Ocean carbon cycle response to AMOC variability during the last deglaciation

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Carbon isotope minima were a ubiquitous feature of the mid-depth Atlantic during Heinrich Stadial 1 (HS1, 14.5–17.5 kyr BP) and the Younger Dryas (YD, 11.5–12.9 kyr BP), with variable AMOC state being the most likely driver [1,2]. Model simulations suggest that slowing of the AMOC increases the residence time of mid-depth waters in the Atlantic, resulting in the accumulation of respired carbon [3]. Here we assess ΣCO_2 variability in the South Atlantic using benthic foraminiferal B/Ca, a proxy for $[CO_3^{2-}]$ [4]. B/Ca records from ~2 km water depth on the Brazil Margin show that $[CO_3^{2-}]$ decreased ~ 22 μmol/kg during HS1 and the YD, slightly less than the HS1 signal in the tropical western Atlantic [5]. Using the combined B/Ca and $\delta^{13}C$ records from the Brazil Margin, we estimate remineralization accounts for ~75% of the mid-depth $\delta^{13}C$ signal, highlightling the non-conservative nature of $\delta^{13}C$ during HS1.

Model simluations of AMOC weakening also yield negative $\delta^{13}C$ anomalies in the surface South Atlantic, Indian and Pacific Oceans, mirrored by positive anomalies at intermediate depths [3]. The simulated reduction in the vertical $\delta^{13}C$ gradient is due to weakening of the biological pump, which limits the export of isotopically light carbon from the surface ocean. Paired records of planktonic-benthic foraminiferal $\delta^{13}C$ from four intermediate depth core sites show a decrease in the surface-intermediate $\delta^{13}C$ gradient during HS1 and YD, consistent with model results [6]. While it is unlikely that the intermediate depth $\delta^{13}C$ signals are due to temperature mediated air-sea gas exchange [6] they may reflect the influence of enhanced wind stress and air-sea equilibration in AAIW formation regions. Here we test this hypothesis using foraminiferal B/Ca from sites in the Southwest Atlantic, Southern Ocean, and equatorial Pacific. If the intermediate depth $\delta^{13}C$ signal reflects a wind-driven response, we would expect lower $[CO_3^{2-}]$ (i.e. higher ΣCO_2), opposite the pattern expected in the biological pump scenario.

[1] Lund et al. (2015) *Paleoceanography* **30** [2] Oppo et al. (2015) *Paleoceanography* **30**. [3] Schmittner and Lund (2015) *Clim. Past,* **11**, 135. [4] Lacerra et al. (2017) *Paleoceanography,* **32**. [5] Yu et al. (2010) *Science,* **330**, 1084. [6] Hertzberg et al. (2016) *GRL,* **43**.