Enteric CH4 emissions predicted from milk MIR spectra : robustness as the key to a model that crosses borders

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EU-LI-PHE European Network on Livestock Phenomics

www.cost.eu/actions/CA22112/

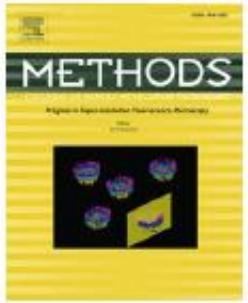
Robustness of a model?

→ Capacity to provide good predictions under various conditions ←

⚠ Avoid extrapolation and overfitting

Methods 186 (2021) 97–111

Large-scale phenotyping in dairy sector using milk MIR spectra: Key factors affecting the quality of predictions



C. Grelet [a], P. Dardenne [a], H. Soyeurt [b], J.A. Fernandez [a], A. Vanlierde [a], F. Stevens [a], N. Gengler [b], F. Dehareng [a,*]

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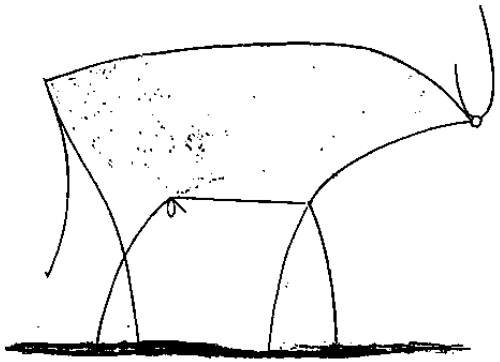
Retrospective example : First published model (2012)

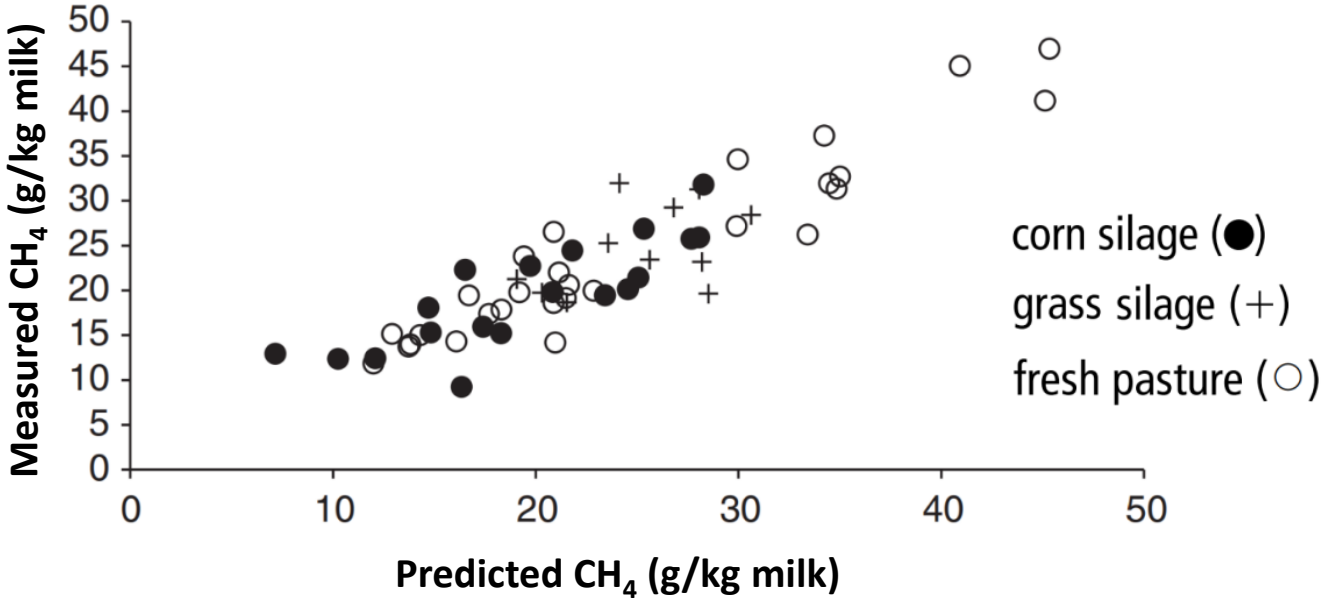
First equation

Animal (2012), **6:10**, pp 1694–1701 © The Animal Consortium 2012
doi:10.1017/S1751731112000456

Potential use of milk mid-infrared spectra to predict individual methane emission of dairy cows

F. Dehareng[1*†], C. Delfosse[1*], E. Froidmont[2], H. Soyeurt[3,4], C. Martin[5], N. Gengler[3,4], A. Vanlierde[1] and P. Dardenne[1]





Equation	N data	N cows	Origin	Pred. variables	R^2c	SEC (g/d)	R^2cv	SECV (g/d)
First equation	77	11	BE	S	0.85	69	0.72	96

! Very interesting but not robust ! (dataset dependant)

An international model to predict CH_4
from milk MIR spectra needs to be robust
to permit routine use in a maximum of situations.

