



## **Dynamic tracer dispersion method: A tool for measuring the total methane emission from individual Danish landfills**

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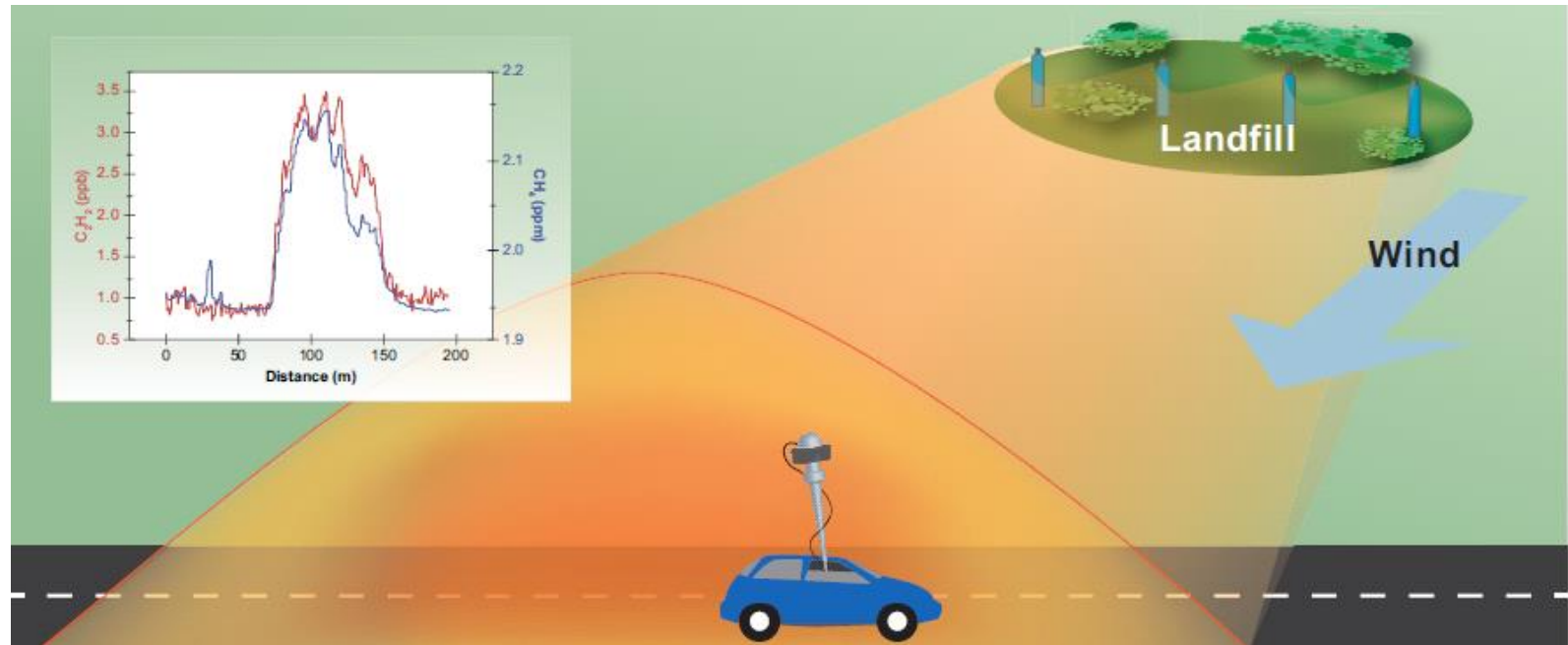
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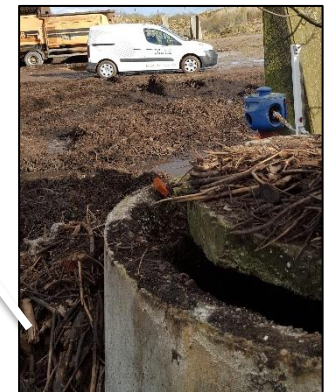
## A tool for measuring the total methane emission from individual Danish landfills

