Atmospheric methane emission from mining areas and its significance.

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New measurement driven approaches to improve greenhouse gas emission estimates.

"On the pathway to new greenhouse gas monitoring systems"

Side event at the German Pavilion at UNFCCC COP24

COP24·KATOWICE 2018

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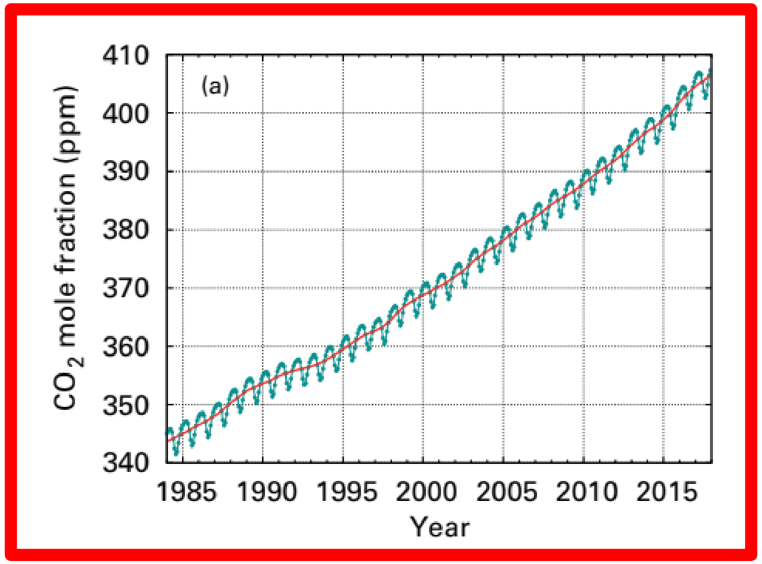
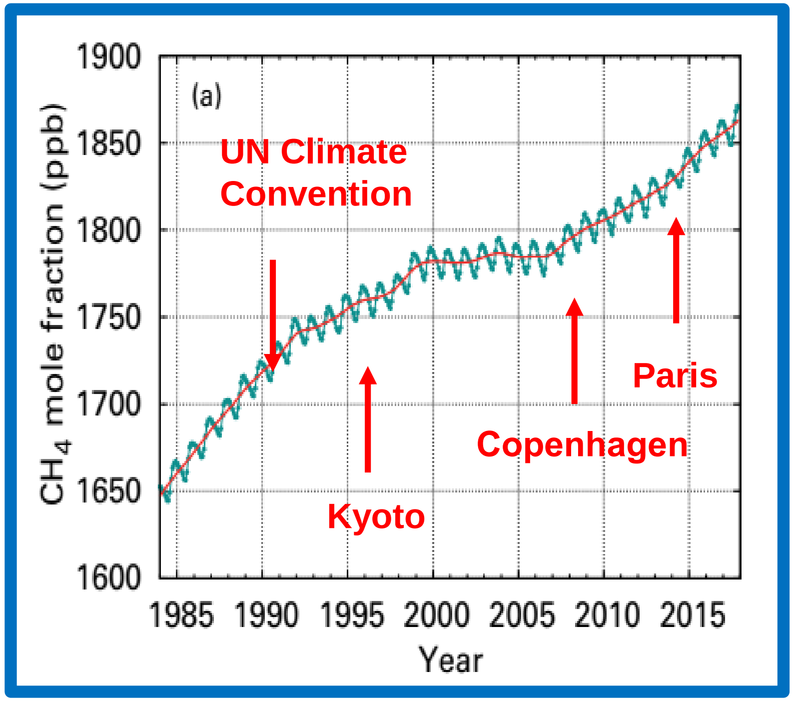
Atmospheric greenhouse gas concentrations continue to rise globally!

CO_2 in the atmosphere



CH_4 in the atmosphere



In comparison to CO_2, the changes in CH_4 are not well understood, due to multitple natural and antropogenic sources

The ability to quantify CH_4 emissions on all temporal and spatial scales is urgently needed!

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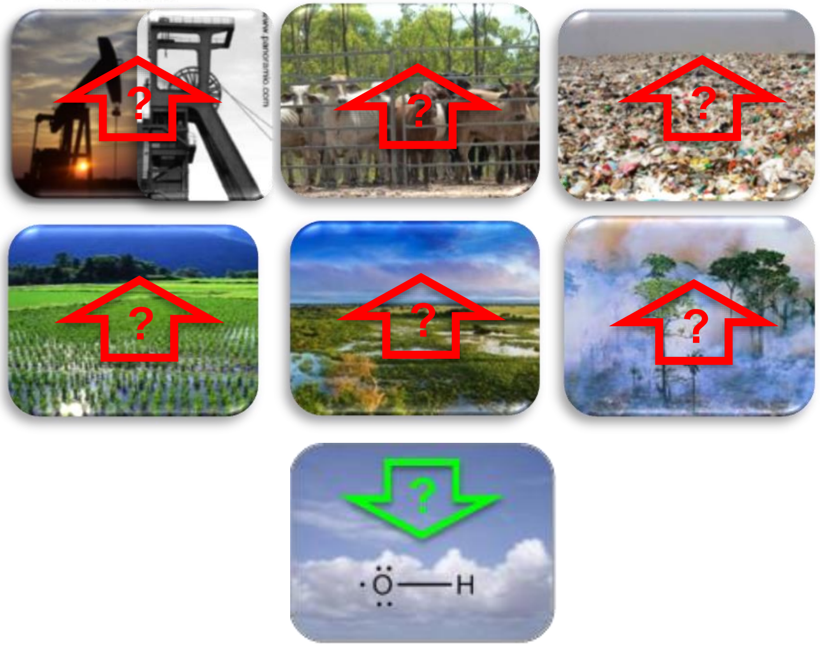


PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

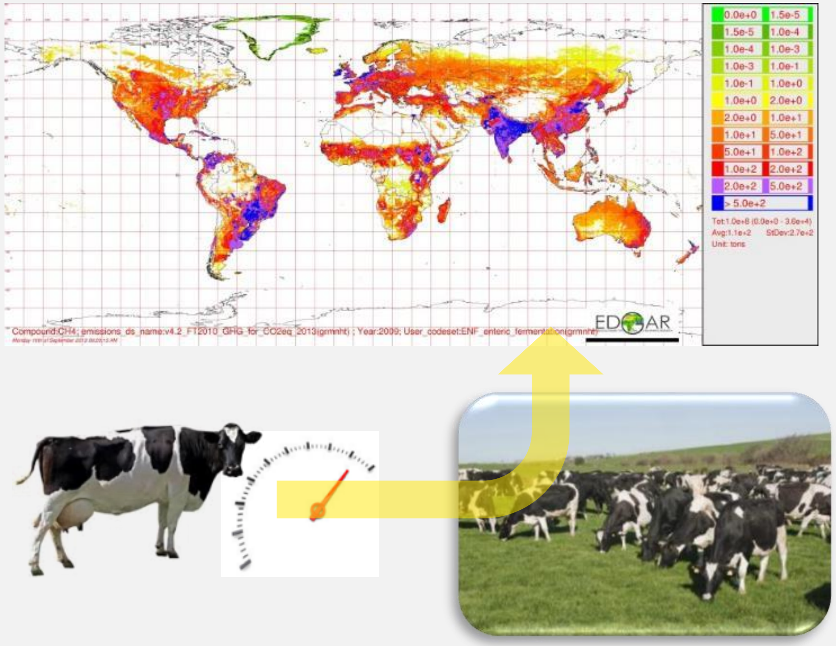
- to understand the processes, cycles, and detect feedbacks (e.g., permafrost thawing, changing wetlands)
- to assess the effectiveness of emission reduction schemes (e.g. Paris Agreement)

