A study on the variability of the deep ocean circulation during glacial climate with a climate model of intermediate complexity

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Ice core reconstructions show that there were abrupt climate changes termed Dansgaard-Oscillation (D-O) oscillations during glacial period, which are most characterized by about 10 ℃ of temperature changes in Greenland within a few decades. Many studies have pointed out the connection between D-O oscillations and changes in the Atlantic Meridional Overturning Circulation (AMOC), while details of its variability is still missing. Previous modeling studies have suggested that the variability of the AMOC including D-O oscillations are invoked by freshwater input from melted ice-sheets into the deep-water formation region in the North Atlantic (e.g. Rahmstrf, 2002). However, some recent model simulations exhibit abrupt and spontaneous oscillations without freshwater forcing in glacial climate (Peltier and Vettoretti, 2014; Brown and Galbraith, 2016), and more researchers are considering that the mechanism of D-O oscillations is involved within the ocean dynamics and its interactions with the atmosphere and sea ice. Since global coupled models usually used in previous simulations contain many processes of the atmosphere and the ocean, they require high computational costs and it is difficult to identify the processes contributing to D-O oscillations from the model simulations. On the other hand, earth system models of intermediate complexity with lighter computational costs have difficulties in reproducing climate features.
In this study, we modified the model in which the atmosphere component is simplified to the energy-balanced model (MIROC-lite, Oka et al., 2011, 2017) by using results of a full-coupled model (MIROC, Hasumi and Emori, 2001) as parameters so as to have equivalent performance to the full-coupled model, then conducted simulations of glacial climate with the model. This model is expected to be effective for investigating the cause of the spontaneous oscillations of full-coupled models since it can better represent thermal feedback between the atmosphere and the ocean by predicting atmosphere temperature from energy balance compared to ocean-only models. In our presentation, we discuss the performance of the model and its implications for the mechanism of D-O oscillations.

Keywords: glacial climate, deep ocean circulation, climate model

