Field Evaluation
Oizom – Dustroid Pro V6

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 12/24/2022 to 02/23/2023, three **Oizom Dustroid Pro V6 (hereinafter Dustroid Pro)** 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

Dustroid Pro (*3 units tested*):

- PM Sensors – Optical (Wuhan Cubic PM3006S, non-FEM)
- Each unit measures: $PM_{1.0}$, $PM_{2.5}$ and PM_{10} (µg/m^3), T (°C), RH (%)
- Unit cost: $6,000
- Time resolution: 1-min
- Units IDs: 0002, 0003, 0004

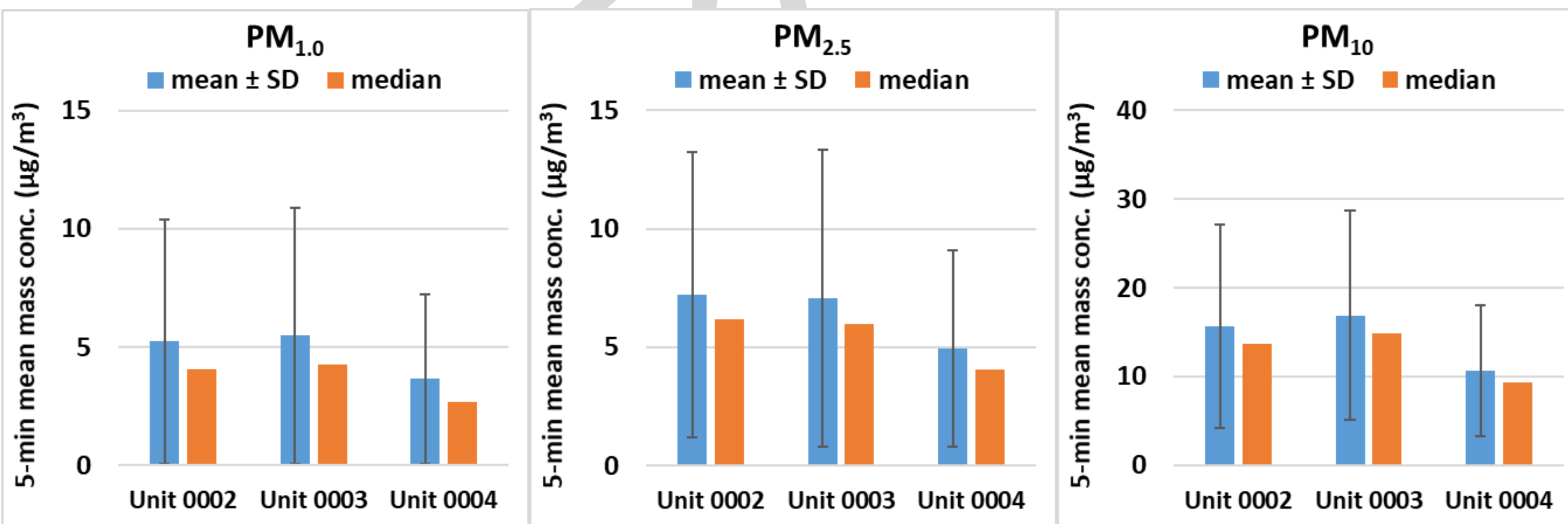
- South Coast AQMD Reference Instruments:
- GRIMM EDM 180 (*hereinafter FEM GRIMM for $PM_{2.5}$, GRIMM otherwise*):
  - Optical particle counter (FEM $PM_{2.5}$)
  - Measures $PM_{1.0}$, $PM_{2.5}$, and PM_{10} (µg/m^3)
  - Cost: ~$25,000 and up
  - Time resolution: 1-min
- Teledyne API T640 (*hereinafter FEM T640 for $PM_{2.5}$, T640 otherwise*):
  - Optical particle counter (FEM $PM_{2.5}$)
  - Measures $PM_{1.0}$, $PM_{2.5}$ and PM_{10} (µg/m^3)
  - Cost: ~$21,000
  - Time resolution: 1-min
- Met Station (T, RH, P, WS, WD):
  - 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 0002, Unit 0003 and Unit 0004 was ~ 100% for all PM measurements

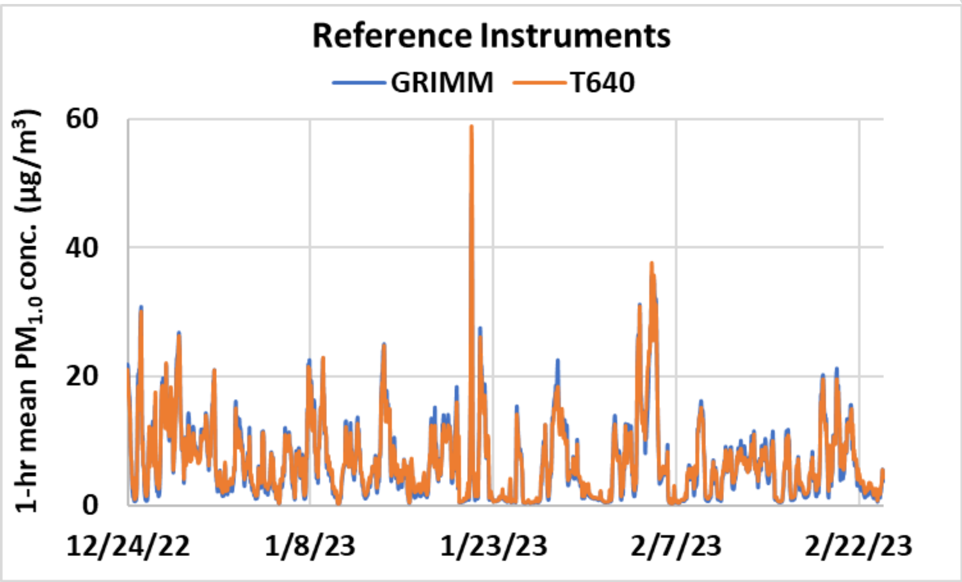
Dustroid Pro; intra-model variability

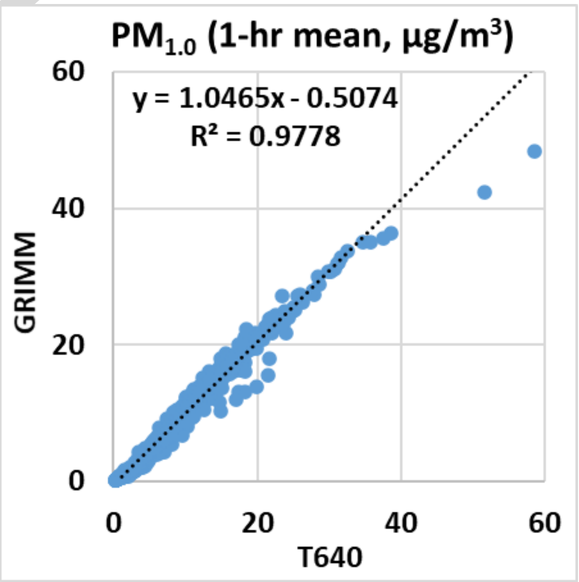
- Absolute intra-model variability was ~ 1.0, 1.3 and 3.3 μg/m^3 for $PM_{1.0}$, $PM_{2.5}$ and PM_{10}, respectively (calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was ~ 20.8%, 19.7% and 23.0% for $PM_{1.0}$, $PM_{2.5}$ and PM_{10}, respectively (calculated as the absolute intra-model variability relative to the mean of the three sensor means)



Reference Instruments: $PM_{1.0}$ GRIMM and T640

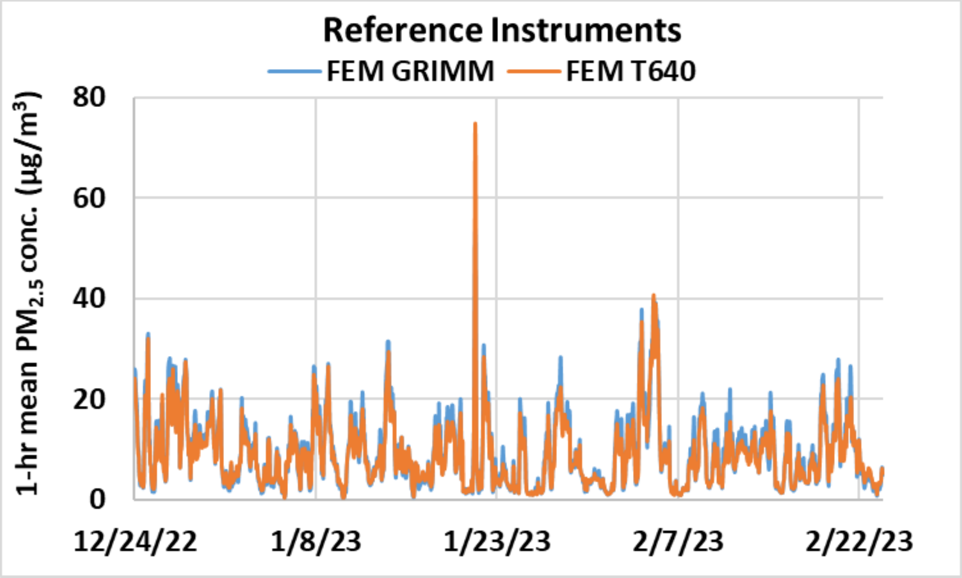
- Data recovery for $PM_{1.0}$ from GRIMM and T640 was ~ 100%.
- Very strong correlations between the reference instruments for $PM_{1.0}$ measurements (R^2 > 0.97) were observed.

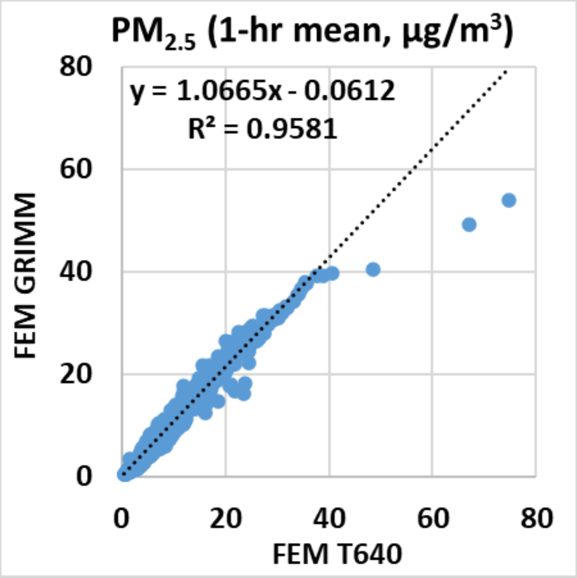




Reference Instruments: $PM_{2.5}$
FEM GRIMM and FEM T640

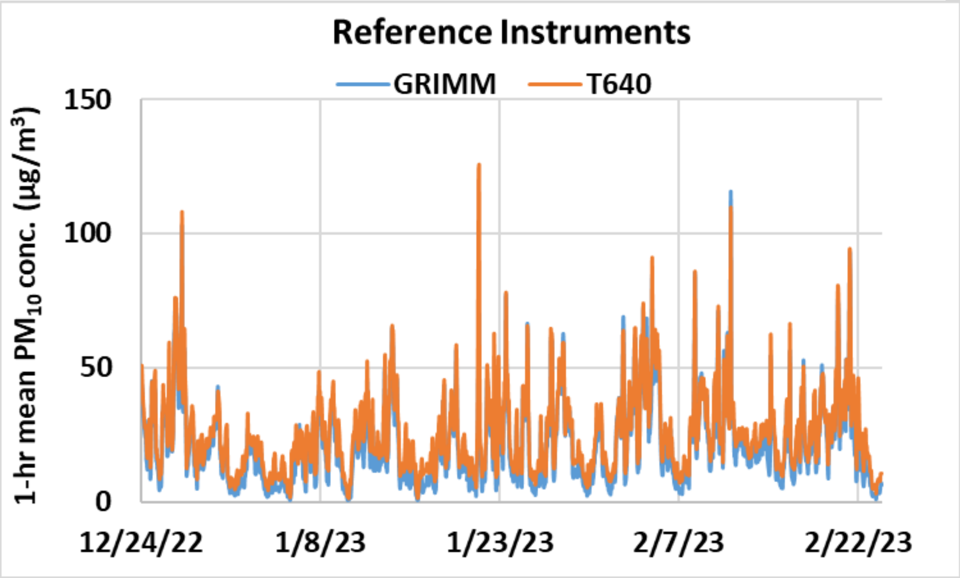
- Data recovery for $PM_{2.5}$ from FEM GRIMM and FEM T640 was ~ 100%.
- Very strong correlations between the reference instruments for $PM_{2.5}$ measurements ($R^2 > 0.95$) were observed.

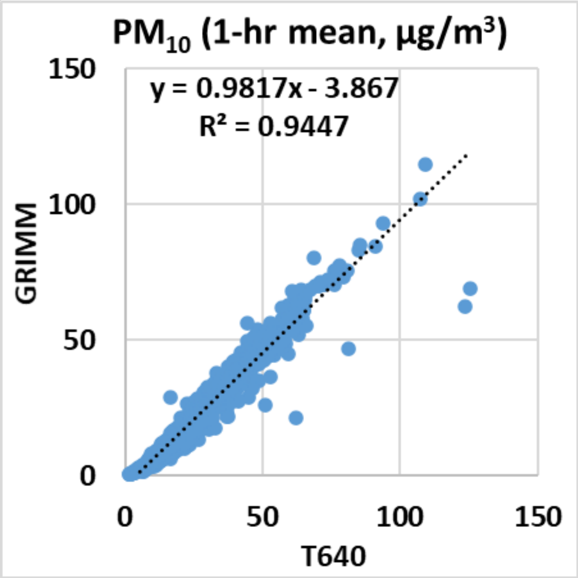




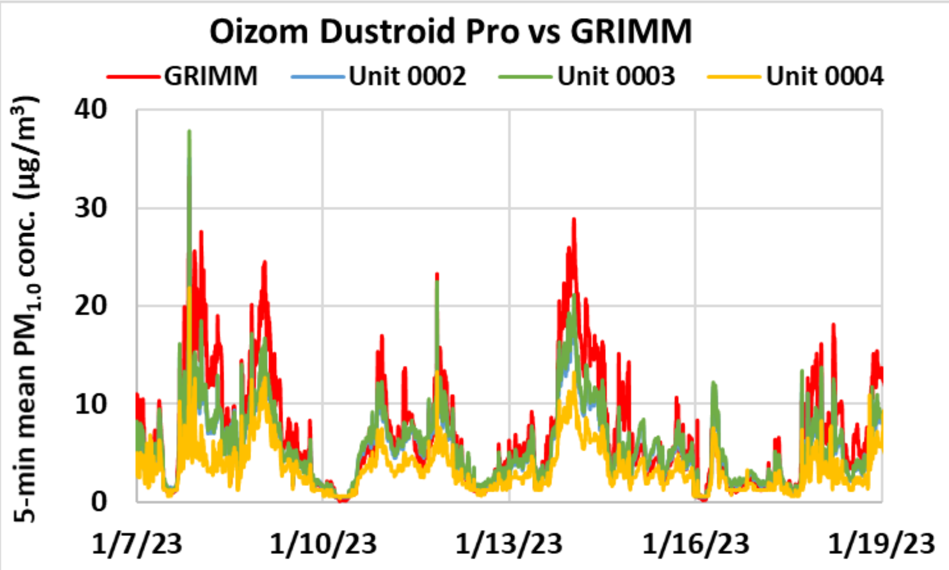
Reference Instruments: PM_{10} GRIMM and T640

- Data recovery for PM_{10} from GRIMM and T640 was ~ 100%.
- Very strong correlations between the reference instruments for PM_{10} measurements ($R^2 > 0.94$) were observed.

