US EPA ARCHIVE DOCUMENT

EPA
United States
Environmental Protection
Agency

Quantification of emissions and near-source air quality impacts using a mobile measurement approach

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EPA mobile measurement collaborators and contractor acknowledgements

- **EPA**
  - **ORD:** Gayle Hagler, Eben Thoma, Rich Baldauf, Vlad Isakov, James Faircloth, Buddy Thompson, Bill Mitchell, Bill Squier, Laura Jackson
  - **OAQPS:** Robin Segall, Jason DeWees, Nealson Watkins
  - **Region 5:** Monica Paguia, Loretta Lehrman, Chad McEvoy, Marta Matwyshyn-Fuoco, Motria Caudill
  - **Region 6:** Mike Miller
  - **Region 8:** Adam Eisele
- **Waste Management**
- **FHWA**
- **ARCADIS (EP-C-09-027)**
- **Duke University:** Andrey Khlystov, Ming-Yeng Lin
- **Picarro**
- **Aerodyne Research**
- **Eastern Research Group (EP-C-07-015)**

Overview

- Motivation for mobile measurement research
- Evolution of EPA program
- Recent and current projects:
  - Emissions quantification studies: landfills, oil and gas
  - Near-source studies: near-road, near-rail yard

Why go mobile?

Benefits:

- ✓Site-accessibility – driving route or parked in target locations
- ✓Ability to assess spatial variability in near-source concentrations
- ✓Ability to locate to emissions plume centerline
- ✓Reduces concerns for instrument intercomparison – same instrument in motion.
- ✓Can complement and add context to stationary sampling

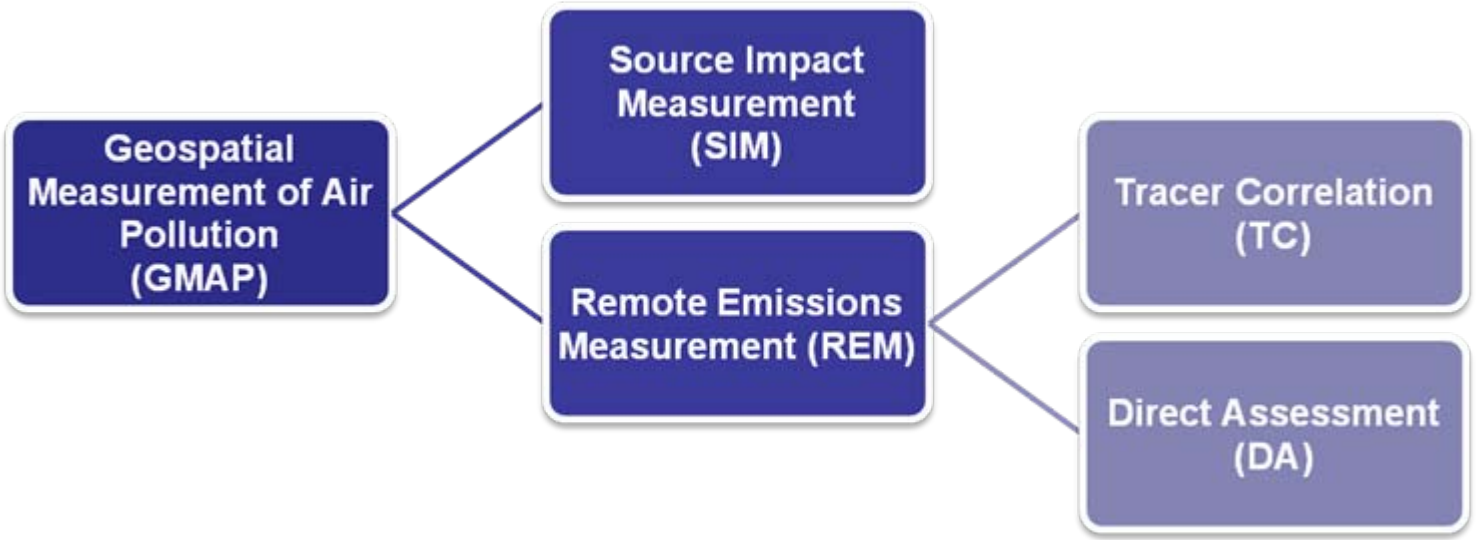
Limitations:

- ✓Focus on local spatial scale (meters to km)
- ✓Deployments usually brief (hours) and over a targeted period of time
- ✓Labor intensive
- ✓More complex data processing and analysis

ORD Geospatial Measurement of Air Pollution (GMAP) Program

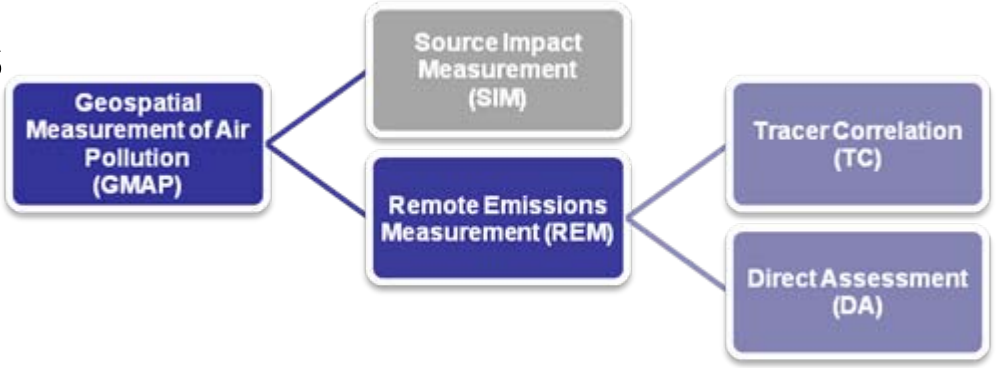
What is it all about?

→Novel emissions characterization program using fast-response instrumentation and a precise global positioning system on-board a mobile platform to map air pollutants.



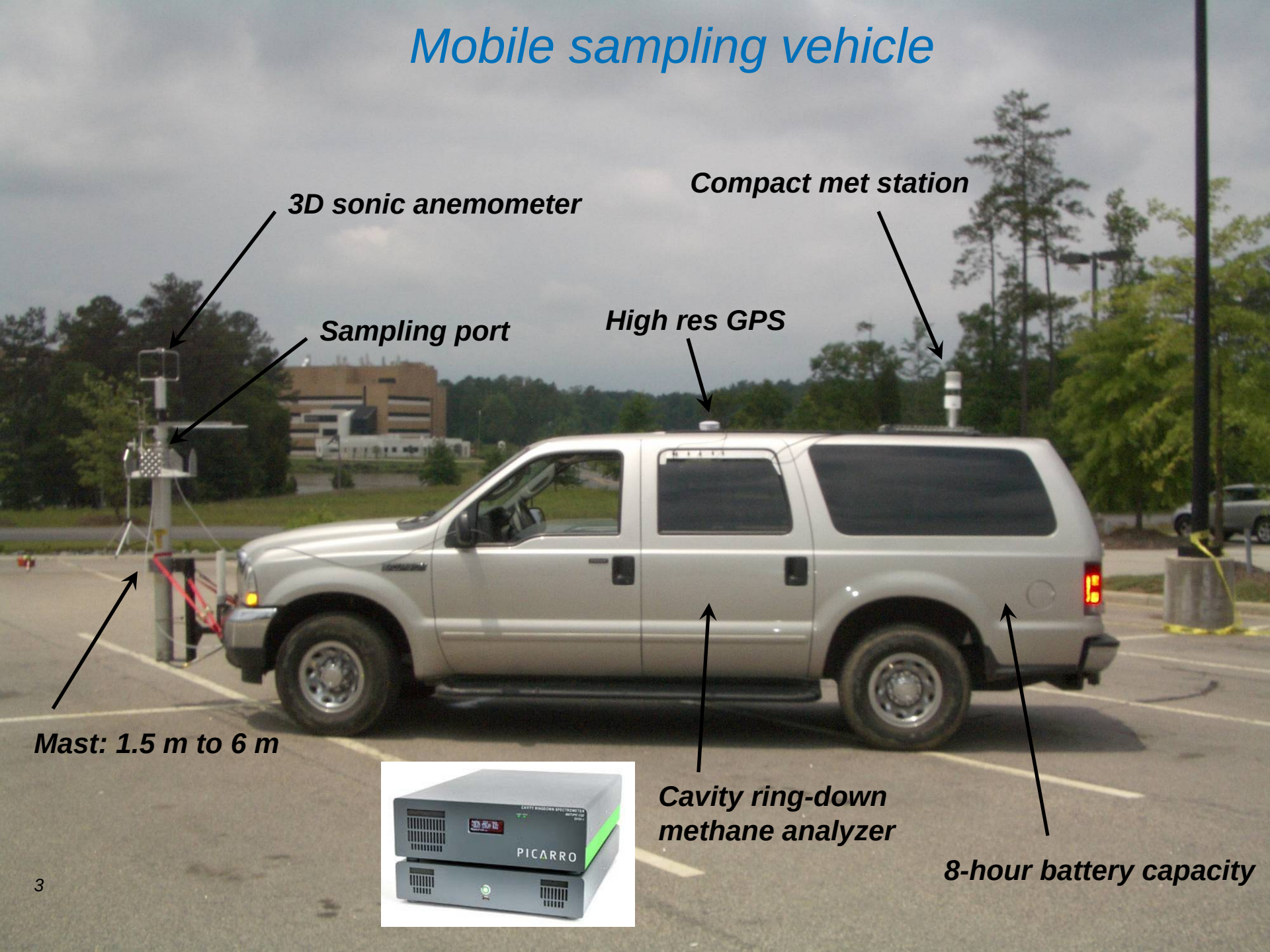
GMAP Remote Emissions Measurement

GMAP-REM Concept:
Detect and quantify emissions of a specific species from a large area or distributed source via mobile sampling and plume dispersion diagnostics.

