Establishing Refinery Emission Inventories - ORS Measurements or Permit Based Calculations

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Flux Measurements or Flux Calculations based on Emission Factors?

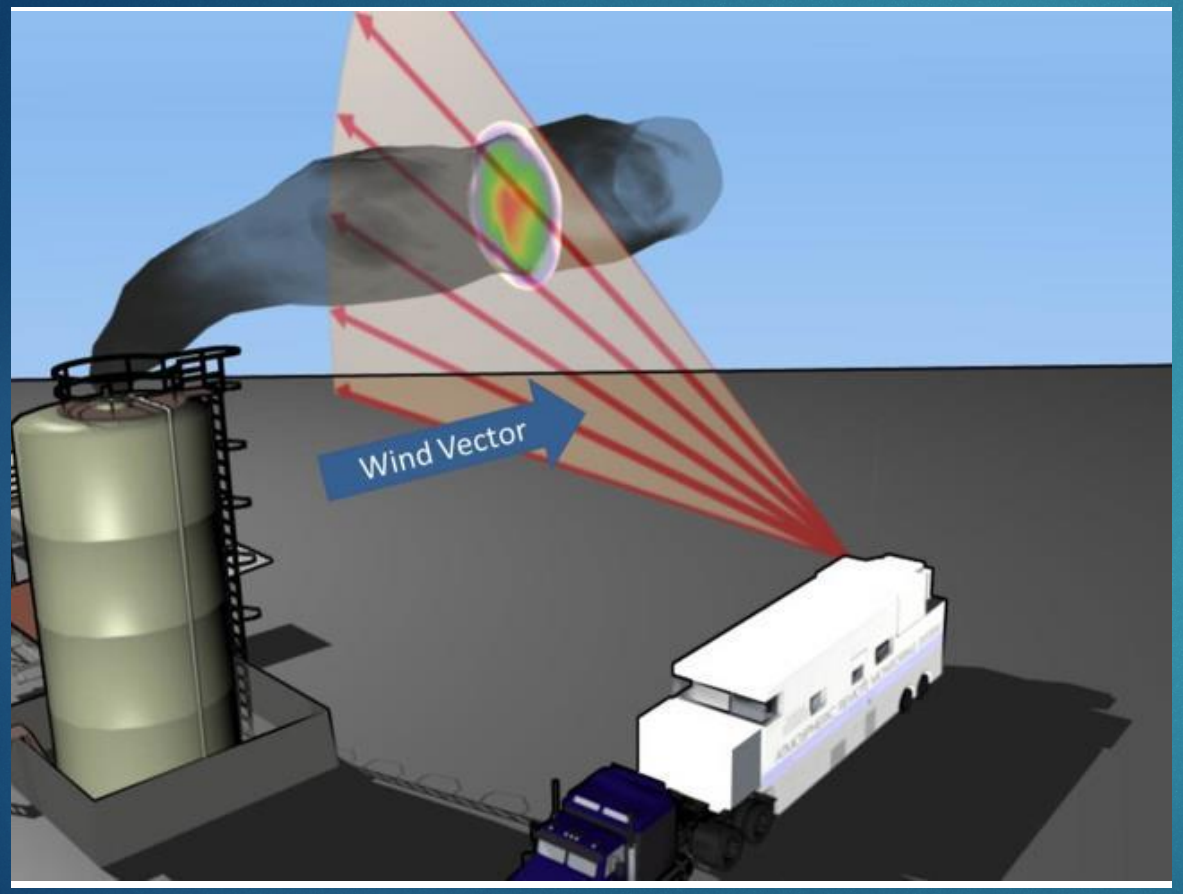
- The EPA - AP42 emissions factors for refinery emission were originally developed in the early 1970's .These emission factors have not been validated
- Relying on emissions factors for air quality modeling and emission reductions have been challenging as facilities' actual emissions can, and do, vary substantially from the reported inventories based on published factors
- In 1988 the DIAL based measurement van was brought to a BP refinery in Sweden to confirm the reported inventories - measurements showed emissions 20 times higher than assumed….
- Sweden instituted regular measurements of refinery emissions with DIAL every 5 years beginning 1992, this rule was changed to every 2 years in early 2000's when SOF became available
- 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 measurements

