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Intercomparison of six fast-response sensors for the eddy-covariance flux measurement of nitrous oxide over agricultural grassland

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Nitrous oxide (N_2O) is the third most important greenhouse gas and its terrestrial budget remains poorly constrained, with bottom up and top down estimates of country emissions often disagreeing by more than a factor of two.

Whilst the measurements of the biosphere / atmosphere exchange of CO_2 with micrometeorological methods is commonplace, emissions of CH_4 and N_2O are more commonly measured with enclosure techniques due to limitations in fast-response sensors with good signal-to-noise characteristics.

Recent years have seen the development of a range of instruments based on optical spectroscopy. This started in the early 1990s with instruments based on lead salt lasers, which had temperamental long-term characteristics. More recent developments in quantum cascade lasers has led to increasingly stable instruments, initially based on pulsed, later on continuous wave lasers.

Within the context of the European FP7 Infrastructure Project InGOS (“Integrated non- CO_2 Greenhouse gas Observing System”), we conducted an intercomparison of six fast response sensors for N_2O : three more or less identical instruments based on off-axis Integrated Cavity Optical Spectroscopy (ICOS) (Los Gatos Research Inc.) and three instruments based on quantum cascade laser absorption spectrometry (Aerodyne Research Inc.): one older generation pulsed instrument (p-QCL) and two of the latest generation of compact continuous wave instruments (cw-QCL), operating at two different wavelengths. One of the ICOS instruments was operated with an inlet drier.

In addition, the campaign was joined by a relaxed eddy-accumulation system linked to a FTIR spectrometer (Ecotech), a gradient system based on a home-built slower QCL (INRA Orleans) and a fast chamber system.

Here we present the results of the study and a detailed examination of the various corrections and errors of the different instruments. Overall, with the exception of the older generation QCL, the average fluxes based on the different fast-response instruments agreed within $\pm 7.4\%$, although fluxes were moderate. The cw-QCL systems showed somewhat better signal-to-noise characteristics and a lower flux detection limit than the ICOS analysers. Intriguingly, there seemed to be some minor differences between the ICOS instruments which showed cross sensitivities to CO to varying degree. Overall the study demonstrates, that, while not cheap, both the ICOS-based instruments and the cw-QCLs are suitable for the measurement of even moderate N_2O fluxes.