



# Mobile BTEX and VOC Monitoring with the AROMA Vapor Analyzer: Results and Lessons from Field Studies and Emergency Response Deployments

Tony Miller

[amiller@entanglementtech.com](mailto:amiller@entanglementtech.com)

Elena Craft, Ph.D., Environmental Defense Fund  
Michael Armen, Ph.D., Entanglement Technologies  
Ricardo Viteri, Ph.D., Entanglement Technologies  
Gunnar Skulason, Entanglement Technologies  
Anthony Miller, Ph.D., Entanglement Technologies

# Overview



- Introduction to AROMA technology
- Hurricane Harvey Emergency Response
- Additional Mobile and Fixed Deployments

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# Lab-Grade Mobile VOC sensing provides insights into environmental exposures

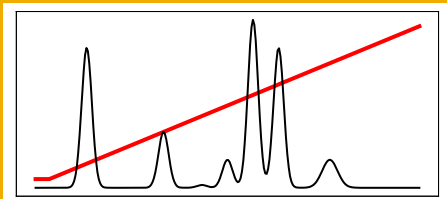


## Real-time Insights:

- Emergency Response rapid threat evaluation
- Distinguish local from regional sources
- Identify patterns of activity associated with elevated/reduced pollution
- Localize and characterize point-sources of pollution

# Technology

## Separation Front End



Ramped thermal desorption chemical concentration and separation: Robust, fast, stable, inert, compact.

- ✓ > 10k cycles
- ✓ Insensitive to O<sub>2</sub>, H<sub>2</sub>O

## Inlet

- ✓ Direct/Air manifold
- ✓ Direct fluid sampling system

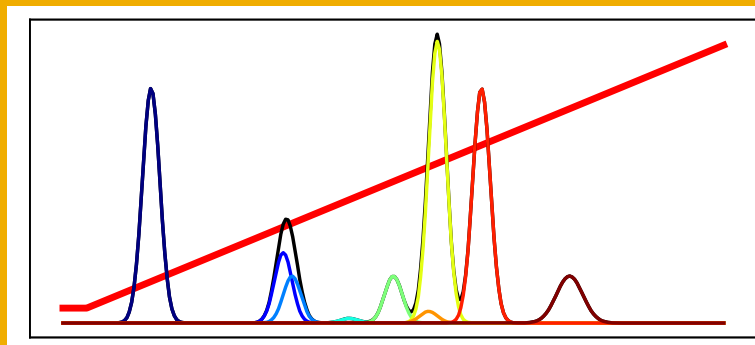
## AROMA Principles

Fast, robust analyte separation is analyzed in a high performance CRDS core to provide speciated, high sensitivity chemical analysis. Direct intake to analyzer core allows for Hz level analysis with species classification

## Embedded Instrument Management

- Proprietary FPGA based laser management
- Real-time data acquisition and management
- High precision analog and digital servo systems
- Internal library and automatic result processing

## Tunable laser + CRDS Core



Rapid broadband spectroscopy eliminates need for complete separation and allows speciation.

- ✓ > 500 nm/sec tuning over ~100nm
- ✓ 50% duty cycle cavity locked CRDS
- ✓ Proprietary electro-optical servos and laser design provide robust performance in harsh vibrational environments
- ✓ MDAL as low as  $1.2 \times 10^{-12} \text{cm}^{-1}/\sqrt{\text{Hz}}$

# Measured Analyzer MDL

## Toxic Vapor Analysis

Species	MDL [ $\mu\text{g}/\text{m}^3$ ]*	MDL [pptv]*
TCE	0.02	6
Benzene	0.0045	1.4
Toluene	0.01	2.6
Ethylbenzene	0.01	4.4
Xylene (combined)	0.04	10
Matrices (typical)	Soil Gas, Indoor Air, Outdoor Air, Sewer Headspace	

## New Compounds: 1,3-Butadiene, Acrolein, Styrene, Isoprene

## Oil-Field Tracer Analysis (via direct sampling front end)

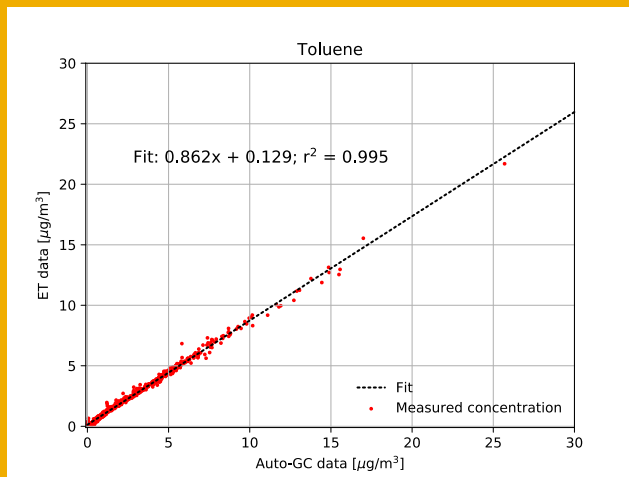
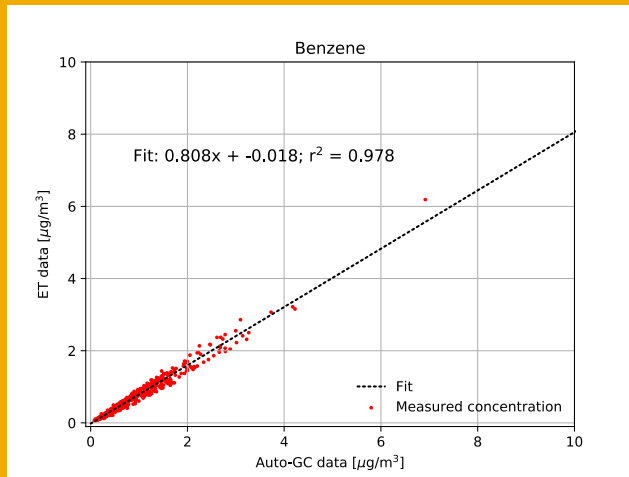
Species	MDL [ppb]*
IPA	6
1-propanol	0.7
1-butanol	0.7
1-pentanol	0.4
Fluoro-alcohol 1	1.5
Fluoro-alcohol 2	1.9
Matrices	Oil-field Produced Brine

\*MDL is 3-sigma, > 7x repeat, @ ~5x MDL delivered as per EPA 301. MDLs recorded simultaneously for all species in grouping.

