73th Annual Meeting of European Federation of Animal Science

Climate care dairy farming

First results of a screening method for GHG and ammonia emission measurements in European dairy cattle barns

X. Vergé, P. Robin, V. Becciolini, A. Cieślak, N. Edouard, L. Fermer, P. Galama, P. Hargreaves, V. Juškienė, G. Kadžiene, L. Leso, A.-S. Lissy, J. Priekulis, B. Rees, D. Ruska, H. Schilder, M. Szumacher-Strabel

6th September, 2022

Climate care dairy farming

I. Project presentation

II. Presentation of the "Simplified Method" (with video supports)

III. Preliminary results – Interest and perspectives

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I. Project presentation

Objectives :

1- Estimating the on-farm emissions through seasonal gas measurements in dairy barns

2- Finding the main source of gas emissions in each building

3- Studying the applicability of such method in various conditions and production systems

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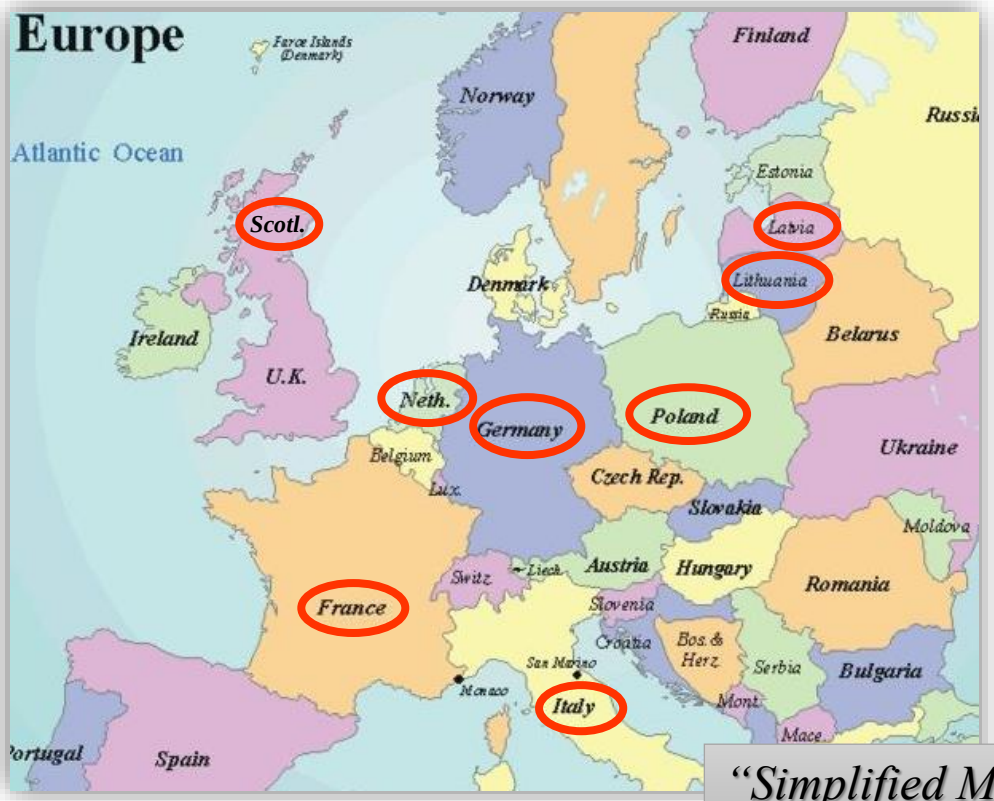
I. Project presentation

European study

- Eight countries
- Eight farms for each
- Four times a year



"Simplified Method"

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II. Presentation of the "Simplified Method" (with video support)

https://cccfarming.eu/

Plan :

1- Overview (vidéo)

2- Issue and calculation pathways

3- Collecting farm management data

4- On-farm air sampling (vidéo)

5- Gas analysis

- Introduction
- Ammonia (NH_3) ➡ Colorimetric tubes (vidéo)
- GHG (CO_2,CH_4,N_2O) ➡ Gas Chromatograph (glass sample tube) - (vidéo)

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II. Presentation of the "Simplified Method" (with video support)

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1- Overview (vidéo)

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Plan :

