

# Field Evaluation SailBri Cooper – SCI-901



# Background

- From 04/08/2022 to 06/09/2022, three **SailBri Cooper – SCI-901 (hereinafter SCI-901)** 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
- SCI-901 (3 units tested):
  - **PM<sub>2.5</sub> – Optical Particle Counter (LP-2510T, Yuanhuida Ltd. Suzhou, non-FEM)**
  - Each unit measures: PM<sub>2.5</sub> (µg/m<sup>3</sup>), PM<sub>10</sub> (µg/m<sup>3</sup>), T (°C), RH (%)
  - **Unit cost: \$5,500, includes 1 year of cloud services**
  - Time resolution: 1-min
  - Units IDs: 0002, 0003, and 0004

## South Coast AQMD Reference Instruments:

- GRIMM EDM 180 (*hereinafter FEM GRIMM for PM<sub>2.5</sub>, GRIMM otherwise*):
  - Optical particle counter (**FEM PM<sub>2.5</sub>**)
  - Measures PM<sub>1.0</sub>, PM<sub>2.5</sub>, and PM<sub>10</sub> (µg/m<sup>3</sup>)
  - **Cost: ~\$25,000 and up**
  - Time resolution: 1-min
- Teledyne API T640 (*hereinafter FEM T640 for PM<sub>2.5</sub>, T640 otherwise*):
  - Optical particle counter (**FEM PM<sub>2.5</sub>**)
  - Measures PM<sub>1.0</sub>, PM<sub>2.5</sub> and PM<sub>10</sub> (µg/m<sup>3</sup>)
  - **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



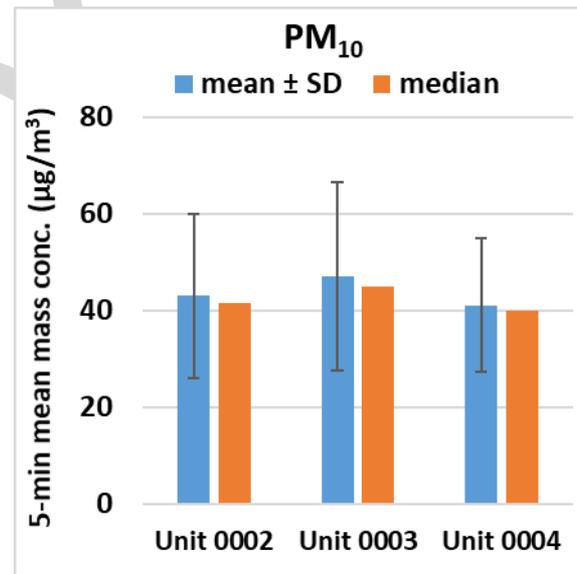
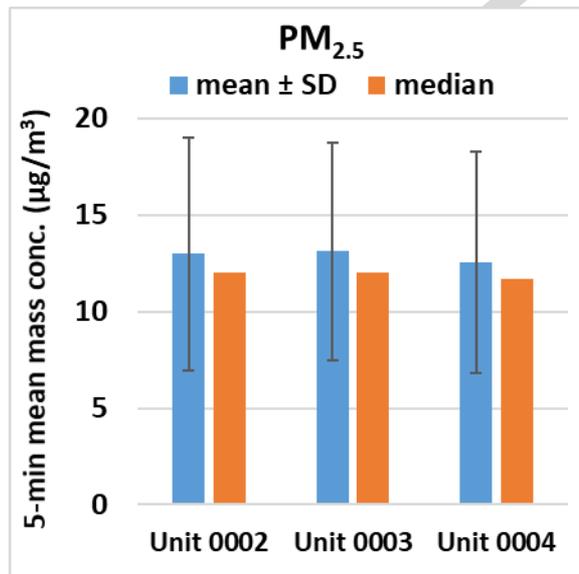
FEM T640

# 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 all units was 100% for all PM measurements.

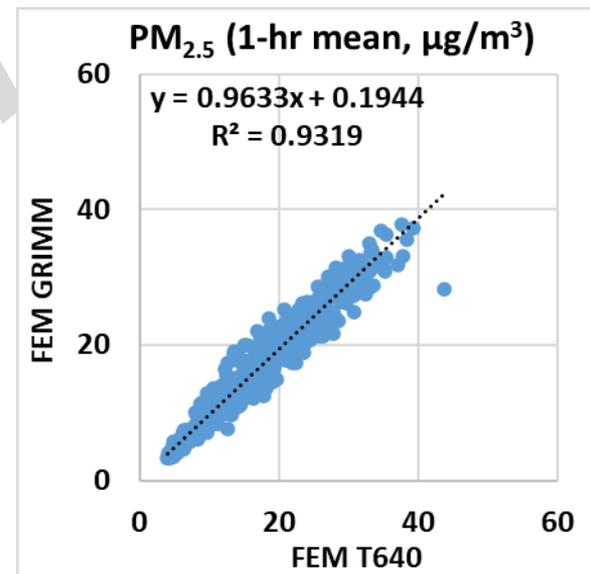
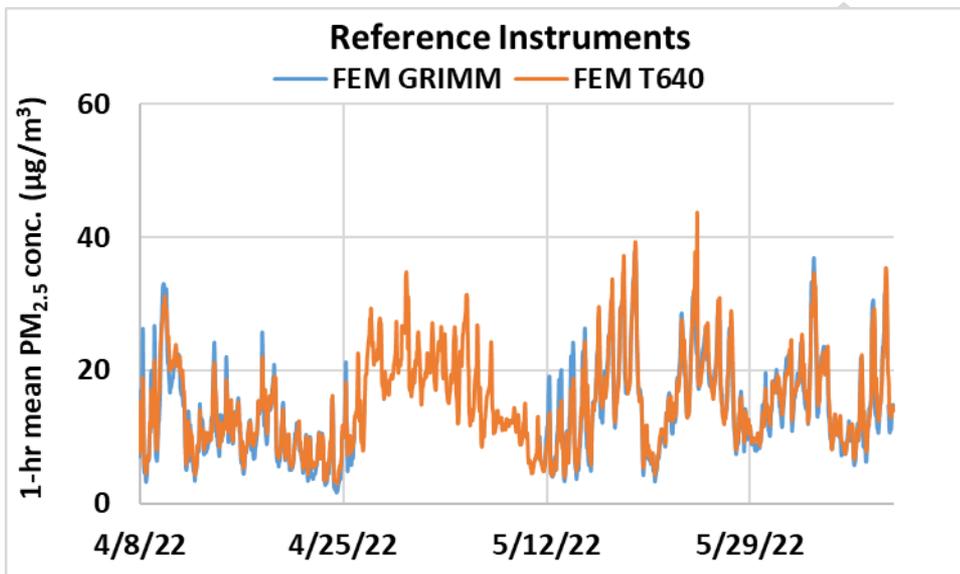
## SCI-901; intra-model variability

- Absolute intra-model variability was  $\sim 0.24$  and  $\sim 2.48 \mu\text{g}/\text{m}^3$  for  $\text{PM}_{2.5}$  and  $\text{PM}_{10}$ , respectively (calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was  $\sim 1.9\%$  and  $\sim 5.7\%$  for  $\text{PM}_{2.5}$  and  $\text{PM}_{10}$ , respectively (calculated as the absolute intra-model variability relative to the mean of the three sensor means)



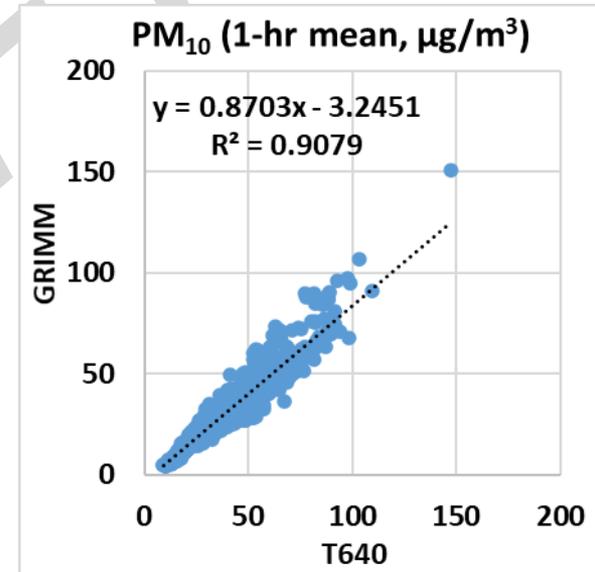
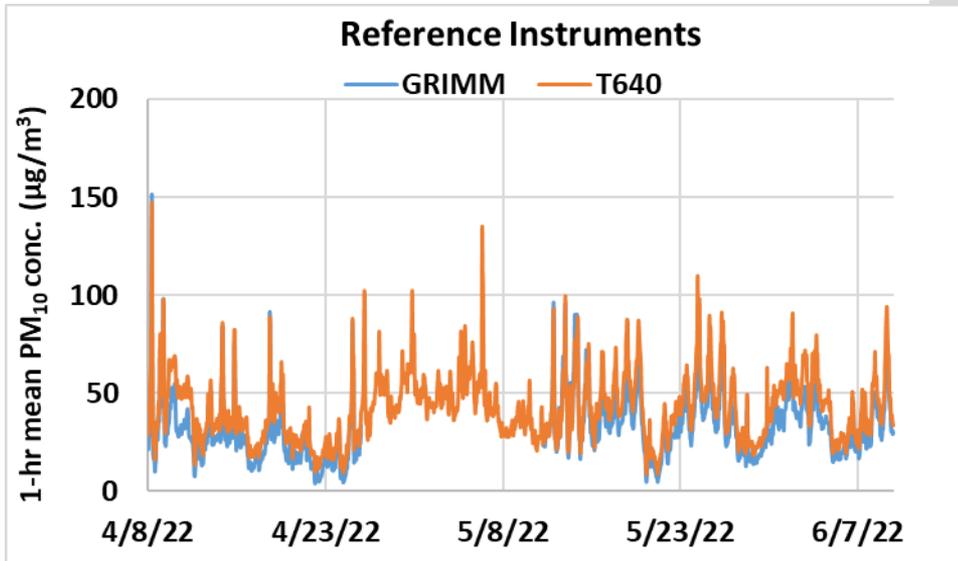
# Reference Instruments: PM<sub>2.5</sub> FEM GRIMM and FEM T640

- Data recovery for PM<sub>2.5</sub> from FEM GRIMM and FEM T640 was ~100%.
- Very strong correlations between the reference instruments for PM<sub>2.5</sub> measurements ( $R^2 \sim 0.93$ ) were observed.

