

PSCAA: Air Sensors



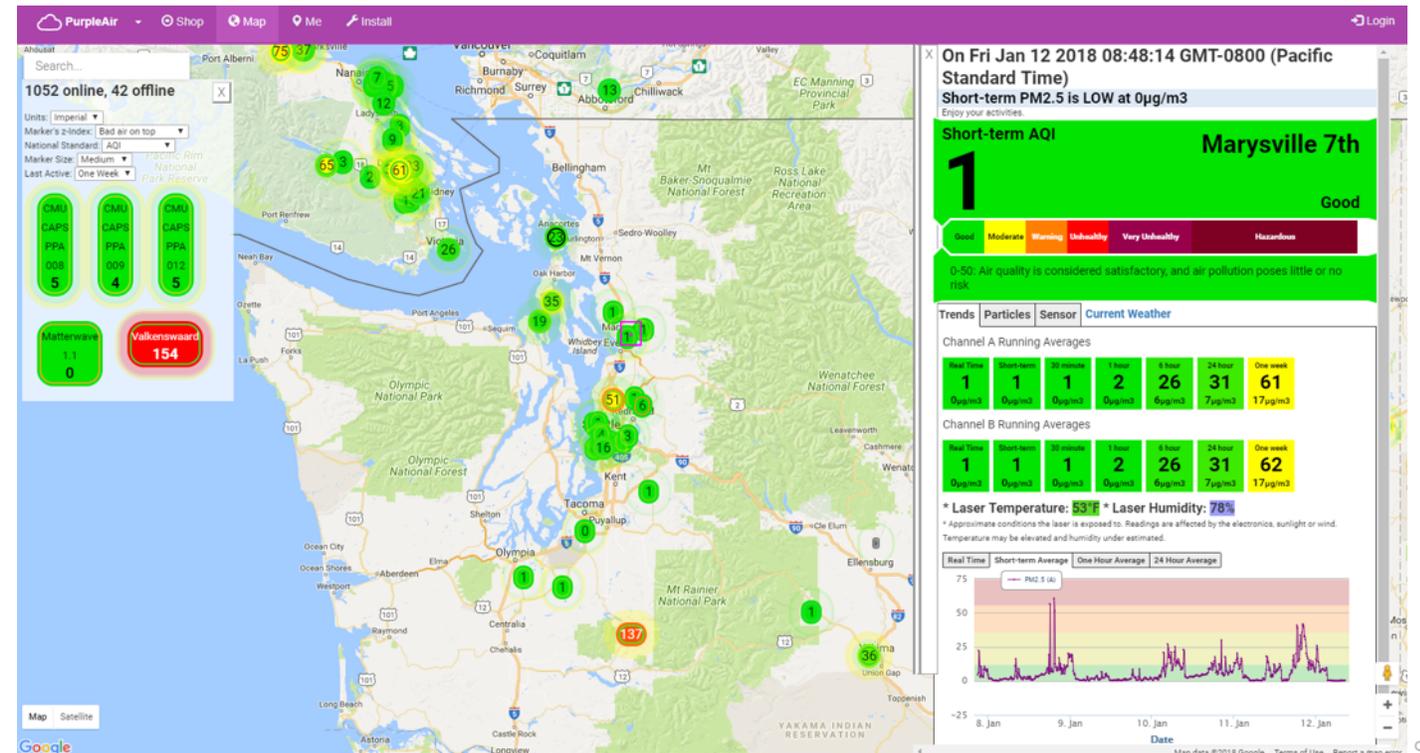
Graeme Carvlin

Overview

- 1. Purple Air collocation**
- 2. Purple Air as a low-cost monitoring tool for network use**
- 3. Lending library and community reporter project**

Purple Air Experiment

- 3 Sites (Marysville, Duwamish, Tacoma South L)
- Data from 12/6/17 to 4/4/18



Comparison to Nephelometer and FEM TEOM

- TEOM ~ Purple Air + RH + Temp
- Hour / day time scale (averaged over 3 sites)

- CF=1

	PA to TEOM	PA to Neph	Neph to TEOM
Correlation	0.91 / 0.96	0.94 / 0.98	0.95 / 0.98
Slope	0.52 / 0.52	0.48 / 0.49	1.08* / 1.05
Intercept	2.01 / 0.79	4.14 / 2.50	-2.35* / -0.36

- Purple air reads ~1.8 times higher
- Purple air correlation with TEOM is close to the correlation between the neph and TEOM