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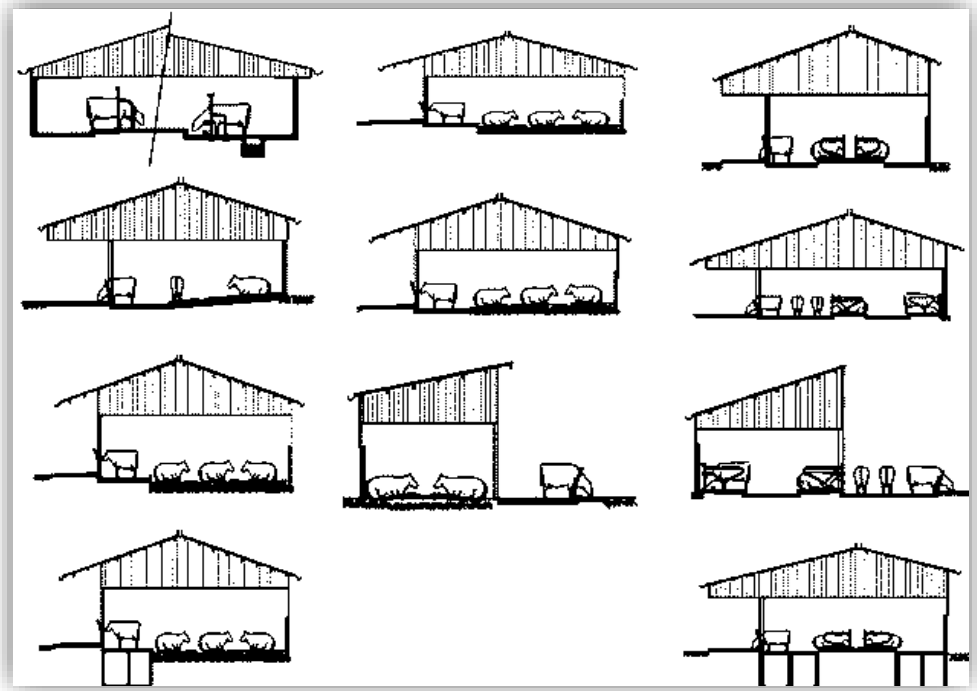
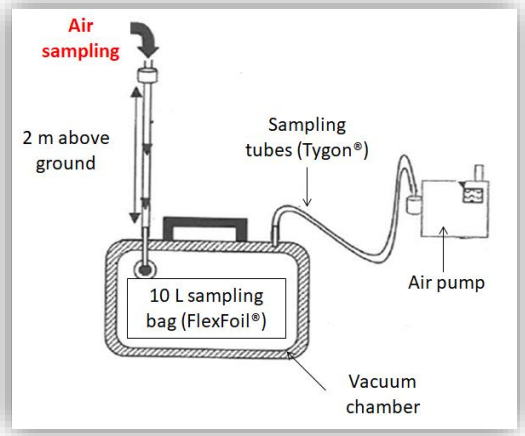
II. Presentation of the "Simplified Method"

https://cccfarming.eu/

$$Emissions_{Gas} = (Q_{air} \times \rho i) \times (Cgas_{in} - Cgas_{out})$$

$$= A \times Gradient_{Gas}$$





Q_{air} : is the air flow rate
ρi : air density
Cgas : gas concentration

II. Presentation of the "Simplified Method"

https://cccfarming.eu/

$$Emissions_{Gas} = A \times Gradient_{Gas}$$

$$A = \frac{Emissions_{Gas}}{Gradient_{Gas}}$$

$$A = \frac{E_{C\text{-}CO2}}{G_{C\text{-}CO2}}$$

$$A = \frac{E_{C\text{-}CH4}}{G_{C\text{-}CH4}}$$

$$A = \frac{E_{N\text{-}N2O}}{G_{N\text{-}N2O}}$$

$$A = \frac{E_{N\text{-}NH3}}{G_{N\text{-}NH3}}$$

Q_{air} : is the air flow rate
ρi : air density
Cgas : gas concentration

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II. Presentation of the "Simplified Method"

https://cccfarming.eu/

$$A = \frac{Emissions_{Gas}}{Gradient_{Gas}}$$

$$A = \frac{E_{C\text{-}CH4}}{G_{C\text{-}CH4}} = \frac{E_{C\text{-}CO2}}{G_{C\text{-}CO2}} = \frac{E_{N\text{-}N2O}}{G_{N\text{-}N2O}} = \frac{E_{N\text{-}NH3}}{G_{N\text{-}NH3}}$$

$$E_{C\text{-}CH4} = E_{C\text{-}CO2} \times \frac{G_{C\text{-}CH4}}{G_{C\text{-}CO2}}$$

$$E_{N\text{-}N2O} = E_{C\text{-}CO2} \times \frac{G_{N\text{-}N2O}}{G_{C\text{-}CO2}}$$

$$E_{N\text{-}NH3} = E_{C\text{-}CO2} \times \frac{G_{N\text{-}NH3}}{G_{C\text{-}CO2}}$$

(INDOOR - OUTDOOR)

