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The Influence of Greenland melt water on the temporal and spatial response of the Holocene Thermal Maximum in the Nordic Seas: a modelling study

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In the early-to-mid Holocene a period of relatively warm climate, known as the Holocene thermal maximum (HTM, 11-5 kyr BP), has been associated with the orbitally-forced northern hemisphere summer insolation maximum at approximately 10 kyr BP. Although the HTM is orbitally forced, the spatial and temporal response of its climate signature is diverse. At 9 kyr BP remnants of glacial ice sheets, most importantly the Laurentide Ice Sheet (LIS), modified the climate of the North Atlantic region by freshening the ocean surface through melt water discharge, and by altering the surface albedo and topography. A previous climate modelling study (*Renssen et al. 2009*) has shown that the LIS delayed the HTM in the Nordic Seas by up to 3000 years. We extend this approach by introducing another source of melt water in the early Holocene, the Greenland Ice Sheet (GIS). The GIS was likely up to 25% larger (at 9 kyr BP) in volume than at present-day (*Vinther et al. 2009*, *Peltier, 2004*) and is therefore potentially an important regional contributor to climate change in the Nordic Seas.

We present here simulations performed with the LOVECLIM1.2 global ocean-atmosphere-vegetation model. These simulations seek to highlight the spatial and temporal impact of GIS melting on the early Holocene climate, in terms of sea surface temperature (SST). Several sensitivity experiments with fixed 9 kyr BP forcings were performed for different Greenland melt water fluxes to test model and climate sensitivity. These melt water fluxes range from 0 to 52 mSv. The sensitivity experiments show that GIS melting considerably influences sea surface conditions around the southern part of Greenland, and that 13 to 26 mSv of GIS melting, in a combination with the LIS background melting, agrees better in that region with proxy-based SST reconstructions. In a further step, transient simulations exhibit the long term (9 to 0 kyr BP) impact of GIS melting on the development of the Holocene climate. Transient simulations are compared to proxy-based SST reconstructions from the Nordic Seas region. We find a better agreement between simulations including GIS melt and proxy-based SST reconstructions. According to marine proxy data the HTM is non-uniform over the Nordic Seas. Yielding higher SST near the Norwegian Coast and cooler near Greenland. The influence of the LIS explains part of this climate variability, but in the Denmark Strait, this forcing is not sufficient enough to explain reconstructed SST trends. Supporting the proposed significance of GIS melting as a regional contributor to climate change in the Nordic Seas.

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