*Neph has already been calibrated to Partisol

Performance Criteria

EPA Air Sensor Toolbox: Suggested Performance Goals for Air Sensors

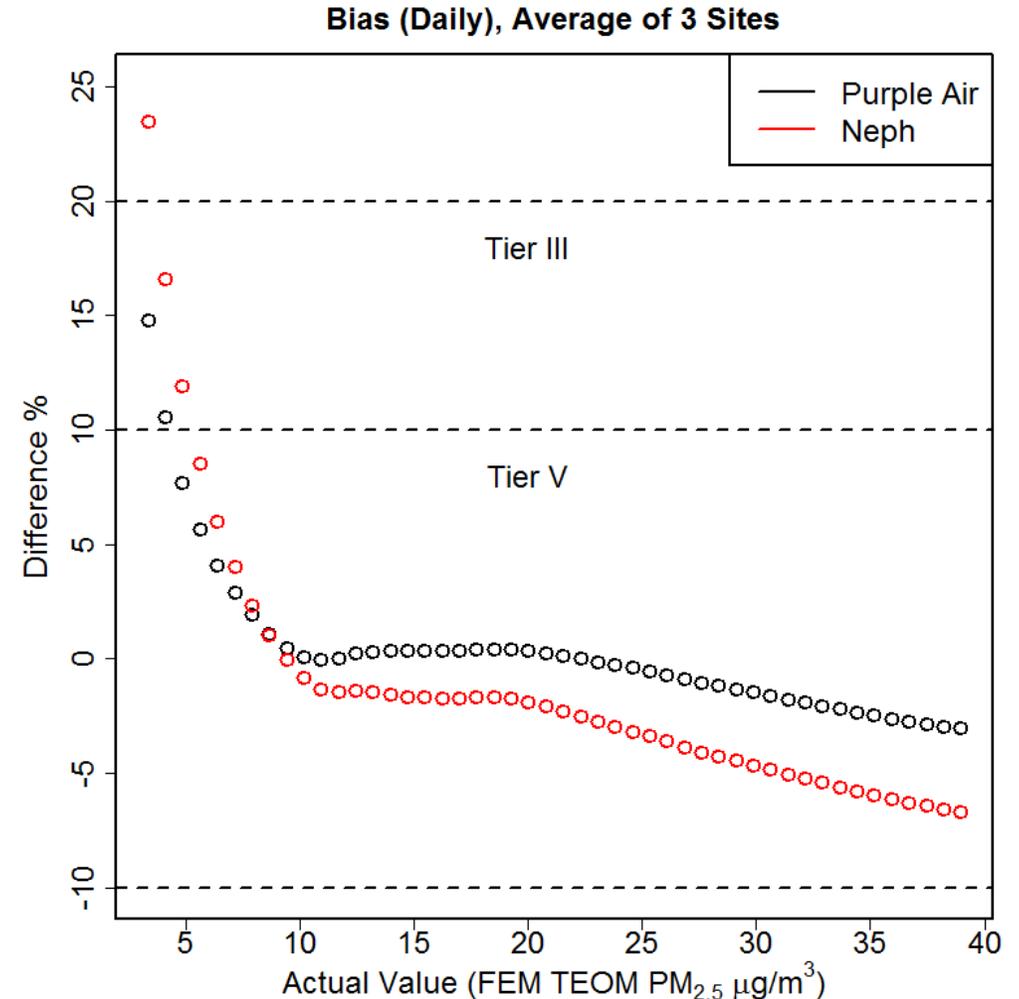
Tier	Name	Precision/Bias %	Data Completeness %
I	Educational	50	50
II	Hotspot identification	30	75
IV	Personal monitoring	30	80
III	Supplemental monitoring*	20	75
V	Regulatory monitoring	10	75

* “Supplemental monitoring might have value in potentially providing additional air quality data to **complement existing monitors**. To be useful in providing such complementary data, it must be of sufficient quality to ensure that the additional information is helping to “**fill in**” **monitoring gaps** rather than making the situation less understood.”

Link: <https://www.epa.gov/air-sensor-toolbox/how-use-air-sensors-air-sensor-guidebook>