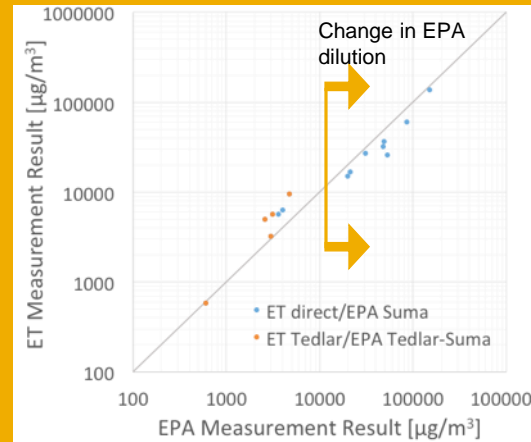
# Performance Validation: BAAQMD, ESTCP, EPA

## BAAQMD

Month-long, 24/7, unattended, side-by-side with dual column auto-GC

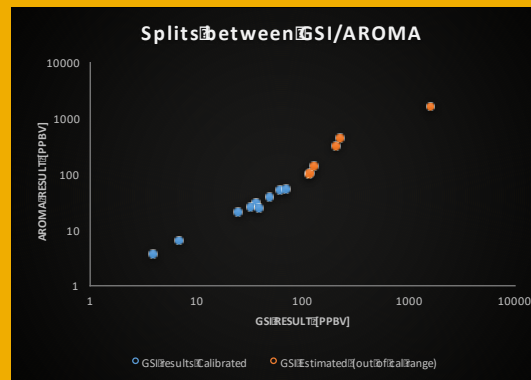


## USEPA



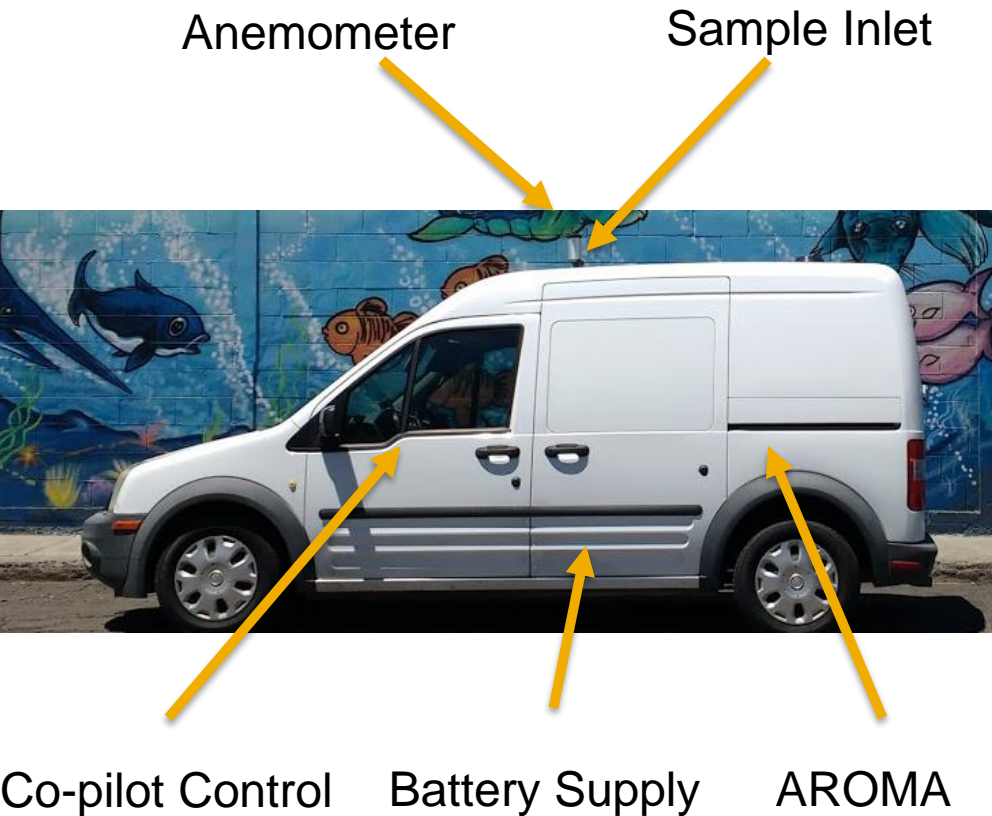
- Side-by-side measurements with gold standard (SUMMA canister + GC/MS by TO-15) measurements performed by EPA lab (region 9).
- The dynamic range was so large that EPA used ET results to select dilution for analysis to prevent contamination of their instrument.

## ESTCP



- Tedlar-based co-sampling of sanitary sewer headspace vs GC/MS
- Included in ESTCP sanitary sewer methodology study.

