Community Air Quality Monitoring Pilot Study Update

Thursday, September 8, 2022

Agenda

1. Community Air Monitoring Pilot Sites & Introductions

2. Public engagement

3. Monitor selection and evaluation

4. Data access and interpretation

5. Next steps

6. Optional PurpleAir map demo

# Community Air Monitoring Pilot Site Introductions

- New Mount Zion Missionary Baptist Church, Tampa

- Seminole Elementary School

- Tampa Heights Junior Civic Association

- Robert J Saunders Library, adjoining Booker T Washington Elementary School

- Future sites:

  - Perry Harvey Park, City of Tampa

  - Robles Park, City of Tampa

  - Sulphur Springs Park, City of Tampa

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Community Collaboration to Date

Goals

- Work with the community and local agencies to select and establish community monitoring pilot sites
- Raise awareness and knowledge about the project and traffic related air pollution

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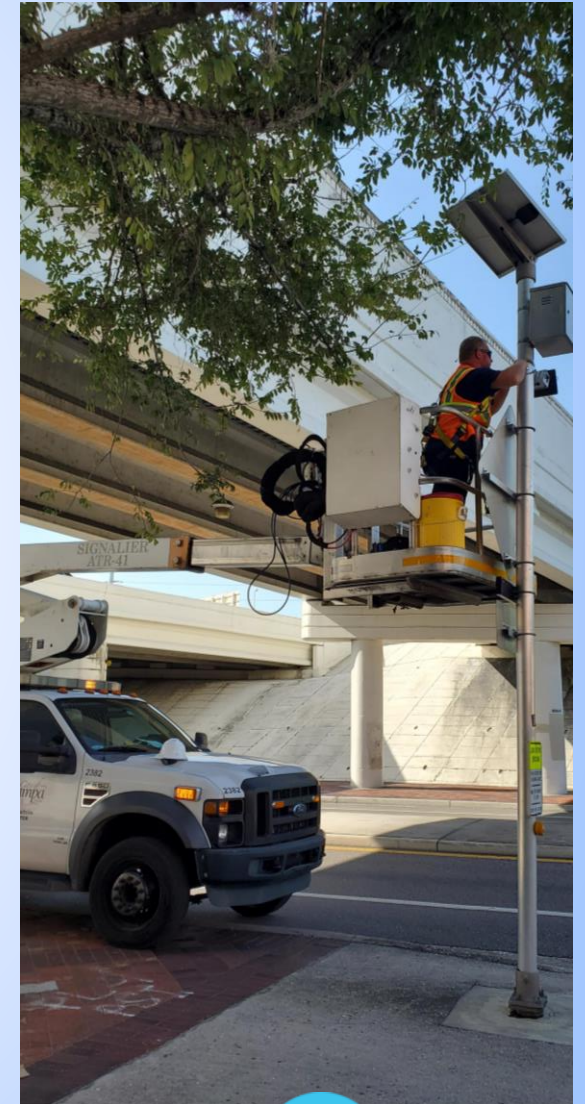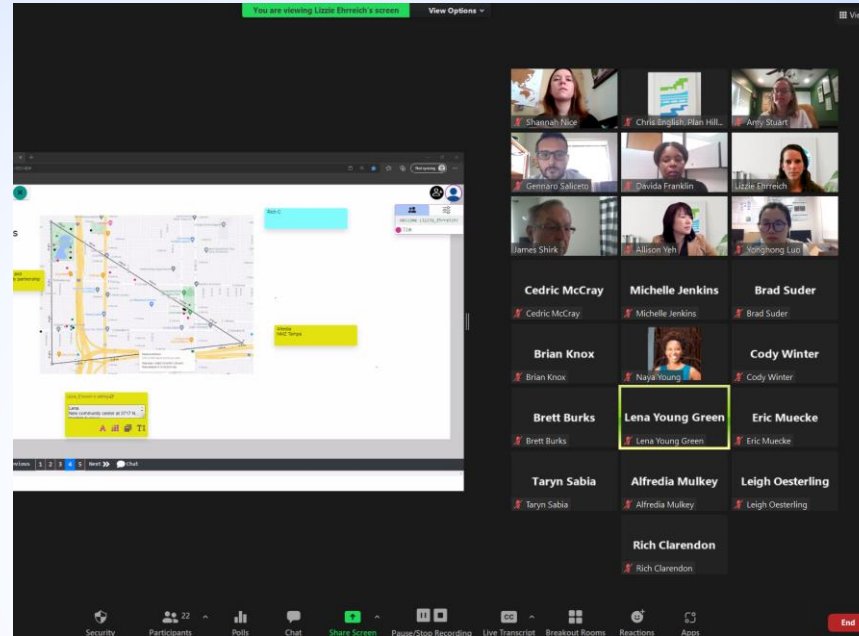
Future Community Collaboration

- Public Engagement Goals:

  - Expand engagement in the community
  - Empower the community to be involved in the site/area selection, establishing sites, conducting outreach, and air quality monitoring
  - Establish a community coalition to monitor air quality and contribute to decision-making

- Public Engagement Objectives for the Upcoming Year:

  - Train community members to
    - Install the monitors, interpret and monitor air quality data, and conduct outreach to increase community involvement in the project and air monitoring
  - Increase engagement and educational events
  - Identify key supporters and representatives from the community and community sites
  - Establish community sites and offer opportunities for individuals to host monitors (as funding allows)
  - Community sites to monitor and report on the status of their air quality (6-month updates).

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Community Collaboration: Next Steps and Discussion

Next Steps

- Information booths at upcoming events (fall-winter)
  - Individualized outreach events, rather than a large event
- Training to interpret the data (fall-winter)
- Training to install the monitors (as funding permits)

Discussion and Input

- Do you have planned events where we can set up an info booth? Would someone be willing/interested to assist at the booth?
- What types of public engagement do you want to see and be involved in?
- What types of events/information will be most beneficial for your community?
- Identify key supporters and representatives from your organizations

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Community Air Monitoring Pilot Study: USF Project Update

Yonghong Luo, Shannah Nice, Amy Stuart

Sept. 8, 2022

UNIVERSITY of SOUTH FLORIDA

Objectives

- Inform methods for the integration of low-cost monitoring data, including its uncertainties, into community and MPO decision-making processes

- Determine ambient levels of traffic-related air pollution in a historically disadvantaged neighborhood near I-275 with predicted disproportionate exposures

- Inform best practices for building government-university-community partnerships for sharing air quality monitoring data and expertise

Outline

- Community monitor selection and evaluation
  - Monitor identification and selection
  - Monitor performance evaluation
  - Monitor installations

- Community data access and interpretation
  - Links to community site data via the project website
  - Accessing Purple Air monitor data
  - Accessing Clarity monitor data
  - Preliminary interpretation of community air quality

Monitor identification and selection

- Methods
  - Review of the scholarly literature, government reports & data, and available manufacturer literature.
  - Pilot set-up and logistical testing in a field setting.

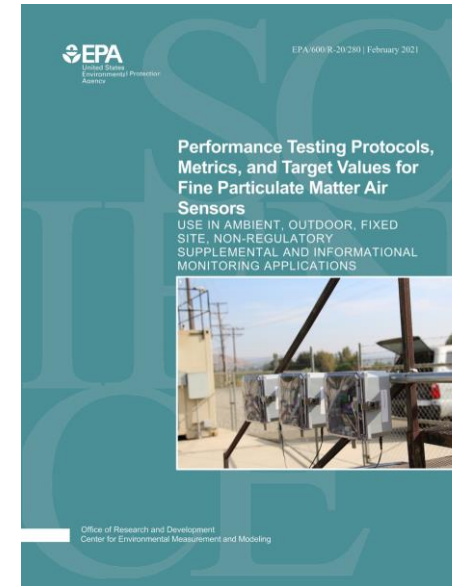## Criteria for selection for community pilot deployment