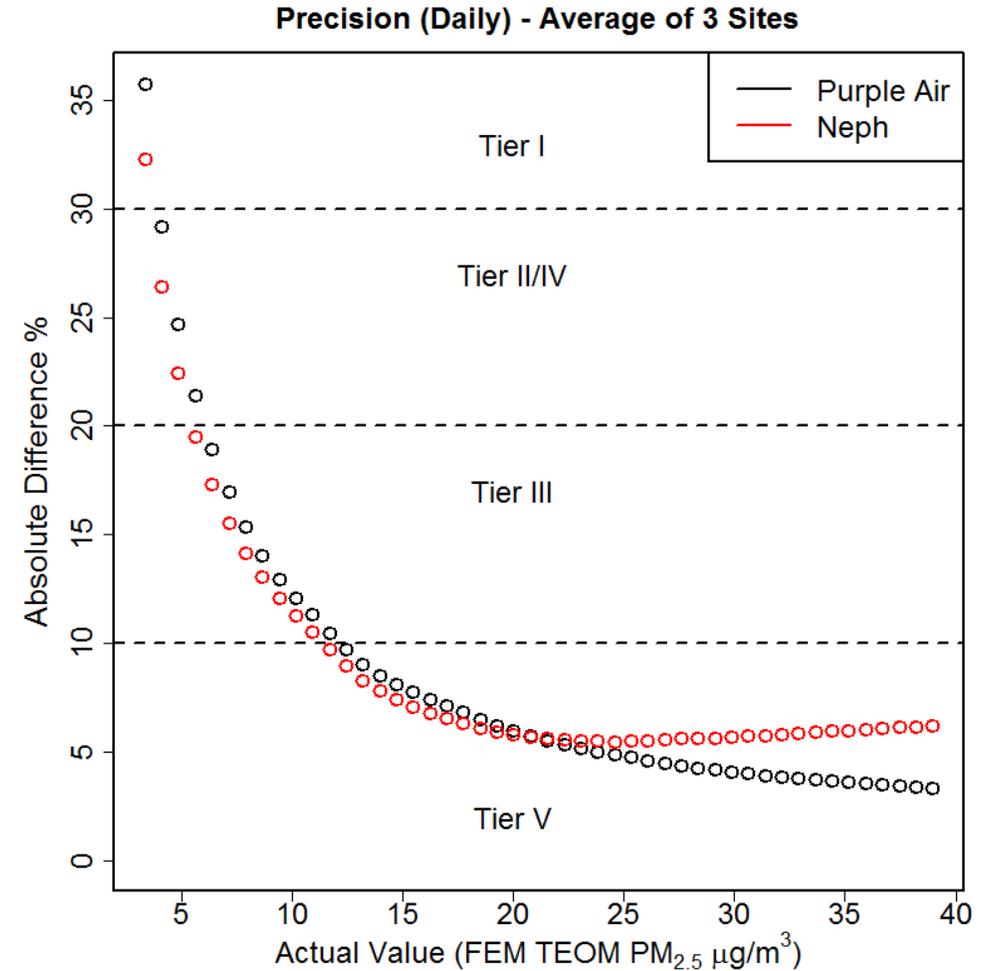
Bias

- $100 * (\text{Purple Air} - \text{TEOM})/\text{TEOM}$
- X-axis starts at $3 \text{ ug}/\text{m}^3$
- Calibrated Purple Air and neph read higher than TEOM at low concentrations and lower at high concentrations
- Meets Tier III criteria from $\sim 4 \text{ ug}/\text{m}^3$ to max measured and Tier V criteria from $\sim 6 \text{ ug}/\text{m}^3$ to max measured



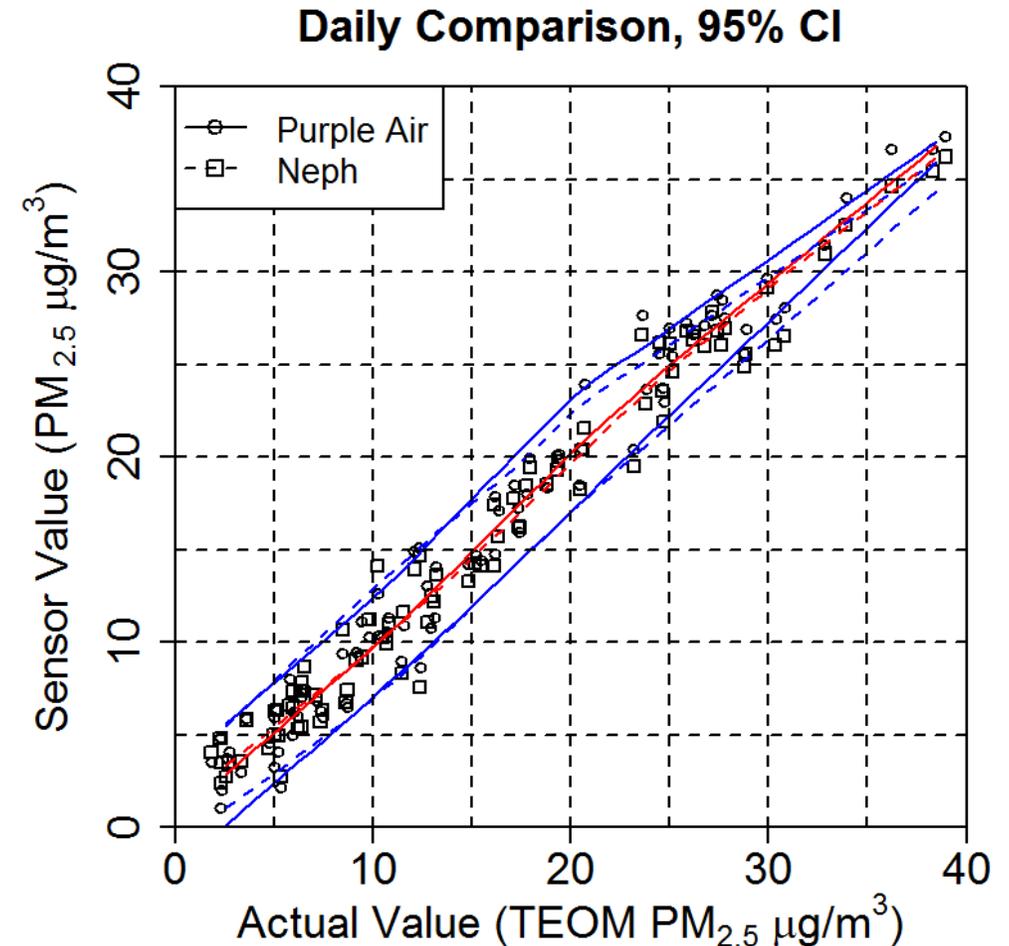
Precision

- $100 * \text{abs}(\text{Purple Air} - \text{TEOM})/\text{TEOM}$
- X-axis starts at $3 \text{ ug}/\text{m}^3$
- Meets Tier III criteria from $\sim 7 \text{ ug}/\text{m}^3$ to max measured



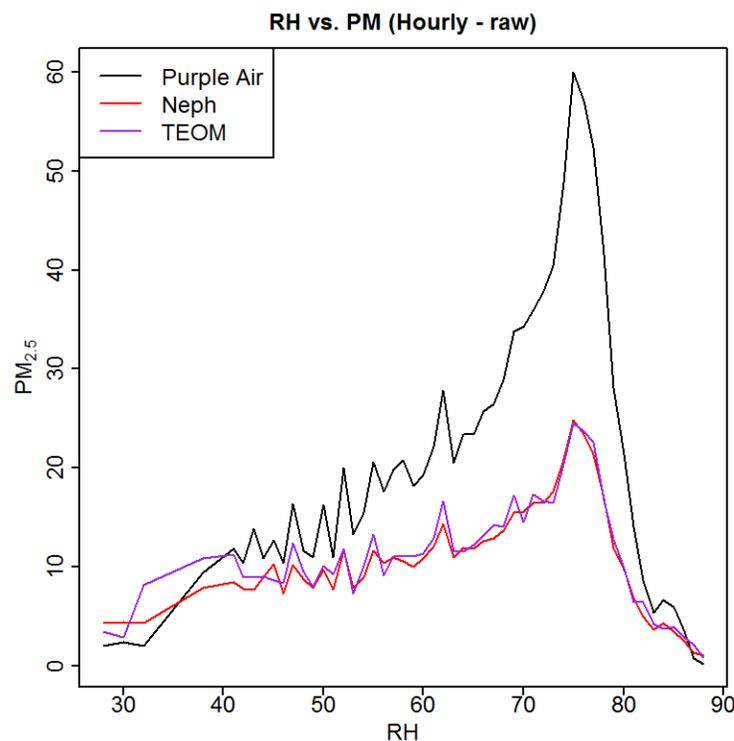
Daily Comparison with 95% Confidence Intervals

