Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Scientific measurements of methane emissions with remote and on-site methods in comparison

Tanja Westerkamp, Torsten Reinelt, Jan Liebetrau

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Overview

Why do we want to quantify emissions from biogas plants?

What are the challenges? Which methods are available?

Techniques in use at DBFZ

Results of a recent research project

- What was quantified?
- Comparison of two methods
- Experiences and complications

Summary

Reasons to quantify methane emissions

- Evaluation of the biogas technology
  - Methane is a GHG
  - Safety
  - Economy and efficiency
- Regulations and certification systems
- Data basis and inventory
- Operational improvement
- Acceptance

Challenges and methods

Several source types

- Stationary and diffuse emission sources
- Point and area sources

Identification of <u>all</u> emission sources

Time variant sources

Methods

- On-site
  - Leakage detection
  - Quantification of single sources
  - Summation of single emission rates
- Remote sensing
  - Spectrometry of downwind plume
  - Wind conditions
  - Dispersion modelling or tracer gas comparison

Methods applied by DBFZ

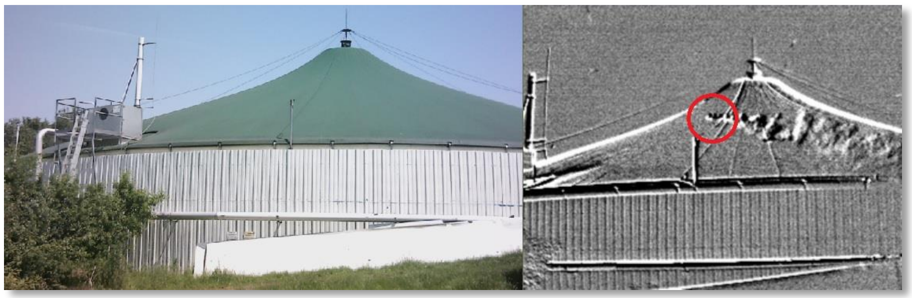
On-site method

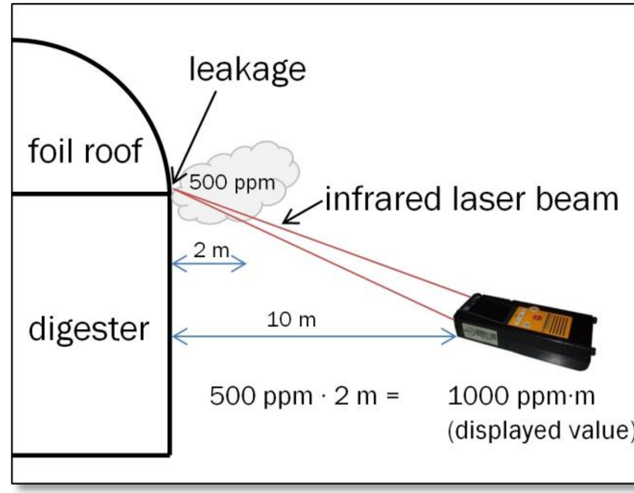
- Identification of emission spots
- Measurement sections at e.g.
  - Digestate storages
  - Leakages
  - Upgrading units
  - Pressure relief valves
- Defined flow rate
- Sampling in evacuated vials and GC analysis in the lab
- Calculation and summation of single emission rates

Remote sensing method

- OpenPath-Tunable Diode Laser Absorption Spectrometry (TDLAS)
- Up- and downwind measurements of the methane concentration
- Measurement of micrometeorological conditions (3D anemometer)
- Inverse dispersion modelling to determine the total emission rate (Windtrax)

On-site method
Identification of leakages





Infrared camera

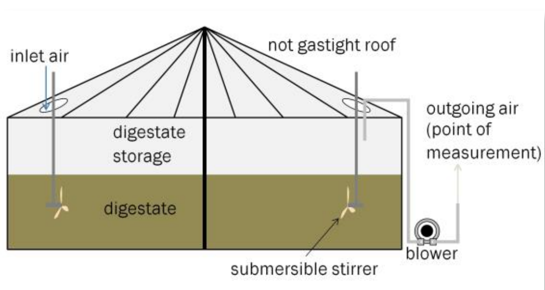
- Remote detection
- Temperature offset between biogas and background radiation

