2023 Greenhouse Gas Workshop

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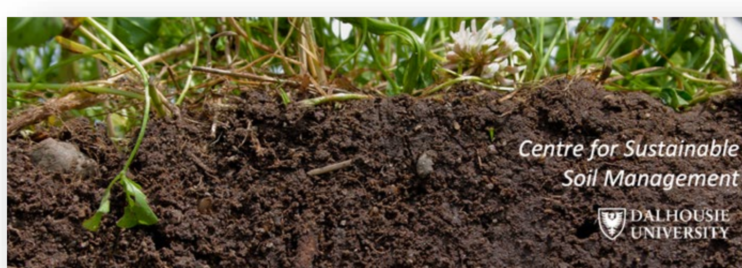

Greenhouse Gas Workshop Agenda

Sunday June 25, 2023

Morning Session – Room 383 Cox Institute, Dalhousie AC Campus

9:00 – 9:20 – Cecile de Klein – Development of the Global Research Alliance N_2O chamber methodology guidelines (virtual)

9:20 – 9:40 – Richard Farrell – Sampling protocols for chamber-based measurements of N_2O emissions in the field: A matter of resource allocation

9:40 – 10:00 – Mario Tenuta – CanN2Onet

10:00 – 10:30 – Break

10:30 – 10:50 – Claudia Wagner Riddle – Micrometeorological Measurements of Greenhouse Gas Fluxes from Cropping Systems

10:50 – 11:10 – David Risk – Methane measurement and larger scale approaches

11:10 – 11:30 – Mark Zondlo – Nitrous oxide fluxes by open-path eddy covariance measurements

Lunch – BBQ – Location to be confirmed (campus or BEEC)

Afternoon – Bio-Environmental Engineering Centre, Dalhousie University

Eosense - Demonstration of various gas sensing and measurement technologies including Eosense chambers, Gasmet multi-gas analysers,

Hoskins - soil moisture sensors

Room 383 Cox Institute, Dalhousie AC Campus

General discussion of issues relating to the measurement of greenhouse gas emissions under field conditions.

Dr. Cecile de Klein, AgResearch, New Zealand

Cecile de Klein is an internationally recognized scientist in environmental management of agricultural systems, with 30+ years of experience in research on nitrogen cycling and greenhouse gas emissions from grazed livestock systems. She is a Principal Scientist with AgResearch and a Principal Investigator of the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC), where she leads the 'low-GHG plants' research program. Cecile also leads and has led many international research programs, funded through the Global Research Alliance on Agricultural Greenhouse gases, including development of international guidelines for measuring N2O emissions; a Biological Nitrification Inhibition program; and the New Zealand contribution to a European Horizons2020 program on developing carbon-neutral farming systems (ClieNFarms).

Dr. Richard Farrell, University of Saskatchewan

Dr. Richard Farrell is an Associate Professor and Saskatchewan Ministry of Agriculture Research Chair – Soils & Environment in the Dept. of Soil Science at the University of Saskatchewan. Originally from Rhode Island, Rich has a BSc in Resource Development from the University of Rhode Island and MSc and PhD degrees in soil chemistry from Iowa State University. Rich is director of the *Prairie Environmental Agronomy Research Laboratory* (PEARL), which houses a suite of state-of-the-art greenhouse gas (GHG) analysis instruments—including two high-throughput gas chromatographs (Bruker 450-GC & SCION 456-GC), a suite of analyzers for the real-time isotopic analysis of CO_2, CH_4, and N_2O (Picarro G1101-i isotopic CO2 analyzer, G2201-i isotopic CH_4 and CO_2 analyzer, and two G5131-i isotopic N_2O analyzers), and a field-portable trailer-mounted GHG analysis system consisting of a Gasmet DX4015 FTIR-gas analyzer interfaced to a 16-port LiCor LI-8150 multiplexor and a series (up to 16) of LiCor LI-8150-104 long-term flux chambers. My research focus is environmental agronomy and addresses the impacts of agricultural management on GHG emissions from integrated agricultural landscapes and the development of advanced fertilizer management strategies. Rich is a Fellow of the Canadian Society of Soil Science (CSSS) and is currently the President-Elect of the CSSS.