- Solid lines are Purple Air, dashed lines are the neph. Circles are PA, squares are neph
- The red lines are the mean, the blue lines are the 95% CIs
- If the TEOM says the $PM_{2.5}$ concentration is $10 \mu\text{g}/\text{m}^3$, 95% of the time the Purple Air or Neph will report 7 to 13 $\mu\text{g}/\text{m}^3$
- If the TEOM says the $PM_{2.5}$ concentration is $30 \mu\text{g}/\text{m}^3$, 95% of the time the Purple Air or Neph will report 27 to 31 $\mu\text{g}/\text{m}^3$

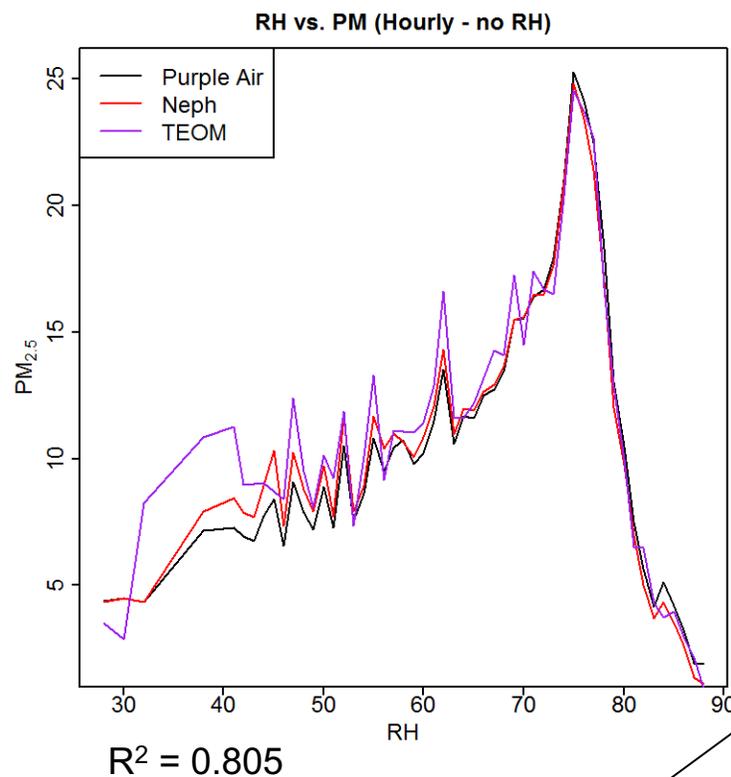


Effect of RH

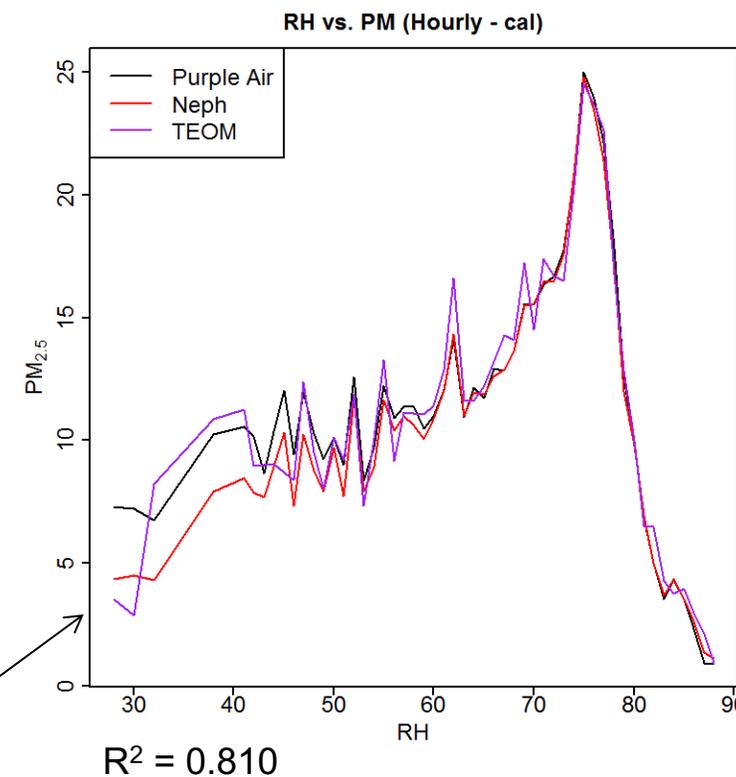
Raw Purple Air



Purple Air Calibrated to TEOM No Temp/RH



Purple Air Calibrated to TEOM And Temp/RH



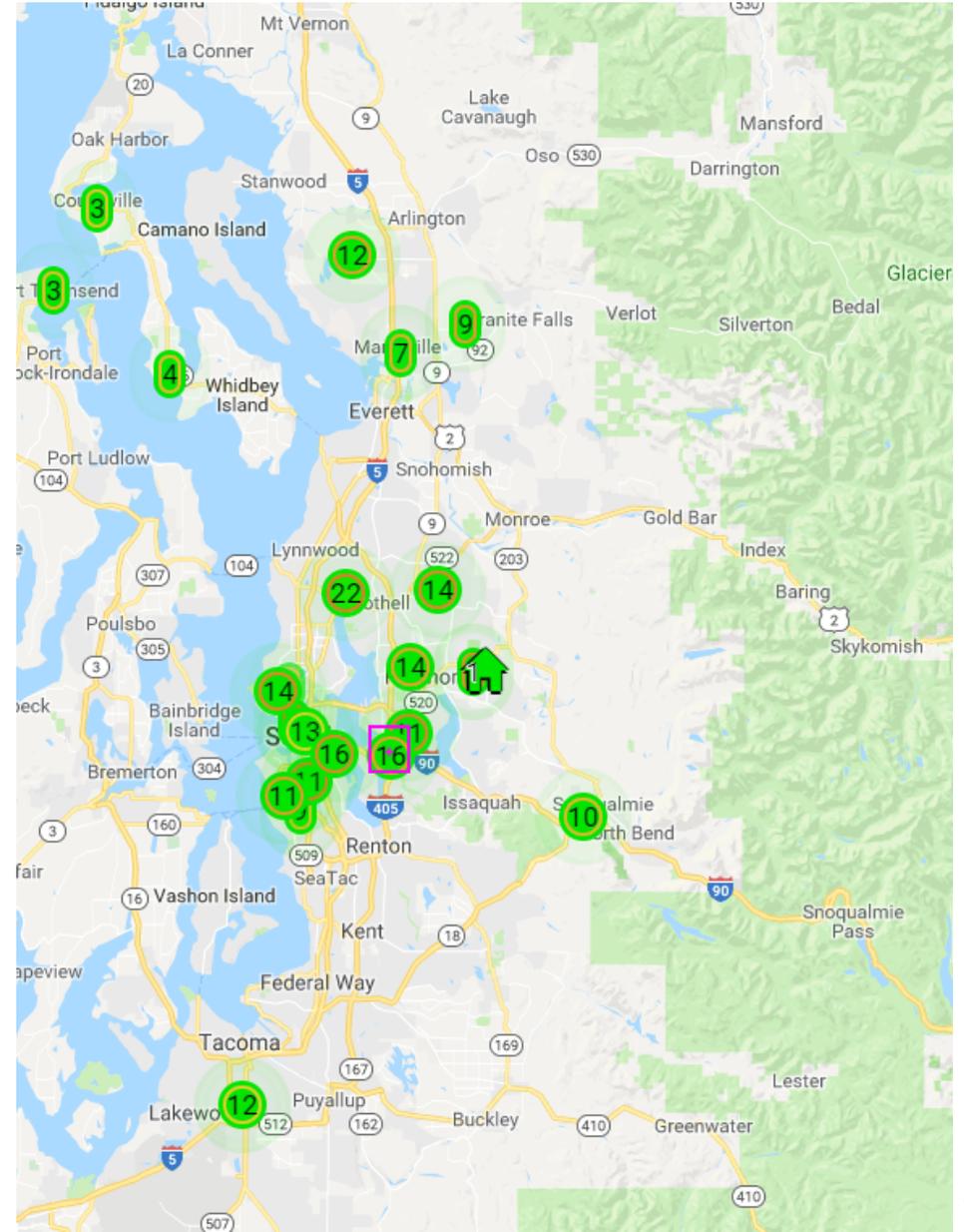
- The addition of RH to the model helps accuracy at low-med RH (30-50%)

Summary

- **Purple Air is very highly correlated to neph and highly correlated to TEOM**
- **Purple Air performs similarly to neph in terms of bias and precision**
- **May be useful in supplemental monitoring as well as education, exploratory analyses, and micro-scale monitoring**
- **Caveats**
 - **Upper limits? (>80 ug/m³ hourly)**
 - **Reliability over time in the field**
 - **Limited amount of data**
 - ▲ **Seasonality**
 - ▲ **Differences by site**