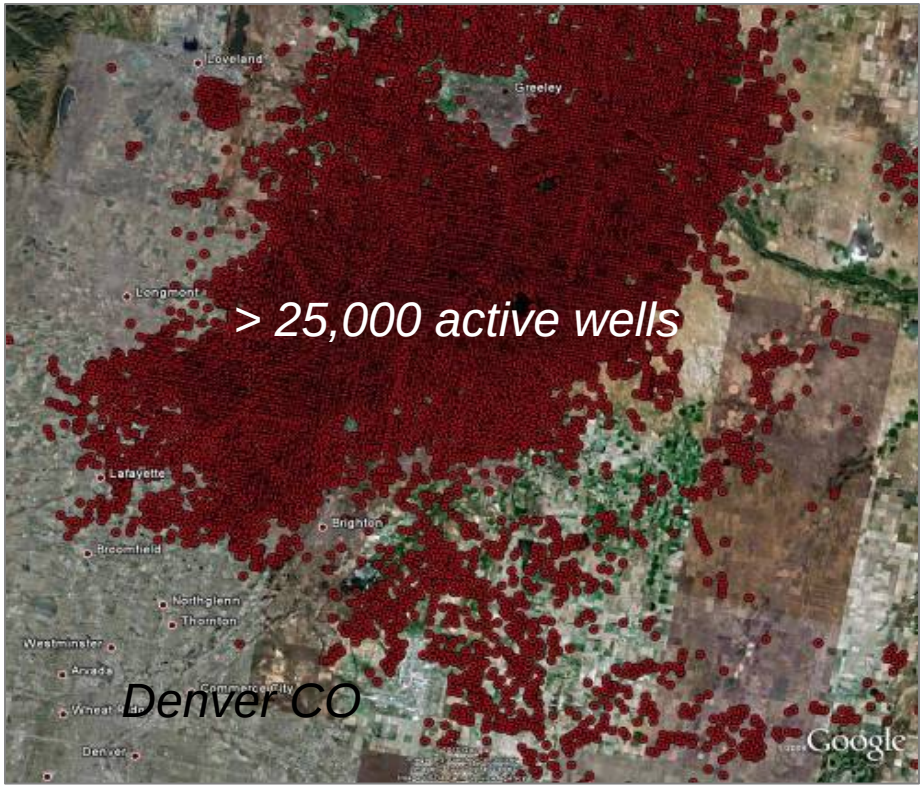


Example projects:
1. Detection of methane emissions from distributed oil and gas production wells using a Direct Assessment (DA) approach
2. Quantification of methane emissions from landfills using an acetylene tracer via the Tracer Correlation (TC) approach

