Field Evaluation
Air Quality Egg v.2
Particulate Matter

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 02/01/2016 to 04/01/2016, three **Air Quality Egg (AQE) v.2 PM** (Particulate Matter) sensors were deployed in Rubidoux and run side-by-side with Federal Equivalent Method (FEM; EPA approved) instruments measuring the same pollutant

- Air Quality Egg (*3 units tested*):
  - PM sensor (non-FEM); Optical Method
  - Pollutant measured: Particulate Matter (0.5 – 10 µm)
  - Unit cost: ~$240
  - Time resolution: 1-min
  - Units IDs: AQE 001, AQE 002, AQE 003

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

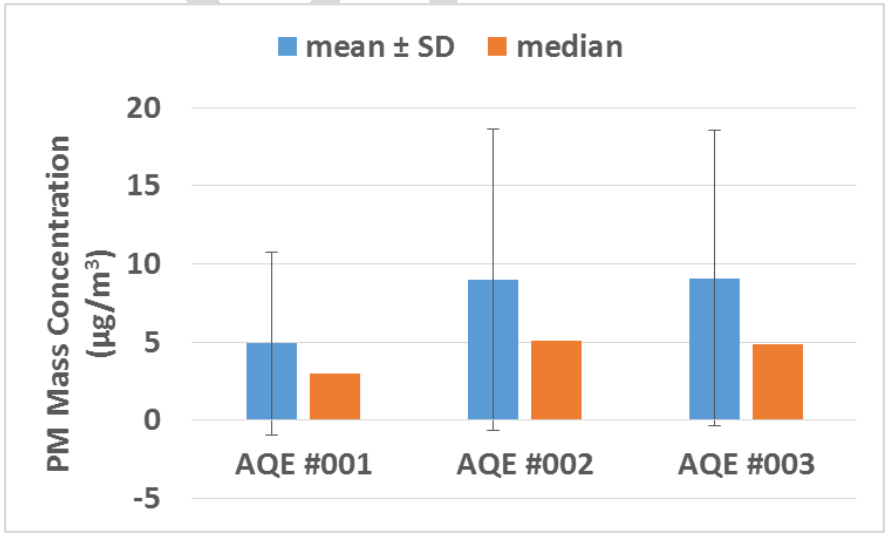
- GRIMM (*reference method*):
  - Optical particle counter (FEM)
  - Uses proprietary algorithms to calculate total PM, $PM_{2.5}$, and PM_1 mass from particle number measurements
  - Unit Cost: ~$25,000 and up
  - Time resolution: 1-min

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 from all three sensor units was close to 100%

Air Quality Egg: intra-model variability

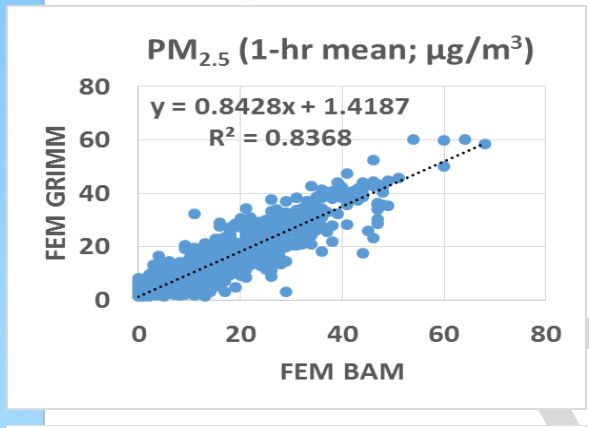
- Very low measurement variation was observed between sensors AQE #002 & #003. Readings from AQE #001 were substantially lower than those from the other two units

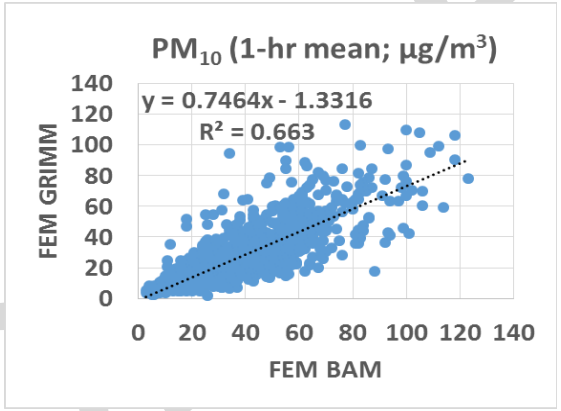


Data validation & recovery

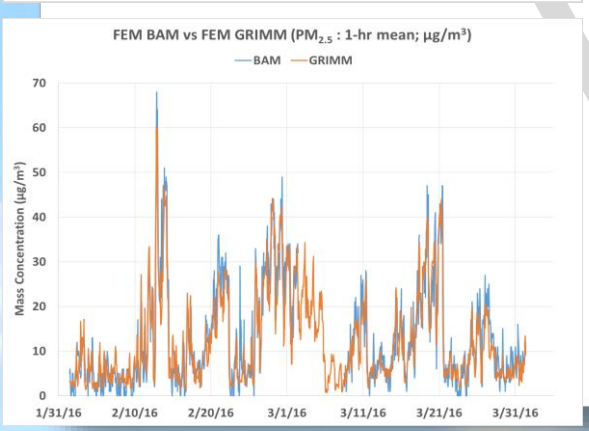
- Basic QA/QC procedures were used to validate the collected FEM data (i.e. obvious outliers, negative values and invalid data-points were eliminated from data-set)
- Data recovery for the GRIMM and BAM instruments was 99% and 89%, respectively

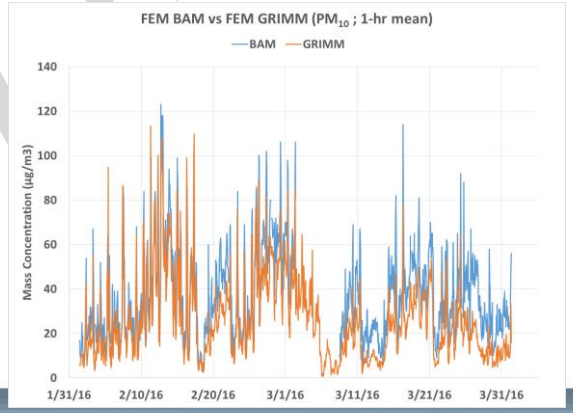
Equivalent Methods; BAM vs GRIMM



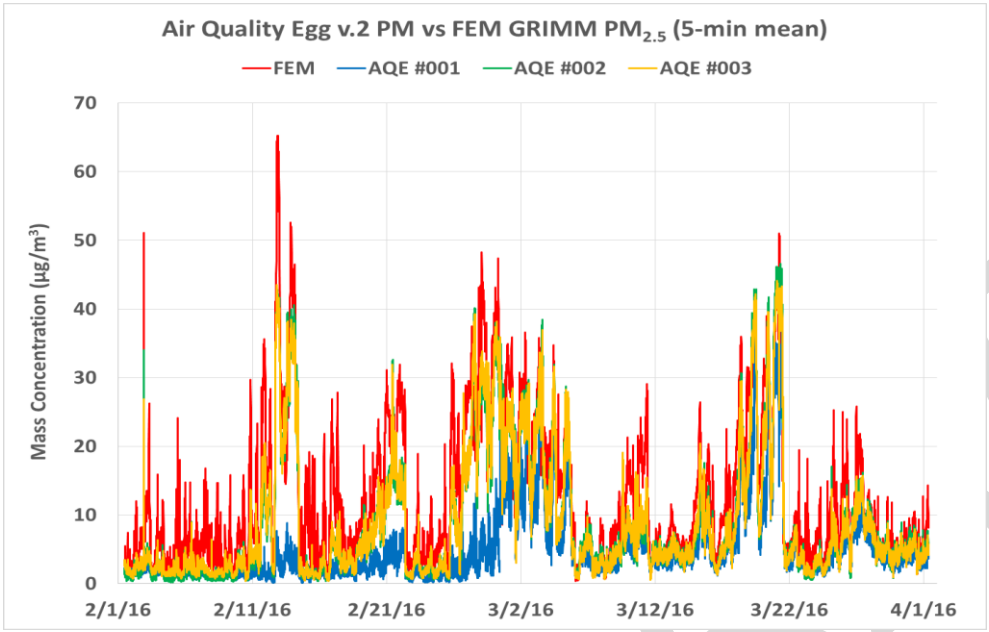


- We observed a good correlation between the two FEM methods for $PM_{2.5}$ and moderate correlation for PM_{10}

