

Laboratory Evaluation

AS-LUNG Portable



Background

Three **AS-LUNG Portable** sensors (units IDs: 0009, 0014, and 0015) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (10/06/2017 to 12/14/2017) 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.

AS-LUNG Portable (3 units tested):

- Particle sensors (**optical; non-FEM**)
- PM sensor: Plantower PMS3003
- Each unit measures: PM_{1.0}, PM_{2.5} and PM₁₀ mass concentration ($\mu\text{g}/\text{m}^3$)
- Unit also carries a CO₂ (ppm) sensor
- **Unit cost: \$999**
- Time resolution: 15 seconds
- Units IDs: 0009, 0014 and 0015



GRIMM (reference method):

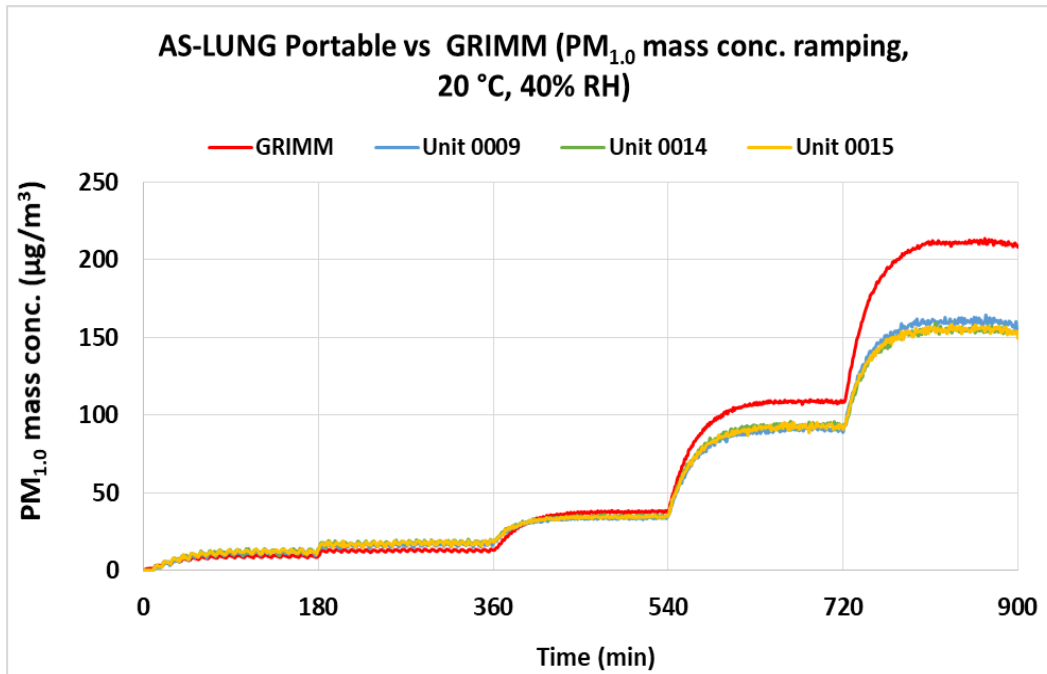
- Optical particle counter
- **FEM PM_{2.5}**
- Uses proprietary algorithms to calculate total PM, PM_{2.5}, and PM₁ mass conc. from particle number measurements
- **Cost: ~\$25,000**
- Time resolution: 1-min



