Supplementary Materials for

Two ocean states during the Last Glacial Maximum

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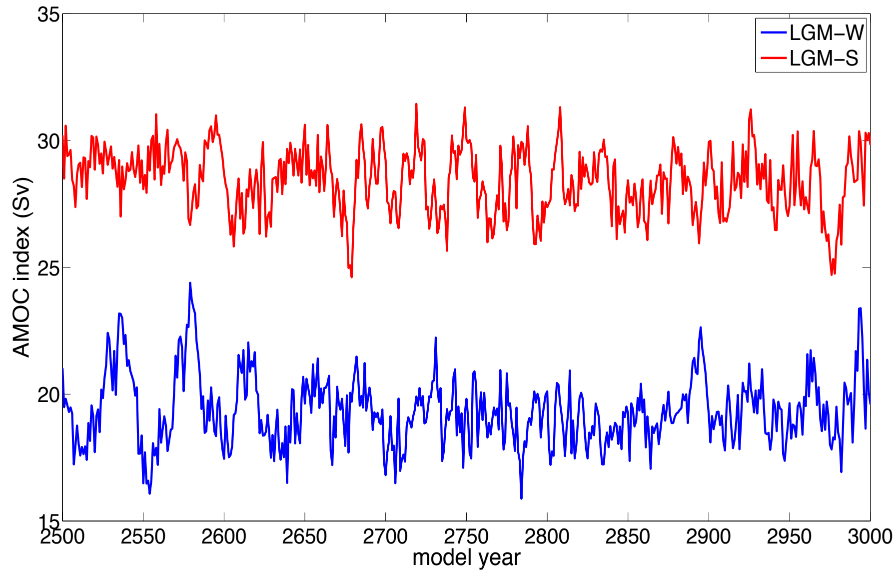
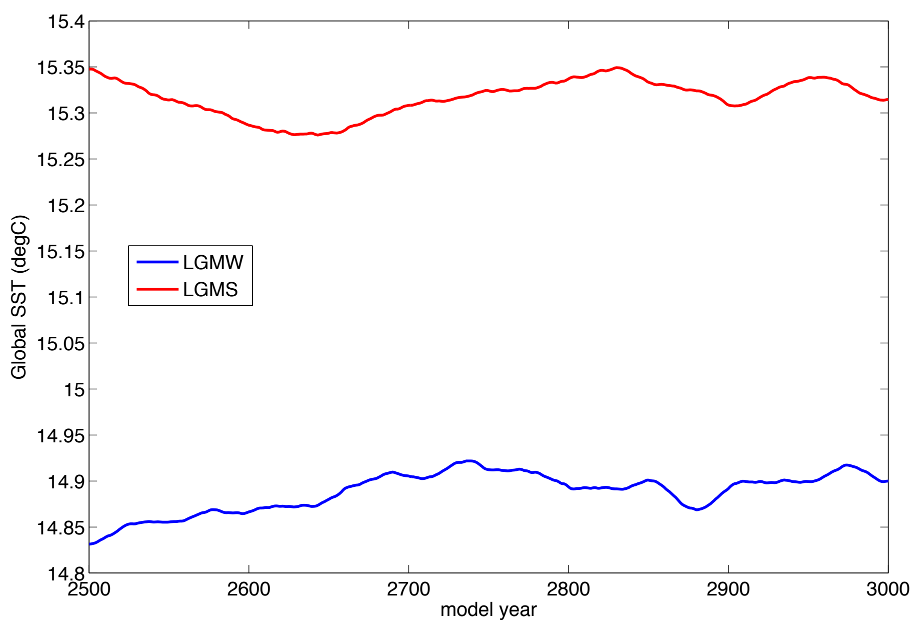


A



B

Figure S1 AMOC indices (a) and (b) 100-year running mean of global mean SST within the transient ocean state LGMS-t (red line, right y-axis) and quasi-equilibrium ocean state LGMW-e (blue line, left y-axis) ocean states.

