



Leveraging a PurpleAir Sensor Network to Inform Air Quality Action in Phoenix, Arizona

Ian A. VonWald¹, Karoline K. (Johnson) Barkjohn¹, Samuel G. Frederick², Sue Kimbrough³, Ben Davis⁴, Nikki Peterson⁴, Ira Domskey⁴, Ron Pope⁴, and Andrea L. Clements³

¹Oak Ridge Institute for Science Education Postdoctoral Fellow at the U.S. EPA Office of Research and Development (ORD)

²Student Services Contractor at U.S. EPA ORD

³U.S. EPA ORD

⁴Maricopa County Air Quality Department

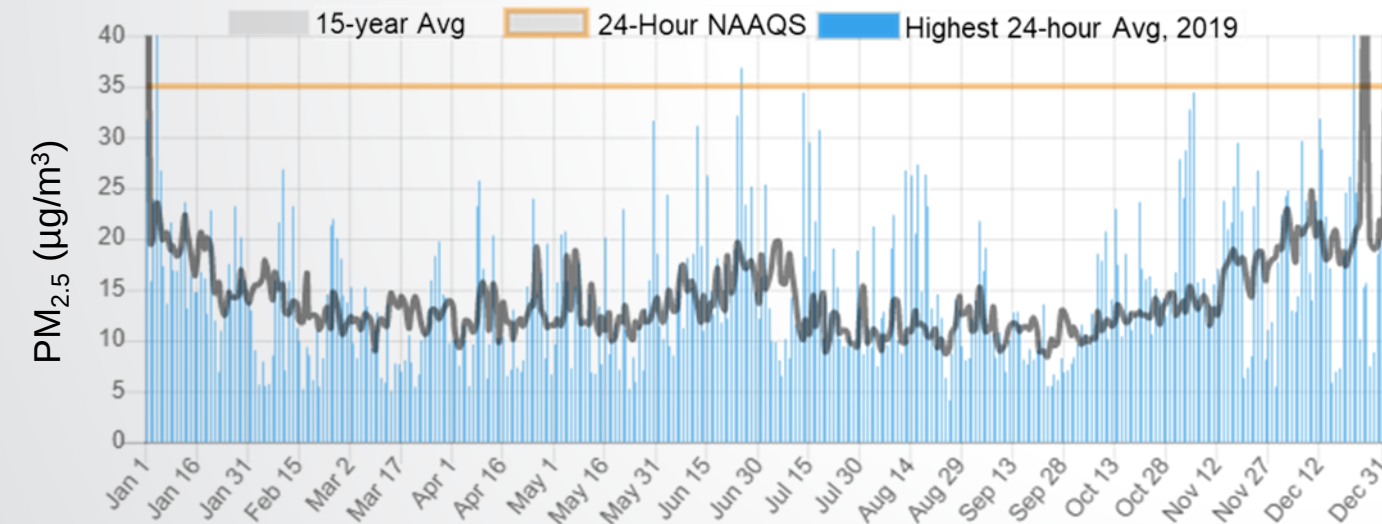
**AAAR Virtual Conference, 17.UA.3
Friday, October 9, 2020, 11:50 AM – 12:00 PM**



PM_{2.5} in Phoenix

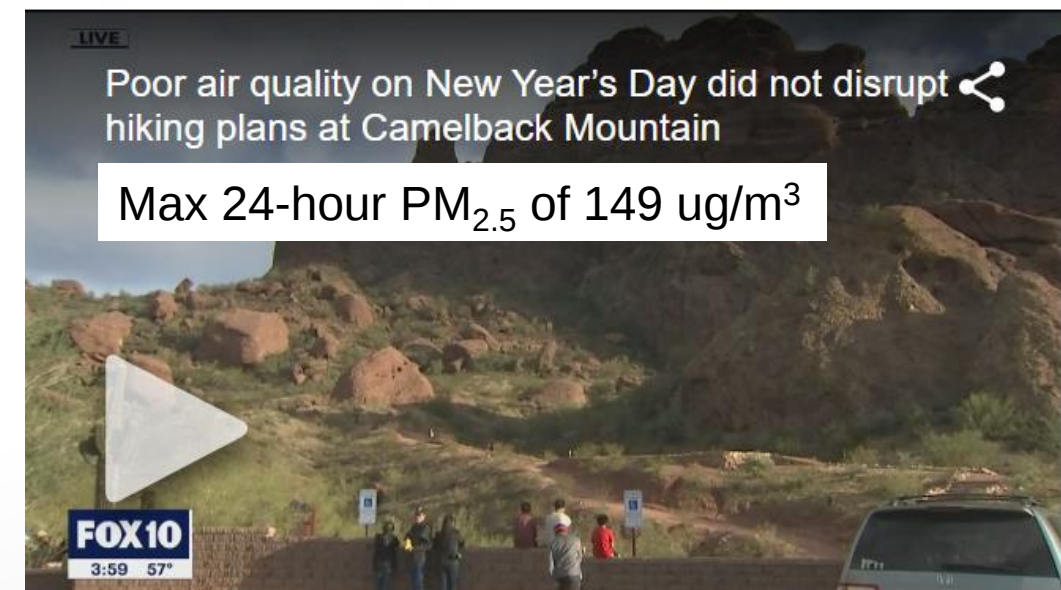
- Sources of elevated PM_{2.5} in Phoenix include traffic, woodsmoke, wildfires, industry, fireworks, and temperature inversions

Daily PM_{2.5} in Phoenix, 2019



Ramadan *et al.*, 2000

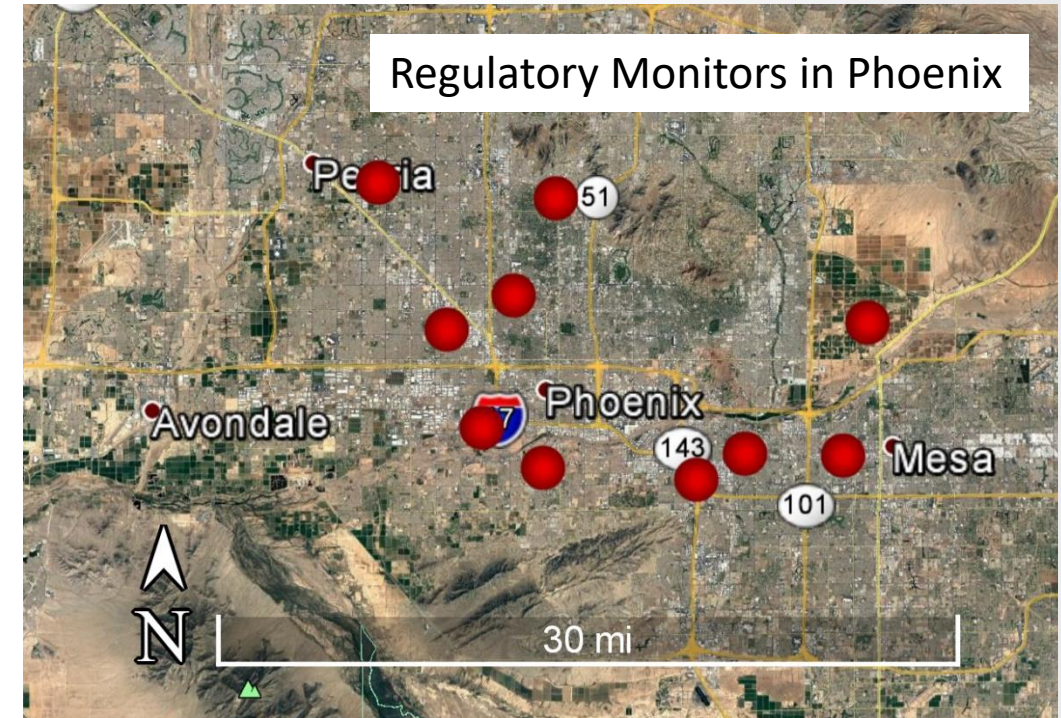
Lewis *et al.*, 2003.





PM_{2.5} in Phoenix

- Existing regulatory network does not capture fine spatiotemporal variation in PM_{2.5}
- The city's air quality actions may be informed by increased monitoring density

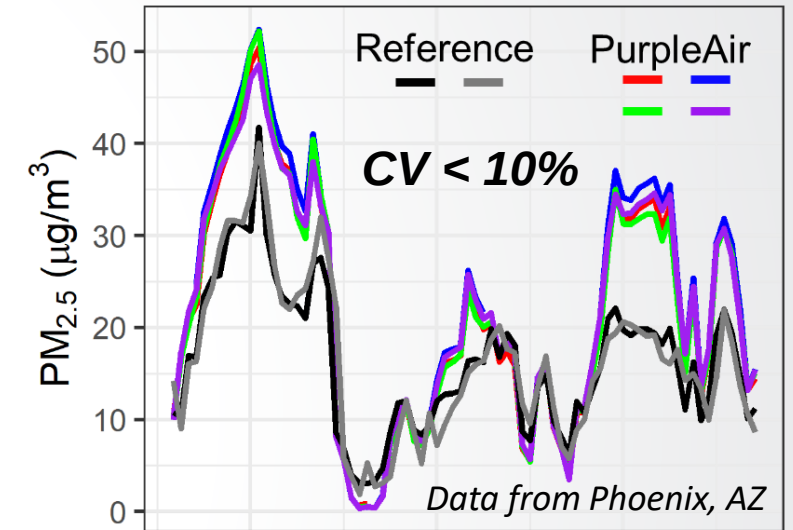


Today is a No Burn Day.
Please consider wood burning alternatives.

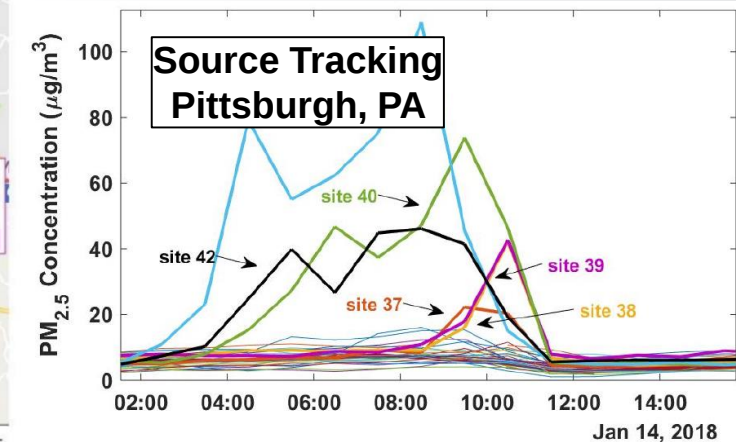
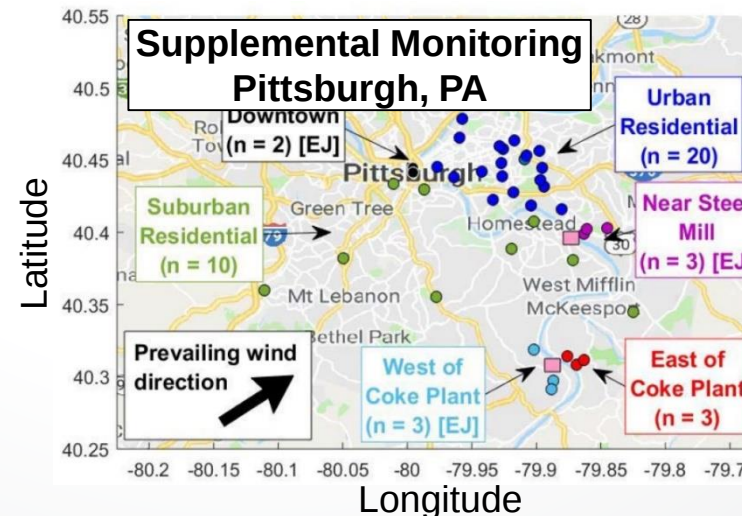


PurpleAir Particulate Matter Sensors

- Inexpensive PM sensor
 - 2 optical particle counter sensors
 - PM_{10} , $PM_{2.5}$, $PM_{1.0}$
 - T, RH
 - 2-minute resolution
 - ~\$250
- Easy to use
 - Plug-in power, SD card and WiFi data streaming to public network
- Overestimate $PM_{2.5}$, very precise
- Variety of applications