Hand-held methane laser

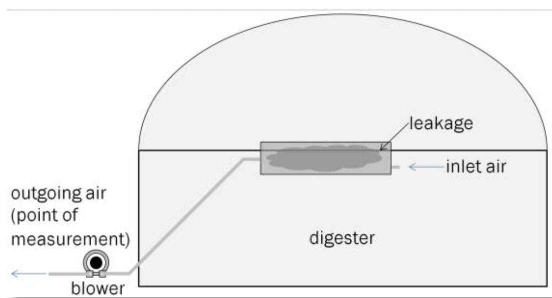
- Remote sensing
- Selective for methane
- Consideration of „moving“ methane plumes

On-site method

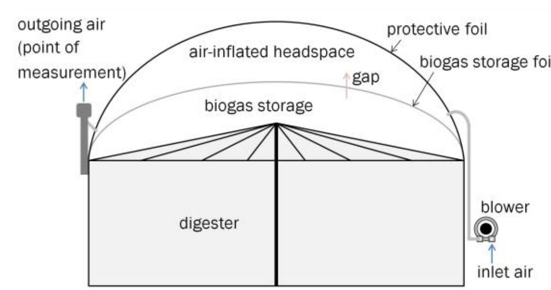
Quantification of single emission sources



not gastight covered digestate storage



encapsulated leakage



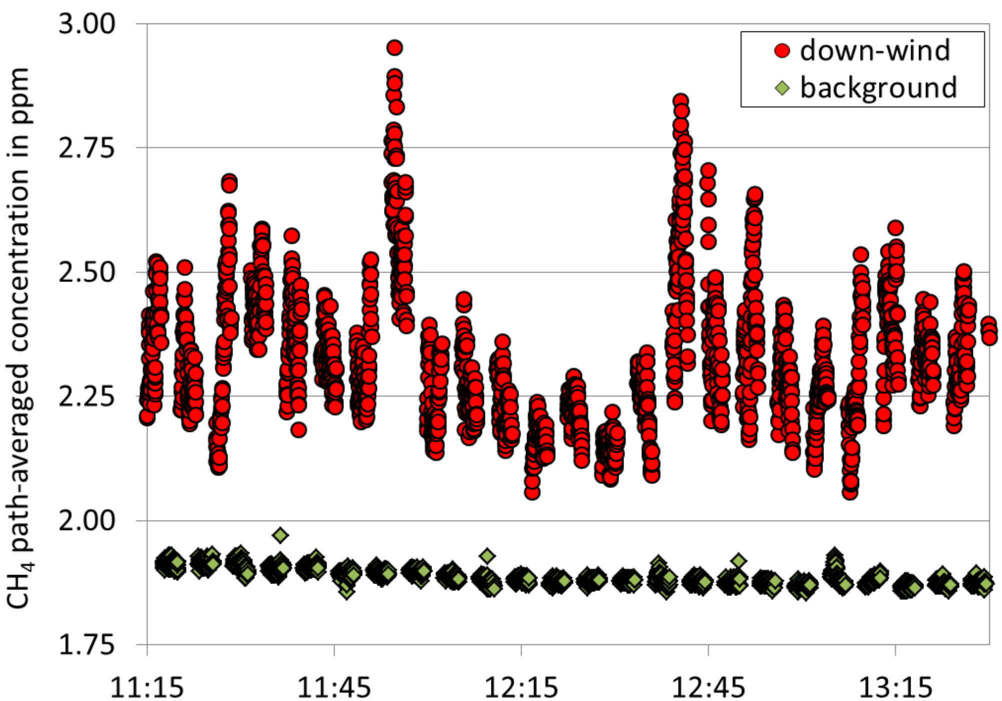
two layer rubber dome

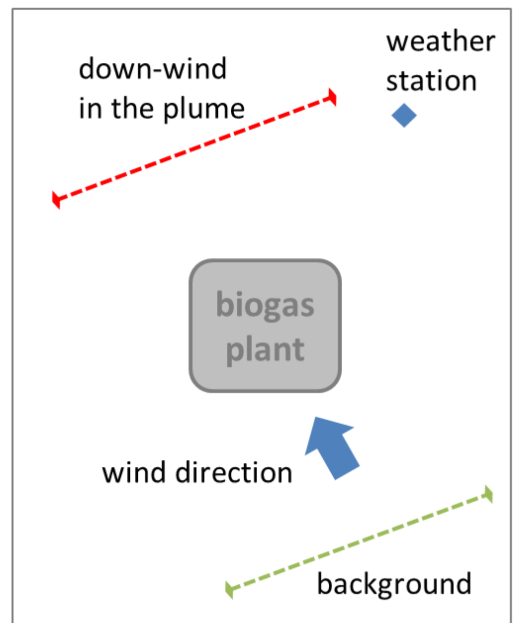
Remote sensing method

Quantification with TDLAS and inverse dispersion modelling

TDLAS

- High time resolution
- Real time concentration values



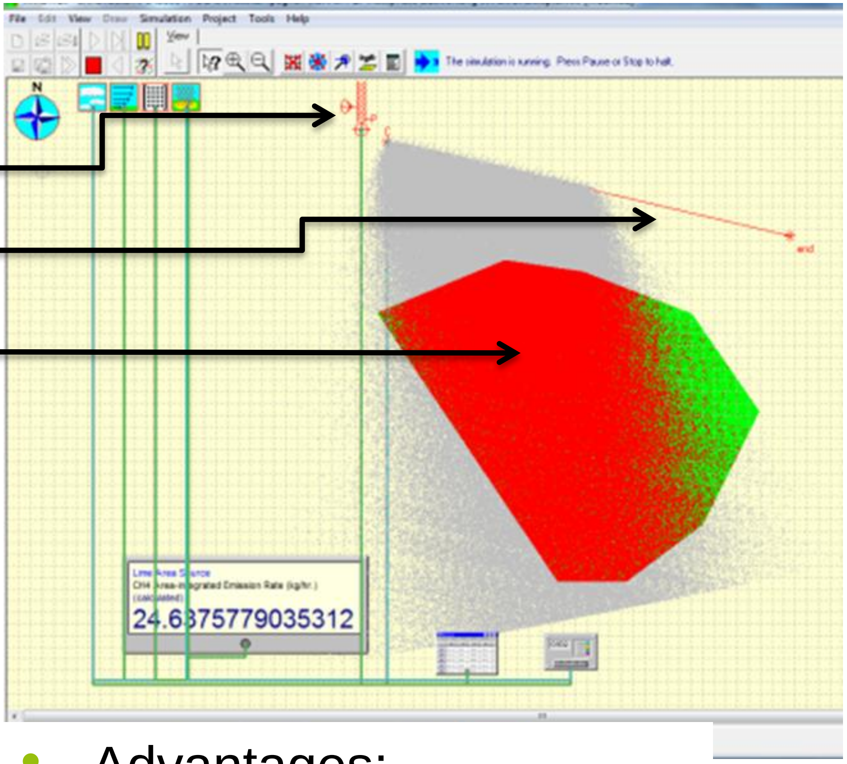


Remote sensing method
Inverse dispersion modelling

Use of Windtrax

- Input parameter
  - Meteorological conditions
  - Concentrations (mean values of ¼h)
  - Area source geometry
- Simulation
  - Backward Lagrangian Stochastic model
  - Air parcels from measurement path backward in time
- Result
  - Emission rate of area source

Running simulation



- Advantages:
  - Easy measurement set-up
  - User friendly due to GUI

Method comparison

	On-site measurement	Remote sensing
Strengths	• Identification of single sources ▶ Single emission rates ▶ Mitigation strategies • Low detection limit (total emission rate) • Weather independent • Variable effort	• Longtime measurements with high resolution • No influence on plant operation • Time effort independent on plant size
Constraints	• Time variant emission sources • Unknown and diffuse sources • High effort on large sites • Influence of measurement on emissions	• No identification of single sources • Wind conditions • Topology • Uncertainties of dispersion model

The strengths complement each other.

