Field Evaluation
Sensirion SPS30 Evaluation Kit

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 03/07/2019 to 05/14/2019, three **Sensirion SPS30 Evaluation Kits** (hereinafter **Sensirion SPS30**) were deployed at the South Coast AQMD stationary ambient monitoring site in Rubidoux and were run side-by-side with three reference instruments measuring the same pollutants

- Sensirion SPS30 (*3 units tested*):
  - Particle sensor: (optical; non-FEM)
  - PM sensor: Sensirion SPS30
  - Each unit reports: $PM_{1.0}$, $PM_{2.5}$ and PM_{10} ($\mu g/m^3$)
  - Also measures $PM_{4.0}$ ($\mu g/m^3$)
  - Unit cost: $100
  - Time resolution: 1 second
  - Units IDs: 7CE8, D038, 5455

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

- GRIMM (*reference instrument*):
  - Optical particle counter (FEM $PM_{2.5}$)
  - Measures $PM_{1.0}$, $PM_{2.5}$, and PM_{10} ($\mu g/m^3$)
  - Cost: ~$25,000 and up
  - Time resolution: 1-min

- Teledyne API T640 (*reference instrument*):
  - Optical particle counter (FEM $PM_{2.5}$)
  - Measures $PM_{2.5}$ & PM_{10} ($\mu g/m^3$)
 - Unit cost: ~$21,000
  - 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 from units 7CE8, D038, 5455 was ~100% for all PM measurements

Sensirion SPS30; intra-model variability

- Very low measurement variability (~ 1%, 1.3% and 2.4%) was observed between the three Sensirion SPS30 units for $PM_{1.0}$, $PM_{2.5}$ and PM_{10} mass conc. measurements, respectively
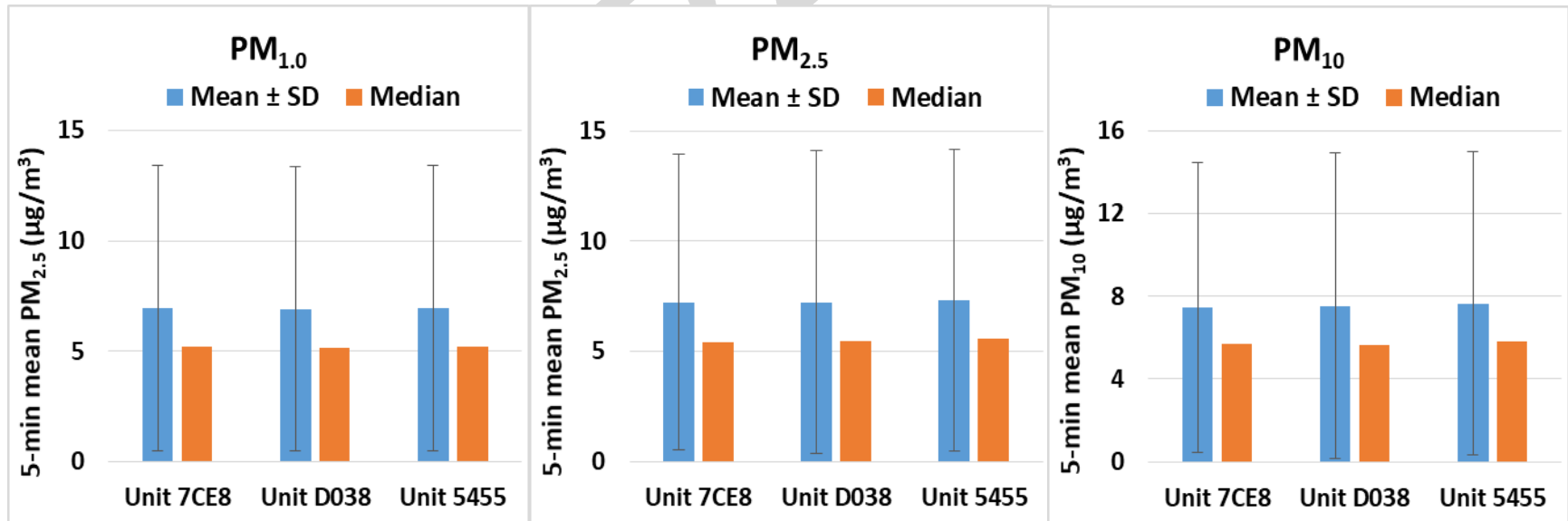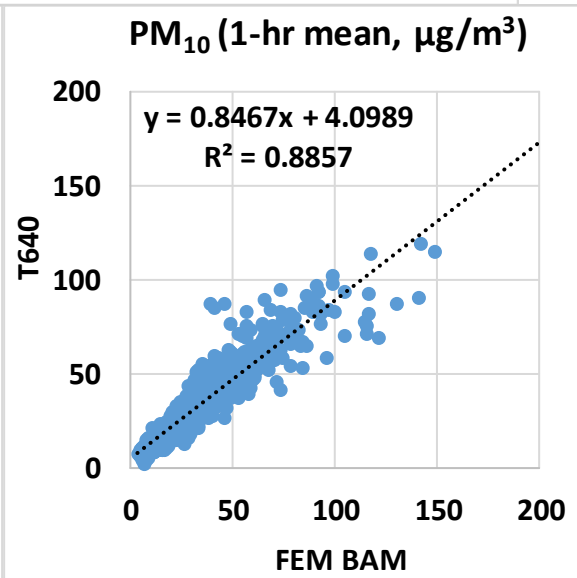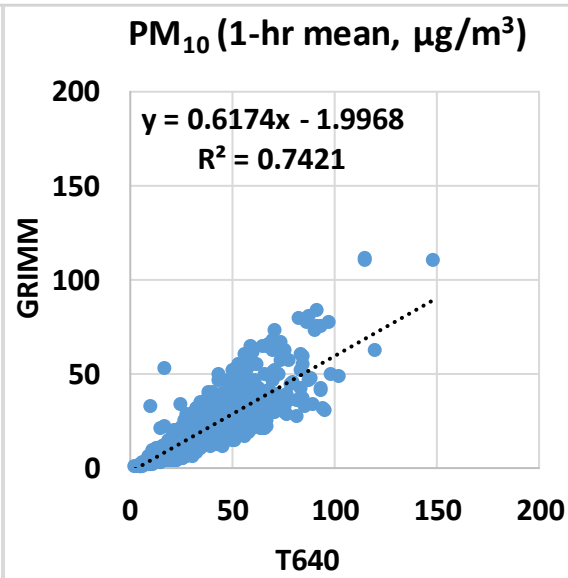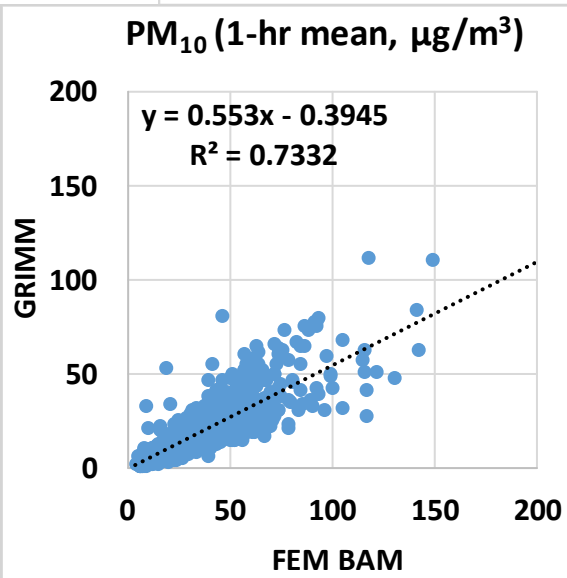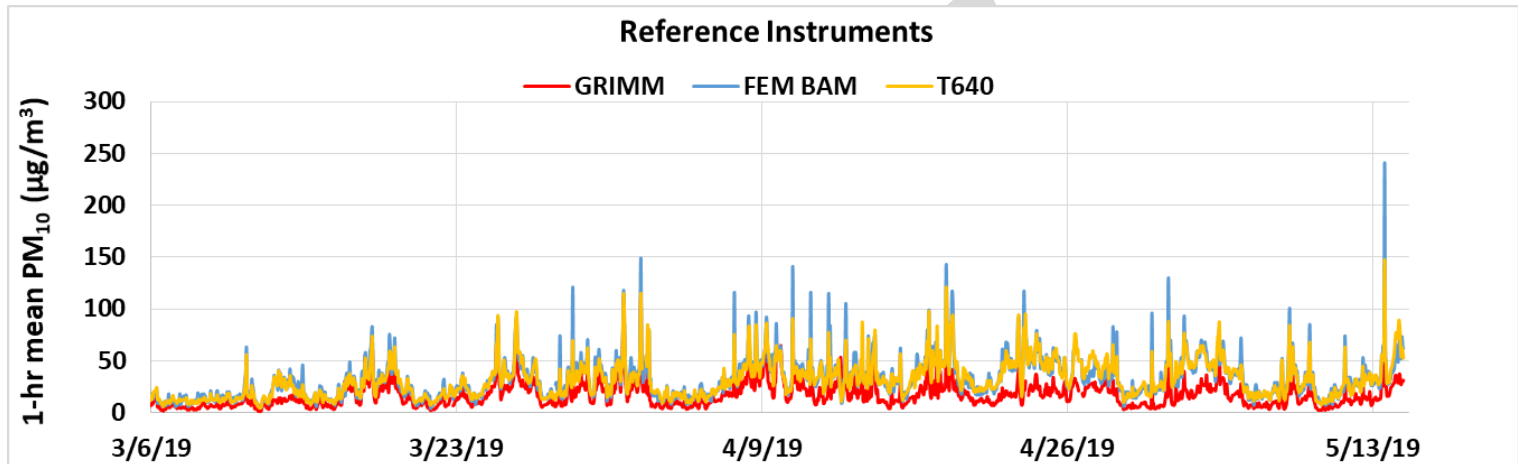
Reference Instruments: PM$_{2.5}$ GRIMM, BAM & T640

- Data recovery for PM$_{2.5}$ from FEM GRIMM, FEM BAM and FEM T640 was 99.4 %, 94.5 % and 99.8%, respectively.
- Moderate to strong correlations between the three reference instruments for PM$_{2.5}$ measurements (0.69 < R^2 < 0.84) were observed.
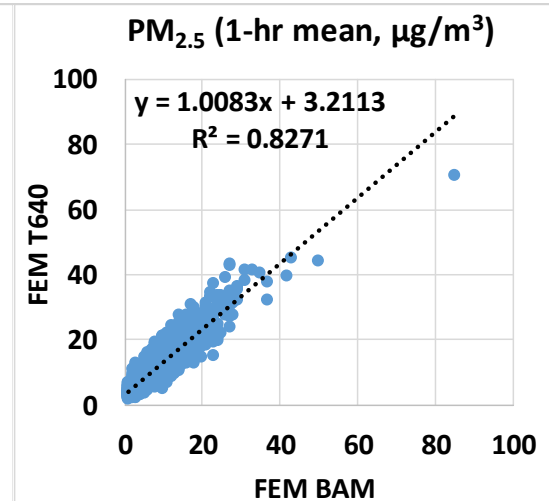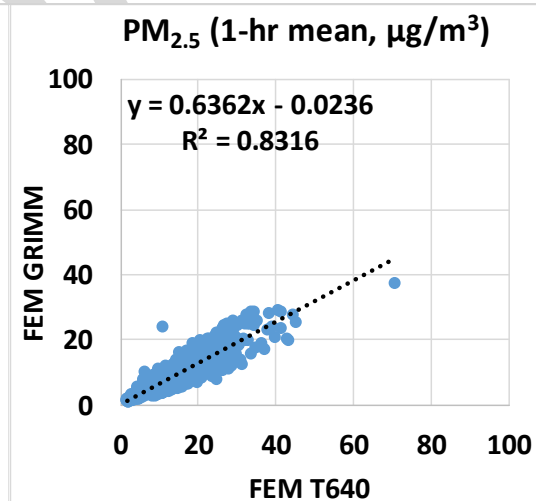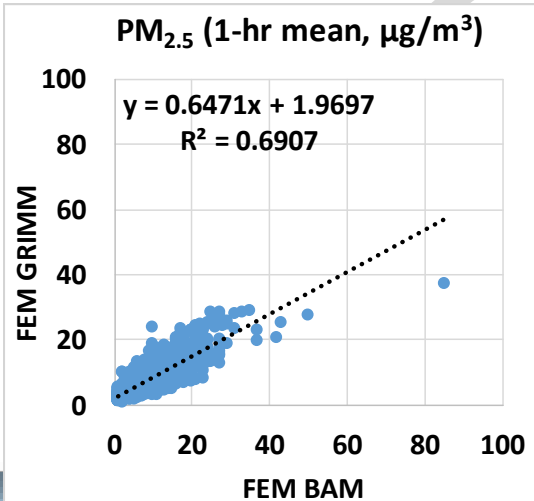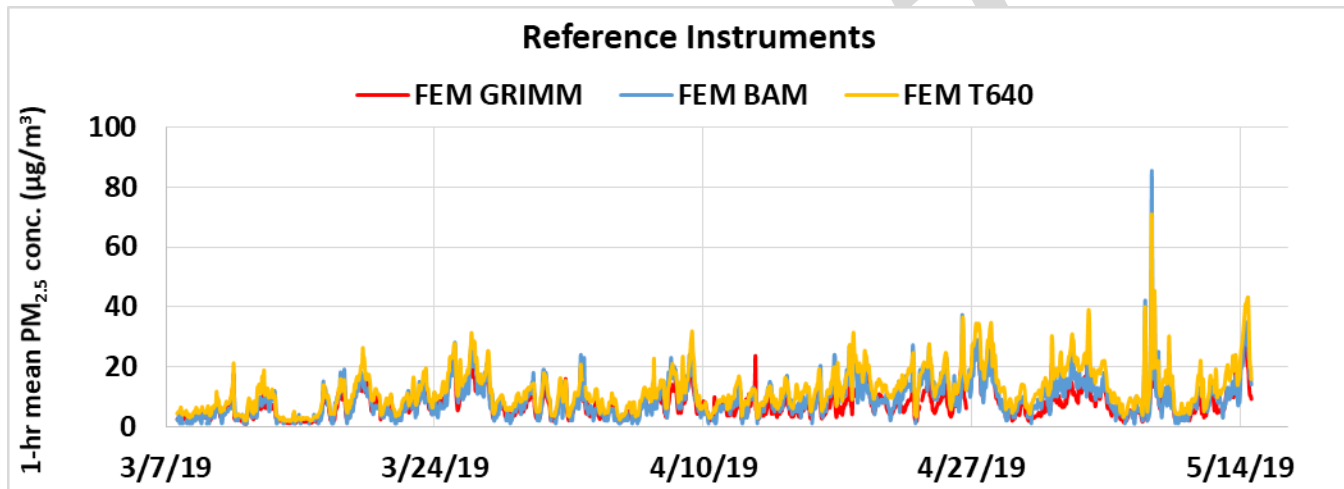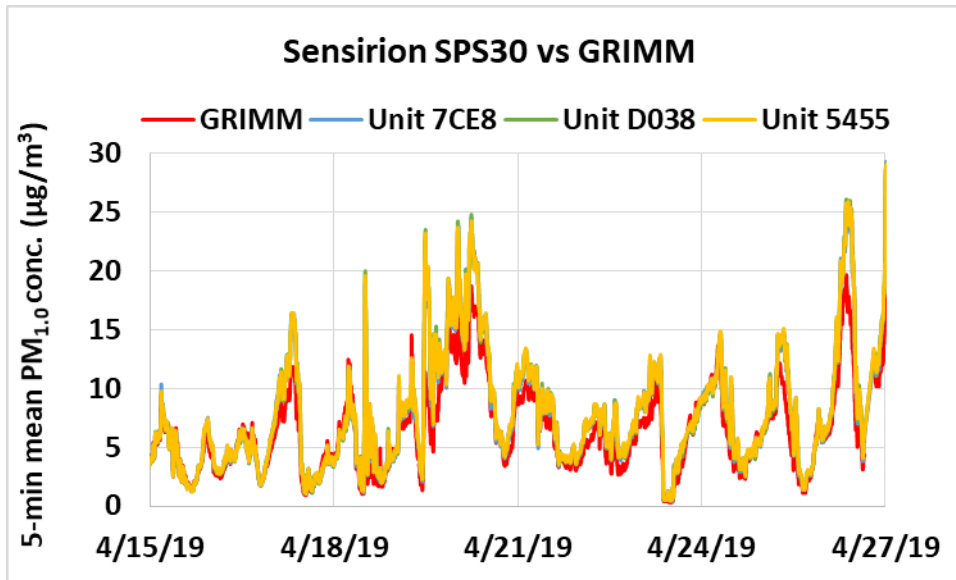
Reference Instruments: PM$_{10}$
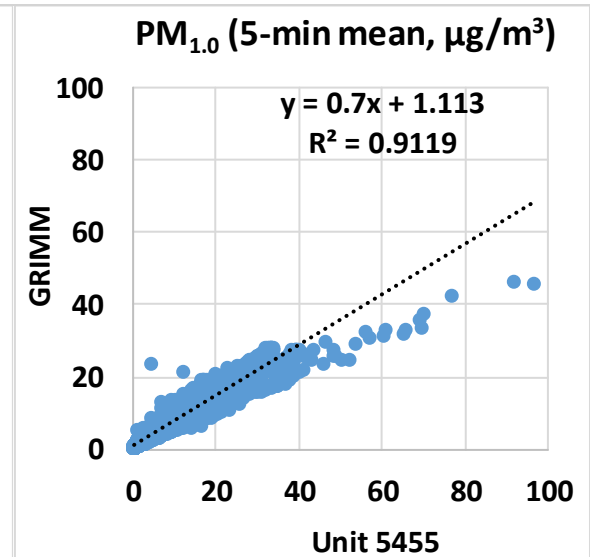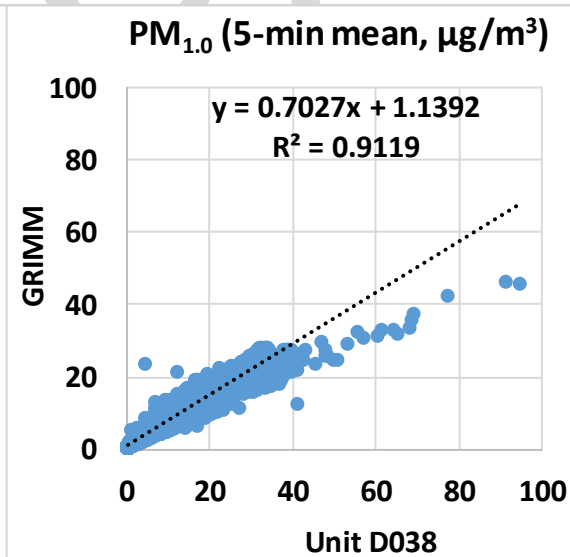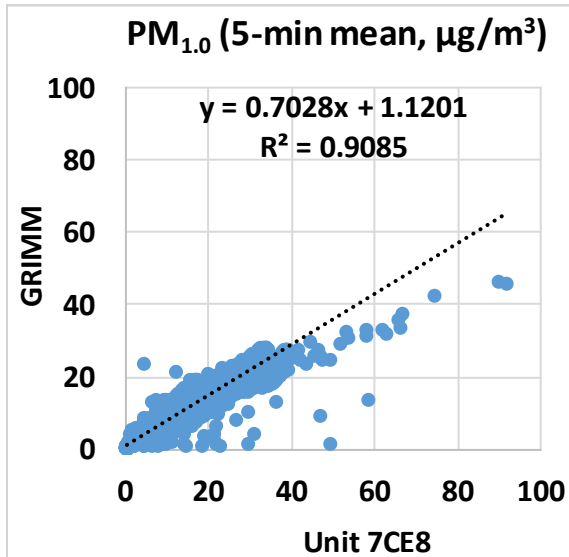# GRIMM, BAM & T640

