Measuring enteric methane emission in dairy cattle using GreenFeed systems

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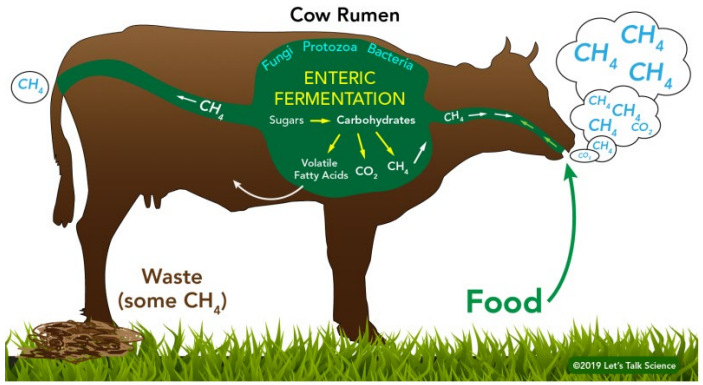
Why?

- Paris Climate Agreement 2015
  - Goal dairy sector: reduction methane emission by 1.0 MT CO2-eq.

- Majority is enteric methane



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How? – GreenFeed system

- Greenfeed, C-lock Inc.
  - CH_4, CO_2, H_2, O_2, airflow
  - Emission in g/cow/day
  - *Voluntary visits*
  - *Multiple spot measurements per animal*
  - *Multiple measuring days/weeks*

GREENFEED™

C-LOCK™

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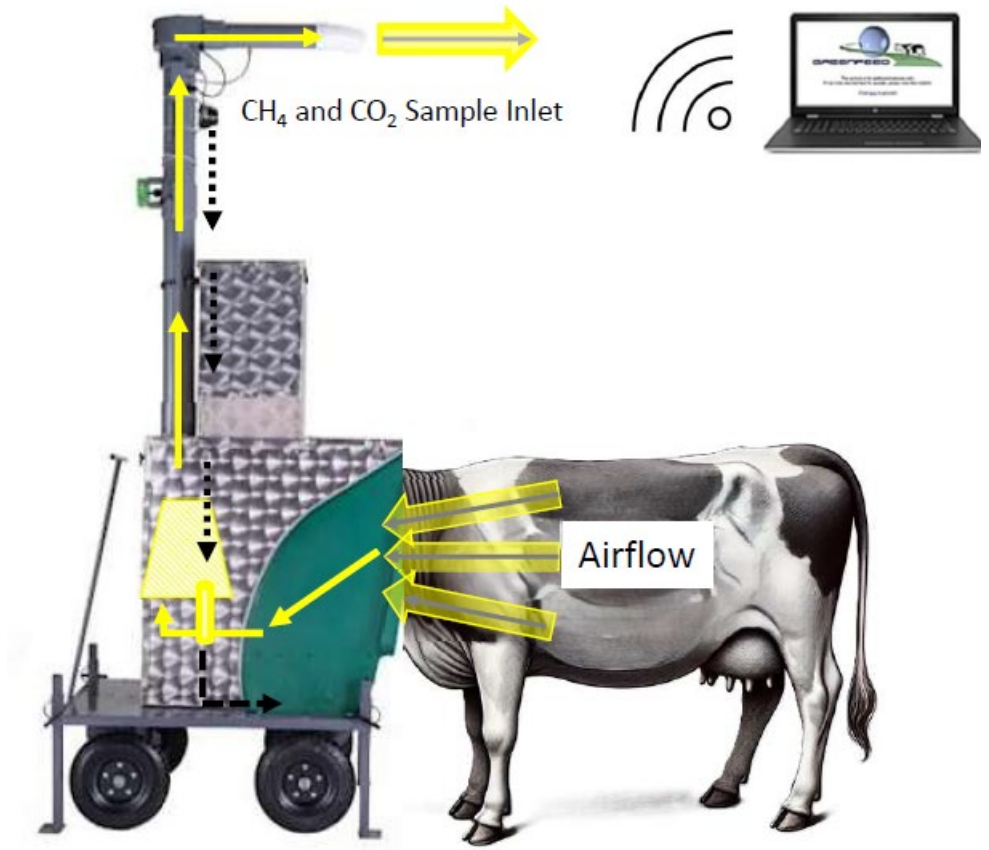
Previous presentation

