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Atmospheric pCO_2 reconstructed across the Early Eocene Hyperthermals

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Negative carbon isotope excursions (CIEs) are commonly associated with extreme global warming. The Early Eocene is punctuated by five such CIEs, the Paleocene-Eocene thermal maximum (PETM, ca. 55.8 Ma), H1 (ca. 53.6 Ma), H2 (ca. 53.5 Ma), I1 (ca. 53.3 Ma), and I2 (ca. 53.2 Ma), each characterized by global warming. The negative CIEs are recognized in both marine and terrestrial substrates, but the terrestrial substrates exhibit a larger absolute magnitude CIE than the marine substrates. Here we reconcile the difference in CIE magnitude between the terrestrial and marine substrates for each of these events by accounting for the additional carbon isotope fractionation by C_3 land plants in response to increased atmospheric pCO_2. Our analysis yields background and peak pCO_2 values for each of the events. Assuming a common mechanism for each event, we calculate that background pCO_2 was not static across the Early Eocene, with the highest background pCO_2 immediately prior to I2, the last of the five CIEs. Background pCO_2 is dependent on the source used in our analysis with values ranging from 300 to 720 ppmv provided an injection of ^{13}C-depleted carbon with $\delta^{13}C$ value of -60‰ (e.g. biogenic methane). The peak pCO_2 during each event scales according to the magnitude of CIE, and is therefore greatest during the PETM and smallest during H2. Both background and peak pCO_2 are higher if we assume a mechanism of permafrost thawing ($\delta^{13}C$ = -25‰). Our reconstruction of pCO_2 across these events is consistent with trends in the $\delta^{18}O$ value of deep-sea benthic foraminifera, suggesting a strong link between pCO_2 and temperature during the Early Eocene.