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Aligning atmosphere and ocean: using geochemical proxies in concert with the (non-)continuous ice cores.

THOMAS B CHALK[1], RACHEL M BROWN[1,2], MATHIS HAIN[3], ETIENNE LEGRAIN[4], MATTHIEU PAULHAC BUISSON[5], TALI L BABILA[6], SOPHIE NUBER[7], JAMES W. B. RAE[8], JIMIN YU[9], MAIDER PLAZA-MORLOTE[10], GIANLUCA MARINO[11] AND GAVIN L FOSTER[2]

[1]Aix Marseille Univ, CNRS, IRD, INRAE, Coll France, CEREGE
[2]University of Southampton
[3]University of California, Santa Cruz
[4]Vrije Universiteit Brussel
[5]CNRS-CEREGE-Aix Marseille Université
[6]Case Western Reserve University
[7]University of Washington
[8]University of St Andrews
[9]Laoshan Laboratory
[10]Centro Oceanográfico de Santander
[11]Universidade de Vigo

Ice cores present the current and enduring gold standard of our knowledge of ancient CO_2, revealing that glacial-interglacial changes are intricately linked with changing CO_2 concentrations. However, even with the advent of new longer continuous records (Beyond EPICA) and snapshots of Neogene ice (Blue ice archives), they cannot cover the entire geological record, and they lack a direct chronological tie to the ocean-based records of the climate system, which is responsible for the majority of short-term CO_2 change. Sediment derived proxy data, such as the boron isotope ($d^{11}B$) based pH proxy can fill this knowledge gap. The Late Pleistocene represents a unique opportunity; we have both high-quality ice core derived estimates of atmospheric CO_2, and a growing database of geochemically derived estimates of the same parameter, giving us the prospect for a geological “Rosetta Stone”. Here we perform an extensive comparison between ice core derived (including blue ice) and geochemically derived (predominantly $d^{11}B$-based) reconstructions of CO_2, in the Pleistocene. We adopt a novel approach to retune the ice and sediment age models by aligning through the greenhouse gas forcing, opening a new way to synchronise ice core records several deep ocean cores across the major ocean basins. This enables a more faithful assessment of leads and lags across glacial-interglacial transitions, including the connections from surface temperature proxies and deep ocean carbon storage proxies to the atmosphere. We also look at the reliability of the different proxy types over the last 1.5 million years, both via the evaluation of continuous geochemical records using the non-continuous blue ice records, but also by investigating the calibrations that are required to transform $d^{11}B$-derived values into atmospheric CO_2 using a variety of temporally derived alternates. Finally, we assimilate the ice cores into a hybrid CO_2 record to refine and extend geochemical estimates of continuous CO_2 into the middle Pleistocene.