

# Field Evaluation of AirThinx IAQ



# Background

- From 5/11/2018 to 7/10/2018, three **AirThinx IAQ** sensor units were deployed at our (SCAQMD) Rubidoux station and ran side-by-side with Federal Equivalent Method (FEM) instruments measuring the same pollutants
- **AirThinx IAQ (3 units tested):**
  - Particle sensor (**optical; non-FEM**) (model Plantower PMS5003)
  - Each sensor reports: PM<sub>1.0</sub>, PM<sub>2.5</sub> and PM<sub>10</sub> mass concentration (µg/m<sup>3</sup>)
  - Unit also carries CO<sub>2</sub> (ppm), CH<sub>2</sub>O (mg/m<sup>3</sup>), VOC (ppm), pressure (hPa), temperature (degree F), and relative humidity (%) sensors
  - **Unit cost: \$1000**
  - Time resolution: 1-min
  - Units IDs:
    - Unit 5797
    - Unit 6258
    - Unit 6772
- **MetOne BAM (reference method):**
  - Beta-attenuation monitor (**FEM PM<sub>2.5</sub>, FEM PM<sub>10</sub>**)
  - **Unit cost: ~\$20,000**
  - Time resolution: 1-hr
- **GRIMM (reference method):**
  - Optical Particle Counter (**FEM PM<sub>2.5</sub>**)
  - Uses proprietary algorithms to calculate total PM<sub>1.0</sub>, PM<sub>2.5</sub>, and PM<sub>10</sub> from particle number measurements
  - **Unit cost: ~\$25,000 and up**
  - Time resolution: 1-min
- **SCAQMD Meteorological Station:**
  - Measures temperature and relative humidity
  - **Unit cost: ~\$5,000**
  - Time resolution: 1-min

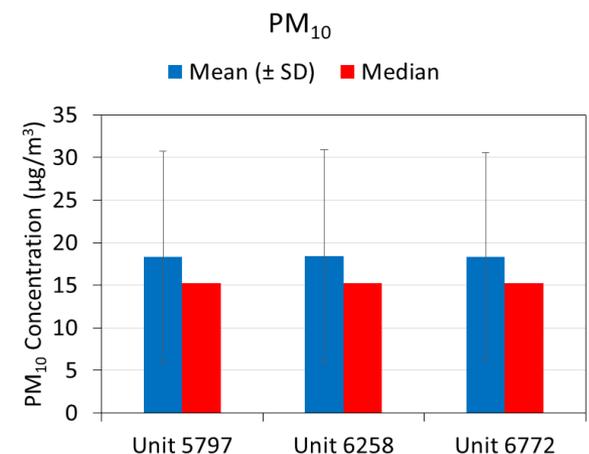
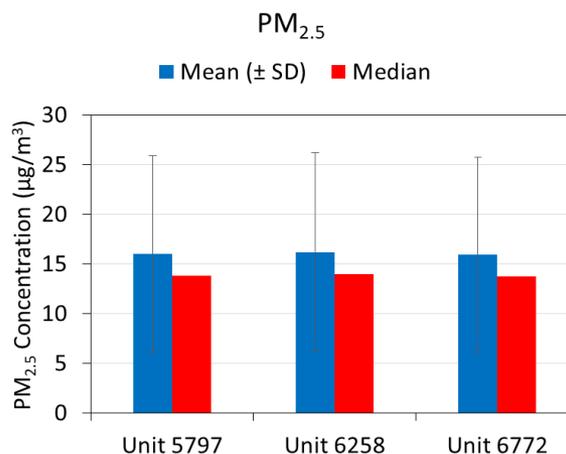
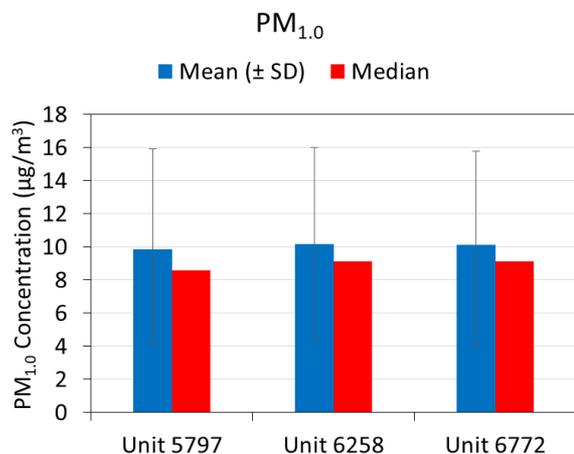


# Data validation & recovery

- 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 was near 100% for all three units tested.

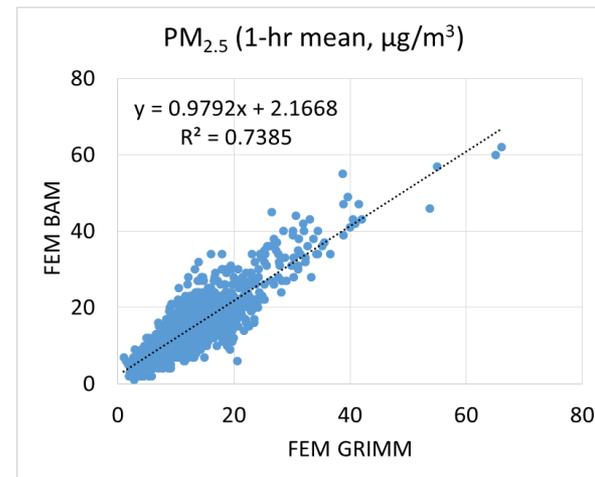
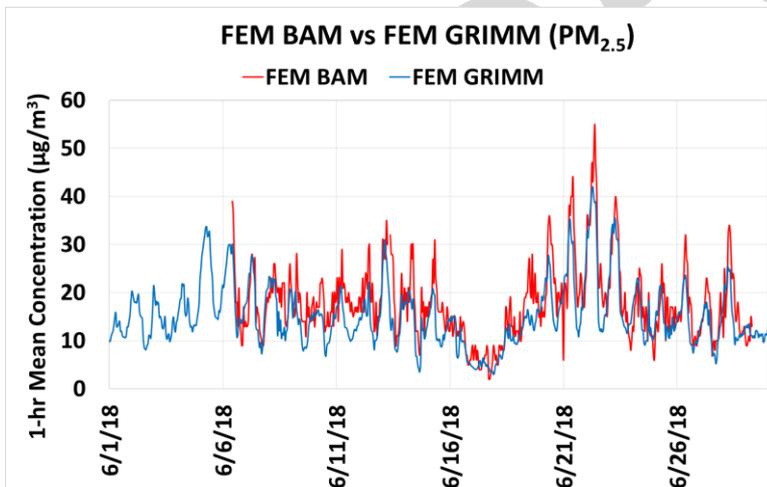
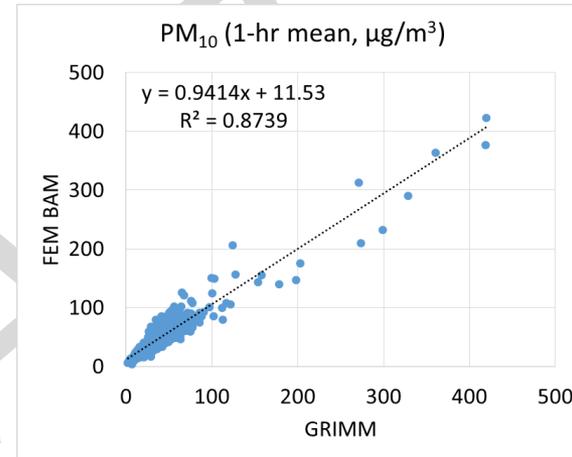
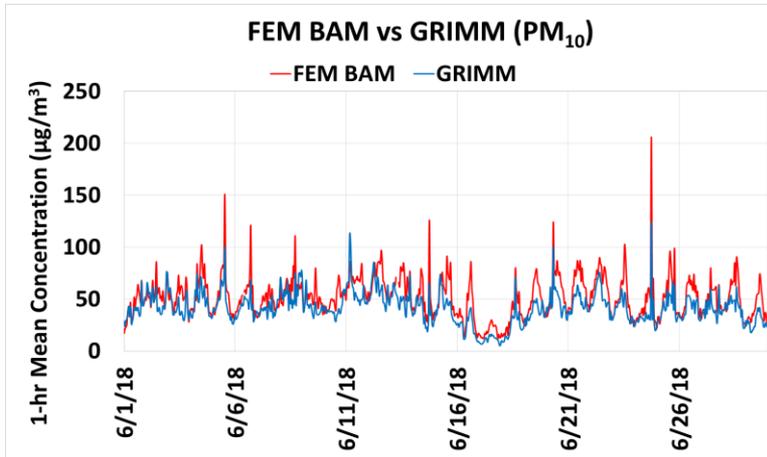
## AirThinx; intra-model variability

- Low intra-model variability was observed for the mass concentrations of  $PM_{1.0}$ ,  $PM_{2.5}$ , and  $PM_{10}$  from the three tested AirThinx units.

