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ABSTRACT TITLE: A Unified Multi-Scale Model for Cross-Scale Assessment of Biogeochemical Process Models in Soils

ABSTRACT: The mathematical representations of soil biogeochemical processes vary with scale. Mechanistic, reaction-based approaches are typically used to describe microbial growth, respiration, organic carbon degradation and CO_2 production at the pore and laboratory scales, while empirical, correlation based approaches are often used at the watershed and regional scales. Soil biogeochemical processes mechanistically occur at the pore-scale that fundamentally control moisture migration, organic carbon degradation, and CO_2 fluxes in soils at the larger scales. The objective of this research is to develop a common modeling approach that can be used to assess the cross-scale manifestation of mechanistic biogeochemical processes. One major challenge for the development of such an approach is that fundamental physical laws governing moisture migration and materials fluxes vary as scale increases from the pore to core, from the core to geological facies, and from the facies to watershed and regional scales. In this presentation, we will report a unified multi-scale model (UMSM), which uses a single set of mathematical equations to simulate moisture migration and materials fluxes at different scales under both saturated and unsaturated conditions. The model unifies physical laws in free water nodes (pores, ponds, lakes, oceans, and rivers) and in porous media nodes (aggregates, aquifer), providing an efficient and cost-effective way to assess the cross-scale manifestation of biogeochemical processes. A series of validation cases were performed to evaluate the modeling approach. The model was then used to describe the pore to core scales of moisture migration in a soil core with its pore structure characterized using computerized x-ray tomography (XCT), and to simulate core to watershed scale of flow and transport with mixed aquifer and surface water bodies. The model is readily to incorporate reaction-based microbial processes in soils. The future work will focus on: 1) development of reaction-based biogeochemical models to describe microbially mediated organic carbon degradation and CO_2/CH_4 production in soils in collaborating with the experimental part of this TES project; and 2) cross-scale evaluation of biogeochemical process models using the UMSM and other modeling approaches such as reaction-based community land model (CLM). The future research will target the soil organic carbon degradation at the Disney Wilderness Preserve (DWP) site, where several TES projects are ongoing at the field scale. The UMSM and reaction-based biogeochemical models will be evaluated at the site.

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