Field Evaluation
Strop de aer

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 06/02/2022 to 08/02/2022, three **Strop de aer** 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

- Strop de aer (*3 units tested*):
  - $PM_{2.5}$ – Optical Particle Counter (SDS011 by Nova Fitness, non-FEM)
  - Each unit measures: $PM_{2.5}$ (µg/m^3), PM_{10} (µg/m^3), T (°C), RH (%)
  - Unit cost: $175 (Standard Version)
  - Time resolution: 1-min
  - Units IDs: Test1, Test2, and Test3

Note: the sensor uses proprietary heated inlet that activates when RH is over 60-70%.

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)
  - Unit cost: ~$21,000
  - Time resolution: 1-min
- Met Station (T, RH, P, WS, WD)
  - Unit cost: ~$5,000
  - Time resolution: 1-min

FEM GRIMM

FEM T640

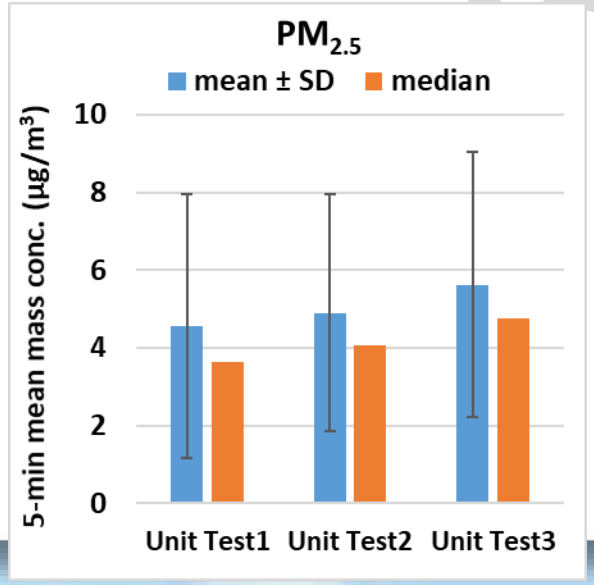
Data validation & recovery

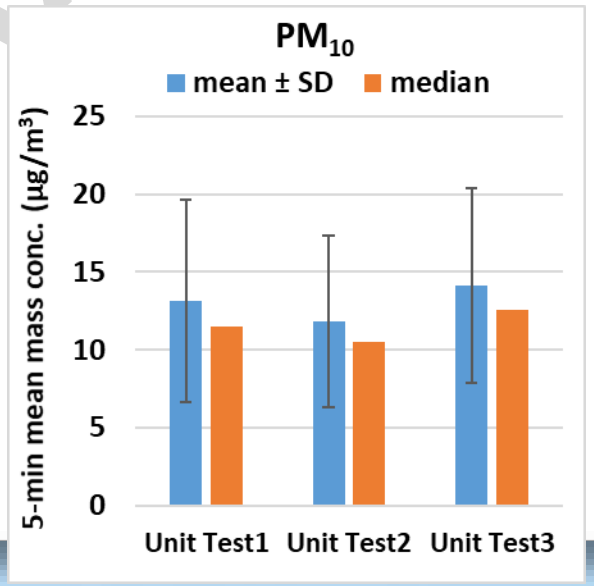
- Basic QA/QC procedures were used to validate the collected data (i.e., obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery from Units Test1, Test2 and Test3 was 74.1%, 81.2% and 82.7% for all PM measurements, respectively

Note: Data from 7/4/2022 20:00 to 7/5/2022 12:59 PST were excluded from data analysis for all sensors and reference instruments to exclude the effect of 4th of July activities.

Strop de aer; intra-model variability

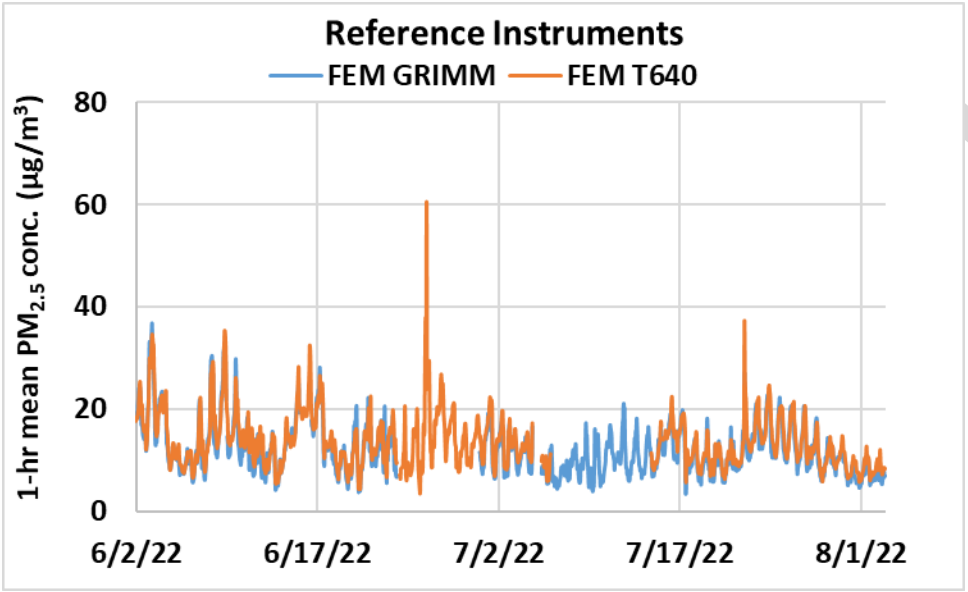
- Absolute intra-model variability was ~0.44 and ~0.93 µg/m^3 for $PM_{2.5}$ and PM_{10}, respectively (calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was ~8.8% and ~7.1% for $PM_{2.5}$ and PM_{10}, respectively (calculated as the absolute intra-model variability relative to the mean of the three sensor means)

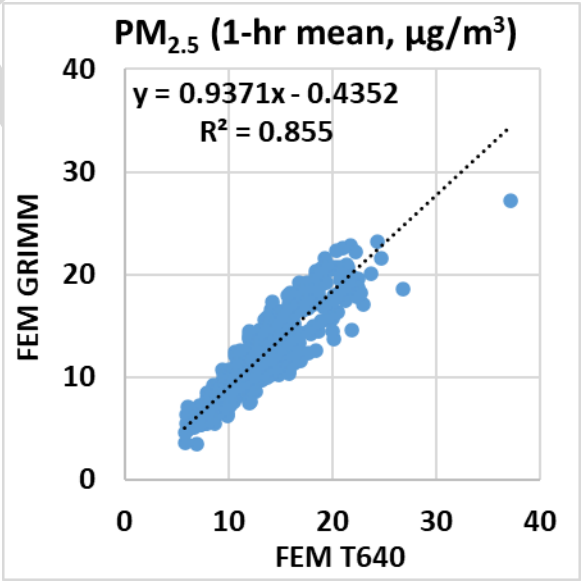




Reference Instruments: $PM_{2.5}$ FEM GRIMM and FEM T640

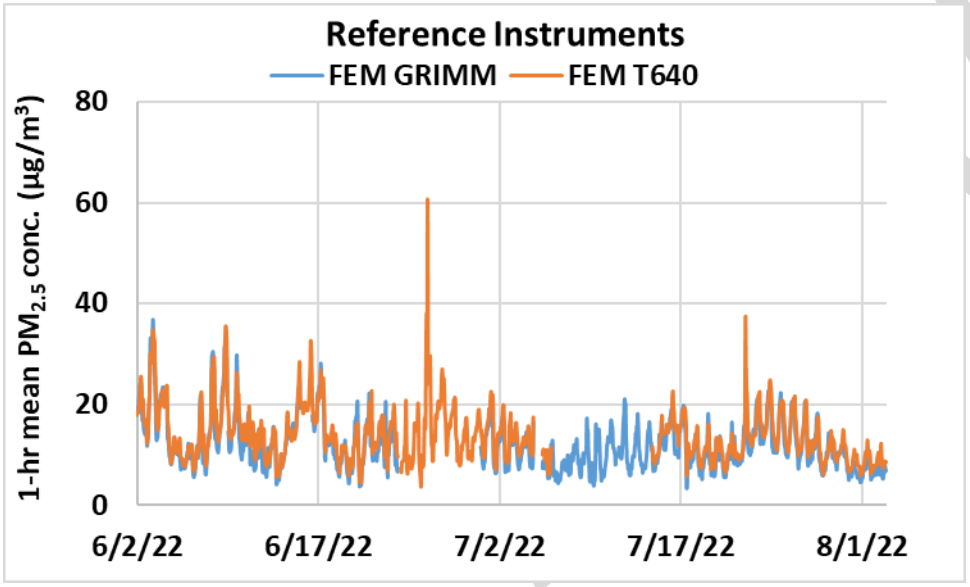
- Data recovery for $PM_{2.5}$ from FEM GRIMM and FEM T640 was ~98% and ~86%, respectively.
- Strong correlations between the reference instruments for $PM_{2.5}$ measurements (R^2 ~0.86) were observed.

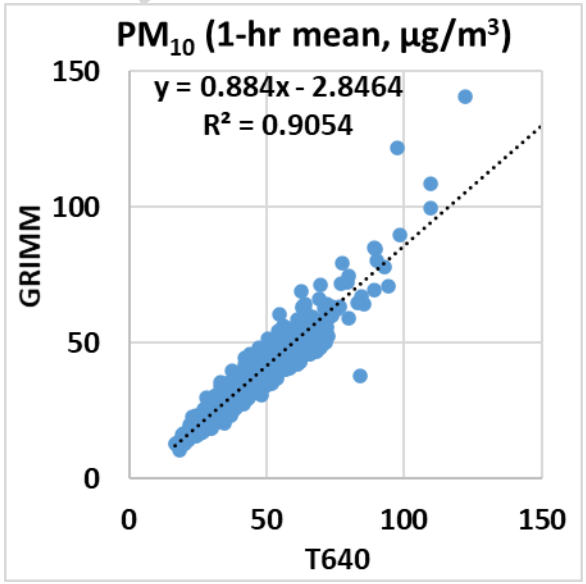




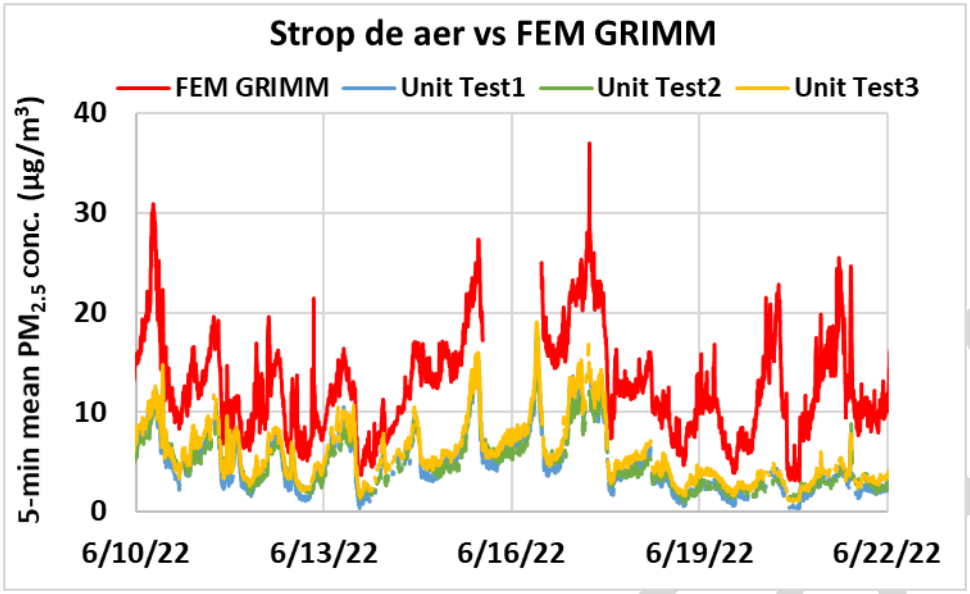
Reference Instruments: PM_{10} GRIMM and T640

- Data recovery for PM_{10} from GRIMM and T640 was ~98% and ~86%, respectively.
- Very strong correlations between the reference instruments for PM_{10} measurements (R^2 ~0.91) were observed.

