



Technical Evaluation of Sensor Technology (TEST) Program

*PurpleAir PA-II Sensor
2020 – 4th Quarter*



Introduction and Sensor Profile

This analysis report is focused on assessing the performance of the PurpleAir PA-II sensor as a part of the District's Technical Evaluation of Sensor Technology (TEST) Program. The PurpleAir PA-II sensor uses an optical laser-based particle counting methodology to estimate the mass of varying diameters of particulate matter, including PM1, PM2.5, and PM10. The PA-II sensor also measures temperature, pressure, and relative humidity.

Background and Approach of Evaluation Test

In November of 2017, NASA began an air quality study to compare the performance of PurpleAir sensors to regulatory PM2.5 monitors. The study is focused on the conditions in the San Joaquin Valley and is based at California Air Resources Board (CARB) air monitoring sites of , Fresno-Garland, Modesto-14th St, Visalia-Church, and Bakersfield-California. In 2019, the District began operating PurpleAir sensors at the District's Clovis-Villa air monitoring site and in the Shafter and South Central Fresno AB 617 communities.

The data sets analyzed for this report compare PM2.5 data collected from PurpleAir sensors and Federal Equivalent Method (FEM) monitors that are collocated at the CARB and District air monitoring sites listed above. The scatter plots and time series graphs below show how the datasets compare for both hourly values and the 24-hour average.

Overview of Analysis Findings from Current Period

The analysis for this report covers the time period of October 1, 2020, through December 31, 2020 (2020 – 4th quarter). During this period, hourly data was removed from the calculation of bias when either the PurpleAir sensor or regulatory monitor did not have a valid hourly sample. For the 24-hour averages, only days with 18 or more valid hourly samples (75% or greater completeness) are included.

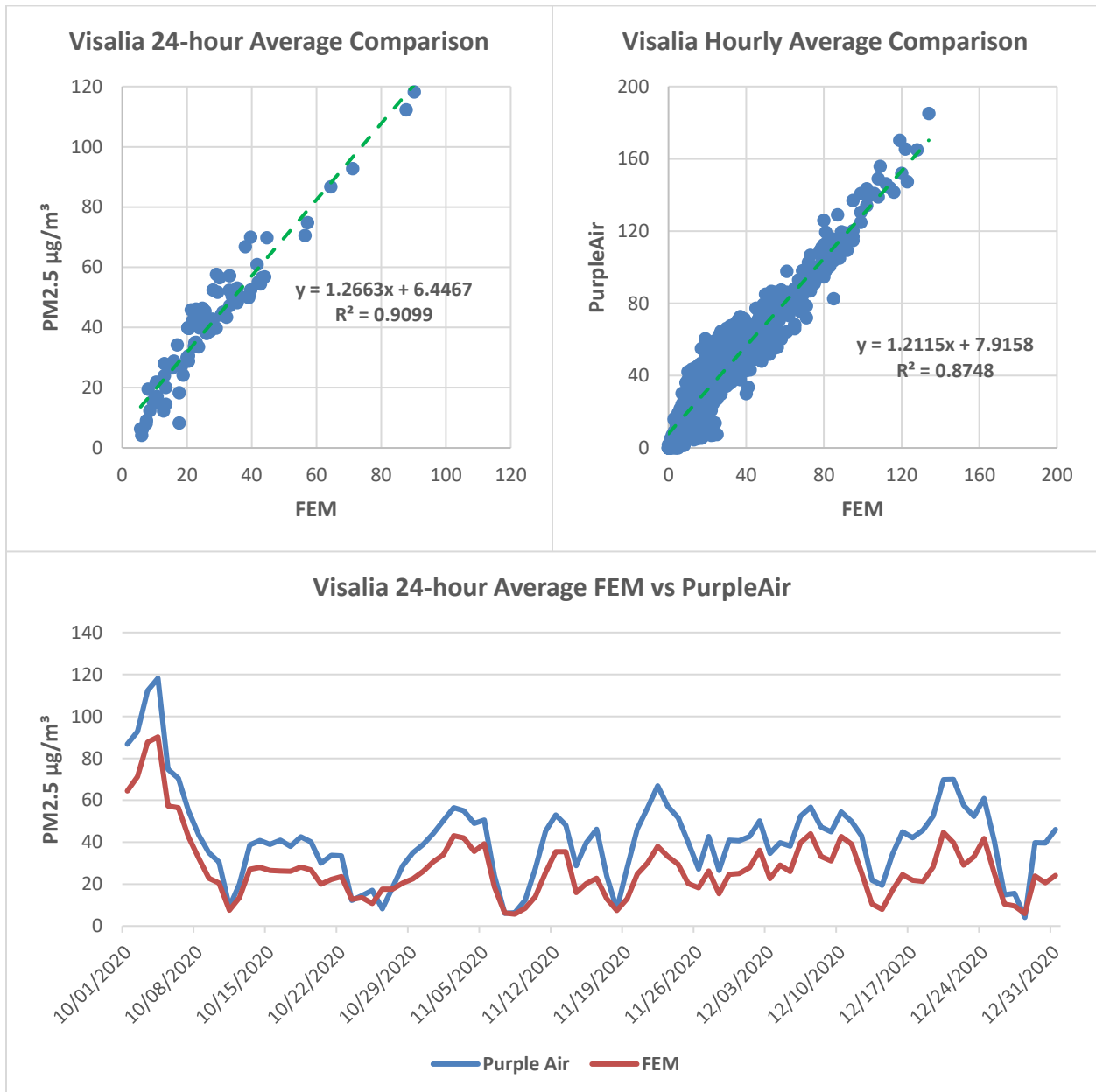
Seasonally, PM2.5 is typically highest during the winter months and lowest during the summer months. Weather systems can influence PM2.5 levels by either trapping pollutants near the surface or dispersing them. Generally, California's weather pattern is characterized by high pressure systems and low pressure systems that move through the region every two to four days in alternating fashion however the high pressure systems that built over the region in October 2020 remained in place for longer durations of time. Much of October was characterized by elevated PM2.5 levels due to the combination of extended periods of strong stability and wildfire smoke impacts. Wildfire activity subsided in November 2020 and PM2.5 concentrations were able to decrease through the month. An alternating pattern of high and low pressures systems moved through region during December, however, the trajectories of most of the low pressure systems that passed through were such that they did not provide good dispersion for the Valley. Thus the majority of December was governed by stability and elevated PM2.5 levels.