- Data recovery for PM$_{10}$ from GRIMM, FEM BAM and T640 was 99.4 %, 98.8 % and 99.8 %, respectively.
- strong correlations between the three reference instruments for PM$_{10}$ measurements (0.73 < R^2 < 0.89) were observed.

Reference Instruments
— GRIMM — FEM BAM — T640

y-axis: 1-hr mean PM$_{10}$ (µg/m³)

x-axis dates: 3/6/19, 3/23/19, 4/9/19, 4/26/19, 5/13/19

PM$_{10}$ (1-hr mean, µg/m³)
y = 0.553x - 0.3945
R^2 = 0.7332
(GRIMM vs FEM BAM)

PM$_{10}$ (1-hr mean, µg/m³)
y = 0.6174x - 1.9968
R^2 = 0.7421
(GRIMM vs T640)

PM$_{10}$ (1-hr mean, µg/m³)
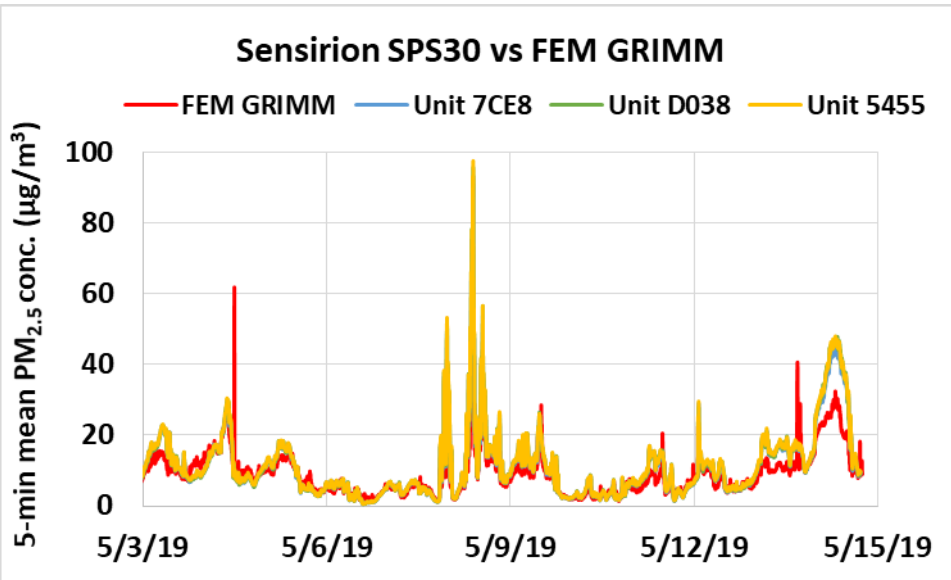y = 0.8467x + 4.0989
R^2 = 0.8857
(T640 vs FEM BAM)

5

Sensirion SPS30 vs GRIMM (PM$_{1.0}$; 5-min mean)

Sensirion SPS30 vs GRIMM

Legend: GRIMM — Unit 7CE8 — Unit D038 — Unit 5455

y-axis: 5-min mean PM$_{1.0}$ conc. (µg/m^3)
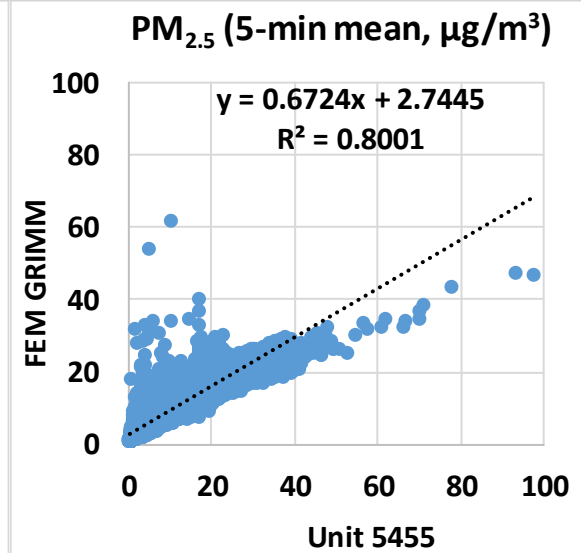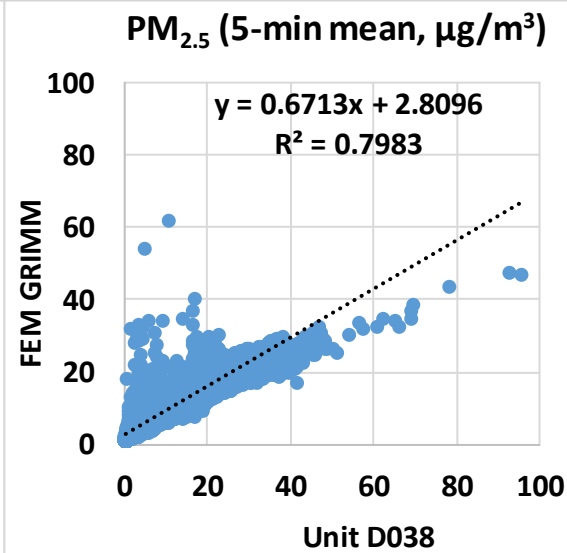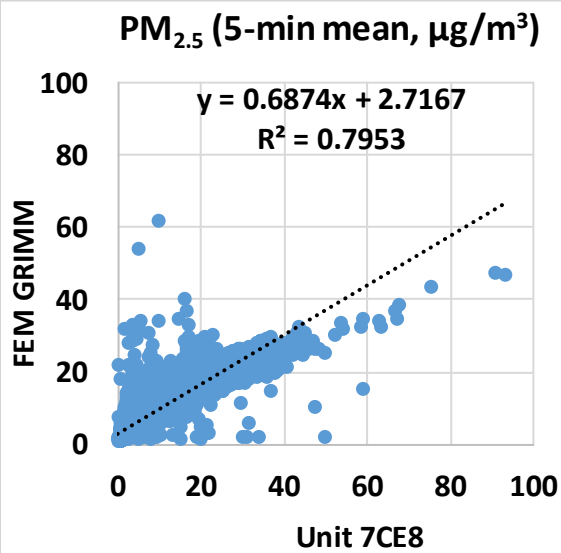
x-axis: 4/15/19, 4/18/19, 4/21/19, 4/24/19, 4/27/19

- Sensirion SPS30 sensors showed very strong correlations with the corresponding GRIMM data (R^2 ~ 0.91)
- Overall, the Sensirion SPS30 sensors overestimated the PM$_{1.0}$ mass concentrations as measured by GRIMM
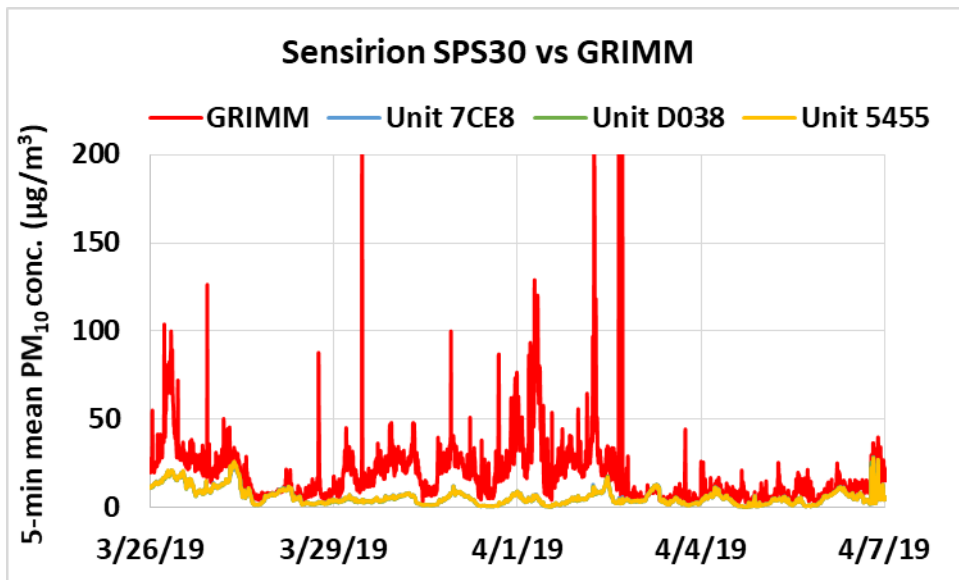- The Sensirion SPS30 sensors seemed to track well the PM$_{1.0}$ diurnal variations as recorded by GRIMM

PM$_{1.0}$ (5-min mean, µg/m^3)

$y = 0.7028x + 1.1201$
$R^2 = 0.9085$

GRIMM vs Unit 7CE8

PM$_{1.0}$ (5-min mean, µg/m^3)

$y = 0.7027x + 1.1392$
$R^2 = 0.9119$

GRIMM vs Unit D038

PM$_{1.0}$ (5-min mean, µg/m^3)

$y = 0.7x + 1.113$
$R^2 = 0.9119$

GRIMM vs Unit 5455

Sensirion SPS30 vs FEM GRIMM (PM$_{2.5}$; 5-min mean)

Sensirion SPS30 vs FEM GRIMM
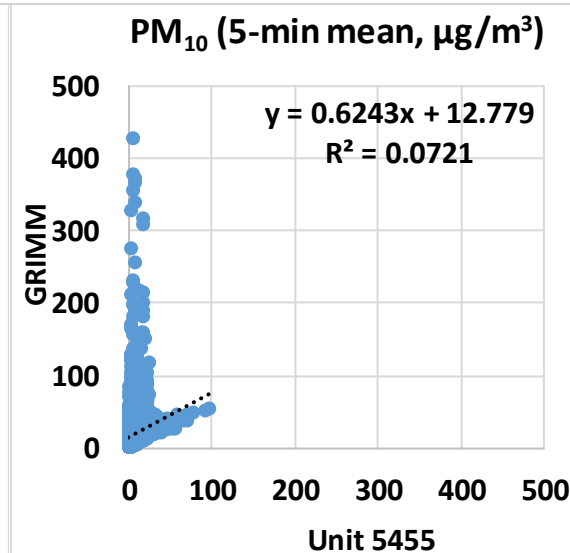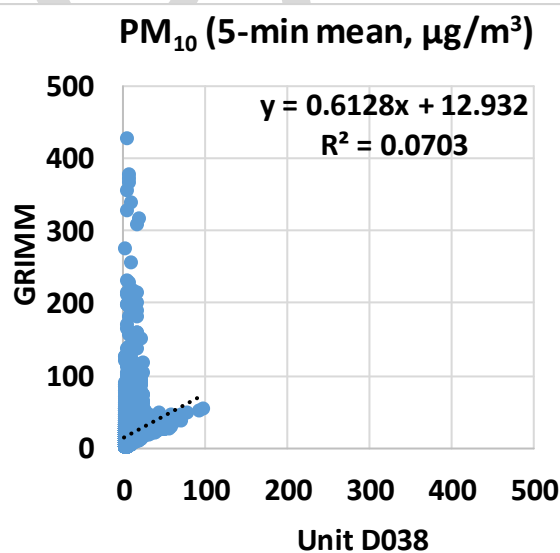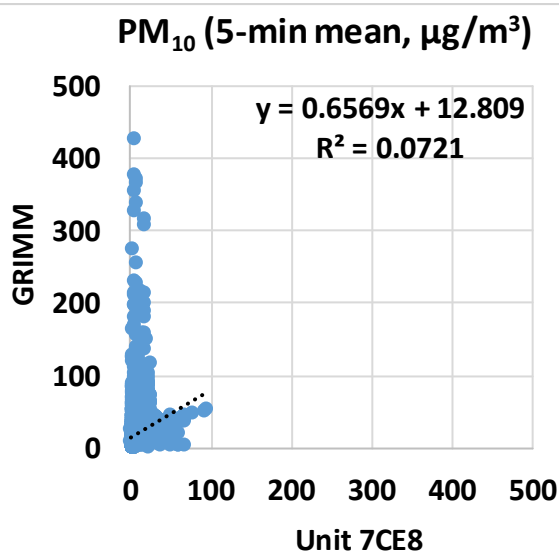
Legend: FEM GRIMM — Unit 7CE8 — Unit D038 — Unit 5455

