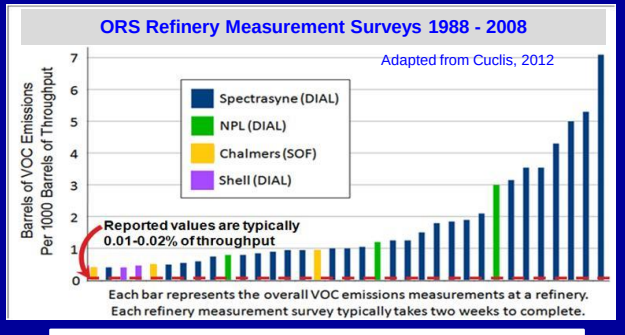
Agenda No. 1

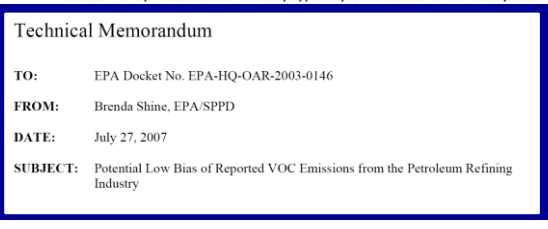
Using Advanced Remote Sensing Technologies to Measure Emissions From Refineries and Other Sources

Stationary Source
Committee
March 17, 2017

Background: VOC Emissions - Refineries

- Mounting evidence that emission inventories may not accurately reflect actual VOC emissions
- Direct measurements can provide more accurate emission estimates
- Optical Remote Sensing (ORS) technologies evolved significantly in the past decade
  - Fully automated, continuous, no calibration required
  - Ideally suited for long-term fenceline monitoring
  - Can characterize and quantify emissions
  - Provide rapid leak detection, concentration mapping and emission flux monitoring




Technical Memorandum

TO: EPA Docket No. EPA-HQ-OAR-2003-0146

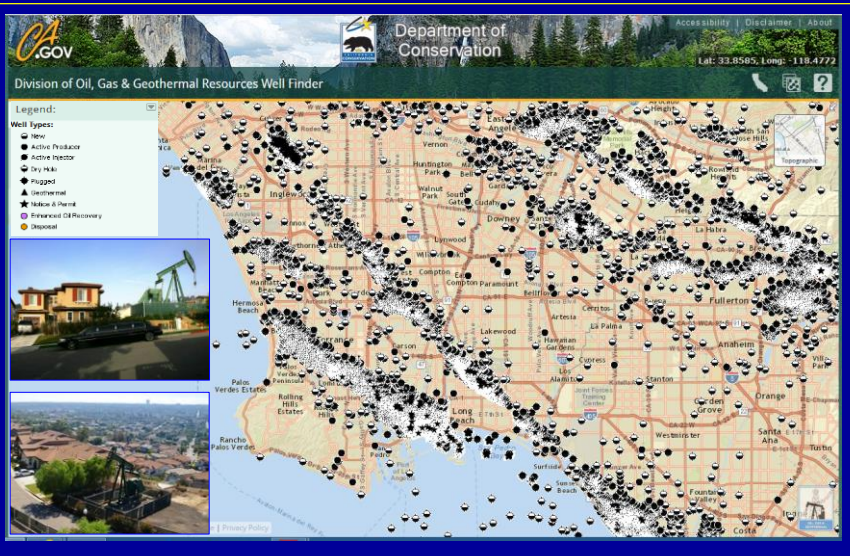
FROM: Brenda Shine, EPA/SPPD

DATE: July 27, 2007

SUBJECT: Potential Low Bias of Reported VOC Emissions from the Petroleum Refining Industry

