Field Evaluation
Oizom - Polludrone Smart

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

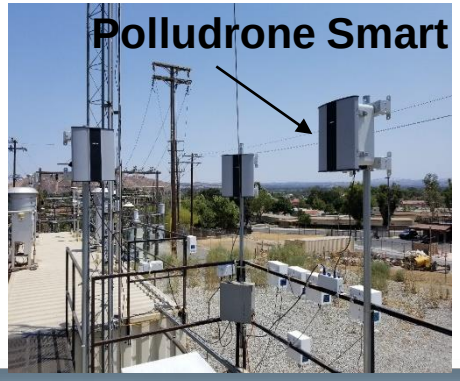
Background

- From 07/31/2021 to 09/29/2021, three **Oizom Polludrone Smart (hereinafter Polludrone Smart)** 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

- Polludrone Smart (*3 units tested*):
  - Sensors: CO – Electrochemical (Alphasense B4, non-FEM)
    O_3 – Electrochemical (Alphasense B4, non-FEM)
    NO – Electrochemical (Alphasense B4, non-FEM)
    NO_2 – Electrochemical (Alphasense B4, non-FEM)
  - PM Sensors – Optical Particle Counter (Wuhan Cubic PM3006S)
  - Each unit measures: CO (ppm), O_3 (ppb), NO and NO_2 (ppb), **$PM_{1.0}$, $PM_{2.5}$ and PM_{10} (µg/m³),** T (°C), RH (%)
  - Unit cost: $8,000 (PM + Gas sensors)
  - Time resolution: 1-min
  - Units IDs: 0001, 0002, 0003

- Teledyne API T640 (*reference instrument*):
  - Optical particle counter (FEM $PM_{2.5}$)
  - Measures $PM_{1.0}$, $PM_{2.5}$ and PM_{10} (µg/m³)
  - Cost: ~$21,000
  - Time resolution: 1-min

- Met Station (T, RH, P, WS, WD):
  - Cost: ~$5,000
  - Time resolution: 1-min

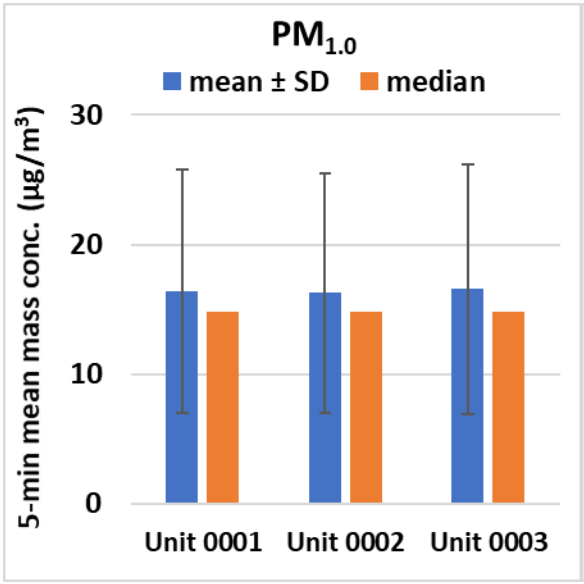


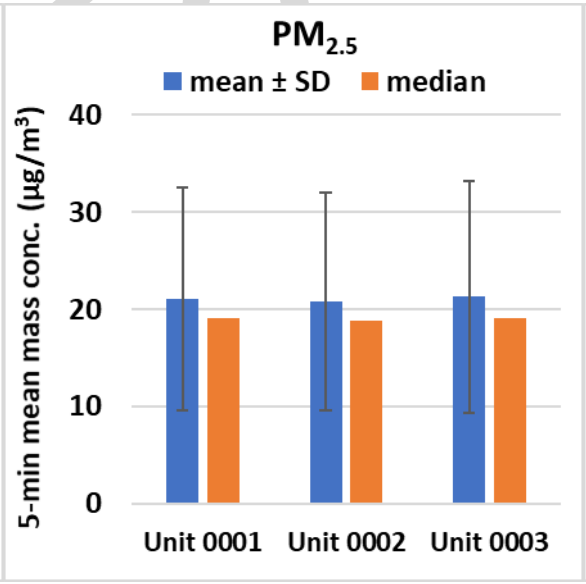
Data validation & recovery

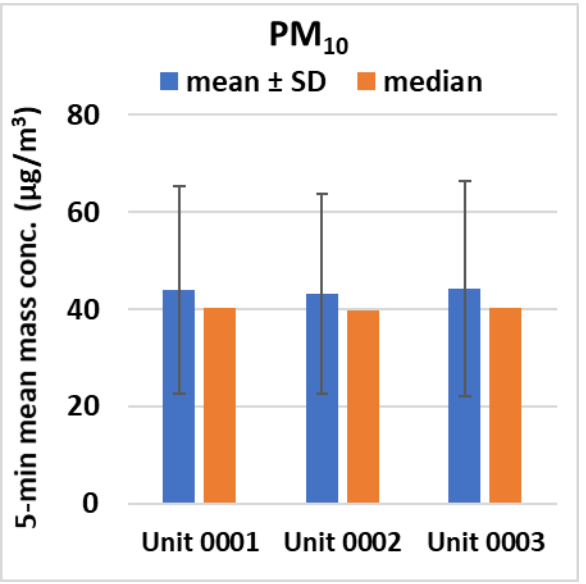
- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery from Unit 0001, Unit 0002 and Unit 0003 was ~ 99%, 95% and 99% for all PM measurements, respectively

Polludrone Smart; intra-model variability

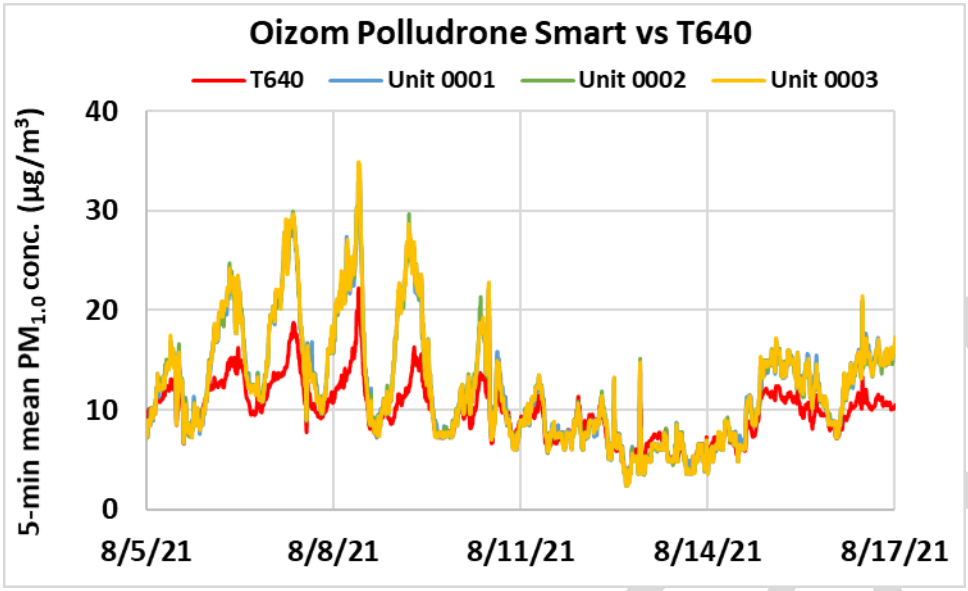
- Absolute intra-model variability was ~ 0.13, 0.20 and 0.48 µg/m^3 for $PM_{1.0}$, $PM_{2.5}$ and $PM_{10,}$ respectively (calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was ~ 0.78%, 0.96% and 1.11% for $PM_{1.0}$, $PM_{2.5}$ and $PM_{10,}$ respectively (calculated as the absolute intra-model variability relative to the mean of the three sensor means)



