

Motivation

Benefits of Emerging Sensors

- Inexpensive (\$10-\$1000)
- Small
- Lightweight
- Low power consumption
- Allow to have more monitoring stations
- Used by many citizen science groups

Possible Applications

- Measuring spatial and temporal variability
- Locating hot spots
- UAV applications
- Citizen Science
- Personal exposure
- Estimating Emissions Factors



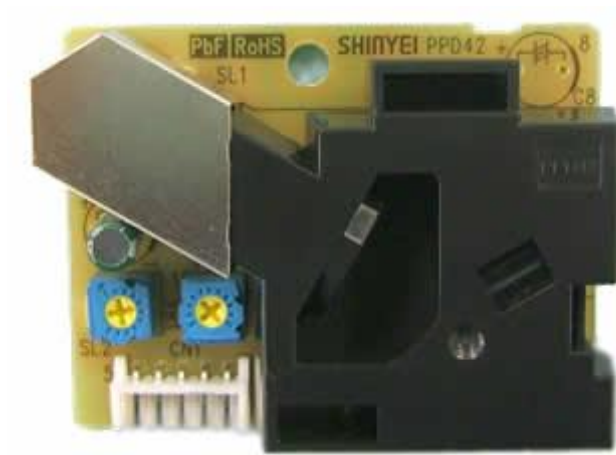
Our Sensors

Particle Sensors

Sensors measure light scattering from particles

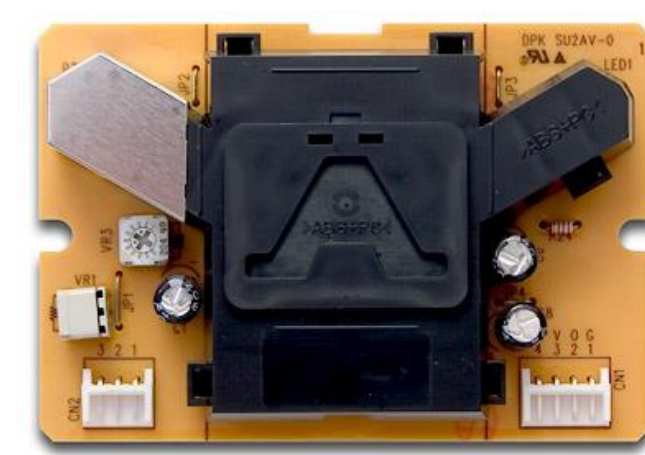
1. Shinyei PPD42NS

- \$20
- > 1um particles
- Widely used by makers
- Digital output



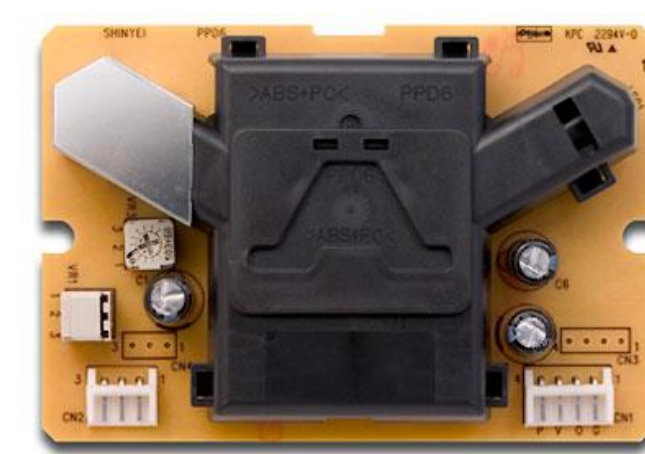
2. Shinyei PPD20V

- \$350
- >1 um particles
- Analog output



3. Shinyei PPD60V

- \$760
- > 0.5 um particles
- Analog output



Additional Sensors and Small Monitors

1. Temperature and Humidity: Parallax SHT11 and SHT15

- \$40

2. CO2: COZIR

- <\$150
- Infrared sensor

3. Black Carbon: MicroAeth

- \$6,000



Img sources:
www.sca-shinyei.com/
www.dfrobot.com
www.datasheetdir.com/SHT15+Temperature+Sensors
co2meter.com
http://aethlabs.com/microaeth

