

# Field Evaluation of Cair



# Background

- From 4/4/2017 to 5/31/2017, three **Cair** sensor units were deployed in Rubidoux and were run side-by-side SCAQMD Federal Reference Method (FRM) instruments measuring the same pollutants
- Cair (3 units tested):
  - Particle sensor (**optical; non-FEM**)
  - Each unit measures the number concentrations of “small” (~1-2  $\mu\text{m}$ ) and “large” particles (~3-10  $\mu\text{m}$ ) in  $\#/ft^3$ , VOC (ppm), ambient air temperature (degree C), and relative humidity (%)
  - “Small” and “large” particles were used as estimates of  $\text{PM}_{2.5}$  and  $\text{PM}_{10-2.5}$ , respectively
  - **Unit cost: ~\$200**
  - Time resolution: 1-min
  - Units IDs:
    - Unit 34CC
    - Unit AC3E
    - Unit B38E
- SCAQMD FRM/FEM instruments:
  - Beta-attenuation monitor (**FEM**)
    - Measures  $\text{PM}_{2.5}$  and  $\text{PM}_{10}$  ( $\mu\text{g}/\text{m}^3$ )
    - **Unit cost: ~\$20,000**
    - Time resolution: 1-hr
  - Meteorological station:
    - Measures temperature and relative humidity
    - **Unit cost: ~\$5,000**
    - Time resolution: 1-min

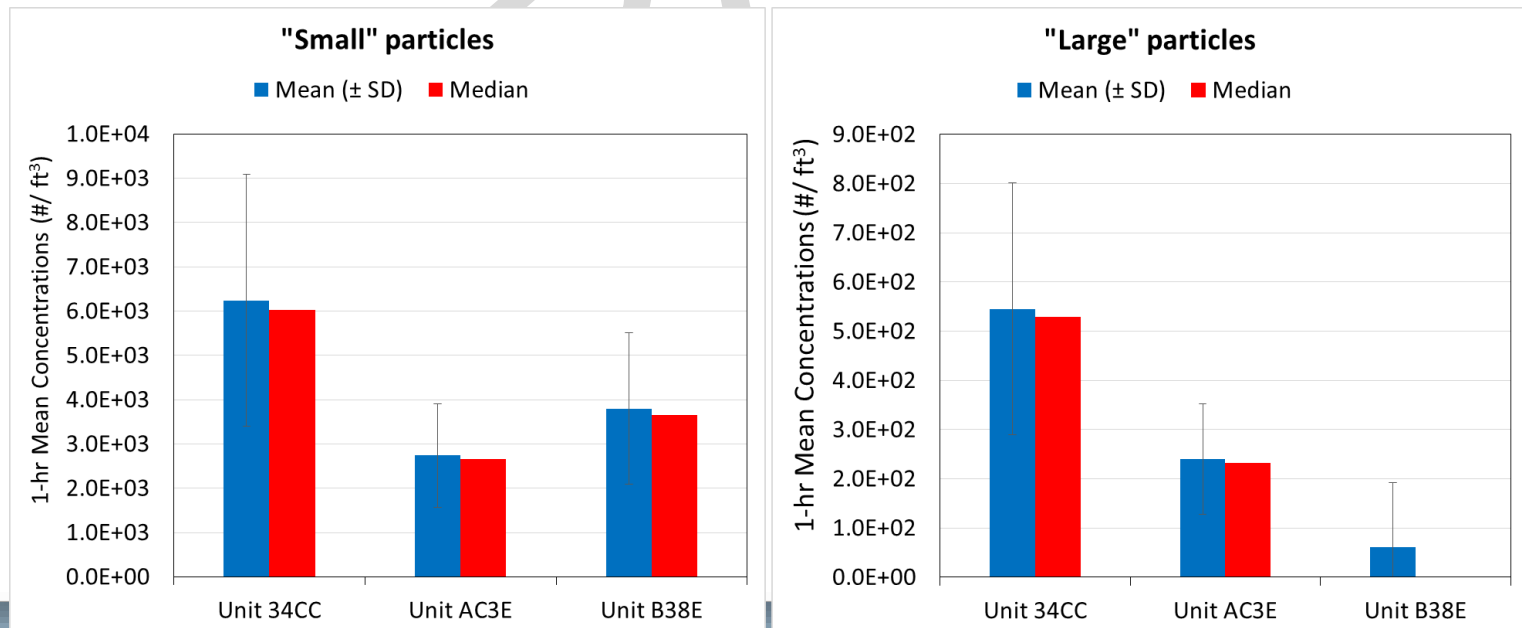


# Data validation & recovery

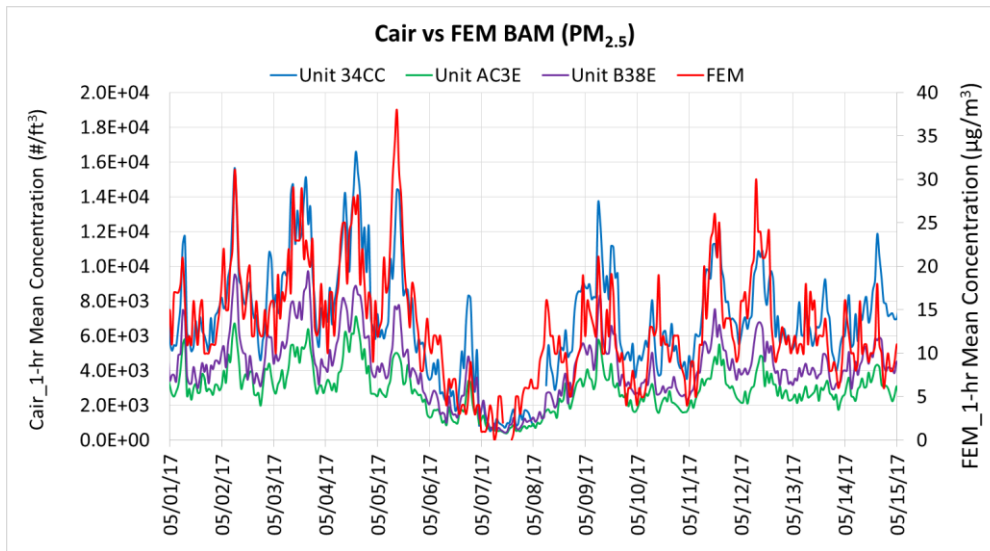
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values, and invalid data-points were eliminated from the data-set)
- Data recovery was near 100% for all three units tested.