- Sensirion SPS30 sensors showed strong correlations with the corresponding FEM GRIMM data (R^2 ~ 0.80)

- Overall, the Sensirion SPS30 sensors overestimated the PM$_{2.5}$ mass concentrations when PM$_{2.5}$ > ~10 µg/m^3 as measured by FEM GRIMM

- The Sensirion SPS30 sensors seemed to track well the PM$_{2.5}$ diurnal variations as recorded by FEM GRIMM
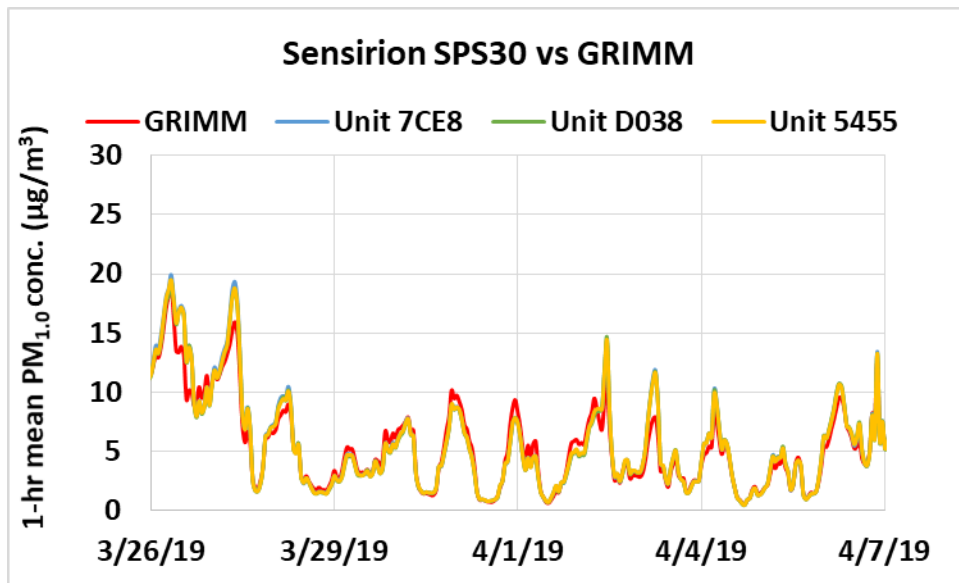
PM$_{2.5}$ (5-min mean, µg/m^3)

$y = 0.6874x + 2.7167$
$R^2 = 0.7953$

Unit 7CE8

PM$_{2.5}$ (5-min mean, µg/m^3)

$y = 0.6713x + 2.8096$
$R^2 = 0.7983$

Unit D038

PM$_{2.5}$ (5-min mean, µg/m^3)

$y = 0.6724x + 2.7445$
$R^2 = 0.8001$

Unit 5455

Sensirion SPS30 vs GRIMM (PM$_{10}$; 5-min mean)

Sensirion SPS30 vs GRIMM

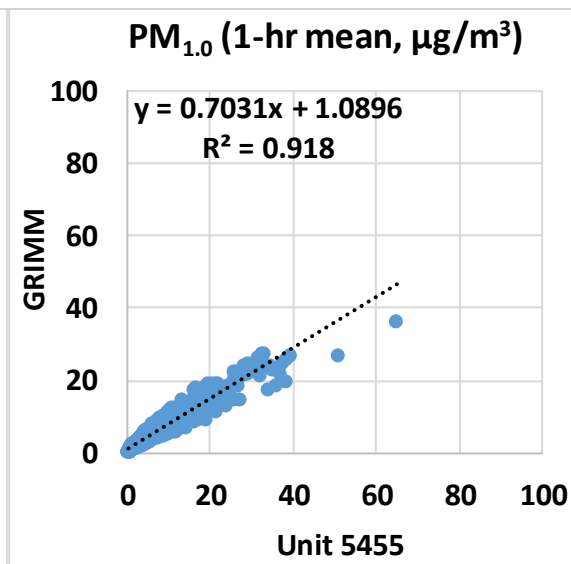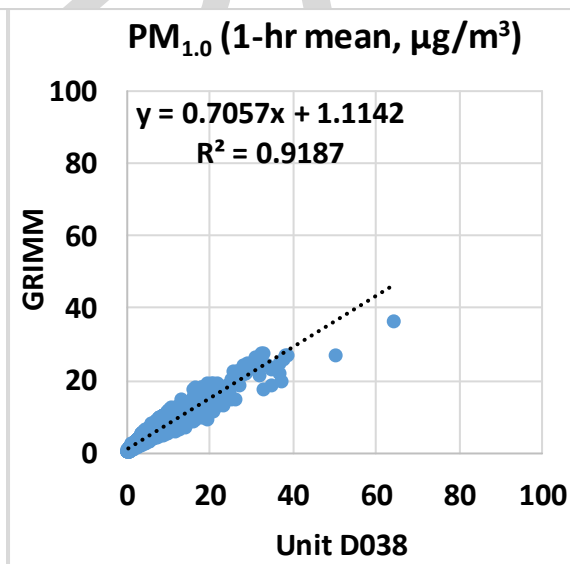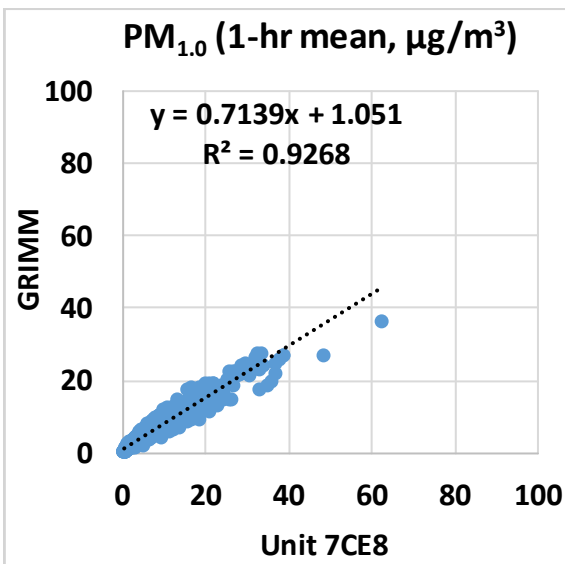
- Sensirion SPS30 sensors did not correlate with the corresponding GRIMM data (R^2 ~ 0.07)
- Overall, the Sensirion SPS30 sensors underestimated the PM$_{10}$ mass concentrations measured by GRIMM
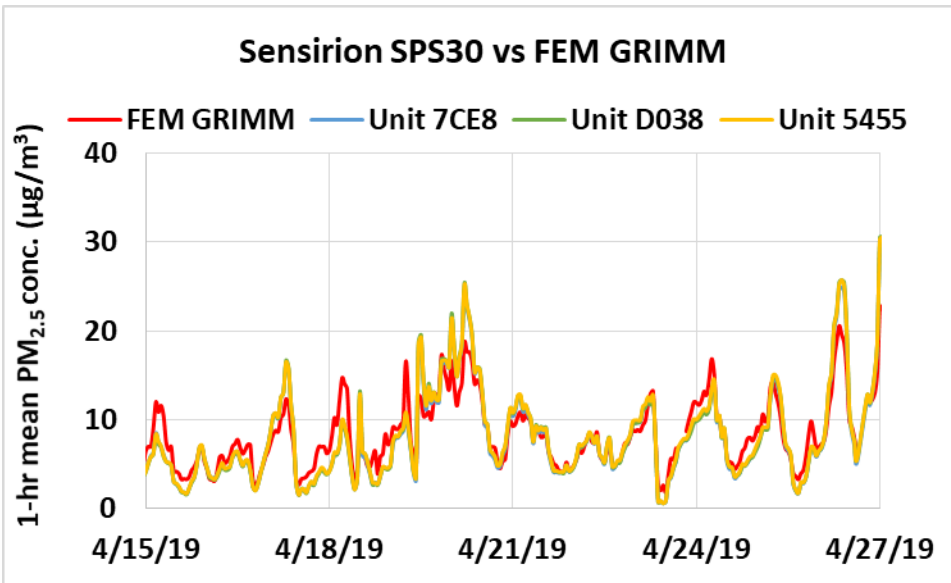- The Sensirion SPS30 sensors seemed to moderately track the PM$_{10}$ diurnal variations as recorded by GRIMM

PM$_{10}$ (5-min mean, µg/m^3)

y = 0.6569x + 12.809
R^2 = 0.0721

Unit 7CE8

PM$_{10}$ (5-min mean, µg/m^3)

y = 0.6128x + 12.932
R^2 = 0.0703

Unit D038

PM$_{10}$ (5-min mean, µg/m^3)

y = 0.6243x + 12.779
R^2 = 0.0721

Unit 5455

Sensirion SPS30 vs GRIMM (PM$_{1.0}$; 1-hr mean)

Sensirion SPS30 vs GRIMM

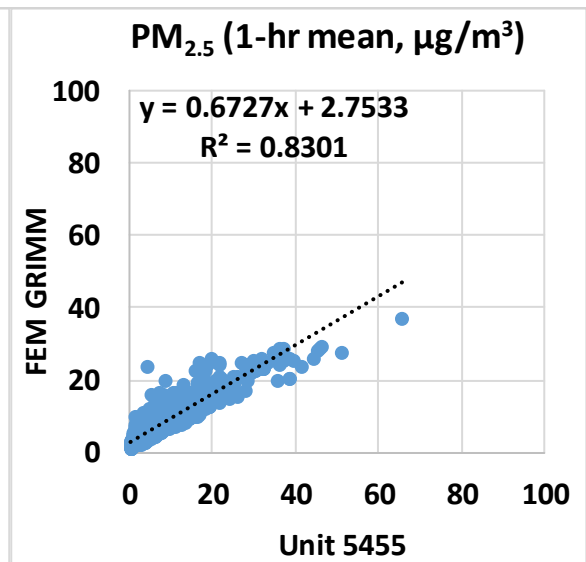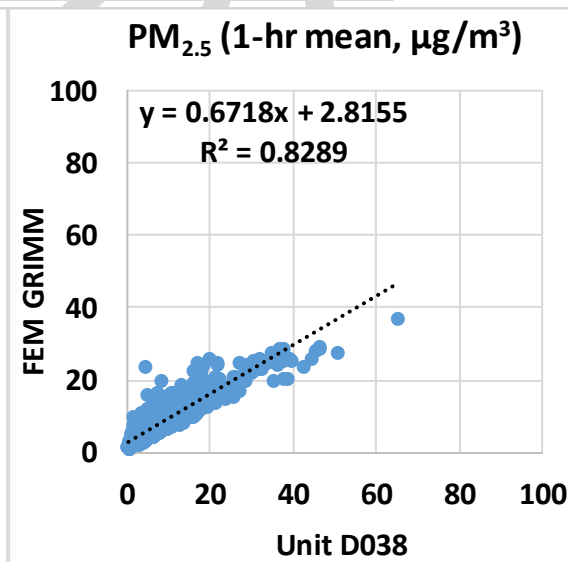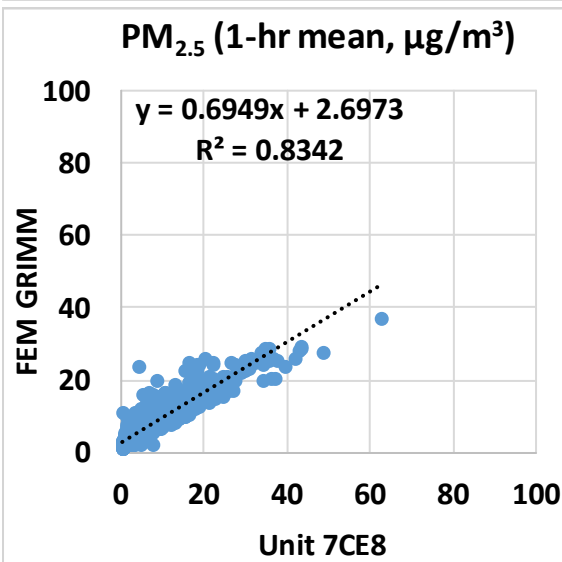GRIMM — Unit 7CE8 — Unit D038 — Unit 5455

- Sensirion SPS30 sensors showed very strong correlations with the corresponding GRIMM data ($R^2 \sim 0.92$)

- Overall, the Sensirion SPS30 sensors overestimated the PM$_{1.0}$ mass concentrations as measured by GRIMM

- The Sensirion SPS30 sensors seemed to track well the PM$_{1.0}$ diurnal variations as recorded by GRIMM
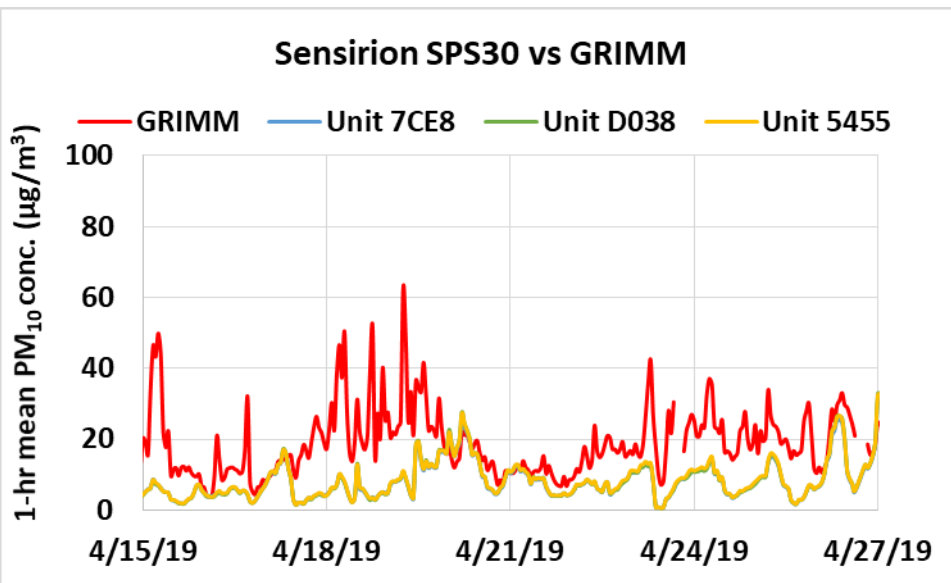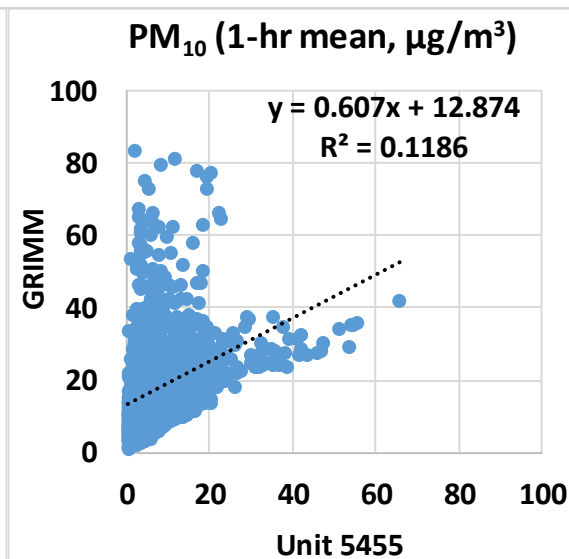
PM$_{1.0}$ (1-hr mean, µg/m³)