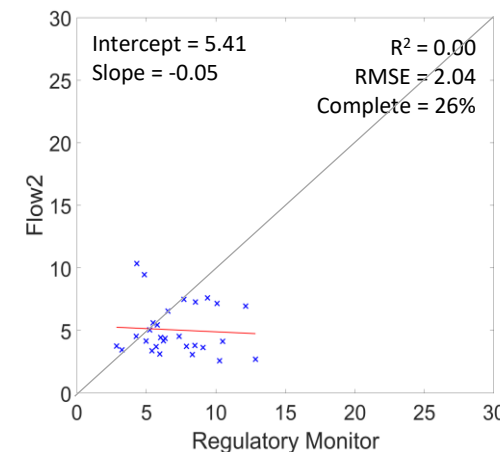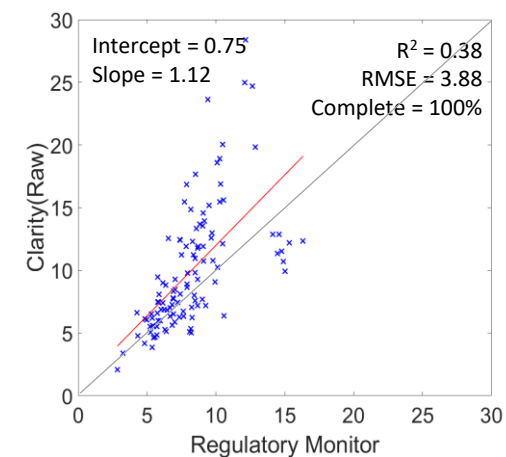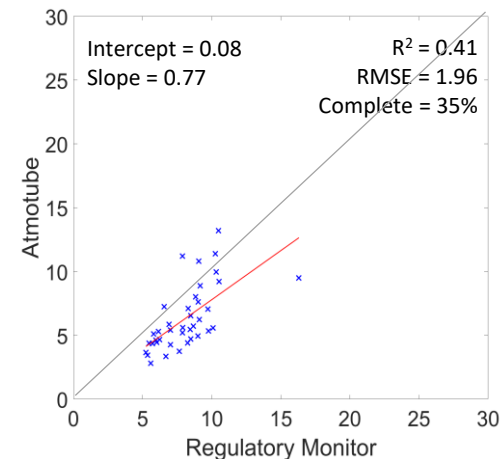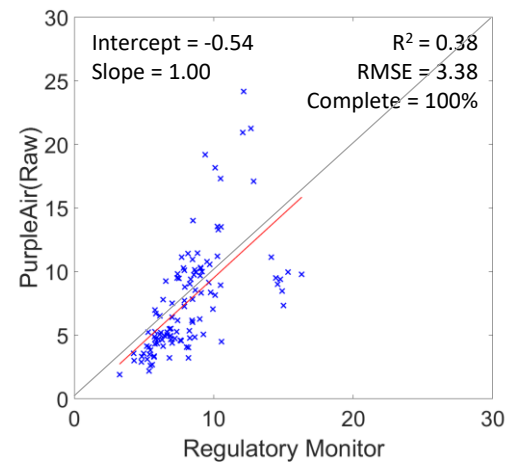| Monitor	Pollutant	Price	Size	Use Logistics	Data Collection / Sharing	Data Quality
Criteria	TRAP (PM$_{2.5}$, NO$_2$, VOCs)	Lowest, <$2000	Small footprint	Easy, few ancillaries, low maintenance	Easy transfer, public sharing website	Moderate (1-hr) R^2 vs EPA FRM/FEM

Candidate Monitors

Monitor	Pollutant	Price	Size	Use Logistics	Data Collection / Sharing	Data Quality
Criteria	TRAP ($PM_{2.5}$, NO_2, VOCs)	Lowest, <$2000	Small footprint	Easy, few ancillaries, low maintenance	Easy transfer, public sharing website	Moderate (1-hr) R^2 vs EPA FRM/FEM
PurpleAir	$PM_{1,2.5,10}$ (T, RH, P)	$249		Requires power and Wi-Fi (SD card optional)	Automatic data upload to public website (available), includes download, map, and trends	$PM_{2.5}$: Strong $R^2 > 0.86$
AirBeam	$PM_{1,2.5,10}$ (T, RH)	$249		Requires power, data logger and Wi-Fi (or co-located cell phone)	Manual data upload to website, includes download, map, trends	$PM_{2.5}$, Moderate to strong $0.68 < R^2 < 0.79$
Liveable Cities	NO_2	$569 + $309/yr		Requires power, includes cellular	Private data management and visualization software	NO_2: Moderate $0.47 < R^2 < 0.59$
Cairsens	NO_2	$1,300		Requires power	Cable connection to computer with app for data collection and visualization	NO_2: Weak, $R^2 < 0.13$
Clarity	$PM_{1,2.5,10}$ NO_2, (T, RH)	$1,200 /yr		Includes solar panel and cellular; Active support and calibration	Automatic data upload to public website (available), includes map and trends	$PM_{2.5}$: Strong $R^2 > 0.73$ NO_2: $R^2 > 0.7$ (Manufacturer)
Atmotube	$PM_{1,2.5,10}$ VOCs (T, RH, P)	$179		Requires co-located cell phone, weekly charging	Data visualization and download via cellphone app	$PM_{2.5}$, Strong $R^2 > 0.79$
Flow2	$PM_{1,2.5,10}$ NO_2, VOCs	$149		Requires co-located cell phone, daily charging	Data visualization and download via cellphone app	$PM_{2.5}$, Weak, $0.02 < R^2 < 0.22$ NO_2: Weak, $0.06 < R^2 < 0.21$

Monitor Performance Evaluation

- Methods
  - Based on field testing in USEPA Guidelines for PM$_{2.5}$
  - Data completeness
  - Accuracy: co-location with a reference monitor
    - EPC Munroe site installations
      - 11/30/2021: 2 Purple Air
      - 04/08/2022: +1 Purple Air, 1 each of Air Beam, Cairsense, Clarity, Atmotube, Flow2
    - Comparison of paired 24-hr and 1-hr averages
      - trend plots and scatterplots
      - bias (slope, intercept), linearity(R^2), error (RMSE, NRMSE)
      - drift over time
  - Precision: co-location of multiple same monitors
    - Comparison of triplicate/duplicate 24-hr and 1-hr averages
    - Trend plots and sample statistics
      - standard deviation (SD), coefficient of variation (CV)
    - Campaigns
      - 3 Purple Air at the EPC Munroe site (04/08/2022 –)
   - 3 Air Beam at a field home site (3/21/2022–5/6/2022)

Raw Performance Results: PM$_{2.5}$ (24-h average)

Accuracy

PM$_{2.5}$ Concentration (ug/m^3)

Legend:
- Regulatory Monitor
- PurpleAir
- Clarity
- Atmotube
- Flow2

Precision

Data Completeness: 100%
SD = 2.2 $\mu g/m^3$
CV = 31.9%

Legend:
- PurpleAir1
- PurpleAir2
- PurpleAir3

PurpleAir(Raw):
Intercept = -0.54
Slope = 1.00
R^2 = 0.38
RMSE = 3.38
Complete = 100%

Atmotube:
Intercept = 0.08
Slope = 0.77
R^2 = 0.41
RMSE = 1.96
Complete = 35%

Clarity(Raw):
Intercept = 0.75
Slope = 1.12
R^2 = 0.38
RMSE = 3.88
Complete = 100%

Flow2:
Intercept = 5.41
Slope = -0.05
R^2 = 0.00
RMSE = 2.04
Complete = 26%

- Generally measurements follow the reference variations, but larger range.
- Raw Purple Air, Clarity, and Atmotube data have weak accuracy over this time period.

