

# Field Evaluation Purple Air (PA-II) PM Sensor



# Background

- From 12/08/2016 to 01/26/2017, three **Purple Air PA-II** sensor nodes were deployed at our (SCAQMD) Rubidoux station and ran side-by-side with two Federal Equivalent Method (FEM) instruments measuring the same pollutant
- Purple Air PA-II Sensor node [3 nodes tested]:
  - Particle sensor (**optical; non-FEM**) (model PMS 5003; *two identical sensor devices per node*)
  - Each sensor reports:  $PM_{1.0}$ ,  $PM_{2.5}$  and  $PM_{10}$  mass concentration ( $\mu\text{g}/\text{m}^3$ )
  - Time resolution: 35-sec
  - **Node cost: ~\$200**
  - IDs: Node #1 (8464, 8464-b); Node #2 (CC53, CC53-b); Node #3 (D688, D688-b)
- MetOne BAM (reference method):
  - Beta-attenuation monitors (**FEM  $PM_{2.5}$ ,  $PM_{10}$** )
  - Measures  $PM_{2.5}$  &  $PM_{10}$  mass ( $\mu\text{g}/\text{m}^3$ )
  - **Unit cost: ~\$20,000**
  - Time resolution: 1-hr
- GRIMM (reference method):
  - Optical particle counter (**FEM  $PM_{2.5}$** )
  - 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

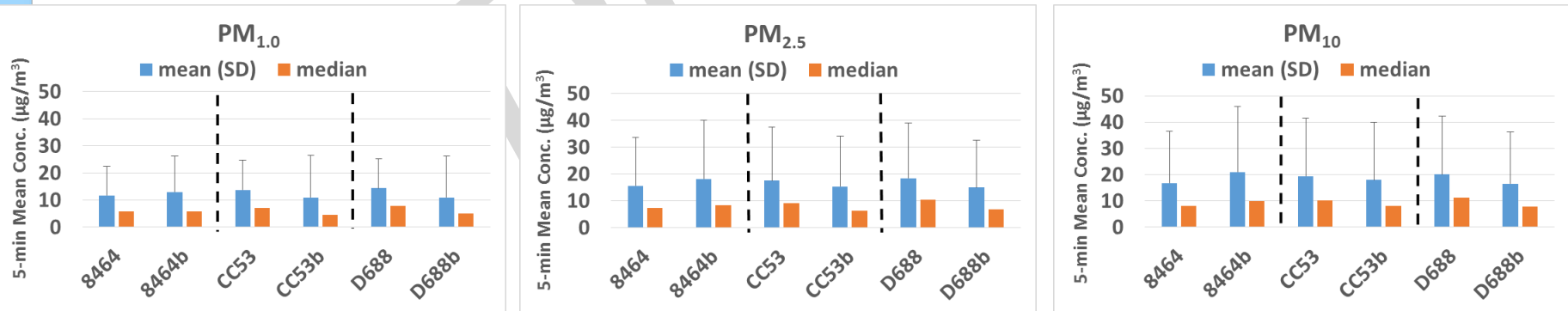


# Data validation & recovery

- 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  $PM_{1.0}$ ,  $PM_{2.5}$  and  $PM_{10}$  from all three Purple Air PA-II sensor nodes was between 95 and 99%.

## Purple Air PA-II; intra-model variability

- Very low measurement variations were observed between the different Purple Air PA-II sensors for  $PM_{1.0}$ ,  $PM_{2.5}$  and  $PM_{10}$  mass concentrations ( $\mu\text{g}/\text{m}^3$ )

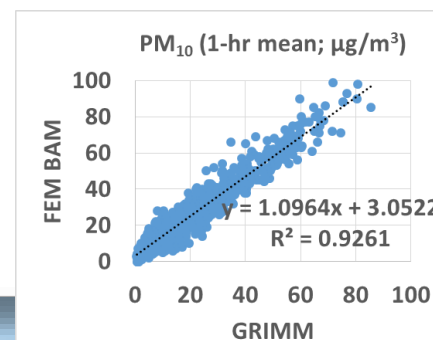
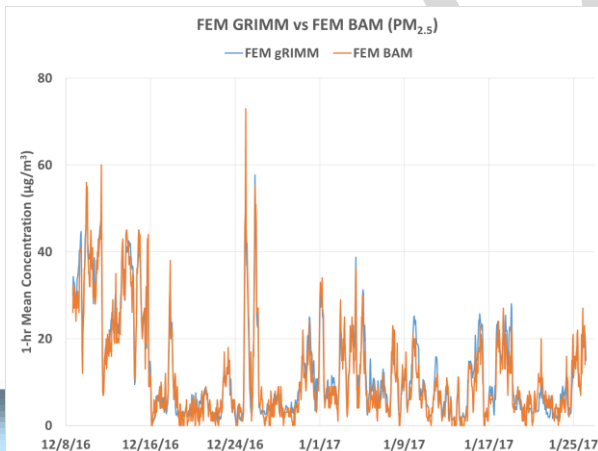
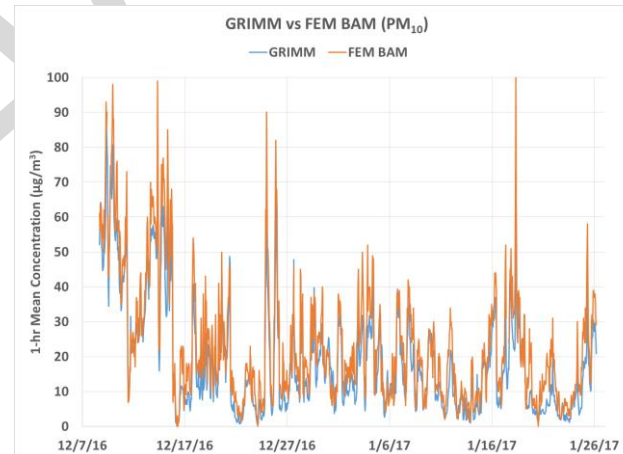
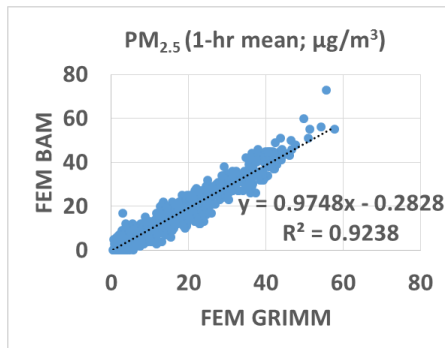


# Data validation & recovery

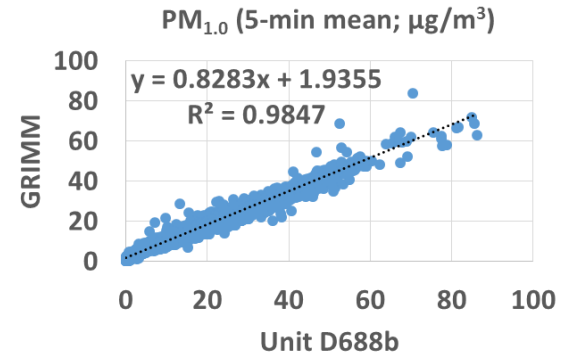
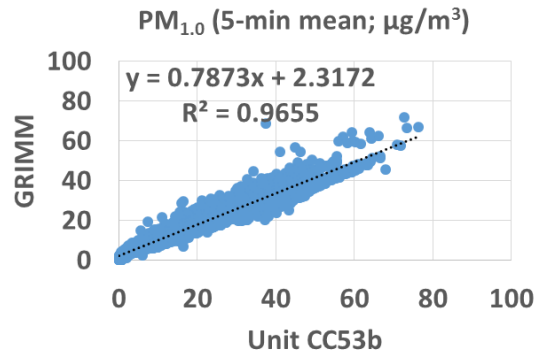
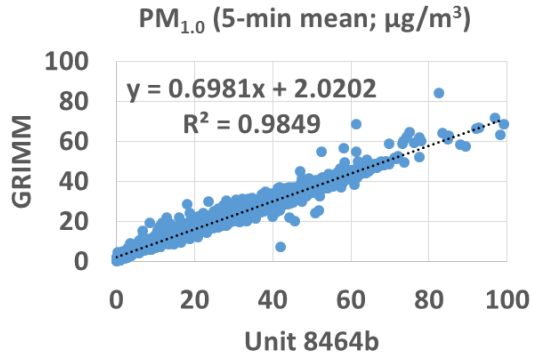
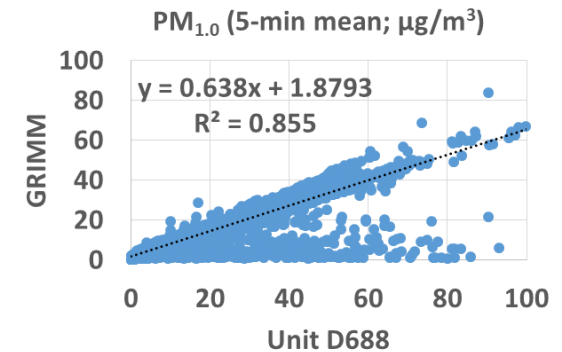
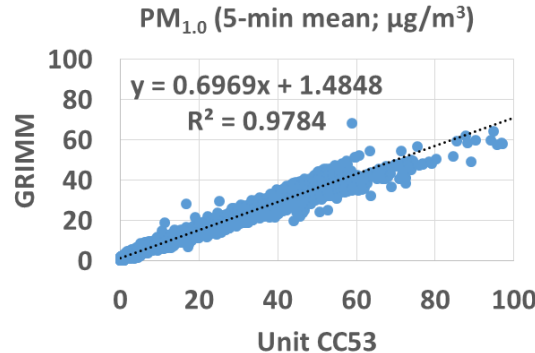
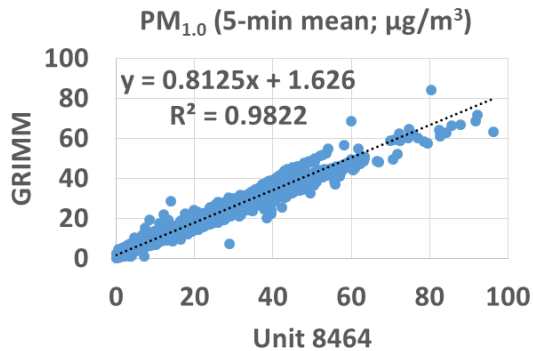
- Basic QA/QC procedures were used to validate the collected PM data (i.e. obvious outliers, negative values and invalid data-points were eliminated from data-set)
- PM<sub>2.5</sub> and PM<sub>10</sub> data recovery was close to 100 % for the GRIMM and the BAM

## Equivalent methods: BAM vs GRIMM

- Excellent correlation between the two equivalent methods for PM<sub>2.5</sub> & PM<sub>10</sub>

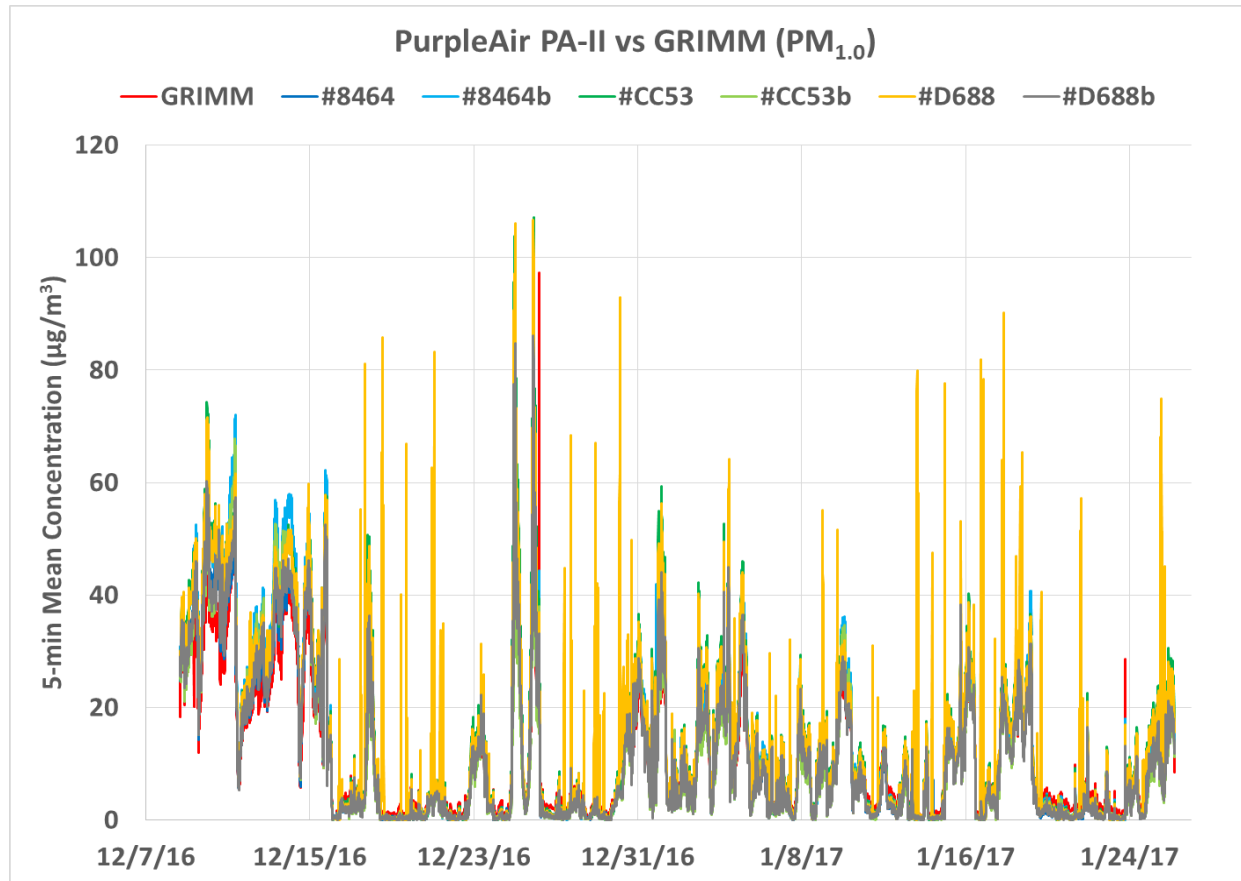


# Purple Air PA-II vs GRIMM (PM<sub>1.0</sub>; 5-min mean)



- Purple Air PA-II PM<sub>1.0</sub> mass measurements correlate very well with the corresponding GRIMM data ( $R^2 > 0.96$ ), with the exception of sensor #D688 ( $R^2 > 0.855$ )
- Measurements from all Purple Air devices are quite accurate

