Lake Tahoe Source Characterization Study

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Sponsors:
California Air Resources Board
Strategic Environmental Research and Development Program
Desert Research Institute – Applied Research Initiative
National Cooperative Highway Research Program
Outline

- Motor Vehicle Exhaust
- Road Dust
- Wood Smoke
- Source Profiles
- Emissions Inventory
Motor Vehicle Exhaust

- Source profiles and emissions measured with In-Plume system
- Pollutants referenced to CO$_2$ emitted from tail pipes
- Emission factors in units of grams pollutant per kilogram fuel
In-Plume System Setup in Incline Village
In-Plume Example Data from Southwood and Mays in Incline Village

- PU Truck; 146; 16%
- HD truck; 21; 2%
- Motorcycle; 2; 0%
- LD Car; 299; 33%
- Van; 24; 3%
- SUV; 389; 44%
- Minivan; 21; 2%

**Pie Chart:**

**Graph:**

- CO (ppm)
- CO2 (ppm)
- NO (ppm)
- NO2 (ppm)
- NH3 (ppm)
- DT PM10 (mg/m³)
- DT PM2.5 (mg/m³)
- DT PM2.5 (mg/m³)

**Data for Peaks:**

- Peak #354: Minivan; 21; 2%
- Peak #355: SUV; 389; 44%
- Peak #356: PU Truck; 146; 16%
- Peak #357: HD truck; 21; 2%
- Peak #358: Motorcycle; 2; 0%
- Peak #359: LD Car; 299; 33%
- Peak #360: Van; 24; 3%
- Peak #361: SUV; 389; 44%
- Peak #362: PU Truck; 146; 16%
- Peak #363: HD truck; 21; 2%
- Peak #364: Motorcycle; 2; 0%
- Peak #365: LD Car; 299; 33%
- Peak #366: Van; 24; 3%
- Peak #367: SUV; 389; 44%
- Peak #368: PU Truck; 146; 16%
- Peak #369: HD truck; 21; 2%
- Peak #370: Motorcycle; 2; 0%
- Peak #371: LD Car; 299; 33%
- Peak #372: Van; 24; 3%
- Peak #373: SUV; 389; 44%
- Peak #374: PU Truck; 146; 16%
- Peak #375: HD truck; 21; 2%
- Peak #376: Motorcycle; 2; 0%
- Peak #377: LD Car; 299; 33%
- Peak #378: Van; 24; 3%
- Peak #379: SUV; 389; 44%
- Peak #380: PU Truck; 146; 16%
- Peak #381: HD truck; 21; 2%
- Peak #382: Motorcycle; 2; 0%
- Peak #383: LD Car; 299; 33%
- Peak #384: Van; 24; 3%
- Peak #385: SUV; 389; 44%
- Peak #386: PU Truck; 146; 16%
- Peak #387: HD truck; 21; 2%
- Peak #388: Motorcycle; 2; 0%
- Peak #389: LD Car; 299; 33%
- Peak #390: Van; 24; 3%
- Peak #391: SUV; 389; 44%
- Peak #392: PU Truck; 146; 16%
- Peak #393: HD truck; 21; 2%
- Peak #394: Motorcycle; 2; 0%
- Peak #395: LD Car; 299; 33%
- Peak #396: Van; 24; 3%
- Peak #397: SUV; 389; 44%
- Peak #398: PU Truck; 146; 16%
- Peak #399: HD truck; 21; 2%
- Peak #400: Motorcycle; 2; 0%
- Peak #401: LD Car; 299; 33%
- Peak #402: Van; 24; 3%
- Peak #403: SUV; 389; 44%
- Peak #404: PU Truck; 146; 16%
- Peak #405: HD truck; 21; 2%
- Peak #406: Motorcycle; 2; 0%
- Peak #407: LD Car; 299; 33%
- Peak #408: Van; 24; 3%
- Peak #409: SUV; 389; 44%
- Peak #410: PU Truck; 146; 16%
- Peak #411: HD truck; 21; 2%
- Peak #412: Motorcycle; 2; 0%
- Peak #413: LD Car; 299; 33%
- Peak #414: Van; 24; 3%
- Peak #415: SUV; 389; 44%
- Peak #416: PU Truck; 146; 16%
- Peak #417: HD truck; 21; 2%
- Peak #418: Motorcycle; 2; 0%
- Peak #419: LD Car; 299; 33%
- Peak #420: Van; 24; 3%
- Peak #421: SUV; 389; 44%
- Peak #422: PU Truck; 146; 16%
- Peak #423: HD truck; 21; 2%
- Peak #424: Motorcycle; 2; 0%
- Peak #425: LD Car; 299; 33%
- Peak #426: Van; 24; 3%
- Peak #427: SUV; 389; 44%
- Peak #428: PU Truck; 146; 16%
- Peak #429: HD truck; 21; 2%
- Peak #430: Motorcycle; 2; 0%
- Peak #431: LD Car; 299; 33%
- Peak #432: Van; 24; 3%
- Peak #433: SUV; 389; 44%
- Peak #434: PU Truck; 146; 16%
- Peak #435: HD truck; 21; 2%
- Peak #436: Motorcycle; 2; 0%
- Peak #437: LD Car; 299; 33%
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- Peak #462: Van; 24; 3%
- Peak #463: SUV; 389; 44%
- Peak #464: PU Truck; 146; 16%
- Peak #465: HD truck; 21; 2%
- Peak #466: Motorcycle; 2; 0%
- Peak #467: LD Car; 299; 33%
- Peak #468: Van; 24; 3%
- Peak #469: SUV; 389; 44%
Wood Smoke

