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Tides of the Glacial Ocean and their role in Heinrich Event Instability

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We investigate the possibility that Heinrich event one (H1), which occurred during the most recent glacial-interglacial transition, may have been triggered and thereafter continuously forced by the tides. For the purpose of this investigation, we have employed a discontinuous Galerkin method to solve the shallow water equations on the sphere using a non-uniform icosahedral grid. The model was fully described in Salehipour, Stuhne and Peltier (OCMOD, 2012) where it was benchmarked against the standard aquaplanet suite as well as modern altimetric observations of the main tidal constituents. Our interest is in the Heinrich event instability that was responsible for triggering the Dansgaard-Oeschger mode of climate variability that dominated such variability during Marine Isotope Stage 3 of the last glaciation cycle (Peltier and Vettoretti, GRL, 2014). The most recent Heinrich event (H1) was similarly responsible for the related Bolling-Allerod warming transition. As all such Heinrich events are known to have involved an instability of the Hudson Strait Ice Stream, we investigate the impact upon the North Atlantic tidal regime of a model of H1 in which the ice loss proceeds up the strait to Nottingham Island or beyond over a period from 500 to 1000 years. We find that the amplitude of the dominant M2 semi-diurnal tide reaches its maximum when Hudson Strait is filled with grounded ice that extended to the shelf break. The instability itself is significantly enabled by the up strait paleo-bathymetry which is controlled by the glacial isostatic adjustment process. Following H1 tidal amplitude falls precipitously throughout the North Atlantic. Equally important is the fact that during the instability an extremum of tidal amplitude tracks the retreat of the grounding line up the strait. Depending upon how deep the instability is assumed to extend up the strait, we find that it is able to sustain a freshwater forcing in the form of iceberg flux as high as 0.1 Sv, an amplitude that would have had a highly significant impact upon the strength of NADW formation and therefore upon the strength of the AMOC. These results strongly suggest that the tides of the glacial North Atlantic ocean may play an active role in controlling the physics of rapid climate change.