Sampling Strategies to Measure Enteric Methane Emissions

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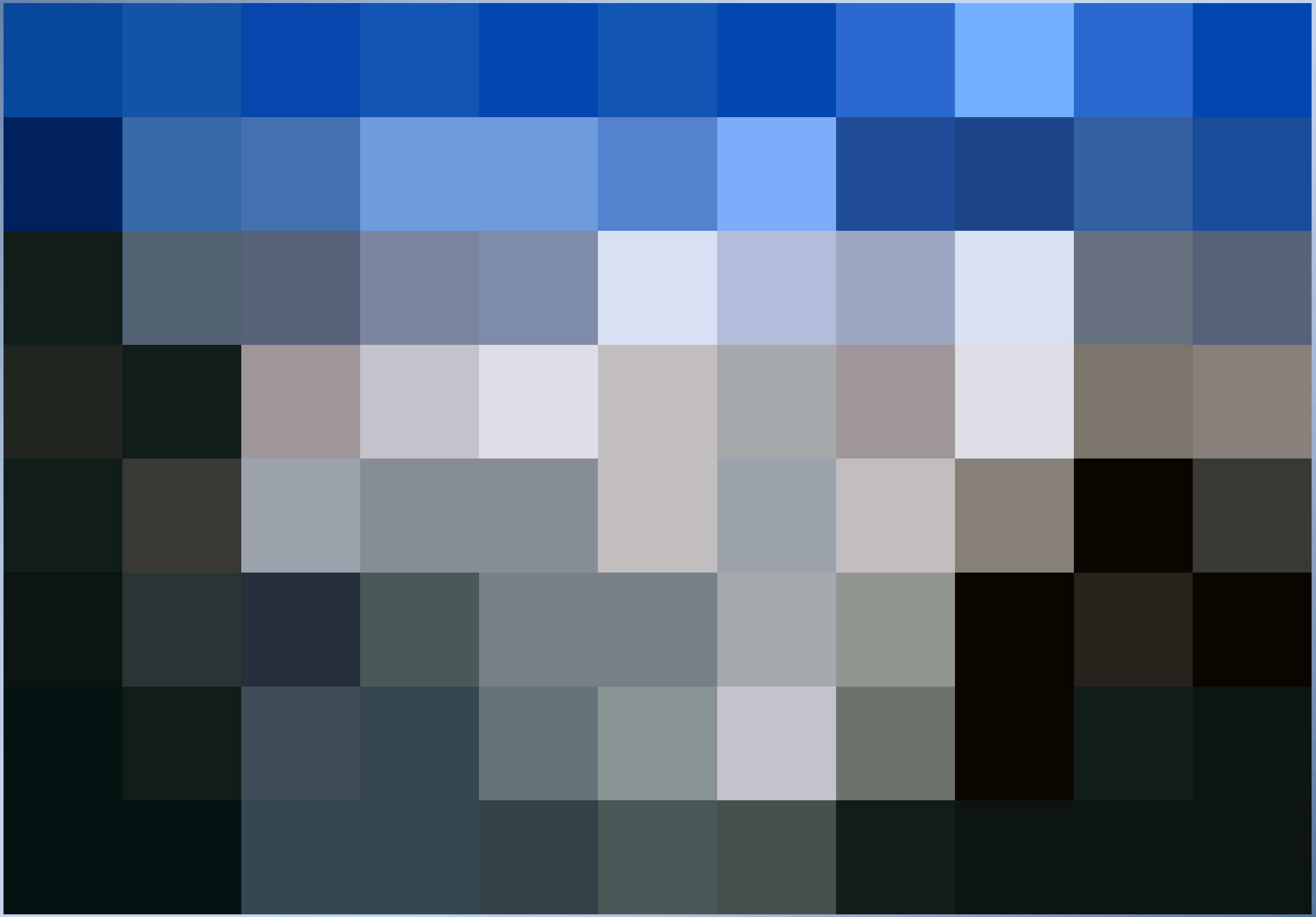
“Spot” Sampling for Fluxes- GreenFeed

- Uses repeated short term measurements
  - Can be completed for many animals each day
  - Long-term
  - Can be operated over extended time periods
  - Low “cost” per animal

  - However, the data is different than integrated sampling methods and there are concerns related to methane variability and spot sampling

Analogy for Spot Sampling…1 KB Image



Low resolution picture, what is it?

Increasing resolution, 3KB Image

Higher resolution picture, may be able to identify?

