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The influence of glacial ice sheets on Atlantic meridional overturning circulation through atmospheric circulation change under glacial climate

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Recent coupled modeling studies have shown that the existence of the glacial ice sheets intensifies the Atlantic meridional overturning circulation (AMOC). Since this may play an important role in maintaining a strong AMOC over the last glacial period, which is suggested by recent reconstruction study, it is very important to understand the process by which glacial ice sheets intensify the AMOC. Here, a decoupled simulation is conducted to investigate the effect of wind change due to glacial ice sheets on the AMOC, the crucial region where wind modifies the AMOC and the mechanism, which remained elusive in previous studies. First, from atmospheric general circulation model (AGCM) experiments, the effect of glacial ice sheets on the surface wind is evaluated. Second, from ocean general circulation model (OGCM) experiments, the influence of the wind stress change on the AMOC is evaluated by applying only the changes in the surface wind as a boundary condition, while leaving surface heat and freshwater fluxes unchanged. Moreover, several sensitivity experiments are conducted. Using the AGCM, glacial ice sheets are applied individually. Using the OGCM, changes in the wind are applied regionally or at different magnitudes, ranging from the full glacial to modern levels. These experiments demonstrate that glacial ice sheets intensify the AMOC through an increase in the wind stress curl mainly at the North Atlantic mid-latitudes. This intensification is caused by the increased Ekman upwelling and gyre transport of salt while the change in sea ice transport works as a negative, though minor, feedback.