Reply to Reviewer2

We are grateful to the reviewer for his/her time in evaluating the manuscript as well as for constructive comments and suggestions. As listed below, we have taken all the comments into account by the reviewer in the revised manuscript. In the following, our responses will be written in blue, while the comments by the reviewer will be written in black.

Major comments:

1. In Figure 1, please add a panel for the ice-sheet anomalies between 36ka and 80ka, since it is a key to interpolate the modelling results.

We will add the following figure in the revised manuscript as Fig. 2.

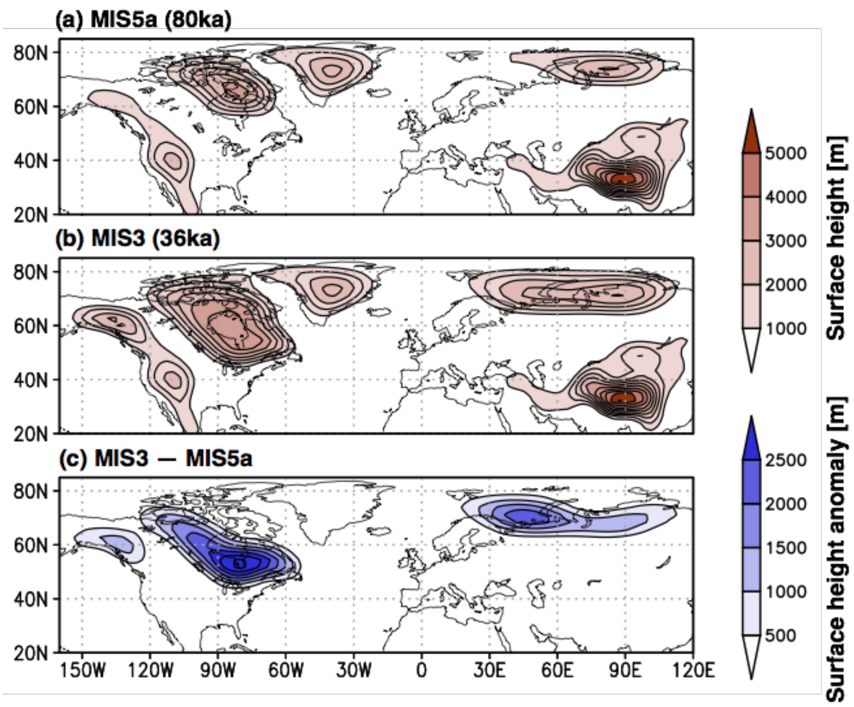

Figure 2: Surface Topography of (a) MIS5a (80 ka), (b) MIS3 (36 ka), and their difference (c) MIS3 - MIS5a. Results from an ice sheet model are presented (Abe-Ouchi et al. 2013). These ice sheet configurations are used for climate model simulations.

2. Line 116: why to use the CO2 concentration and insolation at 35ka, instead of 36ka? A linguistic error? Or specific reason?

To be honest, there is no special reason. At the time we started the experiment, we had the data of the ice sheet of 36ka in our server, hence we used it. Nevertheless, there is very little difference in the simulated ice sheet between 36ka and 35ka. Therefore, we don't think this slight difference in the ice sheet will affect our result.

3. Line 170: Please add a reference for the LGM experiment.

We will add the reference of LGM experiment (Sherriff-Tadano and Abe-Ouchi 2020) in the revised manuscript.

4. Line 195-196: Please give the value of AMOC strength in PI experiment.

We will include the value (16.1 Sv) in the revised Table 1.

Table 1: Forcing and boundary conditions of climate simulations. Results of global mean temperature (GMT) and Atlantic meridional overturning circulation (AMOC) are also shown.

Name	CO_2	Ice sheet	Obliquity	Precession	Ecc	GMT	AMOC
MIS5a	240 ppm	80 ka	23.175	312.25	0.0288	10.58˚C	18.7 Sv
MIS3	200 ppm	36 ka	22.754	251.28	0.0154	7.85˚C	15.6 Sv
MIS3-5aice	200 ppm	80 ka	22.754	251.28	0.0154	8.91˚C	15.1 Sv
PI	285 ppm	0 ka	23.45	102.04	0.0167	12.83˚C	16.1 Sv

5. Line 219 and Figure 6: Please add the curve for the modelled PI state.
We will add the result of PI in the revised Fig. 7.

