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Modelling soil moisture control on soil organic carbon decomposition and land-atmosphere carbon fluxes in a global scale ecosystem model

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Abstract:

Soil moisture (SM) controlled by climate and soil porosity influences spatial distribution and movability of soil organisms and of soluble gases and compounds such as nutrients, minerals and organic matter which in the end, rules soil organic carbon (SOC) stability. Indeed, these biophysical drivers, together with soil temperature, control respiration of heterotrophic organisms which lead to SOC decomposition. In global scale process-based models, these processes are formulated using functions that modify the rate of SOC decay by heterotrophic respiration (SHR) and impact global SOC stock estimated by ecosystem models. A large diversity of SHR modifiers is employed however in each model a unique relationship considering SM serves to adjust the rate of decomposition for all the ecosystems. From a meta-analysis of soil moisture content and soil physical properties emerged an empirical model representing the relationship of SM and SHR. The uniqueness of this empirical model is to reflect spatial heterogeneity of the control of SM on SHR by providing a collection of different relationship based on soil organic carbon content, clay fraction and bulk density.

In the present study, we implemented this empirical model in the ecosystems model ORCHIDEE and assessed the effect of the multivariate approach on SOC stock and SHR estimations at global scale. Results show that the empirical SM modifier enable to double SOC stock in the model while CO2 emissions due to SHR are decreased only by 25%. The latitudinal SOC distribution is maintained displaying a larger SOC stock in tropical regions than under higher latitudes.