MEASUREMENT METHODS COMPARISON CAMPAIGN OF CH_4 EMISSIONS BY GRAZING LIVESTOCK

Carried out by:

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1. Project description:

The important role of livestock on the global climate change was underlined in the last FAO's report (2007). Methane is considered to be the third most important greenhouse gas globally, after water vapor and carbon dioxide. Its concentration has risen by 150% since the pre-industrial era (IPCC, 2007) and currently 20% of the enhanced greenhouse effect is due to methane (IPCC, 2007). In CO_2 equivalents, in France, 30% of agricultural greenhouse gas emission was attributed to enteric fermentation or ruminant animals (Citepa, 2008).

Significant uncertainties in CH_4 measurements still remain, mainly due to spatial and temporal variation and limitations in the measurement equipment. The eddy covariance technique, offers both very precise concentration measurements, a high sampling rate, an integrated continuous measurements over a large footprint area (i.e. measure area) and long periods.

Recent studies have reported the accurate use of Fast Methane Analyzer (FMA, DLT-100 Los Gatos, Canada) in wet grassland systems (Hendricks et al 2007). To our knowledge, FMA was not applied for grazed systems before. In a first approach, to test accuracy of the FMA, 6 months of measurement (2008) were carried out at the French study site Laqueuille, an upland (1040 m a.s.l.) and semi-natural grassland, without any restriction concerning the footprint area. This data set was used to adjust raw data processing (i.e. EdiRE) used to calculated methane fluxes from a sonic anemometer and meteorological data (wind speed and wind direction). To evaluate if cattle, staying in the footprint area can be captured by FMA, my project was to evaluate CH4 emission by using the Gaussian model for estimating CH_4 source strength from plume measurements (see Hensen & Scharff 2001), which was developed by host institute (Arjan Hensen ENC, Wageningen).

2. Purpose of the visit:

The purpose of my visit to the Energy Research Center of the Netherland (ECN) was to evaluate accuracy and use of FMA in grazed grassland. For doing so, I used the simple Gaussian plume model developed by Hensen and collaborators according to my experimental set up. Finally my visit to ECN gave me the possibility to get further information on other methodologies to measure CH_4 emissions (i.e. Tunable Diod Laser, quantum cascade laser).

3. Description of the work carried out before the visit

One field experiment was carried out in October 2009

For model input data, an experiment has been setup (see figure 1). In a defined area, during down wind conditions within the footprint, gas of known methane concentration (about 0.033 g/s) has been diffused from a known point within the footprint area. Simultaneously, one group of 6 cows was kept in a 20x20 m enclosure with an electrified fence line in the footprint area (see figure 1). At 20m downwind of the group and at 2m height, a handheld inlet system of 80 m connected to the FMA was used to measure the CH_4 concentration (plume) along a transect of approximatively 80 meters perpendicular to the methane plume that emerged from cows and cylinder. The so obtained CH_4 emission has been compared with Gaussian plume model calculations (Hensen and Scharff, 2001).

