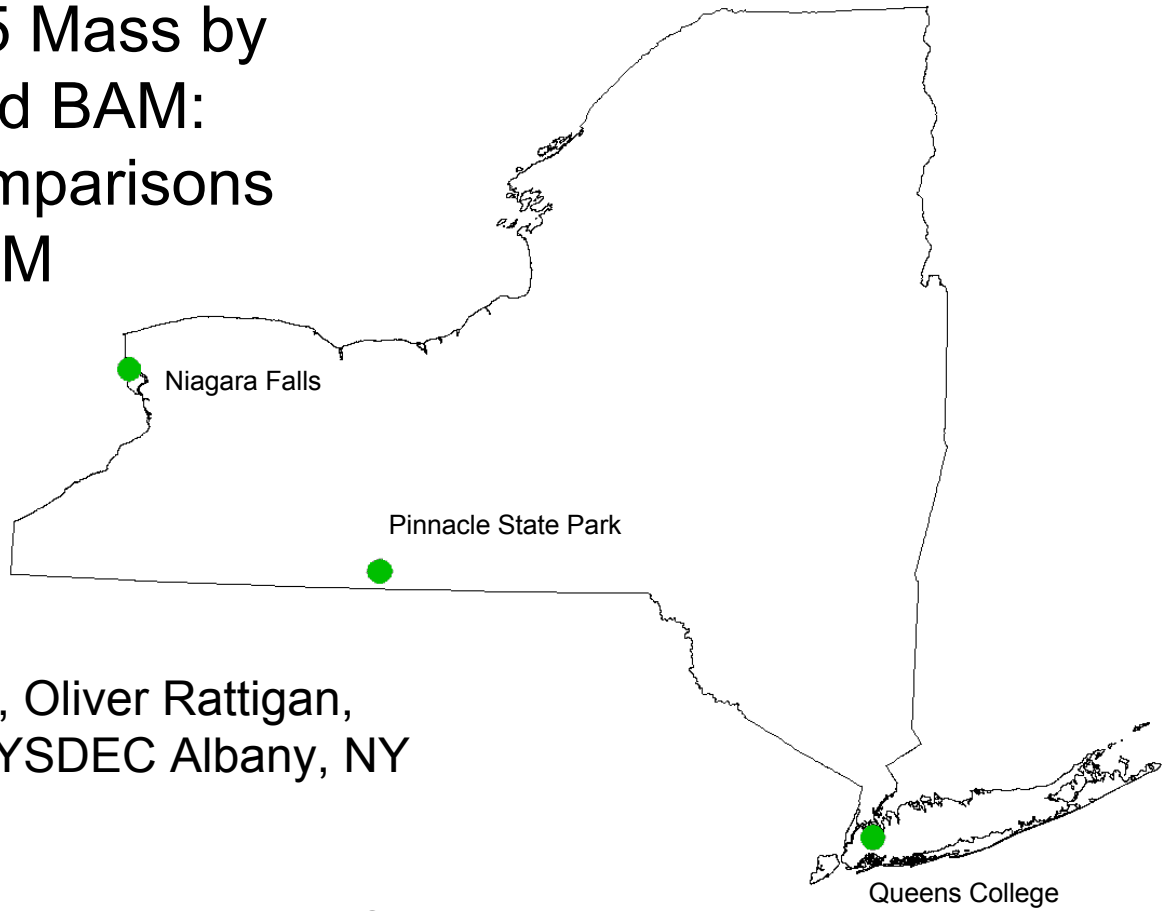
New York State Urban and Rural Measurements of Continuous PM-2.5 Mass by FDMS TEOM and BAM: Evaluation and Comparisons with the FRM



Dirk Felton, Oliver Rattigan,
NYSDEC Albany, NY

Kenneth Demerjian, James Schwab
SUNYA-ASRC Albany, NY

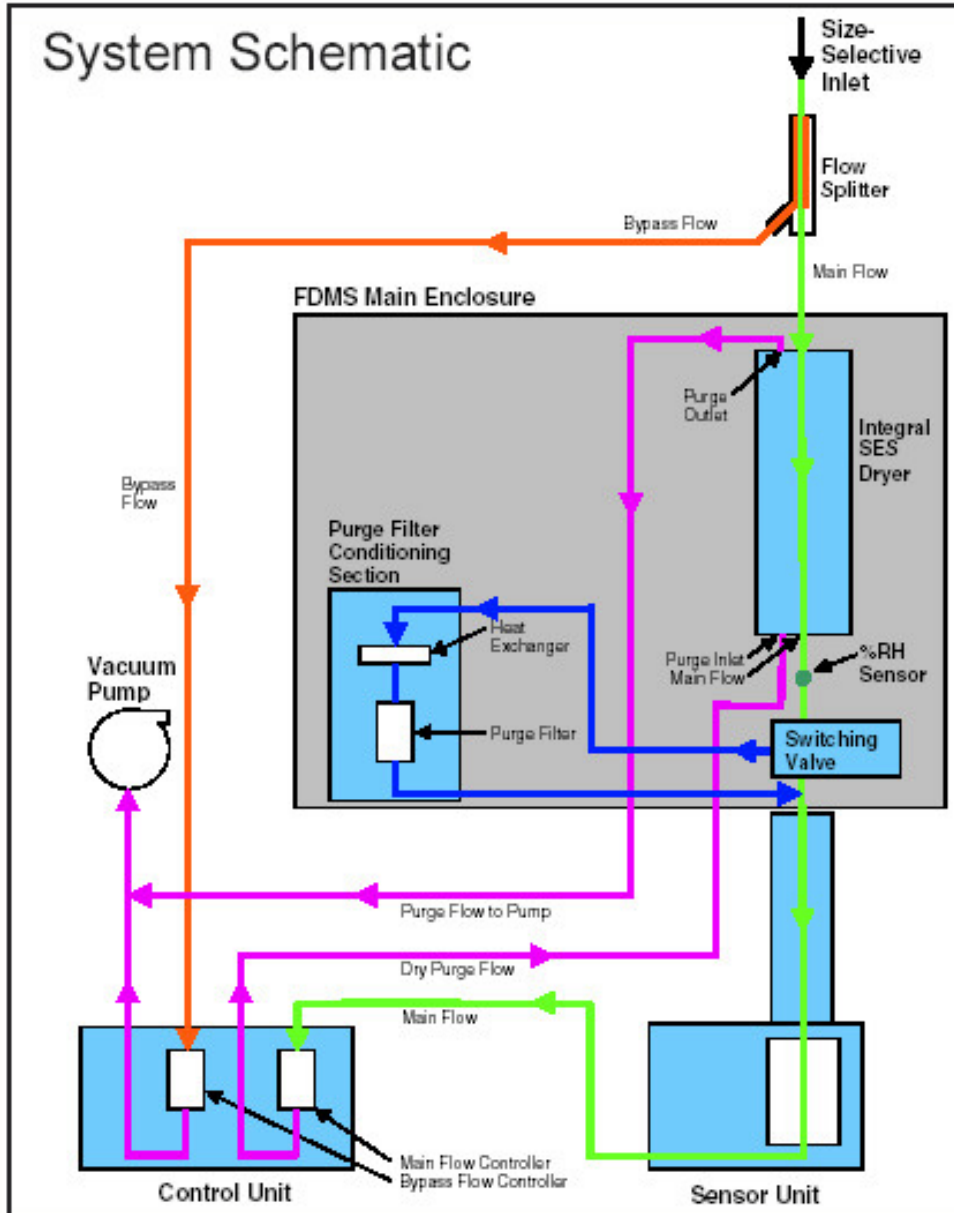
2005 AAAR Meeting February 7-11, 2005 Atlanta, Ga.

R&P F D M S 8500

F Filter
D Dynamic
M Measurement
S System

The 3 FDMS TEOMs and two BAMs operate in outdoor enclosures.

System Schematic



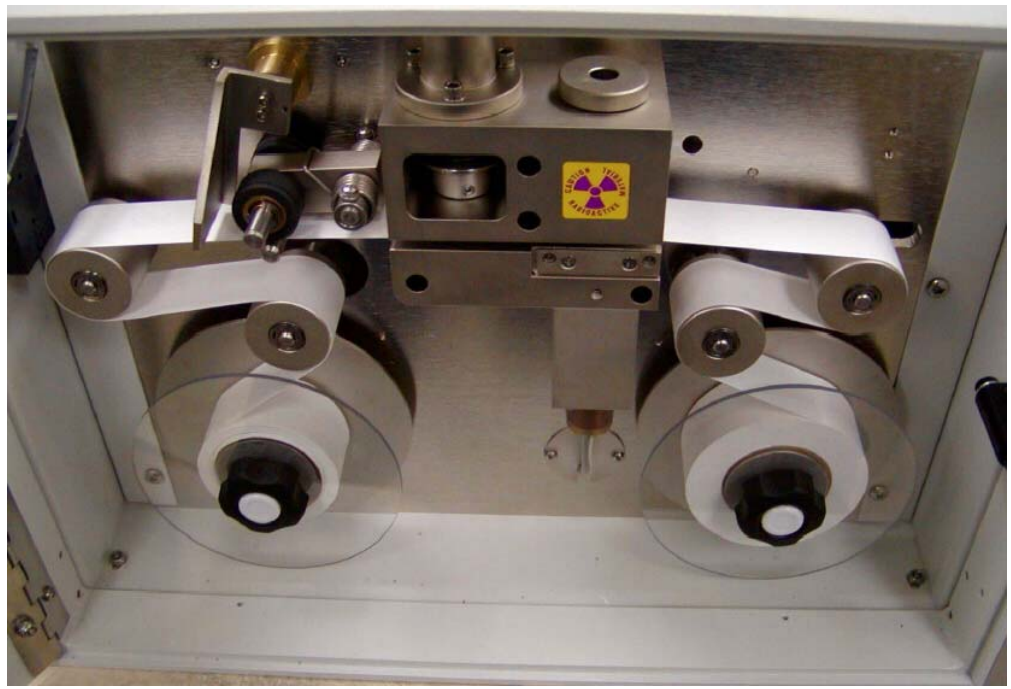
FDMS Main Enclosure.

Exchange of Purge Filter.

