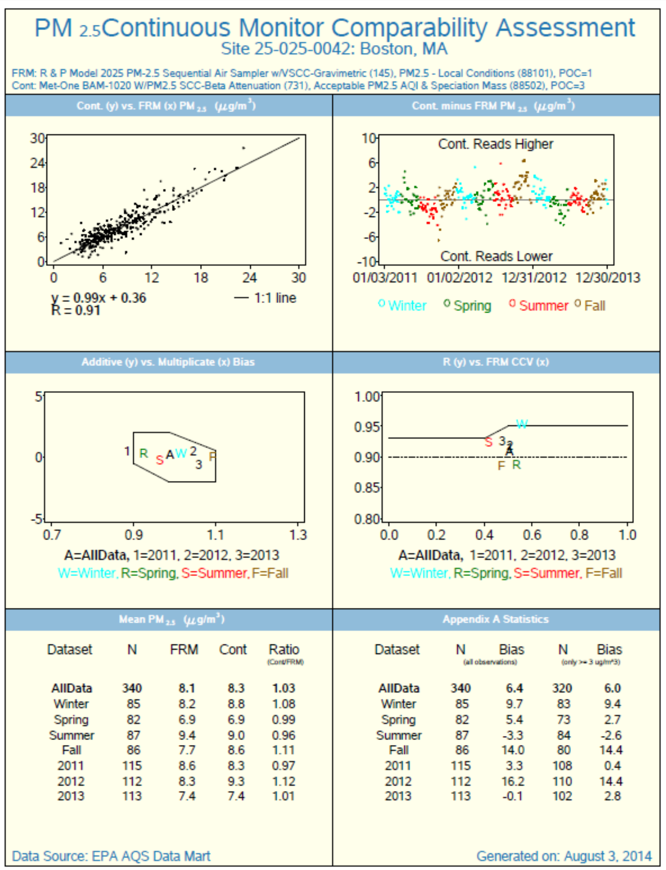
$PM_{2.5}$ Continuous Monitoring

Assessing the Data



Dataset	N	FRM	Cont	Ratio (Cont/FRM)
AllData	340	8.1	8.3	1.03
Winter	85	8.2	8.8	1.08
Spring	82	6.9	6.9	0.99
Summer	87	9.4	9.0	0.96
Fall	86	7.7	8.6	1.11
2011	115	8.6	8.3	0.97
2012	112	8.3	9.3	1.12
2013	113	7.4	7.4	1.01

Dataset	N (all observations)	Bias (all observations)	N (only >= 3 ug/m^3)	Bias (only >= 3 ug/m^3)
AllData	340	6.4	320	6.0
Winter	85	9.7	83	9.4
Spring	82	5.4	73	2.7
Summer	87	-3.3	84	-2.6
Fall	86	14.0	80	14.4
2011	115	3.3	108	0.4
2012	112	16.2	110	14.4
2013	113	-0.1	102	2.8

National Ambient Air Monitoring Conference

Atlanta 2014

Approach for this section:

Take a step by step approach to assess whether your getting good $PM_{2.5}$ continuous FEM data

1. Ensure your getting good FRM data
2. Review and assess your data.
3. Use automated assessment tools
4. Know what to expect for acceptable performance from a $PM_{2.5}$ Continuous Monitor, and
5. What to expect in your data by Method
6. Look at the data in more detail

Ensure your getting good FRM data

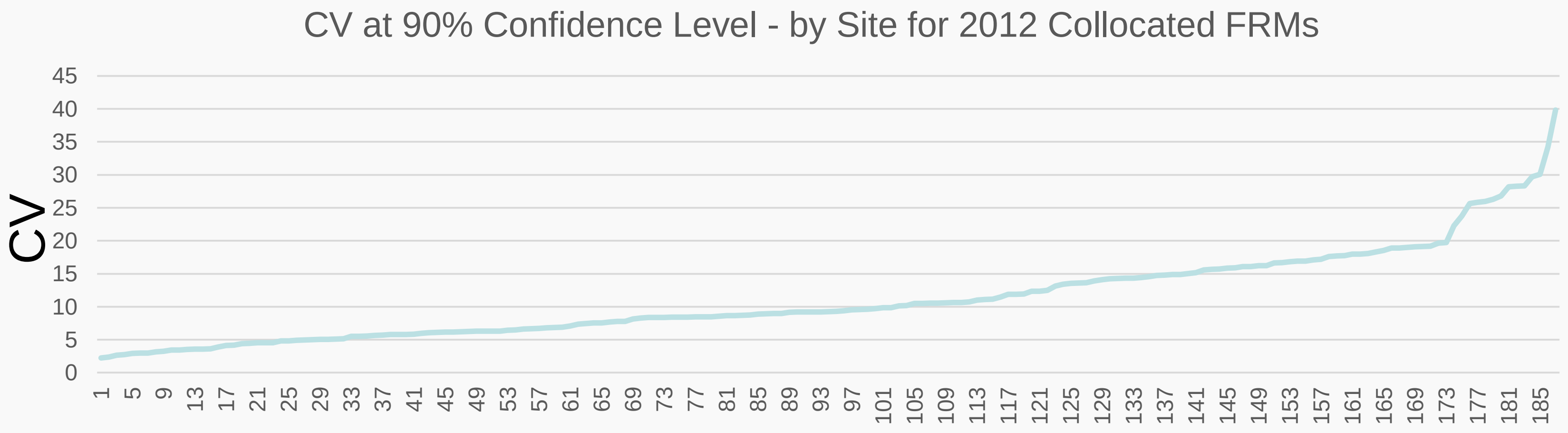
You won't know if your getting $PM_{2.5}$ Continuous FEM data unless you know your program is getting good FRM data

- ✓ Lab – Field Blank data
- ✓ Collocated Precision
- ✓ Performance Audits (with collocated FRMs)

Are you getting good FRM data?

- Mean national <u>Field Blank</u> contamination (years 2011 – 2013) on FRM's =
  - 6.2 micrograms, or (Note: goal is 30 micrograms)
  - 0.26 µg/m^3 (at 24.0 m^3 of air collected with 6.2 µg of contamination)

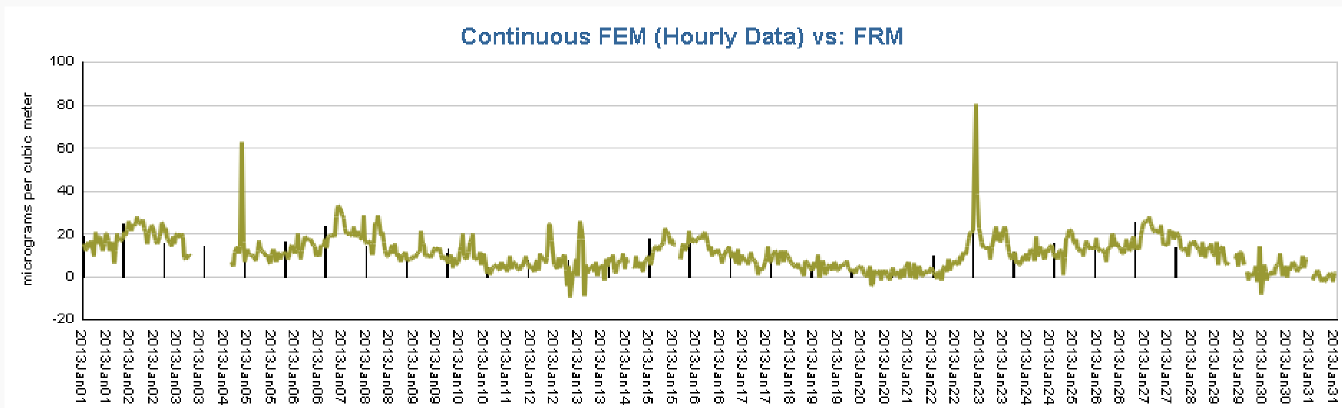
- National collocated precision:



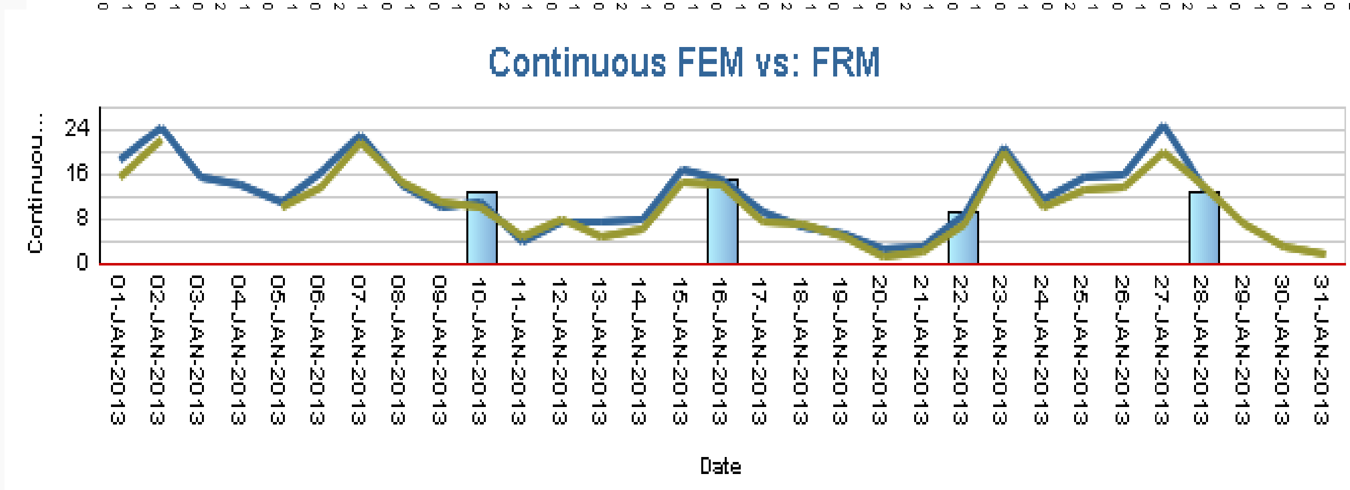
Review and Assess your Data

e.g., One Month of FRM vs Continuous FEM in Time Series

Hourly



24-Hour



Utilize Comparability Assessment Tools

Equation 19

$$\text{Slope} = \frac{\sum_{j=1}^{J}(R_j - \bar{R})(C_j - \bar{C})}{\sum_{j=1}^{J}(R_j - \bar{R})^2}$$

Equation 20

$$\text{Intercept} = \bar{C} - \text{slope} \times \bar{R}$$

Equation 21

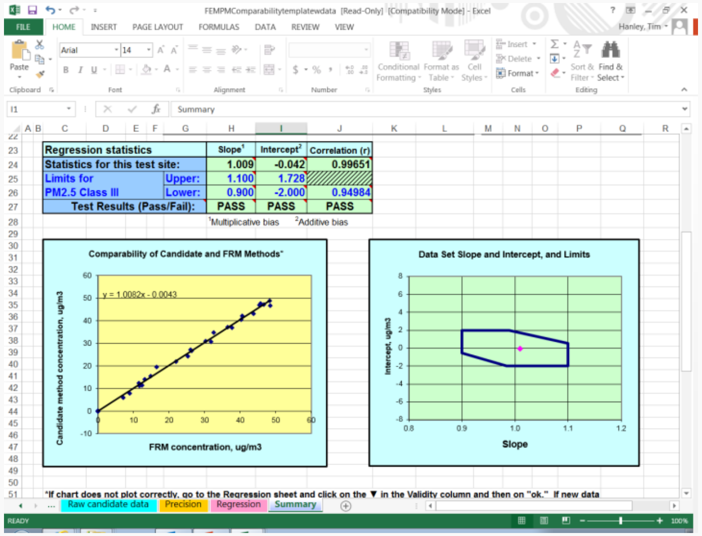
$$r = \frac{\sum_{j=1}^{J}(R_j - \bar{R})(C_j - \bar{C})}{\sqrt{\sum_{j=1}^{J}(R_j - \bar{R})^2 \sum_{j=1}^{J}(C_j - \bar{C})^2}}$$

Equation 22

$$\text{CCV} = \frac{1}{\bar{R}}\sqrt{\frac{\sum_{j=1}^{J}(R_j - \bar{R})^2}{J-1}}$$

=

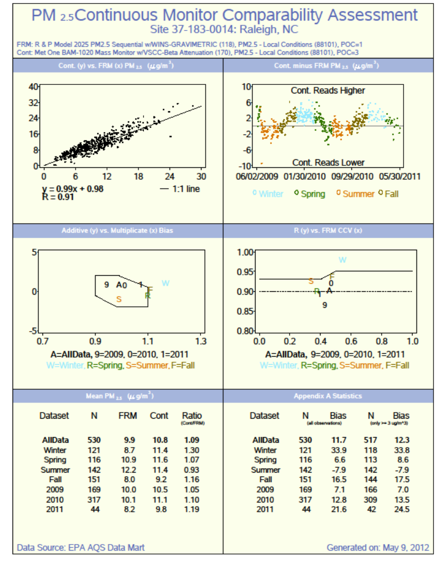
Candidate FEM Excel File



- Four variations of same file available
  - Blank file for up to 70, 122, or 366 collocated pairs
  - Example file
- You have to supply the data

or

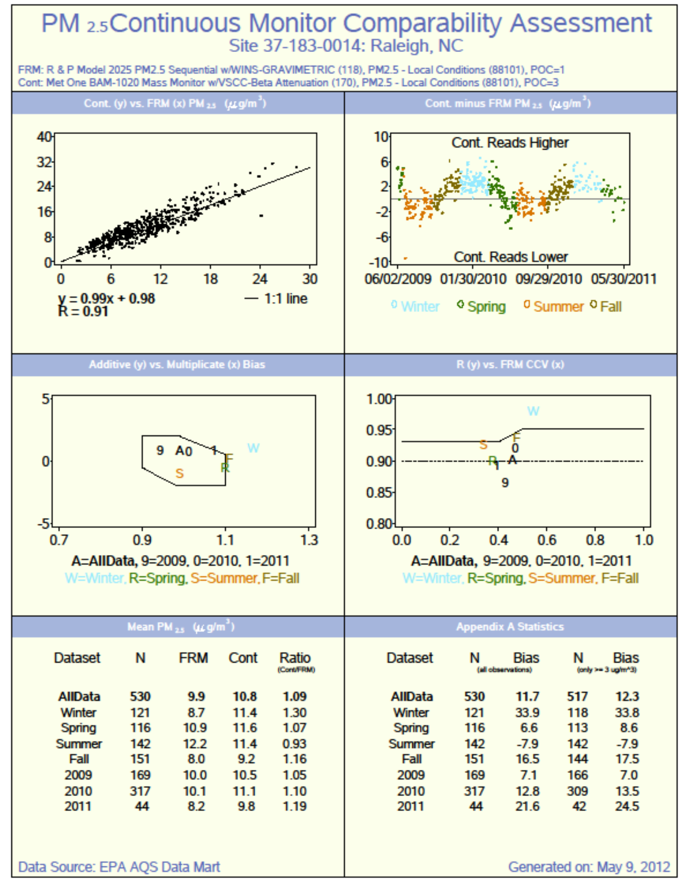
One-Page Automated Assessment



http://www.epa.gov/ttn/amtic/contmont.html

Comparability Assessment Tool

- Available at: http://www.epa.gov/airquality/airdata/ad_rep_frmvfem.html
- Provides one-page assessment
- Data is from AQS Data Mart where there is a collocated $PM_{2.5}$ FRM and $PM_{2.5}$ continuous monitor.
- Includes $PM_{2.5}$ continuous data submitted to any the following parameter codes:
  - 88101, 88500, 88502, 88501
- Technical note explaining tool is available at: http://www.epa.gov/ttn/amtic/files/ambient/pm25/comparabilityassessmenttool.pdf



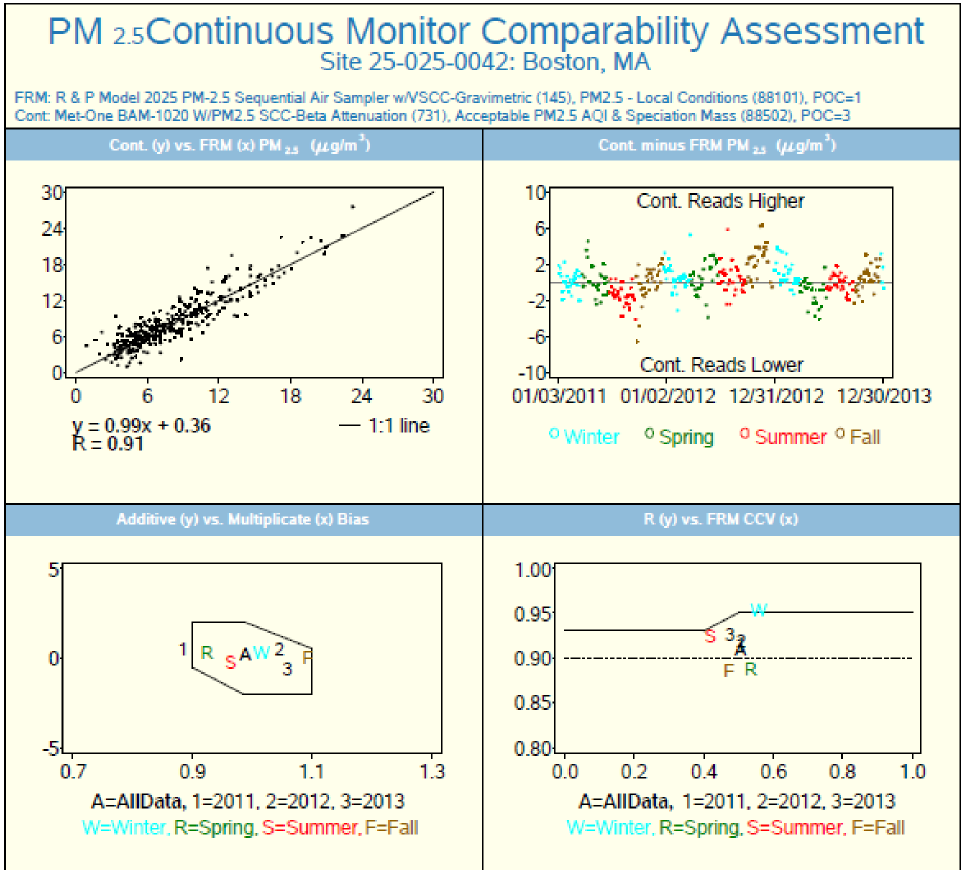
$PM_{2.5}$ Continuous Monitor Comparability Assessment Tool