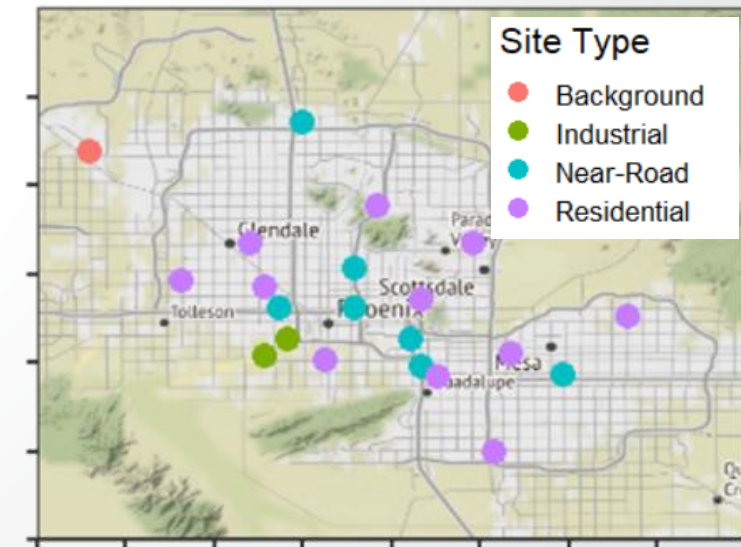
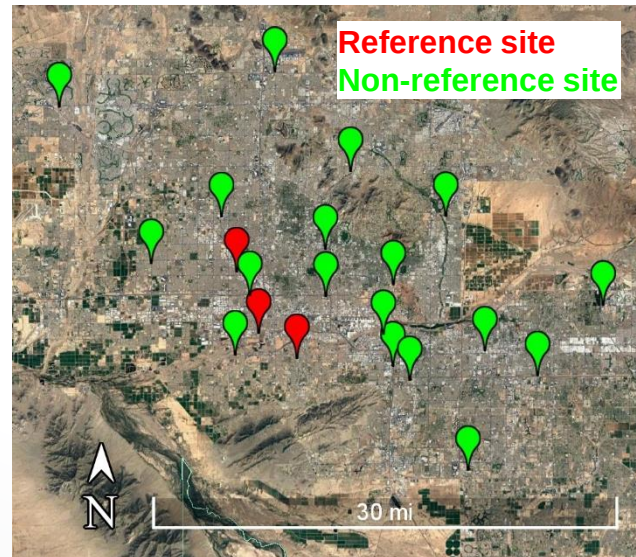
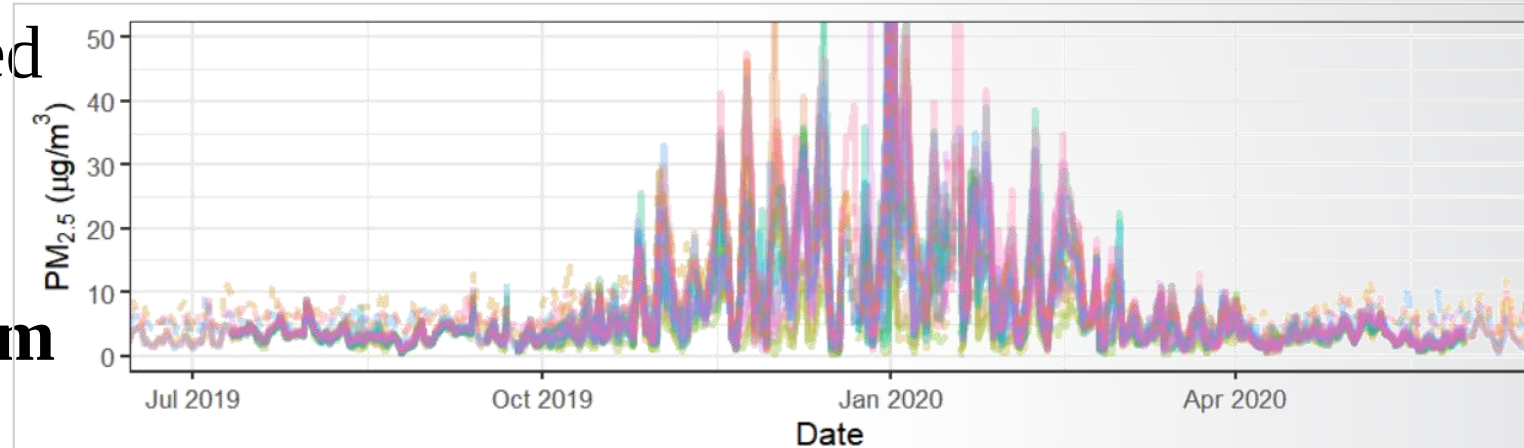


Jan. 8 – 11, 2019



Tanzer et al., 2019.

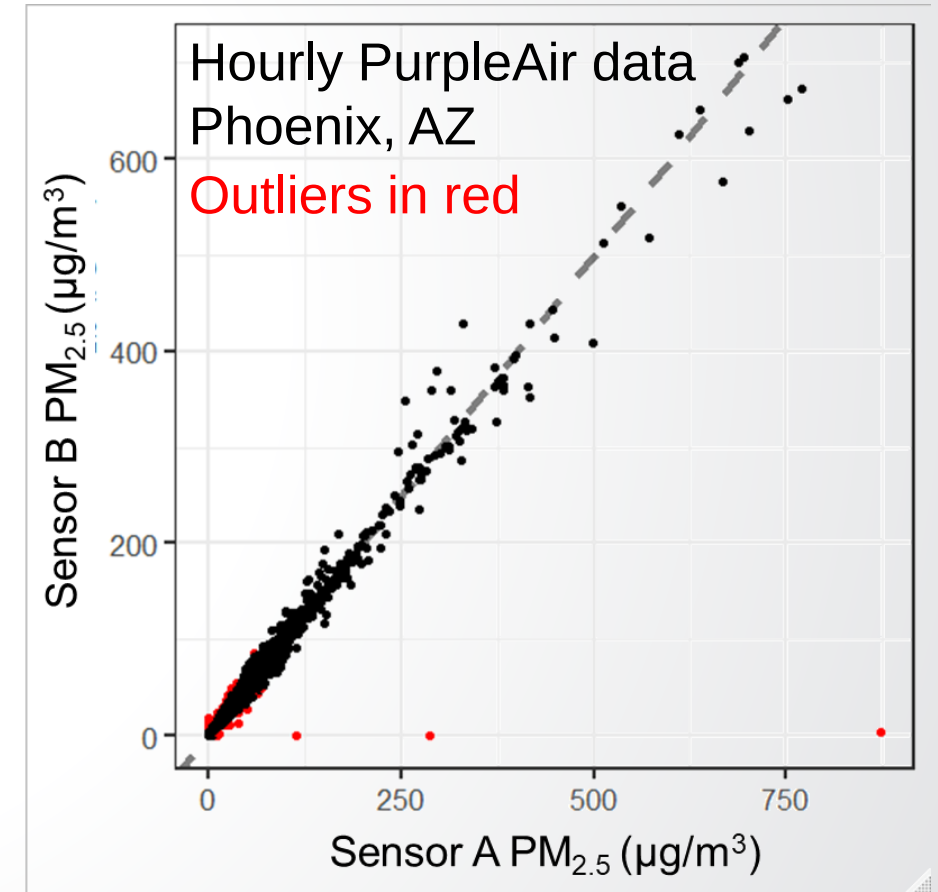
- **PTAQS = Phoenix as a Testbed for Air Quality Sensors**
- **Goal: Increase resolution of $PM_{2.5}$ measurements to inform air quality action**
- Timeline: July 2019 – June 2020
- PurpleAir sensors deployed at 3 reference sites & 20 non-reference sites
- Mix of site types





PurpleAir Data Cleaning

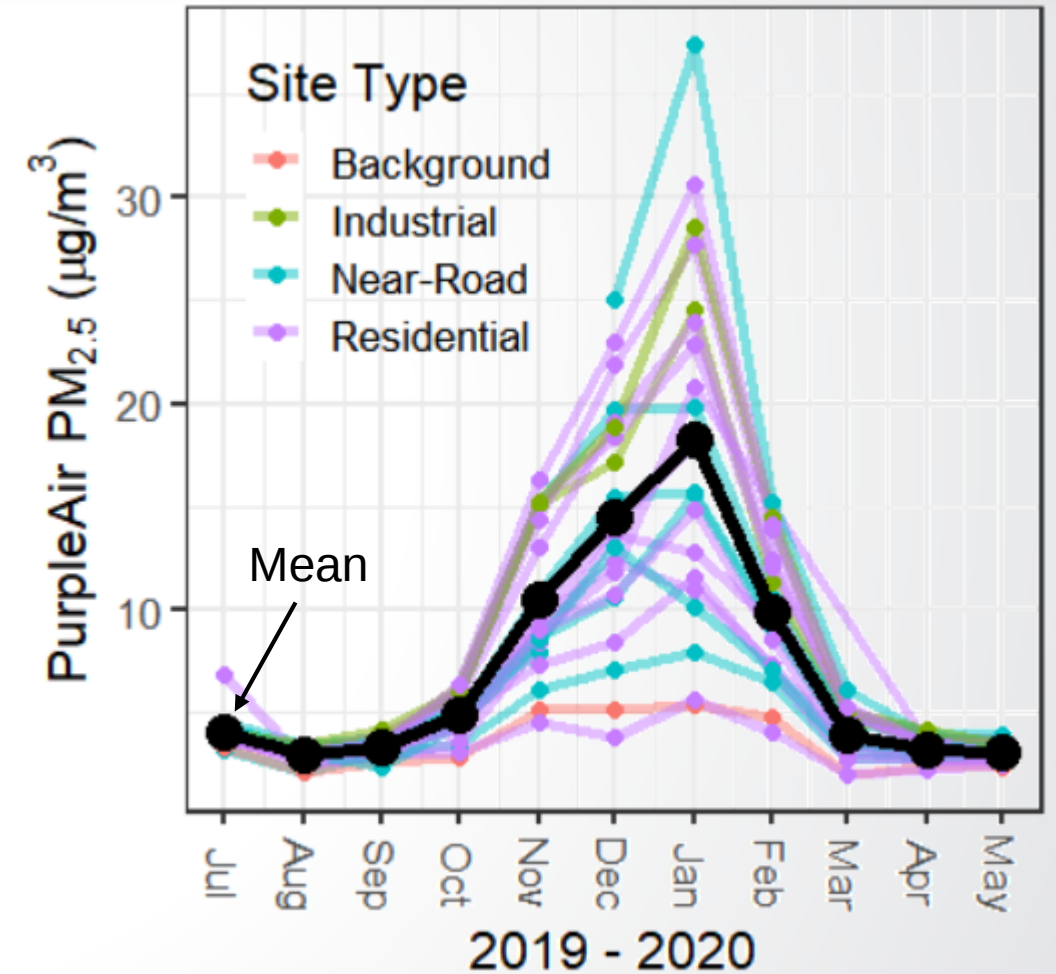
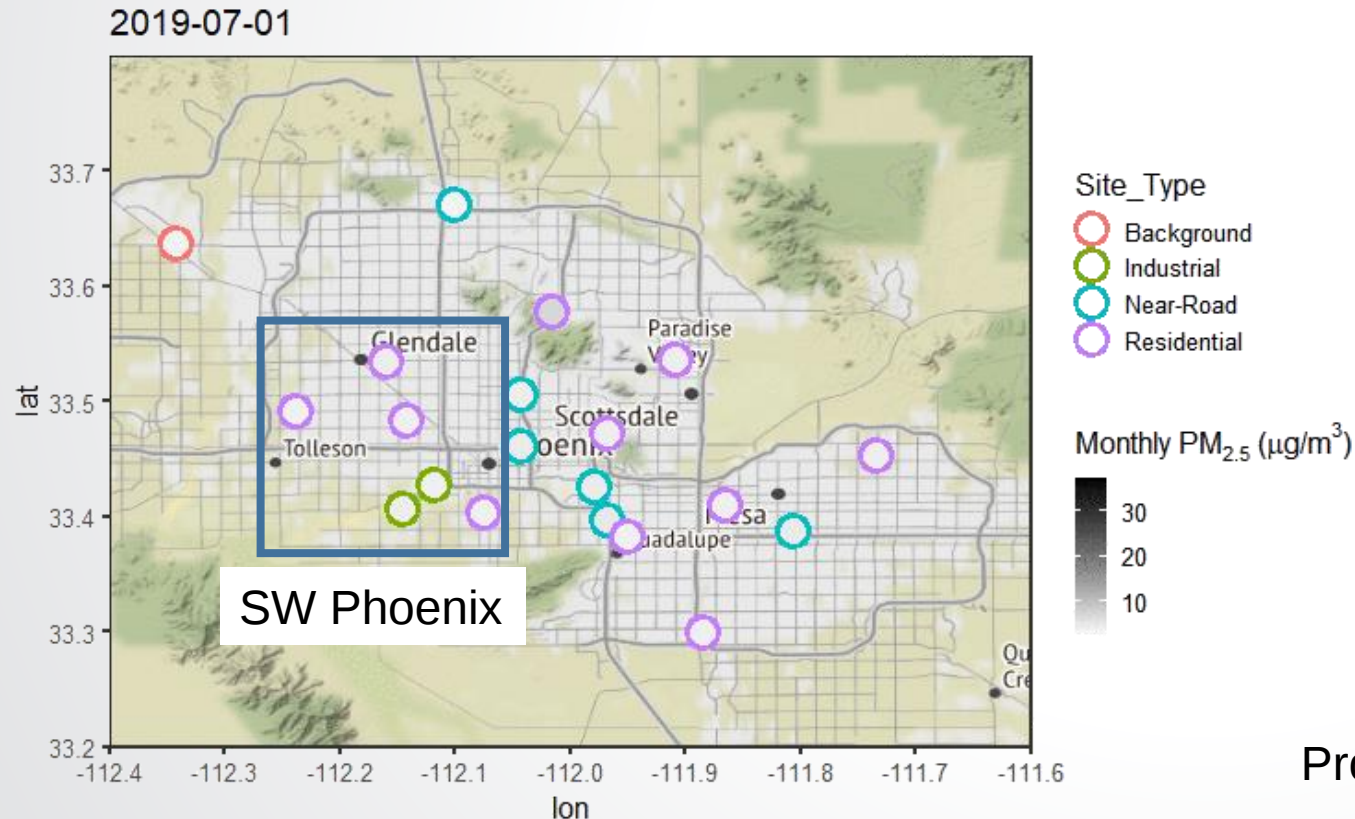
1. Remove formatting irregularities
2. (Optional) Average raw data to longer intervals
 - $\geq 90\%$ completeness threshold for hourly intervals
3. Flag outliers in the higher $\text{PM}_{2.5}$ correction channel (CF = 1) if the A and B channels differ by:
 - $\geq 5 \mu\text{g}/\text{m}^3$ AND
 - $\geq 2 * \text{sd}(\% \text{ error between A and B})$
 - 53 % for 1-hour data
4. Average A and B $\text{PM}_{2.5}$ (CF = 1)
 - No further correction used here



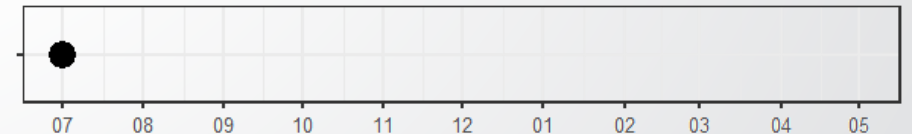


Overall PM_{2.5} in Phoenix

- Phoenix PM_{2.5} is highest in the winter
- Concentration levels are not grouped by site type
- Southwest Phoenix experiences higher PM_{2.5}



