Gembloux Agro-Bio Tech
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AgriGES
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Nitrous oxide flux measurement with a closed chamber system : data treatment

Introduction

The present study is part of the AgriGES project, which aims at quantifying methane and nitrous oxide emission from pastures and crop fields, respectively. Experimental measurement campaigns of N_2O fluxes have been performed in the area of Gembloux, using a system of dynamic closed chambers. In this poster, we discuss how to estimate fluxes from the N_2O concentration data, using different curves to fit these data points. The goodness-of-fit of these curves is used to sort between relevant and irrelevant fluxes. A comparison of the fluxes estimated by these different fits is also performed. These points will be illustrated with the data collected during an experimental campaign on a bare soil with control of water and nitrogen inputs, from the 25th of August to the 29th of September 2014.

Experimental setup

Experimental setup is shown in fig 1. It is composed of eight chambers which are closed each one in turn for 30 minuts, forming a cycle of 4 hours + 30 minuts during which all chambers are left wide opened for the system to purge. During the enclosure period, N_2O acccumulates in the chamber and its concentration within the chamber is measured every 30 seconds. These data are then used to estimate the flux emitted from the soil to the atmosphere. Two moisture probes are placed at the center of the two squares delimited by the chambers.

Fig.1 : Experimental setup made of eight chambers. The closed chamber is the one in which N_2O concentration is measured during the enclosure period, then this chamber reopens and the following chamber is closed.

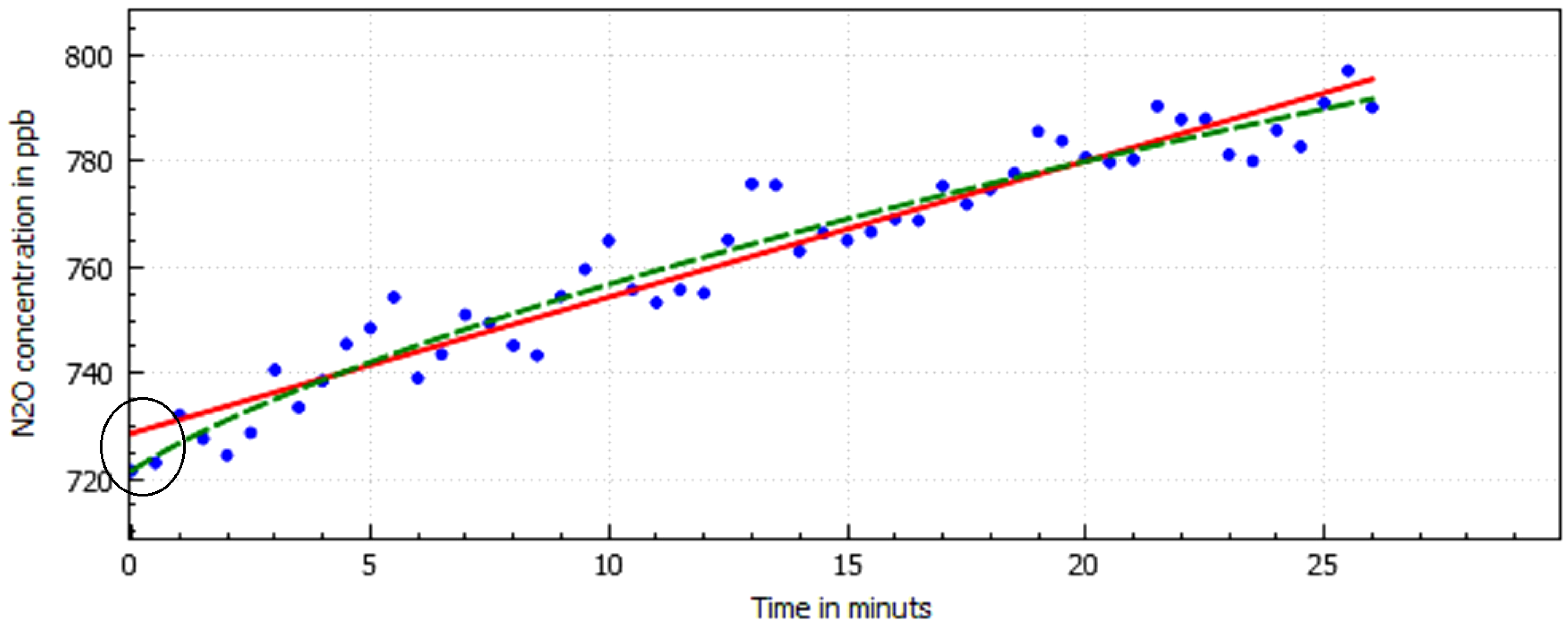

Fig.2 : N_2O accumulation in a chamber during its enclosure period. Linear (red) and NDFE (green) best fit of the data. The flux is supposed directly proportional to the slope of the fit at time t=0.