Project results

„Climate effects of a biomethane economy“

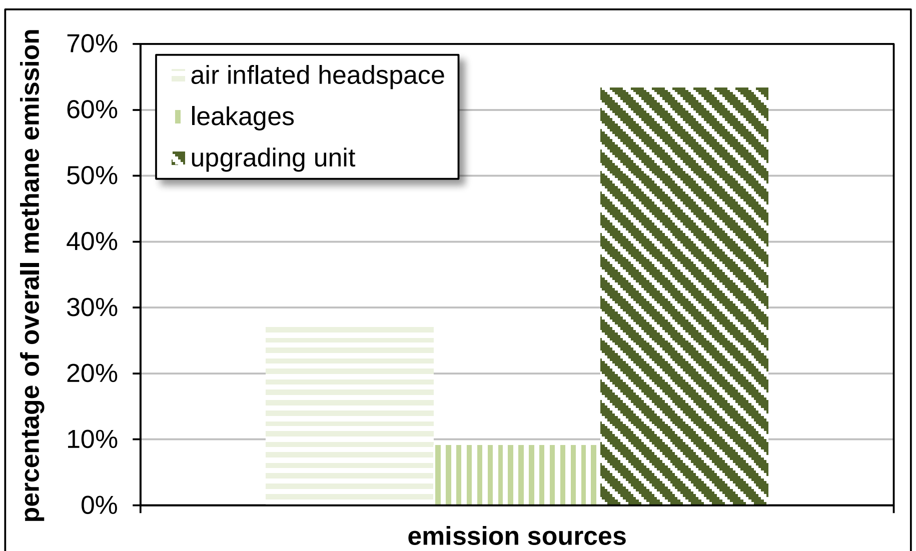
- Funded by the German Federal Ministry of Food and Agriculture
- 3 state of the art biogas plants with upgrading units
- 2 methods in comparison

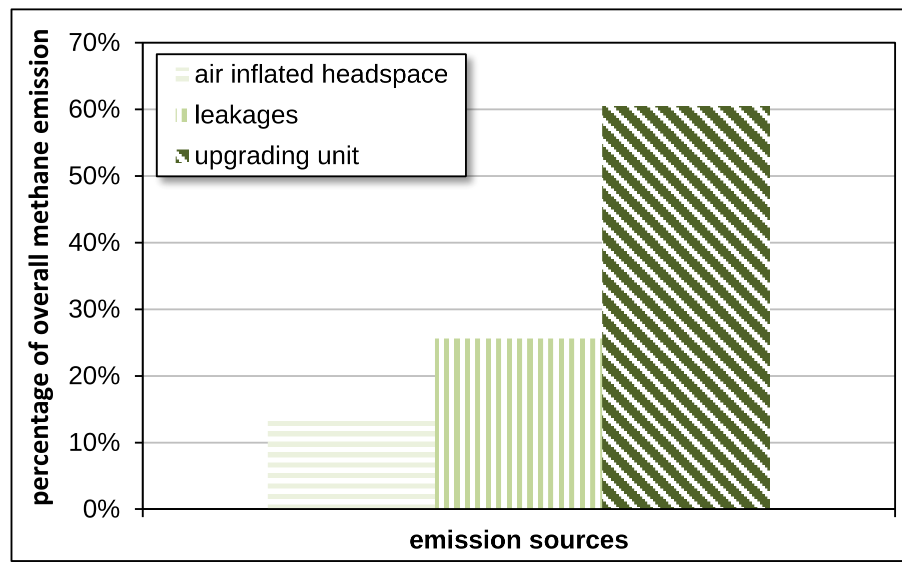
Plant	Treat-ment	Temp. level	Output (m^3 CH_4 h^{-1})	Sub-strates	Retention time (d)	Digestate cover	Up-grading
I	wet fermentation	mesophilic	500 - 600	energy crops	90	gas-tight	amine scrubbing
II			1.800	energy crops	100	not gas-tight	
III			1.500 -2.500	residual material	15 – 40	gas-tight	