## Cair; intra-model variability

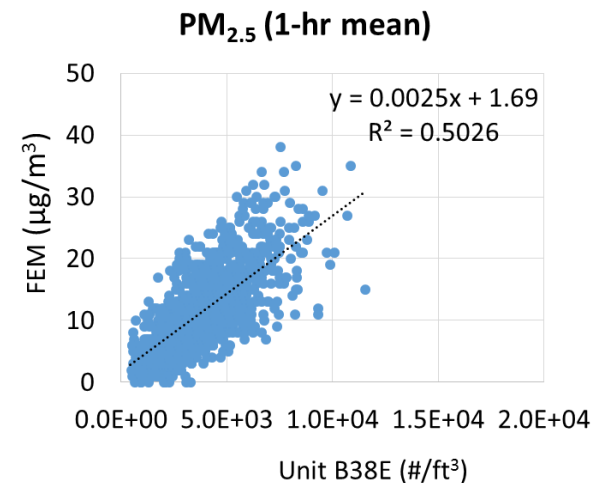
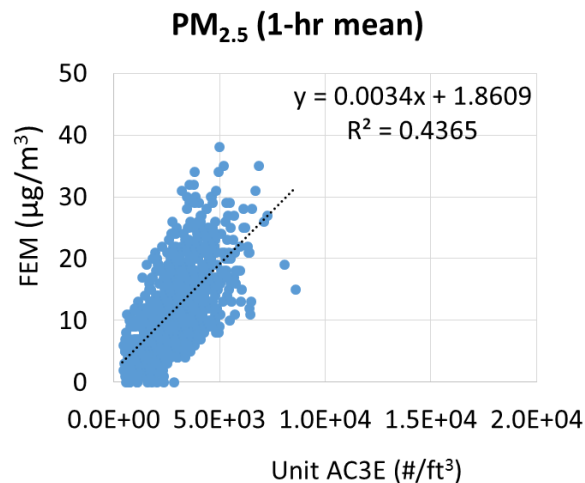
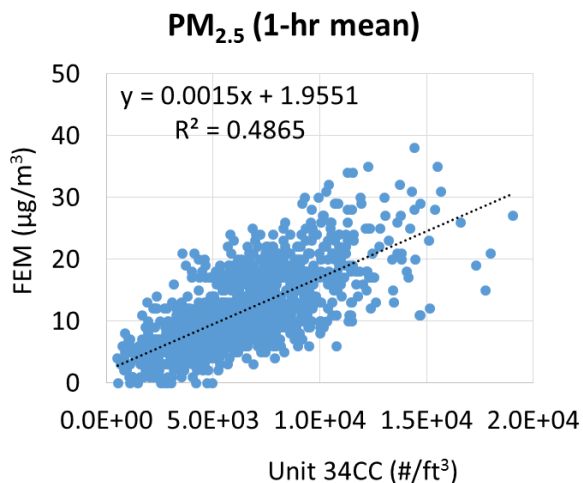
- High intra-model variability was observed for the number concentrations of “small” and “large” particles from the three tested Cair units.



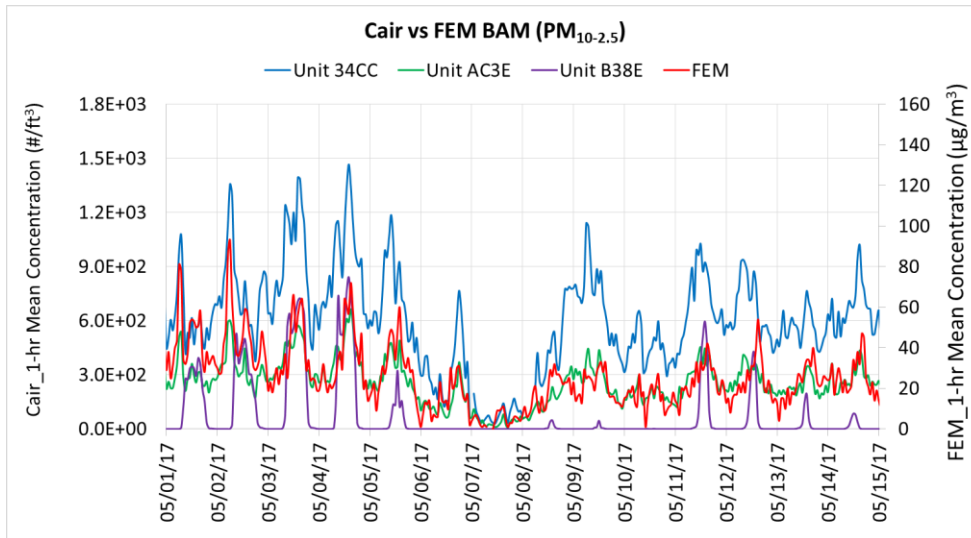
# Cair vs FEM BAM (PM<sub>2.5</sub>; 1-hr mean)



