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: $PM_{2.5}$ and PM_{10} (µg/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 $PM_{2.5}$)
  - Measures $PM_{1.0}$, $PM_{2.5}$, and PM_{10} (µg/m^3)
  - Cost: ~$25,000 and up
  - Time resolution: 1-min

- Teledyne API T640 (*reference instrument*):
  - Optical particle counter (FEM $PM_{2.5}$)
  - Measures $PM_{2.5}$ & PM_{10} (µg/m^3)
  - Unit cost: ~$21,000
  - Time resolution: 1-min

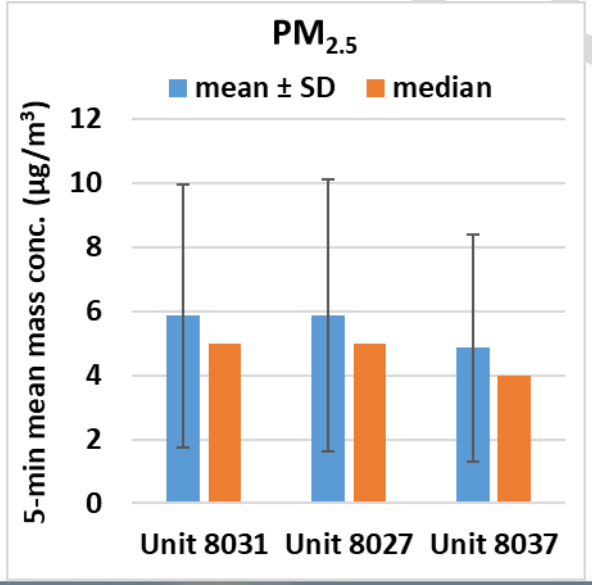
- Met station (*T, RH, P, WS, WD*):
  - Unit cost: ~$5,000
  - Time resolution: 1-min

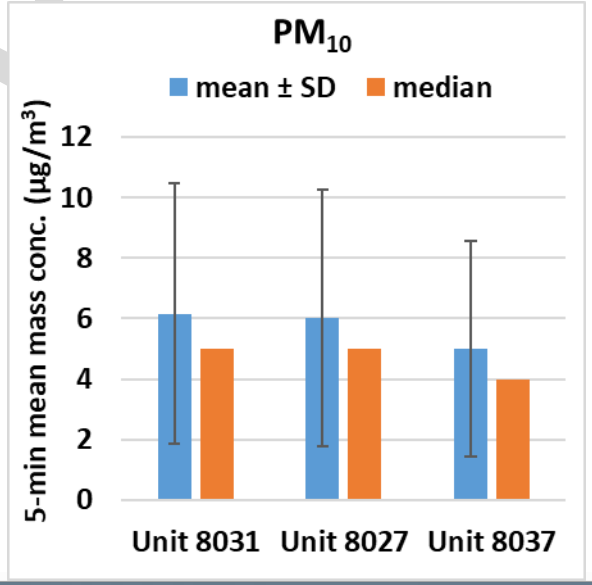
Data validation & recovery

- 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

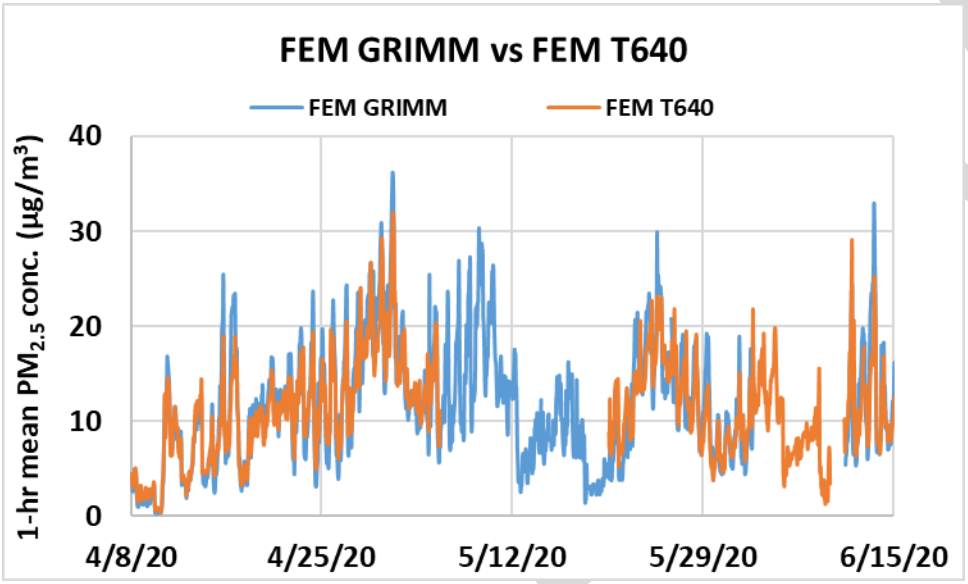
- Absolute intra-model variability was ~ 0.58 and 0.63 µg/m^3 for $PM_{2.5}$ and $PM_{10,}$ respectively (calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was ~ 10.5% and 11 % for $PM_{2.5}$ and $PM_{10,}$ respectively (calculated as the absolute intra-model variability relative to the mean of the three sensor means)

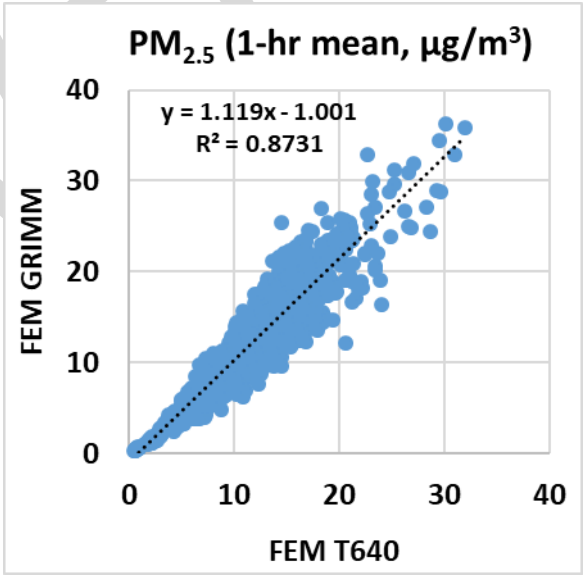




Reference Instruments: $PM_{2.5}$ FEM GRIMM and FEM T640

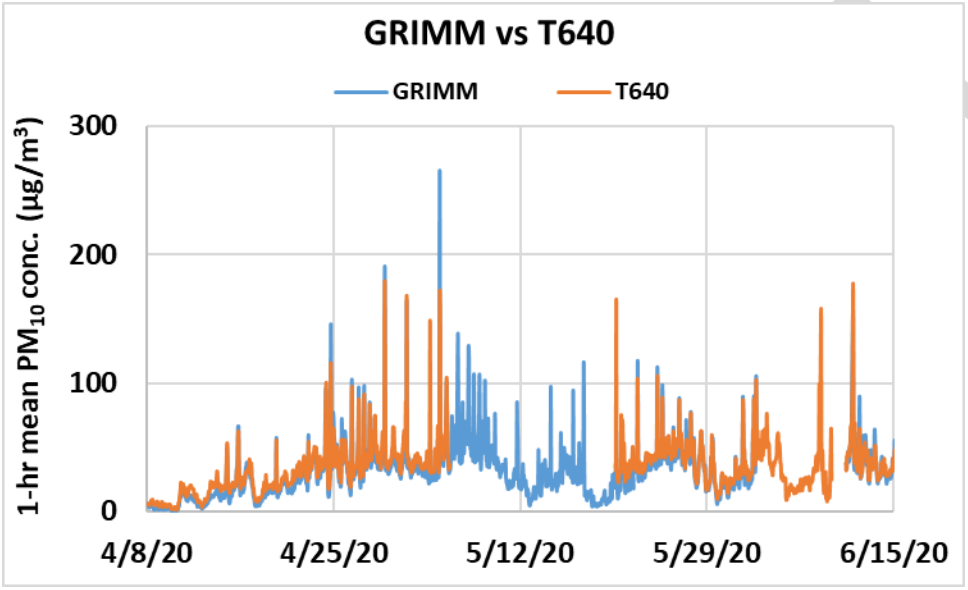
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery for $PM_{2.5}$ measurements from FEM GRIMM and FEM T640 was ~ 88% and 76%, respectively.
- Strong correlations between the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

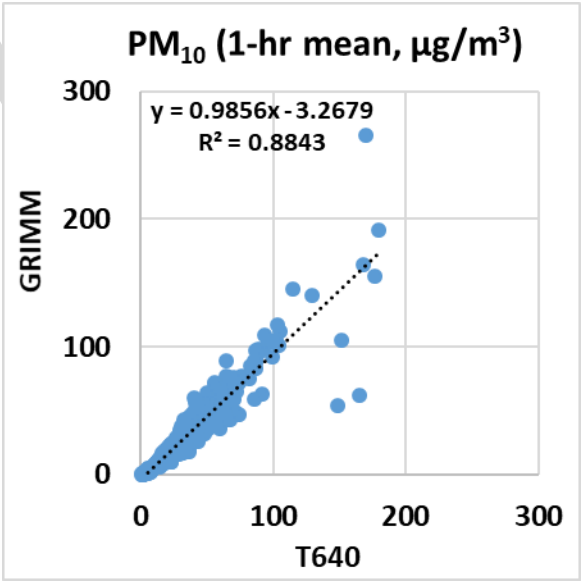




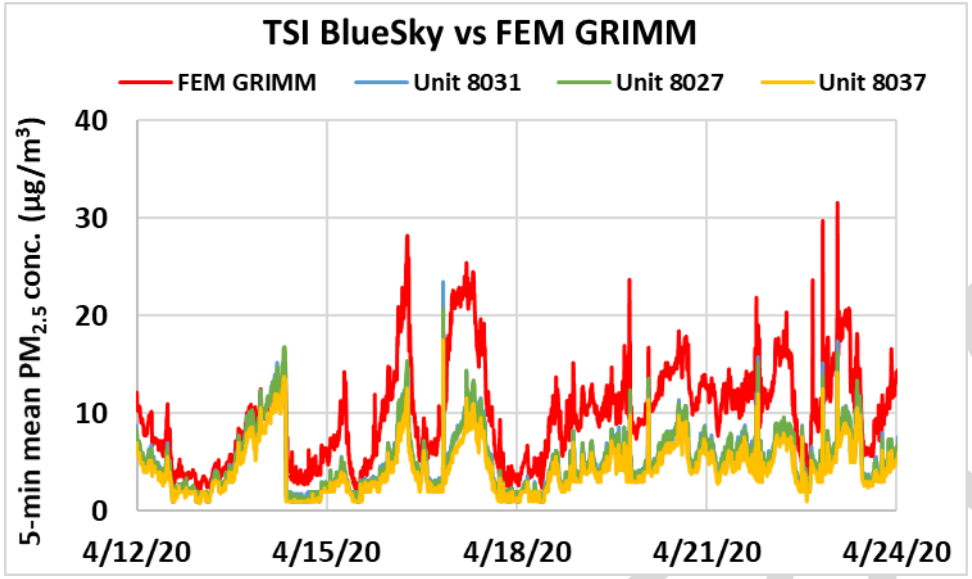
Reference Instruments: PM_{10} GRIMM and T640

- 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.

