Laboratory Evaluation
Shinyei Technology -
PM Sensor Evaluation Kit

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

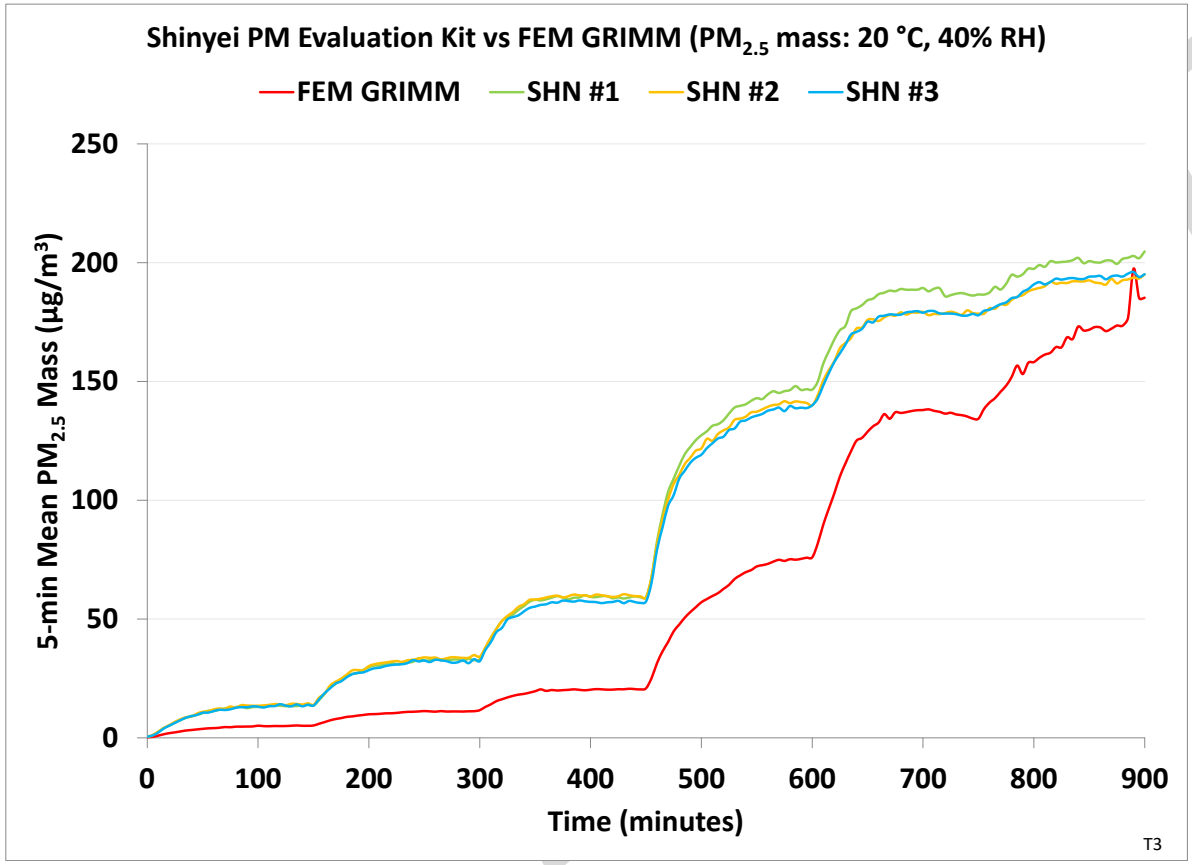
Background

Three **Shinyei Technology - PM Sensor Evaluation Kit** units that were previously evaluated for their performance in the field (deployment period: 02/05/2015 to 04/08/2015) under ambient weather conditions, have now been evaluated in the South Coast AQMD Chemistry Laboratory under controlled artificial aerosol concentration/size range, temperature, and relative humidity conditions.

- **PM Sensor Eval Kit (*3 units tested*):**
  - Particle sensors (optical; non-FEM)
  - Each unit measures: $PM_{2.5}$ ($\mu g/m^3$)
  - Unit cost: ~$1,000
  - Time resolution: 1-min
  - Units IDs: SHN #1, SHN #2, SHN #3

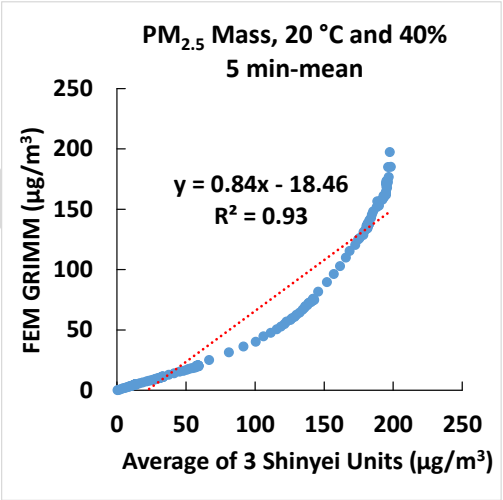
- **GRIMM (*reference method*):**
  - Optical particle counter (FEM)
  - Uses proprietary algorithms to calculate total PM, $PM_{2.5}$, and PM_1 from particle number measurements
  - Cost: ~$25,000 and up
  - Time resolution: 1-min

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



- Over the full $PM_{2.5}$ concentration range tested (0-200 µg/m^3), the Shinyei units tracked well the diurnal variations as recorded by the FEM GRIMM.