$y = 0.7139x + 1.051$
$R^2 = 0.9268$

Unit 7CE8

PM$_{1.0}$ (1-hr mean, µg/m³)

$y = 0.7057x + 1.1142$
$R^2 = 0.9187$

Unit D038

PM$_{1.0}$ (1-hr mean, µg/m³)

$y = 0.7031x + 1.0896$
$R^2 = 0.918$

Unit 5455

Sensirion SPS30 vs FEM GRIMM (PM$_{2.5}$; 1-hr mean)

Sensirion SPS30 vs FEM GRIMM
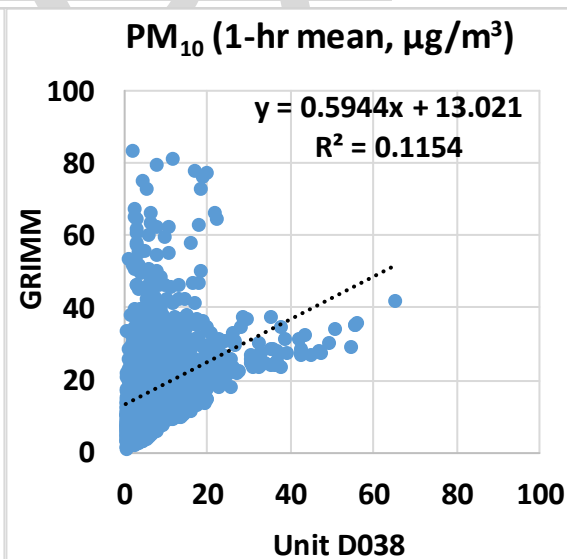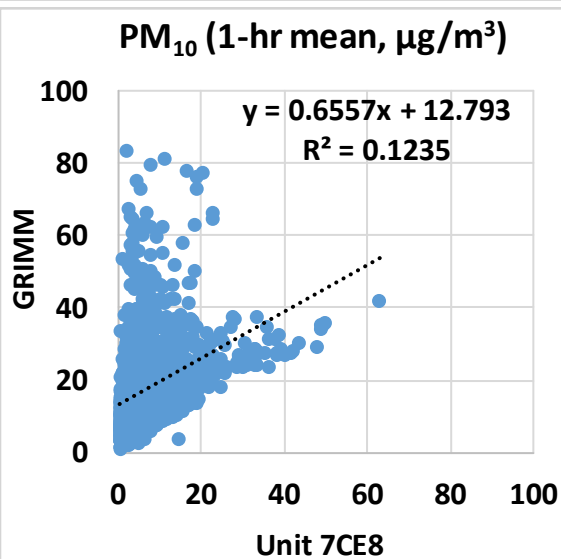
Legend: FEM GRIMM — Unit 7CE8 — Unit D038 — Unit 5455

- Sensirion SPS30 sensors showed strong correlations with the corresponding FEM GRIMM data (R^2 ~ 0.83)

- Overall, the Sensirion SPS30 sensors overestimated the PM$_{2.5}$ mass concentrations when PM$_{2.5}$ > ~10 µg/m^3 as measured by FEM GRIMM

- The Sensirion SPS30 sensors seemed to track well the PM$_{2.5}$ diurnal variations as recorded by FEM GRIMM
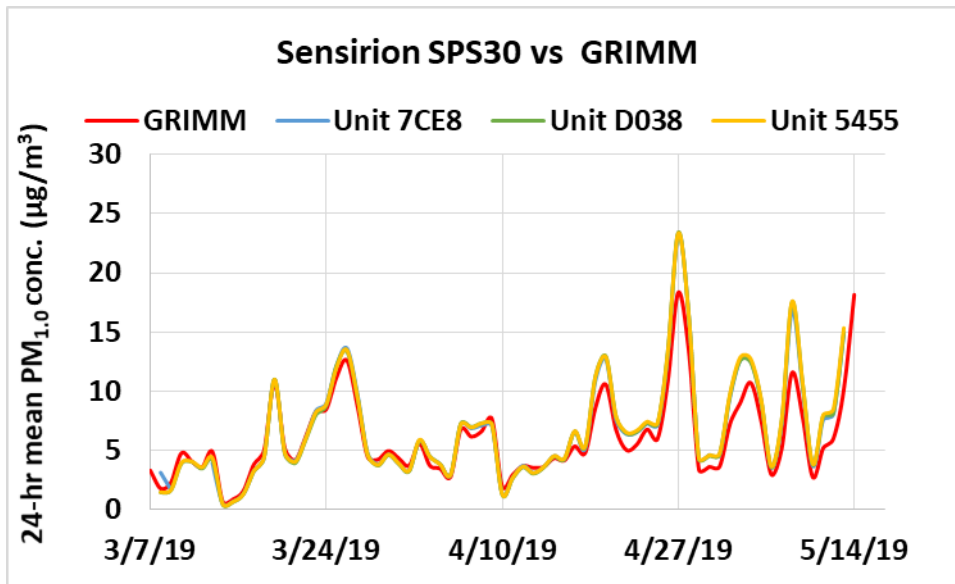
PM$_{2.5}$ (1-hr mean, µg/m^3)

$y = 0.6949x + 2.6973$
$R^2 = 0.8342$

PM$_{2.5}$ (1-hr mean, µg/m^3)

$y = 0.6718x + 2.8155$
$R^2 = 0.8289$

PM$_{2.5}$ (1-hr mean, µg/m^3)

$y = 0.6727x + 2.7533$
$R^2 = 0.8301$

10

Sensirion SPS30 vs GRIMM (PM$_{10}$; 1-hr mean)

Sensirion SPS30 vs GRIMM

Legend: — GRIMM — Unit 7CE8 — Unit D038 — Unit 5455

y-axis: 1-hr mean PM$_{10}$ conc. ($\mu g/m^3$), ranging 0 to 100

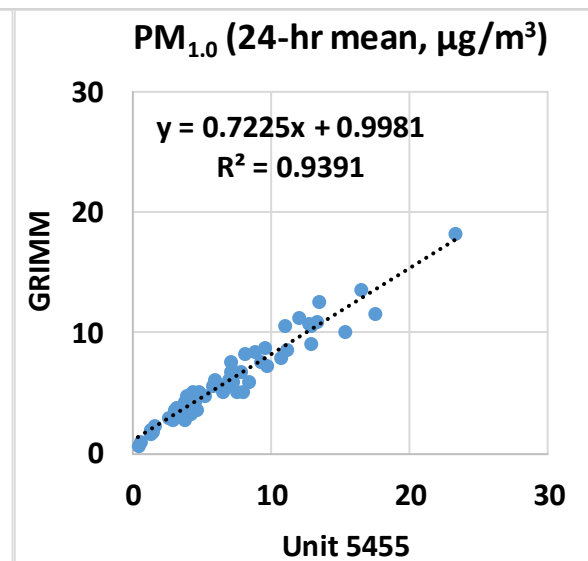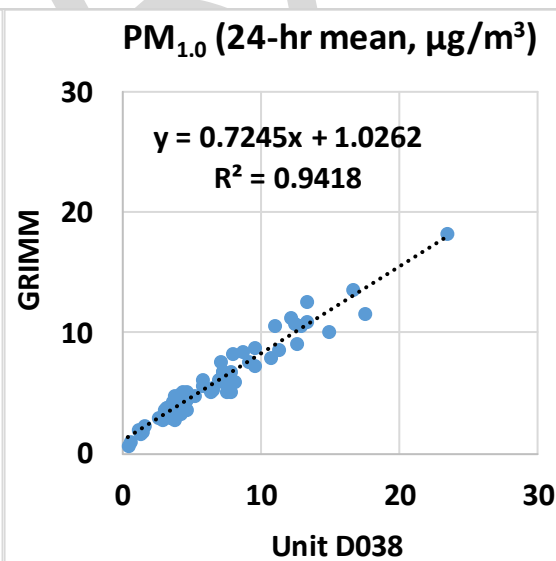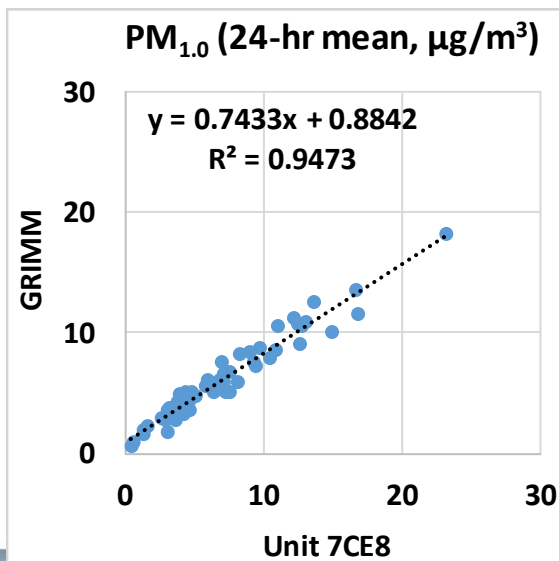x-axis dates: 4/15/19, 4/18/19, 4/21/19, 4/24/19, 4/27/19

- Sensirion SPS30 sensors showed very weak correlations with the corresponding GRIMM data ($R^2 \sim 0.12$)

- Overall, the Sensirion SPS30 sensors underestimated the PM$_{10}$ mass concentrations measured by GRIMM

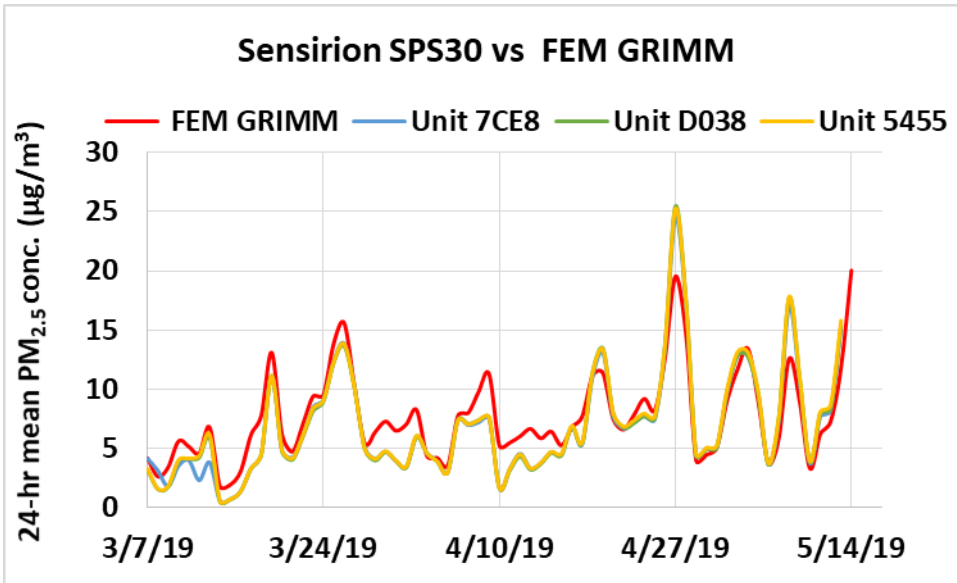- The Sensirion SPS30 sensors seemed to moderately track the PM$_{10}$ diurnal variations as recorded by GRIMM

PM$_{10}$ (1-hr mean, $\mu g/m^3$)

$y = 0.6557x + 12.793$
$R^2 = 0.1235$

GRIMM vs Unit 7CE8

PM$_{10}$ (1-hr mean, $\mu g/m^3$)

$y = 0.5944x + 13.021$
$R^2 = 0.1154$

GRIMM vs Unit D038

PM$_{10}$ (1-hr mean, $\mu g/m^3$)

$y = 0.607x + 12.874$
$R^2 = 0.1186$

GRIMM vs Unit 5455

Sensirion SPS30 vs GRIMM (PM$_{1.0}$; 24-hr mean)