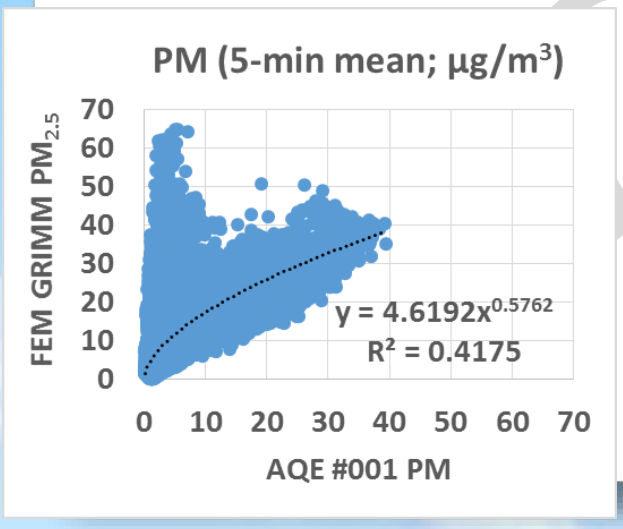


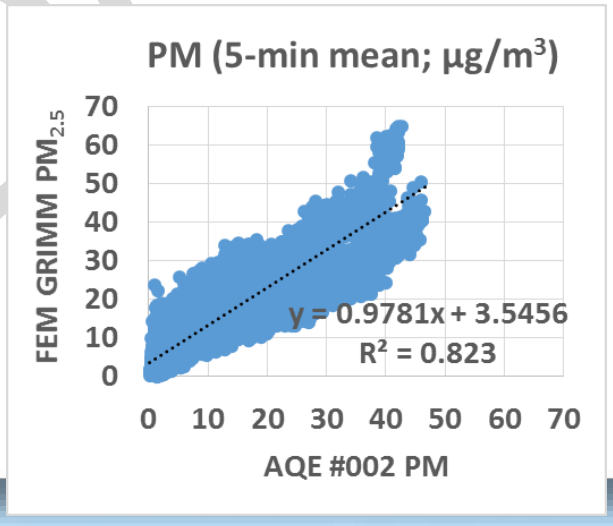


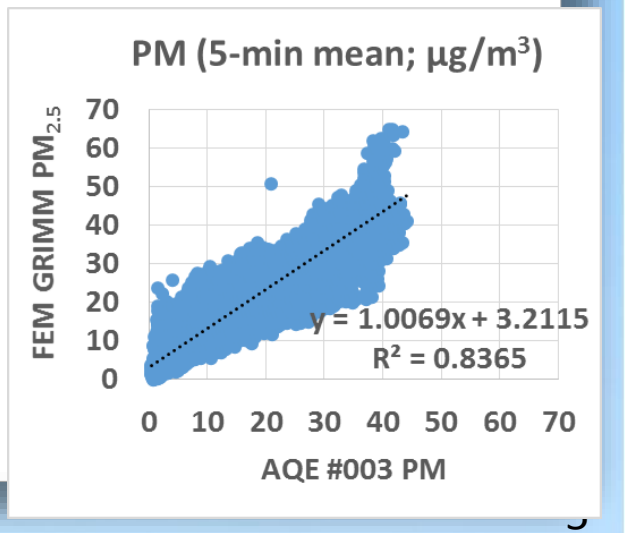
Air Quality Egg v.2 PM vs FEM GRIMM $PM_{2.5}$ (5-min mean)



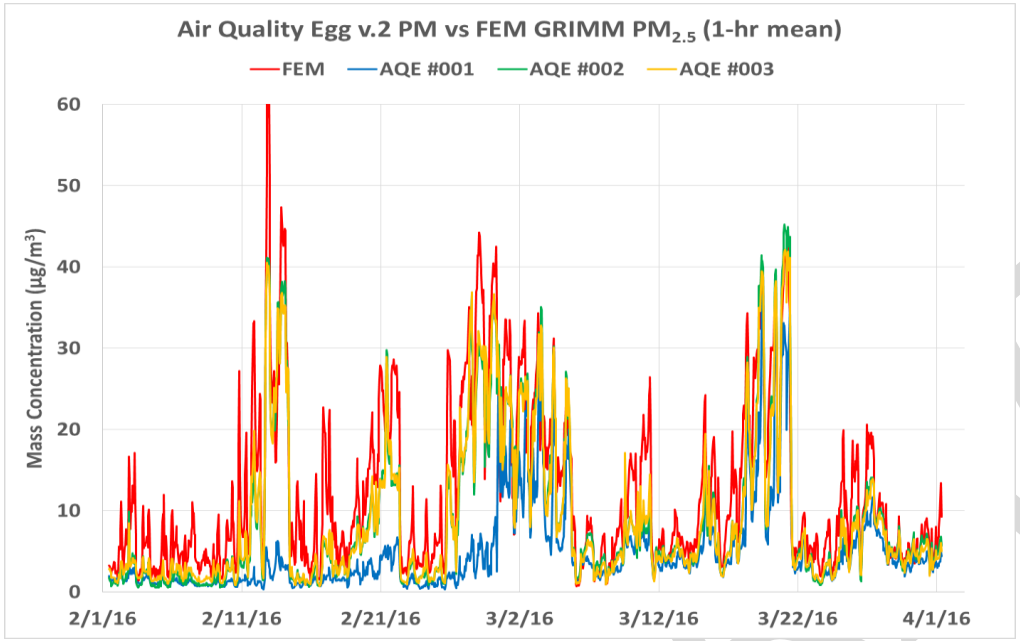
- $PM_{2.5}$ measurements from two of the three AQE sensors (#002 & #003) correlate well with the corresponding GRIMM $PM_{2.5}$ data ($R^2 > 0.82$)
- Readings from AQE #001 are only moderately correlated with the corresponding GRIMM $PM_{2.5}$ data
- In most cases all AQE sensors tracked the diurnal variations of the FEM instrument well



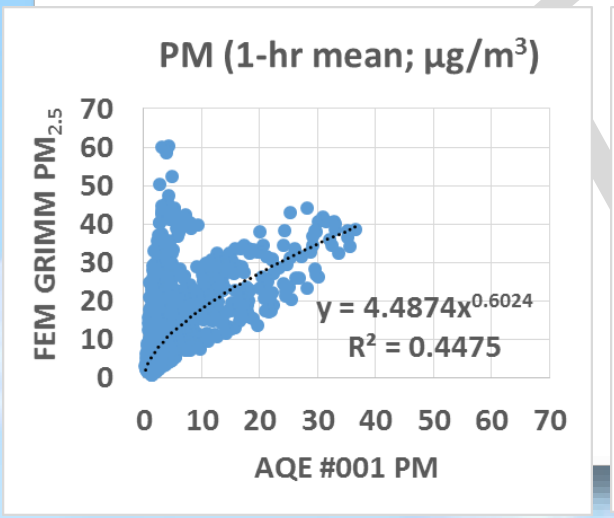


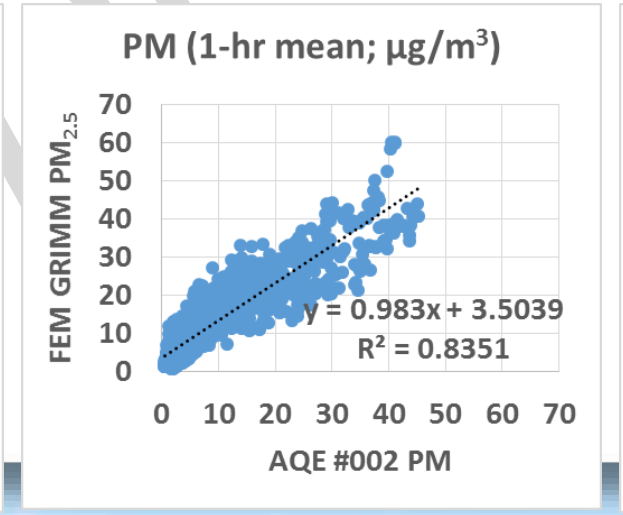


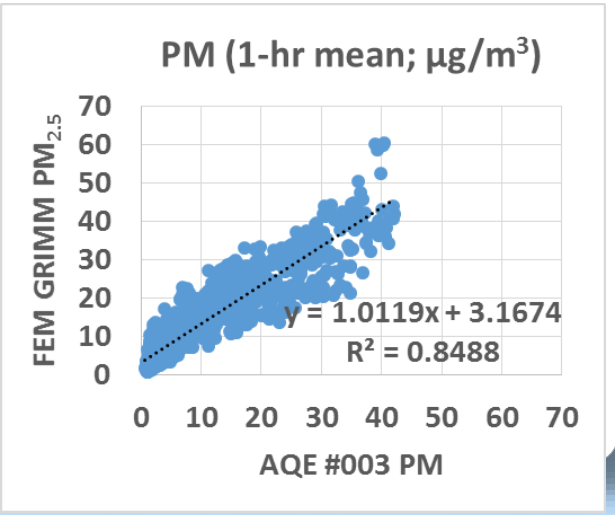
Air Quality Egg v.2 PM vs FEM GRIMM $PM_{2.5}$ (1-hr mean)