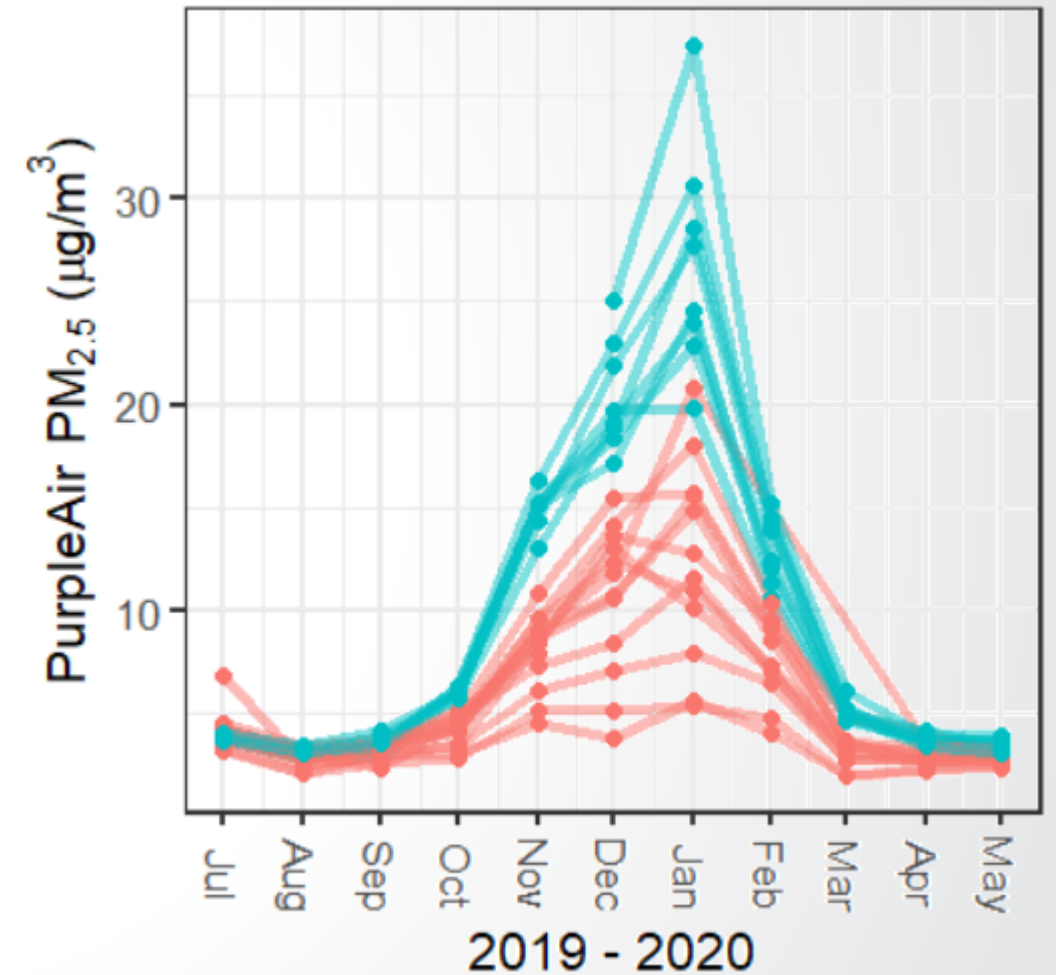
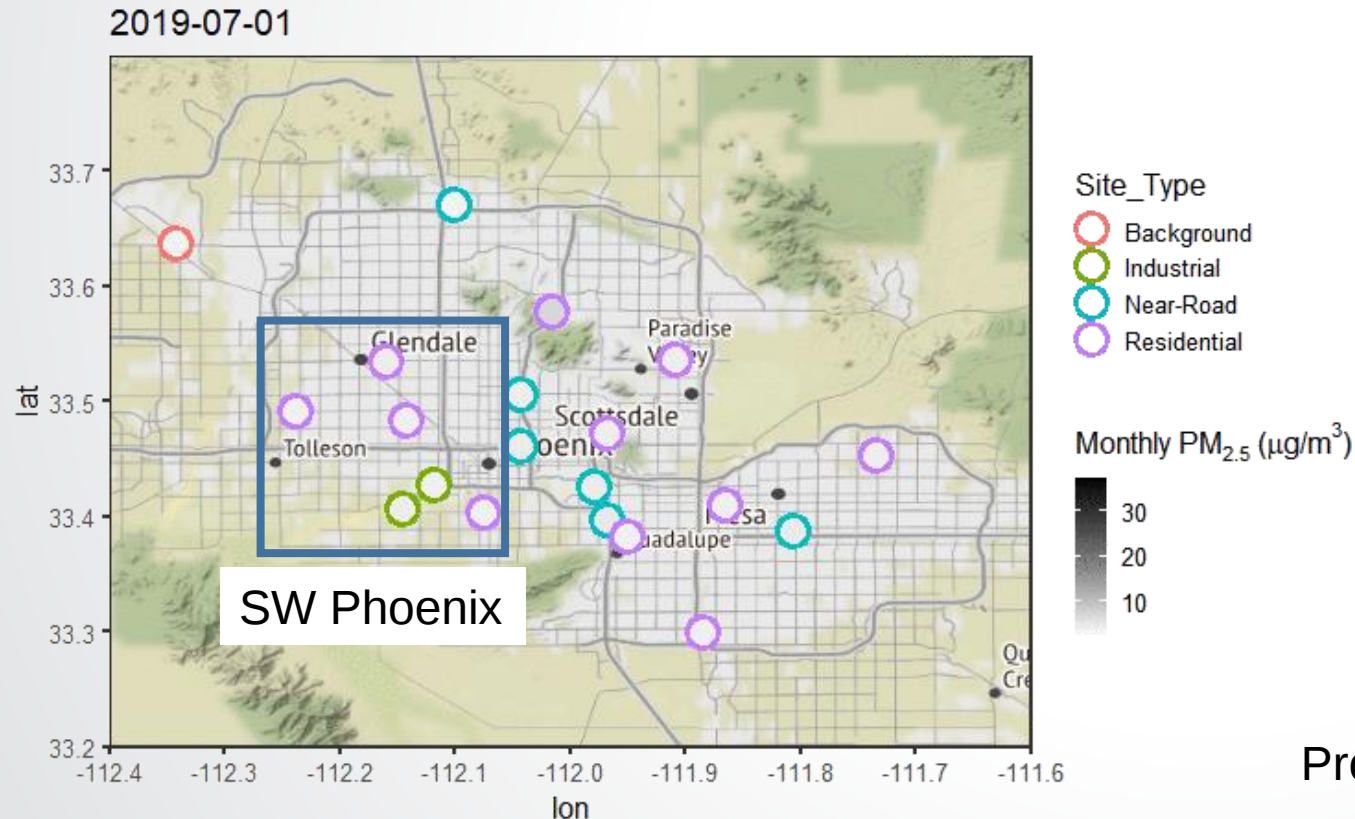
Progress
Bar



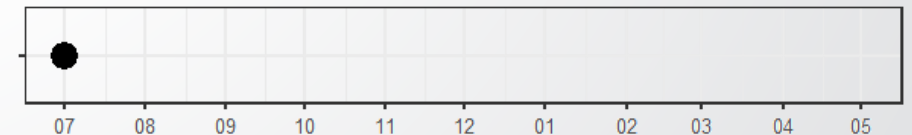


Overall PM_{2.5} in Phoenix

- Phoenix PM_{2.5} is highest in the winter
- Concentration levels are not grouped by site type
- Southwest Phoenix experiences higher PM_{2.5}

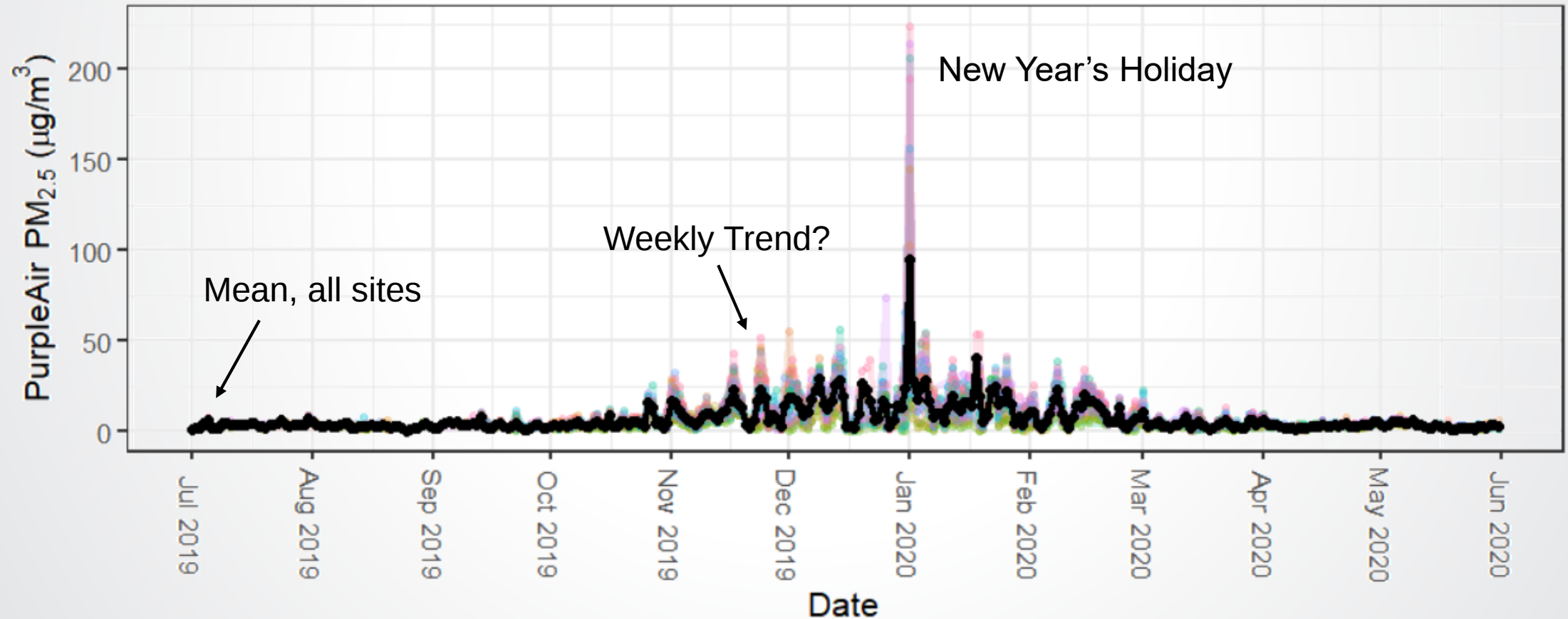


Progress
Bar



Daily PM_{2.5} in Phoenix

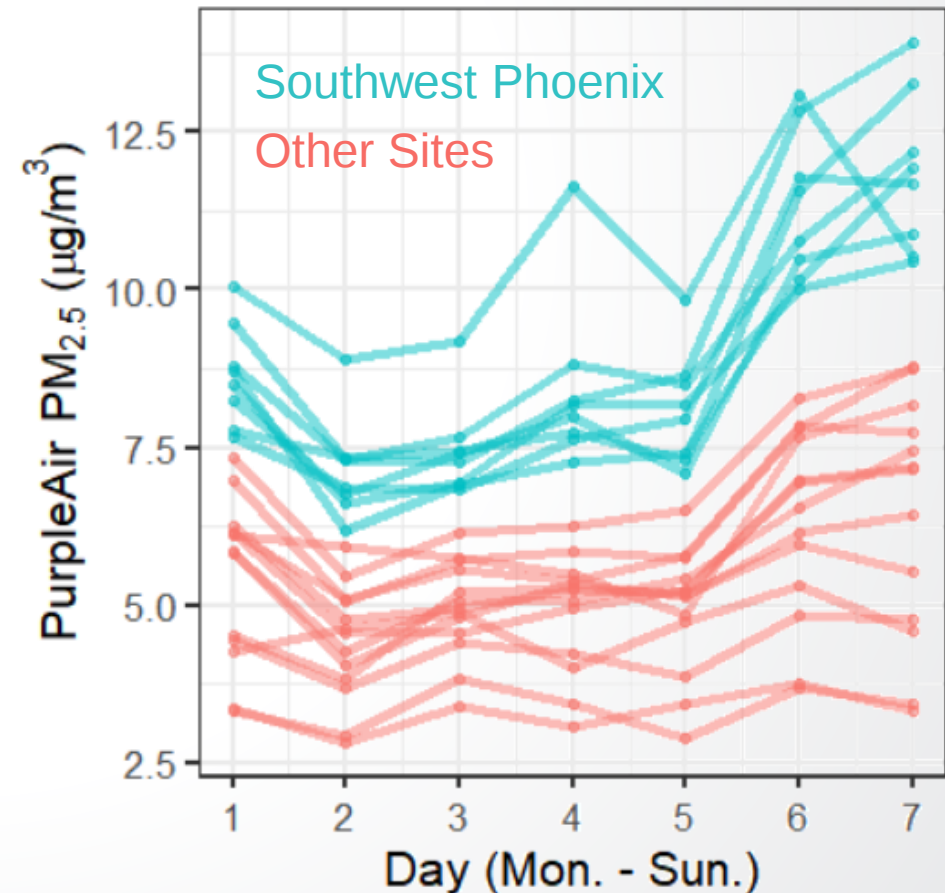
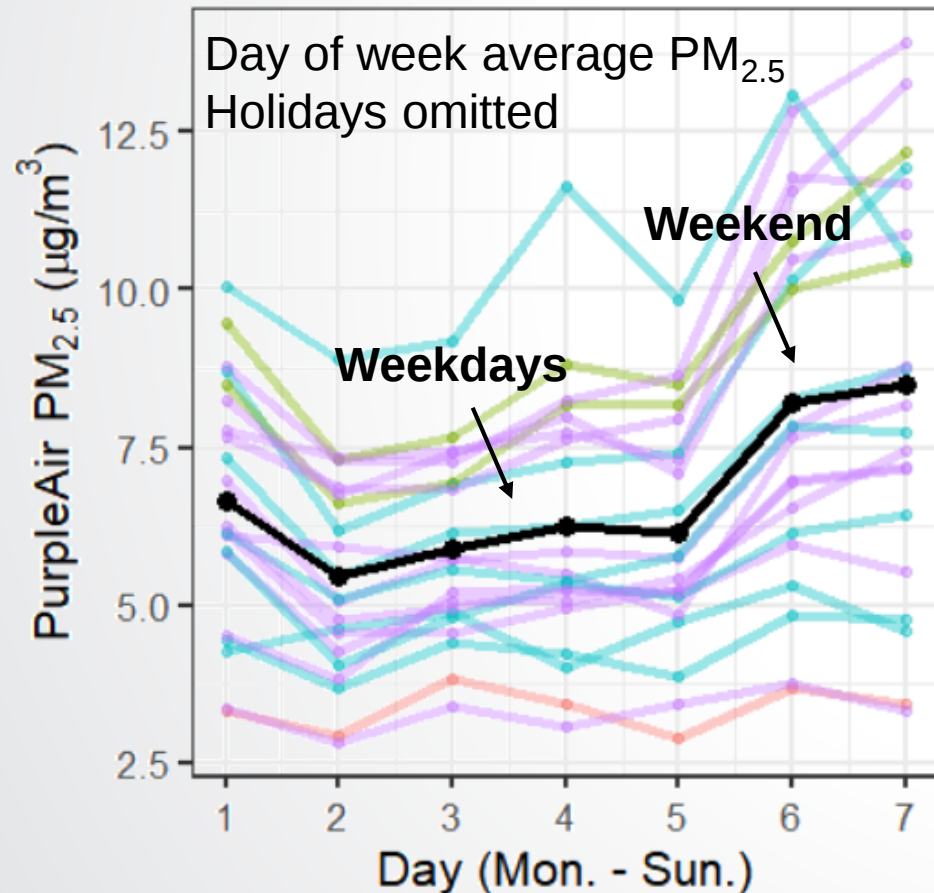
- Daily PM_{2.5} concentrations peak on New Year's day
- PM_{2.5} follows a weekly trend





