Field Evaluation
Air Nut Sensor

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 12/09/2016 to 01/26/2017, three **Air Nut** sensors were deployed at our (SCAQMD) Rubidoux station and ran side-by-side with two Federal Equivalent Method (FEM) instruments measuring the same pollutant

- *Air Nut sensor [3 sensors tested]:*
  - Each sensor reports: $PM_{2.5}$ mass concentration ($\mu g/m^3$), carbon dioxide (CO_2) (ppm), Temp (Celcius) and RH (%)
  - Particle sensor (optical; non-FEM) ($PM_{2.5}$ sensor by Plantower)
  - Time resolution: 5-min
  - Node cost: ~$200
  - IDs: #936EB, #92B4D, #790C2

- MetOne BAM (*reference method*):
  - Beta-attenuation monitors (FEM $PM_{2.5}$)
  - Measures $PM_{2.5}$ mass ($\mu g/m^3$)
  - Unit cost: ~$20,000
  - Time resolution: 1-hr

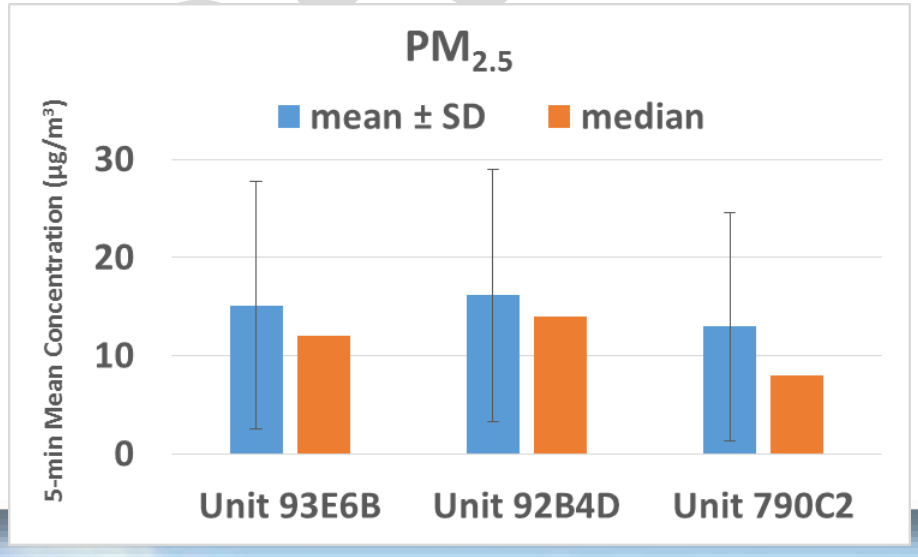
- GRIMM (*reference method*):
  - Optical particle counter (FEM $PM_{2.5}$)
  - Uses proprietary algorithms to calculate total $PM_{1.0}$, $PM_{2.5}$, and PM_{10} mass from particle number measurements
  - Unit Cost: ~$25,000 and up
  - Time resolution: 1-min

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 for $PM_{2.5}$ from all three Air Nut sensor units was between 20 and 23%.

Air Nut; intra-model variability

- Low measurement variations were observed between the three Air Nut sensors for $PM_{2.5}$ mass concentrations ($\mu g/m^3$)

