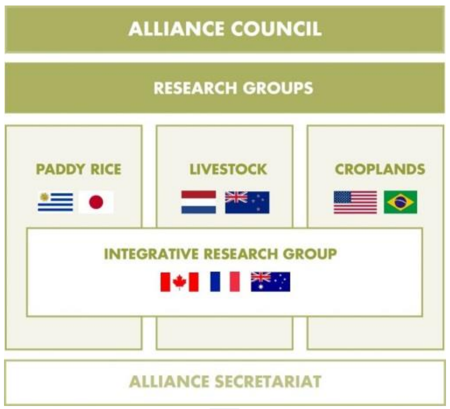
The Feed and Nutrition Network

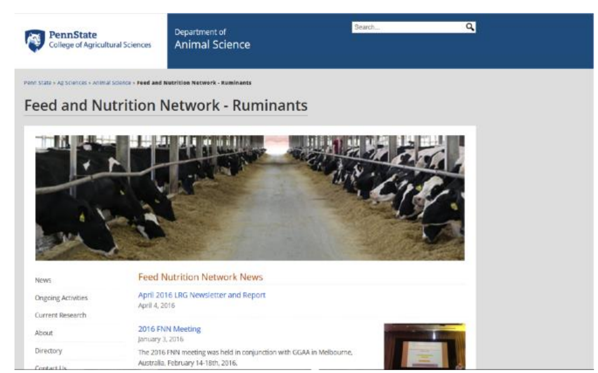
Global Research Alliance on Agricultural GHG



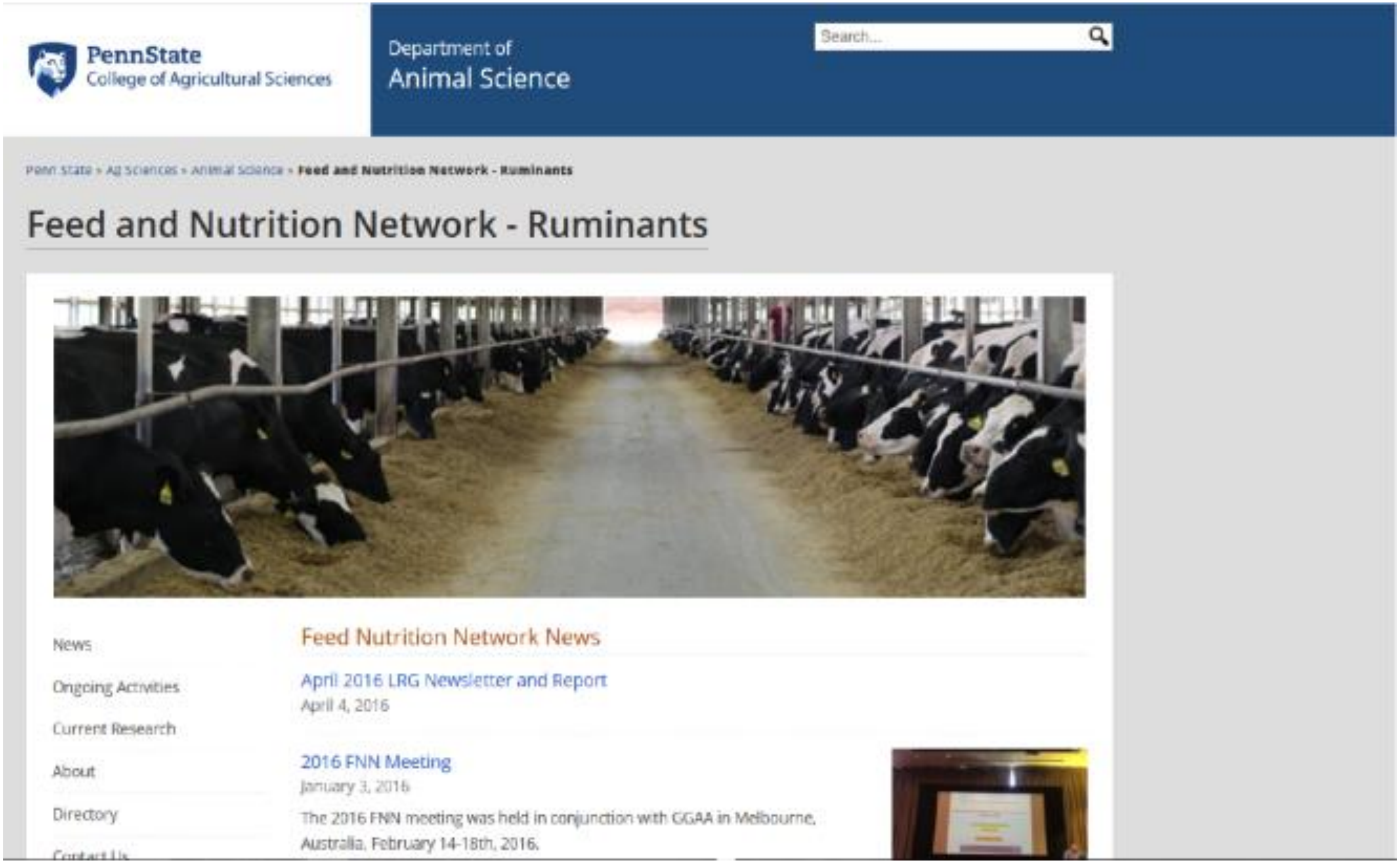
International collaboration in database development:

Livestock Research Group

Research Networks, including FNN



The Feed and Nutrition Network



THE GLOBAL NETWORK PROJECT

A. N. Hristov, E. Kebreab, M. Niu, J. Oh, C. Arndt, A. Bannink, A. R. Bayat, A. F. Brito, D. Casper, L. A. Crompton, J. Dijkstra, P. C. Garnsworthy, N. Haque, A. L. F. Hellwing, P. Huhtanen, M. Kreuzer, B. Kuhla, P. Lund, J. Madsen, S. C. McClelland, P. Moate, C. Muñoz, N. Peiren, J. M. Powell, C. K. Reynolds, A. Schwarm, K. J. Shingfield, T. M. Storlien, M. R. Weisbjerg

PENNSTATE 1855

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

CSIC Consejo Superior de Investigaciones Científicas

Teagasc Agriculture and Food Development Authority

MTT

Wageningen UR For quality of life

University of Reading

UC Davis Animal Science

INRA Science & Impact

The Ohio State University College of Food, Agricultural, and Environmental Sciences

The GLOBAL NETWORK project

- A 4-yr project funded through The Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI); US national funding through USDA-NIFA
- **Objectives**:
  - Create, update, and expand animal and **feed databases for mitigation of enteric methane**
  - Gain understanding of the contribution of **genetic and microbial factors** to variation in enteric methane production
  - **Validate markers** of enteric methanogenesis for the development and monitoring of methane mitigation strategies in ruminants

The GLOBAL NETWORK project

- Create, update, and expand a **database of mitigation strategies aimed at improving dietary N utilization** and lowering N excretion and ammonia and nitrous oxide emissions from manure
- **Develop Standard Operating Procedures (SOP)** and guidelines for conducting and assessing data from in vitro and in vivo studies designed to evaluate nutritional strategies for mitigation of GHG and NH_3
- **Develop new and evaluate existing models** for predicting methane emission and N excretions under various nutritional, animal, and farm management scenarios
- **Identify and recommend GHG and NH_3 mitigation technologies** that are practical and feasible

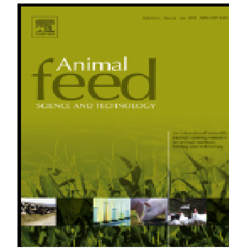
Research method reviews

Animal Feed Science and Technology 216 (2016) 1–18

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci



Review article

Design, implementation and interpretation of *in vitro* batch culture experiments to assess enteric methane mitigation in ruminants—a review

Yáñez-Ruiz D.R.[a,*], Bannink A.[b], Dijkstra J.[c], Kebreab E.[d], Morgavi D.P.[e], O'Kiely P.[f], Reynolds C.K.[g], Schwarm A.[h], Shingfield K.J.[i,j], Yu Z.[k], Hristov A.N.[l]

Research method reviews

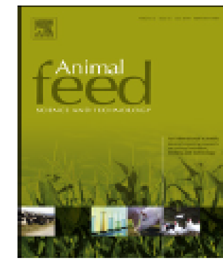
Animal Feed Science and Technology 219 (2016) 13–30

ELSEVIER

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci



Review article

Review of current *in vivo* measurement techniques for quantifying enteric methane emission from ruminants

CrossMark

K.J. Hammond[a], L.A. Crompton[a], A. Bannink[b], J. Dijkstra[c], D.R. Yáñez-Ruiz[d], P. O'Kiely[e], E. Kebreab[f], M.A. Eugène[g], Z. Yu[h], K.J. Shingfield[i,j], A. Schwarm[k], A.N. Hristov[l], C.K. Reynolds[a,*]