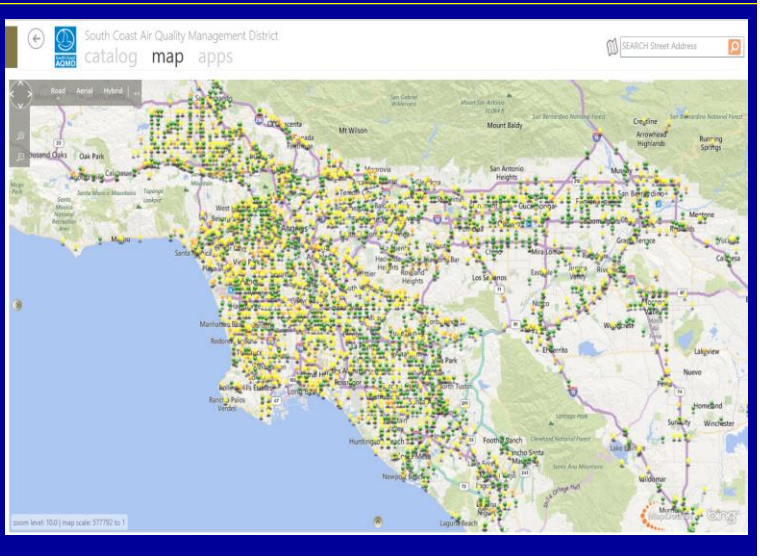
Background:
VOC Emissions - Oil Wells

- Thousands of oil wells in the SCAB, many in residential neighborhoods
- SCAQMD rules:
  - Rule 222: well registration
  - Rule 1148.1: housekeeping practices for emission reduction
  - Rule 1148.2: chemical reporting
- Actual emissions from oil wells and other small sources are highly uncertain



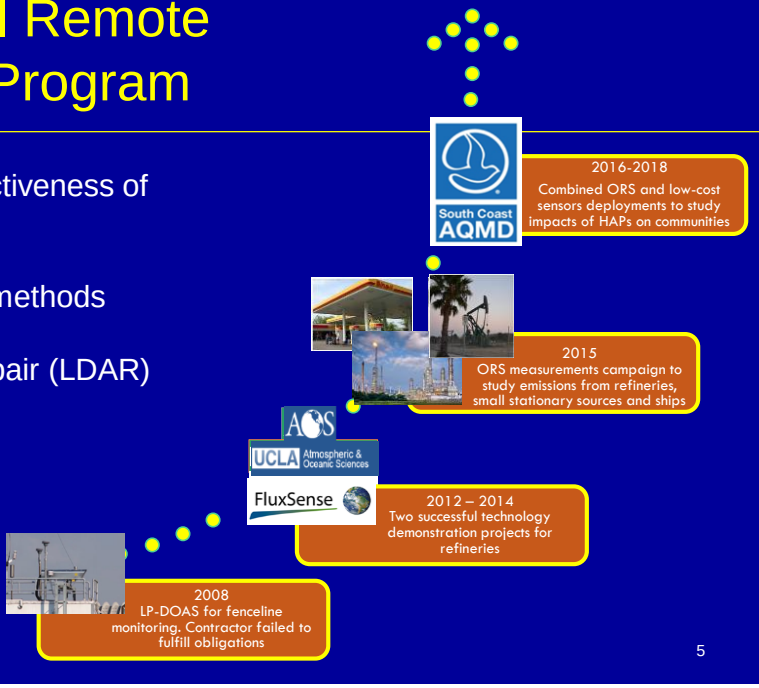
Background:
VOC Emissions - Gas Stations

- 3100+ gas stations, many adjacent to residential buildings
- Enhanced vapor recovery (EVR) and In-Station Diagnostic (IDS) systems required
- SCAQMD rules:
  - Rule 461:
    - Daily inspections of vapor recovery system by owner/operator
    - Inspections by SCAQMD compliance staff
    - Periodic Source Testing
- VOC emissions from this source are uncertain



SCAQMD Optical Remote Sensing (ORS) Program

- Demonstrate feasibility and effectiveness of fenceline monitoring
- Measure emissions using ORS methods
- Improve Leak Detection and Repair (LDAR) program and reduce emissions
- Provide real-time alerts to neighboring communities
- Estimate emissions from large industrial facilities and other sources



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2015 SCAQMD ORS Study

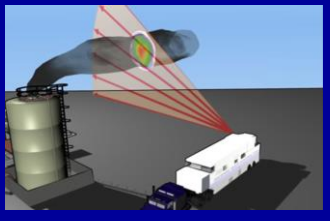
- Project 1: Quantify fugitive emissions from large refineries
- Project 2: Quantify gaseous emissions from small point sources
- Project 3: Quantify stack emissions from marine vessels/ports

Project 1:
Quantify Fugitive Emissions From Large Refineries

FluxSense

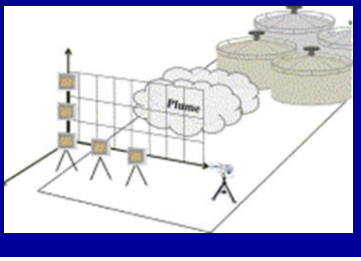
- SOF, FTIR, and DOAS
- Use: facility-wide emissions and real-time leak detection
- Pros: mobile measurements
- Cons: day time only

National Physical Laboratory (NPL)



- DIAL
- Use: emission measurements
- Pros: very accurate
- Cons: one source component at the time

