Ultra fast measurements of temperature at Methane-to-go-Poland campaign

Stanisław Król

Institute of Geophysics, Faculty of Physics, University of Warsaw

Atmospheric Physics Seminar, December 9th, 2022

Disclamer

The data that is about to be shown is not yet published. Do not copy or distribute without permission.

Introduction

Methane concentration

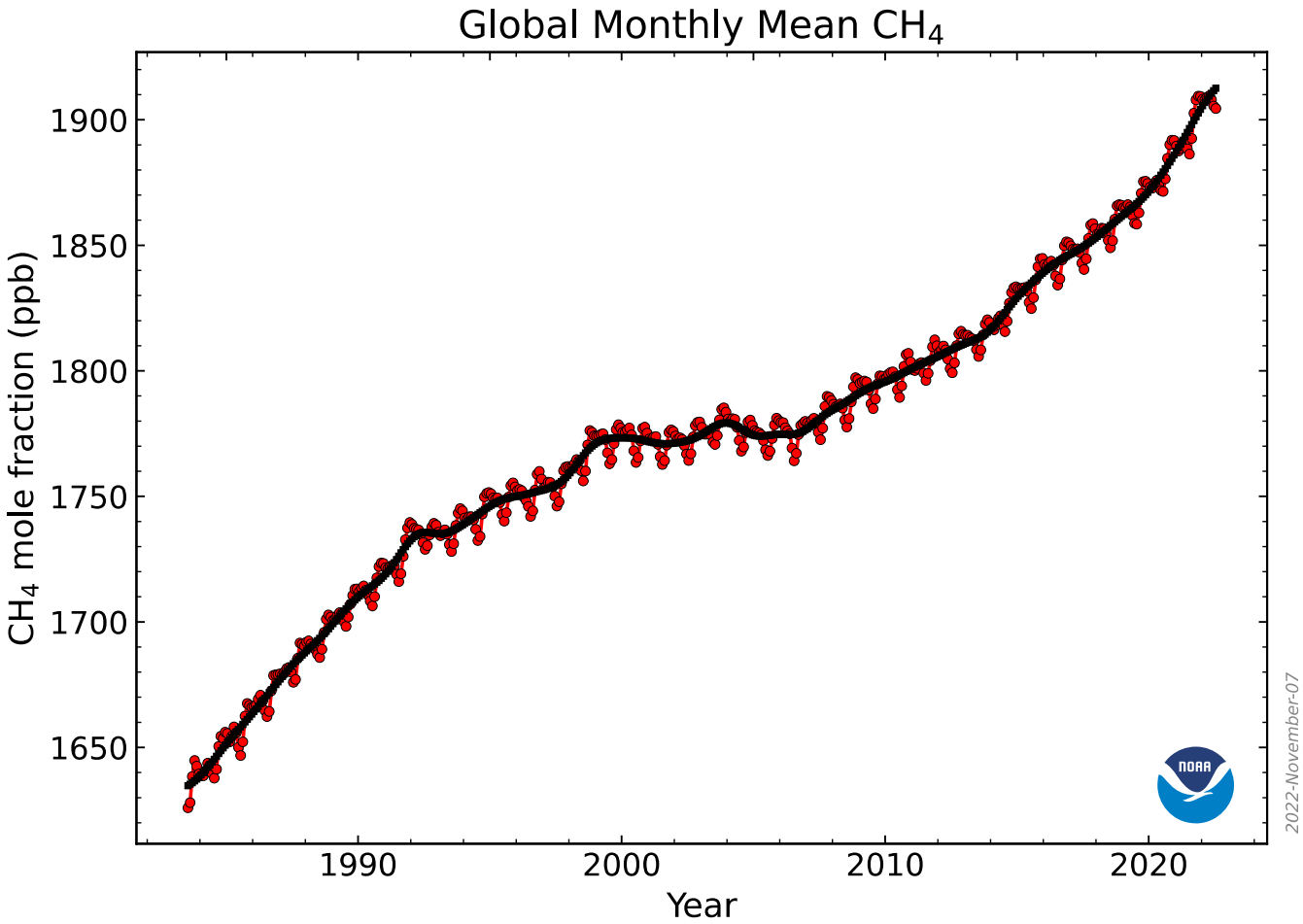


Figure: Background methane concentration with time [1]

Methane as a greenhouse gas

Methane is a greenhouse gas with Global Warming Potential (GWP) of 80 (for 20 years) and 25 (for 100 years) [2]. That means, that over the period of 20 years it traps 80 times more heat than an equivalent mass of CO_2.

