Factor analysis of the millennial time-scale climate variability in glacial periods

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It is well known that in the glacial periods, air temperature changed abruptly over the North Atlantic on millennial time-scale. It is also known that temperature changes over the Southern Ocean were opposite to the North Atlantic, called a bipolar seesaw relationship. It is suggested that changes in the strength of the Atlantic Meridional Overturning Circulation (AMOC) were closely related to such global climate changes.

In recent years, the idea that freshwater forcing causes the climate changes has been questioned. Spontaneous oscillations in AMOC can be reproduced by experiments using atmosphere-ocean coupled general circulation models (AOGCM). These studies proposed that oceanic feedbacks within the North Atlantic surface - subsurface ocean are important in inducing the spontaneous AMOC variabilities. However, the oscillation cycles shown in previous studies (Peltier and Vettoretti, 2014; Brown and Galbraith, 2016) are several hundred years, which are shorter compared to climate variabilities documented in ice core data. On the other hand, in experiments carried out with MIROC4m AOGCM under the medium glacial condition, millennial time-scale climate and AMOC variabilities are reproduced. Therefore, in this study, we analyze factors controlling the millennial time-scale climate variability obtained from MIROC4m AOGCM. Focusing on the fact that this oscillation cycle is close to the time-scale of the Southern Ocean and the bottom ocean circulation, we analyze the behavior of the Southern Ocean and the bottom ocean in detail, especially deeper than 2500 meters, in addition to oceanic feedback suggested by previous studies.

As a result, it is suggested that the density change at the bottom ocean, which is caused by changes in sea ice formation over the Southern Ocean, plays an important role in controlling the oscillation of AMOC on millennial time-scale.

Keywords: AMOC, Glacial climate, AOGCM

