Flux-tower measurement of N_2O flux from Irish grasslands

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Abstract

Nitrous oxide (N_2O) is a powerful greenhouse gas (GHG), having warming potential almost 300 times that of carbon dioxide. One of the main sources of N_2O emission in Ireland is agriculture, which uses high amounts of mineral nitrogen fertilizers and disposes of organic nitrogen in forms of dung and slurry. Furthermore, denitrification processes convert these into gaseous forms, such as N_2O, N_2, NO and others. These emissions are highly variable in space and time and are known to be controlled by nitrogen availability, soil organic carbon and moisture and temperature conditions. Two techniques, closed chambers and eddy covariance, were employed to estimate N_2O flux from Irish grasslands. Seven field sites were established across the Munster province in south-western Ireland for chamber measurements. All sites were located at active dairy or beef farms, and had basic meteorological stations, recording soil temperature, moisture and rainfall at thirty minute intervals, installed. Soil samples taken at the field sites were analysed for common chemical parameters with emphasis on various nitrogen forms. The general NitroEurope methodology was used for sampling. Chamber- and ambient-air samples collected weekly were stored in air-tight pre-evacuated containers and their analysis was performed on a gas chromatograph within 48 hours of collection. One of the sites near Donoughmore, Co. Cork, has an eddy covariance tower producing 10 Hz wind direction and speed data, along with a trace gas analyser system for N_2O concentration. The preliminary measurements of N_2O fluxes between mid-April and the end of August 2007 amounted to an emission of 1.3 kg N / ha.

Introduction

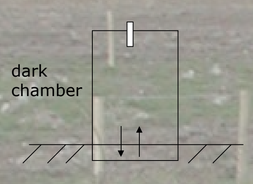
Nitrous oxide is one of the main contributors to increasing the warming potential of the planet. It is being produced in both nitrification and denitrification processes in top soil. Dependency on slurry, manure and urine patches stipulates high spatial variability of fluxes. The eddy covariance technique allows for permanent measurements of emission without disturbance of soil cover and on larger scales. Technique, based on assumption that turbulent eddies are responsible for the vertical transport of gases, requires high frequency measurements of wind velocity and gas concentration.

Methods

Two independent methods are used in this research:

$$flux = \frac{\Delta m}{A \Delta t}$$

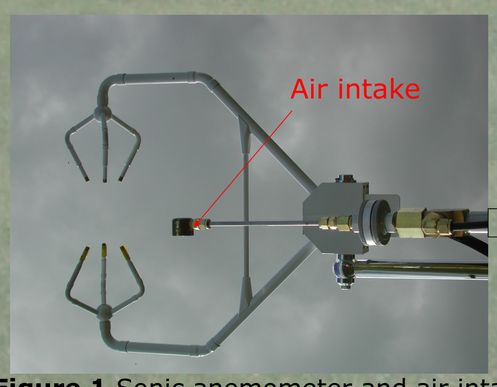
- Closed chambers:
  - ✓ Known volume / area
  - ✓ Known period of time
  - ✓ Measured concentration
  - ➢ Calculated flux
- Eddy covariance (EC):
  - ✓ Measured wing direction and velocity
  - ✓ On-site measured concentration
  - ✓ Calculated flux
  - ➢ Corrected flux



Simple, reliable technique
Widely used
Soil disturbance
Doesn't capture spatial variability
Possible sample handling issues

Remote technique
Large footprint area
Continuous measurements
Complex terrain / high vegetation issues
High costs of installation and maintenance

$$\overline{wc} = \overline{\overline{w}\,\overline{c}} + \overline{w'c'}$$



Sonic anemometer
- 6 m height
- 10 Hz 3D wind speed / direction data

Trace Gas Analyser System (TGA100A, Campbell Sci.)
- N_2O concentration at the same rate

