Poster #1-47

Nonlinear Response of Soil Microbial Respiration to Moisture Variations

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BER Program: TES
Project: ORNL Terrestrial Ecosystem Science SFA
Project Website: https://tes-sfa.ornl.gov/

Globally, soils store over twice as much carbon (C) as the atmosphere. As such, a small change in soil C content may have a large impact on the magnitude of atmospheric CO_2 concentrations, and therefore on climate. Soil microbial respiration, one of the most important CO_2 effluxes from soils to the atmosphere, is dependent on soil moisture conditions. However, the magnitude of microbial respiration in response to drought and wetting is still unclear. Here, we conducted a laboratory incubation experiment and a modeling study to reveal how soil microbial respiration responds to soil moisture variations. In the laboratory incubation experiment, two soils (a sandy soil and a loamy soil) were incubated under a moisture gradient from air dried to complete saturation. The microbial respiration showed a bell-shape response to the moisture variation, with the optimum between 50% and 100% of water holding capacity. In the modeling study, we extended the experimental results by conducting a theoretical analysis of the response of soil microbial respiration to intensified soil moisture extremes by the end of the 21st century at a temperate forest (i.e., MOFLUX site). Results showed that the magnitude of reduced microbial respiration by drought was generally greater than that of increased microbial respiration by wetting, suggesting an asymmetric response of microbial respiration to soil moisture variations. Further analysis indicated that the asymmetric response of microbial respiration was due to greater responses of active microbial biomass and specific respiration rate to drought than to wetting. As a consequence, increased frequency and severity of soil moisture extremes reduced soil C loss through microbial respiration. Both the experimental and modeling studies emphasize the non-linear response of soil microbial response to moisture variations. Currently, most soil carbon studies are focused on temperature responses, while this study points to the importance of the sensitivity of soil CO_2 fluxes to moisture.