

# Laboratory Evaluation

## Alphasense OPC-N3 Sensor



# Background

Three **Alphasense OPC-N3** sensors (units IDs: 0217, 0218 and 0219) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (08/15/2018 to 10/11/2018) under ambient environmental conditions and have now been evaluated in the South Coast AQMD Chemistry Laboratory under controlled artificial aerosol concentration/size range, temperature, and relative humidity. The same three Alphasense OPC-N3 units were tested both in the field (1<sup>st</sup> stage of testing) and in the laboratory (2<sup>nd</sup> stage of testing).

- **Alphasense OPC-N3 (3 units tested):**

- Particle sensor (**optical; non-FEM**)
- Each unit measures: PM<sub>1.0</sub>, PM<sub>2.5</sub> and PM<sub>10</sub> (µg/m<sup>3</sup>)  
Temperature (°C), Relative Humidity (%)
- **Unit cost: ~\$340**
- Time resolution: 10-sec
- Units IDs: 0217, 0218, 0219
- Differences from OPC-N2:
  - Increased particle size range: 0.38 - 40 µm and channels: 24 software bins
  - Equipped with onboard temperature and humidity sensor that is enclosed in raw sensor housing
  - Auto switching when detecting higher range
  - Increased sampling flow rate to 5.5 L/min

- **GRIMM (reference method):**

- Optical particle counter
- **FEM PM<sub>2.5</sub>**
- Uses proprietary algorithms to calculate PM<sub>10</sub>, PM<sub>2.5</sub>, and PM<sub>1.0</sub> mass conc. from particle number measurements
- **Cost: ~\$25,000**
- Time resolution: 1-min

- **TSI APS 3321 (reference method for PM<sub>10</sub> mass):**

- Aerodynamic particle sizer
- Measures particles from 0.5 to 20 µm
- Uses a patented, double-crest optical system for unmatched sizing accuracy
- **Cost: ~\$50,000**

# Evaluation results guideline

- Alphasense OPC-N3 vs GRIMM PM<sub>1.0</sub> mass concentration
- Alphasense OPC-N3 vs FEM GRIMM PM<sub>2.5</sub> mass concentration
- Alphasense OPC-N3 vs GRIMM vs APS PM<sub>10</sub> mass concentration



