Development of Optical Remote Sensing Protocol for the Measurement of Nonpoint Emission Sources

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Need Statement

No recognized method exists for making direct nonpoint source measurements. An accurate and cost-effective method is needed to quantify area emission sources.

Project Sponsor

Environmental

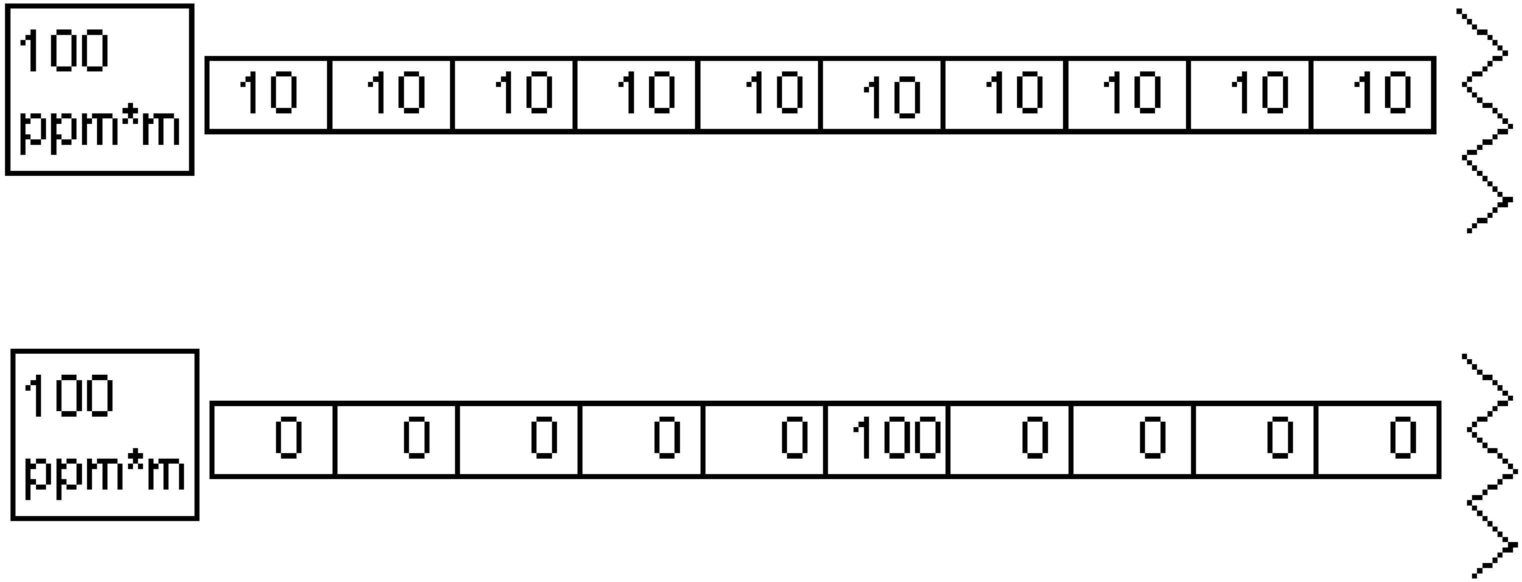
Security

Technology

Certification

Program

Path Integrated Concentration



OP Instrument Summary

Spectroscopic Methods:

- **Open Path Fourier Transform Infra Red (OP-FTIR)**
- **Differential Optical Absorption Spectroscopy (DOAS)**

Advantages:	Disadvantages:
Multiple compounds simultaneously	Interference
Potential Particulate Matter	Relatively slow

Laser Based Techniques:

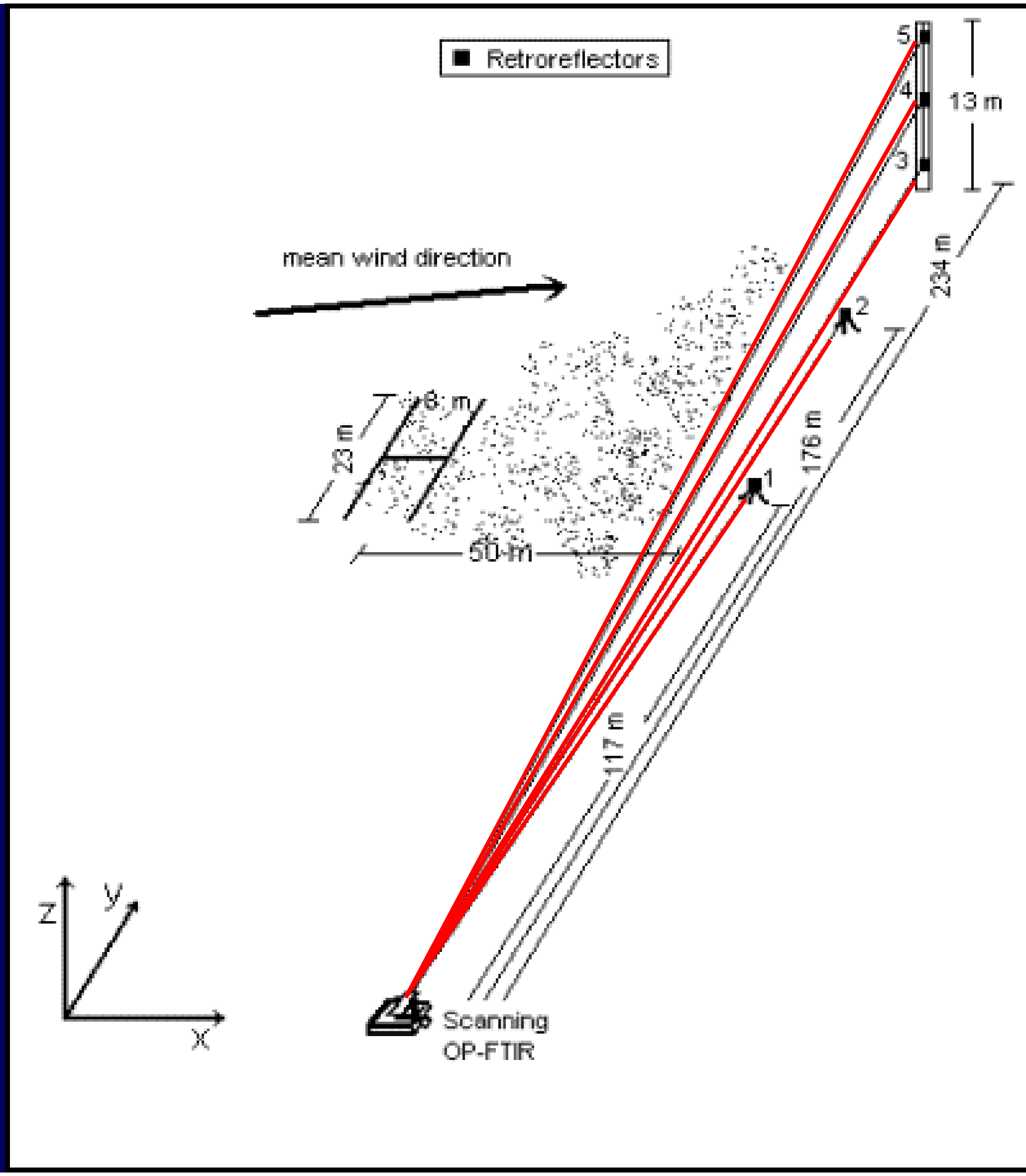
- **Tunable Diode Laser Absorption Spectroscopy (TDLAS)**
- **Differential Absorption Lidar (DIAL)**

