Consideration of fecal near-infrared spectra to estimate methane eructed by dairy or beef cattle

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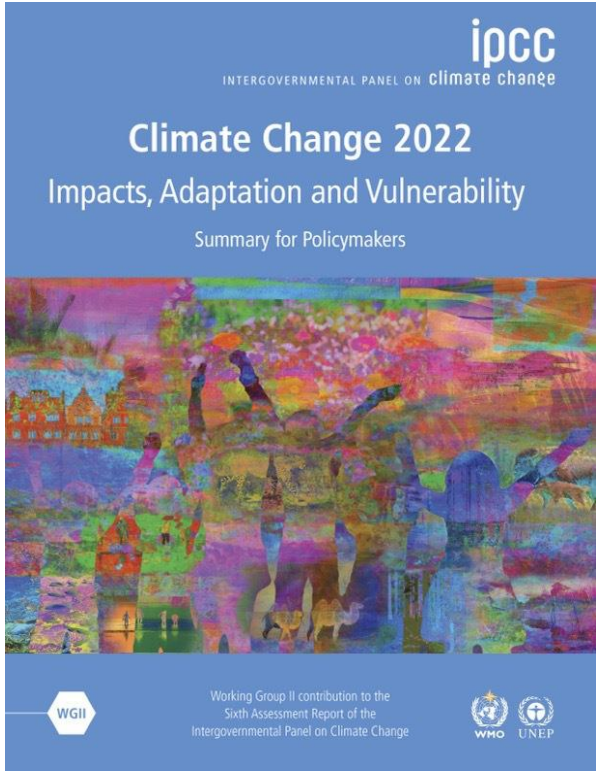
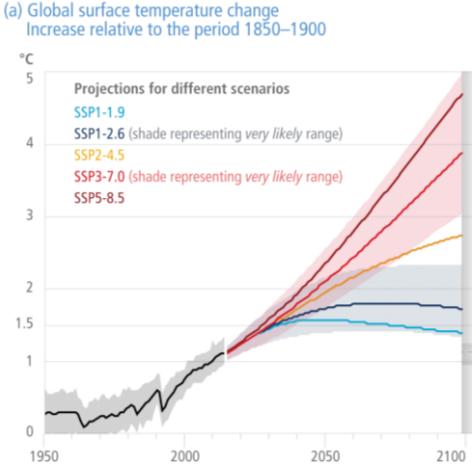
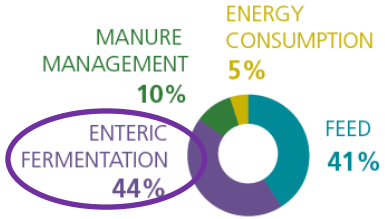
Greenhouse gases and global warming





Efforts from all sectors

What about Breeding?



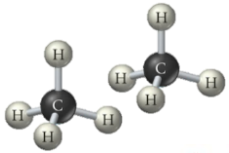
Source: FAO - GLEAM

SmartCow

Quantify CH_4 from livestock and realise large scale studies

- Models for LCA/inventories – more or less detailed but « fixed »
- Animal effect can be significant → Individual level of CH_4 values
- Reference measurement techniques not for large scale studies
- Great interest to have proxies to quantify individual CH_4 emissions
- Existing for lactating cows (*eg*. milk MIR spectra), but… for others?

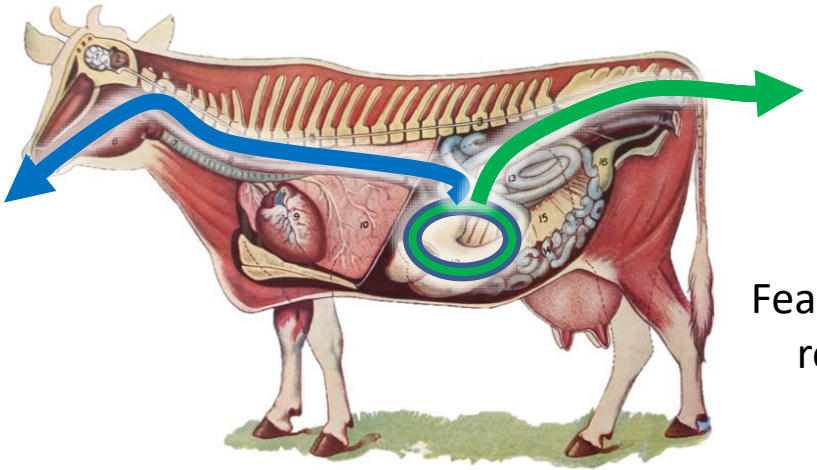
Proxy for CH_4 emitted by non-lactating cows?



