Reducing and Managing Uncertainties in Mobile ORS Flux Measurements of Refinery Emissions

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ORS Based Flux Measurements

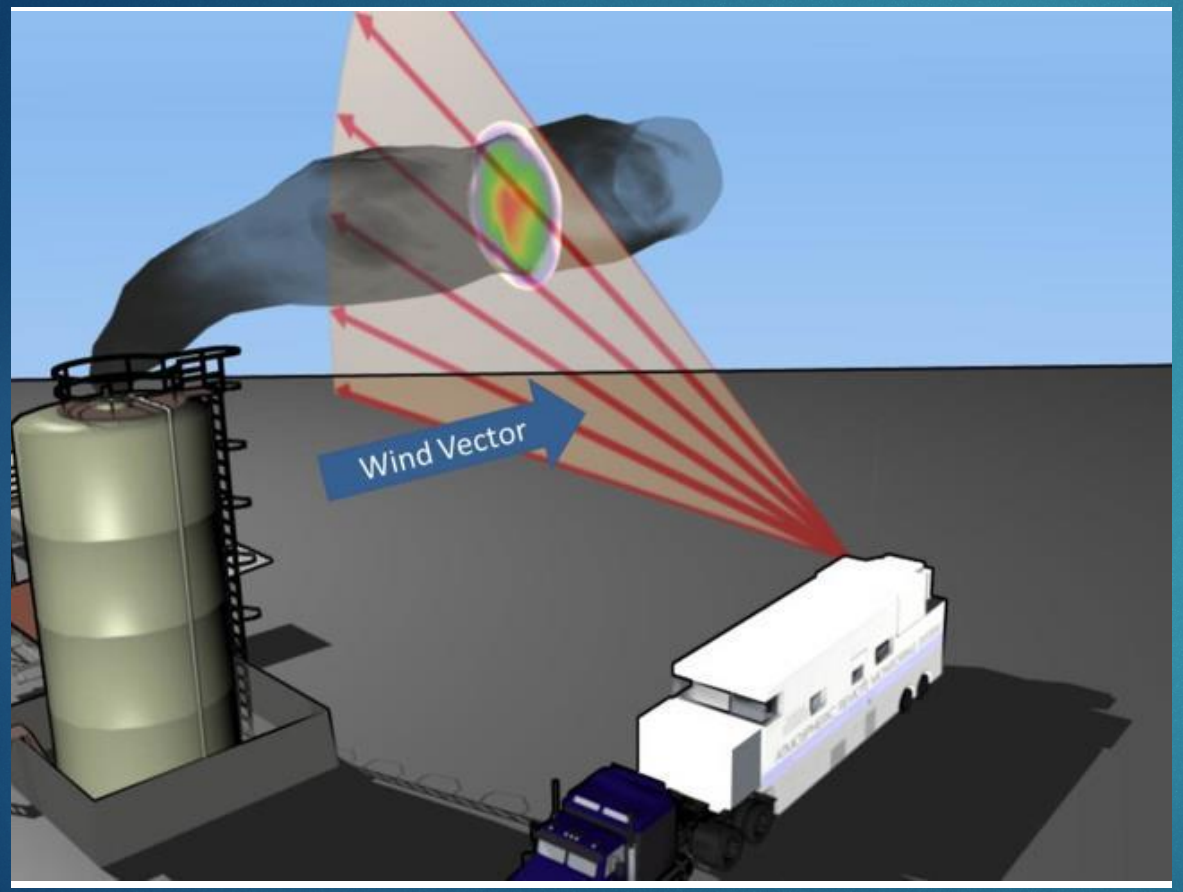
- The transition from calculated refinery emissions to measured flux has been hampered by the published uncertainty of 20-30% ORS measurements
- Refinery emission inventories based on calculations/emission factors contain no such published uncertainties
- Relying on emissions factors to further reduce refinery emissions is difficult as facilities' actual emissions can, and do, vary substantially from the reported inventories
- EU is transitioning from calculated to measured emissions starting 2021 and has developed protocols to manage the perceived uncertainties

Mobile ORS Flux Measurements Technologies of Diffuse VOC emissions

- Differential Absorption Lidar (DIAL) - developed by NPL in the UK 1980's, used in refinery emission measurements in Europe & N America since 1985, Best Available Technique Reference (BREF) in EU - BAT for refinery emission measurements

