



# **Sensing of Industrial Emissions using Differential Absorption Lidar (DIAL)**

Emissions and Atmospheric Metrology Group

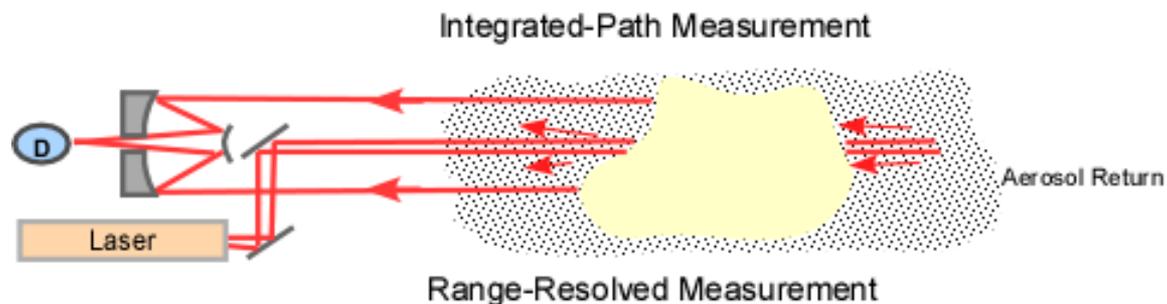
National Physical Laboratory, UK

# Why use remote optical method for industrial emission measurements ?

- Can measure total emissions from complex sites
  - Can cover all emission sources from a site, including fugitive and point sources
  - Measure downwind and upwind concentrations
  - Do not need to access hazardous areas
- Monitor diffuse sources – e.g. landfill, lagoons etc.
- Measurements can be used for
  - Impact assessment,
  - Regulatory compliance
  - Warning/ alarm systems
- NPL have been using the DIAL technique in such applications for over 20 years.



# What is the DIAL technique ?



- Laser Radar system targeted on gas measurements.
- Gives range-resolved concentration along optical path.
- Measurement beam can be scanned to map concentration distribution.
- Able to measure wide range of species :
  - VOCs including methane, ethene, methanol, and general hydrocarbons
  - SO<sub>2</sub>, NO<sub>2</sub>, NO, Hg, HCl
  - Benzene, Toluene, Xylenes
- Spatial resolution <8 metres