PA Network - Current

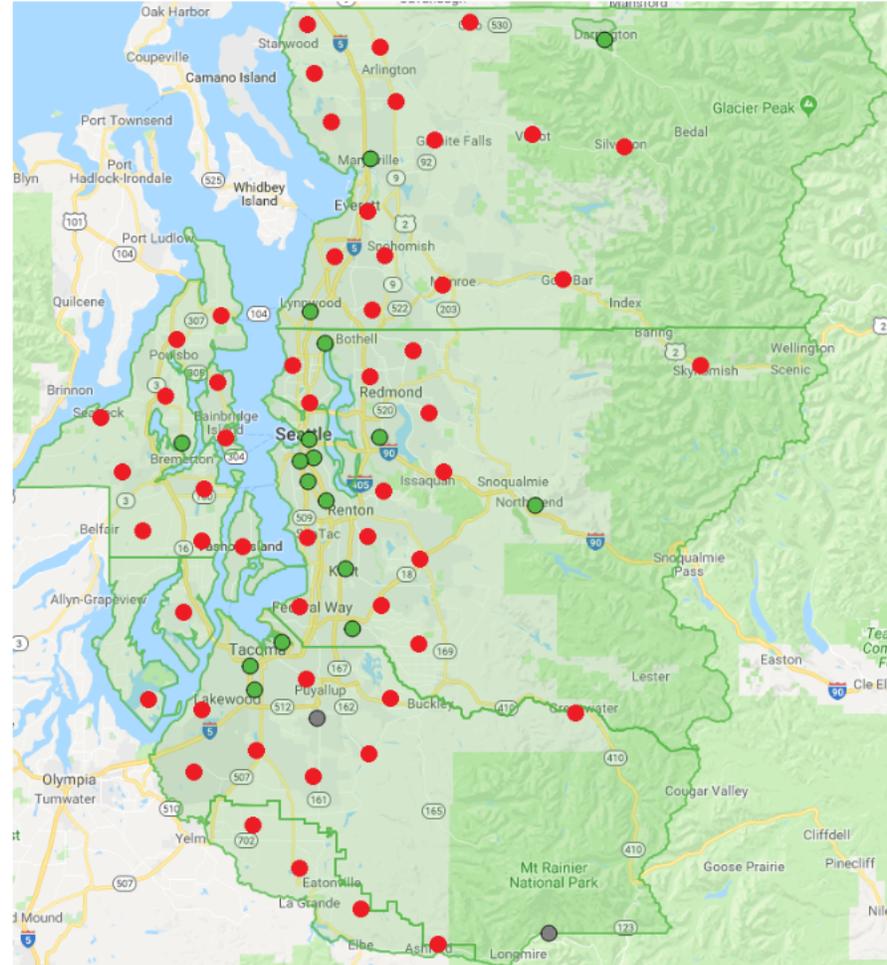
- 18 PA monitors as of 6/6/18 within our jurisdiction



PA Coverage - Future

- **Based on high density PA networks (Salt Lake City, LA) a 4-mile range may be able to be covered by one monitor**
 - Calibration zones defined by topography, meteorology and source characteristics
- **Partnering with other groups for sites**
- **Or asking owners to provide information to approve their monitors so they could be used on our sensor map**