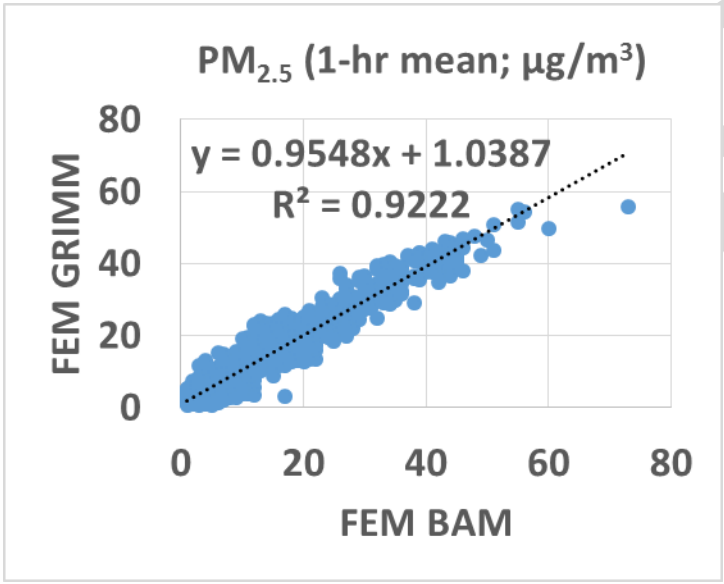


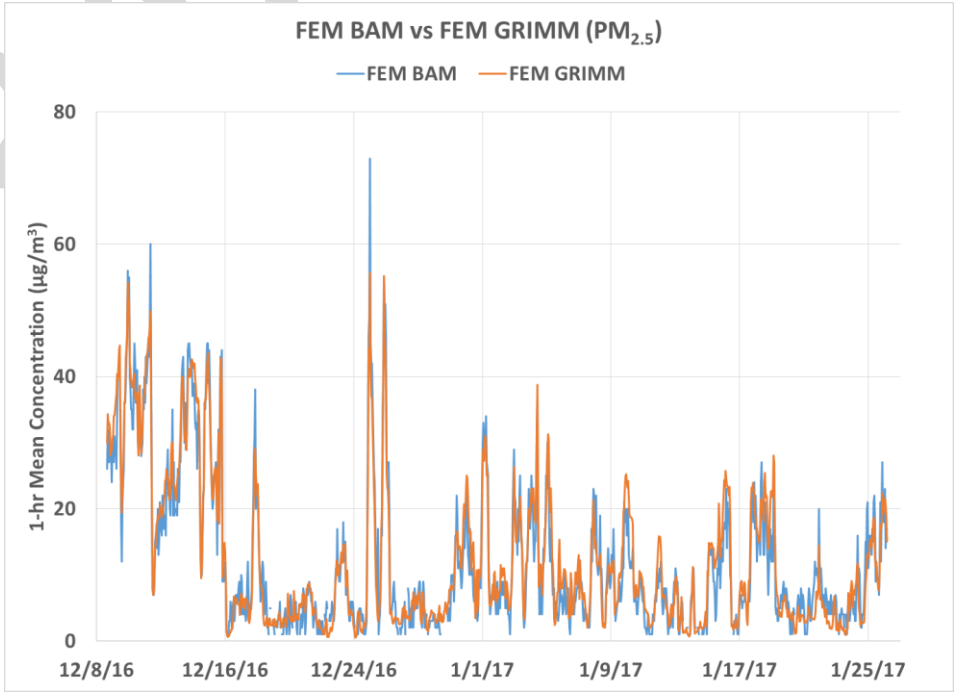
Data validation & recovery

- Basic QA/QC procedures were used to validate the collected PM data (i.e. obvious outliers, negative values and invalid data-points were eliminated from data-set)
- $PM_{2.5}$ data recovery was close to 100% for the GRIMM and the BAM.