- Parts of the device
- Roughly how it works (spot measurement flux method)
- Installation
- Animal identification
- Calibration and recovery tests
- Maintenance
- Pre-experiment checklist
- Data management
- Final data
- Pros and cons



Experimental set ups

- Experimental set up:
  - Randomized Complete Block Design
  - Cross-over designs (Latin Square)
- Timeline:
  - 2 weeks of adaptation
  - (Covariation period)
  - Short term trial: 2 weeks of measurement period (2-week average)
  - Long term trial: more than 2 weeks of measurement period (repeated measures with weekly averages)

Number of cows

- More variation than CRC, thus more animals needed
- Depends on experimental set-up, diet and the minimal relevant difference tested
- Rule of thumb: If the minimal relevant difference is equal to the within group difference, the minimum number of cows needed is 16 per treatment group (RCBD).

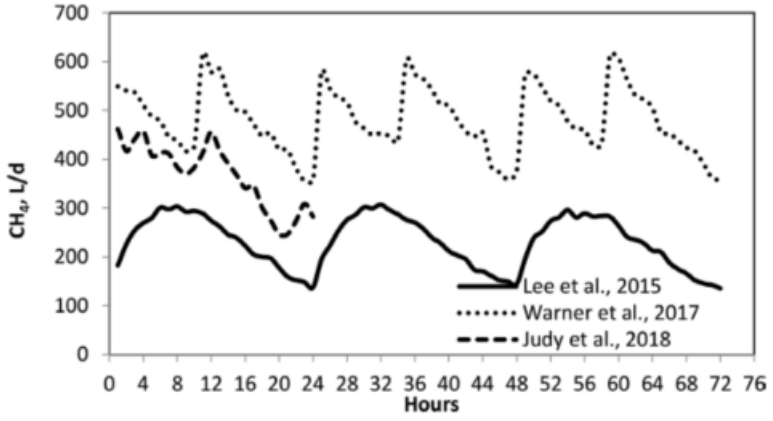
- You can measure ~32 animals per GreenFeed (with 4-6 visits per cow per day)
- You want more visits per cow per day?

  → Less cows per GreenFeed unit

Number of spot measurements per cow

- Involuntary visits – GreenFeed in tie-stall setting
- Sampling schedule of e.g. 8 spot samples at 3h intervals across 3d

  → Number of spot measurements depend on feeding frequency!
- For example: Hristov *et al.* (2015), Van Lingen *et al.* (2023), Lee *et al.* (2022)



Lee *et al.* (2022)

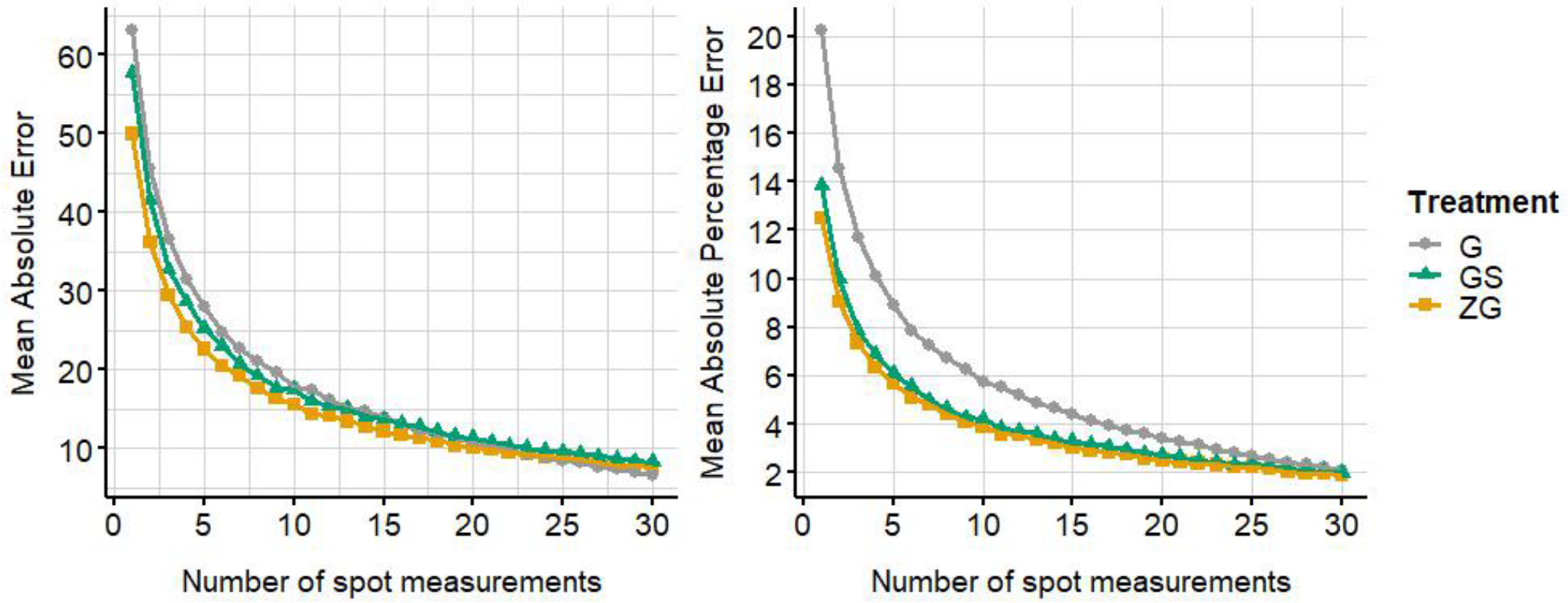
Hour of the day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Sampling moment																								
Day 1										X						X						X		
Day 2				X									X						X					
Day 3	X						X																	

