GLOBAL RESEARCH ALLIANCE
ON AGRICULTURAL GREENHOUSE GASES

IRG Annual meeting

Field scale Network

4-5 February 2019
Cali

Pete Smith, Jean-François Soussana - Network leaders
(Fiona Ehrhardt – Scientific officer)

UNIVERSITY OF ABERDEEN

INRA SCIENCE & IMPACT

Field scale network

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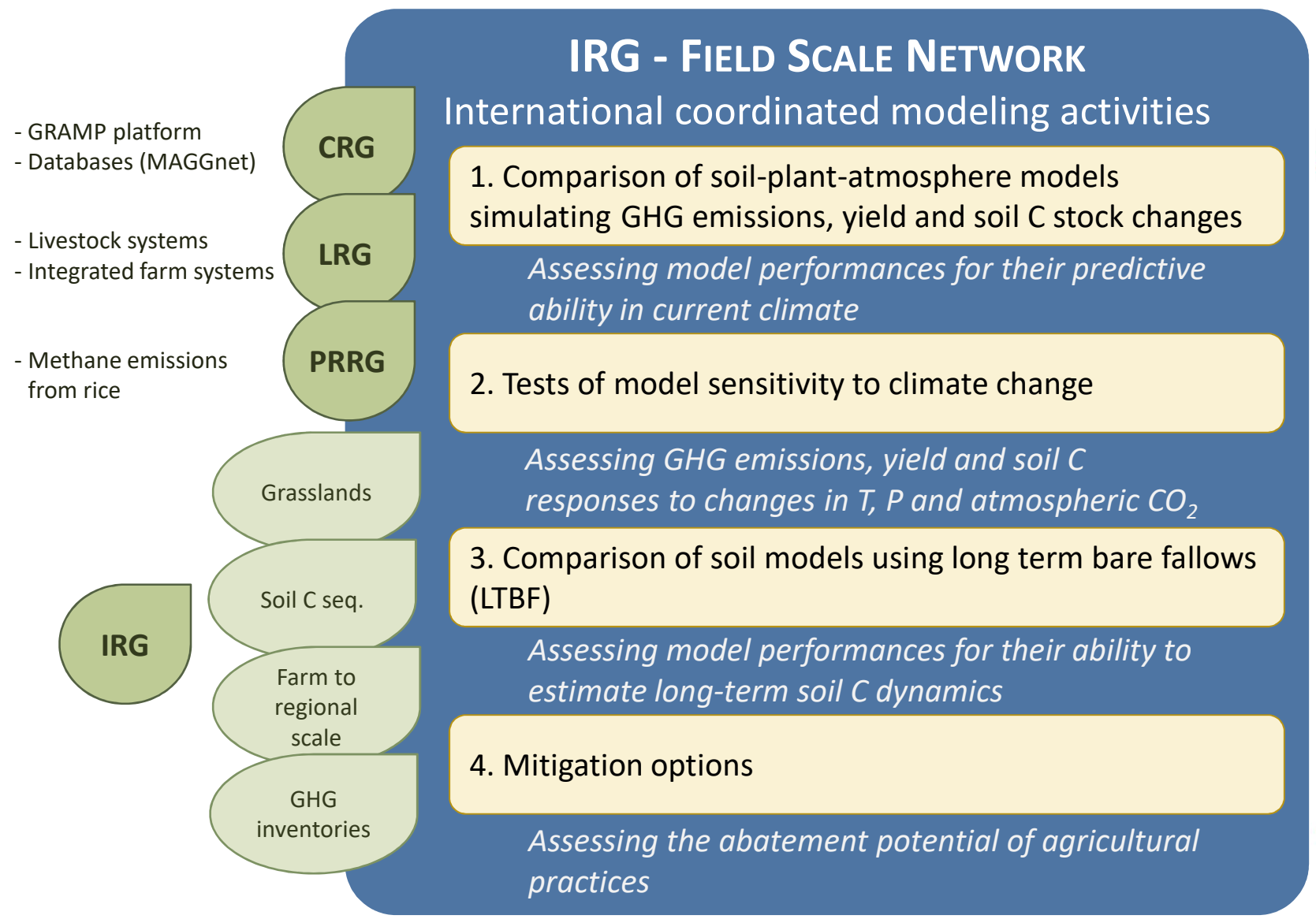
Objective: *Assessing (ensembles of)* ***coupled C-N models*** *able to simulate* ***plant-soil-atmosphere interactions*** *for their applicability and performances at* ***field scale*** *in the estimation of* ***GHG emissions, yield and soil C stock changes*** *in current and future climate for* ***arable crops*** *(rotations),* ***pastures*** *and* ***mixed systems*** *(to be planned)*

- Integration of data from reference sites and simulation models
- Integration of knowledge and development of modeling & robust assessment tools
- Assessment of mitigation and adaptation options

Network leaders: P Smith (UK) & JF Soussana (FR)
Scientific officer: F Ehrhardt (FR)

International cooperation through actions initiated under the *Soil C&N cycling* cross-cutting group of GRA

Interconnections across activities and programs



GRA RESEARCH GROUPS & IRG Networks

ACTIVITIES

PARTNERS

Why such studies?

