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Soil erosion leads to significant mobilisation of terrestrial organic and inorganic carbon

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Soil carbon content is greatly affected by soil degradation – in particular erosional processes – which cannot be ignored in the context of the global C cycle. Soil degradation, driven largely by wind and water erosion, affects up to 66% of Earth's terrestrial surface. Understanding how soil degradation affects soil organic carbon (SOC) and soil inorganic carbon (SIC) stocks is an essential component of understanding global C cycling and global C budgets, and is essential for improved C management and climate-change mitigation policies.

In this study, we quantify the distribution of SOC and SIC, and estimate their combined effects on carbon mobilisation via water and wind-driven erosion. We estimate spatially variable water-driven erosion rates for different land-use systems and degradation severities using values obtained from a meta-analysis of soil erosion rates, and undertake stochastic simulations to account for possible uncertainty in our estimates. For wind-driven soil erosion rates we use modelled dust emission rates from AeroCom Phase III model experiments for the 2010 control year, for 14 different models. We use the Harmonized World Soil Database v1.2 to calculate SOC and SIC stocks, the GLASOD map of soil degradation to estimate soil degradation severities and the Land Use Systems of the World database to estimate water-driven erosion rates associated with different land-use systems.

We find that 651 Pg SOC and 306 Pg SIC (in the top 1-m of soil) is located in degrading soils. We estimate global water-driven soil erosion to be 216.4 Pg yr^{-1}, which results in the mobilisation of ~2.9536 Pg OC yr^{-1}. Accounting for the enrichment of organic carbon in eroded sediment increases these estimates up to 12.2 Pg SOC yr^{-1}. A minimum estimate of SIC mobilisation by water erosion is ~0.5592 Pg IC yr^{-1}. Dust emission model ensemble results indicate that ~19.8 Pg soil is eroded for the 2010 AeroCom reference year, with ~11.1 Pg deposited via dry deposition and ~7.2 Pg deposited via wet deposition. The total amount of SOC and SIC mobilised by water-driven erosion is greater than wind-driven erosion, and the spatial patterns of SIC and SOC mobilisation by wind and water vary considerably. Across all land-use types, water-driven carbon mobilisation is higher than wind. Water-driven SOC mobilisation is highest in cropland (~ 2.6602 Pg OC yr^{-1}) where high erosion rates coincide with average SOC content of 68.4 tonnes ha^{-1}. SIC mobilisation follows the same pattern in relation to land use, with highest water-driven mobilisation in cropland (~0.4660 Pg IC yr^{-1}) and highest wind-driven mobilisation in bare areas (0.05 Pg IC yr^{-1}). Overall, wind-driven

erosion mobilises more IC than OC.

Future land-use change has great potential to affect global soil carbon stocks further, especially with increases in the severity of soil degradation as human pressures on agricultural systems increase.