Advantages:	Disadvantages:
Fast	Typically single compound
Interference free	Expensive
Long range	

New Method Summary

- Beam Configuration: OP-FTIR (or other OP method) multiple beams to determine vertical and horizontal gradients
- Optimization algorithms to directly reconstruct the mass equivalent plume downwind from the source
- No need for tracer release or inverse dispersion modeling approach for plume characterization
- Plane-integrated concentration x wind speed = emission flux

Example: Oxford NC Test



Vertical Scanning

Oxford NC Test Results

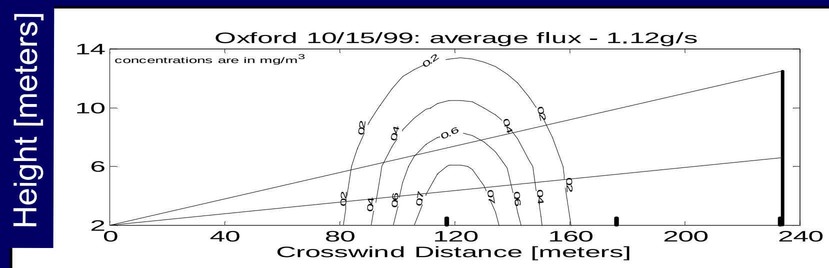
Reconstructed Plumes

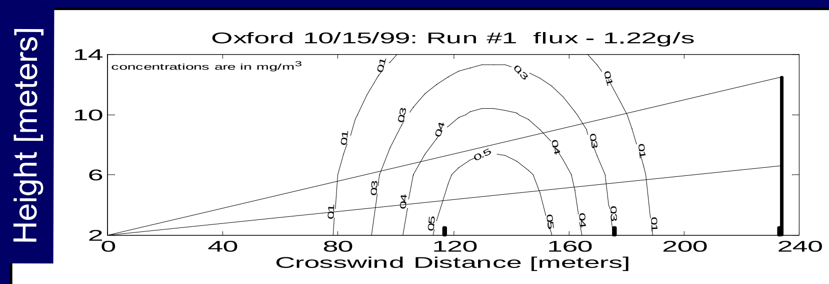
Actual release rate = 1.7 g/s

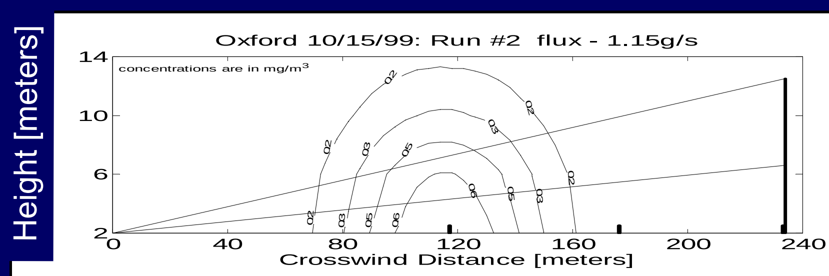
Calculated flux = 1.2 g/s

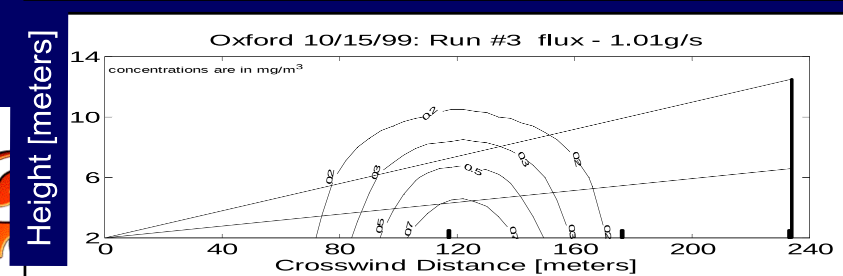
Measured σ_{θ} – 50.7 degrees

(Pasquill-Gifford Stability A - unstable)