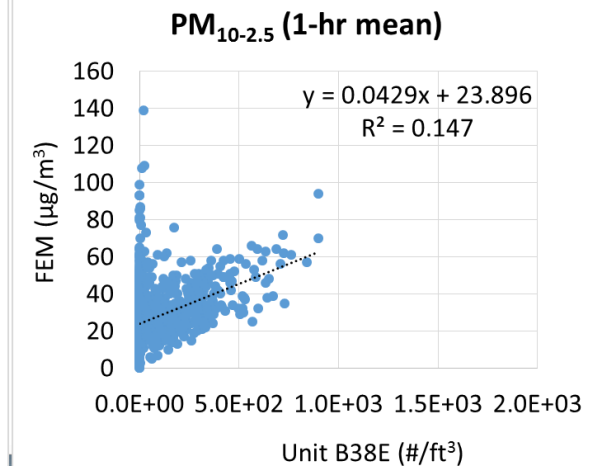
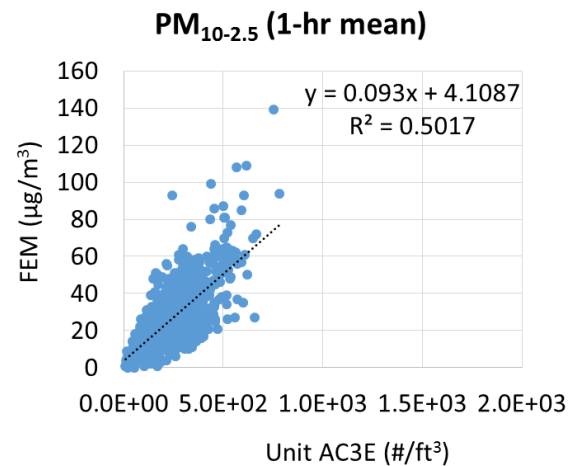
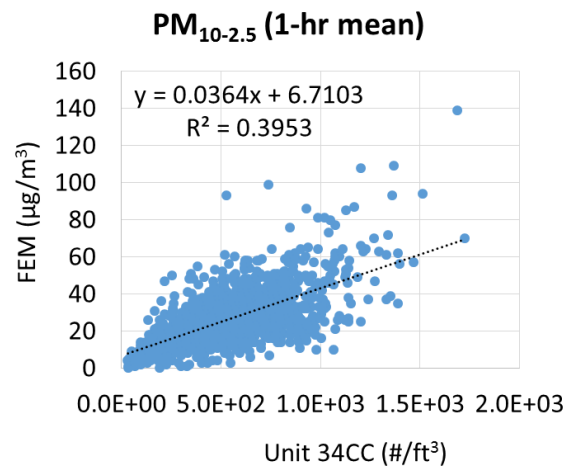
- Cair sensor “small” particles measurements show moderate correlations with the corresponding FEM BAM PM<sub>2.5</sub> mass concentrations data ( $0.43 < R^2 < 0.51$ ).
- The three sensor units tested seem to track well the diurnal PM<sub>2.5</sub> variations recorded by the FEM BAM instrument.



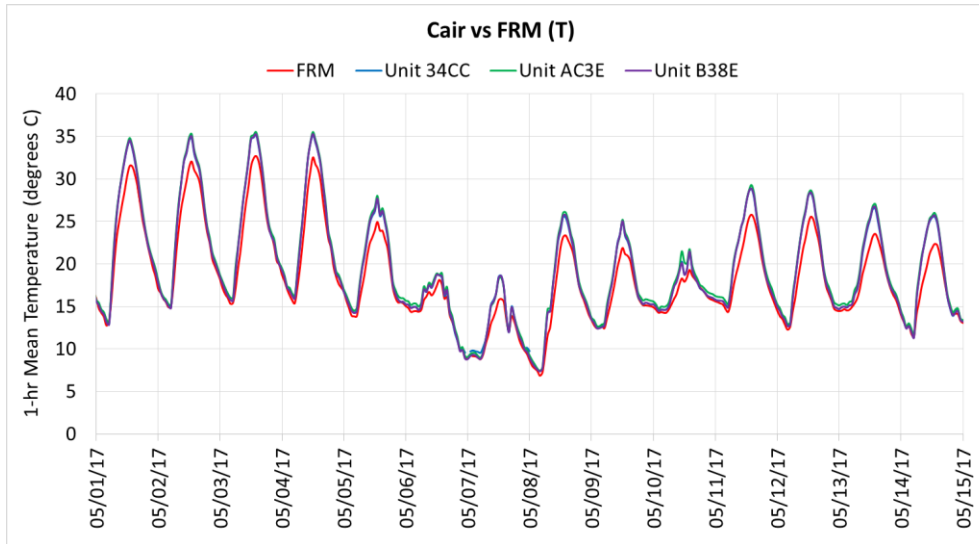
# Cair vs FEM BAM (PM<sub>10-2.5</sub>; 1-hr mean)