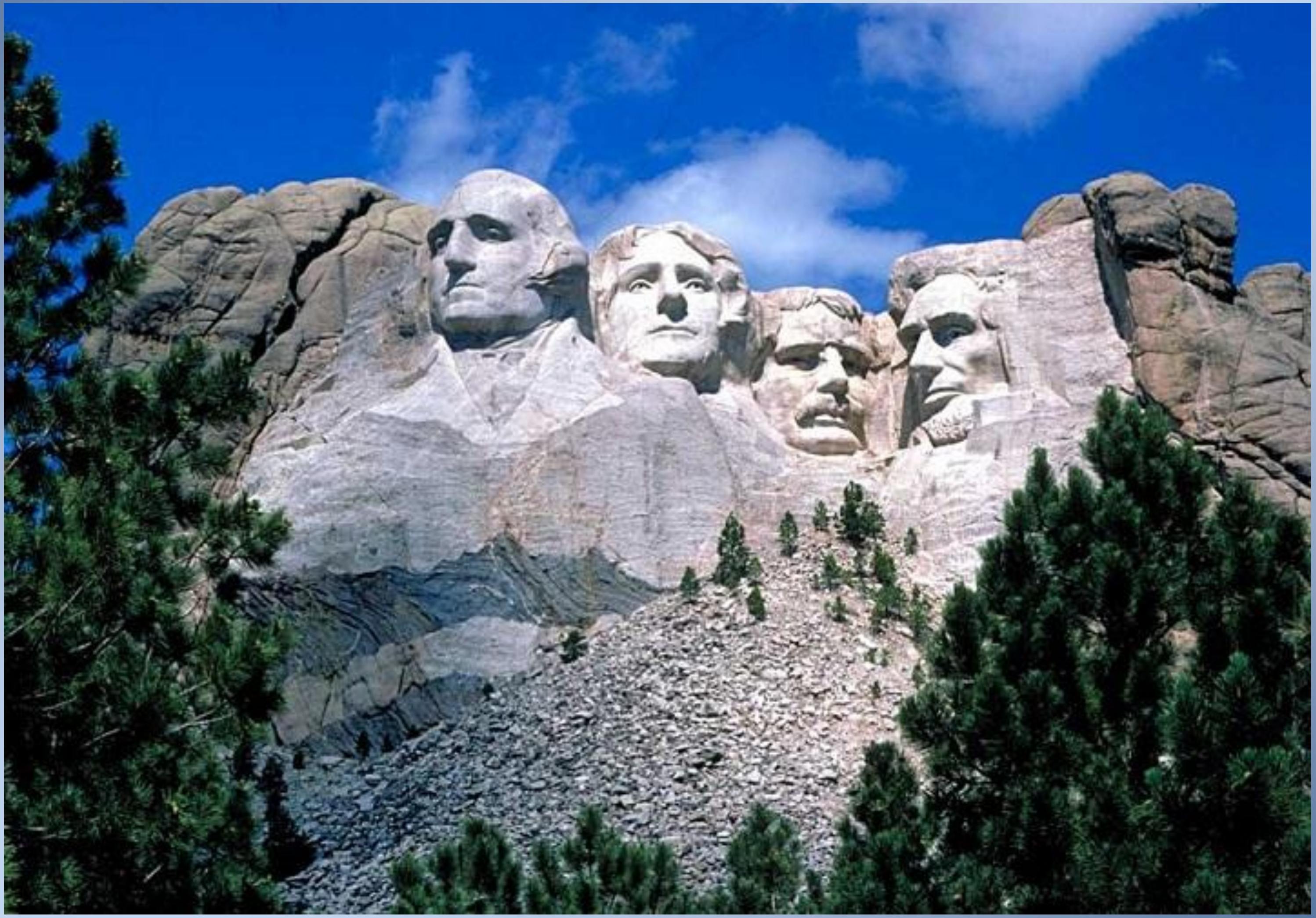
Increasing resolution…7KB Image

Higher resolution picture, most will know what it is?

Increasing resolution…32 KB Image

Higher resolution picture, Mount Rushmore!