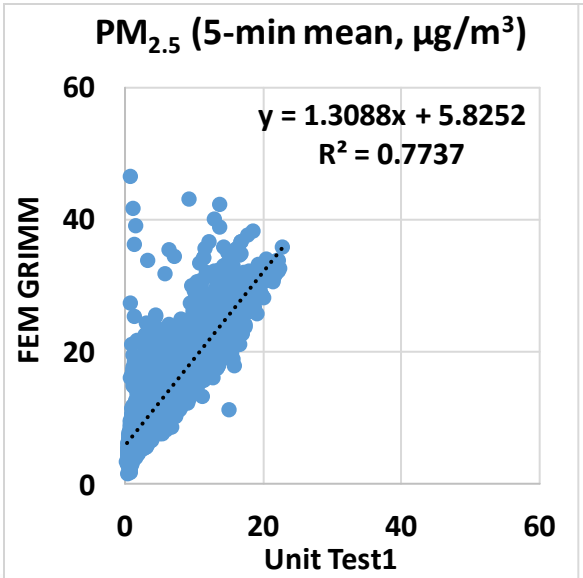


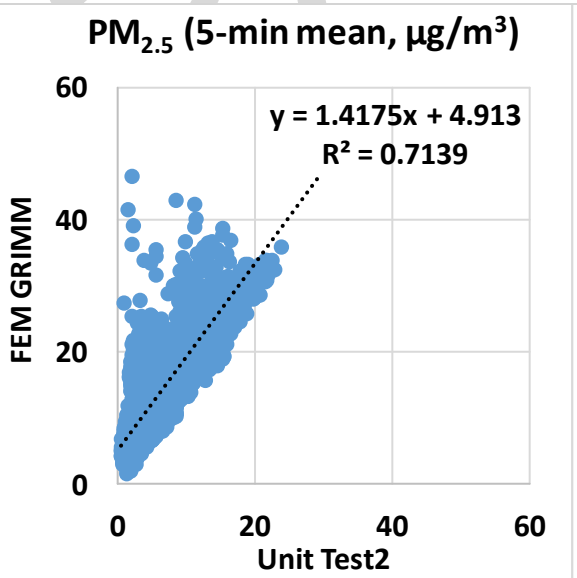


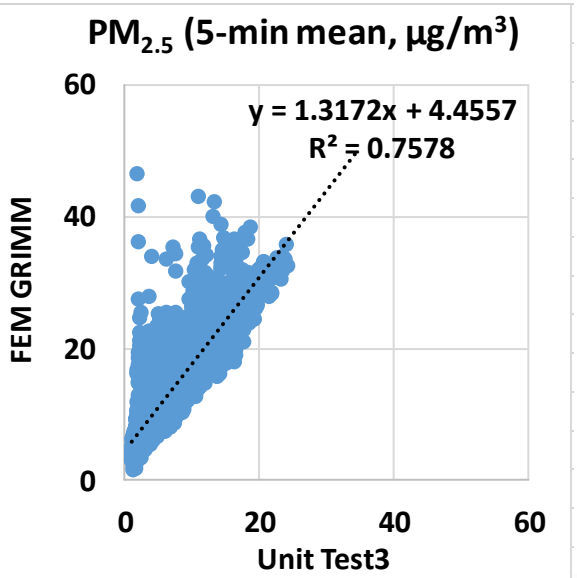
Strop de aer vs FEM GRIMM ($PM_{2.5}$; 5-min mean)



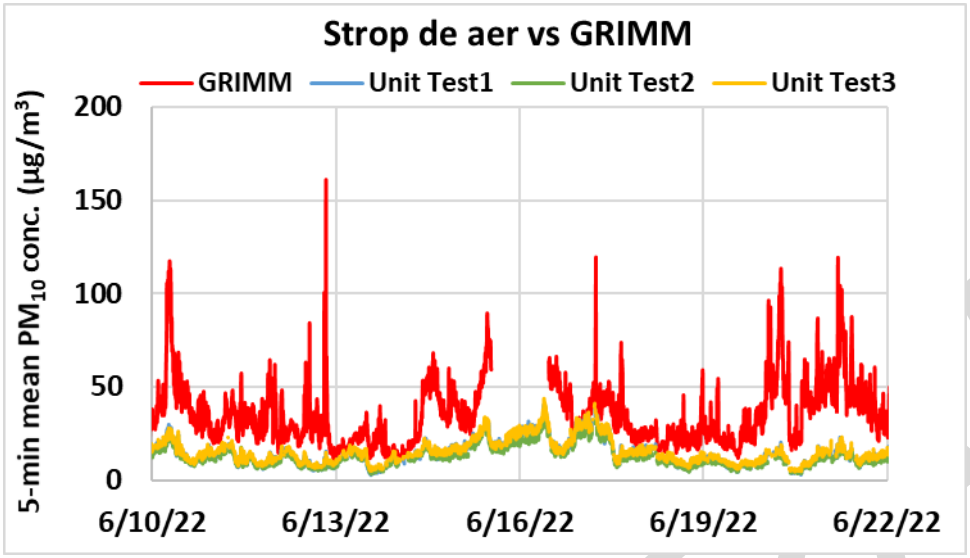
- The Strop de aer sensors showed strong correlations with the corresponding FEM GRIMM data ($0.71 < R^2 < 0.78$)
- Overall, the Strop de aer sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM GRIMM
- The Strop de aer sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM GRIMM



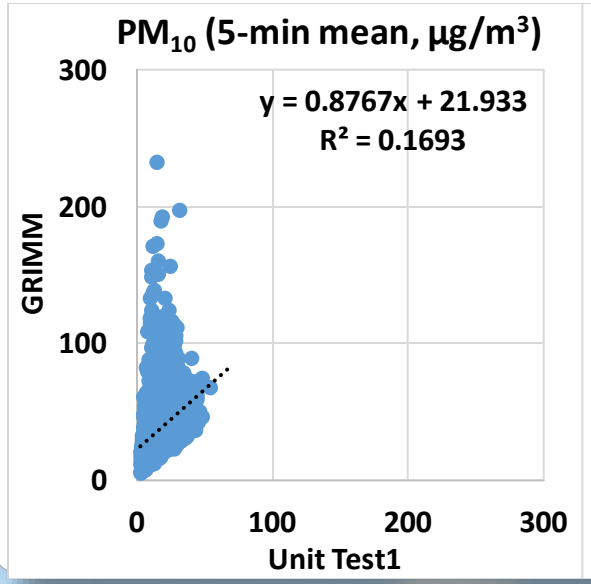


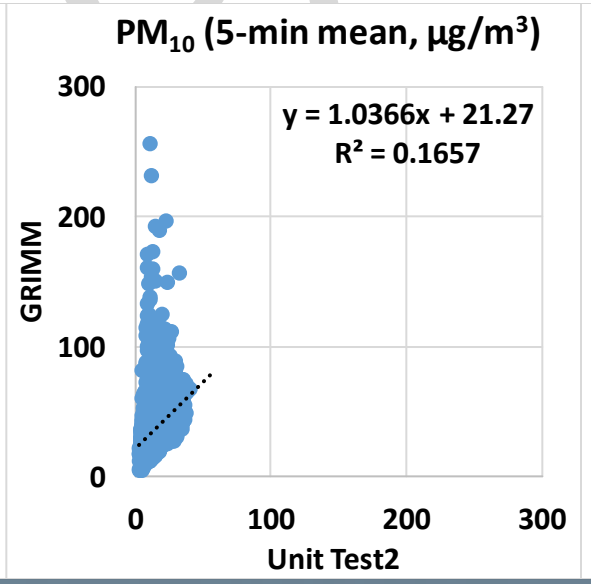


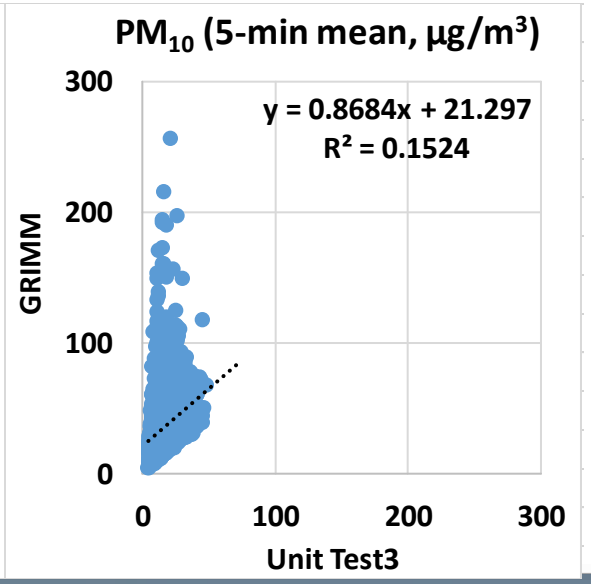
Strop de aer vs GRIMM (PM_{10}; 5-min mean)



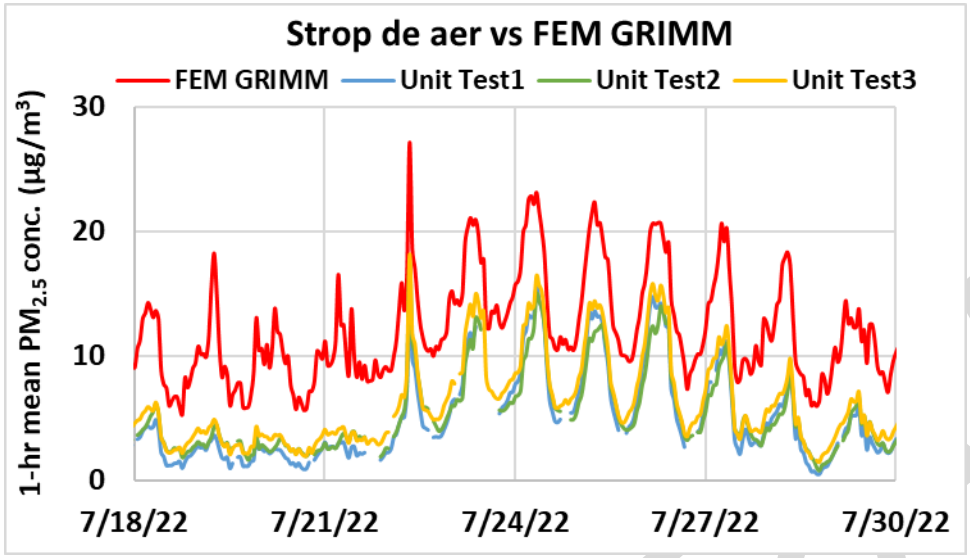
- The Strop de aer sensors showed very weak correlations with the corresponding GRIMM data ($0.15 < R^2 < 0.17$)
- Overall, the Strop de aer sensors underestimated the PM_{10} mass concentrations as measured by GRIMM
- The Strop de aer sensors did not seem to track the PM_{10} diurnal variations as recorded by GRIMM