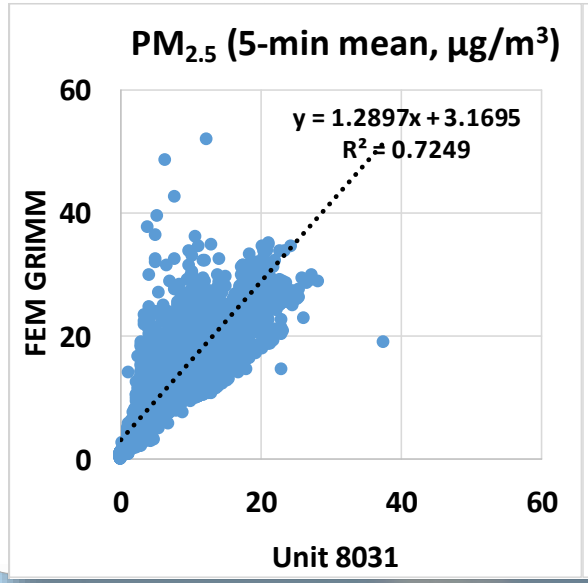


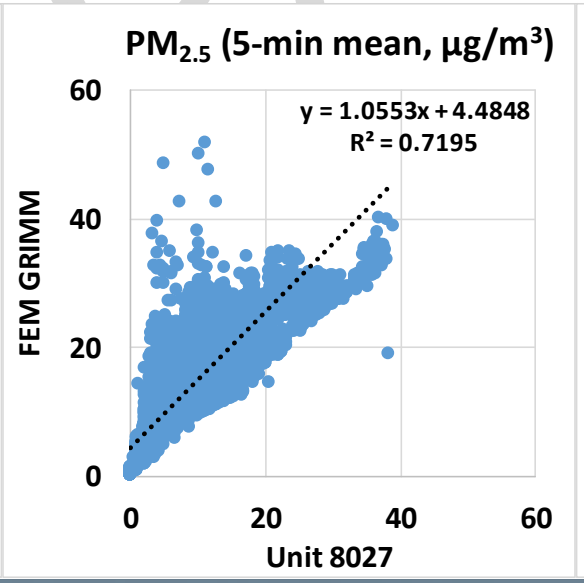


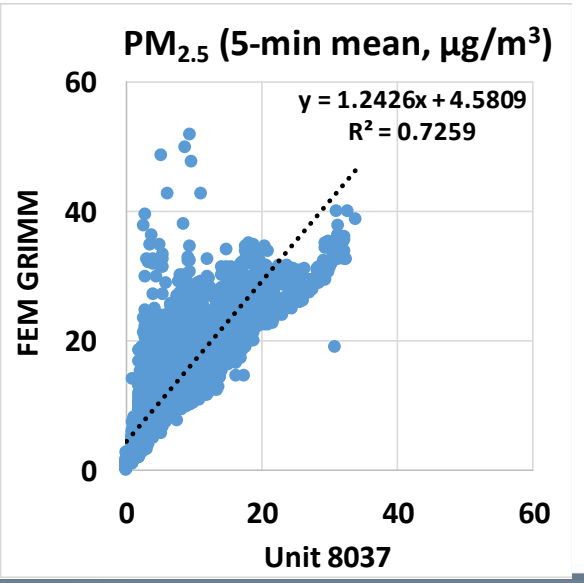
TSI BlueSky vs FEM GRIMM ($PM_{2.5}$; 5-min mean)



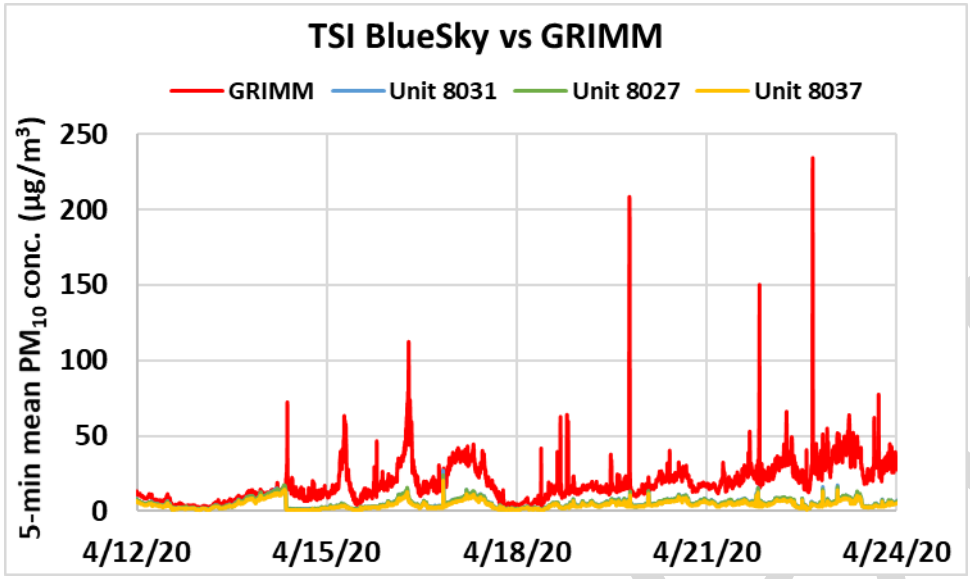
- The TSI BlueSky sensors showed strong correlations with the corresponding FEM GRIMM data (R^2 ~ 0.72)
- Overall, the TSI BlueSky sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM GRIMM
- The TSI BlueSky sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM GRIMM



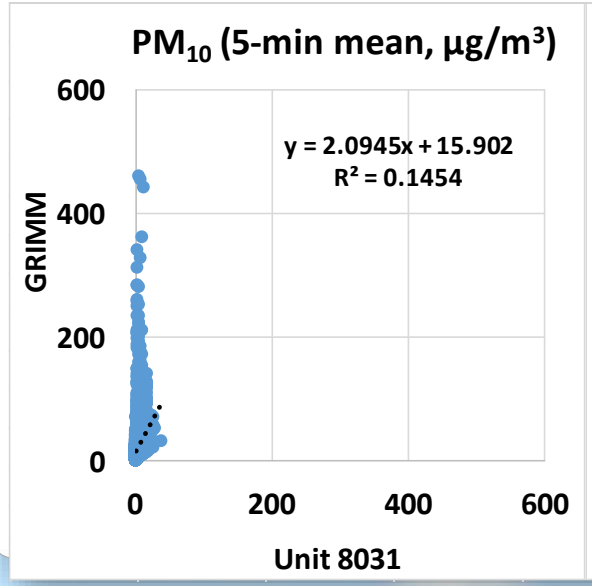


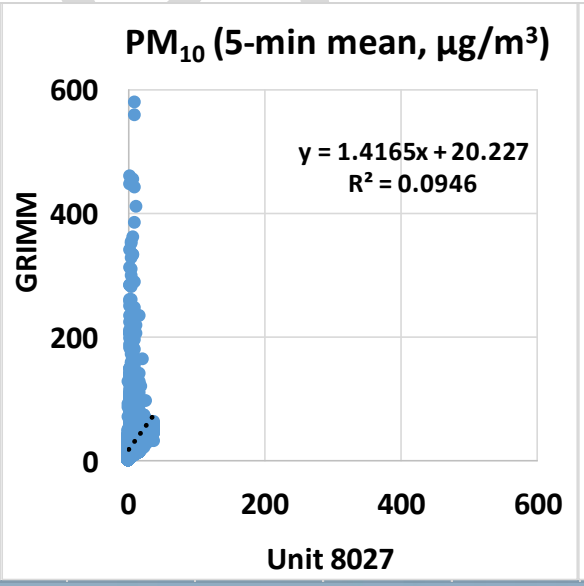


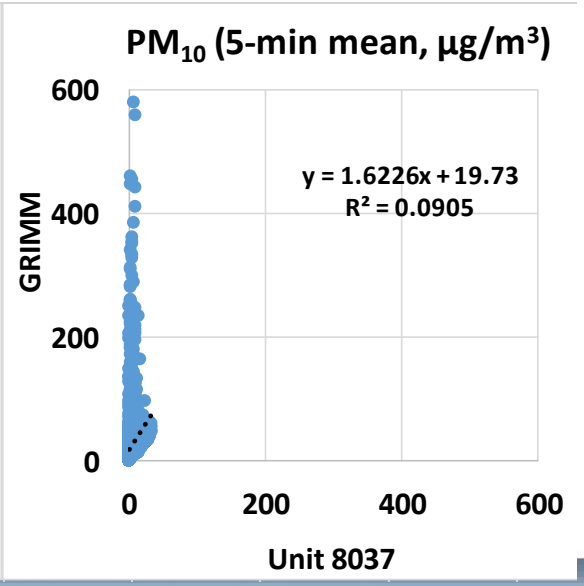
TSI BlueSky vs GRIMM (PM_{10}; 5-min mean)



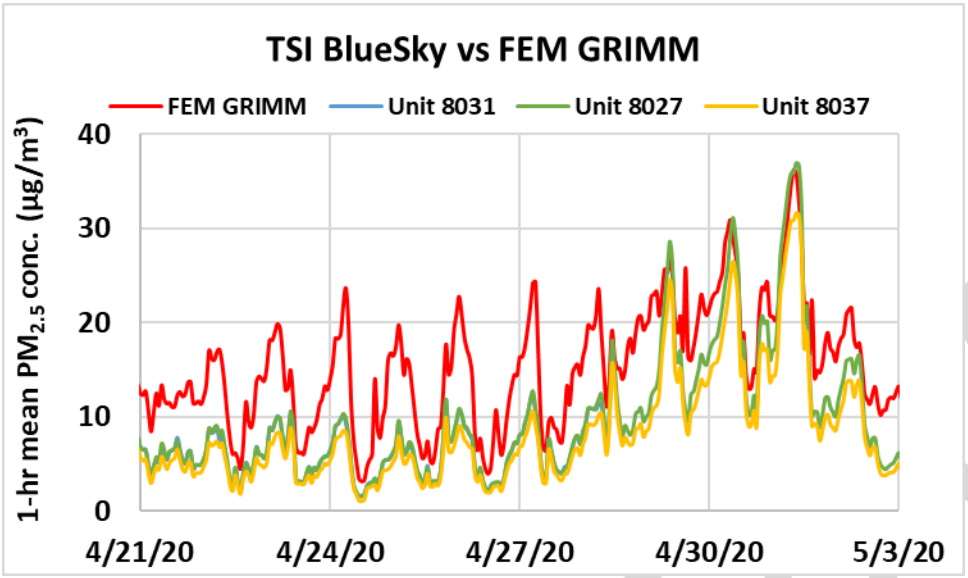
- The TSI BlueSky sensors showed very weak correlations with the corresponding GRIMM data (R^2 ~ 0.11)
- Overall, the TSI BlueSky sensors underestimated the PM_{10} mass concentrations measured by GRIMM
- The TSI BlueSky sensors did not seem to track the PM_{10} diurnal variations as recorded by GRIMM