J. Dairy Sci. 101:1–20
https://doi.org/10.3168/jds.2017-13536

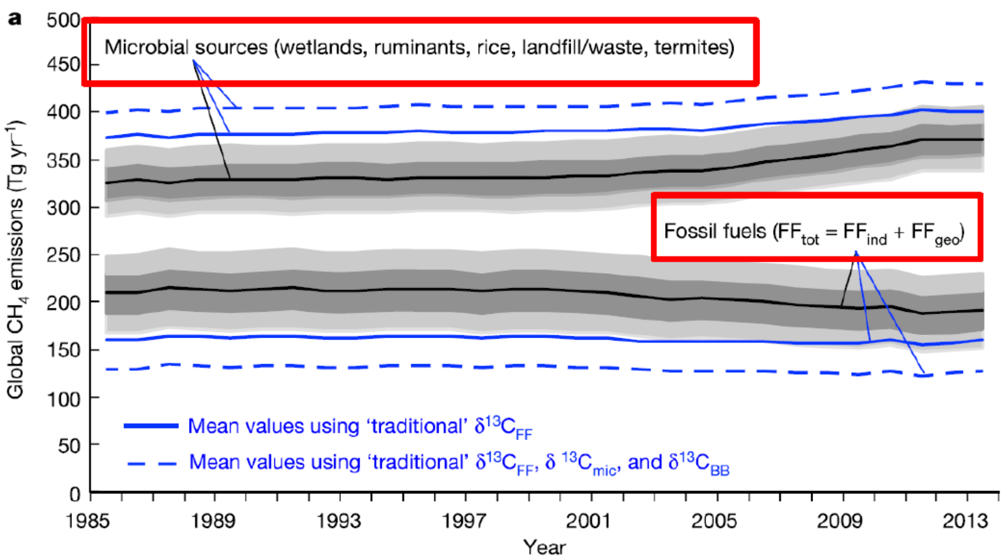
Symposium review: Uncertainties in enteric methane inventories, measurement techniques, and prediction models[1]

A. N. Hristov,*[2] E. Kebreab,† M. Niu,† J. Oh,* A. Bannink,‡ A. R. Bayat,§ T. B. Boland,# A. F. Brito,‖ D. P. Casper,¶ L. A. Crompton,$ J. Dijkstra,€ M. Eugène,¥ P. C. Garnsworthy, N. Haque,†† A. L. F. Hellwing,‡‡ P. Huhtanen,§§ M. Kreuzer,## B. Kuhla,‖‖ P. Lund,‡‡ J. Madsen,†† C. Martin,¥ P. J. Moate,¶¶ S. Muetzel,$$ C. Muñoz,€€ N. Peiren,¥¥ J. M. Powell,*** C. K. Reynolds,$ A. Schwarm,## K. J. Shingfield,†††[3] T. M. Storlien,‡‡‡ M. R. Weisbjerg,‡‡ D. R. Yáñez-Ruiz,§§§ and Z. Yu###**

*Department of Animal Science, The Pennsylvania State University, University Park 16802
†Department of Animal Science, University of California, Davis 91616
‡Wageningen Livestock Research, Wageningen University and Research, 6700 AH Wageningen, the Netherlands
§Milk Production Solutions, Green Technology, Natural Resources Institute Finland, 31600 Jokioinen, Finland
#School of Agriculture and Food Science, University College Dublin, Belfield, Dublin 4, Ireland
‖Department of Nutrition, Agriculture, and Food Systems, University of New Hampshire, Durham 03824
¶Furst McNess Company, Freeport, IL 61032
$School of Agriculture, Policy and Development, University of Reading, Earley Gate, RG6 6AR, United Kingdom
€Animal Nutrition Group, Wageningen University and Research, 6700 AH Wageningen, the Netherlands
¥UMR Herbivores, INRA, VetAgro Sup, Université Clermont Auvergne, 63122 Saint-Genès-Champanelle, France
**School of Biosciences, University of Nottingham, Loughborough, LE12 5RD, United Kingdom
††Department of Large Animal Sciences, University of Copenhagen, 1870 Frederiksberg, Denmark
‡‡Department of Animal Science, Aarhus University, Foulum, 8830 Tjele, Denmark
§§Department of Agricultural Science for Northern Sweden, Swedish University of Agricultural Sciences, SE-901 87 Umeå, Sweden
##ETH Zurich, Institute of Agricultural Sciences, 8092 Zurich, Switzerland
‖‖Institute of Nutritional Physiology, Leibniz Institute for Farm Animal Biology, 18196 Dummerstorf, Germany
¶¶Agriculture Victoria, Ellinbank, Victoria 3821, Australia
$$Ag Research, Palmerston North 4442, New Zealand
€€Instituto de Investigaciones Agropecuarias, INIA Remehue, Osorno, Región de Los Lagos 5290000, Chile
¥¥Animal Sciences Unit, Flanders Research Institute for Agriculture, Fisheries and Food, 9090 Melle, Belgium
***USDA-ARS US Dairy Forage Research Center, Madison, WI 53706
†††Institute of Biological, Environmental and Rural Sciences, Aberystwyth University, Aberystwyth SY23 3EB, United Kingdom
‡‡‡Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, As 1432, Norway
§§§Estación Experimental del Zaidin, CSIC, 1, 18008 Granada, Spain
###Department of Animal Sciences, The Ohio State University, Columbus 43210

PennState
College of Agricultural Sciences

Global methane inventories



Schwietzke et al., 2016 (Nature)

……the recent temporal increases in microbial emissions have been substantially larger (than from fossil fuel)

Schaefer et al., 2016 (Science)

…..Post-2006 source increases are predominantly biogenic, outside the Arctic, and arguably more consistent with agriculture than wetlands

PennState
College of Agricultural Sciences

How reliable are the isotope data?