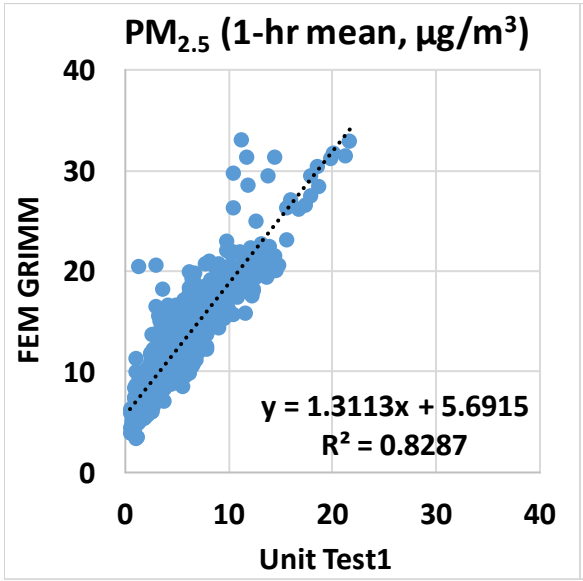


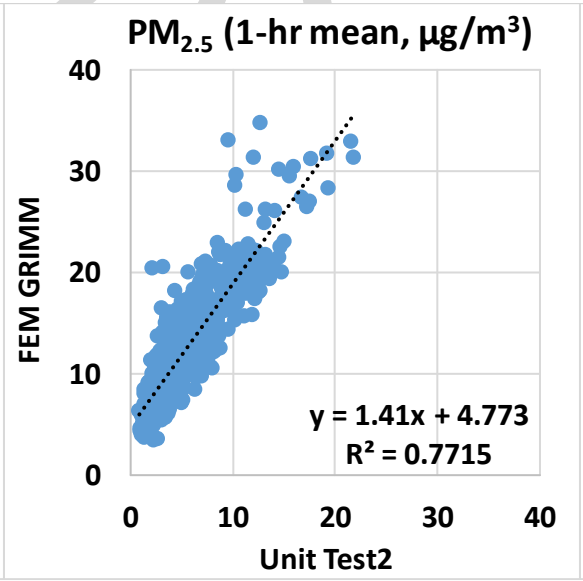


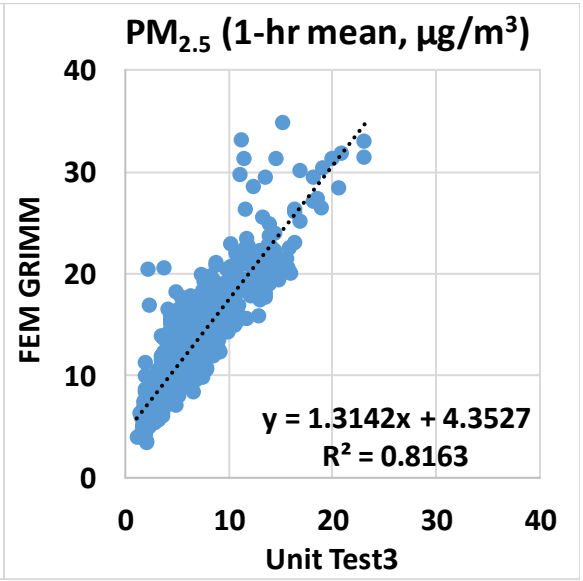
Strop de aer vs FEM GRIMM ($PM_{2.5}$; 1-hr mean)



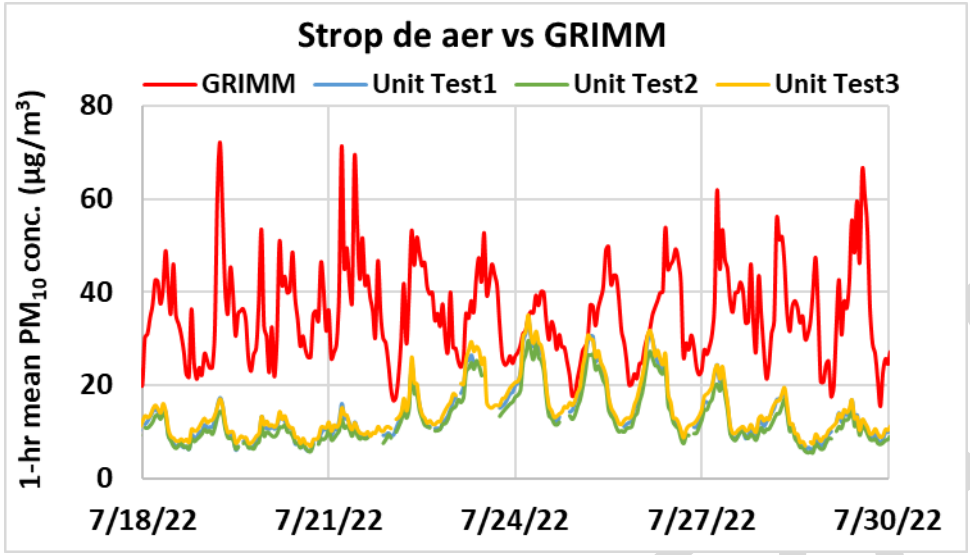
- The Strop de aer sensors showed strong correlations with the corresponding FEM GRIMM data ($0.77 < R^2 < 0.83$)
- Overall, the Strop de aer sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM GRIMM
- The Strop de aer sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM GRIMM



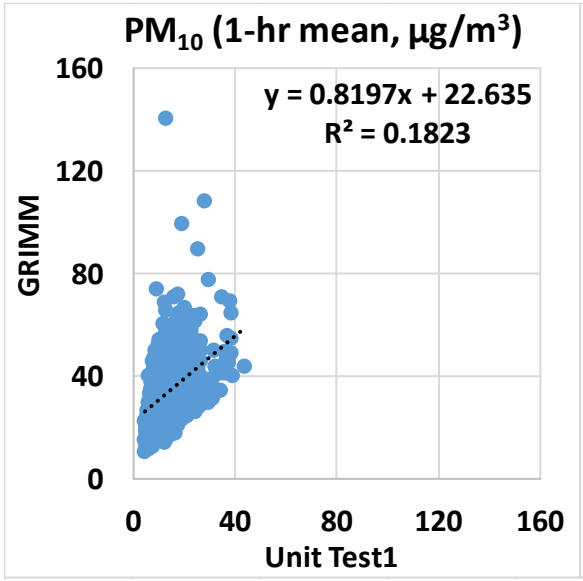


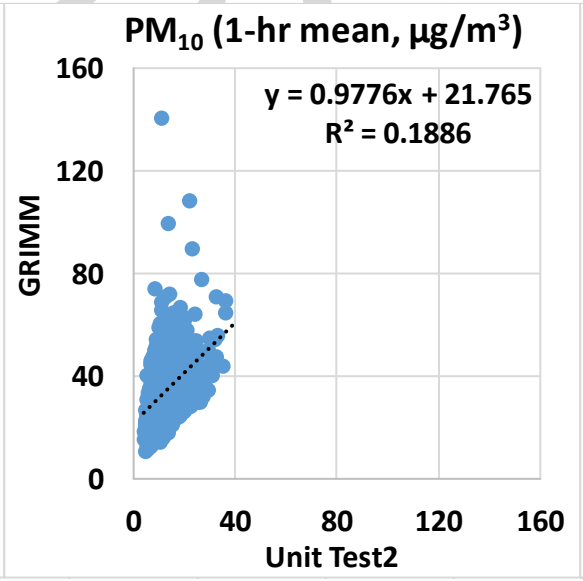


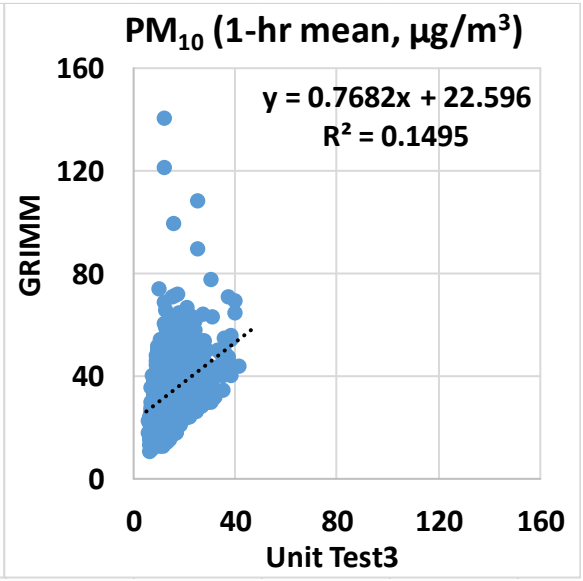
Strop de aer vs GRIMM (PM_{10}; 1-hr mean)



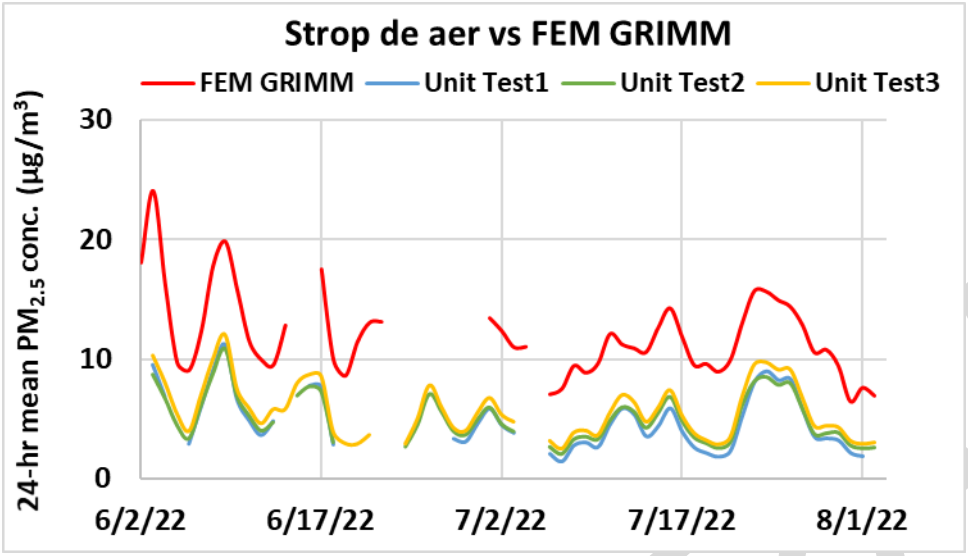
- The Strop de aer sensors showed very weak correlations with the corresponding GRIMM data ($0.14 < R^2 < 0.19$)
- Overall, the Strop de aer sensors underestimated the PM_{10} mass concentrations as measured by GRIMM
- The Strop de aer sensors did not seem to track the PM_{10} diurnal variations as recorded by GRIMM



