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Soil CO_2 emission quantification – A new modelling approach

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Quantifying soil carbon dioxide (CO_2) emission is a crucial step for estimation of global greenhouse gas budget. Natural soil CO_2 emission modelling is challenging to incorporate interactions among the multiple chemical, physical and biological processes. Most of the available agroecosystem models are based on carbon and nitrogen pool assumptions, where each pool turnover is estimated at a mean residence time through a semi-empirical approach. They do not consider fundamental processes of the sequential soil organic matter decomposition reactions and their influence in soil CO_2 emission, leading to uncertainties for estimating CO_2 emission. Here, we used the dual Michaelis-Menten kinetics and Nernst equation, in combination, to formulate the oxidation-reduction potential (ORP) and reaction rates of sequential soil organic matter decomposition in the soil-water zone. The newly developed, mechanistic model of soil respiration was incorporated into the watershed-scale hydrological model, Soil and Water Assessment Tool (SWAT) for simulating soil CO_2 emission at daily time step. Hydrologic processes were coupled with the biogeochemical redox reactions and the associated physical and biological processes were simulated dynamically through SWAT. Outputs were calibrated and validated against the field-scale data from three Canadian sites. Model performance statistics show good match between simulated and observed soil CO_2 emission. The integrated model can be used for quantifying the soil CO_2 emission and other water quality parameters at regional to global scale.