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Soil organic matter (de)stabilization – new experiments needed to inform soil biogeochemistry modules in earth system models

Michael W. I. Schmidt (1), Margaret S. Torn (2), and William J. Riley (2)

(1) University of Zurich, Dept. Geography, Physical Geography, Zurich, Switzerland, (2) Lawrence Berkeley National Laboratory, Climate and Carbon Sciences, Earth Sciences Division, Berkeley, USA

To better predict soil carbon climate feedbacks, the next generation of soil biogeochemistry modules in Earth System Models (ESMs) demand new types of experiments, and a more appropriate use of existing observations. For example, we highlight soil incubations and how they have been misinterpreted when inferring pseudo-first order turnover times and decomposition temperature and moisture sensitivities. Further, for existing pseudo first-order modules, and the new microbial- and mineral-explicit generation of biogeochemistry modules, there is often a mismatch between temporal and spatial observations and how they are used by modelers.

Observation periods should be longer, from annual to decadal, and include transitions, e.g., induced by climate or management. Key observations to better structure and parameterize processes that are important for carbon-climate feedbacks include i) mineral surface interactions, ii) microbial dynamics and activity, including effects of soil temperature and moisture, iii) erosion and export, iv) landscape scale process heterogeneity, and v) the effect of land use change, such as clear cut and changes in tillage. Recent insights and knowledge gaps from traditionally disconnected scientific fields (such as geophysical modeling, agricultural soil science, geomorphology, and soil biogeochemistry) will be discussed in the context of informing ESM-scale terrestrial biogeochemistry models.