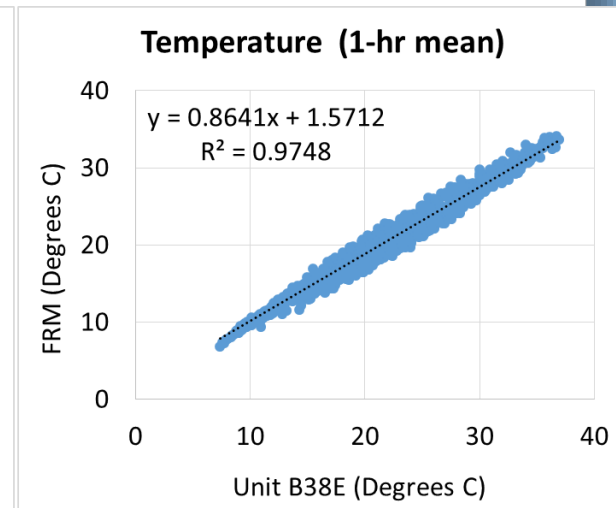
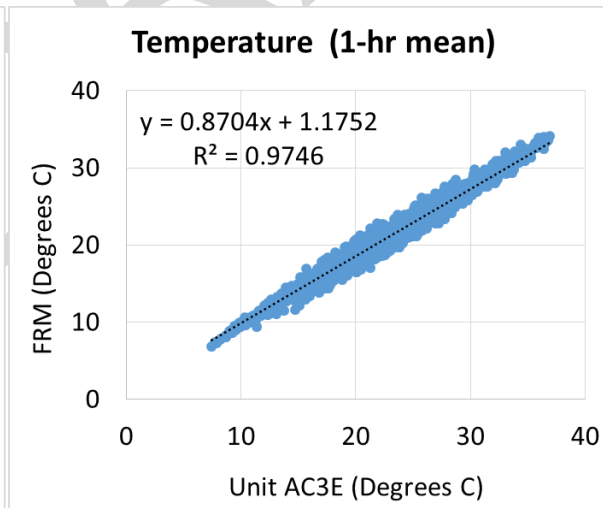
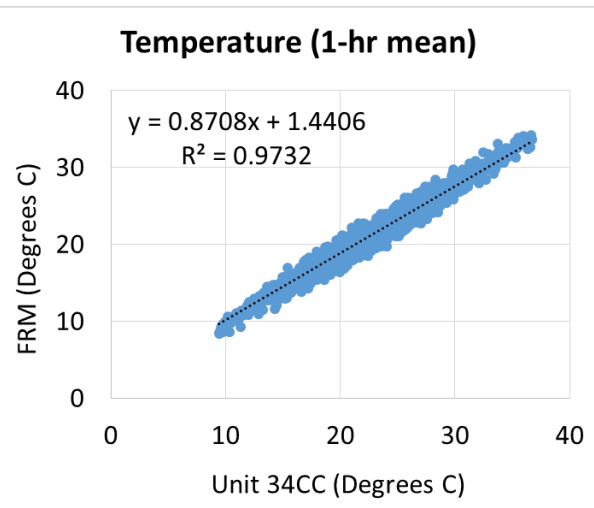
- “Large” particles measurements from Cair sensors (except for Unit B38E) show moderate correlations with the corresponding FEM PM<sub>10-2.5</sub> data ( $0.39 < R^2 < 0.51$ ).
- Considerably lower correlation for Unit B38E is due to the large fraction of zero concentrations measured by this unit
- Two sensor units (34CC and AC3E) seem to track well the diurnal PM<sub>10-2.5</sub> variations recorded by the FEM BAM instrument



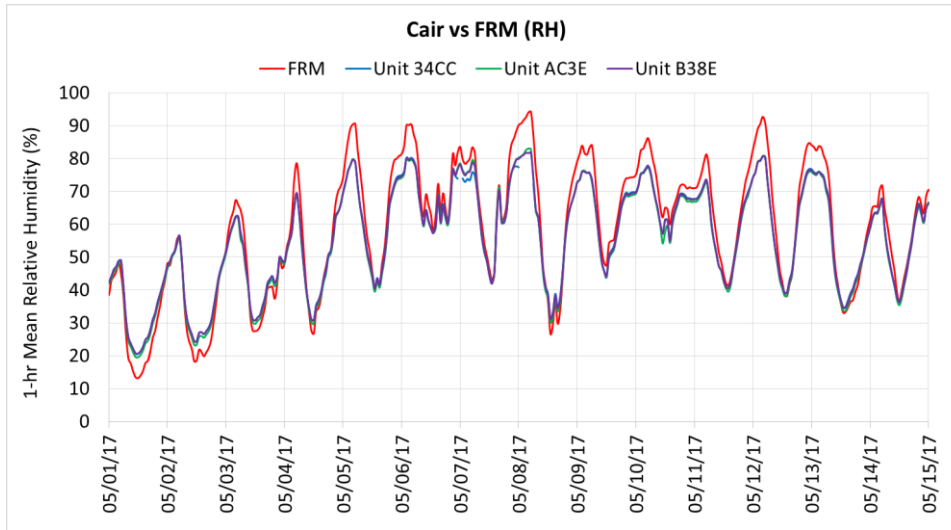
# Cair vs FRM (Temperature; 1-hr mean)



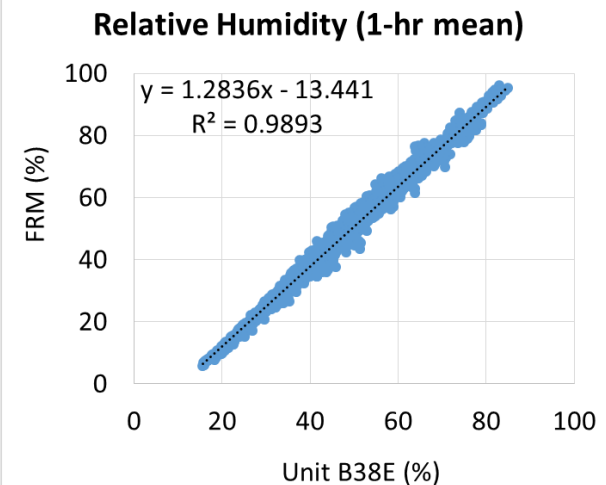
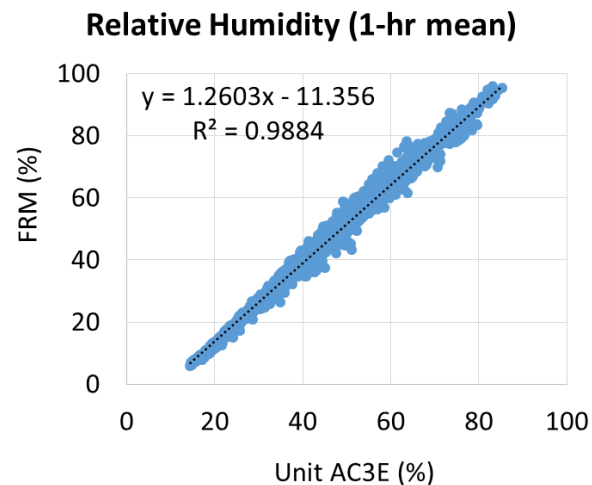
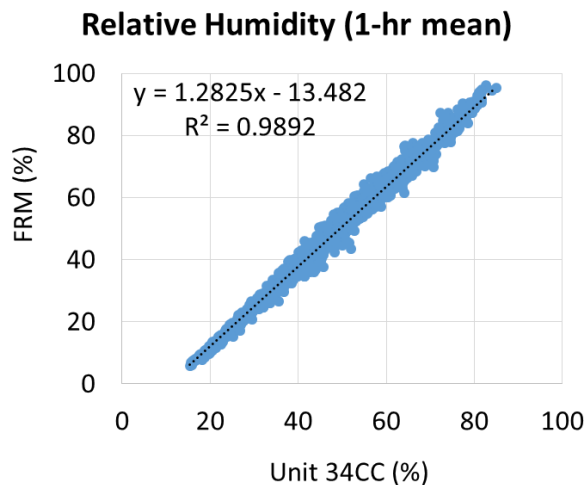
- Temperature measurements from all three Cair sensors correlate very well with the corresponding FRM data ( $R^2 > 0.97$ ), but they slightly overestimate the FRM measured temperature.
- The three sensor units tested track very well the diurnal variations of temperature recorded by the FRM instrument