Figure 1 Sonic anemometer and air intake

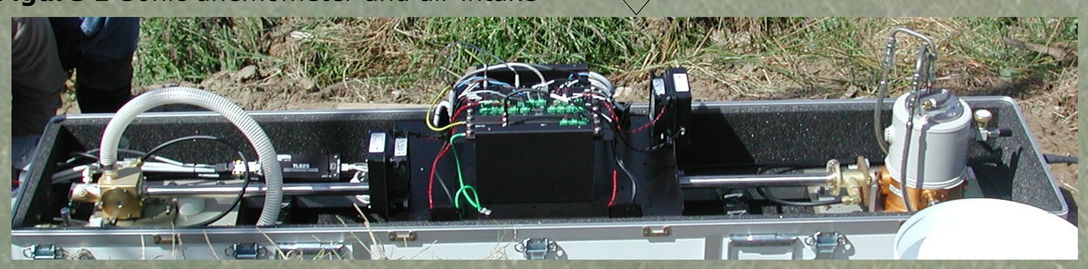


Figure 2 Tuneable diode laser

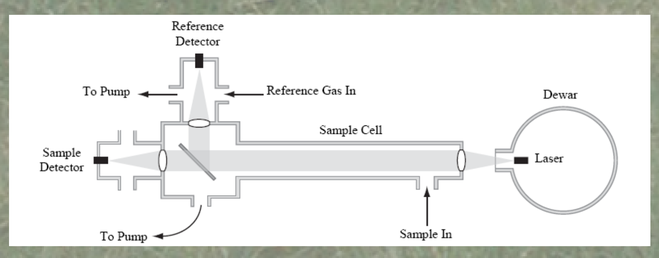


Figure 3 Principal scheme of tuneable diode laser

Tuneable diode laser absorption spectroscopy:

$$C_{sample} = \frac{C_{ref} L_{ref} D}{L_{sample} + L_{sample\text{-}long}(1 - D)},$$

where $D = \frac{A_{sample}}{A_{ref}}$

- Permanent weather conditions monitoring: soil moisture, soil temperature, precipitation

Location: Donoughmore, Co. Cork

Surrounding area

Results

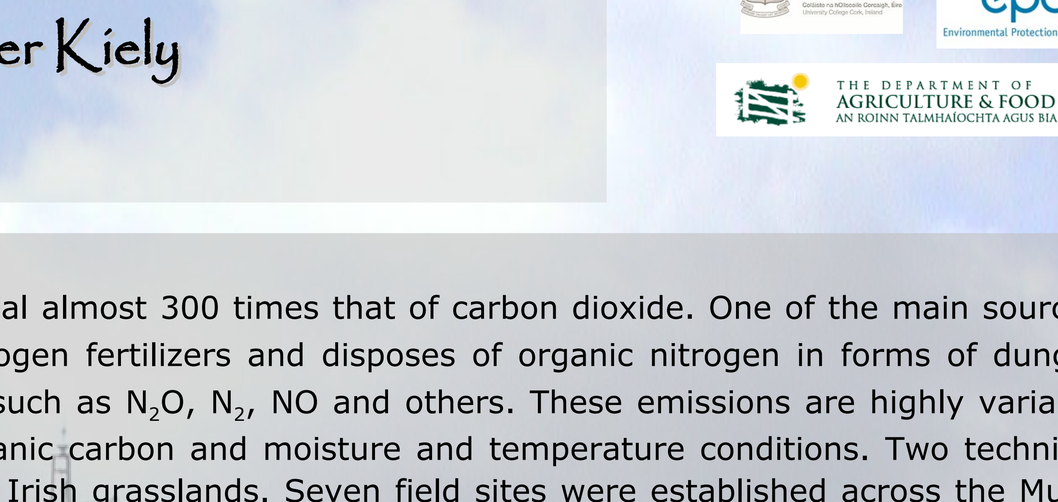


Figure 4 N_2O concentration and vertical wind velocity on 27th August 2007, 16.00 – 16.30

Steps: Pre-filtering, quality assurance, lag, yaw and pitch rotation of the wind direction; de-spiking and de-trending of concentration; covariance calculation.