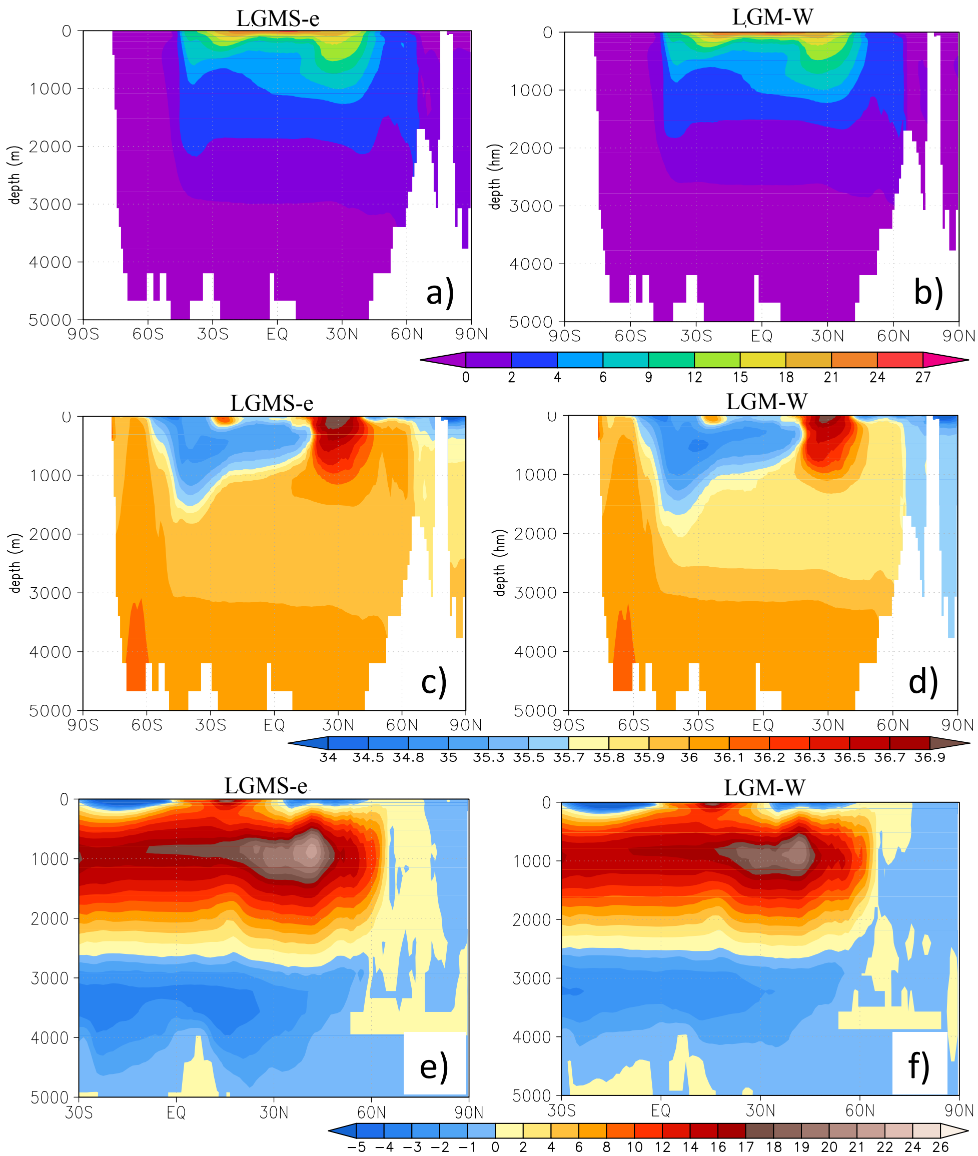


Figure S2 Meridional section of zonal mean temperature (a-b, units: °C), salinity (c-d, units: psu) and stream function (e-f, units: Sv (10^6 m^3/s)) in the Atlantic Ocean for LGMS-e (a, d, e) and climatology of model year 3900-4000 in LGMW (b, d, f).

