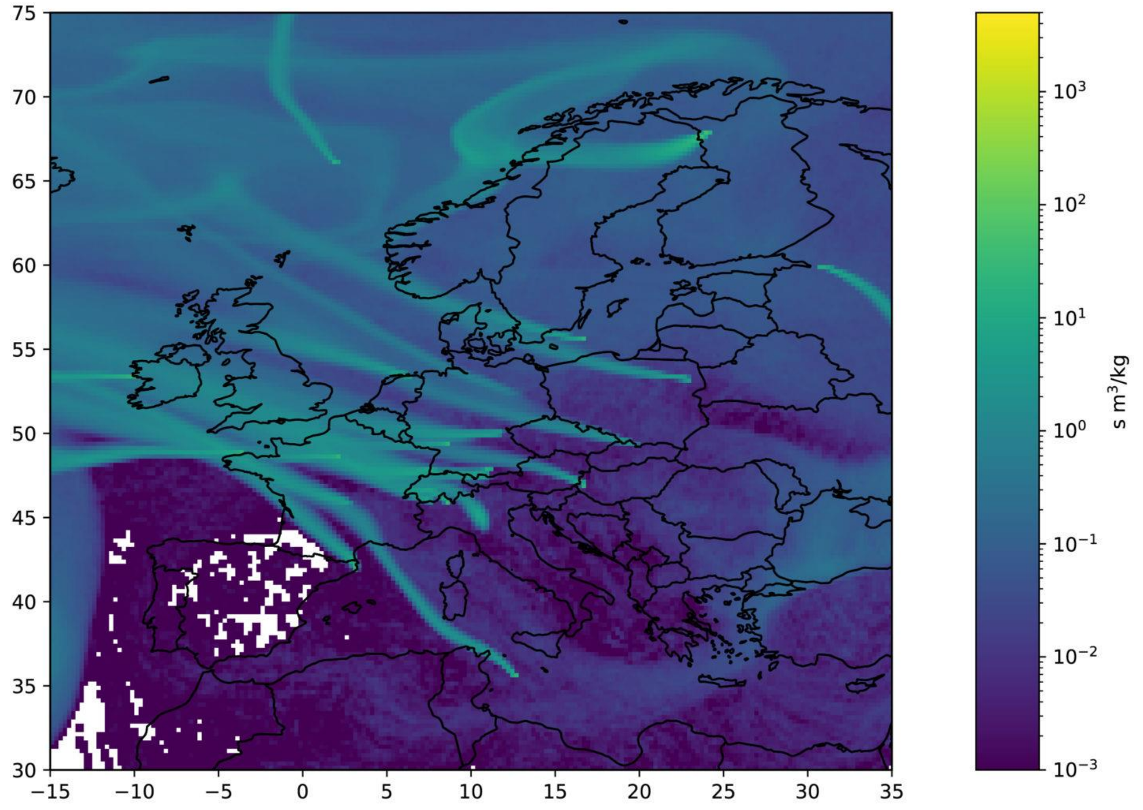
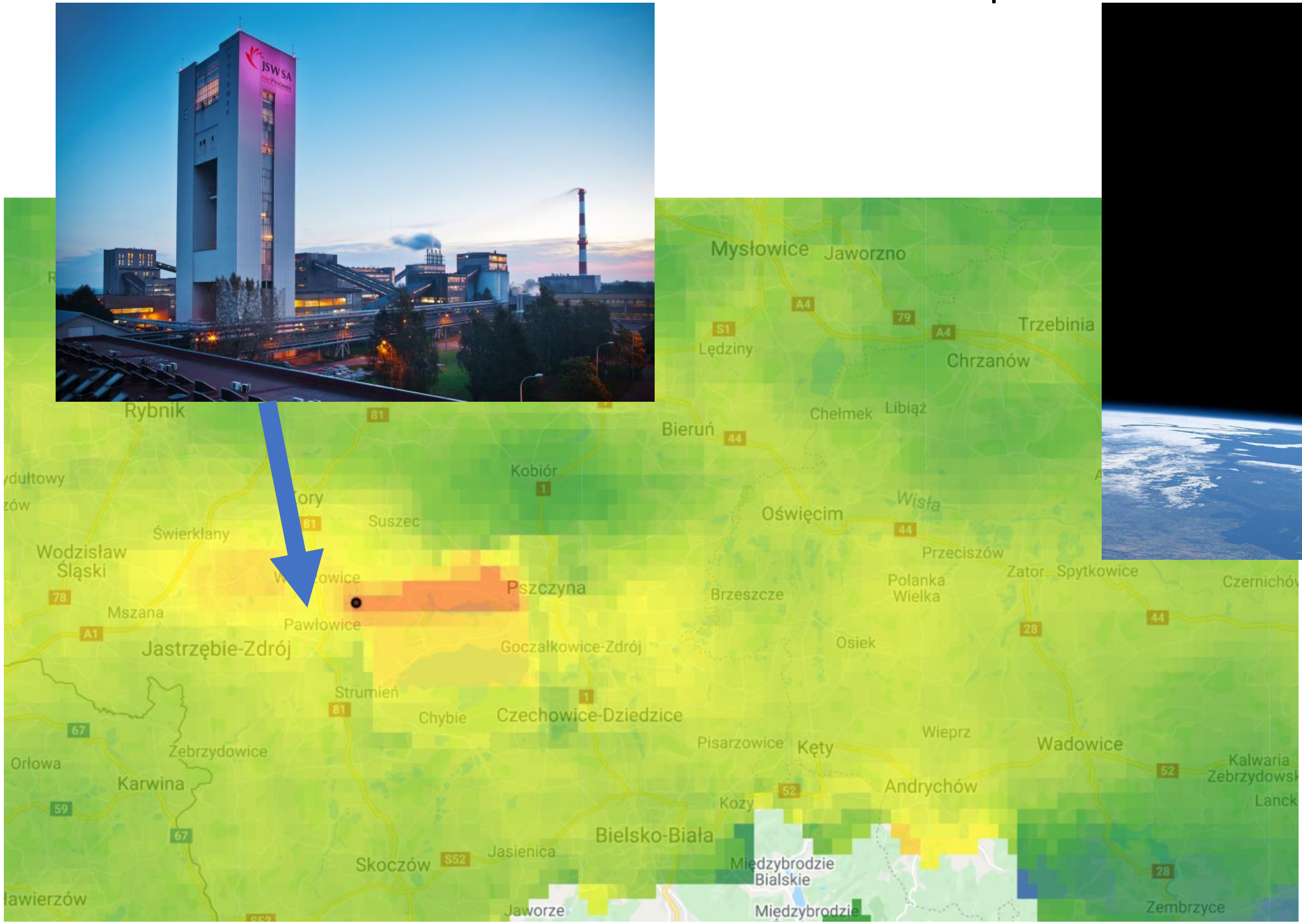
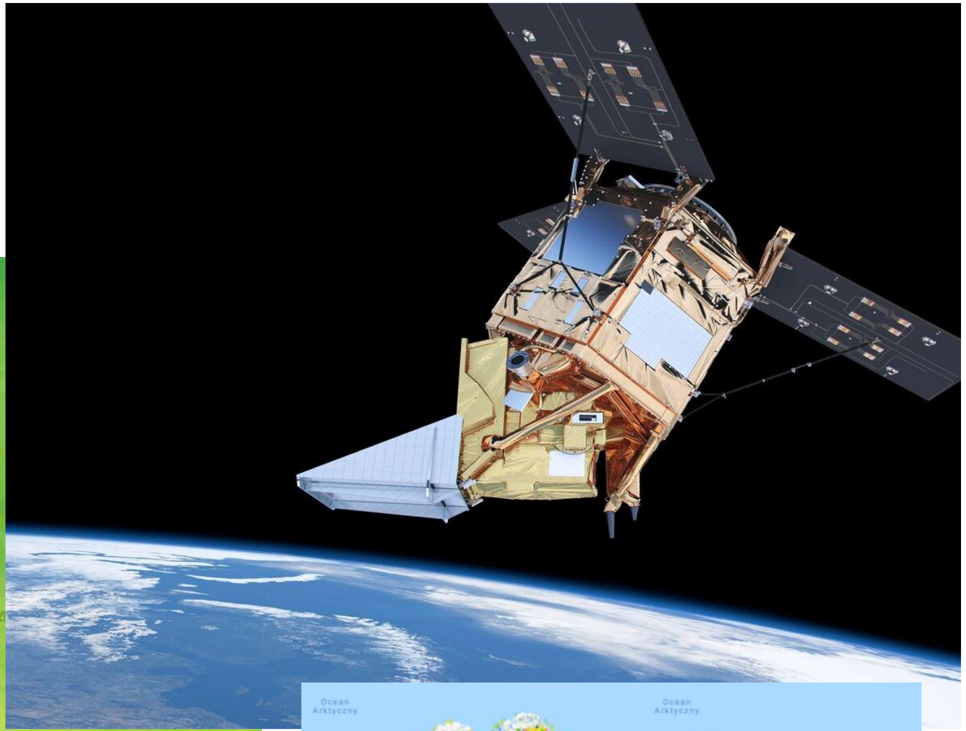
Methan emission verification techniques

