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First validation of high-resolution satellite-derived methane emissions from an active gas leak in the UK

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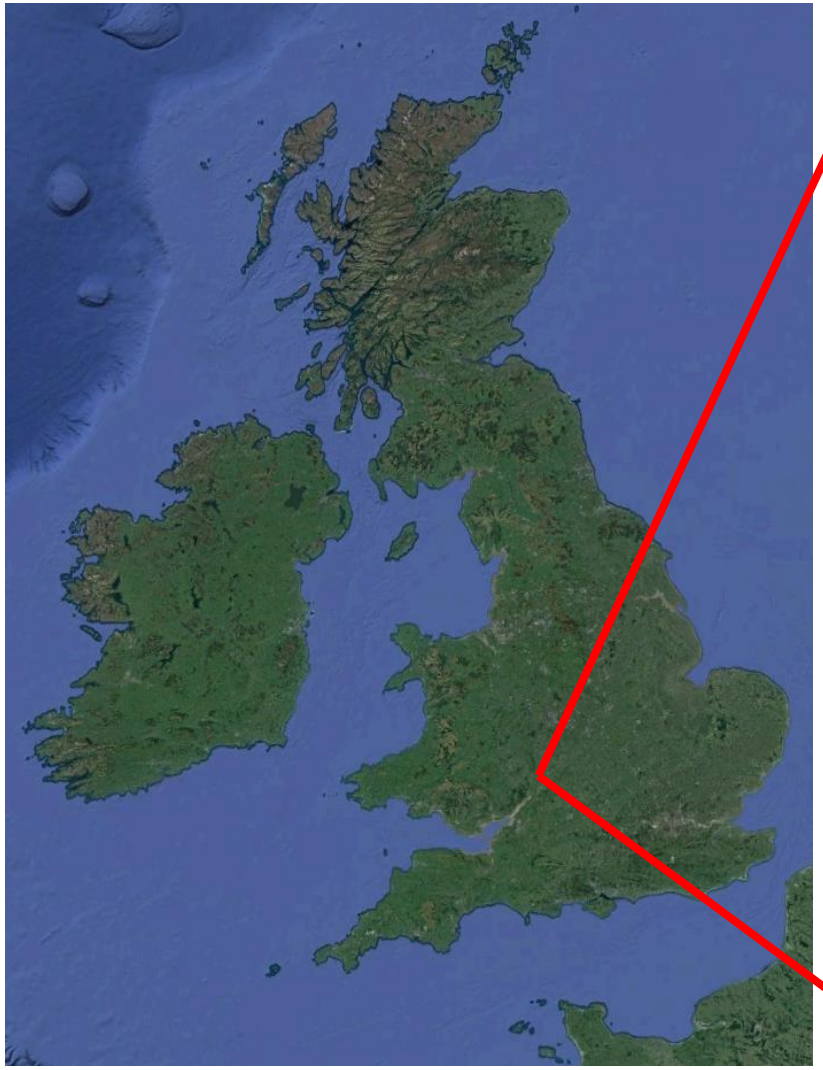
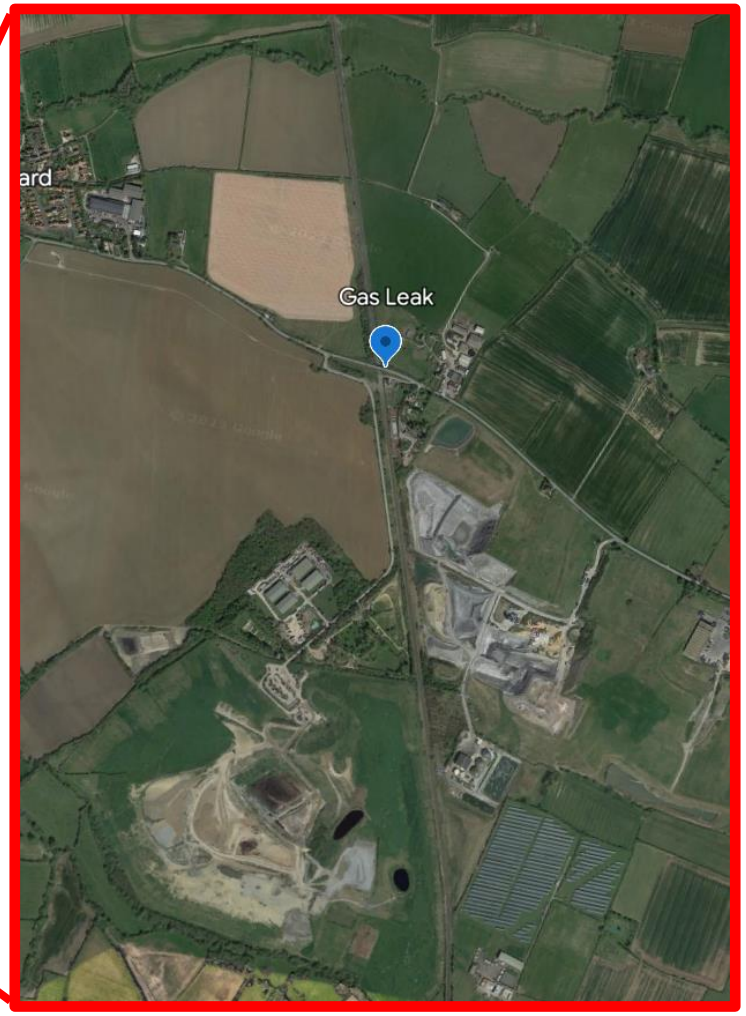
Gas Leak Location – Bishops Cleeve, Cheltenham



