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Modelling soil carbon movement by erosion over large scales and long time periods

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Agricultural intensification accelerates physical erosion rates and the transport of carbon within the landscape. In order to improve understanding of how past, present and future anthropogenic land-use change has and will influence carbon and nutrient cycling, it is necessary to develop quantitative tools that can predict soil erosion and carbon movement at large temporal and spatial scales, that are consistent with the time constants of biogeochemical processes and the spatial scales of land-use change and natural resources.

However, representing erosion and its impact on the carbon cycle over large spatial scales and long time periods is challenging. Erosion and sediment transport processes operate at multiple spatial and temporal scales with splash erosion dominating at the sub-plot scale and occurring within seconds, up to gully formation operating at field-catchment scales over days to months. In addition, most erosion production observations are made at the experimental plot scale, where fine time scales and detailed processes dominate. This is coupled with complexities associated with carbon detachment, decomposition and uncertainties surrounding carbon burial rates and stability - all of which occur over widely different temporal and spatial scales. As such, these data cannot be simply scaled to inform erosion and carbon representation at the regional scale, where topography, vegetation cover and landscape organisation become more important controls on sediment fluxes.

We have developed a simple energy-based regional scale method of soil erosion modelling, which is integration into a hydro-biogeochemical model that will simulate carbon, nitrogen and phosphorus pools and fluxes across the UK from the industrial revolution to the present day. The model is driven by overland flow, dynamic vegetation cover, soil properties, and topographic distributions and produces sediment production and yield at the 5km grid scale.

In this paper we will introduce the modelling approach and examine some of the challenges facing attempts to erosion and carbon transport processes at larger spatial and temporal scales.