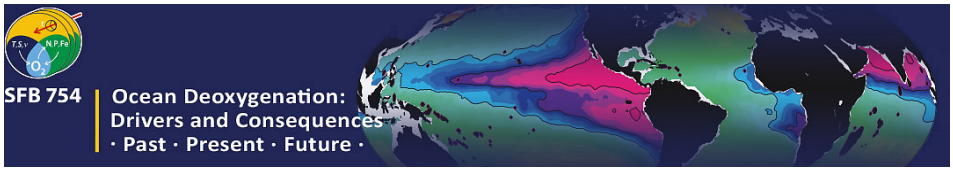

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Role of biological pump in glacial-interglacial carbon and oxygen cycle: a model study

The atmospheric CO_2 concentration during glacial periods is lower than interglacial periods by 80-100 ppm. Ocean has been implicated as key driver of glacial-interglacial CO2 change. However, the mechanisms for oceanic carbon accumulation during glacial periods are still unclear. Enhanced biological pump due to iron fertilization and higher nutrient inventory via sea-level drop accumulate carbon and consume dissolved oxygen in the deep ocean. In this study, we investigated the role of enhanced biological pump in the glacial variations of atmospheric CO2 and dissolved oxygen using AOGCM and ocean biogeochemical model. For the LGM simulation, iron fertilization and higher nutrient inventory via sea-level drop reduce atmospheric CO2 by 20 ppm and 15 ppm, respectively. The total CO2 reduction of 60 ppm (including physical and biogeochemical processes) is smaller than the glacial-interglacial CO2 difference. Simulated oxygenation in upper ocean (~ 1 km) and deoxygenation in global deep ocean under LGM condition are consistent with proxy data (Jaccard and Galbraith, 2012). Enhanced biological pump due to iron fertilization reduces oxygen concentration by about 20 μmol/kg in the Southern Ocean and global deep water. However simulated oxygen reduction of 30 μmol/kg in the deep Southern Ocean is smaller than proxy-based reconstruction of oxygen reduction of 175 μmol/kg (Gottschalk et al., 2016). This is because enhanced mixing in the Southern Ocean supplies oxygen into the deep ocean. Our results suggest that a sluggish circulation in the Southern Ocean is necessary for reducing deep ocean oxygen, thus resulting in further carbon accumulation there.

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