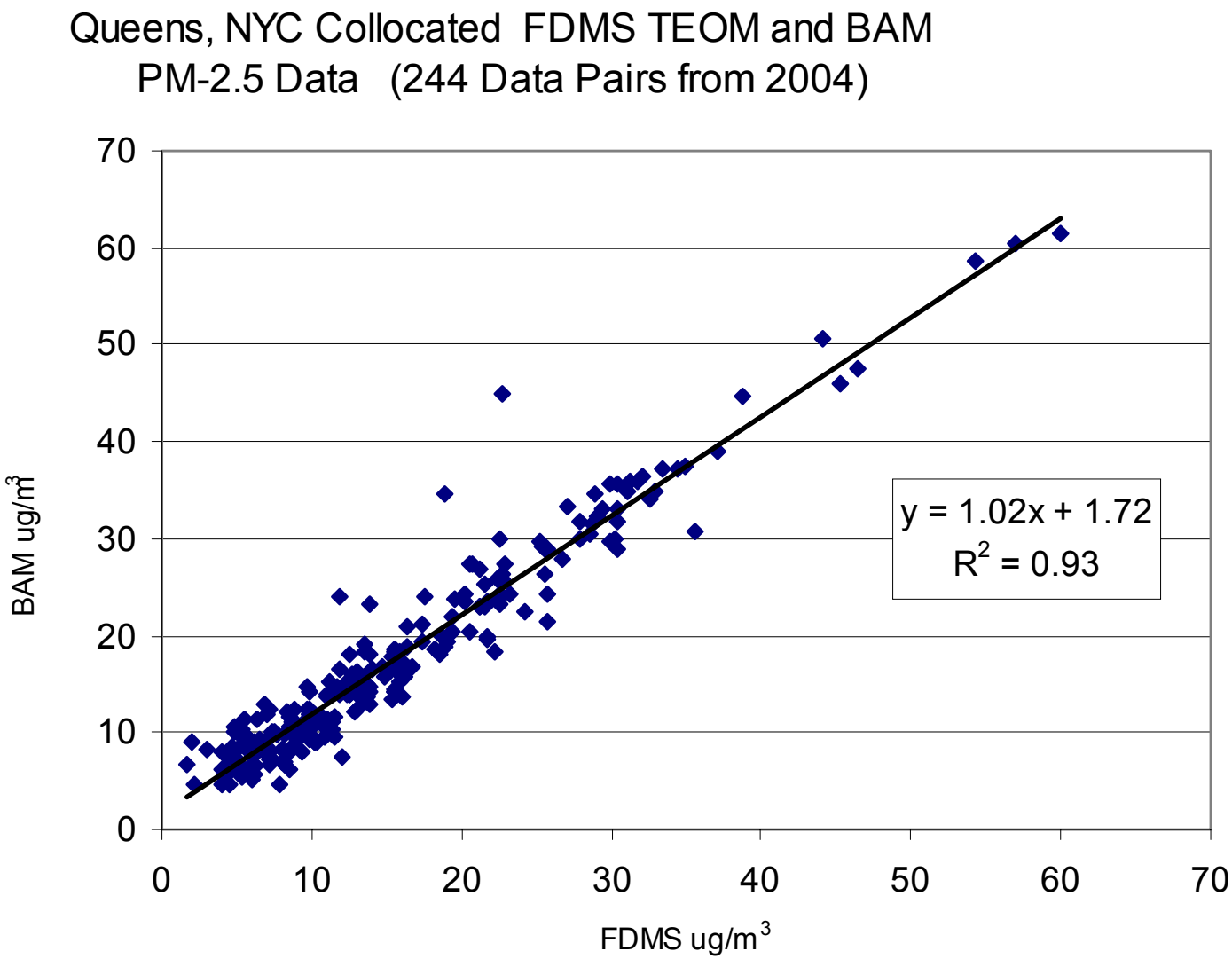
Met One Beta Attenuation Monitor (BAM)
Model 1020 with “Smart Heater”

The shelter is not air conditioned. The shelter heat is only used below 4 or 5 deg C.

“Smart Heater”: This is a canister style heater on the inlet tube.

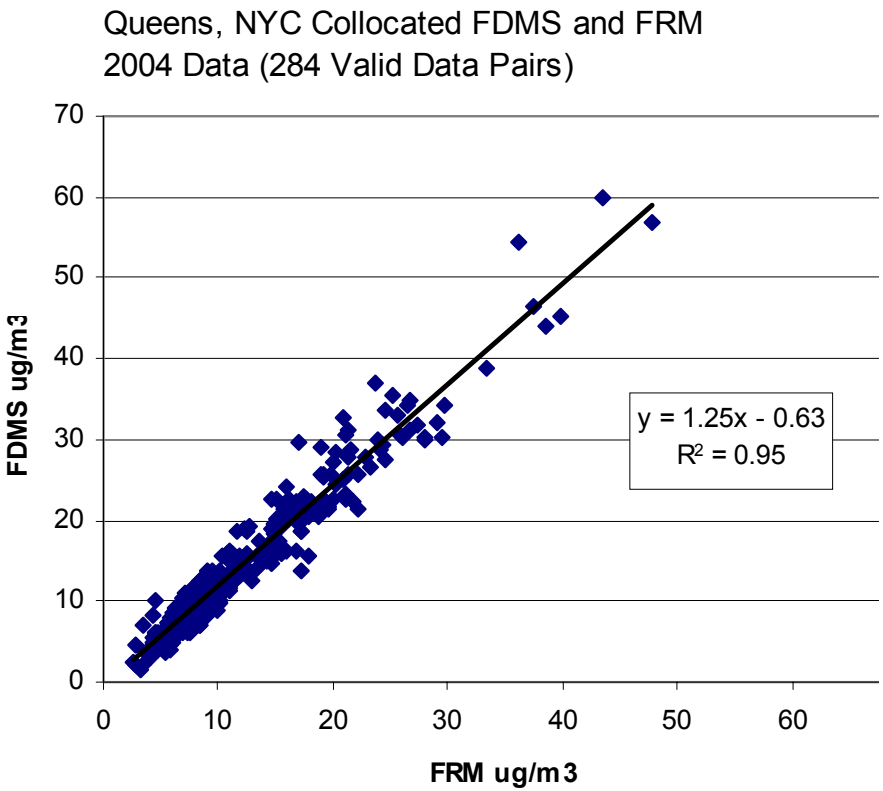


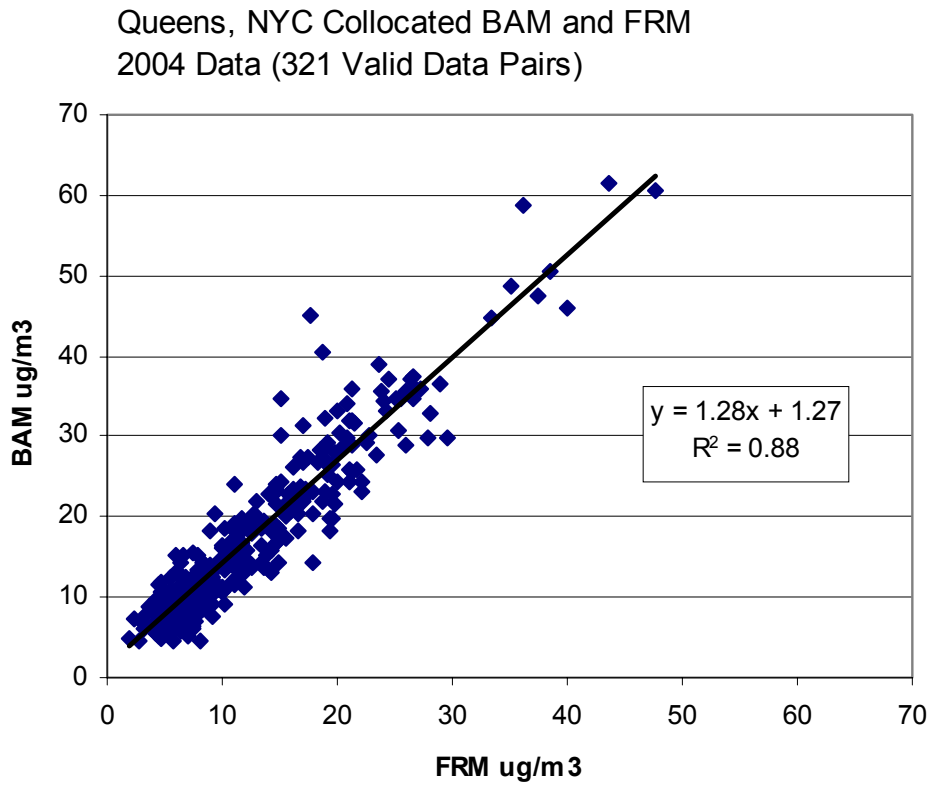
The urban comparison between the FDMS and the BAM.
The BAM has a significant positive offset when compared to the FDMS.



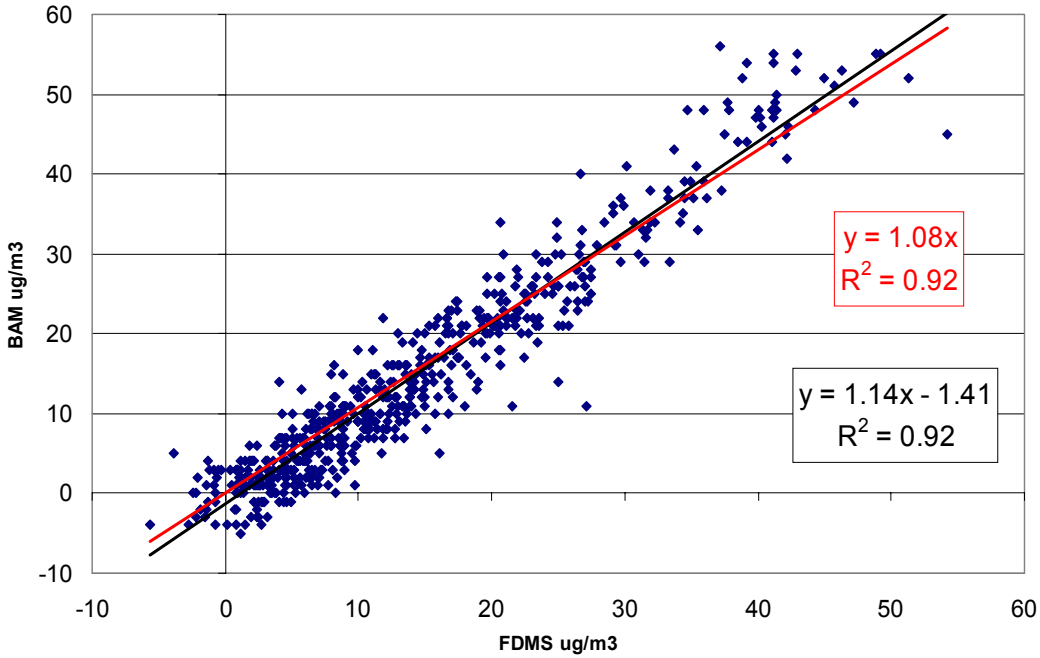
The urban (NorthEast) comparisons between the continuous instruments and the FRM.

Both the FDMS and the BAM measure significantly more mass than the FRM.
The data from the BAM with Quartz tape is slightly more scattered than the FDMS.



