SANDWICH Material Balance Approach for $PM_{2.5}$ Data Analysis

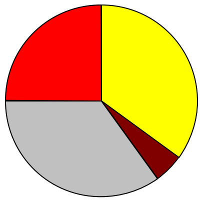
Neil Frank OAQPS/USEPA

For Presentation at

2006 National Air Monitoring Conference

Las Vegas, Nevada

November 6-9, 2006



Outline

- What is “SANDWICH”, why it is good way to describe PM2.5 composition

- How it can help with PM2.5 data QC

- Examples using STN data

Introduction

- What is the **SANDWICH** Approach?
  - **S**ulfate, **A**djusted **N**itrate, **D**erived **W**ater, **I**nferred **C**arbon **H**ybrid material balance approach
    - for estimating PM2.5 mass composition produced by the PM2.5 FRM.
  - The approach uses a combination of speciation measurements and modeled speciation estimates to represent FRM $PM_{2.5}$.

Introduction (cont.)

- Why is it needed?
  - The FRM defines the regulatory indicator of PM2.5.
  - FRM mass may not retain all nitrate, and includes particle bound water and other components not estimated directly with STN measurements.
  - To estimate FRM $PM_{2.5}$ composition including FRM carbonaceous mass without "fudge" factors.
  - To help QC speciation measurements

- SANDWICH is the default method in EPA modeling guidance to define baseline $PM_{2.5}$
  - for SMAT (speciation modeled attainment test)

Old Practice: Use STN measurements to directly characterize PM2.5

FRM and STN measurements						
PM2.5 mass	SO_4^{2-}	NH_4^+	NO_3^-	{Al SI Ca Fe Ti}	OC	EC

These represent a subset of STN speciation measurements

Old Practice: Use STN measurements to directly characterize PM2.5

FRM and STN measurements

PM2.5 mass $SO4^{2-}$ $NH4^{+}$ $NO3^{-}$ {Al SI Ca Fe Ti} OC EC

Sulfate Ammonium Nitrate

Aluminum Silicon Calcium Iron Titanium

Organic and Elemental Carbon

Old Practice: Use STN measurements to directly characterize PM2.5

FRM and STN measurements

PM2.5 mass | SO4 | NH4 | NO3 | {Al SI Ca Fe Ti} | OC | EC

(Teflon filter)
FRM sampler

(Nylon following denuder) (Teflon) (Quartz)
Various Speciation Samplers*

FRM and speciation samplers have different flow rates, face velocity and monitoring protocols.

---

* Various STN speciation samplers,with different design and flow rates compared to FRM:
MetOne (SASS), Anderson (RASS), URG (MASS), R&P

Old Practice: Use STN measurements to directly characterize PM2.5

with limited consideration of the different monitoring protocols

FRM and STN measurements

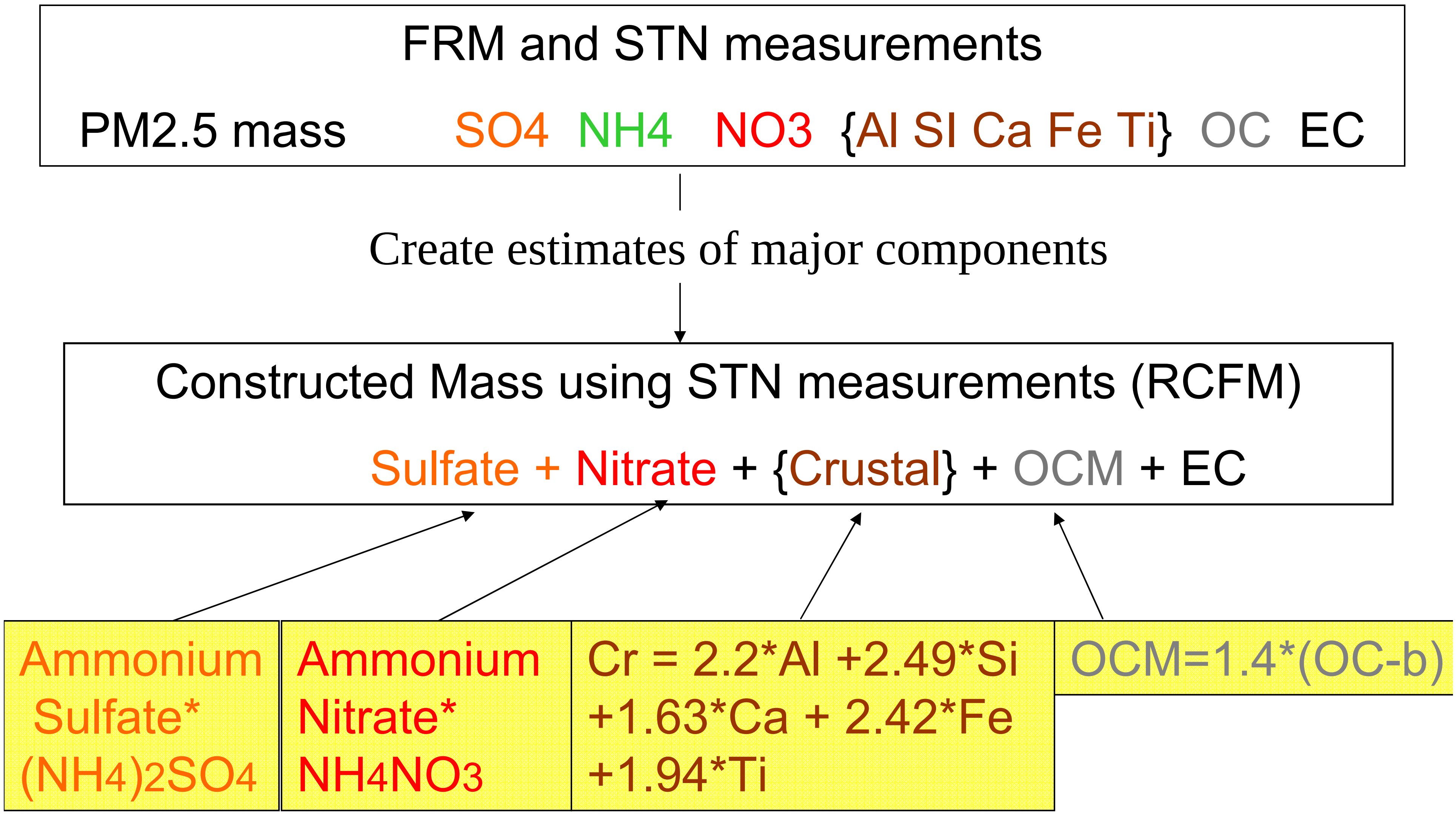
PM2.5 mass SO4 NH4 NO3 {Al SI Ca Fe Ti} OC EC

Create estimates of major components

Constructed Mass using STN measurements

Sulfate Nitrate {Crustal} OCM EC

Old Practice: Use STN measurements to directly characterize PM2.5



Typical formulas to estimate major components

Old Practice: Use STN measurements to directly characterize PM2.5

FRM and STN measurements

PM2.5 mass SO_4 NH_4 NO_3 {Al SI Ca Fe Ti} OC EC

Create estimates of major components

Constructed Mass using STN measurements

Sulfate + Nitrate + {Crustal} + OCM + EC

Ammonium Sulfate* $(NH_4)_2SO_4$

Ammonium Nitrate* NH_4NO_3

$Cr = 2.2*Al + 2.49*Si + 1.63*Ca + 2.42*Fe + 1.94*Ti$

OCM=**1.4***(OC-**b**)

to account for O, H, N in C compounds

From STN field blanks. Imperfect method

Carbonaceous Mass from measured C data is a very uncertain calculation

k*(OC-b)+EC, e.g. k=1.4 or 1.8

Many Sources of error

- Analytical uncertainty
- Blank correction (avg value ~1-1.5ug/m3 OC, STN sites)
  - Varies among our 5 different EPA urban speciation samplers
  - We can't do site or seasonal adjustments
  - NOTE: this is a minor issue with IMPROVE data

STN sampler	24-hr sample Volume(m^3)	Network Average Total Carbon on STN Blank Filters*	
		ug C/ filter	ug C/m^3
MetOne (SASS)	9.6	14.8	1.5
Anderson (RAAS)	10.4	13.5	1.3
R&P 2300	14.4	16.1	1.1
URG (MASS)	24	7.7	0.3

5th speciation sampler is the $PM_{2.5}$ FRM

Uncertainty of k*(OC-b), continued

- Conversion of OC to OCM ($\pm$ 33%), varies with aerosol type and mix
  - 1.4 < k < 1.8 ("typical" urban)
  - 2.0 < k < 2.4 ("typical" rural)
    - Weighted average for mixed urban/regional aerosol
  - Turpin's estimates based on limited speciation data
- OC- EC split (and unaccounted mass for "EC")
- Retained carbon mass on FRM teflon vs STN quartz
  - Volatile or other OC may pass thru Teflon
    - FRM has higher *face velocity* than many STN samplers
  - Water [20-24% of measured PM2.5 water]

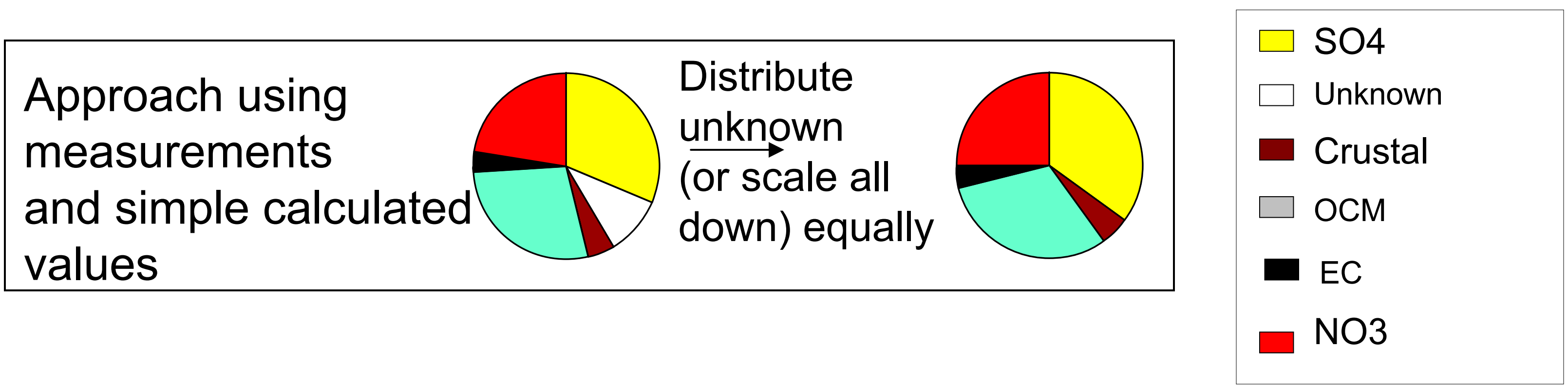
Old Practice: Use STN measurements to directly characterize PM2.5

FRM and STN measurements

PM2.5 mass   SO4 NH4 NO3 {Al SI Ca Fe Ti} OC EC

Constructed Mass using STN measurements (RCFM)

PM2.5 mass ≠ Sulfate + Nitrate + {Crustal} + OCM + EC



Bottom line: Measurement data with standard adjustment does not add up to PM2.5

A better use of the STN speciation data to support the PM2.5 program is needed

Now, lets **modify** the STN measurements using **SANDWICH**

FRM and STN measurements

PM2.5 mass SO4 NH4 NO3 {Al SI Ca Fe Ti} OC EC

Now, lets **modify** the STN measurements using **SANDWICH**

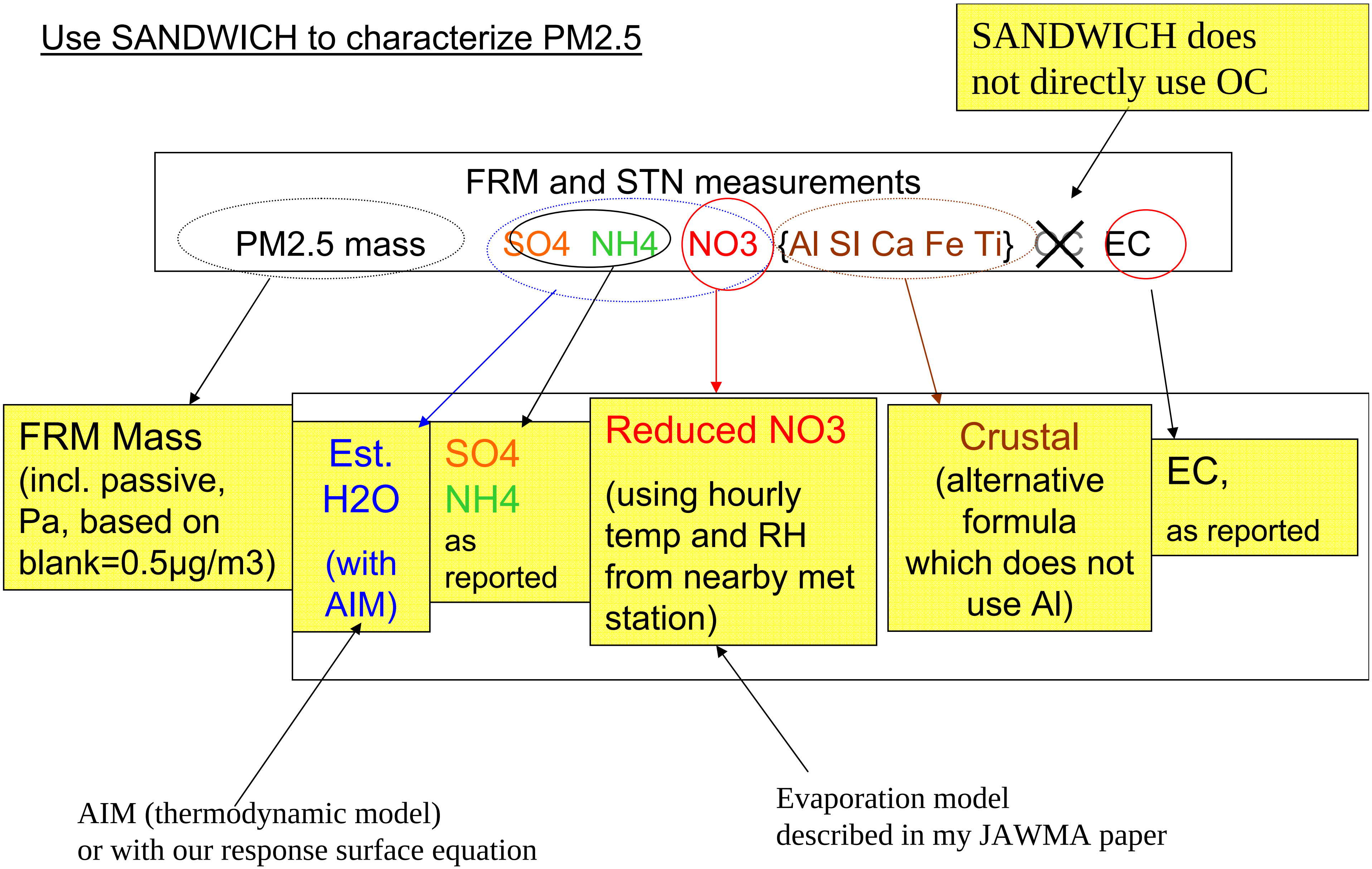
FRM and STN measurements

PM2.5 mass SO_4 NH_4 NO_3 {Al SI Ca Fe Ti} OC EC

PM2.5= "Gravimetric" mass
- Teflon filters are equilibrated at ~21deg C and 35% RH
- Net weight and sample volume are used to produce ug/m3

