Laboratory Evaluation

TSI AirAssure PM$_{2.5}$ Sensor

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

Three **TSI AirAssure PM$_{2.5}$** sensors (units IDs: 004, 005, and 010) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (12/18/2015 to 02/15/2016) under ambient environmental conditions. Now, three new AirAssure sensors (units IDs: 5036, 7003, 7004) have been evaluated in the South Coast AQMD Chemistry Laboratory under controlled artificial aerosol concentration/size range, temperature, and relative humidity.

AirAssure Sensor (*3 units tested*):
- Particle sensors (optical; non-FEM)
- Each unit measures PM$_{2.5}$ mass concentration (μg/m^3)
- Unit cost: ~$1500
- Time resolution: 1-min
- Units IDs: 5036, 7003, 7004

GRIMM (*reference method*):
- Optical particle counter
- FEM PM$_{2.5}$
- Uses proprietary algorithms to calculate total PM, PM$_{2.5}$, and PM$_1$ mass conc. from particle number measurements
- Cost: ~$25,000
- Time resolution: 1-min

TSI AirAssure
Model IPM2.5

FEM GRIMM

2

AirAssure vs FEM GRIMM (PM$_{2.5}$ mass; 5-min mean)

TSI AirAssure vs GRIMM (PM2.5 mass conc. ramping, 20 °C, 40% RH)

— GRIMM — Unit5036 — Unit7003 — Unit7004

Coefficient of Determination

GRIMM vs AirAssure
PM2.5 mass conc.

(*GRIMM conc. higher than 150 μg/m³: **not shown**, b/c AirAssure plateaued at 300 μg/m³)

$y = 0.50x - 5.37$
$R^2 > 0.99$
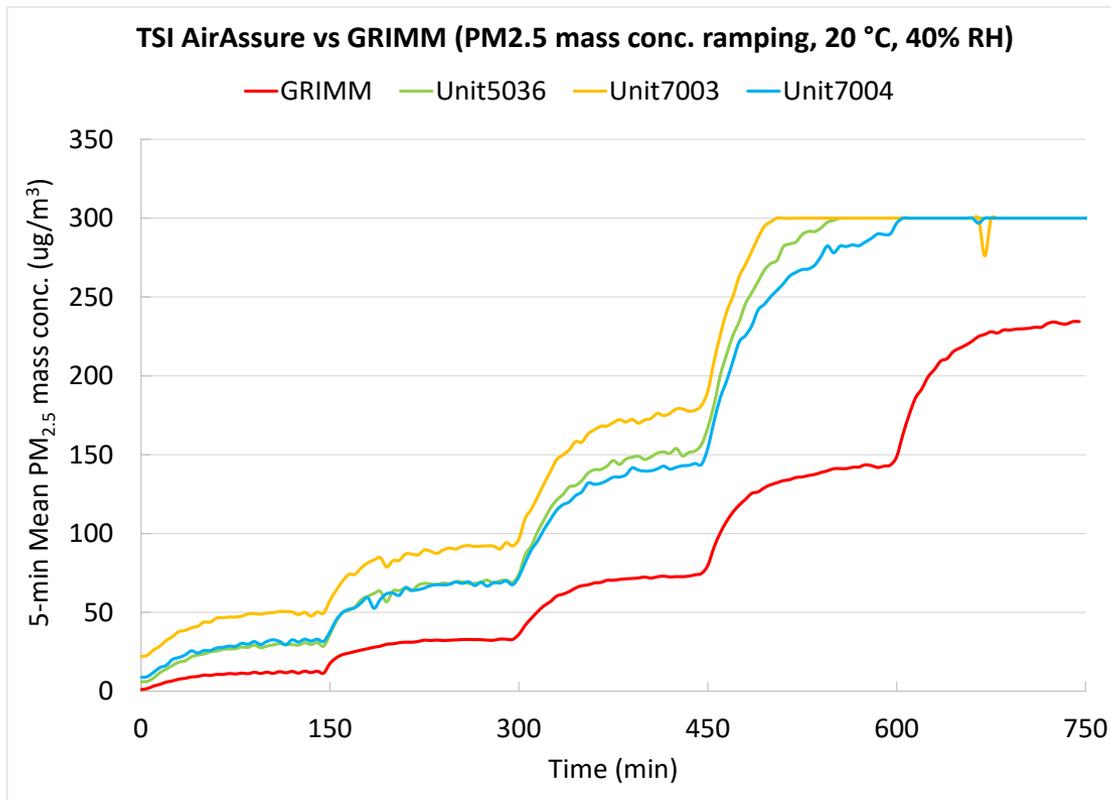
- The three AirAssure sensors tracked well with the concentration variation recorded by FEM GRIMM in the concentration range of 0-150 μg/m³.