Sensirion SPS30 vs GRIMM

Legend: GRIMM — Unit 7CE8 — Unit D038 — Unit 5455

Y-axis: 24-hr mean PM$_{1.0}$ conc. ($\mu g/m^3$)
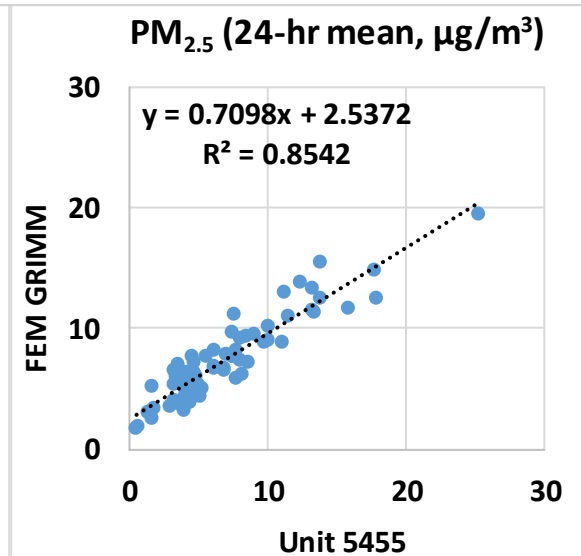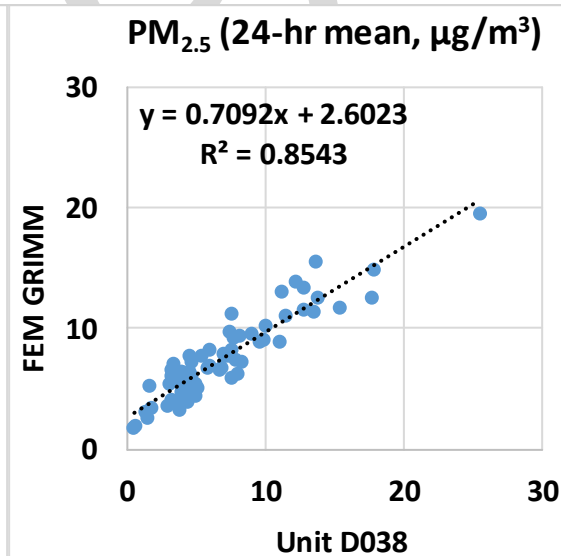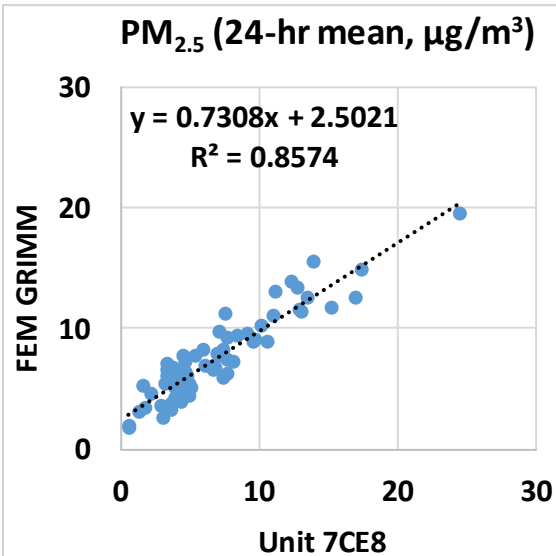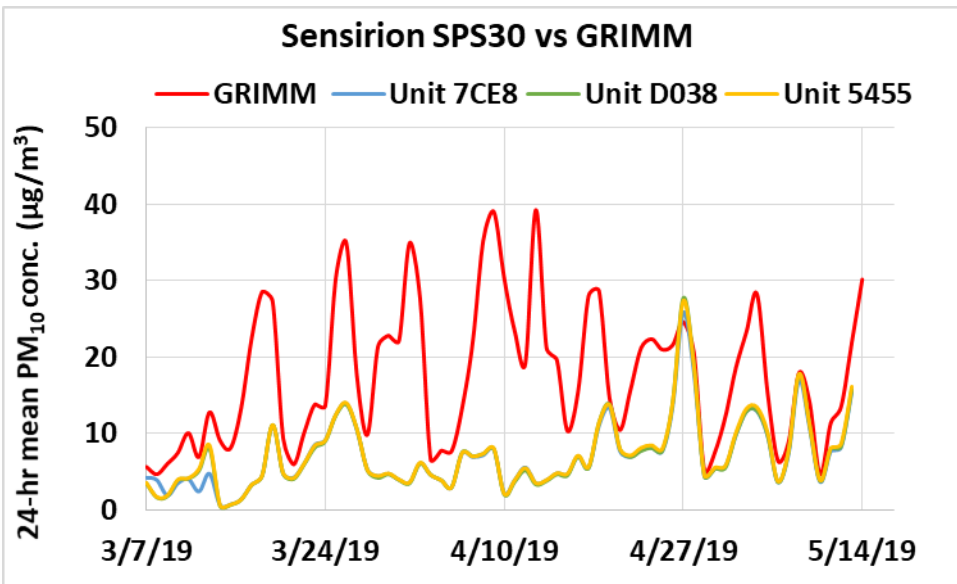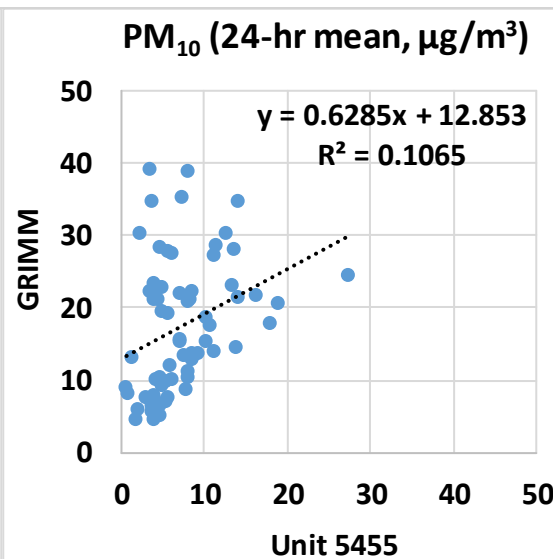
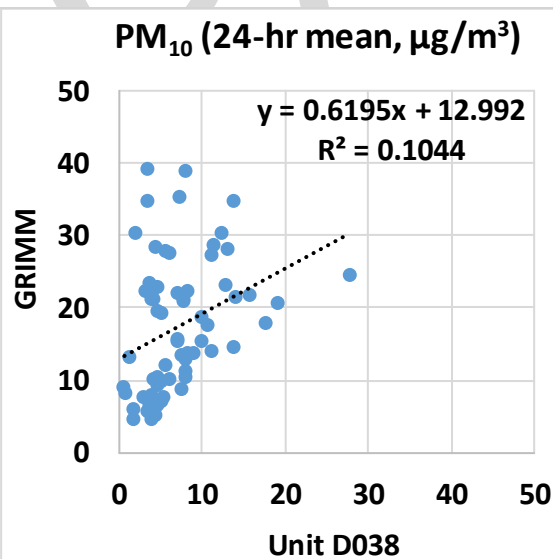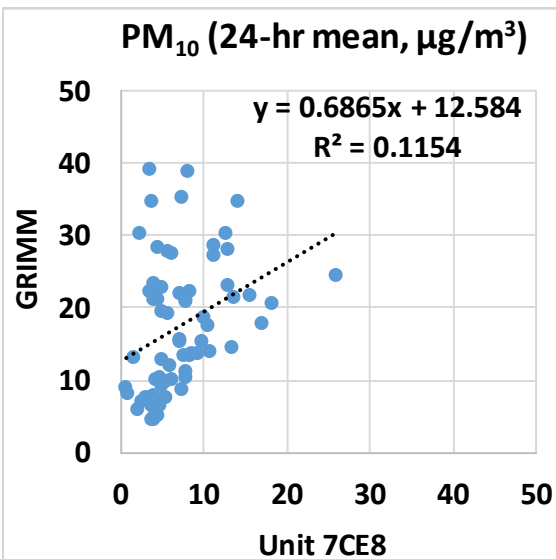X-axis: 3/7/19, 3/24/19, 4/10/19, 4/27/19, 5/14/19

- Sensirion SPS30 sensors showed very strong correlations with the corresponding GRIMM data ($R^2 \sim 0.94$)

- Overall, the Sensirion SPS30 sensors overestimated the PM$_{1.0}$ mass concentrations as measured by GRIMM

- The Sensirion SPS30 sensors seemed to track well the PM$_{1.0}$ diurnal variations as recorded by GRIMM

**PM$_{1.0}$ (24-hr mean, $\mu g/m^3$)**

$y = 0.7433x + 0.8842$
$R^2 = 0.9473$

Y-axis: GRIMM
X-axis: Unit 7CE8

PM$_{1.0}$ (24-hr mean, $\mu g/m^3$)

$y = 0.7245x + 1.0262$
$R^2 = 0.9418$

Y-axis: GRIMM
X-axis: Unit D038

PM$_{1.0}$ (24-hr mean, $\mu g/m^3$)

$y = 0.7225x + 0.9981$
$R^2 = 0.9391$

Y-axis: GRIMM
X-axis: Unit 5455

Sensirion SPS30 vs FEM GRIMM (PM$_{2.5}$; 24-hr mean)

Sensirion SPS30 vs FEM GRIMM

Legend: — FEM GRIMM — Unit 7CE8 — Unit D038 — Unit 5455

- Sensirion SPS30 sensors showed strong correlations with the corresponding FEM GRIMM data (R^2 ~ 0.86)

- Overall, the Sensirion SPS30 sensors overestimated the PM$_{2.5}$ mass concentrations when PM$_{2.5}$ > ~10 µg/m^3 as measured by FEM GRIMM

- The Sensirion SPS30 sensors seemed to track well the PM$_{2.5}$ diurnal variations as recorded by FEM GRIMM

PM$_{2.5}$ (24-hr mean, µg/m^3)

$y = 0.7308x + 2.5021$
$R^2 = 0.8574$

Unit 7CE8

PM$_{2.5}$ (24-hr mean, µg/m^3)

$y = 0.7092x + 2.6023$
$R^2 = 0.8543$

Unit D038

PM$_{2.5}$ (24-hr mean, µg/m^3)

$y = 0.7098x + 2.5372$
$R^2 = 0.8542$

Unit 5455

Sensirion SPS30 vs GRIMM (PM$_{10}$; 24-hr mean)

- Sensirion SPS30 sensors showed very weak correlations with the corresponding GRIMM data ($R^2 \sim 0.11$)
- Overall, the Sensirion SPS30 sensors underestimated the PM$_{10}$ mass concentrations measured by GRIMM
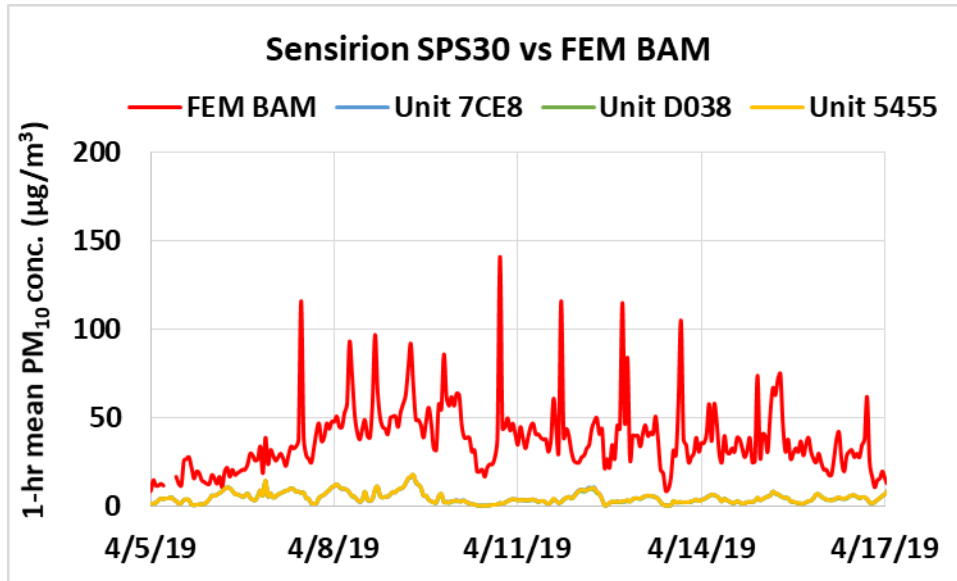- The Sensirion SPS30 sensors seemed to moderately track the PM$_{10}$ diurnal variations as recorded by GRIMM
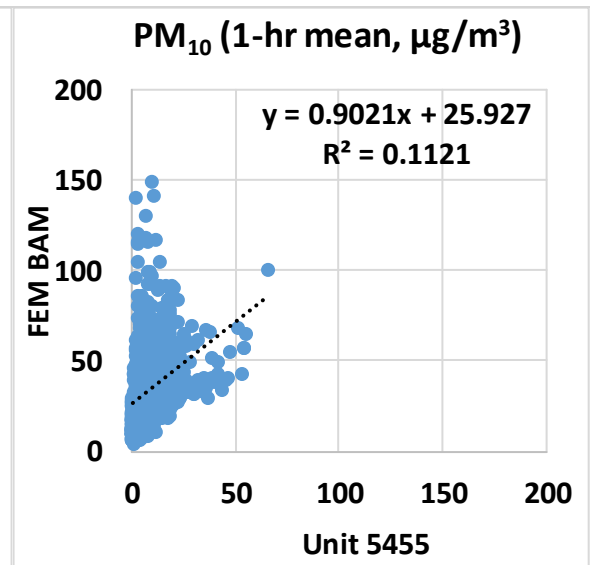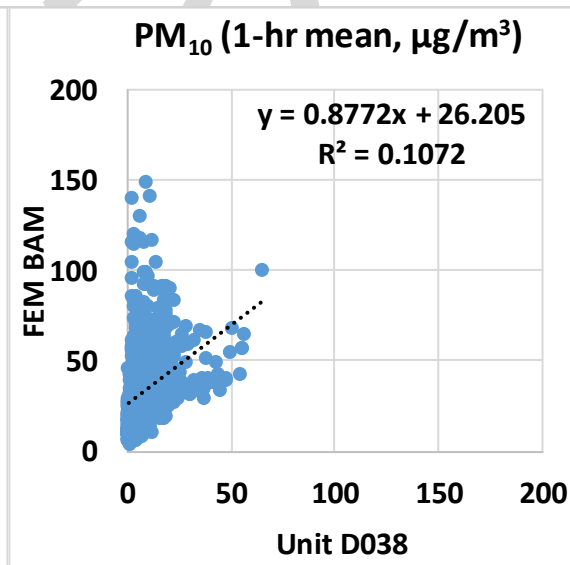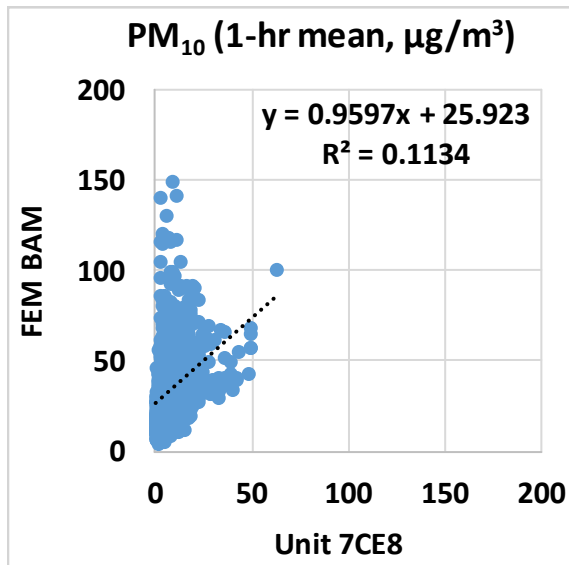
Sensirion SPS30 vs FEM BAM (PM$_{2.5}$; 1-hr mean)
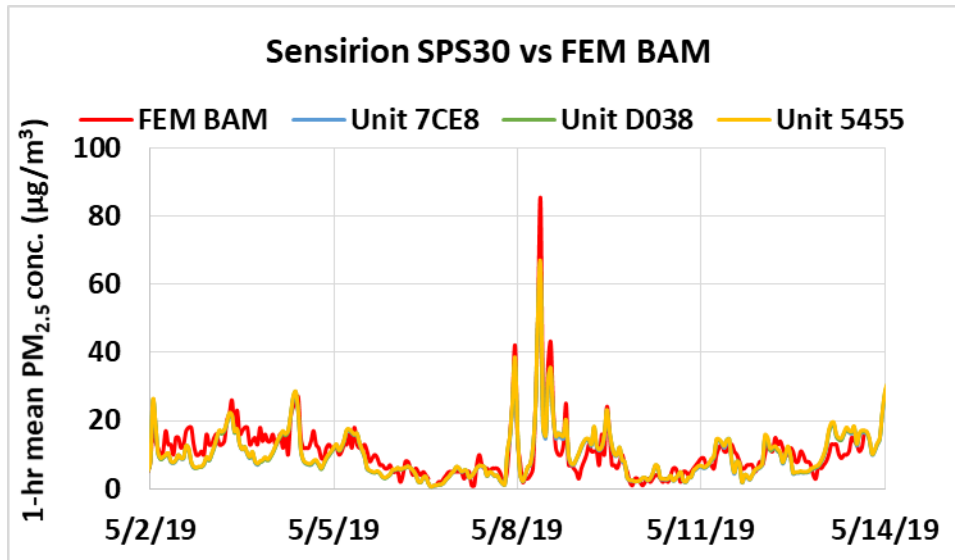
- Sensirion SPS30 sensors showed moderate correlations with the corresponding FEM BAM data (R^2 ~ 0.64)

- Overall, the Sensirion SPS30 sensors overestimated the PM$_{2.5}$ mass concentrations when PM$_{2.5}$ > ~15 µg/m^3 as measured by FEM BAM

