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Beyond Surface Flux: Gathering new insights from in situ warming experiments

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Warming experiments have loomed large in soil carbon research for decades. These experiments have revealed the general sensitivity of soil respiration to warming across ecosystems and time. However, as soil carbon models move toward more mechanistic process representations, the data desired from these empirical experiments for constraining and testing models has moved beyond surface fluxes of CO_2. We will examine the best practices for using existing warming experiments and designing new experiments to inform and test the next generation of soil carbon models. First, depth-explicit measurements of CO_2 production, soil physical properties, and soil climate are needed to inform depth-explicit models. Particular attention should be paid to organic versus mineral horizons, whose responses to warming can diverge due to their differing carbon stabilization mechanisms. Recent experiments have shown that even deep soil carbon responds to climate change, but most soil warming experiments have not measured the depth of warming achieved and may thus underestimate the soil carbon response to climate change. Second, as the long-term responses of carbon flux to warming have demonstrated, there is a need to more explicitly connect changes in CO_2fluxes to the carbon pools/fractions that are driving soil respiration. This can be partly achieved by combining isotopic measurements of carbon pools and soil fluxes or by using respiration quotients, which connect the amount of CO_2 produced per O_2 consumed by respiration to the oxidation state of soil organic matter. Explicit fraction measurements may also help address the sensitivities of the mineral-associated versus particulate organic matter pools. Lastly, to help inform models, we need to move beyond binary (warmed vs control) experimental designs to regression designs that can generate response curves over a range of temperatures.