Modeling the Impact of Traffic Conditions on the Variability of Mid-Block Roadside PM2.5 on an Urban Arterial

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MODELING THE IMPACT OF TRAFFIC CONDITIONS ON THE VARIABILITY OF MID-BLOCK ROADSIDE PM$_{2.5}$ ON AN URBAN ARTERIAL

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Friday Transpo Seminar
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Portland State University has been studying the Powell Boulevard corridor in southeast Portland – Busy arterial linking downtown to suburbs

- Investigating variations in PM levels
- Incorporating many data sources – Traffic, air quality, meteorology
- Utilizing statistical analyses to control for many factors
Exposure to Air Pollution on Roadways

What factors affect exposure to air pollution?

- Vehicle Activity
- Built Environment
- Vehicle Activity
- Meteorological Conditions

Very High Resolution Data Collection
FINE PARTICULATE MATTER (PM$_{2.5}$)

- Cancer
- Heart disease
- Increased mortality rates
- Increased incidence of respiratory disease (asthma, etc.)

Vehicle emissions, brake wear, tire wear
STUDY LOCATION

Downtown

31,500 vehicles daily
1,500-1,800 peak hours

Powell Boulevard
STUDY SITES

May 1, 2013  7:00-9:00am

“Mid-block”

Intersection

map: google.com/maps
MID-BLOCK STUDY SITE

Parking Lot

Powell City Park

(looking south)
EQUIPMENT

Fine Particulate Matter (PM$_{2.5}$)

TSI DustTrak DRX 8533

photo: www.tsi.com
EQUIPMENT

RM Young Ultrasonic Anemometer 81000

Wind Speed
Wind Direction

Onset HOBO U12

Temperature
Relative Humidity

photo: www.youngusa.com
photo: www.onsetcomp.com
EQUIPMENT

CountingCars CountCam System

Video Reference

photo: www.countingcars.com
EQUIPMENT

Vehicle Volume, Speed, Classification, Lane Occupancy

Wavetronix SmartSensor HD
TRAFFIC ACTIVITY

Westbound

Eastbound

Vehicles/min

Speed (mph)

Occupancy (%)

2:00am 7:00am 12:00pm 5:00pm 10:00pm
Can we see vehicle platooning?

map: google.com/maps
VEHICLE PLATOONING

Autocorrelation Function

Partial Autocorrelation Function

One lag = 10 seconds
**Platooning Effect on PM$_{2.5}$**

- Westbound platooning **did not have** a significant effect on PM$_{2.5}$ concentrations.
- Eastbound platooning **did have** a significant effect.

*Cross-correlation Function*

One lag = 10 seconds
EXAMINING CONGESTION

Westbound

- Pre-congestion
- Congestion
- "Active" queuing

N(t)

v₀ₜ, v₀ = 11.27mph

Eastbound

- Pre-congestion

N(t)

v₀ₜ, v₀ = 24.23mph

N(t) - v₀ₜ

7:30am 8:00am 8:30am

7:30am 8:00am 8:30am
Congestion Effect on \( PM_{2.5} \)

- Pre-congestion, active queuing associated with *lower* \( PM_{2.5} \) concentrations
- During congestion, active queuing associated with *raised* \( PM_{2.5} \) concentrations

0.35% decrease

10.8% increase
REGRESSION FINDINGS

Vehicles passing when wind blows across roadway towards monitoring station
– Current and previous observations
    Relative humidity increases
    Congestion worsens

Wind blows from the background as vehicles pass
Wind speed increases

$R^2$ .6589
$R_{adj}^2$ .653
**Vehicle Semi-Elasticities**

<table>
<thead>
<tr>
<th>Variable</th>
<th>lagged...</th>
<th>changed PM$_{2.5}$ by...</th>
<th>per...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupancy</td>
<td>0 sec</td>
<td>.05%</td>
<td>% occupancy increase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When wind was blowing across roadway towards monitoring station:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EB Passenger Vehicle</td>
<td>(80, 110, 200) sec</td>
<td>(.49%, .46%, .45%)</td>
<td>Additional vehicle</td>
</tr>
<tr>
<td>EB Heavy Vehicle</td>
<td>0 sec</td>
<td>2.45%</td>
<td>Additional vehicle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When wind was blowing from background neighborhoods:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WB Passenger Vehicle</td>
<td>0 sec</td>
<td>-.40%</td>
<td>Additional vehicle</td>
</tr>
</tbody>
</table>
CONCLUSIONS

Exposure to Roadside Fine Particulate Matter

- Data Availability
- Platooning
- Congestion
- Model Calibration

Policy Implications to Minimize Exposure
Acknowledgements

**Regression Model**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lag</th>
<th>Coefficient</th>
<th>SE</th>
<th>p</th>
<th>Unit increase effects on dependent variable (Semi-elasticity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0</td>
<td>.63261</td>
<td>.05693</td>
<td>&lt;.001</td>
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<tr>
<td>ln(PM$_{2.5}$)</td>
<td>1</td>
<td>.63829</td>
<td>.03013</td>
<td>&lt;.001</td>
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</tr>
<tr>
<td><strong>Traffic Conditions</strong></td>
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</tr>
<tr>
<td>WB Occupancy</td>
<td>0</td>
<td>.00046</td>
<td>.00013</td>
<td>&lt;.001</td>
<td>Increase by .05% per percentage point occupancy increase</td>
</tr>
<tr>
<td><strong>Meteorological Conditions</strong></td>
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<tr>
<td>Relative Humidity</td>
<td>0</td>
<td>.00138</td>
<td>.00020</td>
<td>&lt;.001</td>
<td>Increase by .14% per percentage point RH increase</td>
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<td>Wind Speed</td>
<td>1</td>
<td>-.01274</td>
<td>.00368</td>
<td>.001</td>
<td>Decrease by 1.27% per 1m/s increase</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>.00917</td>
<td>.00368</td>
<td>.013</td>
<td>Increase by .92% per 1m/s increase</td>
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<tr>
<td><strong>Vehicle Volume × Wind</strong></td>
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<tr>
<td><strong>Wind towards monitoring station</strong></td>
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<tr>
<td>EB Passenger Veh</td>
<td>8</td>
<td>.00488</td>
<td>.00214</td>
<td>.023</td>
<td>Increase by .49% per additional vehicle</td>
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<tr>
<td></td>
<td>11</td>
<td>.00455</td>
<td>.00215</td>
<td>.035</td>
<td>Increase by .46% per additional vehicle</td>
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<tr>
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<td>20</td>
<td>.00448</td>
<td>.00214</td>
<td>.037</td>
<td>Increase by .45% per additional vehicle</td>
</tr>
<tr>
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<td>21</td>
<td>.00448</td>
<td>.00214</td>
<td>.037</td>
<td>Increase by .45% per additional vehicle</td>
</tr>
<tr>
<td>EB Heavy Veh</td>
<td>0</td>
<td>.02418</td>
<td>.01075</td>
<td>.025</td>
<td>Increase by 2.45% per additional vehicle</td>
</tr>
<tr>
<td><strong>Wind away from monitoring station</strong></td>
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<td></td>
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</tr>
<tr>
<td>WB Passenger Veh</td>
<td>0</td>
<td>-.00400</td>
<td>.00144</td>
<td>.006</td>
<td>Decrease by .40% per additional vehicle</td>
</tr>
</tbody>
</table>

$^a$Akaike Information Criterion