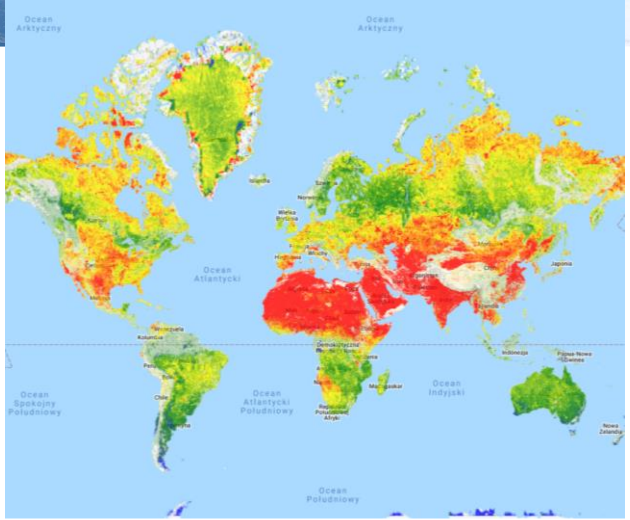
1) Satellites (GOSAT, S5P, Merlin....)
2) Planes (COMET project)
3) Drones
4) FTIR (Fourier Transformed Infared Spectroscopy
5) Ground base - mobile



ESA Sentinel 5P : **JSW** - CH_4 plume (2021)





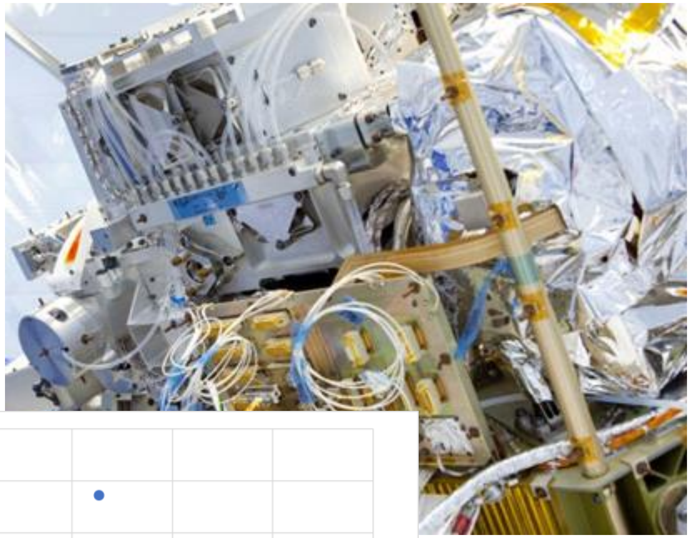


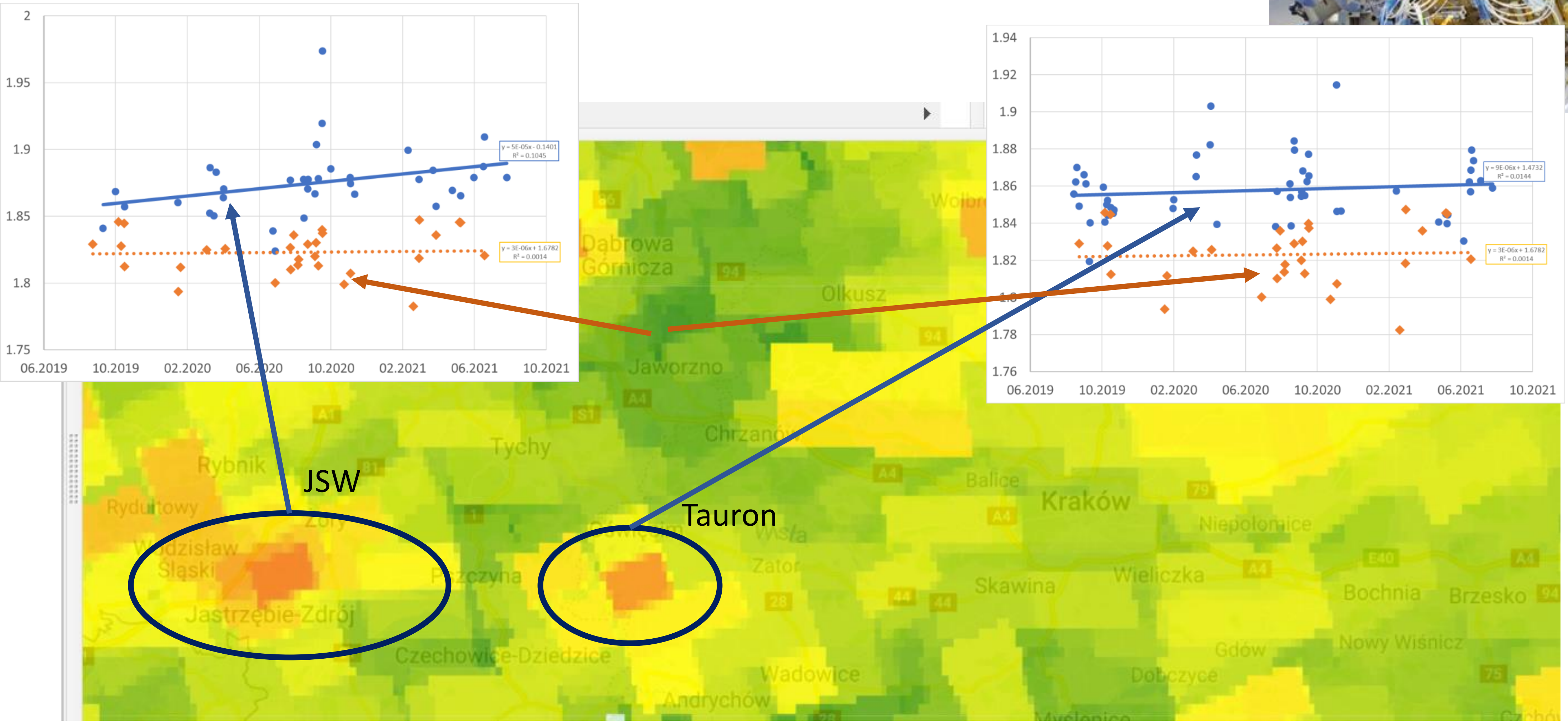
Satellite: ESA Sentinel 5P

Instrument: TROPOMI

Gas: CH_4

Target: south USCB coal mines





Airplane techniques (LIDAR):

Determination of the emission rates of CO₂ point sources with airborne lidar

April 2021 · Atmospheric Measurement Techniques 14(4):2717-2736 · Follow journal
DOI: 10.5194/amt-14-2717-2021

Sebastian Wolff · Gerhard Ehret · Christoph Kiemle · Show all 7 authors · Andreas Fix

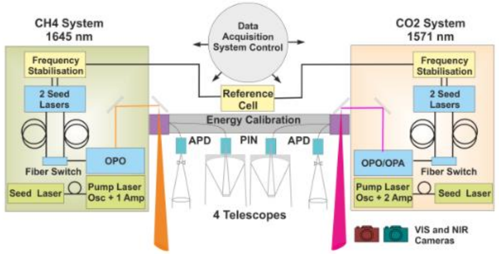


Figure 2: *Schematic set-up of the airborne CO_2 and CH_4 integrated path differential absorption lidar.*

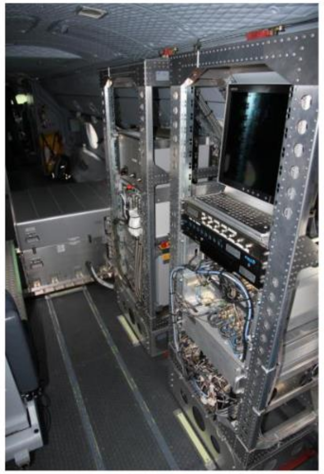
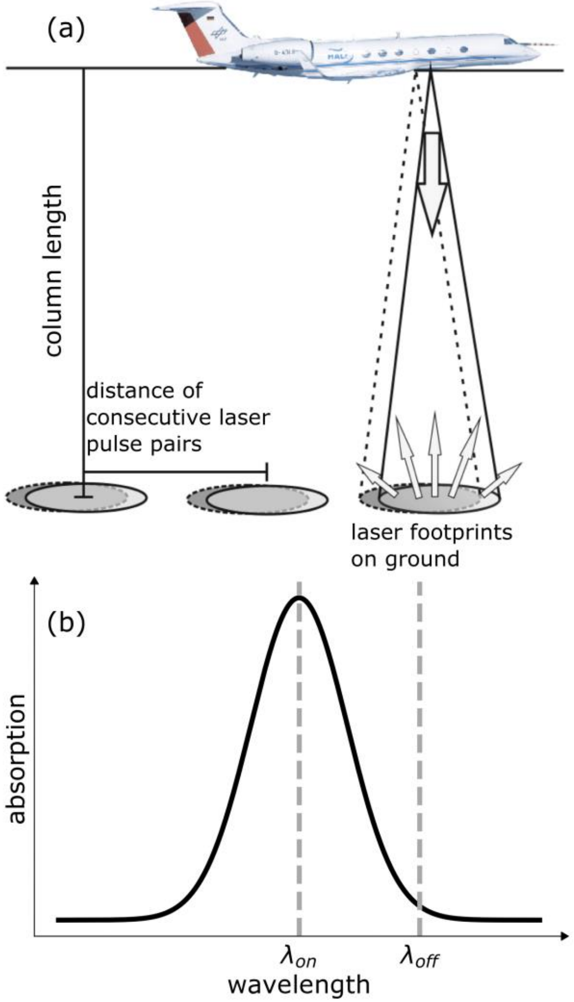


