Field Evaluation
Hanvon PM Sensor

Background

- From 05/18/2016 to 07/27/2016, three **Hanvon PM Sensors** were deployed in Rubidoux and ran side-by-side with two Federal Equivalent Method (FEM) instruments measuring the same pollutant.

- _Hanvon Sensor (3 units tested):_
  - Particle sensors (optical; non-FEM)
  - Each unit reports: $PM_{2.5}$ mass concentration $(\mu g/m^3)$*
  - Unit cost: ~$200
  - Time resolution: 1-min
  - Units IDs: #1236, #1253, #1255

- MetOne BAM (_reference method_):
  - Beta-attenuation monitor (FEM)
  - Measures $PM_{2.5}$ & PM_{10} mass $(\mu g/m^3)$
  - Unit cost: ~$20,000
  - Time resolution: 1-hr

- GRIMM (_reference method_):
  - Optical particle counter (FEM)
  - 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

*The Hanvon sensors also measure formaldehyde HCHO* (mg/m^3). However, these devices were only evaluated for their ability to measure $PM_{2.5}$ since a reference monitor for HCHO is currently not available

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 unit #1236 was 80%, while from both units #1253 and #1255 it was 91%

Hanvon sensors; intra-model variability

- Low measurement variations were observed between the three Hanvon devices tested
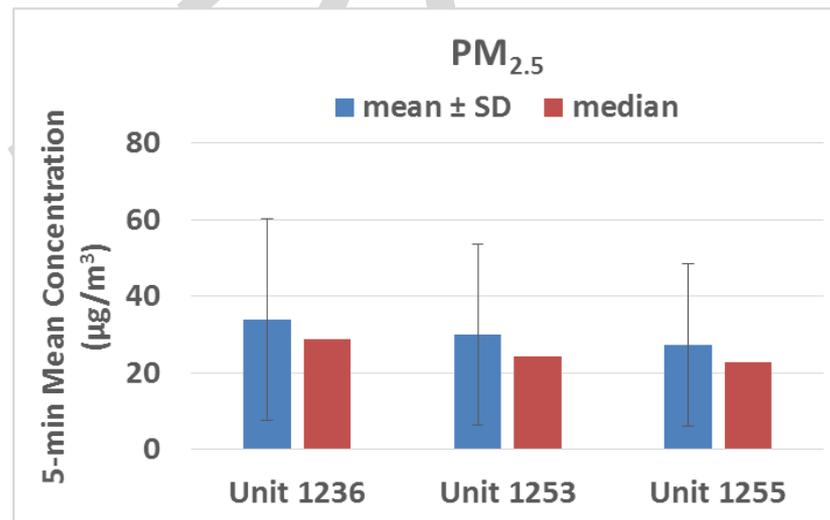
Data validation & recovery

- 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)
- $PM_{2.5}$ data recovery was 89% for the GRIMM and 98% for the BAM