There is a clear need for **observations to support reporting/stocktaking**

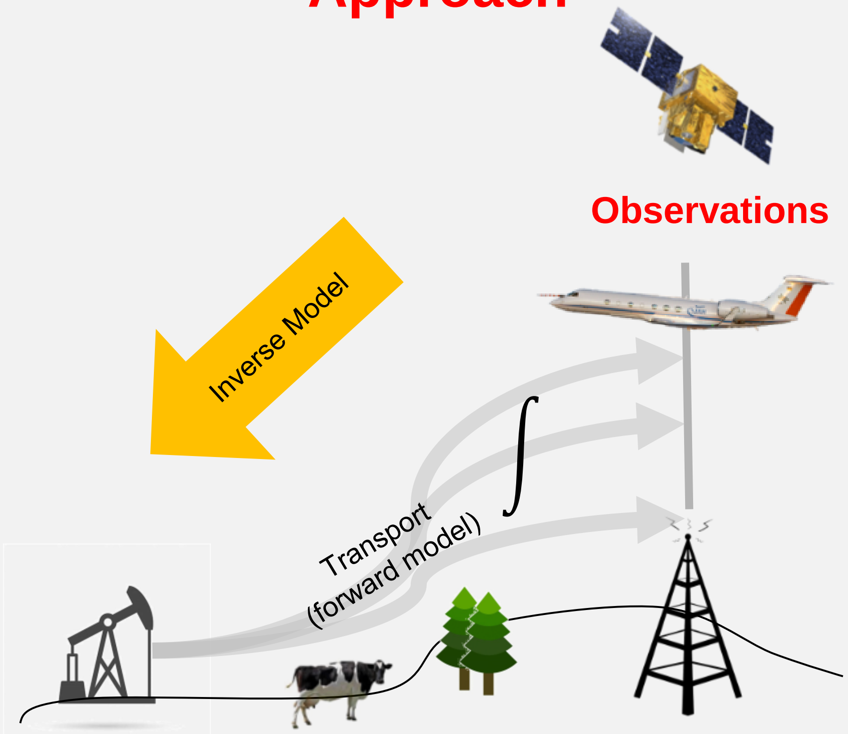
Integrated GHG monitoring system required

Two ways to estimate greenhouse gas emissions

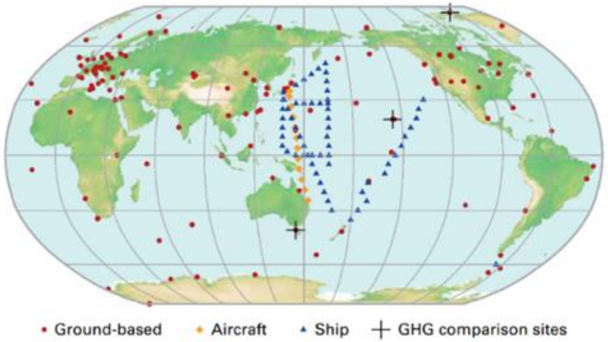
Bottom-Up Approach

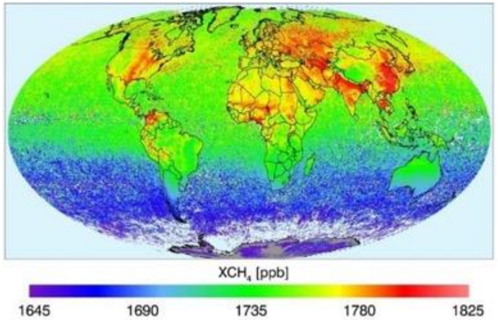


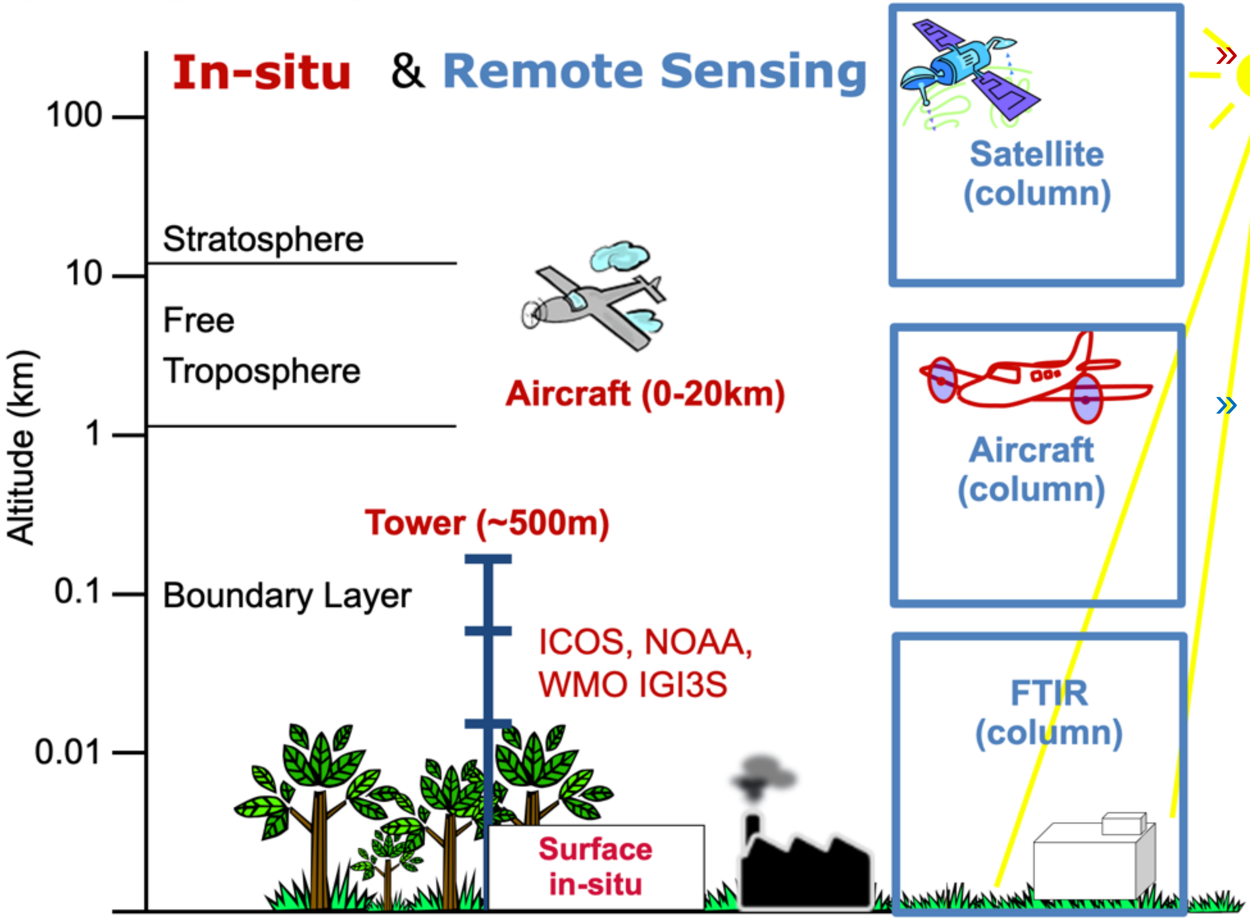
Top-Down Approach



Capabilities of todays Atmospheric Greenhouse Gas Observation System and the need for ist sustained capabilities



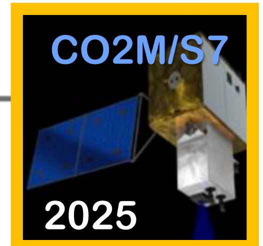




» **In-situ** ground based networks needs better coverage (esp. tropics) and enhanced **isotope measurement** capabilities to discriminate origin of GHG