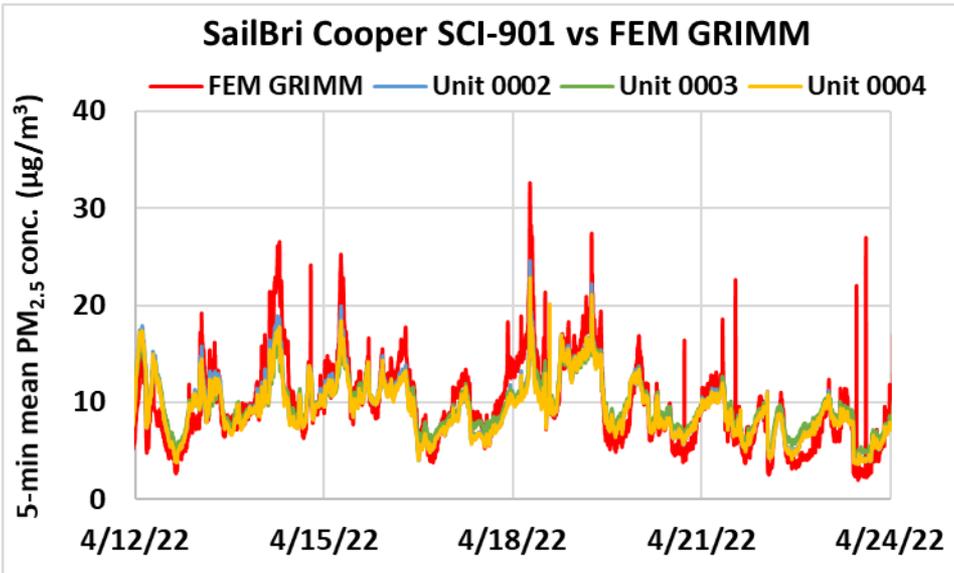


# Reference Instruments: PM<sub>10</sub> GRIMM and T640

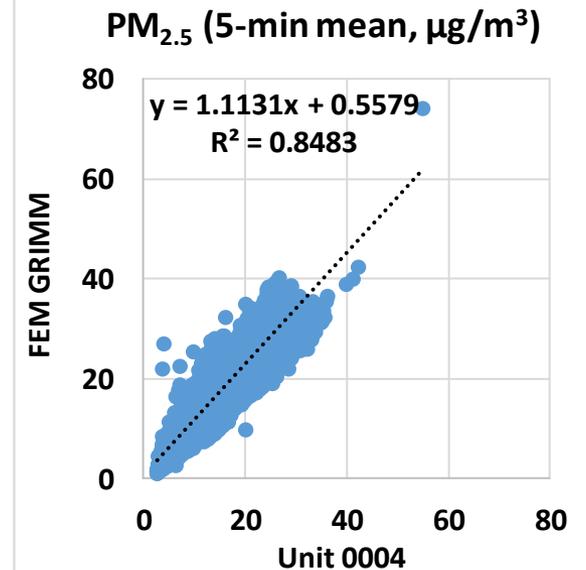
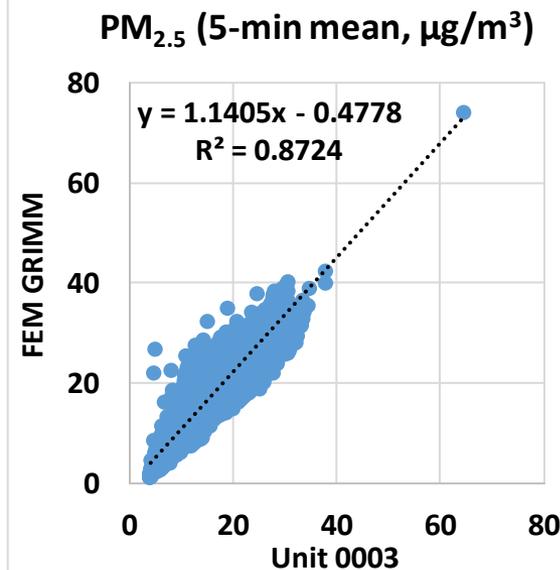
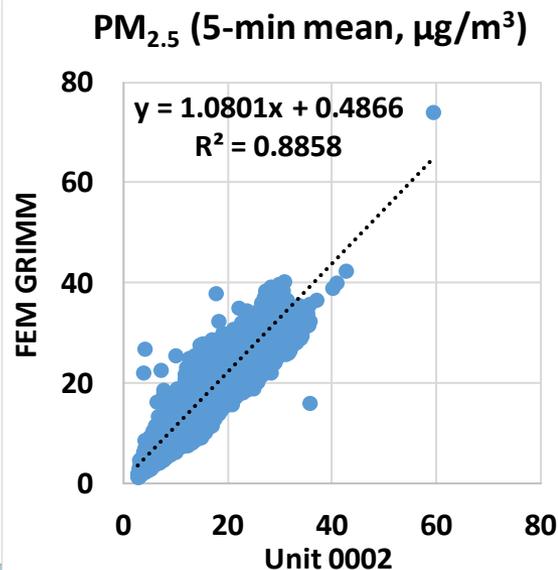
- Data recovery for PM<sub>10</sub> from GRIMM and T640 was ~100%.
- Very strong correlations between the reference instruments for PM<sub>10</sub> measurements ( $R^2 \sim 0.91$ ) were observed.



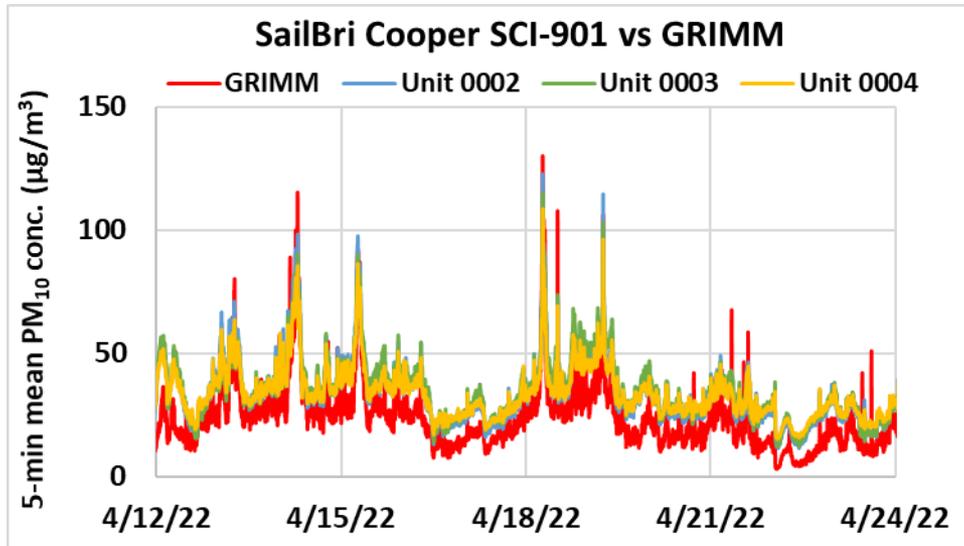
# SCI-901 vs FEM GRIMM (PM<sub>2.5</sub>; 5-min mean)



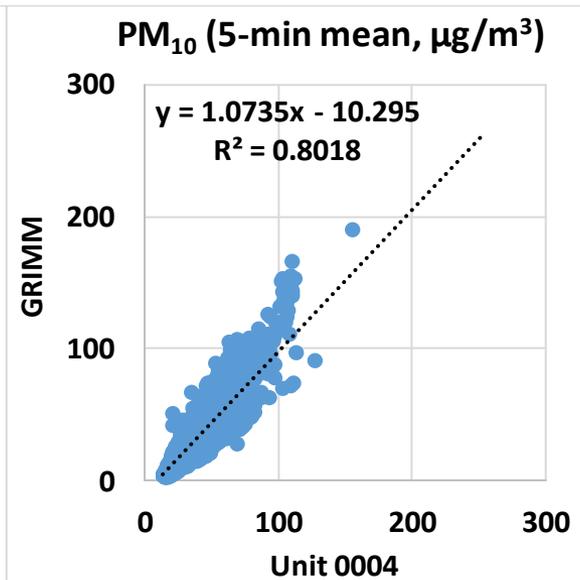
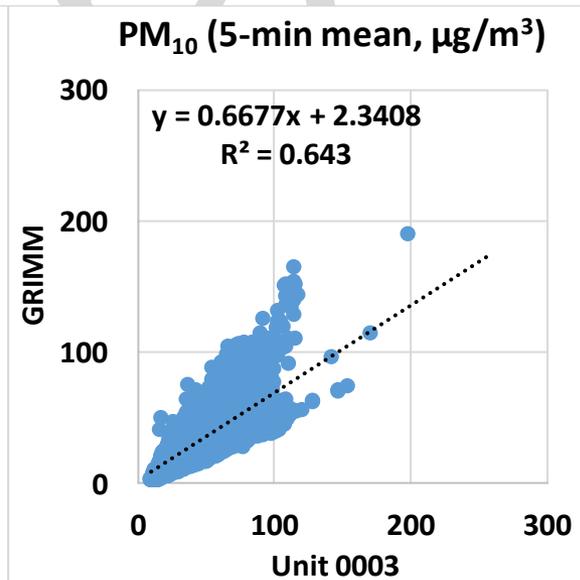
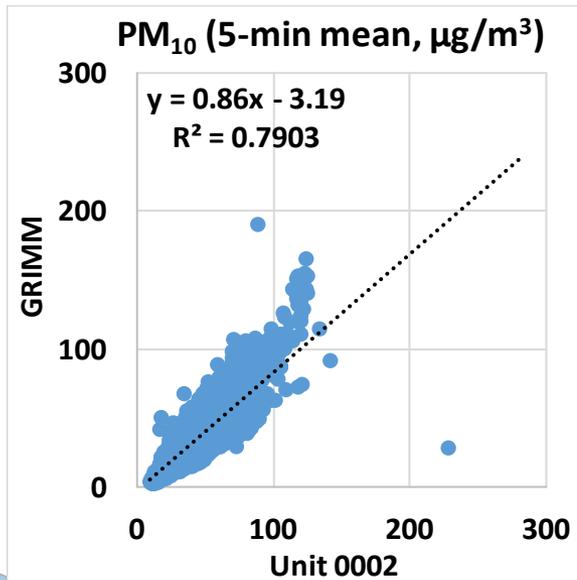
- The SCI-901 sensors showed strong correlations with the corresponding FEM GRIMM data ( $0.84 < R^2 < 0.89$ )
- Overall, the SCI-901 sensors underestimated the PM<sub>2.5</sub> mass concentrations as measured by FEM GRIMM
- The SCI-901 sensors seemed to track the PM<sub>2.5</sub> diurnal variations as recorded by FEM GRIMM



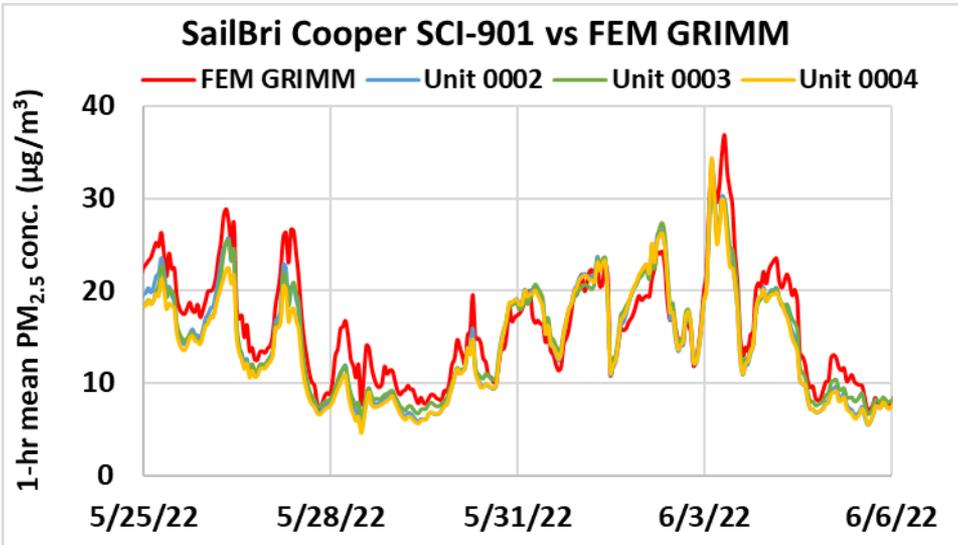
# SCI-901 vs GRIMM (PM<sub>10</sub>; 5-min mean)