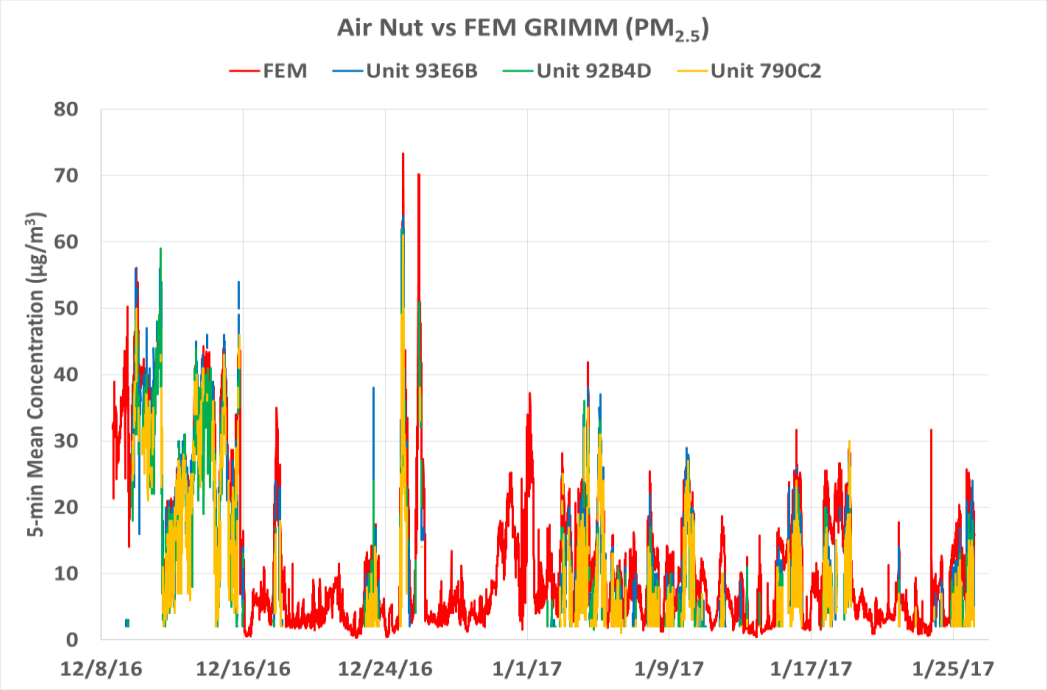
Equivalent methods: BAM vs GRIMM

- Excellent correlation between the two equivalent methods for $PM_{2.5}$

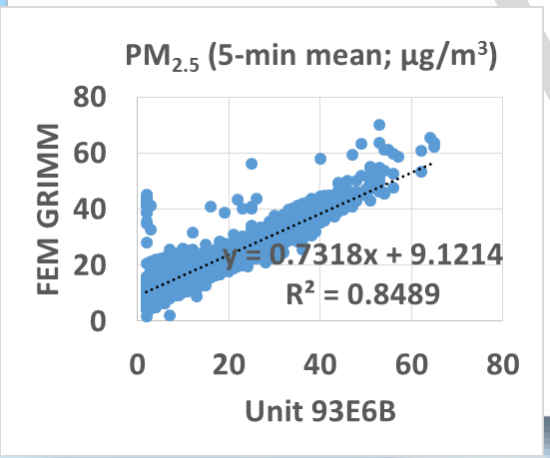


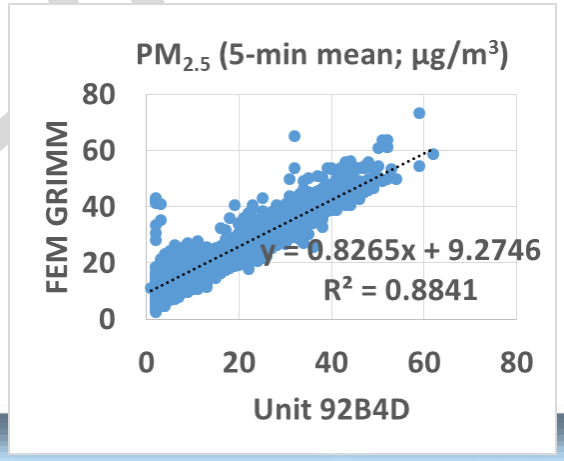


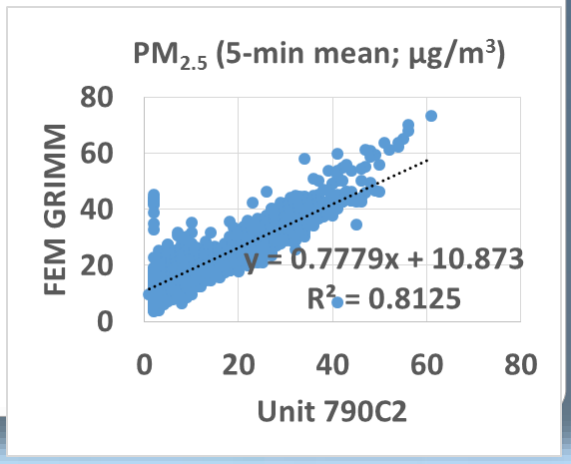
Air Nut vs FEM GRIMM ($PM_{2.5}$; 5-min mean)