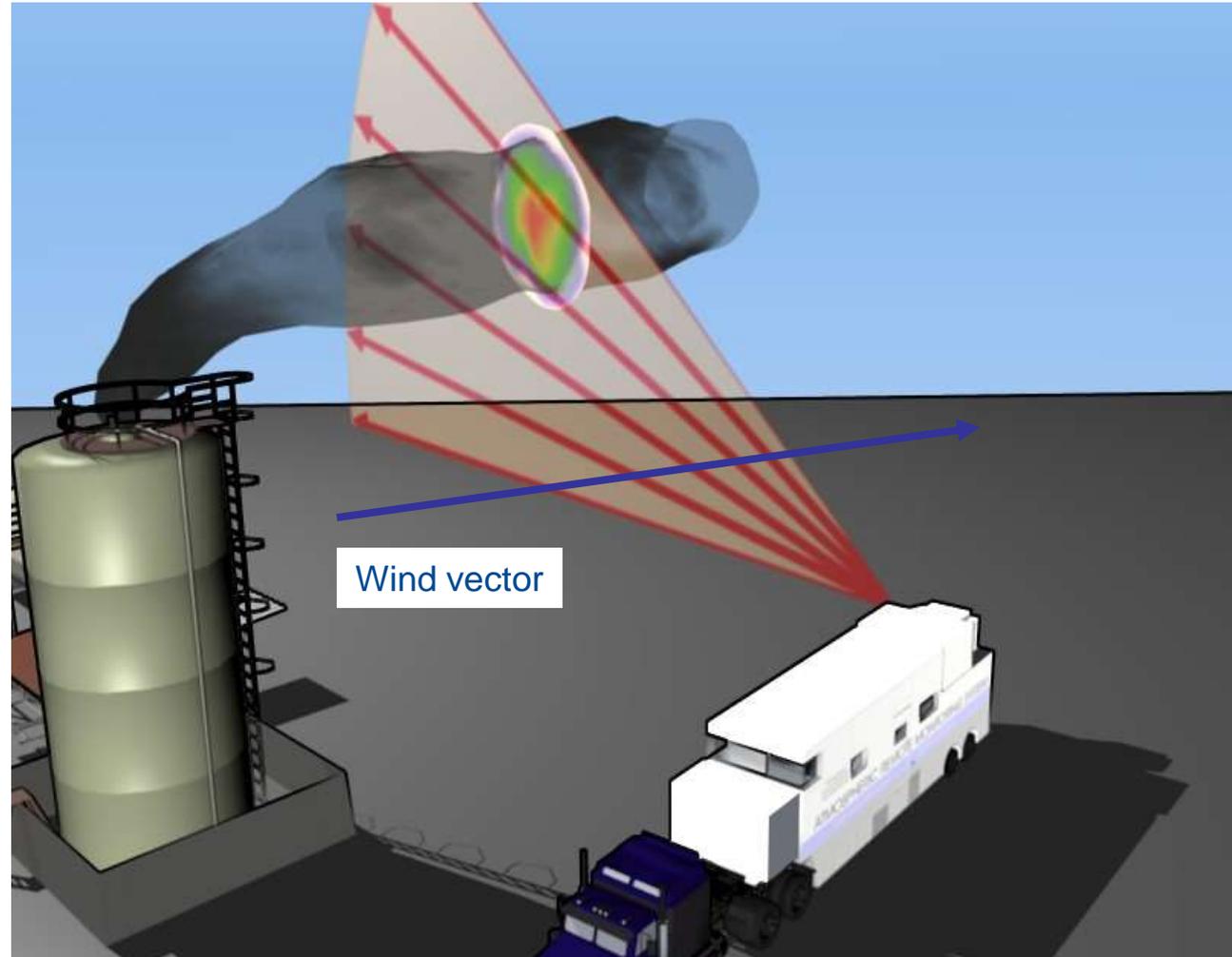
# NPL DIAL – Typical Performance

Infrared DIAL System			UV Side DIAL System		
Species	Sensitivity	Max Range	Species	Sensitivity	Max Range
CH <sub>4</sub>	50ppb	1km	NO	5ppb	500m
CH <sub>2</sub>	40ppb	800m	NO <sub>2</sub>	10ppb	500m
C <sub>2</sub> H <sub>4</sub>	10ppb	800m	SO <sub>2</sub>	10ppb	3km
C <sub>2</sub> H <sub>6</sub>	20ppb	800m	O <sub>3</sub>	5ppb	2km
higher alkanes	40ppb	800m	Hg	0.5ppb	3km
HC	20ppb	1km	Benzene	10ppb	800m
NO	100ppb	800m	Toluene	10ppb	800m
C <sub>3</sub> H <sub>8</sub>	200ppb	500m	Xylene	20ppb	500m

NB These sensitivities apply at a range of 200m  
for a 50m exposure

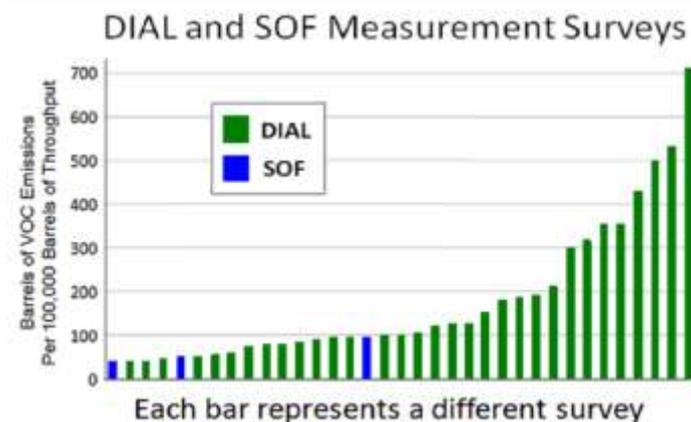
# DIAL measurement configuration for emission rate (flux) measurement

- Vertical scans enable plume mapping and flux calculation
- Combine integrated concentration with simple wind field to give flux
- Can measure away from source – less complex wind