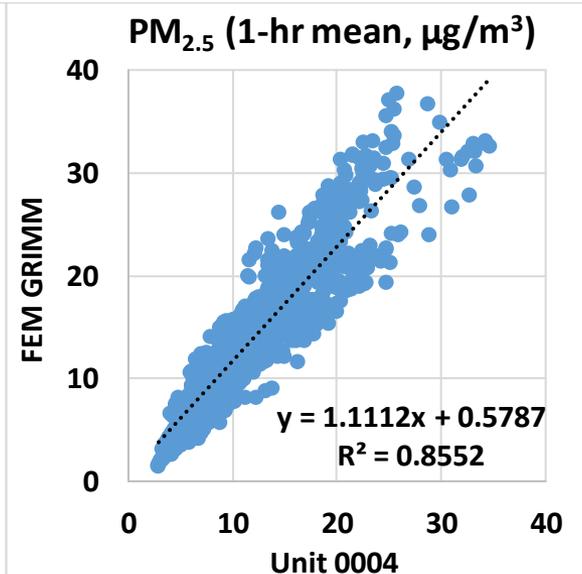
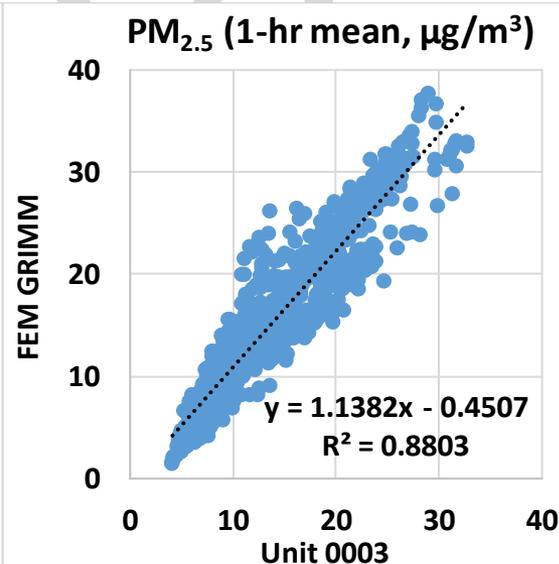
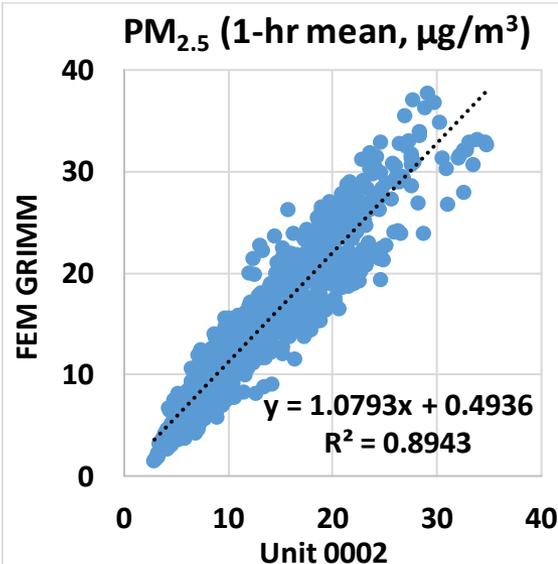
- The SCI-901 sensors showed moderate to strong correlations with the corresponding GRIMM data ( $0.64 < R^2 < 0.81$ )
- Overall, the SCI-901 sensors overestimated the PM<sub>10</sub> mass concentrations as measured by GRIMM
- The SCI-901 sensors seemed to track the PM<sub>10</sub> diurnal variations as recorded by GRIMM



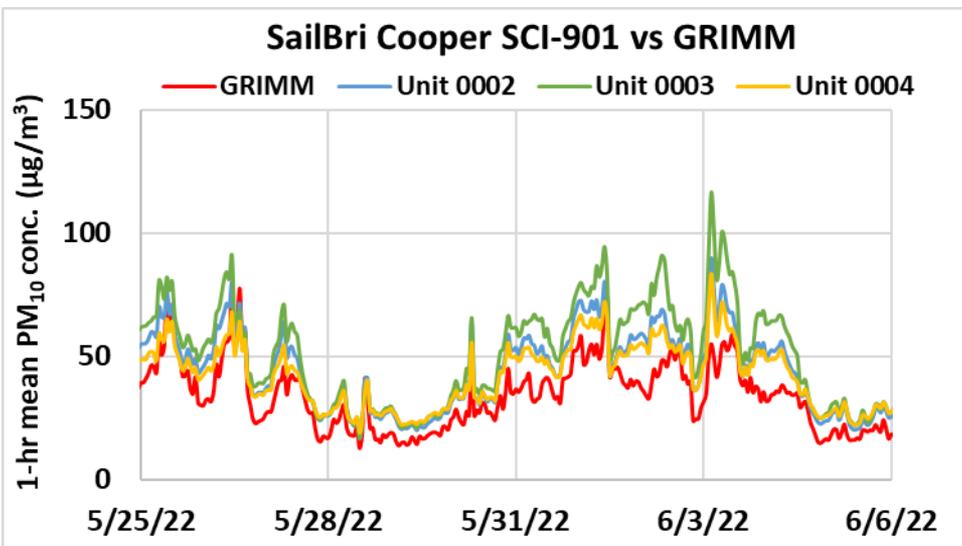
# SCI-901 vs FEM GRIMM (PM<sub>2.5</sub>; 1-hr mean)



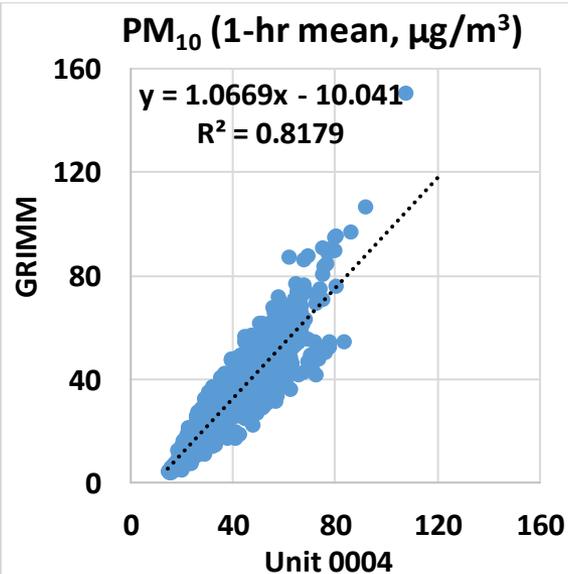
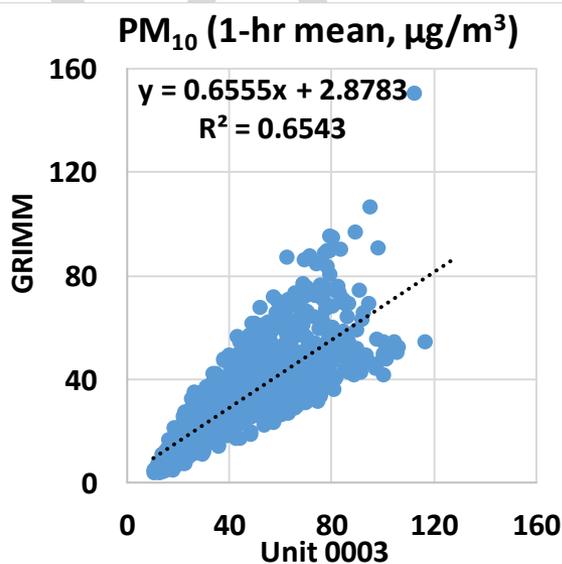
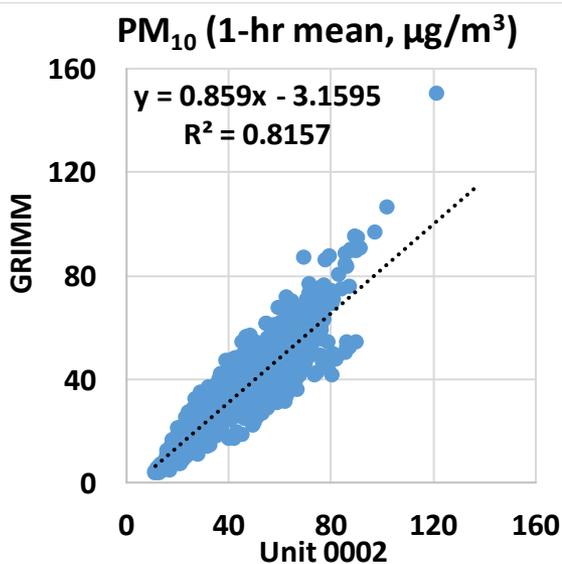
- The SCI-901 sensors showed strong correlations with the corresponding FEM GRIMM data ( $0.85 < R^2 < 0.90$ )
- Overall, the SCI-901 sensors underestimated the PM<sub>2.5</sub> mass concentrations as measured by FEM GRIMM
- The SCI-901 sensors seemed to track the PM<sub>2.5</sub> diurnal variations as recorded by FEM GRIMM



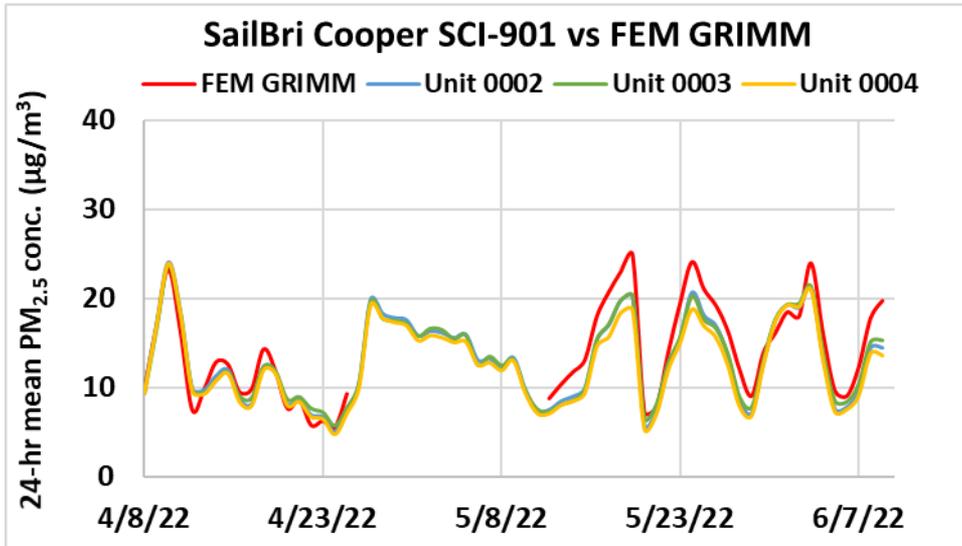
# SCI-901 vs GRIMM (PM<sub>10</sub>; 1-hr mean)