Google Earth Image Landsat/Copernicus



Google Earth Image

- Leak was detected by GHGSat on 27th March 2023
- Leak is from a gas distribution pipe
- 5km north of Cheltenham
- Surrounded by agricultural land
- One farm ~70m to the east
- Two waste management sites <0.5km to south
- One road to south of location within 30m of leak

Natural Gas & UK Emission Inventories

- Natural gas is mostly composed of CH_4
- Fugitive emissions from oil and gas transportation in UK in 2020 were estimated to be 187 kilotonnes of CH_4
- Annual estimates of fugitive emissions of natural gas are provided by gas distribution network (GDN) operators and used in the National Atmospheric Emissions Inventory (NAEI)

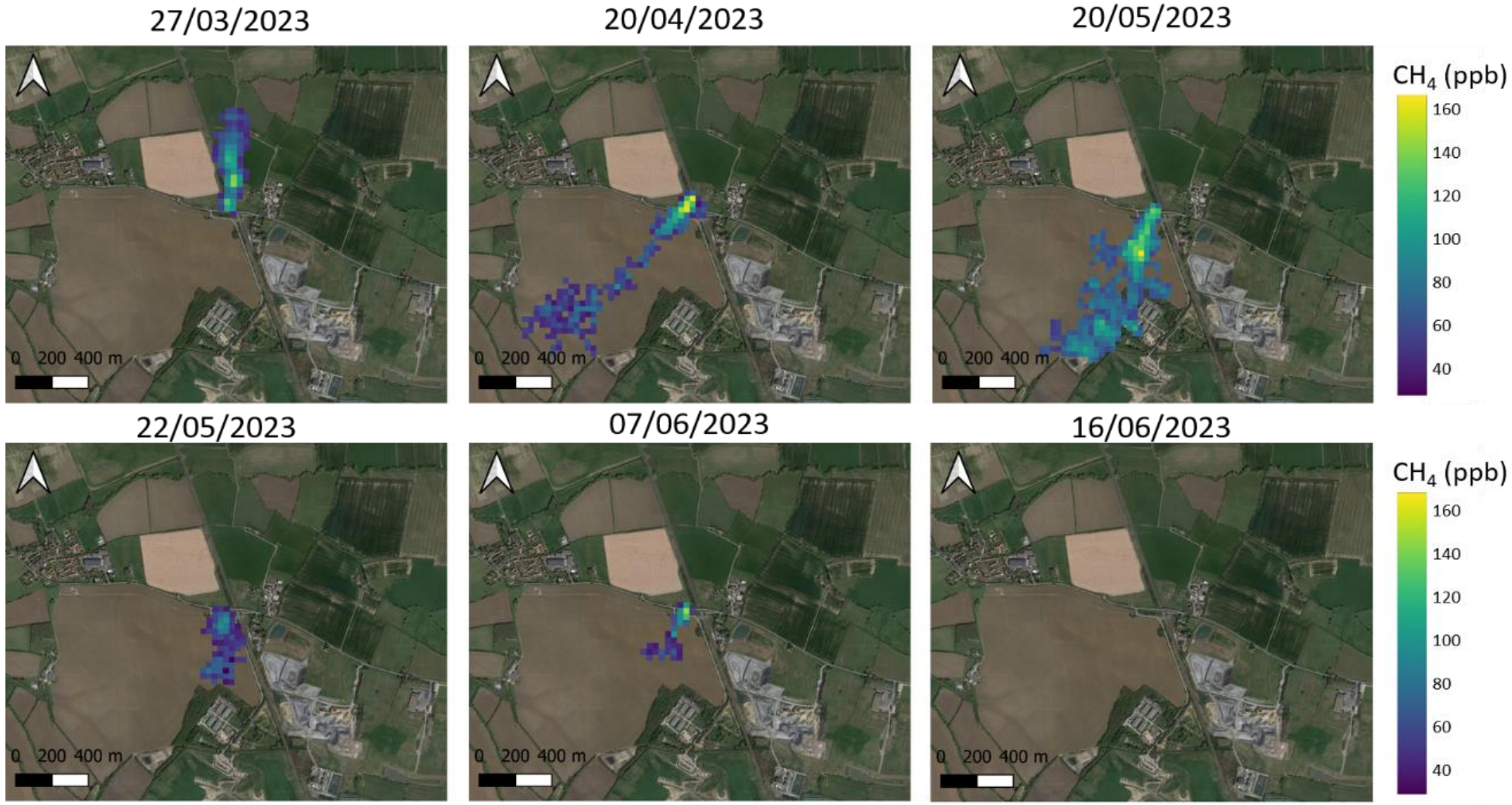
Observations

- Constellation of ~10 SmallSats
- Spatial resolution of 25m
- 12km x 12km field of view
- Capability of 1-2 day revisit time
- Detection limit 100 kg h^{-1}
- 6 observations were taken between March and June 2023
- Flux estimated using a mass enhancement method

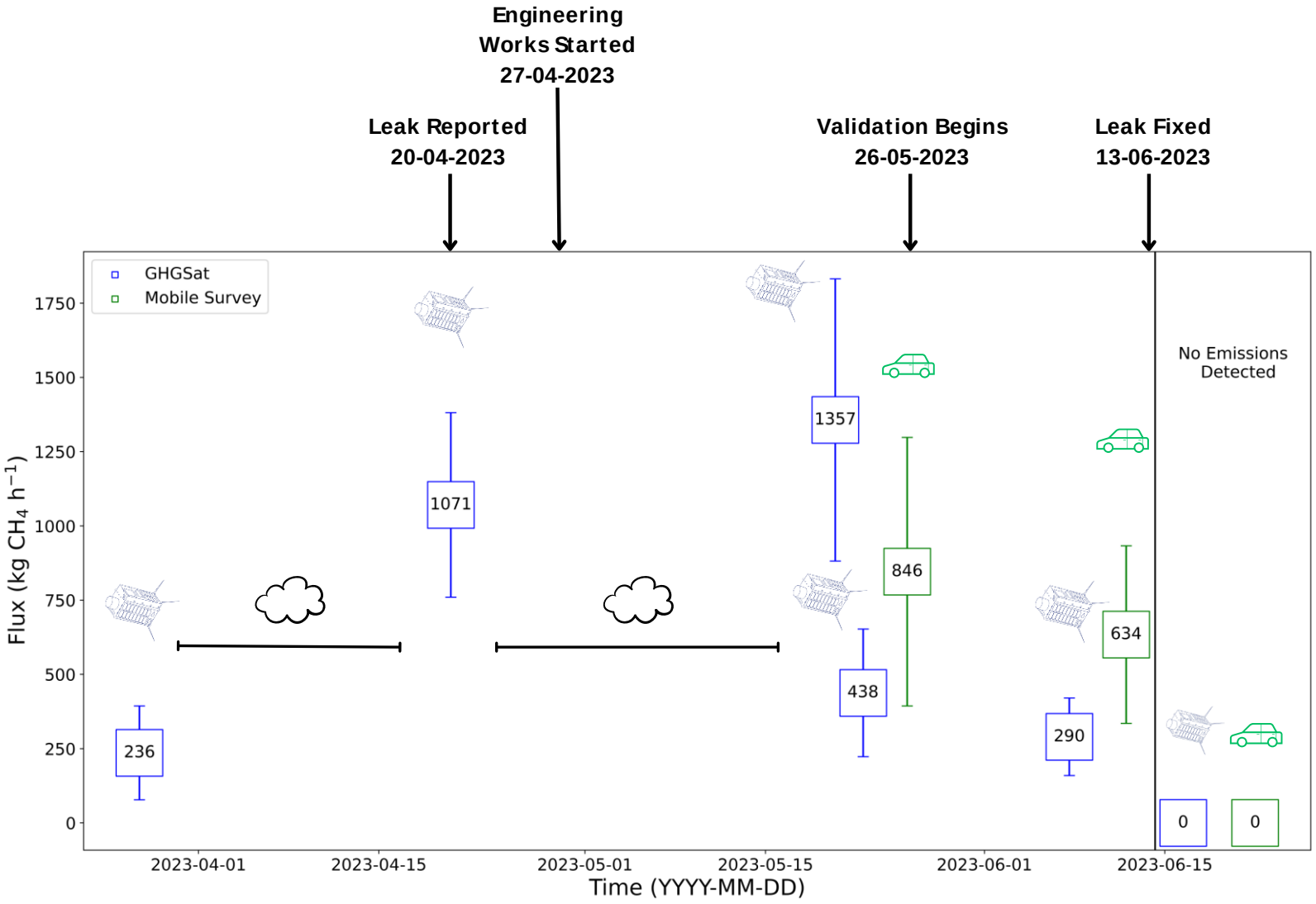
Mobile Survey by Royal Holloway, University of London