Coefficient of Determination



- Three Shinyei units showed very strong correlations with FEM GRIMM $PM_{2.5}$ measurement data (R^2~0.93) between 0-200 µg/m^3. The Shinyei units overestimated the FEM GRIMM $PM_{2.5}$ concentration.

Shinyei PM Sensor Accuracy

- Accuracy (20 °C and 40% RH)

Steady State (#)	Sensor mean (µg/m^3)	FEM (µg/m^3)	Accuracy (%)
1	13.8	5.1	-70.5
2	33.0	11.2	-94.6
3	58.6	20.6	-85.0
4	142.4	75.3	11.0
5	181.2	134.9	65.6
6	197.1	181.2	91.2

- Overall, the three Shinyei units showed distinct accuracy (from -70.5% to 91.2%) for different $PM_{2.5}$ mass concentration levels over the range of 0 – 180 µg/m^3. Low accuracy and overestimation was observed at low PM concentration, when Shinyei units were compared to the FEM GRIMM at 20 °C and 40% RH.

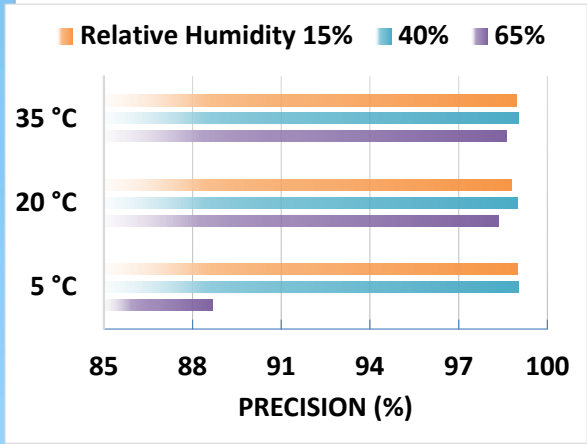
Shinyei Data Recovery & Intra-model Variability

- Data recovery for $PM_{2.5}$ mass concentration from all three units was 100%.
- Low $PM_{2.5}$ measurement variations were observed between the three units.

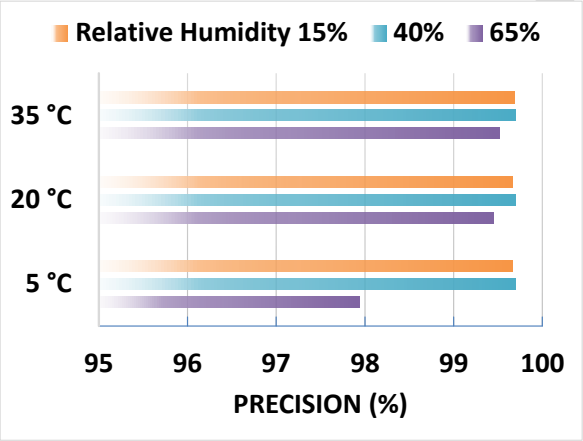
Shinyei PM Sensor Precision

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

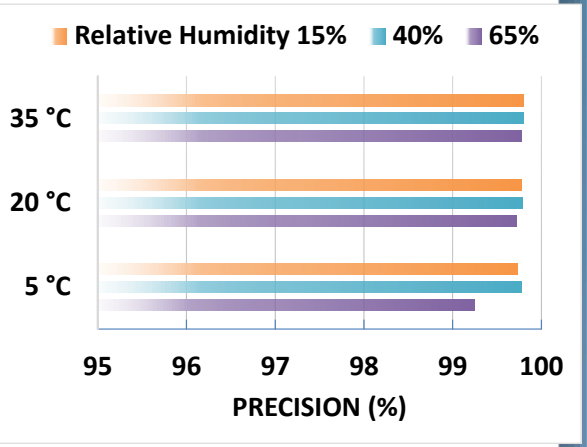
Low conc.



Medium conc.