# Mobile Monitoring



- Vehicle mounted
- 8-hour battery or vehicle alternator
- Data logging and visualization
- 10 Minute full speciated analysis with ppt level detection
- Stationary or mobile operation

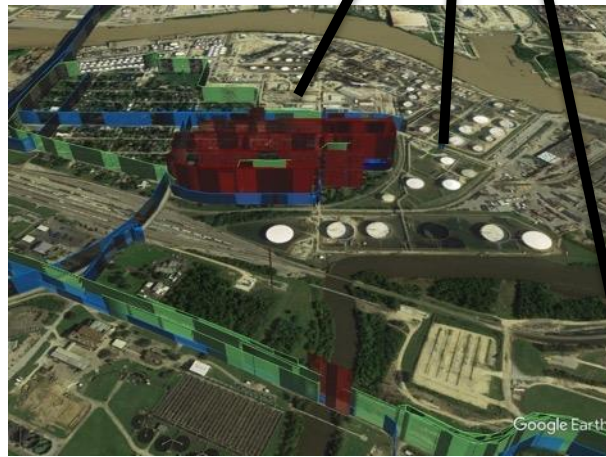
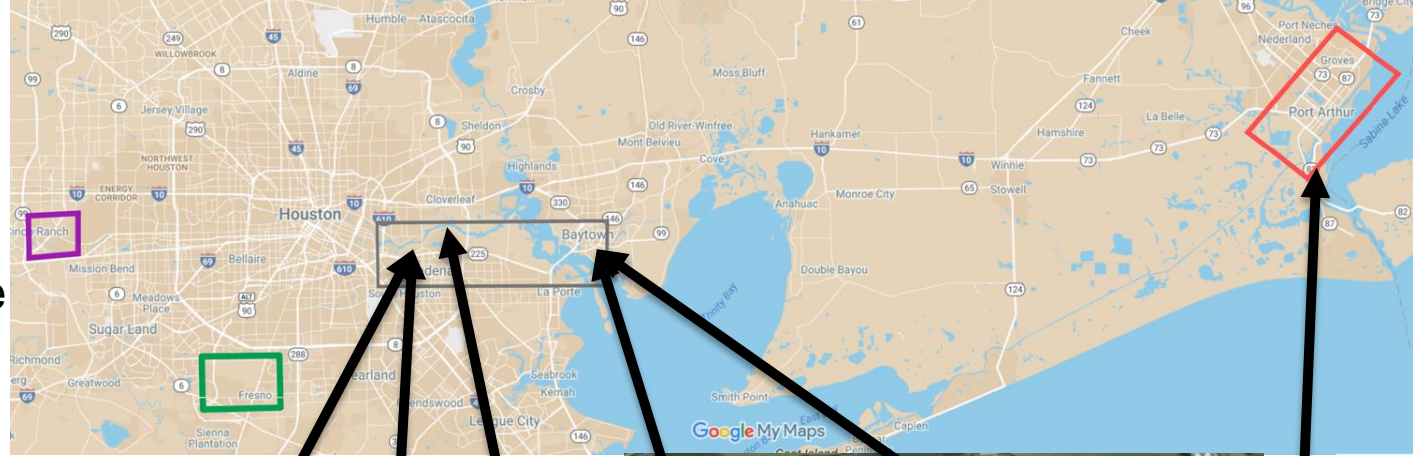
# Post-Harvey Monitoring

- Widespread damage to Houston chemical processing facilities created many significant from chemical releases to ambient air.
- Harvey Leaves Houston: Aug 30
- ET Begins Analysis: Sept 4
- Primary goal to identify areas of elevated risk to drive emergency response and regulator action.
- Six day survey coordinated via EDF with city of Houston to evaluate risk to communities.
- Six plumes identified across the Houston ship channel and Pt Arthur
- > 150 measurements, benzene concentrations ranging from 0.2  $\mu\text{g}/\text{m}^3$  to 538  $\mu\text{g}/\text{m}^3$
- Data verified through QASP including daily blanks and CCV measurements.
- Onboard PID useful for qualitative peak identification; weak correlation with toxicology risk.





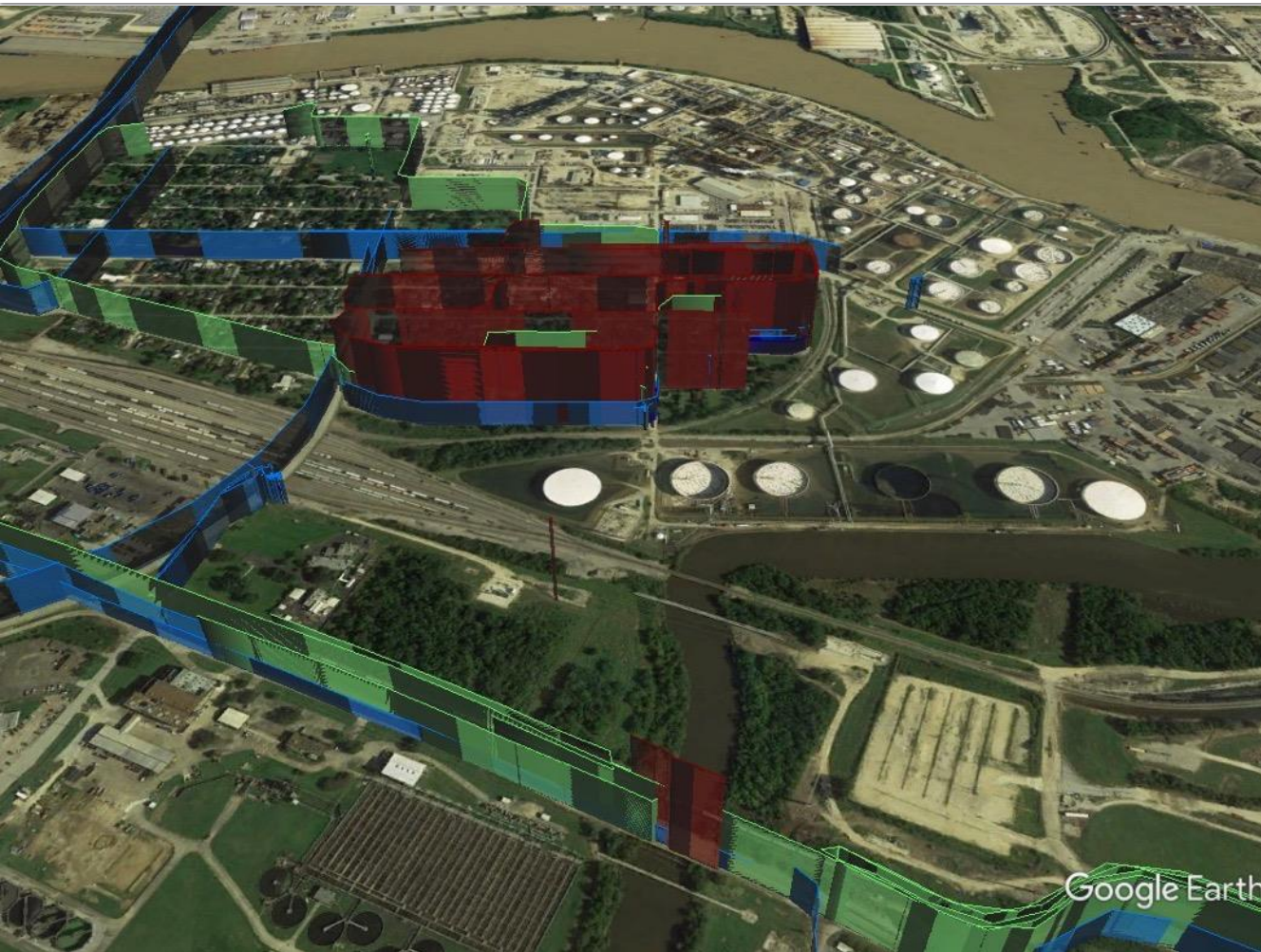
Six significant benzene plumes were identified in exceedance of refinery fence-line standards.