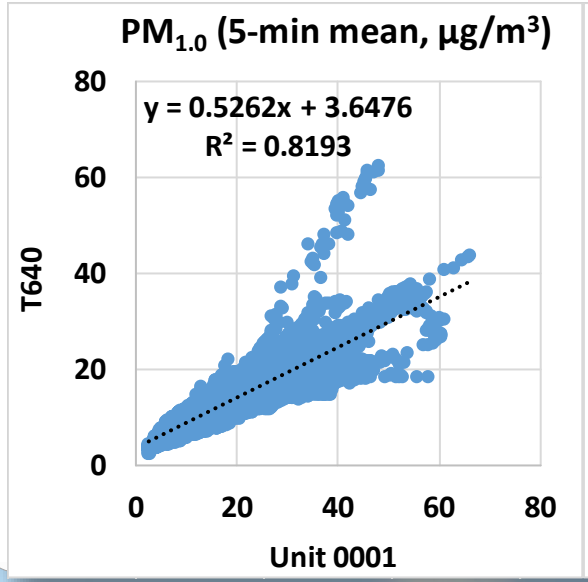


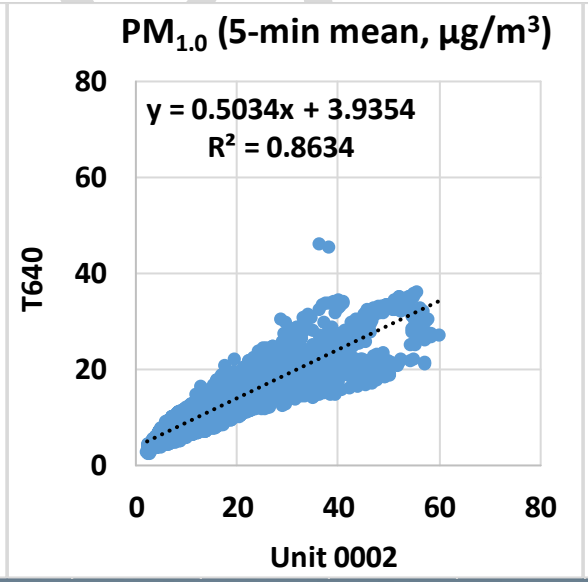


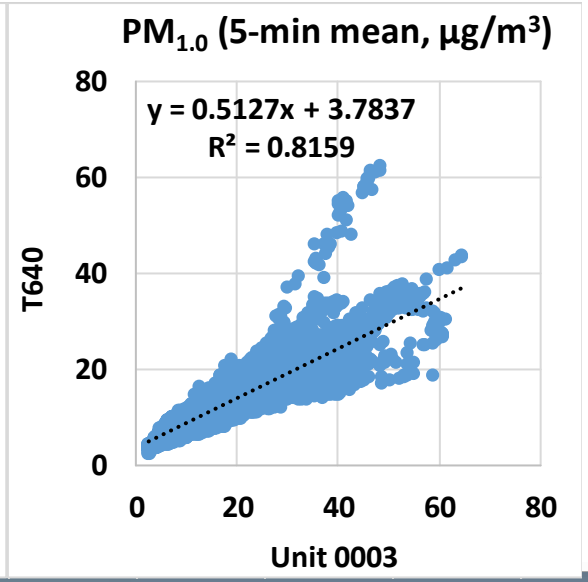
Polludrone Smart vs T640 ($PM_{1.0}$; 5-min mean)



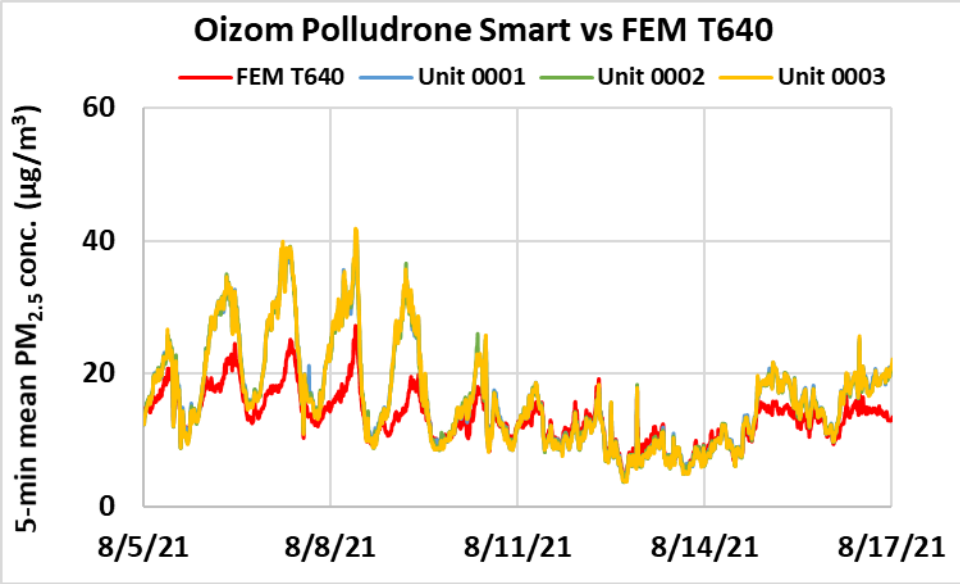
- The Polludrone Smart sensors showed strong correlations with the corresponding T640 data ($0.81 < R^2 < 0.87$)
- Overall, the Polludrone Smart sensors overestimated the $PM_{1.0}$ mass concentrations as measured by T640
- The Polludrone Smart sensors seemed to track the $PM_{1.0}$ diurnal variations as recorded by T640



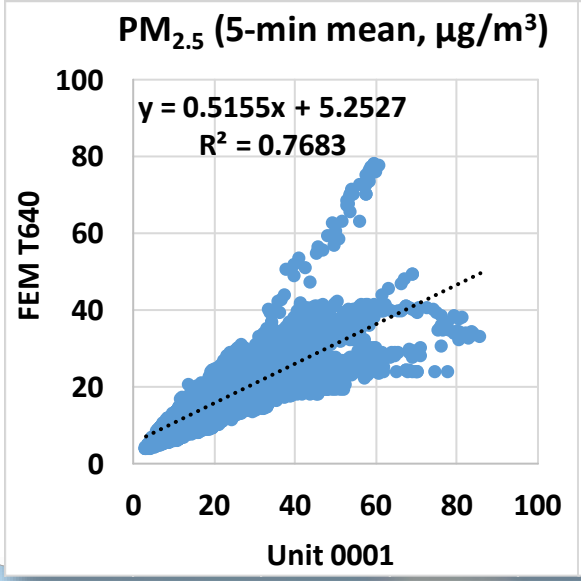


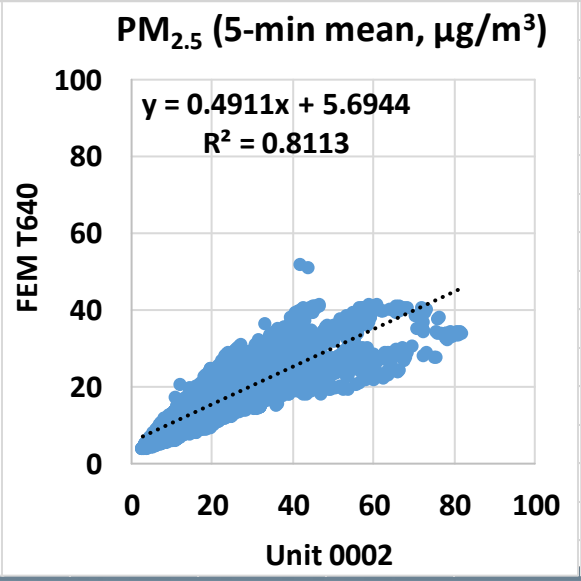


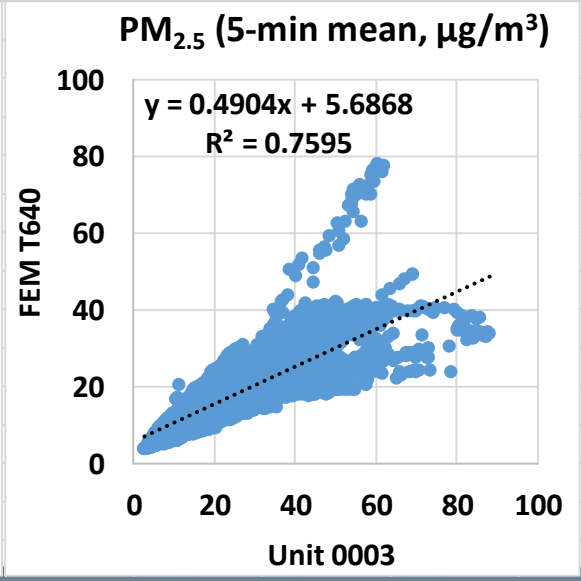
Polludrone Smart vs FEM T640 ($PM_{2.5}$; 5-min mean)