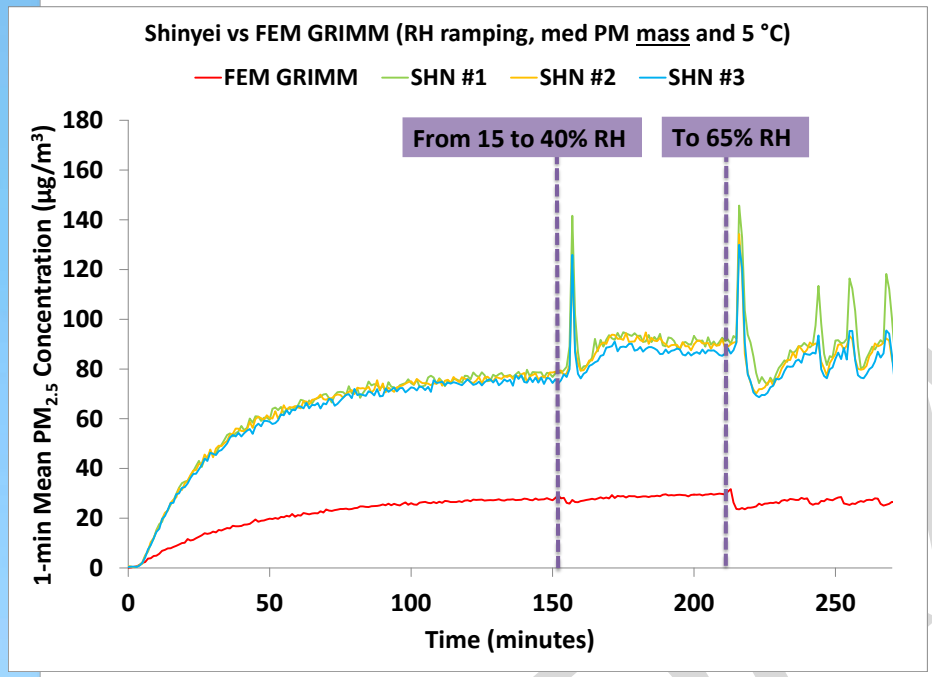


High conc.

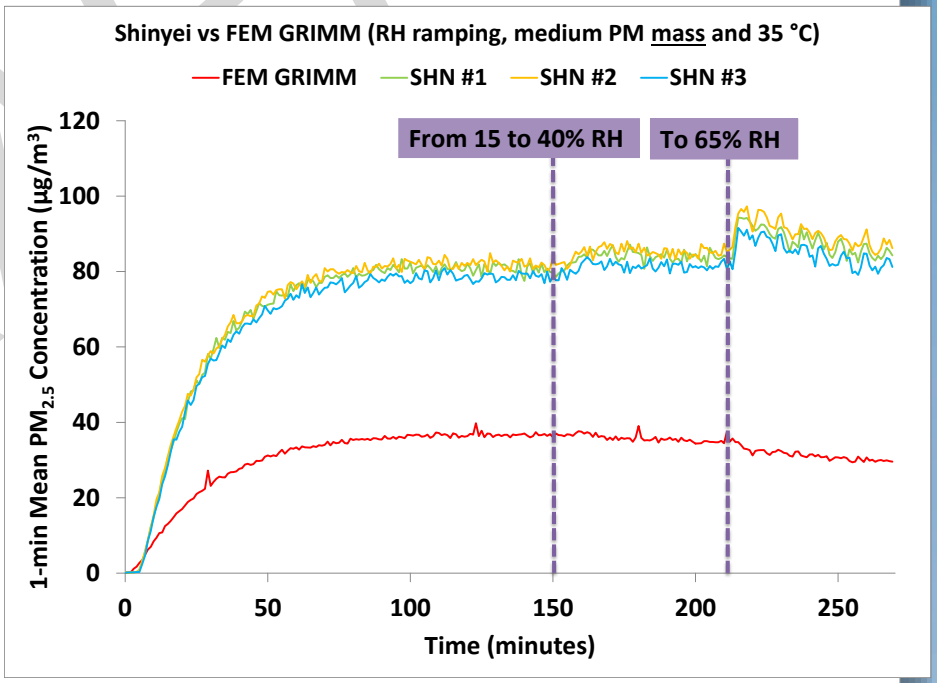


- Overall, the three Shinyei units and the FEM GRIMM showed high precision for almost all combinations of low, medium and high PM conc., T, and RH.
- Only at 5 °C and high relative humidity of 65%, the precision was affected by the spiked values recorded by the Shinyei units.
- FEM GRIMM precision was very high across all conditions.

Shinyei PM Sensor Climate Susceptibility



Low Temp – RH ramping
(medium conc.)



High Temp – RH ramping
(medium conc.)

Discussion

- **Accuracy**: Overall, the three Shinyei units have low accuracy, compared to the FEM GRIMM for $PM_{2.5}$ range 0.0 to 200 µg/m^3. The three Shinyei units generally overestimated the $PM_{2.5}$ mass measured by FEM GRIMM. (refer to slide 4).
- **Precision**: Shinyei units have high precision for almost all test combinations ($PM_{2.5}$, T and RH). (refer to slide 5), except for at 5 °C and high relative humidity where the precision was affected by the spiked values measured by Shinyei units.
- **Intra-model variability**: Low intra-model variability was observed among the three Shinyei units (slide 4).
- **Data Recovery**: Data recovery for $PM_{2.5}$ mass concentration from all three Shinyei units was 100% (slide 4).
- **Coefficient of Determination**: Shinyei units showed very strong correlation/linear response with the corresponding FEM GRIMM $PM_{2.5}$ measurement data (R^2~0.93) for mass concentration range between 0 and 200 µg/m^3 (refer to slides 3)
- **Climate susceptibility**: From the laboratory studies, temperature and relative humidity did not affect Shinyei units' precision in most cases. At 5 °C and 65% RH, Shinyei units reported spiked changes in $PM_{2.5}$ concentrations, resulting into the lowest precision observed around 88%. (slide 5 and 6)