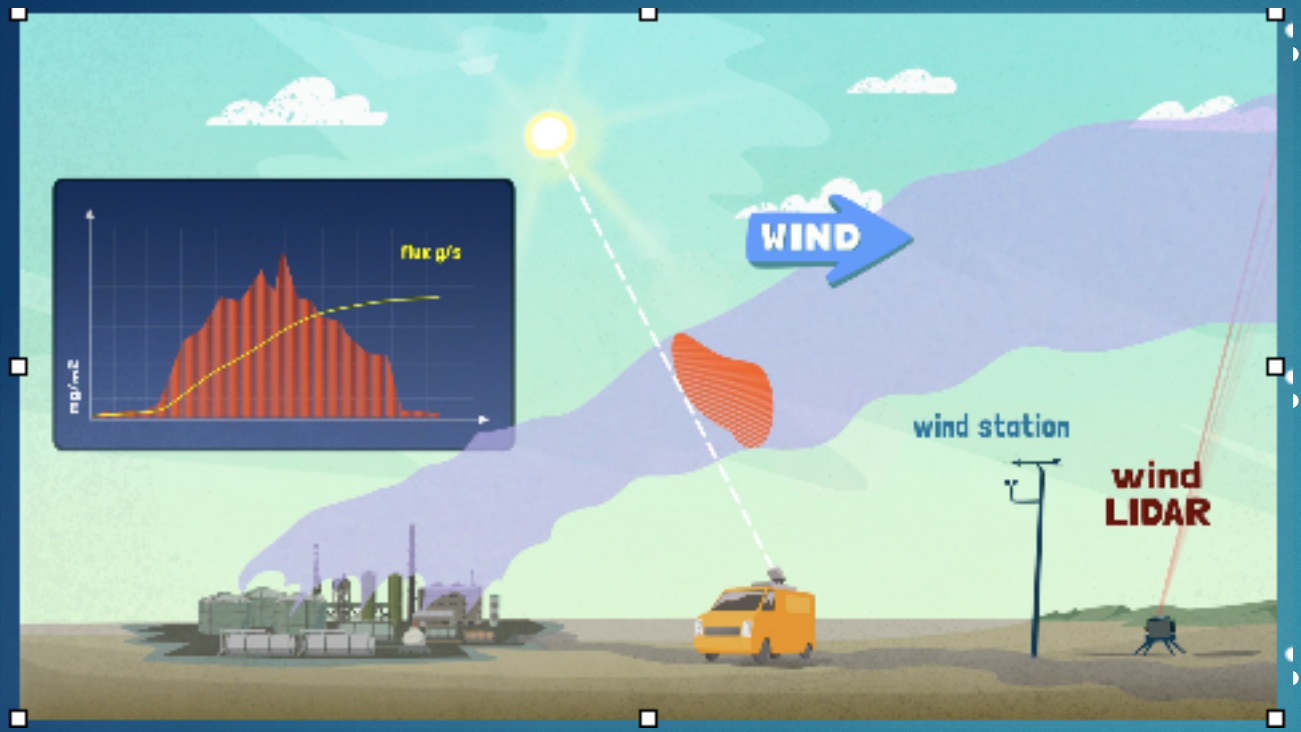
- Solar Occultation Flux (SOF) - developed by Fluxsense in Sweden in late 1990's, used in refinery emission measurements in Europe, N America and Middle East since 2001, Best Available Technique Reference (BREF) in EU - BAT for refinery emission measurements

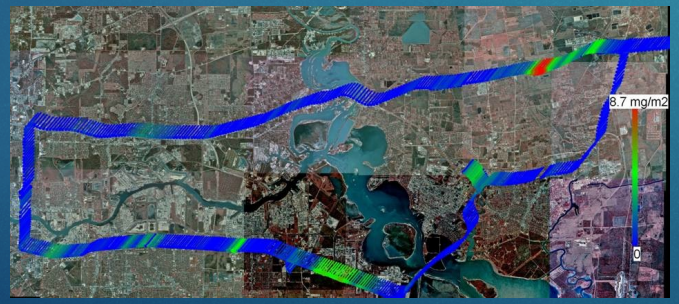
DIAL Measurement Configuration for Flux measurements



- Vertical scans enable plume mapping and flux calculations
- Combine integrated concentration with simple wind field to give flux
- Can measure away from the source
- Bottom up approach

FluxSense Mobile Lab Measurement Concept





- The number of molecules for the key species above the SOF vehicle are estimated from spectroscopic analysis of direct solar IR light and zenith scattered UV light.
- As measurements are conducted while driving it is possible to measure the total mass of molecules along the road traveled.
- The total mass is multiplied by the wind speed which yields the flux in kg/s (compare OTM 10)
- Wind data from LIDAR and/or Wind Masts
- Top down approach