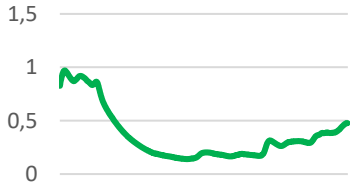
Eructed methane

//

rumen fermentations



Veterinarial *ex libris* – Internal bovine anatomy - 1920



Feaces NIR spectra directly related to digestibility parameters

Fecal NIR spectra as a proxy for CH_4?

Reference data

CH_4 + Feaces NIR spectra

		Dataset	n
Dairy	**Holstein** - Lactating cows	1	45
		2	22
		3	32
		4	162
		5	27
		6	16
		7	8
		8	32
		9	24
Beef	**Charolais** - Heifers	10	263
	Dual purpose Belgian Blue, **Belgian Blue** - Calves, reformed cows, suckling cows	11	83
	Simmental, **Angus**, **Limousine** - Young cattle	12	56

Standardisation of spectrometers!

Reference data

CH_4 + Feaces NIR spectra

		Dataset	n
Dairy	**Holstein** - Lactating cows	1	45
		2	22
		3	32
		4	162
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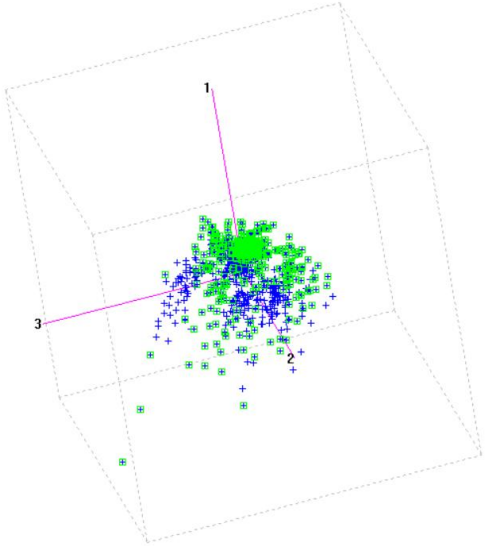
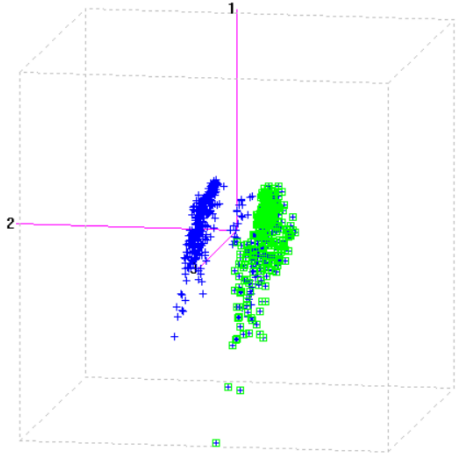
		8	32
		9	24
Beef	**Charolais** - Heifers	10	263
	Dual purpose Belgian Blue, Belgian Blue - Calves, reformed cows, suckling cows	11	83
	Simmental, Angus, Limousine - Young cattle	12	56



Dairy & Beef data considered separately for models

Spectral variability



Reference data

CH_4 + Feaces NIR spectra

		Dataset	n	Ref. CH_4
Dairy	**Holstein** - Lactating cows	1	45	GF
		2	22	GF & RC
		3	32	SF_6 & RC
		4	162	GF
		5	27	GF & SF_6
		6	16	RC
		7	8	SF_6
		8	32	RC
		9	24	RC
Beef	**Charolais** - Heifers	10	263	GF
	Dual purpose Belgian Blue, **Belgian Blue** - Calves, reformed cows, suckling cows	11	83	GF
	Simmental, **Angus**, **Limousine** - Young cattle	12	56	GF

- Biais due to reference technique? (absolute CH_4 value)
- RC and SF_6 = daily while GF = longer period // fecal spectra delay?

