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Demonstration of the C_3 plant proxy: Controlled growth chambers to deep-time applications

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Controlled growth experiments across a wide range of atmospheric carbon dioxide (CO_2) levels (up to 4200 ppm) showed that CO_2 concentration affects the carbon isotope ($\delta^{13}C$) value of C_3 plant tissue. This work produced a unifying hyperbolic relationship between CO_2 and net carbon isotope discrimination and reconciled a wide range of field and chamber studies conducted across smaller changes in CO_2. The applicability of this relationship as a proxy for CO_2 was demonstrated through comparison with CO_2 data from ice core records across the Pleistocene-Holocene transition, and provided the framework for quantifying CO_2 in deep-time records from C_3 plant remains. However, some studies have misapplied this application, while others have confirmed use of the C_3 plant proxy. These disparate evaluations have added to the general confusion as to best practices for interpreting $\delta^{13}C$ change in recent and deep-time terrestrial settings. Here we dissect each issue and demonstrate the proper application of our work across a wide range of previously published datasets. Quantitative reanalysis bolsters our proposed relationship between CO_2 and carbon isotope value, and therefore, the efficacy of the C_3 plant proxy. Our integrated evaluation of existing datasets allows us to describe the common flaws encountered when applying the C_3 plant proxy, while further demonstrating the value of its correct application across Geologic Time.