Impact of glacial dust on the oceanic iron and carbon cycles at the Last Glacial Maximum

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The atmospheric CO_2 concentration at the Last Glacial Maximum (LGM) is lower than the interglacial periods by about 80 ppm. Mechanisms for changes in the atmospheric CO_2 reduction at the LGM are still not clarified yet. About 30% of the ocean’s surface area is “High Nutrient Low Chlorophyll” (HNLC) regions, macronutrients like nitrate and phosphate are abundant, but the lack of iron restricts oceanic primary productivity. The LGM atmosphere is thought to have contained 3–4 times more dust than during the Holocene. Dustborne iron fertilization of HNLC regions and the subsequent sequestration of carbon in the ocean interior due to enhanced biological production has been proposed as a driver of lower levels of atmospheric CO_2 during glacial periods. Previous modeling studies show the important contribution of glaciogenic dust on dust increase in the LGM. Moreover iron solubility of glaciogenic dust (3%) is higher than that of arid soils (less than 1%) (Schroth et al., 2009). In this study, we explore the effect of glacial dust on the oceanic iron and carbon cycle at the LGM using ocean biogeochemical model. Assuming 3% solubility of iron in the glaciogenic dust, we obtain an atmospheric CO_2 reduction of 16 ppm. Sensitivity studies show that most of this CO_2 reduction is caused by enhanced glaciogenic dust. The surface area of HNLC regions reduces by about 60%. Enhanced export production associated with increase in glaciogenic dust reduces dissolved oxygen in the Antarctic Bottom Water, which is consistent with proxy records.

Keywords: ocean carbon cycle, glacial-interglacial cycle, iron cycle, ocean biogeochemical model

