $PM_{2.5}$ can act as a transmitter agent for many viruses.

DATA sources

1. Covid-19 USA Daily new cases (10 days Moving Average)



2. $PM_{2.5}$ concentration level from EPA
3. 2017 average annual VMT
4. Combined statistical area (CSA) as a geographical base

Duration of study (days)	**Number of CSAs**	**Population**		**Land Area**		**VMT**	
		Avg. CSAs	% of the US	Avg. of CSAs (mi^2)	% of the US	Avg. of CSAs	% of the US
145	149	1,842,957	78%	6,414	24%	1.47E+10	73%

Methods

Correlation Analysis:

10-day moving average and sliding window techniques for

1. Entire period $PM_{2.5}$ and COVID-19
2. Short-term $PM_{2.5}$ and COVID-19
3. VMT and ($PM_{2.5}$* Land Area)

day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	[illegible]	137	138	139	140	141	142	143	144	145
COVID19	103	164	312	589	818	1196	1616	2150	2646	3189	3950	4674	5378	5926	6548	7255	7786	8271	9108	9928	10236	10612	10892	11364	11908	12124	12265	12240	11795	11368	11576	11648	[illegible]	11050	762	736	712	675	676	687	682	689
$PM_{2.5}$	5.9	6.0	6.1	5.7	5.7	5.6	5.5	5.3	5.3	5.5	5.7	5.8	5.7	5.4	5.1	4.9	4.6	4.5	4.3	4.0	4.3	4.1	4.1	4.7	4.6	4.6	4.6	5.2	5.6	5.7	5.3	5.3	[illegible]	5.2	5.6	5.5	5.7	5.7	5.7	5.6	5.4	5.4

Results

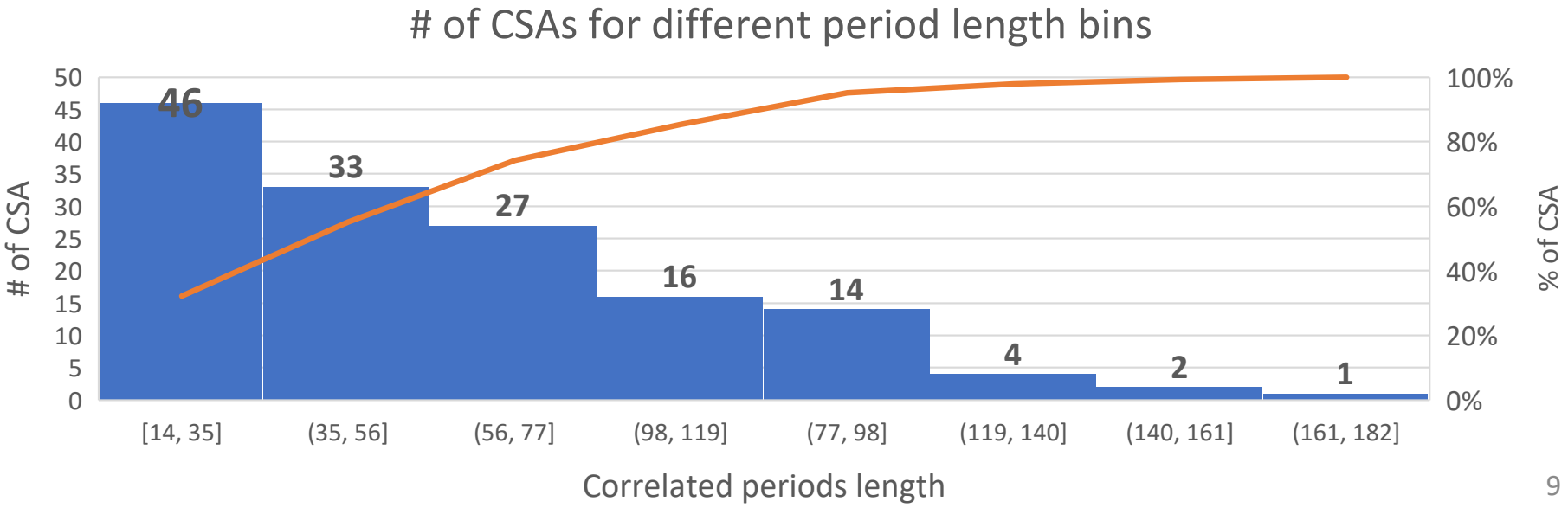
- Correlation in entire 145 days of study – no significant pattern.
- Significant correlated periods:
  - r > 0.8 and P_value < 0.05 and period length > 14 days

Total # of CSA	149
# of CSA with at least one significant correlated period	143
Average period length	44 days
Maximum P_Value	5.0E-4
Maximum total length of correlation period for one CSA	169