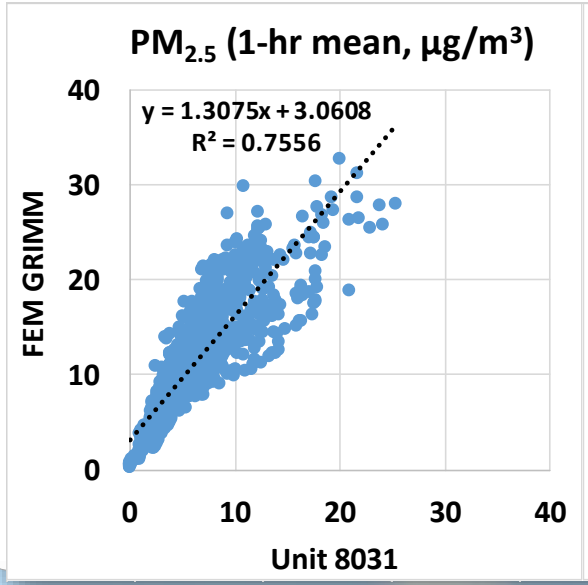


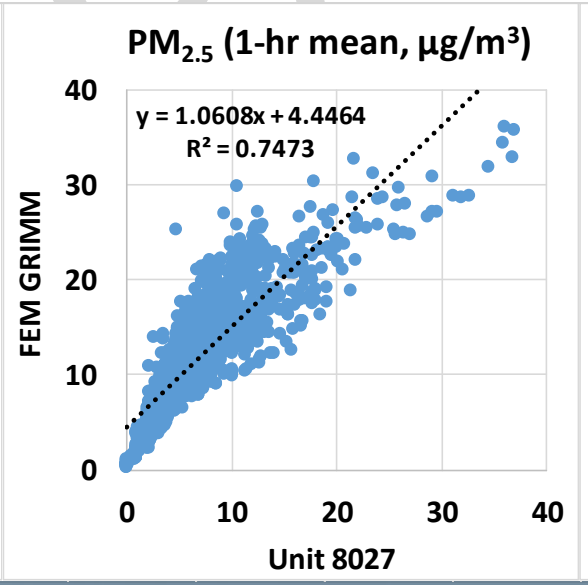


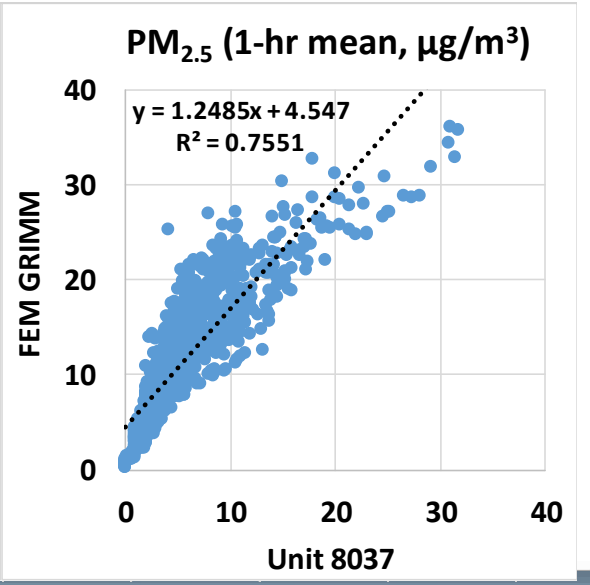
TSI BlueSky vs FEM GRIMM ($PM_{2.5}$; 1-hr mean)



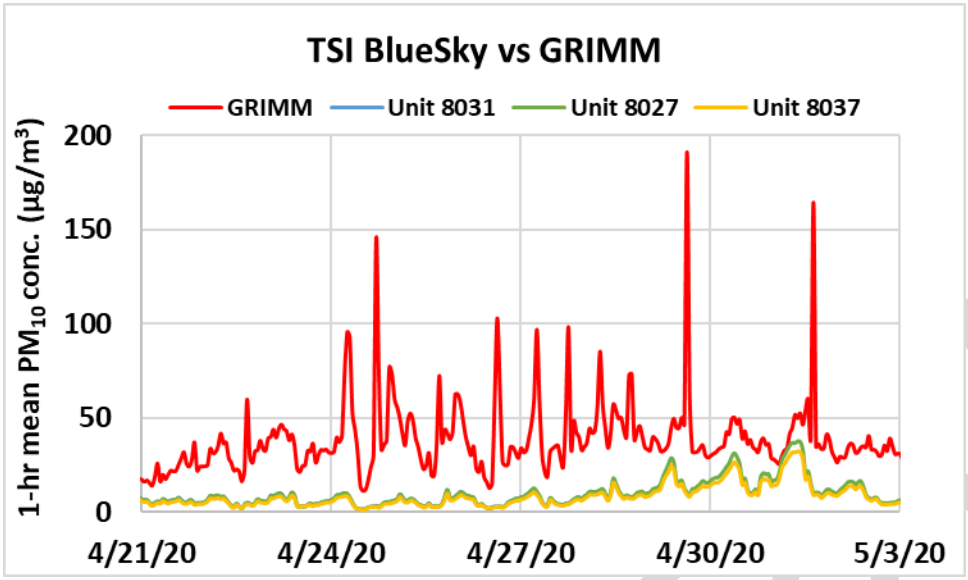
- The TSI BlueSky sensors showed strong correlations with the corresponding FEM GRIMM data (R^2 ~ 0.75)
- Overall, the TSI BlueSky sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM GRIMM
- The TSI BlueSky sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM GRIMM



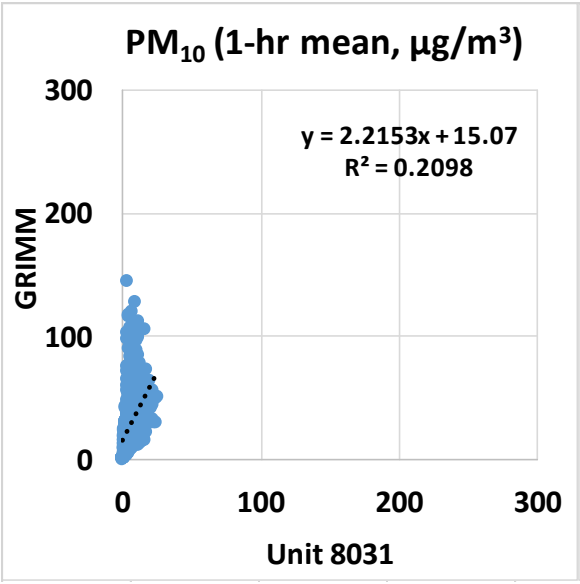


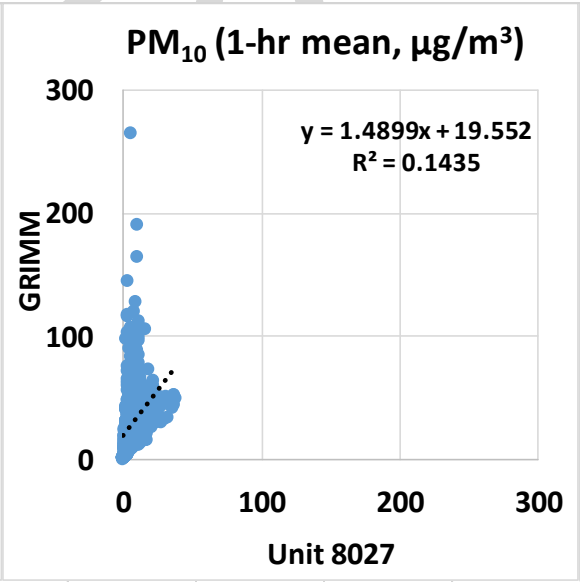


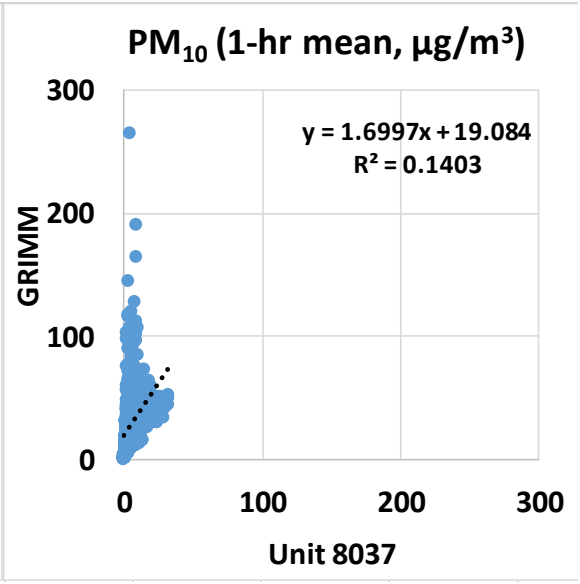
TSI BlueSky vs GRIMM (PM_{10}; 1-hr mean)



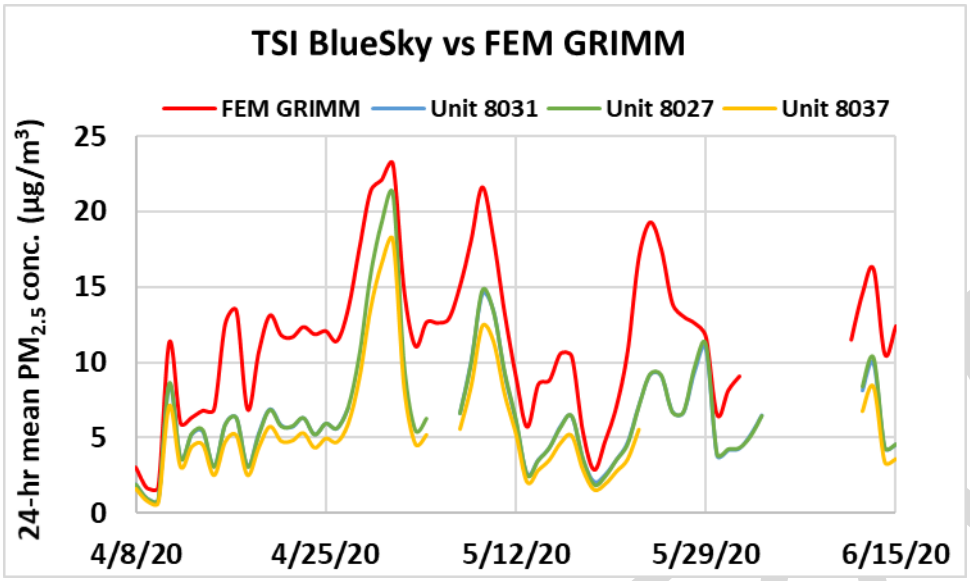
- The TSI BlueSky sensors showed very weak correlations with the corresponding GRIMM data (R^2 ~ 0.16)
- Overall, the TSI BlueSky sensors underestimated the PM_{10} mass concentrations measured by GRIMM
- The TSI BlueSky sensors did not seem to track the PM_{10} diurnal variations as recorded by GRIMM



