

Laboratory Evaluation Alphasense OPC-R2



Outline

1. Background
2. $PM_{2.5}$
3. PM_{10}

DRAFT

Background

Three **Alphasense OPC-R2** sensors were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (10/16/2021 to 12/15/2021) 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.

Alphasense OPC-R2 (3 units tested):

- Particle sensor: **optical; non-FEM (Alphasense OPC-R2)**
- Each unit reports: $PM_{1.0}$, $PM_{2.5}$ and PM_{10} ($\mu\text{g}/\text{m}^3$), Temperature ($^{\circ}\text{C}$), RH (%)
- **Unit cost: ~\$435, including data acquisition interface with software**
- Time resolution: 30-sec
- Units IDs: 0304, 0305, 0307



Reference instruments:

- $PM_{2.5}$ instrument (**Teledyne T640x, San Diego, CA; hereinafter FEM T640x**); **cost: ~\$37,000**
 - Time resolution: 1-min
- PM_{10} instrument (**non-FEM, APS, TSI, Shoreview, MN**); **cost: ~\$55,000**
 - Time resolution: 1-min



FEM T640x

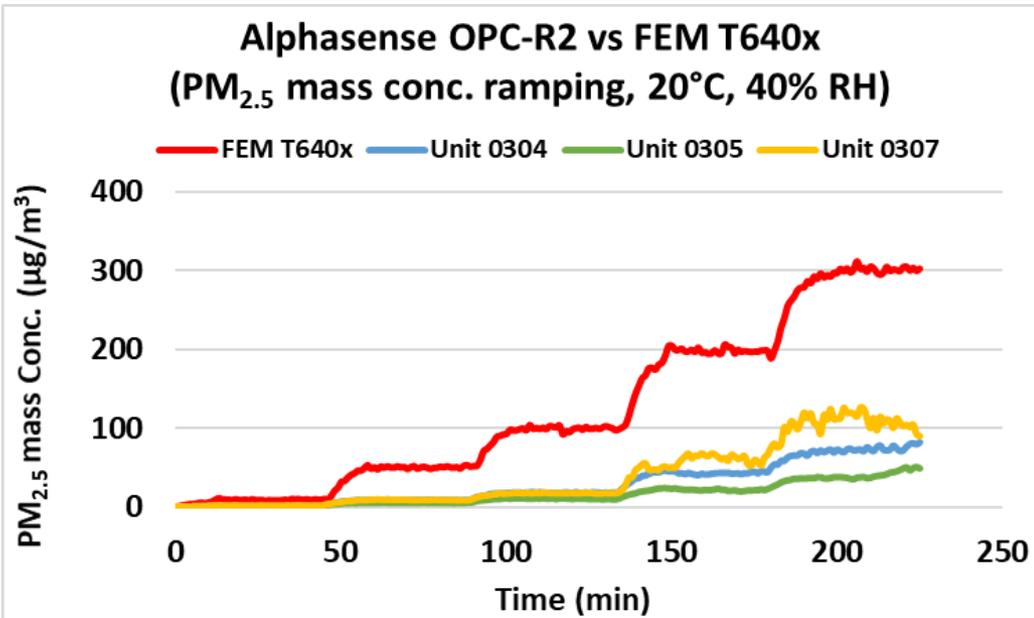


APS

PM_{2.5}

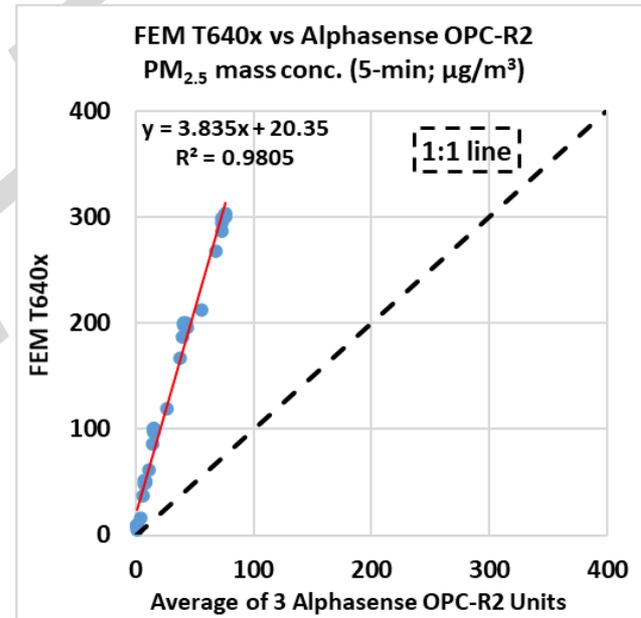
1. **FEM T640x vs Alphasense OPC-R2**
2. **Accuracy, data recovery, and intra-model variability**
3. **Precision**
4. **Climate susceptibility**
5. **Discussion**

