Review of techniques for fugitive methane identification and quantification at landfills

Chaim Kolominskas

Head of Technology - Zephyr Environmental

Zephyr Environmental and methane

1 Methane matters

- Short-lived and potent GHG
- Diffuse sources are hard to measure.
- Lost product

2 Locations

- Large areas, variable rates, no obvious method
- Landfills and coal mines

3 Scope of trials

- Six field techniques
- Plus a co-location study of five instruments
- Alternative data management and interpretation

4 Findings

- Periodic and continuous measurement methodologies
- Better communication and response to methane issues

SECTION 01

Why fugitive methane matters

Importance of methane

1. **Climate**
   Methane is 28 times more potent than CO_2 over 100 years, and 82 times over 20

2. **Timing**
   Methane's short atmospheric life means cuts now show up as avoided warming within a decade

3. **Economic**
   Fugitive methane is lost product

4. **Regulation**
   Captured gas runs generators, and reported gas is now a licence condition



Assessment criteria

1

Accuracy

Identification and quantification

2

Spatial coverage

Covering both working surfaces and infrastructure

3

Temporal coverage

Capture of variability in emissions influenced by wind, temperature, pressure inversions etc.

4

Practicability

It has to work on an operating site

Trade-offs in all methods

Every method tested trades one requirement against another

SECTION 02

Study areas

Two source types, one measurement problem



Open cut coal mines

Emissions from the pit, exposed seams, stockpiles and the preparation plant. Rates vary with mining activity. Topography and local micrometeorology are important.



Landfills

Methane escapes through cover material, with hot spots at cracks and infrastructure. Meteorology (wind speed, wind direction, pressure, temperature/inversions) can affect emission rates and dispersion.

Categories of technologies evaluated

Satellite	Aircraft	Drone survey	Mobile survey	Open path	Flux chamber
Regional > 10 km	Facility 1-10 km	Site 50 m - 1 km	Plume 0.1 - 5 km	Path 100 - 500 m	Point < 1 m
Screening only	**Concentration**	**Concentration to flux**	**Concentration**	**Path average**	**Direct flux**

Large scale · broad coverage, low resolution

Fine scale · high resolution, small area

Trade-off between coverage and resolution

SECTION 03

Technologies trialled

Field surveys

1	**Flux chamber survey**	Picarro G2201-i CRDS	**Direct flux, highest accuracy**
2	**Flux survey**	LI-COR LI-7810 + Smart Chamber	**Direct flux, far more portable**
3	**Mobile monitoring**	Vehicle-mounted Picarro	**Understanding off-site impacts**
4	**Drone survey, upwind-downwind**	Aircore sampling	**Mass balance, proof of concept**
5	**Drone survey, point sensor**	ABB HoverGuard	**Hot spot localisation**
6	**Drone survey, path sensor**	Pergam Laser Falcon Plus	**Column measurement over a path**

Flux chambers





What worked

Picarro chamber surveys were the most accurate for high-concentration sources

The LI-COR system was nearly as accurate and far more portable

Limitations

LI-COR not stable above 200 ppm - Both landfill and coal mine surfaces routinely exceed that

Coverage is small - so needs repetition

Verdict

All chamber options considered further for PEM methodology - flux quantification

Mobile monitoring – offsite measurement



3-4 km

plume widths identified

5 ppm

peak enhancement above background

Findings

Mapping plume geometry changed the drone survey design

Led to a targeted survey of a much smaller area

Limitations

Concentration, not flux

Converting to an emission rate needs inverse modelling

TECHNIQUE 4

Aircore drone surveys



Findings

Upwind-downwind transects with aircore sampling showed that drone surveys can be useful