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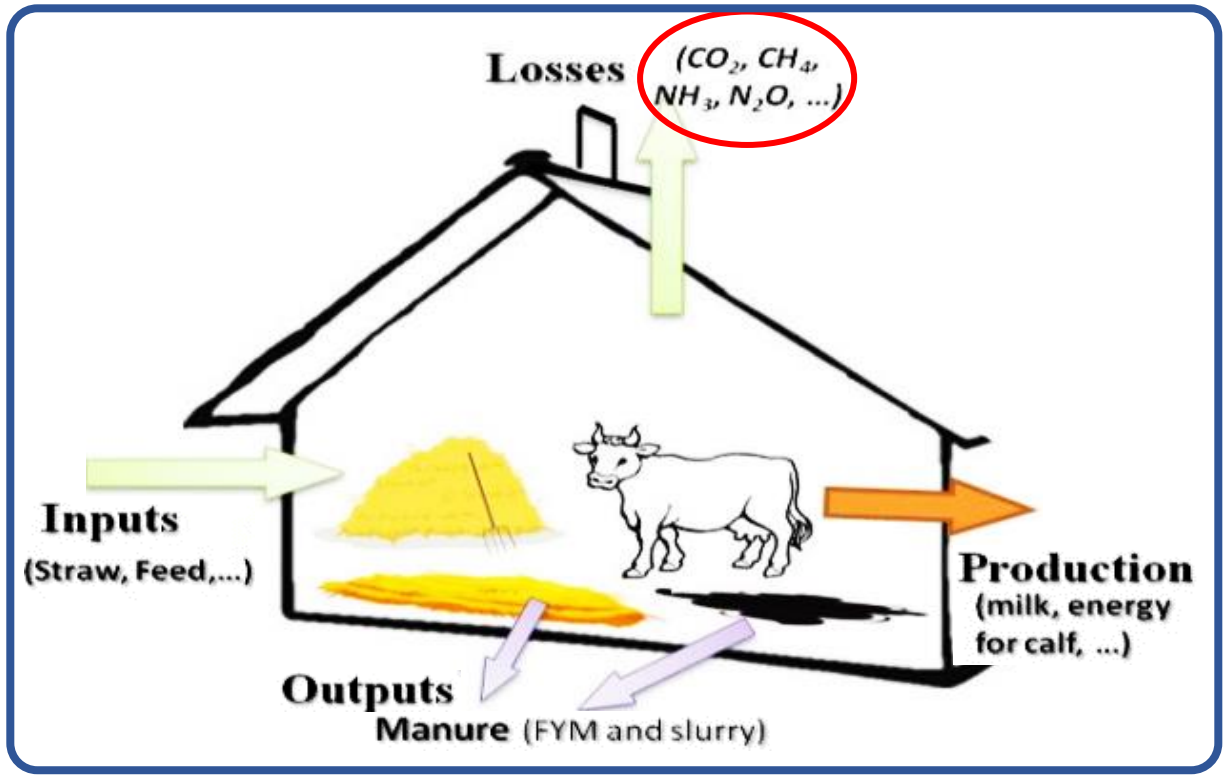
CO_2 emissions estimated with the mass balance approach at the building scale

(with the questionnaire)



$$C_{Losses} = E_{C\text{-}CO2} + E_{C\text{-}CH4}$$

$$E_{C\text{-}CO2} = C_{Losses} - E_{C\text{-}CH4}$$

$$C_{Losses} = (C_{feed} + C_{litter}) - (C_{milk} + C_{Growth} + C_{gestation} + C_{Mobilization} + C_{Excretion})$$

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II. Presentation of the "Simplified Method"

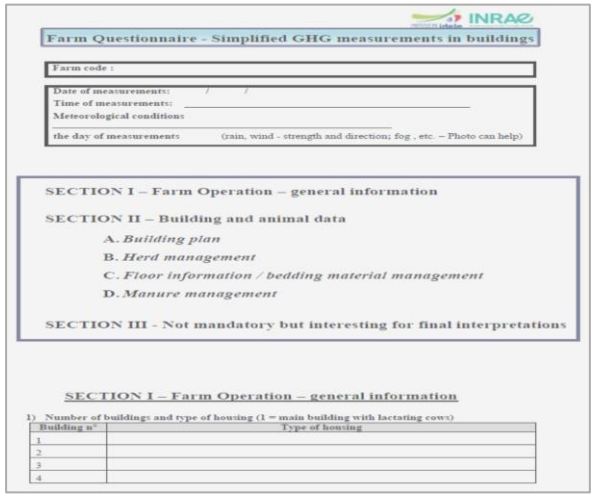
https://cccfarming.eu/

$$E_{C\text{-}CO2} = C_{Losses} - E_{C\text{-}CH4}$$

$$E_{C\text{-}CO2} = \frac{C_{Losses}}{\left(1 + \frac{G_{C\text{-}CH4}}{G_{C\text{-}CO2}}\right)}$$

$$E_{C\text{-}CH4} = E_{C\text{-}CO2} \times \frac{G_{C\text{-}CH4}}{G_{C\text{-}CO2}}$$

=


INRAE

Farm Questionnaire - Simplified GHG measurements in buildings

Farm code :

Date of measurements: / /
Time of measurements:
Meteorological conditions:
the day of measurements (rain, wind - strength and direction; fog , etc. – Photo can help)

SECTION I – Farm Operation – general information

SECTION II – Building and animal data

A. *Building plan*
B. *Herd management*
C. *Floor information / bedding material management*
D. *Manure management*

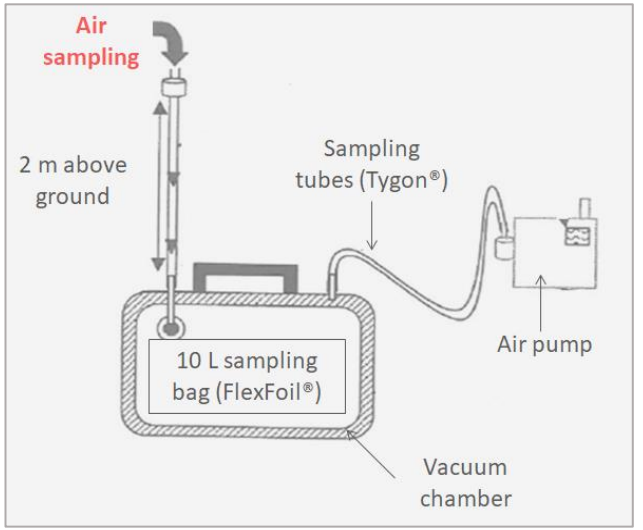
SECTION III - Not mandatory but interesting for final interpretations

