CARBON MANAGEMENT, 2016
VOL. 7, NOS. 3–4, 243–248
http://dx.doi.org/10.1080/17583004.2016.1180586

Taylor & Francis
Taylor & Francis Group

OPEN ACCESS

MAGGnet: An international network to foster mitigation of agricultural greenhouse gases

M.A. Liebig[1], A.J. Franzluebbers[2], C. Alvarez[3], T.D. Chiesa[4], N. Lewczuk[5], G. Piñeiro[6], G. Posse[7], L. Yahdjian[8], P. Grace[9], O. Machado Rodrigues Cabral[10], L. Martin-Neto[11], R. de Aragão Ribeiro Rodrigues[12], B. Amiro[13], D. Angers[14], X. Hao[15], M. Oelbermann[16], M. Tenuta[17], L.J. Munkholm[18], K. Regina[19], P. Cellier[20], F. Ehrhardt[21], G. Richard[22], R. Dechow[23], F. Agus[24], N. Widiarta[25], J. Spink[26], A. Berti[27], C. Grignani[28], M. Mazzoncini[29], R. Orsini[30], P.P. Roggero[31], G. Seddaiu[32], F. Tei[33], D. Ventrella[34], G. Vitali[35], A. Kishimoto-Mo[36], Y. Shirato[37], S. Sudo[38], J. Shin[39], L. Schipper[40], R. Savé[41], J. Leifeld[42], L. Spadavecchia[43], J. Yeluripati[44], S. Del Grosso[45], C. Rice[46] and J. Sawchik[47]