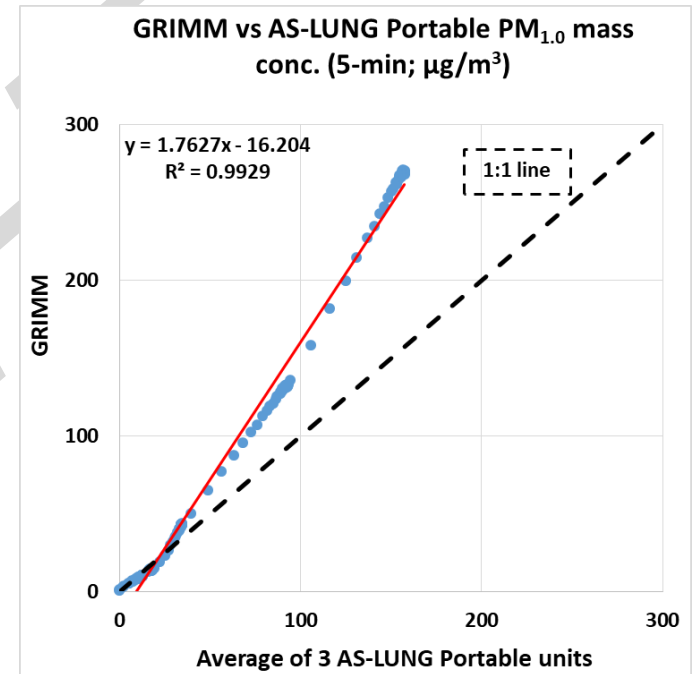
Evaluation results for PM_{1.0} mass concentration

AS-LUNG Portable vs GRIMM

AS-LUNG Portable vs GRIMM (PM_{1.0} mass conc.)



- The AS-LUNG Portable sensors tracked well with the concentration variation recorded by the GRIMM in the concentration range of 0 - $\sim 200 \mu\text{g}/\text{m}^3$.



- The AS-LUNG Portable sensors showed very strong correlations with the GRIMM PM_{1.0} mass conc. ($R^2 > 0.99$) and underestimated PM_{1.0} mass conc. as recorded by GRIMM

AS-LUNG Portable 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	12.1	9.2	67.6
2	17.8	13.0	62.5
3	34.5	38.0	90.8
4	92.4	108.7	85.0
5	155.5	210.2	74.0

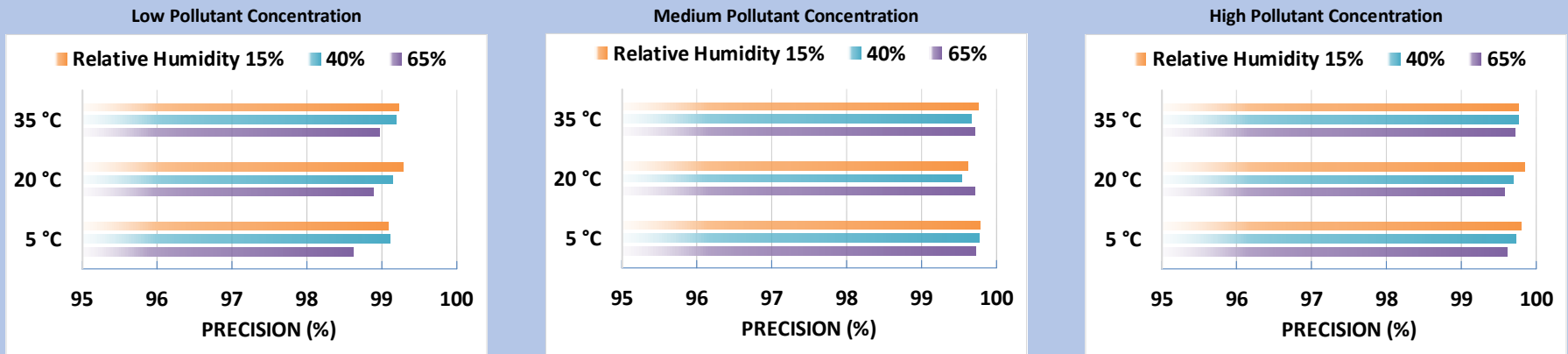
- The AS-LUNG Portable sensors overestimated lower PM_{1.0} conc. (<20 µg/m³) and underestimated higher PM_{1.0} conc. (> ~ 40 µg/m³). The accuracy of the AS-LUNG Portable sensors is higher at PM_{1.0} concentrations greater than or equal to ~ 40 µg/m³, ranging from 62.5% at the lower concentrations to 90.8% at the higher concentrations.