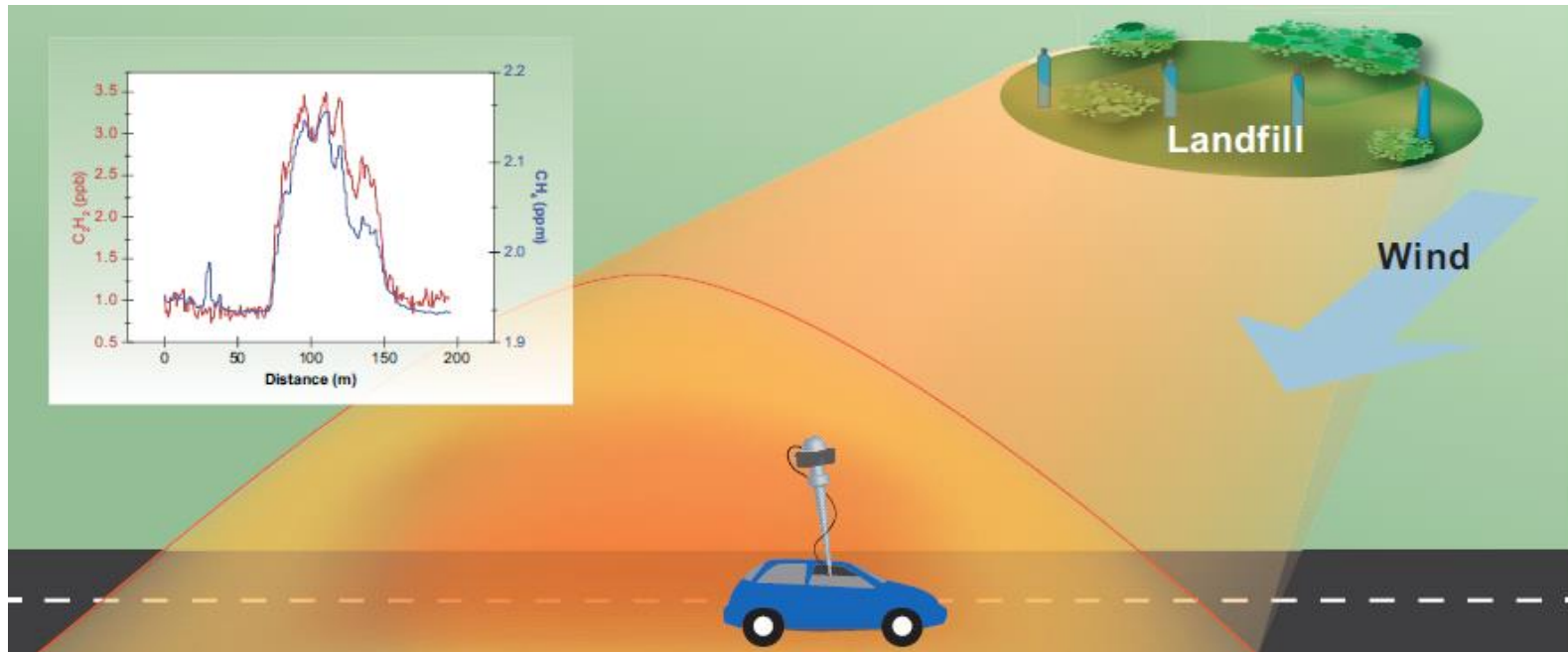


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- Theory
- In practice
- Uncertainties
- Possibilities
- Results & Conclusion

$$E_{\text{gas}} = Q_{\text{tracer}} \cdot \frac{\int_{\text{Plume end 1}}^{\text{Plume end 2}} C_{\text{gas}} dx}{\int_{\text{Plume end 1}}^{\text{Plume end 2}} C_{\text{tracer}} dx} \cdot \frac{MW_{\text{gas}}}{MW_{\text{tracer}}}$$





$$E_{gas} = Q_{tracer} \cdot \frac{\int_{Plume\ end\ 1}^{Plume\ end\ 2} C_{gas} dx}{\int_{Plume\ end\ 1}^{Plume\ end\ 2} C_{tracer} dx} \cdot \frac{MW_{gas}}{MW_{tracer}}$$

- Tracer gas with long atmospheric lifetime
- Good/stable wind & road conditions
- Sensitive analytical instrument

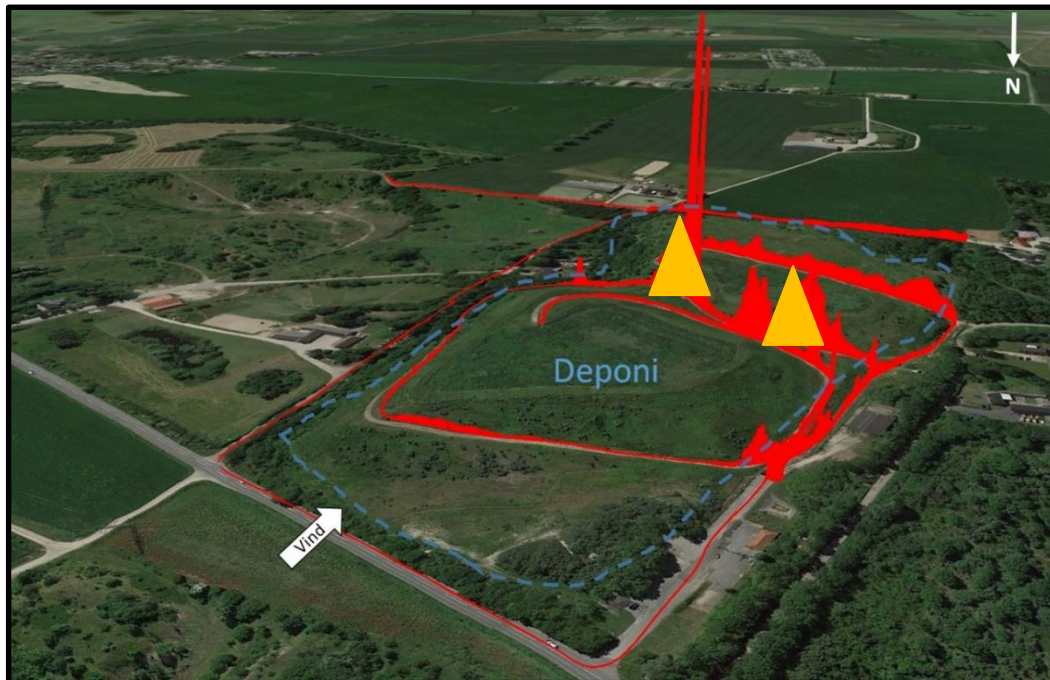




Tracer gas ( $\text{C}_2\text{H}_2$ )