Flux estimation method

A software has been coded in C++ in order to visualize the chamber concentration data. Several fits (polynomial and Non-steady Diffusive Flux Estimator (NDFE, Livingston et al. 2005 and 2006)) can be performed on these data, using the least square method, and the flux is supposed proportional to the slope of the fit at time t=0, i.e. at the time where the flux is the least influenced by the chamber enclosure.

Linear vs. NDFE fit

Linear fits are still widely used in the litterature to estimate N_2O fluxes, despite several well-referenced drawbacks compared to more elaborate fits. Its main drawbacks are: 1) there is no theoretical basis to explain why the linear fit should be used, 2) a poor performance compared to other fits (see fig.3b), and 3) a strong tendancy to underestimate fluxes compared to other fits. See Fig. 2 and 3a for an illustration. During the measurement period from the 25th of August to the 29th of September 2014, cumulative flux estimated by the linear interpolation was 40% lower than the cumulative flux estimated by the NDFE fit.

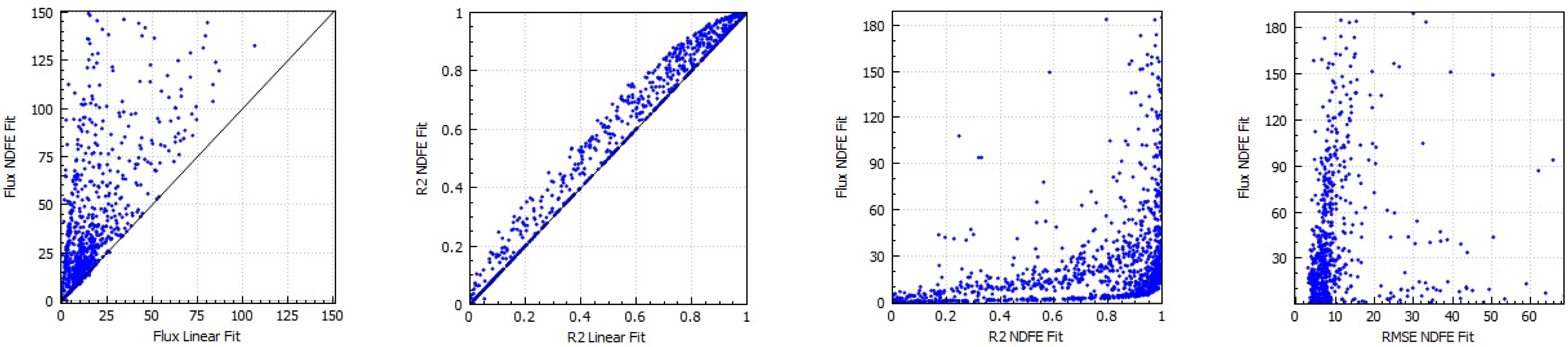

Fig 3. All fluxes expressed in ng N_2O-N m^{-2} s^{-1}. a) linear vs. NDFE flux estimation, b) linear vs. NDFE fits r^2, c) r^2 vs flux estimation of the NDFE fits, and d) RMSE vs flux estimation of the NDFE fits. 1632 concentration data have been used dating from the 25th of August to the 29th of September.

Sorting data - Goodness-of-fit

Due to the precision of the measurement device, temporary failures (e.g. a chamber uncorrectly closed) and/or exceptional conditions pertubing the system (e.g. heavy winds influencing pressure in the chambers), a large part of the estimated fluxes can not be considered as relevant and should therefore be dismissed.

Discriminate between relevant and irrelevant can be partially automated using the goodness-of-fit of the concentration fit. The most widely used statistical parameter is the correlation coefficient (r^2). However, the r^2 coefficient always tends to be lower for lower fluxes. Thus, using r^2, one tends to preferentially eliminate lower fluxes, leading to an artificial increase of the background flux (see fig. 3c). On the examined data set, the root mean square error (RMSE) of the fit seems the best paramater in order to sort the fluxes, since we observe a very low correlation between the flux value and the corresponding RMSE (see fig. 3d).