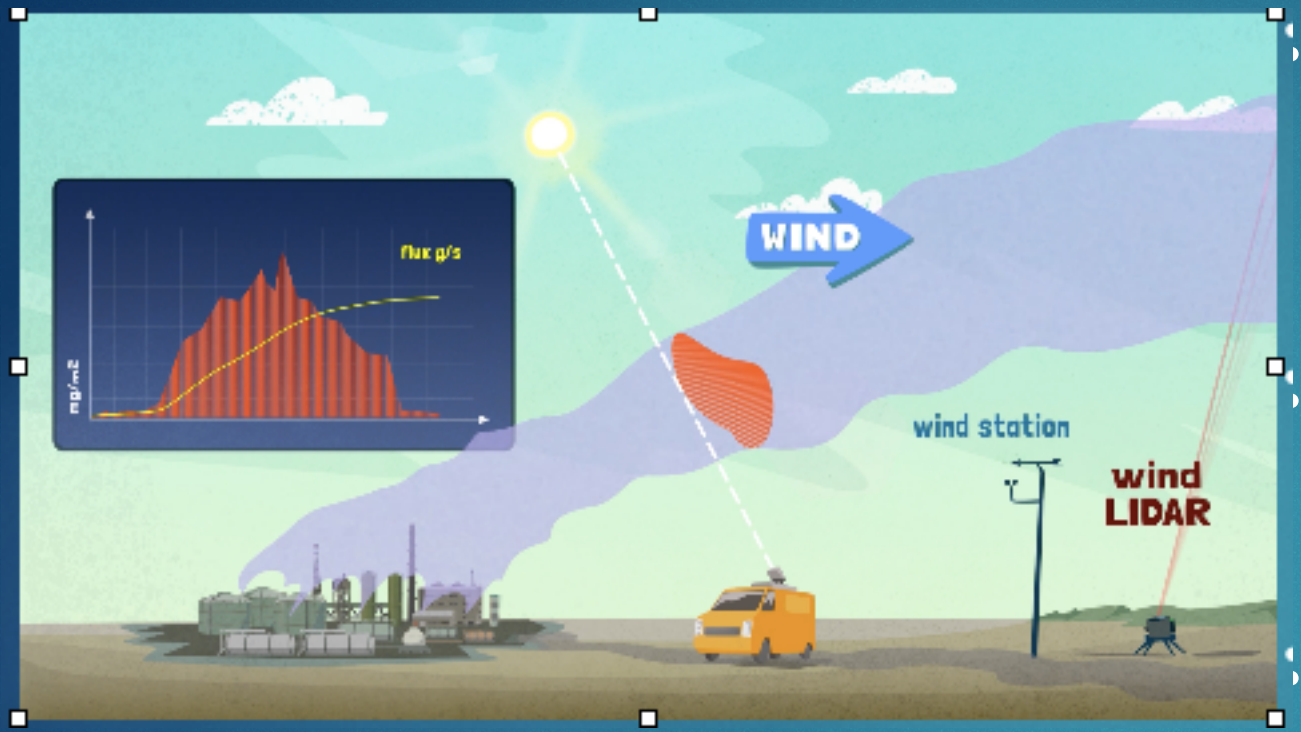
- Solar Occultation Flux (SOF) - developed by Fluxsense in Sweden in late 1990's, used in refinery emission measurements in Europe, N America and Middle East since 2001, Best Available Technique Reference (BREF) in EU - BAT for refinery measurements

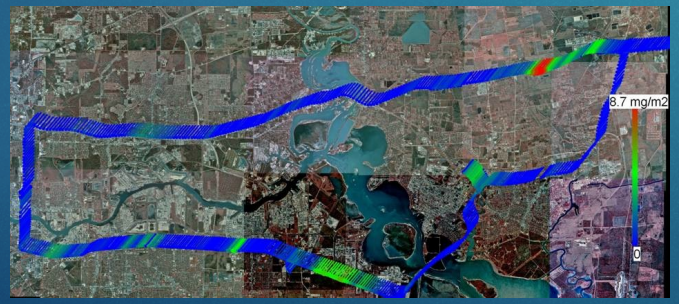
DIAL Measurement Configuration for Flux measurements