Atmosfir Optics



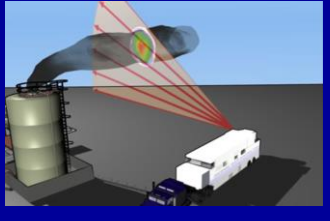
- OP-FTIR
- Use: fixed monitoring
- Pros: continuous 24/7 measurements (EPA OTM-10 method)
- Cons: fixed installation

Project 1:
Quantify Fugitive Emissions From Large Refineries

FluxSense

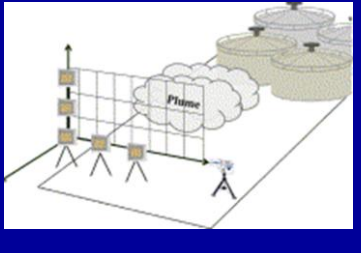
- Role within this project: primary measurement method
- 5 week study at 6 refineries in the SCAB
- Facility-wide emissions of CH4, non-CH4 VOCs, NO2, SO2, BTEX

National Physical Laboratory (NPL)



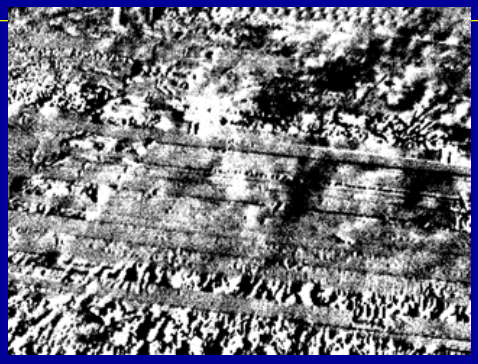
- Role within this project: validation
- 1 week study at 1 refinery
- Emissions of non-CH4 VOCs, BTEX

Atmosfir Optics

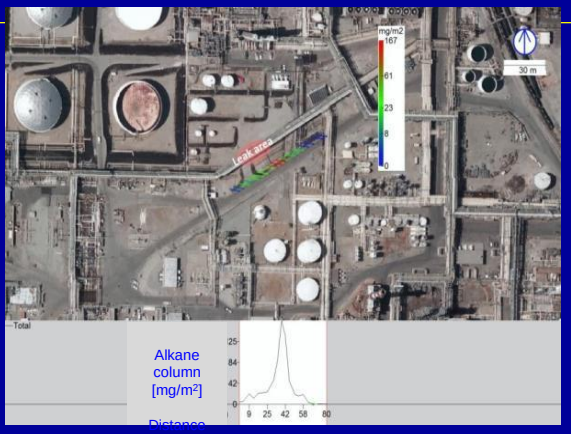


- Role within this project: long term monitoring
- 5 week study at 1 refinery
- Concentration measurements of CH4, non-CH4 VOCs

Project 1 Results: Leak Detection



- Underground leak discovered by FluxSense on September 30, 2015 while driving inside the facility
- FLIR images/videos confirmed emissions from the ground



- Measured alkanes concentrations: ~70,000 ppb
- Average VOC emissions: 31 kg/h

Project 1 Results: Refinery Emissions (FluxSense)

