Correlating Particulate Matter Mobile Source Emissions to Ambient Air Quality

Kevin N. Black, Federal Highway Administration
Frank Divita Jr, Ph.D., E.H. Pechan & Associates
Richard A. Margiotta, Ph.D., Cambridge Systematics, Inc.
Randall Guensler, Ph.D., Trans/AQ

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Background

• Mobile Source component of emissions uncertain
• FHWA PM Research Program
• Designation of nonattainment Areas of NAAQS PM$_{2.5}$ Standard and development of control strategies for SIPs
• Areas must know apportionment of sources, conformity analyses required
Figure 3. Connection Between Transportation Issues and Research Agenda
PM$_{2.5}$ Standard Implementation Schedule

- PM monitors placed
- PM data collected
- PM nonattainment areas designated
- SIPs submitted
- Areas have 10 years to meet standards
Potential Violations of PM2.5 and 8-Hr Ozone
Locations Selected for PM Study
Cities Selected for the PM Study

- Baltimore
- Detroit
- New York
- Pittsburgh
- Atlanta
Baltimore
Detroit
New York
Pittsburgh
Atlanta
Study Variations Considered

- Temporal Variations
  - Time of Day (morning, mid-day, evening)
  - Time of Week (weekday versus weekend)
  - Time of year (seasonal variations)

- Spatial Variations
  - Within Region
  - Across Country (Northeast, Mid-Atlantic, Southeast, Midwest)
Other Variations Considered

- Vehicle types (gasoline, diesel)
- Atmospheric transport
- Fugitive dust
- Background
Data Used in The Study

• Traffic Data
  Regional Counts
  Local Counts
  Supplemental Counts
• Ambient PM Data
  PM, PM precursors, other pollutants
• Meteorological Data
  Wind direction, speed, temperature, other
## Traffic Data

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Measurement</th>
<th>Parameter</th>
<th>Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>Long Island Expwy, Kissena Blvd, Jewel Ave, Main St.</td>
<td>ITS, special counts</td>
<td>Volume, speed, occupancy</td>
<td>ITS continuously for CY2001-2002, counts variable</td>
<td>85 freeway miles, 191 count locations</td>
</tr>
<tr>
<td>Baltimore</td>
<td>Toll Plazas at Tunnels</td>
<td>ITS/AVC, special counts</td>
<td>Volume, vehicle class</td>
<td>Continuous for CY2002</td>
<td></td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>Freeways, Schenley Avenue</td>
<td>ITS</td>
<td>Volume, speed, occupancy</td>
<td>Continuously for CY2001-2002, other counts variable</td>
<td>78 freeway miles, 58 count locations</td>
</tr>
<tr>
<td>Detroit</td>
<td>Freeways, 6-Mile Road</td>
<td>ITS, special counts</td>
<td>Volume, speed, occupancy, vehicle class</td>
<td>Continuously for CY2001-2002, other counts variable</td>
<td>117 freeway miles, 58 count locations</td>
</tr>
<tr>
<td>Atlanta</td>
<td>Freeways, Jefferson St</td>
<td>ITS, special counts</td>
<td>Volume, speed, occupancy</td>
<td>Continuously for CY2001-2002, other counts variable</td>
<td>95 freeway miles, 240 count locations</td>
</tr>
</tbody>
</table>
# Traffic Data

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Proximity to PM Monitor (zone of influence)</th>
<th>Volume Vehicles per hour (vph)</th>
<th>Vehicle Classification</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>Long Island Expressway, Kissena Blvd, Jewel Ave, Main St</td>
<td>1,600 feet to 6,600 feet</td>
<td>500 to 5000 vph</td>
<td>13 length based classes</td>
<td>Local volumes</td>
</tr>
<tr>
<td>Baltimore</td>
<td>Toll Plazas at Tunnels</td>
<td>400 feet to 1.9 miles</td>
<td>500 to 5000 vph</td>
<td>6 axle based classes</td>
<td>Local volumes</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>Freeways, Schenley Ave</td>
<td>3,700 feet to 3 miles</td>
<td>1000 to 7000 vph</td>
<td></td>
<td>Local volumes</td>
</tr>
<tr>
<td>Detroit</td>
<td>Freeways, 6-Mile Road</td>
<td>2,000 feet to 4.6 miles</td>
<td>500 to 4000 vph</td>
<td>13 length based classes</td>
<td>Local volumes</td>
</tr>
<tr>
<td>Atlanta</td>
<td>Freeways, Jefferson St</td>
<td>1.3 miles to 4.8 miles</td>
<td>50,000 to 300,000 vph</td>
<td></td>
<td>Regional and Local volumes</td>
</tr>
</tbody>
</table>
# Air Quality Data

