Field Evaluation
Aurassure Trust

South Coast
AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 06/14/2024 to 08/14/2024, three **Aurassure Trust** multi-sensor units ("Lite" configuration; hereinafter **Aurassure**) were deployed at the South Coast AQMD stationary ambient monitoring site in Rubidoux and were run side-by-side with Federal Equivalent Method (FEM) instrument measuring the same pollutants.

- Aurassure(*3 units tested*):
  - PM – Optical (Sensirion SPS30, non-FEM)
  - Each unit measures: $PM_{1.0}$ ($\mu g/m^3$), $PM_{2.5}$ ($\mu g/m^3$), PM_{10} ($\mu g/m^3$), T (°C), RH (%)
  - Unit cost: $525
  - Time resolution: 1-min
  - Units IDs: 0W8, F44, and WUD

- South Coast AQMD Reference instruments:
  - PM instrument (Teledyne API T640; FEM $PM_{2.5}$, hereinafter FEM T640)
    - Cost: $21,000
  - Time resolution: 1-min
  - Measures $PM_{1.0}$, $PM_{2.5}$, PM_{10} ($\mu g/m^3$)

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

Particulate Matter (PM) in Aurassure

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 0W8, Unit F44 and Unit WUD was ~99.8% for all PM measurements

- Data related to 4th of July activities were excluded from data analysis for all sensors and reference instruments

Aurassure; intra-model variability

- Absolute intra-model variability was ~0.2 µg/m^3 for $PM_{1.0}$, $PM_{2.5}$ and PM_{10}
(calculated as the standard deviation of the three sensor means)
- Relative intra-model variability was ~2.5 %, ~2.3 % and ~2.3 % 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)
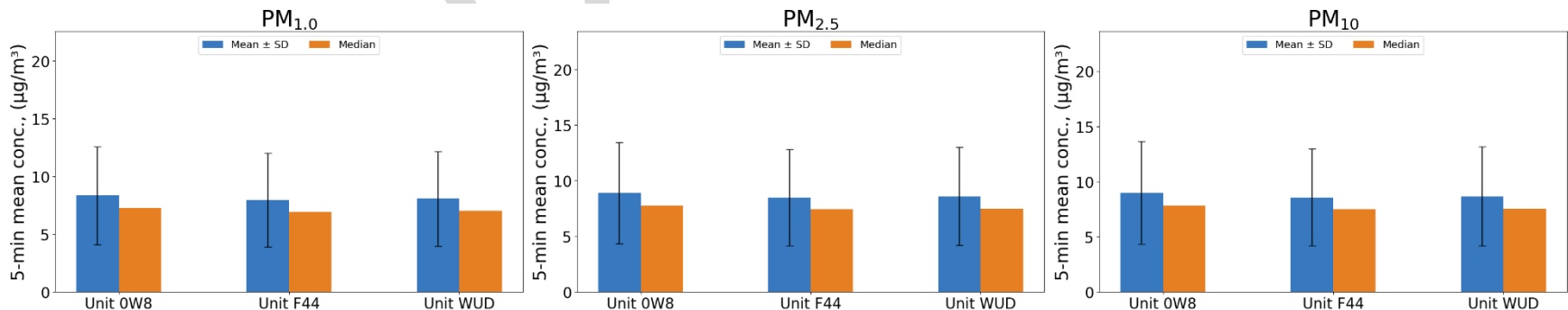
4

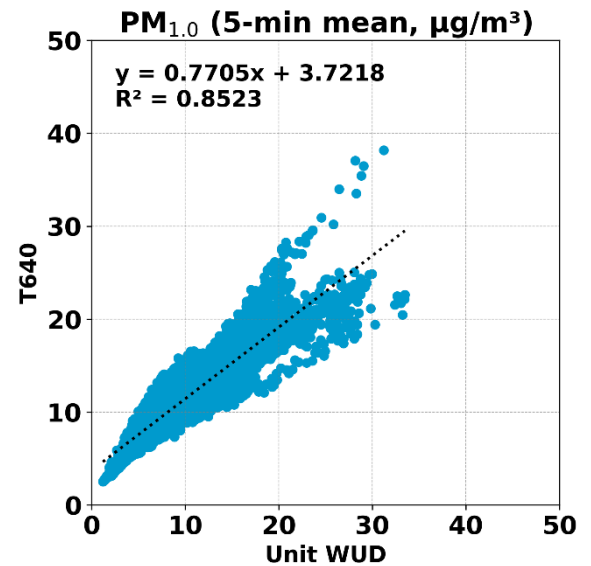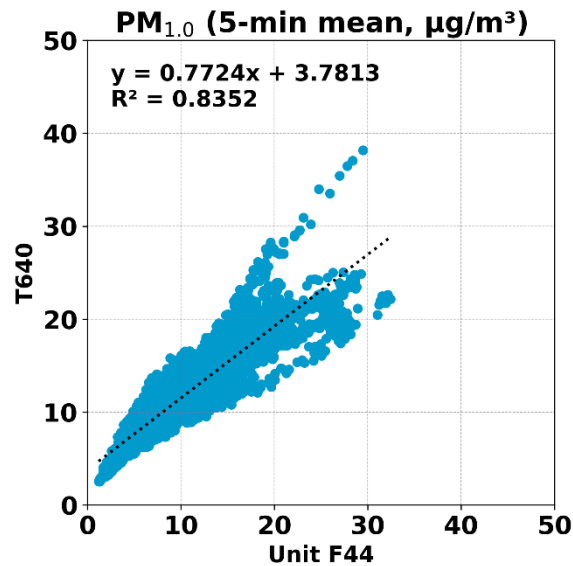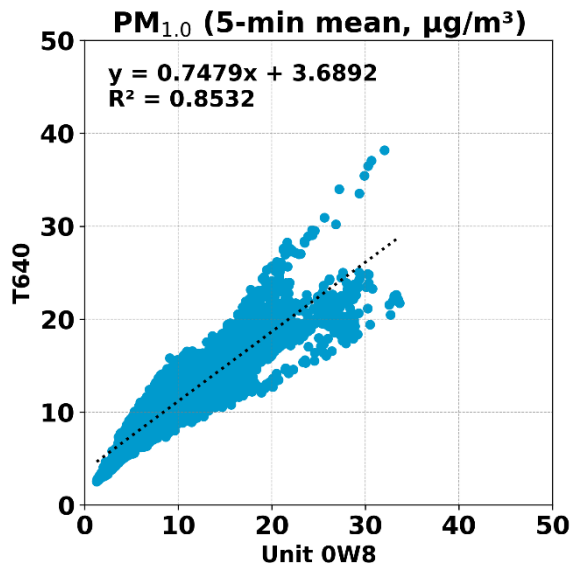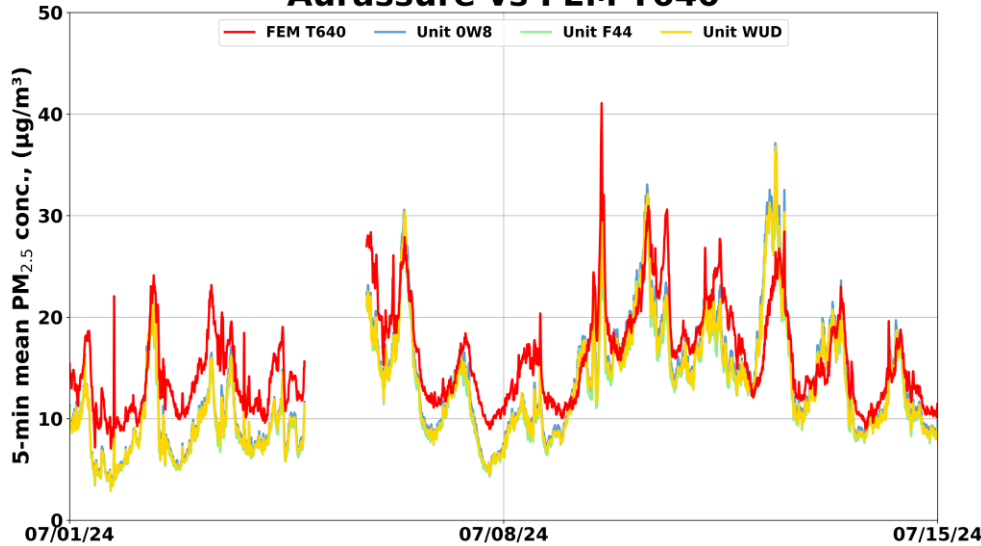# Aurassure vs T640 (PM$_{1.0}$; 5-min mean)
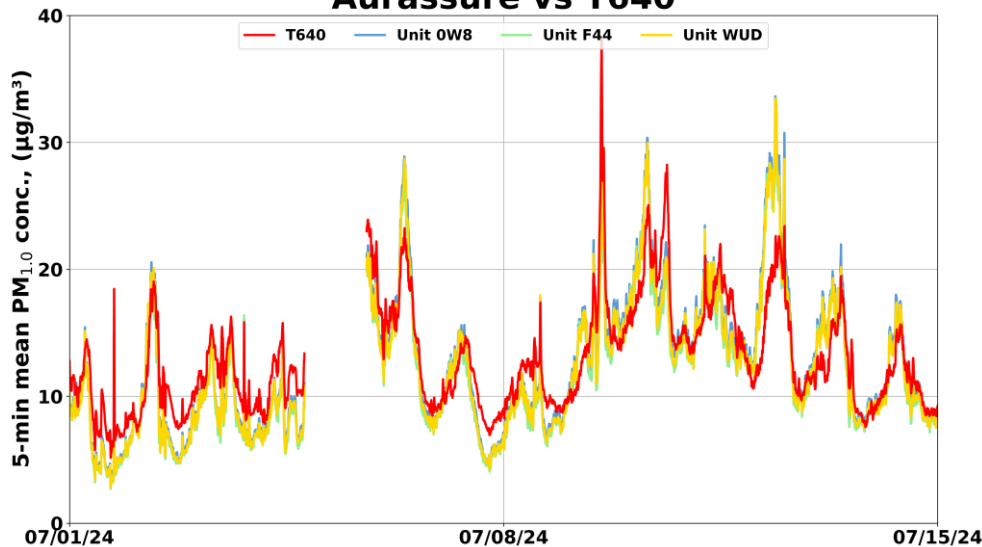
- The Aurassure sensors showed strong correlations with the corresponding T640 data ($0.83 < R^2 < 0.86$)