The SANDWICH approach considers sampling artifacts and idiosyncrasies of FRM's gravimetric mass and STN's monitoring protocols

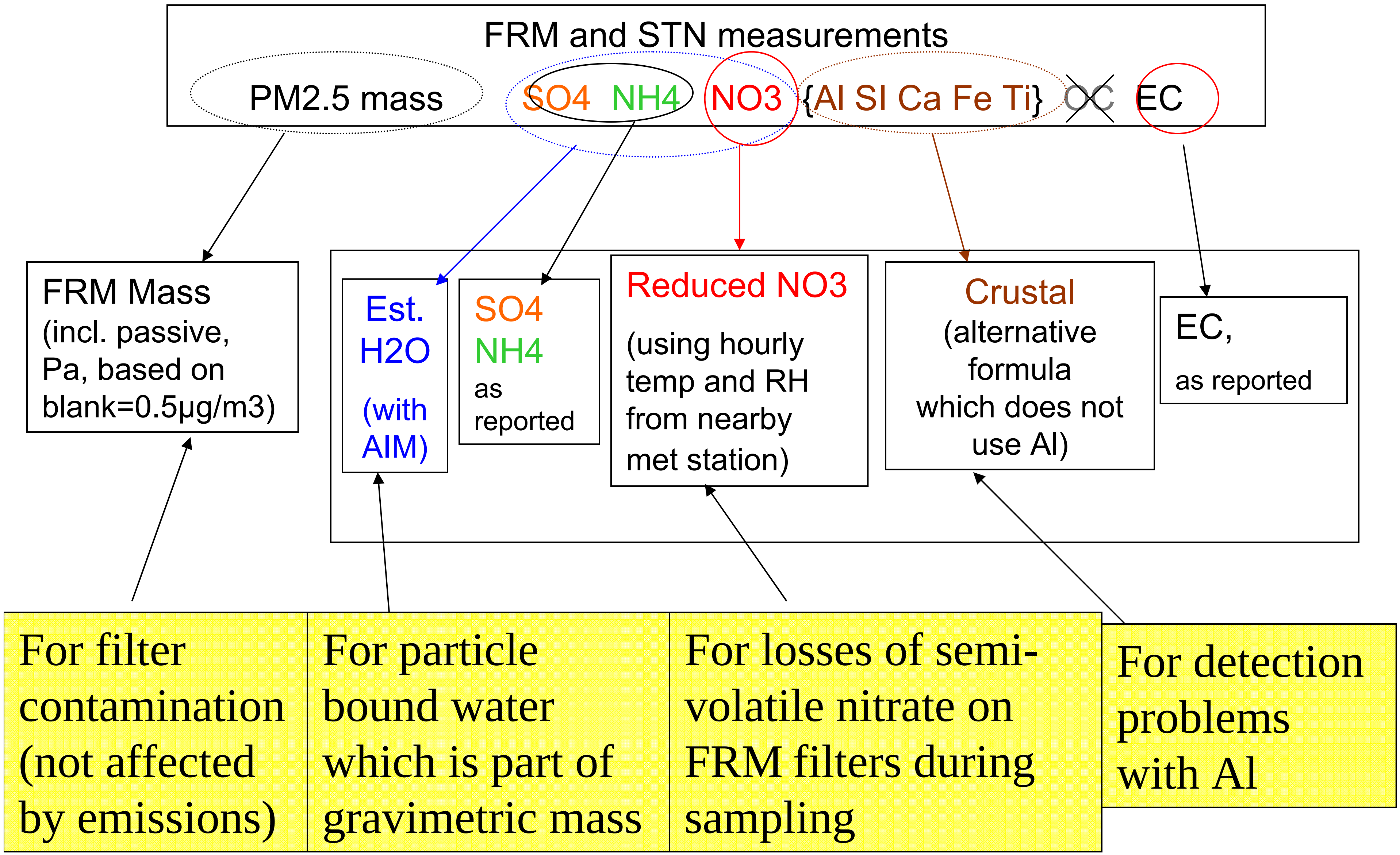
Use SANDWICH to characterize PM2.5



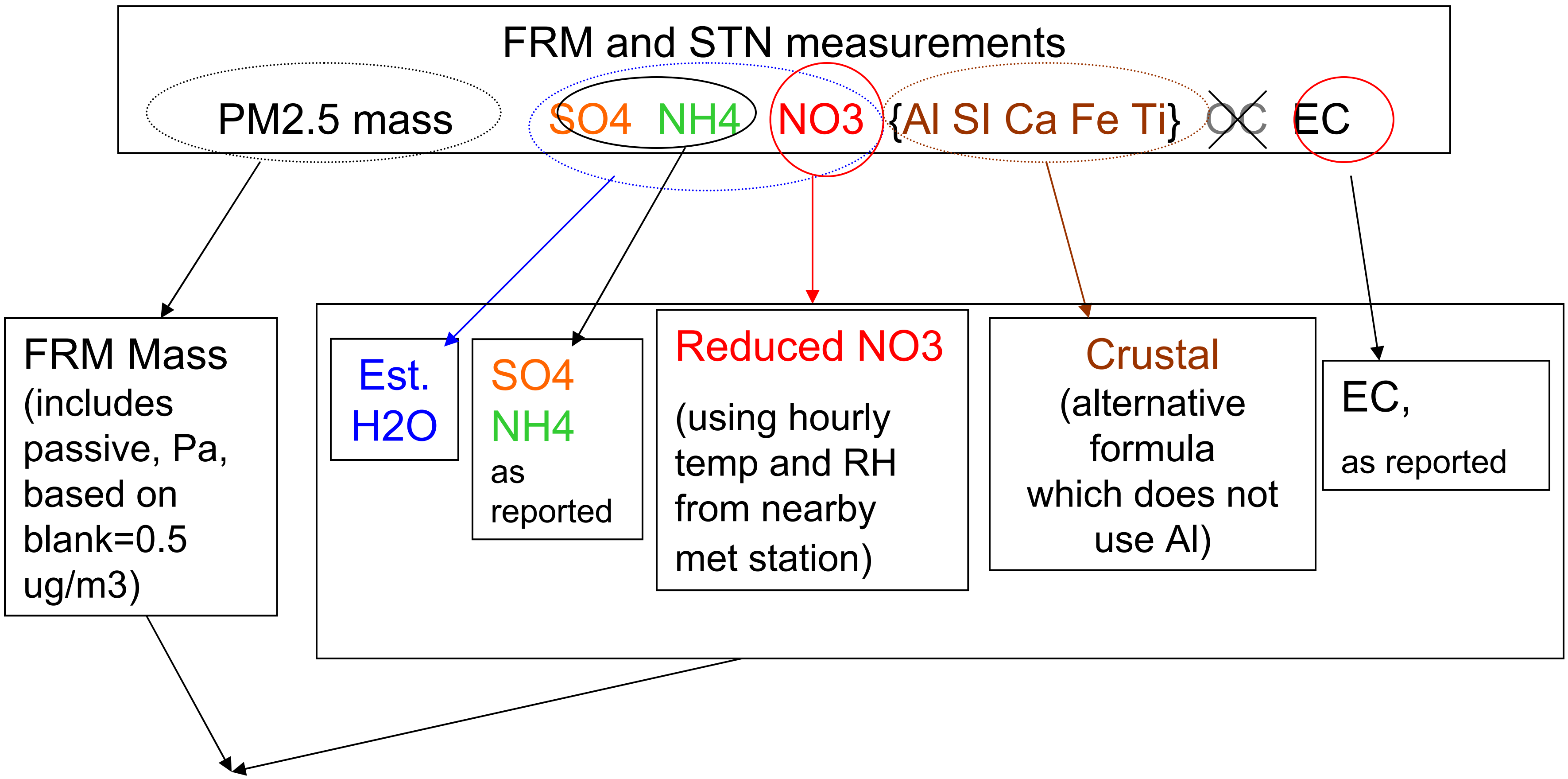
See: http://oaqpswww.epa.gov/tom/wiki/pmteam/index.cfm?doc=Water_Calculations

Frank, N. Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities, *J. Air & Waste Manage. Assoc.* **56** :500–511

Use SANDWICH to characterize PM2.5



Use SANDWICH to characterize PM2.5

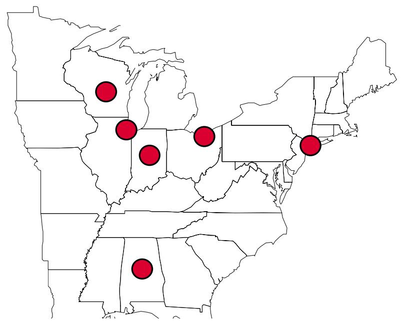


$$OCM_{mb} = FRM - (SO4+NH4+NO3r+H2O+EC+Cr+Pa)$$

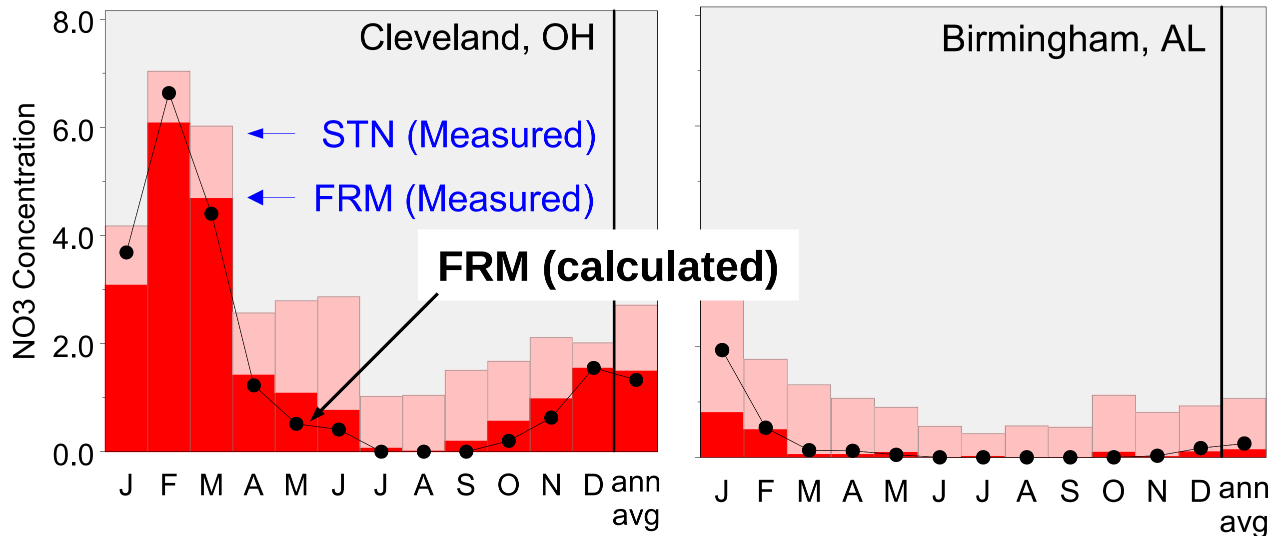
OCMmb explicitly accounts for blank correction (sampling artifact), fudge factor to account for OC to OCM conversion, H2O & less (non-volatile) OC retained on Teflon.