Shinyei Comparison

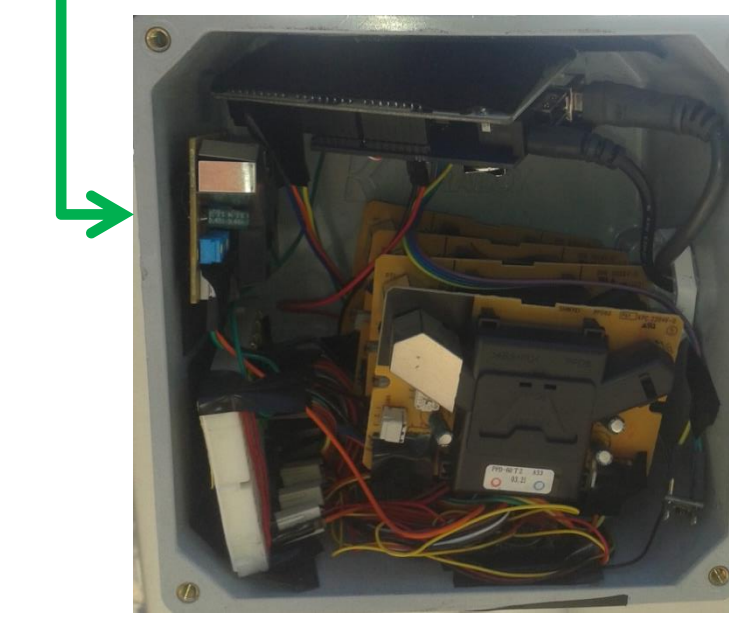
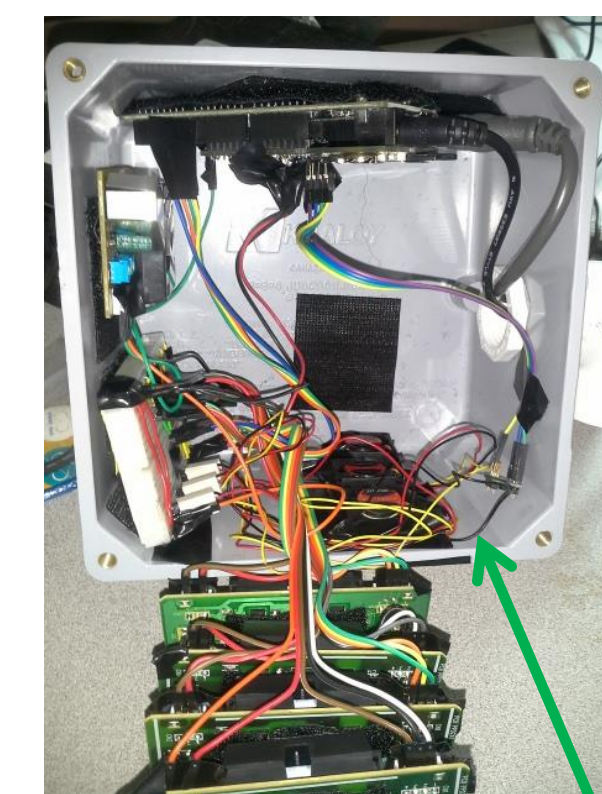
Method

Environmental Beta Attenuation Monitor (E-BAM): ~\$30k
Reference Analyzer in India



Img source: www.navajonationepa.org/aqcp/AirMonitoringSite.htm

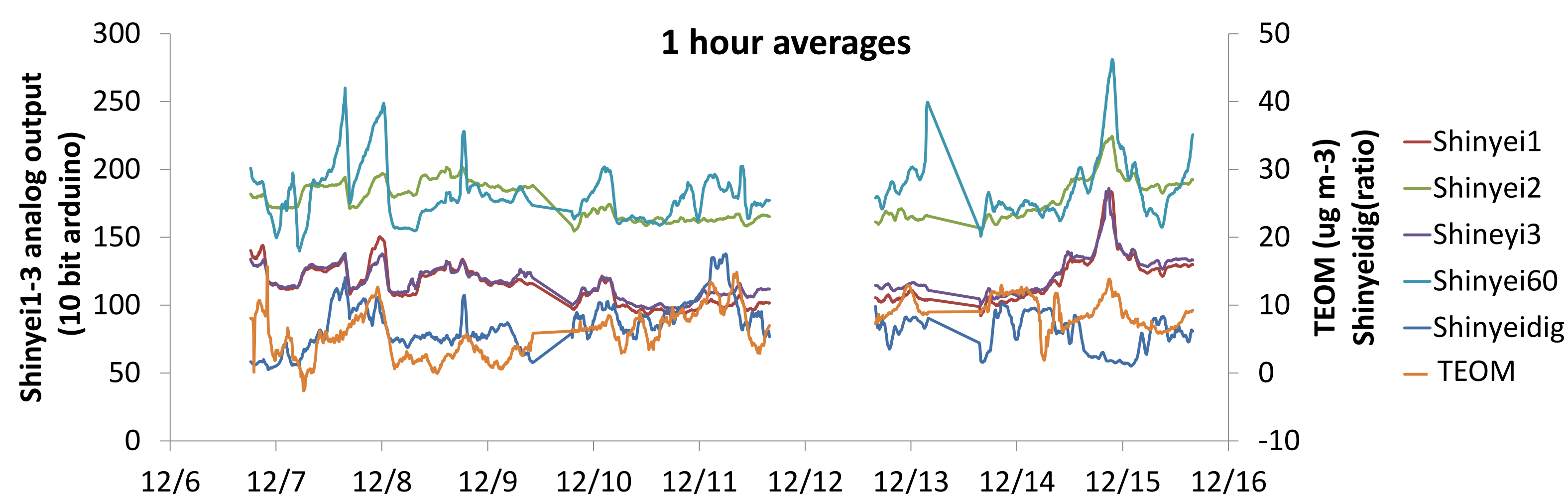
Tapered Element Oscillating Microbalance (TEOM): ~\$40k
Reference Analyzer in US



3 1" fans to provide air flow through sensors and box

- 1 Shinyei PPD42NS (\$20)
- Shinyeidig
- 3 Shinyei PPD20V(\$350)
- Shinyei1, Shinyei2, Shinyei3
- 1 Shinyei PPD60V (\$700)
- Shinyei60

Roof Top Atlanta, GA



- R^2 0.8-0.9 between Shinyeis 1-3
- Poor correlations between all Shinyeis and TEOM at hour averaging interval

Road-Side Atlanta, GA

Evaluation

Black Carbon Comparison:

Multi Angle Absorption Photometer (MAAP)