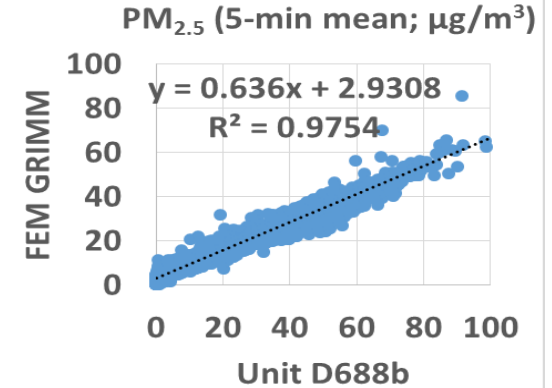
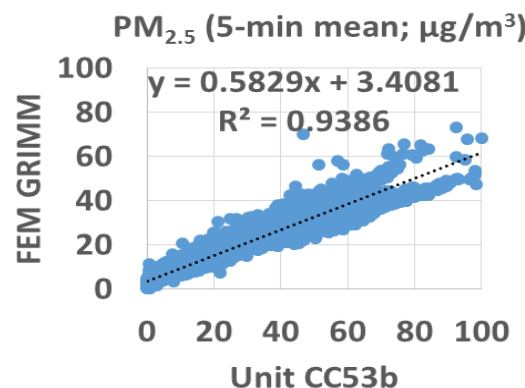
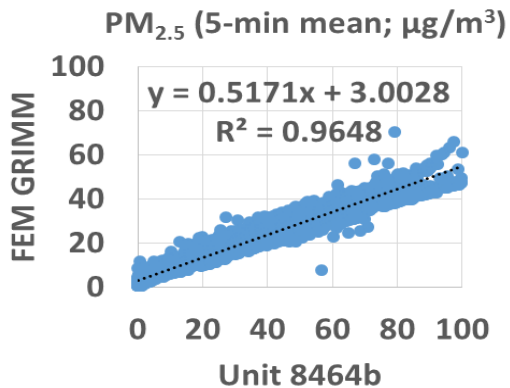
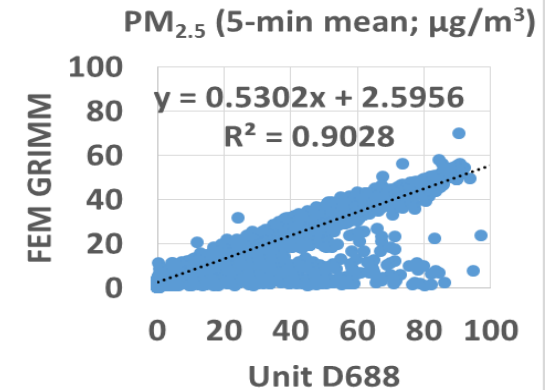
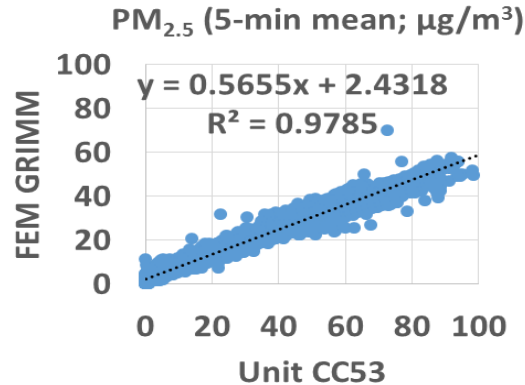
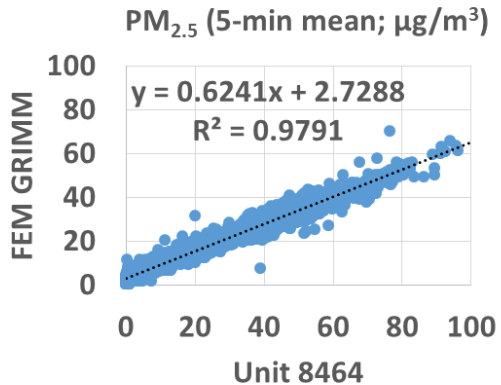
# Purple Air PA-II vs GRIMM (PM<sub>1.0</sub>; 5-min mean)



- PurpleAir PA-II sensors track well the diurnal PM<sub>1.0</sub> variations recorded by the GRIMM instrument with the exception of unit #D688

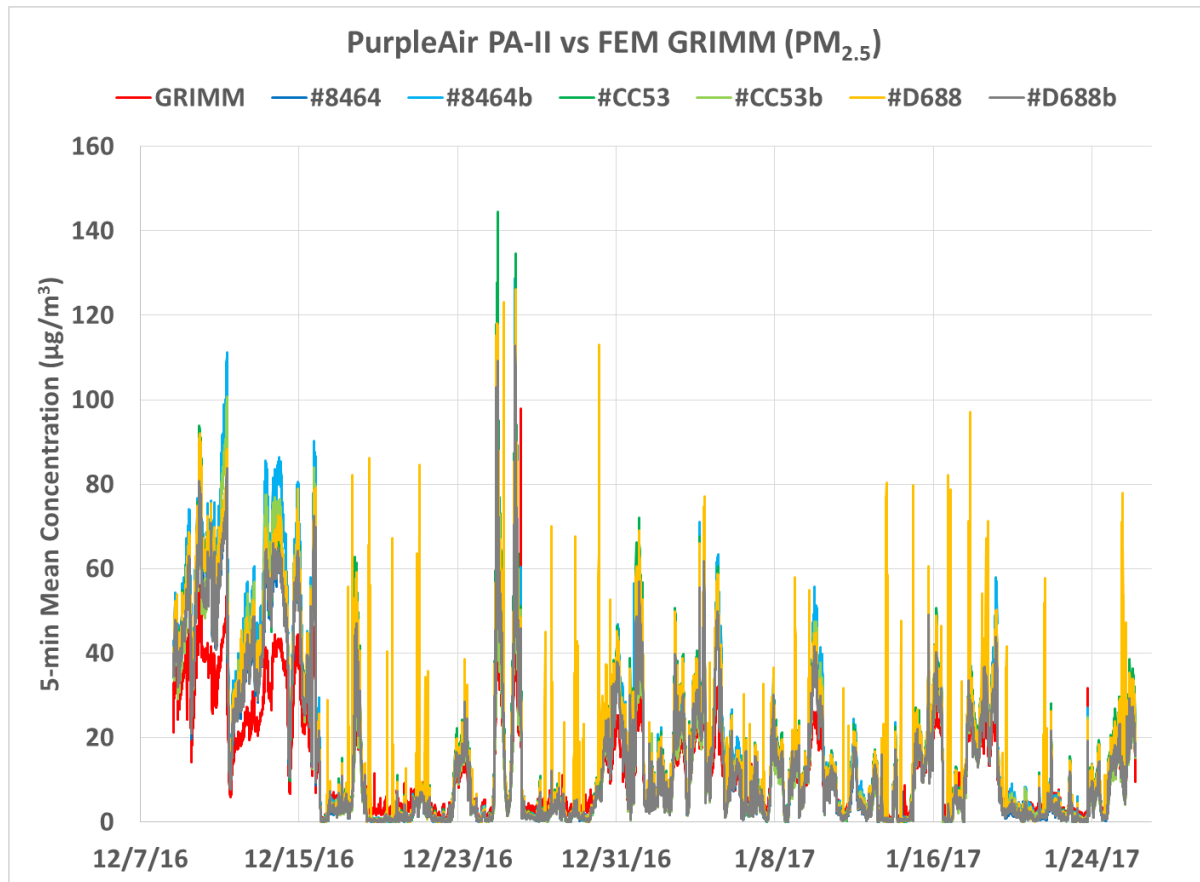


# Purple Air PA-II vs FEM GRIMM (PM<sub>2.5</sub>; 5-min mean)



- Purple Air PA-II PM<sub>2.5</sub> mass measurements correlate very well with the corresponding FEM GRIMM data ( $R^2 > 0.93$ ), with the exception of sensor #D688 ( $R^2 > 0.90$ )
- Measurements from all Purple Air devices are quite accurate

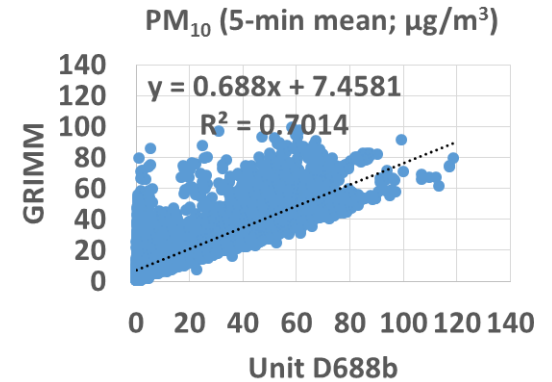
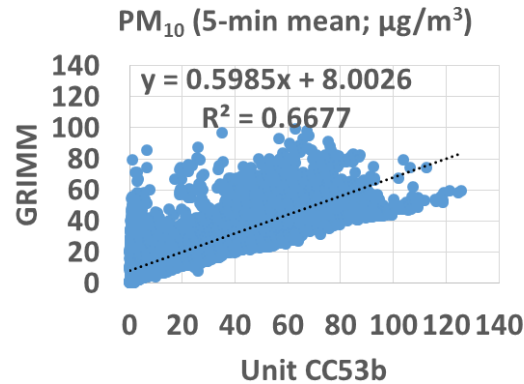
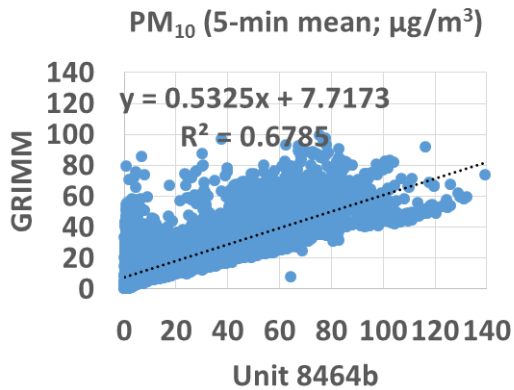
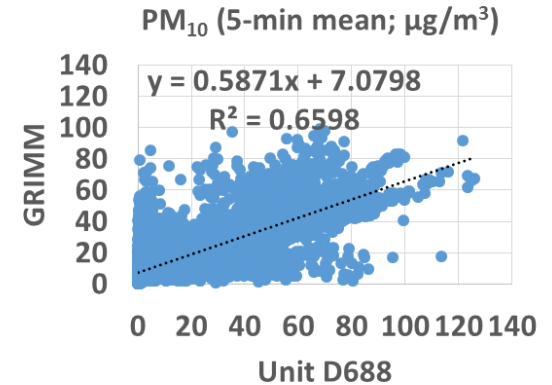
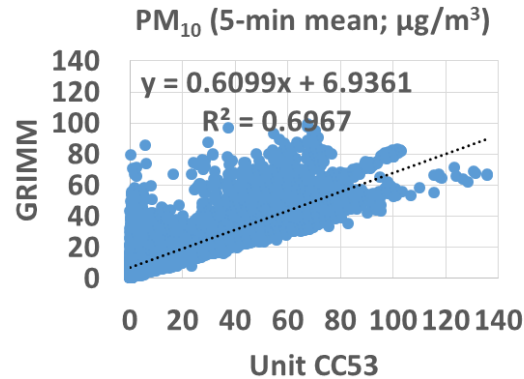
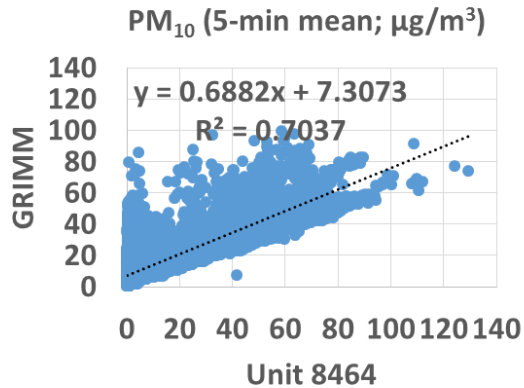
# Purple Air PA-II vs FEM GRIMM (PM<sub>2.5</sub>; 5-min mean)



- PurpleAir PA-II sensors track well the diurnal PM<sub>2.5</sub> variations recorded by the FEM GRIMM instrument, with the exception of unit #D688