Mobile sampling vehicle

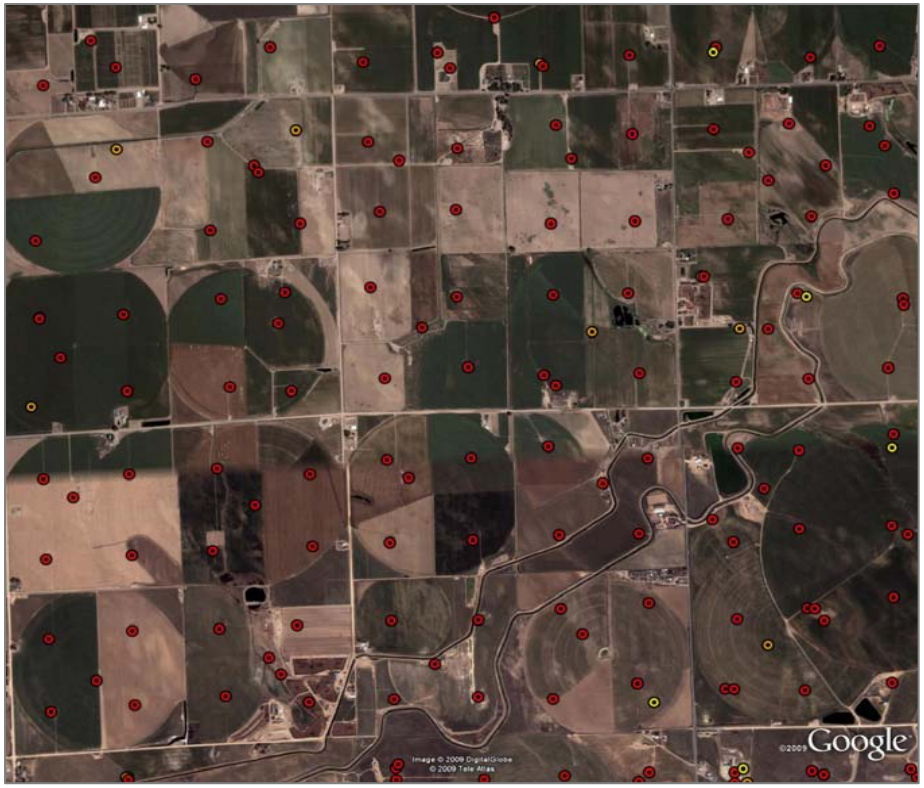


Oil and gas production: distributed sources



> 25,000 active wells

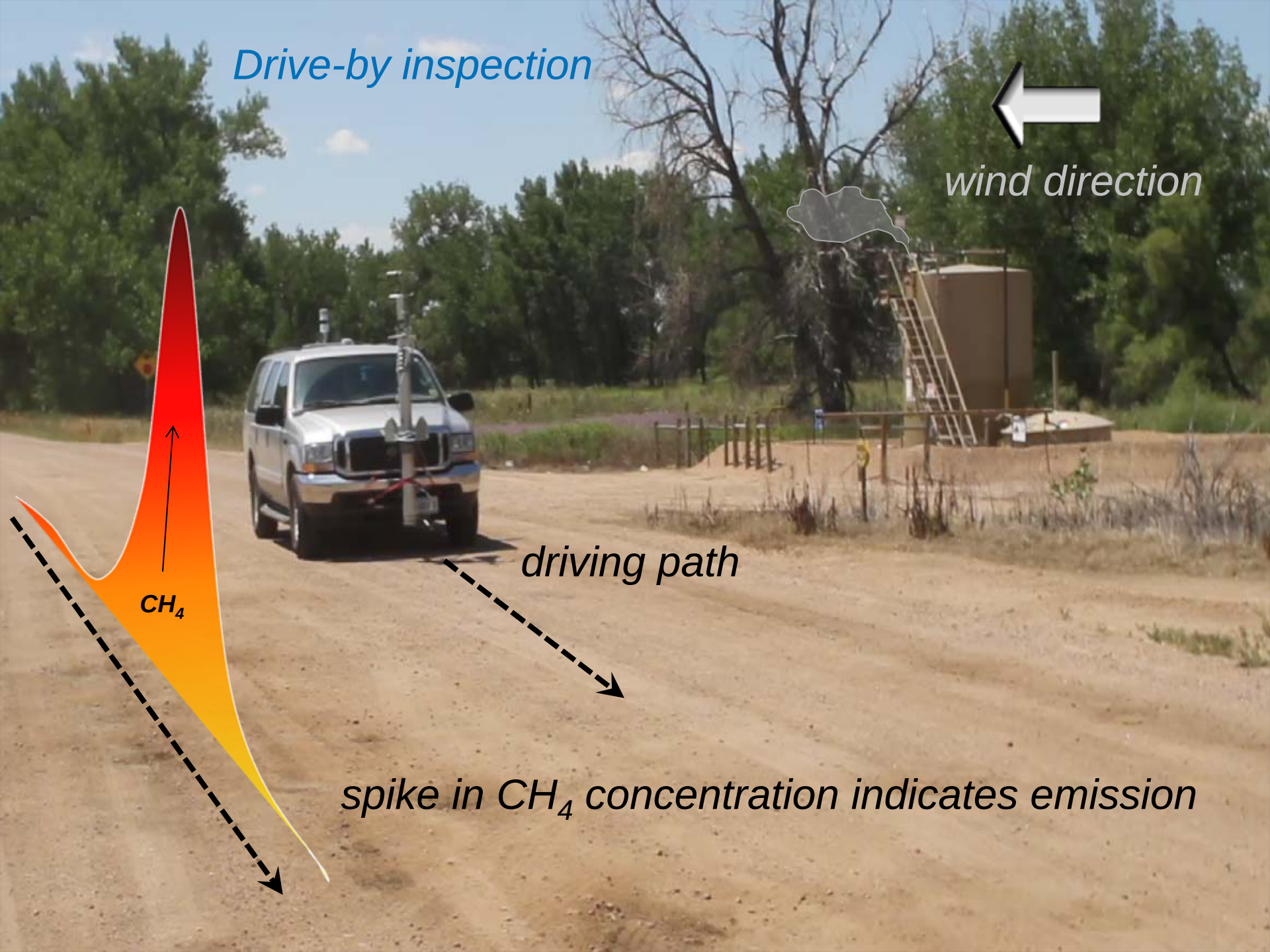
Denver CO



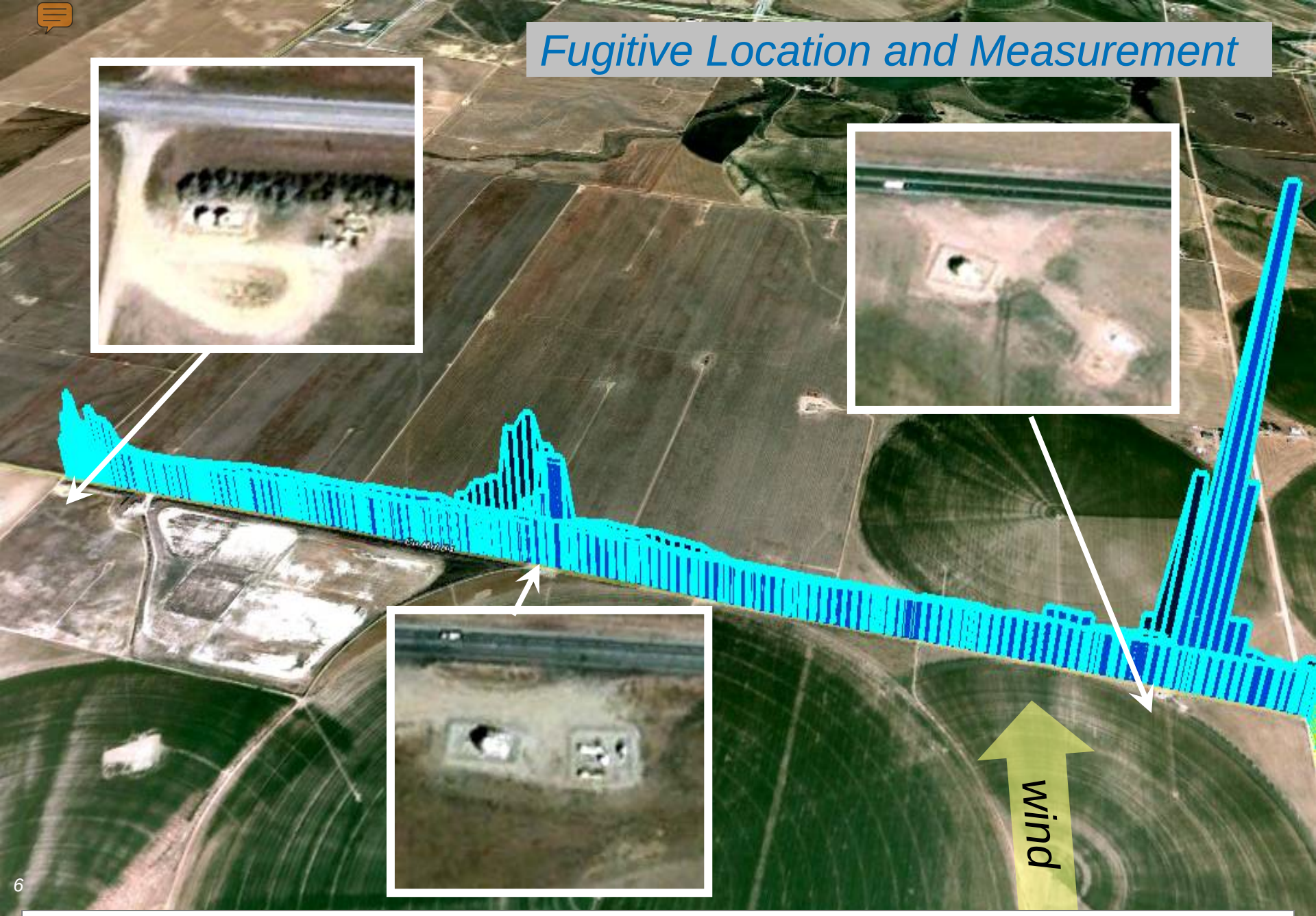
EPA EP-C-09-27, Greeley CO, Nov. 2009

Mobile sampling to locate fugitives

- Drive-by detection of fugitive emissions
  - High sensitivity methane measurement (cavity ring-down spectrometer)
  - On board meteorology and high resolution GPS
  - Data linked to Google Earth maps for visualization
- Rapidly assesses upwind sites from public roadways
- Generate fugitive emission statistics
- Develop a transferable / cost effective inspection method


Drive-by inspection
wind direction
driving path
CH_4
spike in CH_4 concentration indicates emission

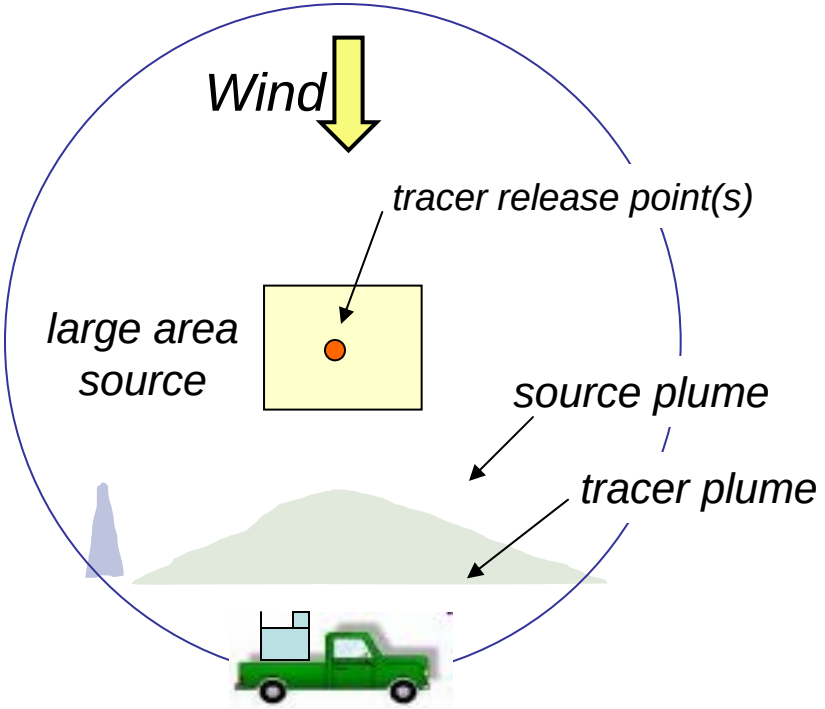
Fugitive Location and Measurement



Detection and Quantification Fugitive Emissions from Colorado Oil and Gas Production Operations Using Remote Monitoring, E. Thoma, et al., Air & Waste Manage Assoc. Conf. - June 22-25, 2010 - Calgary, Alberta, Canada

Large area source measurements
GMAP REM TC

- Release tracer gas from strategic locations within the facility
- Use mobile sampling platform to map target source and tracer plumes
- Calculate dilution ratio based on known tracer rate
- EPA method development research
  Waste Management CRADA #372-A-08, EP-C-07-15 WA 2-10



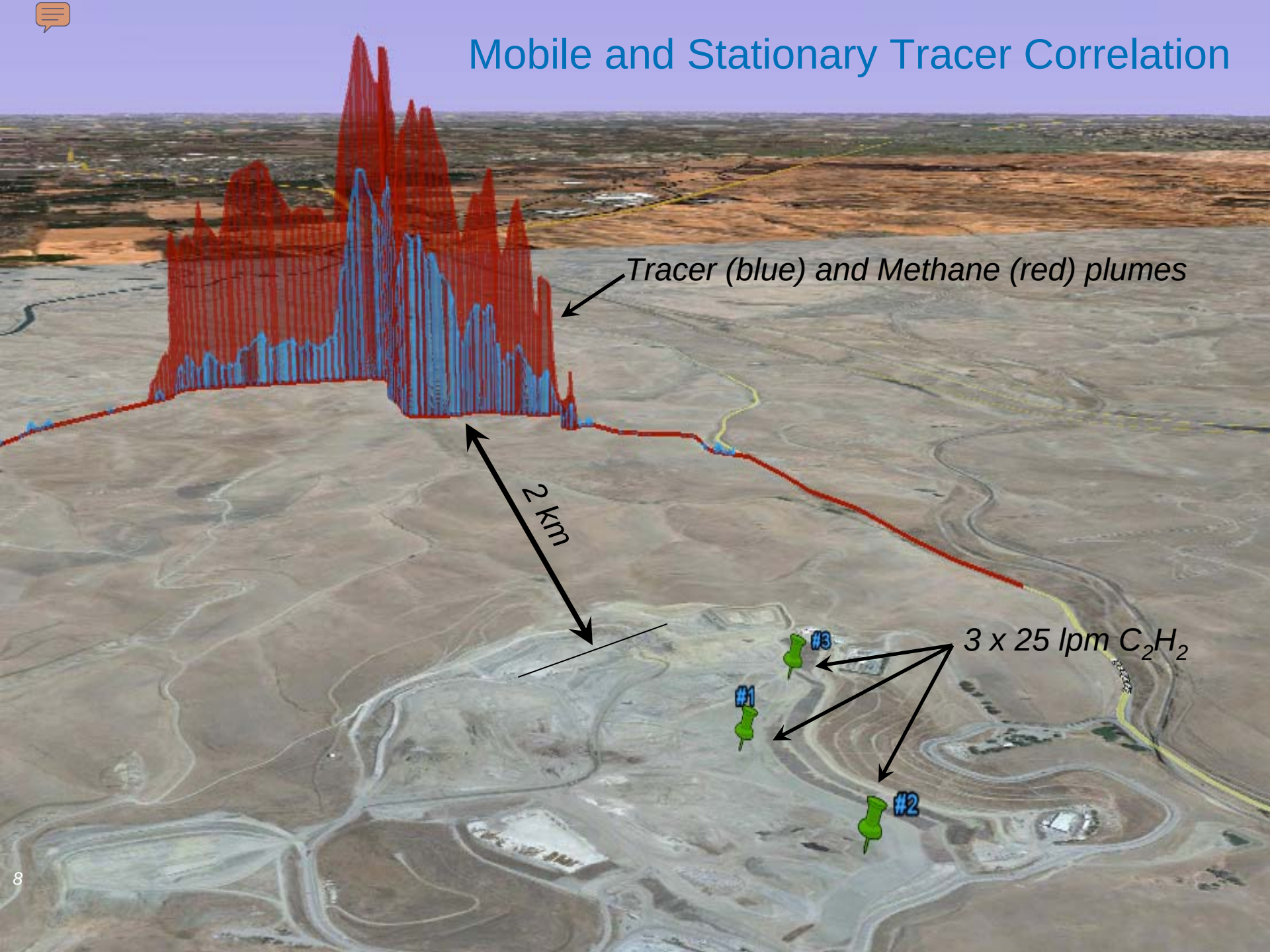
$$\frac{Q_{target}}{Q_{tracer}} = \frac{C_{target} - C_{target,\ bckgnd}}{C_{tracer} - C_{tracer,\ bckgnd}}$$

Quantifying Methane Fluxes Simply and Accurately, The Tracer Dilution Method, C. W. Rella, E. R. Crosson, et al. European Geophysical Union Meeting, 2–7 May 2010, Vienna, Austria.

Methane Emissions at Nine Landfill Sites in the Northeastern United States, B.W. Mosher, P.M. Czepiel, et al. Environ. Sci. Technol. 1999, 33, 2088–2094.

Measurements of Methane Emissions from Landfills Using a Time Correlation Tracer Method Based on FTIR Absorption Spectroscopy, B. Galle, B.; J. Samuelsson, et al. Environ. Sci. Technol. 2001, 35, 21-25.