Old video, but it shows how to operate the unit in tie-stall:

Video: The Use of an Automated System GreenFeed to Monitor Enteric Methane and Carbon Dioxide Emissions from Ruminant Animals

Number of spot measurements per cow

- 20 (Manafiazar *et al.*, 2017), 30
- Voluntary visits

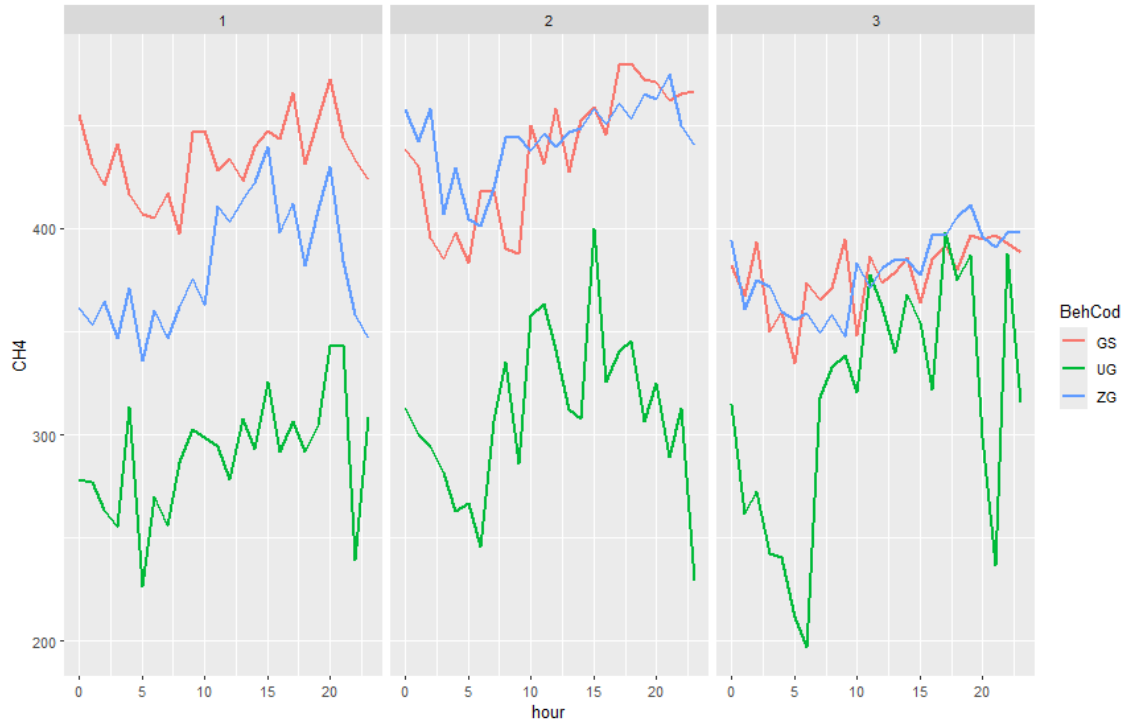


Koning *et al.*, (2024)

