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Long-Term, Open-Path Emissions Monitoring at Oil and Gas Exploration and Production Sites

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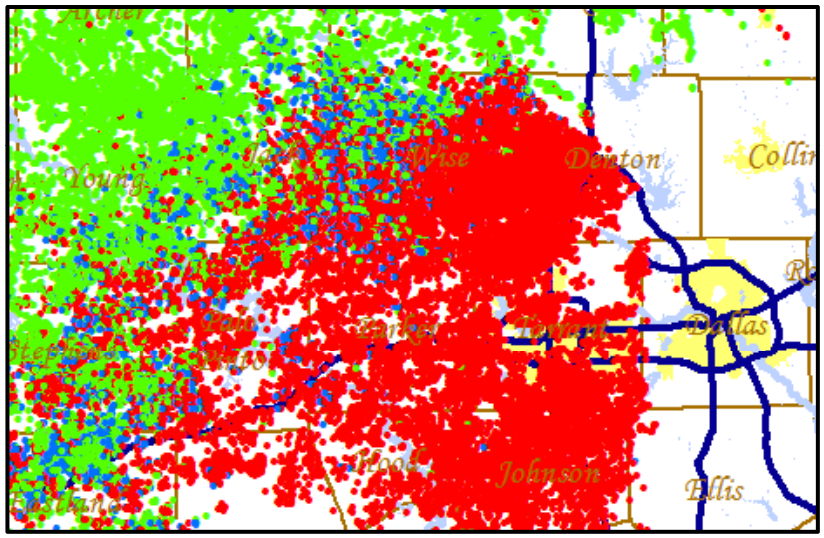
ENVIRON

Shale Gas & Oil:
Economic Boom, Environmental Challenge

Wells in the Barnett Shale
North-Central Texas,
January 2012

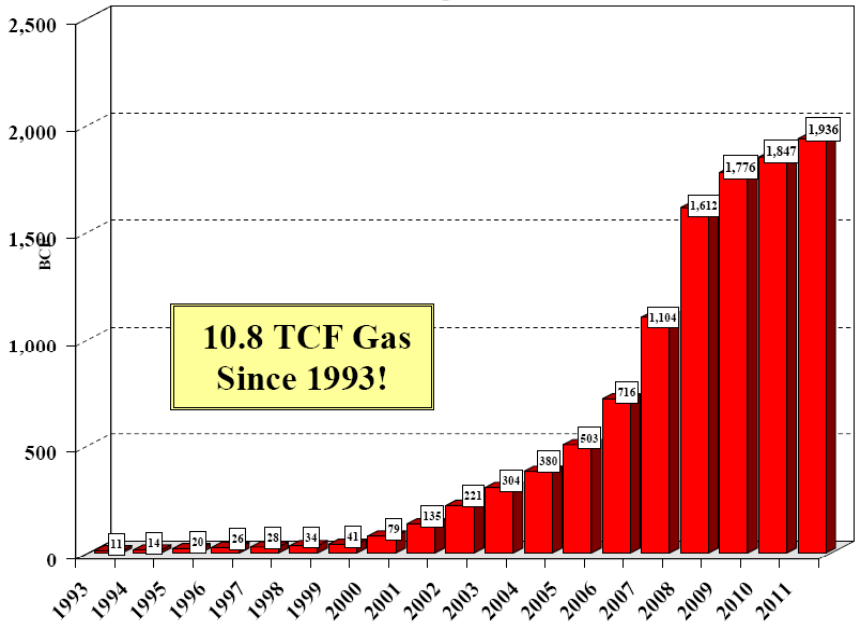


Source: Texas Commission on Environmental Quality

Legend:

- = Active Gas Well
- = Active Oil Well
- = Active Oil & Gas Well

Newark, East (Barnett Shale)
Gas Well Gas Production
1993 through 2011



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Shale Gas & Oil:
Economic Boom, Environmental Challenge