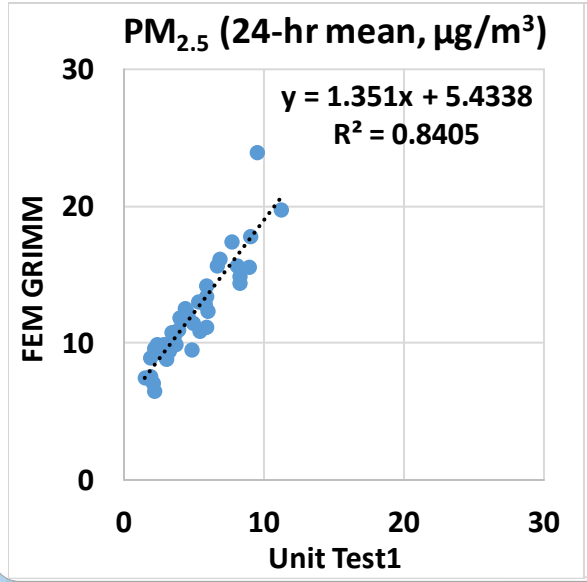


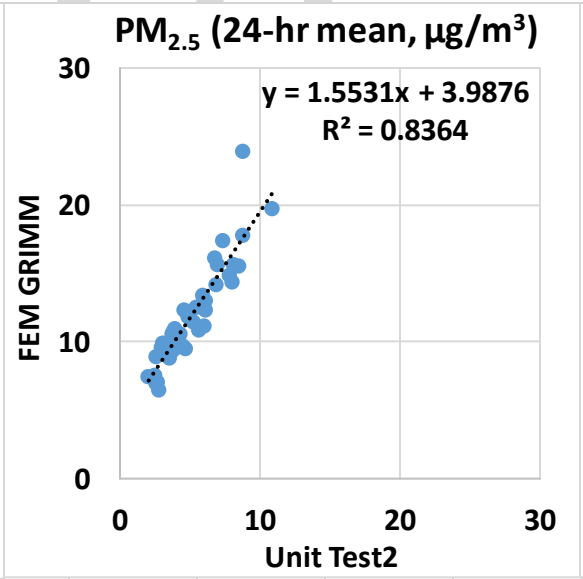


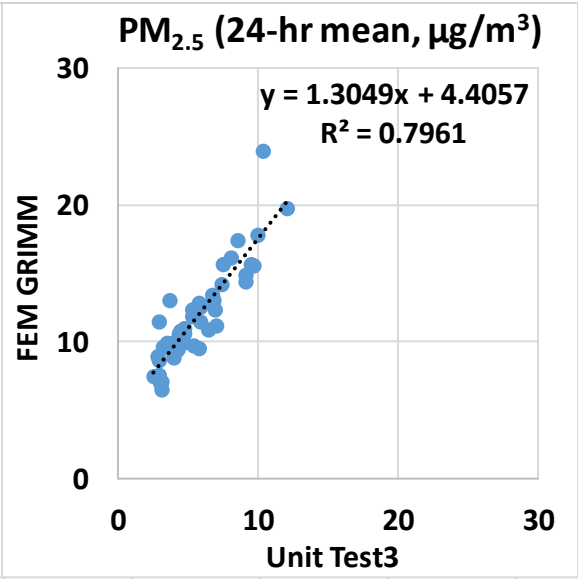
Strop de aer vs FEM GRIMM ($PM_{2.5}$; 24-hr mean)



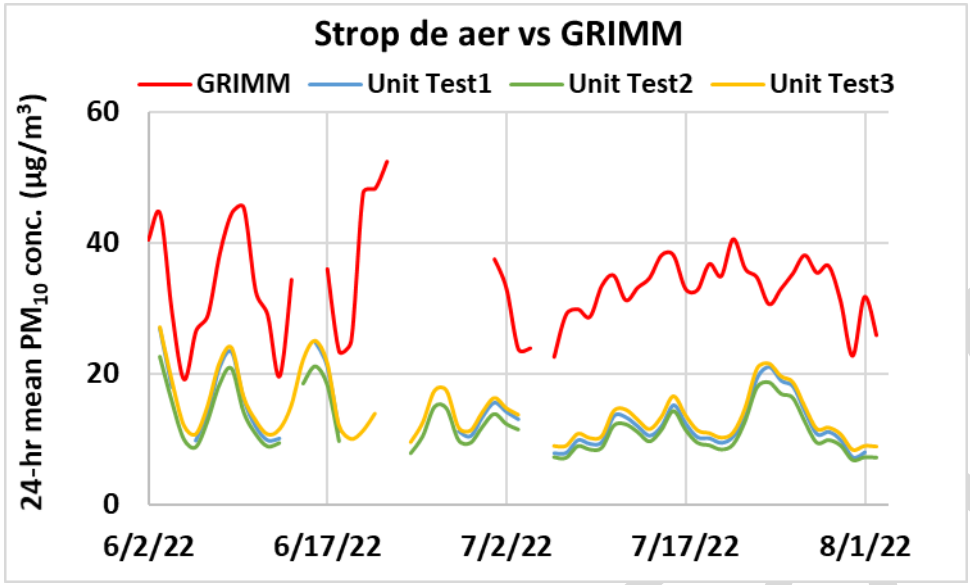
- The Strop de aer sensors showed strong correlations with the corresponding FEM GRIMM data ($0.79 < R^2 < 0.85$)
- Overall, the Strop de aer sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM GRIMM
- The Strop de aer sensors seemed to track the $PM_{2.5}$ daily variations as recorded by FEM GRIMM



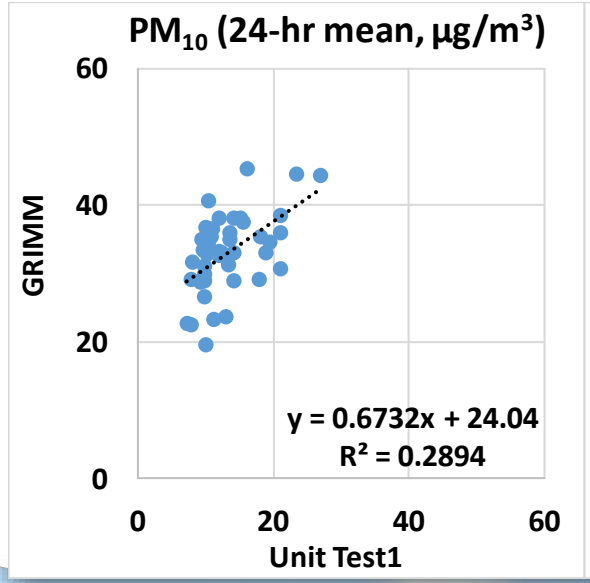


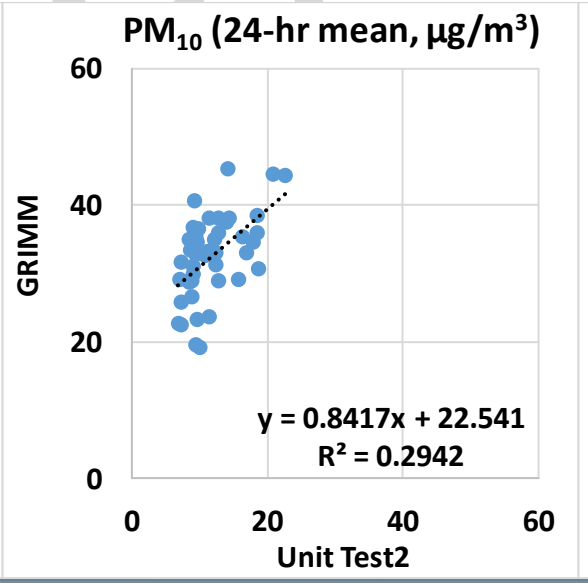


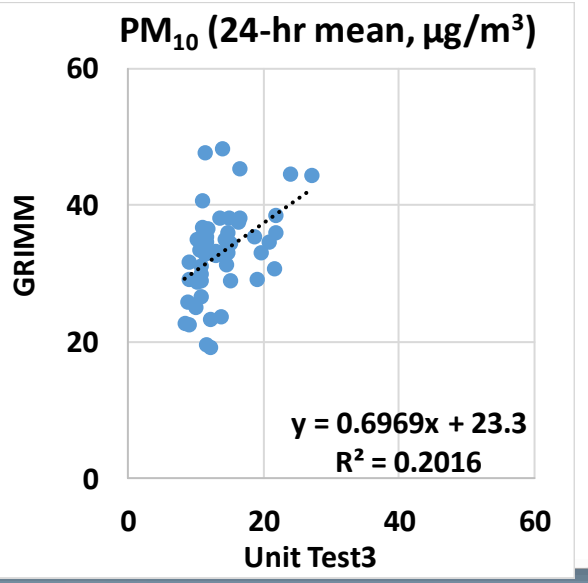
Strop de aer vs GRIMM (PM_{10}; 24-hr mean)



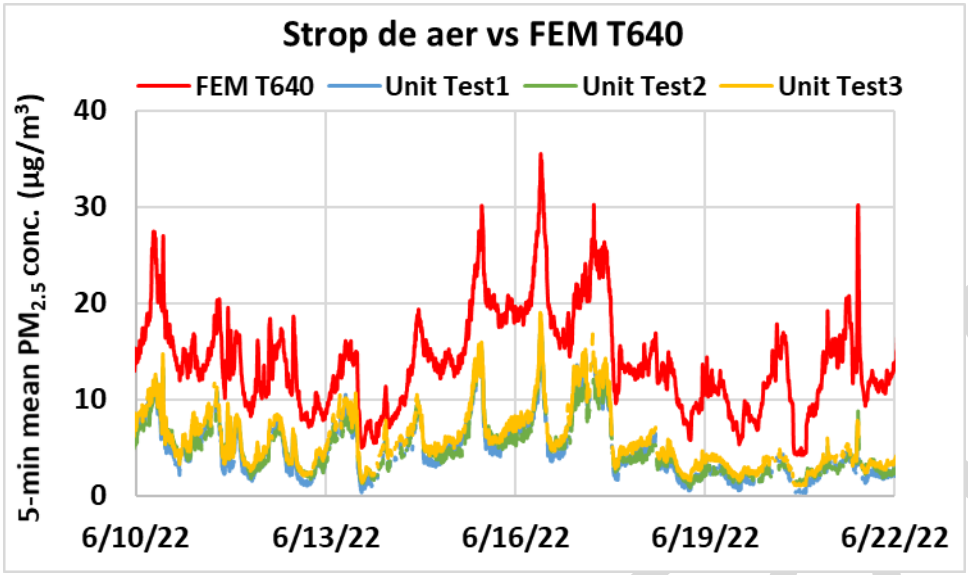
- The Strop de aer sensors showed very weak correlations with the corresponding GRIMM data ($0.20 < R^2 < 0.30$)
- Overall, the Strop de aer sensors underestimated the PM_{10} mass concentrations as measured by GRIMM
- The Strop de aer sensors did not seem to track the PM_{10} daily variations as recorded by GRIMM