Real-time measurement allowed triage assessment of potential health impacts to direct follow on resources.



# Manchester Plume

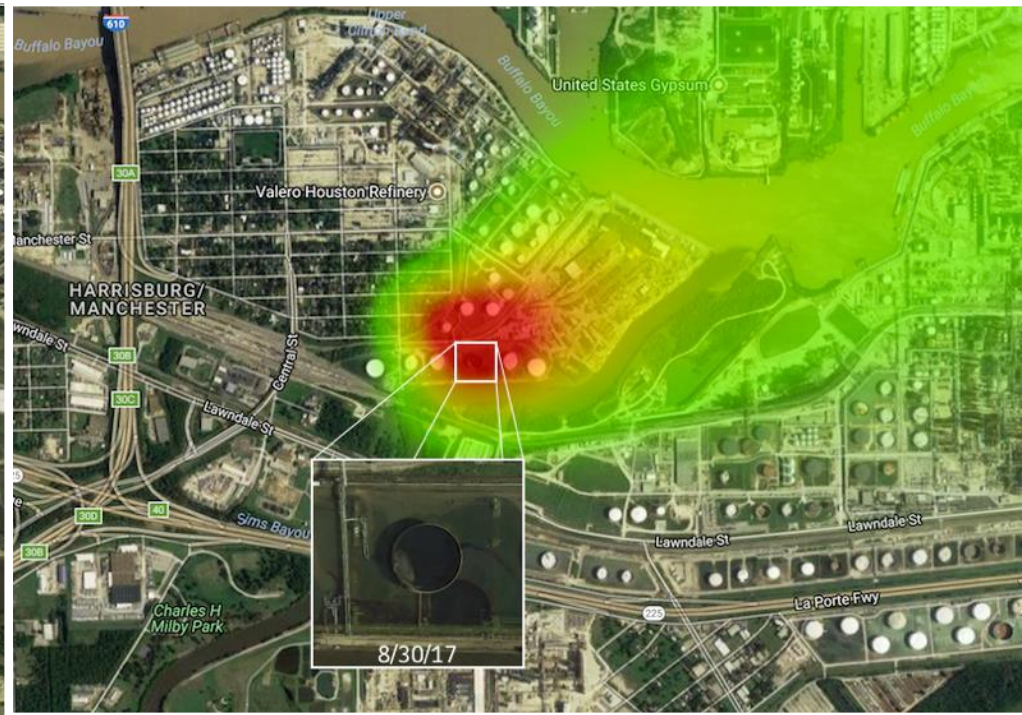
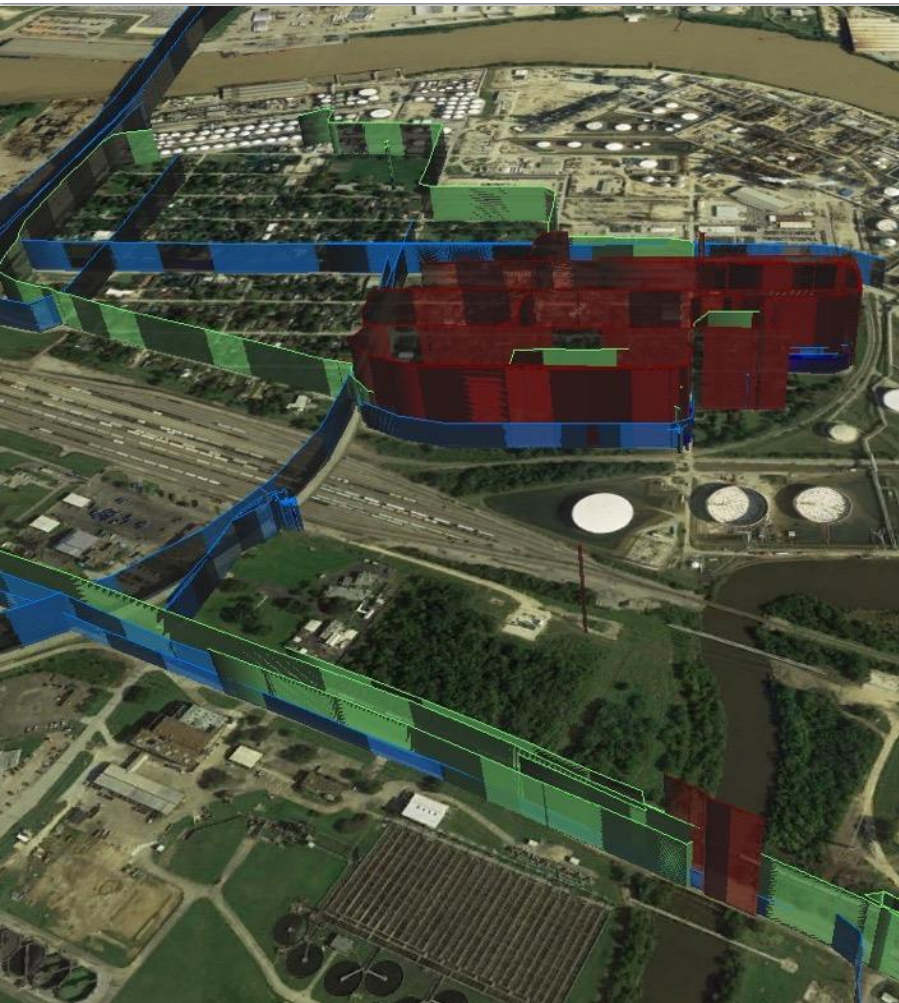


