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Regional and global sea level rise as a trigger for Heinrich events

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The climate over much of the last glacial period was extremely variable on a millennial timescale. The North Atlantic climate was punctuated by warm phases (Dansgaard-Oeschger events) recorded in proxies over most of the Northern Hemisphere. The long-lasting Dansgaard-Oeschger events were preceded by massive ice surges from the northern hemisphere ice sheets. These so-called Heinrich events are documented as thick layers of ice-rafted debris in marine sediments in the North Atlantic. They coincide with cold conditions in the North Atlantic region, warm episodes in Antarctica and with a significant increase in global sea level. So far, the mechanisms that trigger these massive ice surges are poorly understood. Why do the massive ice surges of the northern hemisphere ice sheets, for example, happen during the coldest time periods and not during warmer phases? Several hypotheses have been proposed to explain the nature and timing of Heinrich surges, among them internal ice sheet processes, and subsurface warming in the North Atlantic during the cold climate states.

Here we present a mechanism related to changes in the Atlantic thermohaline overturning circulation (THC) that can potentially explain the onset and the timing of the observed Heinrich events. Model simulations of abrupt glacial climate change with the 3D coupled global ocean-atmosphere-sea ice model ECBILT-CLIO show a substantial regional sea level rise in the northern North Atlantic in response to a total collapse of the THC. The increased heat uptake of the global ocean after the THC collapse leads to an additional rise in global sea level. The total sea level rise in the North Atlantic region has the potential to destabilise northern hemisphere ice shelves and ice sheets and to trigger the large ice surges during Heinrich events. As soon as the ice surge from some ice sheets have started, the global sea level rise due to the melting ice and,

to a smaller extent, the regional sea level rise in the North Atlantic Ocean due to the ongoing freshening of the surface waters are positive feedback mechanisms, causing additional ice sheets around the North Atlantic to surge.