Point source emission estimation through eddy covariance: Validation using an artificial source experiment

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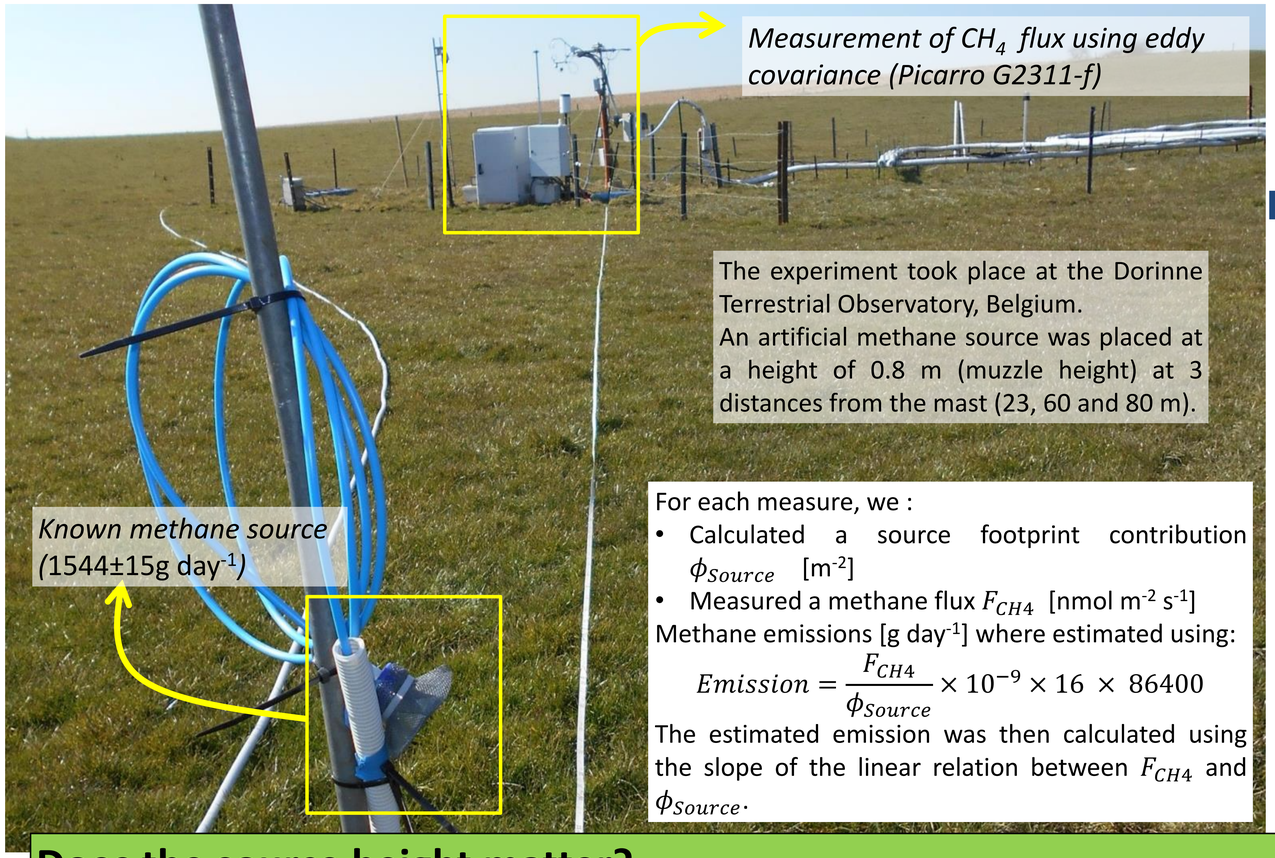
Long term objective: estimate methane emission from grazing cattle.



The experiment took place at the Dorinne Terrestrial Observatory, Belgium.
An artificial methane source was placed at a height of 0.8 m (muzzle height) at 3 distances from the mast (23, 60 and 80 m).

For each measure, we :
- Calculated a source footprint contribution ϕ_{Source} [m^{-2}]
- Measured a methane flux F_{CH4} [nmol m^{-2} s^{-1}]

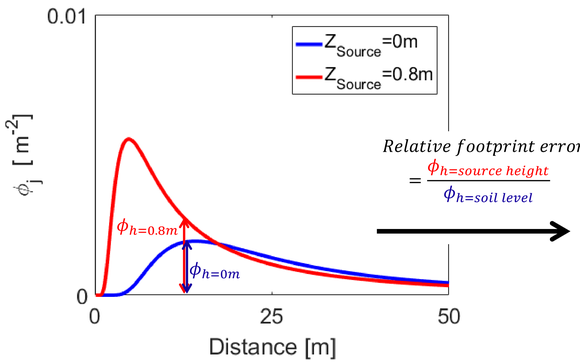
Methane emissions [g day^{-1}] where estimated using:

$$Emission = \frac{F_{CH4}}{\phi_{Source}} \times 10^{-9} \times 16 \times 86400$$

The estimated emission was then calculated using the slope of the linear relation between F_{CH4} and ϕ_{Source}.

