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# Evaluation of field based quantum cascade lasers for measuring $N_2O$ fluxes from static chambers and eddy covariance towers.

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Agricultural soils significantly contribute to increasing atmospheric concentration of nitrous oxide ($N_2O$) and dominate anthropogenic sources of this important greenhouse gas. The current "state of the art" method for measuring soil $N_2O$ emissions is the static chamber method. There are two well-known drawbacks with this method: static chambers cover only small percent of soil area and they cannot be sampled continuously. This means that measurements of soil $N_2O$ emissions are usually performed with very low temporal and spatial resolution. The soil $N_2O$ emissions, on the other hand, have very high spatial and temporal variability and are characterized by high episodic fluxes. This mismatch between our ability to capture flux variability and the nature of $N_2O$ fluxes themselves is a major knowledge gap. We compared three techniques for measurements of soil $N_2O$ emissions throughout three corn growing cycles. Two techniques were based on static chambers method — gas sampling and gas chromatography analysis versus in situ measurement of static chambers using a quantum cascade laser. The third technique was based on a prototype open-path quantum-cascade laser sensor, capable of measuring atmospheric concentrations of $N_2O$ with 10 Hz temporal resolution, mounted on an eddy-covariance tower. Both static chamber based measurement techniques provided highly correlated $N_2O$ flux values. The open-path sensor showed promising potential for ecosystem-scale measurements and successfully measured the flux more than 50% of the time deployed. Cumulative $N_2O$ emissions estimated by the tower based method were well correlated to ground based estimations. Both methods detected increased emissions during afternoon as compared to morning and night hours. Soil $N_2O$ emissions followed soil inorganic N concentration with emissions ranged between 10 to $13\times103$ $\mu$g N $m^{-2}$ $hr^{-1}$ pre- and post-fertilization, respectively. Corn plants had no effect on flux diurnality, but had a strong effect on the magnitude of soil $N_2O$ emissions. Soil temperature exhibited weak correlation to soil $N_2O$ emissions and could not explain observed diurnal patterns. Our results demonstrate that the coupling between water, carbon, and nitrogen cycles is controlling soil $N_2O$ emissions from crop ecosystem in a mesic climate. We conclude that both static chambers based techniques are highly correlated and can be used interchangeably and that eddy-covariance technique exhibited very promising results.