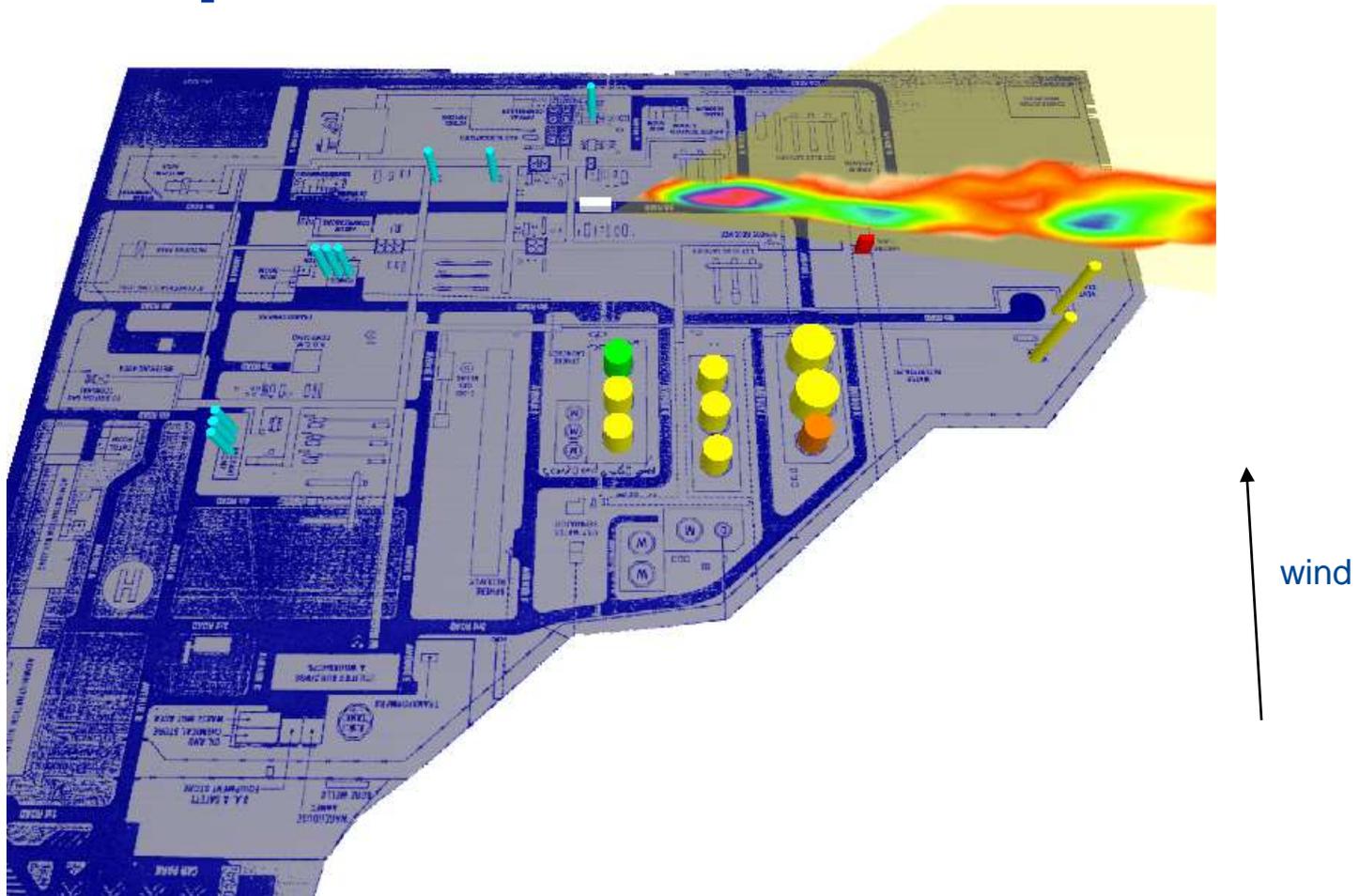


# What are fugitive emissions?

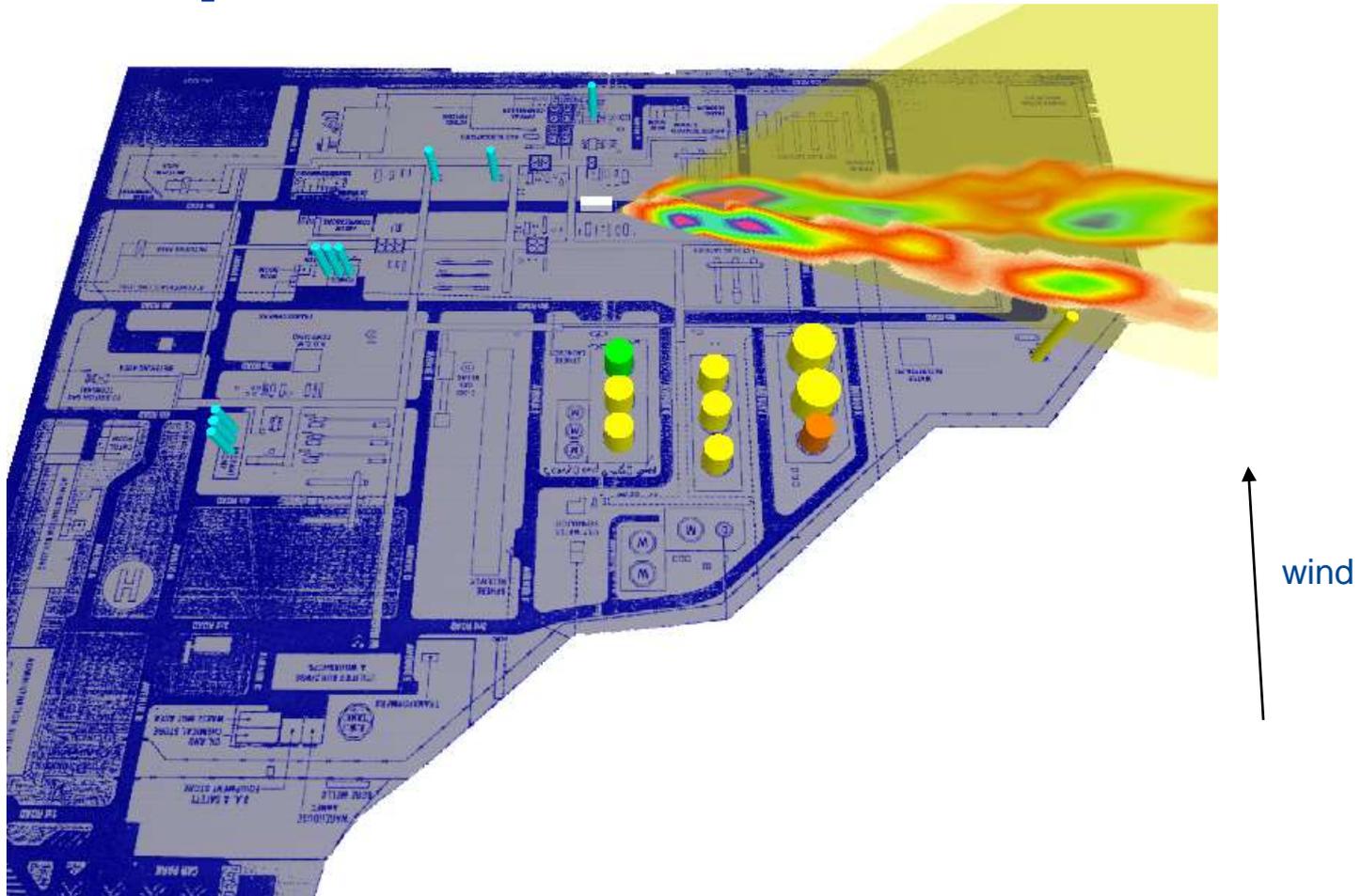
- Emissions from known sources can be measured reasonably well.
- However, there can be, and are, significant fugitive emissions from other parts of a plant – leaks, storage tanks, waste treatment, etc
- Emissions from area sources eg landfill
- Recent studies in US and Canada and historical data from Sweden shows measured total-site emissions from refineries can be a factor of 10 higher than calculated
- Mismatch between ambient concentrations and source terms  
10-50 times higher (Texas AQS 2006)