4-mi coverage

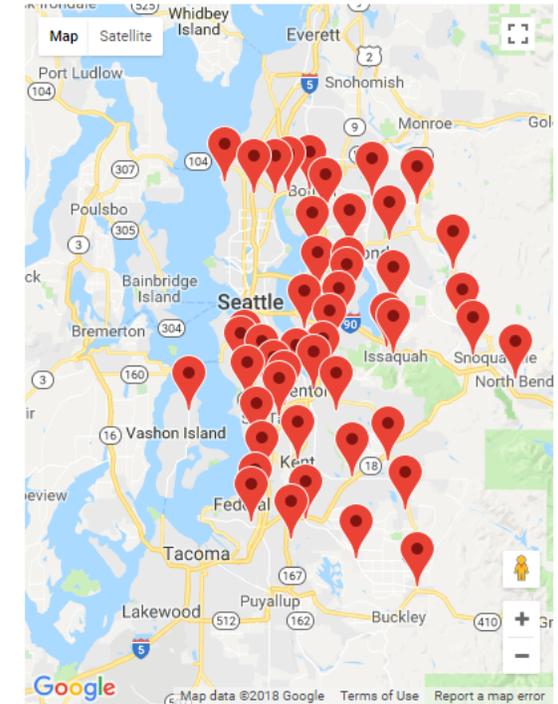


King County Library Locations

55 sites

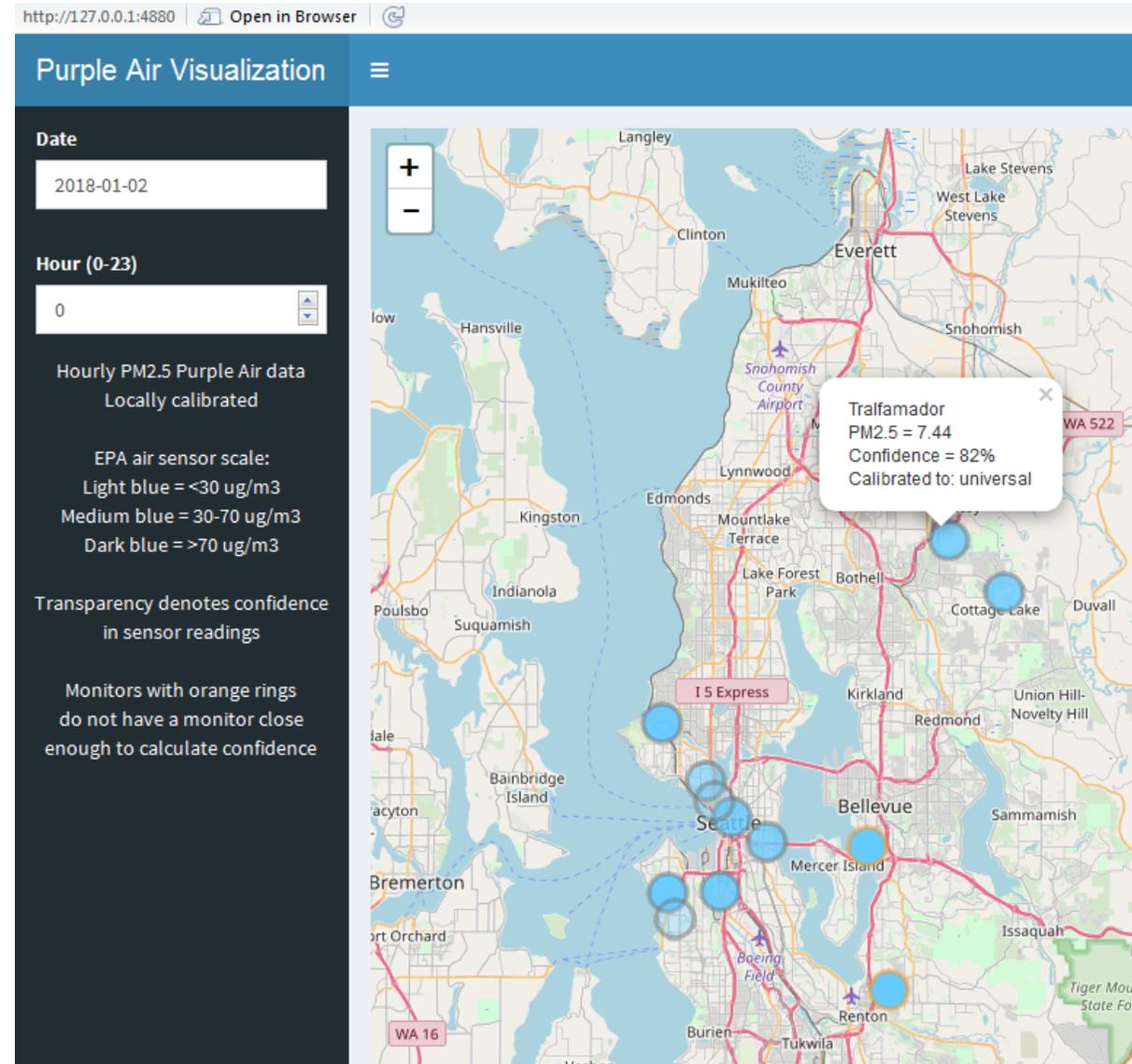


+10 collocations



PA Adjustment Website

- Website showing calibrated sensor data
 - Calibrated to nearest site if close, otherwise calibrated to the average within a window
- Confidence ratings
 - Intra- and inter-monitor
- EPA sensor scale



Lending Library

- **Loan out monitors to community groups and individuals**
 - 10x Dylos, Air Beams, Purple Air
- **Questionnaire to collect information about monitor use**
- **Guidance for monitor operation and how to analyze data**
 - Appropriate guidance for people of all technical skill levels



Community Reporter

- **A tool to help citizen scientists create useful reports from monitoring data**
- **Gets over the barrier of having to manipulated “messy” data**