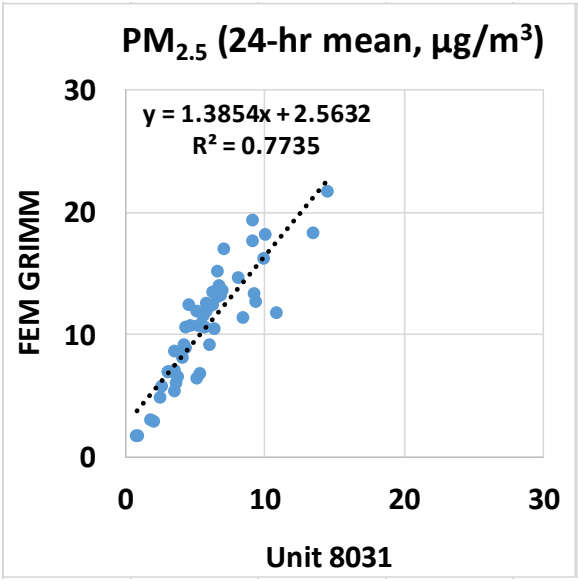


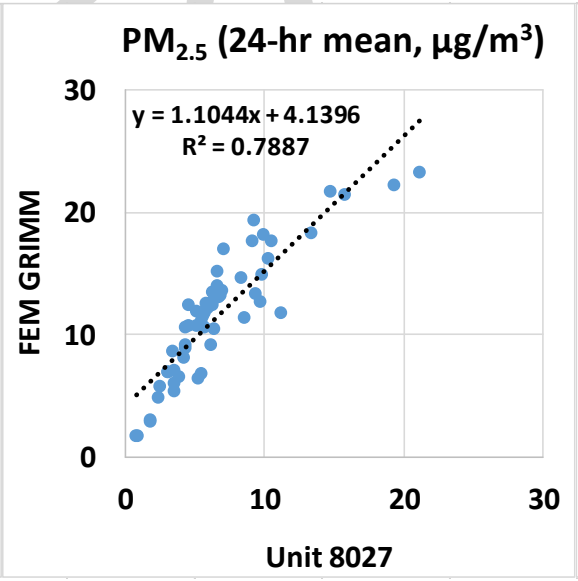


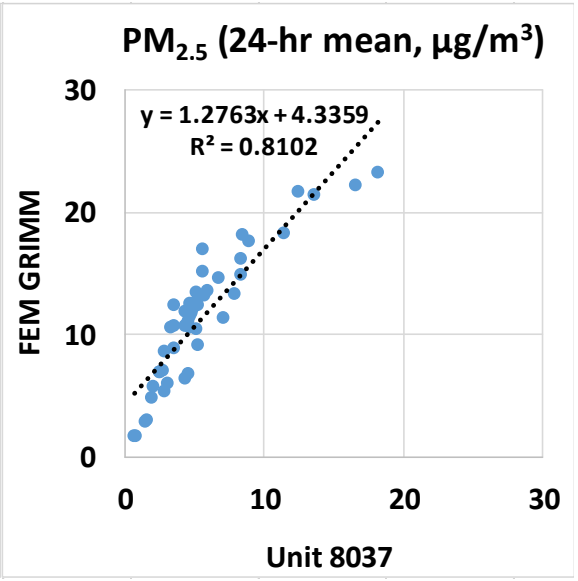
TSI BlueSky vs FEM GRIMM ($PM_{2.5}$; 24-hr mean)



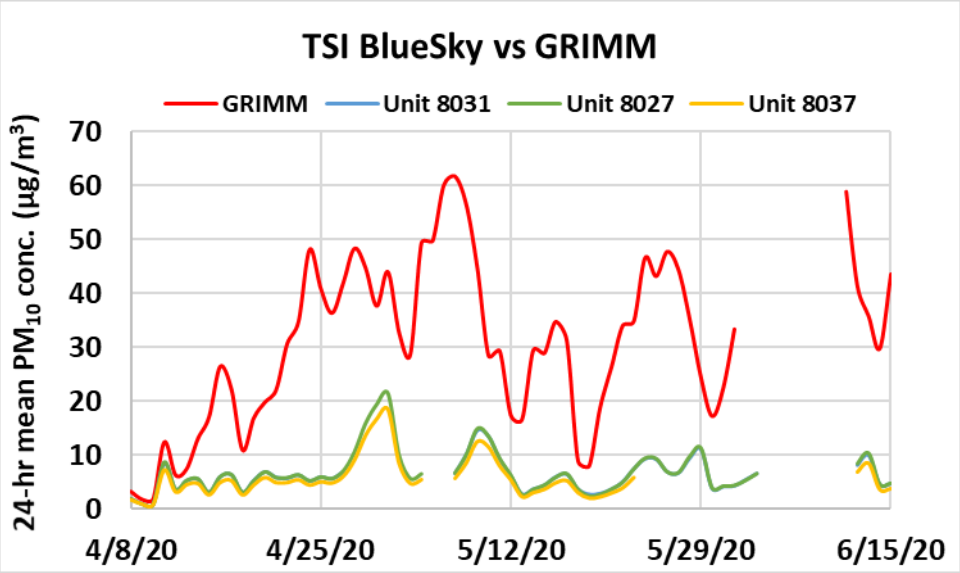
- The TSI BlueSky sensors showed strong correlations with the corresponding FEM GRIMM data (R^2 ~ 0.79)
- Overall, the TSI BlueSky sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM GRIMM
- The TSI BlueSky sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM GRIMM



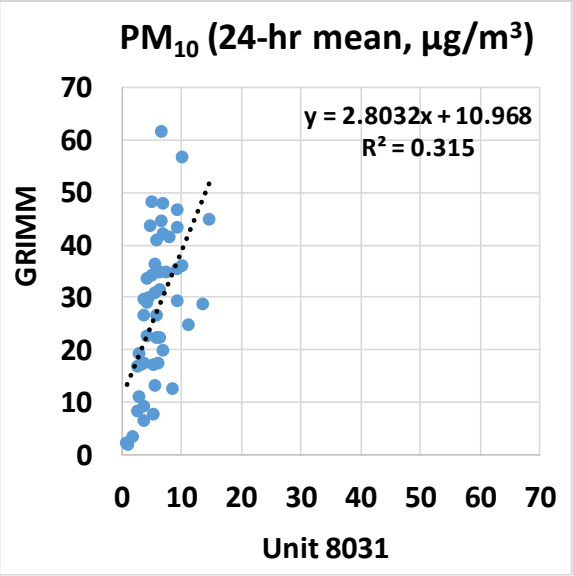


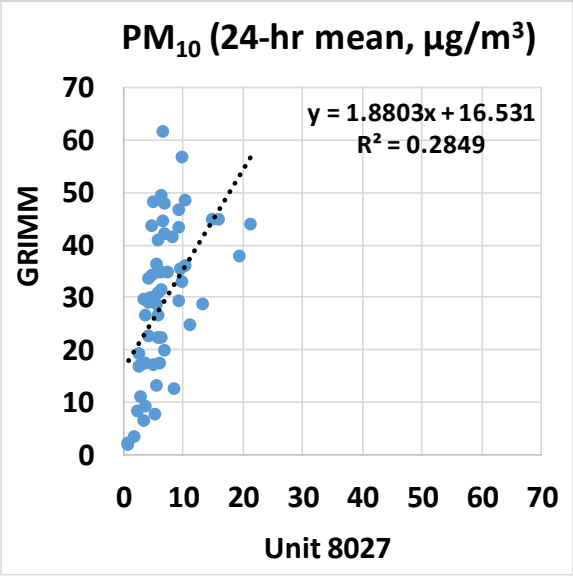


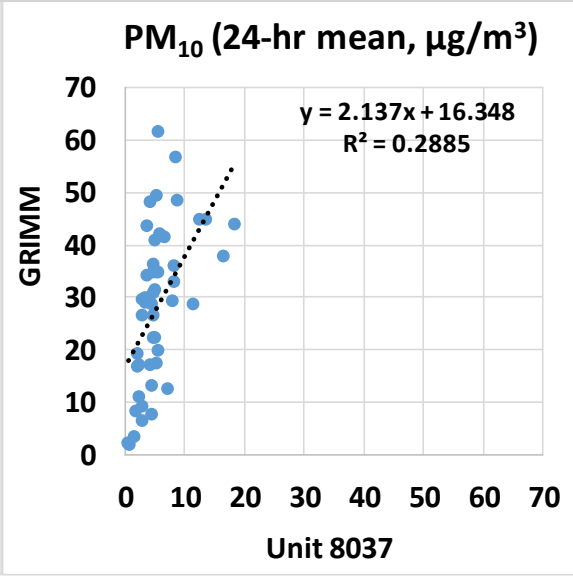
TSI BlueSky vs GRIMM (PM_{10}; 24-hr mean)