Linear Regression

Difference Trend

Part 53 Test Specifications

Correlation Criteria



Data Summary

Appendix A

Mean $PM_{2.5}$ ($\mu g/m^3$)

Dataset	N	FRM	Cont	Ratio (Cont/FRM)
AllData	340	8.1	8.3	1.03
Winter	85	8.2	8.8	1.08
Spring	82	6.9	6.9	0.99
Summer	87	9.4	9.0	0.96
Fall	86	7.7	8.6	1.11
2011	115	8.6	8.3	0.97
2012	112	8.3	9.3	1.12
2013	113	7.4	7.4	1.01

Appendix A Statistics

Dataset	N (all observations)	Bias (all observations)	N (only >= 3 ug/m^3)	Bias (only >= 3 ug/m^3)
AllData	340	6.4	320	6.0
Winter	85	9.7	83	9.4
Spring	82	5.4	73	2.7
Summer	87	-3.3	84	-2.6
Fall	86	14.0	80	14.4
2011	115	3.3	108	0.4
2012	112	16.2	110	14.4
2013	113	-0.1	102	2.8

Data Source: EPA AQS Data Mart

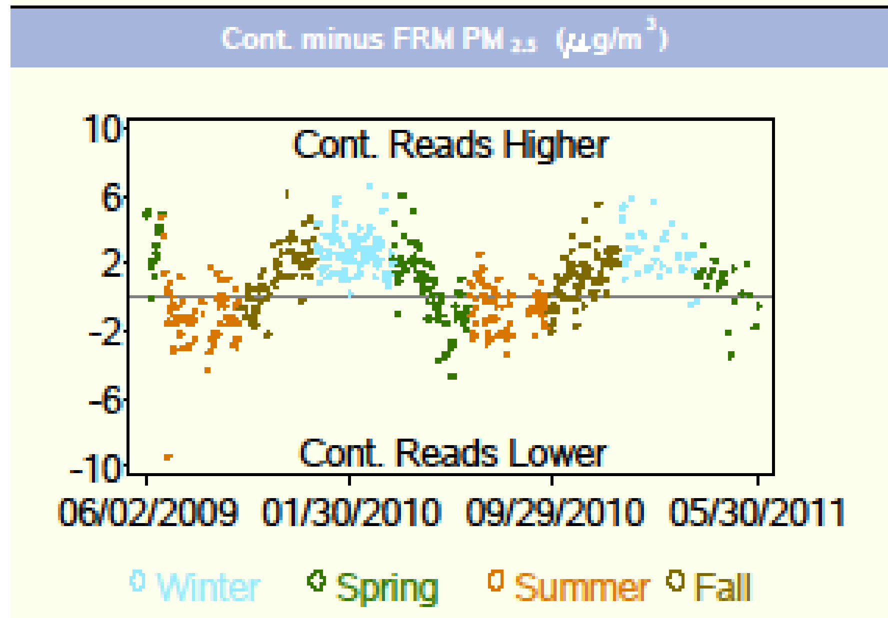
Generated on: August 3, 2014

Title, Site, Methods, and Difference Trend

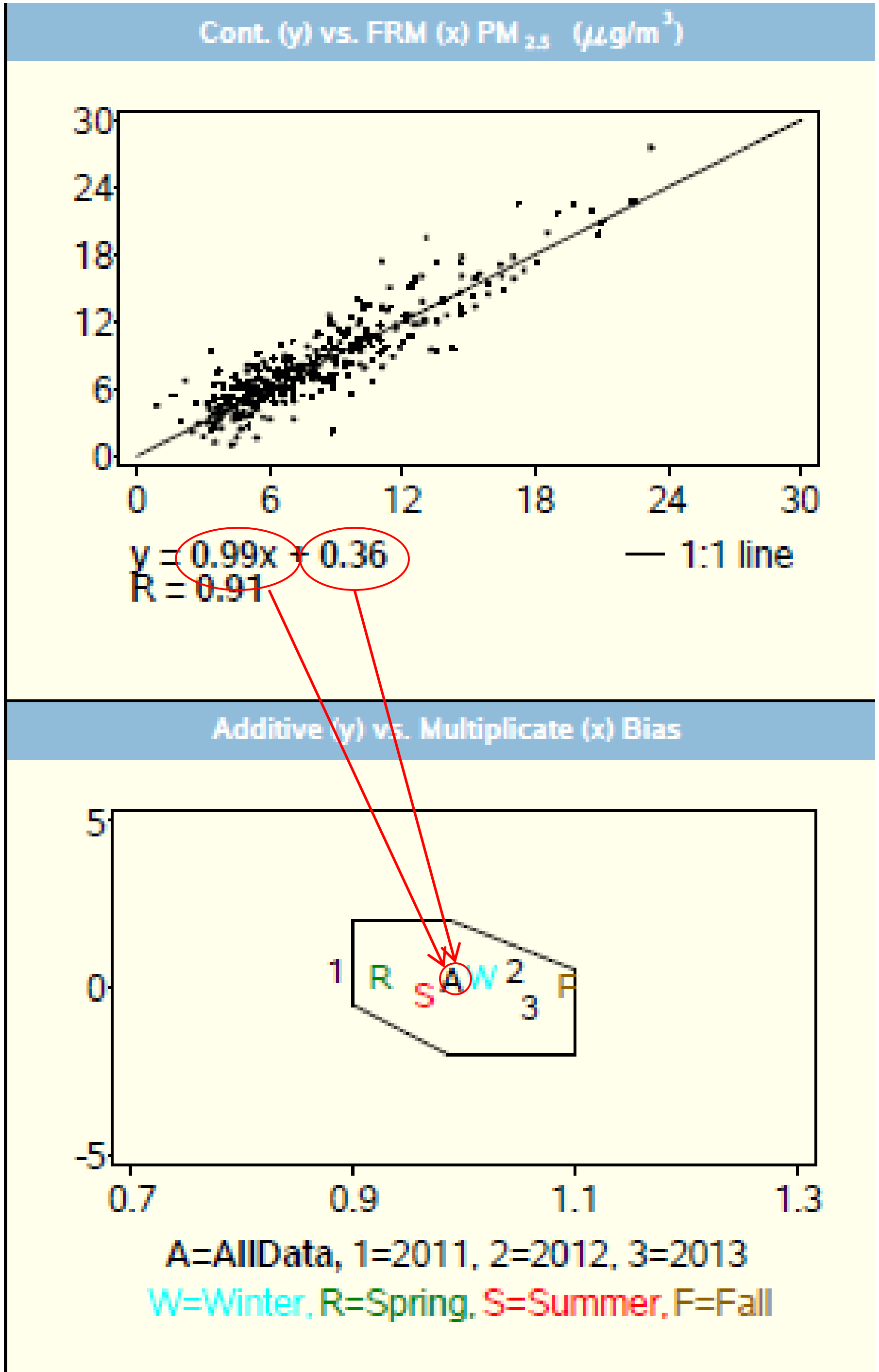
PM 2.5 Continuous Monitor Comparability Assessment

Site 37-183-0014: Raleigh, NC

FRM: R & P Model 2025 PM2.5 Sequential w/WINS-GRAVIMETRIC (118), PM2.5 - Local Conditions (88101), POC=1
Cont: Met One BAM-1020 Mass Monitor w/VSCC-Beta Attenuation (170), PM2.5 - Local Conditions (88101), POC=3



Interpreting the $PM_{2.5}$ Comparability Assessment for Bias



- The primary information we look at in the assessment is slope and intercept in the linear regression equation.