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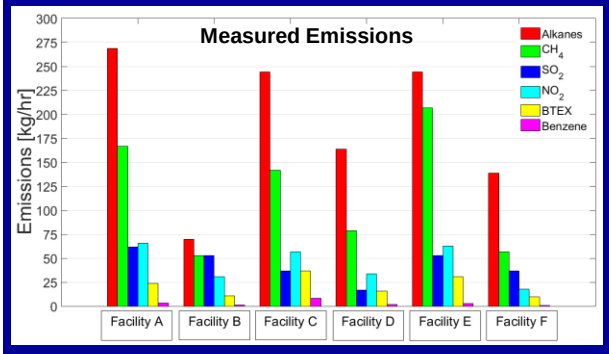
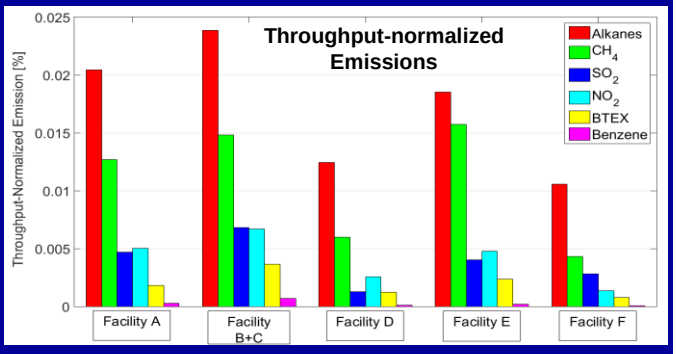
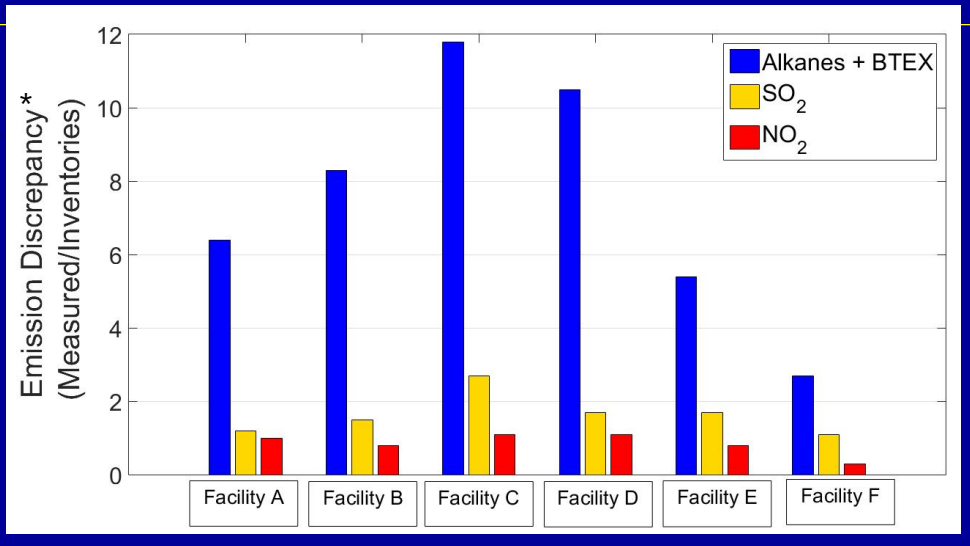




Project 1 Results: Refinery Emissions (FluxSense)



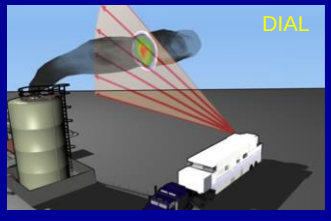
*Median measured emissions (September 2015) / Reported annual emissions divided by 12

Project 2:
Quantify Gaseous Emissions From Small Point Sources

FluxSense

- Role within this project: primary measurement method
- 5 week study of ~100 small sources (e.g., oil wells, intermediate oil treatment facilities, gas stations, other)
- CH4 and non-CH4 VOCs, BTEX, NO2, SO2

National Physical Laboratory (NPL)



- Role within this project: validation
- 1 week study at selected sources
- CH4 and non-CH4 VOCs, BTEX

Kassay Field Services

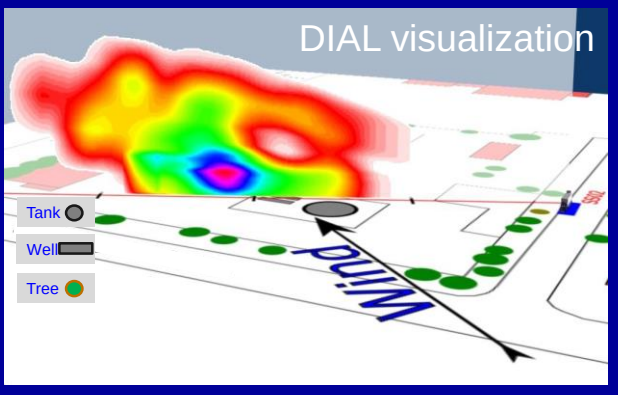
- Role within this project: complement SOF measurements
- 5 week study at ~50 small sources
- CH4 and non-CH4 VOCs

Project 2 Results:
Small Oil Treatment Facility

- Alkanes: 3320 ppb
- Benzene: 21 ppb* (MATES IV Basin annual average: 0.4 ppb)

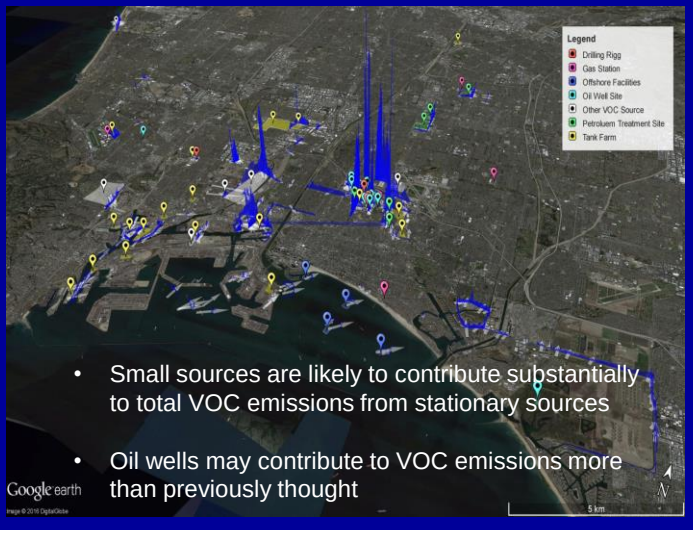
*Concentration measured during this survey