[1]USDA-ARS, P.O. Box 459, Mandan, ND, USA, +1-701-667-3079; [2]USDA-ARS, NCSU Campus Box 7620, Raleigh, NC, USA, +1-919-208-9344; [3]National Institute of Agricultural Technology, Manfredi, Córdoba, Argentina, +54-03572-493053; [4]IFEVA, Facultad de Agronomía, Universidad de Buenos Aires, CONICET, San Martin 4453, Buenos Aires, Argentina, +54-11-45248070; [5]National Institute of Agricultural Technology, Buenos Aires, Argentina, +54-11-46211684; [6]IFEVA, Facultad de Agronomía, Universidad de Buenos Aires, CONICET, San Martin 4453, Bienos Aires, Argentina, +54-11-45248070; [7]National Institute of Agricultural Technology, Buenos Aires, Argentina, +54-11-46210125; [8]IFEVA, Facultad de Agronomía, Universidad de Buenos Aires, CONICET, San Martin 4453, Buenos Aires, Argentina, +5411-45248070; [9]Queensland University of Technology, Brisbane, Queesland, Australia, +61-7-3138-9283; [10]Embrapa Environment, RODOVIA SP340 KM 127, 5, São Paulo, Brazil, +55-19- 33112685; [11]Embrapa Headquarters, Parque Estação Biológica - PqEB s/n, Brasília, Brazil, +55-61-3448-4347; [12]Embrapa Soils, Rua Jardim Botânico, 1024, Rio de Janeiro, Brazil, +55-21-21794601; [13]University of Manitoba, Winnipeg, Manitoba, Canada, +1-204-474-9876; [14]Agriculture and Agri-Food Canada, Québec, Québec, Canada, +1-418-210-5022; [15]Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada, +1-403-317-2279; [16]University of Waterloo, Waterloo, Ontario, Canada, +1-519-888-4567; [17]University of Manitoba, Department of Soil Science, Winnipeg, Manitoba, Canada, +1-204-474-7827; [18]Dept. of Agroecology, Aarhus University, Blichers Allé 20, Postboks 50, DK-8830 Tjele, Denmark, +45 8715-7727; [19]Natural Resources Institute Finland, Tietotie 4, FI-31600 Jokioinen, Finland, +358-50-3061676; [20]French National Institute for Agricultural Research (INRA), UMR1402 Ecosys, 78850 Thiverval-Grignon, France, +33-0-1-30-81-55-32; [21]French National Institute for Agricultural Research (INRA), Paris, France, +33-0-1-42-75-93-68; [22]French National Institute for Agricultural Research (INRA), Orléans, France, +33-0-2-38-41-78-41; [23]Thünen Institute of Climate-Smart Agriculture, Braunschweig, Germany, +49-531-5962665; [24]Indonesian Soil Research Institute, Jl. Tentara Pelajar No. 12, Cimanggu, Bogor 16114, Indonesia, +62-251-8336757; [25]Indonesian Center for Food Crop Research and Development, Jalan Merdeka 147, Bogor 16111, Indonesia, +62-251-8334089; [26]Oak Park Crops Research Centre, Teagasc, Oak Park, Carlow, Ireland, +353-0-599170250; [27]Dipartimento di Agronomia Animali Alimenti risorse Naturali e Ambiente (DAFNAE), Università di Padova, Agripolis, Viale dell'Università 16, 35020 Legnaro, Padova, Italy, +39-049-8272828; [28]Department of Agricultural, Forest and Food Sciences, University of Turin, Largo Braccini 2, 10095 Grugliasco (TO), Italy, +39-011-6708777; [29]Department of Agronomy and Agroecosystem Management (DAGA), University of Pisa, Via S. Michele degli Scalzi 2, 56100 Pisa, Italy, +39-050-2218936; [30]Dipartimento di Scienze Agrarie Alimentari e Ambientali, Università Politecnica delle Marche, via Brecce Bianche, 60131 Ancona, Italy, +39-071-2204157; [31]Nucleo di Ricerca sulla Desertificazione and Dipartimento di Agraria, Università di Sassari, viale Italia 39, 07100 Sassari, Italy, +39-079-229226; [32]Nucleo di Ricerca sulla Desertificazione and Dipartimento di Agraria, Università di Sassari, viale Italia 39, 07100 Sassari, Italy, +39-328-0431585; [33]Dept of Agricultural, Food and Environmental Sciences, University of Perugia, Borgo XX Giugno, 74, 06121 Perugia, Italy, +39-075-5856060; [34]Research Unit for Cropping Systems in Dry Environments (CRA-SCA), Via Celso Ulpiani 5, 70125 Bari, Italy, +39-080-5475011; [35]Dipartimento di Scienze agrarie, Alma Mater Studiorum, Università di Bologna, via Zamboni 33, 40126 Bologna, Italy, +39-055-2096644; [36]National Institute for Agro-Environmental Sciences, 3-1-3 Kannondai, Tsukuba 305-8604, Japan, +81-29-838-8194; [37]National Institute for Agro-Environmental Sciences, 3-1-3 Kannondai, Tsukuba 305-8604, Japan, +81-29-838-8235; [38]National Institute for Agro-Environmental Sciences, 3-1-3 Kannondai, Tsukuba 305-8604, Japan, +81-29-838-8330; [39]National Academy of Agricultural Science, Seoul, South Korea, None available; [40]Environmental Research Institute, University of Waikato, Private Bag 3105, Hamilton, 3240, New Zealand, +64-7-838-4468; [41]Institute of Agrifood Research and Technology (IRTA), Barcelona, Catalonia, Spain, +34-93-4674040 (ext. 1326); [42]Agroscope, Reckenholzstrasse 191, CH-8046, Zürich, Switzerland, +41-58-468-75-10; [43]Department for Environment, Food & Rural Affairs, Area 1B Nobel House, 17 Smith Square, London, United Kingdom, SW1P 3JR, +44-2072-384575; [44]The James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, Scotland, United Kingdom, +44-1224-395282; [45]USDA Agricultural Research Service, 2150 Centre Ave., Building D, Suite 100, Fort Collins, CO, USA, +1-970-492-7281; [46]Kansas State University, 2701 Throckmorton Ctr., Manhattan, KS, USA, +1-785-532-7217; [47]National Institute for Agricultural Research Uruguay, Montevideo, Uruguay, +598-2902-0550