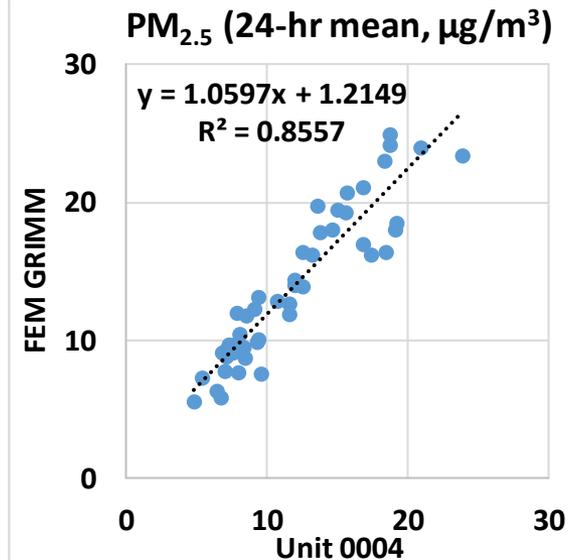
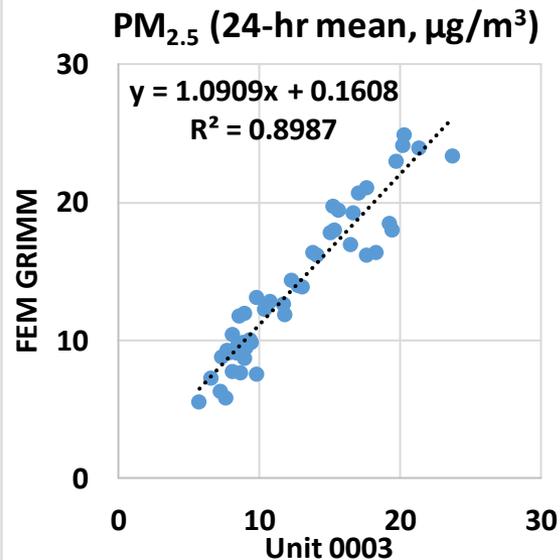
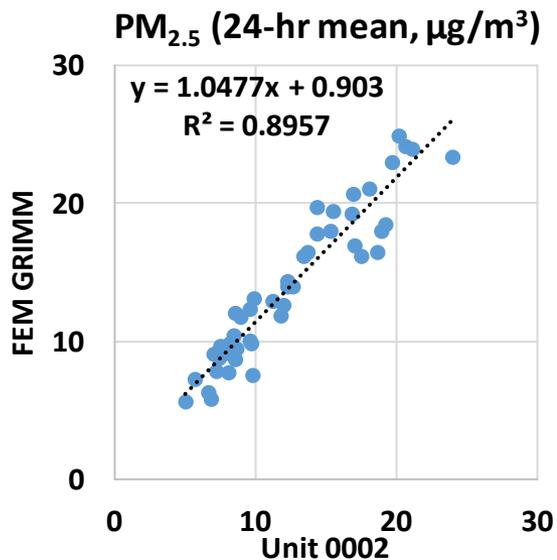
- The SCI-901 sensors showed moderate to strong correlations with the corresponding GRIMM data ( $0.65 < R^2 < 0.82$ )
- Overall, the SCI-901 sensors overestimated the PM<sub>10</sub> mass concentrations as measured by GRIMM
- The SCI-901 sensors seemed to track the PM<sub>10</sub> diurnal variations as recorded by GRIMM



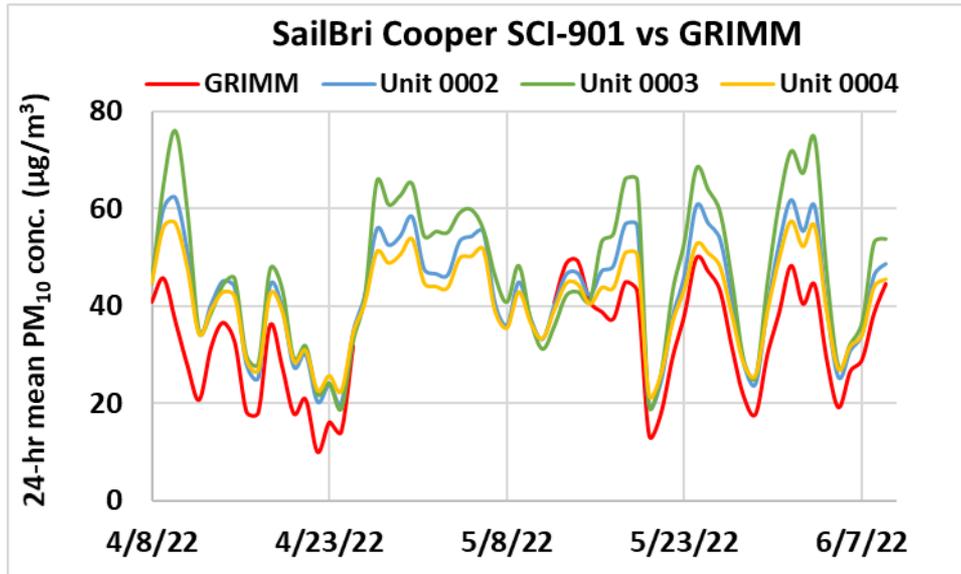
# SCI-901 vs FEM GRIMM (PM<sub>2.5</sub>; 24-hr mean)



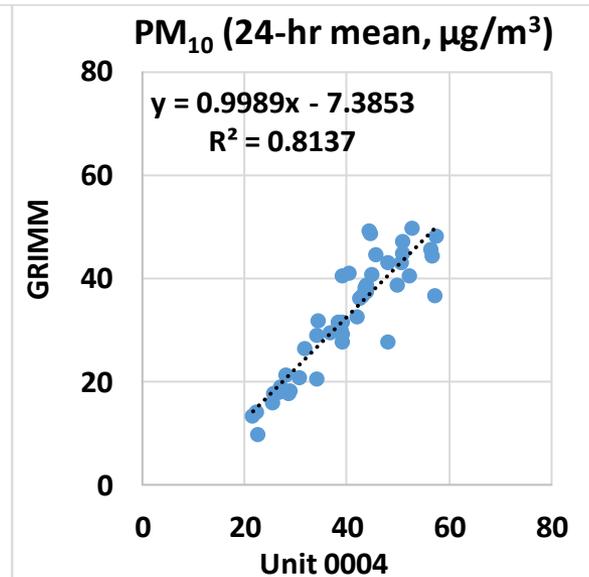
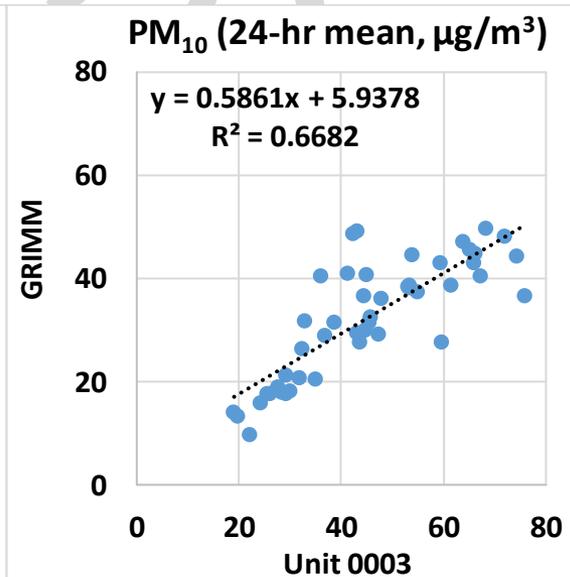
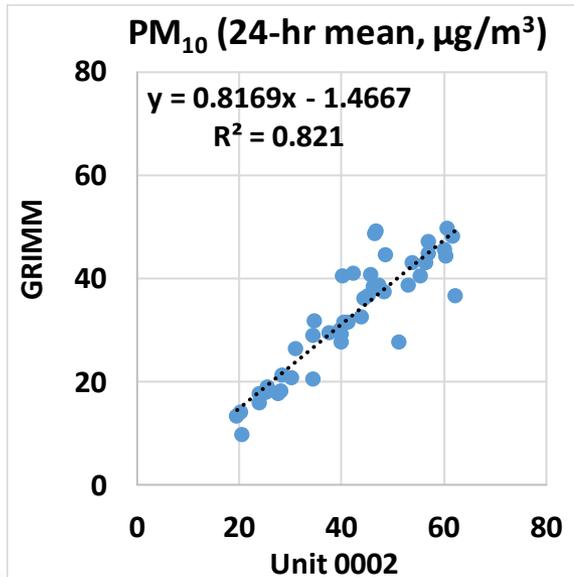
- The SCI-901 sensors showed strong correlations with the corresponding FEM GRIMM data ( $0.85 < R^2 < 0.90$ )
- Overall, the SCI-901 sensors underestimated the PM<sub>2.5</sub> mass concentrations as measured by FEM GRIMM
- The SCI-901 sensors seemed to track the PM<sub>2.5</sub> daily variations as recorded by FEM GRIMM



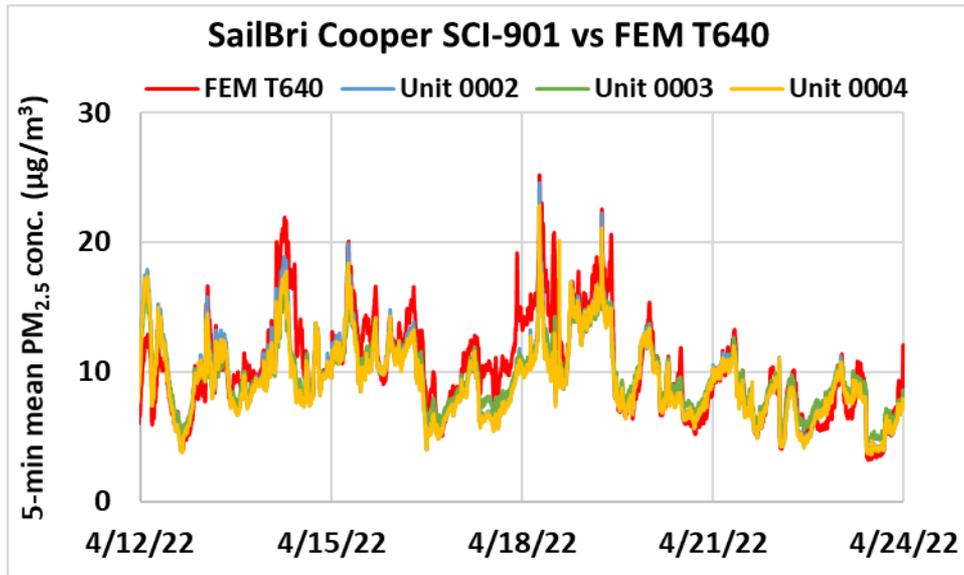
# SCI-901 vs GRIMM (PM<sub>10</sub>; 24-hr mean)