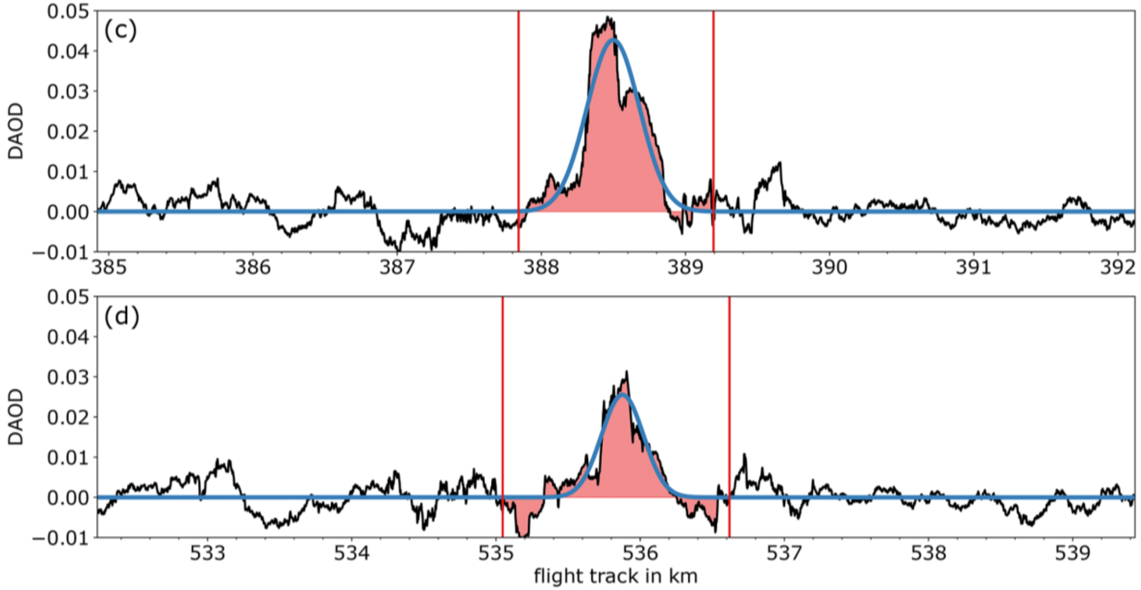
Figure 3: *Photograph of the CO_2 and CH_4 IPDA lidar as installed into the cabin of HALO.*



CH$_4$ AND CO$_2$ IPDA LIDAR MEASUREMENTS DURING THE COMET 2018 AIRBORNE FIELD CAMPAIGN

Andreas Fix[1*], Axel Amediek[1], Christian Büdenbender[1], Gerhard Ehret[1], Christoph Kiemle[1], Mathieu Quatrevalet[1], Martin Wirth[1], Sebastian Wolff [1], Heinrich Bovensmann[2], André Butz[3], Michał Gałkowski[4], Christoph Gerbig[4], Patrick Jöckel[1], Julia Marshall[4], Jarosław Nęcki[5], Klaus Pfeilsticker[3], Anke Roiger[1], Justyna Swolkień[5], Martin Zöger[6], and the CoMet team

[1] *German Aerospace Center (DLR), Institute of Atmospheric Physics, Oberpfaffenhofen, Germany*
2 University of Bremen, Institute of Environmental Physics, Bremen, Germany
[3] *University of Heidelberg, Institute of Environmental Physics, Heidelberg, Germany*
[4] *Max Planck Institute for Biogeochemistry, Jena, Germany*
[5] *AGH University of Science and Technology, Kraków, Poland*
[6] *German Aerospace Center (DLR), Flight Experiments, Oberpfaffenhofen, Germany*
**Email: andreas.fix@dlr.de*



Airplane technique: Mas balance with laser spectrometer (Picarro)


PICARRO

Applications | Products | Technology | Support | Company

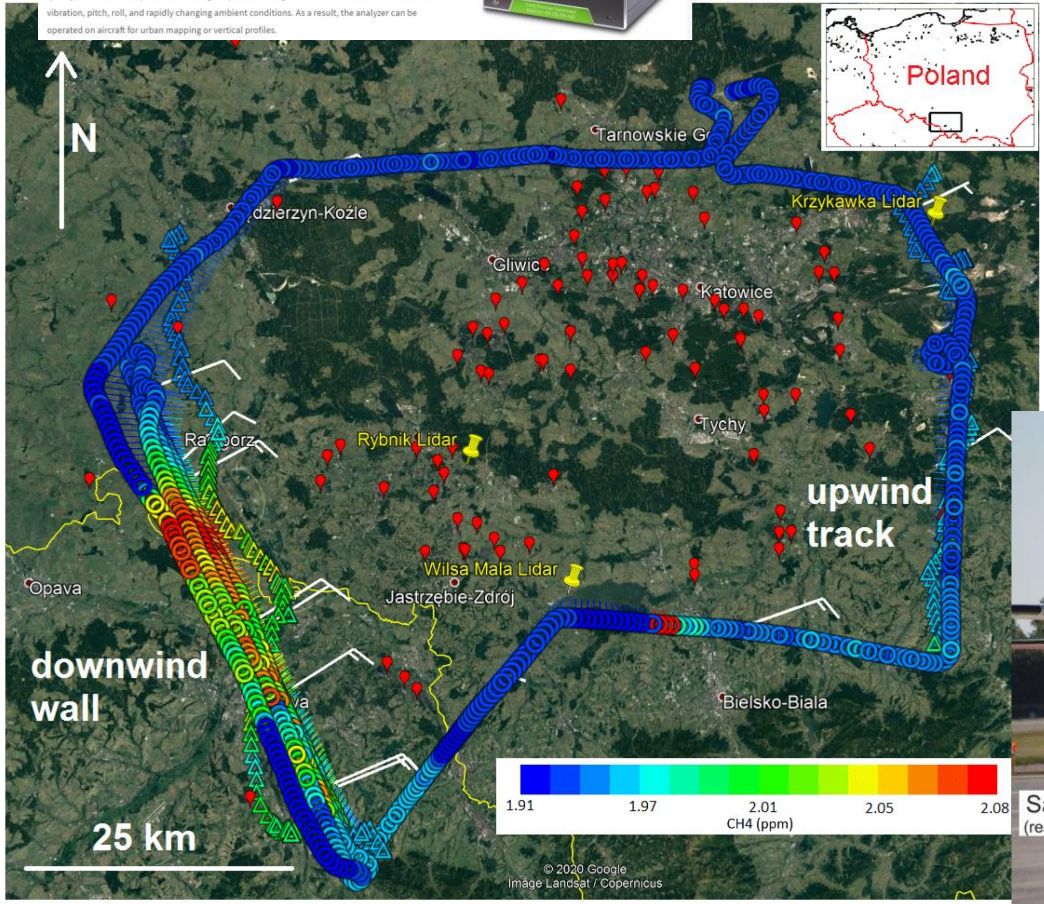
Continuous Monitoring for Real Time Insights

