

Laboratory Evaluation: MagnaSCI SRL uRADMonitor SMOGGIE-PM v1.101



Background

Three **MagnaSCI SRL uRADMonitor SMOGGIE-PM v1.101** (hereinafter **uRADMonitor SMOGGIE**) sensors (units IDs: 0032, 0033, 0034) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (04/17/2020 to 6/27/2020) under ambient environmental conditions and have been evaluated in the South Coast AQMD Chemistry Laboratory under controlled artificial aerosol concentration/size range, temperature, and relative humidity. The same three uRADMonitor SMOGGIE units were tested both in the field (1st stage of testing) and in the laboratory (2nd stage of testing).

uRADMonitor SMOGGIE (3 units tested):

- PM Sensor – Optical Particle Counter (**Plantower PMSA003, non-FEM**)
- Each unit measures: PM_{1.0}, PM_{2.5} and PM₁₀ (µg/m³), T (°C), RH (%)
- **Unit cost: \$110**
- Time resolution: 1-min
- Units IDs: 0032, 0033, 0034



GRIMM (reference method):

- Optical particle counter
- **FEM PM_{2.5}**
- Uses proprietary algorithms to calculate PM_{1.0}, PM_{2.5}, and PM₁₀ mass conc. from particle number measurements
- **Cost: ~\$25,000**
- Time resolution: 1-min