- Overall, the Aurassure sensors underestimated the PM$_{1.0}$ mass concentrations as measured by T640

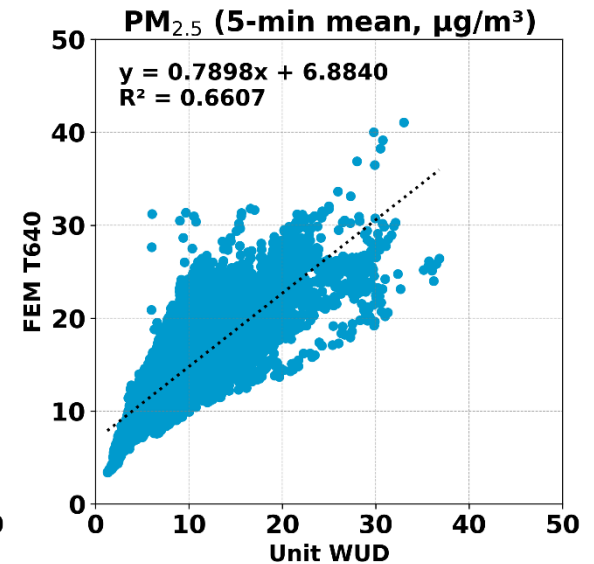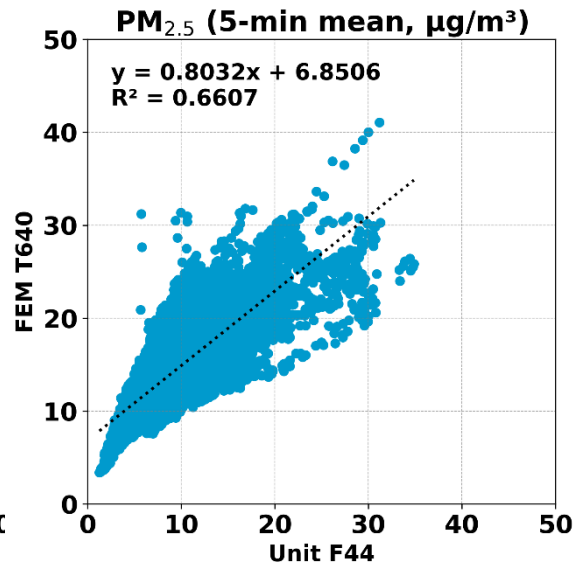- The Aurassure sensors seemed to track the PM$_{1.0}$ diurnal variations as recorded by T640
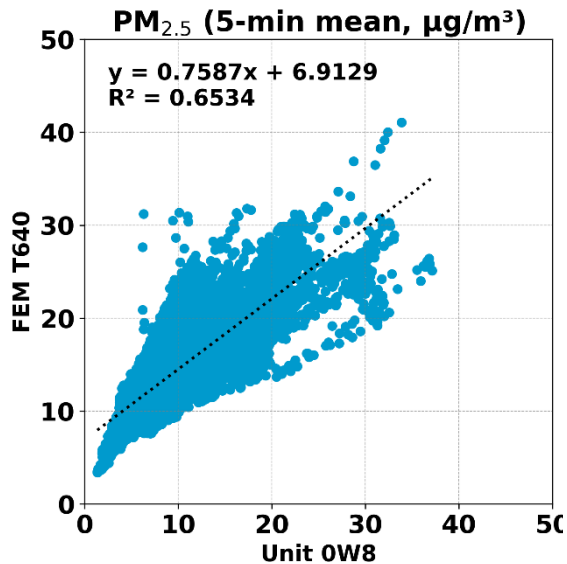
Aurassure vs FEM T640 (PM$_{2.5}$; 5-min mean)

Aurassure vs FEM T640

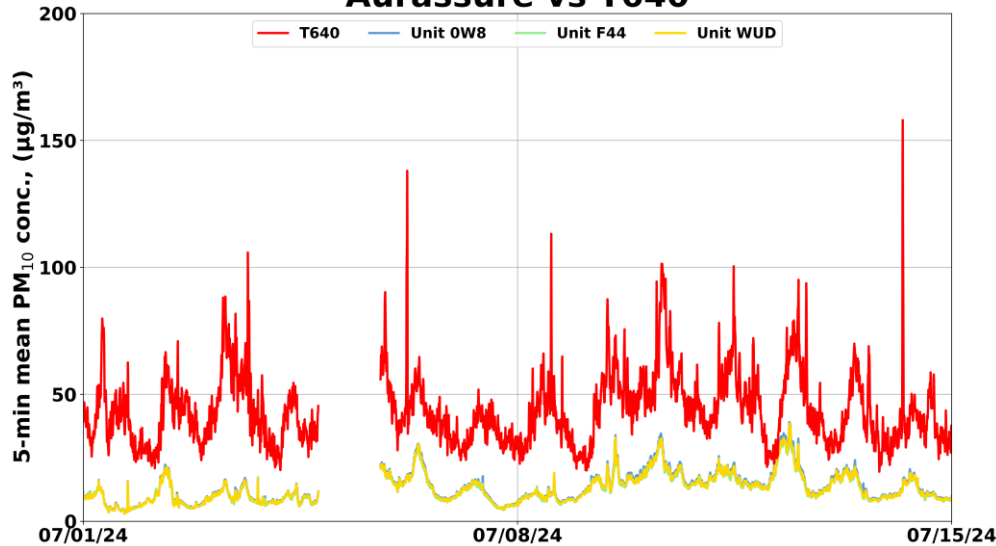Legend: FEM T640 — Unit 0W8 — Unit F44 — Unit WUD

- The Aurassure sensors showed moderate correlations with the corresponding FEM T640 data (0.65 < R^2 < 0.67)

- Overall, the Aurassure sensors underestimated the PM$_{2.5}$ mass concentrations as measured by FEM T640

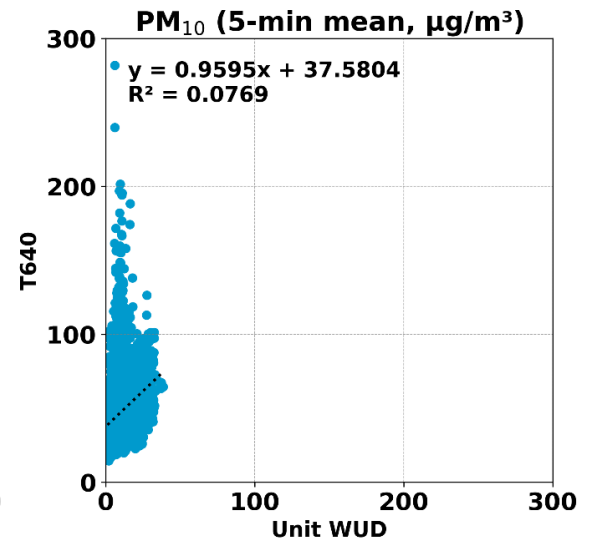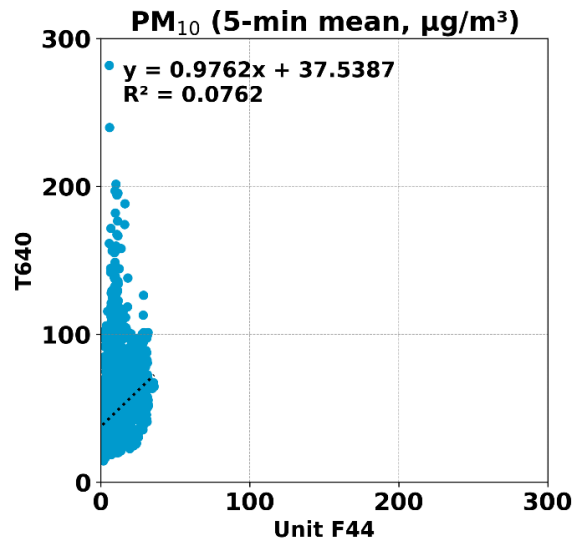- The Aurassure sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM T640