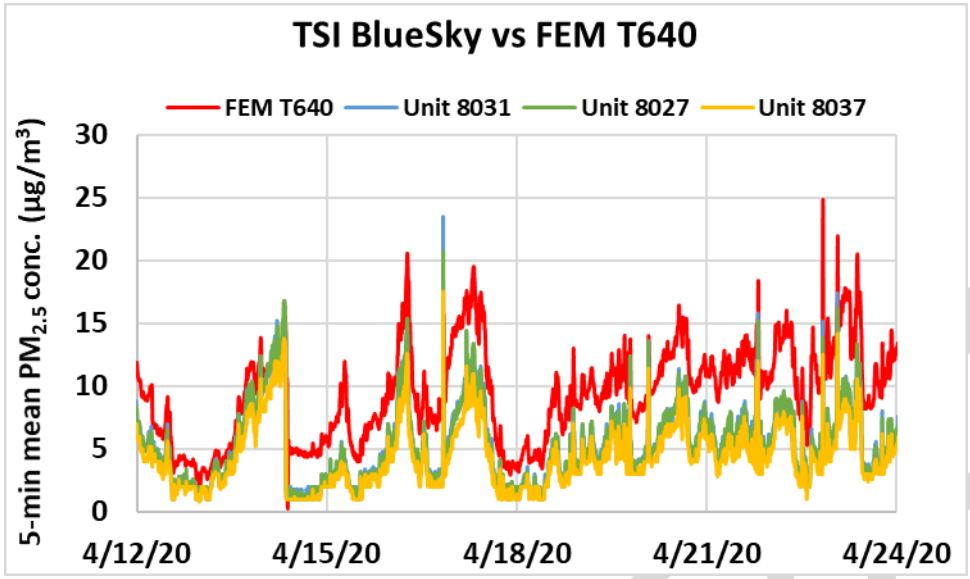
- The TSI BlueSky sensors showed very weak correlations with the corresponding GRIMM data (R^2 ~ 0.296)
- Overall, the TSI BlueSky sensors underestimated the PM_{10} mass concentrations measured by GRIMM
- The TSI BlueSky sensors did not seem to track the PM_{10} diurnal variations as recorded by GRIMM



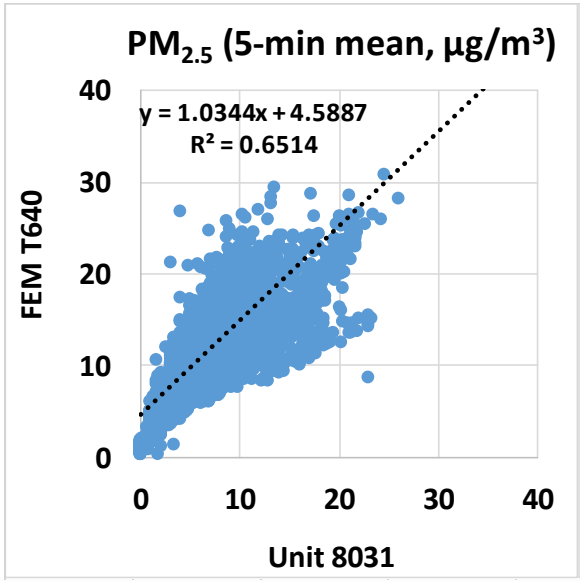


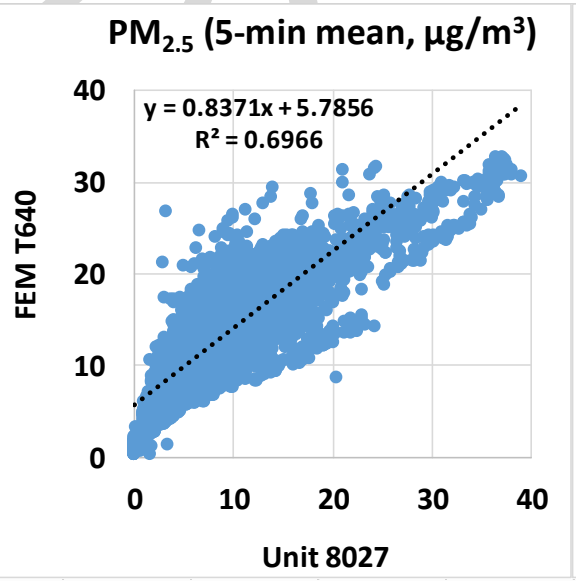


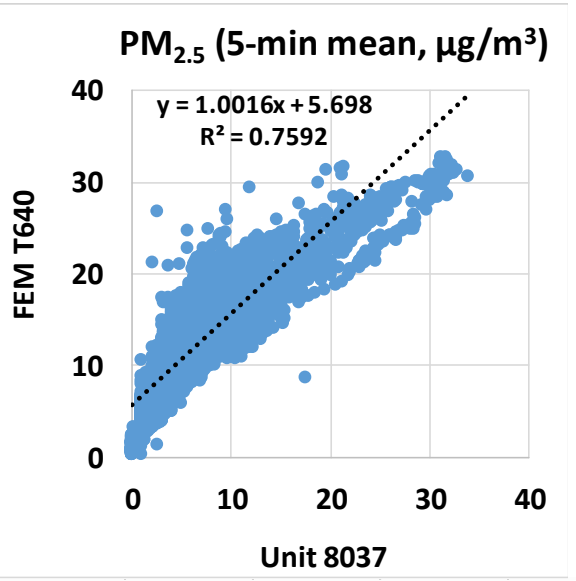
TSI BlueSky vs FEM T640 ($PM_{2.5}$; 5-min mean)



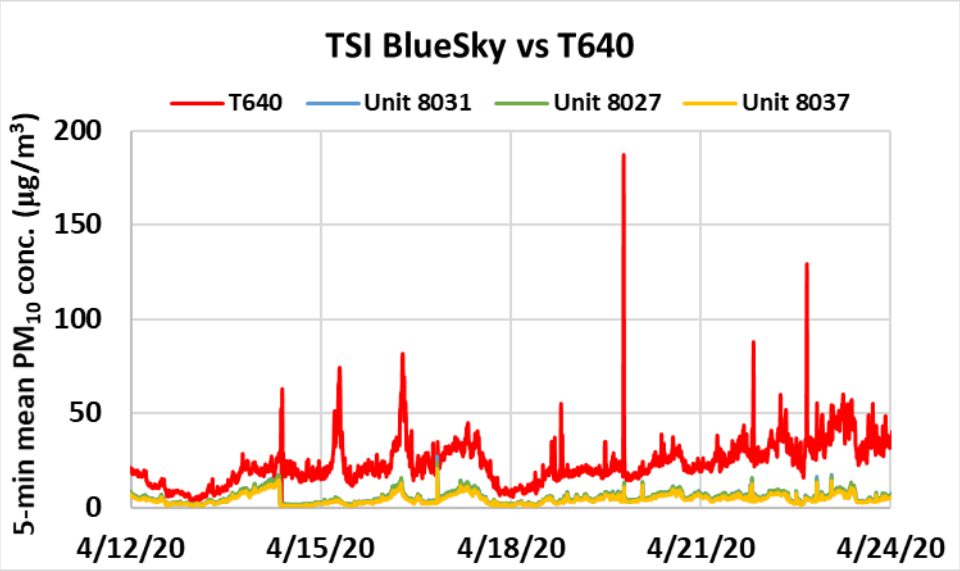
- The TSI BlueSky sensors showed strong correlations with the corresponding FEM T640 data (R^2 ~ 0.70)
- Overall, the TSI BlueSky sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The TSI BlueSky sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



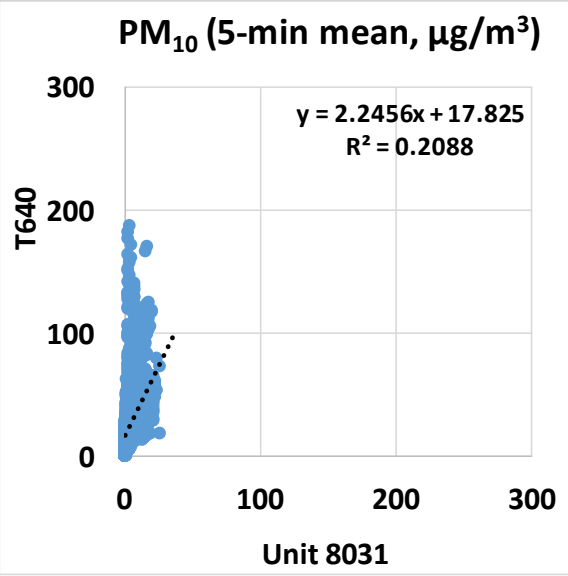


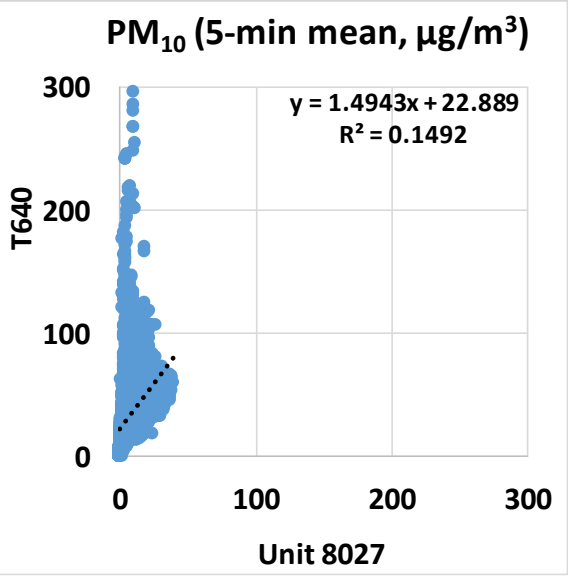


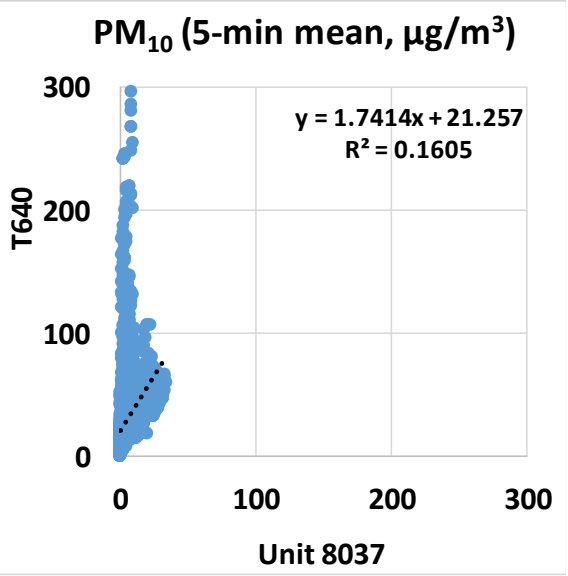
TSI BlueSky vs T640 (PM_{10}; 5-min mean)



