



GEORGIA
DEPARTMENT OF NATURAL RESOURCES

ENVIRONMENTAL PROTECTION DIVISION

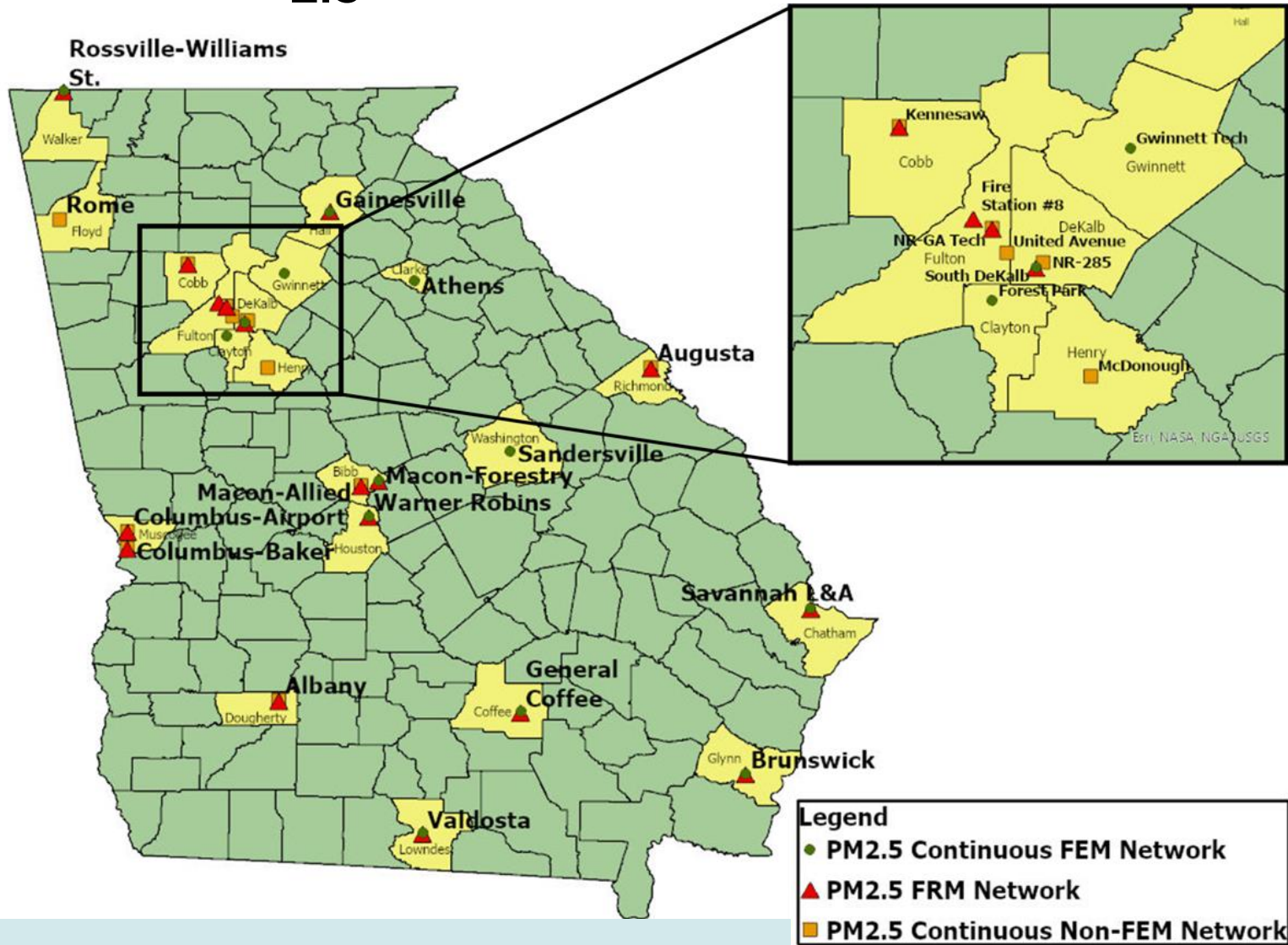
FRM vs. FEM Comparison in GA

Jim Boylan
Chief, Air Protection Branch

AAPCA Ambient Monitoring Committee
Virtual Presentation
May 23, 2024

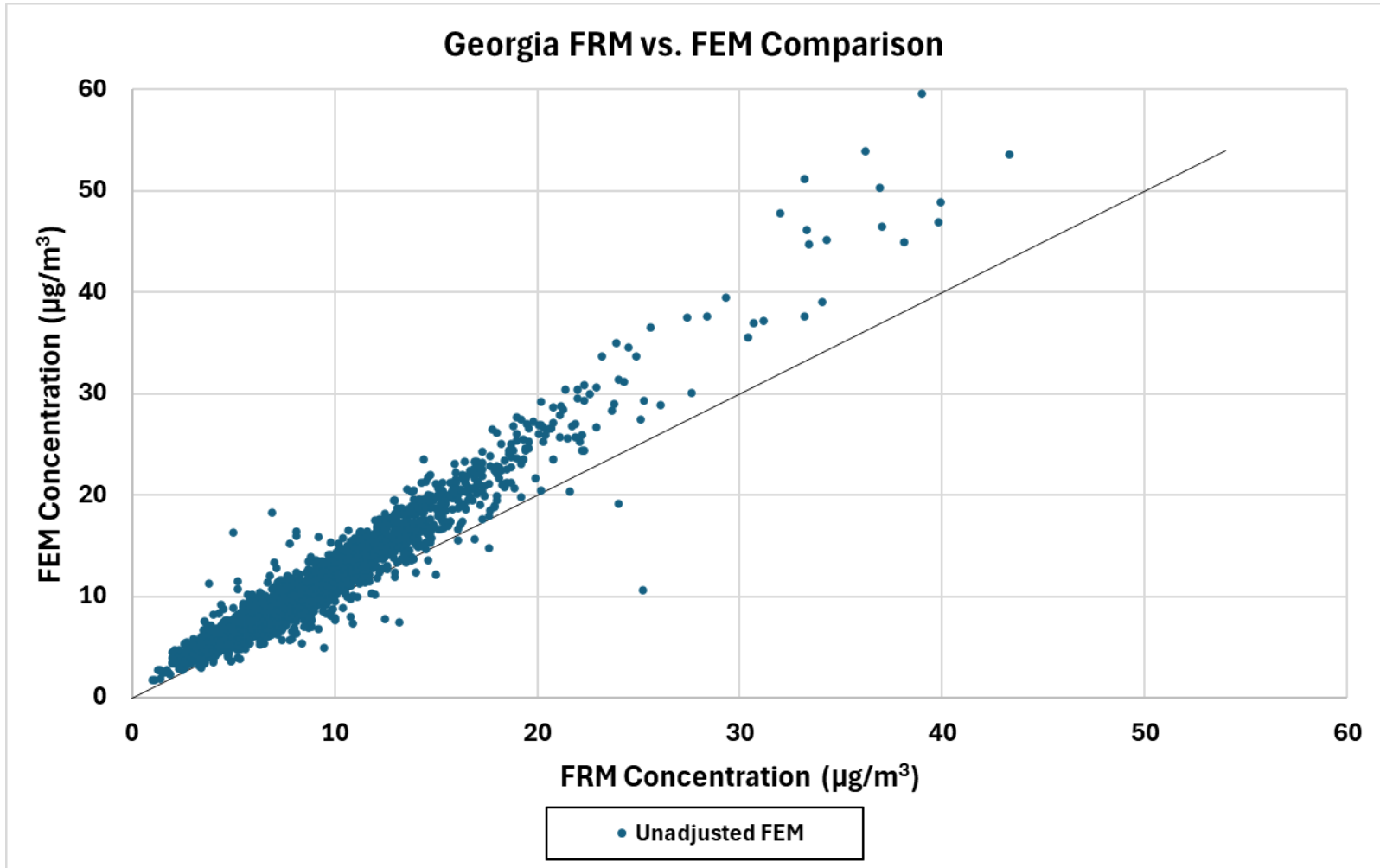


PM_{2.5} MONITOR LOCATIONS





UNADJUSTED FEM



January 1, 2021 – July 31, 2023



TELEDYNE ALIGNMENT ALGORITHM

The alignment factor calculation implemented in the new T640/x software is:

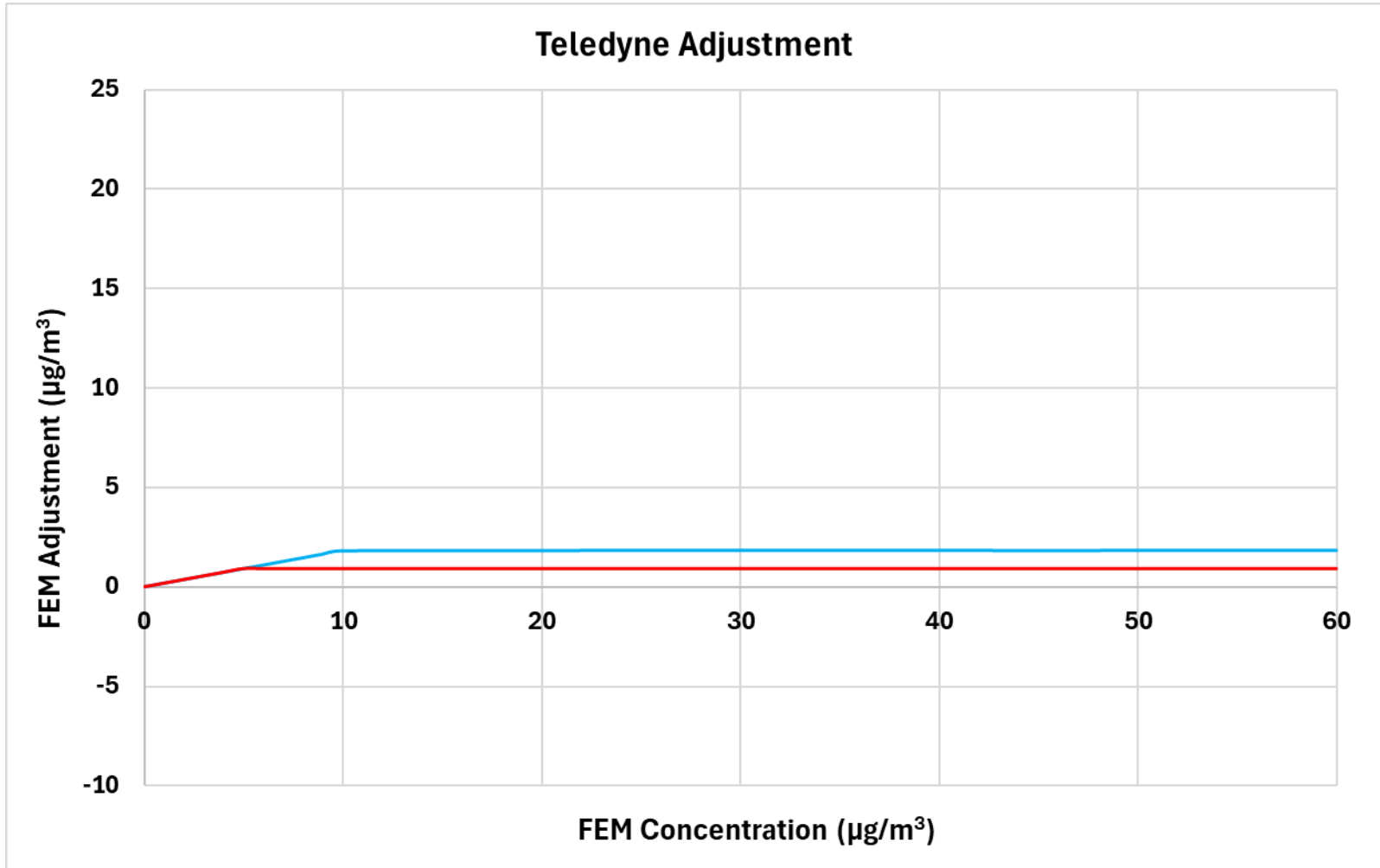
- If the ambient temperature is at or below 20°C
 - - T640/x raw PM value is less than or equal to 10ug/m³, then multiply the T640/x raw PM value by 0.813233
 - - T640/x raw PM value is greater than 10ug/m³, then use the equation (T640/x raw PM – 1.861)

