



**Science
Societies**

Global Research Alliance sponsors new nitrous oxide chamber methodology guidelines

By DJ McCauley

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USDA-ARS soil scientist Rodney Venterea (foreground) and technician Jason Leonard collect gas samples from chambers used to measure flux of nitrous oxide and other greenhouse gases from experiments in a Minnesota corn field. Photo by Stephen Ausmus.

- Nitrous oxide (N₂O) is a potent greenhouse gas, produced by nitrifying and denitrifying microbes in the soil—measuring and managing emissions from agricultural soil is of paramount importance for farmers, researchers, and the global environment.
- The Livestock Research Group of the Global Research Alliance on Agricultural Greenhouse Gases (GRA), with the financial support of the New Zealand Government, coordinated the development of papers on non-steady-state chamber techniques.
- Published in the *Journal of Environmental Quality*, this special section presents guidelines for using an affordable and common technique, with input from leading researchers in N₂O emissions from more than 10 countries across the globe.

In 2018, nitrous oxide (N₂O) made up 7% of total greenhouse gas emissions, according to the USEPA (<https://bit.ly/3l8bYFZ>). The impact of a pound of N₂O is approximately 300 times more powerful than a pound of carbon dioxide when it comes to warming effects on the atmosphere (<https://bit.ly/3ncyy1J>). In addition to its impact as a greenhouse gas, N₂O is also the largest ozone-depleting chemical produced by human

activity.

Agricultural activities impact N₂O emissions as soil microbes convert ammonia from fertilizers and animal excreta to nitrate and other microbes convert nitrate to nitrogen gases, including N₂O.

For farmers, limiting gaseous losses can increase their efficiency as well as mitigate negative impacts on global climate. Finding ways to manage emissions of this potent greenhouse gas is predicated on being able to reliably measure the amount of N₂O emitted from the soil. From accurate measurements, researchers can then find ways to decrease N₂O flux over time.

One method is both affordable and quite common: non-steady-state (NSS) chambers.

An international team of scientists, spearheaded by Cecile de Klein, Principal Scientist with New Zealand's AgResearch, compiled a collection of papers now published in the *Journal of Environmental Quality* (JEQ; <https://bit.ly/2T4A08t>). The special section, titled "Global Research Alliance N₂O Chamber Methodology Guidelines," brings together best practices of NSS chamber methodologies on a global scale.

The section was funded by the New Zealand Government and the Livestock Research Group of the Global Research Alliance on Agricultural Greenhouse Gases (GRA). The papers range from information on flux calculations, to sample collection, chamber design, statistical considerations, and modeling methodologies. Each paper is outlined in the introduction to the section, which also provides health and safety considerations (<https://doi.org/10.1002/jeq2.20131>).

Building Worldwide Guidelines



University of Minnesota technician Sonya Ewert (left) and USDA-ARS soil scientist Rodney Venterea (Technical Editor of the JEQ special section) use a gas chromatograph to determine amounts of greenhouse gases in samples collected from the field. Photo by Stephen Ausmus.

The development of international guidelines occurred in different stages over a number of years, culminating in this JEQ special section, de Klein explains.

“It all started in 2010, at a conference in Banff, Canada,” de Klein recalls. “I was asked to facilitate a workshop on measuring N₂O emissions using chamber methodologies, and during the discussion, it became clear that having international guidelines would be very helpful. That’s where the idea came from.”

That first idea resulted in the development of a set of guidelines that was published on the GRA website in 2013 with contributions from a variety of researchers across the globe.

But in 2015—at a workshop on N₂O methodologies during the Annual Meeting of ASA, CSSA, and SSSA—de Klein noticed there was new research coming in, and new evidence, that ought to be a part of the guidelines.

“So we held a follow-up workshop in New Zealand in 2018, and that kicked off the process for the new guidelines,” de Klein says.

When the team was searching for a home for the new papers, they wanted to make sure it was peer-reviewed and open access.

“Since I served on the JEQ editorial board, I suggested to the chief editor that these guidelines would make a valuable special section, and he agreed,” says Rod Venterea,

Technical Editor of the special section. “Chamber measurement of nitrous oxide is a very active field, and we wanted to get perspectives on how the technology is being used around the world.”