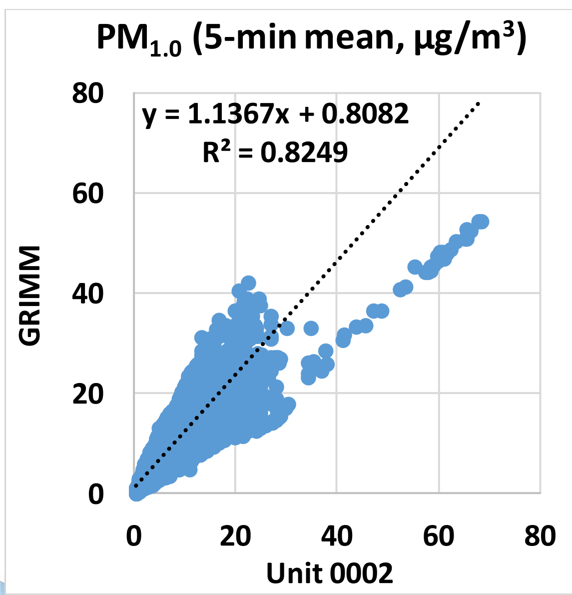


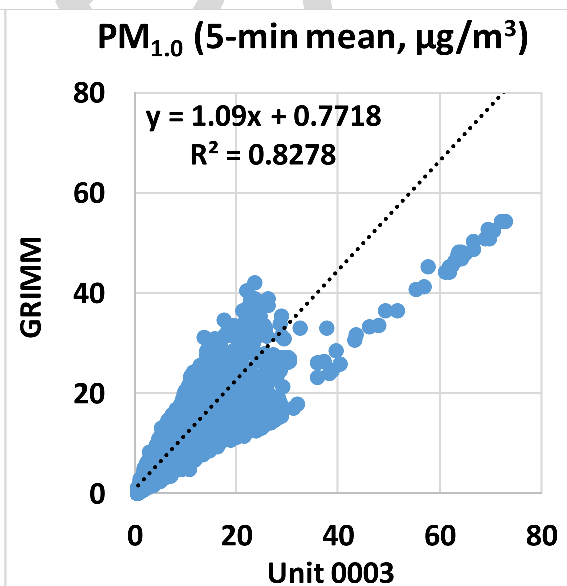


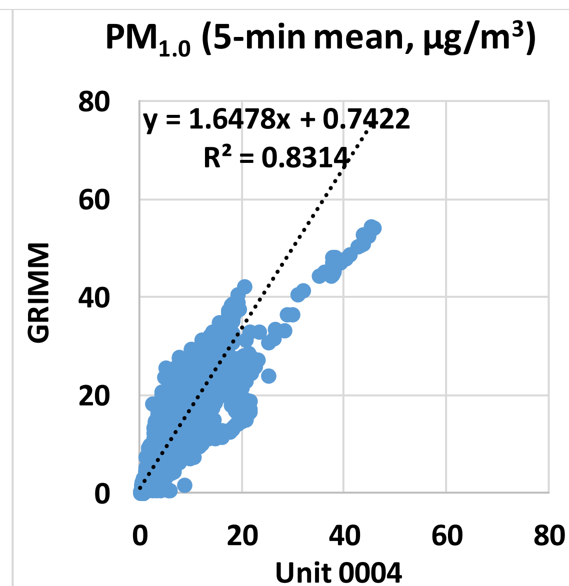
Dustroid Pro vs GRIMM ($PM_{1.0}$; 5-min mean)



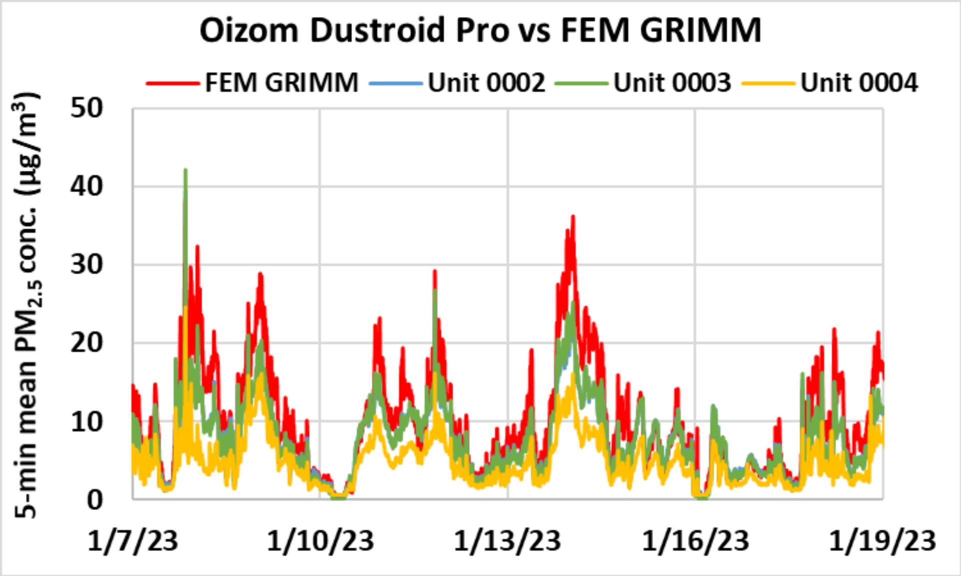
- The Dustroid Pro sensors showed strong correlations with the corresponding GRIMM data ($0.82 < R^2 < 0.84$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{1.0}$ mass concentrations as measured by GRIMM
- The Dustroid Pro sensors seemed to track the $PM_{1.0}$ diurnal variations as recorded by GRIMM



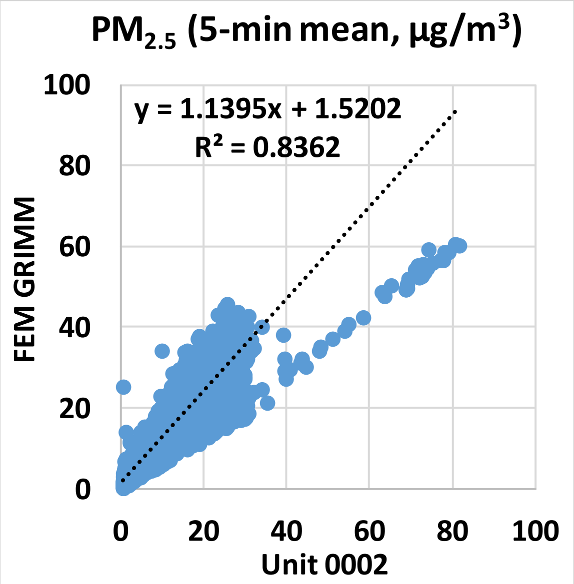


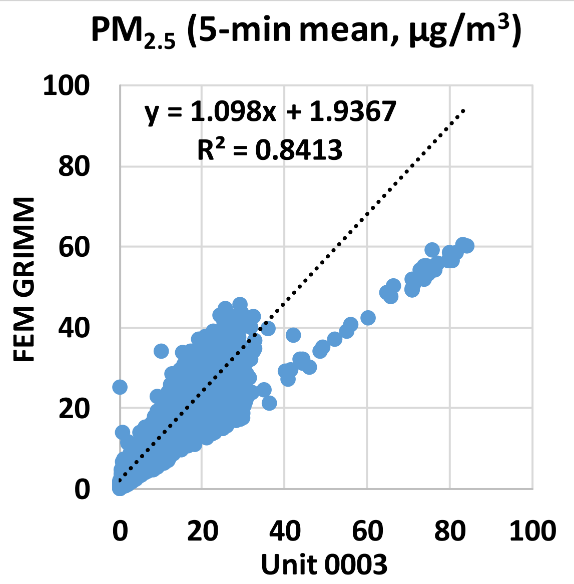


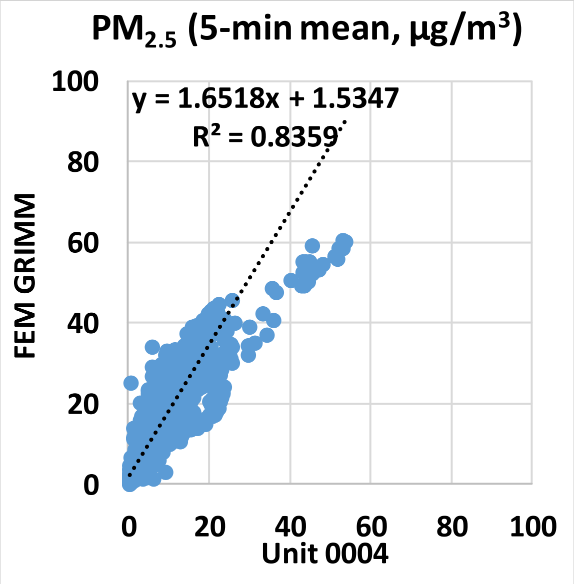
Dustroid Pro vs FEM GRIMM ($PM_{2.5}$; 5-min mean)



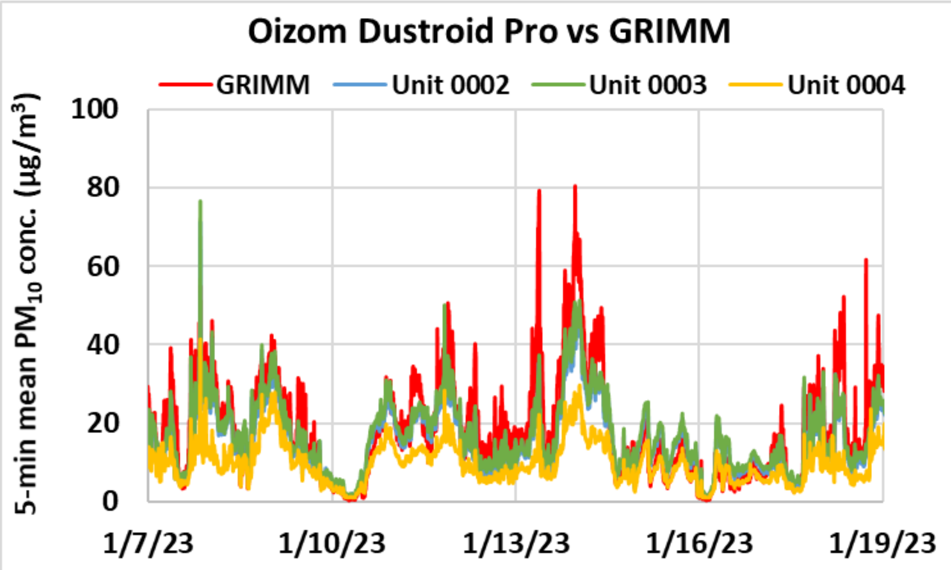
- The Dustroid Pro sensors showed strong correlations with the corresponding FEM GRIMM data ($0.83 < R^2 < 0.85$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM GRIMM
- The Dustroid Pro sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM GRIMM



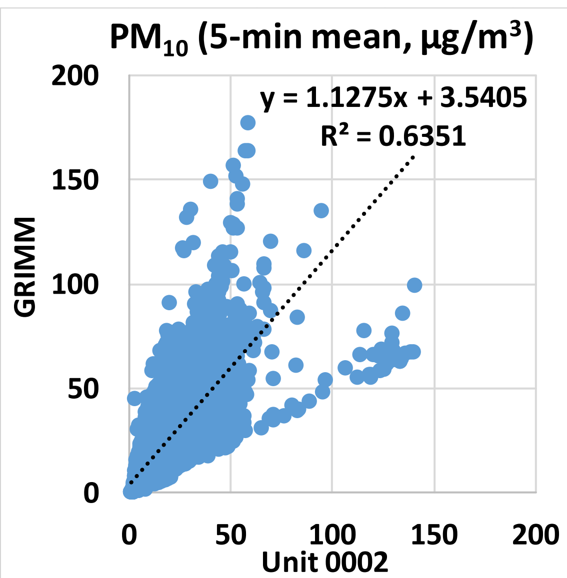


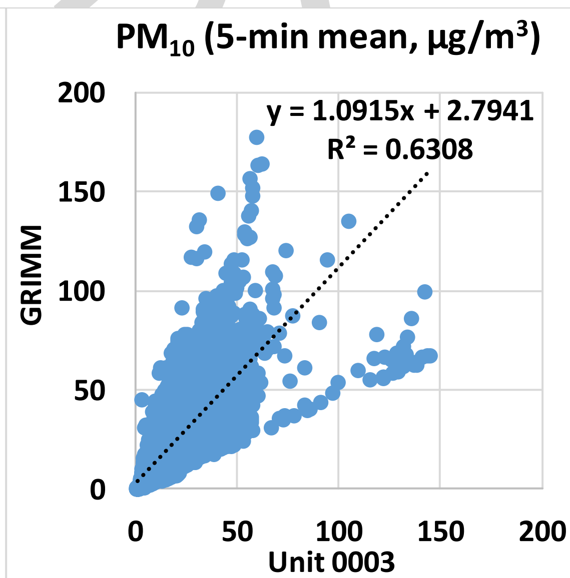


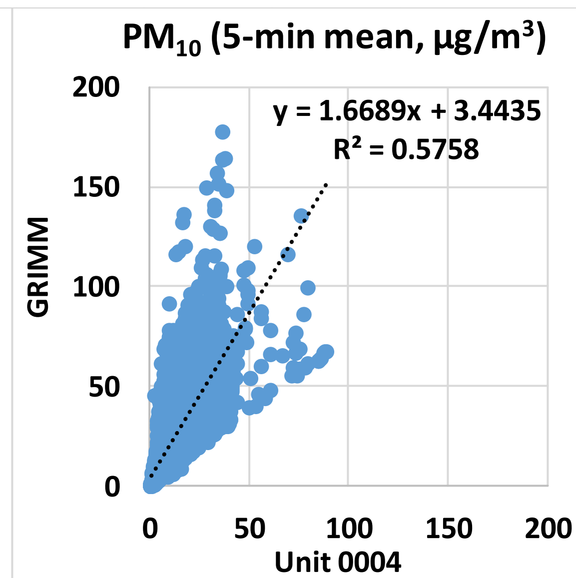
Dustroid Pro vs GRIMM (PM_{10}; 5-min mean)



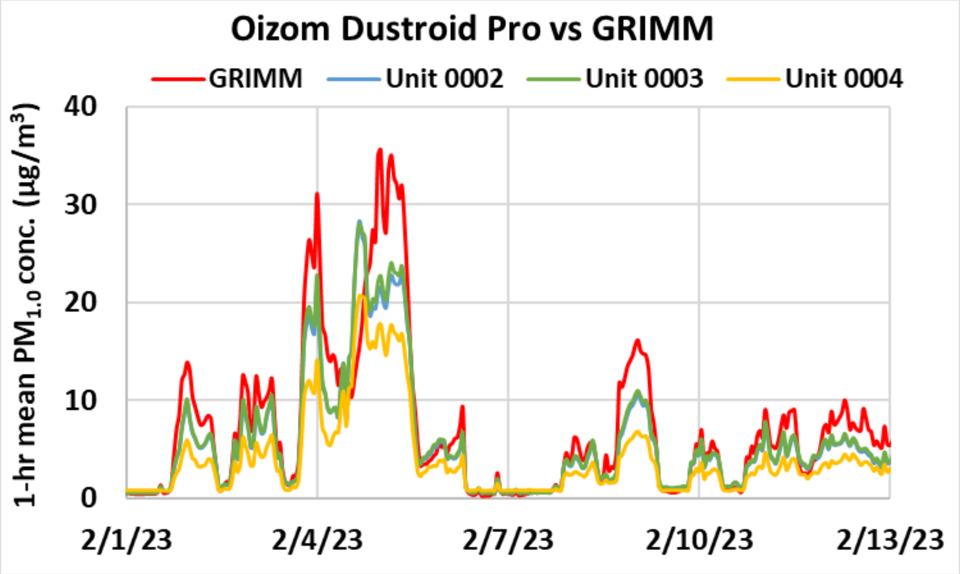
- The Dustroid Pro sensors showed moderate correlations with the corresponding GRIMM data ($0.57 < R^2 < 0.64$)
- Overall, the Dustroid Pro sensors underestimated the PM_{10} mass concentrations as measured by GRIMM
- The Dustroid Pro sensors seemed to track the PM_{10} diurnal variations as recorded by GRIMM