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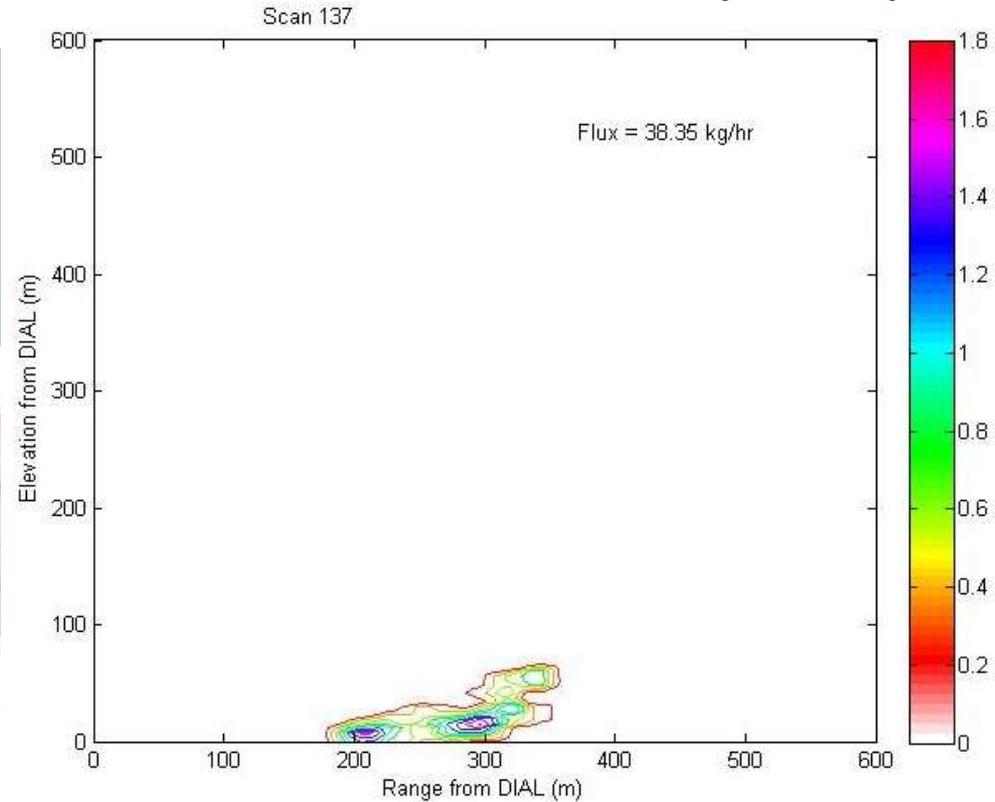
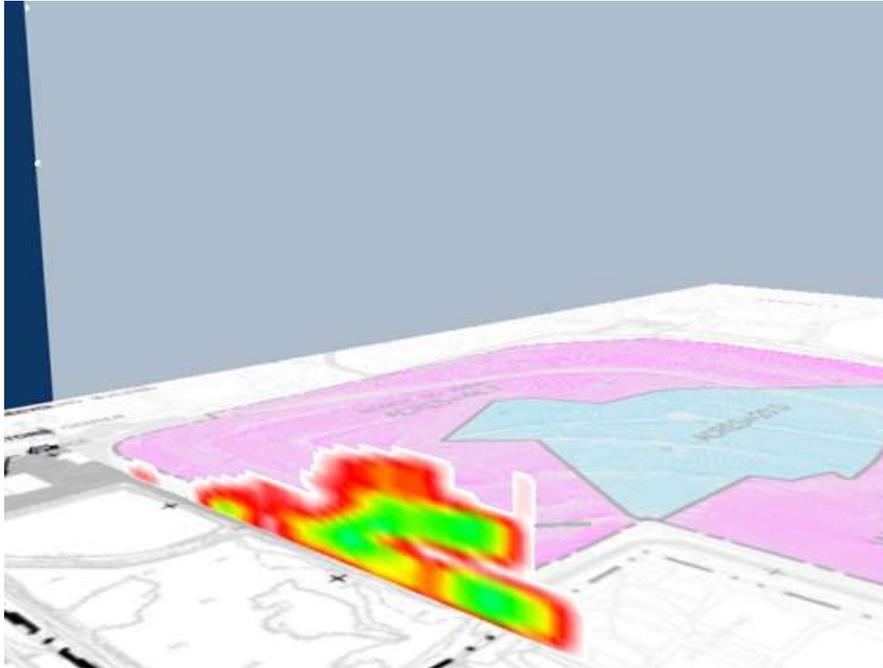