PM$_{2.5}$ (5-min mean, μg/m³)

y = 0.7587x + 6.9129
R² = 0.6534

PM$_{2.5}$ (5-min mean, μg/m³)

y = 0.8032x + 6.8506
R² = 0.6607

PM$_{2.5}$ (5-min mean, μg/m³)

y = 0.7898x + 6.8840
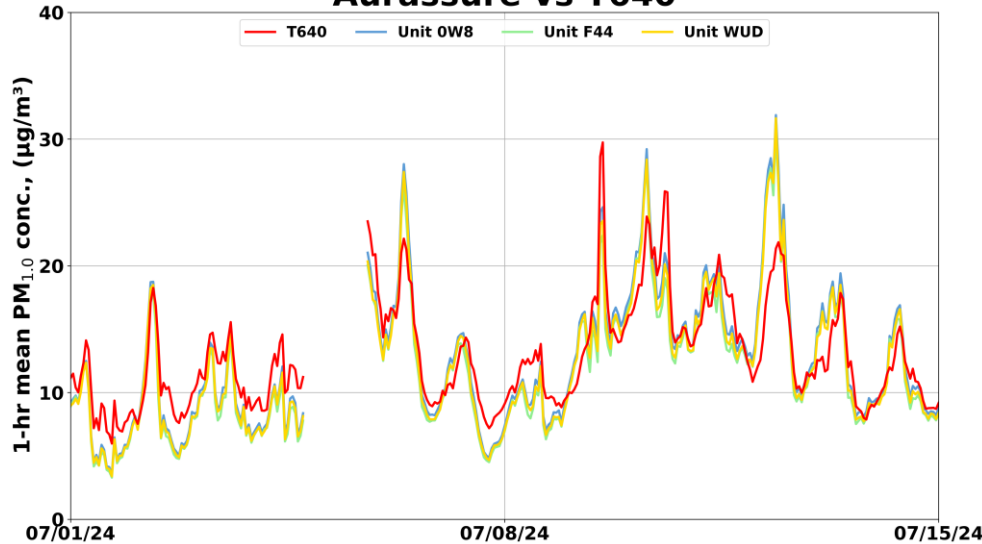R² = 0.6607

Aurassure vs T640 (PM$_{10}$; 5-min mean)

- The Aurassure sensors showed no correlations with the corresponding T640 data ($0.07 < R^2 < 0.08$)

- Overall, the Aurassure sensors underestimated the PM$_{10}$ mass concentrations as measured by T640

- The Aurassure sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by T640
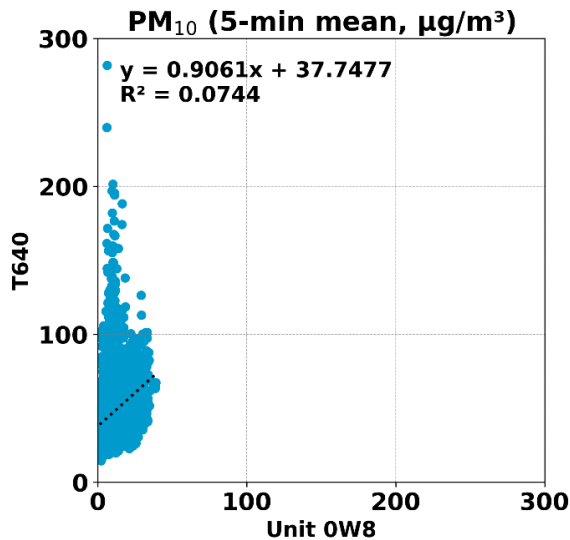
Aurassure vs T640 (PM$_{1.0}$; 1-hr mean)

- The Aurassure sensors showed strong correlations with the corresponding T640 data ($0.84 < R^2 < 0.86$)

- Overall, the Aurassure sensors underestimated the PM$_{1.0}$ mass concentrations as measured by T640

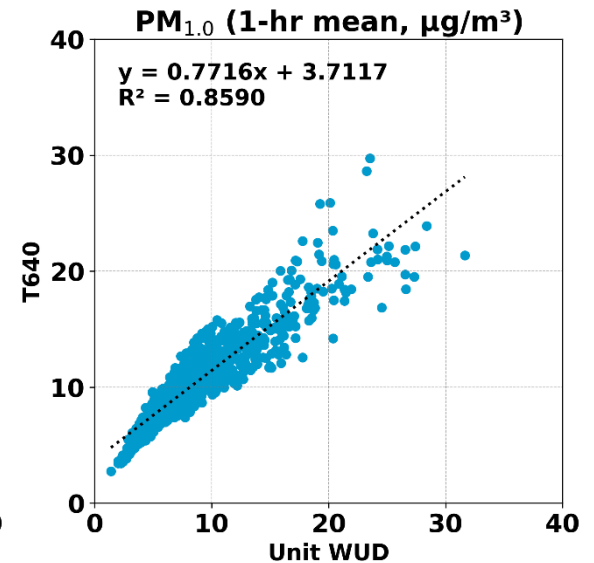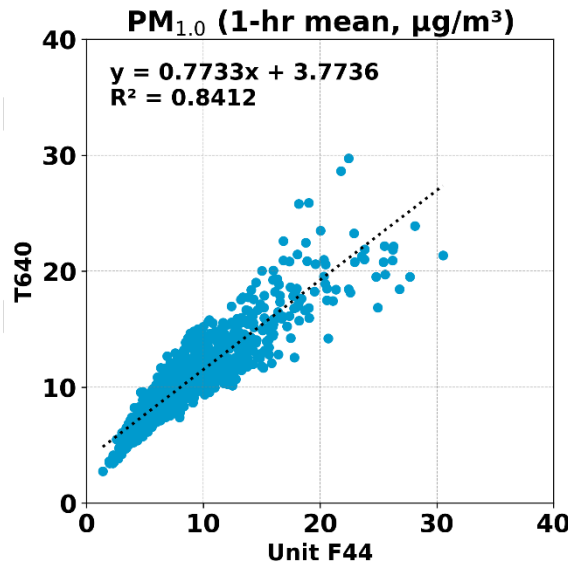- The Aurassure sensors seemed to track the PM$_{1.0}$ diurnal variations as recorded by T640
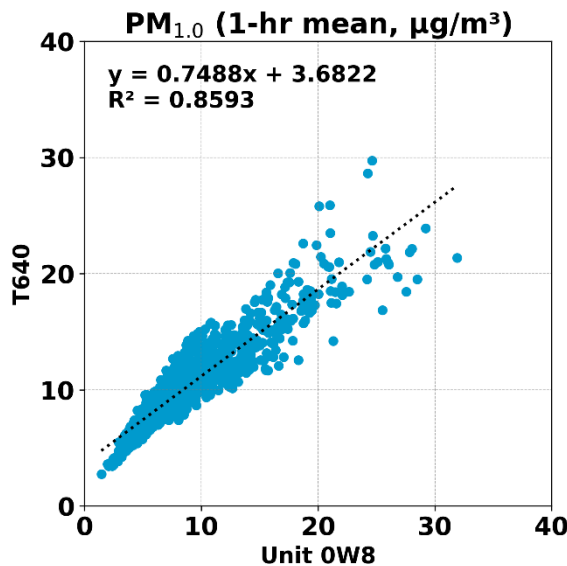
Aurassure vs FEM T640 (PM$_{2.5}$; 1-hr mean)

- The Aurassure sensors showed moderate correlations with the corresponding FEM T640 data ($0.66 < R^2 < 0.67$)

- Overall, the Aurassure sensors underestimated the PM$_{2.5}$ mass concentrations as measured by FEM T640

- The Aurassure sensors seemed to track the PM$_{2.5}$ diurnal variations as recorded by FEM T640