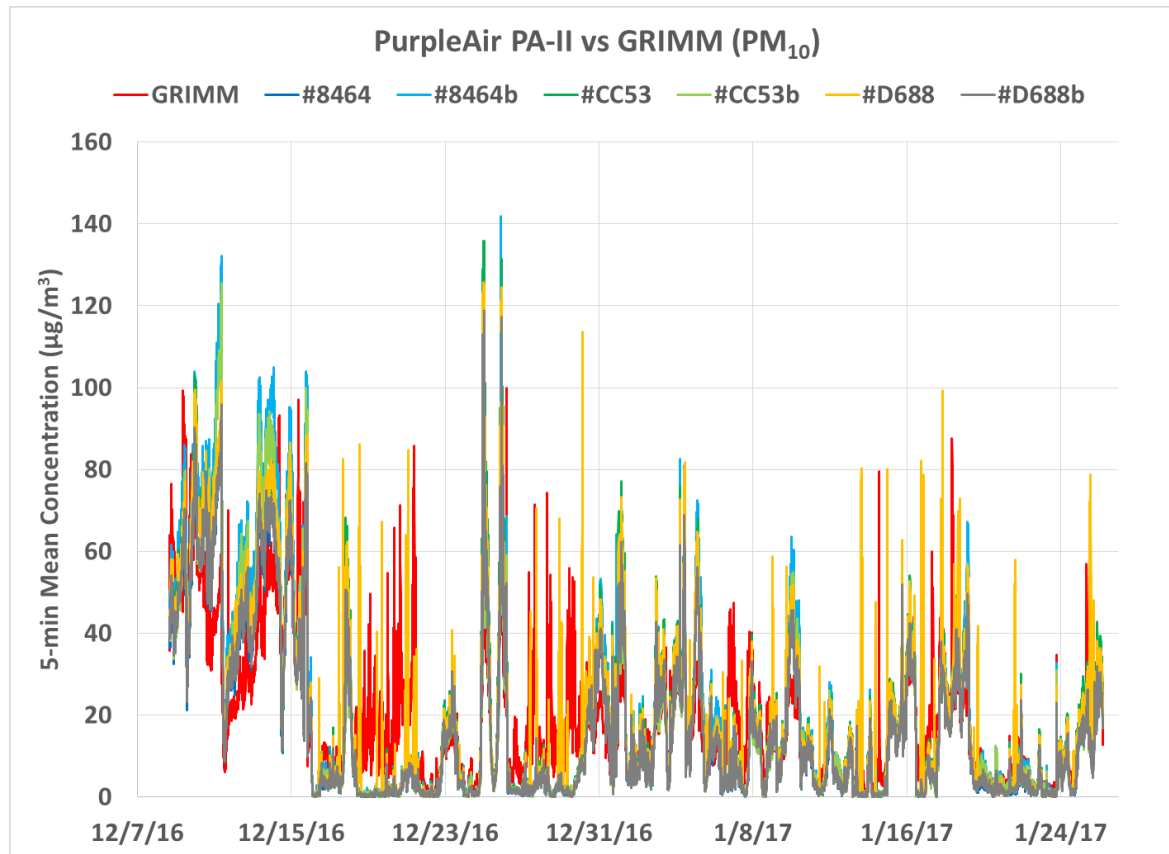


# Purple Air PA-II vs GRIMM (PM<sub>10</sub>; 5-min mean)



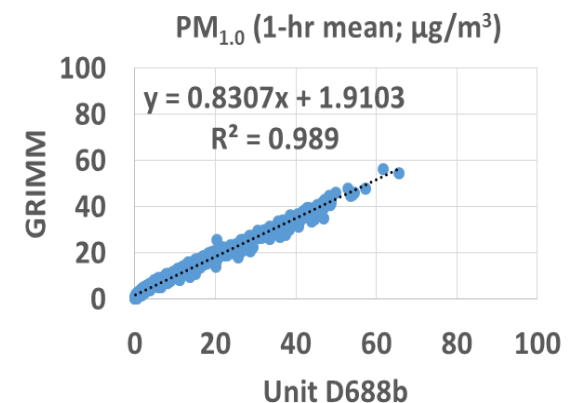
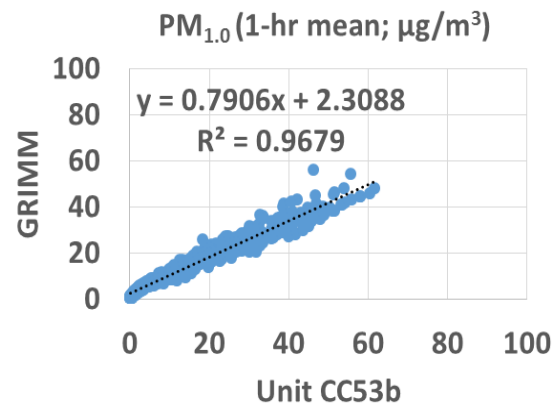
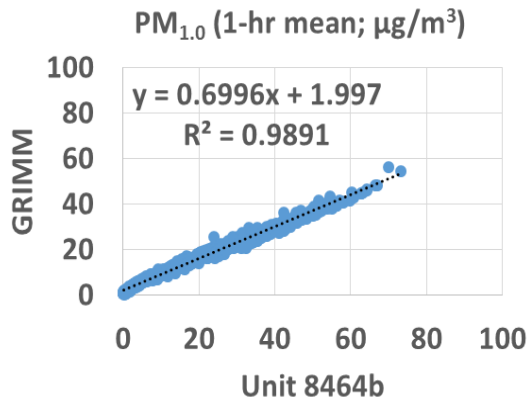
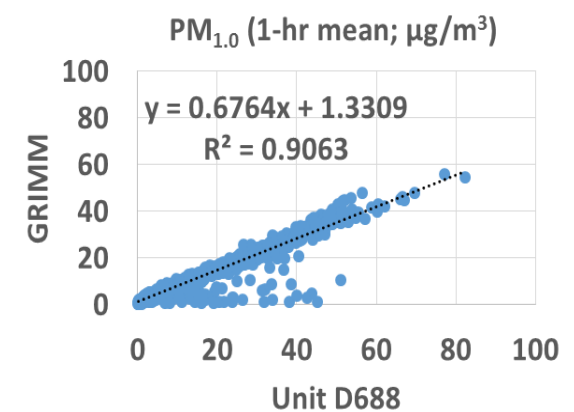
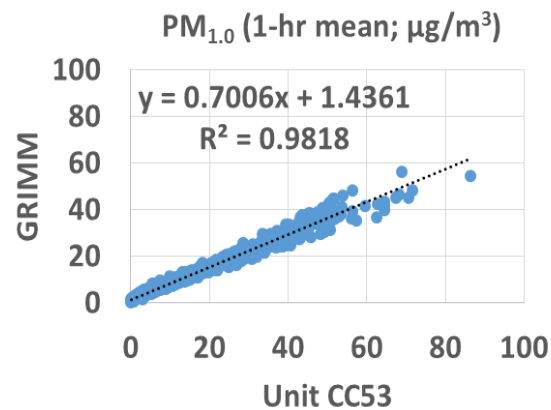
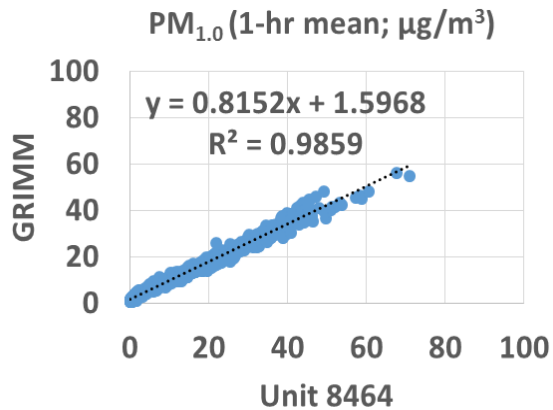
- Purple Air PA-II PM<sub>10</sub> mass measurements correlate well with the corresponding GRIMM data ( $R^2 > 0.65$ )

# Purple Air PA-II vs GRIMM (PM<sub>10</sub>; 5-min mean)



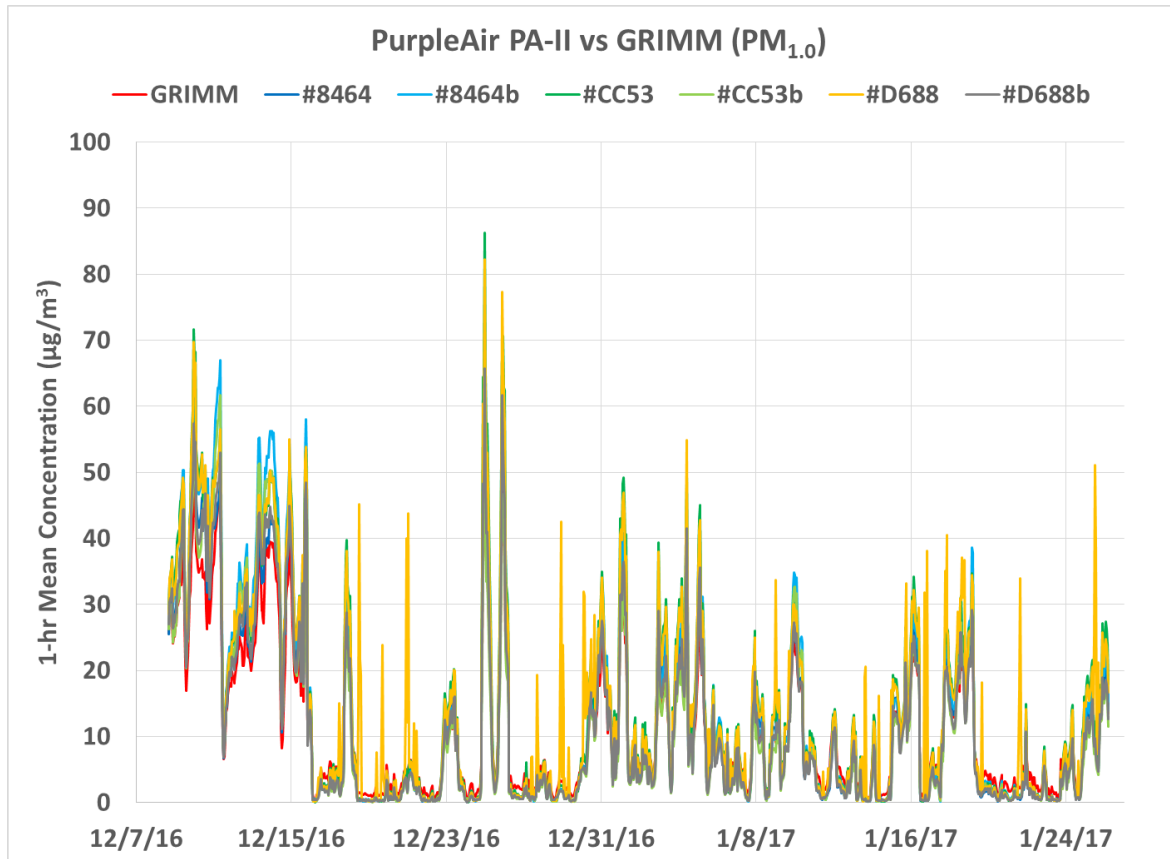
- PurpleAir PA-II sensors seem to track the diurnal PM<sub>10</sub> variations recorded by the GRIMM instrument

# Purple Air PA-II vs GRIMM (PM<sub>1.0</sub>; 1-hr mean)



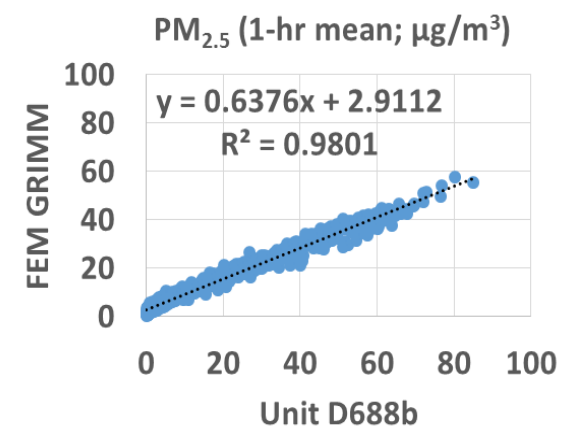
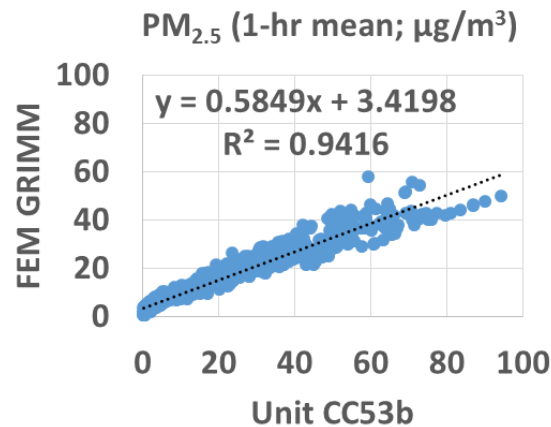
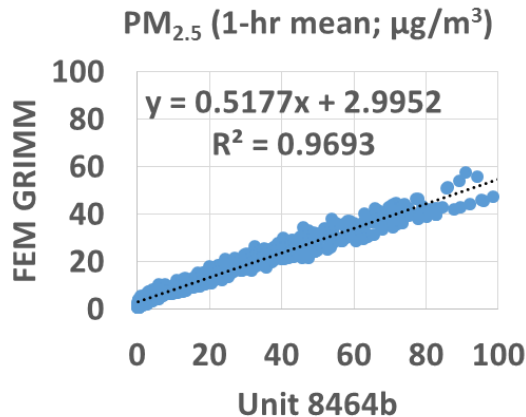
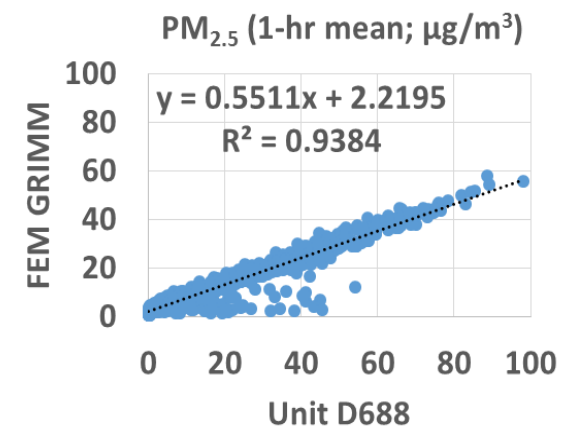
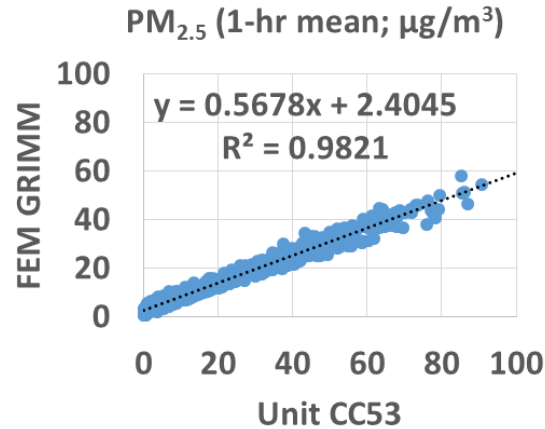
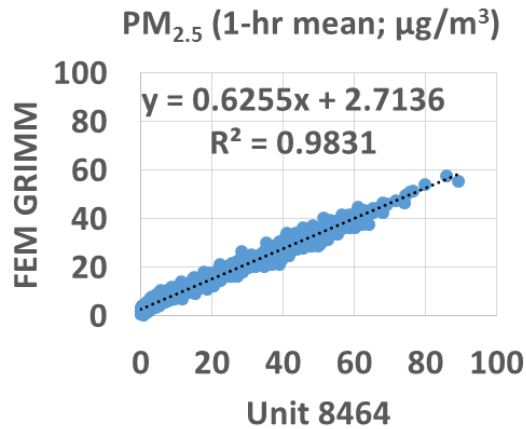
- Purple Air PA-II PM<sub>1.0</sub> mass measurements correlate very well with the corresponding GRIMM data ( $R^2 > 0.96$ ), with the exception of sensor #D688 ( $R^2 > 0.90$ )
- Measurements from all Purple Air devices are quite accurate

