**EPA PM Supersite Final Report**
**PM2.5 Technology Assessment and Characterization Study in New York State (PMTACS-NY)**

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## I. Introduction

As a result of recent clinical and epidemiological studies (NRC, 1998) associating adverse health effects in humans and fine particle mass, a new National Ambient Air Quality Standard for $PM_{2.5}$ mass (15 $\mu g/m^3$ annual and 65 $\mu g/m^3$ 24-hr average) has been promulgated in the United States (Federal Register, 1997). Significant scientific and technical issues surrounding the mitigation of the warm season PM2.5 /co-pollutant complex and its interdependence with $O_3$ air quality through coupled photochemical pathways, common precursors, and similar dependencies upon meteorology must be addressed if effective control strategies are to be implemented, particularly in the eastern U.S.

The long-term monitoring of the PM2.5/co-pollutant complex and its precursors at urban and regional representative sites provides the opportunity to track the impact of emission controls and their effectiveness on air quality. These data can to be used to verify that implemented PM2.5 primary and secondary precursor (including ozone precursor) emission controls are performing according to specifications and verify that PM2.5 and ozone air quality has responded to the emission changes as expected. Without adequate monitoring systems to track the progress and effectiveness of implemented control programs, the air quality management approach remains unaccountable.

The PMTACS-NY Supersite program provides a unique and unparalleled opportunity to enhance our understanding of ozone/$PM_{2.5}$-precursor relationships and track progress in current precursor emission control programs and assess their effectiveness in achieving expected air quality responses. The impact of this research is highly significant, providing a sound scientific basis for informed effective decisions in the management of air quality in New York and significant benefit to its citizens - both environmentally and economically.

## II. Program Objectives

The PMTACS-NY is designed around three major objectives and addresses a series of science policy relevant questions related to hypotheses that have been and will continue to be tested using measurement data collected under the program.

**Objective 1.** Measure the temporal and spatial distribution of the PM2.5/co-Pollutant complex including: $SO_2$, CO, VOCs/Air Toxics, NO, $NO_2$, $O_3$, NOy, $H_2CO$, $HNO_3$, HONO, PM2.5 (mass, $SO4^{=}$, $NO_3^-$, OC, EC, Trace Elements), single particle aerosol composition, particle size distribution and number concentration, OH and $HO_2$ to support regulatory requirements to develop cost effective mitigation strategies for PM2.5 and its co-pollutants and to establish trends in the relevant precursor concentrations to assess the impact of recent and future emission reductions in terms of emission control effectiveness and air quality response.

**Objective 2.** Monitor the effectiveness of new emission control technologies [i.e. Compressed Natural Gas (CNG) bus deployment and Continuously Regenerating Technology (CRT)] introduced in New York City and their impact on ambient air quality, through mobile platform and fixed site measurements of $CO_2$, CO, NO, $H_2CO$, HONO, particle size distribution and number concentration, and aerosol chemical composition.

**Objective 3.** Test and evaluate new measurement technologies and provide tech-transfer of demonstrated operationally robust technologies for network operation in support of process science and observation based analysis tools and health based exposure assessments.

## III. Hypotheses and Related Science Policy Questions

Table 1 provides a summary of the proposed hypotheses for testing and using measurement data collected under the PMTACS-NY program. These hypotheses were developed in association with outstanding PM2.5 science-policy questions that the program set out to address. These science-policy questions are listed in Table 2 and tied to hypotheses listed in Table 1 (right column labeled SPQ#).

| H# | Table 1. PMTACS-NY Hypothesis | SPQ# |
|---|---|---|
| H1. | Trends in historical and PMTACS measurements of PM mass and SO4= and NO3- species provide direct evidence for a nonlinear response to Title IV emission reductions. | 1 |
| H2. | PM10/PM2.5 sulfate and nitrate production efficiencies are directly proportional to ozone production efficiencies | 1 |
| H3. – H5. | PM Fe/Mg ratios provide an effective signature of oil derived combustion aerosol; PM V/Se ratios provide an effective signature of coal vs. oil derived aerosol on the regional scale; PM As/Se ratios provide an effective signature of mid-western vs. Canadian derived aerosols | 2-3 |
| H6. | Enhanced PM composition and gas phase measurements provide an effective means for distinguishing the contribution of local vs. regional source types/classes within the study region. | 2-3 |
| H7.- H8. | NYC summertime SO4 is dominated by local SO2 gas to particle transformation; Regional SO4 in New York State is dominated by long range transport of transformed SO2 emissions from out of state sources | 4 |
| H9. | Biogenic hydrocarbons represent a significant source of the semi-volatile organic matter mass fraction of warm season regional PM2.5 mass | 5 |
| H10. | Changes in ambient PM sulfate mass fraction are anti-correlated with changes in the ambient PM nitrate mass fraction | 6 |
| H11.- H12. | CNG-fueled buses in New York City show measurable reductions of vehicle NO, $SO_2$ and PM emissions, with minimal disbenefits (i.e. increases in H2CO and PM Ultrafine) as compared with their diesel counterparts; CRT control technology with low sulfur fuels in retrofitted diesel buses in New York City shown measurable reductions of vehicle NO, $SO_2$ and PM emissions, with minimal disbenefits (increases in H2CO and PM Ultrafine) as compared with standard diesel buses. | 7 |
| H13. | The deployment of CNG-fueled and CRT-retrofitted diesel fleets show measurable reductions in ambient NO, SO2, H2CO and PM concentrations at the one or more of the PMTACS urban monitoring sites. | 8 |
| H14. | The EPA designated filter based reference method underestimates the actual atmospheric PM2.5 mass by more than 30% as a result of volatile species losses. | 9 |
| H15. | Water management and temperature control of existing continuous automated mass, total sulfur and nitrogen species measurement systems represent a major improvement in PM2.5 measurement technology | 9 |
| H16. | Measurements of the optical properties of the atmosphere (aerosol light scattering and absorption) using fixed and remote sensing systems provide an effective means for verifying the existence and extent of regional haze and correlate with surface measurements of PM2.5 mass | 10 |
| H17. | Quantitative amounts of gaseous pollutants (e.g. PAH, H2CO, xylene, trichlorethylene, etc.) are absorbed on PM and are detectable by Aerosol Mass Spectrometer(AMS) and Single Particle Laser Ablation Time of Flight Mass Spectrometer(SPLAT-MS) analytical techniques. | 11 |
| H18. | PM chemical composition varies by aerodynamic size, which in turn varies in time, and with temperature and season resulting in complex variations in chemical inhalation exposures. | 11 |
| H19. | Heterogeneous processes contribute to the oxidizing capacity of the atmosphere resulting in significant production of PM2.5 mass. | 11 |

