Laboratory Evaluation

SainSmart $PM_{2.5}$ Sensor

South Coast AQMD

AQ-SPEC

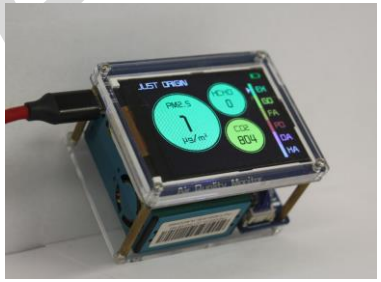
Air Quality Sensor Performance Evaluation Center

Background

Three **SainSmart $PM_{2.5}$** sensors (units IDs: 001, 002, 003) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (from 3/17/2017 to 5/12/2017) under ambient environmental conditions. Now, they have been evaluated in the South Coast AQMD Chemistry Laboratory under controlled artificial aerosol concentration/size range, temperature, and relative humidity conditions

SainSmart Sensor (*3 units tested*):

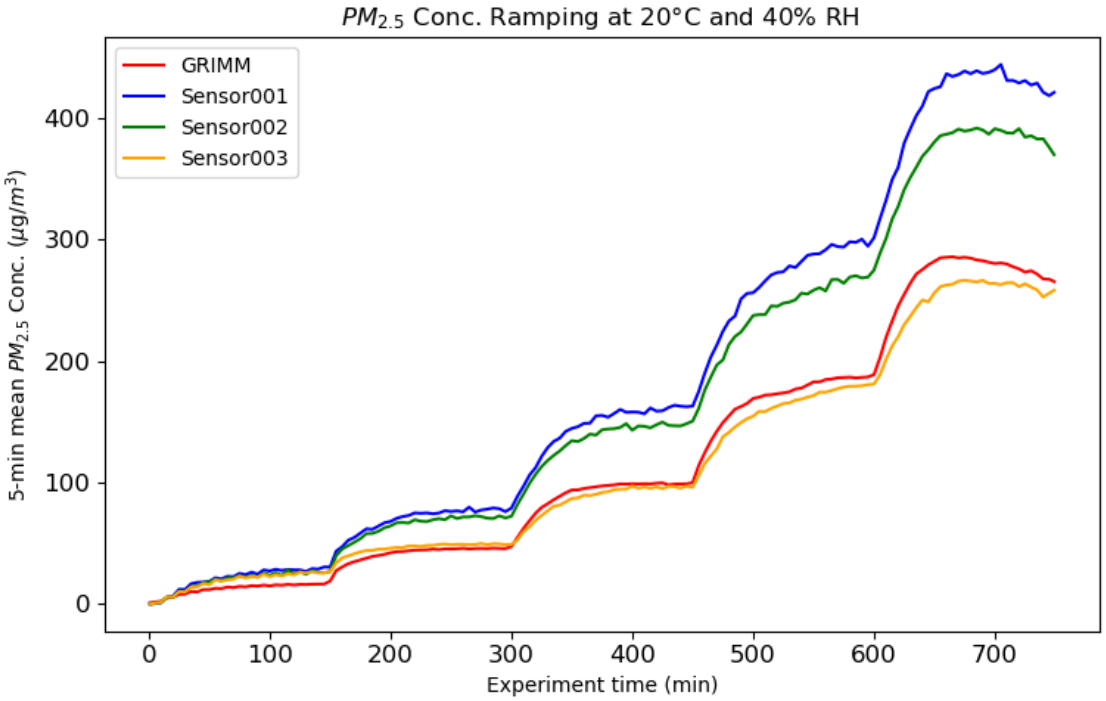
- Particle sensor; Plantower PMS5003 (optical; non-FEM)
  - Each unit measures $PM_{2.5}$ (µg/m^3), HCHO (µg/m^3), CO_2 (ppm), ambient air temperature (C), relative humidity (%)
- Unit cost: ~$170
- Time resolution: 30-sec
- Units IDs: 001, 002, 003



GRIMM (*reference method*):