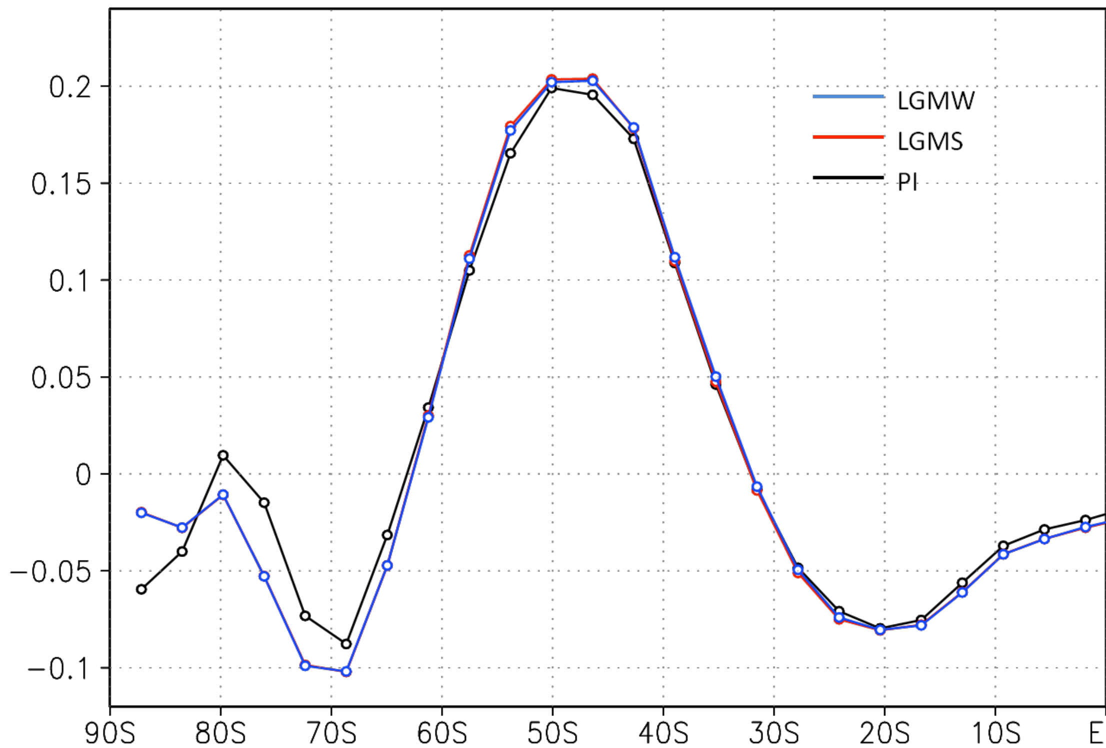


Figure S3 Zonal mean of wind stress in Southern Hemisphere (unit: Pa). PI: preindustrial run; LGMW-e: the LGM simulation is initialized from the glacial Ocean; LGMS-t_{deep}: the LGM simulation is initialized from the Present Day Ocean.