Turner et al., 2017 (PNAS)

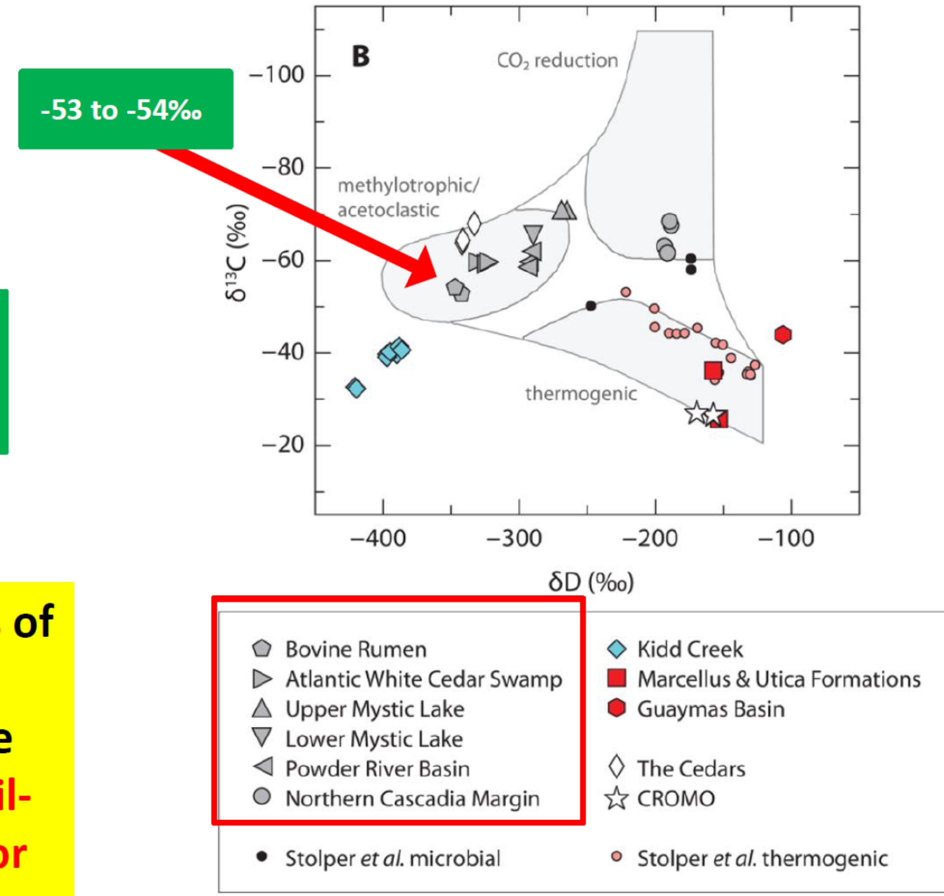
$\delta^{13}CH_4$; fossil-fuel

-15‰ to -76‰

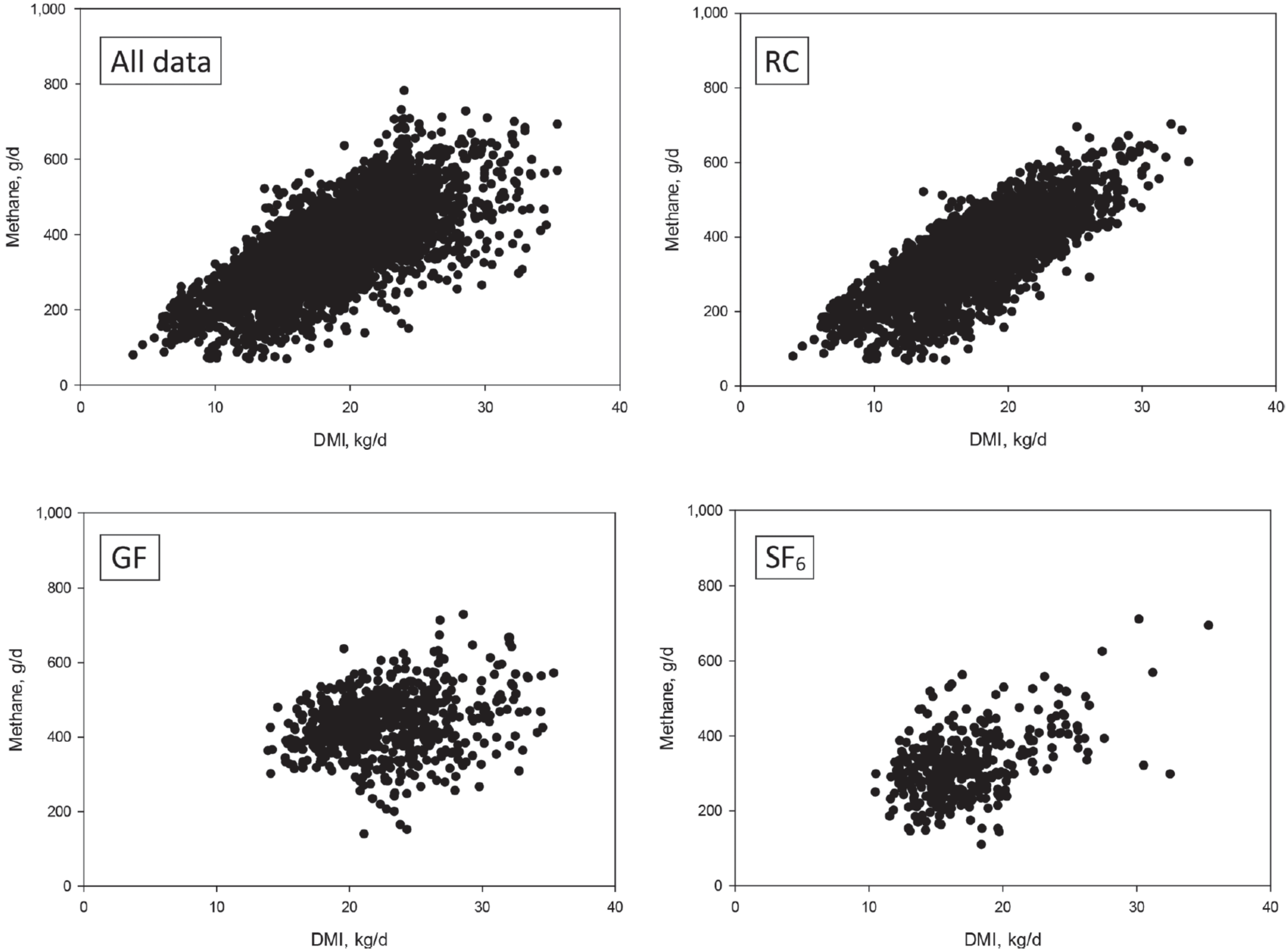
-31‰ to -93‰

$\delta^{13}CH_4$; biogenic

....a large overlap in isotopic signatures of fossil fuel and non-fossil methane........analysis presented here demonstrates that an increase in fossil-fuel methane sources could be a major contributor to the renewed growth in atmospheric methane since 2007



Wang et al., 2016 (Science)


All data
RC
GF
