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The topographic and albedo effect of ice sheets on surface wind stress with implications for glacial ocean circulation

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In the previous presentation of Abe-Ouchi et al. (2012, JpGU), they pointed out that the Atlantic meridional overturning circulation (AMOC) was strongly controlled by the ice sheet and greenhouse gases (GHGs). By comparing the results from a coupled atmosphere ocean general circulation model (AOGCM) with and without glacial ice sheets, they showed that the ice sheets had a large influence on the glacial AMOC. The process behind this is not fully understood, but may be related to atmospheric circulation change due to the presence of huge ice sheets. Some studies have shown that during the Last Glacial Maximum (LGM), the atmospheric circulation was very different to that of today mainly due to the presence of the huge ice sheet, especially in the North Atlantic. These atmospheric circulation differences would cause some changes in wind stress and should therefore affect AMOC. Thus in this study, we investigate the potential/possible influence of the ice sheets on glacial AMOC through wind stress. Here we use an atmosphere general circulation model (AGCM), which is the atmospheric part of MIROC climate model for sensitivity experiments. As ice sheet has two effects (topography effect and albedo effect) on atmospheric circulation, we separate each effect as well. In the North Atlantic, consistent with previous studies, differences between the wind stresses of the modern climate and LGM were mainly explained by the presence of the LGM ice sheets, i.e., Laurentide and Fenno-Scandian ice sheets. Anomalies induced by the ice sheets were a southward wind stress anomaly in the Greenland Sea and the Baffin Bay, and anti-cyclonic wind stress anomaly at mid and low latitudes. It was also found that at high latitudes, the topography effect was dominant and the albedo effect played a secondary role. On the other hand, at mid-latitudes, the albedo effect was dominant and the topography effect played an opposite role compared to the total ice sheet effect. In the zonal mean, there were also net westward and eastward anomalies at mid and low latitudes, respectively.

Keywords: Ice sheet, LGM, wind stress, AMOC