AS-LUNG Portable: Data Recovery and intra-model variability

- Data recovery for PM_{2.5} mass concentration from all units was ~100%
- Very low PM_{1.0} measurement variations were observed between the AS-LUNG portable sensors

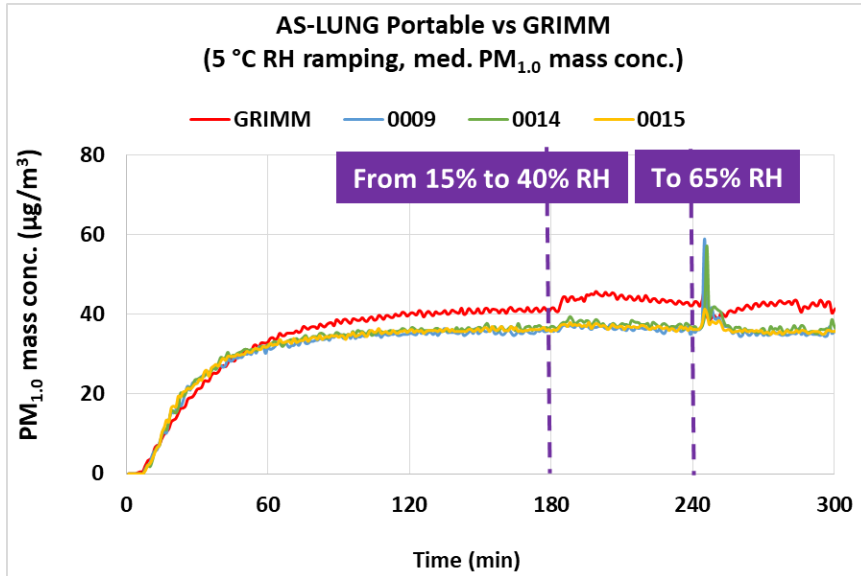
AS-LUNG Portable: PM_{1.0} Precision

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

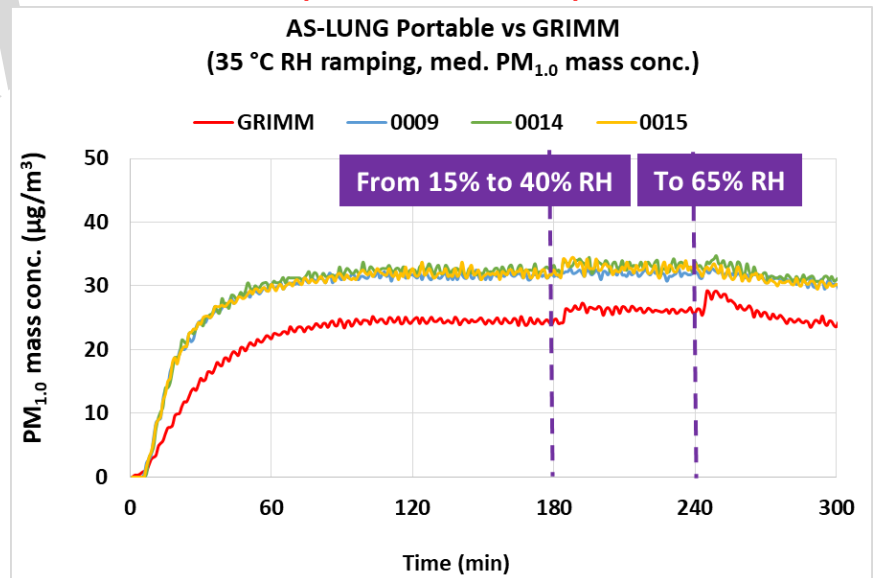


- Overall, the AS-LUNG Portable sensors showed high precision for all of the combinations of low, medium and high PM_{1.0} conc., T, and RH.
- Precision is relatively higher at higher PM_{1.0} concentrations.

