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Modeling the significance of including C redistribution when determining changes in net carbon storage along a cultivated toposequence

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Globally, soil carbon (C) reserves are second only to those in the ocean, and accounts for a significant C reservoir. In the case of arable soils, the quantity of stored C is influenced by various factors (e.g. management practices). Currently, the topography related influences on in-field soil C dynamics remain largely unknown. However, topography is known to influence a multiplicity of factors that regulate C input, storage and redistribution. To understand the patterns and untangle the complexity of soil C dynamics in arable landscapes, our study was conducted with soils from shoulderslope and footslope positions on a 7.1 ha winter wheat field in western Denmark. We first collected soil samples from shoulderslope and footslope positions with various depth intervals down to 100 cm and analyzed them for physical and chemical properties including texture and soil organic C contents. In-situ carbon dioxide (CO_2) concentrations were measured at different soil profile depths at both positions for a year. Soil moisture content and temperature at 5 and 40 cm depth was measured continuously. Additionally, surface soil CO_2 fluxes at shoulderslope and footslope positions were measured. We then used measurement data collected from the two landscape positions to calibrate the one-dimensional mechanistic model SOILCO$_2$ module of the HYDRUS-1D software package and obtained soil CO_2 fluxes from soil profile at two landscape positions. Furthermore, we tested whether the inclusion of vertical and lateral soil C movement improved the modeling of C dynamics in cultivated landscapes. For that, soil profile CO_2 fluxes were compared with those obtained using a simple process-based soil whole profile C model, C-TOOL, which was modified to include vertical and lateral movement of C on landscape. Our results highlight the need to consider vertical and lateral soil C movement in the modeling of C dynamics in cultivated landscapes, for better qualification of net carbon storage.