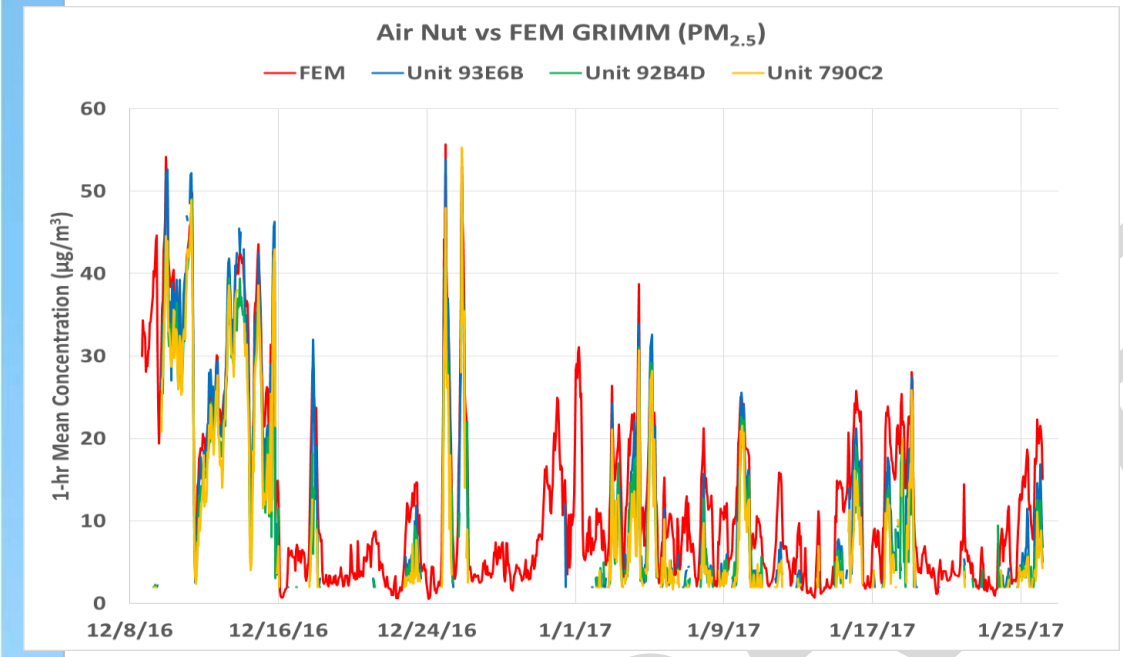
- Air Nut $PM_{2.5}$ mass measurements correlate well with the corresponding FEM GRIMM data ($R^2 > 0.81$)
- Air Nut sensors seem to track the diurnal $PM_{2.5}$ variations recorded by the FEM GRIMM instrument
- However, sensor measurements underestimated the data recorded concurrently by the GRIMM instrument



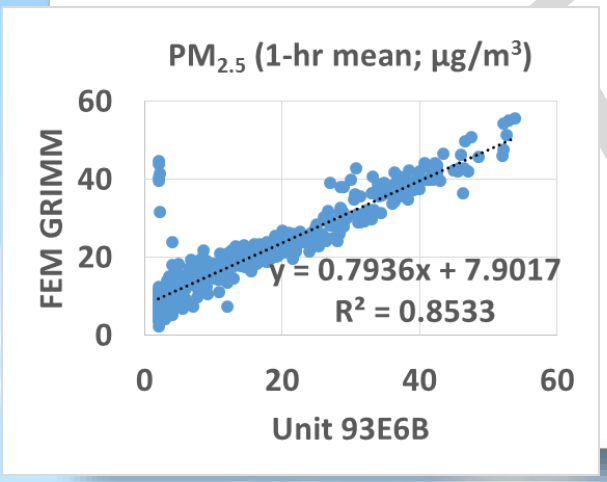


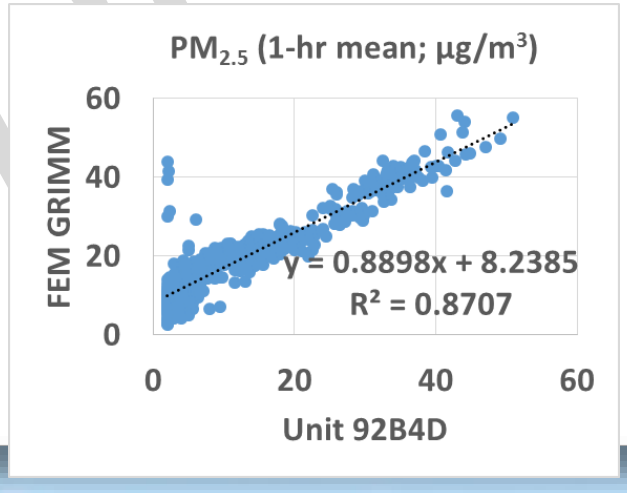


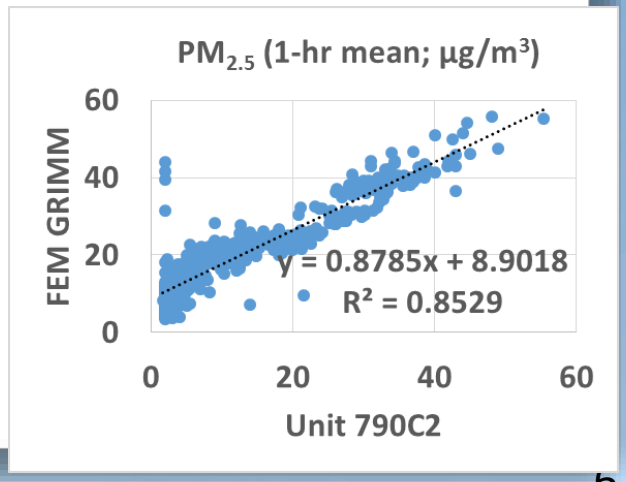
Air Nut vs FEM GRIMM ($PM_{2.5}$; 1-hr mean)