Project 2 Results:
Small Oil Treatment Facility

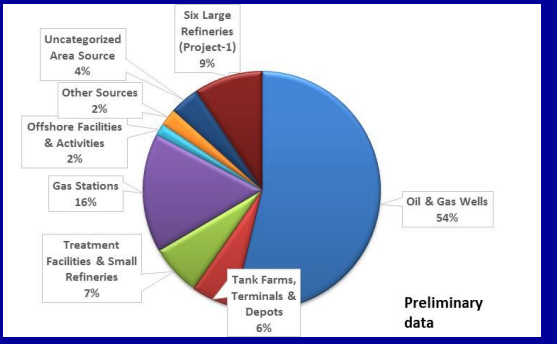


Most of the measured emissions are likely from the main storage tank at this facility

Project 2 Results:
VOC Emissions From Small Sources in the SCAB



- Small sources are likely to contribute substantially to total VOC emissions from stationary sources
- Oil wells may contribute to VOC emissions more than previously thought



*Calculated by scaling-up the average emission value for each category by the total number number of units/sources in the SCAB

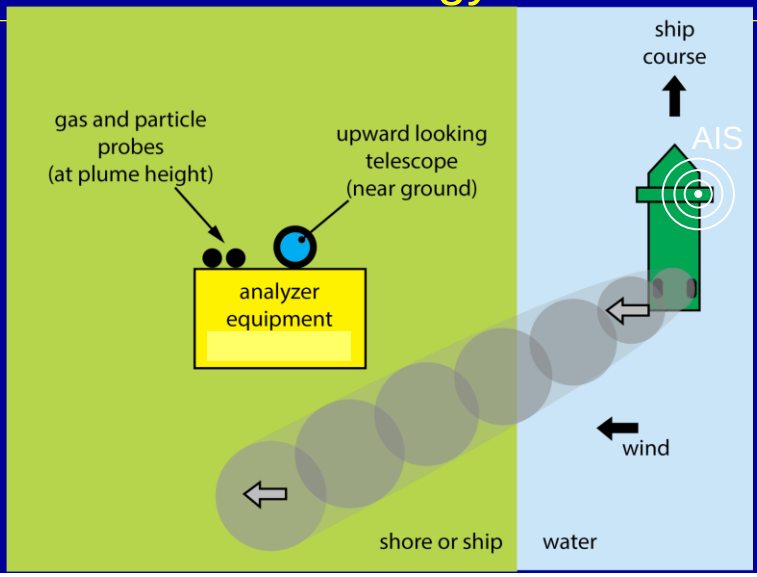
Project 3:
Quantify Stack Emissions From Marine Vessels

- FluxSense only
- Mix of ORS and more traditional measurement methods (i.e., DOAS, SOF, particle and gas monitors)
- 4 week study at Port of Los Angeles (POLA) and Port of Long Beach (POLB)
- On-shore and off-shore measurements
- "Real world" emissions (g/s) of SO_2 and NO_2, and "actual" emission factors (g/Kg fuel burnt) of SO_2, NOx, PM, and BC from individual ships
- 692 ships sampled during the study

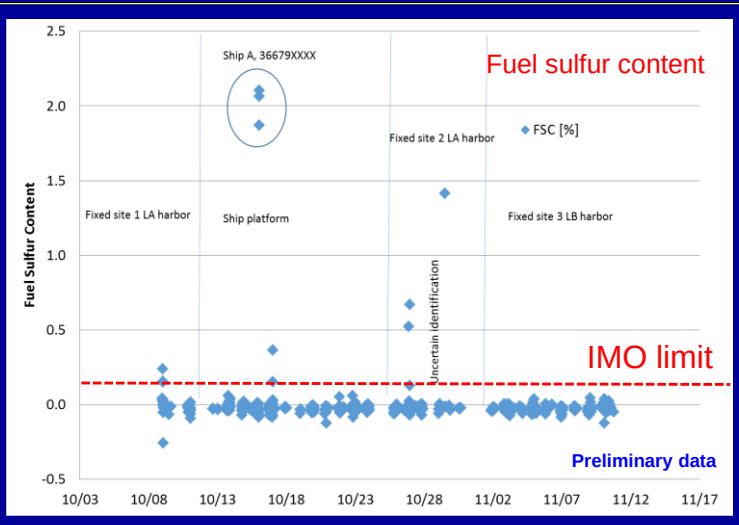
Project 3:
Measurement Equipment

Project 3: Measurement Strategy

- Plume of passing ship detected by measurement station
- Station mounted either at fixed sites or inside a mobile platform
- Passing ship identified by its Automatic Identification System (AIS) signal

