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Impact of Arctic gateways closure on the Atlantic Meridional Overturning Circulation in the Pliocene

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The mid-Pliocene climate is the most recent geological period with a greenhouse gas concentration of approximately 400 ppmv, similar to the present day. Proxy reconstructions indicate enhanced warming in the high North Atlantic in the mid-Pliocene, which has been suggested to be a response to a stronger Atlantic Meridional Overturning Circulation (AMOC). PlioMIP2 ensemble results show a stronger AMOC and simulated North Atlantic sea surface temperatures (SSTs) match reconstructions better than PlioMIP1. A major difference between PlioMIP1 and PlioMIP2 is the closure of the Bering Strait and Canadian Archipelago in the Pliocene. Previous studies have shown that closure of these Arctic gateways leads to an enhanced AMOC due to altered freshwater fluxes in the Arctic.

Analysis of our Community Earth System Model (CESM1) simulations shows that the simulated increase in North Atlantic SSTs and strengthened AMOC in the Pliocene is a result of Pliocene boundary conditions rather than CO_2 concentration increase. Here we compare results from two runs with pre-industrial boundary conditions and 280 and 560 ppmv CO_2 concentrations and three runs with PlioMIP2 boundary conditions and 280, 400 and 560 ppmv CO_2 concentrations. Results show a 10-15% stronger AMOC in the Pliocene simulations as well as enhanced warming and saltening of the North Atlantic sea surface. While there is a stronger AMOC, the Atlantic northward ocean heat transport (OHT) in the Pliocene simulations only increases 0-3% with respect to the pre-industrial. Analysis indicates there is an altered relationship between the AMOC and OHT in the Pliocene, pointing to fundamentally different behavior of the AMOC in the Pliocene simulations. This is supported by a specific spatial pattern of deep water formation (DWF) areas in the Pliocene simulations that is significantly different from that of the pre-industrial. In the Pliocene simulations, DWF areas adjacent to south Greenland disappear and new DWF areas appear further southwards in the Labrador Sea off the coast of Newfounland. These results indicate that insight into the effect of the palaeogeographic boundary conditions is crucial to understanding the Pliocene climate and its potential as a geological equivalent to a future greenhouse climate.