Variations in Wintertime PM Among Communities in Sacramento Measured with a Combination of Traditional and Low-Cost Sensor Methods

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STi Sonoma Technology, Inc. Innovative Environmental Solutions

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Sacramento Background

- **Winter time**
  - Inversion = trapped emissions
  - High Winter PM
  - Wood burning > 50% PM Emission Inventory

- PM Spatial scale and wood smoke toxic contribution is unknown

Images from AirNowTech, SMAQMD

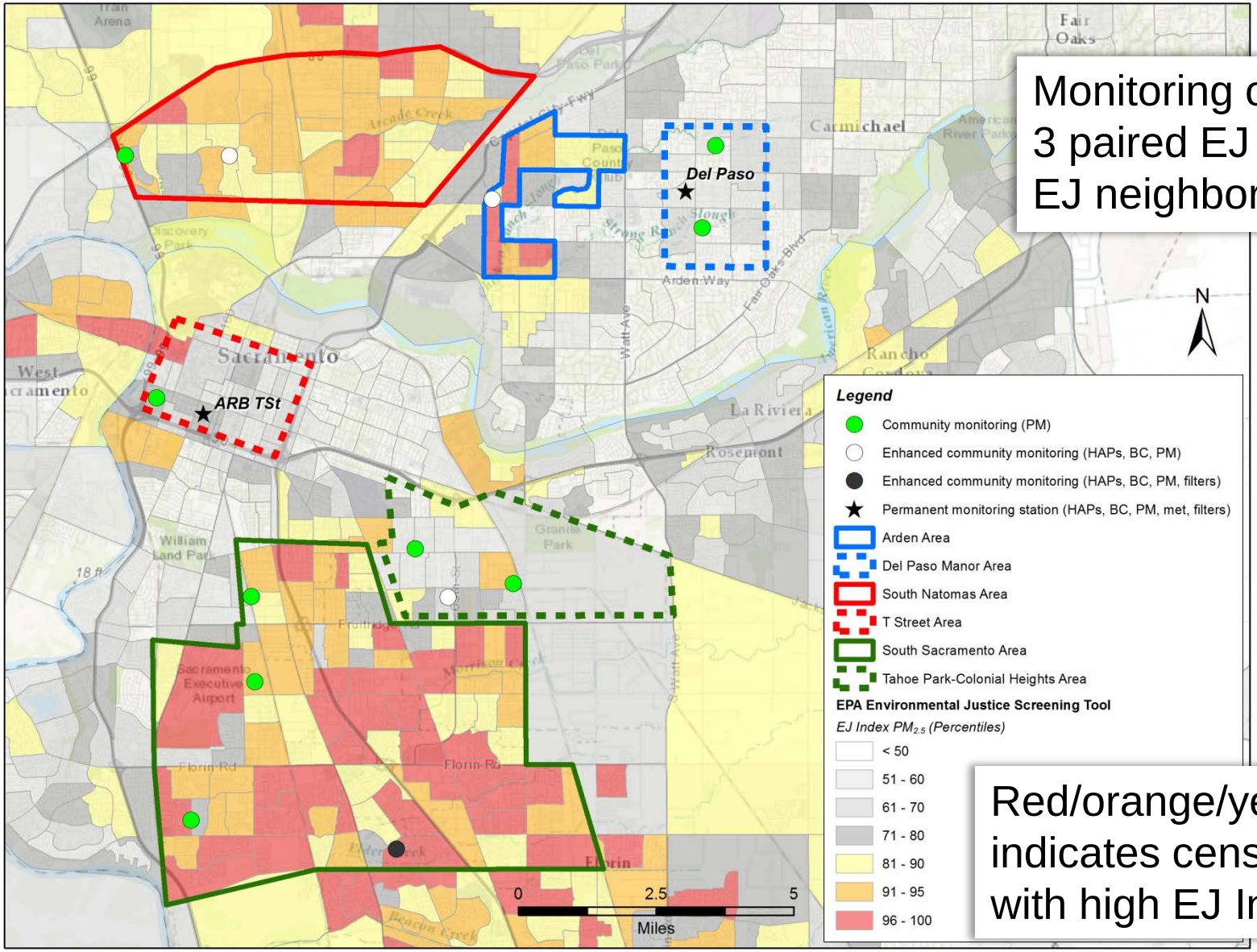
Overview

- **Project Objective:** Understand the wintertime PM spatial differences between environmental justice (EJ) and non-EJ communities in Sacramento County
- **Collected measurements:** December 2016 and January 2017
  - PM with AirBeam sensors and BAMs
  - Black carbon (BC) with Aethalometers
  - Air toxics with canisters
  - Levoglucosan and organic and elemental carbon (OC, EC) with filters
  - Wood burning activity via community survey

Study Design: PM Measurements

- **Traditional Regulatory Grade Monitors** – 2 Locations: Filter (FRM) and Continuous (non-FEM BAMS)
- **Low Cost (AirBeam) sensors:** 1 – 3 locations in 3 EJ and 3 non-EJ communities
- **Collocation:**
  - (Pre & Post Study) Sensors were collocated with BAM and FRM instruments to determine: Sensor Bias, Drift, & Precision
  - (During Study) 2 sensors were collocated during December 2016–January 2017.
- **Data streamed via cellular communications**
  - Central database
  - Data were validated and consolidated to 1-minute and 1-hour values.