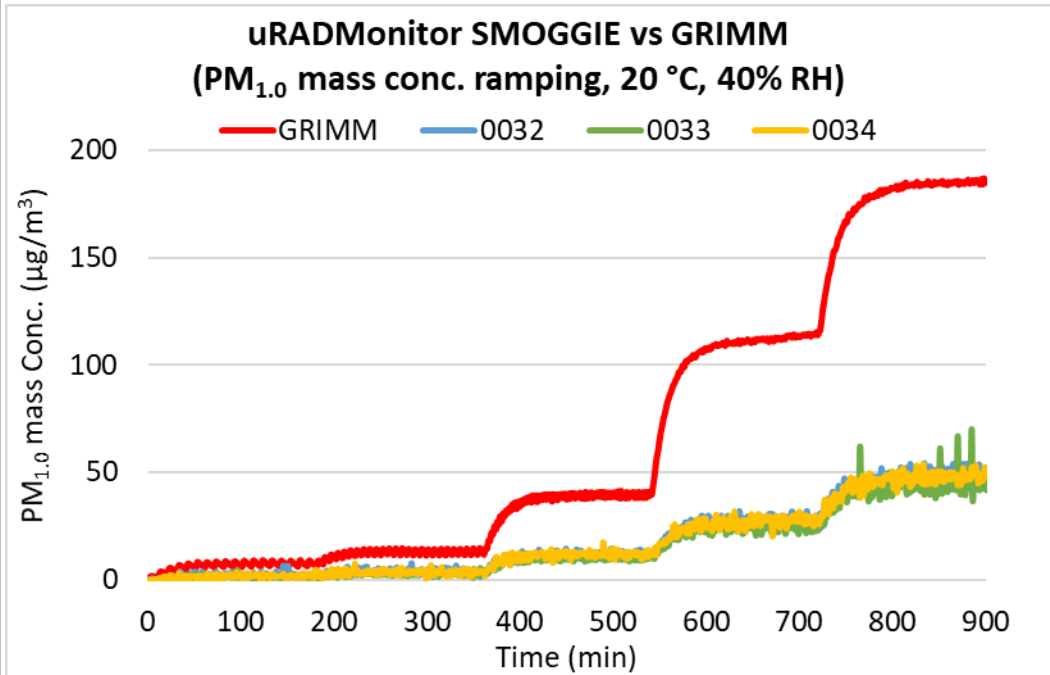


FEM GRIMM

Evaluation results for PM_{1.0} mass concentration

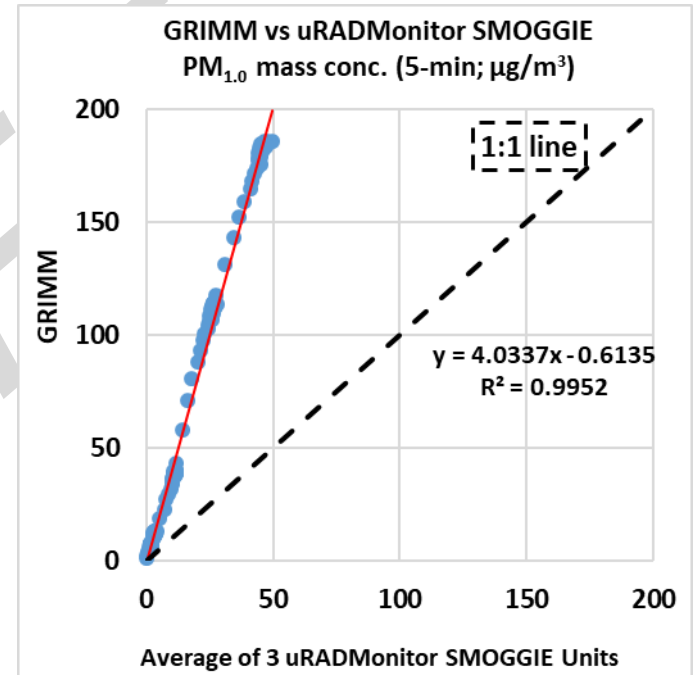
uRADMonitor SMOGGIE vs GRIMM

uRADMonitor SMOGGIE vs GRIMM (PM_{1.0} mass conc.)



- The uRADMonitor SMOGGIE sensors tracked well with the concentration variation as recorded by the GRIMM in the concentration range of 0 - ~200 µg/m³.

Coefficient of Determination



- The uRADMonitor SMOGGIE sensors showed very strong correlations with the GRIMM PM_{1.0} mass conc. ($R^2 > 0.99$)

uRADMonitor SMOGGIE vs GRIMM PM_{1.0} Accuracy

- Accuracy (20°C and 40% RH)

Steady state #	Sensor Mean (µg/m ³)	GRIMM (µg/m ³)	Accuracy (%)
1	1.8	7.5	24.1
2	3.2	12.9	24.4
3	11.4	39.6	28.8
4	26.6	114.1	23.4
5	47.8	185.5	25.7

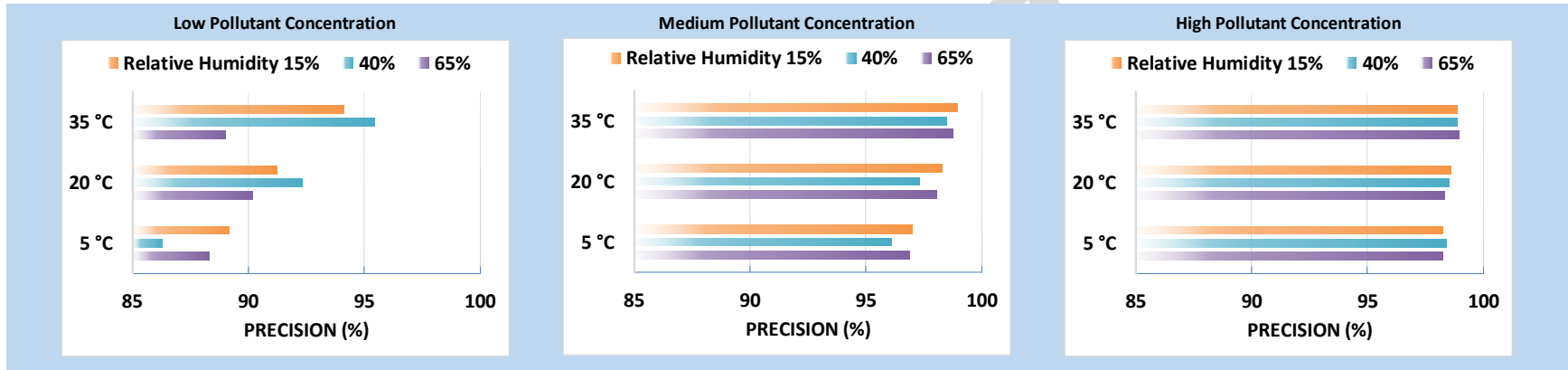
- The uRADMonitor SMOGGIE sensors underestimated GRIMM PM_{1.0} mass concentrations at 20 °C and 40% RH. The accuracy of the uRADMonitor SMOGGIE sensors was fairly constant (~ 23% to 29%) over the range of PM_{1.0} mass concentrations tested.