SECTION I – Farm Operation – general information

1) Number of buildings and type of housing (1 = main building with lactating cows)

Building n°	Type of housing
1	
2	
3	
4	

Questionnaire



Samplings

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II. Presentation of the "Simplified Method" (with video support)

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INRAE – INSTITUT DE L'ELEVAGE – idele

Farm Questionnaire - Simplified GHG measurements in buildings

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SECTION I – Farm Operation – general information

6- Gas sampling

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II. Presentation of the "Simplified Method"

(with video support) *https://cccfarming.eu/*

Plan :

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- **Introduction**
- **Ammonia** (NH_3) ➡ **Colorimetric tubes (vidéo)**
- **GHG** (CO_2,CH_4,N_2O) ➡ **Gas Chromatograph (glass sample tube) - (vidéo)**

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II. Presentation of the "Simplified Method" (with video support)

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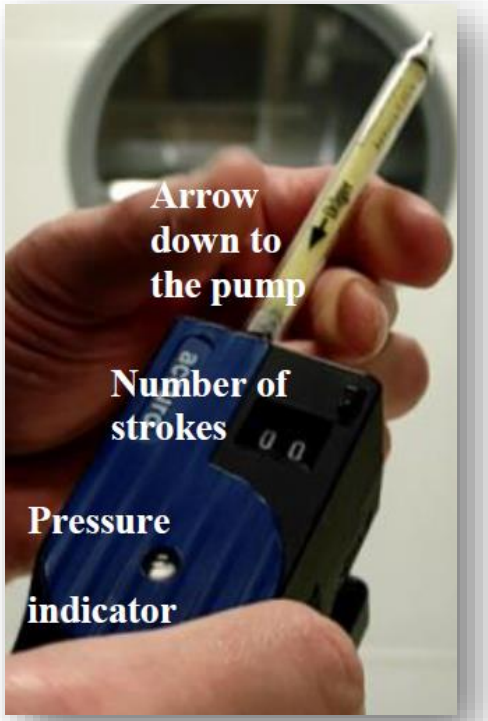
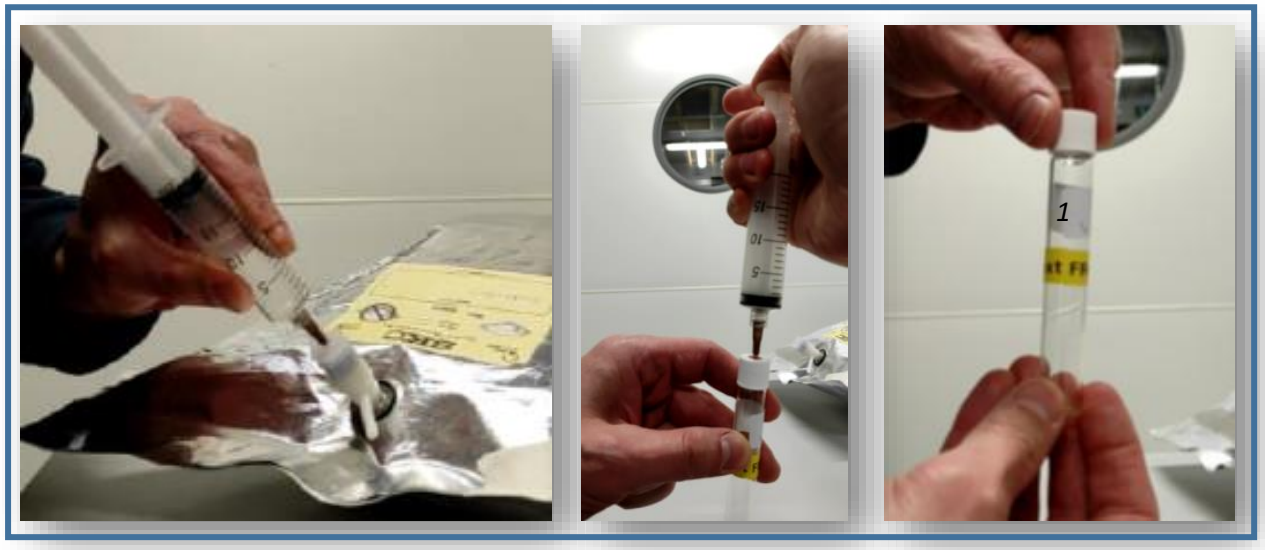
NH_3 Colorimetric tubes



GHG Gas chromatograph



VIDEO

7- Immediate gas concentration determination

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I. Project presentation

II. Presentation of the "Simplified Method" (with video support)

III. Preliminary results – Interest and perspectives

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III. Preliminary results - Interest and perspectives

presented results:

42 farms / 4 seasons

Question-naire	m^2 cow^{-1}	anim. $house^{-1}$	kg cow^{-1}	kg DM cow^{-1}	kg day^{-1}	g L^{-1}	g L^{-1}
	area	nb cows	weight	feed	milk	fat	protein
avg ± SD	9 ± 5	134 ± 141	682 ± 56	22 ± 3	31 ± 8	42 ± 4	34 ± 1
[min ; max]	[2 ; 26]	[8 ; 979]	[500 ; 825]	[16 ; 27]	[17 ; 53]	[32 ; 52]	[30 ; 37]