Overall, the sensors operating during this period had high bias results compared to the regulatory monitors. The Shafter sensor stopped reporting on Aug 6 and was replaced on October 13, 2020 with sensor “Shafter #2”. The PurpleAir sensor “Clovis #3” measured extremely high values for three consecutive weeks starting November 8th, resulting in this sensor having the highest biases for the quarter. The lowest 24-hour bias was 6.9 $\mu\text{g}/\text{m}^3$ at Bakersfield. The lowest hourly bias of 13.9 $\mu\text{g}/\text{m}^3$ was also at Bakersfield. Data continues to be unavailable from the Fresno-Garland sensors during this quarter.

Site Specific Analysis of PurpleAir PA-II Sensor Performance

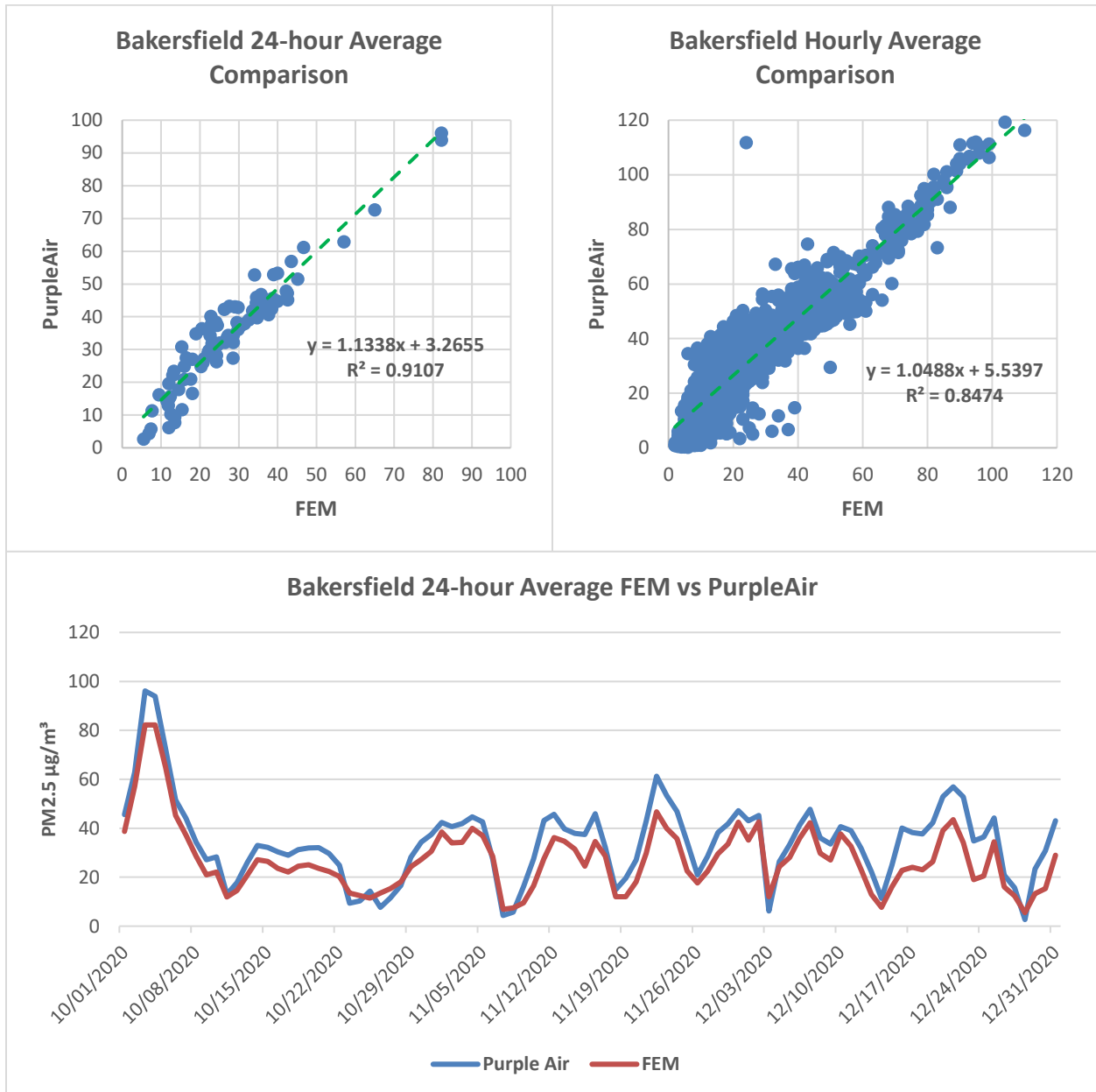
Visalia-Church

For the 24-hour average, PurpleAir data had a 13.8 $\mu\text{g}/\text{m}^3$ high bias during the October 1, 2020, through December 31, 2020, period. For the hourly average, PurpleAir data had a high bias of 28.0 $\mu\text{g}/\text{m}^3$ over the same period.



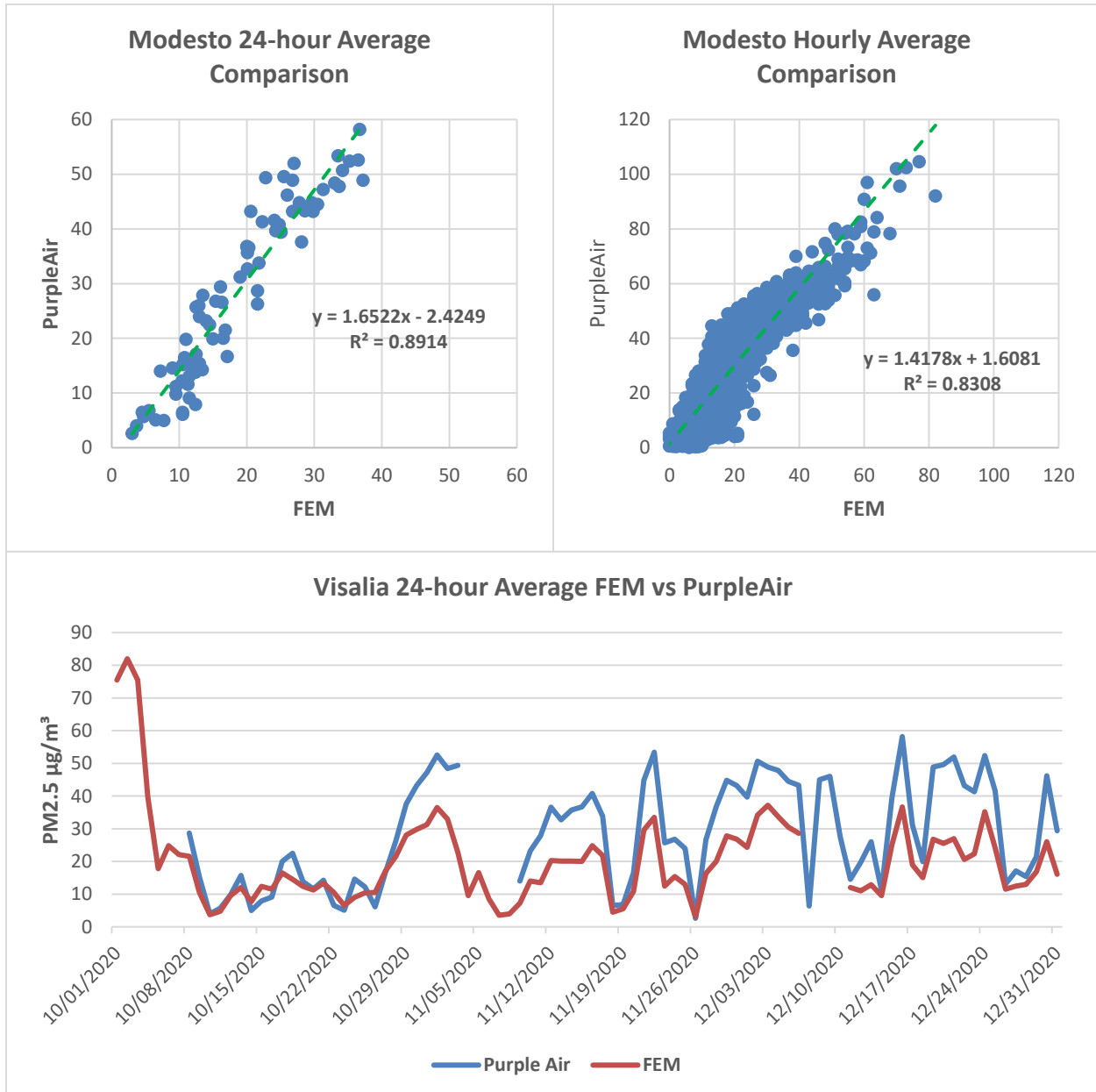
Bakersfield-California

For the 24-hour average, PurpleAir data had a 6.9 $\mu\text{g}/\text{m}^3$ high bias during the October 1, 2020, through December 31, 2020, period. For the hourly average, PurpleAir data had a high bias of 13.9 $\mu\text{g}/\text{m}^3$ over the same period.