9

Aurassure vs T640 (PM$_{10}$; 1-hr mean)
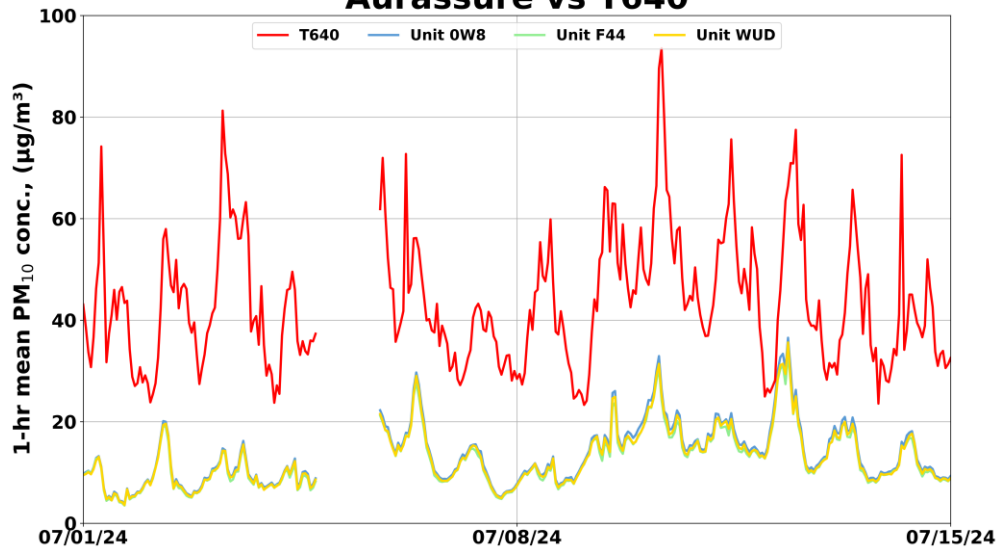
- The Aurassure sensors showed no correlations with the corresponding T640 data ($0.08 < R^2 < 0.10$)

- Overall, the Aurassure sensors underestimated the PM$_{10}$ mass concentrations as measured by T640

- The Aurassure sensors did not seem to track the PM$_{10}$ diurnal variations as recorded by T640
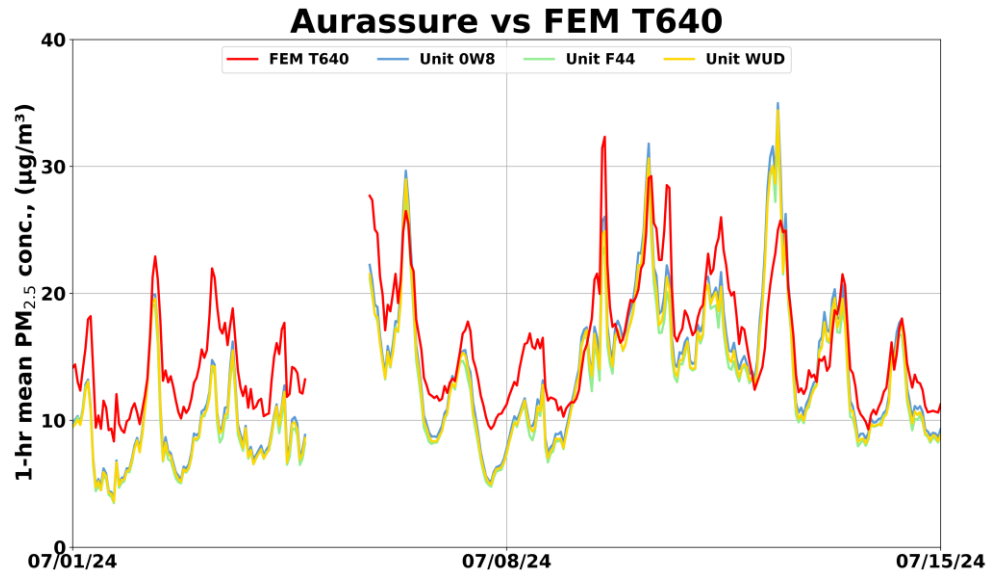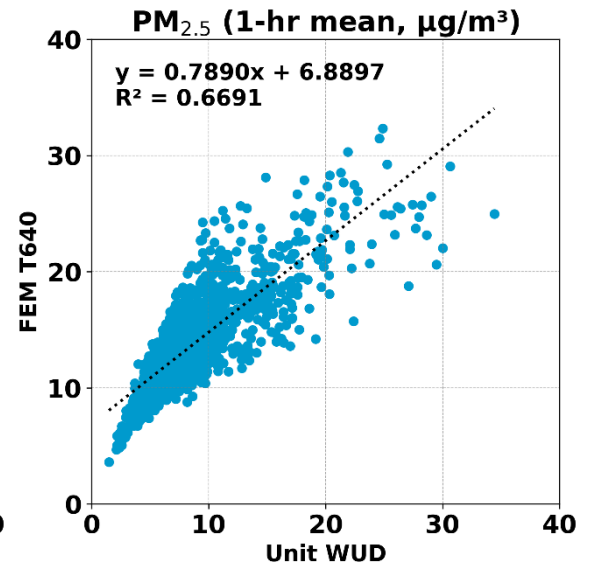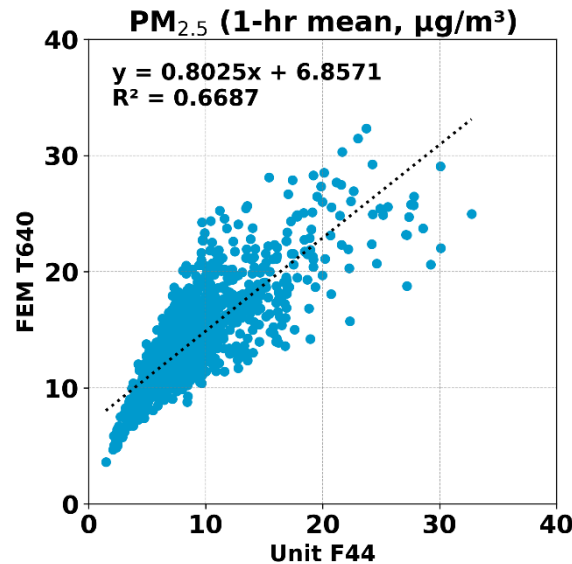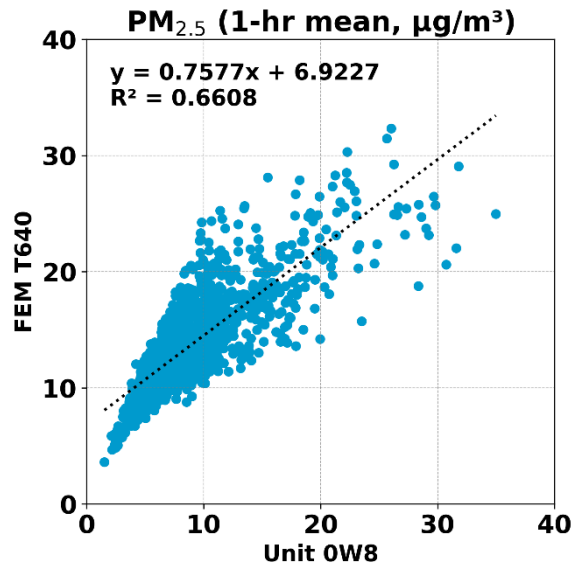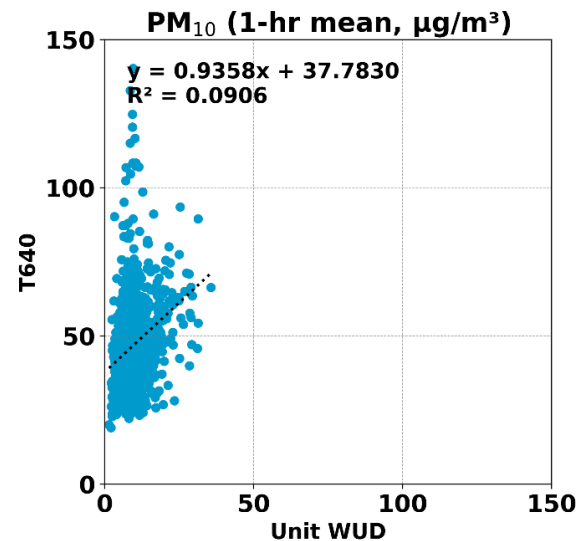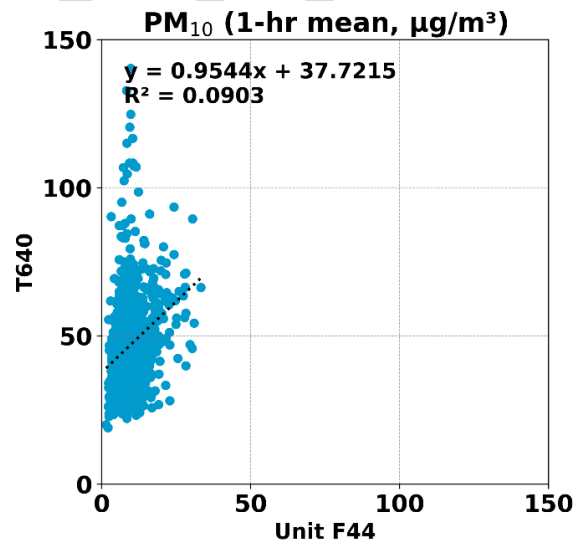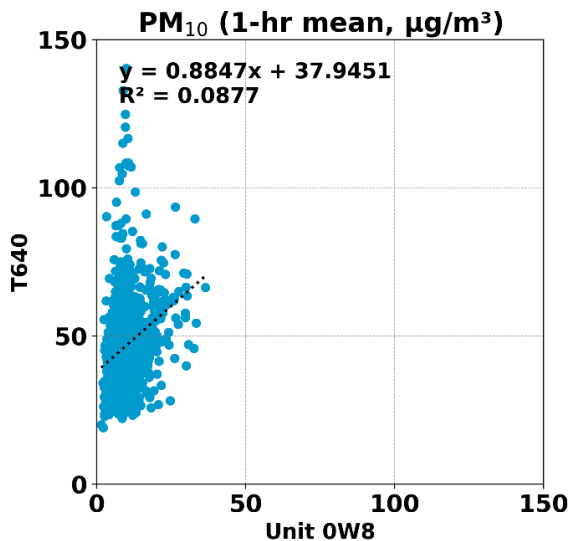
Aurassure vs T640 (PM$_{1.0}$; 24-hr mean)
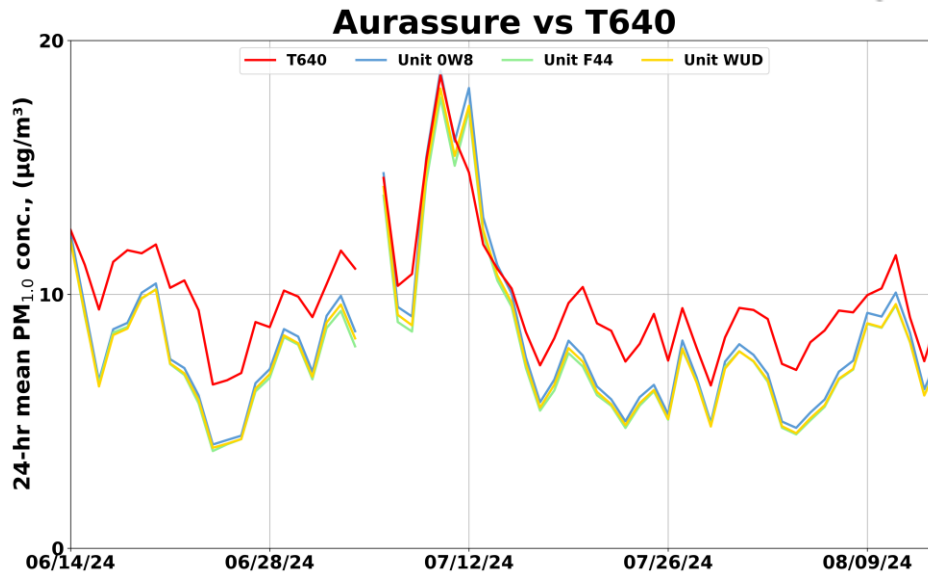
- The Aurassure sensors showed very strong correlations with the corresponding T640 data ($0.90 < R^2 < 0.92$)