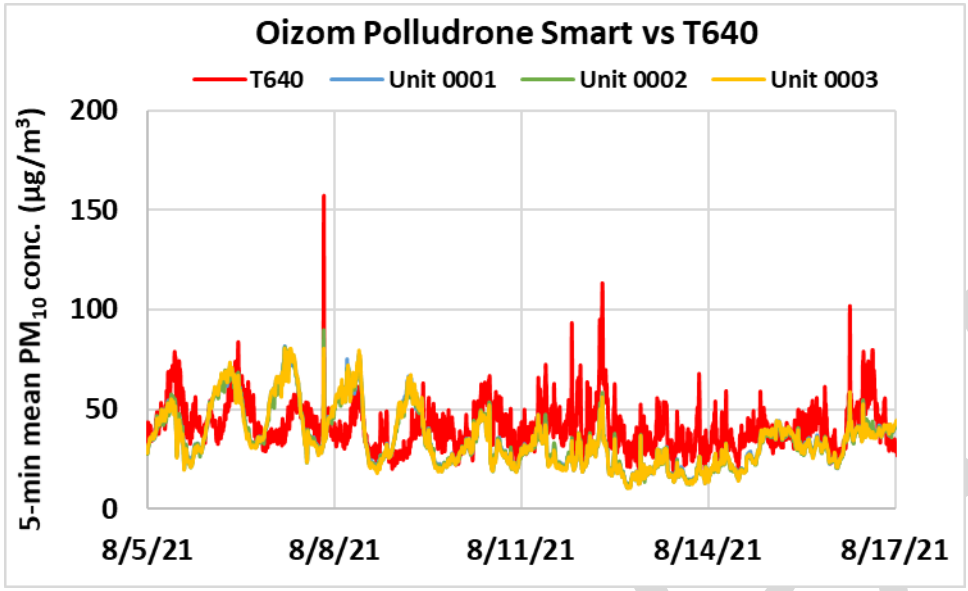
- The Polludrone Smart sensors showed strong correlations with the corresponding FEM T640 data ($0.75 < R^2 < 0.82$)
- Overall, the Polludrone Smart sensors overestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Polludrone Smart sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



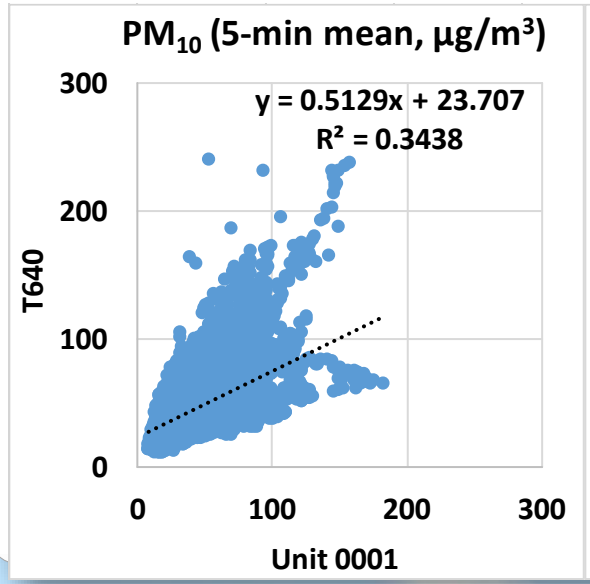


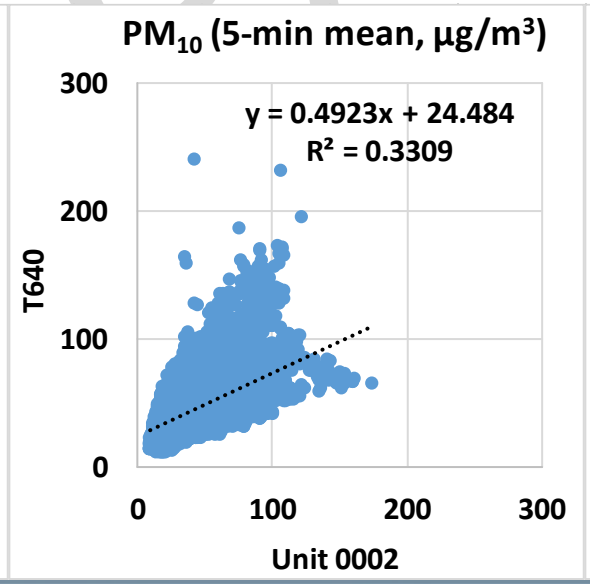


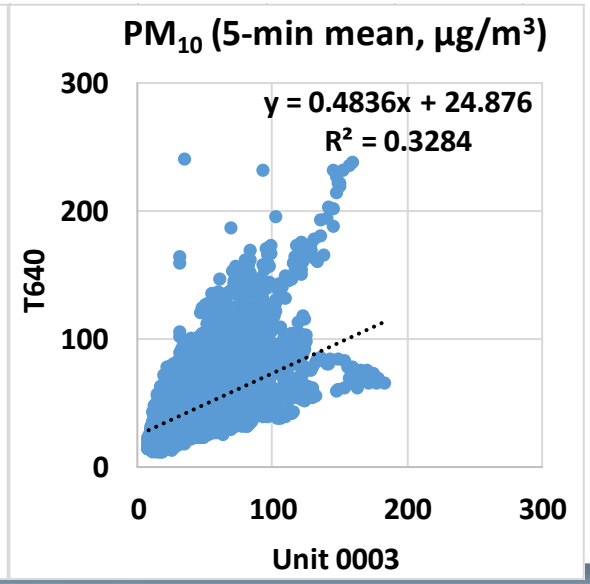
Polludrone Smart vs T640 (PM_{10}; 5-min mean)



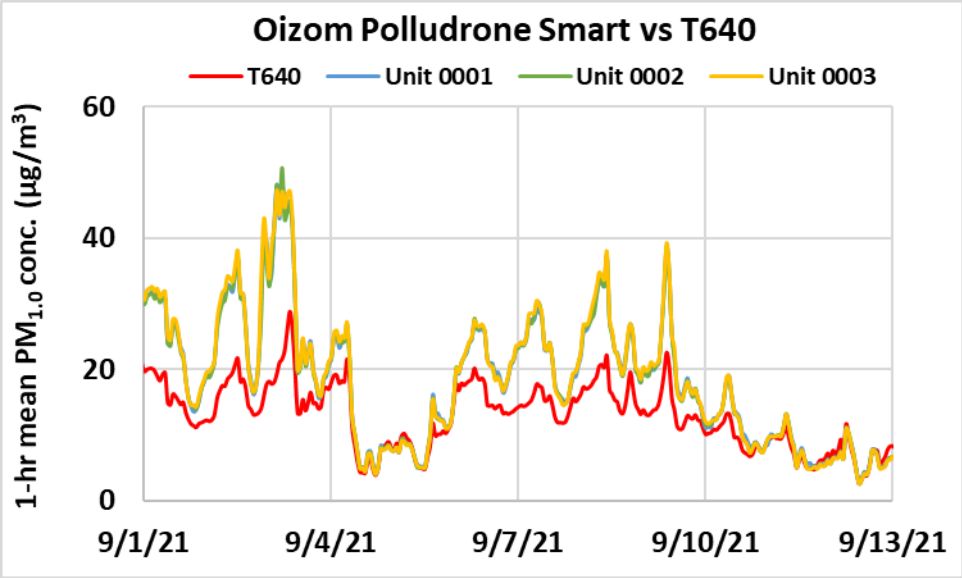
- Polludrone Smart sensors showed weak correlations with the corresponding T640 data ($0.32 < R^2 < 0.35$)
- Overall, the Polludrone Smart sensors underestimated the PM_{10} mass concentrations as measured by T640
- The Polludrone Smart sensors did not seem to track the PM_{10} diurnal variations as recorded by T640



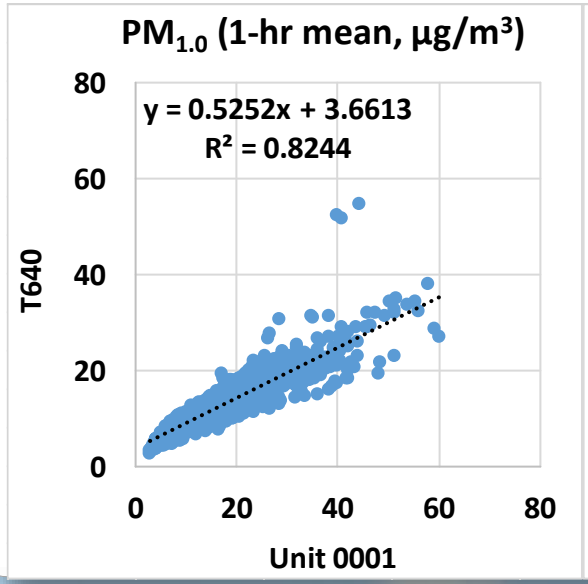


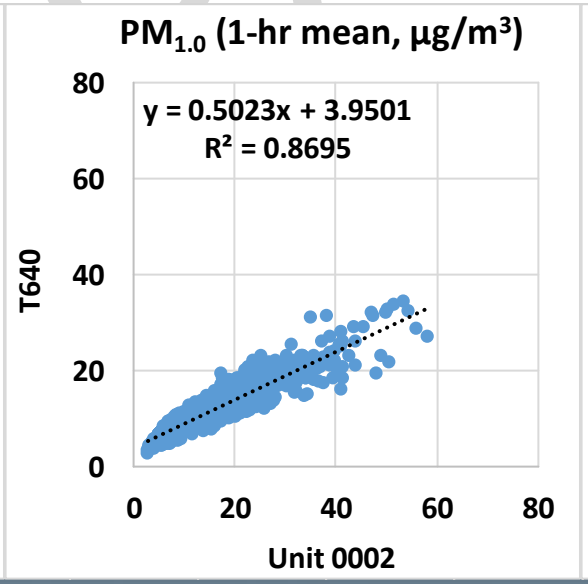


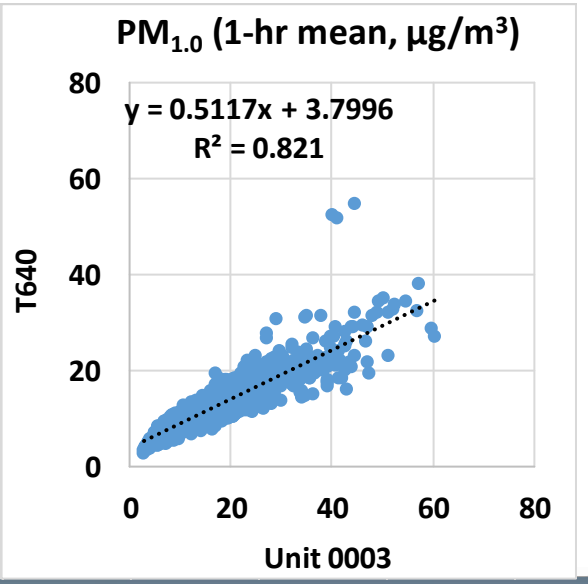
Polludrone Smart vs T640 ($PM_{1.0}$; 1-hr mean)