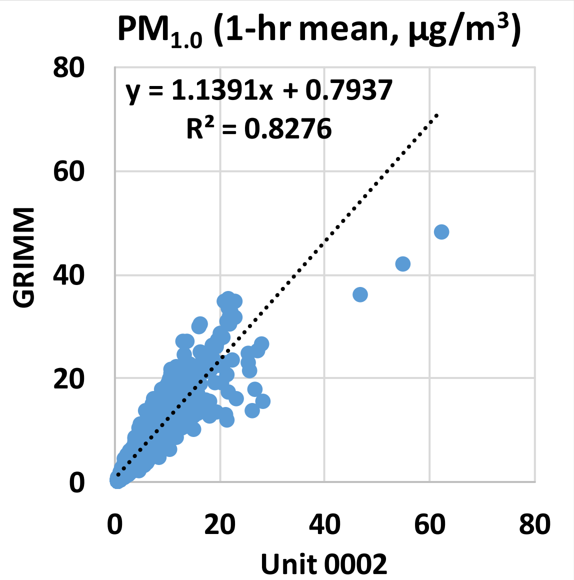


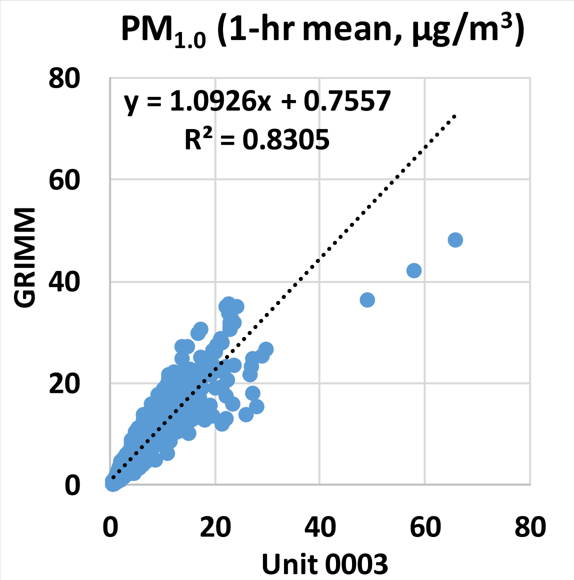


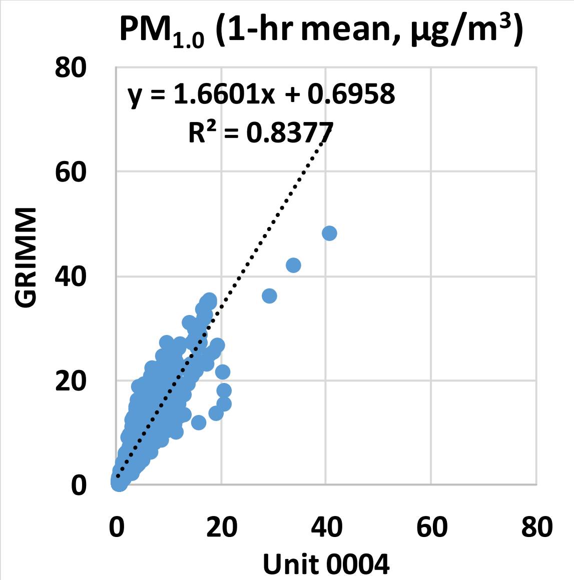
Dustroid Pro vs GRIMM ($PM_{1.0}$; 1-hr mean)



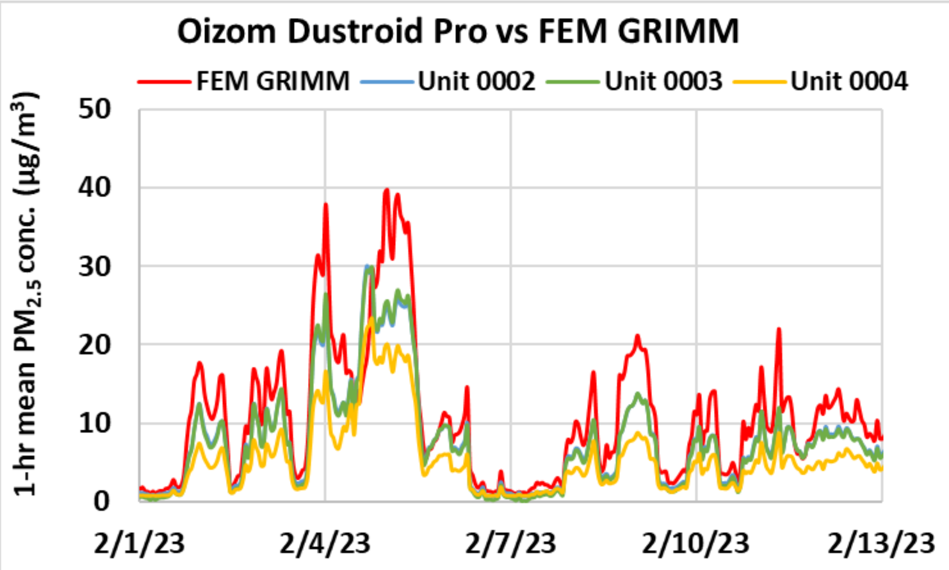
- The Dustroid Pro sensors showed strong correlations with the corresponding GRIMM data ($0.82 < R^2 < 0.84$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{1.0}$ mass concentrations as measured by GRIMM
- The Dustroid Pro sensors seemed to track the $PM_{1.0}$ diurnal variations as recorded by GRIMM



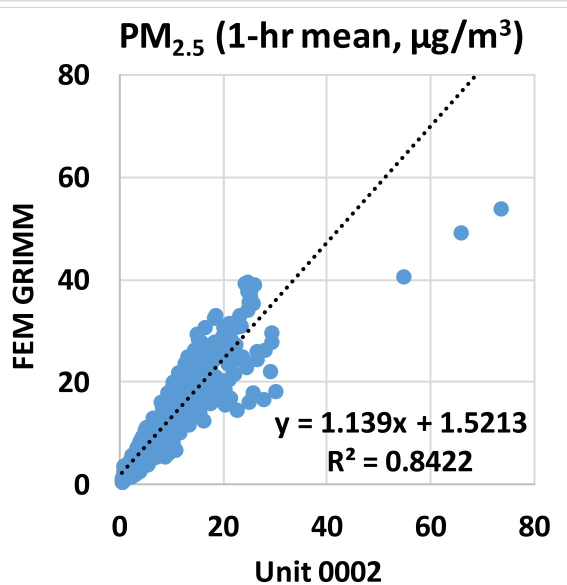


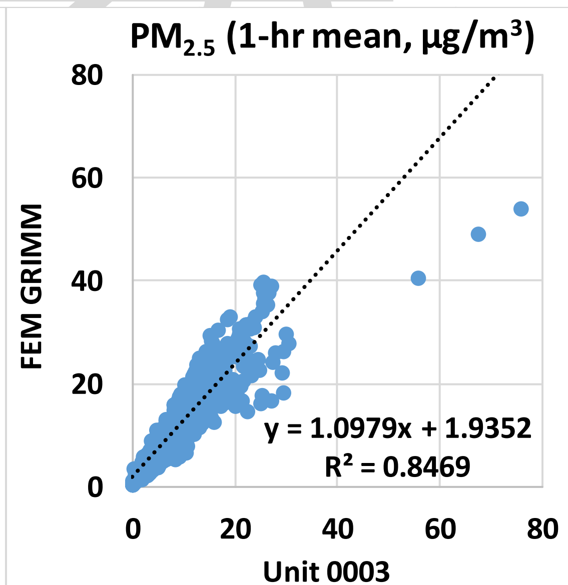


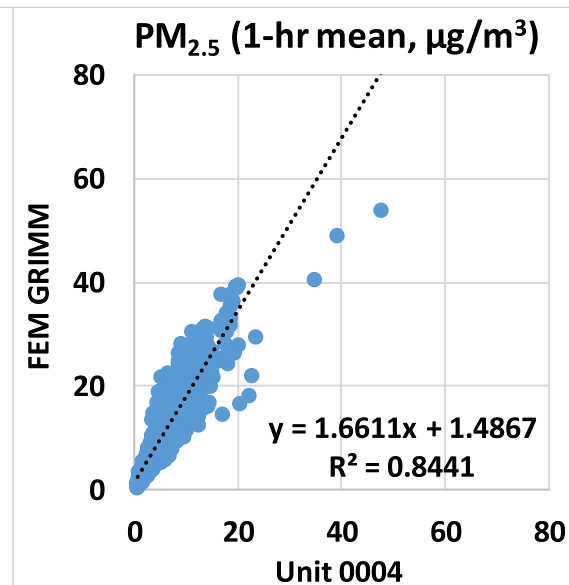
Dustroid Pro vs FEM GRIMM ($PM_{2.5}$; 1-hr mean)



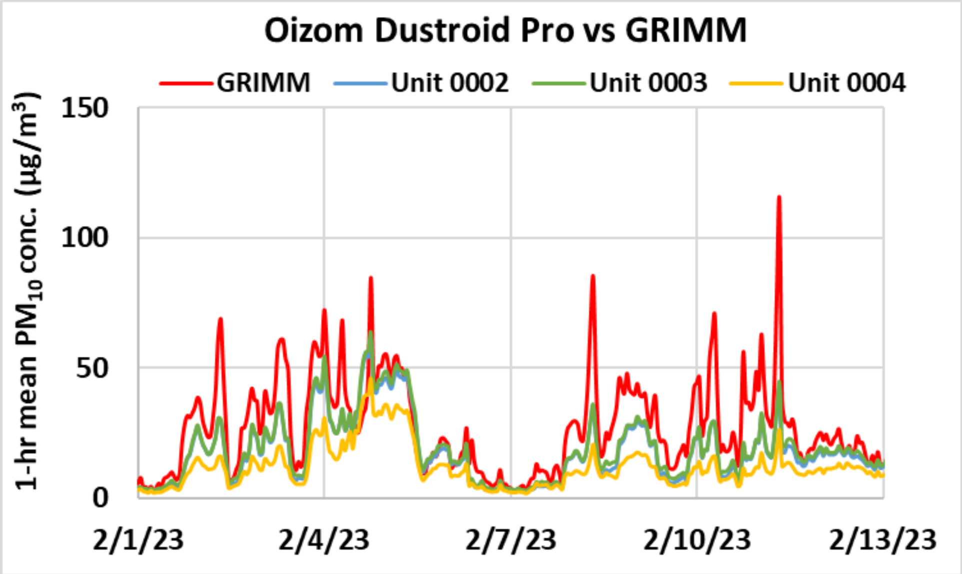
- The Dustroid Pro sensors showed strong correlations with the corresponding FEM GRIMM data ($0.84 < R^2 < 0.85$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM GRIMM
- The Dustroid Pro sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM GRIMM



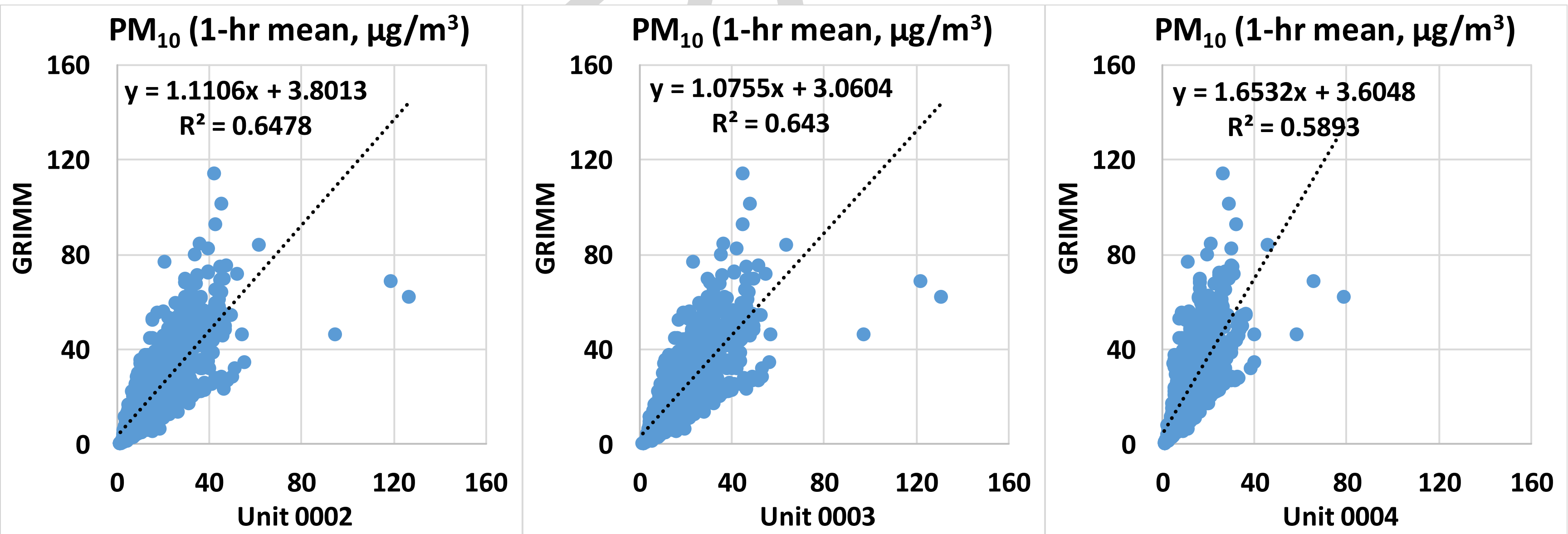




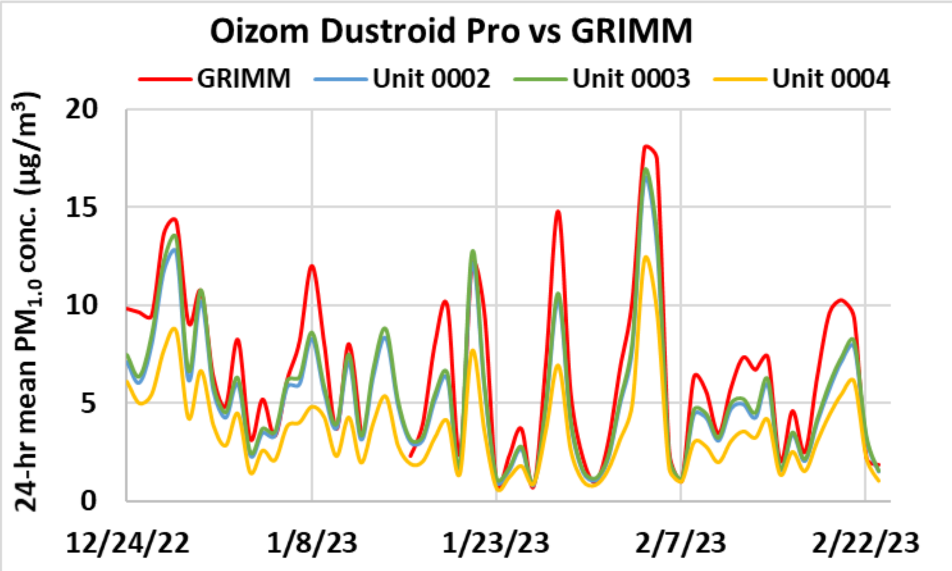
Dustroid Pro vs GRIMM (PM_{10}; 1-hr mean)



