Global Research Alliance
Cross-Cutting Activity C-N Cycles

workshop (July 13-14, 2011)
KUL Leuven , SOM2011 conference

organized by Jean-François Soussana, Katja Klumpp, Sylvie Recous

Agenda

13 juillet 14h-19h

Welcome and Introduction. Jean-François Soussana (30 ‘)

Session 1 – State of the art

* International stock-take of models and data. Sylvie Recous (20')

* The SOM-Net intercomparison of models with data from long term experiments (J Yerupalti, 20’)

* *Recent inter-comparisons of C-N cycles models with flux data:*
Carbon cycle in arable systems (M Wattenbach) (20’)
Nitrogen cycle in arable systems (E Haas) (20’)

* *How to calibrate models and run models for testing mitigation options ?*
Bayesian calibration (J Yerupalti) (20’)
Initialising models (K. Klumpp)
- by a novel algebraic method (20’)
- with measured SOC using paired flux tower sites(20’)
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* *Data availability for modelling mitigation options in agriculture*
- Long term experiments with arable (T Kätterer) (20’)

Discussion
Which mitigation options should we test in priority with models?
Are these relevant to stakeholders needs?
What is feasible and what is not?
How can we test modelling of mitigation?

14 juillet 8h30-11h

Session 2 Sensitivity of models to mitigation options (3h30)

All models will be run for data from an arable flux site (F-Grignon) and from a grassland flux site (CH-Oensingen) with best data in Europe

RothC (J Yerupalti, Aberdeen U.)
DailyDayCent (J Yerupalti, Aberdeen U.)

Mobile DNDC (E Haas, Munich)
PASIM (K Klumpp and R Lardy, INRA, Clermont)
ECOSSE (J Yerupalti, Aberdeen U.)

Sensitivity to nitrogen (reduced N is mitigation)

1° N20 sensitivity vs. N application: Ammonitrate, nitrification inhibitors (reduce nitrification potential by 30 %), addition of pig Slurry

2° SOC stock sensitivity vs. N application
Same as above. How will N application affect C stock ?

3° CO2 equivalents vs. N application
Same as above. How will the CO2 equivalents from N2O and CO2 fluxes vary?

Sensitivity to disturbance (reduced disturbance is mitigation)

For Cropland : shift sowing and harvest date by 2 and 4 weeks earlier and later, and extend growing season by 2 and 4 weeks
For Grassland test, 2, 4, 6 cut yr-1

Discussion on future modelling protocols

Which protocols for model intercomparison?
How to organise participation of modellers from GRA?
Which core data for testing models?

Conclusions

(JF Soussana, S Recous)

Synthesis of the GRA C-N cross-cutting meeting in Leuven (July 2011)

Thirty participants from 16 countries attended the CN workshop in Leuven (as a side event of the SOM2011 meeting hosted by KU Leuven).

The agenda of the 1.5 day meeting, involved:
- an introduction by JF Soussana
- a summary of the stock take regarding CN models and data basis presented by S. Recous
- a series of presentations based on a pilot modeling exercise organized by K. Klump (INRA).

The session focused on methodology for modeling GHG emissions and C sequestration and evaluation of some models for their ability to take into account mitigation options. The presentations were thought as part of a "pilot" exercise to figure out (i) what should be protocols for evaluating the ability of models to simulate impacts of mitigation options, and (ii) what situations/agricultural practices/characteristics of the data sets should be chosen, relevant for the countries and research groups involved in the GRA.
- two additional contributions were given (i) on long-term soil data available (Pr. T. Kätterer from SLU, Sweden) and (ii) GHG calculator tools used by farmers and/or stakeholders in the US (Pr. Keith Paustian, Colorado State University).

A large part of the seminar was dedicated to discussions between the participants. The discussion was led by JF Soussana.

1. **Stock take of data and models**

The presentation are given in the attached files. It was emphasized that it is important to complete the survey of available models and data, and important to better emphasize the farm scale. The concern is how to contact easily scientists from the different countries (apart of those already involved in the two first meetings). It seems important to get a reference person from each country for the activity, and also for the scientist concerned to register on the web site of the GRA.