Alphasense OPC-N3



GRIMM

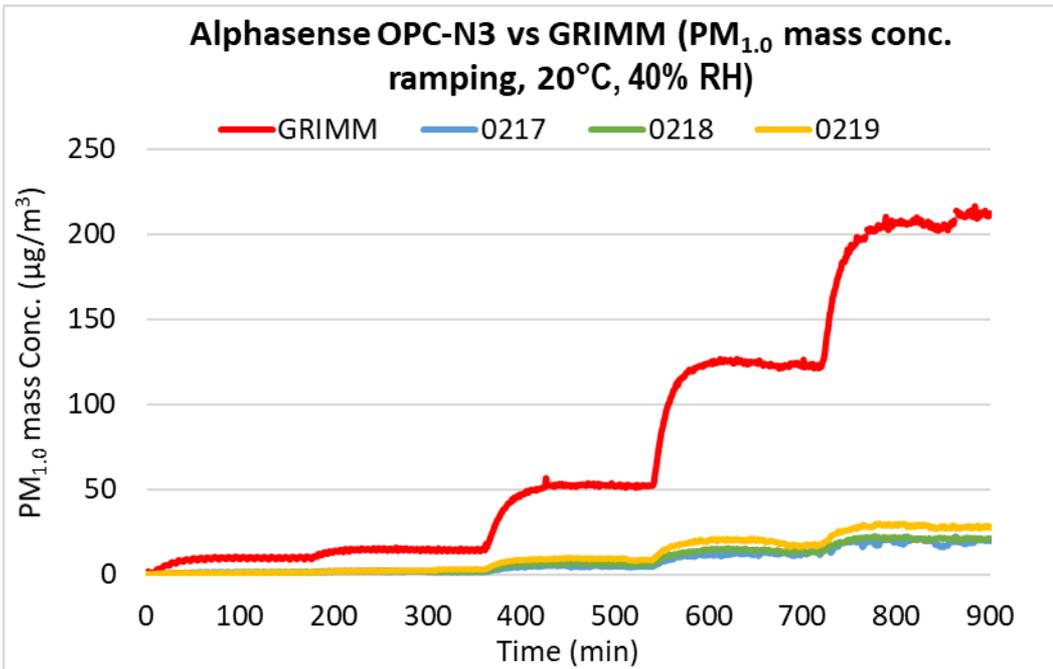


TSI APS 3321

# Evaluation results for PM<sub>1.0</sub> mass concentration

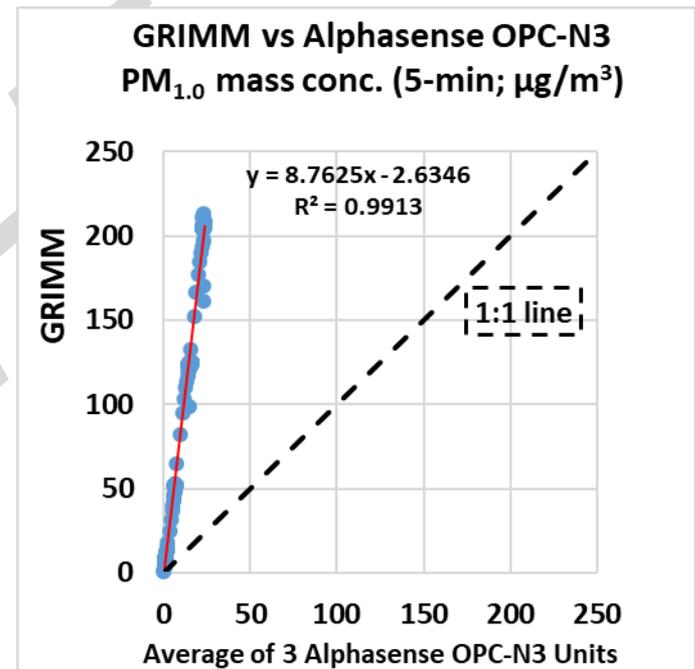
Alphasense OPC-N3 vs GRIMM

# Alphasense OPC-N3 vs GRIMM (PM<sub>1.0</sub> mass conc.)



- The Alphasense OPC-N3 sensors tracked well with the PM<sub>1.0</sub> concentration variations as recorded by GRIMM in the concentration range of 0 - ~200 µg/m<sup>3</sup>.

## Coefficient of Determination



- The Alphasense OPC-N3 sensors showed very strong correlations with the corresponding GRIMM PM<sub>1.0</sub> mass conc. ( $R^2 > 0.99$ )

# Alphasense OPC-N3 vs GRIMM PM<sub>1.0</sub> Accuracy

- Accuracy (20 °C and 40% RH)

| Steady state # | Sensor Mean (µg/m <sup>3</sup> ) | GRIMM (µg/m <sup>3</sup> ) | Accuracy (%) |
|----------------|----------------------------------|----------------------------|--------------|
| 1              | 1.2                              | 9.5                        | 12.2         |
| 2              | 2.0                              | 14.2                       | 14.0         |
| 3              | 6.2                              | 51.9                       | 12.0         |
| 4              | 14.2                             | 123.4                      | 11.5         |
| 5              | 22.8                             | 211.8                      | 10.7         |

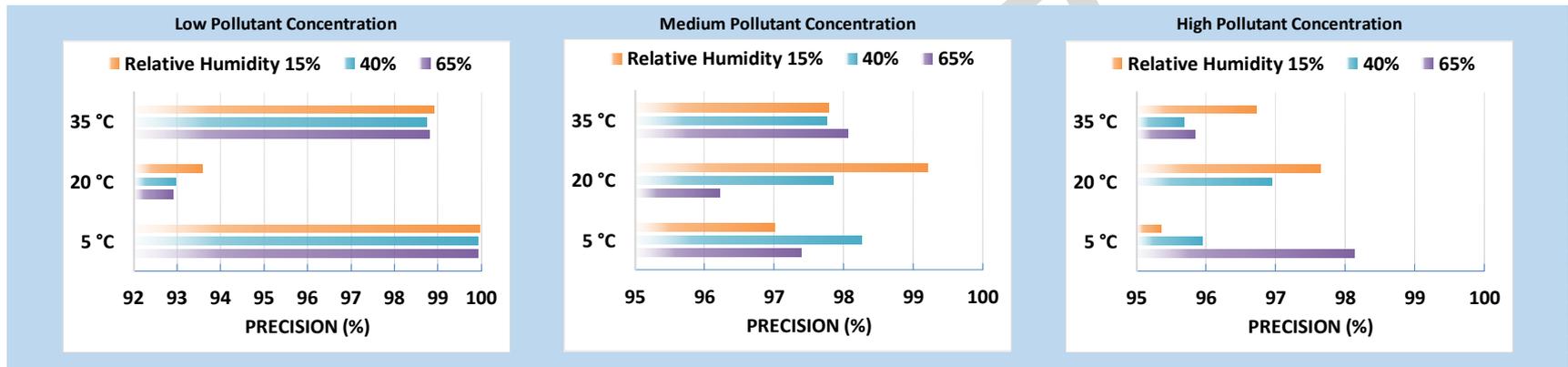
- The Alphasense OPC-N3 sensors underestimated GRIMM PM<sub>1.0</sub> mass concentration. The accuracy of the Alphasense OPC-N3 sensors was constant (11% to 14%) over the range of PM<sub>1.0</sub> mass concentrations tested.