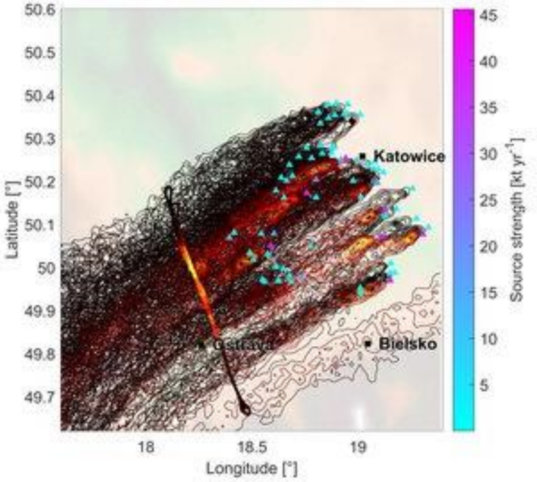
HOME / PRODUCTS / G2401-M IN-FLIGHT GAS CONCENTRATION ANALYZER

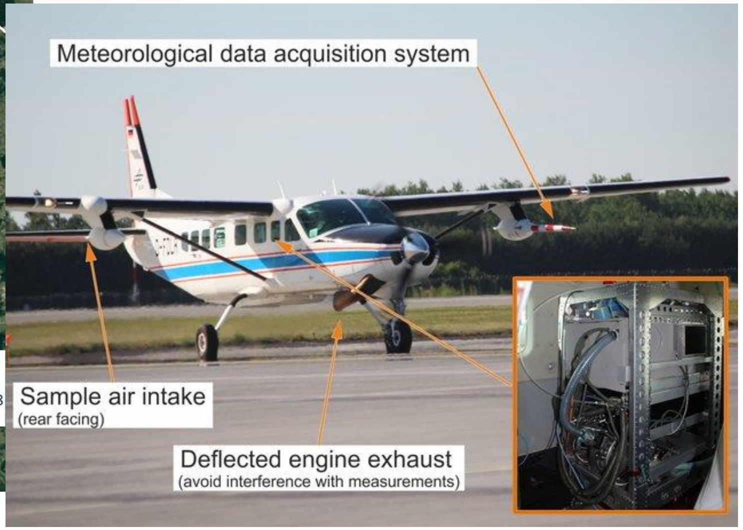
G2401-m In-flight Gas Concentration Analyzer

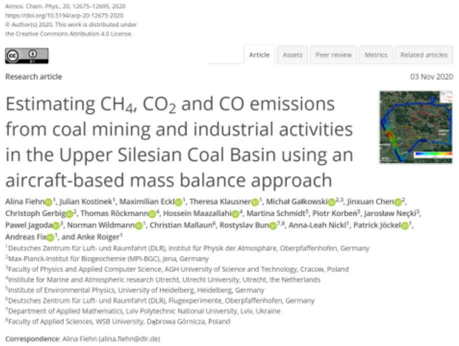
Measures CO, CO_2, CH_4, and H_2O

The Picarro G2401-m gas concentration analyzer provides simultaneous, precise measurement of carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4) at parts-per-billion (ppb), and water (H_2O) vapor at parts-per-million (ppm) sensitivity with negligible drift for atmospheric science, air quality, and emissions quantification. Flight-optimized design elements minimize effects of aircraft vibration, pitch, roll, and rapidly changing ambient conditions. As a result, the analyzer can be operated on aircraft for urban mapping or vertical profiles.









Atmos. Chem. Phys., 20, 12675–12695, 2020
https://doi.org/10.5194/acp-20-12675-2020

Article | Assets | Peer review | Metrics | Related articles

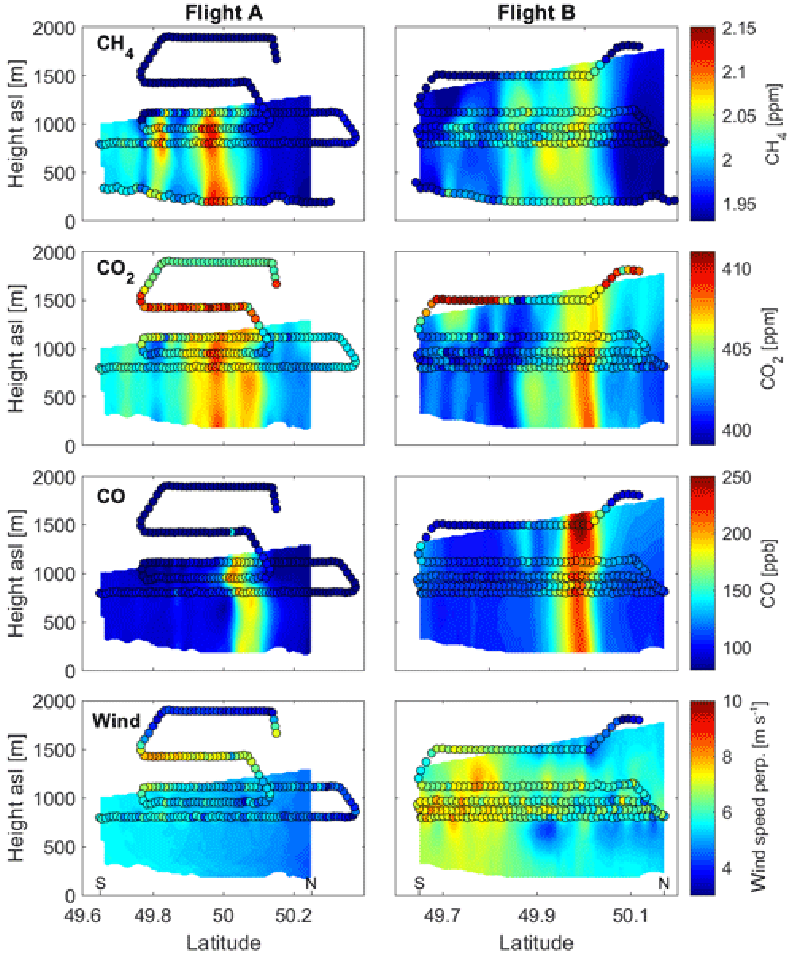
Research article — 03 Nov 2020

Estimating CH_4, CO_2 and CO emissions from coal mining and industrial activities in the Upper Silesian Coal Basin using an aircraft-based mass balance approach

Alina Fiehn[1], Julian Kostinek[1], Maximilian Eckl[1], Theresa Klausner[1], Michał Gałkowski[2,3], Jinxuan Chen[2], Christoph Gerbig[2], Thomas Röckmann[4], Hossein Maazallahi[4], Martina Schmidt[5], Piotr Korbeń[5], Jarosław Nęcki[3], Pawel Jagoda[3], Norman Wildmann[1], Christian Mallaun[6], Rostyslav Bun[7,8], Anna-Leah Nickl[1], Patrick Jöckel[1], Andreas Fix[1], and Anke Roiger[1]

[1]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany
[2]Max-Planck-Institut für Biogeochemie (MPI-BGC), Jena, Germany
[3]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Cracow, Poland
[4]Institute for Marine and Atmospheric research Utrecht, Utrecht University, Utrecht, the Netherlands
[5]Institute of Environmental Physics, University of Heidelberg, Heidelberg, Germany
[6]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Flugexperimente, Oberpfaffenhofen, Germany
[7]Department of Applied Mathematics, Lviv Polytechnic National University, Lviv, Ukraine
[8]Faculty of Applied Sciences, WSB University, Dąbrowa Górnicza, Poland

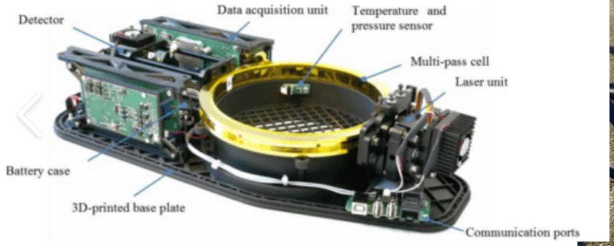
Correspondence: Alina Fiehn (alina.fiehn@dlr.de)



UAV (drone) techniques

direct

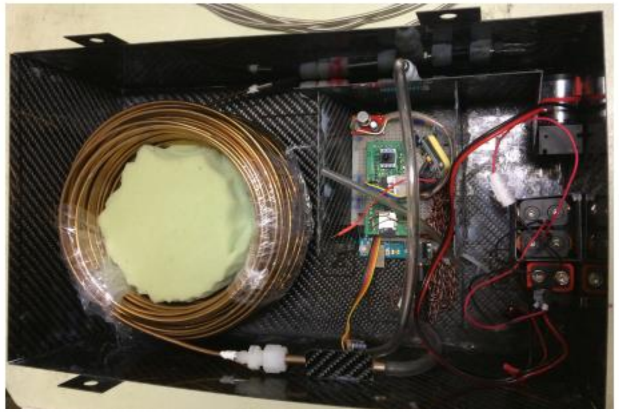
EMPA – analyser (QCL base)

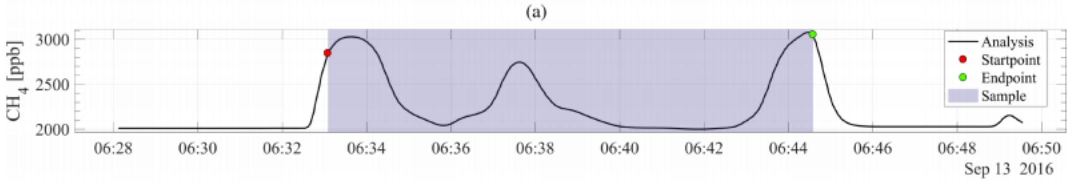


https://www.youtube.com/watch?v=fuQnPOCagI0&t=82s

indirect

CIO RUG – aircore system





https://doi.org/10.5194/amt-11-2683-2018

Atmospheric Measurement Techniques

A UAV-based active AirCore system for measurements of greenhouse gases

Truls Andersen[1], **Bert Scheeren**[1], **Wouter Peters**[1,2], **and Huilin Chen**[1,3]