uRADMonitor SMOGGIE: Data Recovery and Intra-model Variability

- Data recovery for PM_{1.0} mass concentration from all units was 100%
- Low PM_{1.0} measurement variations were observed between the uRADMonitor SMOGGIE sensors

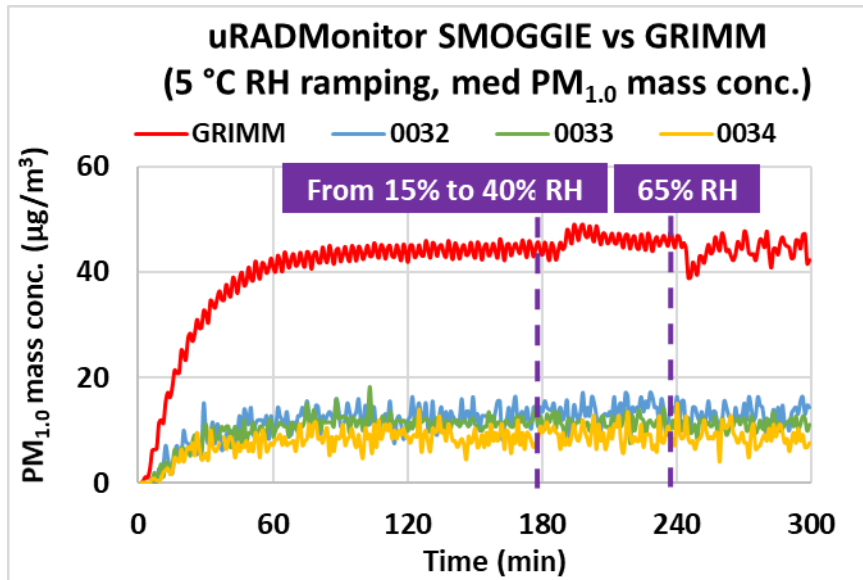
uRADMonitor SMOGGIE vs GRIMM (PM_{1.0}; 1-min mean)

- Precision (Effect of PM_{1.0} conc., Temperature and Relative Humidity)



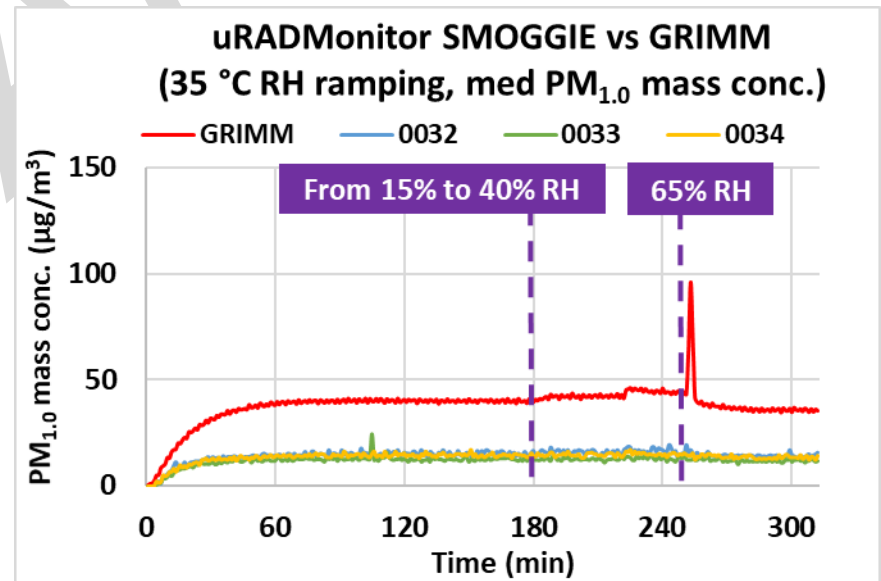
- Overall, the uRADMonitor SMOGGIE sensors showed high precision for all combinations of low, medium and high PM_{1.0} conc., T, and RH.
- Precision was relatively higher at higher PM_{1.0} mass concentrations.

uRADMonitor SMOGGIE PM_{1.0}: Climate Susceptibility



Low Temp – RH ramping
(medium conc.)