## 1) Screening for methan

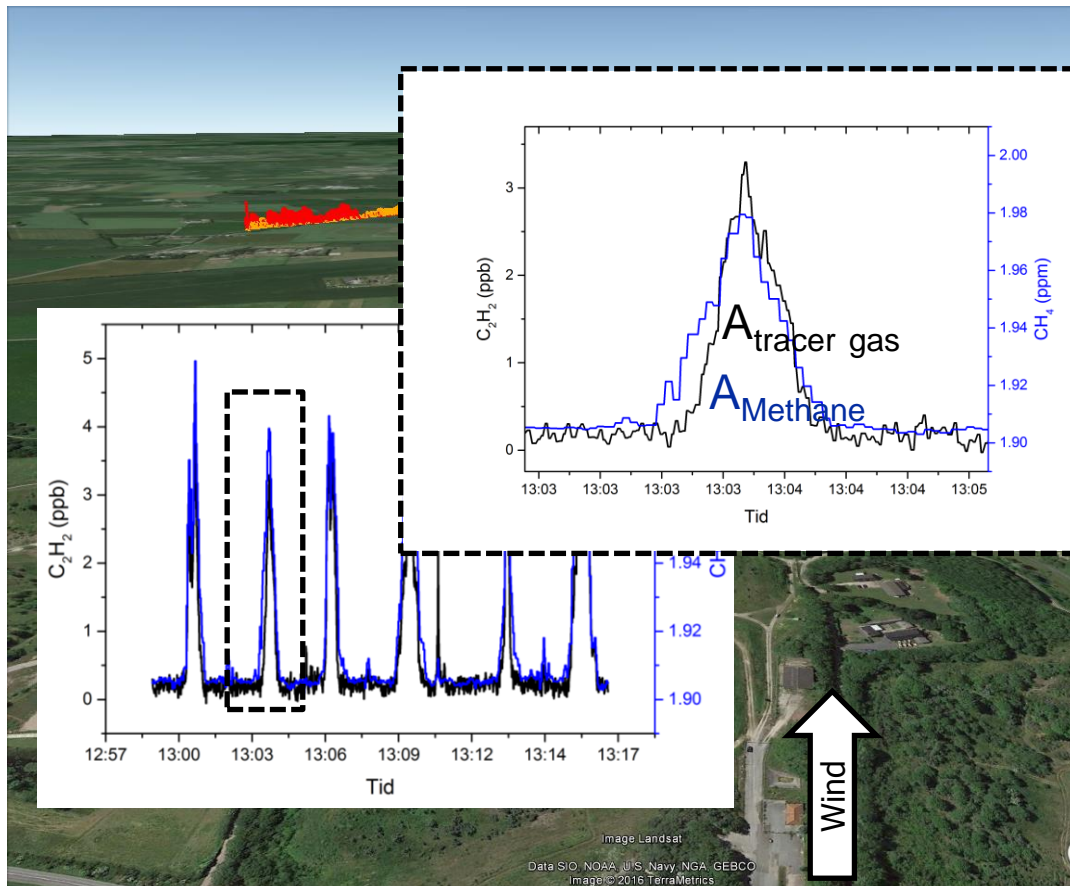


## 2) Tracer gas placement



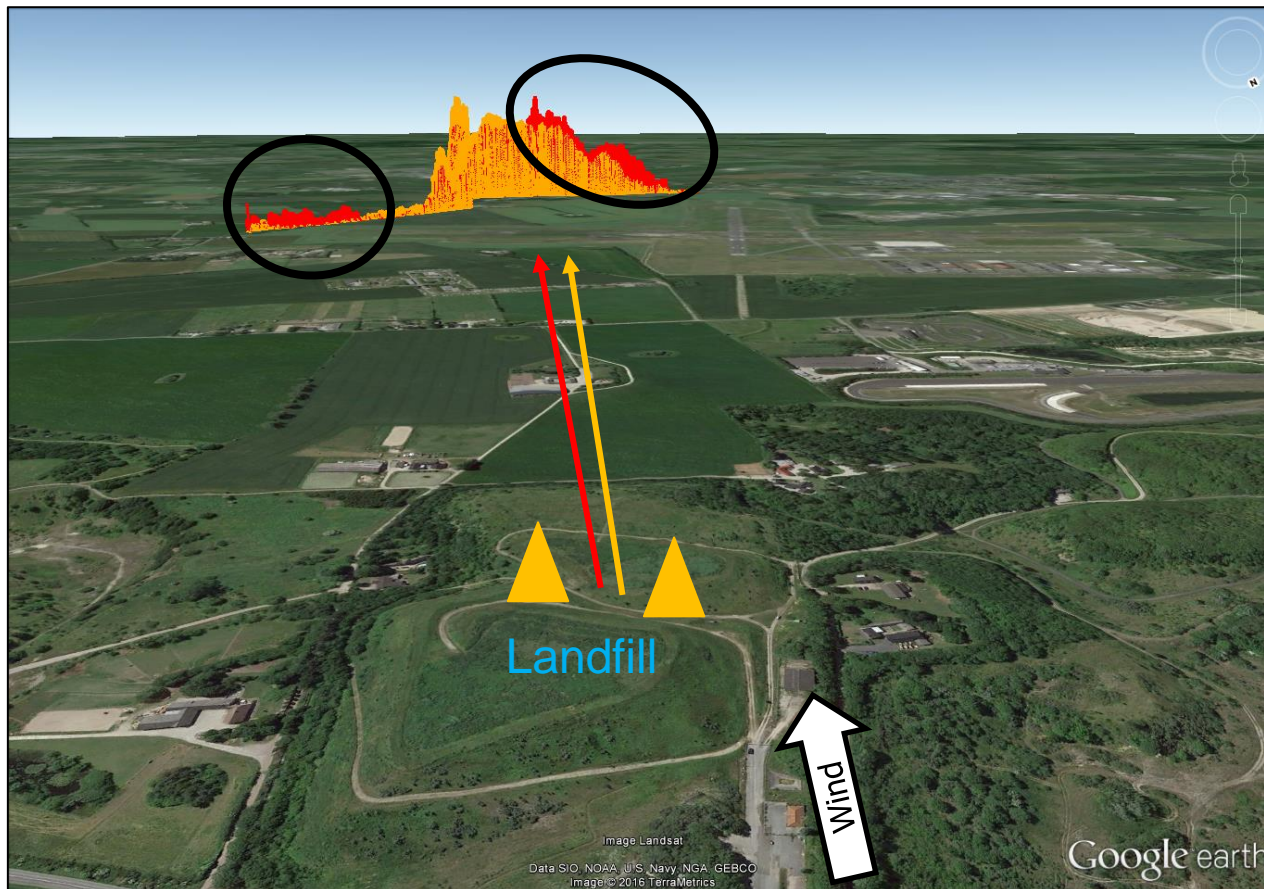


## 3) Measurements of the downwind plumes

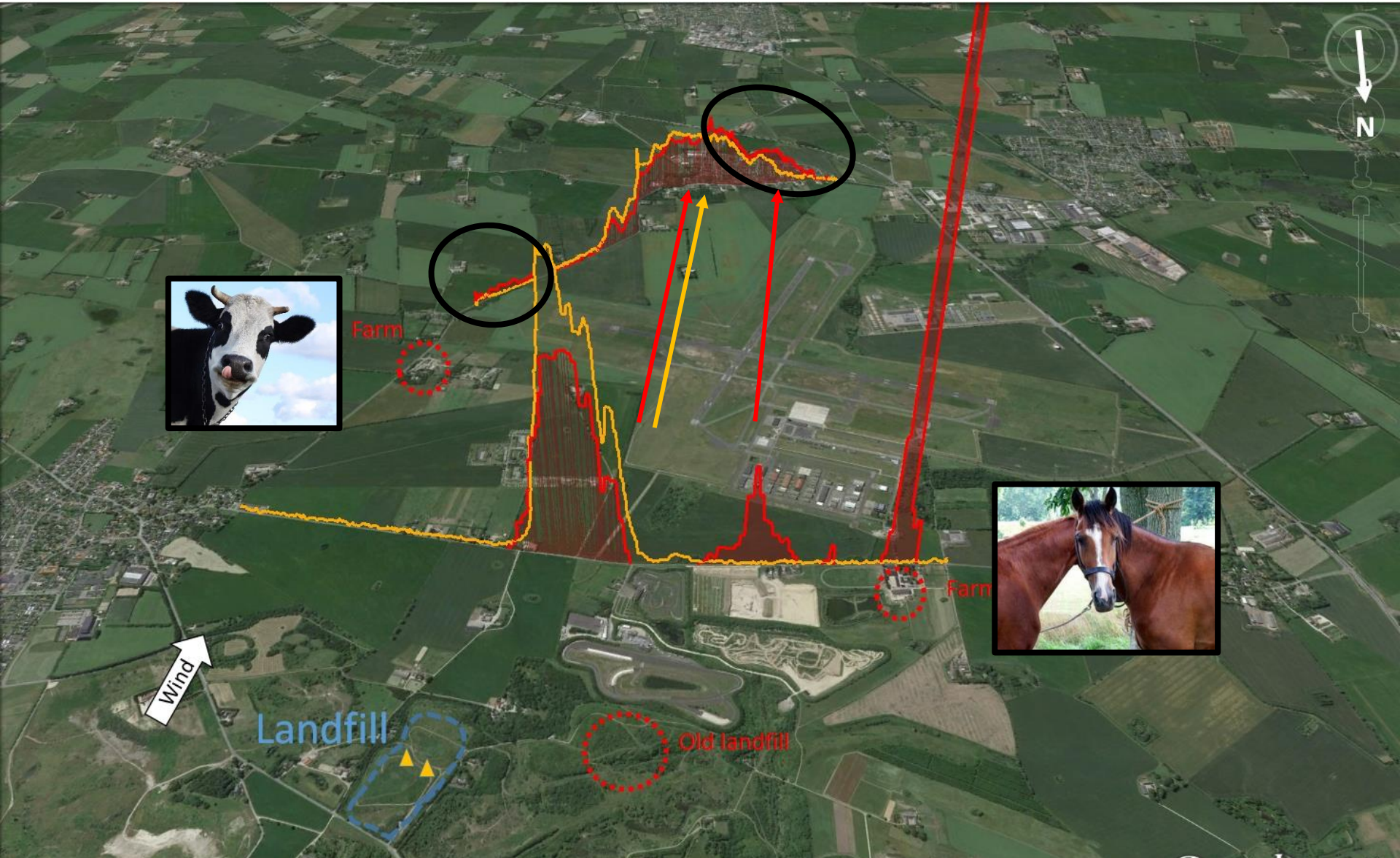


Time (hh:mm)	Methane mission (kg h <sup>-1</sup> )
12:32	10.2
12:44	10.7
12:53	10.6
12:56	12.8
13:01	11.0
