PM2.5 Supersite Revisited – Queens College
2009 Summer Field Intensive

ENVIRONMENTAL MONITORING, EVALUATION,
AND PROTECTION IN NEW YORK:
LINKING SCIENCE AND POLICY
OCTOBER 14-15, 2009
The Albany Marriott • 189 Wolf Road • Albany, NY

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University at Albany
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Outline

• Brief history of PMTACS-NY PM2.5 Supersite
• Major Findings
• Long Term Measurements and Accountability
• Queens College Summer 2009 Revisit Objectives
• Measurement Platforms
• Preliminary Findings - 2009 Summer Intensive
PMTACS-NY Measurement Sites
PMTACS-NY Objectives

- Measure the temporal and spatial distribution of the PM2.5/co-pollutant complex including: SO$_2$, CO, VOCs/air toxics, NO, NO$_2$, O$_3$, NO$_y$, H$_2$CO, HNO$_3$, HONO, PM2.5 (mass, SO$_4^{2-}$, NO$_3^-$, OC, EC, trace elements), aerosol number, size distribution and composition, OH and HO$_2$.

- Monitor the effectiveness of new emission control technologies [i.e. Compressed Natural Gas (CNG) bus deployment and Continuously Regenerating/Diesel Filter Trap (CR-DFT)] introduced in New York City and its impact on ambient air quality.

- Test and evaluate new measurement technologies and provide tech-transfer of demonstrated operationally robust technologies for network operation.
Key Findings of PMTACS-NY

- Carbon contributes ~40% of the annual PM2.5 mass at NYC urban sites (while non-urban sites in NY report contributions of ~ 30%)
- The carbon contribution to PM2.5 varies with season, where it is highest in summer and lowest in winter
- The main source of the season difference is summer secondary organic aerosol (SOA) production involves photochemical reactions with VOC compounds typically >C6 (isoprene the only exception)
- Major elemental carbon (EC) particle emissions in urban environments typically include diesel and gasoline powered internal combustion engines, and oil combustion for residential heating.
- These same EC sources have accompanying primary organic carbon emissions (OC), with one additional source, cooking.
- PM2.5 sulfates and nitrates with accompanying ammonium contribute ~50% of the annual PM2.5 mass at NYC sites.
- PM2.5 nitrates vary seasonally (temperature equilibrium effects), while sulfate and ammonium show little seasonal differences.
Verify that implemented emission controls are performing according to specifications.

Verify that air quality is responding, to emission changes achieved, as expected.

Verify that changes in identified health outcomes agree with expectations given observed changes in air quality.
Tracking Emission and Air Quality

- **PSP Annual Mean SO2 ppb**
- **Annual SO2 Emission: tons /1E6**

YEAR

1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007

PSP Annual Mean SO2 ppb

Annual SO2 Emission: tons /1E6
Tracking Emission and Air Quality

YEAR

PSP Annual Mean NOy ppb
Annual NOx emission: tons/1E6
Revisiting Queens College Summer Intensive 2009

• Objectives
  – 1. Conduct AMS measurements and analyses similar to those performed during the “PM Supersite” summer 2001 field intensive to detect if changes have occurred in aerosol size and composition over the intervening years.
  – 2. Conduct measurements to characterize concentration gradients in the vicinity of major highways and adjacent residential communities to improve our understanding of population exposures.
  – 3. Evaluate advanced measurement technologies (e.g. QCL-TDLAS, HR-tof-AMS, PASS, FMPS, SP-AMS and ACSM).
A: DEC fixed site
   – ASRC: SMPS, PILS-IC,
   PILS-TOC (PM$_{2.5}$), SMPS, APS
   – Aerodyne: ACSM (PM$_{1.0}$)
B: Parking Lot 6 (~140 m from A)
   – ASRC Mobile Van
   – Aerodyne Mobile Van
C: Parking Lot 15 (~40 m from LIE)
   – ASRC Mobile Van

Sampling Period: July 14 - August 3, 2009
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Parameter</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Hi Res ToF AMS</td>
<td>Non-Refrac PM</td>
<td>UA Mobile Van</td>
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<tr>
<td>QCL - TDLAS</td>
<td>H2CO &amp; NO2</td>
<td>UA Mobile Van</td>
</tr>
<tr>
<td>DMT PASS-1</td>
<td>Soot (EC)</td>
<td>UA Mobile Van</td>
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<tr>
<td>FMPS</td>
<td>PM size distribution</td>
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<tr>
<td>2B technologies</td>
<td>NO, NO2, O3</td>
<td>UA Mobile Van</td>
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<tr>
<td>BTEX HC</td>
<td>Select Aromatics</td>
<td>UA Mobile Van</td>
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<tr>
<td>LiCor</td>
<td>CO2</td>
<td>UA Mobile Van</td>
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<tr>
<td>CPC Water based</td>
<td>Particle number</td>
<td>UA Mobile Van</td>
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<tr>
<td>SMPS</td>
<td>PM size distribution</td>
<td>QC Shelter</td>
</tr>
<tr>
<td>Nano SMPS</td>
<td>PM size distribution</td>
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<td>CPC Water based</td>
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<td>PILS</td>
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<td>API 300EU</td>
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<tr>
<td>TEI NOx</td>
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<tr>
<td>TEI Pulsed Fluor</td>
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<td>TEI O3</td>
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<td>SP - AMS</td>
<td>PM Organic &amp; EC</td>
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<td>CAPS extinction</td>
<td>Aerosol Extinction</td>
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<td>MAAP</td>
<td>Black Carbon</td>
<td>ARI - Mobile Van</td>
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<td>SMPS</td>
<td>PM size distribution</td>
<td>ARI - Mobile Van</td>
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<tr>
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<td>LiCor</td>
<td>ARI - Mobile Van</td>
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<tr>
<td>NO/NOx</td>
<td>TECO</td>
<td>ARI - Mobile Van</td>
</tr>
</tbody>
</table>
**PM$_{1.0}$ Composition**