The transects produced a usable mass balance

Limitations

Set-up and post-flight analysis were slow

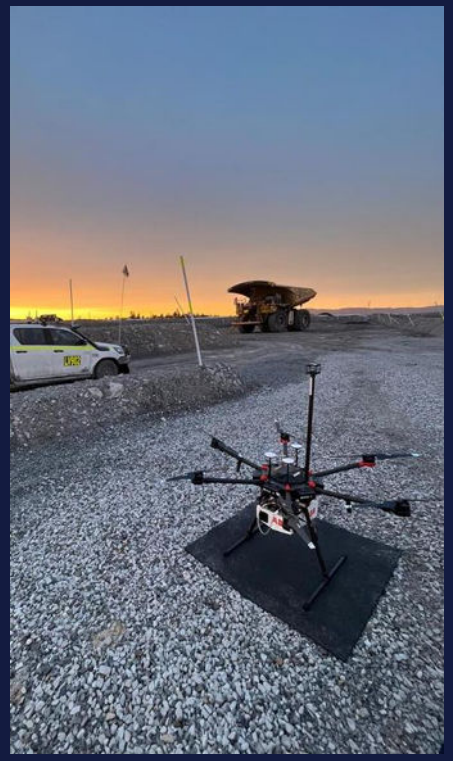
Repeat surveys were impractical

Real-time sensors deliver the same coverage with continuous data

Conclusion: not recommended

Real-time drone-mounted sensors do the same job faster

Real-time drone surveys



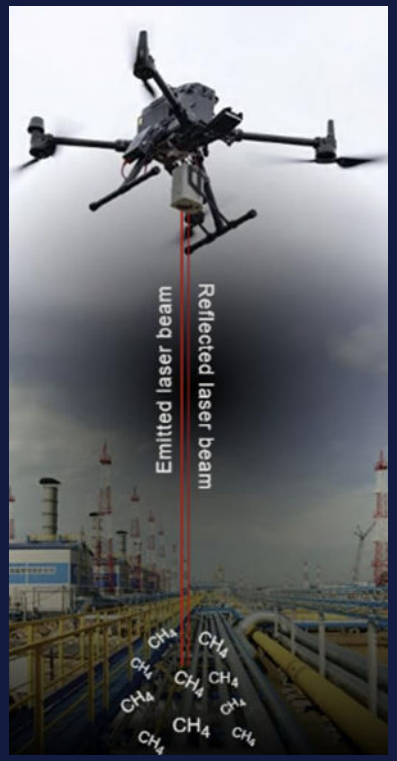




ABB HoverGuard · point

Resolved discrete hot spots and plume structure at the landfill

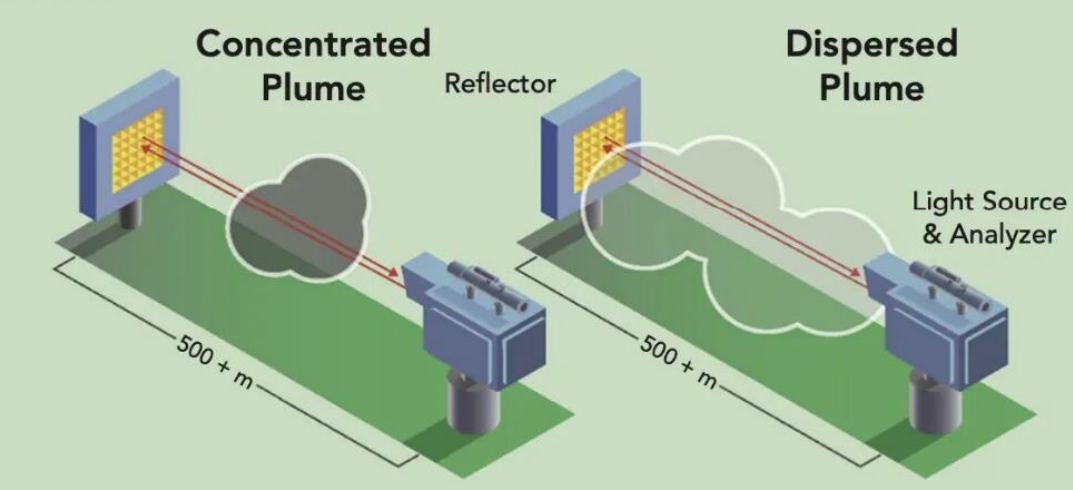
Pergam Laser Falcon Plus · path

Column measurement at 40 Hz
Surveys at 5 m line spacing or finer.

Findings: both taken forward

Point sensors - ABB MicroGuard and Axetris.
Path work continues with the Laser Falcon Plus.