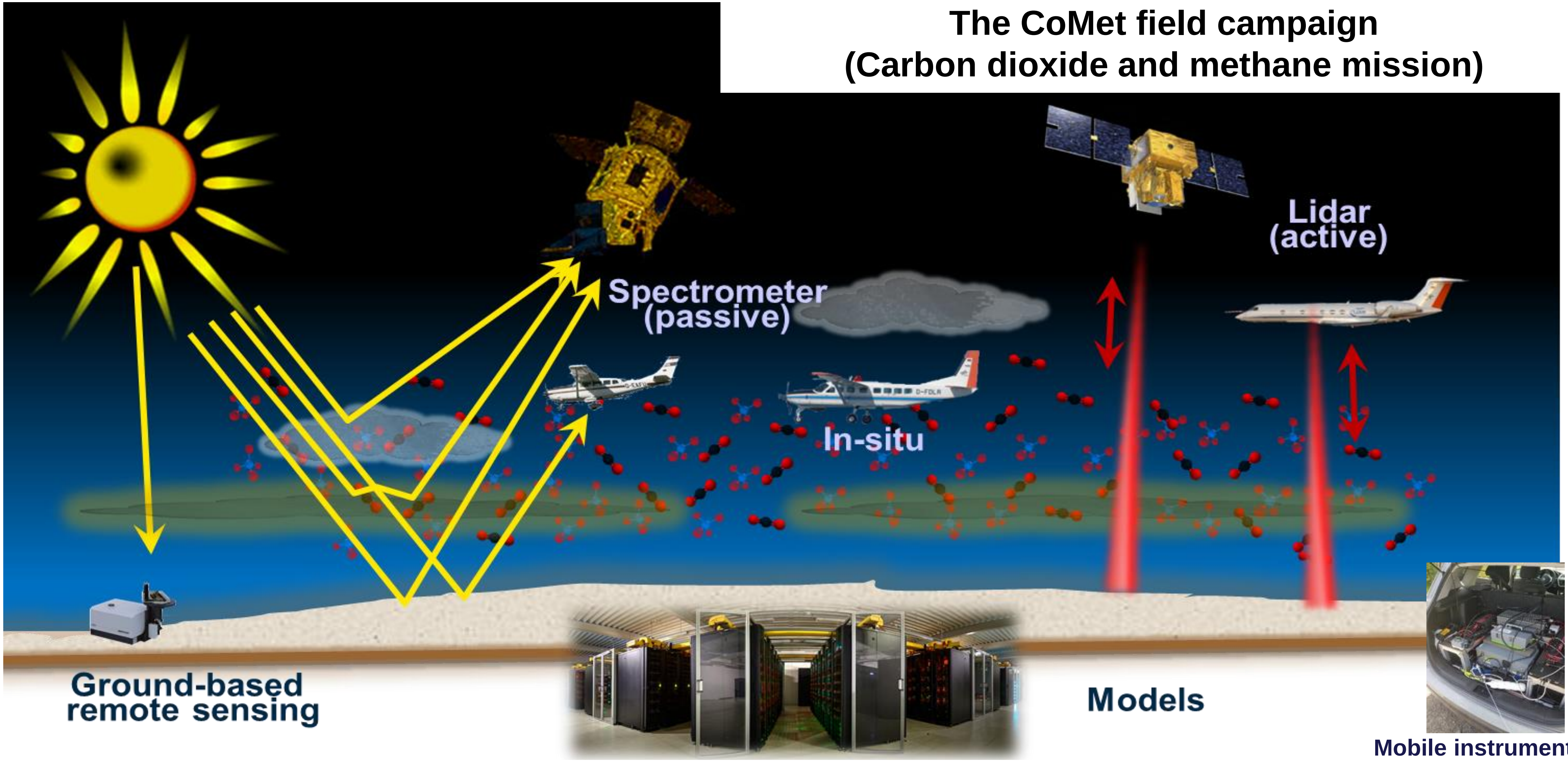
» **Satellite** data to constrain GHG emission needs:

- High precision
- High accuracy
- High spatial resolution
- Good spatial coverage



➤ **Combination of futures satellites**

The CoMet field campaign
(Carbon dioxide and methane mission)



CoMet: A DLR-led coordinated field campaign including various national, international, and in particular also Polish partners.

Upper Silesia as a model case

Goal:

- combine a suite of state-of-the art remote sensing and in-situ instruments on **several aircraft** and **on ground** (and even supported by **satellite measurements**)
- test the measurement capabilities
- provide regional-scale GHG data urgently required
- provide additional information to constrain bottom-up inventories

CoMet: Complementary and innovative airborne payload

✓ **Active (Laser) Remote Sensing**
- high accuracy,
- day / nighttime, high latitudes
- insensitive to clouds and aerosol
- future satellite instruments

✓ **Passive Remote Sensing (Spectrometer)**
- very precise
- well adapted to local sources
- similar to current satellite instruments

✓ **In-situ instruments**
- highest accuracy and precision
- WMO standard
- Isotope analysis for source identification

✓ **Ancillary information**
- Meteorology (wind temperature, humidity)

A view into the aircraft cabin

At Katowice airport, June 2018

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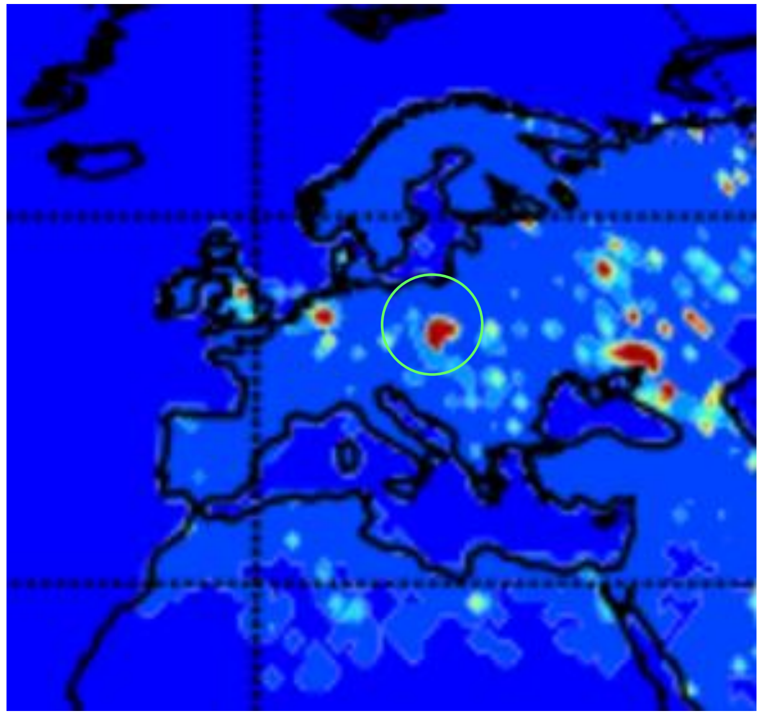
MEMO^2: MEthane goes Mobile-Measurments and MOdeling

Mobile platform

Comparison with Instrument in aircraft

Different analysers

Primary target of CoMet: Why Upper Silesian Coal Basin (USBC POLAND)?