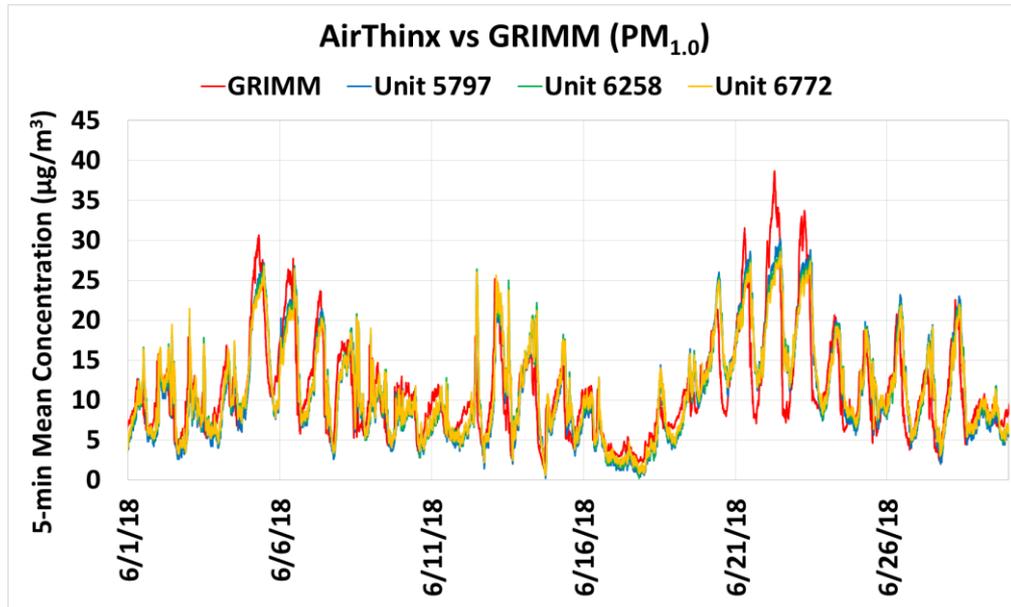


# Equivalent methods: BAM vs GRIMM

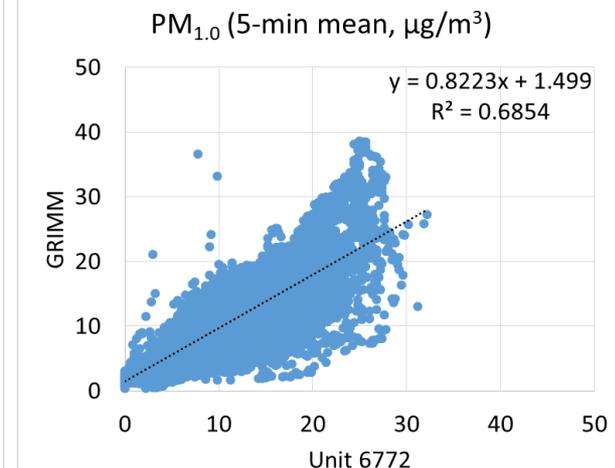
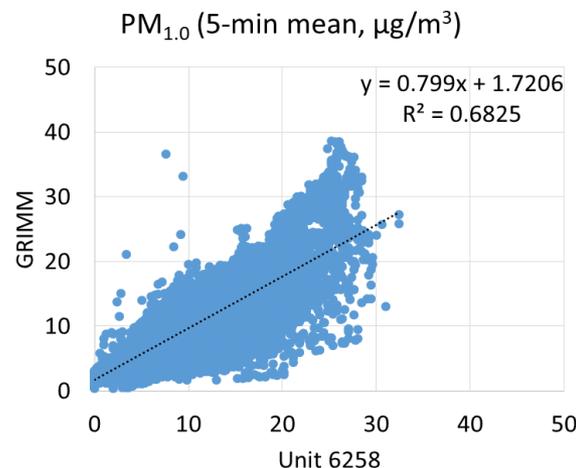
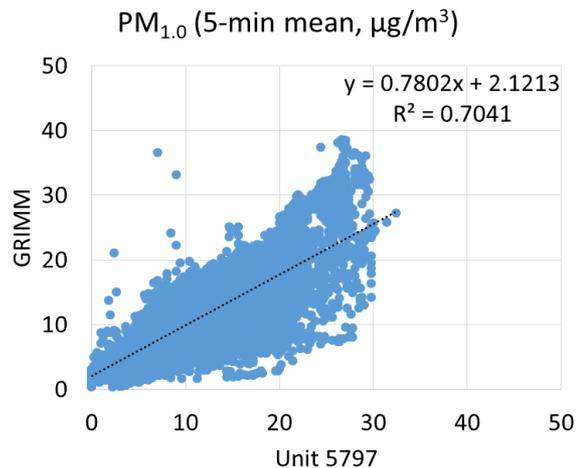
- Good correlation between the two equivalent methods for  $PM_{2.5}$  and  $PM_{10}$  measurements



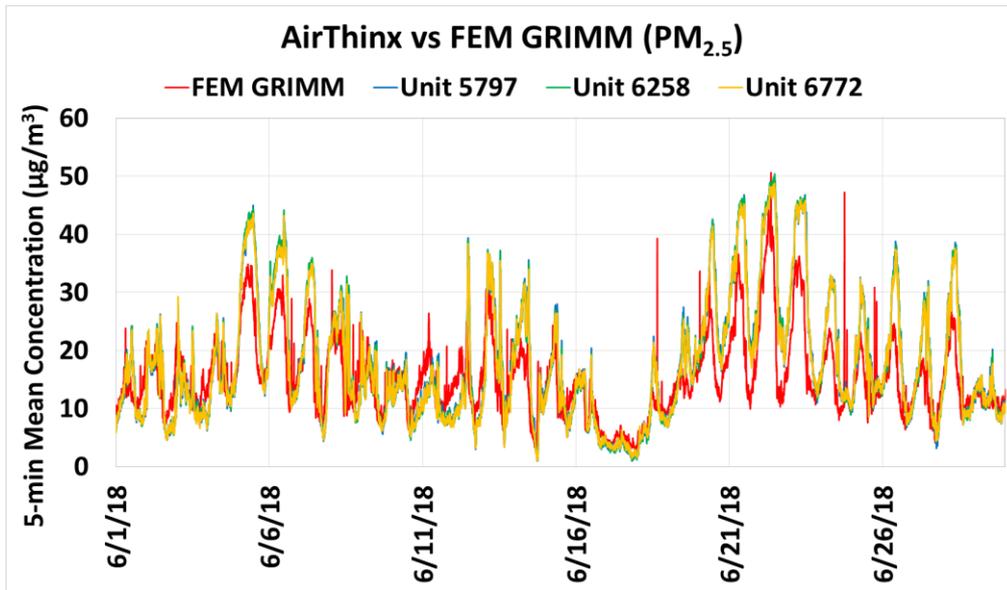
# AirThinx vs GRIMM (PM<sub>1.0</sub>; 5-min mean)



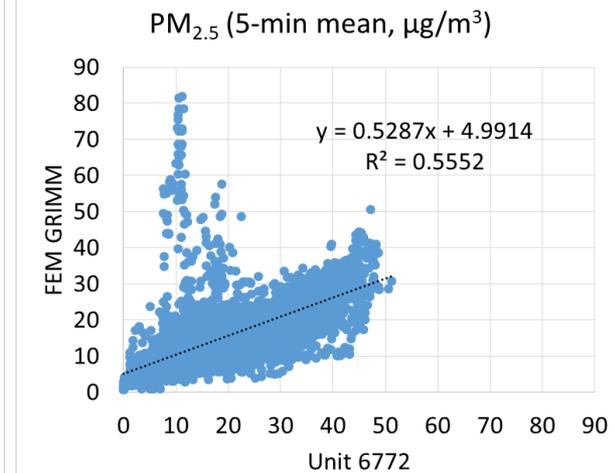
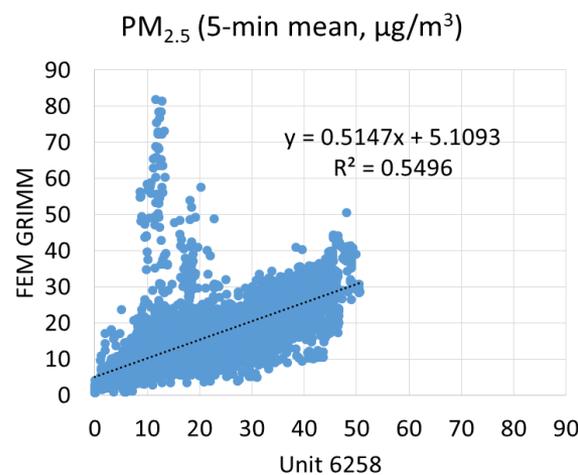
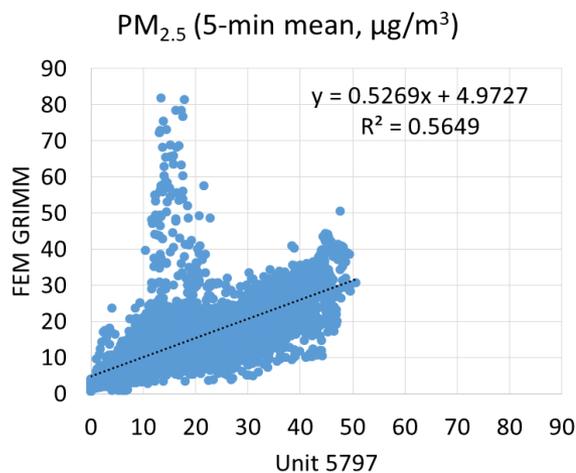
- PM<sub>1.0</sub> measurements from the three AirThinx sensors correlate well with the corresponding GRIMM data ( $0.68 < R^2 < 0.71$ ).
- The three sensor units tested seem to track well the diurnal PM<sub>1.0</sub> variations recorded by the GRIMM instrument.



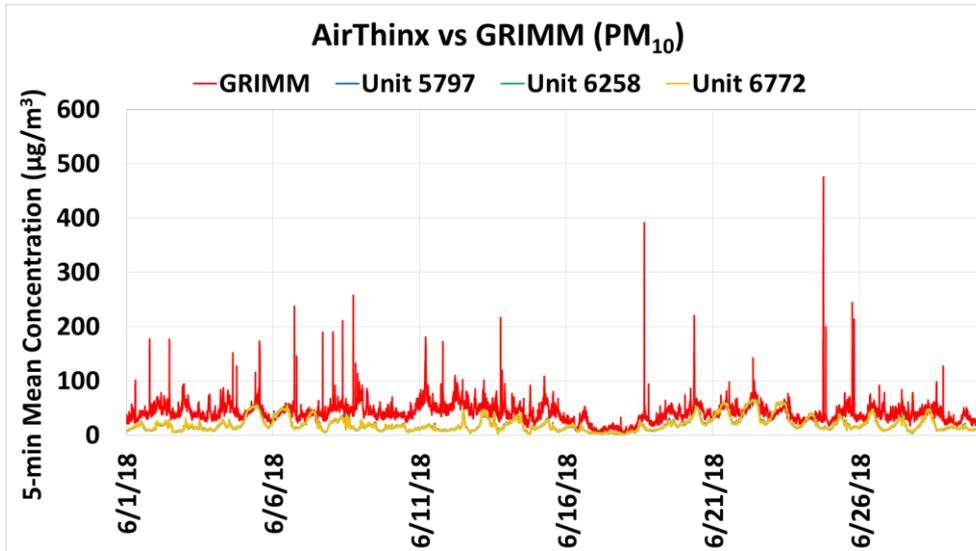
# AirThinx vs FEM GRIMM (PM<sub>2.5</sub>; 5-min mean)



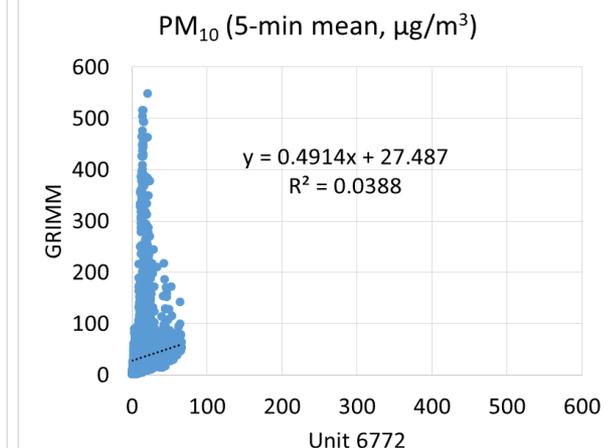
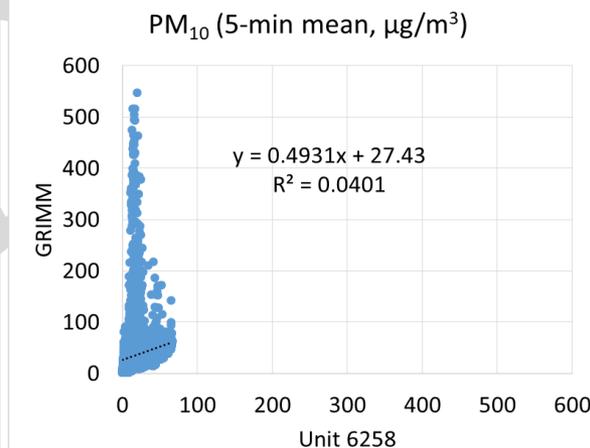
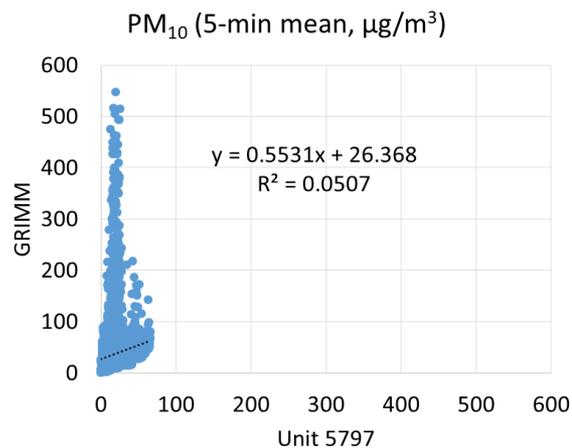
- AirThinx PM<sub>2.5</sub> measurements show moderate correlations with the corresponding FEM GRIMM PM<sub>2.5</sub> mass concentrations ( $0.54 < R^2 < 0.57$ ).
- AirThinx measurements seem to track the PM<sub>2.5</sub> diurnal variations recorded by the FEM instrument.