Calibration: Purple Air and Clarity (24-h PM$_{2.5}$)
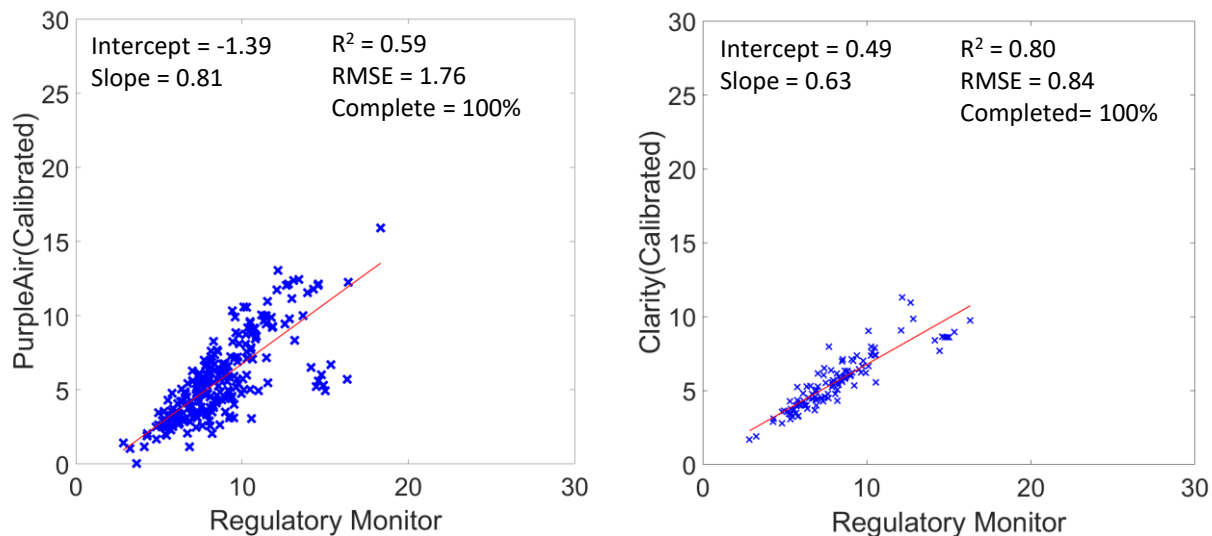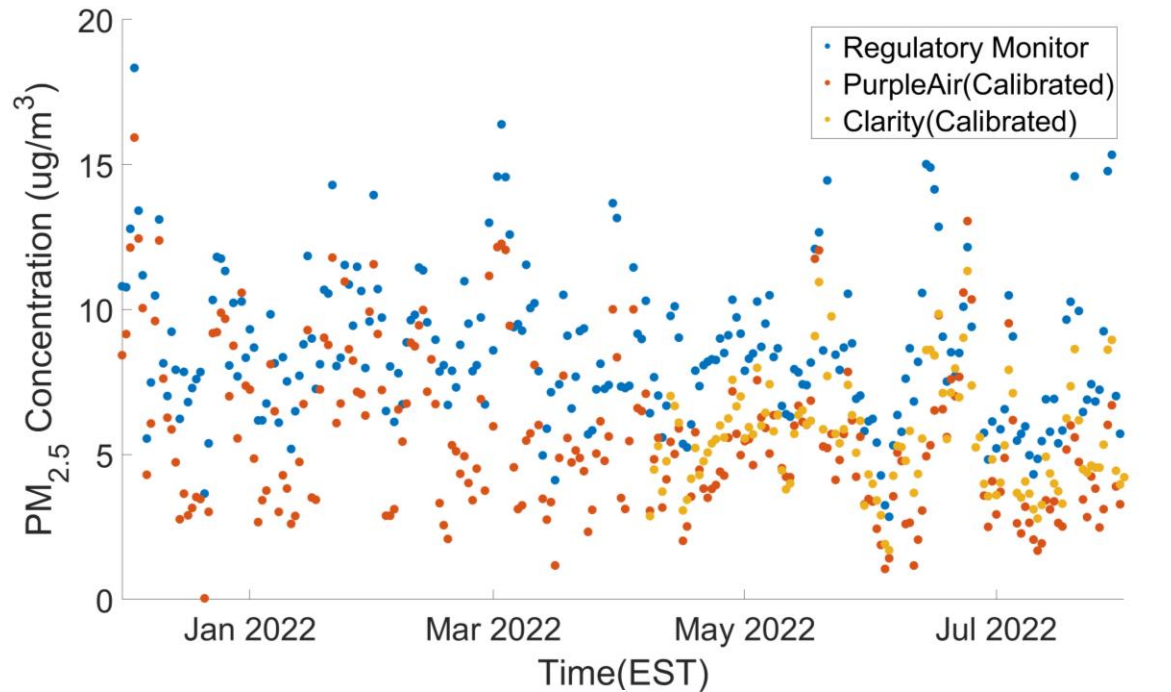
Purple air calibration equation(USEPA):

$$PM_{2.5(Calibrated)} = 0.52 \times PM_{2.5(Raw)} - 0.085 \times RH + 5.71$$

Clarity calibration equation:

$$PM_{2.5(Calibrated)} = 2.55 - 0.94PM_{1.0(raw\_mass)} + 0.89PM_{10(raw\_mass)} + 9.22PM_{1.0(raw\_num)} - 8.69PM_{10(raw\_num)} + 0.06T - 0.03RH$$

Quantity	Bias		Linearity (R²)	RMSE (μg/m³)
	Intercept	Slope (μg/m³)		
Criteria	1.0 ± 0.35	$-5 \leq b \leq 5$	≥ 0.70	≤ 7
PurpleAir (Raw)	-4.11	1.53	0.56	3.57
PurpleAir (Calibrated)	-1.39	0.81	0.59	1.76
Clarity (Raw)	0.75	1.12	0.38	3.88
Clarity (Calibrated)	0.49	0.63	0.80	0.84

- Calibration improves accuracy for both monitors.
- Calibrated data quality is moderate to good.
- Clarity performed better, but more data are needed.

Performance over time: Purple Air & Clarity (24-h PM$_{2.5}$)

Accuracy Statistics

Quantity		Bias		Linearity (R^2)	RMSE ($\mu g/m^3$)
		Intercept	Slope ($\mu g/m^3$)		
Criteria		1.0 ± 0.35	$-5 \le b \le 5$	≥ 0.70	≤ 7
PurpleAir (Calibrated)	12/1/21 – 01/31/22	-3.66	1.15	0.86	1.23
	6/1/22 – 7/31/22	0.37	0.51	0.40	1.99
Clarity (Calibrated)	4/8/2022 – 5/31/2022	0.15	0.67	0.79	0.73
	6/1/2022 – 7/31/2022	0.55	0.61	0.80	0.97

- Performance degrades substantially over time
- A regular maintence protocol will be needed.

