Field Evaluation
TSI BlueSky

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center
Background

• From 04/08/2020 to 06/15/2020, three TSI BlueSky sensors were deployed at the South Coast AQMD stationary ambient monitoring site in Rubidoux and were run side-by-side with Federal Equivalent Method (FEM) instruments measuring the same pollutants

• TSI BlueSky (3 units tested):
  ➢ Particle sensor: optical; non-FEM (SPS30, Sensirion)
  ➢ Each unit reports: PM\textsubscript{2.5} and PM\textsubscript{10} (\(\mu g/m^3\)), Temperature and Relative Humidity
  ➢ Unit cost: $400
  ➢ Time resolution: 1-min
  ➢ Units IDs: Unit 8031, Unit 8027 and Unit 8037

• GRIMM (reference instrument):
  ➢ Optical particle counter (FEM PM\textsubscript{2.5})
  ➢ Measures PM\textsubscript{1.0}, PM\textsubscript{2.5}, and PM\textsubscript{10} (\(\mu g/m^3\))
  ➢ Cost: ~$25,000 and up
  ➢ Time resolution: 1-min

• Teledyne API T640 (reference instrument):
  ➢ Optical particle counter (FEM PM\textsubscript{2.5})
  ➢ Measures PM\textsubscript{2.5} & PM\textsubscript{10} (\(\mu g/m^3\))
  ➢ Unit cost: ~$21,000
  ➢ Time resolution: 1-min

• Met station (T, RH, P, WS, WD):
  ➢ Unit cost: ~$5,000
  ➢ Time resolution: 1-min
Data validation & recovery

- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery from Unit 8031, Unit 8027 and Unit 8037 was ~ 87%, 97% and 80%, respectively, for both PM$_{2.5}$ and PM$_{10}$ measurements

**TSI BlueSky; intra-model variability**

- Absolute intra-model variability was ~ 0.58 and 0.63 µg/m$^3$ for PM$_{2.5}$ and PM$_{10}$, respectively (calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was ~ 10.5% and 11% for PM$_{2.5}$ and PM$_{10}$, respectively (calculated as the absolute intra-model variability relative to the mean of the three sensor means)
Reference Instruments: PM\textsubscript{2.5} FEM GRIMM and FEM T640

- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery for PM\textsubscript{2.5} measurements from FEM GRIMM and FEM T640 was \sim 88\% and 76\%, respectively.
- Strong correlations between the reference instruments for PM\textsubscript{2.5} measurements ($R^2 \sim 0.87$).
Reference Instruments: PM$_{10}$
GRIMM and T640

- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery for PM$_{10}$ measurements from GRIMM and T640 was ~ 88% and 76%, respectively.
- Strong correlations between the reference instruments for PM$_{10}$ measurements ($R^2$ ~ 0.88) were observed.
The TSI BlueSky sensors showed strong correlations with the corresponding FEM GRIMM data ($R^2 \sim 0.72$).

Overall, the TSI BlueSky sensors underestimated the PM$_{2.5}$ mass concentrations as measured by FEM GRIMM.

The TSI BlueSky sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM GRIMM.
The TSI BlueSky sensors showed very weak correlations with the corresponding GRIMM data ($R^2 \approx 0.11$). Overall, the TSI BlueSky sensors underestimated the PM$_{10}$ mass concentrations measured by GRIMM. The TSI BlueSky sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by GRIMM.
The TSI BlueSky sensors showed strong correlations with the corresponding FEM GRIMM data ($R^2 \approx 0.75$).

Overall, the TSI BlueSky sensors underestimated the PM$_{2.5}$ mass concentrations as measured by FEM GRIMM.

The TSI BlueSky sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM GRIMM.
The TSI BlueSky sensors showed very weak correlations with the corresponding GRIMM data ($R^2 \approx 0.16$).

Overall, the TSI BlueSky sensors underestimated the $PM_{10}$ mass concentrations measured by GRIMM.

The TSI BlueSky sensors did not seem to track the $PM_{10}$ diurnal variations as recorded by GRIMM.
The TSI BlueSky sensors showed strong correlations with the corresponding FEM GRIMM data ($R^2 \approx 0.79$).

Overall, the TSI BlueSky sensors underestimated the PM$_{2.5}$ mass concentrations as measured by FEM GRIMM.

The TSI BlueSky sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM GRIMM.
The TSI BlueSky sensors showed very weak correlations with the corresponding GRIMM data ($R^2 \approx 0.296$).

Overall, the TSI BlueSky sensors underestimated the $\text{PM}_{10}$ mass concentrations measured by GRIMM.

