

## The influence of glacial ice sheet on Atlantic Meridional Overturning Circulation through atmospheric circulation change

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In glacial period, huge ice sheet covered the North America and the Northern Europe. Also, the Antarctica Ice sheet had expanded and increased its altitude. It is well known that these ice sheets (hereafter glacial ice sheets) have large influence on climate, for example atmospheric circulation, surface air temperature, and sea surface temperature. On the other hand, recent studies showed that wind stress changes play a crucial role on the AMOC under glacial climate. Moreover, increasing evidence suggests that glacial ice sheets have large influence on the Atlantic Meridional Overturning Circulation (AMOC). However the process how the ice sheets cause such a large impact on the AMOC is yet fully understood. Thus, in this study, we aim to reveal the detailed process of the ice sheet affecting the AMOC through atmospheric circulation change.

Commonly, the Atmosphere-Ocean General Circulation Model (AOGCM) is used to assess the influence of the ice sheet on the AMOC. However, as the atmospheric general circulation model (AGCM) and ocean general circulation model (OGCM) interacts in this model, the wind change as well as other process affect the AMOC. Therefore, it is difficult to divide each effect. Using the AGCM and the OGCM separately can overcome this problem because in this manner, they do not interact and the wind stress or other process can be treated as a boundary condition for the OGCM. This method consists of 2 steps. First, by using the AGCM, the effect of glacial ice sheets on the surface wind stress are evaluated by adding glacial ice sheets as a boundary condition. Second, by using the wind stress result as a boundary condition for the OGCM, the influence of the wind stress change on AMOC is estimated. In addition, by analyzing the results from each model, the underlying mechanism is explored.

As a result, glacial ice sheets largely intensified the AMOC under glacial climate. It was also found that the wind stress change at North Atlantic was important, thus glacial ice sheets at northern hemisphere were important. On the other hand, the AMOC was hardly influenced by wind stress change at Southern Ocean, which is mainly induced by the change in the Antarctica Ice sheet. Therefore change in the Antarctica Ice sheet had small impact on AMOC through surface wind stress change.

By analyzing the results from the AGCM and OGCM, it revealed that two processes were crucial; first, the strengthening of the northward salt transport, which resulted from enhanced westerly due to the North America Ice sheet. Second, the northward sea ice transport due to the southerly wind at Norwegian Sea forced by the Northern Europe Ice sheet. These two processes were found to drastically intensify the AMOC through affecting the sea ice distribution and shifting the NADW formation region.

Keywords: Ice sheet, Glacial climate, AMOC, wind stress