Validation of Source Attribution of Fine Particle Emissions from Mobile Sources

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Overview

- Introduction and Motivation
- Procedures
  - Collection and analysis of PM
  - Chemical Mass Balance Modeling
- Results
- Conclusions

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Introduction

- **Mobile sources of fine PM**
  - Mobile sources represent 16% of non-fugitive dust emissions in U.S. EPA PM2.5 Emission Inventory
  - Diesel-engines represent 60% and gasoline-engines represent 40% of total emissions from mobile sources
- **In urban areas, responsible for elevated levels of fine PM**
  - Local PM "hot-spots", occupational exposure

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Uncertainty about the relative contribution of gasoline versus diesel engines to ambient fine PM levels

EPA Emission inventory: 60% diesel

Receptor Modeling Applications

Schauer et al (1996): 78% diesel

Zheng et al. (2002): 72% diesel

Watson et al. (2002): 74% gasoline*

* Includes contribution of cold start and poorly maintained vehicles

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Importance of Gasoline-Diesel Split

- Evaluate the efficacy of possible control strategies

- Determine the health effects of ambient PM levels

    - Diesel PM is suspected human carcinogen

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Test Accuracy of Receptor Models to Separate Gas and Diesel

- Collected PM in Washburn Tunnel
  - Single bore, forced ventilation tunnel
- Capture different mixture of gasoline and diesel vehicles
- Apply receptor models to pollutant concentrations in tunnel

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Measurements in Washburn Tunnel

- Collected samples of gas-phase and particle-phase species in tunnel and in ventilation air

- Determined pollutant emission index:

$$E_{(P)} = \frac{\Delta[P]}{\Delta[CO_2] + \Delta[CO]}$$

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Traffic Monitoring

Using monitored traffic volumes, divided samples into high fraction diesel and low fraction diesel vehicle traffic

Diesel vehicle traffic relatively constant, but gasoline vehicles (light-duty) increased during evening rush hour

Results from Washburn Tunnel

Date	Time (CDT)	Gasoline-Powered Vehicles (per hour)	Diesel-Powered Vehicles (per hour)	Fraction of Diesel Vehicles
8/29/00	1200 – 1400	873	48	5.4
8/30/00	1200 – 1400	1113	72	6.4
8/30/00	1600 – 1800	2334	55	2.4
8/31/00	1200 – 1400	1145	51	4.4
8/31/00	1600 – 1800	2658	53	2.0
9/1/00	1200 – 1400	1359	59	4.5

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Results from Washburn Tunnel

Date	Time (CDT)	Fraction of Diesel Vehicles	Percentage Carbon from Diesel Vehicles	Emission Index PM2.5 (g/kg C)
8/29/00	1200 – 1400	5.4	20.7	0.50
8/30/00	1200 – 1400	6.4	23.0	0.48
8/30/00	1600 – 1800	2.4	10.1	0.30
8/31/00	1200 – 1400	4.4	16.1	0.55
8/31/00	1600 – 1800	2.0	7.7	0.24
9/1/00	1200 – 1400	4.5	16.5	0.35

