## Assessing the uncertainty of a change in methane emissions from cattle at the herd scale with various micrometeorological methods

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# Introduction

- 9th-28th Nov 2008 at Aorangi Farm, Palmerston North, NZ
- 6 methodologies to measure CH<sub>4</sub> emissions from cattle
- 5 herd-scale method, 1 animal-scale method
- 61 steers
- 3 levels of CH<sub>4</sub> emissions created by:
- 3 feed intake levels



# Experiment design

- 61 steers
- Area 55 m x 80 m
- 3 weeks
- Each week, feed intake increased: 4.26 kg DMI head<sup>-1</sup> day<sup>-1</sup>
  6.71 kg DMI head<sup>-1</sup> day<sup>-1</sup>
  9.29 kg DMI head<sup>-1</sup> day<sup>-1</sup>



# Measurement Methods:

Method	Gas Instrumentation	Institution
1.Mass-balance (IHF)	Los Gatos CH <sub>4</sub> analyser, 7 intakes	LCR
2.BLS* from profile	Los Gatos CH <sub>4</sub> analyser, 7 intakes	LCR
3. BLS from 4 paths	Open-path Boreal Laser GasFinder MC	LCR
4. BLS from 2 paths	Open-path FTIR	UoW
5. External tracer/CH <sub>4</sub> ratio (herd scale)	tracer release canisters on cattle, open- path FTIR	UoW
6. SF <sub>6</sub> /CH <sub>4</sub> tracer ratio (animal scale)	SF <sub>6</sub> release capsules in rumen, yokes on cattle, daily GC analysis	AgRes

\*BLS: Backward-Lagrangian stochastic. It is a micrometeorological model of dispersion which allows to estimate the source strength given an concentration measurement - WindTrax model

### Profile mast method - Method 1,2



#### Instruments

- Profile mast
- Background intakes
- Los Gatos CH<sub>4</sub> analyser

#### Methods

- BLS Profile
- IHF Integrated horizontal flux (mass budget)



Landcare Research Manaaki Whenua



#### **Method 3- Open-path Laser with BLS**



#### Instrumentation

• 4 x Open-path Boreal Laser "GasFinder"

#### Method

• BLS-GF





### Method 4, 5



#### Instrumentation

• 2 x Open-path FTIR spectrometers

#### Methods

- BLS-FTIR
- Tracer ratio





Q<sub>CH4</sub> = enhanced CH<sub>4</sub>/enhanced N<sub>2</sub>O \* N<sub>2</sub>O release rate



#### Method 6 – SF<sub>6</sub> tracer method



# SF<sub>6</sub> Tracer Ratio Method (animal-scale)





#### Weekly mean diurnal variation of CH<sub>4</sub> emission



#### Weekly means based on diurnal variations



#### **BLS: Sensitivity to source area geometry**



# Sensitivity of IHF and BLS results to source area assumption



# Summary 1

- Successfully compared the 6 methods within 3 weeks
- Clear diurnal variation: peak emission in the afternoon and low emission in the morning
- Clear increase pattern with the feeding levels increase from week1 to week3

# Summary 2

- SF<sub>6</sub> (animal-scale) method, week-to-week emission changes were 27 and 33 %
- BLS-FTIR and N<sub>2</sub>O-TR detected smaller yet still significant week-to-week changes
- BLS-GF detected the 30-% changes but with larger uncertainty:
- biggest issue for open-path methods is accuracy of concentration differences
- IHF and BLS (profile mast) failed to detect the first weekly change
- biggest issue for profile-mast methods is sensitivity to source area definition. This can be reduced by larger source-sensor distance – at cost of smaller range of acceptable wind directions
- N<sub>2</sub>O-tracer method was not affected by the source area
- robust quality control criteria are crucial

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### CH<sub>4</sub> Emissions and Feed Intake

(Suggestion – may not have time)

	Feed Intake kg DMI head <sup>-1</sup> day <sup>-1</sup>	SF6 g CH₄ kg DMI ⁻¹	FTIR Tracer g CH <sub>4</sub> kg DMI <sup>-1</sup>	BLS FTIR g CH <sub>4</sub> kg DMI <sup>-1</sup>	BLS Laser g CH <sub>4</sub> kg DMI <sup>-1</sup>	BLS profile g CH <sub>4</sub> kg DMI <sup>-1</sup>	IHF Profile g CH <sub>4</sub> kg DMI <sup>-1</sup>
Week 1	4.26	16.62	19.55	20.56	13.63	26.66	28.58
Week 2	6.71	14.27	14.27	16.02	14.49	18.19	17.84
Week 3	9.29	12.82	12.07	13.06	13.65	17.61	17.34

# Methodology sensitivity

(draft only - still needs lots of thought)

- Instrument Precision: determine the enhanced CH<sub>4</sub> concentrations over local background concentration
  - OP-FTIR 5ppbv
  - Laser ???
  - Los Gatos ???
- OP-FTIR Tracer method:
  - Precision in measuring tracer gas concentration above local background
  - Uncertainty in tracer flow rate
    - Improved design in gas release mechanism
- SF6 tracer method
  - Uncertainty in SF<sub>6</sub> tracer flow rate
- BLS:
  - Assumes a uniform source area
  - Sensitivity to source area geometry