2. **modeling pilot exercise** (the detailed presentations are not provided as the results are unpublished) :

* The SOM-Net intercomparison of models with data from long term experiments (**J Yerupalti**)
* Recent inter-comparisons of C-N cycles models with flux data:
    - Carbon cycle in arable systems (**M Wattenbach**)
    - Nitrogen cycle in arable systems (**E Haas**)
* How to calibrate models and run models for testing mitigation options ?
    - Bayesian calibration (**J Yerupalti**)
    - Initialising models (**K. Klumpp**) by a novel algebraic method; with measured SOC using paired flux tower sites.

Model inter-comparison to determine sensitivity of N2O emission factor, soil organic carbon, GHG emissions (N2O, CO2 in CO2eq) to N fertilisation and disturbance, respectively. Used models were:

- PaSim (pasture simulation mode)l is a process-based biogeochemical model (H2O, C and N cycles) to simulated soil-vegetation-animal-atmosphere in short and long term simulations.
- DNDC (i.e., DeNitrification-DeComposition) It is a process-oriented simulation model to simulate the soil biogeochemical processes in agro-ecosystems (i.e denitrification, litter decomposition and plant growth)
- ECOSSE, Model to Estimate Carbon in Organic Soils – Sequestration and Emissions
- DayCent, Daily version of Century

Models were applied to a grassland (CH-Oensingen) and cropland (F-Grignon) site of the Carbo-/NitroEurop Project. A common protocol was applied for all models:
-models were set to equilibrium by spin-up runs.

-test of sensitivity to N application was done by applying 0, 50, 10, 200, 300 kg N ha-1yr-1 of NH4NO3 at fertilisation dates as done at the study site.
- test of sensitivity to disturbance the grassland site was cut 2, 4, 6 times per year.

Open questions were :
-Does EF increas linear with amount of N-applied?
- I-s EF different from IPCC
-Does amount of fertiliser have an effect on SOC and GWP

The Modeling pilot exercise suggested strong inter-annual variation in emission coefficients, clear response of GHG to increasing N applications, not working with nitrification inhibitors. However models outcome were contradictory, indicating the different ecosystem models do not behave the same with respect to N application. However, DNDC and PaSim model came up with comparable results, showing that EF increases linearly with amount of N applied. Furthermore, model outputs suggested that Soil Organic C and N fertilization were related positively, having a mean slope of about 0.8-1 kg C kg-1 applied fertilizer N .

The discussion raised the following issues:

i. Have to decide what complexity we search for our models according to stake holders requirements ?. (e.g. describe soil C change over 10 years under a specific management)
ii. How to apply model at regional scale to evaluate, for example, the impact of a reduction of fertilization. The main problem at the regional scale, is getting the data and right parameters at this scale. For example, In the NitroEurope project, it took very long to get the data for running the model. To address uncertainty, there is no solution at the moment.
iii. What are the key options for mitigation, what is feasible for the modelers ? We are not limited only by the choice of models or of the data, but also how to initialize the models ?.
    - major for N20 emissions: annual rate of mineral and organic fertilizers
    - minor: fertilizer types, application timing
    - annual time scale is more important than time dynamics.
    - soil C: annual rate of converting from grassland to annual crops should be taken into account.

3. Other contributions

T. Kätterer (SLU, Sweden) showed how long-term field experiments are valuable for quantifying changes in soil C and N stocks due to different agricultural management practices. A global database of these experiments is suggested as one priority activity for GRA. This database could be used for testing long-term simulations using soil or ecosystem models and could serve as a complement to flux measurement networks. This view has been discussed and supported by the GRA Croplands group at their recent meeting in Versailles. As an example, an overview and some highlights from Swedish long-term agricultural field experiments focusing on tillage intensity, crop rotations, residue handling, fertilization and organic amendments, was presented. Especially, interactions between N, P and C were emphasized. Crop responses to N fertilizer were shown to be dependent on PK fertilization. Other interesting findings reported from these experiments were that roots contribute more to soil carbon than corresponding amounts of above-ground residues and that 1 kg C is sequestered in topsoil for each kg of N added as fertilizer. It was also concluded that management effects on subsoil C are not negligible. Long-term field experiments are not fully exploited for testing models aiming at quantifying GHG mitigation options.

