Laboratory Evaluation

Clarity Node PM Sensor

South Coast AQMD

AQ-SPEC

Air Quality Sensor Performance Evaluation Center

Background

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*):

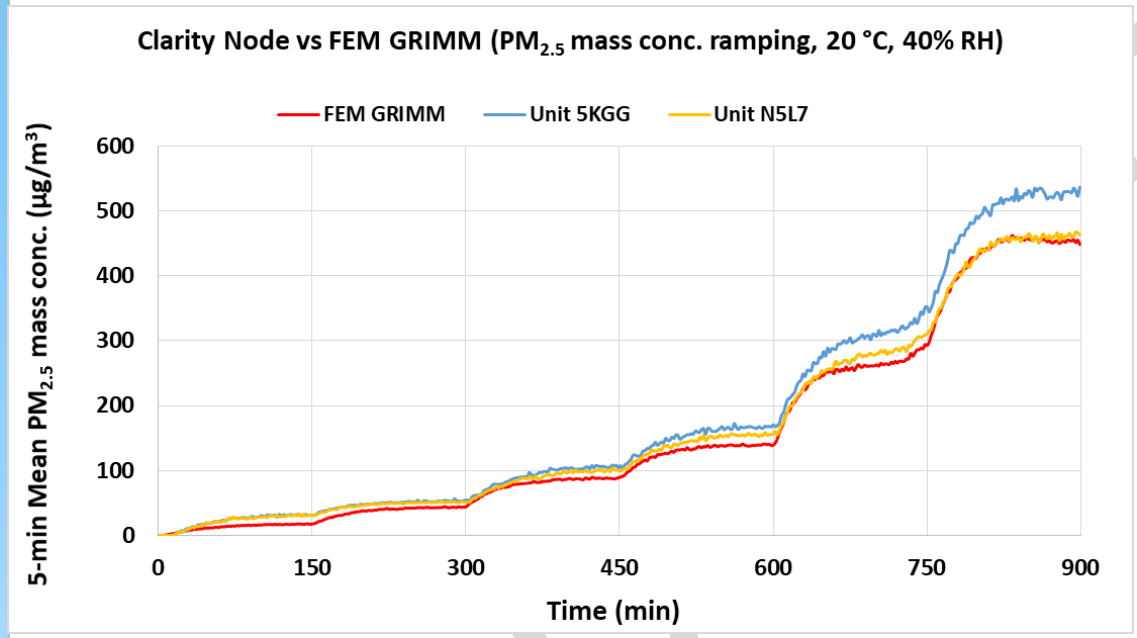
- Particle sensors (optical; non-FEM)
- Each unit measures:
  - $PM_{2.5}$ mass concentration ($\mu g/m^3$)
  - NO_2, CO_2 and TVOC (under Development)
- Unit cost: ~$1300 (includes 1-yr of cloud data access, cellular connectivity and tech support)
- Time resolution: 2-min (90 sec. of sampling time + 20 sec. of warm-up time and 10 sec. of lag time)
- Units IDs: N5L7 and 5KGG

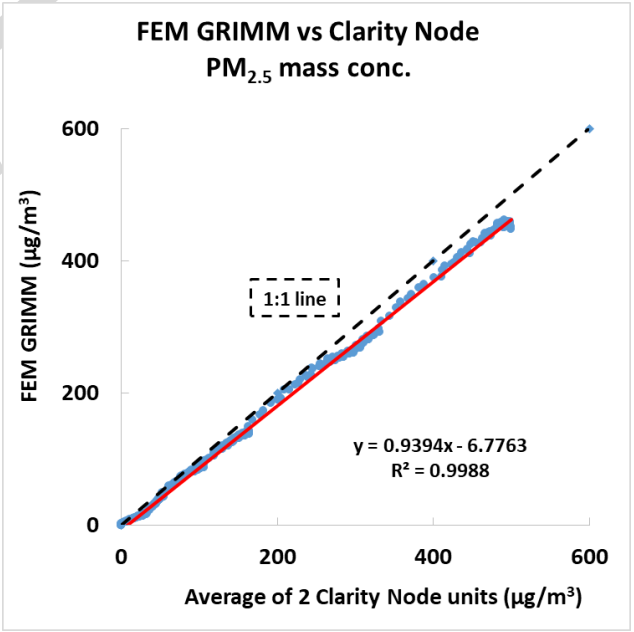
GRIMM (*reference method*):

- 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

FEM GRIMM

Clarity Node vs FEM GRIMM ($PM_{2.5}$ mass conc.)





- The two Clarity Node sensors tracked well with the concentration variation recorded by FEM GRIMM in the concentration range of 0-450 µg/m^3.

- 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)

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

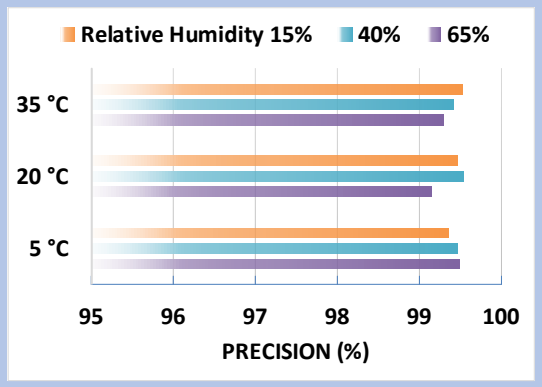
- The two Clarity Node sensors overestimated FEM GRIMM $PM_{2.5}$ mass concentration. The accuracy of the Clarity Node sensors increases as concentration increases, ranging from 19.2% at the lowest concentration to 90.7% at the highest concentration.