Weekly PM_{2.5} in Phoenix

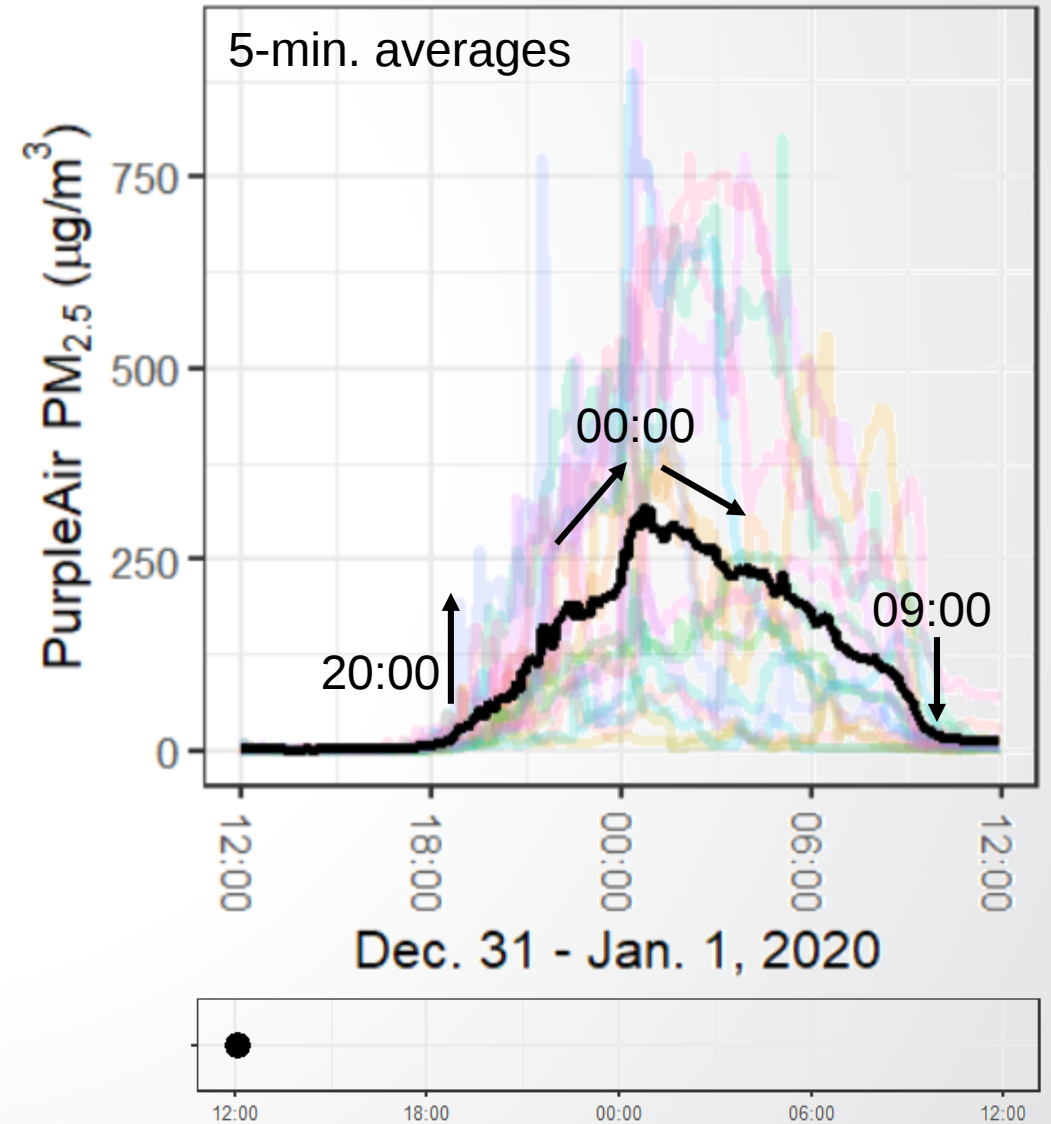
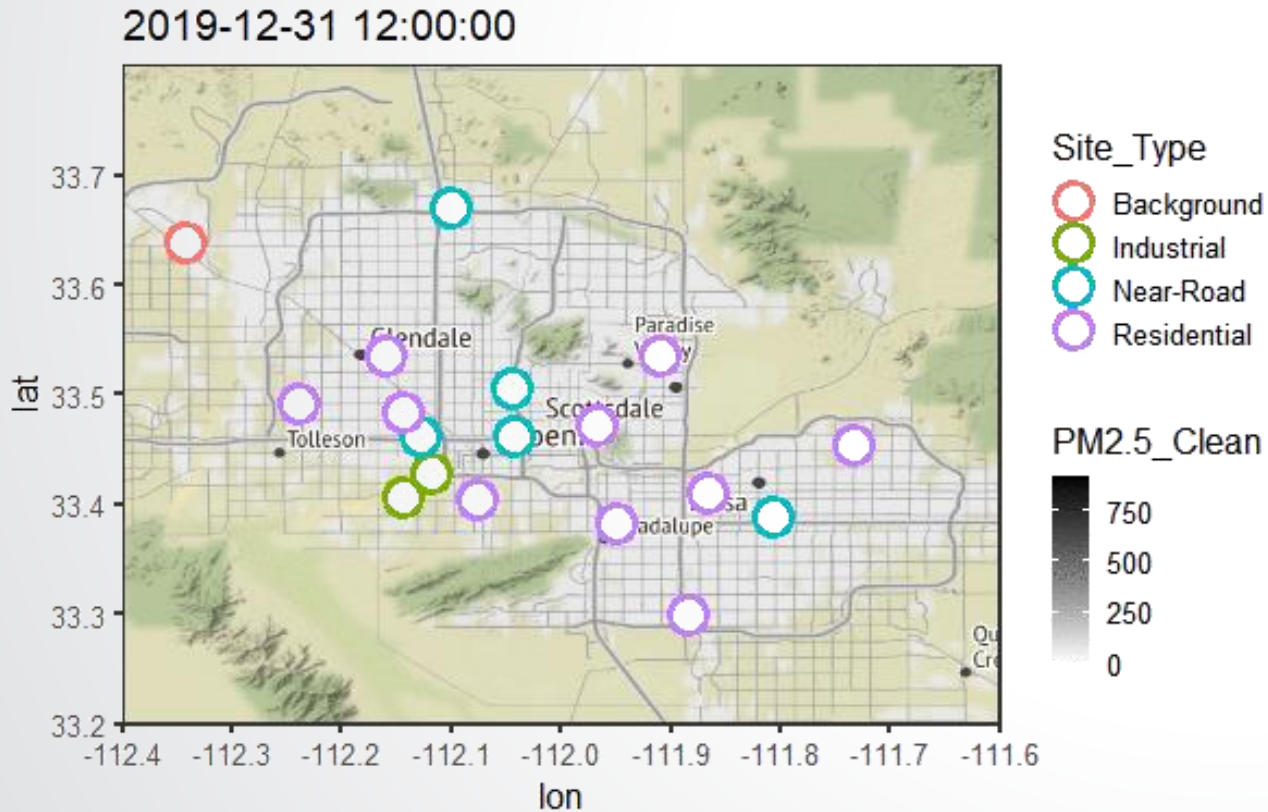
- Weekend PM_{2.5} is higher than weekday PM_{2.5}
- Southwest Phoenix has the highest weekend PM_{2.5}





New Year's 2020: Overview

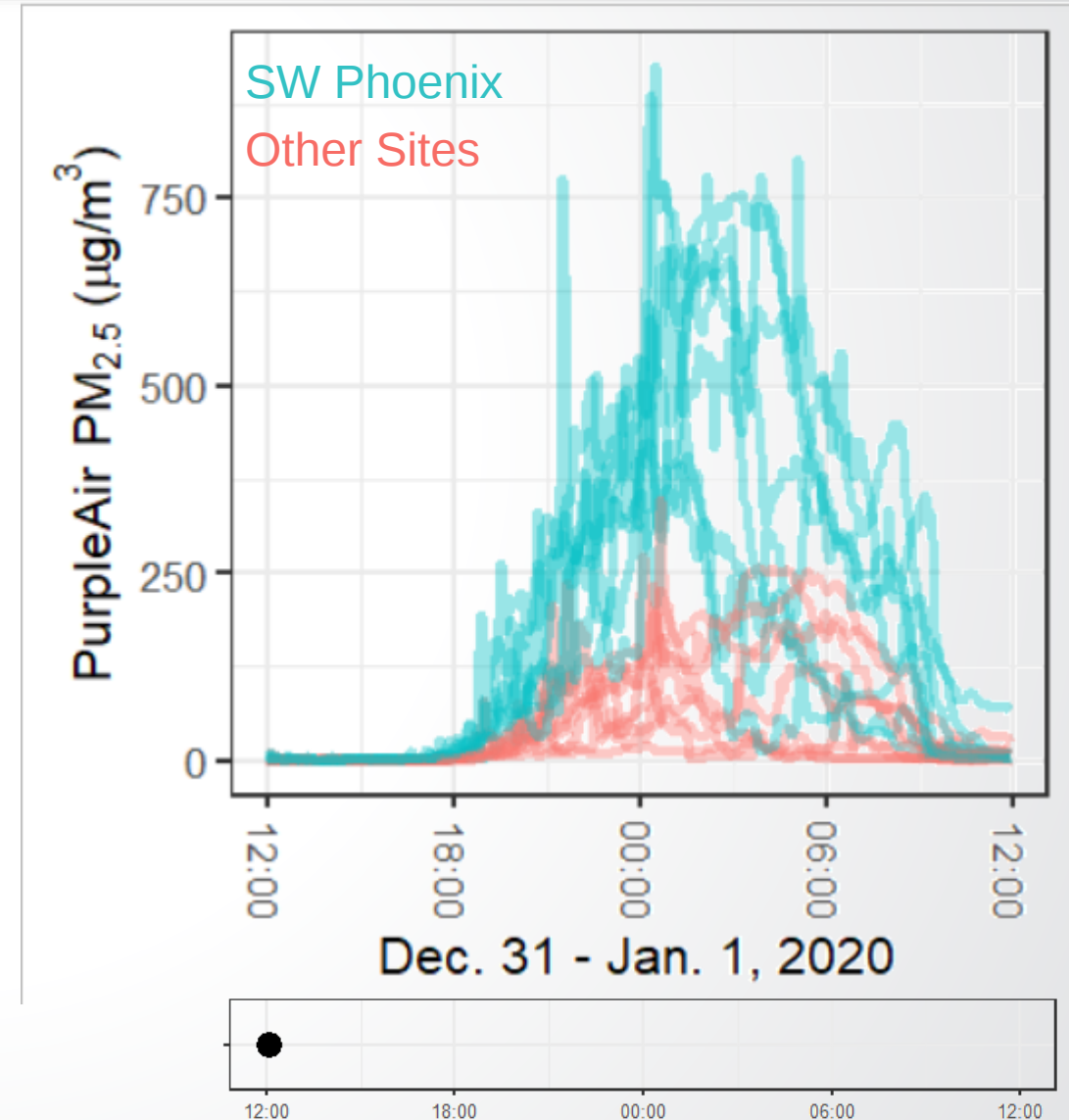
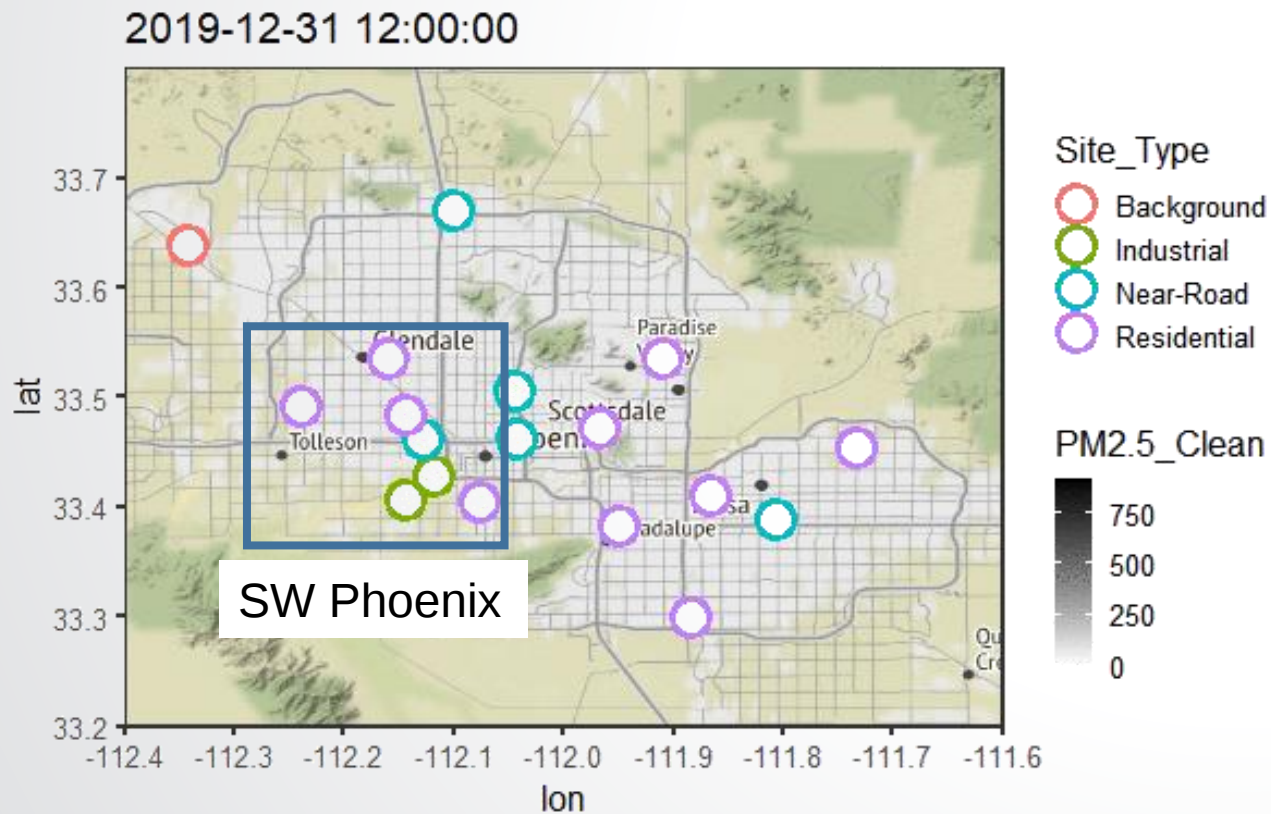
- PM_{2.5} starts increasing ~8 PM on New Year's Eve
- Peak PM_{2.5} is just after midnight
- PM_{2.5} mostly dissipates by ~9 AM on Jan 1





