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Modelling the impact of biogenic particle flux intensity and composition on sedimentary Pa/Th

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There is compelling evidence of a strong relation between the Atlantic Meridional Overturning Circulation (AMOC) and millennial scale climate variability during the last glacial period. Part of the advances in understanding the underlying mechanisms rely on the analysis of the sedimentary Pa/Th ratio, which can be used to qualitatively infer past flow rates in the Atlantic. The compilation of existing North Atlantic records indicates repeated, consistent and significant Pa/Th increases across millennial-scale events, indicating significant reductions of deep-water formation in the Northwest Atlantic. However, the use of sedimentary Pa/Th as a pure kinematic circulation proxy is challenging because Pa and Th are also highly sensitive to changes in particulate flux intensity and composition that have probably occurred across these millennial scale events. A primary control of particles on the available Pa/Th records has been ruled out ensuring the absence of correlation between the reconstructed particle fluxes (e.g. Th-normalized opal fluxes) and the sedimentary Pa/Th. However, quantitative estimates of the impact of particles on the available paleo Pa/Th are still missing.

In this study, we use the Pa/Th enabled iLOVECLIM Earth System Model of Intermediate Complexity to decipher the impact of particles on the sedimentary Pa/Th. We evaluate the impact of imposed changes in biogenic particle flux intensity and composition on the Atlantic Pa/Th in a 3-D geographical perspective. We find that up to 30% of the observed Pa/Th increase across Heinrich Stadial 1 could be explained by changes in particle fluxes and composition. Besides, changes in the Particulate Organic Carbon (POC) most efficiently affects the sedimentary Pa/Th, followed by biogenic opal. Last but not least, the global Atlantic sedimentary Pa/Th response is very sensitive to shifts in the geographical distribution of particles and high scavenging areas. In our simulations, a decrease of the opal production in the Northwest Atlantic can induce a far field Pa/Th increase in a large part of the North Atlantic basin, suggesting that a local monitoring of the particle fluxes might not be enough to rule out any influence of the particles on paleo sedimentary

Pa/Th records.