## Alphasense OPC-N3: Data Recovery and intra-model variability

- Data recovery for PM<sub>1.0</sub> mass concentration from all units was 100%
- High PM<sub>1.0</sub> measurement variations were observed between the Alphasense OPC-N3 sensors

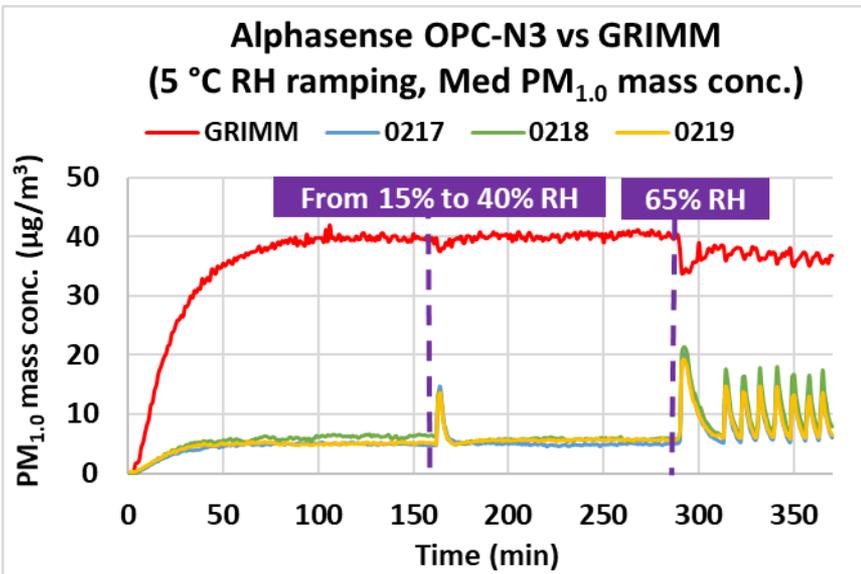
# PM<sub>1.0</sub> Precision: Alphasense OPC-N3

- Precision (Effect of PM<sub>1.0</sub> conc., Temperature and Relative Humidity)



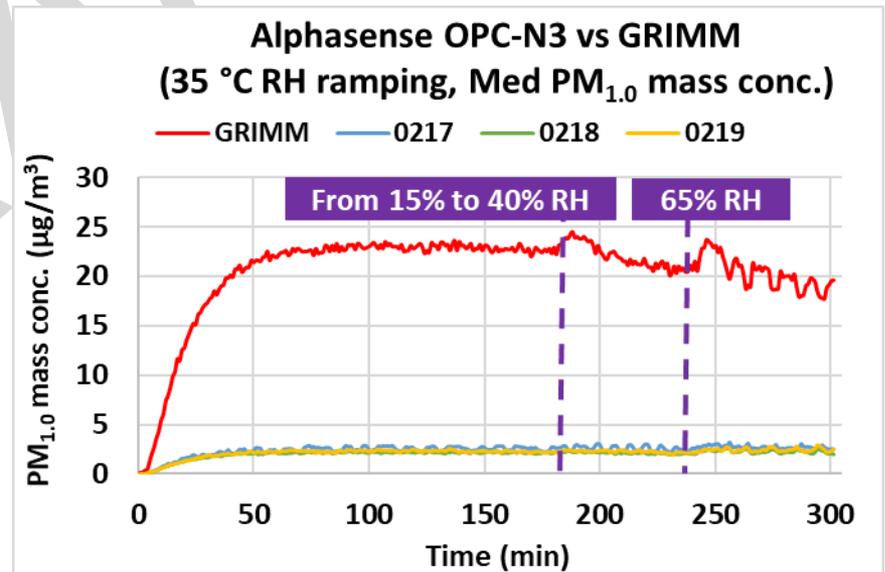
- Overall, the Alphasense OPC-N3 sensors showed high precision for all of the combinations of low, medium and high PM<sub>1.0</sub> conc., T and RH.