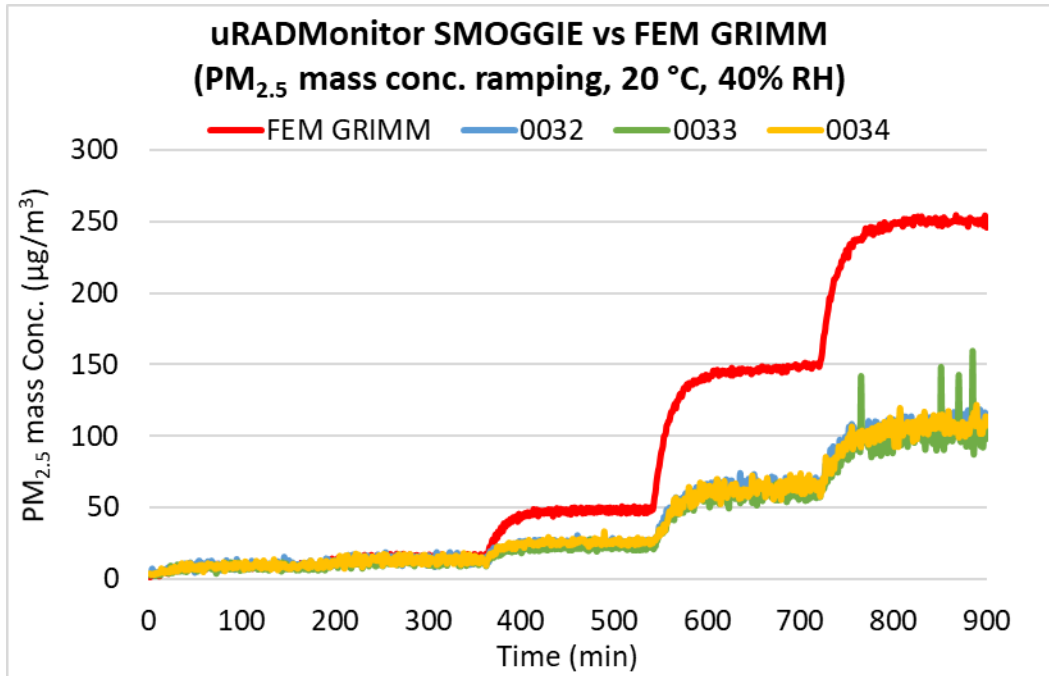
High Temp – RH ramping
(medium conc.)



Evaluation results for PM_{2.5} mass concentration

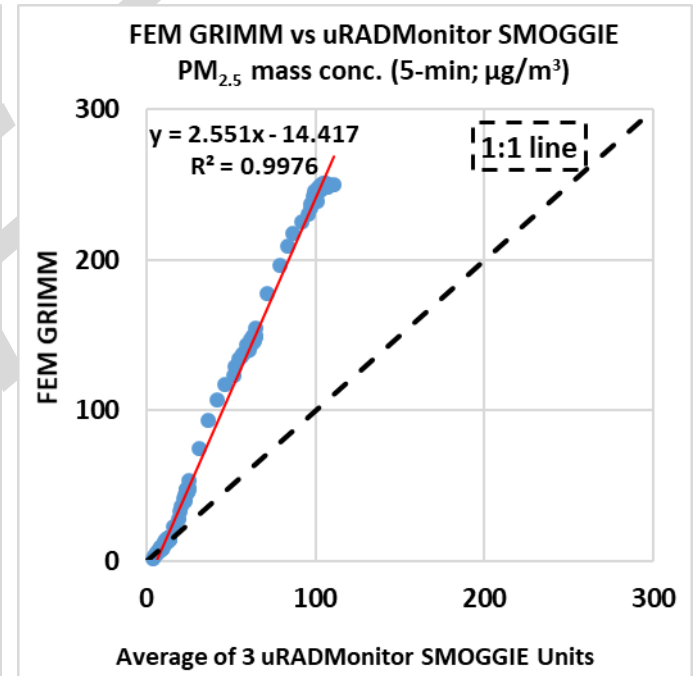
uRADMonitor SMOGGIE vs FEM GRIMM

uRADMonitor SMOGGIE vs FEM GRIMM (PM_{2.5} mass conc.)