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- Assessing model applicability worldwide
- Improving models
- Testing model ensembles vs. individual models
- Provide robust estimates from a small number of models for a given variable? Or, from fully calibrated individual models?
- Fostering the modeling community to simulate and improve estimations for GHG emissions & soil C sequestration
- Cooperation at the international scale
- Comparing with actual prediction methods (e.g. IPCC methods) and improving inventories

link to IRG Networks

Grassl ands

Farm to regiona l scale

GHG invento ries

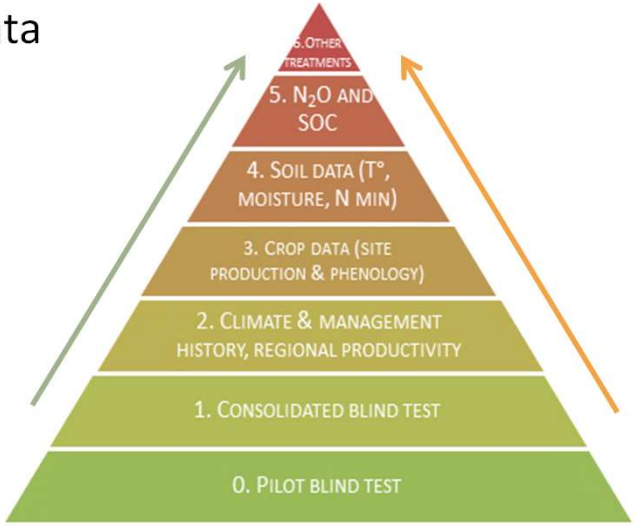
1. Model intercomparison for GHG emissions, yield & Soil C stocks estimations

Activity initiated under the *Soil C&N cycling* cross-cutting group of GRA

- **> 50 scientists**: modelers, site data providers, statisticians
- **24 models from 11 countries ; 10 contrasted sites** from 9 countries /4 continents : 5 grassland sites & 5 arable crop sites in rotation
- **Multi-step approach**, blind procedure, gradual calibration

→ Testing model performances against experimental data

→ Defining reduced model ensembles



- **Added value**:
  - Contrasted pedo-climatic conditions
  - Integrated models (C & N cycles, soil-plant-atm system)
  - Continuous simulations (no re-initialization each season/year)
  - Crop rotations
  - Comparison of multiple variables
- **Highlights:**
  - Grain yield: phenology data are key information for accurate estimates
  - Grasslands ANPP: data and model limitations for accurate estimates
  - N_2O emissions: plausible estimates from stage 1 with regard to range of observations
- Upscaling model estimates: to be tested by use of global databases

GHG model intercomparison - Final

Paris, Oct. 27, 2017

Fiona Ehrhardt *et al*.

fiona.ehrhardt@inra.fr

Global Change Biology

Assessing uncertainties in crop and pasture ensemble model simulations of productivity and N2O emissions.

DOI:10.1111/gcb.13965

Publication status

Article accepted on 10 October, 2017

Take home messages

- Grain yields: Significant improvement with phenology data (stage 3)
- Grasslands ANPP : poorly predicted due to data and model limitations
  - Data: methods of measurements (cutting heights, sampling frequencies, nb of replicates)
  - Models: effect of spatial heterogeneity on prod (vegetation, trampling, dung/urine patches) ; calibration methods in response to grazing offtake; above-ground compartments considered
- N_2O: good models performances with minimum data (stage 1)
- Reduced model ensemble:
  - Wheat, maize (grain yield and N_2O): as good as full ensemble
  - Rice (grain yield and N_2O), grasslands (ANPP): better than full ensemble
- Emissions intensities: significant rank correlation between sim. and obs. across sites, crops and stages

Published papers

2018
The use of biogeochemical models to evaluate mitigation of greenhouse gas emissions from managed grasslandsR Sándor, F Ehrhardt, L Brilli, M Carozzi, S Recous, P Smith, V Snow, ...
Science of The Total Environment 642, 292-306

Assessing uncertainties in crop and pasture ensemble model simulations of productivity and N_2O emissionsF Ehrhardt, JF Soussana, G Bellocchi, P Grace, R McAuliffe, S Recous, ...
Global change biology 24 (2), e603-e616

2017
Review and analysis of strengths and weaknesses of agro-ecosystem models for simulating C and N fluxesL Brilli, L Bechini, M Bindi, M Carozzi, D Cavalli, R Conant, CD Dorich, ...
Science of the Total Environment 598, 445-470

Symposia

C-MIP: an international model inter-comparison simulating organic carbon dynamics in bare fallow soilsR Farina, F Ehrhardt, G Bellocchi, C Chenu, JF Soussana, M Abdalla, ...
6th International Symposium on Soil Organic Matter, np

A multi-model assessment of C cycling and soil C sequestration in grasslands and croplandsR Sandor, F Ehrhardt, B Basso, G Bellocchi, A Bhatia, L Brilli, ...
6th International Symposium on Soil Organic Matter; Harpenden (Royaume Uni), 2

2. Sensitivity of GHG emissions, yield and soil C stock changes to climate change

Grassl ands

Soil C seq.

