N_2O Chamber Intercomparison Campaign 2014, Hyytiälä, Finland

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1. Introduction and motivation

Chamber measurements are associated with systematic and random errors, mainly related to estimation of the flux based on single chamber measurement, and related to the large spatial variability of the soil flux and the low spatial coverage of the measurements. It is difficult to detect small N_2O concentration changes in the chamber headspace using gas chromatography (GC). Recently N_2O laser instruments have become available for soil N_2O flux measurement, and have practically eliminated this problem of random error when estimating the flux for a single chamber.

Systematic errors are typically related to pressure changes inside the chamber, effects of wind speed, or leaking of the chamber. Chamber measurements are based on the assumption that the soil gas storage under the chamber does not change, but pressure and wind effects violate this assumption. In an ideal case, the gas flux during the enclosure saturates, an exponential function is fitted to the gas concentration data against time, and the flux is calculated in the beginning of the enclosure using the fitted parameters of the exponential function. However, if gas is accumulating in the soil then the rate of gas concentration change in the chamber headspace is too low in the beginning, causing erroneous curvature for the exponential function. This naturally leads to underestimation of the flux. In the opposite case, for example if the fan is ventilating the chamber headspace too efficiently, then using exponential fit causes overestimation of the flux. Systematic errors of CO_2 chambers have been quantified by Pumpanen et al. (2004) and systematic errors of static CH_4 by Pihlatie et al. (2013) and Christiansen et al. (2011). In this study, we aim to gain more knowledge on the errors, and also provide methods to control them.

2. Scientific objectives

In this study, we wish to investigate how much changes in the soil gas storage under the chamber affects the N_2O flux estimation, how to identify this in data analysis, and how to correct the flux for the storage effect. In addition, in this study we measure the leaking of the chambers.

3. Reason for choosing station

The N_2O Chamber Intercomparison Campaign in Hyytiälä, Finland, is described in the InGOS project description (DOW Task 5.2)

4. Method and experimental set-up

We tested the chamber at different sand depths (10 and 20 cm) and at different wind speed velocities (external fan OFF or ON) using a calibration tank, where the control N_2O flux was measured based on the N_2O concentration change inside the tank. During the campaign, all investigated chambers will be treated as similarly as possible with respect to enclosure time and N_2O analysis. This is done in order to ensure a uniform protocol throughout the campaign and thus produce the most comparable results. If the chamber is equipped with fan and/or pressure vent-

tube, these attributes should be used as in a normal operation. Once the soil collar has been installed in the sand bed and the whole system has been allowed to settle then the chamber measurement can start. We have chosen a fixed chamber enclosure period of 10 min for all chambers and allow the gas concentration gradient in the sand bed to reestablish for 20 min between measurements. In addition to the standard measurement program, I also tested:

- The chamber with an extension part (10 cm sand bed, external fan OFF)
- My normal gas sampling procedure used for field work (1.5 hr enclosure period; four gas sampling events)
- Normal gas sampling procedure, incl. vent tube which was open during gas sampling

5. Research materials, instrumentation

I brought a two-part static chamber (collar and chamber). The physical dimensions of the chamber is 60 * 60 * 15 cm (B * W * H). I also brought an extension part, which results in a 60 cm high chamber. A N_2O laser (Aerodyne QCL) was used for continuous N_2O analysis of the chamber headspace. Hence, the chamber was used in non-steady-state flow-through mode. An additional Aerodyne laser was used to measure N_2O concentrations at different depths (5, 7.5 or 10 cm) in the sand bed below the chamber. Finally, a LOS GATOS N_2O laser measured N_2O concentrations in the calibration tank.

6. Preliminary results and conclusions

Measurements of N_2O concentrations in the sand bed below the chamber showed clear pressure effects when the chamber was closed, although a vent hole with 4 mm inner diameter was open during chamber closure. After chamber closure, the sand bed N_2O concentration dropped 20-50 ppb due to bulk flow of ambient air from the chamber headspace into the sand bed below the chamber. The overpressure in the chamber was mainly caused by a gas-tight water seal between the soil collar and the chamber. Due to uneven conditions in the field, it is often impossible to place soil collars 100 % horizontally and therefore 1.5-2 cm of water is needed in the water channel to ensure a gas-tight seal.

Within the 10 min enclosure period, the sand bed concentration returned to the original level (level before chamber closure). For the 1.5 hr enclosure periods, sand bed concentrations continued to increase significantly above the original level, indicating N_2O accumulation in the sand bed, potentially leading to underestimation of N_2O fluxes. At present, I only have access to the GC analyses of the manual gas samples collected during the 1.5 hr enclosure periods (Fig. 1).

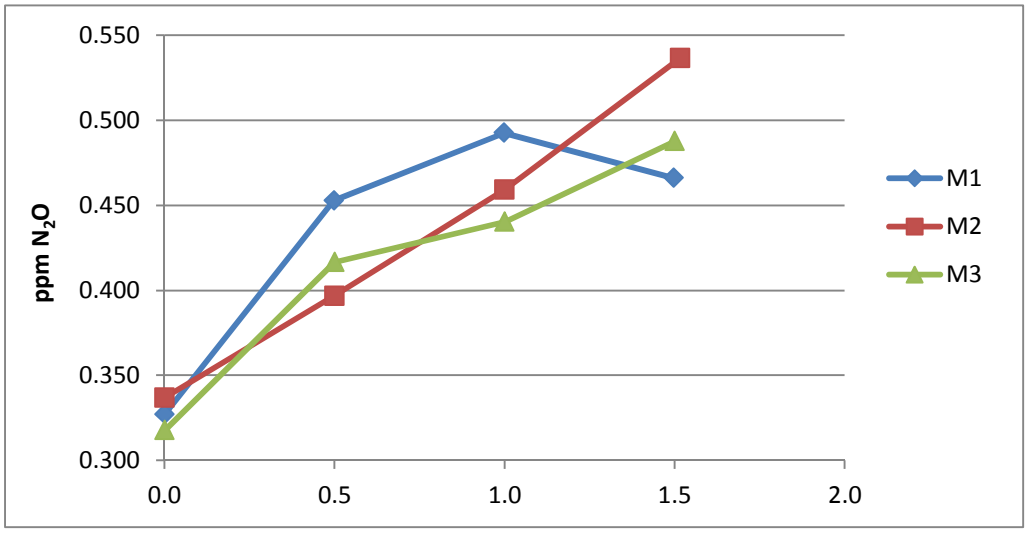

Fig. 1 GC analyses of gas samples collected from chamber headspace during three 1.5 hr enclosure periods performed to test field procedure for N_2O flux measurement

Despite the extremely controlled gas flux conditions, the first test (M1) shows an odd development in headspace N_2O concentrations. The following tests (M2 and M3) show more consistent concentration changes, resulting in flux rates of 34 and 27 µg N_2O-N m^{-2} hr^{-1}, respectively. The second test (M2) was done using an open vent tube during gas sampling.

7. Outcome and future studies

In the coming data analysis, we will compare N_2O flux rates determined using chamber data with the "true" flux rate determined from N_2O concentration changes in the calibration tank. In addition, we will use profile N_2O measurements in the sand bed to understand the physical phenomena, which are biasing the N_2O flux rate estimation using static gas-flux chambers.

8. References

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