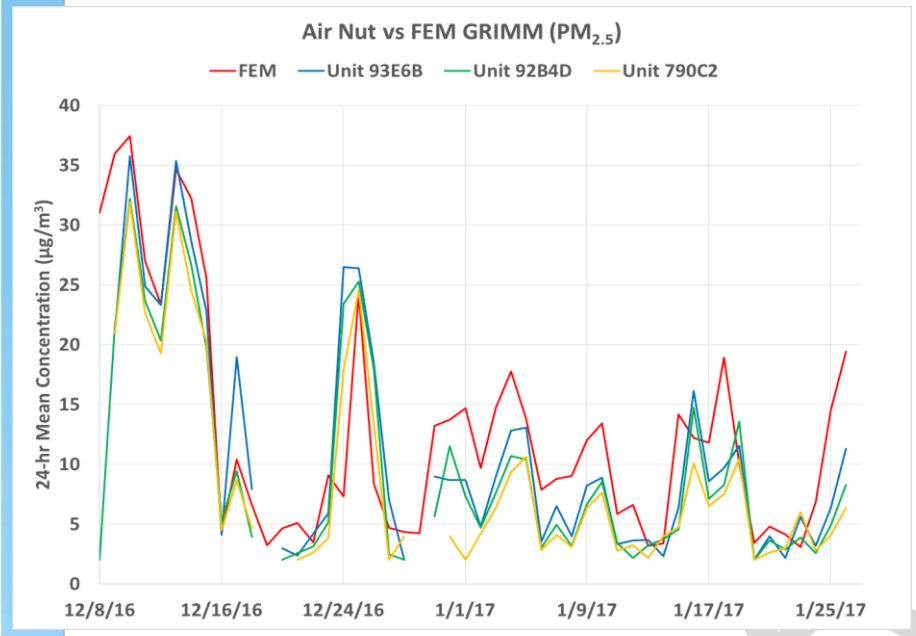
- Air Nut $PM_{2.5}$ mass measurements correlate well with the corresponding FEM GRIMM data ($R^2 > 0.85$)
- Air Nut sensors seem to track the diurnal $PM_{2.5}$ variations recorded by the FEM GRIMM instrument
- However, sensor measurements underestimated the data recorded concurrently by the GRIMM instrument