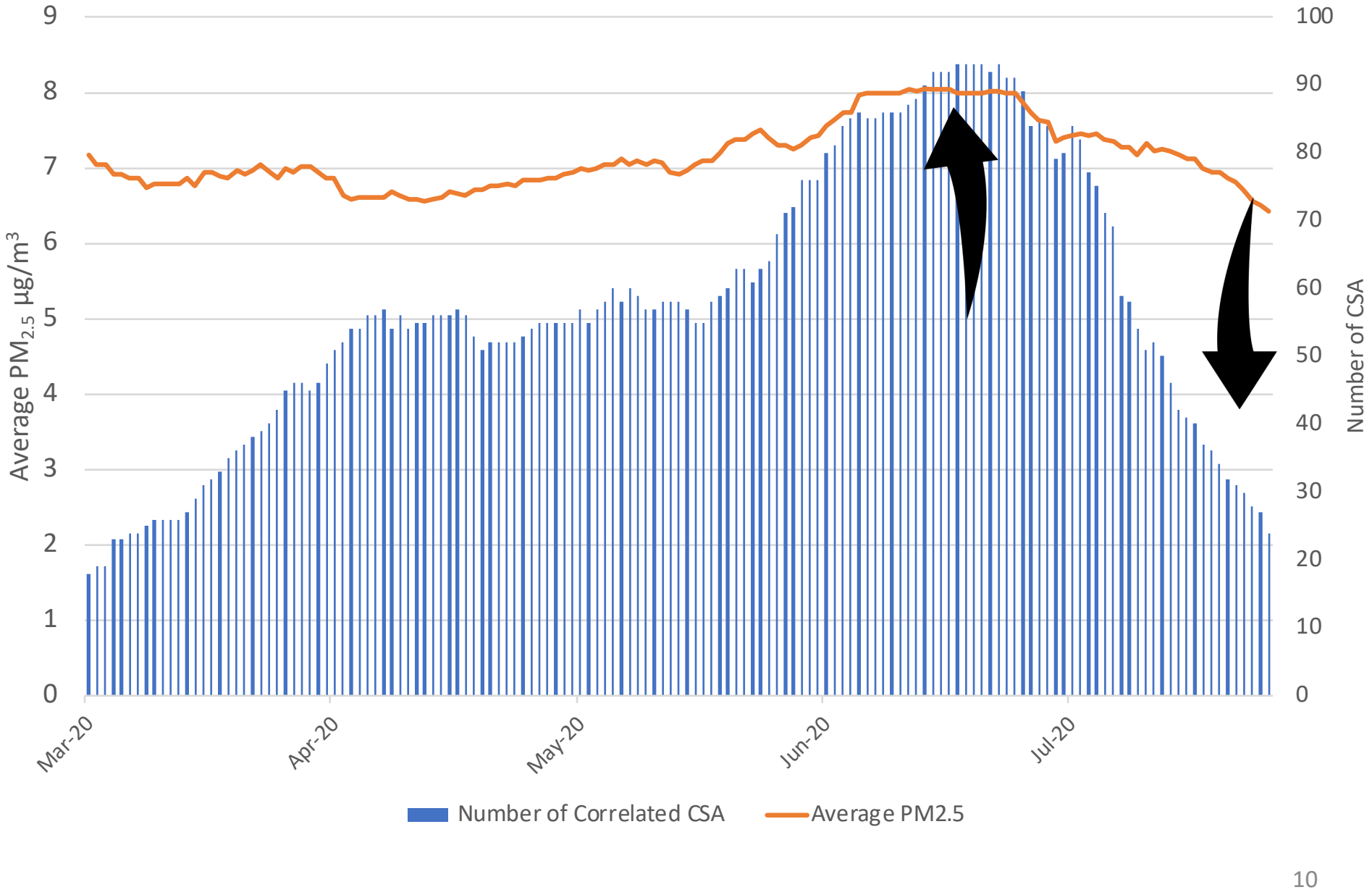
%96

Short-term correlation results

Start date	End date	CSA name	# of correlated days
3/16/2020	8/7/2020	Salt Lake City-Provo-Orem, UT	145
3/16/2020	8/7/2020	Phoenix-Mesa, AZ	145
3/16/2020	7/31/2020	Lubbock-Plainview-Levelland, TX	138
3/16/2020	7/29/2020	Oklahoma City-Shawnee, OK	136
3/16/2020	7/26/2020	Knoxville-Morristown-Sevierville, TN	133
4/13/2020	8/6/2020	Wichita-Winfield, KS	116
4/15/2020	8/7/2020	Greenville-Spartanburg-Anderson, SC	115
3/30/2020	7/21/2020	Lake Charles-Jennings, LA	114
4/17/2020	8/7/2020	Virginia Beach-Norfolk, VA-NC	113
4/17/2020	8/7/2020	Charlotte-Concord, NC-SC	113



