Optical Remote Sensing-Based Monitoring Methods for Non-Point Sources

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Background Information

ARCADIS has supported the U.S. EPA Office of Research & Development for many years through the On-site Research Laboratory Support (ORLS) contract

ARCADIS scientists have worked directly with EPA researchers in developing novel measurement technologies and approaches for characterizing emissions from non-point sources

Many optical remote sensing-based technologies, including OP-FTIR, OP-TDL, and UV-DOAS for fenceline monitoring at industrial facilities, monitoring during remediation activities, or area source emission flux measurements

In recent years, other measurement approaches have been successfully developed and tested, including a fast-response mobile measurement platform, and low-cost sensor packages

Non-Point Sources

Emissions are Generally

- Extended Area
- Spatially Complex
- Temporally Variable

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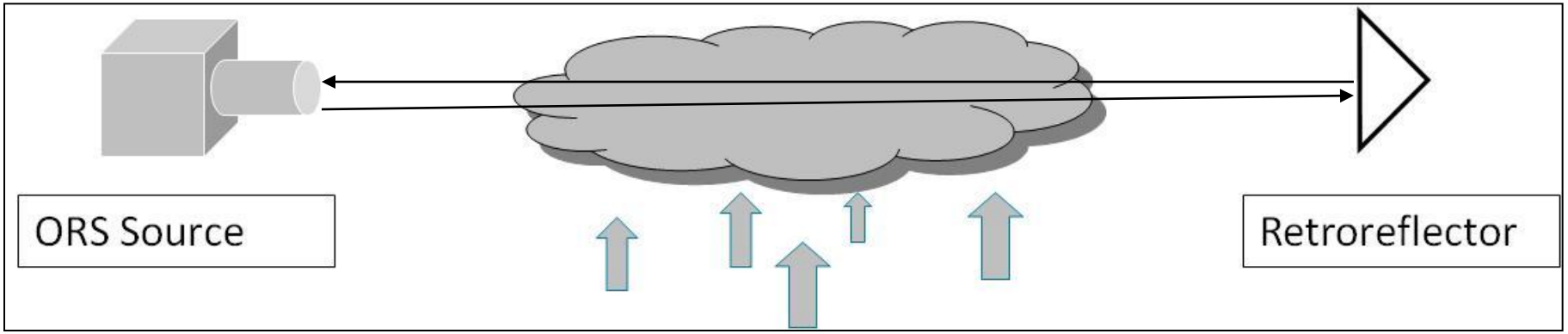
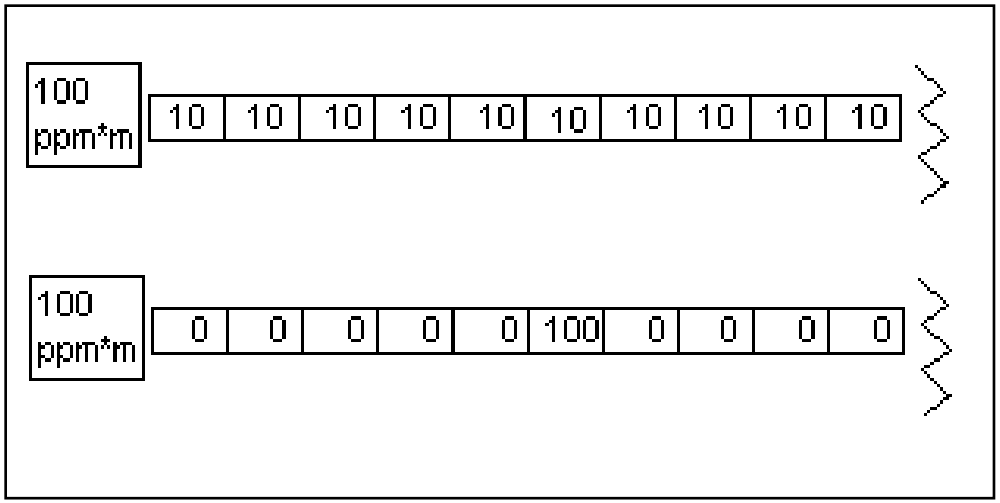
Overview of Optical Remote Sensing Instrumentation

Open-Path Optical Remote Sensing (ORS) Instrumentation



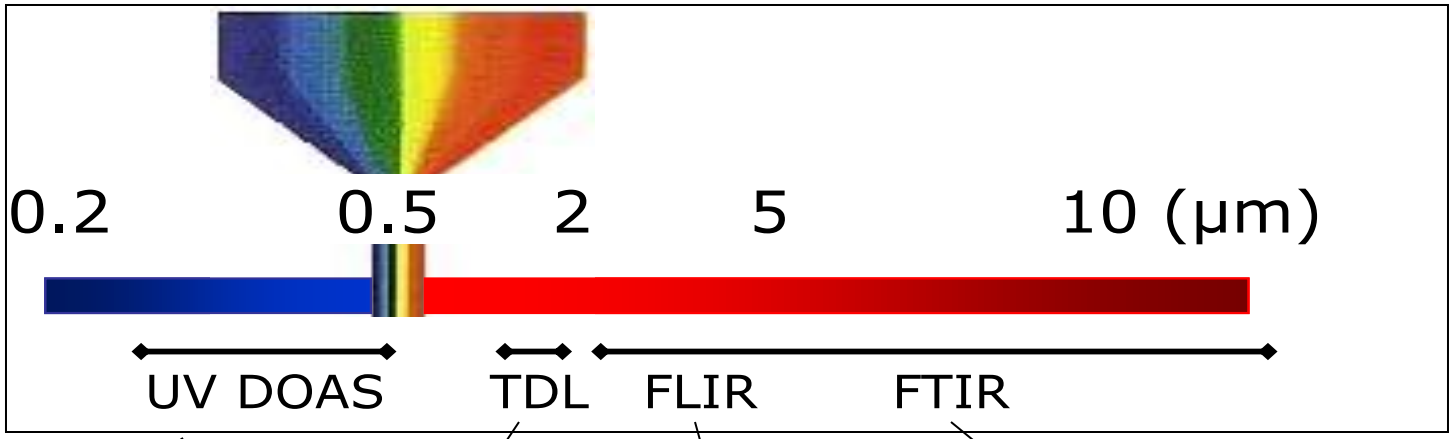
- Uses infrared, laser, or ultraviolet light to measure chemical concentrations. Light signal is sent out to mirrors deployed in the field, and signal is reflected back to the instrument detector
- Data collected over path lengths as long as 500 meters, increasing the chances of pollutant detection when compared to other point monitor approaches