SF_6
Methane, g/d
DMI, kg/d
1,000
800
600
400
200
0
0
10
20
30
40

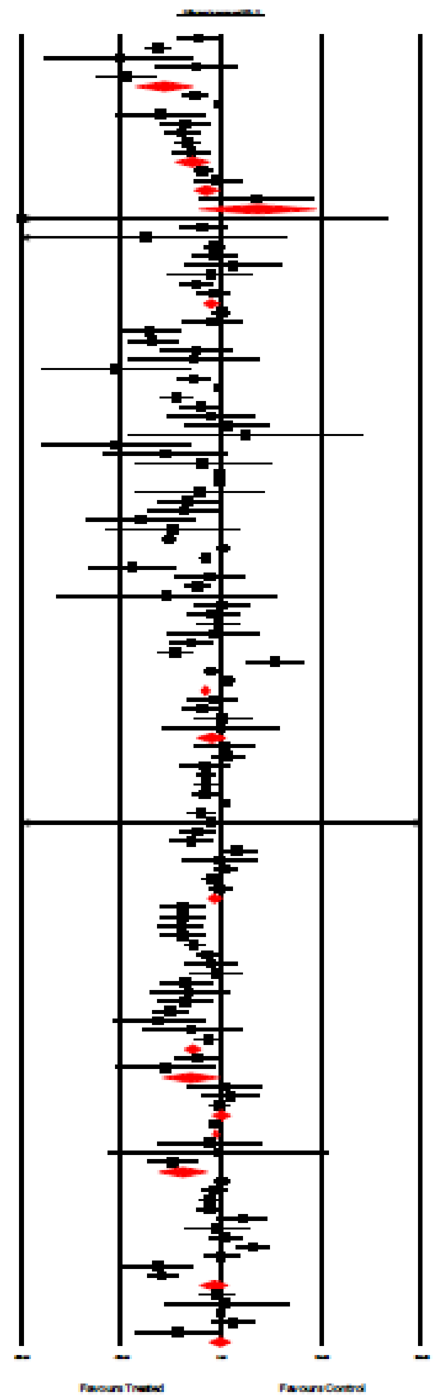
Databases

- Databases being developed:
  - Individual animal database (dairy, beef, small ruminants)
  - Treatment means database
  - Microbial database
- **Treatment means database**
  - 1,796 observations from 410 references
  - From 1964 to 2016
  - MitiGate (http://mitigate.ibers.aber.ac.uk/) database merged; raw data provided by authors
  - **31 treatments/treatment groups** identifies