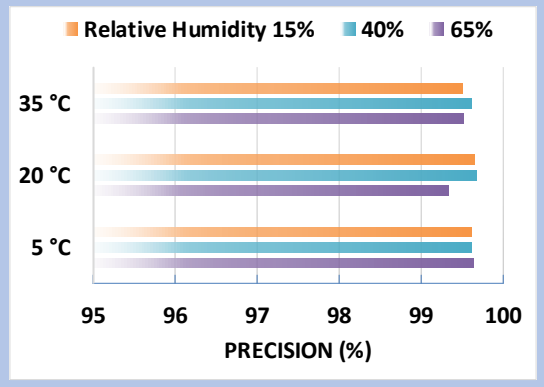
Clarity Node Data Recovery and Intra-model variability

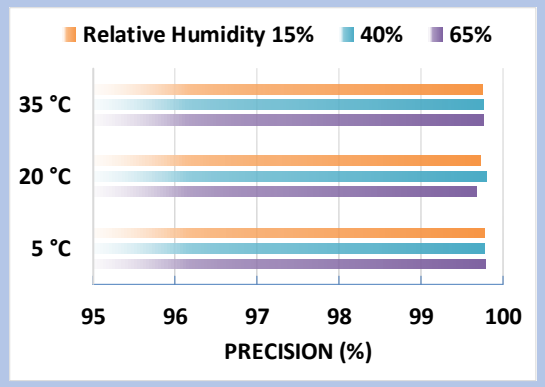
- Data recovery for $PM_{2.5}$ mass concentration from both sensors was 100%
- Very low $PM_{2.5}$ measurement variations were observed among the two Clarity Node sensors

$PM_{2.5}$ Precision: Clarity Node

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

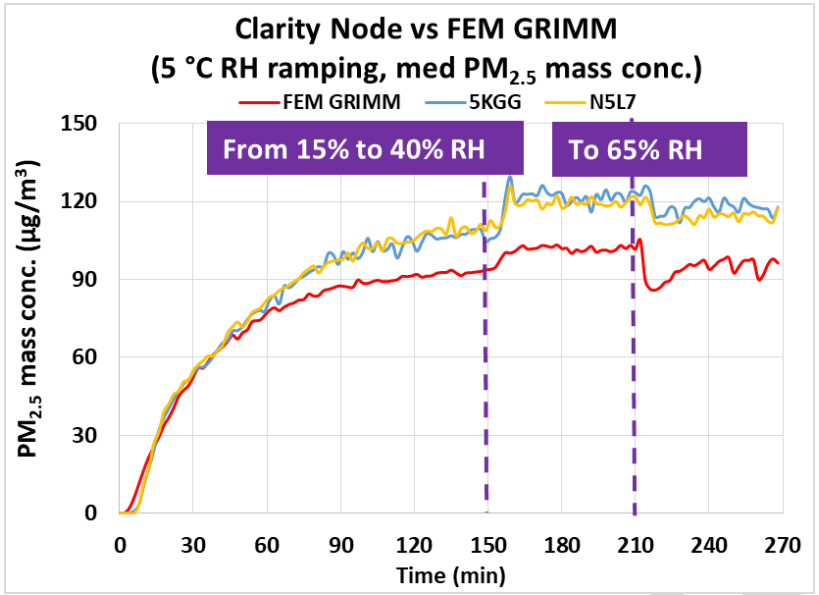






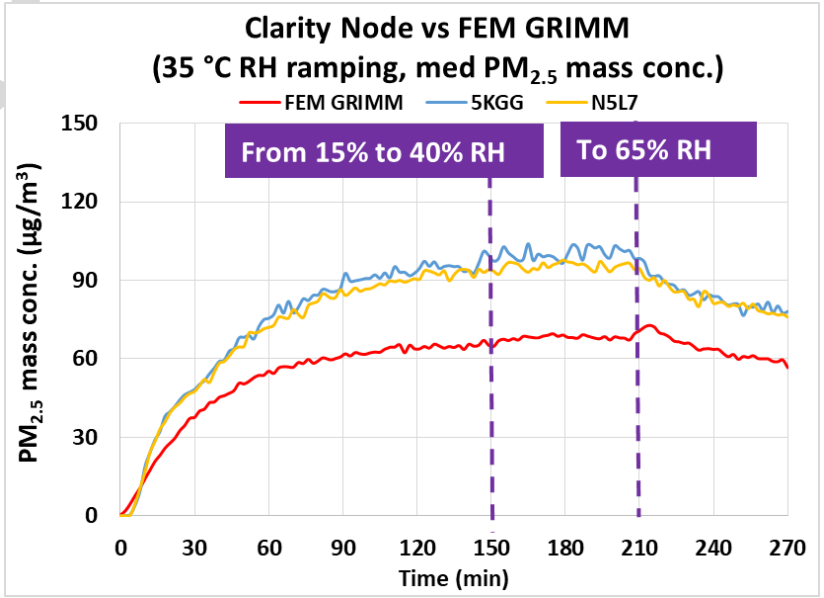
- Overall, the two Clarity Node sensors showed high precision for all of the combinations of low, medium and high $PM_{2.5}$ conc., T, and RH.

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.