Field Evaluation
Purple Air (PA-II) PM Sensor

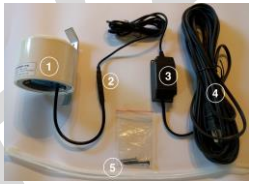
South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

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 ($\mu g/m^3$)
  - 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 ($\mu g/m^3$)
  - Unit cost: ~$20,000
  - Time resolution: 1-hr

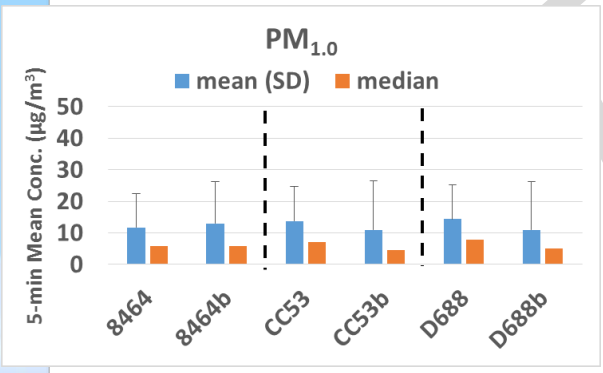
- GRIMM (*reference method*):
  - Optical particle counter (FEM $PM_{2.5}$)
  - Uses proprietary algorithms to calculate total $PM_{1.0}$, $PM_{2.5}$, and PM_{10} mass from particle number measurements
  - Unit Cost: ~$25,000 and up
  - Time resolution: 1-min

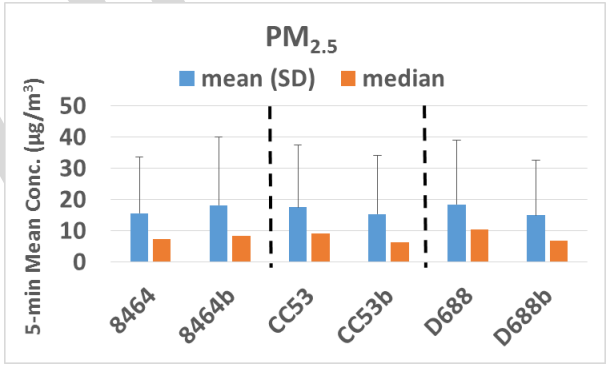
Data validation & recovery

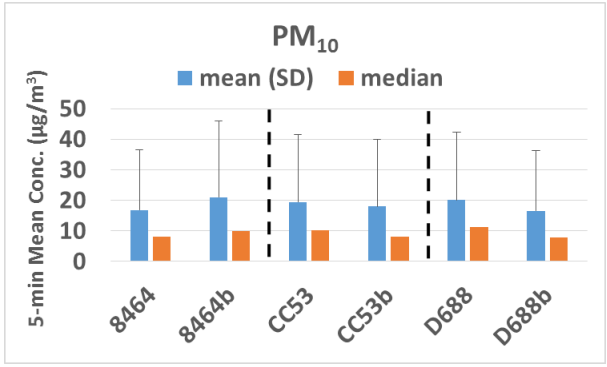
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery for $PM_{1.0}$, $PM_{2.5}$ and PM_{10} from all three Purple Air PA-II sensor nodes was between 95 and 99%.

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 ($\mu g/m^3$)





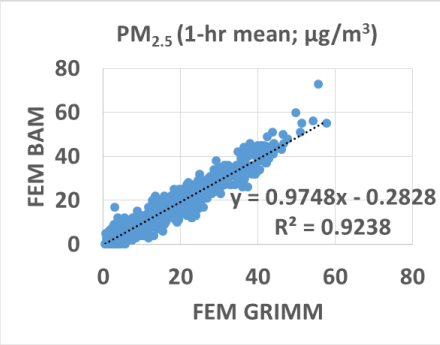


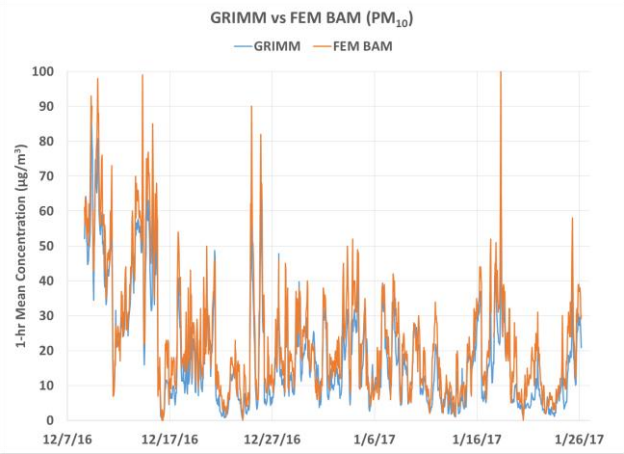
Data validation & recovery

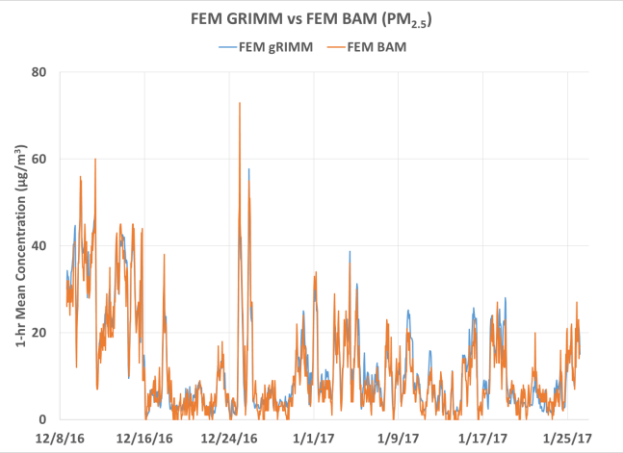
- Basic QA/QC procedures were used to validate the collected PM data (i.e. obvious outliers, negative values and invalid data-points were eliminated from data-set)
- $PM_{2.5}$ and PM_{10} data recovery was close to 100 % for the GRIMM and the BAM

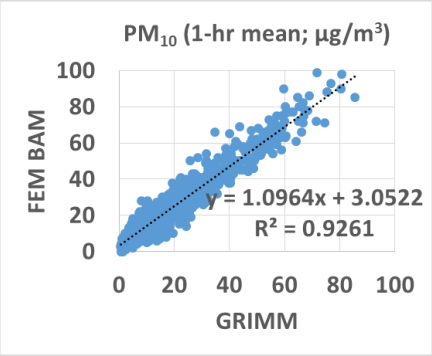
Equivalent methods: BAM vs GRIMM

- Excellent correlation between the two equivalent methods for $PM_{2.5}$ & PM_{10}

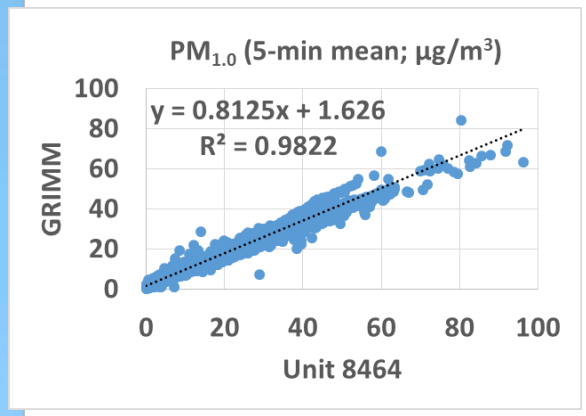


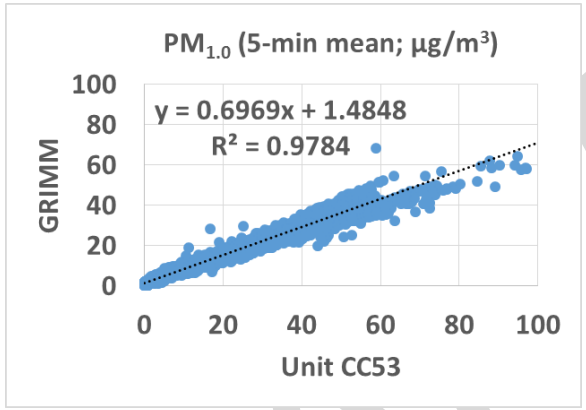


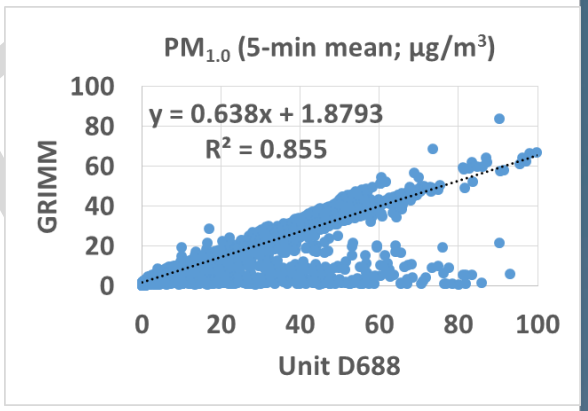


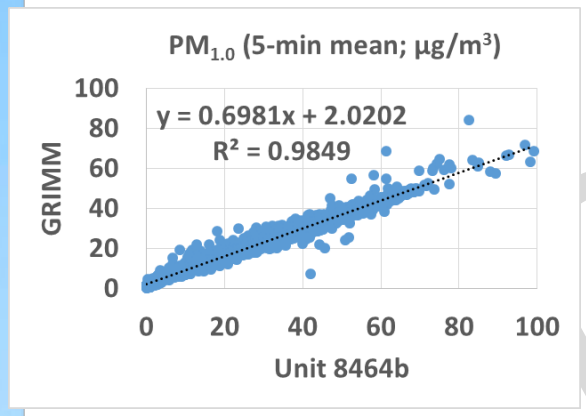


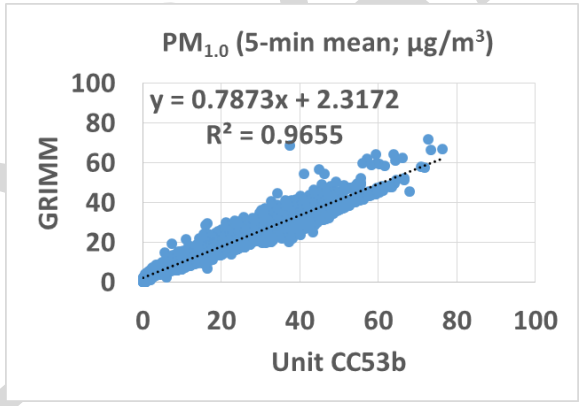
Purple Air PA-II vs GRIMM ($PM_{1.0}$; 5-min mean)

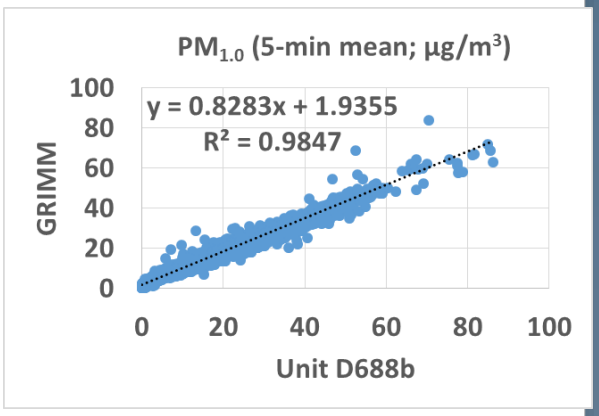






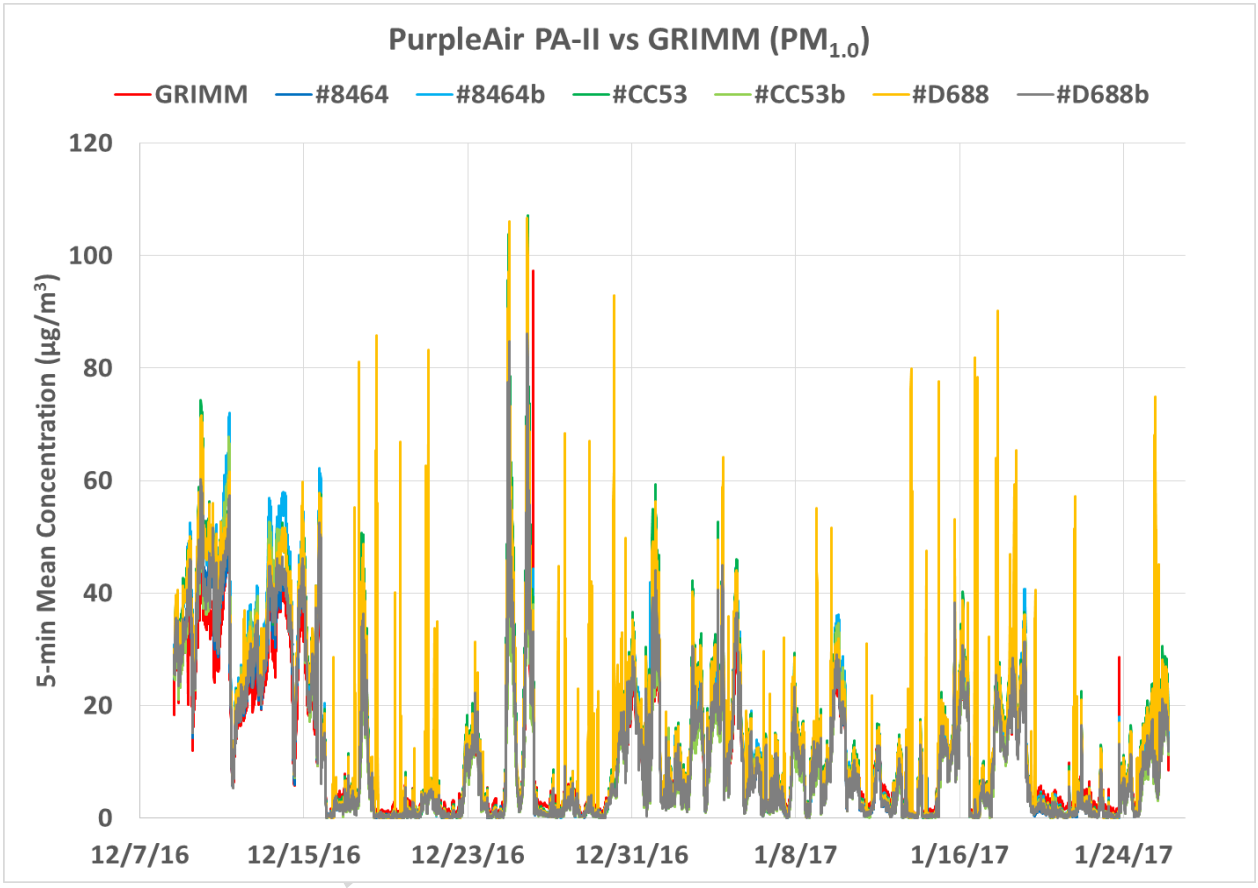






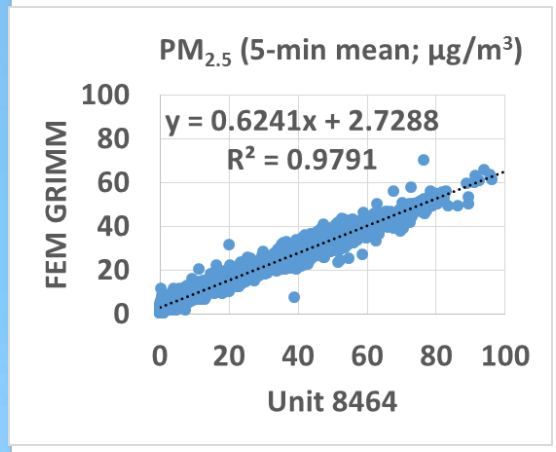
- Purple Air PA-II $PM_{1.0}$ mass measurements correlate very well with the corresponding GRIMM data ($R^2 > 0.96$), with the exception of sensor #D688 ($R^2 > 0.855$)
- Measurements from all Purple Air devices are quite accurate