Path-integrated Concentration



- Optical Remote Sensing instrumentation measure the path-integrated concentration along the measurement path (units of ppm*m)
- Path-averaged concentration is found by dividing the path-integrated concentration by the measurement path length

Open-Path Instruments



UV Diff. Optical Absorption Spectroscopy

Tunable Diode Laser (scanning)

Forward-Looking InfraRed (leak imaging)

Fourier Transform InfraRed (scanning)

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Air Monitoring During Remediation Activities

Deployment of Optical Remote Sensing Instrumentation for Monitoring During Remediation Activities

Optical Remote Sensing instrumentation are ideal for air monitoring during remediation activities due to:

- Spatial extent of measurement paths (up to 500 meters), offering superior coverage to traditional point monitor approaches that may not detect small plume events
- Ability to detect hundreds of hazardous air pollutants simultaneously (OP-FTIR), and provide concentration determinations for each individual analyte

Optical Remote Sensing Instrumentation for Monitoring During Remediation Activities-Case Study

- ARCADIS was hired by an industrial client to perform remediation of a dry creek bed after a benzene spill caused a large amount of benzene to leak into the creek
- The creek flows through a large residential area with houses on both sides of the creek bank
- As part of the site remediation, soil from the creek was excavated and transported offsite
- There was concern that excavation activities could lead to the release of benzene plumes that would migrate into the residential area

Optical Remote Sensing Instrumentation for Monitoring During Remediation Activities-Case Study

- An OP-FTIR was deployed during the excavation. Multiple measurement paths were configured downwind of the excavation site, between the creek bed and the residential area

Optical Remote Sensing Instrumentation for Monitoring During Remediation Activities-Case Study

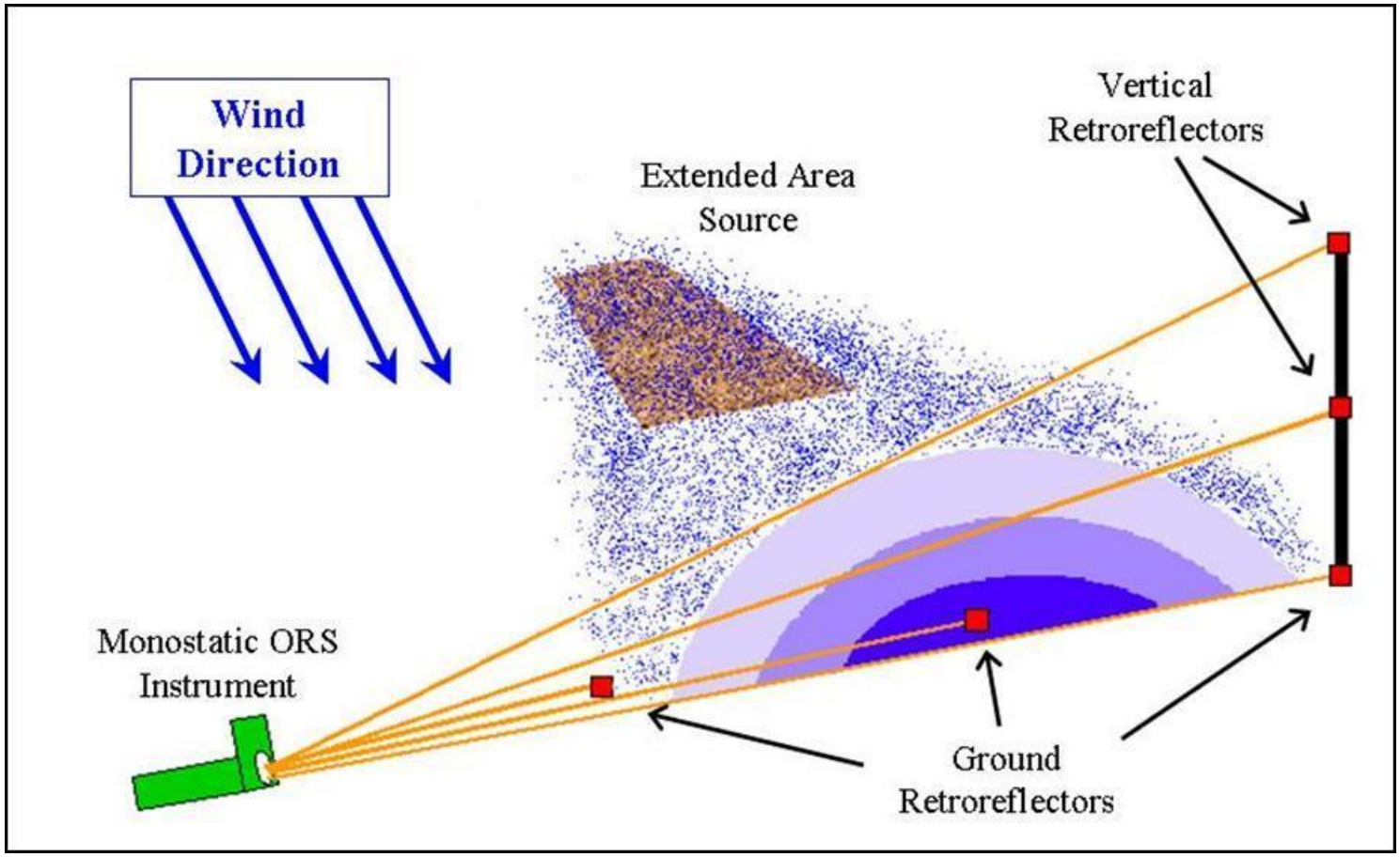
- The OP-FTIR was programmed to alarm if any measured path-integrated benzene concentration values were above the established level of concern. In the event of an alarm, excavation work would stop immediately
- The OP-FTIR was deployed at the site for five weeks and provided data continuously during excavation
- The instrument was moved multiple times, as the excavation activities progressed along the creek bed
- Although fugitive benzene was measured during the study, it was never measured at levels above the level of concern
- The OP-FTIR data was archived and used by the client to document the fact that no benzene plumes were detected during the excavation at concentrations above the level of concern

