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Global cooling linked to increased glacial carbon storage via changes in Antarctic sea ice

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Palaeo-oceanographic reconstructions indicate that the distribution of global ocean water masses has undergone major glacial–interglacial rearrangements over the past ~2.5 million years. Given that the ocean is the largest carbon reservoir, such circulation changes were probably key in driving the variations in atmospheric CO_2 concentrations observed in the ice-core record. However, we still lack a mechanistic understanding of the ocean's role in regulating CO_2 on these timescales. Here, we show that glacial ocean–sea ice numerical simulations with a single-basin general circulation model, forced solely by atmospheric cooling, can predict ocean circulation patterns associated with increased atmospheric carbon sequestration in the deep ocean. Under such conditions, Antarctic bottom water becomes more isolated from the sea surface as a result of two connected factors: reduced air–sea gas exchange under sea ice around Antarctica and weaker mixing with North Atlantic Deep Water due to a shallower interface between southern- and northern-sourced water masses. These physical changes alone are sufficient to explain ~40 ppm atmospheric CO_2 drawdown—about half of the glacial–interglacial variation. Our results highlight that atmospheric cooling could have directly caused the reorganization of deep ocean water masses and, thus, glacial CO_2 drawdown. This provides an important step towards a consistent picture of glacial climates.