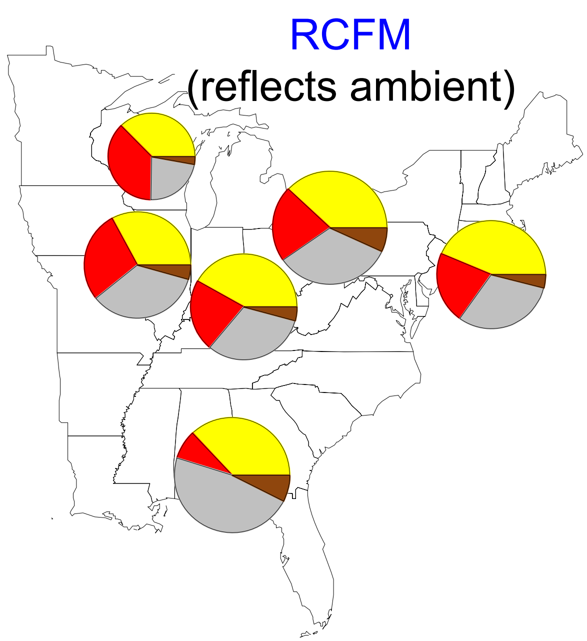
FRM doesn't retain all ambient nitrates

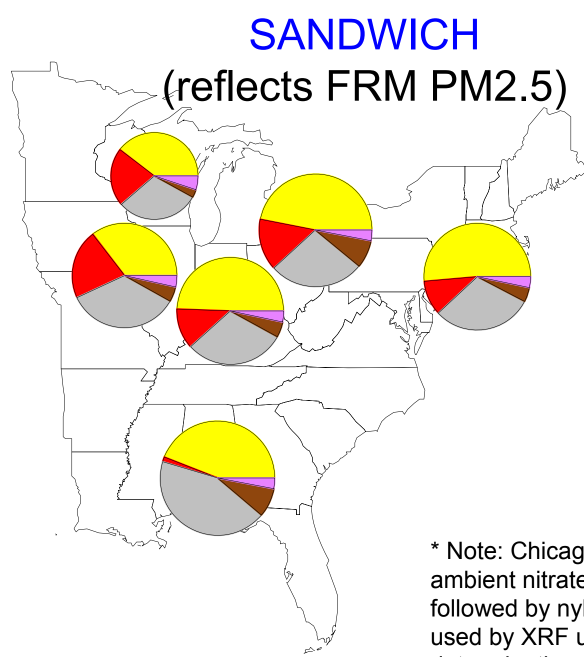
6 Nitrate Study Sites, 2003

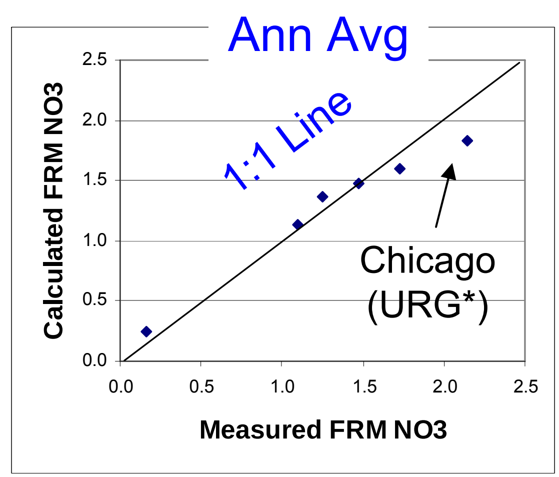


Monthly and Annual Average NO3, 2003







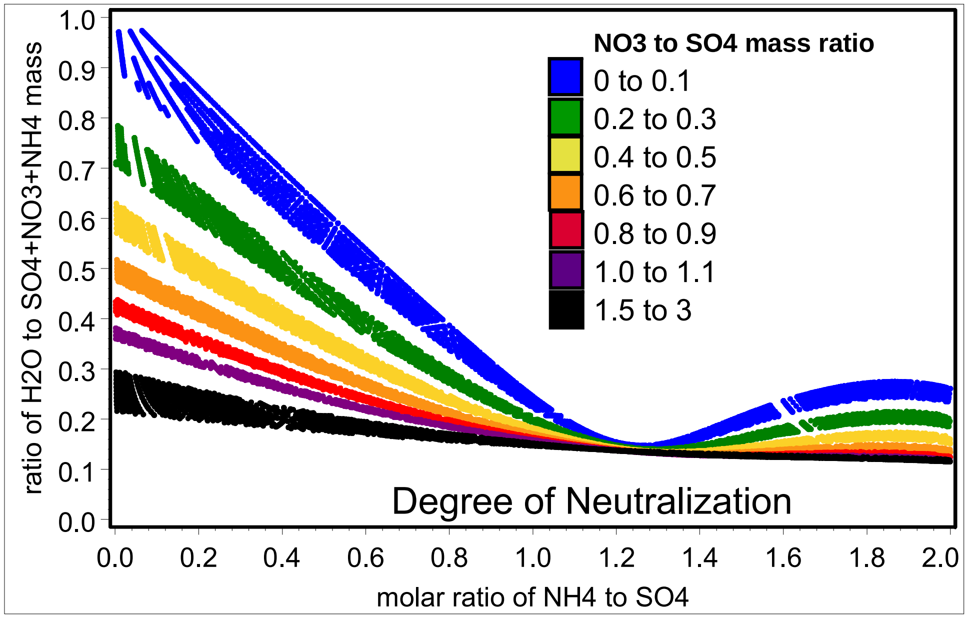


* Note: Chicago has URG sampler whose data may underestimate ambient nitrates. URG has 2 filters to collect nitrates (Teflon followed by nylon). The teflon may loose nitrates when it is first used by XRF under vacuum prior to non-volatile nitrate determination.

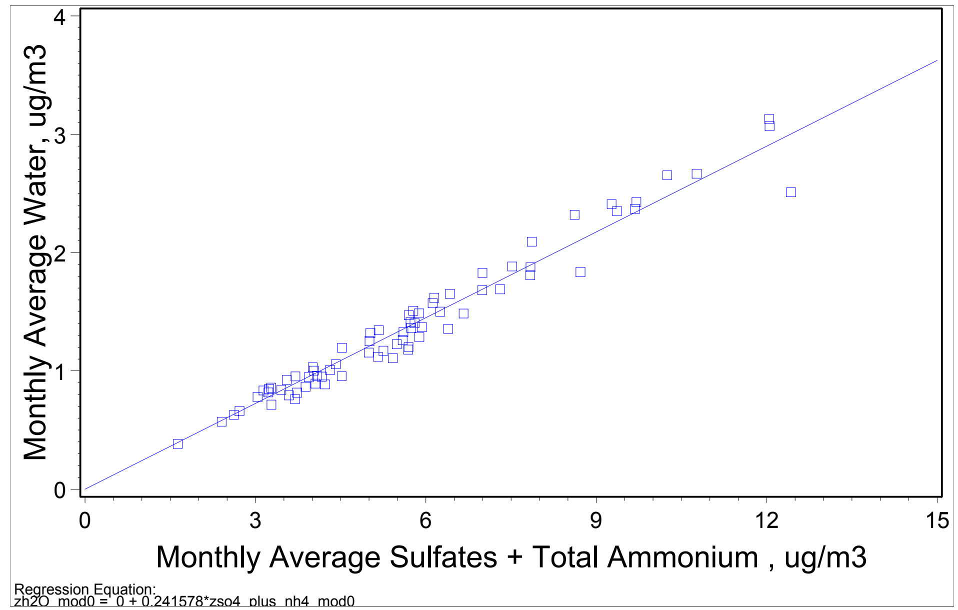
Sulfate Nitrate TCM Crustal Passive

PM2.5 Water Estimated with AIM, using SO_4, NO_3 and NH_4

More water
with higher % of Sulfates
or More Acidic Aerosol



Monthly Average Water
tracks Sulfate plus Total Ammonium
for 6 study sites, 2003 data



Using Aerosol Inorganics Model (AIM) at 35% RH and 21° C (no solids are allowed to form).
http://www.hpc1.uea.ac.uk/~e770/aim.html

New Development (included in Draft Modeling Guidance)

EQUATION TO ESTIMATE WATER
(replicates AIM at FRM equilibration conditions)

Let D = $NH4^s$ / SO4, 0<D<0.375, where $NH4^s$ is the amount associated with SO4.
[The corresponding DON ('degree of neutralization', molar) varies from 0 to 2.]

Define relative amounts of SO4, NO3 (reduced) and NH4:
S=SO4/(SO4+NO3+NH4); N=NO3/(SO4+NO3+NH4); A=NH4/(SO4+NO3+NH4);
Eliminate any excess NH4 not needed to fully neutralize SO4

High acidity: DON <1.2 (D < 0.225)

Water= [595.56 - 1440.58*S - 1126.49*N + 283.91*(S**1.5) - 13.38*(N**1.5)
- 1486.71*(A**1.5) + 764.23*(S**2) + 1502.00*(N * S) + 451.87*(N**2)
- 185.18*(S**2.5) - 375.98*(S**1.5) * N - 16.90*(S**3) - 65.81*(N**1.5) * S
+ 96.83*(N**2.5) + 83.04*(N**1.5) *(S**1.5) - 4.42*(N**3)
+ 1720.82*(A**1.5) * S + 1220.38*(A**1.5) * N - 311.50*(A**1.5) * (S**1.5)
+ 148.77*(A**1.5) * (N**1.5) + 1151.65*(A**3)] * (SO4+NO3+NH4)

Low acidity: DON>1.2 (D>0.225)

Water= [202049.0 - 391494.6*S - 390912.1*N + 442.4*(S**1.5) - 155.3*(N**1.5)
- 293406.8*(A**1.5)+189277.5*(S**2)+377992.6*N*S +188636.8*N**2
- 447.1*S**2.5 -507.2*S**1.5*N -12.8*S**3 +146.2*N**1.5*S +217.2*N**2.5
+ 30.0*N**1.5*S**1.5 - 18.6*N**3 + 216267.0*A**1.5*S + 215419.9*A**1.5*N
- 621.8*A**1.5*S**1.5 +239.1*A**1.5*N**1.5+95413.1*A**3] * (SO4+NO3+NH4)

Use SANDWICH to characterize PM2.5

FRM and STN measurements

PM2.5 mass SO4 NH4 NO3 {Al SI Ca Fe Ti} OC EC

estimates of speciated FRM components

measurements and modeled estimates

SO4 NH4 NO3r H2O Crustal OCMmb EC Pa

Use SANDWICH to characterize PM2.5

FRM and STN measurements

PM2.5 mass SO4 NH4 NO3 {Al SI Ca Fe Ti} OC EC

By design, perfect mass balance

PM2.5 mass = SO4 + NH4 + NO3r + H2O + Crustal + OCMmb + EC + Pa

Sulfate, **A**djusted **N**itrate, **D**erived **W**ater, **I**nferred **C**arbon
Hybrid Material Balance Approach
(SANDWICH)

Use SANDWICH to characterize PM2.5

FRM and STN measurements

PM2.5 mass SO4 NH4 NO3 {Al SI Ca Fe Ti} OC EC

By design, perfect mass balance

SANDWICH and STN measurements

PM2.5 mass = SO4 + NH4 + NO3r + H2O + Crustal + OCMmb + EC + Pa

Simpler representation of major components

SANDWICH and STN measurements

PM2.5 mass = Sulfate + Nitrate + Crustal + TCMmb + Pa

Use SANDWICH to characterize PM2.5

For Data Presention Purposes:

Simplify components of PM2.5 into Sulfate and Nitrate portions, the NH_4 and estimated H_2O must be partitioned.
Carbon can be represented as Total Carbonaceous Mass.

SANDWICH and STN measurements

PM2.5_mass = SO4 + NH4 + NO3r + H2O + Crustal + OCMmb + EC + Pa

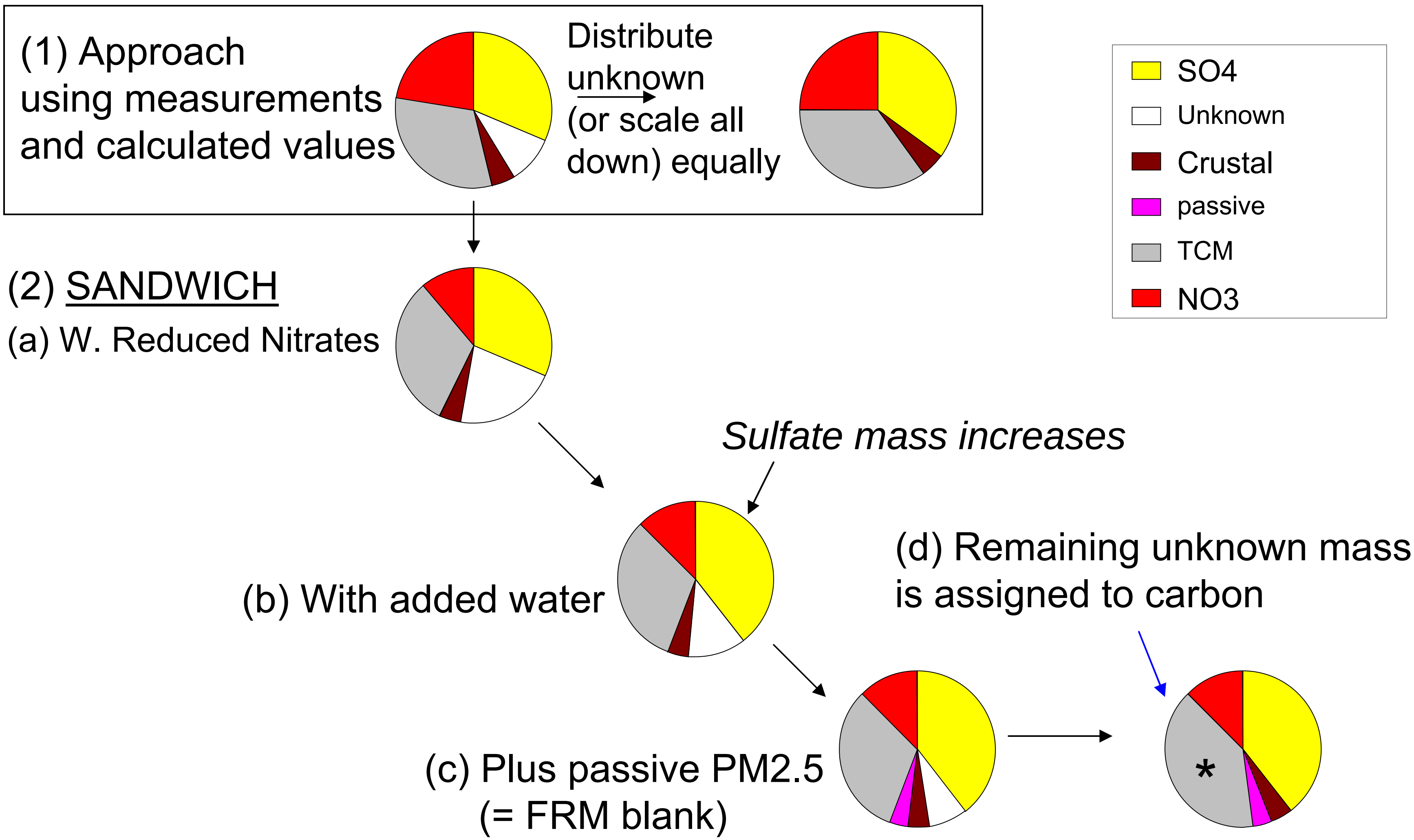
Partition NH4 and H20 ***Combine OCM and EC***

SANDWICH and STN measurements

PM2.5 mass = Sulfate + Nitrate + Crustal + TCMmb + Pa

For further data details, See: http://www.epa.gov/airexplorer/

Conceptual Overview of Mass Balance Approaches



* Default SANDWICH can be modified to consider other components, like salt. This reduces estimate of TCM.