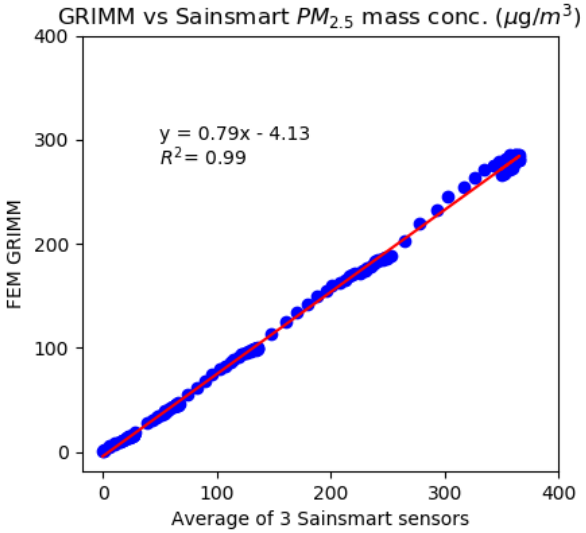
- Optical particle counter
- FEM $PM_{2.5}$
- Uses proprietary algorithms to calculate total PM, $PM_{2.5}$, and PM_1 mass conc. from particle number measurements
- Cost: ~$25,000
- Time resolution: 1-min

Sainsmart vs FEM GRIMM ($PM_{2.5}$ mass; 5-min mean)



- At 20 °C and 40% RH, the three SainSmart sensors tracked well with the concentration variation recorded by FEM GRIMM in the concentration range of 0-350 µg/m^3.
- Sensors 001 and 002 overestimated the GRIMM $PM_{2.5}$ mass conc. Sensor 003 reported $PM_{2.5}$ concentrations in very close agreement with those from the FEM GRIMM.

Coefficient of Determination



- Three SainSmart sensors showed very strong correlations with GRIMM $PM_{2.5}$ mass conc. (R^2 > 0.99) between 0-350 µg/m^3.

$PM_{2.5}$ Accuracy: SainSmart vs FEM GRIMM

- Accuracy (20 °C and 40% RH)

Steady State (#)	Sensor mean (µg/m³)	GRIMM (µg/m³)	Accuracy (%)
1	26.8	16.2	35
2	66.0	45.7	56
3	135.3	98.8	63
4	248.6	186.6	67
5	355.4	270.6	69

- The three SainSmart sensors overestimated FEM GRIMM $PM_{2.5}$ mass concentration over the concentration range of 0-350 µg/m³. SainSmart sensors showed low accuracy.

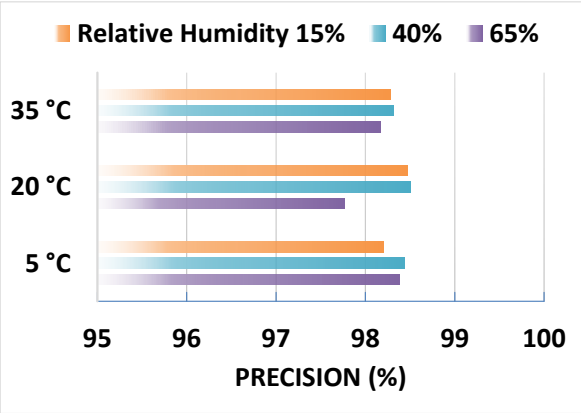
SainSmart Data Recovery and Intra-model variability

- Data recovery for $PM_{2.5}$ mass concentration from 001, 002, and 003 were 99.6%, 99.7%, and 100%.
- Moderate to high $PM_{2.5}$ measurement variations were observed among the three SainSmart units.

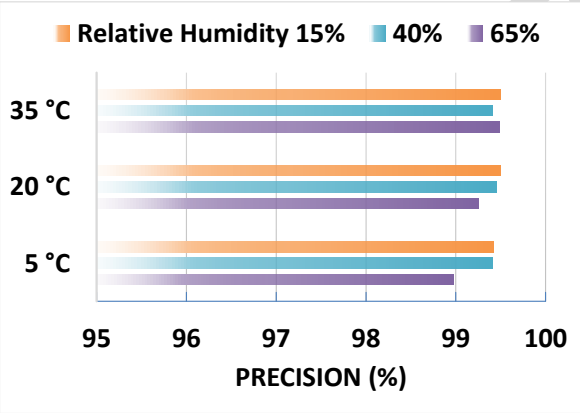
$PM_{2.5}$ Precision: SainSmart

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

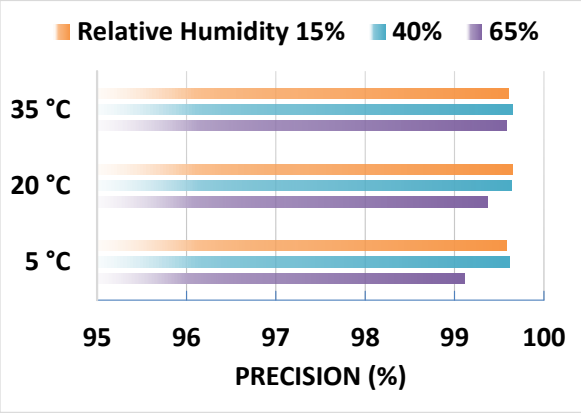
Low conc.



