[Reply to Reviewer #1]

We appreciate the positive evaluation of the first revision and the additional comments by the reviewer.

Q1: This study conducted a two-step spin-up to establish values of DIC and alkalinity that are compatible with glacial ocean restoration. Additional charts or more detailed explanations would make it easier to understand the intent of the method.

A1: A chart (Fig. 2) was added to illustrate the workflow.

Q2: Would you evaluate how much atmospheric pCO2 would be obtained in each LGM experiment if there were no additional increments in DIC and alkalinity, which may come from changes in shallow water deposition of CaCO3? It may support the significance of continental shelf processes.

A2: We had also carried out three more LGM simulations without the additional alkalinity, which had resulted in 20 to 43 ppm higher pCO$_2$ depending on simulations. These simulations depict ocean states that satisfy the constraint of deep-ocean carbon reservoir but lacking the contribution of alkalinity increase. If DIC increase corresponding to the CaCO$_3$ deposition was removed as well, the simulated pCO$_2$ would be somewhat lower than the values shown above. These facts suggest that the shallow-water deposition of CaCO$_3$ would only explain a minor portion of the pCO$_2$ increase on the deglaciation as suggested by Ridgwell et al., (2003). We added a similar description to the manuscript (section 4.2).

Q3: P5/L27: It may be helpful to clarify the additional increase of 100 μmol kg-1 in this sentence.

A3: We modified the sentence to include the information.

Q4: P8/L16: Is AOU calculated explicitly in the model? If not, would you indicate how it is calculated?

A4: Yes, AOU is explicitly calculated in the model. We added a description to Section 2.1.

Q5: P8/L21: What caused the positive anomaly of d13C in the North Pacific in expLGMws. From Fig 7e, it is assumed that this is due to stronger volume transport from the Southern Ocean, which results in a smaller effect of remineralization.

A5: Thank you for the useful discussion, and we agree with the reviewer's opinion. A relevant description was added to the text.

Q6: P10/L15: Is the small MAR of CaCO3 in all experiments in the Southern Ocean due to the dominance of other particle fluxes such as opal?

A6: Yes. The small MAR of $CaCO_3$ in the Southern Ocean results from low $CaCO_3$ productivity compared to opal fixation, as the reviewer assumed. We added a corresponding sentence to section 3.6.

Q7: P10/L21 In Discussion section 4.1, the authors provided changes in the budget of oceanic DIC and alkalinity between the LGM and modern. It would be easier to understand if the estimated fluxes shown here could be visualized.

A7: We added a figure (Fig. 12) to summarize the discussion in Section 4.1.

Q8: Figures: There are abbreviations in the title of figures that are not explicitly stated (e.g. IFRAC). Also, it would be better to correct 330E and 210E in the title of the figure to 30W and 150W, respectively.

A8: We modified the figures accordingly.

[Reply to Reviewer #2]

We appreciate the positive evaluation of the revised manuscript and the additional comments by the reviewer.

Q1:

P1, L20: 'was characterized' not 'is characterized'.

P3, L5: 'inflow' and 'outflow' sound awkward in this context and following. Instead, I recommend 'input' and 'removal'.

P4, L2: Replace 'increment' with 'increase' (also in the abstract).

P4, L16: 'two combined factors' instead of 'combined two factors'.

P5, L33: Please add a reference for the standard CESM1.2 parameters.

P6, L14: Please add a reference to Fig. 1 here.

P12, L31: 'on average' not 'in average'.

P14, L30: 'added' instead of 'appended'.

P15, L29: Change 'influences on the ...' to 'influences the …'.

A1: We modified the manuscript according to these comments.

Q2: Fig. 1: Add 'constant' to the last sentence of the caption (i.e., "to keep the total volume of sea water constant.")

A2: Corrected.

Q3: Fig. 2: To better distinguish both overturning cells in panels a-d it would be beneficial to either mark the zero-isoline with a thicker line or change the contour lines of the negative values to dashed lines.

A3: We changed the filling color of the contours to better show the structures.