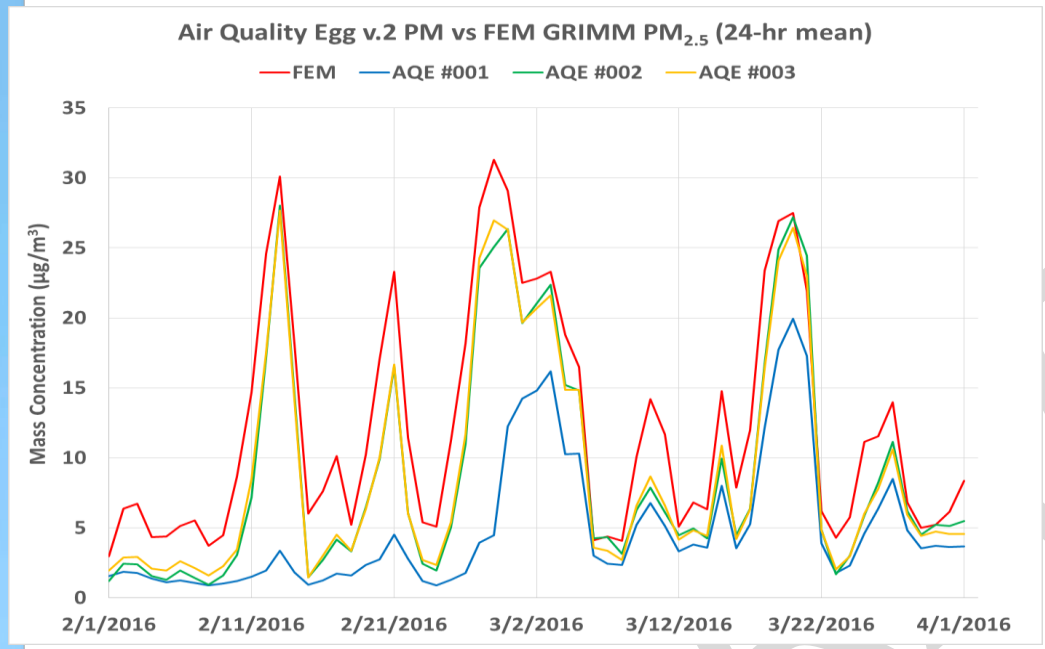
- $PM_{2.5}$ measurements from two of the three AQE sensors (#002 & #003) correlate well with the corresponding GRIMM $PM_{2.5}$ data ($R^2 > 0.83$)
- Readings from AQE #001 are only moderately correlated with the corresponding GRIMM $PM_{2.5}$ data



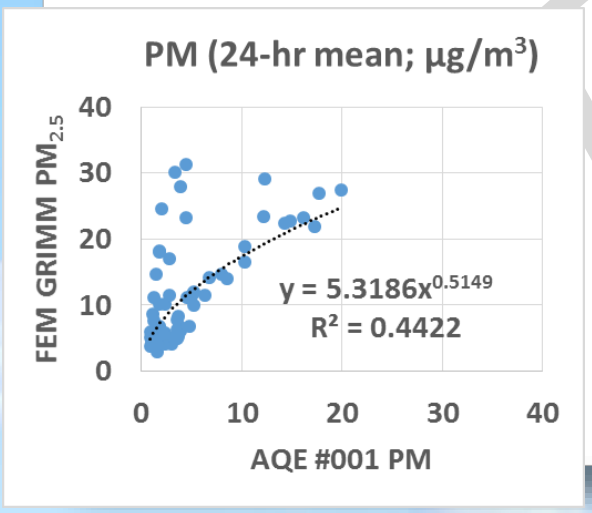


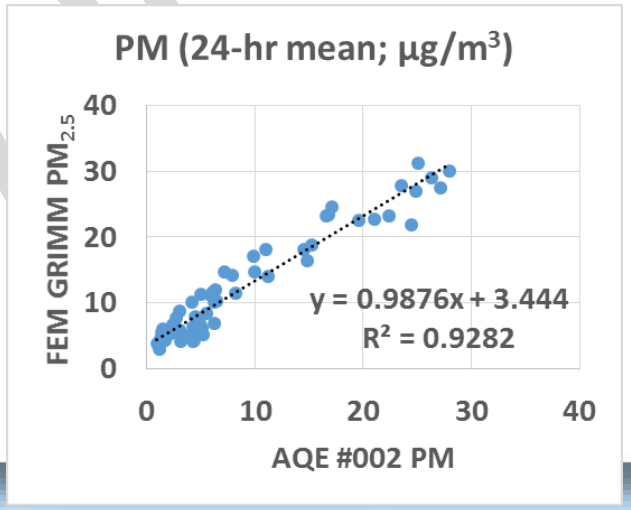


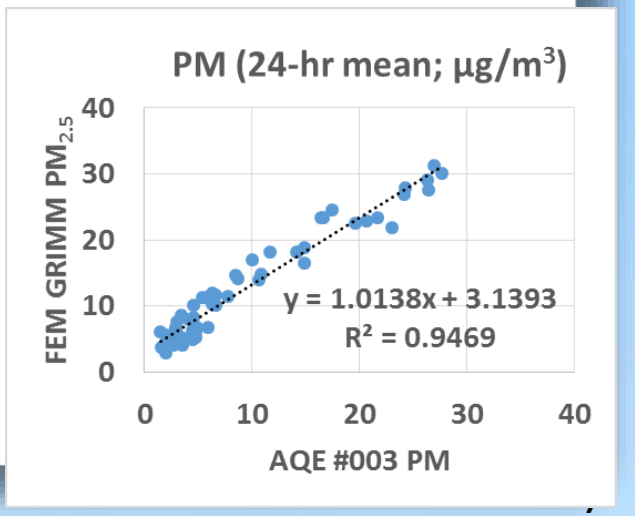
Air Quality Egg v.2 PM vs FEM GRIMM $PM_{2.5}$ (24-hr mean)



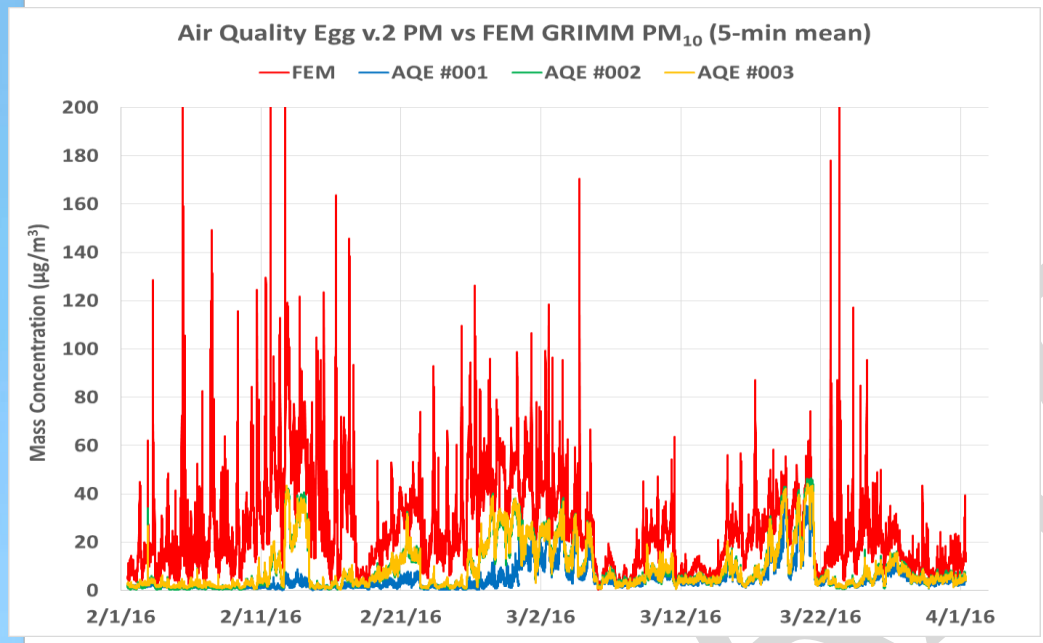
- $PM_{2.5}$ measurements from two of the three AQE sensors (#002 & #003) correlate well with the corresponding GRIMM $PM_{2.5}$ data ($R^2 > 0.925$)
- Readings from AQE #001 are only moderately correlated with the corresponding GRIMM $PM_{2.5}$ data