Dr. Mario Tenuta, University of Manitoba

Dr. Mario Tenuta is a full professor in the Department of Soil Sciences and heads the Applied Soil Ecology Lab. His training includes a B.Sc. in Botany and Physical Geography, an M.Sc. in Soil Science, a Ph.D. in Plant Sciences, and Post-Doctoral research in Nematology. From 2006 to 2017 he served as the Canada Research Chair in Applied Soil Ecology. Mario is one of nine leading researchers in the Canadian 4R Research Network (supported by Fertilizer Canada and Agriculture & Agri-Food Canada's (AAFC) Agri-Innovation Program). Most recently, Mario was named the Natural Sciences and Engineering Research Council of Canada (NSERC) Industrial Research Chair (IRC) in 4R Nutrient Stewardship.

Dr. Claudia Wagner-Riddle, University of Guelph

Dr. Claudia Wagner-Riddle is a Professor in the School of Environmental Sciences (SES), University of Guelph, Canada. Originally from Brazil, Claudia has degrees from the University of Sao Paulo and Guelph. Claudia leads an internationally-renowned research program utilizing the measurement of greenhouse gas emissions to determine the carbon footprint of food, feed, and fuel produced by agriculture. Claudia is a fellow of the Soil Science Society of America, the American Meteorological Society and of the Canadian Society of Agricultural and Forest Meteorology. She is the Editor-in-Chief of the international journal Agricultural and Forest Meteorology and leads a nation-wide training program on Climate-Smart Soils. Claudia is the Director of the North American regional chapter of the International Nitrogen Initiative and was awarded the 2020 IFA Borlaug Award of Excellence in Crop Nutrition.

Dr. David Risk, St. Francis Xavier University

Dave is an emissions measurement scientist whose research helps reduce greenhouse emissions – through instrumentation development, use of chemical tracers, and computation. Dave is well known for his ability to carry out large-scale field studies. Past work has seen FluxLab students and technicians using truck- and aircraft-based measurement to establish levels of methane pollution from oil and gas production at thousands of oil and gas facilities in western Canada, and from oil production platforms off Canada's east coast. More recently Dave has been overseeing a large-scale measurement program documenting landfill methane emission level at over 100 sites from coast-to-coast to establish mitigation opportunities and to help inform the development of new regulation. Dave maintains a footprint in other areas of industrial emissions management, including Carbon Capture and Storage projects where he has continued involvement in the monitoring programs at Aquistore and Weyburn. A soil scientist by training, some of Dave's favourite projects involve documenting methane and other emissions from thawing permafrost and polar terrain. Dave is always interested in moving important expertise into the world and is co-founder of two successful Canadian-based companies called Arolytics, and Ecosense. Outside of work, Dave can be found playing outdoors and traveling with his family, riding some sort of bike, or (slowly) restoring another Land Rover.

Dr. Mark Zondlo, Princeton University

Professor Zondlo's research activities focus on the sources, sinks, and distributions of trace gases important for understanding air quality, the carbon and nitrogen cycles, and climate change. Professor Zondlo's group develops and deploys new optical-based sensors to make innovative field measurements as part of large, multi-disciplinary field studies. They aim to bridge spatiotemporal scales from in-situ to remote sensing measurements to achieve a more complete understanding of the atmosphere and anthropogenic activities on the environment.

ABSTRACTS

Development of the Global Research Alliance N2O chamber methodology guidelines.

