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Heinrich event 1 triggered through warmer Nordic subsurface waters

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A common explanation of Heinrich events consists in a switch of the basal thermal conditions of the Laurentide Ice Sheet (LIS) leading to periodical purges of continental ice through the Hudson Strait into North Atlantic. Nevertheless, no three-dimensional thermomechanical ice-sheet model has yet been able to satisfactorily reproduce the binge-purge mechanism unless adding an ad-hoc basal sliding parameterization. The former theory is furthermore only based on glaciological processes and neglects any link with the oceanic behavior and any relation with Dansgaard-Oeschger (D-O) events.

However, recent observations in the Antarctic Peninsula and new interpretations of proxies suggest a strong coupling between ice sheets, ice shelfs and ocean. The recent disintegration of the Larsen B Antarctic ice shelf and the response of Pine Island glaciers have illustrated the importance of considering the physical interactions between the geometry and thickness of ice shelfs, the ice streams acceleration and the iceberg production. On the other hand, recent studies, based on proxies as well as on model results, have shown the occurrence of a subsurface warming of North Atlanctic waters during the stadial phases of the D-O cycle. This offers a link between the shift into stadial conditions and the basal destabilization of an ice shelf accompanied by an acceleration of grounded ice streams and a massive discharge of icebergs. These features are sustantially compatible with the generation of ice rafted debris Heinrich layers.

Here we combine simulations carried out with a climate model of intermediate complexity and a three-dimensional thermomechanical ice sheet model to show that a modest freshwater fluxes originated in melting and/or calving of the Fennoscandian ice-sheet around 19 kyr BP might have been enough to induce a weakening of the MOC resulting in a subsurface warming of Nordic Sea waters. This warming further propagates towards the Labrador sea, where it induces a destabilization of the ice shelf formed at the mouth of Hudson Strait. The ice streams flowing from Hudson Bay are then accelerated and a massive calving episode is produced. This phenomenom produces in turn a new perturbation of the meridional Atlanctic circulation distingishing then between a "Stadial Atlantic ocean situation" and a "Heinrich Atlantic ocean situation". We hypothesize such a mechanism might have operated during Heinrich event 1.