

Laboratory Evaluation: TSI BlueSky



Background

Three **TSI BlueSky** sensors (units IDs: 8031, 8027, 8037) were field-tested at the South Coast AQMD Rubidoux fixed ambient monitoring station (04/08/2020 to 06/15/2020) 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 TSI BlueSky units were tested both in the field (1st stage of testing) and in the laboratory (2nd stage of testing).

TSI BlueSky (3 units tested):

- Particle sensor: **optical; non-FEM (SPS30, Sensirion)**
- Each unit reports: PM_{2.5} and PM₁₀ (µg/m³), Temperature and Relative Humidity
- **Unit cost: \$400**
- Time resolution: 1-min
- Units IDs: Unit 8031, Unit 8027 and Unit 8037



GRIMM (reference method):

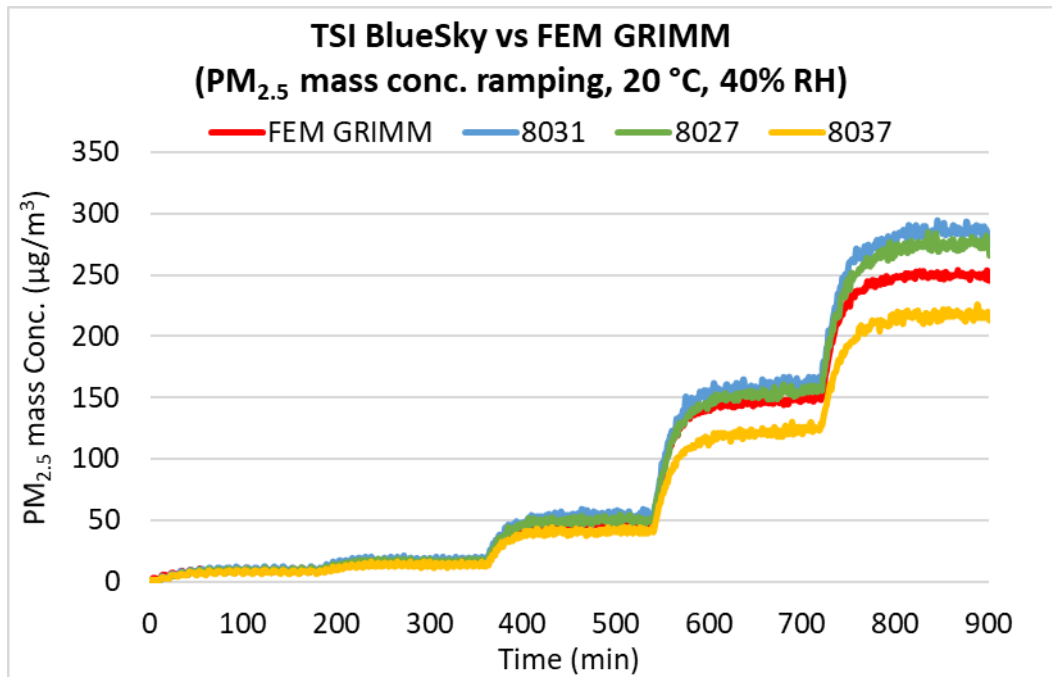
- Optical particle counter
- **FEM PM_{2.5}**
- Uses proprietary algorithms to calculate PM_{1.0}, PM_{2.5}, and PM₁₀ mass conc. from particle number measurements
- **Cost: ~\$25,000**
- Time resolution: 1-min