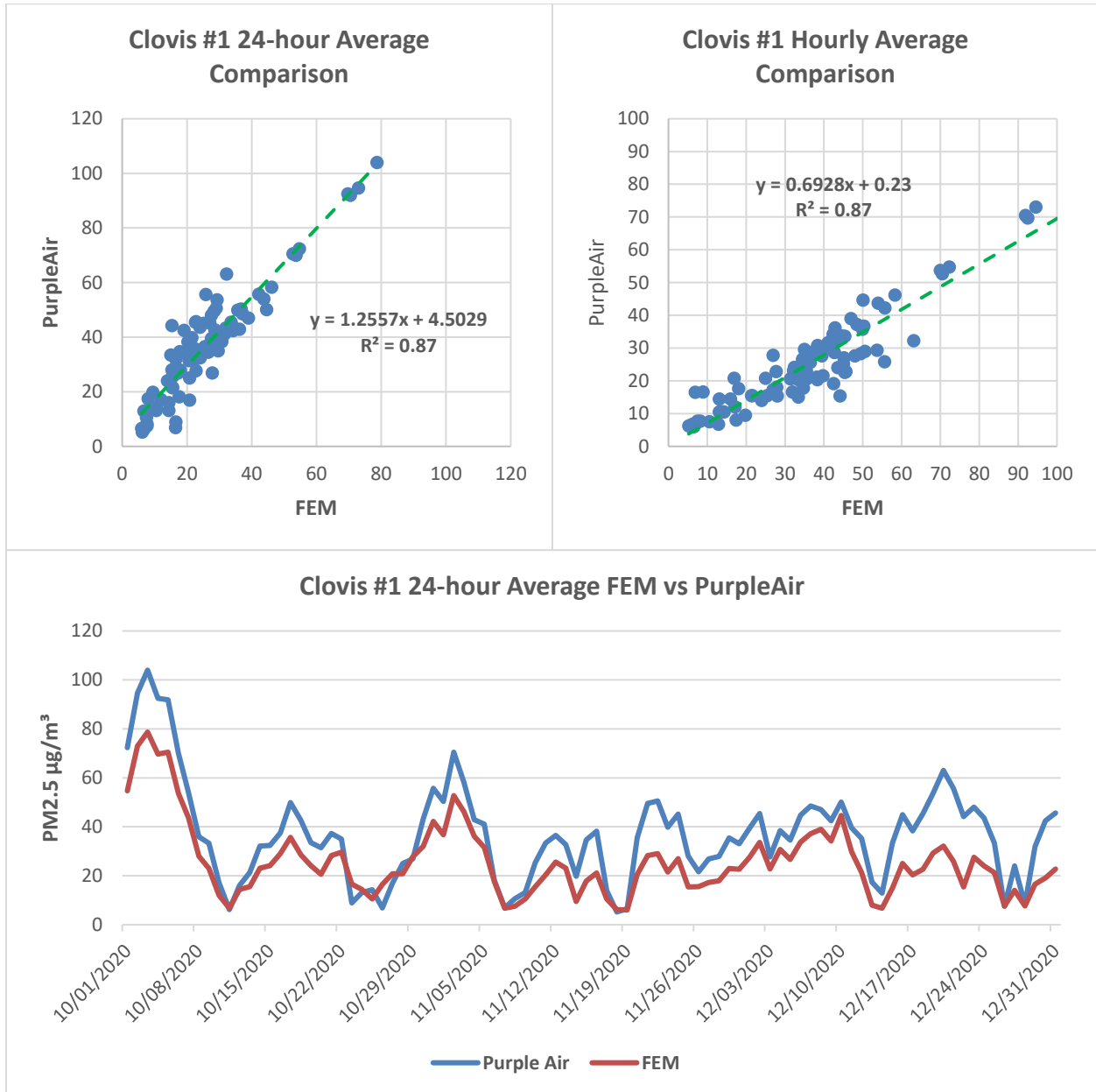
Modesto-14th St.

For the 24-hour average, PurpleAir data had a 9.7 $\mu\text{g}/\text{m}^3$ high bias during the October 1, 2020, through December 31, 2020, period. For the hourly average, PurpleAir data had a high bias of 21.0 $\mu\text{g}/\text{m}^3$ over the same period.