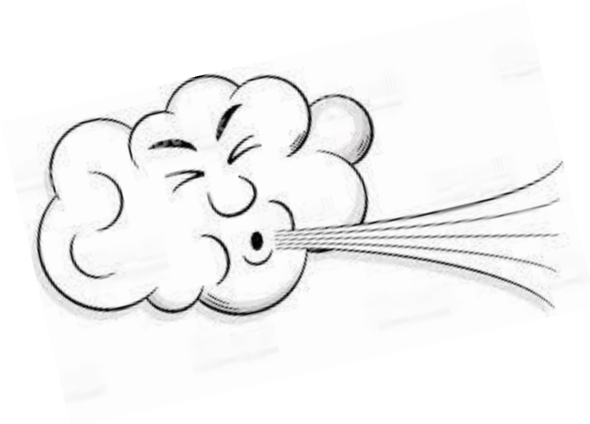


Poland is the 9th largest coal producer in the world

Mining industry in Poland is responsible for 1.8 % of the global anthropogenic CH_4 emission

Underground coal mines are responsible for 36,1 % of anthropogenic emission of CH_4 in Poland

Methane emission from hard coal mines in 2018



511,2 ktCH_4/year

Drained methane but not utilized

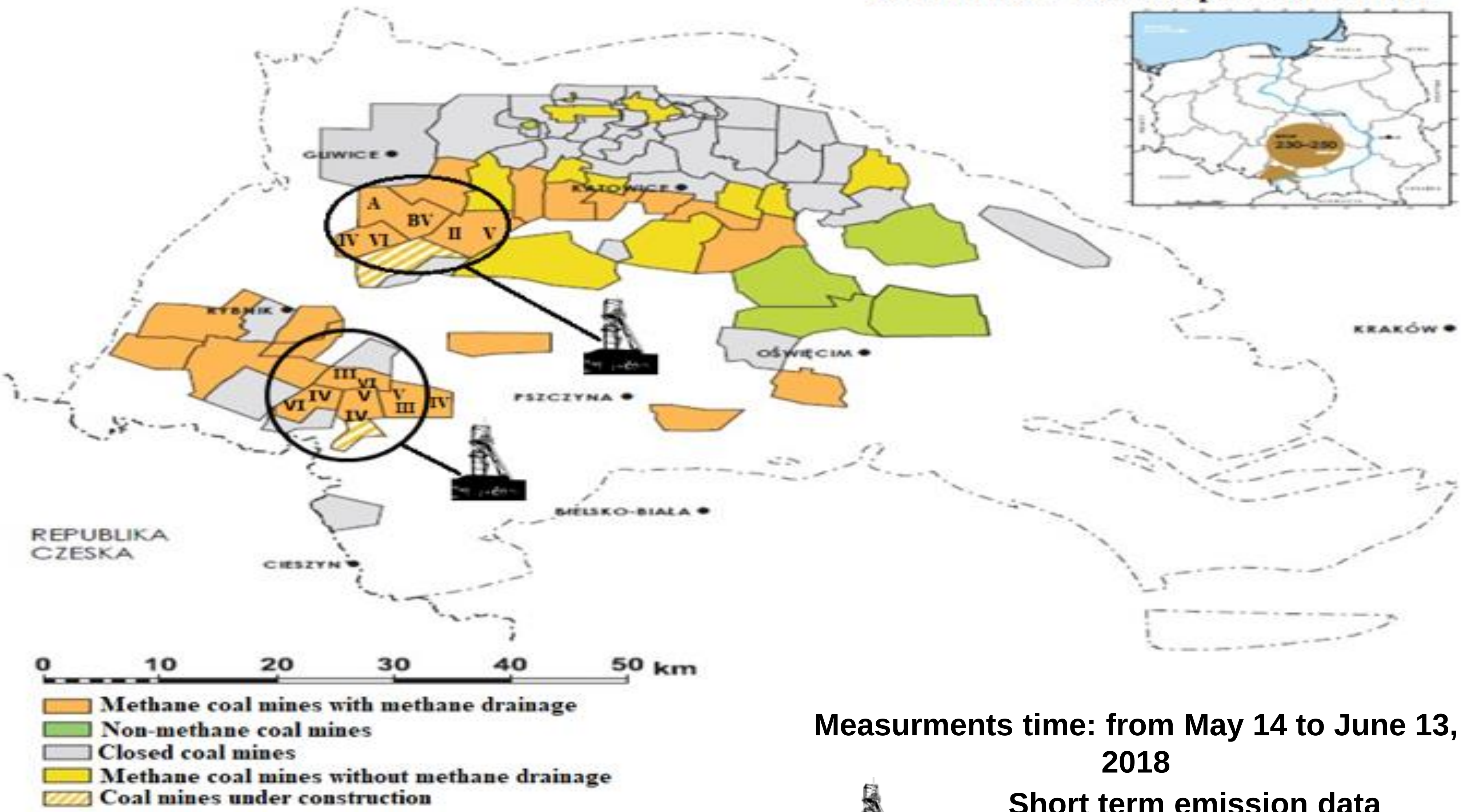
81,62 ktCH_4/year

Ventilation air methane

429,5 ktCH_4/year

Coal mines in Upper Silesia

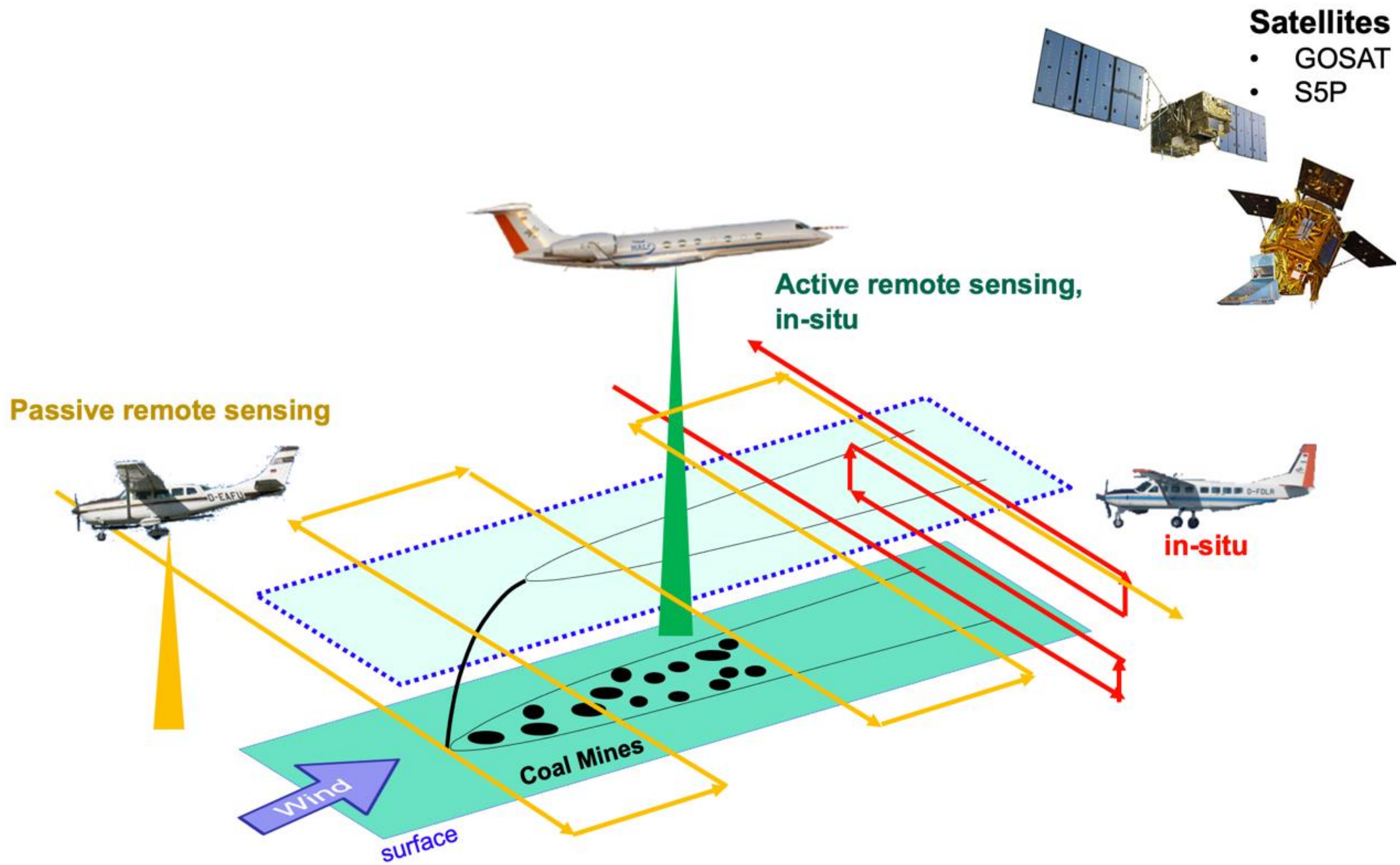
Total methane resource potential in USCB



