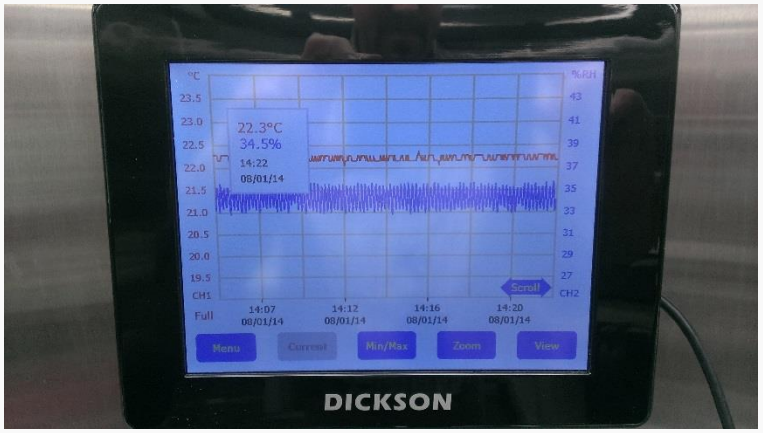
QA 101: PM QA Requirements



Intro/Overview

- *General Requirements*
  - *Quality System: QMP & QAPP*
  - *Equipment*
  - *Network design and Siting*
- *Operational Requirements*
  - *Field*
  - *Lab*
- *Data Management*

- QA Handbook Volume II, Appendix D is the "Rosetta Stone" for QA measurement requirements

http://www.epa.gov/ttn/amtic/files/ambient/pm25/qa/appd_validation_template_amtic.pdf

General Requirements

- FRM requirements in Part 50 Appendices):
    1. Appendix B ……. TSP (applies only to lead)
    2. Appendix J ……. PM-10 (note refers to Appendix L for low-volume measurements)
    3. Appendix L …… $PM_{2.5}$
- FEMs performance specifications and testing requirements are listed in Part 53
- Lab climate and filter conditioning requirements: Part 50

General Requirements cont.

- But there is more ! – The Part 58 appendices
  1. Appendix A (and B in the future) –more later
  2. Appendix C ARMs and Exceptions to Pb-TSP samplers
  3. Appendix D Network Design:
     a. Geospatial scale
     b. Siting criteria
     c. Monitoring objectives

Established by Monitoring Plan and QAPP

You mean these are part of the QA program?

Yes, a site will either

- *Meet established criteria*
- *Not meet established criteria, or*
- *Not meet established criteria, but has waiver*

General Requirements

The FRMs specify, and SOPs and QAPPs should reflect key maintenance procedures.

TSA Finding

After Cleaning

General Requirements cont.

- **And there is still more! --Part 58 appendices**

3. Appendix E: Monitoring Path Siting Criteria for Ambient Air Quality Monitoring
   - Horizontal and Vertical Placement.
   - Spacing from Minor Sources.
   - Spacing From Obstructions.
   - Spacing From Trees
   - Spacing From Roadways.

General Requirements cont.

Courtesy of Laura Niles, CARB

Courtesy of Richard Guillot, EPA Region 4

General Requirements cont.

Courtesy of Thien Bui, EPA Region 8

Courtesy of Florida DEP

The Meat and Potatoes of PM QA

Reference: Appendix A Section 3.2 - 3.3

- ***Field QA***
  1. ***Flow Verifications and Audits***
  2. ***NIST-traceable Parametric measurement devices***
- ***Lab QA***
  1. ***Climate and Static controls***
  2. ***Balance checks, blanks and Audits***
- ***Overall QA***
  1. ***Precision***
  2. ***Bias***

PM Flow Rate Verifications and Audits

You might ask "why are these important?"

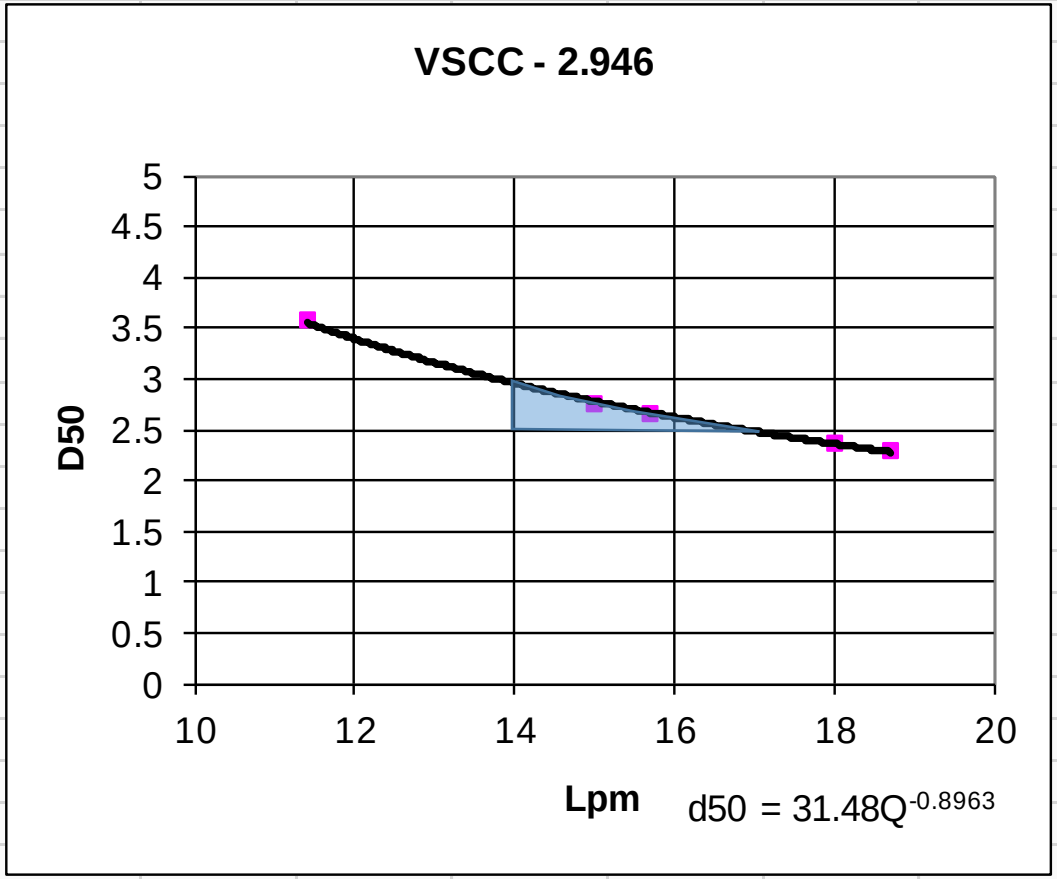
- **Designed to indicate sources of bias or relatively inaccuracy—**
  - ❑ ***The cut point of the PM separators (size of the particles collected) are dependent on the flow rate***
  - ❑ ***The final concentration value is directly influenced by the flow rate, i.e., 24-hour sample volume***

PM Flow Rate Verifications and Audits

Effect of flow on cut point of particle size

Lpm	D50
2	19.768
4	10.057
6	6.773
8	5.116
10	4.116
12	3.446
14	2.965
16	2.603
18	2.32
20	2.094

D50= 2.50
Lpm= 16.67



Kenny Data	
18	2.36
15	2.758
11.4	3.57
15.7	2.66
18.7	2.295

Work Area	
Q	D50
45	1.04

Courtesy of MESA Labs. (BGI Inc)

PM Flow Rate Verifications and Audits

Effect of flow on cut point of particle size

- At 14 Lpm the sampler will collect everything that is PM_3 or smaller
- A difference in *real flow rate* from 16.7 to 14 Lpm will permit particles to be collected that are 1.7 X larger than $PM_{2.5}$ ---remember volume ~ r^3!
- The effect on the Mass that is collected and therefore the apparent concentration will depend on the overall concentration of $PM_{3\text{-}2.5}$ relative to $PM_{2.5}$ and the density of that $PM_{3\text{-}2.5}$ fraction--maybe a little; maybe a lot!

Let's see how dramatic it can be!

PM Flow Rate Verifications and Audits

Effect of Flow on Concentration Value-a hypothetical case

$$C_{ind} = \frac{221.8\ \mu g/filter \times 1\ filter/event \times 1000\ liters/m^3}{16.7\ liters/min \times 60\ min/hr \times 24\ hr/event} = 9.2\ \mu g/m^3$$

$$C_{act} = \frac{221.8\ \mu g/filter \times 1\ filter/event \times 1000\ liters/m^3}{14.0\ liters/min \times 60\ min/hr \times 24\ hr/event} = 11.1\ \mu g/m^3$$

But what you probably don't know is that the concentration of $PM_{3-2.5}$ is 4 µg/m³. So by having a real flow rate that is lower than what the sampler told you, your derived concentration was over 50% higher than the real $PM_{2.5}$ Concentration of 7 µg/m³!