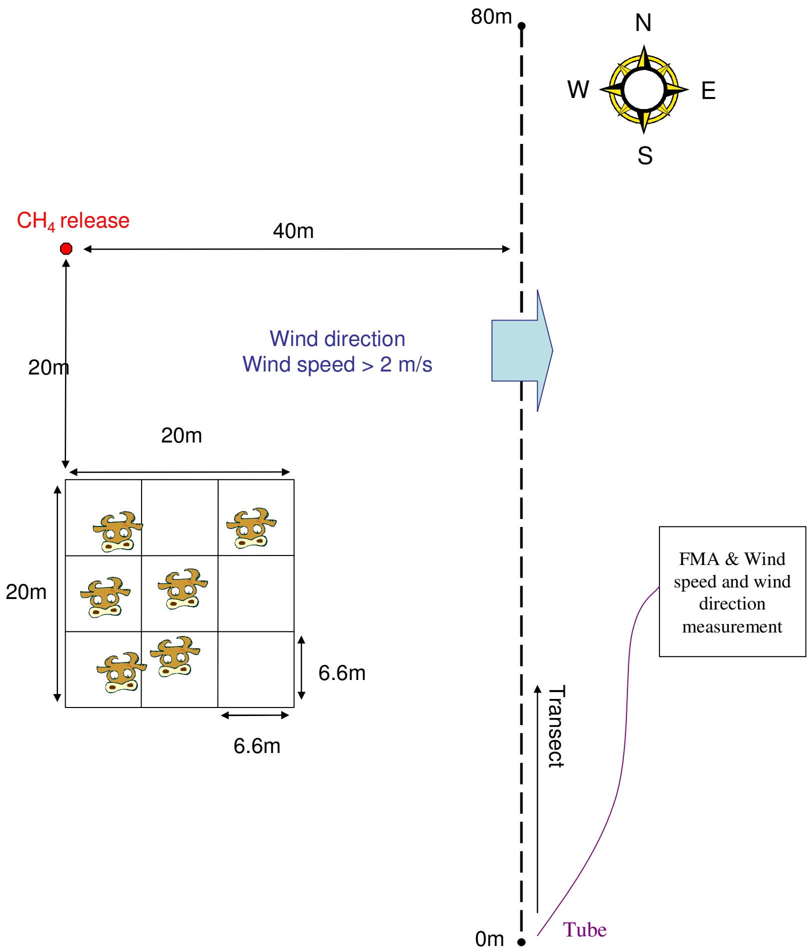

Figure 1: scheme of the experimental setup

The study took place at the French study site Laqueuille, which is a upland (1040 m a.s.l.) and a moderately intensive semi-natural grassland site. The field and the herd used in the experiment belong to "Unité Expérimentale des Monts d'Auvergne". The field was predominantly covered with *Agrostis capillaris* and *Dactylis glomerata*.

Wind speed and wind direction data were obtained with a 3D sonic anemometer. The distribution of the animals within the enclosure was obtained using a grid of (6.6 x 6.6m) and marking the cell where they were. The cow distribution maps have been used as source maps for gaussian dispersion modeling when estimating the separate plumes.
The emission of the group of animals had lead to a plume of methane that crossed the measurement transect. Through the transect, the instrument detected the CH_4 plume of the group of animals and of the cylinder. For each plume we wrote:

Concentration cows = (emission cows)* Dispersion (u, wd, stab, dist)
Concentration cylinder = (emission cylinder)* Dispersion (u, wd, stab, dist)

, where u is the wind speed, wd is the wind direction, stab is the stability, and dist is the position along the transect at the measure time.

CH_4 concentration measurements were obtained using a fast methane analyser. The actual concentration measurements take place in a cell operated at 90 Torr. A sampling frequency of 10 hz was used. Typical background CH_4 concentrations were about 1870 ppb.
The wind direction was western southwest. The mobile human measurements took place on the path south of the paddock which is indicated in figure 1.

4. Description of the work carried out during the visit

Day 1 (13th October): arrival in Alkmaar near about 15:00. Work on my data and Gaussian plume model at hotel with Arjan Hensen until 17h00.
Day 2 (14th October): visit of and work at ECN on Gaussian plume model with Arjan Hensen from 8h30 to 17h00.
Day 3 (15th October): Dimmie Hendricks PhD defence and work again on Gaussian plume model with Arjan Hensen. Presentation and demonstration of Cabauw field site by Arjan Hensen from Powerpoint and photos.

Day 4 (16th October): departure France in the morning.

5. Description of the main results obtained

An example of a part of the data set is shown in figure 2.