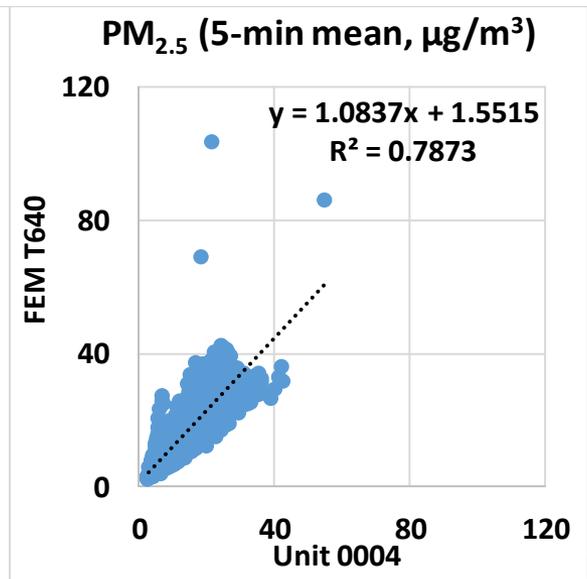
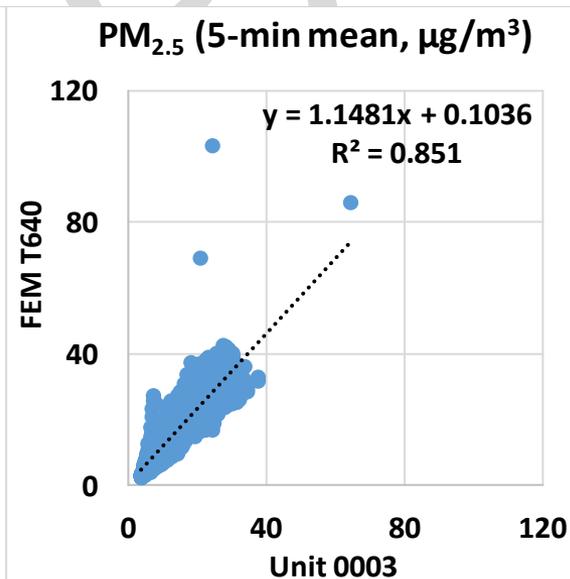
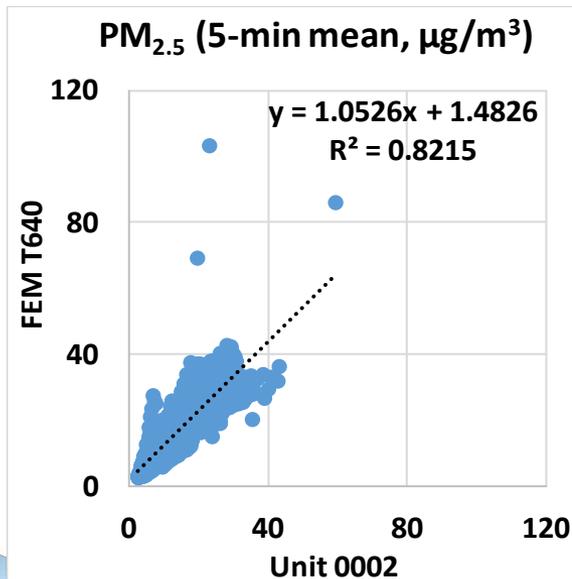
- The SCI-901 sensors showed moderate to strong correlations with the corresponding GRIMM data ( $0.66 < R^2 < 0.83$ )
- Overall, the SCI-901 sensors overestimated the PM<sub>10</sub> mass concentrations as measured by GRIMM
- The SCI-901 sensors seemed to track the PM<sub>10</sub> daily variations as recorded by GRIMM



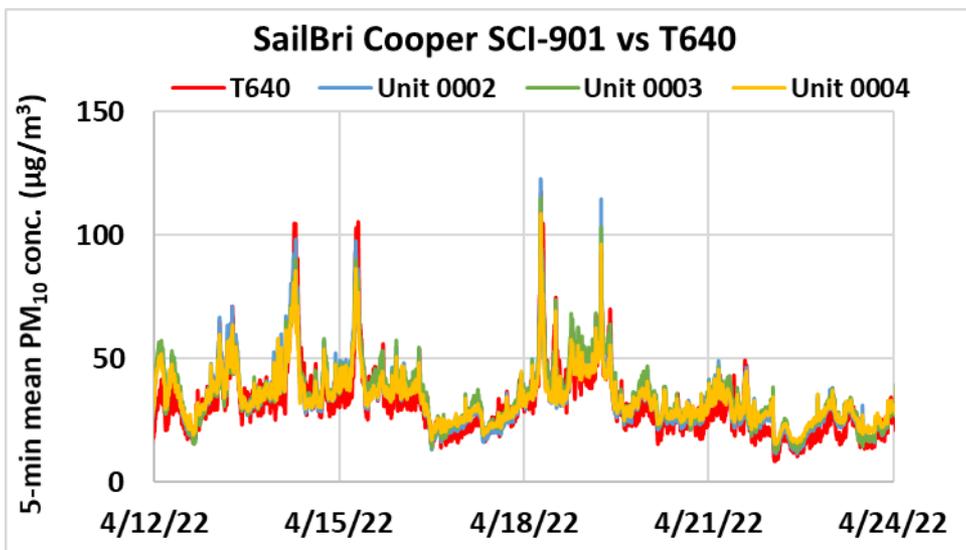
# SCI-901 vs FEM T640 (PM<sub>2.5</sub>; 5-min mean)



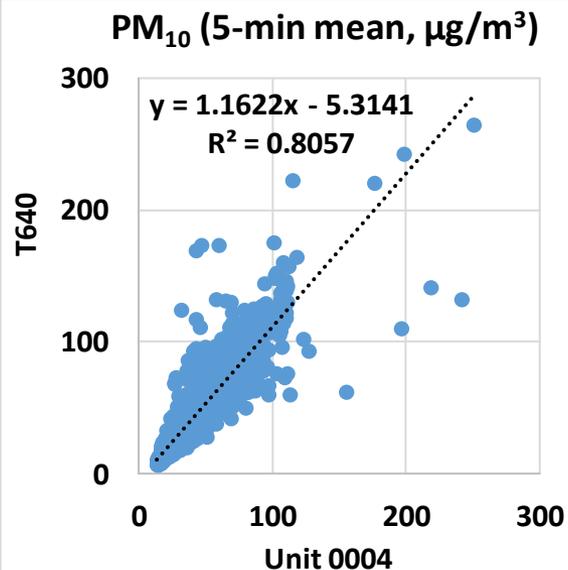
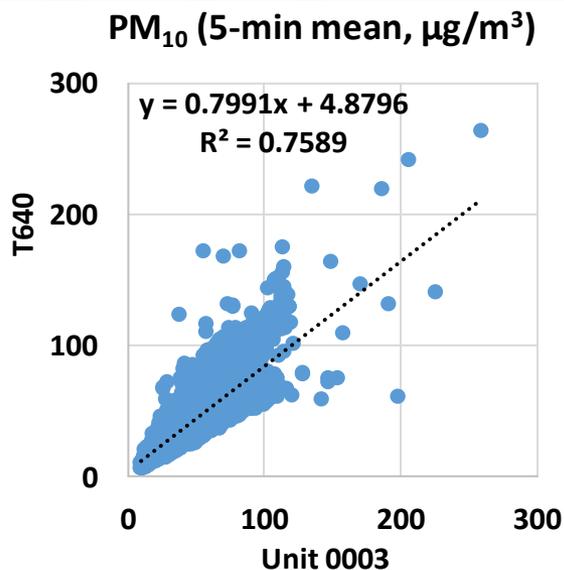
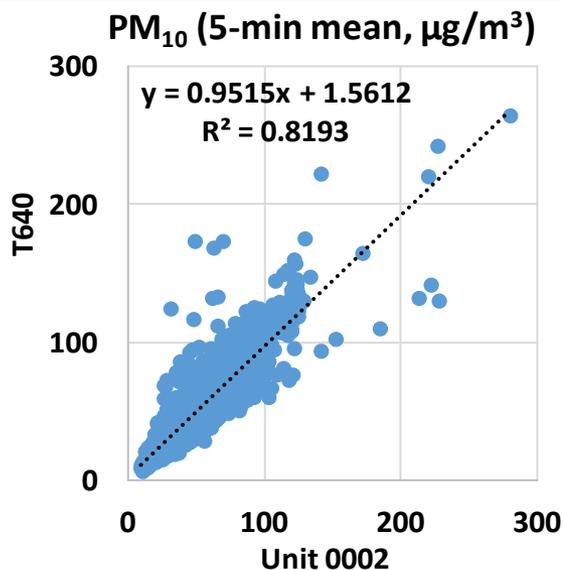
- The SCI-901 sensors showed strong correlations with the corresponding FEM T640 data ( $0.78 < R^2 < 0.86$ )
- Overall, the SCI-901 sensors underestimated the PM<sub>2.5</sub> mass concentrations as measured by FEM T640
- The SCI-901 sensors seemed to track the PM<sub>2.5</sub> diurnal variations as recorded by FEM T640



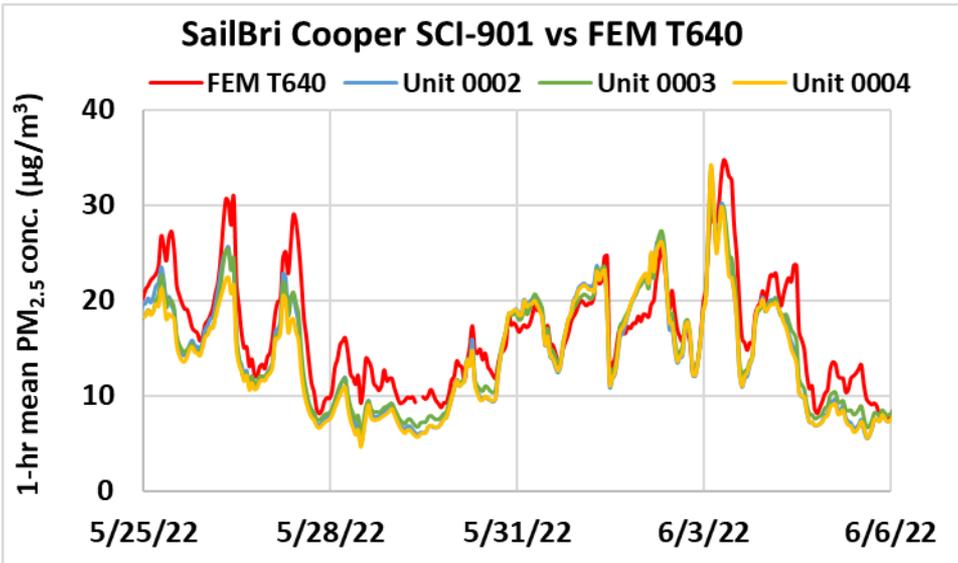
# SCI-901 vs T640 (PM<sub>10</sub>; 5-min mean)