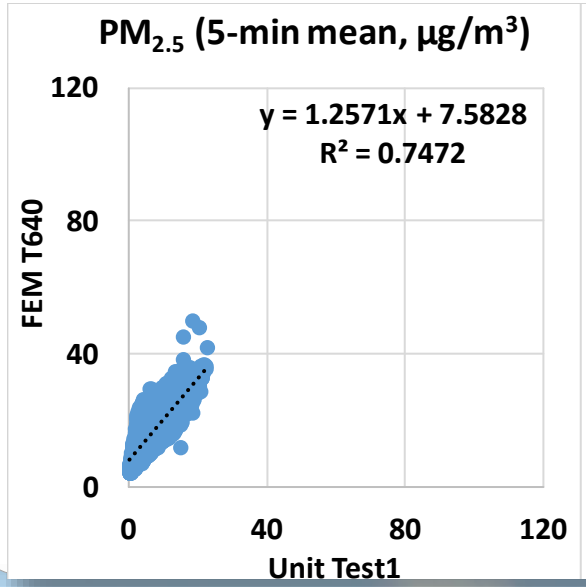


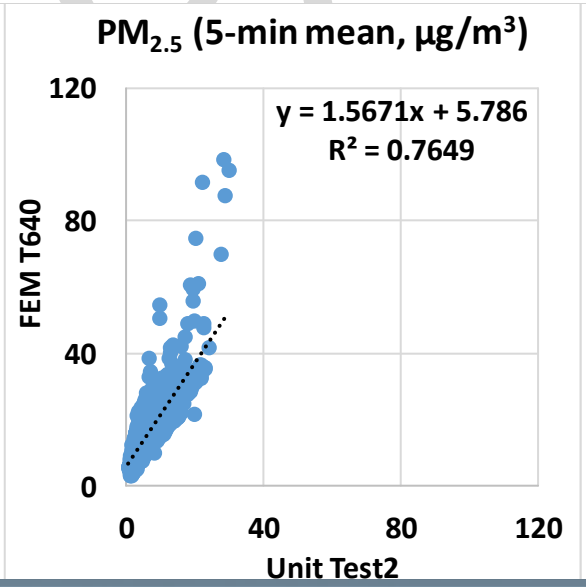


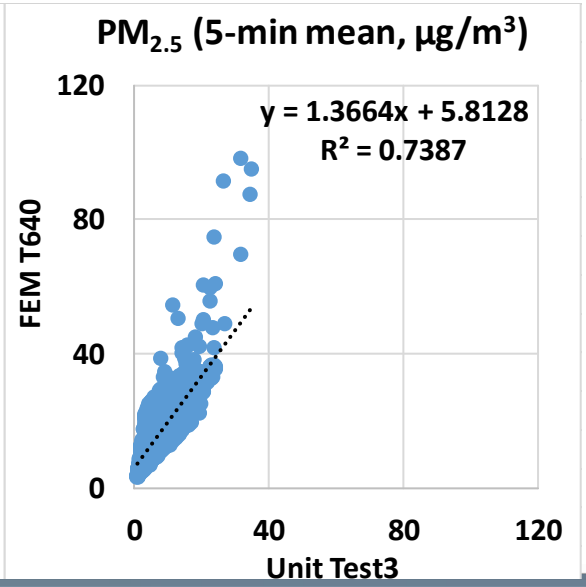
Strop de aer vs FEM T640 ($PM_{2.5}$; 5-min mean)



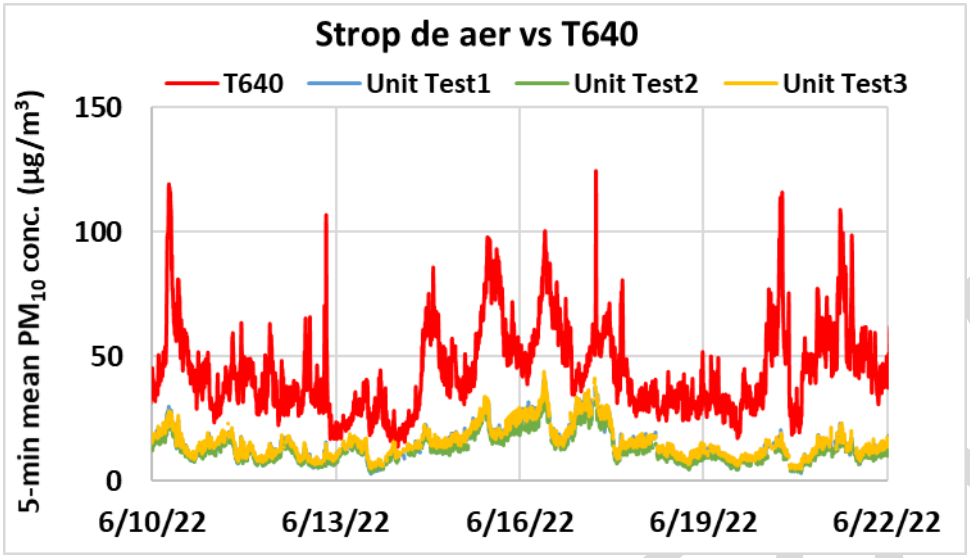
- The Strop de aer sensors showed strong correlations with the corresponding FEM T640 data ($0.73 < R^2 < 0.77$)
- Overall, the Strop de aer sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Strop de aer sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



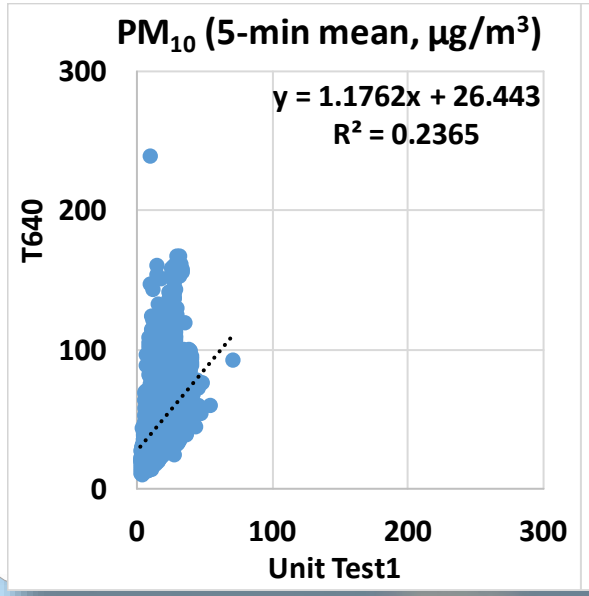


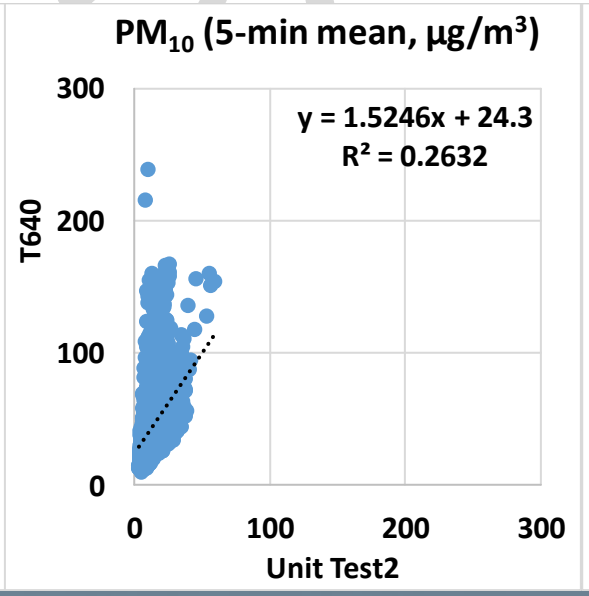


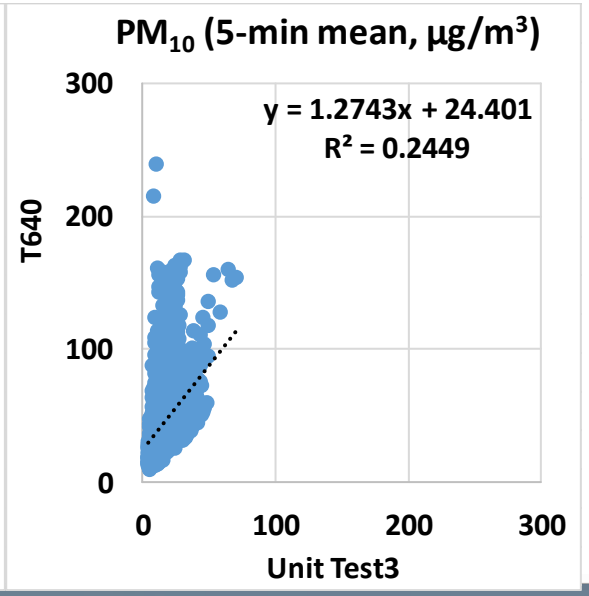
Strop de aer vs T640 (PM_{10}; 5-min mean)



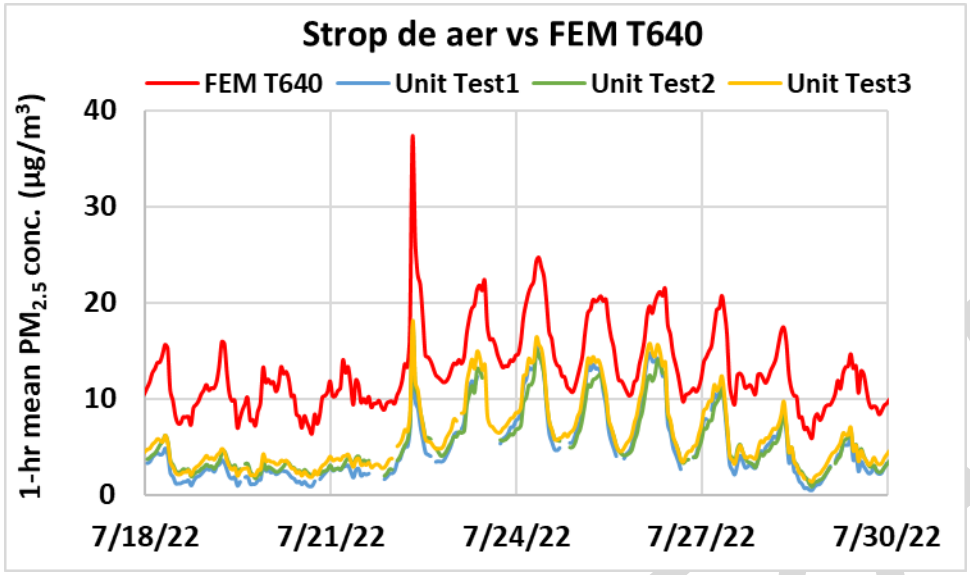
- The Strop de aer sensors showed very weak correlations with the corresponding T640 data ($0.23 < R^2 < 0.27$)
- Overall, the Strop de aer sensors underestimated the PM_{10} mass concentrations as measured by T640
- The Strop de aer sensors did not seem to track the PM_{10} diurnal variations as recorded by T640



