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# Understanding and Managing Nitrous Oxide Emissions from Agricultural Soils

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**International Fertilizer Association Annual  
General Meeting  
November 19, 2020**



# Increased interest in nitrous oxide emissions

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## Balancing nitrogen between food production and climate change

BY JOHANNES LEHMANN, DEBORAH A. BOSSIO AND DOMINIC WOOLF, OPINION CONTRIBUTORS — 11/04/20 03:00 PM EST  
THE VIEWS EXPRESSED BY CONTRIBUTORS ARE THEIR OWN AND NOT THE VIEW OF THE HILL

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YaleEnvironment360 Published at the Yale School of the Environment

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Federal Reserve applies to join group of banks managing climate risks

ENERGY & ENVIRONMENT  
— 6M 6S AGO

Migrant women who accused doctor of abuse face deportation

COURT BATTLES — 7M 47S AGO

Trump supporter charged with attacking elderly couple over political sign

STATE WATCH — 8M 4S AGO



© Getty Images

### Fertilizer Use Driving Rapid Rise in Potent Nitrous Oxide Emissions

Emissions of nitrous oxide (N<sub>2</sub>O) have surpassed projections by the Intergovernmental Panel on Climate Change (IPCC), jeopardizing the goals of the Paris Agreement. In a [recent study](#) published in the journal *Nature*, an international team of scientists discovered that N<sub>2</sub>O emissions are increasing at a faster rate than any other type of greenhouse gas emission, mainly due to a rise in nitrogen fertilizer application for food production.



A woman applies fertilizer on a maize crop in Kenya. B. DAS/CIMMYT

Not only does nitrous oxide have 300 times more heat-trapping power than carbon dioxide, it also depletes the stratospheric ozone layer, which protects the Earth from most of the sun's ultraviolet radiation. N<sub>2</sub>O persists in the atmosphere **an average of 114 years** and

<https://e360.yale.edu/digest/fertilizer-use-driving-rapid-rise-in-potent-nitrous-oxide-emissions>

Technology & Science

### Nitrous oxide, more harmful to the climate than CO<sub>2</sub>, increasing in atmosphere, study finds



If emissions aren't curbed, Earth's temperature could rise by 3 C by 2100, researchers say

Posted: Oct 08, 2020 4:00 AM ET | Last Updated: October 8

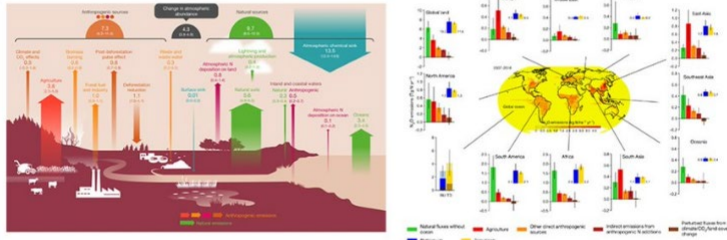


<https://www.cbc.ca/news/technology/nitrous-oxide-climate-1.5753907>



Nature @nature · Oct 8

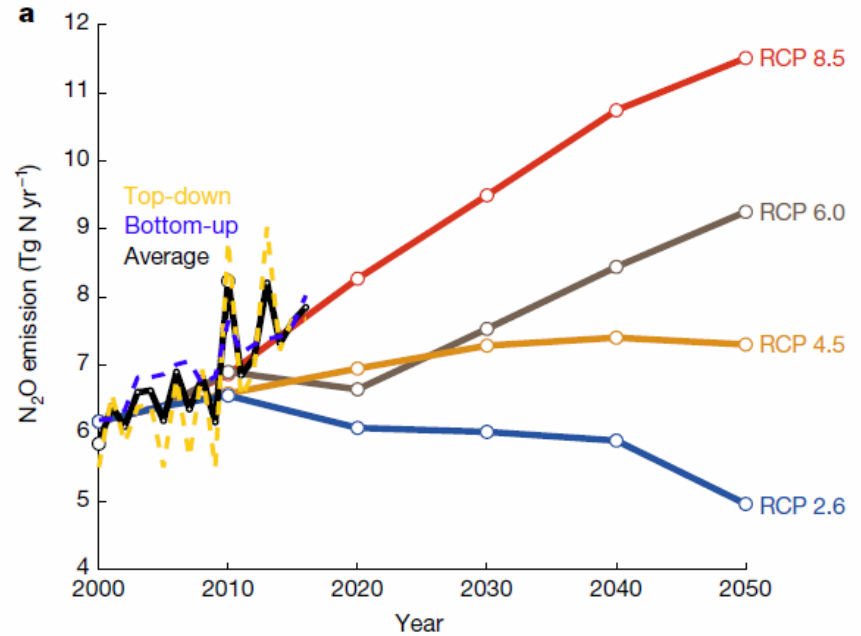
A comprehensive quantification of sources and sinks of global nitrous oxide underscores the need for N<sub>2</sub>O emission reductions, especially in the agricultural sector, according to a study in Nature. [go.nature.com/2GFD6gp](https://go.nature.com/2GFD6gp)



