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The thermal threshold of the Atlantic meridional overturning and its control by wind stress forcing during glacial climate

A. Oka, H. Hasumi, and A. Abe-Ouchi

The University of Tokyo, Atmosphere and Ocean Research Institute, Kahiwa, Chiba, Japan (akira@aori.u-tokyo.ac.jp)

Paleo proxy data suggest that the Atlantic meridional overturning circulation (AMOC) during the Last Glacial Maximum (LGM) was shallower and weaker than the present-day one. In this study, we have identified the existence of a thermal threshold of the AMOC which may explain why many coupled climate models fail to simulate the weaker AMOC during the LGM. By using results obtained from a coupled climate model and conducting sensitivity simulations with an ocean general circulation model, we found that the sudden transition from the present-day AMOC to the weaker glacial AMOC occurs when we gradually change degree of surface cooling from the present-day to glacial conditions. This result is related to response of deep convection in the northern North Atlantic Ocean; moderate cooling enhances deep convection whereas sea ice covers there entirely and prevents deep convection under sufficient cooling. The findings indicate the existence of a thermal threshold controlling the AMOC, where the present-day-type AMOC suddenly shifts to the weaker glacial AMOC once the surface cooling exceeds this threshold. We also demonstrate that wind stress forcing plays a critical role in controlling the value of the thermal threshold. Our study suggests that slight differences in the degree of surface cooling or wind stress forcing for LGM simulations could lead to the very different response of the AMOC during the LGM as reported in previous LGM simulations.