Croplands Research Group

Workshop "Experimental databases and model of N2O emissions by croplands: do we have what is needed to explore mitigation options?"

Paris, France, 17-19 March 2014

Workshop Report

Overview

This workshop was co-organised by component 1 (Quantifying net greenhouse gases emissions in cropland systems) and component 3 (Modelling CN emissions) of the Croplands Research group. It was hosted by INRA (French National Institute for Agricultural Research), in Paris, on 17, 18 and 19 March 2014.

The objectives were to (1) assess the ability of nitrous oxide emission models to account for the effect of agricultural management practices, especially those practices aiming to reduce emissions, (2) share information about experimental data available to evaluate models, and (3) gather modellers and experimentalists together to discuss technical issues associated with measurement and modelling of nitrous oxide emissions from agriculture.

The expected output was a set of recommendations for better synergy between modelling and data collection efforts.

This workshop was immediately followed by a second one about "Models Inter-comparison on agricultural GHG emissions", on 19, 20 and 21 March 2014, organised by the C&N Cycling Cross-cutting Group.
This report is a summary of the discussions and outcomes from the workshop. The program and all presentations given during the meeting are provided separately.

Participants

The workshop was attended by 60 participants from 21 countries : France (22), USA (5), UK (3), Canada (3), Denmark (3), Germany (3), Spain (3) , Brazil (2), Switzerland (2), Ireland (2), Australia (1), Belgium (1), Bangladesh (1), China (1), Italy (1), Japan (1), Mexico (1), N Zealand (1), Poland (1), Russia (1), Vietnam(1).

Meeting outcomes

The meeting achieved the following outcomes:

- Assessment of the main modeled processes of nitrification/denitrification and whether these modelled processes are sufficient. Knowledge gaps about other processes (for instance N_2O consumption during upward diffusion) and to what extent these processes hamper the ability of models to simulate emissions was explored.
- A review paper about fertilising techniques and N_2O emissions would be very useful. Many papers have been published but a global view is missing.
- An assessment on how models do with key management practices (e.g. tillage) is needed. This work can be shared with the CN cross-cutting group.
- The project of a book on the topic of the workshop was discussed. It appeared that not enough authors were ready to contribute. Submitting 4-5 papers to an international journal will be examined instead. This will be further discussed within the scientific committee of the workshop.

Summary of the talks and discussions

Opening session: Basic processes, modelling and databases

Nitrous oxide emissions from agricultural soils are the consequences of complex, not fully elucidated underlying processes. We are still missing a lot of understanding for some processes (e.g. N_2O consumption in soils). Numerous shortcomings remain about measurement techniques. Methodological problems remain with denitrification, not solved with isotope techniques. Consequently we still have difficulties to identify sources. We seldom know which process (nitrification or denitrification) dominates in experimental results and modellers do not often report on the origin of simulated emissions, although some models simulate both processes. In a near future some molecular tools may help to disentangle source and sink processes.

Existing N_2O emission models differ greatly in complexity and process detail. Simple models require fewer inputs, but compromise on process-description. Complex models are not necessarily more accurate, particularly if they cannot be parameterised. Process-based models (e.g. DNDC, Daycent, Stics, etc.) are able to simulate the effect of key agricultural practices like N fertilisation or till versus no-till, although not always the accurate temporal dynamic. We should not fear model failure. Getting it wrong ultimately improves our understanding. The expected better understanding of underlying processes will probably help to improve models but this remains debatable. Most existing models are 1D models. Landscape scale modelling linking hydrological and biogeochemical models needs further efforts.

Some N_2O flux networks and databases exist at the national and international level. Measurements are based on different techniques (manual chambers, automatic chambers, micro-meteorological methods), each of them having its niche and advantages and disadvantages. Since several approaches are possible for data analysis and flux calculations some information about the method which has been used is highly desirable. The availability of auxiliary data is a critical issue. GRA should provide a list of essential versus desirable data for running the models.