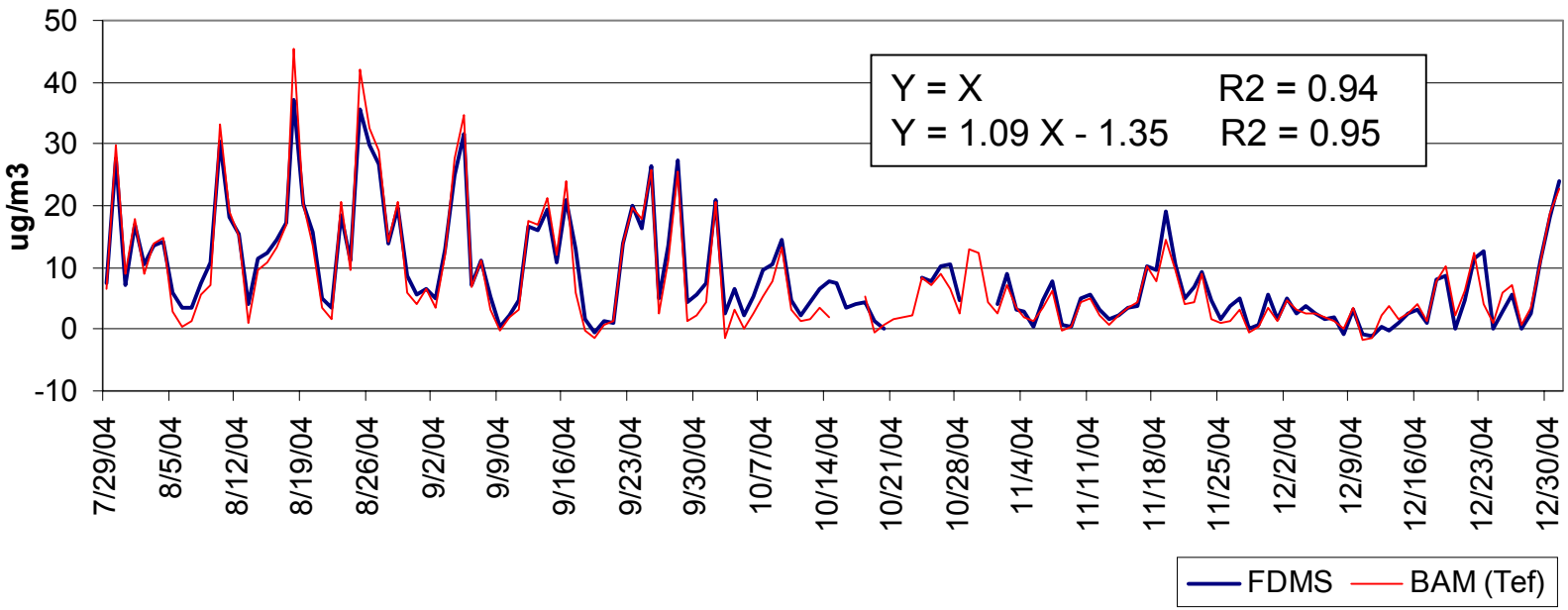


Pinnacle State Park, NY Collocated FDMS vs BAM (Teflon)
Aug 22 to Sep 15 2004 (Hourly Data)

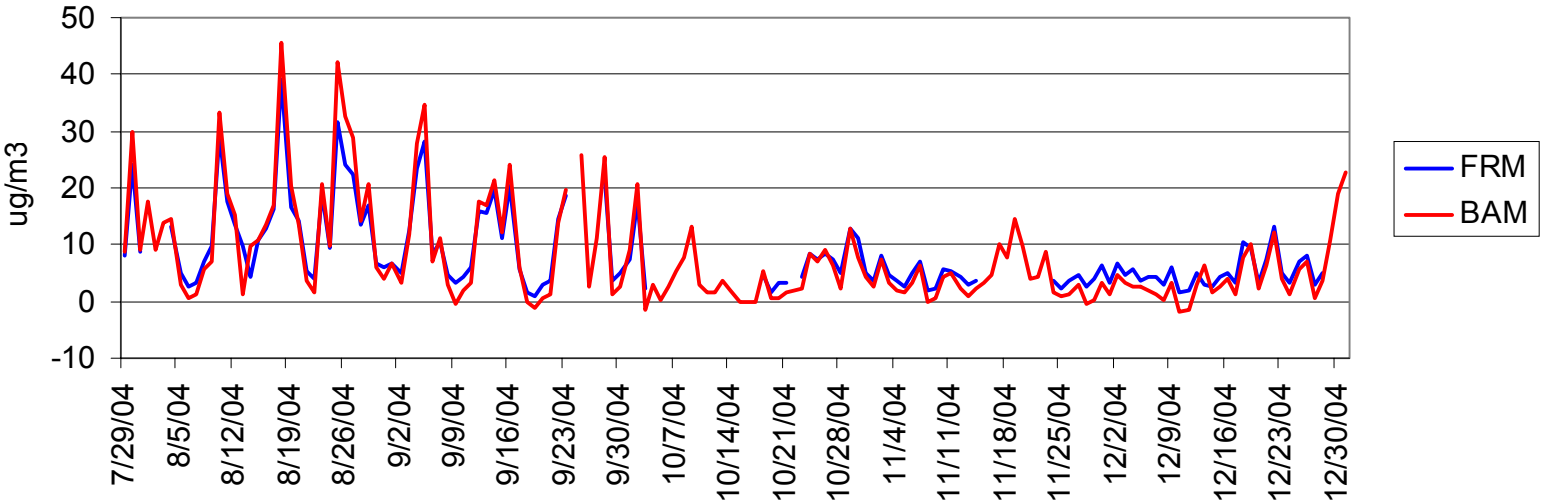


At the rural site:
The BAM with Teflon sampling tape reads higher than the FDMS on high conc. days and lower than the FDMS on low conc. days.

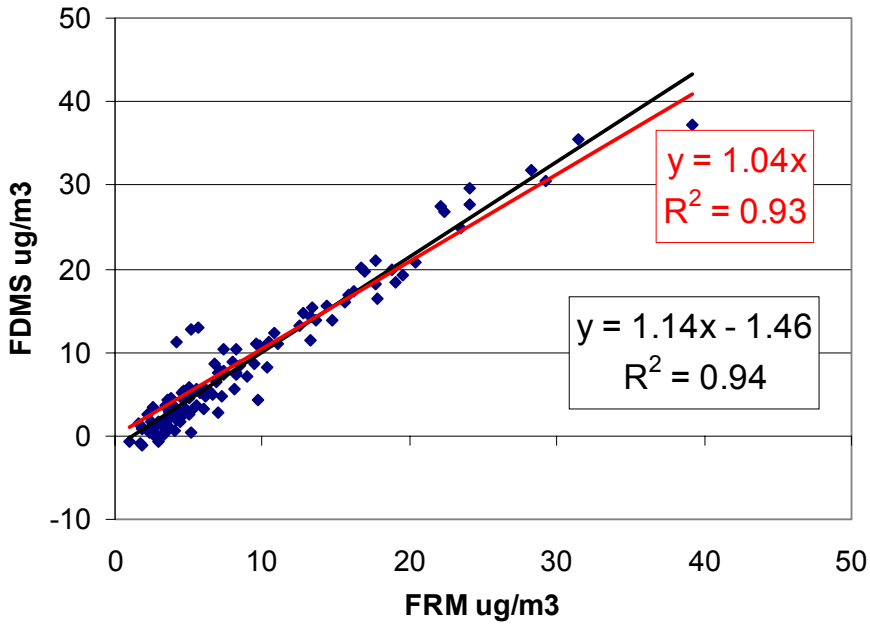
The BAM also has a significant amount of below zero data and a significant y-intercept.



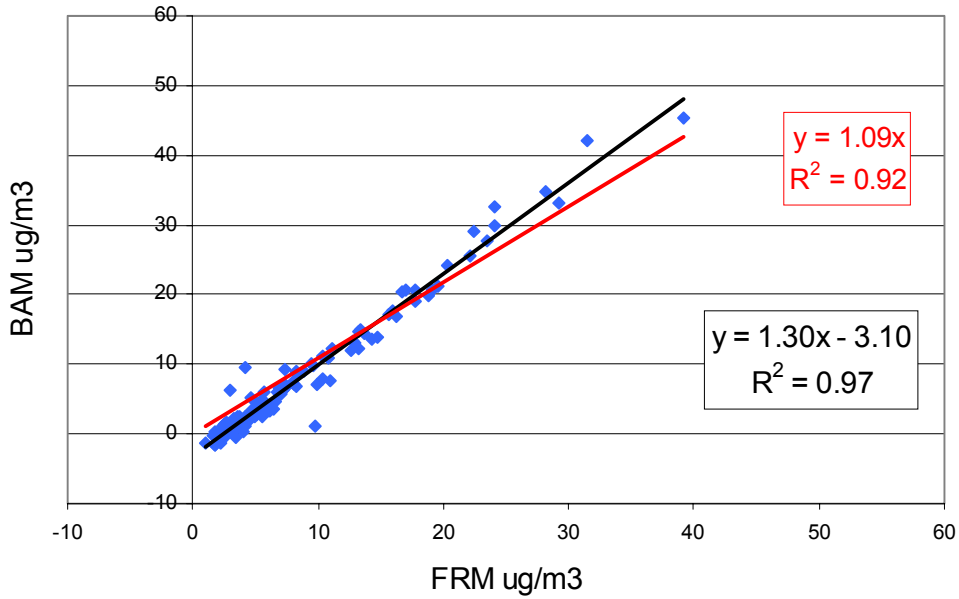
Pinnacle State Park Time Series BAM (Teflon) and FRM
Fall 2004



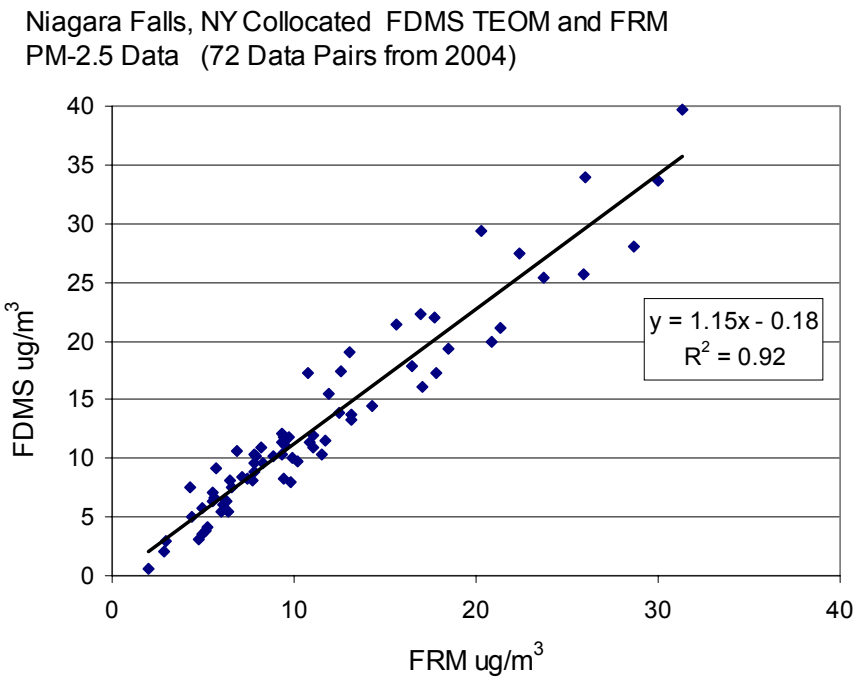
Pinnacle State Park, NY Collocated FDMS vs FRM
July - Dec 2004 (123 Pairs) (24-Hr Ave. Data)