AS-LUNG Portable: Climate Susceptibility



Low Temp – RH ramping
(Medium conc.)

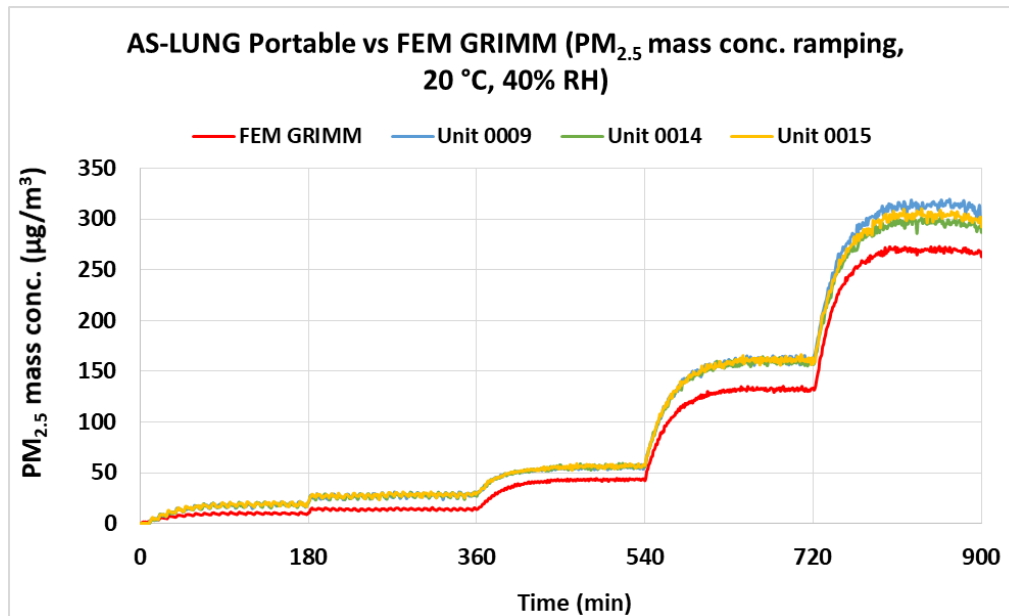


High Temp – RH ramping
(Medium conc.)

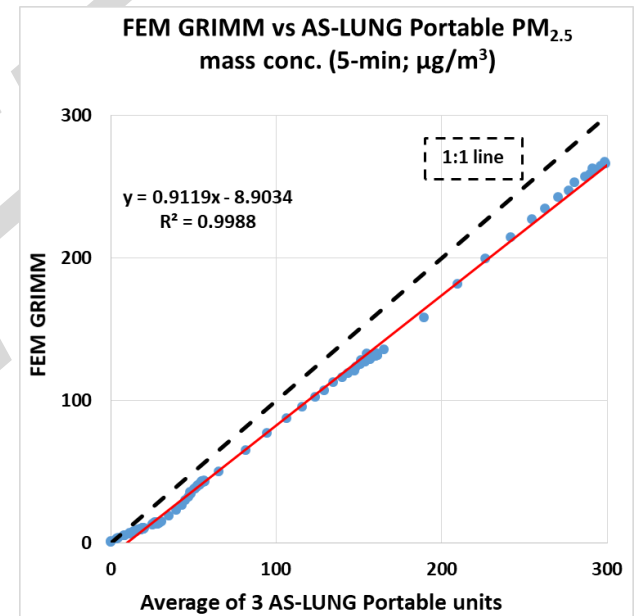
Evaluation results for PM_{2.5} mass concentration

AS-LUNG Portable vs FEM GRIMM

AS-LUNG Portable vs FEM GRIMM (PM_{2.5} mass conc.)