Oxford NC Test Results

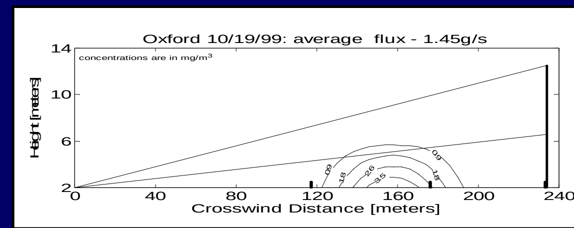
Reconstructed Plumes

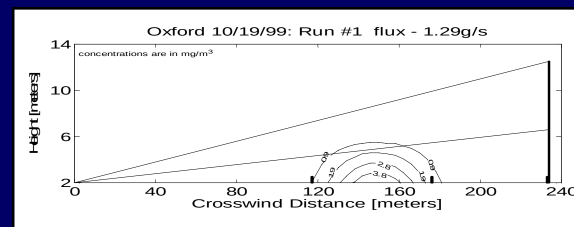
Actual release rate = 1.7 g/s

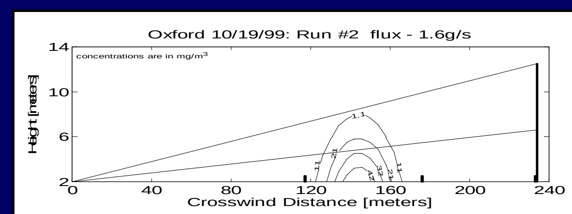
Calculated flux = 1.5 g/s

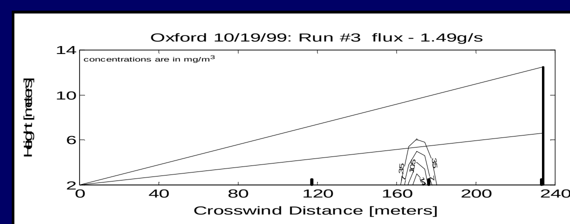
Measured σ_θ – 12.7 degrees

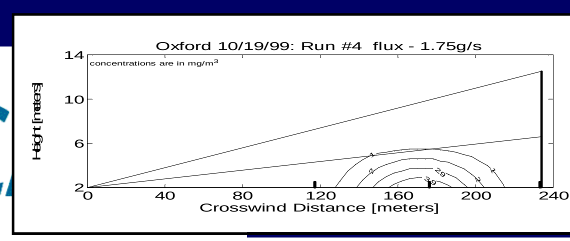
(Pasquill-Gifford Stability C-D - neutral)