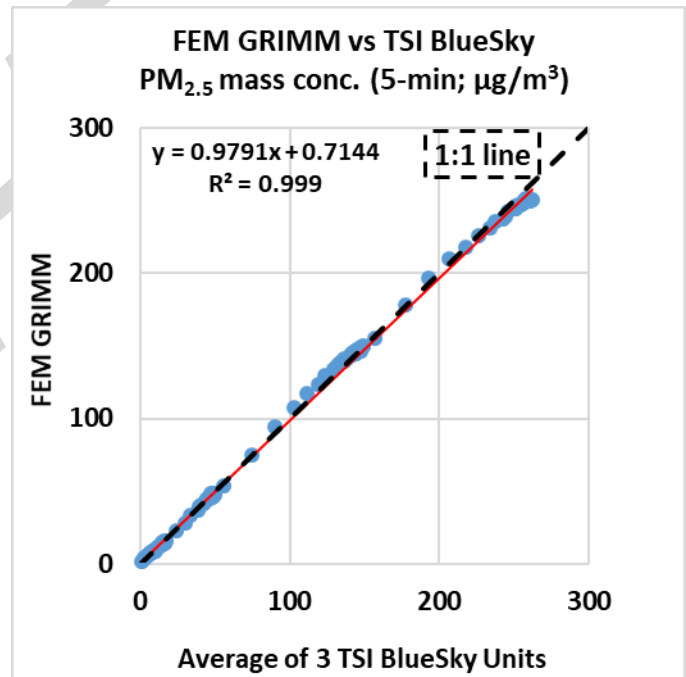
FEM GRIMM

TSI BlueSky vs FEM GRIMM (PM_{2.5} mass conc.)

Coefficient of Determination



- The TSI BlueSky sensors tracked well with the concentration variation as recorded by the FEM GRIMM in the concentration range of 0 - ~250 µg/m³.



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

TSI BlueSky 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 | 9.0 | 8.7 | 96.4 |
| 2 | 16.1 | 14.8 | 91.1 |
| 3 | 48.6 | 48.1 | 98.9 |
| 4 | 148.8 | 149.4 | 99.6 |
| 5 | 260.2 | 250.3 | 96.0 |

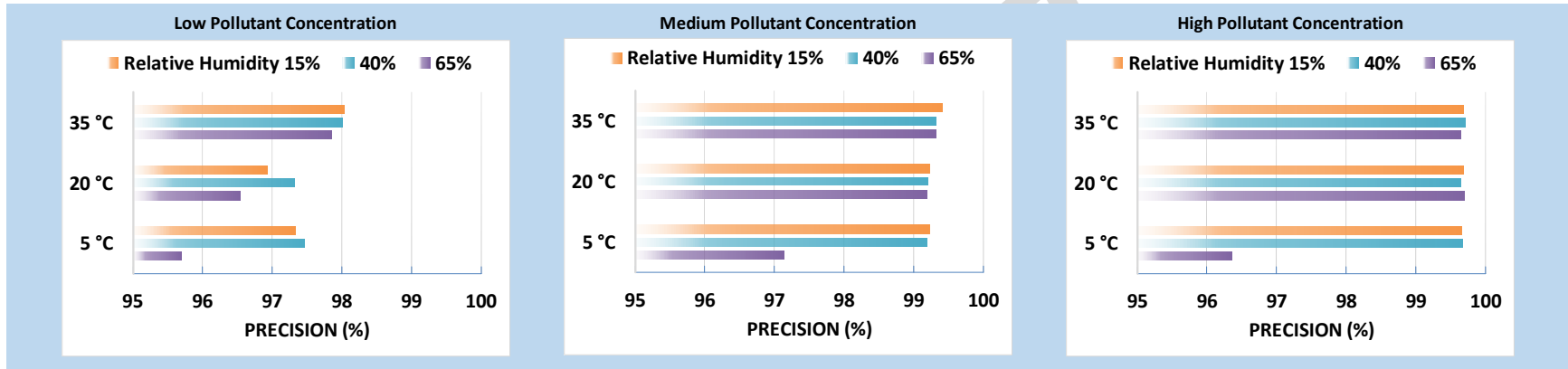
- The TSI BlueSky sensors overestimated FEM GRIMM PM_{2.5} mass concentration at 20 °C and 40% RH. The accuracy of the TSI BlueSky sensors was fairly constant (~ 91% to 99%) over the PM_{2.5} mass concentration range tested.