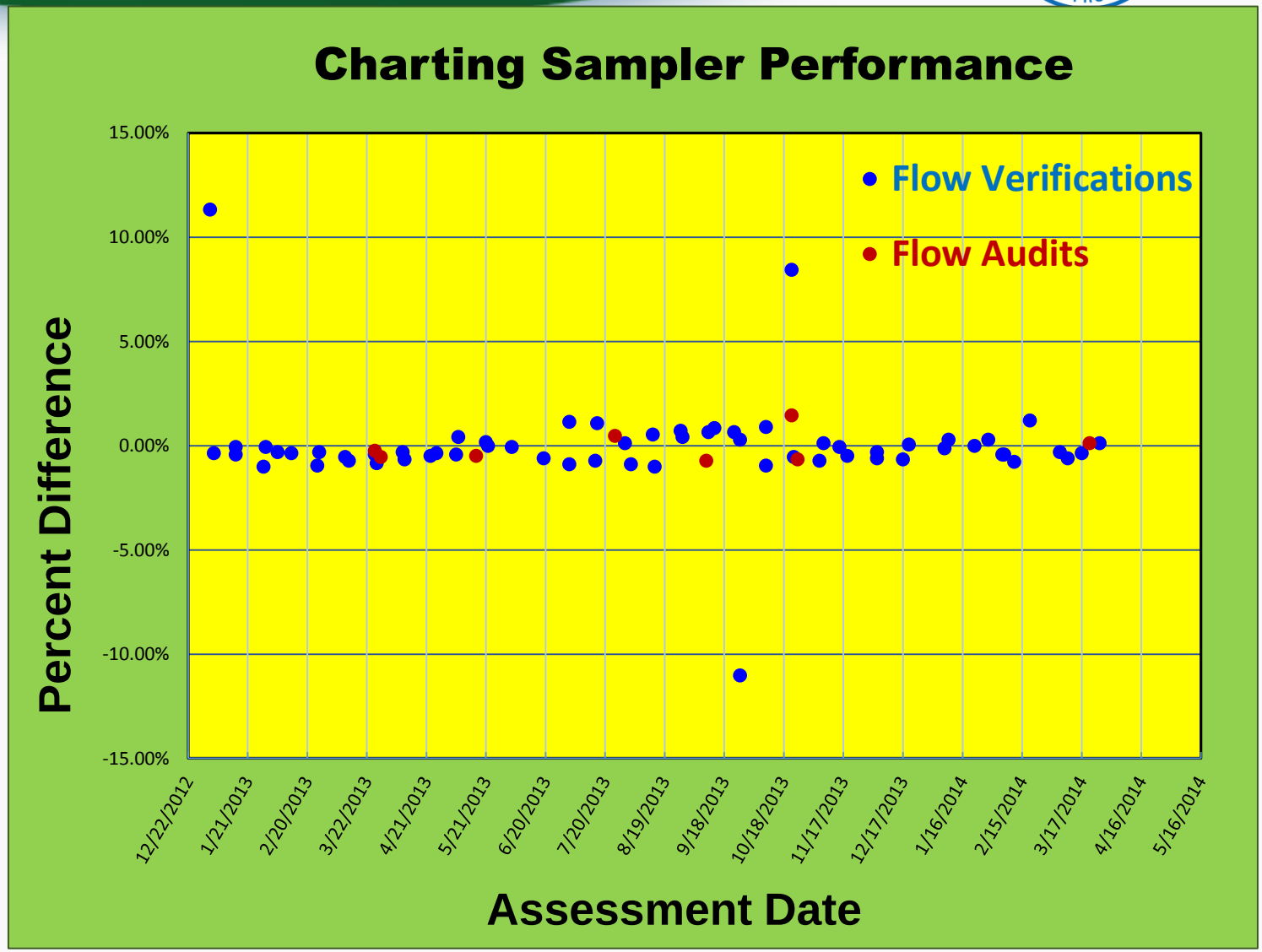
PM Flow Rate Verifications and Audits

So,

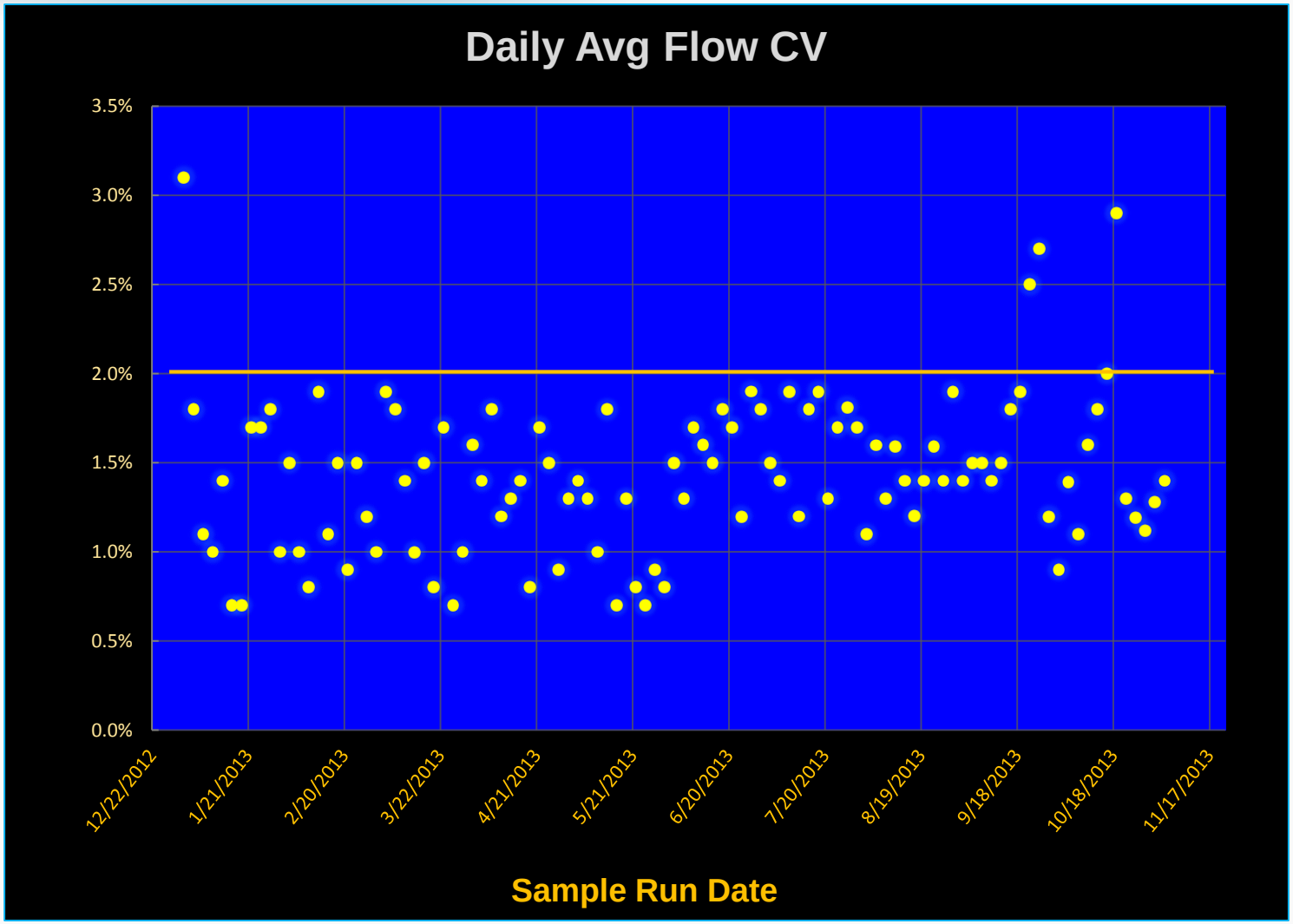
- Do your Verifications
  - Monthly basis
  - Look at Avg Flow CV for each event
- Do your Audits
  - By Independent auditors ***or*** at least with independent, NIST-traceable standards
- Report results to AQS for data certification and AMP 256 Report
- Graph your results for identification of trends

A tribute to George Froelich

PM Flow Rate Verifications and Audits



PM Flow Rate Verifications and Audits



NIST-Traceable Reference Standards

"Traceable" is defined in 40 CFR Parts 50 and 58 as meaning that a local or working standard has been compared and certified, either directly to, or to an intermediate standard that is no lower than one level from, a primary standard such as a National Institute of Standards and Technology Standard Reference Material (NIST SRM) or a USEPA/NIST-approved Certified Reference Material (CRM)”

NIST-Traceable Reference Standards

Frequencies

- ***Verification, calibration and audit ("working") standards should be certified "at least annually"***
- ***Traceable to a NIST "Primary Standard"***
- ***40 CFR Part 50, Appendix L Sec 9.1 & 9.2***

What if I cannot send my 6 working standards to an independent Metrology Lab?

NIST-Traceable Reference Standards

At a minimum, the "certification procedure" for a working standard should:

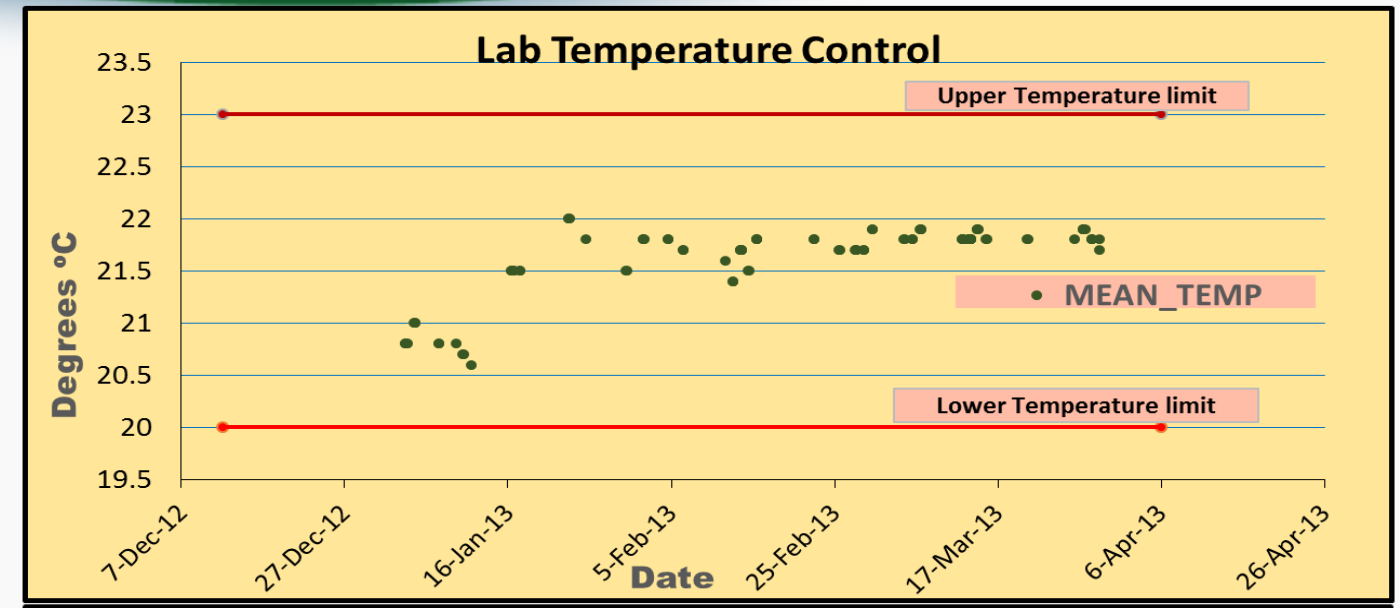
- Establish the parametric range of the working standard relative to the primary (Stationary Bench) standard;
- Certify that the primary standard (and hence the working standard) is traceable to a NIST primary standard;
- Include a test of the stability of the working standard over several days; and
- Specify a recertification interval for the working standard