**Table 2. PMTACS-NY Science Policy Questions Associated with Hypotheses**

1. Will urban/regional atmospheres have a non-linear response of PM10/PM2.5 mass or composition to changes in precursor source gases (NOx, SO2, VOCs)?
2. Can chemical source signatures be effectively applied to attribute specific source contributions to monitored species components (e.g. SO4=, NO3- or carbon)?
3. Can source attribution and/or multivariate/factor analysis techniques distinguish the contribution of local production versus regionally transported PM2.5 mass?
4. What are the sources of PM2.5 affecting NY city/Upstate NY regional air quality?
5. What fraction of the urban/regional PM2.5 mass is semi-volatile organic matter? Are biogenic emissions a significant source of the semi-volatile organic matter PM2.5 mass fraction found in urban/regional atmospheres?
6. Is NH3 concentration a limiting reagent in the production of $NH_4NO_3$ in the urban/regional environment? If so, will reductions in $SO_2$ through Title IV controls and proposed reductions in sulfur in fuels result in an increased fraction of PM2.5 mass as nitrate?
7. What are the air quality benefits (or negative impacts) of a CNG Bus Fleet and CRT-DPF Diesel Fleet Deployment?
8. Are there observable changes in $NO_2$, $SO_2$, $H_2CO$ and PM air quality as a result of the CNG/CRT vehicle fleet deployments?
9. Is the EPA designate FRM for PM2.5 mass an accurate measurement of the mass of atmospheric PM2.5? Does the measurement method have any systematic bias and if so, is it species correlated?
10. Is PM2.5 mass an appropriate surrogate measurement for characterizing regional haze?
11. Are aerosols an effective delivery mechanism for specific gaseous pollutants (e.g. air toxics, oxidants) into the deep lung? What is the role of liquid water in this delivery mechanism?

## IV. Scientific Key Findings

The scientific findings have been organized around the three major objectives of the PMTACS-NY program. Each finding is associated with citations to papers from research conducted within the program and the objectives linked to the specific hypotheses identified in Table 1. The purpose in developing a hypothesis based framework for the proposed research program was to focus the scientific inquiry on addressing these key policy relevant PM air quality questions, to improve knowledge and to reduce uncertainties in support of more informed decision making. As the program evolved and scientific results emerged, some of the initial proposed hypothesis became less relevant and new hypothesis were considered. Ultimately the hypotheses were to drive scientific findings to help address the science-policy questions in Table 2. With this in mind, the hypotheses have been linked to the program objective and the scientific findings within each objective, in turn, linked to the science-policy question they help to address. Finally, it should be noted that the extensive PM2.5 and precursor measurement data set collected and complied over a four year period under this program provides rich data

base that has not been fully utilized. There are significant opportunities for further analyses, some are underway and will be reported on within the next year. Additional analyses beyond those currently underway will likely depend on future support for such activities. The findings summarized below highlight the most prominent and expeditious analyses that support the program objectives.

**Objective 1:** Measure the temporal and spatial distribution of the PM2.5/co-Pollutant complex in Urban and Rural Locations across New York. [H1-H10; H18-H19]

- The annual composition of PM at urban New York City sites suggests that the bulk of PM mass is attributed as follows: Carbon-based (~36%), Sulfate-based (~30%), Nitrate-based (~15%) and Ammonium (~15%); the remaining ~5% is metals/soil related and particle bond water (Schwab et al., 2004a). [Q2-Q4]

- Although the contributions to the annual PM mass by season are comparable for cold and warm season months (16.6 and 15.4 ug/$m^3$ respectively) based on filter based measurement data averaged over three New York city sites in 2002, the PM species composition differs significantly by cold vs. warm season ($SO_4$, 22%/34%; $NO_3$, 23%/8%; $NH_4$, 14%/13%; OC*1.4, 28%/34%; EC, 9%/6%; and soil, 4%/5%), (Drewnick et al., 2004a,b; Schwab et al., 2004a).[Q2-Q4]

- AMS (Aerosol Mass Spectrometer) measurements observed that the summer time carbon-based PM contributes up to 45% of the daily PM mass; empirical estimates of PM production based on OH+VOC measurements suggests that ~ 40% of the total PM organic carbon is generated by photochemical oxidation processes (most likely of local origin), (Drewnick et al., 2004ab; Weimer, et al. 2005; Drewnick et al., 2005). [Q5]