1st 2 months
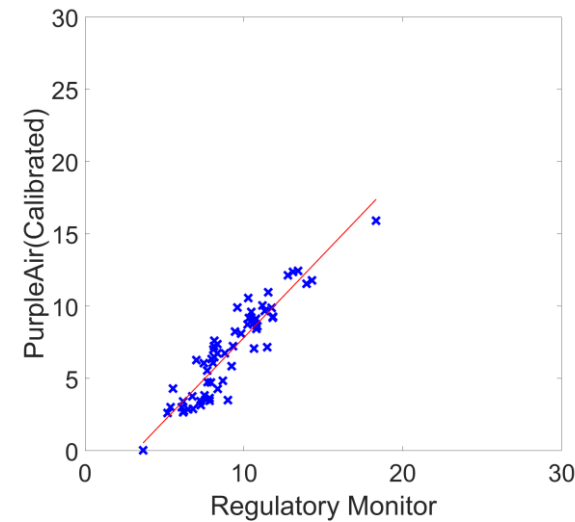
Last 2 months
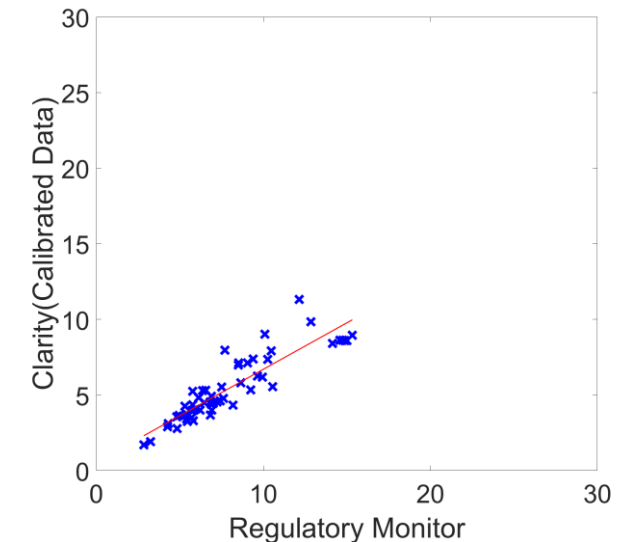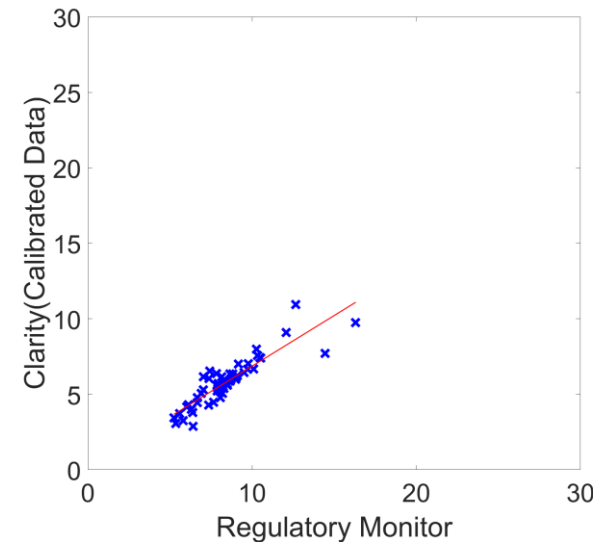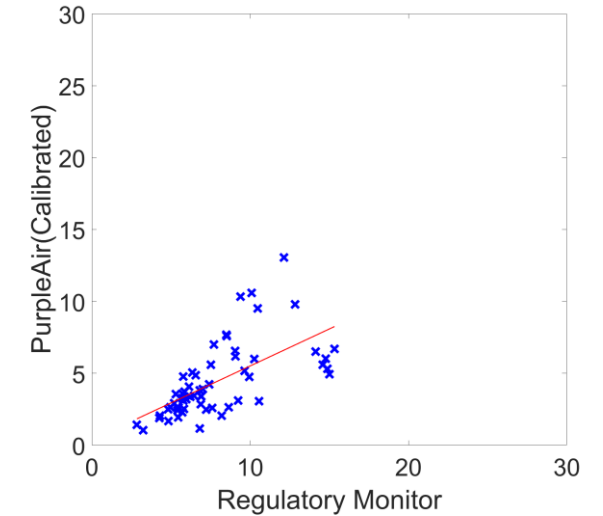
Preliminary performance results: NO$_2$ (1-h average)
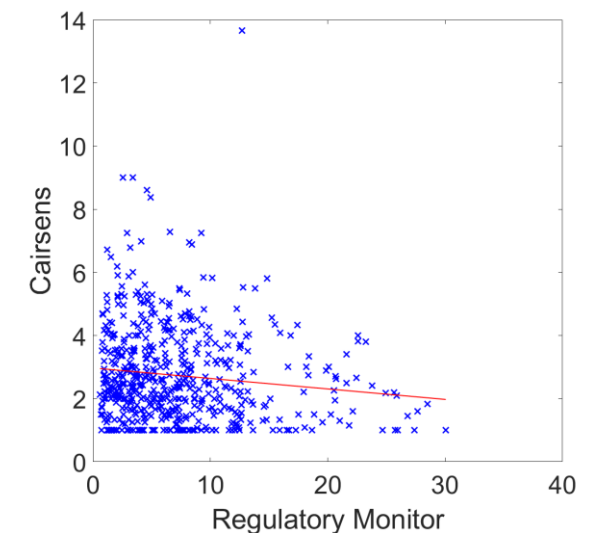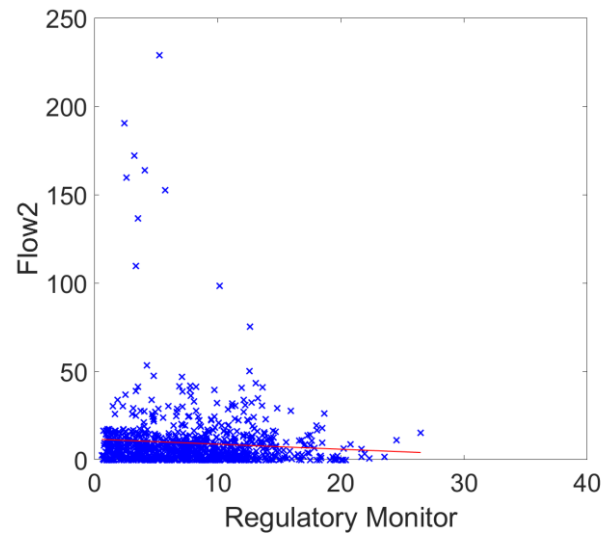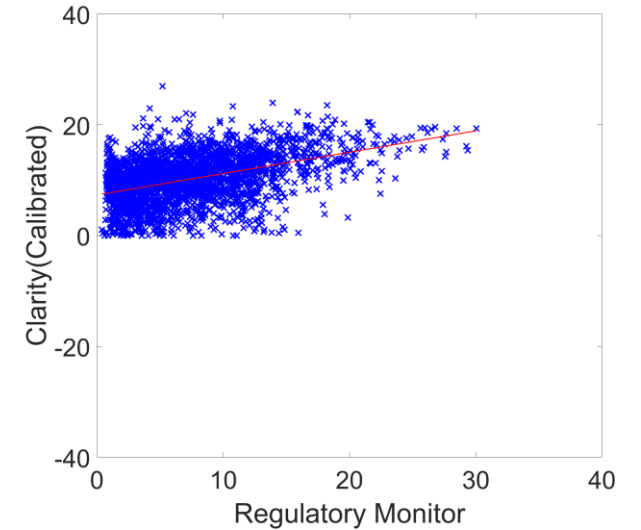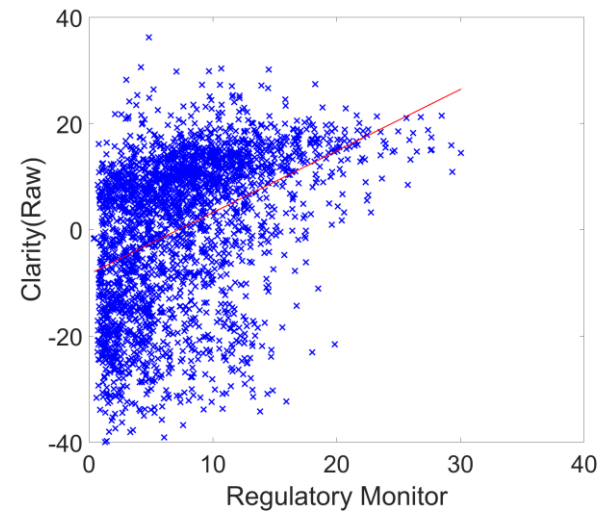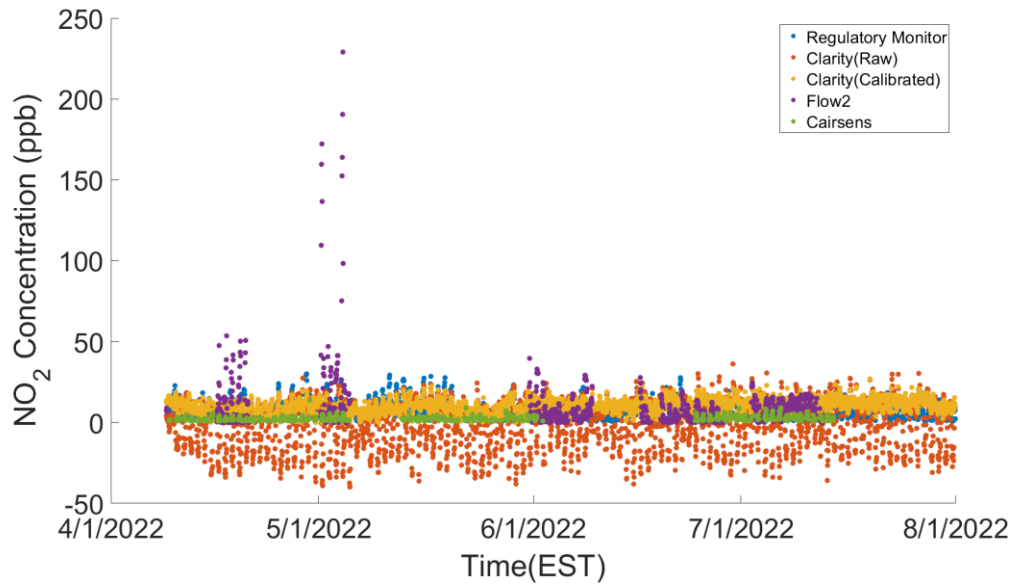
Quantity	Data completeness	Bias		Linearity (R²)	RMSE (ppb)
		Intercept	Slope		
Clarity (Raw)	100%	-8.37	1.16	0.17	13.1
Clarity (Calibrated)	100%	7.34	0.39	0.20	3.92
Flow2	40%	11.7	-0.29	0.01	17.9
Cairsens	26.5%	2.97	-0.03	0.01	1.51