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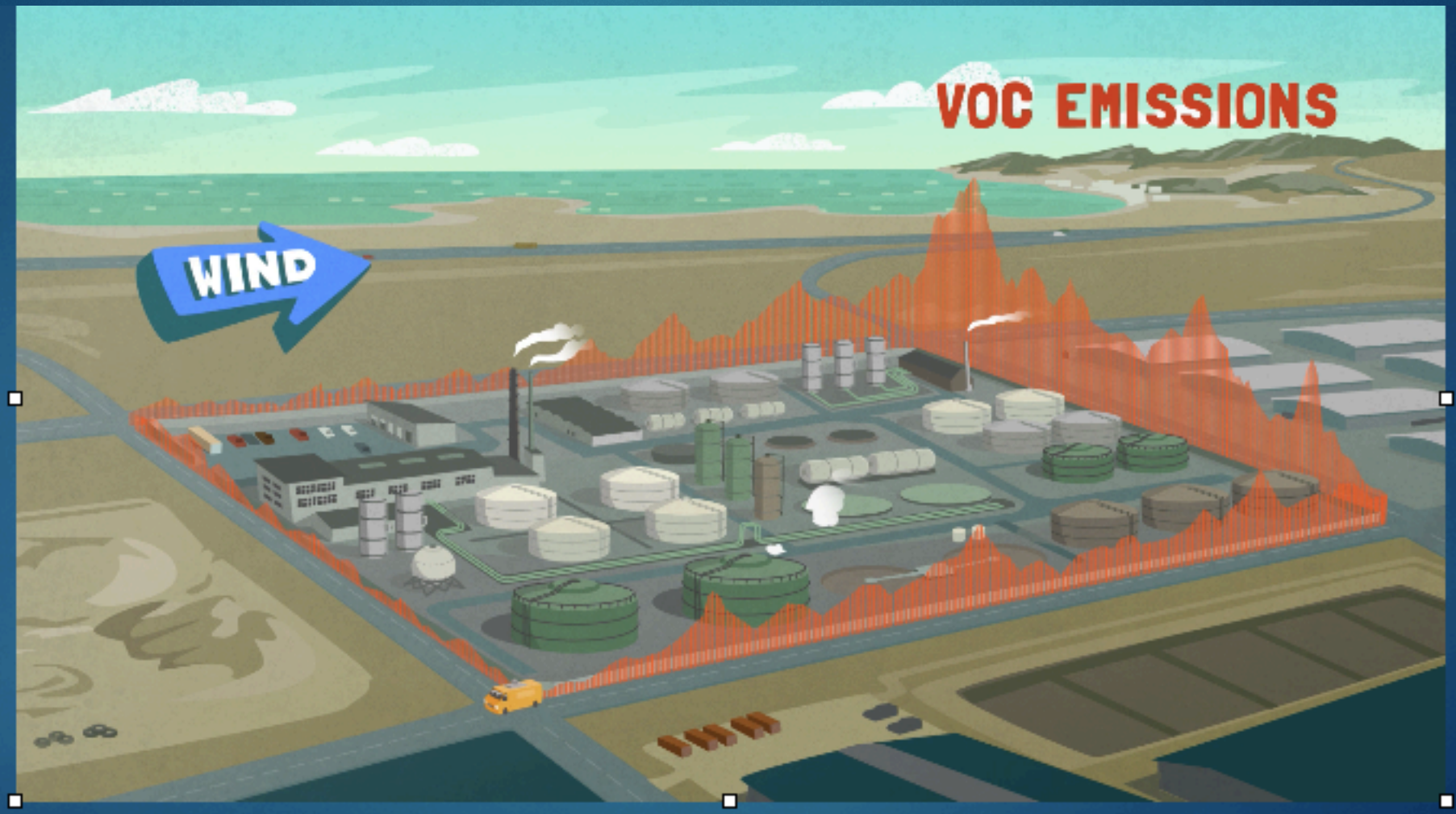
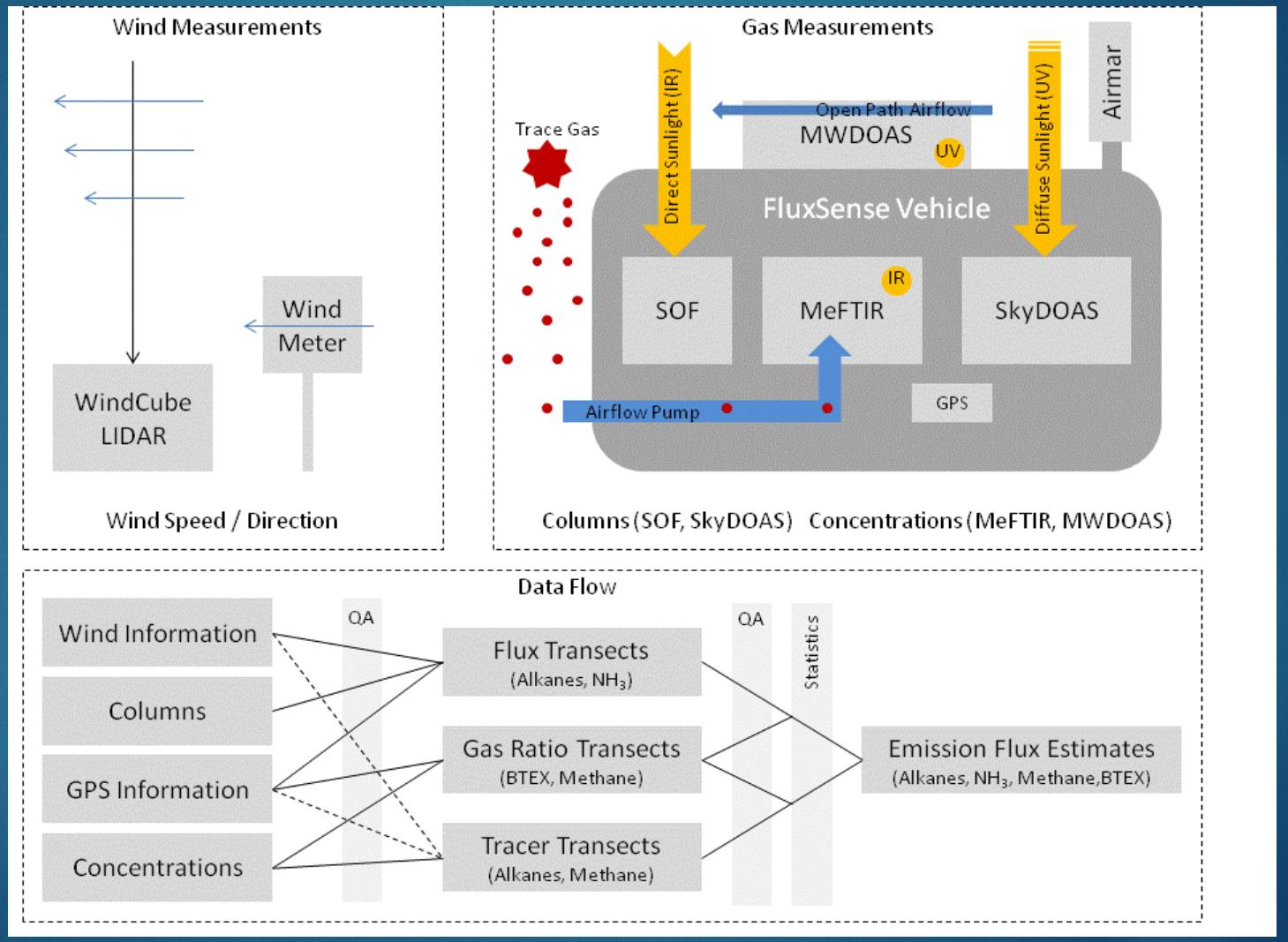
A Typical SOF Flux Measurment