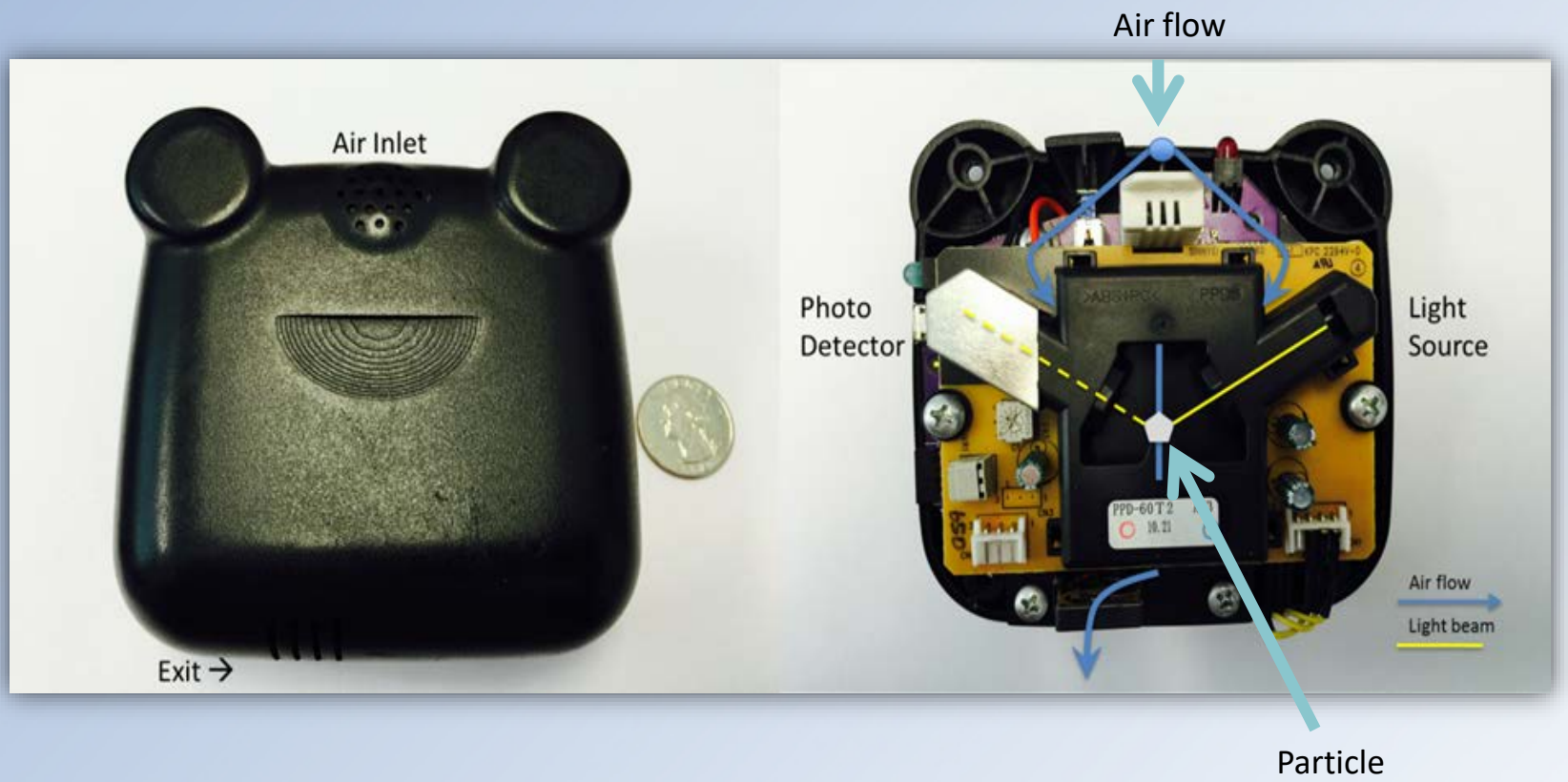
Study Locations



Monitoring occurred in 3 paired EJ and non-EJ neighborhoods

Red/orange/yellow indicates census blocks with high EJ Index

AirBeam “Nuts and Bolts”



AirBeams measure light scattering from particles with an LED light source, and convert the light scattering to a PM concentration.
A fan draws air through the detector.
Unit cost ~$300. Firmware updated Oct 2016.