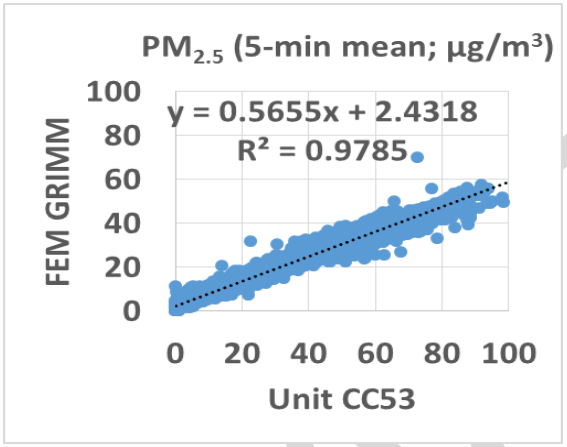
Purple Air PA-II vs GRIMM ($PM_{1.0}$; 5-min mean)

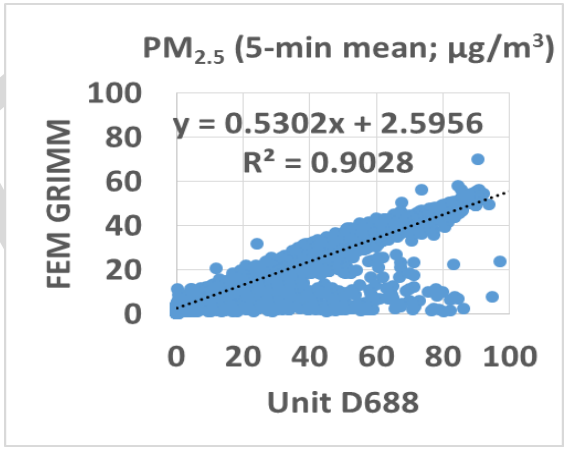


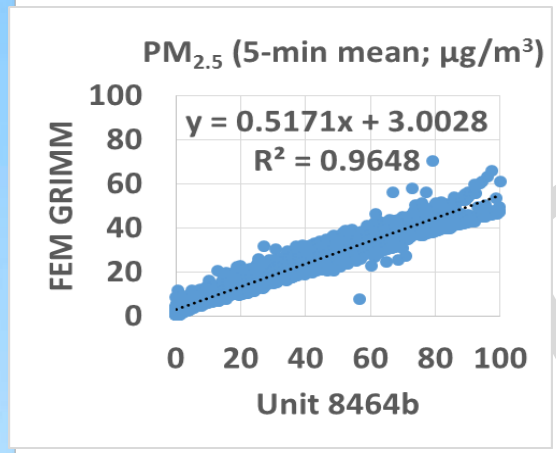
- PurpleAir PA-II sensors track well the diurnal $PM_{1.0}$ variations recorded by the GRIMM instrument with the exception of unit #D688

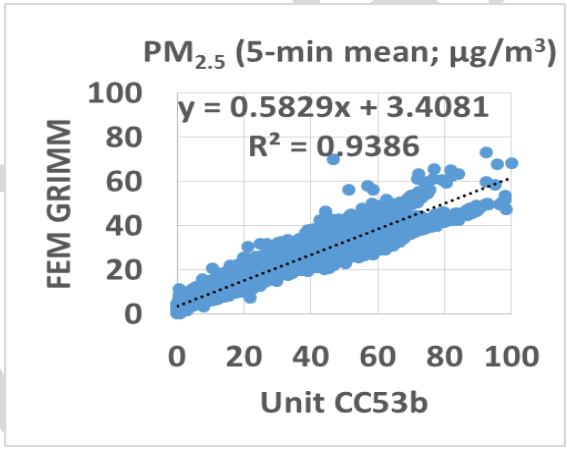
Purple Air PA-II vs FEM GRIMM ($PM_{2.5}$; 5-min mean)

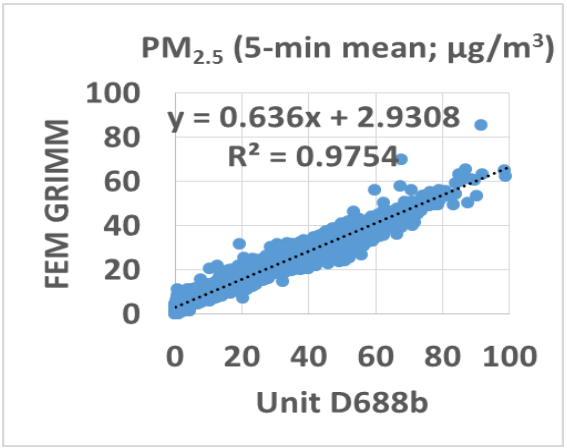






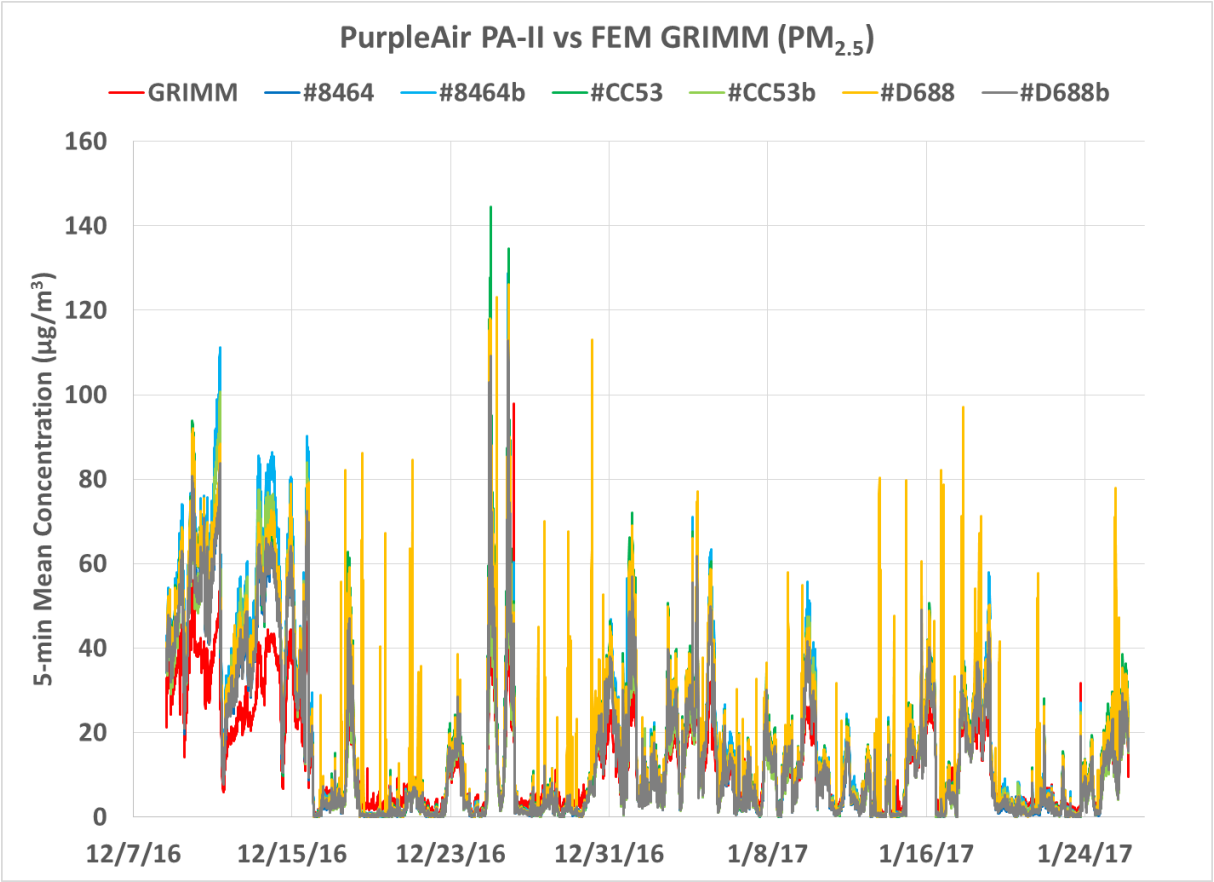






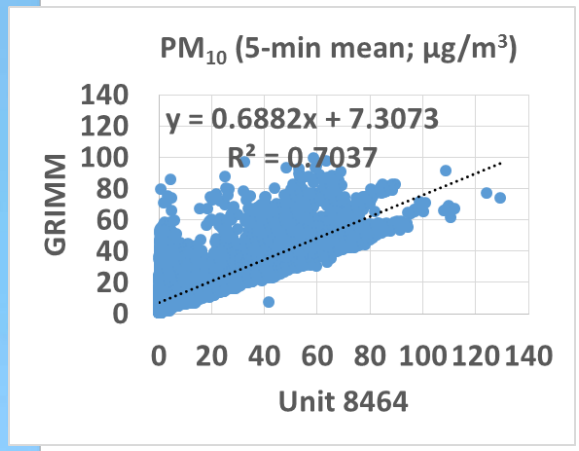
- Purple Air PA-II $PM_{2.5}$ mass measurements correlate very well with the corresponding FEM GRIMM data ($R^2 > 0.93$), with the exception of sensor #D688 ($R^2 > 0.90$)
- Measurements from all Purple Air devices are quite accurate

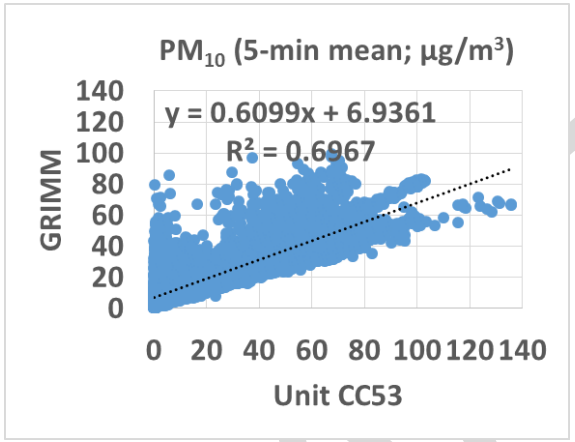
Purple Air PA-II vs FEM GRIMM ($PM_{2.5}$; 5-min mean)

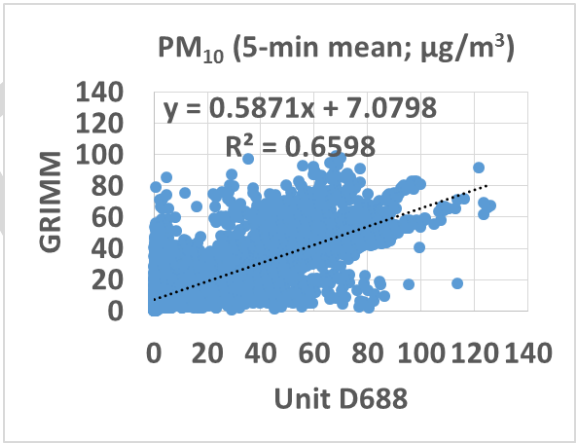


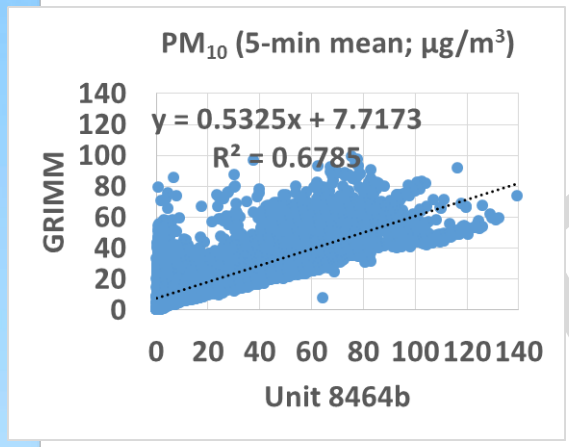
- PurpleAir PA-II sensors track well the diurnal $PM_{2.5}$ variations recorded by the FEM GRIMM instrument, with the exception of unit #D688

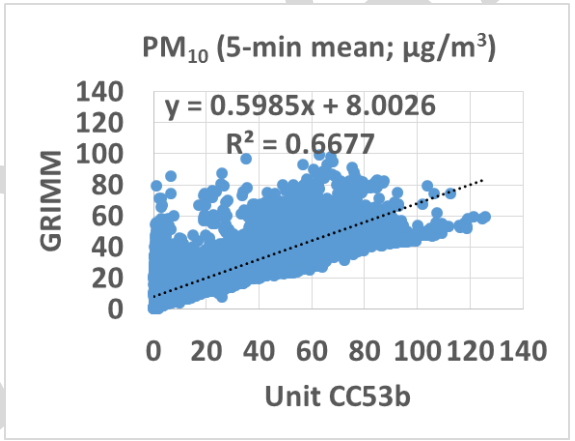
Purple Air PA-II vs GRIMM (PM_{10}; 5-min mean)

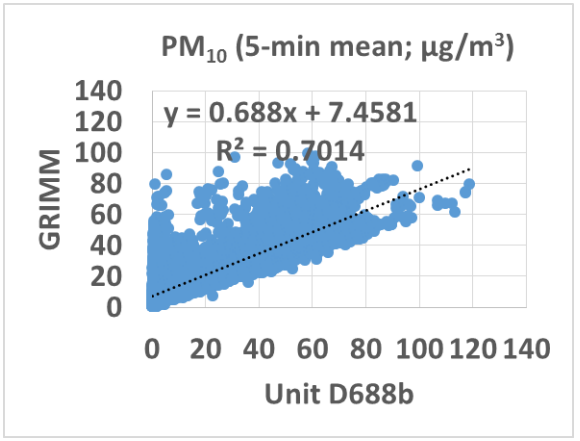






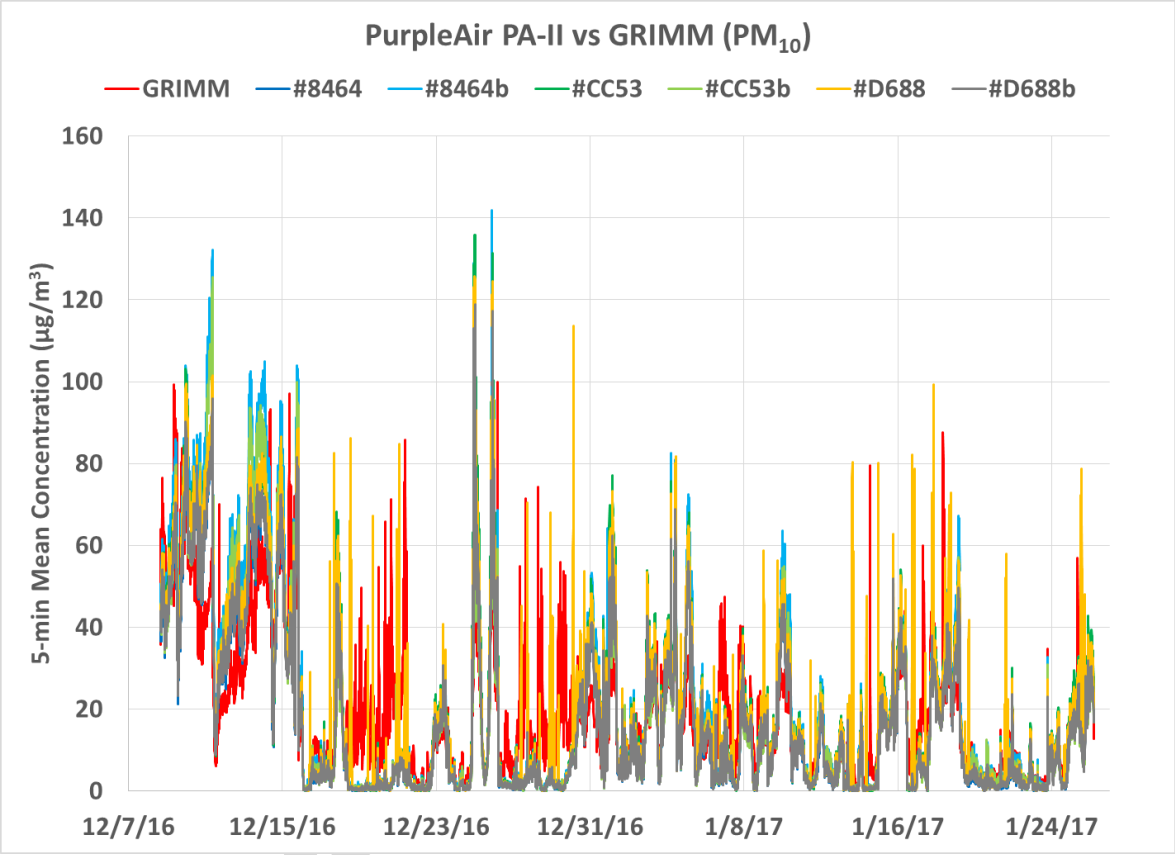






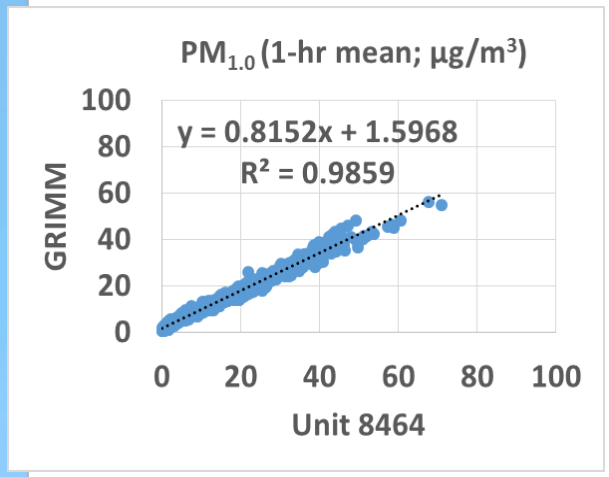
- Purple Air PA-II PM_{10} mass measurements correlate well with the corresponding GRIMM data ($R^2 > 0.65$)