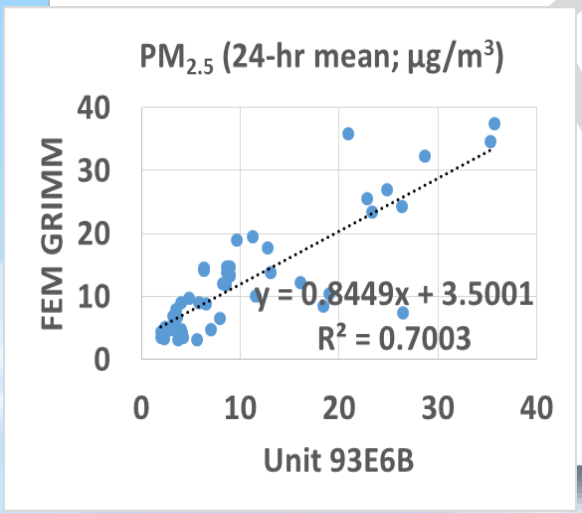


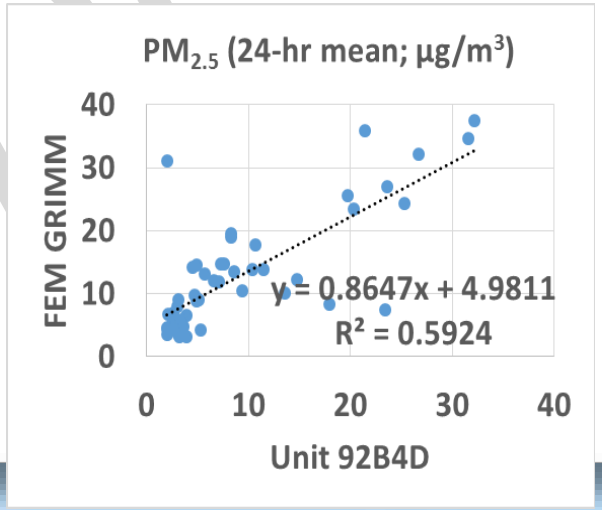


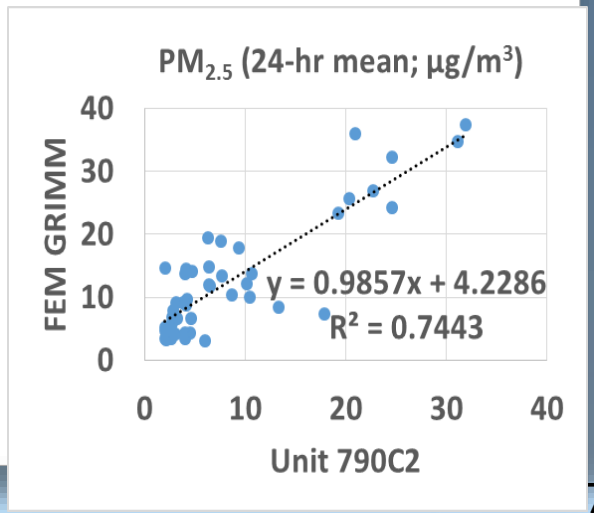
Air Nut vs FEM GRIMM ($PM_{2.5}$; 24-hr mean)



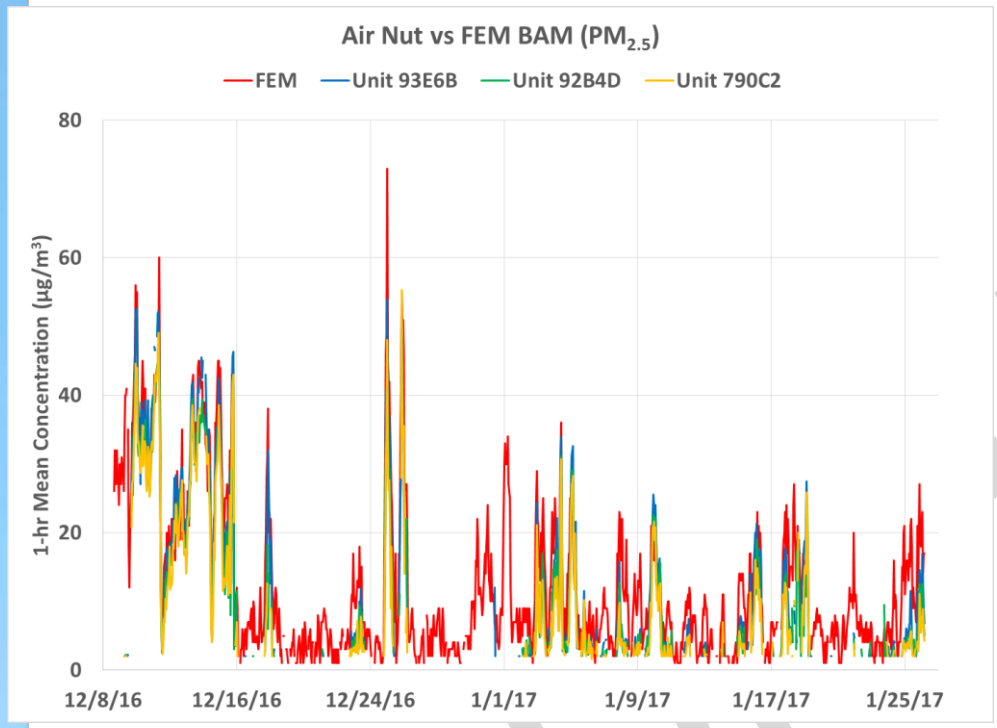
- Although, the Air Nut $PM_{2.5}$ mass measurements correlate well with the corresponding FEM GRIMM data ($R^2 > 0.59$), this correlation is weaker than the 5-min or 1-hr mean ones. This is due to very low sensor data recovery relative to the FEM instrument
- Air Nut sensors seem to track the diurnal $PM_{2.5}$ variations recorded by the FEM GRIMM instrument
- However, sensor measurements underestimated the data recorded concurrently by the GRIMM instrument



