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Quantifying rates of change in ocean conditions with implications for timing of sea level change

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The importance of southern hemisphere driven climate change is increasingly recognized in paleoclimate research. This is in particular relevant with regard to the rate of climate change initiated in the southern hemisphere and the phasing thereof compared to climate variability elsewhere. Here, we use previously published benthic oxygen isotope data from two deep sea sediment cores from the deep N-Atlantic and the intermediate depth Indian Ocean to quantify rates of oceanic change at the millennial-scale. The oxygen isotope data represent an integrated signal of temperature and global sea level changes. At both locations the sea surface ocean records strongly resemble Greenland climate change. When used to synchronize these surface ocean records with the GISP2 ice core chronology we show that the highest rates of change in the benthic oxygen isotope records, occur during late marine isotope stage 5 (MIS 5), MIS 3 and the last deglaciation, whilst generally modest rates of change prevail during the full glacial conditions of MIS 2. The synchronous variation of oceanic rates of change and Antarctic climate history suggests that the benthic oxygen isotope records from the glacial deep N-Atlantic and the intermediate Indian Ocean reflect variations in southern sourced Antarctic Bottom Water (AABW) and Glacial Antarctic Intermediate Water (GAAIW) respectively. Millennial-scale temperature variations in GAAIW are larger than in AABW. The repeated rapid heat storage in GAAIW during northern hemisphere cold phases points to an important role of GAAIW, potentially acting as an energy buffer, maintaining the pole-to-pole climate imbalance as part of the bi-polar seesaw. Combining the benthic oxygen isotope records with independent sea level records shows a pulsed sea level rise history during the deglaciation with conservative estimates of peak rates change of about $\sim$2 m/ 100 yr. Similar rates of sea level change occurred during most Heinrich Events.