Identification of Methane Emissions in an Urban Setting

ESRL Global Monitoring Annual Meeting May 17-18, 2011
Collaborators in this effort

- Nathan Phillips & Lucy Hutyra – Boston University
- Jocelyn Turnbull & Colm Sweeney – NOAA/ESRL
- Paul Shepson & Maria Obiminda Cambaliza – Purdue
- Eric Crosson, Chris Rella, & Sze Tan – Picarro, Inc.
- Robert Ackley – Gas Safety, Inc.
Objectives of this effort

- As an extension of the INFLUX work
  - Identify methane source locations and gather information on methane flux signals (relative magnitudes).
  - Provide prior knowledge for inversion models.
  - Data to help validate inversion model results.
  - Information to help improve flux measurements from aircraft.
  - Data could help to model cross-wind dispersion in an urban environment.
Method: Measuring Methane Plumes to Determine Source Locations

- Map out methane concentrations while driving along roads and highways.
  - CH$_4$: 2 ppb precision at 0.5 Hz.
  - GPS data
  - Wind velocity
Method: Identifying methane source locations

Guidance from Simple Gaussian Plume Model

Source locations calculate from plumes

Four source locations
Winds: 0 to 360° in 20° steps
Atmospheric stability class C
Model Results: Winds from only two orthogonal directions…….source location looks possible.
From Models to Reality: Measurements in Indianapolis

Methane measurements while driving through plume
“Methane Maps” of Indianapolis

Wind direction, 23km/hr
Some Sources are easy to Identify

> 25 ppm
Others are NOT so Easy
Methane Data Taken the Next Day

Wind direction, 23km/hr
Repeated landfill plume measurements taken while driving 2 km from source. (Location: Danville, IN)

- Wind speed = 3.8 ± 1.2 km/hr
- Source Flux ≈ 7,000 grams / minute

High variability in plume shape. Take advantage by……
Stationary Tracer Method to Assess Fluxes

- Fixed location 1300 m downwind of landfill

- Natural variation in wind direction & wind speed will cause variability in signal as the plumes sweep across the detection point

- High correlation indicates good overlap between plumes
Methane Flux Determination (Location: Danville, IN)

- Plot methane vs. acetylene.
- Slope of line gives ratio of emission rates.

<table>
<thead>
<tr>
<th>Type of linear regression</th>
<th>Slope of the line</th>
<th>Total Methane Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constrained</td>
<td>138.1</td>
<td>7,207 g / min = 7.5 moles / s</td>
</tr>
</tbody>
</table>
A Very Complex Methane Map: Boston

Play Video
Natural Gas Leaks in and around Boston
Natural Gas Leaks Destroying Vegetation

• Leaks in aging natural gas pipelines are killing trees all across the northeast.
  – Natural gas leaks can kill trees by displacing oxygen in the soil and drying out their roots.
  – 7,500 to 10,000 trees affected in Boston area alone.

• Several cities are asking for damages in excess of $1M each.

<table>
<thead>
<tr>
<th>Flux (cubic feet / m²-day) at surface</th>
<th>Gas in air 8” below surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.237</td>
<td>26%</td>
</tr>
<tr>
<td>1.407</td>
<td>48%</td>
</tr>
<tr>
<td>1.007</td>
<td>80%</td>
</tr>
<tr>
<td>0.012</td>
<td>63%</td>
</tr>
</tbody>
</table>

http://natgaspollutes.com
Summary

- Identification of methane source locations by driving around looks possible.
- Flasks need to be analyzed.
- Need model to reconstruct methane probability distribution from plume data.
- Need to take more systematic data.