Equivalent methods: BAM vs GRIMM

- Good correlation between the two equivalent methods for $PM_{2.5}$
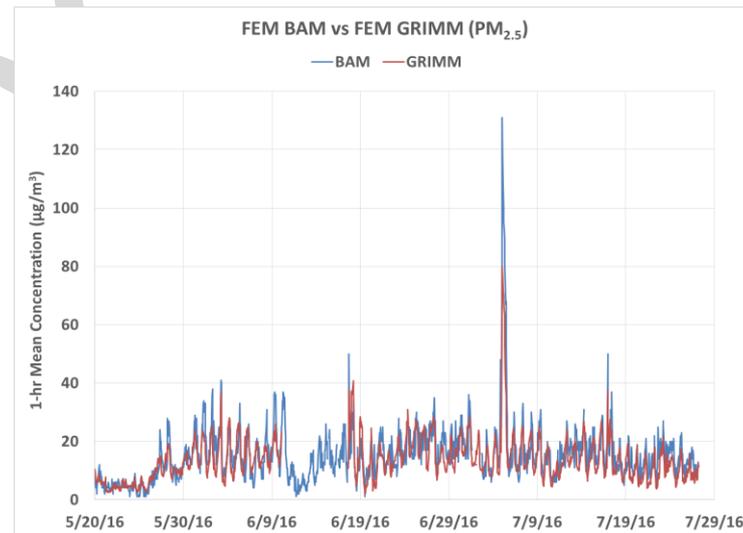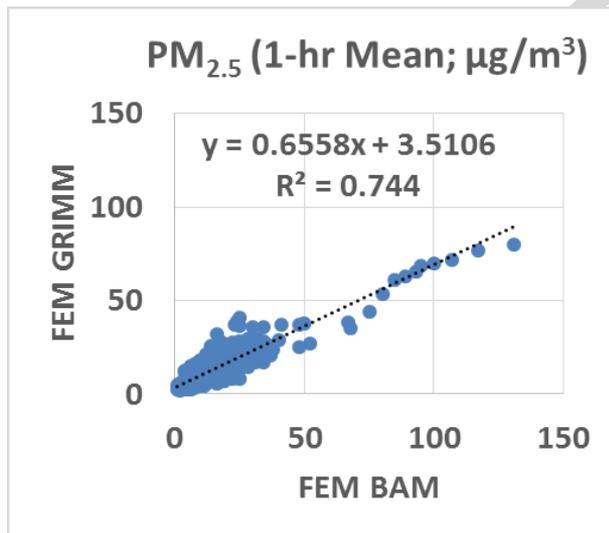
Hanvon Sensor vs FEM GRIMM (PM$_{2.5}$ Mass; 5-min mean)
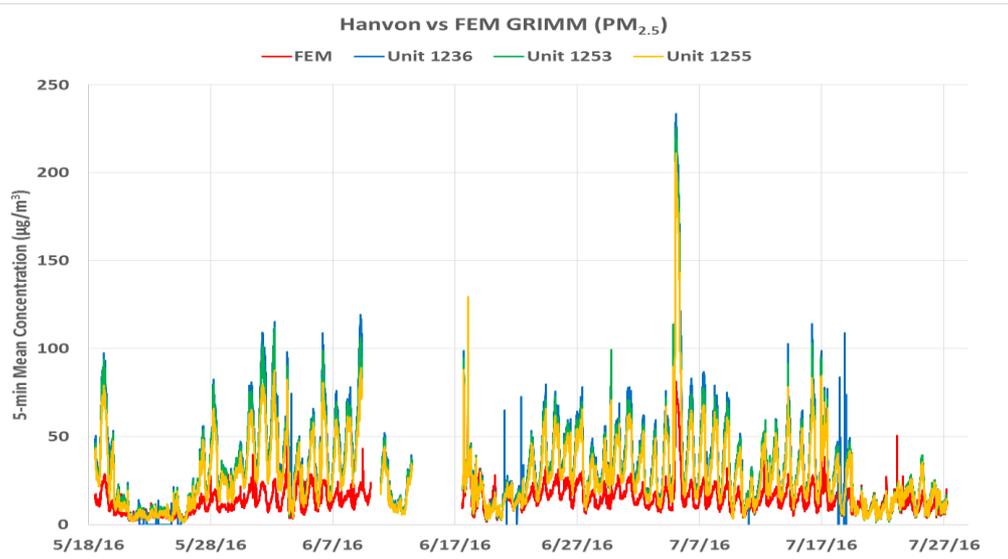
- Hanvon PM$_{2.5}$ mass measurements correlate well with the corresponding FEM GRIMM data ($R^2 > 0.75$)
