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The physical origins of rapid soil CO_2 release following wetting

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A rainfall event after an extended dry period is known to produce large spikes in CO_2 release from soil, a phenomenon referred to as the "Birch effect". The Birch effect is commonly attributed to biological factors, such as the rapid activation of dormant microbial populations and stimulation of soil organic carbon turnover. Evidence suggests that CO_2 emissions set in at time scales too short for microbial activation and growth (seconds to minutes after onset of wetting). We conducted controlled wetting experiments on sterilized soil in the lab showing CO_2 efflux dynamics that are consistent in magnitude with those reported in field studies (up to 4 mmol m^{-2} s^{-1} per mm of precipitation). The explanation proposed is purely physical, involving desorption of CO_2 from soil surfaces as it is replaced by the more polar water during wetting. We present experimental results and a CO_2 adsorption and desorption model that lend credence to the notion that a large fraction of the early soil CO_2 emission during wetting (minutes to an hour) is associated with physical processes independent of microbial activity. This suggests that a significant amount of atmospheric CO_2 becomes bound to soil surfaces during dry seasons and is rapidly released at the onset of wet seasons world-wide, irrespective of the soil organic carbon cycle.