[1]Centre for Isotope Research (CIO), Energy and Sustainability Research Institute Groningen (ESRIG), University of Groningen, Groningen, the Netherlands
[2]Meteorology and Air Quality, Wageningen University and Research Center, Wageningen, the Netherlands
[3]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, Colorado, USA

Correspondence: Huilin Chen (huilin.chen@rug.nl)

Mobile FTIR

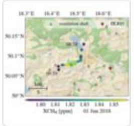
Atmos. Meas. Tech., 12, 5217–5230, 2019
https://doi.org/10.5194/amt-12-5217-2019

Article | Peer review | Metrics | Related articles

Research article

01 Oct 2019

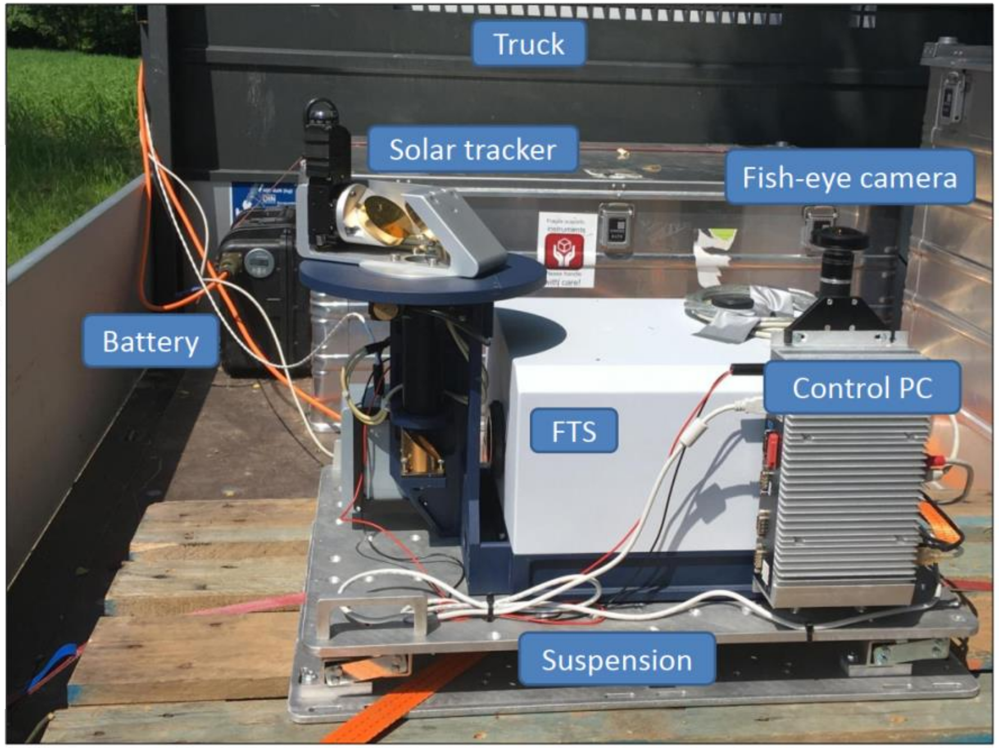
Quantifying CH_4 emissions from hard coal mines using mobile sun-viewing Fourier transform spectrometry

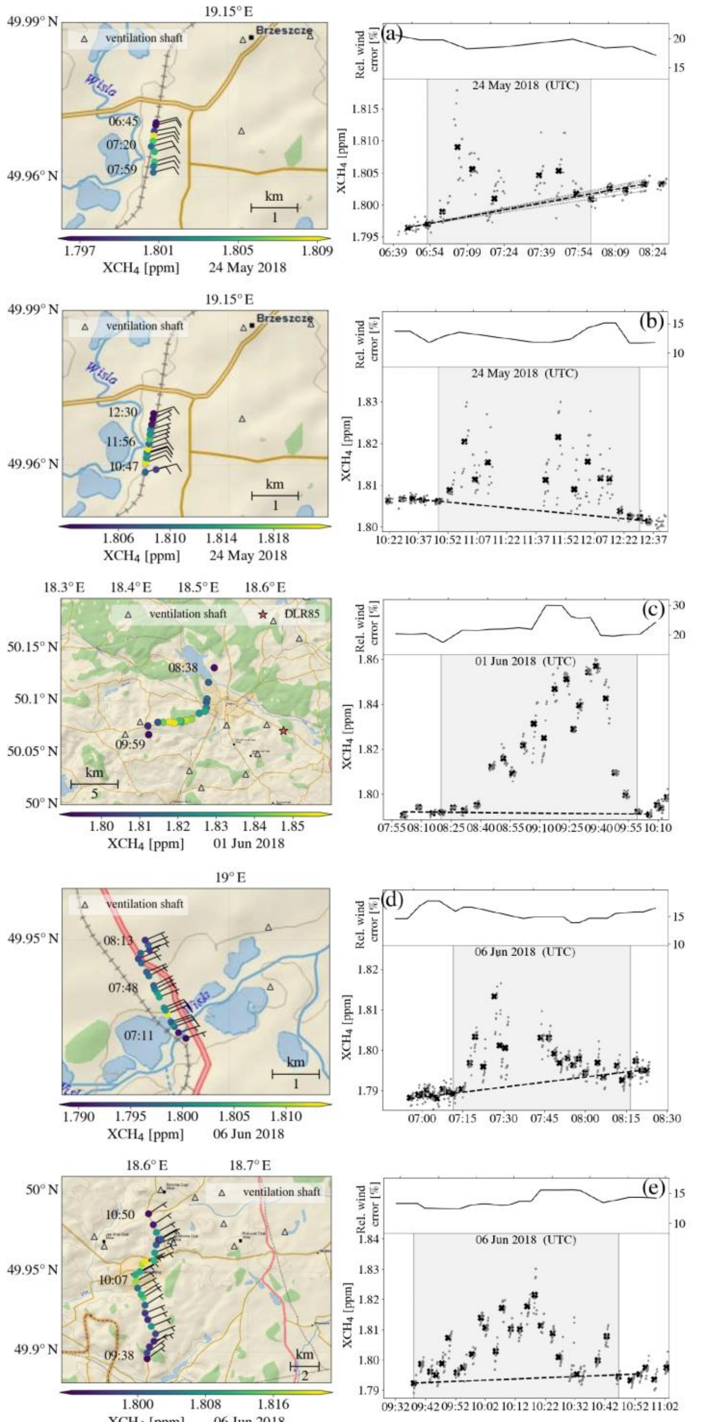


Andreas Luther[1], Ralph Kleinschek[7], Leon Scheidweiler[7], Sara Defratyka[6], Mila Stanisavljevic[4], Andreas Forstmaier[3], Alexandru Dandocsi[5], Sebastian Wolff[1], Darko Dubravica[2], Norman Wildmann[1], Julian Kostinek[1], Patrick Jöckel[1], Anna-Leah Nickl[1], Theresa Klausner[1], Frank Hase[2], Matthias Frey[2], Jia Chen[3], Florian Dietrich[3], Jarosław Nęcki[4], Justyna Swolkień[4], Andreas Fix[1], Anke Roiger[1], and André Butz[7]

[1]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany
[2]Karlsruhe Institute of Technology (KIT), Institute of Meteorology and Climate Research (IMK-ASF), Karlsruhe, Germany
[3]Environmental Sensing and Modeling (ESM), Technische Universität München (TUM), Munich, Germany
[4]AGH – University of Science and Technology, Cracow, Poland
[5]National Institute of Research and Development for Optoelectronics (INOE2000), Măgurele, Romania
[6]Laboratoire des sciences du climat et de l'environnement (LSCE-IPSL) CEA-CNRS-UVSQ Université Paris Saclay, Gif-sur-Yvette, France
[7]Institut für Umweltphysik, University of Heidelberg, Heidelberg, Germany

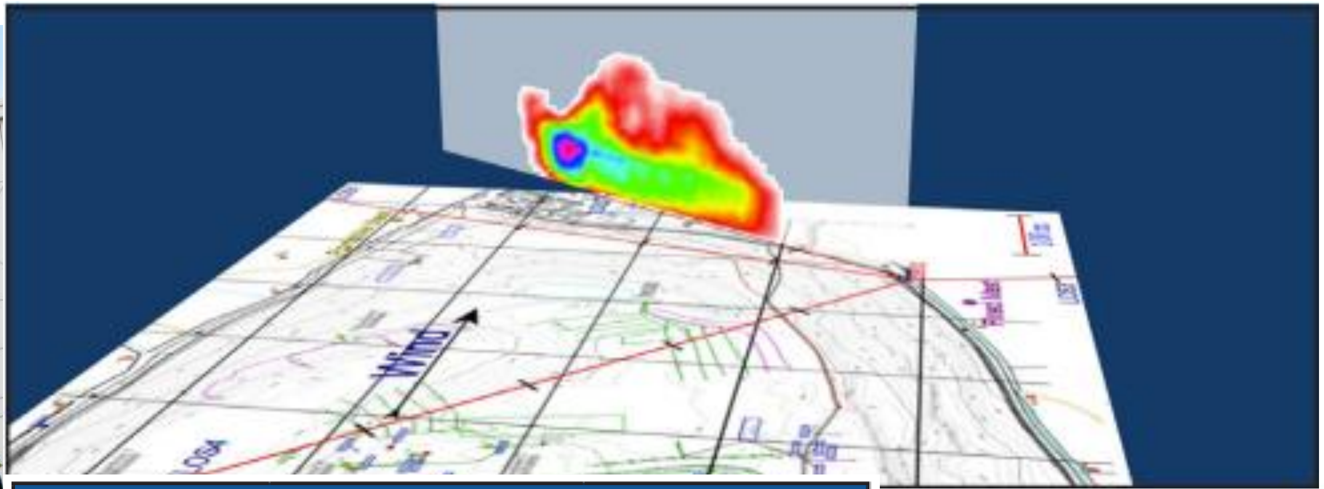
Correspondence: Andreas Luther (andreas.luther@dlr.de)