Community site pilot monitor installation equipment

- Purple Air PM monitors
  - New Mount Zion Baptist Church
  - Tampa Heights Junior Civic Association
  - Seminole Elementary School

- Clarity monitors (NO$_2$ + PM)
  - Seminole Elementary School
  - Tampa Heights Junior Civic Association
  - Saunders Library
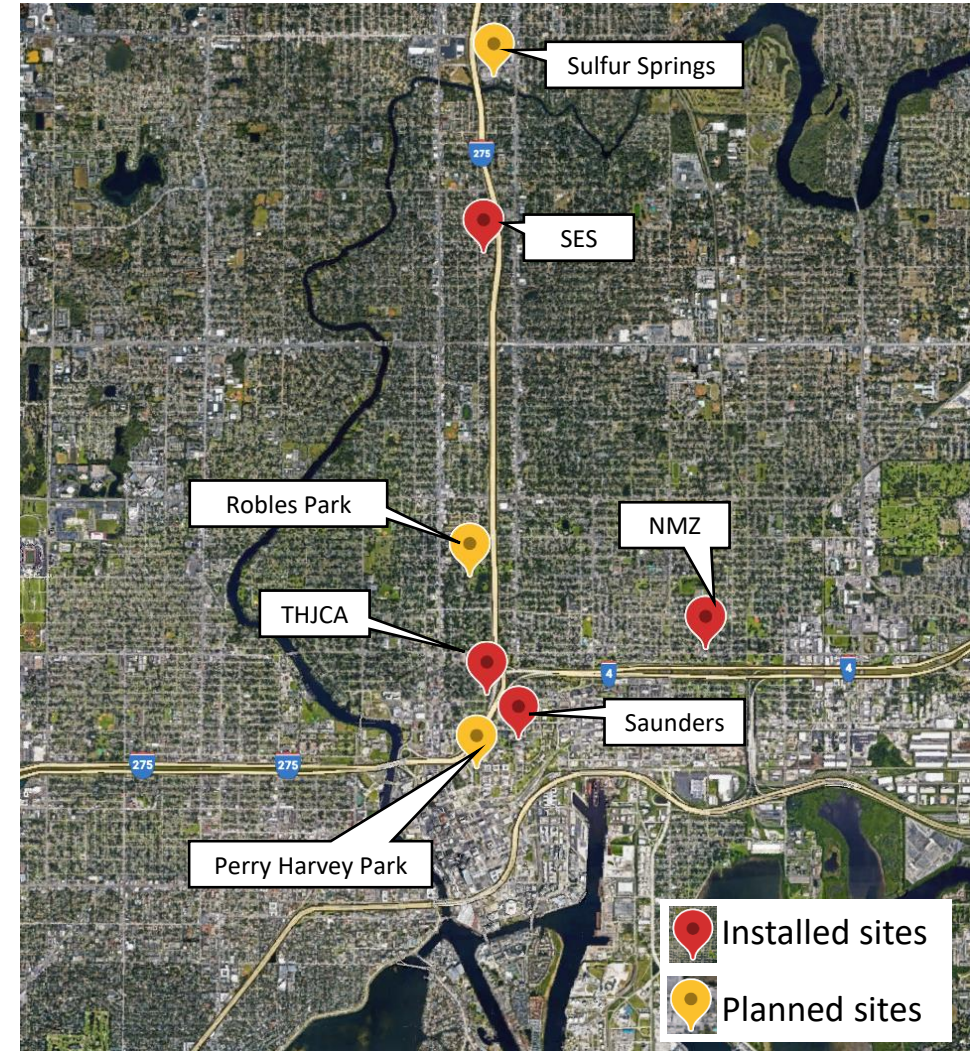
Community site data access

- Project website link
  - https://planhillsborough.org/low-cost-air-quality-monitoring-pilot-study/
- Links to the data.
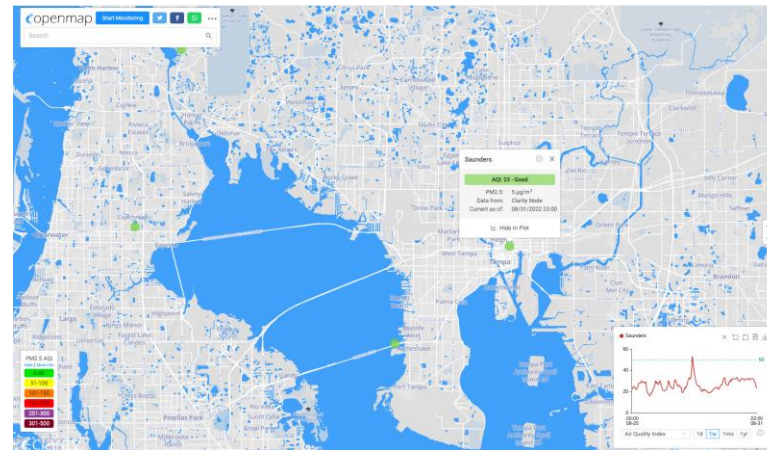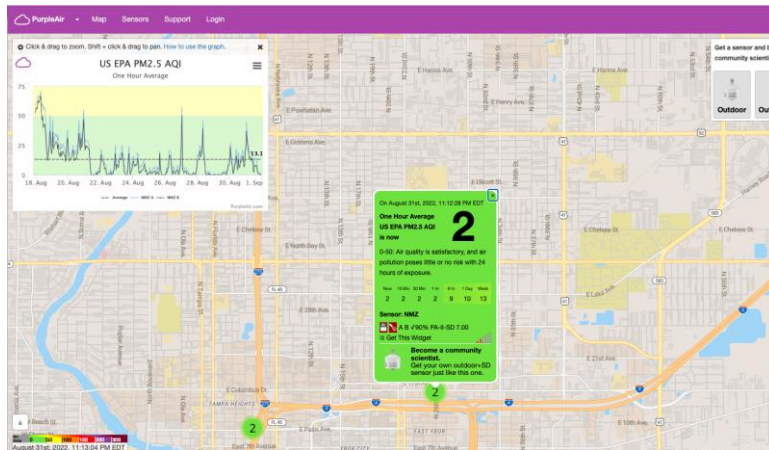
Low-Cost Air Quality Monitoring Pilot Study

Community Air Monitoring Sites

The Low-Cost Air Quality Monitoring Pilot Study established Community Air Monitoring Sites to help communities and governments understand the air quality where people live, work, learn and play. Community sites host a small, affordable air monitor (e.g. PurpleAir monitors) that measure air pollutants. Monitors were also tested at a government regulatory air monitoring site to make sure the data is accurate and reliable.

Click the links below to view air quality data from the Community Air Monitoring Sites on the PurpleAir Map*

New Mount Zion Missionary Baptist Church (NMZ)

Seminole Heights Elementary School (SeminoleES)

Tampa Heights Junior Civic Association (THJCA)