Methane budget

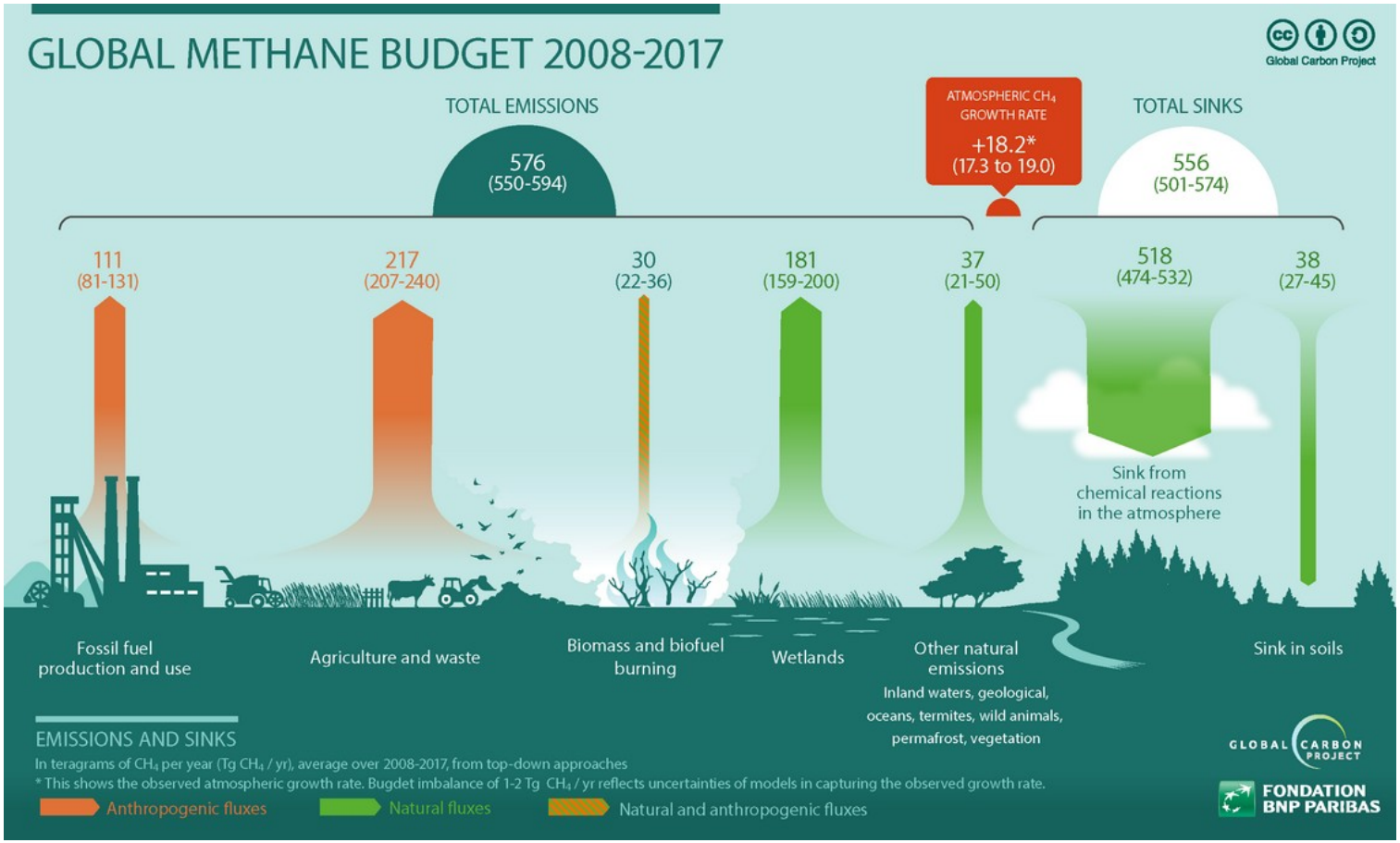


Figure: Global methane budget diagram [3]

Methane budget

Main sources from fossil fuels include:

- Gas pipe leaks
- Combustion engine leaks
- Coal mines

Coal mines as a source of methane

Figure: A photo of the ventillation shaft [4]

Coal mines as a source of methane

In the U.S., ventilation of the coal mines accounts for around 60% of all coal mine methane emmisions [5]. Not all methane can be extracted, as it is very dilluted. Other sources include surface mining, post-mining and gas draining.