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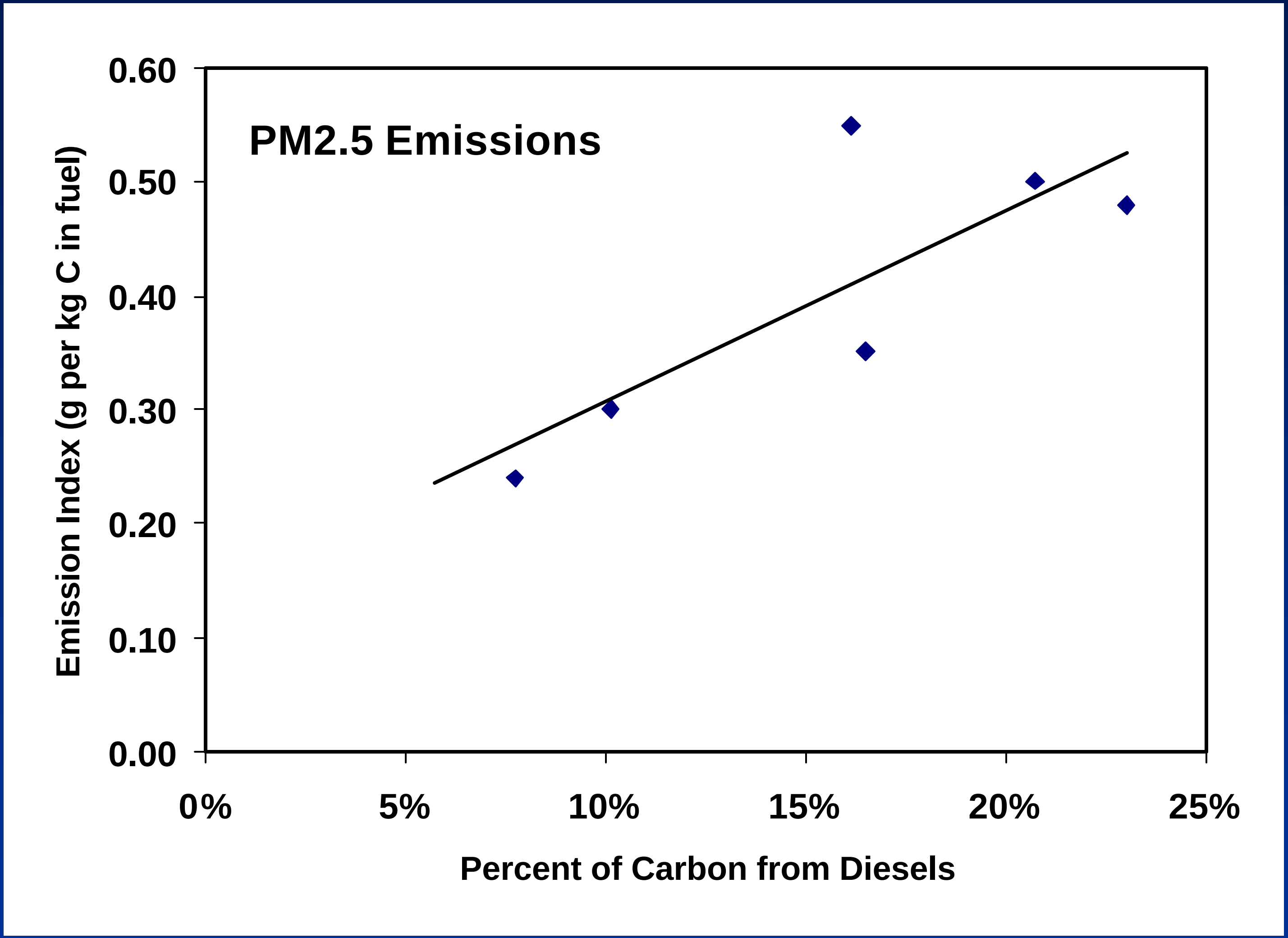
Results from Washburn Tunnel