Increasing resolution…188 KB Image

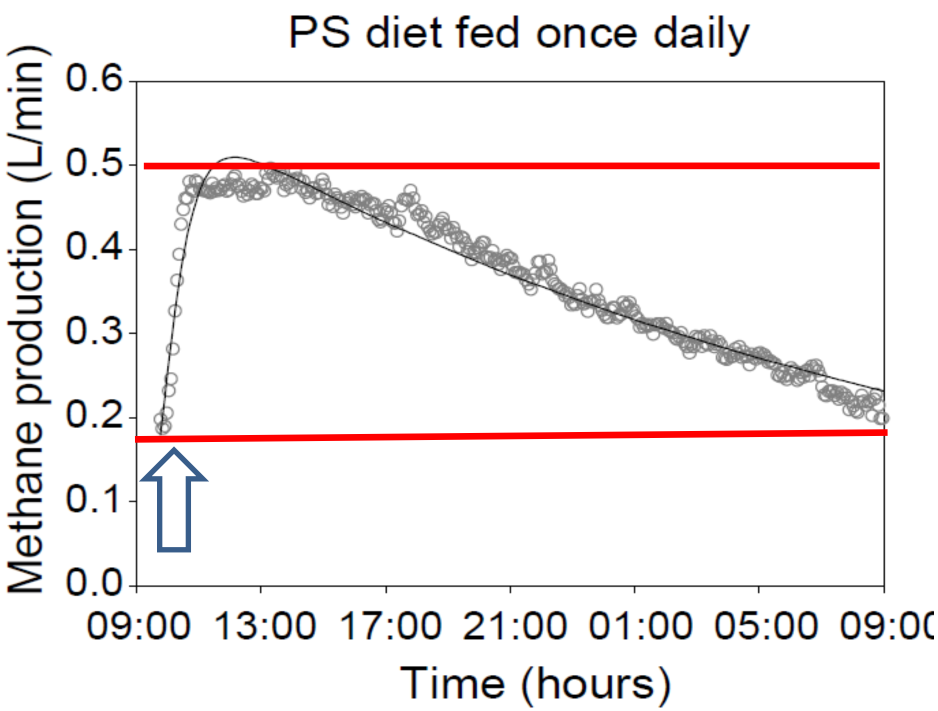


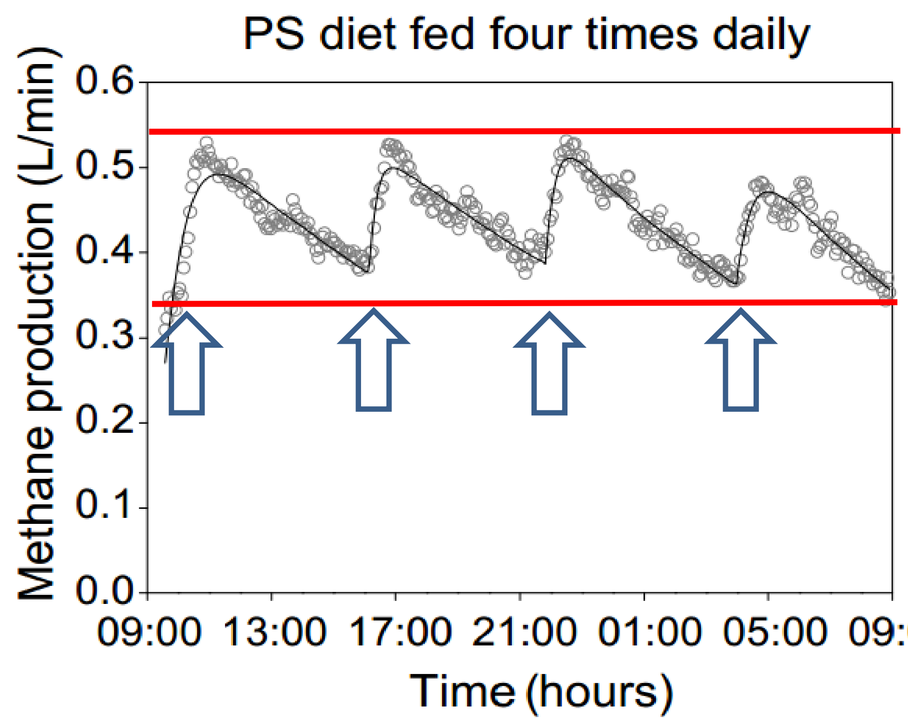
Highest resolution picture, marginal improvement

Variability in CH_4 Emissions Patterns

- CH_4 emissions from ruminant animals are variable at any time scale…..
  - By year
  - By season
  - By day
  - By hour, minute, second
- Variability of CH_4 emissions governs the sampling strategies.
- As variability of CH_4 emissions patterns increases, more sampling is need to maintain the same uncertainty levels.

Diurnal Variability of CH_4





Range = 0.21 - 0.49 L/min
Max/Min Ratio = 2.5

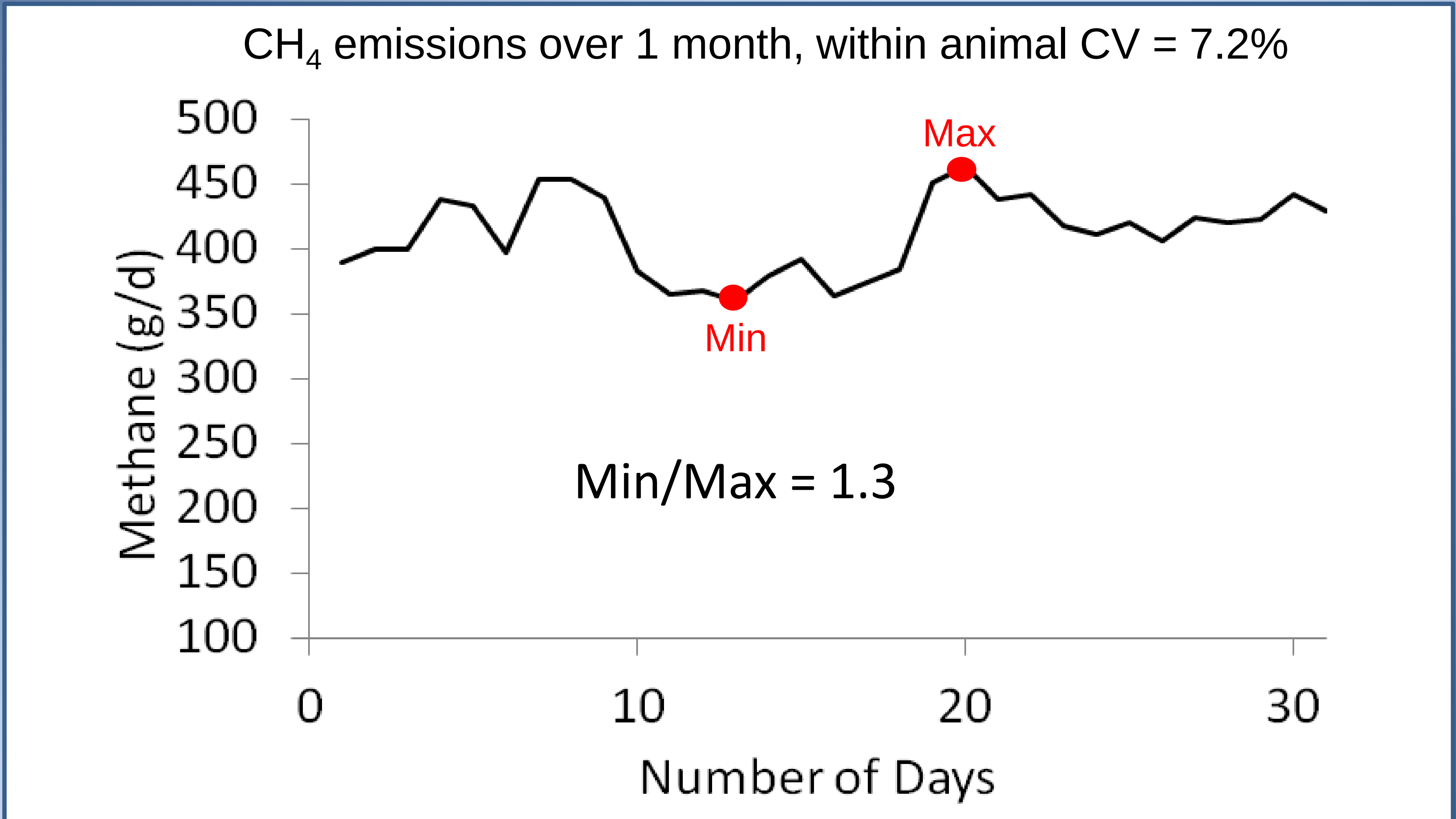
Range = 0.37 - 0.51 L/min
Max/Min Ratio = 1.45