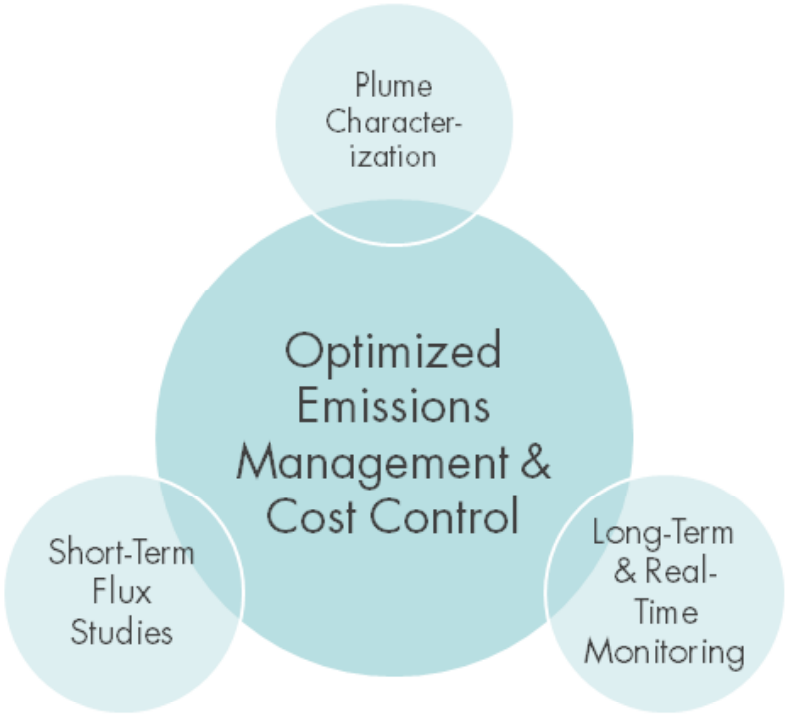
- Historically:
  - Few regulatory requirements
  - Often ignored by regulatory agencies
  - Emissions not or poorly quantified
- Shale gas plays have resulted in heightened scrutiny
  - Large increase in E&P activity.
  - Very large basins in close proximity to urban areas with urban air quality problems:
    - Marcellus Shale
    - Barnett Shale
    - Denver Julesburg Basin (DJB)
- Emissions could be large:
  - NOAA study indicated 2.3-7.% of natural gas produced in DJB is emitted to the air.
  - Applied to the Barnett Shale, hydrocarbon emissions would have been between 923,000 and 3.1 million tons during 2011 (CO_2e: 19.4-65.1 MM tons).

Current Emission Estimation Approaches

- Very good, sophisticated predictive tools for major processing units, such as:
  - GRI-GLYCalc® for glycol dehydration units.
  - API E&P Tank® for flash emissions from storage tanks.
  - Process simulators such as HYSIM® and HYSIS® for various operations.
  - Use requires expertise and good information (garbage in, garbage out).
- Emission for factors for equipment leaks, pneumatics
  - While, perhaps representative of a larger population, may poorly represent individual sources.
  - Studies conducted at refineries and chemical plants indicate that the large majority of fugitive emissions are associated with a few large leaks. Emission factors do not capture this, most likely resulting in a low bias.
- Comparison of bottom-up inventories with top-down measurements (e.g. use of atmospheric concentrations to estimate emissions) consistently indicate that emissions of hydrocarbons from stationary sources are under-reported, often significantly.