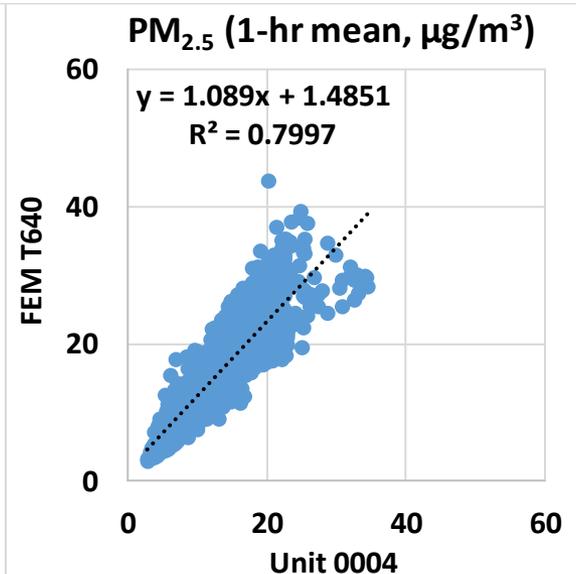
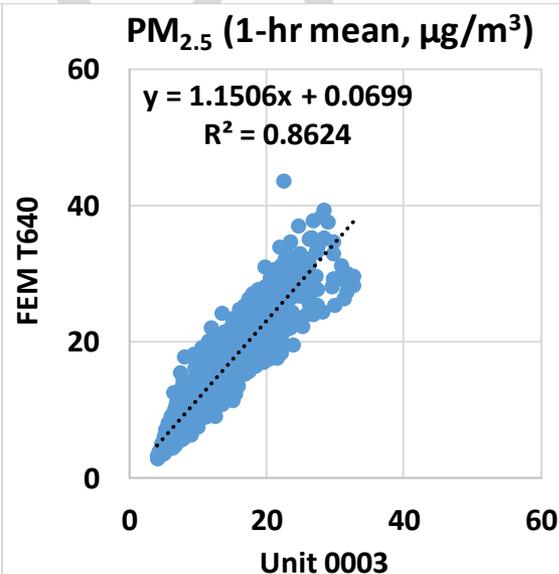
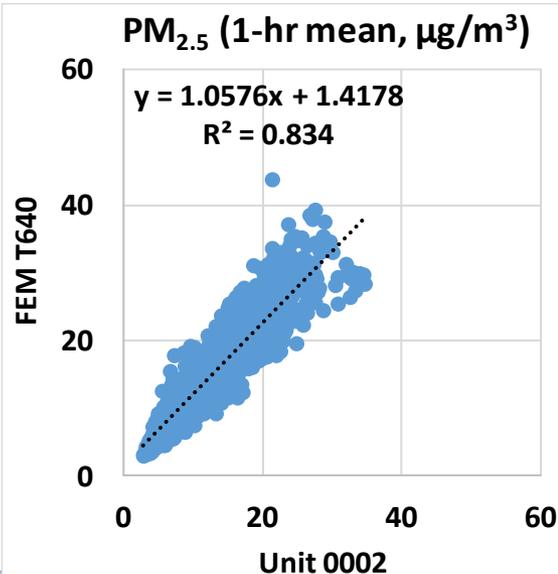
- The SCI-901 sensors showed strong correlations with the corresponding T640 data ( $0.75 < R^2 < 0.82$ )
- Overall, the SCI-901 sensors overestimated the PM<sub>10</sub> mass concentrations as measured by T640
- The SCI-901 sensors seemed to track the PM<sub>10</sub> diurnal variations as recorded by T640



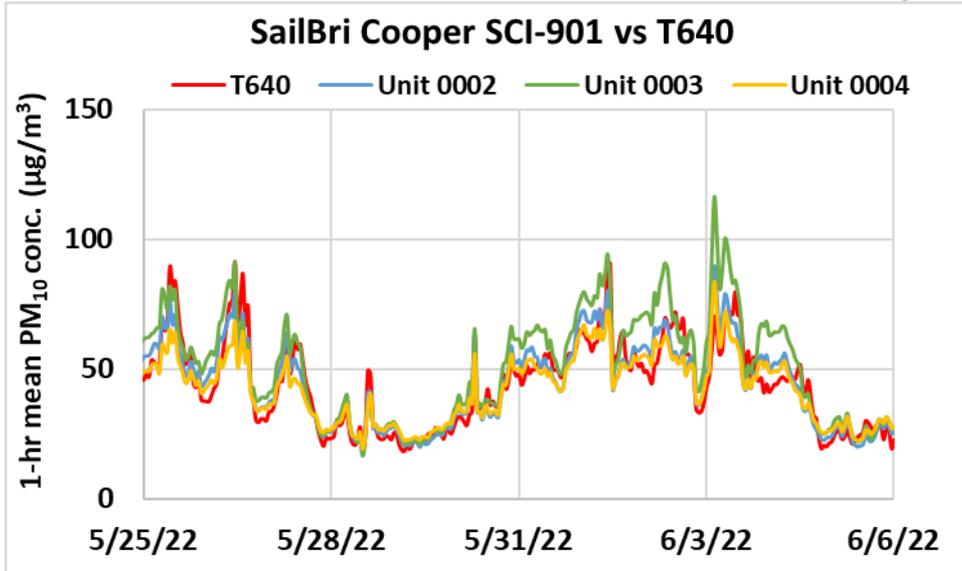
# SCI-901 vs FEM T640 (PM<sub>2.5</sub>; 1-hr mean)



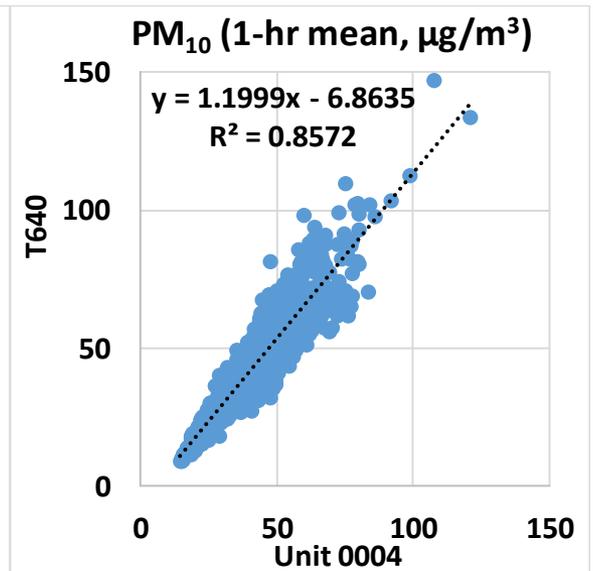
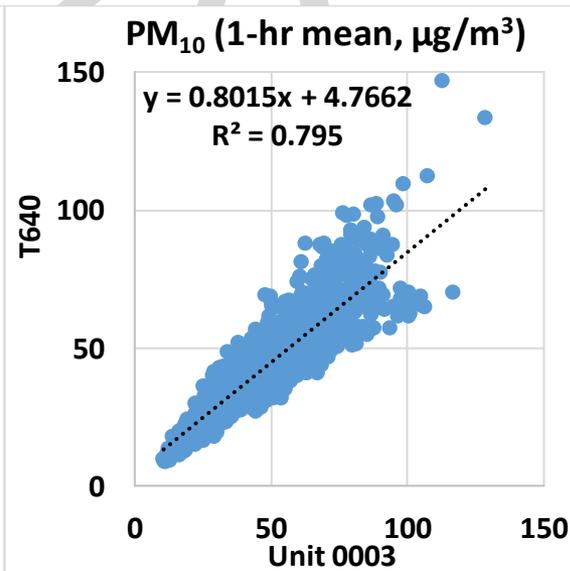
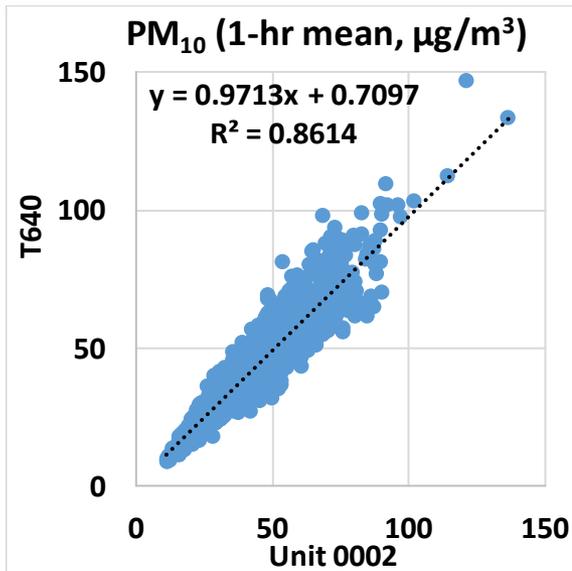
- The SCI-901 sensors showed strong correlations with the corresponding FEM T640 data ( $0.79 < R^2 < 0.87$ )
- Overall, the SCI-901 sensors underestimated the PM<sub>2.5</sub> mass concentrations as measured by FEM T640
- The SCI-901 sensors seemed to track the PM<sub>2.5</sub> diurnal variations as recorded by FEM T640



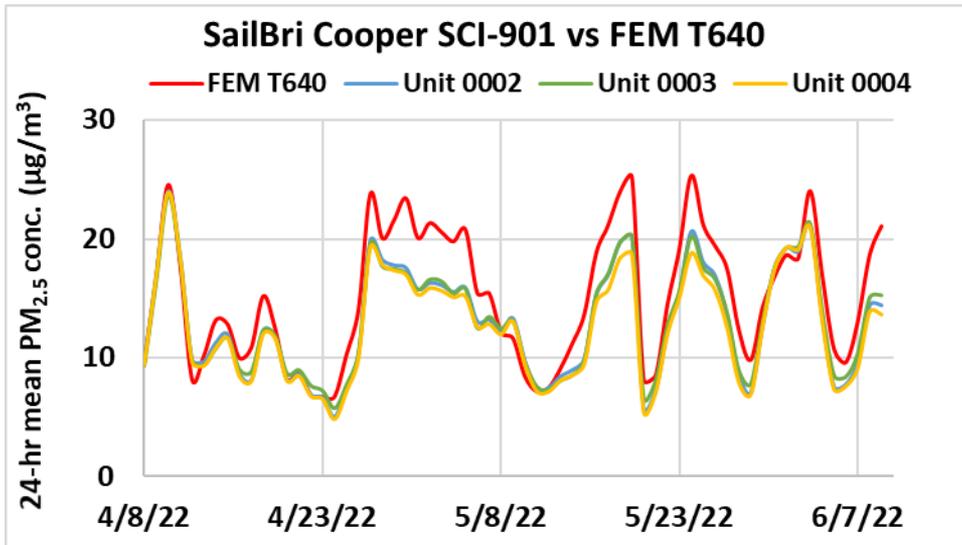
# SCI-901 vs T640 (PM<sub>10</sub>; 1-hr mean)



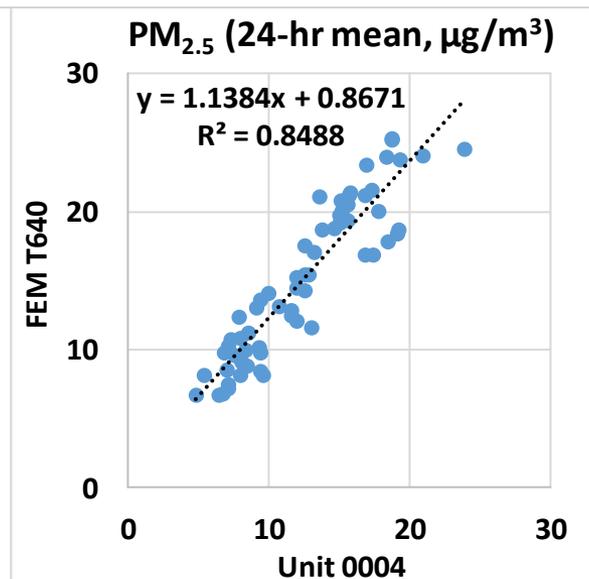
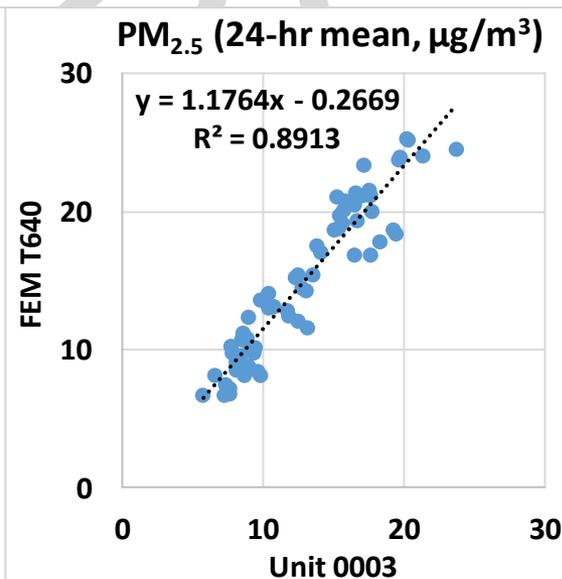
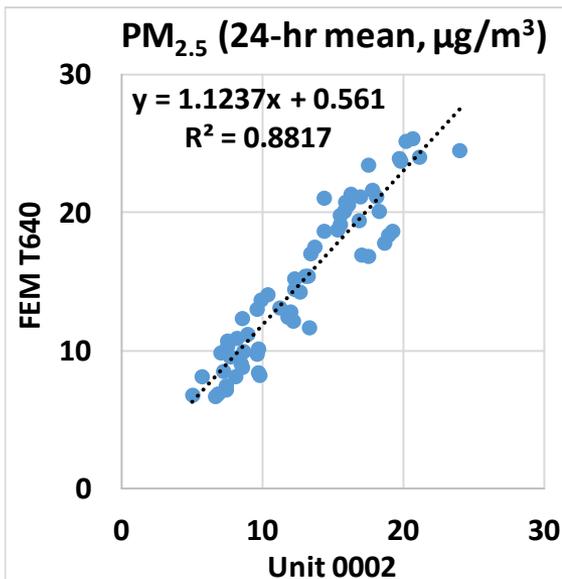
- The SCI-901 sensors showed strong correlations with the corresponding T640 data ( $0.79 < R^2 < 0.87$ )
- Overall, the SCI-901 sensors overestimated the PM<sub>10</sub> mass concentrations as measured by T640
- The SCI-901 sensors seemed to track the PM<sub>10</sub> diurnal variations as recorded by T640