→ Need to include variabiliti**ES** in the calibration set

→ Zootechnical level
(breeds, diets, physiological stage, etc.)
→ CH_4 range level
→ Spectral level
→ Etc.

Increasing the variability of the calibration set
→ Countries and reference methods

METHAGENE

GREENHOUSE MILK

GE PLUS

OptiWIR

afbi Agri-Food and Biosciences Institute

365 ± 44 g/d

Wallonie recherche CRA-W

510 ± 105 g/d

AARHUS UNIVERSITY

367 ± 64 g/d

FBN

405 ± 60 g/d

eagasc

Agriculture and Food Development Authority

347 ± 89 g/d

QUALITAS

ETH zürich

451 ± 75 g/d

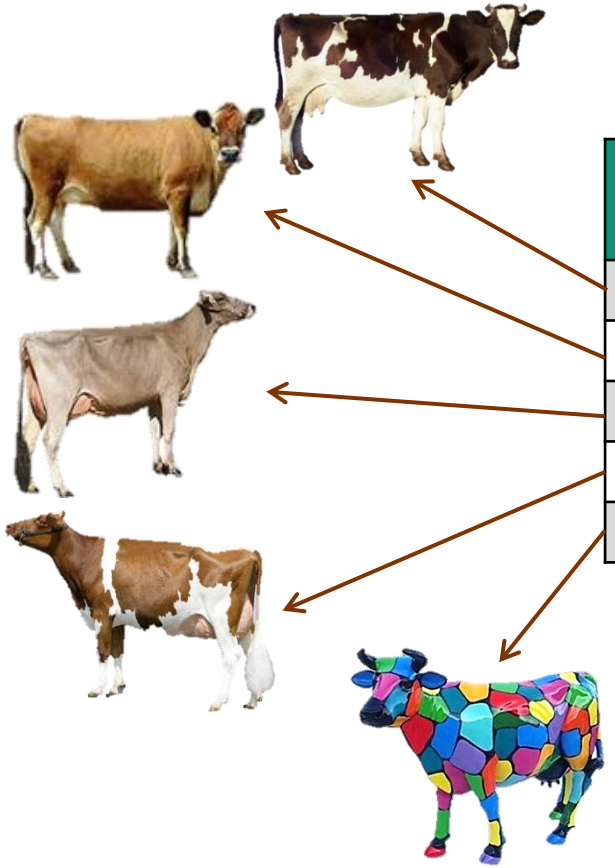
427 ± 127 g/d

INRA SCIENCE & IMPACT

366 ± 61 g/d

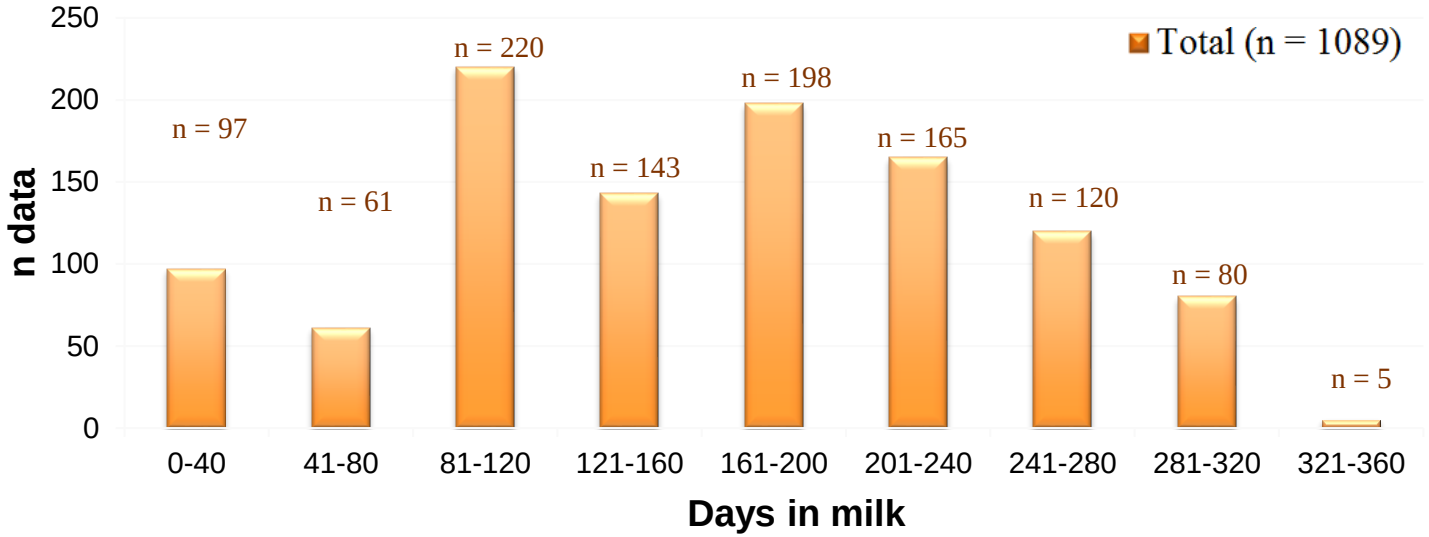
400 ± 72 g/d

Increasing the variability of the calibration set → Breeds