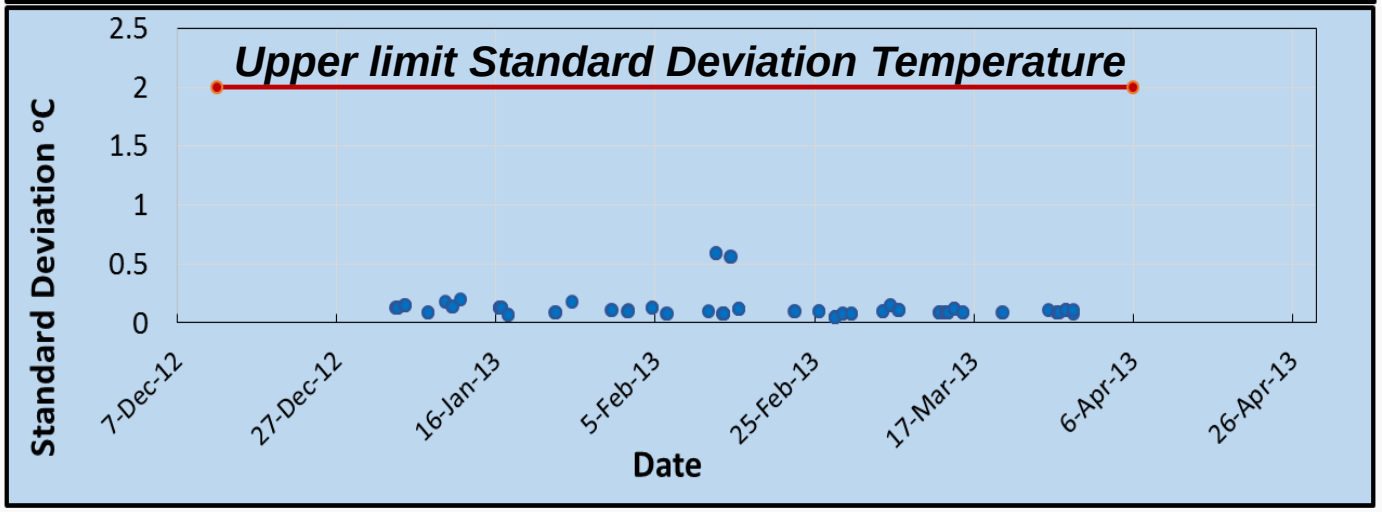
What's Happening… in the LAB?

Four Areas of Control

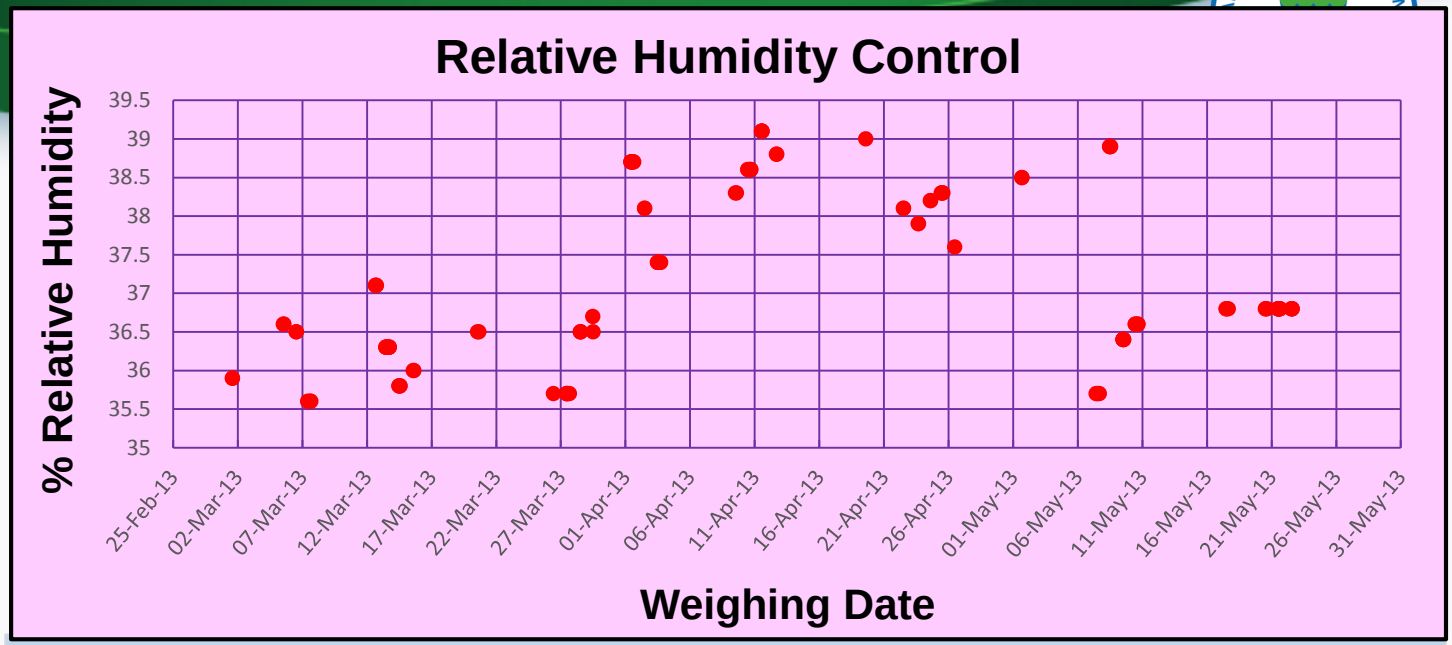
- Lab Environment
- Analytical Equipment
- Analytical and QA/QC procedures
- Data Management