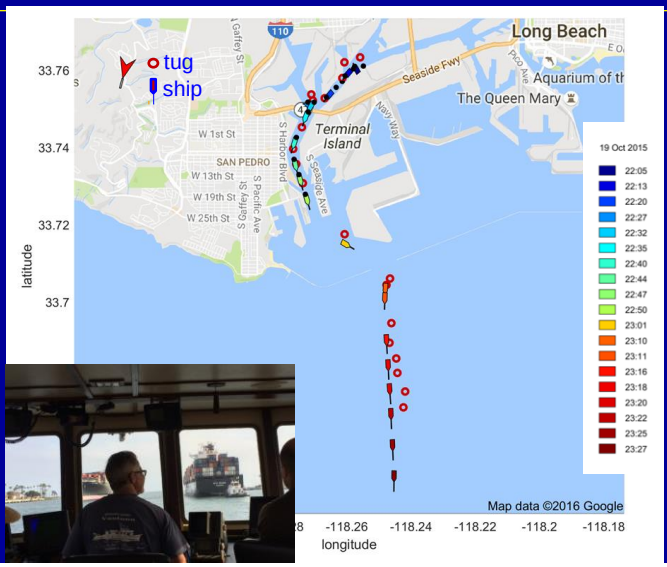


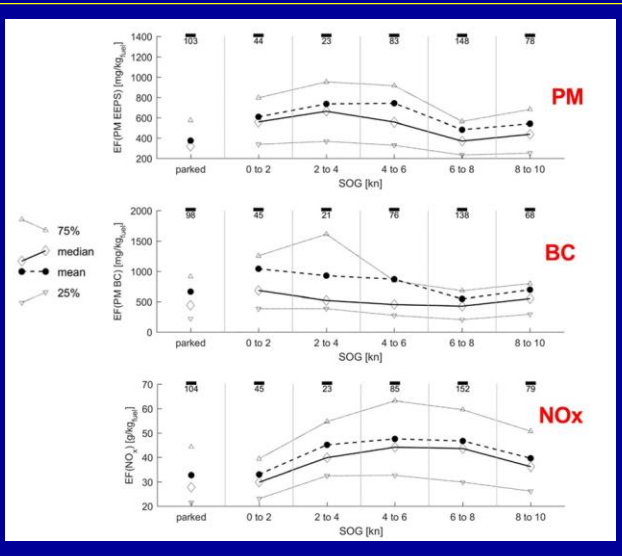
Project 3 Results: Fuel Sulfur Content of Ships



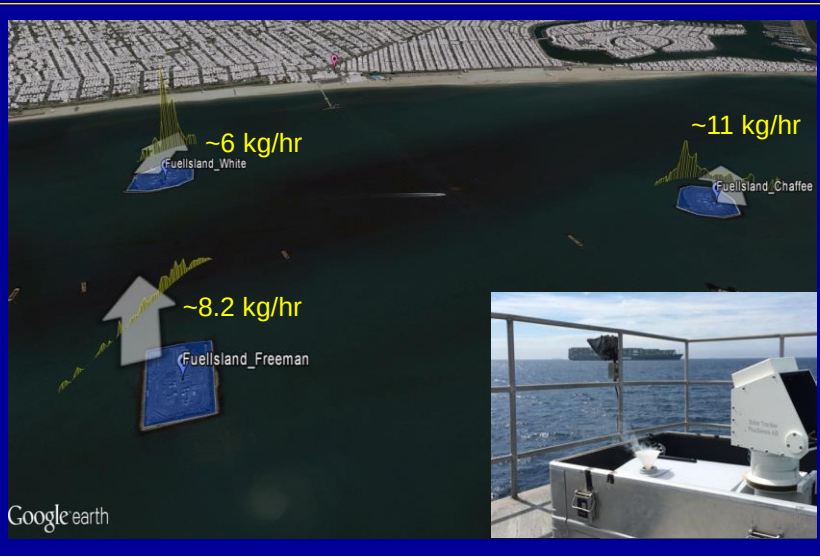
Project 3 Results:
Ship “Chasing” Measurements