Gaussian dispersion

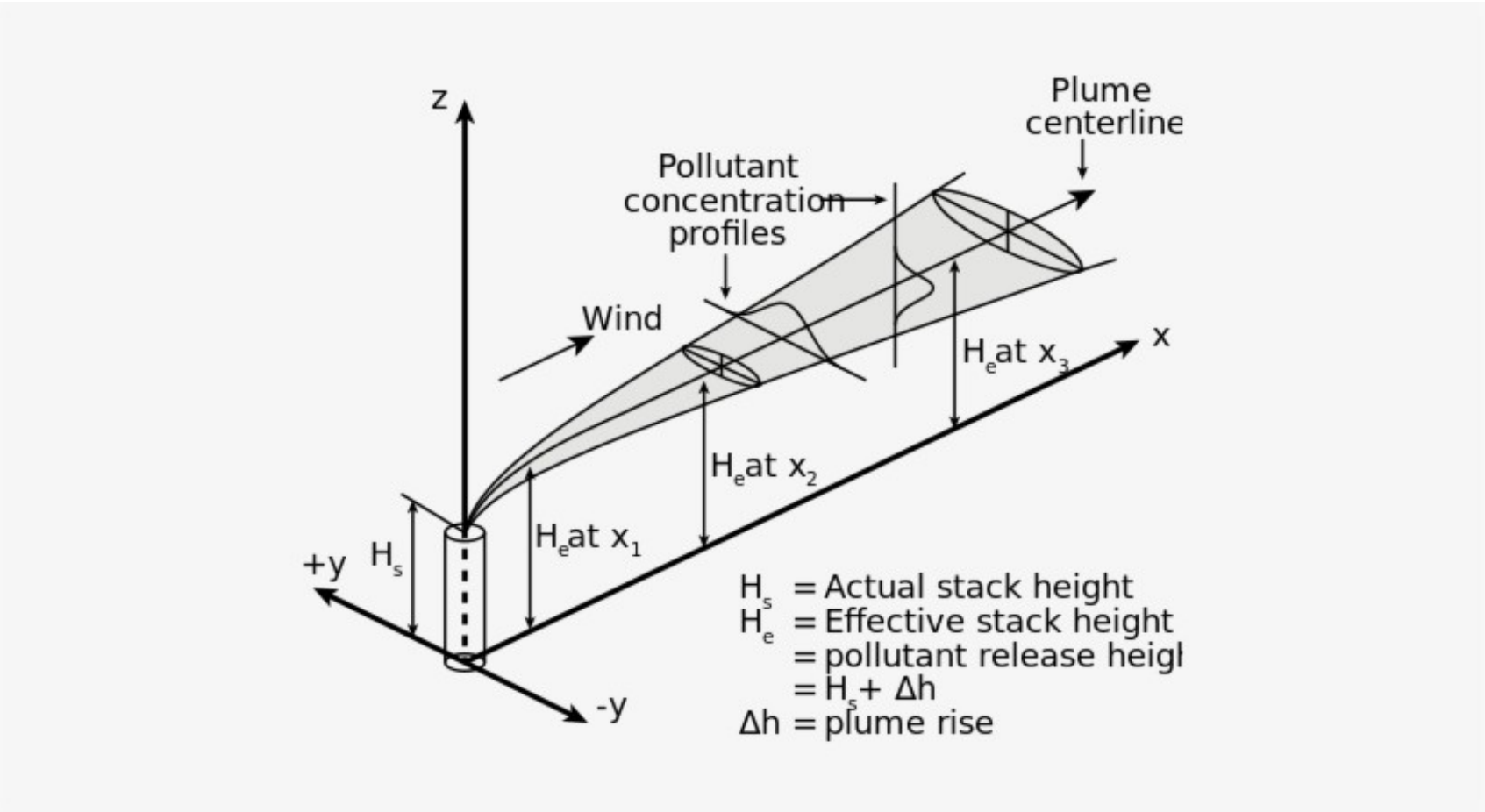


Figure: A diagram of Gaussian plume dispersion

Campaign

Campaign

The main purpose of Methane-to-go-Poland measurement campaign was to study and quantify methane emissions and to compare them with reported values from coal mine operators. The campaign was funded by UNEP within the International Methane Emission Observatory (IMEO) program.

Study area

Because of rich mining activity, Upper Silesia region is one of the hot spots of coal mine methane emissions in Europe. Emissions were studied there previously during e.g. CoMet campaign [6], [7]. This was the region of interest for this campaign.

Study area

The hub of the campaign was localized in the Bielsko-Biała airport, in the Helipoland hangar. From there the helicopter took platform to one of three selected shafts:

1. Pniówek V
2. Brzeszcze-Andrzej IX
3. Agnieszka-Powietrzny V

Campaign organization

Plan of the campaign included a daily flight to one of the shafts and a release test to try to quantify the method. A total of 7 shaft flights and 2 release tests were performed over the course of 9 days. Before each day, the meteorological situation was assesed, and a plan of flight track was made. There was also a drone team and the ground based team for additional measurements.

HELiPOD

A novel method of measurement was also planned to be tested during the campaign.

Figure: HELiPOD platform

HELiPOD

HELiPOD is a helicopter sonde developed by the Deutsches Zentrum für Luft- und Raumfahrt Institute of Atmospheric Physics (DLR-IPA) and Institute of Flight Guidance (IFF) of the Technische Universität Braunschweig (TUBS), designed as a novel concept for quantification of the greenhouse gases.

HELiPOD

The platform was equipped with HMP110 probe from Vaisala, 5-hole-probe for wind measurements, and equipement for CH_4 and CO_2 measurements among others. There was also a contribution from the Institute of Geophysics in the form of Ultra Fast Thermometer (UFT).

Methane measurements

The measurements of methane were done by two instruments:

- Picarro 2401 (CRDS)
- Li-7700 (WMS)

(a) Picarro 2401

(b) Li-7700

UFT at HELiPOD

Because the platform does not require any certificates, the installation of Ultra Fast Thermometer (UFT) was very easy bureaucratically.

UFT at HELiPOD

The setup of the UFT was very similar to the one during the EUREC4A campaign. The sampling frequency was 20 kS/s, which for an average speed equal to 35 m/s yielded centimeter-scale resolution. The data was stored inside an SD card.

UFT at HELiPOD

The reason UFT was installed is because the campaign had a potential of aquiring boundary layer temperature data at a reasonably low cost. The group from IGF could also use their knowledge about turbulence to analyse wind data (at least 50 Hz at $\sim$ 35 m/s). However, high resolution data is not yet available.

Helicopter and comms

During the measurements, 2 people were present in the helicopter (excluding the pilot): one person was giving commands to the pilot, and the other one was the operator responsible for monitoring of the HELiPOD, observing the atmospheric situation, and interesting findings (such as CH_4 peaks).