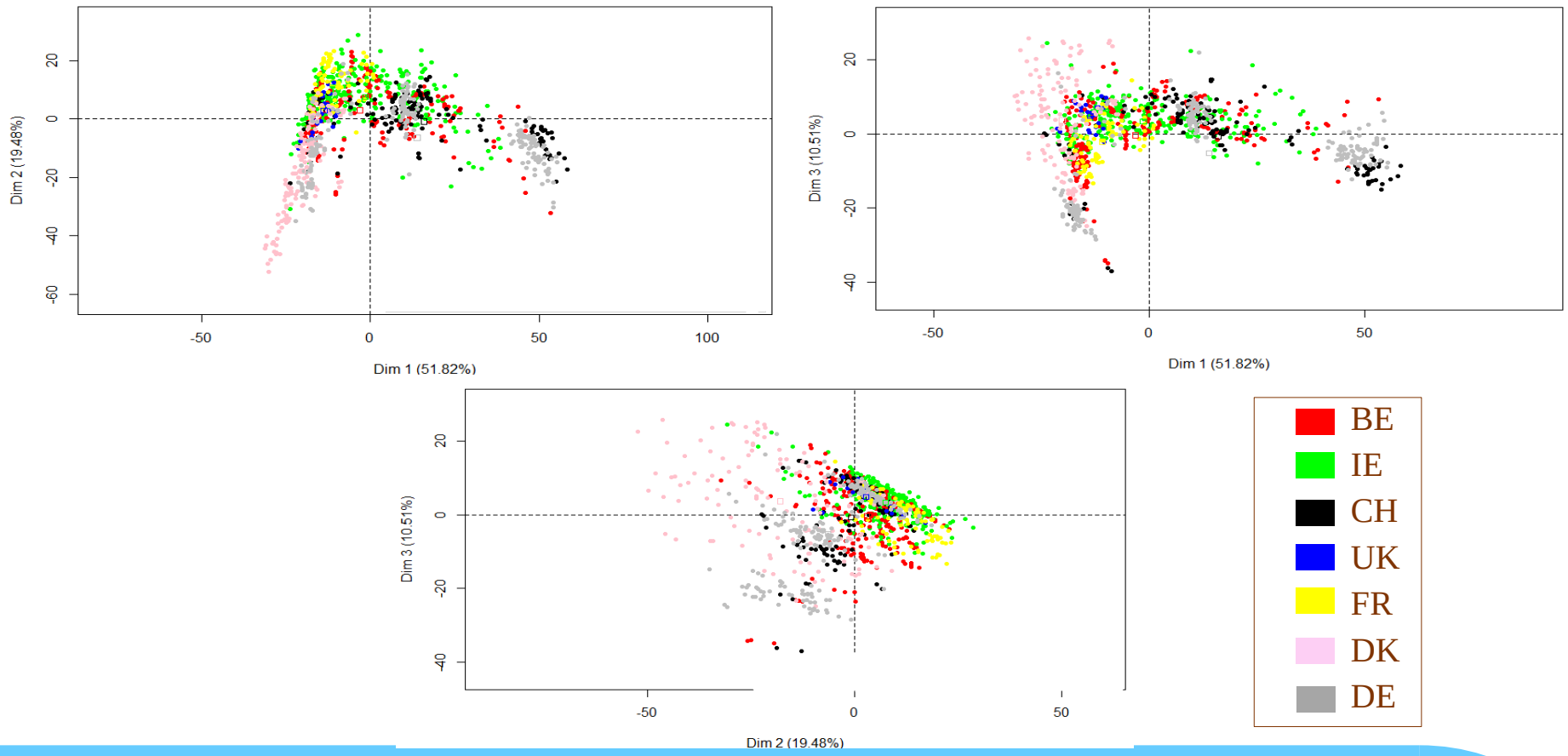


Breed	n data	% of data	n cows	% of cows	CH_4 (g/d) mean ± SD
HOL	891	82	222	74	415 ± 107
JER	67	6	10	3	342 ± 42
BSW	78	7	39	13	458 ± 69
RED	21	2	8	3	427 ± 74
X	32	3	20	7	391 ± 67

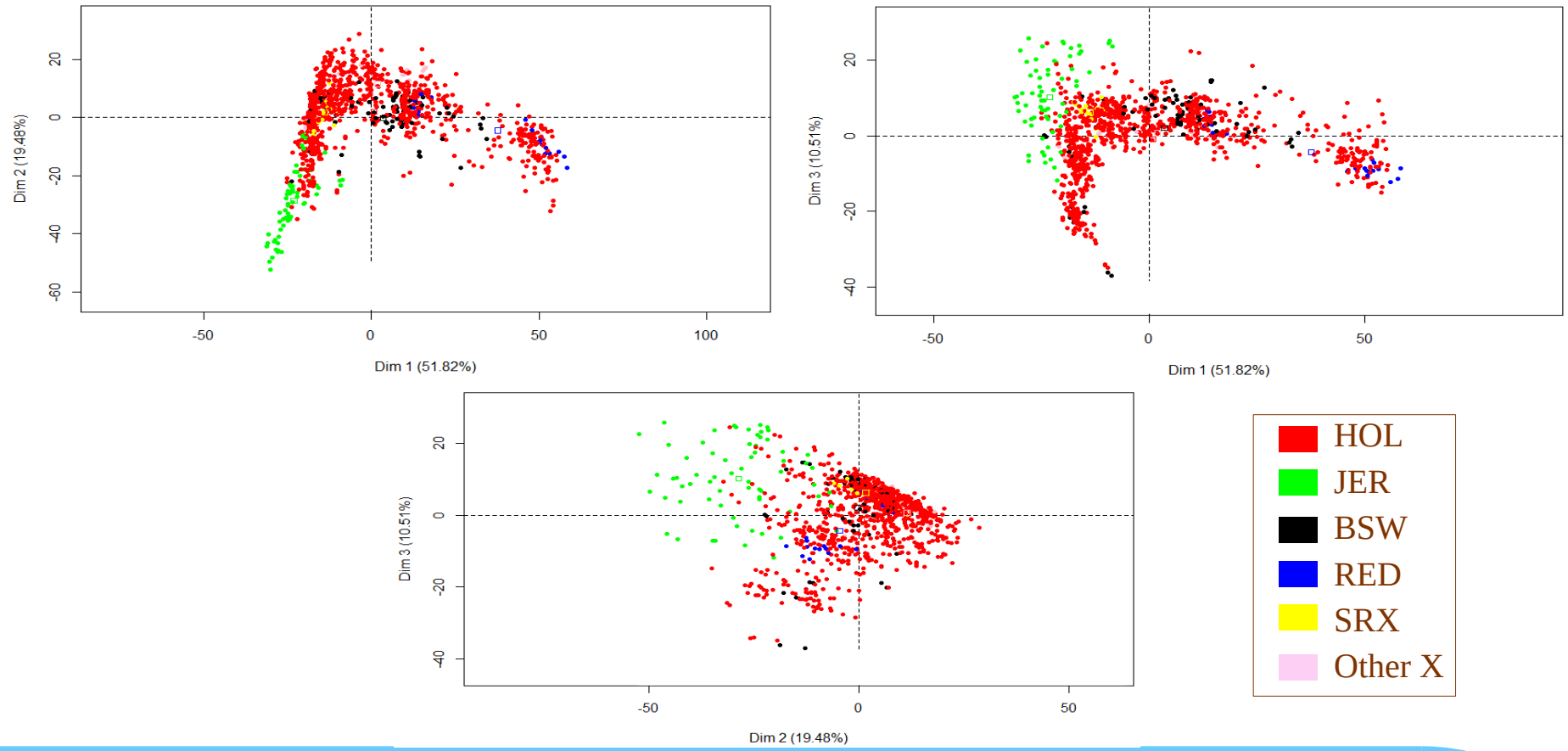
Increasing the variability of the calibration set → Lactation stage