- Study ship emissions as a function of ship speed
- 24 sets of measurements performed
- Ships followed from the time they started engines to up to 10 knots
- Inside the harbor ships are often accompanied by tugs, which may contribute to emissions



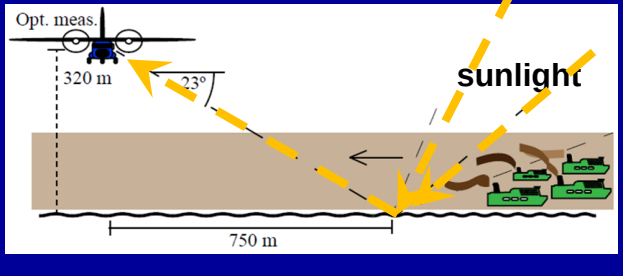


Project 3 Results:
VOC Emissions From Oil Islands

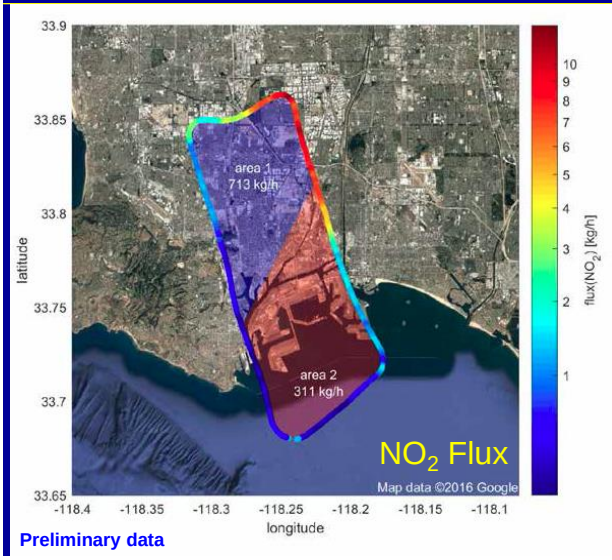


Project 3 Results:
Airborne Measurements

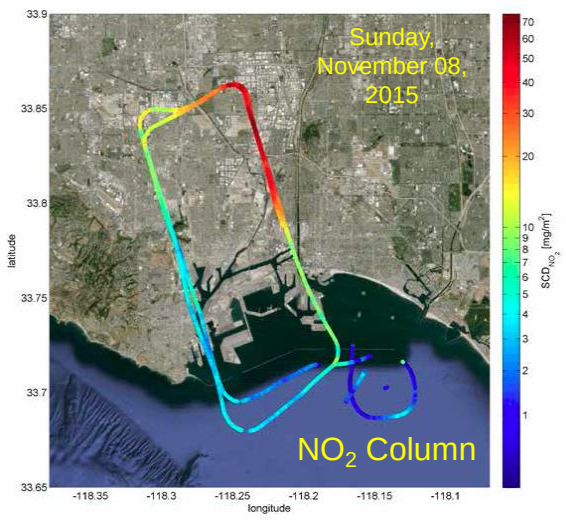
- Downward looking DOAS used to:
  - Measure fluxes from individual ships
  - Measure area-averaged fluxes