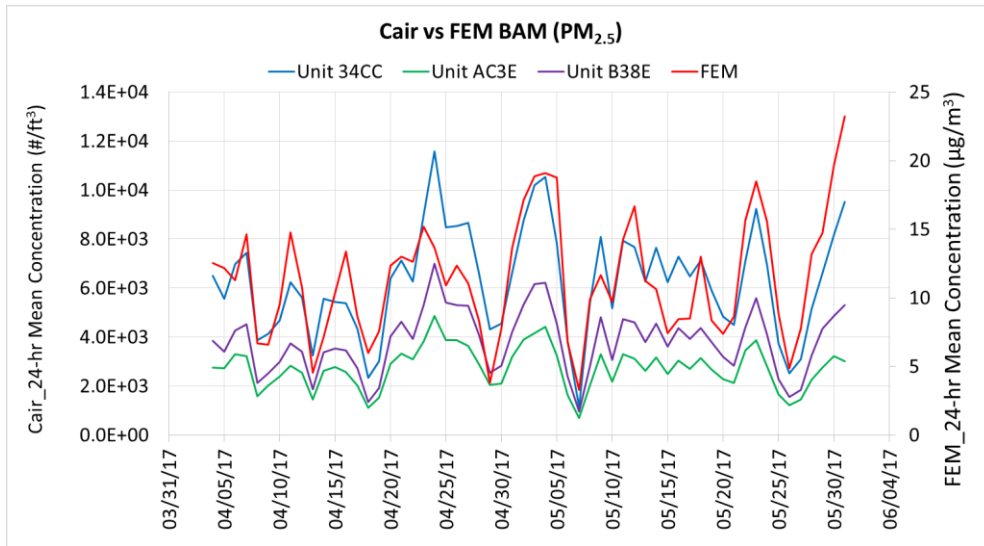
# Cair vs FRM (Relative Humidity; 1-hr mean)



- Cair sensors Relative Humidity (RH) measurements correlate very well with the corresponding FRM data ( $R^2 > 0.98$ )
- Cair sensor units seem to slightly underestimate the FRM data at high RH and slightly overestimate the FRM data at low RH
- Cair sensors track very well the diurnal variations of RH recorded by the FRM instrument

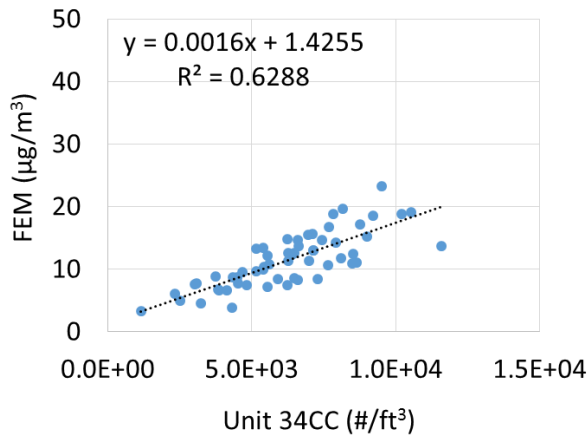


# Cair vs FEM BAM (PM<sub>2.5</sub>; 24-hr mean)

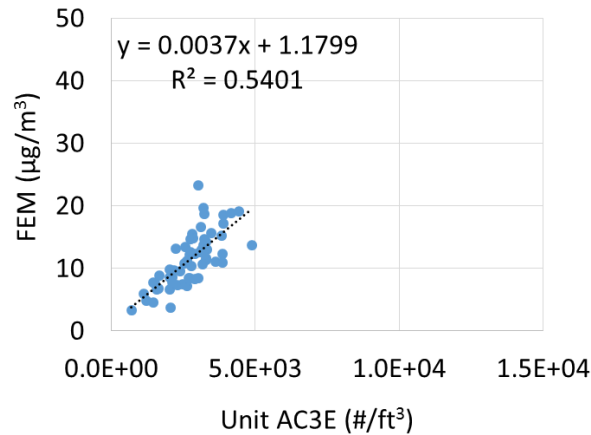


- Cair sensors “small” particles measurements show moderate correlations with the corresponding FEM BAM PM<sub>2.5</sub> mass concentrations data ( $0.54 < R^2 < 0.63$ ).
- The three sensor units track well the day-to-day PM<sub>2.5</sub> variations recorded by the FEM BAM instrument