Increasing the variability of the calibration set → FT-MIR spectra

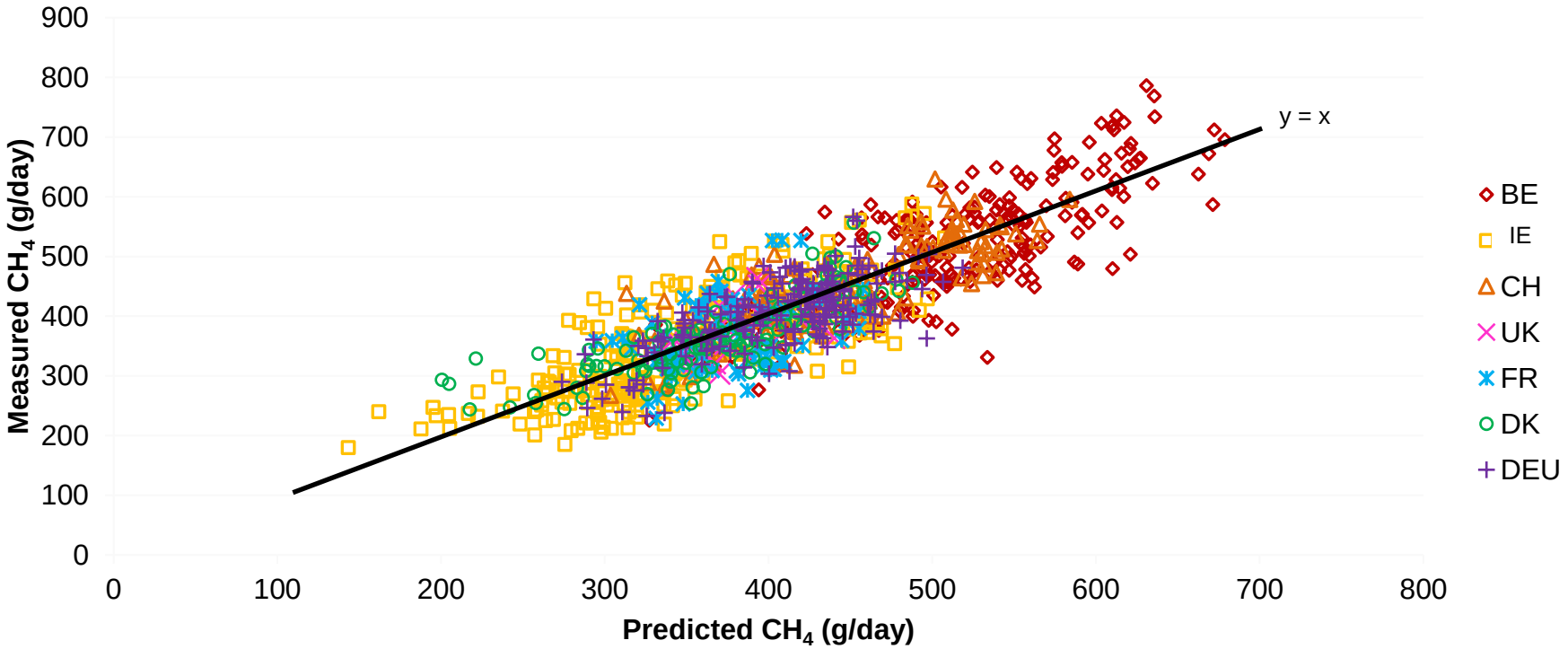


Increasing the variability of the calibration set → FT-MIR spectra



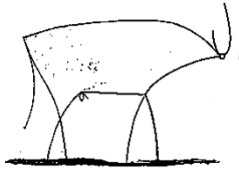
Prediction model

CH_4 Ref. method	n data	n cows	Origin	R^2c	SEC (g/d)	R^2cv	SECV (g/d)
SF_6 & RC	1,089	299	BE, IE, CH, UK, FR, DK, DE	0.73	53	0.68	57

