Field Experiments on Tracer Dispersion About the Pentagon

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Objectives

• Investigate transport & dispersion about the Pentagon
• Study effects of
  - Meteorology -- wind, turbulence, stability
  - Building geometry
  - Source geometry
• Provide dataset for model development and evaluation
Experimental Plan

- Short intensive program
  - 4 SF₆ measurement days
- Focus on conditions for high concentrations
  - Light winds
  - Near neutral to stable stratification
- Detailed meteorology
  - Wind, temperature, turbulence, BL height
  - Have redundancy
- Meteorological forecasting
  - Light winds; S – SW, SE – S; no precip
Experimental Plan (cont’d)

- SF$_6$ sources
  - Quasi-instantaneous line
    \[ C(x,t), \text{longitudinal \& vertical dispersion} \]
  - Continuous point
    \[ C(x,t), \text{lateral \& vertical dispersion} \]
Experimental Components

- $\text{SF}_6$ releases
  - Line -- created by moving source
  - Point – fixed source
- $\text{SF}_6$ sampling
  - 5 real-time monitors (TGAs)
  - 32 bag samplers (PIGS)
- Meteorological forecasts
- Meteorological measurements
SF$_6$ Monitors

Bag sampler (PIGS)

Real time (TGA)
Line Source Release Routes & SF₆ Monitor Locations

SF₆ Monitor Layout: Line source release
- Red: Bag sampler (PIGS)
- Green: Real time sampler (TGA)
- Yellow: Potential TGA site (use 2 of 9)
- Orange: Possible release routes
# Measurement Periods

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Line Rel (#)</th>
<th>Pt Rel (hrs)</th>
<th>Stability</th>
<th>Dir</th>
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</thead>
<tbody>
<tr>
<td>5/1</td>
<td>9:30 – 11:30 AM</td>
<td>8</td>
<td></td>
<td>NN, C</td>
<td>S - SW</td>
</tr>
<tr>
<td>5/4</td>
<td>7 PM – 2 AM</td>
<td>16</td>
<td></td>
<td>NN, WS</td>
<td>S - SW</td>
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<tr>
<td>5/6</td>
<td>7 PM – 2 AM</td>
<td>6</td>
<td></td>
<td>NN, WS</td>
<td>S - SW</td>
</tr>
<tr>
<td>5/8</td>
<td>6 PM – 1 AM</td>
<td>8</td>
<td>3</td>
<td>NN, WS</td>
<td>SE – S</td>
</tr>
</tbody>
</table>

**Stability:**

NN = Near neutral, C = Convective, WS = Weakly stable
Modeling & Analysis

• CFD Models
  - Reynolds-averaged Navier-Stokes (RANS)
  - Large-eddy simulations (LES)
• Other Numerical Models
  - e.g., SCIPUFF with Urban Wind Model
• Conceptual Fluids Models
  - Describe essential physics of urban canopy & PBL, building wake, and dispersion with analytical or simple numerical models.
• Simple Analytical Model
  - Gaussian puff or plume
Gaussian Line Puff
(for reference)

\[ C(x, z, t) = \frac{Q_L}{2\pi \sigma_x \sigma_z} \exp \left( -\frac{(x - Ut)^2}{2\sigma_x^2} \right) \exp \left( -\frac{z^2}{2\sigma_z^2} \right) \]

Peak Concentration: \[ C_p(x, 0) \simeq \frac{Q_L}{\pi \sigma_x \sigma_z} \]

\[ \sigma_x = (\sigma_u x / U) \ f_1(x) \]

\[ \sigma_z = (\sigma_w x / U) \ f_2(x) \]
Example Wind and Temperature Profiles
Line Source Release Routes & SF₆ Monitor Locations

SF₆ Monitor Layout: Line source release
- Bag sampler (PIGS)
- Real time sampler (TGA)
- Potential TGA site (use 2 of 9)
- Possible release routes
Concentration Time History: Line Source, IOP 2  9 PM
Preliminary Line Source Results vs Gaussian Puff

Peak Surface Concentration from TGA Monitors

Peak Concentration \( \left( \frac{C_p}{Q_L} \right) \) (m²)

Distance from Source (m)

- IOP 1: Day, C - NN
- IOP 2: Night, NN - WS

\( \sigma_x, \sigma_z \) based on Tower \( \sigma_u/U, \sigma_w/U \)

T1, T2, T3, T4, T5
Summary

- Intensive SF$_6$ measurement program successfully conducted
  - Concentrations from line and point releases
  - Extensive meteorological measurements
- Nocturnal stability was near neutral; stability ranged from weakly unstable to weakly stable.
- Preliminary line source concentrations agreed with Gaussian line puff upstream of building, were lower than puff in building complex, and higher than puff in wake.
Point Source for S – SW Wind

$\text{SF}_6$ Monitor Locations

**SF6 Monitor Layout: Continuous Point Source (assumes S-SW winds)**

- Bag sampler (PIGS)
- Additional PIGS
- Real time sampler (TGA)
- Potential TGA (use 2 of 7)
- Source (use 1 of 5)
Experimental Components (cont’d)

- Meteorological measurements
  - 15 Anemometers (PWIDS)
  - 10 Sonic anemometers
  - 33-m Tower: wind & temp. (5 levels), turb. (4 levels)
  - Radiosondes (hourly)
  - Sodar
  - TLS (blimp) profiling – wind, temp, turbulence
  - CTI doppler radar – wind field
  - REAL lidar – BL height