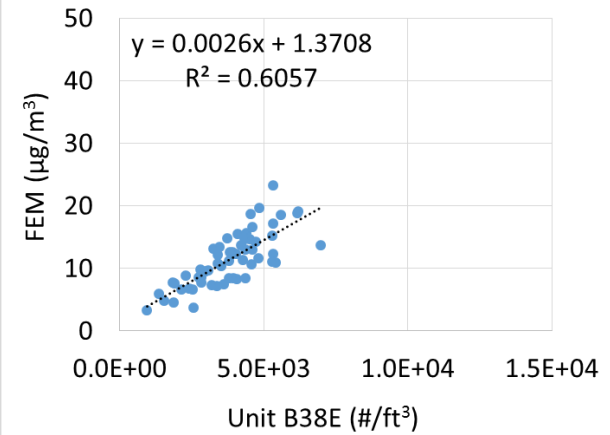
PM<sub>2.5</sub> (24-hr mean)



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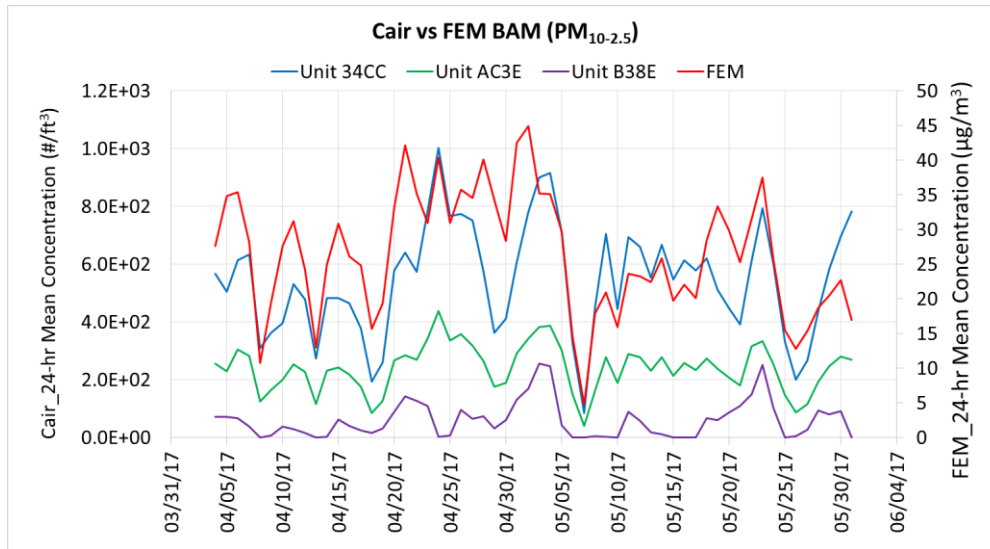


PM<sub>2.5</sub> (24-hr mean)

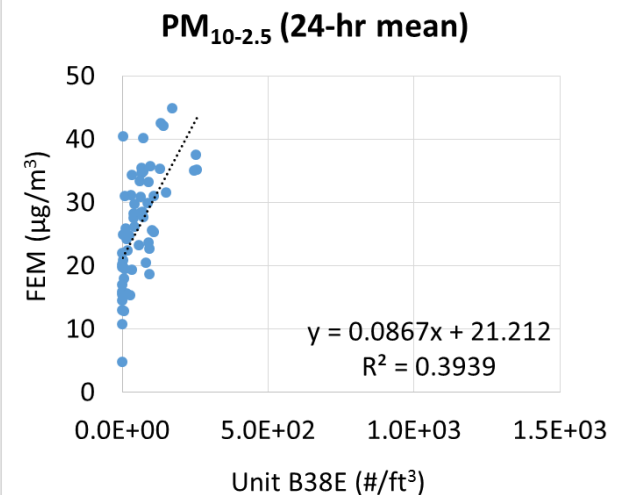
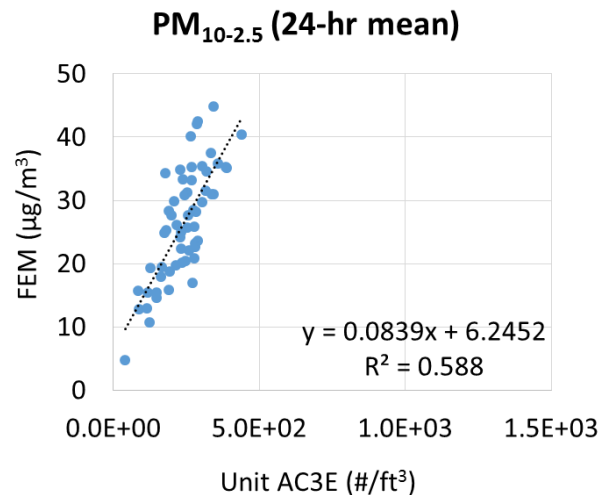
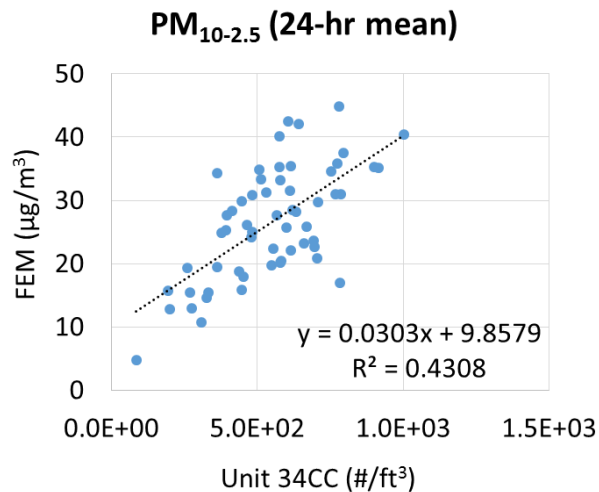