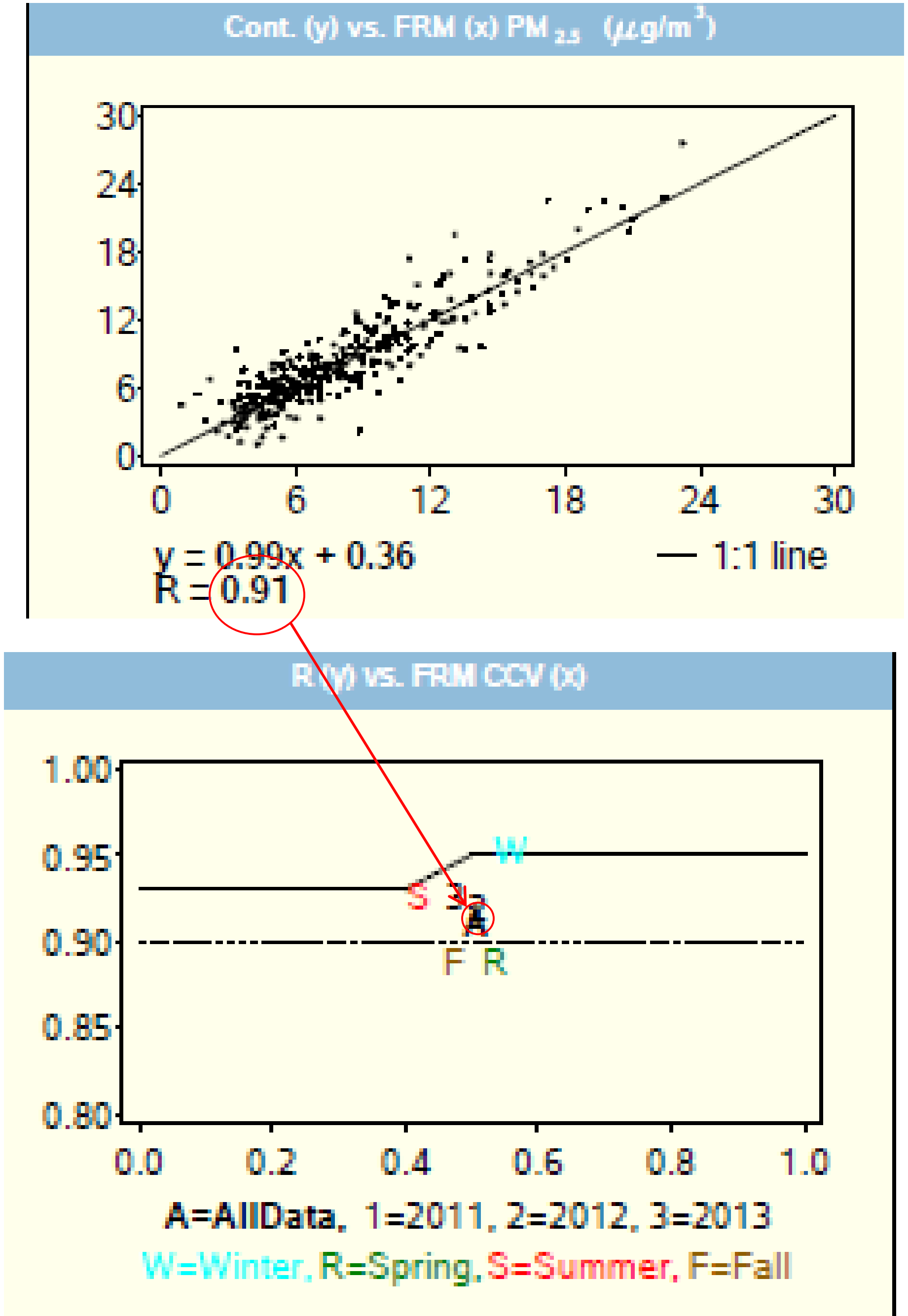
- Intercept from regression equation is displayed as additive bias along y-axis

- Slope from regression equation is displayed as multiplicative bias along x-axis

- Line in regression upper figure is a 1:1 line

- One regression equation is displayed; however, several regression equation outputs are illustrated in the lower figure.

Interpreting the $PM_{2.5}$ Comparability Assessment for Correlation



- Part 53 performance criteria for acceptance of a method includes a statistic for correlation
- Appendix A and DQO's do not include a correlation goal
- Note: Correlation (r) is used, not correlation squared (r^2)
- Interpreting correlation can be challenging, especially at sites with low concentrations. Even sites with very good bias may not meet an expected correlation criteria.
- X-axis is CCV which describes the spread of the sample population; the higher the CCV the higher r (on y-axis) we should expect.
- We do not formally use correlation in deciding to use data; it is used in FEM approvals

Means for each Method & Ratio of Cont/FRM

Appendix A Statistic for Bias

Mean $PM_{2.5}$ ($\mu g/m^3$)				
Dataset	N	FRM	Cont	Ratio (Cont/FRM)
AllData	530	9.9	10.8	1.09
Winter	121	8.7	11.4	1.30
Spring	116	10.9	11.6	1.07
Summer	142	12.2	11.4	0.93
Fall	151	8.0	9.2	1.16
2009	169	10.0	10.5	1.05
2010	317	10.1	11.1	1.10
2011	44	8.2	9.8	1.19

Data Source: EPA AQS Data Mart

Appendix A Statistics				
Dataset	N	Bias (all observations)	N	Bias (only >= 3 ug/m^3)
AllData	530	11.7	517	12.3
Winter	121	33.9	118	33.8
Spring	116	6.6	113	8.6
Summer	142	-7.9	142	-7.9
Fall	151	16.5	144	17.5
2009	169	7.1	166	7.0
2010	317	12.8	309	13.5
2011	44	21.6	42	24.5

Generated on: May 9, 2012

Evaluating the means and ratio of means provides a quick way to assess the comparability of the methods

Appendix A calls for calculating bias when both methods are >= 3 µg/m^3 This is presented in the column on the right

Comparability Assessment Tool Summary

- Tool provides quick and valuable assessment
- The assessment assumes the FRM represents the true value, even though the FRM will have its own uncertainty
- Assessments should be used as a guide and not a bright line

From Section 2.3.1.1 of Appendix A to Part 58:

Measurement Uncertainty for Automated and Manual $PM_{2.5}$ Methods.

The goal for acceptable measurement uncertainty is defined as 10 percent coefficient of variation (CV) for total precision and plus or minus 10 percent for total bias

Appendix A calculation of Bias is based on samples collected in Performance Evaluation Program (PEP) program (PEP data are not included in one page assessment)

Data Challenges

1. Interpreting performance data as air quality levels keep improving.
2. Knowing what to expect in data from a method?
3. Negative Numbers
4. Additional Data Assessment Details

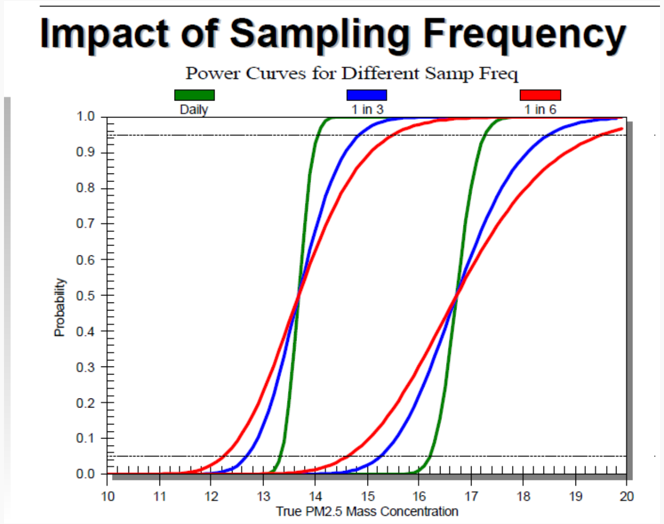
Interpreting performance data as air quality levels keep improving

- DQOs and performance criteria were set up when air quality concentrations were much higher than what we see today.

- As $PM_{2.5}$ concentrations decrease, interpreting the performance criteria may be challenging.
  - An appendix A calculated bias may be off by 20%, but the data otherwise appear very good.

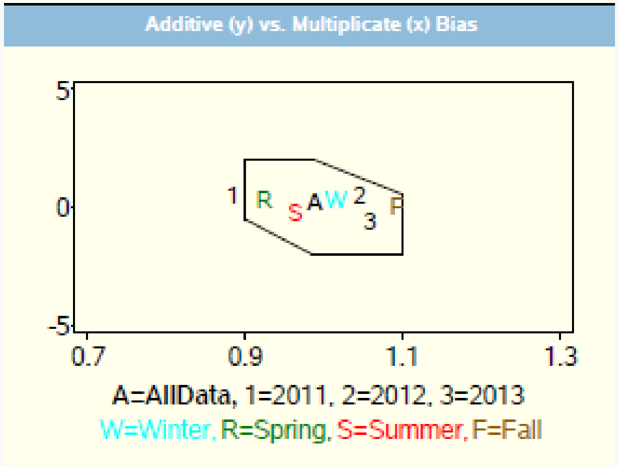
- Appendix A calculations typically provide to exclude data < 3µg/m³

- Linear Regression equation to determine multiplicative and additive bias uses all available data



What to Expect for Acceptable Performance from a $PM_{2.5}$ Continuous Monitor?