- **Requires a moderate level of technical skill**

1. Input Data

- Upload data
- Select monitor type
- Add monitor name
- Add lat, lon

The screenshot shows the 'Community Reporter' web application interface. The browser address bar indicates the URL is `http://127.0.0.1:5224`. The application title is 'Community Reporter'. A sidebar on the left contains navigation links: 'Instructions', '1. Input', '2. Visualize', and '3. Report'. The main content area is titled 'Input' and is divided into two sections:

1. Select Data Files

File Name	Monitor	Site	Remove
test.csv	Dylos	Duwamish	X

Below the table, there are input fields for 'Add File' (with a 'Browse...' button and 'No file sel' text), 'Monitor' (a dropdown menu set to 'Dylos'), 'Site' (a text input field with 'Duwamish'), and an 'Add' button.

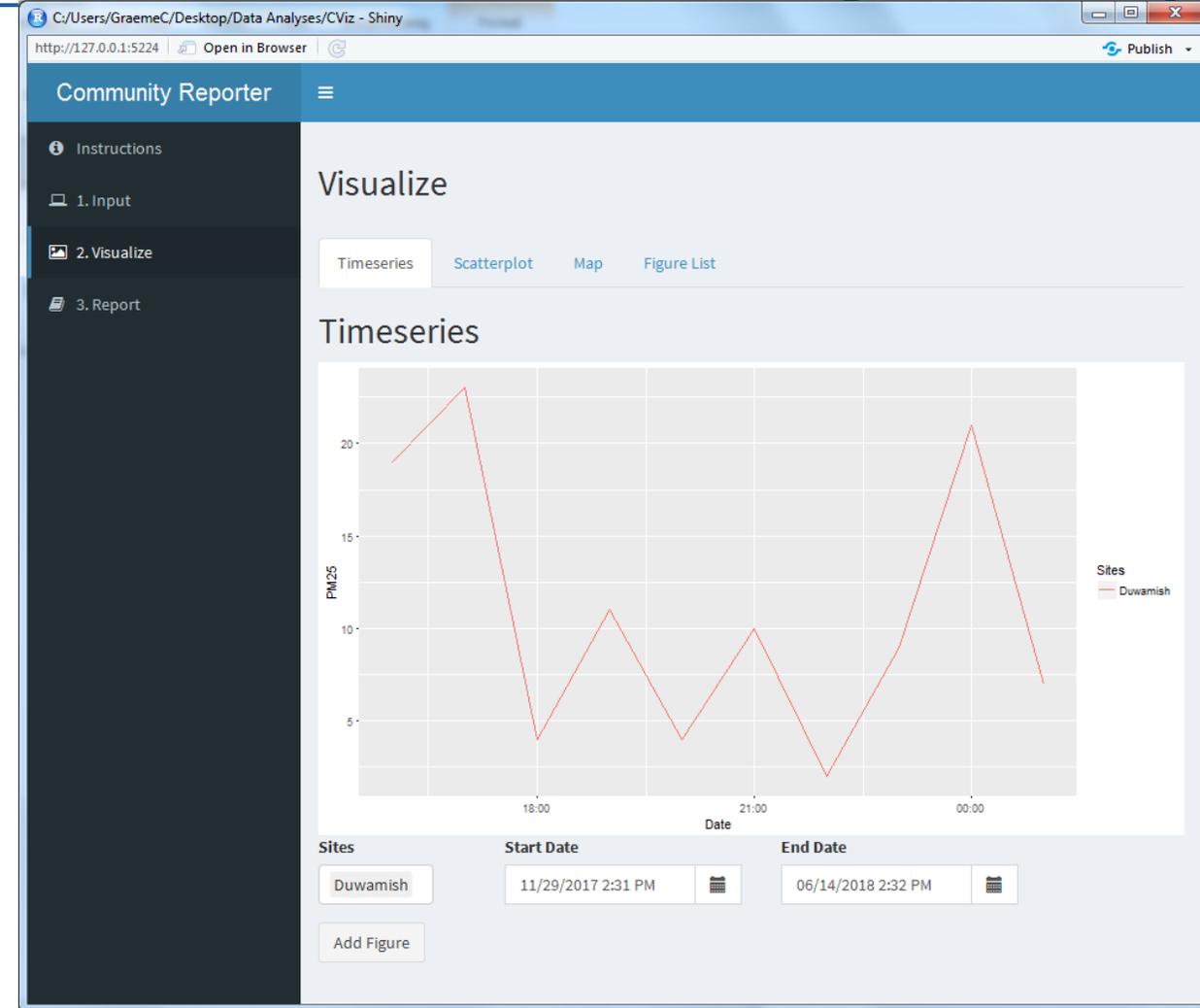
2. Add Location Information (Optional)