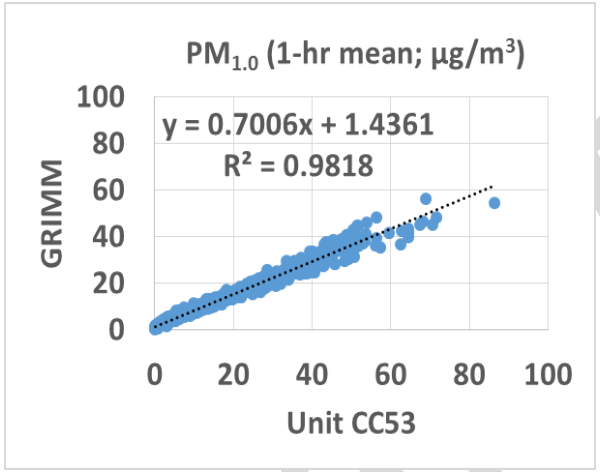
Purple Air PA-II vs GRIMM (PM_{10}; 5-min mean)

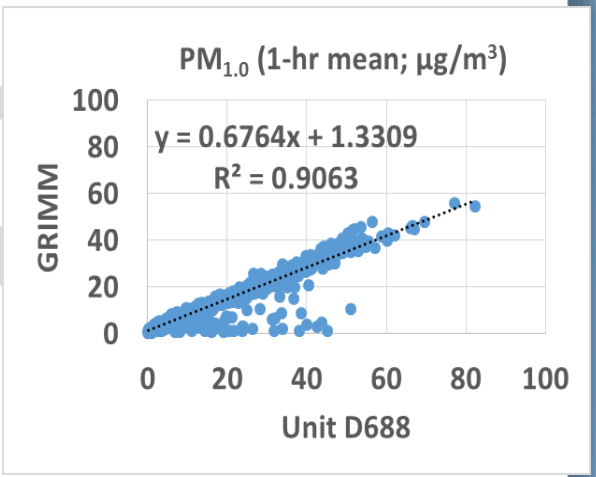


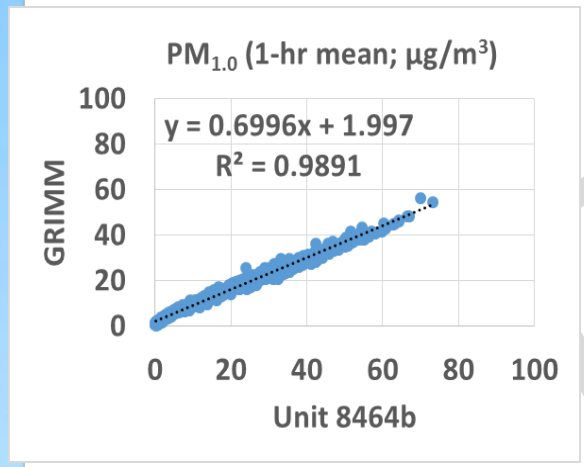
- PurpleAir PA-II sensors seem to track the diurnal PM_{10} variations recorded by the GRIMM instrument

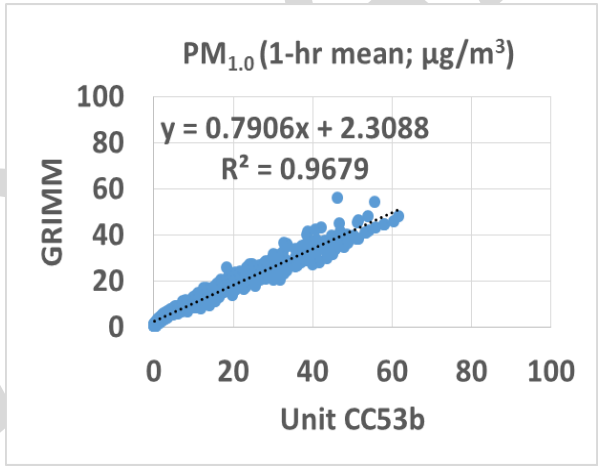
Purple Air PA-II vs GRIMM ($PM_{1.0}$; 1-hr mean)

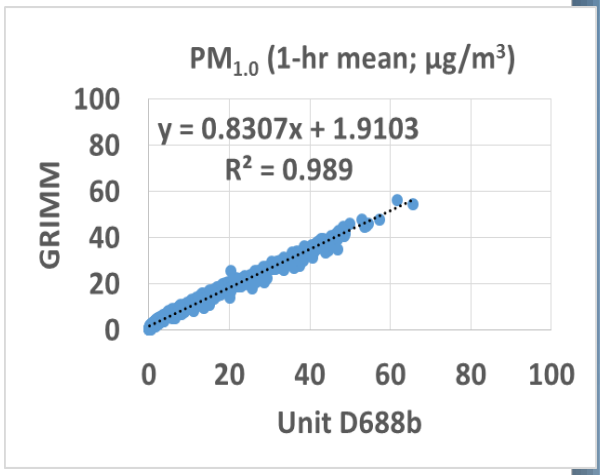






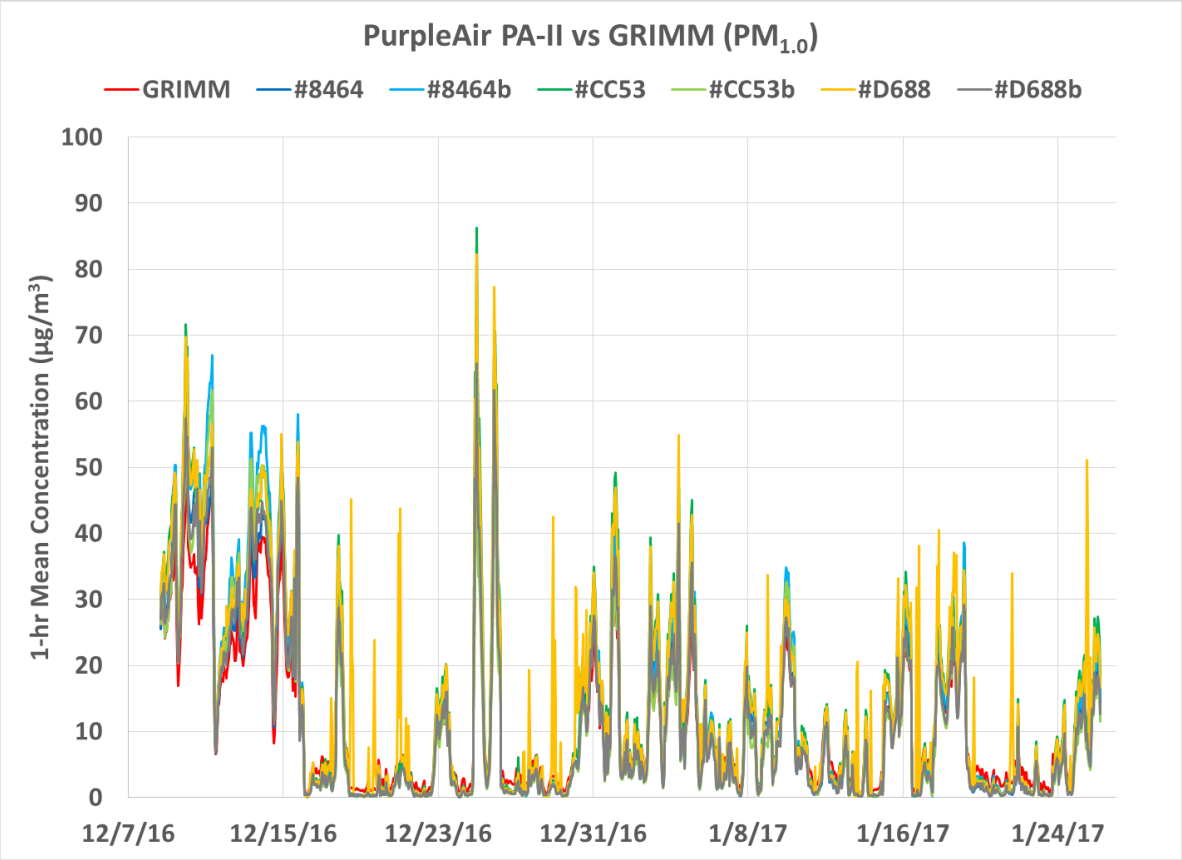






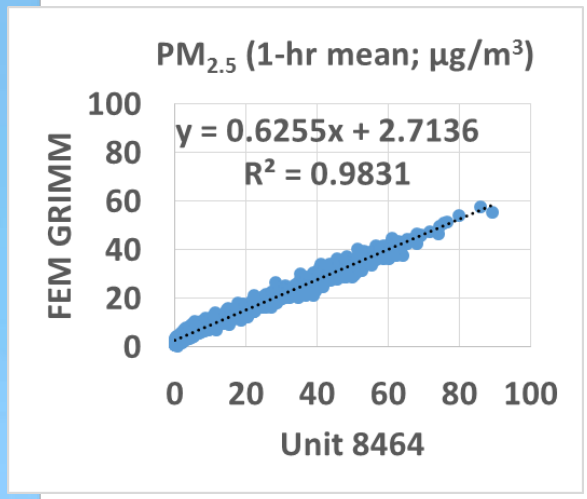
- Purple Air PA-II $PM_{1.0}$ mass measurements correlate very well with the corresponding GRIMM data ($R^2 > 0.96$), with the exception of sensor #D688 ($R^2 > 0.90$)
- Measurements from all Purple Air devices are quite accurate

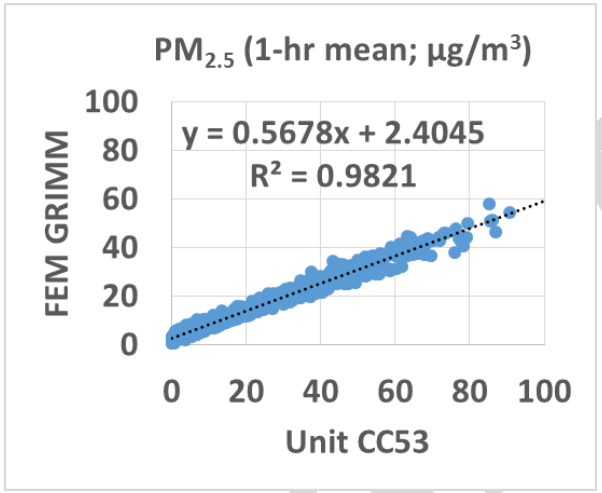
Purple Air PA-II vs GRIMM ($PM_{1.0}$; 1-hr mean)

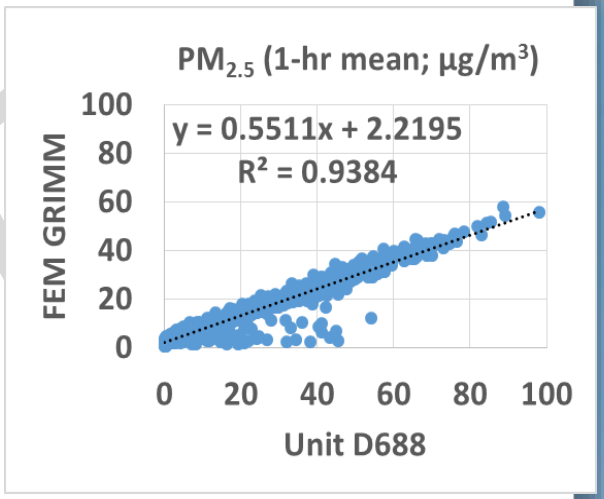


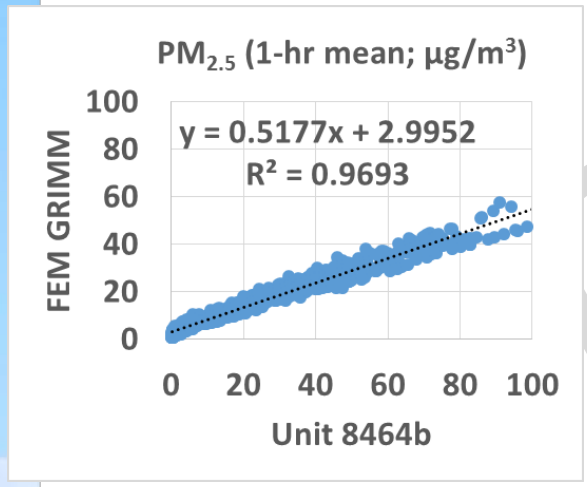
- PurpleAir PA-II sensors track well the diurnal $PM_{1.0}$ variations recorded by the GRIMM instrument, with the exception of sensor #D688

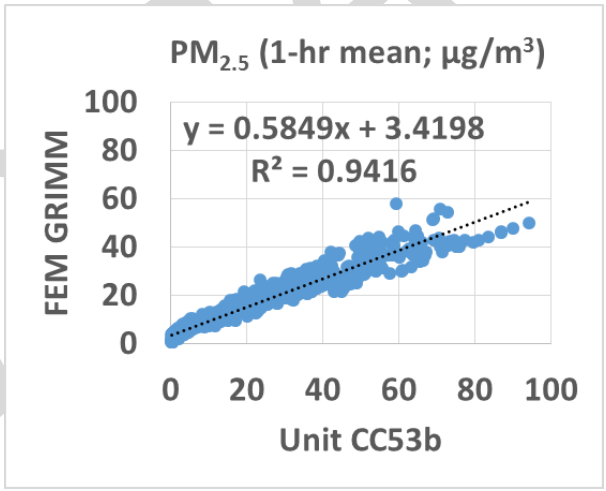
Purple Air PA-II vs FEM GRIMM ($PM_{2.5}$; 1-hr mean)