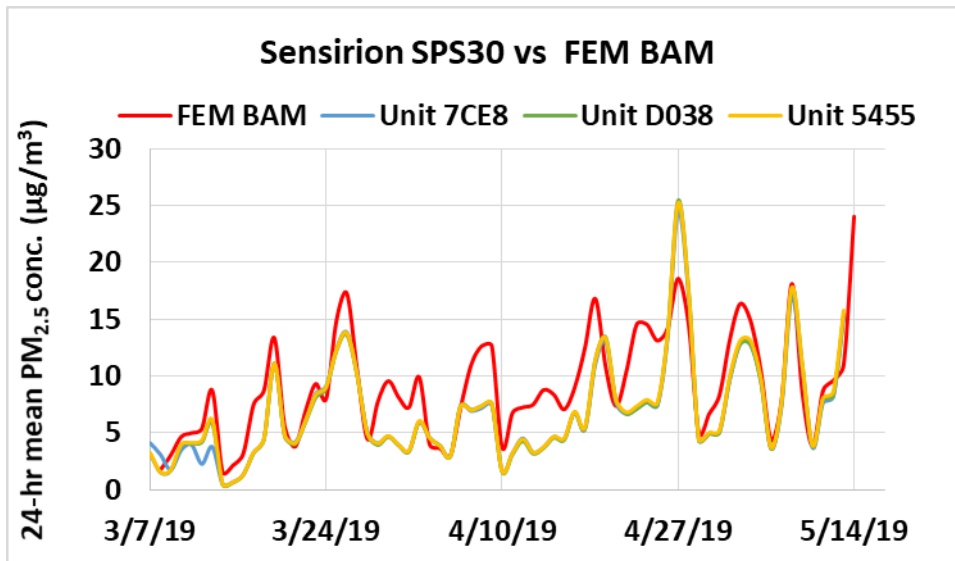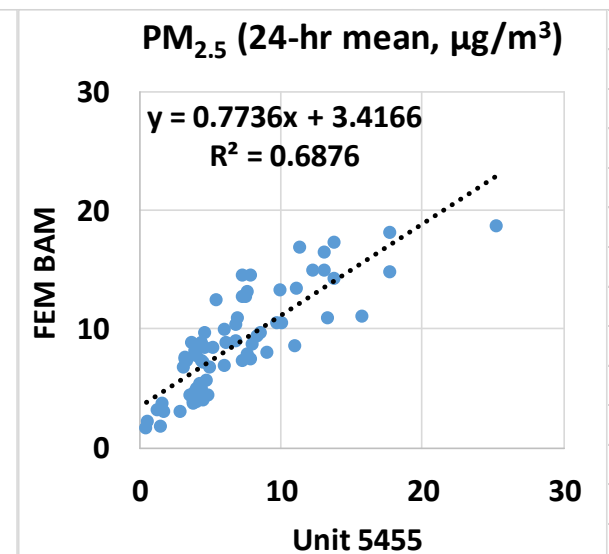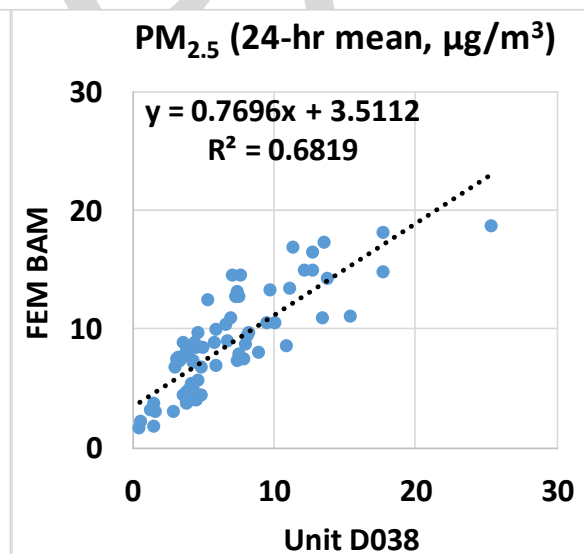- The Sensirion SPS30 sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM BAM
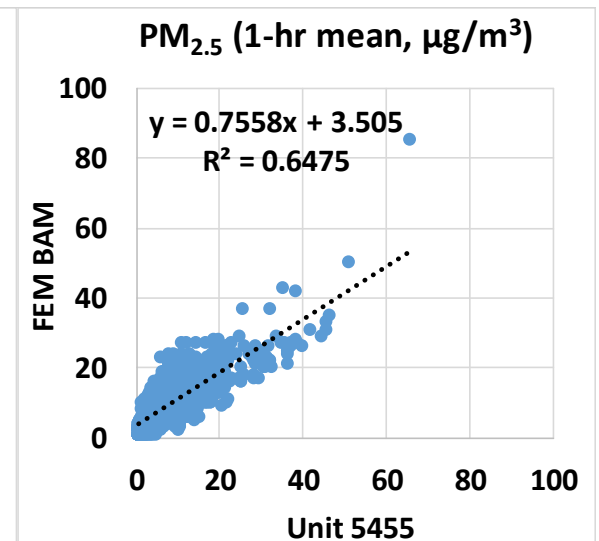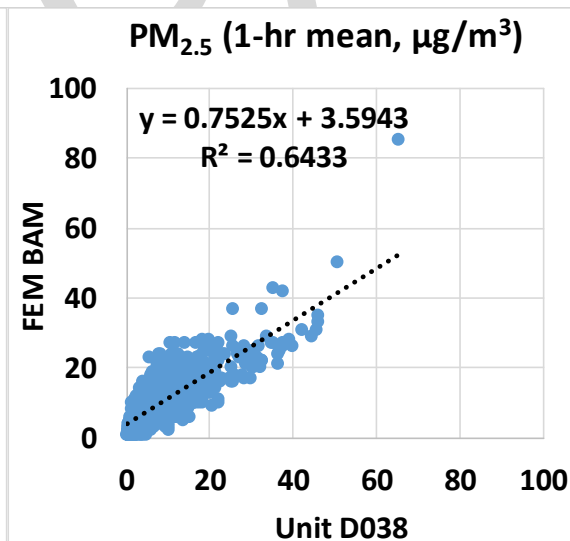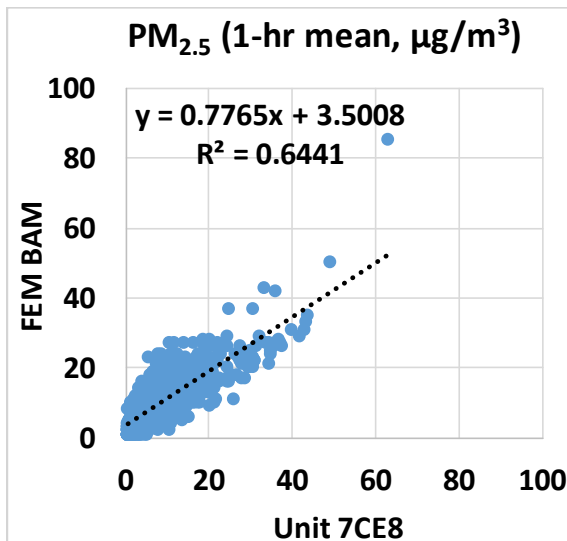
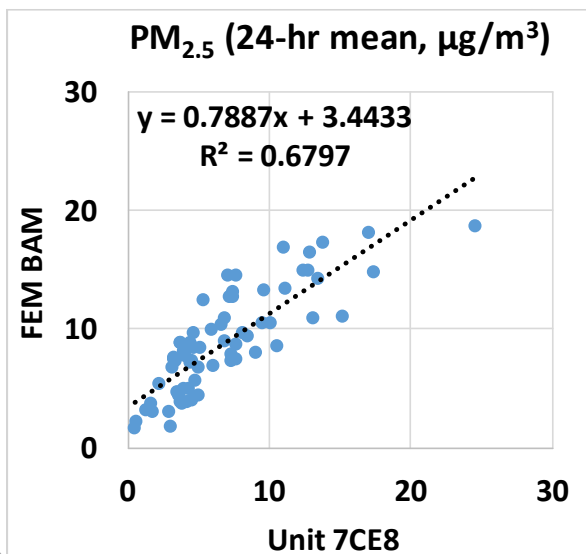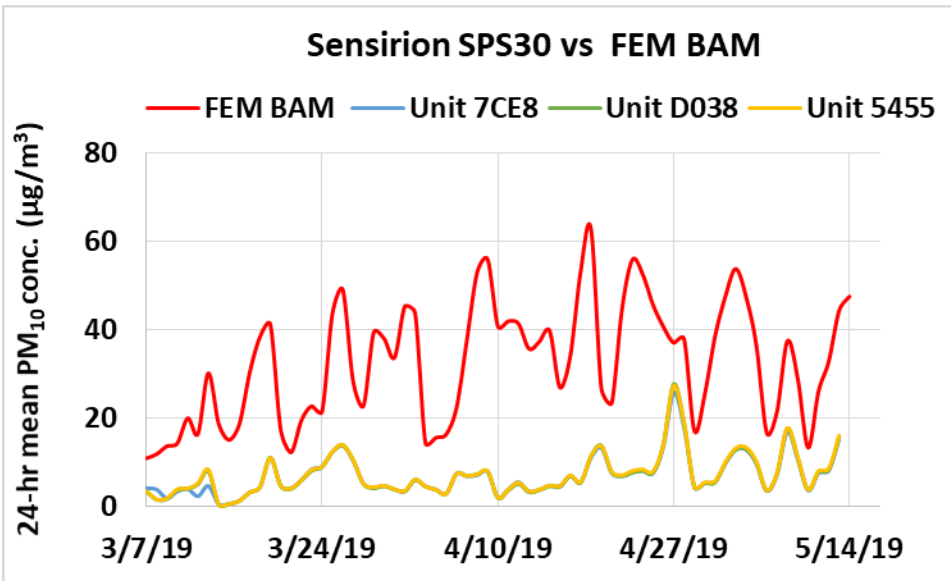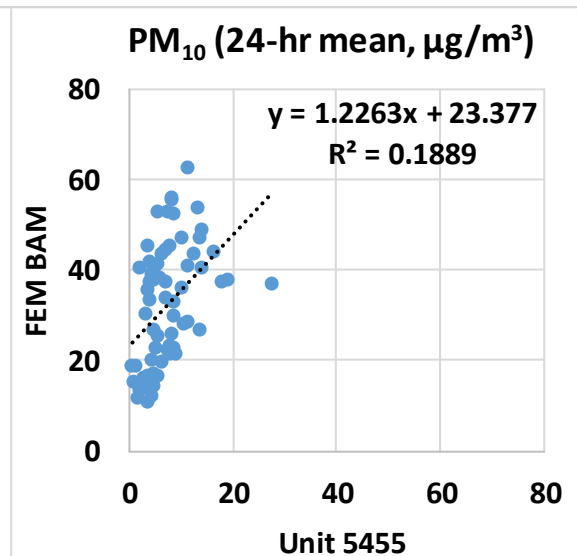# Sensirion SPS30 vs FEM BAM (PM_{10}; 1-hr mean)

- Sensirion SPS30 sensors showed very weak correlations with the corresponding FEM BAM data ($R^2 \sim 0.11$)

- Overall, the Sensirion SPS30 sensors underestimated the PM_{10} mass concentrations measured by FEM BAM

- The Sensirion SPS30 sensors did not track the PM_{10} diurnal variations as recorded by FEM BAM
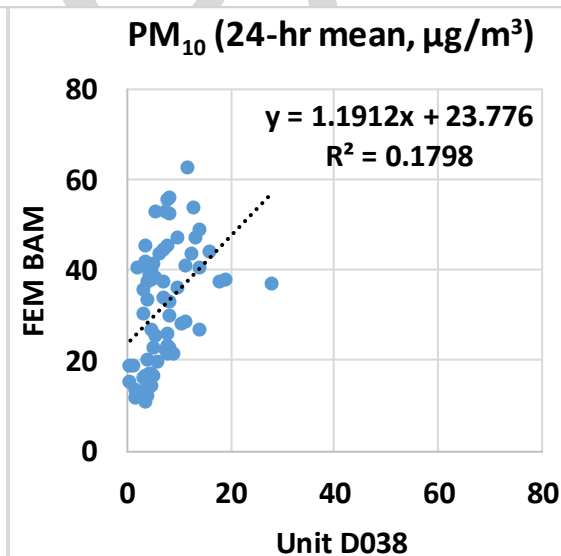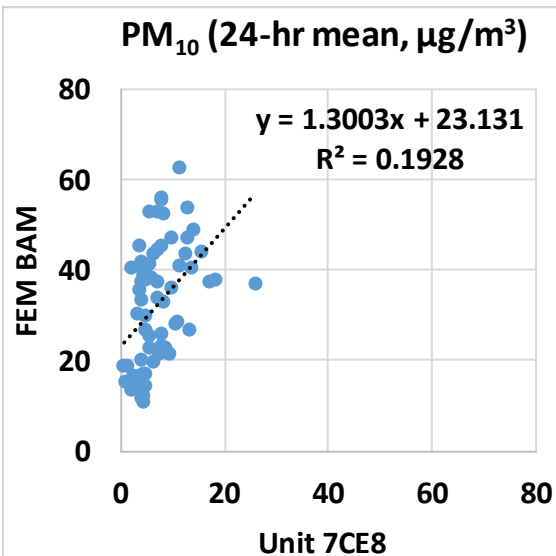
Sensirion SPS30 vs FEM BAM (PM$_{2.5}$; 24-hr mean)

- Sensirion SPS30 sensors showed moderate correlations with the corresponding FEM BAM data (R^2 ~ 0.68)

- Overall, the Sensirion SPS30 sensors overestimated the PM$_{2.5}$ mass concentrations when PM$_{2.5}$ > ~15 μg/m^3 as measured by FEM BAM

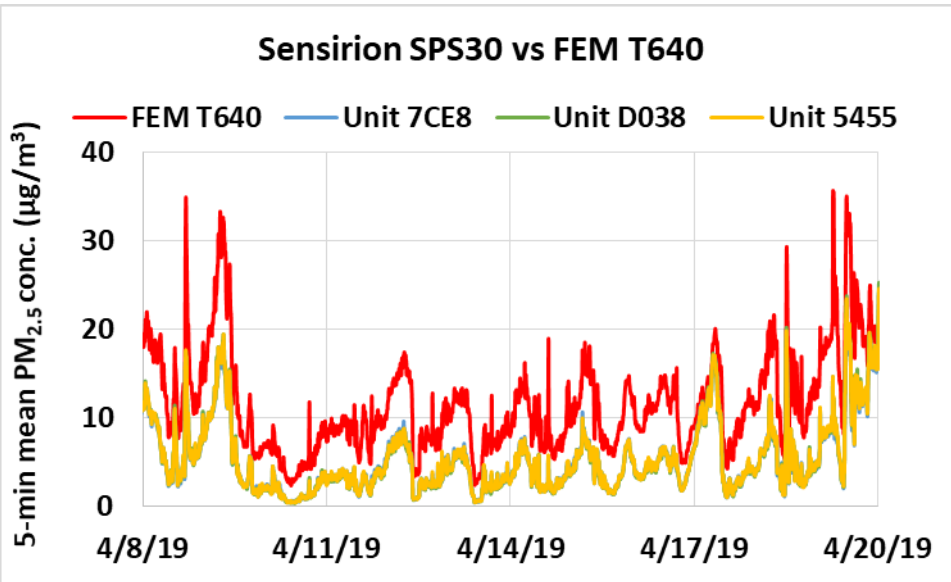- The Sensirion SPS30 sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM BAM

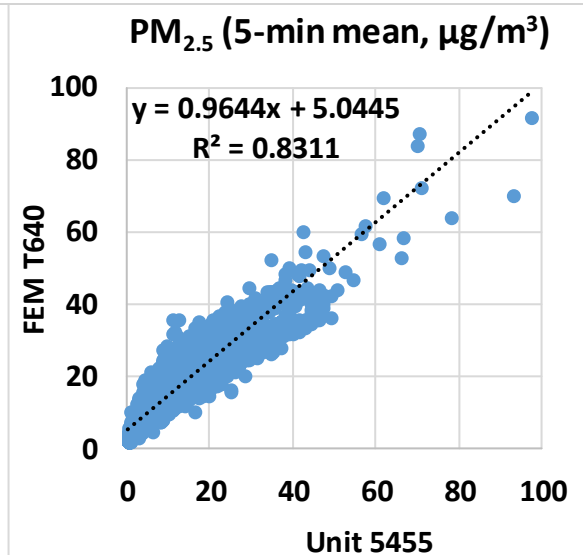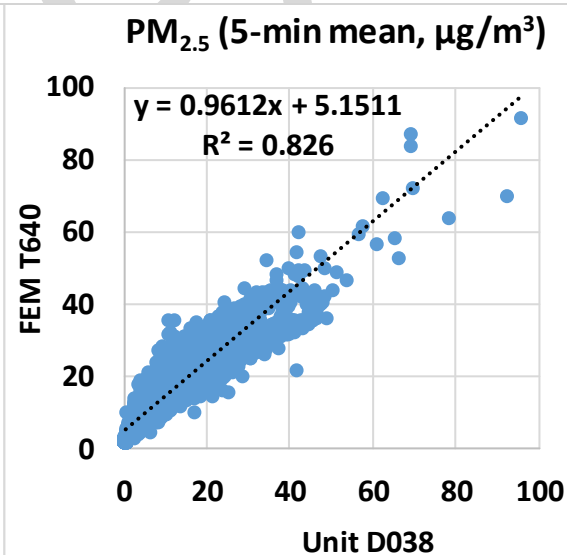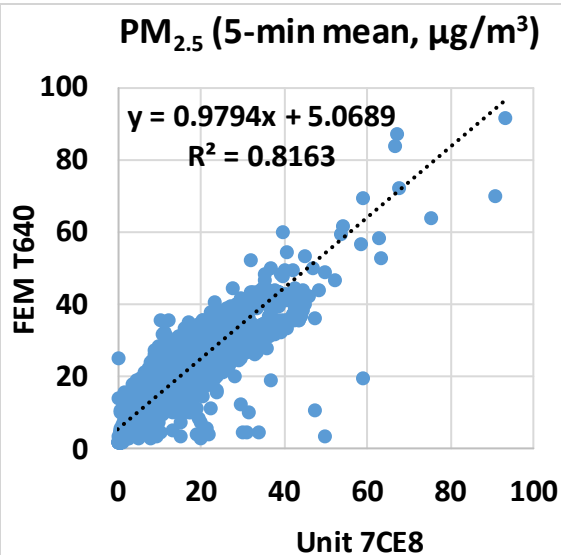# Sensirion SPS30 vs FEM BAM (PM$_{10}$; 24-hr mean)