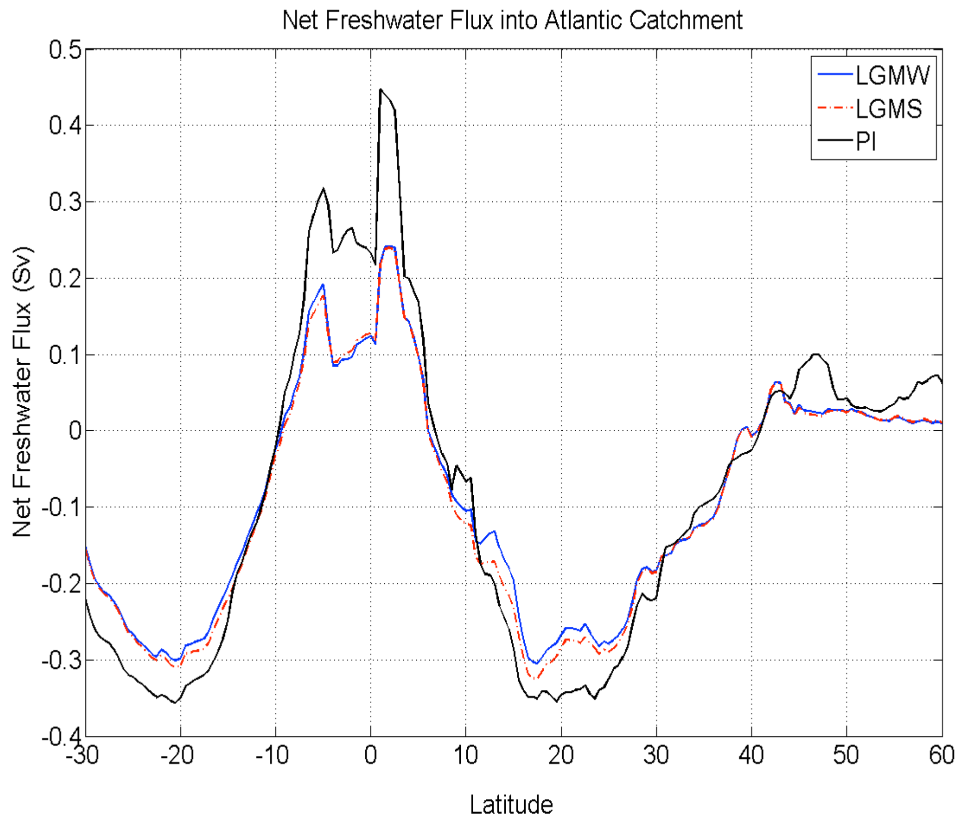
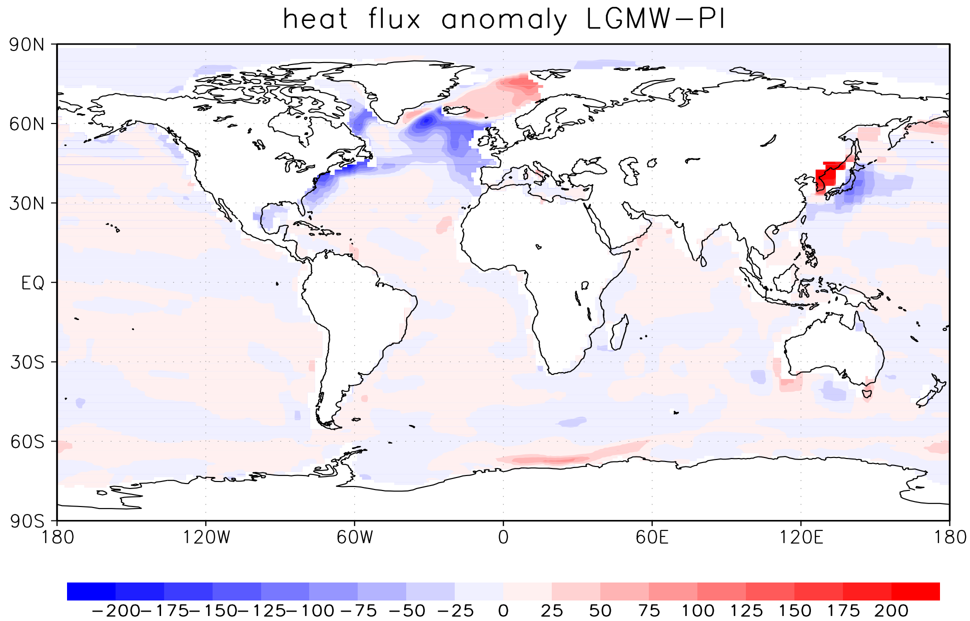
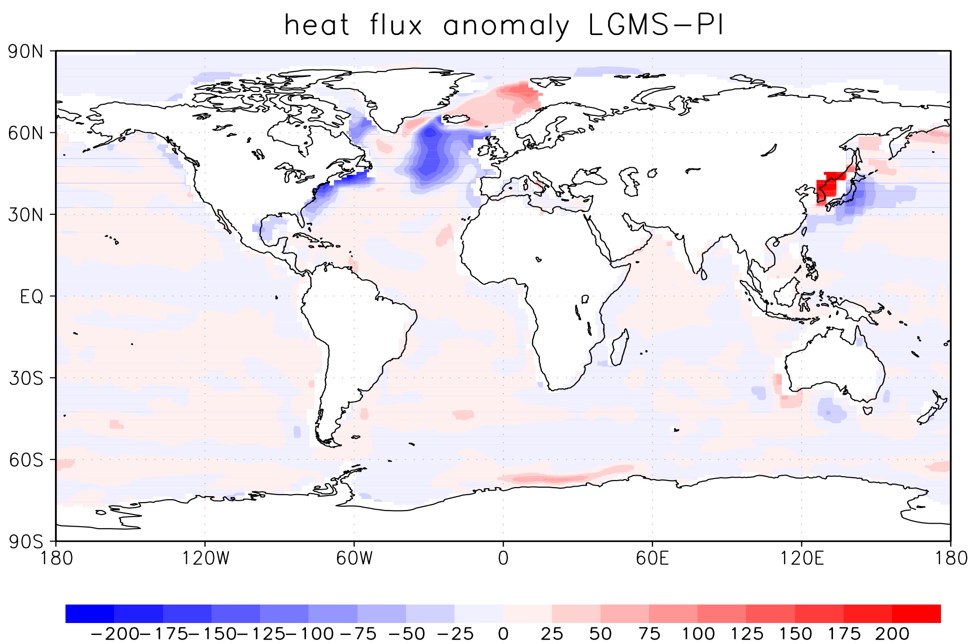


Figure S4 Zonal mean of net freshwater flux (FWF, unit: Sv, $10^6 m^3/s$) in the Atlantic catchment area. Blue line represents LGMW-e, red LGMS-t_{deep} and black PI.

