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Impact of mid-glacial ice sheets on deep ocean circulation and global climate

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Supplementary information: Cause of the slight strengthening of the AMOC in PC experiments compared with the original AOGCM experiments

The Partially Coupled (PC) experiments show a slight strengthening of the AMOC compared with the corresponding original experiments. This overestimation is induced by an initiation of deep-water formation over the Irminger Sea, in association with the change in sea ice transport. In the PC experiments, the sea ice becomes thicker near the south-eastern Greenland shore and thinner in the centre of the subpolar region, which increases the gradient of sea ice thickness from the shore to the open ocean (Fig. S3a). Because the climatological surface wind stress applied to the oceanic component is identical between the PC experiments and original experiments, the only difference in the surface wind stress is the removal of the sub-monthly variations in the surface wind stress in the PC experiments. In fact, in another sensitivity experiment, in which we cyclically apply the raw daily winds of the last 100 years of MIS3 to the oceanic component (PC-MIS3day), the strength of the AMOC and the sea ice thickness resemble that of MIS3 (Fig. 9 and Fig. S3b). Hence, the slight increase in the PC experiments are associated with the removal of sub-monthly variations in the surface wind stress, which transport the sea ice from the shore to the open ocean and reduce the gradient of sea ice thickness. This result implies that the variability in the surface wind on a sub-monthly time-scale plays a role in homogenizing the ice thickness distribution.