As feeding frequency increases, diurnal CH_4 variability decreases

From: Crompton et al. 2010

Day to Day Variance in CH_4

- Has been measured as 4%-9% (Blaxter and Clapperton 1965, Granger et al. 2007, Zimmerman et al. 2013)



CH_4 Variance

- CH_4 diurnal patterns normally vary by <2.0 fold over the day.

  Granger et al 2007, Crompton et al 2010, Pineras et al. 2011, Garnet 2012, Zimmerman et al. 2013, Jonker et al., 2014, Hammond et al. 2015

- Larger variations in CH_4 diurnal patterns are only found in restricted intake “slug” feeding or pelleted concentrate diets.

  Pineras-Panito et al. 2011, Renand et al. 2013, Jonker et al. 2014

- Day-to-day variance of CH_4 is also important

Example Data

- 29 growing beef cattle were monitored over 59 days.

- 90% barley silage and 10% rolled barley grain TMR, as fed, at 8-9 am and 3-4 pm pm.
  - 38.76% DM, 12.5% CP, 29.1% ADF, 44.50% TDN, and 9.56 MJ ME/kg DM
  - Pellets: 88.08% DM, 69.10% TDN, and 10.43 MJ ME/kg DM.

- CH_4 was measured with GreenFeed (3,242 visits)

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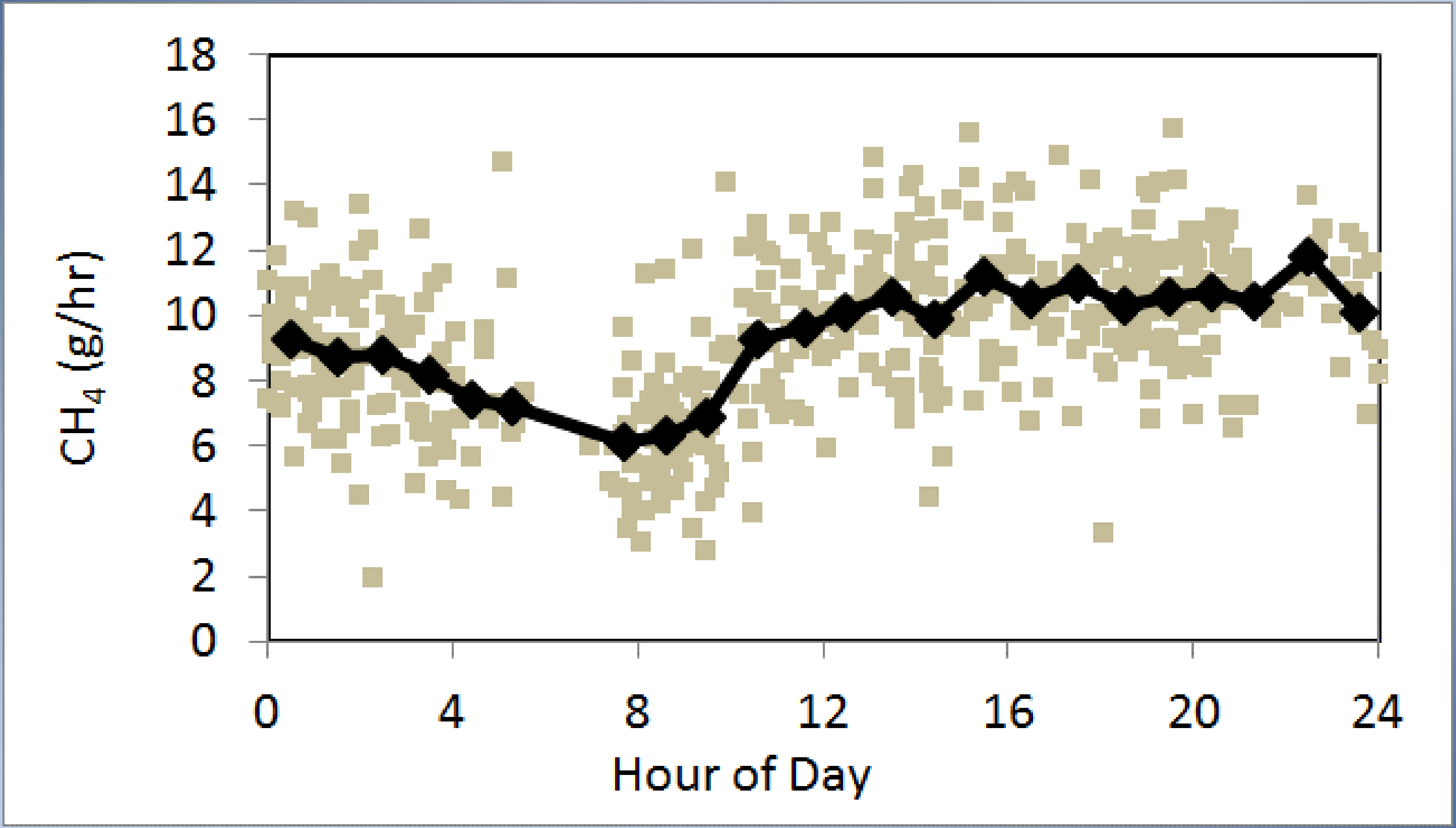
- High resolution feed intake was measured with Growsafe

- 1 day, 3 day, 7 day, and 14 day averages were calculated, then variability, repeatability, and correlations with DMI.