# Alphasense OPC-N3 PM<sub>1.0</sub>: Climate Susceptibility



**Low Temp – RH ramping**  
(medium conc.)

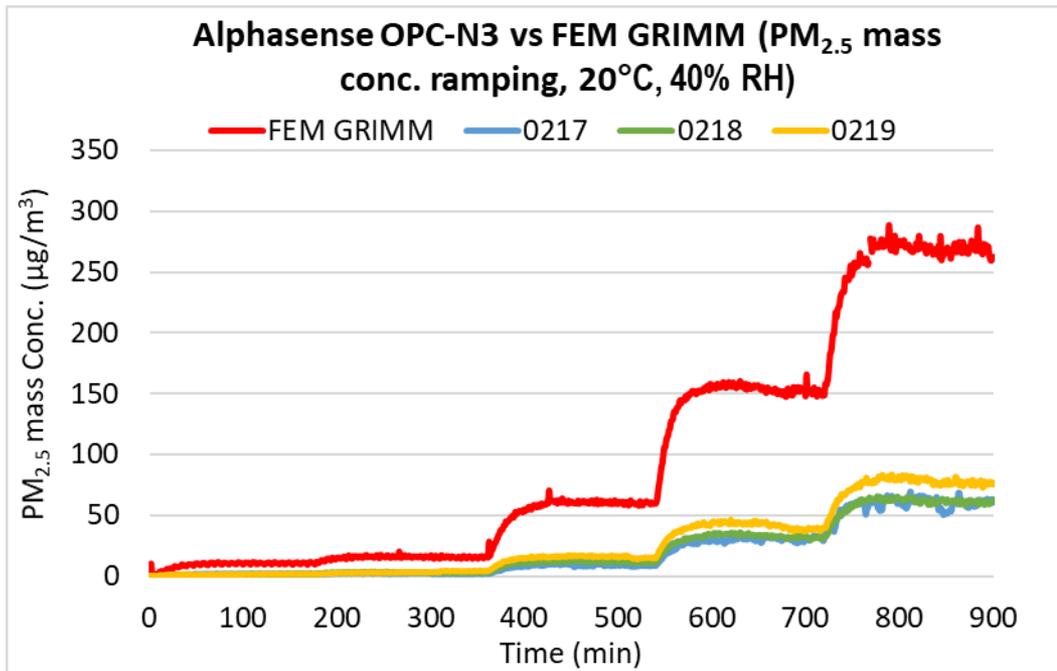
**High Temp – RH ramping**  
(medium conc.)



# Evaluation results for PM<sub>2.5</sub> mass concentration

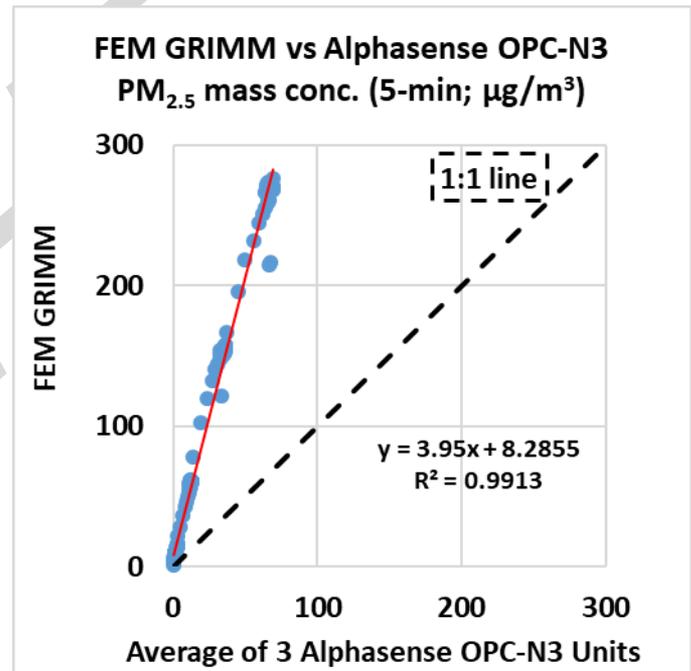
Alphasense OPC-N3 vs FEM GRIMM

# Alphasense OPC-N3 vs FEM GRIMM (PM<sub>2.5</sub> mass conc.)



- The Alphasense OPC-N3 sensors tracked well with the concentration variation as recorded by the FEM GRIMM in the concentration range of 0 - ~300 µg/m<sup>3</sup>.

## Coefficient of Determination



- The Alphasense OPC-N3 sensors showed very strong correlations with the corresponding FEM GRIMM PM<sub>2.5</sub> mass conc. ( $R^2 > 0.99$ ).

# Alphasense OPC-N3 vs FEM GRIMM PM<sub>2.5</sub> Accuracy

- Accuracy (20 °C and 40% RH)

| Steady state # | Sensor Mean (µg/m <sup>3</sup> ) | FEM GRIMM (µg/m <sup>3</sup> ) | Accuracy (%) |
|----------------|----------------------------------|--------------------------------|--------------|
| 1              | 1.7                              | 10.2                           | 16.6         |
| 2              | 2.9                              | 15.2                           | 18.9         |
| 3              | 11.4                             | 59.6                           | 19.1         |
| 4              | 33.3                             | 153.1                          | 21.7         |
| 5              | 65.3                             | 270.1                          | 24.2         |