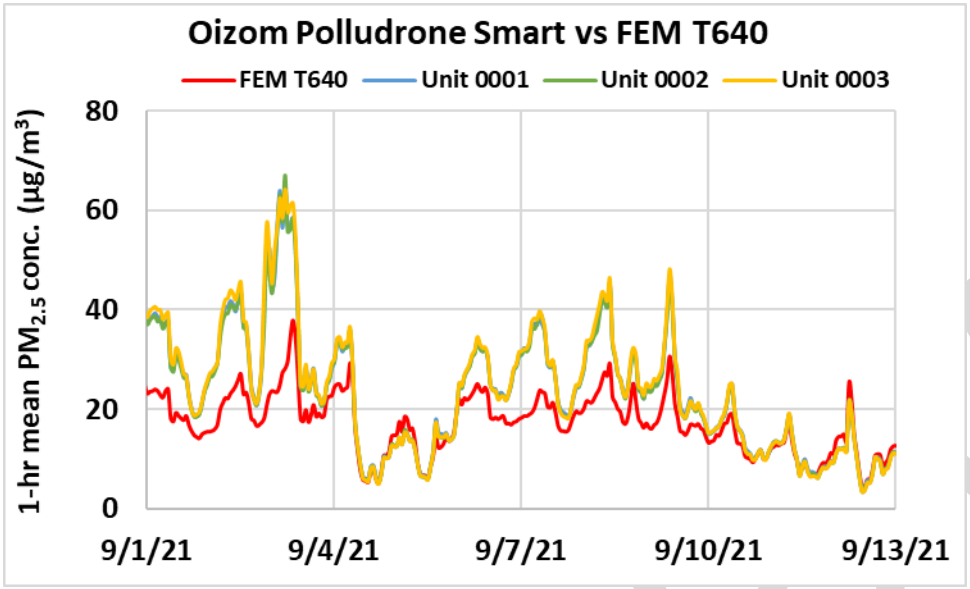
- The Polludrone Smart sensors showed strong correlations with the corresponding T640 data ($0.82 < R^2 < 0.87$)
- Overall, the Polludrone Smart sensors overestimated the $PM_{1.0}$ mass concentrations as measured by T640
- The Polludrone Smart sensors seemed to track the $PM_{1.0}$ diurnal variations as recorded by T640



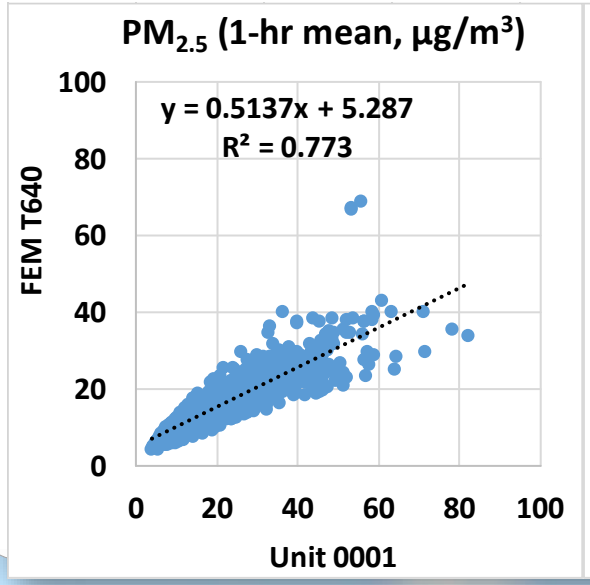


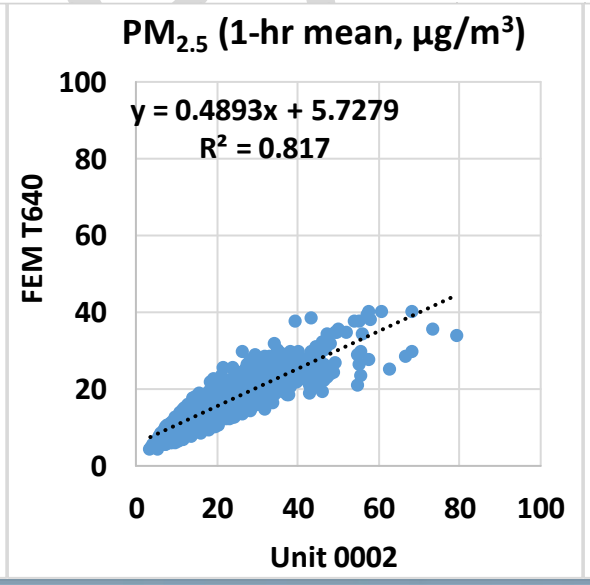


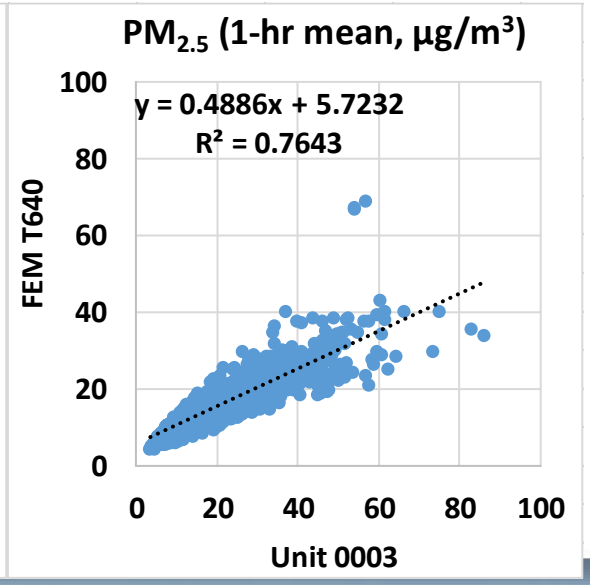
Polludrone Smart vs FEM T640 ($PM_{2.5}$; 1-hr mean)



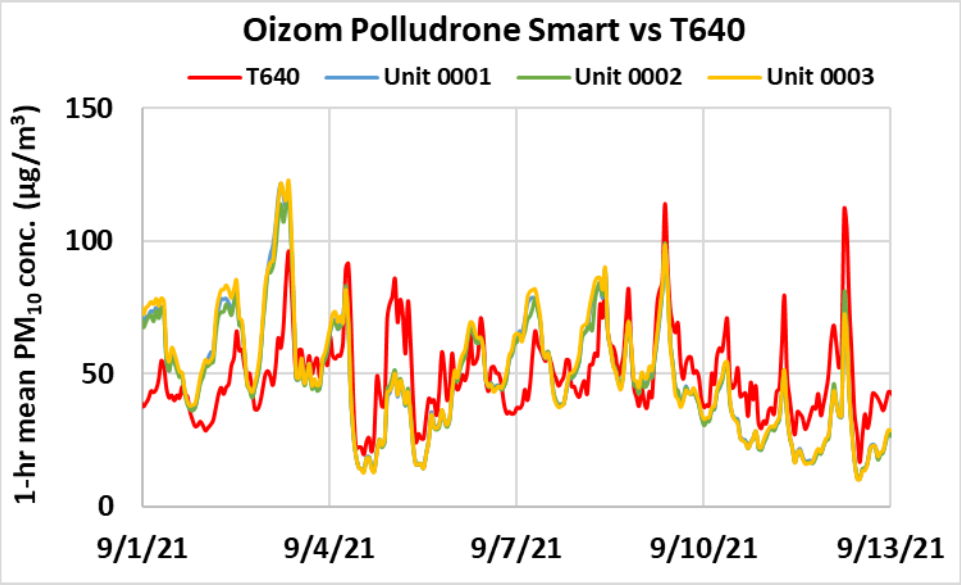
- The Polludrone Smart sensors showed strong correlations with the corresponding FEM T640 data ($0.76 < R^2 < 0.82$)
- Overall, the Polludrone Smart sensors overestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Polludrone Smart sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