- AirAssure sensors overestimated the GRIMM PM$_{2.5}$ mass conc, and stopped to report values higher than 300 μg/m³ (when GRIMM measured above 150 μg/m³). Sensor manufacturer claims a measurement range of 5-300 μg/m³.
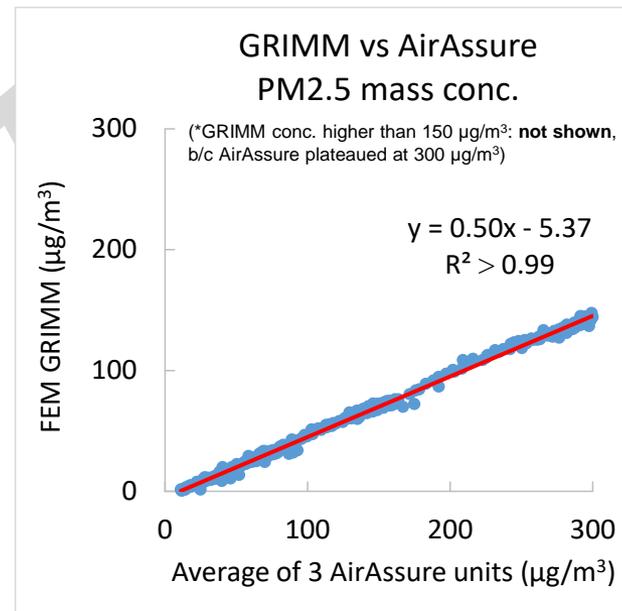
- Three AirAssure sensors showed very strong correlations with GRIMM PM$_{2.5}$ mass conc. ($R^2 > 0.99$) between 0-150 μg/m³.

PM$_{2.5}$ Accuracy: AirAssure vs GRIMM

- Accuracy (20 °C and 40% RH)

| Steady State (#)	Sensor mean (μg/m^3)	GRIMM (μg/m^3)	Accuracy (%)
1	37.4	12.1	-108.1
2	77.3	32.7	-36.5
3	157.7	73.3	-15.2
4	295.9	142.8	-7.2

- AirAssure has low accuracy compared to FEM GRIMM. The three AirAssure sensors overestimated FEM GRIMM PM$_{2.5}$ measurements over the concentration range of 0-150 μg/m^3.

AirAssure Data Recovery and Intra-model variability

- Data recovery for PM$_{2.5}$ mass concentration from 5036, 7003, and 7004 were 97.06%, 97.13%, and 97.13%.

- Moderate to high PM$_{2.5}$ measurement variations were observed among the three AirAssure units.

PM$_{2.5}$ Precision: AirAssure

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

Low conc.

Medium conc.

High conc.

At high PM$_{2.5}$ concentration (higher than 150 μg/m^3, measured by GRIMM), AirAssure plateaued at 300 μg/m^3.
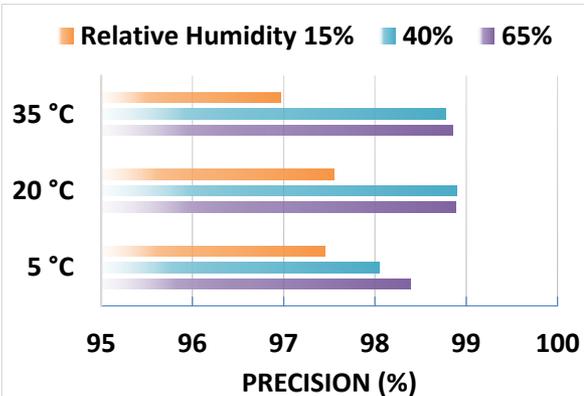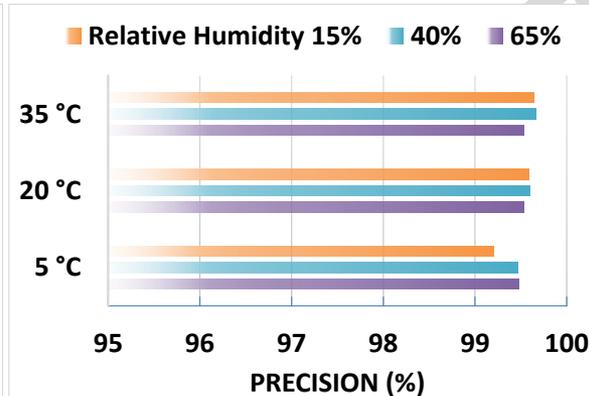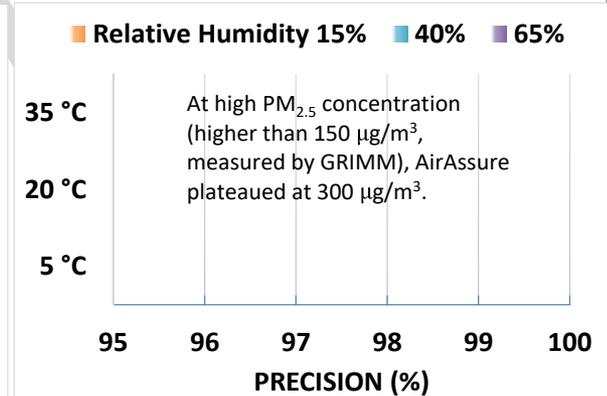
- Overall, the three AirAssure sensors showed high precision for most of the combinations of low and medium PM$_{2.5}$ conc., T, and RH.