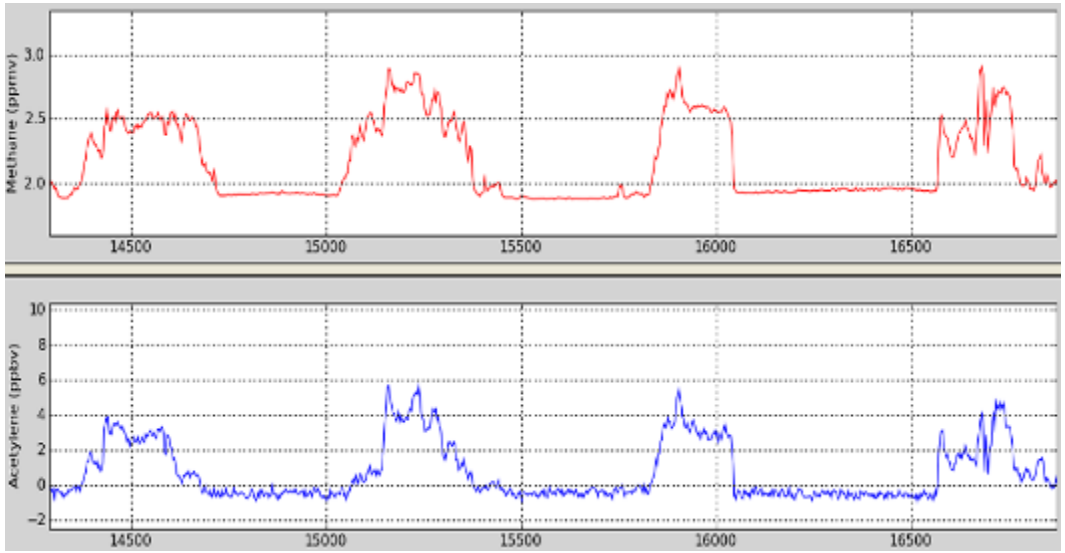
Mobile and Stationary Tracer Correlation

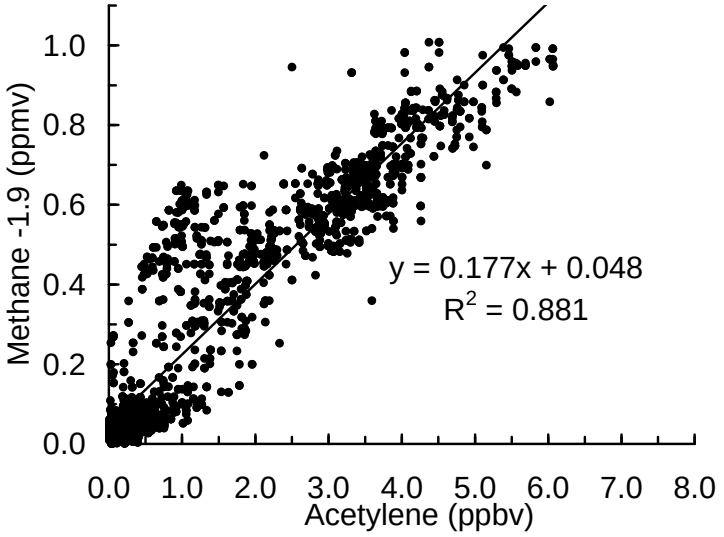


Mobile and Stationary Tracer Correlation

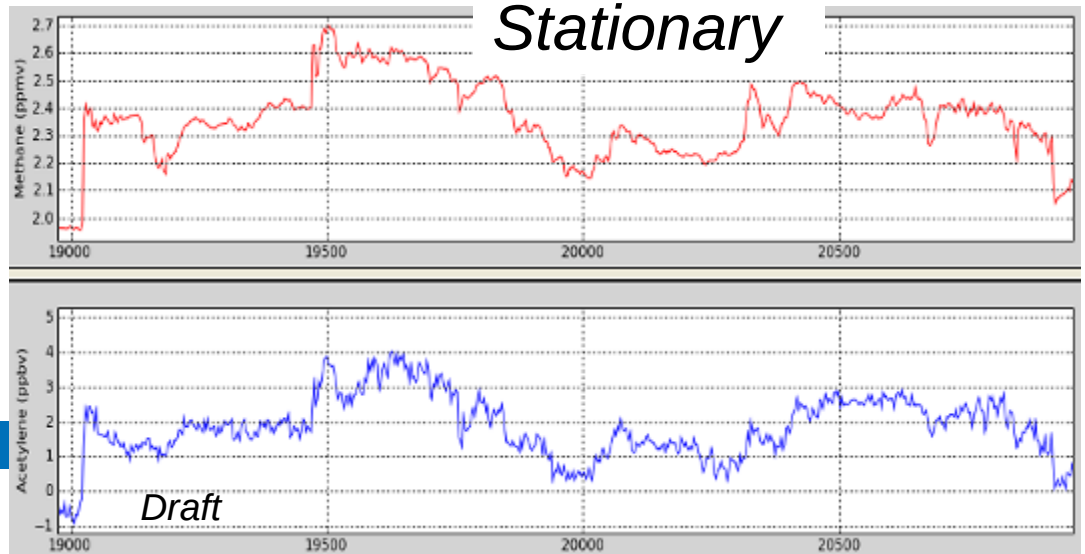
United States Environmental Protection Agency