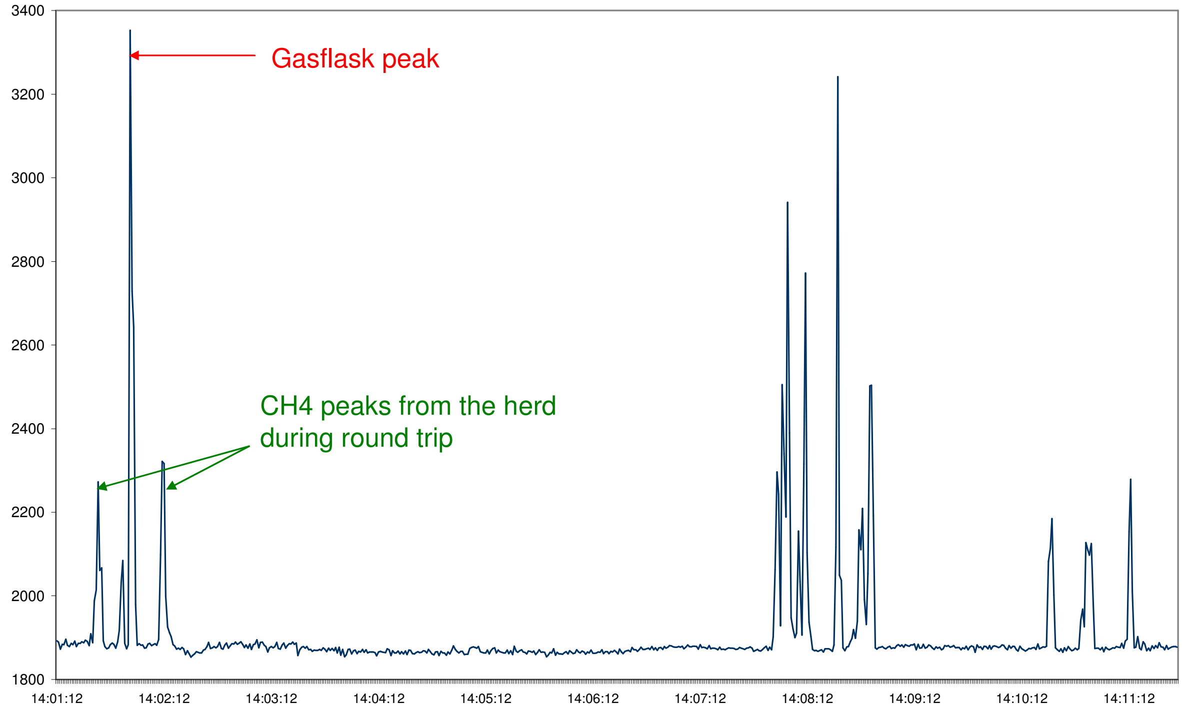

Figure 2: Part of the time series during the experiment

In order to evaluate the measured concentration patterns in terms of emissions these data were used in combination with the observed distribution of the animals within the enclosure.

The animals are free to move around within the enclosure. Since the dilution of the methane in the plume increases with an increase in distance, this would imply higher concentration measurements if the animals make a group at the East side of the enclosure. In order to correct this possible effect the Gaussian dispersion model is used. A map of cows distribution has been made (See figure 3) for each plume measure.

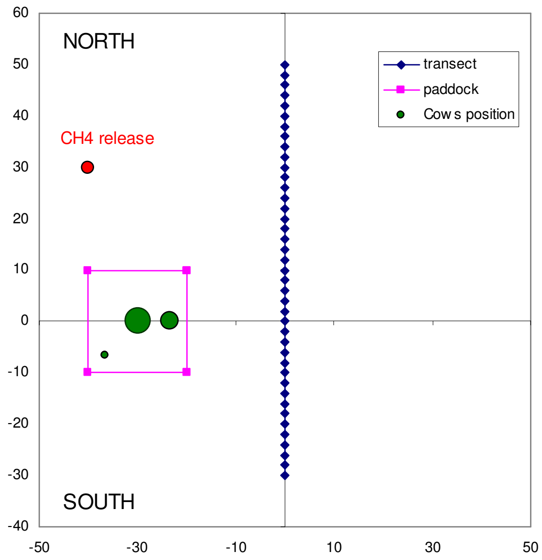

Figure 3: Example of a map of cows distribution

Those maps were used as input for the dispersion model. The plume model was used to evaluate the emission of the herd with source strengths of 1g CH_4/s.

Figure 4 shows the average of plumes (about 9 individual runs) measured along the north south coordinate of the transect. The concentration for CH_4 is in ppb above background level. The ratio of the model plumes and of the measured plumes is 0.76. This indicates that the CH_4 emission from the animals was 24% higher compared to the modelled emission.