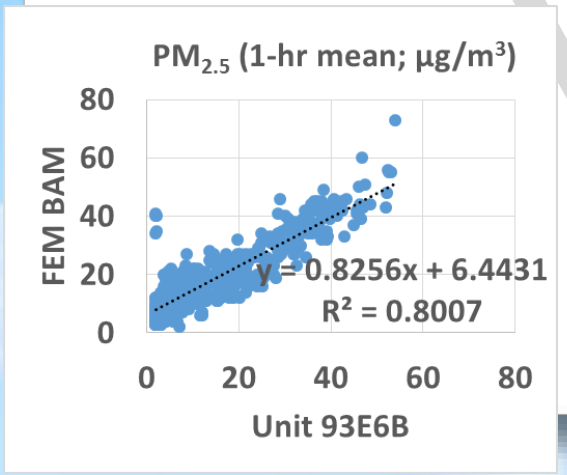


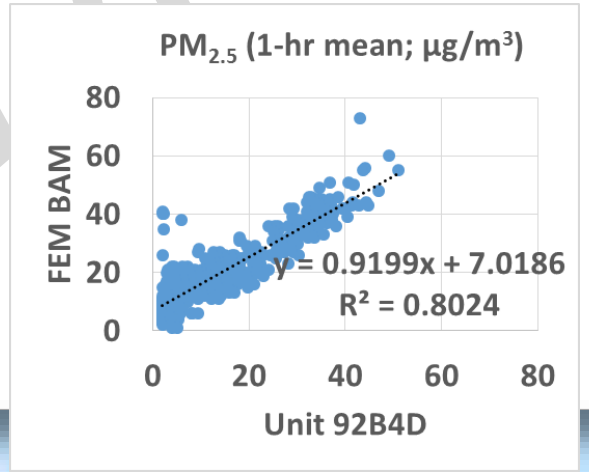


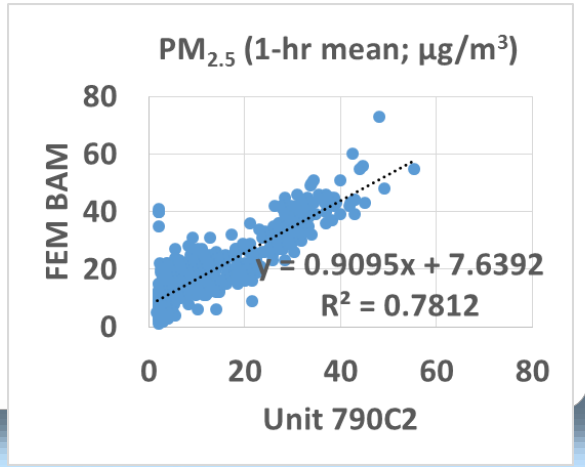
Air Nut vs FEM BAM ($PM_{2.5}$; 1-hr mean)



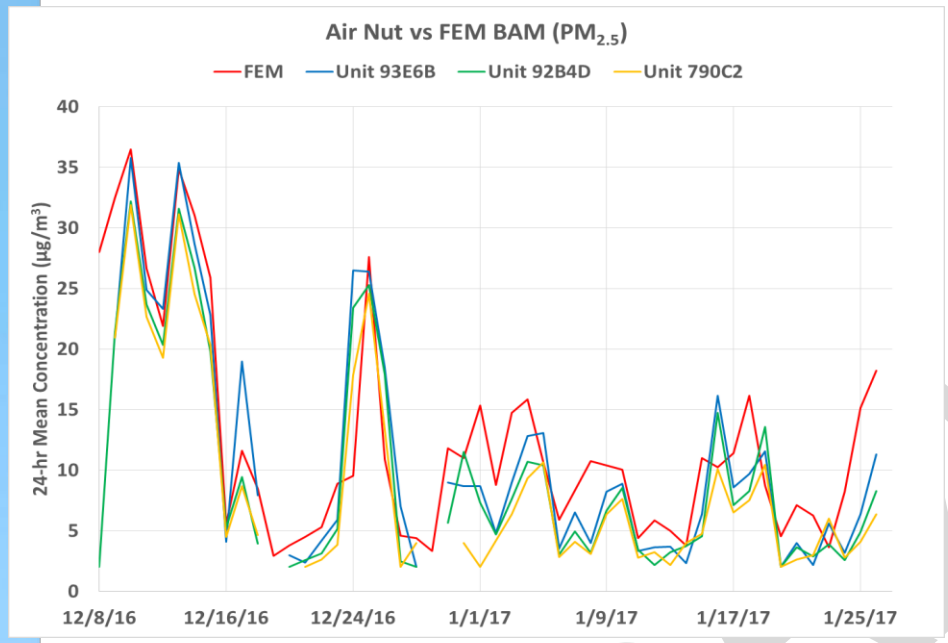
- Air Nut $PM_{2.5}$ mass measurements correlate well with the corresponding FEM BAM data ($R^2 > 0.78$)
- Air Nut sensors seem to track the diurnal $PM_{2.5}$ variations recorded by the FEM BAM instrument
- However, sensor measurements underestimated the data recorded concurrently by the BAM instrument