→ GF values: 3 weeks before fecal sampling (min 20 visits)

GF : GreenFeed ;
RC : Respiration Chambre

Reference data

CH_4 + Feaces NIR spectra

		Dataset	n	Ref. CH_4	Fecal sampling
Dairy	**Holstein** - Lactating cows	1	45	GF	Spot
		2	22	GF & RC	Weekly
		3	32	SF_6 & RC	Weekly
		4	162	GF	Spot
		5	27	GF & SF_6	Spot
		6	16	RC	Weekly
		7	8	SF_6	Weekly
		8	32	RC	Weekly
		9	24	RC	Weekly
Beef	**Charolais** - Heifers	10	263	GF	Spot
	Dual purpose Belgian Blue, **Belgian Blue** - Calves, reformed cows, suckling cows	11	83	GF	Spot
	Simmental, **Angus**, **Limousine** - Young cattle	12	56	GF	Weekly

GF : Greenfeed ;
RC : Respiration Chambre

Same spectral information?

Reference data

CH_4 + Feaces NIR spectra

		Dataset	n	Ref. CH_4	Fecal sampling
Dairy	**Holstein** - Lactating cows	1	45	GF	Spot
		2	22	GF & RC	Weekly
		3	32	SF_6 & RC	Weekly
		4	162	GF	Spot
		5	27	GF & SF_6	Spot
		6	16	RC	Weekly
		7	8	SF_6	Weekly
		8	32	RC	Weekly
		9	24	RC	Weekly
Beef	**Charolais** - Heifers	10	263	GF	Spot
	Dual purpose Belgian Blue, **Belgian Blue** - Calves, reformed cows, suckling cows	11	83	GF	Spot
	Simmental, **Angus**, **Limousine** - Young cattle	12	56	GF	Weekly

GF : Greenfeed
RC : Respiration Chambre

Importance of standardized protocols!

Reference data

CH_4 + Feaces NIR spectra

Lactating dairy cows

		Dataset	n	Ref. CH_4	Ref. CH_4 (g/day, mean ± SD)	Based diet
Dairy	**Holstein** - Lactating cows	1	45	GF	368 ± 41	Grassland or Corn silage
		2	22	GF & RC	310 ± 30	Corn silage
		3	32	SF_6 & RC	258 ± 41	Hay
		4	162	GF	470 ± 65	Grassland and Hay
		5	27	GF & SF_6	394 ± 42	Corn silage
		6	16	RC	311 ± 57	Hay
		7	8	SF_6	455 ± 21	Grass and Corn sillage
		8	32	RC	367 ± 36	Grassland
		9	24	RC	367 ± 68	Corn silage
		Total	368		408 ± 113	

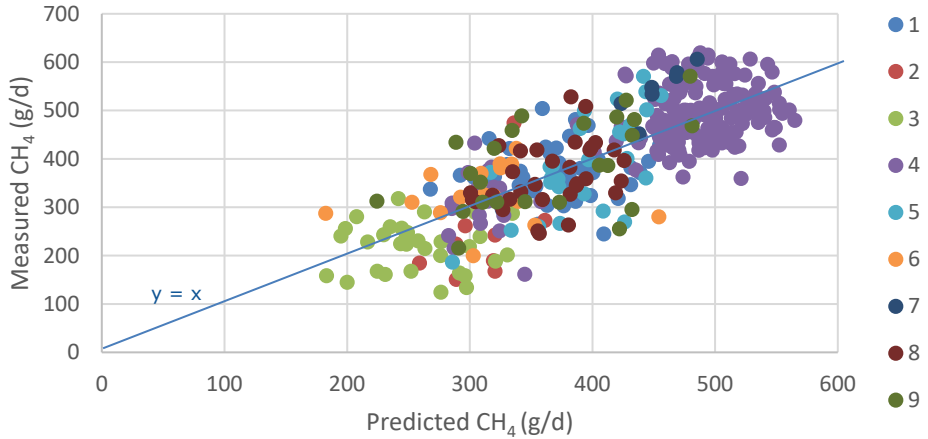
GF : Greenfeed
RC : Respiration Chambre
SD : standard deviation

Explorative approach

To have a reasonnable amount of data, animals and variability
→ no restriction nor correction relative to measurement method
→ Increase the noise