Plume monitored over multiple days.

- Virtual fenceline measurements for localization and average exposure
- Fixed measurements for characterization and 1-hour exposure equivalence
- Co-location validation with Houston's MAMML

Benzene: Blue:  $c < 10 \mu\text{g}/\text{m}^3$  Green:  $10 \mu\text{g}/\text{m}^3 < c < 100 \mu\text{g}/\text{m}^3$   
Red:  $100 \mu\text{g}/\text{m}^3 < c$

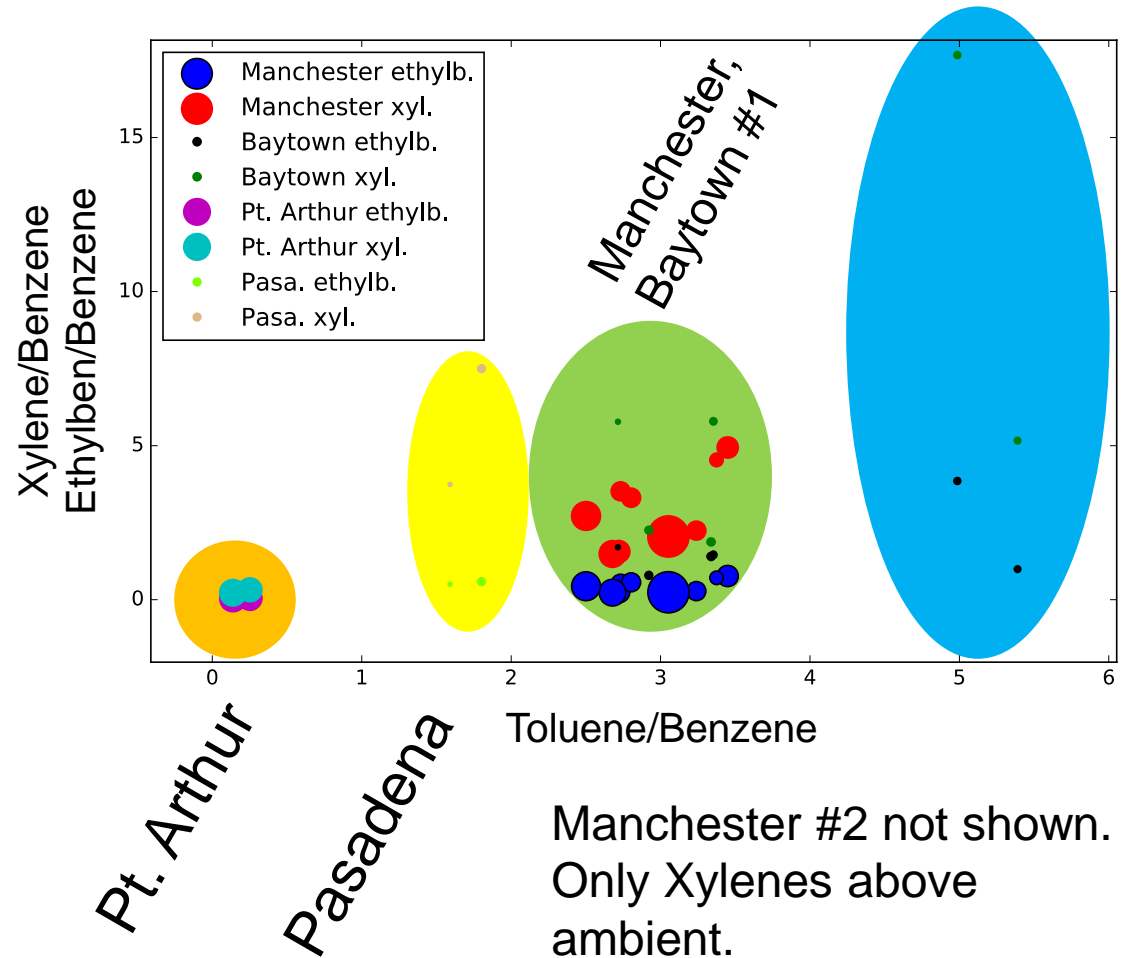
# Source Location Likelihood



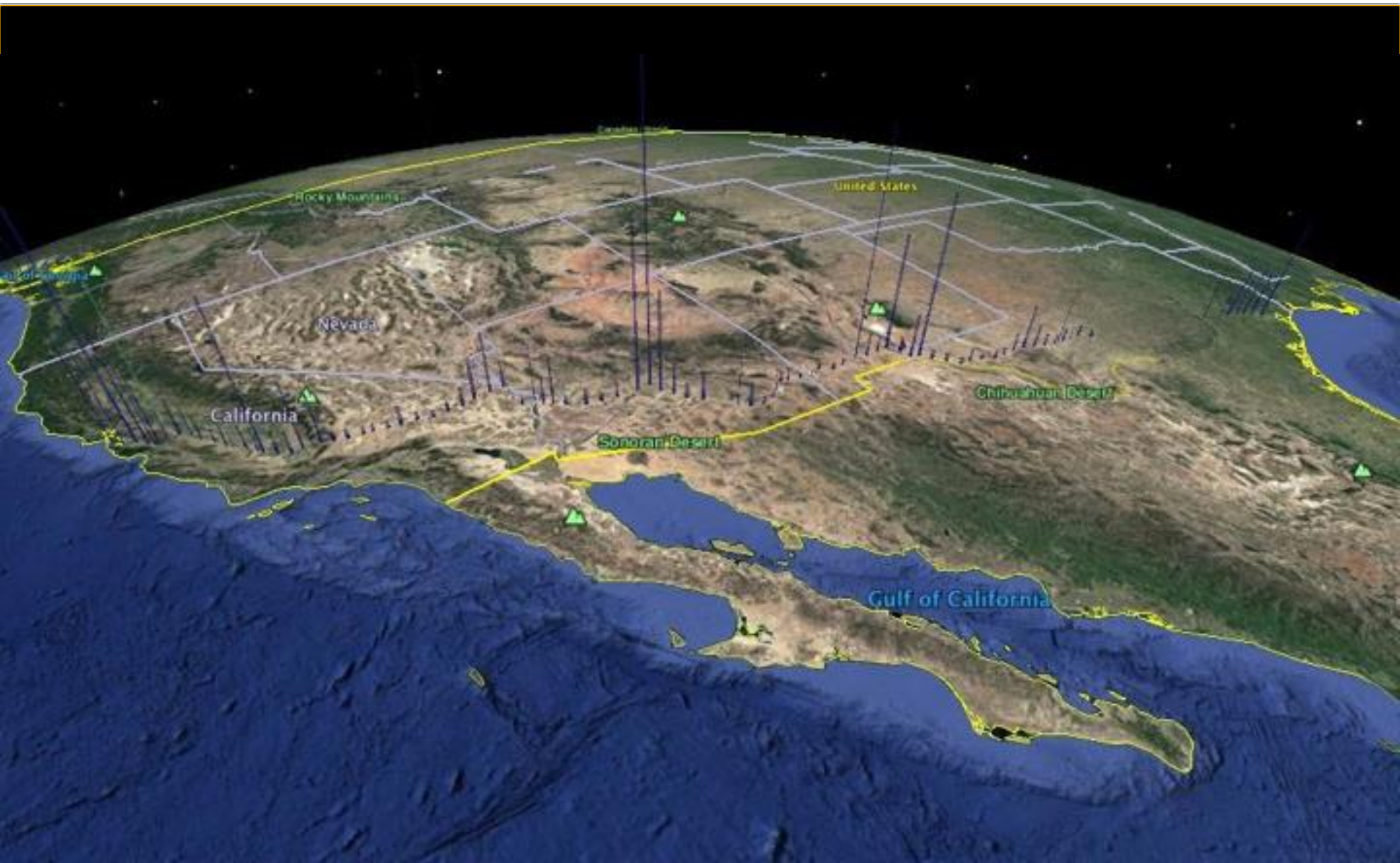
Likelihood of source origin using concentration, locations, and met data. Good agreement with subsequent satellite data