Treatment means database

- **Preliminary data for cattle (CH_4, g/d):**

Treatment	Effect, g/d	SE	Lower limit	Upper limit	P-value
3NOP	-85.37	21.70	-127.90	-42.84	< 0.001
BCM	-43.80	12.70	-68.69	-18.91	< 0.001
Essential oil	-15.80	5.29	-26.17	-5.44	0.003
Fatty acid	-24.04	3.15	-30.21	-17.87	< 0.001
Fumaric acid	-14.93	10.48	-35.47	5.61	0.15
Ionophore	-10.91	4.72	-20.16	-1.67	0.02
Nitrate	-43.10	6.09	-55.03	-31.17	< 0.001
Nitroethane	-46.23	20.75	-86.89	-5.56	0.03
Probiotic	-0.13	6.73	-13.32	13.07	0.98
Saponin	-57.97	18.16	-93.56	-22.38	0.01



Received: 10 August 2017 | Revised: 15 December 2017 | Accepted: 29 January 2018
DOI: 10.1111/gcb.14094

PRIMARY RESEARCH ARTICLE

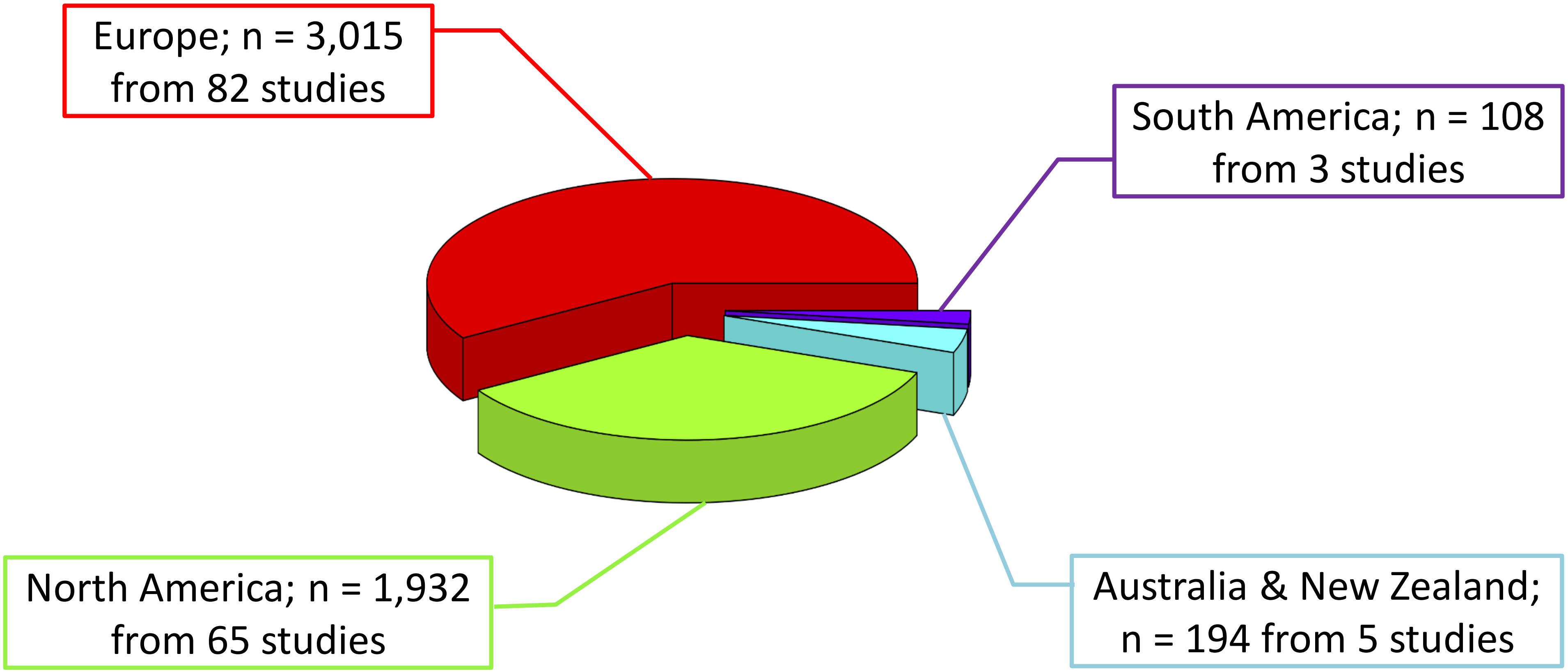
WILEY Global Change Biology

Prediction of enteric methane production, yield, and intensity in dairy cattle using an intercontinental database

