Laboratory Evaluation

Air Quality Egg 2018 Model

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

Three **Air Quality Egg 2018 Model** (Hereinafter AQ Egg 2018 Model) sensors (units IDs: 0111, 0121 and 0122) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (04/25/2018 to 06/26/2018) 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.

Air Quality Egg 2018 Model (*3 units tested*):

- Particle sensors (optical; non-FEM)
- PM sensor: Dual Plantower PMS5003
- Each unit measures: $PM_{1.0,}$ $PM_{2.5}$ and PM_{10} mass concentration ($\mu g/m^3$)
- Unit cost: ~$249
- Time resolution: 1-min
- Units IDs: 0111, 0121 and 0122

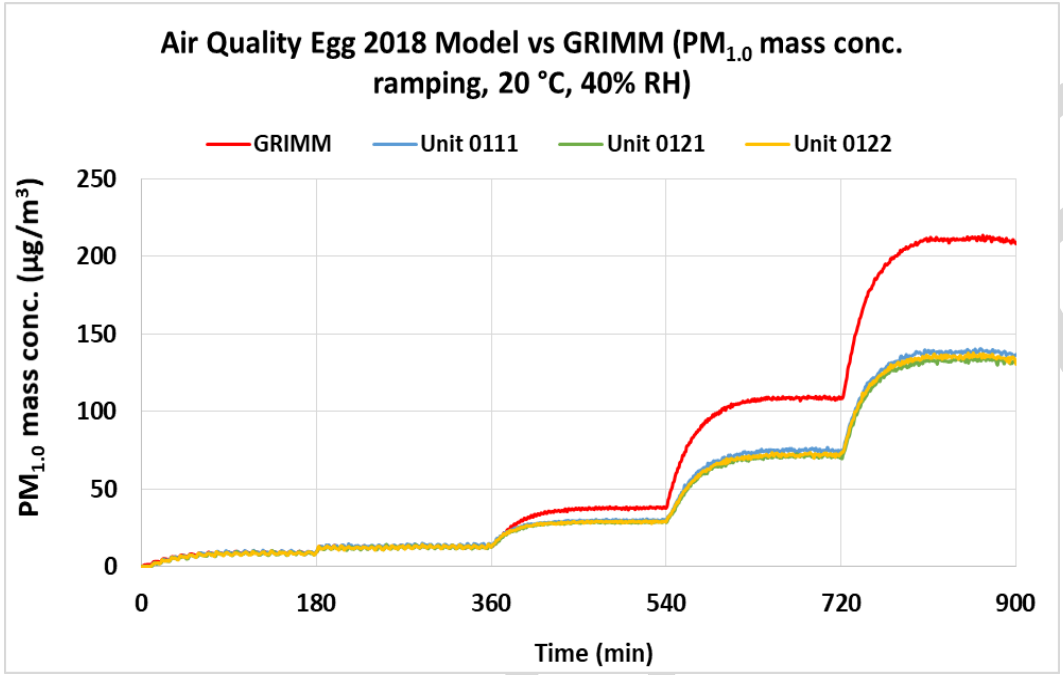
GRIMM (*reference method*):

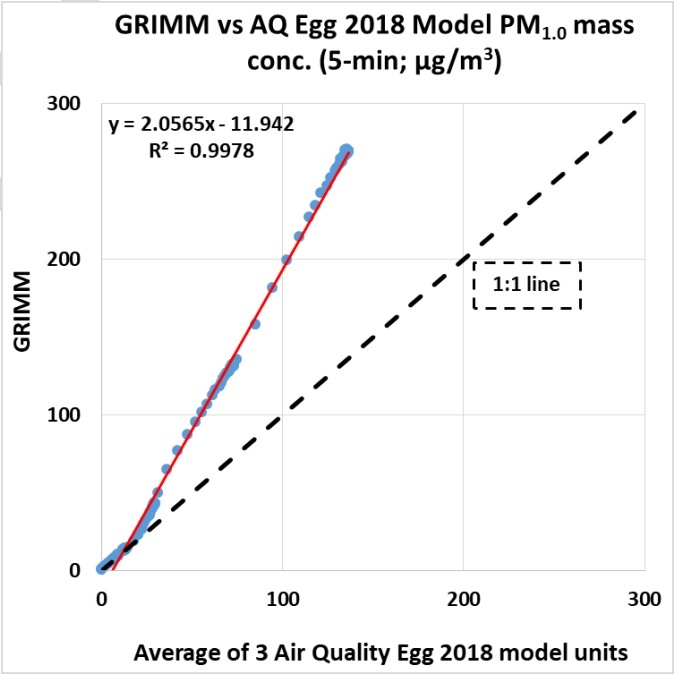
- Optical particle counter
- FEM $PM_{2.5}$
- Uses proprietary algorithms to calculate total PM, $PM_{2.5}$, and PM_1 mass conc. from particle number measurements
- Cost: ~$25,000
- Time resolution: 1-min