# Plume Fingerprinting

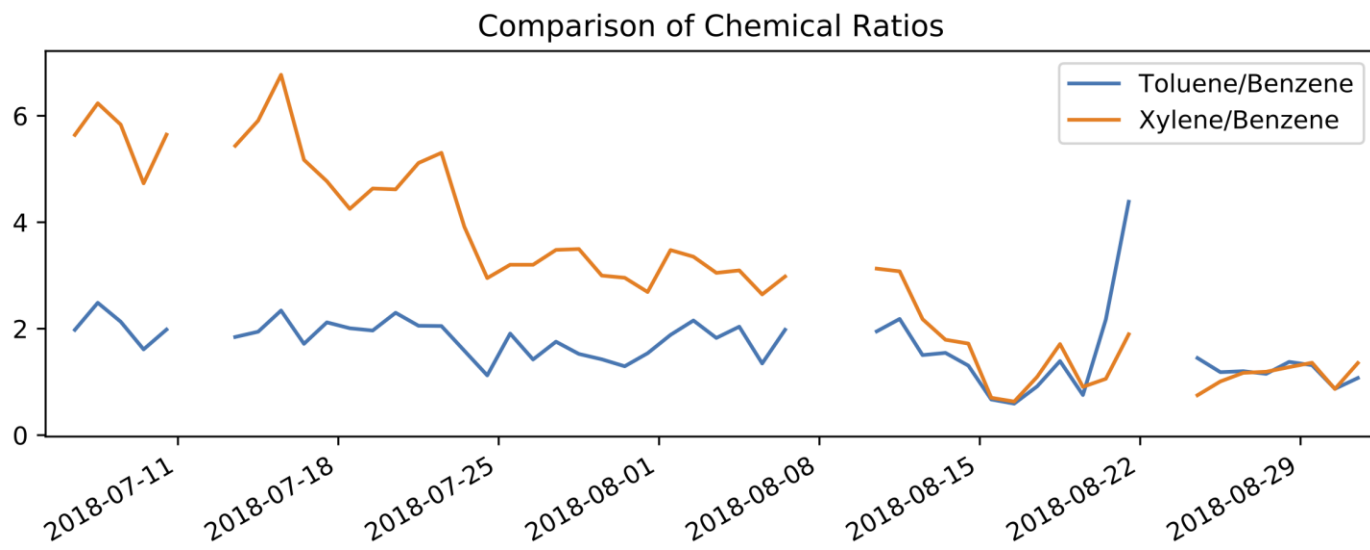
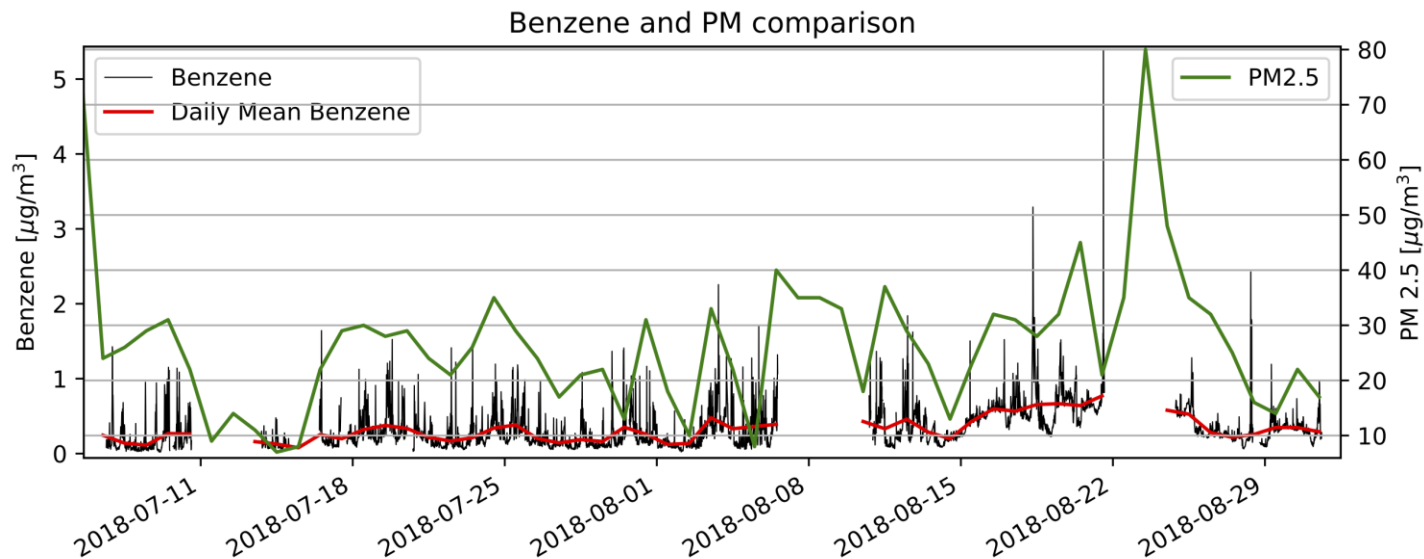
- 5 of 6 plumes show distinct BTEX ratios.
- Allowed for differentiation of two overlapping plumes @ Exxon baytown