Cecile de Klein,
AgResearch, New Zealand

Non-steady-state (NSS) chamber techniques have been used for decades to measure nitrous oxide (N2O) fluxes from agricultural soils. These techniques are widely used because they are relatively inexpensive, easy to adopt, versatile, and adaptable to varying conditions. Much of our current understanding of the drivers of N2O emissions is based on studies using NSS chambers. These chamber techniques require decisions regarding multiple methodological aspects (e.g., chamber materials and geometry, deployment, sample analysis, and data and statistical analysis), each of which may significantly affect the results. Variation in methodological details can lead to challenges in comparing results between studies and assessment of reliability and uncertainty. Therefore, the New Zealand Government, in support of the objectives of the Livestock Research Group of the Global Research Alliance on Agricultural Greenhouse Gases (GRA), funded international projects to develop standardized guidelines on the use of NSS chamber techniques. These guidelines were recently refined and published as a collection of papers in a special issue of the Journal for Environmental Quality.
This talk will present a summary of key guidance considerations and minimum requirements on the various aspects of the use of N2O chamber methodologies, including chamber design and deployment, sample collection, storage and analysis, and flux calculations. The guidance is not meant to be highly prescriptive but instead provide researchers with clear direction on best practices and factors that need to be considered.

Sampling protocols for chamber-based measurements of N_2O emissions in the field: A matter of resource allocation

Richard Farrell
Department of Soil Science, University of Saskatchewan

Most field studies requiring nitrous oxide (N_2O) emissions measurements employ flux chambers because of their affordability and flexibility. When planning a greenhouse gas sampling campaign using the chamber-based approach, researchers are faced with a multitude of decisions regarding the best allocation of their limited resources. Practical considerations constrain both the total number of samples that can be collected in the field and the number of samples that can be processed in the laboratory in a timely fashion. For manipulative field studies, decisions regarding sampling include: (i) how many samples should be collected from the chamber headspace to calculate the flux estimates; (ii) if and how many flux estimates should be collected from multiple locations (sub-samples) within an experimental unit; (iii) the number of replicates required to calculate a representative "average" flux; and (iv) how many treatments and what sampling interval (hours, days, weeks) should be employed. Most N_2O sampling protocols call for the collection of multiple, equally spaced time-points, and though this approach will no doubt increase the accuracy of the daily flux estimate, it also dramatically increases the number of gas samples to be analyzed. Because only a limited number of samples can be collected and analyzed, this invariably means that researchers must compensate by including fewer numbers of treatments and/or replications, or by decreasing sampling frequency. In this presentation, I discuss issues associated with deciding "how much data is enough" to accurately estimate seasonal N_2O emissions. Using manually sampled gas flux chambers (with gas chromatographic analysis of discrete gas samples collected during chamber deployment) and automated gas flux chambers interfaced to an FTIR gas analyzer for semi-continuous flux measurements in the field, we examined the impact of sampling frequency, as well as the influence of utilizing single versus multiple time-point flux estimates to calculate cumulative N_2O loss from field plots receiving varying amounts of fertilizer N. The general requirements and setup for chamber-based GHG measurements in the field methods—including examples from past and recent experiments will be presented.