# Purple Air PA-II vs GRIMM (PM<sub>1.0</sub>; 1-hr mean)



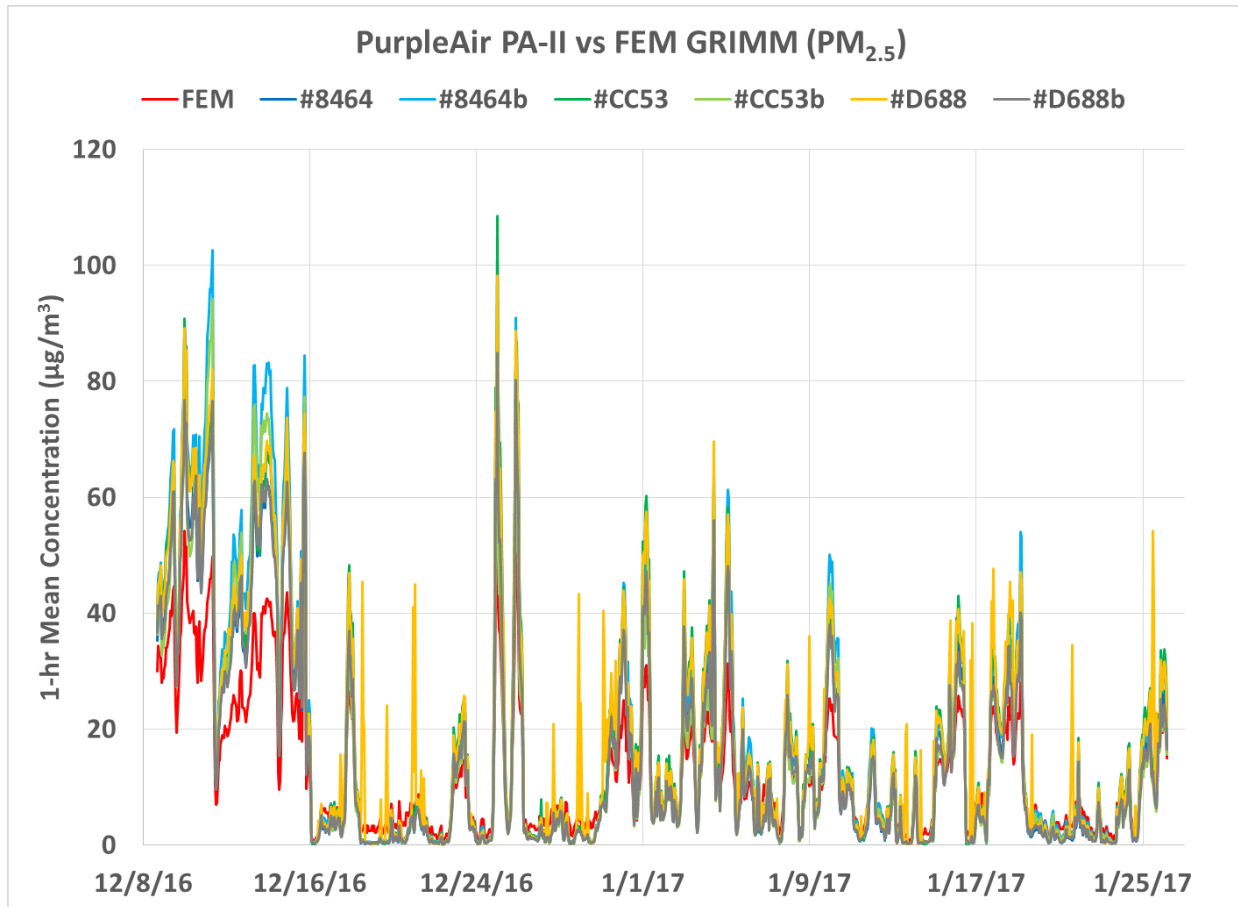
- PurpleAir PA-II sensors track well the diurnal PM<sub>1.0</sub> variations recorded by the GRIMM instrument, with the exception of sensor #D688

# Purple Air PA-II vs FEM GRIMM (PM<sub>2.5</sub>; 1-hr mean)



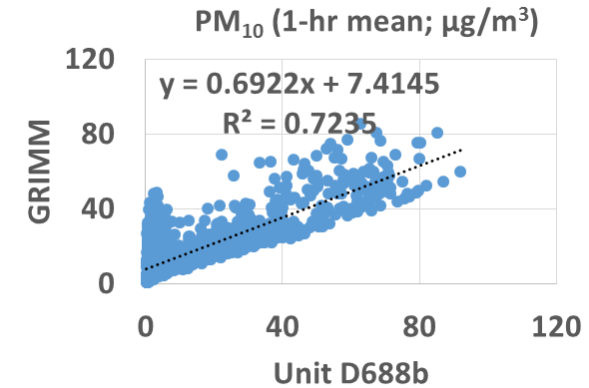
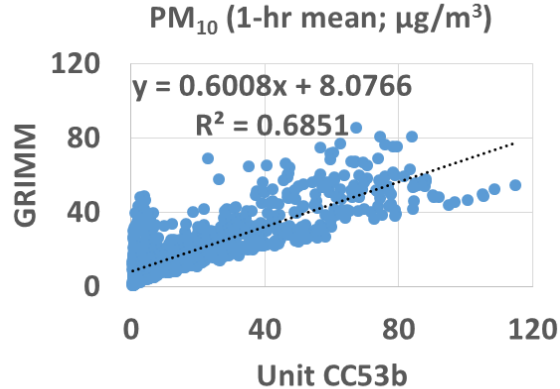
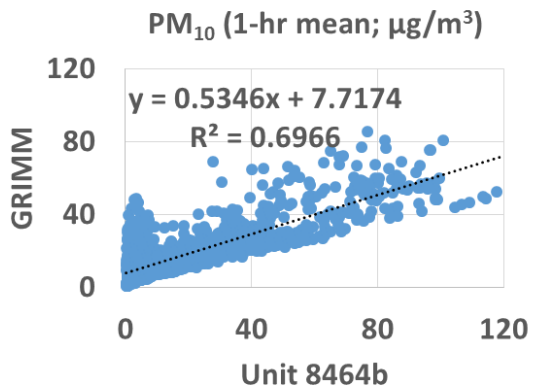
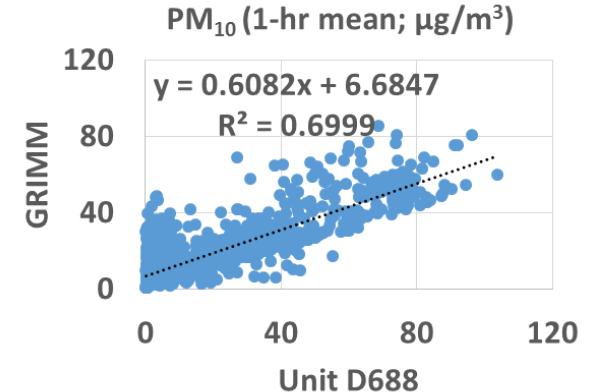
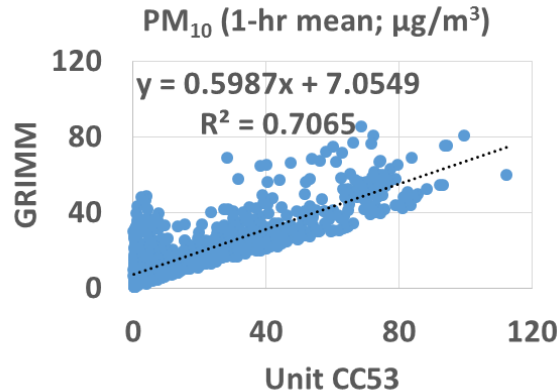
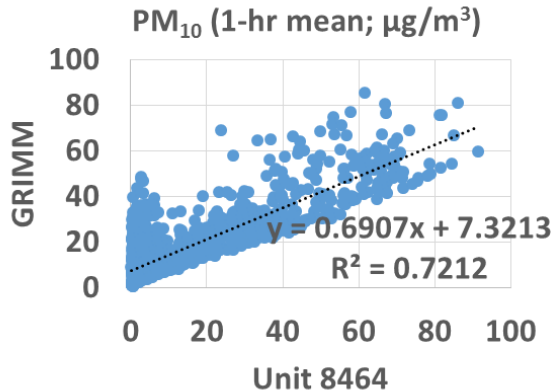
- Purple Air PA-II PM<sub>2.5</sub> mass measurements correlate very well with the corresponding FEM GRIMM data ( $R^2 > 0.93$ )
- Measurements from all Purple Air devices are quite accurate

# Purple Air PA-II vs FEM GRIMM (PM<sub>2.5</sub>; 1-hr mean)



- PurpleAir PA-II sensors track well the diurnal PM<sub>2.5</sub> variations recorded by the FEM GRIMM instrument

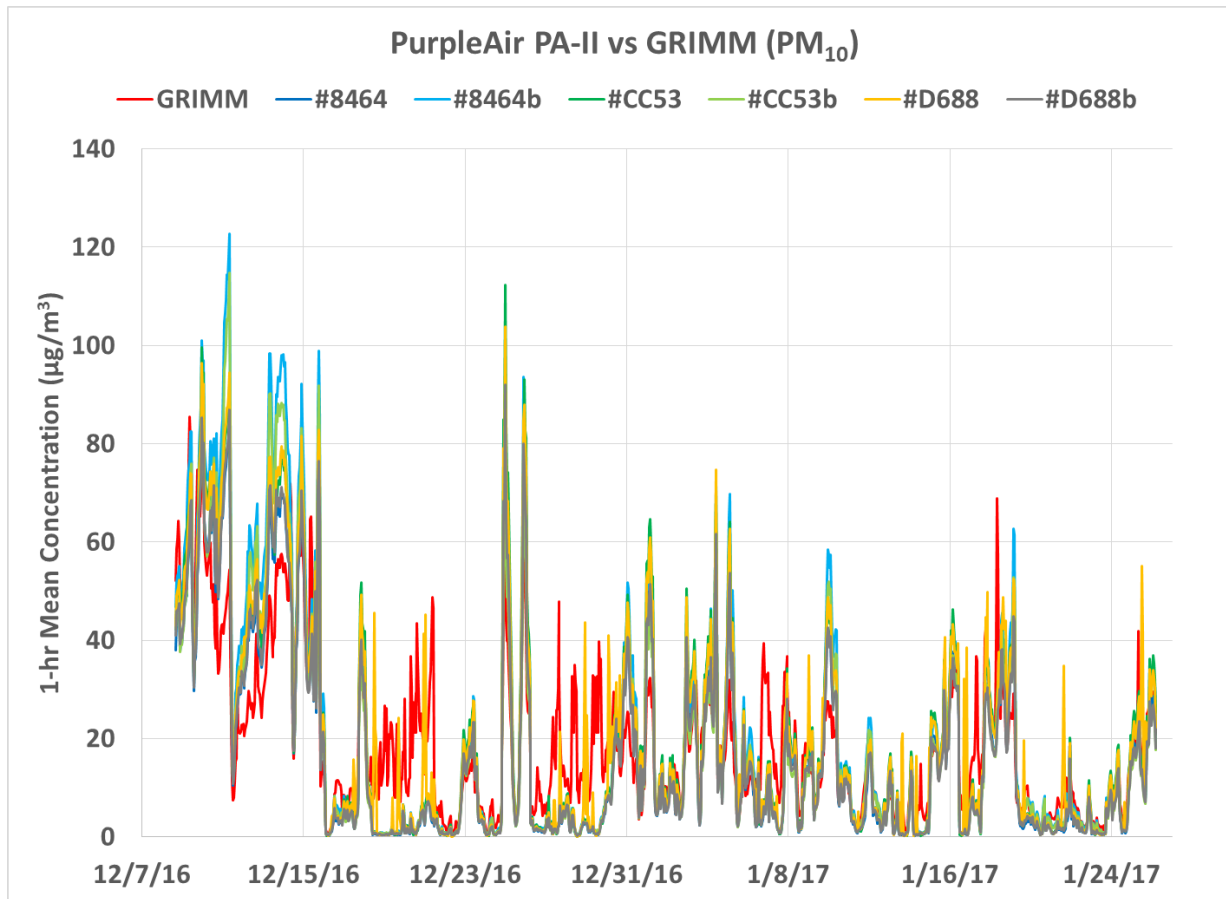
# Purple Air PA-II vs GRIMM (PM<sub>10</sub>; 1-hr mean)



- Purple Air PA-II PM<sub>10</sub> mass measurements correlate well with the corresponding GRIMM data ( $R^2 > 0.68$ )

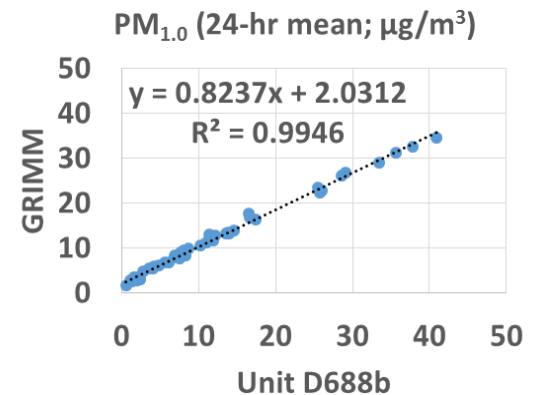
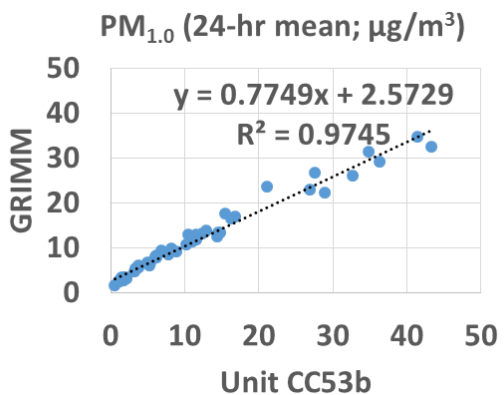
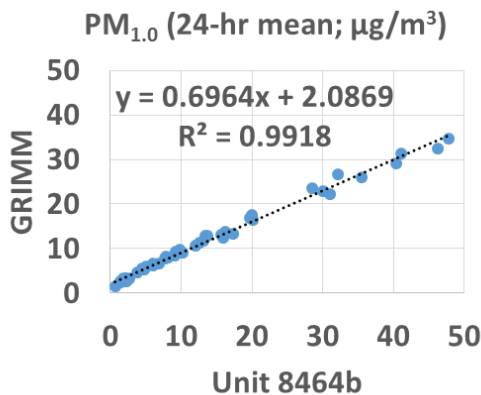
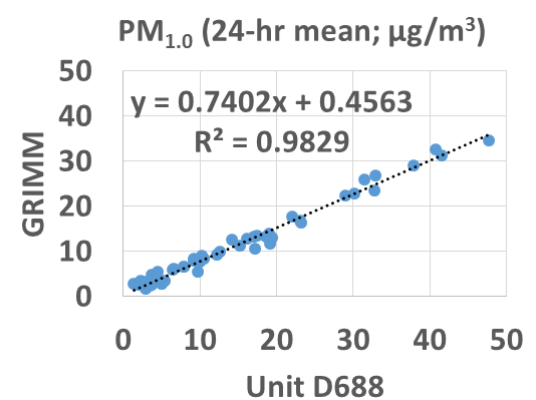
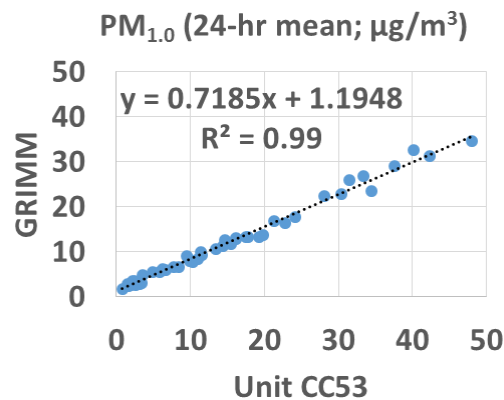
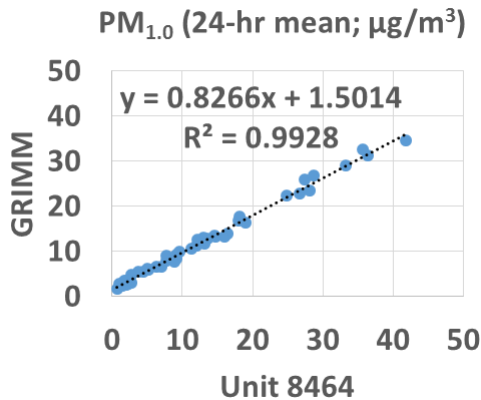


