

# AQ-SPEC

## Air Quality Sensor Performance Evaluation Center

### Evaluation Summary

#### Sensor Description

Manufacturer/Model:  
Sensirion/  
Nubo

Pollutants:  
PM<sub>1.0</sub> and PM<sub>2.5</sub>  
mass concentration

Time Resolution:  
1-min

Type: Optical



- Overall, the accuracy of the Sensirion Nubo was fairly constant (86% to 98% and 81% to 94%) over the range of PM<sub>1.0</sub> and PM<sub>2.5</sub> mass concentration tested, respectively. Overall, the Sensirion Nubo sensors overestimated PM<sub>1.0</sub> measurements when PM<sub>1.0</sub> concentrations were > 100 µg/m<sup>3</sup> and overestimated and PM<sub>2.5</sub> measurements from GRIMM in the laboratory experiments at 20 °C and 40% RH.
- The Sensirion Nubo sensors exhibited high precision for all T/RH combinations and all PM concentrations.
- The Sensirion Nubo sensors (IDs: 2A3E, 1743 and 051E) showed low intra-model variability for both the field and laboratory evaluations.
- Data recovery was ~97% and 100% from all units in the field and laboratory evaluations.
- For PM<sub>1.0</sub>, the Sensirion Nubo sensors showed very strong correlations with the corresponding GRIMM data; and showed strong to very strong correlations with the ref. instruments from the field for PM<sub>2.5</sub> ( $0.76 < R^2 < 0.92$ ) and very strong correlations with GRIMM in the laboratory evaluations ( $R^2 > 0.99$  for PM<sub>1.0</sub> and PM<sub>2.5</sub>).
- The same three Sensirion Nubo 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).

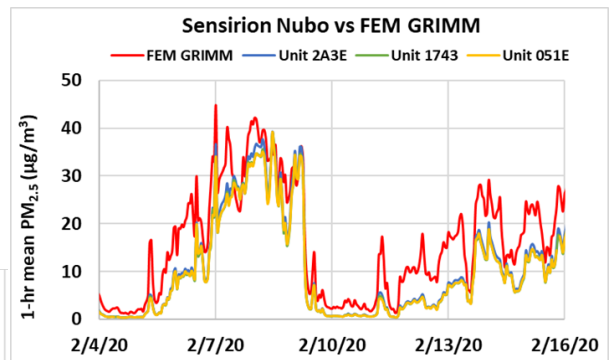
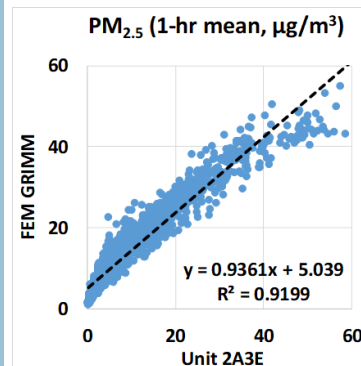
### Field Evaluation Highlights

- Deployment period 12/27/2019 - 02/27/2020: the three Sensirion Nubo sensors showed very strong correlations with the corresponding GRIMM data for PM<sub>1.0</sub>, and strong to very strong correlations with the corresponding FEM GRIMM and FEM BAM for PM<sub>2.5</sub>.
- The units showed low intra-model variability and data recovery was ~ 97%.

1-hr mean, all ref. inst.

PM<sub>1.0</sub>: ~ 0.96

PM<sub>2.5</sub>:  $0.76 < R^2 < 0.92$



Coefficient of Determination ( $R^2$ ) quantifies how the three sensors followed the PM<sub>2.5</sub> concentration change by the reference instruments.

An  $R^2$  approaching the value of 1 reflects a near perfect agreement, whereas a value of 0 indicates a complete lack of correlation.