Boundary and open-path monitoring





Strengths

Continuous

Accurate

Sensitive to temporal variation across a path, not a point

Limitations

Bulky and expensive

Fixed geometry

Reports a path-averaged concentration, not a flux

SECTION 04

Co-location study

Benchmarking against the reference

The reference

Picarro G2201-i cavity ring-down spectrometer

Most accurate but least practical

Heavy, power-hungry, expensive and difficult in the field

Question

Can smaller, cheaper instruments track the Picarro closely enough to serve as continuous static monitors?

Five instruments tested

Aeroqual AQS1 · ABB MicroGuard · Aeris · Axetris · LI-COR LI-7810



The five instruments tested

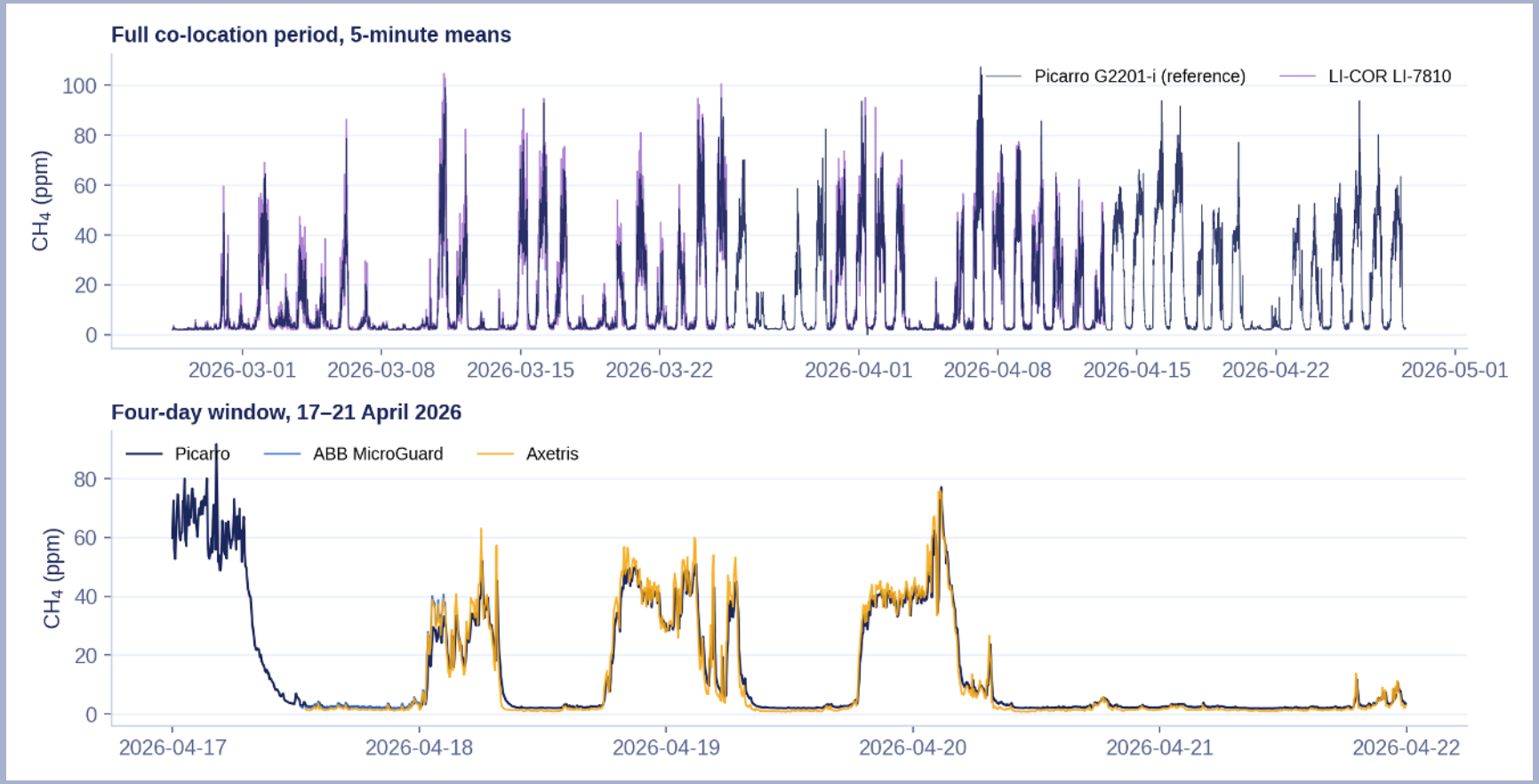






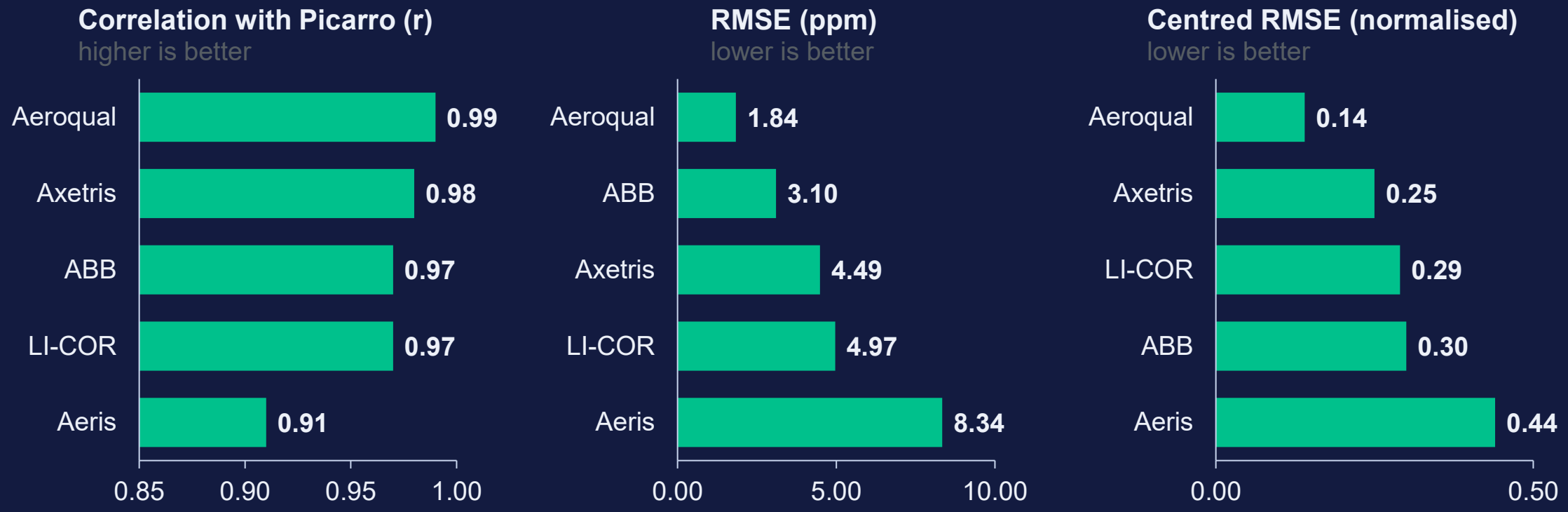


Lower cost devices produce useful information



The instruments identified the same events

Devices compared with reference



Aeroqual AQS1 records the highest correlation (r = 0.99) and the lowest RMSE (1.8 ppm). Axetris. All devices acceptable.

Agreement between devices

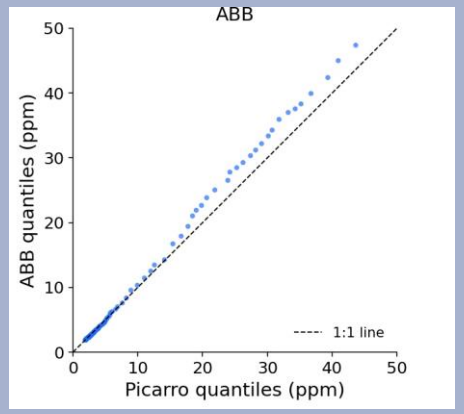
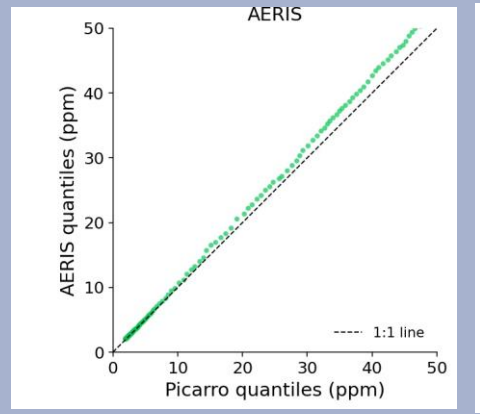
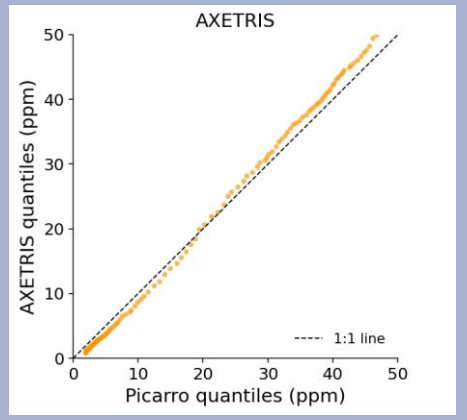