- The three sensors track well the diurnal variations as recorded by the FEM GRIMM instrument
- All Hanvon devices largely <u>overestimate</u> the corresponding FEM measurements
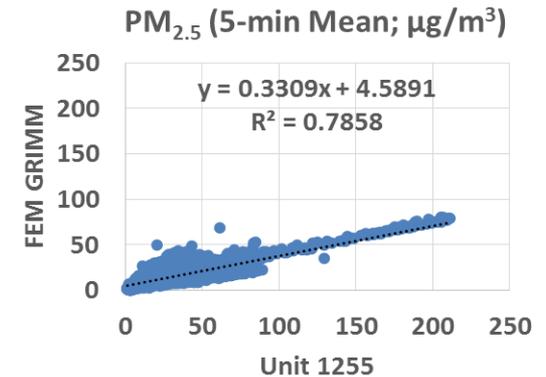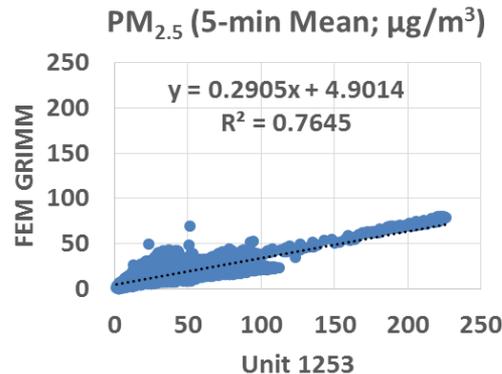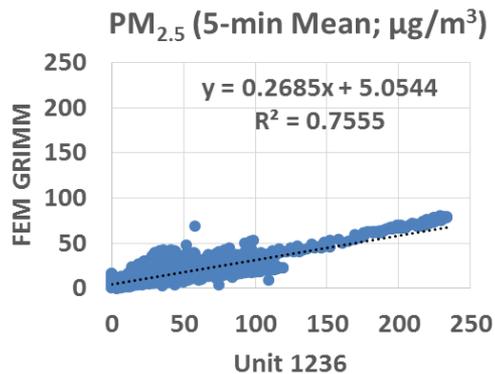
Hanvon Sensor vs FEM GRIMM (PM$_{2.5}$ Mass; 1-hr mean)