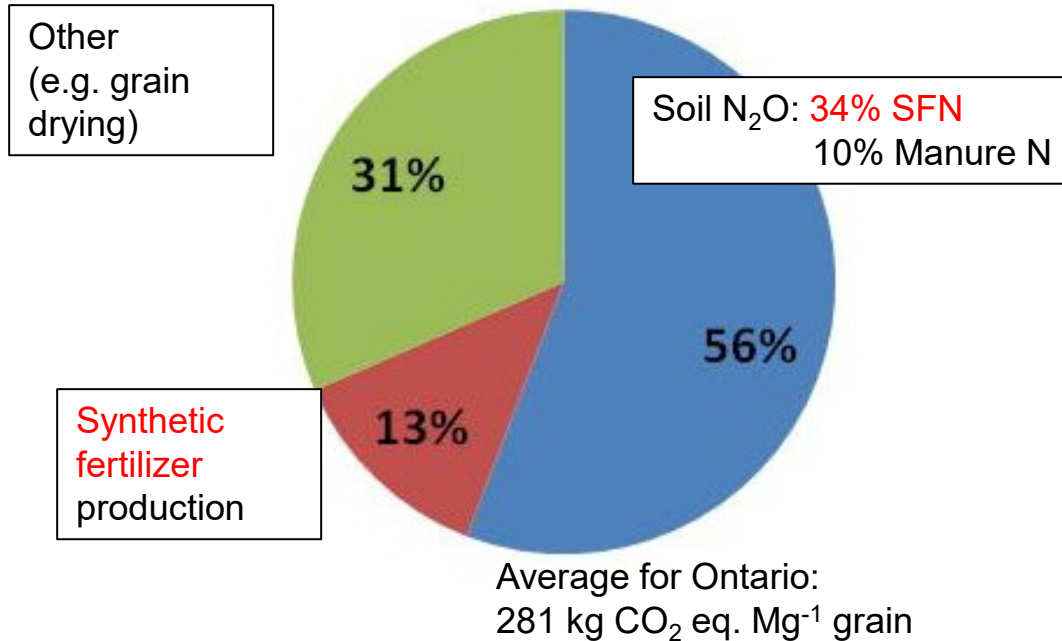
nature

- Agriculture: ~70% of anthropogenic sources
- Worrisome increase over last 4 decades driven by agriculture

Recent global N<sub>2</sub>O budget paper by Tian et al. (2020) shows N<sub>2</sub>O emissions following a worst-case trajectory



# Nitrous oxide emissions make up the majority of the carbon footprint of grain production (example: corn)



Jayasundara\*, S., C. Wagner-Riddle, G. Dias, K.A. Kariyapperuma. 2014. Energy and greenhouse gas intensity of corn production in Ontario: a regional assessment. *Can. J. Soil. Sci.* 94: 77-95.