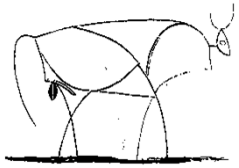


Equation to estimate CH4 from milk FT-MIR spectra: An evolutive model

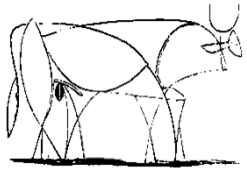
First equation (2012)



Inclusion of lactation stage information (2015)

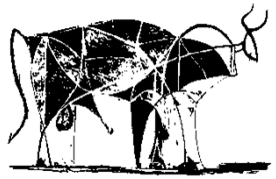


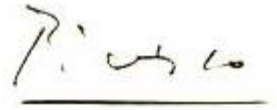
What if CH_4 is measured with gold-standard technique? (2018)



Consideration of additional zootechnical information (2020)

Increase the variability included in the calibration set (permanent process)





Journal of the Science of Food and

SCI where science meets business

Journal of Dairy Science
Volume 98, Issue 8, August 2015, Pages 5740-5747

Journal of Dairy Science
Volume 101, Issue 8, August 2018, Pages 7618-7624

...stness and accuracy of predicted daily
...ons of dairy cows using milk mid-infrared

Research
Short Communication

Short communication: Development of an equation for estimating methane emissions of dairy cows from milk Fourier transform mid-infrared spectra by using reference data obtained exclusively from respiration chambers

...Dehareng, Nicolas Gengler, Eric Froidmont, Sinead McParland, Bell, Peter Lund, Cécile Martin, Björn Kuhla, Hélène Soyeurt

...per 2020 | https://doi.org/10.1002/jsfa.10969

Equation to estimate CH4 from milk FT-MIR spectra: An evolutive model

If new reference data of interest are available &
If users observe questionable results
→ Come back to us ←

Win/win situation to add new reference data :
Local specificities covered, global model improved & access to the model

Getting access to the model?

2 Options

a) Research collaboration

b) European Milk Recording

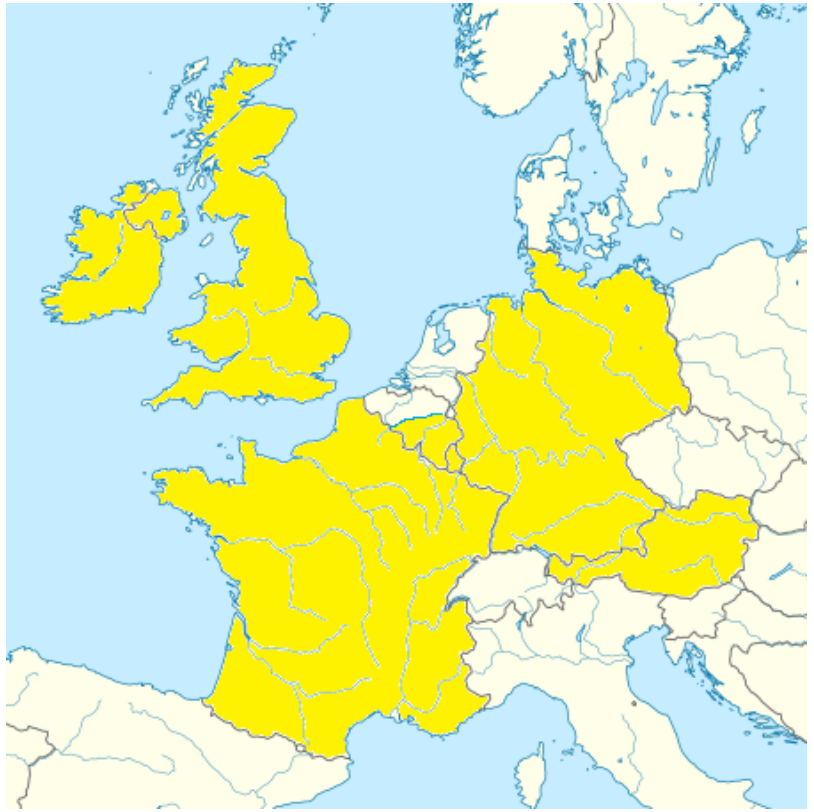
EUROPEAN.MILK.RECORDING EEIG

Bringing solution for new traits from milk spectral data

13 members (MROs in 7 countries)

