

Sea ice expansion in Antarctic warming events in the glacial Southern Ocean

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The Southern Ocean has played an important role in the evolution of the global climate system. Area of sea ice shows a large seasonal variation in the Southern Ocean. Sea ice coverage on sea surface strongly affects the climate of the Southern Hemisphere through its impacts on the energy and gas budget, on the atmospheric circulation, on the hydrological cycle, and on the biological productivity. However, millennial-scale sea ice coverage and its impacts are not well understood. Here we show high-resolution records of sea ice-rafted debris (SIRD) and diatom assemblage to reveal a rapid change of sea ice distribution in the glacial Southern Ocean. The depositions of rock-fragment SIRD excluding volcanic glass and pumice were associated with increasing of sea-ice diatoms, suggesting that the millennial-scale events of cooling and sea-ice expansion were occurred in the glacial South Indian Ocean. The extent of sea ice in the Southern Ocean is occurred during the Antarctic isotope maximum (AIM) events, which is partly linked with the Heinrich Events in the Northern Hemisphere.

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