Measurments time: from May 14 to June 13, 2018

Short term emission data from 15 ventilation shafts in 7 coal mines

CoMet measurement strategies in USCB: aircraft, ground-based, satellites, and models



Plus: Ground based instrumentation

- E.g. in-situ instruments on vans

Halo aircraft over USCB flight plan

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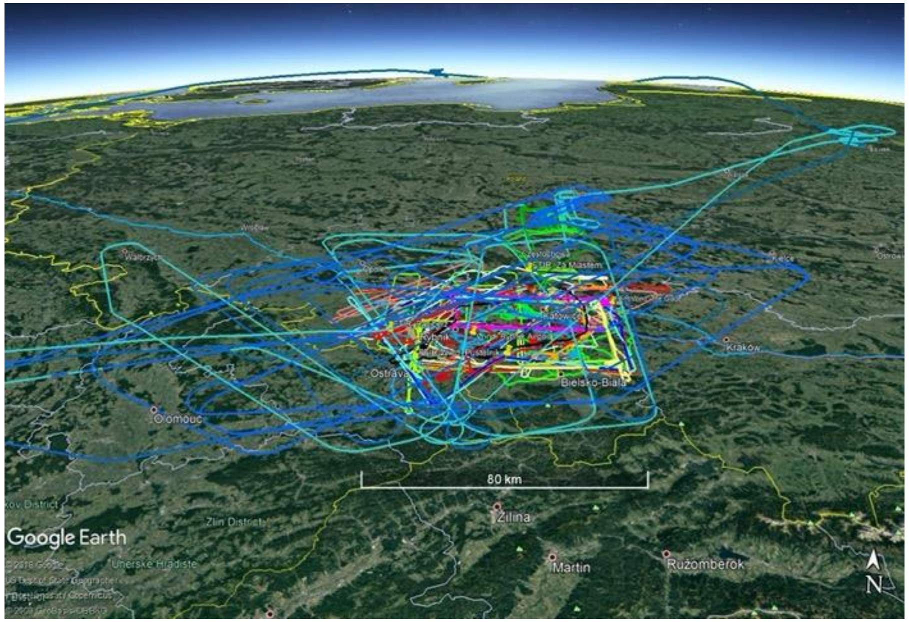
Halo over USCB flight plan

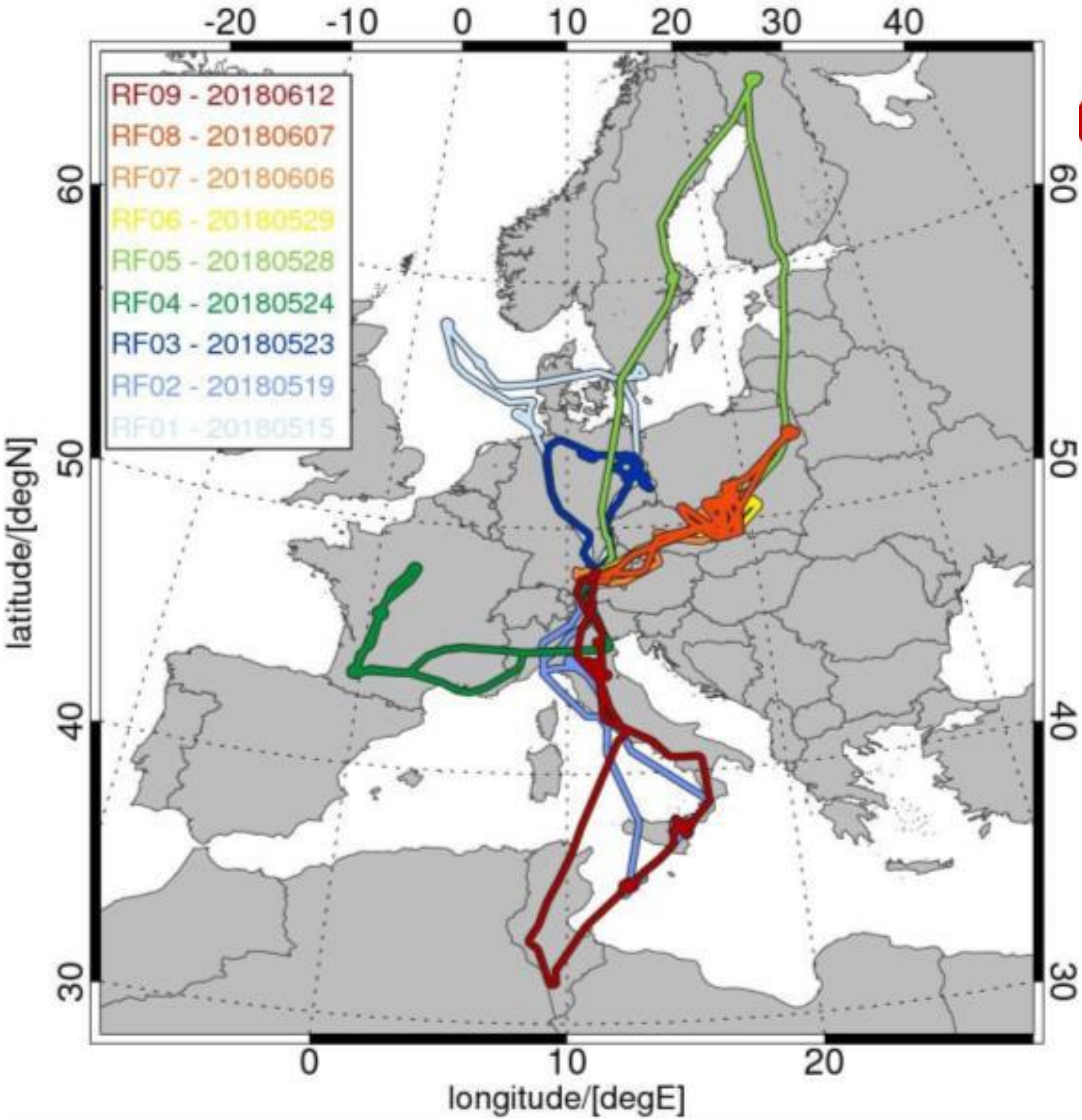
May 28, 2018

May 29, 2018

June 6, 2018

June 7, 2018





Andreas Fix, Axel Amediek, Christian Budenbender, Gerhard Ehret, Christoph Kiemle, Mathieu Quatrevalet, Martm Wirth, Sebastian Wolff, Heinrich Bovensmann, Androe Butz, Michal Galkowski, Christoph Gerbig, Pattick Jöckel, Julia Marshall, Jaroslaw Nęcki, Klaus Pfeilsticker, Anke Roiger, Justyna Swolkień, Martin Zöger, the CoMet team, *CH4 and C02 IPDA Lidar Measurements During the Comet 2018 Airborne Field Campaign*," EPJ Web Conf. 237 03005 (2020), https://doi.org7T0.1051/ep1conf/202023703005

