Laboratory Evaluation
Clarity Node PM Sensor
Three Clarity Movement Co. sensor nodes (units IDs: N5L7, Y3GK, and 5KGG) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (02/15/2018 to 04/25/2018) under ambient environmental conditions. Now, two Clarity Node sensors (units IDs: N5L7 and 5KGG. Unit Y3GK was not able to report data during lab evaluation) have been evaluated in the South Coast AQMD Chemistry Laboratory under controlled artificial aerosol concentration/size range, temperature, and relative humidity.

**Clarity Node Sensor (2 units tested):**
- Particle sensors (optical; non-FEM)
- Each unit measures:
  - PM$_{2.5}$ mass concentration (µg/m$^3$)
  - NO$_2$, CO$_2$ and TVOC (under Development)
- Unit cost: ~$1300 (includes 1-yr of cloud data access, cellular connectivity and tech support)
- Time resolution: 2-min (90 sec. of sampling time + 20 sec. of warm-up time and 10 sec. of lag time)
- Units IDs: N5L7 and 5KGG

**GRIMM (reference method):**
- Optical particle counter
- FEM PM$_{2.5}$
- Uses proprietary algorithms to calculate total PM, PM$_{10}$, PM$_{2.5}$, and PM$_{1}$ mass conc. from particle number measurements
- Cost: ~$25,000
- Time resolution: 1-min
The two Clarity Node sensors tracked well with the concentration variation recorded by FEM GRIMM in the concentration range of 0-450 μg/m³.

Two Clarity Node sensors showed very strong correlations with GRIMM PM$_{2.5}$ mass conc. ($R^2 > 0.99$)
Clarity Node vs FEM GRIMM PM$_{2.5}$ Accuracy

- Accuracy (20 °C and 40% RH)

<table>
<thead>
<tr>
<th>Steady State #</th>
<th>Sensor mean (µg/m³)</th>
<th>FEM GRIMM (µg/m³)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31.2</td>
<td>17.3</td>
<td>19.2</td>
</tr>
<tr>
<td>2</td>
<td>52.4</td>
<td>43.5</td>
<td>79.5</td>
</tr>
<tr>
<td>3</td>
<td>103.0</td>
<td>88.0</td>
<td>82.9</td>
</tr>
<tr>
<td>4</td>
<td>161.2</td>
<td>139.3</td>
<td>84.3</td>
</tr>
<tr>
<td>5</td>
<td>313.7</td>
<td>279.2</td>
<td>87.7</td>
</tr>
<tr>
<td>6</td>
<td>494.7</td>
<td>452.6</td>
<td>90.7</td>
</tr>
</tbody>
</table>

- The two Clarity Node sensors overestimated FEM GRIMM PM$_{2.5}$ mass concentration. The accuracy of the Clarity Node sensors increases as concentration increases, ranging from 19.2% at the lowest concentration to 90.7% at the highest concentration.

Clarity Node Data Recovery and Intra-model variability

- Data recovery for PM$_{2.5}$ mass concentration from both sensors was 100%.
- Very low PM$_{2.5}$ measurement variations were observed among the two Clarity Node sensors.
• Precision (Effect of PM$_{2.5}$ conc., Temperature and Relative Humidity)

Overall, the two Clarity Node sensors showed high precision for all of the combinations of low, medium and high PM$_{2.5}$ conc., T, and RH.
Clarity Node Climate Susceptibility

Low Temp - RH ramping (medium conc.)

High Temp - RH ramping (medium conc.)
Discussion

- **Accuracy**: Overall, the two Clarity Node sensors have high accuracy, compared to FEM GRIMM PM$_{2.5}$ in the range of 0.0 to 450 µg/m$^3$, except for the lowest concentration tested (~17 µg/m$^3$). Clarity Node sensors overestimated FEM GRIMM’s reading in the laboratory experiments.

- **Precision**: The Clarity Node sensors have high precision for all test combinations (PM concentrations, T and RH).

- **Intra-model variability**: Very low intra-model variability was observed among the two Clarity Node sensors.

- **Data Recovery**: Data recovery for PM$_{2.5}$ mass concentration from both units was 100%.

- **Coefficient of Determination**: The two Clarity Node sensors showed very strong correlation/linear response with the corresponding FEM GRIMM PM$_{2.5}$ measurement data ($R^2 > 0.99$).

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