# Policy Brief of the workshop on “Climate change, reactive nitrogen, food security and sustainable agriculture”

15-16 April, 2019 Garmisch-Partenkirchen, Germany

## Addressing nitrous oxide: An often ignored climate and ozone threat

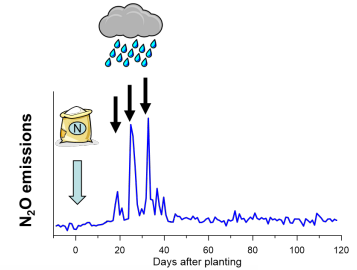
- **Given the importance of N in food production, phasing out N fertilizers is not an option**
- **Implementation of targeted mitigation options for N<sub>2</sub>O are needed**

Scheer C, Pelster D, Butterbach-Bahl K, Van Cleemput O, Kanter D, Winiwarter W, Ogle S, Boeckx P, Fuchs K, Baggs E, Bakken L, Barton L, Cardenas L, Clough T, DelGrosso S, Dorich C, Friedl J, Hu C, Leitner S, Massad R, Peterson SO, Skiba U, Smith W, Subbarao GV, Vogeler I and Wagner-Riddle C. (2019) Addressing nitrous oxide: An often ignored climate and ozone threat. *Policy Brief of the workshop on “Climate change, reactive nitrogen, food security and sustainable agriculture” Garmisch-Partenkirchen, Germany*

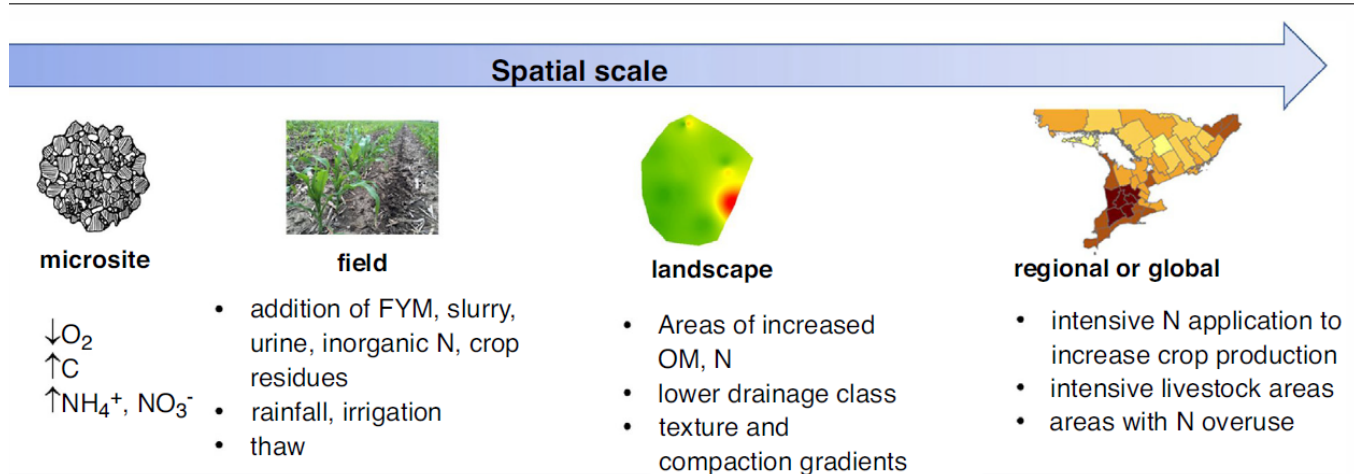


# Highlights of research programme

- Understanding N<sub>2</sub>O emissions: measurements and connections to other disciplines
- Managing N<sub>2</sub>O emissions:
  - Design practices for emission reduction
  - Connect to other environmental issues (e.g. water quality)
  - Collaborate with stakeholders
  - Communicate with farmers and general public
  - Inform policy makers
  - Train the next generation of scientists