- Overall, the Aurassure sensors underestimated the PM$_{1.0}$ mass concentrations as measured by T640

- The Aurassure sensors seemed to track the PM$_{1.0}$ daily variations as recorded by T640

# Aurassure vs FEM T640 (PM$_{2.5}$; 24-hr mean)

Aurassure vs FEM T640

- The Aurassure sensors showed moderate correlations with the corresponding FEM T640 data (0.61 < R^2 < 0.65)

- Overall, the Aurassure sensors underestimated the PM$_{2.5}$ mass concentrations as measured by FEM T640

- The Aurassure sensors seemed to track the PM$_{2.5}$ daily variations as recorded by FEM T640
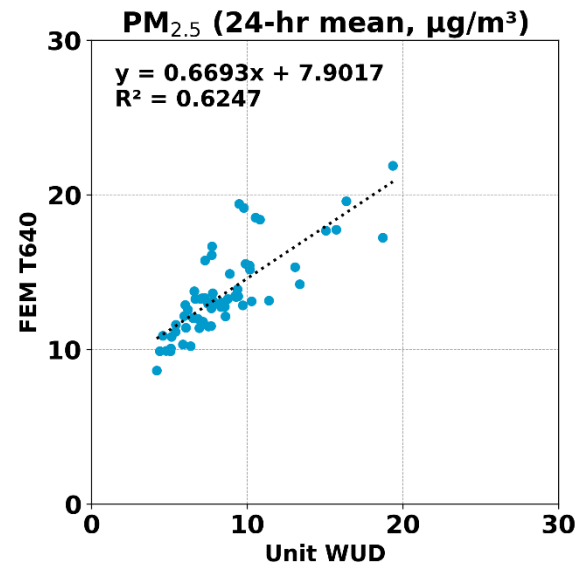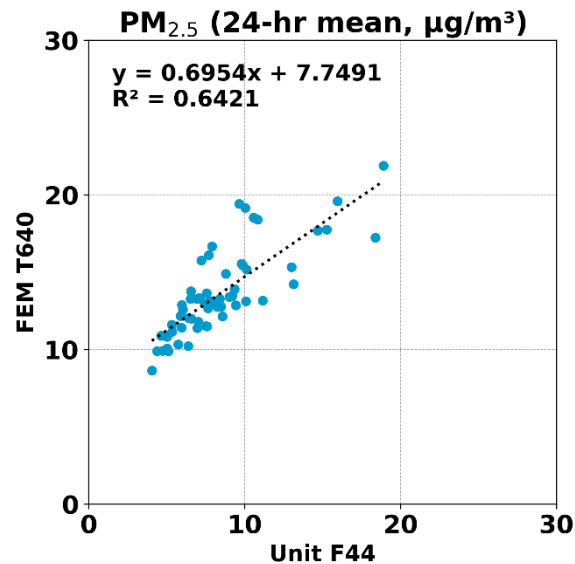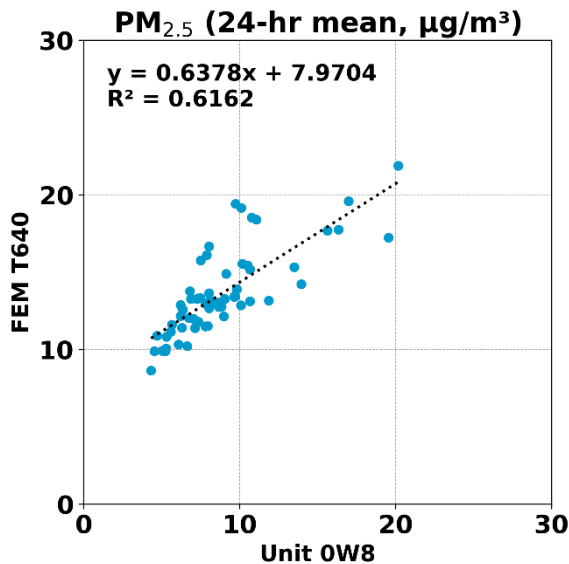
PM$_{2.5}$ (24-hr mean, µg/m³)

$y = 0.6378x + 7.9704$
$R^2 = 0.6162$

PM$_{2.5}$ (24-hr mean, µg/m³)

$y = 0.6954x + 7.7491$
$R^2 = 0.6421$

PM$_{2.5}$ (24-hr mean, µg/m³)

$y = 0.6693x + 7.9017$
$R^2 = 0.6247$

Aurassure vs T640 (PM$_{10}$; 24-hr mean)

Aurassure vs T640

Legend: T640, Unit 0W8, Unit F44, Unit WUD

y-axis: 24-hr mean PM$_{10}$ conc., (µg/m³)