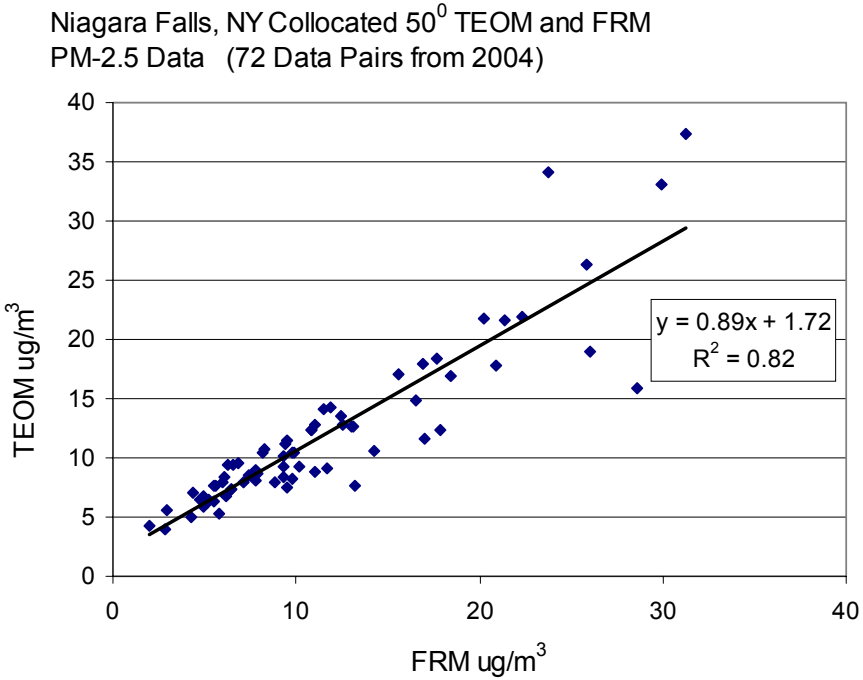


Pinnacle State Park BAM (Teflon) vs FRM
Fall 2004 (122 Valid Data Pairs)



Niagara Falls: Industry and transport dominated site (FDMS, 50 Deg C TEOM and an FRM)





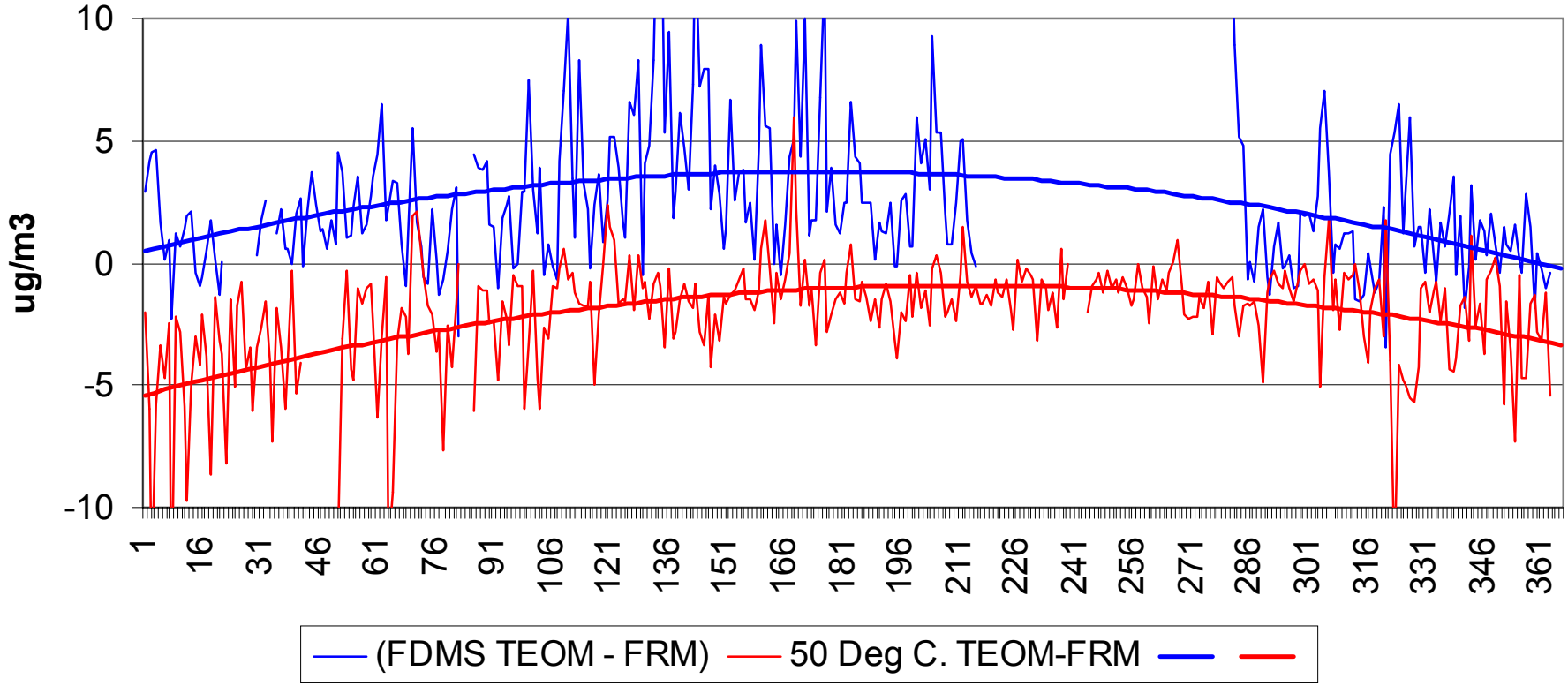
The FDMS and the 50 Deg C TEOM show considerably more scatter at this site. It may be that the natural variability of the industrial sources combined with transport and colder weather make for a more difficult monitoring environment.

Three Site Summary:

		R^2	Pairs
Urban: Queens	FDMS = 1.25 (FRM) - 0.63	0.95	284
	BAM_Q = 1.28 (FRM) + 1.27	0.88	321
Rural: Pinnacle State Park	FDMS = 1.14 (FRM) - 1.46	0.94	123
	BAM_T = 1.30 (FRM) - 3.10	0.97	122
Industrial: Niagara Falls	FDMS = 1.15 (FRM) + 1.72	0.92	72

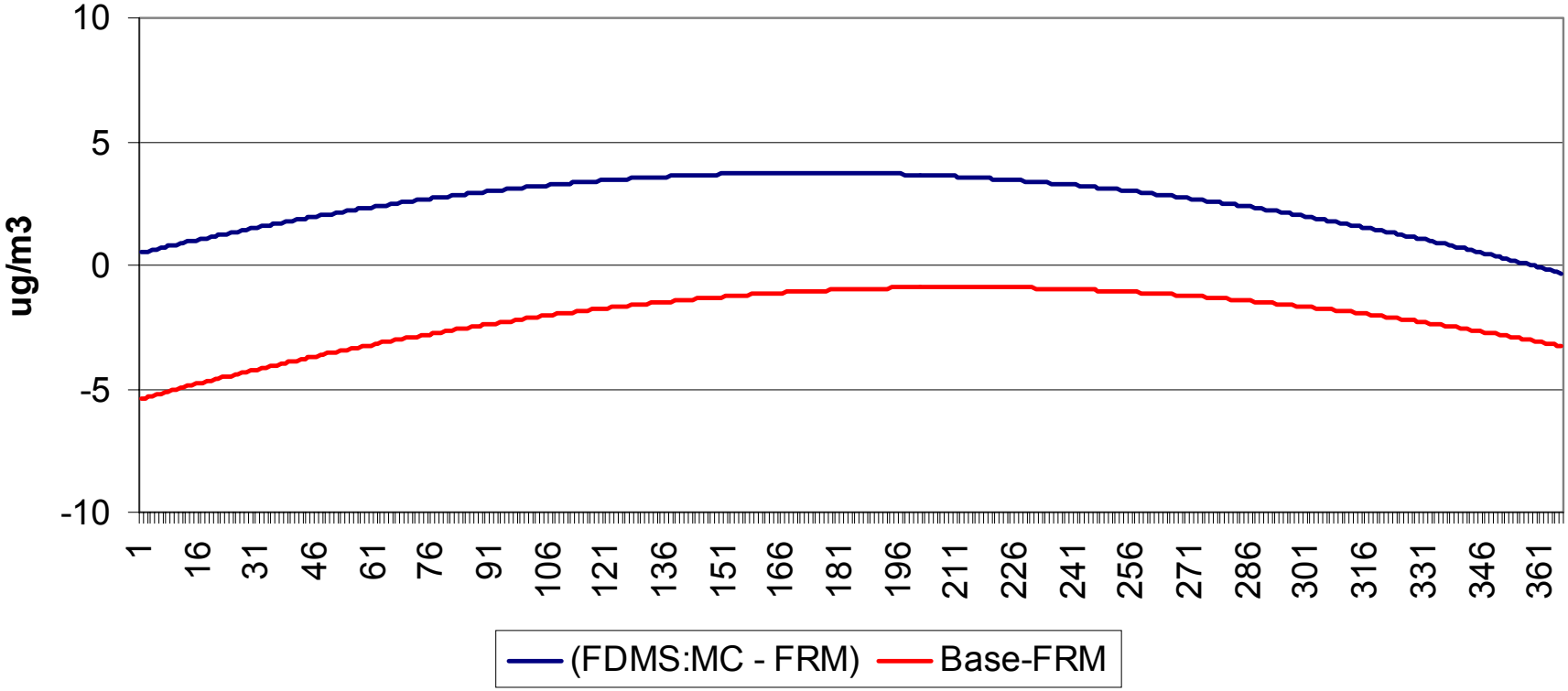
The FDMS and the BAM read higher than the FRM particularly in urban areas that have higher volatile mass concentrations.