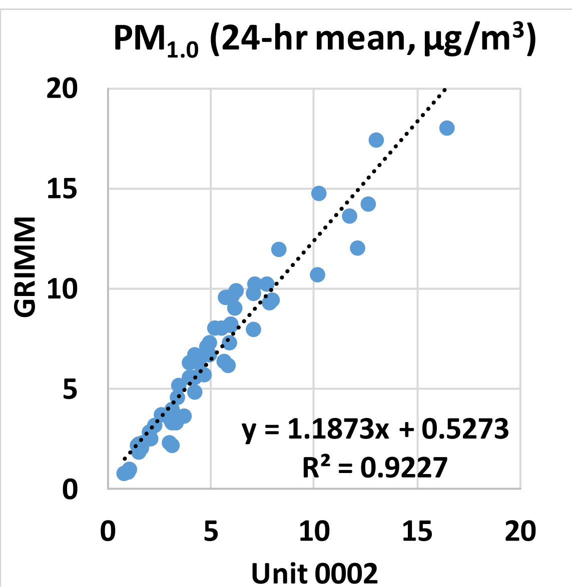
- The Dustroid Pro sensors showed moderate correlations with the corresponding GRIMM data ($0.58 < R^2 < 0.65$)
- Overall, the Dustroid Pro sensors underestimated the PM_{10} mass concentrations as measured by GRIMM
- The Dustroid Pro sensors seemed to track the PM_{10} diurnal variations as recorded by GRIMM

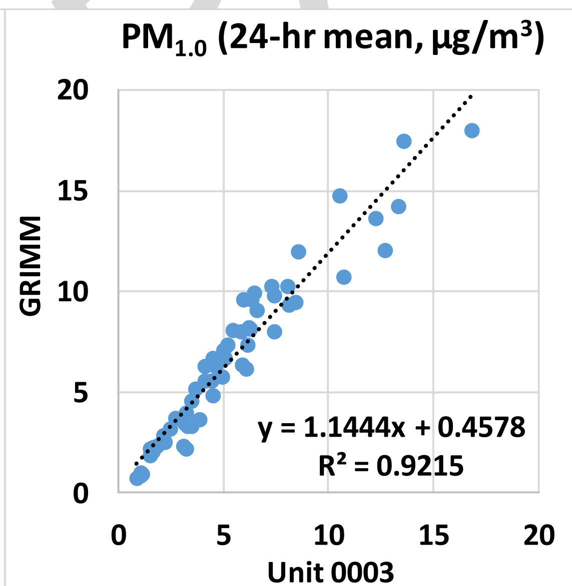


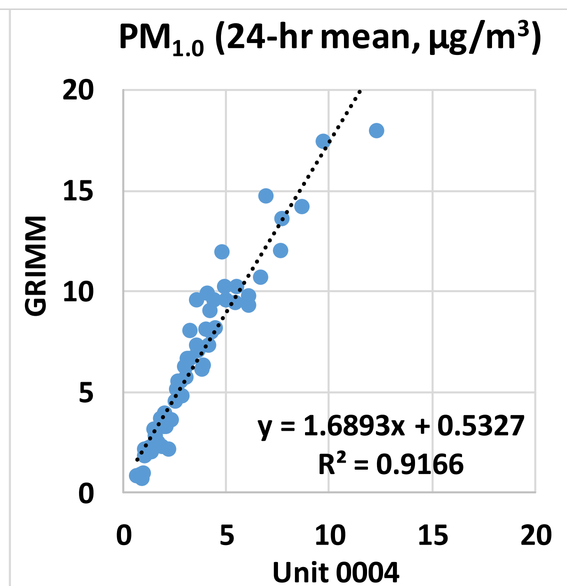
Dustroid Pro vs GRIMM ($PM_{1.0}$; 24-hr mean)



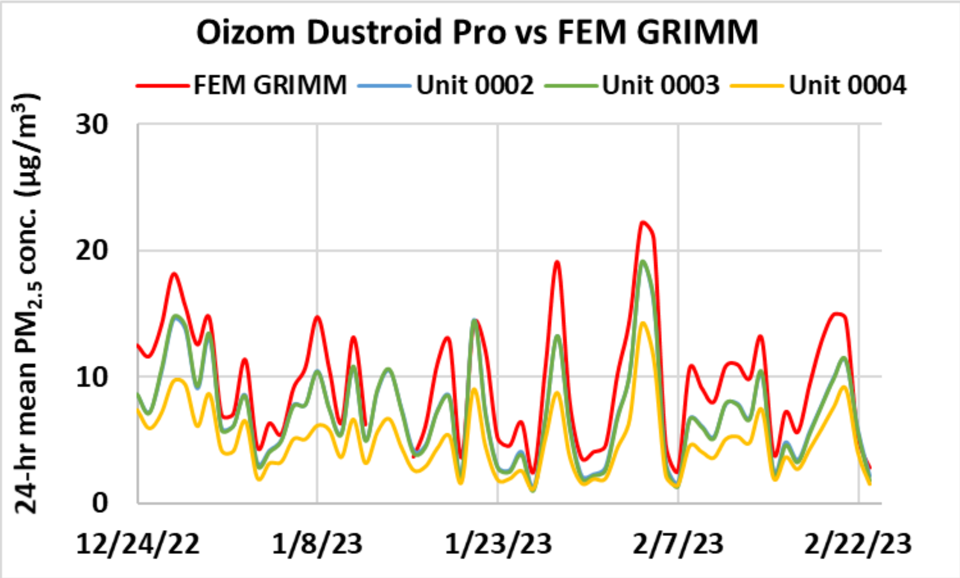
- The Dustroid Pro sensors showed very strong correlations with the corresponding GRIMM data ($0.91 < R^2 < 0.93$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{1.0}$ mass concentrations as measured by GRIMM
- The Dustroid Pro sensors seemed to track the $PM_{1.0}$ diurnal variations as recorded by GRIMM



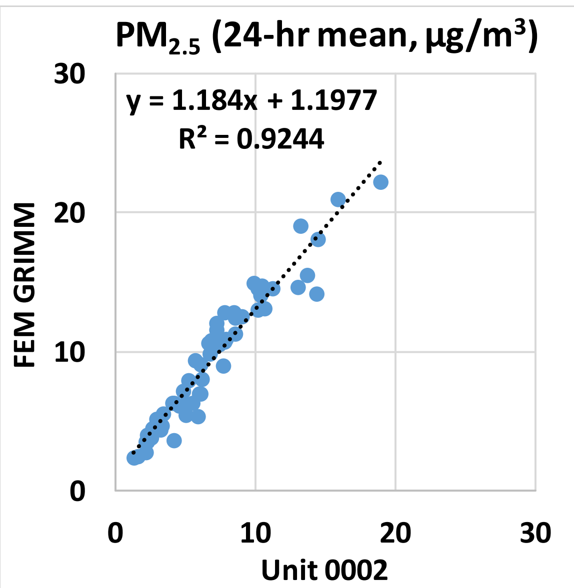


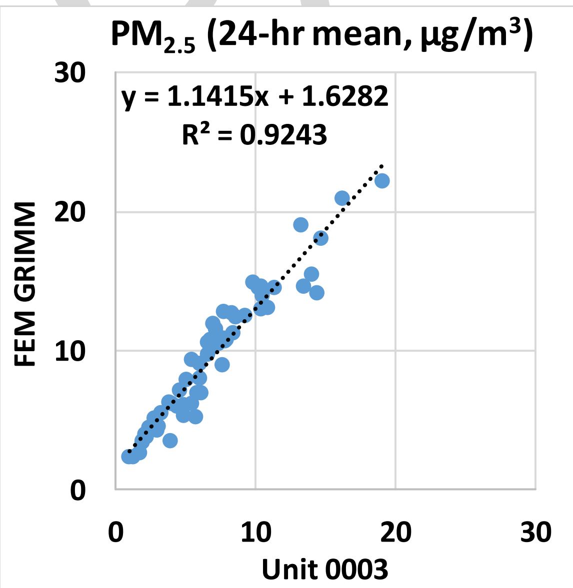


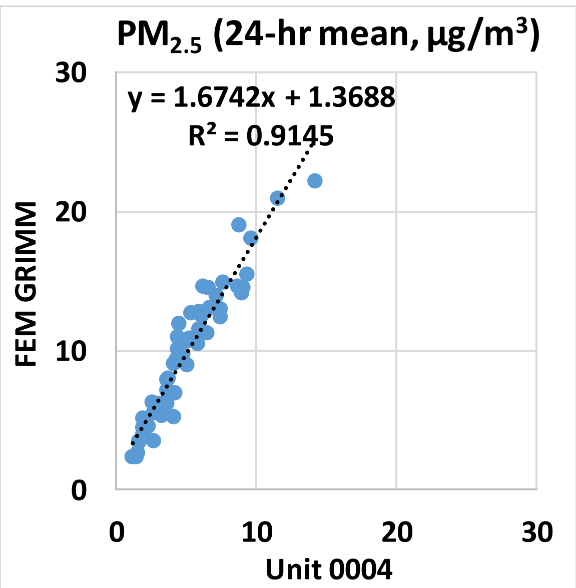
Dustroid Pro vs FEM GRIMM ($PM_{2.5}$; 24-hr mean)



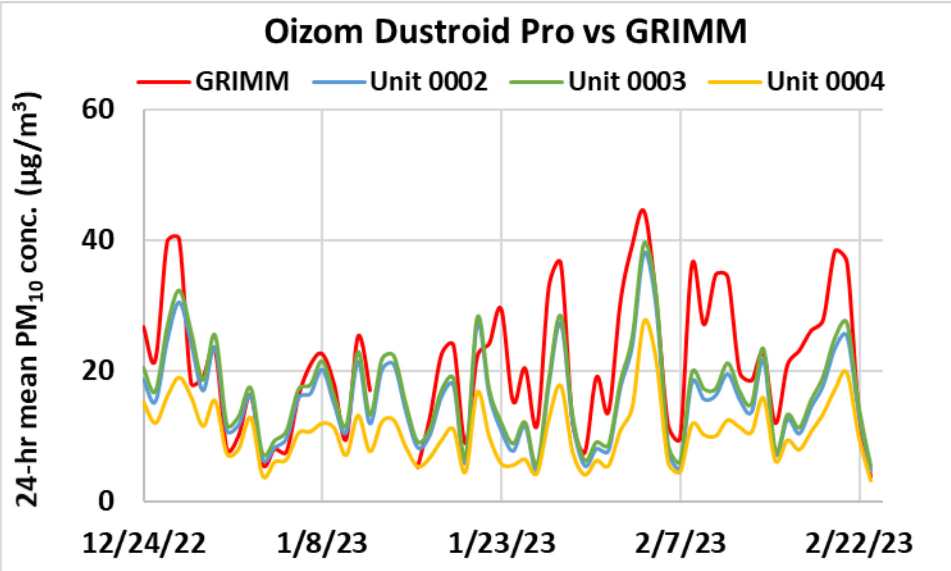
- The Dustroid Pro sensors showed very strong correlations with the corresponding FEM GRIMM data ($0.91 < R^2 < 0.93$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM GRIMM
- The Dustroid Pro sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM GRIMM



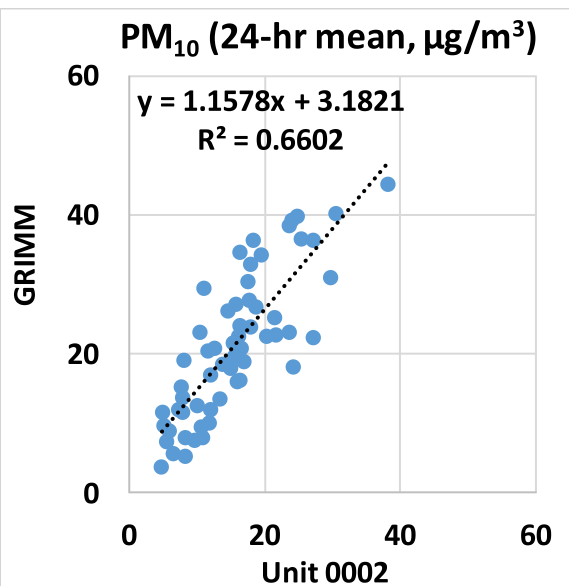


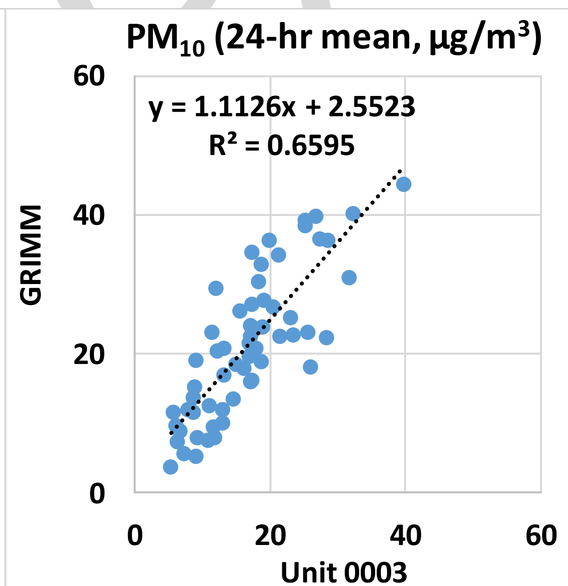


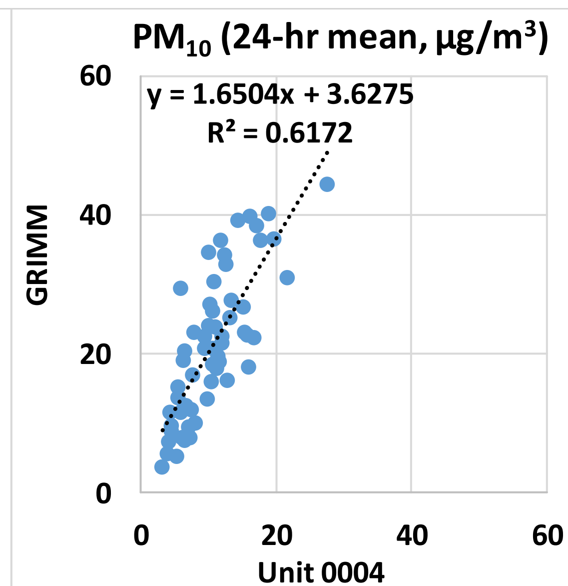
Dustroid Pro vs GRIMM (PM_{10}; 24-hr mean)



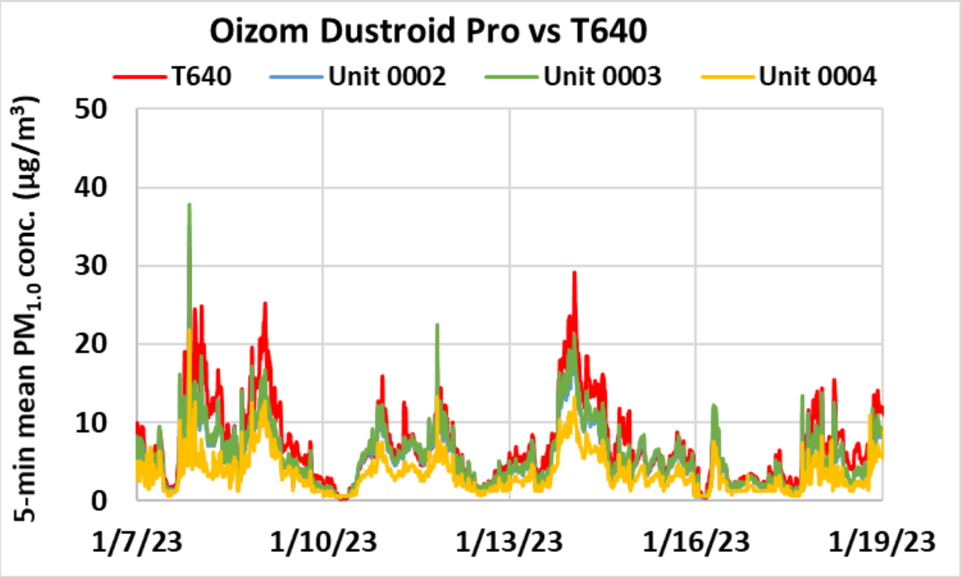
- The Dustroid Pro sensors showed moderate correlations with the corresponding GRIMM data ($0.61 < R^2 < 0.67$)
- Overall, the Dustroid Pro sensors underestimated the PM_{10} mass concentrations as measured by GRIMM
- The Dustroid Pro sensors seemed to track the PM_{10} diurnal variations as recorded by GRIMM