Ventilation

- *Half open/half closed barn*
- *Closed barn*
- *Open barn*

Sampling	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}
	CO_2	CH_4	NH_3	N_2O
avg ± SD	1397 ± 1662	23.4 ± 40.4	0.55 ± 0.43	0.71 ± 0.44
[min ; max]	[720 ; 17410]	[0.4 ; 352.4]	[0.07 ; 2.57]	[0.34 ; 4.91]

Housing

- *Cubicle, slatted floor*
- *Cubicle, sloping straw floor*
- *Cubicle, deep straw*
- *Cubicle with sand bedding and rubber floor*
- *Freewalk wood chips*
- *Compost bedded pack barn*
- *Compost barn, scraping alley*
- *Tie stall, deep straw*
- *Tie stall, scraping alley*

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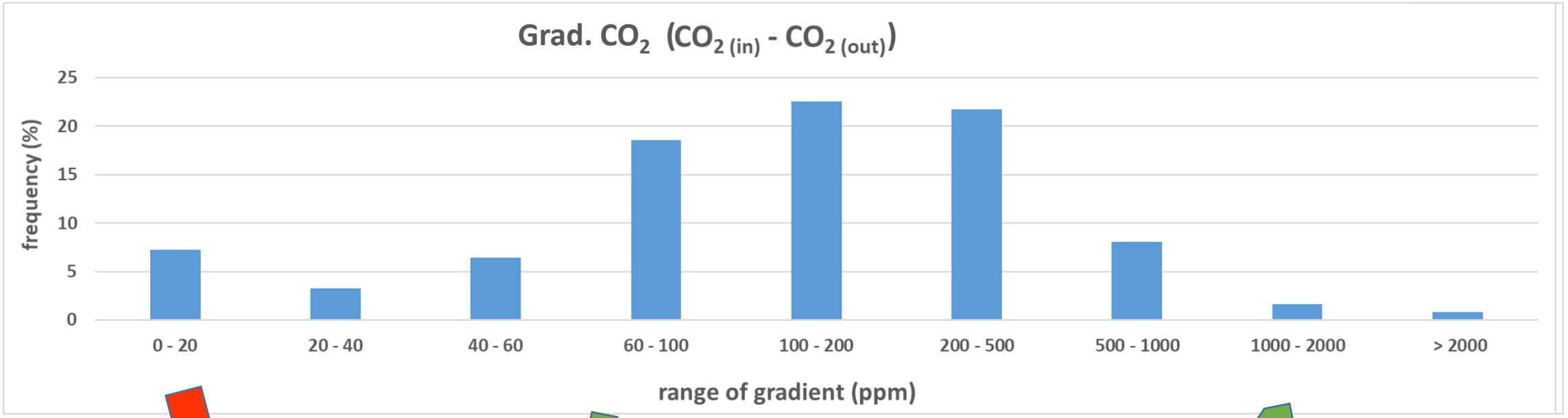
III. Preliminary results - Interest and perspectives

SCREENING

Indicating emission <u>environments</u> and potential <u>issues</u> with CO_2 gradients



Reliability of indication

Cannot be used without checking

Open building, high ventilation (Ex: warm season)

Confined situation, low ventilation (ex: cold season)

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SCREENING

III. Preliminary results - Interest and perspectives

Indicating emission sources and potential issues with CO_2/CH_4 ratios

***Hypothesis**: limited variability of CO_2 and CH_4 emissions from animals*

$$\frac{G_{C\text{-}CO2}}{G_{C\text{-}CH4}}$$

standard for dairies:
8 to 15 *(from litt.)*

small = CH_4 emission from manure

high = CO_2 emission from manure

very small or high = pb CO_2 or CH_4

(presence of cattle? very small sampling duration?)