Queens, NYC (FDMS TEOM and 50^0 C. TEOM-FRM)
2004, Subtraction of Daily Averages

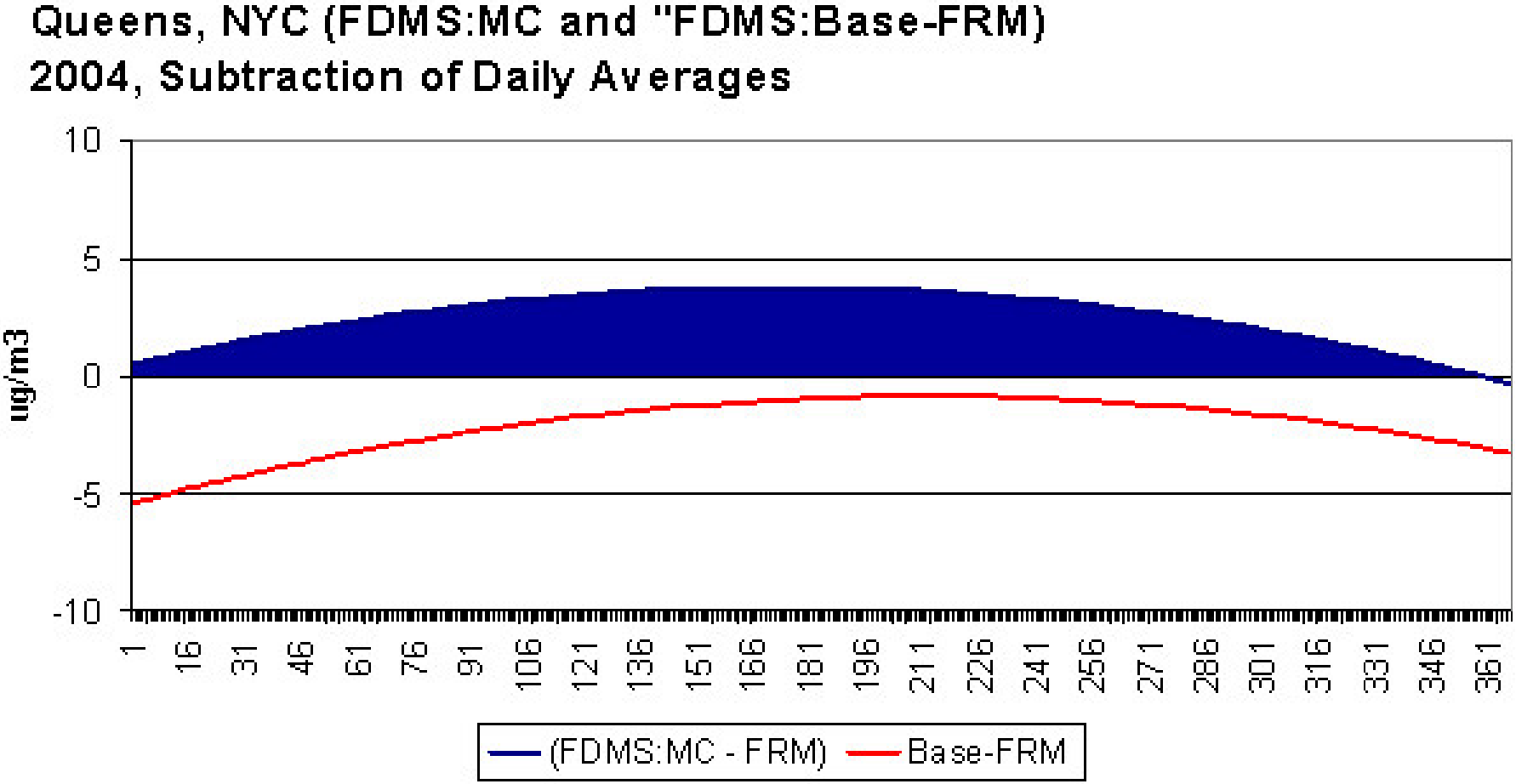


2nd Order Polynomials can be fitted to the daily difference between the FDMS and the FRM and between the 50 Deg C TEOM and the FRM. This is a good way to look at the seasonal bias between instruments.

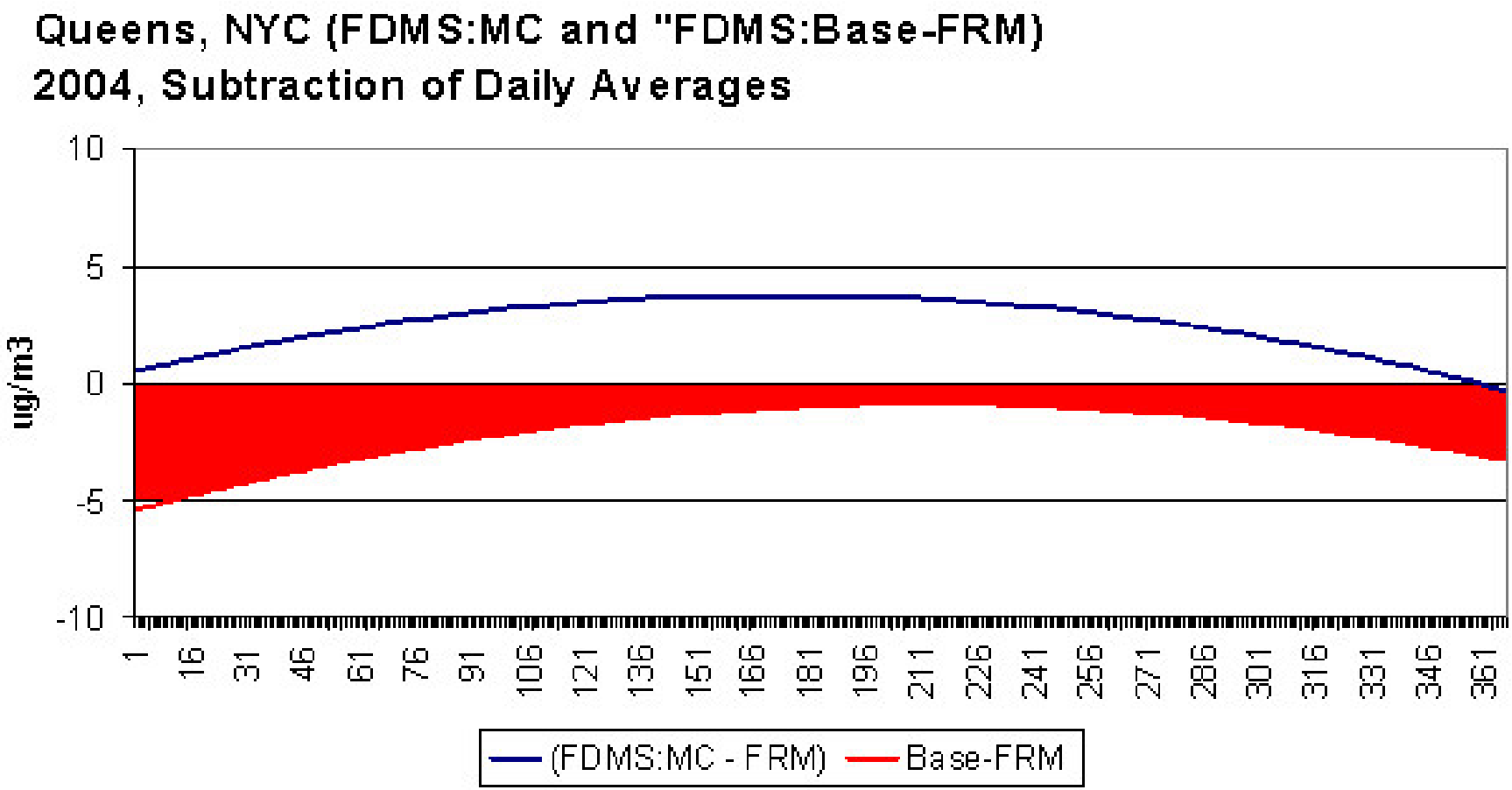
Queens, NYC (FDMS:MC and "FDMS:Base-FRM)
2004, Subtraction of Daily Averages



If we had a perfect “FRM-like” continuous mass monitor it would be represented by a horizontal line near zero.



The Blue shaded area represents mass that is not retained by the FRM but is retained by the FDMS.

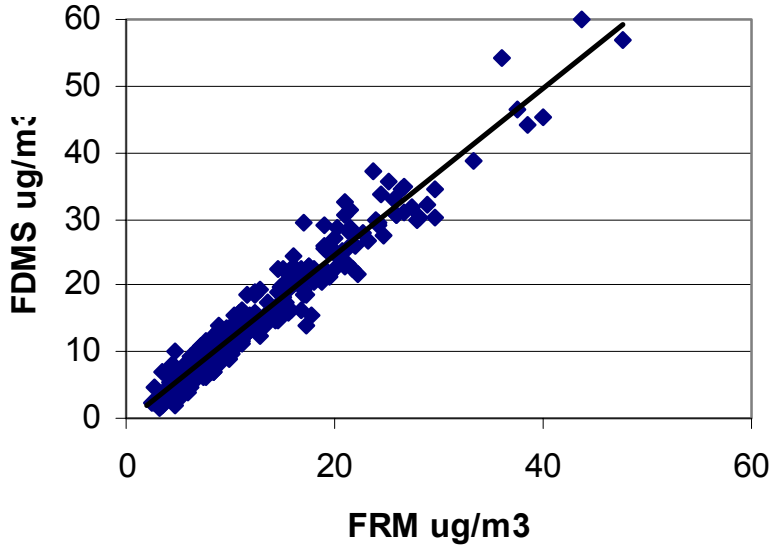


The red shaded area represents mass that is not retained by the FDMS BASE measurement (or 50 Deg C TEOM) but is retained by the FRM.