- If the ambient temperature is above 20°C
 - - T640/x raw PM value is less than or equal to 5ug/m³, then multiply the T640/x raw PM value by 0.813233
 - - T640/x raw PM value is greater than 5ug/m³, then use the equation (T640/x raw PM – 0.925)

CASE	PM _{2.5} Conc.	Temp. ≤ 20 °C	CASE	PM _{2.5} Conc.	Temp. > 20 °C
A	≤ 10 µg/m ³	T640/x * 0.813233	C	≤ 5 µg/m ³	T640/x * 0.813233
B	> 10 µg/m ³	T640/x - 1.861	D	> 5 µg/m ³	T640/x - 0.925

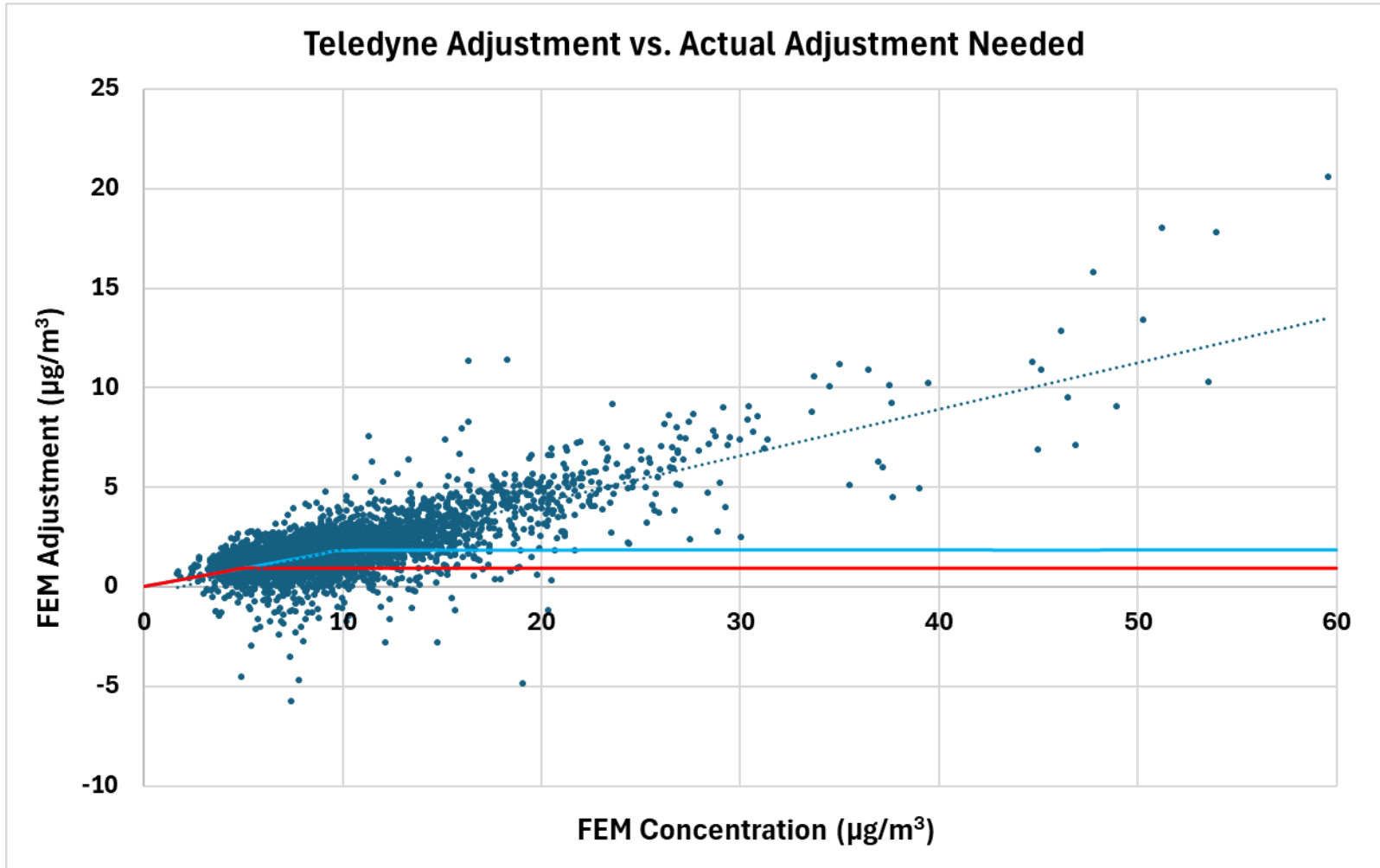


TELEDYNE ADJUSTMENT





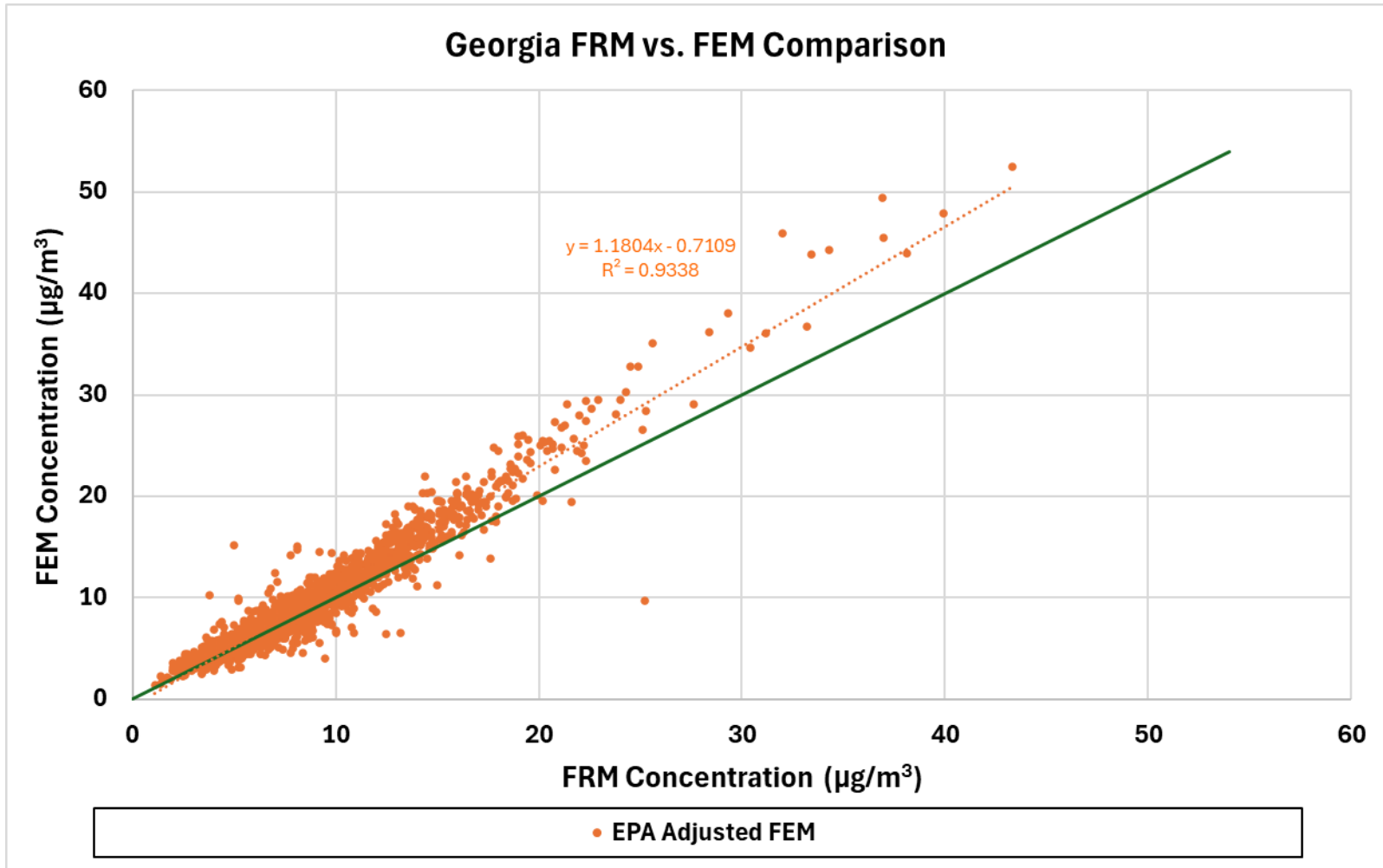
TELEDYNE vs. ACTUAL ADJUSTMENT



January 1, 2021 – July 31, 2023



EPA ADJUSTED FEM



January 1, 2021 – July 31, 2023



ALTERNATIVE ALIGNMENT ALGORITHM

The alignment factor calculation implemented in the new T640/x software is:

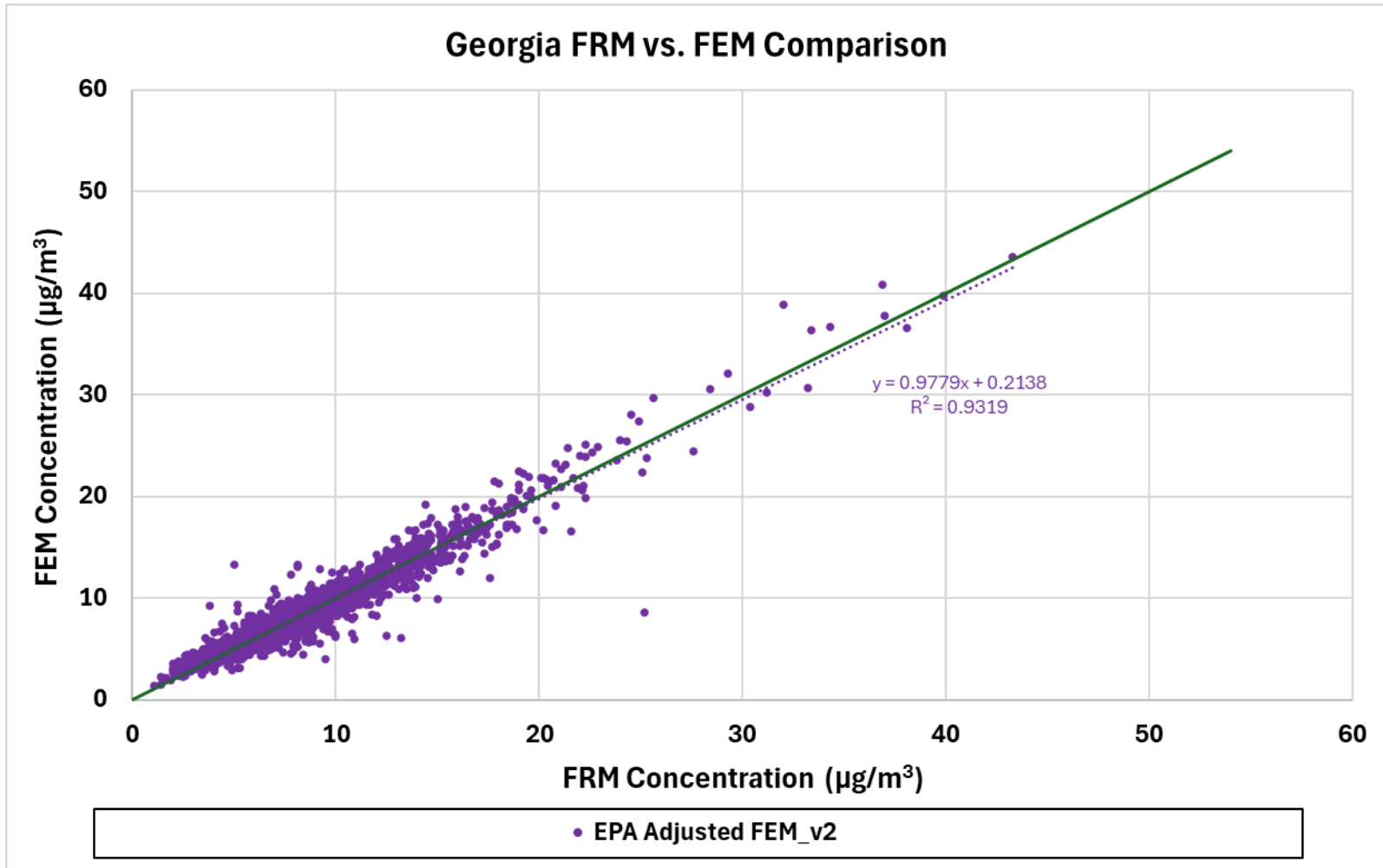
- ~~- If the ambient temperature is at or below 20°C~~
- ~~-- T640/x raw PM value is less than or equal to 10ug/m³, then multiply the T640/x raw PM value by 0.813233~~
- ~~-- T640/x raw PM value is greater than 10ug/m³, then use the equation (T640/x raw PM - 1.861)~~

- ~~- If the ambient temperature is above 20°C~~
- ~~-- T640/x raw PM value is less than or equal to 5ug/m³, then multiply the T640/x raw PM value by 0.813233~~
- ~~-- T640/x raw PM value is greater than 5ug/m³, then use the equation (T640/x raw PM - 0.925)~~