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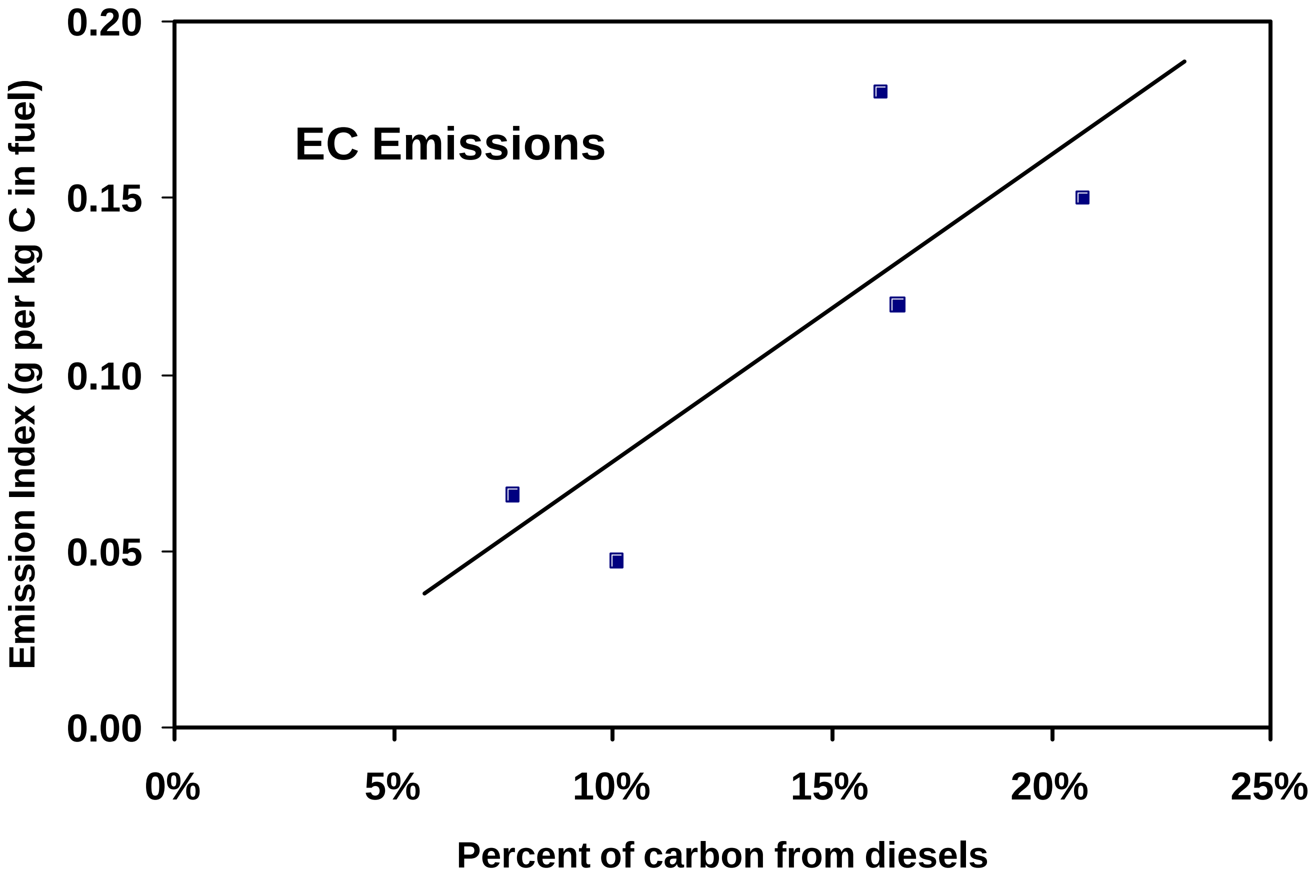
Results from Washburn Tunnel