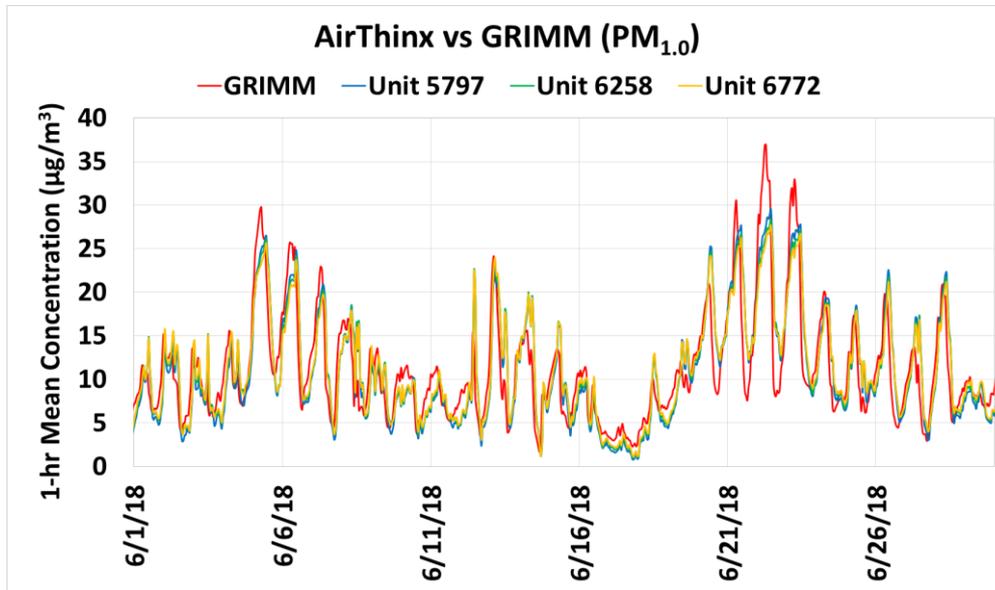
# AirThinx vs GRIMM (PM<sub>10</sub>; 5-min mean)



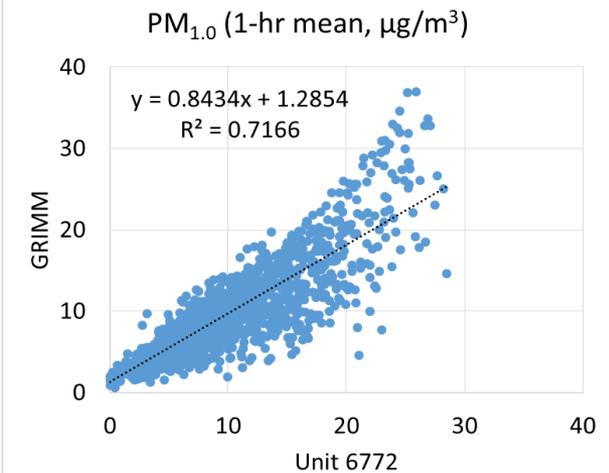
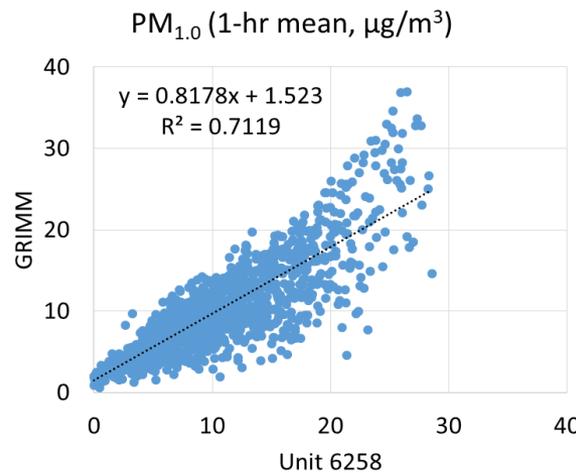
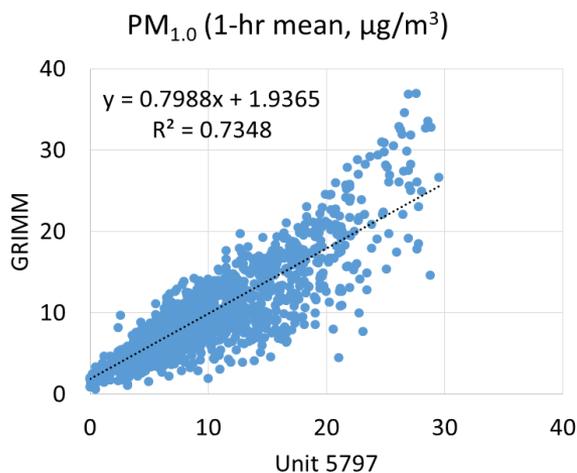
- PM<sub>10</sub> measurements from the three AirThinx sensors do not correlate with the corresponding GRIMM data.
- The three sensor units tested seem to track the diurnal PM<sub>10</sub> variations recorded by the GRIMM instrument well.
- The sensors PM<sub>10</sub> measurements largely underestimate the corresponding GRIMM data.



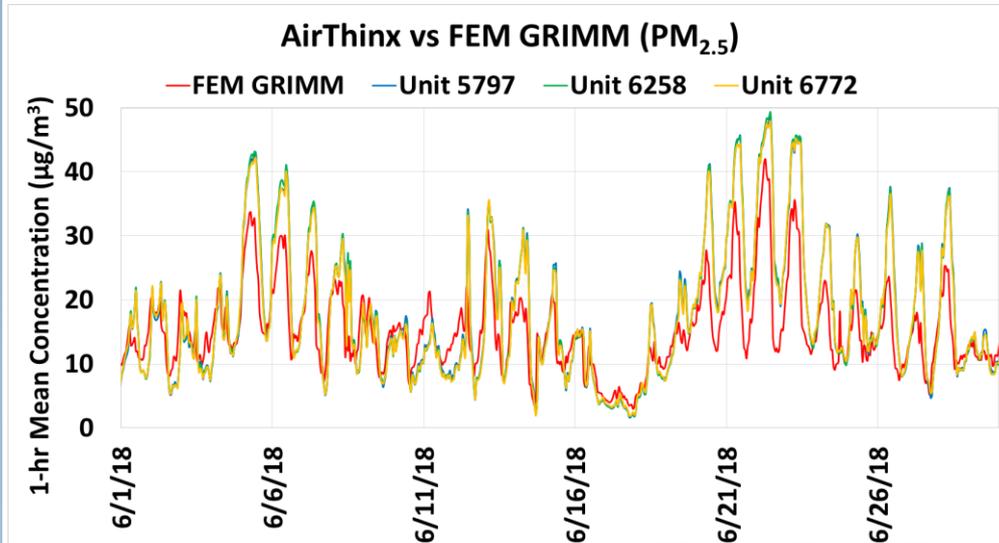
# AirThinx vs GRIMM (PM<sub>1.0</sub>; 1-hr mean)



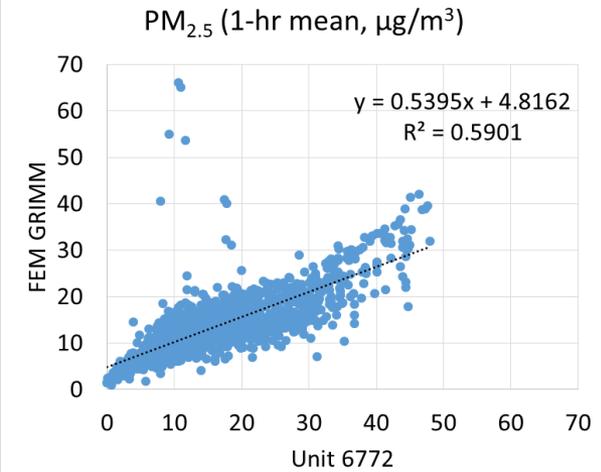
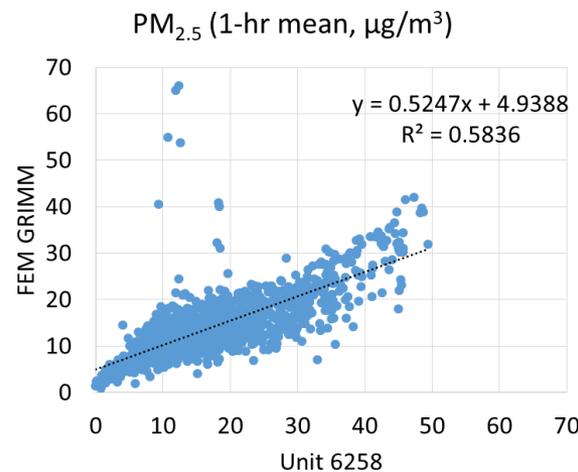
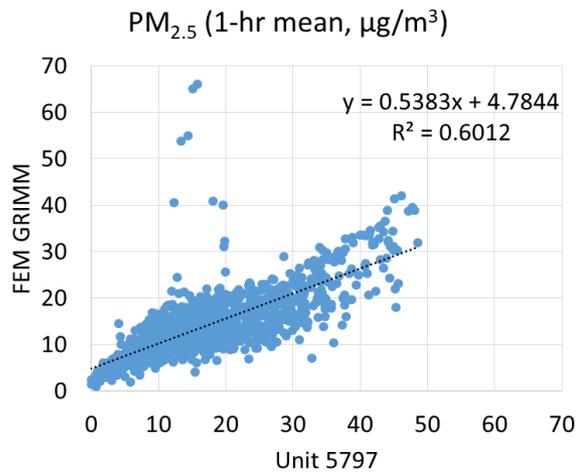
- AirThinx PM<sub>1.0</sub> measurements correlate well with the corresponding GRIMM PM<sub>1.0</sub> mass concentrations ( $0.71 < R^2 < 0.74$ ).
- The three sensor units tested track well the diurnal PM<sub>1.0</sub> variations recorded by the GRIMM instrument.



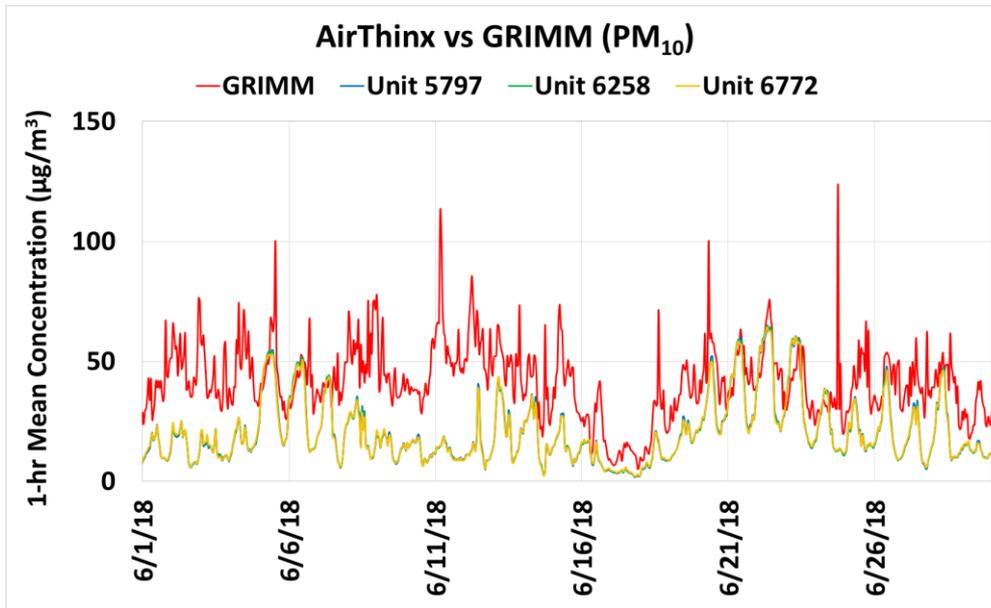
# AirThinx vs FEM GRIMM (PM<sub>2.5</sub>; 1-hr mean)