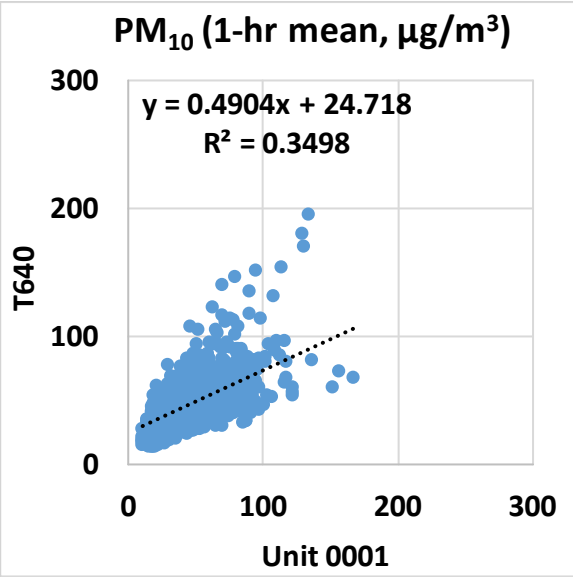


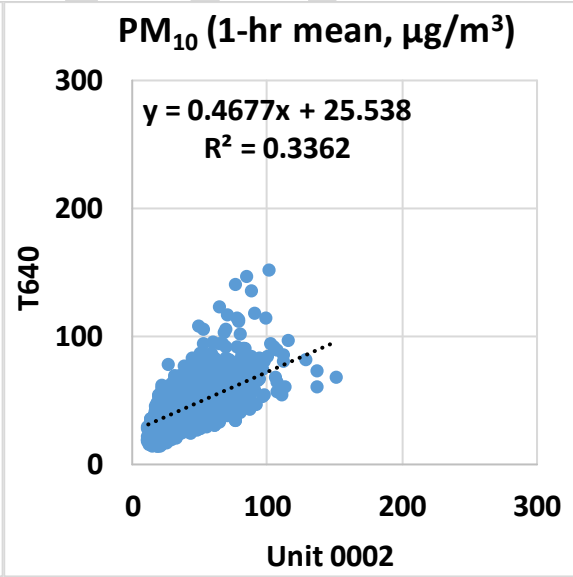


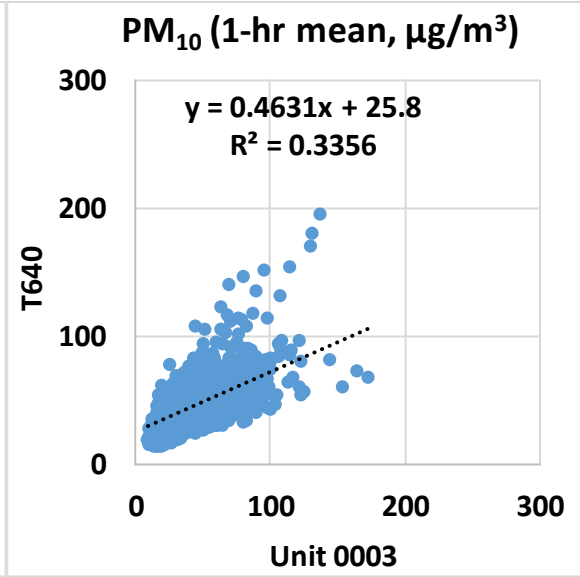
Polludrone Smart vs T640 (PM_{10}; 1-hr mean)



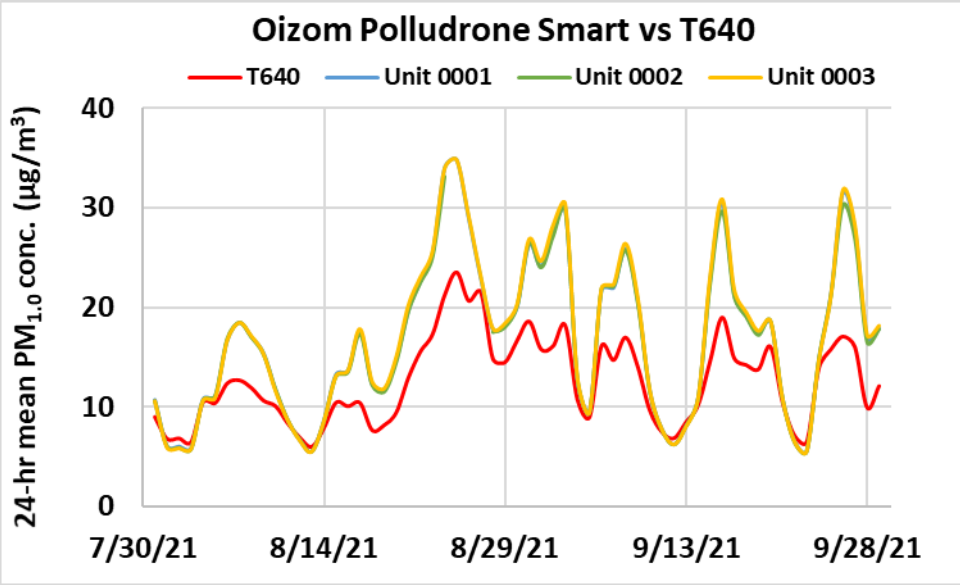
- The Polludrone Smart sensors showed weak correlations with the corresponding T640 data ($0.33 < R^2 < 0.35$)
- Overall, the Polludrone Smart sensors underestimated the PM_{10} mass concentrations as measured by T640
- The Polludrone Smart sensors did not seem to track the PM_{10} diurnal variations as recorded by T640



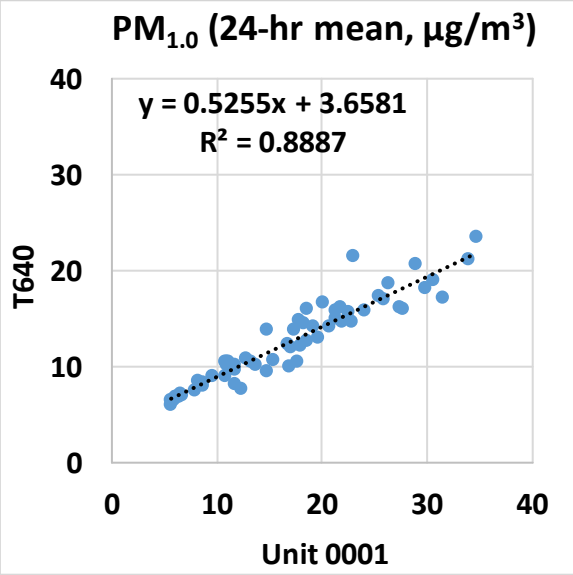


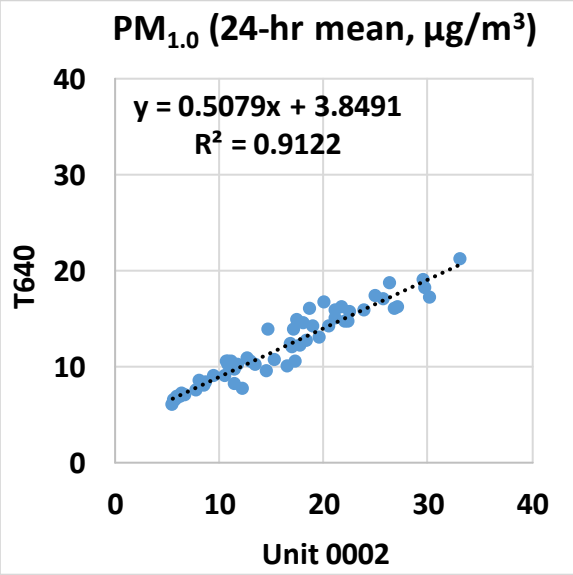


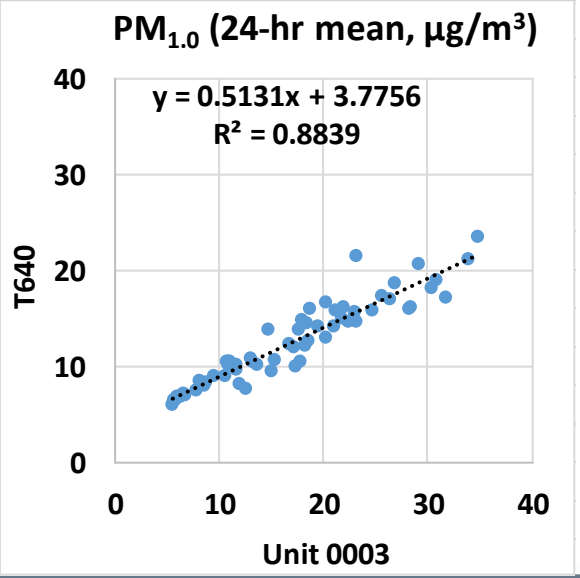
Polludrone Smart vs T640 ($PM_{1.0}$; 24-hr mean)