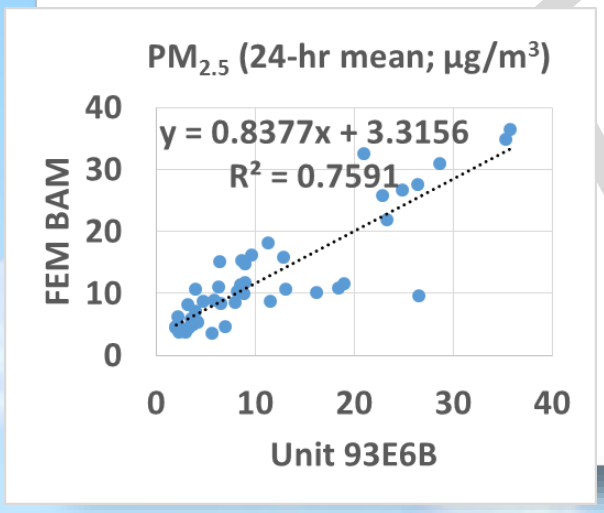


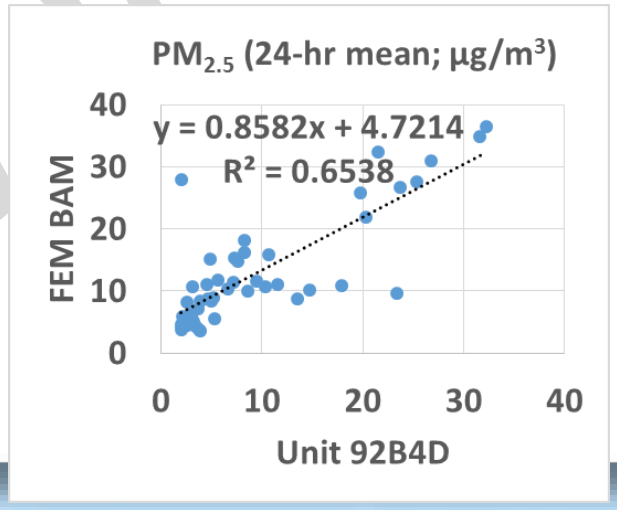


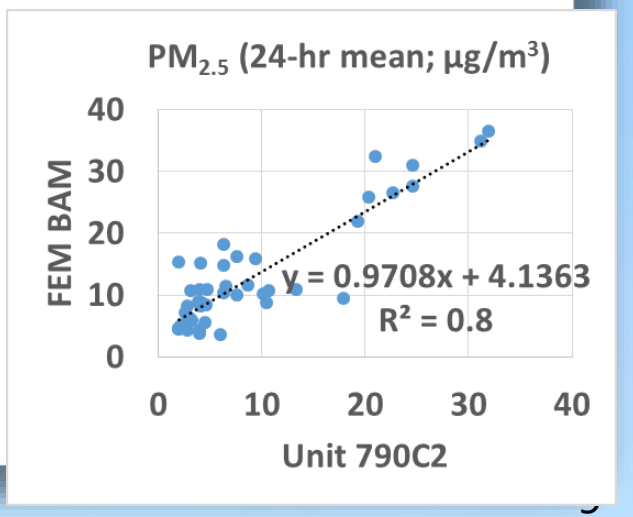
Air Nut vs FEM BAM ($PM_{2.5}$; 24-hr mean)



- Although Air Nut $PM_{2.5}$ mass measurements correlate well with the corresponding FEM BAM data ($R^2 > 0.65$), this correlation is weaker than the 1-hr mean one. This is due to very low sensor data recovery relative to the FEM instrument
- Air Nut sensors seem to track the diurnal $PM_{2.5}$ variations recorded by the FEM BAM instrument
- However, sensor measurements underestimated the data recorded concurrently by the BAM instrument







Discussion

- The three **Air Nut** PM sensors were not reliable (data recovery was between 20 and 23% for all units tested), but were characterized by low intra-model variability
- $PM_{2.5}$ sensor data correlated well with the corresponding FEM GRIMM and FEM BAM values ($R^2 > 0.81$ and $R^2 > 0.78$, respectively)
- Due to the low sensor data recovery relative to the reference methods data recovery, averaged sensor values over a 24-hour time period do not correlate that well with the reference methods measurement data.
- No sensor calibration was performed by SCAQMD Staff prior to the beginning of this test
- 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