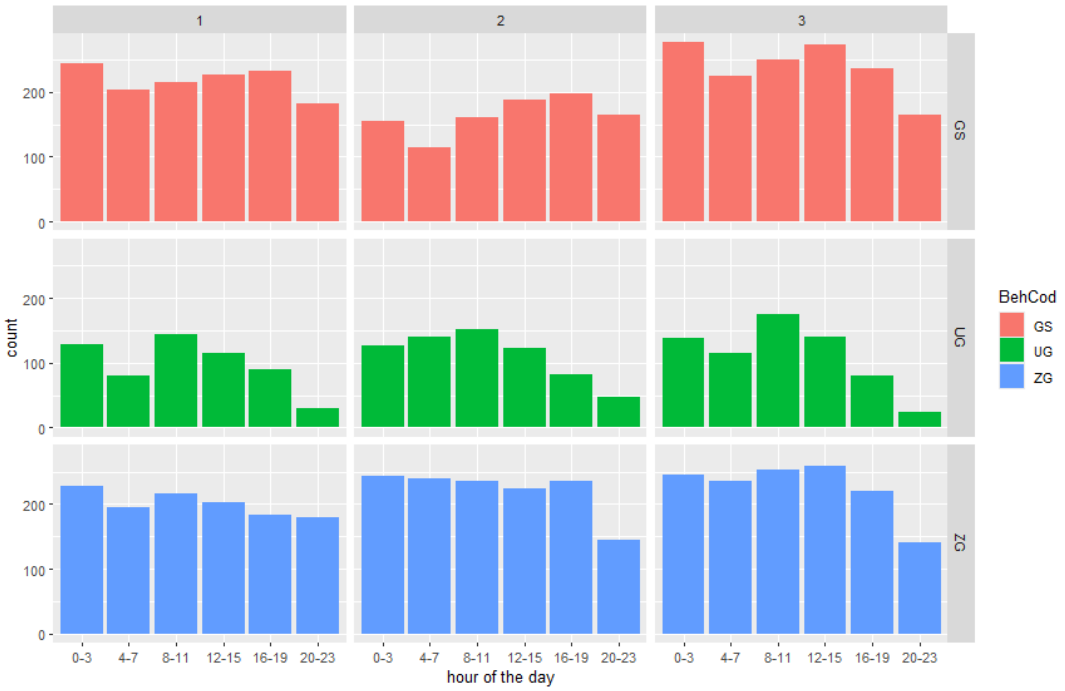
Why grasslands?

Distribution of measurements over the day

- Example of our data in 2020
- Variation over the day



Makes distribution more important



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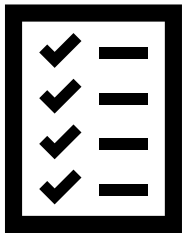
Training – Tips and tricks

- In 2 week adaptation period
- Our experience: dairy cows learn relatively easily
- Others sometimes experience more problems
  (e.g. Garnett (2012) experienced that cows did not learn from peers)

- Training in pasture takes more time / less visits will be reached compared to indoors
- “Play” with settings, “play” with alleyway
- Use tasty pellet
- Locate GreenFeed centrally

Contact with C-lock

- Service contract
- Pre-experiment checklist
- Service and support
- Final review of the data



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Data processing

- Data from C-lock:
  - Raw data (ppm) – per second
  - Preliminary visit data (g/d) – per visit
  - Final visit data (g/d) – per visit

Data processing – by C-lock

Raw data

Ppm

Per second

Measured concentration – background, accounted for airflow, when head positioning was within certain range, only measurements of at least 120 seconds, apply current calibration factors

Corrected for wind speed, airflow (in case below 34 L/s) and temperature

$$Q_{c(i)} = C_{p(i)} * (Conc_{(i)} - BkConc_{(i)}) * \frac{Q_{air(i)}}{10^6}$$

$$Q_{m(i)} = Q_{c(i)} * \frac{273.15}{273.15 + T_{air(i)}} * \rho_c$$

Preliminary visit data

g/d

Per visit

Verify / assess all calibration and correction factors

Analyse flags recorded by the system

Compare unit consistency

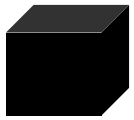
Put outliers in separate file

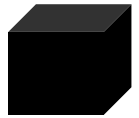
Data is imported to Excel for the client