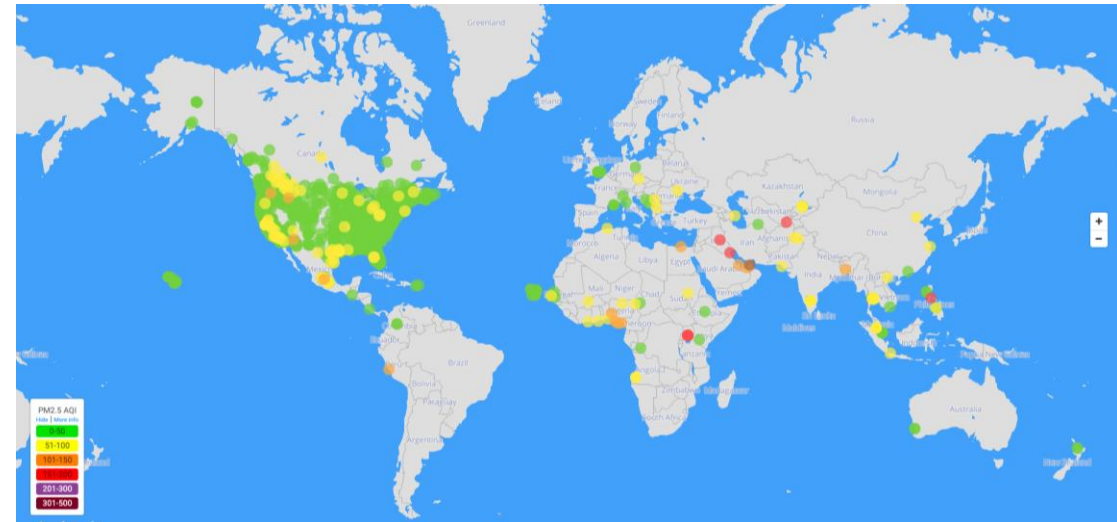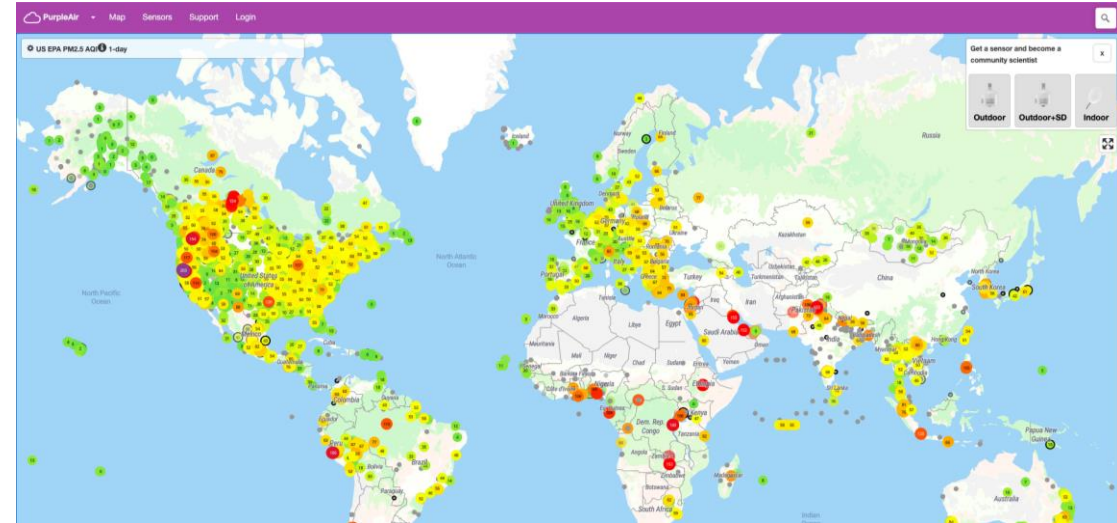*If the sites do not show up change your settings on the map. Set "Averaging period" to "1-hour" and set "Reporting or modified within" to "All-time."
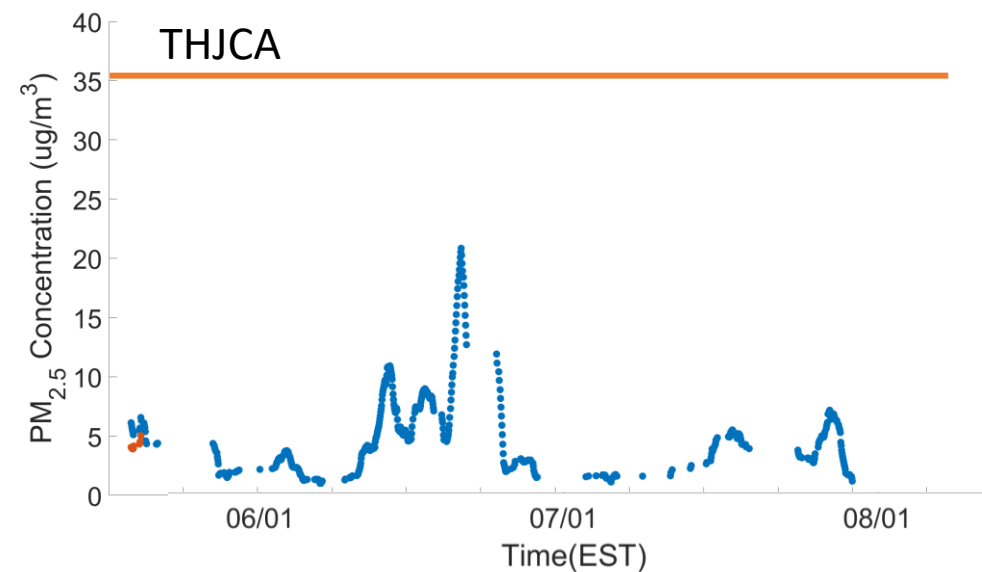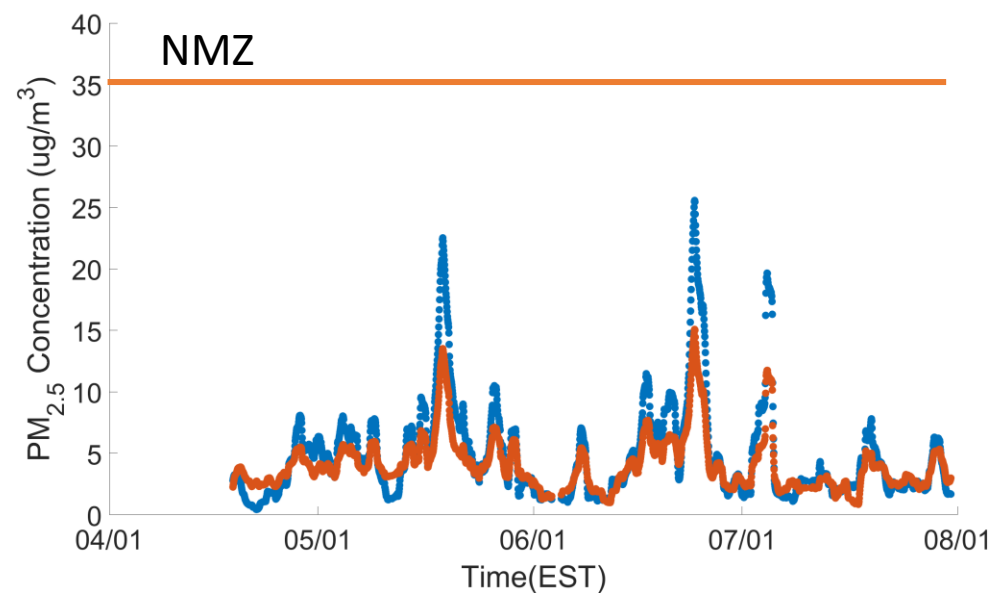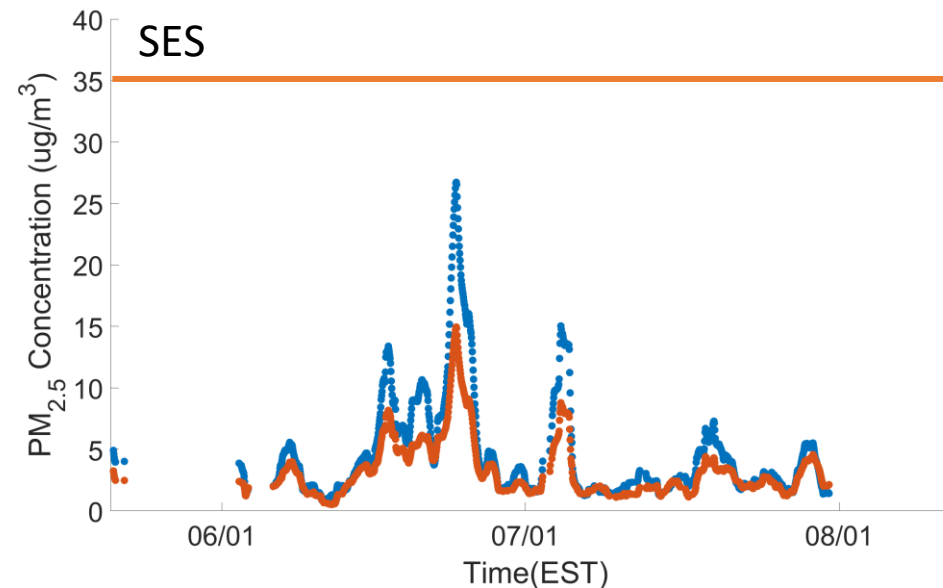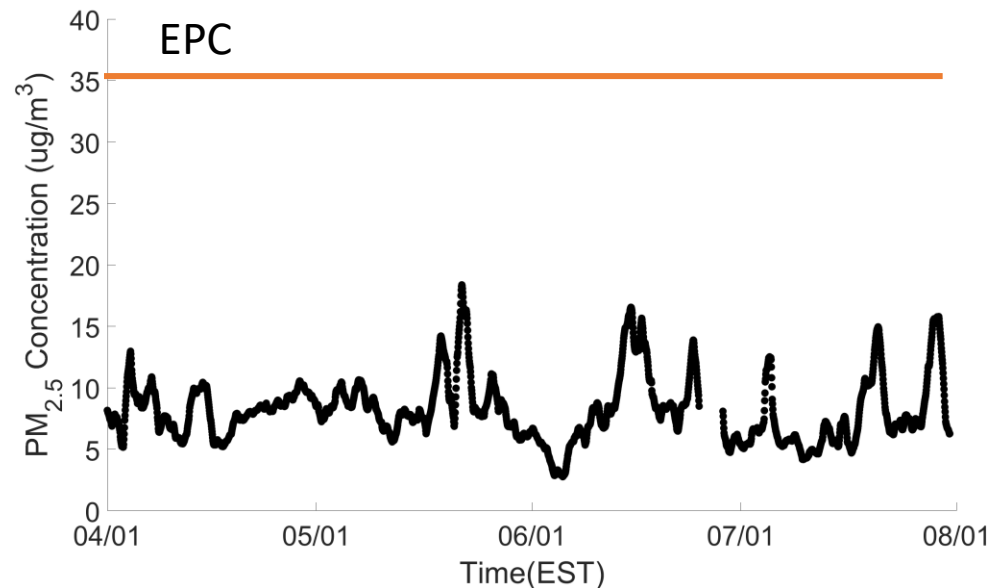
Accessing Purple Air data

