The association of AMOC and Atlantic sea ice in a transient CGCM simulation for the past 2.6 million years.

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The Quaternary period (0–2.58 million years) is an important time in the early evolution of our human ancestors. This period is featured by distinctive glacial-interglacial cycles, primarily caused by variations in orbital parameters (i.e., eccentricity (100 thousand years (kyr)), obliquity (41 kyr), and precession (23/19 kyr)), atmospheric CO₂ concentration (GHG), and their feedbacks. Therefore, it is essential to understand the climate system, mainly focusing on the variability of the Atlantic Meridional Overturning Circulation (AMOC) due to its huge impact.

In this study, we have employed a quasi-continuous simulation to understand the AMOC variability in response to changes in orbital, GHG, and continental ice sheet forcings over the past 2.6 million years. It is found that the AMOC variability is associated with the sea ice coverage and mixed layer depths over the Labrador Sea and Irminger and Iceland basins. The overall mixed layer depth over the Labrador Sea, Irminger, and Iceland basins and the corresponding AMOC variability vary in precession and obliquity periodicity. Meanwhile, the mixed layer depth in the Labrador Sea exhibits a dominant precession, and the Irminger and Iceland basins exhibit a dominant obliquity periodicity. Further, we have divided the entire Quaternary period into three subsets based on the dominant periodicity of the climate state: 0ka–700ka (post-MPT; 100kyr dominant), 700ka–1200ka (MPT; 100–80kyr and 41kyr dominant), and 1200ka–2600ka (pre-MPT; 41kyr dominant). We have found that sea ice coverage and mixed layer depth in the Labrador Sea (Irminger and Iceland basins) are out of (in) phase with a Pearson correlation coefficient of −0.70 (0.42) during post-MPT, −0.78 (0.32) during MPT, and −0.85 (0.38) during pre-MPT periods. These results indicate that during glacial periods, the southward expansion of Labrador sea ice covered the deep convection sites, which impeded deep convection and weakened the AMOC strength. Therefore, the expansion and contraction of Labrador sea ice and its feedback contributed to AMOC variability over glacial-interglacial cycles for the past 2.6 million years.