Assessment of Carbonaceous PM$_{2.5}$ for New York State and the Region

2007 NYSERDA EMEP CONFERENCE
ENVIRONMENTAL MONITORING, EVALUATION, AND PROTECTION IN NEW YORK:
LINKING SCIENCE AND POLICY
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Project Goals

• Produce a policy-relevant assessment of scientific and technical understanding of behavior and control of carbonaceous PM$_{2.5}$ for the State of New York
  – Two equally important perspectives for assessment
    • Attainment of NAAQS for PM$_{2.5}$ (and ozone) for the New York Metro area (three-state area, NY, Conn., NJ) : urban focus
    • Public health and human exposure to PM$_{2.5}$ (across the state including rural areas) : human exposure focus

• Provide recommendations to decision makers on how to move forward (science, technology, controls, need for future work)

• Report written for broad audience
Assessment Report

• Final product: A written assessment report
  – In two volumes
    • Volume I: Executive Summary (six pages) and a Synthesis Document (21 pages; includes recommendations); both written for broad audience
    • Volume II: Three-chapter comprehensive assessment report (chapters on atmospheric processes, human health effects, and control technologies and strategies), and six detailed appendices (PM$_{2.5}$ Emission Inventory, Diesel Engine Technologies, Cost-Effectiveness Analysis, New Vehicle and Engine Emission Standards, Airports and Aircrafts, and PM$_{2.5}$ Speciation profiles)
Focus Questions (two of five)

• (1) Do carbonaceous aerosols contribute significantly to high levels of ambient PM$_{2.5}$ in the New York State?

• (2) What proportion of carbonaceous PM$_{2.5}$ present in NY is derived from in-state sources?

Ambient data used to illustrate temporal (seasonal, daily, sub-daily) & spatial (regional, urban, community) variation of carbonaceous aerosol in New York State.

Combined with available emissions inventory information, provide answer to above questions.
Emissions Inventory

- Information Sources: US EPA National Emissions Inventory and MANE-VU Inventory
- PM2.5 emissions speciated with US EPA profiles
- Seven emission areas emphasized, based on their contribution to EC and OC fraction of PM2.5 emissions:
  1. commercial meat cooking
  2. residential fuel combustion
  3. light-duty vehicles
  4. heavy-duty trucks and buses
  5. nonroad engines
  6. airports
  7. marine ports
Monitoring Sites

- Met1 Sampler *
- R & P Sampler
- SOAP study site S
Ambient Measurements and Data Analysis Findings

• Filter-based Measurements in New York State
  – Blank Correction & Organic Carbon Mass Adjustment Factor
  – Reconstructed Mass Data
  – Monthly Variation of Carbonaceous PM$_{2.5}$
  – EC Tracer Method
  – Weekday-weekend Analysis
  – Local versus Regional Analysis
Ambient Measurements and Data Analysis Findings: Filter-based Measurements -Mass Adjustment Factor

- This work employed a mass-balance approach based on Frank’s (2006) SANDWICH approach
- Sample-specific OC adjustment factors calculated for blank corrected data
- Sulfate, Nitrate, Ammonium, EC and Crustal mass subtracted from total sample mass
- Adjustment made for particle-bound water and seasonally adjusted nitrate loss

<table>
<thead>
<tr>
<th>Site Name</th>
<th>OC Factor</th>
<th>Site Name</th>
<th>OC Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffalo (BUFF)</td>
<td>1.5</td>
<td>Botanical Gardens (NYBG)</td>
<td>1.4</td>
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<tr>
<td>Whiteface (WHITE)</td>
<td>1.6</td>
<td>IS 52 (IS52)</td>
<td>1.4</td>
</tr>
<tr>
<td>Rochester (ROCH)</td>
<td>1.6</td>
<td>Queens College (QCII)</td>
<td>1.5</td>
</tr>
<tr>
<td>Pinnacle State Park (PINN)</td>
<td>1.6</td>
<td>Canal St (CANL)</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Ambient Measurements and Data Analysis Findings: Filter-based Measurements - Reconstructed Mass

Annual SO₄ mass constant across NYS, NO₃, OC and EC greater in urban areas than in rural ones; OC mass represents 1/4 -1/3 of total PM₂.₅ mass.
Ambient Measurements and Data Analysis Findings: Filter-based Measurements - Reconstructed Mass

- PM$_{2.5}$ peaks in Summer
- Summer sulfate twice winter sulfate in urban areas, three times for rural ones.