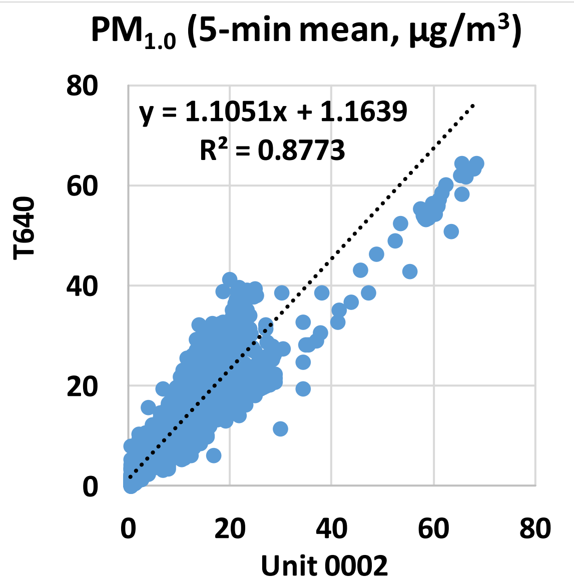


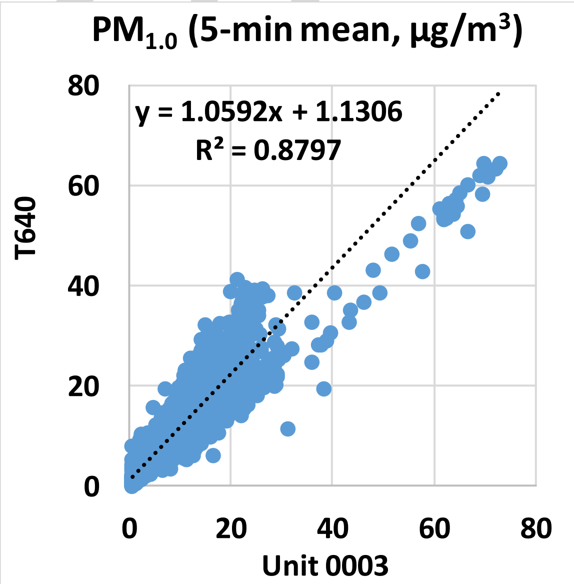


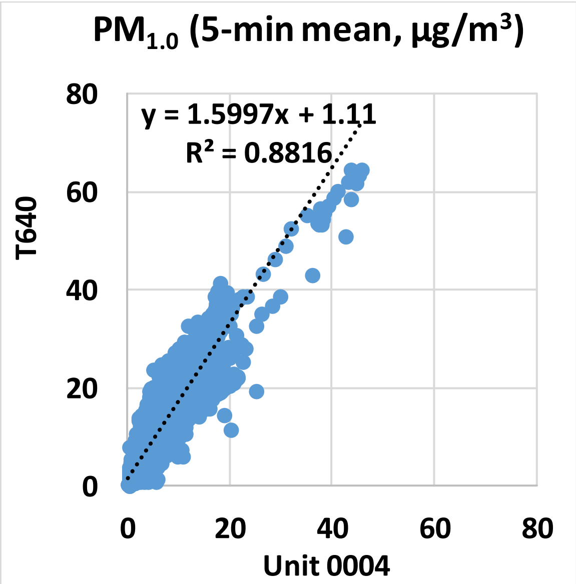
Dustroid Pro vs T640 ($PM_{1.0}$; 5-min mean)



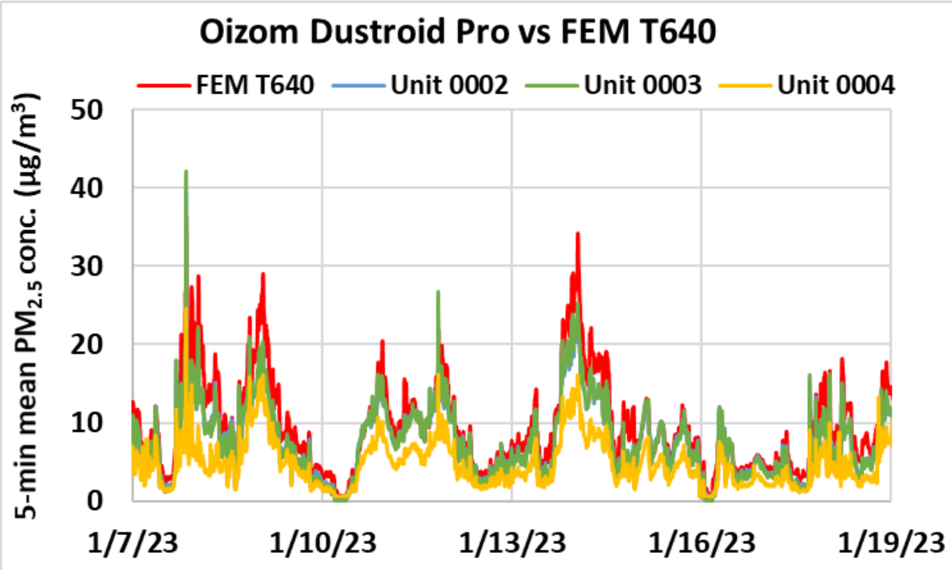
- The Dustroid Pro sensors showed strong correlations with the corresponding T640 data ($0.87 < R^2 < 0.89$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{1.0}$ mass concentrations as measured by T640
- The Dustroid Pro sensors seemed to track the $PM_{1.0}$ diurnal variations as recorded by T640



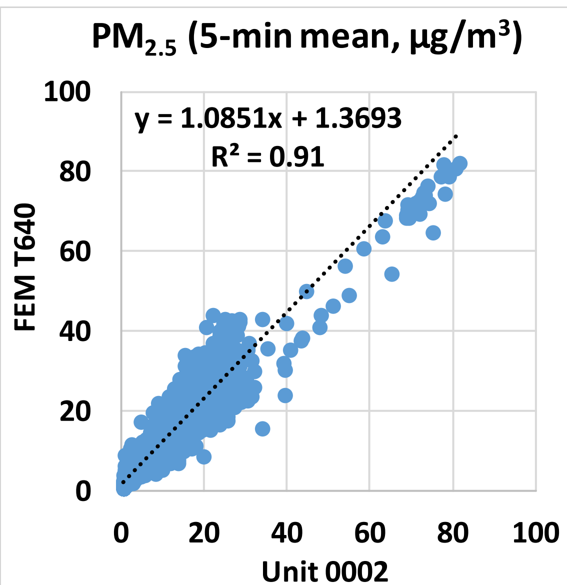


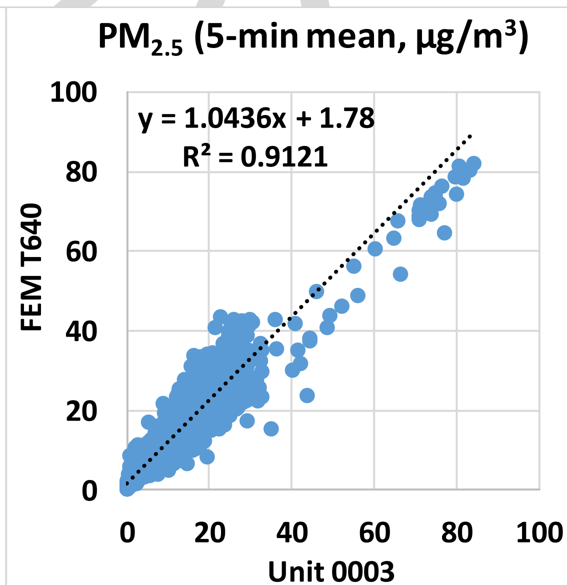


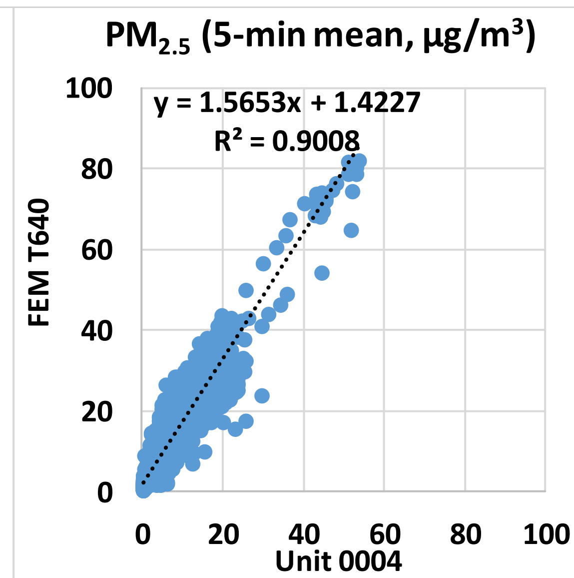
Dustroid Pro vs FEM T640 ($PM_{2.5}$; 5-min mean)



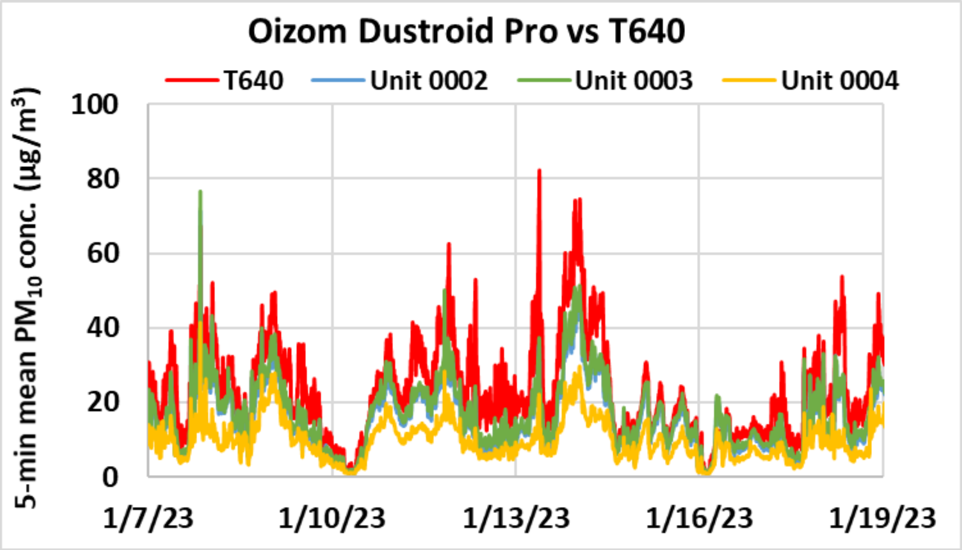
- The Dustroid Pro sensors showed very strong correlations with the corresponding FEM T640 data ($0.90 < R^2 < 0.92$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Dustroid Pro sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



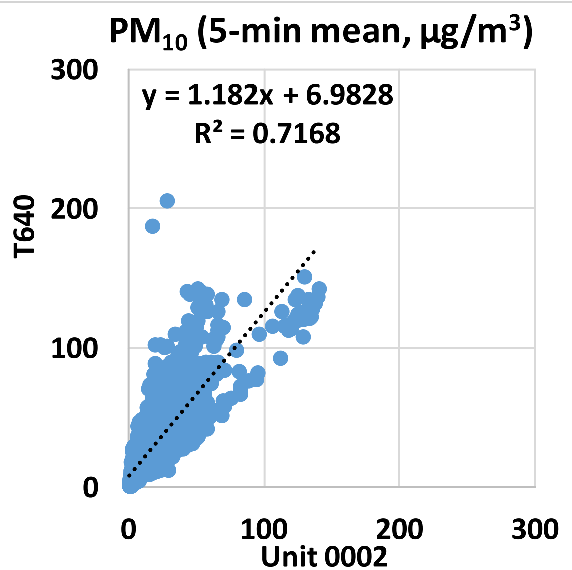


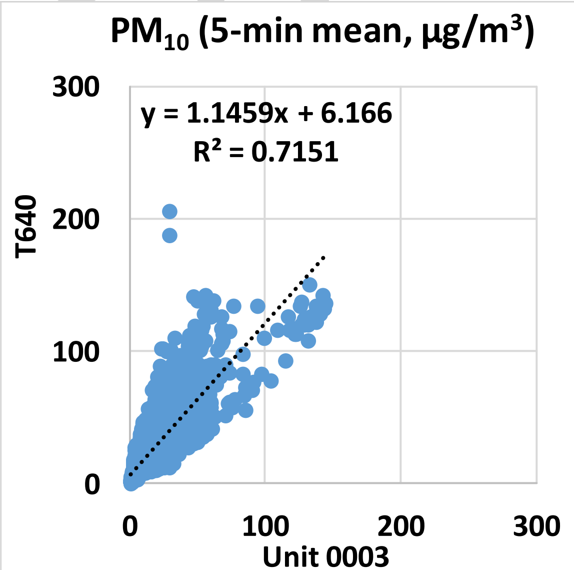


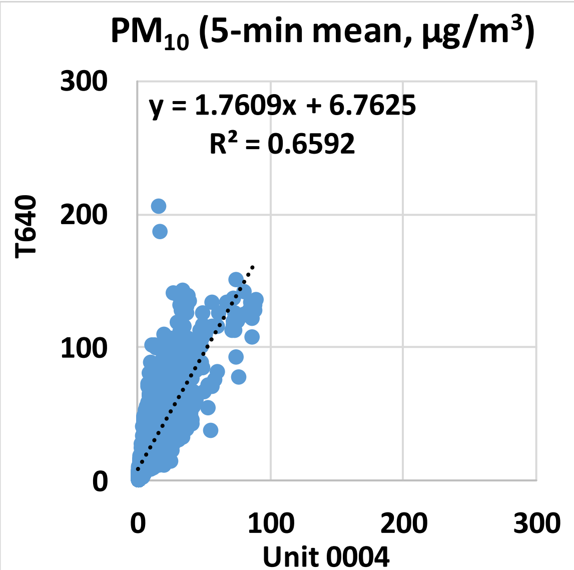
Dustroid Pro vs T640 (PM_{10}; 5-min mean)