Final visit data

g/d

Per visit





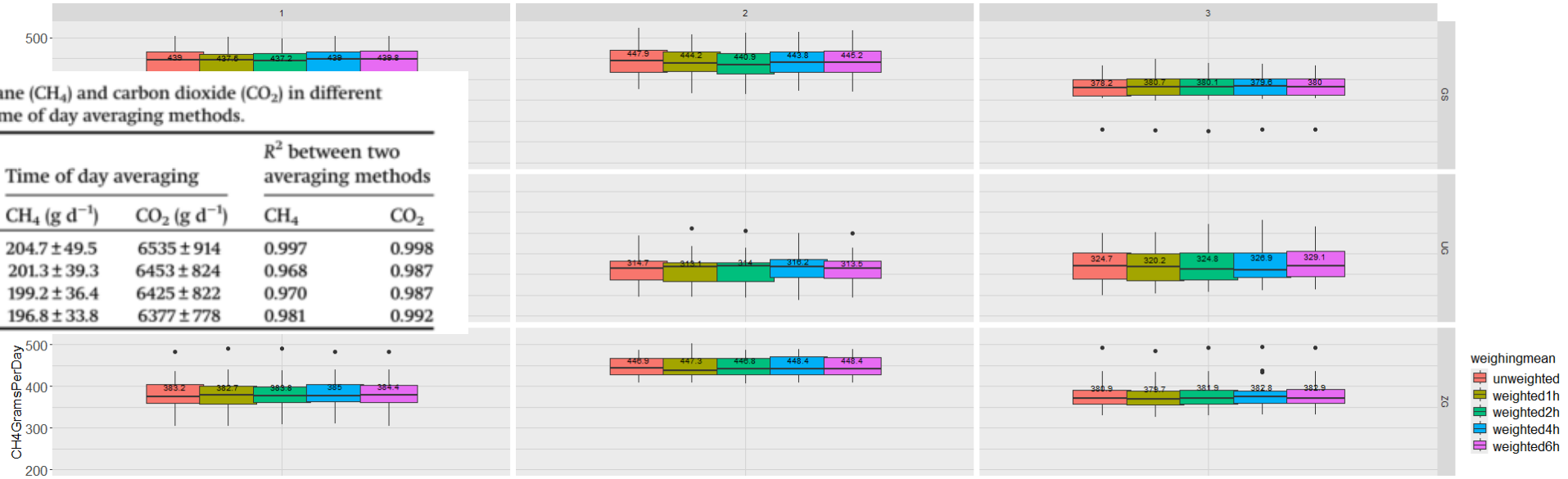
Data analysis

- Data for analysis: visit data in g/d
- Average the data per measurement period (week or two weeks)
- Use averages for statistical analysis

Table 2. Herd averaged fluxes (±SD) for methane (CH_4) and carbon dioxide (CO_2) in different averaging periods using the arithmetic and time of day averaging methods.

Averaging period (d)	Arithmetic averaging		Time of day averaging		R^2 between two averaging methods	
	CH_4 (g d^{-1})	CO_2 (g d^{-1})	CH_4 (g d^{-1})	CO_2 (g d^{-1})	CH_4	CO_2
1	204.7 ± 49.6	6532 ± 915	204.7 ± 49.5	6535 ± 914	0.997	0.998
3	203.5 ± 37.6	6479 ± 815	201.3 ± 39.3	6453 ± 824	0.968	0.987
7	201.8 ± 34.8	6456 ± 812	199.2 ± 36.4	6425 ± 822	0.970	0.987
14	201.4 ± 33.7	6422 ± 780	196.8 ± 33.8	6377 ± 778	0.981	0.992

Manafiazar *et al.* (2017)



Own data (2020)

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Few final notes

- Make sure the airflow stays above 27 L/s, but ideally above 34 L/s, so no correction will be applied
- Aim for visits above 3 minutes
- Check outliers yourself and decide what to do with them
- If possible, add extra animals that will drop if they do not learn to use the GreenFeed in time
- In case of multiple GreenFeeds: make sure all animals have access to all units (or switch)

Thanks!

Questions?

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