Date and time UTC	Esti. emissions ($kt\,a^{-1}$)	Combined σ ($kt\,a^{-1}$)	Combined σ %	E-PRTR ($kt\,a^{-1}$)
24 May 07:00 to 08:00	**6**	**1**	19	**9.63**
24 May noon	**10**	**1**	15	**9.63**
1 June 08:00 to 10:00	**109**	**33**	30	–
6 June 07:00 to 08:00	**17**	**3**	16	**24.3**
6 June noon	**81**	**13**	16	**∼80**

Differential Absorption Lidar (DIAL)



Typical DIAL IR performance		
Species	Sensitivity (ppb)	Max Range (m)
CH_4	80	600
C_2H_6	20	600
C_2H_4	130	600
C_2H_2	30	600
HCs	30	600
HCl	15	800

Ground-base mobile techniques

PICARRO

Natural Gas Asset Management Solution

Natural gas asset management solution

Advanced Leak detection
Emission quantification and reduction
Pipeline replacement optimization

IS IT TIME TO LAUNCH YOUR **SUPER EMITTER PROGRAM?**

Drive

Data Collection

Analyze

Data Analytics & Visualization

Act

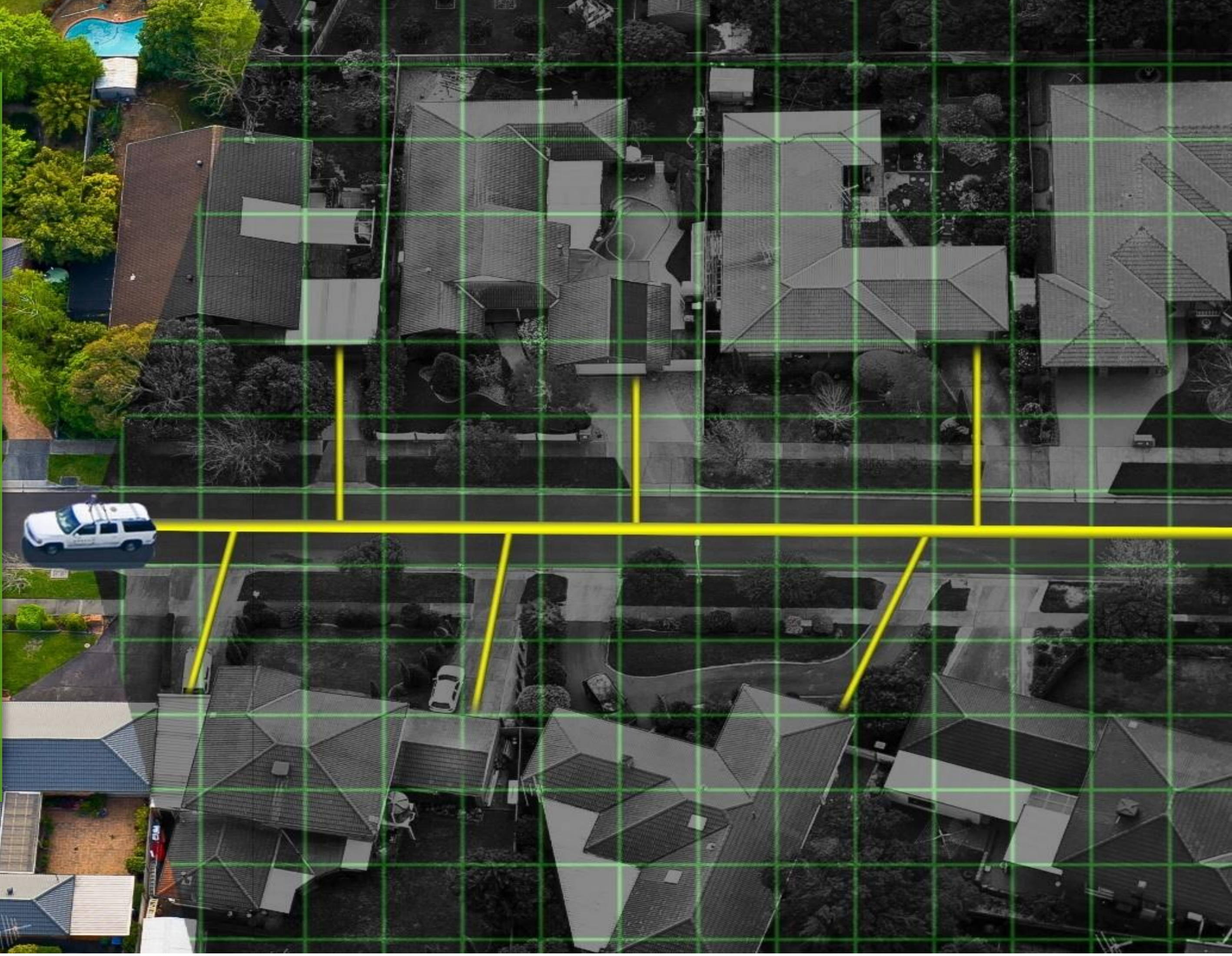
Target Super Emitters & Reduce Emissions

Picarro Natural Gas Asset Management

Picarro Natural Gas Asset Management solution proposes a new set of methane data for distribution network operators :

- Safety enhancement
- Emissions mitigation
- Pipeline replacement plan

Digitalize your distribution network



Picarro Natural Gas Asset Management

The Picarro Solution is a hardware-enabled software and data analytics platform that combines mobile methane emissions measurements with geospatial analytics and visualization packages using the P-Cubed software. The Picarro Solution enables natural gas operators to manage their networks to be more safe, clean, and cost-effective than ever before, increasing capital efficiency while simultaneously reducing risk in their infrastructure.

Applications supported include:

- **Leak Survey** – Picarro analytics allow utilities to focus on the most important leaks, keeping backlogs under control and maximizing the risk reduction impact per dollar of expense.

- **Emissions Quantification and Reduction** – The Picarro solution can measure an entire gas distribution network annually, to identify and prioritize the remediation of the highest-emitting "super emitters," resulting in annual emissions reduction exceeding 30%.

- **Pipeline replacement optimization** – Pipe segments can be ranked by emissions and predicted leak density to better inform capital pipe replacement priorities, accelerating risk reduction, and providing significant O&M cost avoidance.

Picarro Natural Gas Asset Management - Solutions

Natural Gas Compliance Leak Surveys

Advanced Leak Detection (ALD) allows natural gas leaks measurement at speed and scale, prioritizing leaks by risk to **increase network safety and reduce gas emergency interventions**.

Emission quantification & reduction

Quantify methane leaks and measure GHG emissions on your network.

Prioritize repairs of large emitters which frequently contribute disproportionately to network emissions as part of an informed and **cost-effective emission reduction strategy**.
Quantify annual emissions on your infrastructure.

Pipeline replacement program optimization

Identify individual network health and replace in priority sections of your network which require highest attention. Combine methane data with your own infrastructure pipeline integrity variables **Optimize your capital investment and reduce your operational repair budget**.

Optimize Asset management through predictive risk-based analytics

Develop a comprehensive risk model for your infrastructure. Assess the health of your infrastructure using Methane data collected on your network and combining it with network risk characteristics (likelihood of failure or consequence of failure).

Decarbonization of Natural Gas

Decarbonization of Natural Gas infrastructure requires identification or fugitive emissions and their abatement.

Picarro reports emission rates for individual leaks and to prioritize the largest emitters in leak detection and reporting (LDAR) or pipeline replacement programs. To leverage Picarro technology at scale, it's important to consider the following.

- DSOs are mostly regulated and so is their spending. Tariffs will need to be organised and managed in a way which helps DSOs manage networks in a flexible way.
- Monitoring, reporting and verification (MRV) methodologies will need to be harmonized. OGMP 2.0, as one example, has proposed a voluntary template. This could be made compulsory.
- While harmonization of methodology and reporting templates will ensure higher comparability, flexibility should still be left between countries on the measures they implement to address emissions depending on their systems.
- Synergies – for example, between data captured for leak detection and its potential for developing MRV systems – should be supported by the upcoming legislation.