FDMS:MC vs FRM

$y = 1.25x - 0.66$

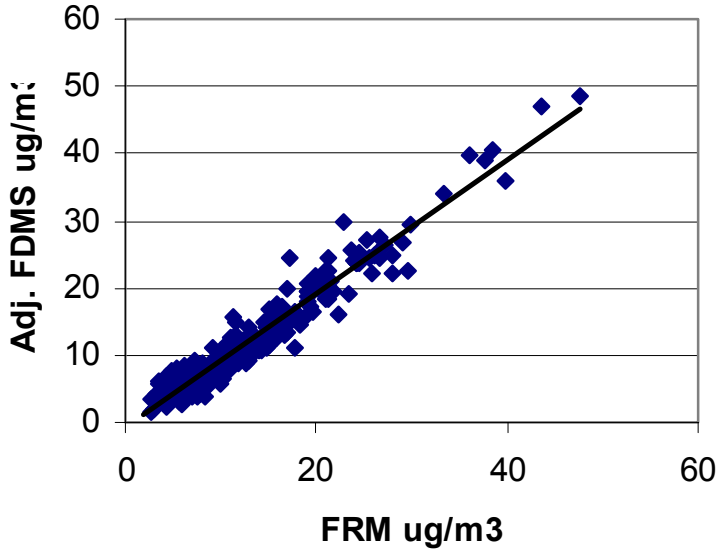
$R^2 = 0.95$



Adj. FDMS:MC vs FRM

$y = 1.00x - 0.82$

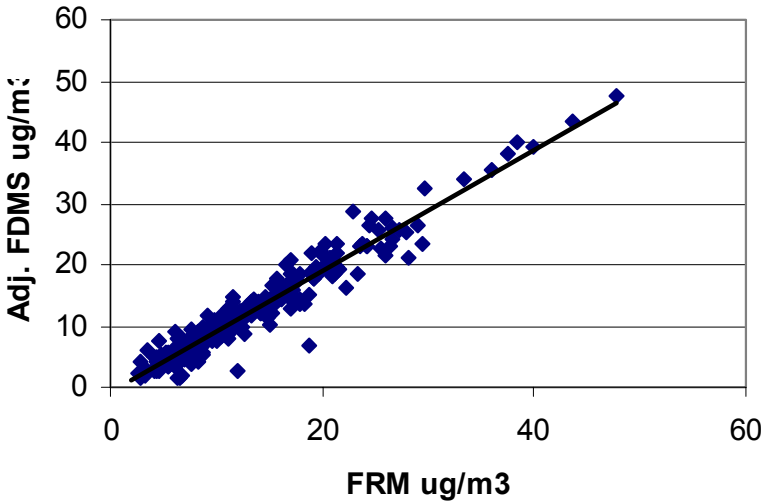
$R^2 = 0.94$



FDMS Hr Adj TEOM to FRM

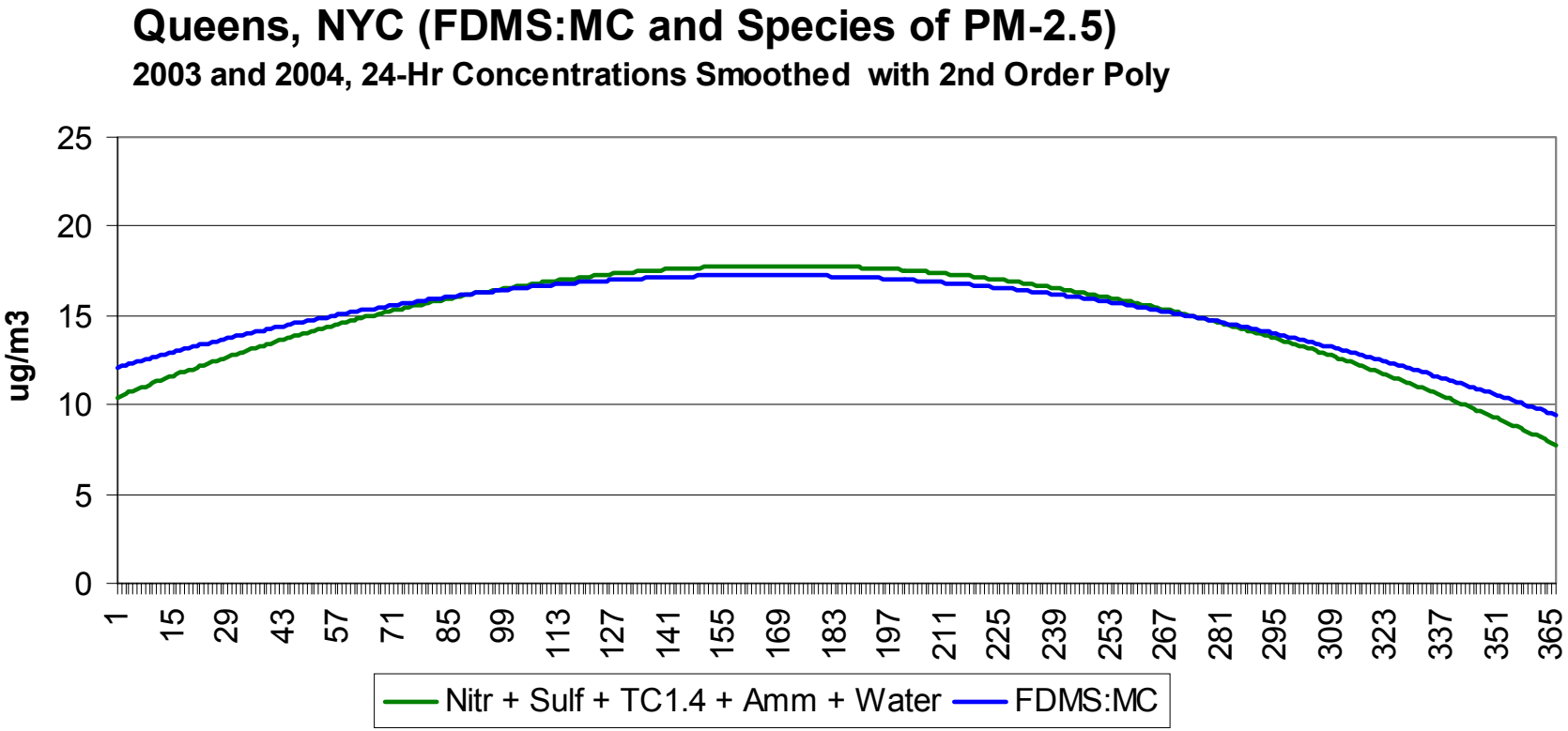
$y = 0.99x - 0.72$

$R^2 = 0.94$



FDMS data can be adjusted to match the FRM using the relationship between the BASE and the REFERENCE channel or between the FDMS:MC and a 50 Deg C TEOM.

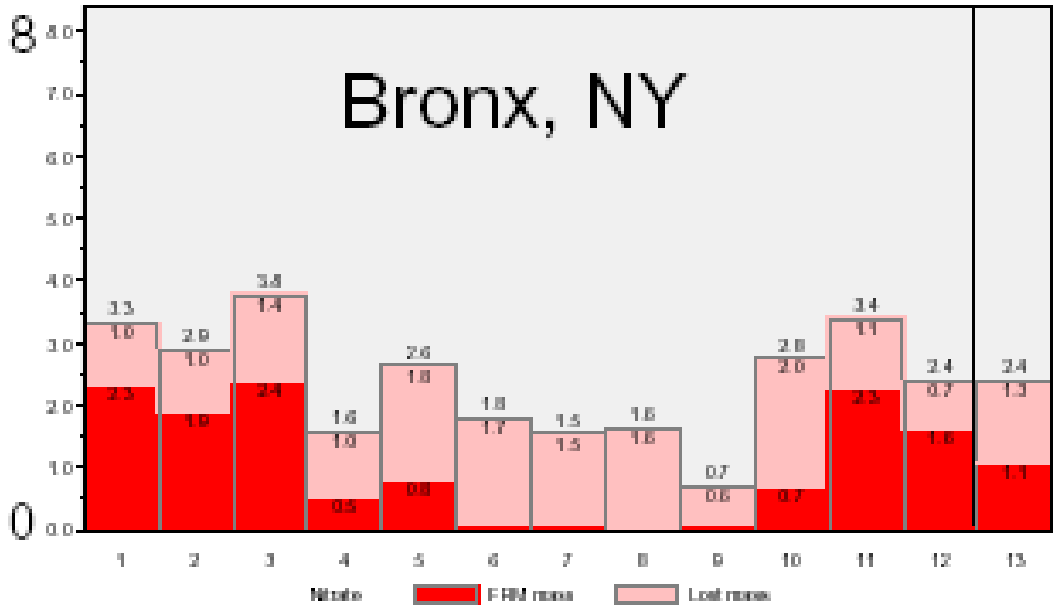
The Species that make up the FDMS:MC measurement can be derived from adjusted STN measurements.

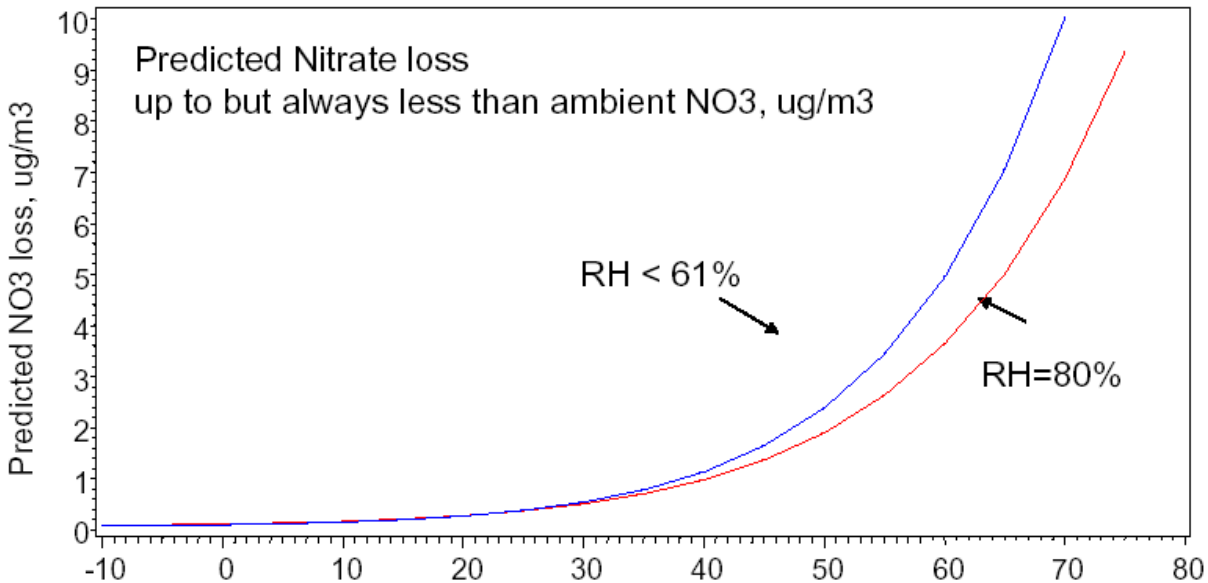


Nitrate: As reported by STN

OC: Multiplied by 1.4 and Blank Corrected (–1 ug/m3)

Water: Added from thermodynamic theory.





The NYSDEC participated in a study sponsored by the EPA to examine Nitrate retention on FRM filters.

FRM filters for calendar year 2003 were analyzed for Nitrate and the results were compared to the STN sampler.

The results helped in the development of a model to predict the %retention of Nitrate on the FRM Teflon filters vs the STN Nylon filters (with denuder).

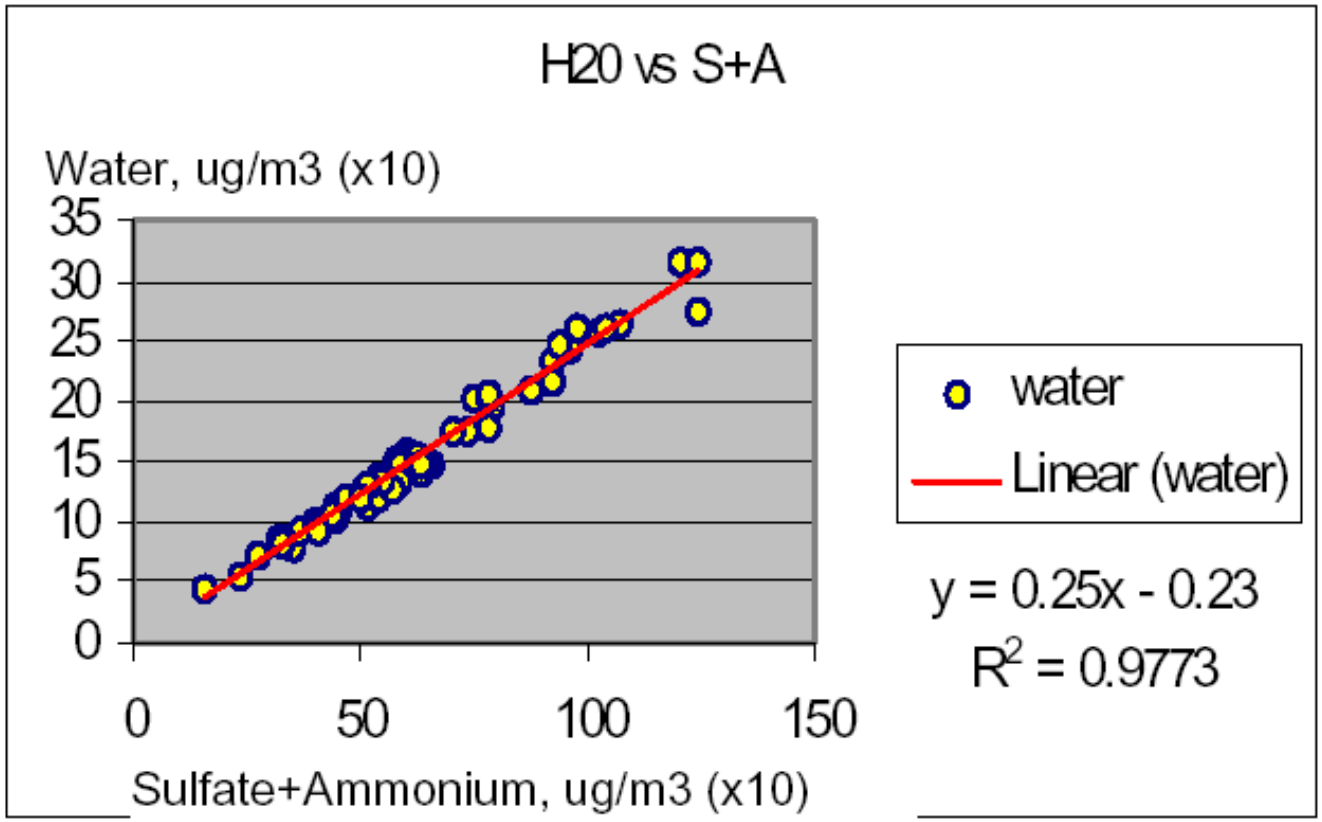
See Poster 17PD-5

References: Zhang and McMurray (1992), Mozurkewich (1993), Hering and Cass (1999), Chang et al (2000)