Uncertainties, Caveats and Data Use

- Assumptions:
  - Reduced nitrate and enhanced sulfate are more reflective of what might be measured by the FRM
  - OCM is the most uncertain mass component
- TCM_{mb} is upper estimate and subject to errors in the non-C components
    - Inclusion of all "known" components is good
      - E.g. Salt for coastal areas or urban wintertime
- Sometimes, TCM_{mb} can be negative
  - But, so can measurement derived "OC-b"
  - So, modified SANDWICH uses measurement data as an "OCM floor" (See discussion on Air Explorer)
- TCM_{mb} can be used to ground truth k*(OC-b) +EC

Application of SANDWICH to STN Data

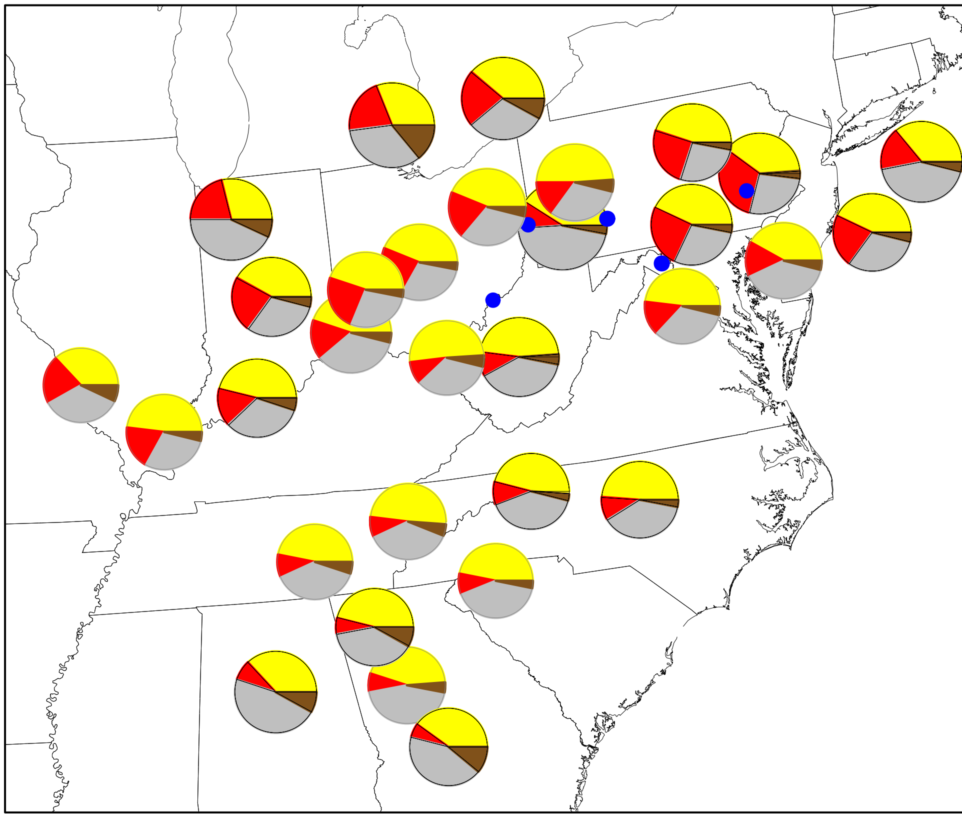
and

Some examples of SANDWICH for QC

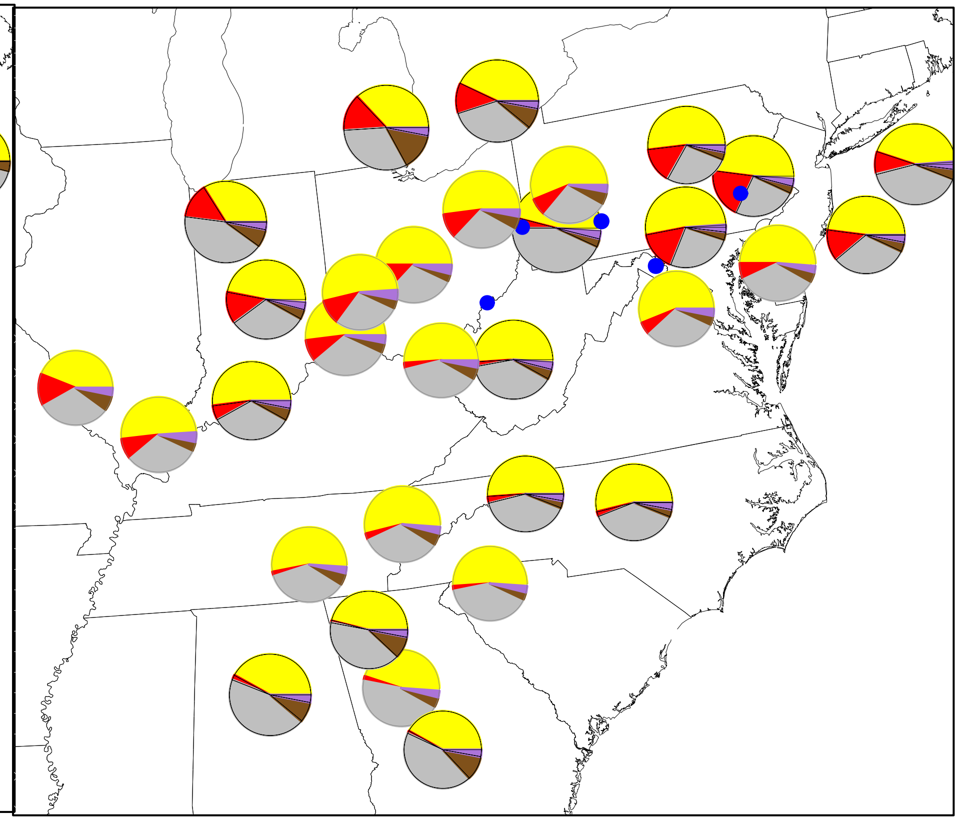
Annual Average Composition (2002-04) in East NA areas

Less nitrate and more sulfate mass with SANDWICH

RCFM



SANDWICH



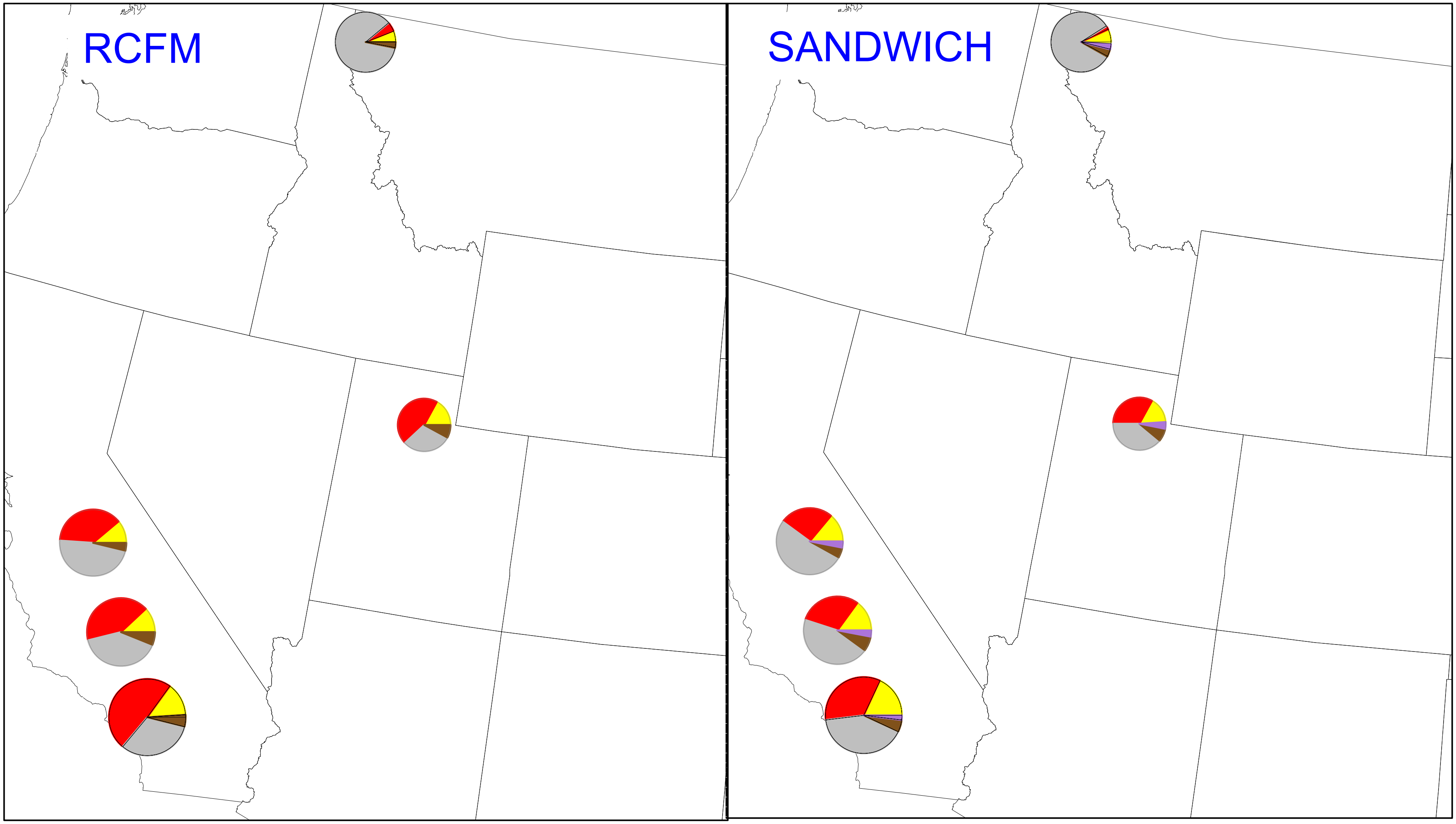
area	area_annual_dv
NA area: Johnstown, PA	15.3
NA area: Martinsburg, WV-Hagerstown, MD	16.1
NA area: Parkersburg-Marietta, WV-OH	15.2
NA area: Reading, PA	16.1
NA area: Steubenville-Weirton, OH-WV	17
NA area: Wheeling, WV-OH	15.1

● NA area without STN data (02-04)

Black outlined pies have collocated FRM and speciation

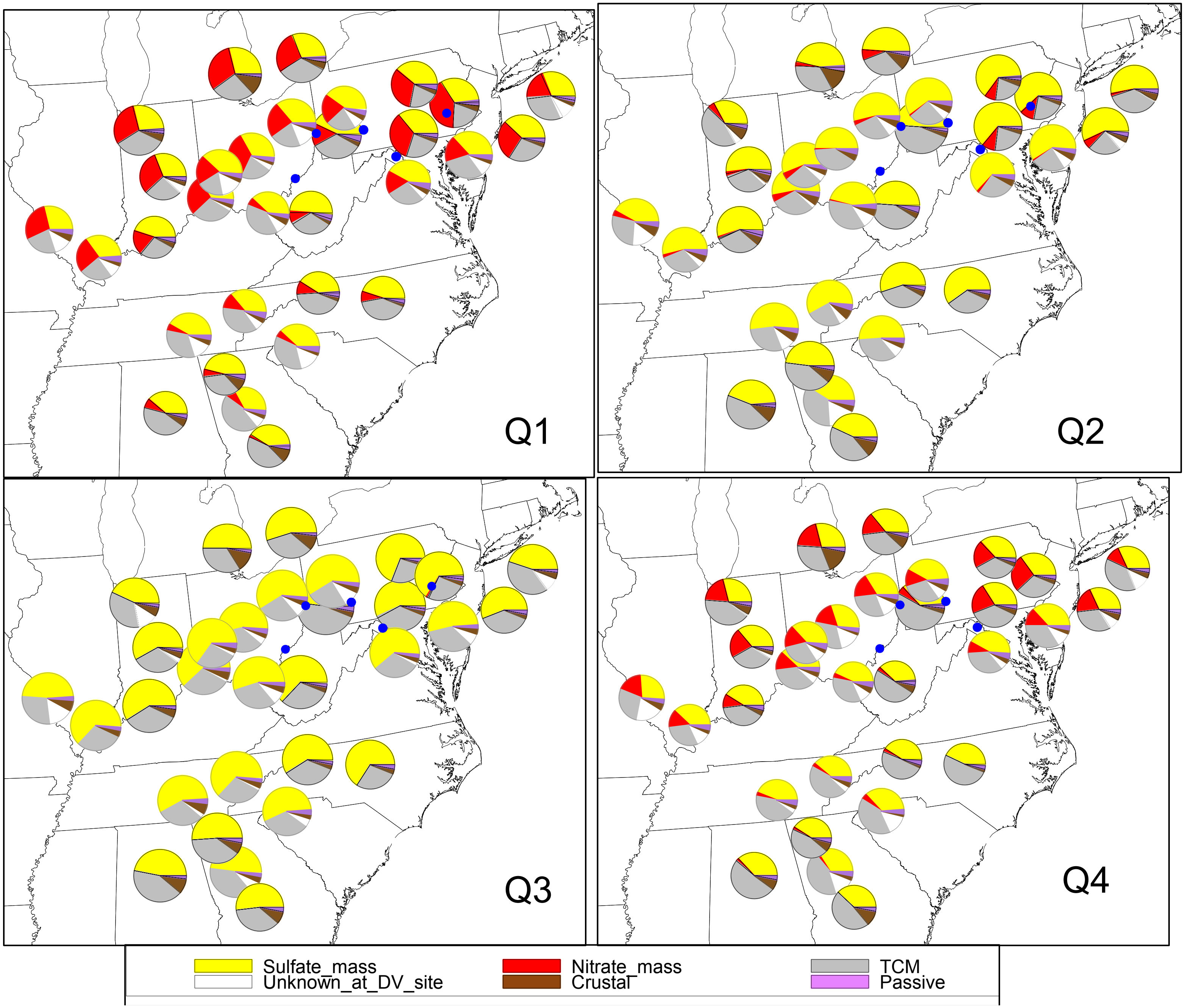
Annual Average Composition (2002-04) in West NA areas