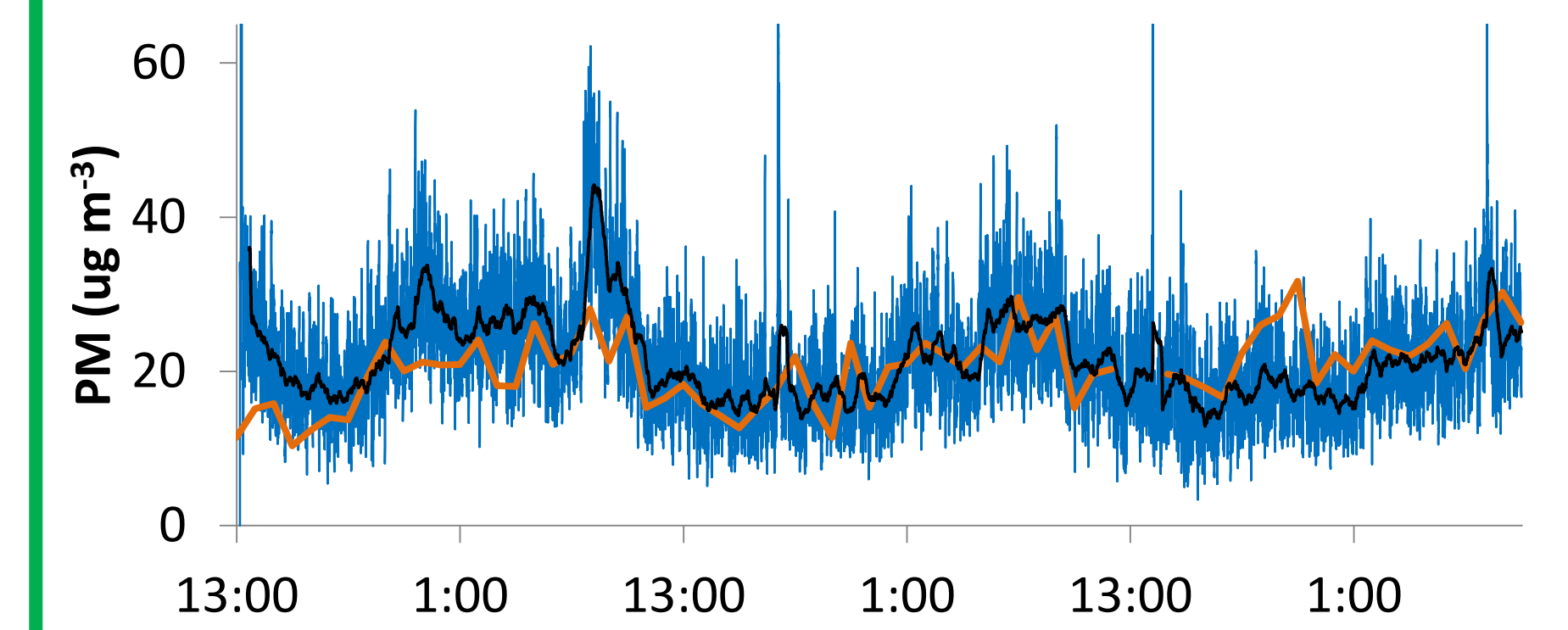
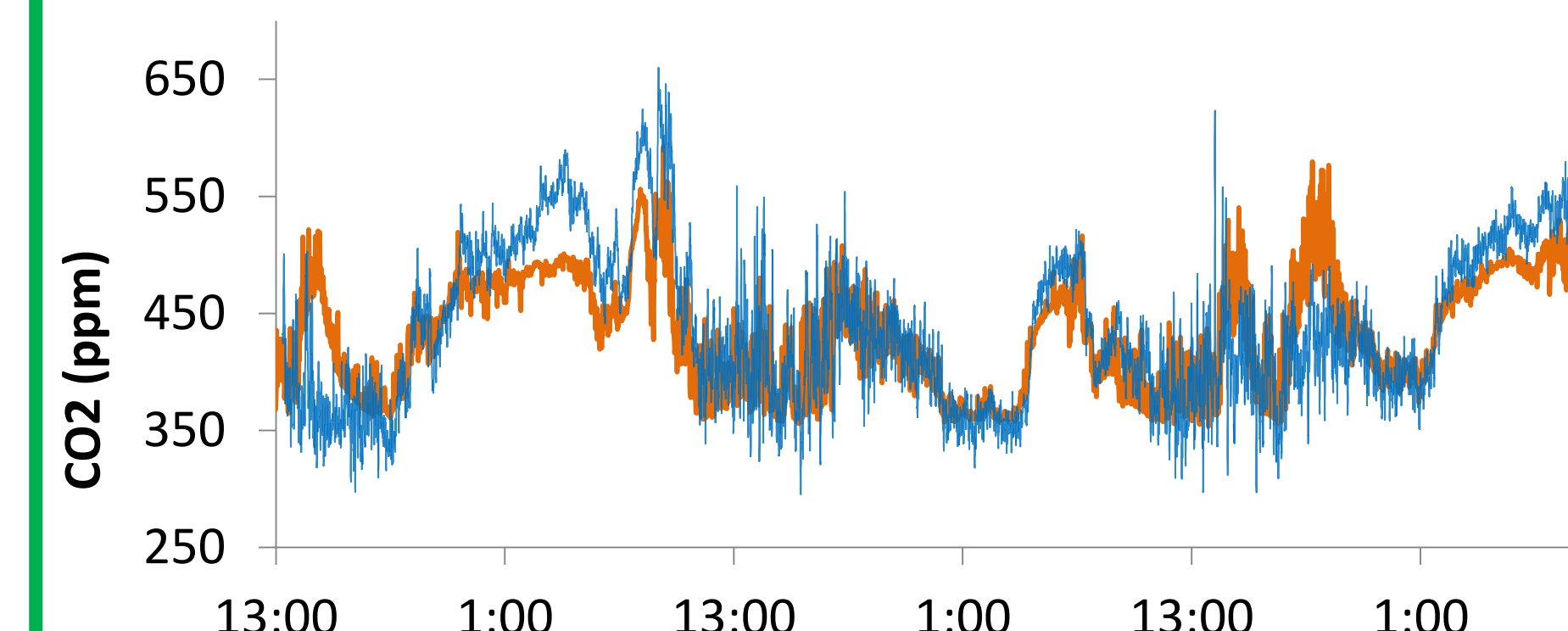