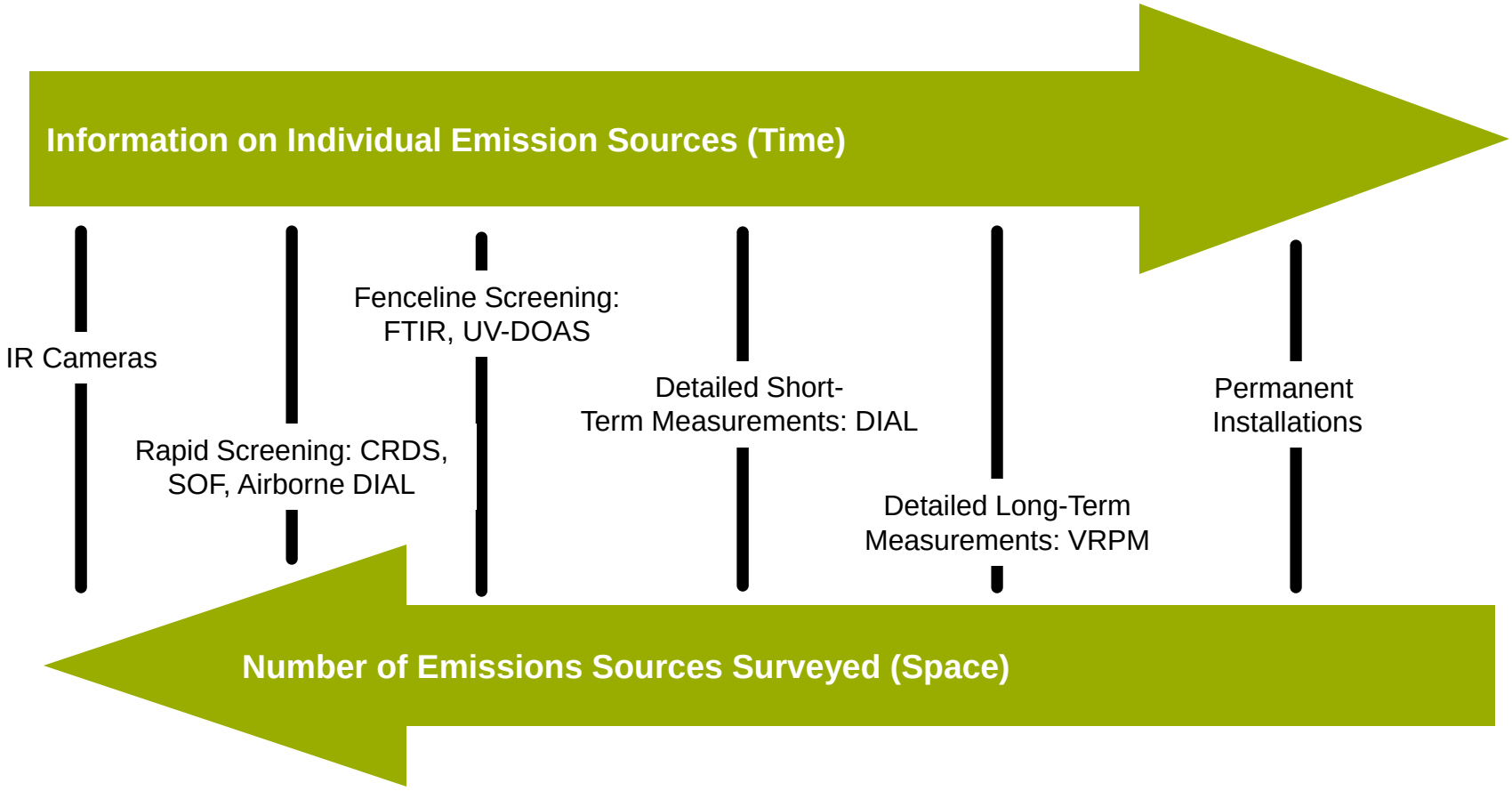
Using Open-Path Monitoring to Improve Emissions Inventories

- Intensive, short-term studies to measure mass flux.
- Plume characterization / speciation.
- Long-term monitoring, correlated with mass flux, to discern variability over time.



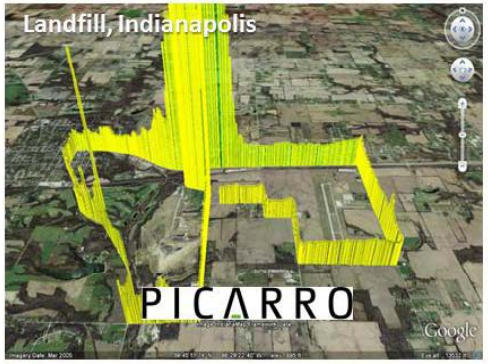
Open-Path Monitoring Continuum

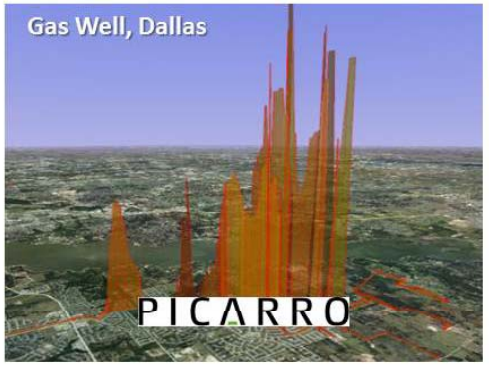
Technology selection and survey design should be made considering the objectives of the project, the types of sources, what is being emitted, as well as the spatial proximity and configuration of the sources. ***There is no "best" technology.***



Short-Term Studies to Measure Mass Flux:
Cavity Ring-Down Spectroscopy

- Highly-precise, real-time analysis of downwind methane concentrations.
- When coupled with estimated plume heights and wind speed, can be a very effective method for rapid, cost-effective estimation of emissions.
- Small, compact, easy to use analyzers can be mounted on almost any mobile platform.