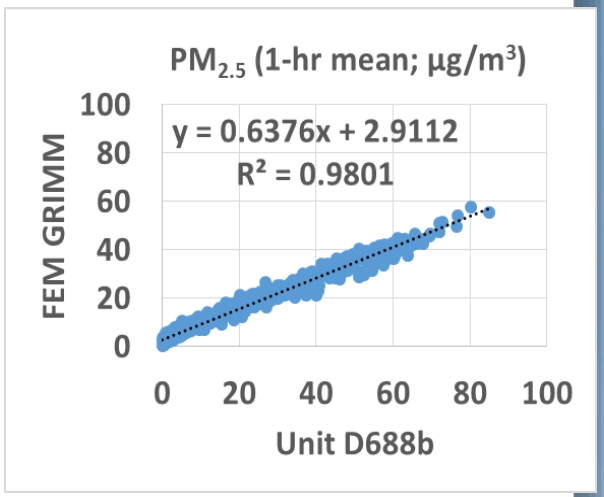






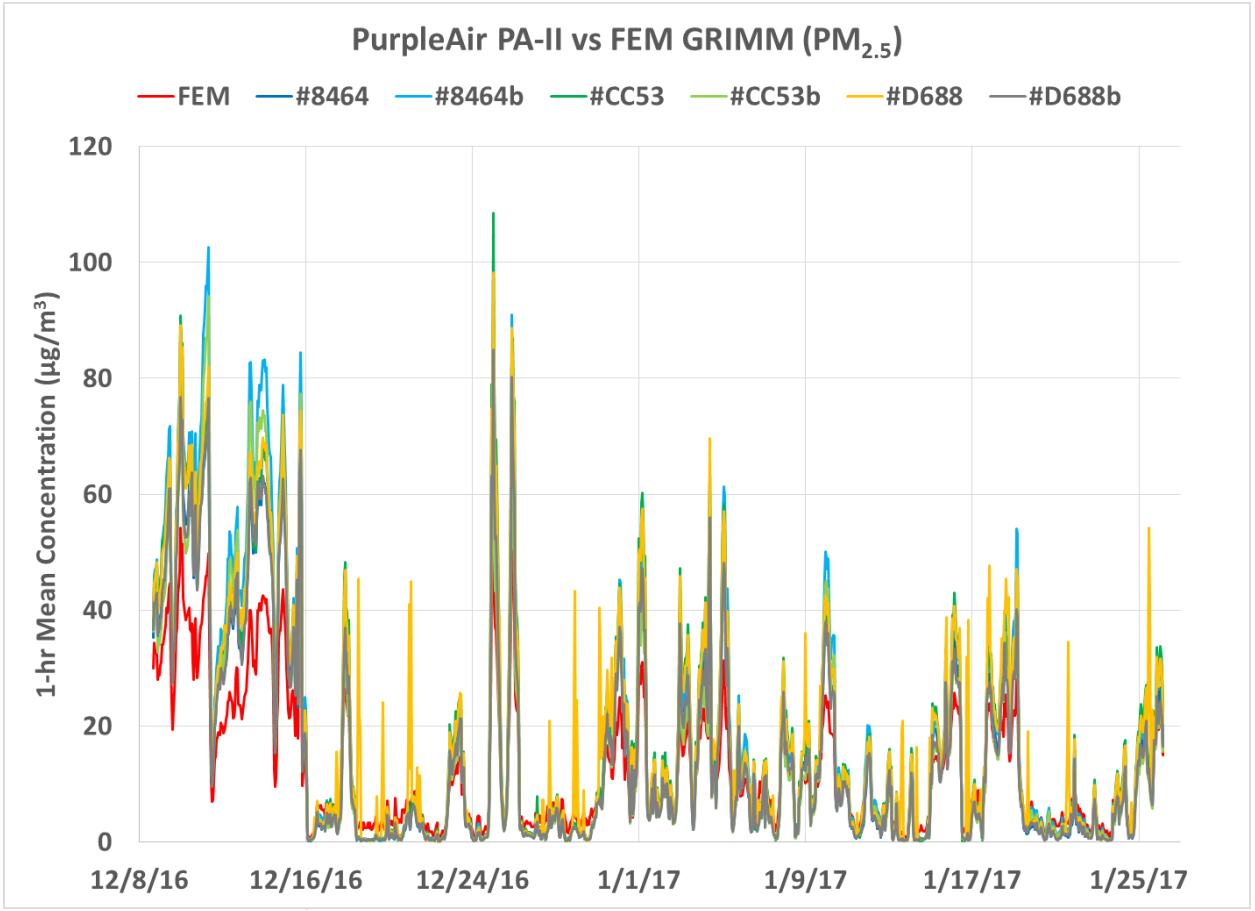






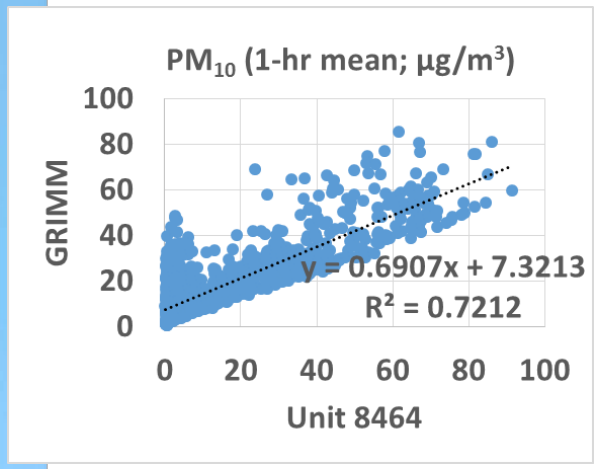
- Purple Air PA-II $PM_{2.5}$ mass measurements correlate very well with the corresponding FEM GRIMM data ($R^2 > 0.93$)
- Measurements from all Purple Air devices are quite accurate

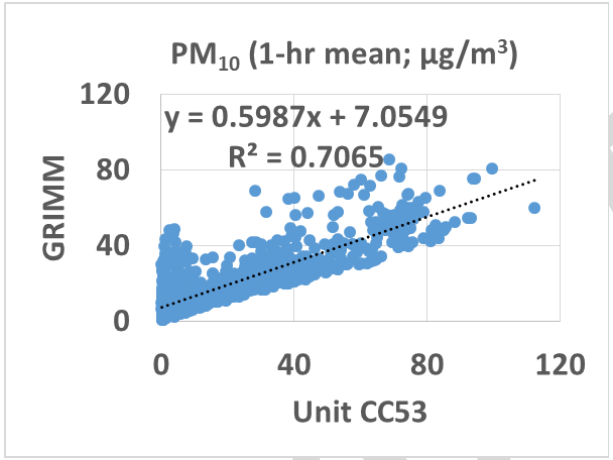
Purple Air PA-II vs FEM GRIMM ($PM_{2.5}$; 1-hr mean)

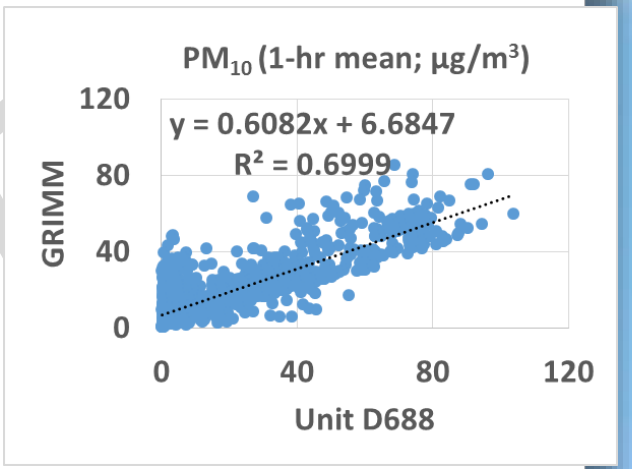


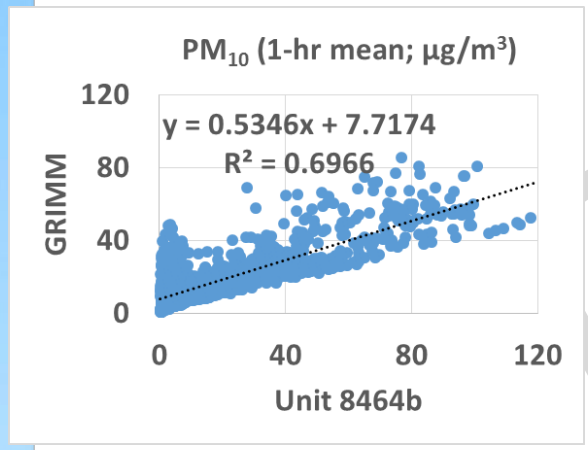
- PurpleAir PA-II sensors track well the diurnal $PM_{2.5}$ variations recorded by the FEM GRIMM instrument

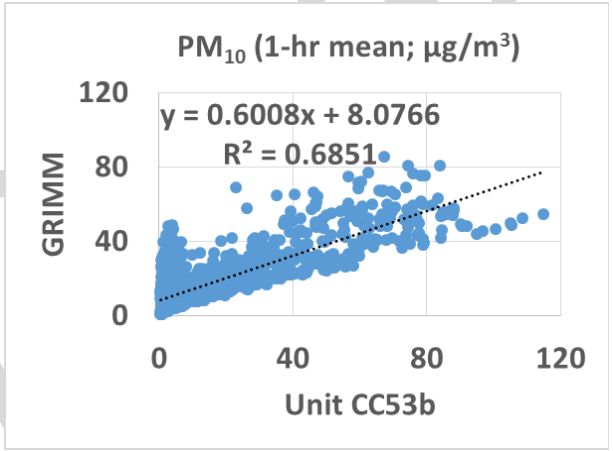
Purple Air PA-II vs GRIMM (PM_{10}; 1-hr mean)

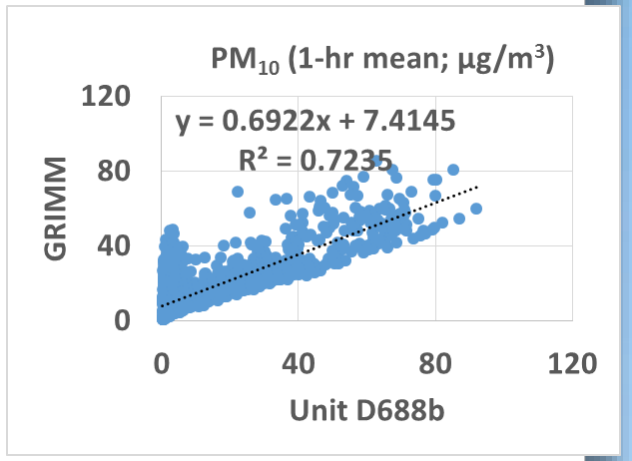






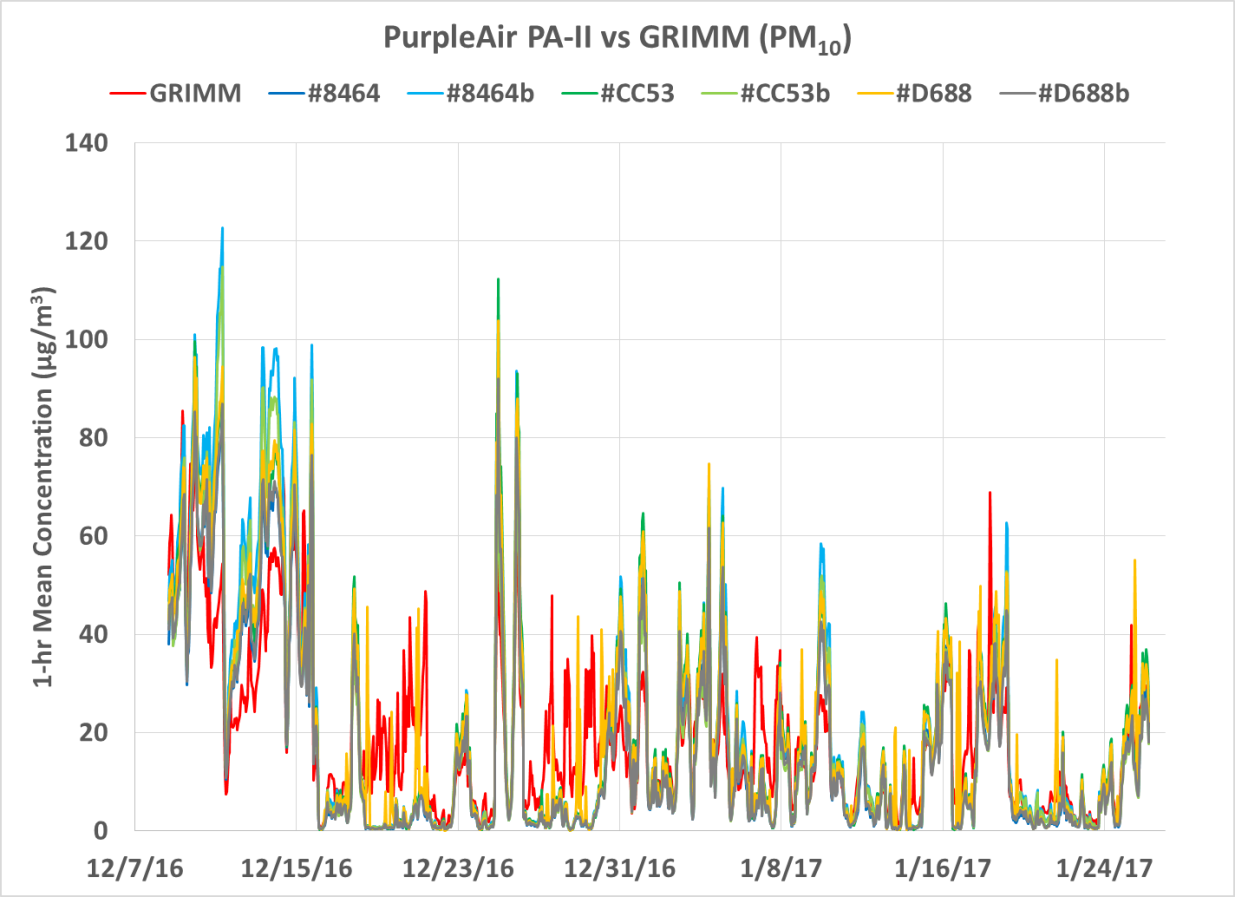






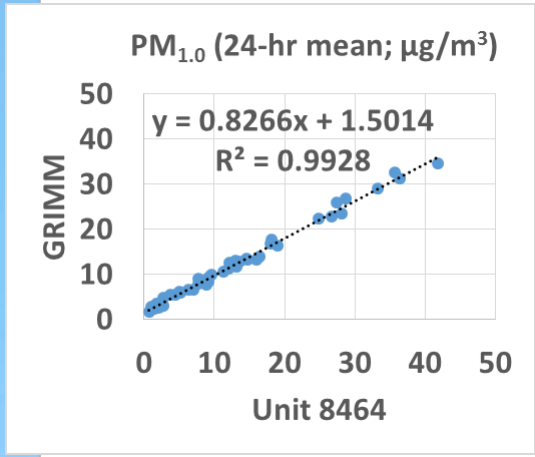
- Purple Air PA-II PM_{10} mass measurements correlate well with the corresponding GRIMM data ($R^2 > 0.68$)

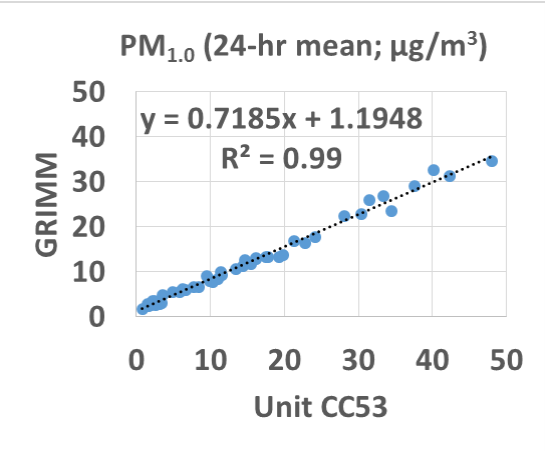
Purple Air PA-II vs GRIMM (PM_{10}; 1-hr mean)

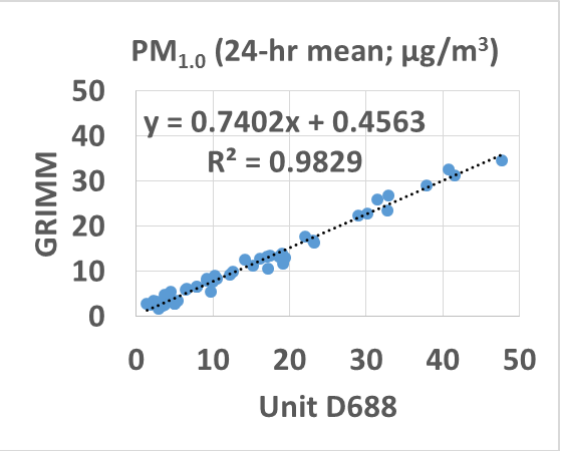


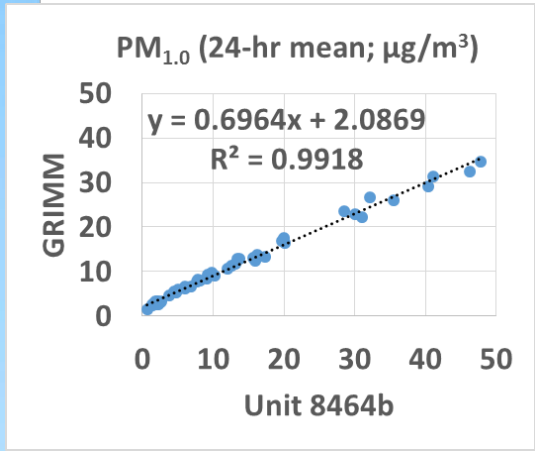
- PurpleAir PA-II sensors seem to track the diurnal PM_{10} variations recorded by the GRIMM instrument