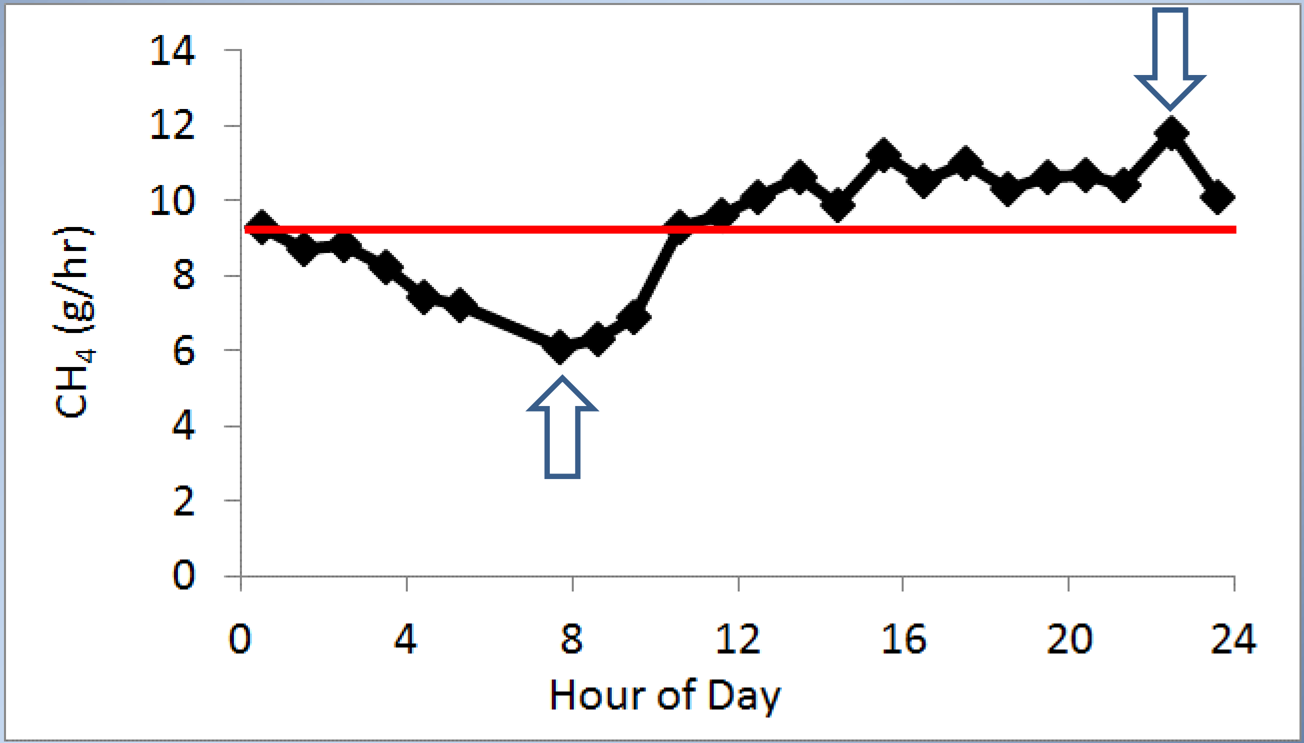
Typical CH_4 Diurnal Pattern in the Study