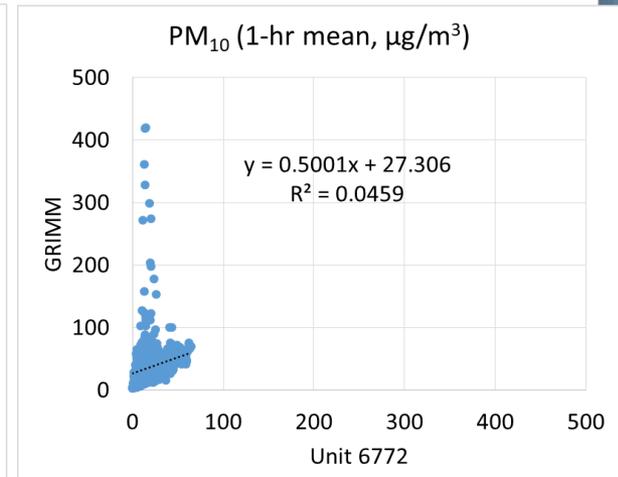
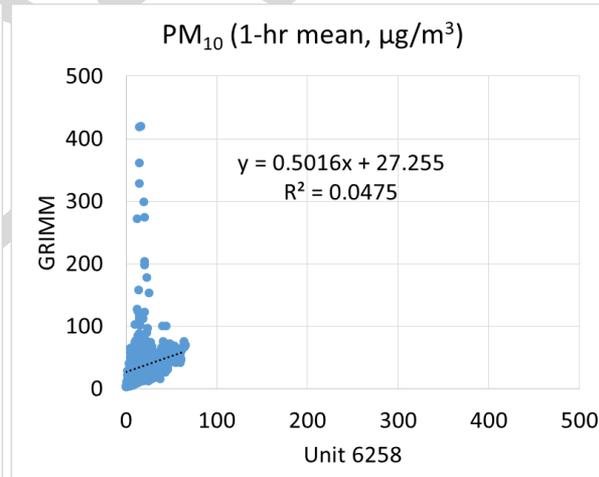
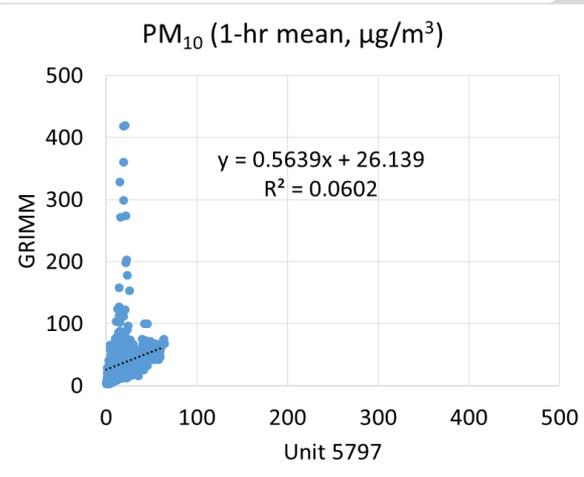
- PM<sub>2.5</sub> measurements from AirThinx sensors correlate moderately with the corresponding FEM GRIMM data ( $0.58 < R^2 < 0.61$ )
- The three sensor units tested seem to track well the diurnal PM<sub>2.5</sub> variations recorded by the FEM GRIMM instrument.



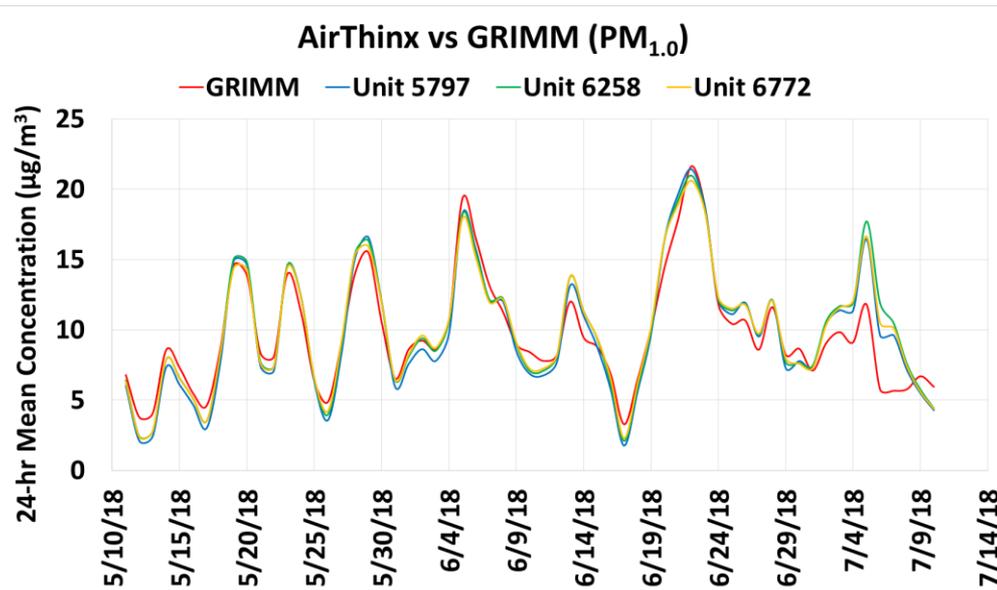
# AirThinx vs GRIMM (PM<sub>10</sub>; 1-hr mean)



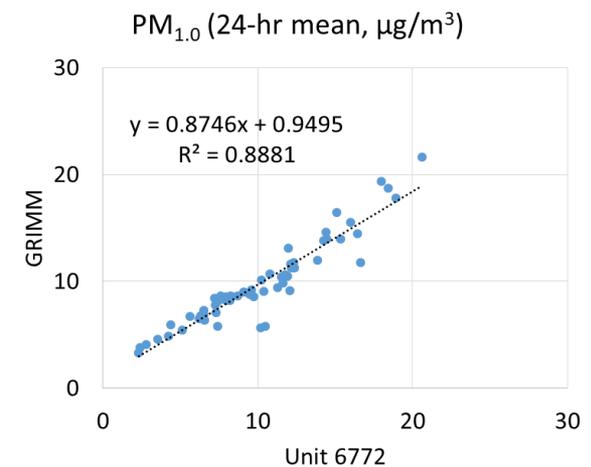
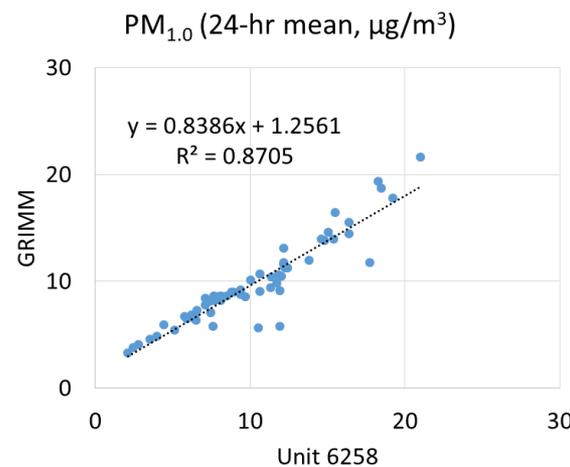
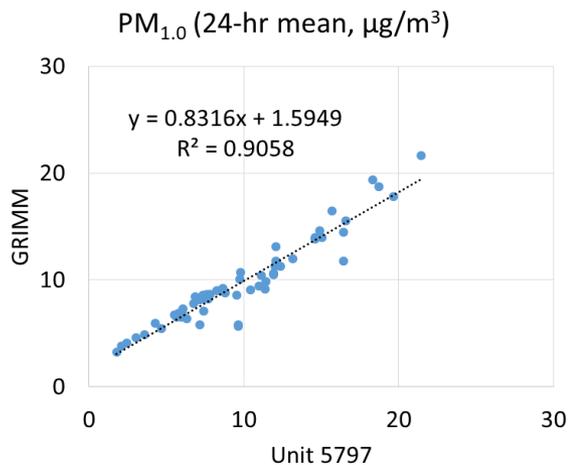
- AirThinx PM<sub>10</sub> measurements do not correlate with the corresponding GRIMM PM<sub>10</sub> mass concentrations.
- The three sensor units tested seem to track well the diurnal PM<sub>10</sub> variations recorded by the GRIMM instrument.
- The sensors PM<sub>10</sub> measurements largely underestimate the corresponding GRIMM data.



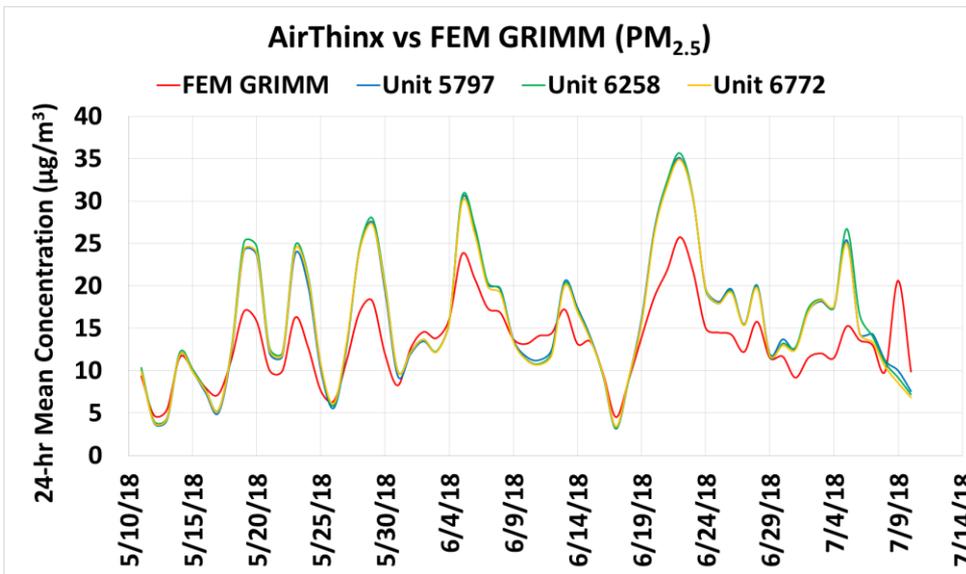
# AirThinx vs GRIMM (PM<sub>1.0</sub>; 24-hr mean)



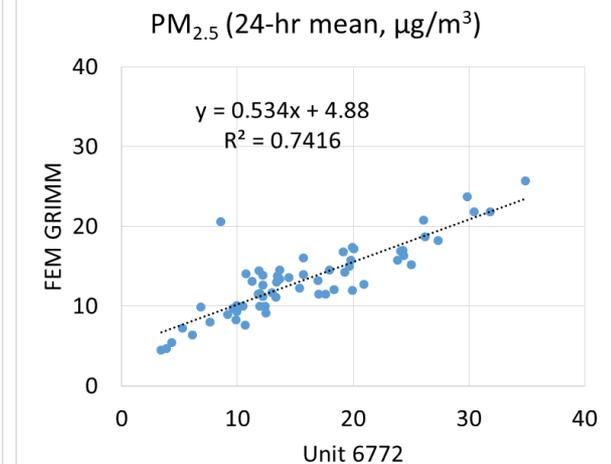
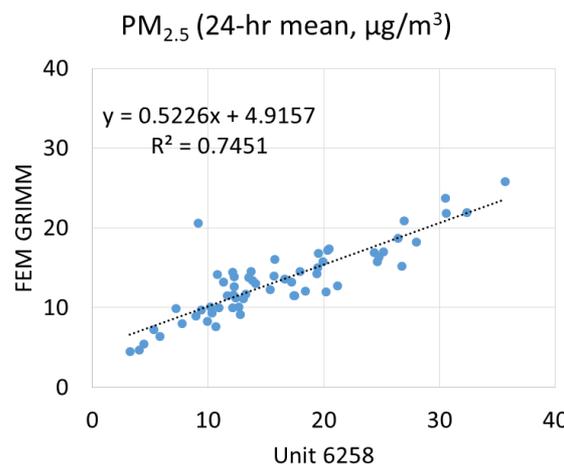
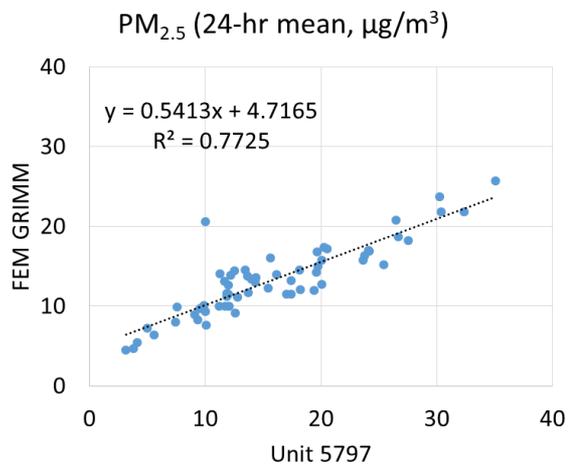
- AirThinx PM<sub>1.0</sub> measurements correlate well with the corresponding 24-hr mean GRIMM PM<sub>1.0</sub> mass concentrations ( $0.87 < R^2 < 0.91$ ).
- The three sensor units tested seem to track well the daily PM<sub>1.0</sub> variations recorded by the GRIMM instrument.