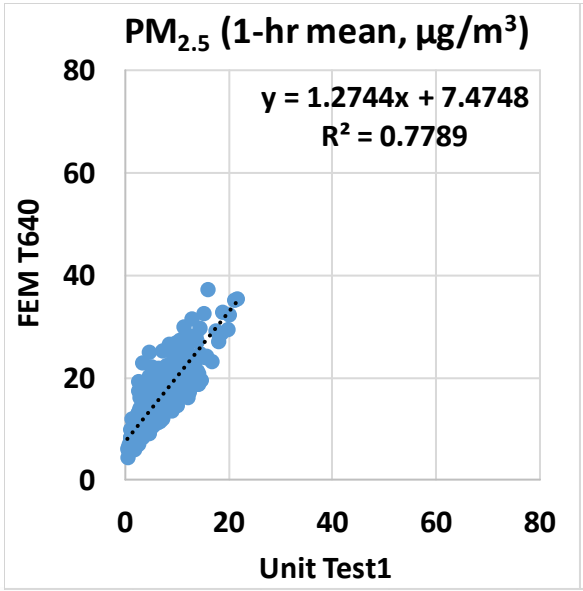


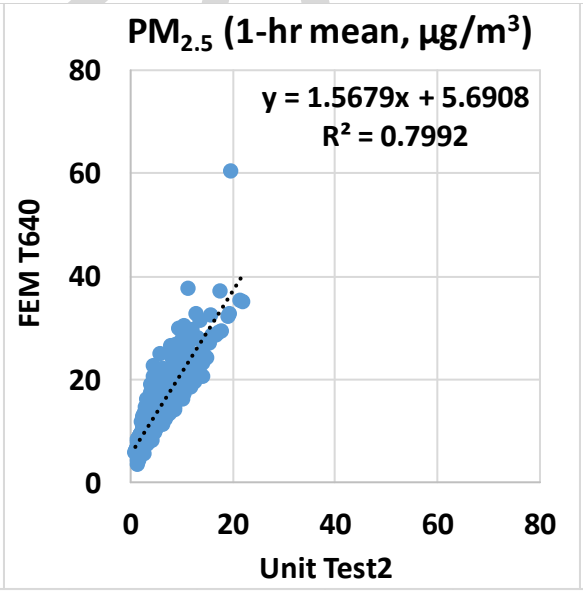


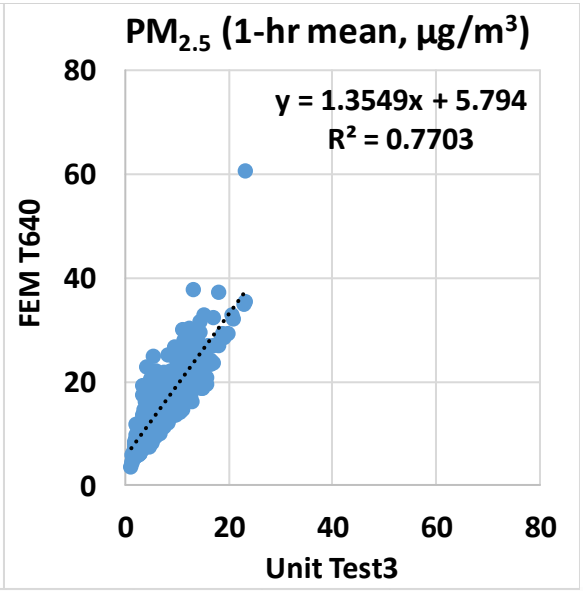
Strop de aer vs FEM T640 ($PM_{2.5}$; 1-hr mean)



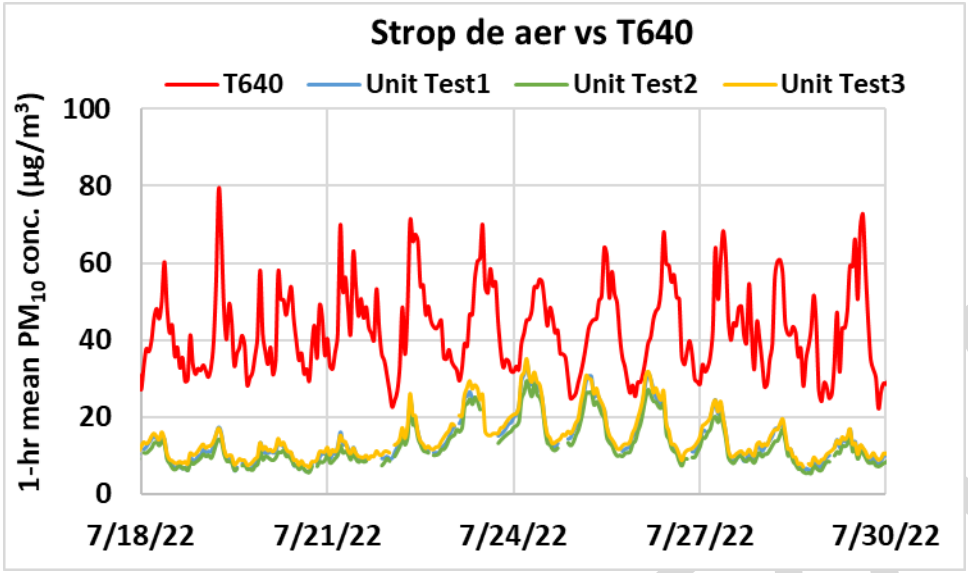
- The Strop de aer sensors showed strong correlations with the corresponding FEM T640 data ($0.77 < R^2 < 0.80$)
- Overall, the Strop de aer sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Strop de aer sensors seemed to track the $PM_{2.5}$ diurnal variations as recorded by FEM T640



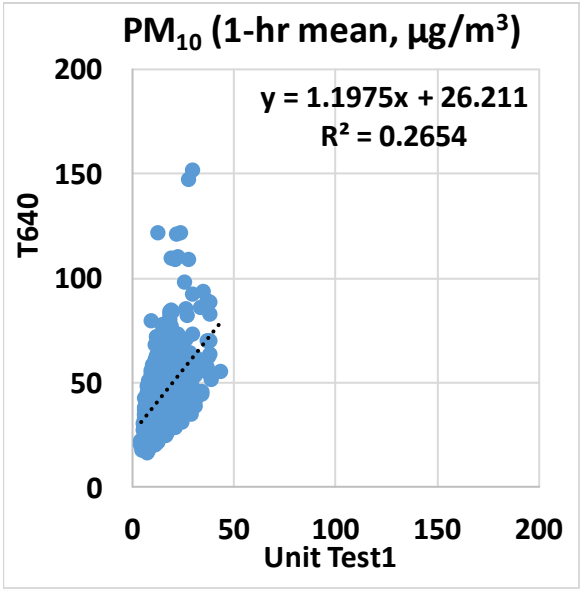


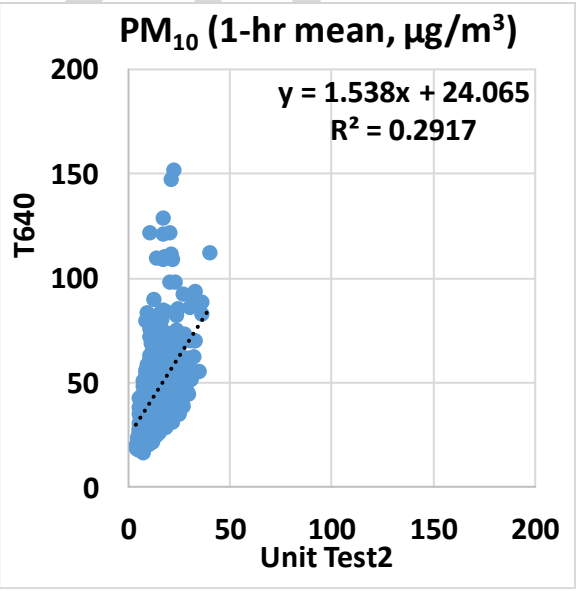


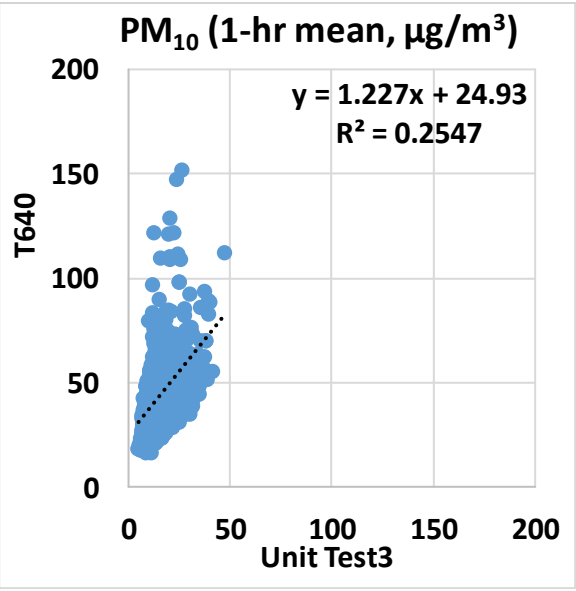
Strop de aer vs T640 (PM_{10}; 1-hr mean)



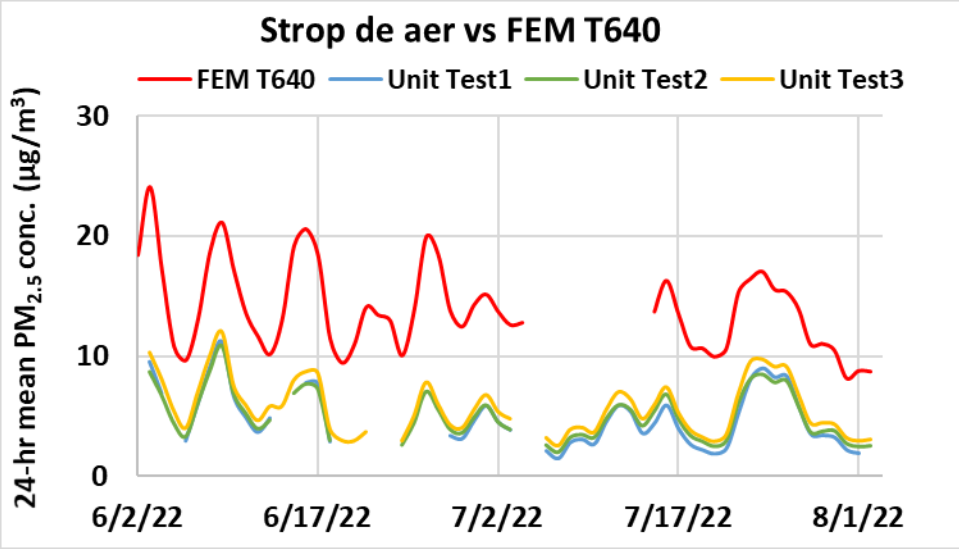
- The Strop de aer sensors showed very weak correlations with the corresponding T640 data ($0.25 < R^2 < 0.30$)
- Overall, the Strop de aer sensors underestimated the PM_{10} mass concentrations as measured by T640
- The Strop de aer sensors did not seem to track the PM_{10} diurnal variations as recorded by T640