Results - Flux dynamics vs Soil moisture

Fig. 4 represents the emitted nitrous oxide flux (red), evaluated with the NDFE model, over the measurement period. On the same graph, the soil moisture is also represented in black. One can clearly see the moisutre peaks resulting from the weekly watering (plus soluble nitrogen input) and the emission peaks appearing 24 to 48 hours after the watering events. These peaks are due to the denitrification process occuring in anoxic conditions, i.e. when the soil is wet and there is not enough oxygen anymore for the denitryfing bacteria to respire.

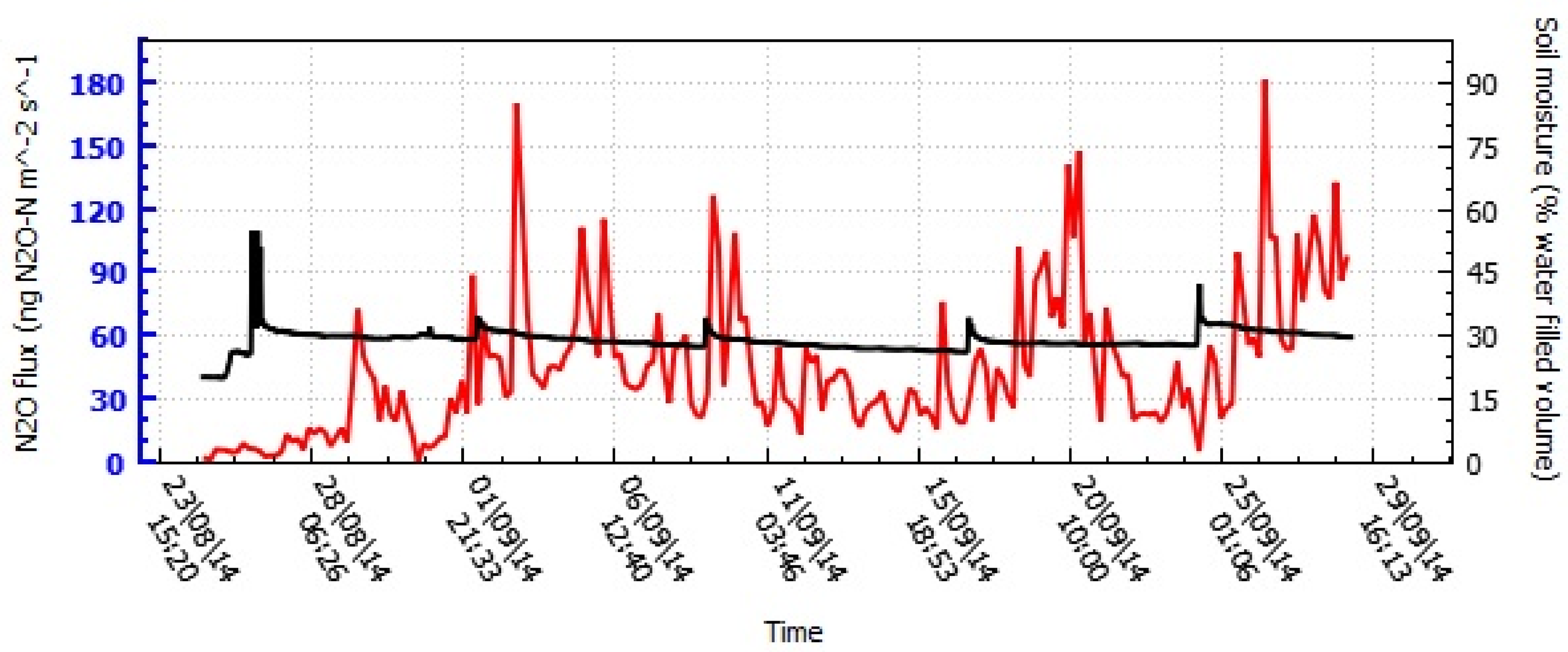

Fig.4 : Flux dynamics (red) and soil moisture (black) over the measurement period. Fluxes are computed as the mean of the eight chamber measurement over a whole cycle.

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