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Impact of the background conditions on the climate response to external forcings

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Recent observational evidence suggests that when the Atlantic deep convection weakens during the Heinrich events, the deep convection in the North Pacific strengthens. This reorganization of the oceanic meridional overturning circulation would significantly change the poleward heat transport in the Atlantic and Pacific basins. Here, using a fully coupled climate model, we show that this oceanic reorganization may only occur during glacial time when the global mean sea level is about 50 meters below present day level. When sea level is this low, the oceanic pathway between the North Pacific and the Arctic is restricted, and the water mass exchange between these two oceans is shut off. As a result, when the Atlantic deep convection weakens due the discharge of melt ice-sheet water into the North Atlantic, the corresponding freshwater anomaly stays in the North Atlantic, preventing the deep convection to restart after the massive discharge of the melt ice-sheet water. However, under present day condition, when a massive freshwater discharged into the North Atlantic, part of it will be transported into the North Pacific, inducing a freshening effect there and preventing the occurrence of the deep convection there. This export of the North Atlantic freshwater anomaly into the North Pacific also helps the North Atlantic deep convection to restart sooner than otherwise. Therefore, our study suggests that the earth climate system's response to external forcing changes may be significantly different under glacial condition from that under present day condition.