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Influence of sensor type on the error of automatic chamber derived CO2 fluxes and gap-filled emission estimates

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Improved agricultural practices are considered as one of the potential solutions for mitigating global climate change. However, agricultural used landscapes are complex and their function as source and sink of greenhouse gases like CO_2, CH_4, and N_2O might differ substantially in time and space. Hence, accurate and precise information on the complex spatio-temporal gas flux pattern is needed to evaluate the effects/benefits of new agricultural practices aiming towards increasing soil organic carbon. Automatic chamber measurements are increasingly used in agricultural systems to determine emissions of greenhouse gases as well as the net ecosystem C balance (NECB). While the eddy covariance (EC) technique remains to be the most common method at field scale, automated chamber measurements might close a gap, by detecting small-scale spatial emission patterns, while still compromising a sufficient temporal resolution. Infrared gas analysers (IRGAs) have been available for decades and helped to facilitate CO_2 measurements substantially. In addition, further technical progress resulted in the development of multigas analysers, which are able to measure not only CO_2, but also CH_4, N_2O, as well as their isotopes. However, most of these analysers are rather cost-intensive and many of them are primary designed for use in the laboratory.

Here, we compare CO_2 fluxes and derived emission estimates, obtained using a widely applied IRGA (LI-850 CO_2/H_2O, Licor, Germany) with results of a new, medium cost, CO_2, CH_4, and N_2O gas analyser (ProCeas GENERAL, AP2E, France). Two of both sensors were mounted on a novel robotic chamber system ("CarboCrane"), which was installed in 2019 at an undulating summit position of the hummocky ground moraine landscape of NE Germany. The system is comprised of a gantry crane mounted on two tracks (110 m) transporting the sensors and two transparent closed chambers. Measurements of the net CO_2 exchange were performed by moving the system along the tracks with each chamber along one half of the covered area. Altogether, 36 measurement plots have been established. On each of these plots, an area for net CO_2 exchange measurement has been set up by inserting round iron frames (diameter=1.59 m) 5 cm deep into the soil on

which the transparent chambers were deployed for measurements. CO_2 fluxes were determined by measuring the development of chamber headspace CO_2 concentrations (4 sec frequency; measurements of both sensors in parallel) over chamber deployment time (7 min; see 2.5) in a flow-through non-steady-state (FT-NSS) mode (Livingston and Hutchinson, 1995). CO_2 fluxes and emission estimates were derived for all four sensors for a test period of three month (April – June 2021) at six plots, covered with winter rye situated at a mineral fertilized, non-eroded Calcic Luvisol. To guarantee an enhanced variability in measured CO_2 fluxes, the six measured plots divide into topsoil diluted and non-diluted treatments. Our results show in general a great consistency between the results delivered by both sensors and support the assumption of a rather small error fraction of the sensor type for both, the calculated CO_2 flux and the emission estimates based on it.