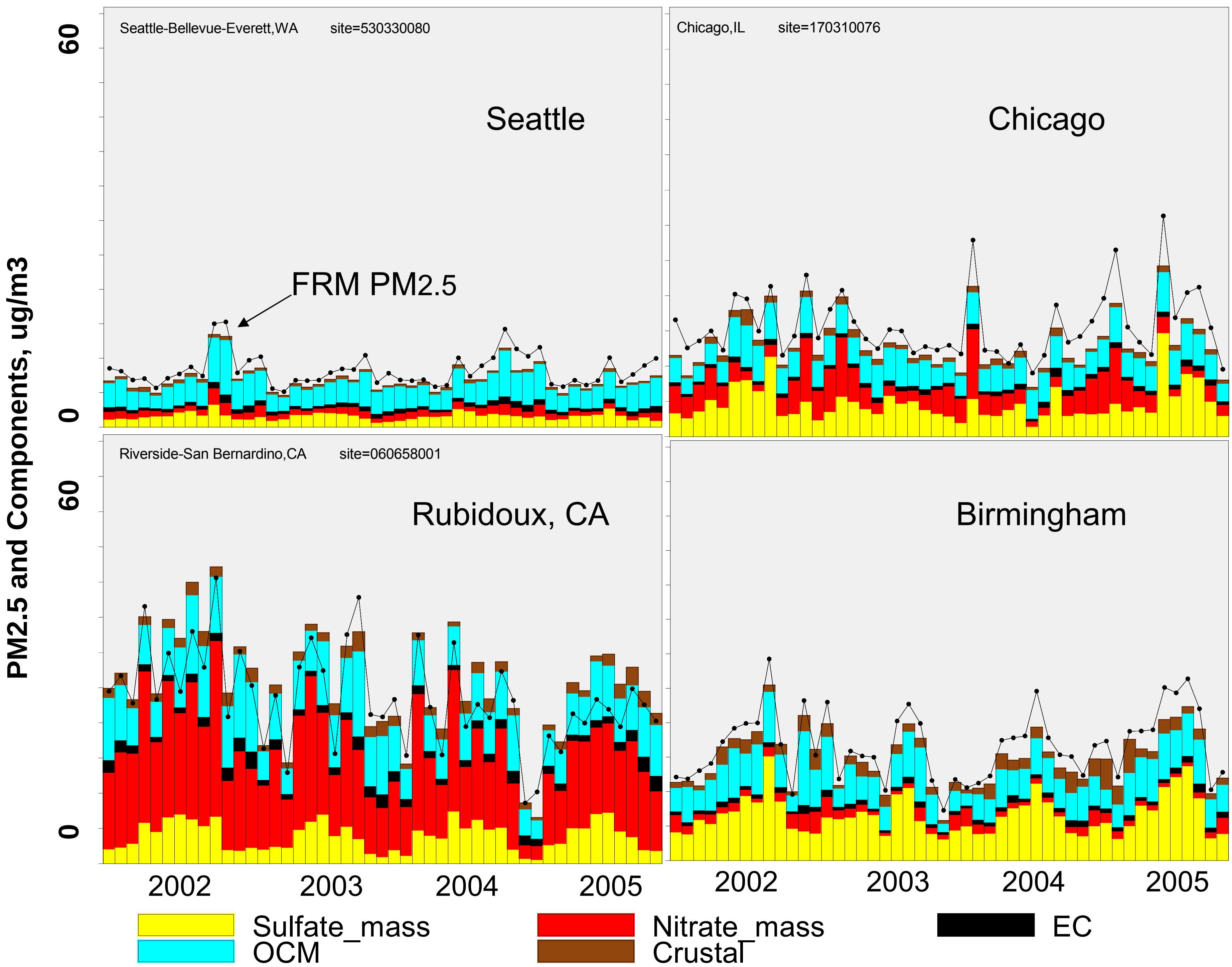
Less nitrate and more carbon mass with SANDWICH



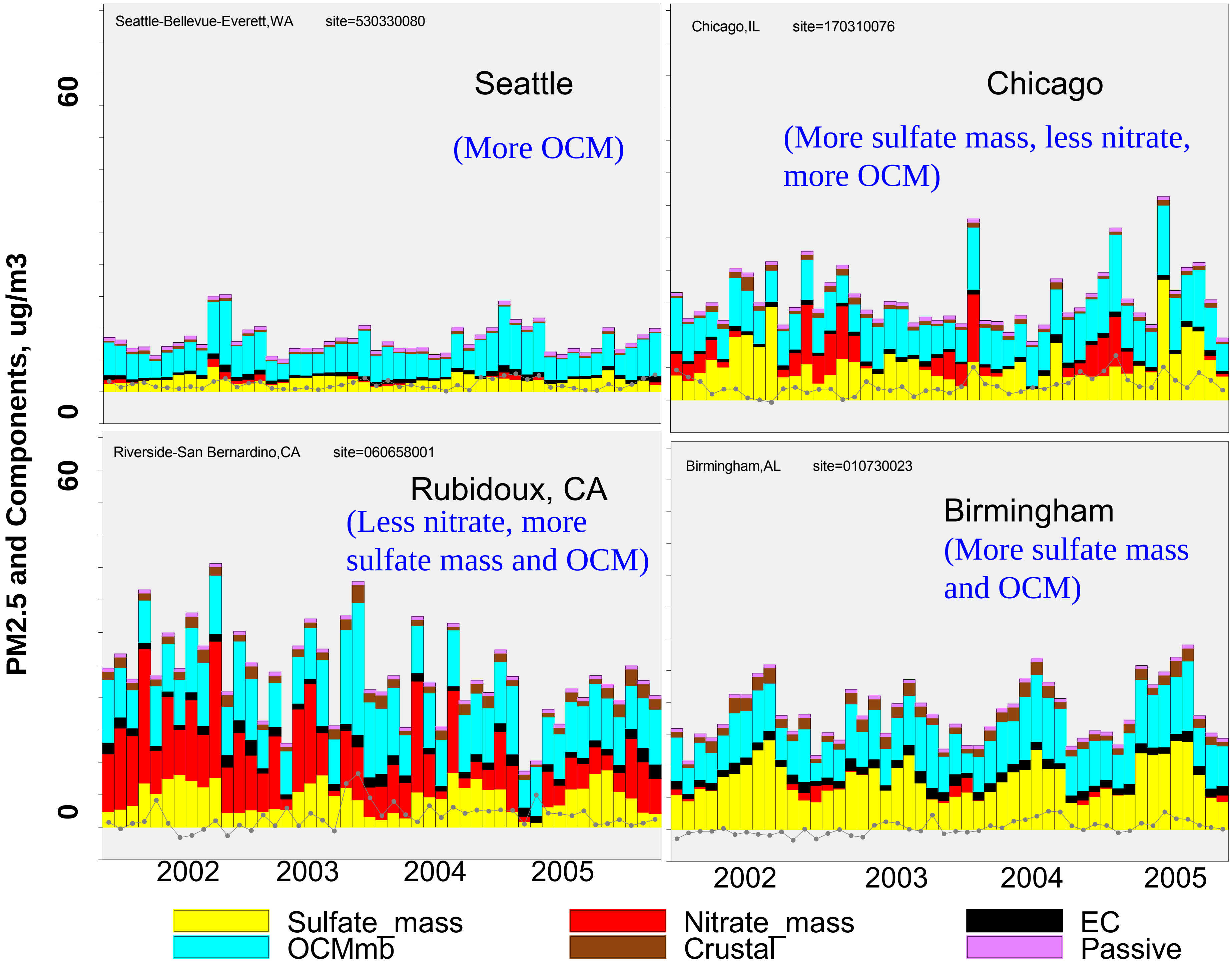
Black outlined pies have collocated FRM and speciation

Quarterly PM2.5 Composition in Eastern NA areas, 2002-04



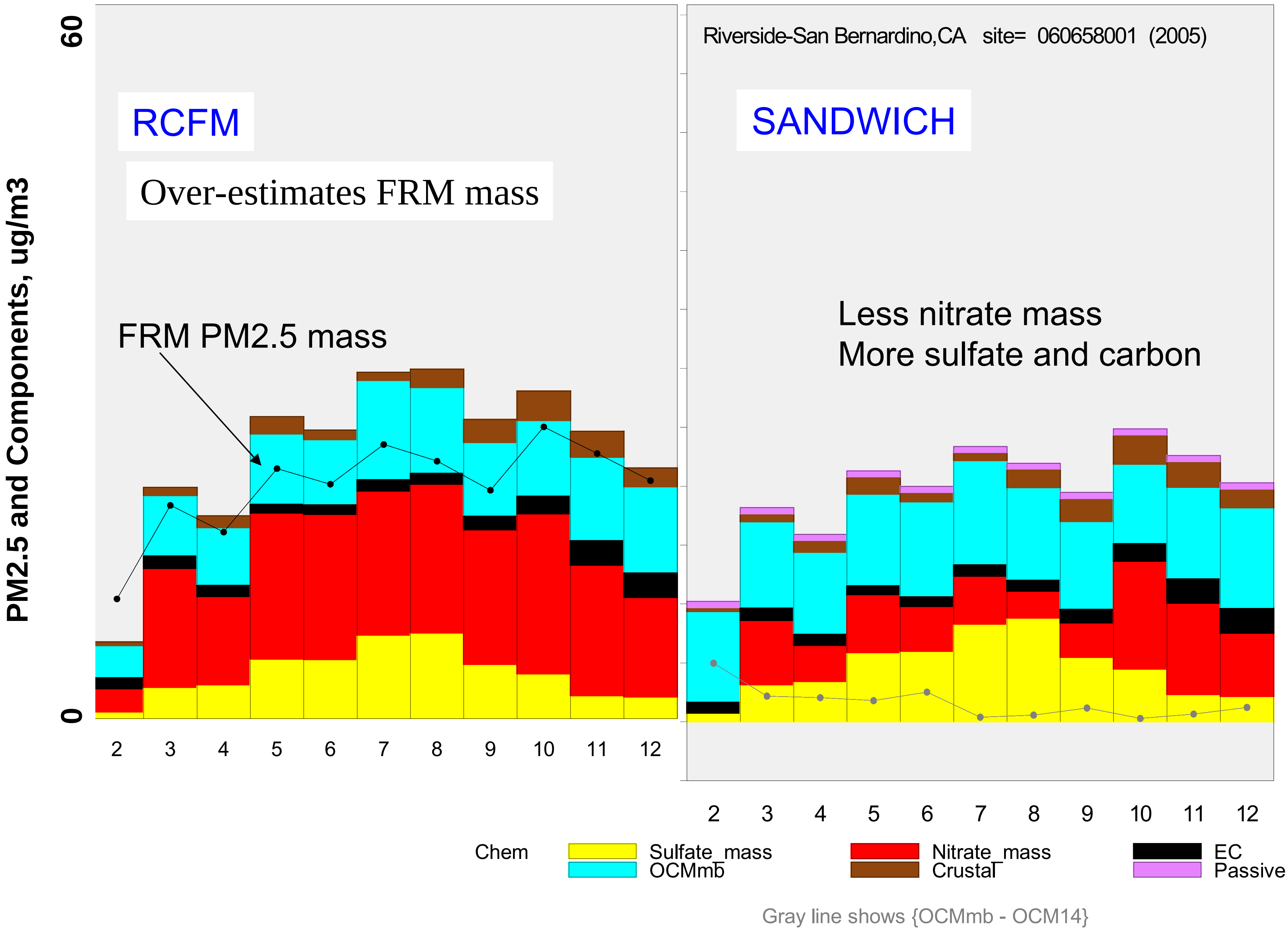


PM2.5 and Components, ug/m3
Seattle-Bellevue-Everett,WA site=530330080
Seattle
FRM PM2.5
Chicago,IL site=170310076
Chicago
Riverside-San Bernardino,CA site=060658001
Rubidoux, CA
Birmingham
60
0
60
0
2002
2003
2004
2005
2002
2003
2004
2005
Sulfate_mass
OCM
Nitrate_mass
Crustal
EC

