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Modelling the effect of agricultural management practices on soil organic carbon stocks: does soil erosion matter?

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Over the last decades, an increasing number of studies have been conducted to assess the effect of soil management practices on soil organic carbon (SOC) stocks. At regional scales, biogeochemical models such as CENTURY or Roth-C have been commonly applied. These models simulate SOC dynamics at the profile level (point basis) over long temporal scales but do not consider the continuous lateral transfer of sediment that takes place along geomorphic toposequences. As a consequence, the impact of soil redistribution on carbon fluxes is very seldom taken into account when evaluating changes in SOC stocks due to agricultural management practices on the short and long-term.

To address this gap, we assessed the role of soil erosion by water and tillage on SOC stocks under different agricultural management practices in the Walloon region of Belgium. The SPEROS-C model was run for a 100-year period combining three typical crop rotations (using winter wheat, winter barley, sugar beet and maize) with three tillage scenarios (conventional tillage, reduced tillage and reduced tillage in combination with additional crop residues).

The results showed that including soil erosion by water in the simulations led to a general decrease in SOC stocks relative to a baseline scenario (where no erosion took place). The SOC lost from these arable soils was mainly exported to adjacent sites and to the river system by lateral fluxes, with magnitudes differing between crop rotations and in all cases lower under conservation tillage practices than under conventional tillage. Although tillage erosion plays an important role in carbon redistribution within fields, lateral fluxes induced by water erosion led to a higher spatial and in-depth heterogeneity of SOC stocks with potential effects on the soil water holding capacity and crop yields. This indicates that studies assessing the effect of agricultural management practices on SOC stocks and other soil properties over the landscape should account for the impact of soil erosion (both by water and tillage).