Alphasense OPC-R2 vs FEM T640x (PM_{2.5})



- The Alphasense OPC-R2 sensors tracked well with the concentration variation but underestimated PM_{2.5}, compared to the FEM T640x in the concentration range of 0 - 300 µg/m³.

Coefficient of Determination



- The Alphasense OPC-R2 sensors showed very strong correlations with the FEM T640x PM_{2.5} mass conc. ($R^2 \sim 0.98$)

Alphasense OPC-R2 vs FEM T640x PM_{2.5} Accuracy

- Accuracy (20 °C and 40% RH)

Steady State #	Sensor Mean (µg/m ³)	FEM T640x (µg/m ³)	Accuracy (%)
1	1.4	9.1	15.1
2	7.8	50.4	15.5
3	15.6	99.3	15.7
4	42.5	197.5	21.5
5	75.2	301.6	24.9

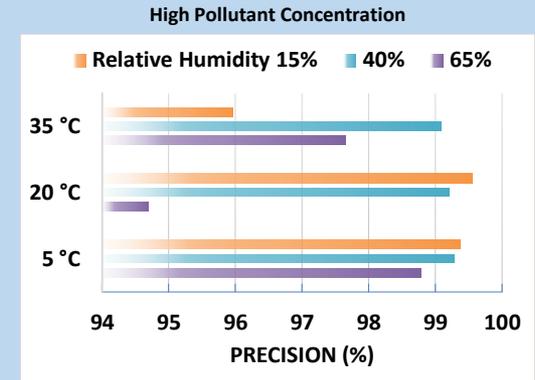
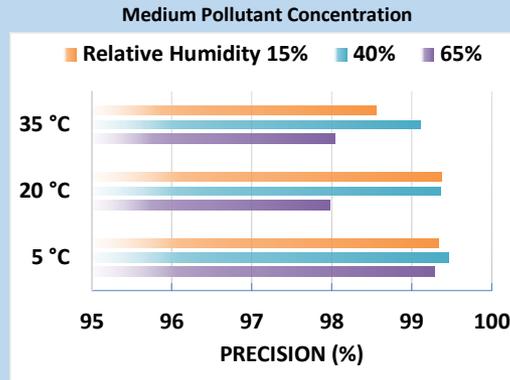
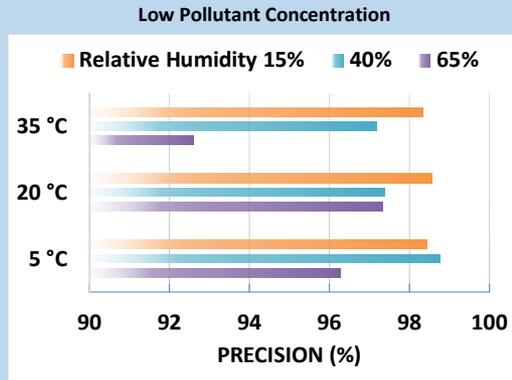
- The Alphasense OPC-R2 sensors underestimated PM_{2.5} concentration values compared to the FEM T640x PM_{2.5} mass concentration at 20 °C and 40% RH. The Alphasense OPC-R2 sensors showed fairly constant accuracy (15.1% to 24.9%) for all tested PM_{2.5} concentrations compared to the reference FEM T640x for the entirety of test.