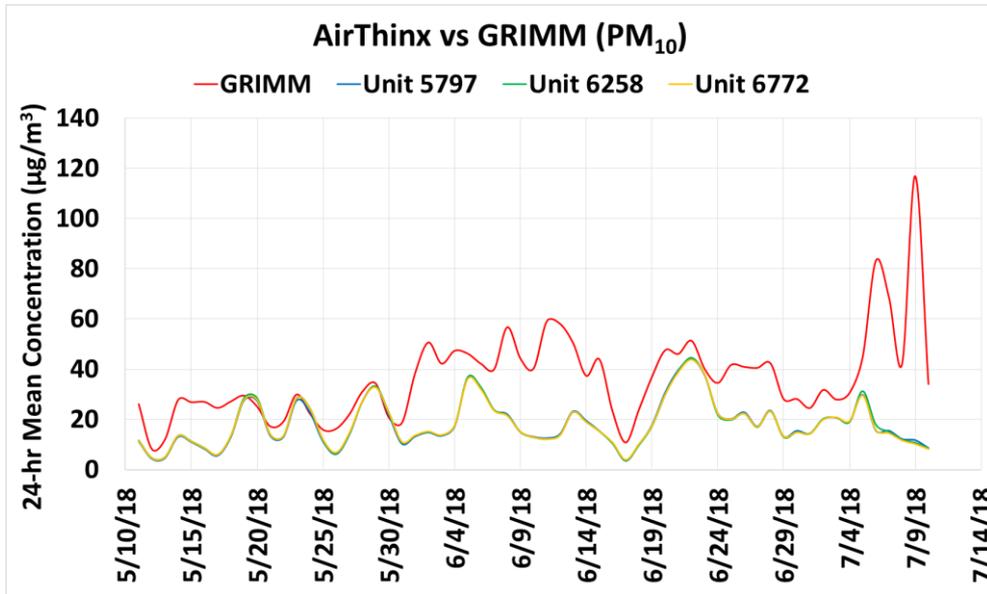
# AirThinx vs FEM GRIMM (PM<sub>2.5</sub>; 24-hr mean)



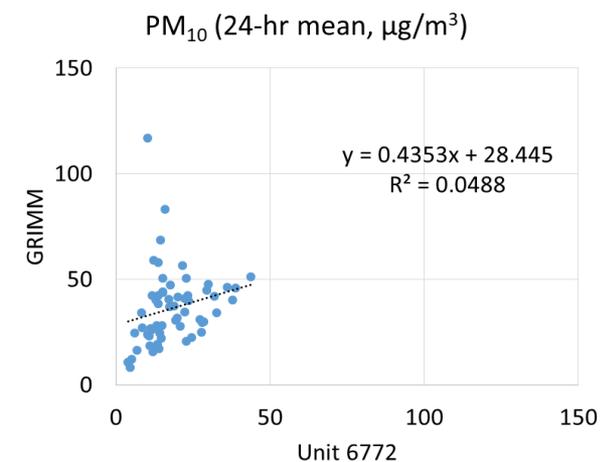
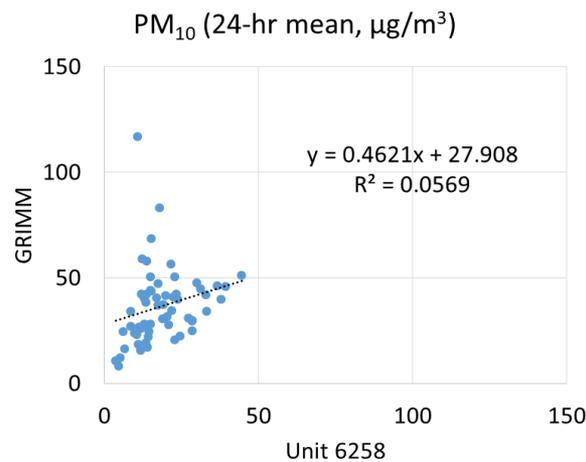
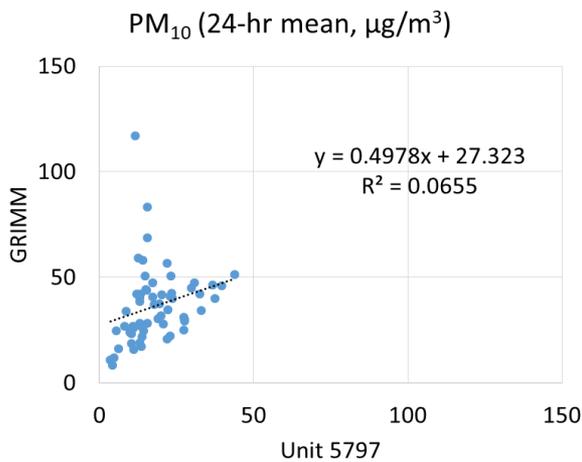
- AirThinx PM<sub>2.5</sub> measurements correlate well with the corresponding FEM GRIMM PM<sub>2.5</sub> mass concentrations ( $0.74 < R^2 < 0.78$ ).
- The three sensor units tested seem to track well the daily PM<sub>2.5</sub> variations recorded by the FEM GRIMM instrument.



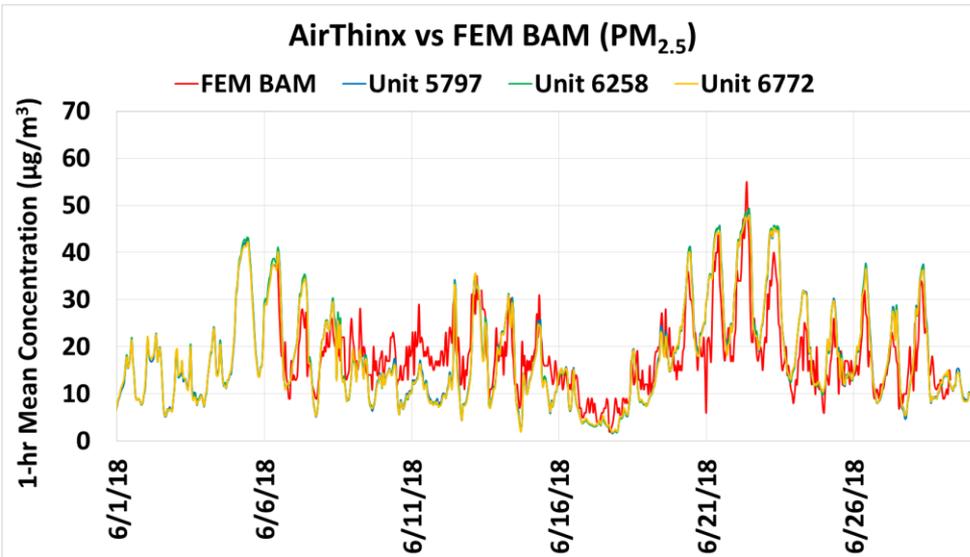
# AirThinx vs GRIMM (PM<sub>10</sub>; 24-hr mean)



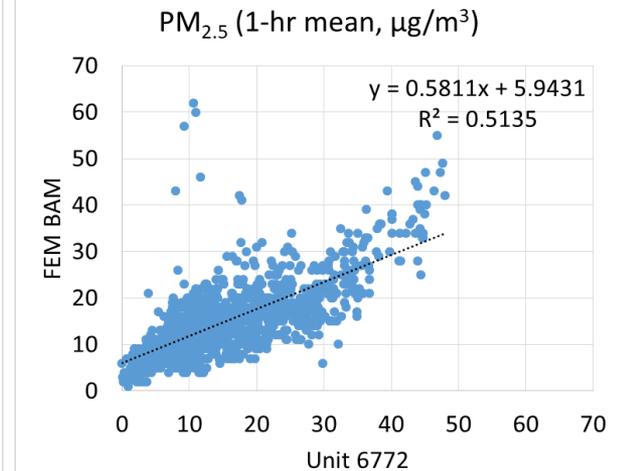
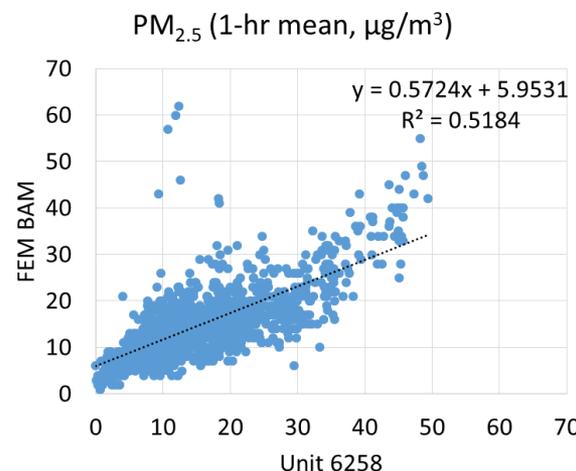
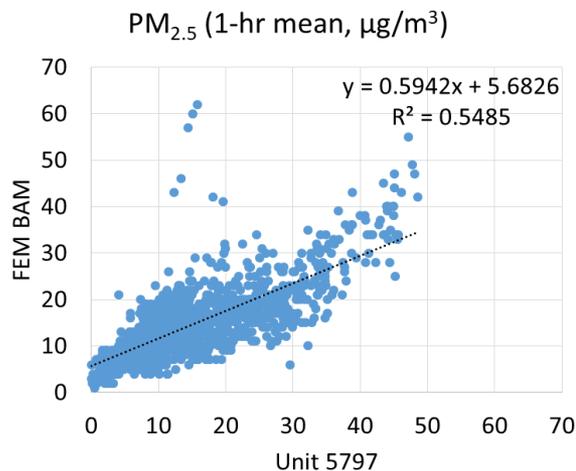
- AirThinx PM<sub>10</sub> measurements do not correlate with the corresponding GRIMM PM<sub>10</sub> mass concentrations ( $R^2 < 0.1$ ).
- The sensors PM<sub>10</sub> measurements largely underestimate the corresponding GRIMM data.