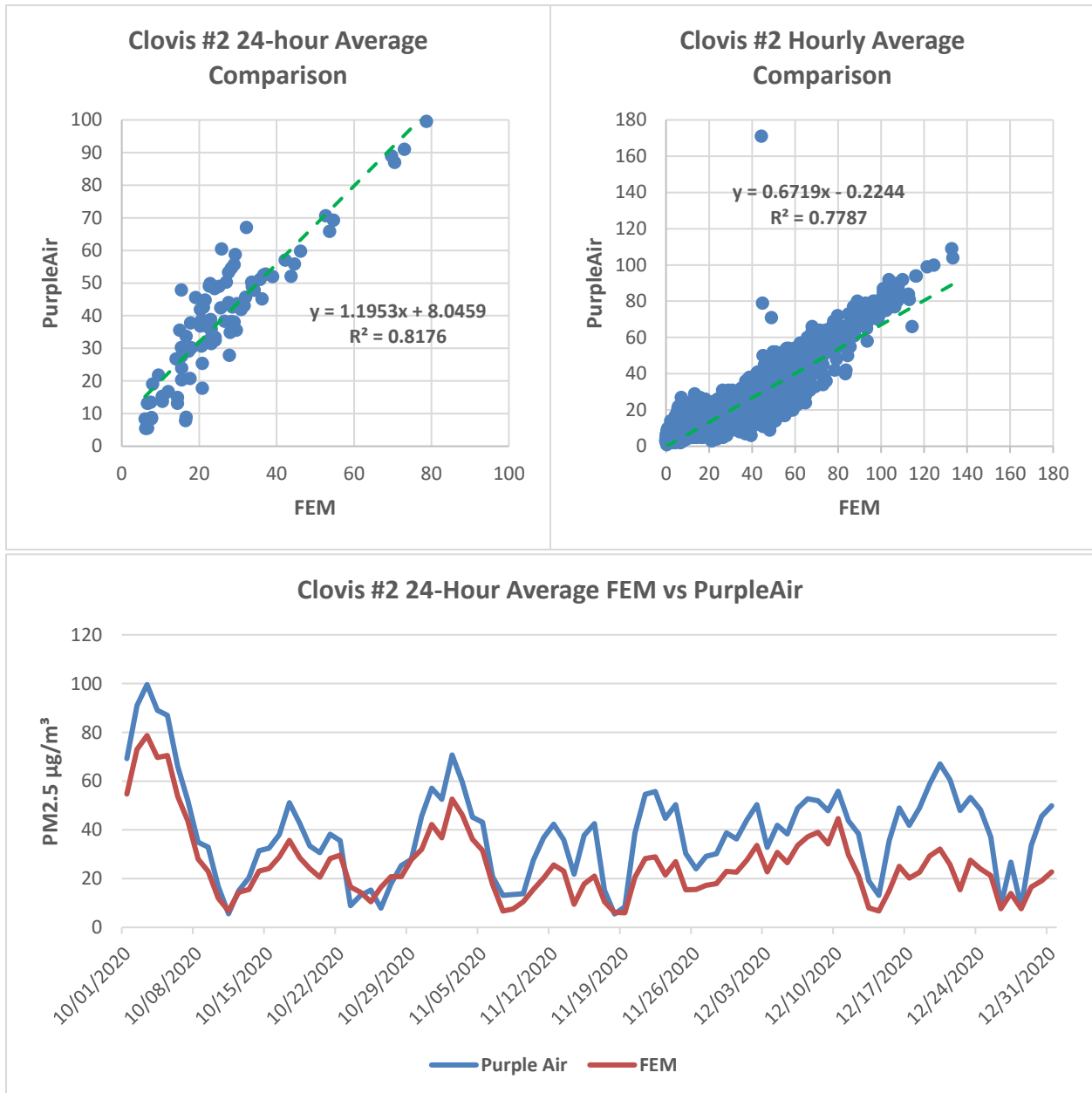
Clovis-Villa #1

For the 24-hour average, PurpleAir data had an 11.1 $\mu\text{g}/\text{m}^3$ high bias during the October 1, 2020, through December 31, 2020, period. For the hourly average, PurpleAir data had a high bias of 25.3 $\mu\text{g}/\text{m}^3$ over the same period.