- Sensirion SPS30 sensors showed very weak correlations with the corresponding FEM BAM data ($R^2 \sim 0.19$)

- Overall, the Sensirion SPS30 sensors underestimated the PM$_{10}$ mass concentrations measured by FEM BAM

- The Sensirion SPS30 sensors seemed to moderately track the PM$_{10}$ diurnal variations as recorded by FEM BAM
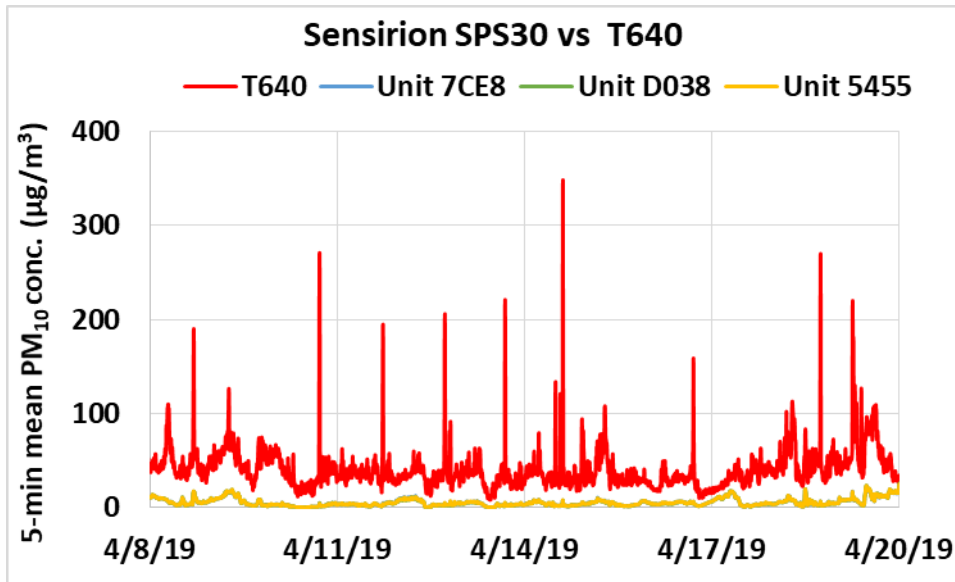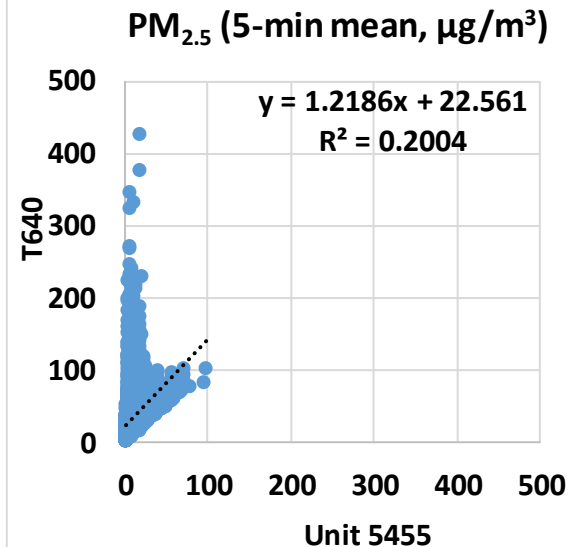
Sensirion SPS30 vs FEM T640 (PM$_{2.5}$; 5-min mean)

- Sensirion SPS30 sensors showed strong correlations with the corresponding FEM T640 data (R^2 ~ 0.82)

- Overall, the Sensirion SPS30 sensors underestimated the PM$_{2.5}$ mass concentrations measured by FEM T640

- The Sensirion SPS30 sensors seemed to track well the PM$_{2.5}$ diurnal variations as recorded by FEM T640

Sensirion SPS30 vs T640 (PM$_{10}$; 5-min mean)

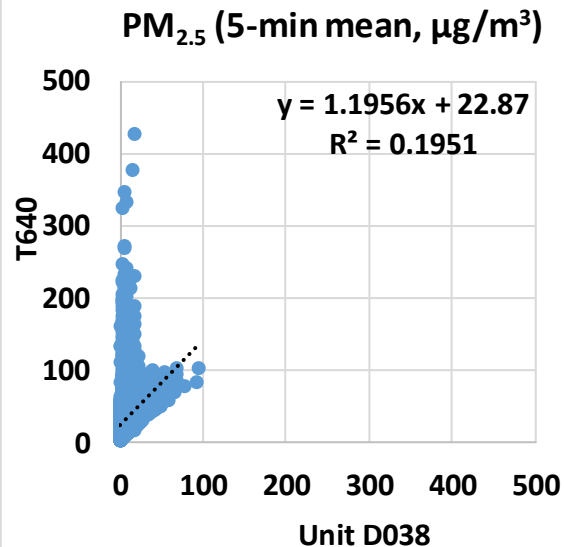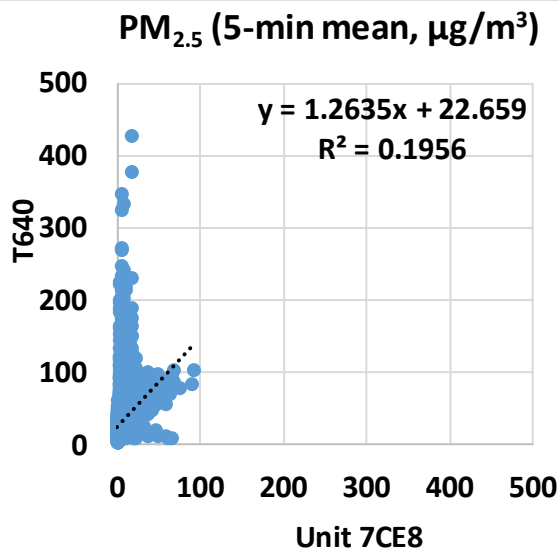Sensirion SPS30 vs T640

— T640 — Unit 7CE8 — Unit D038 — Unit 5455

- Sensirion SPS30 sensors showed very weak correlations with the corresponding T640 data ($R^2 \sim 0.20$)

- Overall, the Sensirion SPS30 sensors underestimated the PM$_{10}$ mass concentrations measured by T640

- The Sensirion SPS30 sensors did not track the PM$_{10}$ diurnal variations as recorded by T640

PM$_{2.5}$ (5-min mean, µg/m³)

$y = 1.2635x + 22.659$
$R^2 = 0.1956$

Unit 7CE8

PM$_{2.5}$ (5-min mean, µg/m³)

$y = 1.1956x + 22.87$
$R^2 = 0.1951$

Unit D038

PM$_{2.5}$ (5-min mean, µg/m³)

$y = 1.2186x + 22.561$
$R^2 = 0.2004$

Unit 5455

Sensirion SPS30 vs FEM T640 (PM$_{2.5}$; 1-hr mean)

- Sensirion SPS30 sensors showed strong correlations with the corresponding FEM T640 data (R^2 ~ 0.84)

- Overall, the Sensirion SPS30 sensors underestimated the PM$_{2.5}$ mass concentrations measured by FEM T640

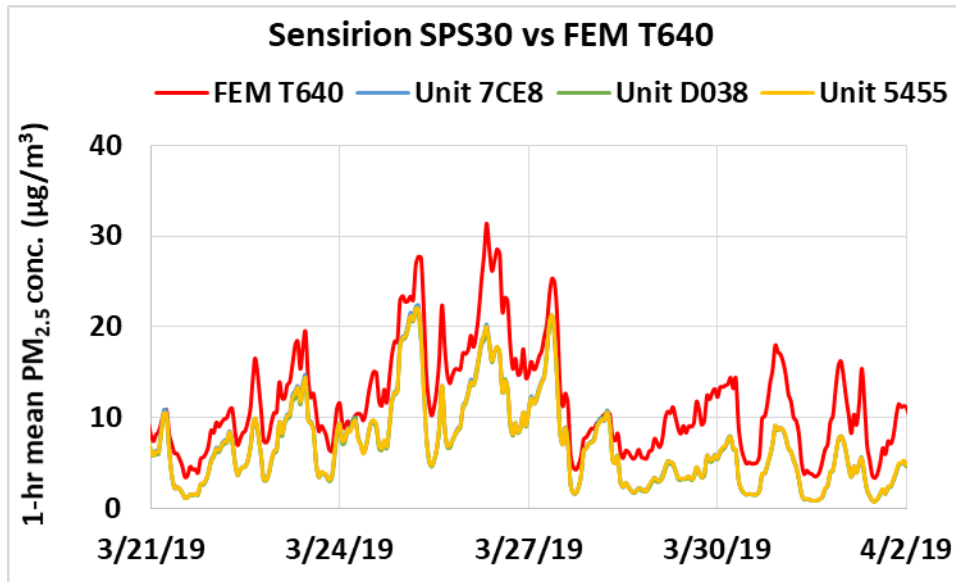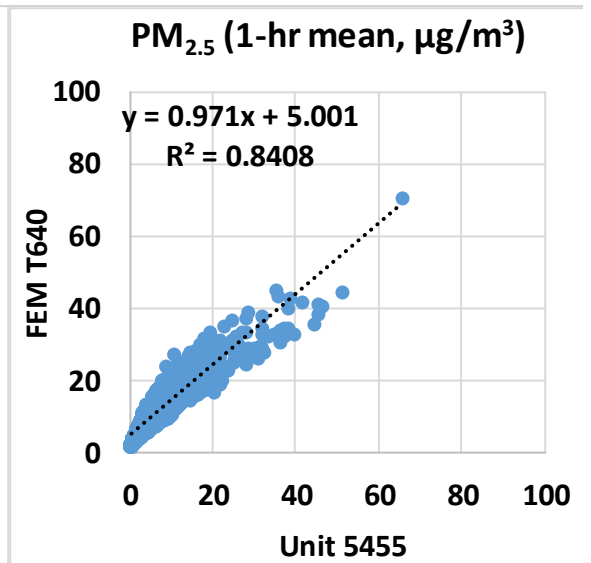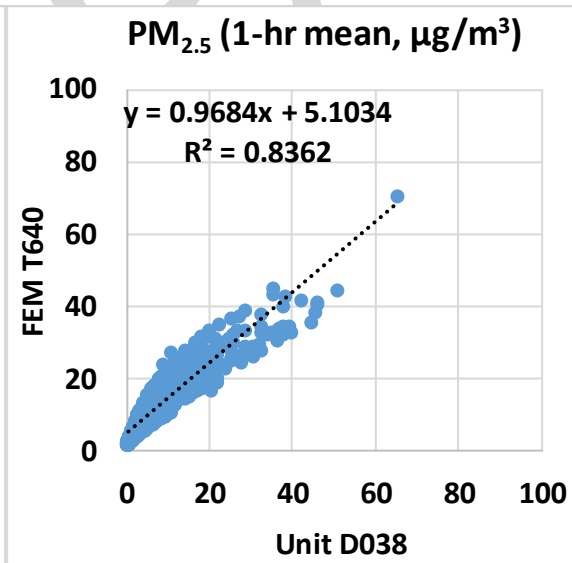- The Sensirion SPS30 sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM T640

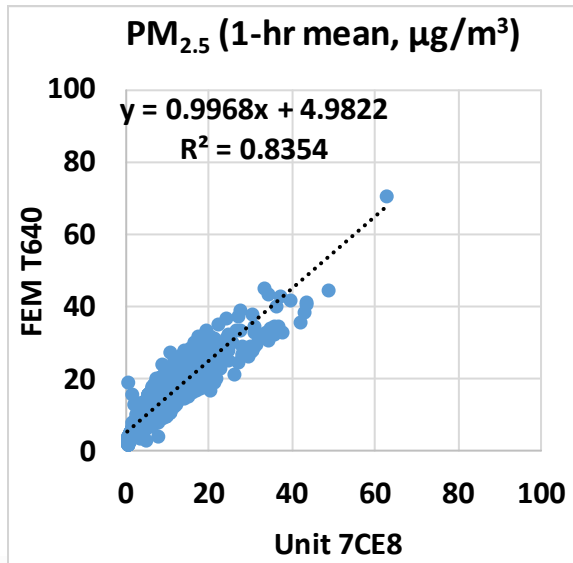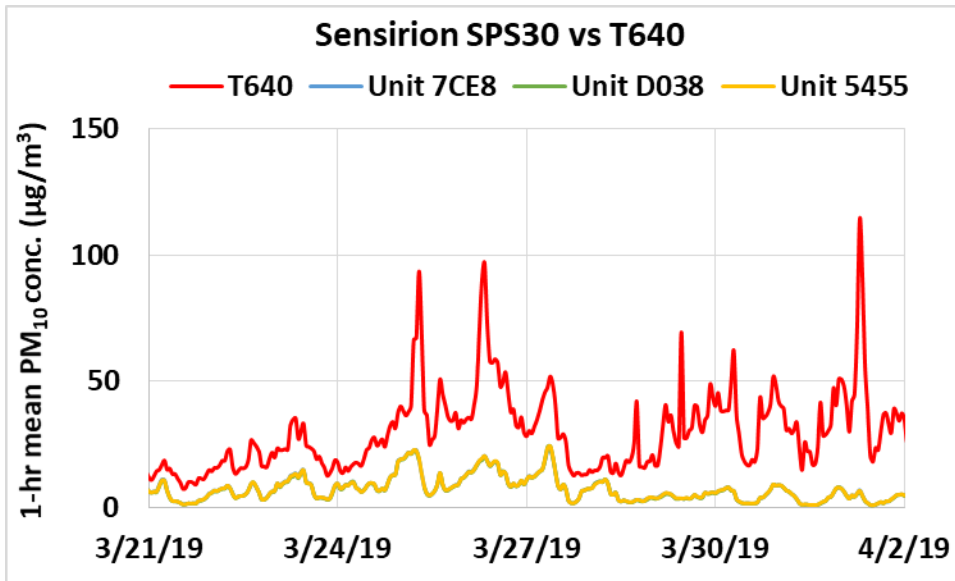# Sensirion SPS30 vs T640 (PM$_{10}$; 1-hr mean)

- Sensirion SPS30 sensors showed very weak correlations with the corresponding T640 data ($R^2 \sim 0.25$)

- Overall, the Sensirion SPS30 sensors underestimated the PM$_{10}$ mass concentrations measured by T640

- The Sensirion SPS30 sensors seemed to moderately track the PM$_{10}$ diurnal variations as recorded by T640