The TSI BlueSky sensors did not seem to track the $\text{PM}_{10}$ diurnal variations as recorded by GRIMM.

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**PM$_{10}$ (24-hr mean, $\mu g/m^3$)**

- **Unit 8031**
  
  $y = 2.8032x + 10.968$
  
  $R^2 = 0.315$

- **Unit 8027**
  
  $y = 1.8803x + 16.531$
  
  $R^2 = 0.2849$

- **Unit 8037**
  
  $y = 2.137x + 16.348$
  
  $R^2 = 0.2885$
The TSI BlueSky sensors showed strong correlations with the corresponding FEM T640 data ($R^2 \sim 0.70$).

Overall, the TSI BlueSky sensors underestimated the PM$_{2.5}$ mass concentrations as measured by FEM T640.

The TSI BlueSky sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM T640.
The TSI BlueSky sensors showed very weak correlations with the corresponding T640 data ($R^2 \sim 0.17$).

Overall, the TSI BlueSky sensors underestimated the PM$_{10}$ mass concentrations as measured by T640.

The TSI BlueSky sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by T640.
TSI BlueSky vs FEM T640 (PM$_{2.5}$; 1-hr mean)

- TSI BlueSky sensors showed strong correlations with the corresponding FEM T640 data ($R^2 \approx 0.72$)
- Overall, the TSI BlueSky sensors underestimated the PM$_{2.5}$ mass concentrations as measured by FEM T640
- The TSI BlueSky sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM T640
- TSI BlueSky sensors showed very weak correlations with the corresponding T640 data ($R^2 \sim 0.18$)
- Overall, the TSI BlueSky sensors underestimated the PM$_{10}$ mass concentrations as measured by T640
- The TSI BlueSky sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by T640
The TSI BlueSky sensors showed moderate correlations with the corresponding FEM T640 data ($R^2 \approx 0.68$).

Overall, the TSI BlueSky sensors underestimated the PM$_{2.5}$ mass concentrations as measured by FEM T640.

The TSI BlueSky sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM T640.
The TSI BlueSky sensors showed weak correlations with the corresponding T640 data ($R^2 \approx 0.30$).

Overall, the TSI BlueSky sensors underestimated the PM$_{10}$ mass concentrations as measured by T640.

The TSI BlueSky sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by T640.
The TSI BlueSky sensors showed strong correlations with the corresponding South Coast AQMD Met Station data ($R^2 \approx 0.89$).

Overall, the TSI BlueSky temperature measurements overestimated the corresponding South Coast AQMD Met Station data.

The TSI BlueSky sensors seemed to track the temperature diurnal variations as recorded by South Coast AQMD Met Station.

Note: The TSI BlueSky sensors measure temperature and RH inside of the sensors.
The TSI BlueSky sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ($R^2 \approx 0.91$).

Overall, the TSI BlueSky temperature measurements underestimated the corresponding South Coast AQMD Met Station data.

The TSI BlueSky sensors seemed to track the temperature diurnal variations as recorded by South Coast AQMD Met Station.

Note: The TSI BlueSky sensors measure temperature and RH inside of the sensors.
Discussion

• The three TSI BlueSky sensors' data recovery from Unit 8031, Unit 8027 and Unit 8037 was ~ 87%, 97% and 80%, respectively for both PM$_{2.5}$ and PM$_{10}$ measurements.

• The absolute intra-model variability was ~ 0.55 and 0.54 µg/m$^3$ for PM$_{2.5}$ and PM$_{10}$, respectively.

• Strong correlations between FEM GRIMM and FEM T640 for PM$_{2.5}$ ($R^2$ ~ 0.87, 1-hr mean) and PM$_{10}$ ($R^2$ ~ 0.88, 1-hr mean) mass concentration measurements.

• PM$_{2.5}$ mass concentrations measured by TSI BlueSky sensors showed moderate to strong correlations with the corresponding FEM GRIMM and FEM T640 data ($0.66 < R^2 < 0.78$, 1-hr mean). The sensors underestimated PM$_{2.5}$ mass concentrations as measured by FEM GRIMM and FEM T640.

• PM$_{10}$ mass concentrations measured by TSI BlueSky sensors showed very weak correlations with the GRIMM and T640 data ($R^2$ ~ 0.16 and 0.18, respectively; 1-hr mean) and underestimated PM$_{10}$ mass concentrations measured by GRIMM and T640.

• No sensor calibration was performed by South Coast AQMD Staff prior to the beginning of this test.

• Laboratory chamber testing is necessary to fully evaluate the performance of these sensors under known aerosol concentrations and controlled temperature and relative humidity conditions.

• All results are still preliminary.