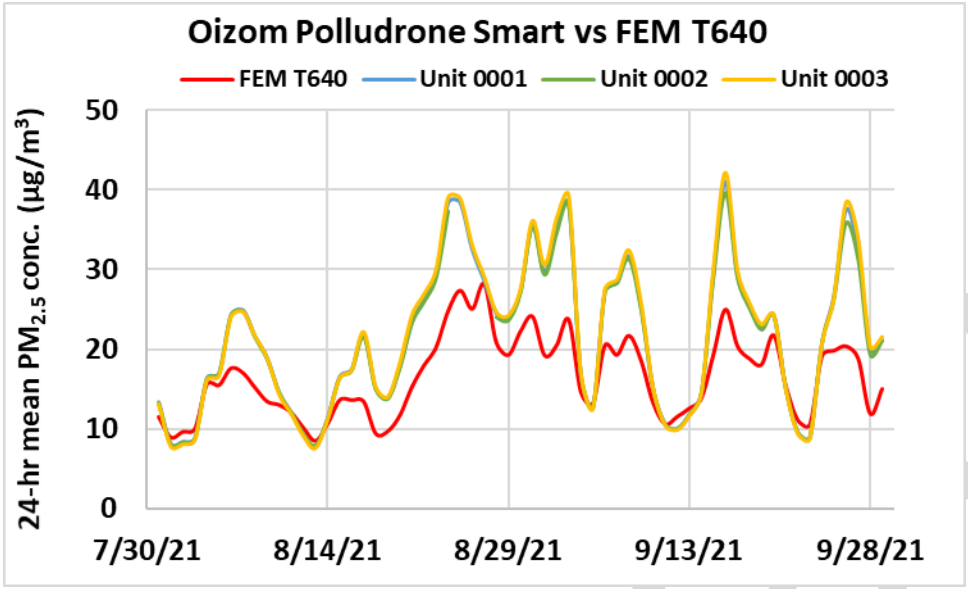
- The Polludrone Smart sensors showed strong to very strong correlations with the corresponding T640 data ($0.88 < R^2 < 0.92$)
- Overall, the Polludrone Smart sensors overestimated the $PM_{1.0}$ mass concentrations as measured by T640
- The Polludrone Smart sensors seemed to track the $PM_{1.0}$ diurnal variations as recorded by T640



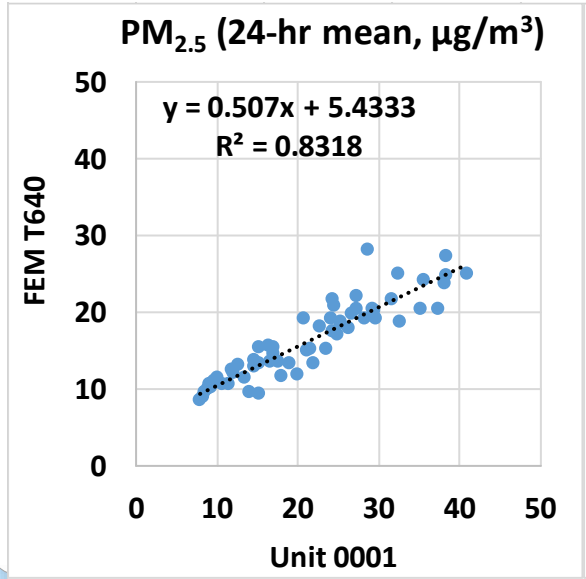


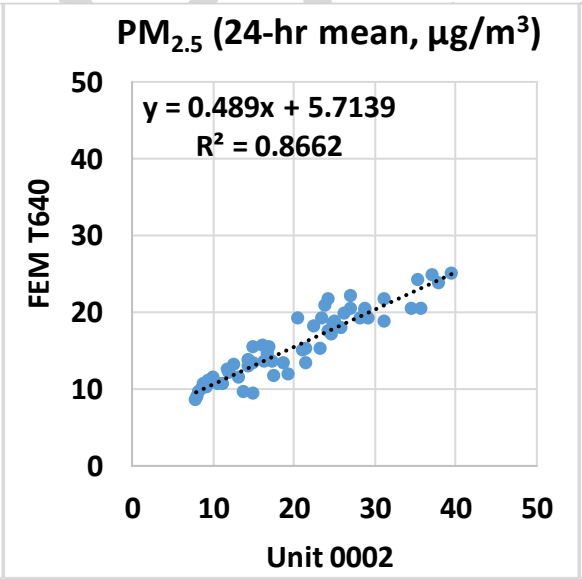


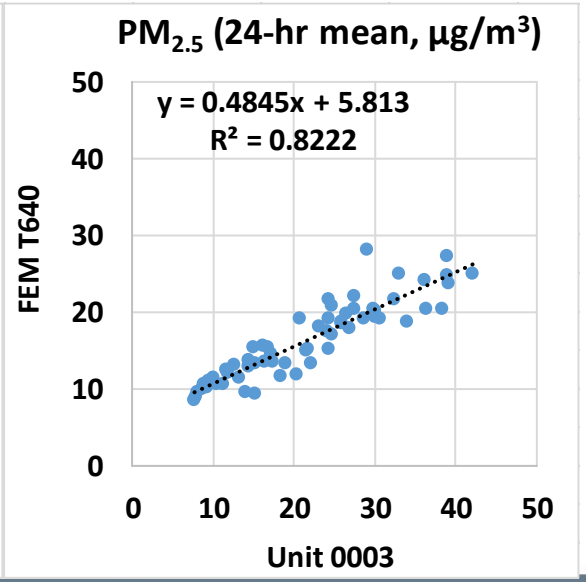
Polludrone Smart vs FEM T640 ($PM_{2.5}$; 24-hr mean)



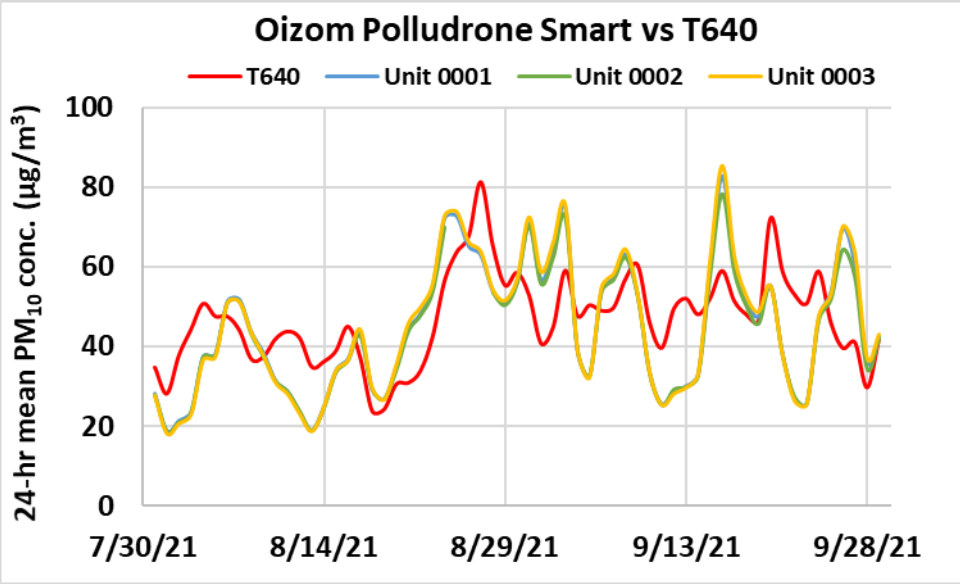
- The Polludrone Smart sensors showed strong correlations with the corresponding FEM T640 data ($0.82 < R^2 < 0.87$)
- Overall, the Polludrone Smart sensors overestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Polludrone Smart sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



