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Soil organic carbon redistribution by water erosion: An experimental rainfall simulation approach

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Water erosion influences the redistribution of soil organic carbon (SOC) in landscapes and there is a strong need to better understand these processes with respect to the carbon (C) budget, from local to global scales.
We present a study in which the total carbon budget of a loess soil under erosion was determined in an experimental set-up. We measured fluxes of SOC, dissolved organic C (DOC) and CO_2 in a climate controlled pseudo-replicated rainfall-simulation laboratory experiment. This approach has been rarely followed to integrate all components of the C budget in one experiment. We characterized different C fractions in soils and redistributed sediments using density fractionation and determined C enrichment ratios (CER) in the transported sediments. Erosion, transport and subsequent deposition resulted in a significantly higher CER of the sediments exported ranging between 1.3 and 4.0. In the exported sediments, C contents (mg per g soil) of particulate organic C (POC, C not bound to soil minerals) and mineral-associated organic C (MOC) were both significantly higher than those of non-eroded soils indicating that water erosion resulted in losses of C-enriched material both in forms of POC and MOC. The averaged SOC fluxes as particles (4.7 g C m-2 yr-1) were 18 times larger than DOC fluxes. Cumulative emission of soil CO_2 slightly decreased at the erosion zone while increased by 27% at the deposition zone in comparison to non-eroded soils. Overall, CO_2 emission was the predominant form of C loss contributing to about 90.5% of total erosion-induced C losses in our 4-month experiment. However, only 1.5 % of redistributed C was mineralized highlighting that the C sink induced by deposition is much larger than previously assumed. Our study also underlines the importance of C losses by particles and as DOC for understanding effects of water erosion on the C balance at the interface of terrestrial and aquatic systems. Furthermore our study revealed that the sediment and C fluxes showed good correspondence with values obtained in real landscapes as reported in literature. This confirms that a lab-approach, despite its shortcomings with respect to scale, is valuable and gives additional information on processes affecting the soil carbon budget. This is urgently needed and improves our knowledge on the fate of SOC in erosion-depositional systems.