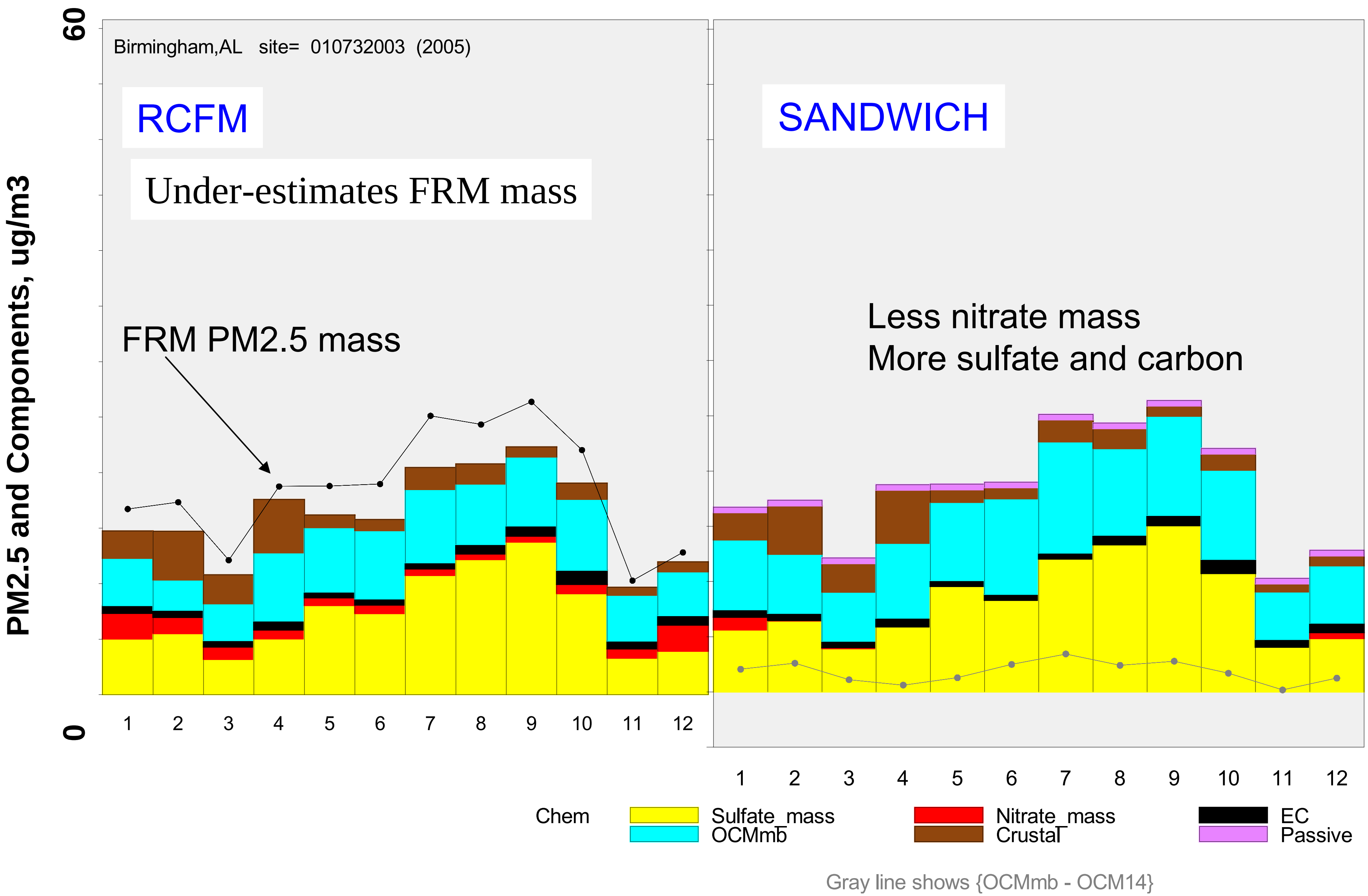


PM2.5 and Components, ug/m3
Seattle-Bellevue-Everett,WA site=530330080
Seattle
(More OCM)
Chicago,IL site=170310076
Chicago
(More sulfate mass, less nitrate, more OCM)
Riverside-San Bernardino,CA site=060658001
Rubidoux, CA
(Less nitrate, more sulfate mass and OCM)
Birmingham,AL site=010730023
Birmingham
(More sulfate mass and OCM)
60
0
2002
2003
2004
2005
Sulfate_mass
OCMmb
Nitrate_mass
Crustal
EC
Passive

Rubidoux, CA (2005)



Birmingham, AL (2005)



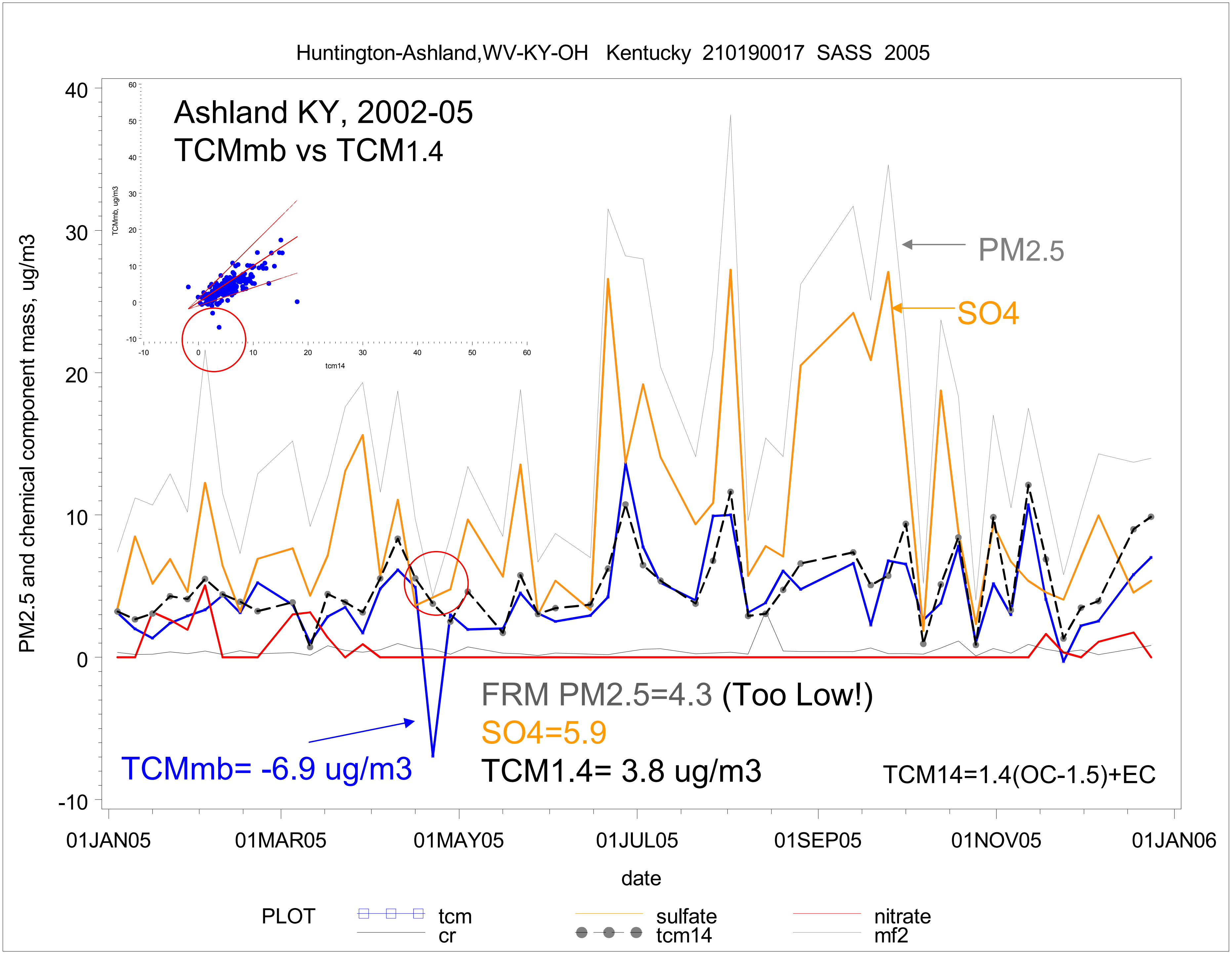
How to Use SANDWICH for QC

- Comparisons of Constructed Fine Mass with measured FRM mass
  - Using reduced nitrate and hydrated sulfate

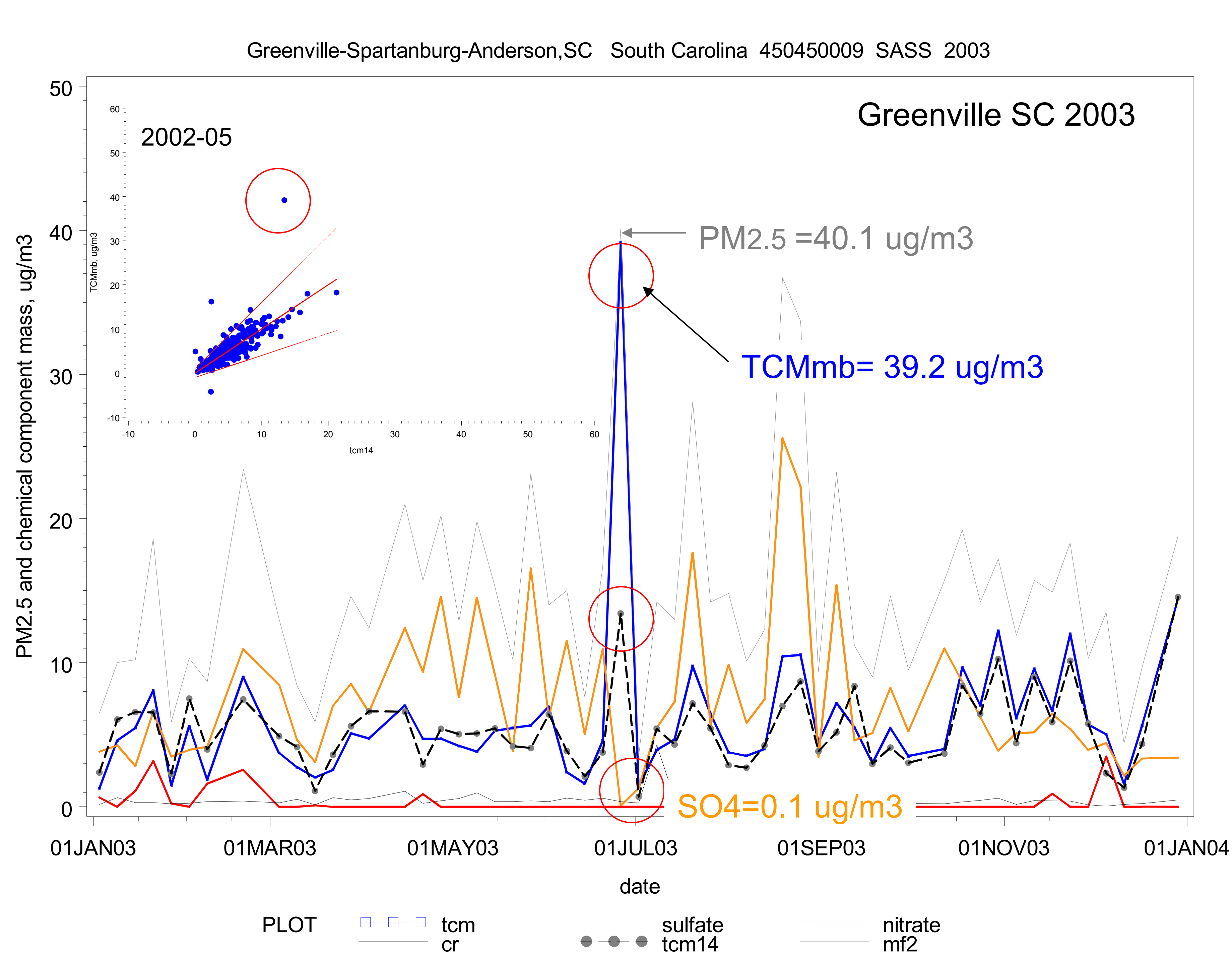
Instead of CFM=[SO4]+[NO3]+[NH4]+ [TCM14]+[Cr]

Use CFM=[SO4]+[NO3r]+[NH4]+[H2O] [TCM14]+[Cr]

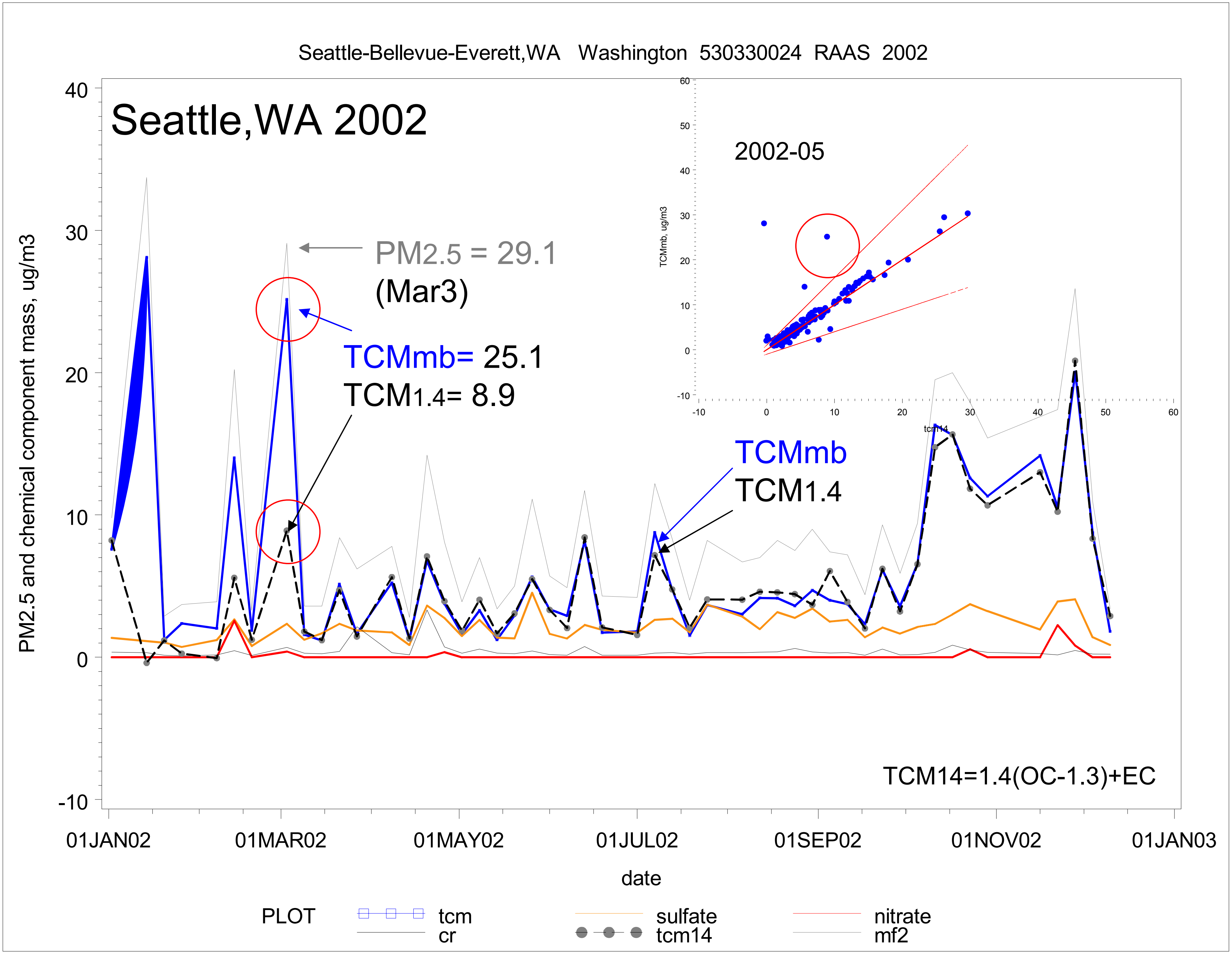
- Examine TCMmb vs. [k*(OC-b)+EC]
  - Negative numbers and large deviations can be informative.
  - Three examples
    - Use time series and scatter plots
    - Preliminary QC findings are presented