-- Multiply the T640/x raw PM value by 0.813233



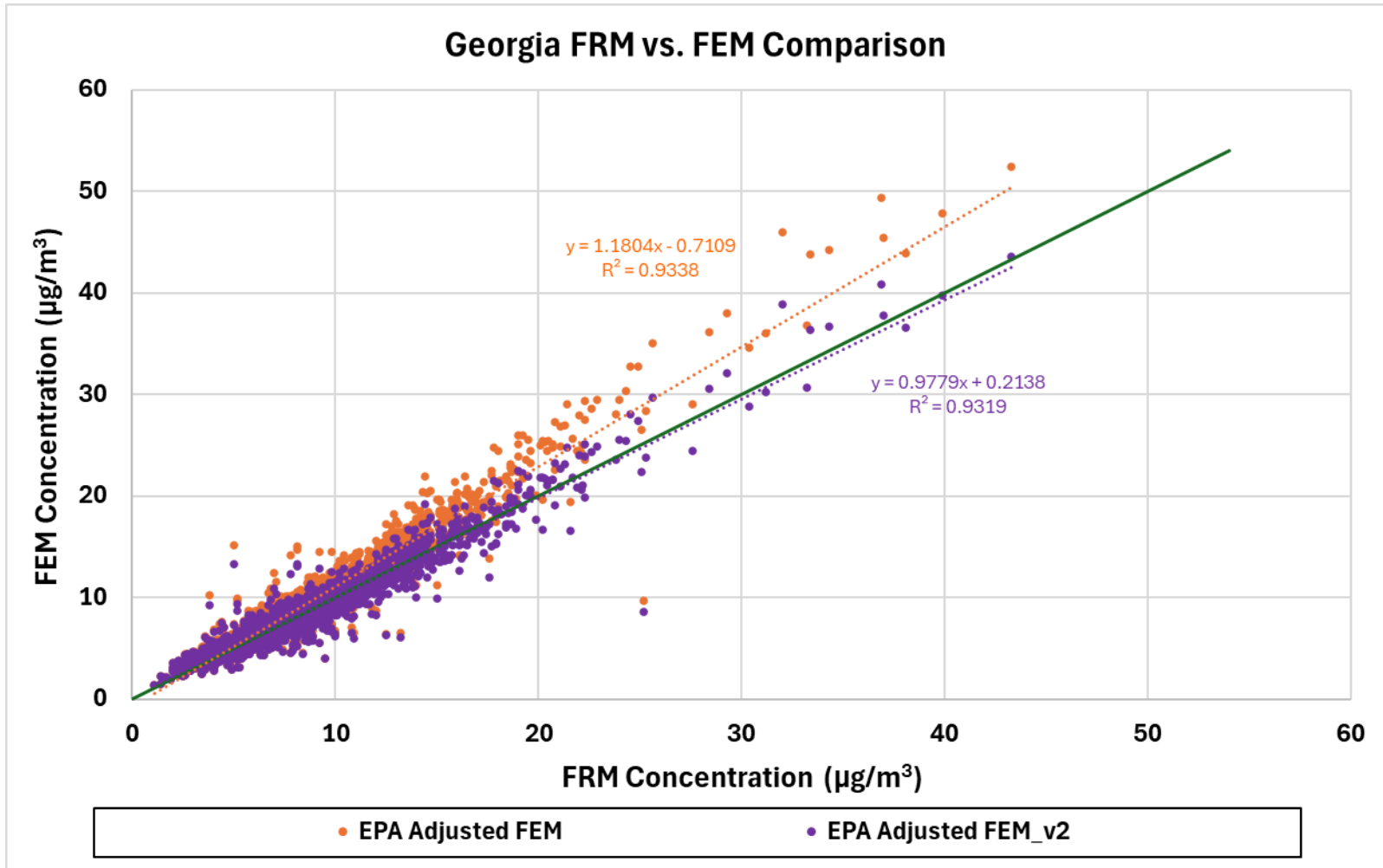
EPA ADJUSTED FEM v2



January 1, 2021 – July 31, 2023



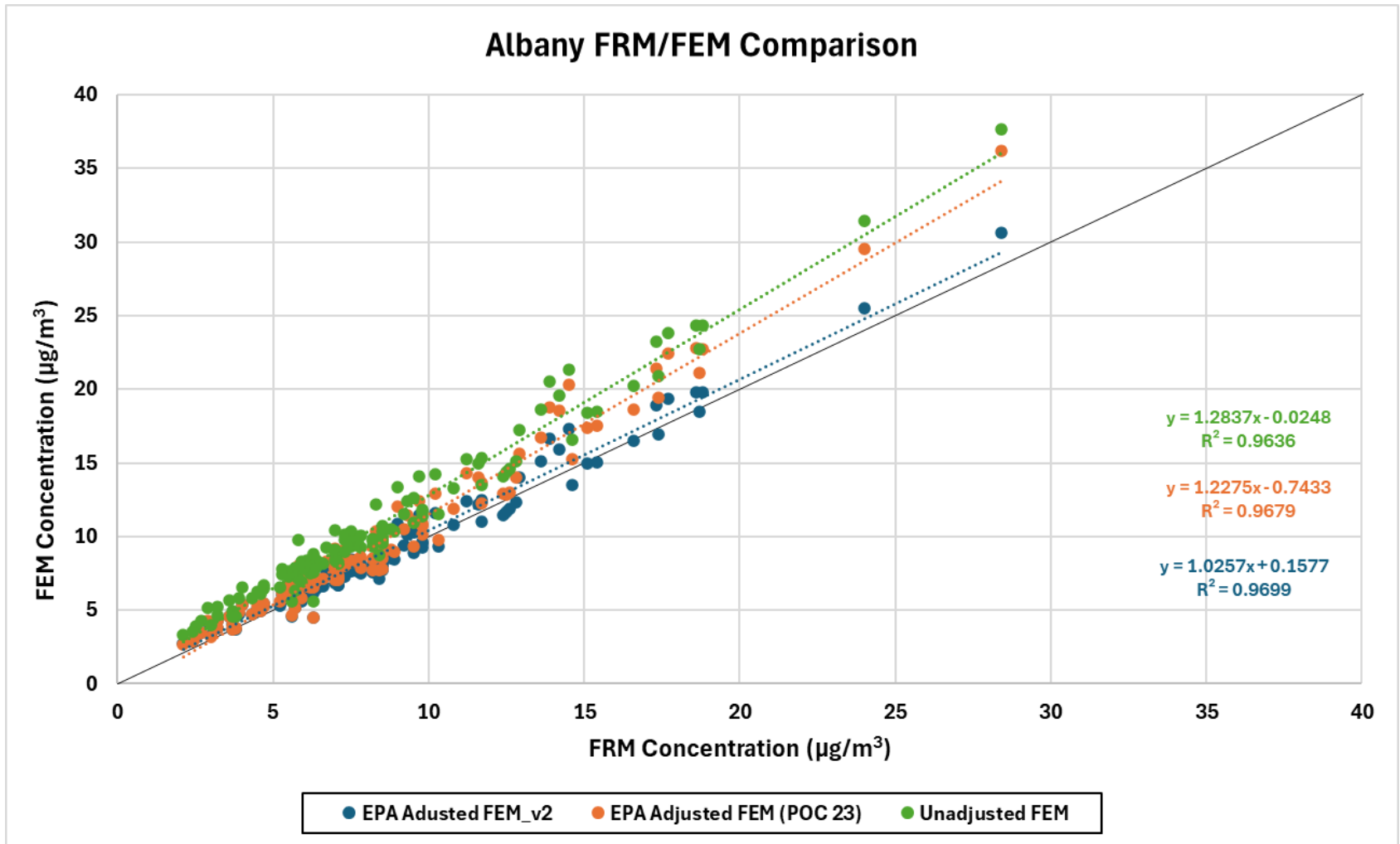
EPA ADJUSTED FEM v1 vs. v2



January 1, 2021 – July 31, 2023



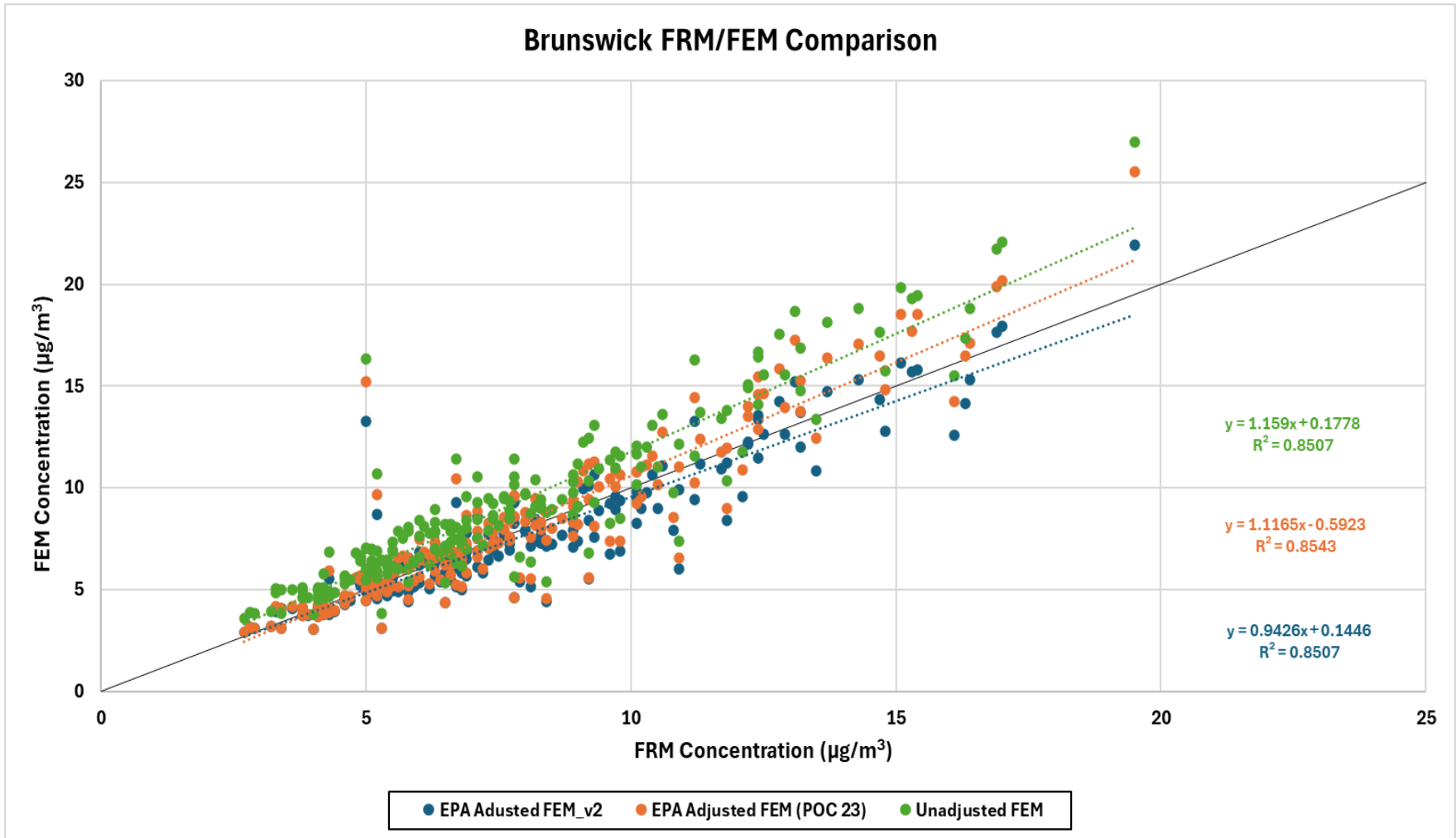
ALBANY



January 1, 2021 – July 31, 2023



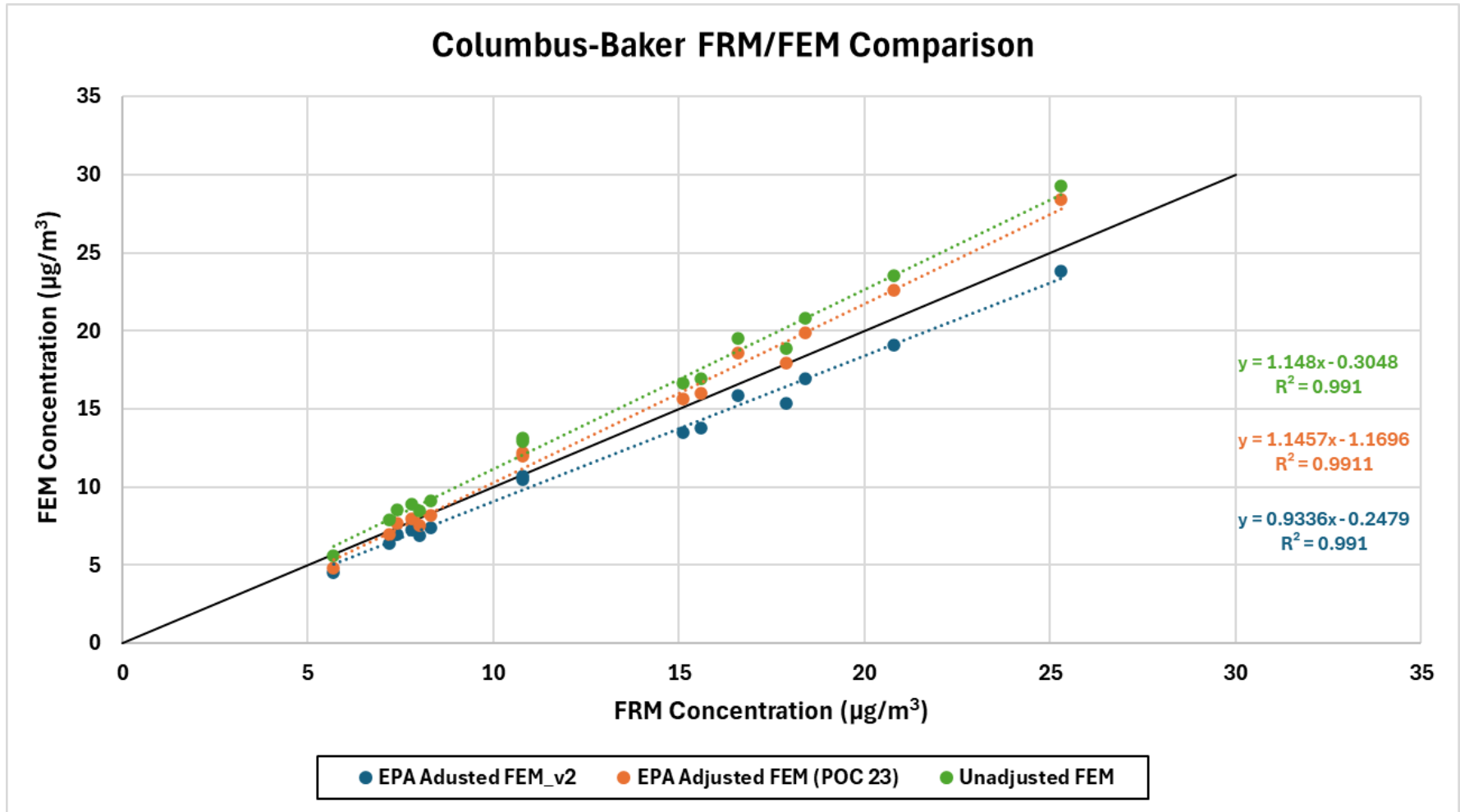
BRUNSWICK



January 1, 2021 – July 31, 2023



COLUMBUS

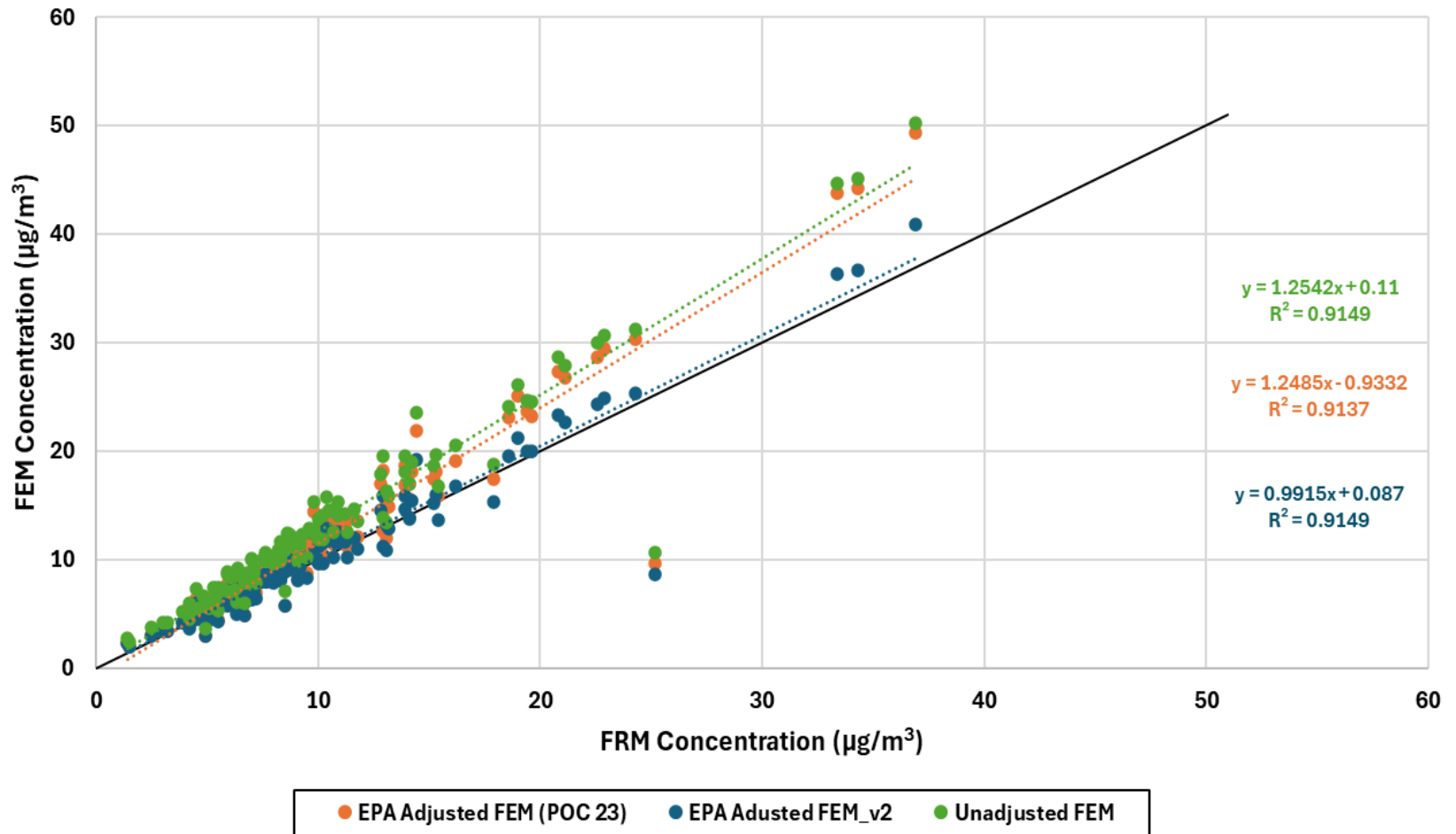


January 1, 2021 – July 31, 2023



GAINESVILLE