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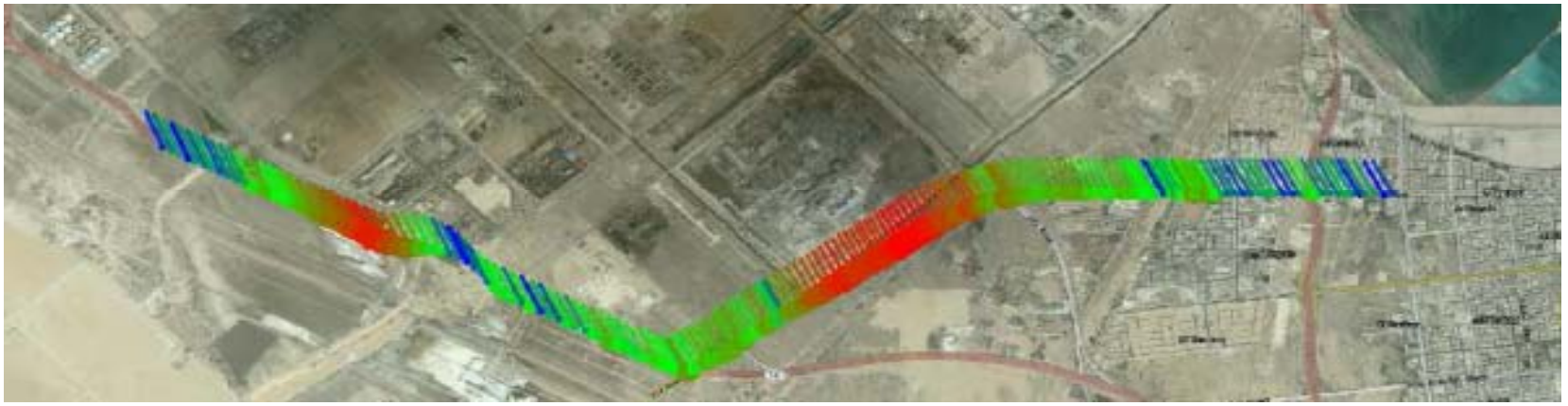
Short-Term Studies to Measure Mass Flux:
Solar Occultation Flux (SOF):

- Been in use since the late 1990s
- Mobile system that measures concentration of target pollutant in entire atmosphere column.
- Integrates two-dimensional concentration profiles with wind speed to estimate emission rates.
- Numerous surveys of refineries, chemical plants, oil storage terminals, oil and gas production facilities.