Overview of EPA Method OTM 10 for Emission Flux Measurement

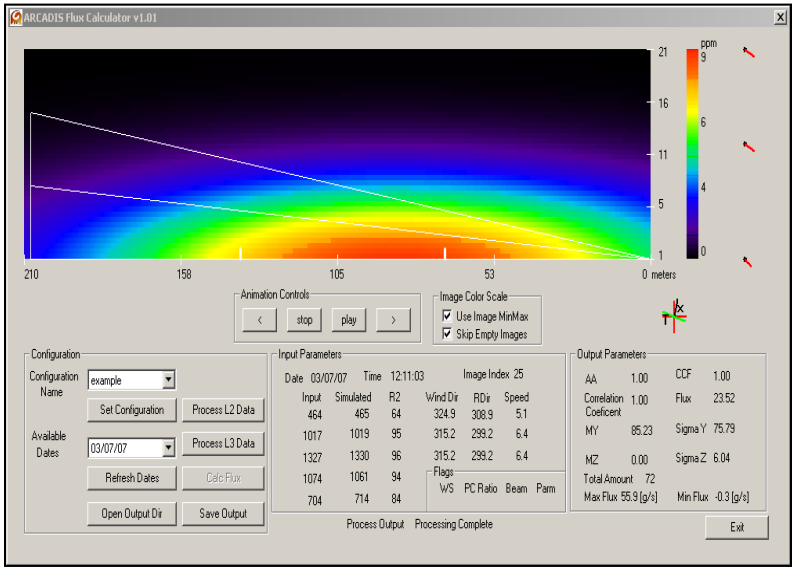
EPA Method OTM 10

- Developed at the University of Washington during the 1990's
- Involves using a configuration of multiple, non-overlapping optical beams to map pollutant concentration contours in the vertical plane (Vertical RPM)
- Measurement configuration is deployed directly downwind of the area of interest
- Optical Remote Sensing instrument is mounted to a scanner, and collects concentration data along multiple beam paths in the configuration
- Wind data, collected concurrently with the ORS measurements, are combined with the concentration data to yield an emission rate from the upwind area source

Radial Plume Mapping (RPM) Method



EPA Method OTM 10



Automated Software for OTM 10
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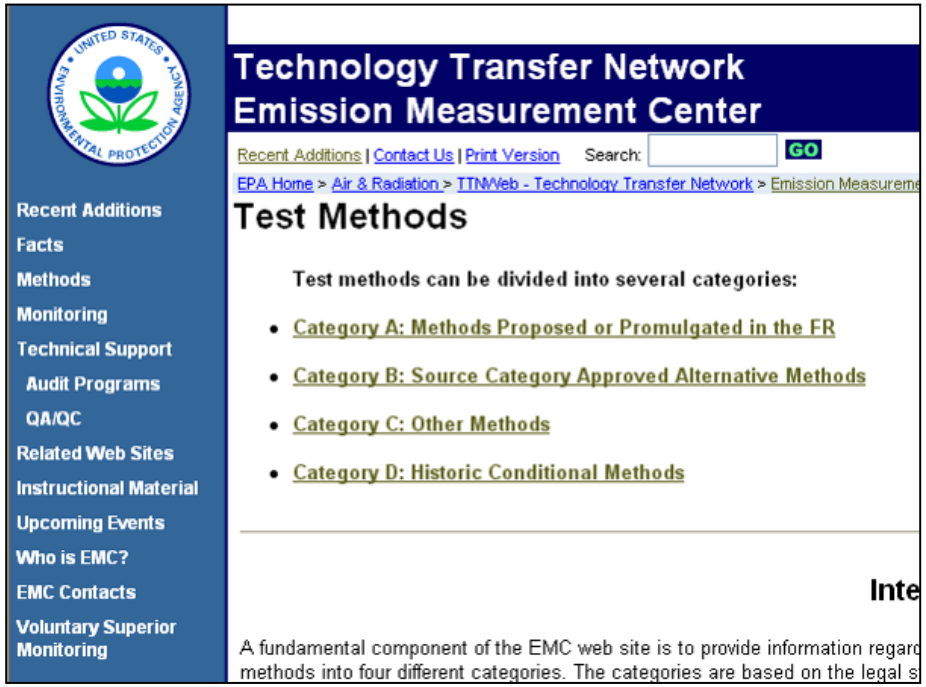