Alphasense OPC-R2 Data Recovery and Intra-model Variability

- Data recovery for PM_{2.5} measurements was 100% for all three units
- High PM_{2.5} concentration variations were observed between the three units at 20° C and 40% RH, at low, medium and high PM_{2.5} as measured by the FEM T640x.

Precision: Alphasense OPC-R2

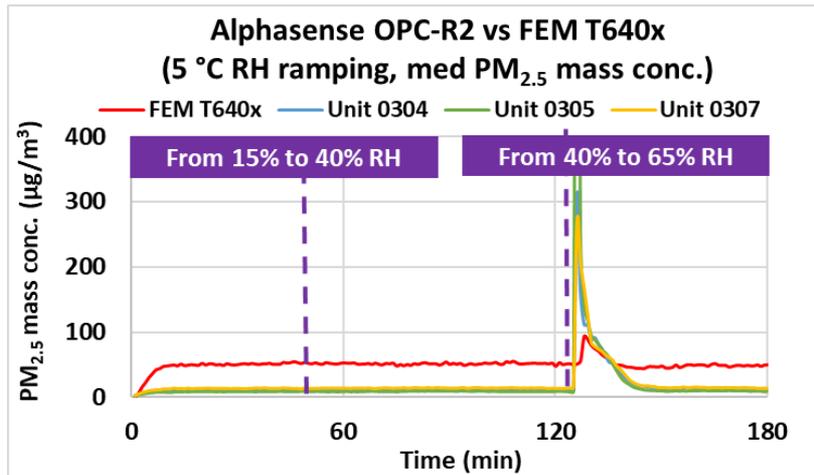
- Precision (Effect of $PM_{2.5}$ conc., Temperature and Relative Humidity)



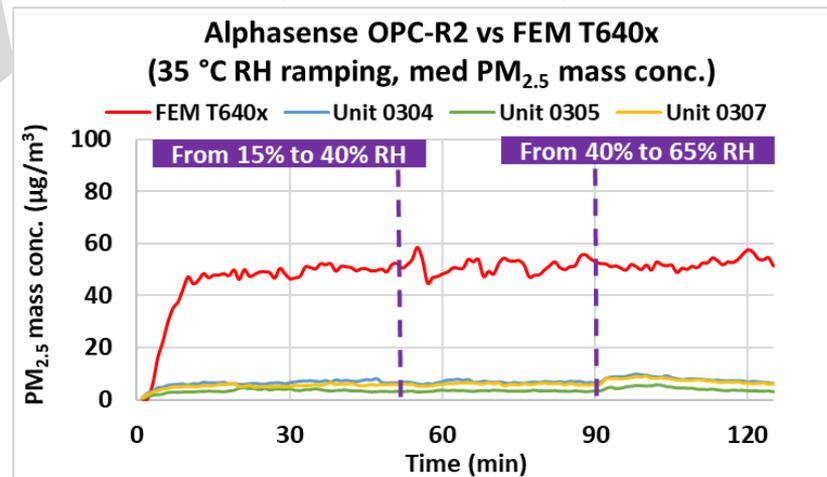
- Overall, Alphasense OPC-R2 sensors showed high precision for all the combinations of $PM_{2.5}$ conc., T, and RH.

Climate Susceptibility: Alphasense OPC-R2

Low Temp - RH ramping
(medium conc.)



High Temp - RH ramping
(medium conc.)



Discussion: PM_{2.5}

- **Accuracy:** The three Alphasense OPC-R2 sensors showed accuracy ranged from 15.1% to 24.9%.
- **Precision:** The three Alphasense OPC-R2 sensors exhibited high precision during all tested PM_{2.5} conc., T, and RH conditions.
- **Intra-model variability:** High PM_{2.5} measurement variations were observed among the three Alphasense OPC-R2 sensors at 20 °C and 40% RH.
- **Data Recovery:** Data recovery for PM_{2.5} measurements was 100% for all three units.
- **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 m³ chamber volume, it was not possible to reach a high pollutant concentration within a short time.
- **Linear Correlation:** The three Alphasense OPC-R2 sensors showed very strong correlation/linear response with the corresponding FEM T640x PM_{2.5} measurement data ($R^2 \sim 0.98$).
- **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 Alphasense OPC-R2 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.