- Max/min = 1.9

Modeling Systematic Error

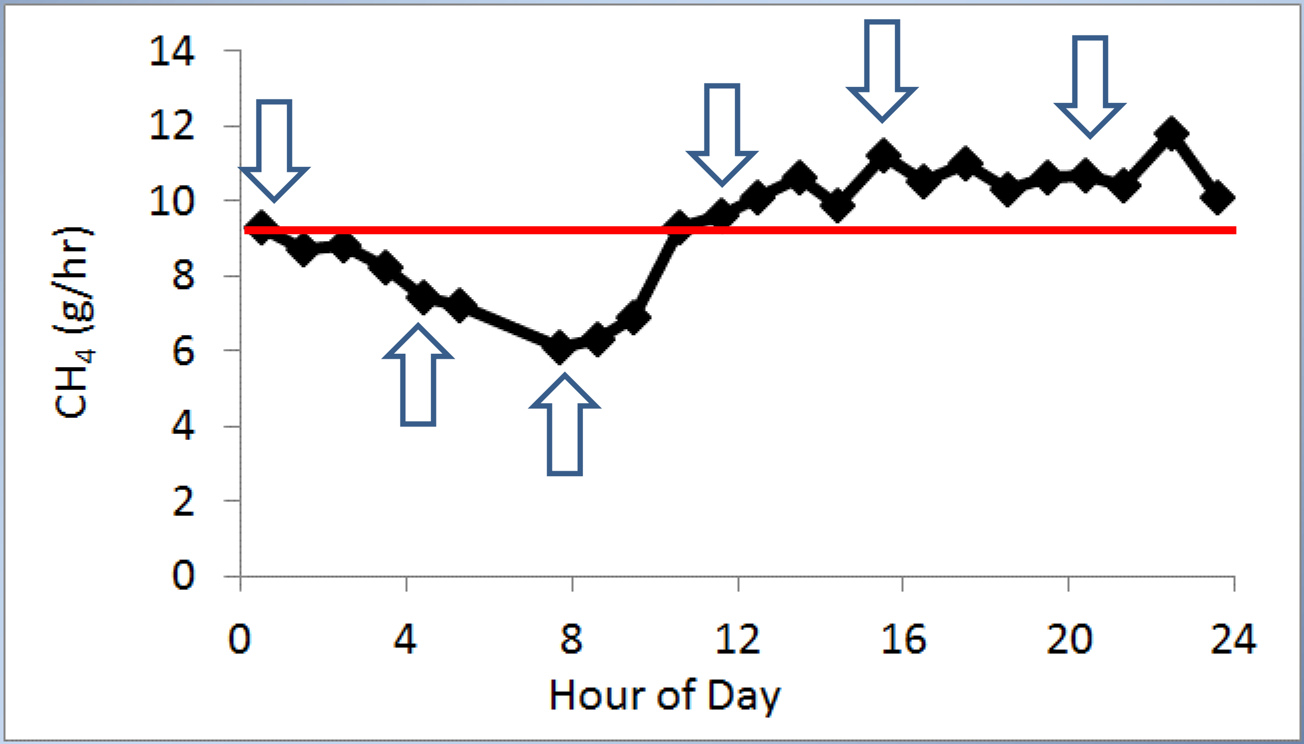
- Worst situation possible, 1 time per day visits, coinciding with high or low emissions times



- Maximum possible error = 35%

Modeling Systematic Error

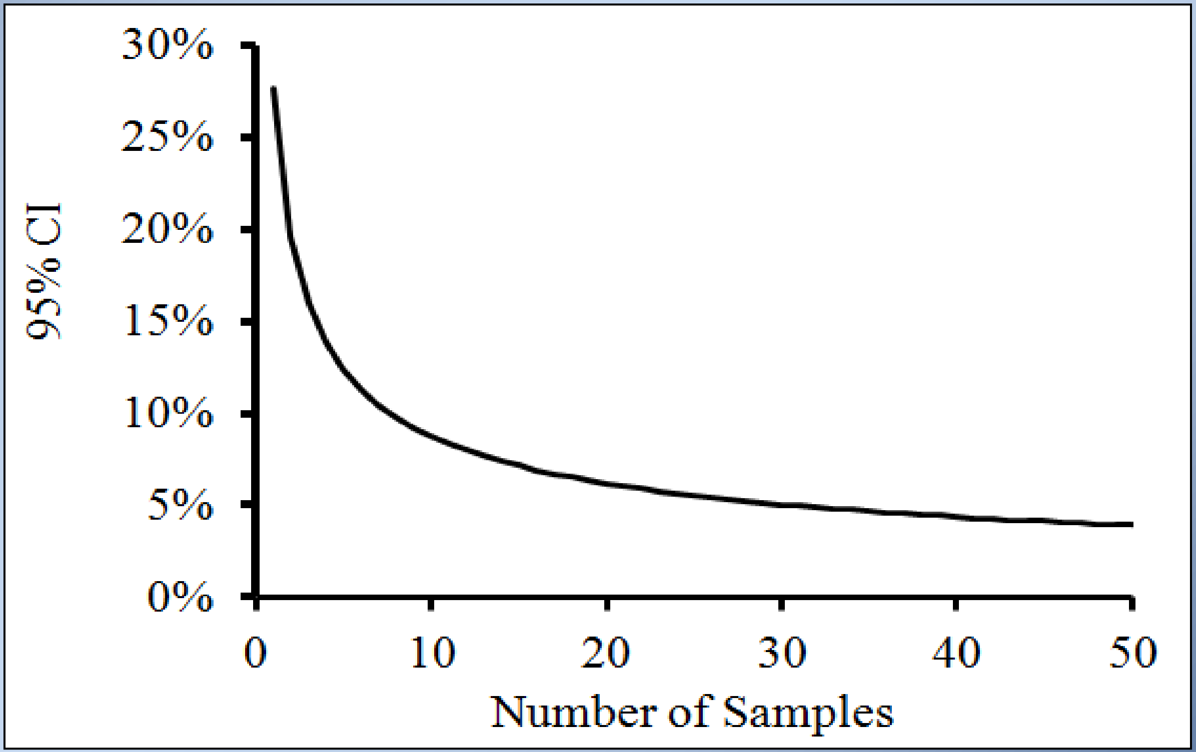
- Better sampling, 6 visits spread over the CH_4 diurnal pattern



- Maximum possible error = 3%

Error from Randomness

- 95% CI = SD/sqrt(N)*1.96
  - Where:
    - SD = Standard deviation (can be expressed as CV)
    - N = number of samples



- CV of spot samples = 14% (from Dorich et al. 2015)

Total Error

- Low number of samples (<10-15) = Very high uncertainty (> 50% error)

- Higher number of samples (>20) + Visitation over the day = Low uncertainty (6-8% for the 95% CI)
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- Only marginal gains in uncertainty are possible for very frequent sampling

- Animals with low visitation are uncertain, they can cause errors in statistical analysis