K. Paustian (Colorado University, US) exhibited results of quantification approaches performed at the farm scale (Practice-based methods using models). Can we ensure that agriculture GHG reductions/removals are ‘real’ and that mitigation practices can maintain or enhance

environmental quality? According to this contribution, the attributes for an acceptable quantification system are:

- Acceptable accuracy & precision, known uncertainty
- Applicable at regional/country/global scales, but locally-specific (i.e., farm/project scale)
- Flexible – incorporates multiple management options
- Considers all significant sources and sinks (full GHG accounting)
- Cost-effective
- Consistent across spatial scales – i.e., sum of 'project-scale' activities should be consistent with national-level reporting

The presentation showed the rapid increase in quantification tools available (COMET-VR, COOL FARM TOOL), and their test against a number on factors: Impact of different soil types, Impact of land management history, Impact of land use history. The contribution emphasized the question of how detailed modeling is necessary and can be incorporated in tools ? the need for work at farm scale, in addition to other work, seems to be particularly necessary for cross cutting activity

Tracks for the future

- how to considerer "disturbance " (like through number of cuts). The problem is that we have to modify many parameters to simulate disturbance (like date of harvest etc.). Require a strong agronomy background to change multiple cropping practices in a consistent way.
- the future protocole for simulation should compare cover crop vs. non cover crops. irrigation, etc... that are important options for management.
- need to consider both short term and long term balances (important for mitigation options).
- use also a site with arable monoculture

The set of models should include simple models available for a larger range of scientists from the different countries together with a limited set of "ecosystem" models more complex, used by specialists only.
The data available should be determined.

The next meeting of the CN cross cutting activity could be in **Bari, Italy during EUROSOIL (**2-5 july 2012).

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ON AGRICULTURAL GREENHOUSE GASES

Enhancing cooperation in agricultural greenhouse gas research

Structure, Vision and Work plans for Research Groups and Cross-cutting Groups

www.globalresearchalliance.org

36 Member Countries

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The Netherlands
New Zealand
Norway
Peru
The Philippines
Republic of Korea
Spain
Sweden
Switzerland
United Kingdom
United States of America
Uruguay
Vietnam

Rome
Ministerial Summit, June 2011

Cross-cutting Groups

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Concert io

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Paddy R s Group

Inventory and Measurement

Soil Carbon and Nitrogen Cycling

The Journey So Far

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Emergence of the Global Research Alliance on Agricultural Greenhouse Gases

Carbon Management (2011) 2(3), 209–214

"Member countries of the Alliance recognize opportunities to reduce GHG emissions and sequester carbon in soil by improving the efficiency and productivity of agricultural systems through robust ecologically based management practices and technologies, as well as developing novel approaches."

Steven R Shafer, Charles L Walthall, Alan J Franzluebbers[†] *et al.*

Group Group Group Group

Our Collective Vision

GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES

- **Increase agriculture production with lower emissions**
  Feeding the world within the carrying capacity of earth
- **Improve global cooperation in research & technology**
  Accelerate/strengthen knowledge and technology development that would not happen without the Alliance
- **Work with farmers and partners, provide knowledge**
  Develop relevant mitigation options and strengthen productivity and resilience of food systems