# Purple Air PA-II vs GRIMM (PM<sub>10</sub>; 1-hr mean)



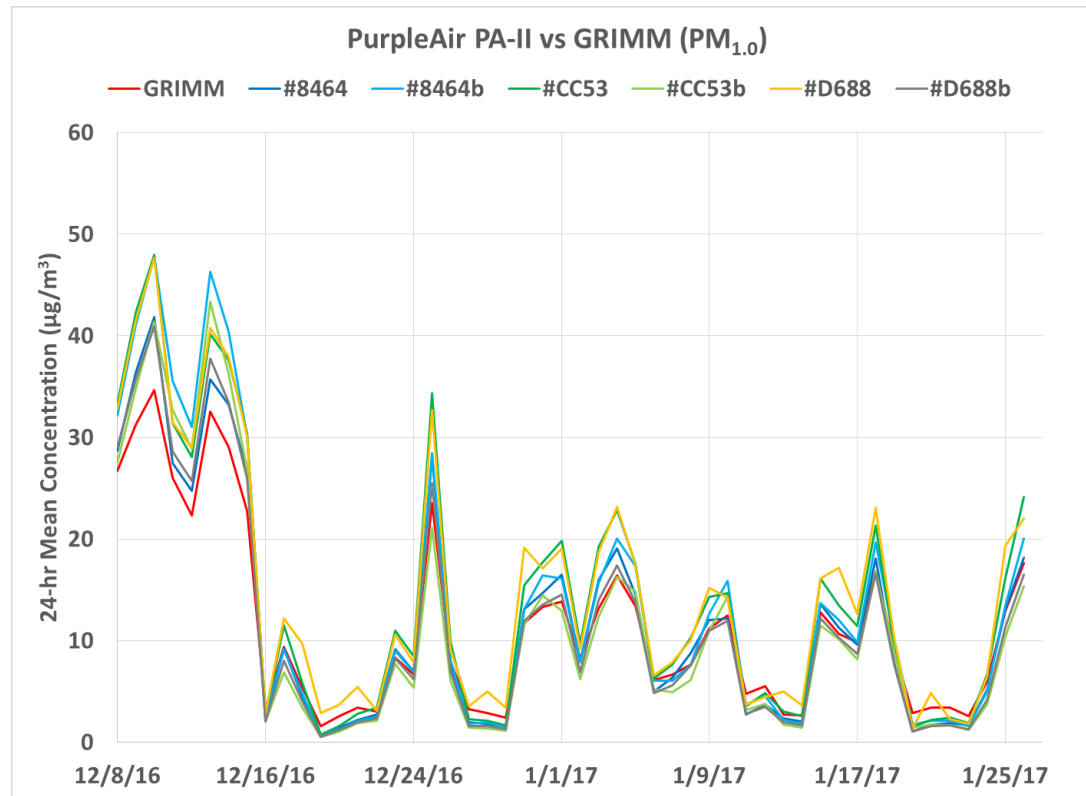
- PurpleAir PA-II sensors seem to track the diurnal PM<sub>10</sub> variations recorded by the GRIMM instrument

# Purple Air PA-II vs GRIMM (PM<sub>1.0</sub>; 24-hr mean)



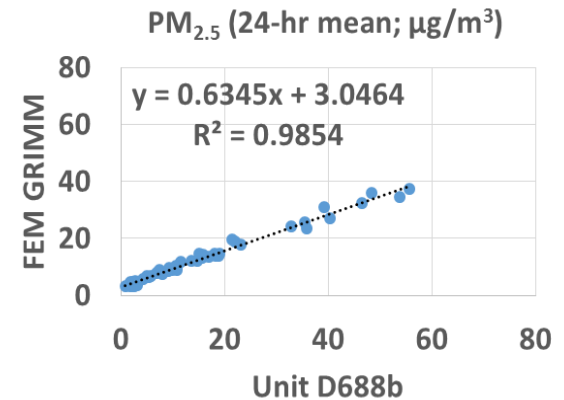
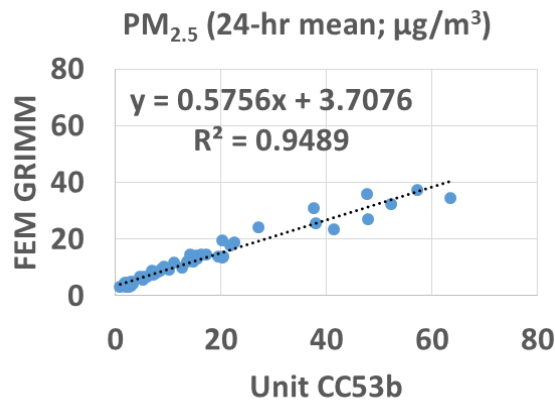
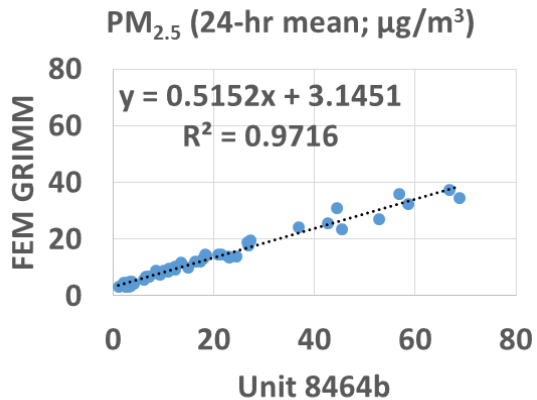
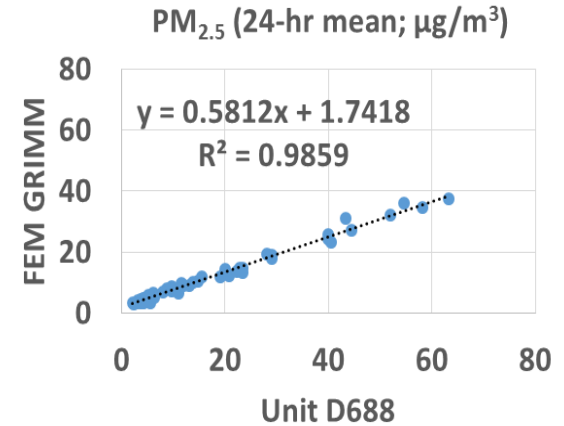
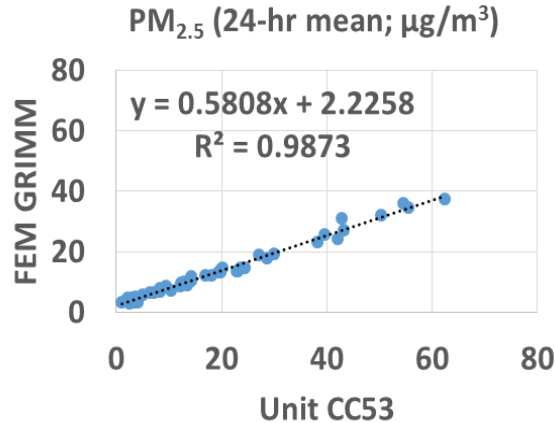
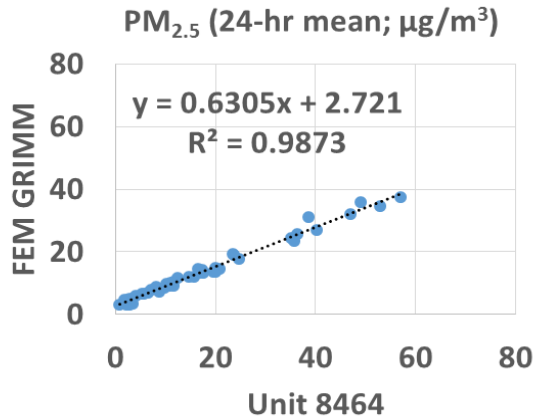
- Purple Air PA-II PM<sub>1.0</sub> mass measurements correlate very well with the corresponding GRIMM data ( $R^2 > 0.97$ )
- Measurements from all Purple Air devices are quite accurate

# Purple Air PA-II vs GRIMM (PM<sub>1.0</sub>; 24-hr mean)



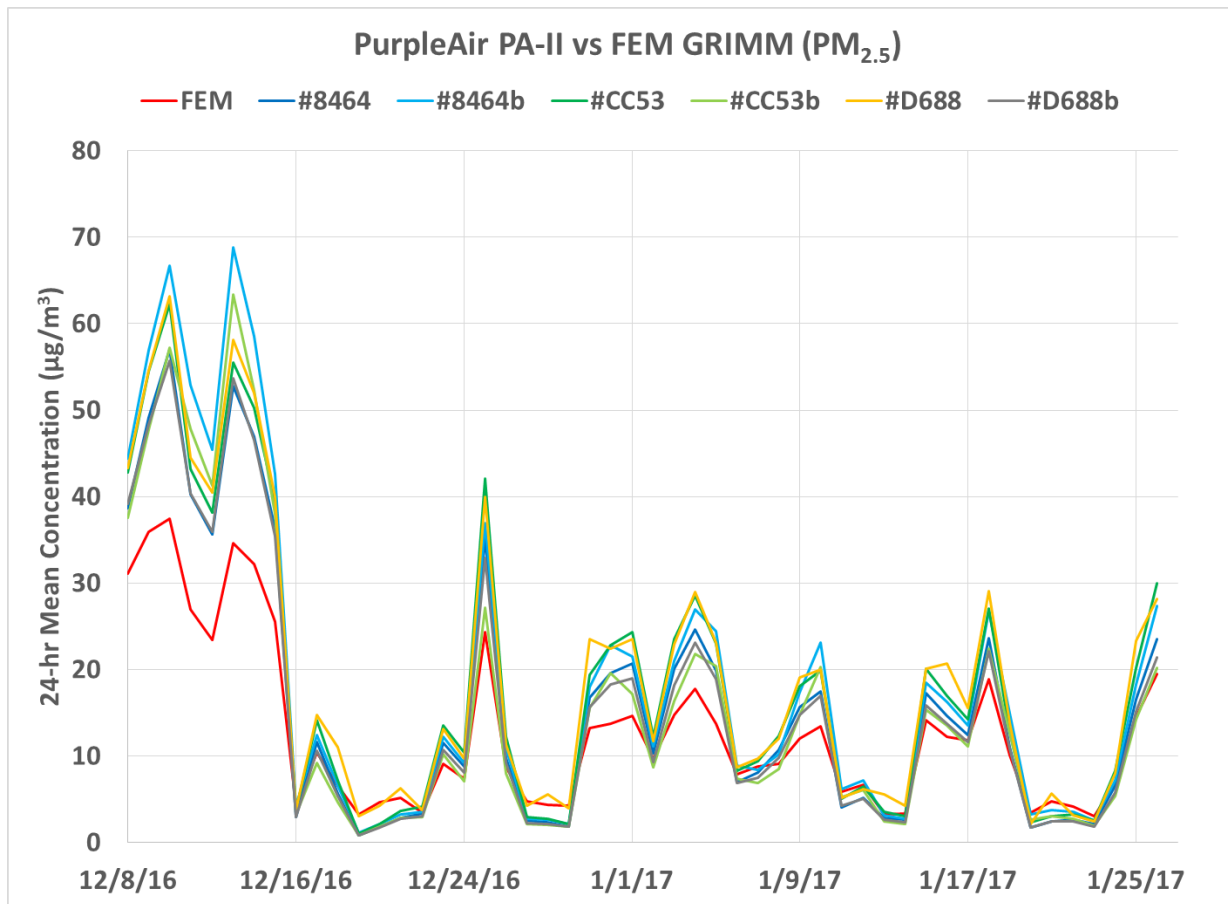
- PurpleAir PA-II sensors track very well the diurnal PM<sub>1.0</sub> variations recorded by the GRIMM instrument