- Bias:
  - Drives decision errors
  - **Ideally, total bias is within within +/- 10%**
  - A goal, not a requirement; however,
  - Certain monitors may be excluded from NAAQS if they do not meet total bias and are approved for exclusion.
- Precision:
  - Does not drive decision errors due to large data set with an effective daily sample schedule
  - Class III Continuous method precision criteria is within 15%
- Correlation
  - Used in Class III Method approvals based on sample population
  - From 2002 AQI DQO Document we established a goal for an R of 0.9 (R^2 = 0.81)
  - However, as previously stated correlation can be hard to interpret at low air quality concentrations



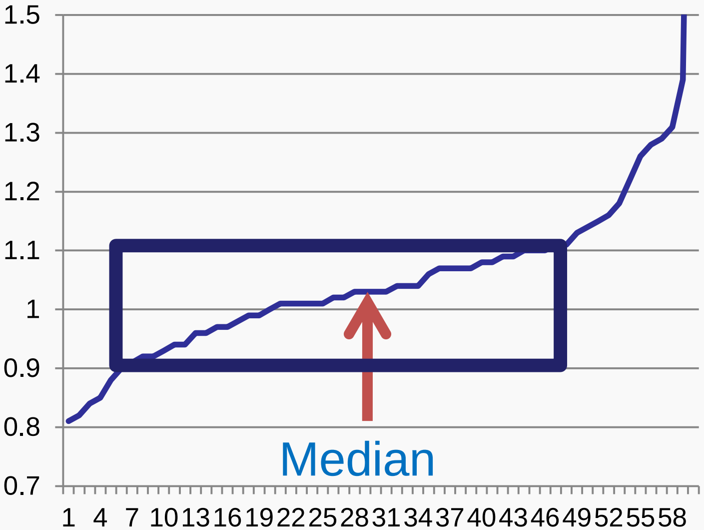
What to expect in your data by Method – Looking at available data

- Large collocated data set available to evaluate Met One BAM 1020
- Smaller collocated data sets available for FDMS 8500C and 5030 SHARP
- Very little collocated data sets available for the rest of the methods.

Slope on the Met One BAM 1020 – FEM (compared to collocated FRMs)

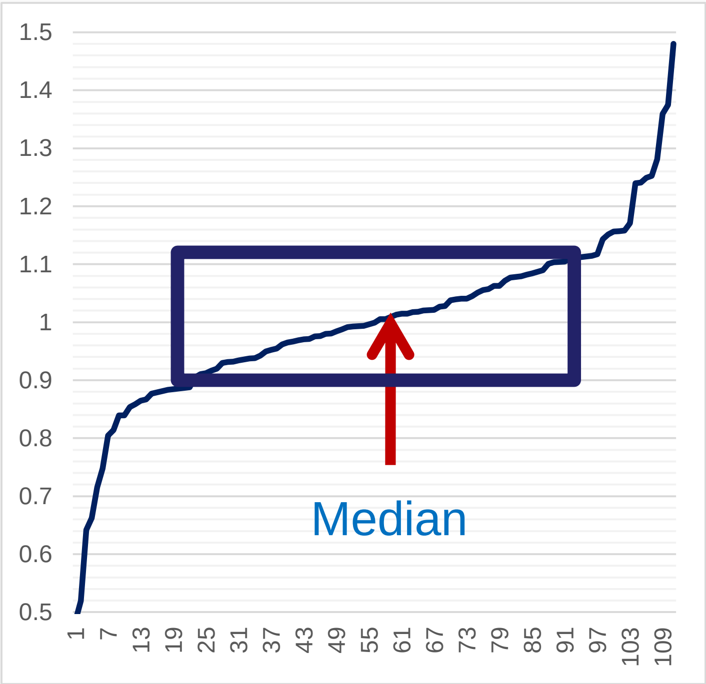
Assessment from April 7, 2011 memo to PM NAAQS docket

Average slope for all sites = 1.081
Average slope for sites with an intercept within +/- 2 µg = 1.066



Assessment of 2013 data

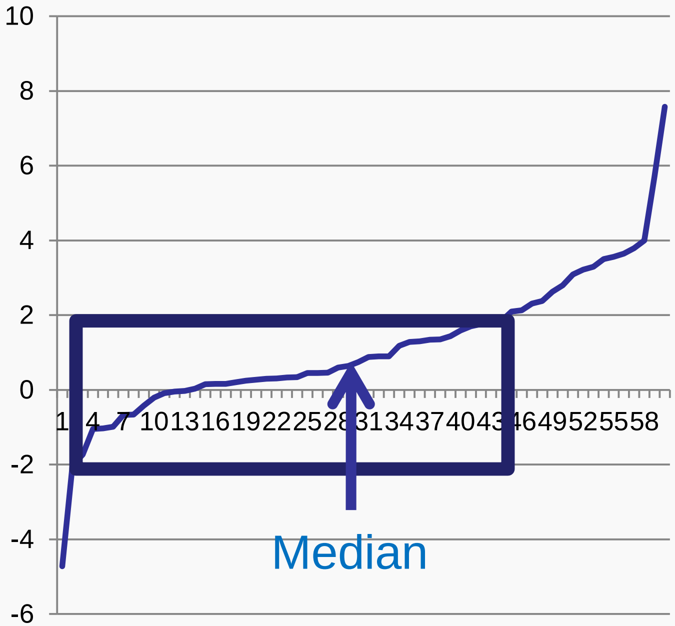
Percent of Sites with a slope of 0.9 to 1.1 = 68%
Average slope for all sites = 1.00
Average slope for sites with an intercept within +/- 2 µg = 1.02



Intercept on the Met One BAM 1020 – FEM (compared to collocated FRMs)

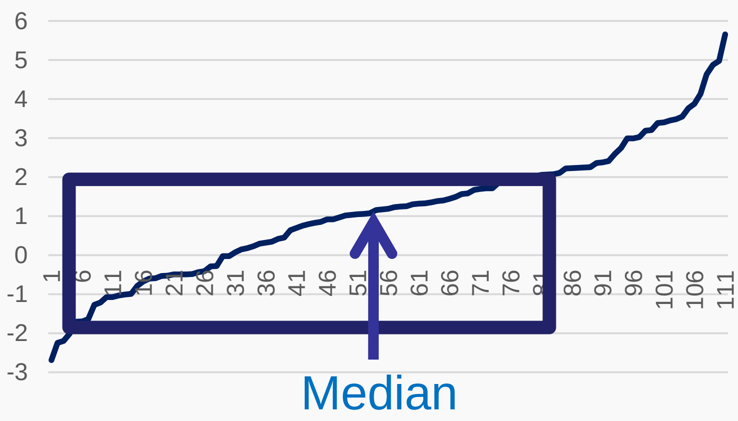
Assessment from April 7, 2011 memo to PM NAAQS docket

Average intercept for all sites = 1.12 µg/m3
Average intercept for sites with a slope within +/- 10% of 1 = 1.34 µg/m3



Assessment of 2013 data

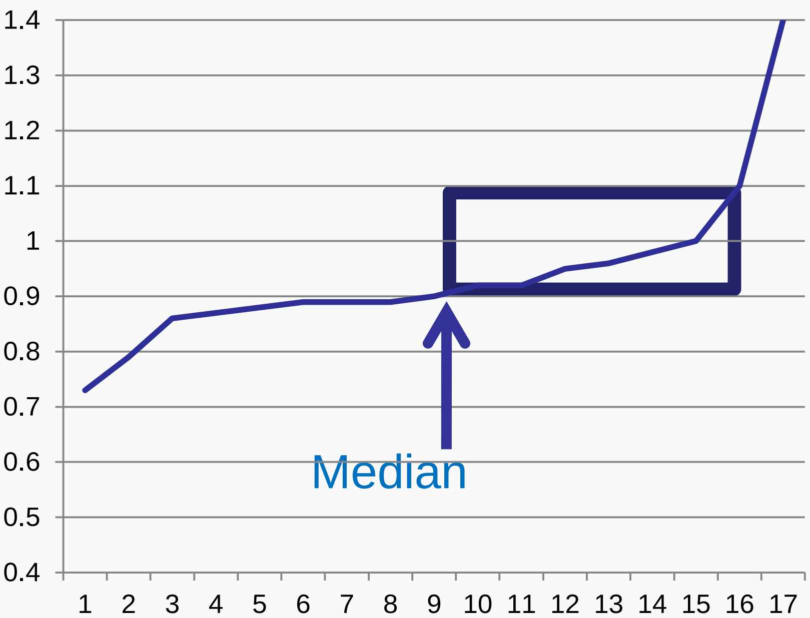
Percent of Sites with an Intercept within +/- 2 = 62%
Average intercept for all sites = 1.12 µg/m3
Average intercept for sites with a slope within +/- 10% of 1 = 1.16 µg/m3



<u>Slope</u> on the Thermo 8500C FDMS (compared to collocated FRMs)

