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A high-resolution measurement technique for vertical CO_2 and H_2O profiles within and above crop canopies and its use for flux partitioning

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We present a portable elevator-based setup for measuring CO_2, water vapor, temperature and wind profiles from the soil surface to the surface layer above crop canopies. The end of a tube connected to a closed-path gas analyzer is continuously moved up and down over the profile height (currently 2 m), while concentrations are logged at a frequency of 20 Hz. Temperature and wind speed are measured at the same frequency by a ventilated finewire thermocouple and a hotwire, respectively, and all measurements are duplicated as a continuous fixed-height measurement at the top of the profile. Test measurements were carried out at the TERENO research site of Selhausen (50°52'09"N, 06°27'01"E, 104.5 m MSL, Germany, ICOS site DE-RuS) in winter wheat, winter barley and a catch crop mixture during different stages of crop development and different times of the day (spring 2015 to autumn 2016). We demonstrate a simple approach to correct for time lags, and the resulting half-hourly mean profiles of CO_2 and H_2O over height increments of 2.5 cm. These results clearly show the effects of soil respiration and photosynthetic carbon assimilation, varying both during the daily cycle and during the growing season.

Post-harvest measurements over bare soil and short intercrop canopy (<20 cm) were analyzed in the framework of Monin-Obukhov similarity theory to check the validity of the measurement and raw data processing approach. Derived CO_2 and latent heat fluxes show a good agreement to eddy-covariance measurements.

In a next step, we applied a dispersion matrix inversion (modified after Warland and Thurtell 2000, Santos et al. 2011) to the concentration profiles to estimate the vertical source and sink distribution of CO_2 and H_2O. First results showed reasonable values for evaporation, transpiration and aboveground net primary production, but a likely overestimation of soil respiration. We discuss possible causes associated with exchange processes near the soil surface below a dense canopy, and the potential use of the wind and temperature profiles in efforts to improve the dispersion parametrization in this region.

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Warland, J.S. and Thurtell, G.W. (2000): A Lagrangian solution to the relationship between a distributed source and concentration profile. Boundary-Layer Meteorology 96: 453-471.