Hanvon vs FEM GRIMM (PM$_{2.5}$)

— FEM — Unit 1236 — Unit 1253 — Unit 1255
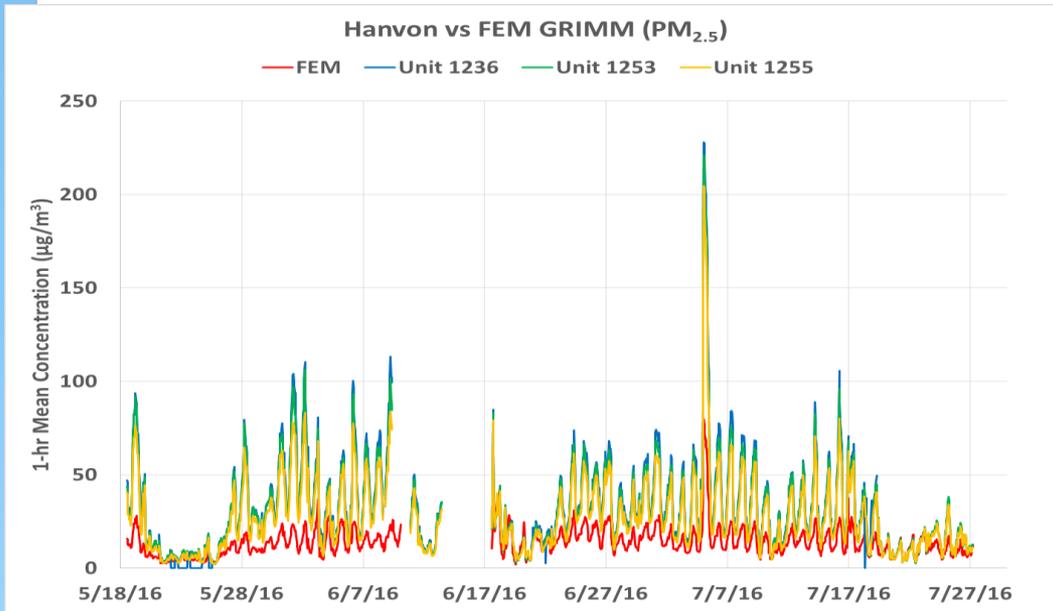
- Hanvon PM$_{2.5}$ mass measurements correlate well with the corresponding FEM GRIMM data ($R^2 > 0.76$)
- The three sensors track well the diurnal variations as recorded by the FEM GRIMM instrument
- All Hanvon devices largely <u>overestimate</u> the corresponding FEM measurements