ABSTRACT

Research networks provide a framework for review, synthesis and systematic testing of theories by multiple scientists across international borders critical for addressing global-scale issues. In 2012, a GHG research network referred to as MAGGnet (Managing Agricultural Greenhouse Gases Network) was established within the Croplands Research Group of the Global Research Alliance on Agricultural Greenhouse Gases (GRA). With involvement from 46 alliance member countries, MAGGnet seeks to provide a platform for the inventory and analysis of agricultural GHG mitigation research throughout the world. To date, metadata from 315 experimental studies in 20 countries have been compiled using a standardized spreadsheet. Most studies

KEYWORDS

Carbon sequestration; Global Research Alliance; Managing Agricultural Greenhouse Gases Network; Nitrous oxide

CONTACT M.A. Liebig mark.liebig@ars.usda.gov

Supplemental data for this article can be accessed http://dx.doi.org/10.1080/17583004.2016.1180586.

were completed (74%) and conducted within a 1−3-year duration (68%). Soil carbon and nitrous oxide emissions were measured in over 80% of the studies. Among plant variables, grain yield was assessed across studies most frequently (56%), followed by stover (35%) and root (9%) biomass. MAGGnet has contributed to modeling efforts and has spurred other research groups in the GRA to collect experimental site metadata using an adapted spreadsheet. With continued growth and investment, MAGGnet will leverage limited-resource investments by any one country to produce an inclusive, globally shared meta-database focused on the science of GHG mitigation.

GRA	Global Research Alliance
GRACEnet	Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network
MAGGnet	Managing Agricultural Greenhouse Gases Network

Introduction

Concurrent efforts to mitigate agricultural greenhouse gases (GHGs) while adapting production practices to projected hardships of climate change will be essential to ensure long-term sustainability and food security [1,2]. Mitigation research in agriculture should provide a mechanistic understanding of the underlying processes affecting natural resources, be scalable to provide useful predictions, and be translated in such a way that it effectively supports both adoption of best practices/systems and informed decision making for policies [3]. Although a significant number of research projects have been completed or are underway to understand how agriculture can mitigate GHG emissions, a coordinated effort is lacking to catalogue and synthesize disparate research efforts around the world.

In response to these challenges, the Global Research Alliance on Agricultural Greenhouse Gases (GRA) was formed in 2009 to develop trans-national strategies for reducing GHG intensity of agricultural production [4]. To facilitate focused efforts, the GRA established three research groups (Cropland, Livestock, Paddy Rice) and two cross-cutting teams (Soil Carbon−Nitrogen Modeling, Inventories-Monitoring). Each group and team developed work plans to enable successful collaborations, as well as to share knowledge and best practices, build capacity and capability among participants, and move towards transformative solutions to reduce agricultural GHG emissions ([5] GRA, 2016). Membership in the GRA is voluntary, and 46 countries have already become members of one or more GRA research groups and/or cross-cutting teams (verified May 10, 2016).

The organizational platform of the GRA facilitates the development of research networks. As reviewed by Baldocchi et al. [6], networks occupy a central role in GHG research. Broadly, GHG networks provide a forum for generating creative solutions to critical mitigation challenges using diverse perspectives. More specifically, data archives and management activities often serve as a key focus for GHG networks, given the complexity of the subject and the need to provide data for the development and testing of models. Modeling efforts and meta-analyses that use high-quality data archives from GHG networks provide critical information to predict GHG emissions from agricultural activities and inform policy decisions focused on mitigating emissions [7].

Here, a GHG research network formed under the auspices of the GRA Croplands Research Group is introduced. Referred to as the Managing Agricultural Greenhouse Gases Network (MAGGnet), the network represents a coordinated, multi-national effort that serves as a foundation for inventory and analysis of GHG mitigation research. Through this brief report, MAGGnet's development, metadata collection method, current status and recent applications are described.