New Year's 2020: Overview

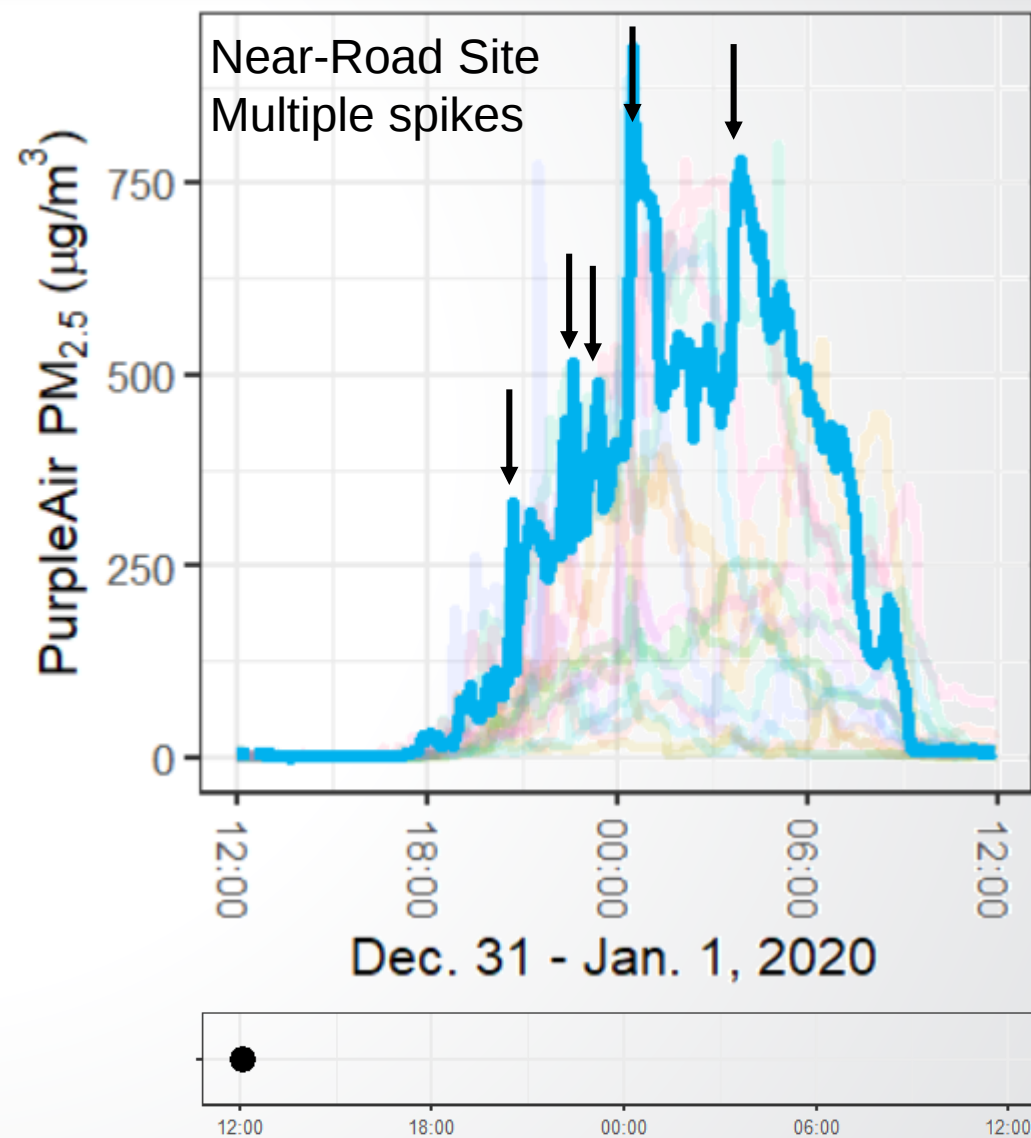
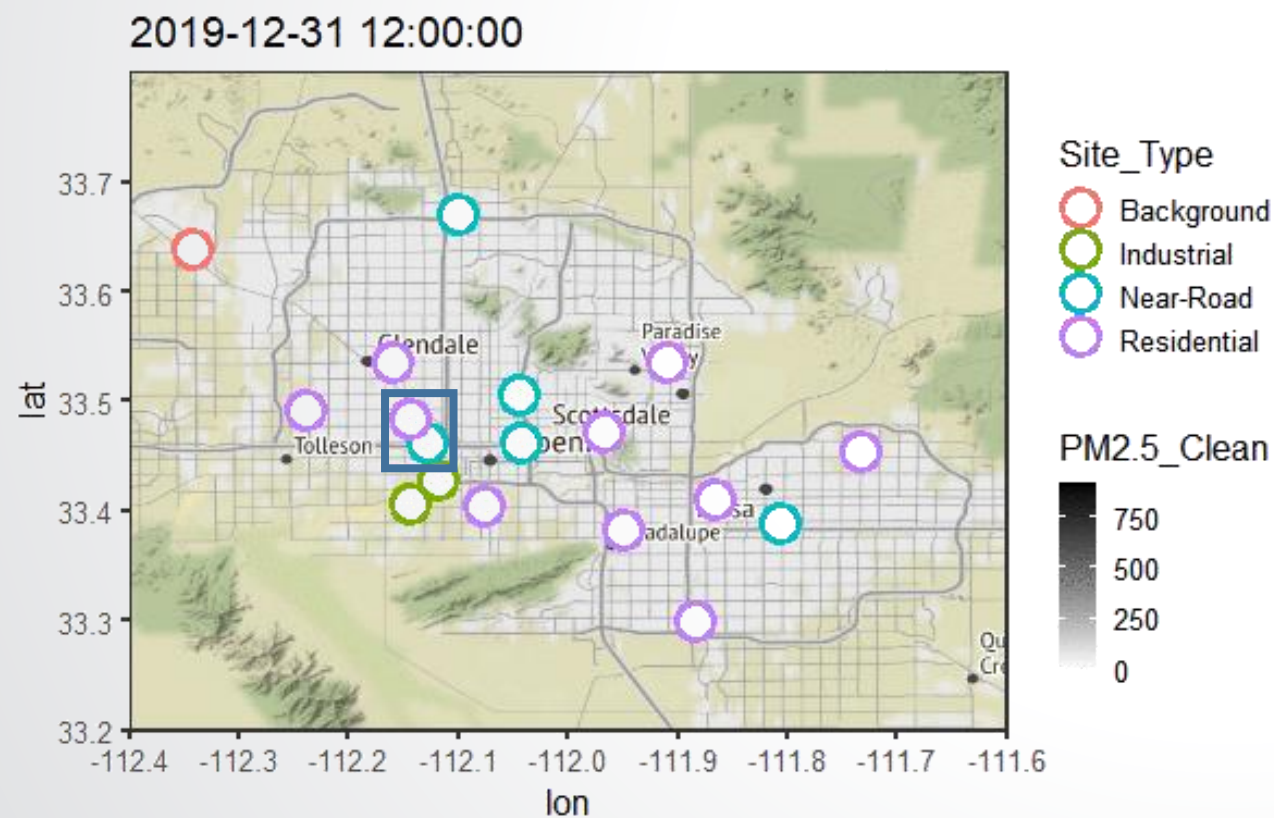
- Sites in southwest Phoenix experience higher $PM_{2.5}$ on New Year's





New Year's 2020: Overview

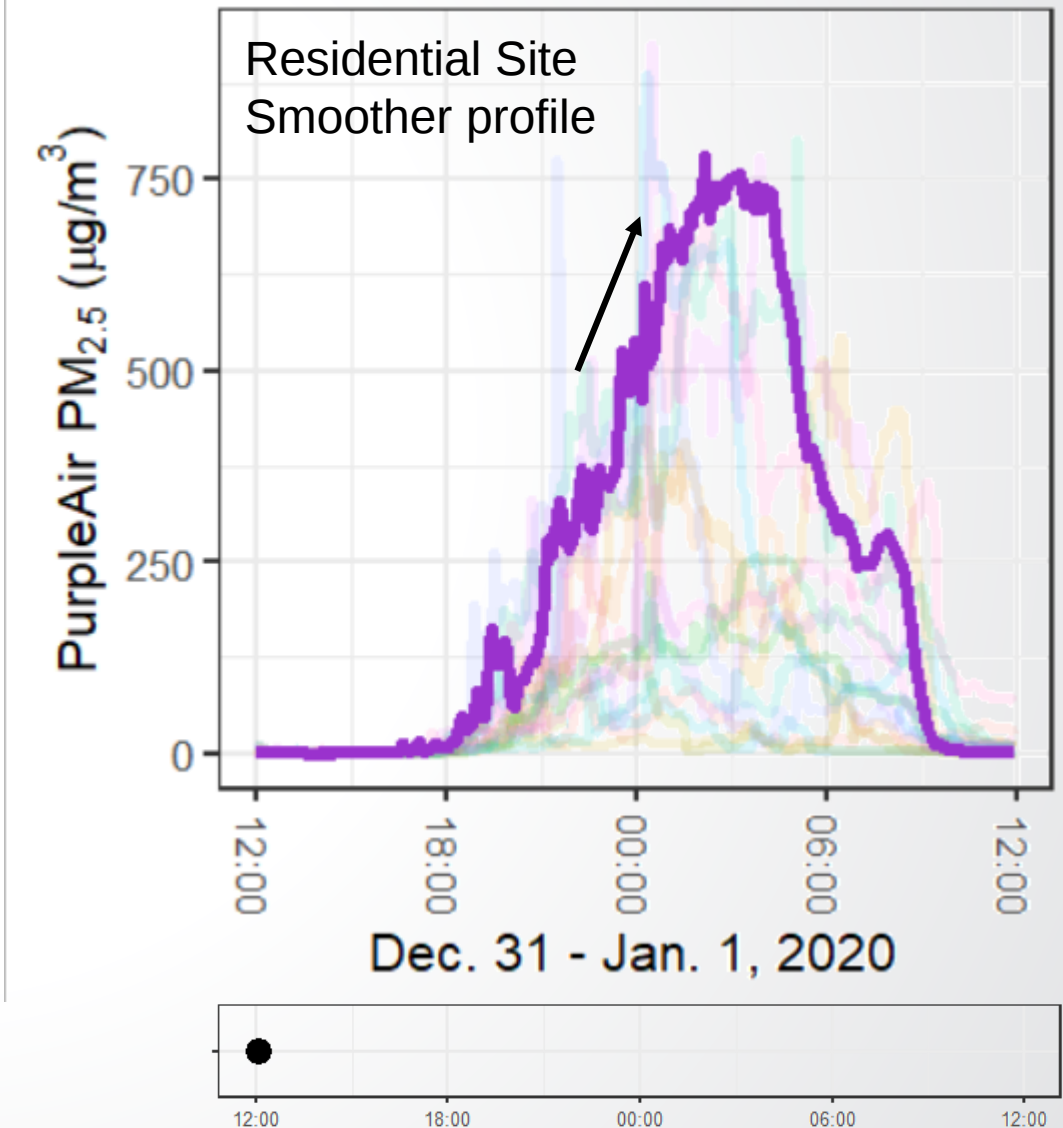
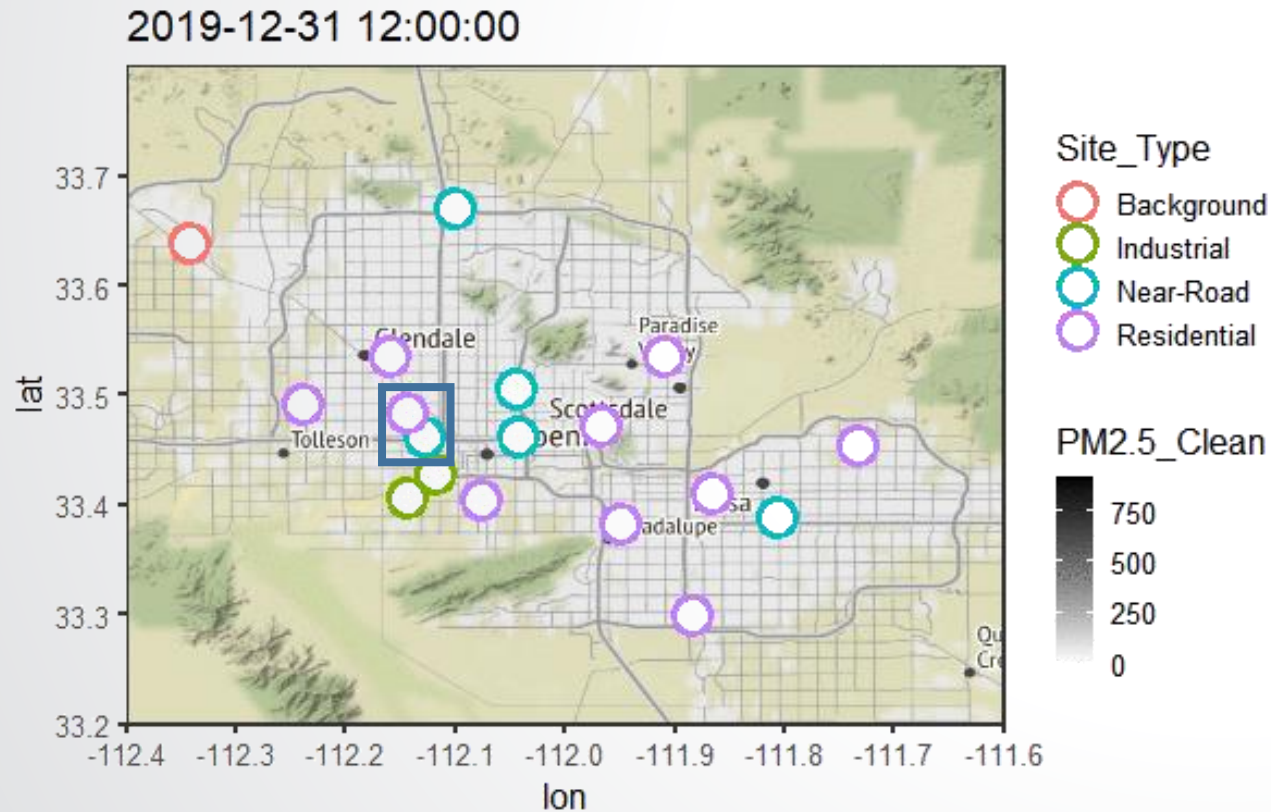
- Different sites have distinct PM_{2.5} profiles





