THE IMPACT OF ROADSIDE BARRIERS ON NEAR-ROAD CONCENTRATIONS OF TRAFFIC RELATED POLLUTANTS

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Overview
Overview

› Goal
  › Determine if barriers can be used to reduce near-road concentrations
  › Give guidelines for the use of barriers

› Results
  › A model that can explain the effect of barriers

› Main Conclusions
  › Barriers reduce concentrations
  › Reduction persists farthest during stable atmospheric conditions, when concentrations are normally largest
Outline

- Effects of barriers
  - Measurements
  - Two barrier models
- Comparison with measurements
- Sensitivity of model predictions to changes in barrier height

Introduction
Idaho Falls  (Finn et al. 2010)

- SF$_6$ released from two sources simultaneously
- Concentrations measured at 56 receptors
- Spanned neutral, unstable, and stable conditions
Idaho Falls (Finn et al. 2010)

- Neutral
- Slightly Stable
- Very Stable

Graphs showing the dependency of concentration (C) on distance (x) under different stability conditions with and without a barrier.
Idaho Falls

Dilution during neutral stability

Experiments
Source Shift Model (Heist et al. 2009)

- Source shifted upwind by a distance, $s$
- Vertical plume spread increased by a factor $\alpha$

$$(\quad) = E + F$$

Models
CFD Simulation  (Hagler et al. 2011)

Models
Mixed Wake Model

- Concentration is well mixed over the height of the barrier, $H$
- Vertical plume spread increased by a factor $\alpha$

\[
(\ ) = E F E F + 2F \bar{u}_2
\]
Idaho Falls

Unstable

Stable

- With Barrier
- Without Barrier

Models
Idaho Falls

Atmospheric turbulence

Barrier

Shear generated turbulence

\[ \frac{h}{U(H)/u_*} = \text{E.F.} \]

Models
Idaho Falls

Unstable

Stable

Neutral

\( U_{\sigma_z} \) [m²s⁻¹]

Distance [m]

Models

- With Barrier
- Without Barrier
Models

We used a numerical model to check this idea.

\[ K = UH \]
Models

Increase in Initial Vertical Plume Spread

\[ \frac{\sigma_z}{H} \]

- Neutral
- Unstable
- Stable
- Very Stable
Comparison with Idaho Falls

Neutral Conditions

Source Shift

Mixed Wake

Comparison with Data
Comparison with Idaho Falls

Unstable Conditions

Source Shift

Mixed Wake

Comparison with Data
Comparison with Idaho Falls

Stable Conditions

Source Shift

Mixed Wake

Comparison with Data
Comparison with Idaho Falls

Very Stable Conditions

Source Shift

Mixed Wake

Comparison with Data
Without γ model

Comparison with Data
Sensitivity to Barrier Height

Unstable

Stable

Sensitivity to Barrier Height
Example

- Receptor 40 m from road
- Meteorology from 2006 – 2007
- PM2.5 emissions
  - 0.03 g km$^{-1}$
  - 86000 vehicles day$^{-1}$
Example

<table>
<thead>
<tr>
<th></th>
<th>Without Barrier</th>
<th>With Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum (μg m⁻³)</td>
<td>120</td>
<td>28</td>
</tr>
<tr>
<td>Annual Average (μg m⁻³)</td>
<td>15</td>
<td>4.5</td>
</tr>
<tr>
<td>Background (μg m⁻³)</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>
Conclusion

- Barrier causes:
  - Larger initial vertical plume spread
  - More rapid increase in the plume spread with distance from the source
- Barrier effect persists farthest during stable conditions
Conclusion

- Mixed wake model:
  - Compares well with observations
  - Gives useful estimates of concentrations
Thank You
Questions?

Overview

- Living near major roads is linked to
  - Development of asthma
  - Impaired lung function
  - Total and cardiovascular mortality
  - Birth and developmental effects
  - Cancer
Idaho Falls

Plume spread during very stable stability

![Graph showing plume spread with and without barrier](image)

- With Barrier
- Without Barrier

Conclusion
Source Shift Model

We formulate a model of the shift distance, $s$, in terms of barrier height, $H$

$E - E - F_F = \bar{\epsilon}^2$

- Location of barrier
- Location of source

$\beta$ – Empirical correction factor
Comparison with Wind Tunnel

Source Shift

- $mg = 1.28$
- $sg = 1.26$
- $fact2 = 95\%$
- $r^2 = 0.88$

Mixed Wake

- $mg = 1.30$
- $sg = 1.16$
- $fact2 = 100\%$
- $r^2 = 0.95$
Comparison with Wind Tunnel

Source Shift

- $mg = 0.82$
- $sg = 1.41$
- $fact2 = 87\%$
- $r^2 = 0.91$

Mixed Wake

- $mg = 1.16$
- $sg = 1.16$
- $fact2 = 100\%$
- $r^2 = 0.96$

Comparison with Data