~ 250 mg / ha

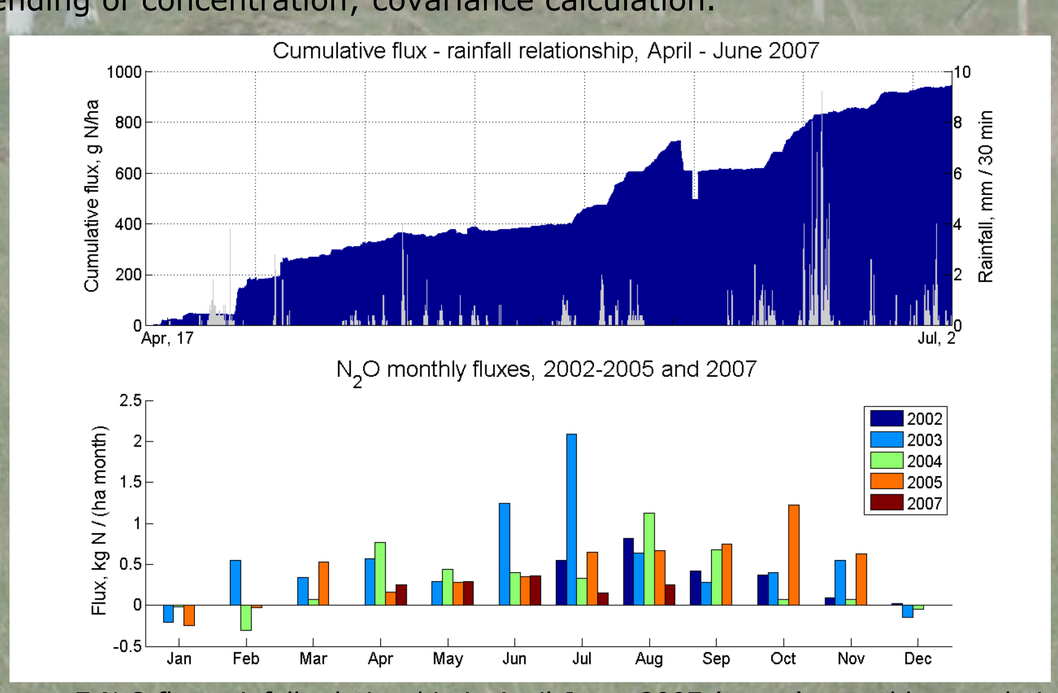


Figure 5 N_2O flux-rainfall relationship in April-June, 2007 (upper), monthly cumulative fluxes in 2002-2005 and 2007 (lower).

Annual cumulative fluxes, 2002–2005 and 2007

Year	2002 (5.5 months)	2003	2004	2005 (11 months)	2007 (4.5 month)
Annual flux, kg N/ha	2.273	6.582	3.555	4.959	1.301

Discussion

A significant portion of N_2O is being produced in a limited number of emission events (pulses), occurrence of which is mainly regulated by micrometeorological parameters (such as precipitation and soil temperature), as well as the presence/introduction of mineral and organic N (i.e. management practices). The robustness and reliability of the EC technique help in accounting of total N_2O emission of grass lands on a landscape scale. Intensive use of pastures are prone to increasing percentage of N_2O being lost to the atmosphere.

Based on the eddy covariance measurements we will develop a mathematic model of soil biogeochemistry, which will be used to simulate and predict fluxes of nitrous oxide and other trace gases.

References

- Leahy, P., Kiely G. and T. Scanlon. (2004) Managed grasslands: a greenhouse sink or source? Geophysical Research Letters **37**, L20507.
- Scanlon T., Kiely G. (2003) Ecosystem-scale measurements of nitrous oxide fluxes for an intensely grazed, fertilized grassland. Geophysical Research Letter, **30**(16), ASC 9.

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