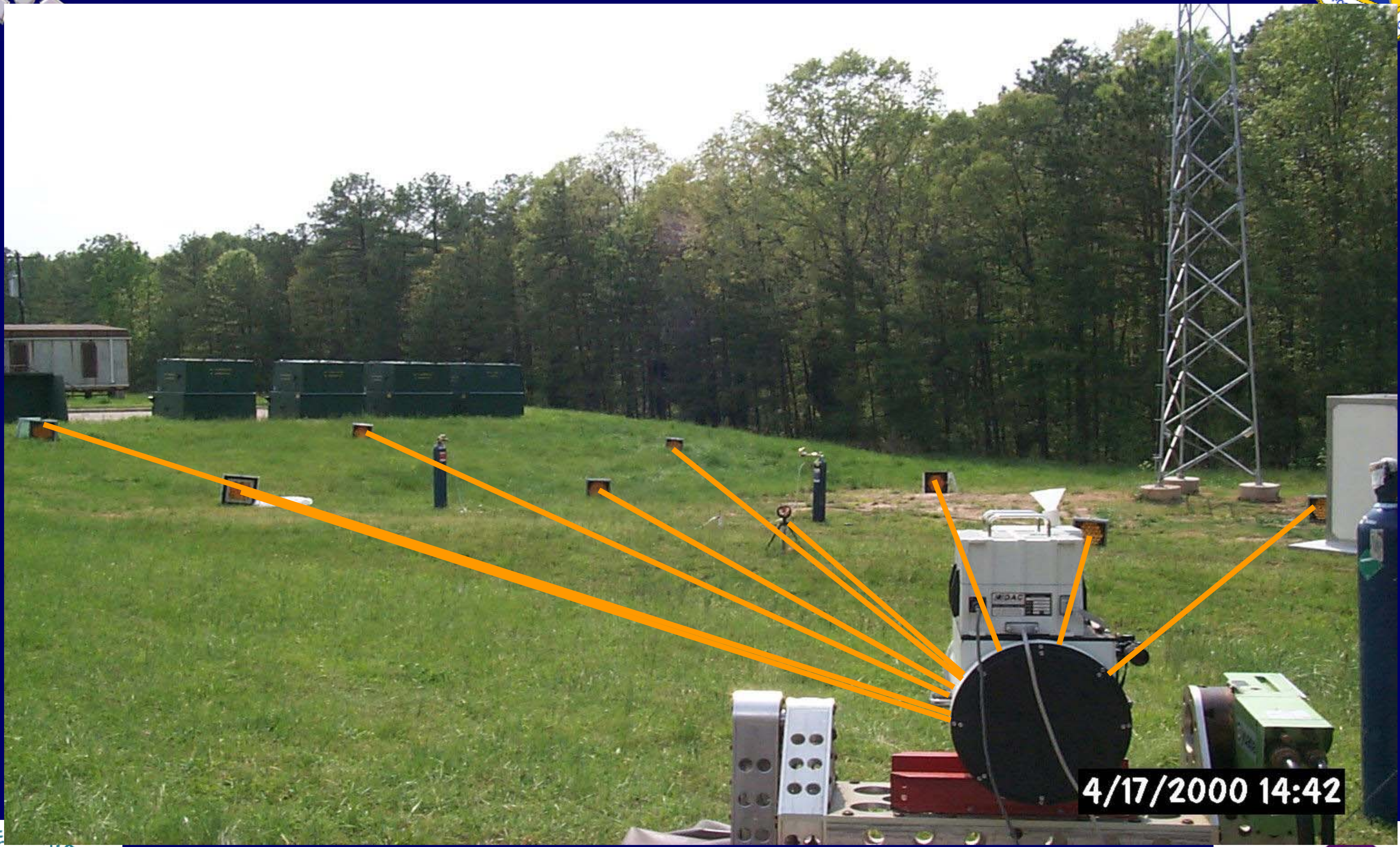




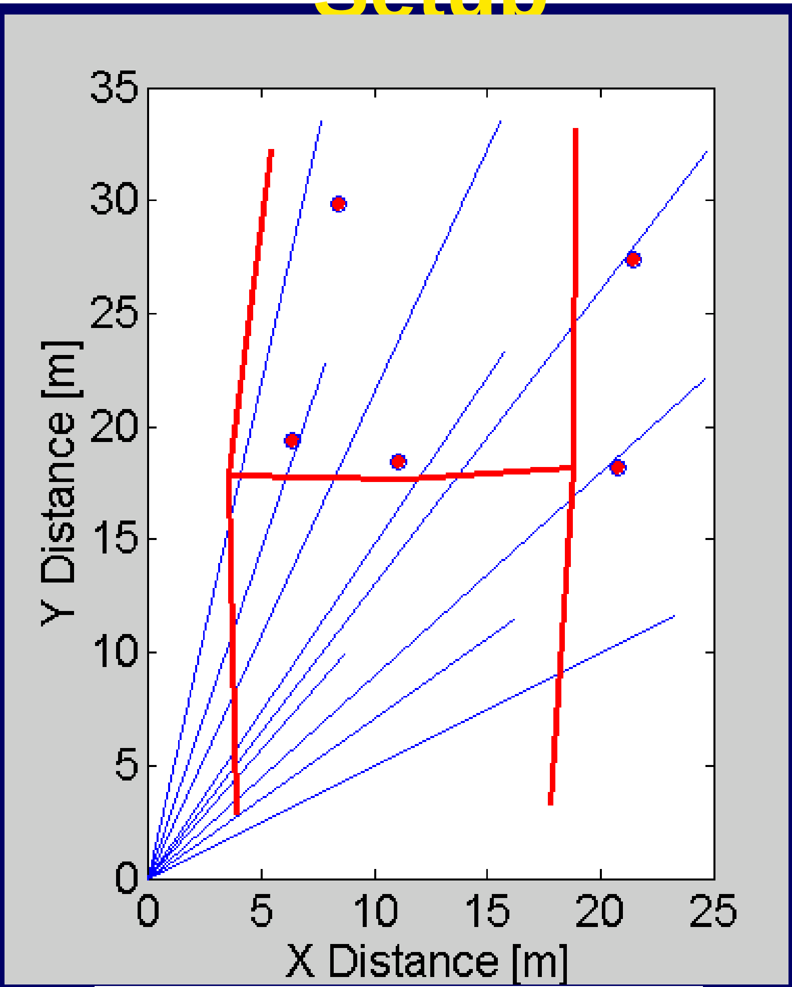




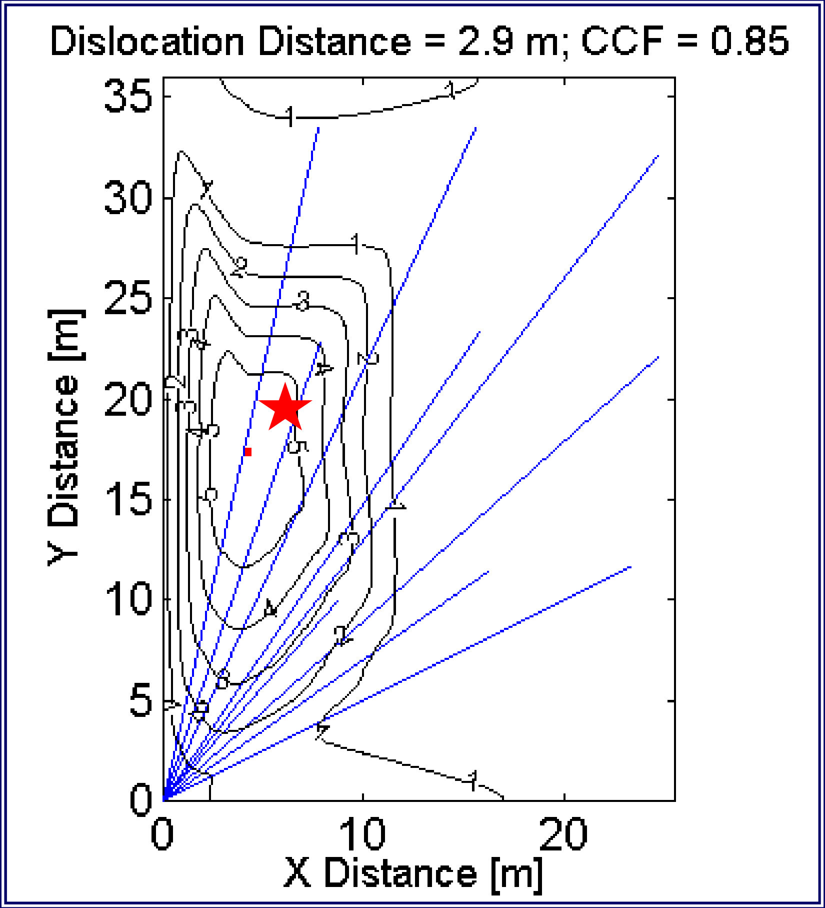
Radial Scanning

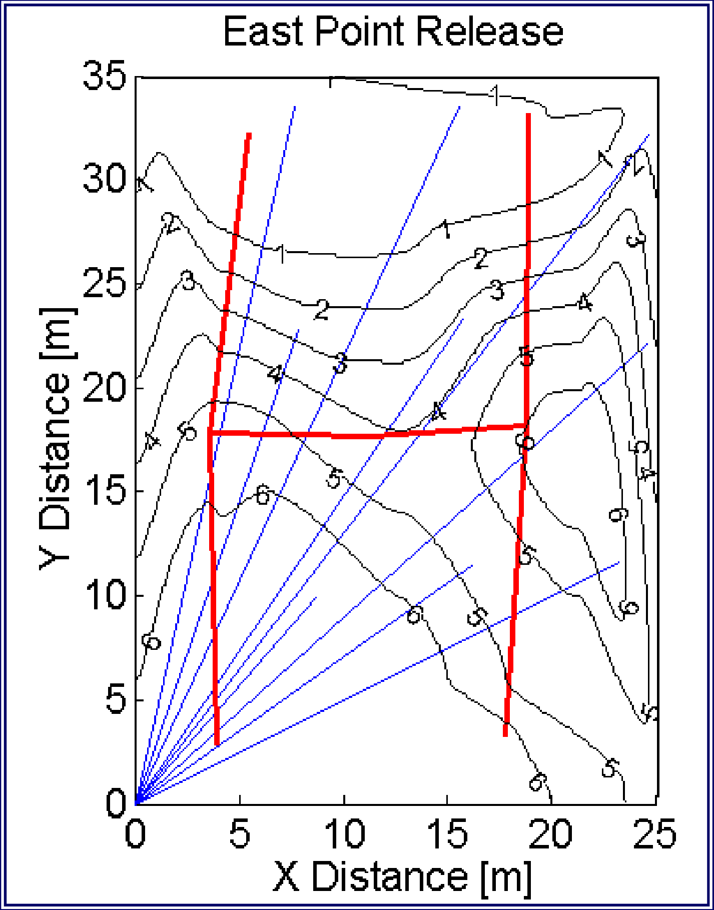


Validation Study Experimental Setup