Sensor Communications

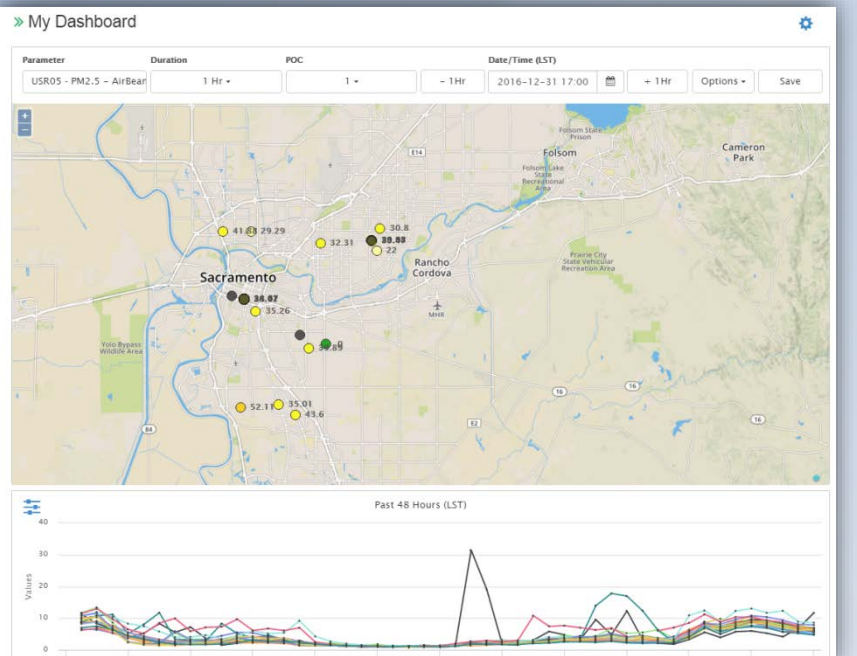
Pushes data multiple times a minute

Data acquired via VALARM Yocto Hub

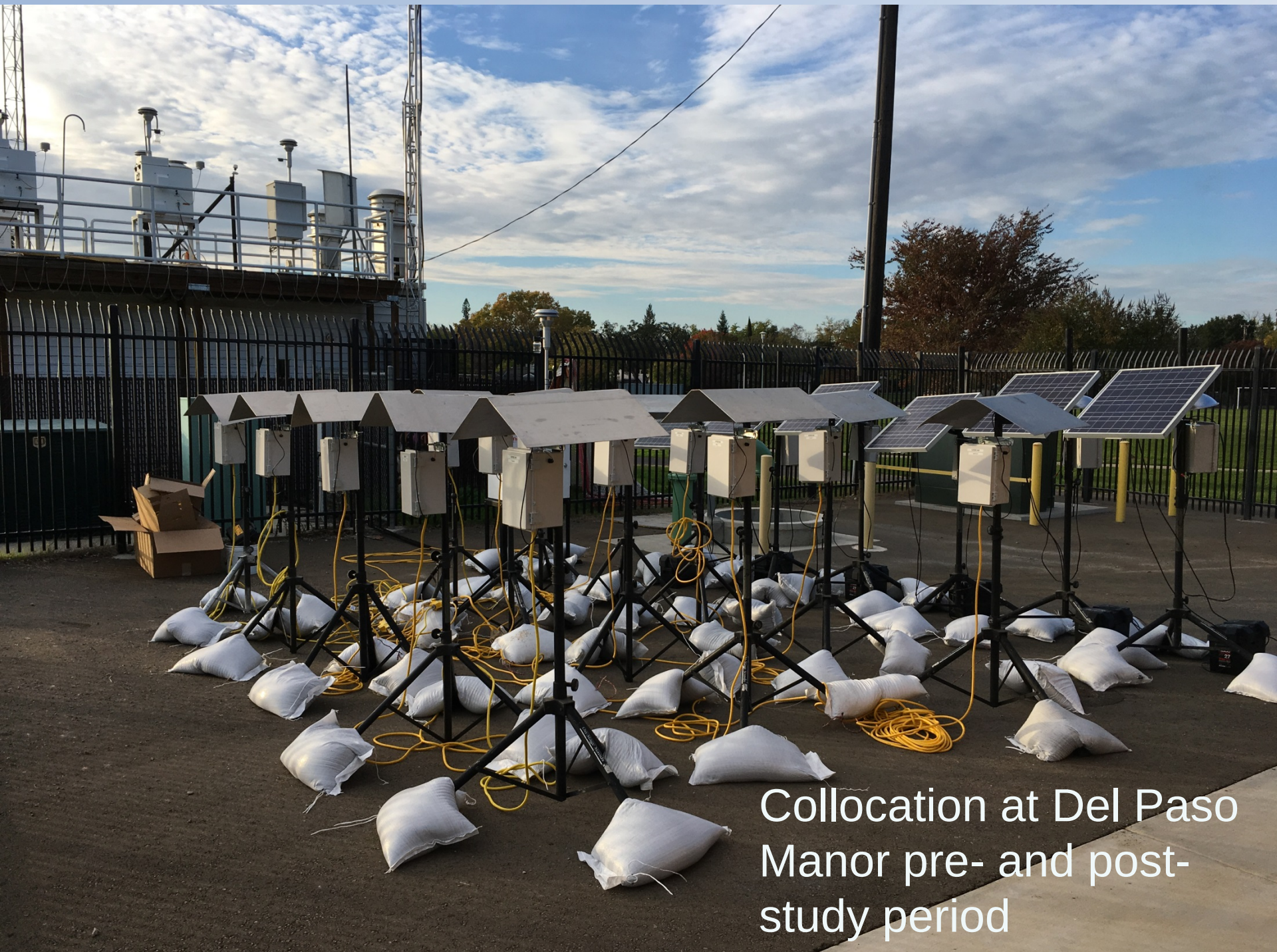
Data pushed via API to STI's data management system (Insight)