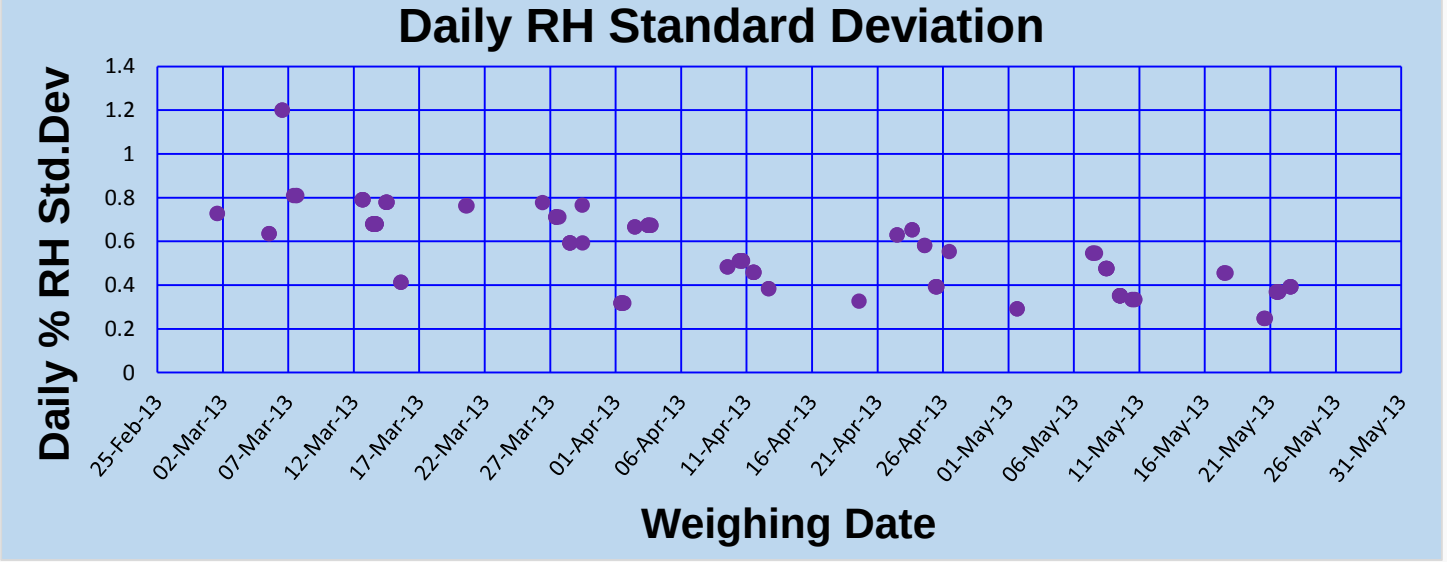
Lab: Environment Control



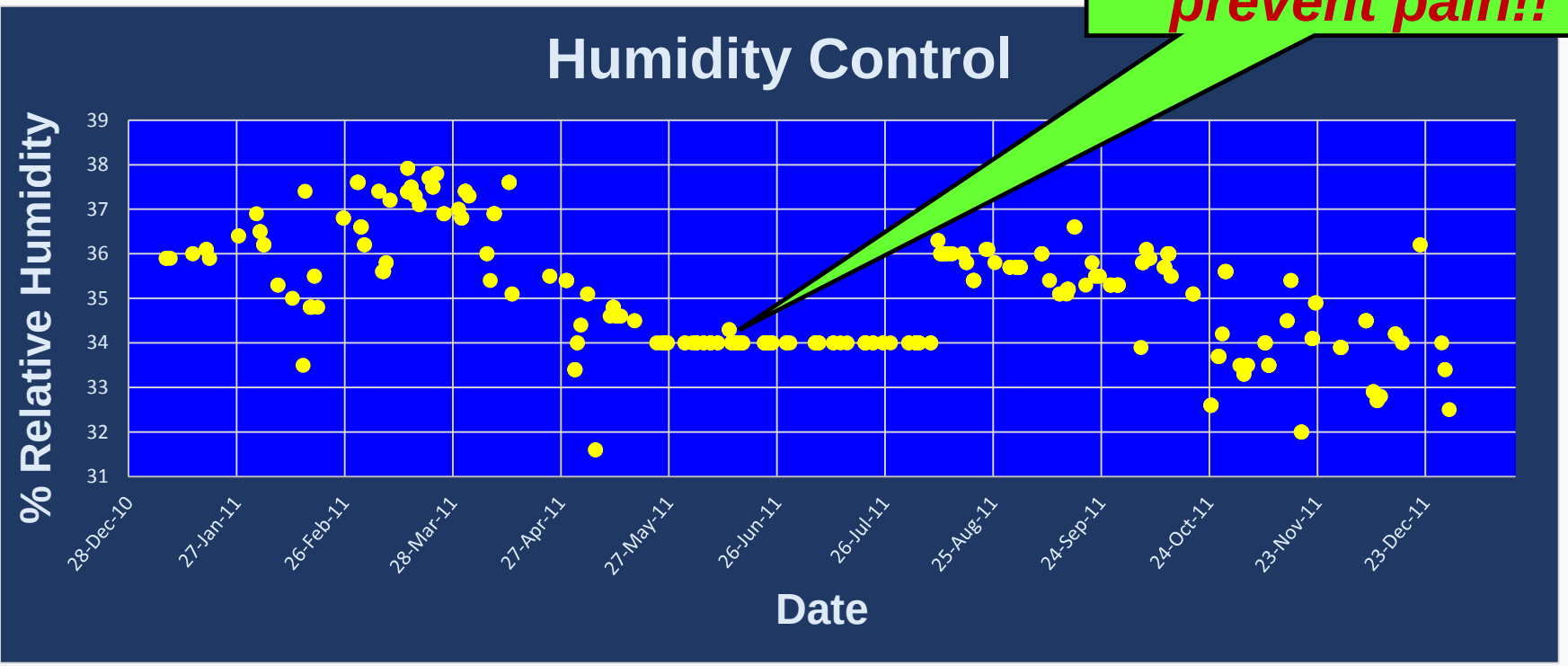


Lab: Environmental Control





Lab: Environmental Control



Redundant monitoring devices can prevent pain!!

Lab: Analytical Equipment-- Static Control

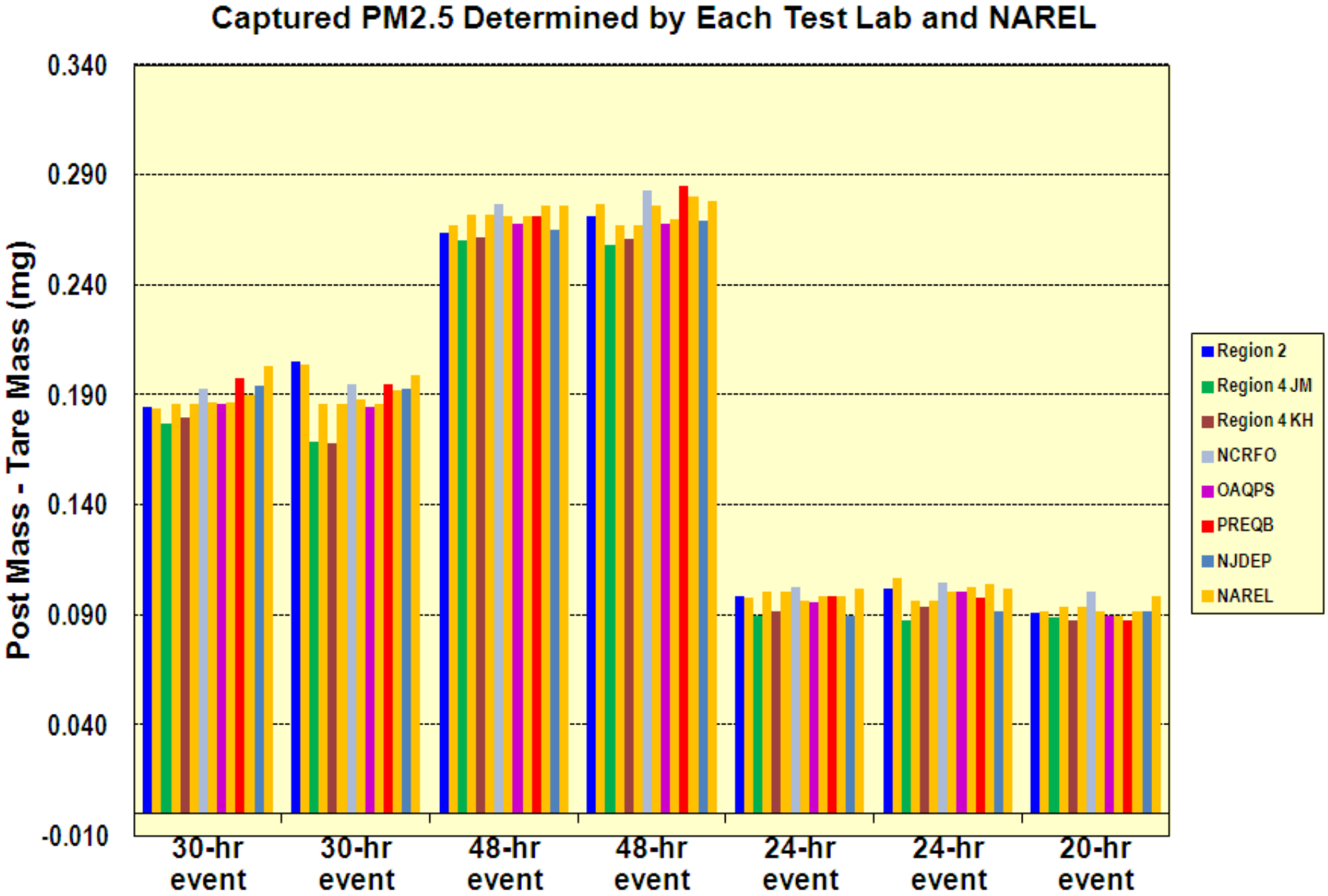
- Grounded Equipment
- Fresh Polonium 210 (more efficient)
  - Center filters between strips positioned 2 inches apart
  - Give it time! Waving a filter between 2 strips for a half a second probably will not be adequate
- Additional equipment such as U-bars and faraday cages also improve the dissipation of electrons
- Test your procedure by charging, weighing and then reweighing filters. (hint: slide them in a petri across a counter top)
- Consult with the filter and balance venders.

LAB: Analytical Equipment

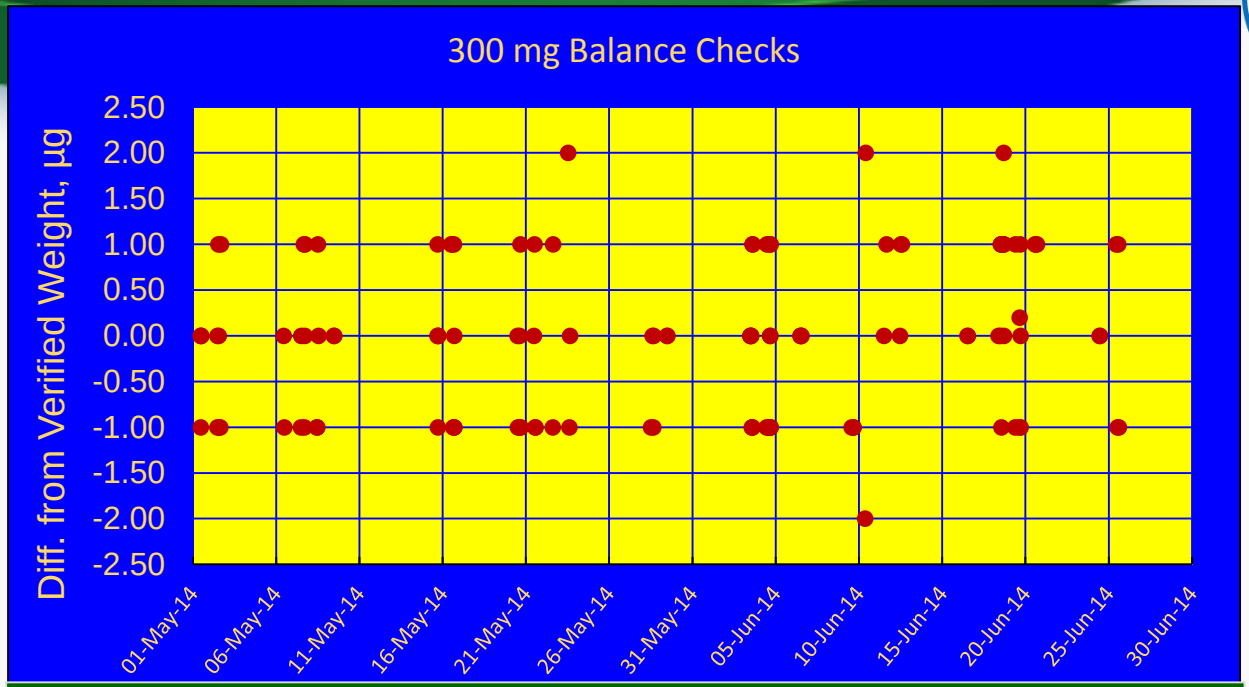
- Gravimetric balance: Vender maintenance and calibration—1/year
- ASTM Calibration Weights: NIST Certification—1/year
- ASTM Check Weights compare against Calibration weights—1/quarter
- Remember to Bracket the combined mass of the filter and expected PM filtrate 1-500 mg and 1-300 mg