FluxSense

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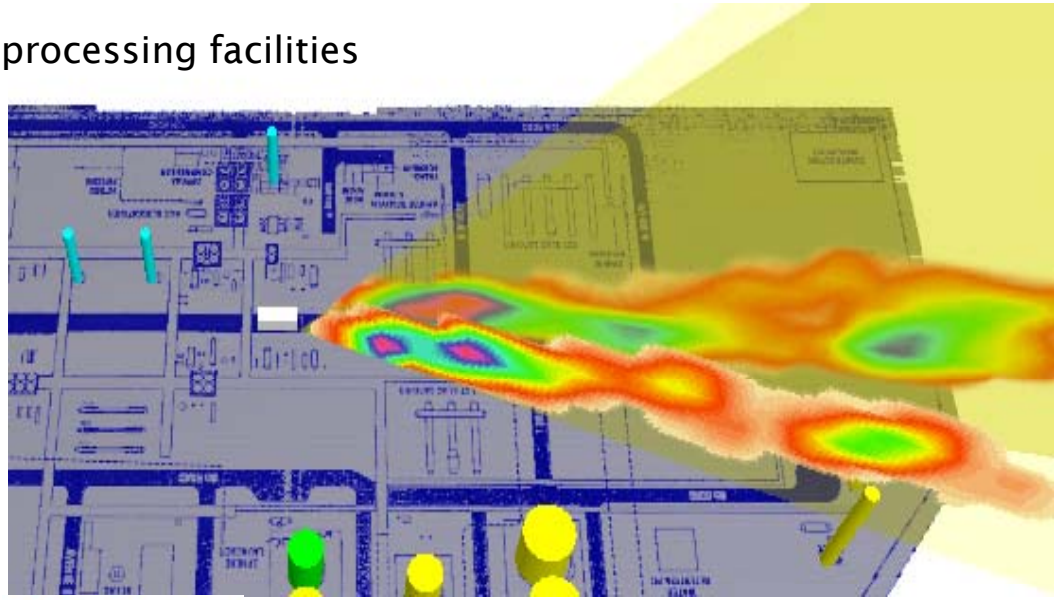
Short-Term Studies to Measure Mass Flux:
Differential Absorption LIDAR (DIAL)

- Been in use since the early 1990s.
- Integrates two-dimensional DIAL profiles with wind speed to measure emission rates.
- Over 200 surveys concluded, including:
  - Refineries
  - Chemical plants
  - Natural gas and oil sands processing facilities