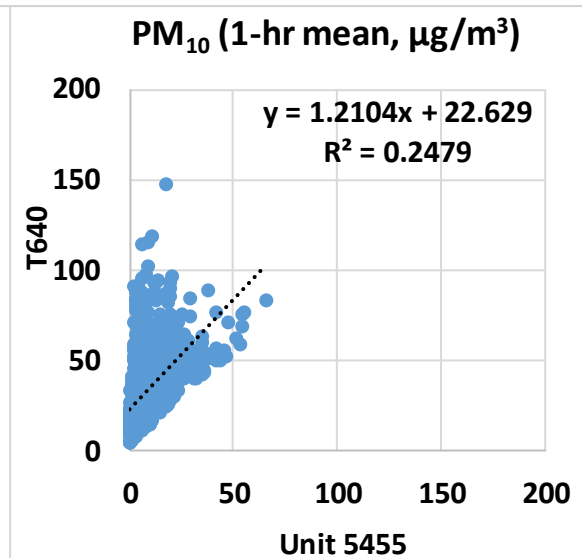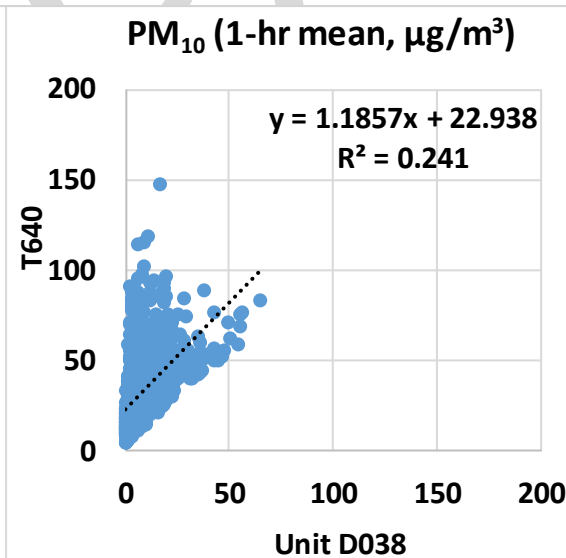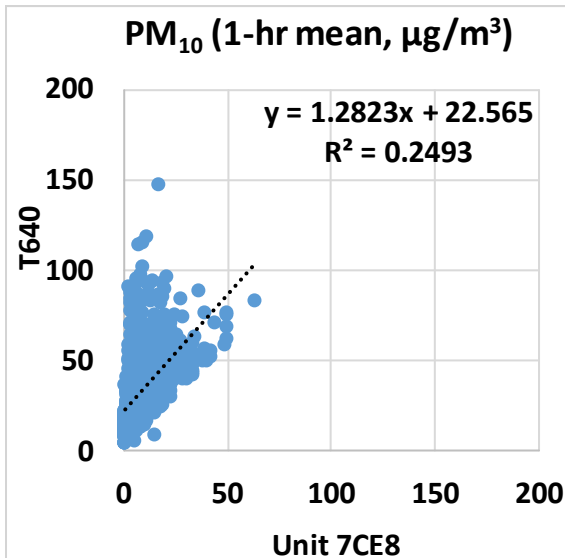# Sensirion SPS30 vs FEM T640 (PM$_{2.5}$; 24-hr mean)

- Sensirion SPS30 sensors showed strong correlations with the corresponding FEM T640 data ($R^2 \sim 0.84$)

- Overall, the Sensirion SPS30 sensors underestimated the PM$_{2.5}$ mass concentrations measured by FEM T640

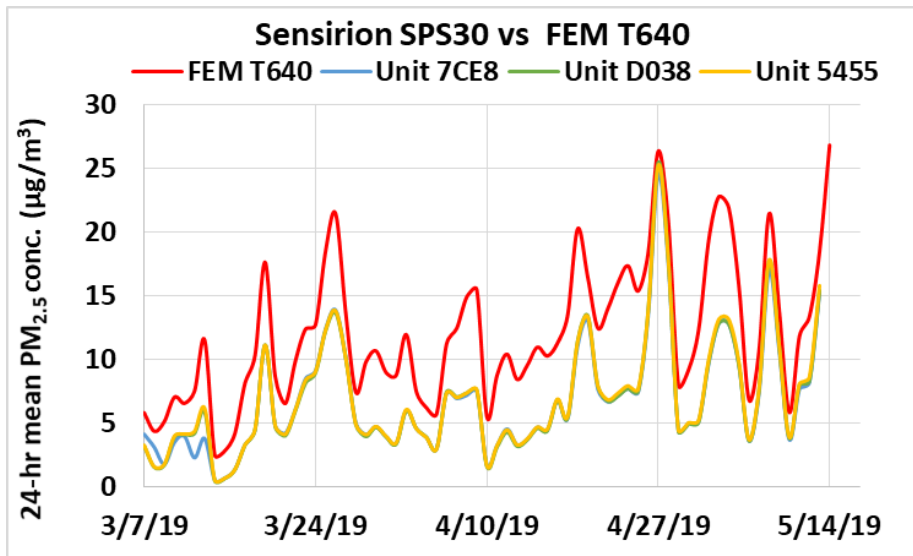- The Sensirion SPS30 sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM T640
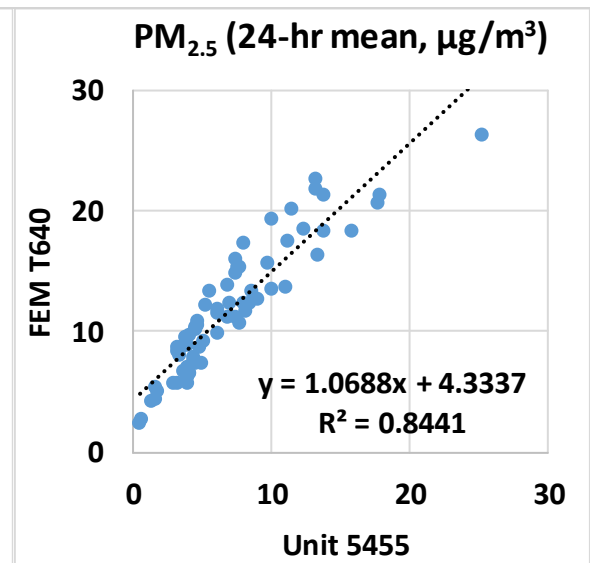
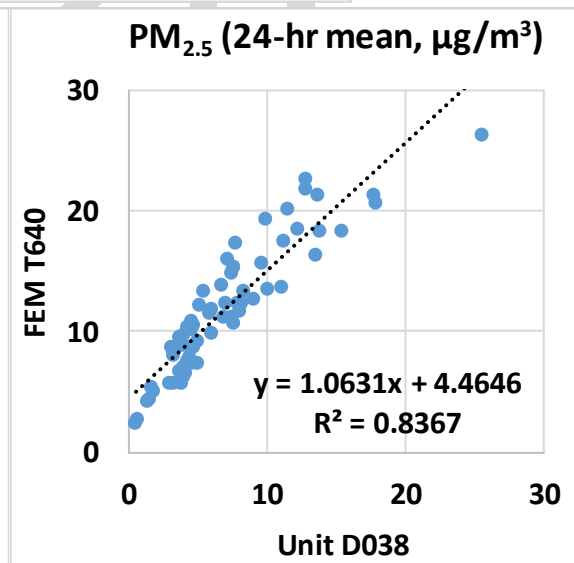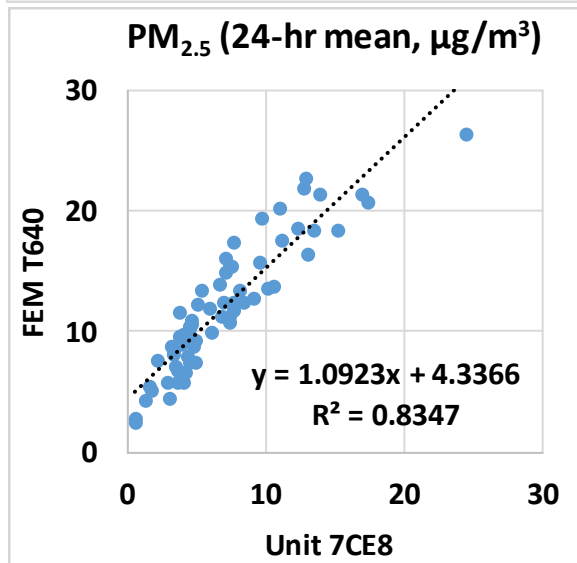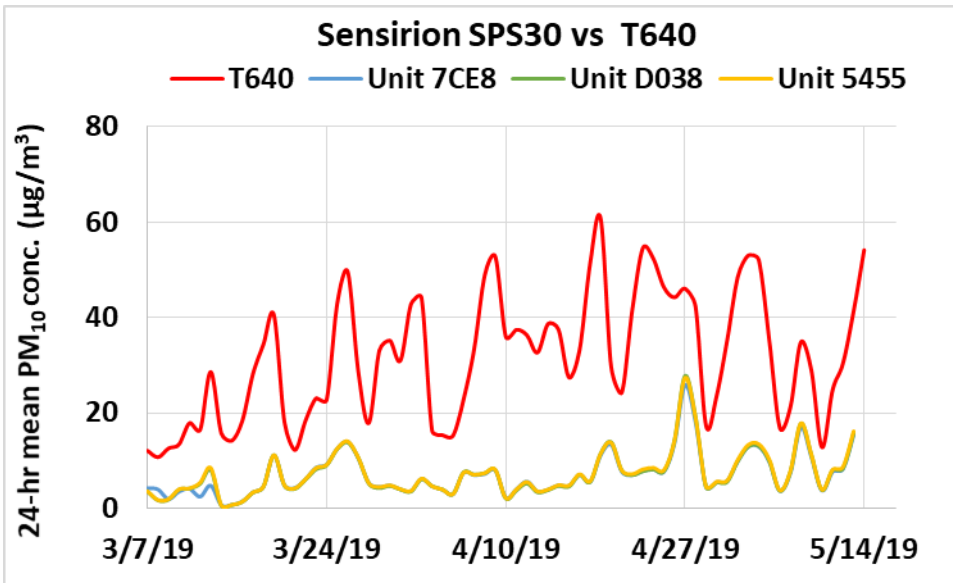# Sensirion SPS30 vs T640 (PM$_{10}$; 24-hr mean)

- Sensirion SPS30 sensors showed very weak correlations with the corresponding T640 data ($R^2 \sim 0.29$)
- Overall, the Sensirion SPS30 sensors underestimated the PM$_{10}$ mass concentrations measured by T640
- The Sensirion SPS30 sensors seemed to moderately track the PM$_{10}$ diurnal variations as recorded by T640

PM$_{10}$ (24-hr mean, µg/m³)

$y = 1.5919x + 20.122$
$R^2 = 0.2964$

PM$_{10}$ (24-hr mean, µg/m³)

$y = 1.4737x + 20.802$
$R^2 = 0.2823$

PM$_{10}$ (24-hr mean, µg/m³)

$y = 1.5063x + 20.387$
$R^2 = 0.2924$
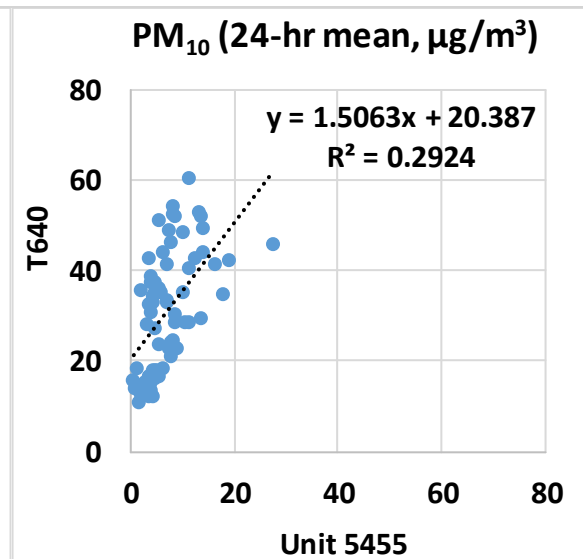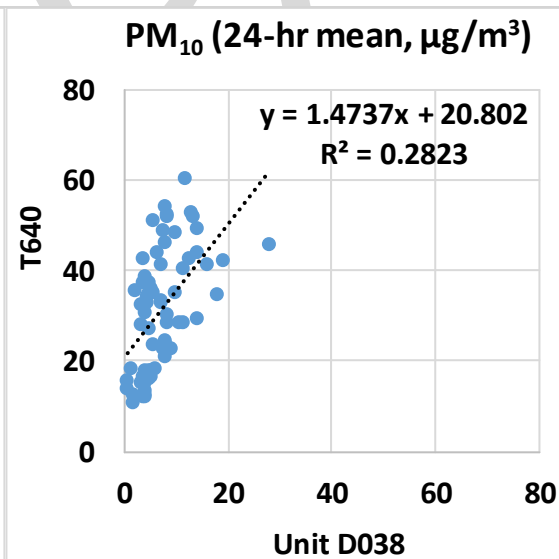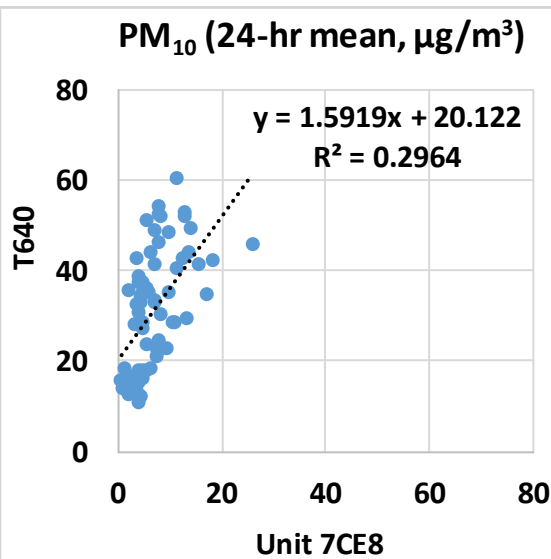
Discussion

- The three **Sensirion SPS30** sensors' data recovery from all units was ~ 100% for all PM measurements

- The three sensors showed very low intra-model variability (~ 1%, 1.3 and 2.4% for $PM_{1.0}$, $PM_{2.5}$ and PM_{10} mass conc. measurements, respectively)

- The reference instruments (GRIMM, BAM and T640) showed strong correlations with each other for both $PM_{2.5}$ (R^2 ~ 0.78) and PM_{10} (R^2 ~ 0.79) mass concentration measurements (1-hr mean)

- $PM_{1.0}$ mass concentration measurements measured by Sensirion SPS30 sensors showed very strong correlations with the corresponding GRIMM data (R^2 ~ 0.91, 1-hr mean) and overestimated $PM_{1.0}$ mass concentrations measured by GRIMM

- $PM_{2.5}$ mass concentration measurements measured by Sensirion SPS30 sensors showed moderate to strong correlations with the corresponding FEM GRIMM, FEM BAM and FEM T640 data (R^2 ~ 0.83, 0.64 and 0.84, respectively, 1-hr mean). The sensors overestimated $PM_{2.5}$ mass concentrations measured by FEM GRIMM and FEM BAM and underestimated $PM_{2.5}$ mass concentrations measured by FEM T640

- PM_{10} mass concentration measurements measured by Sensirion SPS30 sensors showed very weak correlations with the corresponding GRIMM, FEM BAM and T640 data (R^2 ~ 0.12, 0.11 and 0.25, respectively; 1-hr mean) and underestimated PM_{10} mass concentrations measured by GRIMM, FEM BAM andT640

- No sensor calibration was performed by South Coast AQMD Staff prior to the beginning of this test

- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors under known aerosol concentrations and controlled temperature and relative humidity conditions

- <u>All results are still preliminary</u>