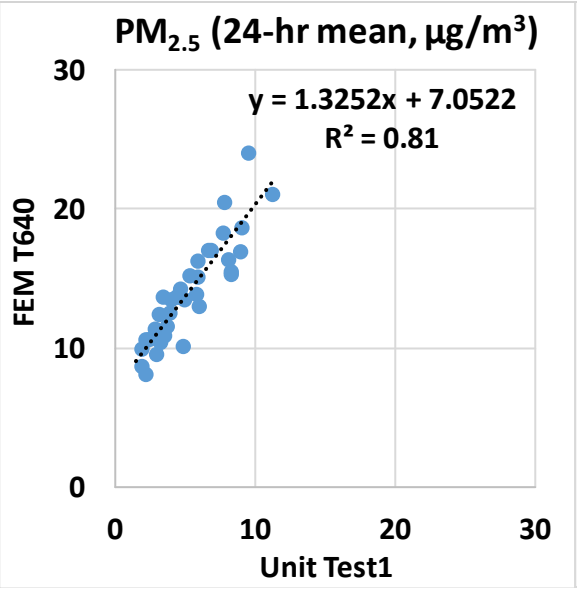


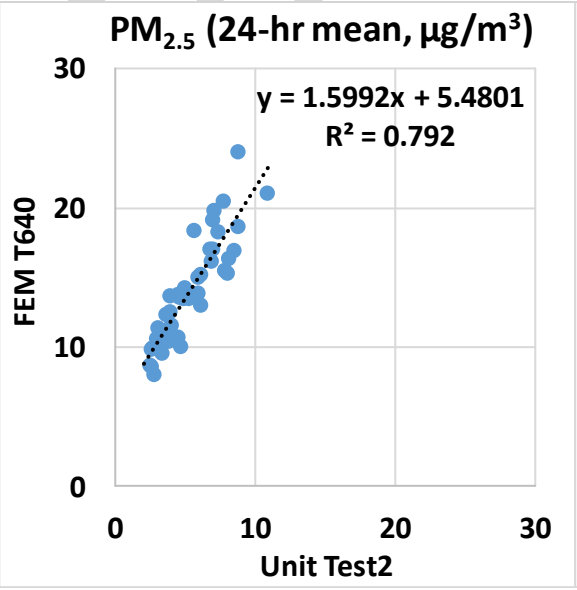


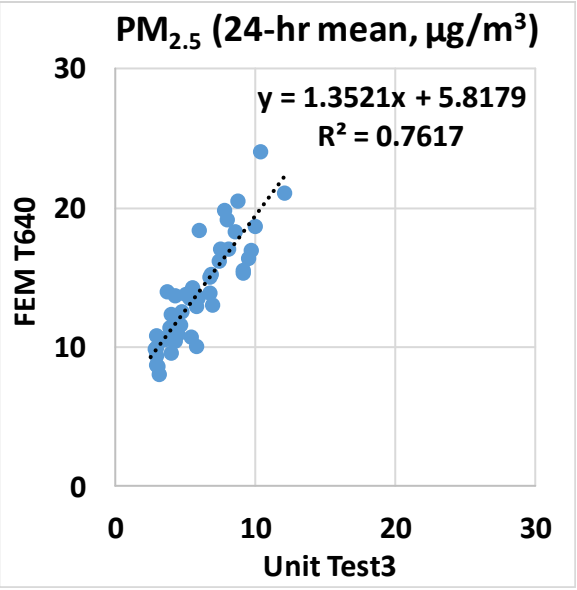
Strop de aer vs FEM T640 ($PM_{2.5}$; 24-hr mean)



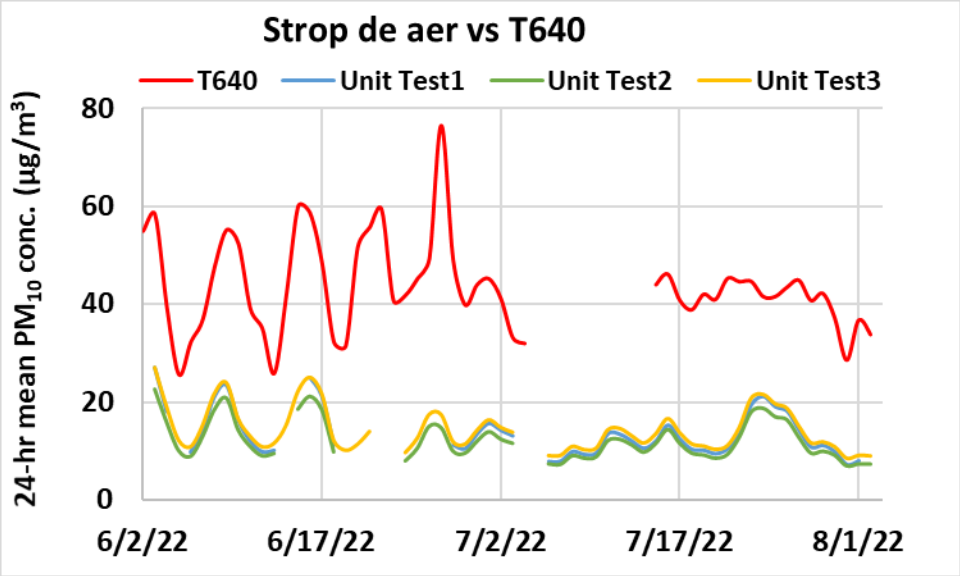
- The Strop de aer sensors showed strong correlations with the corresponding FEM T640 data ($0.76 < R^2 < 0.82$)
- Overall, the Strop de aer sensors underestimated the $PM_{2.5}$ mass concentrations as measured by FEM T640
- The Strop de aer sensors seemed to track the $PM_{2.5}$ daily variations as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



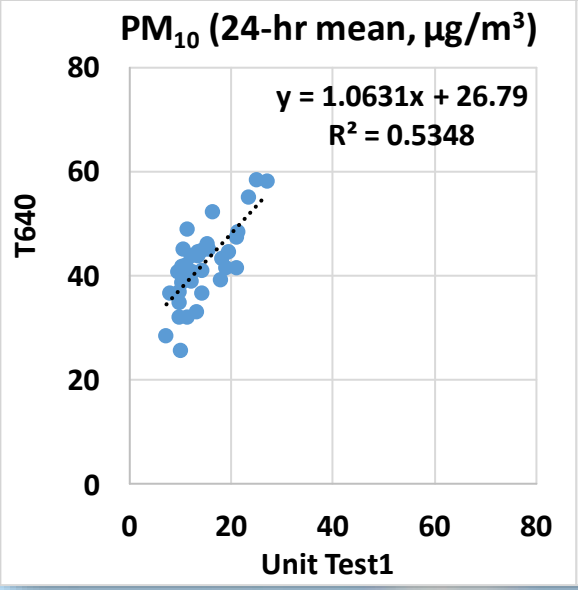


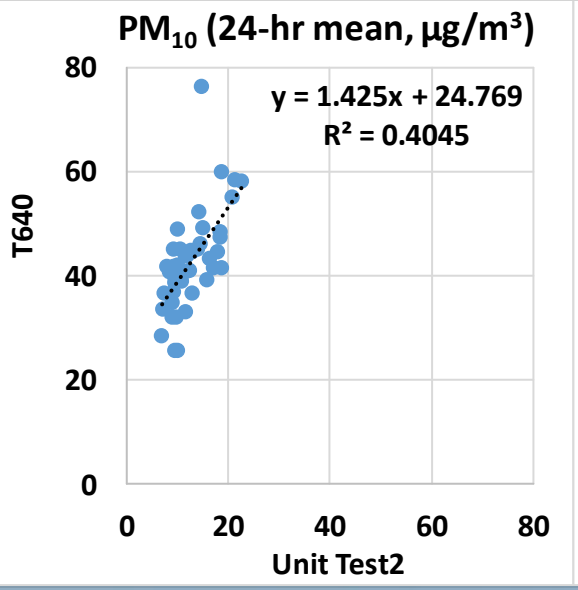


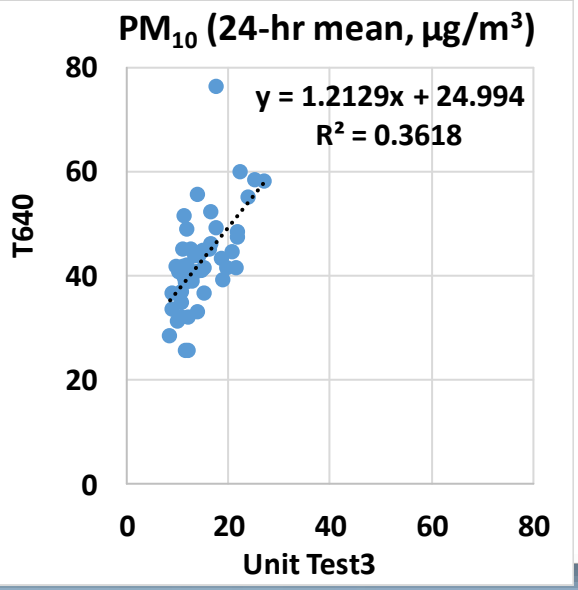
Strop de aer vs T640 (PM_{10}; 24-hr mean)



- The Strop de aer sensors showed weak to moderate correlations with the corresponding T640 data ($0.36 < R^2 < 0.54$)
- Overall, the Strop de aer sensors underestimated the PM_{10} mass concentrations as measured by T640
- The Strop de aer sensors did not seem to track the PM_{10} daily variations as recorded by T640





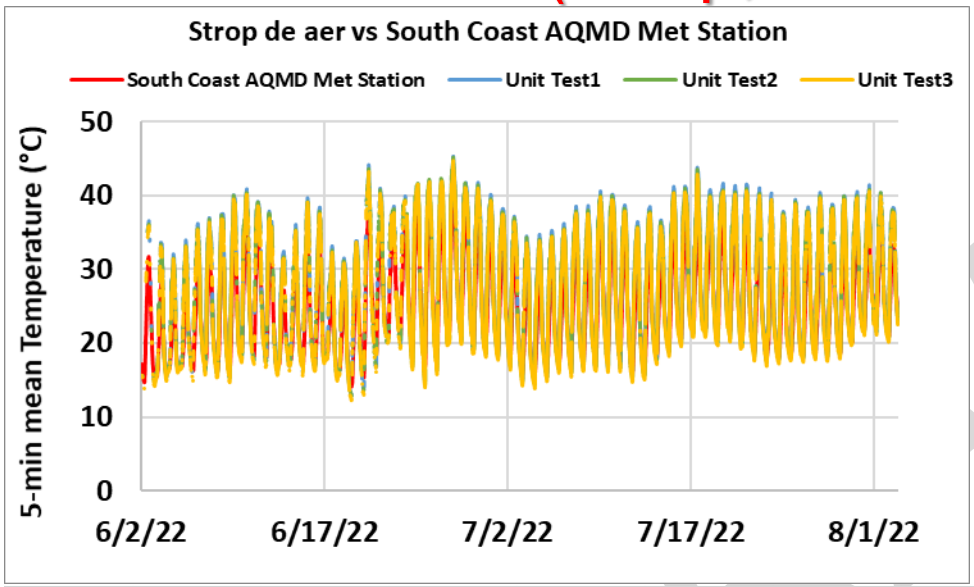


Summary: PM

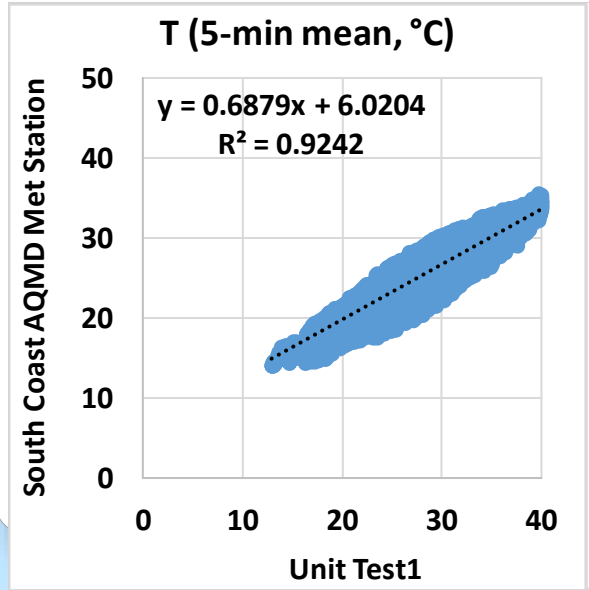
	Average of 3 Sensors, $PM_{2.5}$		Strop de aer vs FEM GRIMM & FEM T640, $PM_{2.5}$						FEM GRIMM & FEM T640 ($PM_{2.5}$, $\mu g/m^3$)		
	Average ($\mu g/m^3$)	SD ($\mu g/m^3$)	R^2	Slope	Intercept	MBE[1] ($\mu g/m^3$)	MAE[2] ($\mu g/m^3$)	RMSE[3] ($\mu g/m^3$)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	5.0	3.3	0.71 to 0.77	1.26 to 1.57	4.5 to 7.6	-8.8 to -6.3	6.3 to 8.8	6.8 to 9.2	12.0 to 13.8	5.3 to 5.6	1.7 to 98.5
1-hr	5.0	3.2	0.77 to 0.83	1.27 to 1.57	4.4 to 7.5	-8.8 to -6.1	6.1 to 8.8	6.6 to 9.1	12.0 to 13.8	5.1 to 5.4	3.4 to 60.7
24-hr	5.2	2.2	0.76 to 0.84	1.30 to 1.60	4.0 to 7.1	-8.7 to -6.1	6.1 to 8.7	6.4 to 8.9	12.0 to 13.8	3.5 to 3.6	6.5 to 24.1
	Average of 3 Sensors, PM_{10}		Strop de aer 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	13.1	6.2	0.15 to 0.26	0.87 to 1.52	21.3 to 26.4	-30.7 to -19.4	19.5 to 30.7	23.3 to 34.2	33.7 to 43.1	14.4 to 17.2	5.3 to 256.7
1-hr	13.0	6.0	0.15 to 0.29	0.77 to 1.54	21.8 to 26.2	-30.6 to -19.3	19.3 to 30.6	22.4 to 33.5	33.6 to 43.1	12.6 to 16.0	10.7 to 152.5
24-hr	13.3	4.4	0.20 to 0.53	0.67 to 1.43	22.5 to 26.8	-30.2 to -19.0	19.0 to 30.2	20.0 to 31.0	33.4 to 43.3	7.2 to 9.5	19.1 to 76.3