Estimate Water using a thermodynamic model (AIM)

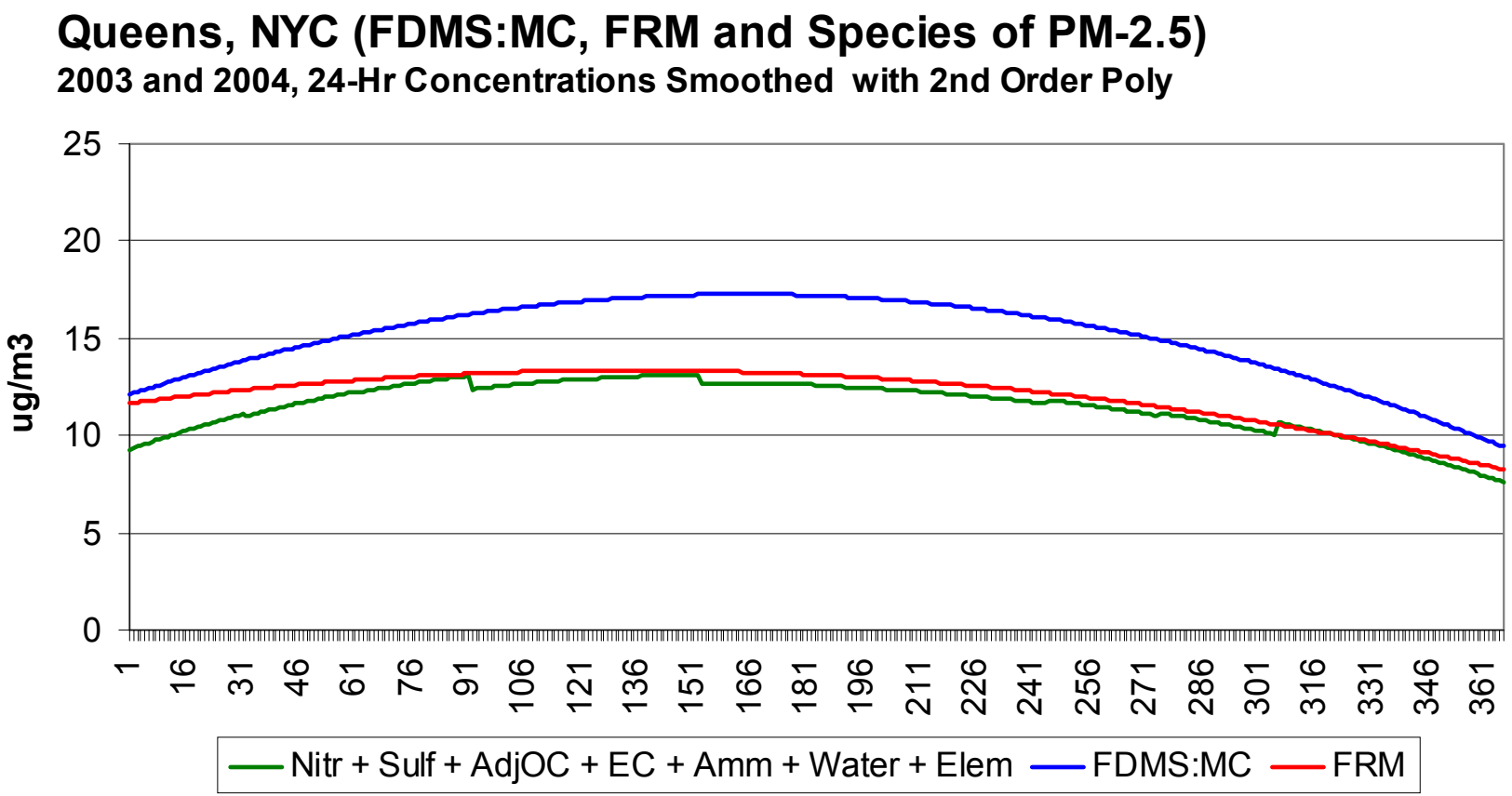
Water is approximately 25% of the sulfate + ammonium concentration

Less during periods with high nitrates



See Poster 17PD-6

The Species that make up the FRM Measurement can also be derived from adjusted STN measurements.



Nitrate: Adjusted to match 2003 Retention Study Results (by % of STN)

OC: Adjusted with Julian Day % reduction from (FDMS – FRM) vs (FRM – 50 Deg TEOM)

Water: Not adjusted (Seasonal Bias unknown) The FRM does retain water.

Conclusions:

The data from the newer continuous mass instruments can be adjusted (on average) to match the FRM for public reporting requirements.

States that will have to devise control strategies will need to know as much as possible about the volatile portion of the PM-2.5 mass, including temporal resolution and species identification.

The true value of the FDMS instrument may be its ability to provide insight into the stable vs volatile proportion of PM-2.5 mass at fairly high time resolution.

Adjusting Nitrate and Organic Carbon seasonally may be sufficient to predict the species that make up the FRM measurement.

Future Work:

Test FDMS data adjustment with 2005 data.

Look at sulfate and lagged temperature instead of the Julian Day in the relationship between the volatile mass and the FRM.

Look at OC+Nitr / EC+Sulfate hourly ratios (Sunset Labs) instead of the Julian Day in the relationship between the volatile mass and the FRM.

Look at significance of seasonal or Monthly OC blank corrections.

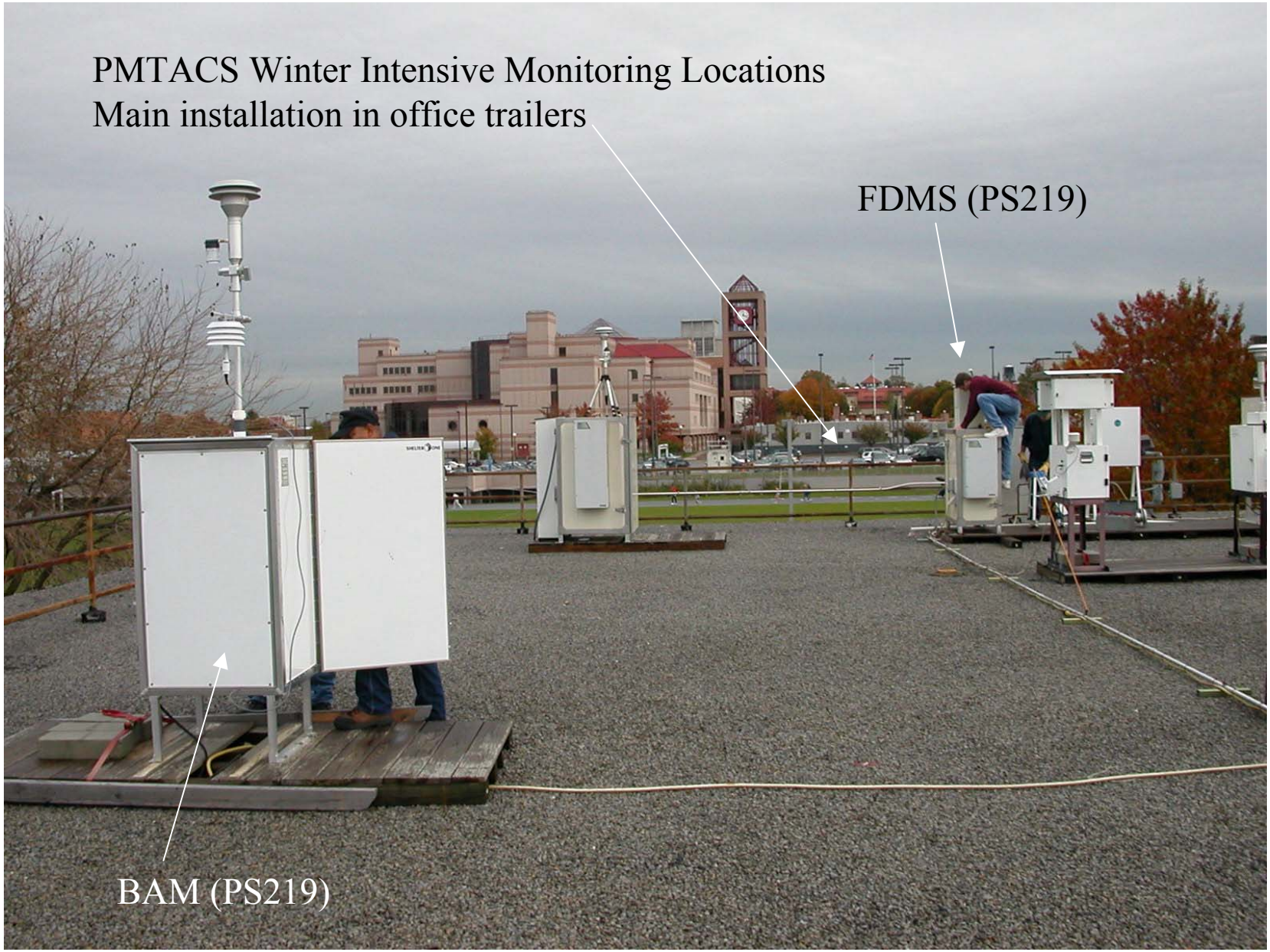
Look at the relationship between the R&P 5400 data vs the STN Carbon for the filter mass balance analysis.
The 5400 OC is collected at 50 Deg C (not volatile)