FluxSense Mobile Lab
Real-Time Flux & Concentrations Measurements



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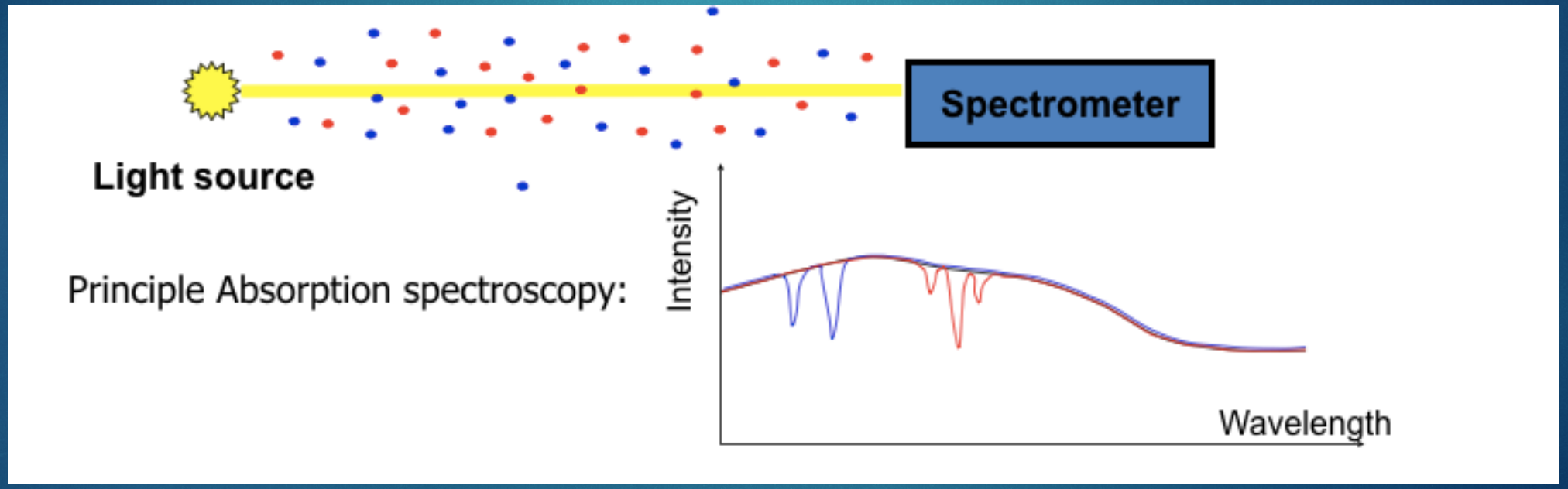
What are the Uncertainties of Flux Measurements?

- Species and Concentrations
- Wind
- Influence of ambient sources
- ‘Snap Shot’
- Seasonal variations
- Daytime/night time variations

Uncertainties of Species and Concentrations

- The species and mass determined through absorption spectroscopy where the species are identified through ‘fingerprints’ and the total mass of the plume measured - uncertainty 2-3%

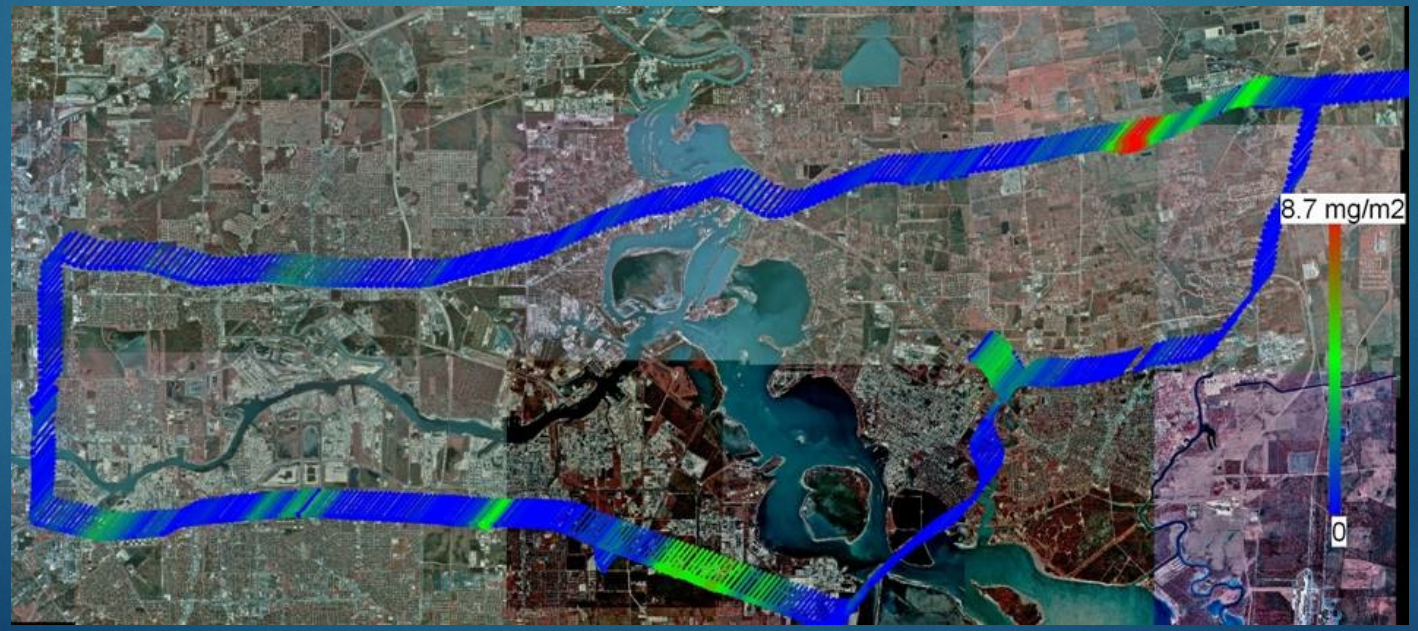


Uncertainty of Wind Measurements 10-30%

- The flux is calculated by multiplying the mass with the wind speed
- The accuracy of the wind measurements determines the overall accuracy of the emissions estimates
- The introduction of wind profilers - LIDAR - has significantly improved the accuracy of the wind measurements
- The LIDAR is further supported by local wind masts closer to the source and wind measurements from local meteorological stations
- Repeated flux measurements during different wind conditions further reduces the uncertainty of the wind