Mutian Niu[1] | Ermias Kebreab[1] | Alexander N. Hristov[2] | Joonpyo Oh[2] | Claudia Arndt[3] | André Bannink[4] | Ali R. Bayat[5] | André F. Brito[6] | Tommy Boland[7] | David Casper[8] | Les A. Crompton[9] | Jan Dijkstra[10] | Maguy A. Eugène[11] | Phil C. Garnsworthy[12] | Md Najmul Haque[13] | Anne L. F. Hellwing[14] | Pekka Huhtanen[15] | Michael Kreuzer[16] | Bjoern Kuhla[17] | Peter Lund[14] | Jørgen Madsen[13] | Cécile Martin[11] | Shelby C. McClelland[18] | Mark McGee[19] | Peter J. Moate[20] | Stefan Muetzel[21] | Camila Muñoz[22] | Padraig O'Kiely[19] | Nico Peiren[23] | Christopher K. Reynolds[9] | Angela Schwarm[16] | Kevin J. Shingfield[24] | Tonje M. Storlien[25] | Martin R. Weisbjerg[14] | David R. Yáñez-Ruiz[26] | Zhongtang Yu[27]

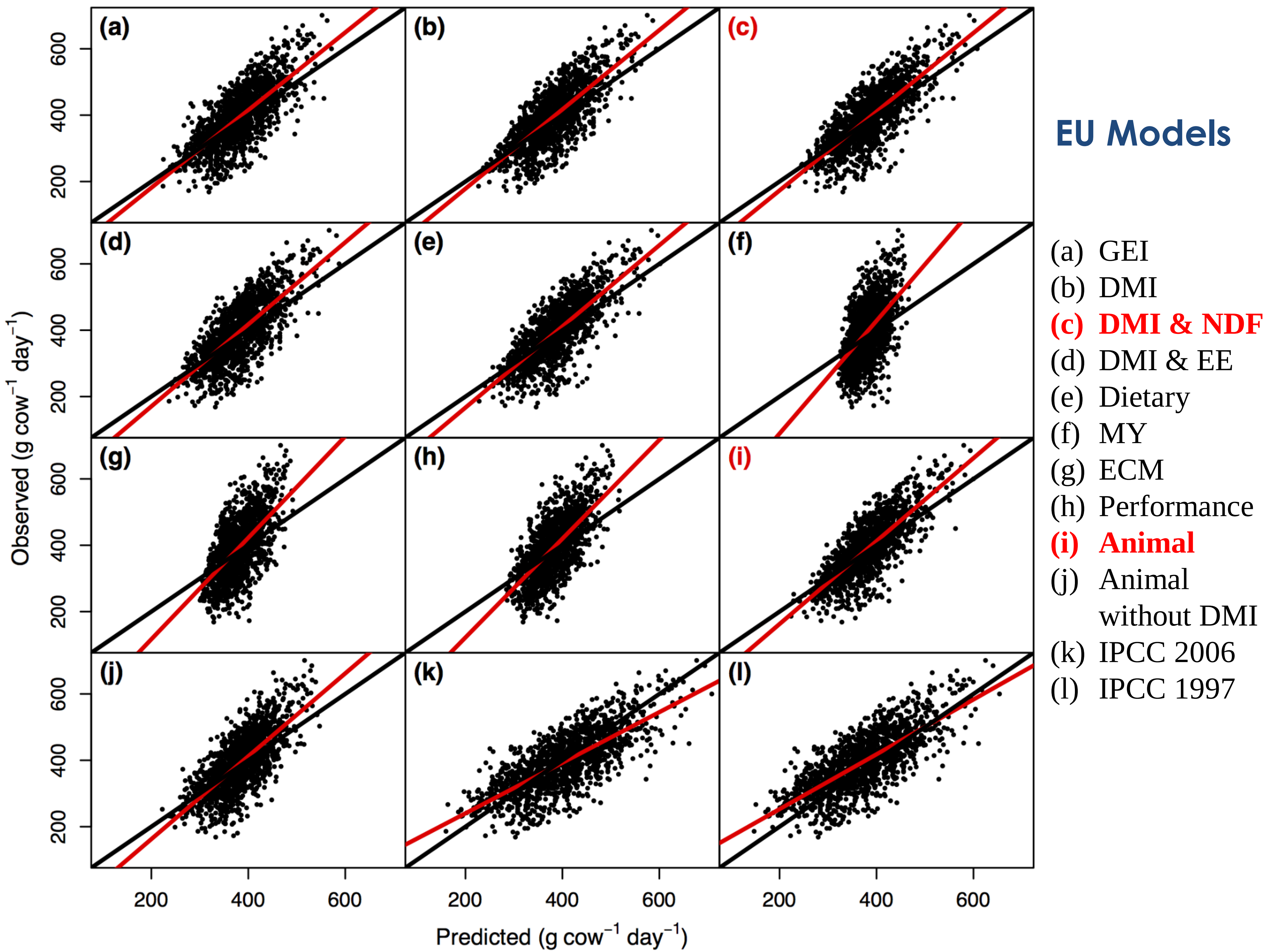
[1]Department of Animal Science, University of California, Davis, CA, USA
[2]Department of Animal Science, The Pennsylvania State University, University Park, PA, USA
[3]Environmental Defense Fund, San Francisco, CA, USA
[4]Wageningen Livestock Research, Wageningen University & Research, Wageningen, The Netherlands
[5]Milk Production Solutions, Green Technology, Natural Resources Institute Finland (Luke), Jokioinen, Finland
[6]Department of Agriculture, Nutrition and Food Systems, University of New Hampshire, Durham, NH, USA
[7]School of Agriculture and Food Science, University College Dublin, Belfield, Dublin 4, Ireland
[8]Furst McNess Company, Freeport, IL, USA
[9]School of Agriculture, Policy and Development, University of Reading, Reading, UK
[10]Animal Nutrition Group, Wageningen University & Research, Wageningen, The Netherlands
[11]UMR Herbivores, INRA, VetAgro Sup, Université Clermont Auvergne, Saint-Genès-Champanelle, France
[12]School of Biosciences, University of Nottingham, Loughborough, UK
[13]Department of Large Animal Sciences, University of Copenhagen, Copenhagen, Denmark
[14]Department of Animal Science, Aarhus University, Tjele, Denmark
[15]Department of Agricultural Science for Northern Sweden, Swedish University of Agricultural Sciences, Umeå, Sweden
[16]ETH Zurich, Institute of Agricultural Sciences, Zurich, Switzerland
[17]Institute of Nutritional Physiology, Leibniz Institute for Farm Animal Biology, Dummerstorf, Mecklenburg-Vorpommern, Germany
[18]Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO, USA
[19]Teagasc, Agriculture and Food Development Authority, Carlow, Ireland
[20]Agriculture Research Division, Department of Economic Development, Jobs, Transport and Resources, Melbourne, Vic., Australia
[21]Ag Research, Palmerston North, New Zealand
[22]Instituto de Investigaciones Agropecuarias, INIA Remehue, Osorno, Chile
[23]Animal Sciences Department, Flanders Research Institute for Agriculture, Fisheries and Food, Melle, Belgium
[24]Institute of Biological, Environmental and Rural Sciences, Aberystwyth University, Aberystwyth, UK
[25]Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, Ås, Norway
[26]Estación Experimental del Zaidín (CSIC), Granada, Spain
[27]Department of Animal Sciences, The Ohio State University, Columbus, OH, USA