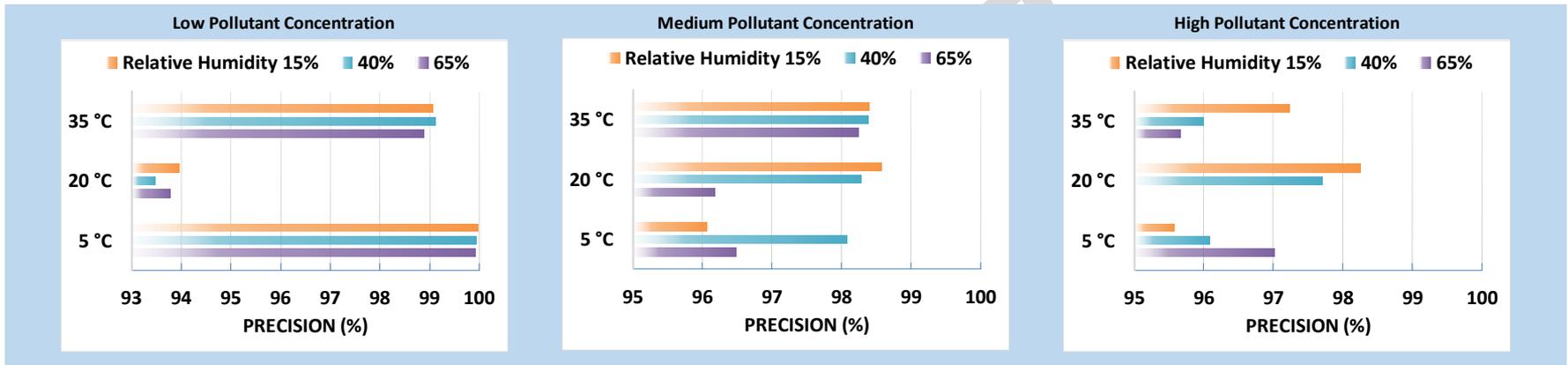
- The Alphasense OPC-N3 sensors underestimated FEM GRIMM PM<sub>2.5</sub> mass concentration at 20 °C and 40% RH. The accuracy of the Alphasense OPC-N3 sensors increased slightly as PM<sub>2.5</sub> mass conc. increased.

## Alphasense OPC-N3: Data Recovery and intra-model variability

- Data recovery for PM<sub>2.5</sub> mass concentration from all units was 100%
- High PM<sub>2.5</sub> measurement variations were observed between the Alphasense OPC-N3 sensors

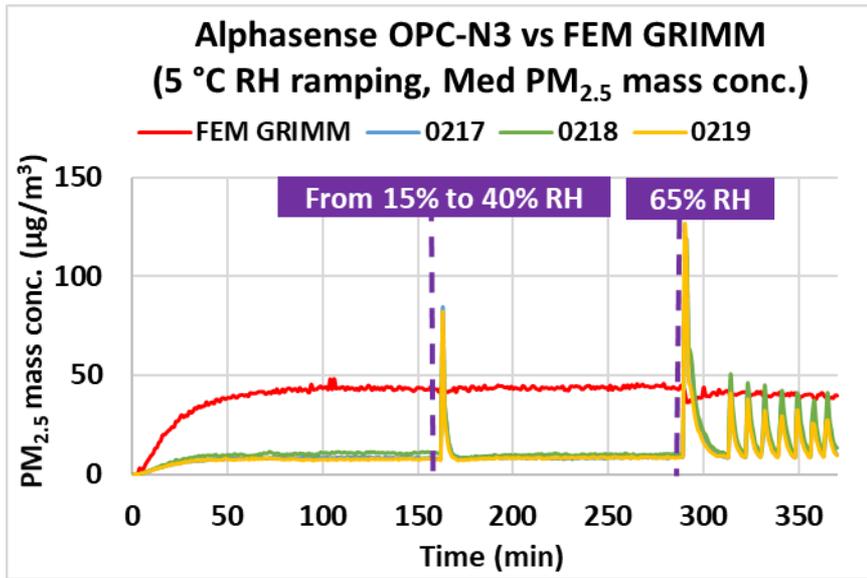
# PM<sub>2.5</sub> Precision: Alphasense OPC N-3

- Precision (Effect of PM<sub>2.5</sub> conc., Temperature and Relative Humidity)