# Purple Air PA-II vs FEM GRIMM (PM<sub>2.5</sub>; 24-hr mean)



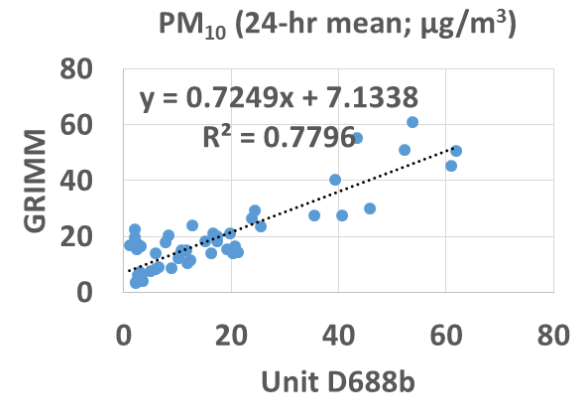
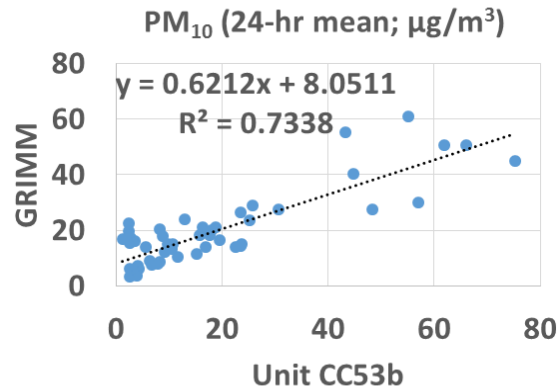
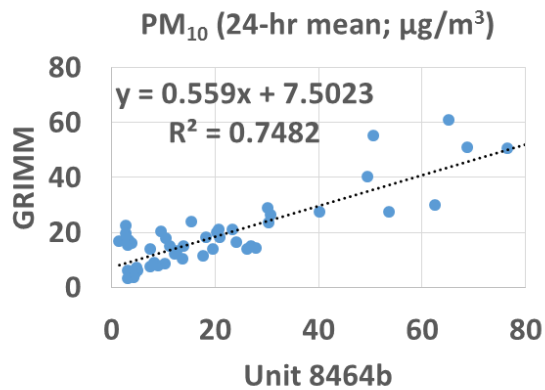
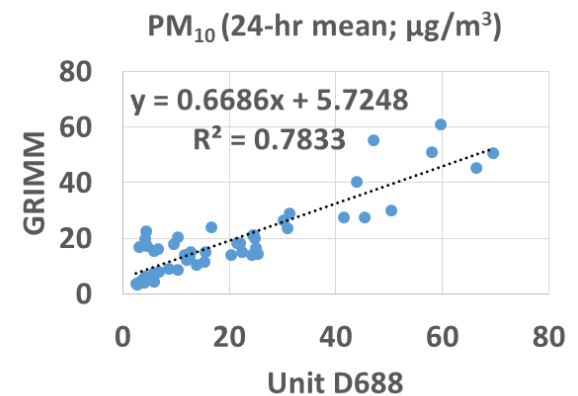
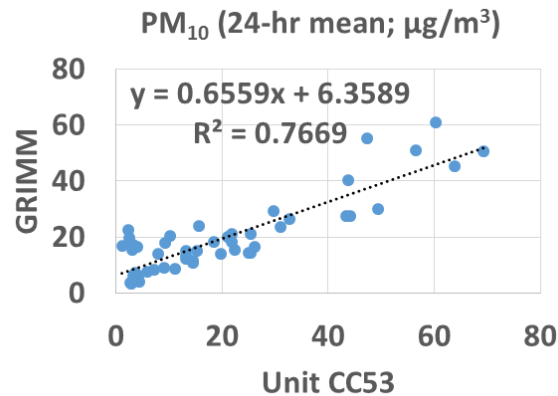
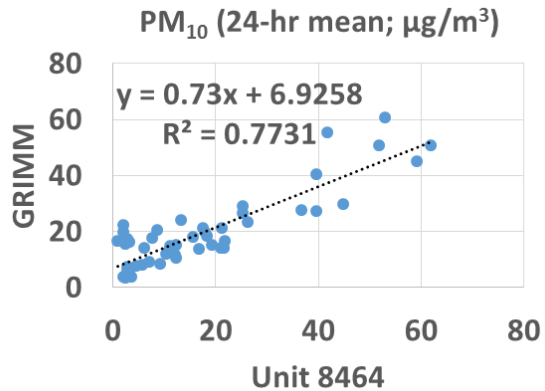
- Purple Air PA-II PM<sub>2.5</sub> mass measurements correlate very well with the corresponding FEM GRIMM data ( $R^2 > 0.94$ )
- Measurements from all Purple Air devices are quite accurate

# Purple Air PA-II vs FEM GRIMM (PM<sub>2.5</sub>; 24-hr mean)



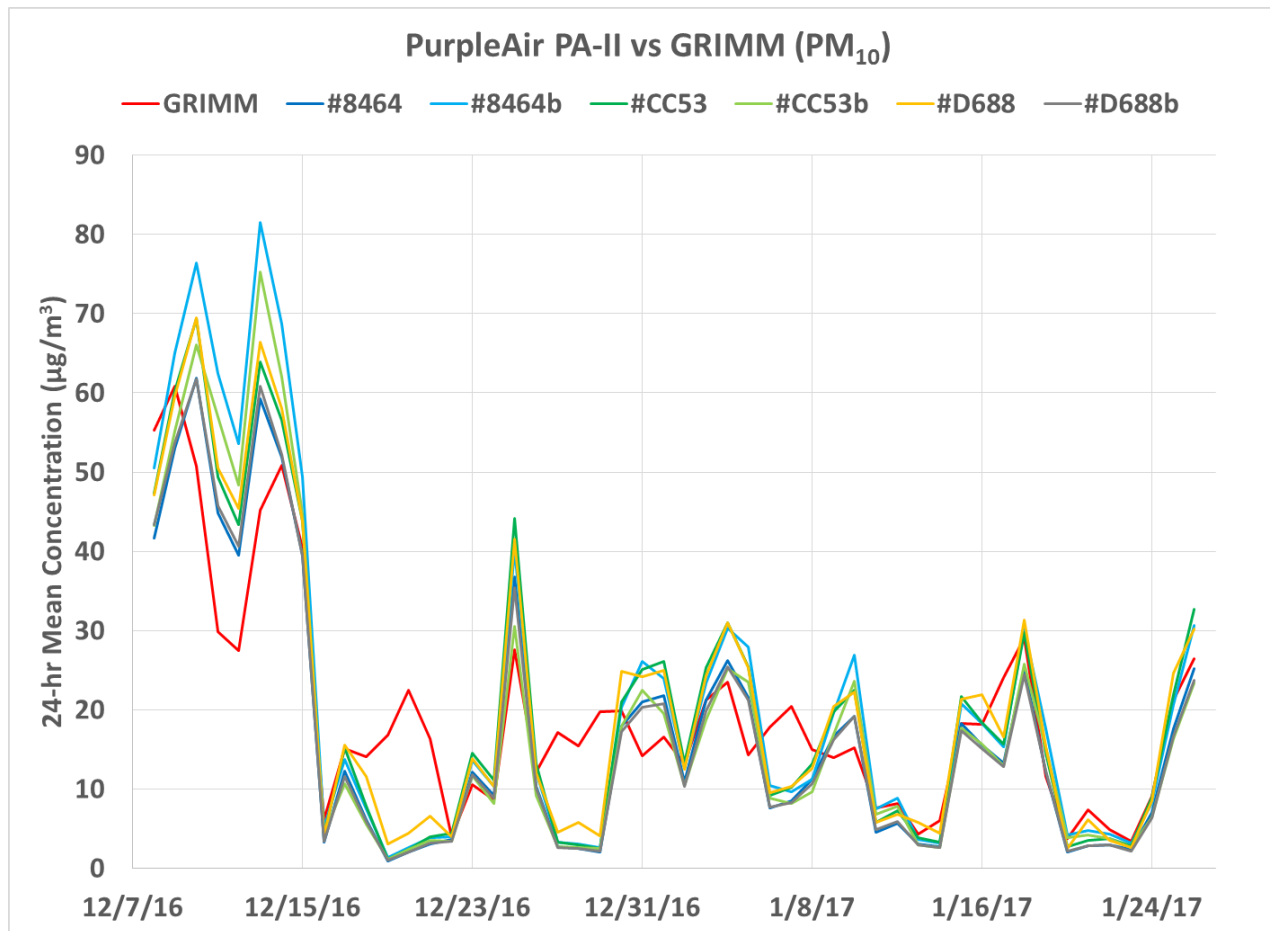
- PurpleAir PA-II sensors track very well the diurnal PM<sub>2.5</sub> variations recorded by the FEM GRIMM instrument

# Purple Air PA-II vs GRIMM (PM<sub>10</sub>; 24-hr mean)



- Purple Air PA-II PM<sub>10</sub> mass measurements correlate well with the corresponding GRIMM data ( $R^2 > 0.73$ )

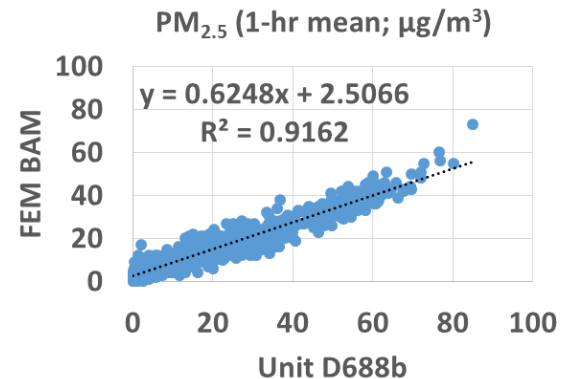
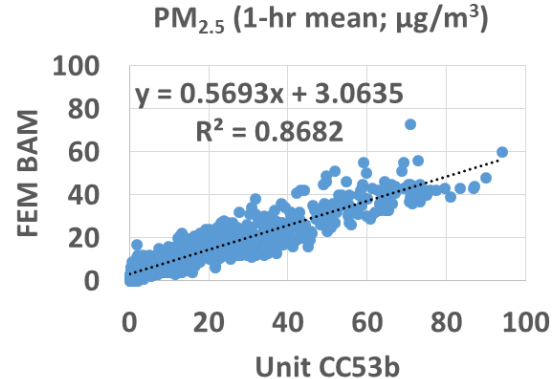
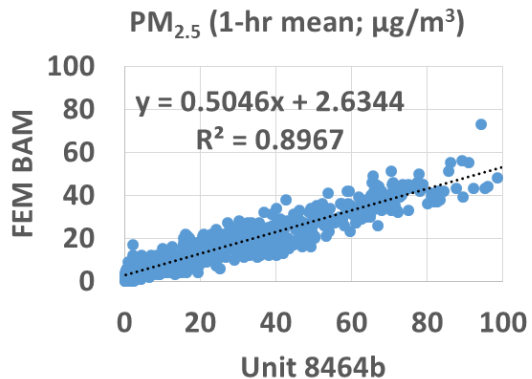
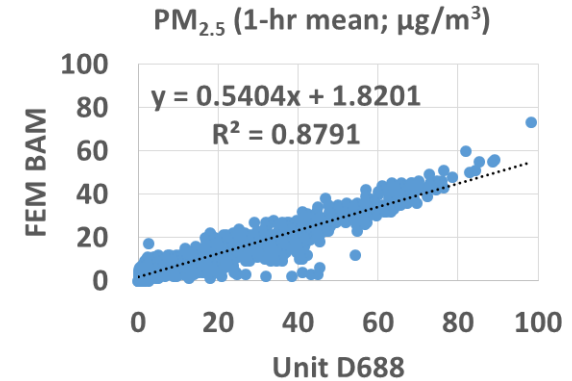
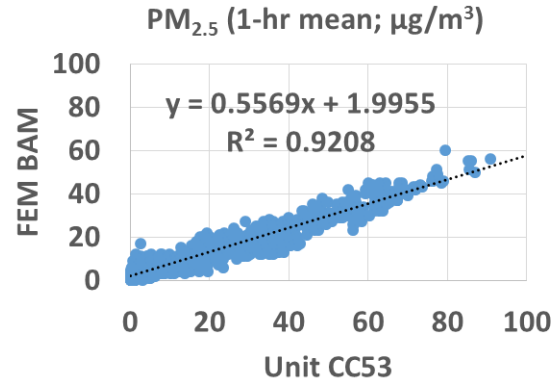
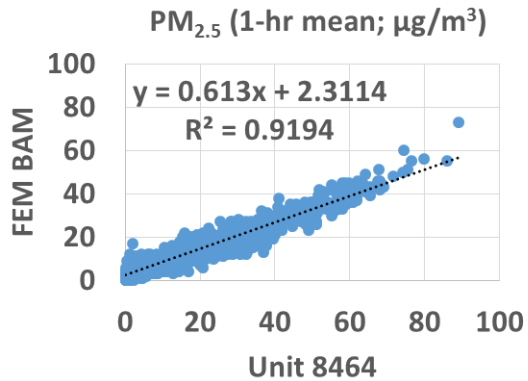
# Purple Air PA-II vs GRIMM (PM<sub>10</sub>; 24-hr mean)



- PurpleAir PA-II sensors seem to track the diurnal PM<sub>10</sub> variations recorded by the GRIMM instrument