#### Additional Information

##### Field evaluation report:

<http://www.aqmd.gov/aq-spec/evaluations/field>

##### Lab evaluation report:

<http://www.aqmd.gov/aq-spec/evaluations/laboratory>

##### AQ-SPEC website:

<http://www.aqmd.gov/aq-spec>

# Laboratory Evaluation Highlights

## Accuracy (PM<sub>2.5</sub>)

$$A (\%) = 100 - \frac{|\bar{X} - \bar{R}|}{\bar{R}} * 100$$

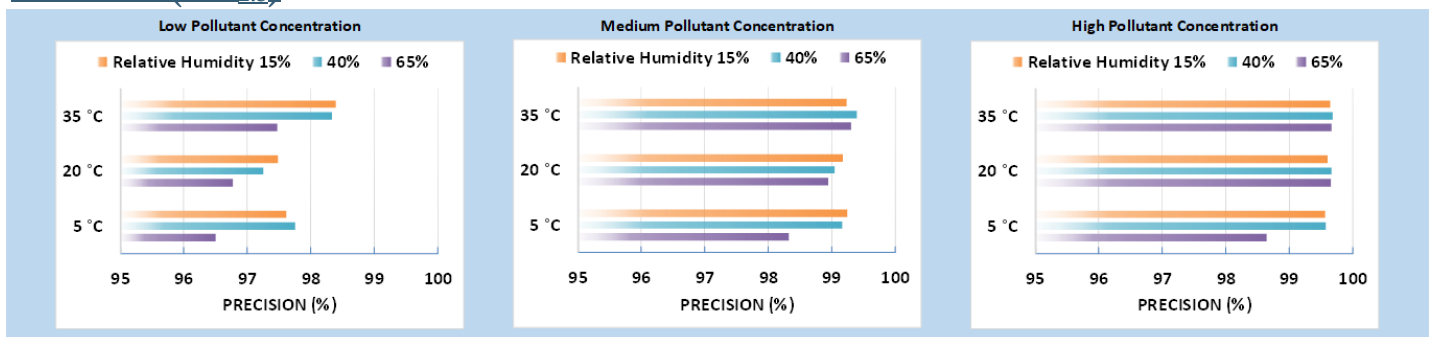
Steady state #	Sensor Mean (µg/m <sup>3</sup> )	FEM GRIMM (µg/m <sup>3</sup> )	Accuracy (%)
1	8.9	8.4	93.9
2	16.4	13.7	80.9
3	52.3	45.3	84.5
4	131.5	117.7	88.3
5	308.5	261.5	82.0

Accuracy was evaluated by a concentration ramping experiment at 20 °C and 40%. The sensor's readings at each ramping steady state are compared to the reference instrument.

A negative % means sensors' overestimation by more than two fold. The higher the positive value (close to 100%), the higher the sensor's accuracy.



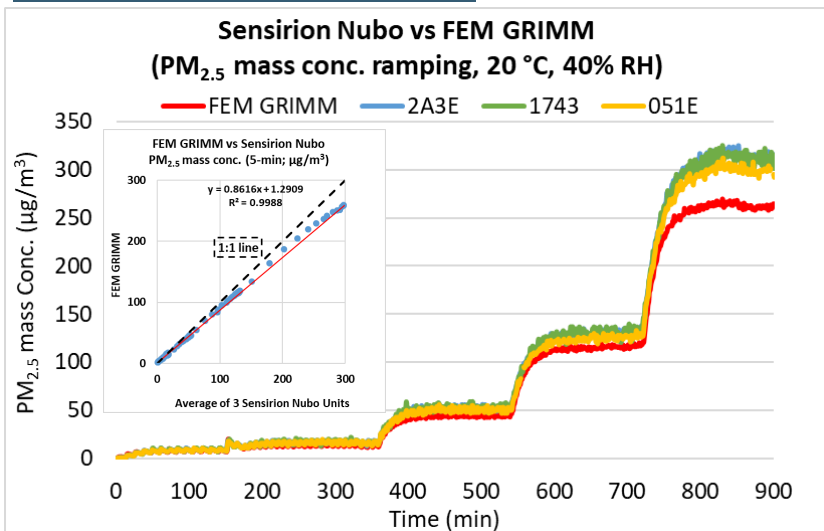
## Precision (PM<sub>2.5</sub>)



100% represents high precision.

Sensor's ability to generate precise measurements of PM<sub>2.5</sub> concentration at low, medium, and high pollutant levels were evaluated under 9 combinations of T and RH, including extreme weather conditions like cold and dry (5 °C and 15%) cold and humid (5 °C and 65%), hot and humid (35 °C and 65%), or hot and dry (35 °C and 15%).

## Coefficient of Determination



The Sensirion Nubos sensors showed very strong correlations with the corresponding FEM PM<sub>2.5</sub> data ( $R^2 > 0.99$ ) at 20 °C/40% RH. For conc. ramping experiments of PM<sub>1.0</sub>, please see the lab report.

## Climate Susceptibility

From the laboratory studies, temperature and relative humidity had minimal effect on the Sensirion Nubos sensor precision. At the set-points of RH changes, the sensors reported spiked changes in concentration for all PM levels at 5 °C.

## Observed Interferents

N/A



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