- The uRADMonitor SMOGGIE sensors tracked well with the concentration variation as recorded by the FEM GRIMM in the concentration range of 0 - ~250 µg/m³.

Coefficient of Determination



- The uRADMonitor SMOGGIE sensors showed very strong correlations with the FEM GRIMM PM_{2.5} mass conc. ($R^2 > 0.99$)

uRADMonitor SMOGGIE vs FEM GRIMM PM_{2.5} Accuracy

- Accuracy (20°C and 40% RH)

Steady state #	Sensor Mean (µg/m ³)	FEM GRIMM (µg/m ³)	Accuracy (%)
1	9.1	8.7	95.2
2	12.9	14.8	87.3
3	24.3	48.1	50.6
4	63.5	149.4	42.5
5	106.8	250.3	42.7

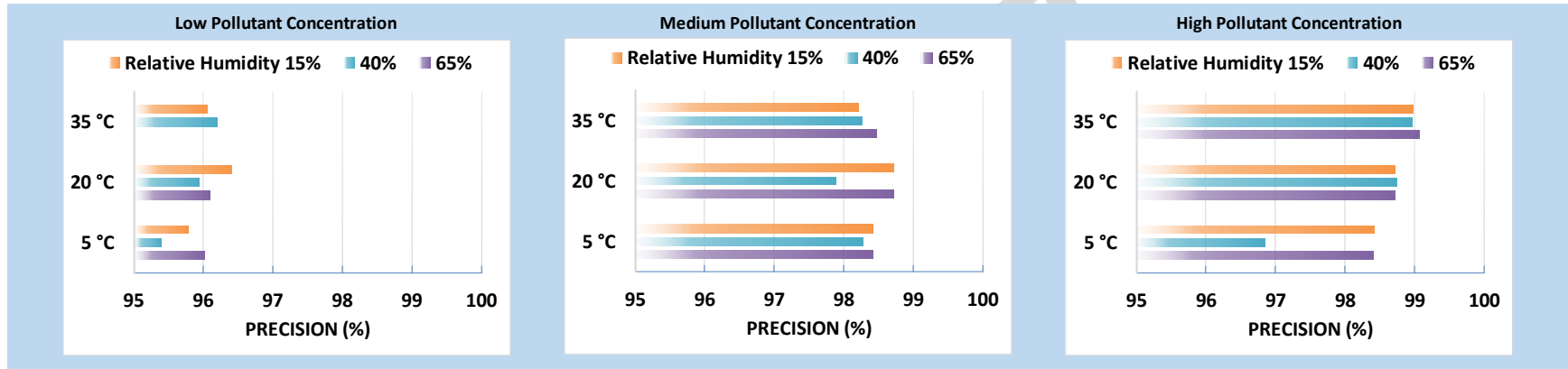
- The uRADMonitor SMOGGIE sensors underestimated FEM GRIMM PM_{2.5} mass concentrations at 20 °C and 40% RH. The accuracy of the uRADMonitor SMOGGIE sensors decreased (from ~95% to 43%) as PM_{2.5} mass concentrations increased.

uRADMonitor SMOGGIE: Data Recovery and Intra-model Variability

- Data recovery for PM_{2.5} mass concentration from all units was 100%
- Low PM_{2.5} measurement variations were observed between the uRADMonitor SMOGGIE sensors