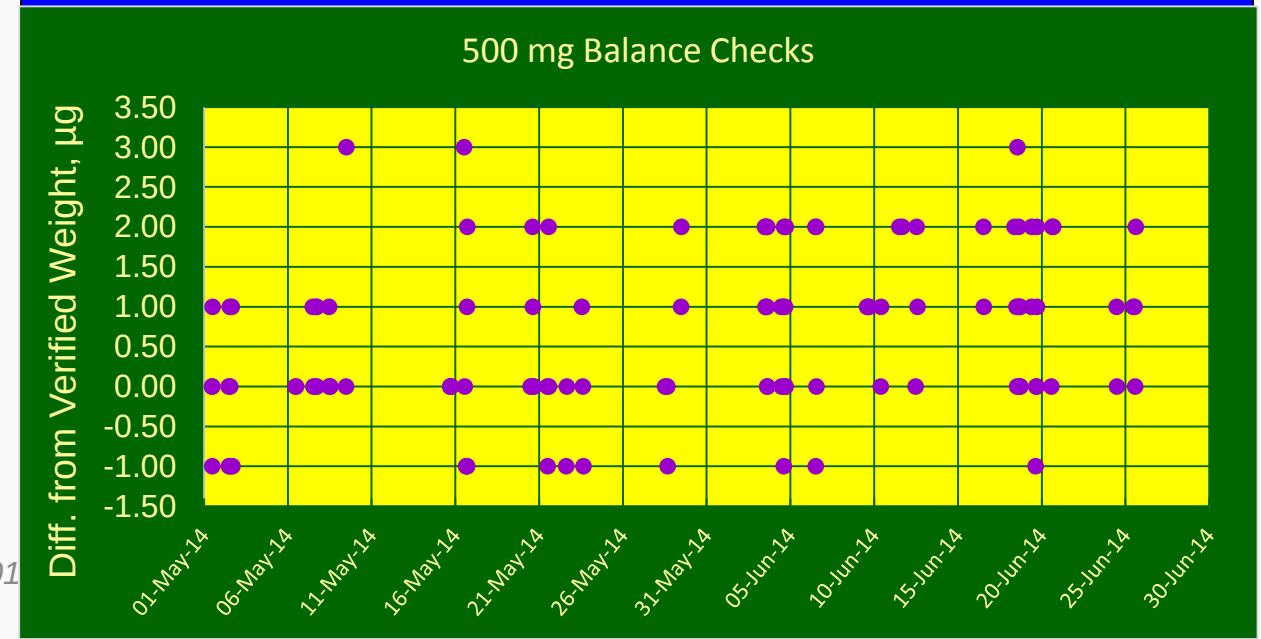
LAB: Analytical QA/QC Procedures

- Internal and independent performance testing
  - Technician accuracy and precision
  - Bias between/among several Technicians
- ASTM/NIST-traceable Check and calibration weights
  - Monitor the condition and performance of the balance
- Lab Blanks and Trip blanks, Batch and Inter-batch duplicates
  - Indicate what is going on in the lab environment and the filter handling process
- Field Blanks
  - Indicate level of contamination in lab and the field

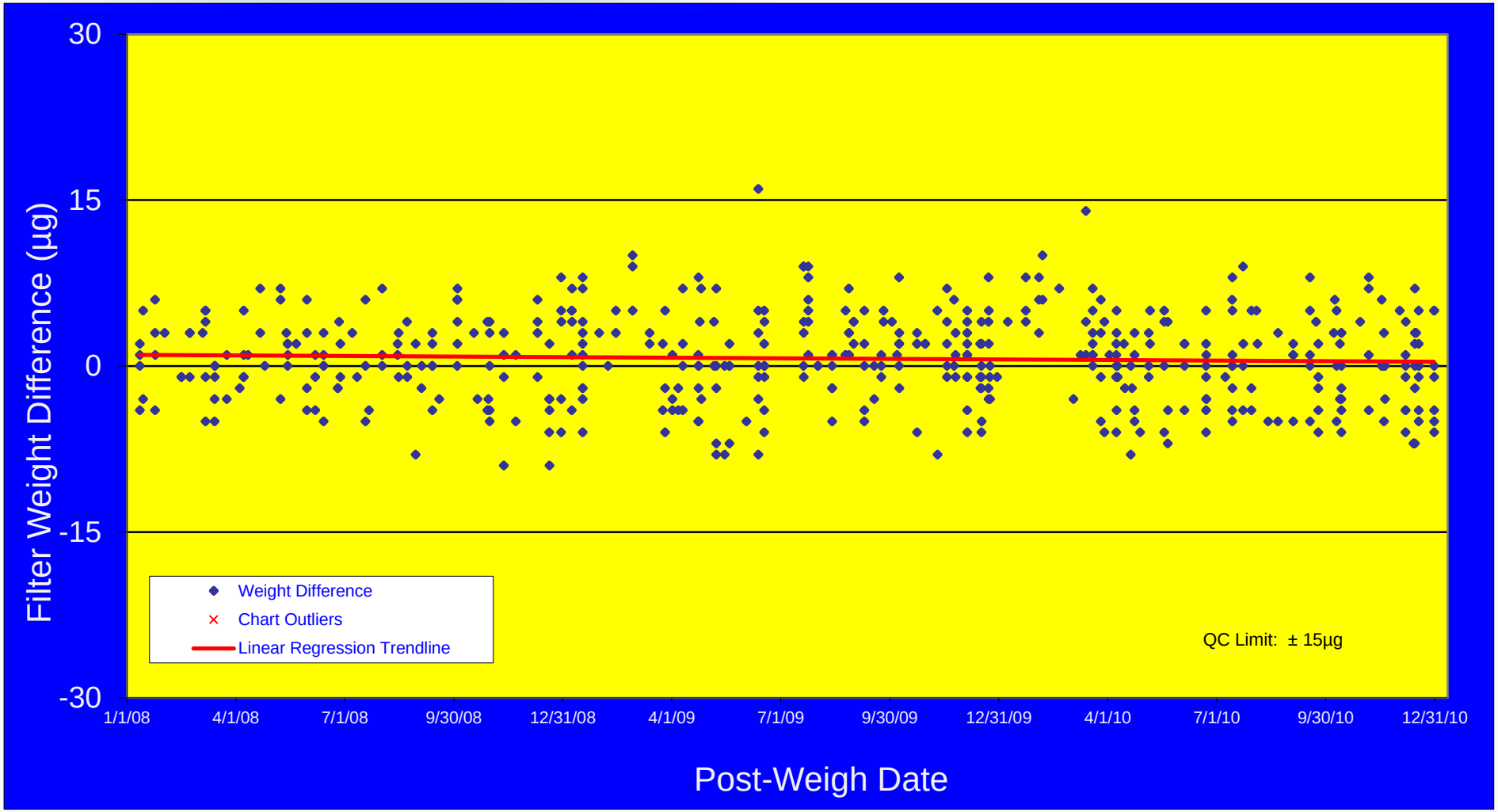

Captured PM2.5 Determined by Each Test Lab and NAREL
Post Mass - Tare Mass (mg)
0.340
0.290
0.240
0.190
0.140
0.090
0.040
-0.010
30-hr event
30-hr event
48-hr event
48-hr event
24-hr event
24-hr event
20-hr event
Region 2
Region 4 JM
Region 4 KH
NCRFO
OAQPS
PREQB
NJDEP
NAREL

