Heinrich Stadial 1 caused by acceleration of Eurasian deglaciation ~18.5 ka

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Heinrich Stadial 1 (~18-15 ka) is characterised by slow Atlantic Meridional Overturning Circulation (AMOC) and relatively cold Northern Hemisphere temperatures. Until recently, such conditions were largely attributed to the effect of North Atlantic surface freshening from enhanced iceberg calving (Heinrich Event 1). However, climate models have repeatedly struggled to simulate Heinrich Stadial 1 using realistic iceberg-derived freshwater fluxes, and it has recently been shown that Heinrich Event 1 began well after the onset of the AMOC slow down and northern cooling, and thus could not have caused it.

We ran the ICE-6G_C (VM5a) global ice sheet reconstruction through a high resolution drainage network routing model to produce fully-distributed meltwater discharge for the period spanning 21-17 ka. We then used the resultant global, transient meltwater flux to force the coupled ocean-atmosphere-vegetation General Circulation Model HadCM3, which was otherwise set up according to conditions at 21 ka.

The model simulates a 20% reduction in maximum AMOC strength in response to accelerated Eurasian ice sheet melt delivered to the Arctic Ocean, starting ~18.5 ka. This in turn drives North Atlantic sea surface and surface air cooling of 1-5 °C, with even greater cooling occurring over regions with increased sea ice cover. Surface air temperature anomalies are largest during the Boreal Winter, but sea surface temperature changes are less seasonal. More widely, Eurasia cools by 1-3 °C, and the Southern Hemisphere undergoes weak warming of under +1 °C. The simulated climate matches a suite of geochemical climate proxy indicators, including Pa/Th measures of AMOC strength, alkenone-derived North Atlantic sea surface temperatures, Greenland ice core surface air temperatures, and precipitation changes inferred from Hulu Cave speleothems and Cariaco Basin reflectance data.