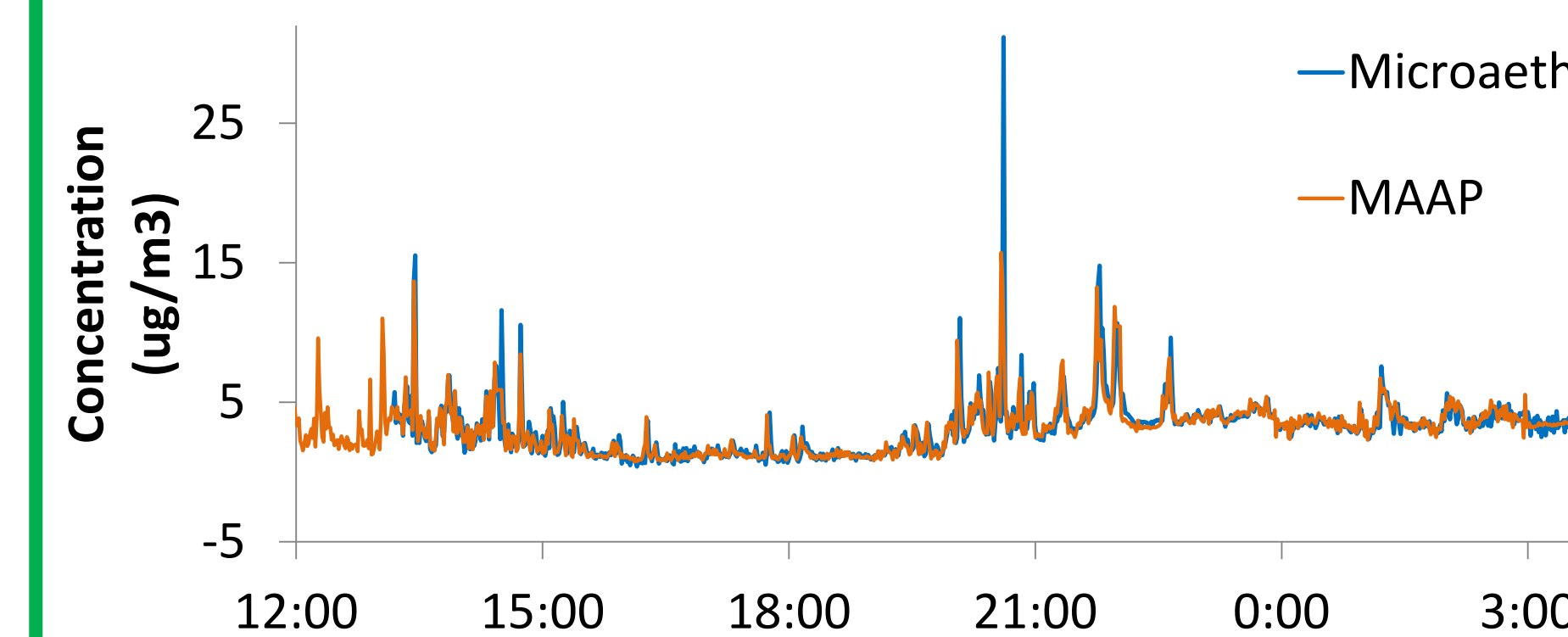
~\$25k