Increasing Numbers of Samples

Herd Averaged Values

Averaging period	Herd Averages – Absolute Values, SD			
	GreenFeed samples per animal	SDMI (kg/d)	CH_4 (g/d)	CH_4/SDMI (g/kg)
1d	2.6	8.94±1.81	206±49.3	24.8±9.58
3d	8.8	8.85±1.65	204±38.2	24.3±3.68
7d	18.4	8.75±1.53	204±35.2	24.4±3.19
14d	35.9	8.57±1.50	204±34.0	24.7±2.40

SDMI = DMI * ME/10

Increasing Numbers of Samples

Repeatability of Averaged Values

Averaging period	Herd Averages – Repeatability			
	GreenFeed Samples per animal	SDMI	CH_4	CH_4/SDMI
1d	2.6	0.52	0.33	0.08
3d	8.8	0.64	0.62	0.28
7d	18.4	0.67	0.69	0.40
14d	35.9	0.71	0.79	0.51

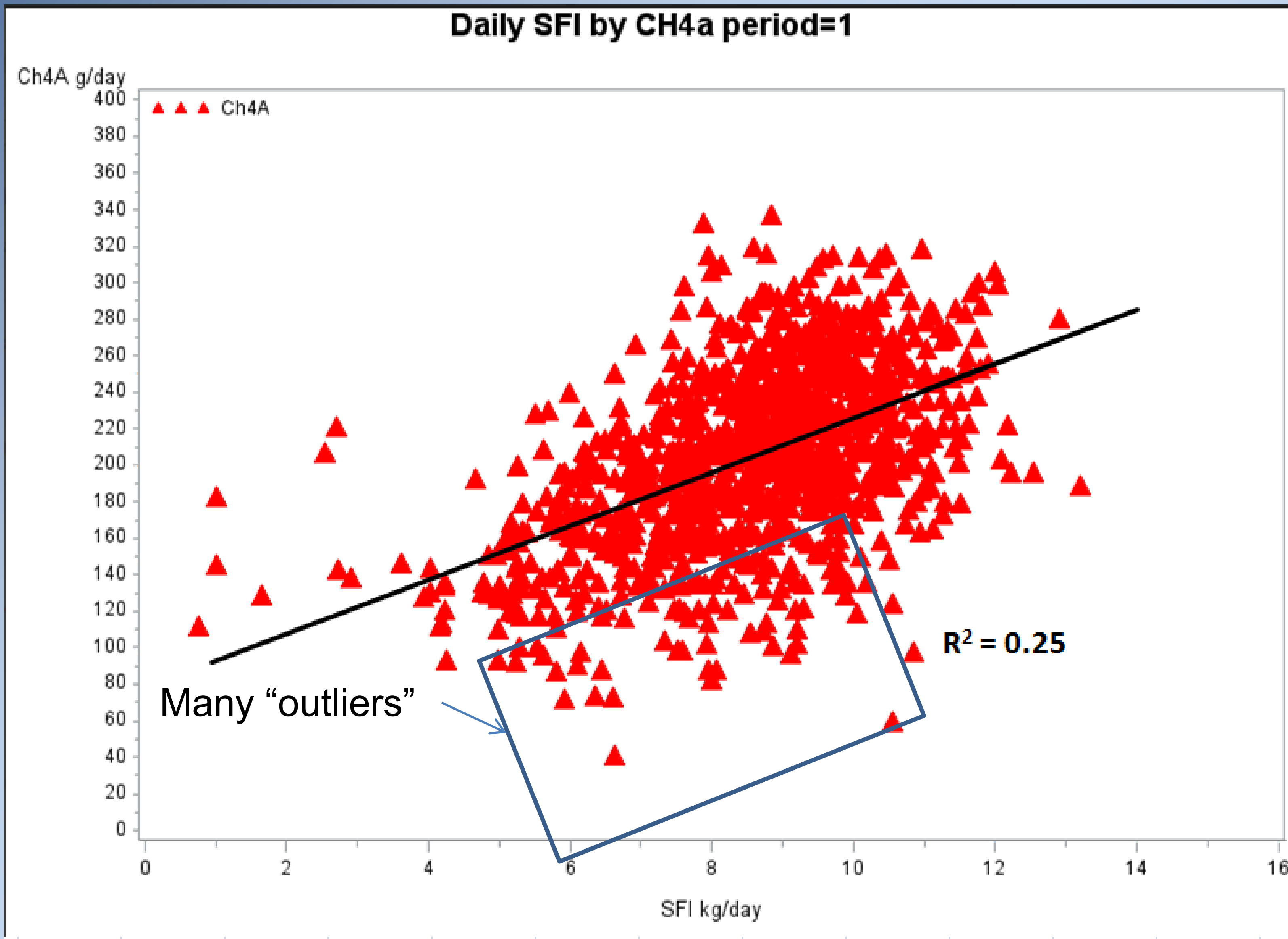
SDMI = DMI * ME/10

Increasing Numbers of Samples

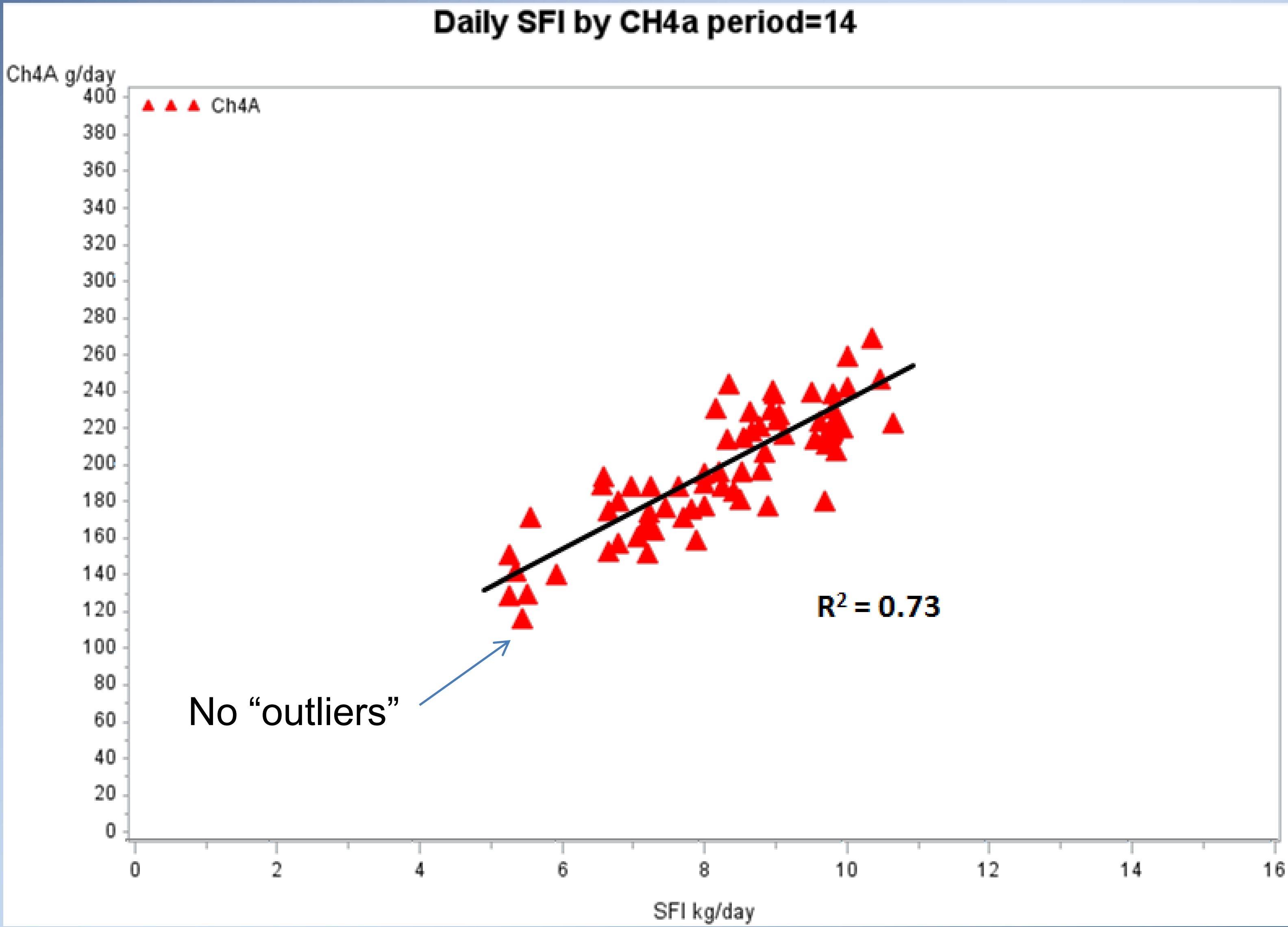
R^2 correlations with SDMI

Averaging period	**Herd Averages –vs SDMI, R^2**		
	GreenFeed Samples per animal	CH_4	CO_2
1d	2.6	0.25	0.39
3d	8.8	0.50	0.57
7d	18.4	0.62	0.70
14d	35.9	0.73	0.79

CH_4 vs. SDMI (1 day or 2.54 visits per animal)



CH_4 vs SDMI
(14 day averaging, 35.91 visits per animal)



Visitation Rates to GreenFeed

Study	Visits/ Day	SD	Conditions	Animals
PASTURE STUDIES				
Garnett (2012)	3.5	NA	Perennial ryegrass and white clover	Lactating Friesian Cows
Utsumi et al. (2011)	2.6	NA	Pasture grass grazing	Holstein cows
