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Experimental investigations of interrill erosion, crusting and soil respiration

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Lateral movement of Carbon in terrestrial ecosystems represents one of the greatest uncertainties in the global Carbon cycle. Currently, studies are largely done on a point-scale (Soil sciences, Ecology) or focus on sediment transport (Geomorphology). Neither approach appreciates the connections between different perspectives and consequently, the need for studying a 'boundless' carbon cycle to better appreciate the couplings between land and water have been raised. Within such a holistic study of the global c-cycle, experimental simulations using rainfall simulation can fill important gaps in our current knowledge on the relevance of erosion processes in the carbon cycle.

Interrill processes appear to require particular attention. Globally, soils contain an estimated 1500GT of carbon, over twice that present in the atmosphere. The fate of eroded carbon in terrestrial systems is dependent on the balance between sequestration and mineralisation during transport across land. Terrestrial carbon transport in sediment has been predominantly focused on processes with the ability to move large volumes of sediment, that is, mass wasting by tillage and rill and gully erosion at catchment scale. Interrill erosion involves the mechanical breakdown of soil aggregates by raindrop impact. As a consequence, crusts form at the soil surface comprised of deposited or rainfall compacted sediment with structurally different properties than bulk soil. The changes in structure alter gas diffusivity between the soil and atmosphere and the reduced level of aggregation can enhance bioavailability of carbon6 by exposing previously encapsulated organic matter.

Relative to tillage, and rill and gully erosion sediment movement by interrill processes is spatially and temporally limited, however, the total global volume of sediment mobilised may be large. The amount of soil affected globally by interrill processes in a one millimetre layer on all agricultural land ranges from 14.2 to 17.05 million m^3 annually, equating to the mobilisation of 0.29 to 0.67 Pg of C (based on soil carbon content of 2% and 3% respectively). Given that soil crusts are typically up to 5 mm in depth, the mobilisation of carbon may be as much as 3.35 Pg of C annually. Due to the change in structure, the CO_2 efflux from land affected by intense interrill processes can be up to 60% greater than from bulk soil. Furthermore, experiments have shown that the turnover rate of C in the crust can be as low as 2.7 years, a tenfold increase compared to bulk soil. Such differences between bulk soil and crusted sediment need to be appreciated when determining the soils role in the global carbon cycle. In addition, the future development of interrill processes requires consideration. Occurring at the soil atmosphere interface, interrill processes are highly sensitive to changes in rainfall intensity and as such the volume of sediment produced is likely to alter with climate change.

The estimates presented above are only based on small number of soil samples. However they demonstrate the potential interrill processes have in being a major source of carbon in the global cycle. The huge uncertainty and the pressing need for a better understanding of the role of interrill processes in the global carbon cycle illustrate the need for a new push of experimental investigations into the relationships between rainfall, crust development, soil respiration and the global carbon cycle. In this study, a short proposal for coordinated experimental research on experimental interrill erosion and the global carbon cycle is presented.