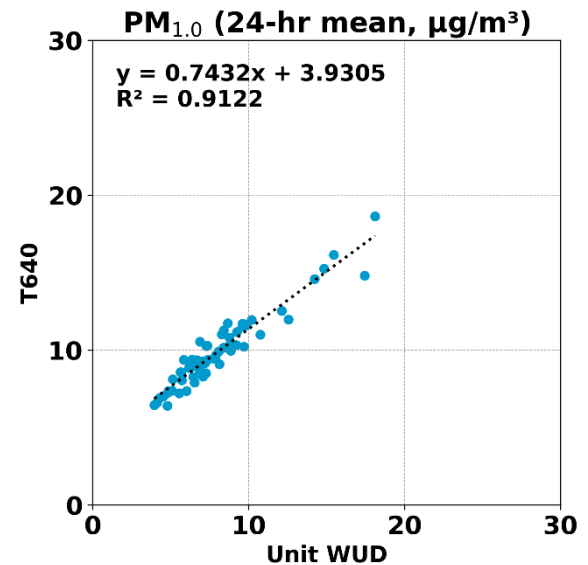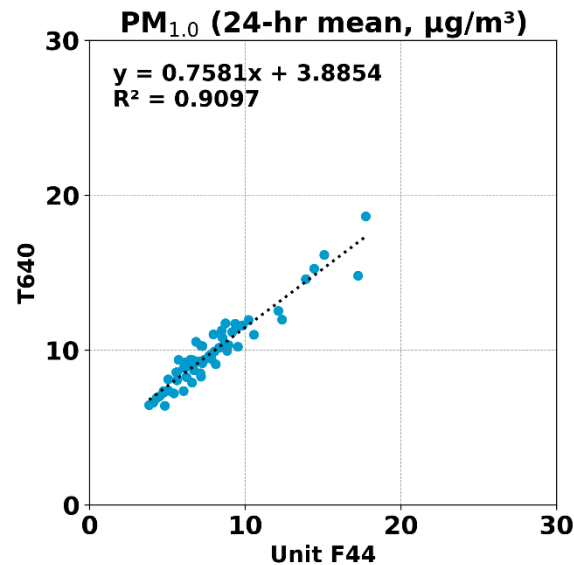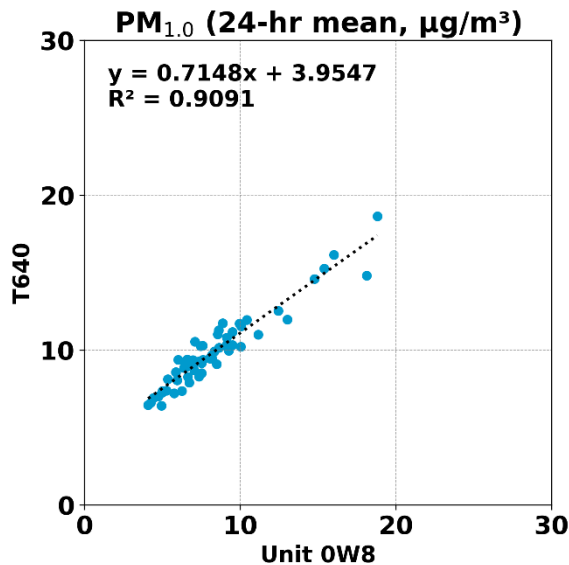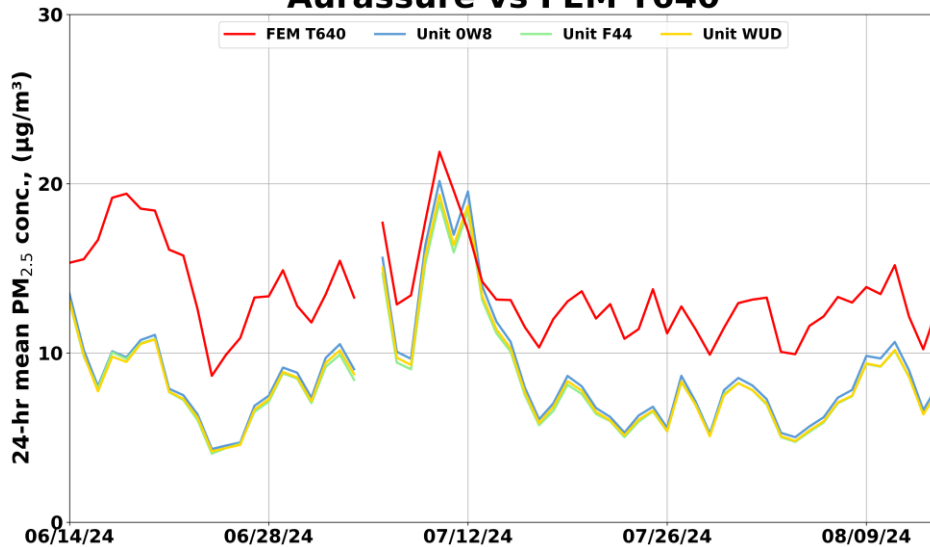x-axis dates: 06/14/24, 06/28/24, 07/12/24, 07/26/24, 08/09/24
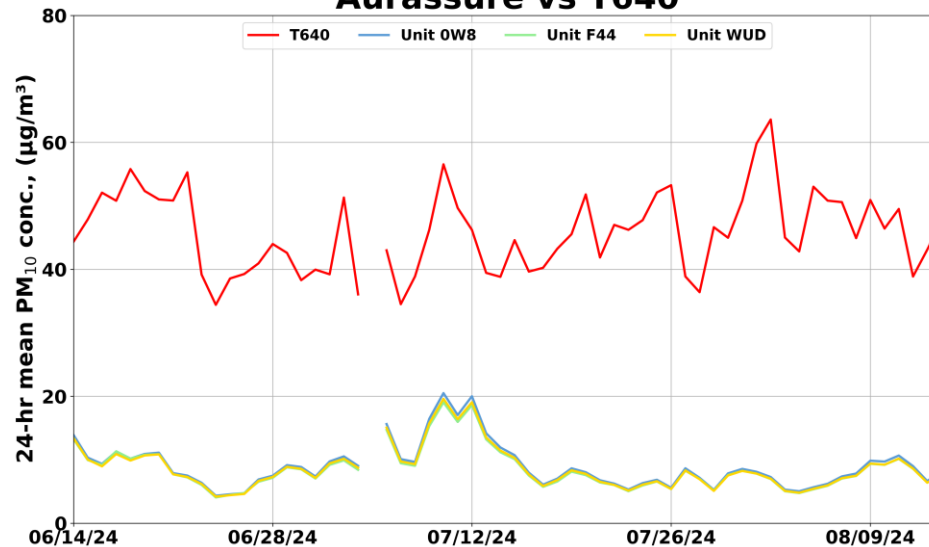
- The Aurassure sensors showed no correlations with the corresponding T640 data ($0.02 < R^2 < 0.03$)
- Overall, the Aurassure sensors underestimated the PM$_{10}$ mass concentrations as measured by T640
- The Aurassure sensors did not seem to track the PM$_{10}$ daily variations as recorded by T640

PM$_{10}$ (24-hr mean, µg/m³)

$y = 0.2638x + 43.4579$
$R^2 = 0.0208$

x-axis: Unit 0W8 ; y-axis: T640

PM$_{10}$ (24-hr mean, µg/m³)

$y = 0.3176x + 43.1122$
$R^2 = 0.0261$

x-axis: Unit F44 ; y-axis: T640

PM$_{10}$ (24-hr mean, µg/m³)