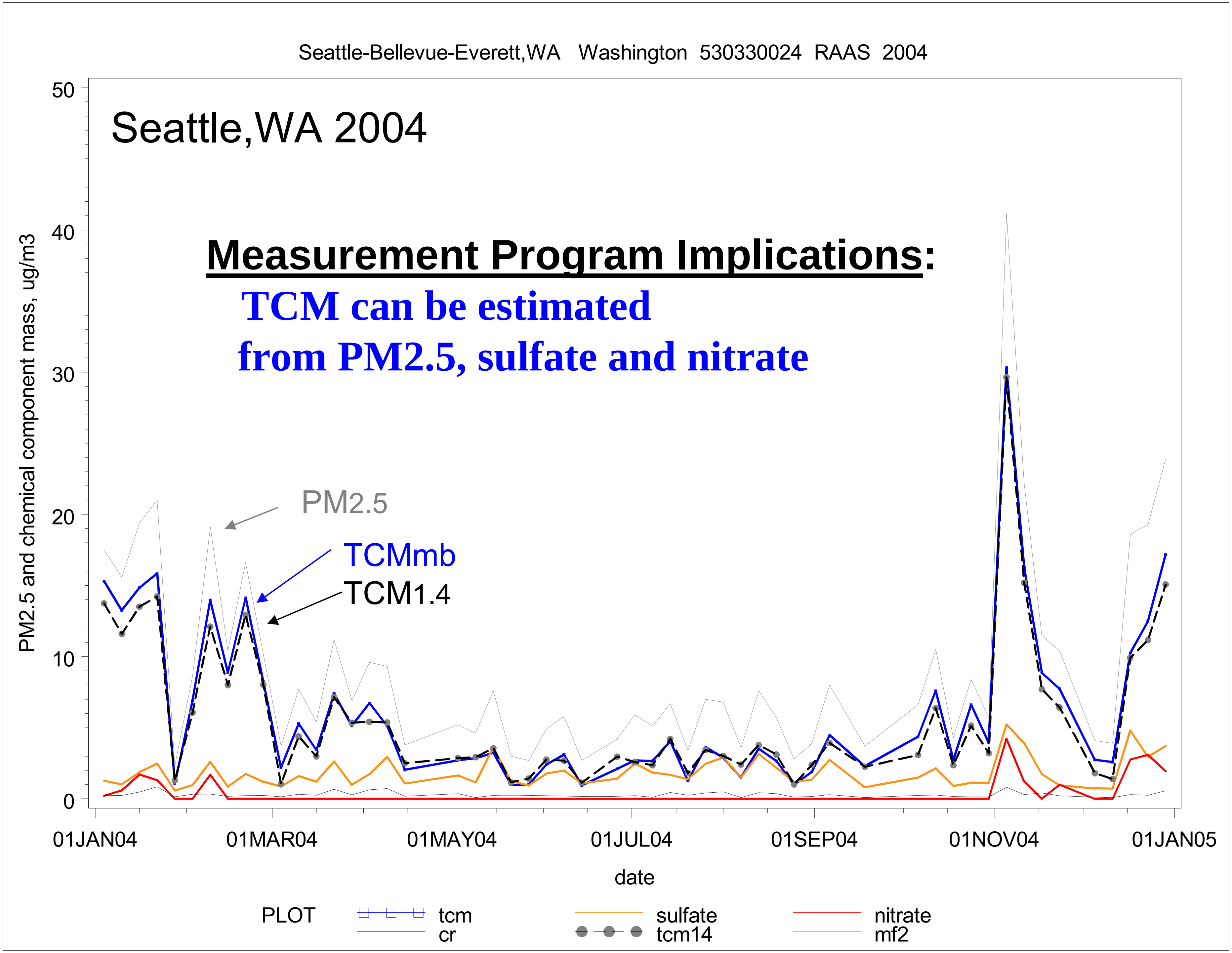


Huntington-Ashland,WV-KY-OH Kentucky 210190017 SASS 2005
Ashland KY, 2002-05
TCMmb vs TCM1.4
TCMmb, ug/m3
tcm14
PM2.5
SO4
FRM PM2.5=4.3 (Too Low!)
SO4=5.9
TCM1.4= 3.8 ug/m3
TCMmb= -6.9 ug/m3
TCM14=1.4(OC-1.5)+EC
PM2.5 and chemical component mass, ug/m3
01JAN05
01MAR05
01MAY05
01JUL05
01SEP05
01NOV05
01JAN06
date
PLOT
tcm
cr
sulfate
tcm14
nitrate
mf2



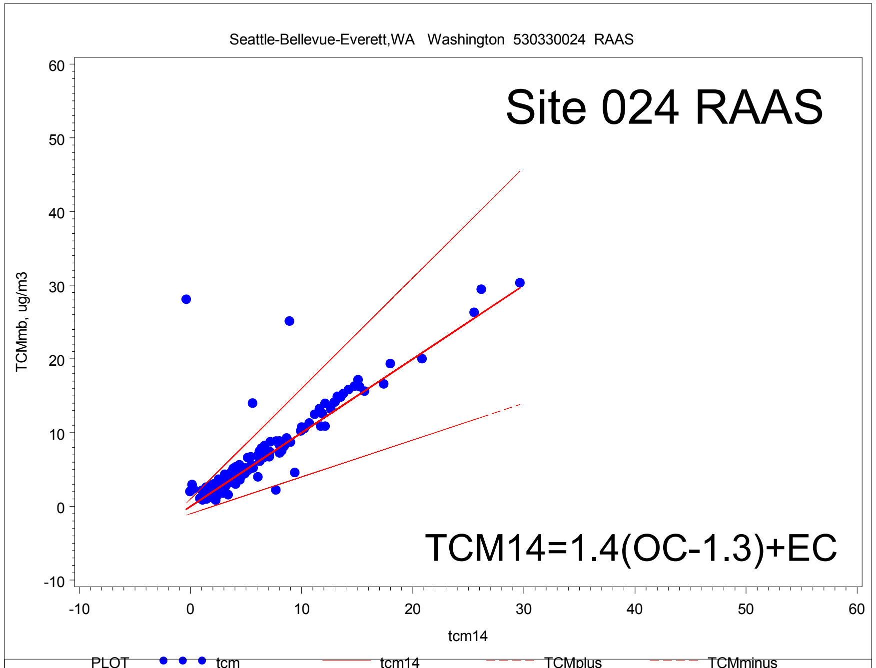
Greenville-Spartanburg-Anderson,SC South Carolina 450450009 SASS 2003
Greenville SC 2003
2002-05
TCMmb, ug/m3
tcm14
PM2.5 =40.1 ug/m3
TCMmb= 39.2 ug/m3
SO4=0.1 ug/m3
PM2.5 and chemical component mass, ug/m3
date
01JAN03
01MAR03
01MAY03
01JUL03
01SEP03
01NOV03
01JAN04
PLOT
tcm
cr
sulfate
tcm14
nitrate
mf2

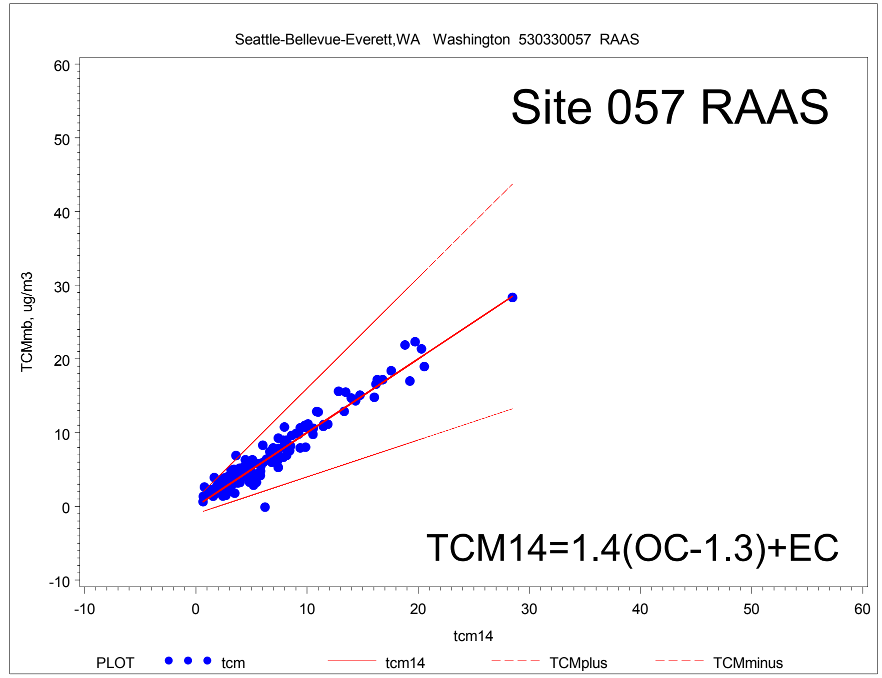

Seattle-Bellevue-Everett,WA Washington 530330024 RAAS 2002
Seattle,WA 2002
PM2.5 = 29.1
(Mar3)
TCMmb= 25.1
TCM1.4= 8.9
2002-05
TCMmb, ug/m3
tcm14
TCMmb
TCM1.4
TCM14=1.4(OC-1.3)+EC
PM2.5 and chemical component mass, ug/m3
01JAN02
01MAR02
01MAY02
01JUL02
01SEP02
01NOV02
01JAN03
date
PLOT
tcm
cr
sulfate
tcm14
nitrate
mf2

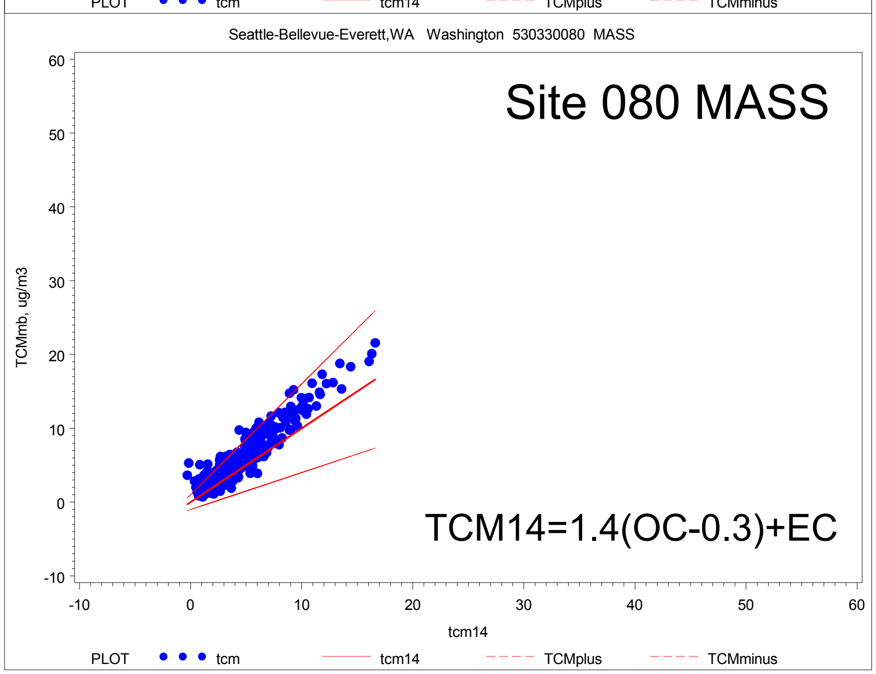


Seattle-Bellevue-Everett,WA Washington 530330024 RAAS 2004
Seattle,WA 2004
Measurement Program Implications:
TCM can be estimated
from PM2.5, sulfate and nitrate
PM2.5
TCMmb
TCM1.4
PM2.5 and chemical component mass, ug/m3
0
10
20
30
40
50
01JAN04
01MAR04
01MAY04
01JUL04
01SEP04
01NOV04
01JAN05
date
PLOT
tcm
cr
sulfate
tcm14
nitrate
mf2

TCMmb vs TCM1.4 for 3 sites in Seattle (2002-05)