CO2 Comparison: CO2 analyzer

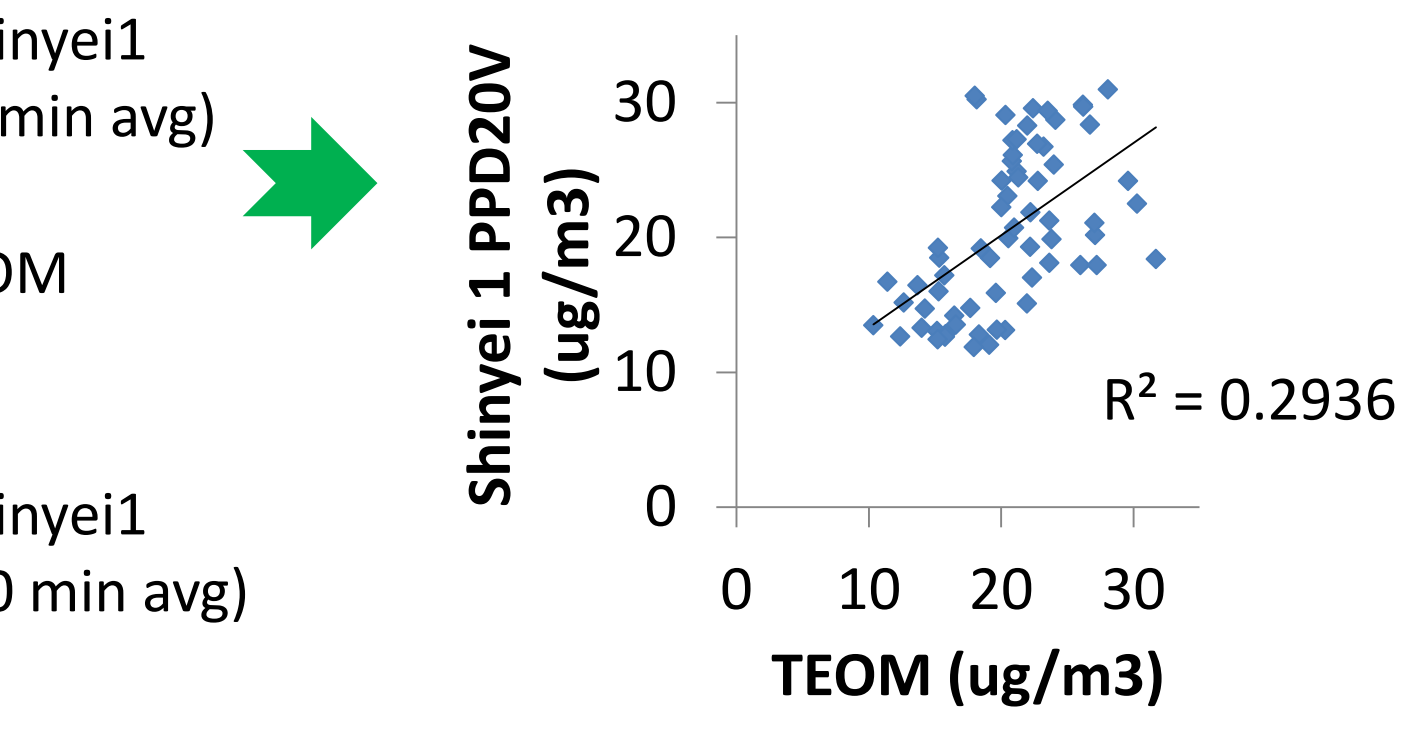
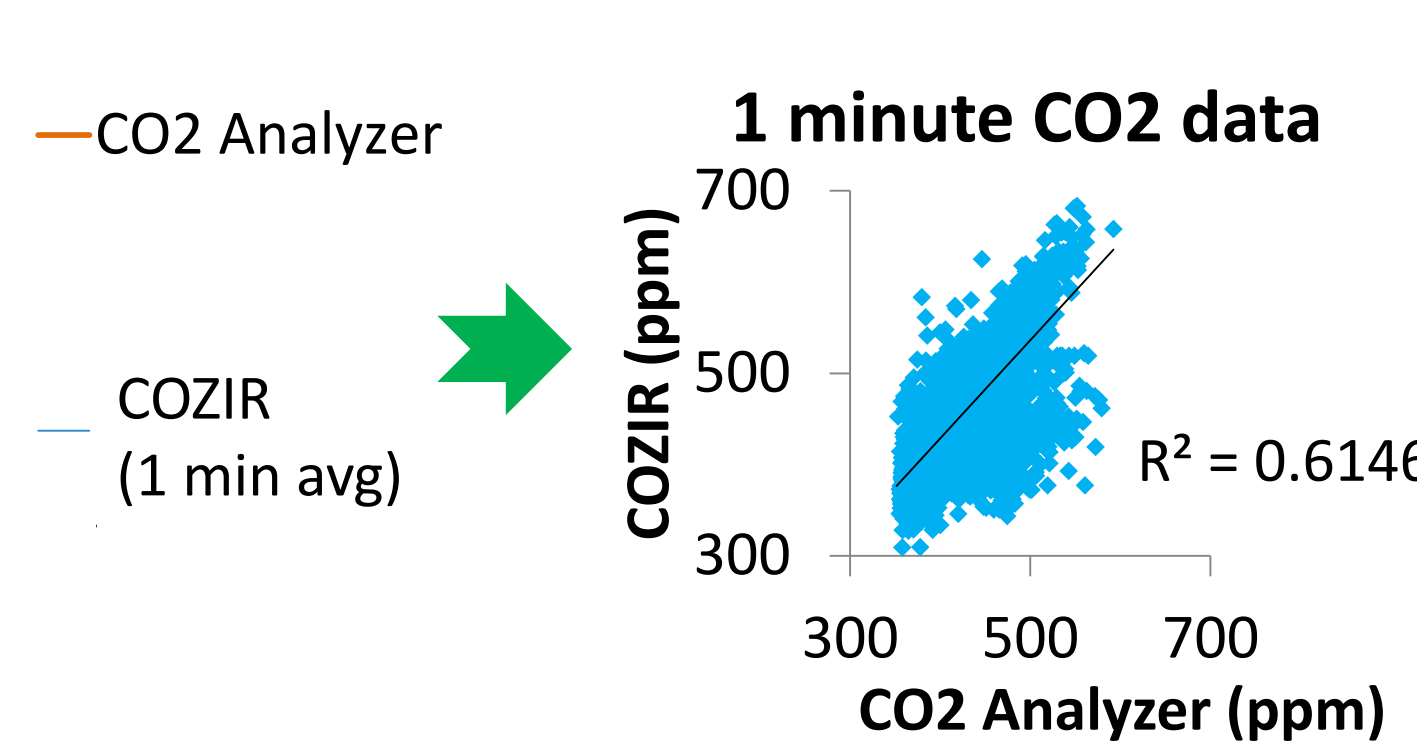