http://www.epa.gov/ttn/emc/tmethods.html

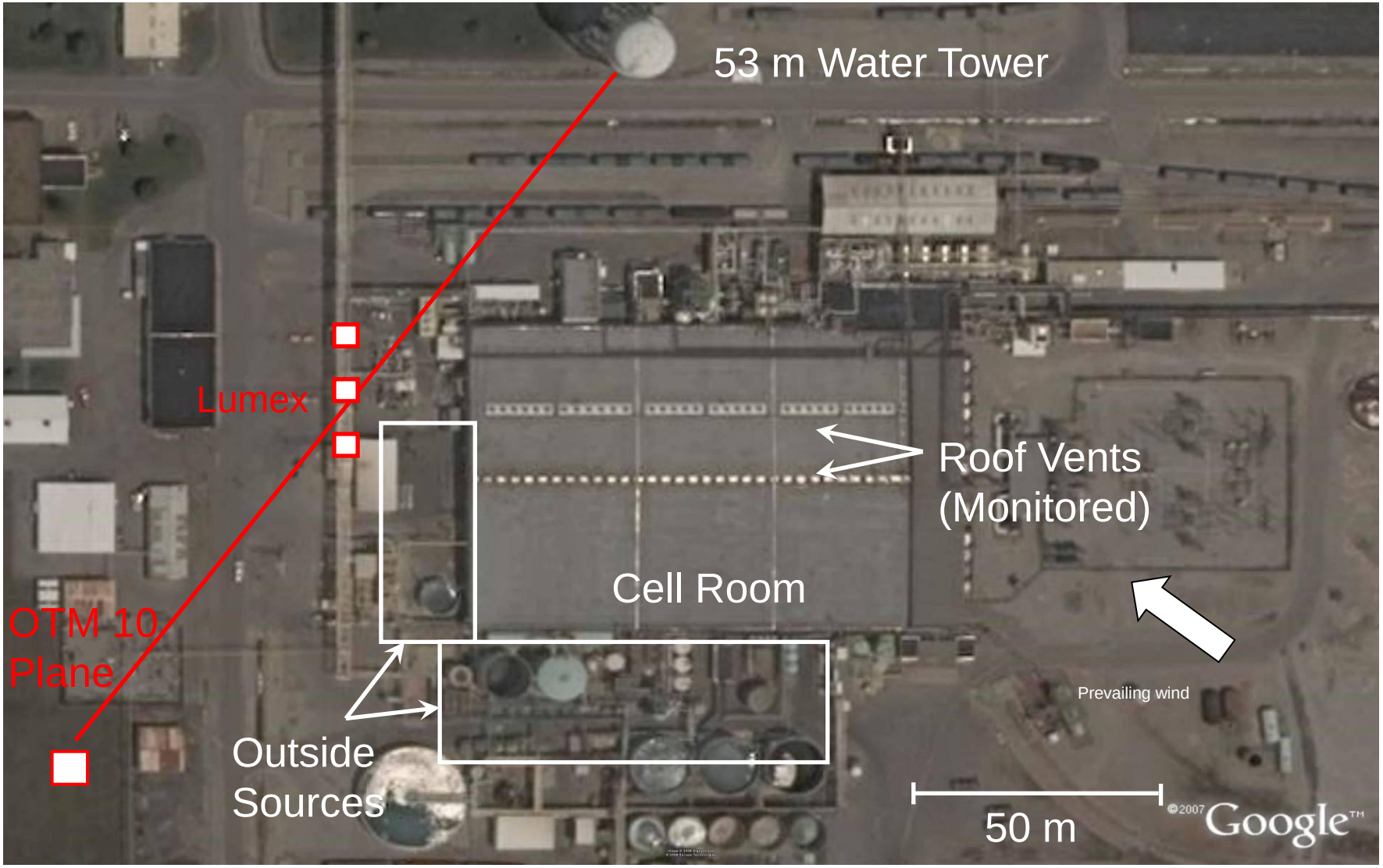
Industrial Monitoring Example: Mercury Emissions from Chlor-Alkali Facility

- Fugitive mercury emissions
  - leaks in cell equipment and transfer piping
  - maintenance and repair of sealed equipment
  - process upsets
- Most previous studies, 1-2 weeks, using DIAL
- This was an 8-week study using remotely operated UV DOAS
- Emissions from cell room roof vents and outside sources

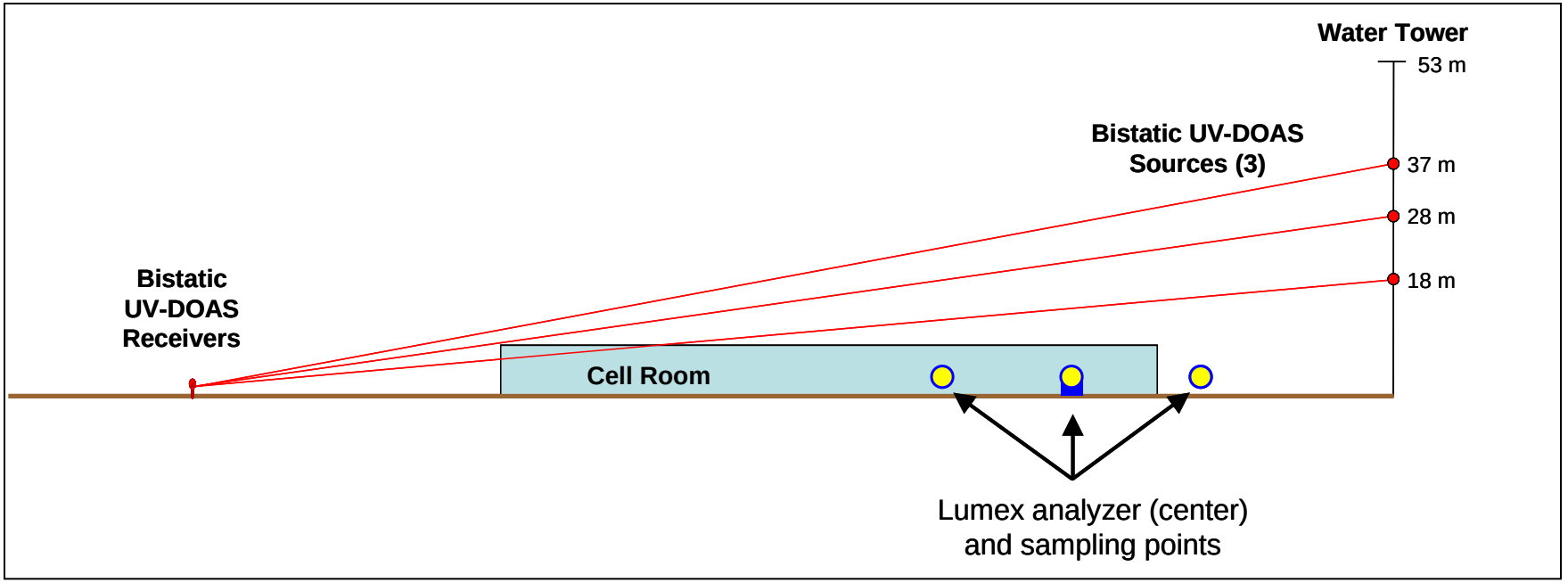
EPA, 2007, Measurement of Total Site Mercury Emissions from a Chlor-alkali Plant Using Open-Path UV-DOAS" U.S. EPA Report /600/R-07/077 (2007). http://www.epa.gov/nrmrl/pubs/600r07077/600r07077.pdf