# N<sub>2</sub>O emissions occur due to Hot Spots and Hot Moments



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

**ScienceDirect**

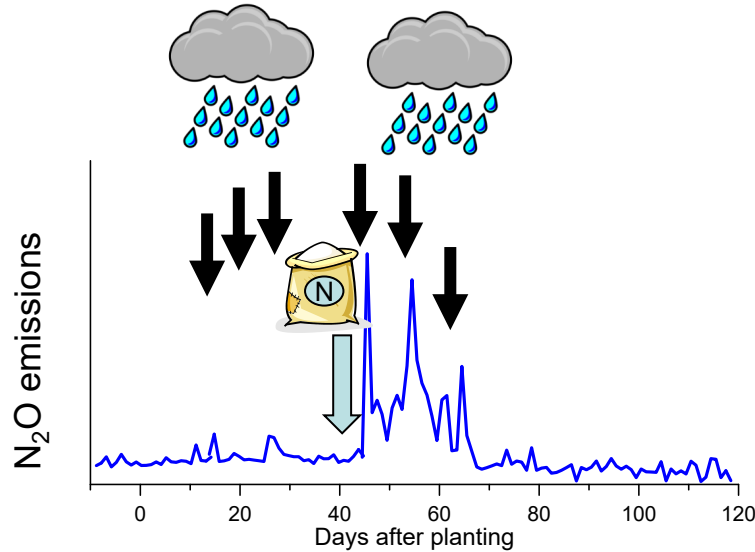
Current Opinion in  
**Environmental  
Sustainability**

**Mitigation of nitrous oxide emissions in the context of nitrogen loss reduction from agroecosystems: managing hot spots and hot moments**

Claudia Wagner-Riddle<sup>1</sup>, Elizabeth M Baggs<sup>2</sup>, Tim J Clough<sup>3</sup>, Kathrin Fuchs<sup>4</sup> and Søren O Petersen<sup>5</sup>



# Need a measurement approach that captures hot moments and integrates hot spots over larger areas year-round



Growing season



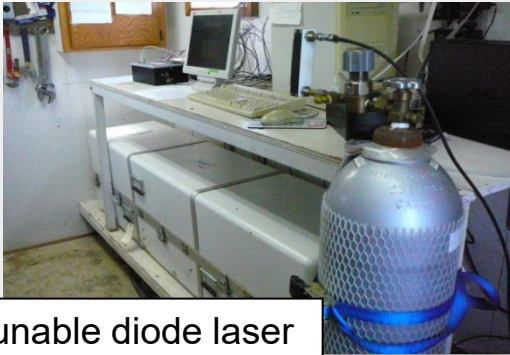
Non-growing season



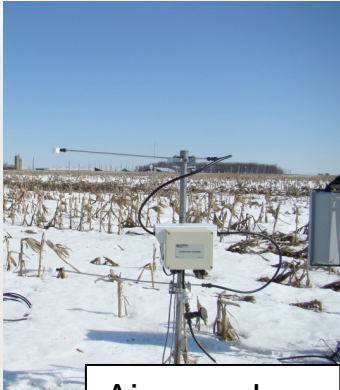


# Micromet method

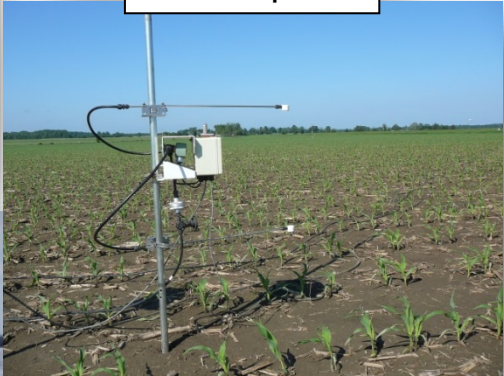
Ideal for year-round studies



Tunable diode laser trace gas analyzer



Air samplers



nature  
geoscience

ARTICLES

PUBLISHED ONLINE: 6 MARCH 2017 | DOI: 10.1038/NGEO2907

## Globally important nitrous oxide emissions from croplands induced by freeze-thaw cycles

Claudia Wagner-Riddle<sup>1\*</sup>, Katelyn A. Congreves<sup>1</sup>, Diego Abalos<sup>2</sup>, Aaron A. Berg<sup>3</sup>, Shannon E. Brown<sup>1</sup>, Jaison Thomas Ambadan<sup>3</sup>, Xiaopeng Gao<sup>4</sup> and Mario Tenuta<sup>4</sup>