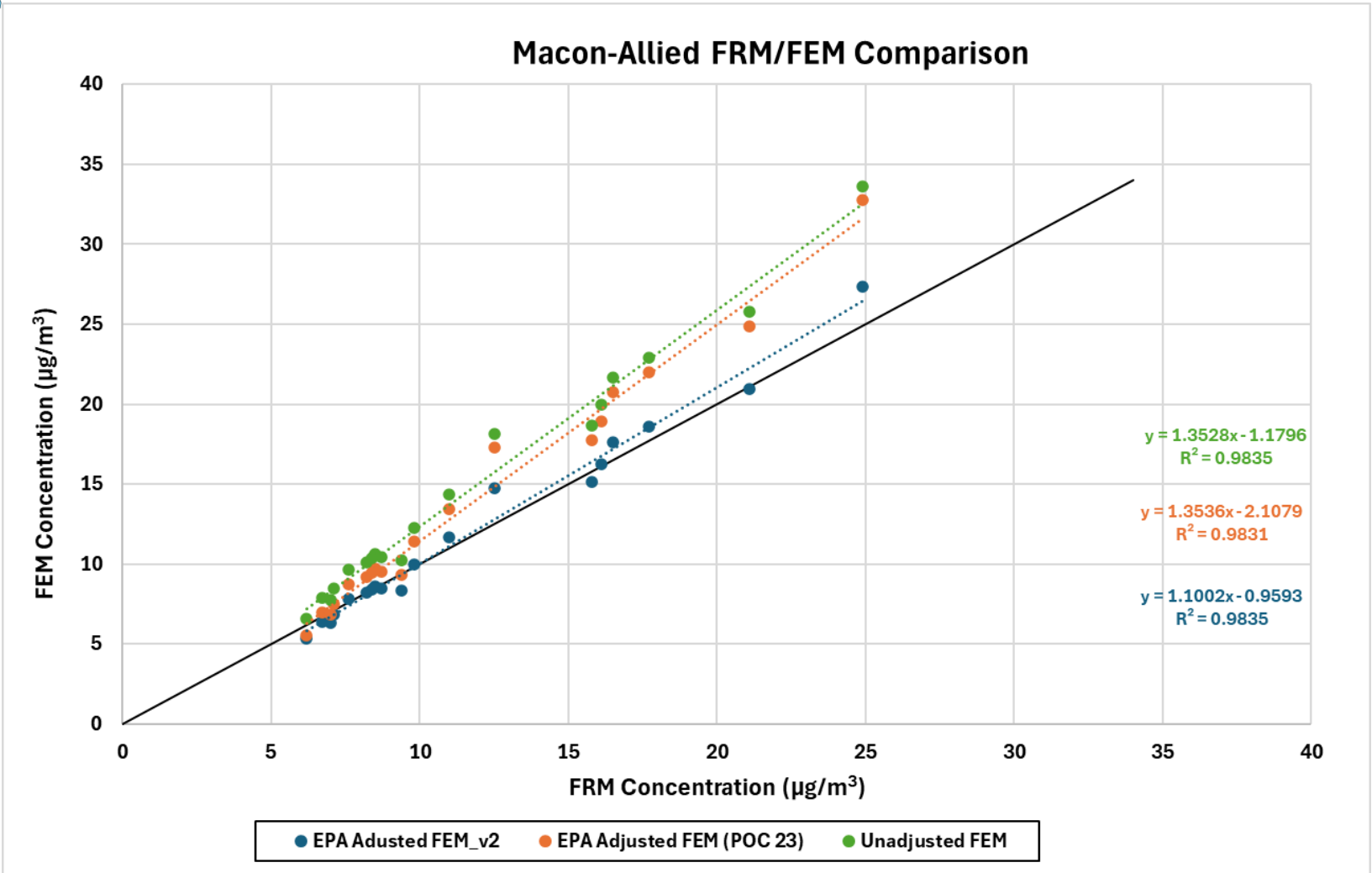
Gainesville FRM/FEM Comparison



January 1, 2021 – July 31, 2023



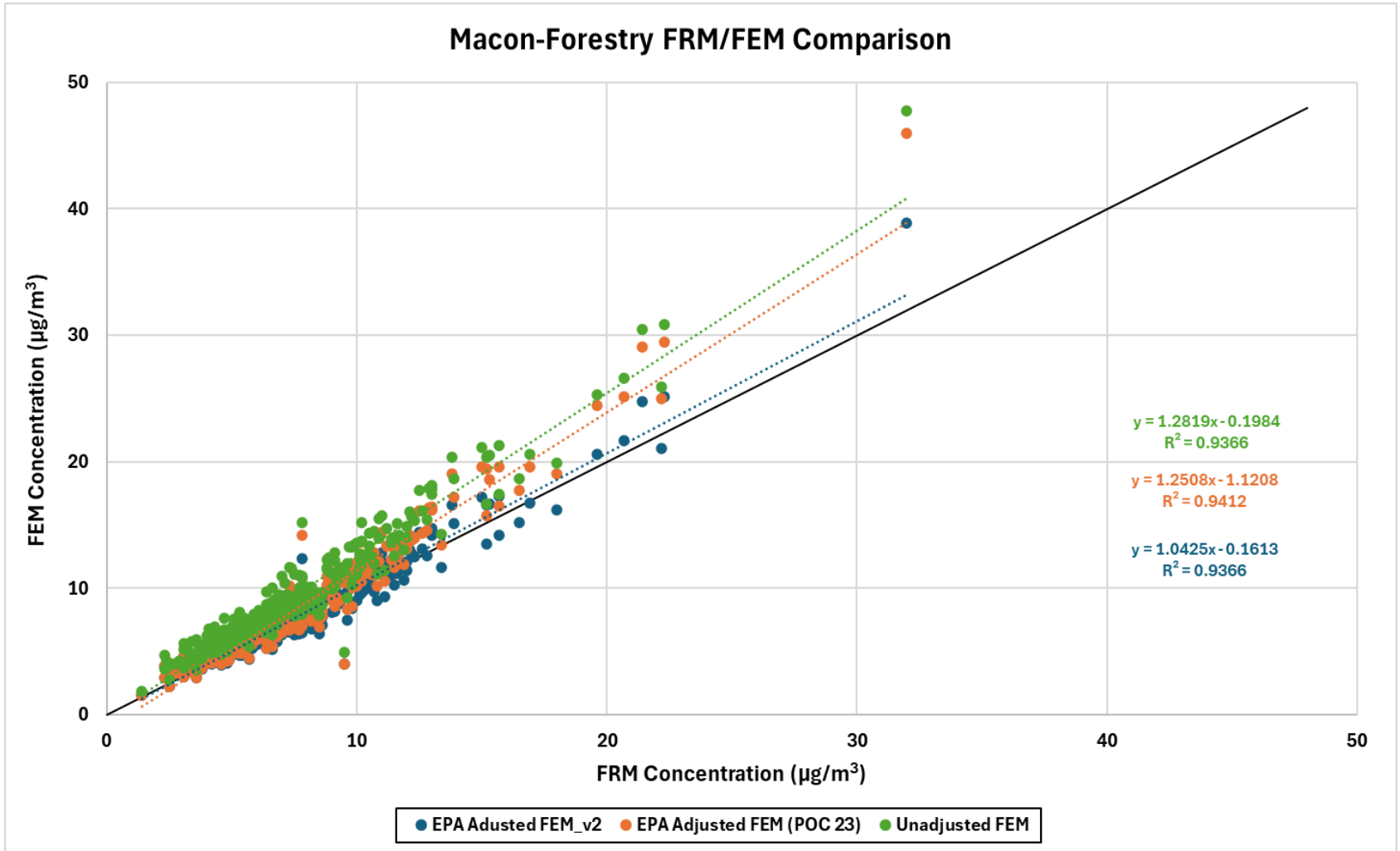
MACON-ALLIED



January 1, 2021 – July 31, 2023



MACON-FORESTRY

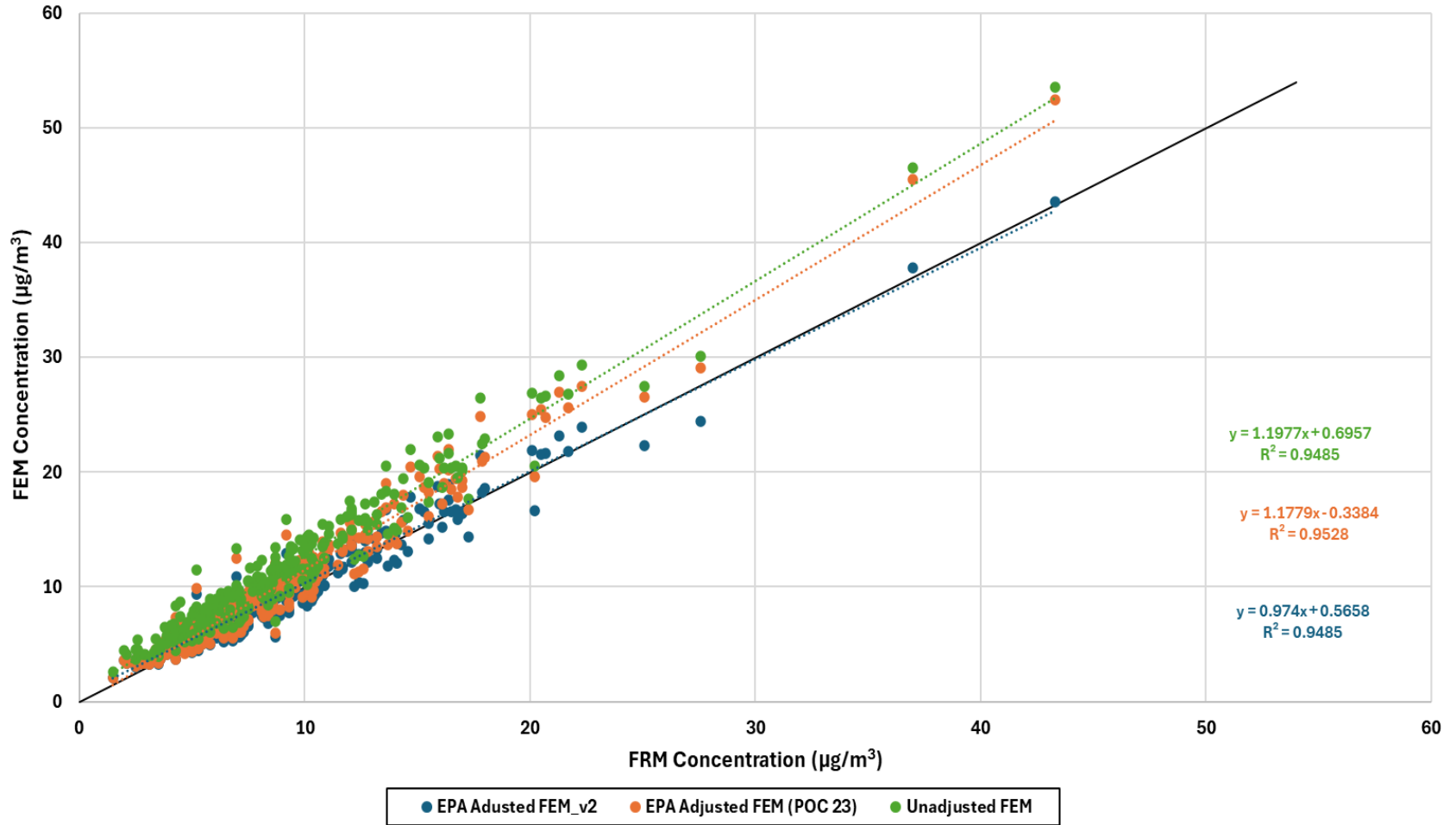


January 1, 2021 – July 31, 2023



ROSSVILLE

Rossville-Williams St. FRM/FEM Comparison

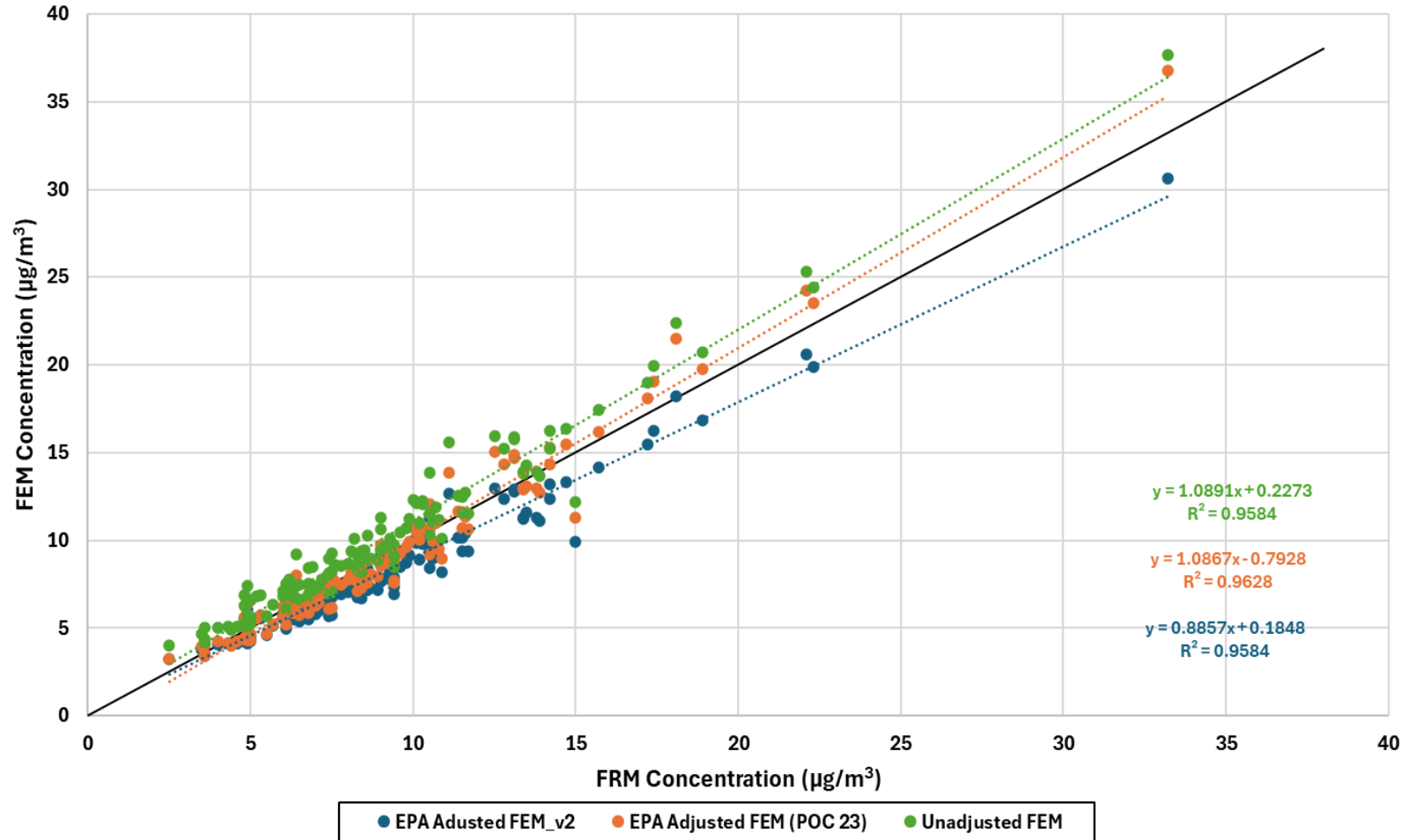


January 1, 2021 – July 31, 2023



SAVANNAH

Savannah L&A FRM/FEM Comparison

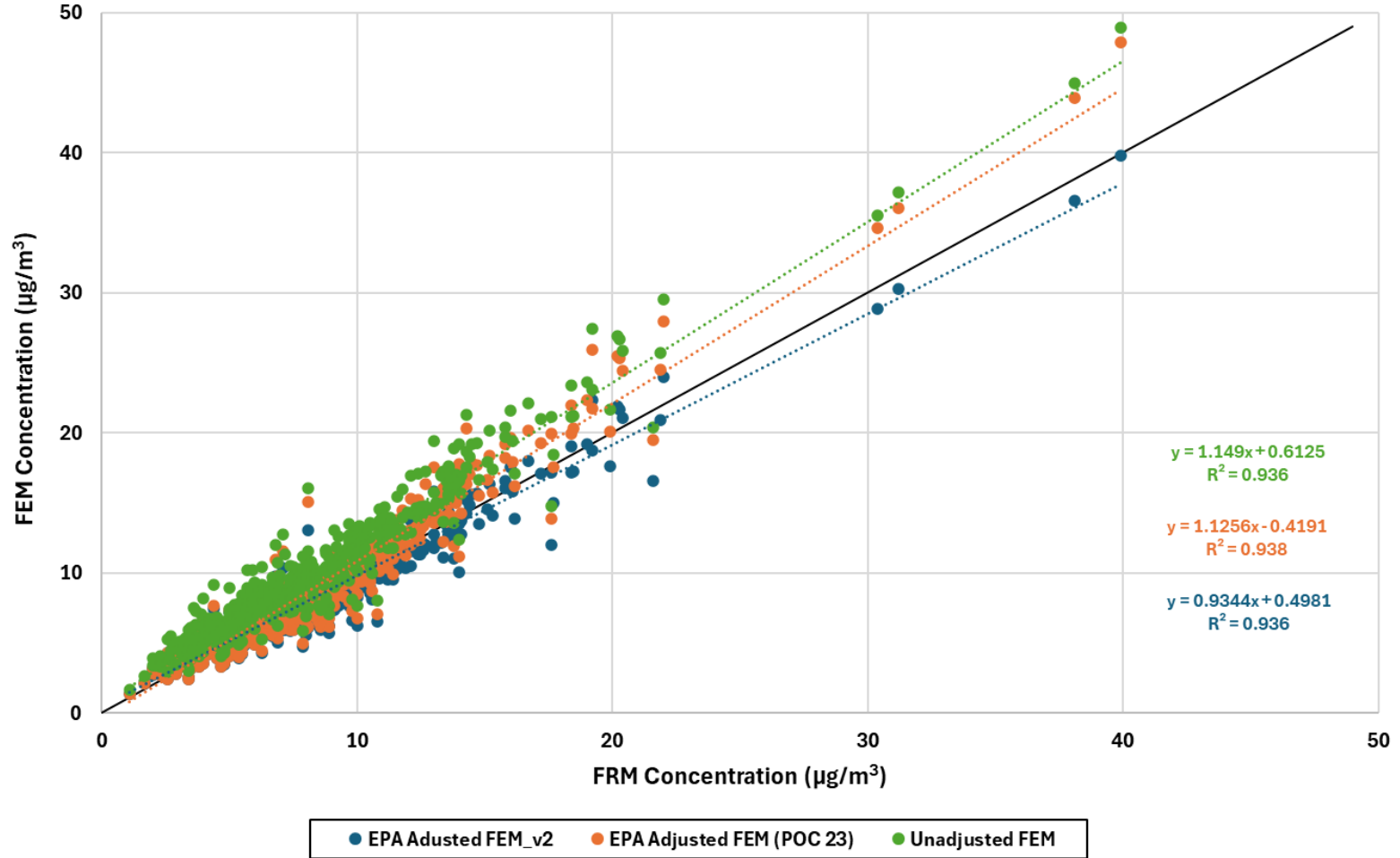