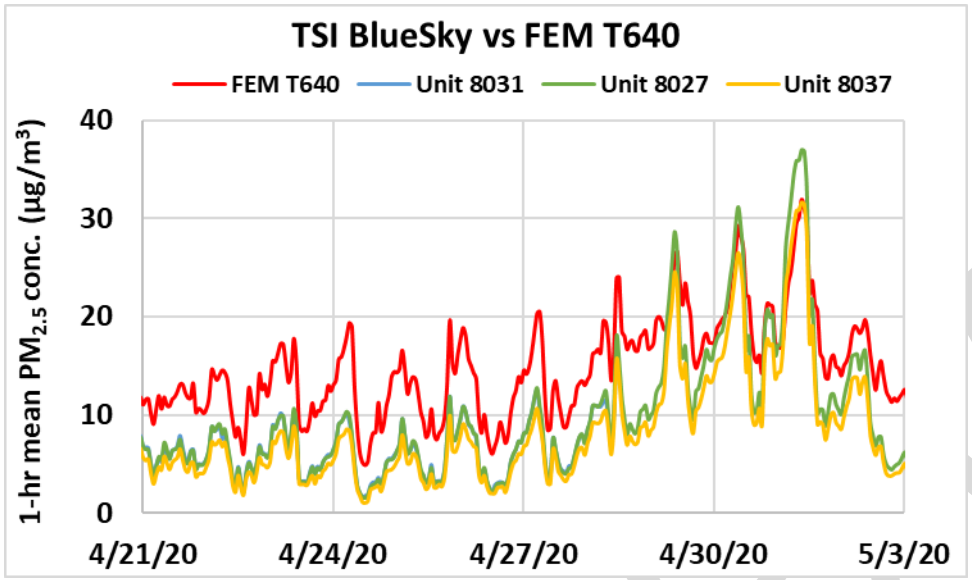
- The TSI BlueSky sensors showed very weak correlations with the corresponding T640 data (R^2 ~ 0.17)
- Overall, the TSI BlueSky sensors underestimated the PM_{10} mass concentrations as measured by T640
- The TSI BlueSky sensors did not seem to track the PM_{10} diurnal variations as recorded by T640



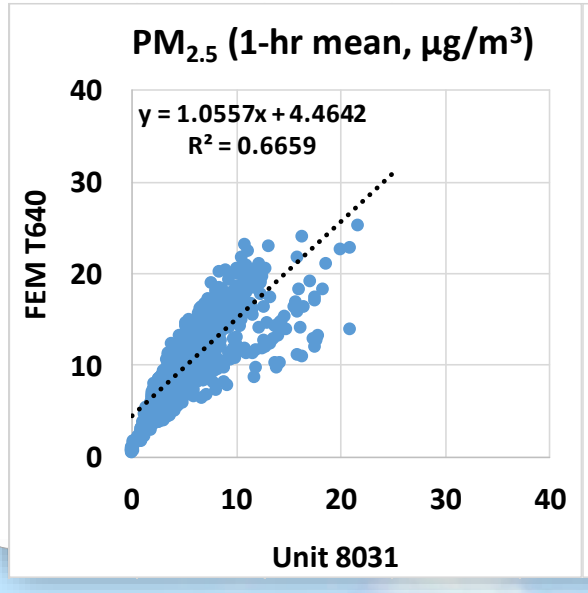


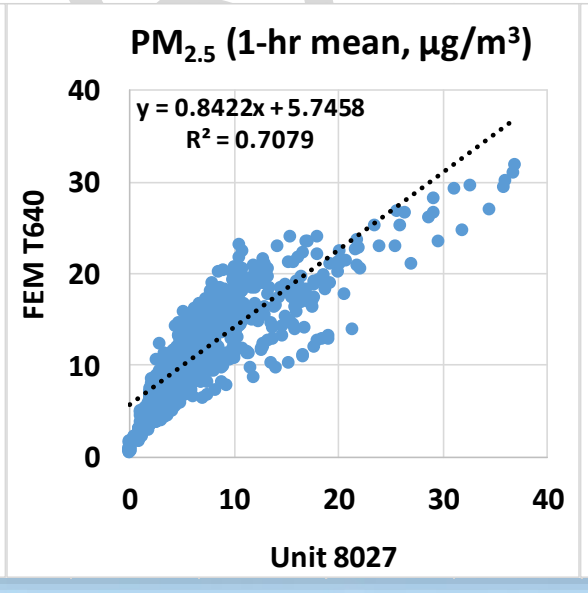


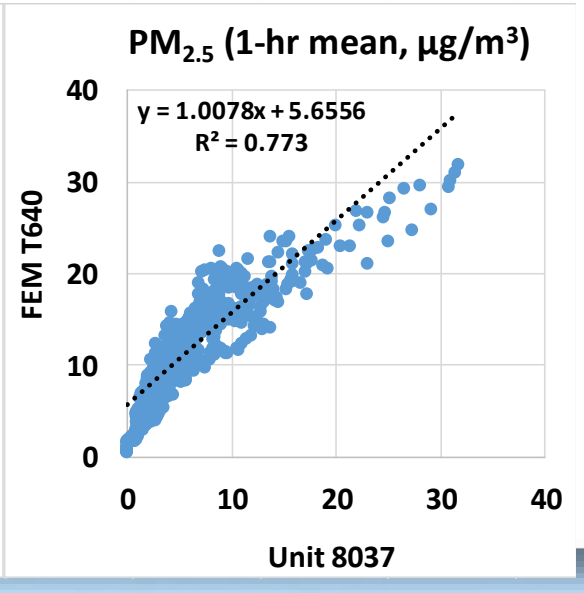
TSI BlueSky vs FEM T640 ($PM_{2.5}$; 1-hr mean)



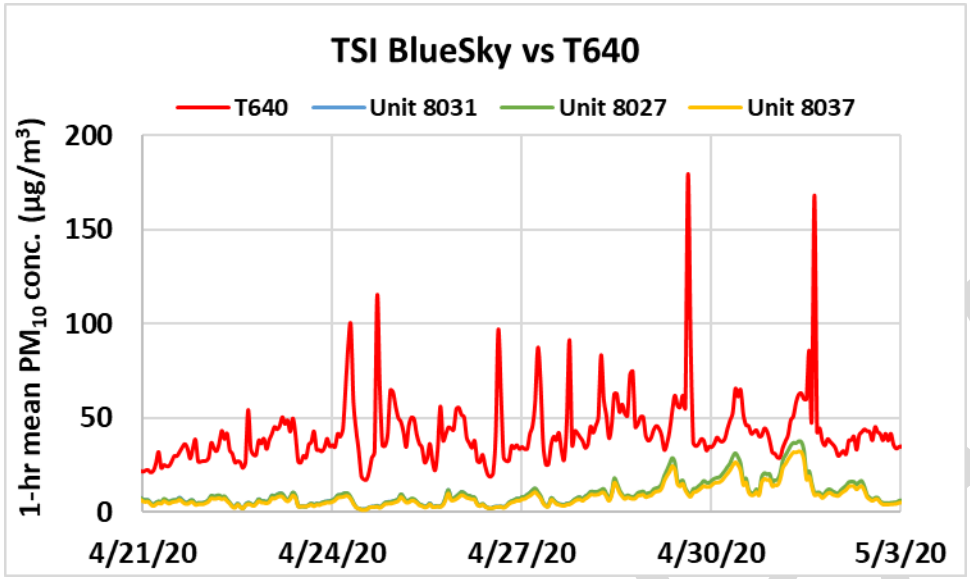
- TSI BlueSky sensors showed strong correlations with the corresponding FEM T640 data (R^2 ~ 0.72)
- Overall, the TSI BlueSky sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The TSI BlueSky sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



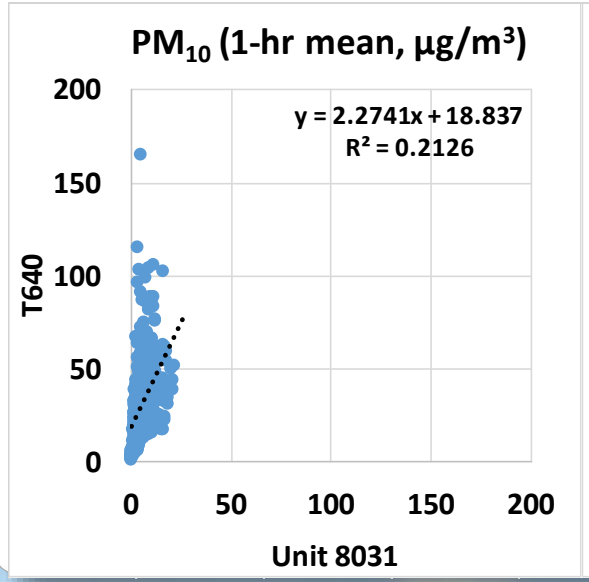


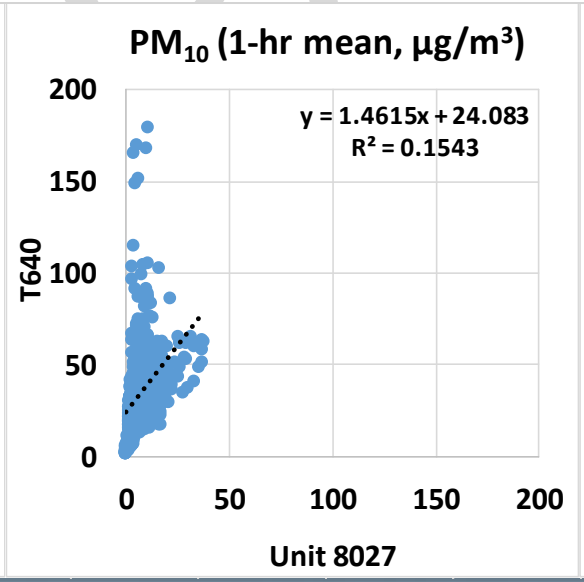


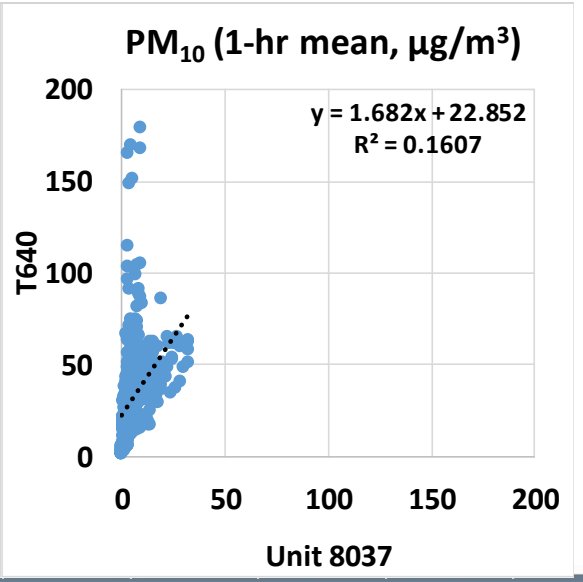
TSI BlueSky vs T640 (PM_{10}; 1-hr mean)