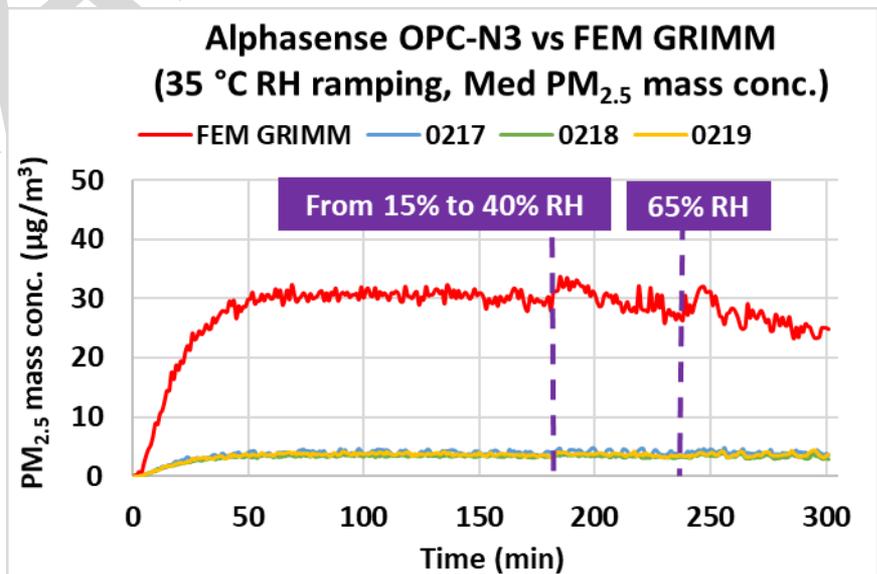
- Overall, the Alphasense OPC-N3 sensors showed high precision for all of the combinations of low, medium and high PM<sub>2.5</sub> conc., T and RH.

# Alphasense OPC-N3 PM<sub>2.5</sub>: Climate Susceptibility



**Low Temp – RH ramping**  
(medium conc.)

**High Temp – RH ramping**  
(medium conc.)



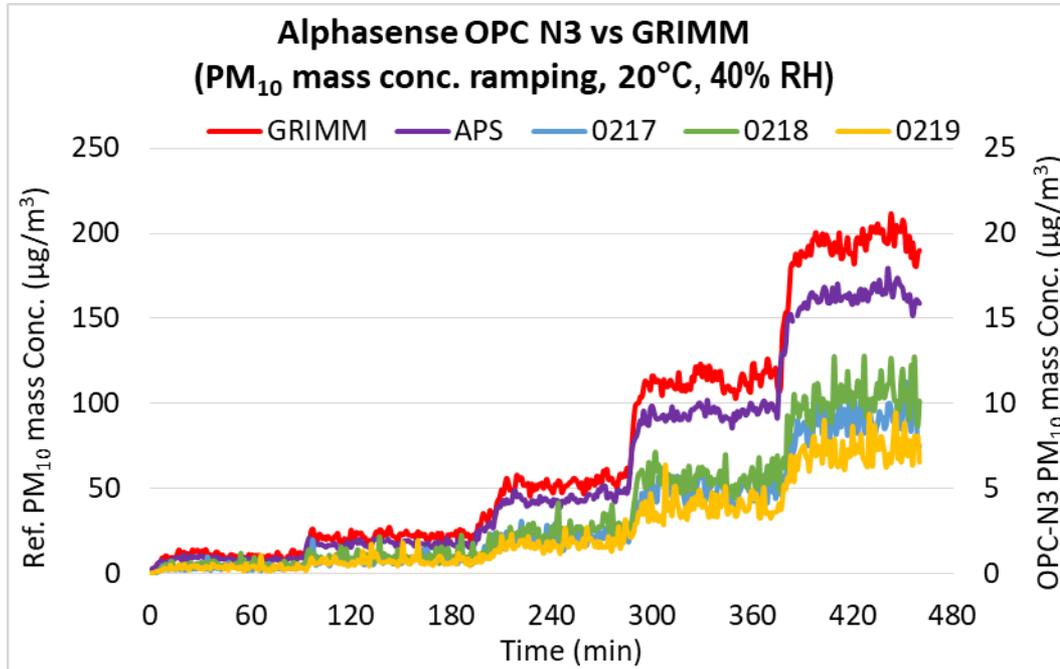
# Discussion (PM<sub>1.0</sub> and PM<sub>2.5</sub>)

- **Accuracy:** Overall, the accuracy of the Alphasense OPC-N3 sensors was constant (11% to 14%) over the range of PM<sub>1.0</sub> mass concentrations tested. The accuracy of the Alphasense OPC-N3 sensors increased slightly as PM<sub>2.5</sub> mass conc. increased. The Alphasense OPC-N3 sensors largely underestimated both PM<sub>1.0</sub> and PM<sub>2.5</sub> measurements from GRIMM in the laboratory experiments at 20 °C and 40% RH.
- **Precision:** The Alphasense OPC-N3 sensors showed high precision for all test combinations (PM concentrations, T and RH) for both PM<sub>1.0</sub> and PM<sub>2.5</sub> mass concentrations
- **Intra-model variability:** High intra-model variability was observed among the Alphasense OPC-N3 sensors.
- **Data Recovery:** Data recovery for PM<sub>1.0</sub> and PM<sub>2.5</sub> mass concentration from all units was 100%.
- **Coefficient of Determination:** The Alphasense OPC-N3 sensors showed very strong correlation/linear response with the corresponding GRIMM PM<sub>1.0</sub> and FEM GRIMM PM<sub>2.5</sub> measurement data ( $R^2 > 0.99$ ).
- **Climate susceptibility:** For most of the temperature and relative humidity combination, the climate condition had minimal effect on the Alphasense OPC-N3 sensors except that the sensors showed significant variations in PM conc. at 65% RH at 5°C.

