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Origin of melt water pulses underlying isotope stage 3 sea-level variability

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Abrupt climate change, such as that associated with the millennial-scale Dansgaard-Oeschger (DO) variability, is increasingly ascribed to abrupt reorganisations in the oceanic meridional overturning circulation (MOC). The most dramatic reorganisations were closely associated with major ice-berg release events from northern ice sheets, especially the Laurentide (Heinrich events). Modelling suggests that meltwater fluxes equivalent to 3-10 m sea-level rise would suffice to terminate the North Atlantic MOC, in agreement with suggestions from a variety of deep-water ventilation proxies. It has also been established that there are differences in structure and phasing between the millennial-scale variability observed in the Antarctic/Southern Ocean ("Antarctic type") and in Greenland ("DO type"). The combined picture is often considered in terms of the "bipolar see-saw" concept, or derivatives thereof. Modelling studies have been able to generate Antarctic-type climate cycles of appropriate phasing and magnitude in high southern latitudes in response to prescribed DO-type variability in the ocean-climate system. Also, models studying the consequences of large (3-10 m sea-level equivalent) freshwater fluxes into the N Atlantic have shown global responses that resemble proxy records. However, the issue has become complicated by the Red Sea-based sea-level reconstruction, which is complementary to, and closely agrees with, the other techniques (dated corals and deep-sea benthic foraminiferal oxygen isotopes). It suggests that sea level varied not in association with the DO variability, but instead followed the "Antarctic rhythm". The variability was not dominated by 3-10 m jumps associated with Heinrich events, but instead showed rises over 1000-1500 year periods that reached magnitudes of up to 30m for single shifts. The present contribution briefly reviews this sea-level reconstruction, and then explores where the melt-water may have come from?