- 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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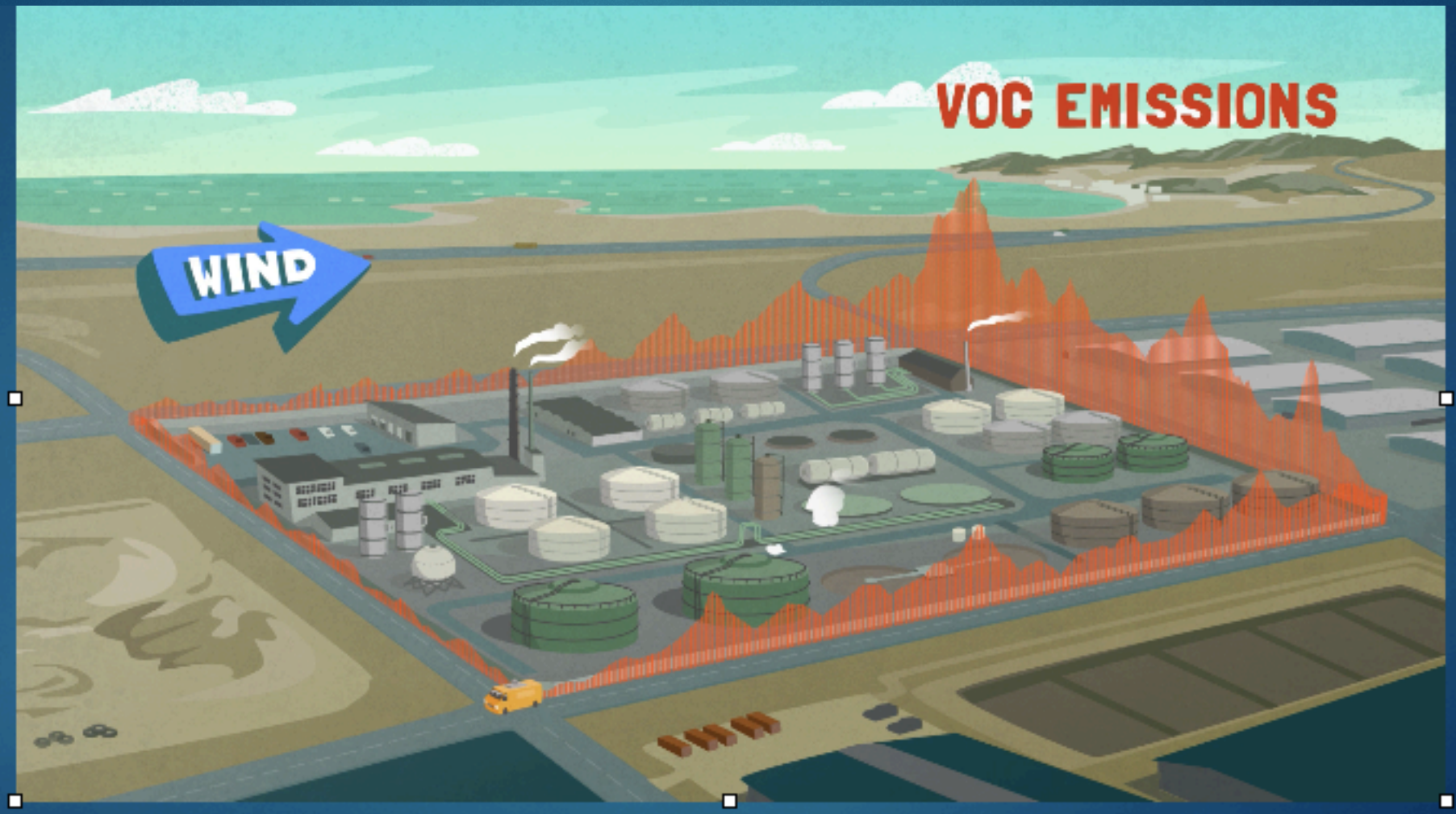
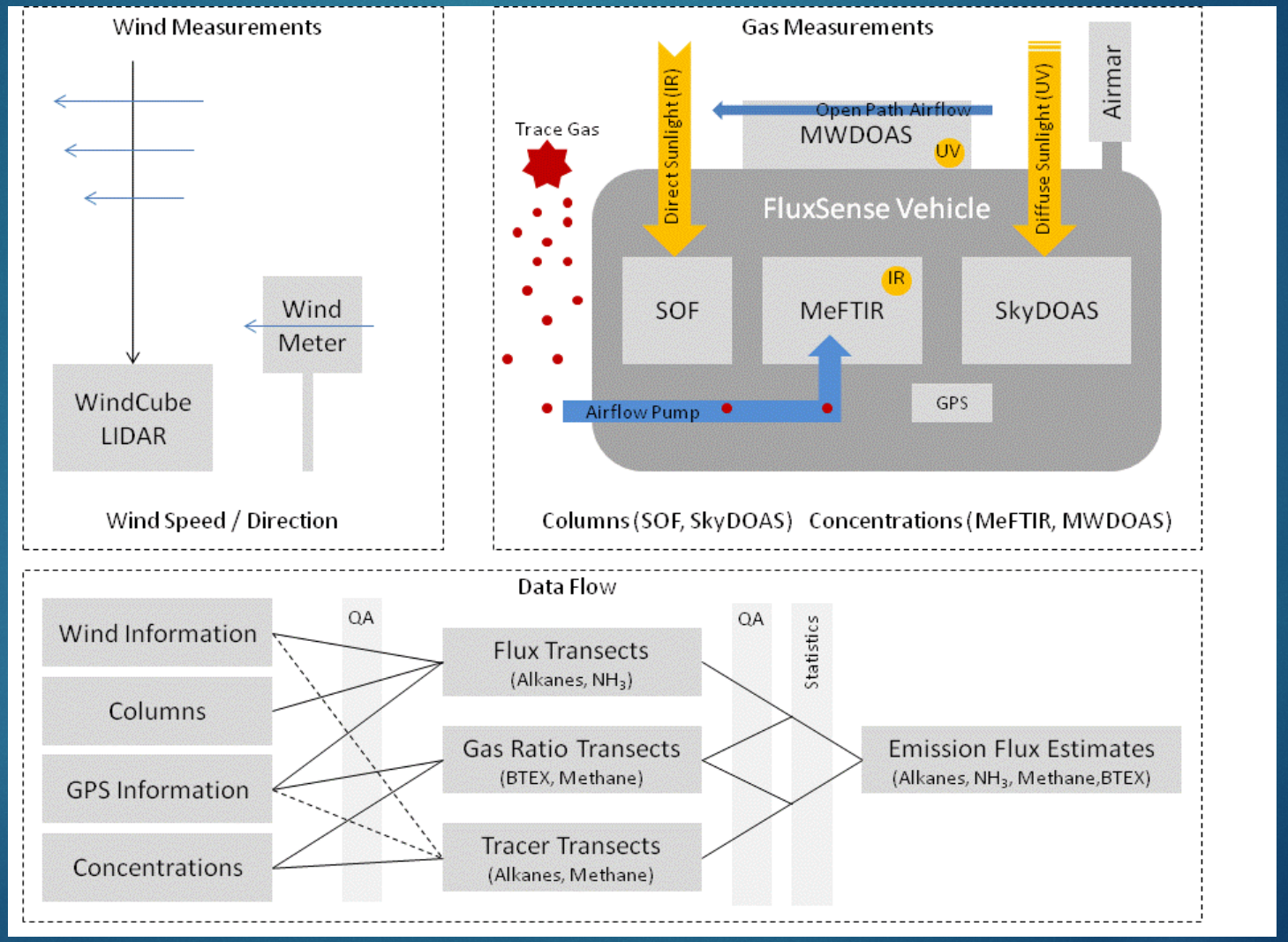
A Typical SOF Flux Measurement