- Summer vs. winter AMS compositional size distribution measurements in Queens, NY indicated significant a shift in mean mode volume size distribution ranging from 350-400nm to 150-200nm for summer and winter respectively. The observed difference in mean mode size distributions is likely the result of significant summertime photochemical production of secondary aerosol and its condensation/coagulation on the background aerosol (Drewnick et al., 2004ab; Weimer, et al., 2005; Drewnick et al., 2005). [Q5,Q11]

- Summertime PM secondary organic aerosol (SOA) contributions correlate with photochemical oxidant formation and will vary (i.e. the % SOA contributions to PM mass) as function of the severity of the oxidant season. Estimates of photochemical production of SOA from the direct measurement of OH and VOC are consistent with estimates from AMS analyses that attribute PM organic carbon into Hydrocarbon-based Organic Aerosol (HOA) and Oxidized Organic Aerosol (OOA) species. These estimates suggest that summer time contributions of SOA production from photochemical reactions of OH+VOC in Queens New York can account for 40% of the observed PM organic carbon observed at this location. (Demerjian et al., 2005; Ren et al., 2003ab, 2005). [Q5]

- Estimates of summer PM $SO_4$ photochemical production based measurements in Queens, NY in the summer of 2001 and reactions kinetics OH + $SO_2$ indicated a mean production rate of 0.14μg/$m^3$-$hr^{-1}$ or 3.38μg/$m^3$-$day^{-1}$. These results indicate that 15-60% of observed PM $SO_4$ at Queens, NY is generated by photochemical oxidation processes (most likely of local origin). These results are consistent with source apportionment estimates that suggest ~ 50% of the observed warm season sulfate in New York City is transported into the metropolitan region. Summertime PM $SO_4$ contributions correlate with local photochemical oxidant formation and the % $SO_2$ conversion contributing to PM $SO_4$ mass is in part a function of the severity of the oxidant event (Demerjian et al., 2005; Ren et al., 2003ab, 2005; Dutkiewicz et al., 2004; Kim and Hopke, 2004). [Q4]

- Source apportionment techniques utilizing metals analyses from the speciation trends network and enhanced 6-hr filter sampler data collected during PMTACS-NY intensive field studies suggest that these methods are hampered by the limit of detection of many metals key to resolving fuel based combustion sources (Li et al., 2004; Qureshi et al., 2005; Schwab et al., 2004a). [Q2-Q3]

- Wintertime ambient $NH_3$ measurements are correlated with vehicle emissions, with the highest emission rates associated with cold start vehicles. These results suggest that vehicle emissions are a significant source of the observed cold season ambient $NH_3$ concentrations (Li et al., 2005).

**Objective 2:** Monitor the effectiveness of new emission control technologies [i.e. Compressed Natural Gas (CNG) bus deployment and Continuously Regenerating Technology (CRT) – Diesel Particle Filter (DPF)] introduced in New York City and its impact on ambient air quality. [H11-H13]

- On-road vehicle emissions flux measurements of residual gases and PM mass and chemical composition using a mobile measurement platform has been demonstrated as a viable means to sample large populations of in-use vehicles (Kolb et al., 2004).

- CNG powered and CRT-DPF equipped diesel buses show significant reduction in PM emissions as compared to their standard diesel counterparts (Herndon et al., 2005). [Q7]

- The comparison of vehicle chase study and dynamometer emissions for PM are consistent in the mean, but real-world in situ emission measurements suggest significantly more variation than dynamometer tests (Shorter et al., 2005). [Q7]

- CNG powered buses have significant formaldehyde emissions that will require additional controls (oxy-catalyst) (Herndon et al., 2005). [Q8]

- CRT-DPF equipped diesel buses significantly change the NO2/NOx ratio, which may have to be addressed in the long term (Shorter et al., 2005). [Q8]

- Ultra low sulfur fuels have significant direct benefits with respect to PM, THC, CO and SO2 emissions, in addition to the control technology benefits requiring these fuels Herndon et al., 2005). [Q7-Q8]

- AMS diesel PM organic emissions measured in chase studies during the warm season in New York City show a bimodal distribution (70nm and 400nm modes) that is also reflected in ambient AMS measurements. Ambient AMS measurements made during the cold season at the same location showed a significantly diminished small particle mode. This may be the result of the broadened small particle wintertime size distribution masking the 70nm mean mode particles or that the small particle mode source has shifted out of the particle transmission range of the AMS (i.e. 30nm). These results suggest that low ambient temperatures affect the formation of lube oil particles either prior to or immediately after exiting the exhaust system (Weimer et al., 2005; Herndon et al., 2005; Drewnick et al., 2004a,b). [Q4, Q8]

- The observed diurnal pattern in ambient AMS PM organic measurements is consistent with other precursor emissions and indicates that a substantial portion of PM organic emission can be attributed to mobile sources (Drewnick et al., 2004a,b; Weimer, et al., 2005). [Q4]

**Objective 3:** Test and evaluate new measurement technologies and provide tech-transfer of demonstrated operationally robust technologies for network operation. [H14-H17]

- Continuous PM mass measurement technologies (SES TEOM, FDMS-TEOM, BAM) have shown continued progress in achieving the "true" measurement of PM mass. The designation of FRM as the mass measurement standard for the "true" ambient PM mass is now being challenged. Recent measurements based on FDMS technology indicates that the "true" PM mass is underestimated by the FRM which loses NH4NO3 and semi-volatile organics and these losses exhibit significant seasonal dependence (Schwab et al., 2003; Schwab et al., 2004bc; Schwab et al., 2005a). [Q9]

