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Simulation of ocean carbon and iron cycles at the LGM

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With a biogeochemical ocean model including explicit iron cycle, we carry out numerical simulations of preindustrial (CTL) and LGM climates.
We compare simulated export production (EP) with the paleoclimate reconstruction and evaluate the role of changes in ocean physical fields and atmospheric dust deposition by conducting series of sensitivity simulations.
In the Southern Ocean, the model successfully reproduces the dipole pattern of the paleo reconstruction: EP increases in lower latitudes and decreases in higher latitudes at the LGM.
We clarify that the higher-latitude decrease is caused by reduction of surface shortwave due to spreading of sea ice there, and iron fertilization effects by enhanced dust deposition lead to the lower-latitude increase.
In the Pacific Ocean, as some paleoclimate data suggest, iron fertilization effects increase EP over the basin except near the Kamchatka island where EP decreases due to reduction of shortwave and vertical mixing. On the contrary, the model fails to reproduce changes in EP in the Atlantic Ocean: the model simulates the reduction, whereas the paleo reconstruction suggests the increase in some regions.
In the model, changes in ocean physical fields tend to reduce EP since vertical mixing and upwelling of deep water significantly decline as a result of the weakened Atlantic deep circulation at the LGM.
In addition, nevertheless dust input significantly increases in the Atlantic Ocean, it also reduces EP there.
The latter response is explained by the fact that the biological production is limited not by iron but by phosphate there in our CTL simulation.
It is implied that the accurate evaluation of the iron limitation in the present ocean is critical for evaluating changes in EP and associated reduction of atmospheric CO2 concentration at the LGM.

Keywords: paleo climate modeling, ocean biogeochemical modeling, ocean biological production