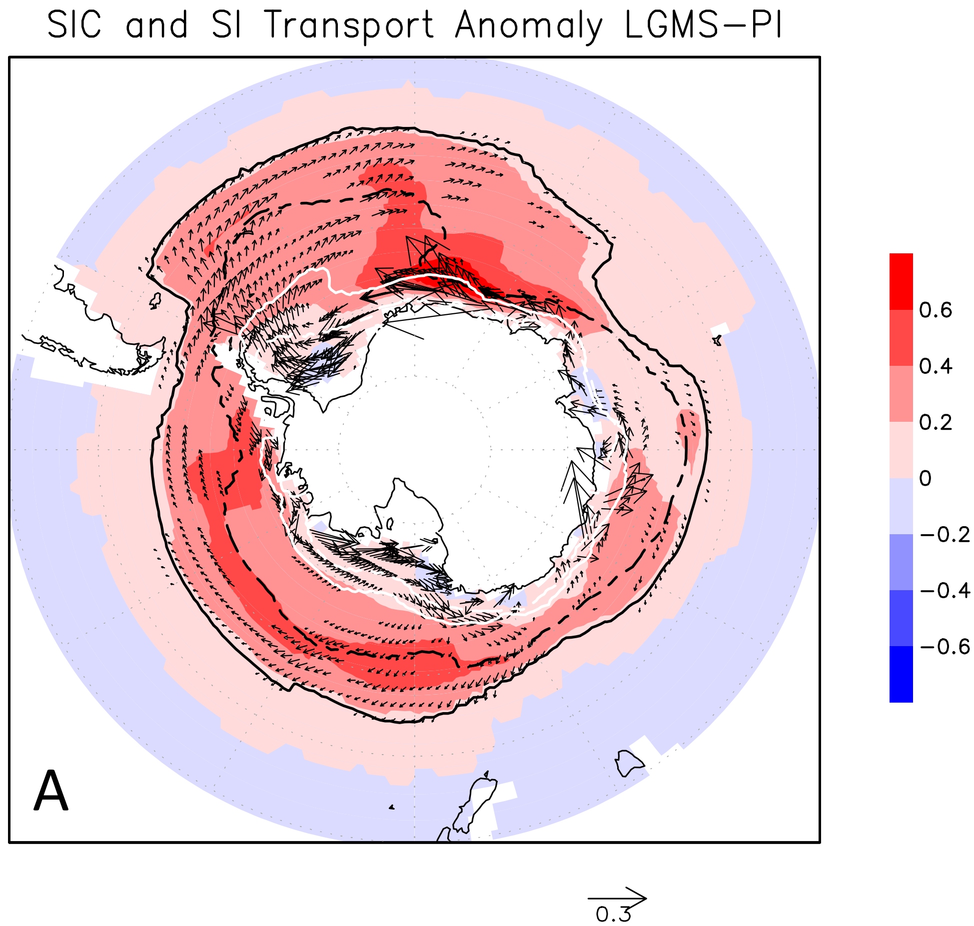


A



B

Figure S5 Anomaly of heat flux (unit: W/m^2) between A) LGMW-e and PI, B) LGMS-t_{deep} and PI. Negative values indicate heat loss from the ocean. The reduced heat loss from the ocean in Nordic sea and in the Japan Sea is attributed to the enhanced sea ice cover (Fig. 4).



SIC and SI Transport Anomaly LGMS−PI
A
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
0.3