TSI BlueSky: Data Recovery and Intra-model Variability

- Data recovery for PM_{2.5} mass concentration from all units was 100%
- Moderate PM_{2.5} measurement variations were observed between the TSI BlueSky sensors

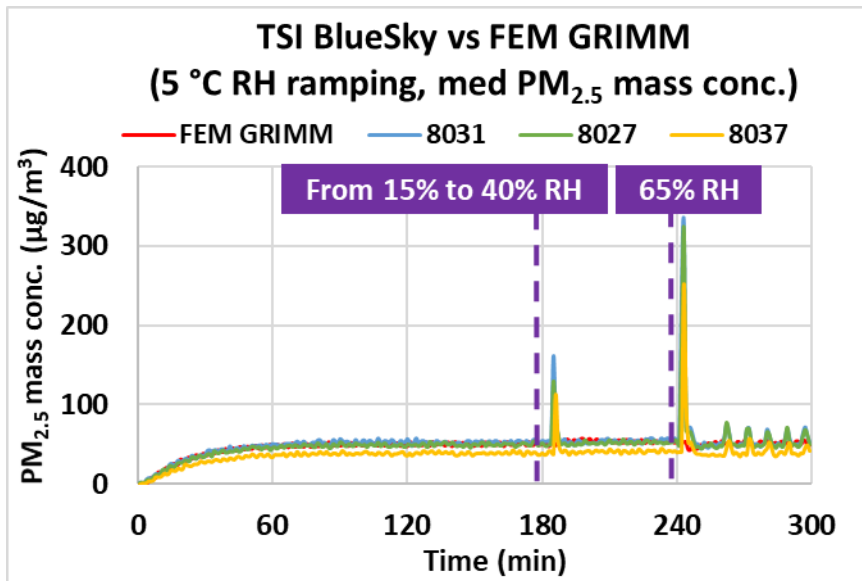
TSI BlueSky vs FEM GRIMM (PM_{2.5}; 1-min mean)

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



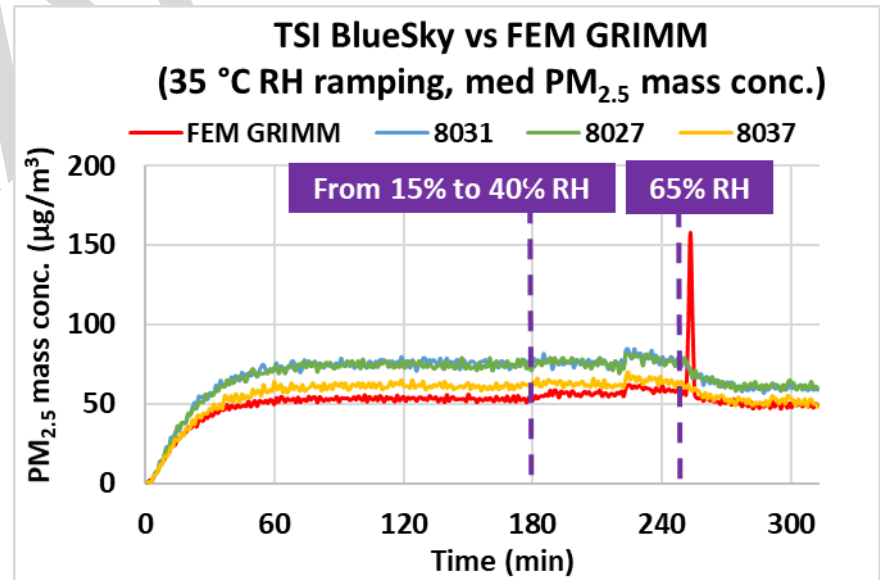
- Overall, the TSI BlueSky sensors showed high precision for all combinations of low, medium and high PM_{2.5} conc., T, and RH.
- Precision was relatively higher at higher PM_{2.5} mass concentrations.

TSI BlueSky PM_{2.5}: Climate Susceptibility



Low Temp – RH ramping
(medium conc.)

High Temp – RH ramping
(medium conc.)



Discussion

- **Accuracy:** Overall, the accuracy of the TSI BlueSky sensors was fairly constant (~ 91% to 99%) over the PM_{2.5} mass concentration range tested. The TSI BlueSky sensors overestimated PM_{2.5} measurements from FEM GRIMM in the laboratory experiments at 20 °C and 40% RH.
- **Precision:** The TSI BlueSky 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 TSI BlueSky sensors.
- **Data Recovery:** Data recovery for PM_{2.5} mass concentration was 100% from all TSI BlueSky units
- **Coefficient of Determination:** The TSI BlueSky sensors showed very strong correlation/linear response with the corresponding 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 TSI BlueSky sensors' precision; the sensors showed spiked conc. change at the RH change points at 5 °C and showed significant concentration variation at 5 °C/65% RH.