- At high PM$_{2.5}$ concentration (higher than 150 μg/m^3, measured by GRIMM), AirAssure plateaued at 300 μg/m^3.

AirAssure Climate Susceptibility

AirAssure vs GRIMM
(5 °C RH ramping, med PM$_{2.5}$ mass conc.)

Legend: GRIMM — Unit5036 — Unit7003 — Unit7004

From 15% to 40% RH   To 65% RH

Low Temp - RH ramping
(medium conc.)

AirAssure vs GRIMM
(35 °C RH ramping, med PM$_{2.5}$ mass conc.)

Legend: GRIMM — Unit5036 — Unit7003 — Unit7004

From 15% to 40% RH   To 65% RH
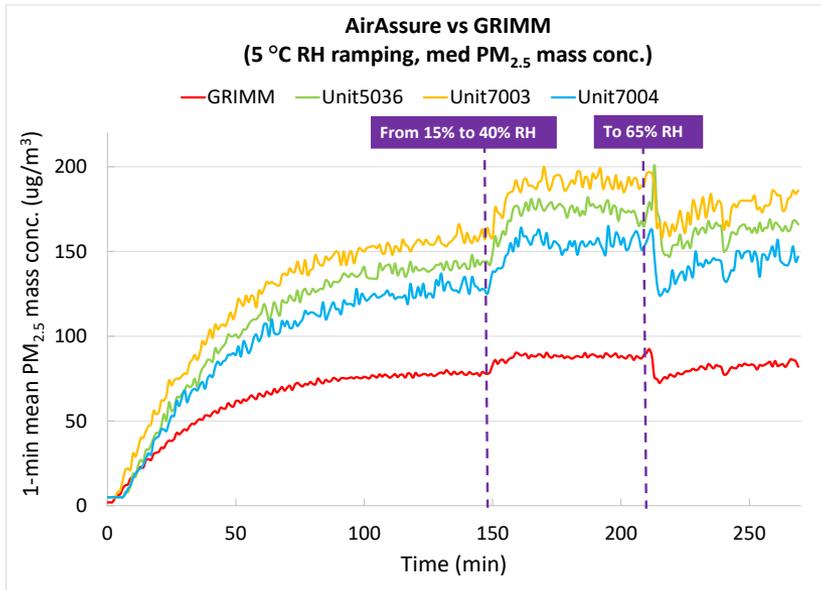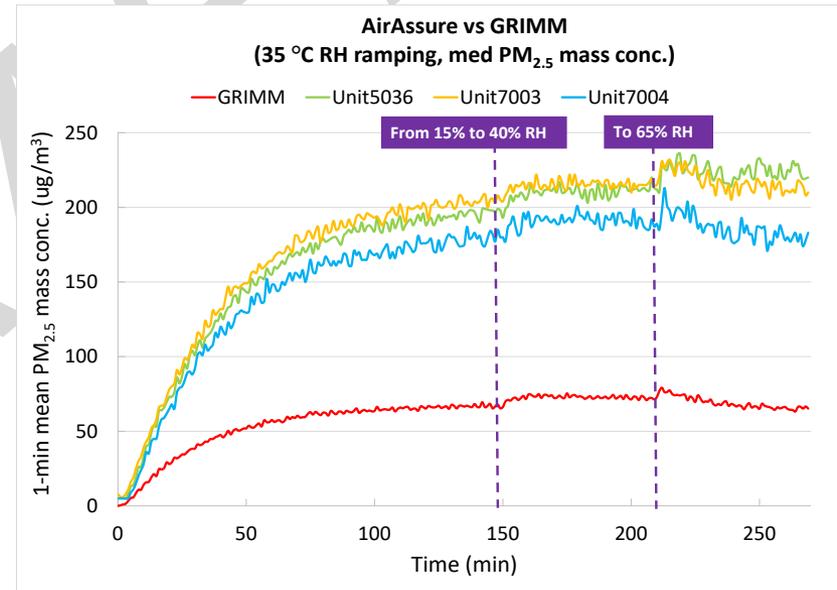
High Temp - RH ramping
(medium conc.)

Discussion

➢ **Accuracy**: Overall, the three AirAssure sensors have low accuracy, compared to GRIMM $PM_{2.5}$ in the range of 0.0 to 150 µg/m^3. AirAssure overestimated FEM GRIMM's reading in the laboratory experiments.

➢ **Precision**: The AirAssure sensors have high precision for most of the test combinations (low, medium PM concentrations, T and RH).

➢ **Intra-model variability**: Moderate to high intra-model variability was observed among the three AirAssure sensors.

➢ **Data Recovery:** Data recovery for $PM_{2.5}$ mass concentration from 5036, 7003, 7004 was 97.06%, 97.13%, and 97.13%.

➢ **Coefficient of Determination**: The three AirAssure sensors showed very strong correlation/linear response with the corresponding GRIMM $PM_{2.5}$ measurement data ($R^2 > 0.99$) for mass concentration range between 0 and 150 µg/m^3.

➢ **Climate susceptibility**: For most of the temperature and relative humidity combination, the climate condition had minimal effect on the AirAssure's precision. At the set-points of RH changes at low PM concentrations, AirAssure sensors had some small spikes.