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Modelling Soil respiration in agro-ecosystems

Emilie Delogu (1), Valerie LeDantec (1), Patrick Mordelet (1), Pauline Buysse (2), Marc Aubinet (2), and Elizabeth Pattey (3)

(1) CESBIO/CNRS, toulouse, France (emilie.delogu@cesbio.cnes.fr), (2) GxABT, gembloux, Belgique, (3) AAFC, Ottawa, Ontario, Canada

A soil respiration model was developed to simulate soil respiration in crops on a daily time step. The soil heterotrophic respiration component was derived from Century (Parton et al., 1987). Soil organic carbon is divided into three major components including active, slow and passive soil carbon. Each pool has its own decomposition rate coefficient. Carbon flows between these pools are controlled by carbon inputs (crop residues), 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 model the soil autotrophic respiration component, maintenance respiration is calculated from the nitrogen content and assuming an exponential relationship to account for temperature dependence (Ryan et al., 1991). Growth respiration is calculated assuming a dependence on both growth rate and construction cost of the considered organ (MacCree et al., 1982)

A database, made of four different soil and climate conditions in mid-latitude was used to study the two components of the soil respiration model in wheat fields. Soil respiration were measured in three winter wheat fields at Lamasquère (43°49'N, 01°23'E, 2007) and Auradé (43°54'N, 01°10'E, 2008), South-West France and Lonzée (50°33'N, 4°44'E, 2007), Belgium, and in a spring wheat field at Ottawa (45°22'N, 75°43'W, 2007, 2011), Ontario, Canada. Manual closed chambers were used in the French sites. The Belgium and Canadian sites were equipped with automated closed chamber systems, which continuously collected 30-min soil respiration exchanges. All the sites were also equipped with eddy flux towers. When eddy flux data were collected over bare soil, the net ecosystem exchange (NEE) was equal to soil respiration exchange. These NEE data were used to validate the model.

The carbon pools in the model needed to be initialized at each site, by running iteratively simulations of a same climatic year in a given wheat field, until equilibrium was reached. The model performance was evaluated by comparing simulated and measured soil respiration values. The predicted heterotrophic soil respiration compared well with the seasonal dynamic fluxes at each site. The measured values of heterotrophic soil respiration were also well calculated by the model. Then, the autotrophic soil respiration was validated. The parameterization of the Root/Shoot ratio dynamic was a key factor to retrieve the seasonal dynamic of observed root+rhizosphere respiration during vegetation growth period.

Finally, the total soil respiration model was validated on independent datasets from calibration, of four wheat crops and could be used as a prediction model for comparison between different scenario of irrigation, ploughing, or crop rotation.