Project results

Details – On-site

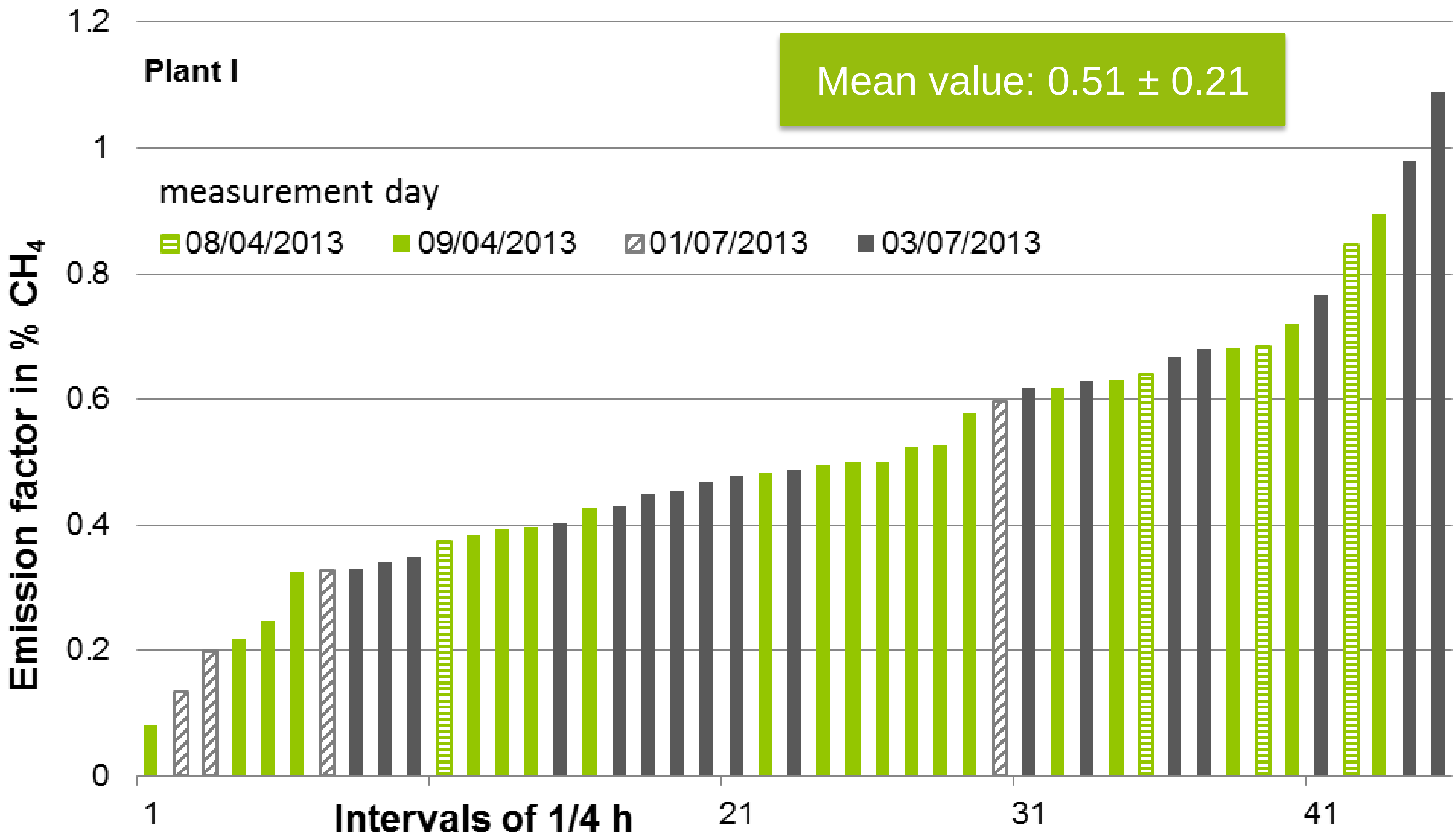
- Biogas plant I
  - Sole plant that could be measured completely by on-site method
  - Three types of emission sources
  - Active pressure relief vents were not detected visually





