Laboratory Evaluation

Davis Instruments - AirLink
Background

Three Davis Instruments AirLink (hereinafter AirLink) sensors were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (04/02/2021 to 06/01/2021) under ambient environmental conditions. Following field-testing, the same three units were evaluated in the South Coast AQMD Sensor Environmental Testing Chamber 2 (SENTEC-2) under controlled artificial aerosol concentration/size range, temperature, and relative humidity.

AirLink (3 units tested):
- Particle sensor: optical; non-FEM (PMSA003, Plantower)
- Each unit reports: PM$_{1.0}$, PM$_{2.5}$, and PM$_{10}$ (μg/m$^3$), Temperature (°F), RH (%)
- Unit cost: ~$179
- Time resolution: 1-min
- Unit IDs: 023B, 023F, 0206

Reference instruments:
- PM$_{2.5}$ instrument (Teledyne T640x, San Diego, CA; hereinafter FEM T640x); cost: ~$37,000
- Time resolution: 1-min
PM$_{2.5}$

1. FEM T640x vs AirLink
2. Accuracy, data recovery, and intra-model variability
3. Precision
4. Climate susceptibility
5. Discussion
The AirLink sensors tracked well with the concentration variation but tended to overestimate PM$_{2.5}$ concentration values at lower levels, while underestimating at higher levels, compared to the FEM T640x in the concentration range of 0 - 300 μg/m$^3$.

The AirLink sensors showed very strong correlations with the FEM T640x PM$_{2.5}$ mass conc. ($R^2 > 0.99$).
AirLink vs FEM T640x PM$_{2.5}$ Accuracy

- Accuracy (20 °C and 40% RH)

<table>
<thead>
<tr>
<th>Steady State #</th>
<th>Sensor Mean ($\mu$g/m$^3$)</th>
<th>FEM T640x ($\mu$g/m$^3$)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.74</td>
<td>9.05</td>
<td>96.5%</td>
</tr>
<tr>
<td>2</td>
<td>51.14</td>
<td>47.50</td>
<td>92.3%</td>
</tr>
<tr>
<td>3</td>
<td>103.57</td>
<td>97.71</td>
<td>94.0%</td>
</tr>
<tr>
<td>4</td>
<td>192.09</td>
<td>196.31</td>
<td>97.8%</td>
</tr>
<tr>
<td>5</td>
<td>273.76</td>
<td>296.41</td>
<td>92.4%</td>
</tr>
</tbody>
</table>

- The AirLink sensors tended to overestimate PM$_{2.5}$ concentration values at lower levels, while underestimating at higher levels compared to the FEM T640x PM$_{2.5}$ mass concentration at 20 °C and 40% RH. The AirLink sensors showed high accuracy (92.3% to 97.8%) for all tested PM$_{2.5}$ concentrations compared to the reference FEM T640x for the entirety of test.

AirLink Data Recovery and Intra-model Variability

- Data recovery for PM$_{2.5}$ measurements was 100% for all units.

- Low to moderate PM$_{2.5}$ concentration variations were observed between the three units at 20 °C and 40% RH, at 10, 50, and 150 $\mu$g/m$^3$ PM$_{2.5}$ as measured by the FEM T640x.
Precision: AirLink (PM$_{2.5}$)

- Precision (effect of PM$_{2.5}$ conc., temperature and relative humidity)

Overall, the three AirLink sensors showed high precision for all combinations of PM$_{2.5}$ conc., T, and RH.
Climate Susceptibility: AirLink (PM$_{2.5}$)

Low Temp - RH ramping (medium conc.)

High Temp – RH ramping (medium conc.)
Discussion: PM$_{2.5}$

- **Accuracy**: The three AirLink sensors showed accuracy ranged from 92.3% to 97.8%. (refer to slide 5)
- **Precision**: The three AirLink sensors exhibited high precision during all tested PM$_{2.5}$ conc., T, and RH conditions. (refer to slide 6)
- **Intra-model variability**: Low to moderate PM$_{2.5}$ measurement variations were observed among the three AirLink sensors at 20 °C and 40% RH. (refer to slide 5)
- **Data Recovery**: Data recovery for PM$_{2.5}$ measurements was 100% for all units. (refer to slide 5)
- **Bias**: N/A
- **Detection limit**: The detection limit cannot be estimated due to limitations in the chamber system design.
- **Response time**: Response time could not be studied due to the design of the chamber system. With a 1.6 m$^3$ chamber volume, it was not possible to reach a high pollutant concentration within a short time.
- **Linear Correlation**: The three AirLink sensors showed very strong correlation/linear response with the corresponding FEM T640x PM$_{2.5}$ measurement data ($R^2 > 0.99$). (refer to slide 4)
- **Selectivity**: N/A for PM sensors test
- **Interferences**: N/A for PM sensors test
- **Note about PM$_{1.0}$**: The field evaluation compared the PM$_{1.0}$ values reported from the AirLink sensors against the field GRIMM and T640 that reported PM$_{1.0}$. However, PM$_{1.0}$ was not compared in this lab evaluation because at the time of lab testing (before March 2022) the lab T640x firmware upgrade to report PM$_{1.0}$ was not finalized yet.
**Discussion: PM$_{2.5}$**

- **Measurement duration**: AirLink sensors report 1-minute averaged values.
- **Measurement frequency**: AirLink sensors report 1-minute averaged values. The obtained data was used as-is for calculation of statistics (e.g. data recovery, intra-model variability, mean, accuracy, precision), but condensed into 5-minute averages for linear correlation studies against the FEM T640x.
- **Sensor contamination and expiration**: Prior to the laboratory evaluation, the AirLink sensors were tested in the field for two months. The PM$_{2.5}$ laboratory studies lasted for about 9 days with intermittent non-operating periods and a storage period of ~ 6 months. For PM$_{2.5}$ measurements, all of the AirLink sensors maintained their functionalities and operated normally throughout the duration of the testing.
- **Concentration range**: PM$_{2.5}$ concentration range was not listed by the manufacturer. During the laboratory evaluation, the AirLink sensors were challenged with PM$_{2.5}$ concentrations up to 300 µg/m$^3$. (refer to slide 4)
- **Drift**: N/A
- **Climate susceptibility**: During the lab studies, climate did not significantly impact precision. Increasing temperatures led to more underestimation by the sensors, at RH levels below 65%. Above 65% RH, increasing temperatures resulted in sustained overestimation by the sensors compared to the FEM T640x. (refer to slides 6 and 7)
- **Response to loss of power**: AirLink sensors were powered through the entirety of the lab tests.