Decarbonization of Natural Gas – Innovation to reduce emissions

- Europe leads the way in becoming carbon neutral and gas technologies will become key to meet ambitious decarbonization goals and stay competitive in the global market using innovative way to manage their infrastructure

"A balanced combination of hardware, software, and data analytics that can help companies better manage assets, improve worker safety and perform well in the field with reduced environmental impact."

eurogas 30 years

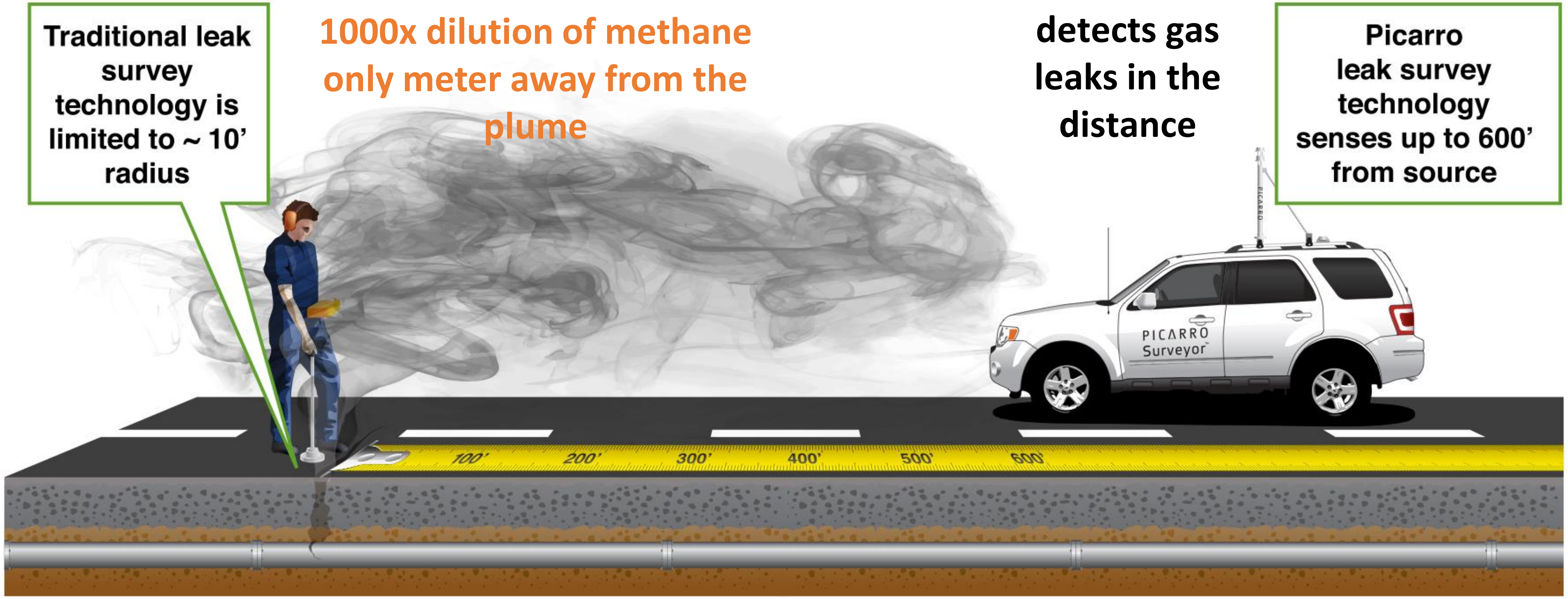
Gas Tech Talk: Methane leak detection for utilities

Picarro is a leading provider of asset management solutions for the natural gas industry.

https://www.youtube.com/watch?v=XUBP3XkN2bU

Picarro - Natural gas detection concept

- Traditional leak survey equipment sensitivity requires “in-leak” measurement to be efficient. Performance degrade very quickly (0.5m) as the plume starts to dilute in the atmosphere.
- Detecting leaks from the distance requires very high sensitivity down to ppb level, a very reliable modeling of atmospheric conditions and analytics to prioritize leaks and avoid false alarms.



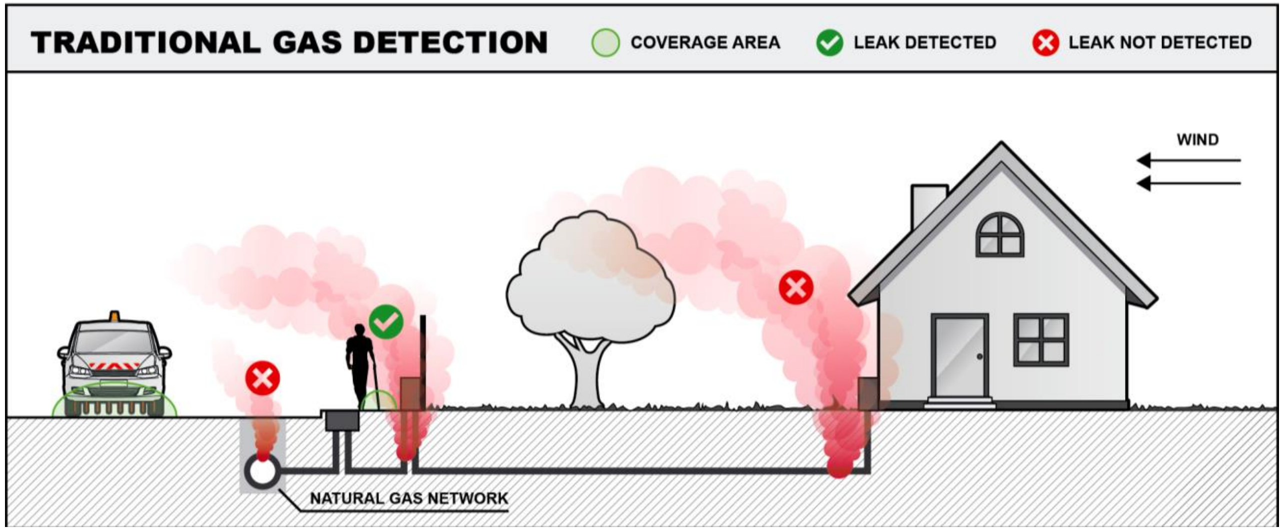
Picarro Proprietary Hardware

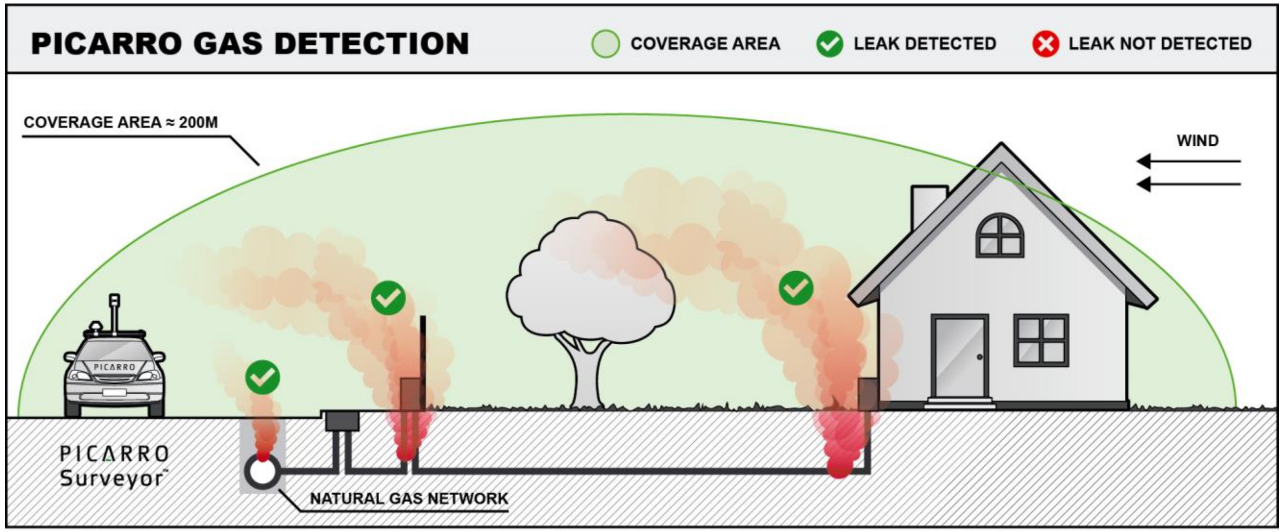
- The Picarro's technology built in a dedicated vehicle

Hardware

- High sensitivity gas analyzer based on CRDS
- Methane/Ethane + other gases at ppb in 1 Hz
- Anemometer - Wind speed and direction
- Atmospheric modelling algorithms
- High precision GPS with inertial movement control
- 4G connection and router
- Tablet computer
- Gas inlet system
- 1000x more sensitive than traditional technology