New Year's 2020: Overview

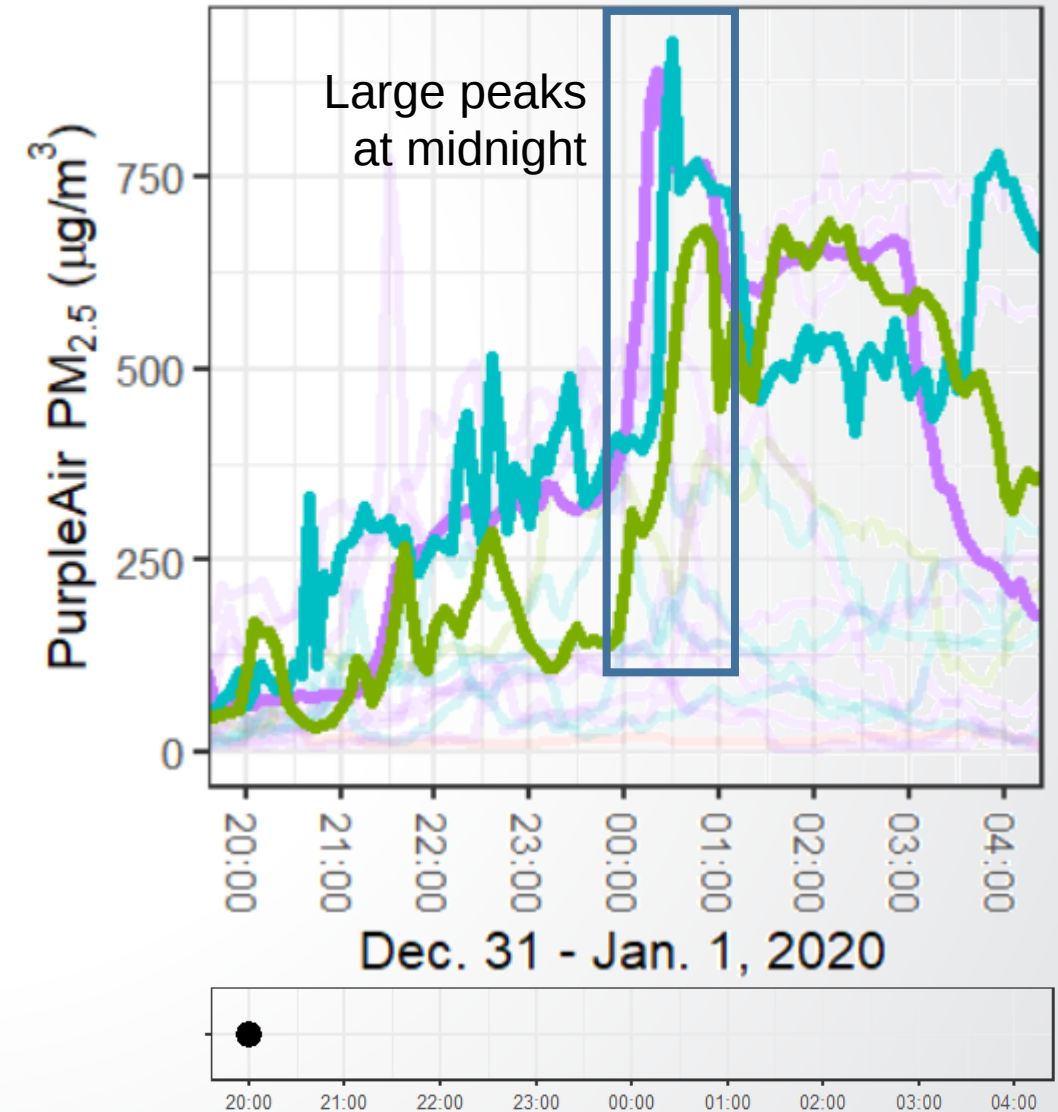
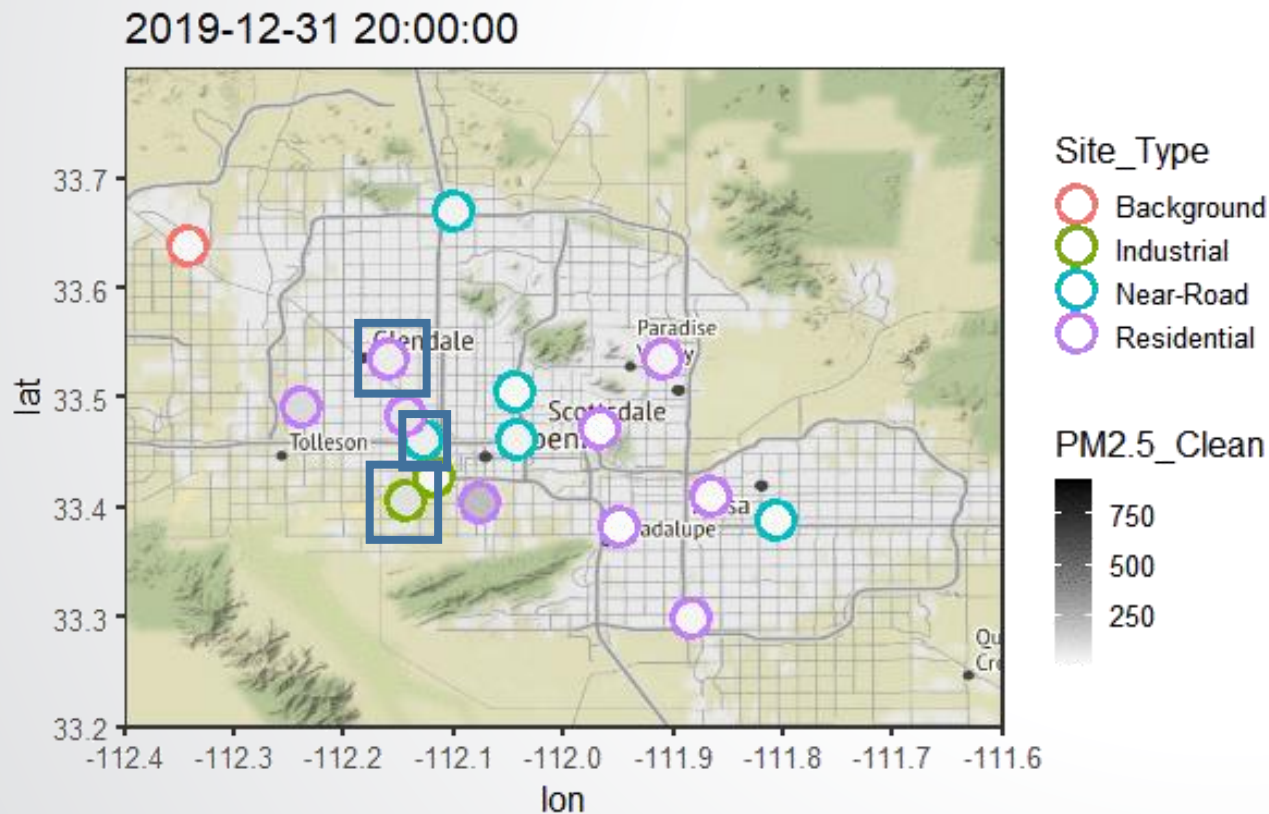
- Different sites have distinct PM_{2.5} profiles





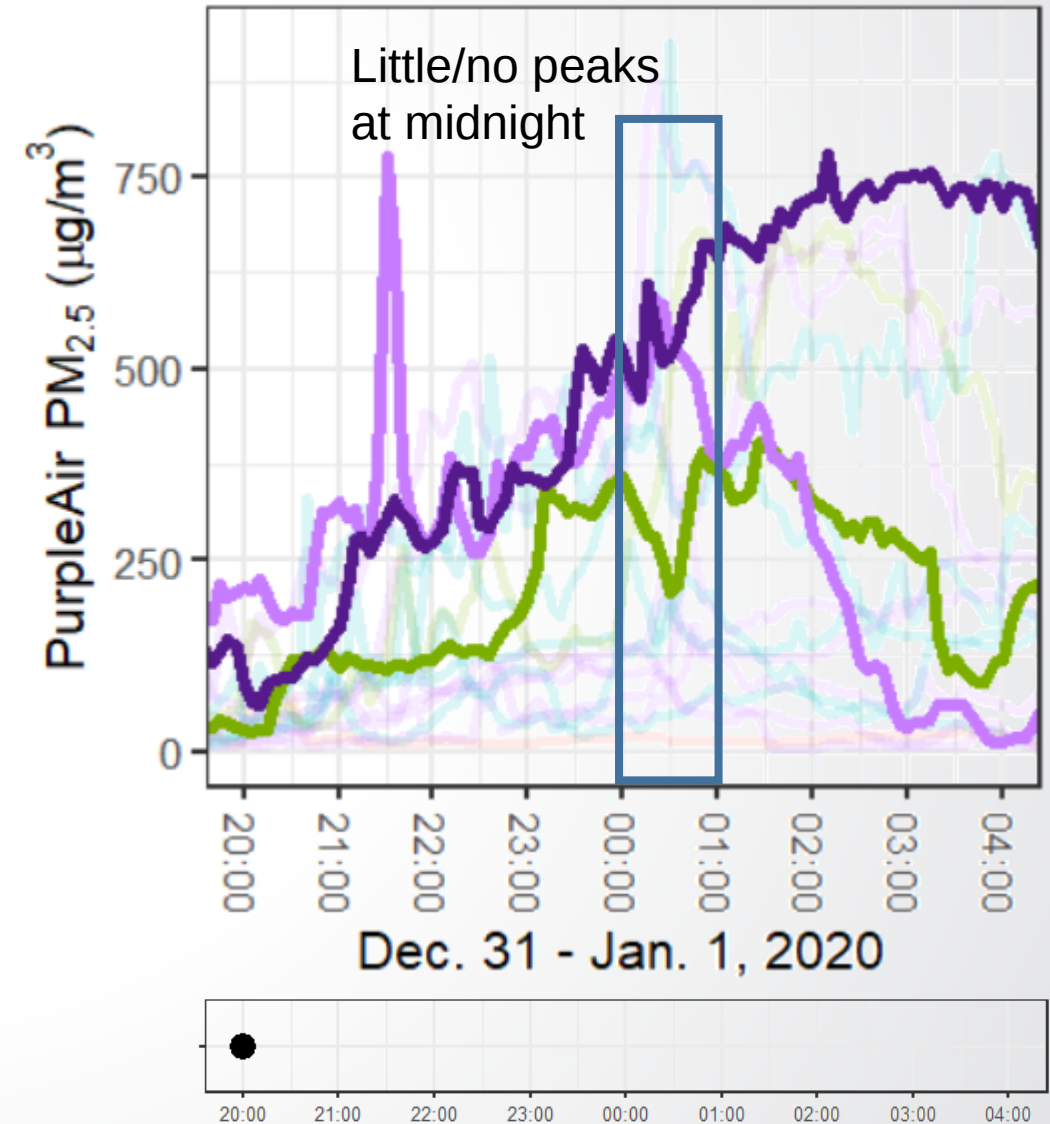
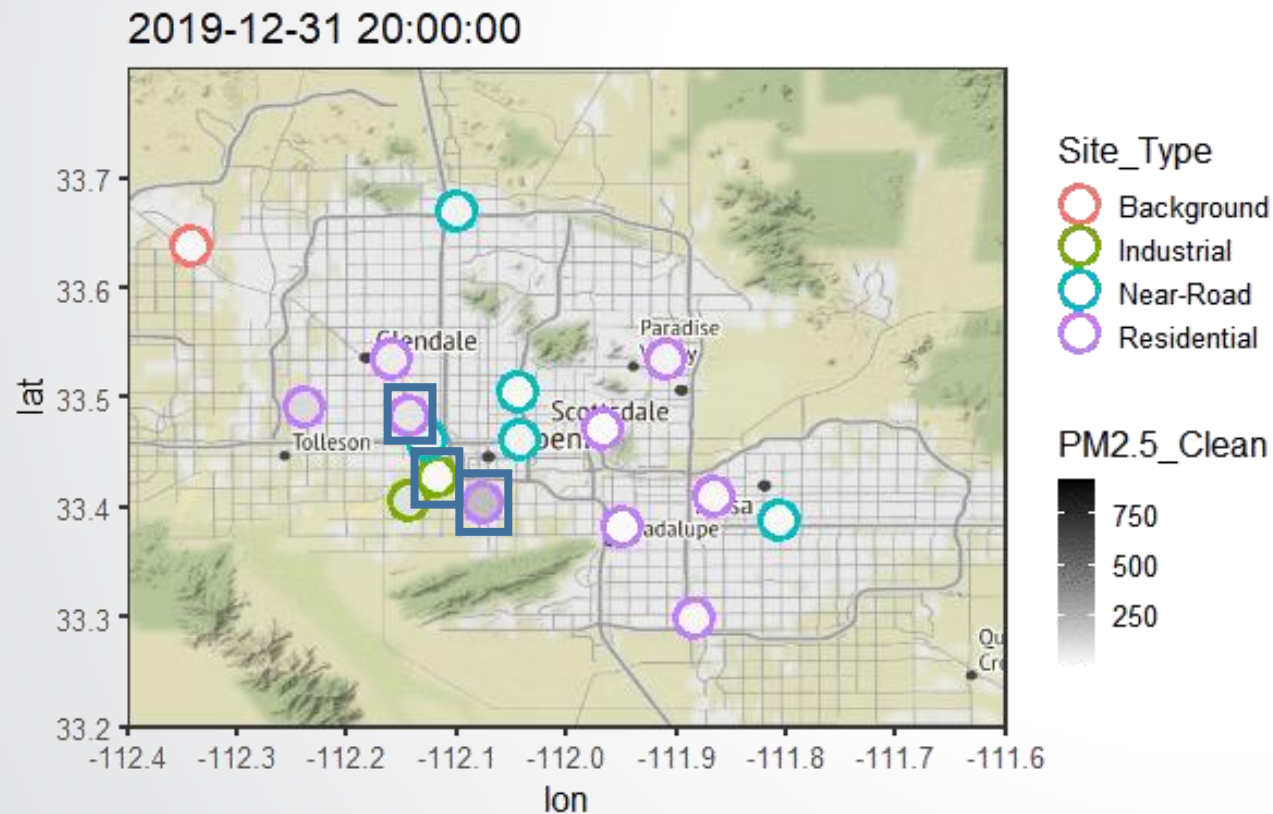
New Year's 2020: Midnight