Development and description

MAGGnet arose from member discussions during the GRA Croplands Research Group annual meeting in San Antonio, Texas, USA, October 20, 2011. A key action item identified during the meeting was the "development of an inventory database on long-term measurement experiments," which was distilled from a broader goal to create a global network of reputable GHG emission and soil C sequestration data from specific management practices for synthesis evaluations and model testing/validation across a diversity of environments [4]. Following discussions with Croplands Research Group co-chairs in late 2011, the action item was focused to compile key metadata from cropland experimental sites throughout the world where biomass yields, GHG flux and soil C dynamics were monitored. Experimental sites with a record of documented outcomes in peer-reviewed publications were targeted, a limitation intentionally imposed to increase the likelihood of compiling high-quality metadata.

Metadata from experimental sites were compiled using a Microsoft Excel spreadsheet (Microsoft Corp., Redmond, Washington, USA). Loosely patterned after a data entry template used by the Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network (GRACEnet) [8], 11 worksheet tabs were established to collect background information and experiment metadata. Within the spreadsheet, a

Table 1. Metadata input variables within worksheet tabs included in the Managing Agricultural Greenhouse Gases Network (MAGGnet) spreadsheet.

Worksheet tab	Input variables
Experiment description	Experiment keywords; brief description
Experiment location	Country; province/state; nearest city; latitude (decimal degrees); longitude (decimal degrees)
Experiment duration	Year experiment began; year experiment ended
Climate attributes	Mean annual precipitation (mm); mean annual temperature (°C)
Soil and drainage attributes	Soil taxonomic description; soil taxonomy system; surface soil texture; minimum water table depth (m)
Data type	Soil carbon; soil properties; CO_2 flux; CH_4 flux, N_2O flux; grain; stover; roots; other
Treatments	Treatment description; tillage type; fertilizer treatment; nitrogen rate (kg N ha^{-1}); synthetic N fertilizer type; manure/amendment type; crop rotation; cover crop; residue removal; burning; irrigation; other
Key findings	Key findings
Journal citations	Corresponding author last name; corresponding author first name; manuscript reference
Primary contact	Last name; first name; email address

User Guide/Directions worksheet served as the leftmost tab, and was followed by Experiment Description, Experiment Location, Experiment Duration, Climate Attributes, Soil and Drainage Attributes, Data Type, Treatments, Key Findings, Journal Citations and Primary Contact worksheet tabs (Table 1). To facilitate efficient metadata entry, general instructions provided within the User Guide/Directions worksheet tab were supplemented by strategically placed comment boxes throughout the spreadsheet for additional guidance. Input variables requiring Yes/No responses used drop-down menus, as did numerous variables within the Soil and Drainage Attributes and Treatments worksheet tabs.

A beta version of the MAGGnet spreadsheet was developed, pre-tested and revised in February 2012. Version 1.1 of the MAGGnet spreadsheet was released to GRA Croplands Research Group members in March 2012. Following the first round of metadata collection and comments from GRA members throughout 2012, version 1.2 of the MAGGnet spreadsheet was released in December 2012. Version 1.2 incorporated additional response categories and improved directions/guidance within most worksheet tabs. To address potential concerns dealing with intellectual property rights associated with sharing and using metadata from multiple countries, a metadata sharing agreement was developed in 2014 and posted on the GRA website (see Supplementary material).

Metadata synopsis

As of August 2015, there were 315 experimental studies included in MAGGnet (Table 2). Studies were distributed across 20 countries, with over 50% located in France, the United Kingdom and the United States (Figure 1). Studies were spread across 14 Köppen-Geiger climate subdivisions [9] on 11 surface soil textures (data not shown). Seventy-four percent of the studies were completed, with the balance ongoing. Most studies were 1−3 yr in duration (68%), while 17 and 15% of the studies were conducted over 3−10 yr and >10 yr, respectively (Table 2). Over 55% of the ongoing long-term studies were located in Italy, Switzerland and the United States.

Table 2. Number, current status and duration of studies included in the Managing Agricultural Greenhouse Gases Network (MAGGnet), December 2015.

