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Assessing linkages between ice sheet calving, subpolar gyre density and deep water ventilation during the last glaciation

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Deep ocean circulation plays an important role in the Earth's climate system and is postulated to be closely linked to ice sheet dynamics and abrupt climate oscillations. However, the nature of this coupling remains unclear. Iceberg and freshwater pulses have been hypothesized as both the trigger for, and the response to, reduced Atlantic meridional overturning circulation (AMOC). Differentiating between these two hypotheses requires high-resolution records constraining the relative timing of ice sheet, freshwater, and ocean circulation changes.

Here we assess the relative timing and linkages between iceberg discharge, surface water physical properties in the subpolar gyre, and North Atlantic deep water ventilation using proxy records co-registered in the same sediment sequence. High-resolution stable isotope analysis (δ^{18}O & δ^{13}C) of planktonic (*N. pachyderma* (s)) and benthic (*C. wuellerstorfi*) foraminifera and ice-rafted debris (IRD) records from the core GS15-196-02GC taken in the Irminger basin (59^{o}37.1 N, 40^{o}44.25 W, 2468 water depth) document a clear relationship between increasing freshwater fluxes (IRD and planktonic δ^{18}O), decreasing deep water ventilation (benthic δ^{13}C), and temperature and salinity changes in the subpolar gyre surface waters (planktonic δ^{18}O). Our benthic (*C. wuellerstorfi)* carbon isotope record documents clear variability in deep ocean ventilation throughout the last glacial and deglacial periods. Notably, periods of high iceberg discharge and freshening of the subpolar gyre surface waters are preceded by decreases in deep water ventilation (benthic δ^{13}C); consistent with the hypothesis that reduced AMOC is important for triggering ice sheet melting/collapse. However, ventilation decreases of similar scale occur without accompanying peaks in IRD, suggesting circulation changes do not always trigger ice sheet collapse. In addition, the periods of weakest ventilation (low benthic δ^{13}C) are clearly coincident with the largest IRD peaks and planktonic δ^{18}O decreases, consistent with a feedback of ice sheet melting and subpolar freshening on deep water circulation. Indeed, the largest IRD and lowest planktonic δ^{18}O values are associated with Heinrich event 1 and the onset of this anomaly is marked by the period of weakest deep water ventilation (lowest benthic δ^{13}C) observed in our record. Taken together we find support for ice sheet melting and increased freshwater supply as both a trigger for, and a feedback on, ocean circulation changes during the late glacial and deglacial period.