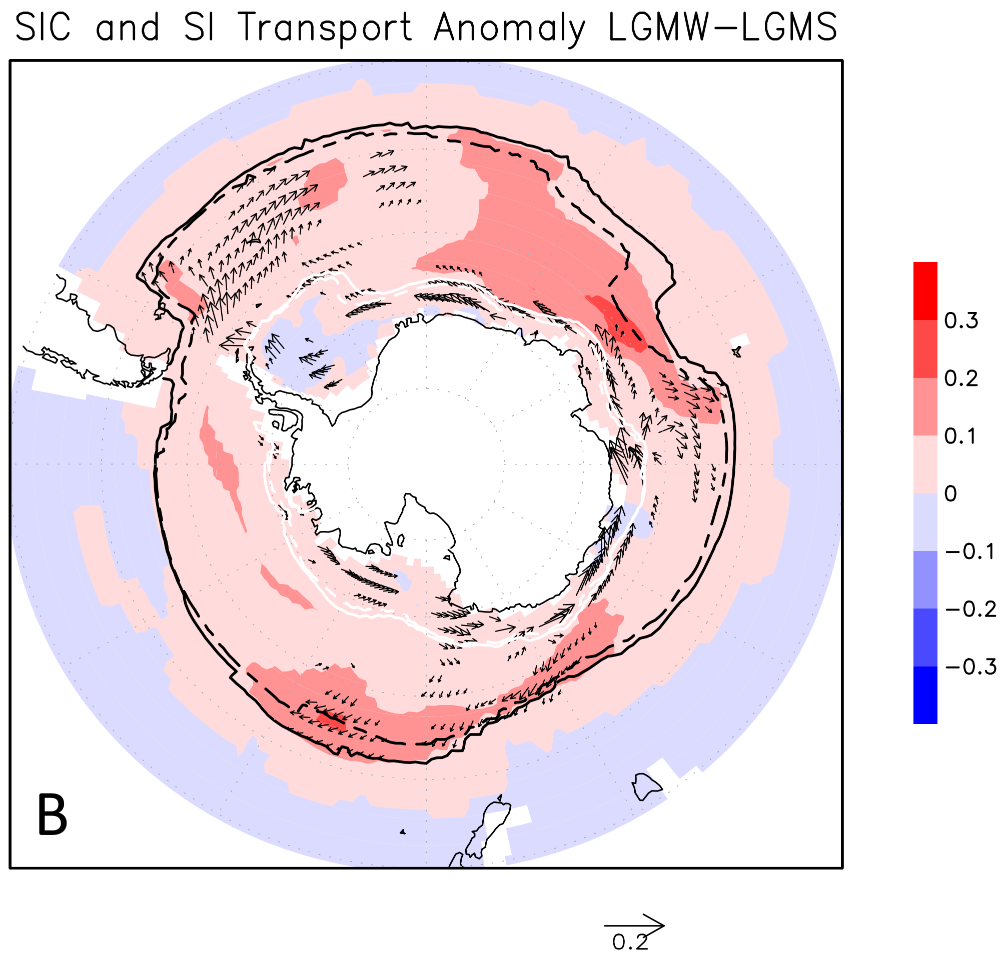


Figure S6 A. Anomaly of climatological SIC (%, shaded) and Sea Ice Transport (m^2/s, vector, the scale is indicated by the black arrow below the panels) between LGMS-t_{deep} and PI. Black contour represent 15% SIC, while blue for 90% SIC. Solid line indicates SIC in LGMS-t_{deep}, and the dashed is for PI. B) Same as A), but for LGMW-e and LGMS-t_{deep}. In our LGM runs, the extensive SIC and SIC export contribute to enhanced brine rejection, which is of great importance to maintain the AABW formation during the LGM.

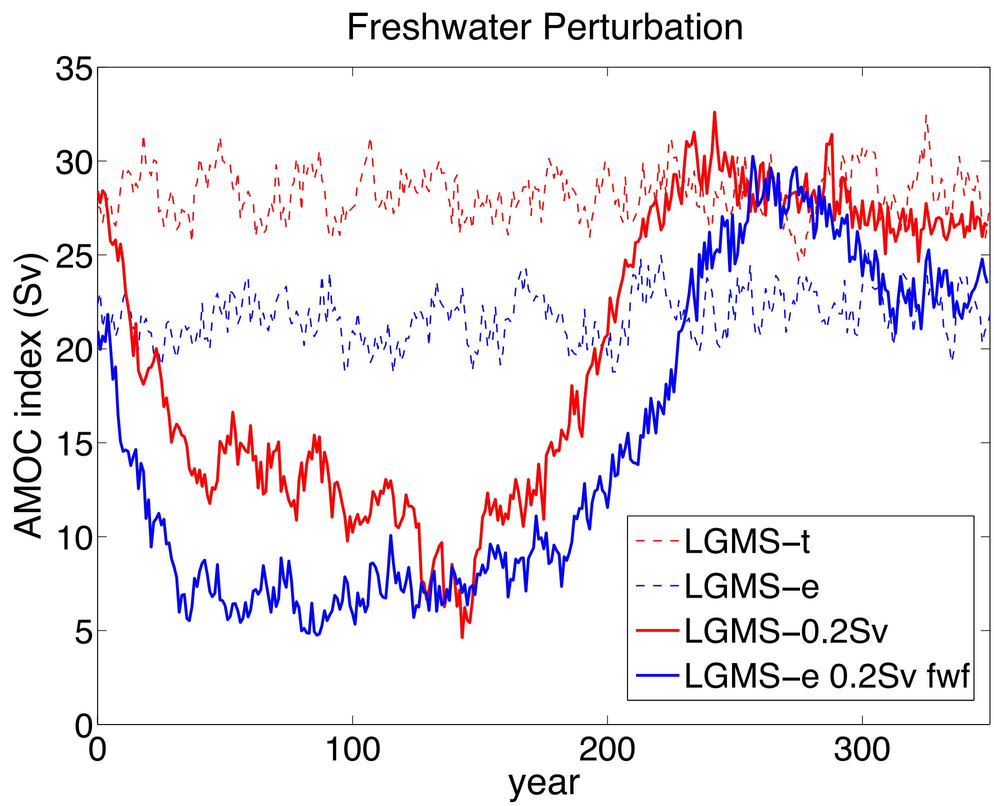


Figure S7 Time series of AMOC in the 0.2Sv (FWP lasts for 150 years) hosing experiments of LGMS-t_{deep} (red) and LGMS-e (blue). The hosing experiments started from the model year 2700 and 4500 in the LGMS simulation for LGMS-t_{deep} and LGMS-e, respectively. The dashed lines represent the LGMS control runs, and solid line for hosing experiments. It is shown that after the FWP an AMOC overshoot was found in LGMS-e as LGMW-e, while no overshoot in LGMS-t_{deep}. This suggests an important role of ocean stratification on AMOC overshoot after the FWP.

