Modelling the deep ocean circulation at the Last Glacial Maximum

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The deep ocean circulation in the present climate is characterized by thermohaline circulation driven by deep convection in the Labrador and Greenland Seas. This circulation consists of sinking part in the Atlantic Ocean and upwelling part in Southern and Pacific Oceans. Although the flow in the deep ocean is very slow, it carries huge amount of water in the deep ocean and the heat transport associated with this circulation is comparable to that by atmosphere. This heat transport has an important role in the present climate, especially near northern North Atlantic Ocean. In addition, because the ocean stores large amount of carbon (60 times larger than that of atmosphere), the deep ocean circulation significantly affects the carbon cycle in the climate system. From both physical and biogeochemical aspects, the deep ocean circulation is one of key factors controlling the climate system.

It is pointed out by many studies that changes in the deep ocean circulation could cause drastic climate changes. It is also anticipated that the deep ocean circulation may be significantly affected by freshwater flux from melting ice sheet on Greenland if the global warming proceeds in the future. Climate models are powerful tool for understanding the role of the deep ocean circulation in the climate system and provide future climate change projections. Although these models are carefully developed to reproduce the present climatology, the constraint from past climate changes is expected to be used for the model validation and give us an important information on future climate changes.

The Last Glacial Maximum (LGM), when the ice sheet covered over the north American continent 20,000 years ago, is one of the most promising period for collaboration between the paleoclimatological and modelling studies. In this period, various kinds of paleoclimatological proxy from ice core, deep ocean sediment, lake, and so on are collected over the globe. They give the opportunity to test the ability of the climate model to simulate the LGM climate realistically. In fact, the LGM is one of the period targeted by the Paleoclimate Model Intercomparision Project (PMIP). However, the proxy for the deep ocean circulation changes is still limited and difficult to be interpreted. The carbon isotope data suggests that the Atlantic deep circulation at the LGM was weaker and shallower than the present one. Because the carbon isotope is affected not only by the circulation changes but by biological activity and gas exchange, the interpretation of this proxy is difficult and still on debate.

In this presentation, we focus on the deep ocean circulation at the Last Glacial Maximum (LGM) and introduce the modelling studies on it.