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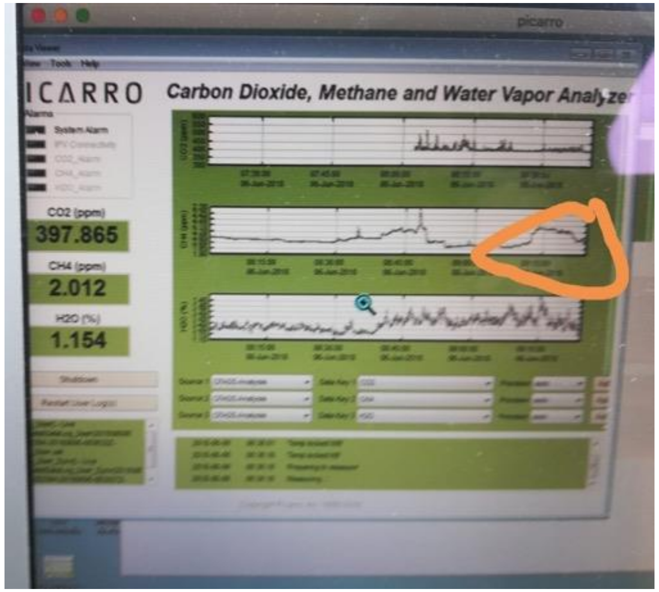
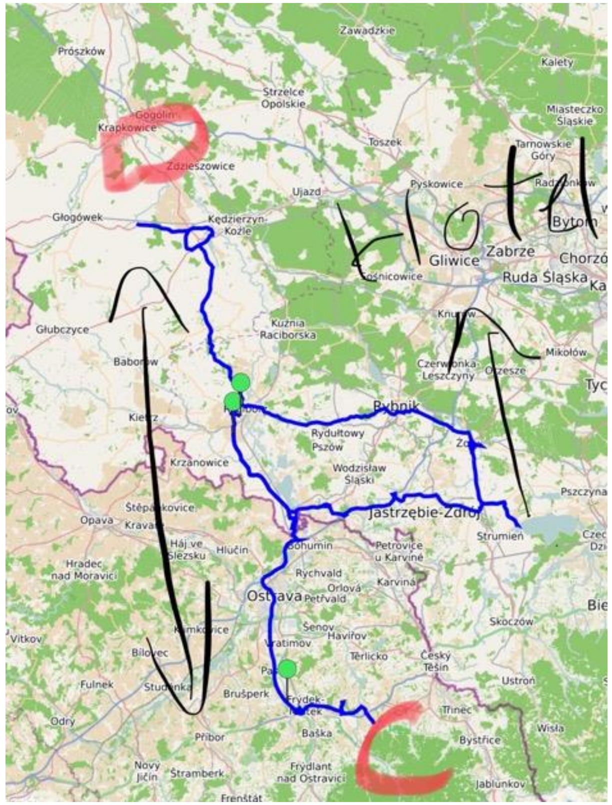
MEMO^2:Mobile instruments

Ground transects in Silesia – operator view

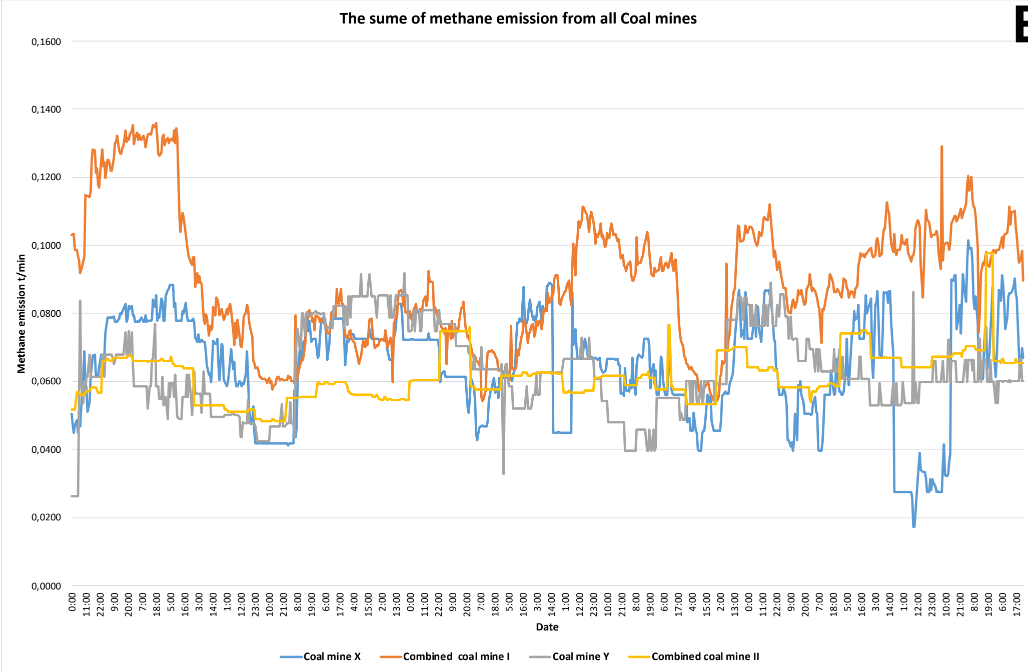


Direct sampling from shafts

Exchange info with airplane team



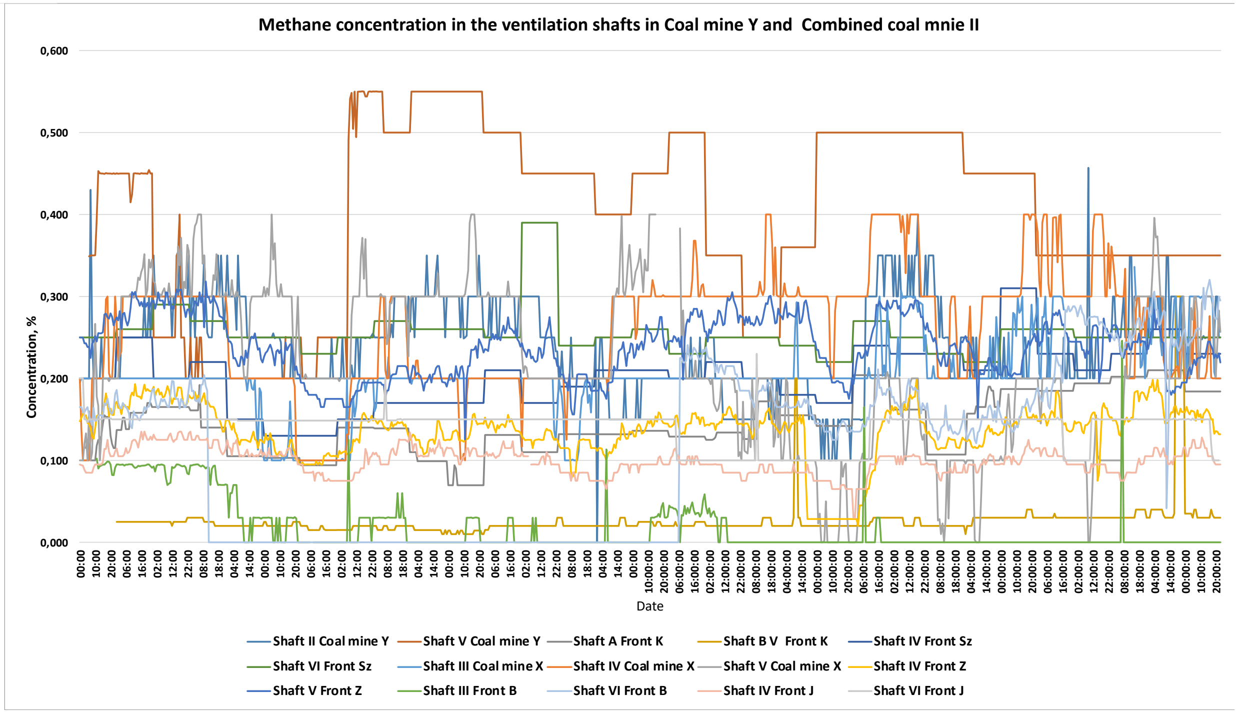
Emissions temporal variation to compare with airborn measurments

