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Comparing laser-based gas analyzers for greenhouse gas measurements with closed chambers – precision and field applicability

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Manual chamber measurements have been widely used to monitor the three major greenhouse gases (GHG), carbon dioxide (CO_2), methane (CH4) and nitrous oxide (N2O) in natural and managed ecosystems. While the eddy covariance technique is the most common method at the field scale, automated and manual-chamber measurements are used at plot scale. Infrared gas analysers (IRGAs) have been available for decades and have facilitated CO_2 measurements substantially including the ability to use automated systems. Fairly recently, however, new technologies have evolved that lead to the development of laser-based gas analysers (LBGA) for measuring also CH4 and N2O as well as their isotopes and isotopologues. A big advantage of LBGA is the possibility to check and optimise chamber measurements directly in the field, which can lead to a better quality of flux measurements. Further, they offer the possibility to reduce the time of chamber closure whilst increasing the number of concentration data at single flux measurements. This in return reduces the potential bias from e.g. saturation and opens the chance for a higher number of temporal and/or spatial replicates (Brümmer et al. 2017), and, thus, increases the robustness of single flux estimates. However, many of the currently available devices are designed for the lab and only a few are lightweight enough to be carried into the field.

Apart from considerations of measurement precision and flux estimation, LBGAs also need a variety of characteristics that are important for researchers during in-situ measurements. Although automatic chamber systems are becoming increasingly popular, manual chamber measurements will likely be used in the future for remote study sites lacking grid power or for extensive treatment comparisons with a high number of spatial replicates. For these applications, truly field-ready LGBAs can be checked according to some criteria, inter alia, number of GHG measured with one device, recording frequency, universal applicability, reliability, portability, possibility to visualise real-time data.

Here, we compare four field-ready, promising LBGAs (as of 2017) of the major manufacturers (Picarro Inc, ABB, Ansyco GAS) against the above described list of criteria that are important for the application of manual-chamber measurements. To back up our qualitative comparison, we (i) applied a number of manual-chamber and standard-gas concentration measurements where up to four LBGAs measured CH4 and CO_2 fluxes or fluxes of all three major GHGs in parallel. In addition, (ii) continuous automated chamber measurements with two of the four LBGAs were analysed to quantitatively supporting the results from the manual chamber measurements. Finally, we (iii) summarise and discuss the qualitative and quantitative results from the measurement campaigns in the light of the defined criteria. Our analysis provides interesting insights for all researchers that are thinking about employing LBGAs in the field and may be of interest for manufacturers because we define and discuss criteria that matter most for truly field-ready LBGAs.