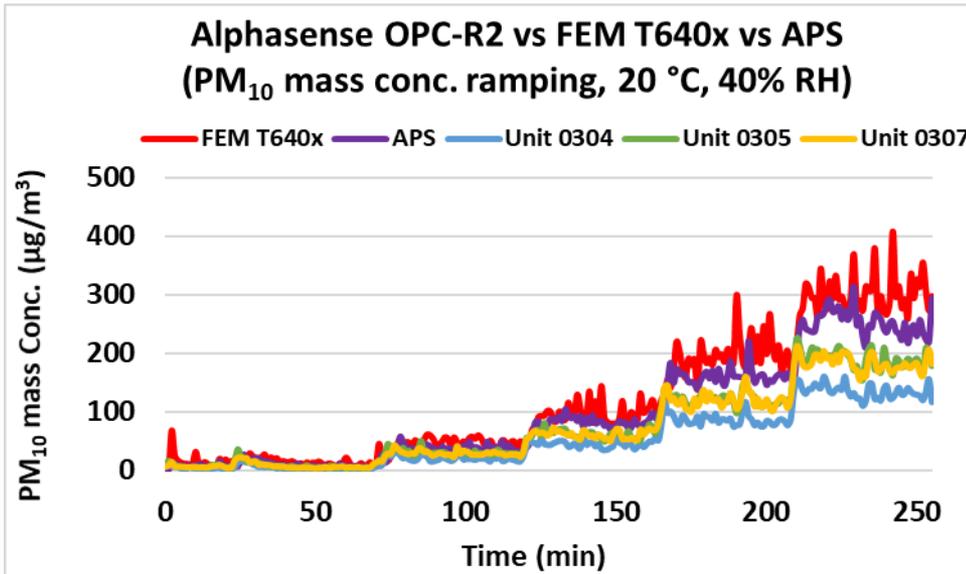
Discussion: PM_{2.5}

- **Measurement duration:** The Alphasense OPC-R2 sensors underestimated PM_{2.5} concentration values compared to the FEM T640x PM_{2.5} mass concentration at 20 °C and 40% RH. The Alphasense OPC-R2 sensors showed fairly constant accuracy (15.1% to 24.9%) for all tested PM_{2.5} concentrations compared to the reference FEM T640x for the entirety of test.
- **Measurement frequency:** Alphasense OPC-R2 sensors report 30-sec 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 1-minute to 5-minute averages for linear correlation studies against the FEM T640x.
- **Sensor contamination and expiration:** Prior to the laboratory evaluation, the Alphasense OPC-R2 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 ~ 2 months. For PM_{2.5} measurements, all of the Alphasense OPC-R2 sensors maintained their functionalities and operated normally throughout the duration of the testing.
- **Concentration range:** Up to 1000 µg/m³ as suggested by the manufacturer. During the laboratory evaluation, the Alphasense OPC-R2 sensors were challenged with PM_{2.5} concentrations up to 300 µg/m³.
- **Drift:** N/A
- **Climate susceptibility:** During the lab studies, climate did not significantly impact precision. Increasing RH led to less underestimation compared to the FEM T640x.
- **Response to loss of power:** Alphasense OPC-R2 sensors were powered through the entirety of the lab tests.