Sample results

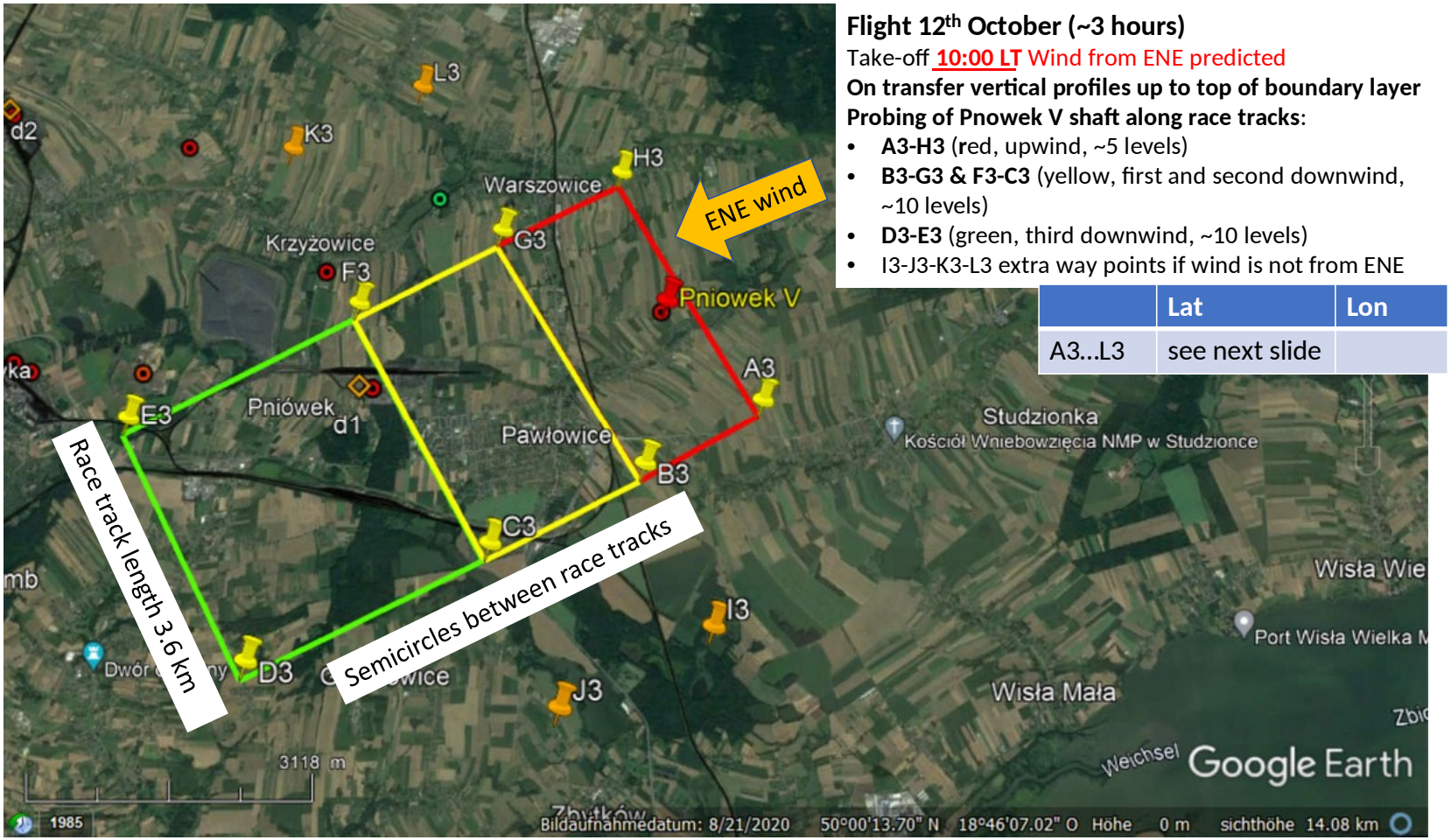
Case study

The presented results are from the 12th of October. This day was chosen, because I had a privilege of being the operator in the helicopter at that day.

Meteorological situation

On that day, it was estimated that the wind will come from the northeast. The sky was suposed to be clear, with small fog in the morning. In practice, the fog dissipated around 10, and the start was at 11.

Plan



Flight 12th October (~3 hours)

Take-off **10:00 LT** Wind from ENE predicted

On transfer vertical profiles up to top of boundary layer

Probing of Pnowek V shaft along race tracks:

- **A3-H3** (red, upwind, ~5 levels)
- **B3-G3 & F3-C3** (yellow, first and second downwind, ~10 levels)
- **D3-E3** (green, third downwind, ~10 levels)
- I3-J3-K3-L3 extra way points if wind is not from ENE