# Evaluation results for PM<sub>10</sub> mass concentration

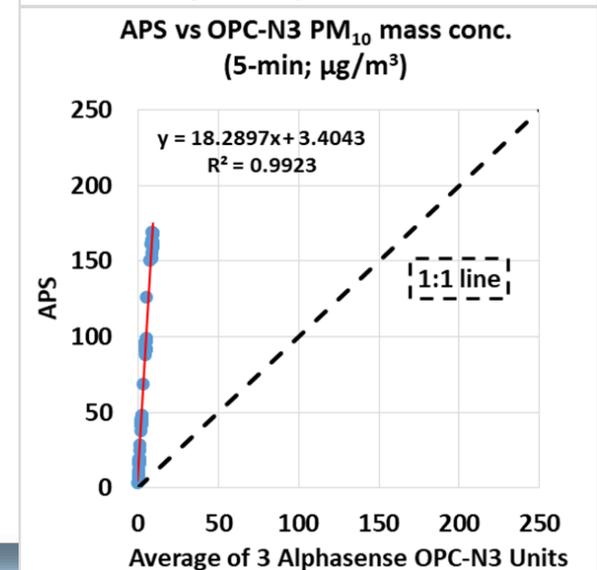
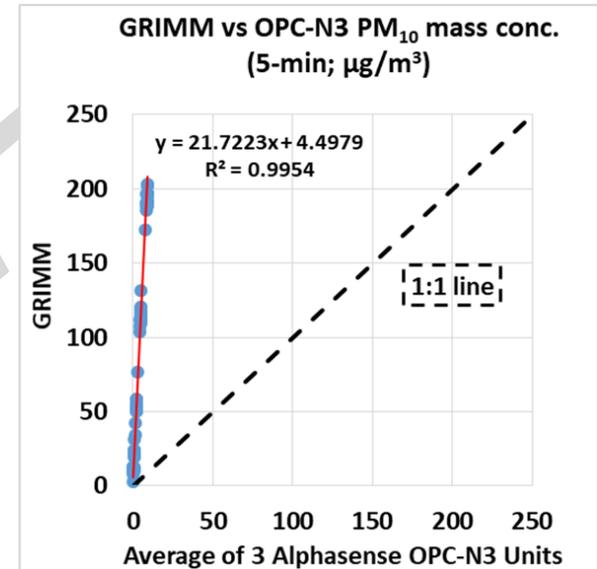
Alphasense OPC-N3 vs GRIMM vs APS

# Alphasense OPC-N3 vs GRIMM vs APS (PM<sub>10</sub> mass conc.)



- The Alphasense OPC-N3 sensors tracked well with the concentration variation as recorded by GRIMM and APS in the concentration range of 0 - ~200 µg/m<sup>3</sup>.
- The Alphasense OPC-N3 sensors showed very strong correlations with the corresponding GRIMM and APS PM<sub>10</sub> mass conc. ( $R^2 > 0.99$ ).

## Coefficient of Determination



# Alphasense OPC-N3 vs GRIMM vs APS PM<sub>10</sub> Accuracy

- Accuracy (20 °C and 40% RH)

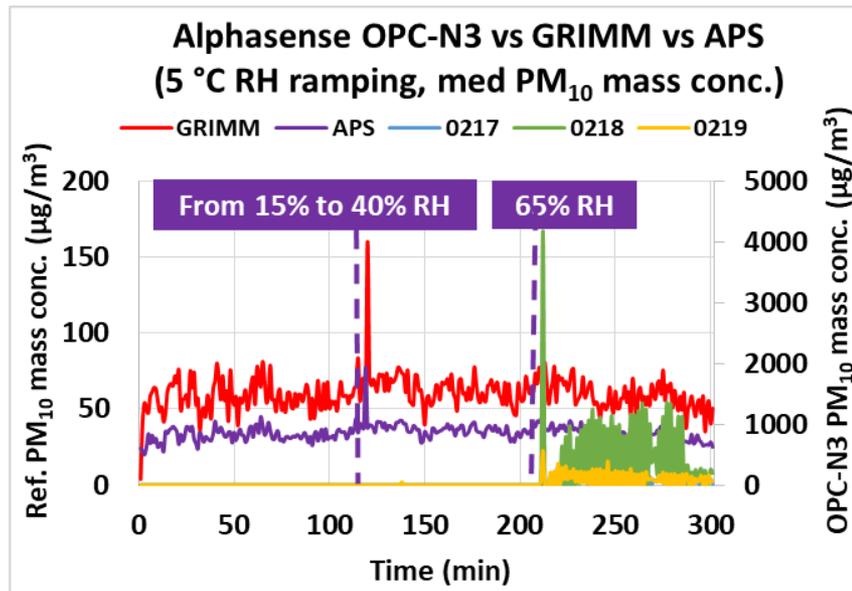
| Steady state # | Sensor Mean (µg/m <sup>3</sup> ) | GRIMM (µg/m <sup>3</sup> ) | Accuracy (%) | Steady state # | Sensor Mean (µg/m <sup>3</sup> ) | APS (µg/m <sup>3</sup> ) | Accuracy (%) |
|----------------|----------------------------------|----------------------------|--------------|----------------|----------------------------------|--------------------------|--------------|
| 1              | 0.4                              | 10.1                       | 4.1          | 1              | 0.4                              | 7.5                      | 5.5          |
| 2              | 0.9                              | 21.8                       | 4.0          | 2              | 0.9                              | 17.5                     | 5.0          |
| 3              | 2.0                              | 51.5                       | 4.0          | 3              | 2.0                              | 42.5                     | 4.8          |
| 4              | 4.9                              | 116.9                      | 4.2          | 4              | 4.9                              | 96.4                     | 5.1          |
| 5              | 9.0                              | 198.5                      | 4.5          | 5              | 9.0                              | 166.7                    | 5.4          |

