Evaluation of a closed tunnel for field-scale measurements of N_2O fluxes at the soil-atmosphere interface

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Background & Objectives

Emissions of the powerful greenhouse gas nitrous oxide (N_2O) from soils are commonly highly variable in space. An upscaling of classical small-scale chamber measurements is thus questionable and adds uncertainty to emission inventories or empirical emission factors. Therefore, field-scale approaches will become increasingly important. Since micrometeorological tech-niques are often limited by stable atmospheric conditions and their low spatial resolution, we used a closed tunnel on an area of 500 m^2 equipped with an open-path Fourier Transform Infrared (FTIR) spectrometer and aimed to

(i) evaluate its feasibility for measuring N_2O concentrations and calculating field-scale N_2O fluxes from an unfertilized grassland soil and

(ii) compare those results with small-scale fluxes obtained from closed chamber measurements.

Tunnel experiment, chambers and flux calculation

- Measuring plot: unfertilized grassland on Gleyic Podzol in North Germany
- Tunnel: Aluminium liner structure (99 m × 5 m × 0.6 m), closed with a plastic cover for emission measurements (Figure 1a,b); N_2O concentration measurements by path-averaged Fourier transform infrared (FTIR) spectrometry

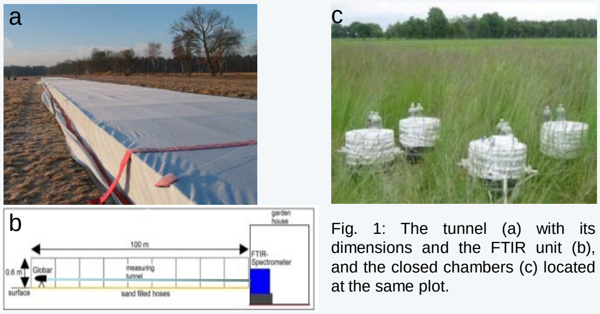

Fig. 1: The tunnel (a) with its dimensions and the FTIR unit (b), and the closed chambers (c) located at the same plot.

- **Calculation of a predeployment N_2O flux Q_0 by inverse modelling (IMQ0) (Schäfer et al., 2012)**: 1D numerical model which takes into account specific tunnel geometry, N_2O diffusion from soil into the tunnel, N_2O diffusion within the tunnel atmosphere, N_2O detection by FTIR in 0.3 m above ground, and the diameter of the radiation beam (0.1 m)
- Concurrent **small-scale (0.05 m^2) chamber measurements in close vicinity to the tunnel**; calculation of N_2O fluxes from four concentration measurements using the NDFE model (Livingston et al., 2006)

Results

- Combined tunnel / FTIR method enables precise, high-density concentration measurements (about 12 per hr) during stable atmospheric conditions
- Measurements are biased by high wind speeds, heavy rain and sun radiation (Figure 2a)

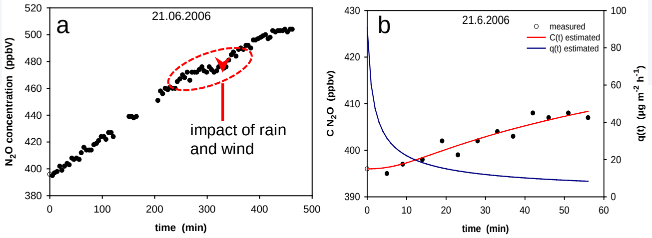

Fig. 2: Representative time course of N_2O concentrations during a single measuring campaign (a) and measured concentrations during the first measuring hour with inversely estimated N_2O concentrations and N_2O flux q(t) (b).

- Reliability of the IMQ0 model was confirmed using site-specific „virtual emission scenarios“ (Schäfer et al., 2012)
- IMQ0 flux estimation was succesfully applied to the experimental data (Figure 2b)
- N_2O fluxes measured by the tunnel were small at a typical positive background level, whereas chamber-derived fluxes partly exhibited huge variability and slight N_2O uptake (Figure 3a,b)
- High emissions obtained by single chambers occurred after rainfall events, but this hot spot behaviour was obviously not representative for the field or tunnel scale

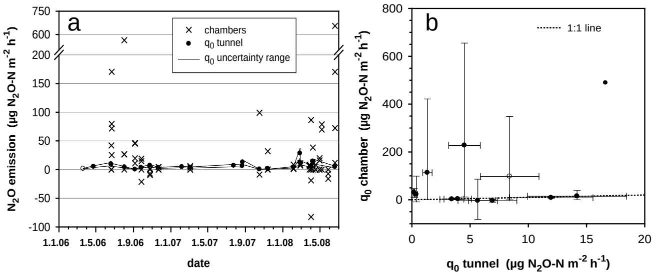

Fig. 3: Comparison of N_2O fluxes obtained by the small-scale chamber and field-scale tunnel methods.

Conclusions

- ❖ **N_2O concentration measurements with the tunnel / FTIR set up are reliable, especially for dry, stable nocturnal conditions**
- ❖ **The IMQ0 model predicts the unbiased, pre-deployment N_2O flux with a good accuracy**
- ❖ **Field-scale tunnel method may serve as a gap-filling technique between small-scale chamber and ecosystem-level micrometeorological methods**

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References:
Livingston et al., (2006) *Soil Sci. Soc. Am. J.*, 70, 1459-1469.
Schäfer et al., (2012) paper in press, doi:10.2135/jeq2011.0475, *J. Environ. Qual.*