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Soil respiration under mature deciduous forest trees after 7 years of CO2 enrichment

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The anthropogenic rise in atmospheric CO2 is expected to impact carbon fluxes not only at ecosystem level but also at the global scale by altering carbon cycle processes in soils. At the Swiss Canopy Crane (SCC), we examined how 7 years of free air CO2 enrichment (FACE) affected soil CO2 dynamics in a c. 100-year-old mixed deciduous forest. The use of 13C-depleted CO2 for canopy enrichment allowed us to trace the flow of recently fixed carbon (C). In the seventh year of growth at ∼550 ppm CO2, soil respiratory CO2 consisted of 39% labelled C. During the growing season, soil air CO2 concentration was significantly enhanced under CO2-exposed trees. However, elevated CO2 failed to stimulate cumulative soil respiration (Rs) over the growing season. We found periodic reductions as well as increases in instantaneous rates of Rs in response to elevated CO2, depending on soil temperature and soil volumetric water content (VWC; significant 3-way interaction). During wet periods, soil water savings under CO2-enriched trees led to excessive VWC (>45%) that suppressed Rs. Elevated CO2 stimulated Rs only when VWC was ≤40% and concurrent soil temperature was high (>15 °C). Seasonal Q10 estimates of Rs were significantly lower under elevated (Q10 = 3.30) compared to ambient CO2 (Q10 = 3.97). However, this effect disappeared when 3 consecutive sampling dates of extremely high VWC were disregarded. This suggests that elevated CO2 affected Q10 mainly indirectly through changes in VWC. Fine root respiration did not differ significantly between treatments but soil microbial biomass (Cmic) increased by 14% under elevated CO2 (marginally significant). Our findings do not indicate enhanced soil C emissions in such stands under future atmospheric CO2. It remains to be shown whether C losses via leaching of dissolved organic or inorganic C (DOC, DIC) help to balance the carbon budget in this forest.