Project 3 Results: Airborne Measurements



Preliminary data



Preliminary data

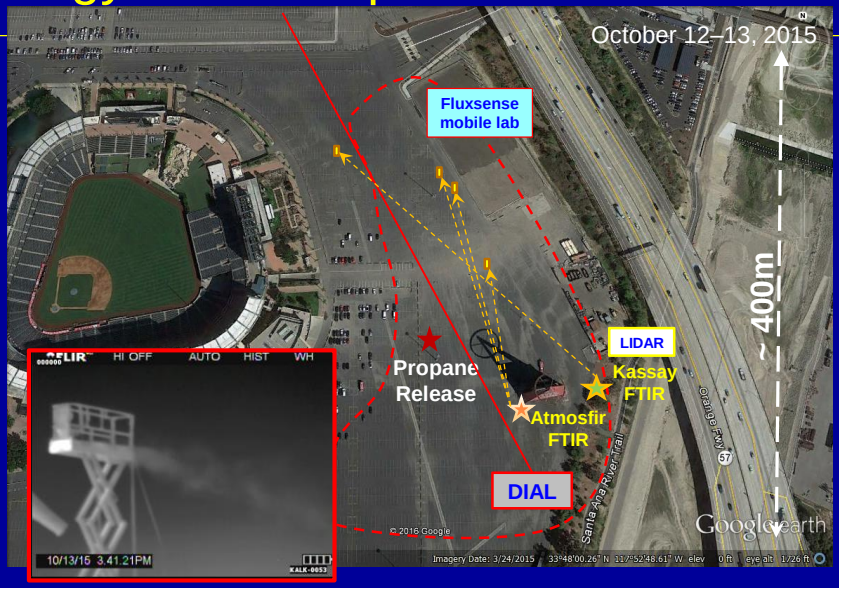
Conclusions

- ORS techniques provide:
  - Good characterization and quantification of certain industrial emissions
  - Reliable fenceline monitoring
  - Rapid identification of potential leaks
  - Real-time alarm system for communities
- SCAQMD fenceline monitoring projects demonstrated that:
  - Refineries in the SCAB are well operated and maintained (Project1)
  - There may be a discrepancy between measured and reported inventory emissions for VOCs (Projects 1 and 2)
  - Oil wells, gas stations, and other small industrial sources are substantial contributors to total VOC emissions from stationary sources (Project 2)
  - More than 99% of the ships entering/exiting POLA and POLB are compliant with current fuel sulfur content regulations (Project 3)
  - NOx emissions from POLA/POLB are likely to be overestimated (Project 3)
  - Results from the ORS methods used for this study are in very good agreement (data not shown)

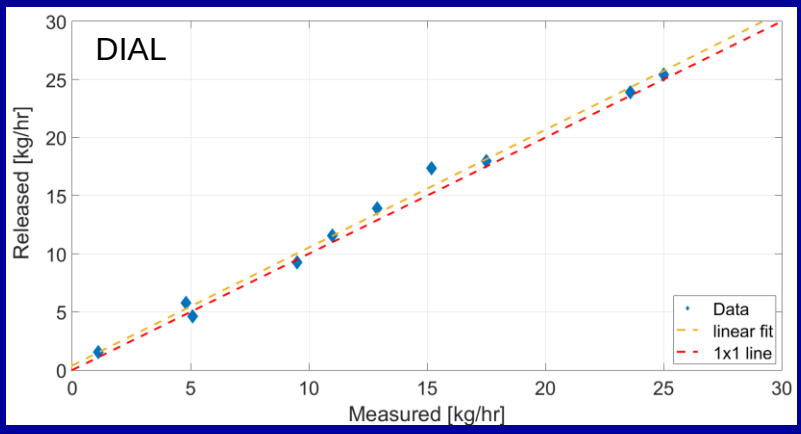
Additional Slides

Project 1: Technology Inter-comparison

- Parking lot of the Angels' Stadium in Anaheim (complex urban environment)
- Non-odorized propane released at various emission rates and heights (i.e., 3m, 6.4m, 7.9m)
- Blind measurements performed by all ORS contractors
- Meteorological data collected by and shared with all vendors
- SCAQMD operated a LIDAR to provide accurate wind profile data



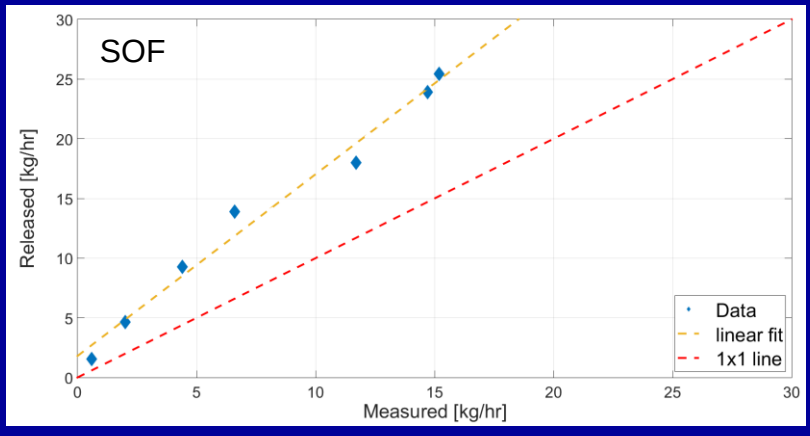
Project 1:
Technology Inter-comparison



- DIAL method accurately quantified and visualized propane emission plume
- DIAL measurements not affected by meteorological conditions

$$y = 1.01x + 0.4$$
$$R^2 = 0.99$$

Project 1:
Technology Inter-comparison



- Excellent linearity and correlation coefficient

$$y = 1.52x + 1.81$$
$$R^2 = 0.98$$

- SOF method consistently underestimated emissions by ~35-40%
- Close proximity to release source caused underestimation