East





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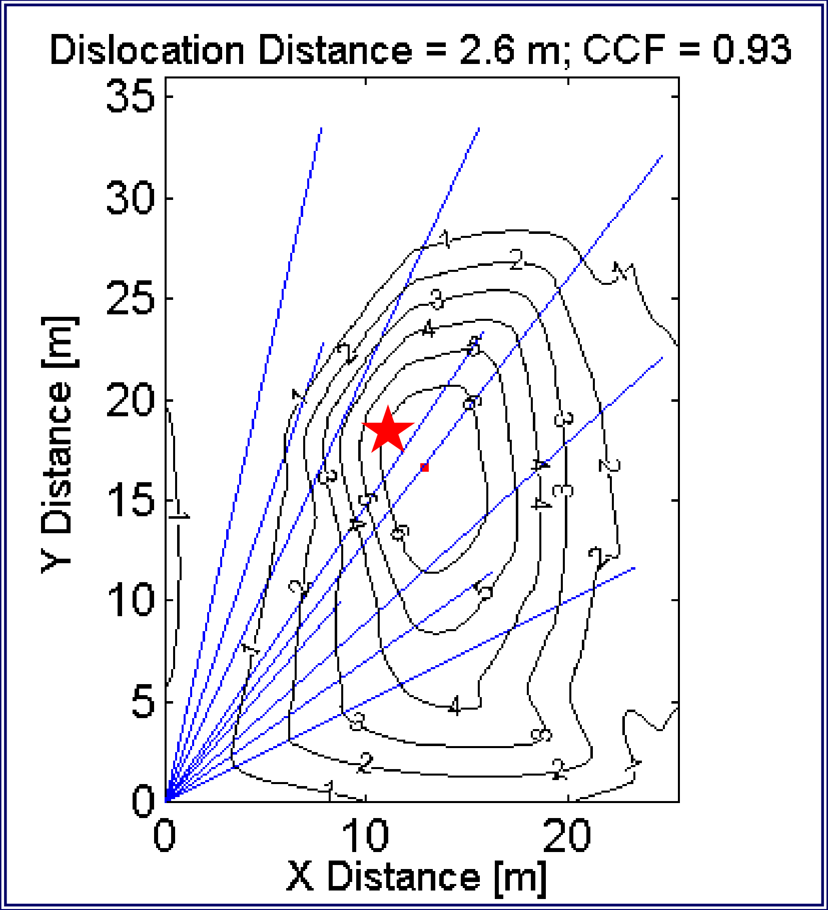
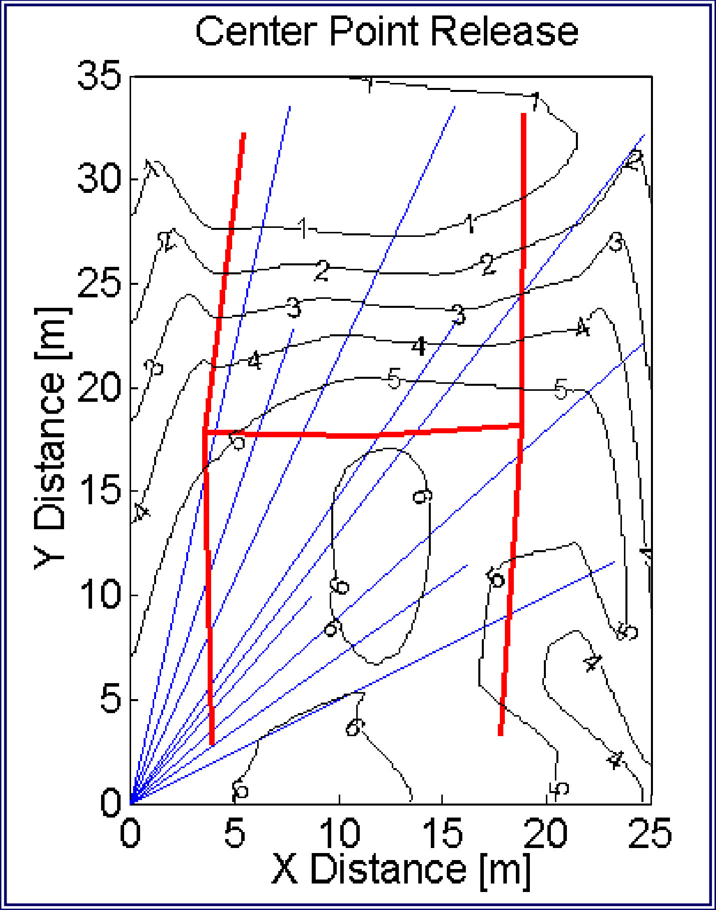
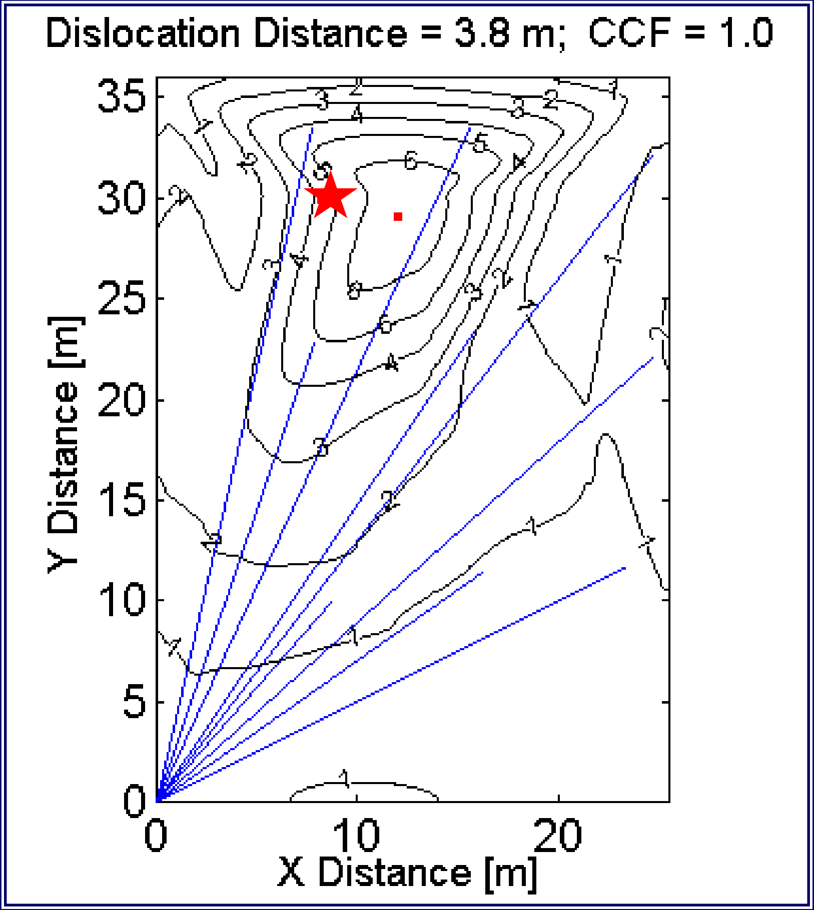
Center