- The AS-LUNG Portable sensors tracked well with the concentration variation recorded by the FEM GRIMM in the concentration range of 0 - ~300 µg/m³.



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

AS-LUNG Portable 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	19.0	9.9	8.7
2	28.7	14.2	2.5
3	56.3	43.4	70.4
4	160.1	132.1	78.8
5	300.8	267.4	87.5

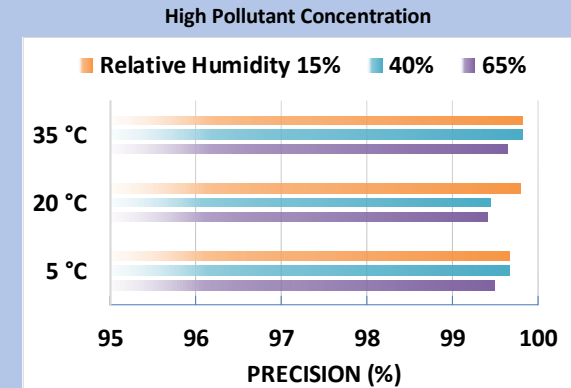
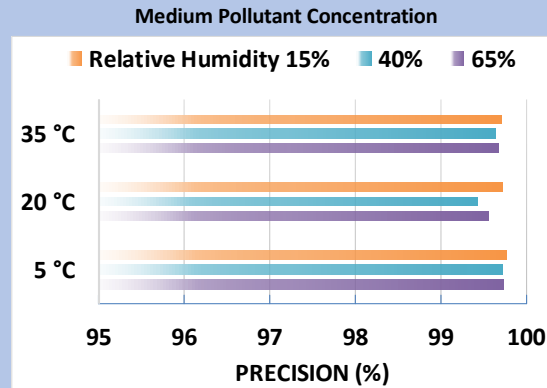
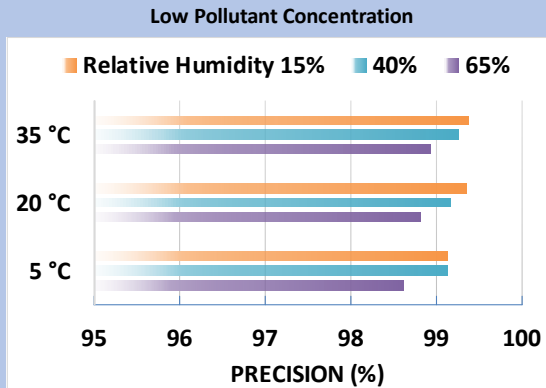
- The AS-LUNG Portable sensors overestimated FEM GRIMM PM_{2.5} mass concentration. The accuracy of the AS-LUNG Portable sensors is higher at PM_{2.5} concentrations greater than or equal to ~ 50 µg/m³, ranging from 2.5% at the lower concentrations to 87.5% at the higher concentrations.

AS-LUNG Portable: 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 AS-LUNG portable sensors