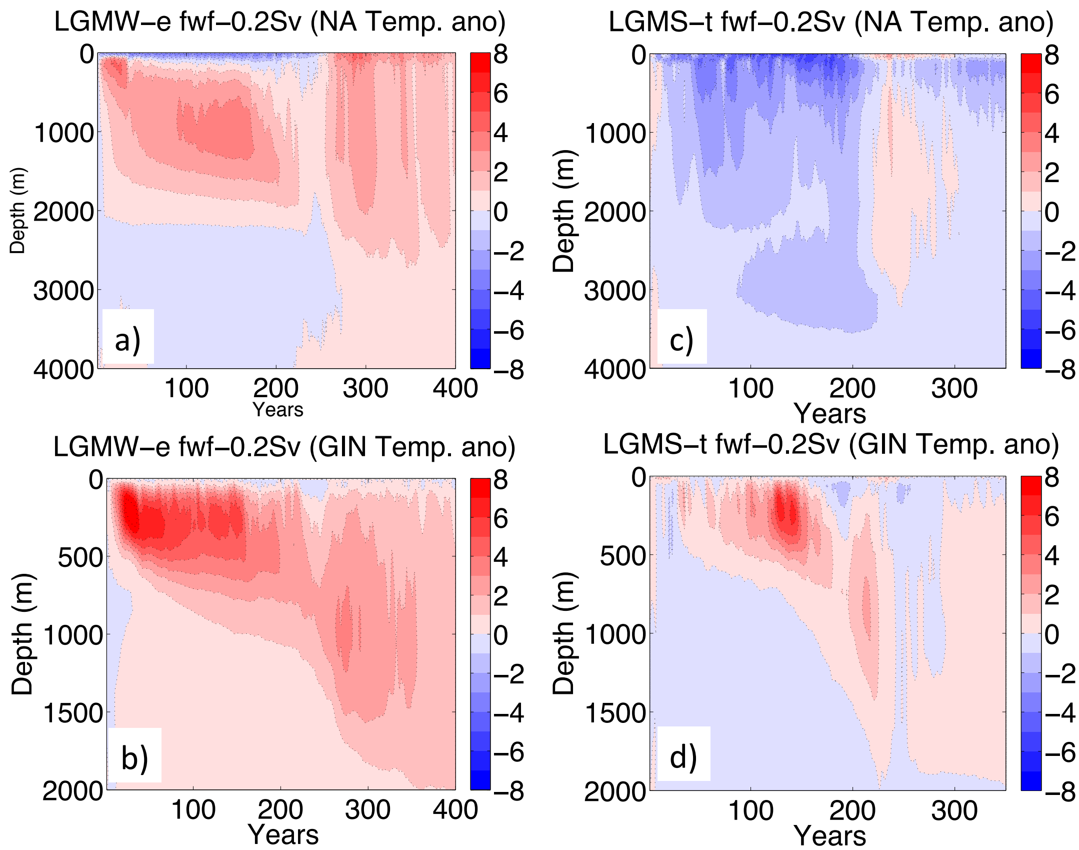


Figure S8 The vertical structure of the temperature anomaly between 0.2Sv hosing and corresponding control runs in the convection sites of the North Atlantic (20°W-40°W, 50-60°N) (a, c) and the Nordic Sea (20°W-10°E, 65-75°N) (b, d) for the 0.2Sv hosing experiments of LGMW-e (a, b) and LGMS-t_{deep} (c, d). It is shown that the subsurface warming in quasi-equilibrium ocean state is much more pronounced than the transient ocean state LGMS-t in response to the FWP, especially in the convection sites of the North Atlantic. This will benefit a rapid destabilization of water column and eventually the AMOC overshoot (Mignot et al., 2007).