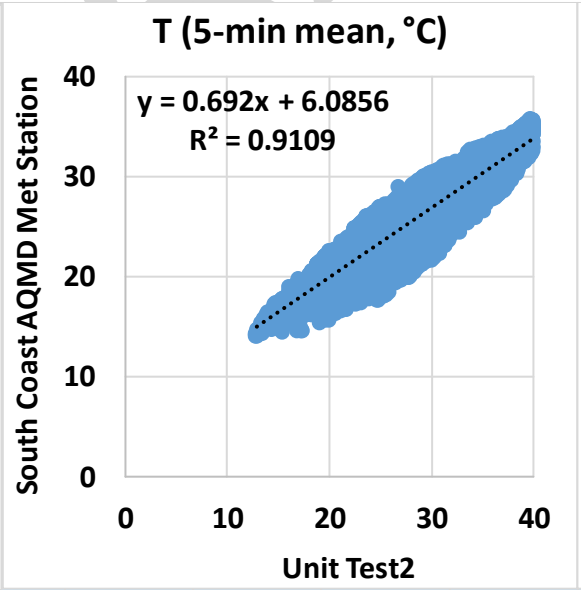
[1] Mean Bias Error (MBE): the difference between the sensors and the reference instruments. MBE indicates the tendency of the sensors to underestimate (negative MBE values) or overestimate (positive MBE values).
[2] Mean Absolute Error (MAE): the absolute difference between the sensors and the reference 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.

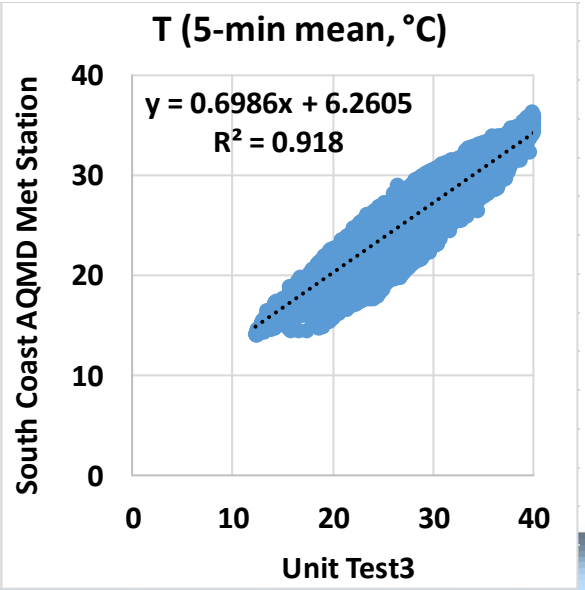
Strop de aer vs South Coast AQMD Met Station (Temp; 5-min mean)



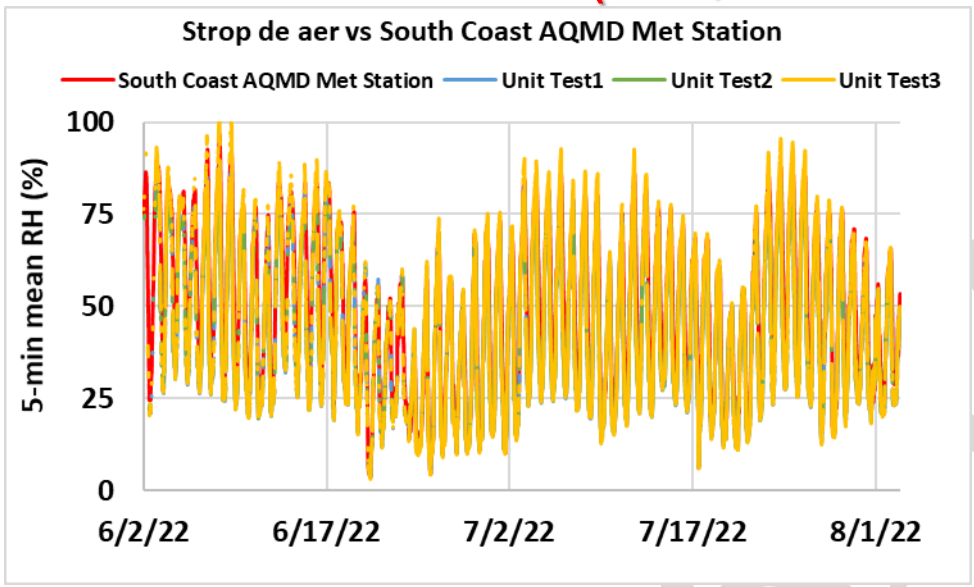
- The Strop de aer sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ($0.91 < R^2 < 0.93$)
- Overall, the Strop de aer sensors overestimated the temperature measurement as recorded by South Coast AQMD Met Station
- The Strop de aer sensors seemed to track the diurnal temperature variations as recorded by South Coast AQMD Met Station



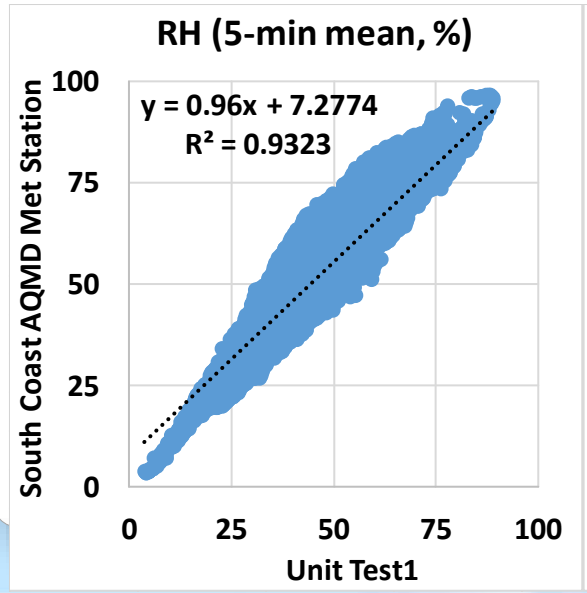


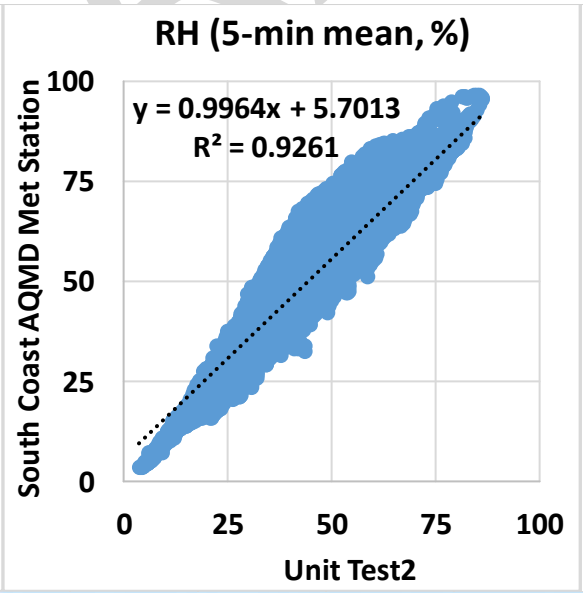


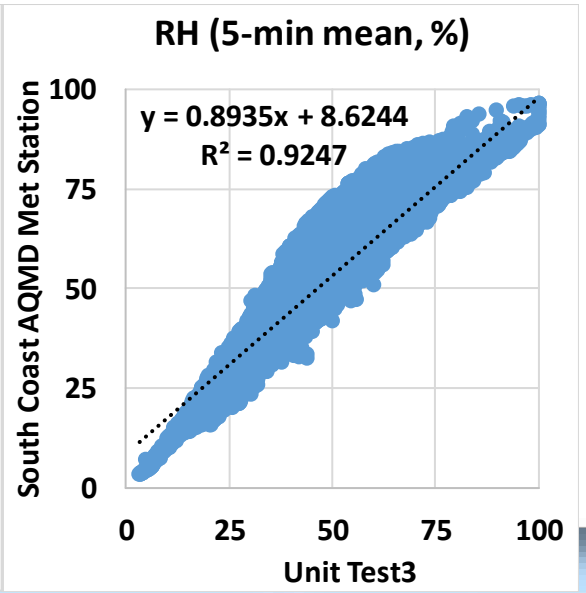
Strop de aer vs South Coast AQMD Met Station (RH; 5-min mean)



- Strop de aer sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ($0.92 < R^2 < 0.94$)
- Overall, the Strop de aer sensors underestimated the RH measurement as recorded by South Coast AQMD Met Station
- The Strop de aer sensors seemed to track the diurnal RH variations as recorded by South Coast AQMD Met Station







Discussion

- The three **Strop de aer** sensors' data recovery from Units Test1, Test2 and Test3 was 74.1%, 81.2% and 82.7% for all PM measurements, respectively.
- The absolute intra-model variability was ~0.44 and ~0.93 µg/m^3 for $PM_{2.5}$ and PM_{10}, respectively.
- Reference instruments: strong correlations between FEM GRIMM and FEM T640 for $PM_{2.5}$ (R^2 ~0.86, 1-hr mean) and very strong correlations between GRIMM and T640 for PM_{10} (R^2 ~0.91, 1-hr mean) mass concentration measurements.
- The Strop de aer sensors showed strong correlations with the corresponding reference $PM_{2.5}$ data ($0.77 < R^2 < 0.83$, 1-hr mean) and the sensors underestimated $PM_{2.5}$ mass concentrations as measured by FEM GRIMM and FEM T640.
- The Strop de aer sensors showed very weak correlations with the corresponding reference PM_{10} data ($0.14 < R^2 < 0.30$, 1-hr mean) and the sensors underestimated PM_{10} mass concentrations as measured by GRIMM and T640.
- No sensor calibration was performed by South Coast AQMD staff for this evaluation.
- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors under controlled T and RH conditions, and known target and interferent pollutants concentrations.

- These results are still preliminary