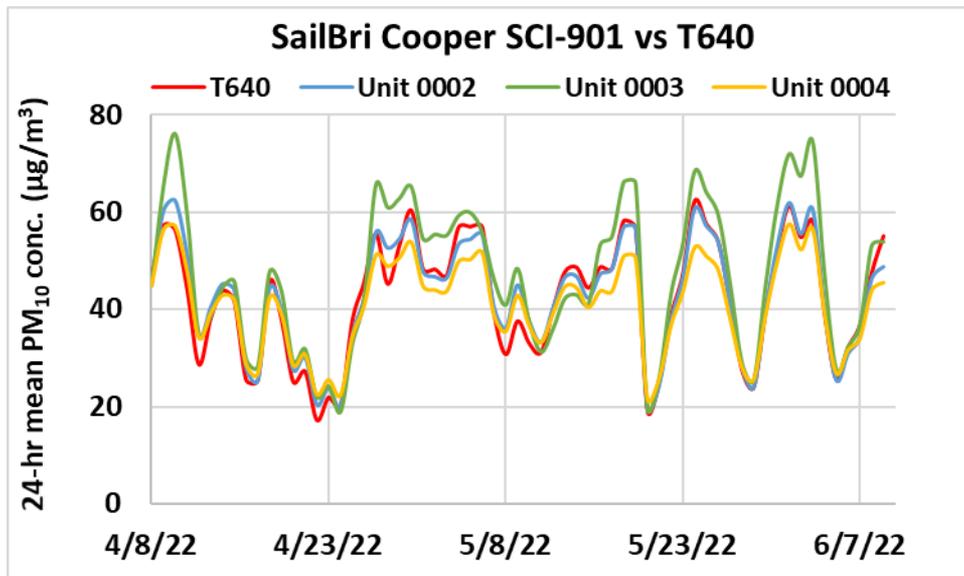
# SCI-901 vs FEM T640 (PM<sub>2.5</sub>; 24-hr mean)



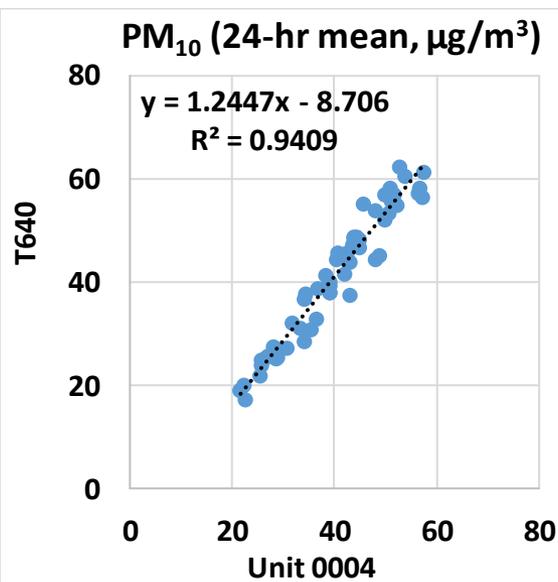
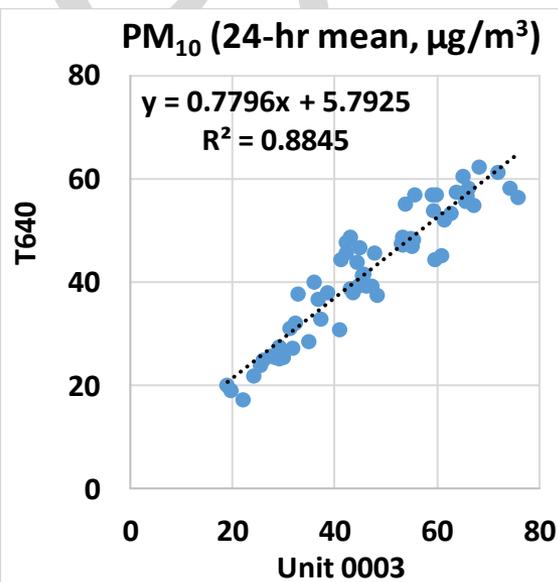
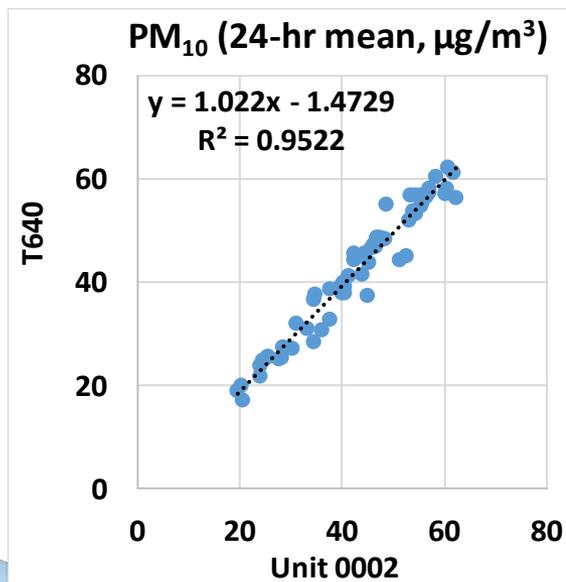
- The SCI-901 sensors showed strong correlations with the corresponding FEM T640 data ( $0.84 < R^2 < 0.90$ )
- Overall, the SCI-901 sensors underestimated the PM<sub>2.5</sub> mass concentrations as measured by FEM T640
- The SCI-901 sensors seemed to track the PM<sub>2.5</sub> daily variations as recorded by FEM T640



# SCI-901 vs T640 (PM<sub>10</sub>; 24-hr mean)



- The SCI-901 sensors showed strong to very strong correlations with the corresponding T640 data ( $0.88 < R^2 < 0.96$ )
- Overall, the SCI-901 sensors overestimated the PM<sub>10</sub> mass concentrations as measured by T640
- The SCI-901 sensors seemed to track the PM<sub>10</sub> daily variations as recorded by T640



# Summary: PM

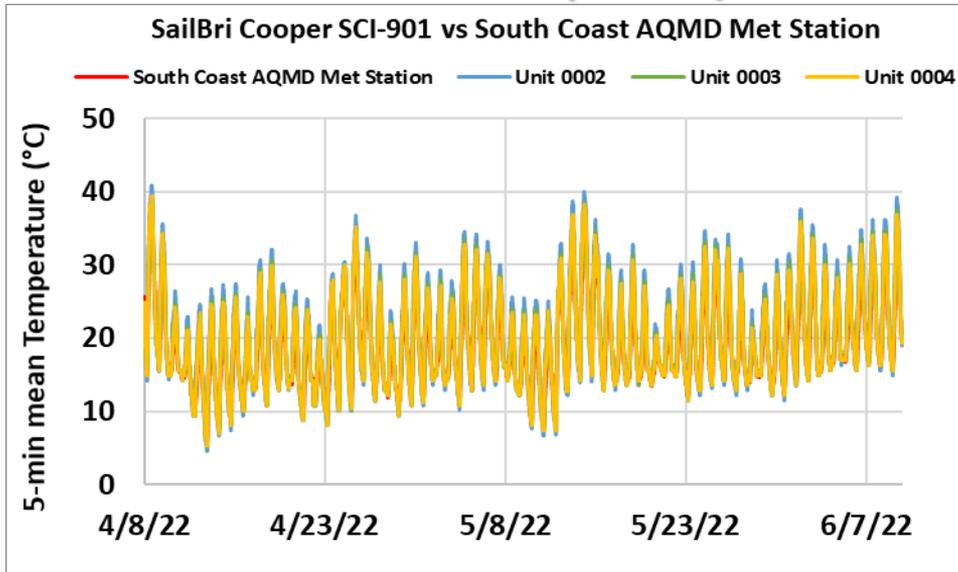
	Average of 3 Sensors, PM <sub>2.5</sub>		SCI-901 vs FEM GRIMM & FEM T640, PM <sub>2.5</sub>						FEM GRIMM & FEM T640 (PM <sub>2.5</sub> , µg/m <sup>3</sup> )		
	Average (µg/m <sup>3</sup> )	SD (µg/m <sup>3</sup> )	R <sup>2</sup>	Slope	Intercept	MBE <sup>1</sup> (µg/m <sup>3</sup> )	MAE <sup>2</sup> (µg/m <sup>3</sup> )	RMSE <sup>3</sup> (µg/m <sup>3</sup> )	Ref. Average	Ref. SD	Range during the field evaluation
<b>5-min</b>	12.9	5.8	0.79 to 0.89	1.05 to 1.15	-0.5 to 1.6	-2.6 to -1.3	2.2 to 3.1	2.9 to 4.2	13.9 to 15.2	7.0 to 7.2	1.2 to 103.6
<b>1-hr</b>	12.9	5.7	0.80 to 0.89	1.06 to 1.15	-0.5 to 1.5	-2.6 to -1.3	2.2 to 3.1	2.8 to 4.1	13.9 to 15.2	6.9 to 7.1	1.5 to 43.8
<b>24-hr</b>	12.9	4.5	0.85 to 0.90	1.05 to 1.18	-0.3 to 1.2	-2.6 to -1.3	1.8 to 2.8	2.2 to 3.4	14.0 to 15.2	5.4 to 5.5	5.6 to 25.4
	Average of 3 Sensors, PM <sub>10</sub>		SCI-901 vs GRIMM & T640, PM <sub>10</sub>						GRIMM & T640 (PM <sub>10</sub> , µg/m <sup>3</sup> )		
	Average (µg/m <sup>3</sup> )	SD (µg/m <sup>3</sup> )	R <sup>2</sup>	Slope	Intercept	MBE <sup>1</sup> (µg/m <sup>3</sup> )	MAE <sup>2</sup> (µg/m <sup>3</sup> )	RMSE <sup>3</sup> (µg/m <sup>3</sup> )	Ref. Average	Ref. SD	Range during the field evaluation
<b>5-min</b>	43.7	16.9	0.64 to 0.82	0.67 to 1.16	-10.3 to 4.9	-1.4 to 12.6	5.6 to 14.1	7.7 to 17.5	32.4 to 42.5	16.9 to 18.0	3.1 to 264.3
<b>1-hr</b>	43.7	16.3	0.65 to 0.86	0.66 to 1.20	-10.0 to 4.8	-1.4 to 12.6	4.9 to 13.9	6.4 to 17.2	32.4 to 42.5	16.1 to 17.2	4.0 to 150.8
<b>24-hr</b>	43.7	12.0	0.67 to 0.95	0.59 to 1.24	-8.7 to 5.9	-1.4 to 12.8	2.0 to 13.5	2.7 to 15.7	32.4 to 42.5	11.2 to 12.2	9.9 to 62.3

<sup>1</sup> 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).