- Different sites have distinct PM_{2.5} profiles
- Midnight PM_{2.5} peak varies by site

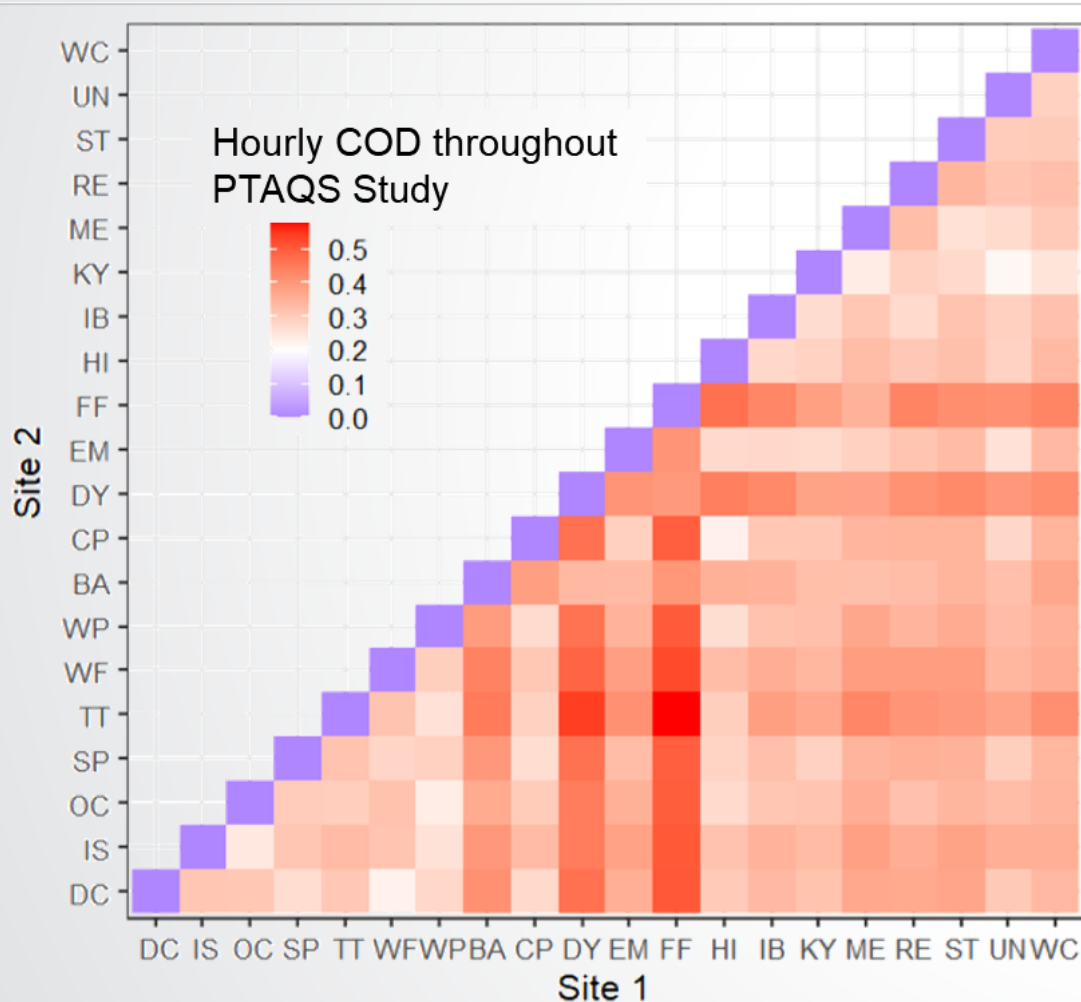


New Year's 2020: Midnight

- Different sites have distinct PM_{2.5} profiles
- Midnight PM_{2.5} peak varies by site



PM_{2.5} Inhomogeneity in Phoenix



$$\text{Coefficient of Divergence (COD)} = \sqrt{\frac{1}{N} \sum_{i=1}^N \left(\frac{x_{iA} - x_{iB}}{x_{iA} + x_{iB}} \right)^2}$$

N = # paired observations

x_{iA} = measurement at time i , site A

x_{iB} = measurement at time i , site B

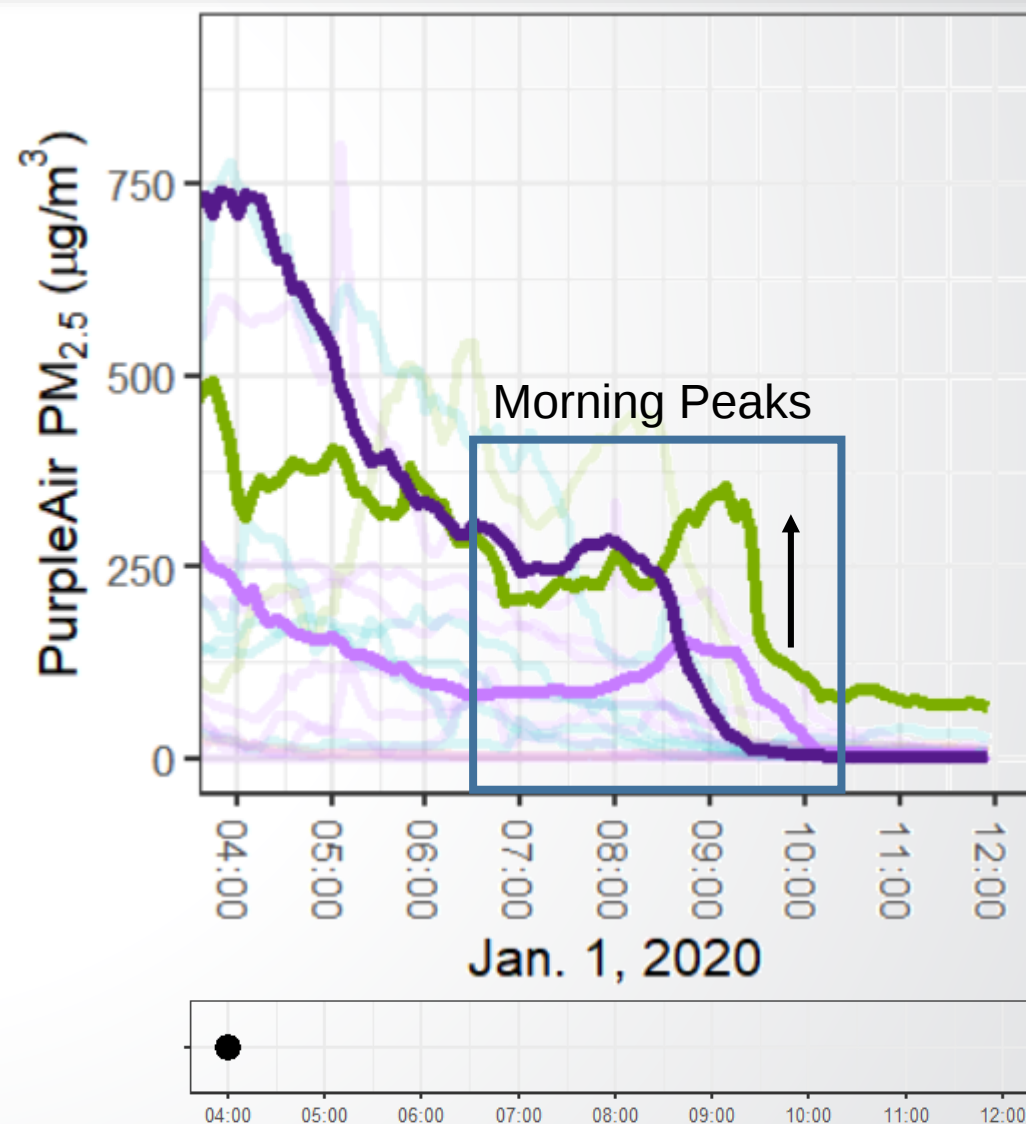
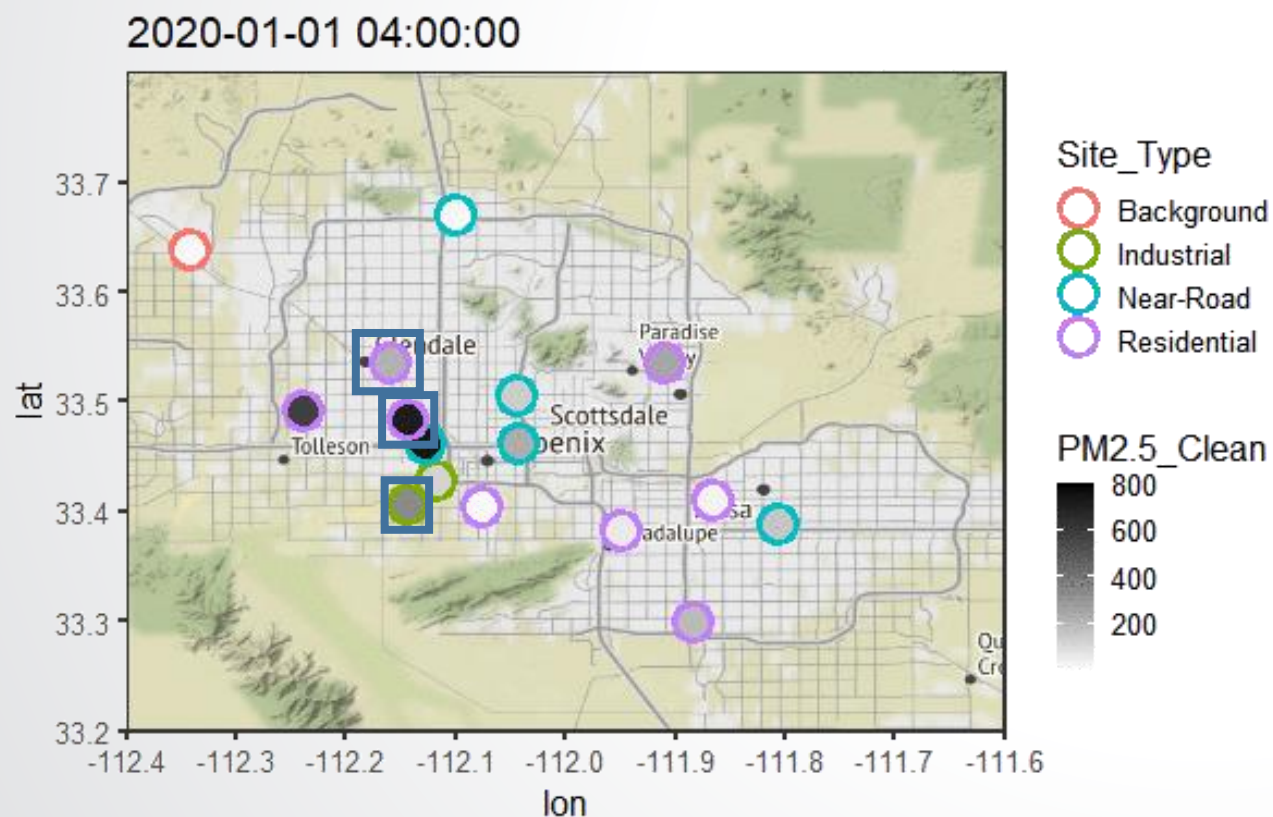
- COD > 0.2 = sites are significantly different
- COD < 0.2 = sites are similar
- 208/209 Site Pairs have COD > 0.2.

There are localized sources of PM_{2.5} in Phoenix that the PTAQS network may not resolve.
Sensor loans or giveaways may be able to increase measurement density, awareness, and education.



