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Temperature and moisture content influences aggregate stability: linking climate induced microbial change to aggregate (de)stabilisation

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Soil is a critical resource that delivers numerous ecosystem services, yet this capacity is diminished by soil erosion and further threatened by the impacts of climate change. Soil erodibility is largely overlooked when considering soils' response to climate change. Aggregate stability is widely recognised as a key indicator of soil erodibility and is influenced by multiple physical, chemical and biological mechanisms operating simultaneously. The microbial community has been reported to respond to changing climatic conditions, yet it remains unclear how microbial change influences microbially mediated aggregation and therefore aggregate stability. The microbial community in terms of composition, activity, and growth, can change over rapid timescales in response to climate conditions. The short timescale of such microbial shifts could rapidly impact microbially-mediated soil (de)stabilisation and aggregate stability.

The aim of this work is to experimentally test whether climatic conditions, in terms of temperature and moisture content, influence the microbial community and microbially-mediated soil (de)stabilisation, in turn influencing aggregate stability and soil erodibility. A series of laboratory-controlled experiments using environmental chambers and rainfall simulation examined the effects of temperature and moisture content in both static and fluctuating treatments on two surface soils (a sandy loam and a clay loam). Treatments were conducted with single layer aggregate microcosms and multi-layered soil trays to explore aggregate-scale mechanisms and the potential upscaling to run-off processes.

Key findings from this research demonstrate that temperature and moisture content affect aggregate stability and the importance of climate induced microbial shifts influence on microbially mediated soil (de)stabilisation. Static temperature and moisture content conditions significantly affected aggregate stability, however the effects varied dependent on soil texture. Increasing temperature significantly increased aggregate stability in clay loam aggregates, while moisture content significantly decreased aggregate stability in sandy loam aggregates. Multiple regression analysis showed that aggregate stability was best predicted by soil moisture content, microbial biomass carbon, gram-negative bacterial abundance and fungal abundance in the sandy loam. Temperature was the sole significant predictor in the clay loam. Aggregate stability was significantly lower under fluctuating conditions and higher under static conditions. Aggregate stability was not significantly different between fluctuating climate treatments representing summer and winter cycles under future emission scenarios. Although, these treatments did significantly affect the microbial community. Our results have implications for our current understanding of microbial function in terms of soil stabilisation, and the relationship between climate, aggregate stability and soil erodibility.