Livestock Research Group

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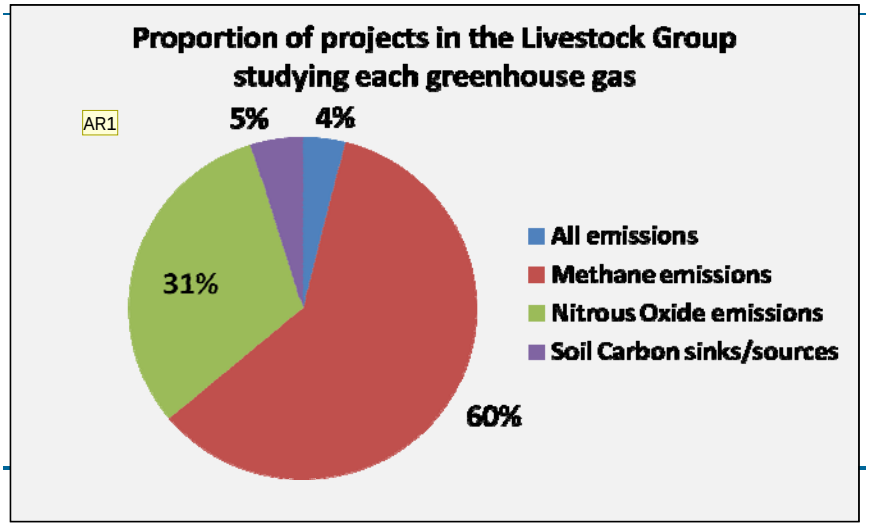

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AR1 check with Laura
Andy Reisinger; 09/06/2011

Croplands Group

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- **Coordinators**
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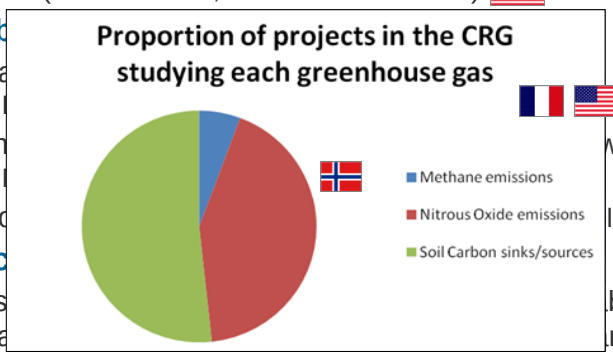

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Paddy Rice – Goals & Benefits

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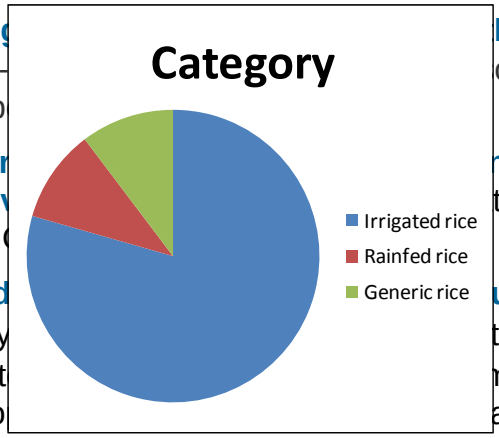

Inventories and Measurement Cross-Cutting Group

(CANADA / NETHERLANDS)

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Concentrate on addressing issues that affect and benefit more than one Research Group

- Complement and support the Research Groups
- Further consistent methodological approaches

Information, knowledge, and data sharing

- Inventory methods, common priorities for collaboration
- Improve quantification of emissions and mitigation actions
- Workshop, late 2011 in Canada (proposed)

Guidelines for measurements

- Improve comparability, coherence, quality, verifiability

Soil Carbon-Nitrogen Cycles Cross-Cutting Group

(FRANCE / AUSTRALIA)

(JF Soussana, B Slattery)

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- Improved methodologies and models for mitigation
  - Define common objectives across Research Groups
  - Build a common modelling platform from multiple models
  - Build collective expertise on applicability of models, uncertainty and range of mitigation options
- Workshops and activities to advance these goals:
  - First workshop (Orléans, March 3, 2011): stock-take of C-N models and datasets
  - Second workshop (Leuven, July 2011): model-data intercomparison, including hands-on training

C-N cycle cross-cutting Model intercomparison

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- Intercomparing and benchmarking carbon and nitrogen cycle models
- Data bases on carbon and nitrogen cycles in agriculture, including greenhouse gas fluxes
- Two workshops to be organised:
  - To define scientific protocols for experiments, measurements and data bases;
  - To analyse results, intercompare models and draft papers

C-N cycle workshop Orléans (March 3, 2011)

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- 86 participants
- 27 participating countries
- 12 countries with potential contribution to data/models