- The Alphasense OPC-N3 sensors underestimated GRIMM and APS PM<sub>10</sub> mass concentration at 20 °C and 40% RH. The accuracy of the Alphasense OPC-N3 sensors was fairly constant (~4% to 5%) over the PM<sub>10</sub> mass concentration range tested.

## Alphasense OPC-N3: Data Recovery and intra-model variability

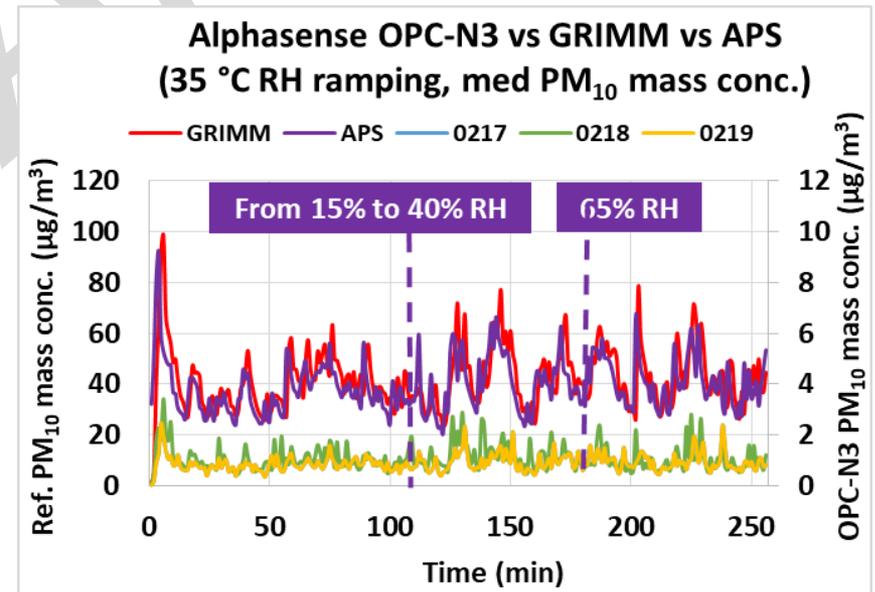
- Data recovery for PM<sub>10</sub> mass concentration from all units was 100%
- High PM<sub>10</sub> measurement variations were observed between the Alphasense OPC-N3 sensors

# Alphasense OPC-N3 PM<sub>10</sub>: Climate Susceptibility



**Low Temp – RH ramping  
(medium conc.)**

**High Temp – RH ramping  
(medium conc.)**



# Discussion (PM<sub>10</sub>)

- **Accuracy:** The Alphasense OPC-N3 sensors underestimated the corresponding GRIMM and APS PM<sub>10</sub> mass concentration at 20 °C and 40% RH. The accuracy of the Alphasense OPC-N3 sensors was constant (~4% to 5%) over the PM<sub>10</sub> mass concentration range tested.
- **Precision:** Due to the nature of Arizona test dust, the aerosol concentration showed some variability, therefore, the precision cannot be fairly estimated.
- **Intra-model variability:** High intra-model variability was observed among the Alphasense OPC-N3 sensors.
- **Data Recovery:** Data recovery for PM<sub>10</sub> mass concentration from all units was 100%.
- **Coefficient of Determination:** The Alphasense OPC-N3 sensors showed very strong correlation/linear response with the corresponding GRIMM and APS PM<sub>10</sub> measurement data ( $R^2 > 0.99$ ).
- **Climate susceptibility:** For most of the temperature and relative humidity combination, the climate condition had minimal effect on the Alphasense OPC-N3 sensors except that the sensors showed significant variations in PM<sub>10</sub> conc. At 65% RH at 5°C.