Insight

Data graphed and updated every minute on STI's web app for visualizing real-time data

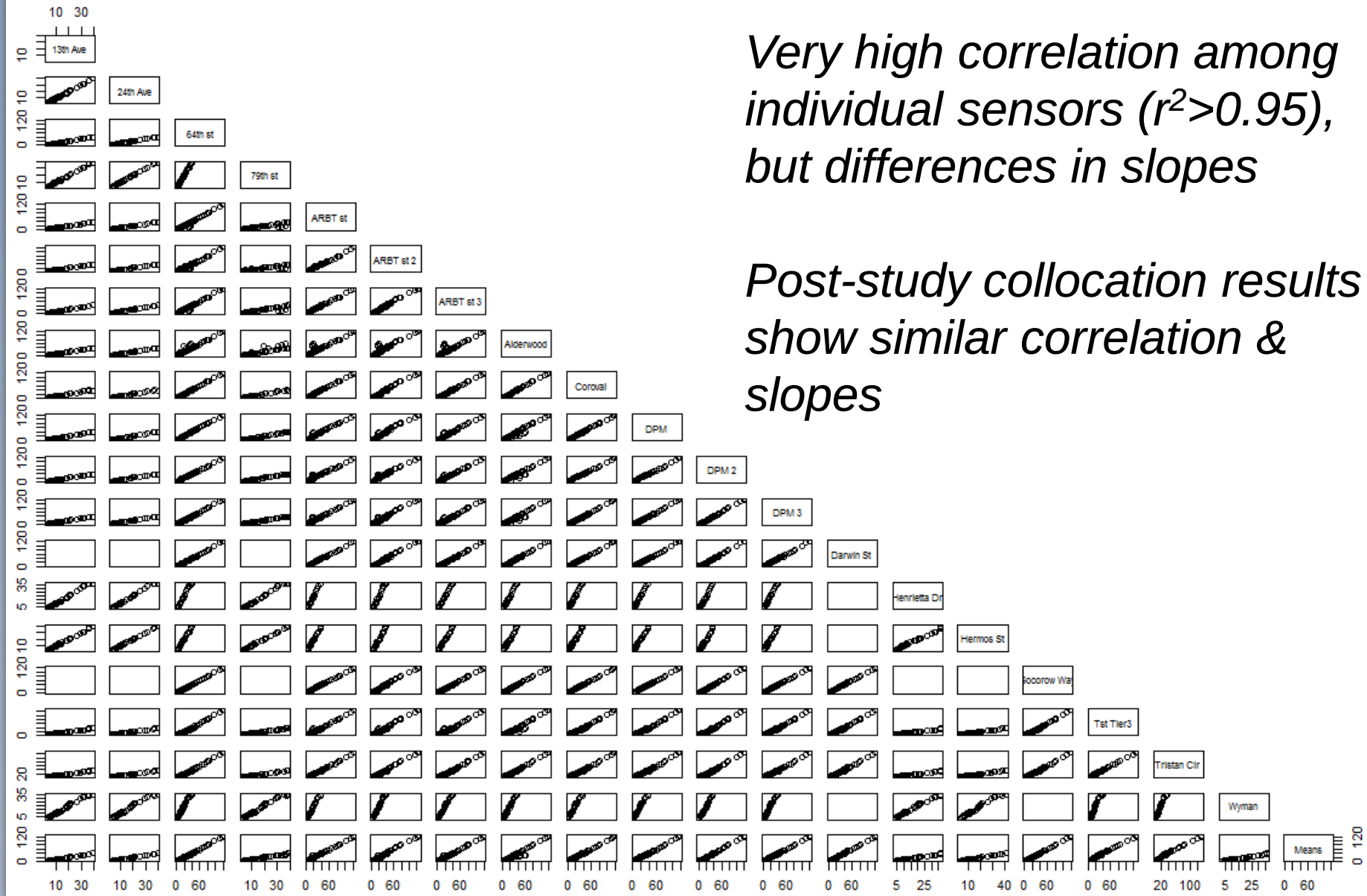


- Powered through:
  - Solar panels with rechargeable batteries
  - Power Outlets
- Shielded with a “hat” to minimize rain/fog impacts
- Hardware box housed VALARM hub and cell modem