PM$_{2.5}$ (1-hr Mean; μg/m^3)

$y = 0.2689x + 5.0321$
$R^2 = 0.7678$

FEM GRIMM — Unit 1236

PM$_{2.5}$ (1-hr Mean; μg/m^3)

$y = 0.2898x + 4.9178$
$R^2 = 0.7755$

FEM GRIMM — Unit 1253

PM$_{2.5}$ (1-hr Mean (μg/m^3)

$y = 0.3303x + 4.6046$
$R^2 = 0.7973$

FEM GRIMM — Unit 1255
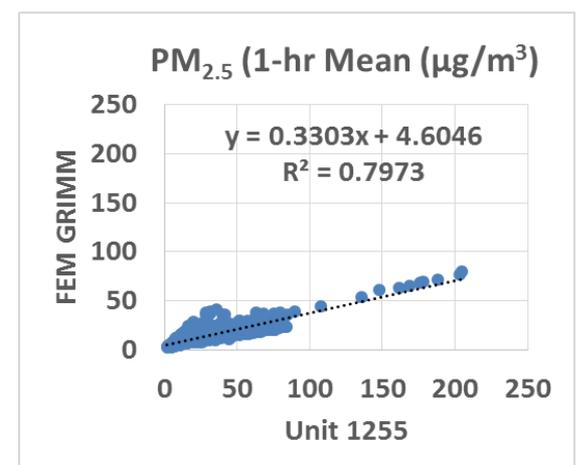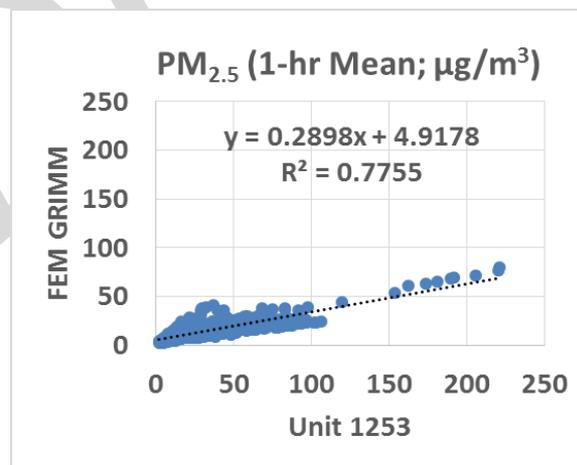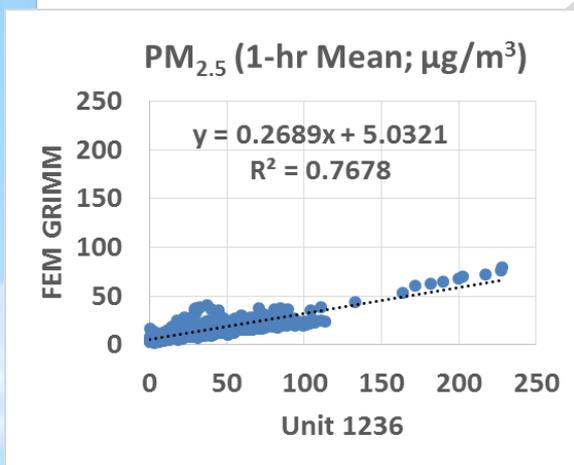
Hanvon Sensor vs FEM GRIMM (PM$_{2.5}$ Mass; 24-hr mean)
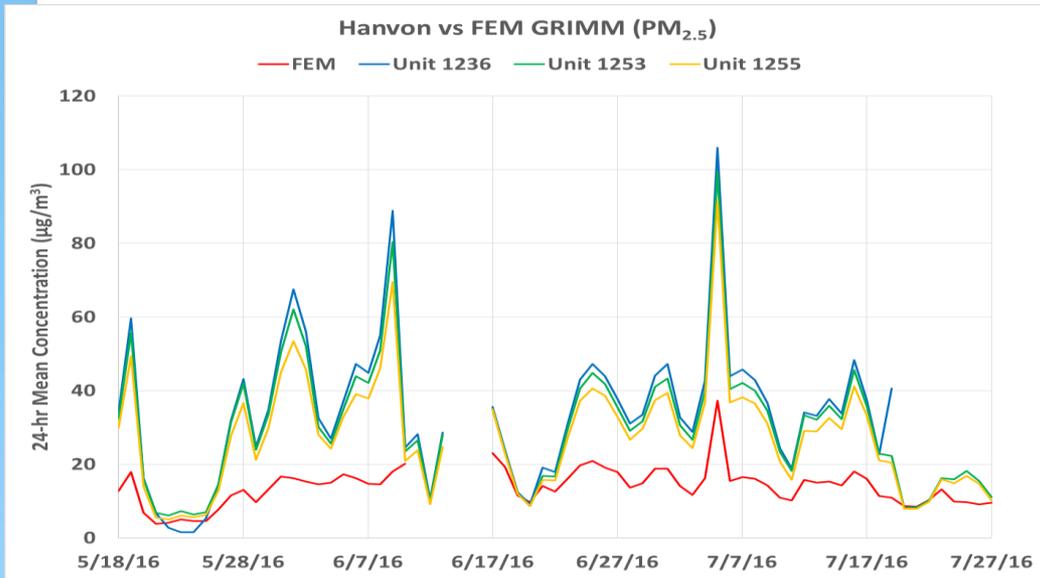
- Hanvon PM$_{2.5}$ mass measurements correlate well with the corresponding FEM GRIMM data ($R^2 > 0.62$)
