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Link Pore-scale Hydro-biogeochemical Processes to Core-scale Soil Heterotrophic Respiration Rates

Zhifeng Yan, Ben Bond-Lamberty, Katherine Todd-Brown, Chongxuan Liu, Siliang Li, and Vanessa Bailey
Tianjin University, Institute of Surface-Earth System Science, China (yanzf17@tju.edu.cn)

The response of soil heterotrophic respiration (HR) rates to hydrological processes has been intensively studied. These studies, however, are often empirical, leaving the sub-models that describe soil organic carbon turnover in Earth system models (ESMs) highly depend on empirical relationships between soil HR rates and hydrological state variables such as moisture. By contrast, how pore-scale hydro-biogeochemical processes accumulatively determine core-scale or plot-scale soil HR rates remains elusive, bring uncertainty in projecting soil carbon turnover in ESMs. In this study, we investigated how hydro-biogeochemical interactions and hydrodynamic movement at the pore scale affect soil HR rates at the core scale by integrating X-ray microtomography imaging tools, pore-scale models, and core-scale measurements. The pore-scale interactions mechanistically interpreted core-scale or plot-scale soil HR dynamics observed in laboratories or fields. Furthermore, we derived a process-based soil HR rates-moisture relationship in the light of the pore-scale investigations. The novel relationship predicted better responses of soil HR rates to moisture changes across different types of soils than most empirical counterparts widely used in current ESMs, and could reduce the uncertainty in projecting soil carbon turnover in ESMs.