The researchers publishing in this special section do represent a swath of global talent. Rod Venterea is a soil scientist with the USDA-ARS and an adjunct professor at the University of Minnesota. Another founding member—Søren Petersen—is a professor in the Department of Agroecology at Aarhus University in Denmark.

“Around the world, there is a strong focus on climate change,” Petersen says. “Doing research to identify and mitigate greenhouse gases is really common—lots of countries rely on low-cost methods of analysis. If we want to mitigate nitrous oxide, we need to understand emissions. And, in fact, chamber methods can help us understand changes in emission due to changes in management with more confidence.”

Non-Steady-State Chambers

“It’s a simple concept—you’re just placing a chamber on the soil and analyzing the gas that collects inside,” Venterea says. “The problem is there’s a lot of variation in how people do things—for example, the size of the chamber, the timing, and the calculations—and these details can affect the results. The implications are important because the data are used to calibrate models and develop national and global greenhouse gas inventories.”

Non-steady-state chambers sit on top of the soil, just as Venterea described. Inside, the gases emitted from the soil accumulate, and from this headspace, small samples of gas are collected for analysis.

The method is great for side-by-side comparisons of emissions when testing different management practices. Because the emitting surface—the soil—is confined, there’s no

problem setting chambers in small test plots. This allows researchers to minimize variability between treatments; they can focus, instead, on how management impacts emissions.

As you might expect, there are lots of variables that can influence the amount of N_2O flux at a given time.

“There can be large variations in emissions within the same field as well as over time,” Venterea says, “so being thorough and taking into consideration the potential sources of error is key.”

Factors like time of day, soil temperature, and location can impact the flux. To get accurate flux measurements, researchers must balance two primary considerations: the number of samples taken from a given chamber and the number of chambers spread out over a space.

The rub is that researchers who set up many individual chambers, taking samples from multiple locations across a field, likely won't be able to sample at a high frequency from any given chamber.

“We try to recommend a good balance,” Søren Petersen says. “Chamber methods are really labor intensive, but



choosing the right method can give more flexibility in planning sampling campaigns.”

Headspace sampling from a non-steady-state chamber. Photo by Cecile de Klein, AgResearch, New Zealand.

Petersen is a coauthor (along with Venterea) of a paper in the JEQ special section on flux calculations (<https://doi.org/10.1002/jeq2.20118>).

The special section also provides detailed recommendations for the best way to run statistical analysis of gas samples. The goal is to use the NSS chambers to accurately calculate N₂O flux from the soil at time “zero”—that is, what was the gas emission from the soil before the chamber was on top of it?

“We know that when chambers are left on the soil surface, the flux starts to decline although this may not be evident,” Petersen says. “But by charting emissions over time and selecting the right method, then flux estimates are quite robust.”

In short, the special section provides detailed information—plus a great deal of supplemental “practice” data—for both well-versed researchers and new practitioners of chamber methods to understand best practices and pitfalls to avoid.

Impacts of a Methods Section

As you might guess, the better we understand soil emissions and can gain accurate measurements of greenhouse gas flux, the better job we can do managing agricultural soils.

The reason the GRA emphasized NSS chambers, as de Klein explains, is because they are so affordable and so widely used. And the reason the team chose to find their papers a home at JEQ is because publication in an international journal would make the guidelines globally available. With financial support from the GRA, it was possible to

ensure that all papers were open access.

“Researchers in developing countries can benefit from this work, but they may not always have access to information like most institutional researchers do,” de Klein says. “It was really important and exciting for us to make sure this research was published in a peer-reviewed, open access publication.”

The team sees the special section as a fantastic resource for people who are new to the method and for current researchers to make sure they are using the best practices possible.

“It’s not prescriptive,” de Klein says, “but it is really good to recognize that these guidelines can help us improve the consistency of our results that come from chamber methodologies.”

Across the board, de Klein, Petersen, and Venterea recognize the importance of their work, and how it plays into understanding greenhouse gas emissions on a global scale.

“So many people from different continents are facing the same challenges,” Petersen says. “When we started this in 2011, we all had a lot of questions. But we got everyone to sit down at the table and disregard what they’ve been doing in the past, so we can do things in new ways; there’s a real advantage to that. It’s really hard to do.”

Dig deeper

You can view this special section, “Global Research Alliance N₂O Chamber Methodology Guidelines,” in the *Journal of Environmental Quality* at

<https://bit.ly/2T4A08t>.

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