# Collaboration to Link Functional Genes of the Nitrogen Cycle to Field N<sub>2</sub>O Emissions



Soil Biology and Biochemistry 142 (2020) 107703



ELSEVIER

Contents lists available at ScienceDirect

Soil Biology and Biochemistry

journal homepage: <http://www.elsevier.com/locate/soilbio>

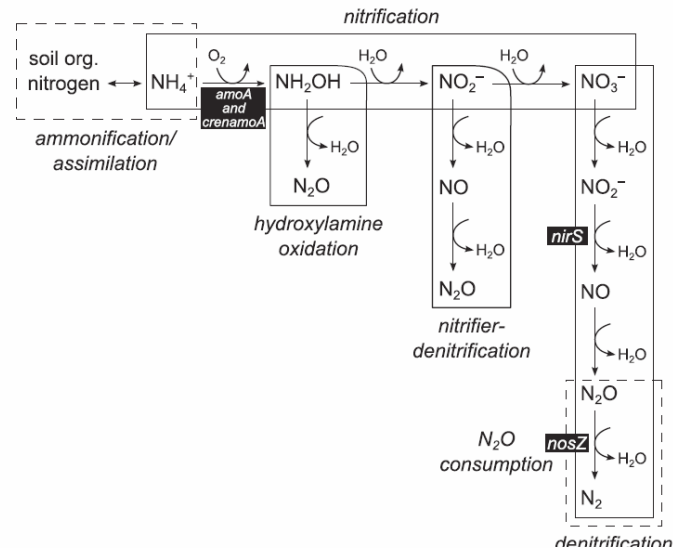


Check for updates

Short-term response of soil N-cycling genes and transcripts to fertilization with nitrification and urease inhibitors, and relationship with field-scale N<sub>2</sub>O emissions

Micaela Tosi, Shannon Brown, Pedro Vitor Ferrari Machado, Claudia Wagner-Riddle, Kari Dunfield\*

School of Environmental Sciences, University of Guelph, Guelph, Ontario, N1G 2W1, Canada



Soil Biology & Biochemistry 88 (2015) 197–213



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Soil Biology & Biochemistry

journal homepage: [www.elsevier.com/locate/soilbio](http://www.elsevier.com/locate/soilbio)

Molecular techniques and stable isotope ratios at natural abundance give complementary inferences about N<sub>2</sub>O production pathways in an agricultural soil following a rainfall event

David Snider<sup>a,\*</sup>, Karen Thompson<sup>a</sup>, Claudia Wagner-Riddle<sup>a</sup>, John Spoelstra<sup>b</sup>, Kari Dunfield<sup>a</sup>

<sup>a</sup> School of Environmental Science, University of Guelph, Guelph, Ontario N1G 2W1, Canada  
<sup>b</sup> Canada Centre for Inland Waters, Environment Canada, Burlington, Ontario L7R 4A6, Canada



# Evaluating 4R practices for reduced N<sub>2</sub>O emissions



4R Nutrient Stewardship can **help** grow crops sustainably

The 4Rs work to increase production/profitability for farmers while ensuring the future of the agricultural industry



<https://fertilizercanada.ca/nutrient-stewardship/>

## EEF: Fertilizer + nitrification and urease inhibitors

RIGHT  
N P  
K  
SOURCE

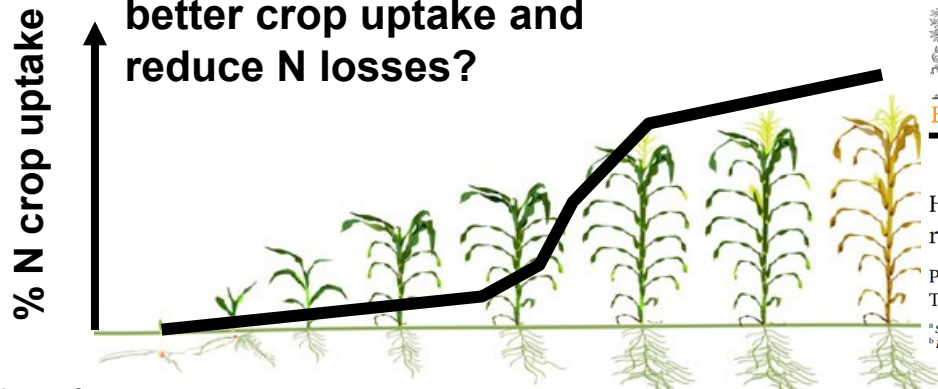


VS.