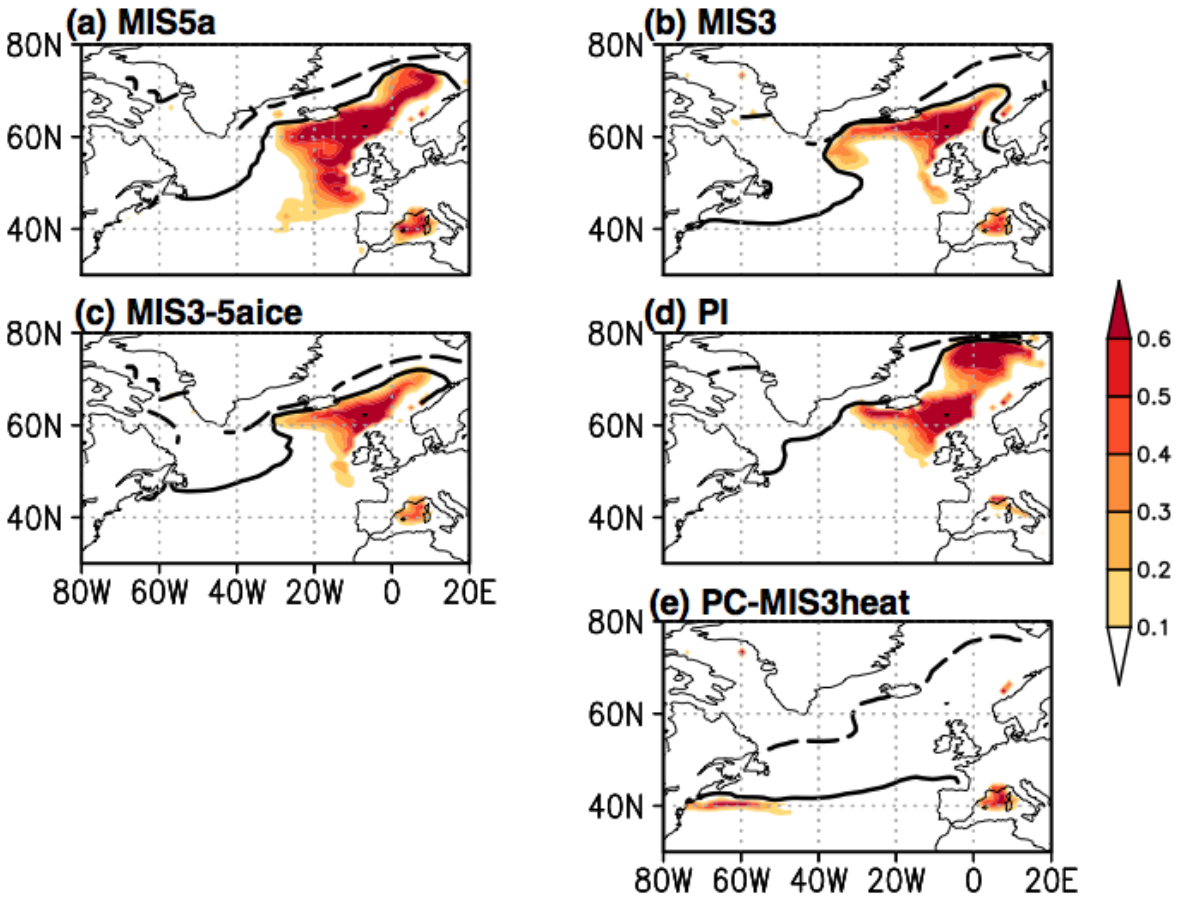

Figure S1: Spatial maps of sea ice edge (contour) and deepwater formation region (color) at the North Atlantic. For sea ice, climatology of 15% sea ice concentration at February (solid) and August (dashed) are shown. For deepwater formation region, frequency of convective adjustment at 600-meter depth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

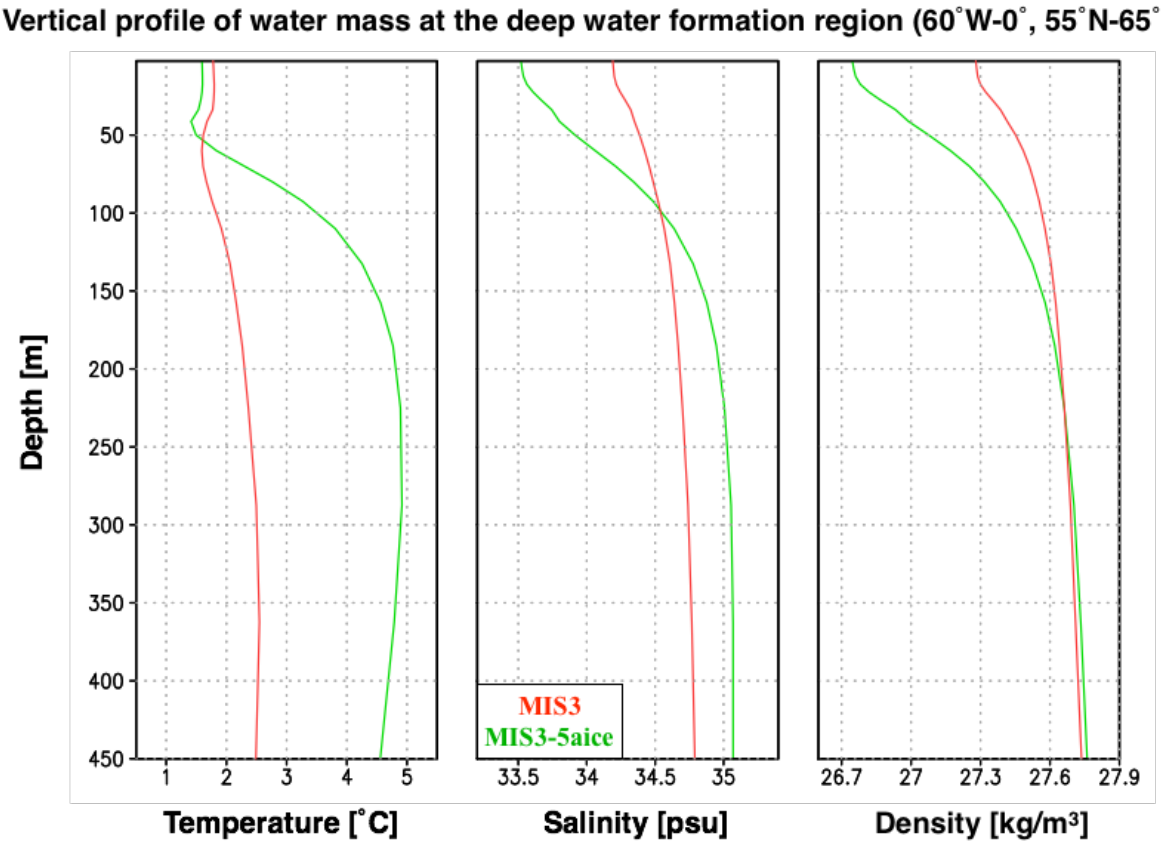

Figure S2: Vertical profile of oceanic properties at the North Atlantic Deep Water formation region (60˚W-0˚, 55˚N-65˚N). Red: MIS3 and Green: MIS3-5aice. Cold water occupies the subsurface ocean in MIS3 compared with MIS3-5aice. The climatology of the last 100 years is used to create these figures.