Zimmerman et al. (2013)	2.5	1.1	Grass pasture to blue grass straw	Angus cows
Pereira et al. (2013)	1.8	0.4	Cool-season grass-legume herbage mix	Lactating Jersey Cows
Hammond et al. (2015)	1.6	1.1	Range of ryegrass to flowers	Holstein Friesian heifers
FREE-STALL STUDIES				
Renand et al. (2013)	10.4	NA	Medium energy pellet diet	Charolais cattle
Garnet et al. (2012)	4.6	1.3	Lucerne Silage	Hereford/Friesian dry cows
Utsumi et al. (2011)	3.0	NA	TMR	Holstein cows
Huhtanen et al. (2015)	3.0[1], 2.8[2]	1.00[1],1.20[2]	Grass-grass clover, Corn-based TMR	Swedish Red, Holstein
Valazco et al. (2014)	2.7	NA	Finishing diets with or without nitrogen or urea	Angus steers
Hammond et al. (2015)	2.3	1.1	Hayledge, varied treatments	Holstein Friesian heifers

Recommendations

- Avoid analyzing GreenFeed data with low numbers of samples. Animals with low visitation will skew statistical results!
- Gather 20-30 samples over two weeks per animal if individual animal data is required. In some cases, fewer samples may be needed if variably is lower.
- Use GreenFeed software to check for visit distribution over the day.
- “Over sampling” has marginal benefits.
- GreenFeed can be quite accurate, repeatable, and produce low variability with care in collecting and analyzing data

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