Medium conc.



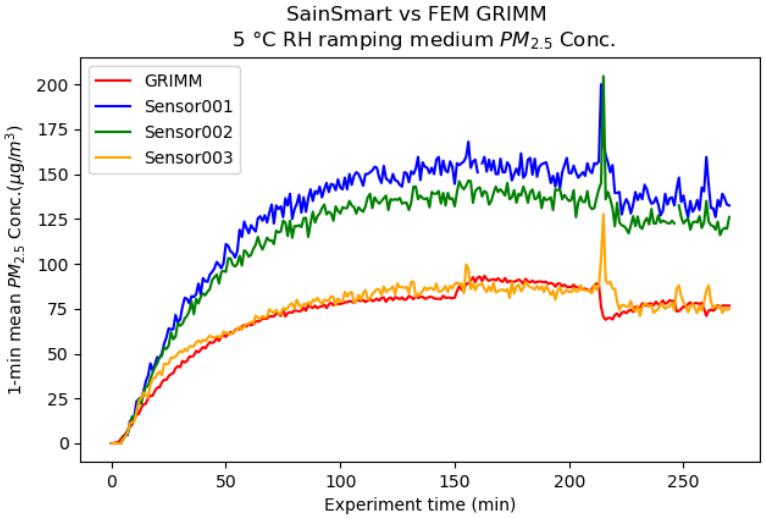
High conc.



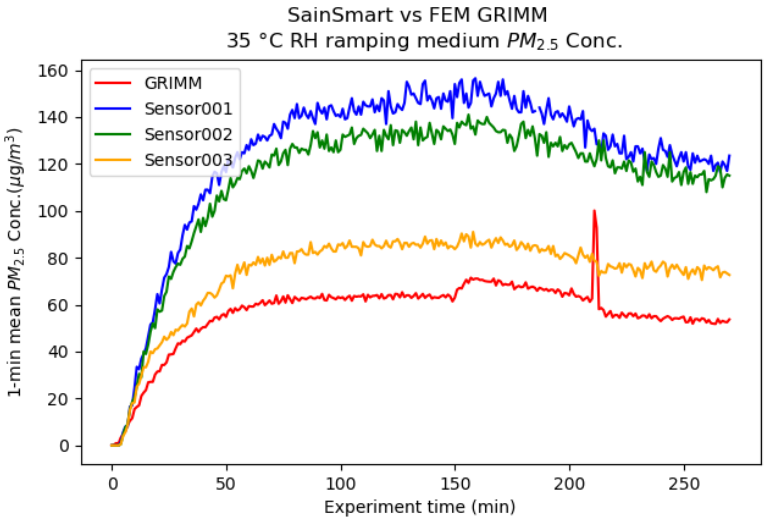
- Overall, the three SainSmart sensors showed high precision for all the combinations of low and medium $PM_{2.5}$ conc., T, and RH.

SainSmart Climate Susceptibility

Low Temp - RH ramping (medium conc.)



High Temp - RH ramping (medium conc.)



Discussion

- **Accuracy**: The three SainSmart sensors overestimated FEM GRIMM $PM_{2.5}$ mass concentration over the concentration range of 0-350 µg/m^3. SainSmart sensors have low accuracy compared to FEM GRIMM.
- **Precision**: The SainSmart sensors have high precision for all test combinations (low, medium PM concentrations, T and RH).
- **Intra-model variability**: Moderate to high intra-model variability was observed among the three SainSmart sensors.
- **Data Recovery:** Data recovery for $PM_{2.5}$ mass concentration from 001, 002, and 003 was 99.6%, 99.7%, and 100%.
- **Coefficient of Determination**: The three SainSmart sensors showed very strong correlation/linear response with the corresponding GRIMM $PM_{2.5}$ measurement data ($R^2 > 0.99$) for mass concentration range between 0 and 350 µg/m^3.
- **Climate susceptibility**: For most of the temperature and relative humidity combinations, the climate condition had minimal effect on the SainSmart's precision. At the set-points of RH changes at low PM concentrations, SainSmart sensors exhibited spiked concentration responses.