- Continuous PM sulfate measurement technologies (8400S and Thermo 5020) show promise for routine network deployment. Sulfate measurements are in good agreement with collocated instruments and 24 hr STN filters. Outstanding operational/maintenance issues with some systems remain to be resolved (Drewnick et al., 2003; Hogrefe et al., 2004; Rattigan et al., 2005; Schwab et al., 2005b). [Q5, Q9]

- Continuous PM nitrate measurement technology (8400N) shows promise for routine network deployment, but measured PM $NO_3$ levels are significantly lower (30-40%) than other collocated semi-continuous instruments and 24 hr STN filters. Some measurement data indicate a non-linear response with increasing PM nitrate levels suggesting a changing or limiting reductive capacity of the flash conversion system (Hogrefe et al., 2004; Hering et al., 2004;Rattigan et al., 2005) [Q5, Q9]

- Continuous PM carbon measurement technology (Sunset Labs - EC/OC) shows promise for routine network deployment, indicating good agreement with collocated instruments and 24 hr STN filters and AMS – OC measurements. R&P 5400 EC/OC tracks total relative carbon well, but is not quantitative, as it does not provide comparable EC/OC with 24 hr STN filters (Venkatachari et al., 2005; Weimer, et al., 2005). [Q5, Q9]

## V. Knowledge Gaps

Over the course of the PMTACS-NY Supersite program and as a result of findings therein, additional scientific questions as well as areas of uncertainty have surfaced that will need further attention. These findings, the knowledge gaps and suggested recommendations for future work are briefly summarized as follows.

- Warm season AMS diesel PM organic emissions measured in chase studies show a bimodal distribution (70nm and 400nm modes) that was also reflected in ambient AMS measurements in Queens, NY (Herndon et al., 2005, Drewnick et al., 2004a,b); Similar AMS chase studies of heavy duty diesel vehicles under cold season conditions must be performed to characterize the size distribution of diesel PM organic in the source plume and confirm the depletion of the bimodal distribution in the emission source, as suggested by ambient AMS PM organic measurements performed during the 2004 winter intensive field studies.

- The accurate determination of ambient PM2.5 mass concentration is critically important to the development and implementation of PM2.5 National Ambient Air Quality Standards. Recent instrumentation evaluation and intercomparison studies of PM2.5 mass measurement devices performed as part of the PMTACS-NY Supersite program indicate that the "true" ambient PM mass is underestimated by the FRM and that the likely source of these differences is the loss of $NH_4NO_3$ and semi-volatile organics, which exhibit significant seasonal dependencies (Schwab et al., 2003; Schwab et al., 2004bc; Schwab et al., 2005a). The implications of these findings are significant in the interpretation of the epidemiological time series studies used in the development of the PM2.5 NAAQS and suggest that seasonal and regional differences in PM2.5 mass may not be properly depicted in these epidemiological studies. The systematic loss of seasonally averaged semi-volatile components of PM2.5 mass by the FRM measurement technique also raises questions as to the composition and toxicological importance of the volatized species.

- Tracking the trends in PM2.5, photochemical oxidants and their precursor species in response to regulatory actions is critically important to the demonstration of accountability in air quality management system. Tracking the impacts of the NOx SIP call, the impending the sulfur fuel regulation, and the Clean Air Interstate Rule, on air quality requires several strategically placed Supersite like monitoring systems within and downwind of affected source regions, and the commitment to keep such sites operational for a decade or longer through the course of these regulations.

## VI. Technical and Economic Feasibility

PMTACS-NY findings have provided insight regarding options for effective control strategies to mitigate urban PM2.5 and its potential toxic components.

- Results from chase studies of heavy duty diesel buses retrofitted with CRT- DPF oxidation catalysts suggest that implementation of a diesel truck retrofit CRT-DPF program would be an extremely effective means of reducing organic PM in major metropolitan areas (e.g. Boston to Washington corridor) both by reduction in direct primary OC/EC emission and in the reduction of precursor VOCs contributing to SOA.

- The demonstration of instrumentation for the measurement of on-road vehicle emissions fluxes of residual gases and PM mass and chemical composition provides a viable means to sample large populations of in-use vehicles and effectively evaluate the performance and overall uncertainty of mobile emission model predictions. Although our studies suggest that the comparison of vehicle chase study and dynamometer emissions for PM are consistent in the mean, the real-world in situ emission measurements also showed significantly more variation than dynamometer tests as well as the potential for PM organic gross emitters from both diesel and gas fueled vehicles. (Shorter et al., 2005).

- The linkage between OH reactions with $SO_2$, VOC and $NO_2$ in the secondary formation of PM sulfates, organics and nitrates, suggests that oxidant control strategies will have a direct benefit in mitigating warm season PM production. But strategies that consider controls only during the oxidant season (e.g. NOx SIP call) are not providing maximum benefits with respect to PM mitigation.

## VII. Comprehensive Bibliography

Table 3 provides a compilation of published peer-review journal articles from the PMTACS-NY Supersite program to date.