Collocation at Del Paso Manor pre- and post-study period

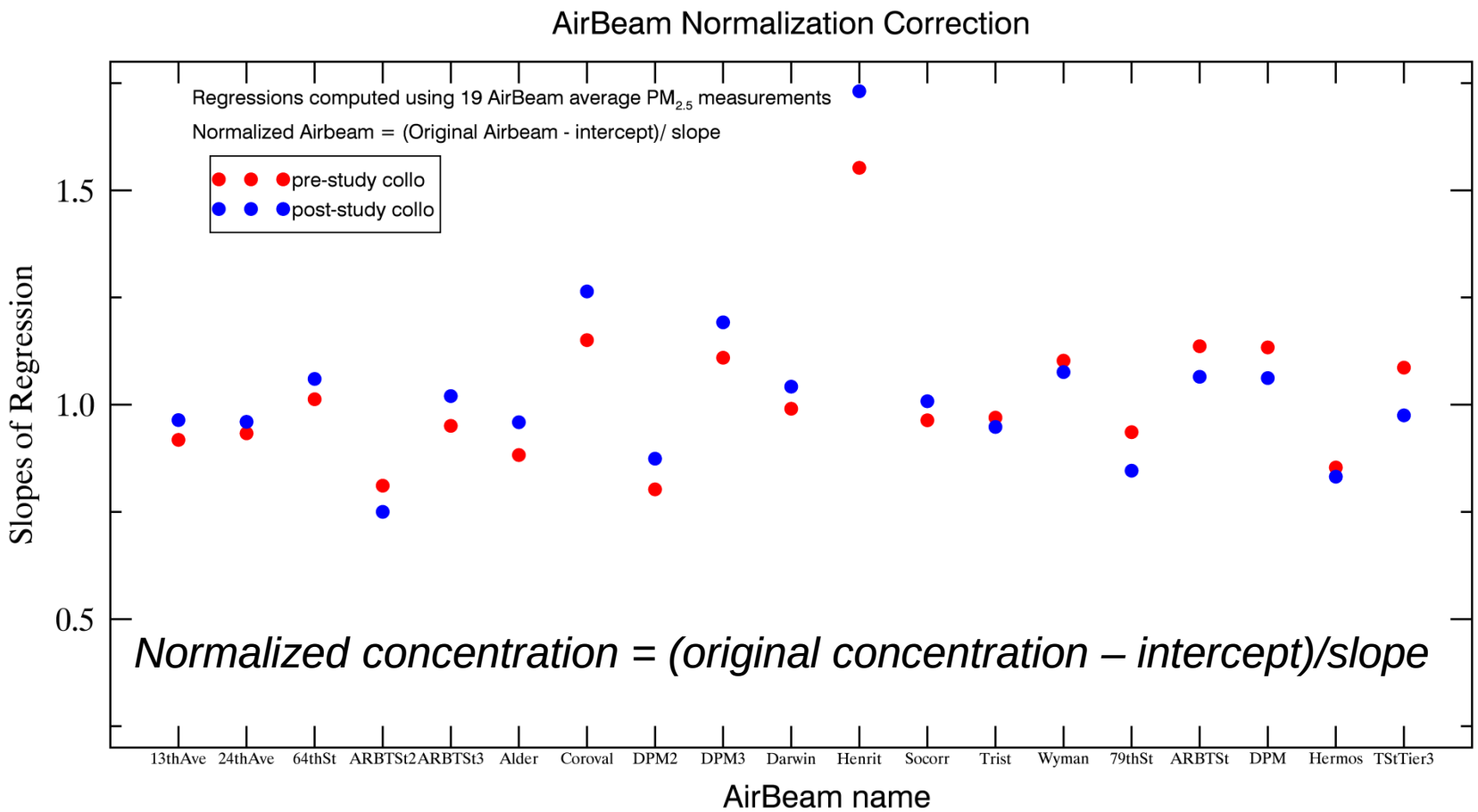
Pre-Study Collocation



Very high correlation among individual sensors (r^2>0.95), but differences in slopes