- Nitrate levels highest in winter
- EC shows limited seasonality, although increase observed in urban areas during wintertime
Ambient Measurements and Data Analysis Findings: Filter-based Measurements -EC Tracer Method

- EC used as tracer for primary emissions. Derived primary ratio based on dataset.
- Note: this approach assumed constant averaged primary source ratio of OC:EC

Estimated contribution of secondary organic aerosol to total OC

<table>
<thead>
<tr>
<th>Site</th>
<th>Cooler Months</th>
<th>Warmer Months</th>
<th>Site</th>
<th>Cooler Months</th>
<th>Warmer Months</th>
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<tbody>
<tr>
<td>Buffalo</td>
<td>42%</td>
<td>47%</td>
<td>Pinnacle State Park</td>
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<td>78%</td>
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<td>Canal St.</td>
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<td>61%</td>
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<tr>
<td>NY Botanical Gardens</td>
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<td>39%</td>
<td>Whiteface</td>
<td>50%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Warmer months = May to September
Ambient Measurements and Data Analysis Findings: Filter-based Measurements - Weekday-weekend Analysis

Little difference seen between weekday-weekend OC levels. Differences apparent for EC concentrations in urban areas.
Ambient Measurements and Data Analysis Findings: Filter-based Measurements - Local versus Regional

- NYC sites compared to Pinnacle State Park site
  - Pinnacle site assumed to represent regional background
  - Sample dates matched
- Intra-Urban [(max-min)/max)] comparison represents a lower bound for local source contribution (sampler specific comparison ~10% less than in table)
- Urban-rural [(urban-rural)/urban] estimate may or may not accurately portray local source contribution

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Comparison</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Fall</th>
<th>Annual</th>
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<tbody>
<tr>
<td>Sulfates</td>
<td>Intra-Urban</td>
<td>5%</td>
<td>15%</td>
<td>10%</td>
<td>5%</td>
<td>10%</td>
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<tr>
<td></td>
<td>Urban-Rural</td>
<td>30-35%</td>
<td>10-25%</td>
<td>0-10%</td>
<td>-15 – (-5%)</td>
<td>5-15%</td>
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<tr>
<td>Nitrates</td>
<td>Intra-Urban</td>
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<td>35%</td>
<td>30%</td>
<td>25%</td>
<td>25%</td>
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<td>50-65%</td>
<td>75-80%</td>
<td>55-65%</td>
<td>55-65%</td>
</tr>
<tr>
<td>Organic Carbon</td>
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<td>35%</td>
<td>30%</td>
<td>40%</td>
<td>35%</td>
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<tr>
<td></td>
<td>Urban-Rural</td>
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<td>30-55%</td>
<td>10-35%</td>
<td>25-50%</td>
<td>25-50%</td>
</tr>
<tr>
<td>Elemental Carbon</td>
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<td>50%</td>
<td>40%</td>
<td>45%</td>
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<tr>
<td></td>
<td>Urban-Rural</td>
<td>70-85%</td>
<td>65-80%</td>
<td>70-85%</td>
<td>70-80%</td>
<td>70-85%</td>
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</table>
Major Findings

• We still have a lot to learn about carbonaceous aerosols
• We know they contribute significantly to PM$_{2.5}$ levels in New York City and the rest of the State
• A substantial fraction of OC and most EC is likely of local in origin for New York City
Special Thanks to:

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