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

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It is well known that glacial ice sheets (Laurentide, Fennoscandian and Antarctic ice sheets) exert a large influence on the climate including the atmospheric circulation. Moreover, recent climate modeling studies suggest that glacial ice sheets have a large impact on the Atlantic meridional overturning circulation (AMOC). However, the process by which the ice sheets impact on the AMOC is not yet fully understood. On the other hand, recent studies showed that surface wind changes play a crucial role on changes to the AMOC under glacial climate. Therefore, in this study, we investigate in detail, the process by which the ice sheet modifies the AMOC through surface wind change. Here we conduct numerical experiments using an atmospheric general circulation model (AGCM) and an ocean general circulation model (OGCM) separately. Our method consists of 2 steps. First, from AGCM experiments, we evaluate the effect of glacial ice sheets on the surface wind. Second, from OGCM experiments, we evaluate the influence of the wind stress change on the AMOC by applying the surface wind change as a boundary condition, while leaving other boundary conditions (surface heat and water fluxes) unchanged. In addition, we conduct several sensitivity experiments. Using the AGCM, we explore individual ice sheet effect, ice sheet topography effect and albedo effect on surface wind change. Moreover, using the OGCM, we change the surface wind gradually or apply the surface wind change only at a specific region in order to explore the wind change effect in detail. We find that glacial ice sheets largely intensify the AMOC by surface wind change under glacial climate. Compare to other regions, it reveals that the wind change at the North Atlantic (NA) is a key region. There, the northern glacial ice sheet topography intensifies the Icelandic Low and anti-cyclonic circulation over the Laurentide ice sheet. However, this wind effect is effective only when the NA is not widely covered by sea ice. From our sensitivity experiments, we conclude that glacial ice sheets intensify the AMOC thorough enhancing the salt transport at high latitude NA surface.