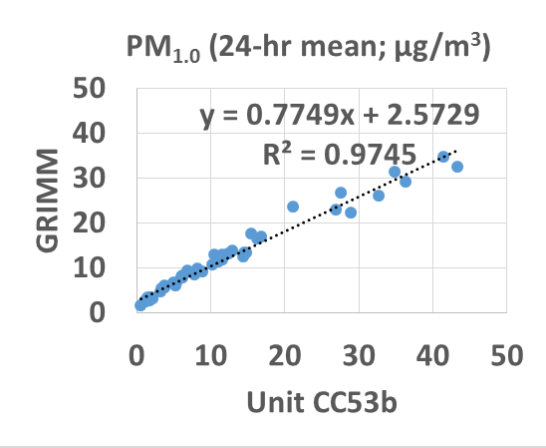
Purple Air PA-II vs GRIMM ($PM_{1.0}$; 24-hr mean)

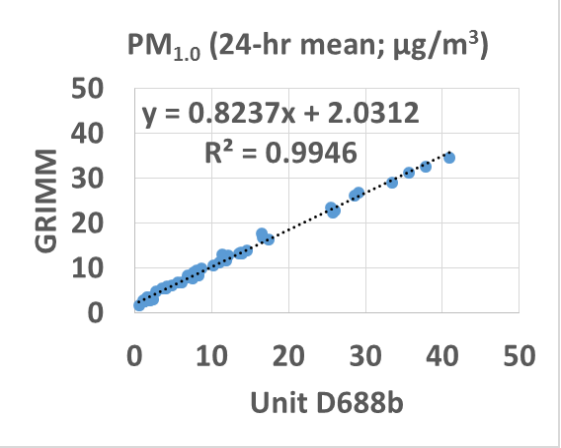






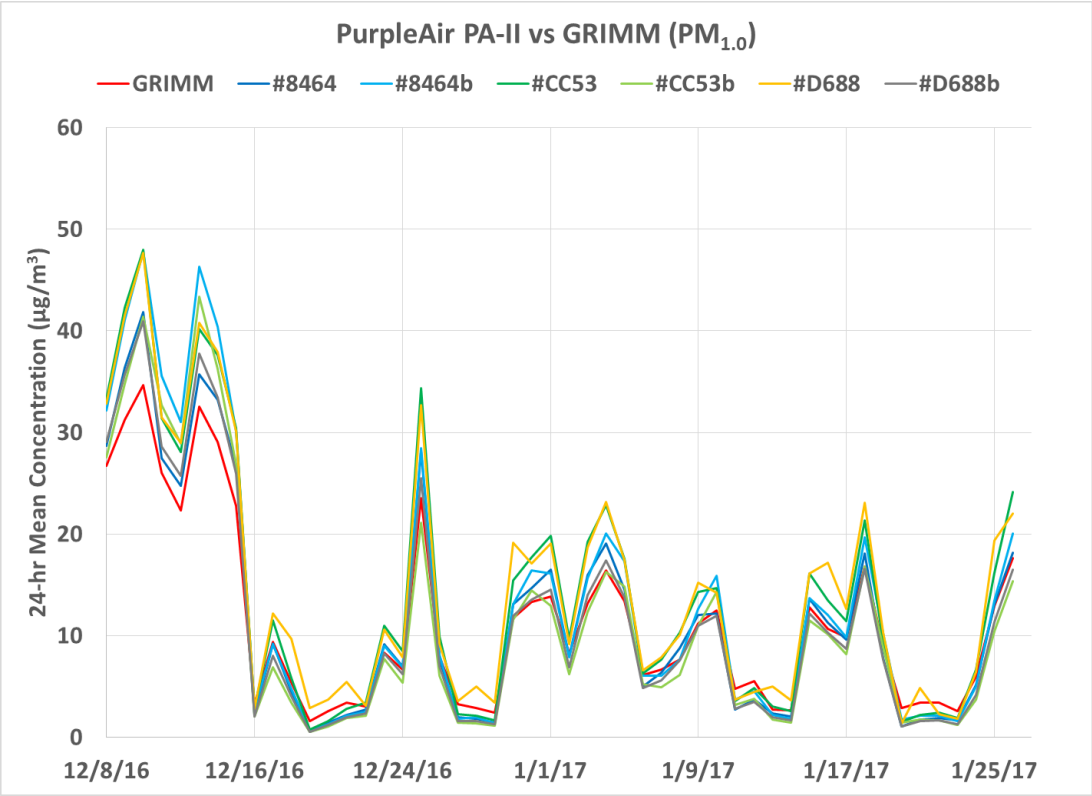






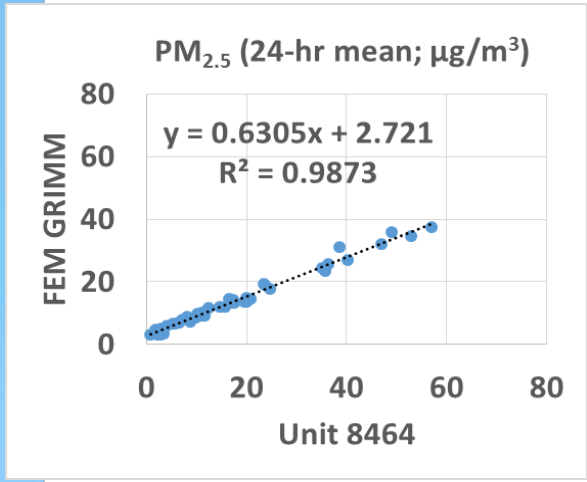
- Purple Air PA-II $PM_{1.0}$ mass measurements correlate very well with the corresponding GRIMM data ($R^2 > 0.97$)
- Measurements from all Purple Air devices are quite accurate

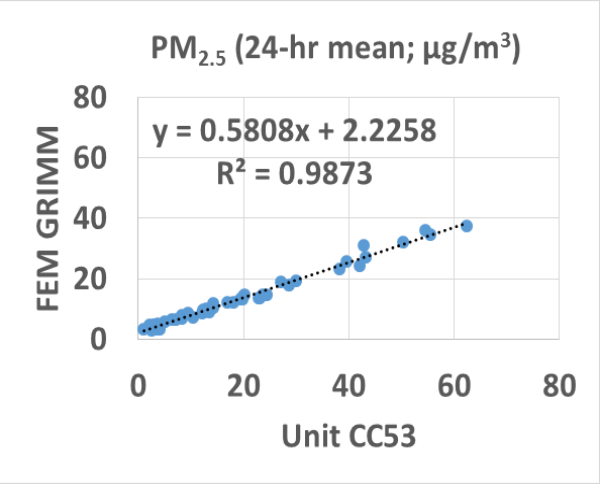
Purple Air PA-II vs GRIMM ($PM_{1.0}$; 24-hr mean)

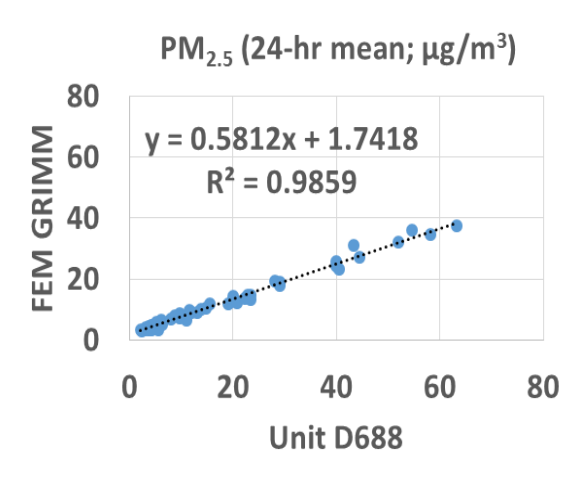


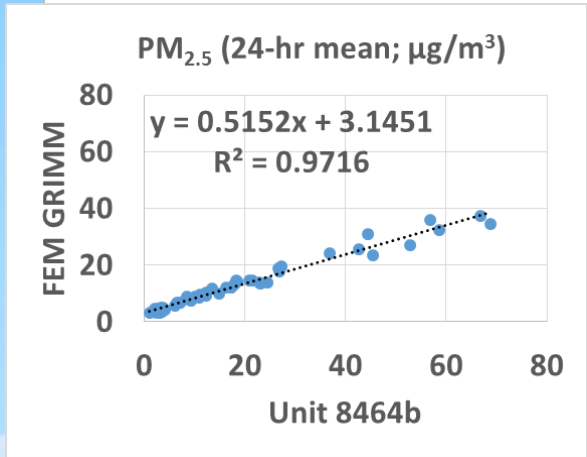
- PurpleAir PA-II sensors track very well the diurnal $PM_{1.0}$ variations recorded by the GRIMM instrument

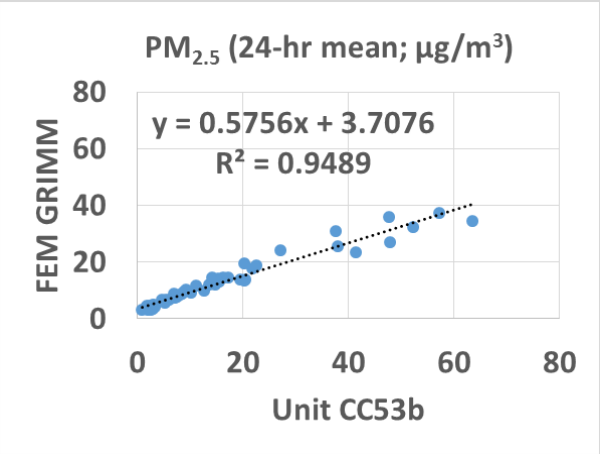
Purple Air PA-II vs FEM GRIMM ($PM_{2.5}$; 24-hr mean)

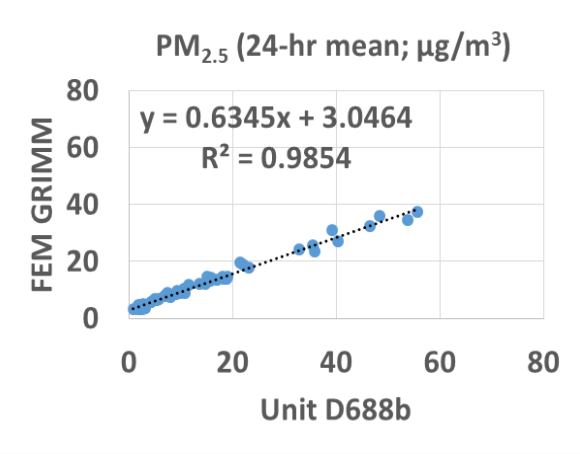






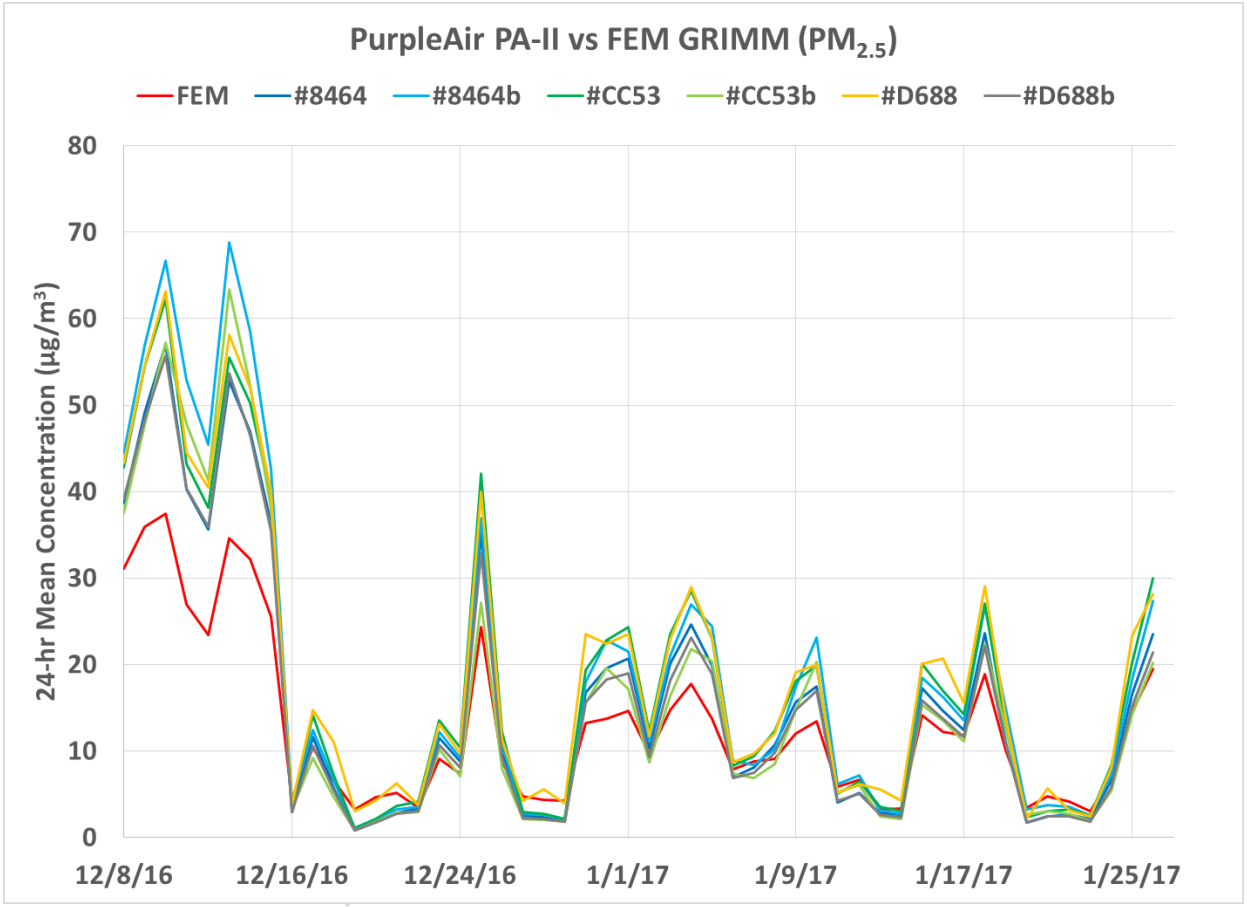






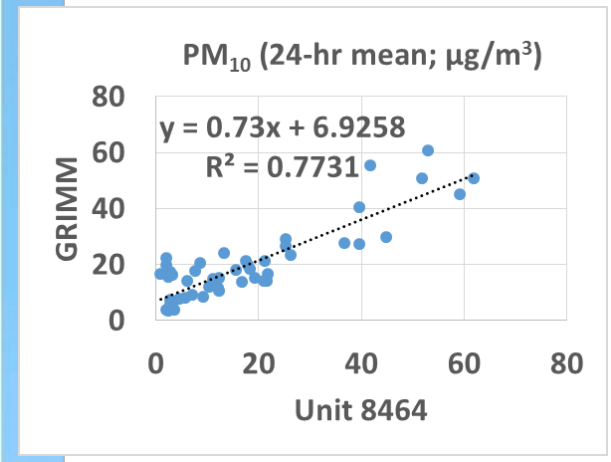
- Purple Air PA-II $PM_{2.5}$ mass measurements correlate very well with the corresponding FEM GRIMM data ($R^2 > 0.94$)
- Measurements from all Purple Air devices are quite accurate

