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A portable, high-precision optical analyzer based on hybrid laser absorption cell for simultaneous measurements of N2O, CH4, and CO2 fluxes from soils

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Laser spectrometers have shown good capability in measuring mixing ratios for atmospheric greenhouse gases (GHGs). Given the fact that spectral bands of CO_2, CH_4, and N_2O covering from near to mid-infrared (NIR to MIR) wavelengths, and the limitations in the wavelength coverage of the laser and photodetector, it is very challenging to analyze CO_2, CH_4, and N_2O simultaneously for most cavity-enhanced analyzers using NIR lasers. Alternative solutions, such as combining multiple quantum cascade laser (QCL) beams and analyzing all GHGs in the MIR wavelengths, would significantly increase the instrumental cost.

Here, we present a recently developed analyzer utilizing the advantages of detecting CO_2/H_2O in the NIR spectral region and N_2O/CH_4 in the MIR region, respectively. Through a unique optical design, two independent optical paths are formed in a single Herriott gas cell so that low temperature-related drift and mechanical robustness are achieved. The mixing ratios of CO_2 and H_2O are analyzed by a NIR laser and a photodetector at ~4995cm^{-1}, while CH_4 and N_2O are analyzed by a QCL and an MCT photodetector at ~1275cm^{-1}. The analyzer facilitates high-sensitivity, field-deployable measurements of CO_2, CH_4, N_2O and H_2O altogether in a compact, portable instrumental design. In addition, this analyzer can be completely powered by rechargeable battery, facilitating all-day *in situ* measurements without grid power supply.

In the laboratory, side-to-side comparisons were performed between our newly developed analyzer and another commercial gas analyzer based on cavity ring down spectroscopy (CRDS). The results showed high consistency in GHG mixing-ratio measurements with the two spectrometers. Attached to soil chambers, we also found comparable performance of two analyzers in determining GHG fluxes. In particular, we found that the presented analyzer could precisely capture transient changes in gas mixing ratios from the soil chamber. Recently, field deployment in different soil conditions, including upland forest soils and riparian soils, was carried out for simultaneous N_2O, CH_4, CO_2 soil flux measurements. The overall results suggest that our analyzer is suitable for continuous GHG flux monitoring under variable field conditions, and shows potentials in simultaneous measurements of multiple GHG fluxes from natural ecosystems.