Micrometeorological Measurements of Greenhouse Gas Fluxes from Cropping Systems

Claudia Wagner-Riddle,
School of Environmental Science, University of Guelph

Micrometeorological methods for greenhouse gas (GHG) flux measurements are also referred to as tower-based method as they involve instrumentation above a crop canopy placed on a tower, yielding flux values integrated over a relatively large area depended on the height of the measuring tower, atmospheric and surface conditions. The monitored area needs to be relatively flat and homogeneous, and methods are ideally suited for assessing the impact of mitigation practices at the farm field-scale as they spatially integrate fluxes over areas > 1 ha and can be operated quasi-continuously over the year. The most common approaches in use for measuring GHG fluxes are the eddy covariance (EC) and flux-gradient (FG) methods. Each method requires the deployment of sonic anemometers and fast response gas analyzers, but the specific instrumentation requirements and setup are different. Eddy covariance is based on the direct quantification of vertical turbulent transport of scalars such as N_2O or CO_2, given by the covariance between fluctuations in vertical wind velocity and gas mixing ratio and considered the reference standard. Instrumentation gets deployed in one tower for each field being monitored. Due to the cost of using multiple analyzers, studies have typically placed a tower with an analyzer dedicated to EC on the border of two fields and used wind direction to select which field is being measured at any given time. For N_2O, biases can result from this setup when comparing practices given the highly variable temporal nature of fluxes (e.g. if measurements in one field coincide with rainfall, while the other field is not being monitored). In addition, uncertainty is added to the measurements because of extended gaps in the flux time series (i.e. when one field is being measured the other is not) and prevents the direct comparison of mitigation practices. In contrast, the FG method is more versatile as it can be setup in a multi-plot arrangement were typically up to four large fields (~2-4 ha each) can be monitored in a half-hourly sequence using a single analyzer under the same soil and weather conditions. However, in the FG method the turbulent vertical flux of a gas is proportional to its vertical time-averaged mixing ratio gradient through a proportionality factor called the eddy diffusivity that is parameterized so it is considered a semi-empirical measurement. The advantage of the FG method is that it does not require fast fluctuations in gas mixing ratio measurements as in the EC method; hence, long tubing and manifolds can be used to sample air from each of four tower and direct the sample to a centrally located gas analyzer. In this presentation, general requirements and setup for EC and FG methods will be covered and examples from past and recent experiments will be presented.

Nitrous oxide fluxes by open-path eddy covariance measurements

Mark A. Zondlo
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Eddy covariance flux measurements of nitrous oxide (N_2O) allow for field-scale footprints of emissions to be measured on nearly continuous timescales, pending sufficient micrometeorological conditions. However, because the ambient air conventionally must be pumped through an inlet, sampling manifold, and closed-path optical cell of a commercial instrument, fast pumping speeds are required for independent 10 Hz measurements. This results in large power consumption (200-500 W) and prevents remote field deployment as a wall power source is needed. To this end, we have developed an open-path, laser-based N_2O sensor that consumes 50 W of power (solar/battery) using new advances in mid-infrared lasers near the fundamental absorption band of N_2O near 4.5 μm. Open-path eddy covariance flux measurements are inherently fast, but they also can suffer from large density correction terms due to temperature (and water vapor) fluctuations. For N_2O, very small enhancements (0.1-1 ppbv) are noted above a relatively large ambient background (~ 335 ppbv) even for relatively large fluxes. Fast measurements of temperature can correct for density-driven fluctuations, but there remain two problems: 1) fast temperature measurements are often displaced from the optical sensing volume, sometimes leading to unknown biases given the spatial separation; and 2) the correction terms (and associated errors) for the temperature effects alone are orders of magnitude larger than the measured fluxes. We have eaddressed these problems by developing an open-path N_2O sensor using an absorption line of N_2O that is isolated from other atmospheric species, and it also has a spectroscopic temperature dependence of comparable magnitude but in the opposite direction of the temperature density-driven effects. Therefore, the open-path N_2O sensor developed here is relatively insensitive to temperature density corrections. The sensor has a precision of 0.1 ppbv N_2O at 10 Hz and consumes 50 W of power. We deployed the open-path N_2O sensor over a corn field at the Kellogg Biological Station in Michigan for two summers, and we also intercompared to flux chamber measurements within the tower footprint with high correlation (r^2=0.96) and a slope near unity (1.0±0.3). Flux detection limits of 60 (80) ng N_2O-N m^{-2} hr^{-1} (95% confidence interval) were demonstrated.

Overall temperature-related corrections were only 6% of the nominal flux magnitude, reducing random errors by a factor of 20 over previously proposed N_2O absorption lines. The sensor has been operated over a range of temperatures from +34ºC to -37ºC with no noticeable change in optical alignment, suggesting field robustness for other applications including polar regions. The spectroscopic/density compensating approach used in this instrument is adaptable for open-path methane (CH_4) and carbon dioxide (CO_2) measurements as well for improved greenhouse gas flux measurements. Ongoing efforts to improve sensor performance in terms of power, field robustness, and additional field measurements will also be discussed.