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 (μg/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 (μg/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)
- \( \text{PM}_{2.5} \) and \( \text{PM}_{10} \) 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 \( \text{PM}_{2.5} \) & \( \text{PM}_{10} \)
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 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 ($R^2 > 0.68$)
• 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
• 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
• 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 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