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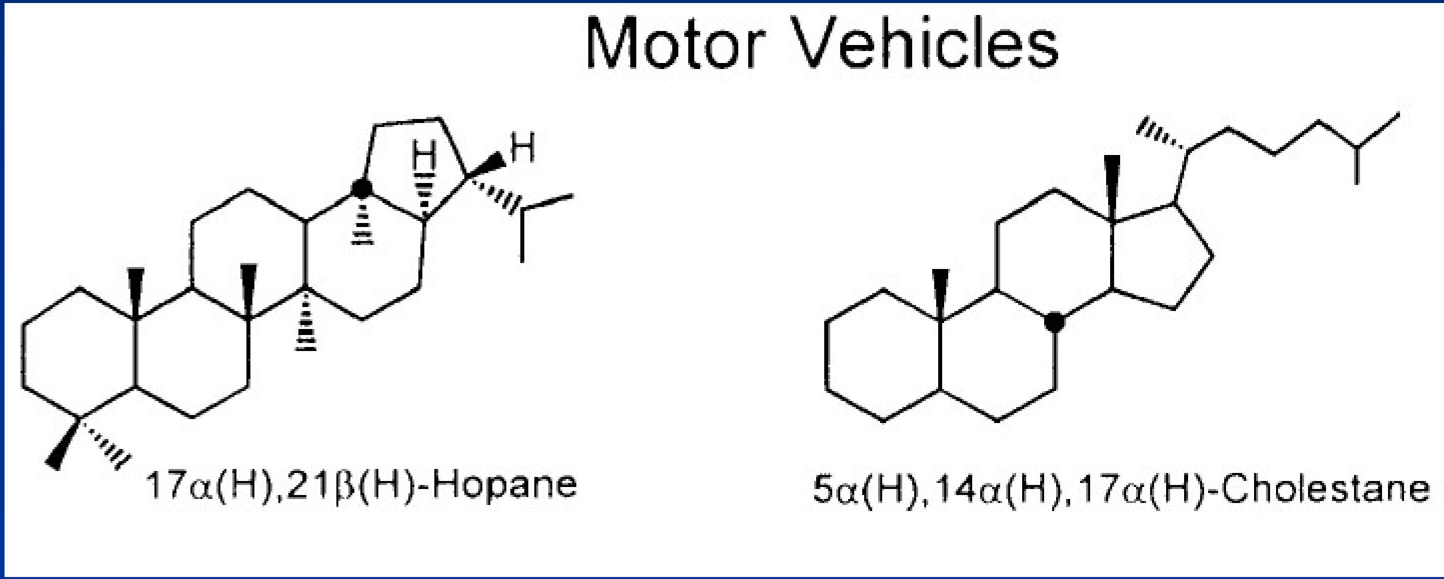
Molecular Marker Technique

- Identify and quantify organic compounds that are unique to different emission sources

- Use ambient quantification of same compounds to trace emissions from source to receptor



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Chemical Mass Balancing

$$C_{(ij)} = S \; a_{(jk)} \, s_{(ik)} + e_{(ij)}$$

where: i = compounds (1, 2, …)
j = samples (1, 2, …)
k = sources (1, 2, …)

C = concentration of species in ambient samples
a = emission source strengths
s = source profiles
e = difference between ambient concentration and reconstructed source contribution

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Molecular Markers Used in CMB

Used to separate 3 sources: diesel, gasoline road dust

11 Organic Compounds

- normal alkanes
- petroleum biomarkers
- polycyclic aromatic hydrocarbons
- alkanoic acids

3 Bulk Composition Species

- Al, Si
- Elemental Carbon

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Sample Analysis

Organic Extraction using recovery standards

Analysis by gas-chromatography and
mass spectrometry

Quantification using authentic standards

Extraction efficiency and blowdown loss
monitored with recovery standards

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CMB Results

	1200-1400 CDT	1400-1600 CDT
Gasoline-Powered Vehicles	1252 per hour	2496 per hour
Diesel-Powered Vehicles	55 per hour	54 per hour
Measured PM2.5	99.1 ± 4.2 mg m^{-3}	102.8 ± 4.5 mg m^{-3}
CMB Gasoline Exhaust	17.6 ± 4.7 mg m^{-3}	28.8 ± 6.6 mg m^{-3}
CMB Diesel Exhaust	64.3 ± 8.4 mg m^{-3}	67.3 ± 9.1 mg m^{-3}
CMB Road Dust	4.8 ± 0.7 mg m^{-3}	5.7 ± 0.9 mg m^{-3}
Percentage of Measured Mass Apportioned by CMB	87.5%	99.0%