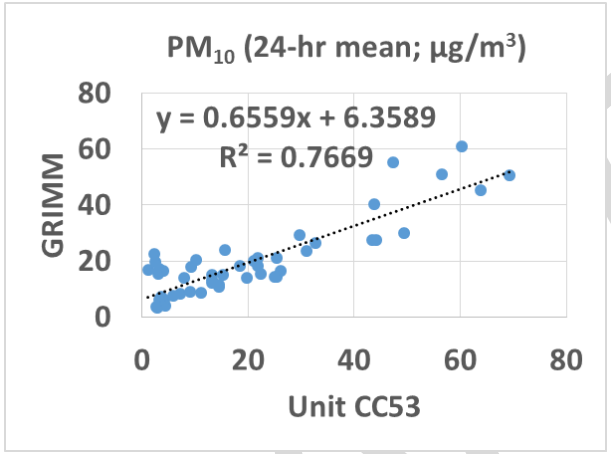
Purple Air PA-II vs FEM GRIMM ($PM_{2.5}$; 24-hr mean)

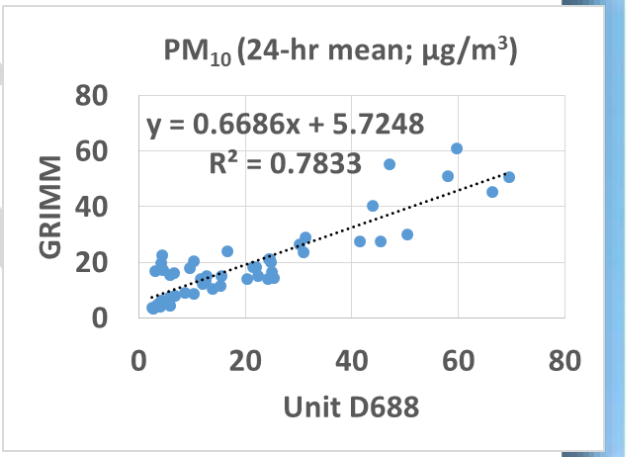


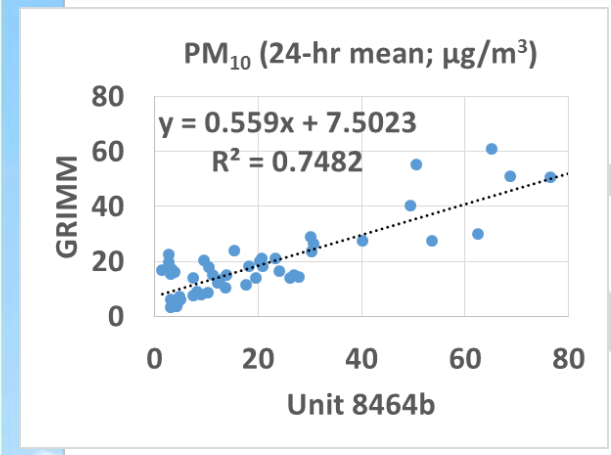
- PurpleAir PA-II sensors track very well the diurnal $PM_{2.5}$ variations recorded by the FEM GRIMM instrument

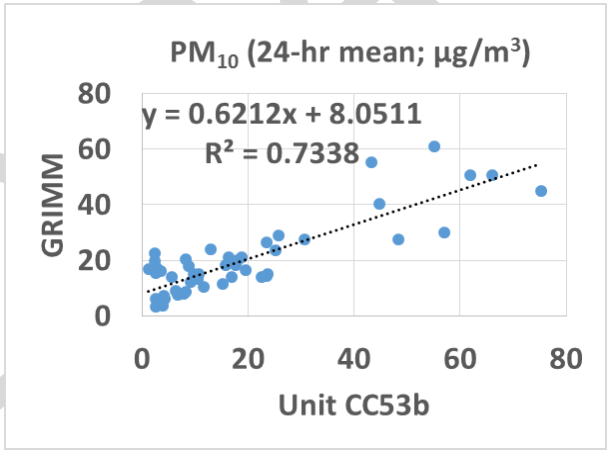
Purple Air PA-II vs GRIMM (PM_{10}; 24-hr mean)

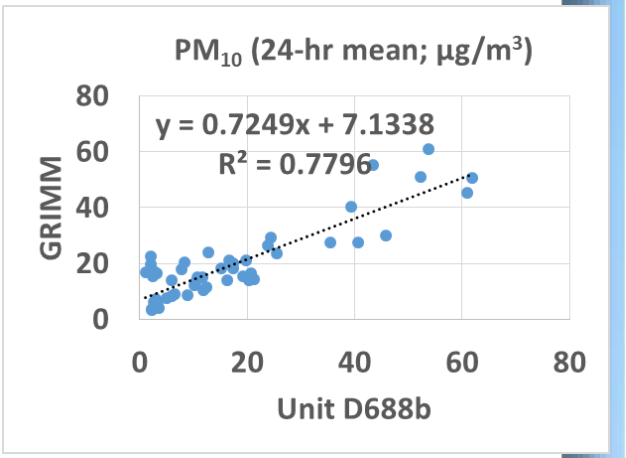






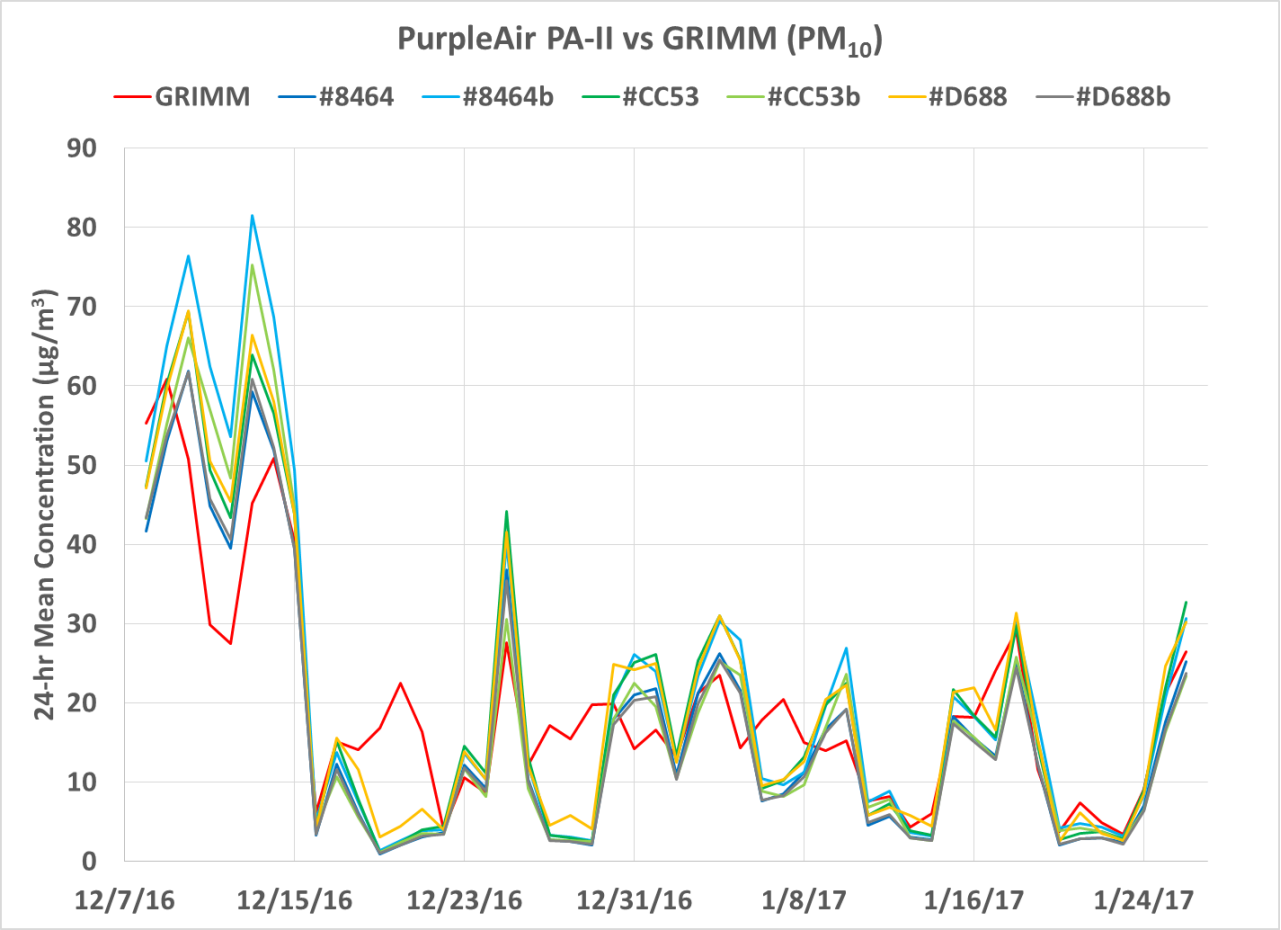






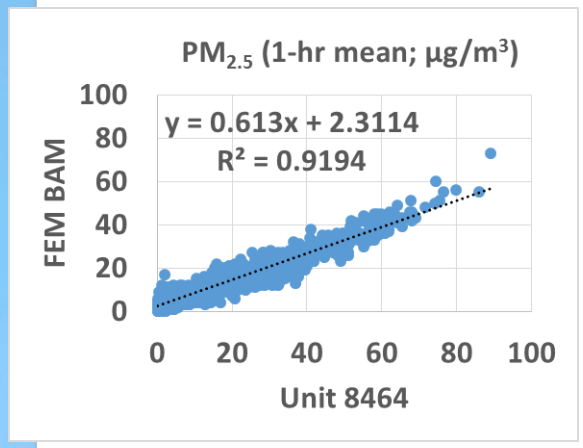
- Purple Air PA-II PM_{10} mass measurements correlate well with the corresponding GRIMM data ($R^2 > 0.73$)

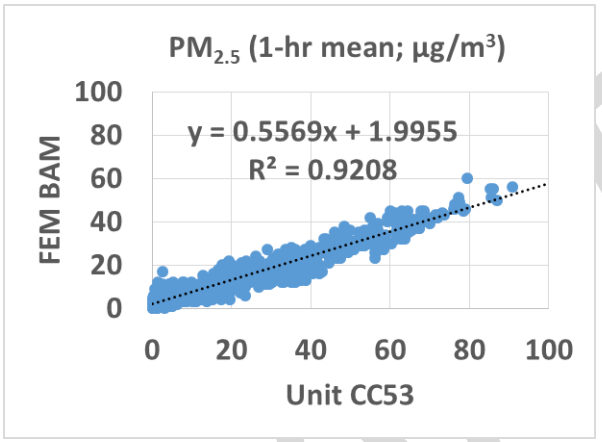
Purple Air PA-II vs GRIMM (PM_{10}; 24-hr mean)

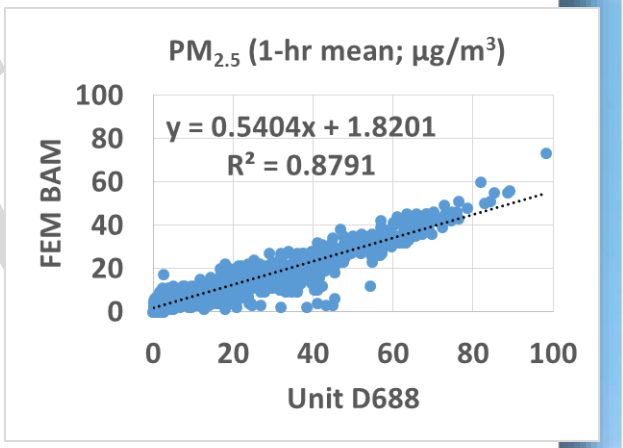


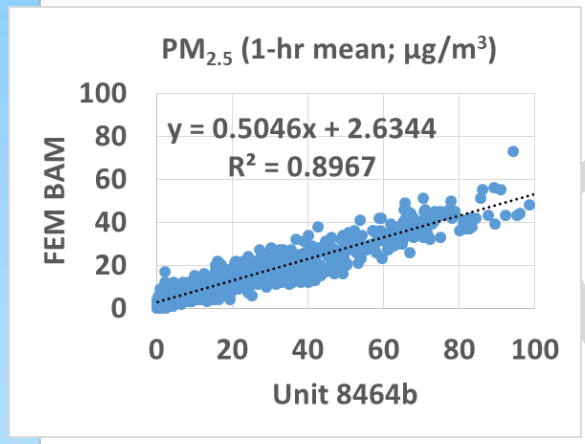
- PurpleAir PA-II sensors seem to track the diurnal PM_{10} variations recorded by the GRIMM instrument

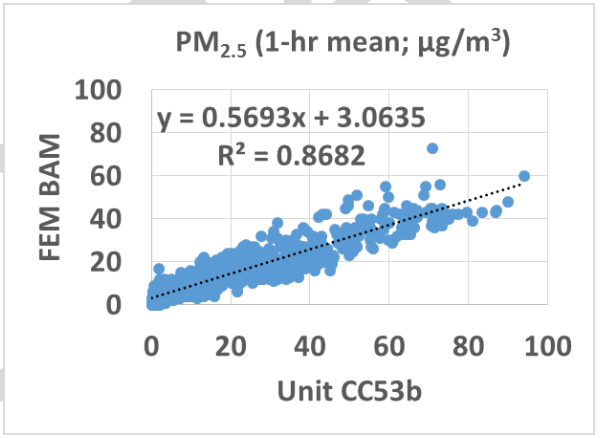
Purple Air PA-II vs FEM BAM ($PM_{2.5}$; 1-hr mean)