Evaluation results for $PM_{1.0}$ mass concentration

Air Quality Egg 2018 Model vs GRIMM

AQ Egg 2018 Model vs GRIMM ($PM_{1.0}$ mass conc.)





- The AQ Egg 2018 Model sensors tracked well with the $PM_{1.0}$ concentration variation as recorded by the GRIMM in the concentration range of 0 - ~200 µg/m^3.

- The AQ Egg 2018 Model sensors showed very strong correlations with the GRIMM $PM_{1.0}$ mass conc. (R^2 > 0.99) and underestimated $PM_{1.0}$ mass concentration as recorded by GRIMM

AQ Egg 2018 Model vs GRIMM $PM_{1.0}$: Accuracy

- Accuracy (20 °C and 40% RH)

Steady state #	Sensor Mean (µg/m³)	GRIMM (µg/m³)	Accuracy (%)
1	8.8	9.2	96.2
2	13.1	13.0	98.9
3	29.2	38.0	76.9
4	72.8	108.7	67.0
5	134.6	210.2	64.0

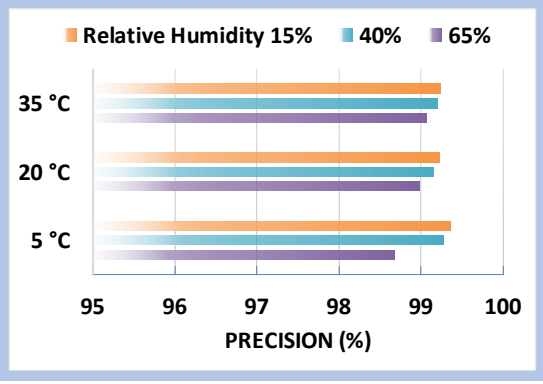
- The AQ Egg 2018 Model sensors underestimated GRIMM $PM_{1.0}$ mass concentration. The accuracy of the AQ Egg 2018 Model sensors is higher at $PM_{1.0}$ concentrations lower than or equal to ~ 40 µg/m³, ranging from 64% at the higher concentrations to 98.9% at the lower concentrations.

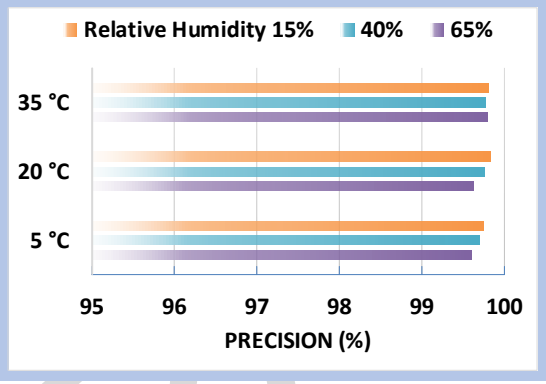
AQ Egg Model 2018: Data Recovery and intra-model variability

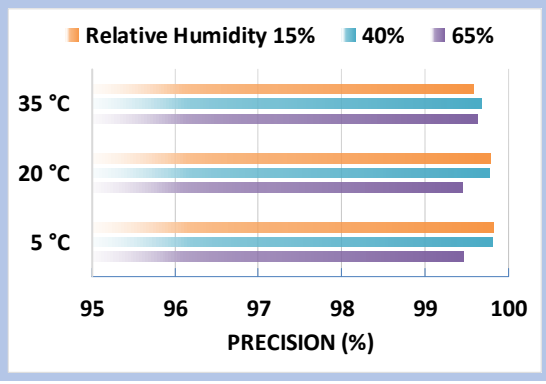
- Data recovery for $PM_{1.0}$ mass concentration from all units was 100%
- Very low $PM_{1.0}$ measurement variations were observed between the AQ Egg 2018 Model sensors