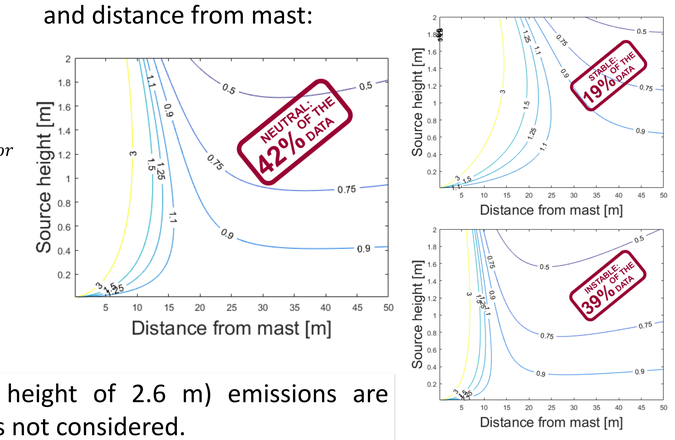
Does the source height matter?

Different source heights were tested using the FIDES footprint model (Loubet et al., 2011).



$$Relative\ footprint\ error = \frac{\phi_{h=source\ height}}{\phi_{h=soil\ level}}$$

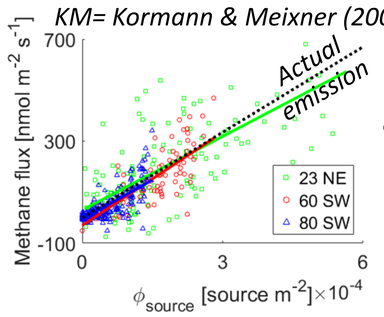
Relative footprint error according to source height and distance from mast:

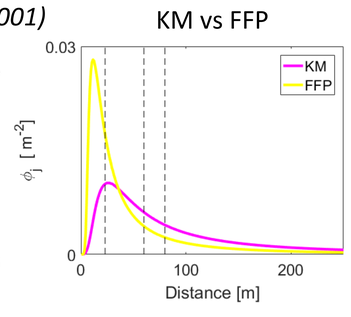


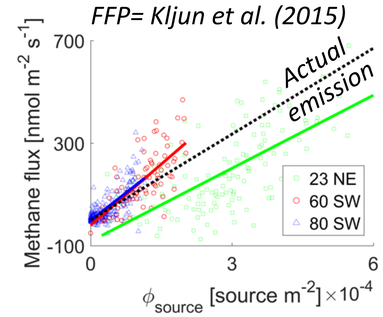
For distances larger than 10 to 20 m (mast height of 2.6 m) emissions are underestimated by up to 25% if the source height is not considered.

Main results from Dumortier *et al.* (2019)

Two popular footprint models were tested:







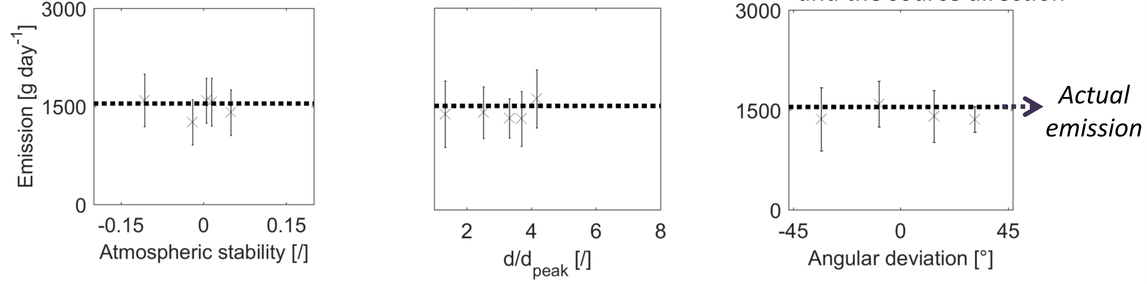
❑ All three regression curves are almost parallel to the actual emission curve

❑ KM and FFP footprint models produce very different footprint shapes

❑ Regression curves are not parallel and do not correspond to the actual emission curve

At our site, the KM footprint model provides accurate and stable emission estimates

Sensitivity analysis using the KM footprint model



Estimated methane emissions were robust, no matter the atmospheric stability, the distance from the mast or wind direction relatively to the source

Problem: Both footprint models can only consider a source placed at soil level although the source is placed at a height of 0.8 m

Conclusions and perspectives

- Using the Kormann & Meixner (2001) footprint model estimated methane emissions were never significantly different from the actual emission, no matter the atmospheric conditions or the wind direction.
- Source height influence becomes critical for sources close to the mast.
- If source height is not considered, measurements should be discarded when cattle are close to the mast.
- The artificial source was mobile in the footprint, indicating that the present method could be compatible with moving point source (e.g. cattle).