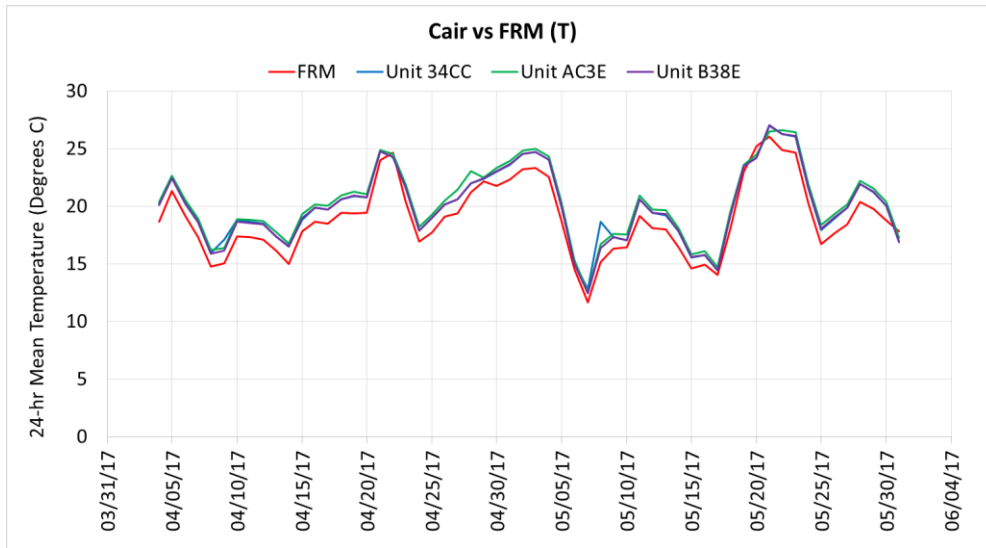
# Cair vs FEM BAM (PM<sub>10-2.5</sub>; 24-hr mean)



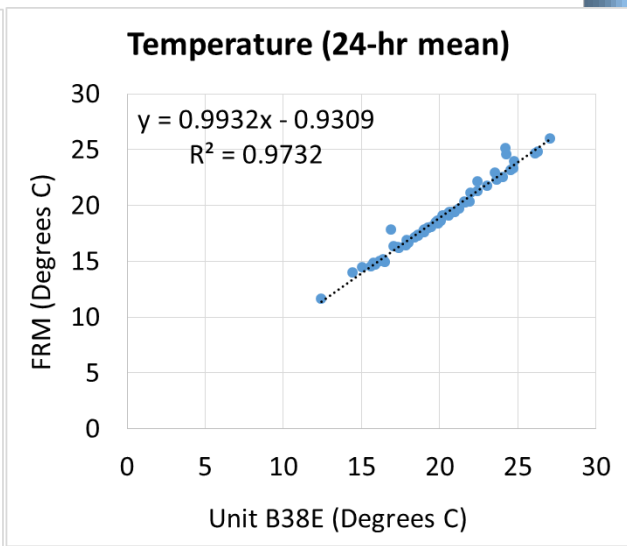
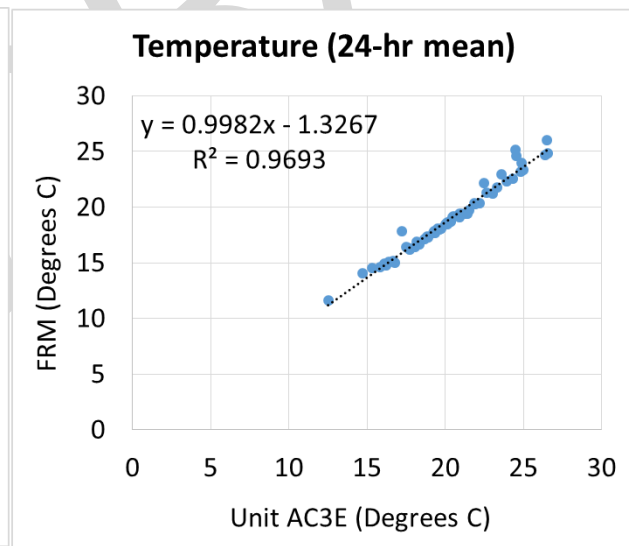
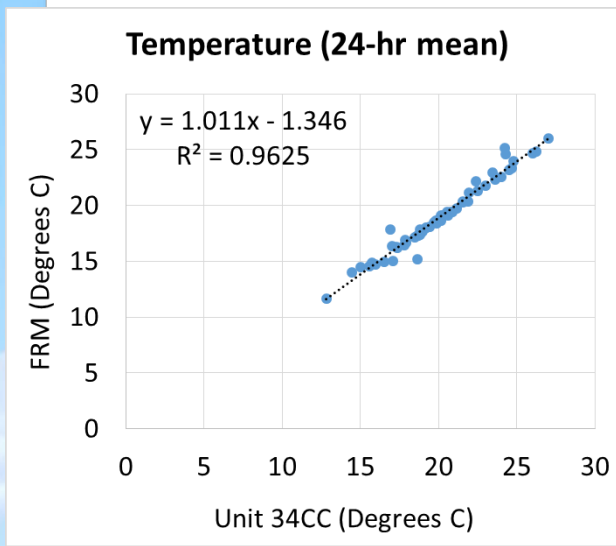
- “Large” particles measurements by Cair sensors show moderate correlations with the corresponding FEM PM<sub>10-2.5</sub> data ( $0.39 < R^2 < 0.59$ ).
- Cair sensors seem to track well the day-to-day PM<sub>10-2.5</sub> variations recorded by the FEM BAM instrument