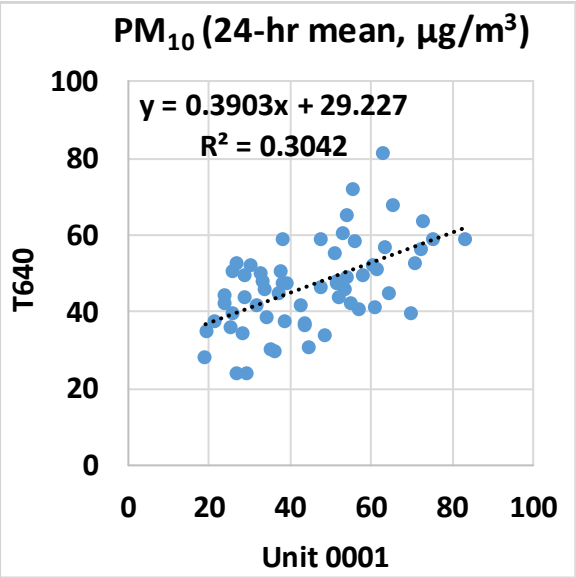


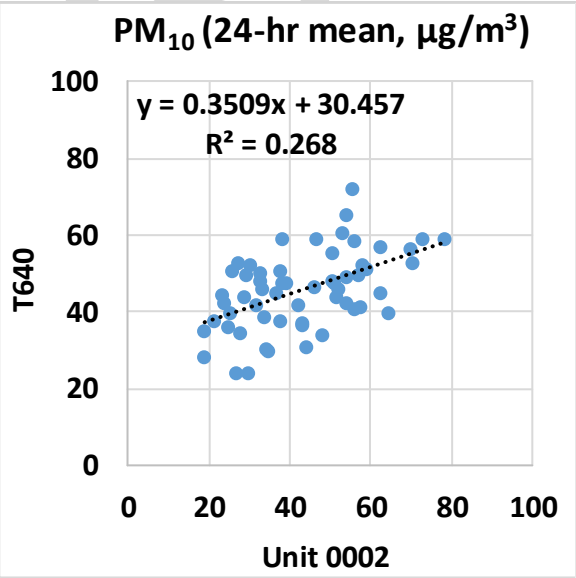


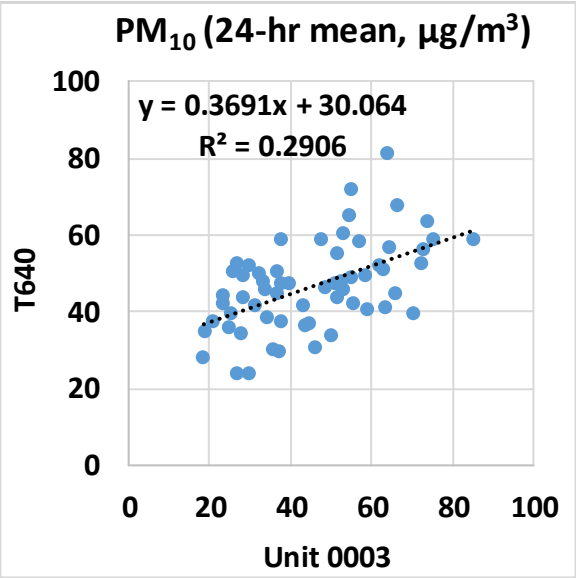
Polludrone Smart vs T640 (PM_{10}; 24-hr mean)



- The Polludrone Smart sensors showed very weak to weak correlations with the corresponding T640 data ($0.26 < R^2 < 0.31$)
- Overall, the Polludrone Smart sensors underestimated the PM_{10} mass concentrations as measured by T640
- The Polludrone Smart sensors did not seem to track the PM_{10} diurnal variations as recorded by T640







Summary

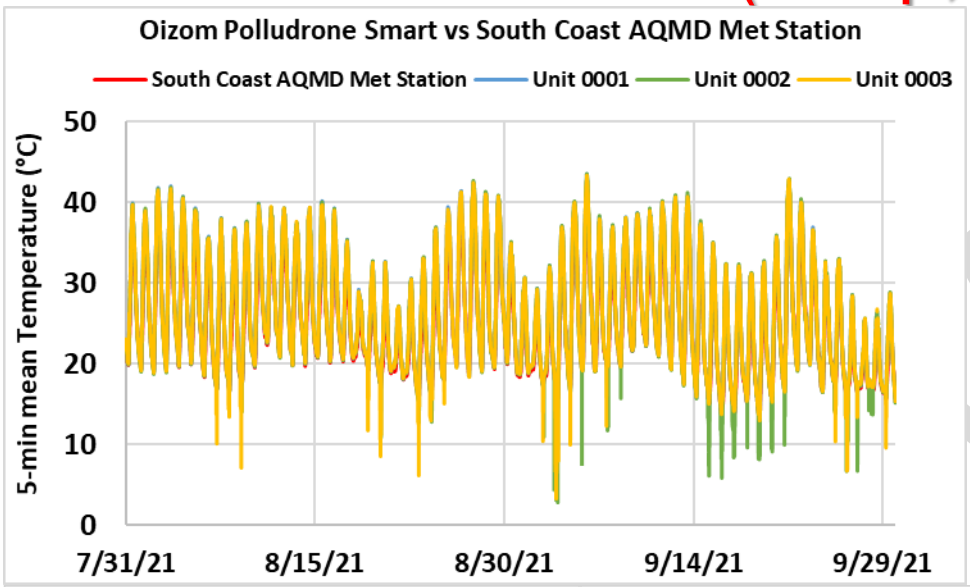
	Average of 3 Sensors, $PM_{1.0}$		Polludrone Smart vs T640, $PM_{1.0}$						T640 ($PM_{1.0}$, $\mu g/m^3$)		
	Average ($\mu g/m^3$)	SD ($\mu g/m^3$)	R^2	Slope	Intercept	MBE[1] ($\mu g/m^3$)	MAE[2] ($\mu g/m^3$)	RMSE[3] ($\mu g/m^3$)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	16.8	9.7	0.82 to 0.86	0.50 to 0.53	3.6 to 3.9	4.1 to 4.6	4.5 to 5.0	6.5 to 7.1	12.6	5.7	2.3 to 62.5
1-hr	16.8	9.6	0.82 to 0.87	0.50 to 0.53	3.7 to 4.0	4.1 to 4.6	4.4 to 4.9	6.4 to 7.1	12.6	5.6	2.7 to 54.8
24-hr	16.8	7.7	0.88 to 0.91	0.51 to 0.53	3.7 to 3.8	4.1 to 4.6	4.3 to 4.8	5.6 to 6.2	12.6	4.3	6.0 to 23.6
	Average of 3 Sensors, $PM_{2.5}$		Polludrone Smart vs FEM T640, $PM_{2.5}$						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	21.5	11.7	0.76 to 0.81	0.49 to 0.52	5.3 to 5.7	4.9 to 5.5	5.4 to 6.1	8.0 to 9.0	16.4	6.9	3.4 to 78.1
1-hr	21.4	11.6	0.76 to 0.82	0.49 to 0.51	5.3 to 5.7	4.9 to 5.5	5.4 to 6.1	7.9 to 8.9	16.4	6.8	4.2 to 68.8
24-hr	21.4	9.0	0.82 to 0.87	0.48 to 0.51	5.4 to 5.8	4.9 to 5.5	5.3 to 5.9	6.8 to 7.6	16.4	5.0	8.4 to 28.1
	Average of 3 Sensors, PM_{10}		Polludrone Smart vs T640, PM_{10}						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	44.5	21.8	0.33 to 0.34	0.48 to 0.51	23.7 to 24.9	-2.6 to -1.5	14.3 to 15.5	17.9 to 19.8	46.8	19.3	10.8 to 240.6
1-hr	44.5	21.5	0.34 to 0.35	0.46 to 0.49	24.7 to 25.8	-2.6 to -1.5	14.1 to 15.3	17.3 to 19.1	46.8	18.1	13.3 to 194.7
24-hr	44.5	15.8	0.27 to 0.30	0.35 to 0.39	29.2 to 30.5	-2.5 to -1.5	11.3 to 12.3	13.1 to 14.2	46.8	11.3	23.7 to 81.3

[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).

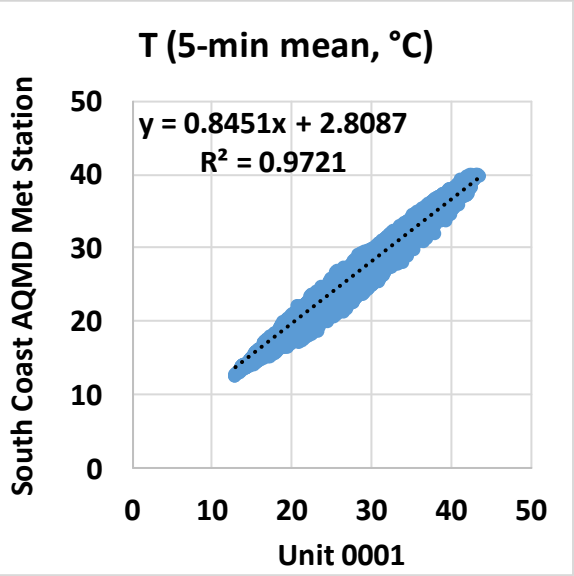
[2] Mean Absolute Error (MAE): the absolute difference between the sensors and the reference instruments. The larger MAE values, the higher measurement errors as compared to the reference instruments.