> 5 000 000 recorded cows

86 FT-MIR spectrometers in 25 partner labs



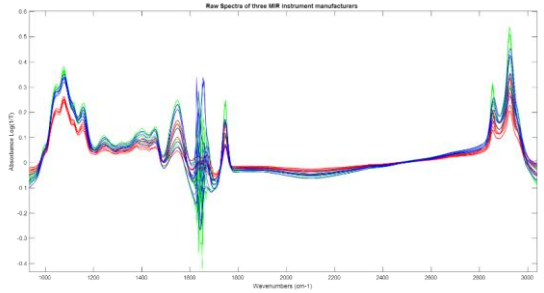
EUROPEAN.MILK.RECORDING EEIG

Bringing solution for new traits from milk spectral data

Technical considerations

Different brands,
different analyzers

Different spectra



NEED FOR STANDARDIZATION

- To pool data together and compare them
- To build robust models with high variability
- To transpose models on every FT-MIR spectrometers

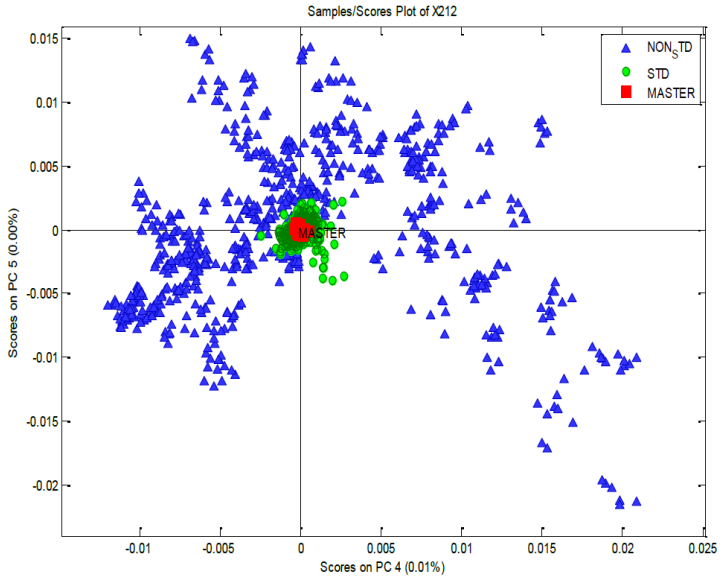
EUROPEAN.MILK.RECORDING EEIG

Bringing solution for new traits from milk spectral data

Standardisation of spectral data

Method developed by Grelet et al. (2015) to standardize all analyzers.

- → Potential to share spectra and reference values throughout this network to **build new equations**
- → Needed to **apply equations** and ensure the quality of predictions



www.milkrecording.eu

EUROPEAN.MILK.RECORDING EEIG

Bringing solution for new traits from milk spectral data

Developed models

Predictions can be direct or indirect:

1. Direct models
   - Protein, lactose, urea, fatty acids, casein in milk
2. Indirect models
   - In milk: Acetone, BHB, Citrate, minerals, lactoferrin
   - In blood: BHB, NEFA
   - Milk properties and ability to be transformed
   - Phenotypes: energy status, methane, nitrogen efficiency, …

www.milkrecording.eu

Available predictions?

Pack A	Methane emission Fatty acids in milk
Pack B	BHB in milk Acetone in milk Citrates in milk
Pack C	Minerals in milk Lactoferrin in milk
Pack D	BHB in blood NEFA in blood