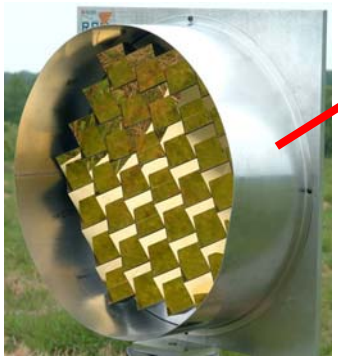
spectrasyne

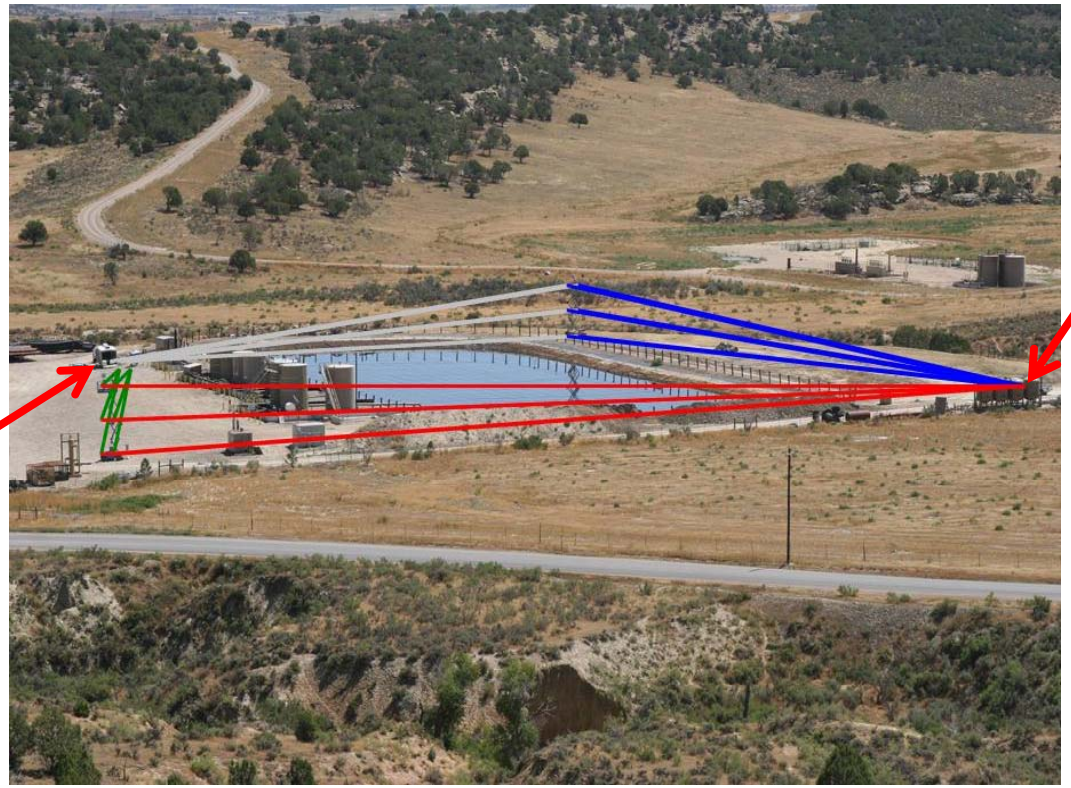


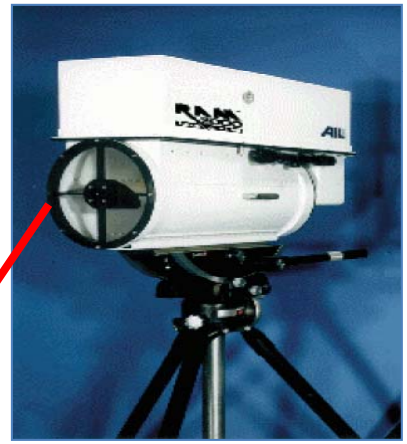
NPL
National Physical Laboratory

Long-Term Studies to Measure Mass Flux:
Vertical Radial Plume Mapping

- Vertical Radial Plume Mapping (VRPM) survey of emissions from a produced water pond in Colorado.

