Improving Air Quality at Our Port and Airports

NJ CLEAN AIR COUNCIL PUBLIC HEARING
Prof. Monica Mazurek, Civil & Environmental Engineering Department
April 9, 2008
Improving Air Quality in Our Port and Airports Requires.....

Monitoring

Spatial and temporal gas and particle phase chemical constituents

Modeling

Emissions and operations

Measurement

Emissions sources and operations

Rutgers
Center for Advanced Infrastructure and Transportation
New tools for modeling emissions and quantifying operations in PNYNJ

Ongoing research at Rutgers Center for Advanced Infrastructure and Transportation (CAIT)

- Transportation models
  -- microsimulation
  -- regional scale

- Chemical emissions profiles

➤ Compare to existing inventories & ambient concentrations
FMP’s Large Scale Network Traffic Microsimulation Tool

- Most realistic representation of traffic conditions on large scale networks by time of the day
- Multiple vehicle classes (different types of autos and light, medium, heavy trucks) and type of movement (e.g. full/empty truck, full/empty container, bobtail, etc.)
- Traffic dynamics and time of day variations in traffic (individual vehicles traced every 6 seconds measuring speed, delays, idling in addition to travel time, VMTs, average speed)
- Internet based (accessible anytime, anywhere, from any machine, real time sharing of information among agencies)
- GIS based
- Data Warehouse (Stores all data: Network, Demand, Controls, Outputs, GIS Data) Query and manipulate data directly. Accessible from: Microsoft Excel, Access, any ODBC-enabled application
Air Pollution Modeling from Large-Scale Traffic Networks – Prof. Kaan Ozbay

- Microscopic simulation based estimation of the spatio-temporal change in air pollution levels
- Disaggregates spatial estimation & analysis of emissions (improves current aggregate system-wide estimations)
- Uses vehicle-based, calibrated microscopic simulation model of NJ TPK network in PARAMICS (PARAlell Microsimulation software) to disaggregate emission estimation
- US EPA MOBILE 6.2 source emission model integrated in PARAMICS (simulation air pollution levels – CO, HC, NOx, PM10) calculated each vehicle type as function of speed
Sources of fine particles in NYC area

- Monitoring PM2.5
- Measuring molecular markers
- Chemical Mass Balance (CMB-MM) model output

» Compare to emissions inventory
Receptor modeling and CMB-MM

Professor Glen Cass
Chemical species mass balance for ambient PM2.5

- Accounts for various forms of organic carbon
- Multiple analytical measurements
- Monitor variations in fine aerosol composition from bulk C to molecular organic C

Cass Group, eg., Rogge et al., *Atmos. Env.* 1993
Urban sources of fine carbonaceous particles

Los Angeles, CA fine particle emissions inventory

- Oil-fired boiler
- Autos (non- and catalyst-equipped)
- Heavy-duty diesel trucks
- Home heating furnace
- Home fireplace
- Roofing tar pots

- Road dust
- Tire dust
- Brake dust
- Cigarette smoke
- Meat cooking operations
- Vegetation (cultivated, native)

Mathematical Models Accounting for Individual Emission Contributions from Discrete Urban Sources
Estimating source contribution

**Total C (EC+OC) : Organic Matter (1.4 X OC) : Elutable Organic Matter : Molecular Tracer**

Mass emission ratios

\[
\text{hopane concentration ng/m}^3 = \frac{\text{OC concentration } \mu\text{g/ m}^3}{\text{Rogge et al., 1993 vehicle exhaust } = 2.7 \times 10^{-3}}
\]

Relative Source Contribution to Modeled OC Compounds
Ambient Concentrations

- Diesel vehicles = 60%
- Gasoline Vehicles = 30%
- Paved road dust = 10%

Schauer et al., 1996
Urban sources of PM2.5 mass

- Chemical Mass Balance – Molecular Markers (CMB-MM)
- Requires detailed chemical analysis
- Mathematical modeling tool
- Linear combinations of source types
- Emissions inventories for major sources PM$_{2.5}$

What is the organic composition of PM 2.5?

What are its sources?

What components are directly emitted vs. secondary?

NY, NJ CT Fine Particulate Matter Study

Toll Plaza 13, NJ Turnpike
Elizabeth, NJ
PM-2.5 Collection in Port and Airports Vicinity

SOAP 2002-2003 network field program

Queen’s College NY Supersite
Elizabeth, NJ
Chester, NJ
Westport, CT

Completed full annual cycle May 2002-2003 using Speciation Trends Network Schedule

400 successful ambient filters
Current State Monitoring Sites Do Not Capture PNYNY and Surroundings
Motor vehicle emissions profiles

- Collaborative research with NY State DEC Automotive Emissions Laboratory

Goals

- Updated emission profiles for light-duty diesel and gasoline-powered vehicles
- Mass balance relationships for vehicle molecular markers to EC and OC mass emission rates
- Identify molecular markers for CMB modeling
NYSDEC Automotive Emissions Lab

**Light duty dynamometer**

**Vehicle selection**
- availability, engine characteristics, age/mileage, type of service, repeatability

**Species measured**
- HC, CO, CO$_2$, NO$_x$, PM2.5 (filter & real-time), EC, OC, gas & particle-phase PAHs, PM surface area
## Vehicles tested

<table>
<thead>
<tr>
<th>Vehicle Make/Type</th>
<th>Model Year</th>
<th>No. of Cylinders</th>
<th>Engine Displacement (L)</th>
<th>Rated Power (hp)</th>
<th>Odometer (mi)</th>
<th>Test Wt. (lb)</th>
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</table>
Emissions profiles of regulated pollutants highly variable for on-road vehicles tested

Tang et al., 2008, *SAE*
Organic complex mixtures diesel & gasoline powered vehicles
PAH mixtures in motor vehicle PM2.5

- Chevy 02 Venture (Gas)
- Chevy 04 Cavalier (Gas)
- Honda 04 Civic (Gas)
- Ford 99 F350 (Diesel)
- VW 03 Jetta (Diesel)
Extensive air quality monitoring provides long term pollutant concentrations in NYC area, but NOT adequate to assess improvements to PNYNJ

Transportation models at micro and large-scale network levels under development with on-road emissions profiles based on NYDEC AEL tests (emissions function of vehicle speed)

Distributions or chemical profiles distinct patterns for key molecular markers used in CMB modeling; source profiles of “INPORT” vehicles needed to enhance accuracy model output

Vehicle chemical emission profiles important for NE U.S. state emissions inventories and SIPs – model output versus observed concentrations -- predict impact of motor vehicle emissions on urban airsheds from transportation systems
New York Air Quality Circa 1953

Control of gas phase pollutants ($\text{NO}_x$, $\text{SO}_x$, $\text{O}_3$) and PM has improved air quality in urban atmospheres
End of Presentation

Thank you

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Acknowledgements

Grants from
NSF ATM - #0120906
NESCAUM
NYSERDA #7616
US EPA STAR RD-83216501

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