Lab: QC Balance Checks

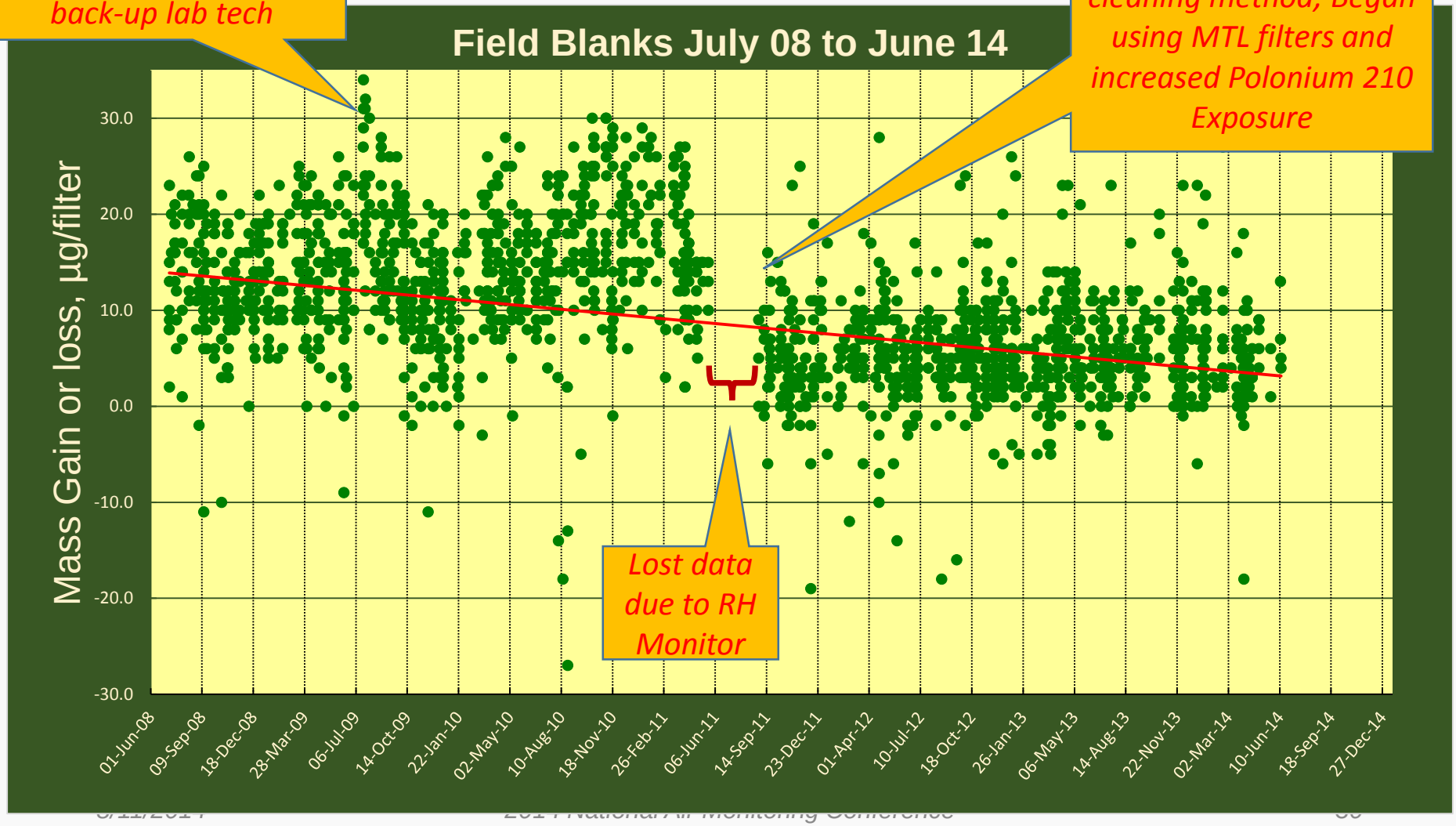




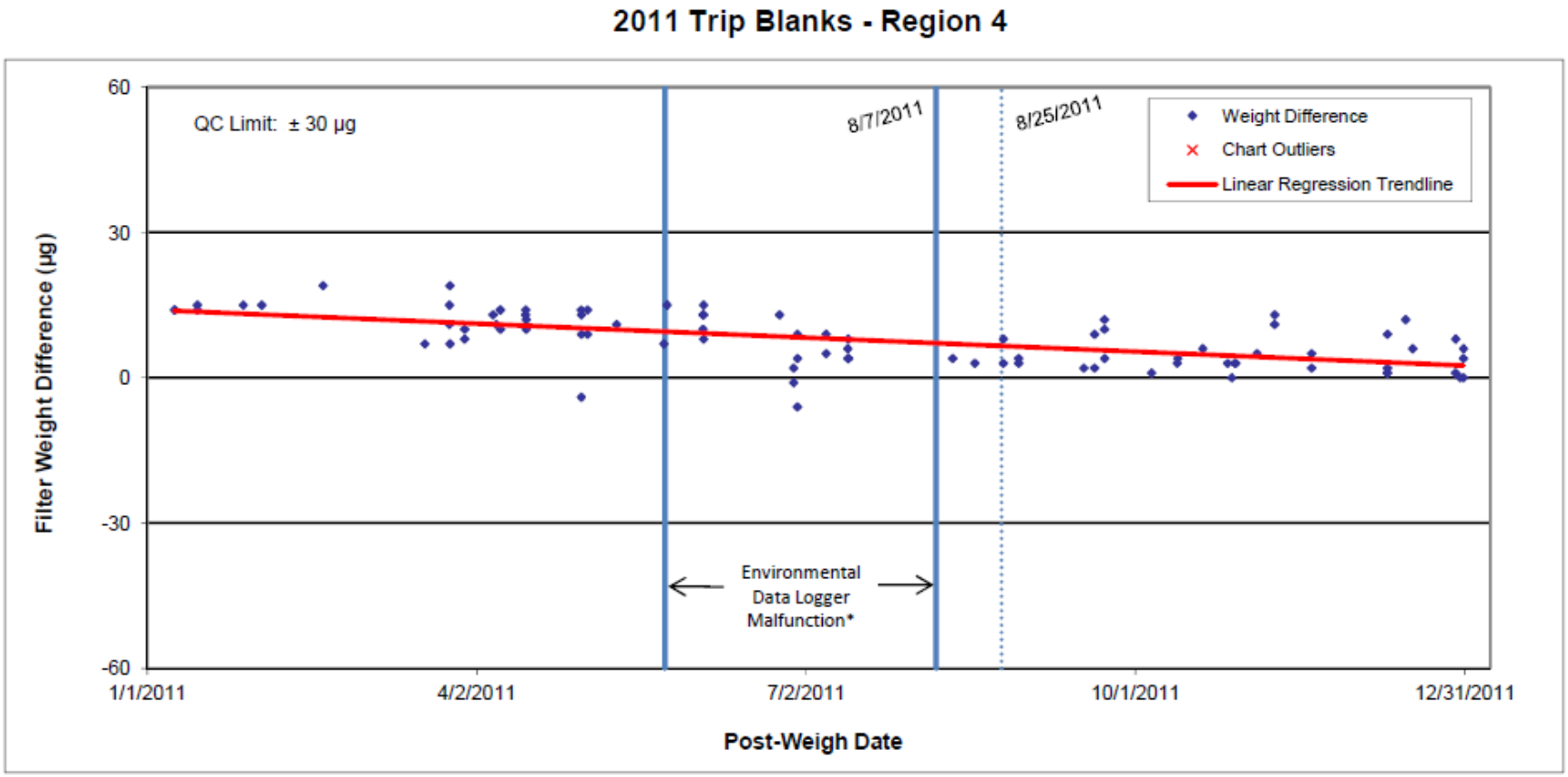
Lab: QC Practices
Lab Blanks



Lab: QC Practices
Field Blanks



Lab: QC Practices
Trip Blanks



Lab: Data Management

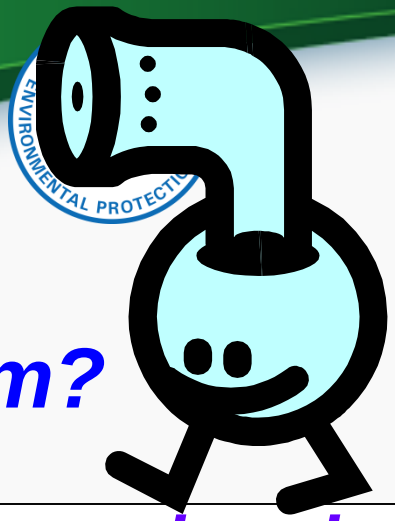
"Did you get the Drift?"

So How is Your Network Performing?

Data Quality Objectives

- ***40 CFR Part 58 Appendix A***
  - ➢ 2.3.1.1 Measurement Uncertainty for Automated and Manual $PM_{2.5}$ Methods.
    - ✓ 10 % CV for total precision, and
    - ✓ ±10 % difference for total bias.
  - ➢ ***Aggregated over 3 years at the PQAO level!***

So How is Your Network Performing?



Where does the data come from?

- ***Precision derived from Agency owned and operated collocated samplers***
  - ***Appendix A, Section 3.2.5***
- ***Bias provided by "independent" FRM samplers collocated with Primary samplers***
  - ***Appendix A, Section 3.2.7 Performance Evaluation Program***

What is a collocated sampler?

- Any sampler placed beside a primary sampler for measurement or collection of data that can be related to the primary sampler
- Picture shows precision and PEP (Bias)

Section 3.2.5 $PM_{2.5}$ and $PM_{10-2.5}$ Collocation Requirements

❖Why do we want to collocate samplers?

- *There is no single physical "reference" standard, material or measuring device for (most aggregated forms of) PM.*
- *Therefore the only way to gain some level of confidence in a measurement is to*
  a. *Insure the sampler or monitor is performing within design specifications and*
  b. *Independently check on its ability to reproduce the results that it achieves*
  c. *Establish that other instruments designed to measure the same values achieve the same or at least consistently-different results*

About Collocated Samplers?

What is the primary sampler?

Sampler that produces ambient concentration data for determining compliance with NAAQS or other regulatory requirements

1. Make sure your primary sampler is designated correctly in AQS.

2. Know your order of data extraction for the purposes of precision and bias calculations

A couple more things to remember About Collocations!

1. *In the FRM World a collocation sampler used for precision must be of identical design and operation (e.g., WINS to WINS; VSCC to VSCC)*
2. *With respect to deployment of the new FEMS, a collocation sampler will not be identical to the primary sampler. However it can provide a relative bias and a precision value if a sufficient number of collocated values are provided over an extended period of time.*
   a. *The average of the difference measurements provide the bias and*
   b. *The relative change in difference from one pair of measurements to the next provides the precision.*

