EGU21-11206, updated on 20 Jan 2022
https://doi.org/10.5194/egusphere-egu21-11206
EGU General Assembly 2021

Global-scale quantification of organic and inorganic carbon mobilisation via wind- and water-driven erosion

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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 (OC) and soil inorganic carbon (IC) 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 soil OC and soil IC (using Harmonized World Soil Database v1.2), and estimate the amount of OC and IC that is mobilised by wind- and water-driven erosion. For water-driven erosion, we estimate spatially variable water-driven erosion rates for different land-use systems (using the Land Use Systems of the World database) and degradation severities (using the GLASOD map of soil degradation), using values obtained from a meta-analysis of soil erosion rates. We account for potential uncertainty in our estimates of soil erosion rates by undertaking stochastic simulations. For wind-driven soil erosion rates we use modelled dust emission rates from AeroCom Phase III model experiments for the 2010 reference year, for 15 participating models. Global surface soil stocks of carbon (in the top 1-m of soil) are 1218 Pg OC and 452 Pg IC, and of this, 651 Pg OC and 306 Pg IC is located in degrading soils. We estimate that global water-driven soil erosion is 217.54 Pg yr^{-1} which results in the mobilisation of 4.82 Pg OC yr^{-1}. A minimum estimate of soil IC mobilisation by water erosion is 0.45 Pg IC yr^{-1}. AeroCom model ensemble results indicate that 1.58 Pg dust (ensemble mean) is emitted for the 2010 AeroCom reference year, containing 0.0082 Pg OC and 0.0121 Pg IC. We found that patterns of wind- and water-driven mobilisation of OC and IC are completely different. The total amount of soil OC and soil IC mobilised by water-driven erosion is much greater than wind-driven erosion, and whereas mobilisation of OC dominates carbon mobilisation via water-driven erosion, IC dominates carbon mobilisation in dust emissions. Across all land-use types, water-driven carbon mobilisation is higher than wind. In particular, water-driven SOC mobilisation is highest in cropland (4.30 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 (0.33 Pg IC yr^{-1}). Future land-use change has great potential to affect global soil carbon stocks further, especially with increases in the severity of soil degradation and consequential mobilisation of OC and IC by wind-and water-driven erosion as human pressures on

agricultural systems increase.