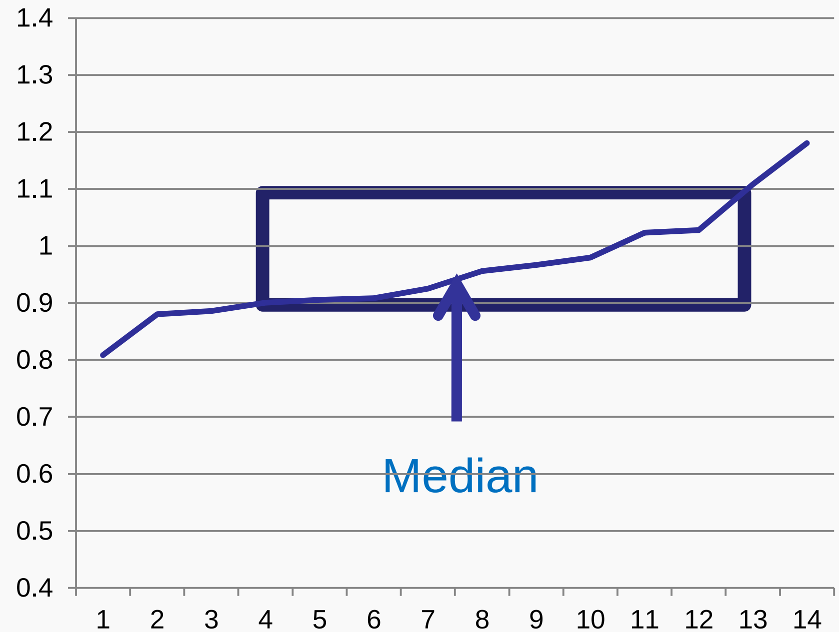
Assessment from April 7, 2011 memo to PM NAAQS docket

Average slope for all sites = 0.937
Average slope for sites with an intercept within +/- 2 µg = 0.926



Assessment of 2013 data

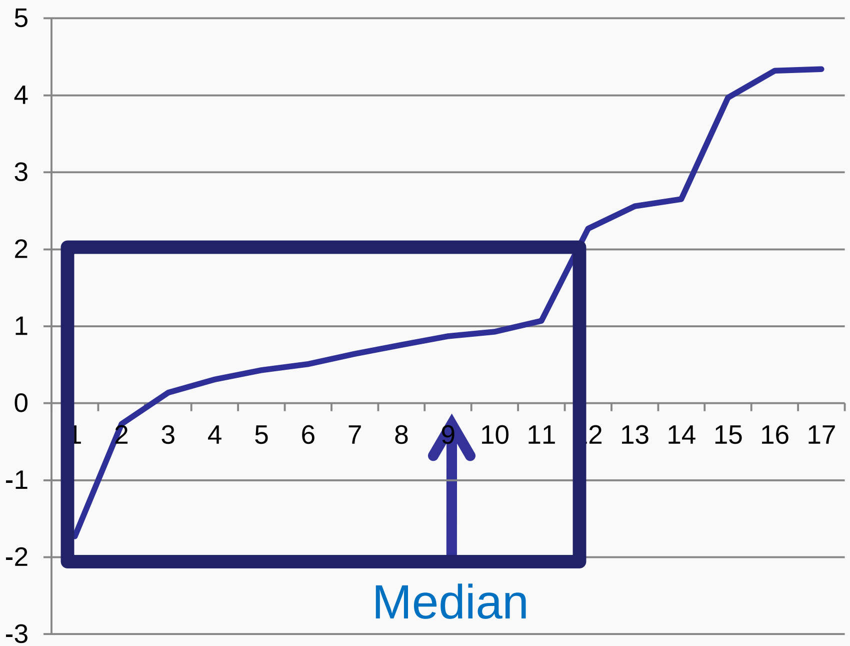
Percent of Sites with a slope of 0.9 to 1.1 = 64%
Average slope for all sites = 0.96
Average slope for sites with an intercept within +/- 2 µg = 1.02



Intercept on the Thermo 8500C FDMS (compared to collocated FRMs)

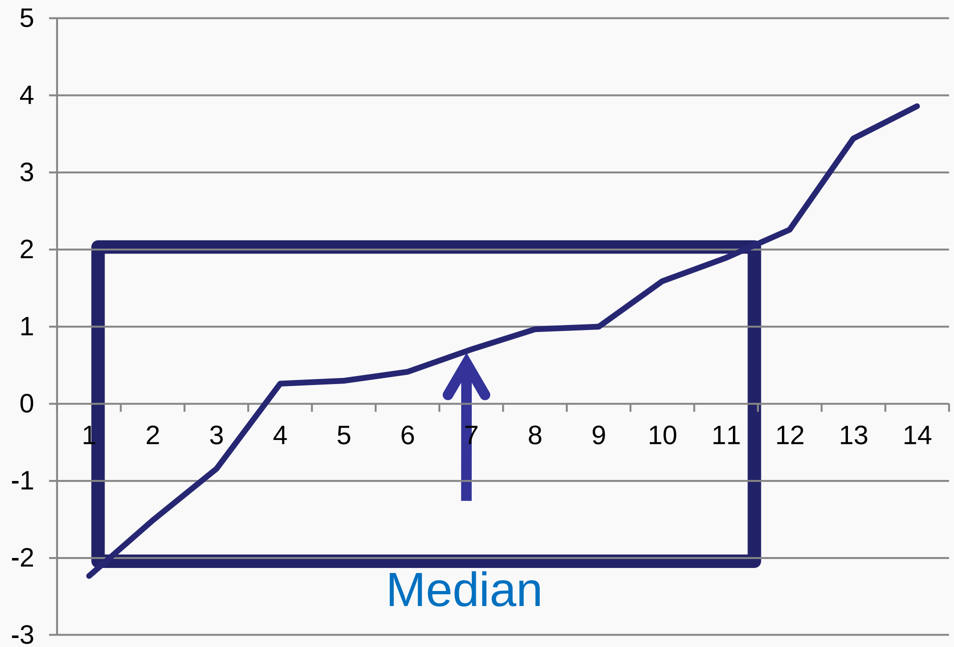
Assessment from April 7, 2011 memo to PM NAAQS docket

Average intercept for all sites = 1.40 µg/m3
Average intercept for sites with a slope within +/- 10% of 1 = 0.68 µg/m3



Assessment of 2013 data

Percent of Sites with an Intercept within +/- 2 = 71%
Average intercept for all sites = 0.86 µg/m3
Average intercept for sites with a slope within +/- 10% of 1 = 1.03 µg/m3



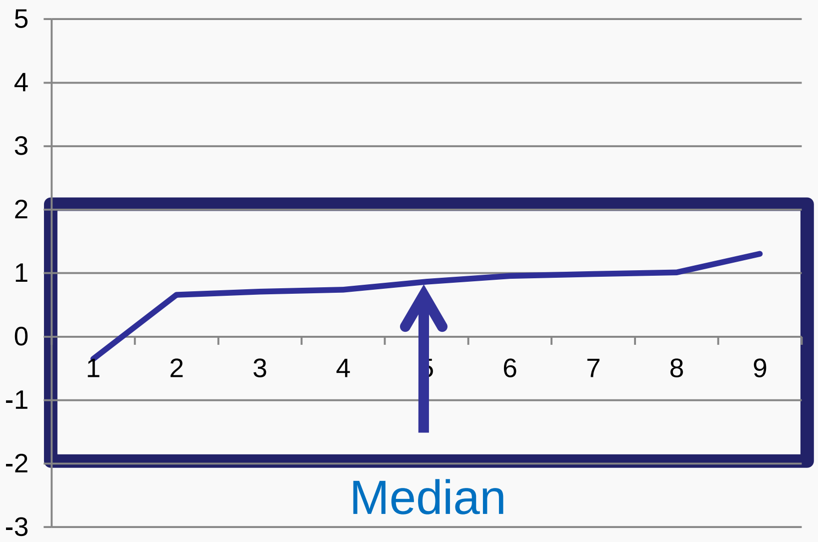
Slope and Intercept on the Thermo 5030 SHARP (compared to collocated FRMs)

Assessment of 2013 data

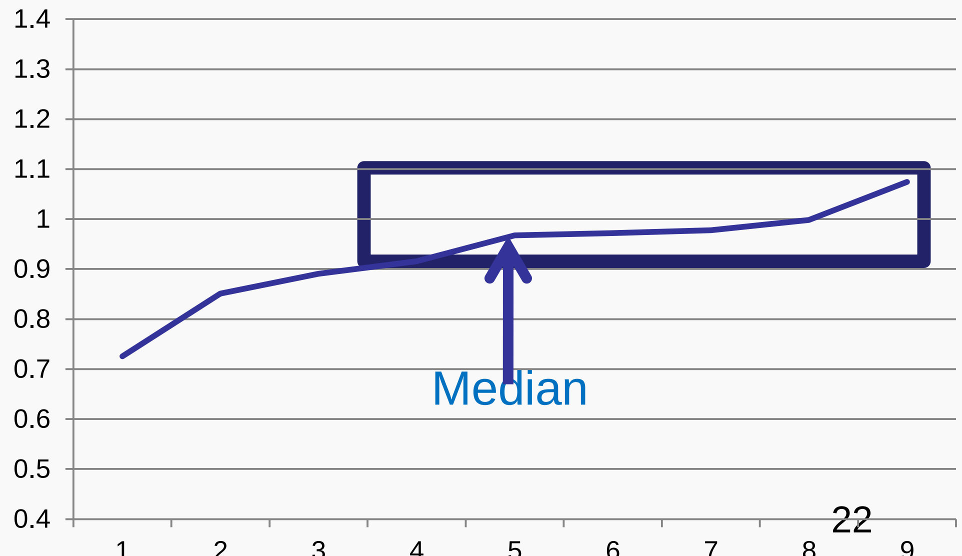
Percent of Sites with an intercept within +/-2 µg/m3
Average intercept for all sites = 0.76

Percent of Sites with a slope of 0.9 to 1.1 = 67%
Average slope for all sites = 0.96
Average slope for sites with an intercept within +/- 2 µg = 1.02

Intercept



Slope



$PM_{2.5}$ Continuous Method Comparability Summary

Note: Small number of sample pairs for most methods.