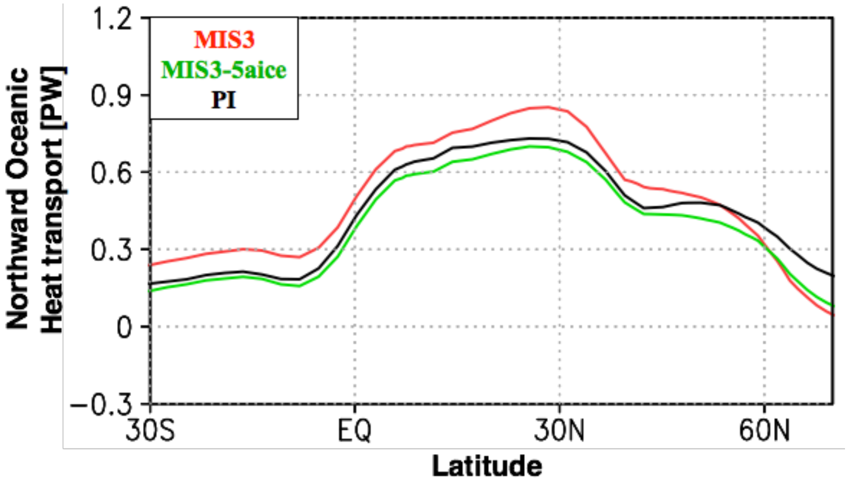

Figure 7: Northward oceanic heat transport over the Atlantic basin simulated from the AOGCM. Red: MIS3, Green: MIS3-5aice, and Black: PI. The climatology of the last 100 years is used to create these figures.

6. In what area are the NADW formed? Are they consistent among experiments? Any response of the NADW formation in the NORDIC Sea?
The deepwater mainly forms at the Nordic Sea and Irminger Sea. They are similar among the experiments, but there is a slight southward shift in the Nordic Seas in MIS3 compared with MIS5a. We will add a figure of deepwater formation region in the supplementary figure.

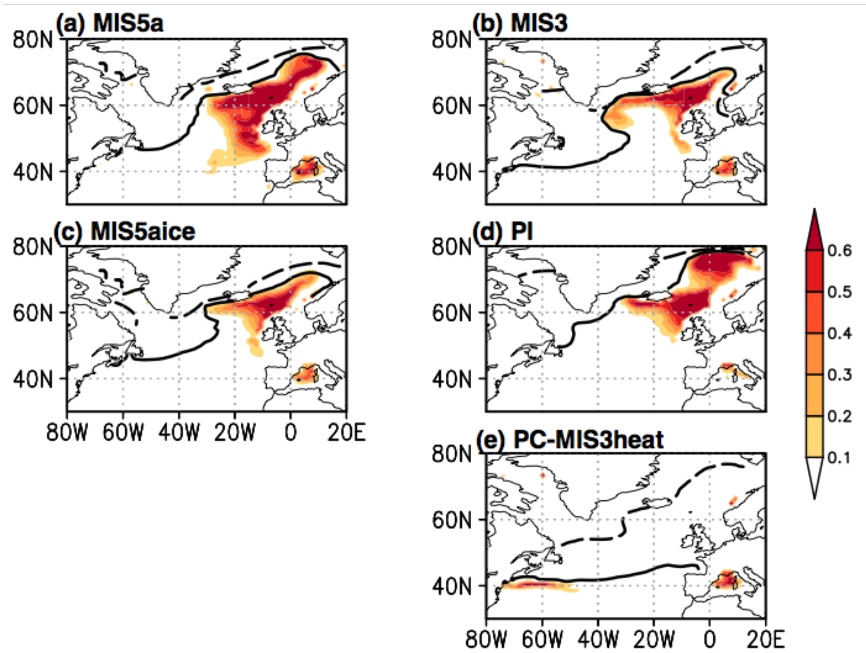

Figure S1: Spatial map of sea ice edge (contour) and deepwater formation region (color) at the North Atlantic. For sea ice, climatology of 15% sea ice concentration at February (solid) and August (dashed) are shown. For deepwater formation region, frequency of convective adjustment at 600 meter depth is shown. The climatology of the last 100 years is used to create these figures

7. Line 249: bottom ocean stratification with respective to density? If so, please add the information for density in Figure 4.

Yes, in deed. We will add a figure of density in the revised figure 5. Also, we noticed that the previous figure was showing the zonal average of the global ocean. We fixed this mistake in the revised manuscript.

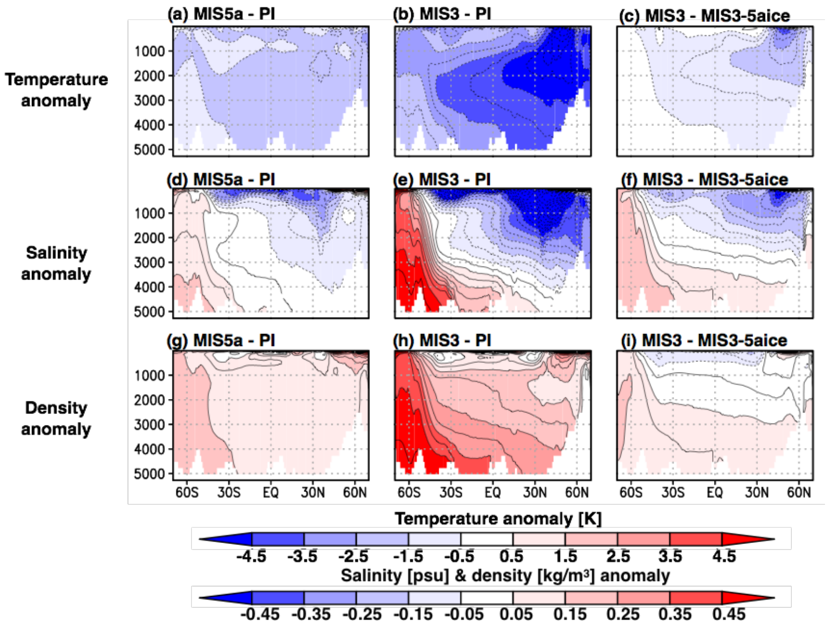

Figure 5: Anomalies of zonally averaged oceanic properties over the Atlantic simulated from the AOGCM. The top panels show temperature anomalies, the middle panels show salinity anomalies, and the bottom panels show density anomalies. (a, d, g) MIS5a minus PI, (b, e, h) MIS3 minus PI, (c, f, i) MIS3 minus MIS3-5aice. The climatology of the last 100 years is used to create these figures.