- Significant reductions in N<sub>2</sub>O emissions were measured
- Response is dynamic and varies with weather (need to manage Hot Moments)

Question: do EEFs  
delay N release for  
better crop uptake and  
reduce N losses?



Agriculture, Ecosystems and Environment 300 (2020) 106996

Contents lists available at ScienceDirect



ELSEVIER

Agriculture, Ecosystems and Environment

journal homepage: [www.elsevier.com/locate/agee](http://www.elsevier.com/locate/agee)



High temporal resolution nitrous oxide fluxes from corn (*Zea mays* L.) in response to the combined use of nitrification and urease inhibitors

Pedro Vitor Ferrari Machado<sup>a,\*</sup>, Katarina Neufeld<sup>a</sup>, Shannon E. Brown<sup>a</sup>, Paul R. Voroney<sup>a</sup>, Thomas W. Bruulsema<sup>b</sup>, Claudia Wagner-Riddle<sup>a</sup>

<sup>a</sup> School of Environmental Sciences, University of Guelph, 50 Stone Road East, Guelph, ON, N1G2W1, Canada

<sup>b</sup> International Plant Nutrition Institute, 18 Maplewood Drive, Guelph, ON, N1G1L8, Canada





# Inform policy makers

WORKSHOP PACKAGE

## Policy Options for Improved Efficiency in Nitrogen Fertilizer Management

March 10, 2020—09:00AM to 03:00PM

Guelph Turfgrass Institute, 328 Victoria Rd S, Guelph, ON N1H 6H8

**Organizers**—Dr Claudia Wager-Riddle, University of Guelph; Paul Smith; Cameron Ogilvie, *SOILS AT GUELPH*

**Facilitator**—Bronwynne Wilton

### Background

The Smart Prosperity Institute (SPI) is beginning a multi-year engagement around sustainable agriculture in 2020. The research and convening will focus on a set of in-depth case studies for key regions and commodities, emphasizing environmental issues such as greenhouse gas emissions, soil health and water quality.

## Protocol development

Alberta Government

### Quantification Protocol for Agricultural Nitrous Oxide Emission Reductions Specified Gas Emitters Regulation

Version 2.0

September 2015

<https://www.alberta.ca/alberta-emission-offset-system.aspx#toc-2>

A workshop between with stakeholders to:

- Review current programs and policies that affect nitrogen fertilizer use in Ontario
- Understand barriers and opportunities to improve nitrogen use efficiency
- Discuss policy options for improving nitrogen use efficiency and reducing the environmental impact of nitrogen fertilizer use



# Communicating with farmers and general public



## CONTENTS

- 1 Background
- 2 Site Description
- 3 Lysimeter Installation
- 4 Soils
- 5 Cropping History
- 6 Measurements & Data

## BOOKMARKS

- Elora Research Station Weather Data
- SHIC Lysimeter Dataverse
- Soil Health Interpretive Centre



# Training the next generation of scientists



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## Addressing climate change through soil science training

The CREATE in **Climate-Smart Soils** (CREATE-CSS) is the first **multi-institutional soil-centered program** to address the need for highly qualified personnel training to sustainably lead Canada's agri-food sector.

FIND OUT MORE



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CONSEIL CANADIEN DE  
CONSERVATION DES SOLS

# Hey Canada!

It's time to #SoilYourUndies...  
in the name of soil conservation

<https://smartsoils.ca/>





Thanks to students, funders and collaborators!



Thank you for your attention!

Contact information:  
[cwagnerr@uoguelph.ca](mailto:cwagnerr@uoguelph.ca)