Soil organic carbon determines spatial variability in nitrous oxide hot moments at the field scale

Emily Stuchiner, William Eddy, Evan DeLucia, Wendy Yang

Most soil-emitted nitrous oxide (N_2O) is generated from short periods of very high emissions ("hot moments"). However, it is difficult to predict and manage the environmental variables that drive hot moments, as drivers (e.g., soil temperature, O_2) vary both spatially and temporally. High temporal and spatial resolution measurements of soil N_2O emissions and driving variables are needed to improve N_2O emissions' management, but manual chamber measurements lack temporal resolution due to labor constraints and autochamber measurements lack spatial resolution due to equipment costs. We generated this critical high spatiotemporal resolution dataset by deploying 20 autochambers paired with soil sensors in a ~1400 m^2 area in one maize field in Champaign County, Illinois, that exhibited high variation in soil properties (soil organic carbon (SOC), soil moisture, and pH). To determine how soil properties could control the response of soil N_2O emissions to changes in environmental conditions, we collected hourly measurements of soil N_2O and carbon dioxide (CO_2) emissions along with O_2 concentration, volumetric water content (VWC), and temperature. Our measurements captured hot moments of N_2O emissions driven by summer storms, winter freeze-thaw, and spring thaw. Across five hot moments observed from June 2021 through April 2022, we found that areas of the field with lower SOC emitted more N_2O than areas of the field with higher SOC. We hypothesized that lower N_2O emissions in high SOC areas could be caused by high microbial respiration rates drawing down soil O_2 to stimulate N_2O reduction to N_2. However, principal components analysis did not show the expected negative associations between soil N_2O emissions and soil O_2 concentrations or N_2O emissions and heterotrophic respiration rates. We now hypothesize that the high SOC areas may have less labile forms of soil organic matter that limit microbial metabolism relative to the low SOC areas and are performing laboratory soil incubations to test this hypothesis. Our novel dataset reveals that SOC can indicate field-scale spatial variability in the magnitude of N_2O hot moments triggered by large rain events and thaw.

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