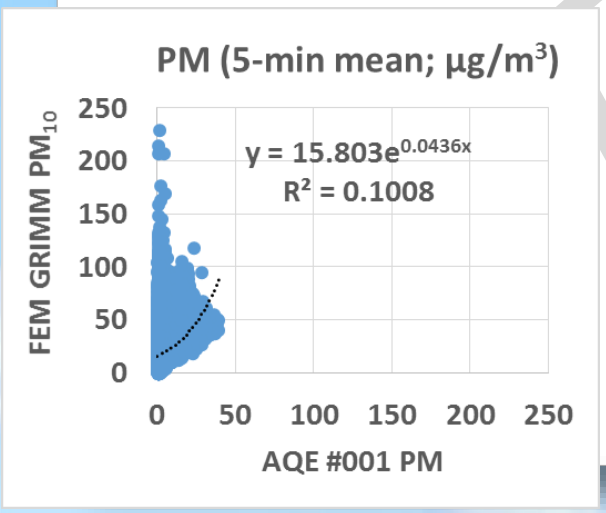


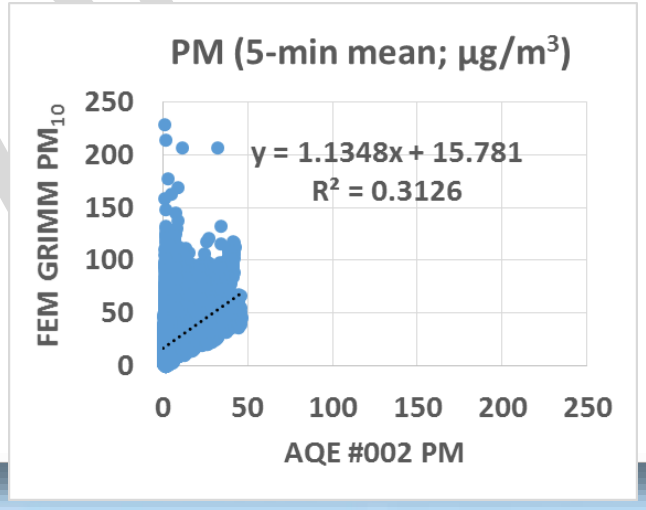


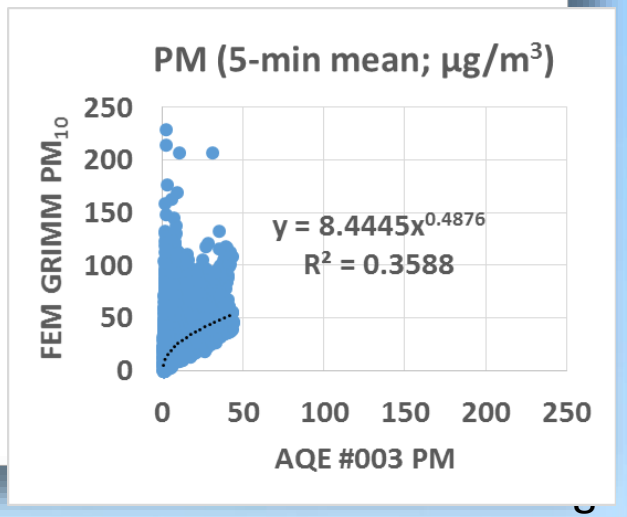
Air Quality Egg v.2 PM vs FEM GRIMM PM_{10} (5-min mean)



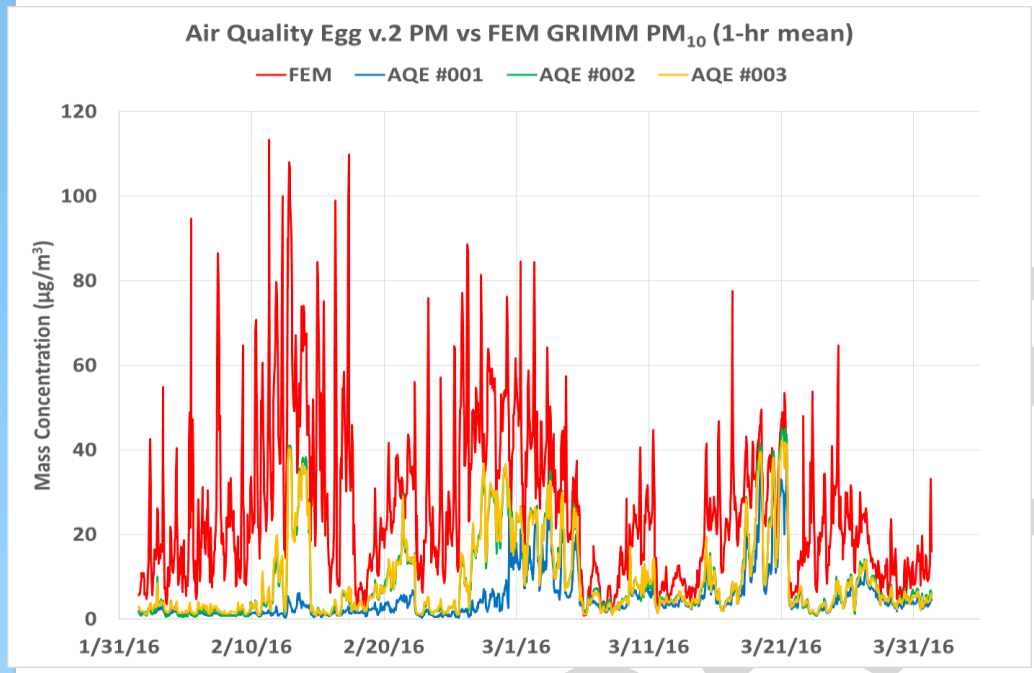
- PM_{10} measurements from all three AQE sensors exhibit a weak correlation with the corresponding GRIMM PM_{10} data ($R^2 < 0.36$)
- None of the AQE sensors tested seem to consistently track the diurnal PM_{10} variations provided by the GRIMM
- AQE sensors largely underestimated "actual" GRIMM PM_{10} data