		Status		Duration		
Country	**No. of studies**	**Completed**	**Ongoing**	**1−3 yr**	**3−10 yr**	**> 10 yr**
Argentina	10	4	6	8	1	1
Australia	16	16	0	16	0	0
Brazil	8	8	0	8	0	0
Canada	12	11	1	11	0	1
Costa Rica	1	1	0	1	0	0
Denmark	5	2	3	0	0	5
Finland	12	12	0	8	4	0
France	104	90	14	95	8	1
Germany	15	15	0	14	1	0
Indonesia	2	2	0	2	0	0
Ireland	7	7	0	2	5	0
Italy	19	0	19	1	4	14
Japan	9	4	5	2	2	5
Korea	1	0	1	0	1	0
New Zealand	2	1	1	1	1	0
Spain	12	3	9	3	9	0
Switzerland	10	6	4	0	3	7
United Kingdom	36	36	0	35	0	1
United States	30	15	15	6	15	9
Uruguay	4	0	4	1	0	3
Total	**315**	**233**	**82**	**214**	**54**	**47**

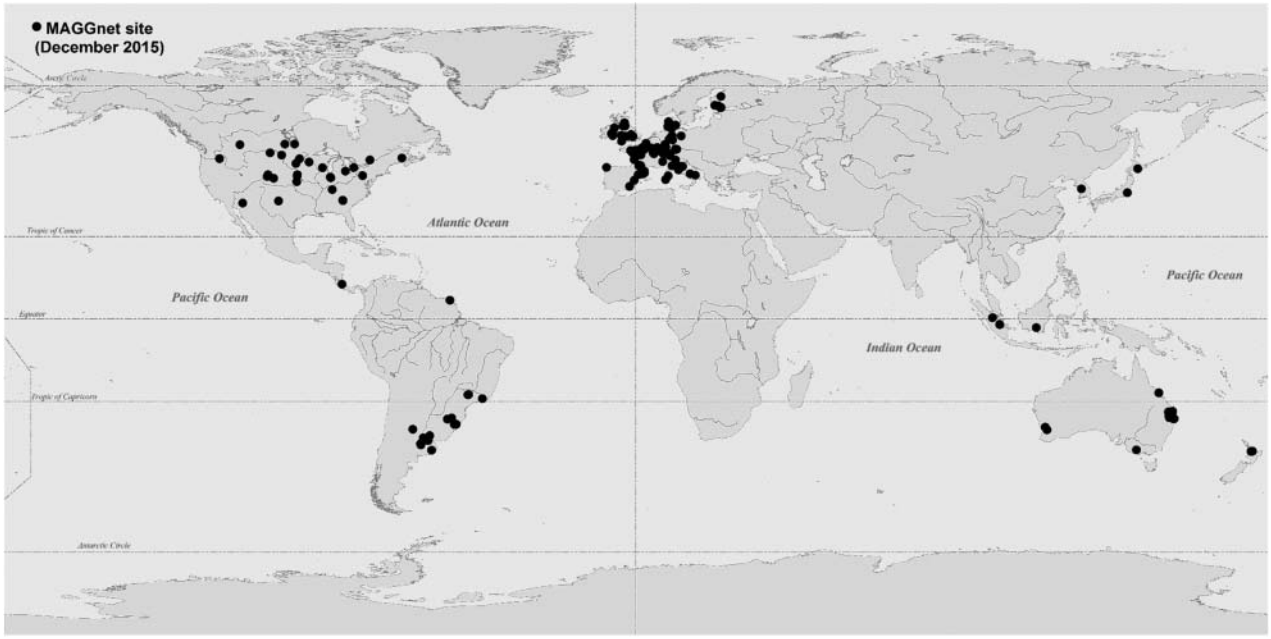

Figure 1. Global distribution of study sites included in Managing Agricultural Greenhouse Gases Network (MAGGnet), December 2015.

Soil carbon, an important metric for quantifying cropland GHG mitigation potential [1], was monitored in 83% of studies included in MAGGnet (Table 3). Among GHG flux measurements, nitrous oxide (N_2O) was measured most frequently across studies (82%), followed by carbon dioxide (CO_2; 45%) and methane (CH_4; 29%). Grain, stover and roots were assessed in 56, 35 and 9% of the studies. Treatments most commonly measured in MAGGnet included fertilizer rate, manure/soil amendment and tillage type, included in 68, 52 and 43 studies, respectively (Table 4). Emphasis on such management practices was unsurprising, as they corresponded to an overarching goal of generating recommendations to mitigate agricultural GHG emissions.

