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Millennial-scale variability in NADW strength during the last glacial: a multi-proxy comparison between the north and south Atlantic.

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Global thermohaline circulation, and in particular the rate of Atlantic Meridional Overturning, is closely linked to rapid climate changes. While benthic carbon isotopes have been widely used to monitor North Atlantic deepwater (NADW) circulation, they are not independent of nutrient cycling, which has led to a search for new proxies, more directly controlled by deep water flow speed and mixing. Here we compare records using two of these new proxies and we focus on a period of rapid glacial climate changes (MIS 3-4), occurring beyond the limit of radiocarbon dating.

Large amplitude, short-term fluctuations are observed in the concentration of magnetic particles in North Atlantic sediment cores during MIS 3, caused by the changes in the bottom current transport of magnetic particles. The progressive southward decrease in the average concentration of magnetic particles indicates that the signal initiated in the northern basaltic provinces (Iceland-Faeroe Islands) was propagated to the Bermuda Rise by the flow of NADW. Stacking multiple high resolution records, after normalizing to their mean value, filters out possible local differences in flow speed. When placed on the GISP2 age scale using stable isotopic data, the fluctuations in NADW strength match Greenland paleotemperature (ice delta18O) changes with high fidelity.

Comparison of our North Atlantic overturning record is made with a published Nd isotopic record from the South Atlantic, which monitors the presence of NADW relative to southern-sourced waters in the deep Cape Basin. The chronology of the South Atlantic record is tied to the North Atlantic one using geomagnetic-assisted stratig-

raphy, therefore the chronological relationship between both records can be directly compared within the accuracy of our time scale transfer. The agreement between the northern hemisphere magnetic property-based NADW flow speed and the southern hemisphere Nd isotope NADW export record is remarkable. Interstadials were accompanied by increased flow speed of NADW and relatively more NADW reaching the Southern Ocean, while during stadials and Heinrich Events, both the North Atlantic flow speed of NADW and its presence in the South Atlantic were reduced. This finding confirms that these two proxies, as they have been used in each oceanic basin, are reliable for reconstructing the changes in the strength and presence of NADW. The difference in the proxy record resolutions and the time constants on the order of 400-500 years of the fluctuations of the dipolar field used for the time scale transfer, are challenging quantitative estimates of phasing differences. However, during the most prominent and best defined cycles (IS12, and 8), the south Atlantic record appears to lag changes in North Atlantic flowspeeds by about 600-800 years and this significant offset may document the needed time for glacial circulation changes in the North Atlantic to propagate to the Southern Ocean. These records indicate that the strength of Atlantic overturning was closely coupled with Dansgaard-Oescher paleotemperature changes and Heinrich ice rafting events throughout the last glacial period.