- Suite of cavity enhanced laser absorption spectrometers
- Measured CH_4, CO_2, C_2H_6 and CH_4 isotopes
- Car was driven on nearest road
- Mobile surveys were carried out on 26th May, 12th June and 22nd June 2023
- Flux estimated using Gaussian plume model

GHGSat Retrievals



Timeline of Events



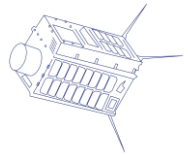
Site Images

Google Earth Image Airbus 2023

Numerical Atmospheric-dispersion Modelling Environment (NAME)

- Lagrangian dispersion model driven by Met Office's NWP meteorology UKV at 1.5km x 1.5km horizontal resolution
- Simulated the gas leak for 3 hours at 10m and 25m to estimate the flux in NAME

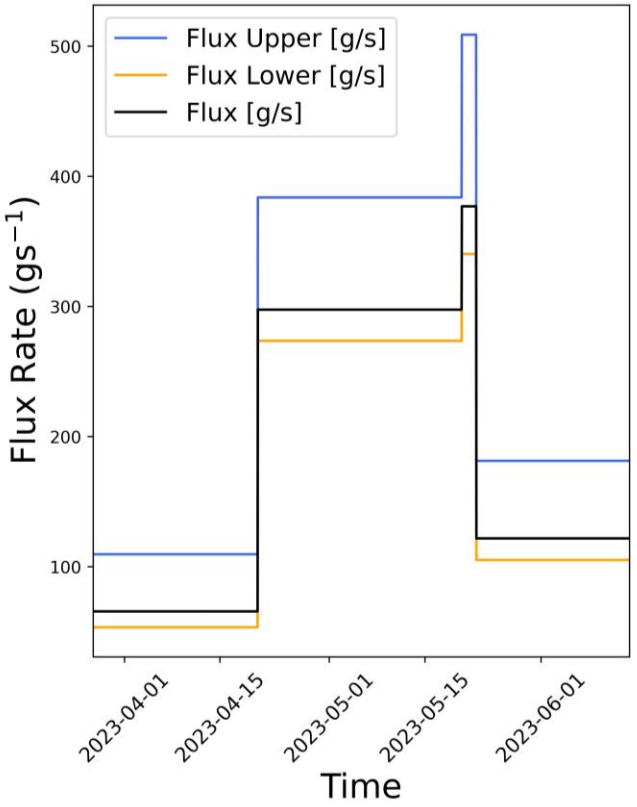




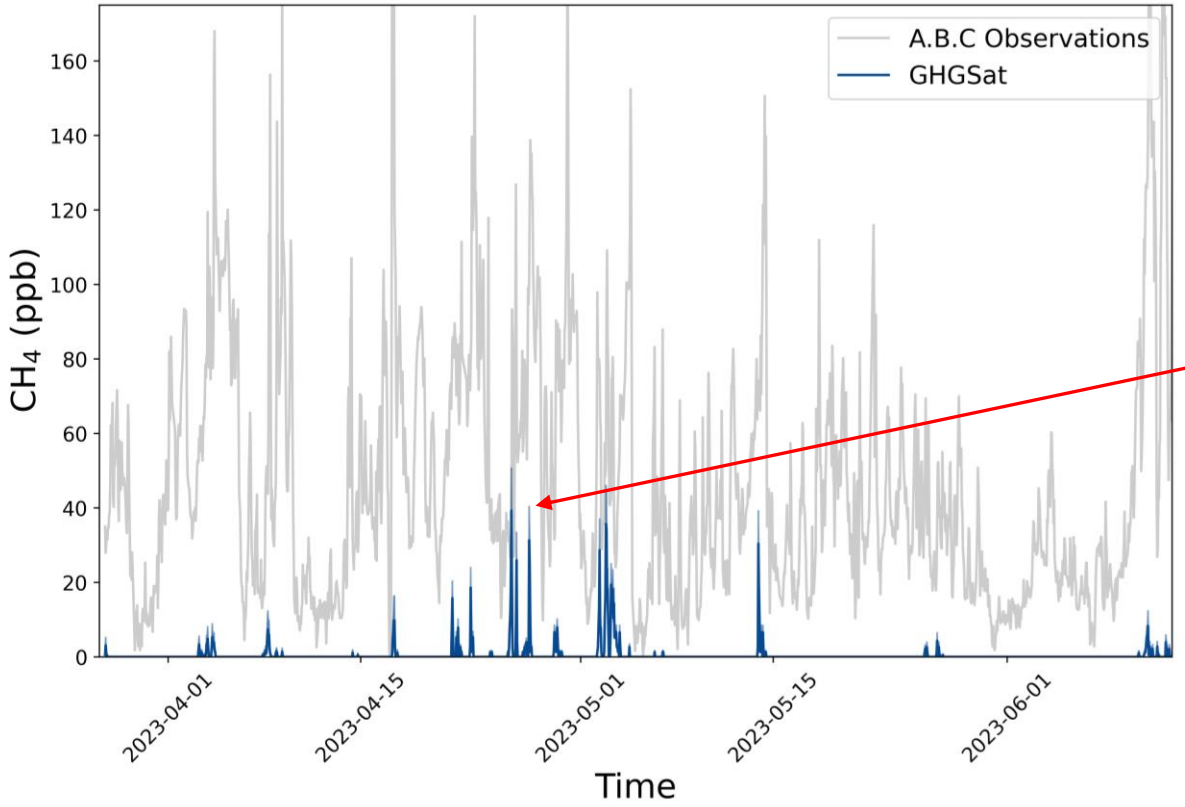

Date	Mobile Survey Flux (kg h^{-1})	NAME Derived Flux from MS Concentrations (kg h^{-1})	GHGSat Flux (kg h^{-1})	NAME Derived Flux from GHGSat Concentrations (kg h^{-1})
27/03/2023	-	-	236 ± 157	181 [133, 322]
20/04/2023	-	-	1071 ± 310	745 [539, 1376]
20/05/2023	-	-	1375 ± 481	1243 [931, 2322]
22/05/2023	-	-	438 ± 215	384 [173, 292]
26/05/2023	846 ± 453	406 [366, 680]	-	-
07/06/2023	-	-	290 ± 131	204 [77, 244]
12/06/2023	634 ± 299	512 [498, 681]	-	-

Contribution at Ridge Hill Tall Tower

Model Flux Variation in Time



Ridge Hill



A.B.C: Above-Background Concentrations

Pollution Event on 25/04/2023

- Simulated NAME for 3 months at 2.5km horizontal resolution
- Flux held constant until next observation
- Time series output at Ridge Hill, compare with above-background observations
- Defined pollution events as >2σ above-background and > 90% of above-background concentrations
- One pollution event at Ridge Hill over 3 months

Ridge Hill approx. 30km away

Google Earth Image Landsat/Copernicus

Conclusions

- Validated satellite data with mobile survey measurements
- Steps were taken to resolve the leak and this was confirmed by our measurements
- Satellite and mobile survey derived fluxes differ, likely due to:
  - Different flux estimation methods (wind speed estimates)
  - Work being done on the pipe during measurements
- Modelling shows that the tall tower site cannot be used to estimate the flux of the leak using inverse modelling techniques
- Incident specific emission estimates are not provided for the NAEI
- Demonstrates need for multi-scale observations to detect fugitive emissions
- The gas leaked over 11 week-period was equivalent to the annual electricity consumption of more than 7,500 average homes (EPA calculator).

With thanks to esa academy