Influence of Ambient Sources

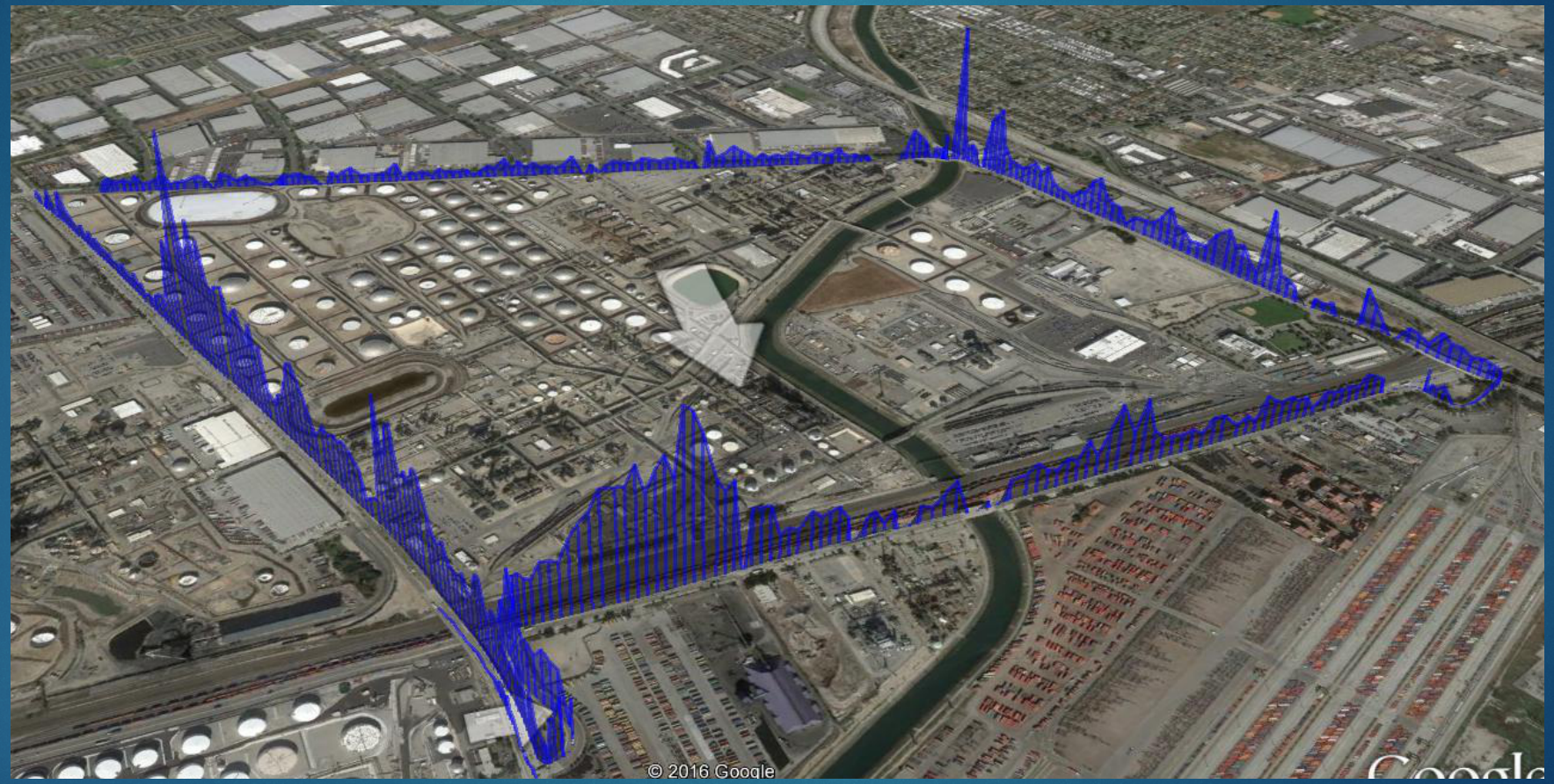
- Flux measurements are based on variation to background - a ‘clean’ baseline is always established before start of measurements
- By circumventing the facility and taking measurements during different wind conditions is is possible to eliminate the influence of any ambients sources