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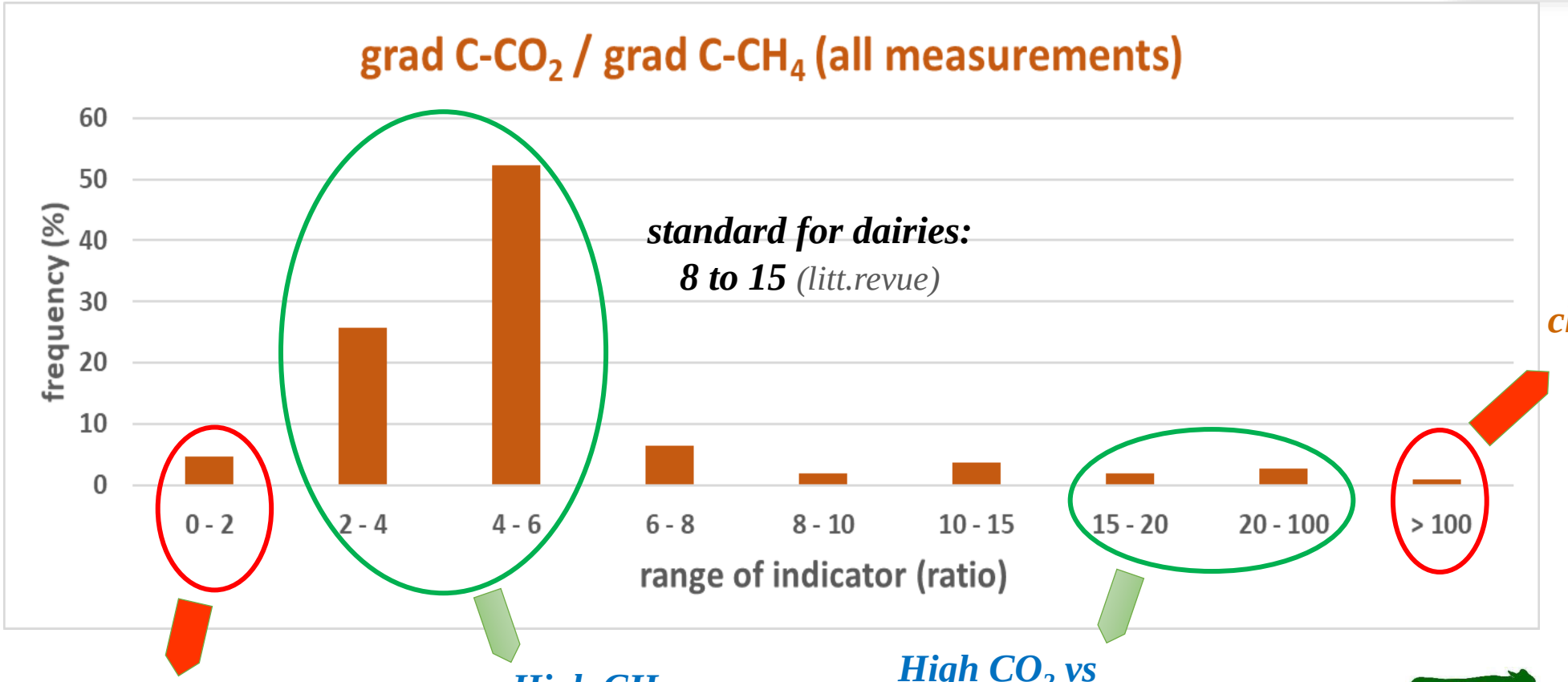
III. Preliminary results - Interest and perspectives

SCREENING

Indicating emission sources and potential issues with CO_2/CH_4 ratios