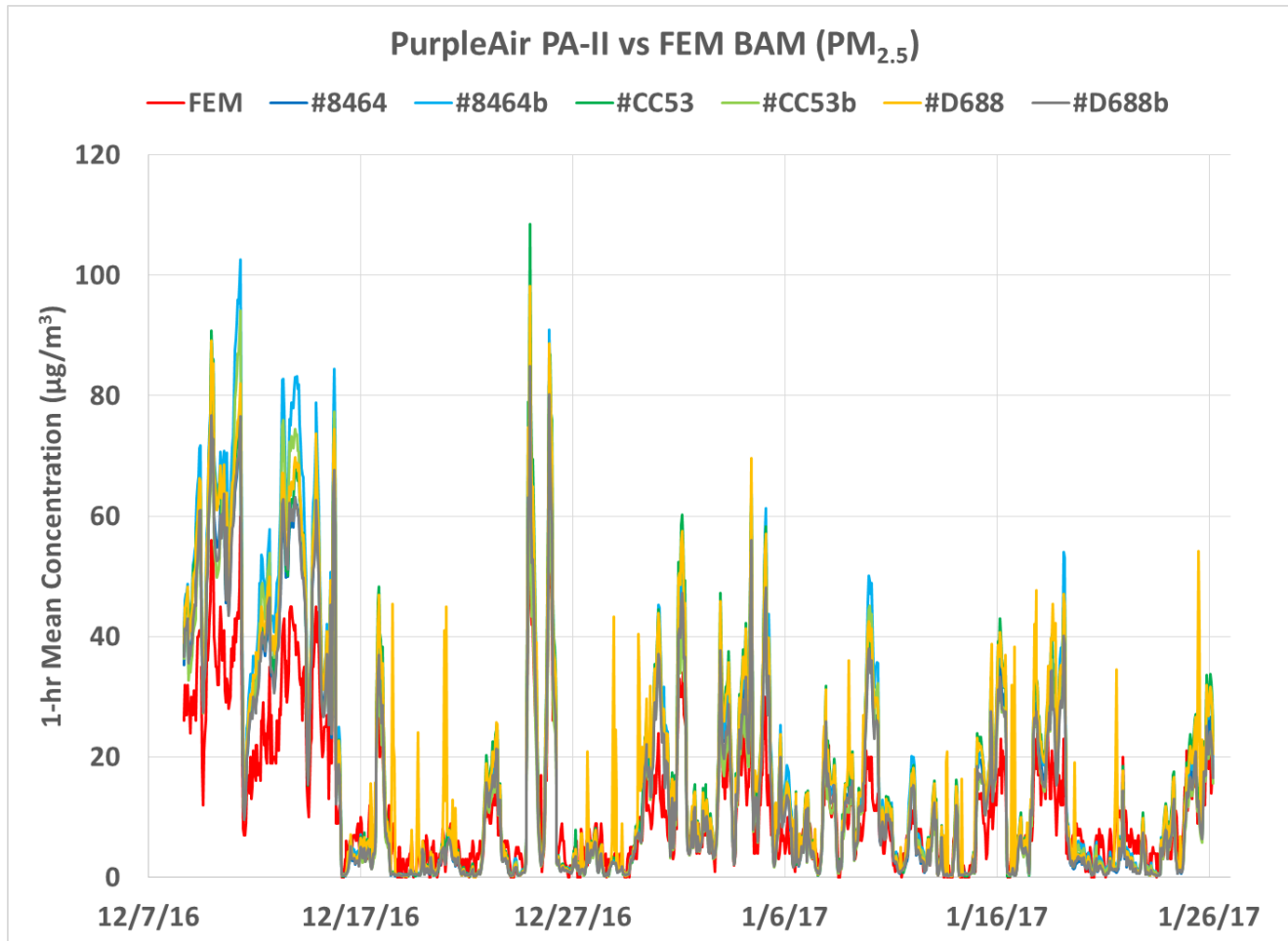


# Purple Air PA-II vs FEM BAM (PM<sub>2.5</sub>; 1-hr mean)



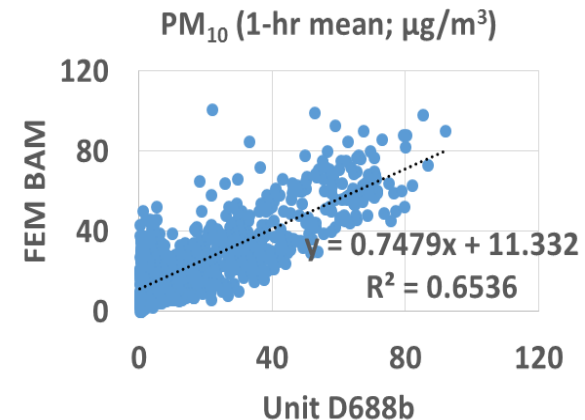
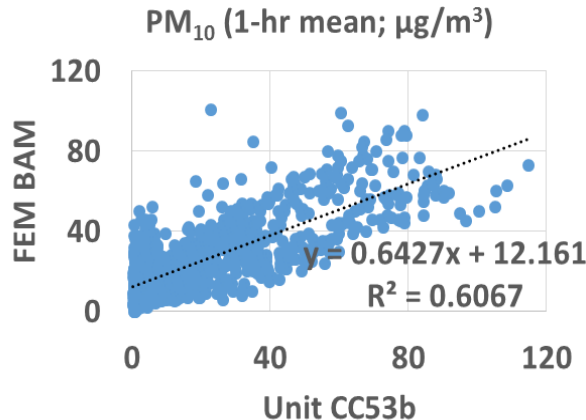
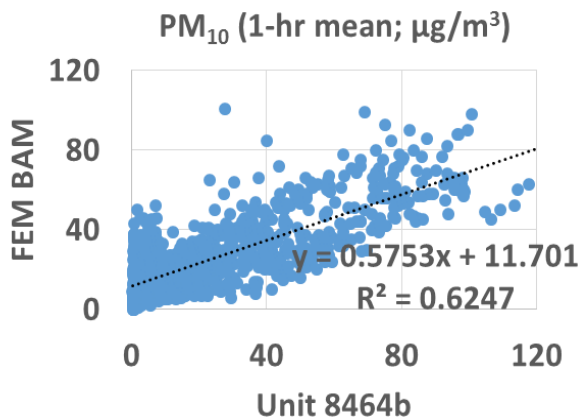
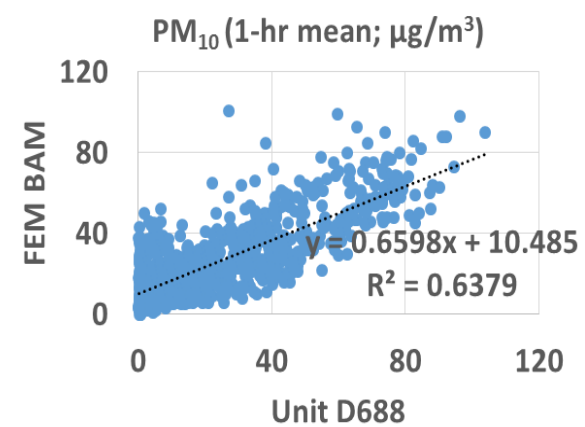
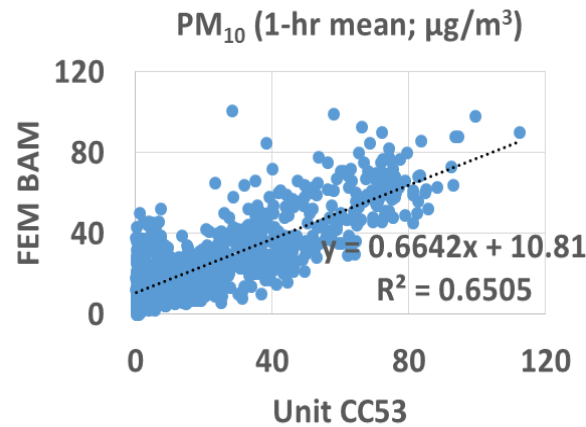
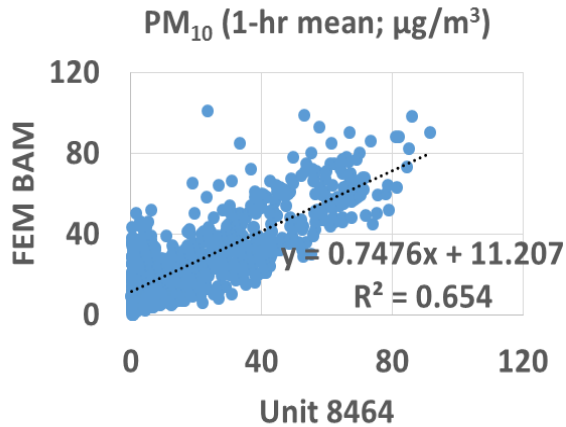
- Purple Air PA-II PM<sub>2.5</sub> mass measurements correlate very well with the corresponding FEM BAM data ( $R^2 > 0.86$ )
- Measurements from all Purple Air devices are quite accurate

# Purple Air PA-II vs FEM BAM (PM<sub>2.5</sub>; 1-hr mean)



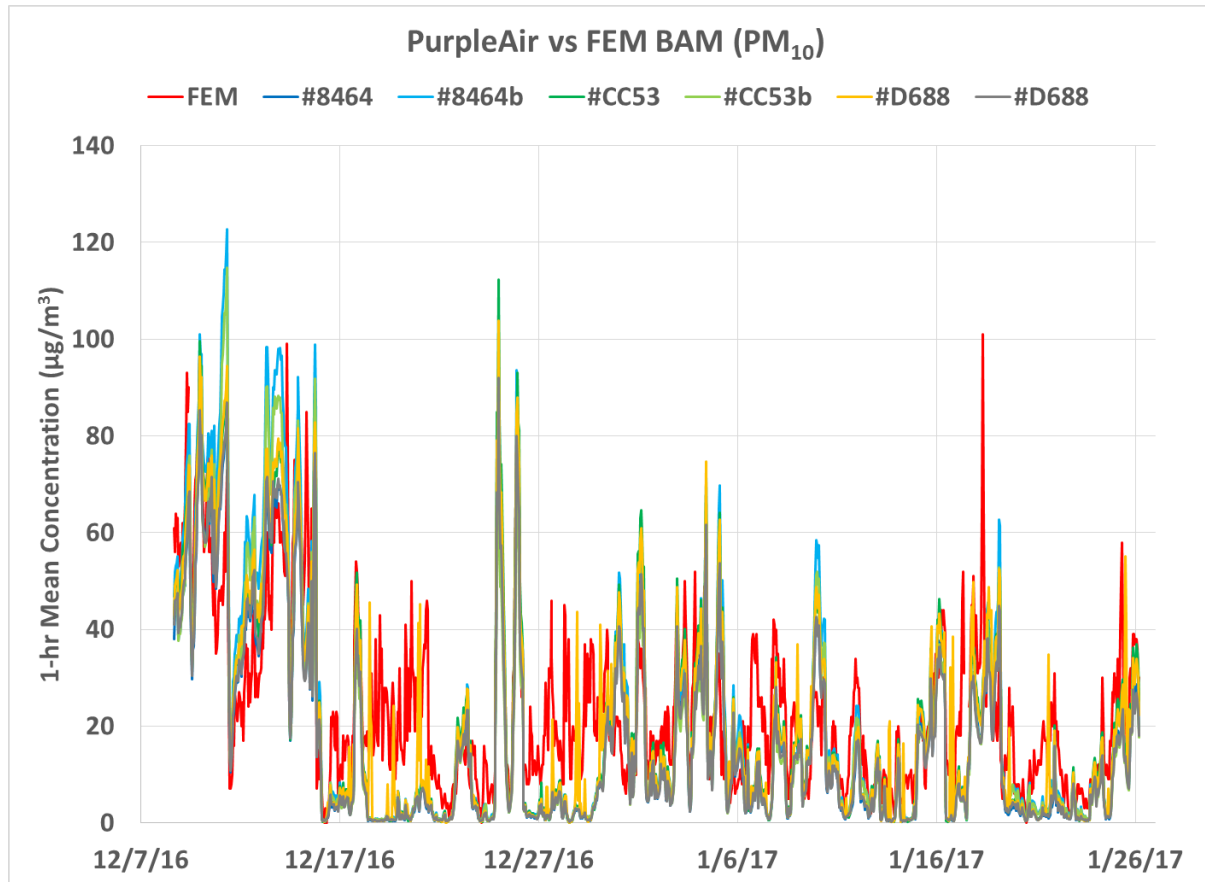
- PurpleAir PA-II sensors track well the diurnal PM<sub>2.5</sub> variations recorded by the FEM BAM instrument, with the exception of sensor #D688

# Purple Air PA-II vs FEM BAM (PM<sub>10</sub>; 1-hr mean)



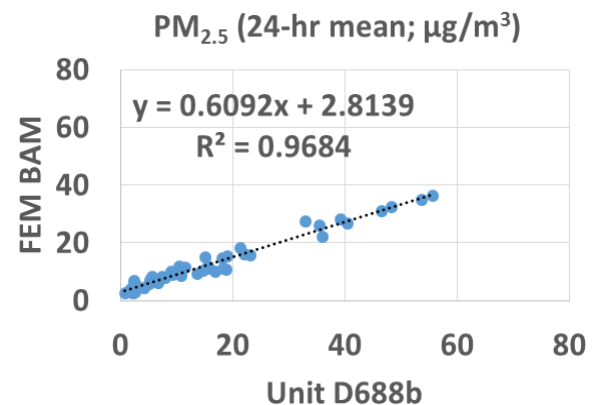
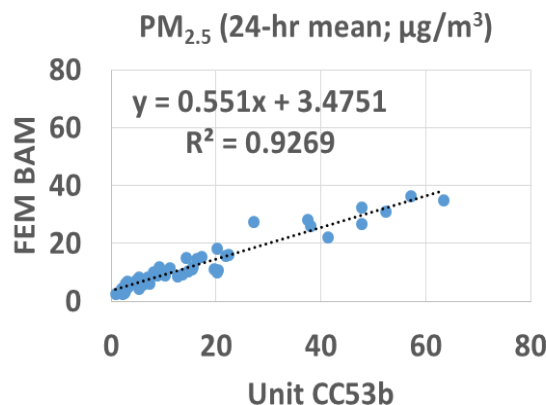
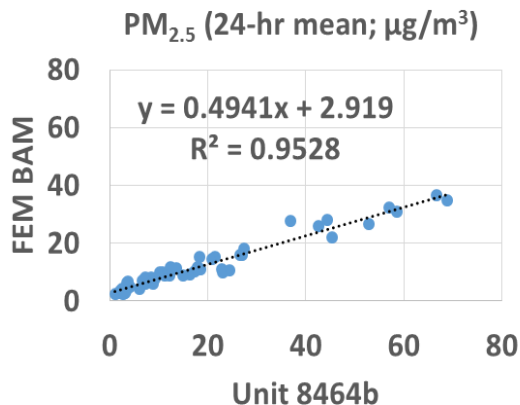
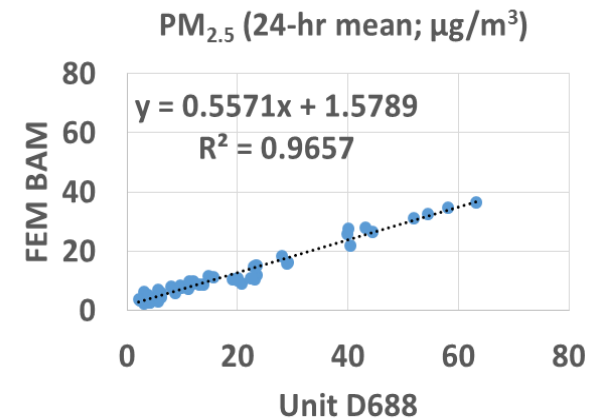
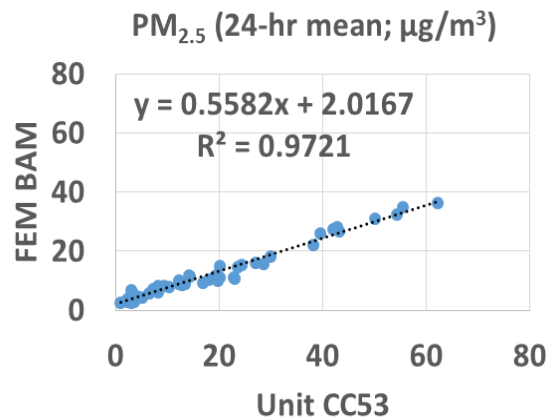
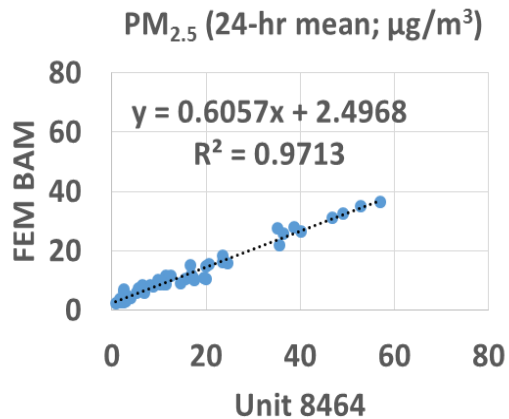
- Purple Air PA-II PM<sub>10</sub> mass measurements correlate well with the corresponding FEM BAM data ( $R^2 > 0.60$ )