Sessions 1-4: Management practices and N_2O emissions

Fertilising techniques and N_2O emissions

- Emission factors (EFs) are biased towards temperate, humid regions, because this is where the data are. We need data from other regions and agricultural systems, and models to be evaluated in these contexts.
- Predicting N_2O emissions from organic fertilizers remains difficult. We need models that address both C and N dynamics.
- Many technical options offer a mitigation potential (e.g. N fertilizer source, nitrification inhibitor, controlled release fertilizers, placement, timing, precision agriculture,…). An overview (synthesis paper) would be very useful. It may include an assessment of the mitigation potential for each of these levers, the number of related studies, the consistency of results and the remaining uncertainty. The impact on crop yield, and indirect emissions (e.g. for fertilizer sources) should be also considered.

Soil tillage and N_2O emissions

- Soil tillage may affect N_2O emissions through short term effects and long term effects
- Long term effects involve intermediate variables (like soil temperature, water content, pH, porosity, bacterial communities…) which are affected in a complex way. Moreover compensations may occur between soil layers.

- The overall effect of no-till on N_2O emissions is site specific. It seems to depend on the climatic context (more pronounced effect of no tillage under dry climates). This may be related to the dominant emission process (nitrification vs denitrification).
- Disturbing events (e.g. ploughing of grasslands, mechanical weeding, freeze-thaw) often generate emission peaks, which may last for days to weeks.
- Interactive effects with other management practices (e.g. fertilisation or residue management) are often more important than single effects.
- How models do with soil tillage options is often unclear. An intercomparison of models on this respect would be useful.

Legumes, crop residues and N_2O emissions at rotation scale

- The low N_2O emissions of legumes have been confirmed. The use of legumes in cropping systems reduces the need for synthetic N applications and thus lowers N_2O emissions.
- However emissions of N_2O from crop residues and cover crops (legumes or non legumes) are poorly understood, and likely to be influenced by residue quality and management. Again C-N models are needed.

Other management practices and combination of techniques

- Biochars offer mitigation potential but the effect depends on the context. Underlying mechanisms must be better understood. Long term studies are needed.
- Other levers like liming warrant more studies.
- Process-based models provide good estimates of annual N_2O emissions as affected by key management practices, even in combination (e.g. N application rate and residue management). Effect of tillage is more difficult to simulate. Experiments often lack explanatory variables (see above).

Cross-cutting session

Uncertainty in N_2O emissions: can we trust data for model development, calibration and validation?

- N_2O emissions are highly variables in space and time
- It is necessary to report uncertainties in both model calibration and validation exercises as well as for measurement data
- For experimentalists: need to decide how to fill gaps in space, time and footprint restrictions
- For modellers: need to decide on the choice of time scale for data/model comparison

Characterization of management practices

- long term effects of management practices should be predicted thanks to a modular approach (e.g. a separate algorithm to simulate the effect of tillage on soil bulk density)

How far should we go with biotic pools and process in N_2O emission models?

- microbial biomass is already included in some models
- it seems essential to have explicit rates of nitrification and denitrification
- More focus should be put on the nitrite pool

General comments and concluding remarks

- The metrics used to compare agricultural practices are critical (area-scaled N_2O and/or yield-scale N_2O?).
- Interactions between management practices play a key role.
- We need to complete N budget data (N_2O, N_2, NO_x, NO_3, NH_3) and other GHG. We also need (multi)year round continuous measurements for N_2O.
- Auxiliary data and intermediate variables should be measured. For modelling purposes wide range of high quality auxiliary measurements are required.
- What are the models used for is a key question. Accurate prediction (lots of data, high level of detail) or decision making (predicting general trends, less data, less accuracy)?
- We need to format experimental data, not only for achieving research objectives, but also to provide some scientific and technical support for policy makers.
- Quantification of mitigation practices is what is really needed to get an emission factor reduction method and to get something simpler that can be used at different scales.
- Landscape scale modelling, which is the relevant scale for inventory purposes and policy making is an important objective.