**Table 3. PM2.5 Technology Assessment and Characterization Study – New York (PMTACS-NY) Publications as of May 2005**


1. Canagaratna, M. J., J. T. Jayne, D. Ghertner, S. Herndon, Q. Shi, J. L. Jimenez , P.J. Silva, P. Williams, T. Lanni, F. Drewnick, K. L. Demerjian, C. Kolb, D. Worsnop, 2004. Chase Studies of Particulate Emissions from in-use New York City Vehicles, Aerosol Science & Technology, 38, 555-573.
2. Drewnick, F., J.J. Schwab, J.J., Hogrefe, O., Peters, S., Husain,L., Diamond, D., Weber, R., Demerjian, K.L., 2003. Intercomparison and evaluation of four semi-continuous PM2.5 sulfate instruments, Atmospheric Environment, 37, 3335-3350.
3. Drewnick, F., J. J. Schwab, J. T. Jayne, M. Canagaratna, D.R. Worsnop, and K.L. Demerjian, 2004a. Measurement of ambient aerosol composition during the PMTACS-NY 2001 campaign using an aerosol mass spectrometer. Part I: Mass concentrations, Aerosol Science and Technology, 38(SI), 92-103.
4. Drewnick, F., J.T. Jayne, M. Canagaratna, D.R. Worsnop and K.L. Demerjian, 2004b. Measurement of ambient aerosol composition during the PMTACS-NY 2001 campaign using an aerosol mass spectrometer. Part II: Chemically speciated mass distribution, Aerosol Science and Technology, 38(SI):104-117.
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9. Hogrefe, O., F. Drewnick, G.G. Lala, J. J. Schwab, and K.L. Demerjian, 2004a. Development, operation and applications of an aerosol generation, calibration and research facility, Aerosol Science and Technol.ogy, 38(SI): 196-214.
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11. Kim, E., P.K. Hopke, 2004. Improving source identification of fine particles in a rural northeastern U.S. area utilizing temperature-resolved carbon fractions, J.Geophys. Res., 109, D09204, doi:10.1029/2003JD004199.
12. Kolb, C. E., S.C. Herndon, J.B. McManus, J.H. Shorter, M.S. Zahniser, D.D. Nelson, J.T. Jayne, M.R. Canagaratna, D.R. Worsnop, 2004. Mobile Laboratory with Rapid Response Instruments for Real-time Measurements of Urban and Regional Trace Gas and Particulate Distributions and Emission Source Characteristics, Environmental Science and Technology 21, 5694-5703.
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Table 4 lists manuscripts submitted for publication in Special Issues based on results reported at the American Association for Aerosol Research (AAAR) February 2005 International Specialty Conference in Atlanta, GA.

**Table 4. Manuscripts Submissions: Special Issues from AAAR Feb. 2005 Meeting Contributions from PMTACS-NY EPA Supersite Program**

1. Demerjian, K.L., M. Tang, J.J. Schwab, S. Weimer, Q, Zhang, X. Ren, W. Brune, Quantification of the Seasonal Contribution of Secondary Aerosol Photochemical Production Processes to PM2.5 Mass in Queens, NY, submitted to Atmospheric Environment.
2. Drewnick, F., S. S. Hings, P. DeCarlo, J. T. Jayne, M. Gonin, K. Fuhrer, S. Weimer, J. L. Jimenez, K. L. Demerjian, S. Borrmann, D. R. Worsnop, A New Time-of-Flight Aerosol Mass Spectrometer (TOF-AMS) – Instrument Description and First Field Deployment, submitted to Aerosol Science and Technology.
3. Dutkiewicz, V.A., S. Qureshi, A.R. Khan, L. Husain, J. J. Schwab, and K. L. Demerjian, 2005a. Field test data for 42 liter per minute PM2.5 aerosol sampler used to collect 6-hr aerosols samples during the PMTACS-NY Intensives held at Queens College, Queens, NY, submitted to Special Issue: Atmospheric Environment.
4. Dutkiewicz, V.A., S. Qureshi, L. Husain, J. J. Schwab, and K. L. Demerjian, 2005b. Elemental Composition of $PM_{2.5}$ Aerosols in Queens, New York: Evaluation of Sources of Fine-Particle Mass, submitted to Special Issue: Atmospheric Environment.
5. Hogrefe, O., G. G. Lala, B.P. Frank, J.J. Schwab, K. L. Demerjian, 2005. Field Evaluation of a TSI Model 3034 Scanning Mobility Particle Sizer in New York City: Winter 2004 Intensive Campaign, submitted to Special Issue Aerosol Science and Technology.
6. Li, Y.J. Schwab, K.L. Demerjian, 2005. Measurements of Ambient Ammonia Using a Tunable Diode Laser Absorption Spectrometer: Characteristics of Ambient Ammonia Emissions in an Urban Area of New York City, submitted to Special Issue J. Geophys. Research.
7. Qureshi, S., V. A. Dutkiewicz, K. Swami, K. X. Yang, L. Husain, J. J. Schwab, and K. L. Demerjian, 2005. Elemental Composition of $PM_{2.5}$ Aerosols in Queens, New York: Solubility and Temporal trends, submitted to Special Issue: Atmospheric Environment
8. Rattigan, O.V., O. Hogrefe, H.D. Felton, J. J. Schwab, U. K. Roychowdhury and K. L. Demerjian,2005. Multi-year Urban and Rural Semi-continuous PM2.5 Sulfate and Nitrate Measurements in New York State: Evaluation and Comparison with Filter Based Measurements, submitted Special Issue Atmospheric Environment.
9. Ren, X., W.H. Brune, J. M., M. J. Mitchell, R.L. Lesher, A.R. Metcalf, J. B. Simpas, J. J. Schwab, K. L. Demerjian, H.D. Felton, G. Boynton, Y. He, X. Zhou, and J. Hou, 2005. Behavior of OH and $HO_2$ in the Winter Atmosphere in New York City, submitted to Special Issue: Atmospheric Environment.
10. Ren, X., W.H. Brune, A. Oliger, A.R. Metcalf, R.L. Lesher, J.B. Simpas, T. Shirley, J. J. Schwab, C. Bai, U. Roychowdhury, Y. Li, C. Cai, K.L. Demerjian, Y. He, X. Zhou, H. Gao, J. Hou (2005), "OH and HO2 during the PMTACS-NY Whiteface Mountain 2002 Campaign: Observations and Model Comparison", submitted to J. Geophys. Res.
11. Schwab, J.J., H.D. Felton, O.V. Rattigan, and K.L. Demerjian, 2005a. New York State Urban and Rural Measurements of Continuous PM2.5 Mass by FDMS TEOM and BAM: Evaluation and Comparisons with the FRM, and Fitted Reconstructions of Mass with and without Volatile Species, submitted to Special Issue: J. Air & Waste Management Assoc.
12. Schwab, J.J., O. Hogrefe, K. L. Demerjian, V. A. Dutkiewicz, L. Husain, H. D. Felton, 2005b. Field and Laboratory Evaluation of the Thermo Electron 5020 Sulfate Particulate Analyzer, submitted to Special Issue AS&T or Atmospheric Environment.
13. Venkatachari, P., L. Zhou, P. K. Hopke, H. D. Felton, O. Rattigan, J. J. Schwab, K. L. Demerjian, Spatial and Temporal Variability of Black Carbon in New York City, submitted to Special Issue Atmospheric Environment.
14. Venkatachari, P., L. Zhou, P.K. Hopke, J.J. Schwab, K.L. Demerjian, O. Hogrefe, D. Felton, O. Rattigan, An Intercomparison of Measurement Methods for Carbonaceous Aerosol in the Ambient Air in New York City, submitted to Special Issue: Aerosol Science and Technology.
15. Weimer, S. F. Drewnick, O. Hogrefe, J. J. Schwab, K. Rhoads, D. Orsini, M. Canagaratna, D. R. Worsnop, K. L. Demerjian, Size-Selective Non Refractory Ambient Aerosol Measurements during the PMTACS-NY 2004 Winter Intensive in New York City, submitted to Special Issue: Atmospheric Environment.