<table>
<thead>
<tr>
<th>Site Location</th>
<th>Site Type</th>
<th>PM$_{2.5}$ Measurement Dates</th>
<th>PM Data Obtained by the Team</th>
<th>Sampling Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Atlanta, GA</td>
<td>Supersite</td>
<td>July 1999 - Ongoing</td>
<td>Aug. 2002 - Sept. 2002</td>
<td>Ongoing</td>
</tr>
<tr>
<td>2 St. Louis, MO</td>
<td>Supersite</td>
<td>April 2001 - Ongoing</td>
<td>July 2001</td>
<td>12 months or longer</td>
</tr>
<tr>
<td>8 Seattle, WA: 0057, 2004, 0017</td>
<td>AIRS</td>
<td>1997 - Ongoing</td>
<td>None</td>
<td>Ongoing</td>
</tr>
</tbody>
</table>
## Air Quality Data

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Measurement</th>
<th>Parameter</th>
<th>Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>New York Supersite</td>
<td>Air Quality</td>
<td>PM$_{2.5}$ mass, EC, OC, CO, NOx, NO$_2$, SO$_2$, O$_3$, Trace Elements, Organics</td>
<td>1 hour to 24 hours</td>
<td></td>
</tr>
<tr>
<td>Baltimore</td>
<td>Baltimore Supersite</td>
<td>Air Quality</td>
<td>PM$_{2.5}$ mass, EC, OC, CO, NO, NOx, NO$_2$, SO$_2$, O$_3$, Trace Elements, other</td>
<td>1 hour to 24 hours</td>
<td>NO$_3$, Na, NH$_4$, SO$_4$</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>Pittsburgh Supersite</td>
<td>Air Quality</td>
<td>PM$_{2.5}$ mass, EC, OC, CO, NO, NOx, NO$_2$, SO$_2$, O$_3$, Trace Elements, other</td>
<td>1 hour to 24 hours</td>
<td>NO$_3$, NH$_4$, SO$_4$, Cl</td>
</tr>
<tr>
<td>Detroit</td>
<td>Goddard Street</td>
<td>Air Quality</td>
<td>PM$_{2.5}$ mass, EC, OC, Trace Elements, Organics, other</td>
<td>1 hour to 24 hours</td>
<td>Na, NH$_4$, SO$_4$</td>
</tr>
<tr>
<td>Atlanta</td>
<td>Atlanta Supersite</td>
<td>Air Quality</td>
<td>PM$_{2.5}$ mass, EC, OC, CO, NO$_3$, Trace Elements</td>
<td>1 hour to 24 hours</td>
<td></td>
</tr>
</tbody>
</table>
# Air Quality Data - Baltimore

<table>
<thead>
<tr>
<th>City</th>
<th>Location</th>
<th>Measurement</th>
<th>Parameter</th>
<th>Duration</th>
<th>Year</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>Ponca Street</td>
<td>Air Quality</td>
<td>PM$_{2.5}$ Mass</td>
<td>1-hr</td>
<td>Jan-Dec</td>
<td>Jan-Sep</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EC, OC</td>
<td>24-hr</td>
<td>Apr-Dec</td>
<td>Jan-Aug</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CO, NO$_X$</td>
<td>1-hr</td>
<td>Jun-Dec</td>
<td>Jan-Aug</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NO$_2$, SO$_2$, O$_3$</td>
<td>1-hr</td>
<td>Jun-Dec</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trace Elements, Organics</td>
<td>1-hr, 24-hr</td>
<td>Jan-Dec</td>
<td></td>
</tr>
</tbody>
</table>
# Meteorological Data