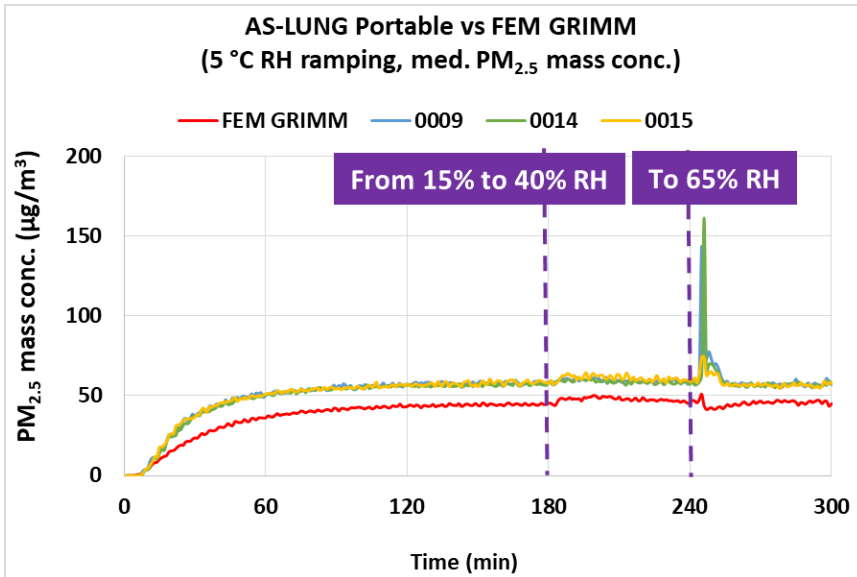
AS-LUNG Portable: PM_{2.5} Precision

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



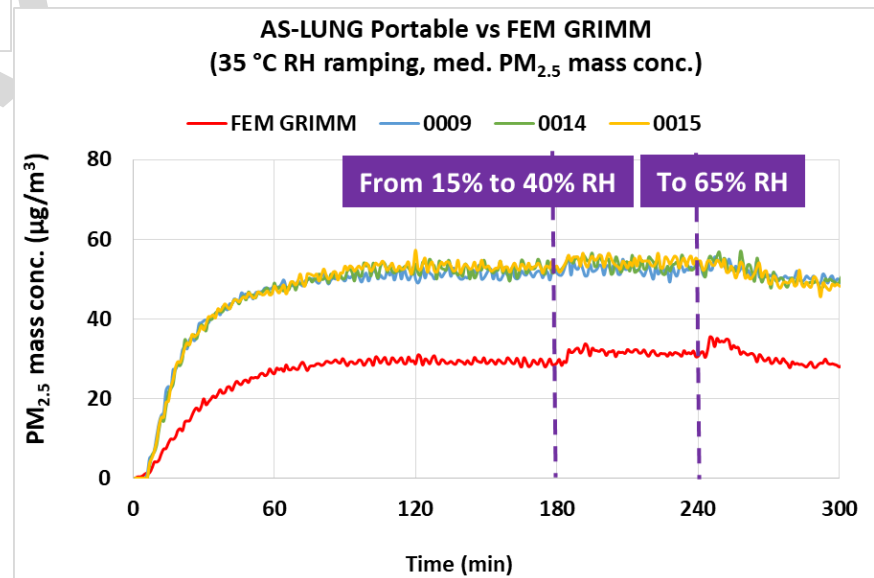
- Overall, the AS-LUNG Portable sensors showed high precision for all of the combinations of low, medium and high PM_{2.5} conc., T, and RH.
- Precision is relatively higher at higher PM_{2.5} concentrations.

AS-LUNG Portable: Climate Susceptibility



Low Temp – RH ramping
(Medium conc.)

High Temp – RH ramping
(Medium conc.)



Discussion

- **Accuracy:** Overall, the AS-LUNG Portable sensors have relatively high accuracy at higher PM_{1.0} and PM_{2.5} conc. compared to the reference instrument in the range of 0.0 to ~300 µg/m³; accuracy is lower at the lower PM_{1.0} and PM_{2.5} concentrations tested (< 20 µg/m³). In general, the AS-LUNG Portable sensors underestimated PM_{1.0} conc. and overestimated the PM_{2.5} conc. as recorded by the reference instrument in the laboratory experiments.
- **Precision:** The AS-LUNG Portable sensors have high precision for all test combinations (all PM concentrations, T and RH).
- **Intra-model variability:** Low intra-model variability was observed among the AS-LUNG Portable sensors.
- **Data Recovery:** Data recovery for both PM_{1.0} and PM_{2.5} mass concentrations from all units was ~100%.
- **Coefficient of Determination:** The AS-LUNG Portable 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 AS-LUNG Portable's precision. The AS-LUNG Portable sensors showed some spikes at the set-points of RH changes, especially at the 65% RH set-point at low and medium PM concentrations.