Geophysical Research Abstracts
Vol. 20, EGU2018-2579, 2018
EGU General Assembly 2018

Acceleration of northern ice sheet melt triggered AMOC slowdown and northern cooling 19-18 ka

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The cause of a rapid weakening in Atlantic Meridional Ocean Circulation (AMOC) and northern cooling that took place at the onset of Heinrich Stadial 1 ∼18.5 ka is unclear. Previous studies have simulated the event using ice sheet and/or iceberg meltwater forcing, but these idealised freshwater fluxes have been unrealistically large.

Here, we use a different approach, driving a high-resolution drainage network model with a recent time-resolved global palaeo ice sheet reconstruction to generate a realistic meltwater forcing. We input this flux to the HadCM3 climate model without adjusting the timing or amplitude and find that an acceleration in northern ice sheet melting (up to ∼7.5 m/kyr global mean sea level rise equivalent) triggers a 20% reduction in the AMOC.

The simulated pattern of ocean circulation and climate change matches an array of palaeoclimate and ocean circulation reconstructions for the start of Heinrich Stadial 1, both in terms of rates and magnitude of change. This is achieved with a meltwater flux that is consistent with constraints on sea level rise and ice sheet evolution around 19-18 ka, which is less than half of the freshwater forcing used in previous studies. Furthermore, we find that AMOC need not be in a bi-stable state, nor must it totally collapse, to trigger the onset of the Heinrich Stadial.

The rates of melting that drove the AMOC slowdown are similar to those projected for Greenland by 2200. Therefore, constraining the melt rates and magnitude of climate change during Heinrich Stadial 1 would provide an important test of climate model sensitivity to future ice sheet melt.