Measurement of Total Site Mercury Emissions from a Chlor-Alkali Plant Using Ultraviolet Differential Optical Absorption Spectroscopy and Cell Room Roof-Vent Monitoring, E. D. Thoma et al, Atmos Environ (in press).

Industrial Monitoring Example: Mercury Emissions from Chlor-Alkali Facility



Side View of OTM 10 Configuration

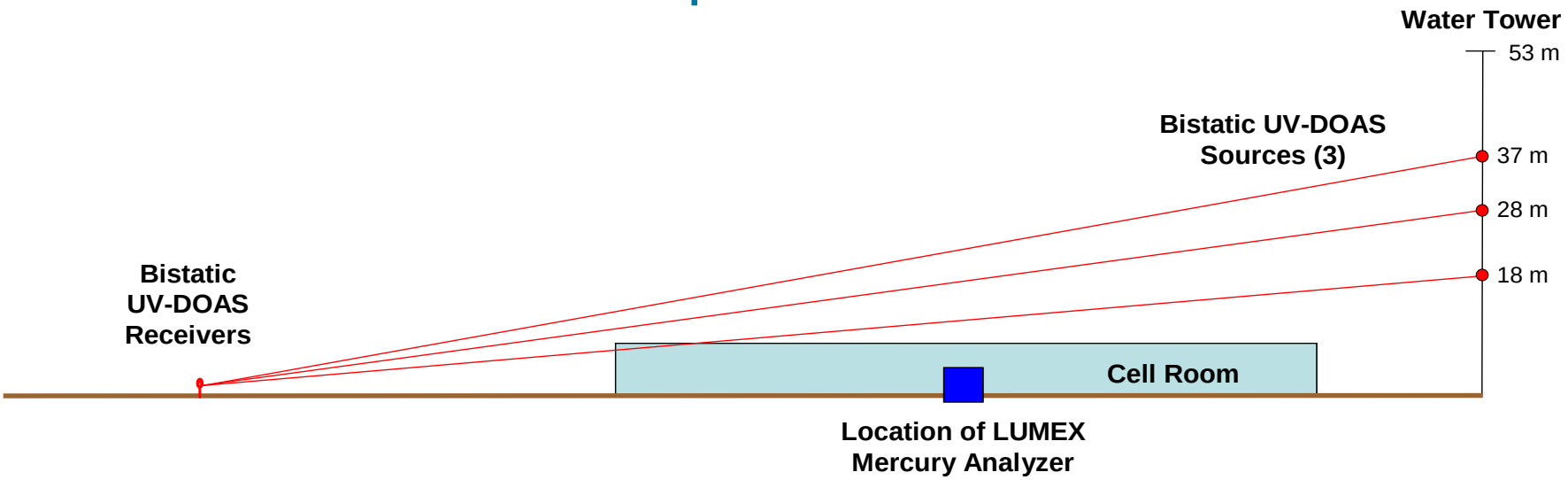


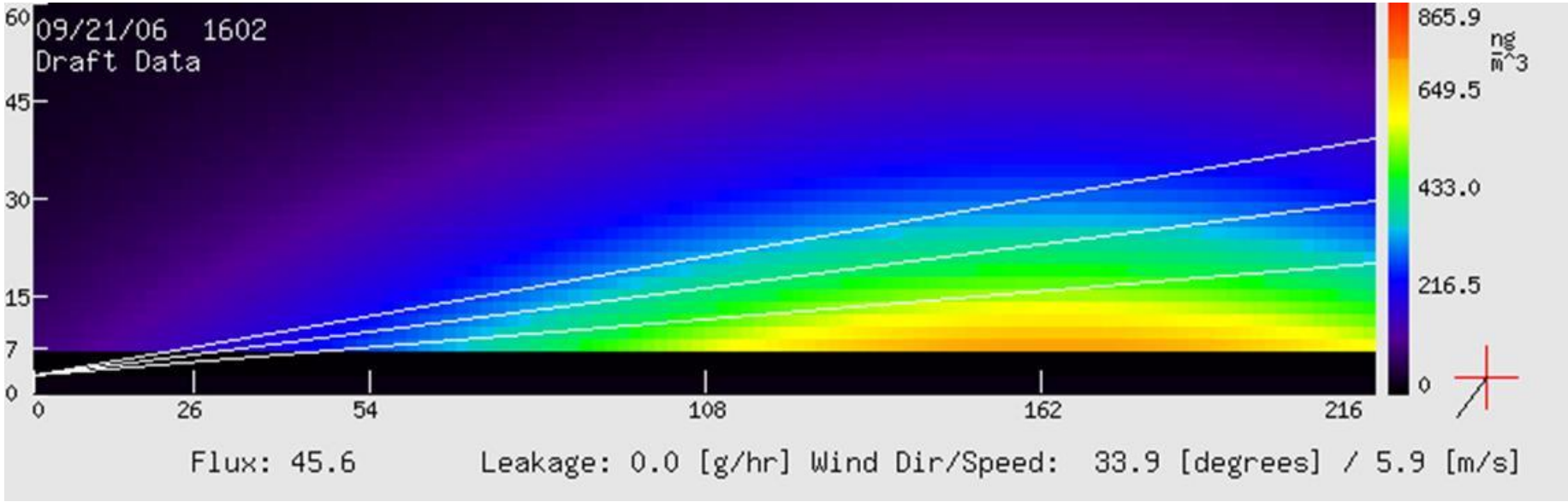
Mounting UV Sources on Water Tower

Aiming UV Sources

UV Receivers