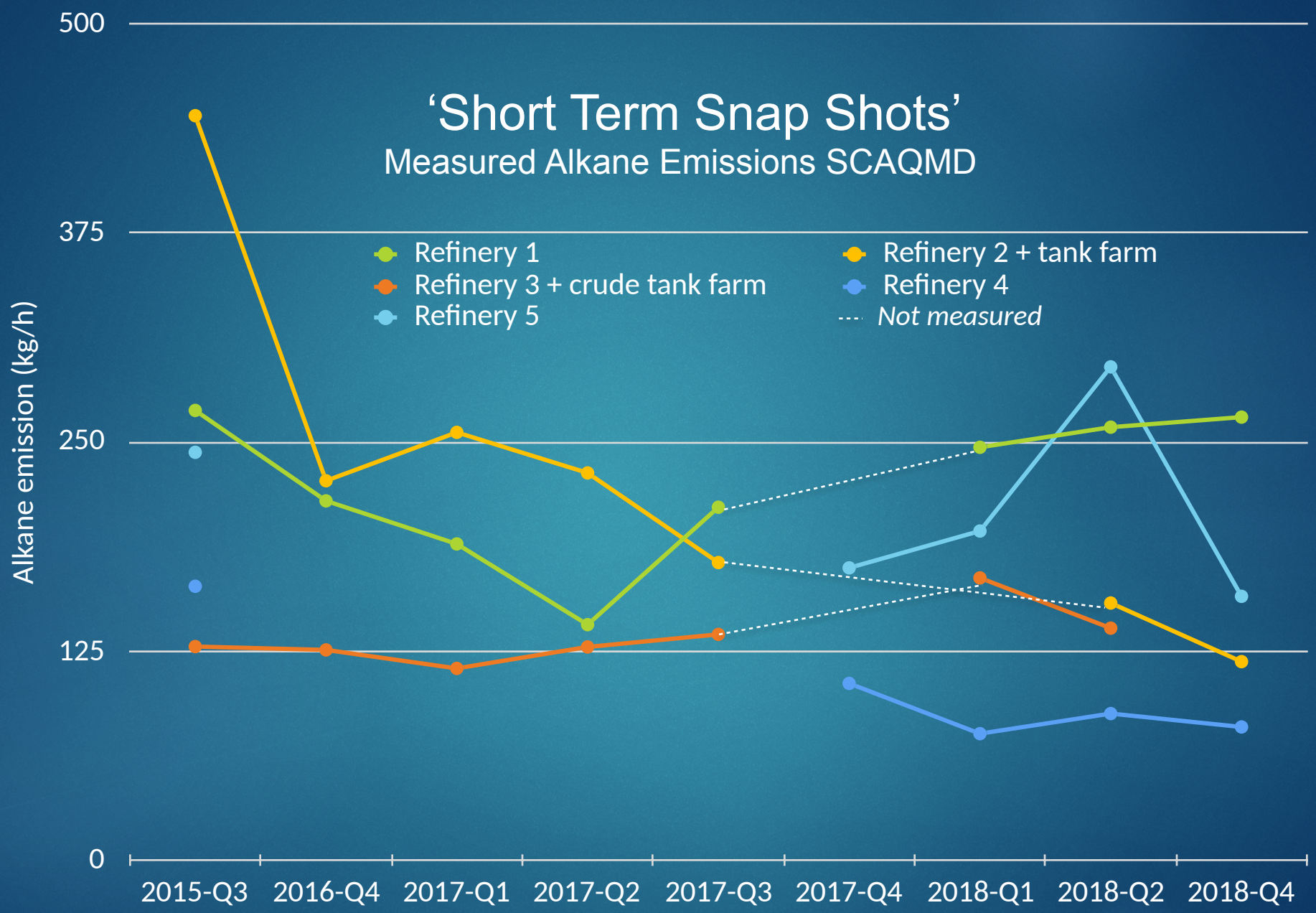


‘Snap Shots ‘, Seasonal Variations, Daytime/Night Time Variations

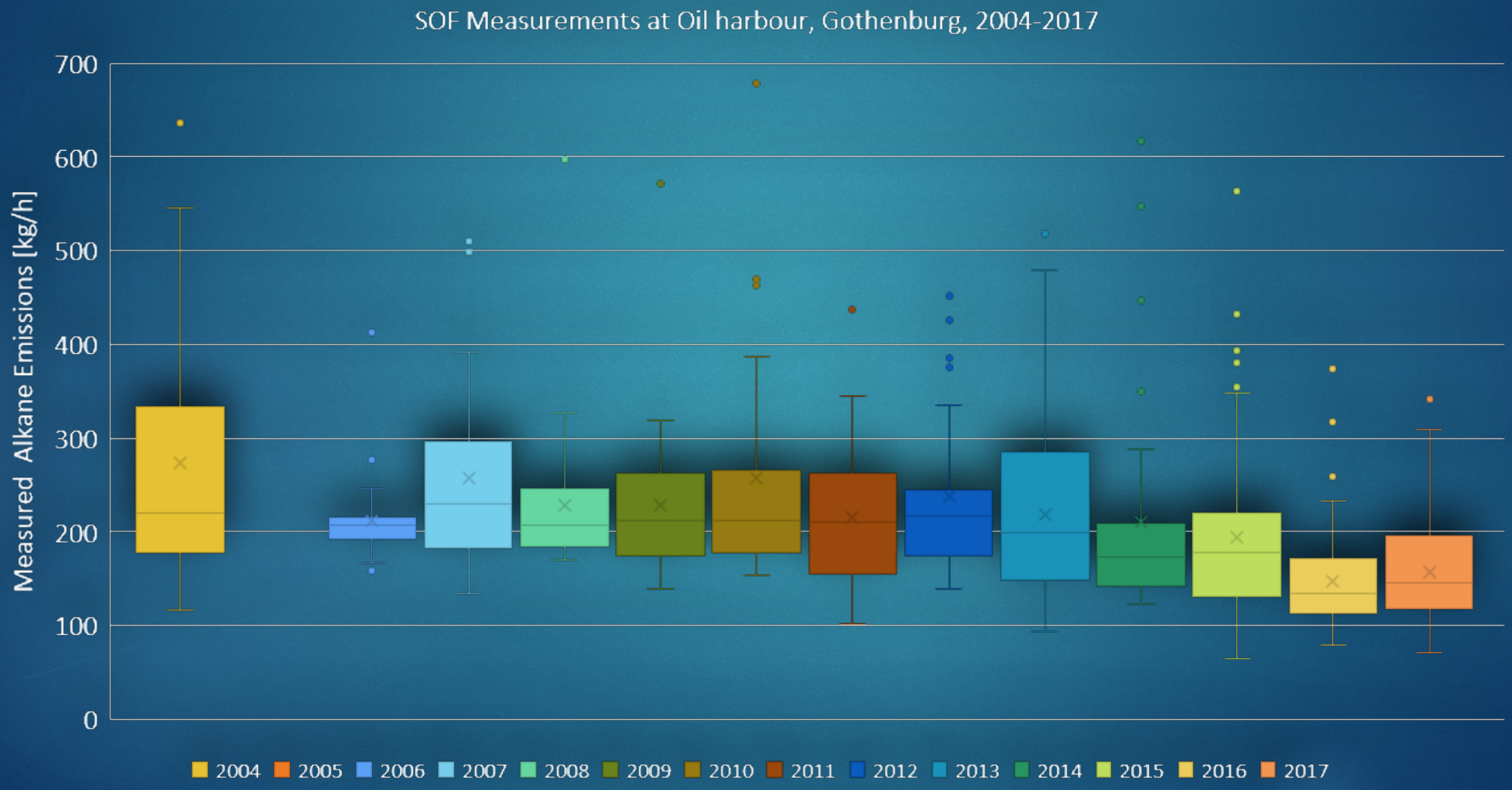
- Measurement protocols and QA procedures
- Measurements in close collaboration with the industrial facility to avoid undue influence of special events
  - ~2/3 of the diffuse emissions originate from storage tanks,
  - ~1/3 from process and wastewater treatment
- Measurements repeatedly during ~10 days and at different times of the year and from different wind directions
- DIAL nighttime measurements show very limited variations between daytime and night time flux