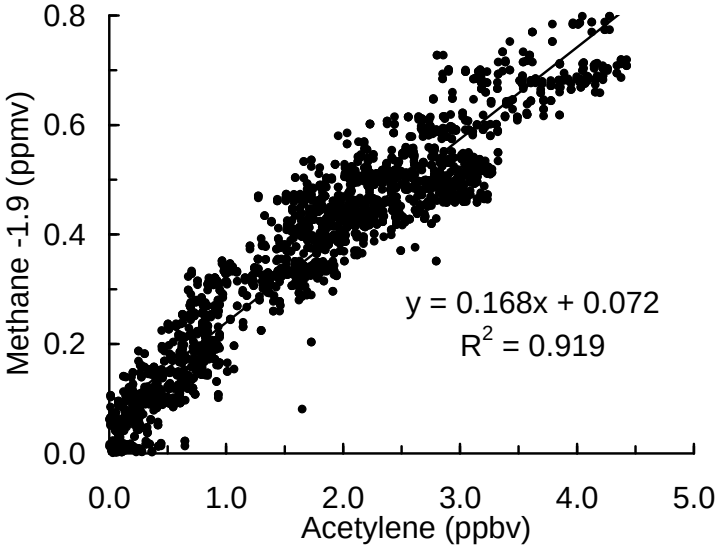
Mobile



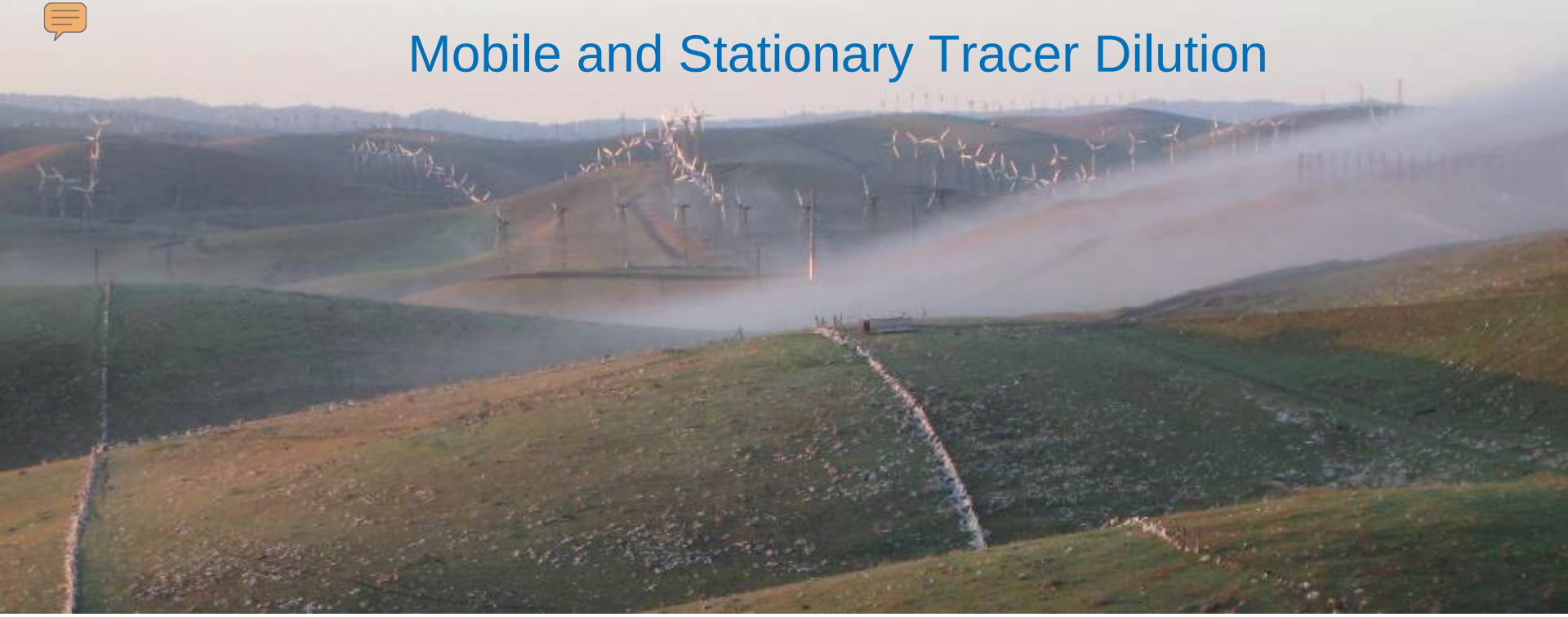


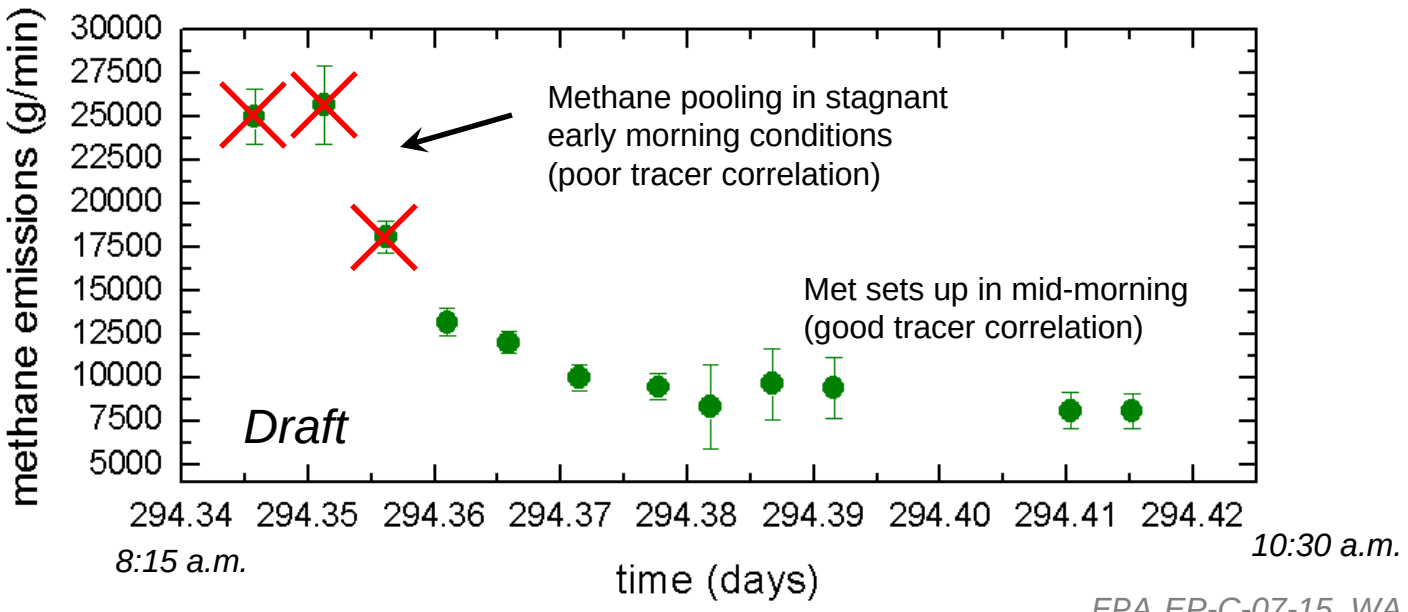
Stationary





Mobile and Stationary Tracer Dilution

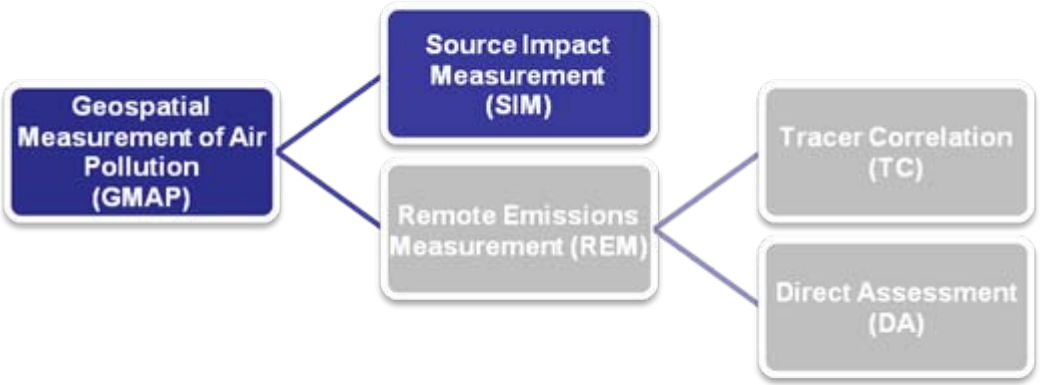




EPA EP-C-07-15, WA 2-10 (2009)

GMAP Source Impact Measurement

GMAP-SIM Concept:
Assess the spatial extent and spatial variability of elevated air pollutant concentrations downwind of a large line or area source under multiple meteorological scenarios.



Example past and *upcoming* projects:
Near-road air quality: Raleigh-Durham-Chapel Hill, North Carolina (2006-2008); Las Vegas, Nevada (2009); *Detroit, Michigan (2011)*
Near-rail yard air quality: *Chicago, IL (2010); Atlanta, GA (2011)*

High-resolution mobile monitoring of carbon monoxide and ultrafine particle concentrations in a near-road environment, G. Hagler, E. Thoma, and R. Baldauf, 2010. Journal of the Air & Waste Management Assoc, 60: 328-336

GMAP-SIM Equipment

1. Rapidly deployable and solar powered meteorology station
2. Parked SUV with measuring 1-2 min time series of roadside concentrations
3. Zero exhaust, electric vehicle equipped with high-resolution GPS, mapping 1-5 second measurements of air pollutants

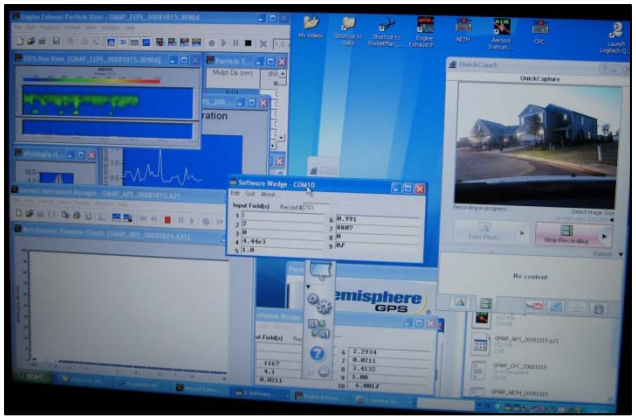
** Some field studies use both driving-mode + stationary vehicles, some use only driving-mode vehicle*

GMAP-SIM Typical Measurements

United States Environmental Protection Agency

Location:

- Longitude
- Latitude
- Elevation
- Webcam



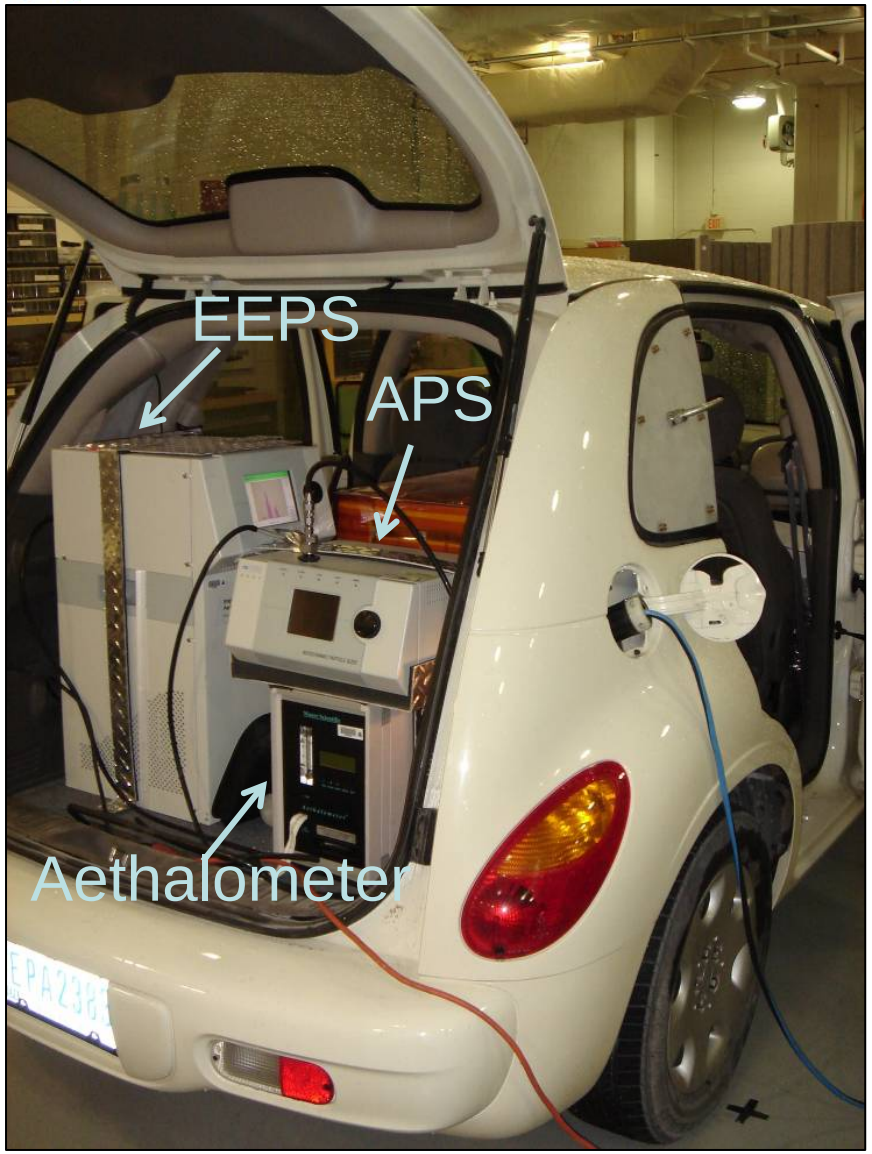
Pollutants:

- Ultrafine Particles (D_p < 100 nm)
- Carbon monoxide
- Fine/coarse particles ($PM_{2.5}$, PM_{10})
- Black carbon

Meteorology:

- Wind speed and direction
- Relative humidity
- Temperature

GMAP Source Impact Measurement



Data Collection

Typical Sampling Session:

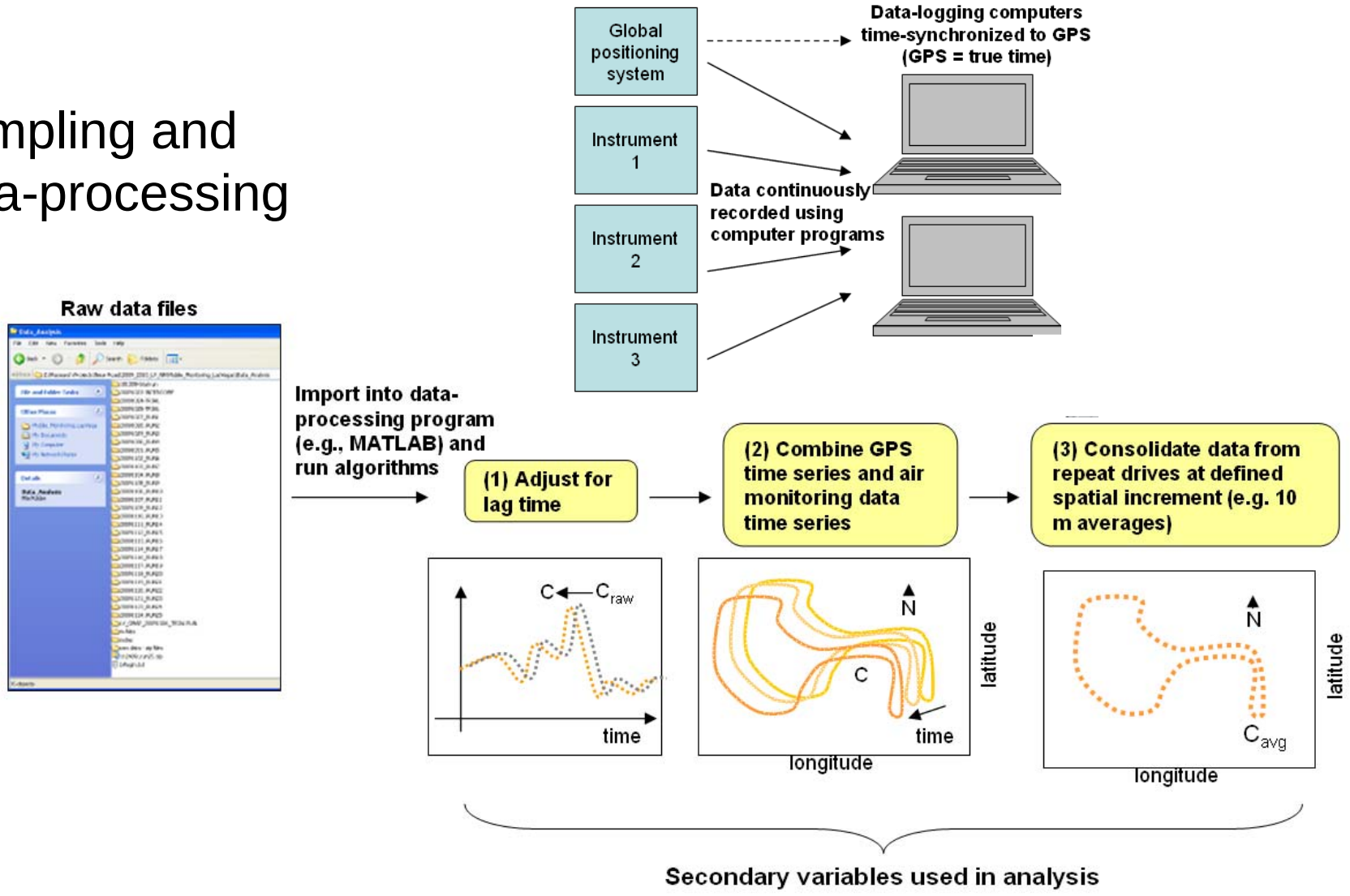
- **30 min:** Arrive at site, set-up instruments onboard vehicles and meteorology station, perform calibration/QC checks
- **2-4 hours:** Drive planned route and maintain ongoing sampling
- **30 min:** End driving mode sampling, perform side-by-side intercomparison/QC sampling
- **~4 hrs**: Recharge electric vehicle

→1-second data for 3 hours: >10,000 data points per species, per session

GMAP-SIM Flow of Data

United States Environmental Protection Agency

Sampling and data-processing

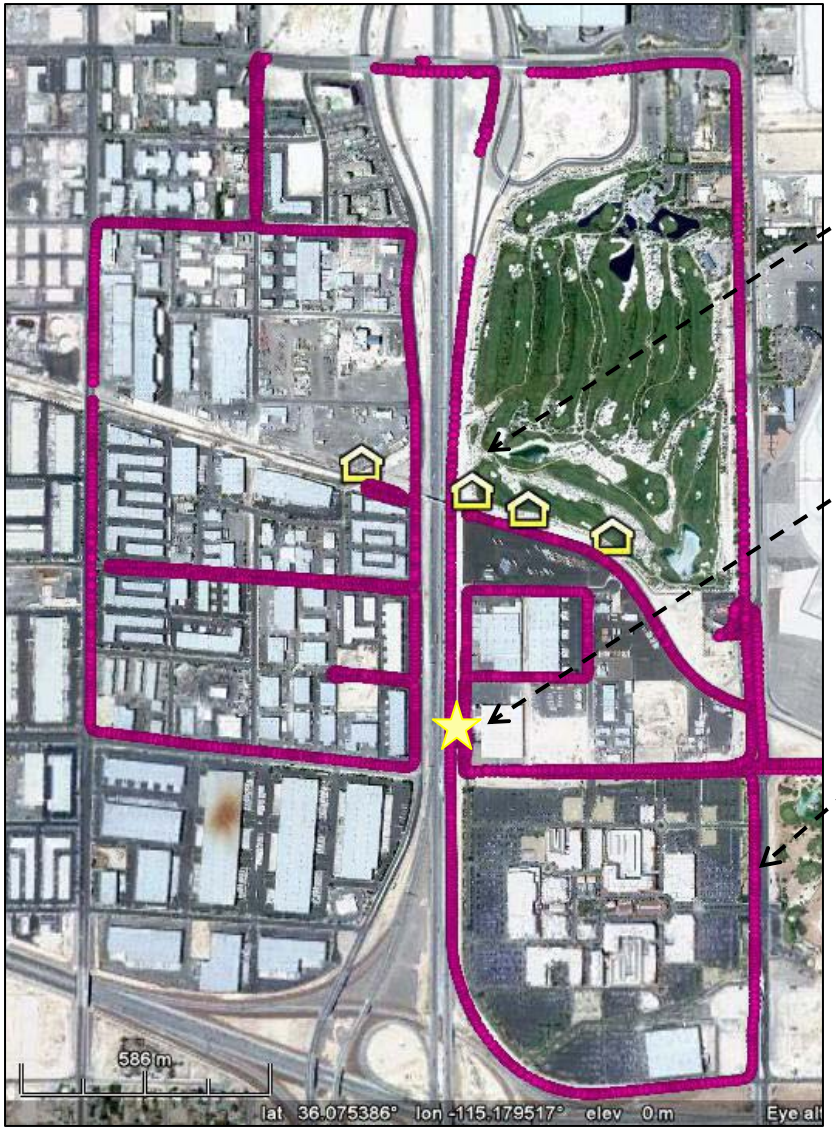


GMAP Source Impact Measurement

Las Vegas Near-Road Study

Features of interest in mobile data sets:

- Highway cut-section effect
- Variability of downwind and upwind areas
- On-road concentrations



Continuous measurement (4 sites, one year)

Stationary vehicle (~3 hrs per day, 4 weeks)

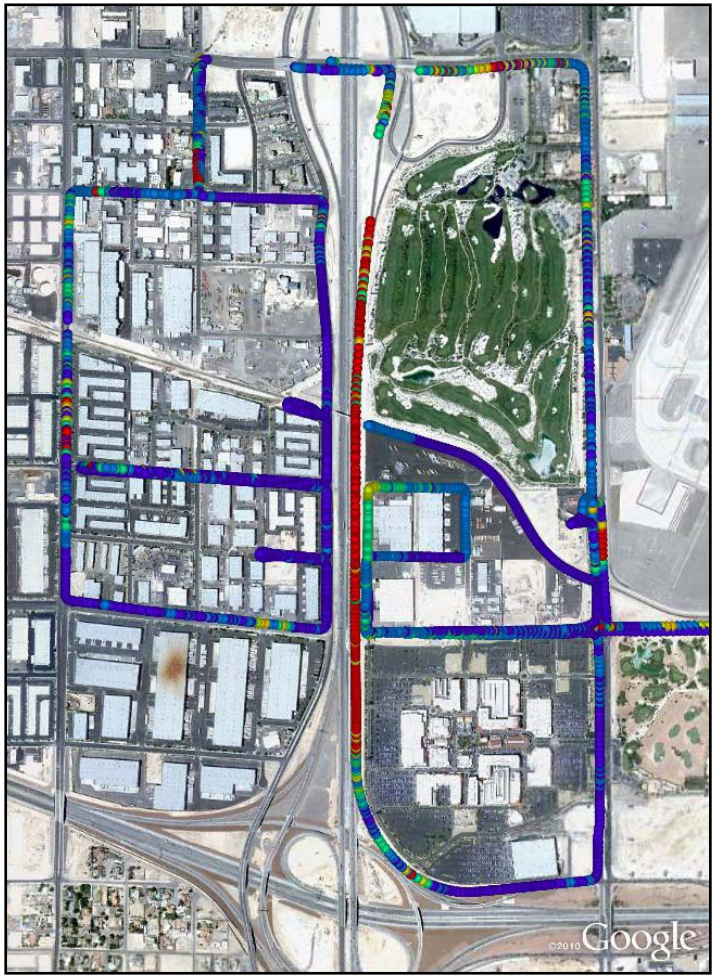
Electric car driving route (~3 hrs per day, 4 weeks)

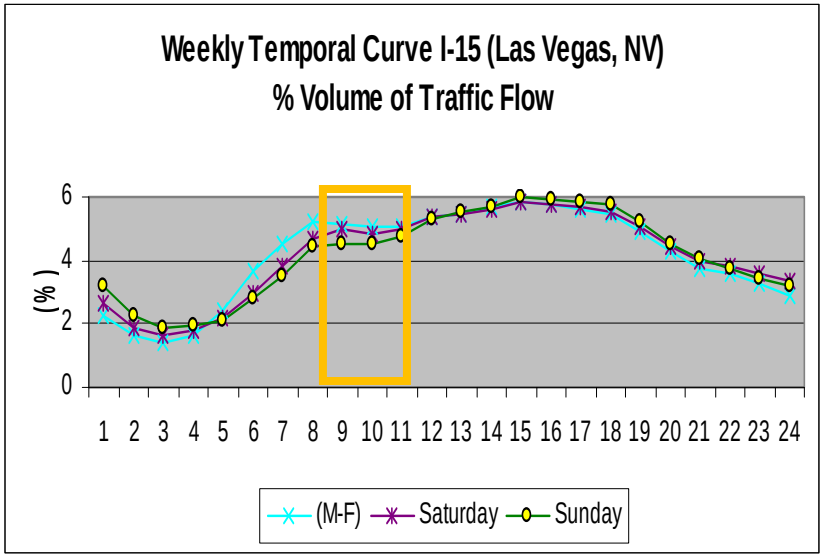
EPA EP-C-09-027, Las Vegas, 2009-2010

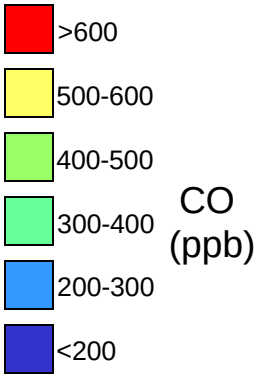
GMAP Source Impact Measurement

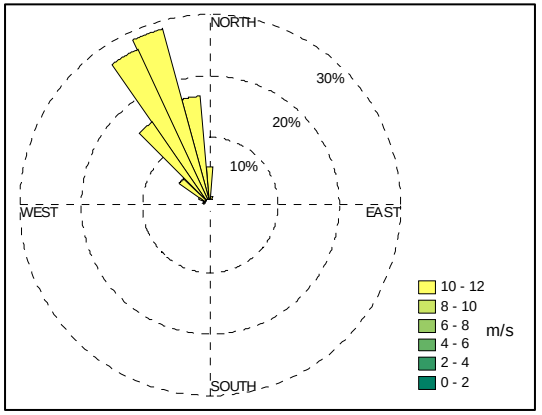
United States Environmental Protection Agency