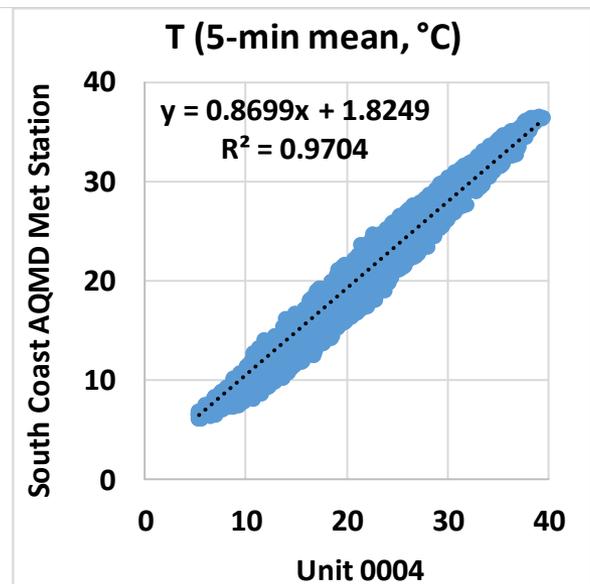
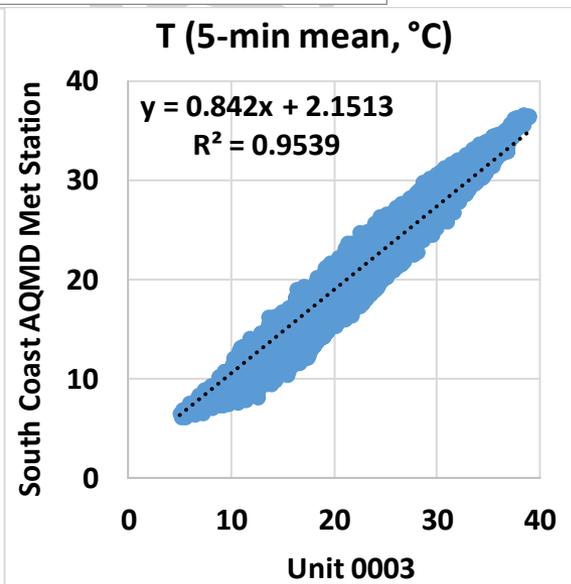
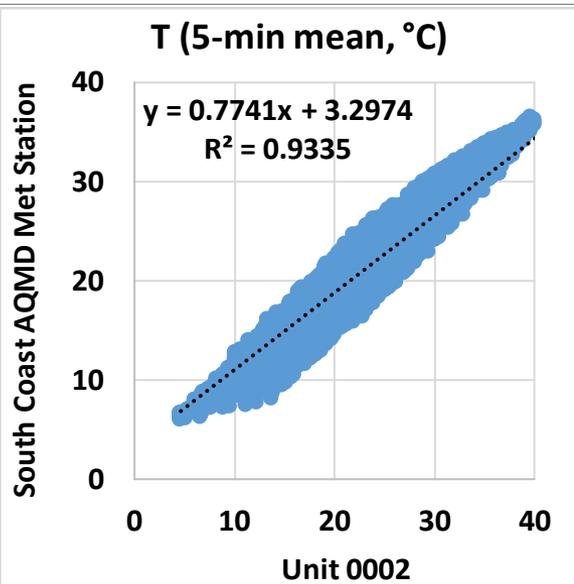
<sup>2</sup> Mean Absolute Error (MAE): the absolute difference between the sensors and the reference instruments. The larger MAE values, the higher measurement errors as compared to the reference instruments.

<sup>3</sup> Root Mean Square Error (RMSE): another metric to calculate measurement errors.

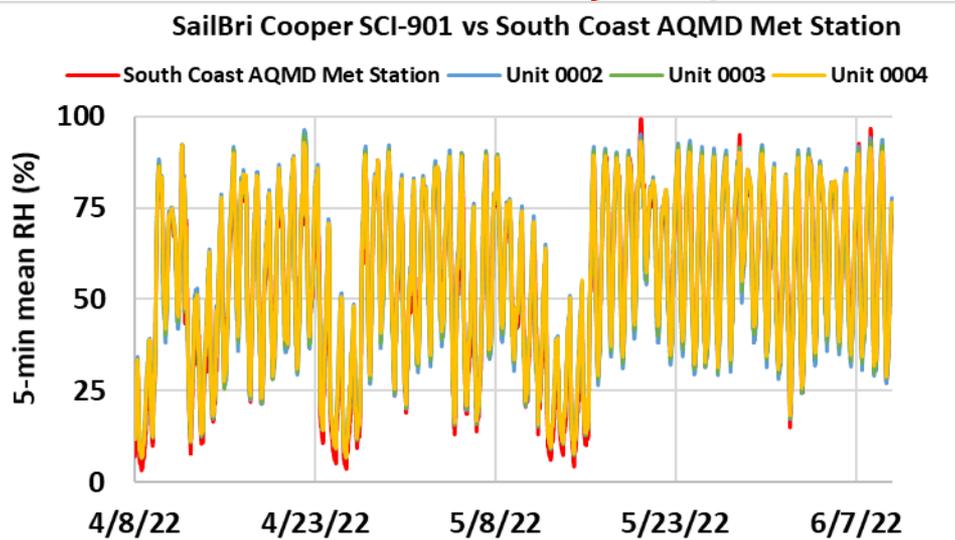
# SCI-901 vs South Coast AQMD Met Station (Temp; 5-min mean)



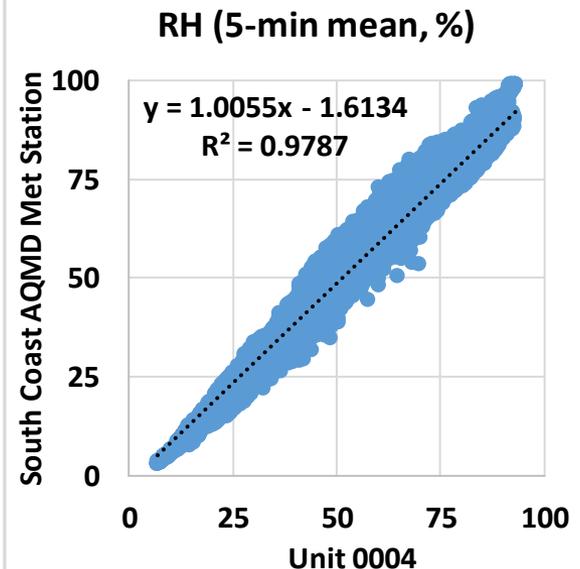
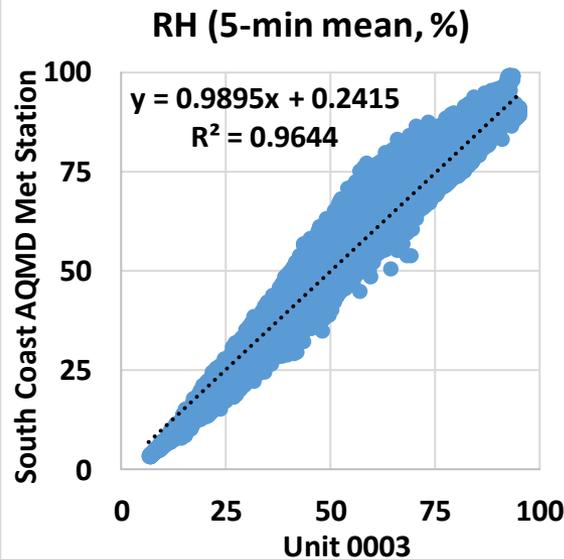
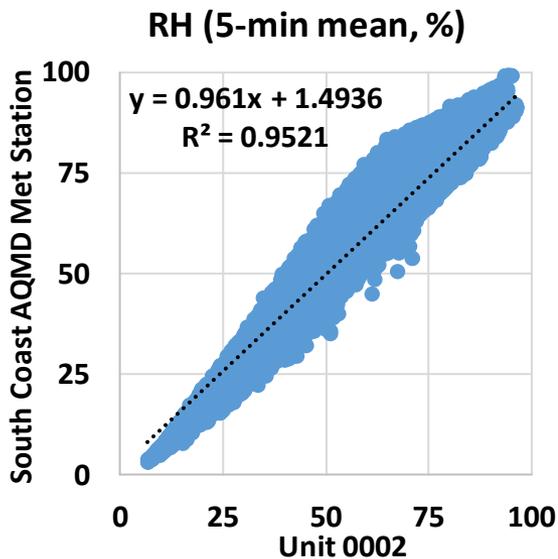
- The SCI-901 sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ( $0.93 < R^2 < 0.98$ )
- Overall, the SCI-901 sensors overestimated the temperature measurement as recorded by South Coast AQMD Met Station
- The SCI-901 sensors seemed to track the diurnal temperature variations as recorded by South Coast AQMD Met Station



# SCI-901 vs South Coast AQMD Met Station (RH; 5-min mean)



- SCI-901 sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ( $0.95 < R^2 < 0.98$ )
- Overall, the SCI-901 sensors overestimated the RH measurement as recorded by South Coast AQMD Met Station
- The SCI-901 sensors seemed to track the diurnal RH variations as recorded by South Coast AQMD Met Station



# Discussion

- The three **SCI-901** sensors' data recovery was 100% for all PM measurements.
- The absolute intra-model variability was  $\sim 0.24$  and  $\sim 2.48 \mu\text{g}/\text{m}^3$  for  $\text{PM}_{2.5}$  and  $\text{PM}_{10}$ , respectively.
- Reference instruments: Very strong correlations between FEM GRIMM and FEM T640 for  $\text{PM}_{2.5}$  ( $R^2 \sim 0.93$ , 1-hr mean) and very strong correlations between GRIMM and T640 for  $\text{PM}_{10}$  ( $R^2 \sim 0.91$ , 1-hr mean) mass concentration measurements.
- The SCI-901 sensors showed strong correlations with the corresponding reference  $\text{PM}_{2.5}$  data ( $0.79 < R^2 < 0.90$ , 1-hr mean) and the sensors underestimated  $\text{PM}_{2.5}$  mass concentrations as measured by FEM GRIMM and FEM T640.
- The SCI-901 sensors showed moderate to strong correlations with the corresponding reference  $\text{PM}_{10}$  data ( $0.65 < R^2 < 0.87$ , 1-hr mean) and the sensors overestimated  $\text{PM}_{10}$  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