- The three sensors track well the diurnal variations as recorded by the FEM GRIMM instrument
- All Hanvon devices largely <u>overestimate</u> the corresponding FEM measurements
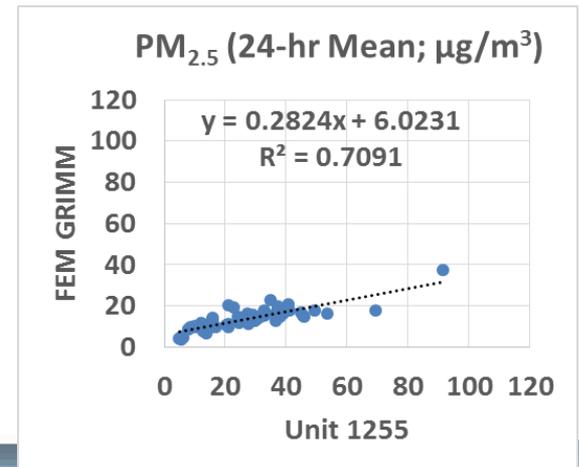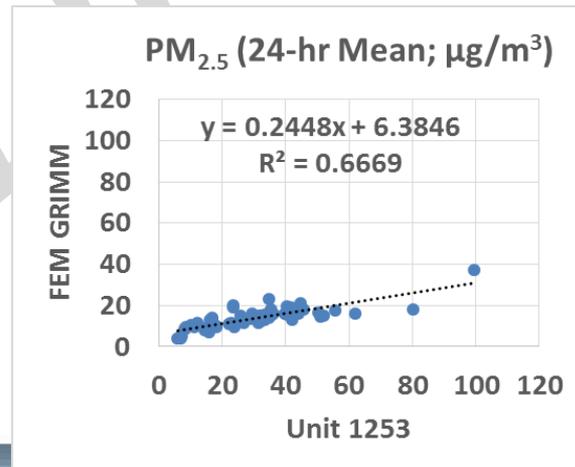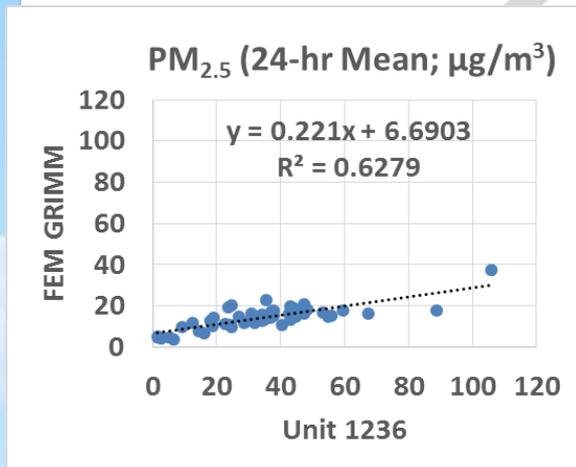
Hanvon Sensor vs FEM BAM (PM$_{2.5}$ Mass; 1-hr mean)
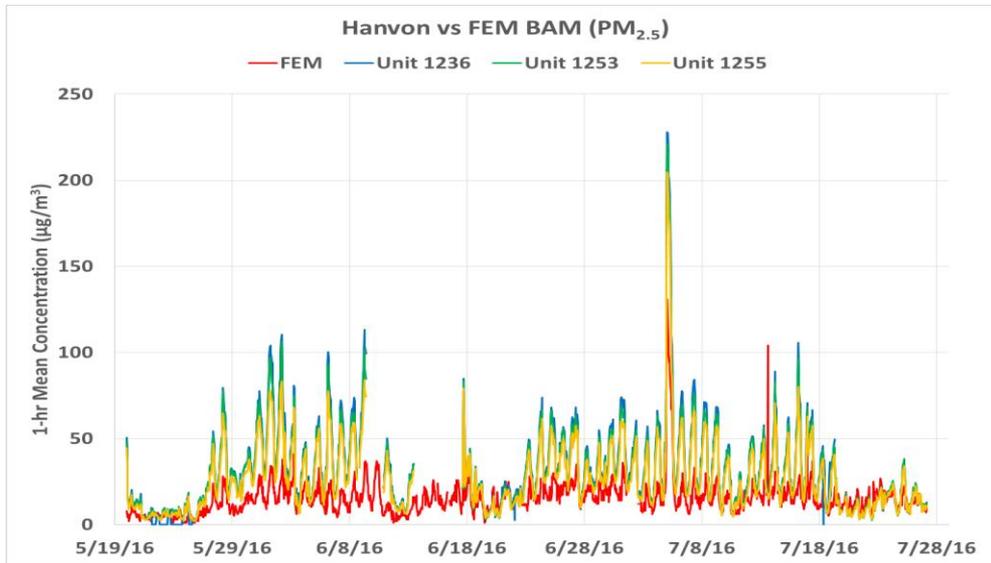
- Hanvon PM$_{2.5}$ mass measurements correlate fairly well with the corresponding FEM BAM data (R^2 > 0.62)
- The three sensors seem to track the diurnal variations as recorded by the FEM BAM instrument
- All Hanvon devices largely overestimate the corresponding FEM measurements

