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Model inversion to improve estimates of autotrophic and heterotrophic soil respiration in winter wheat

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Soil respiration is the second largest flux of carbon between ecosystems and the atmosphere and small changes can lead to a huge impact on the global climate. Modelling soil respiration helps to improve the understanding of environmental processes. Especially the separation of soil respiration into its heterotrophic and autotrophic fraction is a current key challenge. In order to distinguish between heterotrophic and autotrophic soil respiration we coupled the SOILCO2-RothC model, calculating carbon turnover, carbon dioxide production and transport in the soil, with the crop growth model SUCROS. The original procedure of calculating plant root respiration in SOILCO2-RothC is based on a depth-specific optimal CO_2 production, which is modified according to depth-specific soil temperature, water content and CO_2 concentration in the soil air over time. This rather simple approach for plant root CO_2 production was replaced by the plant physiological approach implemented in SUCROS, based on relating maintenance and growth respiration to the CO_2 assimilation rate of the crop. We inverted the model for heterotrophic and autotrophic soil respiration using chamber-based flux measurements in a winter wheat stand near Jülich (Germany) for the growing periods of 2008 and 2009. The chamber-based separation of heterotrophic and autotrophic respiration was done by root exclusion. 7-cm and 50-cm soil collars were used to measure the sum of heterotrophic and autotrophic respiration and single heterotrophic respiration, respectively. Autotrophic respiration was then calculated as the difference between the CO_2 fluxes of the two collar types. Furthermore, the growth and biomass of the plants, soil temperature, soil water content and meteorological data were measured. From this, we improved the model in terms of a more realistic calculation of the plant root and microbial contributions to the overall soil respiration.