AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Evaluation Summary

Sensor Description

Manufacturer/Model:
FabLab/
Smart Citizen Kit v2.1

Pollutants:
$PM_{1.0}$, $PM_{2.5}$ and PM_{10}
mass concentration

Time Resolution:
1-min

Type: Optical

Additional

Field evaluation report:

http://www.aqmd.gov/aq-spec/evaluations/field

Lab evaluation report:

http://www.aqmd.gov/aq-spec/evaluations/laboratory

AQ-SPEC website:

http://www.aqmd.gov/aq-spec

- Overall, the accuracy of the Smart Citizen Kit v2.1 (SCK 2.1) sensors increased (from ~63% to 80%) as $PM_{1.0}$ mass concentrations increased; the accuracy decreased (from ~93% to 64%) as $PM_{2.5}$ mass concentrations increased. Overall, the SCK 2.1 sensors underestimated the corresponding $PM_{1.0}$ measurements and overestimated the corresponding $PM_{2.5}$ measurements from GRIMM in the laboratory experiments at 20 °C and 40% RH.
- The SCK 2.1 sensors exhibited high precision for all T/RH combinations and all PM concentrations for $PM_{1.0}$ and $PM_{2.5}$ mass concentrations.
- The SCK 2.1 sensors (IDs: 7FD1, 3423 and 4E34) showed low intra-model variability for both the field and laboratory evaluations.
- Data recovery was ~100% from all units in the field and laboratory evaluations for all PM measurements.
- For $PM_{1.0}$, the SCK 2.1 sensors showed very strong correlations with the corresponding GRIMM data ($R^2 \sim 0.96$); and showed strong correlations with the corresponding reference data from the field evaluations for $PM_{2.5}$ ($0.71 < R^2 < 0.80$) and very strong correlations with GRIMM in the laboratory evaluations ($R^2 > 0.99$ for $PM_{1.0}$ and $PM_{2.5}$). For PM_{10}, the sensors showed no correlations with the corresponding reference data ($0.03 < R^2 < 0.10$).
- The same three SCK 2.1 units were tested both in the field (1st stage of testing) and in the laboratory (2nd stage of testing).
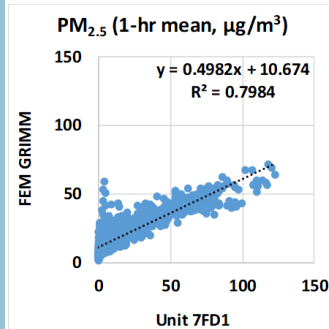
Field Evaluation Highlights

- Deployment period 09/19/2019– 11/19/2019: the three SCK 2.1 sensors showed very strong, strong and no correlations with the corresponding reference data for $PM_{1.0}$, $PM_{2.5}$ and PM_{10} mass concentrations, respectively.
- The units showed low intra-model variability and data recovery was ~ 100%.
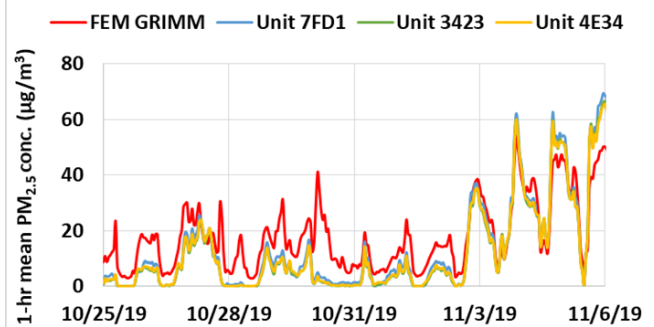
1-hr mean, all ref inst.

$PM_{1.0}$: ~ 0.96

$PM_{2.5}$: $0.71 < R^2 < 0.80$

PM_{10}: $0.03 < R^2 < 0.10$

PM$_{2.5}$ (1-hr mean, µg/m^3)

$y = 0.4982x + 10.674$
$R^2 = 0.7984$

FEM GRIMM

Unit 7FD1

SCK 2.1 vs FEM GRIMM

FEM GRIMM — Unit 7FD1 — Unit 3423 — Unit 4E34

1-hr mean PM$_{2.5}$ conc. (µg/m^3)

Coefficient of Determination (R^2) quantifies how the three sensors followed the $PM_{2.5}$ concentration change by the reference instruments.

An R^2 approaching the value of 1 reflects a near perfect agreement, whereas a value of 0 indicates a complete lack of correlation.