Presentations at Major Conferences and Meetings are summarized in Table 5.

| **Table 5. PMTACS-NY Presentations at Major Conferences, Symposia and Briefings** | |
|---|---|
| **Conference/Symposia: 222nd Annual ACS Fall National Meeting, August 26-31, 2001 Chicago, IL**<br>**Presentation Title:** | **Speaker** |
| A comparison of urban and rural PM2.5 chemical species composition in New York State | Demerjian |
| **Conference/Symposia: Environmental Monitoring, Evaluation, and Protection in New York: Linking Science and Policy. NYSERDA Conference, September 24-25, 2001, Albany, NY**<br>**Presentation Title:** | **Speaker** |
| New York Fine Particle Technology Assessment and Characterization Study | Demerjian |
| **Conference/Symposia: Symposium on Indoor and Urban Environmental Systems, October 31, 2001, Syracuse University**<br>**Presentation Title:** | **Speaker** |
| PM2.5 Air Quality Issues and the U.S. EPA Supersites Program | Demerjian |
| **Conference/Symposia: American Geophysical Union Fall 2001 meeting, December 10-14, San Francisco**<br>**Presentation Title:** | **Speaker** |
| Preliminary Results of the Measurement of Ambient Aerosol Composition During the PMTACS-NY 2001 Using an Aerosol Mass Spectrometer,<br><br>Mobile Gas and Particulate Emission Studies of the New York City Transit Bus Fleet | Drewnick<br><br>Jayne |
| **Conference/Symposia: Annual AAAR Conference, Oct 7-11, 2002, Charlotte, NC**<br>**Presentation Title:** | **Speaker** |
| PMTACS-NY: An Overview of the 2001 Summer Intensive in Queens, NY- **PL 4A2**<br><br>Ongoing Development of a Continuous Reference Standard PM Mass Monitor for Ambient Air - **PL 4AC1**<br><br>Intercomparison and Evaluation of Four Semi-continuous Particulate Sulfate Instruments During the New York 2001 Supersite Summer Intensive **- PL 5A1**<br><br>Intercomparison and Performance Evaluation of Semi-Continuous PM-2.5 Nitrate Instruments During the PMTACS-NY Summer 2001 Campaign in New York City - **PL 5A2**<br><br>Measurement of Ambient Aerosol Composition using an Aerosol Mass Spectrometer: New York 2001 Supersite Summer Intensive Study - **PL 5D1**<br><br>Characterization of Continuous $PM_{2.5}$ Sulfate and Nitrate Instruments in an Aerosol Flow Chamber - **PL 10B1**<br><br>Regional Contributions to the Concentrations of Sulfate and Trace Elements in New York, New York - **PL 13A1**<br><br>Advances in Continuous Mass Measurement Technology: TEOM Mass Monitor at 30° C with a Nafion Dryer **- PS PA3-04**<br><br>Comparisons of Speciated PM-2.5 Mass at Rural and Urban New York State - **PS PA3-07** | Demerjian<br><br>Patashnick<br><br>Drewnick<br><br>Hogrefe<br><br>Drewnick<br><br>Rattigan<br><br>Qureshi<br><br>Schwab<br><br>Felton |