Number of CSAs with correlated periods per day



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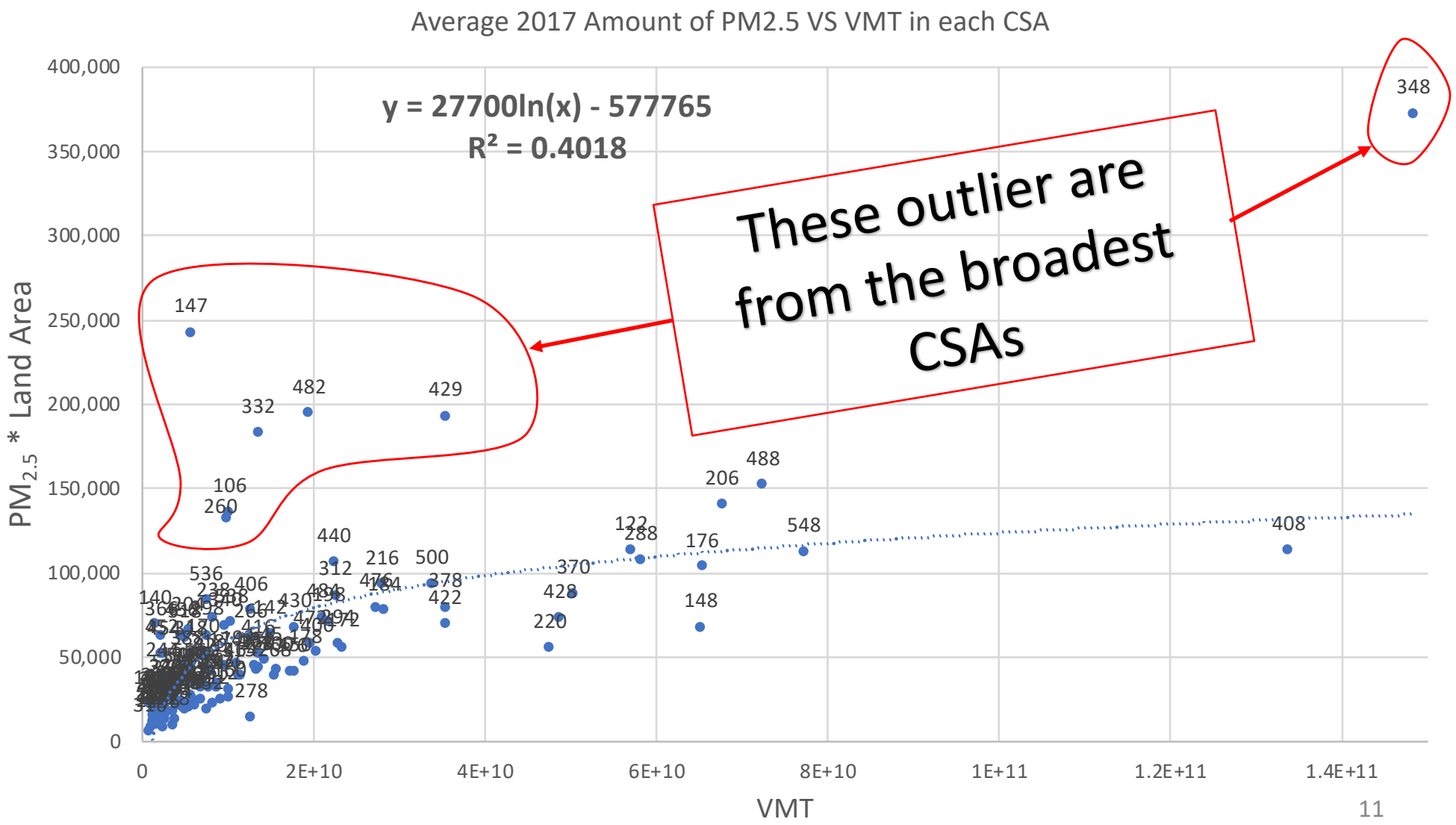
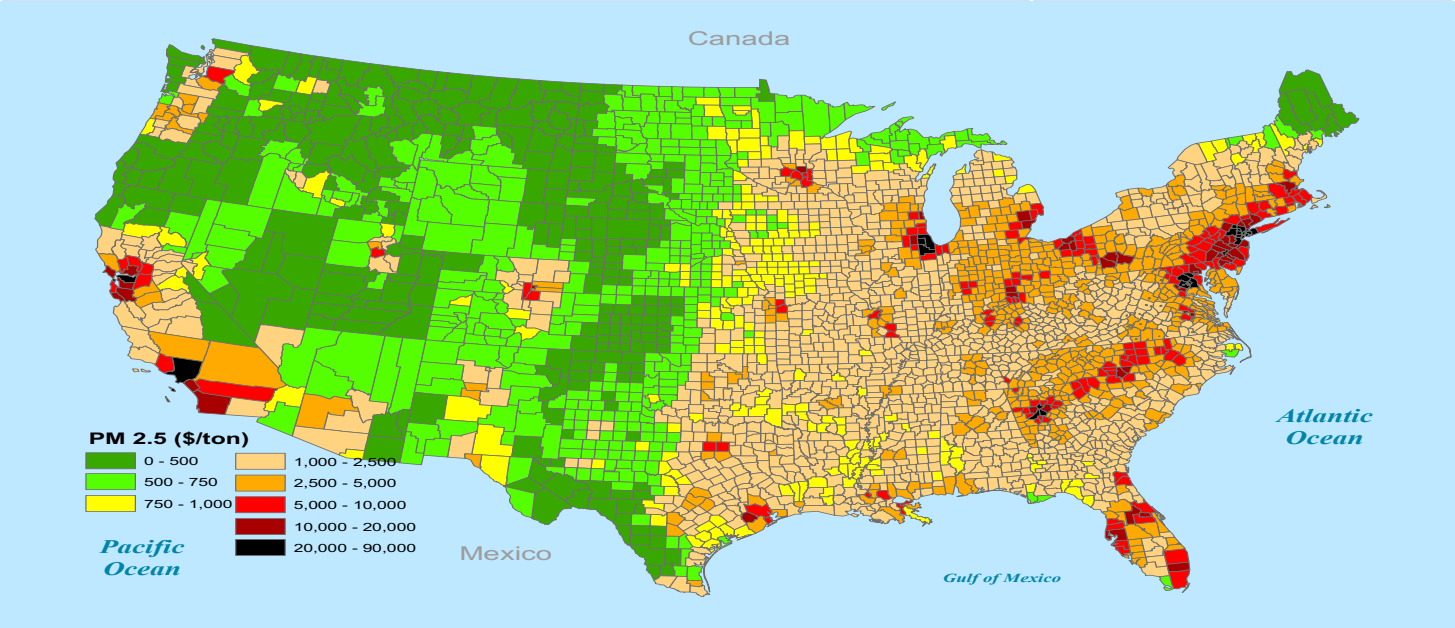
VMT vs. ($PM_{2.5}$ x Land Area)

