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Climate of the Past Discussions

Interactive comment on "Quantifying the roles of ocean circulation and biogeochemistry in governing ocean carbon-13 and atmospheric carbon dioxide at the last glacial maximum" *by* A. Tagliabue et al.

Anonymous Referee #1

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The authors describe a set of modeling experiments designed to investigate the impact of changes in ocean circulation and biogeochemistry on oceanic carbon isotopes and atmospheric CO2 between Pre-Industrial and Last Glacial Maximum periods. The model description relies on previous publications, and the implementation of the carbon-13 in the complex biogeochemical model refers to Tagliabue and Bopp (2008). The experimental strategy has a sufficient number of simulations to separate the various mechanisms. The section 3.1 "LGM ocean carbon-13" identifies the mechanisms responsible for the carbon isotopes distribution and points to a reduc-

tion of both North Atlantic and Southern Ocean ventilations. The section 3.2 "LGM atmospheric CO2" describes more carefully the changes in the carbon cycle. The discussion considers all necessary aspects. Nevertheless, regional changes in biogeochemical properties could be more detailed. Changes in export production among the various simulations are describedin section 3.2 and Table 3. Earlier comments on this aspect are needed in section 3.1 already (see specific comments below). Tables and Figures are sufficient to support the discussion. Nevertheless, Figures could be enlarged to facilitate the model-data comparison.

Scientific Significance: Good(2): the modeling of carbon isotopes in a state-of-the-art ocean general circulation and biogeochemical model for paleo studies is substantially new and contributes to important discussions on the topics addressed in this work.

Scientific Quality: Good (2). The scientific approach and applied methods are valid.

Presentation Quality: Good (2). A few sentences need re-phrasing.

Therefore, I recommend for publication after minor corrections.

Specific Comments

3 Results and discussion

3.1 LGM ocean carbon-13

p1470, line 1. "While increasing dust iron supply..."

C: Figure 1a shows a reduction of d13C-DIC in the Southern Ocean and a slight increase in the rest of the ocean, not a reduced d13C in deep-water. Are the primary production and the export production significantly modified by the additional iron supply in this dust only simulation ? Please already refer to your Table 3, and that you will comment the changes in export production in section 3.2.

p1470, line 7. "Increased LGM overturning..."

C: Please rephrase.

p1470, line 11. "... an excellent regional agreement with NA delta-d13C-DIC..."

C: Table 2 is for the entire ocean. Is the correlation coefficient better than 0.6 for the NA ?

p1471, line 7. "...since dust is insufficient..."

C: Once again, what is the response of the ecosystem to the dust supply in terms of export production ? Your simulation "Circa+PI_dust" mentioned in table 3 should help to separate this effect. Your interpretation in section 3.2 is satisfying, but comments on this aspect are missing at this stage of the paper to discard the biological effect.

p1472, lines 11-14. "In fact, colder temperatures,... elevate deep oxygen in some regions".

C: Is this new deep oxygen distribution only due to the circulation ? What about biology reorganization and remineralization ? Seesaw effects are visible on the export production: the PI+LGM_dust simulation has +15% of Cex in the SO, and -2.6% in the global ocean. Remineralization and oxygen consumption are linked to the biology reorganization and not only circulation.

3.2 LGM atmospheric CO2

p1472, line 23 "...reduce pCO2atm by $\sim$15ppm..."

C: To which simulation do you refer ?

p1473, line 6 to 9. "That we measure..."

C: Having changes in preformed nutrients and export production does not mean that the system is at the equilibrium. This will be visible on time series.

p1473, lines 25-26. "This results from..."

C: Please re-phrase.

p1475, line 10. What is "the Antarctic sector of the Southern Ocean" ?

p1476, lines 1-2. "due to reduced vertical nutrient supply"

C: We are talking here about the SO. So which vertical nutrient supply are we talking about ? Is it a deep nutrient feedback ?

p1476, lines 8 to 11. Interestingly, increasing the C/N ratio by 12% increases the SO Cex, but also decreases the global Cex (Table 3). In this experiment CircA+LGM_dust+CN, the further 9 ppm draw down is occurring while the global biological Cexport has decreased by 2%. By favoring the biological pump with the C/N ratio, you end up with a less efficient biological pump globally, and a more efficient physical pump. This is counter intuitive to me. Is this a robust result of you model ? Did you modify the C/N planktonic ratio only in the southern ocean ?

Minor corrections:

p1471, line 21. "... is not the forcing which we have used..." or "..which has been used..."

p1473, line 7. I guess you are referring to Table 3, not 2.

Fig. 1. Change the order of deltas in the unit along the color scale.

Interactive comment on Clim. Past Discuss., 5, 1463, 2009.