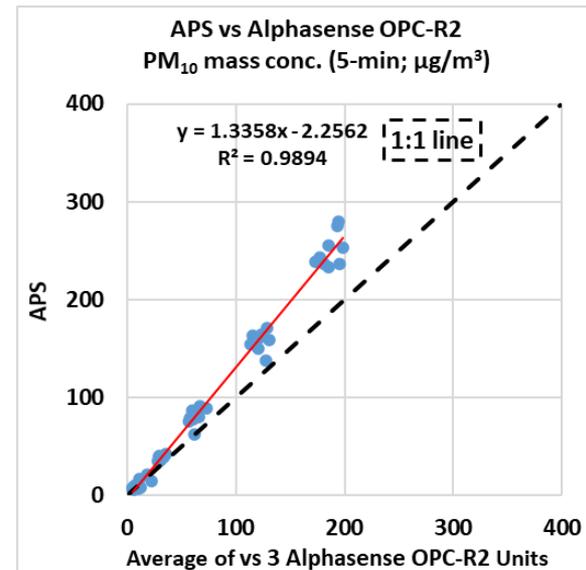
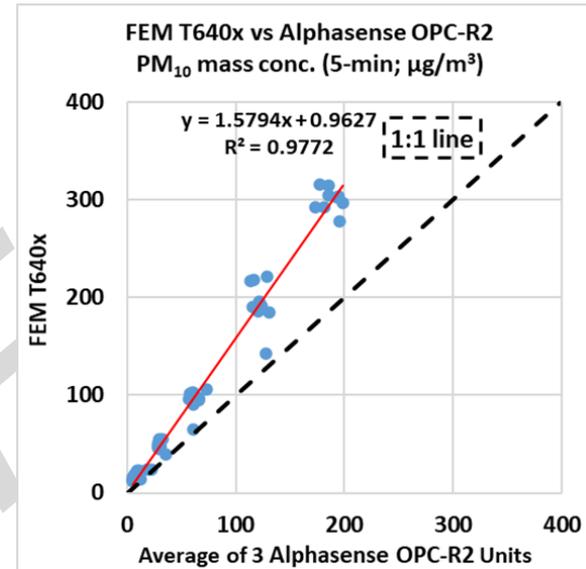
PM₁₀

1. **FEM T640x vs APS vs Alphasense OPC-R2**
2. **Accuracy, data recovery, and intra-model variability**
3. **Climate susceptibility**
4. **Discussion**

Alphasense OPC-R2 vs FEM T640x vs APS (PM₁₀)



- The Alphasense OPC-R2 sensors tracked well with the PM₁₀ concentration variations as recorded by the FEM T640x and APS in the concentration range of 0 - 300 µg/m³.
- The Alphasense OPC-R2 sensors showed very strong correlations with both FEM T640x and APS PM₁₀ measurement data ($R^2 > 0.97$).



Alphasense OPC-R2 vs FEM T640x vs APS PM₁₀ Accuracy

- Accuracy (20 °C and 40% RH)

Steady State #	Sensor Mean (µg/m ³)	FEM T640x (µg/m ³)	Accuracy (%)
1	4.5	12.3	36.8
2	26.1	48.3	54.0
3	56.3	98.3	57.3
4	108.4	211.5	51.3
5	165.9	306.7	54.1

Steady State #	Sensor Mean (µg/m ³)	APS (µg/m ³)	Accuracy (%)
1	4.5	6.8	66.3
2	26.1	38.5	67.6
3	56.3	80.6	69.8
4	108.4	163.6	66.3
5	165.9	241.9	68.6

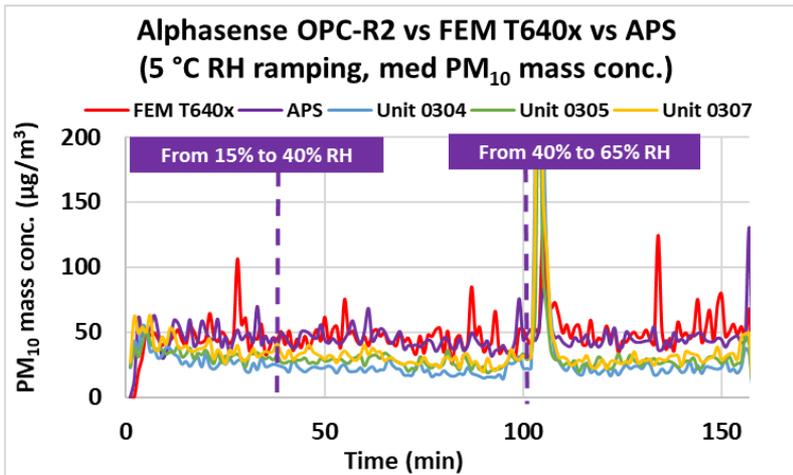
- The Alphasense OPC-R2 sensors underestimated PM₁₀ concentration values compared to the FEM T640x and APS PM₁₀ mass concentration at 20 °C and 40% RH. The Alphasense OPC-R2 sensors showed fairly constant accuracy (36.8% to 54.1% for the FEM T640x and 66.3% to 69.8% for the APS) for all tested PM₁₀ concentrations compared to the reference FEM T640x for the entirety of test.