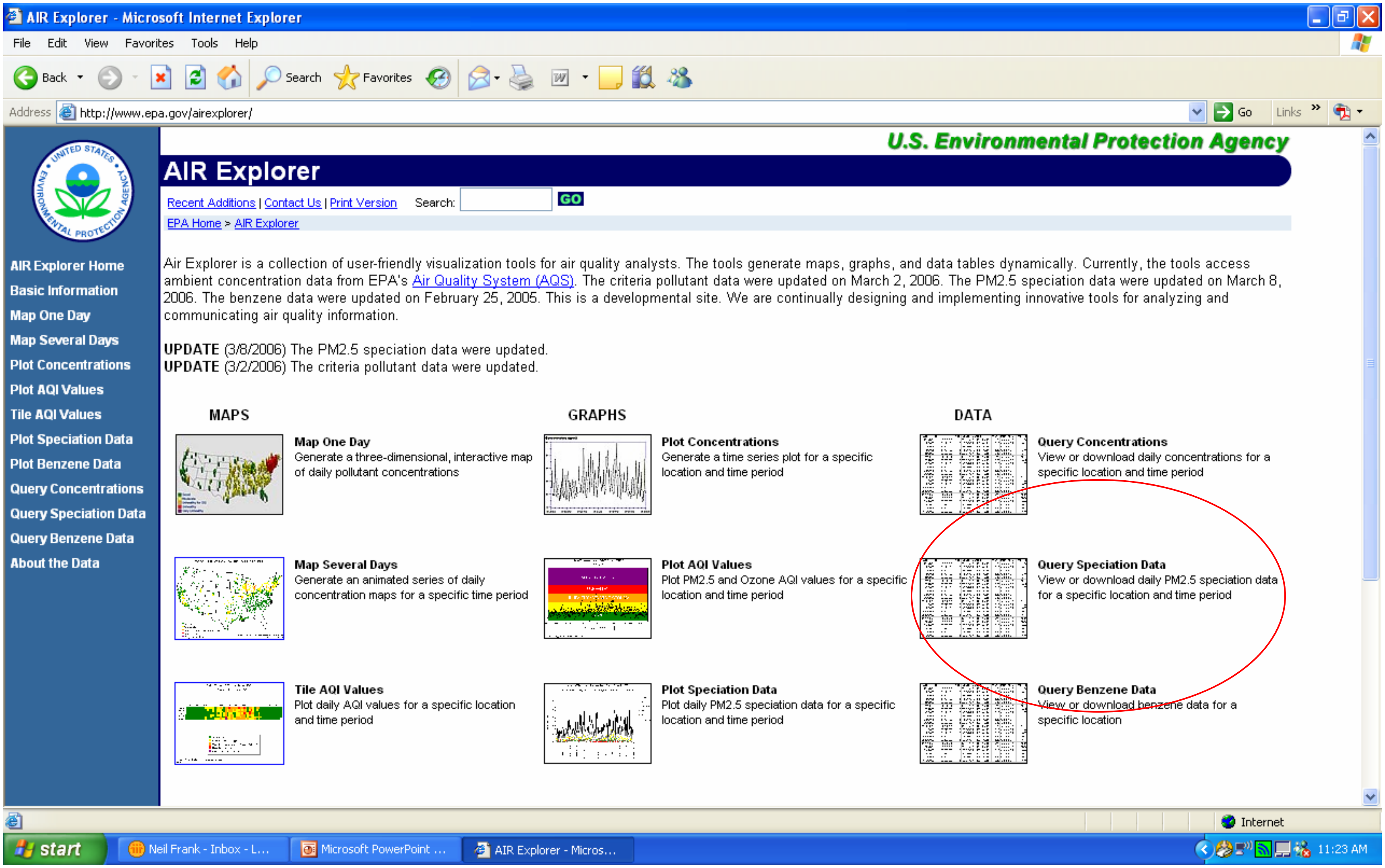
MASS sampler appears to require different combination of “k” and “b” to attain consistency between TCMmb and k*(OC-b)

Higher “k” =1.8 more consistent with woodsmoke aerosol
→ suggests that SASS sampler may retain add’l artifact in proportion to particle OC (this is offset by “k=1.4”)
See TCM poster (for further discussion)

SANDWICH data are now available on Air Explorer

http://www.epa.gov/airexplorer/

See Mark Schmidt's Demo, Wednesday 3:30pm



A Few Summary Points

- Adjustments to STN speciation measurements are needed to represent FRM $PM_{2.5}$ mass
- SANDWICH estimates composition as might have been measured by the FRM
- TCMmb
  - helps evaluate C fudge factors (k & b) and validate C measurements
  - Use it to estimate TCM without measured C

Questions?

Now or at Tomorrow's Poster Session

I hear they will be serving Frank Sandwiches!

Trends in Carbonaceous PM2.5 using Measured STN Carbon and “SANDWICH”

Neil Frank

Office of Air Quality Planning and Standards, USEPA Research Triangle Park NC 27711

Background

Carbonaceous mass is one of the largest PM2.5 chemical components, but is the most challenging to estimate. The typical method to calculate total carbonaceous mass (TCM) involves correcting measured organic carbon (OC) for positive sampling artifact (blank correction), multiplying the result by a simple factor (e.g. 1.4) to account for oxygen, hydrogen and other elements in ambient carbon compounds and then adding measured EC. Neither of these OC adjustments can be accurately estimated from existing STN measurements or data. The STN program does not currently utilize backup filters; therefore, field and trip blanks together with sampler flow rate permit at best a crude estimate of the OC artifact. EPA has used a single network wide value derived from 2001-02 STN data. For the multiplier to create OCM, generic values are usually taken from the literature; but in reality vary with the mix of particulate OC compounds and could therefore vary by location, season and even day. To estimate FRM PM2.5 (retained on Teflon with typically higher face velocity), different adjustments are probably needed. This poster provides estimates of TCM by material balance with FRM mass and its non-C components. These “SANDWICH” results are compared to measurement derived TCM. Trends in STN blank values are also considered.

Sources of error in TCM =k(OC-b)+EC*

- **Analytical uncertainty**
- **Blank correction** to account for positive sampling artifact
  - With STN field blanks, no dynamic back up filters.
  - Differs among urban STN speciation samplers

STN sampler	24-hr sample Volume(m^3)	Network Average Total Carbon on STN Blank Filters*	
		ug C/ filter	ug C/m^3
MetOne (SASS)	9.6	14.8	1.5
Anderson (RAAS)	10.4	13.5	1.3
R&P 2300	14.4	16.1	1.1
URG (MASS)	24	7.7	0.3

*Network-wide values from 2001-02 data as reported by RTI and previously used by EPA to adjust OC

- **Conversion of OC to OC mass (OCM)** (± 33%)
  - 1.4 < k < 1.8 ("typical" urban) *ref: Turpin (2001)*
  - 2.0 < k < 2.4 ("typical" rural)
    - Weighted average needed for mixed urban/regional aerosol
  - Turpin's revised estimates based on limited speciation data
- **OC- EC split** (and unaccounted mass for “EC”)
- **Retained carbon mass on FRM Teflon vs STN quartz**
  - Less volatile OC may be retained on Teflon **
  - Water [= ~10-24% of PM2.5 water]

** Volatile OC can vary by location and sampling day. Retained particulate OC depends on filter face velocity.

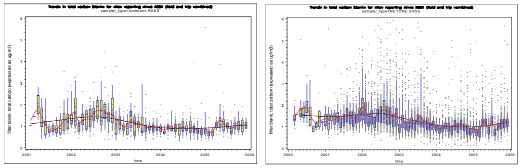
"SANDWICH“ Approach

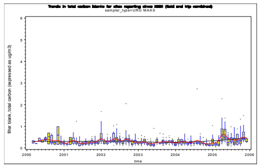
- Sulfate, Adjusted Nitrate, Derived Water, Inferred Carbonaceous mass Hybrid material balance approach
- TCMmb = PM2.5 - { [SO4] + [NO3FRM] +[NH4] +[water] + [Crustal] + [FRM blank]}
- OCMmb = [TCMmb] – [EC]
- Water and reduced FRM NO3 are estimated by models.
- Other PM2.5 constituents eg. salt, could also be considered
- TCMmb explicitly accounts for positive and negative sampling artifacts, OC hydration, and mass multipliers for carbonaceous material retained on FRM Teflon.
- TCMmb is upper estimate for TCM and is subject to error in non-C components.

Reference: Frank, N. Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities, *J. Air & Waste Manage. Assoc.* **56**: 500–511 (2006)

Nov 1, 2006 Email: frank.neil@epa.gov

Trends in STN TC field blanks





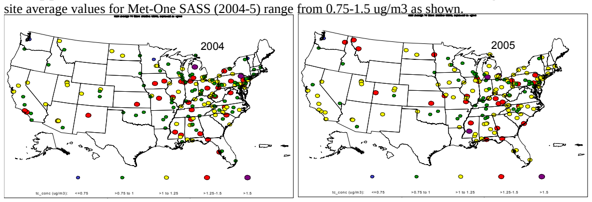
Average Total Carbon Blank by year, ug/m3

Sampler	sites	2001	2002	2003	2004	2005
Anderson RASS	22	1.19	1.50	1.03	0.90	0.99
METONE SASS	140	1.53	1.63	1.21	1.01	1.09
URG MAAS	5	0.29	0.34	0.25	0.26	0.43

Since 2002, STN field and trip blanks values for SASS and RAAS samplers have decreased 33% and values for MASS samplers have increased 25%. Reasons for the change are not known at this time

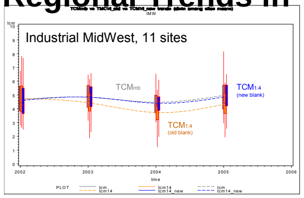
Site Specific Differences in STN Field Blanks

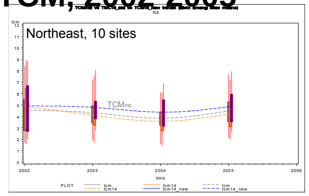
No apparent consistent difference in TC field blank values among sites. Most site average values for Met-One SASS (2004-5) range from 0.75-1.5 ug/m3 as shown.

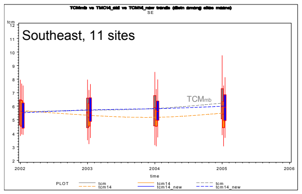


Similarly, no apparent pattern was observed among TC field blank values by calendar quarter (preliminary analysis). Due to large within-site and between year variability and few samples, multi-year network-wide values seem reasonable to use.

Regional Trends in TCM, 2002-2005

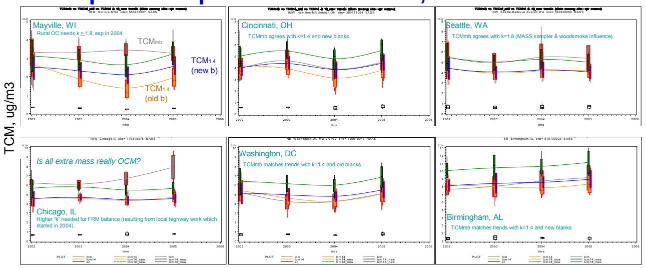




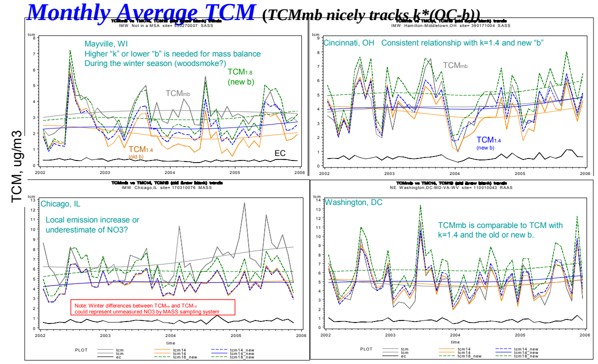


Regional average values of TCM agree well with k*(OC-b) using k=1.4 and year specific b values. For some US Regions and sites, the old b values seem better. The successful choice of k to represent retained FRM mass (on Teflon) appears to depend on the selected value for “b”. The value for “k” may also depend on the particular thermal analytical technique and OC-EC split. Distribution of site-quarterly averages of TCM are shown.

Example Site-Specific TCM Trends, 2002-2005



Monthly Average TCM (TCMmb nicely tracks k*(OC-b))



Summary and Next Steps

***Inferred carbon by mass balance** (TCMmb, using SANDWICH)*

- Directly accounts for
  - Adsorbed organic gases and carbon-particle water (positive artifacts)
  - Volatilized OC and other carbonaceous particles not retained on Teflon (negative artifacts);
  - Total FRM mass associated with carbon.
- Eliminates need for blank corrections or site/season-specific multipliers to account for non-carbon elements associated with measured organic or elemental carbon.
- Can be used to corroborate measurement derived carbon mass and visa versa.

Comparison of TCMmb with k*(OC-b)+EC

- The correct combination of “k” and “b” is critical for calculating TCM from measurement data.
  - With STN’s Met One (SASS) and Anderson (RAAS) data in urban sampling environments, TCMmb generally agrees best with k=1.4 and year specific blank corrections. Assuming that k=1.8 would be more appropriate for a mixed urban-regional aerosol, then higher blank correction (b) would be needed to maintain mass balance. This suggests that backup filters behind Teflon might record higher values than quartz field blanks .
  - For sites with the URG MASS sampler, higher “k” appears to be needed. This is consistent with published values. Data from these higher flow rate samplers require smaller blank correction & are more sensitive to “k” for calculating mass.

Next Steps

- For national consistency in ambient carbon monitoring, EPA is switching the STN carbon protocol to the IMPROVE method. STN’s new IMPROVE like samplers (22 Lpm flow rate) to be phased in over three years will also likely have less carbon sampling artifact than current STN data from SASS and RAAS samplers.
- EPA has funded DRI to recommend procedures to estimate sampling artifact for the new urban samplers (using backup filters) and to develop appropriate factors for estimating