Field Evaluation
Air Quality Egg v.2
Particulate Matter
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
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.
• 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
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.
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
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.
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.
- 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
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 underestimates “actual” BAM PM$_{10}$ data
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