Realtime environment monitoring vs. traditional techniques





Downsides:

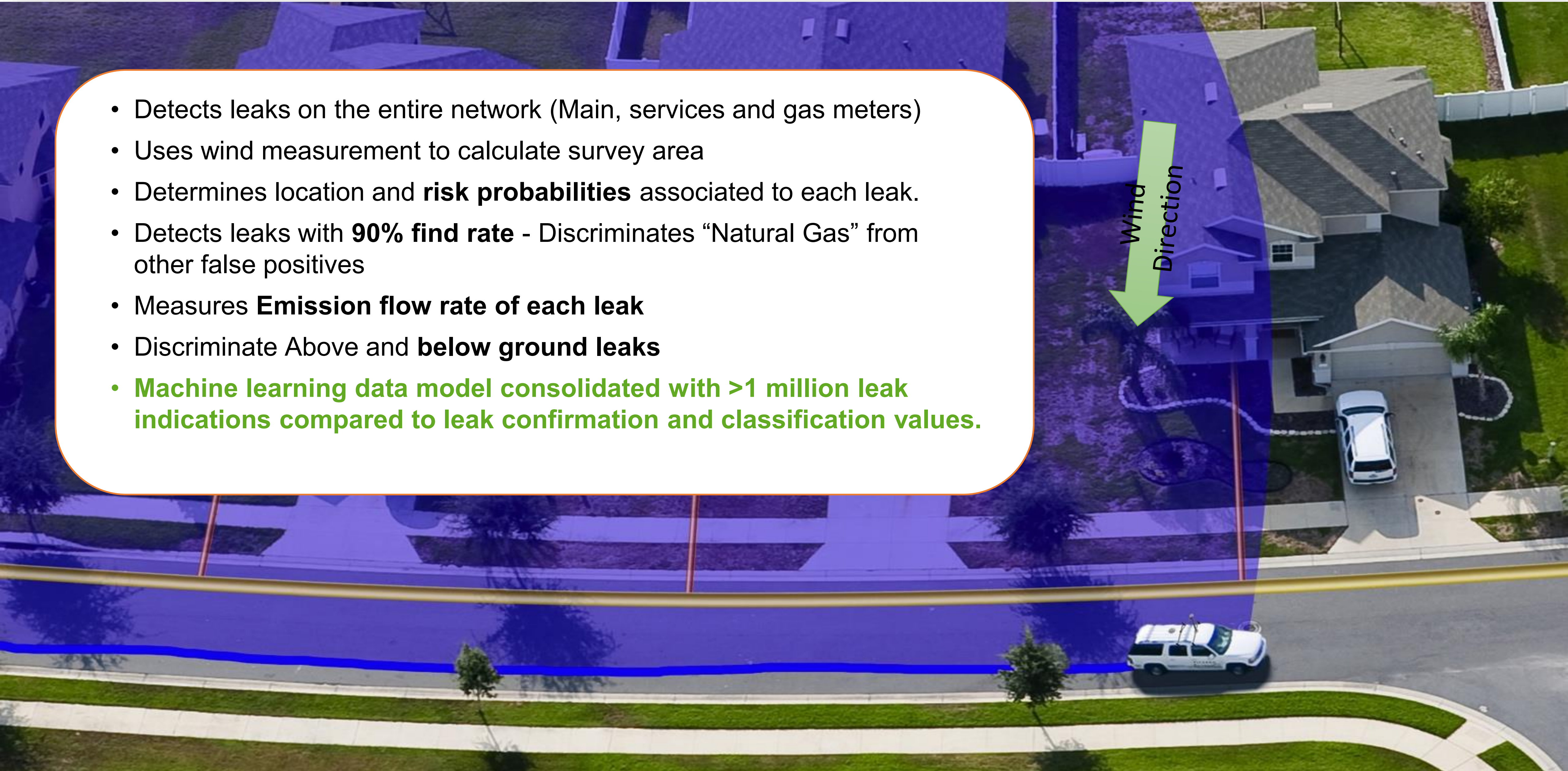
- Poor detection gas leaks
- Detects only leaks on main pipeline
- Detects only CH_4
- Low survey area - Vehicles must pass over the pipelines
- Sensitive to weather conditions

Upsides:

- Very high detection of leaks including underground leaks
- Detects leaks on the entire network (Main, services, aerial and smart meters)
- Discriminates “Natural Gas” from other false positives
- Large survey area
- Not sensitive to weather conditions

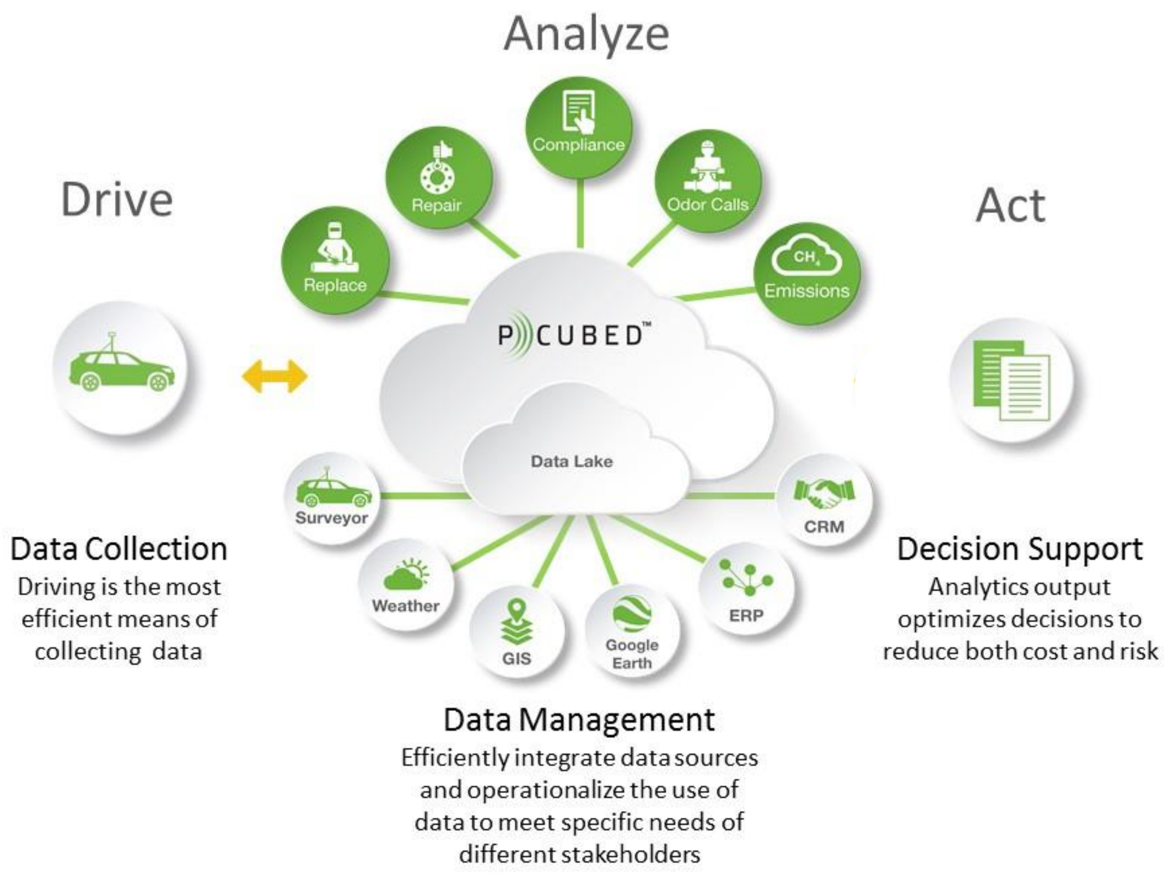
Picarro Advanced Leak Detection - Concept

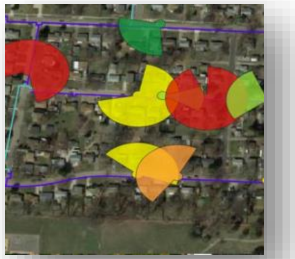
- Detects leaks on the entire network (Main, services and gas meters)
- Uses wind measurement to calculate survey area
- Determines location and **risk probabilities** associated to each leak.
- Detects leaks with **90% find rate** - Discriminates "Natural Gas" from other false positives
- Measures **Emission flow rate of each leak**
- Discriminate Above and **below ground leaks**
- **Machine learning data model consolidated with >1 million leak indications compared to leak confirmation and classification values.**



Picarro natural gas asset management – data driven actions

Data is collected by car, analyzed by **proprietary algorithms, and transformed into actionable information**





Prioritize leaks

- Calculate the risk associated to each leak
- Prioritize leak repair based on risk
- Optimize operational resources

Reduce fugitive emissions

- Measure emissions from the vehicle
- Identify and repair highest emitters
- Quantify network emissions

Optimize pipeline replacement

- Identify below ground leak density on your network
- Replace leaking pipeline instead of repairing leaks