First models to estimate eructated CH_4 from feaces NIR spectra

Lactating dairy cows



- Complementarity of datasets
- Interesting trend
- Error of 80 g CH_4/d

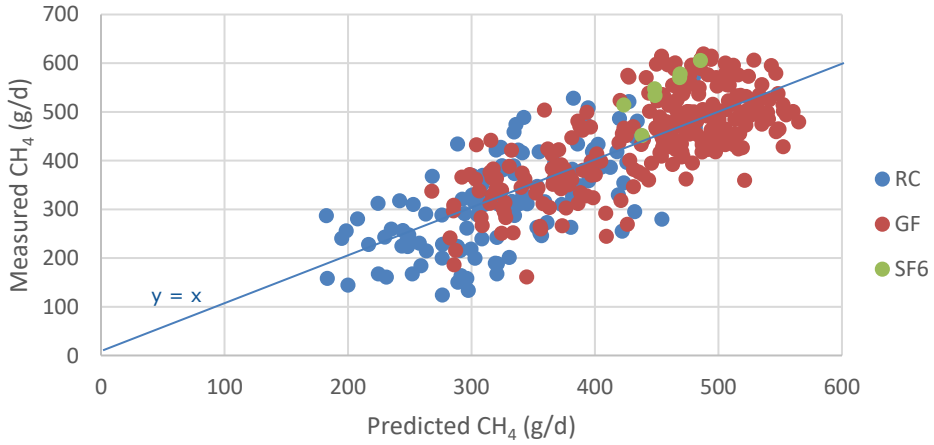
- Should be improved without « noise » related to different measurement and sampling methods

Modified PLS – 2nd derivative – 4 groups CV

n	R^2c	SEc (g CH_4/d)	R^2cv	SEcv (g CH_4/d)
368	0.61	70	0.50	80

First models to estimate eructated CH_4 from feaces NIR spectra

Lactating dairy cows



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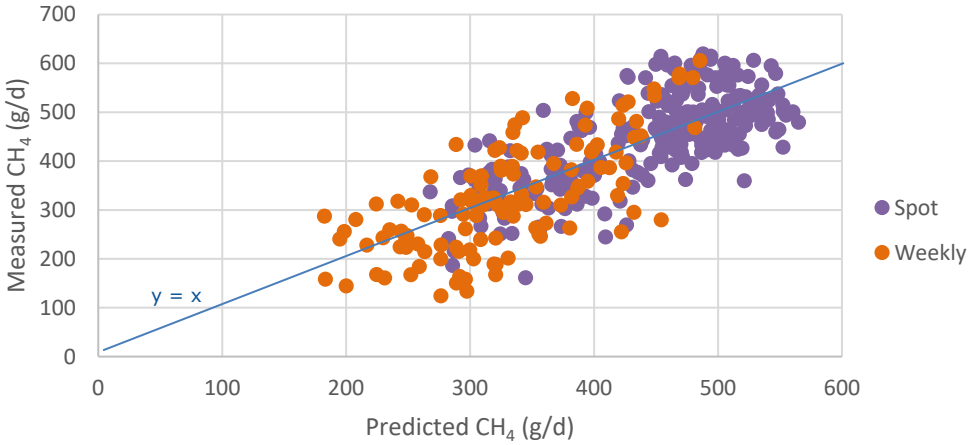

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368	0.61	70	0.50	80

→ **Need to collect data from young cattle, heifers and dry cows**

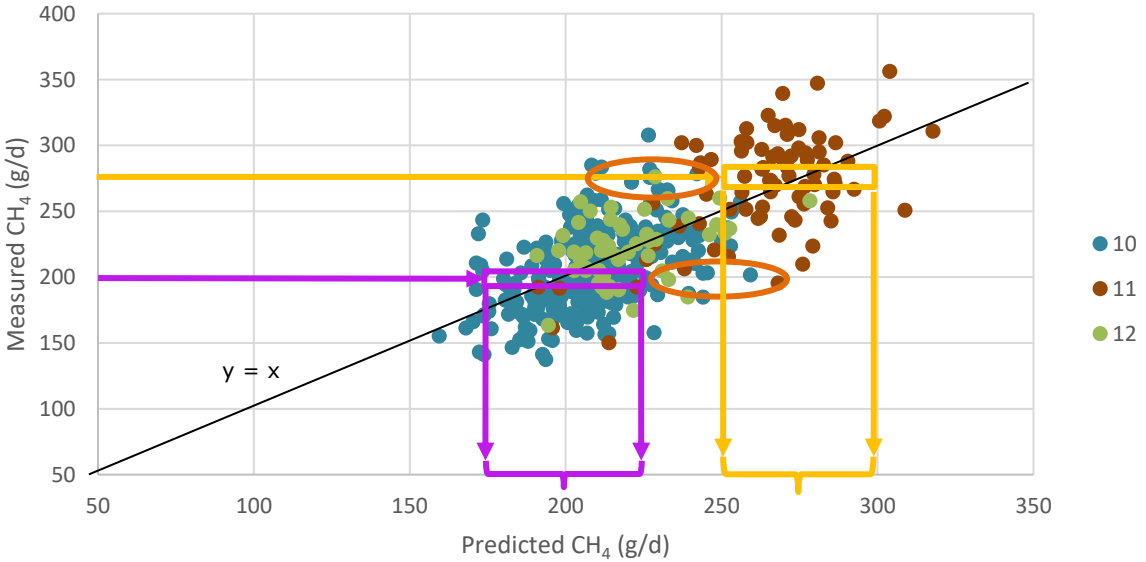
First models to estimate eructated CH_4 from feaces NIR spectra