Site	Start Date	End Date	Latitude	Longitude	Remove
No data available in table					

Below the table, there are input fields for 'Site' (a dropdown menu set to 'Duwamish'), 'Start Date' (a date picker), and 'End Date' (a date picker). Below these are input fields for 'Lat' (with placeholder 'xx.xxxxxx') and 'Lon' (with placeholder 'xx.xxxxxx'), and an 'Add' button.

2. Create Graphs

- Add timeseries, scatterplots, maps
- Could be automatically picked based on study design
 - i.e. A study looking at pollution near a source would have a map



The screenshot shows the 'Figure List' interface. It has tabs for 'Timeseries', 'Scatterplot', 'Map', and 'Figure List'. The 'Figure List' tab is active, displaying a table with the following data:

Figure	Type	Sites	Start Date	End Date	Remove
2	timeseries	Duwamish	11/29/2017 2:31 PM	06/14/2018 2:32 PM	X

3. Report

- Add text describing what was done and explaining the figures
- Click Download to get a pdf

The screenshot shows a web browser window displaying a report interface. The browser's address bar shows the URL `http://127.0.0.1:5224`. The page title is "CViz - Shiny". The interface is divided into several sections:

- Observations:** A text box containing the text: "Write down things that may have interfered with your data, e.x.: There is a business near the 2nd and Main site that was seen emitting heavy smoke on multiple occasions. We saw people smoking on a bench nearby the 6th and Jackson site."
- Figures:** A section titled "Figure 1" containing a line graph. The y-axis is labeled "PM2.5" and the x-axis is labeled "Date". The graph shows a red line with several peaks, particularly around 18:00 and 21:00. A legend indicates "Sites" with a red line and "Downwind" with a blue line.
- Figure Description:** A text box containing the text: "Write a description of the figure, ex: In Figure X a few high peaks can be seen at the 6th and Jackson site that weren't seen at other sites. Also, all sites had higher levels on Jan 1st and 2nd."
- Summary:** A text box containing the text: "Summarize your results, e.x.: We found that PM levels are higher near I-5. Also, PM levels were much higher on Jan 1st and 2nd than other days. This may be because of the New Year's fireworks show that happened nearby."
- Download Report:** A button with a download icon and the text "Download Report".

Community Reporter - Report

- Pdf report

Project Title

Project Description
Write a basic description of your project, e.x.: We placed Dylos monitors at three community sites from Jan 1st 2018 to Feb 1st 2018 to look at how distance to I-5 affect PM concentrations in our neighborhood.

Site Information
Write down your site information, e.x.: The first site is at the corner of 8th and King and is the closest to I-5 (1000 ft). The second site was at 6th and Jackson and is 2500 ft away from I-5. The third site is 2nd and Main and is the furthest away from I-5 (3500 ft).

Observations
Write down things that may have interfered with your data, e.x.: There is a business near the 2nd and Main site that was seen emitting heavy smoke on multiple occasions. We saw people smoking on a bench nearby the 6th and Jackson site.

Figures

Figure 1

Date	PM25
18:00	22
19:00	7
20:00	18
21:00	2
22:00	12
23:00	12
24:00	1
25:00	16
26:00	5

Write a description of the figure, ex: In Figure X a few high peaks can be seen at the 6th and Jackson site that weren't seen at other sites. Also, all sites had higher levels on Jan 1st and 2nd.

Summary
Summarize your results, e.x.: We found that PM levels are higher near I-5. Also, PM levels were much higher on Jan 1st and 2nd than other days. This may be because of the New Year's fireworks show that happened nearby.

Summary

- **Purple Air (plantower) is very precise and, once calibrated, quite accurate**
- **Can potentially be used for supplemental monitoring in a low-cost monitoring network**
- **Proper data display is key**
- **Sensors can also be loaned out on a small/short-term project basis**
- **Tools are being developed to help citizen scientists participate in the analysis and discussion of air quality data**