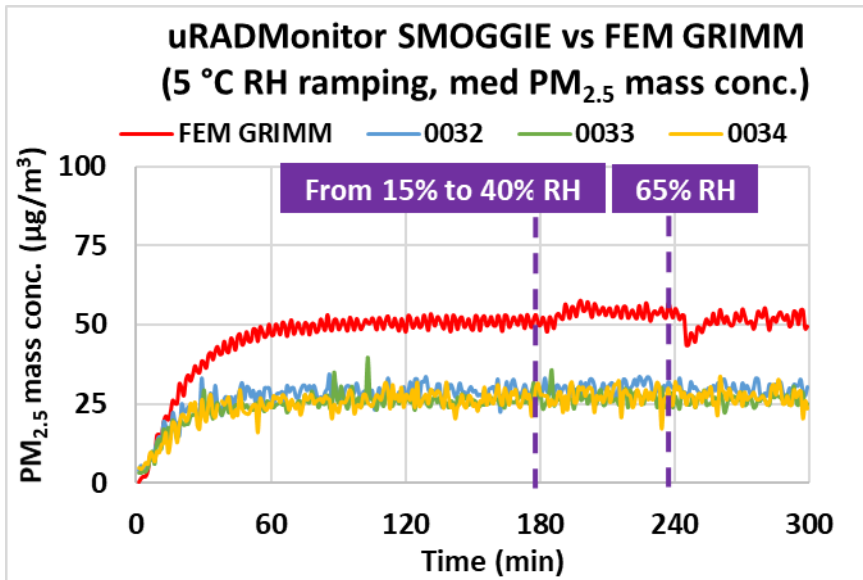
uRADMonitor SMOGGIE vs FEM GRIMM (PM_{2.5}; 1-min mean)

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



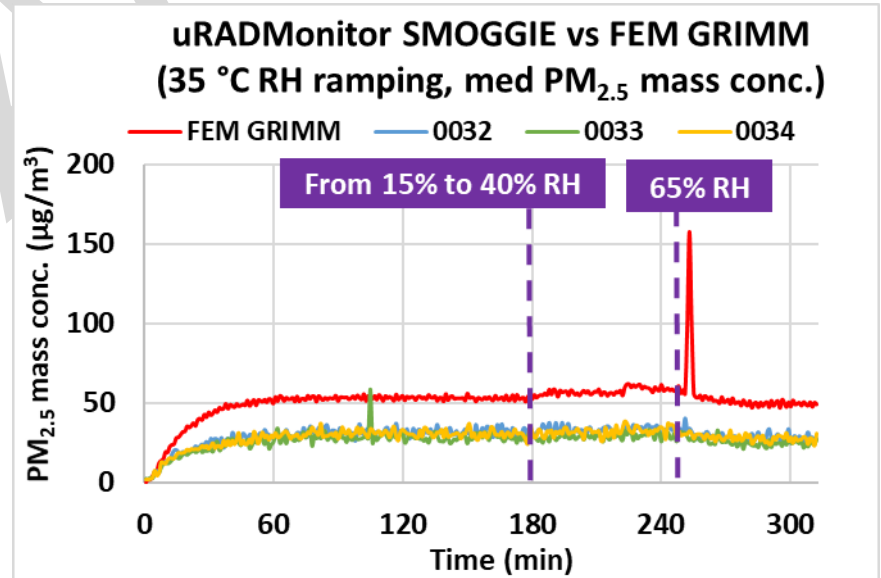
- Overall, the uRADMonitor SMOGGIE sensors showed high precision for all combinations of low, medium and high PM_{2.5} conc., T, and RH.
- Precision was relatively higher at higher PM_{2.5} mass concentrations.

uRADMonitor SMOGGIE vs PM_{2.5}: Climate Susceptibility



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

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



Discussion

- **Accuracy:** Overall, the accuracy of the uRADMonitor SMOGGIE sensors was fairly constant (~ 23% to 29%) over the range of PM_{1.0} mass concentrations tested; the accuracy decreased (from ~95% to 43%) as PM_{2.5} mass concentrations increased. The uRADMonitor SMOGGIE sensors underestimated the corresponding PM_{1.0} and PM_{2.5} measurements from GRIMM in the laboratory experiments at 20 °C and 40% RH.
- **Precision:** The uRADMonitor SMOGGIE sensors showed high precision for all test combinations (PM concentrations, T and RH) for PM_{1.0} and PM_{2.5} mass concentrations
- **Intra-model variability:** Low intra-model variability was observed among the uRADMonitor SMOGGIE sensors for PM_{1.0} and PM_{2.5} mass concentrations.
- **Data Recovery:** Data recovery for PM_{1.0} and PM_{2.5} mass concentration was 100% from all uRADMonitor SMOGGIE units
- **Coefficient of Determination:** The uRADMonitor SMOGGIE sensors showed very strong correlation/linear response with the corresponding GRIMM PM_{1.0} and FEM GRIMM PM_{2.5} 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 uRADMonitor SMOGGIE sensors' precision; the sensors showed significant concentration variation at low PM levels.