13:03	13.6
13:06	10.7
13:09	11.7
13:13	12.9
13:19	11.9
13:21	11.5
13:23	11.7
13:26	11.2
13:32	12.7
13:34	13.9
13:36	13.6
13:38	12.8
13:43	10.6
13:46	11.7
Average	11.9
Std. Dev.	1.1
95% Conf. Int.	0.6

## Interfering sources







### Measurement uncertainties:

Other sources\*

Tracer gas release (flow & placement\*)

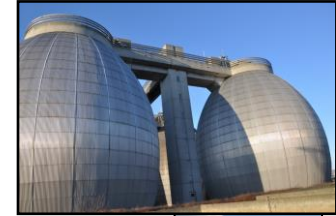
Elevated sources\*

Variation of background concentration\*

Too low concentrations\*

Sudden change in atmospheric conditions\*

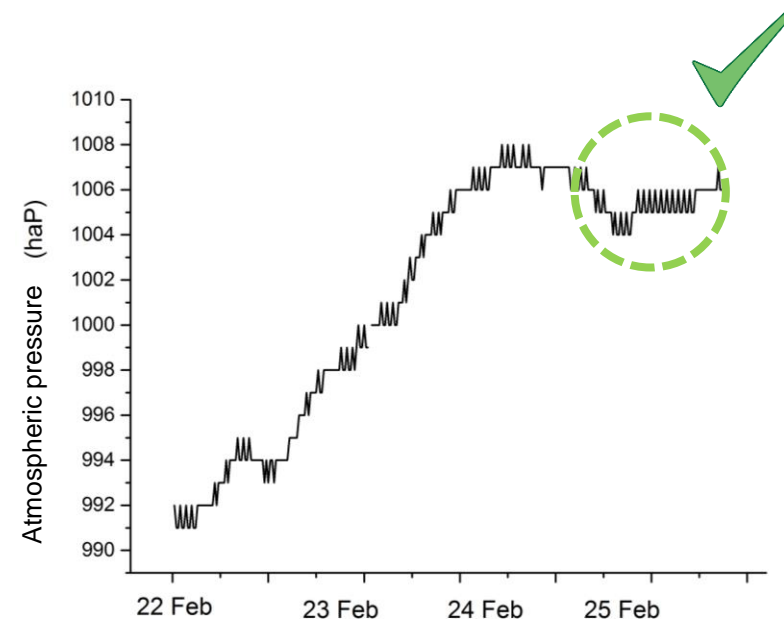
\*) site specific



### Landfill emission variation

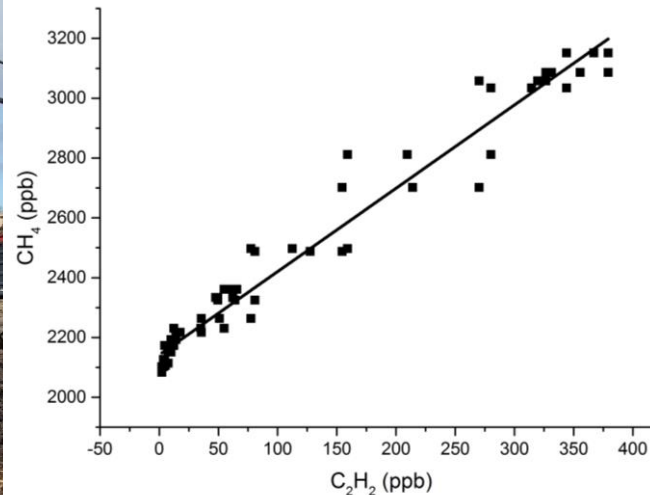
Atmospheric pressure (absolute & change)