# Measurements of methane emissions from landfills

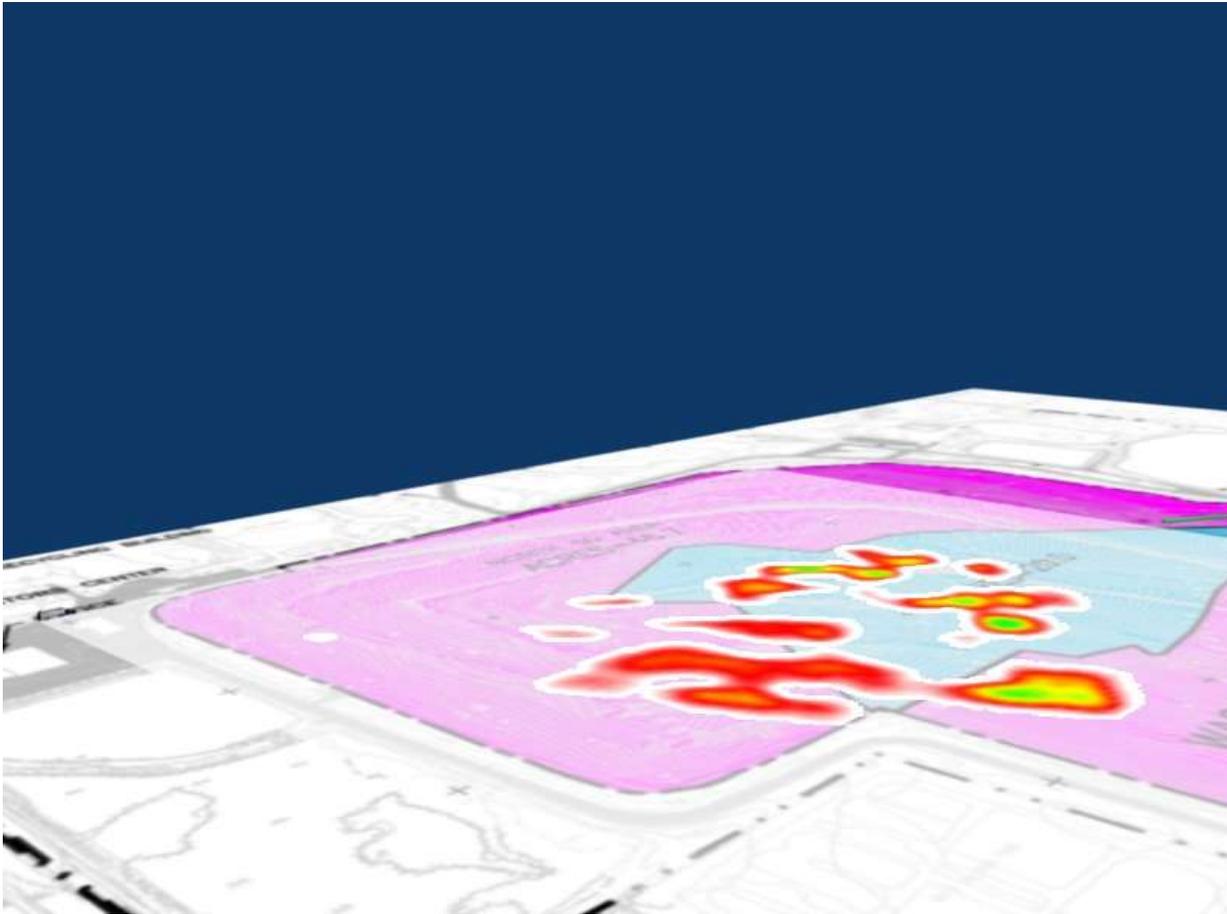
- Recent measurement campaigns in UK, France and USA have demonstrated use of DIAL for measurement methane emissions from landfill
- Able to map methane emissions and identify 'hotspots' by scanning horizontally across the site.
- Measured levels of emissions from 'active' areas and from capped areas



# Measure downwind emissions



# Horizontal scan to locate emission hot-spots



# Summary

- The DIAL technique provides a method to identify and quantify fugitive emissions of key industrial species and GHGs
- One of the most direct methods to quantify fugitive emissions flux
- Can work in most conditions
- Non intrusive – remote steerable measurements
- Provides the ‘best way to measure whole site emission fluxes’
- Often identifies emission sources which are not known to the operators.