The Australian nitrous oxide research program

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Abstract
Nitrous oxide emissions are highly variable across industries, soils, climates and management practices. The Australian Nitrous Oxide Research Program (NORP) is a network of six experimental sites developing spatial and temporal scaling tools using both automatic and manual chambers comparing best management practices to reduce emissions whilst maintaining agricultural productivity and profitability. NORP delivers multiple benefits to Australia's primary producers through a comprehensive database for advanced analysis of N_2O emissions datasets, aligned with soil C, climate, and management data with easy access for end users and the simulation community.

Key Words
Nitrous oxide, mitigation, chambers, nitrogen, simulation.

Introduction

Full greenhouse gas accounting is critical when developing emissions reduction strategies for irrigated and dryland farming systems. The relatively short duration, episodic emissions of the most potent greenhouse gas (nitrous oxide - N_2O) are closely related to water, carbon and nitrogen management require specific attention. To fully understand the implications of soil and plant management and the biophysical interactions requires the collection of long-term, high spatial and temporal resolution data afforded by automatic greenhouse gas monitoring systems. Australia is at the forefront of evidence based agricultural production and greenhouse gas research. It is also the only country which has taken the initiative of developing a purpose built Tier 3 greenhouse gas accounting system, the National Carbon Accounting System (NCAS) which includes both carbon and nitrogen emissions from soils. High quality calibration and validation data are critical elements in any predictive modelling examining the impact of management options and developing mitigation strategies.

An informal network of automated high (spatial and temporal) resolution greenhouse gas sampling devices has existed in Australia since 2005, the majority using the automated sampling and analysis system with gas chromatography and infra-red CO_2 analysis, based on the design of Butterbach-Bahl *et al*. (1997). Since 2009, the Australian Nitrous Oxide Research Program (NORP) has explicitly linked six experimental sites from around Australia collecting real-time N_2O emissions data, as well as carbon dioxide (CO_2), and (in some cases) methane (CH_4) consumption data from a broad geographical range of irrigated and dryland, crop and pasture farming systems. Fourier Transform Infrared Spectroscopy (FTIR) and Tuneable Diode Laser (TDL) technologies are also being used at some sites.

The objective of NORP is to develop a detailed biophysical understanding of the processes and agricultural practices influencing N_2O emissions from agricultural systems of Australia. This will provide landholders with management strategies which have a significant impact on reducing N_2O losses whilst maintaining productivity and profitability as well as the base data for the further development and testing of the NCAS. NORP is principally funded by the federal Department of Agriculture, Fisheries and Forestry (DAFF) under its Australia's Farming Future (AFF) initiative (2009-1012), with additional funding from four Research and Development Corporations (RDCs) – Grains (GRDC), Sugar (SRDC), Dairy (SRDC), Cotton (CRDC) and Incitec Pivot, as well cash and in-kind contributions from state governments and university participants.

Methods

The major elements of NORP are an overarching integration and coordination project; six automated greenhouse gas sampling and analysis projects with multiple treatments at experimental locations throughout Australia; and a laboratory based project examining the impact of nitrification inhibitors on N_2O production. The specific activities of the integration project are the development of standardised data collection protocols in concert with the analogous soil carbon program (also funded by DAFF through the AFF initiative); a methodological comparison at selected sites within the automated site network, specifically an investigation into the spatial-temporal relations between manual and automatic sampling methods; the development of a web-based remote data management; and the overall management and technical oversight of the NORP.

The integration project coordinates data acquisition, database development and maintenance, data entry and web-based management, synthesis, analysis and retrieval. The database is totally scalable to ensure addition of new sites as they come on-line. The objective comparison and development of scaling methods between chambers and methodologies also lays the foundation for future investments with respect to comprehensiveness in data acquisition and the timely identification of best management practices for mitigation. The integration project also provides a centralised data platform for the development of the NCAS as well as diverse farming systems simulation groups to improve their own models and collaborate with peers in the simulation of greenhouse gas emissions. Whilst N_2O mitigation is the underlying premise, CO_2 and CH_4, along with ancillary soil nutrient and water, plant growth, development and climate data is collected at high temporal and spatial resolutions at the majority of the experimental sites.

The location of the experimental sites and their specific objectives are:

1. Grains/cotton (Queensland) – irrigated systems at Kingsthorpe, 10 km east of Toowoomba, examining the impacts of water management on emissions.
2. Grains (Western Australia) – rainfed systems at Wongan Hills, examining the emissions of N_2O associated with the substitution of grain legumes for sources of nitrogen, and the liming of cereals.
3. Grains (New South Wales) – rainfed systems at Tamworth, examining the use of legumes as alternate nitrogen sources in cereals.
4. Sugar cane/grains (Queensland) – rainfed systems at Mackay. The treatments include the use of nitrification inhibitors with fertilisers to reduce N_2O emissions and substituting legume sources of nitrogen for fertilisers.
5. Dairy (Victoria) – high rainfall pasture systems at Terang, measuring N_2O and CO_2 emissions following the application of urine and inhibitors at the DemoDairy site.
6. Grains (Victoria) – high rainfall systems at Hamilton, measuring N_2O and CO_2 emissions from direct drilled and conventionally sown legume/wheat rotations, including the use of nitrification inhibitors.

Results

The NORP sites have gradually been activated since May 2009, with the first full season of data available for release from the majority of sites in mid 2010. The data from each of the sites will be presented at the 19th World Congress of Soil Science.

Conclusion

The basic biogeochemical processes underpinning N_2O emissions are generic across soils and climates, with the sharing of management specific information across the primary industries enhancing the development of robust mitigation strategies and the development of whole system accounting methods for reducing greenhouse gas emissions from mitigation simulation for all industries.

References

Butterbach-Bahl K, Gasche R, Breuer L, Papen H (1997). Fluxes of NO and N_2O from temperate forest type, N deposition and of liming on the NO and N_2O emissions, *Nutrient Cycling in Agroecosystems* **48**, 79-90.