Orléans workshop March 2011

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Keynote: Modelling agricultural GHG emissions and removals, Pete Smith

Building a common set of objectives and work topics (Chair: Denis Angers)
Reports from the Research Groups

Planning for joint modelling activities on C and N cycles (Chair: Peter Kuikman)
Model stock-take (Sylvie Recous)

Lunch, Visit of Orleans Centre

Planning for joint data activities on C and N cycles (Chair: Bill Slattery)
Data stock-take (Sylvain Pellerin)

Conclusions (Jean-François Soussana)

Key questions

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- Applicability of C-N cycle models across regions/systems
- Robustness, uncertainties
- Initialisation, parametrisation
- Ability to simulate mitigation options

C-N cycles model intercomparison

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- **C-N cycle model intercomparison for core sites in major systems (crop, rice, livestock) and regions**
- **Sensitivity tests of emissions/ removals to:**
  - **soil (e.g. texture) and climate (T, P) drivers**
  - **management (compare with e.g. emission factors)**

Model intercomparison for mitigation

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- **Define major mitigation options for systems/regions**
- **Are mitigation options simulated by models?**
  - **No (why?)**
  - **Yes, intercompare across models, benchmark with experimental data**

C-N cycle cross-cutting Short-term

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Stakeholders
HOW TO:
Test mitigation options?
Detection?
Side-effects?
Verifiable?
To link with inventories?

Cooperate ↔

Scientists
Compare and combine:

DATA	MODELS
Representative?	Ensemble
Which GHGs?	Sensitivity
Ancillary data?	Uncertainty
Duration?	Detection

A note on needs from stakeholders

A pilot model –data intercomparison

Framework C-N cycle cross-cutting Long-term

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Research groups Stakeholders ↔

Testing mitigation in mixed systems ↔

Tools for stakeholders

Capacity building

Platform
Ensemble of models that can be combined
- Applicability
- Uncertainty
- Mitigation options range

C-N cycle cross-cutting

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Thank you!

C-N cycling. Pilot sensitivity study design.

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Step 1. Benchmark an ensemble of models at GHG/ soil C measurement sites

Step 2. Analyse the sensitivity of the model ensemble to simple and widespread mitigation options at these sites

Step 3. Prepare a multisite database showing impacts of mitigation options according to both experiments and models

C-N cycling. Pilot sensitivity study design.

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Step 1. Benchmark an ensemble of models at GHG/ soil C measurement sites

Which sites?

Flux sites or long term experiments
Including management/mitigation options
=> Two pilot flux sites:
Grignon(F), arable
Oensingen (CH), grassland

How to apply models?

Bayesian calibration? No (or already done)
Initialisation? Spin-up runs (current management)

C-N cycling. Pilot sensitivity study design.

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Step 1. Benchmark an ensemble of models at GHG/ soil C measurement sites

Arable models:

Ceres EGC, DayCent, DNDC, mobileDNDC, ECOSSE, RothC

Grassland models:

DayCent, DNDC, mobileDNDC, ECOSSE, PASIM, RothC

Germany:	*E. Haas and Klaus Butterbach-Bahl*
France:	*K. Klumpp, R. Lardy, Jean-Francois Soussana*
	P. Cellier, Benoit Gabrielle
UK-Scotland:	*J. Yerupalti, Pete Smith*
	...Scotland and Germany: M. Wattenbach

C-N cycling. Pilot sensitivity study design.

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Step 2. Analyse sensitivity of models ensemble to simple and widespread mitigation options at these sites

Mitigation options:

N: reduce (mineral) N supply, reduce nitrification (inhibitors)

C: reduce disturbance of primary productivity

Arable: longer growth cycle

Grassland: longer regrowth periods

GHG fluxes: N_2O (and CH_4 ?) emissions, SOC stock change,
=> GHG balance in CO_2 equivalents

Production, yield

=> GHG balance per unit production

C-N cycling. Pilot sensitivity study design

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Nitrogen

Mineral N: 0, 50, 100, 200, 300 kg N ha^{-1} yr^{-1}

Nitrification inhibitors (-30 % nitrification potential)

Farmyard manure (or pig slurry) (to be tested)