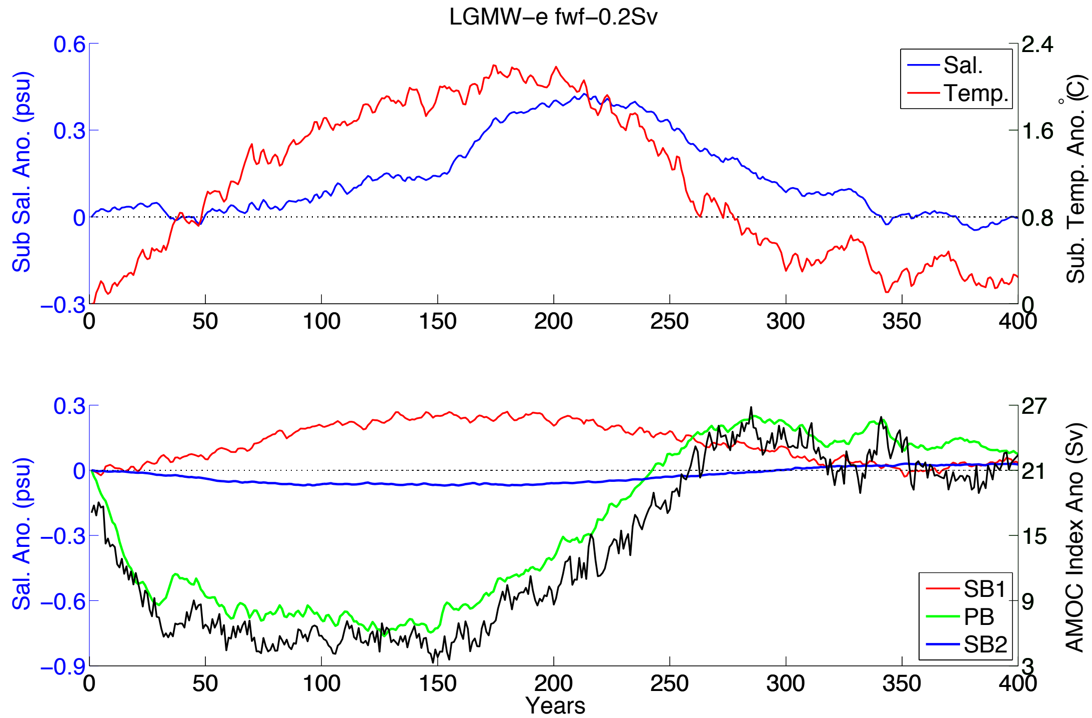


Figure S9 Upper panel: Subsurface temperature (red, right y-axis) and salinity (blue, left y-axis) in Tropical regions (20°S-30°N, 100-500 m). Lower panel: Time series for AMOC transport (black, right y-axis) and box salinities (red, green and blue, left y-axis) for the 0.2 Sv hosing experiments in the simulation LGMW-e. The Atlantic basin is partitioned into box SB1 (45°S-20°S, 0-500 m), PB (35°N-80°N, 0-2000 m) and SB2 (45°S-20°S, 500-2000 m). Combined with Fig. S10, we propose that the AMOC overshoot in quasi-equilibrium ocean states can also be attributed to the basin-wide salinity adjustment (Liu et al., 2009), while the tropical contribution might also play a role on restoring the AMOC by transportation of warmer and saltier subsurface water to the convection sites (Cheng et al., 2010).

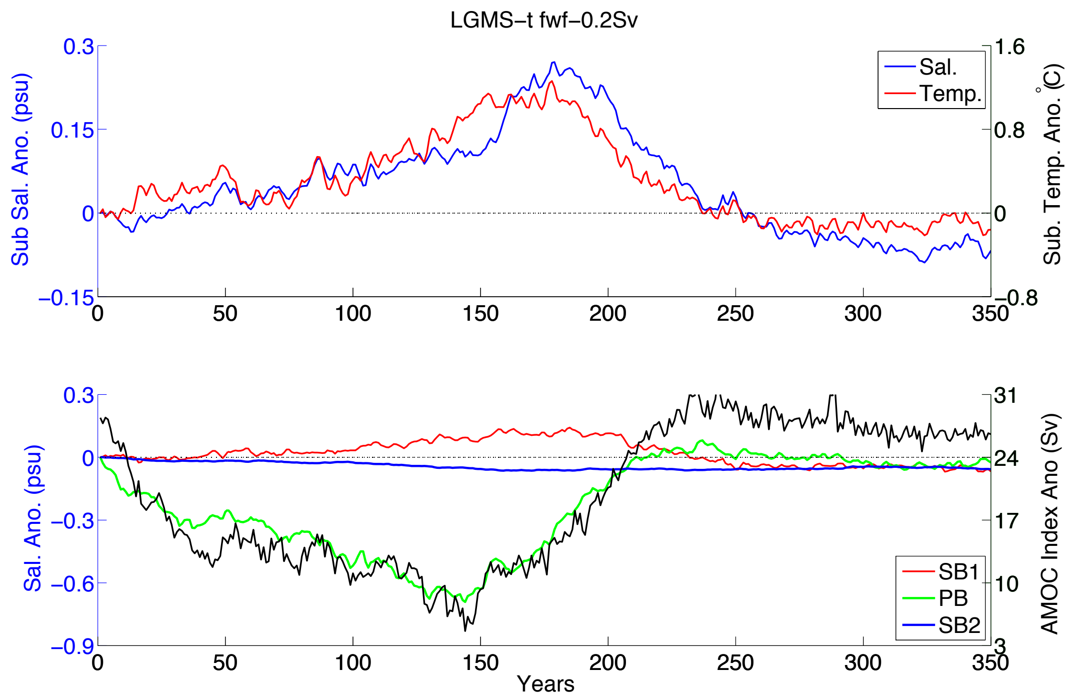


Figure S10 Same as Fig. S9 but for 0.2 Sv hosing experiment in LGMS-t_{deep}.