$y = 0.2783x + 43.4194$
$R^2 = 0.0211$

x-axis: Unit WUD ; y-axis: T640

13
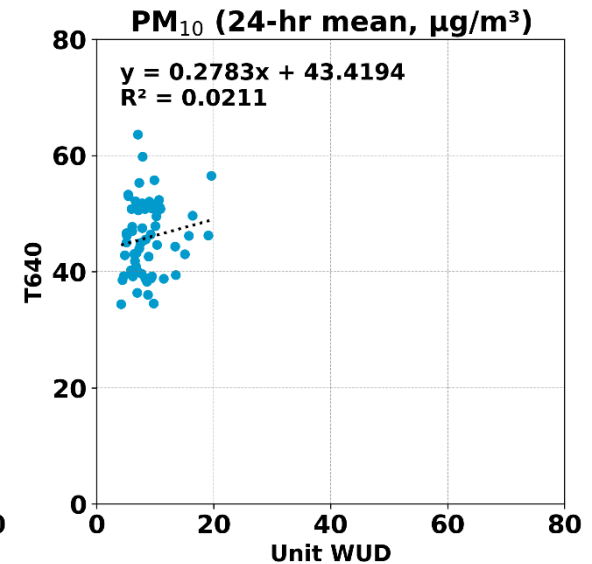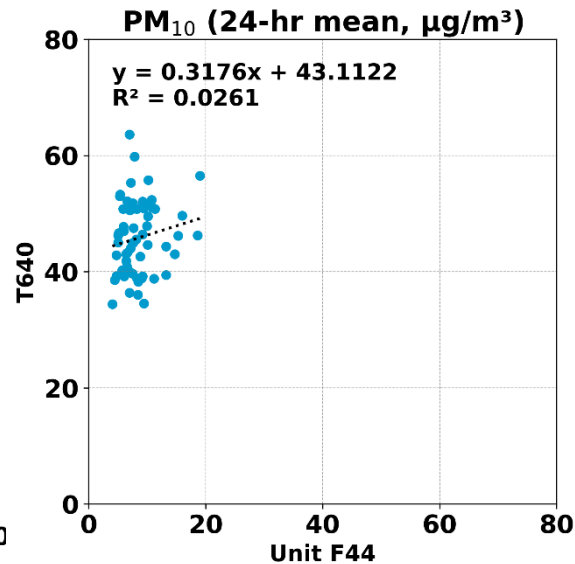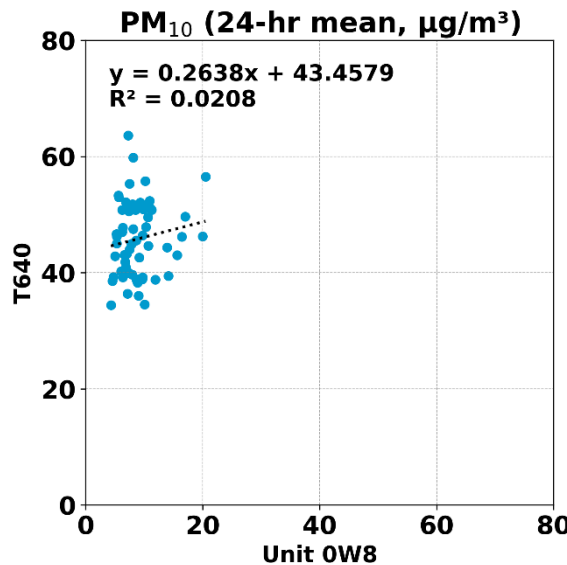
Summary: PM

	Average of 3 Sensors, PM$_{1.0}$		Aurassure vs T640, PM$_{1.0}$						T640 (PM$_{1.0}$, µg/m^3)		
	Average (µg/m^3)	SD (µg/m^3)	R^2	Slope	Intercept	MBE[1] (µg/m^3)	MAE[2] (µg/m^3)	RMSE[3] (µg/m^3)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	8.1	4.1	0.84 to 0.85	0.75 to 0.77	3.7 to 3.8	-2.0 to -1.6	2.0 to 2.3	2.3 to 2.6	9.9	3.4	2.5 to 38.2
1-hr	8.1	4.1	0.84 to 0.86	0.75 to 0.77	3.7 to 3.8	-2.0 to -1.6	2.0 to 2.3	2.3 to 2.6	9.9	3.4	2.8 to 29.7
24-hr	8.1	3.1	0.91	0.71 to 0.76	3.9 to 4.0	-2.0 to -1.6	1.7 to 2.1	2.0 to 2.2	9.9	2.4	6.4 to 18.6

	Average of 3 Sensors, PM$_{2.5}$		Aurassure vs FEM T640, PM$_{2.5}$						FEM T640 (PM$_{2.5}$, µg/m^3)		
	Average (µg/m^3)	SD (µg/m^3)	R^2	Slope	Intercept	MBE[1] (µg/m^3)	MAE[2] (µg/m^3)	RMSE[3] (µg/m^3)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	8.7	4.4	0.65 to 0.66	0.76 to 0.80	6.9 to 6.9	-5.2 to -4.8	5.0 to 5.3	5.5 to 5.8	13.7	4.3	3.4 to 41.1
1-hr	8.7	4.4	0.66 to 0.67	0.76 to 0.80	6.9	-5.2 to -4.8	5.0 to 5.3	5.5 to 5.8	13.7	4.2	3.6 to 32.3
24-hr	8.6	3.3	0.62 to 0.64	0.64 to 0.70	7.7 to 8.0	-5.2 to -4.8	4.8 to 5.2	5.2 to 5.5	13.6	2.8	8.6 to 21.9

	Average of 3 Sensors, PM$_{10}$		Aurassure vs T640, PM$_{10}$						T640 (PM$_{10}$, µg/m^3)		
	Average (µg/m^3)	SD (µg/m^3)	R^2	Slope	Intercept	MBE[1] (µg/m^3)	MAE[2] (µg/m^3)	RMSE[3] (µg/m^3)	Ref. Average	Ref. SD	Range during the field evaluation
5-min	8.7	4.5	0.07 to 0.08	0.91 to 0.98	37.5 to 37.7	-37.3 to -36.9	36.9 to 37.3	39.8 to 40.2	45.9	15.5	14.6 to 281.8
1-hr	8.7	4.5	0.09	0.88 to 0.95	37.7 to 37.9	-37.3 to -36.9	36.9 to 37.3	39.2 to 39.6	45.9	13.8	19.1 to 140.3
24-hr	8.7	3.4	0.02 to 0.03	0.26 to 0.32	43.1 to 43.5	-37.3 to -36.9	36.9 to 37.3	37.5 to 37.9	45.8	6.4	34.4 to 63.6

[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.

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

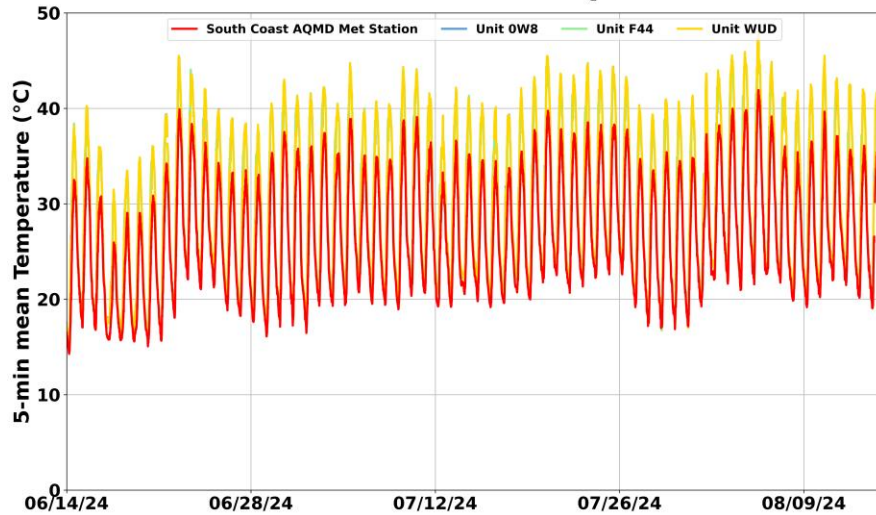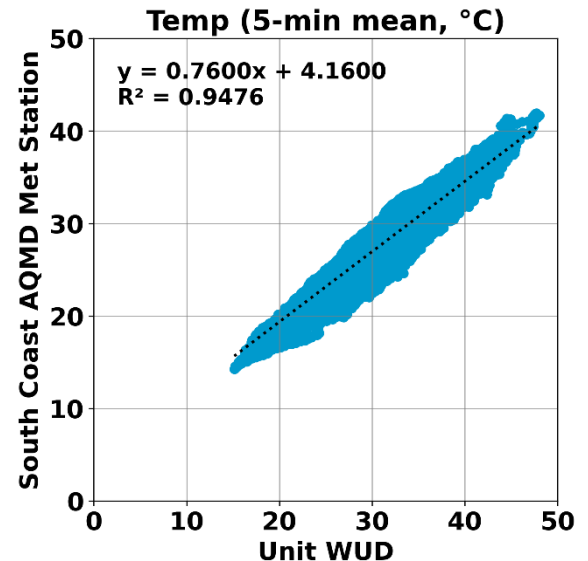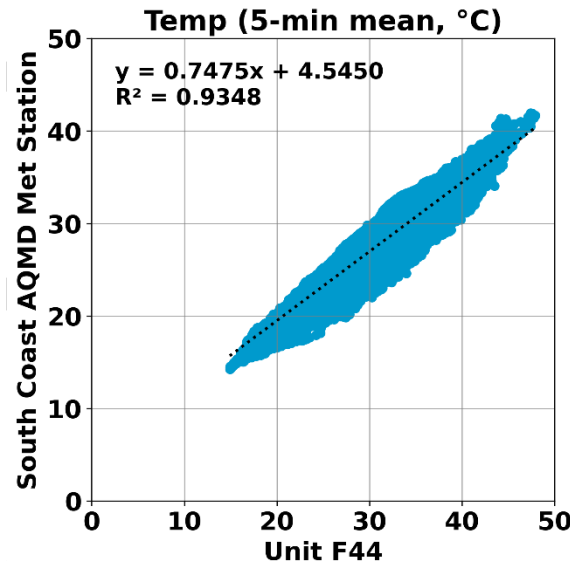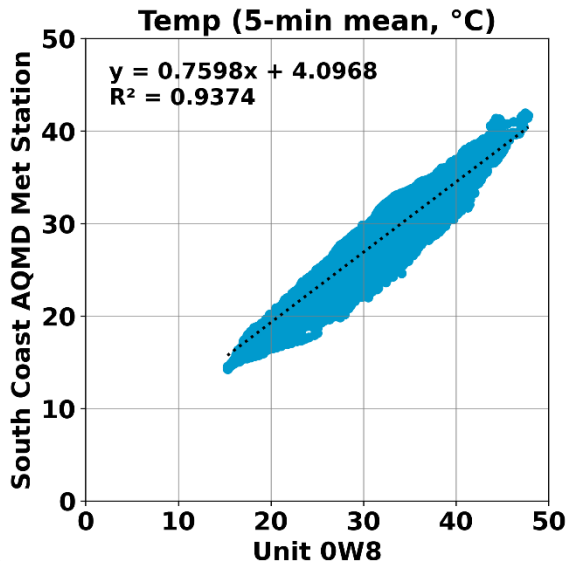### Aurassure vs. South Coast AQMD Met Station