OTM 10 Plume Maps

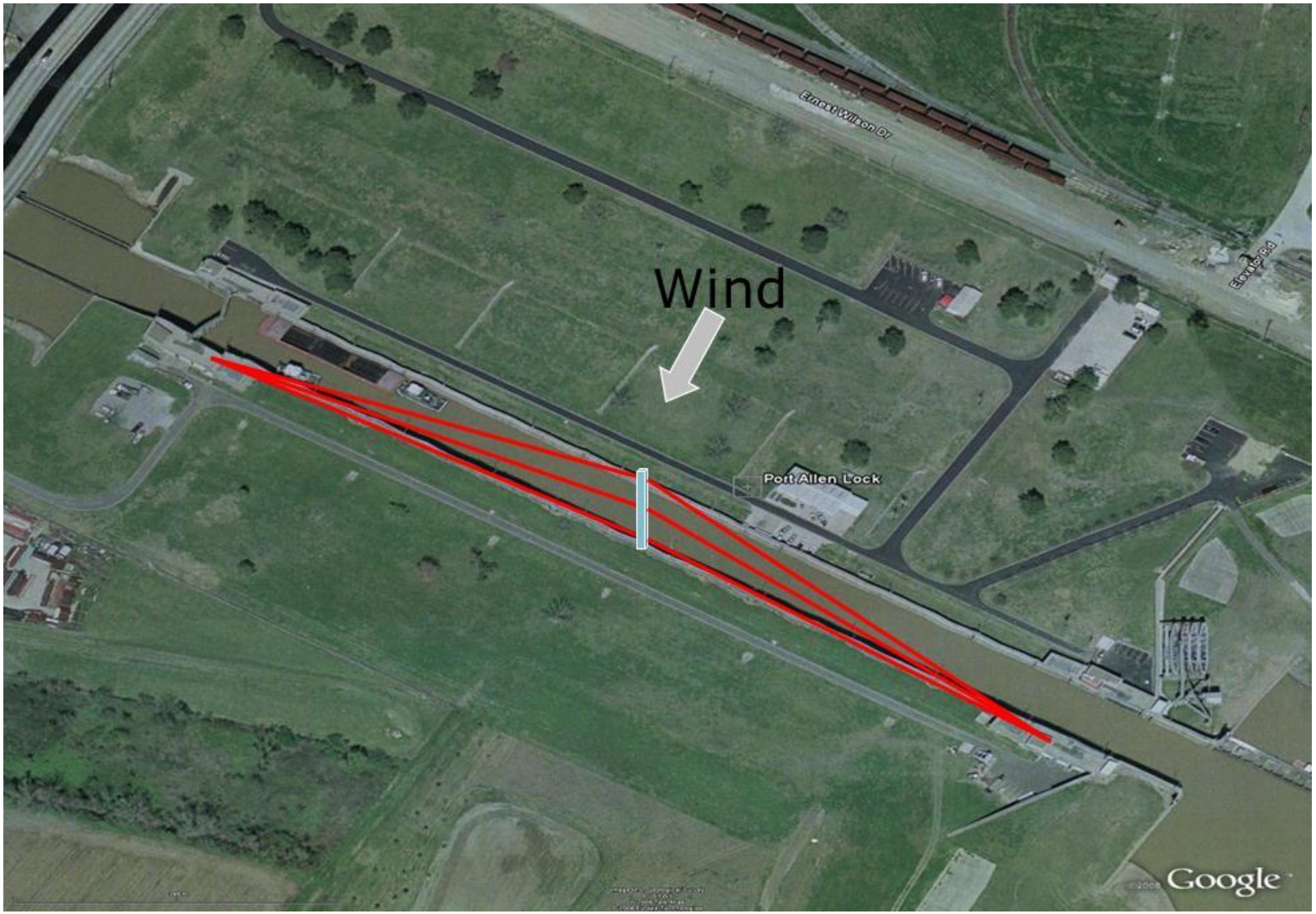




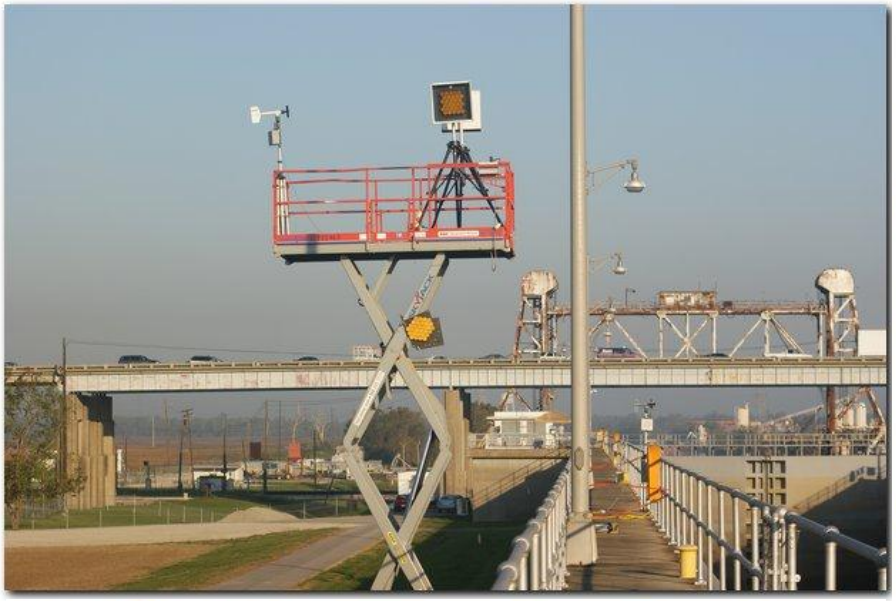
VOC Emissions from Transport Barges

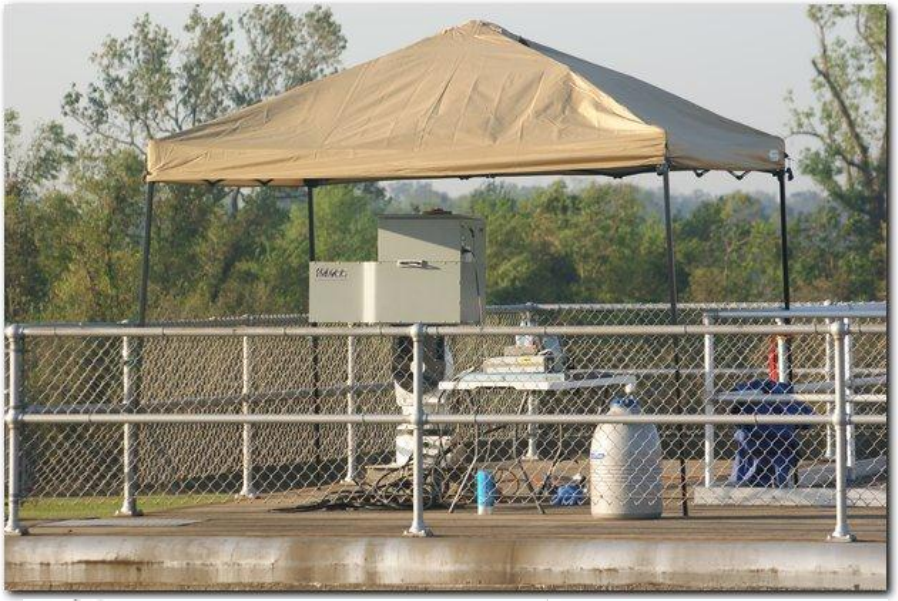
- Gain understanding of fugitive VOC from petrochem barges
- *Collaboration:* EPA ORD, OAQPS, R6, R4 TCEQ, LADEQ, Army Corp of Engineers, MSCHD
- First field study Baton Rouge LA, September 2008
  - Airborne and ground FLIR leak detection
  - Onboard leak measurements
  - OTM 10 on Port Allen Lock Wall