# Purple Air PA-II vs FEM BAM (PM<sub>10</sub>; 1-hr mean)



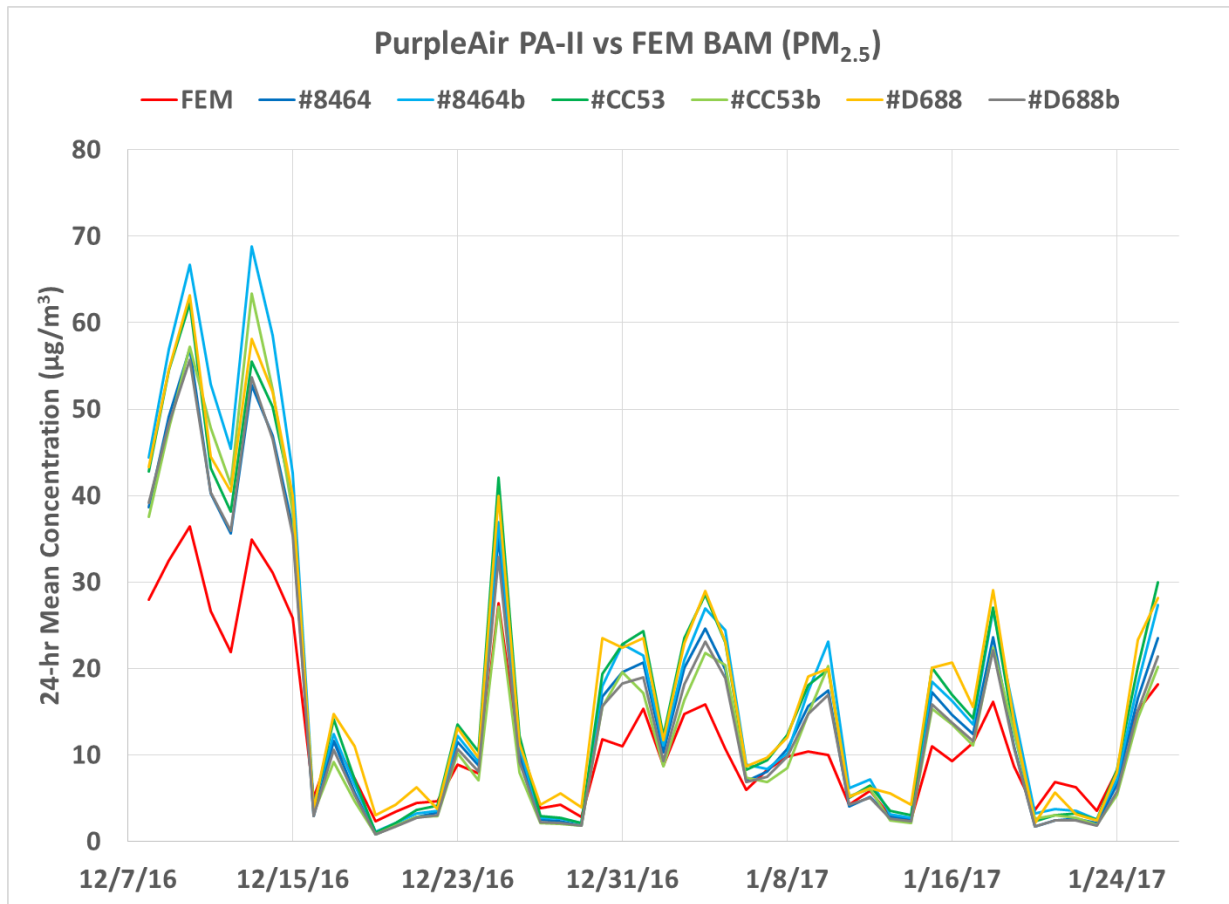
- PurpleAir PA-II sensors seem to track the diurnal PM<sub>10</sub> variations recorded by the FEM BAM instrument

# Purple Air PA-II vs FEM BAM (PM<sub>2.5</sub>; 24-hr mean)



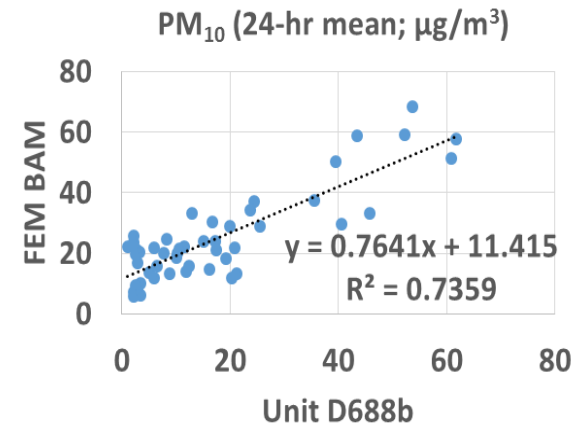
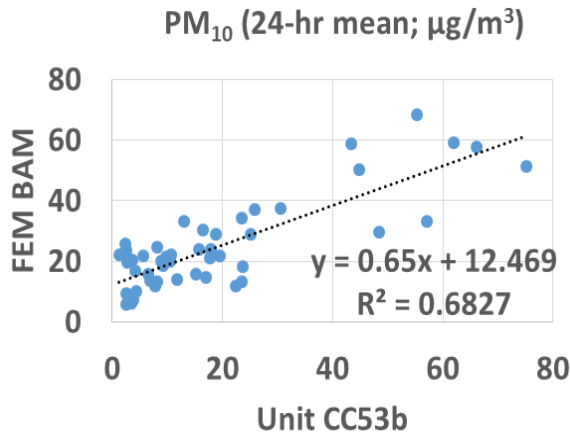
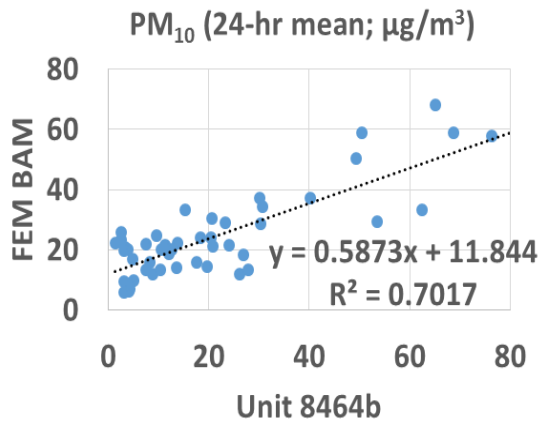
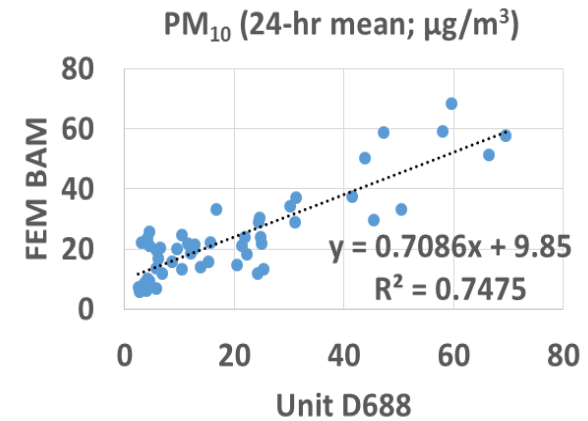
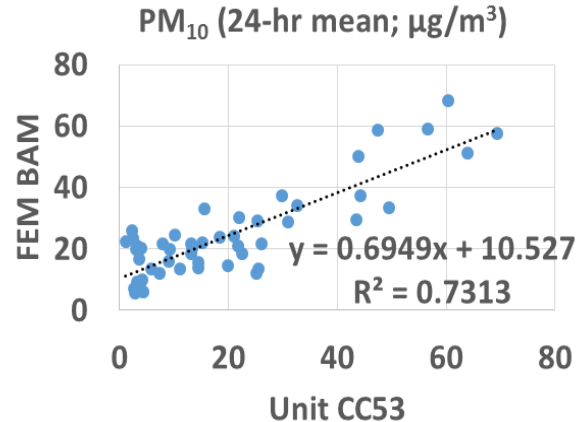
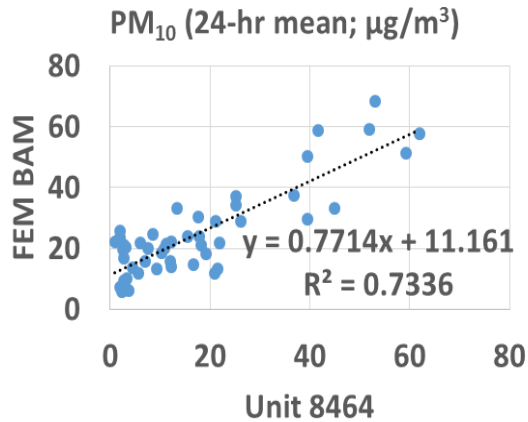
- Purple Air PA-II PM<sub>2.5</sub> mass measurements correlate very well with the corresponding FEM BAM data ( $R^2 > 0.92$ )
- Measurements from all Purple Air devices are quite accurate

# Purple Air PA-II vs FEM BAM (PM<sub>2.5</sub>; 24-hr mean)



- PurpleAir PA-II sensors track well the diurnal PM<sub>2.5</sub> variations recorded by the FEM BAM instrument

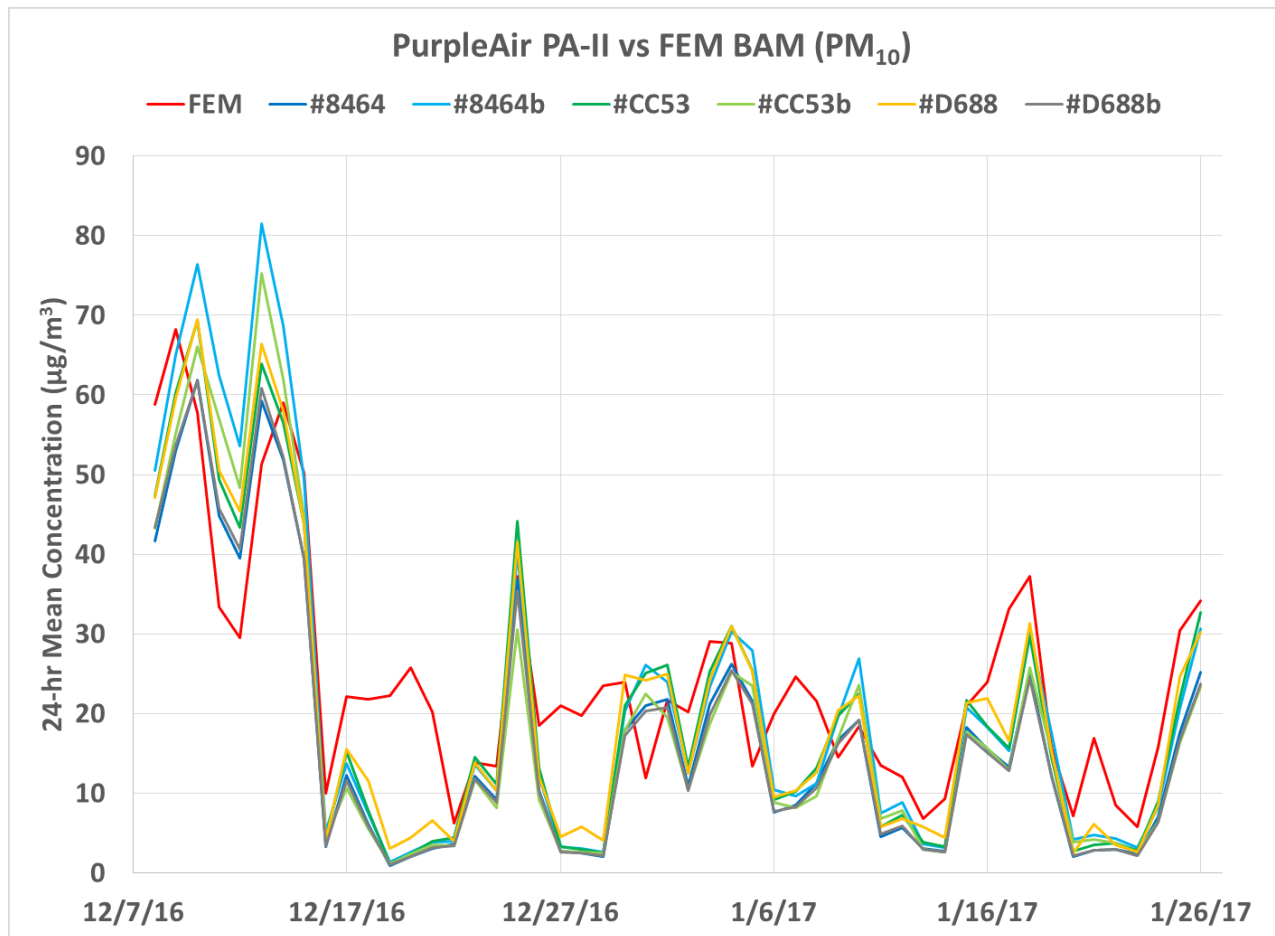
# Purple Air PA-II vs FEM BAM (PM<sub>10</sub>; 24-hr mean)



- Purple Air PA-II PM<sub>10</sub> mass measurements correlate well with the corresponding FEM BAM data ( $R^2 > 0.68$ )



# Purple Air PA-II vs FEM BAM (PM<sub>10</sub>; 24-hr mean)



- PurpleAir PA-II sensors seem to track the diurnal PM<sub>10</sub> variations recorded by the FEM BAM instrument

# Discussion

- The three **Purple Air PA-II** sensor nodes (two raw sensors in each node) were very reliable (data recovery was between 95 and 99% for all units tested) and were characterized by very low intra-model variability
- PM<sub>1.0</sub> sensor data correlated very well ( $R^2 > 0.96$ ) with the corresponding values collected using a substantially more expensive particle instrument (GRIMM) and were quite accurate
- PM<sub>2.5</sub> sensor data correlated very well with the corresponding FEM GRIMM and FEM BAM values ( $R^2 > 0.93$  and  $R^2 > 0.86$ , respectively) and were quite accurate
- PM<sub>10</sub> sensor measurements correlated well with the corresponding GRIMM and FEM BAM values ( $R^2 > 0.68$  and  $R^2 > 0.60$ , respectively) (1-hr average)
- The designs of the raw sensor inlet/outlet and node housing in PA-II (PMS5003) are both different than those in PA-I (PMS1003)
- Two raw sensors are attached to each other in PA-II compared to one raw sensor in PA-I
- The user manuals for PMS5003 as well as for PMS1003 (PA-I) can be found in:  
[http://www.aqmd.gov/aq-spec/resources#&MainContent\\_C001\\_Col00=1](http://www.aqmd.gov/aq-spec/resources#&MainContent_C001_Col00=1)
- No sensor calibration was performed by SCAQMD Staff prior to the beginning of this test
- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors over different / more extreme environmental conditions
- All results are still preliminary