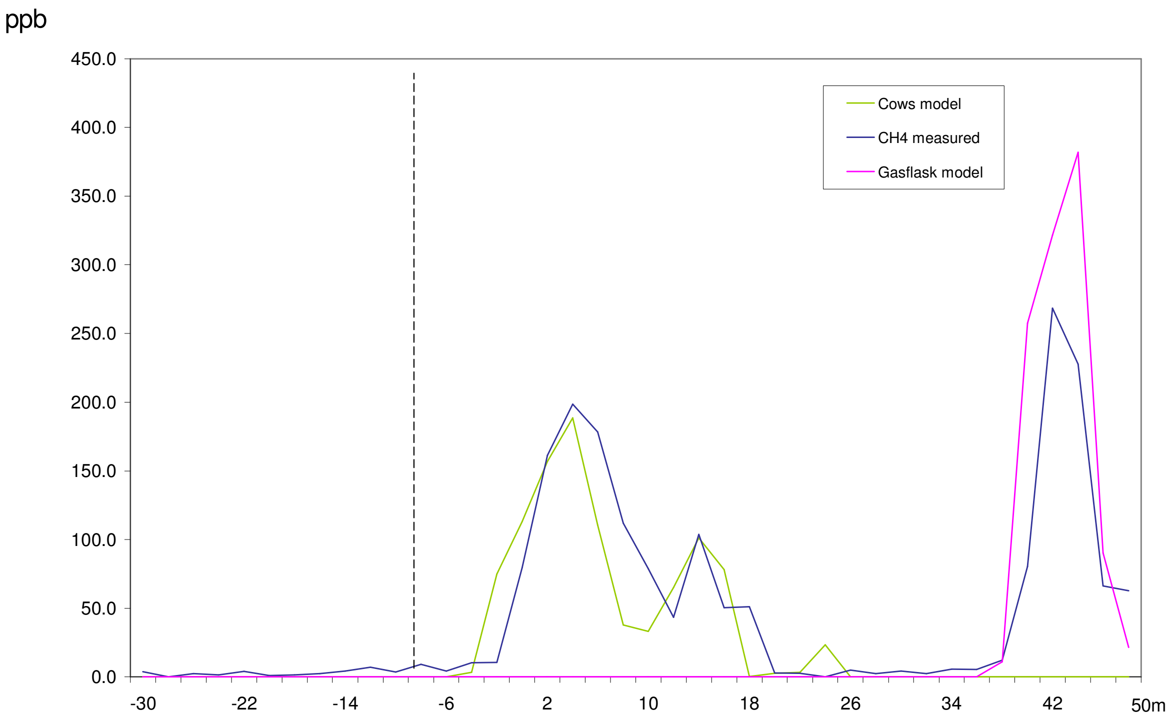

Figure 4 Averaged plumes for the measurement campaign

Based on the ratio of the modelled plumes and of the measured plumes an absolute estimate of the emission from the 6 cows can be made. The result of this calculation is shown in table 1.

Table 1 Emission levels; Absolute emission levels estimated using the modelled CH_4 plume (avg 1g/s)

	kg CH_4/cow/yr	gCH_4/cow/h	total cows	gCH_4/h for 6 cows	mgCH_4/sec for 6 cows
Measure	132	15	6	90	25
Model	100	11	6	68	19
Ratio model/measure					76

From those results, it appears that one cow emit about 132 kg (± 32) of CH_4 per year. A percentage of error between the modelled and the measured gasflask data has been determined and a correction factor has been estimated to be 0.68. However, according to model results this last result should be taken precautiously because of a possible failure in the released gas flow.

6. Discussion and conclusion

The measurement campaign is difficult to set up (changing windirection, analyser failure etc.), and needs to be repeated in the future to obtain more data to compare. The difference between the cows plumes with respect to distance to the measurement transect, the presence of the instable downwind caused an increased scatter in the measured emission data.

Despite the difficulties to carry out the experiment, we obtained model results which were in agreement with measurements of the Fast Methane Analyser Los Gatos indicating a good accuracy of measurement of CH_4 with an incertitude of the data estimated at about 30%.

However, to valid those preliminary results, more measurement campaigns with a better stability of the downwind direction and cows position are needed.

7. Future collaboration with host institution *(if applicable)*

As the purchase of another analyzer is planned next year to measure CH_4 emission in extensive grassland in order to compare the effect of both management, another collaboration could be envisaged. This would allow in plus to test another type of analyzer and invite Arjan Hensen to come for a new measure campaign with experimental material of ECN as the Tunable Diode Laser.

8. Projected publications/articles resulting or to result from your grant

In a second approach, Fast Methane Analyzer measurements has been compared with the dual tracer (SF_6) method. This work has been done in collaboration with Cecile Martin (INRA, Theix). When all data from SF_6 tracer measurement campaign will also be entirely analyzed, a publication of those results is planned next year. This paper will include a comparison of both methods, Gaussian plume and SF_6 methods, to test the accuracy of FMA.

9. References

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