Laboratory Evaluation

Samyoung S&C – SY-DS-DK3 PM

Sensor Evaluation Kit

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

Three **Samyoung S&C – SY-DS-DK3 PM Sensor Evaluation Kit (hereinafter Samyoung S&C)** sensors (units IDs: Unit 1, Unit 2, and Unit 3) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (03/07/2019 to 05/14/2019) 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 Samyoung S&C units were tested both in the field (1st stage of testing) and in the laboratory (2nd stage of testing).

Samyoung S&C (*3 units tested*):
- Particle sensor: (optical; non-FEM)
- PM Sensor: PSMU2.5
- Each unit reports: $PM_{2.5}$ ($\mu g/m^3$)
- Unit cost: $100
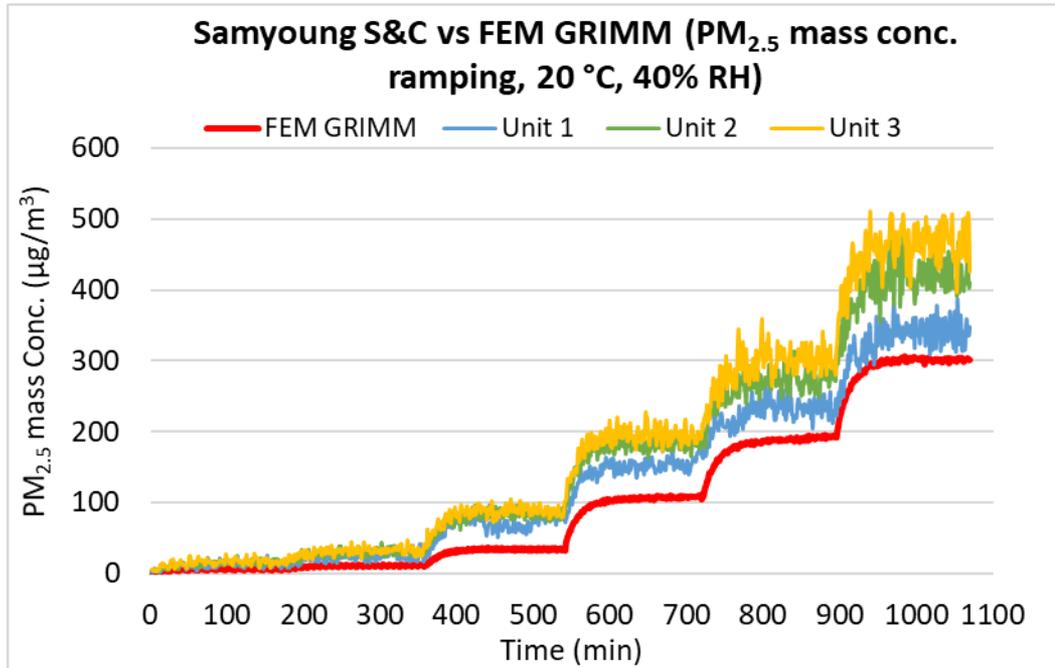- Time resolution: 1 second
- Units IDs: Unit 1, Unit 2, Unit 3

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.

Samyoung S&C

FEM GRIMM

Samyoung S&C vs FEM GRIMM (PM$_{2.5}$ mass conc.)

Coefficient of Determination

Samyoung S&C vs FEM GRIMM (PM$_{2.5}$ mass conc. ramping, 20 °C, 40% RH)

FEM GRIMM vs Samyoung S&C PM$_{2.5}$ mass conc. (5-min; µg/m^3)