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| The ASRC Aerosol Generation, Calibration & Research Facility - **PS P16-02** | Hogrefe |
| **Conference/Symposia: Environmental Quality Systems Symposium at Syracuse, October 29-30, 2002, Syracuse University**<br>**Presentation Title:** | **Speaker** |
| PM2.5 Technology Assessment and Characterization Study in New York – PMTACS-NY: An Overview of the 2001 Summer Intensive in Queens, NY | Demerjian |
| **Conference/Symposia: Air & Waste Management Association, Symposium on Air Quality Measurement Methods and Technology—2002 November 13-15, 2002 San Francisco, CA**<br>**Presentation Title** | **Speaker** |
| Long-term Comparison of TEOM, SES TEOM, and FRM Measurements at Rural and Urban New York Sites | Schwab |
| **Conference/Symposia: American Geophysical Union 2002 Fall Meeting, 6-10 December 2002, San Francisco, California**<br>**Presentation Title:** | **Speaker** |
| PM2.5 Technology Assessment and Characterization Study in New York - PMTACS-NY: The 2001 Summer Field Intensive in Queens, NY - A52C-0128 | Demerjian |
| Intercomparison and Evaluation of Semi-Continuous PM-2.5 Nitrate and Sulfate Instruments During PMTACS-NY Summer 2001 Campaign in New York City - A52C-0132 | Hogrefe |
| Measurement of Ambient Aerosol Composition Using an Aerosol Mass Spectrometer: New York 2001 Supersite Summer Intensive Study - A52C-0129 | Drewnick |
| Observations of OH, HO2 and OH Reactivity during PMTACS-NY2001: Comparison of Calculations and Observations - A52C-0126 | Ren, X |
| Mobile Particulate Emission Measurements of New York City Transit Buses and Other in use Vehicles – A52C-0130 | Jayne |
| Comparisons of Speciated PM-2.5 Mass At Rural And Urban New York State Locations - A52C-0133 | Felton |
| Advances in Continuous Mass Measurement Technology: TEOM Mass Monitor at 30° C with a Nafion Dryer at Rural and Urban New York State Locations - A52C-0131 | Schwab |
| **Conference/Symposia: AAAR Conference PM: Atmospheric Sciences, Exposure and the 4th Colloquium on PM and Human Health, March 31- April 4, 2003, Pittsburgh, PA**<br>**Presentation Title:** | **Speaker** |
| [P07-22] Intercomparison of Semi-Continuous Particulate Sulfate and Nitrate Measurement Technologies At A New York State Urban and Rural Location. | Hogrefe |
| [P07-21] Semi-Continuous Pm2.5 Sulfate and Nitrate Measurements In New York City. | Rattigan |
| [P04-59] Urban and Rural Chemical Composition of Fine Particulate Matter in New York State. | Schwab |
| [P04-36] Measurement Uncertainty in The Determination of Fine Particle Mass And Mass Concentrations of Sulfate and Transition Metals | Schwab |
| [P04-08] Source Resolution of Sulfate and Trace Elements in PM2.5 in New York, New York. | Qureshi |
| [P10-09] Aerosol Size Distributions: A Comparison of Measurements from Urban and Rural Sites. | Lala |

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| [P07-27] Correlation of Visibility and PM2.5 Mass Concentration and Related Precursors in the Adirondack Region of Upstate New York During The PMTACS-NY Summer Intensive of 2002.<br><br>[OR11-14] A Particulate Matter Air Quality Forecast Modeling System for the Northeast U.S. – Comparisons with Summer 2001 EPA Supersite Field Intensive Data<br><br>Plenary Session H: Tracking Long Term Changes in PM Air Quality and Related Health and Welfare Outcomes. | Roychowdhury<br><br>Cai<br><br>Demerjian |
| **Conference/Symposia: Air & Waste Management Association, Symposium on Air Quality Measurement Methods and Technology—2004 April 20-22, 2004 Research Triangle Park, NC**<br>**Presentation Title** | **Speaker** |
| Semi-continuous Formaldehyde Measurements with a Diffusion Scrubber/Liquid Fluorescence Analyzer | Schwab |
| **Conference/Symposia: United Nations Economic Commission for European (UNECE) European Monitoring and Evaluation Program (EMEP) Workshop on Particulate Matter (PM) Measurement and Modeling, April 20-23, 2004, New Orleans, LA** | **Speaker** |
| A Review of Time Integrated PM2.5 Monitoring Data in the United States<br><br>R&P8400S and 8400N Ambient Particulate Sulfate and Nitrate Monitors: Performance during PMTACS-NY Intensive Field Campaigns and Routine Measurements | Demerjian<br><br>Hogrefe |
| **Conference/Symposia: 23rd Annual AAAR Conference, October 4-8, 2004, Atlanta, GA**<br>**Presentation Title:** | **Speaker** |
| 3PC7 Intercomparison of Semi-Continuous Particulate Sulfate And Nitrate Measurement Technologies In New York City: Summer 2001 and Winter 2004 Intensive Studies<br><br>8PA10 Field Evaluation of A Laminar-Flow Waterbased Condensation Particle Counter<br><br>8E1 PM2.5 Technology Assessment and Characterization Study in New York – PMTACS-NY: An overview of the 2004 Winter Intensive in Queens, NY<br><br>5PE4 Measurements of Ambient Aerosol Composition Using an Aerodyne Aerosol Mass Spectrometer In New York City: Winter 2004 Intensive Study<br><br>LB13 Continuous Sulfate, Carbon, and PM2.5 Mass at Addison, NY during the Summer 2004 NEAQS/ITCT Intensive | Hogrefe<br><br>Hering<br><br>Demerjian<br><br>Weimer<br><br>Schwab |
| **Conference/Symposia: AAAR International Specialty Conference: Particulate Matter Supersites Program and Related Studies, February 7-11, 2005, Atlanta, GA**<br>**Presentation Title:** | **Speaker** |
| 20C-4 New York State Urban and Rural Measurements of Continuous PM2.5 Mass by FDMS TEOM and BAM: Evaluation and Comparisons with the FRM<br><br>4B-1 Semi-continuous PM2.5 Sulfate and Nitrate Measurements in New York: Routine Field Measurements and Intensive Field Campaigns<br><br>5B-1 Evaluation and Quality Assurance of Continuous and Semi-continuous PM Instrumentation<br><br>7PA-8 Continuous PM2.5 Sulfate and Carbon at Addison in Rural New York State: Measurements From and Evaluations of the Thermo 5020 Sulfate and the Sunset Labs OCEC Instruments | Felton<br><br>Hogrefe<br><br>Schwab<br><br>Schwab |