farming

III. Preliminary results - Interest and perspectives

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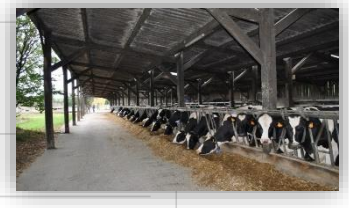
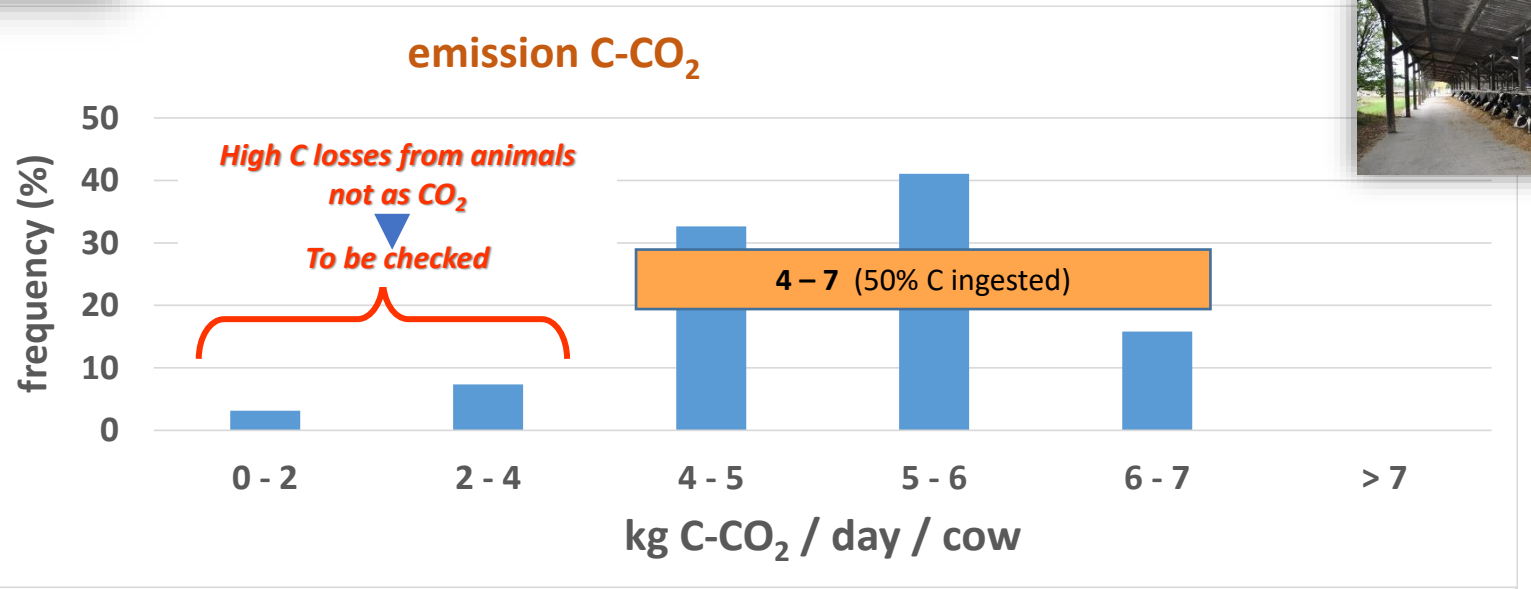
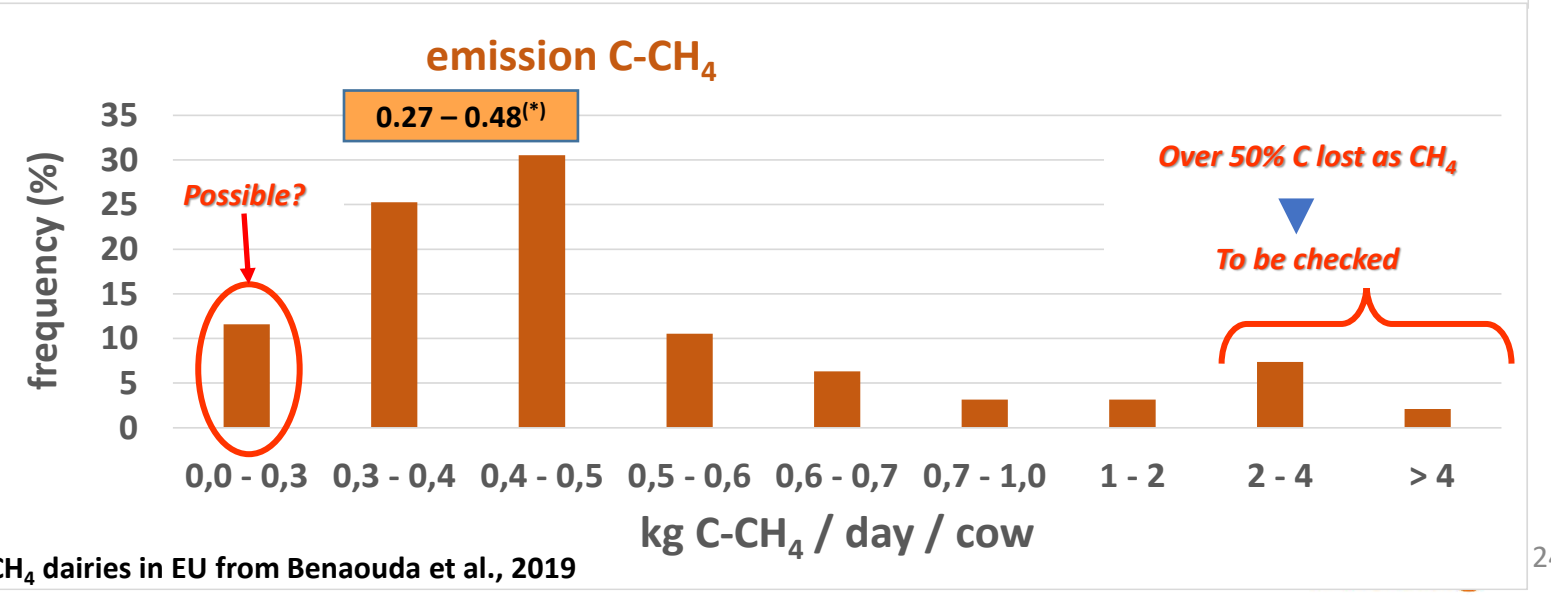