Despite the explicit cropland focus within MAGGnet, 29 sites included a pasture/grazing system (Table 4). Data submissions from this land use were encouraged given the clear engagement by researchers focused on grazed systems and the strong linkages between grazed lands and imported feed from cropland. Insights that emerge from concurrent analysis of cropland and grazing land management are likely to contribute to new integrated approaches for increased food production with lowered environmental impact [10].

Recent applications

Despite its recent emergence as a GHG network, MAGGnet has served to leverage limited resource investments within individual countries to produce an inclusive, shared meta-database for use by all GRA-member countries. While its potential as a functioning network has yet to be fully realized, MAGGnet occupies a unique niche among GHG networks given its geographical domain (global) and intended focus (cropland) [7]. With time and continued effort, MAGGnet can serve to further GHG mitigation science through new collaborations among contributing members.

Table 3. Percentage of studies included in the Managing Agricultural Greenhouse Gases Network (MAGGnet) measuring soil, gas flux and plant variables, December 2015.

Category/variable	Percentage of studies measuring variable (%)
Soil	
Soil carbon	83
Soil properties	82
Gas flux	
N_2O	82
CO_2	45
CH_4	29
Plant	
Grain	56
Stover	35
Roots	9

Table 4. Ten most common treatment components included in the Managing Agricultural Greenhouse Gases Network (MAGGnet), December 2015.

Treatment component	Number of studies assessing treatment component
Fertilizer rate	68
Manure/soil amendment	52
Tillage type	43
Fertilizer type	41
Crop rotation	38
Residue management/removal	36
Crop type	29
Pasture/grazing system	29
Agroecosystem monitoring	24
Cover crop	20

MAGGnet has contributed to modeling efforts since its inception, and has spurred other research groups in the GRA to collect experimental site metadata. MAGGnet was used in January 2014 to help identify experimental sites for potential inclusion in an international model intercomparison exercise coordinated by the GRA Soil Carbon–Nitrogen Modeling cross-cutting team [11]. This ambitious exercise, involving 28 models used in 11 countries, seeks to quantify prediction accuracy among models for estimates of crop yield, grassland dry-matter production, N_2O emission, net CO_2 exchange and soil C stocks. In other work, the Global Research Alliance Modeling Platform (GRAMP) was created to facilitate development, evaluation and adaptation of ecosystem models for estimating GHG emissions from agroecosystems [12]. GRAMP currently includes selected metadata derived from MAGGnet through an interactive map ([13] GRAMP, 2016). Finally, the MAGGnet spreadsheet was adapted by members of the GRA Paddy Rice Research Group in August 2014 to gather metadata from experiments focused on rice production. As of August 2015, metadata from 13 sites across five countries were included in the adapted spreadsheet, which included additional input metadata related to weather variables, field type, and water and rice management.

Open invitation

MAGGnet was initiated in the spirit of advancing GHG mitigation science through a multi-national research effort facilitated by the GRA. The value of MAGGnet to the scientific community will be directly proportional to its capacity to provide useful information for the analysis of GHG mitigation data. As currently organized, MAGGnet serves as a conduit for that purpose, with an explicit focus on metadata. We believe the focus on metadata was an appropriate "first step" to illustrate potential value. We envision the voluntary addition of key response data will provide even greater value to the scientific community as the "next step."

Information from additional studies continues to be entered into MAGGnet. Researchers interested in contributing or accessing metadata from experimental sites with published outcomes are encouraged to contact the corresponding author for the most recent versions of the MAGGnet spreadsheet and metadata sharing agreement. Alternatively, the spreadsheet and sharing agreement may be obtained through the GRA Croplands Research Group website (http://globalresearchalliance.org/maggnet).