PM$_{2.5}$ (1-hr Mean; μg/m^3)

$y = 0.3452x + 3.891$
$R^2 = 0.653$

Unit 1236

PM$_{2.5}$ (1-hr Mean; μg/m^3)

$y = 0.3551x + 4.6928$
$R^2 = 0.6216$

Unit 1253

PM$_{2.5}$ (1-hr Mean; μg/m^3)

$y = 0.4089x + 4.2059$
$R^2 = 0.6547$

Unit 1255
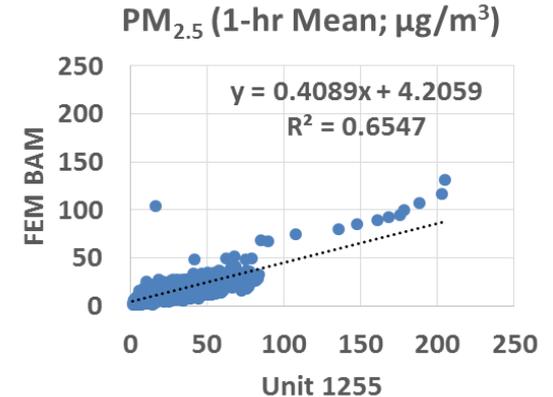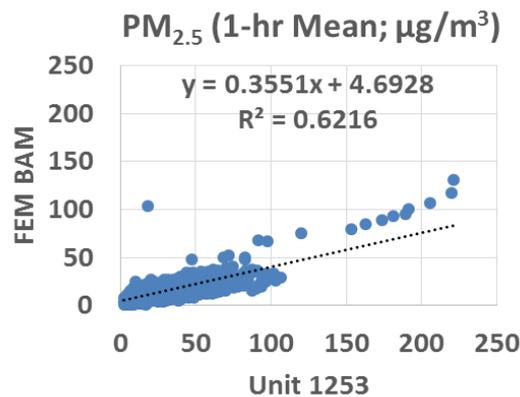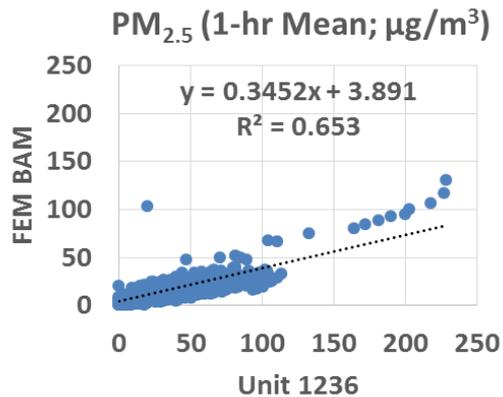
Hanvon Sensor vs FEM BAM (PM$_{2.5}$ Mass; 24-hr mean)
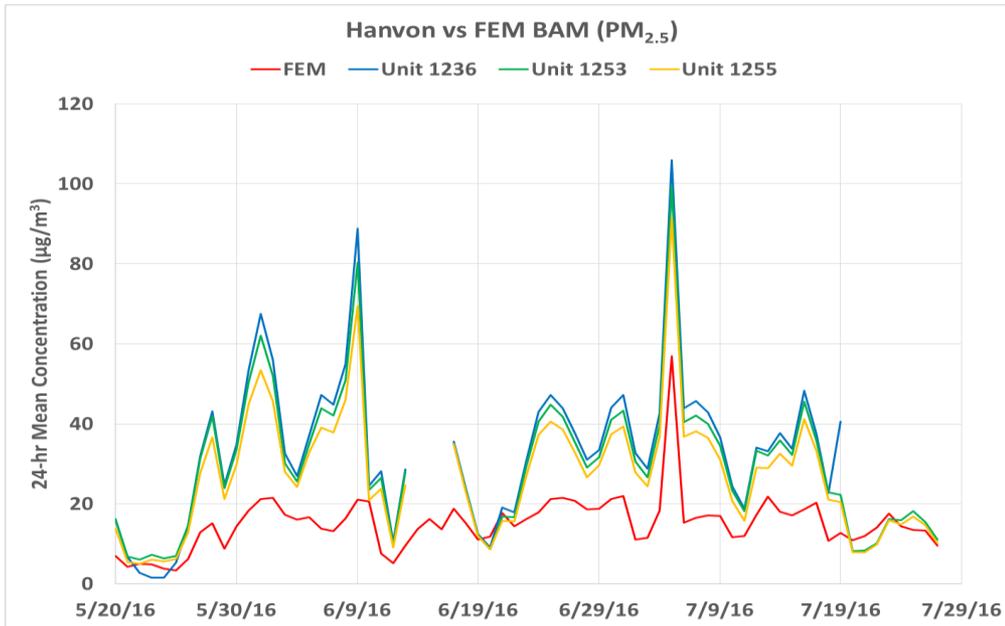
Hanvon vs FEM BAM (PM$_{2.5}$)

— FEM   — Unit 1236   — Unit 1253   — Unit 1255

- Hanvon PM$_{2.5}$ mass measurements correlate fairly well with the corresponding FEM BAM data ($R^2 > 0.63$)
- The three sensors seem to track the diurnal variations as recorded by the FEM BAM instrument
- All Hanvon devices largely overestimate the corresponding FEM measurements