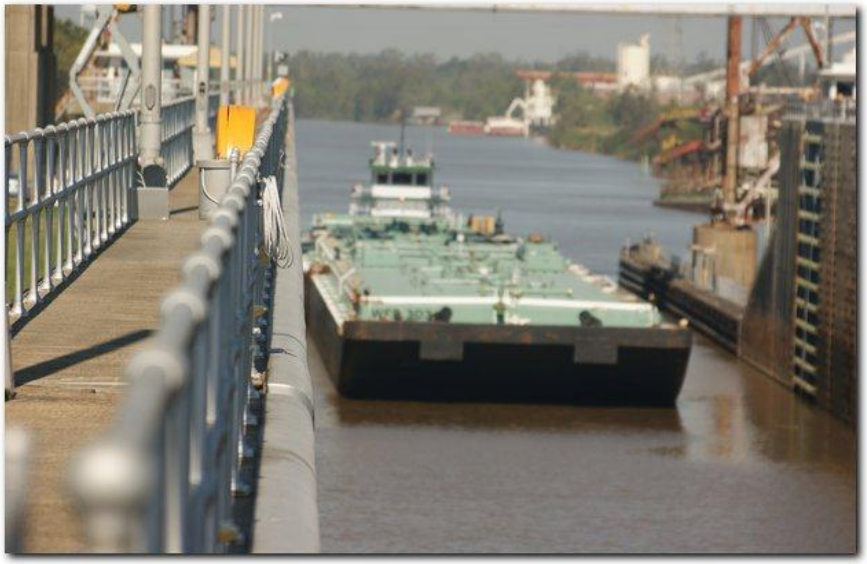
Port Allen Lock- Baton Rouge, LA



Port Allen Study Images







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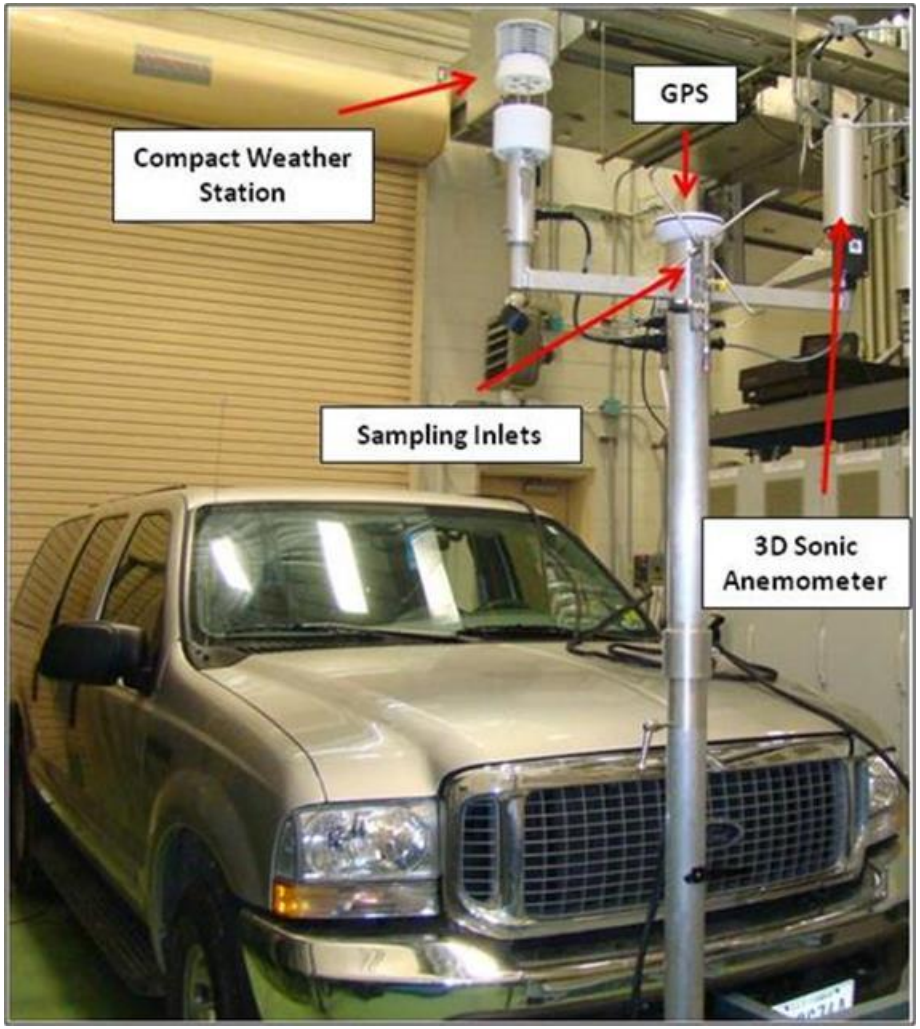
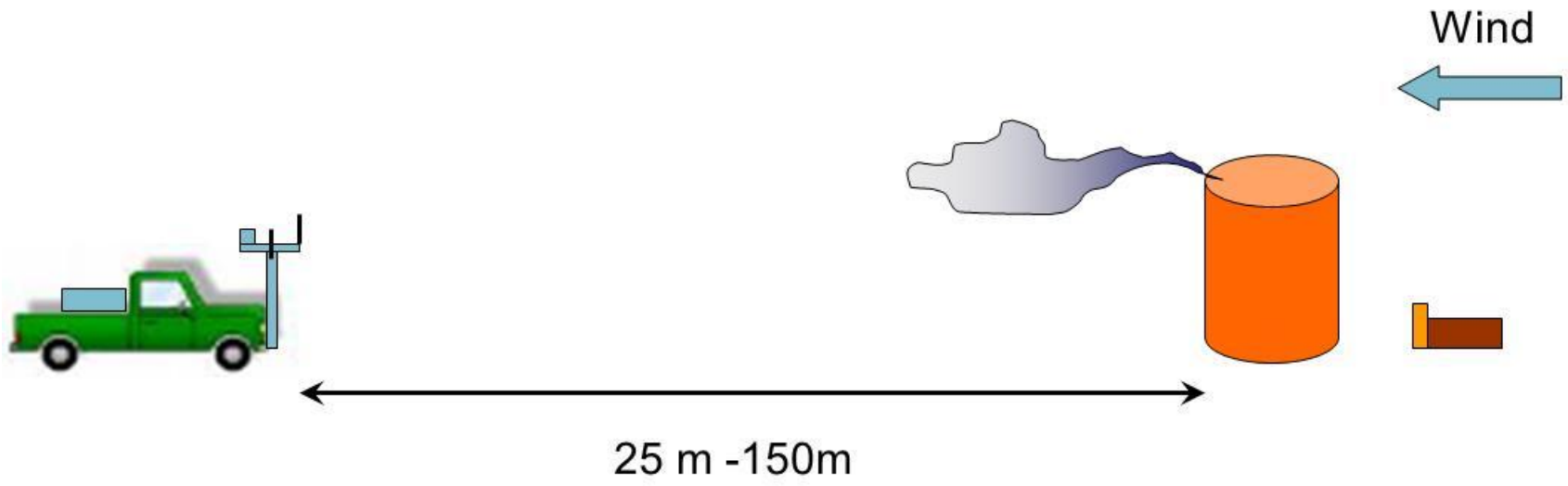
Other Recently Developed Measurement Approaches

Fast-Response Mobile Measurement Platform for Oil & Gas Well Pad Measurements



Collection of Mobile Measurements Downwind of Source

- A typical emission is from the top of the condensate tank
- Looks at point source from distance (single tank)
- Emission point heights range from about 2 m to 6 m
- Downwind range from about 25 m to 150 m



Low-Cost Sensor Stations for Monitoring VOC at Industrial Site Fencelines

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Summary

ARCADIS scientists have worked directly with EPA researchers in developing novel measurement technologies and approaches for characterizing emissions from non-point sources

Many optical remote sensing-based measurement methods have been developed, validated, and applied for various measurement applications

Other measurement approaches have been recently developed and tested, including a fast-response mobile measurement platform for upstream oil & gas source measurements, and low-cost sensor packages for long-term industrial fenceline monitoring