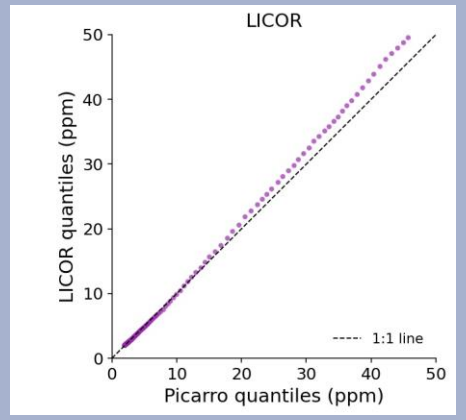
ABB MicroGuard



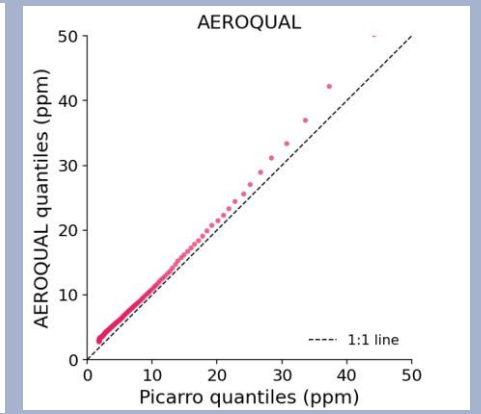
Aeris



Axetris



LI-COR LI-7810

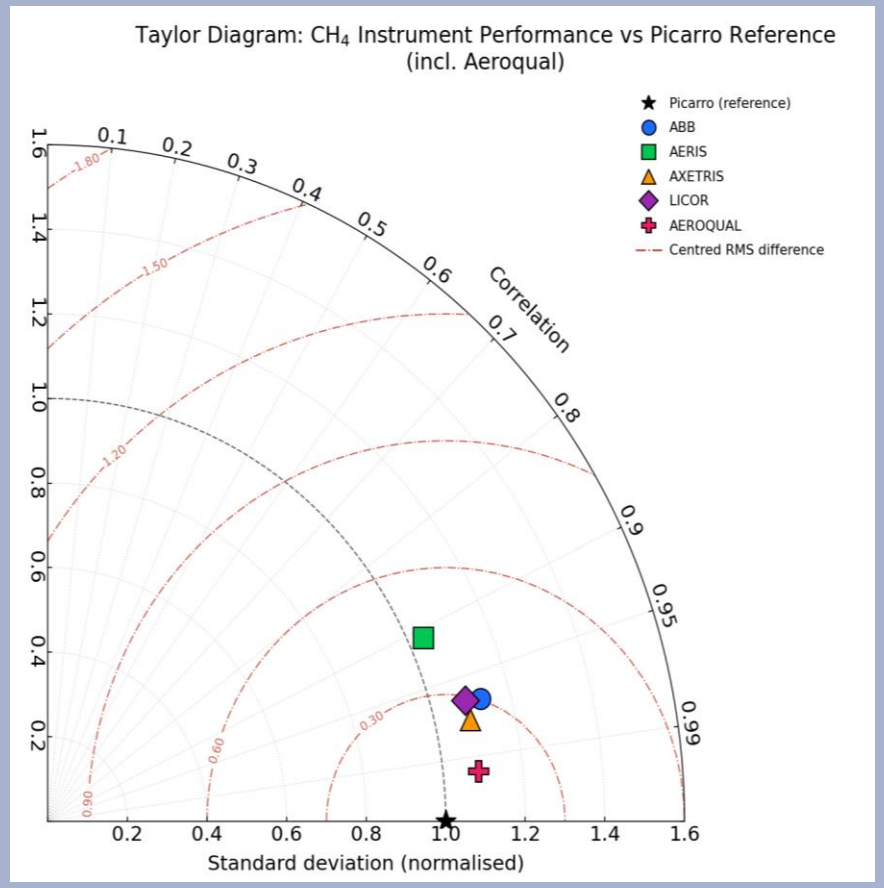


Aeroqual AQS1

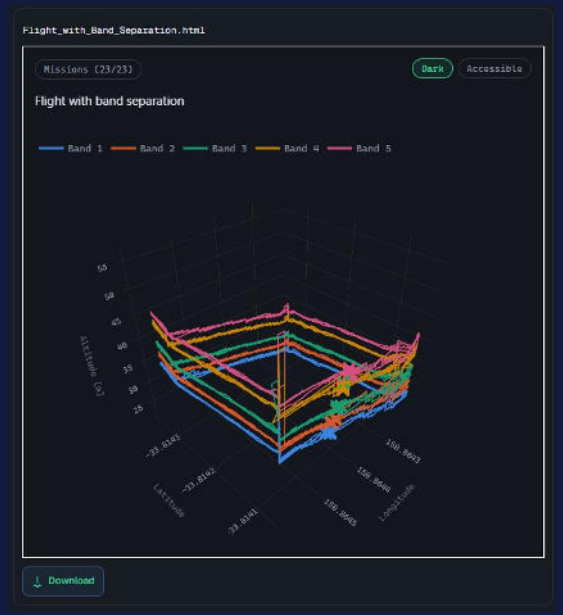
Reading the plots

Each point compares a quantile of the instrument distribution with the same quantile of the Picarro. All devices read high and deviate more near the top of the range although within acceptable limits for most operational purposes.

Taylor diagram

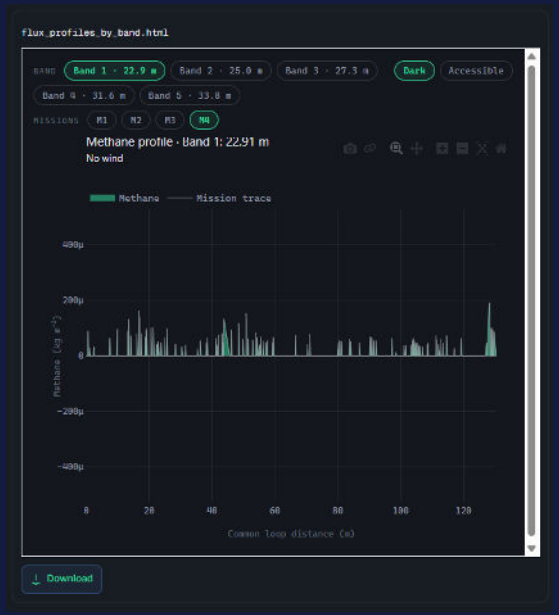


Data management and distribution









Important for the site to be able to access useful information on fugitive emissions quickly and easily

- Near-real time processing of leak location and magnitude.
- Web-based access to drone and sensor data important.

SECTION 05

Conclusions

Conclusions

1. No single technique met all four requirements for site-wide, inventory-grade monitoring
2. Flux chamber survey remains the most accurate option for high-concentration sources
3. Drone-mounted point and path sensors detect hot spots with better coverage than walkovers
4. Aircore retired - Set-up and analysis are too slow for routine survey work
5. Low-cost sensors are viable for point source measurement - Aeroqual AQS1 and Axetris track a Picarro closely enough to serve as continuous static monitors, provided they are corrected at high concentration
6. Characterising fugitive methane across source types and scales may require a suite of techniques

THANK YOU

Questions?

Chaim Kolominskas
Head of Technology, Zephyr Environmental
chaim.kolominskas@zephyrenviro.com

ACKNOWLEDGEMENTS

We thank the site operators for site access, and the Zephyr field crews who ran the monitoring campaigns.