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The global Holocene soil and carbon erosion on agricultural land and its implications for future C release

Sebastian Doetterl (1) and Kristof Van Oost (2)

(1) Ghent University, ISOFYS – Isotope Bioscience Laboratory, Applied Analytical and Physical Chemistry, Gent, Belgium (sebastian.doetterl@ugent.be), (2) University of Louvain - ELI, Environmental Sciences, Louvain-la-Neuve, Belgium

The influence of soil erosion, namely the loss of fertile soil material from agricultural land and its export to river systems, has been extensively studied in the past decades for its effects on soil quality and water pollution. Recently, the effect of soil redistribution on soil-atmosphere carbon exchange has come more into focus, whereby erosion is considered to affect close surface C fluxes and C turnover. Furthermore, the burial of soil material in depositional environments has been identified as a potential sink of carbon over centennial timescales due to the slower turnover of the deposited, buried carbon.

These erosional C fluxes are relatively small on an annual or decadal timescales when compared to other C fluxes such as i.e. ocean-atmosphere C exchange but their relevance for longer-term C budgets has been highlighted for several case-studies. However, to date, no longer-term estimate for the amount of eroded and potentially deposited sediment exists at a global scale. Hence, C fluxes by soil redistribution are typically not considered in earth-system models. We argue that, the potential Holocene total flux of soil and sediment and the associated C is an important part of the past, contemporary and future C cycle. The main objective of this study is to develop a simple dynamic model of soil property evolution and carbon transport and burial in response to agricultural land use. Then, we use the model to provide a first estimate for the global total agricultural soil flux as well as the spatial and temporal pattern of these fluxes for the Holocene period. We parameterize a simplified erosion model driven by coarse global databases using spatially and temporally explicit datasets for the key parameters of soil erosion, land use and rainfall.

Our estimates show that more than 7000 Pg of soil has been eroded by water and tilling from cropland and grassland worldwide within the Holocene, corresponding to a lateral flux of more than 140 Pg Carbon. We use the information on the timing of deposition to explore several scenarios on the potential future C release from buried soil. Although the uncertainty associated with our estimates is high, we can provide a first assessment of the spatial and temporal patterns of agriculturally induced lateral C fluxes.