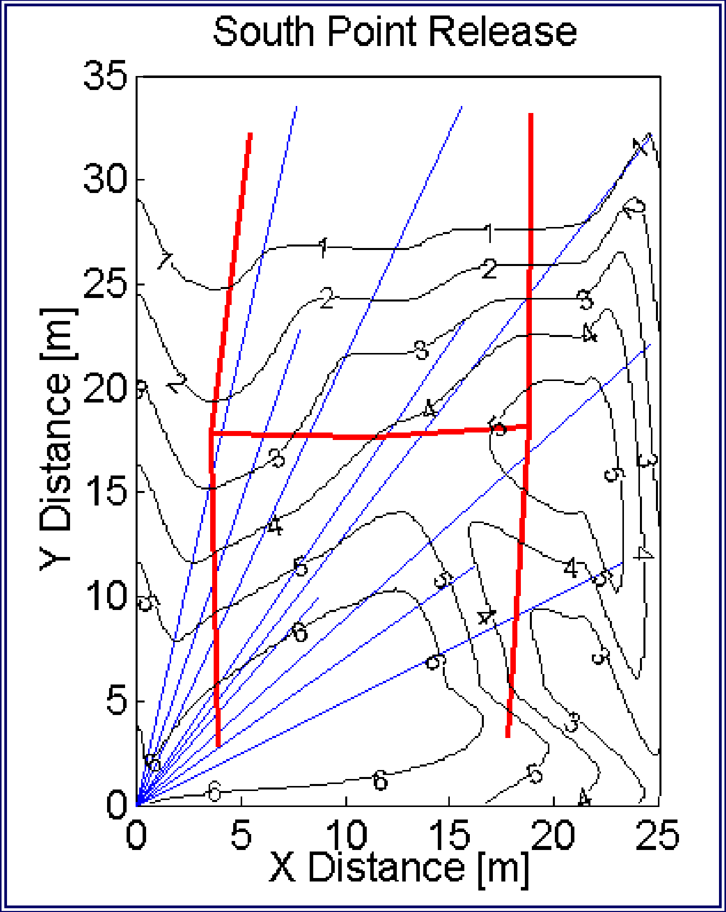

Dislocation Distance = 2.6 m; CCF = 0.93
Y Distance [m]
X Distance [m]


Center Point Release
Y Distance [m]
X Distance [m]