Acknowledgments

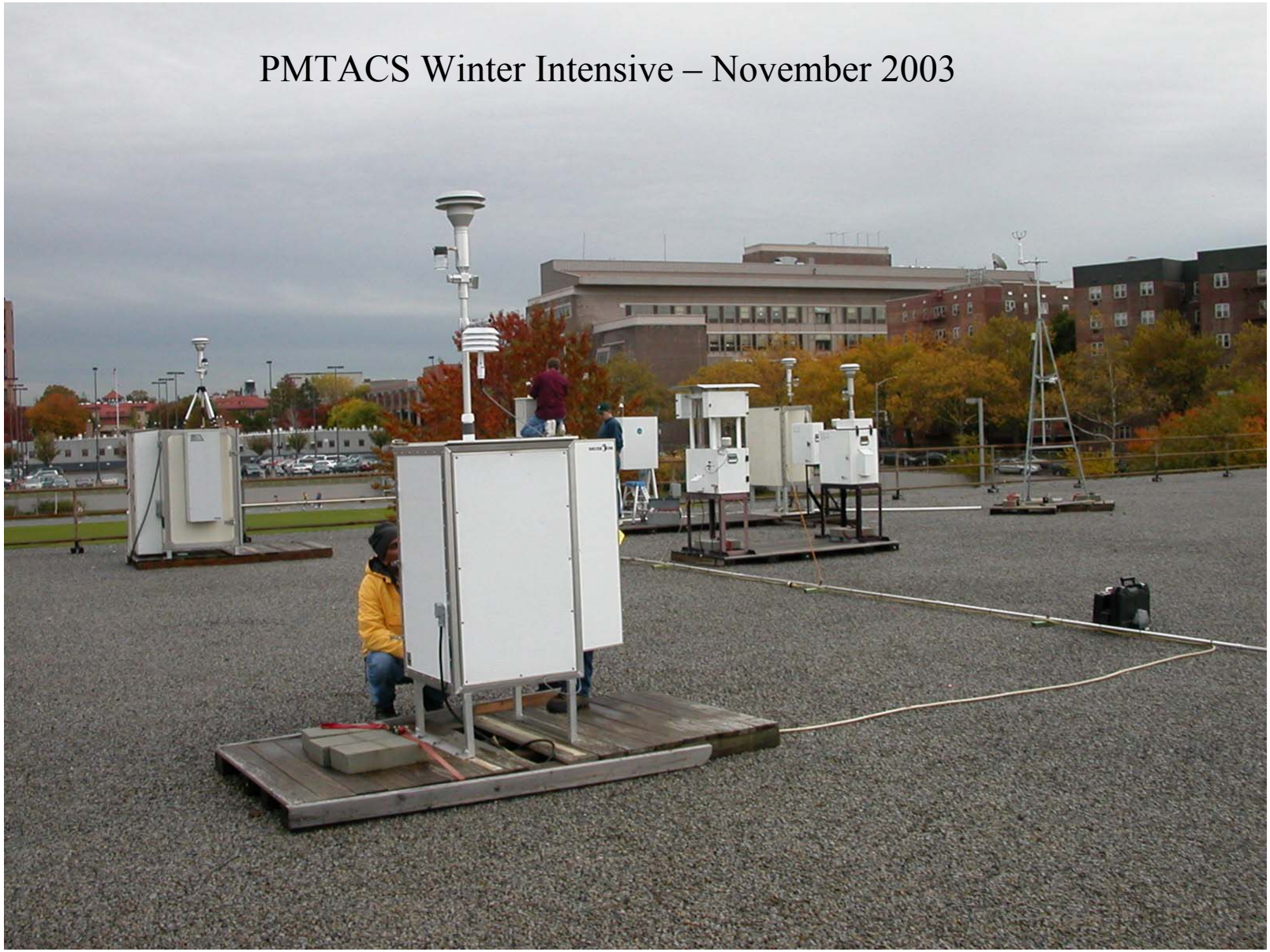
This work was supported in part by

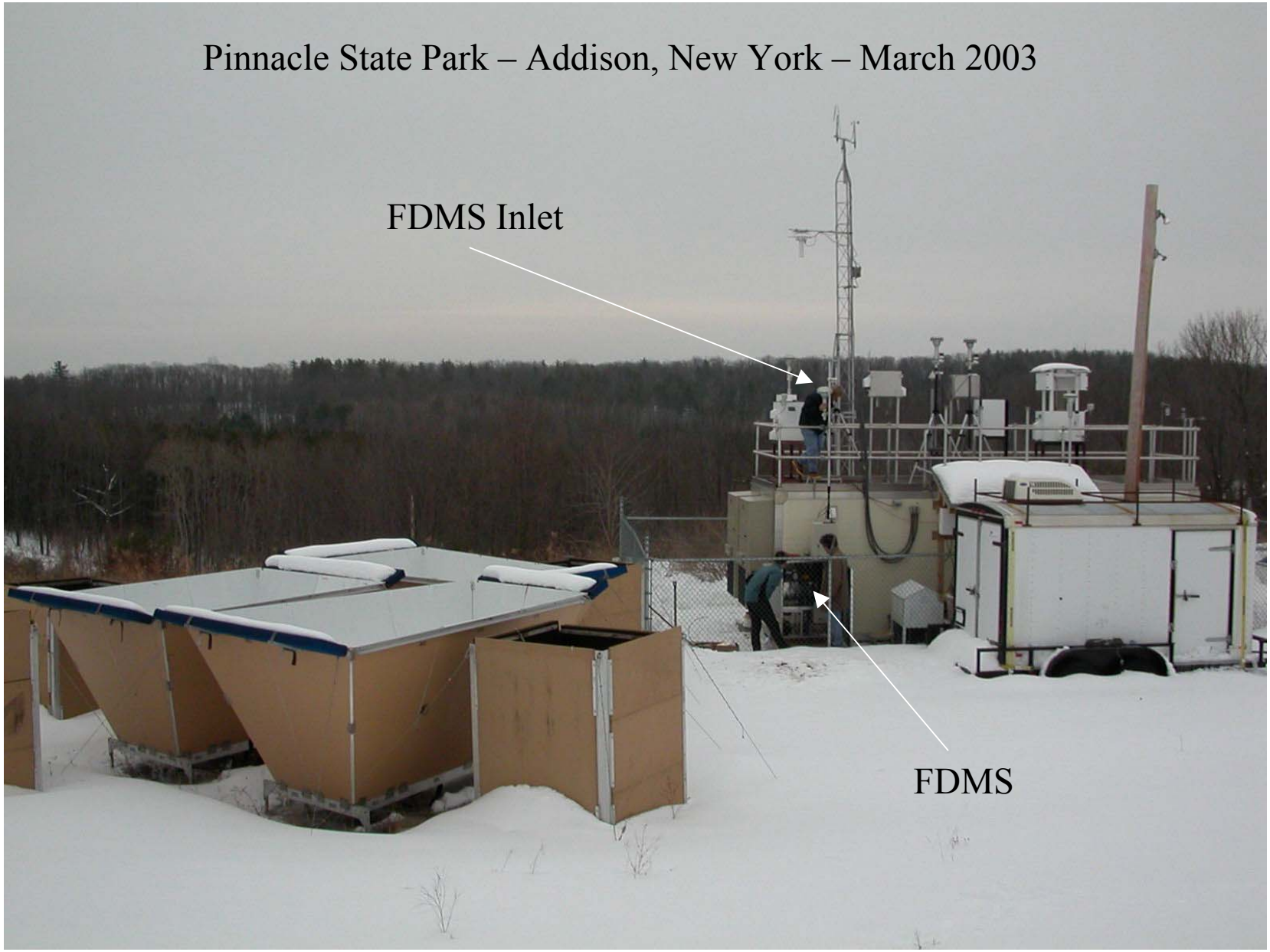
- U.S. Environmental Protection Agency (EPA) cooperative agreement # R828060010
- EPA: Neil Frank's FRM Nitrate Retention Study
- New York State Energy Research and Development Authority (NYSERDA), contract # 4918ERTERES99,
- New York State Department of Environmental Conservation (NYS DEC), contract # C004210.

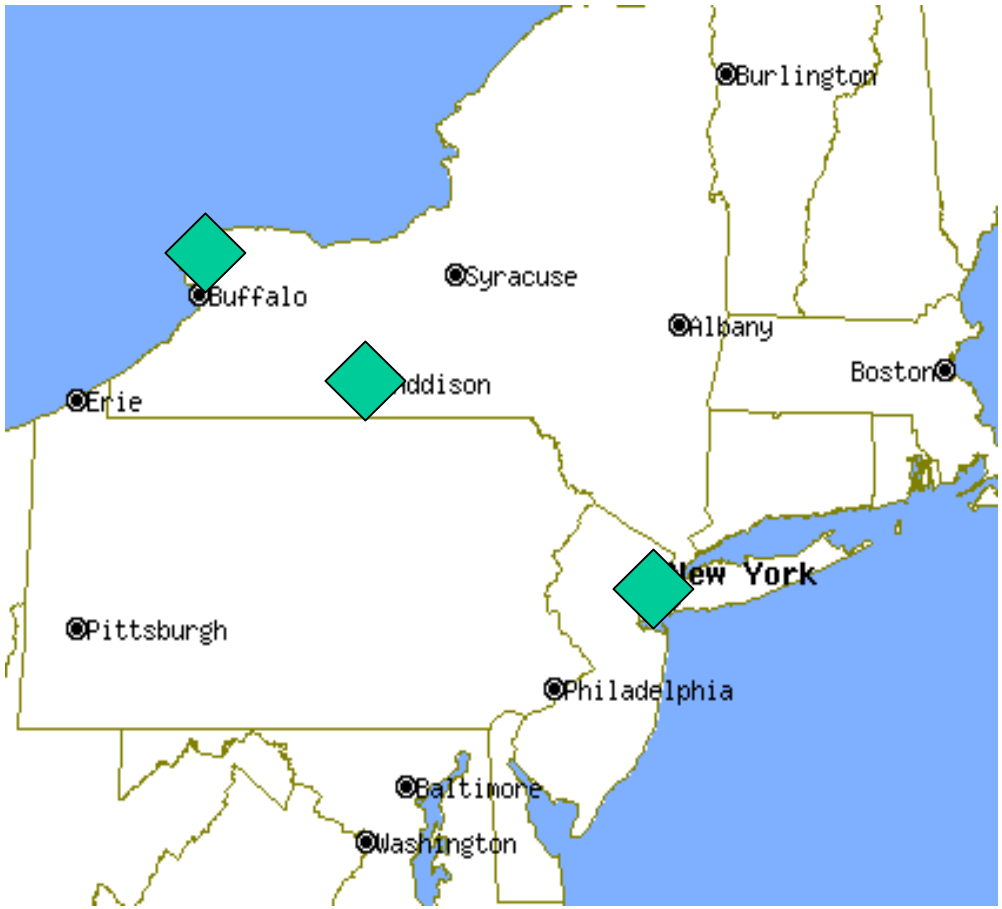
End of Slide Show


PMTACS Winter Intensive Monitoring Locations
Main installation in office trailers
FDMS (PS219)
BAM (PS219)

PMTACS Winter Intensive – November 2003




Pinnacle State Park – Addison, New York – March 2003
FDMS Inlet
FDMS



Site #1: Queens College NYC
FDMS Start Date – Jan. 2003
BAM Start Date - Nov 2003
FRM Daily
TEOM 50 Deg C
STN 1/3 Day

Site #2: Pinnacle State Park
FDMS Start Date – Mar. 2003
BAM (Tef) – April 2004
FRM Daily BAM
TEOM 50 Deg C
STN 1/3 Day
IMPROVE 1/3 Day

Site #3: Niagara Falls
FDMS Start Date – July 2003
FRM 1/3 Day
TEOM 50 Deg C
STN 1/6 Day (Buffalo)