- Wind
- Precipitation
- Temperature

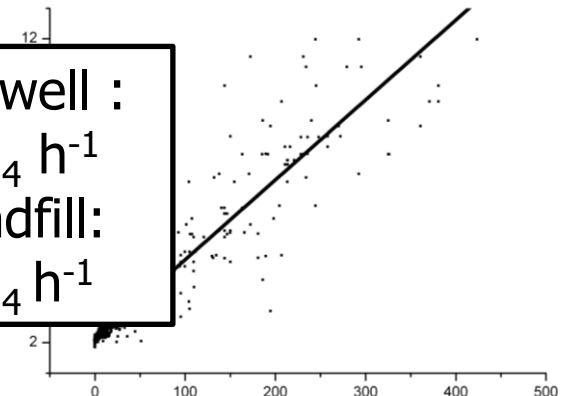




Leachate well in the middle of a  
composting area:  $0.6 \text{ kg CH}_4 \text{ h}^{-1}$

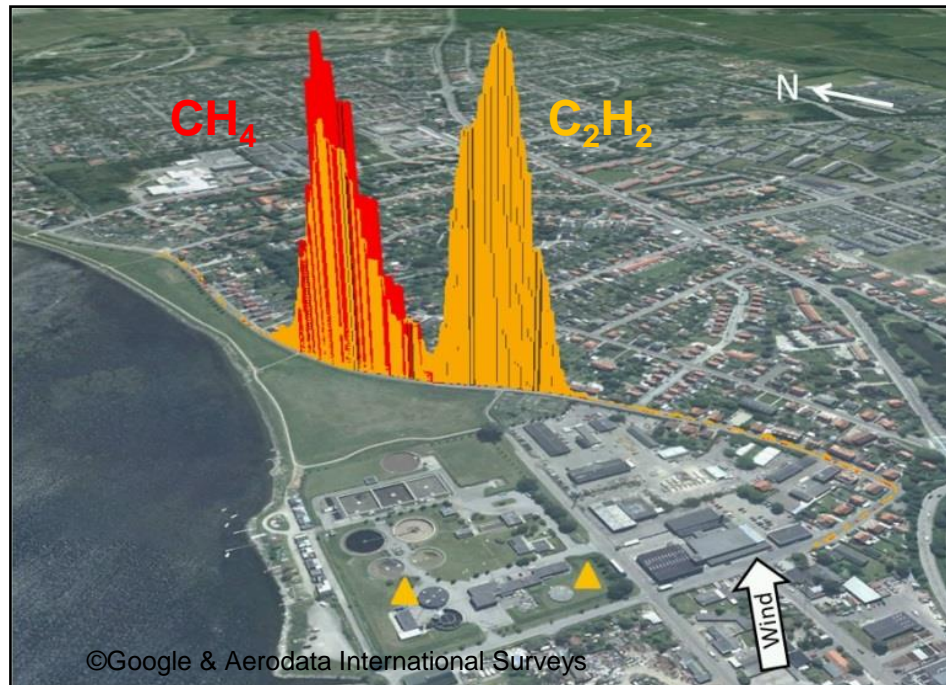


Leachate well :  
 $5.3 \text{ kg CH}_4 \text{ h}^{-1}$   
Whole landfill:  
 $6.9 \text{ kg CH}_4 \text{ h}^{-1}$