8. Line 271: In addition to Figure 10, please show the convection map as that in Fig.7c.
We will add a figure of the convection map in the revised figure S1 as shown above.

9. Also in Line 271: please add a figure for the statement 'colder water occupies the subsurface ocean in MIS3 compared with MIS3-5aice.' , in either Main text or SI.
We will add a figure of the vertical profile of ocean temperature in the supplementary figure.

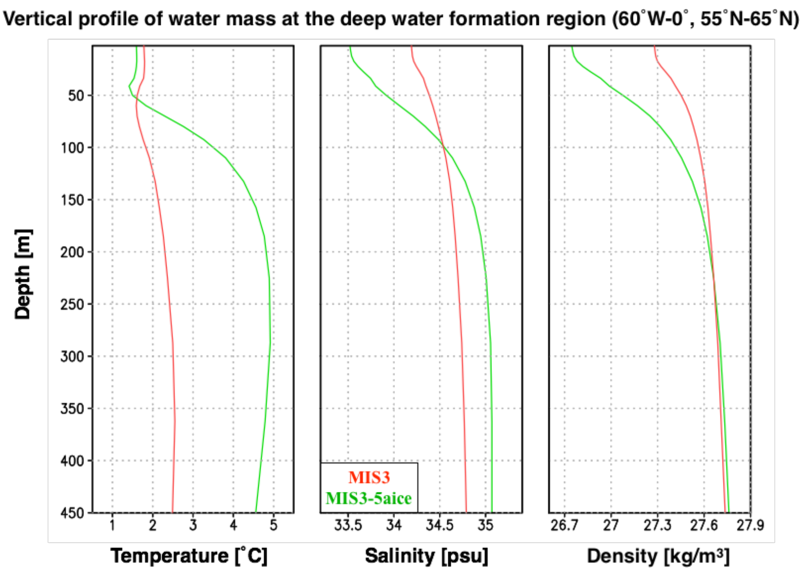

Figure S2: Vertical profile of oceanic properties at the North Atlantic Deep Water formation region (60˚W-0˚, 55˚N-65˚N). Red: MIS3 and Green: MIS3-5aice. Cold water occupies the subsurface ocean in MIS3 compared with MIS3-5aice. The climatology of the last 100 years is used to create these figures.

10. In Table 1: please add the information also for the PI and LGM experiments together with their references.
We will add the information of PI in the revised Table 1 since the results of PI appear in several figures (please see the revised Table 1 shown above). For LGM, we decided not to add in the table, as the results do not appear in other figures, and it is discussed only for once. Nevertheless, we will add a reference of LGM in the revised manuscript.

11. In Figure 11, how to address the impact of stronger surface winds on the northward ocean heat transport and surface cooling in the northern North Atlantic? Any indications based on the experiments in this study?
As pointed out by the reviewer, the stronger wind can increase the strength of the northward oceanic heat transport at high latitude by strengthening the wind-driven ocean circulation. This can then increase the strength of the surface cooling (or atmosphere-ocean heat exchange) by increasing the temperature difference between the atmosphere and ocean. This result implies that the strengthening of the surface wind by the ice sheets also increases the strength of the surface cooling, and hence may work as a brake of the AMOC strengthening. We will add a following paragraph on this point in the revised manuscript:
"While the present study shows the individual effect of surface cooling and surface wind on the AMOC by means of partially coupled experiment, we should note that these two components can interact. For example, the strengthening of the surface wind can increase the strength of the northward oceanic heat transport at high latitude by strengthening the wind-driven ocean circulation. This can then increase the strength of the surface cooling (or atmosphere-ocean heat exchange) by increasing the temperature difference between the atmosphere and ocean. This result implies that the strengthening of the surface wind also increases the strength of the surface cooling, and hence may work as a brake of the AMOC strengthening. Further studies will be required to assess the interaction of these two effects."

Also, we decided to remove the information of internal feedback in the schematic figure to make the figure simple and to focus on the main topic of this paper, which is to show that the impact of the ice sheet is determined by the two competing effects, surface wind and surface cooling. Nevertheless, we will keep the discussion on the internal feedback in the revised manuscript.

Minor comments:
Line 37: 'Project' to 'Projects'
Corrected.

Line 210: please refer to Figure 2d, for the warmer surface around Alaska
Corrected.

Line 303: '.' has been double used.
Corrected. Thank you for pointing out.