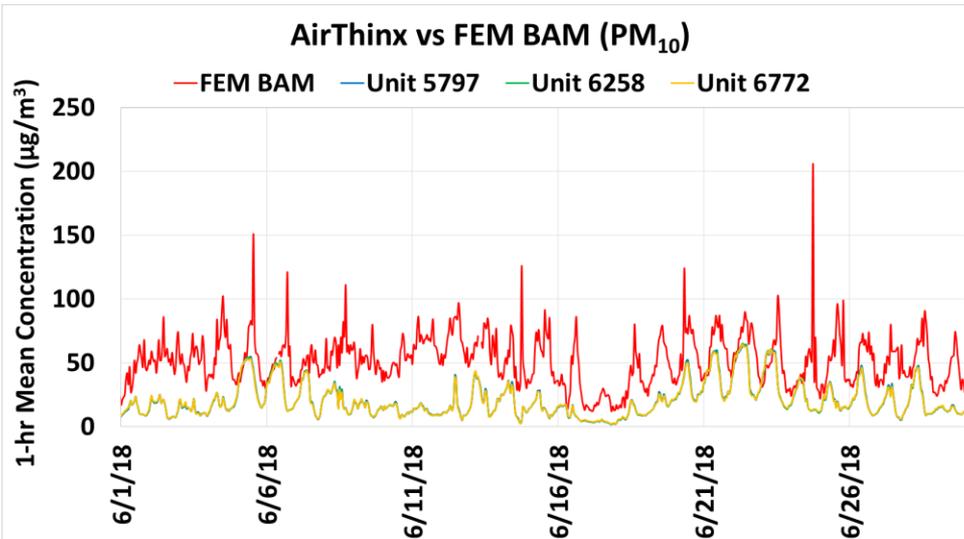
# AirThinx vs FEM BAM (PM<sub>2.5</sub>; 1-hr mean)



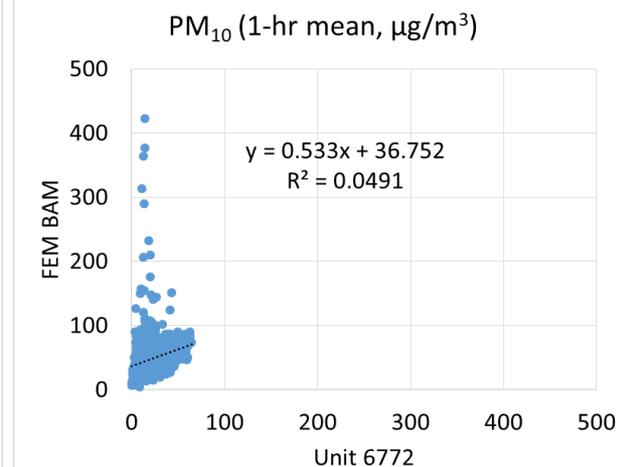
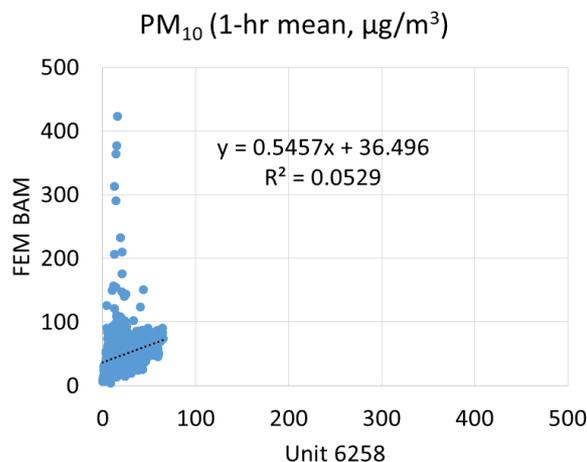
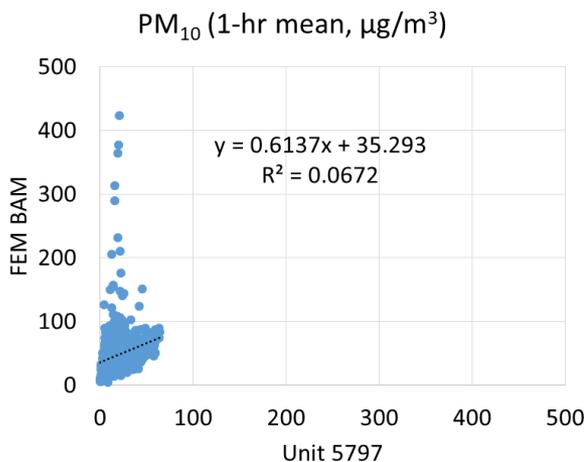
- AirThinx PM<sub>2.5</sub> measurements correlate moderately with the corresponding FEM BAM PM<sub>2.5</sub> mass concentrations ( $0.51 < R^2 < 0.55$ ).
- The three sensor units tested seem to track well the diurnal PM<sub>2.5</sub> variations recorded by the FEM BAM instrument.



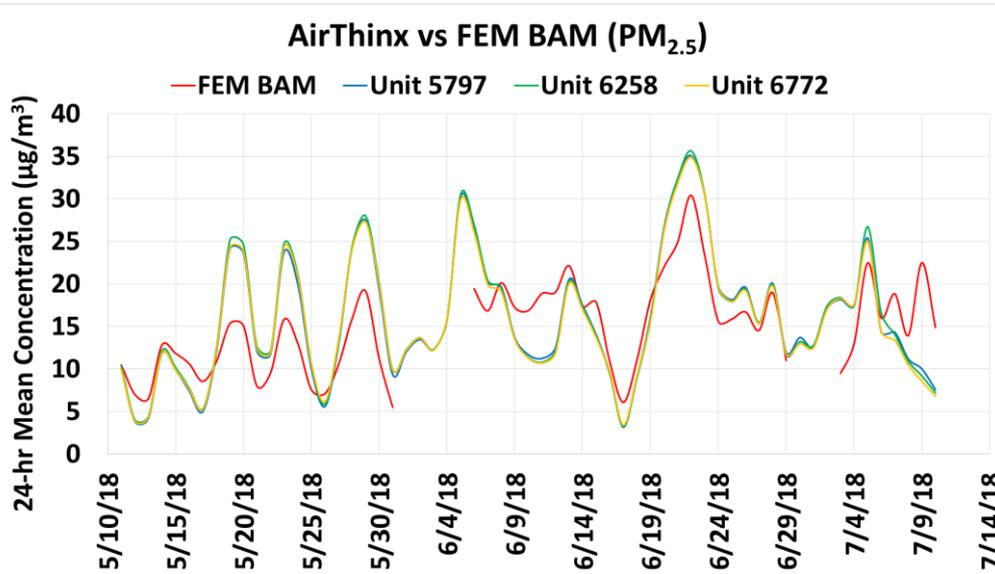
# AirThinx vs FEM BAM (PM<sub>10</sub>; 1-hr mean)



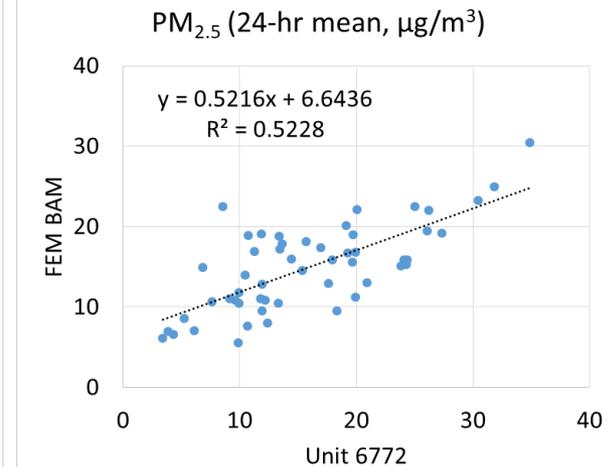
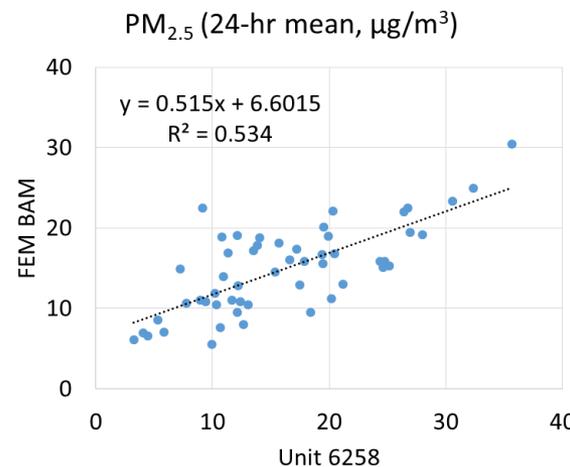
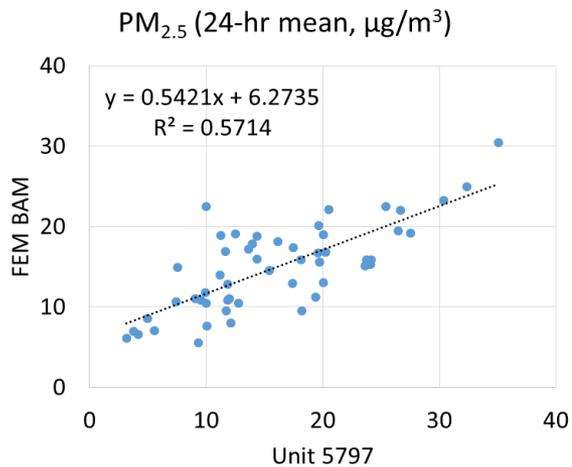
- PM<sub>10</sub> measurements from AirThinx sensors do not correlate with the corresponding FEM BAM PM<sub>10</sub> data ( $0.04 < R^2 < 0.07$ ).
- The tested sensors seem to track the diurnal PM<sub>10</sub> variations recorded by the FEM BAM instrument.
- All AirThinx sensors largely underestimate the corresponding FEM PM<sub>10</sub> measurements.



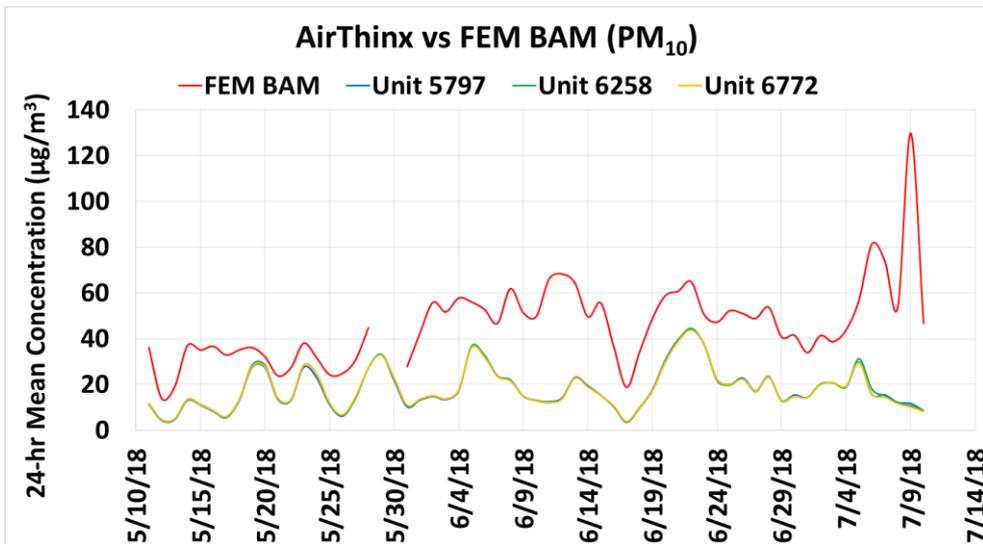
# AirThinx vs FEM BAM (PM<sub>2.5</sub>; 24-hr mean)



