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How energetic and environmental constraints of microorganisms determine the carbon turnover in soils

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Microorganisms are the main catalysts driving carbon fluxes from soils. Traditional concepts of soil carbon stabilization failed to account for environmental and energy constraints of microorganisms. The distribution and density of organic carbon in the soil profile maybe a key factor determining the carbon stability and carbon flux. Decomposition is a two-step process following the Michaelis Menten kinetics: In a first step enzyme and substrate form a joint complex and then the decomposition reaction is catalyzed. Thus, biological decomposition relies on the encounter of substrate and the degradation catalyst, the microorganisms. Lower substrate concentration decreases the likelihood of an enzyme to hit a substrate molecule, to form an enzyme-substrate complex, and thus to catalyze the reaction. However, it was unproofen if this concept can be appliued to soils also.

A long-term lab experiment revealed that the soil carbon turnover decreased with increasing carbon dilution due to mixture with soil minerals. The ability of microorganisms to move towards substrate in soils seems to be limited. To elucidate the effect of concentration-controlled carbon turnover, we devised the simple simulation model SCAMP based on the two-step kinetic with microorganism and carbon particles been simulated explicitly. The SCAMP model was able to simulate soil carbon profiles and age profiles in a realistic manner. The only carbon stabilization mechanism implemented in the model is the distribution of microorganisms and carbon particles in the soil and thus the availability of carbon for microorganism, which is especially important for subsoil carbon dynamics. The experiments and the model help to explain why large fractions of soil carbon have been stabilized for millennia and decoupled from the global carbon cycle.