

Control of N2O emissions by soil hydraulic functioning at the local scale

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Control of N₂O emissions by soil hydraulic functioning at the local scale



Hénault C., Rabot E., Lacoste M., Cousin I.

INTRODUCTION

N₂O emissions are largely controled by soil WFPS

WFPS, combines informations on soil water content and on soil porosity. It is a proxy of the aerobic status of soil



Example of th Fw function in N₂O models (from Hénault and Germon, 2000)

The relation between soil WFPS and N₂O emissions (denitrification) is exponential, N₂O emissions are very sensitive to little changes in soil WFPS

This creates large uncertainties in N₂O assessments by simulations







To investigate the « soil – water » interactions at the local scale and their consequences on soil N₂O emissions

CONTENTS

 \geq Dynamics of N₂O emissions during wetting-drying cycles

 \geq Soil porosity and N₂O emissions during wetting-drying cycles

> Modeling of new knowledges ...







01 Dynamics of N₂O emissions during wetting-drying cycles



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Study site

- Cultivated with rape (Brassica napus L.)
- Classified as Glossic Retisol (WRB, 2014)
 - Silt loam texture

clay = 13.7%, silt = 82.0%, sand = 4.3%

- Soil organic carbon = 9.5 g kg⁻¹
- Bulk density = 1.43 g cm⁻³

Soil sampling

Undisturbed soil core collected in a PVC cylinder (13.2-cm diameter by 7-cm height) from the surface horizon





N₂O measurements

- Closed-chamber method
- N₂O monitoring: infrared correlation spectroscopy (N₂O Analyzer model 46i, Thermo Scientific), detection limit 0.02 ppm, concentration value recorded every minute
- Flux calculated linearly from the observed change in N₂O concentration during the first 10 min after the chamber was closed





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- Main peaks of N₂O emissions are observed
 - → not during the wetting phase
 - \rightarrow but during the drying one
- The shapes of the peaks depend of the rate of the drying phase
 - Peaks are attributed to
 - → N₂O dissolution during the wetting phase
 - → N₂O transport when soil pores are reconnected
- To continue to investigate the effect of soil structure (porosity)
- ➡ To introduce a transport module and a dissolution module into N₂O models





O2 Study of the soil porosity and N₂O emissions during wetting-drying cycles







X-ray computed tomography



Medical X-ray scanner: Siemens Somatom Definition AS

Acquisition time: 70 s

Voxel size: 316 × 316 × 100 µm

1 scan at the end of the wetting phase

7 to 9 scans during the drying phase
Alternating with N₂O measurements





Image analysis

Pre-processing: ImageJ (Rasband, 1997-2014) and Avizo software



- Description of the pore network geometry : Image J software, C/C++ QuantIm library (Vogel, 2008)
 - Volume of air-filled and water-filled macropores
 - Euler number : connectivity of the air-filled pore space (vogel et al., 2010)
- Functionning description
 - Relative gas diffusion coefficient (DS/D0) from the segmented air-filled pore space





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03 Modeling of this new knowledges





The NOE ALGORITHM (Hénault et al., 2005 – Global Change Biology)

 $N_2O = (N_2O)_{denit} + (N_2O)_{nit}$ • denit = K. F_T . F_{NO3-} . F_{WFPS}

• nit = $f \cdot (H_m \cdot [NH_4^+] \cdot T)$

Biological parameters

Environmental functions and parameters











Conceptual proposition (NOE_{GTE})

A transport module

- 1D diffusion equation of Fick
- Use of the Millington and Quirk model (1961)

A dissolution module

 A gas-liquid equilibrium according to Henry's law



Fig. 1 Simulated nitrous oxide flux with time for water-filled pore space in the range [0, 1]. At time = 0 h, initial conditions were applied. For the next time increments, the nitrous oxide production module, and the gas transport and equilibrium modules were activated

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Experimental evaluation

Measurements and simulation of N₂O emissions in laboratory on undisturbed soil cores submitted to wetting/drying cycles with different rates



Fig. 5 Measured (*black squares*) and 95 % confidence interval of simulated N₂O fluxes (*grey areas*). Sample names refer to the number of decreasing pressure heads applied during one wetting-

drying cycle (Fast: 3 values, Medium: 4 values, Slow: 6 values, *BD* bulk density in g cm⁻³). *Yellow areas* represent the drying phases, and *white areas* the wetting phases. (Color figure online)

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Great interest of dynamic studies : they have revealed peaks of N₂O emissions during the drying phase of wetting-drying cycles

To continue to characterise soil structure, pore soil network. This is probably a key for understanding soil emissions dynamics (our study could be improved by higher resolution tomography) and intensity.

To continue to define some physical indicators of soil structure and to introduce them in modeling