January 1, 2021 – July 31, 2023



SOUTH DeKALB

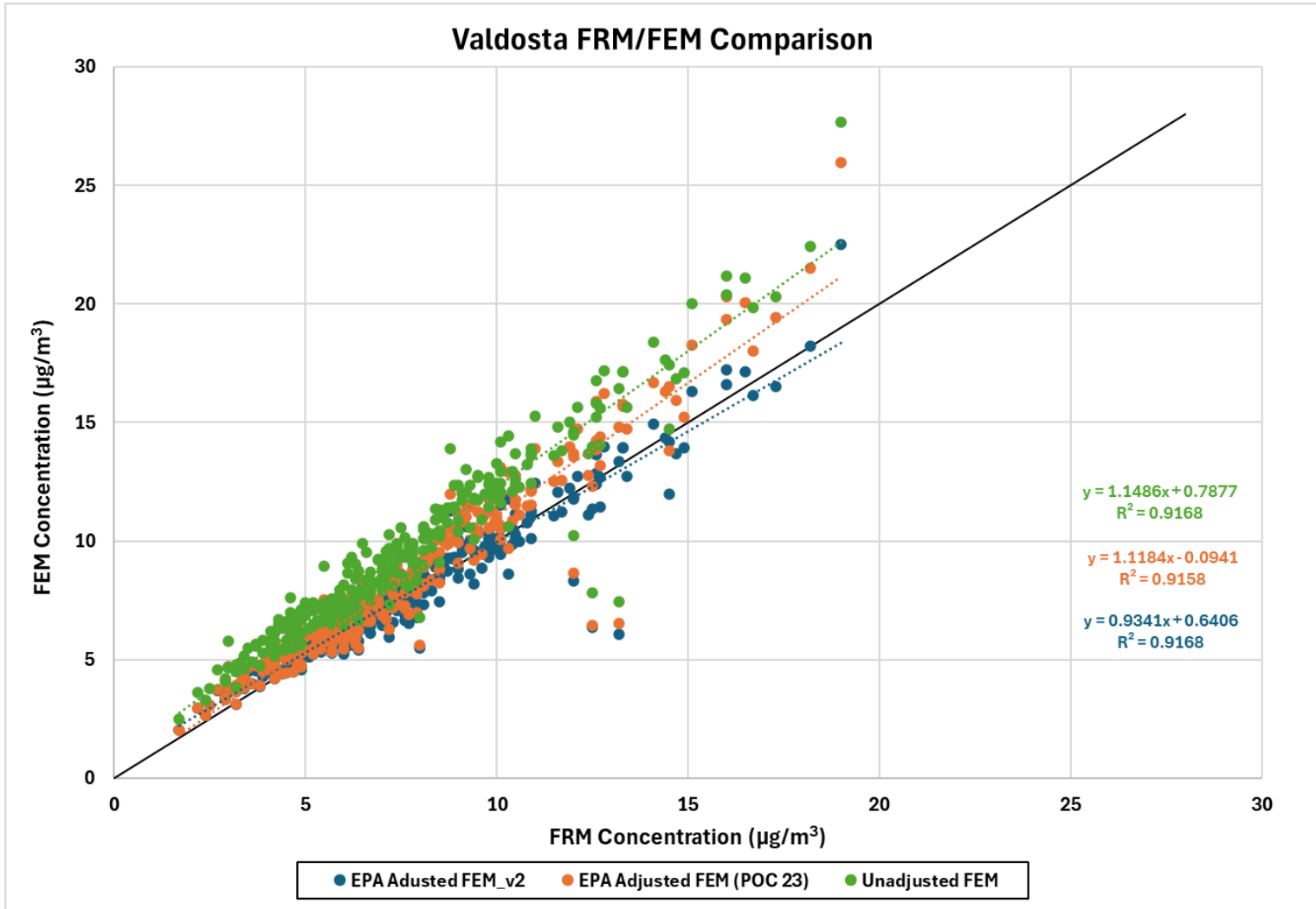
South DeKalb FRM/FEM Comparison



January 1, 2021 – July 31, 2023



VALDOSTA

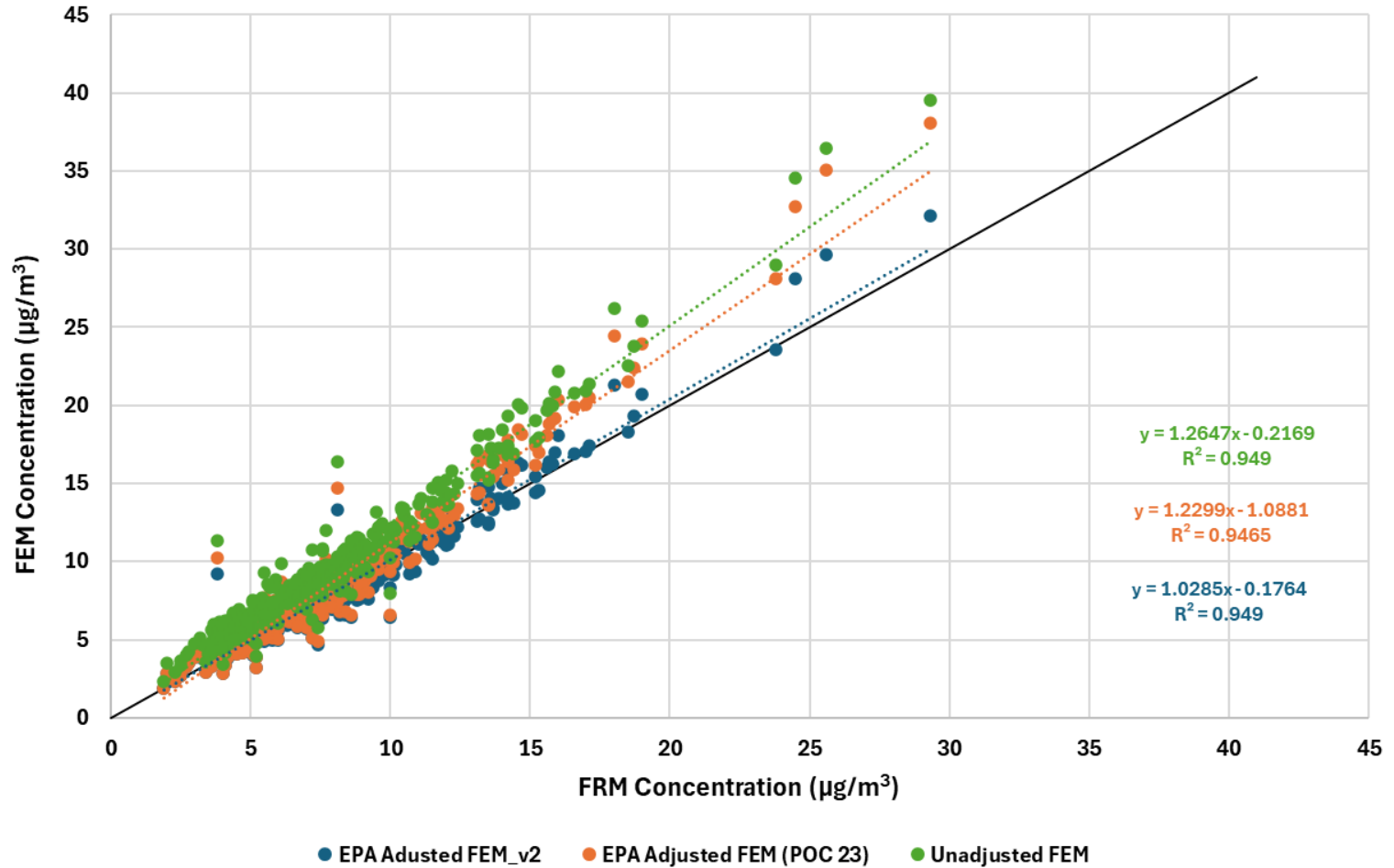


January 1, 2021 – July 31, 2023



WARNER ROBINS

Warner Robins FRM/FEM Comparison



January 1, 2021 – July 31, 2023



EPA ADJUSTED FEM v1 vs. v2

Monitor Name (AQS Number)	Unadjusted FEM	EPA Adjusted FEM (POC 23)	EPA Adusted FEM_v2
Albany (13-095-0007)	28.41%	14.03%	4.43%
Augusta (13-245-0091)	X	X	X
Brunswick (13-127-0006)	18.18%	4.06%	-3.89%
Columubus-Airport (13-215-0008)	X	X	X
Columbus-Baker (13-215-0012)	12.47%	5.61%	-8.54%
Gainesville (13-139-0003)	26.50%	15.68%	2.88%
Macon-Allied (13-021-0007)	25.24%	17.41%	1.85%
Macon-Forestry (13-021-0012)	25.57%	10.26%	2.11%
Rossville-Williams St (13-295-0004)	27.21%	14.18%	3.45%
Savannah-L&A (13-051-1002)	11.43%	-0.14%	-9.38%
South DeKalb (13-089-0002)	22.11%	7.63%	-0.70%
Valdosta (13-185-0003)	25.27%	10.60%	1.87%
Warner Robins (13-153-0001)	23.78%	9.47%	0.66%
Statewide	23.37%	9.59%	-0.24%