Beef cattle

		Dataset	n	Ref. CH_4	Ref. CH_4 (g/day, mean ± SD)	Based diet
Beef	**Charolais** - Heifers	10	263	GF	206 ± 37	Grassland
	Dual purpose Belgian Blue, **Belgian Blue** - Calves, reformed cows, suckling cows	11	83	GF	269 ± 41	Grassland or Grass silage
	Simmental, **Angus**, **Limousine** - Young cattle	12	56	GF	218 ± 38	Corn silage
		Total	402		221 ± 41	

First models to estimate eructated CH_4 from feaces NIR spectra

Beef cattle



- Complementarity of datasets
- Interesting trend
- Error of 29 g CH_4/d

Modified PLS – 2nd derivative – 4 groups CV

n	R^2c	SEc (g CH_4/d)	R^2cv	SEcv (g CH_4/d)
346	0.62	26	0.55	29

Conclusions & Next steps

- First models estimating CH_4 from feaces NIR spectra showed interesting trends and moderate errors

- Need more reference datasets to conclude about feasability

- Correction of the reference value in function of the CH_4 measurement technique? Or choose one protocol and increase the reference dataset?

- Predictive models dedicated to spectific breed/specific diet?
  Or include these information as explanatory variables in an unique model?

Conclusions & Next steps

- Main interest for beef cattle & young and dry dairy cattle
- For lactating dairy cows, complementarity between milk MIR spectra and faecal NIR spectra to estimate CH_4? (… And in practice?)
- Importance of standardized protocols and apparatus for future projects to merge datasets
- Always consider sampling of milk and/or feaces during trials for IR analyse

Thank you for your attention

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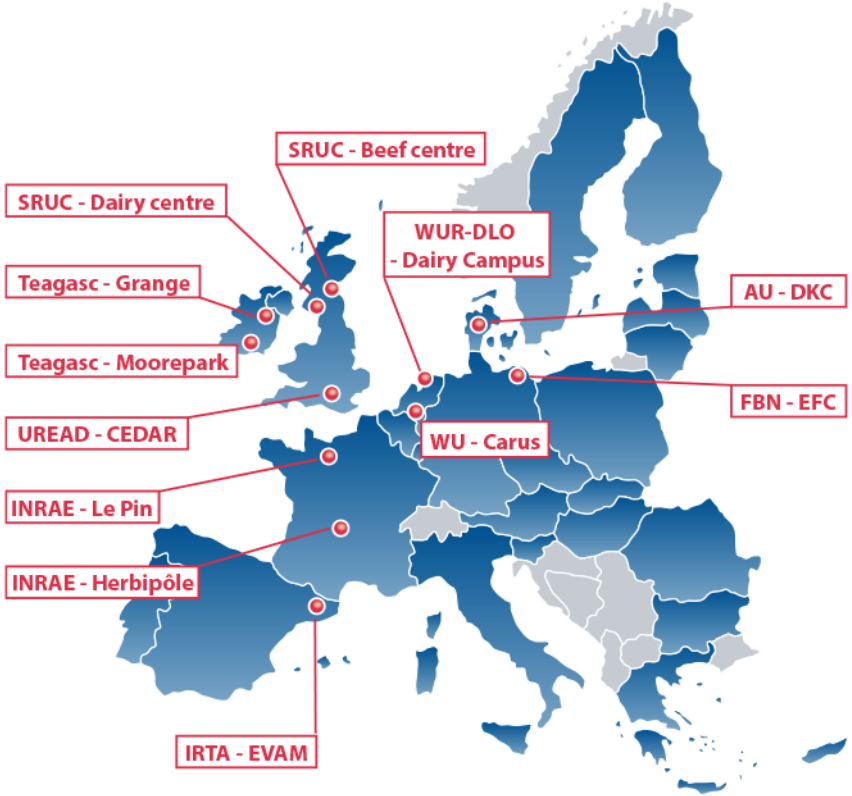
SmartCow at a glance