$PM_{1.0}$ Precision: AQ Egg 2018 Model

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

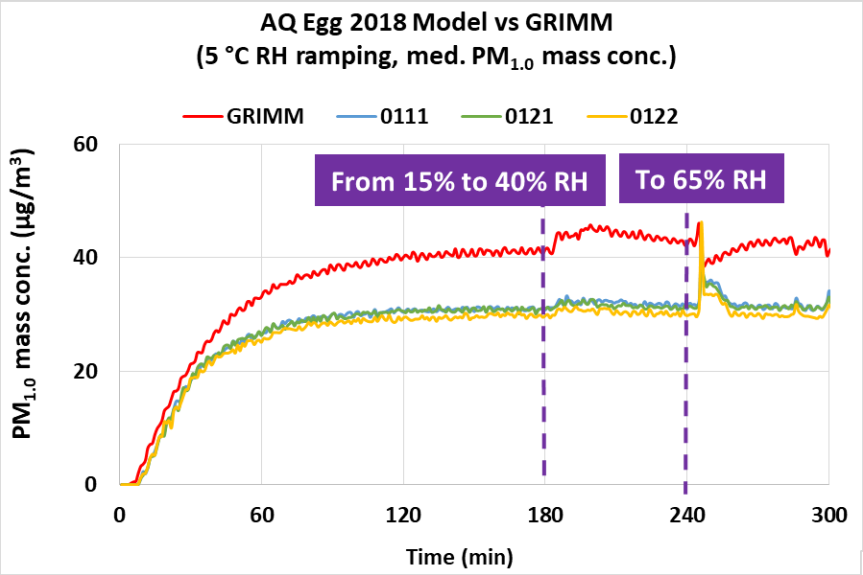






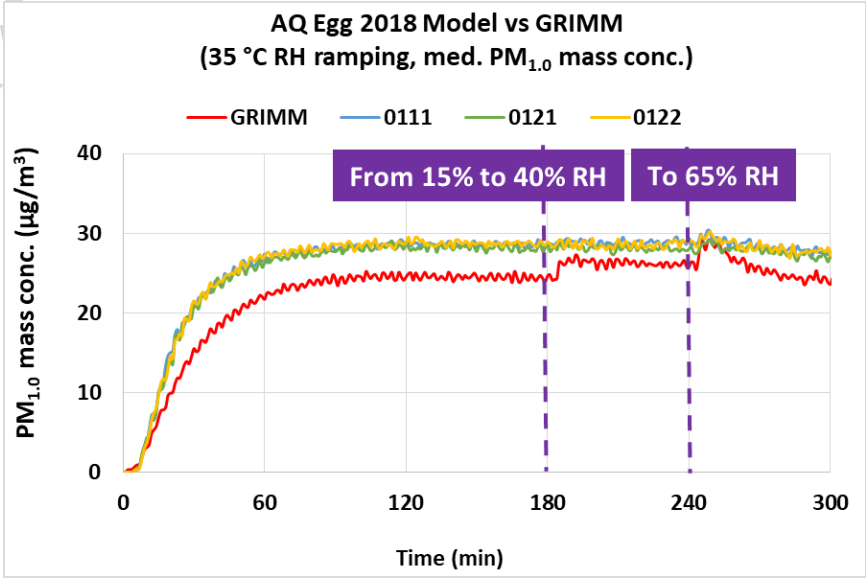
- Overall, the AQ Egg 2018 Model sensors showed high precision for all of the combinations of low, medium and high $PM_{1.0}$ conc., T and RH.

AQ Egg 2018 Model Climate Susceptibility



Low Temp – RH ramping (medium conc.)