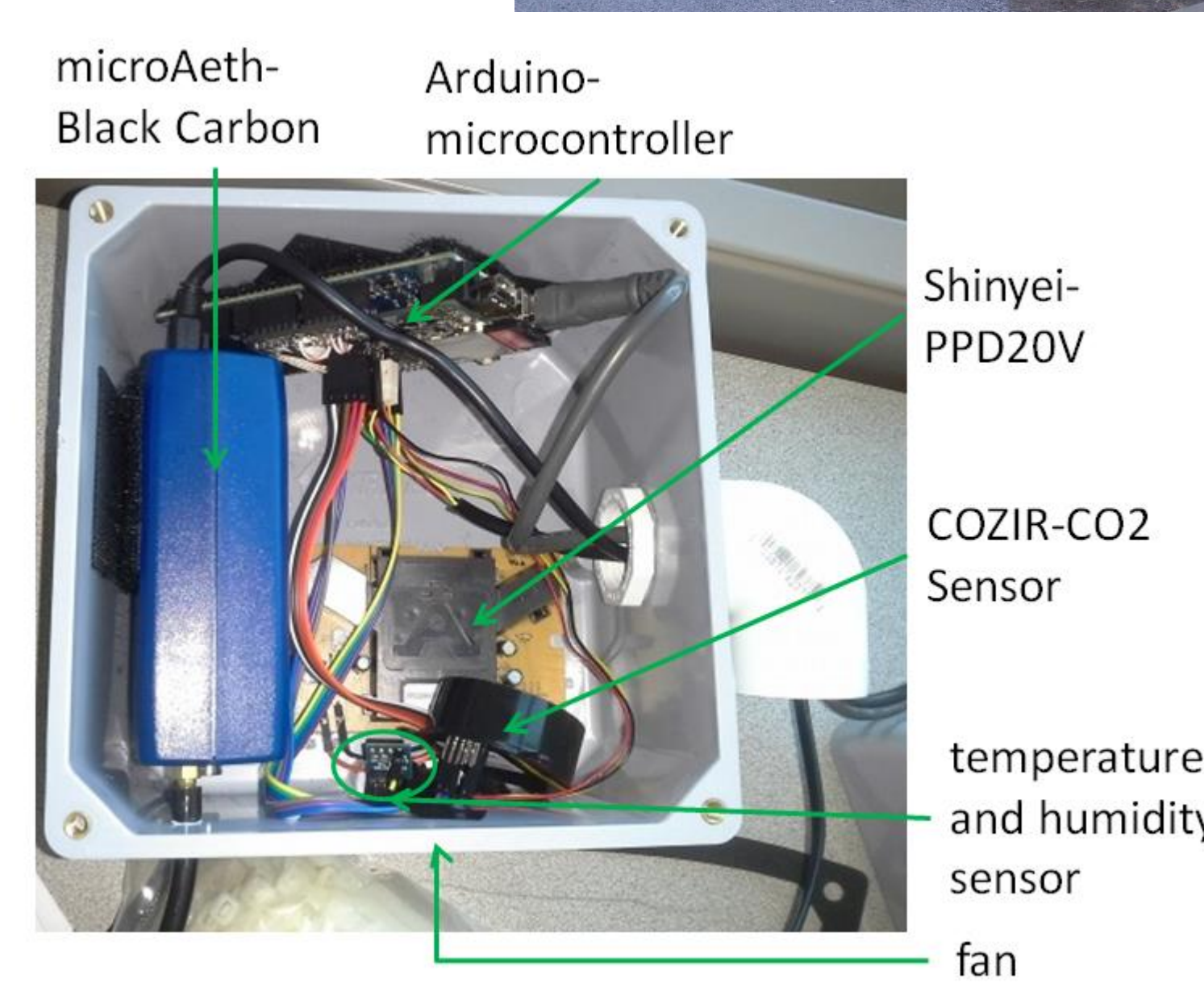
Thermo Scientific Model 410i