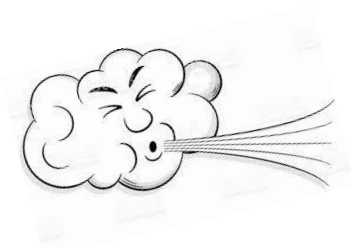


Concentration of CH_4 in 15 shafts vary between 0.10 % and 0.55 %

Temporal variation of CH_4 emission

0.23 t/min to 0.36 t/min





Coal mines under observation in just one month discharged 12.04 kt of methane.

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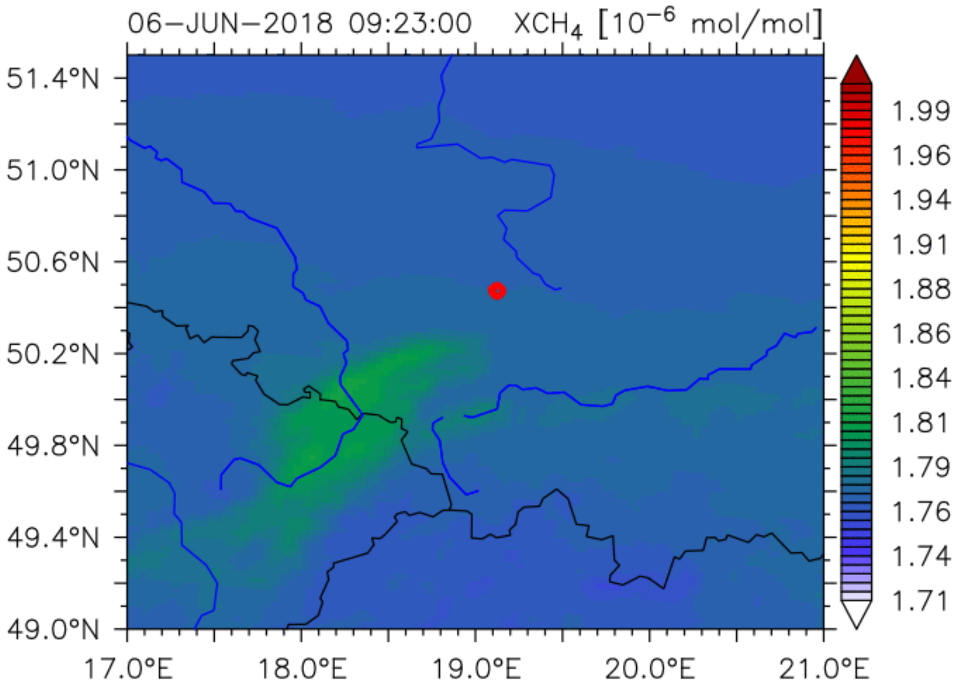
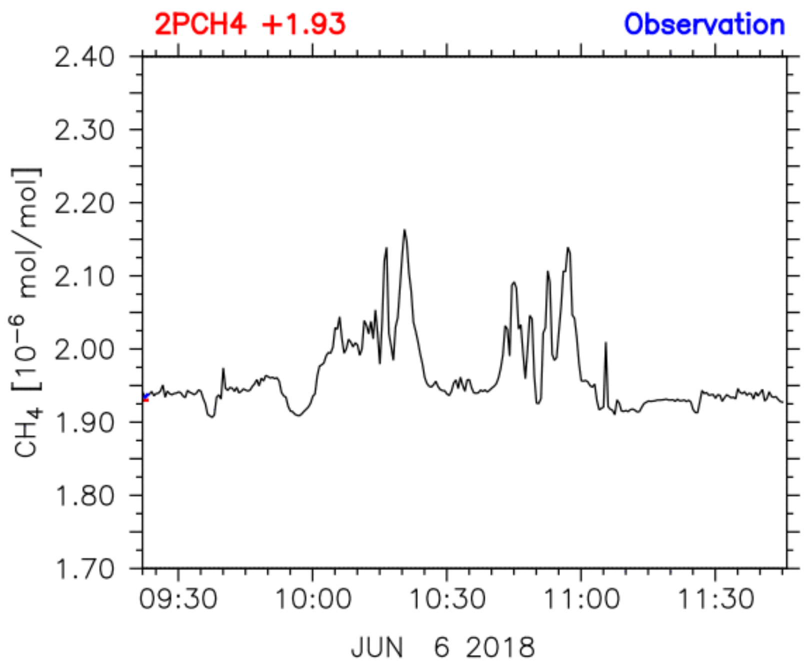
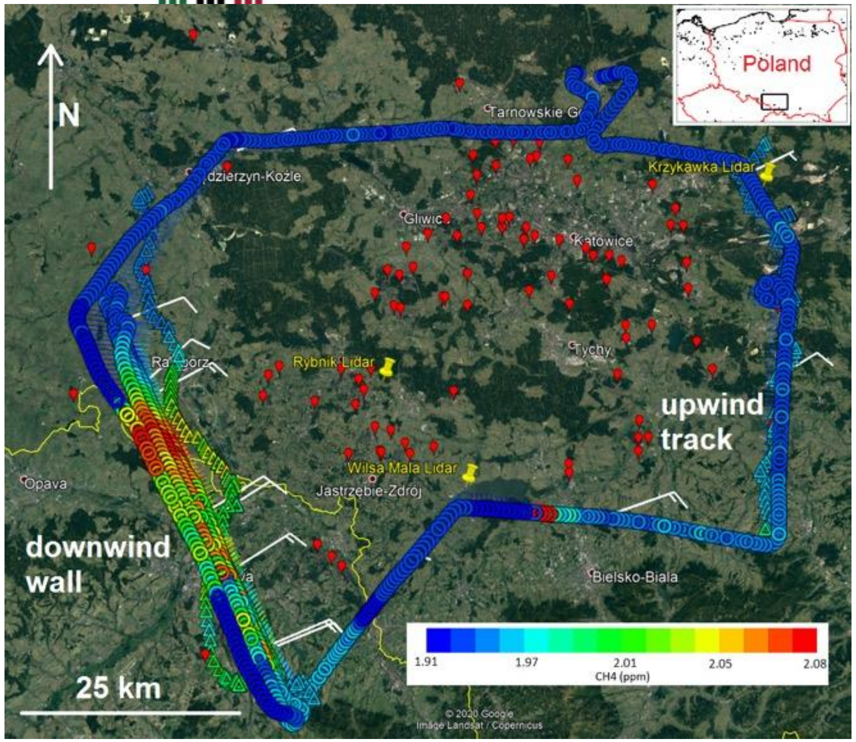
Model (resolution 2.7 km) and measurement comparison (Cessna in-situ flight on June 6, 2018)



