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High-resolution Atmospheric pCO_2 Reconstruction across the Paleogene Using Marine and Terrestrial $\delta^{13}C$ records

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The early Paleogene (63 to 47 Ma) is considered to have a greenhouse climate[1] with proxies suggesting atmospheric CO_2 levels (pCO_2) approximately ~2× pre-industrial levels. However, the proxy based pCO_2 reconstructions are limited and do not allow for assessment of changes in pCO_2 at million to sub-million year time scales. It has recently been recognized that changes in C_3 land plant carbon isotope fractionation can be used as a proxy for pCO_2 with quantifiable uncertainty[2]. Here, we present a high-resolution pCO_2 reconstruction (n = 597) across the early Paleogene using published carbon isotope data from both terrestrial organic matter and marine carbonates. The minimum and maximum pCO_2 values reconstructed using this method are broad (i.e., 170 +60/-40 ppmv to 2000 +4480/-1060 ppmv) and reflective of the wide range of environments sampled. However, the large number of measurements allows for a robust estimate of average pCO_2 during this time interval (~ 400 +260/-120 ppmv), and indicates brief (sub-million-year) excursions to very high pCO_2 during hyperthermal events (e.g., the PETM). By binning our high-resolution pCO_2 data at 1 million year intervals, we can compare our dataset to the other available pCO_2 proxies. Our result is broadly consistent with pCO_2 levels reconstructed using other proxies, with the exception of paleosol-based pCO_2 estimates spanning 53 to 50 Ma. At this timescale, no proxy suggests pCO_2 higher than 2000 ppmv, whereas the global surface ocean temperature is considered to be >10 ^{o}C warmer than today. Recent climate modeling suggests that low atmospheric pressure during this time period could help reconcile the apparent disconnect between pCO_2 and temperature and contribute to the greenhouse climate[3].

References

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3. Poulsen, C.J., Tabor, C., White, J.D., 2015. Science 348, 1238-1241.