C-N cycling.
Pilot sensitivity study design

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Carbon

Arable: extend growing season by 2 and 4 weeks
(sowing and harvest dates)
Cover crops, no-till? To be tested later

Grasslands: cutting frequency (2, 4, 6 cuts yr^{-1})
Grazing frequency or intensity, to be tested later

C-N cycle cross-cutting Model intercomparison

GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES

- Intercomparing and benchmarking carbon and nitrogen cycle models
- Data bases on carbon and nitrogen cycles in agriculture, including greenhouse gas fluxes
- Two workshops to be organised:
  - To define scientific protocols for experiments, measurements and data bases;
  - To analyse results, intercompare models and draft papers

CN workshop Leuven, July 2011
Discussion: results of simulation

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- N_2O: Annual rates -> mineral, organic fertilizers
  - Minor: fertilizer types, application timing
- Soil C: land use change…
  - Select options from IPCC, Smith et al. ….Distribute survey to know which options can be performed by models?
- Are basic processes in models representing management?
  - Eg tillage, discretize by depth carbon distribution and decomposition;
  - some N fertilizers are not well described (e.g. urea…)
  - Very different managements in some regions (burning etc…)
- Annual time scale is more important than time dynamics
  - Soil C, strong interannual variability
  - Interaction between mitigation options and interannual variability. Needed.

CN workshop Leuven, July 2011
Discussion: results of simulation

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- Detectable effect of mitigation?
  - How sensitive are they for climate? (including increased climatic variability)
  - They should not lead to increased GHGs (calculate risk of failure with climate variability, eg in temperature)
- **Novel options**
  - Short rotation coppices, bioenergy crops, organic farming…
- **Explore 'management space'** by changing site based practices to reduce net GHGs
  - While preserving yields… GHGs per unit grain/forage product
- **Initial objectives**: do not include indirect land use change, lifecycle, economics (e.g. costs of cover crops, of nitrification inhibitors)
- **Outputs**: Need to simulate consequences of policies (e.g. linked to water directives, air pollution…).

CN workshop Leuven, July 2011
Discussion: results of simulation

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- Rice systems ?
  - Test mitigation options, differences in soil C (eg modified RothC): eg water management
- Manure management ?:
  - is also a target for a link between arable and livestock =>Test mitigation from manure spreading
  - Manure is treated differently in different models
  - If manure is already present in the situation simulated, increase the range of application
  - C from manure will also play a role (humification coefficient) not only N
- Need also sites with arable monoculture

CN workshop Leuven, July 2011
Discussion: results of simulation

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About the simulations run :

- Use cover crops rather than change in duration of crop cycle
- We look at first years only (changes in SOC will level off): we need also long term for deriving carbon factors
- Some models have a ceiling yield so increased N makes no difference
- Slope 1 kgC/kg N is realistic for long term (Sweden)
- Use also a site with arable monoculture
- Include no till as an option. It is poorly described quite often.

CN workshop Leuven, July 2011
Discussion: results of simulation

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- Systematic differences across models in e.g. emission factors, carbon sequestration?
- What is the relative weight of climatic variability vs. Management? And the interaction?
- Are they systems/options that result in larger(smaller) emission from some models?
- Higher N_2O emission factor from organic N compared to mineral N?

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Discussion: decisions for future work

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- **To do: simulations including options:**
  - Cover crops in the rotations
  - Application of Manure N
  - Situation with arable monoculture
- **Circulate draft protocols that will need revision/improvements**
- **Should we include also simple models**? or should we use a limited set of ecosystem models shared between scientists and applied to a large range of situations ? Will the model specialists do the modelling only?
- **Which Data? :** Do we need meta-analysis of data? e.g. N_2O vs N (but site specific)

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Discussion

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1. Revise protocols for model sensitivity
2. Finalise the first results presented today (possible paper)
3. Extended sensitivity runs with more sites/models (include e.g. rice and other grassland types)

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Discussion

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- Circulate stock take (data and models)
  - Meta data
  - IP rights
- Building a data base?
  - Which purpose? How? Redundant with GRA groups activity ? (provide links on the portal)
  - For model benchmarks

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Discussion

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- Tri society meeting, San Antonio, October 16-19, USA
  - Cropland GRA group: October 20 (Tuesday)
  - Apply models for a few flux sites or long term experiments (GraceNet) in US, Canada…
- EUROSOIL
  - July 2012, Italy present results in a GRA cross-cutting session ?
- Tasmania Joint session

Participants to the GRA C-N meeting in Leuven , 13-14 july 2011.