South

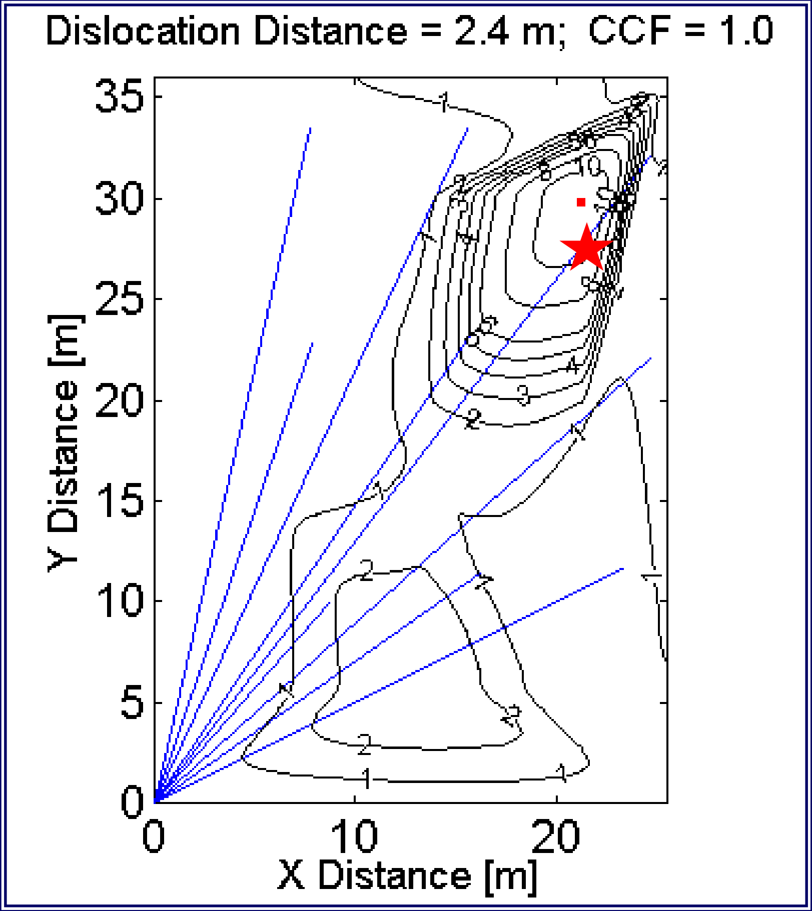


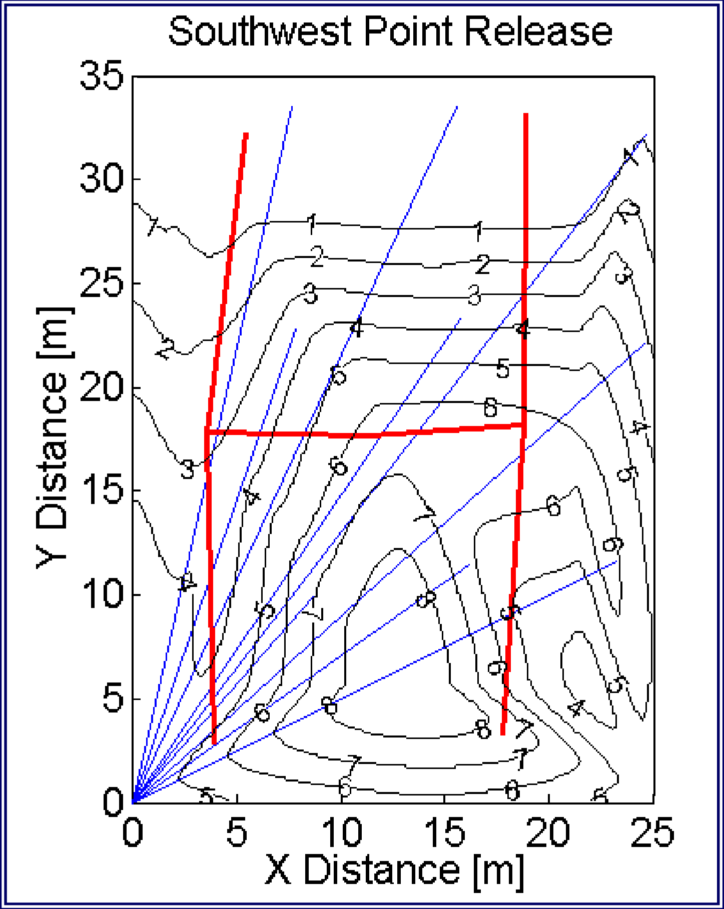
Dislocation Distance = 3.8 m; CCF = 1.0
Y Distance [m]
X Distance [m]



South Point Release
Y Distance [m]
X Distance [m]