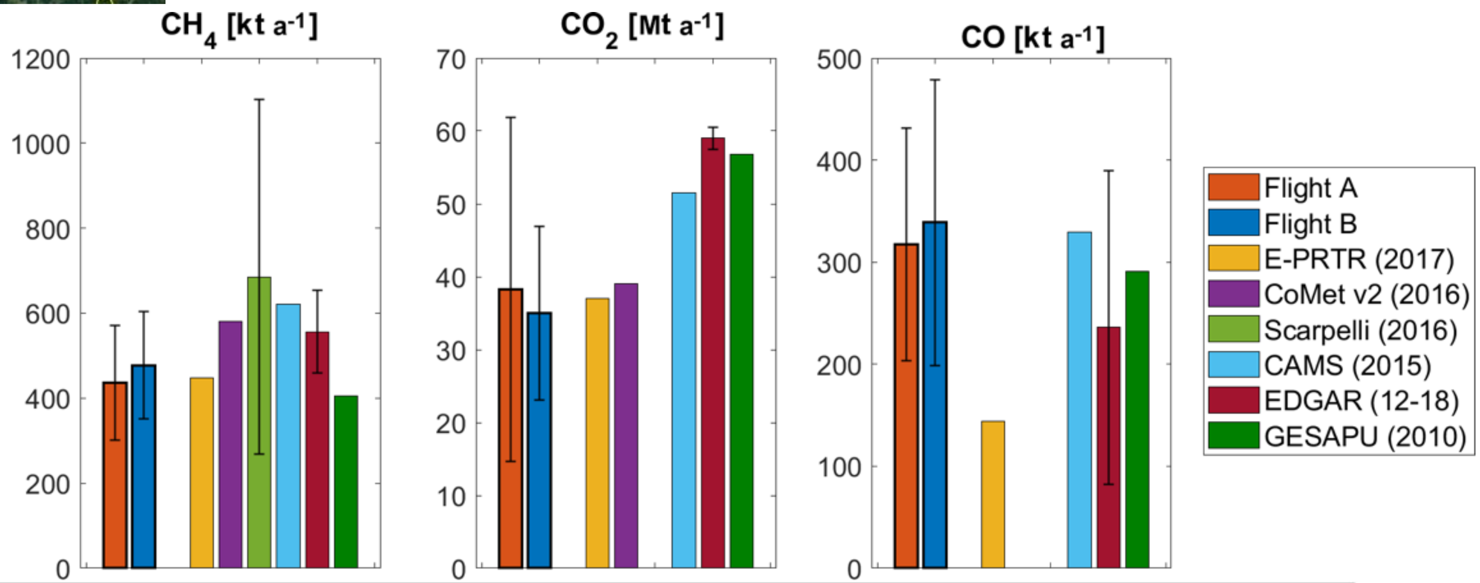


Aircraft-based mass balance approach (Cessna in-situ flight on June 6, 2018)



Flight track for flight B, color-coded with in-situ-measured CH4 mole fractions. Red markers show the locations of active coal mine shafts from the CoMet v2 inventory.

Figure 9. Comparison of USCB emission estimates of the CoMet mass balance flights A and B with bottom-up emission inventories. Error bars show 1 standard deviation of the estimates, where available.



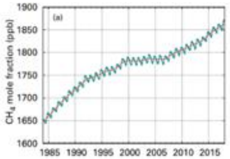
Fiehn, A, Kostinek, J., Eckl, M., Klausner, T., Gaikowski, M., Chen, 1., Gerbig, C., Röckmann, T, Maazallahi, H., Schmidt, M.i Korben, P.,Necki, J., Jagoda, P.,Wildmann, N., Mallaun, C., Bun, R., Nicki, A.-L., Jöckel, P., Fix, A., and Roiger, A.: *Estimating CH4, C02, and CO emissions from coal mining and industrial activities in the Upper Silesian Coal Basm using an aircraft-based mass balance approach*, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-282 , 2020. Atmos. Meas. Tech., 12, 5217-5230, https://doi.t.rg/10.5194/amt-12-5217-2019, 2CIT9

Temporal variations of methane emissions to compare with airborn measurments

Obtaining **temporal variation of methane emissions** from particular point source is highly important to validate the operation of the measuring devices, which will then be placed on board satellites.

The results collected during the CoMet field campaign are unique and comprehensive and will have a significant impact on the visualization of the spread of methane in the atmosphere on a global scale.

Takehome messages



Methane is an important contributor to global warming!

The methane cycle is still inadequately understood.

Lifetime of CH_4 is much shorter than for CO_2, mitigation strategies can work on shorter time scales.

Highly sophisticated observation technologies and evaluation methods are under development

Those can provide independent validation of the emission inventories and give new scientific insight into the methane cycle.

Satellite observations show much promise as one component in GHG observing systems.

Continuing research into this direction is required to turn research oriented missions into operational systems and integrate their results into future IPCC reports

DLR Universität Bremen AGH JAXA Japan Aerospace Exploration Agency

Federal Ministry of Education and Research

Scientific Publications from CoMet team

Andreas Fix, Axel Amediek, Christian Budenbender, Gerhard Ehret, Christoph Kiemle, Mathieu Quatrevalet, Martm Wirth, Sebastian Wolff, Heinrich Bovensmann, Androe Butz, Michal Galkowski, Christoph Gerbig, Pattick Jöckel, Julia Marshall, Jaroslaw Nęcki, Klaus Pfeilsticker, Anke Roiger, Justyna Swolkień, Martin Zöger, the CoMet team, *CH4 and C02 IPDA Lidar Measurements During the Comet 2018 Airborne Field Campaign*," EPJ Web Conf. 237 03005 (2020), https://doi.org7T0.1051/ep1conf/202023703005

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https://doi.t.rg/10.5194/amt-12-5217-2019, 2CIT9

Luther, A, Kleinschek, R., Scheidweiler, L., Defratyka, s., Stanisavljevic, M.. Forstmaier. A, Dandocsi. A.. Wolff. S.. Dulravica, o., Wildmann, N., Kostinek, J., Jöckel, p., Nickl, A.-L., Klausner, T., Hase, F., Frey, M., Chen, 1., Dietrich, F., Nęcki, J., Swolkień, J, Fix, A., Roiger, A., and Butz, A.. *Quantifying CH4 emissions from ham coal mines using mobile sun-viewing Fourier transform spectrometry*, Atmos. Meas. Tech., 12, 5217-5230, 2019, https://doi.org/10.5194/amt-12-5217-2019

Julian Kostinek , Anke Roiger , Maximilian Eckl , Alina Fiehn , Andreas Luther , Norman Wildmann , Theresa Klausner , Andreas Fix , Christoph Knote , Andreas Stohl , and André Butz *Estimating Upper Silesian coal mine methane emissions from airborne in situ observations and dispersion modeling* Atmos. Chem. Phys., 20, 12675–12695, 2020, https://doi.org/10.5194/acp-20-12675-2020

Sven Krautwurst, Konstantin Gerilowski, Jakob Borchardt, Norman Wildmann, Michal Galkowski,Justyna Swolkien, Julia Marshall, Alina Fiehn, Anke Roiger, Thomas Ruhtz, Christoph Gerbig, Jaroslaw Necki, John P. Burrows, Andreas Fix, and Heinrich Bovensmann, *Quantification of CH4 coal mining emissions in Upper Silesia by passive airborne remote sensing observations with the MAMAP instrument during CoMet*, Atmos. Chem. Phys https://doi.org/10.5194/acp-2020-1014, Preprint. Discussion started: 8 January 2021

Justyna Swolkień, *Polish underground coal mines as point sources of methane emission to the atmosphere* , International Journal of Greenhouse Gas Control, 2020 vol. 94, 1–12. Available online since: 2019-11-28

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Thank you for your attention