2009  
Total = 10.98 µg/m$^3$

- OOA-II: 57.8%
- COA: 25.7%
- HOA: 4.5%
- N-Factor: 11.7%
- Other: 0.3%

<table>
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<tr>
<th>Component</th>
<th>Percentage</th>
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<td>OOA-II</td>
<td>16.3%</td>
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<tr>
<td>COA</td>
<td>9.4%</td>
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<tr>
<td>HOA</td>
<td>7.7%</td>
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<tr>
<td>N-Factor</td>
<td>3.1%</td>
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<tr>
<td>Other</td>
<td>0.3%</td>
</tr>
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</table>

2001  
Total = 12.06 µg/m$^3$

- OOA-II: 48.1%
- HOA: 31.9%
- N-Factor: 5.6%
- Other: 14.1%

<table>
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<tbody>
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<td>24.4%</td>
</tr>
<tr>
<td>HOA</td>
<td>14.6%</td>
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<tr>
<td>N-Factor</td>
<td>9.0%</td>
</tr>
<tr>
<td>Other</td>
<td>0.3%</td>
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</tbody>
</table>

2009  
Total = 11.41 µg/m$^3$

2001  
Total = 12.06 µg/m$^3$
Size Distributions
Diurnal Patterns: Using the same period, i.e., July 14 – August 3

Mean

Median

Concentration (µg/m$^3$)

Organic (Org)

OOA-I

OOA-II

HOA

Chlorophyll (Chl)

Sulfate ($\text{SO}_4$)

Nitrate ($\text{NO}_3$)

Ammonium ($\text{NH}_4$)
2001 Data: 30-100nm vs 100-1000 nm
Elemental Composition: Diurnals
**OA Components vs. HR Ions**

**OOA-I:** \( C_x H_y O_2^+ \) > \( C_x H_y O_1^+ \) > \( C_x H_y^+ \)

**OOA-II:** \( C_x H_y O_1^+ \) > \( C_x H_y O_2^+ \) ≈ \( C_x H_y^+ \)

**COA:** \( C_5 H_8 O^+, C_6 H_{10} O^+, C_7 H_{12} O^+, C_8 H_{14} O^+ \)

**HOA:** \( C_x H_y^+ \) >> \( C_x H_y O_z^+ \)

**N-Factor:** \( C_2 H_4 N^+, C_3 H_8 N^+, C_4 H_{10} N^+ \)
OA Components: Diurnals

- HOA
- OOA-I
- OOA-II
- N-Factor
- COA
July 28th, 2009 (0430-0845)

- Drove between LIE frontage road and Memorial Drive (N-S, ~400 m) and between Main St and Kissena Blvd (E-W, ~500 m) completing five full loops.

- Winds were light and constant (S-SW, 2 m/s) - the north side of LIE is our “downwind side”

- Look at temporal and spatial evolution of gaseous and aerosols species on the downwind side (side roads have been excluded)

- Two loops on the upwind side also carried out.
**CO₂ (ppm)**

- **< 50 m downwind LIE**
  - CO₂ > 430 ppm
  - Peak between 0700-0745 (520 ppm)

- **50 to 300 m downwind LIE**
  - CO₂ < 450 ppm
  - Gradient established 0700 – 0745
  - Highest between 0615 – 0745
  - CO₂ is lower by 0800

**Black carbon MAAP (sub 2.5 μm)**

- **< 50 m downwind LIE**
  - BC between 4 – 10 ug/m³
  - Highest between 0800-0845

- **50 to 300 m downwind LIE**
  - BC mostly < 4 ug/m³
  - Highest BC between 0615 - 0745
  - Gradient established 0700-0745
  - BC returns to low levels by 0800
**CPC total counts (sub 1 μm)**

- Number between 35 and $65 \times 10^3$ p/cc
- Peak between 0700 - 0745

**PM 2.5 (sub 2.5 μm)**

- PM2.5 between 50 and $60 \times 10^{-3}$
- Peak between 0700 - 0745

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**< 50 m downwind LIE**

- PM2.5 between 50 and $60 \times 10^{-3}$
- Peak between 0700 - 0745

**50 to 300 m downwind LIE**

- PM2.5 ~ $50 \times 10^{-3}$
- Gradient established 0430 – 0600
- Highest PM2.5 between 0615 – 0745
- PM2.5 is lower by 0800

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**< 50 m downwind LIE**

- Number between 35 and $65 \times 10^3$ p/cc
- Peak between 0700 - 0745

**50 to 300 m downwind LIE**

- p/cc < $30 \times 10^3$
- Gradient established 0515 – 0600
- Highest p/cc between 0615 – 0700
- p/cc is lower after 0700
1) Before 0800, particle number peaks at 20 nm (circled areas)
2) After 0800, particle number peaks at 60 nm (square)
3) Overall particle number peaks between 40-60 nm; volume is mostly above 80 nm
Acknowledgment of Participants

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