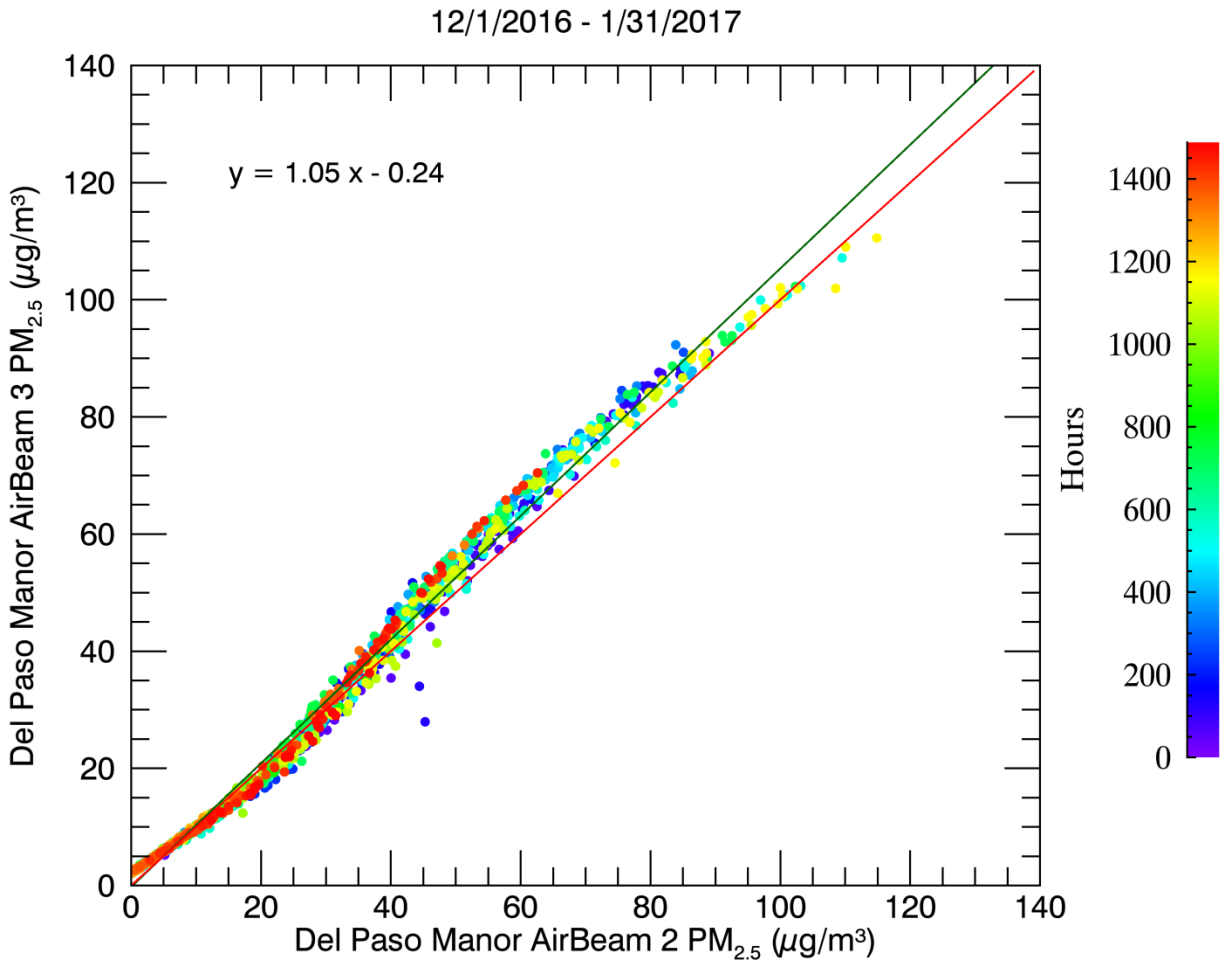
Post-study collocation results show similar correlation & slopes

Individual Air Beam Bias Consistent During Study



Data points show the slope of the regression between each individual AirBeam and the AirBeam average during the pre- and post-study collocations. There is a consistent bias and little drift, enabling correction.

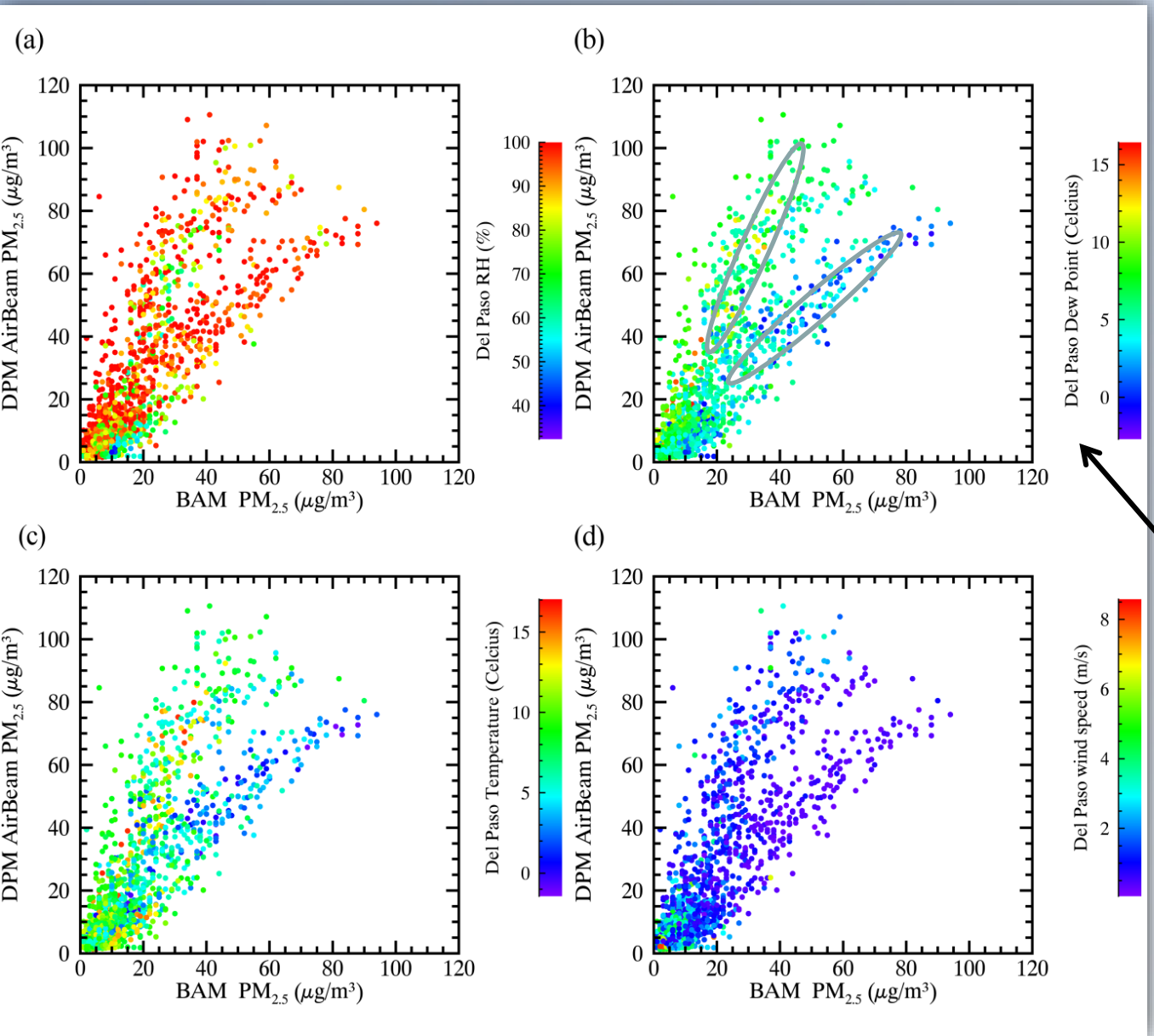
Bias Results of Collocated AirBeams During Study Period