Las Vegas Near-Road Study – 10/27/09, 9 AM – noon local time



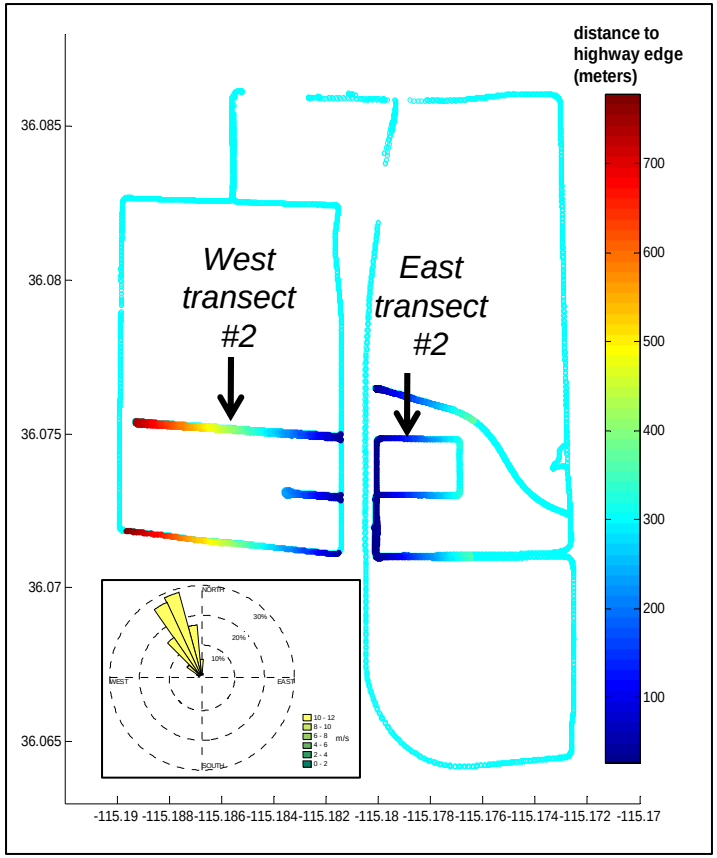


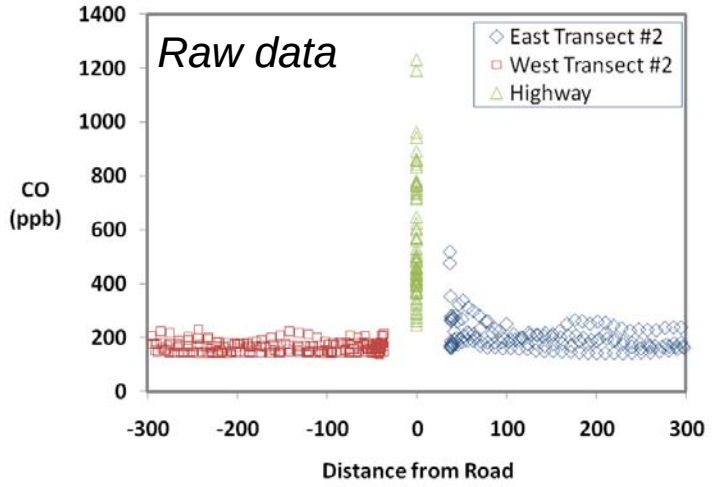


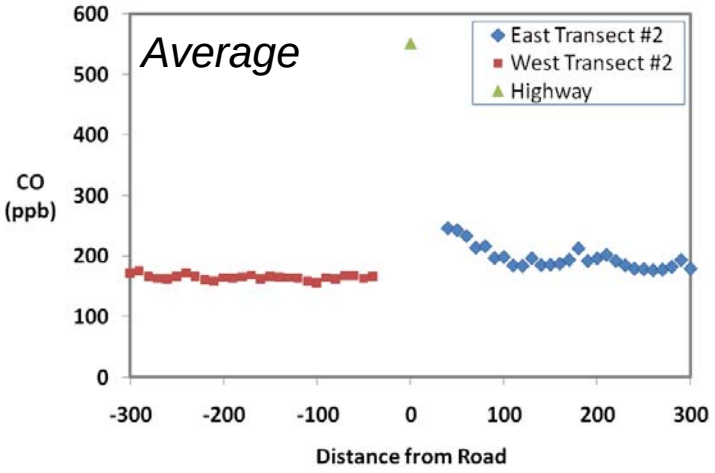


GMAP Source Impact Measurement

Las Vegas Near-Road Study – 10/27/09, 9 AM – noon local time, high wind speeds (>10 m/s), from the NNW



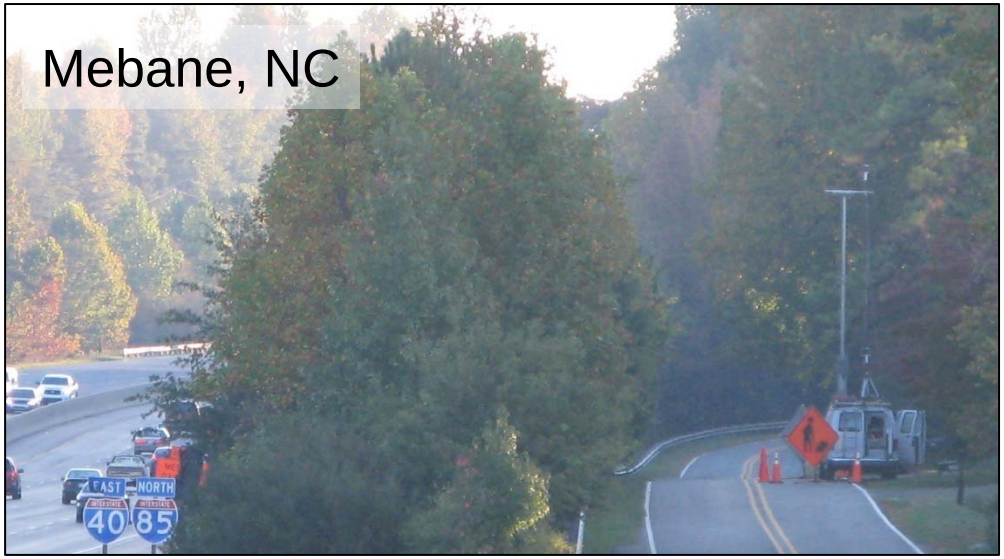


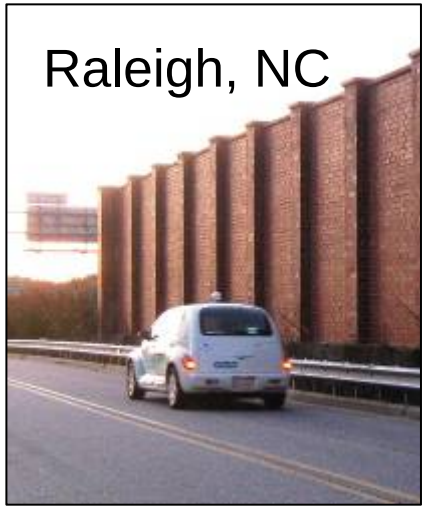


GMAP-SIM – roadside barrier mitigation assessments

Triangle-Area Barriers Study (2008)

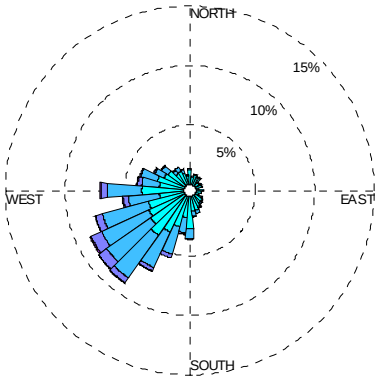
- 3 sampling sites
- Combined mobile and stationary sampling approach
- Sampled before and after leaves fell at vegetative barrier sites
- Measured:
  - Fine/coarse particle size and count
  - Ultrafine particle size and count
  - Black carbon particles
  - Carbon monoxide
  - Wind speed, direction, and turbulence