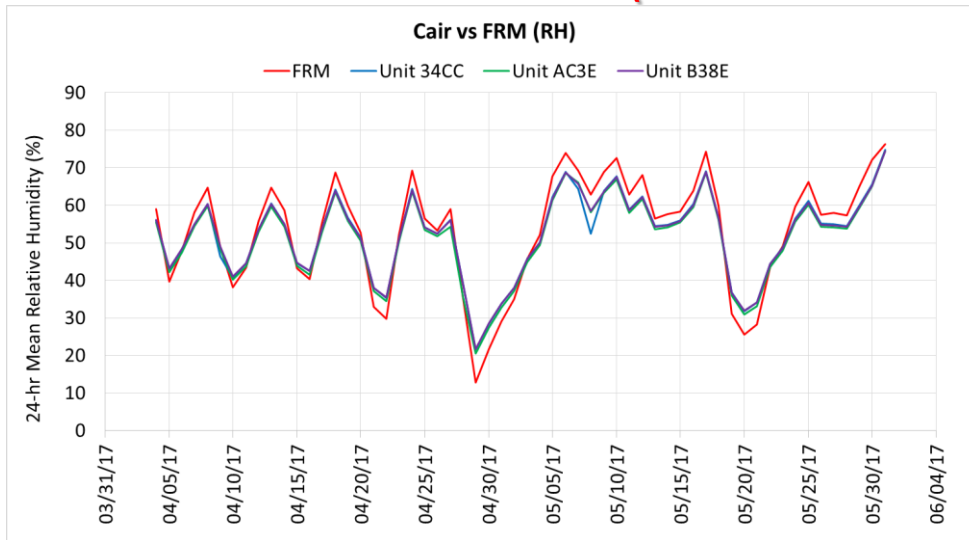
# Cair vs FRM (Temperature; 24-hr mean)



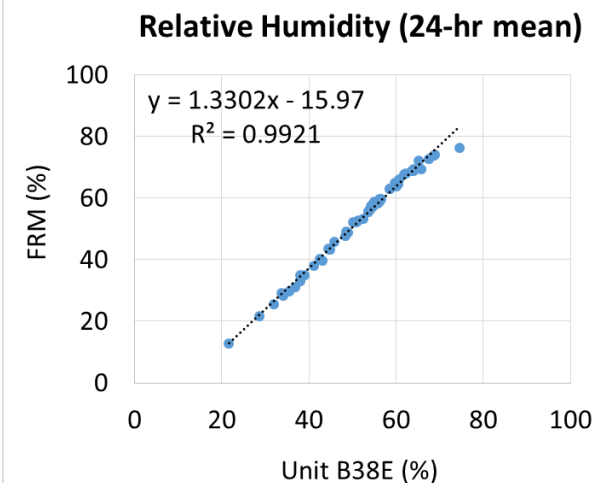
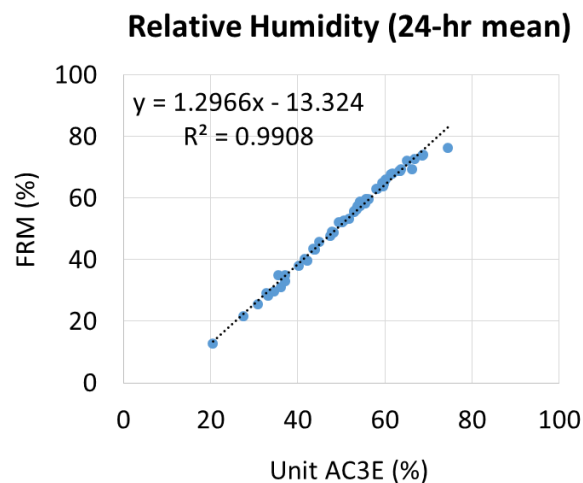
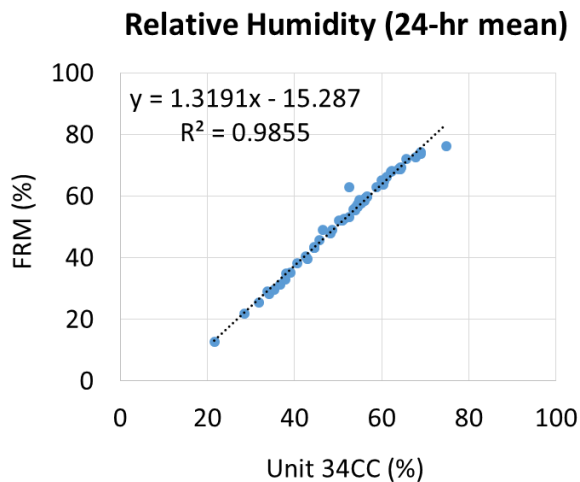
- Temperature measurements from all three Cair sensors correlate very well with the corresponding FRM data ( $R^2 > 0.96$ ), but they slightly overestimate the FRM measured temperature.
- The three sensor units tested track very well the day-to-day variations of temperature recorded by the FRM instrument



# Cair vs FRM (Relative Humidity; 24-hr mean)



- Cair sensors Relative Humidity (RH) measurements correlate very well with the corresponding FRM data ( $R^2 > 0.98$ ).
- Cair sensor units seem to slightly underestimate the FRM data at high RH and overestimate the FRM data at low RH.
- Cair sensors track very well the day-to-day variations of RH recorded by the FRM instrument



# Discussion

- Overall, Cair sensor units were reliable with high data recovery (~100%)
- The three units tested showed high intra-model variability for number concentrations of “small” and “large” particles
- Cair sensors “small” and “large” particles number concentrations showed moderate correlations ( $0.43 < R^2 < 0.51$  and  $0.39 < R^2 < 0.51$ ) with the FEM BAM  $PM_{2.5}$  and  $PM_{10-2.5}$  mass measurements, respectively
- Temperature and relative humidity measured by Cair sensors correlated very well ( $R^2 > 0.96$ ) with the corresponding values collected using a substantially more expensive meteorological instrument and were quite accurate
- It should be noted that no sensor calibration had been performed by SCAQMD Staff prior to the beginning of this field testing
- Laboratory chamber testing may be necessary to fully evaluate the performance of these sensors over different / more extreme environmental conditions
- All results are still preliminary