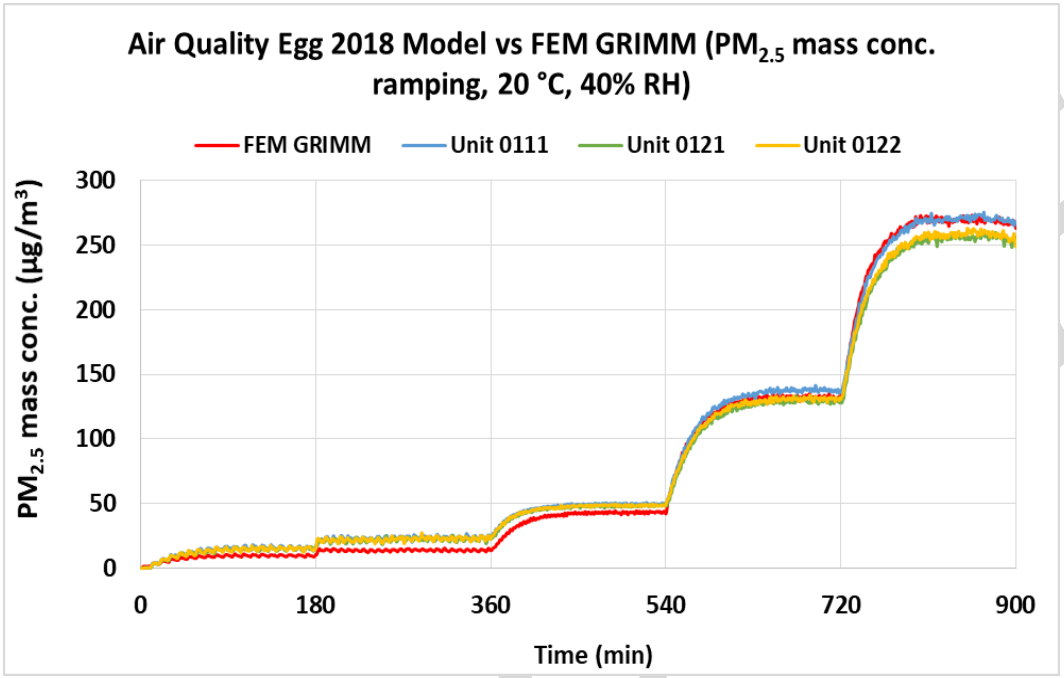
High Temp – RH ramping (medium conc.)

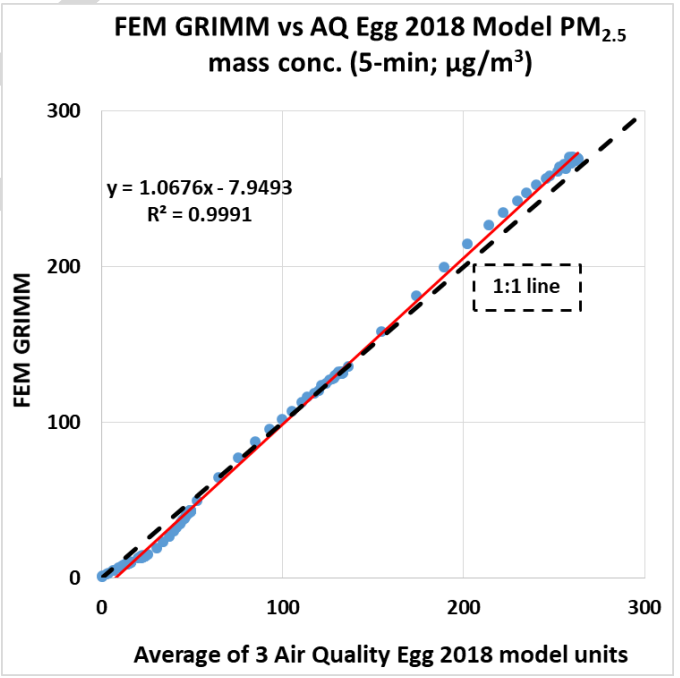


Evaluation results for $PM_{2.5}$ mass concentration

Air Quality Egg 2018 Model vs FEM GRIMM

AQ Egg 2018 Model vs FEM GRIMM ($PM_{2.5}$ mass conc.)





