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# Reconstruction of $pCO_2$ levels from carbon isotopes in terrestrial organic matter

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The concentration of atmospheric carbon dioxide ($pCO_2$) has long been suspected to affect the carbon isotope composition of plant tissue ($\delta^{13}C_p$). Previous workers have generally hypothesized that the effect might be linear, citing values that range from 0.7 to 2.0‰ per 100 ppm. Our recent experiments growing multiple species of plants under a wide range of $pCO_2$ levels showed that the increase fractionation (*S*, ‰/ppm) is not a constant, but instead decreases with increasing $pCO_2$ level, thus reconciling the wide range of reported values. Here, we show how the $pCO_2$ effect can be used to quantify $pCO_2$ levels across even small intervals of $pCO_2$ change, such as that observed during Pleistocene glacial-interglacial cycles. For this analysis we compiled a total of 450 $\delta^{13}C$ measurements made on individual leaves, bulk terrestrial organic carbon (TOC), and *n*-alkanes from 17 published studies representing 22 distinct records from across the glacial-interglacial transition (18,000 to 11,500 years BP). Application of the $pCO_2$ effect to these data yields reconstructed $pCO_2$ levels that show excellent agreement with $pCO_2$ levels determined from ice. The reconstruction based on leaf tissues shows the greatest precision and highest correlation to the ice core record compared with the other substrates; the TOC data yields high correlation to the ice core, but lower precision, and the *n*-alkane dataset slightly overestimates the change in $pCO_2$ across this interval. Competing environmental effects, such as changes in moisture availability or changes in vegetation type will also be discussed. Our work demonstrates the need to account for changing $pCO_2$ levels when analyzing even small scale changes in the $\delta^{13}C$ value of terrestrial substrates, particularly for intervals with moderate to low $pCO_2$ levels.