TRAKER: A Method for Fast Assembly and Update of Paved and Unpaved Road Dust Emission Inventories

V. Etyemezian, H. Kuhns, G. Nikolich, A. Gertler
Desert Research Institute, Las Vegas, NV

D. Fitz, K. Bumiller
CE-CERT, Riverside, CA

R. Merle, and R. Langston
Clark County DAQEM, Las Vegas, NV
Outline

• Road Dust Introduction
• Mobile Platform for Road Dust Measurement
  – The TRAKER Concept
  – TRAKER Characteristics and Calibration
• Examples of completed TRAKER Applications
  – Las Vegas, NV
  – Lake Tahoe, NV/CA
  – Treasure Valley (Near Boise), ID
• Conclusions and Plans for Future Work
Road Dust Emissions

- PM emissions of fugitive dust from paved and unpaved roads due to vehicle travel
- Road Dust Emission Measurement
  - Towers upwind and downwind of road segment
  - Silt loading/content
    - Calibrated against upwind/downwind measurements
  - Vehicle-based technologies (DRI, CE-CERT)
Road Dust Measurement

• Planning agencies largely use silt loading (paved roads) and silt content (unpaved roads) to determine emission factors (AP-42 guidance document)

• Silt loading (paved roads)
  – Lane closure
  – Vacuum/sweep material
  – Use sieves to determine silt
  – Per Sample/Location ~ 10 labor hours + planning + hazards
Testing Re-Entrained Aerosol Kinetic Emissions from Roads (TRAKER)

Top View

Front

Background Monitor

Influence Monitor

Side View

Front

Background Monitor

Influence Monitor
TRAKER

- Particle Sensors
  - TSI DustTrak 5820
  - Grimm Particle Size Analyzer 1.108
- GPS
Data Acquisition and Processing

• Lab View program displays and logs data from
  – 6 DustTraks
  – 3 Grimms
  – 1 GPS
• Uniform time stamp applied to all data for synchronization
• Data tables are loaded into MS Access for processing and analysis
TRAKER Signal vs Vehicle Speed

- $T = C_{\text{tire}} - C_{\text{bkgrnd}}$
- $T = aS^3$

- On the same paved road the TRAKER signal increases with the speed cubed

- Factoring out speed leaves a signal proportional to the emission potential of the road.
TRAKER Calibration with Upwind/Downwind Flux Towers

\[ T = T_T - T_B \]

Unpaved Road EMF (g/veh-km) = 8.36 \( T^{1/3} \)

Paved Road EMF (g/veh-km) = 0.33 \( T^{1/3} \)
Example TRAKER Use: Las Vegas

- 150 km loop in Las Vegas Valley
- Covering Road Types, Locations, Construction Influence
- TRAKER operated:
  - 6/30/04, 7/1/04 (Loop 1)
  - 2/14/05 – 2/17/05 (Loop 2)
Emission Potentials (g/veh-km) on 2/14/05
Average of PM$_{10}$ Emission Factor (g/vkt) on a road link basis for all 4 days of sampling (2/14/05 – 2/17/05)

Legend

AvgOfEF

- 0.036861 - 0.081997
- 0.081998 - 0.096922
- 0.096923 - 0.109589
- 0.109590 - 0.123021
- 0.123022 - 0.139861
- 0.139862 - 0.163684
- 0.163685 - 0.185409
- 0.185410 - 0.230433
- 0.230434 - 0.302439
- 0.302440 - 1.052711

5 Kilometers

5 2.5 0
Comparison of Link-averaged emissions potentials from 4 consecutive days of TRAKER measurement in Las Vegas

02/14/05  2.0%

02/16/05  0.1%

02/15/05  4.3%

02/17/05  -6.9%
What about wind effects?

Day 1: +2.0%
Day 2: +4.3%
Day 3: +0.1%
Day 4: -6.9%
Correction for Cross-winds

Avoid cross-wind effects by considering data where TRAKER speed > 10 mph
Example TRAKER Use: Lake Tahoe

- 13 runs over a mountain pass
- 9 circuits around the lake
- Comparison with flux tower measurements
<table>
<thead>
<tr>
<th>Sampling Period</th>
<th>Condition</th>
<th>( \text{PM}_{2.5} ) EMF (mg/km)</th>
<th>( \text{PM}_{10} ) EMF (mg/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baseline</td>
<td>76</td>
<td>229</td>
</tr>
<tr>
<td>2</td>
<td>After salting</td>
<td>99</td>
<td>310</td>
</tr>
<tr>
<td>3</td>
<td>1\textsuperscript{st} dry day after storm</td>
<td>112</td>
<td>612</td>
</tr>
<tr>
<td>4</td>
<td>2\textsuperscript{nd} dry day</td>
<td>133</td>
<td>660</td>
</tr>
<tr>
<td>5</td>
<td>After sweeping</td>
<td>211</td>
<td>735</td>
</tr>
</tbody>
</table>
Emission Factor Using TRAKER

Date of Measurement

Emission Factor (g/vkt)

- Total
- Best Linear Fit to Data
Paved Road Calibration

Unpaved EF = 8.36 T^{1/3}

Lake Tahoe Paved
EF = 0.33 T^{1/3}
Example TRAKER Use: Treasure Valley, ID

- Winter/Summer TRAKER measurements over a closed loop
- Develop emission inventories based on road characteristics and traffic speeds/volumes
- Assess effect of road sanding, street sweeping, seasons
Time Series of Emissions from Roads

Principal Arterial Emissions Factors (g/VKT)

Winter

End of Road Sanding for Winter

Date


EF (g/VKT)

0 1 2 3 4 5 6 7 8 9 10

Summer
Use Roadway Properties To Extend TRAKER Results to Entire Network

Statistically significant differences found based on Season, County, Setting (urban/Rural), and Road Speed.
Use Traffic Demand Model to Obtain Link-level Emission Inventory
Another Interesting Finding About Street Sweepers

![Graph showing PM10 levels before and after sweeping at different locations.](graph.png)

- **QUARTER Before**: Left PM10 = 0.00002, Right PM10 = 0.0003
- **QUARTER After**: Left PM10 = 0.0002, Right PM10 = 0.0001
- **STILLWELL Before**: Left PM10 = 0.000005, Right PM10 = 0.00001
- **STILLWELL After**: Left PM10 = 0.000005, Right PM10 = 0.00001

**SWEPT**

**NOT SWEPT**
Conclusions

• Vehicle-based methods for road dust emissions measurement are efficient and comparatively fast
  – Cover 100’s of mile of road
  – No need to worry about “picking” representative sections of road
• For TRAKER
  – Las Vegas Study shows day to day differences (precision) is on the order of 5% overall and generally better than 20% on a link by link basis
  – Important to recognize the effect of cross-winds
  – Can use to
    • Efficiently assemble emission inventories for road dust
    • Test effects of parameters: sweeping, sanding, season, location, construction, traffic volume, etc
• Technology has been around for 6 years and multiple studies
Planned Future Work

• Increase # calibration data points for paved roads using upwind/downwind technique (Las Vegas, summer 2005)
• Quantitatively compare with CE-CERT SCAMPER (summer 2005)
• Redesign towards achieving turnkey application (Winter, 2006). Features for TRAKER III will include:
  – New Platform: Dodge Sprinter
  – On-the-fly span and zero for DustTraks onboard
  – On-the-fly switching between paved and unpaved road sampling
  – Real-time mapping of dust emission potentials and factors
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