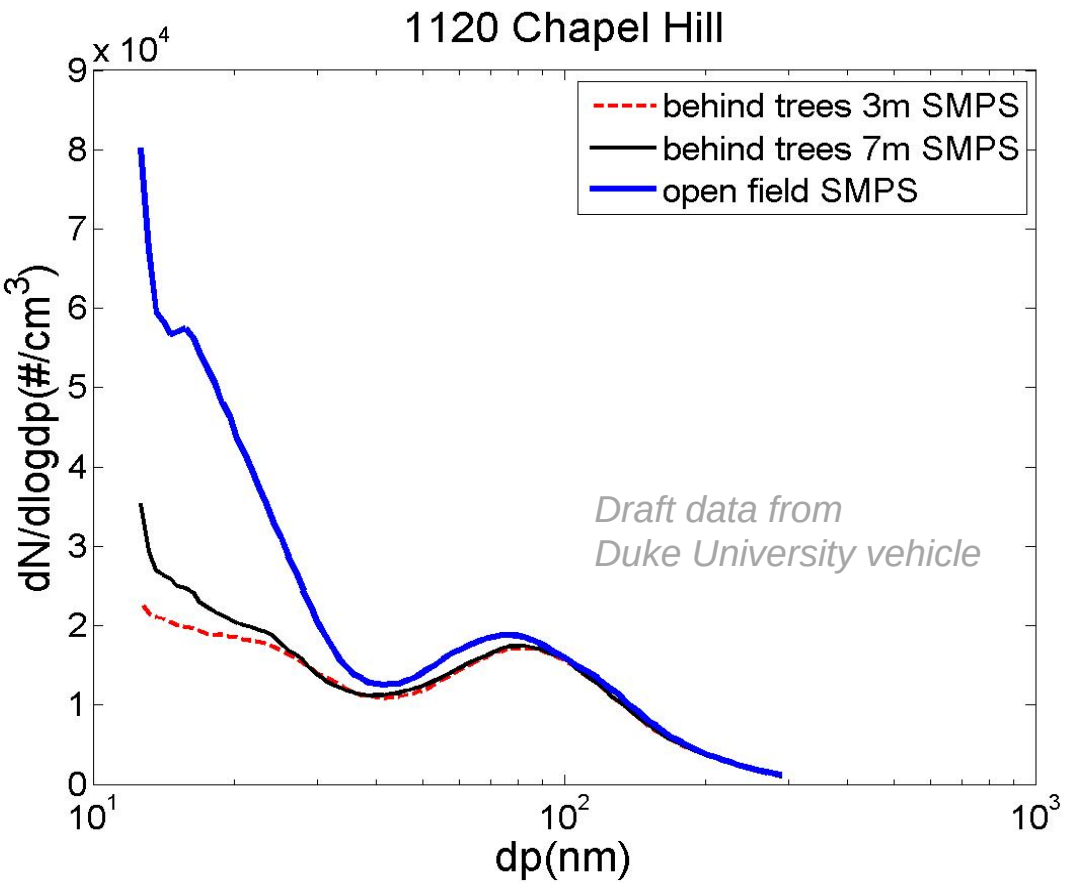




GMAP-SIM – Barrier mitigation assessments

Triangle-Area Barriers Study (2008) – example 2 hour period of sampling downwind of road + evergreen barrier





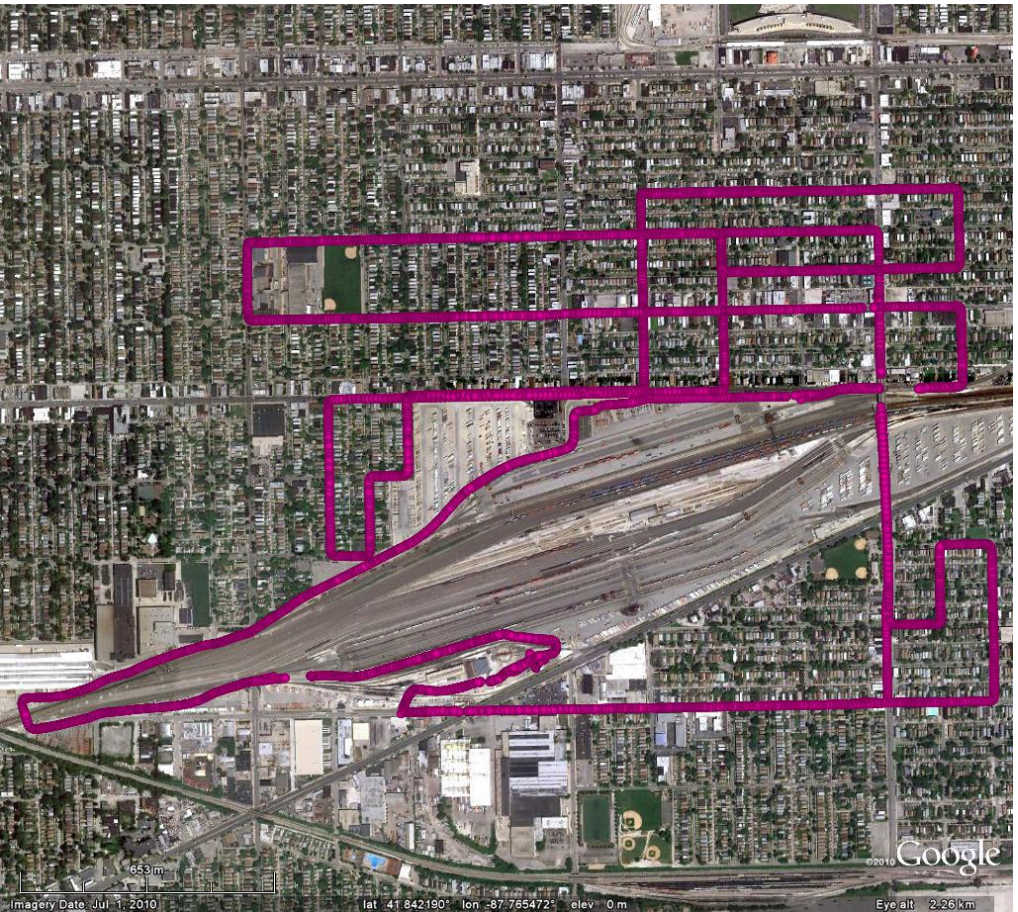
Lin et al., in preparation

GMAP-SIM – Rail Yards

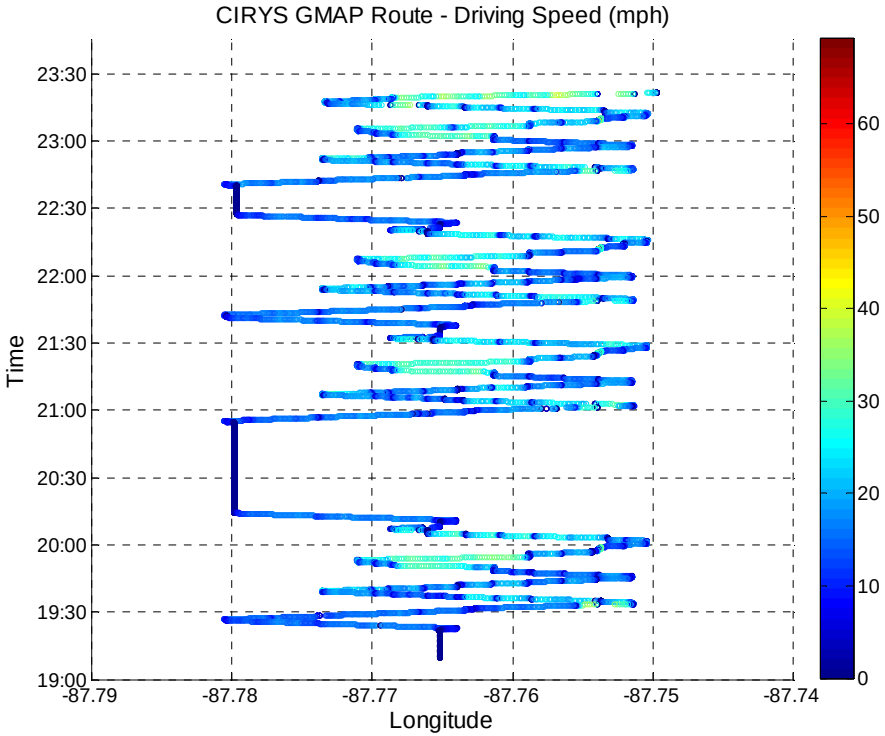
Two mobile monitoring field studies this year – Atlanta, GA and Chicago, IL

→Multiple deployment periods (early morning, midday, evening) to represent varying source activity and atmospheric mixing states.

Illinois rail yard study (ongoing)



Repeat laps of route



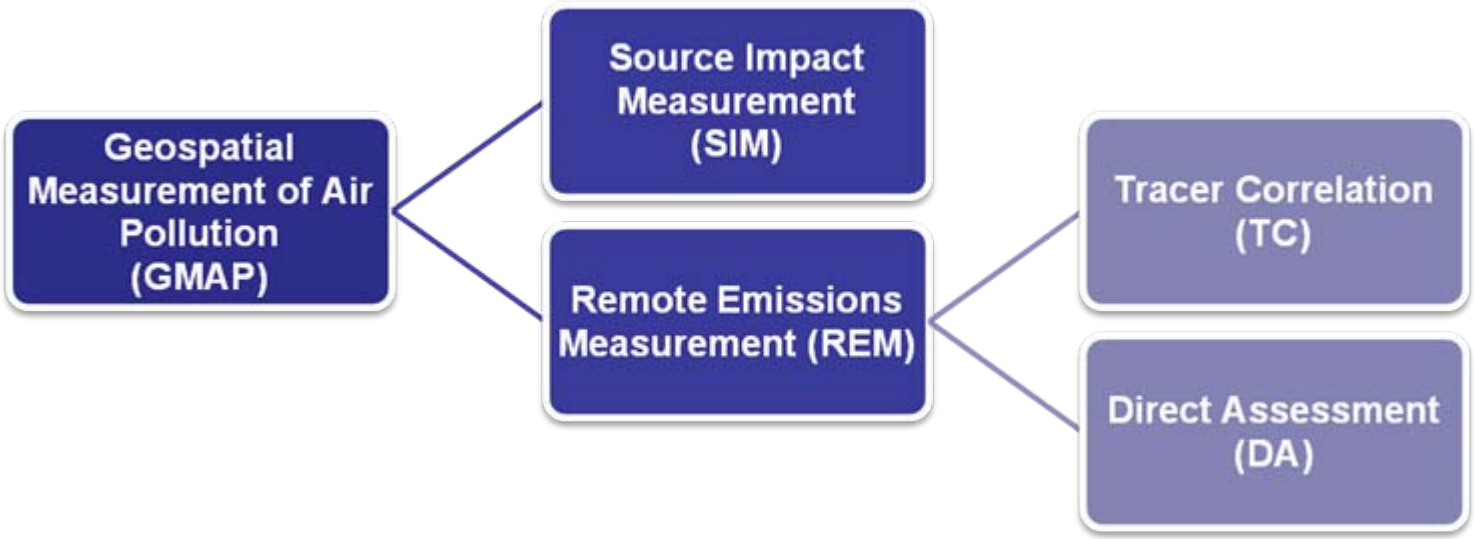
EPA EP-C-09-027, WA 1-47 2010-2011

Future work

→Development of transferable mobile data visualization program with the EPA's Environmental Modeling and Visualization Center, supported by High Performance Computing

→Development of real-time uplink of mobile sampling data to internet for GMAP-Remote Emissions Measurement studies

→Continued field work to develop and apply mobile sampling techniques to quantify emissions and evaluate source-to-ambient process.



Acknowledgements

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  - **ORD:** Rich Baldauf, James Faircloth, Buddy Thompson, John Kinsey, Sue Kimbrough, Bill Mitchell, Bill Squier
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