$y = 0.8385x - 16.168$
$R^2 = 0.9884$

1:1 line

Average of 3 Samyoung S&C Units

- The Samyoung S&C sensors tracked well with the concentration variation as recorded by the FEM GRIMM in the concentration range of 0 - ~300 µg/m^3.
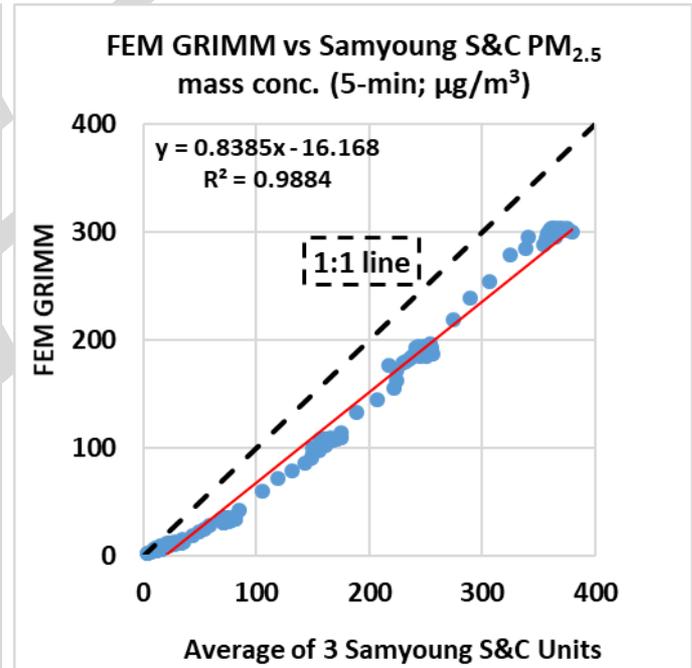
- The Samyoung S&C sensors showed very strong correlations with the FEM GRIMM PM$_{2.5}$ mass conc. ($R^2 > 0.98$)

Samyoung S&C 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	14.6	6.5	-27.0
2	30.2	11.4	-64.6
3	82.1	34.8	-36.0
4	179.2	108.8	35.2
5	271.7	193.5	59.6
6	407.0	302.7	65.5

- The Samyoung S&C sensors overestimated FEM GRIMM PM$_{2.5}$ mass concentration at 20 °C and 40% RH. The accuracy of the Samyoung S&C sensors was negative at lower PM$_{2.5}$ mass concentrations and increased from ~35% to 65% as PM conc. increased from ~100 to 300 µg/m³.

Samyoung S&C Data Recovery and Intra-model Variability

- Data recovery for PM$_{2.5}$ mass concentration was 100% from all sensors.

- Moderate PM$_{2.5}$ measurement variations were observed between the Samyoung S&C sensors
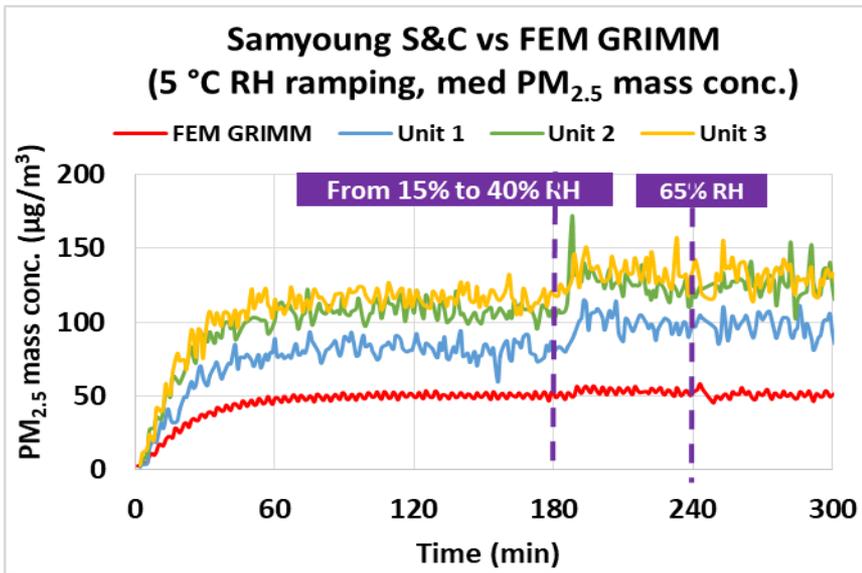
Samyoung S&C PM$_{2.5}$: Precision