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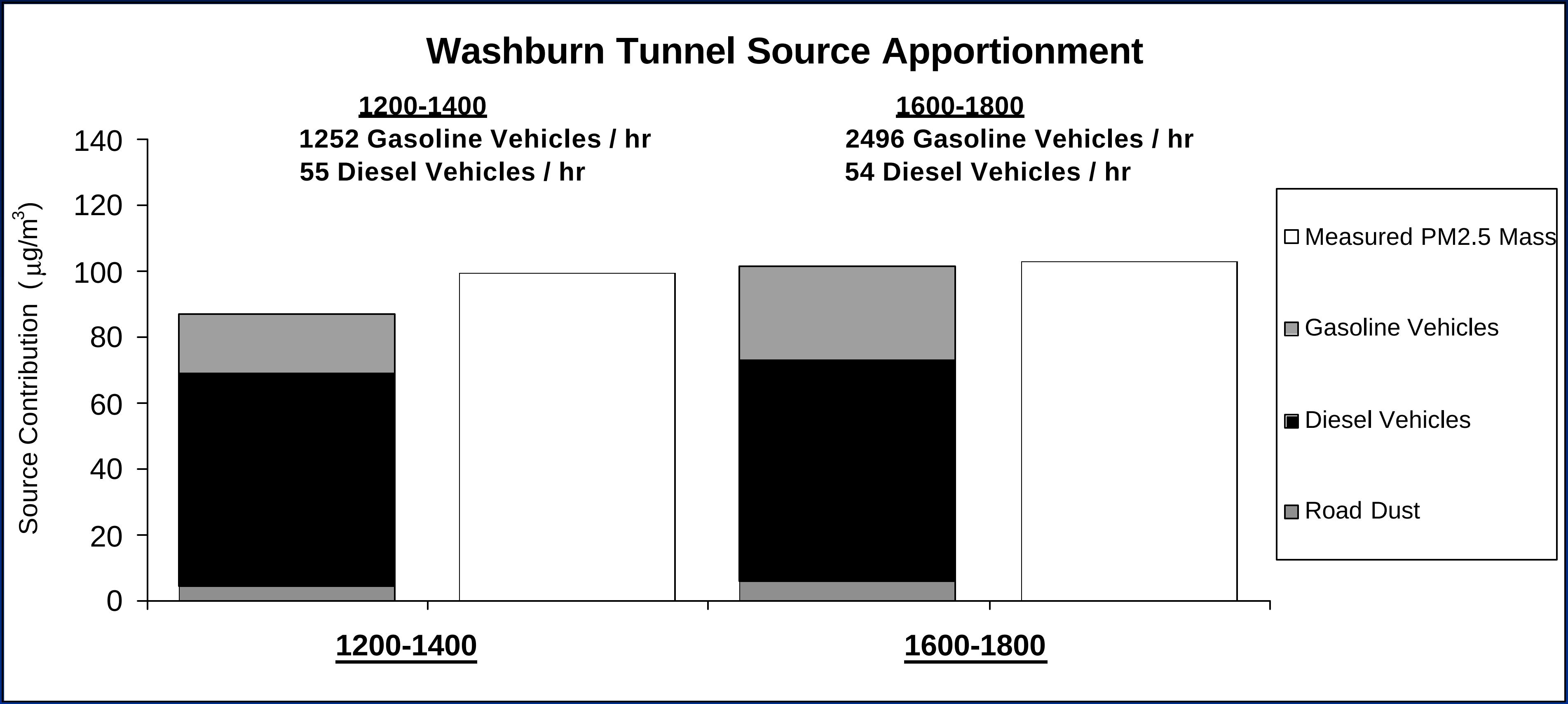
CMB Results



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Conclusions

Source apportionment modeling can accurately separate gasoline and diesel exhausts

In this case, diesel emissions contribute ~65% of fine PM from mobile sources*

Can be used to determine relative contributions for determing control strategies or health impacts

* Does not include cold start operations

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