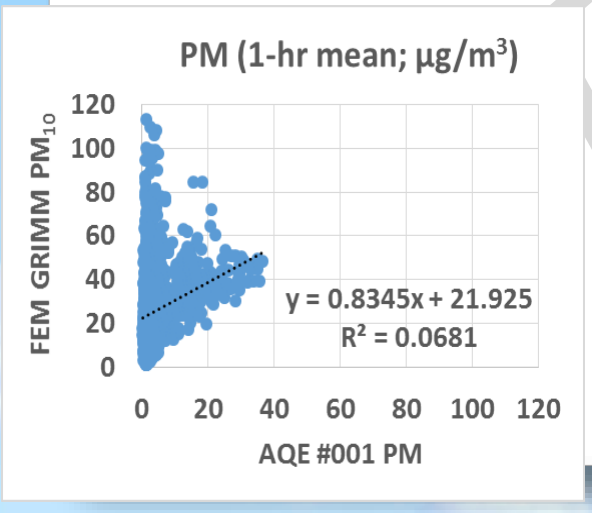


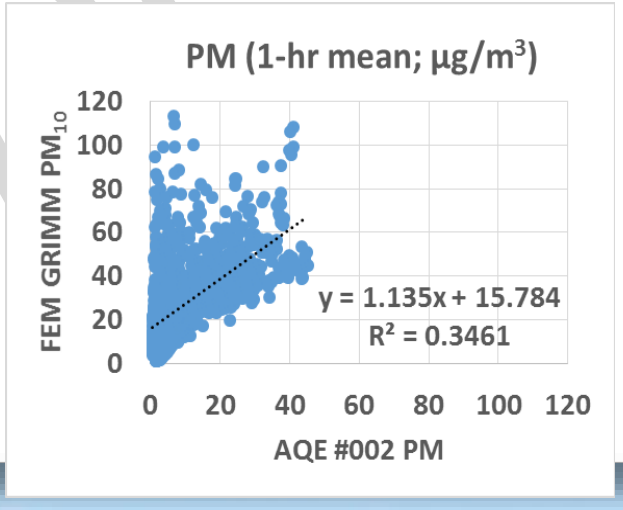


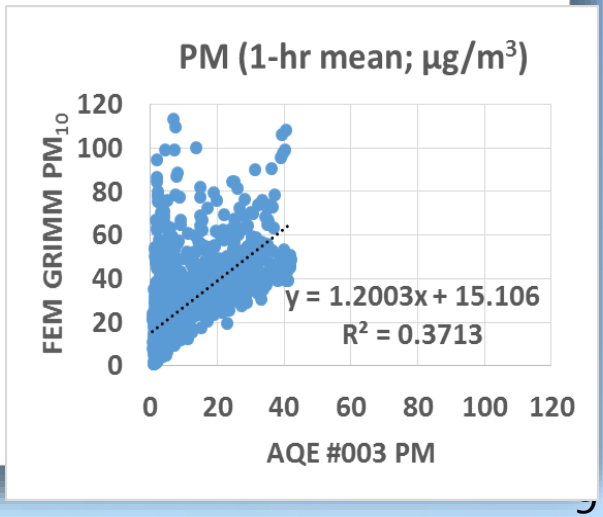
Air Quality Egg v.2 PM vs FEM GRIMM PM_{10} (1-hr mean)



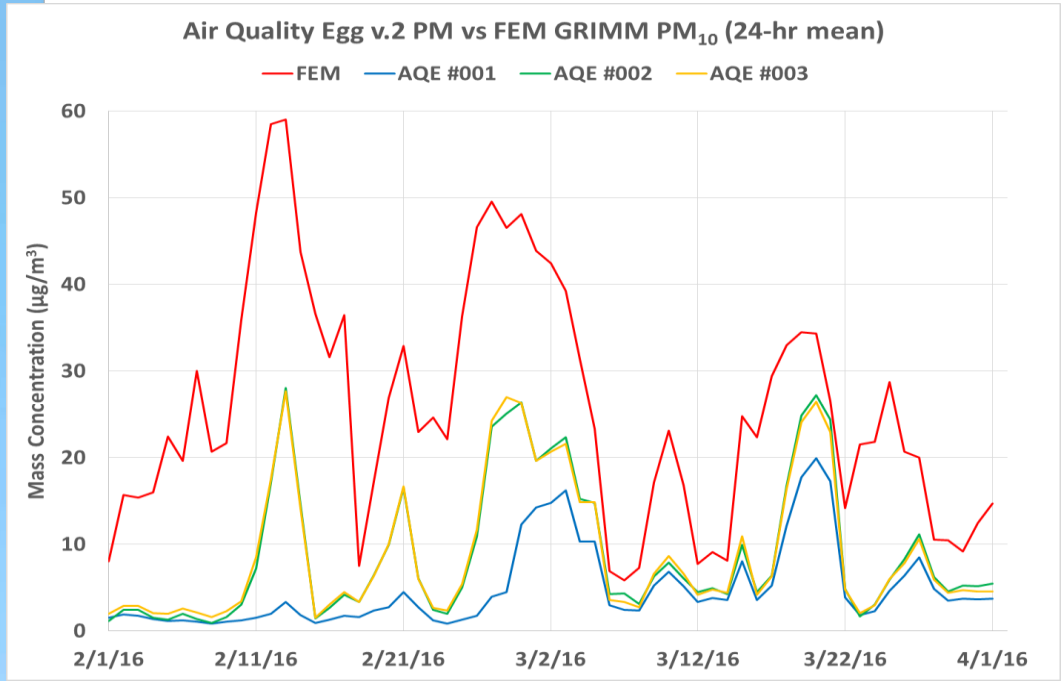
- PM_{10} measurements from all three AQE sensors exhibit a weak correlation with the corresponding GRIMM PM_{10} data ($R^2 < 0.375$)
- None of the AQE sensors tested seem to consistently track the diurnal PM_{10} variations provided by the GRIMM
- AQE sensors largely underestimated "actual" GRIMM PM_{10} data



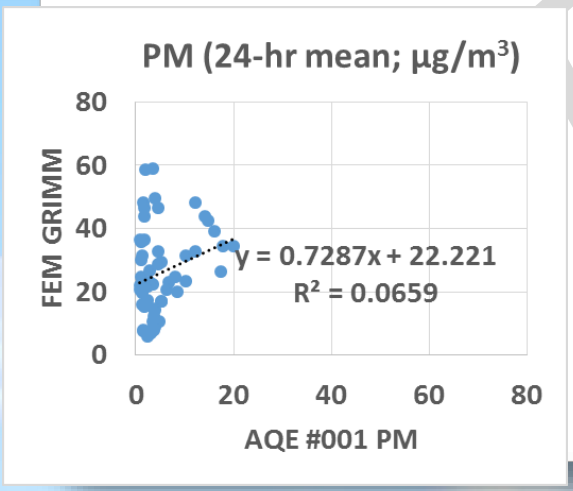


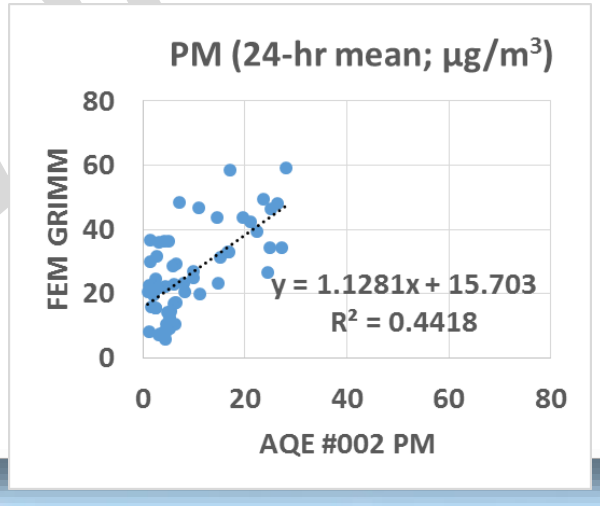


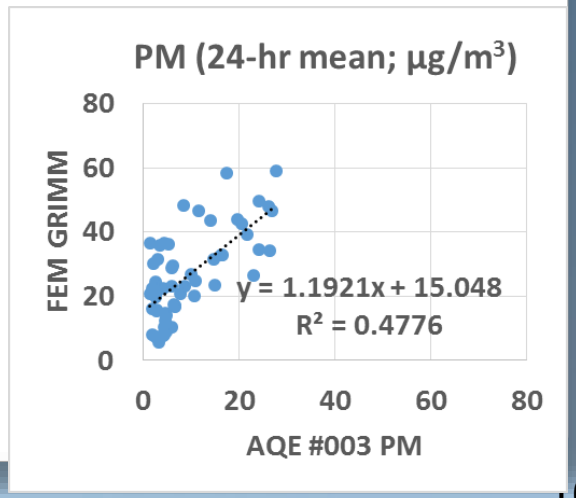
Air Quality Egg v.2 PM vs FEM GRIMM PM_{10} (24-hr mean)