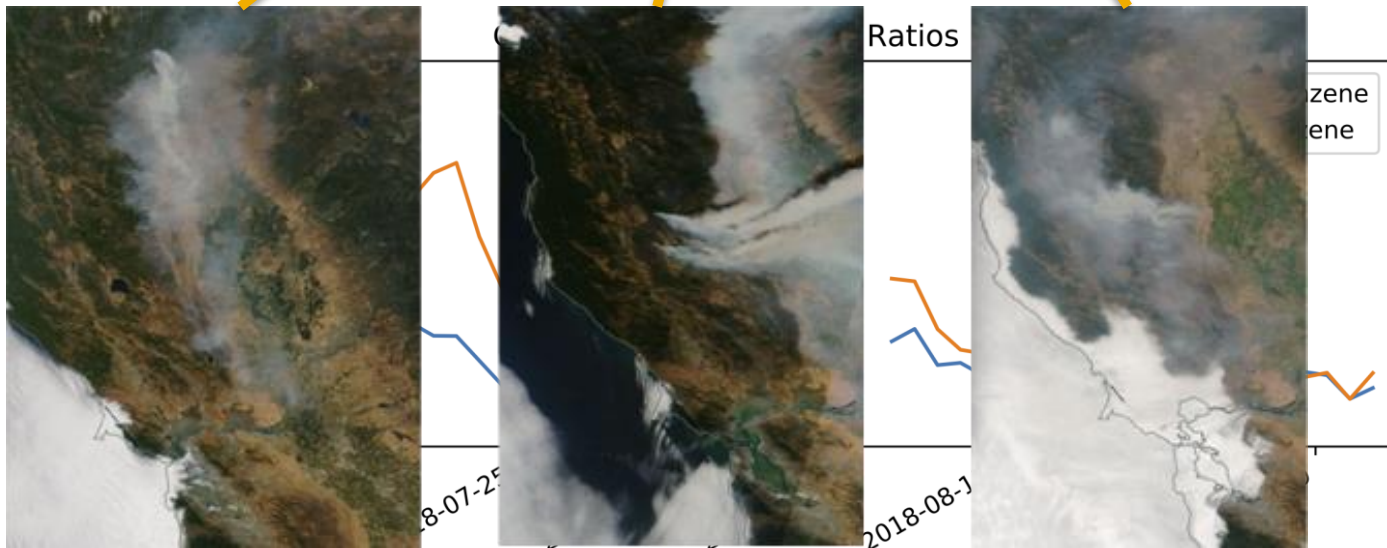
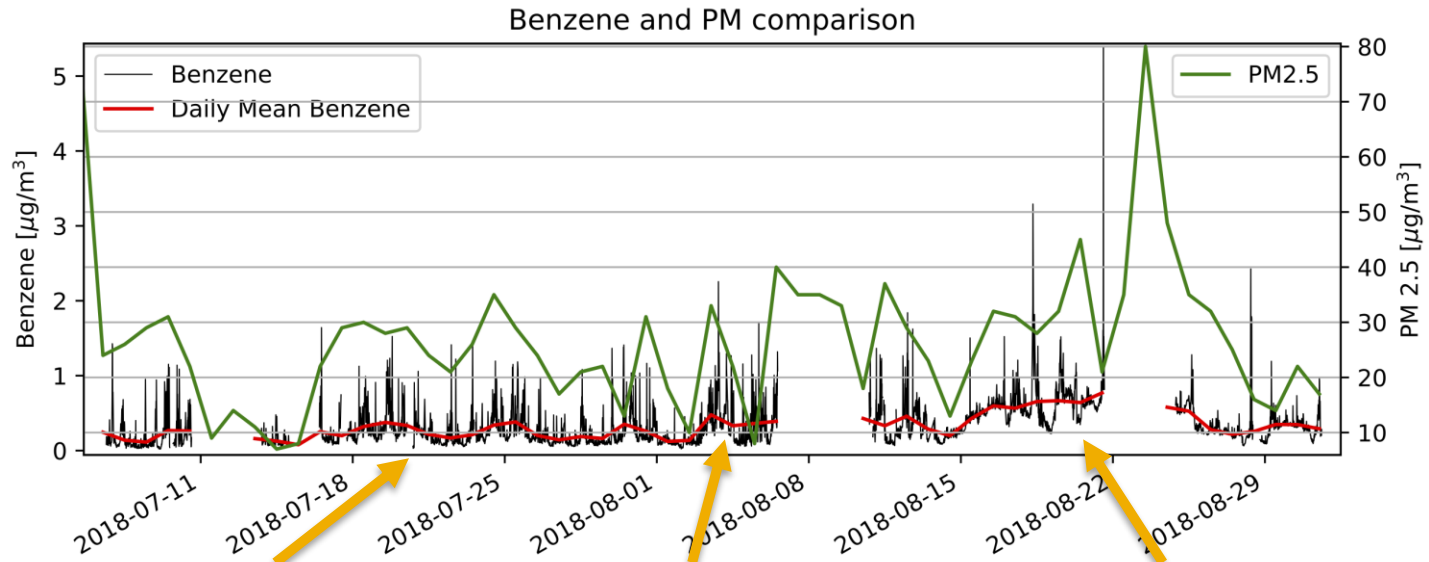
# Cross Country Mapping



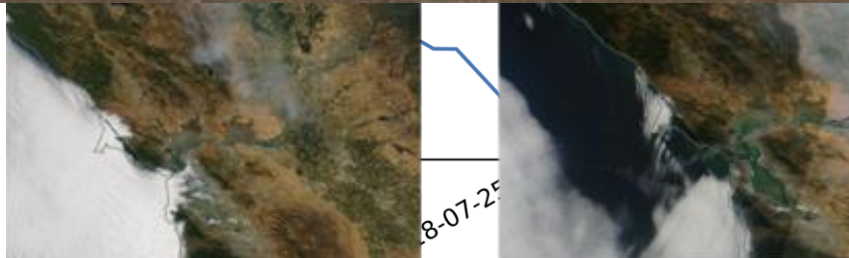
