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Impact of brine induced stratification on the glacial carbon cycle

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The link between carbon cycle and climate is at the core of the understanding of the climate system, and drives many researches. Various mechanisms have been proposed to explain the variations of atmospheric CO_2 and oceanic δ^{13}C measured during the glacial/interglacial cycles. Still, though the addition of several mechanisms does help, even the most recent scenarios are neither sufficient to fully explain the low atmospheric CO_2 concentration of approximately 190 ppm observed during the Last Glacial Maximum, about 21 kyrs ago (e.g. Brovkin et al., 2007) nor producing an oceanic δ^{13}C distribution compatible with what is inferred from sediment cores proxy data (Curry & Oppo, 2005).

In this context, the ocean is believed to play a major role as it can stock huge amounts of carbon, especially in the abyss, a carbon reservoir that could widen during glacial time. To create a larger carbon reservoir in the deep ocean, one possible mechanism is to produce very dense glacial waters thereby stratifying the deep ocean and reducing the carbon exchange between the deep and surface ocean. The existence of such very dense waters was inferred in the deep Atlantic during the LGM from sediment cores data, and the deep ocean stratification has been shown as a possible mechanism to store carbon in the ocean and ultimately decrease the atmospheric CO_2 concentration (Paillard & Parrenin, 2004).

Based on these data we propose a new mechanism that sets up such deep stratification, relying on the formation and rapid sink of brines, very salty water rejected during sea ice formation. We investigate the impact of this mechanism on the carbon cycle using the CLIMBER-2 fully coupled intermediate complexity climate model, well suited for the long simulations we run. As the model version used explicitly computes the evolution of the carbon cycle and carbon isotopes (such as δ^{13}C) in every reservoir, it allows us to directly compare the model output with data from sediment cores. We show that the brine induced stratification both leads to low glacial CO_2 and very negative deep δ^{13}C values, as observed in the proxy data. In particular, the LGM drop is quite large as it reaches 47 ppm with the brine induced stratification and can be further extended to 76 ppm with a simultaneous reduced oceanic vertical diffusion.

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