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Measurement</th>
<th>Parameter</th>
<th>Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>New York Supersite</td>
<td>Meteorology</td>
<td>WD, WS, temperature, barometric pressure</td>
<td>1 hour</td>
<td>other parameters may have been measured but only those used are noted</td>
</tr>
<tr>
<td>Baltimore</td>
<td>Baltimore Supersite</td>
<td>Meteorology</td>
<td>WD, WS, temperature, barometric pressure</td>
<td>1 hour</td>
<td>other parameters may have been measured but only those used are noted</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>Pittsburgh Supersite</td>
<td>Meteorology</td>
<td>WD, WS, temperature, barometric pressure</td>
<td>1 hour</td>
<td>other parameters may have been measured but only those used are noted</td>
</tr>
<tr>
<td>Detroit</td>
<td>Goddard Street</td>
<td>Meteorology</td>
<td>WD, WS, temperature, barometric pressure</td>
<td>1 hour</td>
<td>other parameters may have been measured but only those used are noted</td>
</tr>
<tr>
<td>Atlanta</td>
<td>Atlanta Supersite</td>
<td>Meteorology</td>
<td>WD, WS, temperature, barometric pressure</td>
<td>1 hour</td>
<td>other parameters may have been measured but only those used are noted</td>
</tr>
</tbody>
</table>
Data Analysis

• Graphical Correlation Analysis
• Statistical Correlation Analysis
  General
  Pearson
  Analysis of Covariance
Graphical Analysis

- Traffic plotted against PM$_{2.5}$ Ambient Concentrations
- Data plotted represents different time periods based on site sampling frequency
Graphical Analysis for Baltimore

04/2002 - 3/2003
~266 days

PM2.5 Concentration (µg/m³)

Local ITS Traffic Volume (No. of Veh.)

Time of Day

- Avg. Hourly Concentration
- Avg. Hourly Traffic Volume
Graphical Analysis for Detroit

02/2001 - 12/2001
~330 days

PM2.5 Concentration (µg/m³)

Local ITS Traffic Volume (No. Of Veh.)

Time of Day

- Avg. Hourly Concentration
- Avg. Hourly Traffic Volume
Graphical Analysis for New York

03/2001 - 9/2002
~490 days

PM2.5 Concentration (μg/m³)

0  10  20  30  40  50  60  70  80  90  100

Time of Day

Local ITS Traffic Volume (No. Of Veh.)

Avg. Hourly Concentration
Avg. Hourly Traffic Volume
Graphical Analysis for Pittsburgh

07/2001 - 8/2002
~400 days

PM2.5 Concentration (ug/m³) vs. Time of Day

- Avg. Hourly Concentration
- Avg. Hourly Traffic Volume

Local ITS Traffic Volume (No. Of Veh.)
Graphical Analysis for Atlanta

08/2002 - 09/2002
~20 days

PM2.5 Concentration (μg/m³)

Local ITS Traffic Volume (No. Of Veh.)

Time of Day

- Avg. Hourly Concentration
- Avg. Hourly Traffic Volume
## Weekday vs. Weekend Comparisons

<table>
<thead>
<tr>
<th>City</th>
<th>Weekend</th>
<th></th>
<th>Weekday</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily Avg. PM$_{2.5}$</td>
<td>Regional VMT (thousands)</td>
<td>Daily Avg. PM$_{2.5}$</td>
<td>Regional VMT (thousands)</td>
</tr>
<tr>
<td>Baltimore</td>
<td>17.44</td>
<td>N/A</td>
<td>19.53</td>
<td>N/A</td>
</tr>
<tr>
<td>Detroit</td>
<td>11.36</td>
<td>10,884</td>
<td>13.45</td>
<td>15,755</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>31.99</td>
<td>51,372</td>
<td>46.47</td>
<td>59,653</td>
</tr>
<tr>
<td>New York$^1$</td>
<td>12.34</td>
<td>4,242</td>
<td>15.28</td>
<td>5,314</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>17.07</td>
<td>3,114</td>
<td>19.24</td>
<td>4,107</td>
</tr>
</tbody>
</table>
Meteorological Analysis for Baltimore