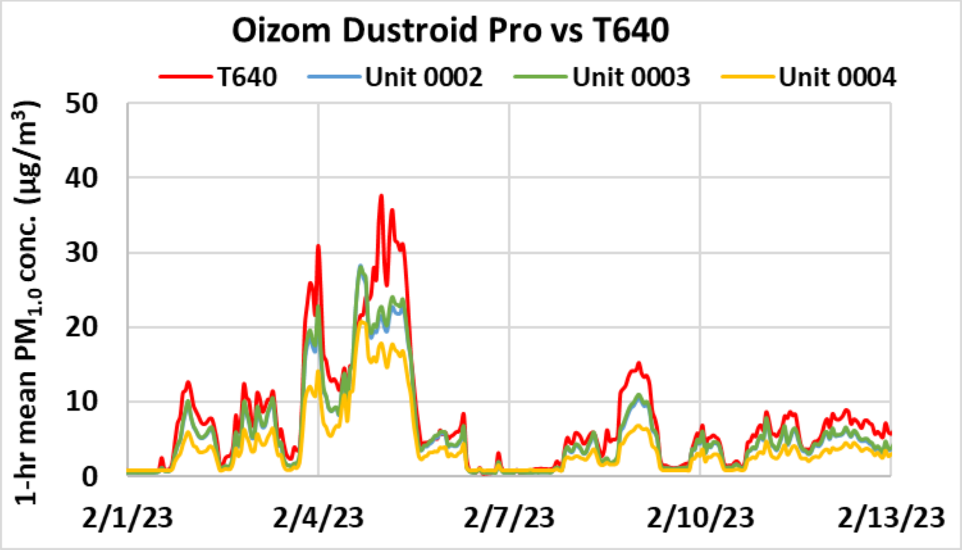
- Dustroid Pro sensors showed moderate to strong correlations with the corresponding T640 data ($0.65 < R^2 < 0.72$)
- Overall, the Dustroid Pro sensors underestimated the PM_{10} mass concentrations as measured by T640
- The Dustroid Pro sensors seemed to track the PM_{10} diurnal variations as recorded by T640



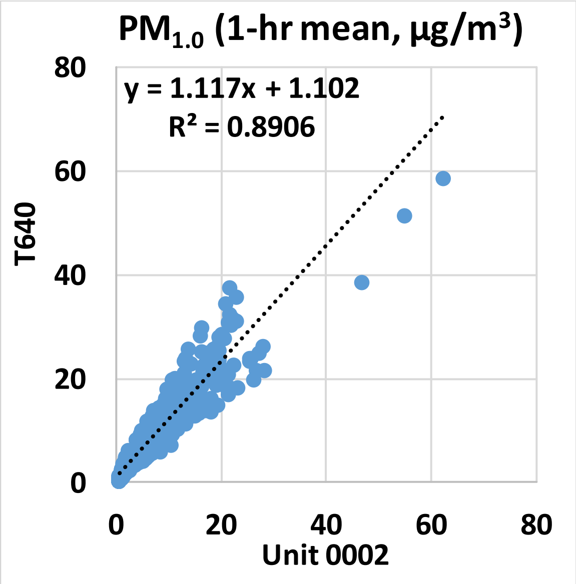


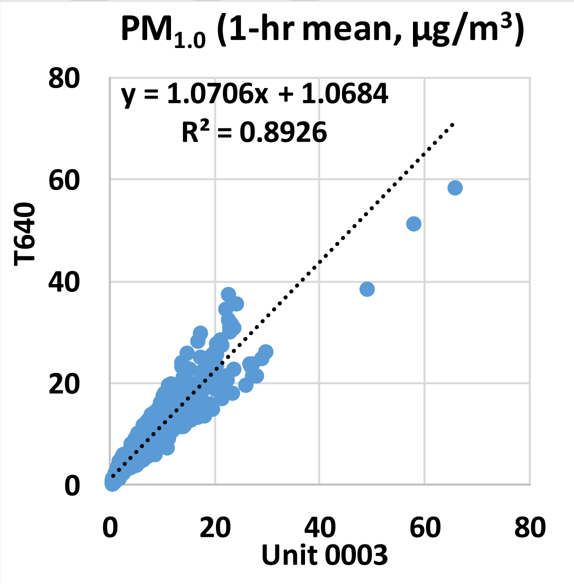


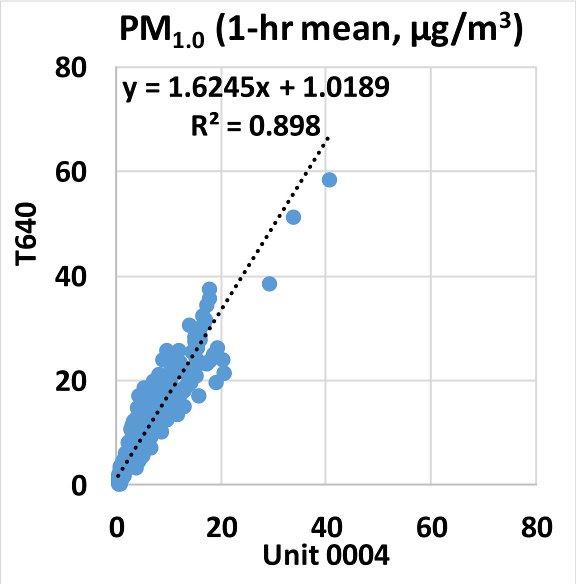
Dustroid Pro vs T640 ($PM_{1.0}$; 1-hr mean)



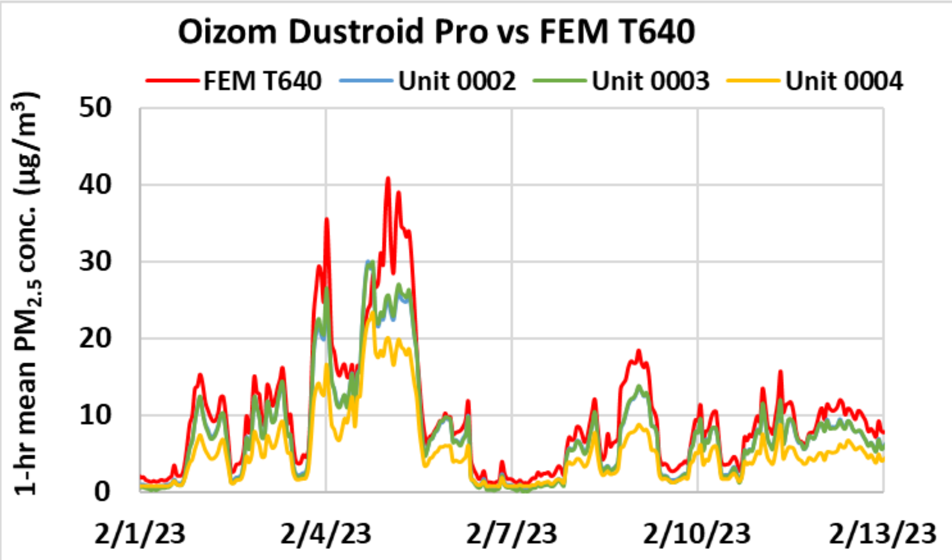
- The Dustroid Pro sensors showed strong correlations with the corresponding T640 data ($0.89 < R^2 < 0.90$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{1.0}$ mass concentrations as measured by T640
- The Dustroid Pro sensors seemed to track the $PM_{1.0}$ diurnal variations as recorded by T640



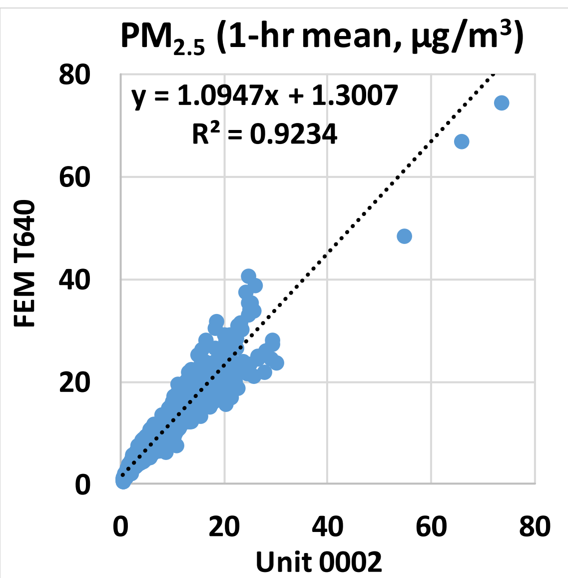


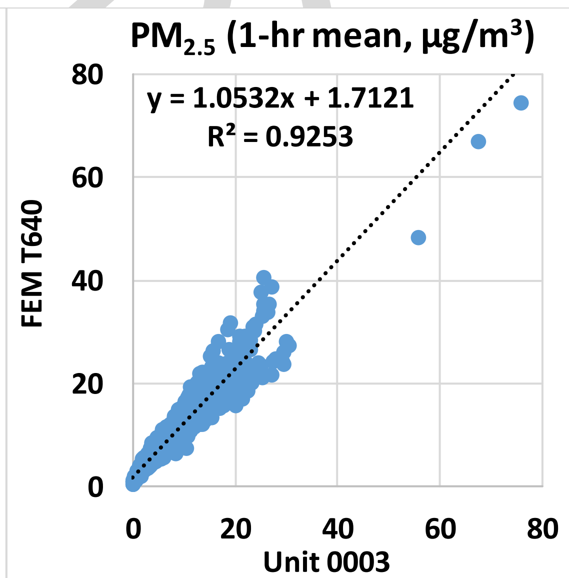


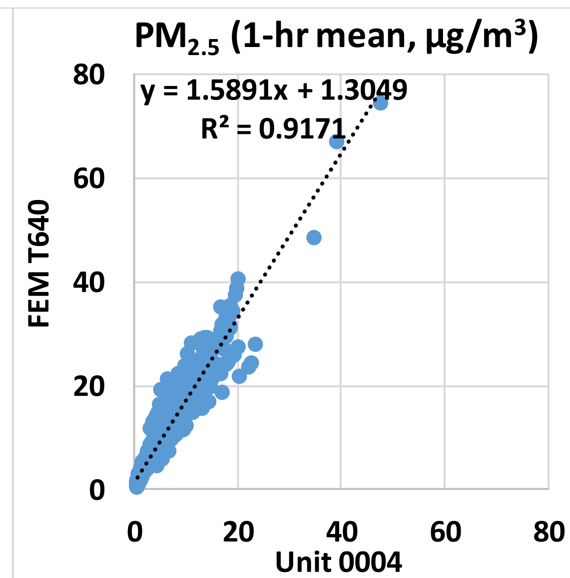
Dustroid Pro vs FEM T640 ($PM_{2.5}$; 1-hr mean)



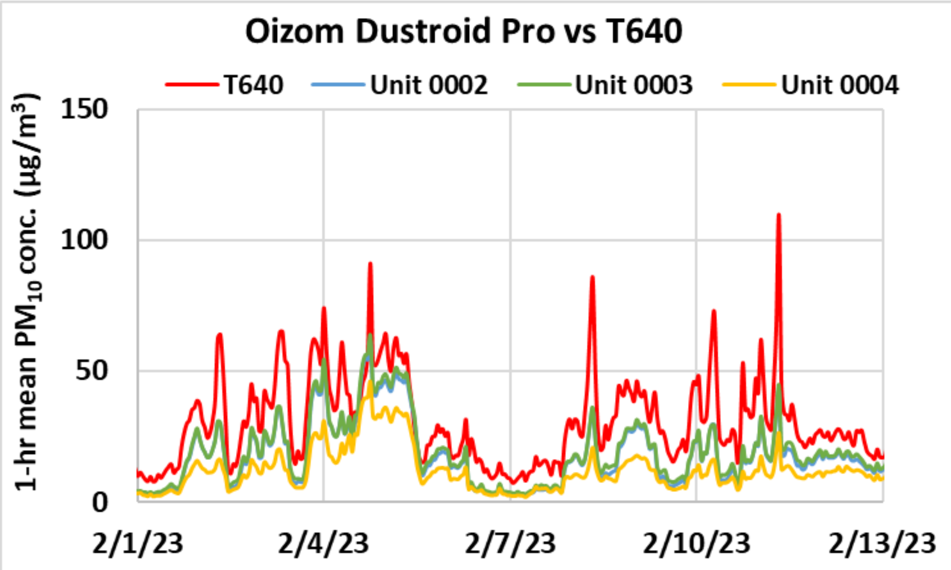
- The Dustroid Pro sensors showed very strong correlations with the corresponding FEM T640 data ($0.91 < R^2 < 0.93$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Dustroid Pro sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



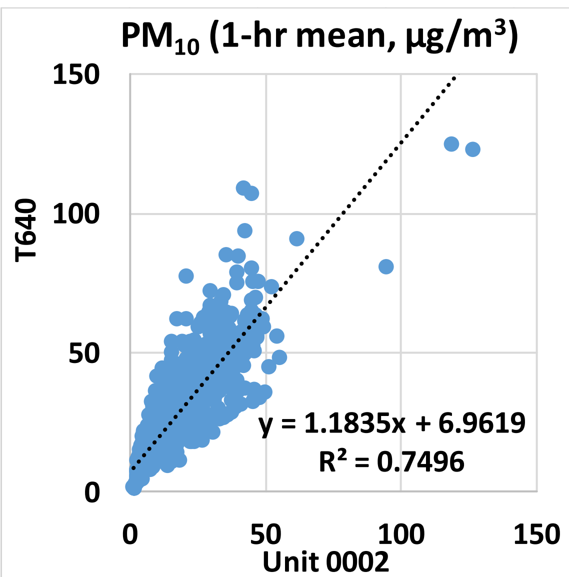


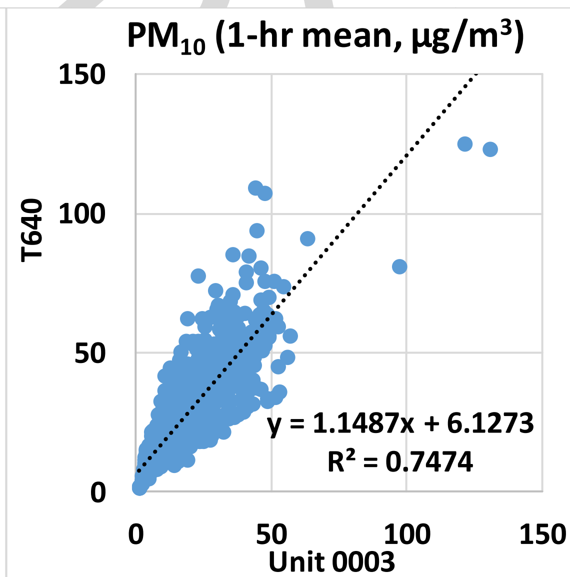


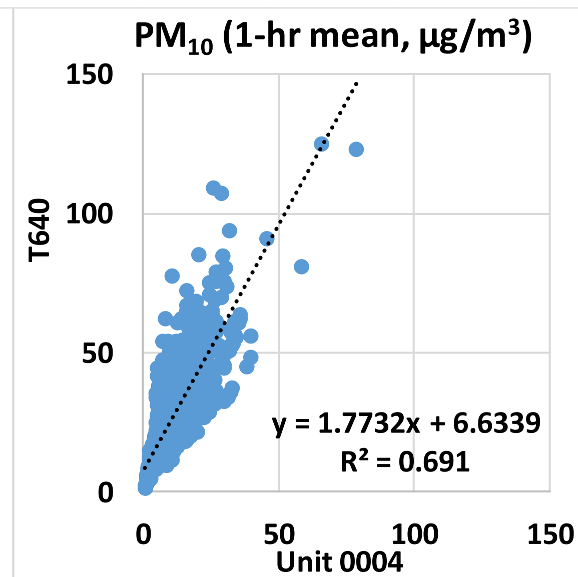
Dustroid Pro vs T640 (PM_{10}; 1-hr mean)