- The Aurassure sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ($0.93 < R^2 < 0.95$)

- Overall, the Aurassure sensors overestimated the temperature measurement as recorded by South Coast AQMD Met Station

- The Aurassure sensors seemed to track the diurnal temperature variations as recorded by South Coast AQMD Met Station

Temp (5-min mean, °C)

$y = 0.7598x + 4.0968$
$R^2 = 0.9374$

Unit 0W8

Temp (5-min mean, °C)

$y = 0.7475x + 4.5450$
$R^2 = 0.9348$

Unit F44

Temp (5-min mean, °C)

$y = 0.7600x + 4.1600$
$R^2 = 0.9476$

Unit WUD

15

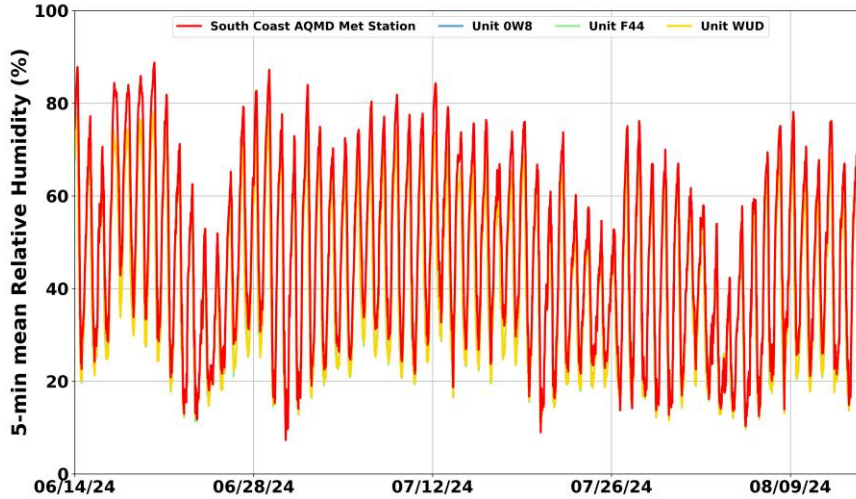# Aurassure vs South Coast AQMD Met Station (RH; 5-min mean)

- Aurassure sensors showed very strong correlations with the corresponding South Coast AQMD Met Station data ($0.94 < R^2 < 0.96$)

- Overall, the Aurassure sensors underestimated the RH measurement as recorded by South Coast AQMD Met Station

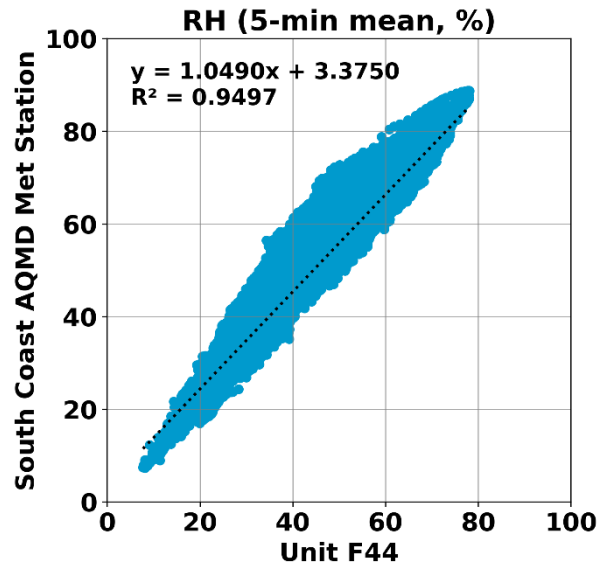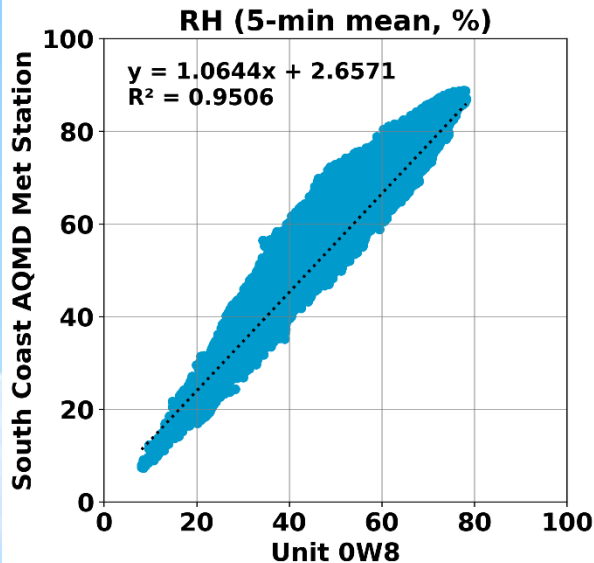- The Aurassure sensors seemed to track the diurnal RH variations as recorded by South Coast AQMD Met Station

$y = 1.0644x + 2.6571$
$R^2 = 0.9506$

$y = 1.0490x + 3.3750$
$R^2 = 0.9497$

$y = 1.0696x + 2.3048$
$R^2 = 0.9584$
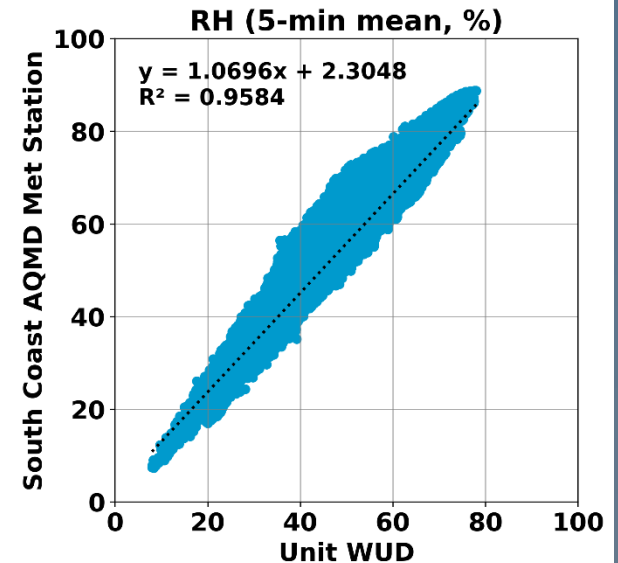
Discussion

- The three **Aurassure** sensors' data recovery for all PM fractions was ~99.8%.

- Absolute intra-model variability was ~0.2 $\mu g/m^3$ for $PM_{1.0}$, $PM_{2.5}$ and PM_{10}

- $PM_{1.0}$ mass concentrations measured by the Aurassure sensors showed strong correlations with the corresponding T640 $PM_{1.0}$ data ($0.84 < R^2 < 0.86$, 1-hr mean). The sensors underestimated $PM_{1.0}$ mass concentrations as measured by T640.

- $PM_{2.5}$ mass concentrations measured by the Aurassure sensors showed moderate correlations with the corresponding FEM T640 $PM_{2.5}$ data ($0.66 < R^2 < 0.67$, 1-hr mean). The sensors underestimated $PM_{2.5}$ mass concentrations as measured by FEM T640.

- PM_{10} mass concentrations measured by the Aurassure sensors showed no correlations with the corresponding T640 PM_{10} data ($0.08 < R^2 < 0.10$, 1-hr mean). The sensors underestimated PM_{10} mass concentrations as measured by T640.

- Temperature and relative humidity sensors showed very strong correlations with the South Coast AQMD Met Station T and RH data, respectively ($R^2 \sim 0.94$ for T and $R^2 \sim 0.95$ for RH) and overestimated the T and underestimated the RH data as recorded by the South Coast AQMD Met Station

- 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