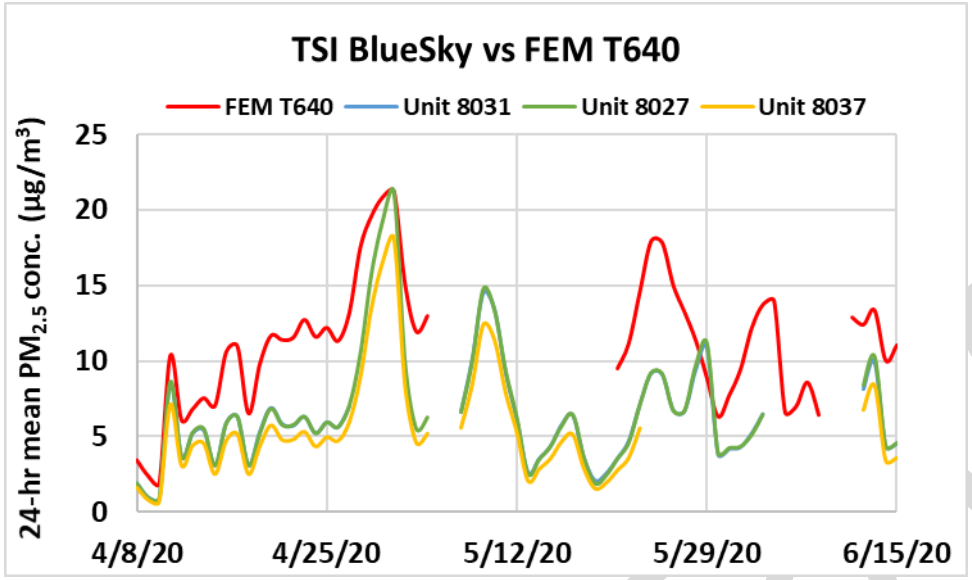
- TSI BlueSky sensors showed very weak correlations with the corresponding T640 data (R^2 ~ 0.18)
- Overall, the TSI BlueSky sensors underestimated the PM_{10} mass concentrations as measured by T640
- The TSI BlueSky sensors did not seem to track the PM_{10} diurnal variations as recorded by T640



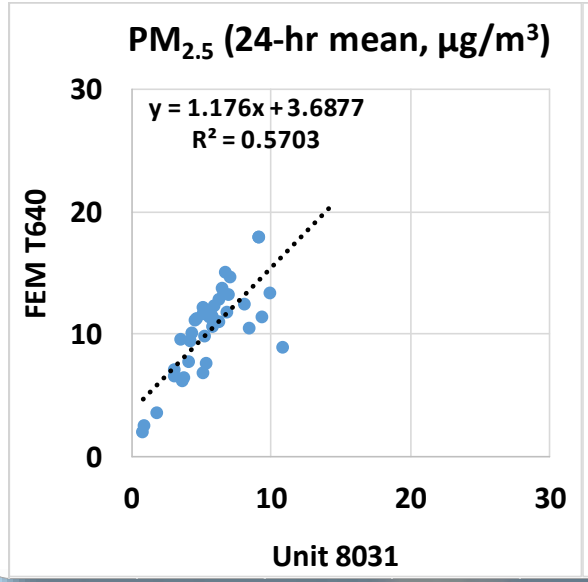


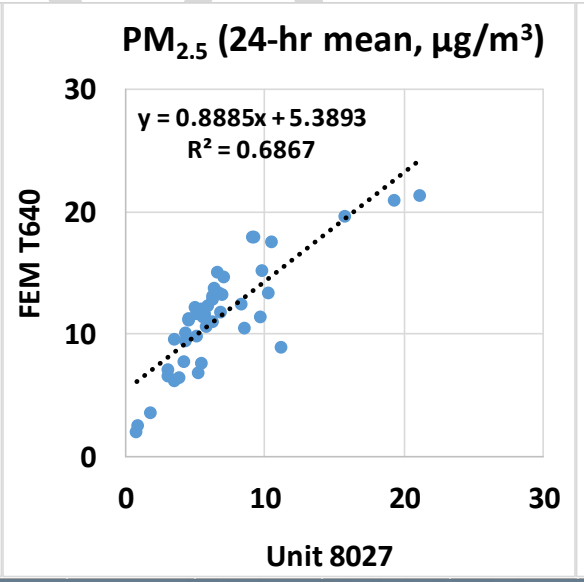


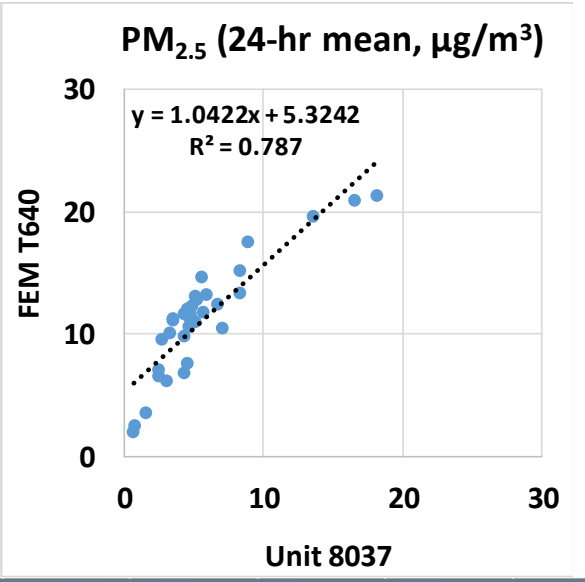
TSI BlueSky vs FEM T640 ($PM_{2.5}$; 24-hr mean)



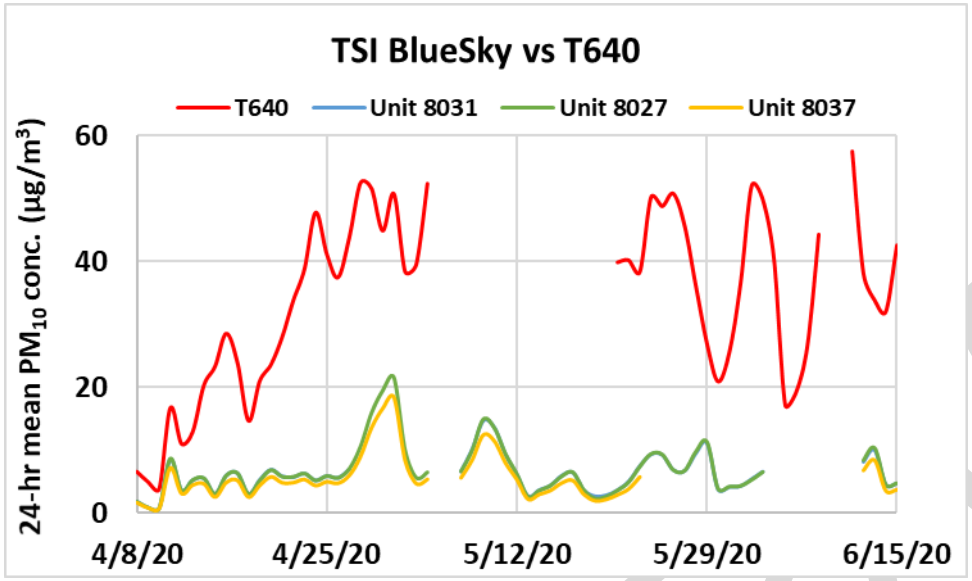
- The TSI BlueSky sensors showed moderate correlations with the corresponding FEM T640 data (R^2 ~ 0.68)
- Overall, the TSI BlueSky sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The TSI BlueSky sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



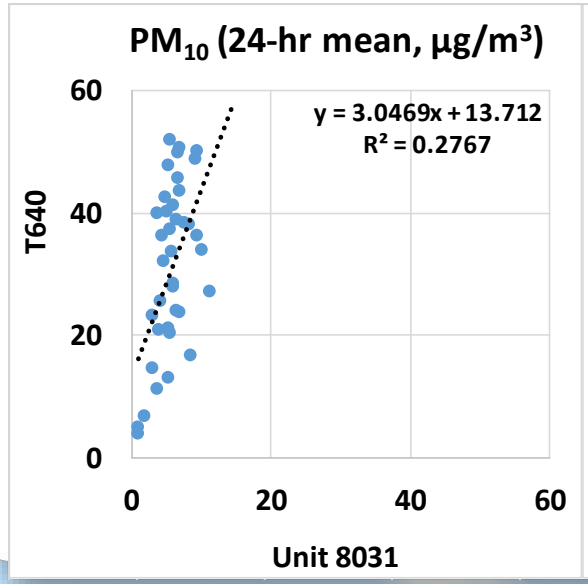


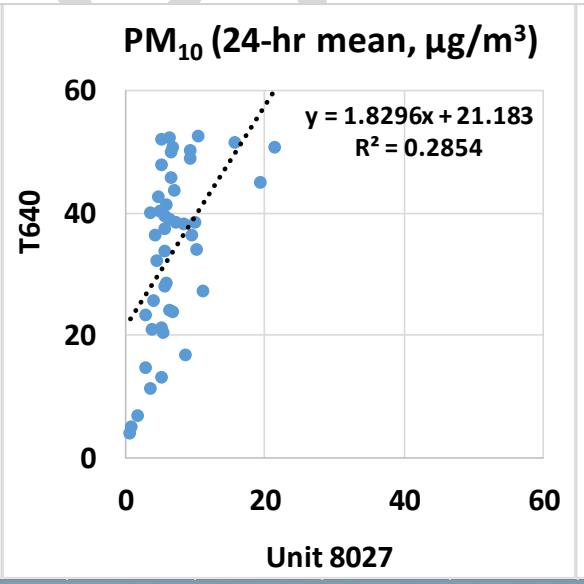


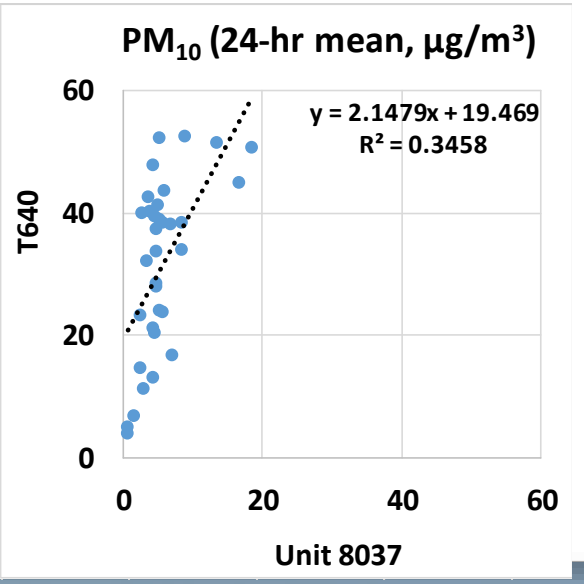
TSI BlueSky vs T640 (PM_{10}; 24-hr mean)



