Glacial north Atlantic deep water production drives Atlantic carbon storage

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Reduced deep ocean ventilation is commonly invoked as the primary cause of lower glacial atmospheric carbon dioxide. Despite the efforts of both proxy and modeling studies, the glacial deep Atlantic water mass structure and the mechanism by which it may have sequestered carbon remains elusive [1]. Low $\delta^{13}C$ values in the deep North Atlantic during the Last Glacial Maximum have been interpreted as reflecting southern-sourced waters filling the abyssal North Atlantic, although this interpretation has recently been challenged [2].

We present authigenic Nd isotope measurements from cores located at various depths throughout the North and South Atlantic which reveal glacial-interglacial changes in water mass structure. The glacial data spatially trace the sustained production and circulation of North Atlantic Deep Water. When water mass proportions are calculated from this Atlantic Nd isotope cross-section, they show that the deep glacial North Atlantic was ~70% NADW, only slightly different to the ~90% NADW seen in the modern ocean.

These Nd isotope results preclude southern-sourced deep waters dominating the deep Atlantic, and mean that the low benthic $\delta^{13}C$ observed in the deep glacial Atlantic [3] can not be explained solely by water mass circulation changes. This implies a greater amount of respired organic carbon in the glacial deep Atlantic Ocean. We infer that this was achieved by a sluggish meridional overturning cell, comprised of well-mixed northern- and southern-sourced waters. The accumulation of respired carbon in these waters would have increased deep ocean carbon storage during glacial times. The penetration of northern-sourced waters with a low pre-formed nutrient concentration into the glacial deep Atlantic would thereby have helped to drive an efficient biological pump. Thus this data reveals how the structure of Atlantic overturning contributed to the drawdown of atmospheric CO_2 during the Last Glacial Maximum.

[1] Lynch-Stieglitz et al. (2007), *Science*, **316**, 66-69. [2] Gebbie (2014), *Paleoceanography*, **29**, 190-209. [3] Curry & Oppo (2005), *Paleoceanography*, **20**.