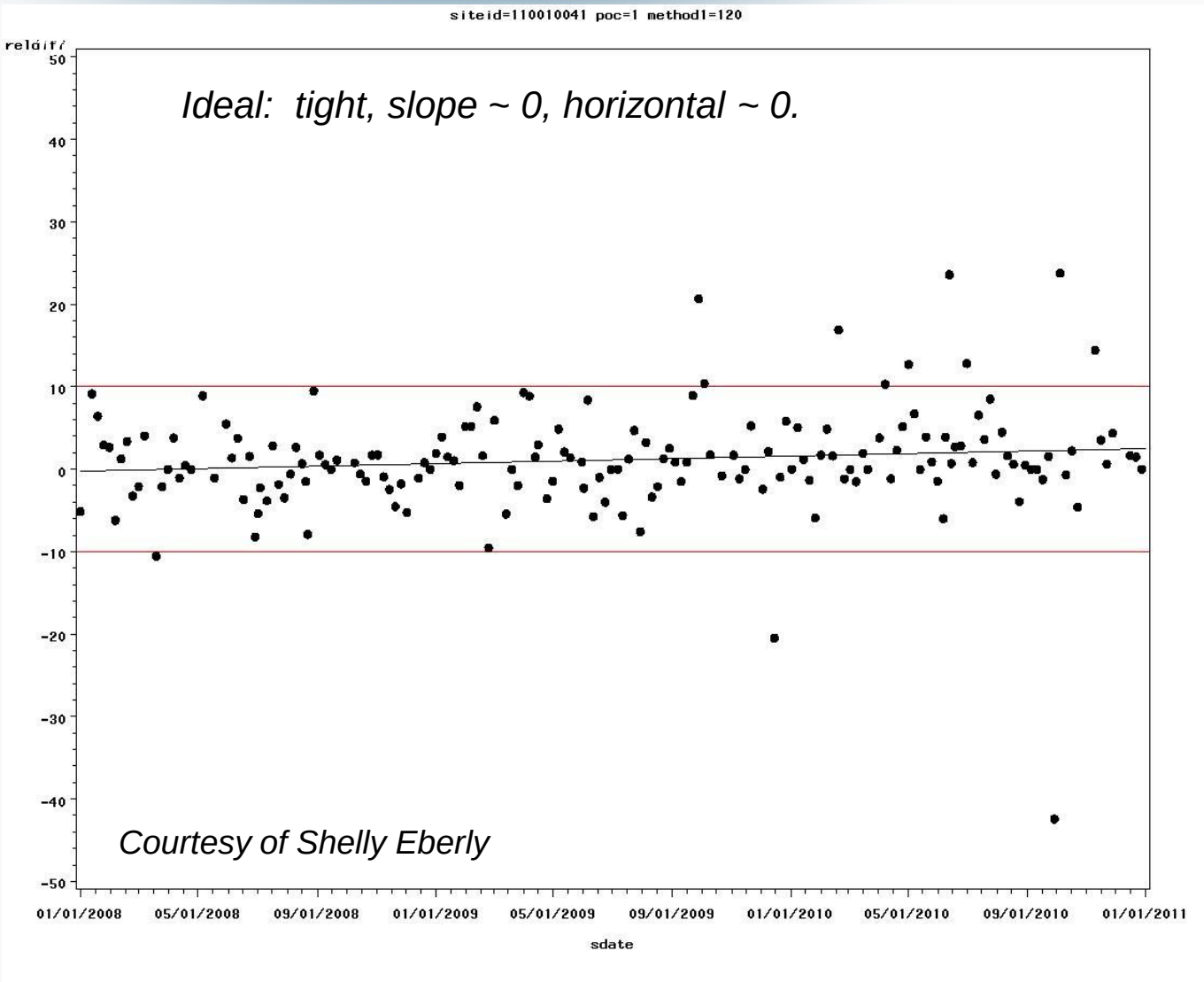
A few things regarding SLT Precision VS PEP Bias data

1. *The monitoring agency (PQAO) has more control over how much precision data they generate and how fast the data becomes available.*
   - ❑ *At least 30 data points per year*
   - ❑ *Use their own site operators, gravimetric lab, or a contract gravimetric lab*
   - ❑ *Validation in-house*
2. *Less PEP Bias data is generated per PQAO and in general takes at least 60 days from the sampling event to posting in AQS*
   - ❑ *Usually not more than 9 data points per year*
   - ❑ *Always independent operators and gravimetric lab*

Analyses you can get from your collocations

- Primary vs collocated scatter plot showing outliers
- Calculate and plot CV via the DASC tool
  - Overall CV
  - FRM-FRM
  - FEM-FRM
  - FEM-FEM, if you have FEM-FEM collocations
- Plot of % difference FEM(s) vs FRM (the $PM_{2.5}$ Bias equation gives an in-house bias
  - Plot of Daily Bias over time using 1 point QC check equation provides precision

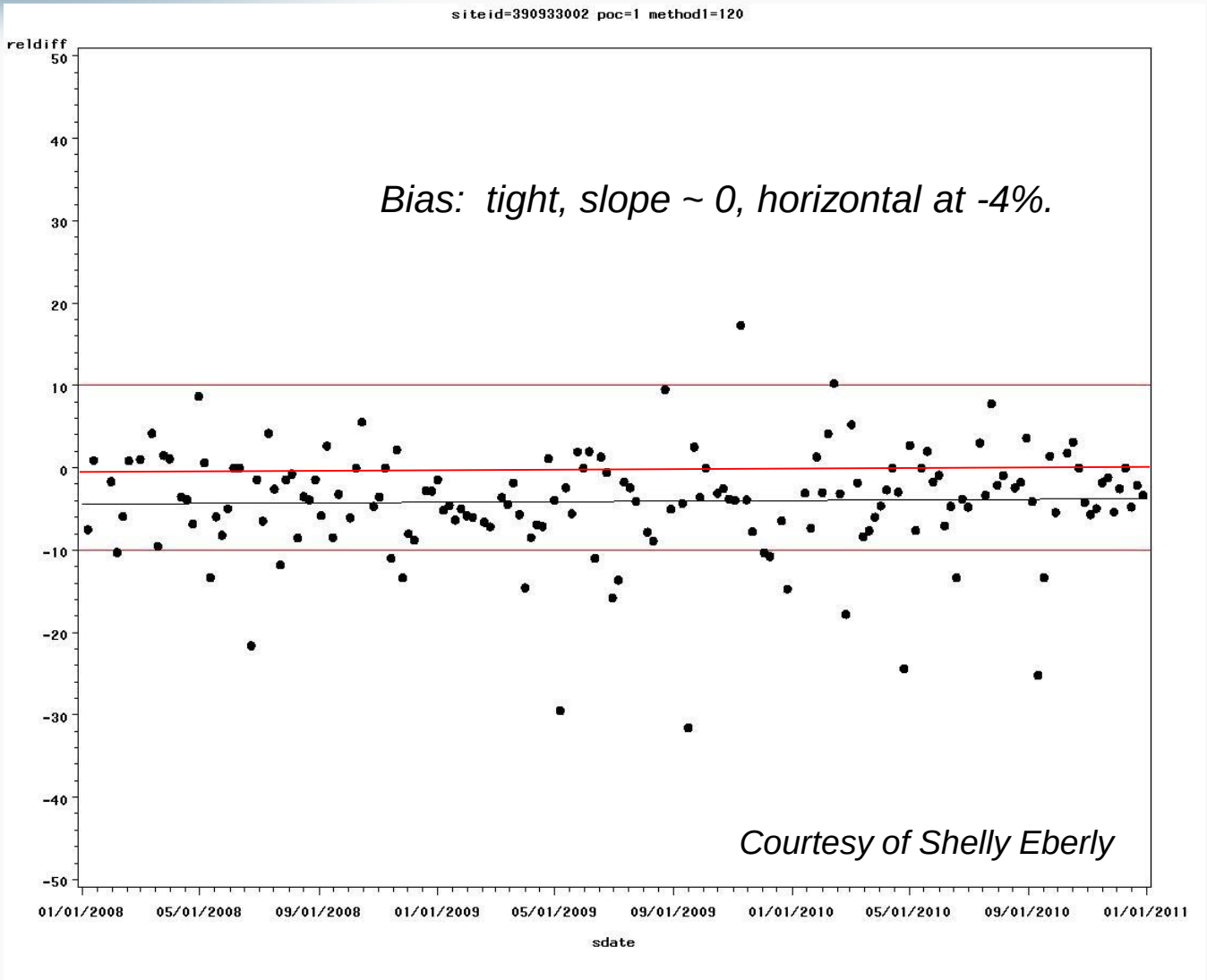
Can Precision Data Give Insights into Bias?



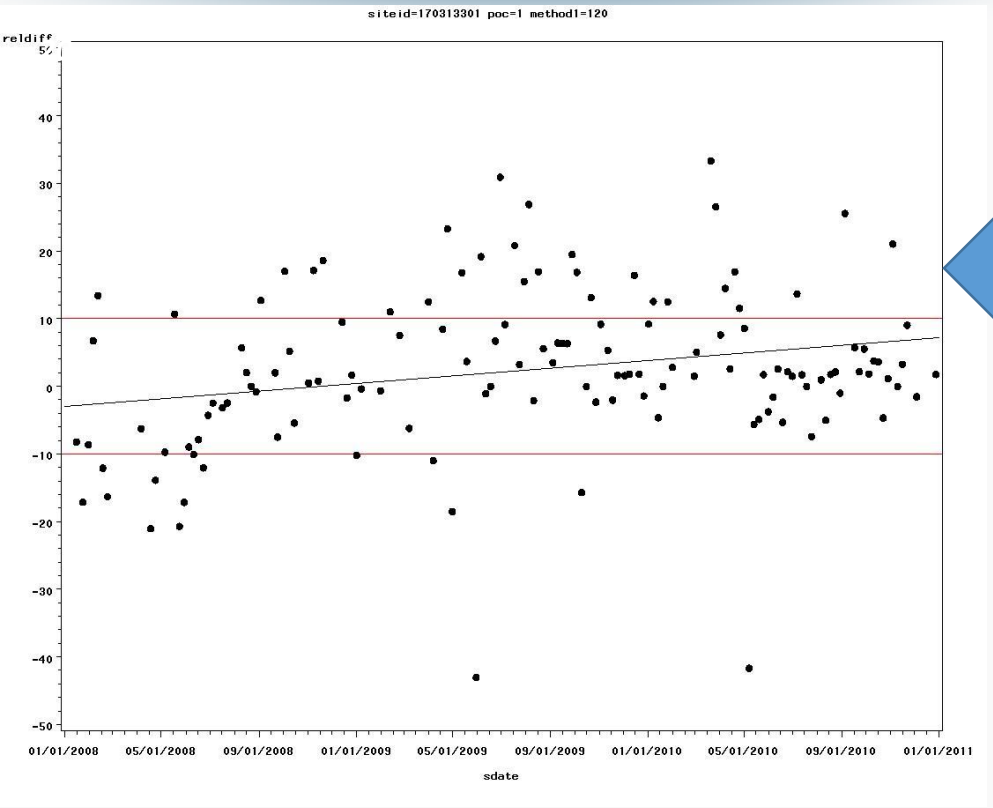
- Using 2008-2010 precision data,
  - consistent differences suggest bias in one or both samplers.
  - trends in differences suggest trends in bias in one or both samplers.

