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Modelling erosion-driven soil carbon and nutrient movement over large scales and long time periods

John Quinton (1), Jessica Davies (1), Ed Tipping (2), Vicky Bell (3), and Pam Naden (3)

(1) Lancaster University, Lancaster Environment Centre, Lancaster, United Kingdom (j.davies4@lancaster.ac.uk), (2) Centre for Ecology and Hydrology, Lancaster, (3) Centre for Ecology and Hydrology, Wallingford

Soil as a resource is, by its very nature, long term and large scale. The soil's capacity as a carbon store or its ability to provide food and clean water is necessarily spatially expansive. Soil also has long memory – the biogeochemical and physical processes that shape the soil's properties and its capacity to provide these provisionary or regulatory services integrate over long (decadal, centennial) time-scales. Thus, if we are to manage this resource, and understand how past, present and future anthropogenic activities and climate have and will influence carbon and nutrient cycling, it is necessary that we develop quantitative tools that explore soil processes at large spatial and long temporal scales.

Physical erosion, and the associated movement of carbon and other particulate nutrients, is influenced by large scale land-use and landscape organization and long-term plant-soil interactions. 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 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 integrated into a hydro-biogeochemical model that simulates carbon, nitrogen and phosphorus pools and fluxes across the UK from the industrial revolution to the present day. The erosion 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. The modelling approach will be discussed alongside some of the challenges associated with representing and verifying erosion and carbon transport processes at larger spatial and temporal scales.