$C\text{-}CO_2$ and $C\text{-}CH_4$ emissions

Observed variability of CO_2 and CH_4 emissions:

- *feeding*
- *litter*
- *manure management*





(*) range CH_4 dairies in EU from Benaouda et al., 2019

III. Preliminary results - Interest and perspectives

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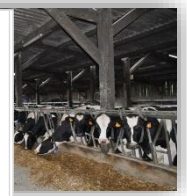
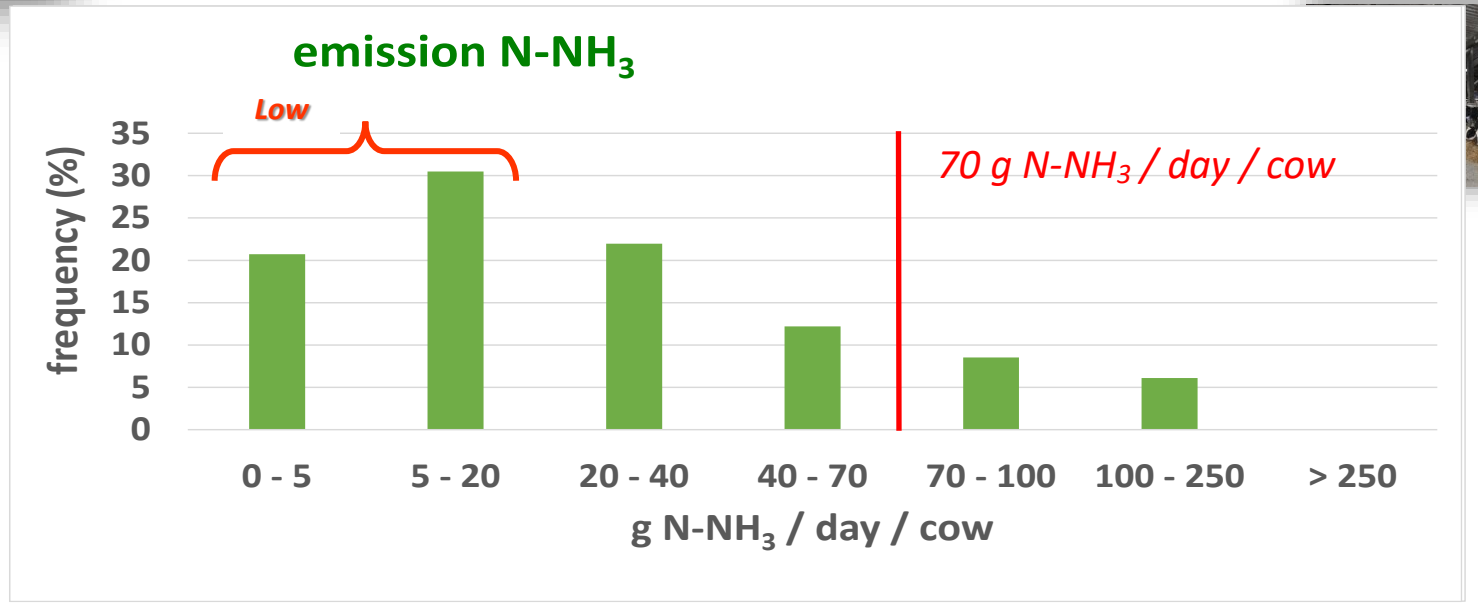
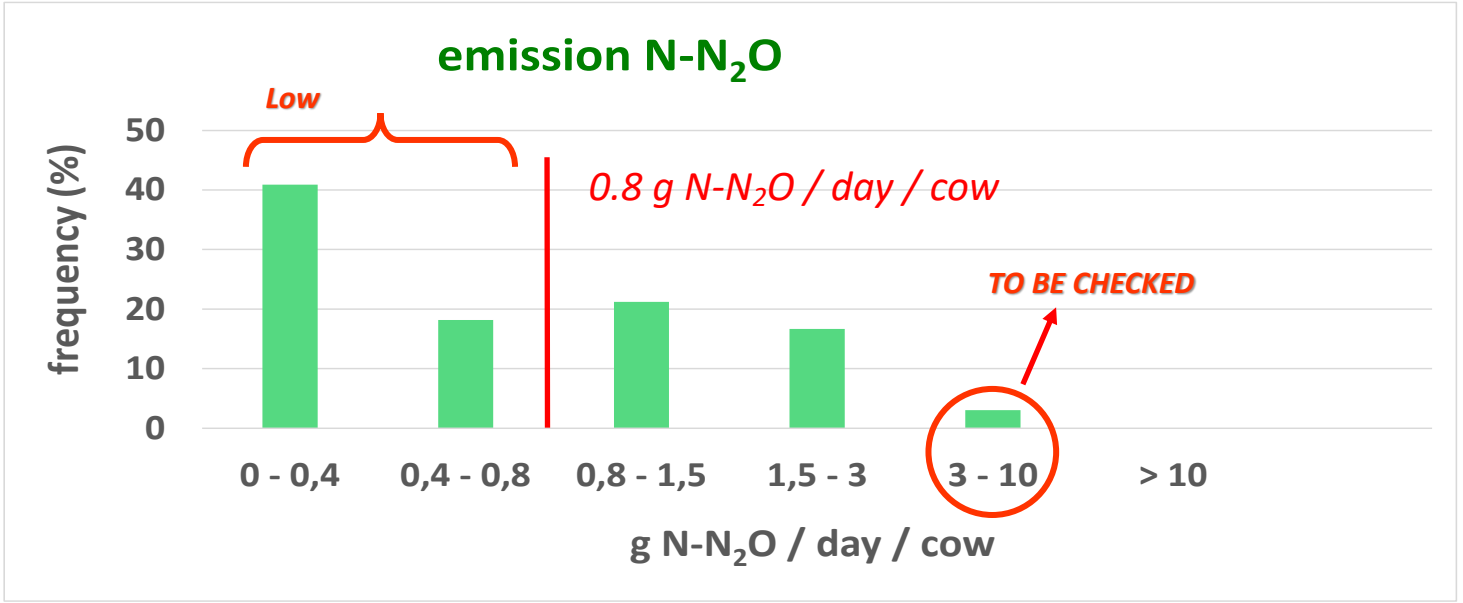
- *Threshold N-NH_3 : **70 g day^{-1} cow^{-1}** = 20% average N excreted (Webb et al., 2021)*
- *Most observations « low »*
- *In the range 0.82 – 250 g day^{-1} cow^{-1} (Hristov et al., 2011)*





- *Threshold N-N_2O : **0.8 g day^{-1} cow^{-1}** = 0.25% average N excreted (Webb et al., 2021)*
- *Most observations « low »*
- *N-N_2O concern (> 3 g day^{-1} cow^{-1})*



CONCLUSIONS

1. The "Simplified Method" has been developed to avoid difficult or impossible on-farm measurements for emission calculations

2. Gas samplings and farm questionnaire are used to estimate the NH_3 and GHG emissions

3. Importance of the CO_2 (and CH_4) gas which is used as reference for all other gases

4. Robust method applicable to a large variety of farming systems

CONCLUSIONS

6. Concentration and grad. concentration ratios are useful indicators:

   - for data quality insurance

   - to improve knowledge of the relevant ranges in the different countries

5. Method useful - to detect low emitting systems → learn from them

   - to detect practices increasing the emissions

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Thank you !