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Modelling autotrophic and heterotrophic components of soil respiration in wheat fields

E. Delogu (1), V. LeDantec (1), P. Buysse (2), P. Mordelet (1), and M. Aubinet (2)
(1) CESBIO, France (emilie.delogu@cesbio.cnes.fr), (2) FUSAGx, Belgium

Partitioning soil respiration into its heterotrophic and autotrophic components is a current key challenge to improve understanding of soil processes in croplands.

For this purpose, we coupled a daily-time step soil organic carbon model derived from the CENTURY (Parton et al, 1987) calculating carbon turnover and carbon dioxide production in the soil with root sub-model from the plant process-based model CASTANEA (Dufrêne et al, 2005). In the Century model, soil organic carbon is divided into three major components including active, slow and passive soil carbon. Each pool has its own decomposition constant. Carbon flows between these pools are controlled by carbon inputs (crop residue), decomposition rate and microbial respiration loss parameters, both of which are a function of soil texture, soil temperature and soil water content. The model assumes that all C decompositions flows are associated with microbial activity and that microbial respiration occurs for each of these flows. Heterotrophic soil respiration is the sum of all these microbial respiration processes. To simulate autotrophic component, maintenance respiration is calculated from the nitrogen content and assuming an exponential relationship to account for temperature dependence. Growth respiration is calculated assuming that daily growth respiration depends on both growth rate and construction cost of the considered organ. To investigate model performances, simulations of soil CO_2 efflux were compared with 3 datasets recorded in three different fields under different soil and climate conditions. Soil respiration measurements were performed on three winter wheat crops on Lamasquère (2007) and Auradé (2008), South-West France and in Lonzée (2007), Belgium. The French sites data come from manual measurement chambers, PP systems. The Belgium site is equipped with an automatic (half-hour resolution time) measurement system.

The model was run on the three climatic years of data on bare soil and a first comparison between the simulated values and the measurements had been carried out. The heterotrophic component of the model is able to reproduce the mean flux values and the day-to-day fluxes dynamic for each site. The model is then able to reproduce the different level of soil carbon contain as well as the different magnitude in respiration fluxes between the three sites. The fluxes seasonal variations are well predicted.

The ability of the model to reproduce differences in CO_2 fluxes - functions of site - is related to high sensitivity of heterotrophic component to soil texture and to initial partioning of soil carbon content among pools. Moreover, autotrophic component is highly dependent to the root biomass quantity.