- The AQ Egg 2018 Model sensors tracked well with the concentration variation as recorded by the FEM GRIMM in the concentration range of 0 - ~300 µg/m^3.
- The AQ Egg 2018 Model sensors showed very strong correlations with the FEM GRIMM $PM_{2.5}$ mass conc. (R^2 > 0.99)

AQ Egg 2018 Model 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	15.5	9.9	43.6
2	23.5	14.2	34.2
3	49.1	43.4	86.9
4	132.6	132.1	99.6
5	259.6	267.4	97.1

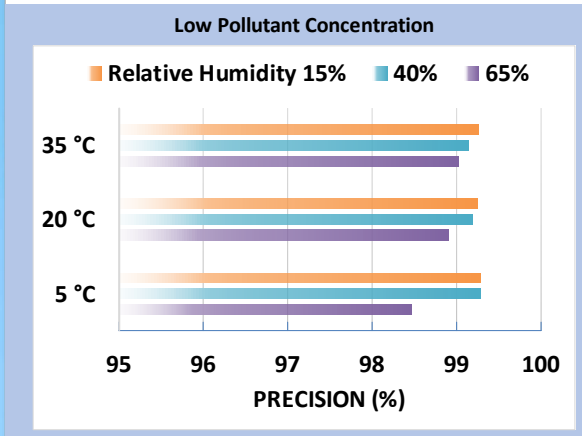
- The AQ Egg 2018 Model sensors overestimated FEM GRIMM $PM_{2.5}$ mass concentration. The accuracy of the AQ Egg 2018 Model sensors is higher at $PM_{2.5}$ concentrations greater than or equal to ~ 50 µg/m³, ranging from 34% at the lower concentrations to 99.6% at the higher concentrations.

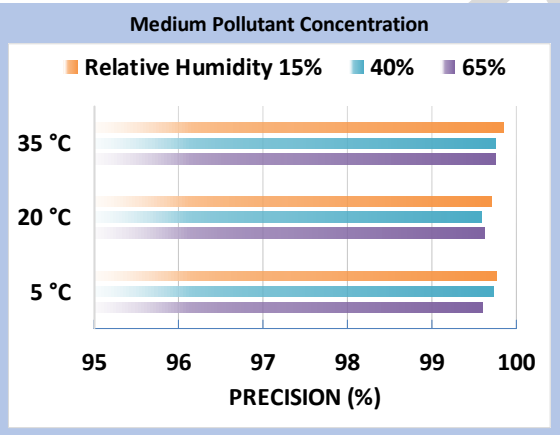
AQ Egg Model 2018: Data Recovery and intra-model variability

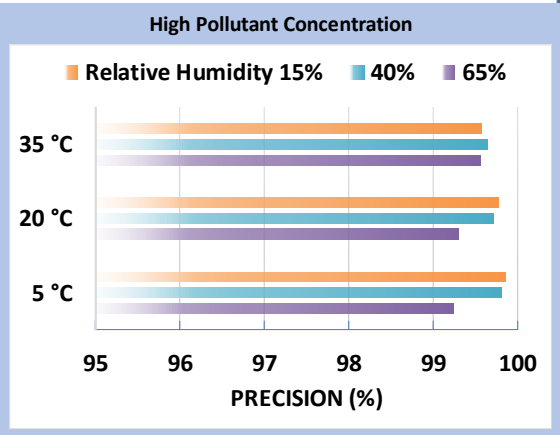
- Data recovery for $PM_{2.5}$ mass concentration from all units was 100%
- Very low $PM_{2.5}$ measurement variations were observed between the AQ Egg 2018 Model sensors