$$\text{Normalized Mean Bias (\%)} = (\text{FEM} - \text{FRM}) / (\text{FRM})$$



EPA ADJUSTED FEM BACK vs. FORWARD

Monitor Name (AQS Number)	EPA Adjusted FEM (01/01/21-07/31/23)	EPA Adjusted FEM (08/01/23-12/31/23)
Albany (13-095-0007)	14.03%	10.95%
Augusta (13-245-0091)	X	-2.05%
Brunswick (13-127-0006)	4.06%	4.80%
Columbus-Airport (13-215-0008)	X	8.96%
Columbus-Baker (13-215-0012)	5.61%	6.77%
Gainesville (13-139-0003)	15.68%	27.33%
Macon-Allied (13-021-0007)	17.41%	13.52%
Macon-Forestry (13-021-0012)	10.26%	12.72%
Rossville-Williams St (13-295-0004)	14.18%	18.73%
Savannah-L&A (13-051-1002)	-0.14%	-1.74%
South DeKalb (13-089-0002)	7.63%	6.90%
Valdosta (13-185-0003)	10.60%	12.42%
Warner Robins (13-153-0001)	9.47%	2.07%
General Coffee (13-069-0002)	X	25.32%
Kennesaw (13-067-0003)	X	32.97%

$$\text{Normalized Mean Bias (\%)} = (\text{FEM} - \text{FRM}) / (\text{FRM})$$



2021-2023 DESIGN VALUES

MSA	Site Name	Site ID	2021-23 PM2.5 Annual DV (Before EPA Correction)	2021-23 PM2.5 Annual DV (After EPA Correction)	2021-23 PM2.5 Annual DV (After EPA_v2 Adjusted)	Δ DV v1-v2
Macon-Bibb County MSA	Macon-Allied	13-021-0007	9.4	9.4	9.4	0.0
	Macon-Forestry	13-021-0012	9.4	8.4	7.9	0.5
Savannah MSA	Savannah-L&A	13-051-1002	9.8	8.8	8.4	0.4
Athens-Clarke County MSA	Athens	13-059-0002	9.7	8.8	8.1	0.7
Atlanta-Sandy Springs-Alpharetta MSA	Forest Park	13-063-0091	8.9	8.9	8.9	0.0
	Kennesaw	13-067-0003	8.9	8.9	8.9	0.0
	South DeKalb	13-089-0002	9.3	8.7	8.5	0.2
	Fire Station #8	13-121-0039	9.1	9.1	9.1	0.0
	NR-GA Tech	13-121-0056	9.7	9.7	9.7	0.0
	Gwinnett Tech	13-135-0002	9.6	8.6	8.1	0.5
Coffee County	General Coffee	13-069-0002	7.3	7.3	7.3	0.0
Albany MSA	Albany	13-095-0007	9.3	9.1	8.8	0.3
Brunswick MSA	Brunswick	13-127-0006	8.3	7.9	7.6	0.3
Gainesville MSA	Gainesville	13-139-0003	9.0	8.2	7.8	0.4
Warner Robins MSA	Warner Robins	13-153-0001	9.3	8.7	8.3	0.4
Valdosta MSA	Valdosta	13-185-0003	9.2	8.6	8.1	0.5
Columbus, GA-AL MSA	Columbus-Airport	13-215-0008	8.6	8.5	8.5	0.0
	Columbus-Baker	13-215-0012	10.0	10.0	10.0	0.0
Augusta-Richmond County, GA-SC MSA	Augusta	13-245-0091	10.1	9.7	9.4	0.3
Chattanooga, TN-GA MSA	Rossville-Williams St.	13-295-0004	10.7	10.0	9.5	0.5
Washington County	Sandersville	13-303-0001	11.0	10.0	9.2	0.8



QA/QC ON ADJUSTMENT APPLICATION

- **GA EPD wanted to replicate EPA adjusted values.**
 - This “benchmarking” process is fairly common in modeling exercises.
 - It is also a good way to verify that the alignment algorithm has been applied correctly.
- **We found many inconsistencies between EPA adjusted values and our replication values.**
 1. Less than or Equal (\leq) vs. Less than ($<$)
 2. Rounding vs. truncation for concentrations
 3. Unexplained errors



QA/QC ON ADJUSTMENT APPLICATION

CASE	Date & Time	Site Name	Site ID	T (°C)	Unadjusted FEM	EPA Adjusted FEM	Replication Adjusted w/o Trunc.	Replication Adjusted FEM*	Adjusted FEM Diff (EPA - Repl.)		
A	3/3/2021 23:00	Savannah-L&A	13-051-1002	10.7	10	B	9.1	8.13233	A	8.1	1
B	10/1/2022 19:00	Valdosta	13-185-0003	20	122.7	D	121.8	120.839	B	120.8	1
C	6/15/2023 13:00	Macon-Allied	13-021-0007	23.3	5	D	4.1	4.066165	C	4.0	0.1
D	5/6/2022 0:00	Athens	13-059-0002	22.2	230.6	D	229.7	229.675	D	229.6	0.1
D	9/30/2021 6:00	Savannah-L&A	13-051-1002	20.7	28.6	B	26.7	27.675	D	27.6	-0.9
D	10/15/2021 0:00	Savannah-L&A	13-051-1002	21	19	B	17.1	18.075	D	18.0	-0.9
D	9/26/2021	Savannah-L&A	13-051-1002	21.1	9.2	A	7.5	8.275	D	8.2	-0.7
A	1/30/2022 0:00	Athens	13-059-0002	-2.8	8.8	D	7.9	7.15645	A	7.1	0.8

CASE	PM _{2.5} Conc.	Temp. ≤ 20 °C	CASE	PM _{2.5} Conc.	Temp. > 20 °C
A	≤ 10 µg/m ³	T640/x * 0.813233	C	≤ 5 µg/m ³	T640/x * 0.813233
B	> 10 µg/m ³	T640/x - 1.861	D	> 5 µg/m ³	T640/x - 0.925

*Following the truncation rule for 1-hour values prescribed in Appendix N.



QA/QC ON ADJUSTMENT APPLICATION

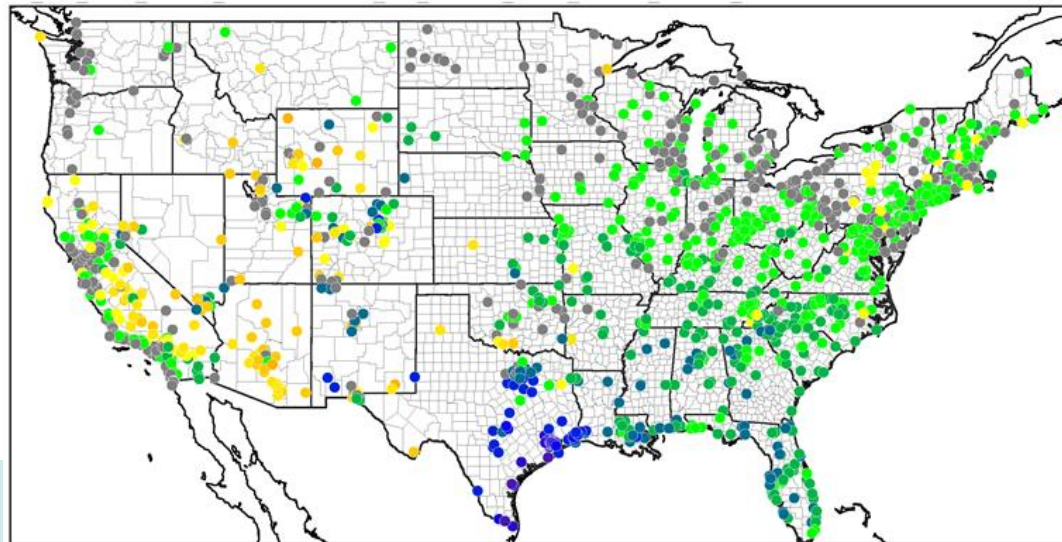
Case	# of All Cases	# of Non-zero Diff Cases	% of Non-zero Diff Cases	Max Diff	Min Diff	Avg of Diff	Std of Diff
A	84,960	43,871	51.64%	1	0	0.0543	0.0754
B	53,768	3,624	6.74%	1	0	0.0169	0.1207
C	15,478	8,442	54.54%	0.1	0	0.0531	0.0493
D	114,504	114,494	99.99%	0.1	-0.9	0.0975	0.0376

- All non-zero differences for Cases A, B, and C are positive, i.e., EPA adjusted FEM values are higher than replication FEM values.
- There are about 2,000 cases across 13 monitors where EPA Adjusted FEM values exist when no temperature data is available.
- As of 05/21/24, there are about 40,000 cases across 3 monitors (Columbus-Airport, Augusta, and Albany) where EPA Adjusted FEM values do not exist when temperature data and unadjusted FEM values are available.



UPDATED ALGORITHM?

- Develop our own alignment algorithm (state-wide or site-specific) based on Georgia data.
- Ask EPA to reanalyze the data and develop a new alignment algorithm.
 - Multiply the $T640/x$ raw PM value by 0.813233?
 - Develop algorithm that varies spatially (by Region or State)
 - Need to perform a full performance evaluation of the algorithm





OPTIONS UNDER CONSIDERATION...

- If EPA does not fix the Teledyne alignment algorithm, here are some options:
 1. Replace all FEMs with FRMs in our network
 - Lose hourly, real-time PM_{2.5} concentrations for AQI, exceedance reports, and exceptional event demos
 - Very expensive solution (filters, analysis, personnel)
 - APA does not allow the purchase of non-regulatory FEMs with EPA grant money
 2. Recommend “unclassifiable” for all areas that use FEM data until we have 3 years of FRM data.



CONTACT INFORMATION

James Boylan, Ph.D.

**Georgia Dept. of Natural Resources
4244 International Parkway, Suite 120
Atlanta, GA 30354**

James.Boylan@dnr.ga.gov

470-524-0697