Ponca Street, Baltimore, MD
PM-Wind Rose Plot 04/2002-03/2003

Wind Orientation: Blowing From

- ≥45 μg/m³
- 30.0 - 45.0 μg/m³
- 15.0 - 30.0 μg/m³
- 0.0 - 15.0 μg/m³

Duration: 10 minutes
Valid Count: 6385
Meteorological Analysis for Detroit

Goddard Street, Detroit, MI
PM-Wind Rose Plot 01/2001 - 12/2001

Wind Orientation: Blowing From

Duration: 1-Hour
Valid Count: 7916
Meteorological Analysis for New York

Queens College, Queens Co., NY
PM-Wind Rose Plot 03/2001-09/2002

Wind Orientation: Blowing From

Duration:
1 Hour
Valid Count:
11694
Meteorological Analysis for Pittsburgh

Schenley Park, Pittsburgh, PA
PM-Wind Rose Plot 07/2001-08/2002

- >45 ug/m³
- 30.0 - 45.0 ug/m³
- 15.0 - 30.0 ug/m³
- 0.0 - 15.0 ug/m³

Wind Orientation: Blowing From

Duration: 10-minute Valid Count...
Meteorological Analysis for Atlanta

Jefferson Street, Atlanta, GA
PM-Wind Rose Plot 08/2001 - 09/2001

Wind Orientation: Blowing From

Duration:
1-Hour
Valid
Count:
480

- 45 ug/m³
- 30.0 - 45.0 ug/m³
- 15.0 - 30.0 ug/m³
- 0.0 - 15.0 ug/m³
Statistical Analysis

• Various statistical parameters compared including (number of measurements, minimum value, maximum value, mean, median)

• Allowed comparison with NAAQS

• Allowed comparison between cities
# Pearson Correlation Coefficients for PM$_{2.5}$

<table>
<thead>
<tr>
<th>PM$_{2.5}$ Sampling Site</th>
<th>Coefficient</th>
<th>PM$_{2.5}$</th>
<th>Local ITS Volume</th>
<th>Regional VMT</th>
<th>Local Street Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goddard Street, Detroit, MI</td>
<td>1.00000</td>
<td>0.06162</td>
<td>0.06112</td>
<td>-0.10262</td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>7,883</td>
<td>6,234</td>
<td>6,194</td>
<td>7,883</td>
<td></td>
</tr>
<tr>
<td>Riverside, Los Angeles, CA</td>
<td>1.00000</td>
<td>0.08928</td>
<td>0.40646</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>836</td>
<td></td>
<td>807</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queens College, Queens, NY</td>
<td>1.00000</td>
<td>0.08928</td>
<td>0.08930</td>
<td>0.05674</td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>11,746</td>
<td>3,440</td>
<td>2,881</td>
<td>11,746</td>
<td></td>
</tr>
<tr>
<td>Schenley Park, Pittsburgh, PA</td>
<td>1.00000</td>
<td>-0.02887</td>
<td>0.12254</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>500</td>
<td>178</td>
<td>123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ponca Street, Baltimore, MD</td>
<td>1.00000</td>
<td>0.3513</td>
<td>0.20851</td>
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</tr>
<tr>
<td>Count</td>
<td>6,395</td>
<td>5,589</td>
<td></td>
<td>6,395</td>
<td></td>
</tr>
</tbody>
</table>
PM$_{2.5}$ As A Project Level Issue

- Is PM$_{2.5}$ regional issue or a project level issue
- Implications for transportation plans
- Implications for NEPA analysis
- Atlanta site evaluated
PM$_{2.5}$ As A Project Level Issue

- MOBILE-Matrix Model
- CALINE-Grid Model
- Pearson Correlation Analysis
PM$_{2.5}$ As A Project Level Issue

- **MOBILE-Matrix**
  - MOBILE6 model run in Monte Carlo mode to create a multi-dimensional lookup matrix
  - Emission rates for any link, fleet, speed, temp, etc.

- **CALINE-Grid**
  - A grid-based iterative CALINE4 application
  - Emissions impacts for a grid of receptors (or one receptor) from every transportation link
Findings

• Graphical analysis suggested weak correlation although some correlation in morning, not in afternoon

• Pearson correlations showed weak correlations at best, some locations no correlation
Findings

- Proximity Effect must be evaluated
- Information needed on other sources
- Information needed on background concentrations
Findings

- Temporal variations exist at least as related to morning/evening/weekends
- Spatial variations exist but no conclusions can be made at this time
- Vehicle type contribution requires further evaluation of speciation data
Findings

• Role of atmospheric processes (transport), fugitive dust, and background must be evaluated

• Atmospheric warming during day may be a factor
Atmospheric Processes Potentially Effecting Concentrations
Summary

• Findings indicate additional work needed
  – Speciation data
  – Modeling data
• Proximity to monitors important
• Surrogate used for analysis may be modified
Summary

• Look at remaining data at current sampling sites
• Apply the Mobile6/CALINE4 modeling tool in other locations
• More information about this project

Kevin Black, FHWA

Kevin.n.black@fhwa.dot.gov