Farm to regional scale

link to IRG Networks

Pilot test performed within AgMIP for temperate grasslands

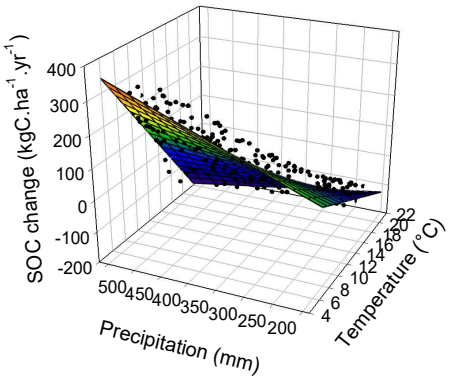
- **16 temperate grasslands from 7 countries** over 3 continents
- **10 models:** 7 site-calibrated models, 3 global ecosystem models ;
- Using **99 scenarios** defined **by {Temperature, Precipitation, CO_2} changes** on historical data;

→ Defining main trends in the responses of GHG emissions, soil C and yields to T, P and C changes

→ Simplified statistical tools (emulators)

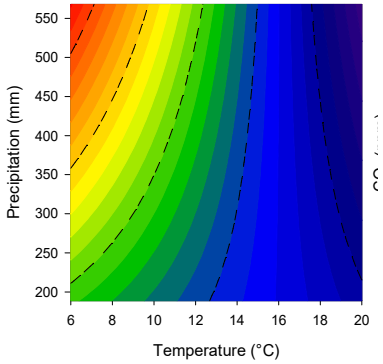
→ Local, regional and global scales

→ Extension of the exercise to 24 calibrated models on 10 sites (5 grasslands and 5 crop rotations)



$$Y(CO_2,T,P) = a + b(T) + c(T)^2 + d(P) + e(P)^2 + f(CO_2) + g(CO_2) + h(T*P) + i(T*CO_2) + j(P*CO_2) + k(T*P*CO_2),$$

From model simulations to a surface response



FACCEJPI Agriculture, Food Security and Climate Change

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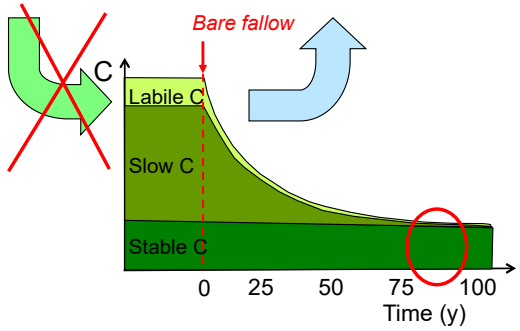
AgMIP The Agricultural Model Intercomparison and Improvement Project

Soil C seq. network

3. Intercomparison of soil models using long term bare fallows

Objective: Compare the ability of models to simulate soil C dynamics, with particular reference to recalcitrant pools, using data from long-term experiments with continuous bare fallow.

- **Collaboration** with a Long Term Bare Fallow (LTBF) network (Barré et al, 2010)
- **7 sites** without vegetation cover (**no C returns**)
- Periods of **25 to 79 years** of C measurements
- **14 models** including **C dynamics** already identified to contribute
- 2 modeling steps: blind vs. calibrated models against experimental data
- Initial study in 1997: Smith P, Smith JU, Powlson DS et al. (1997) *A comparison of the performance of nine soil organic matter models using datasets from seven long-term experiments: evaluation and comparison of soil organic matter models*. Geoderma, 81, 153–225.



Next steps and perspectives

- No more coordinated activities in 2019, but individual projects continue and forthcoming papers are planned especially on mitigation options and bare fallow models intercomparison
- Note that a number of papers have been published on 4 per 1000 contributing to the soil C network more than to the field network

- Matching policy and science: Rationale for the '4 per 1000-soils for food security and climate'initiativeJF Soussana, S Lutfalla, F Ehrhardt, T Rosenstock, C Lamanna, P Havlík, ...Soil and Tillage Research
- Reducing greenhouse gas emissions in agriculture without compromising food security? S Frank, P Havlík, JF Soussana, A Levesque, H Valin, E Wollenberg, ... Environmental Research Letters 12 (10), 105004

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Thanks for your attention

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