First-class Cattle Research Infrastructures (RIs) across Europe:

- 11 major RIs distributed in 7 EU countries
- 12 locations, which include 18 installations
- 2500 dairy and 1000 beef cows

- **Networking of RIs** to inventorize resources, harmonize procedures, and share data
- **Joint research activities** to improve experimental methods and phenotyping capability
- **Interaction with stakeholders** to stay in line with industry needs and improve dissemination

http://www.smartcow.eu/stakeholders/

TRAINING PROGRAM

For Scientists, Technicians, Stakeholders, PhD students

- Face-to-face training courses
- Free web-conferences
- One-day study tours in 4 different countries

http://www.smartcow.eu/resources/training/

TRANSNATIONAL ACCESS CALLS

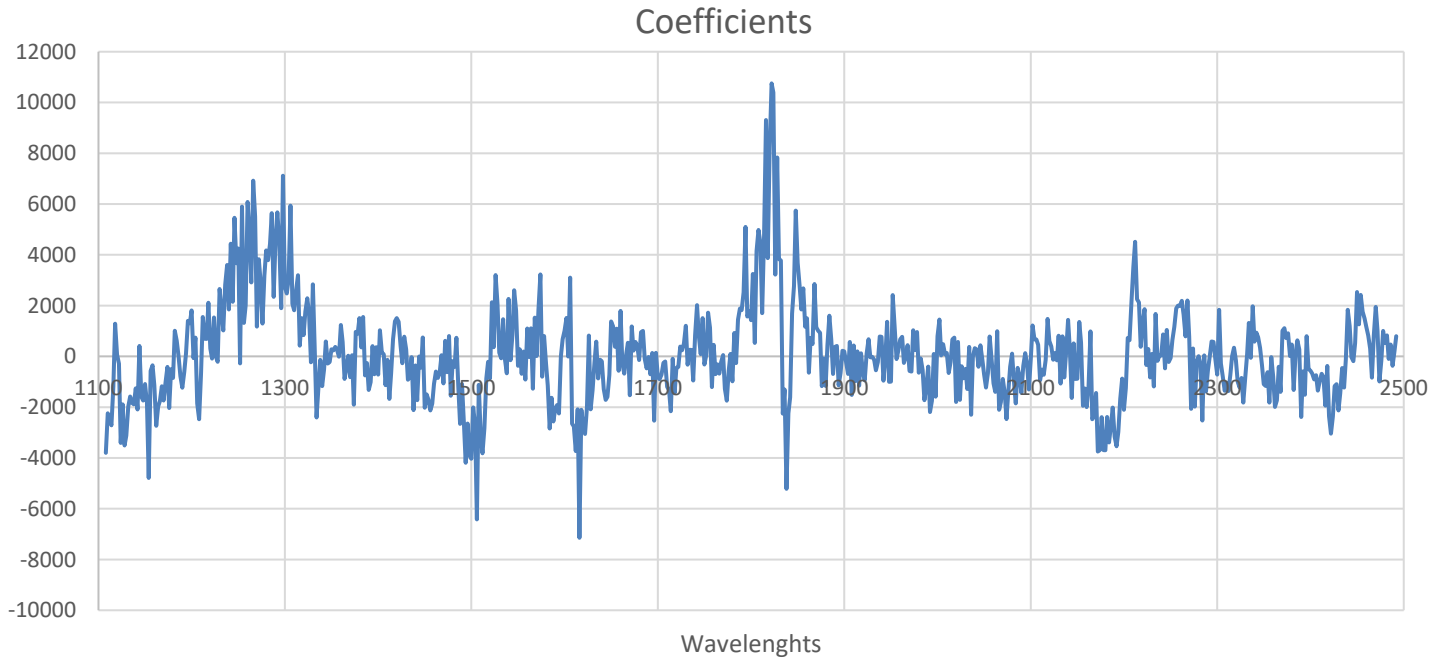
Offers external users (academic and industry) free access to SmartCow RIs

- 30 projects during the 4 years of SmartCow
- Access to around 10,000 cow-weeks

http://www.smartcow.eu/calls/

This project has received funding from the European Union's Horizon 2020 research and innovation program under the Grant Agreement n°730924.

First models to estimate eructated CH_4 from feaces NIR spectra



First models to estimate eructated CH_4 from feaces NIR spectra

Decruyenaere et al., 2006