In-Plume System used to measure emission factors and source profiles.

<table>
<thead>
<tr>
<th>Type of furnace</th>
<th>Model</th>
<th>Type of Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified Woodstove</td>
<td>Country Striker</td>
<td>Juniper/Cedar</td>
</tr>
<tr>
<td></td>
<td>S160</td>
<td></td>
</tr>
<tr>
<td>Conventional Woodstove</td>
<td>Trailblazer Classic</td>
<td>Almond (hardwood)</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>Pine (softwood)</td>
</tr>
<tr>
<td>Fireplace</td>
<td></td>
<td>Oak (hardwood)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Juniper (softwood)</td>
</tr>
</tbody>
</table>

Woodstove Composite

- Hardwood (Almond)
- Softwood (Pine)
Road Dust with TRAKER
• TRAKER vehicle operated on >2000 km of roads around lake and over Mt. Rose pass
Roadside Sampling
Near Sand Harbor State Park
Emissions Inventories

Estimates based on

• Wood consumption (CE-CERT Survey)
• Fuel consumption (gal/pump, pumps/basin)
• Measured emission factors

Results compared with CARB EI
## EI Comparison

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Data Source</th>
<th>PM$_{10}$ (Mg/Yr)</th>
<th>NO (Mg/Yr)</th>
<th>CO (Mg/Yr)</th>
<th>Total Organic Gasses (TOG) (Mg/Yr)</th>
<th>NH$_3$ (Mg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust including Cold Start</td>
<td>CARB (EMFAC)</td>
<td>24</td>
<td>1568</td>
<td>14654</td>
<td>935</td>
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<tr>
<td>Exhaust including Cold Start</td>
<td>This Study</td>
<td>6.7</td>
<td>148</td>
<td>2489</td>
<td>421</td>
<td>28</td>
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<tr>
<td>Paved Road Dust</td>
<td>CARB (EMFAC)</td>
<td>479</td>
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<tr>
<td>Paved Road Dust</td>
<td>This Study</td>
<td>287</td>
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<tr>
<td>Residential Wood Combustion and Campfires</td>
<td>CARB</td>
<td>761</td>
<td>138</td>
<td>4944</td>
<td>1174</td>
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<tr>
<td>Residential Wood Combustion and Campfires</td>
<td>This Study</td>
<td>680</td>
<td>187</td>
<td>6400</td>
<td>570</td>
<td>68</td>
</tr>
</tbody>
</table>
Conclusions

• Road Dust and Residential Wood Combustions are large PM Sources
• Coarse mode of road dust leads to deposition closer to the source
• Fine mode of fire aerosols allows for extended atmospheric lifetime
• Road sanding is a large source of dust
• Sweeping needs to be conducted in all jurisdictions especially residential neighborhoods
Recommendations

• Wind resuspension of PM on road shoulder may be unaccounted source
• Wildland and prescribed burning activity needed to estimate these sources
• Deposition measurements needed to better understand flux to Lake
• Scavenging by vegetation is likely to be significant for sources of coarse particles
Future Work

• Funding secured for year round TRAKER study including extensive paved road dust calibration
  – EPA Region 9 sponsor through SNPLMA