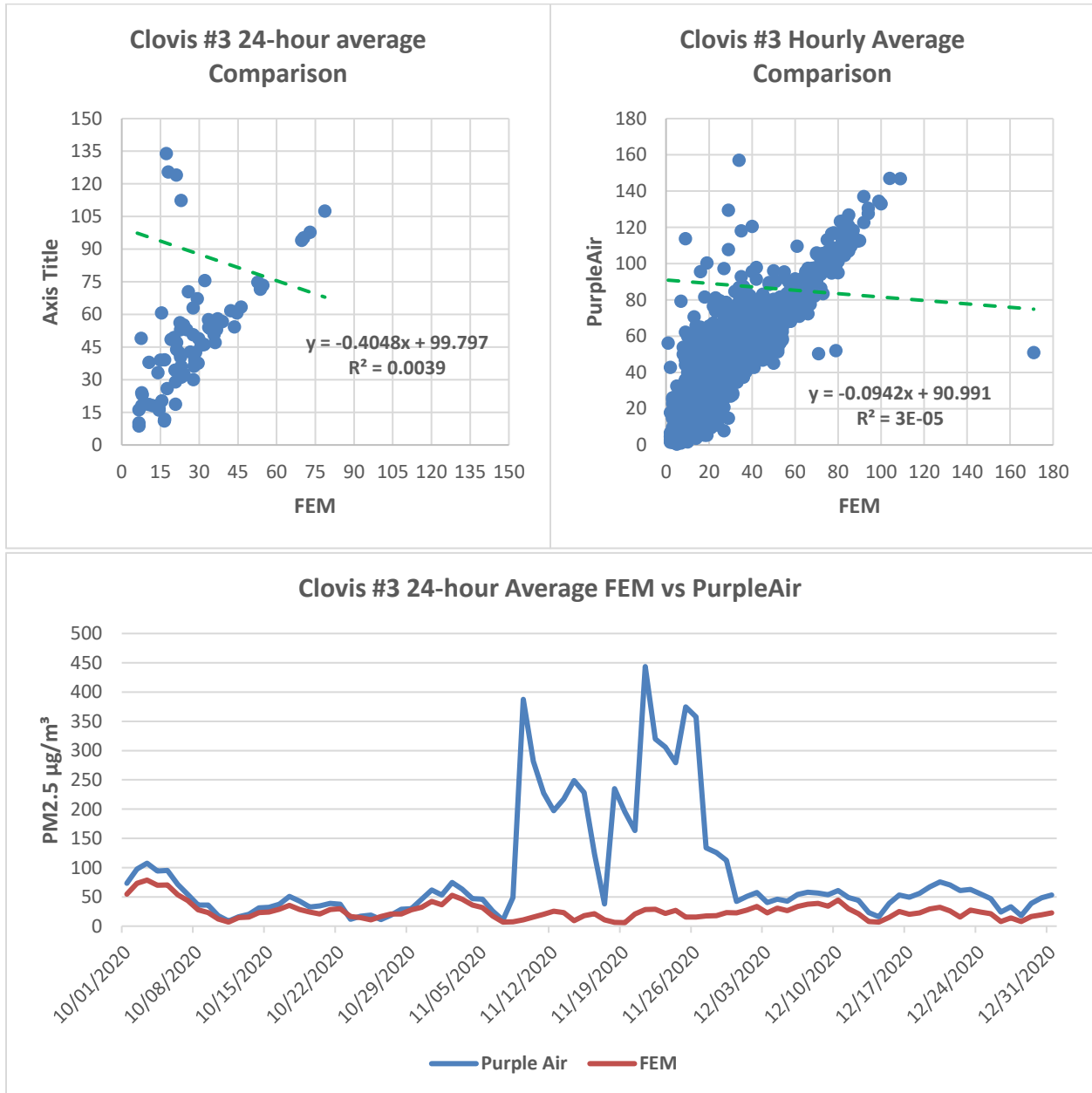
Clovis-Villa #2

For the 24-hour average, PurpleAir data had a 13.1 $\mu\text{g}/\text{m}^3$ high bias during the October 1, 2020, through December 31, 2020, period. For the hourly average, PurpleAir data had a high bias of 20.9 $\mu\text{g}/\text{m}^3$ over the same period.