- Precision (Effect of PM$_{2.5}$ conc., temperature and relative humidity)
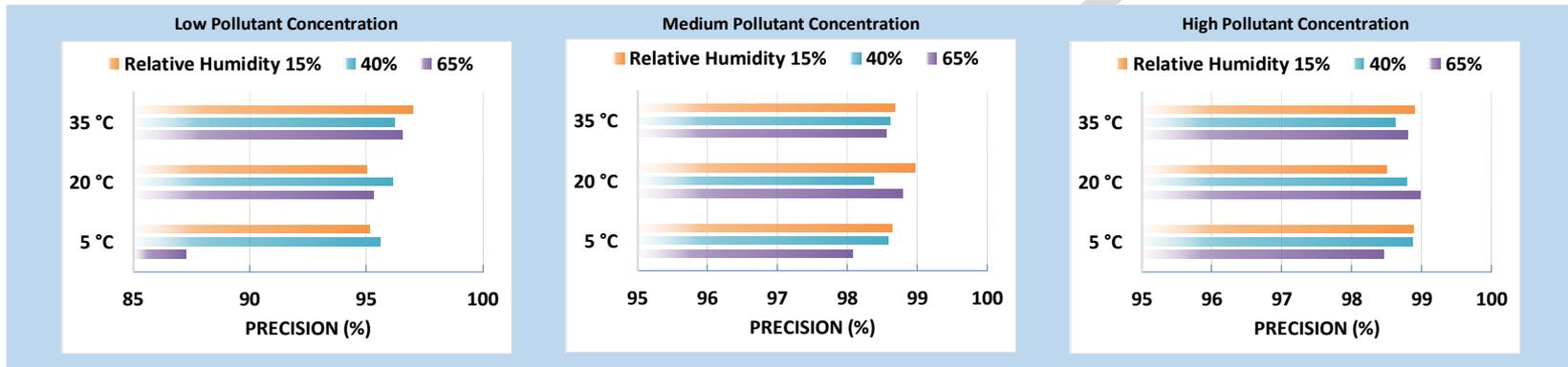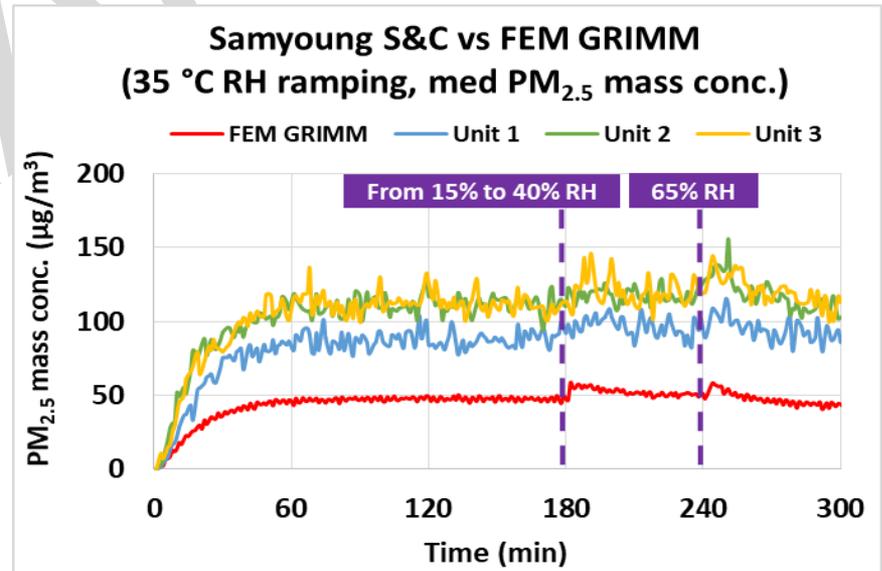

- Overall, the Samyoung S&C sensors showed high precision for all of the combinations of low, medium and high PM$_{2.5}$ conc., T, and RH.

- Precision was relatively higher at higher PM$_{2.5}$ concentrations.

Samyoung S&C PM$_{2.5}$: Climate Susceptibility

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

FEM GRIMM — Unit 1 — Unit 2 — Unit 3

From 15% to 40% RH   65% RH

Low Temp – RH ramping (medium conc.)

High Temp – RH ramping (medium conc.)

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

FEM GRIMM — Unit 1 — Unit 2 — Unit 3

From 15% to 40% RH   65% RH

Discussion

➢ **Accuracy**: The accuracy of the Samyoung S&C sensors was negative at lower $PM_{2.5}$ mass concentrations and increased from ~35% to 65% as PM conc. increased from ~100 to 300 µg/m^3. The Samyoung S&C sensors overestimated $PM_{2.5}$ measurements from FEM GRIMM in the laboratory experiments at 20 °C and 40% RH.

➢ **Precision**: The Samyoung S&C sensors showed high precision for all test combinations (PM concentrations, T and RH) for $PM_{2.5}$ mass concentrations.

➢ **Intra-model variability**: Moderate intra-model variability was observed among the Samyoung S&C sensors.

➢ **Data Recovery:** Data recovery for $PM_{2.5}$ mass concentration was 100% for all units

➢ **Coefficient of Determination**: The Samyoung S&C sensors showed very strong correlation/linear response with the corresponding FEM GRIMM $PM_{2.5}$ measurement data ($R^2 > 0.98$).

➢ **Climate susceptibility**: For most of the temperature and relative humidity combination, the climate condition had minimal effect on the Samyoung S&C sensors; at the set-points of RH changes, the sensors showed some small spiked conc. changes.