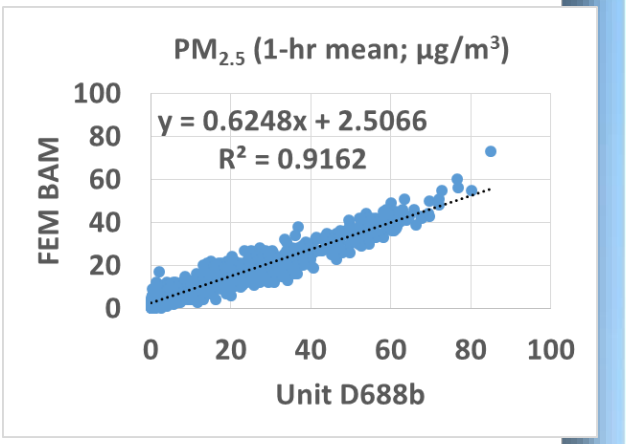






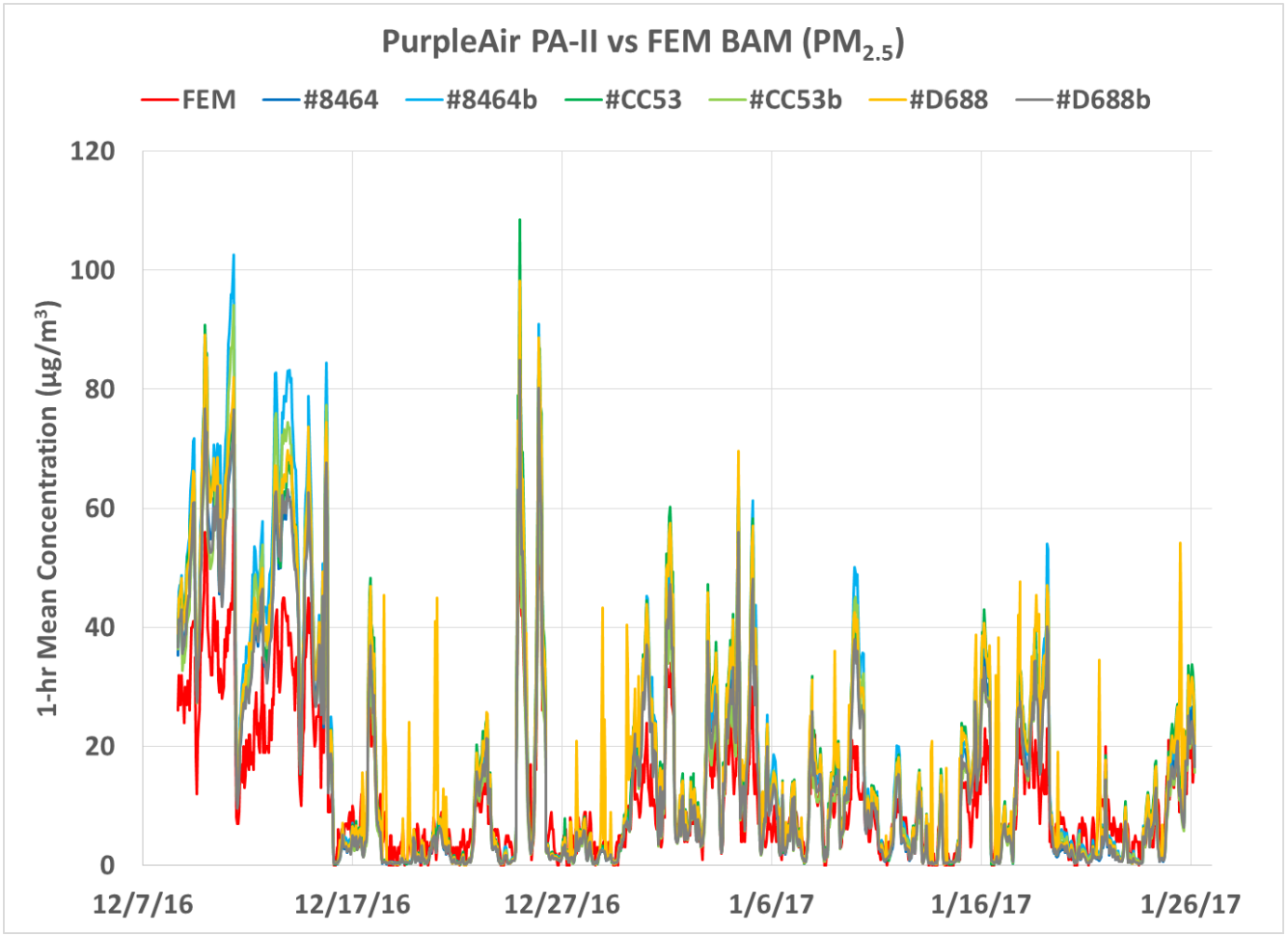






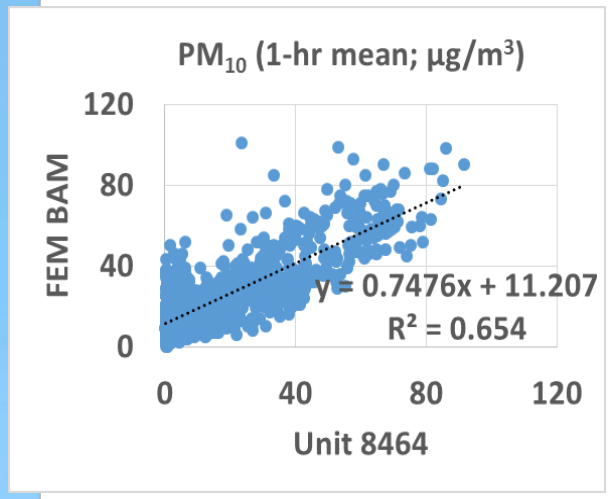
- Purple Air PA-II $PM_{2.5}$ mass measurements correlate very well with the corresponding FEM BAM data ($R^2 > 0.86$)
- Measurements from all Purple Air devices are quite accurate

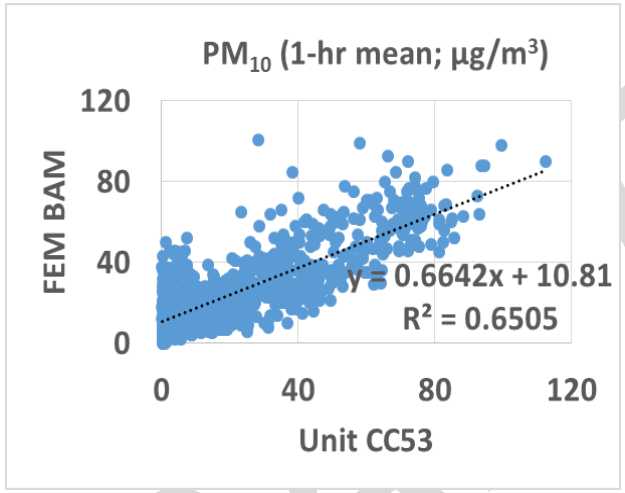
Purple Air PA-II vs FEM BAM ($PM_{2.5}$; 1-hr mean)

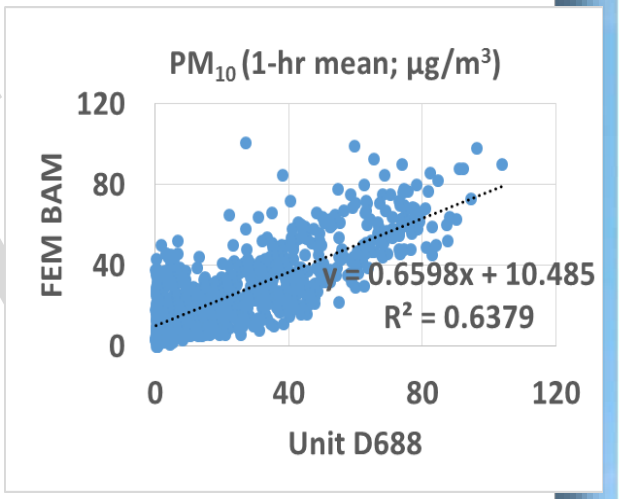


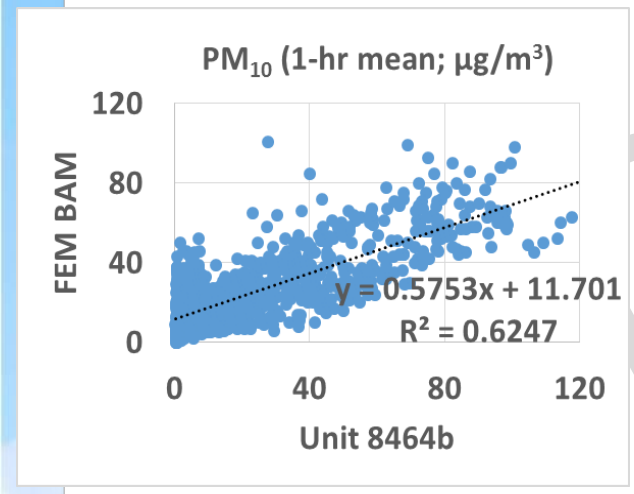
- PurpleAir PA-II sensors track well the diurnal $PM_{2.5}$ variations recorded by the FEM BAM instrument, with the exception of sensor #D688

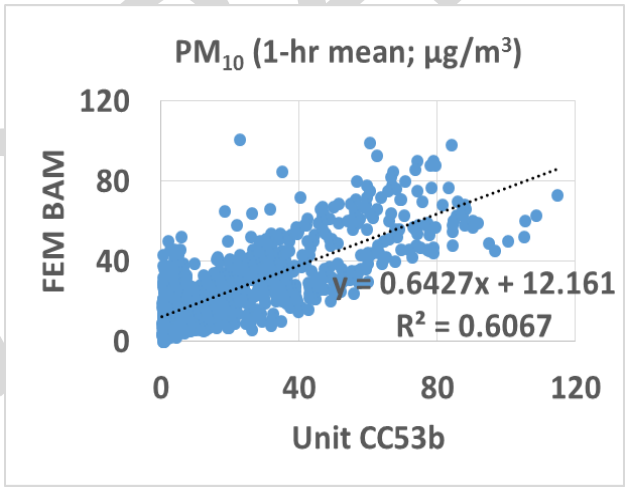
Purple Air PA-II vs FEM BAM (PM_{10}; 1-hr mean)

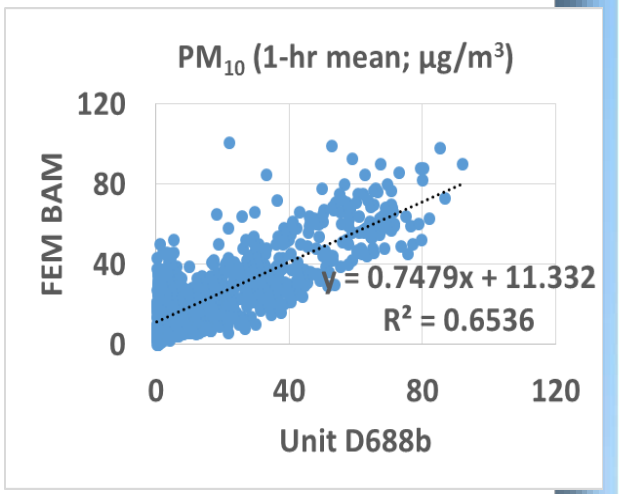






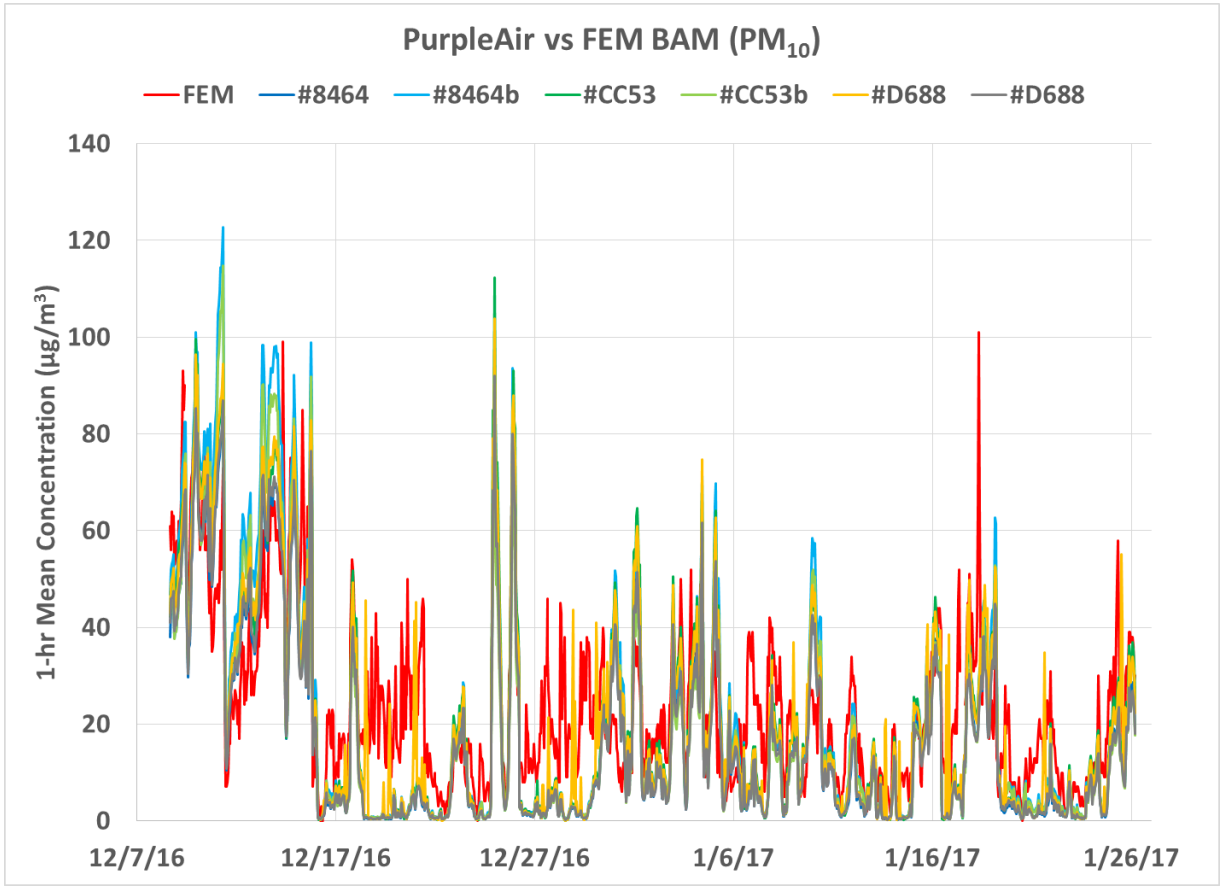






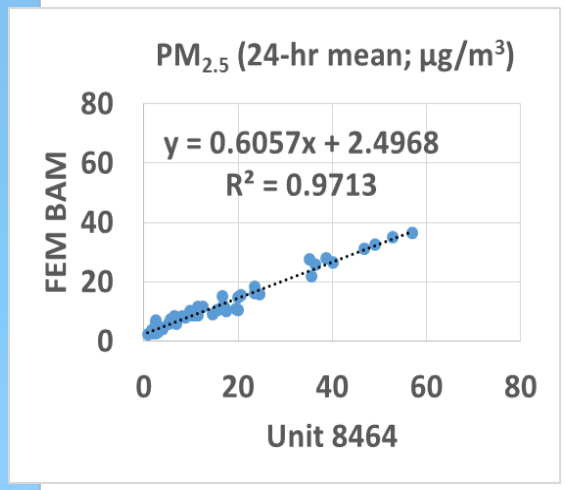
- Purple Air PA-II PM_{10} mass measurements correlate well with the corresponding FEM BAM data (R^2 > 0.60

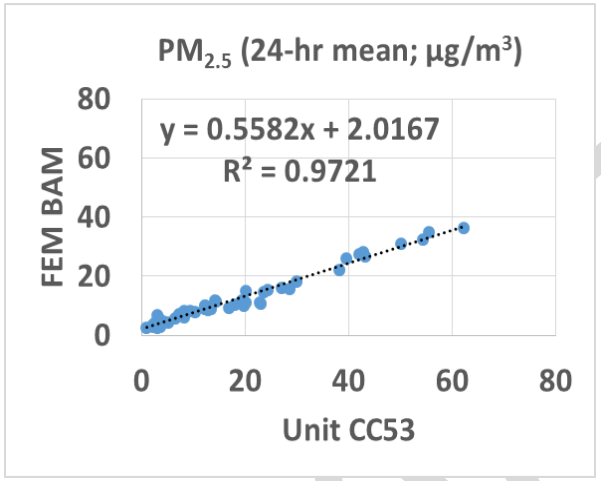
Purple Air PA-II vs FEM BAM (PM_{10}; 1-hr mean)

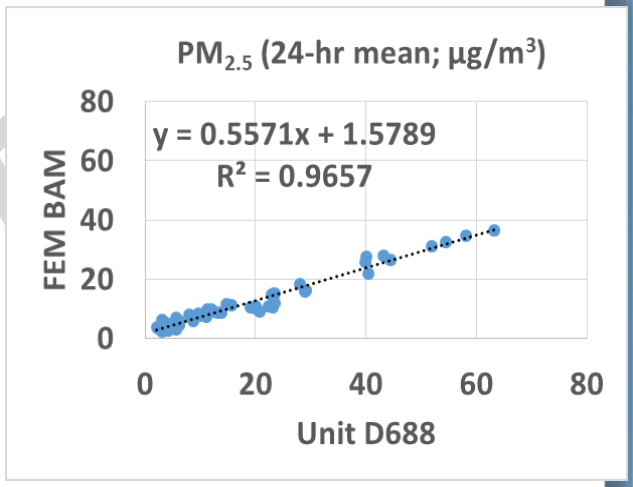


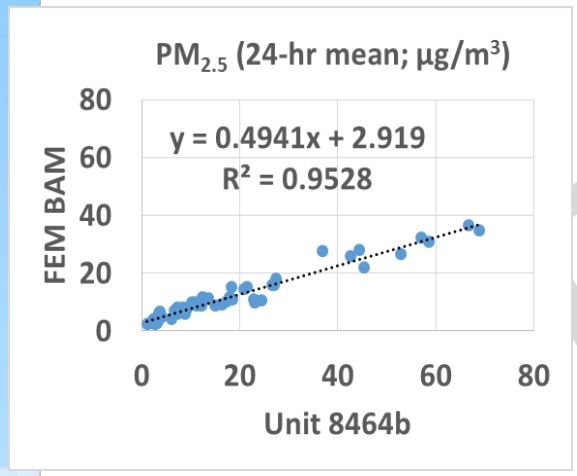
- PurpleAir PA-II sensors seem to track the diurnal PM_{10} variations recorded by the FEM BAM instrument