Laboratory Evaluation Highlights

Accuracy (PM$_{2.5}$)

$$A (\%) = 100 - \frac{|\bar{X}-\bar{R}|}{\bar{R}} * 100$$

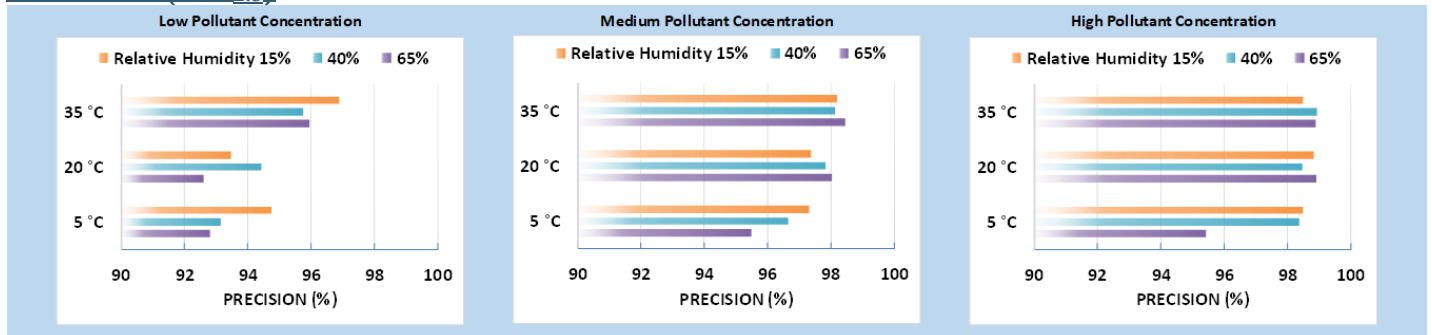| Steady state #	Sensor Mean (µg/m³)	FEM GRIMM (µg/m³)	Accuracy (%)
1	9.3	8.7	92.7
2	17.6	14.8	81.4
3	63.0	48.1	69.0
4	195.3	149.4	69.2
5	340.2	250.3	64.1

Accuracy was evaluated by a concentration ramping experiment at 20 °C and 40% RH. The sensor's readings at each ramping steady state are compared to the reference instrument.

A negative % means sensors' overestimation by more than two fold. The higher the positive value (close to 100%), the higher the sensor's accuracy.
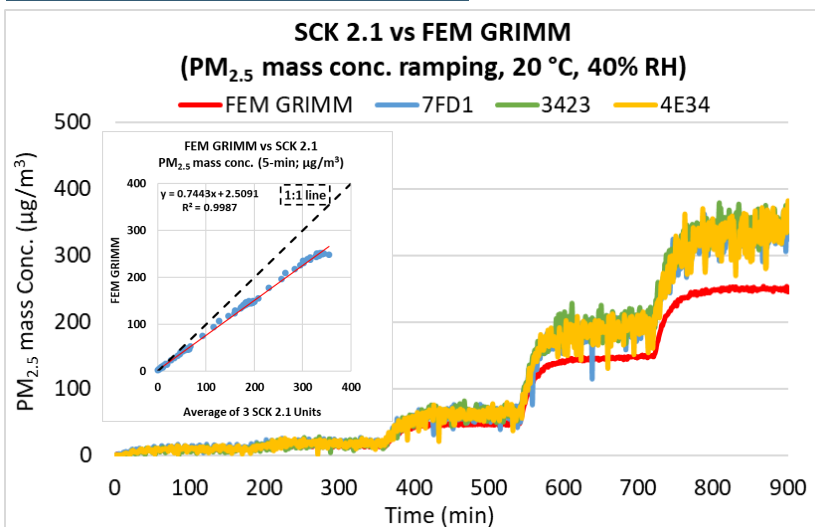
Precision (PM$_{2.5}$)

Low Pollutant Concentration — Relative Humidity 15% | 40% | 65%

Medium Pollutant Concentration — Relative Humidity 15% | 40% | 65%

High Pollutant Concentration — Relative Humidity 15% | 40% | 65%

100% represents high precision.

Sensor's ability to generate precise measurements of PM$_{2.5}$ concentration at low, medium, and high pollutant levels were evaluated under 9 combinations of T and RH, including extreme weather conditions like cold and dry (5 °C and 15% RH), cold and humid (5 °C and 65% RH), hot and humid (35 °C and 65% RH), or hot and dry (35 °C and 15% RH).

Coefficient of Determination

SCK 2.1 vs FEM GRIMM
(PM$_{2.5}$ mass conc. ramping, 20 °C, 40% RH)
FEM GRIMM — 7FD1 — 3423 — 4E34

FEM GRIMM vs SCK 2.1
PM$_{2.5}$ mass conc. (5-min; µg/m³)
y = 0.7443x + 2.5091
R² = 0.9987
1:1 line

The SCK 2.1 sensors showed very strong correlations with the corresponding FEM PM$_{2.5}$ data (R² > 0.99) at 20 °C/40% RH.

For conc. ramping experiments of PM$_{1.0}$, please see the lab report.

Climate Susceptibility

From the laboratory studies, temperature and relative humidity had minimal effect on the SCK 2.1 sensors' precision. At the set-points of RH changes, the sensors showed spiked conc. changes at 5 °C and showed significant concentration variation at 5 °C/65% RH.

Observed Interferents
N/A