New Year's 2020: Morning After

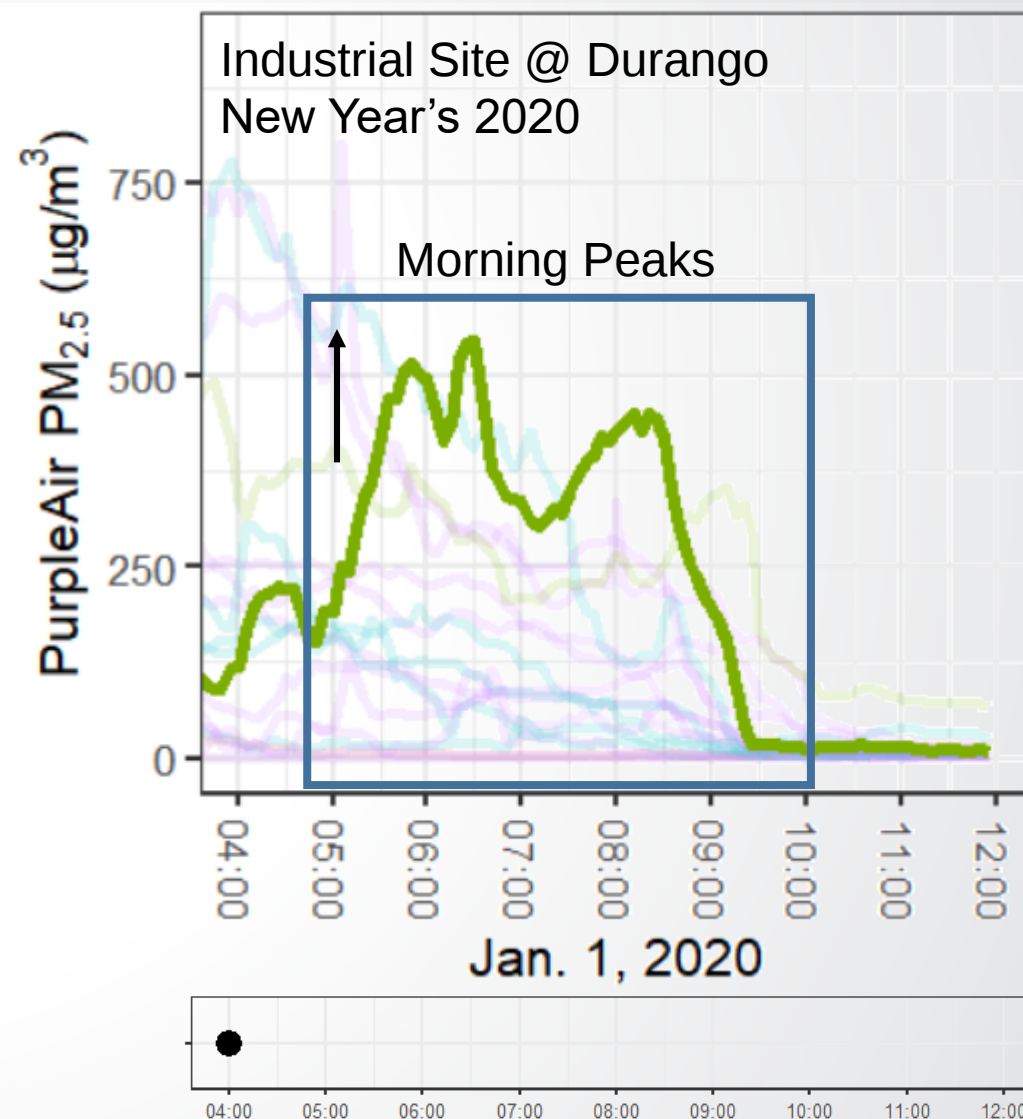
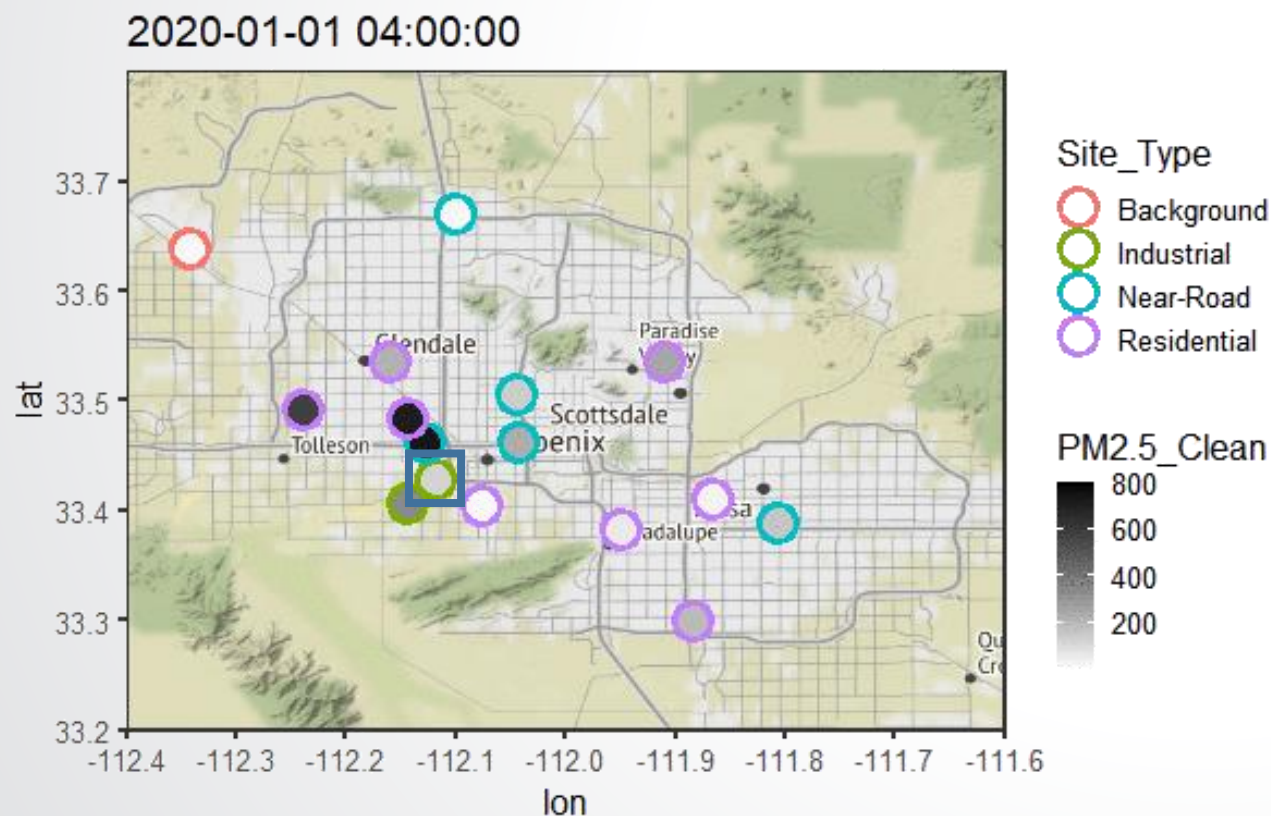
- Sites in southwest Phoenix experience morning $PM_{2.5}$ peak on Jan. 1 @ 8 – 9 AM





New Year's 2020: Morning After

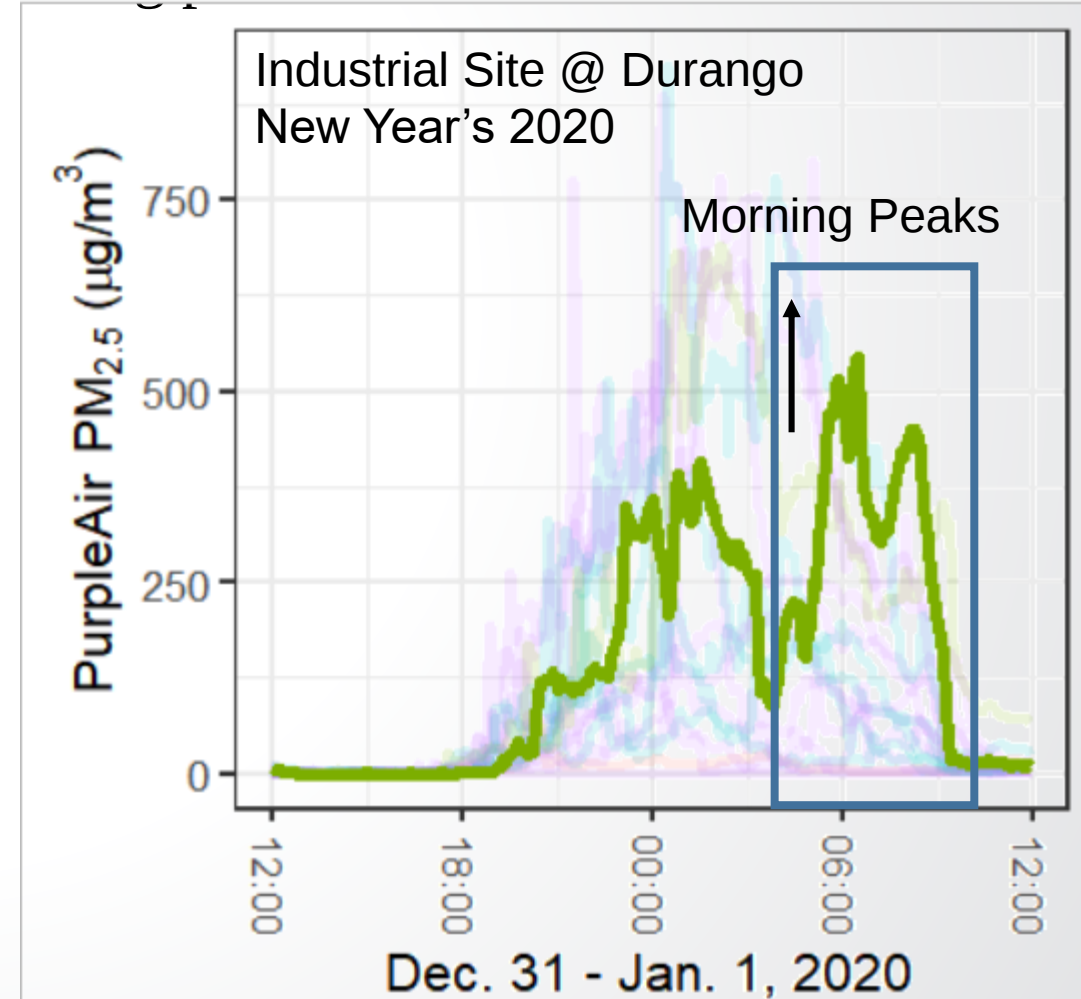
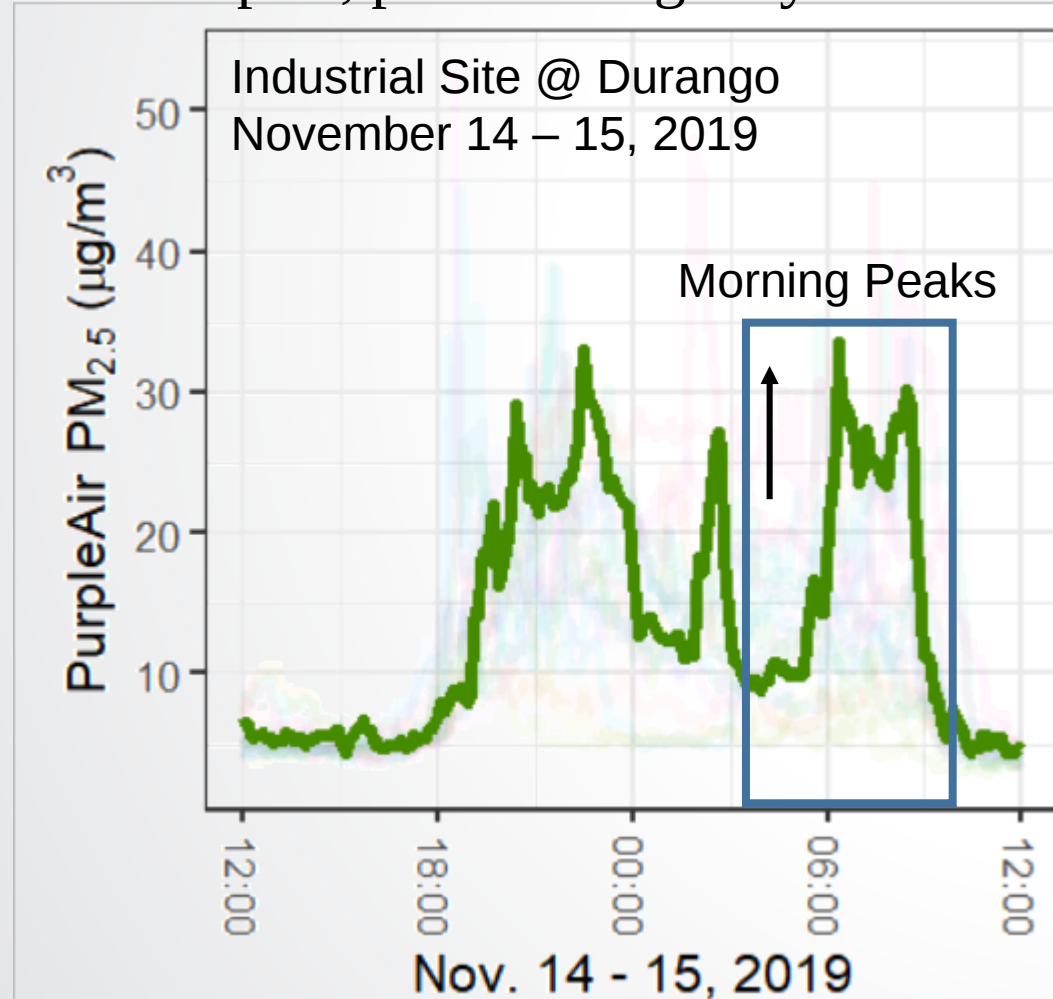
- Sites in southwest Phoenix experience morning PM_{2.5} peak on Jan. 1 @ 8 – 9 AM
- Especially pronounced at Durango





New Year's 2020: Morning After

- SW Phoenix experiences $PM_{2.5}$ peaks on most mornings
- Mass transport, poor mixing may contribute to morning peaks



- PM_{2.5} concentrations in Phoenix are elevated in the winter, on the weekends, and on New Year's Day
- The highest concentrations of PM_{2.5} were observed in southwest Phoenix at all timescales
 - Mass transport and poor mixing may contribute to elevated PM_{2.5} in the morning
- Localized concentration profiles on New Year's Eve/Day are consistent with inhomogeneity of PM_{2.5} in Phoenix
- Air quality action may be able to increase spatiotemporal density and increase awareness of air sensors and air quality



Acknowledgements

- EPA ORD: Sensor group
- Jacobs: Parik Deshmukh
- Maricopa County Air Quality Dept.



Disclaimer: Although this presentation was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.



References

- Slide 2: <https://www.12news.com/article/weather/talking-weather/heres-why-phoenix-was-hazy-this-morning/353450553>
- Slide 2: <https://azdeq.gov/aq/ytd?year=2019&pollutant=pm25&location=statewide&type=conc#mtop>
- Slide 2: Ramadan, Z., et al. (2000). J Air Waste Manag Assoc **50(8): 1308-1320.**
- Slide 2: Lewis, C. W., et al. (2003). J Air Waste Manag Assoc **53(3): 325-338.**
- Slide 3: <http://cleanairmakemore.com/>
- Slide 4: Tanzer, R., et al. (2019). Int J Environ Res Public Health **16(14).**
- Slide 5: https://mazamascience.github.io/AirSensor/articles/articles/purpleair_failure_modes.html
- Slide 22 - Elevation map: <https://viewer.nationalmap.gov/>

Thank you!