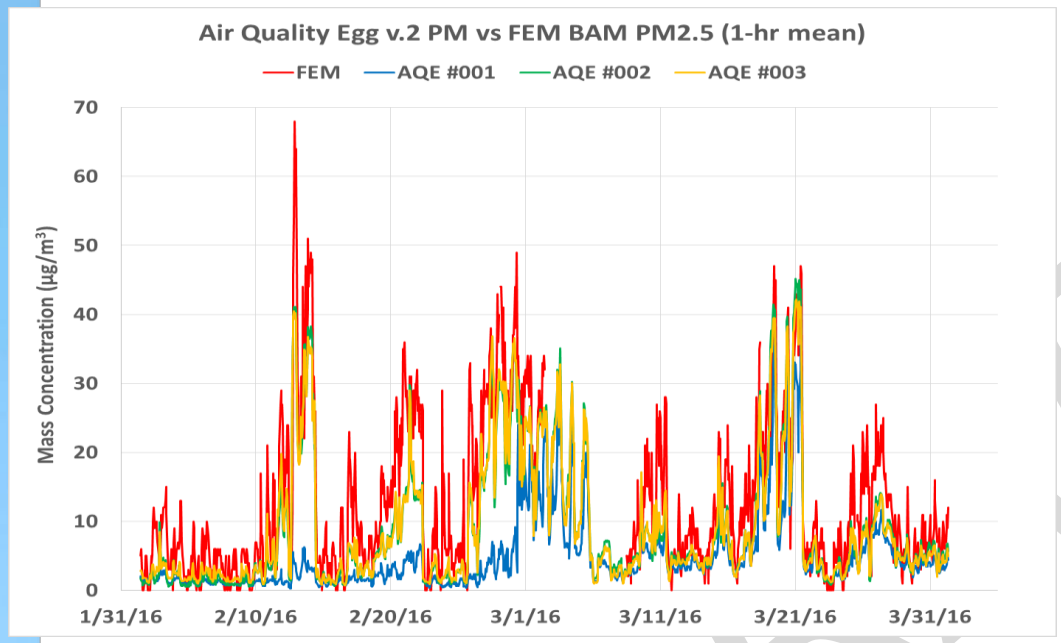
- PM_{10} measurements from the three AQE sensors exhibit a modest to weak correlation with the corresponding GRIMM PM_{10} data ($R^2 < 0.48$)
- None of the AQE sensors tested seem to consistently track the diurnal PM_{10} variations provided by the GRIMM
- AQE sensors largely underestimated "actual" GRIMM PM_{10} data



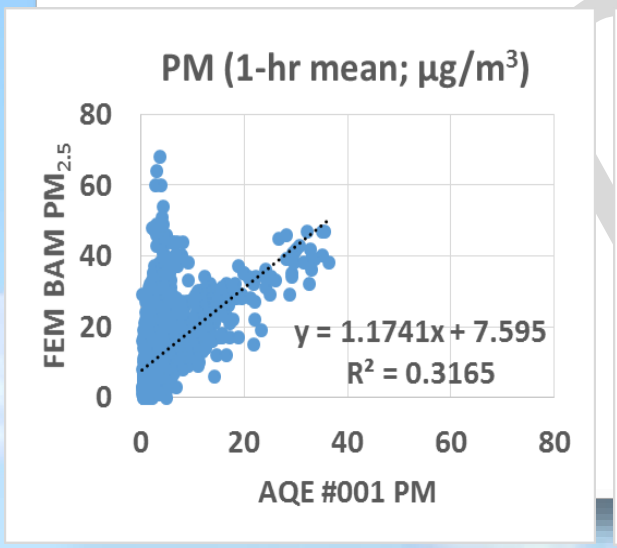


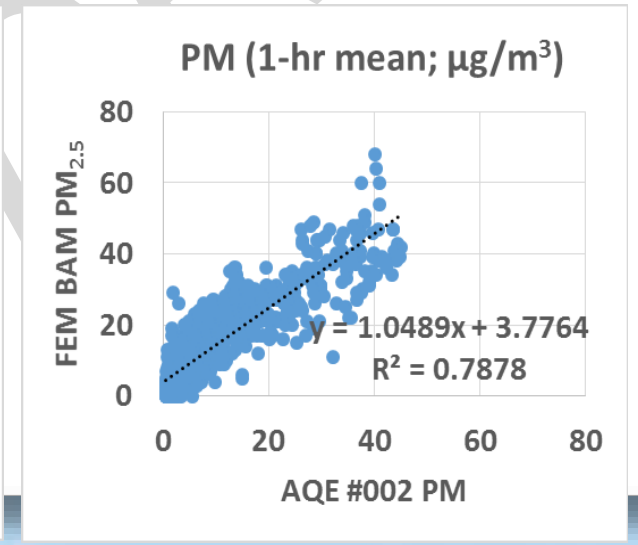


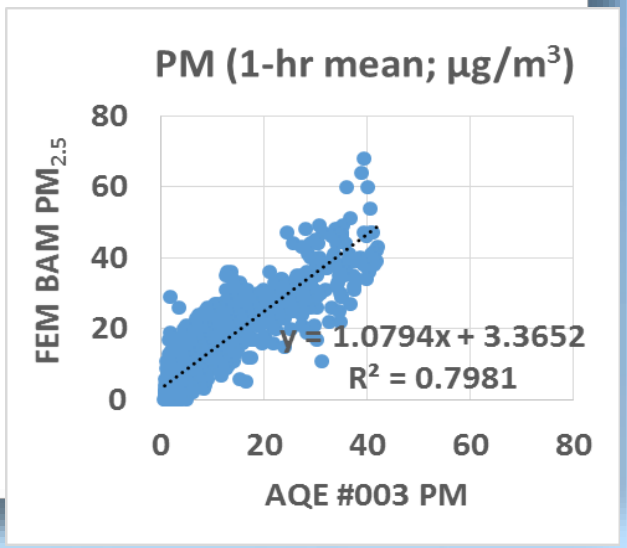
Air Quality Egg v.2 PM vs FEM BAM $PM_{2.5}$ (1-hr mean)



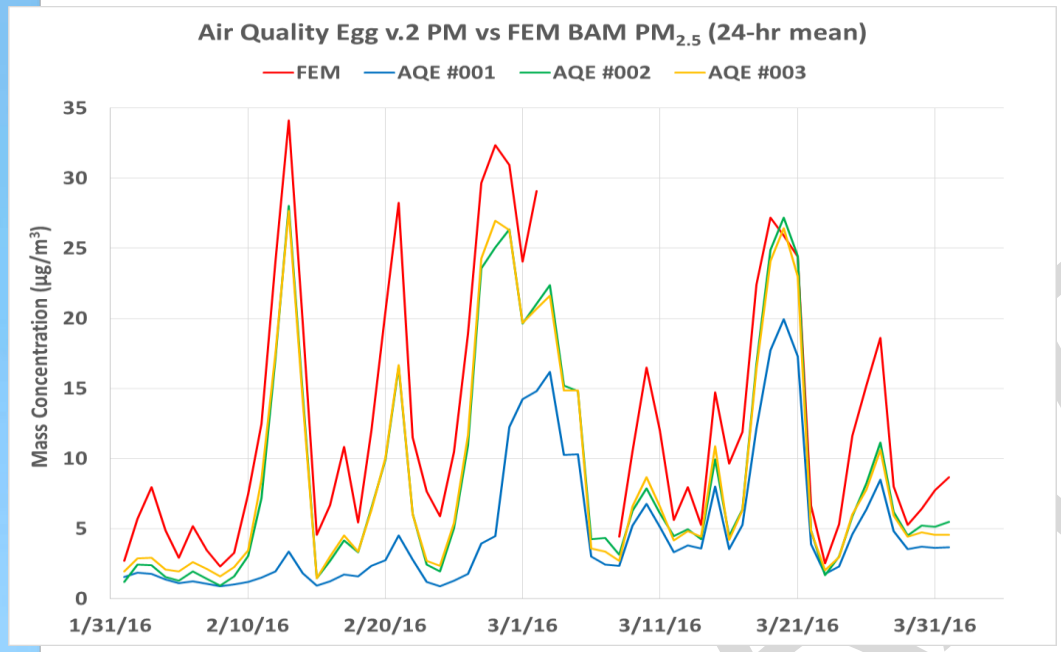
- $PM_{2.5}$ measurements from two of the three AQE sensors (#002 & #003) correlate well with the corresponding BAM $PM_{2.5}$ data ($R^2 > 0.785$)
- Readings from AQE #001 are weakly correlated with the corresponding BAM $PM_{2.5}$ data
- In most cases all AQE sensors tracked the diurnal variations of the FEM instrument well