List of Participants

Family name	First Name	country	Institution	Adress	Adress (2)	email
ALMAGRO	Marta	Spain	Spanish research council		CEBAS-CSIC	mbonmati@cebas.csic.es
ALVARO-FUENTES	Jorge	Spain	Spanish research council	Dpt Soil and water		JORGEAF@eead.csic.es
ANGERS	Denis	Canada	Agriculture Canada	Quebec		denis.angers@agr.gc.ca
BEARE	Mike	New Zealand	Plant Food Research	Christchurch	soil water and e	mike.beare@plantandfood.co.nz
CHABBI	Abad	France	INRA	Lusignan	BioemCo	abad.chabbi@lusignan.inra.fr
CHATSKIKH	Dmitri	Belgium	UCL Louvain,	Earth life institute		dmitry@shatskikh@uclouvain.be
DE CLERCQ	Tim	Belgium	Bodem hurdige Dienst von België			tdeclercq@bdb.be
DODD	Mike	New Zealand	AgResearch Ltd			mike.dodd@agresearch.co.nz
HAAS	Edwin	Germany	Karlsruhe Institute of Technology	Garmish-Partenkirchen		edwin.haas@kit.edu
KÄTTERER	Thomas	Sweden	SLU	Uppsala		thomas.katterer@slu.se
KELLER	Armin	Switzerland	ART Agroscope	Zürich		armin.keller@art.admin.ch
KHALIL	Ibrahim	Ireland	Environmental Protection Agency		wexford	i.khalil@epa.ie
KLUMPP	Katja	France	Inra	Clermont-Ferrand		katja.klumpp@clermont.inra.fr
LASHERMES	Gwenaëlle	France	Inra	Reims		gwenaelle.lashermes@reims.inra.fr
MOREL	Christian	France	Inra	UMR TCEM Bordeaux		morel@bordeaux.inra.fr
PAUSTIAN	Keith	USA	Colorado State University	Dpt Soil and Cro	Fort Collins	keithp@nrel.colostate.edu
RASSE	Daniel	Norway	Norwegian Inst. Agricultural adn environmental sciencs			daniel.rasse@bioforsk.no
RECOUS	Sylvie	France	Inra	Reims		sylvie.recous@reims.inra.fr
REGINA	Kristiina	Finland	MTT Agrifood Research Finland			kristiina.regina@mtt.fi
ROELANDT	Caroline	Norway	Bergen University	Geophysical Institute		caroline.roelandt@gfi.uib.no
SENAPATI	Nimai	Australia	University of New England	NSW	School of Rural	nsenapat@une.edu.au
SHARP	Joanna	New Zealand	Plant Food Research	Christchurch	System Modellir	joanna.sharp@plantandfood.co.nz
SHIRATO	Yasuhito	Japan	National Institute for agro-environemental sciences			yshirato@affrc.go.jp
SINGH	Bharat	USA	Fort Valley State University	Fort Valley		singhb@fvsu.edu
SOUSSANA	Jean-François	France	Inra	Paris		
VAN DE VREKEN	Philippe	Belgium	KULEUVEN	Dpt of Earth anc	Leuven	philippe.vandevreken@ees.kuleuven.
VIAUD	Valérie	France	Inra	Rennes	UMR SAS	valerie.viaud@rennes.inra.fr
VILLADA	Antia	England	Forest research	Reading		a.villada@pgr.reading.ac.uk
WATTENBACH	Martin	Germany	GEZ Postdam			m.wattenbach@abdn.ac.uk
YELURIPATI	Jagaseesh	Scotland / UK	University of Aberdeen			j.yeluripati@abdn.ac.uk