Role of Southern Ocean in glacial atmospheric CO2 reduction

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Atmospheric carbon dioxide concentration ($pCO2^{atm}$) during glacial periods is known to be considerably lower than during interglacial periods. However, previous studies using an ocean general circulation model (OGCM) fail to reproduce this. Therefore, the detailed mechanism is still unclear.

Paleoclimate proxy data of the Last Glacial Maximum indicate high salinity and long water mass residence time in the deep Southern Ocean, suggesting that salinity stratification was enhanced and more carbon was stored there. The Southern Ocean has been recognized as a key region for carbon uptake during glacial periods. Here, we conducted numerical experiments using an OGCM to investigate the role of the Southern Ocean process in the variation of $pCO2^{atm}$; we evaluate the glacial response of ocean carbon cycles under the high salinity and old water mass age in the glacial Southern Ocean.

We found that deep water formation in East Antarctica is required to explain high salinity in the South Atlantic. Contrary to previous estimates, saltier deep Southern Ocean resulted in increased $pCO2^{atm}$. This is because Antarctic Bottom Water flow increased and residence time of carbon decreased in the deep Pacific Ocean. On the other hand, weakening of vertical mixing contributed to the increase of the vertical gradient of dissolved inorganic carbon and decrease of $pCO2^{atm}$. However, we show that it is unable to explain the full magnitude of recorded reduction of glacial $pCO2^{atm}$ in our simulations which include the above-mentioned contribution of the Southern Ocean process in addition to SST and SSS changes, ocean circulation changes, and iron fertilization changes [1]. Our findings indicate that detailed understanding of the impact of enhanced stratification in the Southern Ocean on the Pacific Ocean might be crucial to understanding the mechanisms behind the glacial–interglacial ocean carbon cycle variations.

[1] Kobayashi *et al*. (2015) *Paleoceanography* **30**, 1202–1216.