- PurpleAir Map
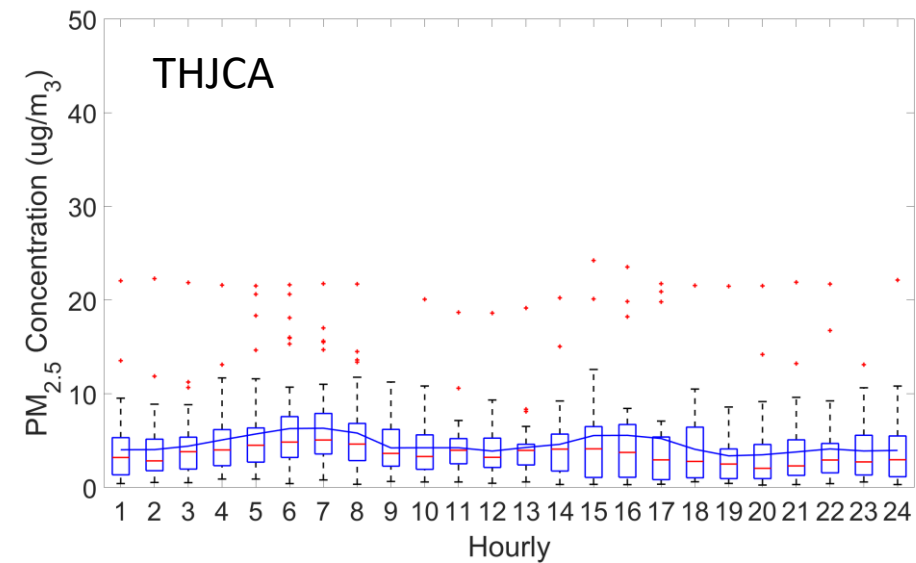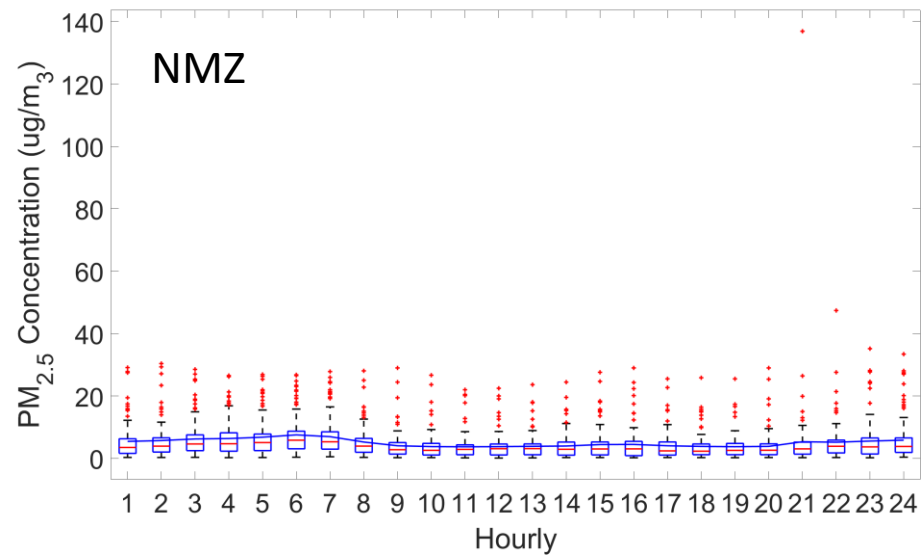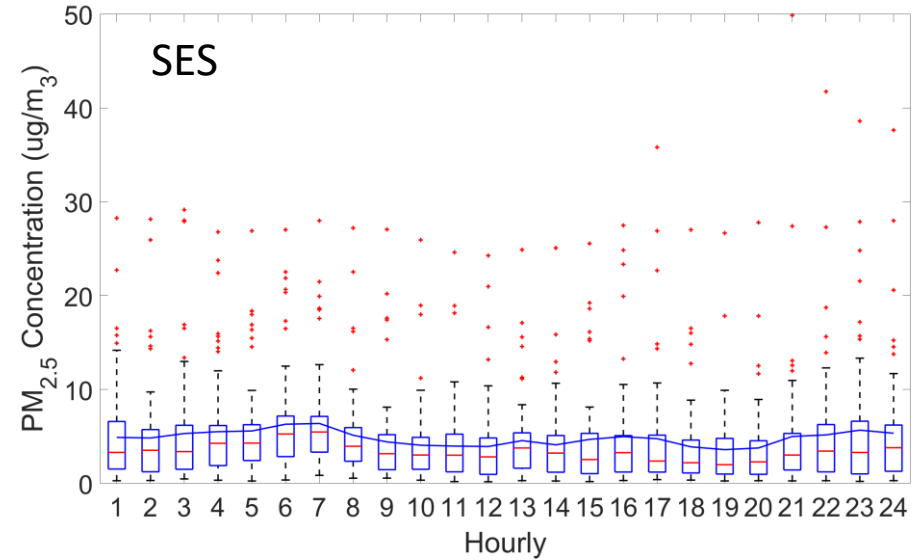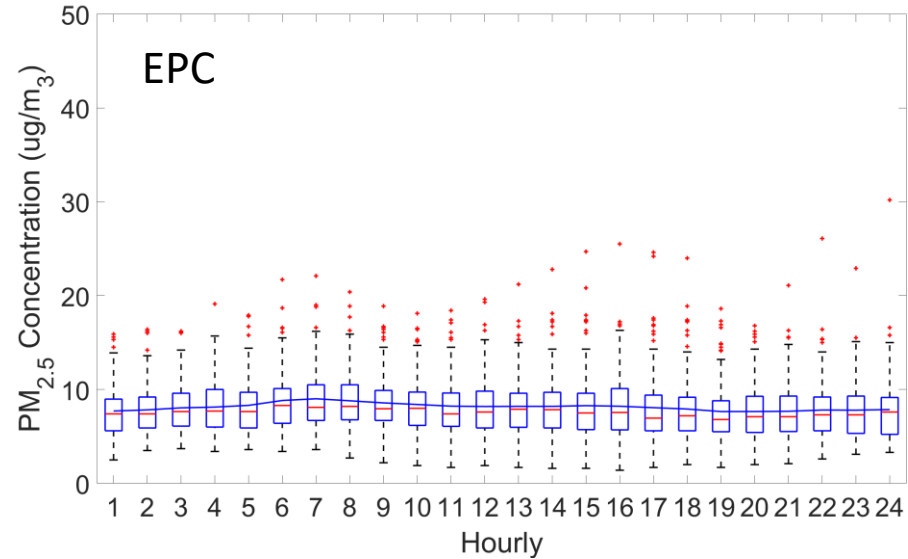 - https://map.purpleair.com/

