Seasonal and diurnal variation in CO fluxes from an agricultural bioenergy crop

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Carbon monoxide (CO) is an important trace gas in the atmosphere and participates in the tropospheric chemistry with ozone and hydroxyl radicals (OH). Global emission estimates of CO sources and sinks have large uncertainties implying that the sources and sinks in are not fully understood. Anthropogenic activities related to burning of fossil fuel and biomass (e.g. forest fires) and photochemical oxidation of CH_4 are the main sources, while the reactions with OH are the major sink of CO. Soils are globally considered as a sink for CO due to microbial oxidation processes in the soil. Emissions of CO have been reported from a wide range of soils, degrading plant material and organic matter. The CO emissions have mostly been related to thermal or UV-induced degradation of organic matter or plant material, or production of CO by anaerobic microbes. Most of the reported flux measurements are either short-term field experiments or laboratory incubations, while long-term and continuous flux measurements are rare. We measured CO fluxes by micrometeorological eddy covariance method from an arable bioenergy crop (reed canary grass) in Eastern Finland over a full growing season in 2011. We compared the CO fluxes to simultaneously measured CO_2, N_2O, heat and energy fluxes as well as a multitude of soil, plant and meteorological variables. This allowed us to analyze the seasonal and diurnal variation in CO fluxes and to link the CO exchange dynamics to biological activity of the soil and plants.

The bioenergy crop was a net source of CO from mid-April to the mid-summer, and a nearly constant sink of CO throughout the rest of the measurement period until November 2011. The CO fluxes had a distinct diurnal pattern with a constant CO uptake in the night and an emission during the daytime with a maximum emission at noon. This pattern was most pronounced during the spring emission period, during which the most pronounced relationships were found between daytime CO fluxes and NEE, GPP and sensible heat flux. During the autumn CO uptake period, the strength of the correlations decreased; and the highest correlations were found between daytime CO fluxes and ecosystem respiration, air and soil temperatures. Our findings show that the understanding of the CO sources and sinks in terrestrial ecosystems is not complete. The clear diurnal pattern and the relationship between CO fluxes and NEE and GPP also indicate process-level links between the activity of the growing crop and CO emissions. The study shows a clear need for detailed process-studies connected with continuous and long-term flux measurements to obtain full understanding of the processes behind CO exchange.