High-resolution \( pCO_2 \) reconstruction across the early Cenozoic greenhouse and late Cenozoic icehouse climates

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Historical data and ice core records provide the best-constrained data on global temperatures and atmospheric carbon dioxide concentrations (\( pCO_2 \)), which can be used to calculate short-term estimates of climate sensitivity. These data, however, may not be representative of longer timescales and represent a period of Earth history when \( pCO_2 \) and global temperatures were relatively low; recent work suggests that climate sensitivity may change under different climate states and timescales. Here we present a new high-resolution \( pCO_2 \) reconstruction for the early (65 to 50 Ma) and late (30 to 0 Ma) Cenozoic using a proxy based on changes in carbon isotope fractionation in C3 land plants. This work uses widely available carbon isotope data from various terrestrial organic substrates to produce a nearly continuous record of \( pCO_2 \). This record identifies both large-scale trends (e.g., the early Cenozoic is characterized by higher \( pCO_2 \) than the late Cenozoic), as well as transient, highly elevated \( pCO_2 \) during the early Eocene hyperthermals. We discuss the uncertainties associated with this new \( pCO_2 \) reconstruction, which include the effects of precipitation, plant community shifts, and source effects on the \( \delta^{13}C \) record. Additionally, uncertainty associated with the correlation in time between \( \delta^{13}C \) estimates of atmospheric CO\textsubscript{2} and the terrestrial \( \delta^{13}C \) of organic matter is included in the error propagation. Comparison of the new \( pCO_2 \) record to existing global average temperature records based on the \( \delta^{18}O \) value of well-preserved marine foraminifera can yield new insight into Earth system climate sensitivity across a wide range of climate states and timescales.