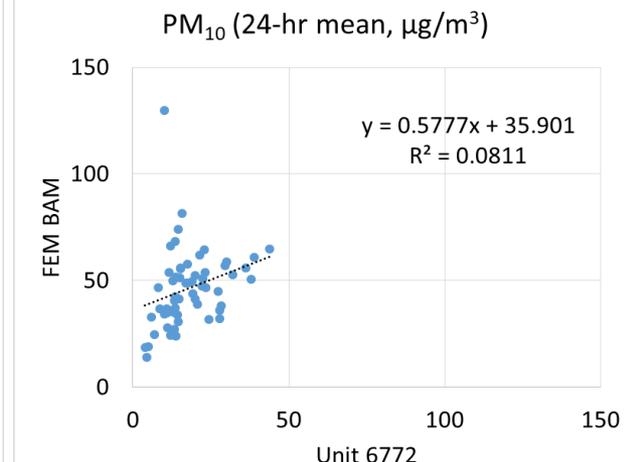
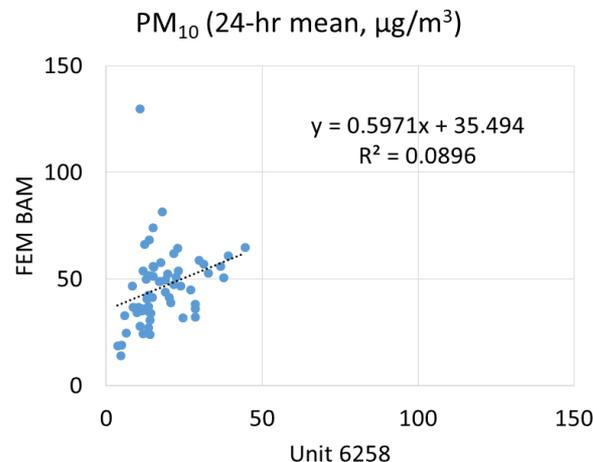
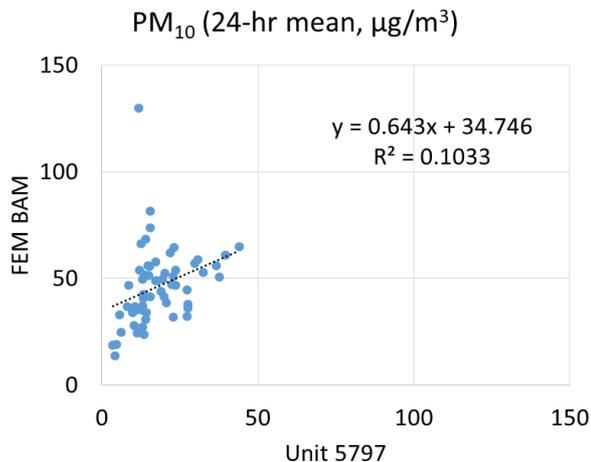
- AirThinx PM<sub>2.5</sub> measurements correlate moderately with the corresponding FEM BAM PM<sub>2.5</sub> mass concentrations data ( $0.52 < R^2 < 0.58$ ).
- The three sensor units track well the daily PM<sub>2.5</sub> variations recorded by the FEM BAM instrument.



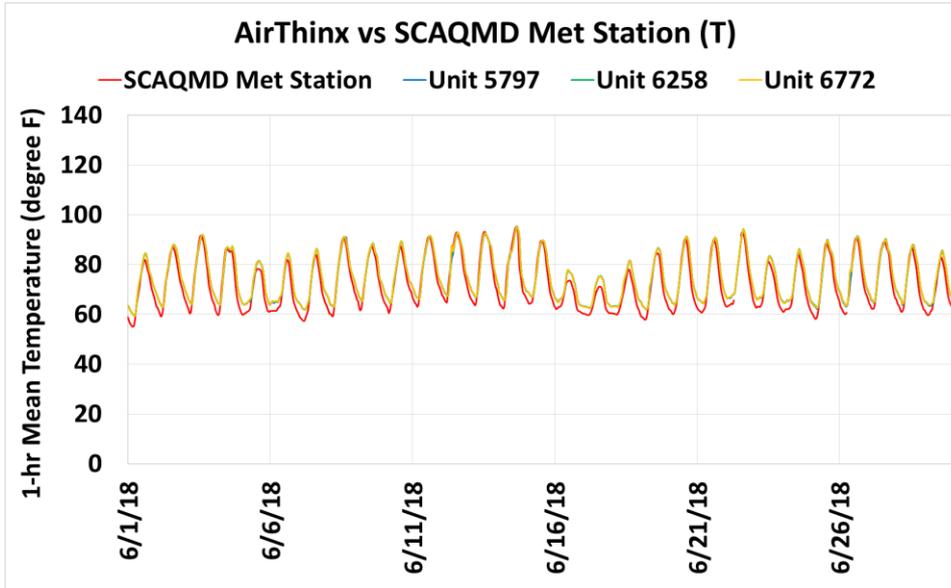
# AirThinx vs FEM BAM (PM<sub>10</sub>; 24-hr mean)



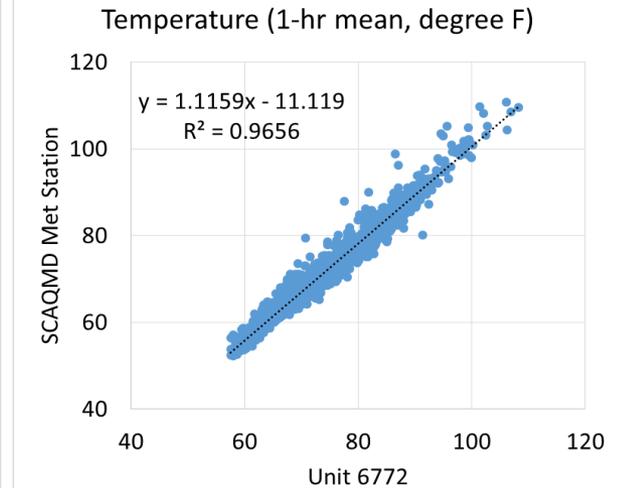
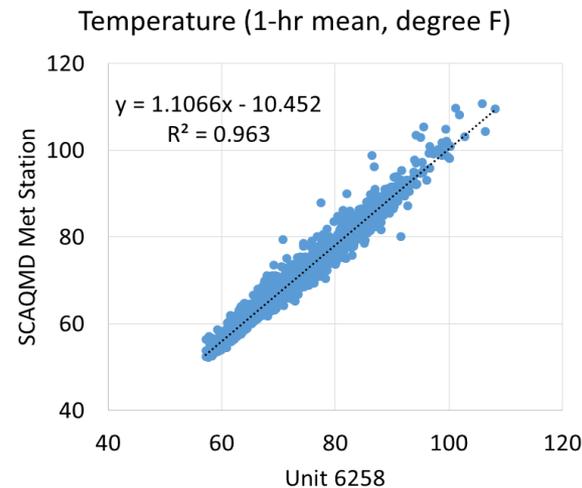
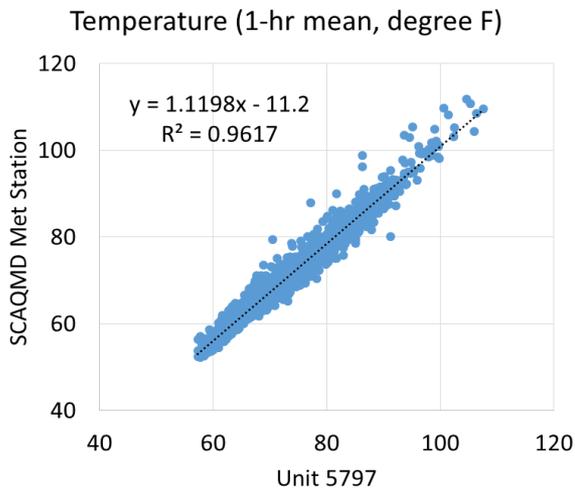
- PM<sub>10</sub> measurements by AirThinx sensors do not correlate with the corresponding FEM BAM PM<sub>10</sub> data ( $0.08 < R^2 < 0.11$ ).
- AirThinx sensors seem to track the daily PM<sub>10</sub> variations recorded by the FEM BAM instrument.



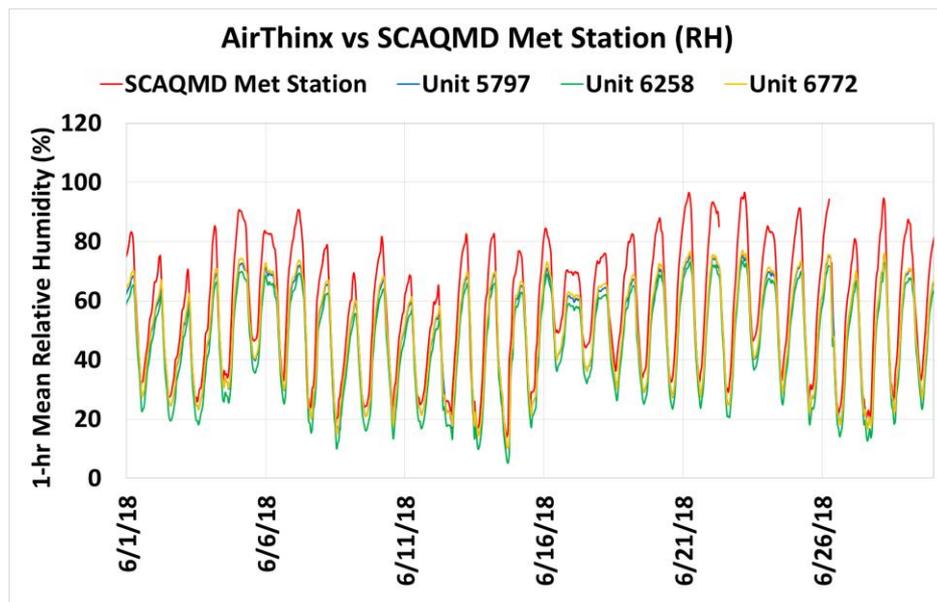
# AirThinx vs SCAQMD Met Station (Temperature; 1-hr mean)



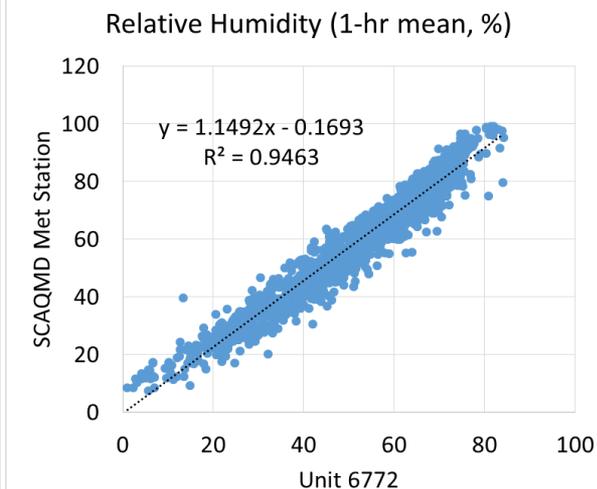
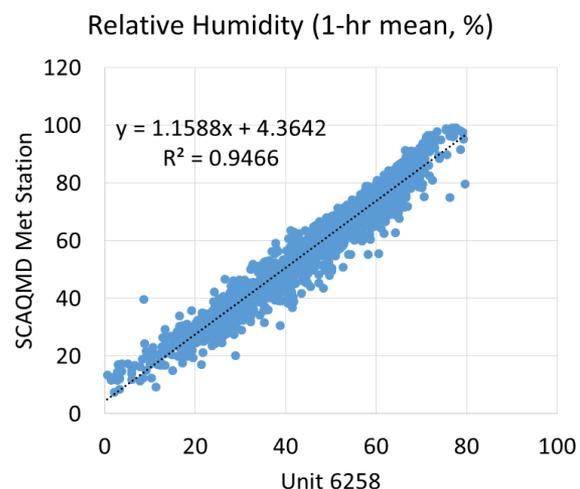
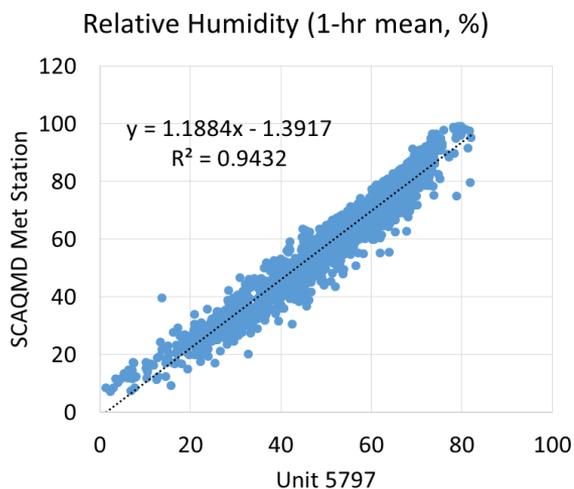
- Temperature measurements from all three AirThinx sensors correlate well with the corresponding reference data ( $R^2 > 0.96$ ), but they slightly overestimate the ambient temperature as measured by SCAQMD met station.
- The three sensor units track well the diurnal variations of ambient temperature as measured by the SCAQMD met station.