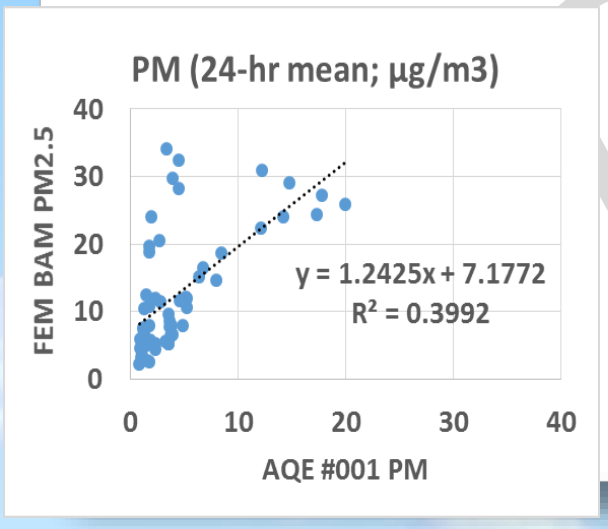


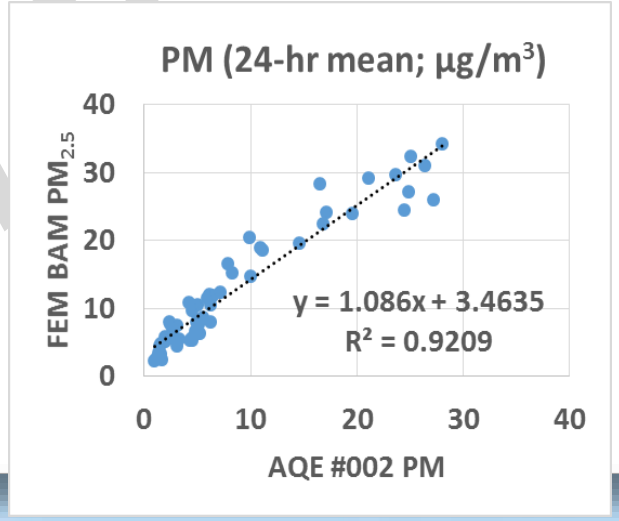


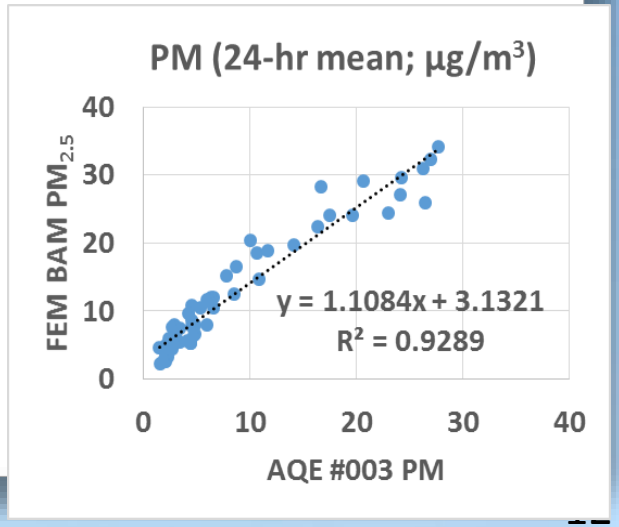
Air Quality Egg v.2 PM vs FEM BAM $PM_{2.5}$ (24-hr mean)



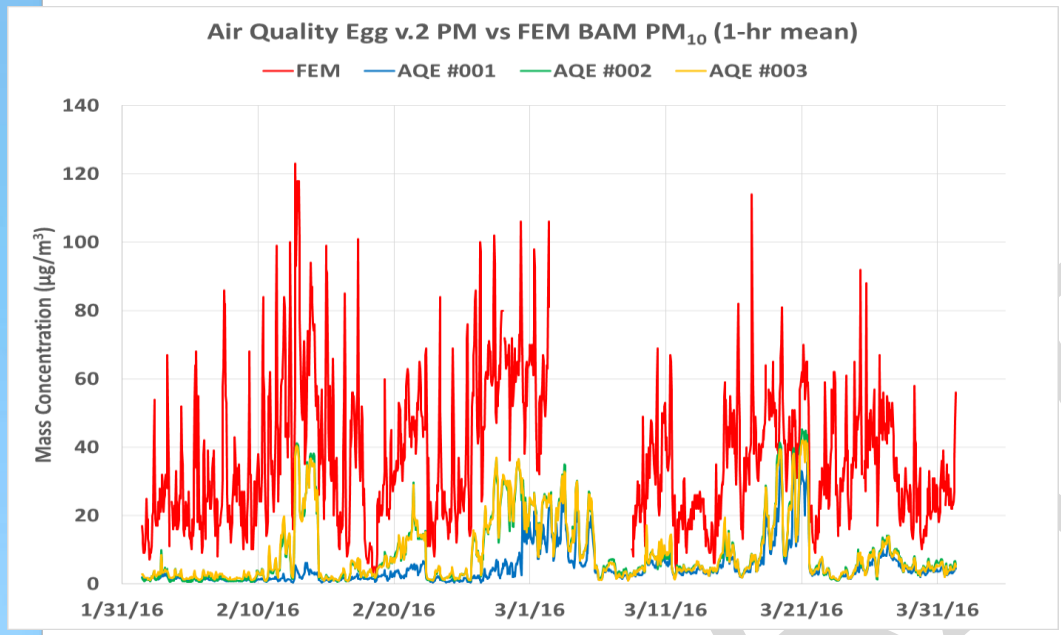
- $PM_{2.5}$ measurements from two of the three AQE sensors (#002 & #003) correlate well with the corresponding BAM $PM_{2.5}$ data ($R^2 > 0.92$)
- Readings from AQE #001 are weakly correlated with the corresponding BAM $PM_{2.5}$ data
- In most cases all AQE sensors tracked the diurnal variations of the FEM instrument well



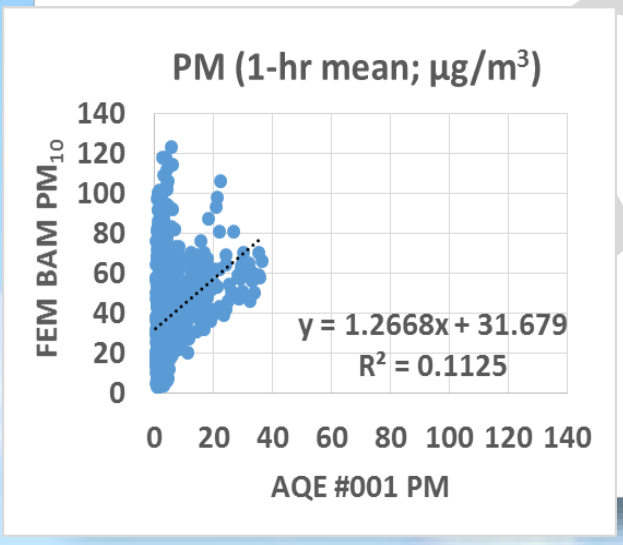


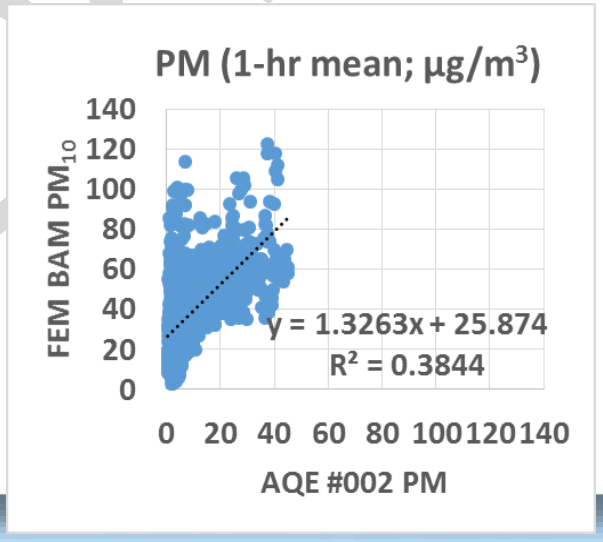


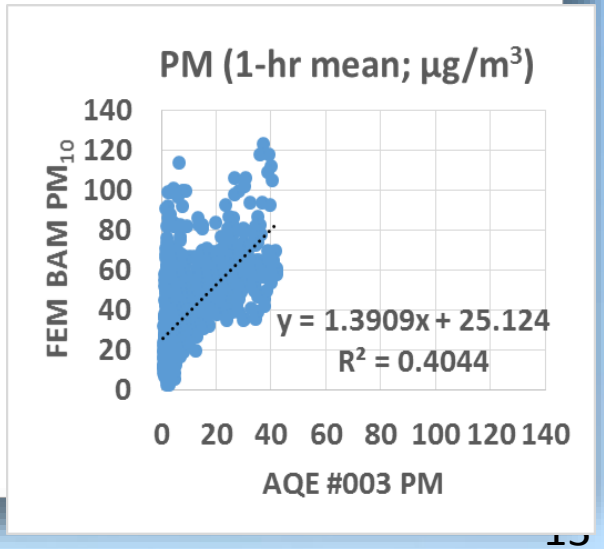
Air Quality Egg v.2 PM vs FEM BAM PM_{10} (1-hr mean)