FluxSense Mobile Lab
Real-Time Flux & Concentrations Measurements



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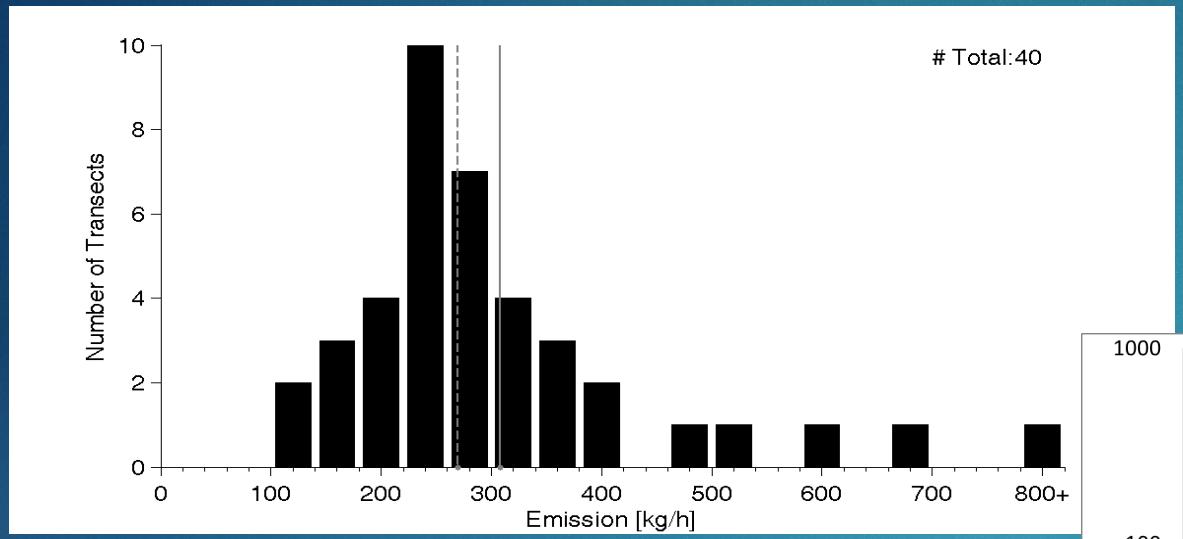
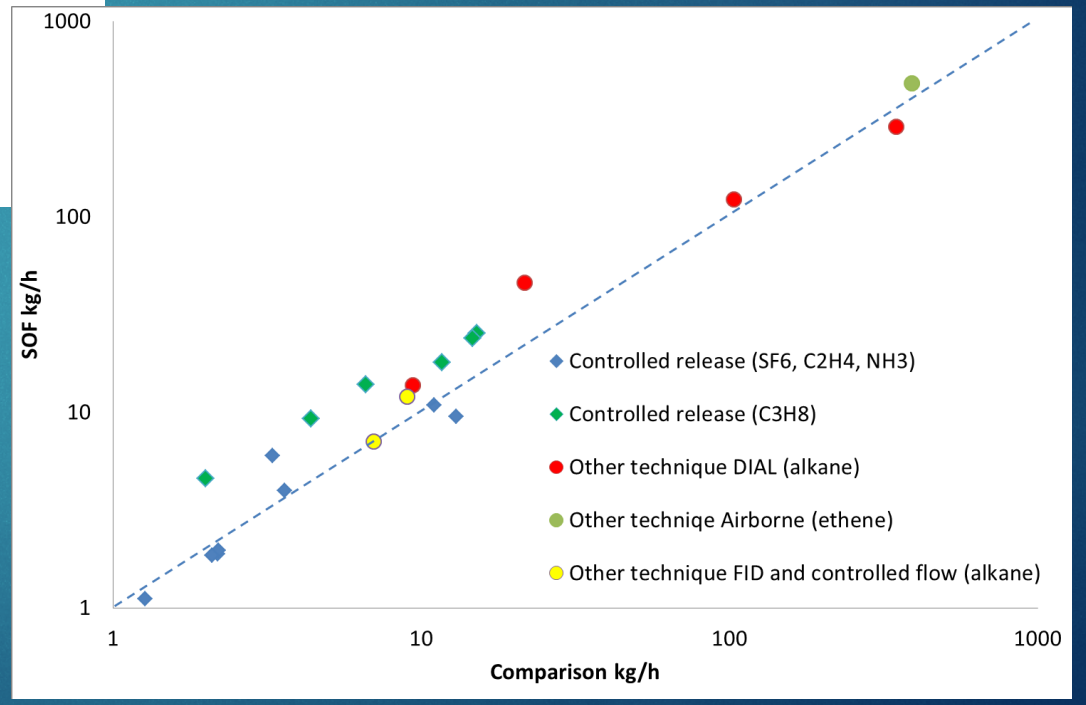
Mobile Measurement Reliability/Repeatability