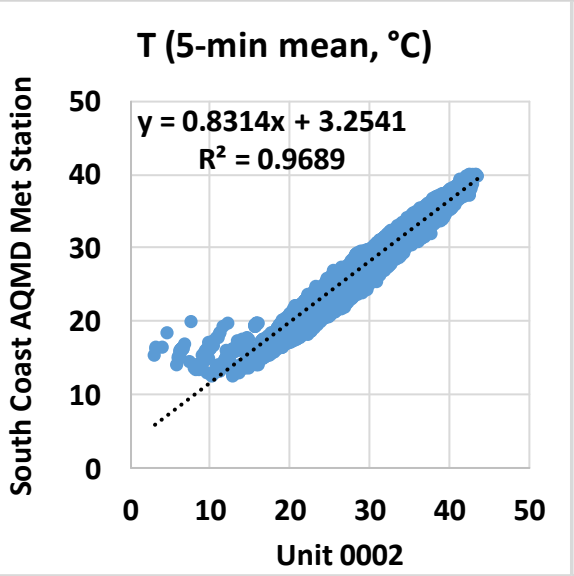
[3] Root Mean Square Error (RMSE): another metric to calculate measurement errors.

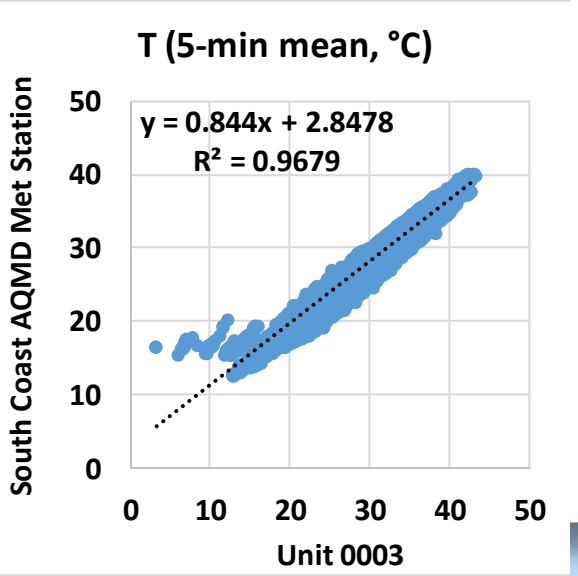
Oizom Polludrone Smart vs South Coast AQMD Met Station (Temp; 5-min mean)



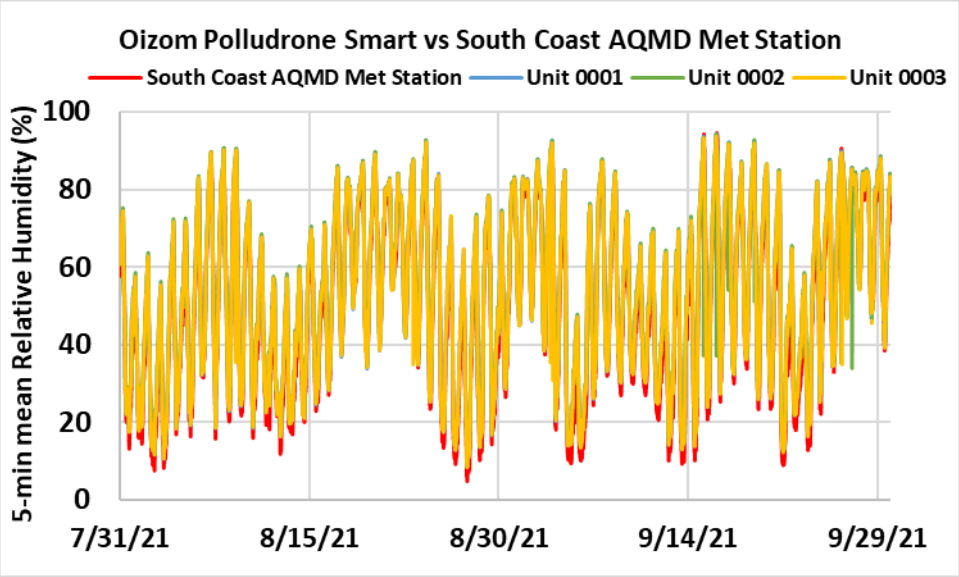
- The Polludrone Smart sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data (R^2 ~ 0.97)
- Overall, the Polludrone Smart temperature measurements overestimated the corresponding South Coast AQMD Met Station data
- The Polludrone Smart sensors seemed to track the temperature diurnal variations as recorded by South Coast AQMD Met Station



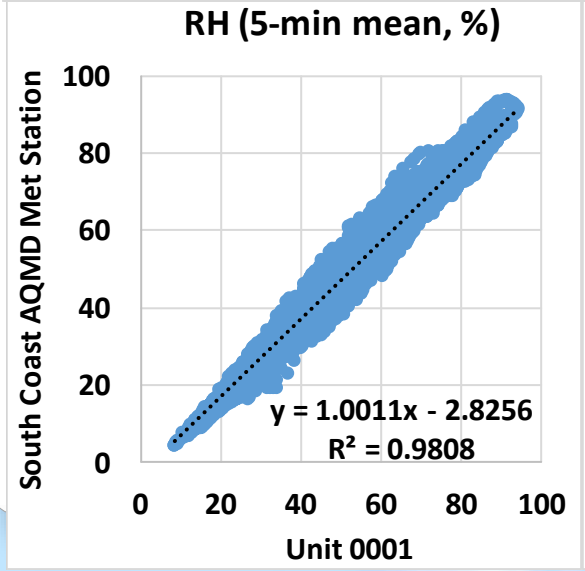


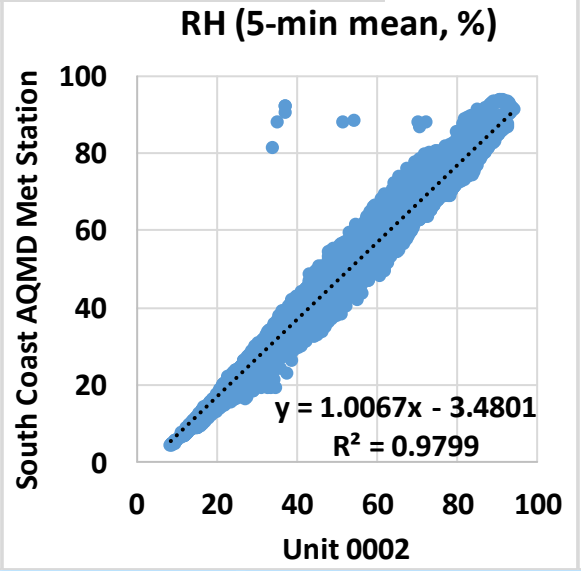


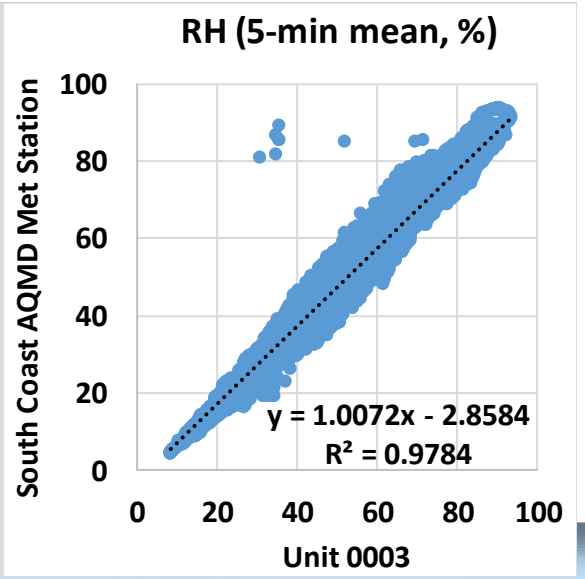
Oizom Polludrone Smart vs South Coast AQMD Met Station (RH; 5-min mean)



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







Discussion

- The three **Polludrone Smart** sensors' data recovery from Unit 0001, Unit 0002 and Unit 0003 was ~ 99%, 95% and 99% for all PM measurements, respectively
- The absolute intra-model variability was ~ 0.13, 0.20 and 0.48 µg/m^3 for $PM_{1.0}$, $PM_{2.5}$ and $PM_{10,}$ respectively
- $PM_{1.0}$ mass concentrations measured by the Polludrone Smart sensors showed strong correlations with the corresponding T640 data ($0.82 < R^2 < 0.87$, 1-hr mean). The sensors overestimated $PM_{1.0}$ mass concentrations as measured by T640
- $PM_{2.5}$ mass concentrations measured by the Polludrone Smart sensors showed strong correlations with the corresponding FEM T640 data ($0.76 < R^2 < 0.82$, 1-hr mean). The sensors overestimated $PM_{2.5}$ mass concentrations as measured by FEM T640
- PM_{10} mass concentrations measured by the Polludrone Smart sensors showed weak correlations with the corresponding T640 data ($0.33 < R^2 < 0.35$; 1-hr mean). The sensors underestimated PM_{10} mass concentrations as measured by 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