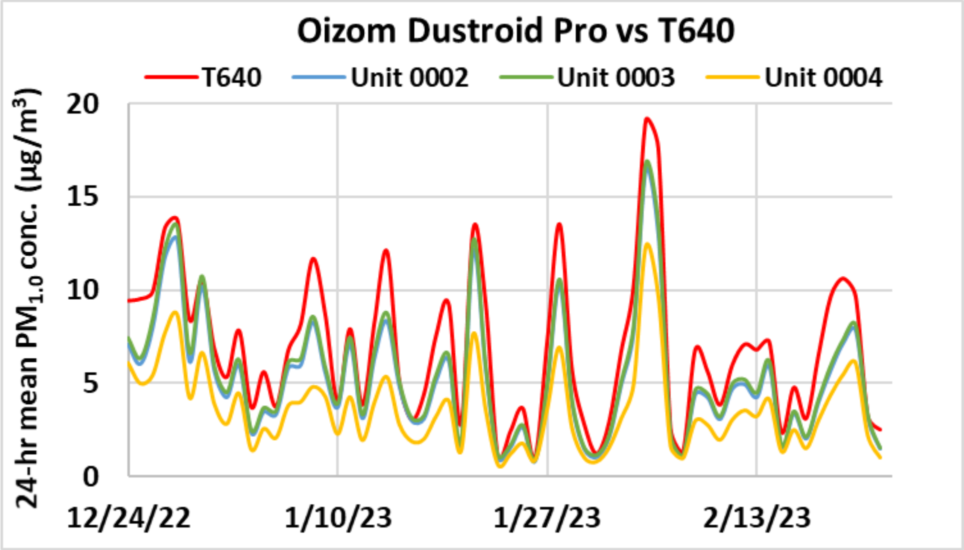
- The Dustroid Pro sensors showed moderate to strong correlations with the corresponding T640 data ($0.69 < R^2 < 0.75$)
- Overall, the Dustroid Pro sensors underestimated the PM_{10} mass concentrations as measured by T640
- The Dustroid Pro sensors seemed to track the PM_{10} diurnal variations as recorded by T640



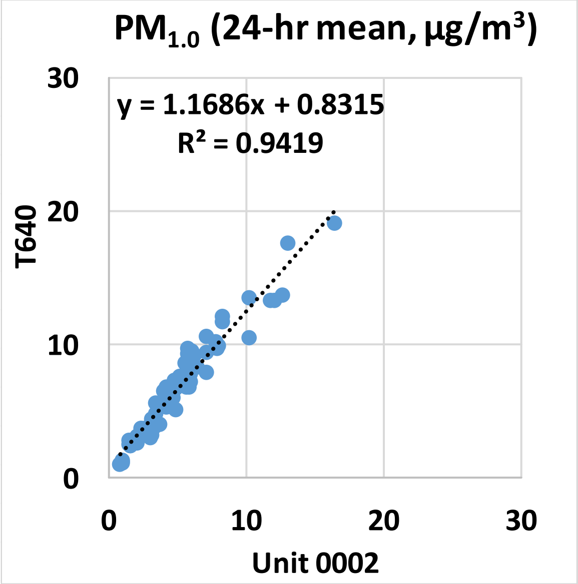


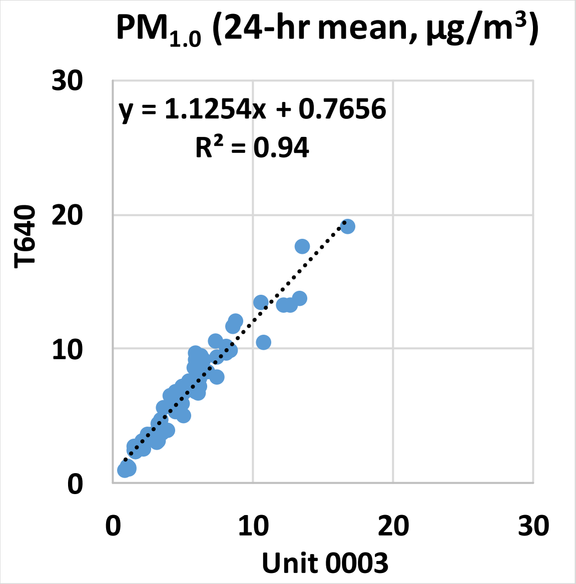


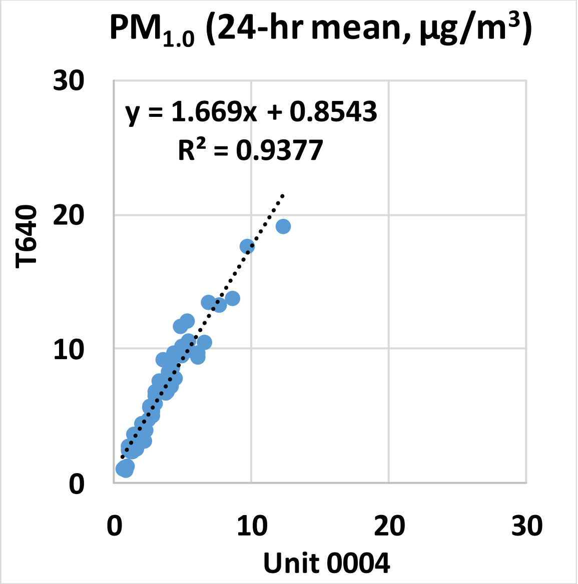
Dustroid Pro vs T640 ($PM_{1.0}$; 24-hr mean)



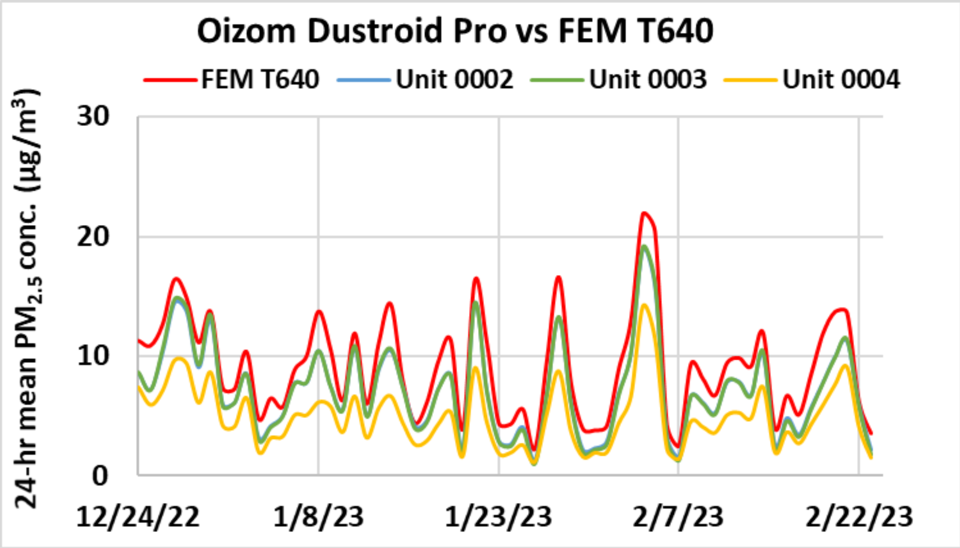
- The Dustroid Pro sensors showed very strong correlations with the corresponding T640 data ($0.93 < R^2 < 0.95$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{1.0}$ mass concentrations as measured by T640
- The Dustroid Pro sensors seemed to track the $PM_{1.0}$ diurnal variations as recorded by T640



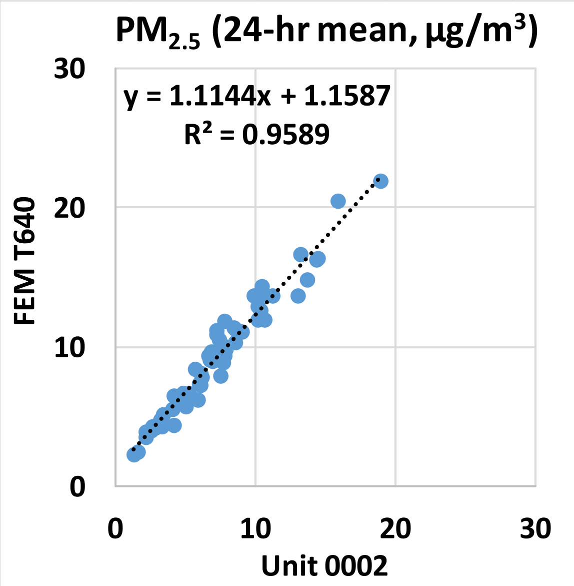


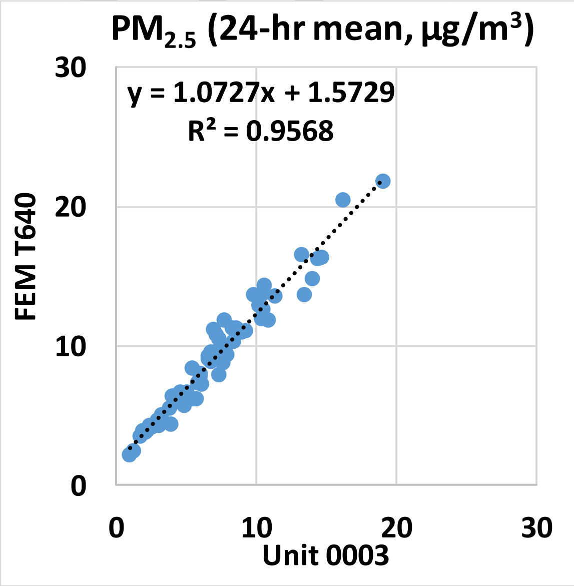


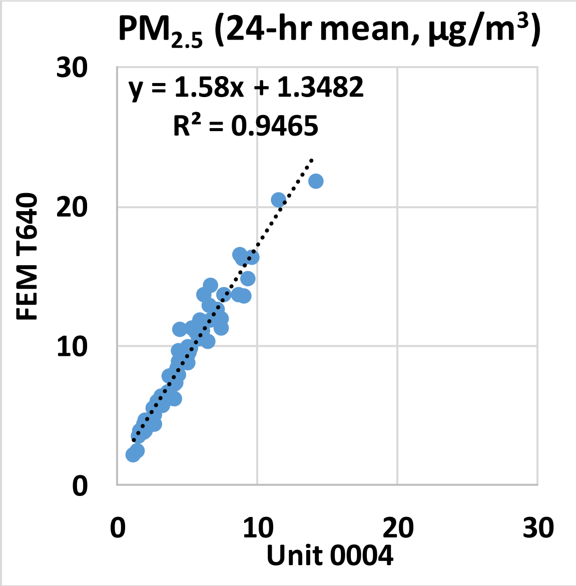
Dustroid Pro vs FEM T640 ($PM_{2.5}$; 24-hr mean)



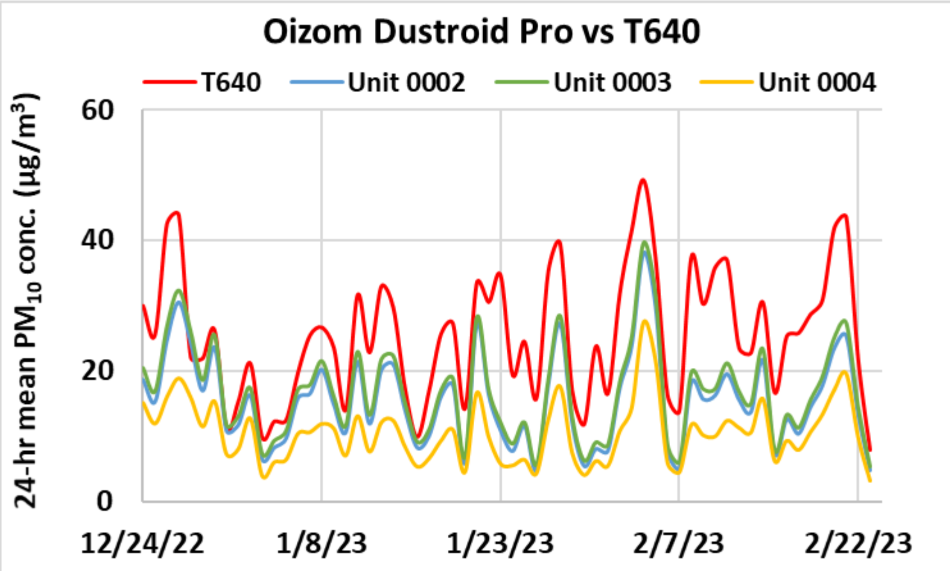
- The Dustroid Pro sensors showed very strong correlations with the corresponding FEM T640 data ($0.94 < R^2 < 0.96$)
- Overall, the Dustroid Pro sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Dustroid Pro sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



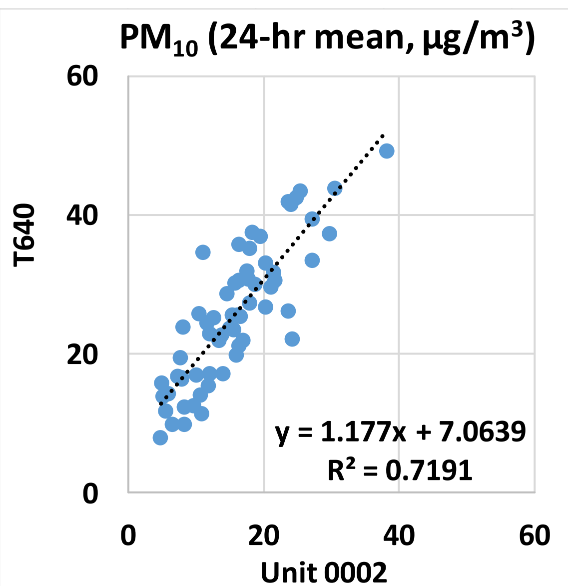


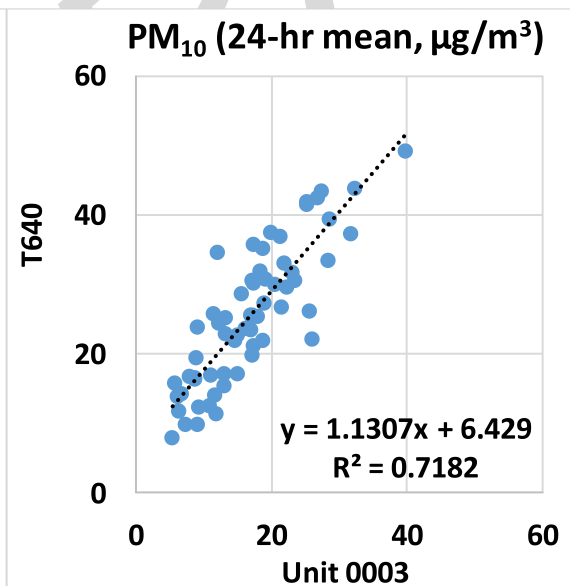


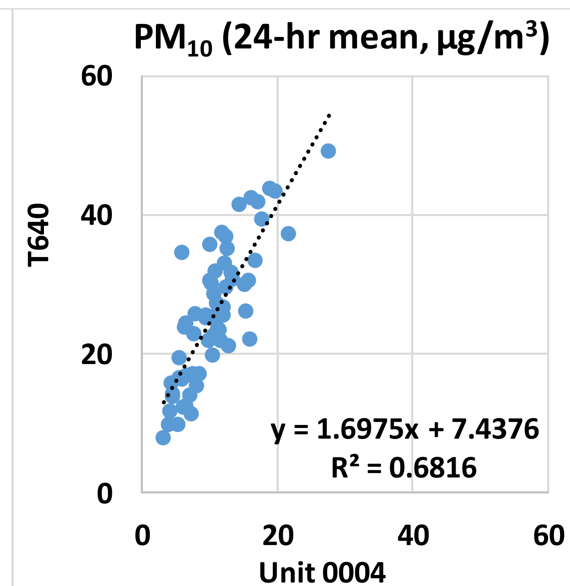
Dustroid Pro vs T640 (PM_{10}; 24-hr mean)



- The Dustroid Pro sensors showed moderate to strong correlations with the corresponding T640 data ($0.68 < R^2 < 0.72$)
- Overall, the Dustroid Pro sensors underestimated the PM_{10} mass concentrations as measured by T640
- The Dustroid Pro sensors seemed to track the PM_{10} diurnal variations as recorded by T640





