

Southern Ocean processes sustain Ice Age millennial climate variability

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Millennial climate variability during Pleistocene Ice Ages, known as Dansgaard-Oeschger (DO) cycles, are characterised by abrupt transitions between Greenland cold stadial states and warm interstadial states, which coincide with gradual warming and cooling over Antarctica, respectively, via the bipolar seesaw. DO cycles are associated with reorganisations of the Atlantic Meridional Overturning Circulation (AMOC), but the mechanisms driving them remain unclear. Here, from nudging experiments based on intrinsic millennial AMOC variability in a complex climate model, we show that gradual changes in sea ice over the Southern Ocean induced by the bipolar seesaw act as a negative feedback to sustain the millennial AMOC variability. Southern Ocean surface warming during the stadial states reduces regional sea ice-related salt and freshwater fluxes. This eventually strengthens the AMOC by weakening the oceanic stratification over the North Atlantic Deep Water formation regions by decreasing and increasing the density of Antarctic bottom water and Antarctic intermediate water, respectively. The Southern Ocean feedback becomes important for DO cycles with long (inter)stadial durations exceeding a thousand years. Our results suggest that the Southern Ocean feedback helps drive the DO cycles, demonstrating the globally connected nature of these events.

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