Alphasense OPC-R2 Data Recovery and Intra-model Variability

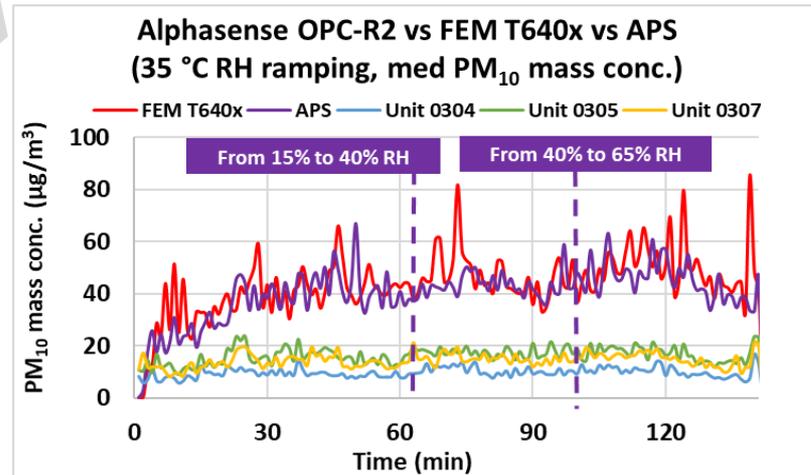
- Data recovery for PM₁₀ measurements was 100% for all three units
- Moderate PM₁₀ concentration variations were observed between the three units at 20° C and 40% RH, at low, medium, and high µg/m³ PM_{2.5} as measured by the FEM T640x.

Climate Susceptibility: Alphasense OPC-R2

Low Temp - RH ramping
(medium conc.)



High Temp - RH ramping
(medium conc.)



Discussion: PM₁₀

- **Accuracy:** The Alphasense OPC-R2 sensors underestimated PM₁₀ concentration values compared to the FEM T640x and APS PM₁₀ mass concentration at 20 °C and 40% RH. The Alphasense OPC-R2 sensors showed fairly constant accuracy (36.8% to 54.1% for the FEM T640x and 66.3% to 69.8% for the APS) for all tested PM₁₀ concentrations compared to the reference FEM T640x for the entirety of test.
- **Precision:** Due to the nature of Arizona Test Dust dispersion, the aerosol concentration showed some variability, therefore, the precision cannot be fairly estimated.
- **Intra-model variability:** Moderate PM₁₀ measurement variations were observed among the three Alphasense OPC-R2 sensors at 20 °C and 40% RH.
- **Data Recovery:** Data recovery for PM₁₀ measurements was 100% for all three units.
- **Bias:** N/A
- **Detection limit:** The detection limit cannot be estimated due to limitations in the chamber system design.
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Discussion: PM₁₀

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- **Measurement frequency:** Alphasense OPC-R2 sensors report 30-sec averaged values. The obtained data was condensed into 1-minute for calculation of statistics (e.g. data recovery, intra-model variability, mean, accuracy, precision), and to 5-minute averages for linear correlation studies against the FEM T640x and APS.
- **Sensor contamination and expiration:** Prior to the laboratory evaluation, the Alphasense OPC-R2 sensors were tested in the field for two months. The PM₁₀ laboratory studies lasted for about 9 days with intermittent non-operating periods and a storage period of ~ 2 months. For PM₁₀ measurements, all of the Alphasense OPC-R2 sensors maintained their functionalities and operated normally throughout the duration of the testing.
- **Concentration range:** Up to 1000 µg/m³ as suggested by the manufacturer. During the laboratory evaluation, the Alphasense OPC-R2 sensors were challenged with PM₁₀ concentrations up to 300 µg/m³.
- **Drift:** N/A
- **Climate susceptibility:** During the lab studies, climate did not significantly impact precision.
- **Response to loss of power:** Alphasense OPC-R2 sensors were powered through the entirety of the lab tests.