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Glacial climate and thermohaline circulation: an ocean biogeochemical modeling toward direct comparison with proxy data

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The deep ocean circulation in the present climate is characterized by the existence of the Atlantic meridional overturning circulation (AMOC) accompanied with deep water formations in the Labrador and Greenland Seas. This circulation consists of sinking part in the northern North Atlantic Ocean and upwelling part in the 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 has a great influence on the climate. In addition, because the ocean stores large amount of carbon (60 times larger than that of the 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.

During glacial climate, abrupt climate changes known as Dansgaard-Oeshger events are considered to be caused by changes in the AMOC. The thermohaline circulation is also believed to have an important role in the changes in atmospheric CO2 concentration from glacial to interglacial periods. Simulation of the Last Glacial maximum has been a target of the Paleoclimate Model Intercomparision Project (PMIP), and various coupled climate models have challenged the LGM simulation by following the protocol proposed by PMIP. Therein, substantial differences in the glacial AMOC among models have been observed, with half of models simulating a weakening of the AMOC while the other half simulate a strengthening. Because paleo proxy data such as d13C and 231Pa/230Th ratio suggest that the AMOC became shallower and reduced by up to 30 % during the LGM compared with the present climate, it is widely believed that the AMOC during the LGM is weaker than that at the present climate. However, a couple of studies using another paleo proxy data, Nd isotope ratio, imply that the AMOC during the LGM may be almost the same or even slightly stronger than the present one. This means that there is also discrepancy among paleo proxy data themselves or their interpretation.

In order to validate climate model simulations directly with paleo proxy data, explicit simulation of these proxy data with ocean biogeochemical model is getting important recently. Such simulations are also very helpful for interpretation of proxy data because they can quantitatively evaluate which processes are important for controlling the distribution of paleo proxy. In this talk, recent attempts for simulation of paleo proxy with biogeochemical model are introduced.