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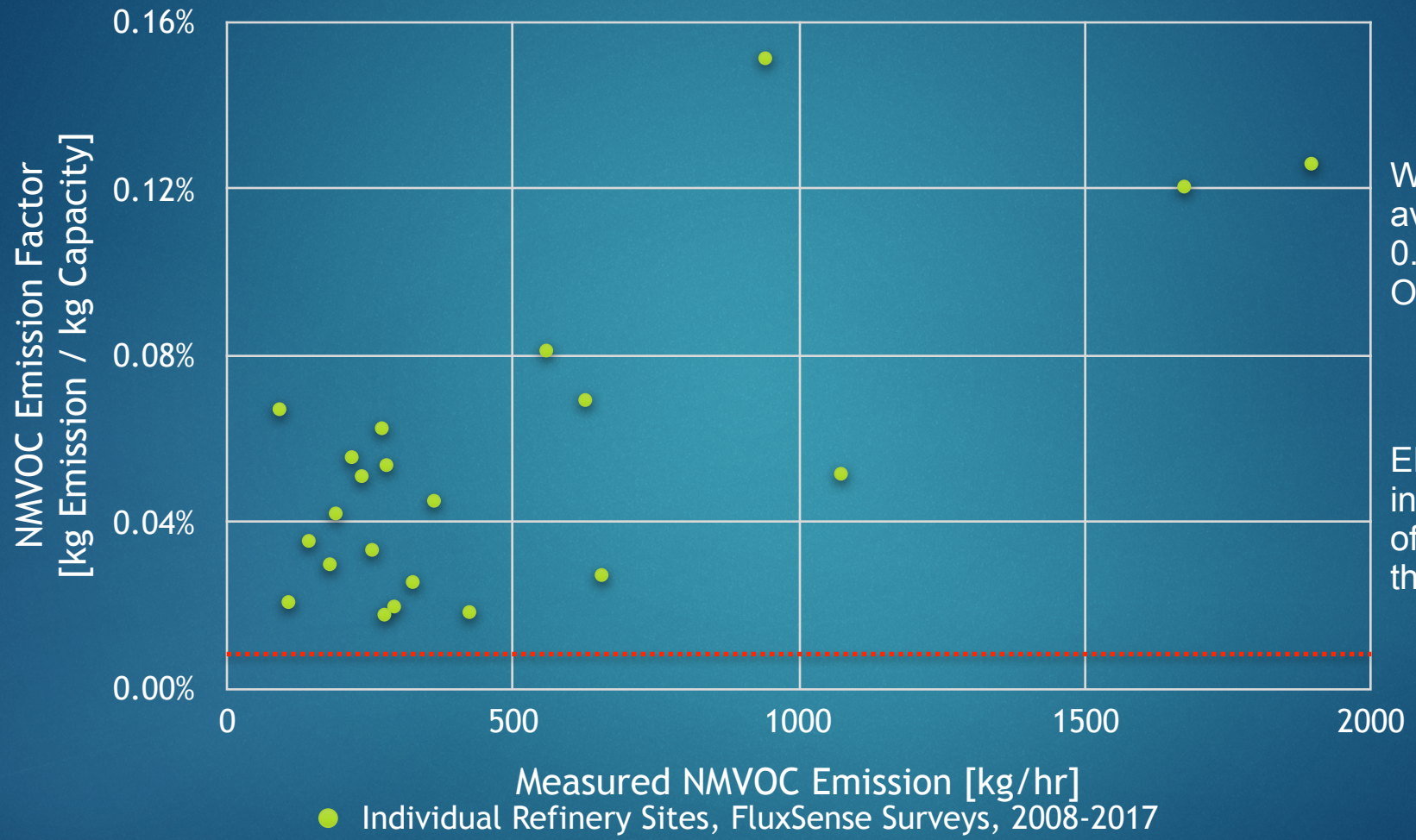
Transitioning to Flux Measurements

The transition from calculated refinery emissions to measured flux have been hampered by the perceived uncertainty of ORS measurements and the published uncertainties of 20-30%.

Refinery emission inventories based on calculations/emission factors contain no such published uncertainties

The uncertainties of ORS based Flux measurements are mostly dependent of the difficulty to correctly assess the wind impact at different elevations