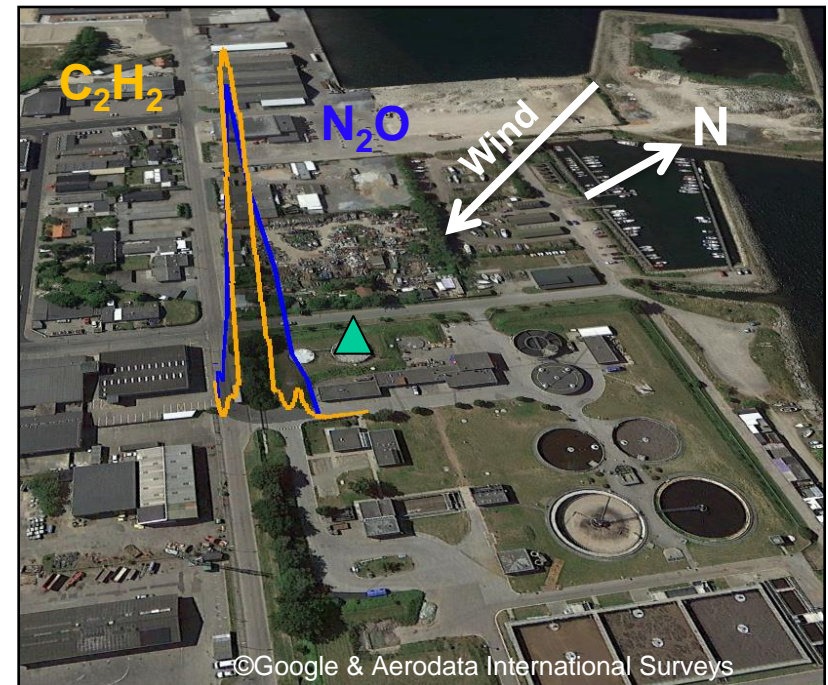


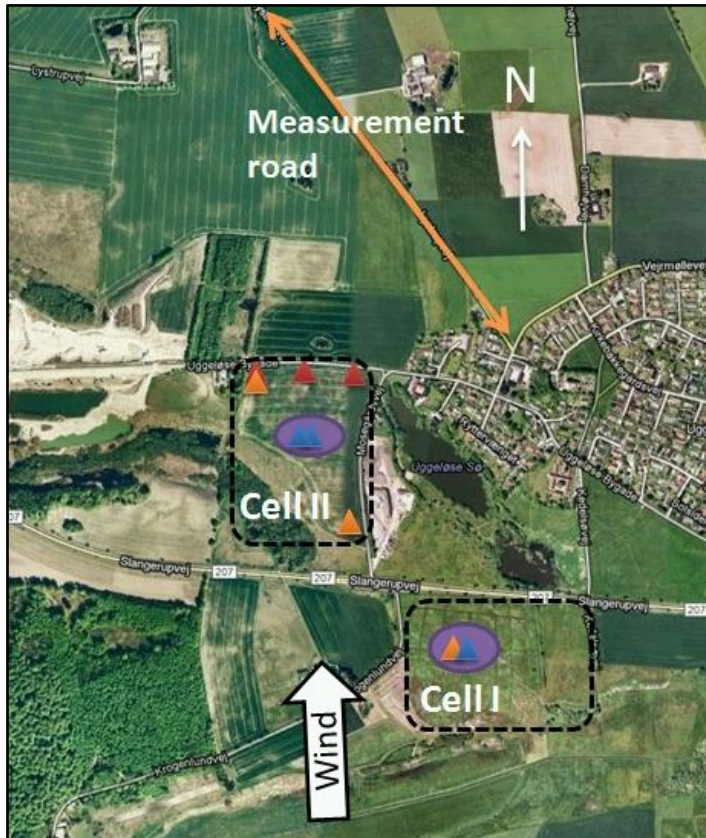


Whole site/area

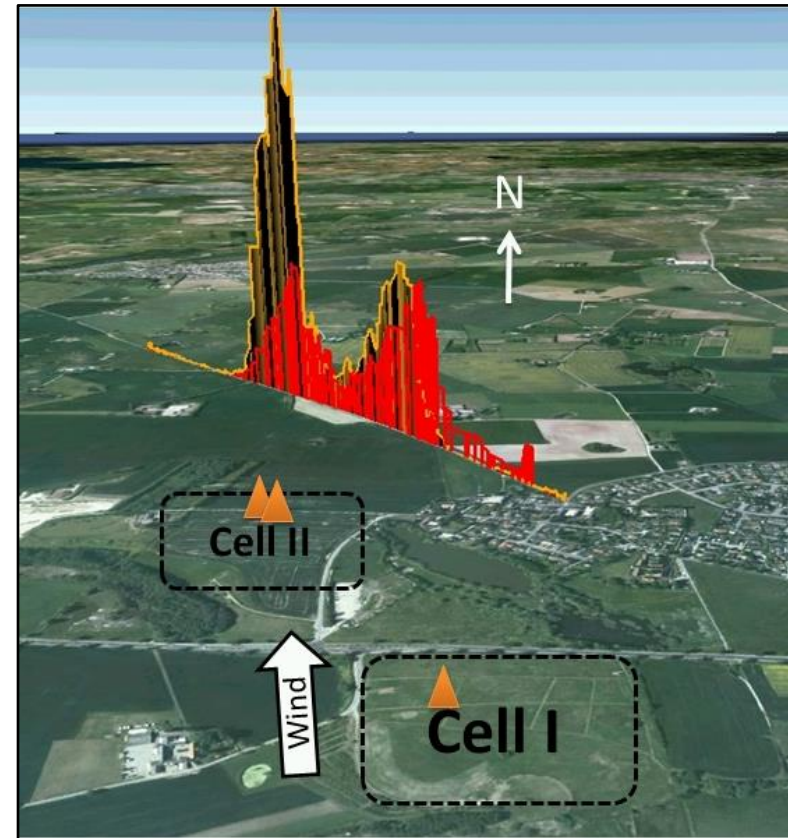


Single process



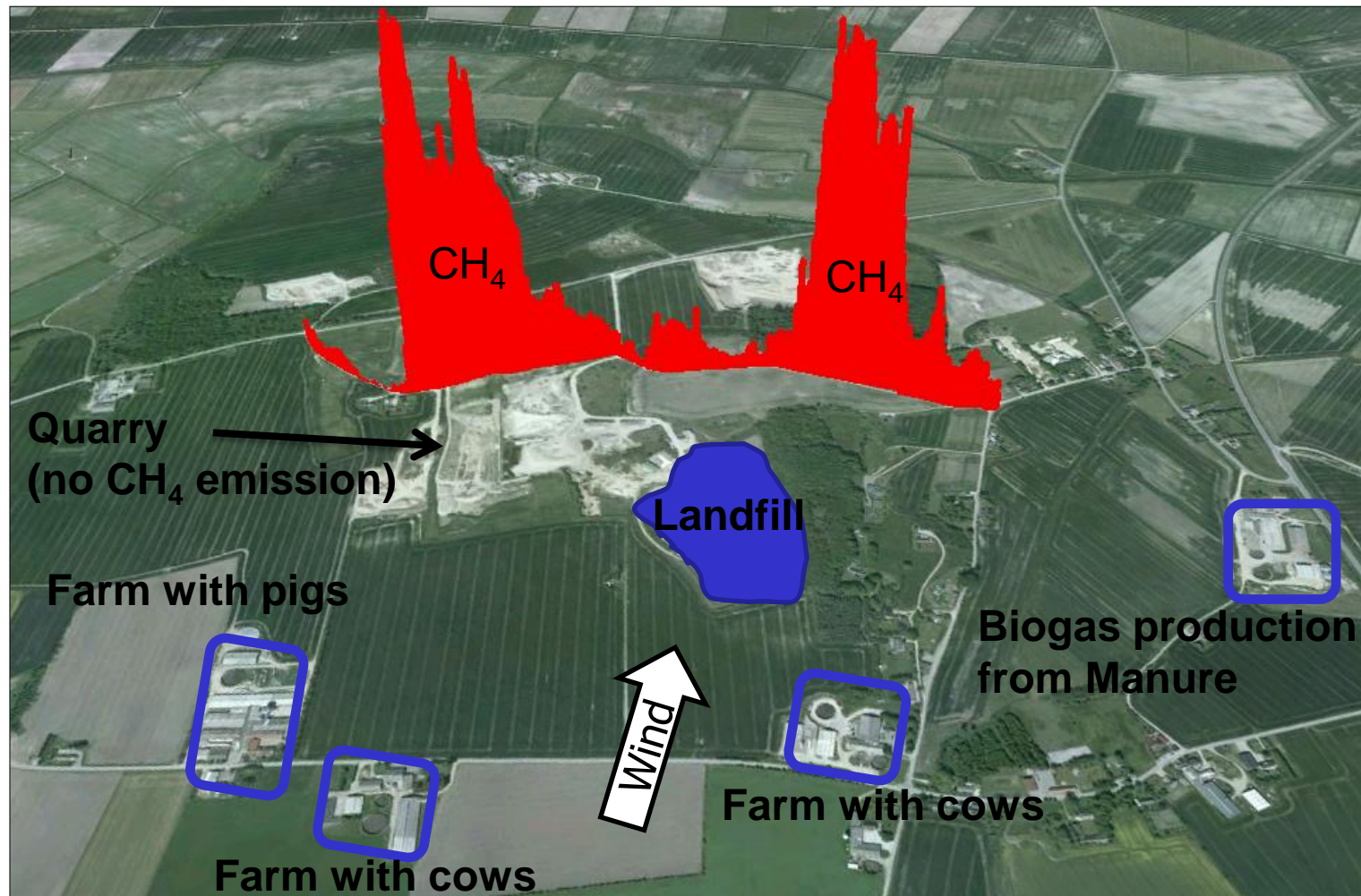


3 tracer gas configurations



Seperated plumes for quantification







# Dynamic tracer dispersion method

## Results

Landfill	CH <sub>4</sub> emission measured		CH <sub>4</sub> emission reported
	(kg CH <sub>4</sub> h <sup>-1</sup> )	(tons CH <sub>4</sub> y <sup>-1</sup> )	(tons CH <sub>4</sub> y <sup>-1</sup> )
Audebo	16.0	140	664
AV Miljø	32.4	284	28
Eskelund	6.1	53	NR
Fakse	42.2	370	129
Feltengård	3.9	34	298
Frederiksværk	8.9	78	17
Glatved	60.8	533	3490
Hedeland	3.1	27	3390
Klintholm	15.0	131	1490
Odense	33.1	290	487
Skovsted	2.6	23	500
Skårup	11.9	104	24
Uggeløse	9.5	83	NR
Viborg	11.1	97	1260
Ærø	6.9	60	118
Average	17.6	154	793

X 5

- + Emission of methane (real time)
- + Locate and quantify emission hotspots
- + Quantify emission areas e.g. single landfill cell or biocover)

Measure down to 1 kg methane h<sup>-1</sup>  
Point source down to 10 g methane h<sup>-1</sup>

Both depends on many factors

- Relative small time window
- Other sources
- Emission variation



# Dynamic tracer dispersion method

## Future work



Further validation of the method and instrumentation

- + Additional controlled release campaigns
- + Instrumentation intercomparison
- + Additional method intercomparison





## Thank you for your attention

Further information: [jmn@force.dk](mailto:jmn@force.dk)

### References in presentation

**Mønster, et al., 2014.** Quantifying methane emission from fugitive sources by combining tracer release and downwind measurements - a sensitivity analysis based on multiple field surveys. *Waste Management* 34, 1416–1428.

**Mønster, et al., 2015.** Quantification of methane emissions from 15 Danish landfills using the mobile tracer dispersion method. *Waste Management* 35, 177–186.

# Spørgsmål?

Artikler og anden dokumentation/information:

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