Multiscale Investigations on Responses of Soil Heterotrophic Respiration to Moisture Changes

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Soil heterotrophic respiration (HR) is an important source of soil-to-atmosphere CO_2 flux, but its response to moisture changes is poorly understood. Earth system models (ESMs) commonly use empirical moisture functions developed from specific sites to describe the HR-moisture relationship in soils, introducing significant uncertainty in predicting CO_2 flux at different sites or at regional to global scales. Generalized, tractable models that address this uncertainty and reflect mechanisms determining soil HR are thus urgently needed. We investigated the responses of soil HR to moisture changes using pore-scale modeling and core- and field-scale measurements, and developed a process-based moisture function, f_m, that encapsulates primary physicochemical processes controlling microbial respiration in soils. Two parameters, SOC-microorganism collocation factor (*a*) and O_2 supply restriction factor (*b*) were introduced in f_m to describe the HR-moisture relationship under dry and wet conditions, respectively. The quantitative relationships between the parameters, *a* and *b*, and measurable soil properties were established by integrating modeling and measuring results for a wide range of soil types. Consequently, f_m is able to predict the HR-moisture relationship for different soils across spatial scales. The results illustrated that f_m described the HR-moisture relationship well for different soil types, and performed better in predicting the response of soil HR rates to moisture changes compared with most empirical functions used in ESMs. Therefore, f_m could better predict the HR-moisture relationship across soil types according to soil properties, and potentially reduce uncertainty in projecting the response of soil organic carbon stocks to climate changes.