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The response of deep soil carbon to climate change: Empirical studies from forests to farmland and the tropics to the arctic

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Over half of global soil organic carbon (SOC) is stored in subsurface soils (>20 cm depth), but the vulnerability of this deeper SOC to climate change has only begun to be tested. Most soil warming experiments have either only warmed surface soils or only examined the response of the surface carbon dioxide flux, so the sensitivity of SOC at different soil depths and the potential of various soil depths to generate a positive feedback to climate change is undetermined. As predictive models of terrestrial carbon storage move toward more mechanistic process representations, we need to understand how the carbon cycle differs across soil depths. We present depth-explicit measurements of soil CO_2 production from seven studies, including five in situ deep soil warming experiments and two laboratory incubations. The experiments' locations ranged from coniferous to hardwood temperate forests in the United States and from volcanic soils in Hawaii to agricultural soils in France. The incubated soils came from a former agricultural field and arctic tundra. We have found that in temperate forests, deep soil carbon is just as vulnerable to warming-induced losses as surface soils and that warming has caused a shift in the source of carbon being respired at all depths. However, where minerals are strongly associated with organic carbon, as in Hawaii, or in degraded soils where much of the organic carbon has been lost, deep soil carbon is not vulnerable to warming-induced losses. Thus, the response of deep soil to climate change seems to be dependent on how available deep soil carbon is to microbes.