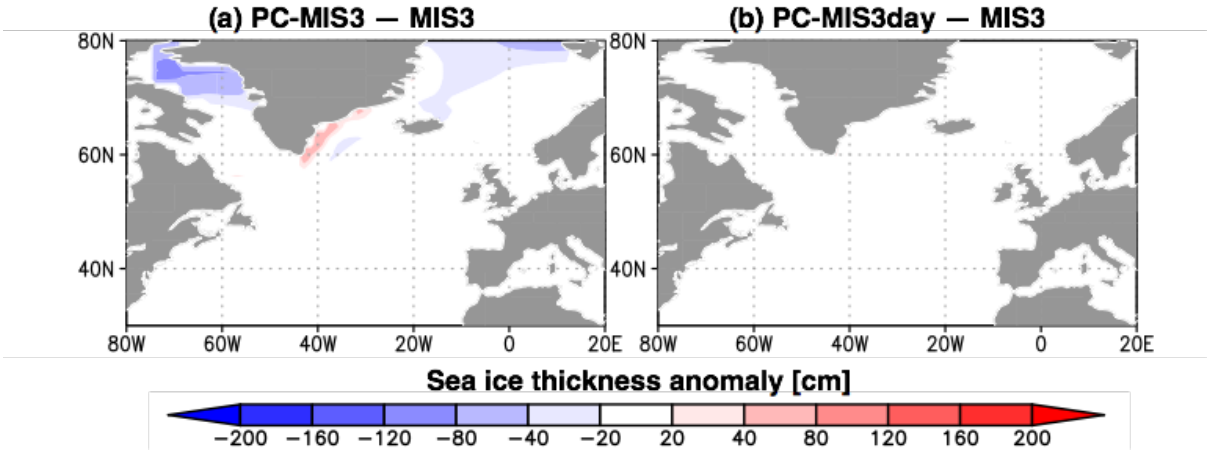

Figure S3: Differences of annual mean sea ice thickness (cm, colour) over the North Atlantic between the partially coupled experiments and the original AOGCM experiment. (a) Difference between PC-MIS3 and MIS3. (b) Difference between PC-MIS3day and MIS3. These figures show the reproducibility of sea ice thickness by the partially coupled experiment. In (a), the results of the last 100 years are used. In (d), the results of the last 50 years are used for PC-MIS3day.

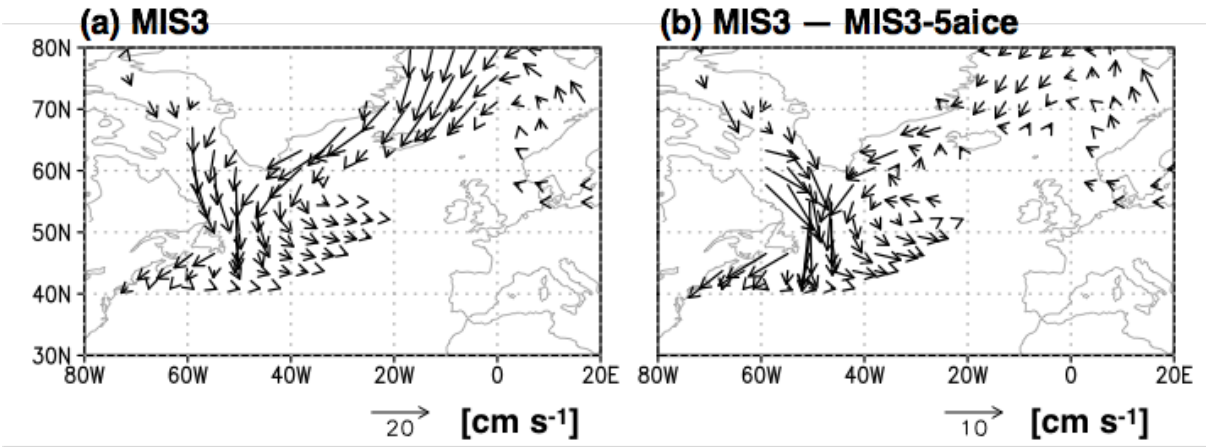

Figure S4: Spatial maps of annual mean sea ice velocity (arrow, cm s^{-1}) from AOGCM experiments. (a) MIS3 and (b) differences between MIS3 and MIS3-5aice. The results of the last 100 years are used.