	Lat	Lon
A3...L3	see next slide	

Figure: Plan for 12th of October, credit: H. Huntreiser

Vertical profiles

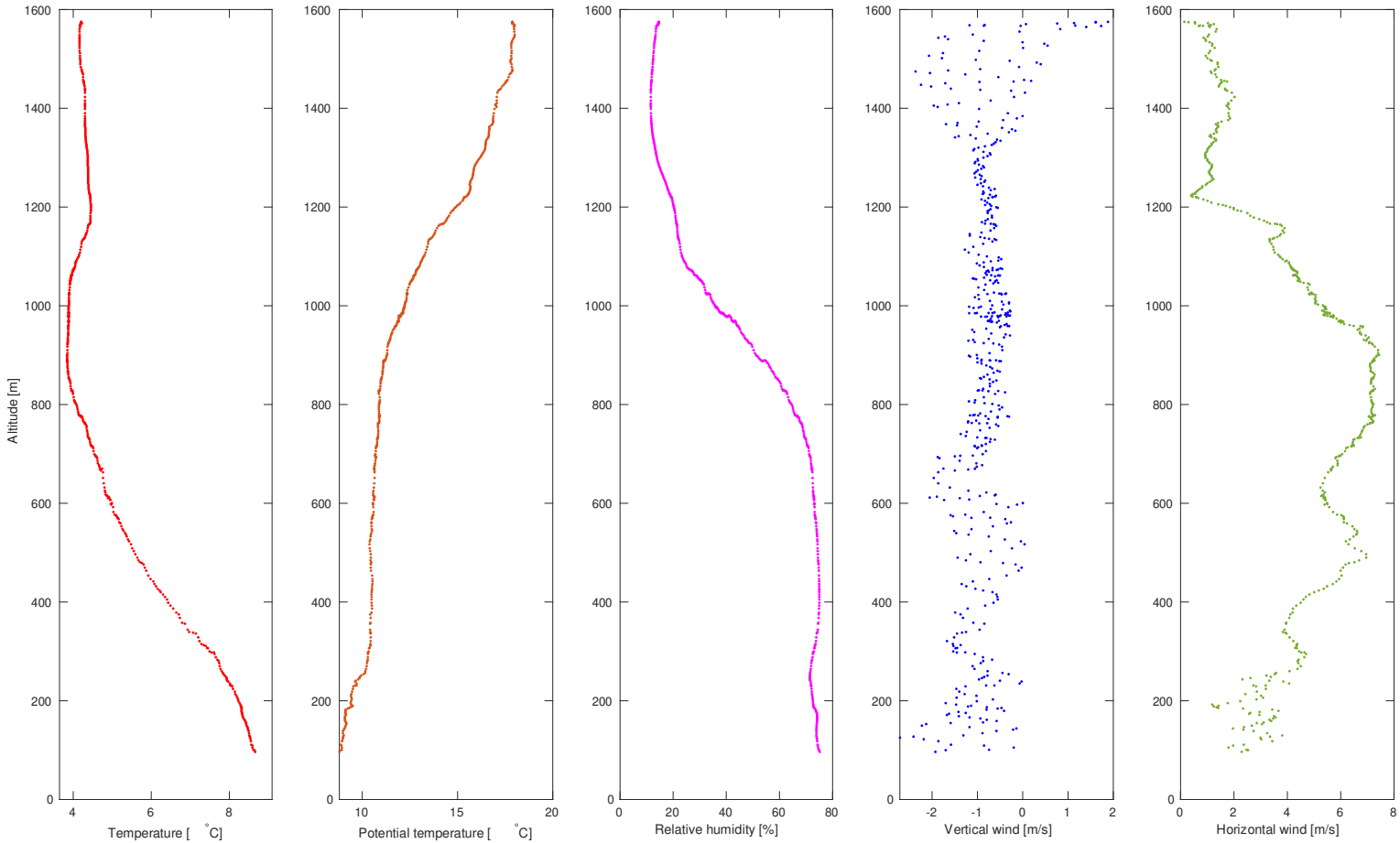


Figure: Thermodynamic profiles

Vertical profiles

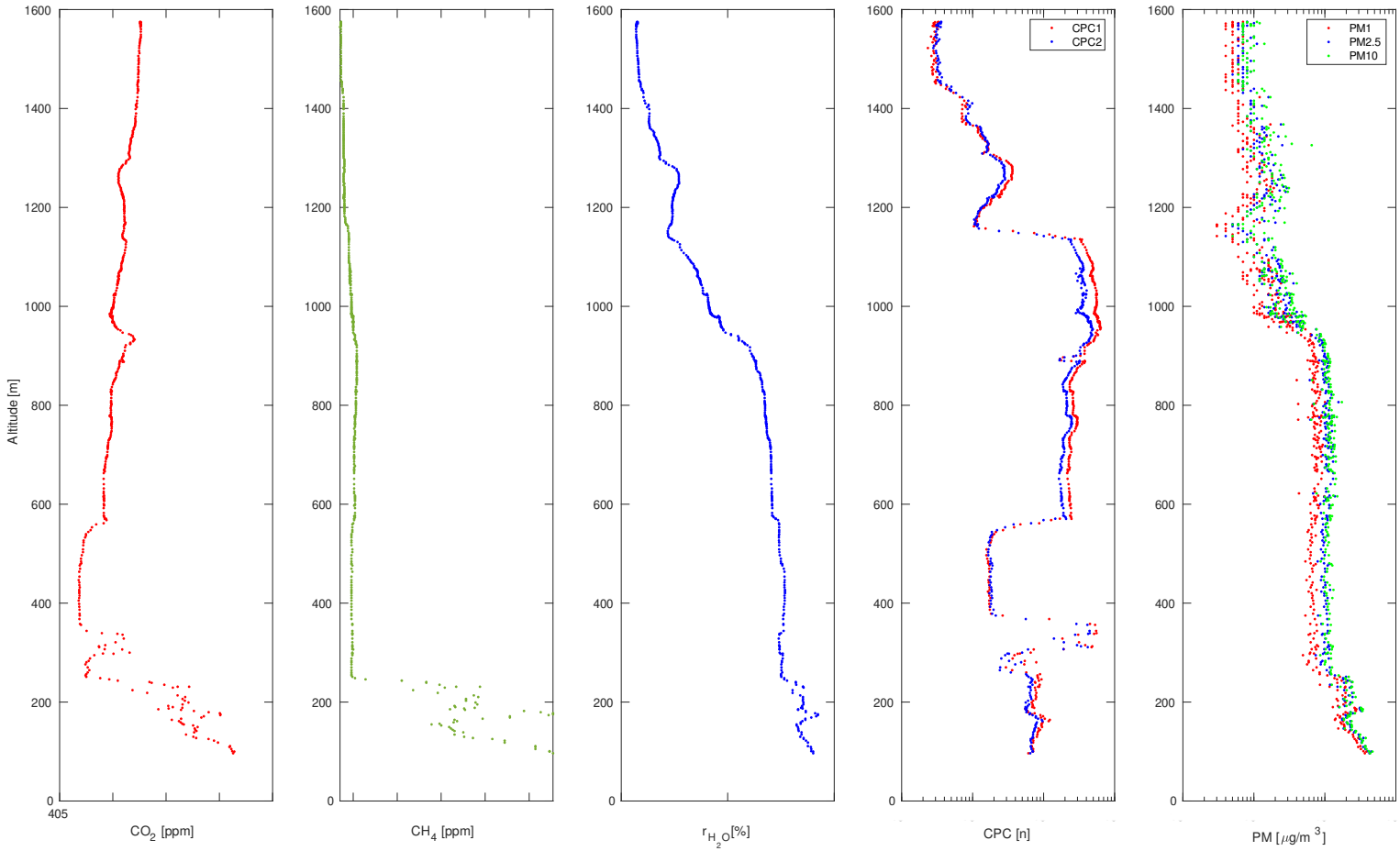


Figure: Composition profiles

Methane

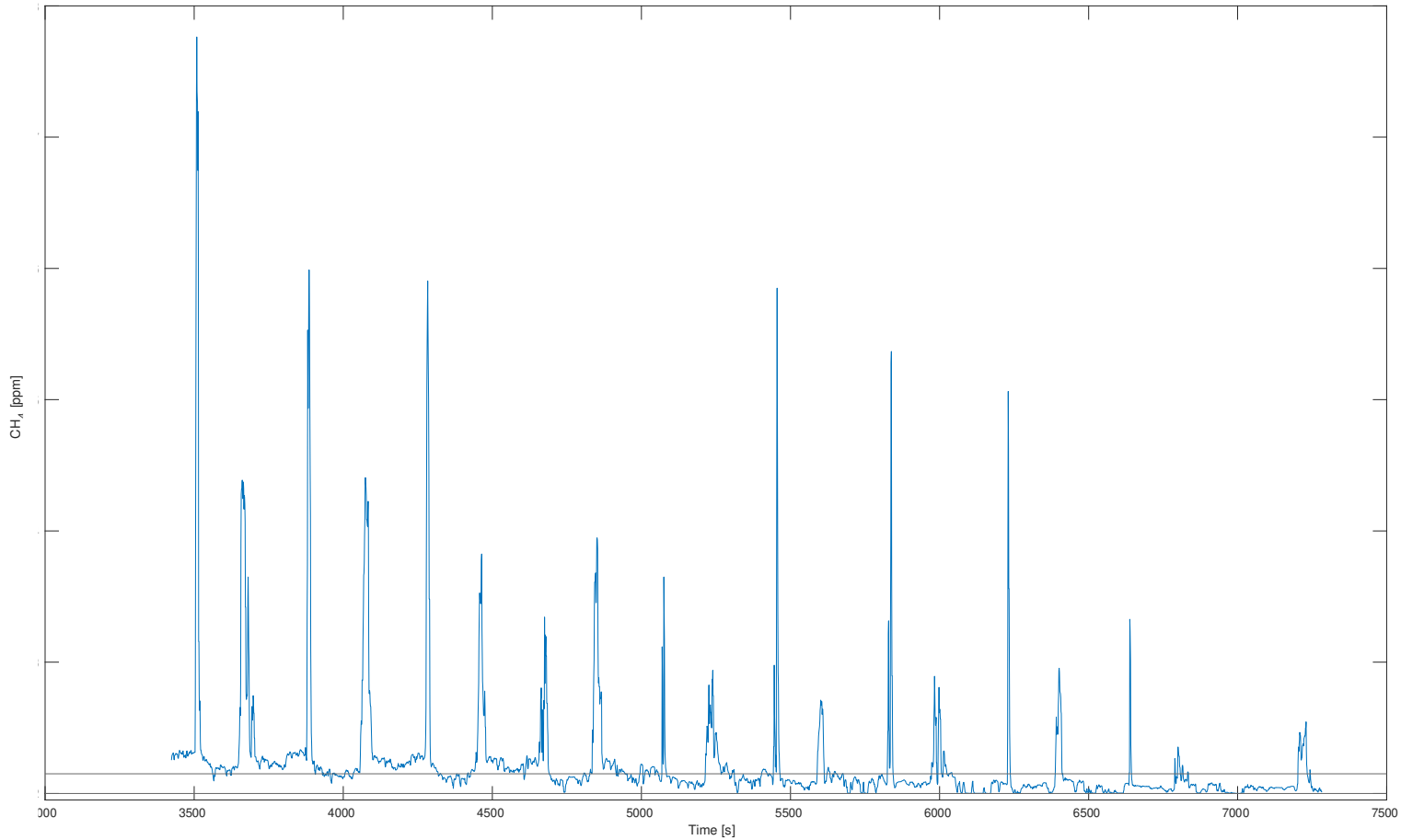


Figure: Methane concentration with time

Methane

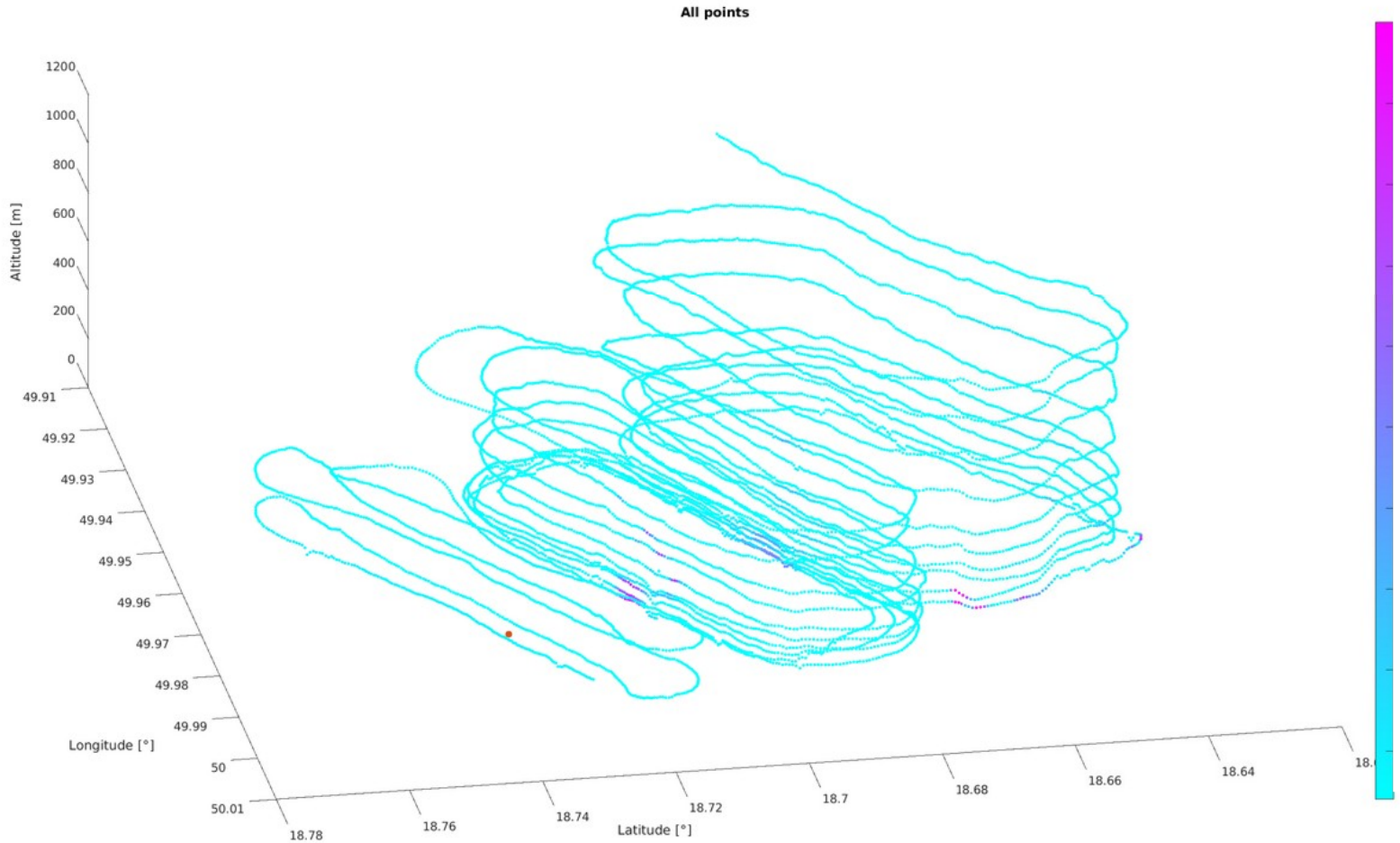


Figure: Methane concentration with space

Methane

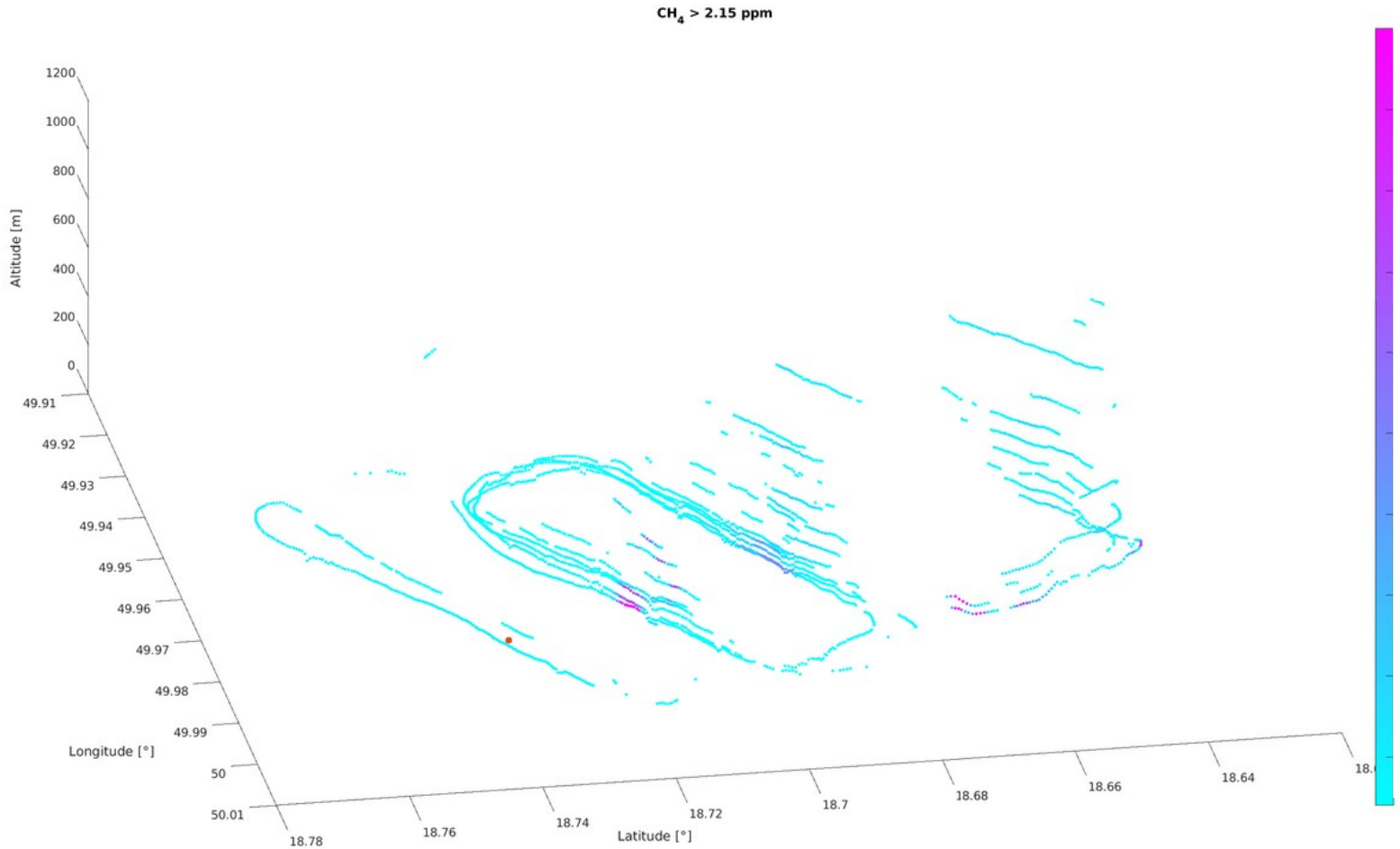