Collocated data at Del Paso Manor show very consistent bias hour by hour

Standard deviation of residuals between linear regression and measured values was 2 μg/m^3

Correlation: AirBeam to BAM

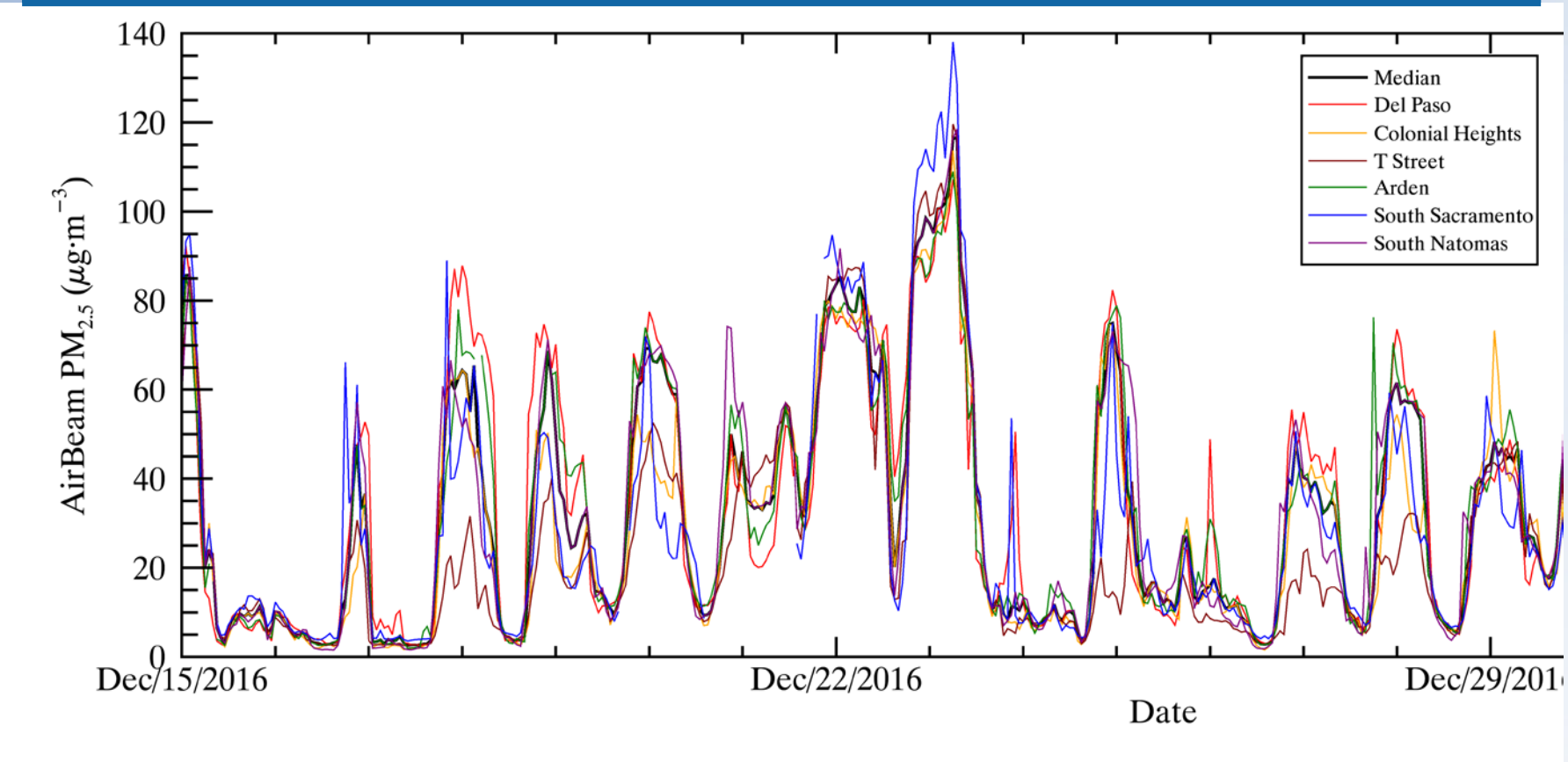


(r^2 = 0.65)