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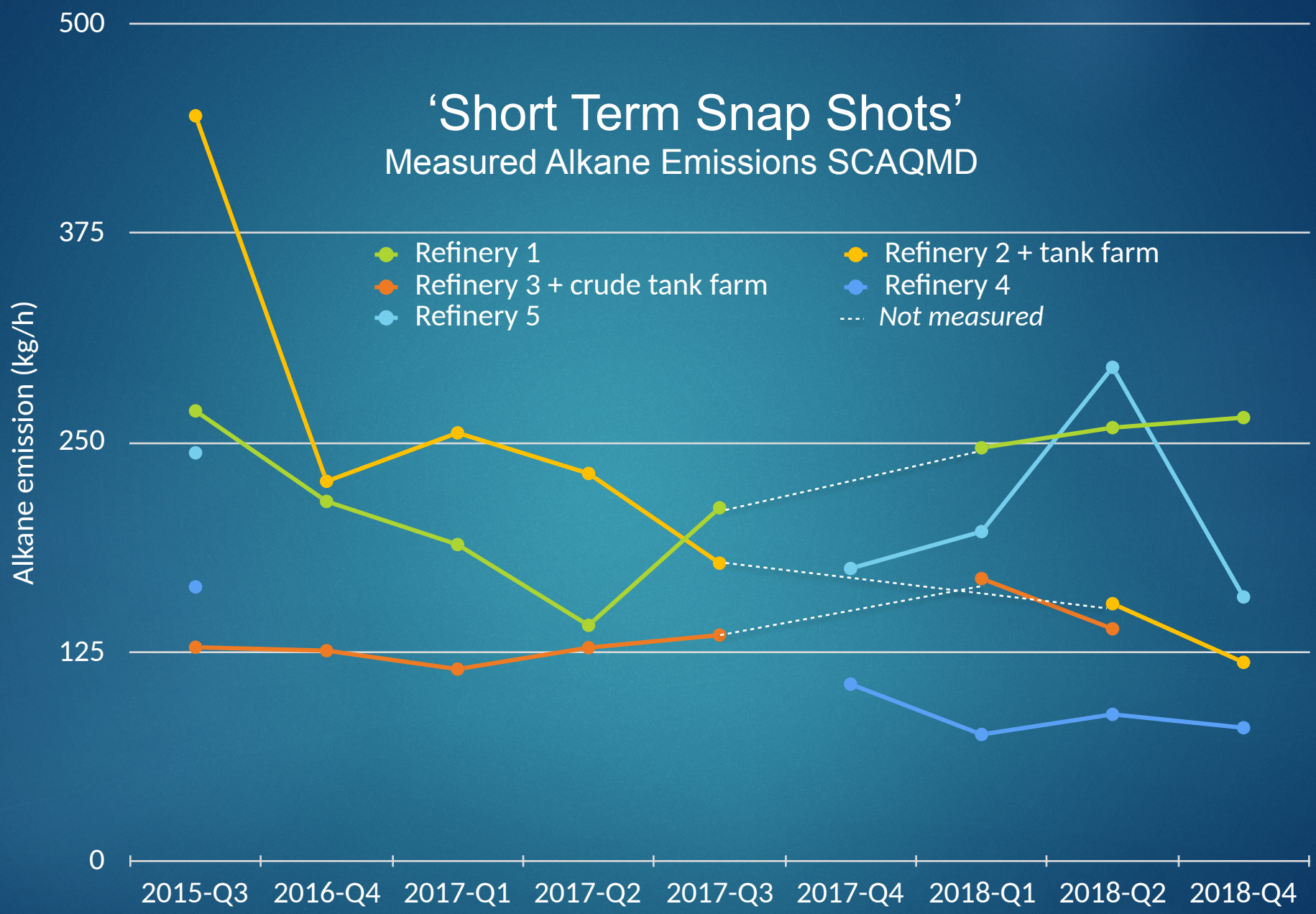
‘Short Term Snap Shots’
Measured Alkane Emissions SCAQMD
Alkane emission (kg/h)
500
375
250
125
0
Refinery 1
Refinery 2 + tank farm
Refinery 3 + crude tank farm
Refinery 4
Refinery 5
Not measured
2015-Q3
2016-Q4
2017-Q1
2017-Q2
2017-Q3
2017-Q4
2018-Q1
2018-Q2
2018-Q4

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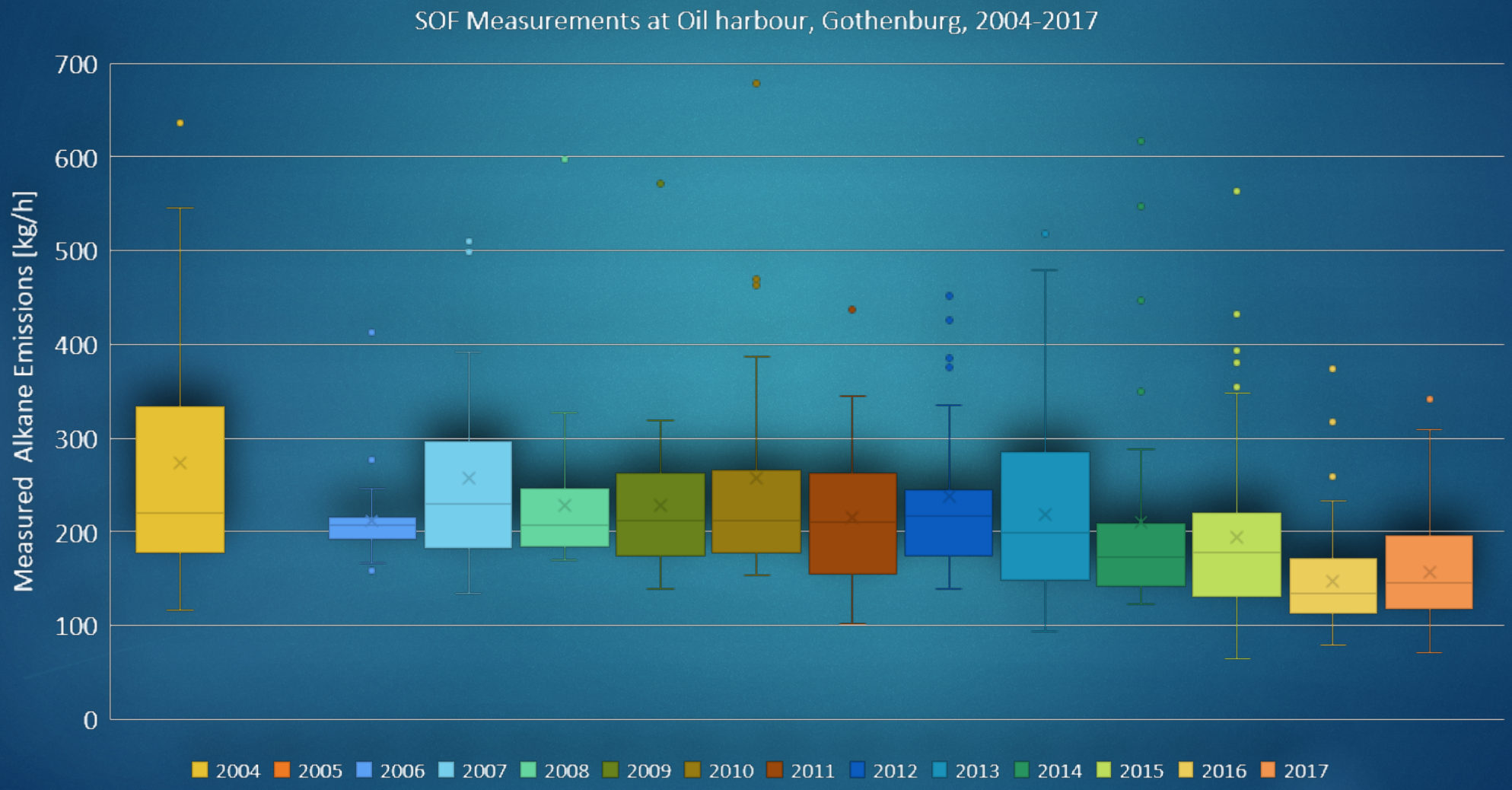
‘Snap Shots‘