Southwest





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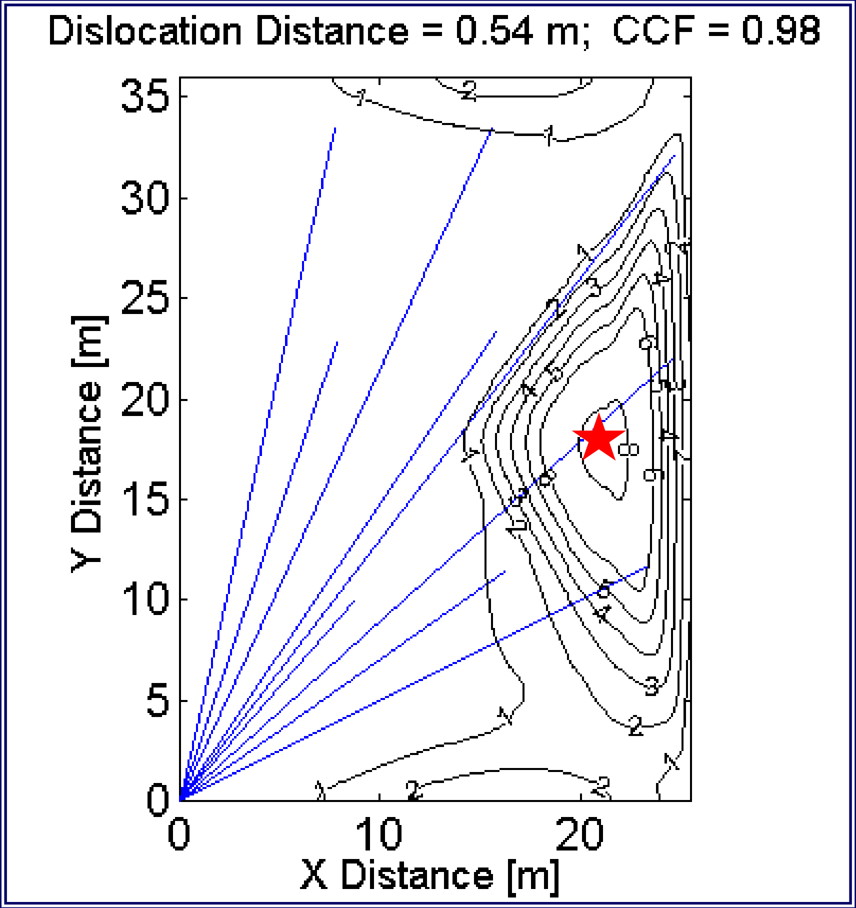
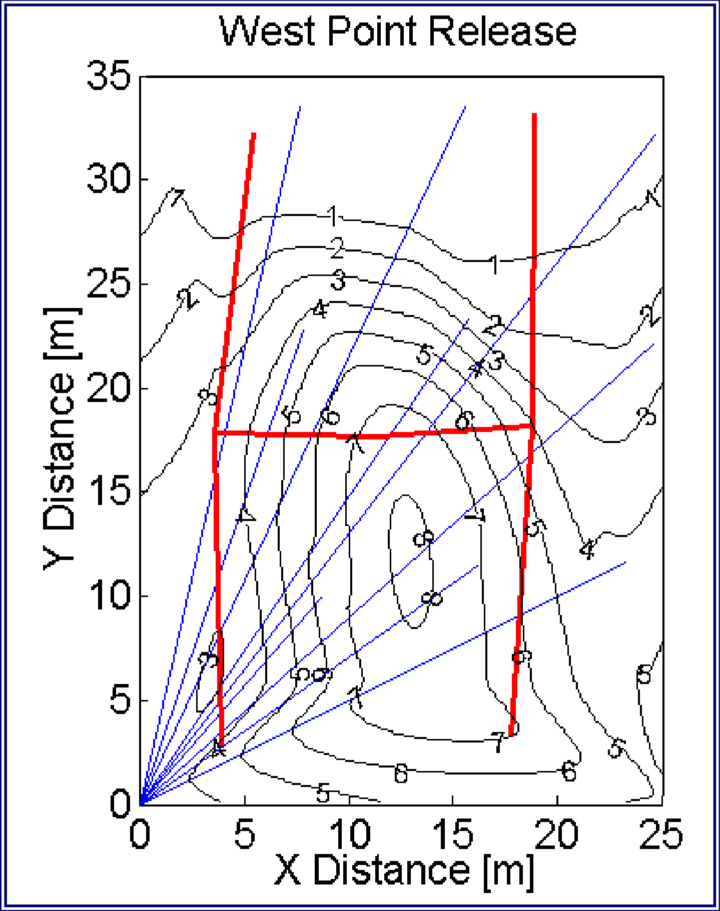
West





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Cost Comparison Estimate

#	*Task*	*Conventional ($)*	*ORS + Conventional ($)*
1	Preparation	22,000	7,000
2	Set-up	6,000	3,000
3	Test	50,000	30,000
4	Report	25,000	10,000
5	Travel	7,000	5,000
6	Subcontractor Expenses	60,000	15,000
7	Other Expenses	20,000	30,000
	Total	190,000	100,000

Key Performers

- Pat Sullivan, PI, AFRL/MLQF
  - Robin Segall, QA, Reg Lead, EPA-OAQPS
    - John Bosch, Reg Advisor, EPA-OAQPS
    - Thomas Logan, Tech Advisor, EPA-OAQPS
  - Ram Hashmonay, Tech Lead, ARCADIS
    - Various Scientists, Technicians, ARCADIS
  - Bruce Harris, Tech Advisor, EPA-APPCD
  - Various Site Coordinators, Army, Navy, AF

Controlled Validation Design

- Soaker hose in ‘H’ pattern to simulate area source
- Point release to simulate a “hot spot”
- Ethylene, N_2O test gas and others
- Plane-integrated OP-FTIR downwind
- Radial scanning OP-FTIR over the source
- Met station and optical anemometer for wind
- Self-calibrated Gilson Tapered-tube flowmeter
- Weigh the gas cylinder before and after a 1-hour run to confirm the flowmeter

Demonstration

- Actual area sources at DoD installations will be measured and protocols refined
- Examples: WWTP, Landfills, Flightline Operations
- Methodology and actual costs to be documented

Technology Transfer

Published EPA Method

Optimization algorithms will be licensed to equipment manufacturers

Optimization algorithms will be licensed to A&E firms providing base support services

Summary

New OP multiple beam method can provide accurate quantification of area sources, with lower cost and complexity than conventional methods. This project will validate/demonstrate this method.

This demonstration is strongly supported by the EPA. The project objective is to publish a standard protocol for measuring nonpoint sources.

The OP multiple-beam method can become a powerful tool for DoD and industrial facility managers to solve P2 and compliance problems.