Left: April 2013; right: July 2013

Project results
Details – Remote sensing

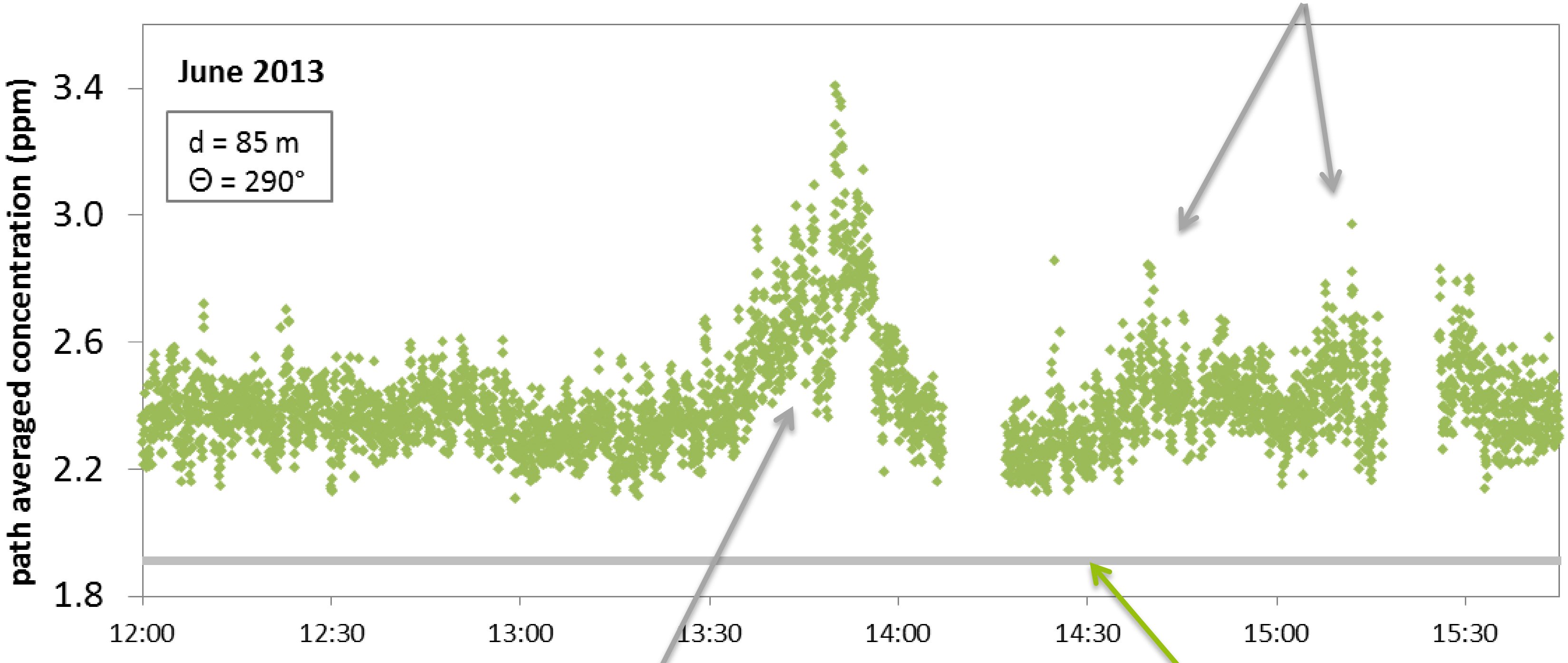


Project results

Details – Remote sensing

Plant II

over pressure reliefs



background concentration

switch between compressor units

Project results

Measurement extend	spring		summer	
Plant	On-site	Remote	On-site	Remote
I	4 days	2 days, 17 intervals	4 days	2 days, 14 intervals
II	5 days	2 days, 21 intervals	5 days	2 days, 30 intervals
III	5 days	2 days, 23 intervals	5 days	3 days, 20 intervals

Emission factors (% CH_4)	spring		summer	
Plant	On-site	Remote	On-site	Remote
I	0.12 ± 0.02	0.1 – 0.9	0.13 ± 0,02	0.1 – 1.0
II	0.7 ± 0.3	0.2 – 0.5	1.35 ± 0.65	1.2 – 4.0
III	0.13 ± 0.03	0.05 - 0.40	0.05 ± 0.01	0.05 - 0.40

Project results
General observations

- Plant I and III (gas-tight):
  - no seasonal variations
  - remote sensing results follow Gaussian distribution
- Plant II:
  - seasonal variation of the emissions
  - malfunctions during the measurements → higher emissions
  - Only 140 h malfunctions out of 7600 h in 2013 lead to an increase of the mean emission factor from 1.5 % CH_4 to 2.1 % CH_4 over the year (remote sensing result).

Project results

Discussion of difficulties

General	On-site method	Remote sensing
On-site results lower than remote results Malfunctions have a large influence on results Mean over the year → large variations possible	Plant size and no. of leaks → not all sources measured → extrapolations with high uncertainties → measurement at pressure relief vents necassary Measurements might influence emission rates → to which extend?	Temperature dependence of signal → calibration with uncertainties Correlation between wind speed and emission rate → real effect or model specific? Wind conditions • No simulation for ~ 1/3 of the measurements No simultaneous measurement of plume and background

Summary and Outlook

- On-site method essencial to identify mitigation potentials
- On-site method with lower results than remote sensing
- All three plants had leakages
- Remote sensing yields reliable results regarding total emission rates
- Most concentration rises during remote sensing could be correlated to malfunctions on the plant
- Advantages of both methods are complemental

○ Joint measurement in Sweden next week

○ Further research programs:

operational emissions, open digestate storage, different dispersion model

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DBFZ Deutsches
Biomasseforschungszentrum
gemeinnützige GmbH

Torgauer Straße 116
D-04347 Leipzig
Tel.: +49 (0)341 2434 – 112
E-Mail: info@dbfz.de
www.dbfz.de