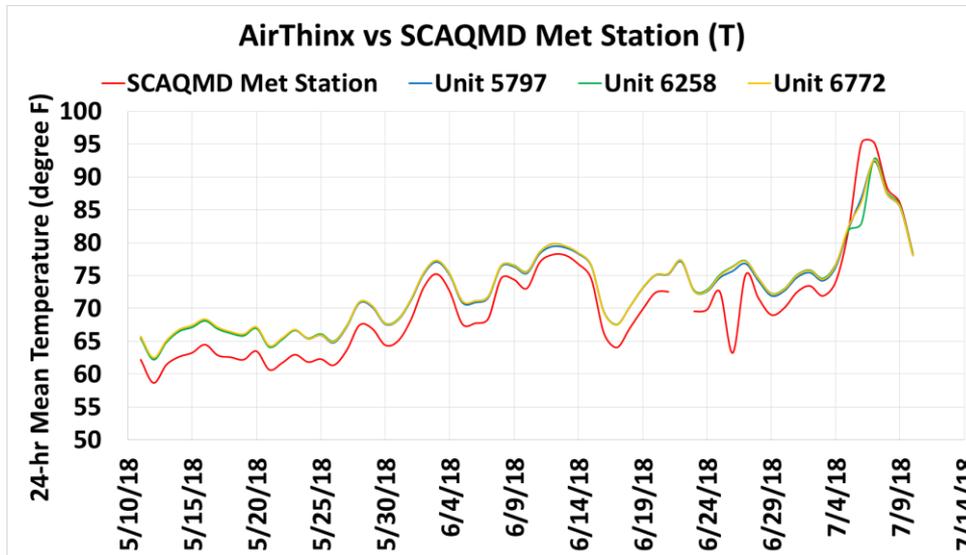
# AirThinx vs SCAQMD Met Station (Relative Humidity; 1-hr mean)



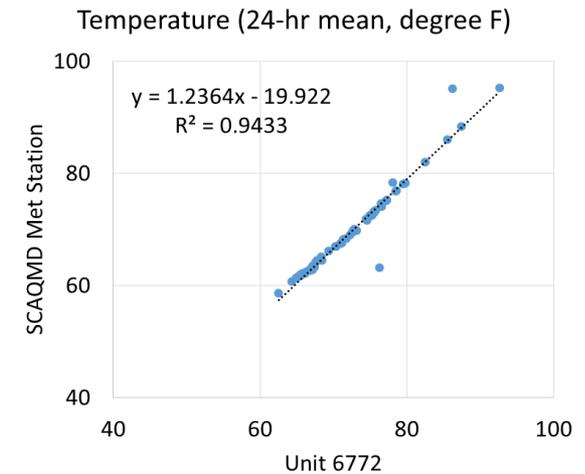
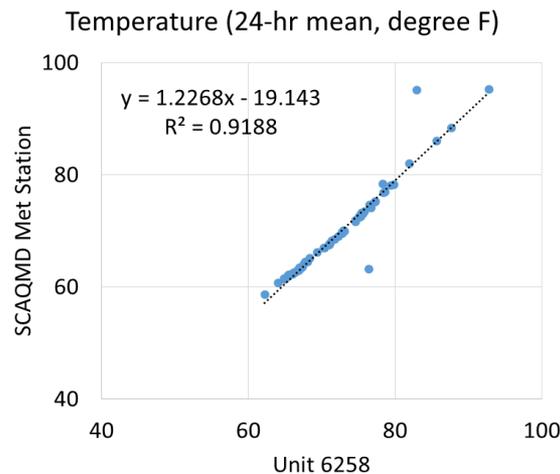
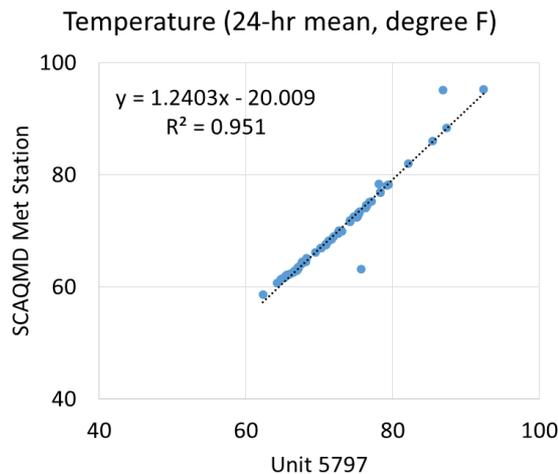
- AirThinx sensors Relative Humidity (RH) measurements correlate well with the corresponding SCAQMD met station data ( $R^2 > 0.94$ )
- AirThinx sensors track well the diurnal variations of ambient RH as measured by the SCAQMD met station.



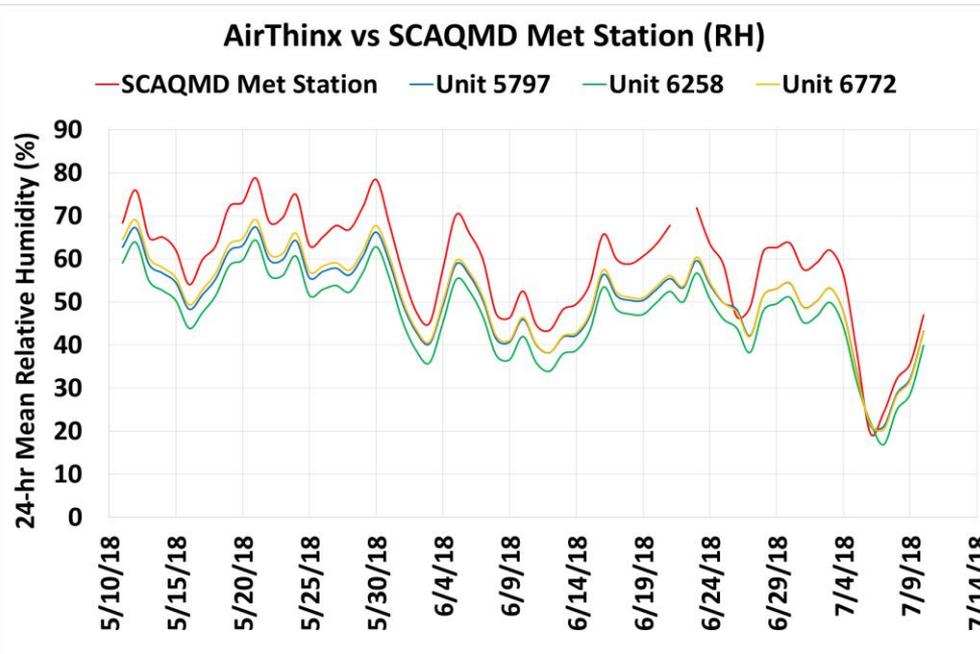
# AirThinx vs SCAQMD Met Station (Temperature; 24-hr mean)



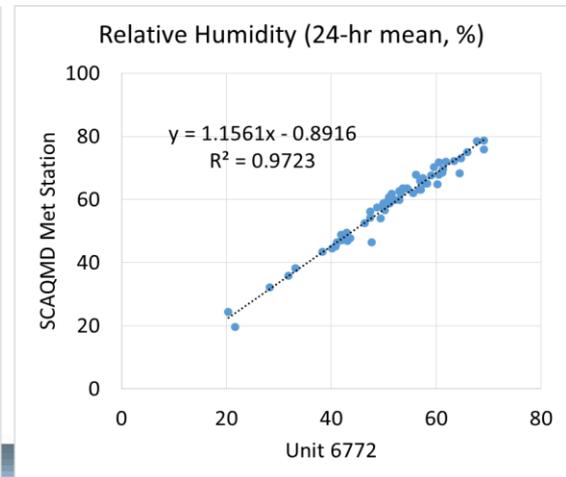
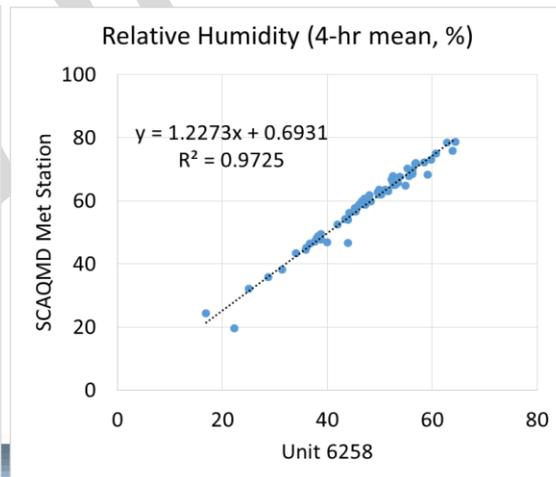
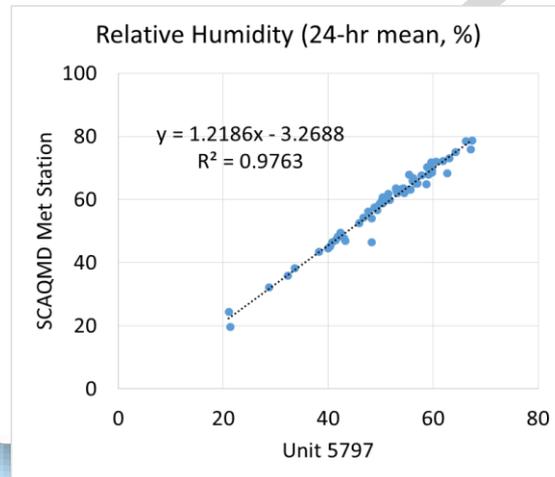
- Temperature measurements from all three AirThinx sensors correlate well with the corresponding reference data ( $R^2 > 0.91$ ), but they slightly overestimate the SCAQMD's met station measured temperature.
- The three sensor units track well the daily variations of ambient temperature as measured by the SCAQMD met station.



# AirThinx vs SCAQMD Met Station (Relative Humidity; 24-hr mean)



- AirThinx sensors Relative Humidity (RH) measurements correlate well with the corresponding SCAQMD met station data ( $R^2 > 0.97$ ).
- AirThinx sensor units seem to slightly underestimate the SCAQMD met station data.
- AirThinx sensors track well the daily variations of ambient RH as measured by the SCAQMD met station.



# Discussion

- Overall, the **AirThinx** sensor units were reliable with high data recovery (~100%)
- The three units tested showed low intra-model variability for the mass concentrations of PM<sub>1.0</sub>, PM<sub>2.5</sub>, and PM<sub>10</sub>
- AirThinx PM<sub>1.0</sub> data correlated well ( $0.68 < R^2 < 0.71$ ) with the corresponding 5-min values collected using substantially more expensive particle instrument (GRIMM)
- AirThinx PM<sub>2.5</sub> mass concentrations showed moderate correlations ( $0.54 < R^2 < 0.57$ ) with 5-min FEM GRIMM PM<sub>2.5</sub> mass measurements
- AirThinx PM<sub>10</sub> mass concentrations did not correlate ( $R^2 < 0.06$ ) with the GRIMM PM<sub>10</sub> mass measurements
- Comparison of AirThinx to FEM BAM showed moderate correlation for PM<sub>2.5</sub> ( $0.51 < R^2 < 0.55$ ) but did not correlate for PM<sub>10</sub> ( $0.04 < R^2 < 0.07$ )
- AirThinx PM<sub>2.5</sub> data was usually overestimated, while PM<sub>10</sub> data were largely underestimated compared to the corresponding FEM BAM and GRIMM values
- Temperature and relative humidity measured by AirThinx sensors correlated very well ( $R^2 > 0.94$ ) with the corresponding values collected using a substantially more expensive meteorological instrument
- 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 may be necessary to fully evaluate the performance of these sensors over different / more extreme environmental conditions
- All results are still preliminary