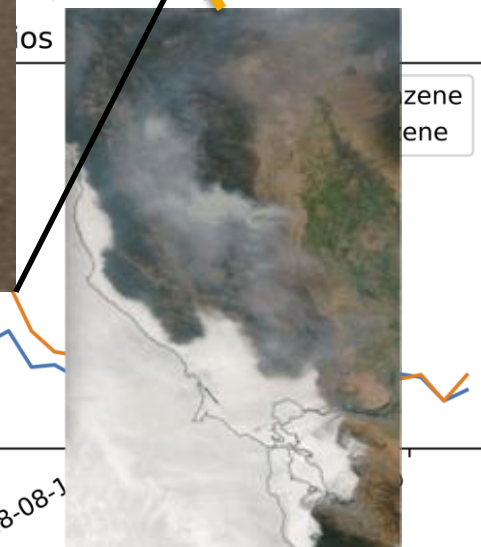
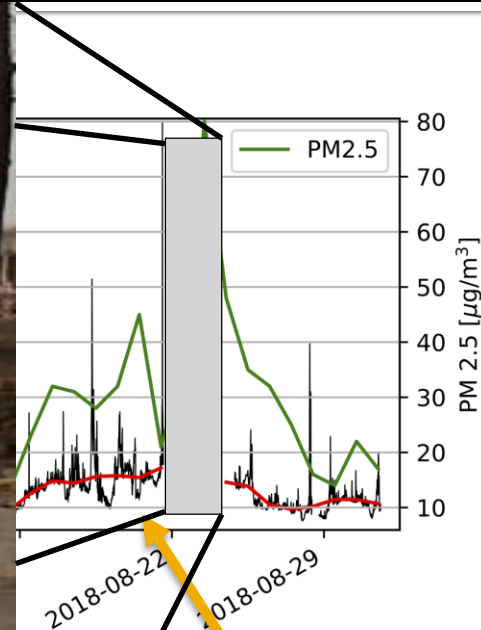
# Fire Impacts



# Fire Impacts



# Fire Impacts





# Fixed Monitoring