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| 20C-1 Field Assessment of the Dynamics of Particulate Nitrate Vaporization Using Differential TEOM® And Automated Nitrate Monitors | Hering |
| 7PA-16 Field Evaluation of a TSI Model 3034 Scanning Mobility Particle Sizer in New York City: Winter 2004 Intensive Campaign | Hogrefe |
| 14A-1 Aerosol Size Distributions: A Comparison of Measurements From Summer and Winter Field Campaigns in Queens, NY | Lala |
| 17PD-13 PILS-IC (Particle Into Liquid Sampling Analyzed by Ion Chromatography) Overview of Results for the PM2.5 Technology Assessment and Characterization Study In New York (PMTACS-NY) | Rhoads |
| 17PD-15 Urban And Rural Measurements of Ambient Aerosol Composition in New York State Using an Aerodyne Aerosol Mass Spectrometer | Weimer |
| 17PD-16 Estimates of PM2.5 Aerosol Acidity From Inorganic Ion Balance Measurements at Urban And Rural New York State Locations From STN Integrated Filters. | Schwab |
| 8B-2 Elemental Composition of PM2.5 Aerosols Measured During the PM2.5 Technology Assessment and Characterization Study-New York (PMTACS-NY) | Dutkiewicz |
| 10A-4 Characteristics of Primary snd Oxygenated Organic Aerosols in Multiple Urban, Rural, and Remote Atmospheres | Zhang |
| 17PD-10 Relationship Between NOy, PM_nitrate And PM2.5 at a Mountain Site in Upstate New York During the PMTACS-NY Program | Roychowdhury |
| 18C-1 Quantification of Primary And Partially Oxidized Organic PM Emission and The Formation of Secondary Organic Aerosol Queens, NY in Summer and Winter | Demerjian |
| 7PA-11 Measurements of Ambient Ammonia Using a Tunable Diode Laser Absorption Spectrometer and an Aqueous Scrubbing-chemical Derivative Technique at Urban and Rural New York Location | Li |
| 7PG-37 HOx Behavior in the Winter Urban Atmosphere in New York City | Ren |
| 1C-4 Molecular Composition of Organics in PM2.5 at the New York City Supersite during Winter 2004 | Min |
| 7PG-30 A Particulate Matter Air Quality Forecast Modeling System for the Northeast U.S. – Comparisons with PMTACS-NY Field Measurement Campaigns and PM Network Data | Cai |
| 8A-3 Highlights and Lessons Learned: PM2.5 Technology Assessment and Characterization Study in New York – PMTACS-NY Supersite Program | Demerjian |
| 20B-5 New Particle Formation Associated with $SO_2$ Emissions from Power Plants: 3-Dimensional Modeling | Yu |
| Plenary Comparison of PM Mass and Chemical Species Measurement Technologies: Implications for Network Monitoring | Demerjian |

| **Policy Briefings: NYSDEC, EPA Region II, EPA ORD, and MTA**<br>**Presentation Title:** | |
|---|---|
| Joint Enhanced Ozone and PM2.5 Technology Assessment and Characterization Study in New York (PMTACS-NY) -Roundtable Discussion NYSERDA –NYSDEC, Briefing May 1, 2003 | Demerjian |
| Particle and Gaseous Emission Testing of Diesel and CNG Buses in New York City Metropolitan Transit Authority Briefing July 29, 2003 | Demerjian |
| PM2.5 Technology Assessment and Characterization Study in New York – PMTACS-NY EPA Region II Briefing July 31, 2003 | Demerjian |
| Carbonaceous PM2.5: Lessons [*Being*] Learned from the New York Supersite, EPA Carbonaceous PM: The State of the Science (CPM II)April 12, 2004 | Demerjian |
| Joint Enhanced Ozone and PM2.5 Technology Assessment and Characterization Study in New York – PMTACS-NY: 2005 and Beyond, Roundtable discussion NYSERDA –NYS DEC Briefing November 17, 2004 | Demerjian |

## VIII. Appendices

**A. Electronic versions of published journal articles, preprints of manuscript submissions from AAAR 2005 for Supersite Special Issues and select presentations at Conferences, Symposia, Specialty Meetings and Policy Briefings, as listed in Table 5.**

**B. Quality Assurance Final Report**