Figure: Methane concentration with space

Methane

Figure: Map of study area

UFT

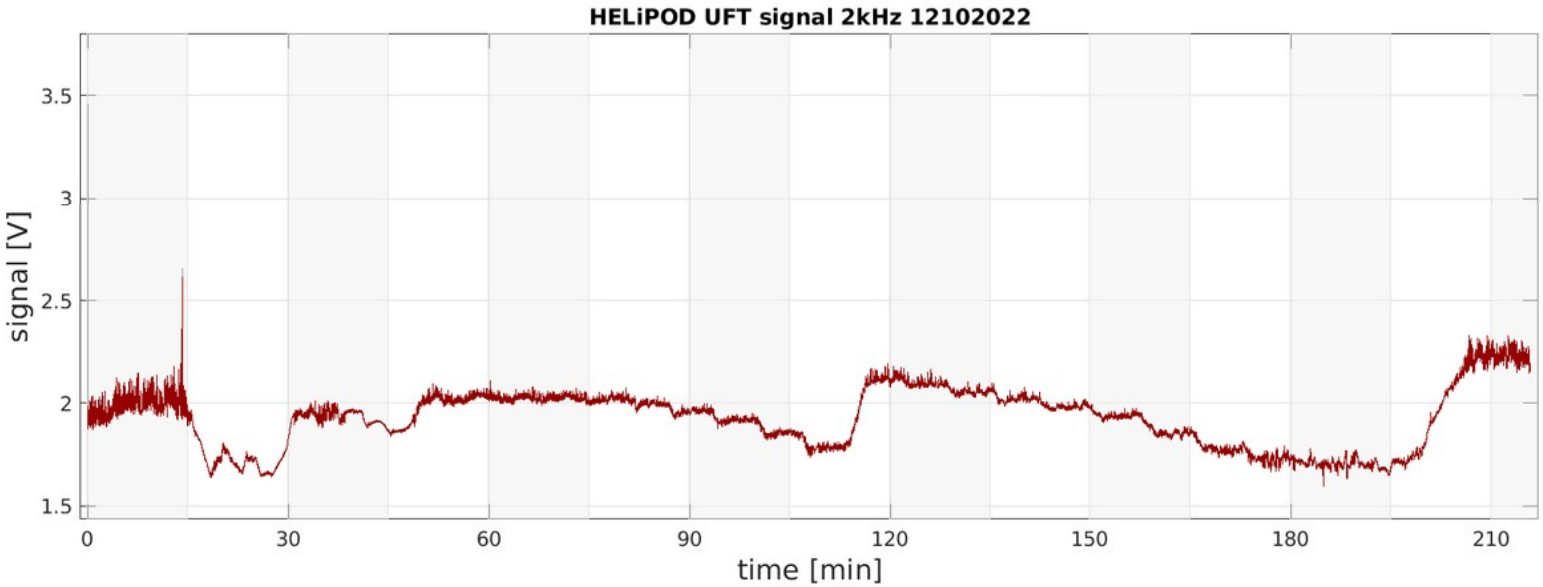


Figure: UFT measurements for UFT signal 12.10

UFT

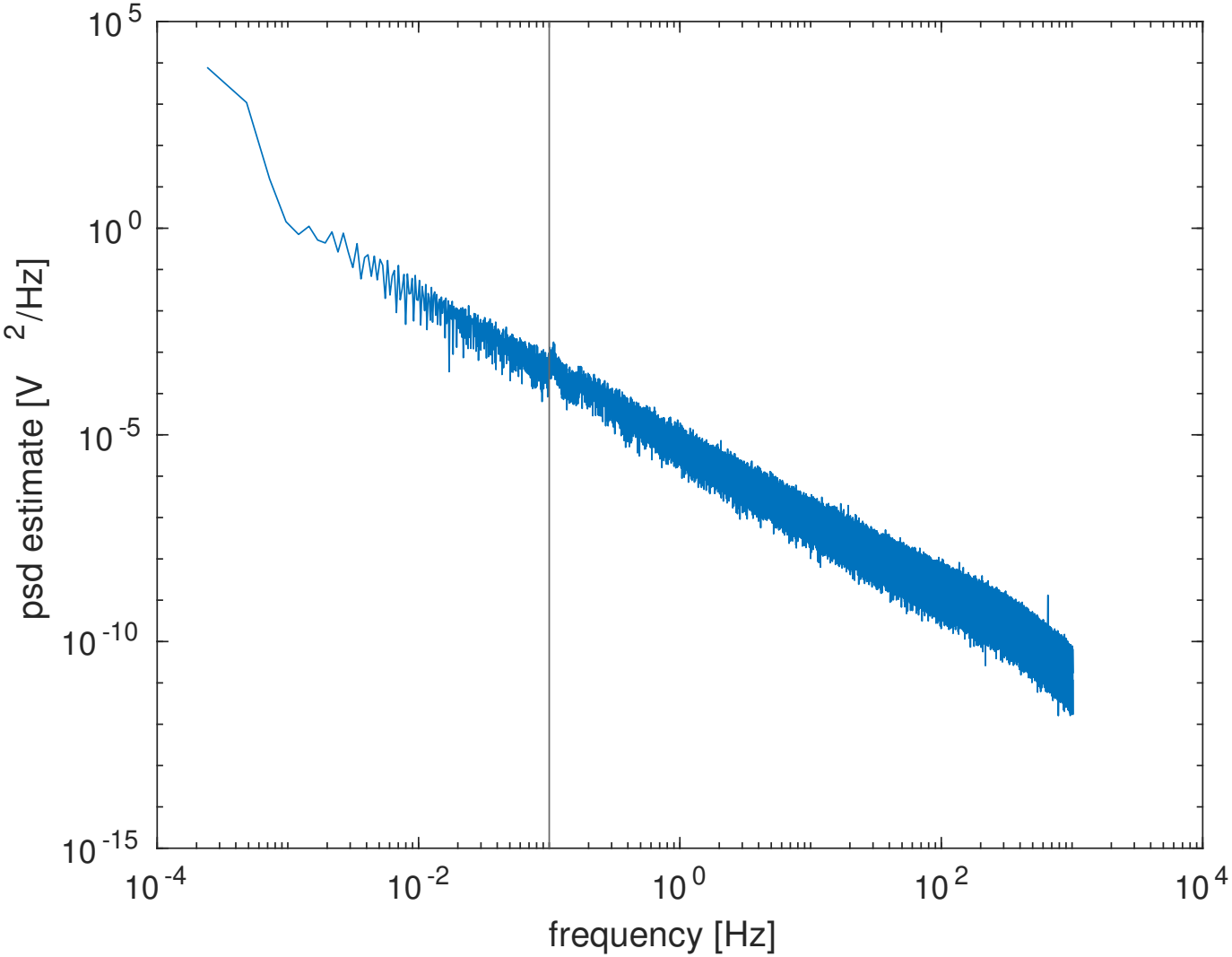


Figure: UFT psd estimate for UFT signal 12.10

Conclusions

The campaign was succesful. Good quality data was gathered, and it awaits analysis. In the future, a mission in Oman is planned, as there is a lack of measurements in the middle east, where the fossil fuel industry is important. The contribution from us will include an analysis of turbulence and temperature from the gathered data.

Acknowledgements to the HELiPOD team:

- TUBS (Falk Pätzold, Lutz Bretschneider)
- DLR (Heidi Huntrieser, Michael Lichtenstern, Eric Förster)

To UNEP for fundning. To Wojciech Kumala and Szymon Malinowski for technical support before the campaign. To Jarek Nęcki for the idea.

Bibliography

- https://doi.org/10.15138/P8XG-AA10
- https://www.ipcc.ch/assessment-report/ar5/
- http://www.globalcarbonatlas.org/en/CH4-emissions
- https://www.jswpbsz.pl/o-nas/aktualnosci/wydarzenie/szyb-iv-w-kwk-pniowek-gotowy
- https://www.epa.gov/cmop/sources-coal-mine-methane
- https://doi.org/10.5194/acp-21-17345-2021
- https://doi.org/10.5194/acp-2021-1061

Future

As an individual, you can cut methane emissions by:

- Reducing fossil fuel consumption,
- Switching to a plant-based diet (or just incorporating more plants and less meat in your diet),
- If you eat meat - choose it from a trusted source,
- Don’t throw away the food,
- Segregate the rubbish better.