Can Precision Data Give Insights into Bias?

- Using 2008-2010 precision data,
  - consistent differences suggest bias in one or both samplers.
  - trends in differences suggest trends in bias in one or both samplers.

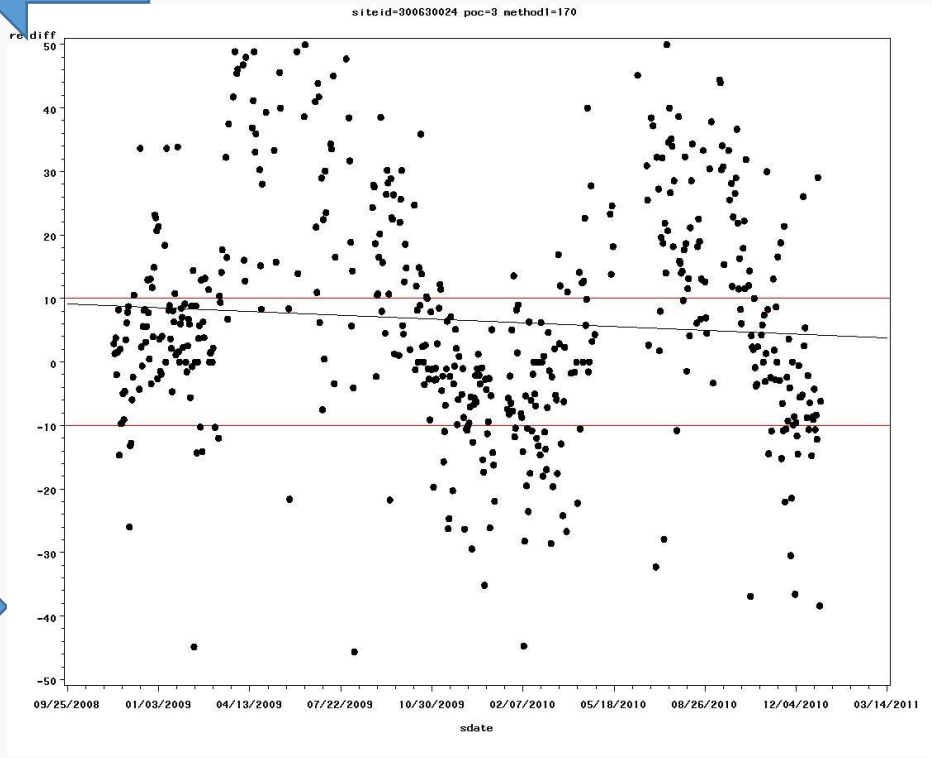


What do these indicate????



Noisy precision with possible upward trend in bias.

Noisy precision with oscillations. Larger positive relative differences in summer, larger negative relative differences in winter (Method 170).



Courtesy of Shelly Eberly

Section 3.2.5-3.2.6: $PM_{2.5}$ and $PM_{10-2.5}$ Collocation Requirements

- **What are the requirements and Process for Collocation**
  - 15 % of the PQAO network monitors must be collocated (values of 0.5 and greater round up);
  - At least 1 collocated monitor (if the number of network monitors is less than 3).
  - The first collocated monitor must be a designated FRM monitor
  - In the case of PM10-2.5, Have at least 2 collocated monitors (if the total number of primary monitors is less than 10).
    - The second must be a monitor of the same method designation.
    - Both collocated FRM and FEM monitors can be located at the same site—based on each one's purpose.

Section 3.2.5 QA Requirements for $PM_{2.5}$ Collocation Precision

- OK, How is it done for FEMs
  1. The significant qualification is
     - The first collocation with an FEM that is proposed "primary sampler" must be with an FRM initially for a year prior to formal designation to verify that it is site/geo appropriate
     - A FEM that is a collocation monitor can only be placed with another FEM.

       FEMs are not collocation monitors for FRMS
  2. Collocate 50% of the FEMs used by the PQAO, with identical FEMS and the other 50% of the monitors designated for collocation shall be accompanied by a audit FRM.

Section 3.2.7: $PM_{2.5}$ FRM/FEM Performance Evaluation Program

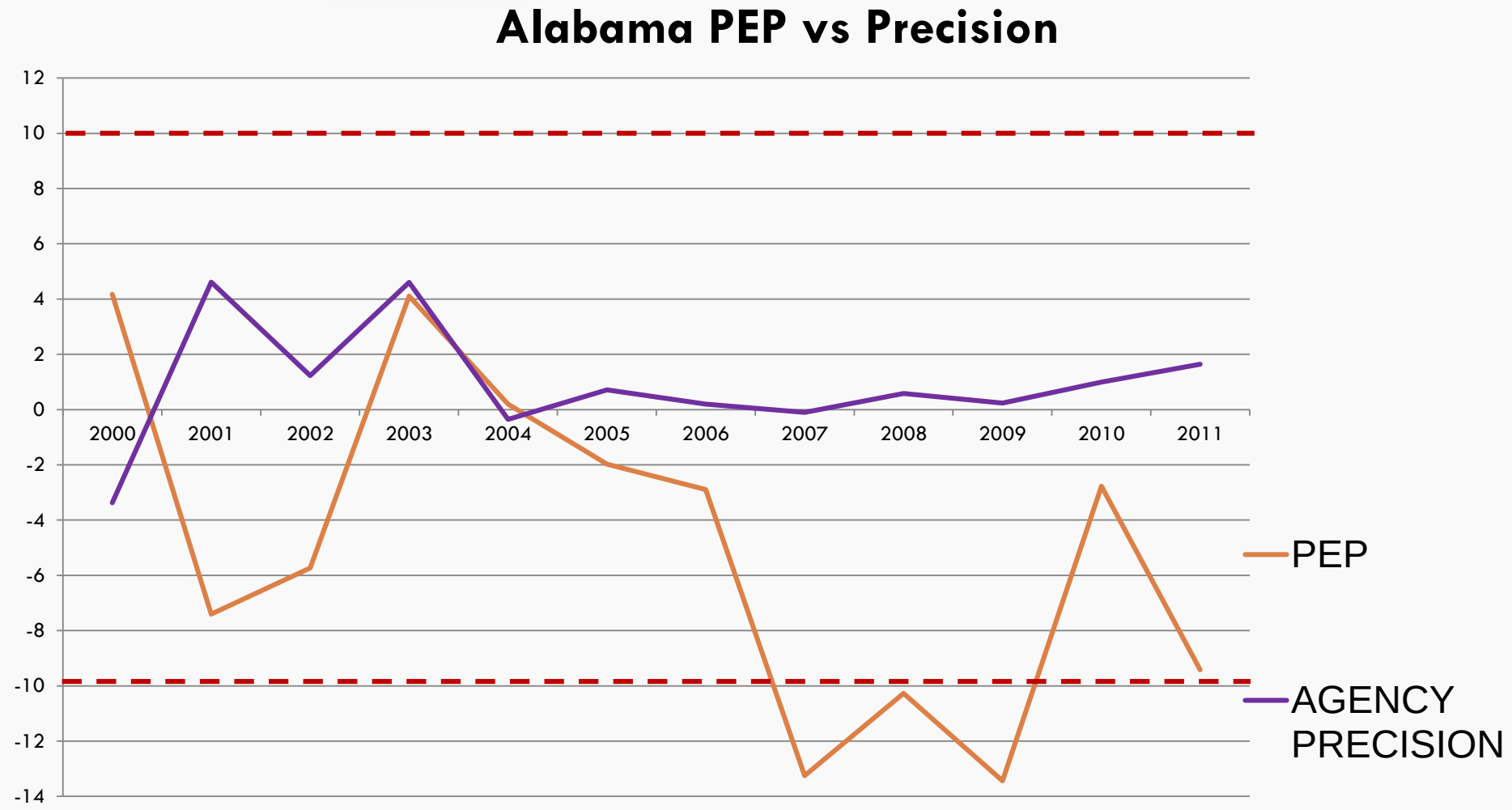
- **Collocates** an **independent** FRM audit sampler **beside a FRM/FEM**
- Applies **rigorous performance and QA/QC requirements** to field and laboratory operations
- Provides **independent assessment** of **network sampler bias**
- Might indicate if the monitoring agency's FRM is experiencing performance issues, BUT
  - 60 days after the fact!
  - It is only 1 data point for one isolated sampling event

$PM_{2.5}$ FRM/FEM Performance Evaluation Program

- **PEP Requirements for Each PQAO:**
  - **15% of all sites audited per year**; all sites in 6 years
  - If **5 sites or less ----- 5 audits per year**
  - If **>5 sites ----- 8 sites per year**
  - **At least one of each "monitor type" audited each year, including "regulatory" FEMs and SPMS**

$$Bias = \frac{SLTPrim - PEP}{PEP}$$

USES for PEP Bias data



Section 3.3.1 QA for PM_{10}

- **Collocated (precision) Requirements**
  - **15% of sites in PQAO**
  - **Hi-vols TSP cannot be Surrogate Primary samplers for PM_{10} HI-vol samplers**
  - **$PM_{10-2.5}$ Primary Samplers may Constitute a Primary PM_{10} Sampler provided same method designation**
  - **Low-vol Pb and PM_{10} samplers may serve as collocations for each other, in which case**
    - **Total Mass of Pb filter must be measured before chemical analysis for Pb**

What happens When the Ambient Concentration Gets Small

- **There are practical minimum limits on the DQOs for PM Methods**
  - **At certain Concentrations the Statistics do not provide data for Collocated Sampler or PEP measurements**
    - (1) TSP: 20 µg/m3.
    - (2) Pb: 0.15 µg/m3.
    - (3) PM10 (Hi-Vol): 15 µg/m3.
    - (4) PM10 (Lo-Vol): 3 µg/m3.
    - (5) PM10–2.5 and PM2.5: 3 µg/m3.