$PM_{2.5}$ Precision: AQ Egg 2018 Model

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

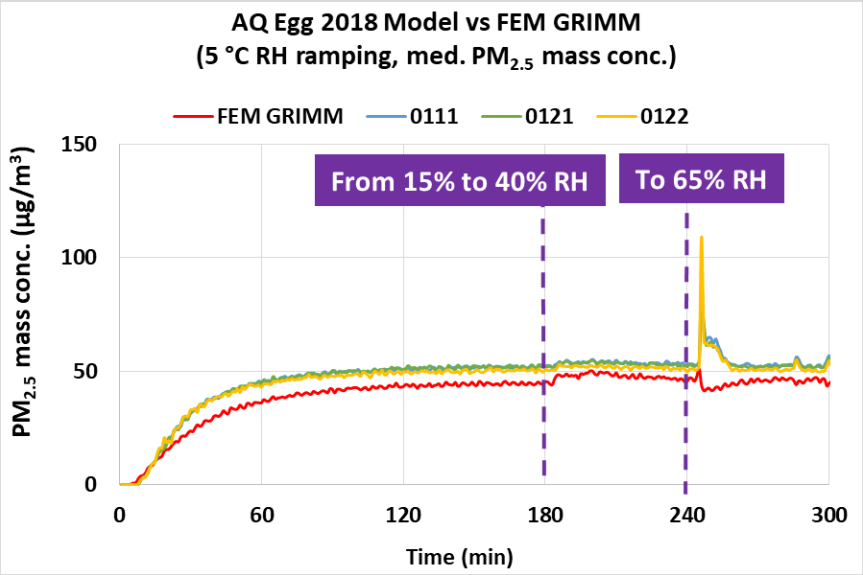






- Overall, the AQ Egg 2018 Model sensors showed high precision for all of the combinations of low, medium and high $PM_{2.5}$ conc., T and RH.

AQ Egg 2018 Model Climate Susceptibility



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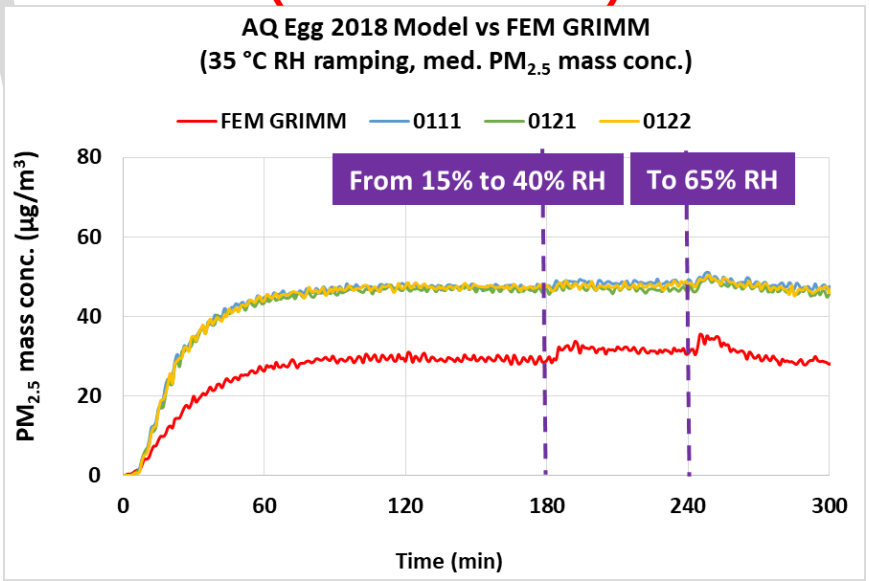

Discussion

- **Accuracy**: Overall, the accuracy of the AQ Egg 2018 Model sensors is higher at $PM_{1.0}$ concentrations lower than or equal to ~ 40 µg/m^3, ranging from 64% at the higher concentrations to 98.9% at the lower concentrations. The AQ Egg 2018 Model sensors have high accuracy, compared to FEM GRIMM $PM_{2.5}$ in the range of 0.0 to ~300 µg/m^3, except for the lower concentrations tested (< 20 µg/m^3). In general, the AQ Egg 2018 Model sensors underestimated $PM_{1.0}$ mass concentrations as measured by GRIMM and overestimated $PM_{2.5}$ mass concentrations as measured by FEM GRIMM in the laboratory experiments.
- **Precision**: The AQ Egg 2018 Model sensors have high precisions for all test combinations (PM concentrations, T and RH).
- **Intra-model variability**: Low intra-model variability was observed among the AQ Egg 2018 Model sensors.
- **Data Recovery:** Data recovery for $PM_{1.0}$ and $PM_{2.5}$ mass concentrations from all units was 100%.
- **Coefficient of Determination**: The AQ Egg 2018 Model 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 AQ Egg 2018 Model's precision. The AQ Egg 2018 Model sensors showed some spikes at the set-points of RH changes, especially at the 65% RH set-point.