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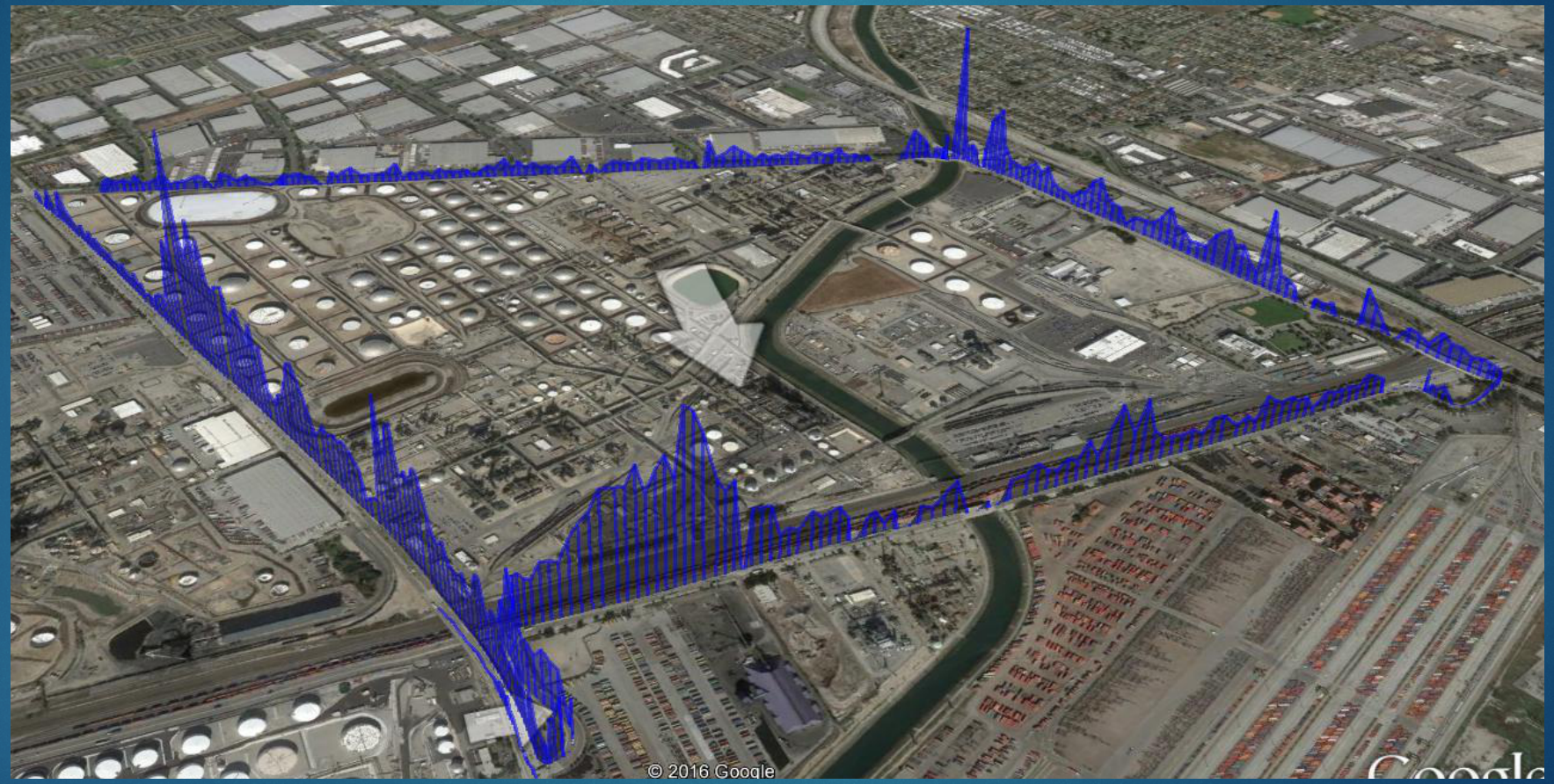
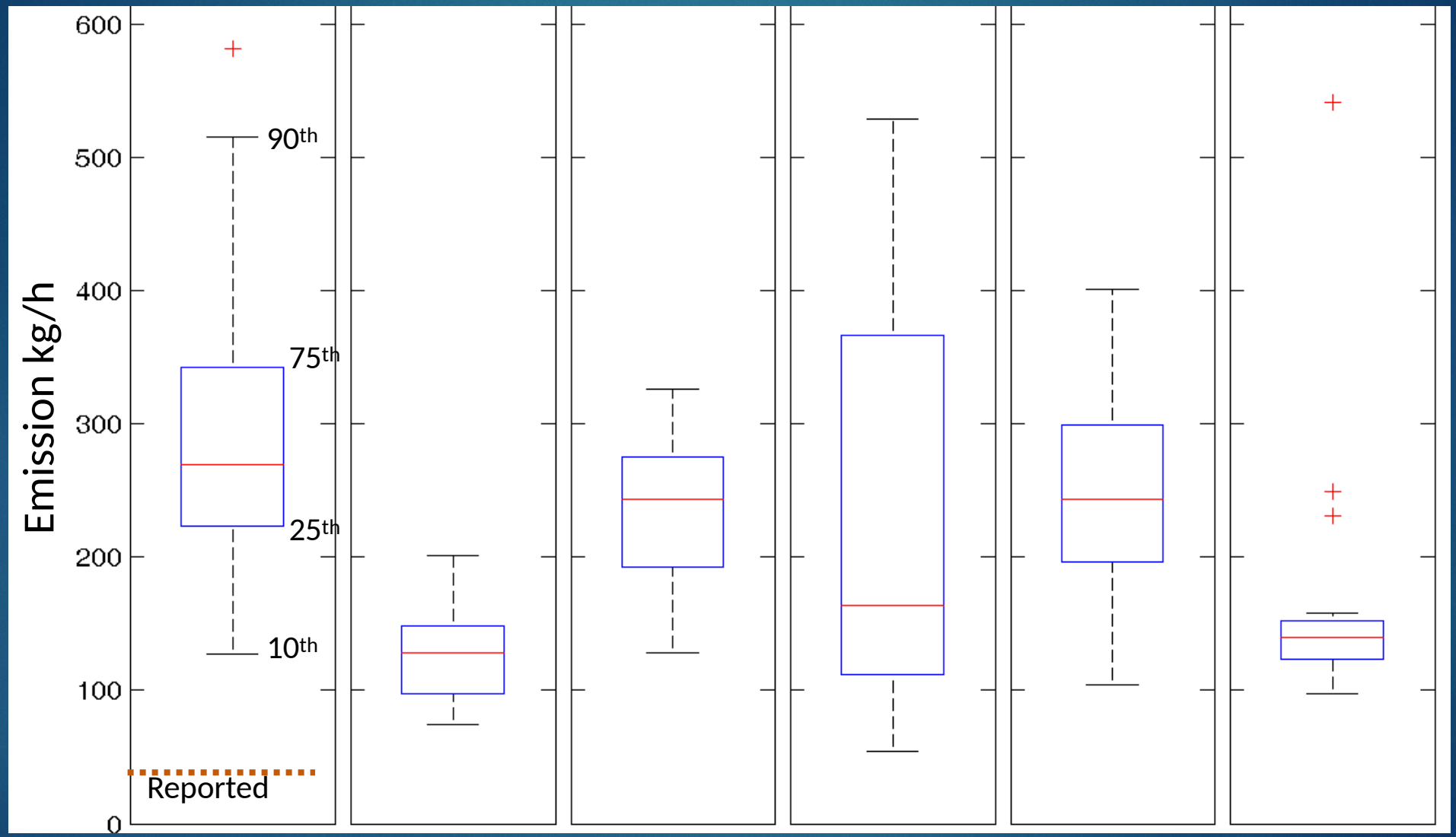
Emission Measurment



Box plots of median VOC emission from 6 refineries, 5-40 individual measurements 4-15 days



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Measurements or Calculated Emission Inventories

- The total measured emissions (Alkanes+BTEX) from refineries in California exceed the reported inventories with an order of magnitude despite excellent LDAR programs and frequent facility inspections
- Emission factors based on measurements in California range from 0.016% to 0.045% of crude oil capacity, emission factors based on current inventories range between 0.004% to 0.009%
- Air quality modeling based on reported inventories will therefore by necessity be inaccurate and proposed mitigation efforts may not necessarily be as effective as intended
- Fence-line monitoring will provide good information about emission concentrations at ground level but cannot gage total emissions from a facility due to plume lift

Summary and Conclusions

- The actual uncertainties of ORS Flux measurements can be reduced through good measurement protocols with good wind data
- Measurements consistently show actually emissions exceeding reported inventories 3-10 times , thus reducing the relevance of the measurement uncertainties
- Inventories based on measurements provides for more accurate air quality modeling
- 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
- The key source of diffuse emissions at a refinery are the tanks (2/3 of emissions)

Vehicles are SMOG tested as wear and tear impact emissions…..
The same is true for industrial facilities