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The influence of soil carbonic anhydrase on the partitioning of gross CO_2 fluxes using the oxygen isotopes of CO_2 and water.

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Measuring terrestrial gross CO_2 fluxes at large scales presents one of the main challenges in global carbon cycle research. The oxygen isotopic composition ($\delta^{18}O$) of atmospheric CO_2 offers the possibility to partition net CO_2 fluxes into photosynthesis and respiration at ecosystem, regional and global scales. This approach relies on a detailed knowledge of the $\delta^{18}O$ signature of the terrestrial gross CO_2 fluxes. The latter reflects the $\delta^{18}O$ of leaf and soil water because CO_2 exchanges isotopically with water. This exchange can be accelerated by the enzyme carbonic anhydrase (CA). The high CA content in leaves of plants amplifies the impact of leaf photosynthesis on the $\delta^{18}O$ of atmospheric CO_2 (δ_a) by enhancing the equilibration of atmospheric CO_2 with isotopically enriched leaf water. Here, we report that the accelerated isotopic exchange between CO_2 and water due to CA activity may be a widespread phenomenon in soils as well. Across a range of ecosystems, we found that CO_2 hydration was 10 to 300 times faster than the uncatalysed rate, with highest values in the hottest ecosystems. At the global scale, accounting for soil CA activity dramatically shifts the influence of soil and leaf fluxes on δ_a, thus changing the estimates of terrestrial gross CO_2 fluxes. At a time when new laser technologies are poised to deliver more extensive data coverage of variations in δ_a, our finding indicates that δ_a signals should enable us to constrain CO_2 gross fluxes in regions where this information has been particularly difficult to obtain, such as in the tropics.