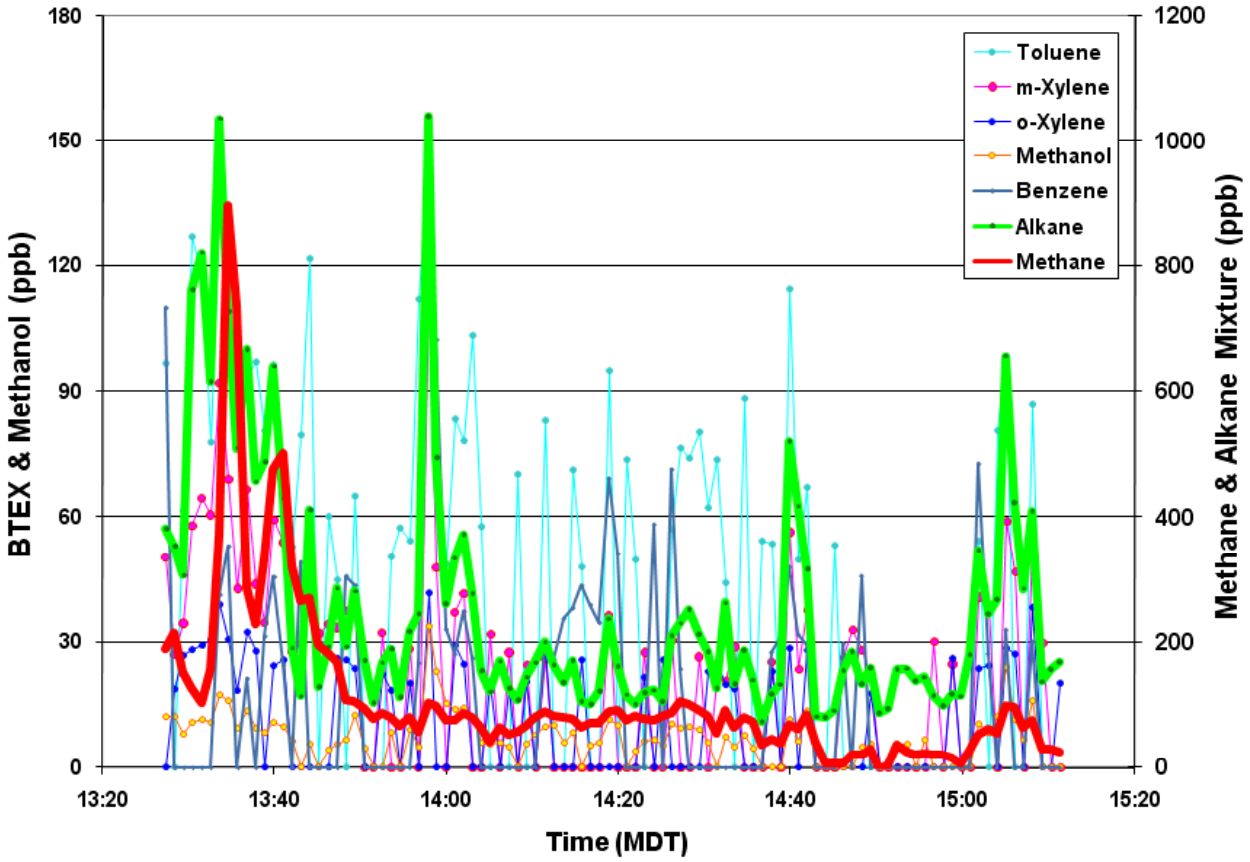






Long-Term Studies to Measure Mass Flux:
Vertical Radial Plume Mapping

- Correlation between emissions of methane and total alkanes is not always strong.



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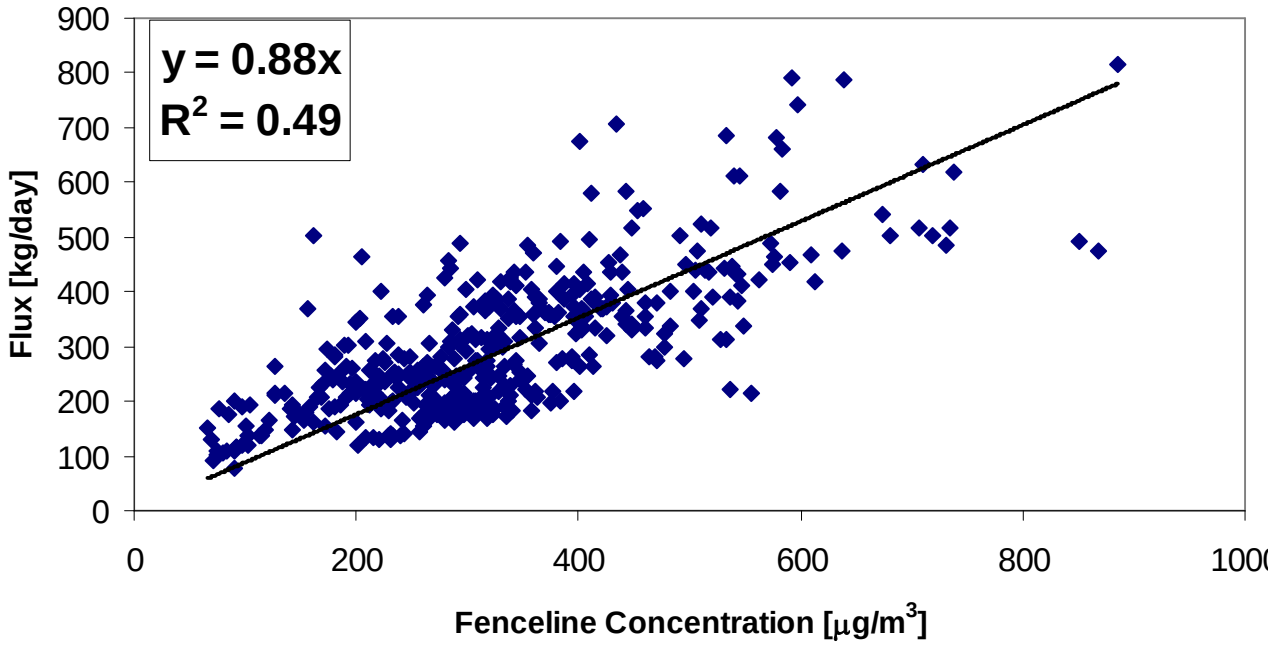
Long-Term Studies to Measure Mass Flux:
Long-Term to Permanent Fenceline Installations

- If you can establish the relationship between downwind concentration and mass flux, you can use simple, single-beam open-path configurations to generate good estimates of emissions over the long-term.



Conclusions

- There are some very good, fully-demonstrated open-path technologies for conducting screening to detailed, short-term surveys of emissions from E&P operations.
- These technologies can and have been used to validate inventories and/or find the holes.
- Long-term measurements can be used to overcome objections that short-term emissions are not representative of long-term emissions.
- Combined with short-term emission measurements, simple single-beam open-path monitoring systems can be used to accurately estimate emissions over long periods of time, providing even better information on emissions variability over time.

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