PM$_{2.5}$ (24-hour Mean; µg/m^3)

y = 0.3269x + 4.3277
R^2 = 0.6594

FEM BAM / Unit 1236

PM$_{2.5}$ (24-hour Mean; µg/m^3)

y = 0.3338x + 5.2236
R^2 = 0.6318

FEM BAM / Unit 1253

PM$_{2.5}$ (24-hour Mean; µg/m^3)

y = 0.3827x + 4.8092
R^2 = 0.6659

FEM BAM / Unit 1255
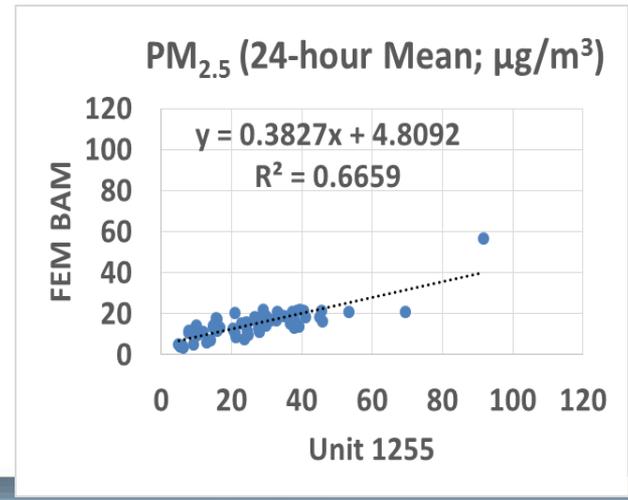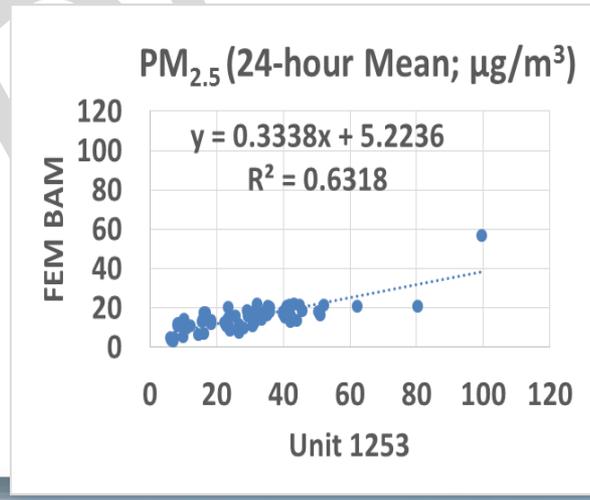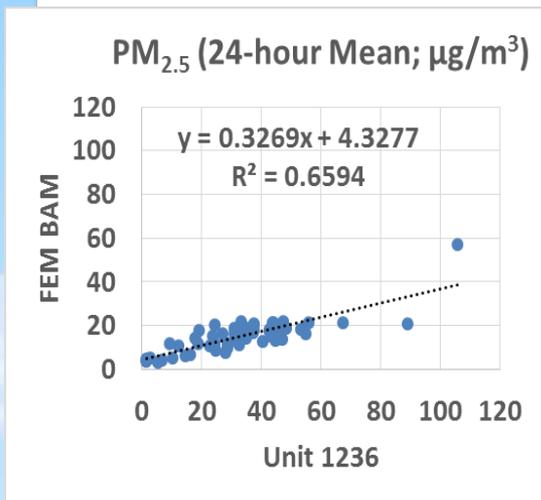
Discussion

- Overall, the three **Hanvon PM$_{2.5}$ Sensors** were quite reliable (data recovery was between 80-90% across the three units tested) and were characterized by low intra-model measurement variability

- The Hanvon sensors demonstrated a modest-to-good correlation (R^2: 0.52 – 0.79) with the reference (FEM) instruments used for this evaluation, but largely overestimated the FEM measurement data

- All units tested tracked well the PM$_{2.5}$ diurnal variations as recorded by the FEM instruments

- 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 is necessary to fully evaluate the performance of these sensors over different / more extreme environmental conditions

- All results are still preliminary