Examples of concrete use of CH_4 predictions

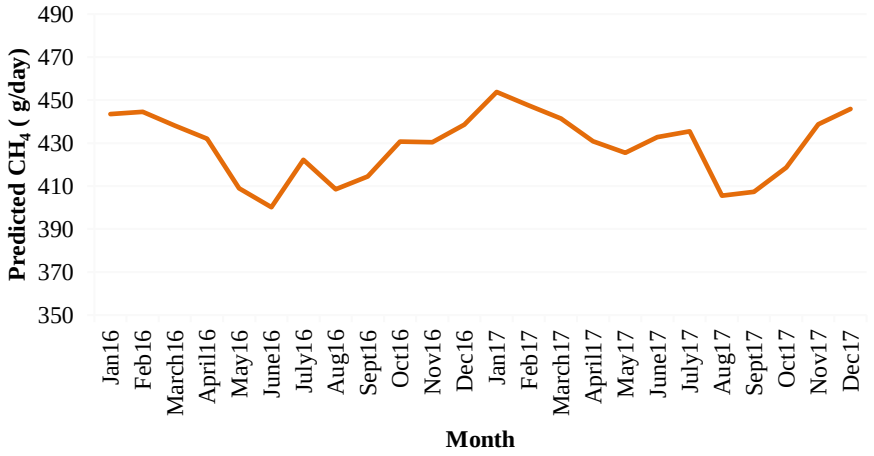
- Advices to breeders in France

  Lait'Age

  Feeding advice and feeding strategies

- Large scale studies in Walloon part of Belgium

n = 538,510



Journal of Dairy Science
Volume 100, Issue 7, July 2017, Pages 5578-5591

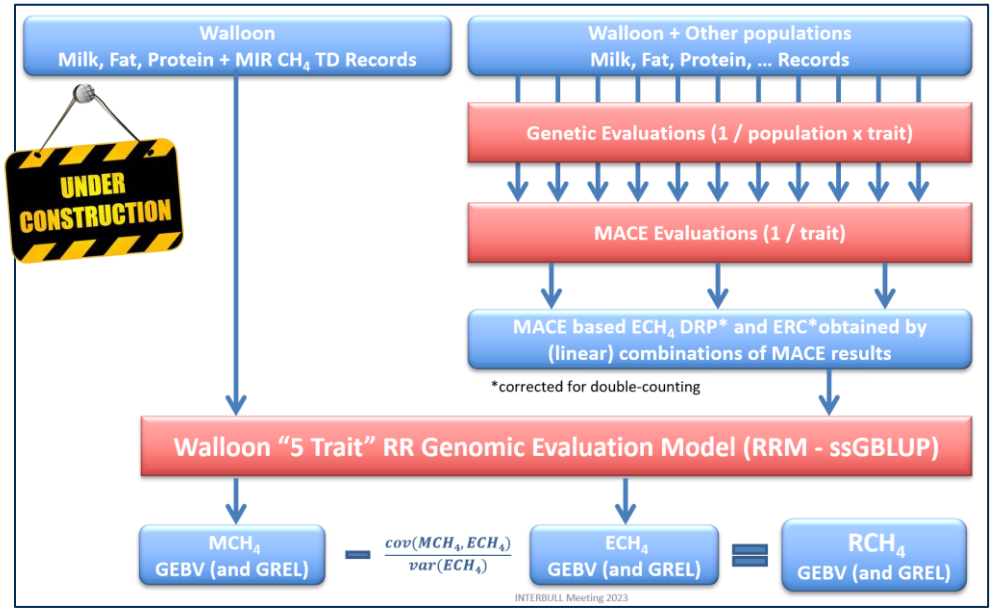
Genetic parameters of mid-infrared methane predictions and their relationships with milk production traits in Holstein cattle

P.B. Kandel *, M.-L. Vanrobays *, A. Vanlierde †, F. Dehareng †, E. Froidmont ‡, N. Gengler *, H. Soyeurt *

Examples of concrete use of CH_4 predictions

- Walloon genomic evaluation for "Residual CH_4"

  - Direct CH_4 predictions test-day-records (cows):
    - 1st : 1,529,282 (229,465)
    - 2nd : 1,062,013 (151,726)
    - 3rd : 642,735 (90,484)
  - Workflow (including use of external information) ➔
  - Sires from many different countries (1103 with ≥ 30 daughters with CH_4)
    - USA: 291
    - BEL: 194
    - NLD: 149
    - CAN: 135
    - DEU: 121
    - FRA: 100
    - ITA: 66
    - GBR: 23
    - DNK: 10



Main strenghts and limitations of milk MIR spectra as a proxy for CH_4 emissions?

Strenghts

- Milk sampling and MIR analyses already implemented in routine
- Fast
- Cost effective
- Error of prediction known
- Scalable
- Maybe closer to physiology (H → CH_4)

Limitations

- Specific variability needs to be included to avoid extrapolation (GH spectra, diet, breed, THI conditions, etc.)
- Effect of some diet additives on CH_4 emissions can not be considered
- Need standardized milk MIR spectra
- Only for lactating dairy cows

Take home messages

- Transparency of methodology and datasets
- Huge potential of application
- Not focus *only* on models statistics
- Need to cover local variabilities and avoid extrapolation
- Importance of collaborations
- Need standardized procedures (CH_4 value, spectral information,…) to merge datasets and apply prediction models

Reference method used

Journal of Dairy Science
Volume 105, Issue 11, November 2022, Pages 9271-9285

Methodological guidelines: Cow milk mid-infrared spectra to predict reference enteric methane data collected by an automated head-chamber system

M. Coppa [1], A. Vanlierde [2], M. Bouchon [3], J. Jurquet [4], M. Musati [5 6], F. Dehareng [2], C. Martin [5]

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Thank you!

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