Acknowledgments

We acknowledge Nicanor Saliendra for creating Figure 1, and Eva Magnuson for compiling author contact information. MAGGnet activities are partially supported by a Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI) with funding from the Italian Ministry of Agricultural, Food, and Forestry Policies, Swiss National Science Foundation, and USDA National Institute of Food and Agriculture (award numbers documented below).

The US Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability and, where applicable, sex, marital status, family status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program (not all prohibited bases apply to all programs). USDA is an equal-opportunity provider and employer. Mention of commercial products and organizations in this manuscript is solely to provide specific information. It does not constitute endorsement by USDA-ARS over other products and organizations not mentioned.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

U.S. Department of Agriculture National Institute of Food and Agriculture (2014-35615-21934), Swiss National Science Foundation (NRP 68, No. 40FA40_154244/1), and Italian Ministry of Agricultural Food and Forestry Policies (DM 25659/7303/2013).

ORCID

M. Oelbermann http://orcid.org/0000-0003-0996-4140

References

1. Lal R, Delgado JA, Groffman PM, Millar N, Dell C, Rotz A. Management to mitigate and adapt to climate change. *J. Soil Water Conserv.* 66(4), 276–285 (2011).
2. Steenwerth KL, Hodson AK, Bloom AJ, et al. Climate-smart agriculture global research agenda: scientific basis for action. *Agr. Food Secur.* 3(11), 1–39 (2014).
3. Walthall CL, Shafer SR, Jawson MD. GRACEnet: Addressing policy needs through coordinated cross-location research. In: *Managing Agricultural Greenhouse Gases: Coordinated Agricultural Research Through GRACEnet to Address Our Changing Climate*. Liebig MA, Franzluebbers AJ, Follett RF (Eds). Academic Press, San Diego, CA, 13–19 (2012).
4. Shafer SR, Walthall CL, Franzluebbers AJ, et al. Emergence of the Global Research Alliance on Agricultural Greenhouse Gases. *Carbon Manage.* 2(3), 209–214 (2011).
5. GRA, 2016. Global Research Alliance on Agricultural Greenhouse Gases. Available at http://globalresearchalliance.org/ (Accessed 10 May 2016).
6. Baldocchi D, Reichstein M, Papale D, et al. The role of trace gas flux networks in the biogeosciences. *Eos* 93(23), 217–218 (2012).
7. Baker JM, Follett RF. Potential GRACEnet linkages with other greenhouse gas and soil carbon research and monitoring programs. In *Managing Agricultural Greenhouse Gases: Coordinated Agricultural Research Through GRACEnet to Address Our Changing Climate*. Liebig MA,

Franzluebbers AJ, Follett RF (Eds). Academic Press, San Diego, CA, 457−466 (2012).
8. Del Grosso SJ, White JW, Wilson G, et al. Introducing the GRACEnet/REAP data contribution, discovery and retrieval system. *J. Environ. Qual.* 42, 1274−1280 (2013).
9. Kottek M, Grieser J, Beck C, Rudolf B, Rubel F. World map of the Köppen-Geiger climate classification updated. *Meteorol. Z.* 15(3), 259−263 (2006).
10. Lemaire G, Franzluebbers A, de F Carvalho PC, Dedieu B. Integrated crop-livestock systems: Strategies to achieve synergy between agricultural production and environmental quality. *Agr. Ecosyst. Environ.* 190, 4−8 (2014).
11. Ehrhardt F, Soussana J-F, Grace P, et al. 2015. An international inter-comparison and benchmarking of crop and pasture models simulating GHG emissions and carbon sequestration. *Climate-Smart Agriculture 2015: Global Science Conference*. CIRAD, Montpellier, France. Meeting abstract Available at: http://csa2015.cirad.fr/ (Accessed 16 December 2015).
12. Yeluripati JB, del Prado A, Sanz-Cobeña A, et al. Global Research Alliance Modelling Platform (GRAMP): An open web platform for modelling greenhouse gas emissions from agro-ecosystems. *Comput. Electron. Agr.* 111, 112−120 (2015).
13. GRAMP, 2016. Global Research Alliance Modeling Platform. Available at http://www.gramp.org.uk/ (Accessed 10 May 2016).