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Glacial ocean circulation in response to spatio-temporal freshwater discharges derived from an ice sheet model

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Decaying Northern Hemisphere ice sheets during deglaciation affect the high latitude hydrological balance and therefore the thermohaline circulation at the Last Glacial Maximum. Using a coupled three-dimensional atmosphere-ocean model we investigate the response of the thermohaline circulation to spatio-temporal variable freshwater discharges and time varying routing. Inputs are taken from a three-dimensional thermomechanically coupled ice sheet model of the Northern Hemisphere for the last glacial cycle. The discrimination between surface runoff and calving as the most contributing components does not only reflect different darinage mechanisms of the huge ice sheets, it also represents different climatic states of the glacial period; e.g., stadial/interstadial temperature oscillations over the ice sheets provide for increased surface runoff (Dansgaard-Oeschger cycles), while phases of increased ice sheet growth induce exceptionally large iceberg discharges (Heinrich events). We investigate the impact of this characteristically different signature of the freshwater pulses and the location of the drainage region in dependence of different background climate states on the Atlantic thermohaline circulation during deglaciation. We found that during Heinrich events, freshwater fluxes mainly occur through Hudson Strait and strongly affect the deep water formation region in Labrador Sea, leading to a complete breakdown of the overturning circulation after H1. In contrast during DO-events, meltwater floods the subtropical Atlantic through the Missisippi-Route with short dated, strong collapse of the THC but immediate recovery after the decay of the freshwater pulse. MWP-1A can therefore be seen as a precursor and preconditioning of the THC during Younger Dryas cold phase, following the Boelling-Alleroed warming.