Result: for 149 CSAs, $\boldsymbol{r = 0.78}$ and $\boldsymbol{P\_Value = 4.2E-20}$



Top 10:
highest Pollution ~ highest COVID-19 rates ~ highest VMT



Area name	Confirmed Cases per 1,000,000 Pop.
New York-Newark, NY-NJ-CT-PA	691,123
Los Angeles-Long Beach, CA	502,952
Chicago-Naperville, IL-IN-WI	299,542
Houston-The Woodlands, TX	227,030
Dallas-Fort Worth, TX-OK	225,986
Washington-Baltimore-Arlington, DC-MD-VA-WV-PA	221,602
Atlanta--Athens-Clarke County--Sandy Springs, GA-AL	209,069
Boston-Worcester-Providence, MA-RI-NH-CT	171,575
Philadelphia-Reading-Camden, PA-NJ-DE-MD	149,144
San Jose-San Francisco-Oakland, CA	140,745

Correlation does not imply causation

- COVID-19 potential risk factors: age, race/ethnicity, gender, medical conditions, poverty, and maybe $PM_{2.5}$ exposure
- $PM_{2.5}$ can act as a facilitator for viral transmissions including SAR-Cov-2.
- People living in areas with high concentration of $PM_{2.5}$ may already be at higher risks due to long-term exposures.

Significant positive relationship between $PM_{2.5}$ concentration and VMT, as well as COVID-19 daily new cases and the $PM_{2.5}$ concentration level

Policy implications

- Efforts to decrease urban driving will have important impacts on mortality and morbidity rates.
- The transportation sector can play a major role in lowering $PM_{2.5}$ concentration level and the consequential health impacts.
- Mobility, safety and accessibility performance measures must include air pollution safety criteria.
- Air pollution safety criteria guidelines must be provided to local transportation authorities, especially those with higher air pollution.

Future research

- Exploring the impacts and interactions of other factors (e.g. epidemiology, climatology) .
- Exploring real-time daily VMT and its effects on $PM_{2.5.}$
- Using AI techniques for predictive modeling of daily VMT, and COVID-19 cases.

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$PM_{2.5}$ concentration level is lower in colder season