‘Snap Shots ‘




‘Short Term Snap Shots’
Measured Alkane Emissions SCAQMD
Alkane emission (kg/h)
500
375
250
125
0
Refinery 1
Refinery 2 + tank farm
Refinery 3 + crude tank farm
Refinery 4
Refinery 5
Not measured
2015-Q3
2016-Q4
2017-Q1
2017-Q2
2017-Q3
2017-Q4
2018-Q1
2018-Q2
2018-Q4

‘Snap Shots‘



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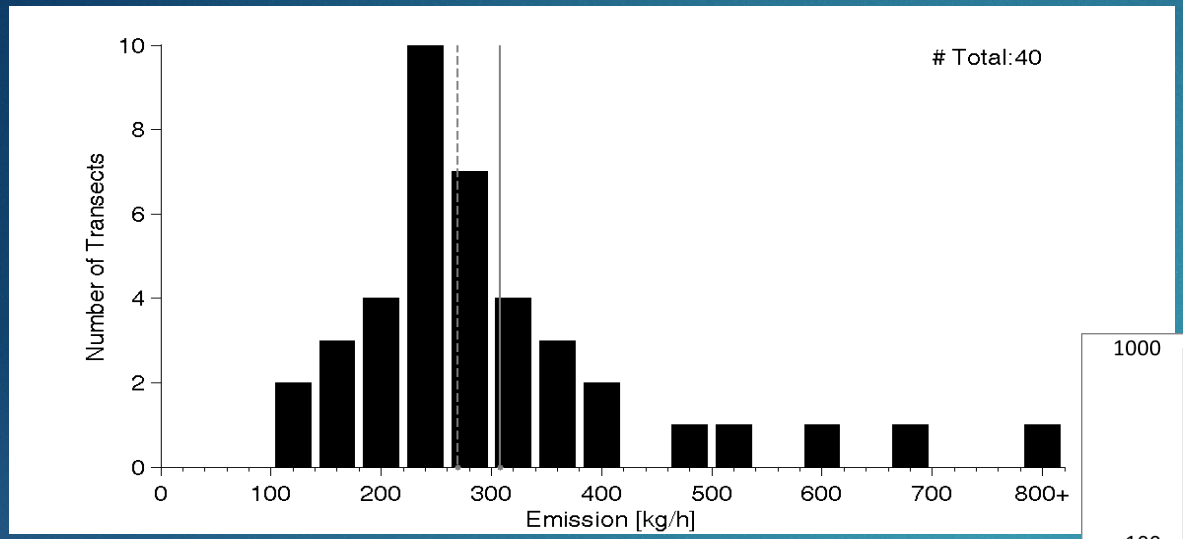
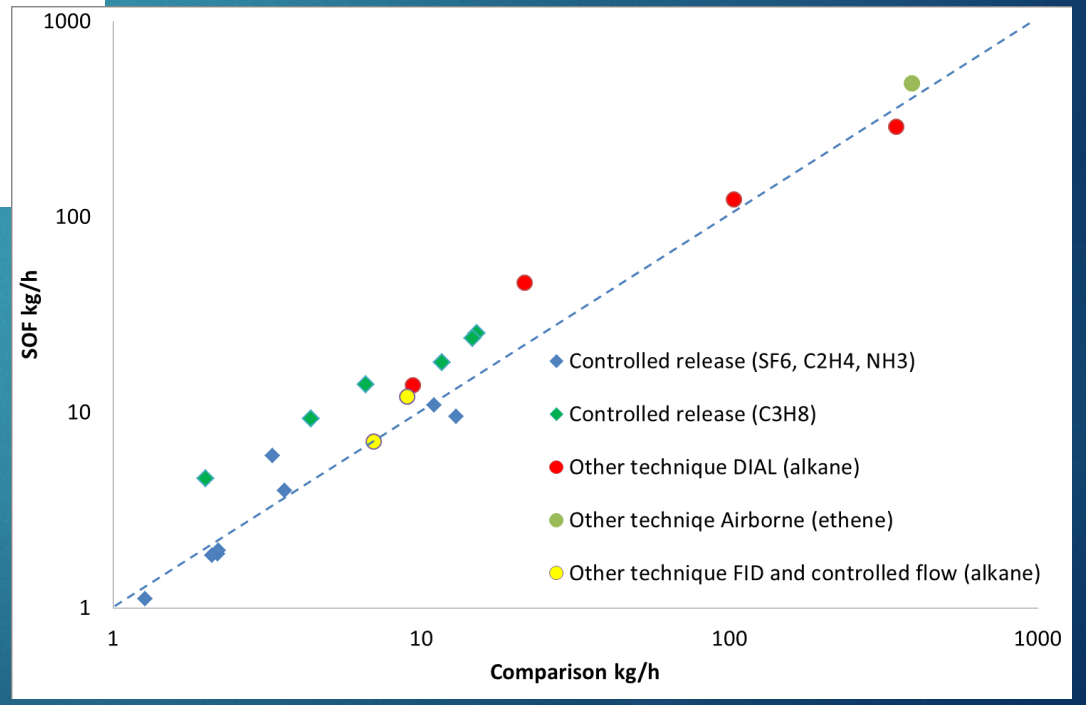
Mobile Measurement Reliability/Repeatability