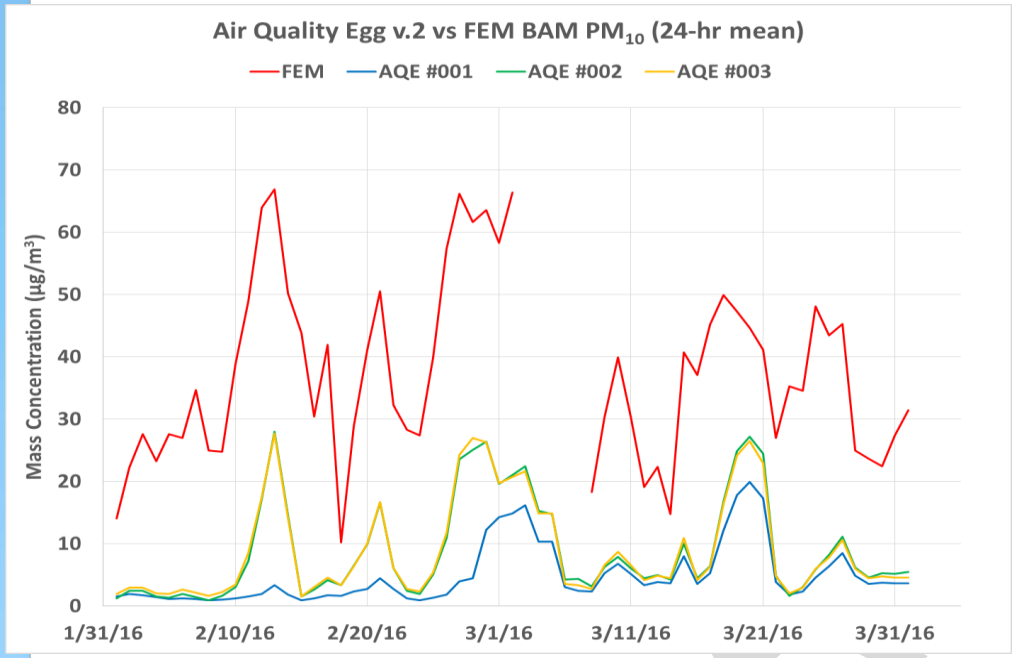
- PM_{10} measurements from all three AQE sensors exhibit a weak correlation with the corresponding BAM PM_{10} data ($R^2 < 0.405$)
- None of the AQE sensors tested seem to consistently track the diurnal PM_{10} variations provided by the BAM
- AQE sensors largely underestimated "actual" BAM PM_{10} data



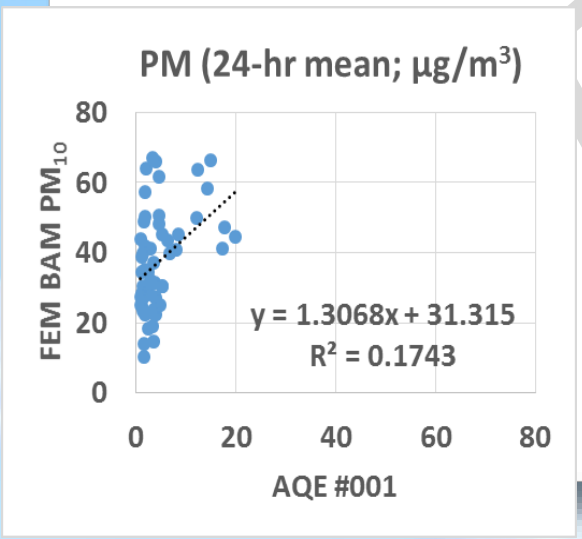


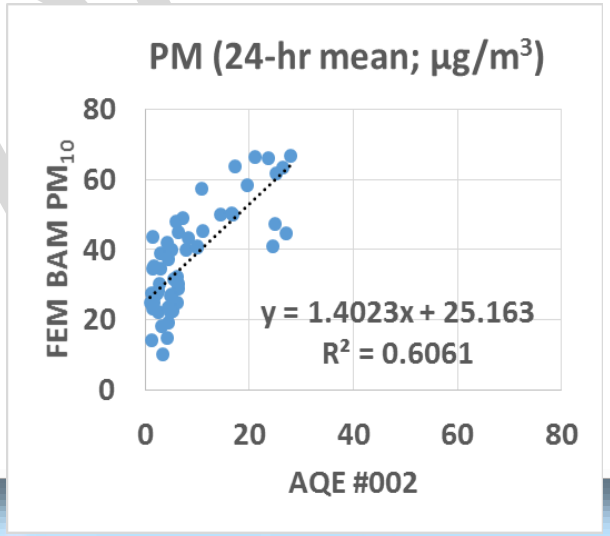


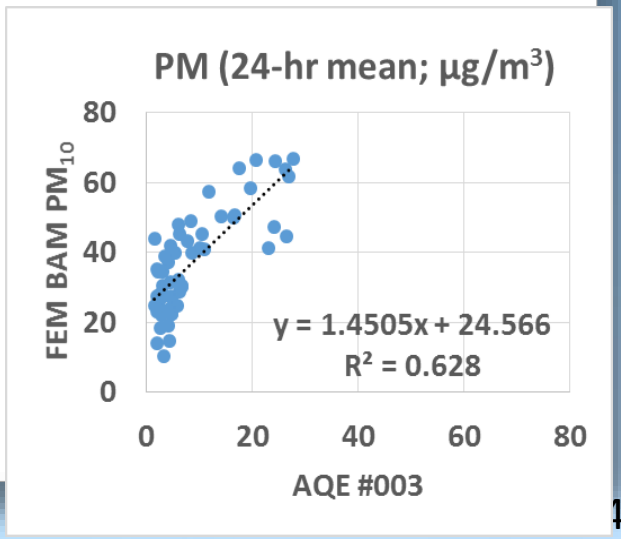
Air Quality Egg v.2 PM vs FEM BAM PM_{10} (24-hr mean)



- PM_{10} measurements from the three AQE sensors exhibit a modest to weak correlation with the corresponding BAM PM_{10} data ($R^2 < 0.63$)
- None of the AQE sensors tested seem to consistently track the diurnal PM_{10} variations provided by the BAM
- AQE sensors largely underestimated "actual" BAM PM_{10} data







Discussion

- Overall, the three Air Quality Egg v.2 PM sensors were reliable (i.e. no down time over a period of about two months) and allowed for a data recovery close to 100%
- Very low measurement variation was observed between sensors AQE #002 & #003. Readings from AQE #001 were substantially lower than those from the other two units
- PM data measured using two of the three AQE sensors (#002 & #003) correlate well with the FEM $PM_{2.5}$ data from both the GRIMM and the BAM, and seem to track the diurnal $PM_{2.5}$ variations provided by the FEM instruments
- PM data measured using the three sensors does not correlate well with the corresponding FEM PM_{10} data recorded by the GRIMM and the BAM, and do not seem to track the diurnal PM_{10} variations provided by the FEM instruments
- The Air Quality Egg v.2 PM sensors largely underestimated "actual" PM_{10} measurements as recorded by both the GRIMM and BAM. However, no sensor calibration was performed by SCAQMD staff prior to the beginning of this field testing
- Chamber testing under known target gas concentrations and controlled (temperature and relative humidity) conditions is necessary to fully evaluate the performance of these sensor devices

- All results are still preliminary