Method Description	# Collocated Sites	Sites with Slope 1 +/- 0.1	Sites with Intercept +/- 2 ug/m3
Met One BAM-1020	111	69	75
Thermo 8500C FDMS	14	9	10
Thermo 1405 FDMS	2	2	2
Thermo 1405-DF FDMS	2	1	2
Thermo 5014i or FH62C14-DHS	4	4	2
Thermo 5030 SHARP	9	6	9
GRIMM EDM 180	2	1	1
Teledyne 602 Beta	1	0	1
Totals	**145**		

Collocated FRM and Continuous FEMs Reporting to AQS in 2013

Looking at the Data in more detail

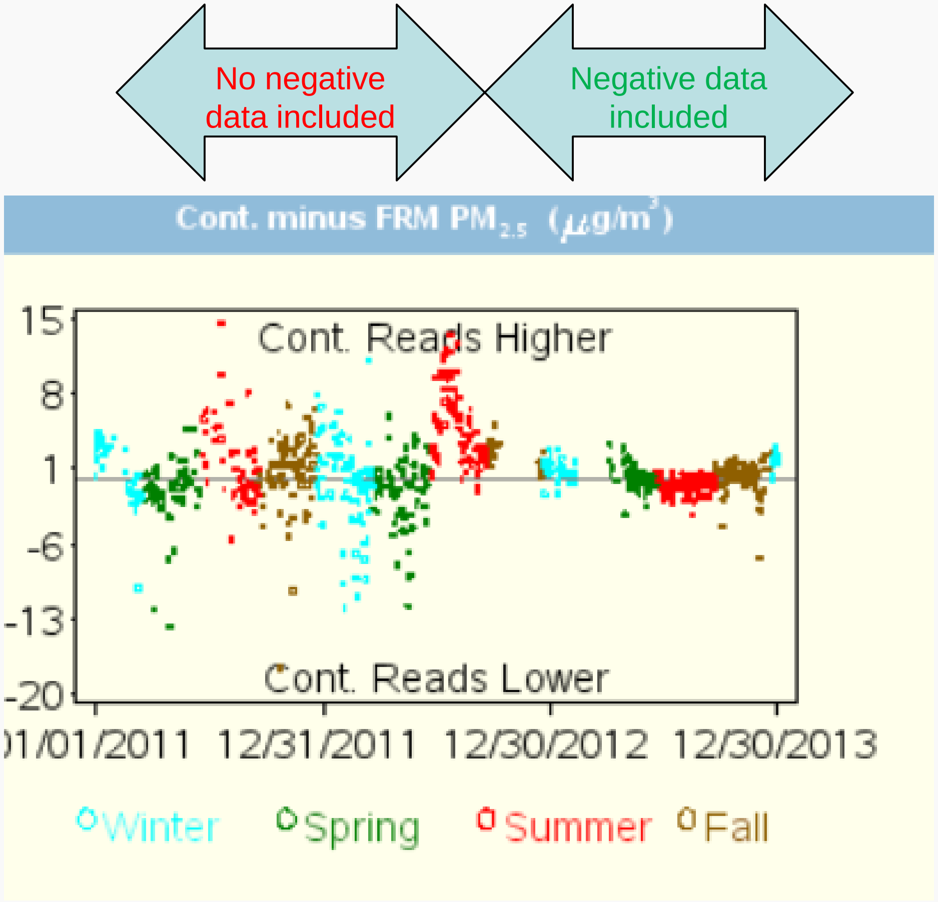
1. Negative Numbers
2. Use of the VSCC or WINS on the FRM
3. Hourly Variation

1. Negative numbers?

- How to handle negative numbers?
  - Of course the atmosphere cannot have a negative amount of PM in it.
  - The regulation does not address negative numbers.
  - EPA has had a long standing convention of allowing negative data into AQS
    - If the atmosphere is very clean (approaching 0 µg/m^3) and there is noise in the measurement, then a negative number may in fact be valid.
      - Invalidating data or correcting to 0 would lead to biasing data higher
    - How much is too negative?
      - Reference instrument manual, if addressed (e.g., Met One BAM allows up to -15 µg/m^3)
- Databases:
  - **AQS** - generally allows negative data for $PM_{2.5}$ continuous monitors up to a -10 ug/m3
  - **AIRNow** – default flag of data less than -4.99 ug/m3

- Valid negative numbers should be carried and included in reporting to data bases; however, public reports of data should not include negative numbers

Example of excluding and then including negative numbers



- For this site negative numbers were not included until mid 2012
- Inclusion of negative 1-hour data led to large improvement in 24-hour variability between FRM and continuous FEM (Met One BAM 1020)

Summary of Methods and Negative Data Submitted to AQS in 2013

Method	Total Number of Monitors Reporting	Number of Monitors Reporting with at least one Negative Hour	Total number of Hours Reported in 2013	Lowest Hourly data point Submitted	Highest Hourly data point Submitted
Met One BAM	258	194	1,948,125	-10	593
Thermo 5014i	9	8	61,012	-10	131.3
Thermo SHARP	17	13	107,195	-7.5	320
Thermo 8500C FDMS	25	9	190,396	-9.5	914
Thermo 1405DF	22	21	144,941	-10	787
Thermo 1405 FDMS	5	1	29,594	-7.5	157.7
GRIMM 180	2	0	12,976	0	130.9
Teledyne 602 Beta	1	1	1,747	-6.9	37

2. Does the selection of the Second Stage Separator have any effect on the comparability of data?

- Good size data set available to look at VSCC and WINS on the FRM collocated with Met One BAM 1020, which all use the VSCC.
- Met One BAM sites where the:
  - FRMs have WINS = 51
  - FRMs have VSCC = 60

WINS

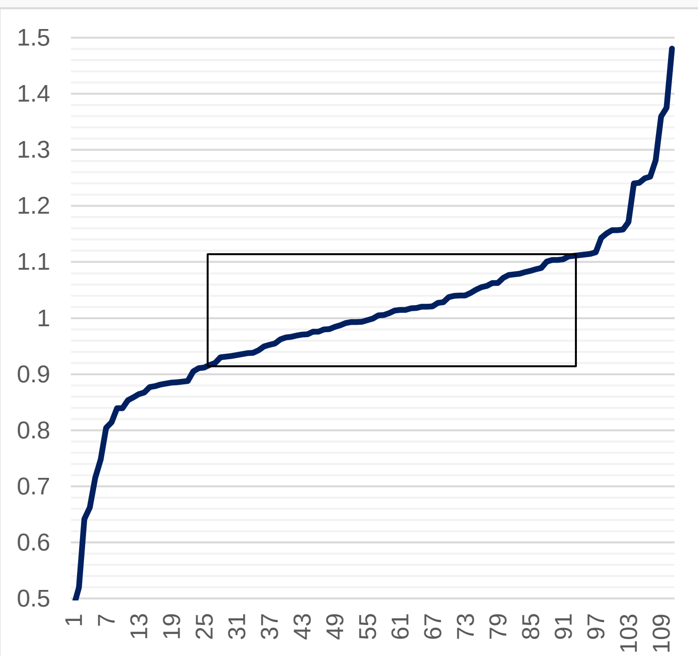
VSCC

Slope on the Met One BAM 1020 – FEM (compared to collocated FRMs)

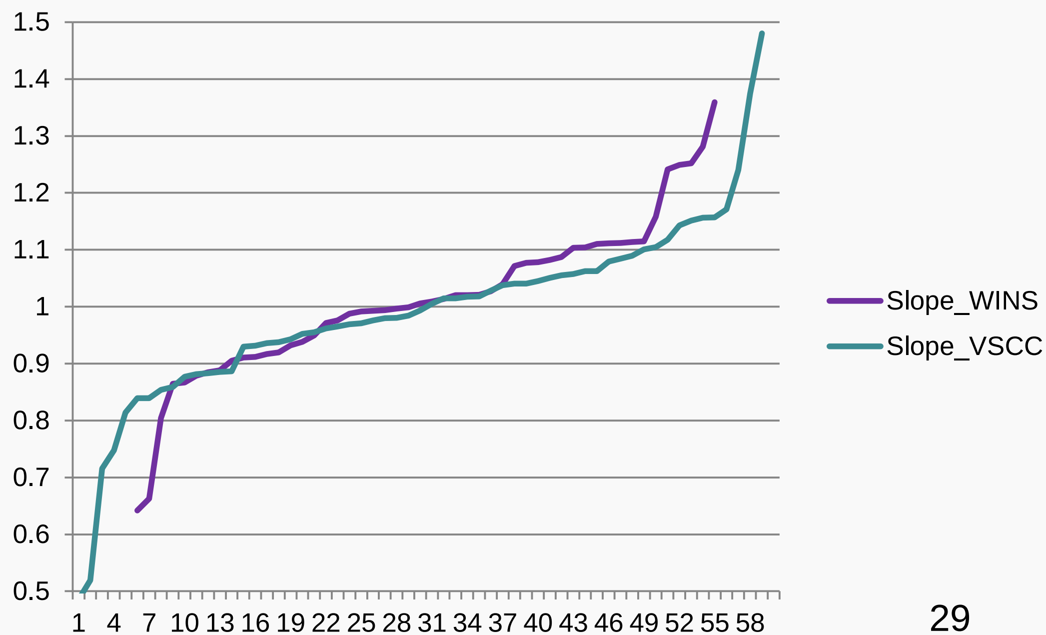
Average Slope where the Intercept criteria was met:

- All Sites = 1.02
- WINS on the FRM = 1.04
- VSCC on the FRM = 1.01

All Sites



By $PM_{2.5}$ Separator on FRM

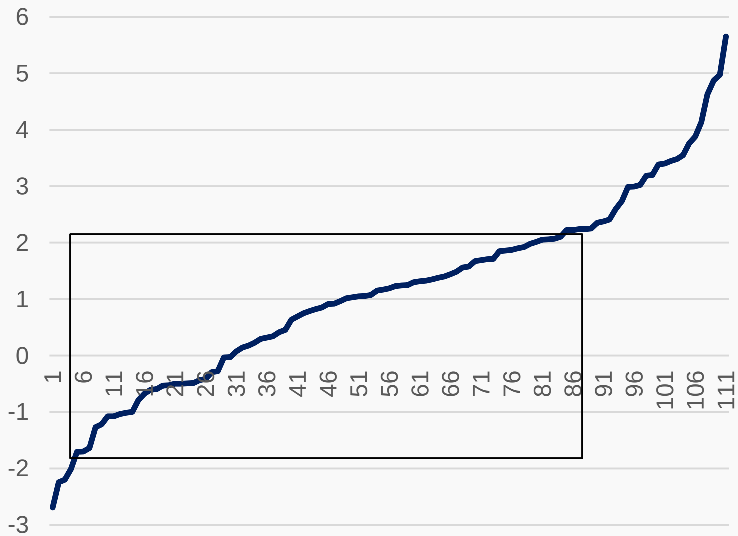


Intercept on the Met One BAM 1020 – FEM (compared to collocated FRMs)

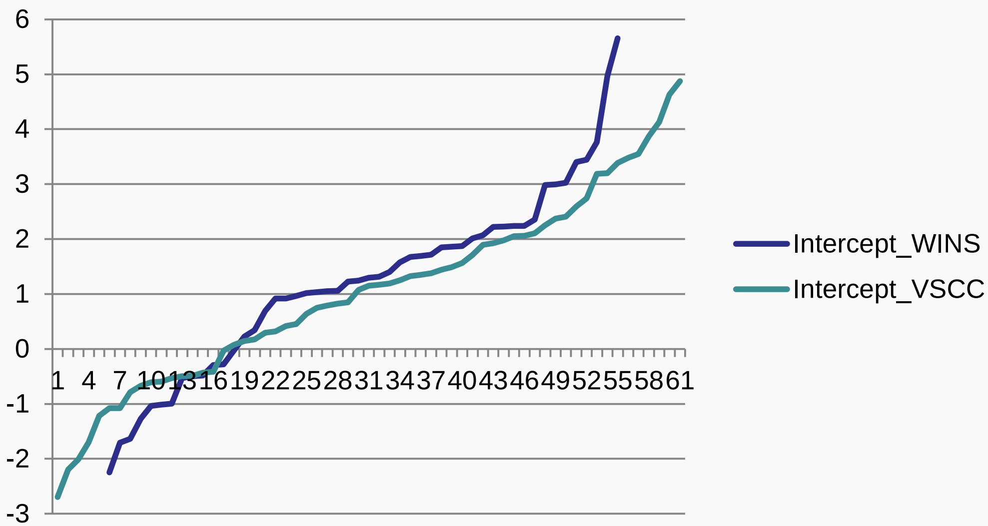
Average Intercept where the slope criteria was met:

- All Sites = 1.14
- WINS on the FRM = 1.11
- VSCC on the FRM = 1.15

All Sites



By PM$_{2.5}$ Separator on FRM

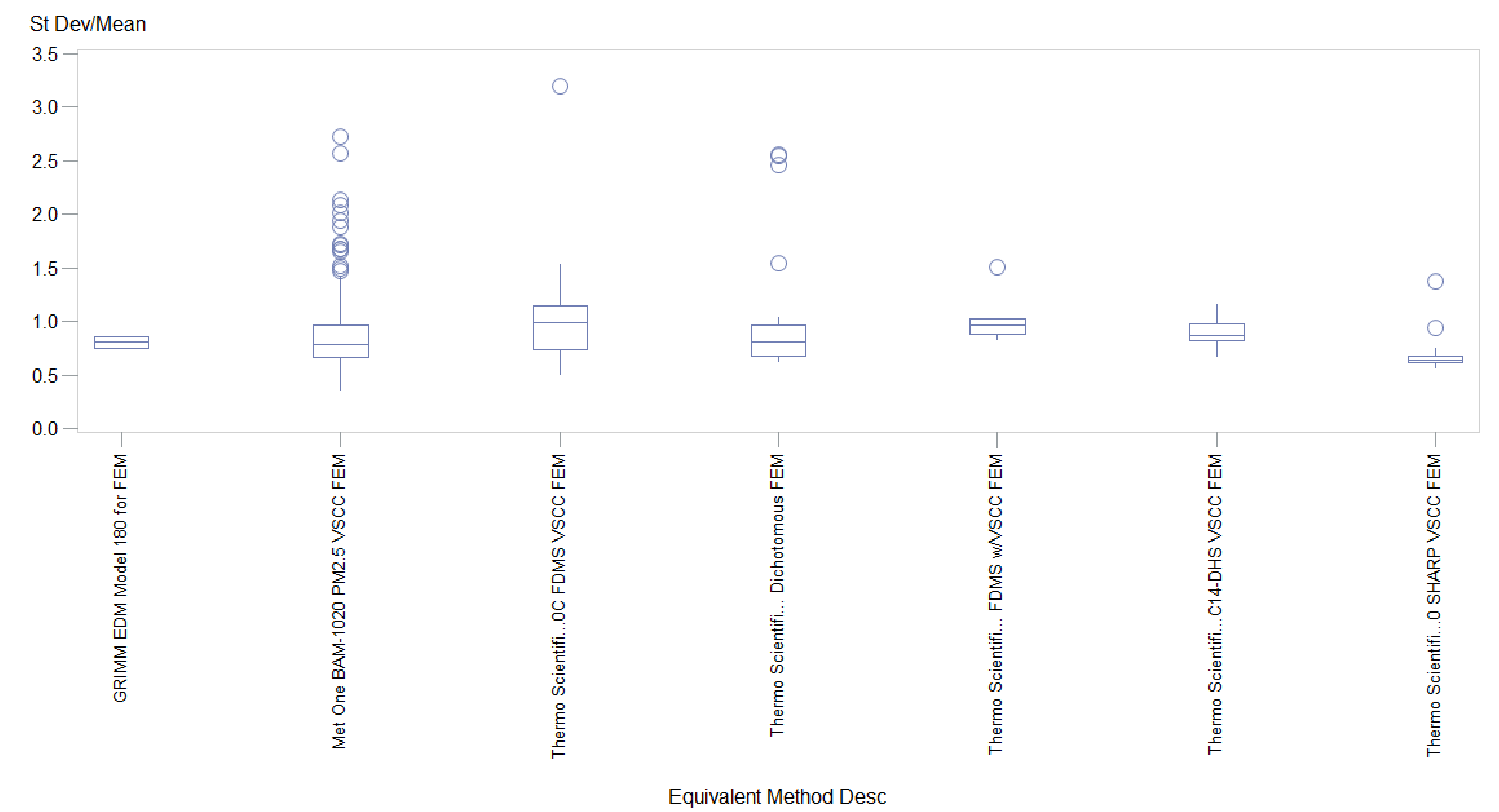


WINS vs VSCC on FRM

Quick Sensitivity test:

- Consider a continuous FEM that reads 10.0 µg/m^3
  - Using the average slopes and intercepts where the performance criteria was met, what would an FRM with a WINS and an FRM with a VSCC have read?
    - WINS on FRM; 10.0 = 1.04(FRM) + 1.11; FRM = 8.55
    - VSCC on FRM; 10.0 = 1.01(FRM) + 1.15; FRM = 8.76
    - Ratio = 1.02
- Therefore, an FRM with a VSCC will read ~2% closer to a continuous FEM than an FRM with a WINS

3. Standard Deviation/Mean of the hourly values for each FEM, grouped by Method



Assessing the Data - Summary

- Ensure you have good FRM data
- Use Assessments to evaluate the comparability of your data
- Methods can meet expected performance criteria, but much work remains
- Negative numbers matter and should be reported when valid (noise near zero)
- Sites that use a VSCC on the FRM tend to have slightly better comparability to the Met One BAM than sites with a WINS on the FRM