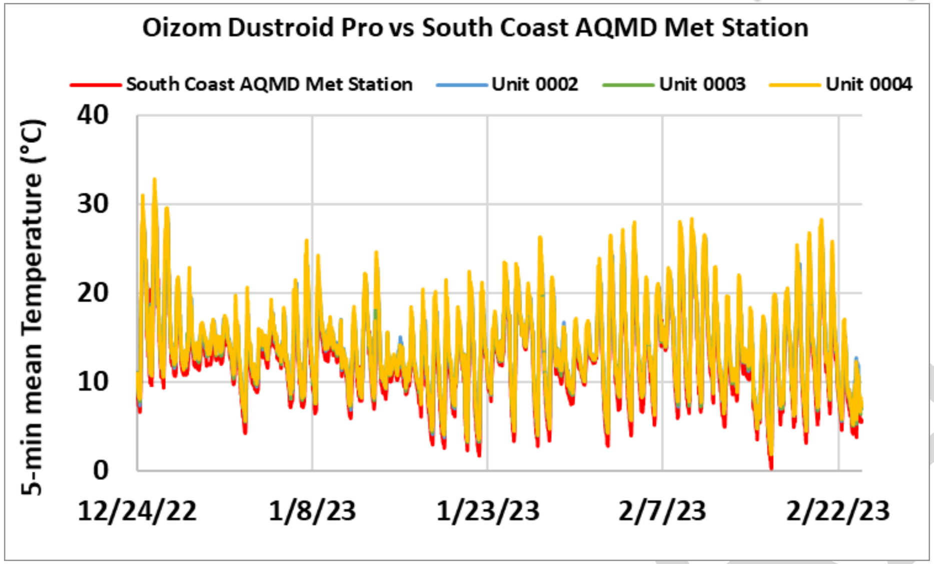


Summary

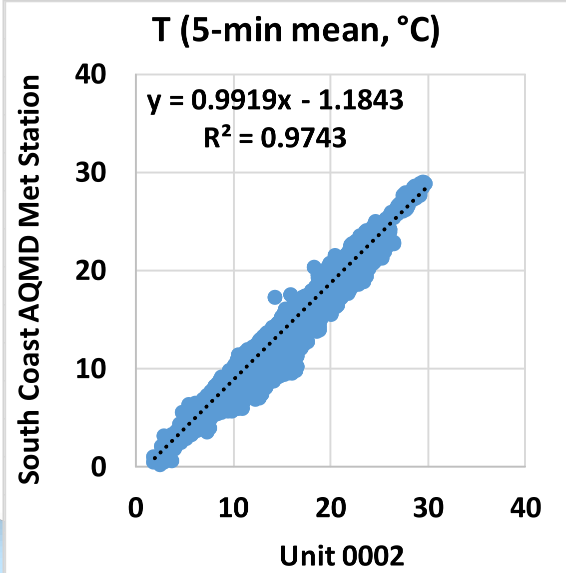
	Average of 3 Sensors, $PM_{1.0}$		Dustroid Pro vs GRIMM & T640, $PM_{1.0}$						GRIMM & T640 ($PM_{1.0}$, $\mu g/m^3$)		
	Average ($\mu g/m^3$)	SD ($\mu g/m^3$)	R^2	Slope	Intercept	MBE[1] ($\mu g/m^3$)	MAE[2] ($\mu g/m^3$)	RMSE[3] ($\mu g/m^3$)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	4.8	4.7	0.82 to 0.88	1.06 to 1.65	0.7 to 1.2	-3.3 to -1.3	1.8 to 3.3	2.6 to 4.7	6.8 to 7.0	6.1 to 6.5	0.1 to 64.6
1-hr	4.8	4.6	0.83 to 0.90	1.07 to 1.66	0.7 to 1.1	-3.3 to -1.3	1.7 to 3.3	2.5 to 4.6	6.8 to 7.0	6.0 to 6.3	0.2 to 58.7
24-hr	4.8	3.0	0.92 to 0.94	1.13 to 1.69	0.5 to 0.9	-3.3 to -1.2	1.4 to 3.3	1.8 to 3.8	6.7 to 7.0	4.0 to 4.2	0.8 to 19.2
	Average of 3 Sensors, $PM_{2.5}$		Dustroid Pro vs FEM GRIMM & FEM T640, $PM_{2.5}$						FEM GRIMM & FEM T640 ($PM_{2.5}$, $\mu g/m^3$)		
	Average ($\mu g/m^3$)	SD ($\mu g/m^3$)	R^2	Slope	Intercept	MBE[1] ($\mu g/m^3$)	MAE[2] ($\mu g/m^3$)	RMSE[3] ($\mu g/m^3$)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	6.4	5.5	0.84 to 0.91	1.04 to 1.65	1.4 to 1.9	-4.8 to -2.0	2.2 to 4.8	2.9 to 6.3	9.2 to 9.7	6.9 to 7.5	0.3 to 82.2
1-hr	6.4	5.3	0.84 to 0.93	1.05 to 1.66	1.3 to 1.9	-4.8 to -2.0	2.1 to 4.8	2.8 to 6.2	9.2 to 9.7	6.7 to 7.3	0.4 to 74.6
24-hr	6.4	3.5	0.91 to 0.96	1.07 to 1.67	1.2 to 1.6	-4.7 to -2.0	2.0 to 4.7	2.2 to 5.2	9.2 to 9.6	4.3 to 4.8	2.3 to 22.2
	Average of 3 Sensors, PM_{10}		Dustroid Pro vs GRIMM & T640, PM_{10}						GRIMM & T640 (PM_{10}, $\mu g/m^3$)		
	Average ($\mu g/m^3$)	SD ($\mu g/m^3$)	R^2	Slope	Intercept	MBE[1] ($\mu g/m^3$)	MAE[2] ($\mu g/m^3$)	RMSE[3] ($\mu g/m^3$)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	14.4	10.2	0.58 to 0.72	1.09 to 1.76	2.8 to 7.0	-14.9 to -4.3	6.8 to 14.9	10.8 to 18.4	21.3 to 25.6	16.0 to 16.2	0.3 to 206.3
1-hr	14.4	9.9	0.59 to 0.75	1.08 to 1.77	3.1 to 7.0	-14.9 to -4.3	6.7 to 14.9	10.2 to 18.0	21.3 to 25.6	15.2 to 15.3	0.5 to 125.4
24-hr	14.4	6.4	0.62 to 0.72	1.11 to 1.70	2.6 to 7.4	-14.9 to -4.4	5.9 to 14.9	7.5 to 16.2	21.2 to 25.6	9.9 to 10.4	3.7 to 49.2

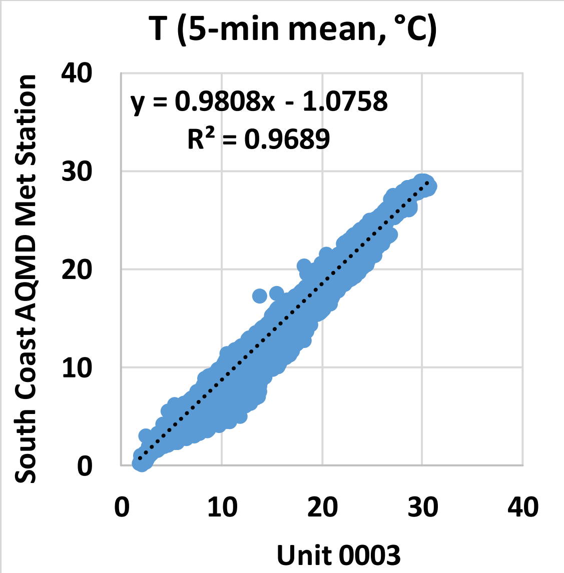
[1] Mean Bias Error (MBE): the difference between the sensors and the reference instruments. MBE indicates the tendency of the sensors to underestimate (negative MBE values) or overestimate (positive MBE values).
[2] Mean Absolute Error (MAE): the absolute difference between the sensors and the reference instruments. The larger MAE values, the higher measurement errors as compared to the reference instruments.
[3] Root Mean Square Error (RMSE): another metric to calculate measurement errors.

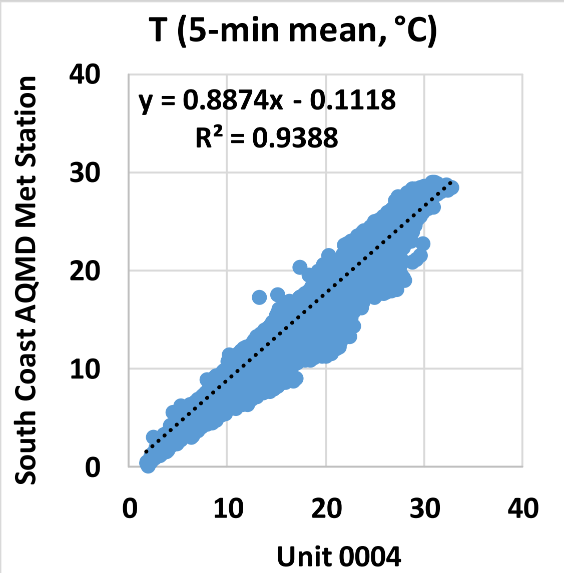
Oizom Dustroid Pro vs South Coast AQMD Met Station (Temp; 5-min mean)



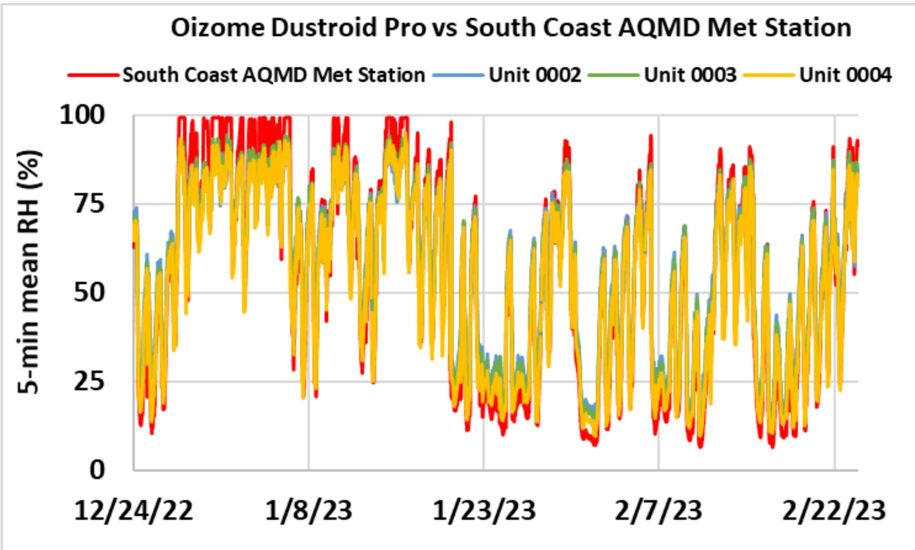
- The Dustroid Pro sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ($0.93 < R^2 < 0.98$)
- Overall, the Dustroid Pro temperature measurements overestimated the corresponding South Coast AQMD Met Station data
- The Dustroid Pro sensors seemed to track the temperature diurnal variations as recorded by South Coast AQMD Met Station



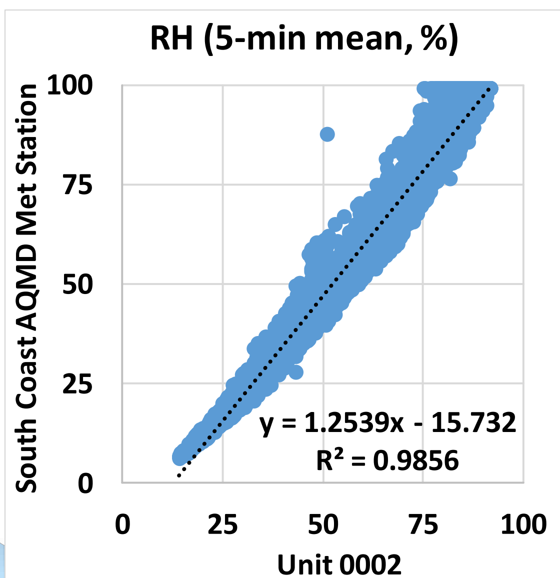


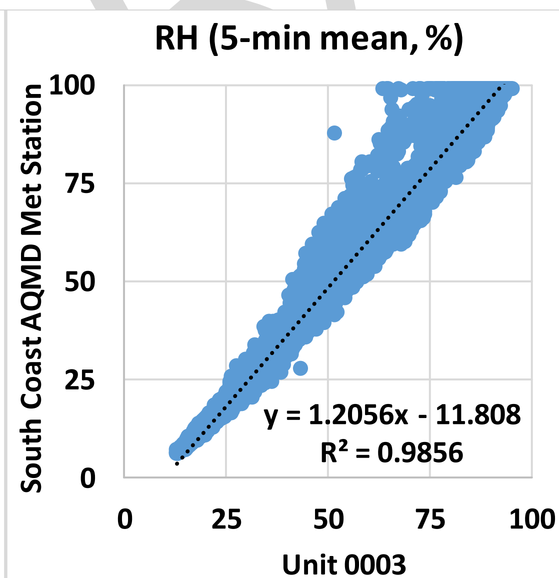


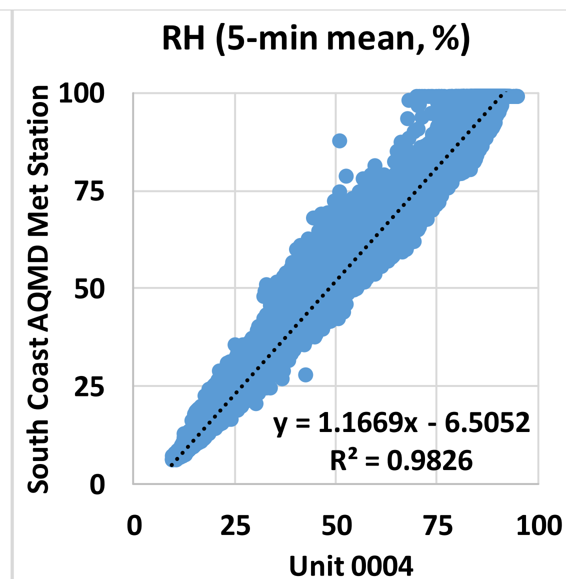
Oizom Dustroid Pro vs South Coast AQMD Met Station (RH; 5-min mean)



- The Dustroid Pro sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data (R^2 ~ 0.98)
- Overall, the Dustroid Pro RH measurements underestimated the corresponding South Coast AQMD Met Station data
- The Dustroid Pro sensors seemed to track the RH diurnal variations as recorded by South Coast AQMD Met Station







Discussion

- The three **Dustroid Pro** sensors' data recovery from Unit 0002, Unit 0003 and Unit 0004 was ~ 100% for all PM measurements
- The absolute intra-model variability was ~ 1.0, 1.3 and 3.3 µg/m^3 for $PM_{1.0}$, $PM_{2.5}$ and PM_{10}, respectively
- $PM_{1.0}$ mass concentrations measured by the Dustroid Pro sensors showed strong correlations with the corresponding GRIMM and T640 data ($0.82 < R^2 < 0.90$, 1-hr mean). The sensors underestimated $PM_{1.0}$ mass concentrations as measured by GRIMM and T640
- $PM_{2.5}$ mass concentrations measured by the Dustroid Pro sensors showed strong to very strong correlations with the corresponding FEM GRIMM and FEM T640 data ($0.84 < R^2 < 0.93$, 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 the Dustroid Pro sensors showed moderate to strong correlations with the corresponding GRIMM and T640 data ($0.58 < R^2 < 0.75$; 1-hr mean). The sensors underestimated PM_{10} mass concentrations as 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