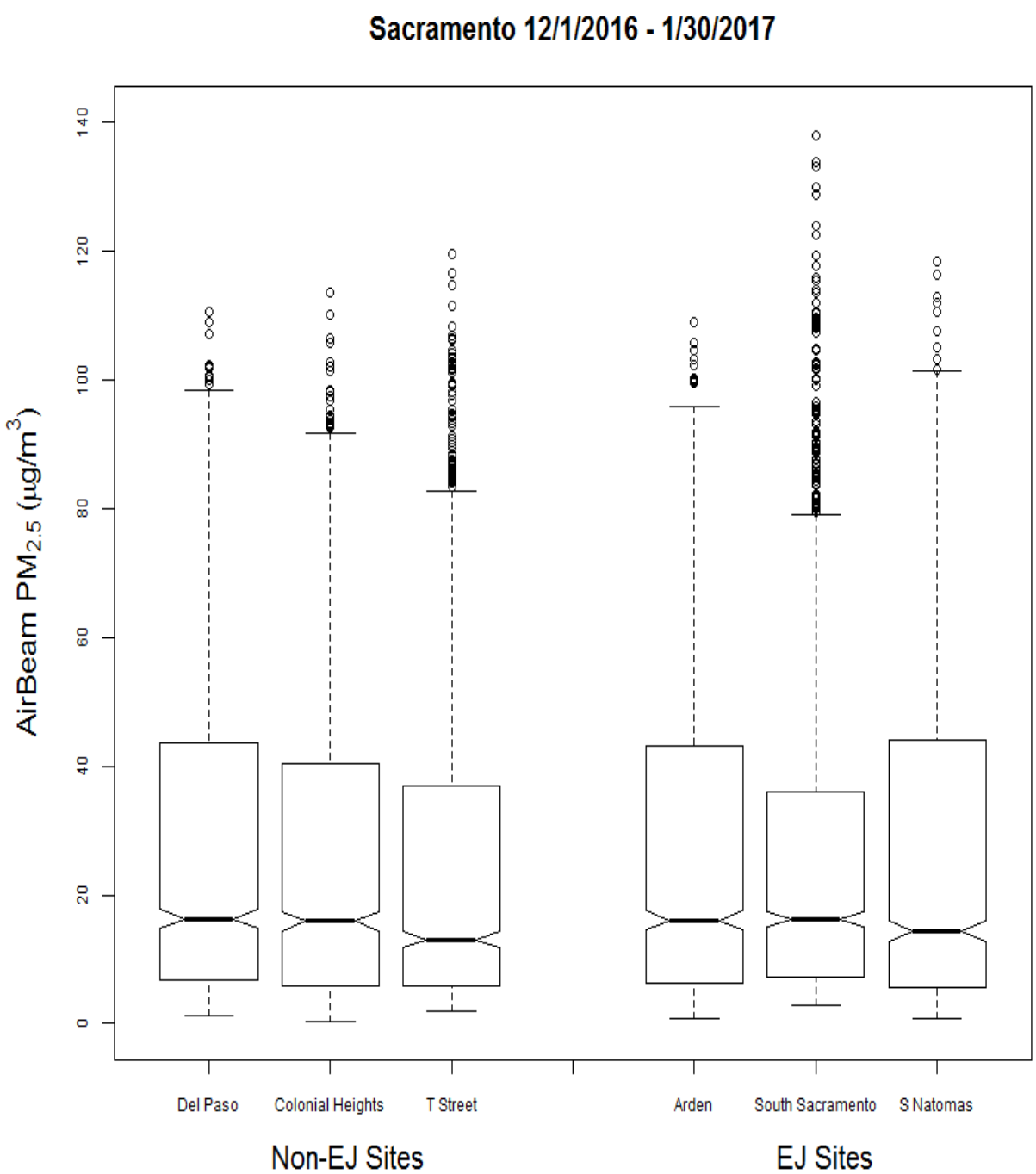
We looked at how AirBeam to BAM varies with meteorology

Dew point was the most explanatory variable

Neighborhood Differences



- In general, sites tend to trend together in a diurnal pattern, however on any given hour, there can be differences of > 20 µg/m^3 across neighborhoods.



- Distinctive Difference at T Street site than at other sites
- Other than T street, PM is similar across neighborhoods.
- Overall, no statistically significant difference between EJ and non-EJ sites.

Summary

- AirBeam output was very consistent during the study, allowing us to correct the raw data and compare concentrations across sites.
- AirBeams had a modestly high correlation with the BAM (correlation was variable by dew point).
- PM was modestly variable across neighborhoods, and while there were some inter-neighborhood differences, overall there was no statistically significant difference between EJ and non-EJ areas.

References

- **Source Apportionment of Fine (PM1.8) and Ultrafine (PM0.1) Airborne Particulate Matter during a Severe Winter Pollution Episode** Michael J. Kleeman, Sarah G. Riddle, Michael A. Robert, Chris A. Jakober, Phillip M. Fine, Michael D. Hays, James J. Schauer, and Michael P. Hannigan *Environmental Science & Technology* **2009** *43* (2), 272-279 DOI: 10.1021/es800400m

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