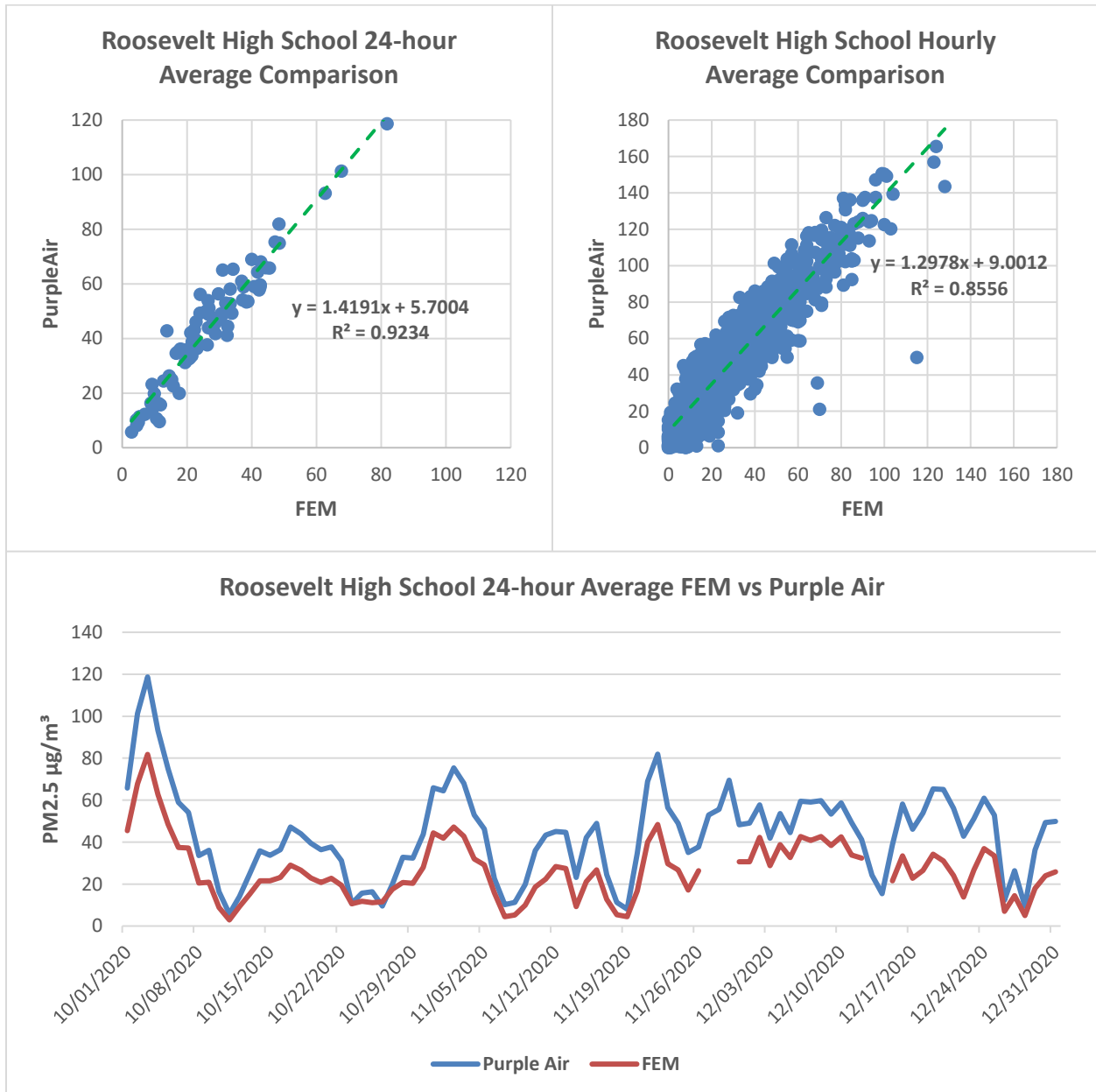
Clovis-Villa #3

For the 24-hour average, PurpleAir data had a 63.6 $\mu\text{g}/\text{m}^3$ high bias during the October 1, 2020, through December 31, 2020, period. For the hourly average, PurpleAir data had a high bias of 364.9 $\mu\text{g}/\text{m}^3$ over the same period.



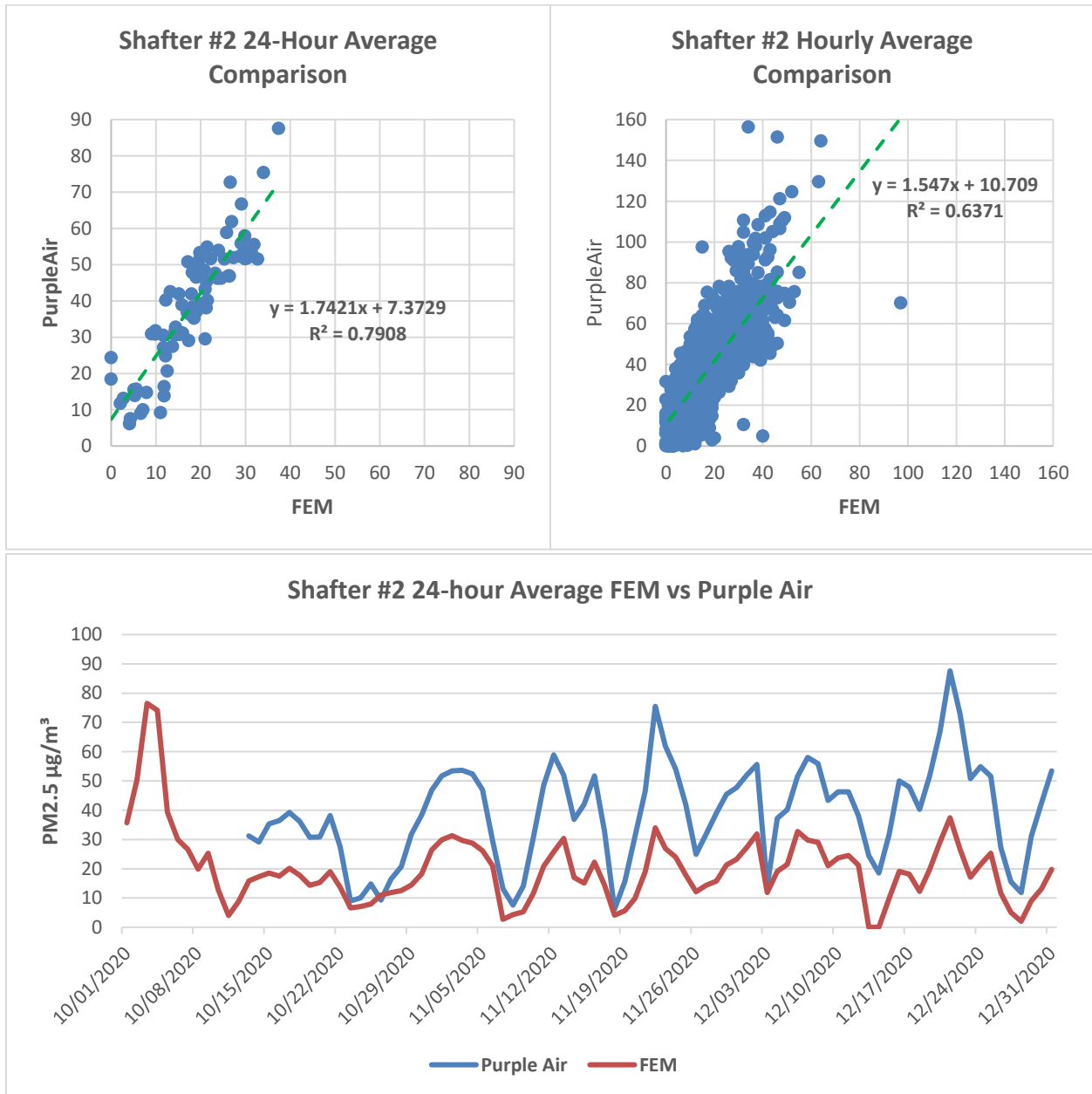
South Central Fresno – Roosevelt High School