~\$9k

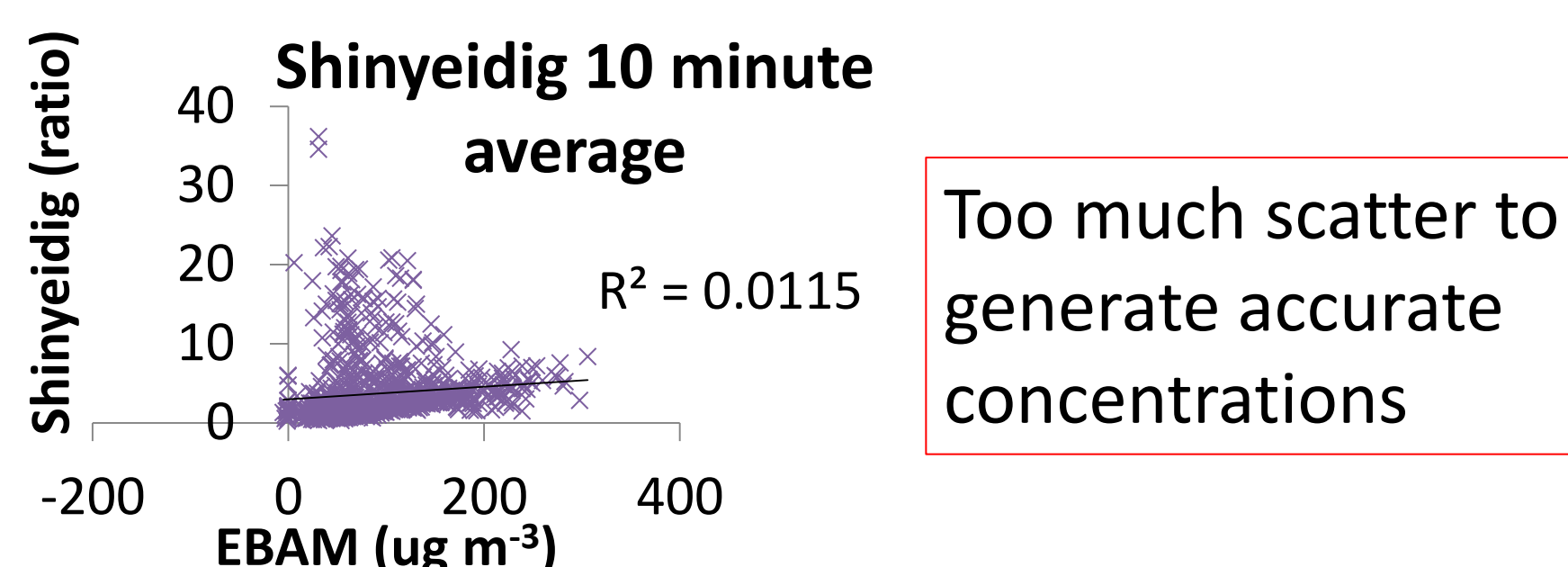
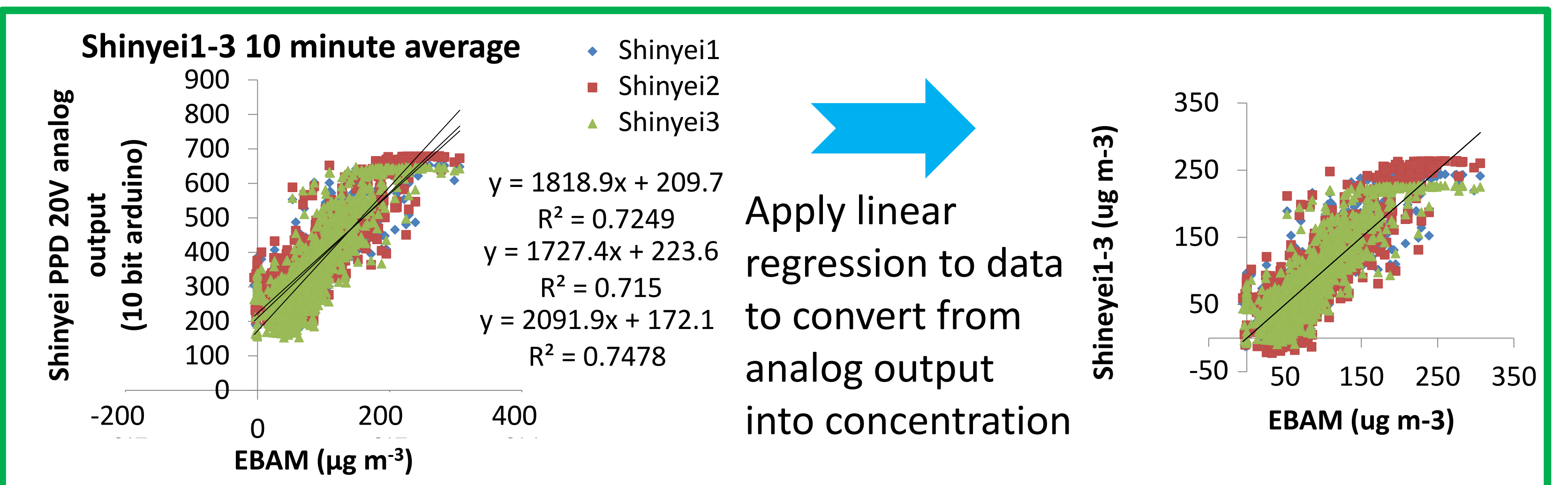
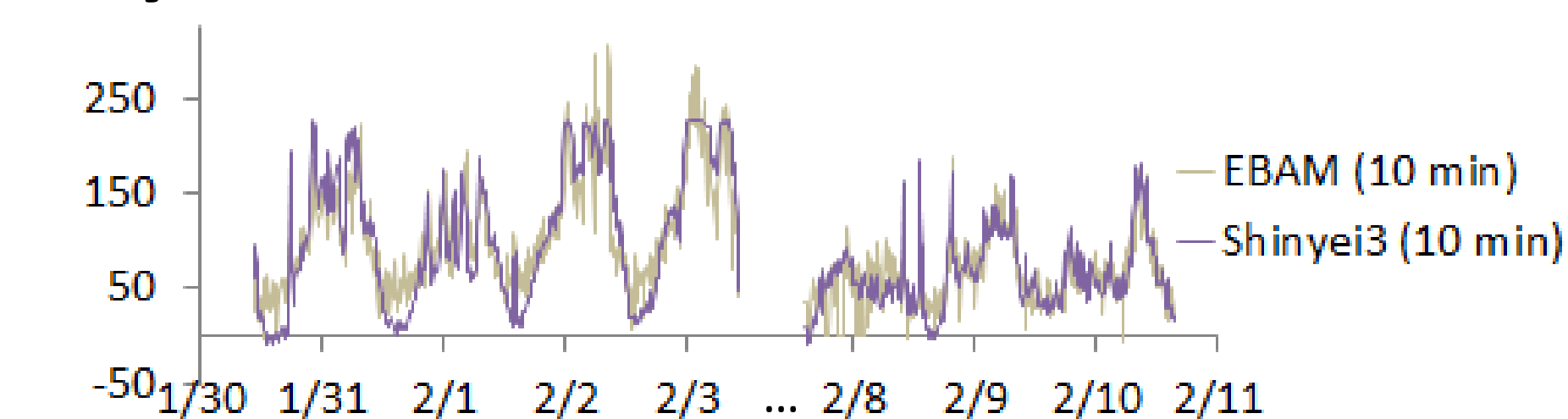
Img sources:
http://www.thermo.com/en/product/model-410-i-carbon-dioxide-gas-analyzer.html
http://www.environmental-expert.com/



