Laboratory Evaluation
TSI AirAssure PM$_{2.5}$ Sensor
Background

Three TSI AirAssure PM$_{2.5}$ sensors (units IDs: 004, 005, and 010) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (12/18/2015 to 02/15/2016) under ambient environmental conditions. Now, three new AirAssure sensors (units IDs: 5036, 7003, 7004) have been evaluated in the South Coast AQMD Chemistry Laboratory under controlled artificial aerosol concentration/size range, temperature, and relative humidity.

**AirAssure Sensor (3 units tested):**
- Particle sensors (optical; non-FEM)
- Each unit measures PM$_{2.5}$ mass concentration ($\mu$g/m$^3$)
- Unit cost: ~$1500
- Time resolution: 1-min
- Units IDs: 5036, 7003, 7004

**GRIMM (reference method):**
- Optical particle counter
- FEM PM$_{2.5}$
- Uses proprietary algorithms to calculate total PM, PM$_{2.5}$, and PM$_1$ mass conc. from particle number measurements
- Cost: ~$25,000
- Time resolution: 1-min
AirAssure vs FEM GRIMM (PM$_{2.5}$ mass; 5-min mean)

- The three AirAssure sensors tracked well with the concentration variation recorded by FEM GRIMM in the concentration range of 0-150 µg/m$^3$.
- AirAssure sensors overestimated the GRIMM PM$_{2.5}$ mass conc, and stopped to report values higher than 300 µg/m$^3$ (when GRIMM measured above 150 µg/m$^3$). Sensor manufacturer claims a measurement range of 5-300 µg/m$^3$.

Coefficient of Determination

- Three AirAssure sensors showed very strong correlations with GRIMM PM$_{2.5}$ mass conc. ($R^2 > 0.99$) between 0-150 µg/m$^3$. 

\[ y = 0.50x - 5.37 \]

$R^2 > 0.99$
PM$_{2.5}$ Accuracy: AirAssure vs GRIMM

- Accuracy (20 °C and 40% RH)

<table>
<thead>
<tr>
<th>Steady State (#)</th>
<th>Sensor mean (µg/m$^3$)</th>
<th>GRIMM (µg/m$^3$)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>37.4</td>
<td>12.1</td>
<td>-108.1</td>
</tr>
<tr>
<td>2</td>
<td>77.3</td>
<td>32.7</td>
<td>-36.5</td>
</tr>
<tr>
<td>3</td>
<td>157.7</td>
<td>73.3</td>
<td>-15.2</td>
</tr>
<tr>
<td>4</td>
<td>295.9</td>
<td>142.8</td>
<td>-7.2</td>
</tr>
</tbody>
</table>

- AirAssure has low accuracy compared to FEM GRIMM. The three AirAssure sensors overestimated FEM GRIMM PM$_{2.5}$ measurements over the concentration range of 0-150 µg/m$^3$.

AirAssure Data Recovery and Intra-model variability

- Data recovery for PM$_{2.5}$ mass concentration from 5036, 7003, and 7004 were 97.06%, 97.13%, and 97.13%.
- Moderate to high PM$_{2.5}$ measurement variations were observed among the three AirAssure units.
**PM$_{2.5}$ Precision: AirAssure**

- Precision (Effect of PM$_{2.5}$ conc., Temperature and Relative Humidity)

<table>
<thead>
<tr>
<th>Low conc.</th>
<th>Medium conc.</th>
<th>High conc.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

- Overall, the three AirAssure sensors showed high precision for most of the combinations of low and medium PM$_{2.5}$ conc., T, and RH.

- At high PM$_{2.5}$ concentration (higher than 150 µg/m$^3$, measured by GRIMM), AirAssure plateaued at 300 µg/m$^3$. 
AirAssure Climate Susceptibility

Low Temp - RH ramping (medium conc.)

High Temp - RH ramping (medium conc.)


**Discussion**

- **Accuracy**: Overall, the three AirAssure sensors have low accuracy, compared to GRIMM PM$_{2.5}$ in the range of 0.0 to 150 µg/m$^3$. AirAssure overestimated FEM GRIMM’s reading in the laboratory experiments.

- **Precision**: The AirAssure sensors have high precision for most of the test combinations (low, medium PM concentrations, T and RH).

- **Intra-model variability**: Moderate to high intra-model variability was observed among the three AirAssure sensors.

- **Data Recovery**: Data recovery for PM$_{2.5}$ mass concentration from 5036, 7003, 7004 was 97.06%, 97.13%, and 97.13%.

- **Coefficient of Determination**: The three AirAssure sensors showed very strong correlation/linear response with the corresponding GRIMM PM$_{2.5}$ measurement data ($R^2 > 0.99$) for mass concentration range between 0 and 150 µg/m$^3$.

- **Climate susceptibility**: For most of the temperature and relative humidity combination, the climate condition had minimal effect on the AirAssure’s precision. At the set-points of RH changes at low PM concentrations, AirAssure sensors had some small spikes.