Database (n=5,249)



CH_4 Production Models

	Model Development		Model Performance
Level	Model	Predictor	RMSPE, %
1	GEI Level	GEI	15.8
2	DMI Level	DMI	15.6
3	**DMI & NDF Level**	**DMI, NDF**	**14.5**
4	DMI & EE Level	DMI, EE	15.8
5	Dietary Level	DMI, EE, NDF	14.8
6	Dietary Composition Level	EE, NDF	24.1
7	MY Level	MY	20.1
8	ECM Level	ECM	18.7
9	Performance	ECM, MP	17.7
10	**Animal Level**	**DMI, EE, NDF, MF, BW**	**14.5**
11	Animal without DMI Level	EE, NDF, MP, ECM, BW	16.3
-	IPCC, 2006	GEI	16.1
-	IPCC, 1997	GEI	16.6



(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
(k)
(l)
200
400
600
Observed (g cow^{-1} day^{-1})
Predicted (g cow^{-1} day^{-1})
EU Models
(a) GEI
(b) DMI
(c) DMI & NDF
(d) DMI & EE
(e) Dietary
(f) MY
(g) ECM
(h) Performance
(i) Animal
(j) Animal without DMI
(k) IPCC 2006
(l) IPCC 1997

J. Dairy Sci. Invited Review

NITROGEN IN RUMINANT NUTRITION: A REVIEW OF MEASUREMENT TECHNIQUES

A. N. Hristov[a,1], A. Bannink[b], A. R. Bayat[c], L. A. Crompton[d], J. Dijkstra[e], P. Huhtanen[f], E. Kebreab[g], M. Kreuzer[h], M. McGee[i], P. Nozière[j], C. K. Reynolds[d], A. Schwarm[h], K. J. Shingfield[k]*, D. R. Yáñez-Ruiz[l], Z. T. Yu[m]

CEDERS - Capturing Effects of Diet on Emissions from Ruminant Systems

ERAGAS project

October 2017 till November 2020

9 eligible partners; various supporting partners

Total 3-year budget € 3.527.000, -

Building on & strong alliance with the FACCE-JPI Global Network project & the GRA through the FNN (A. Hristov)

Capturing Effects of Diet on Emissions from Ruminant Systems

9 partners

INRA
SCIENCE & IMPACT

LIVESTOCK RESEARCH
WAGENINGEN UR

LEIBNIZ INSTITUTE
FOR FARM ANIMAL BIOLOGY

Luke
NATURAL RESOURCES INSTITUTE FINLAND

SLU
Swedish University of Agricultural Sciences

AARHUS UNIVERSITY

agresearch
āta mātai, mātai whetū

University of Reading

teagasc
Agriculture and Food Development Authority

France
Germany
Denmark
United Kingdom
Netherlands
Finland
Sweden
New Zealand
Ireland

FACCE ERA-GAS

MONITORING & MITIGATION OF GREENHOUSE GASES FROM AGRI- AND SILVI-CULTURE