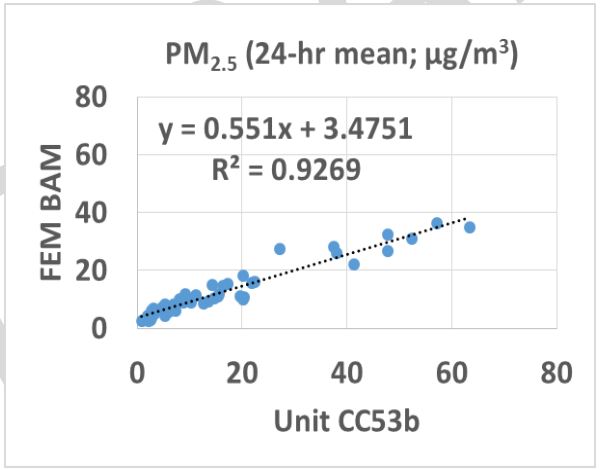
Purple Air PA-II vs FEM BAM ($PM_{2.5}$; 24-hr mean)

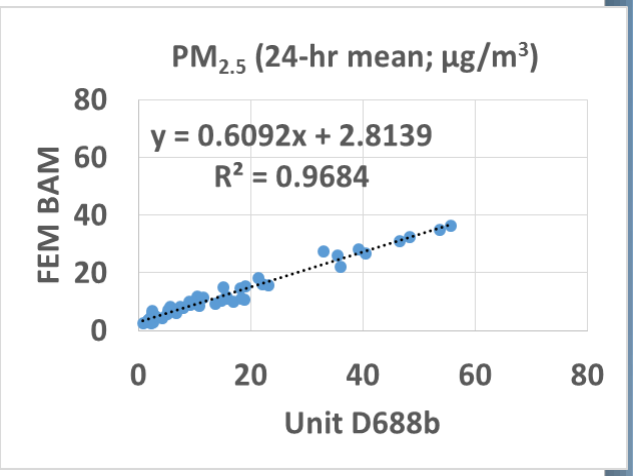






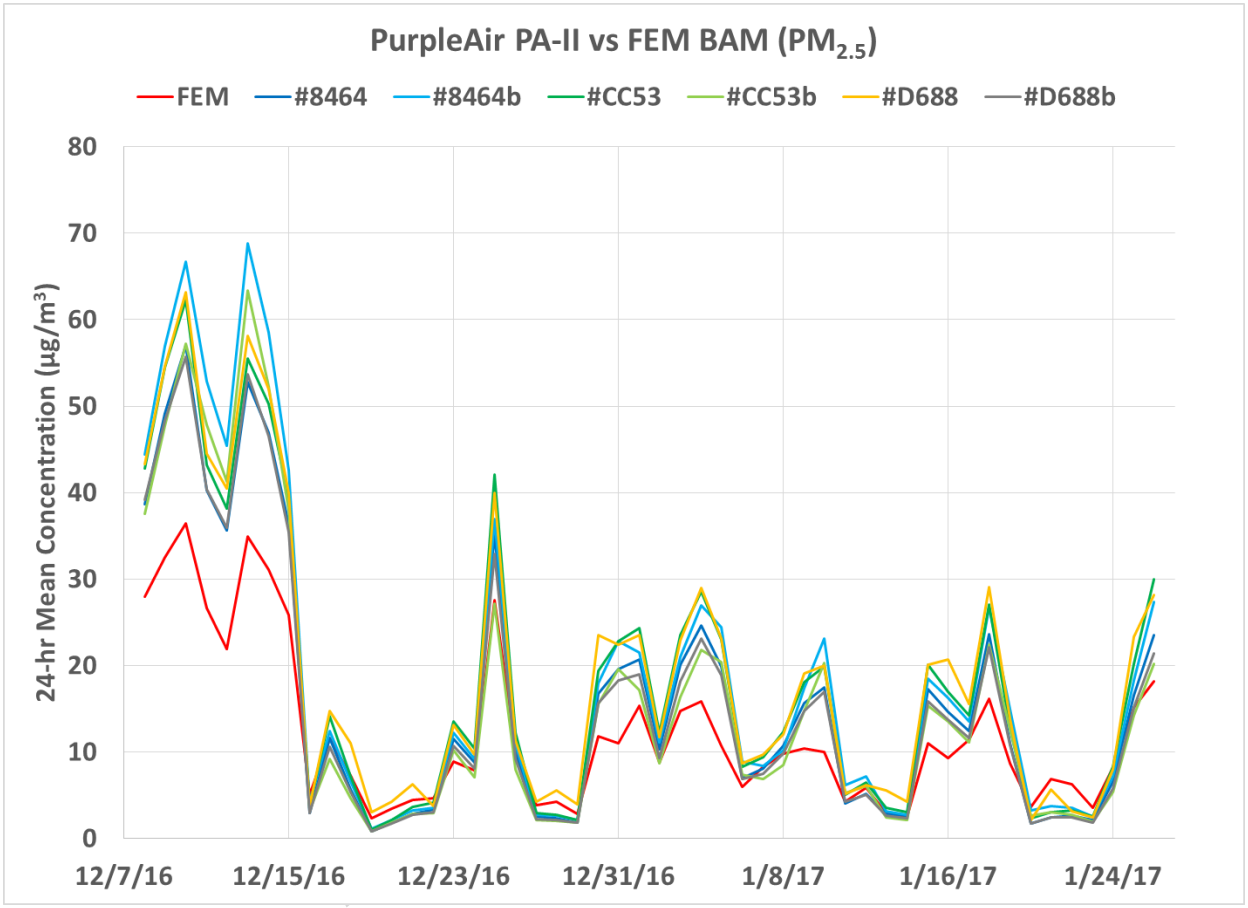






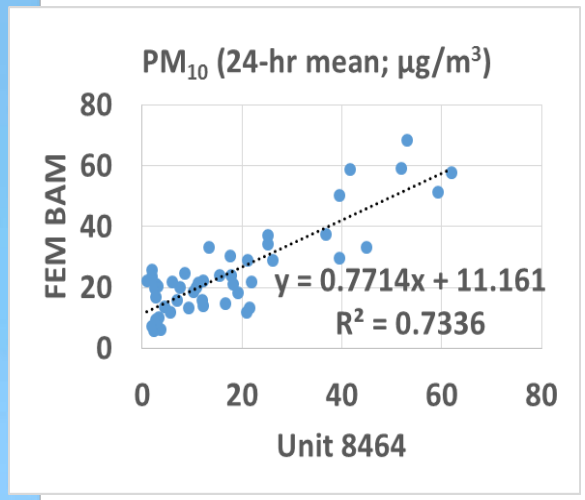
- Purple Air PA-II $PM_{2.5}$ mass measurements correlate very well with the corresponding FEM BAM data ($R^2 > 0.92$)
- Measurements from all Purple Air devices are quite accurate

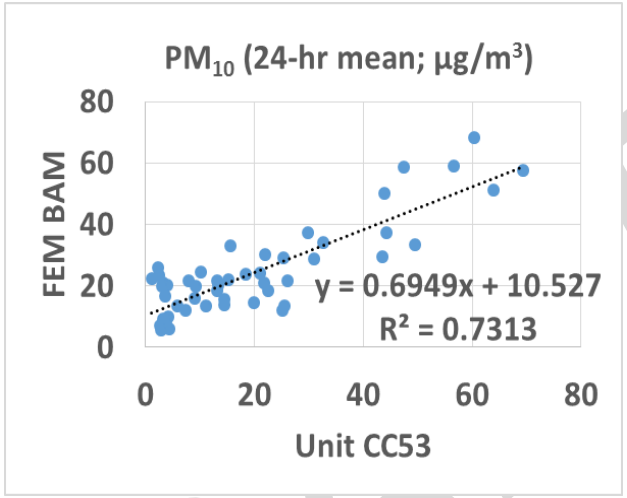
Purple Air PA-II vs FEM BAM ($PM_{2.5}$; 24-hr mean)

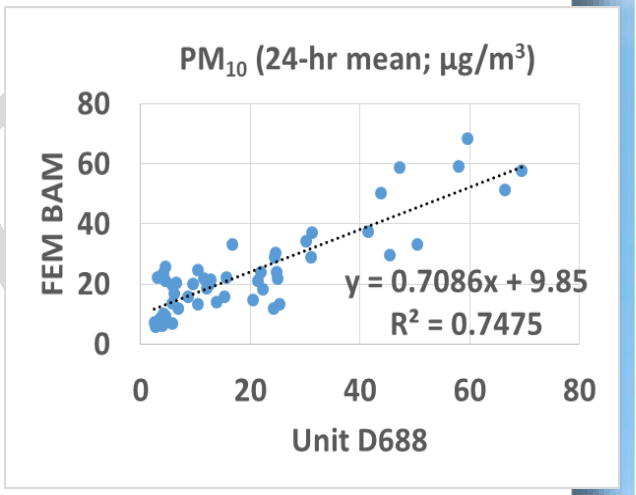


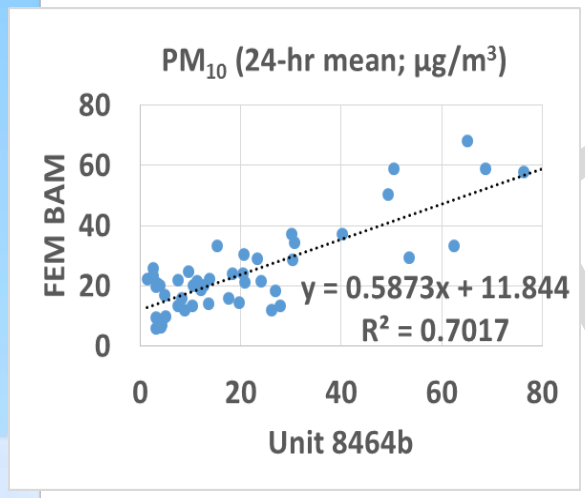
- PurpleAir PA-II sensors track well the diurnal $PM_{2.5}$ variations recorded by the FEM BAM instrument

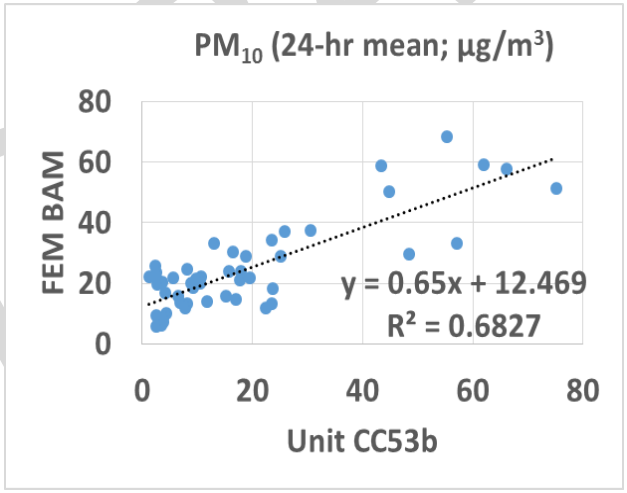
Purple Air PA-II vs FEM BAM (PM_{10}; 24-hr mean)

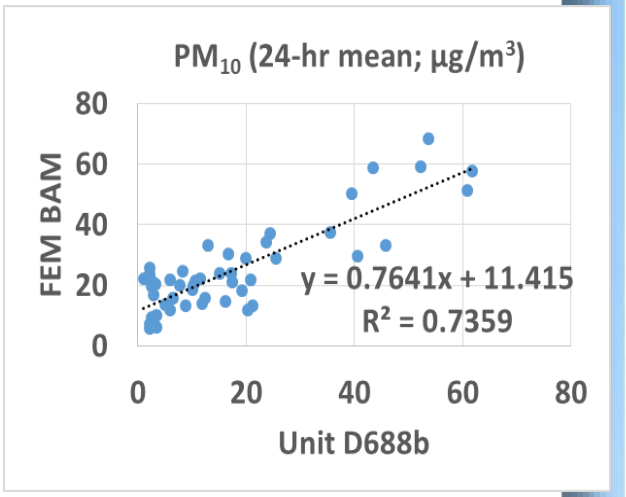






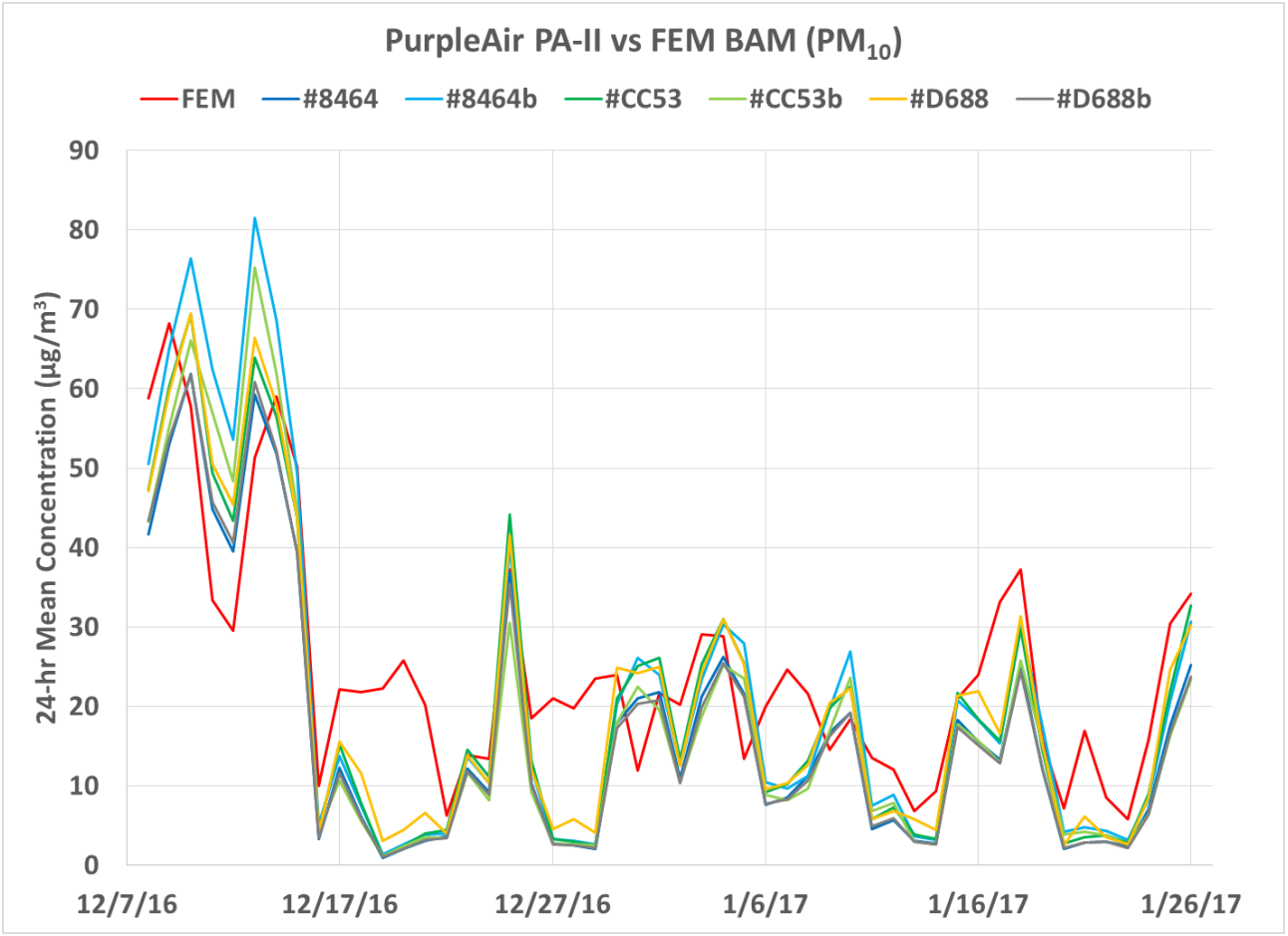






- Purple Air PA-II PM_{10} mass measurements correlate well with the corresponding FEM BAM data (R^2 > 0.68

Purple Air PA-II vs FEM BAM (PM_{10}; 24-hr mean)



- PurpleAir PA-II sensors seem to track the diurnal PM_{10} 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
- $PM_{1.0}$ 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
- $PM_{2.5}$ 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_{10} 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
- 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