Monitors and sensors set up on the edge of a 10 lane freeway



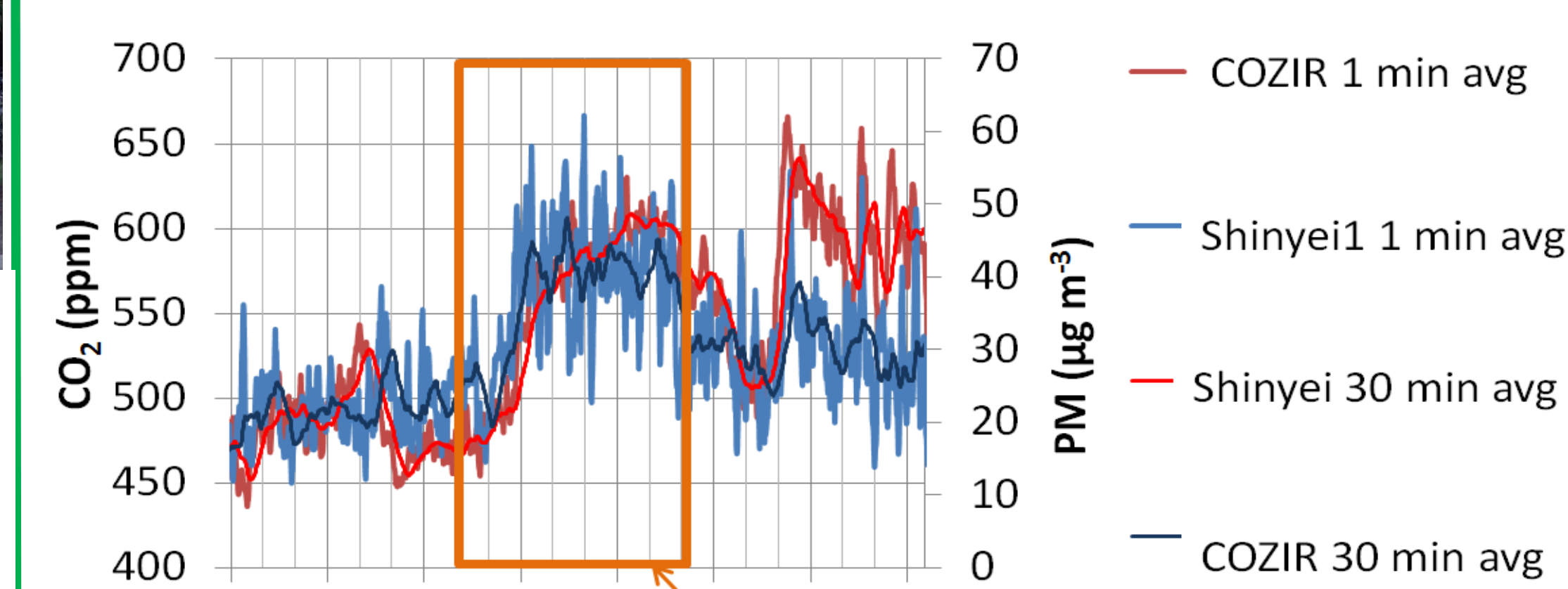
Hyderabad India



Too much scatter to generate accurate concentrations

After comparison between these 3 Shinyei models, the PPD20V is best for higher concentration applications but has an upper limit around 250 $\mu\text{g m}^{-3}$

Emissions Factors Estimates: Morning Rush Hour



Emissions factor calculated based on peak pollutant concentration less the pre rush hour background concentration

$$= \Delta\text{PM}/\Delta\text{CO}_2$$

$$= 0.079\mu\text{g m}^{-3} \text{ PM/ppmCO}_2$$

$$= 0.39 \text{ g PM/kg fuel (assuming octane)}$$

	Our Study Atlanta (g kg^{-1})	Heavy Duty Diesel ¹ (g kg^{-1})	Light Duty Gasoline ² (g kg^{-1})
PM2.5	0.39	1.4	0.038
BC	0.075	0.86	0.010

Calculated values seem reasonable as they fall between light duty gasoline and heavy duty diesel values

Future Work

- Deployment of multiple packages in China in July
- Humidity corrections for the particle sensors since RH will affect scattering of particles
- Extend upper and lower ranges
- Design improved sensors
- Wireless data transmission
- Evaluate additional sensors including the sharp dust sensor

Acknowledgments

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References

1. Long-term changes in emissions of nitrogen oxides and particulate matter from on-road gasoline and diesel vehicles, George A. Ban-Weiss, John P. McLaughlin, Robert A. Harley, Melissa M. Lunden, Thomas W. Kirchstetter, Andrew J. Kean, Anthony W. Strawa, Eric D. Stevenson, Gary R. Kendall, Atmospheric Environment, Volume 42, Issue 2, January 2008, Pages 220-232, ISSN 1352-2310, <http://dx.doi.org/10.1016/j.atmosenv.2007.09.049>.
2. Quantifying On-Road Emissions from Gasoline-Powered Motor Vehicles: Accounting for the Presence of Medium- and Heavy-Duty Diesel Trucks Timothy R. Dallmann, Thomas W. Kirchstetter, Steven J. DeMartini, and Robert A. Harley *Environmental Science & Technology* 2013 47 (23), 13873-13881