Accessing Clarity data

- Clarity Map
  - https://openmap.clarity.io/

- US EPA Air Quality Index
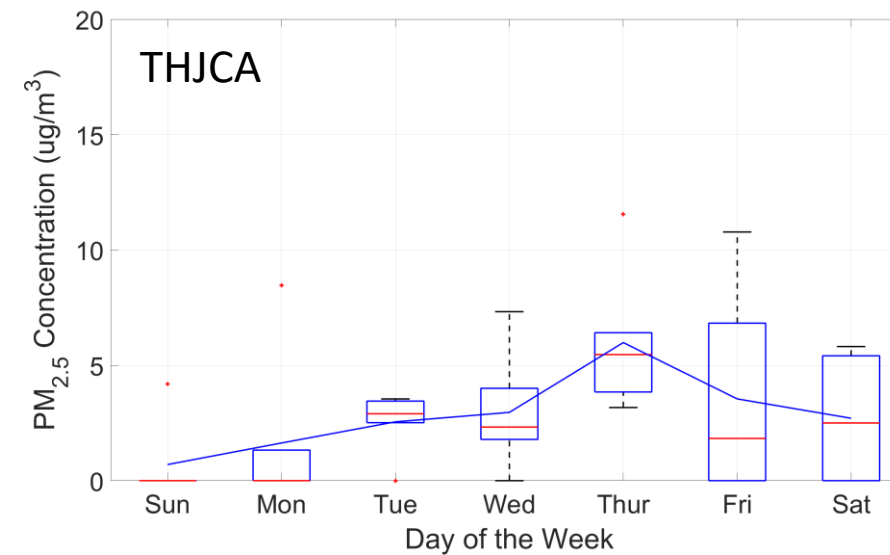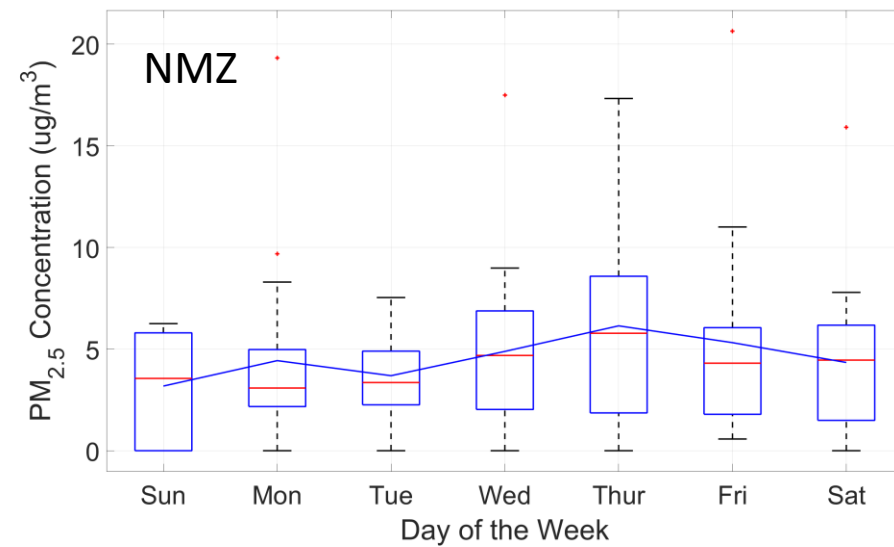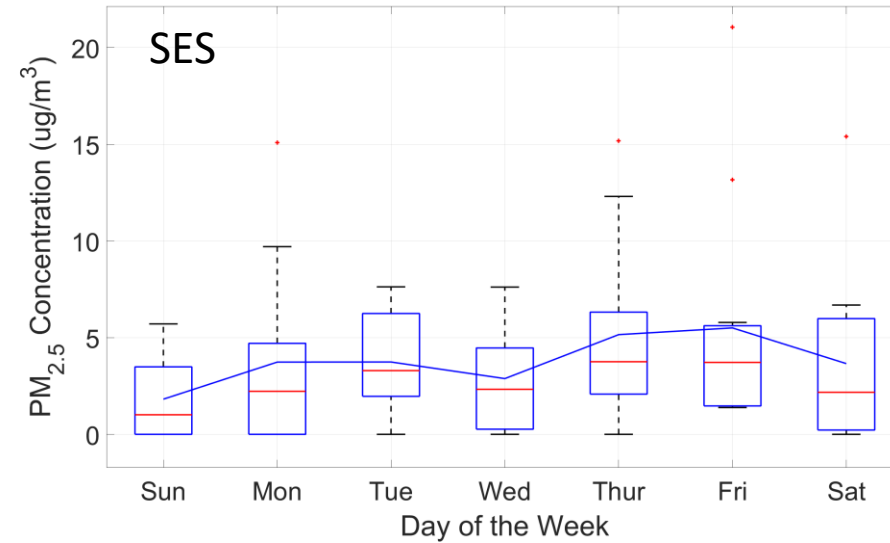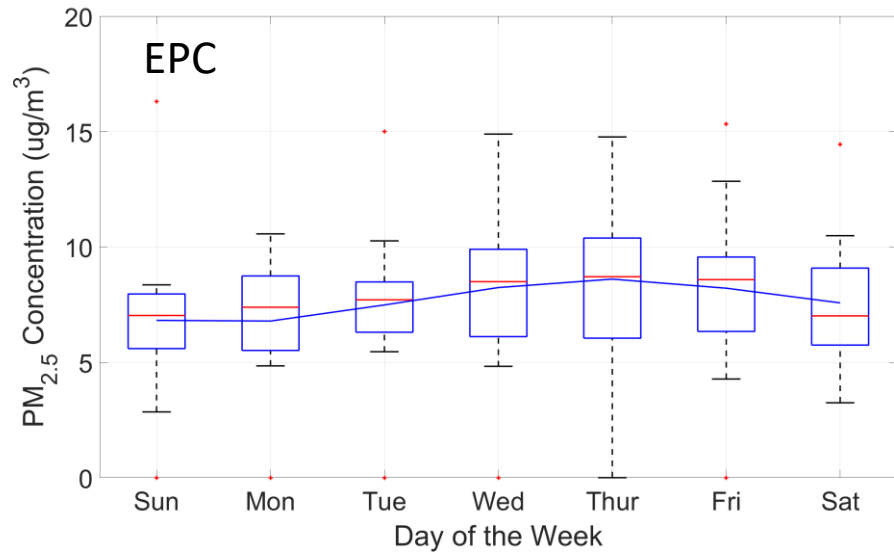 - https://www.airnow.gov/aqi/aqi-basics/

First look at community data: Purple Air PM$_{2.5}$

Community data: Diurnal cycle – PM$_{2.5}$

Community data: Weekly cycle – PM$_{2.5}$

Current conclusions

- Community air quality doesn't appear to exceed standard levels for the time period studied, but more analysis of variations and comparisons are needed
- Truly low cost and easy to use monitors that provide public data remain limited.
  - Clarity is very facile to install and provides both $PM_{2.5}$ and NO_2
  - Purple Air also for $PM_{2.5}$, but power and wifi requirements have been limiting
  - The Livable Cities NO_2 (and PM) monitors may be worth testing – they integrate with the streetlight system for power.
- Initial and ongoing calibration of network will need to be designed.
  - PM2.5 data degrade over time
  - NO_2 data have lower quality, initial calibration of each Clarity monitor at the EPC site is needed for a 2-month period prior to future installations
  - Novel methods of ongoing multi-variate statistical calibration of network data is likely needed.
- Results show promise for widespread community monitoring and data sharing, but sustainable network will take further development.

Next steps

- Continued monitor testing and evaluation (longer time periods)
- Develop data calibration methods, especially for NO_2 monitors
- Additional community monitor installations
- Community learning on data interpretation
- Develop ongoing engagement materials (presentations, website, videos)
- Develop methods and instruments for studying engagement/empowerment (surveys, focus group questions)

Thanks for your attention

Q & A