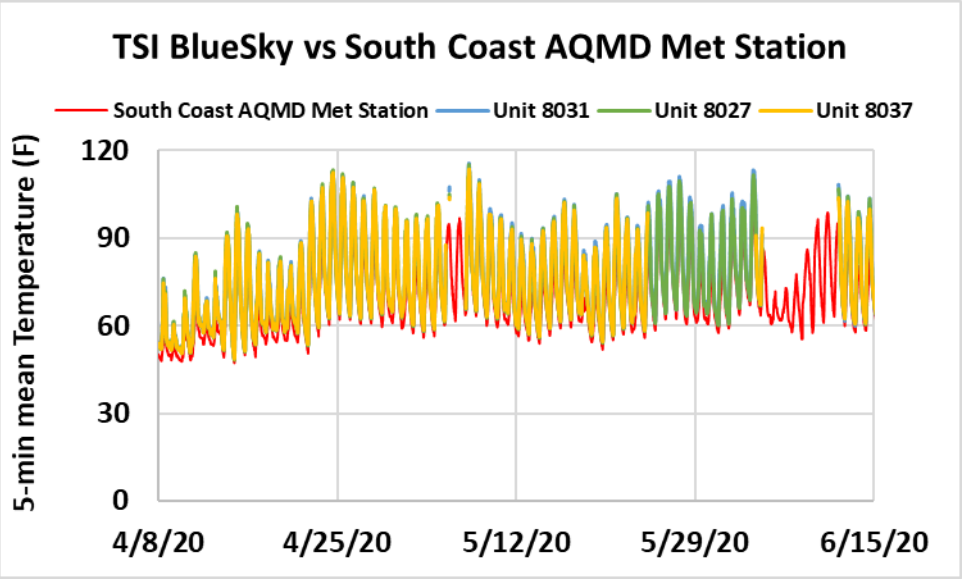
- The TSI BlueSky sensors showed weak correlations with the corresponding T640 data (R^2 ~ 0.30)
- Overall, the TSI BlueSky sensors underestimated the PM_{10} mass concentrations as measured by T640
- The TSI BlueSky sensors did not seem to track the PM_{10} diurnal variations as recorded by T640





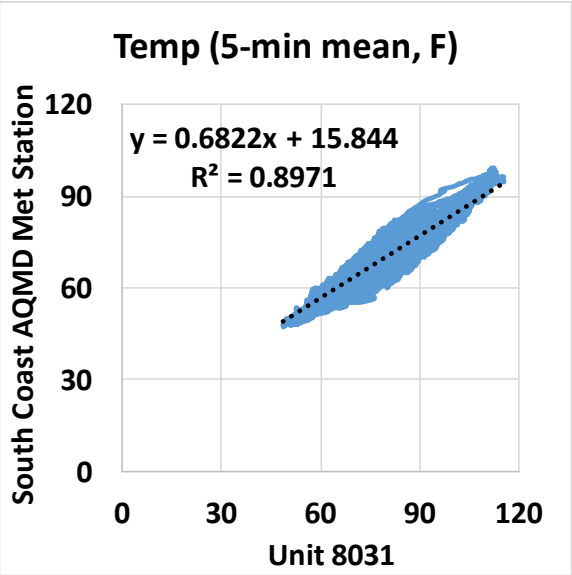


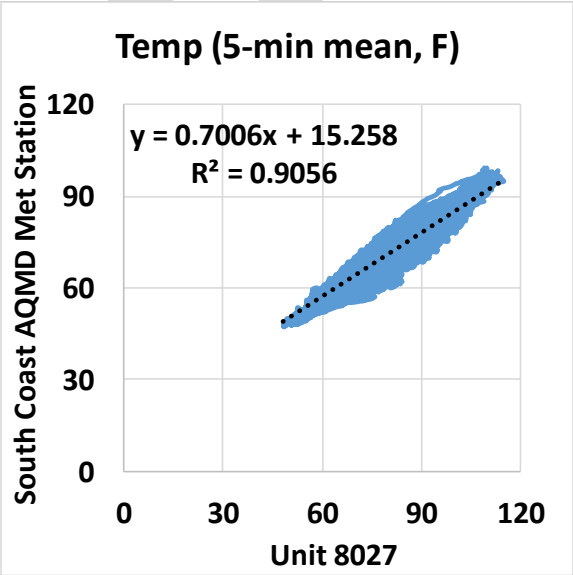
TSI BlueSky vs South Coast AQMD Met Station (Temp; 5-min mean)

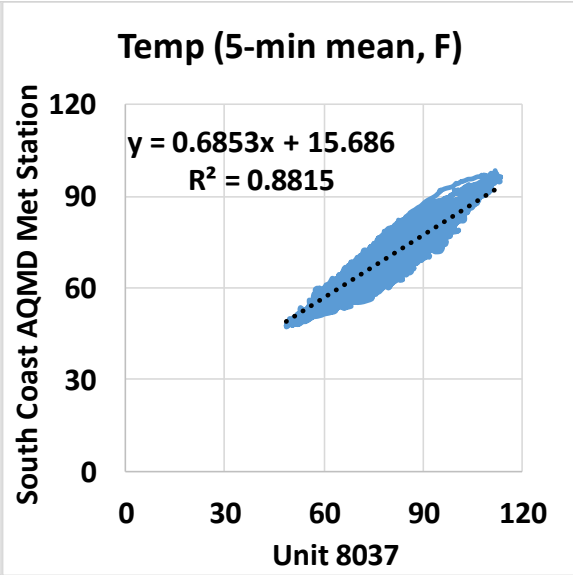


- The TSI BlueSky sensors showed strong correlations with the corresponding South Coast AQMD Met Station data (R^2 ~ 0.89)
- Overall, the TSI BlueSky temperature measurements overestimated the corresponding South Coast AQMD Met Station data
- The TSI BlueSky sensors seemed to track the temperature diurnal variations as recorded by South Coast AQMD Met Station

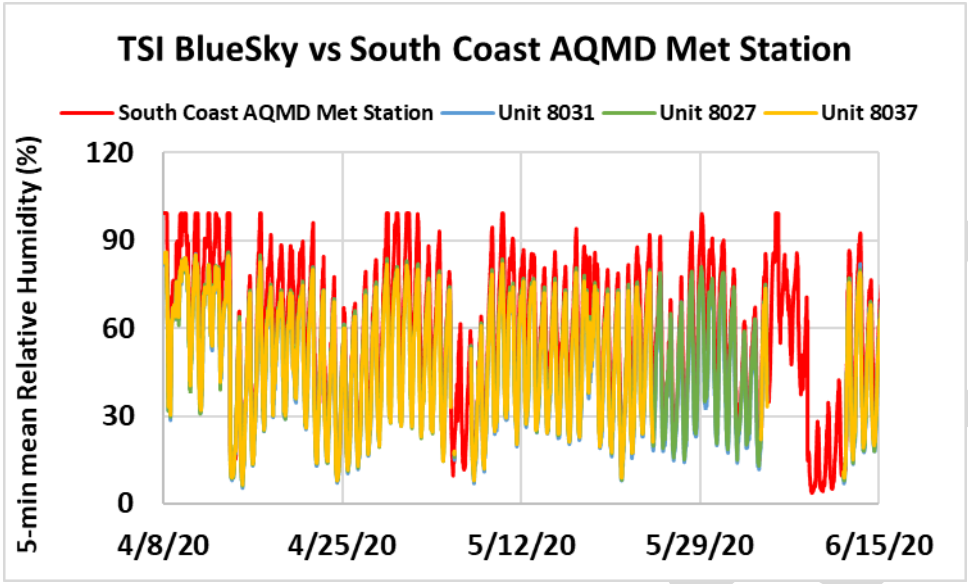
Note: The TSI BlueSky sensors measure temperature and RH inside of the sensors





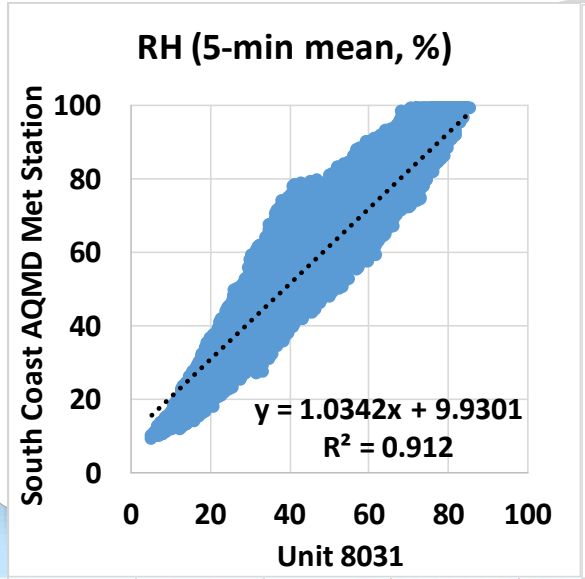


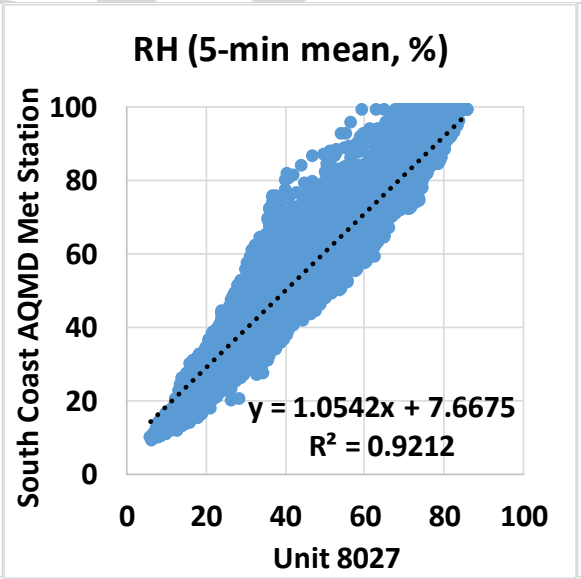
TSI BlueSky vs South Coast AQMD Met Station (RH; 5-min mean)

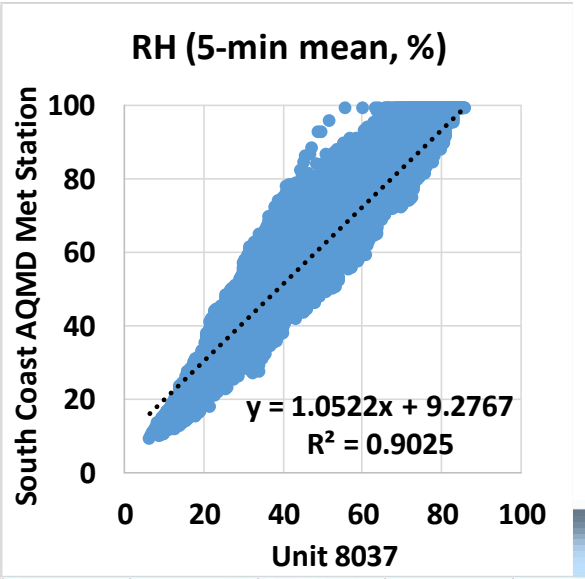


- The TSI BlueSky sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data (R^2 ~ 0.91)
- Overall, the TSI BlueSky temperature measurements underestimated the corresponding South Coast AQMD Met Station data
- The TSI BlueSky sensors seemed to track the temperature 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