For the 24-hour average, PurpleAir data had a 16.9 $\mu\text{g}/\text{m}^3$ high bias during the October 1, 2020, through December 31, 2020, period. For the hourly average, PurpleAir data had a high bias of 36.9 $\mu\text{g}/\text{m}^3$ over the same period.



Shafter #2

For the 24-hour average, PurpleAir data had a 20.7 µg/m³ low bias during the October 13, 2020, through December 31, 2020, period. For the hourly average, PurpleAir data had a low bias of 50.2 µg/m³ over the same period.



Non-Reporting Sites

Fresno-Garland

Data from this sensor was not available for the October 1, 2020, through December 31, 2020, period. This sensor will be included in future analysis reports if the data becomes available.

Statistical Summary

The following tables provides a statistical summary of the PM2.5 data collected during the analysis period of this report.

Table A – Fresno-Garland, Visalia-Church, Bakersfield-California, and Modesto-14th Sites

Statistic	Fresno-Garland	Visalia-Church	Bakersfield-CA	Modesto-14 th
FEM Avg 24-hr	PurpleAir sensor at this site did not report during this period	27.7	27.5	18.6
Sensor Avg 24-hr		41.6	34.4	28.4
FEM Max 1-hr		134	110	82
Sensor Max 1-hr		185	119.3	104.6
FEM Max 24-hr		90.2	82.2	37.2
Sensor Max 24-hr		118.2	96.1	58.2
1-hr R ²		0.8748	0.8474	0.8308
1-hr Slope		1.2115	1.0488	1.4178
1-hr Intercept		7.9158	5.5397	1.6081
24-hr R ²		0.9099	0.9107	0.8914
24-hr Slope		1.2663	1.1338	1.6522
24-hr Intercept		6.4467	3.2655	-2.4249

Table B – Clovis-Villa Site

Statistic	Clovis-Villa PurpleAir #1	Clovis-Villa PurpleAir #2	Clovis-Villa PurpleAir #3
FEM Avg 24-hr	25.8	25.8	25.8
Sensor Avg 24-hr	36.9	38.8	89.4
FEM Max 1-hr	171	171	171
Sensor Max 1-hr	137.1	133.4	3406.4
FEM Max 24-hr	78.7	78.7	78.7
Sensor Max 24-hr	104.0	99.6	443.6
1-hr R ²	0.87	0.7787	0.00003
1-hr Slope	0.6928	0.6719	-0.0942
1-hr Intercept	0.23	-0.2244	90.991
24-hr R ²	0.87	0.8176	0.0039
24-hr Slope	1.2557	1.1953	-0.4048
24-hr Intercept	4.5029	8.0459	99.797

Table C – South Central Fresno and Shafter Sites

Statistic	South Central Fresno	Shafter
FEM Avg 24-hr	26.8	18.0
Sensor Avg 24-hr	43.7	38.7
FEM Max 1-hr	128	97
Sensor Max 1-hr	165.5	156.5
FEM Max 24-hr	81.8	37.4
Sensor Max 24-hr	118.7	87.6
1-hr R ²	0.8556	0.6371
1-hr Slope	1.2978	1.547
1-hr Intercept	9.0012	10.709
24-hr R ²	0.9234	0.7908
24-hr Slope	1.4191	1.7421
24-hr Intercept	5.7004	7.3729