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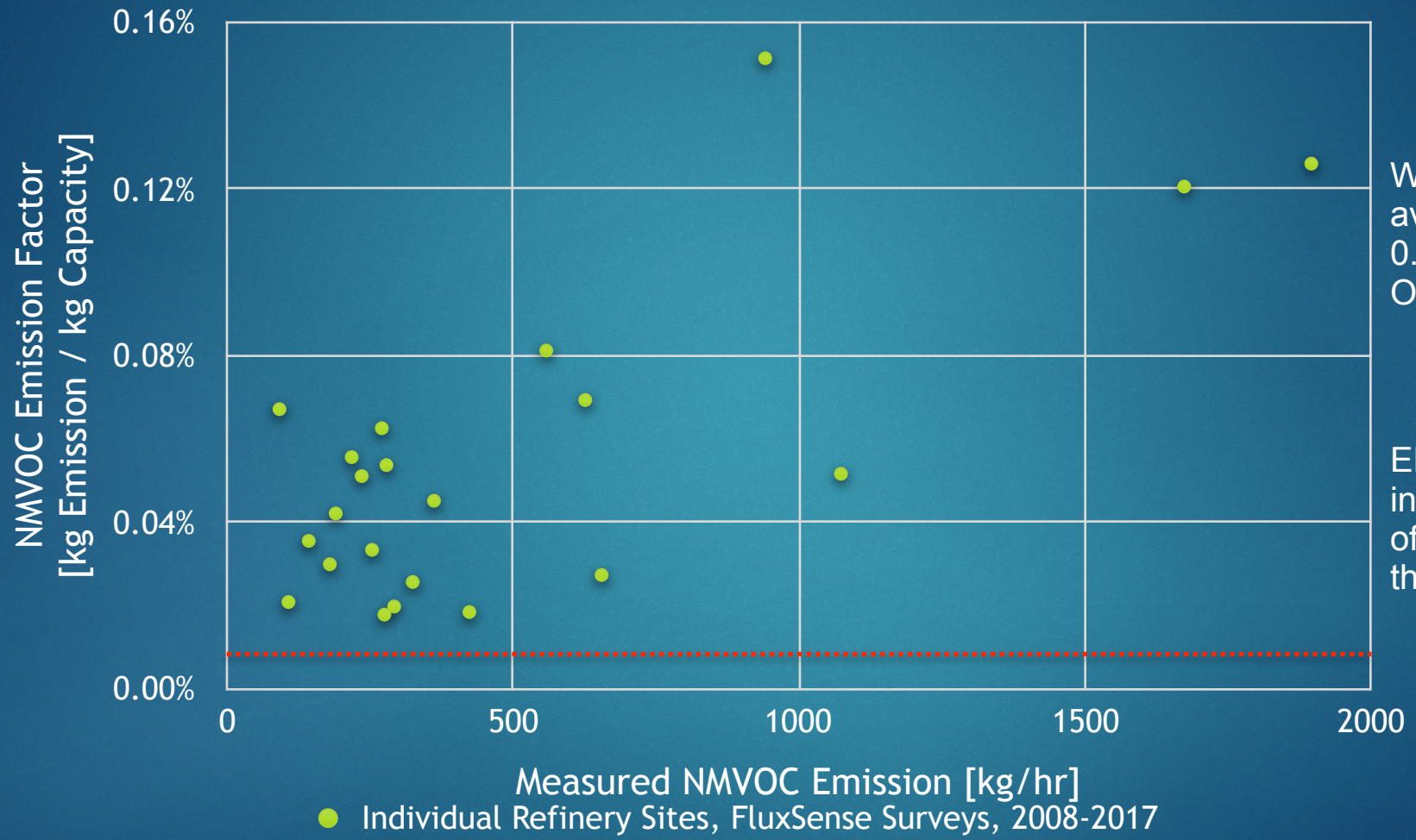
Measured Refinery Emissions



Well run refineries average emission of 0.02%-0.04% of Crude Oil Capacity

EPA/API inventories indicate emission levels of 0.001%-0.01% of throughput

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Summary and Conclusions

- ORS Flux Measurements generally publish an uncertainty of 20-30%
- The actual uncertainties can be reduced through good measurement protocols with good wind data
- Measurements consistently show actually emissions exceeding reported inventories 3-10 times reducing the relevance of the measurement uncertainties in the emissions estimate
- ORS based flux measurements identifies the actual emission sources with high certainty and allows industry and regulating agencies targeted and cost effective emission reduction efforts