EGU25-8265, updated on 08 Apr 2026
https://doi.org/10.5194/egusphere-egu25-8265
EGU General Assembly 2025

Ice age and deglacial stratification of the polar Antarctic Zone

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The Antarctic Zone has long been suspected to play a crucial role in the glacial-interglacial changes in atmospheric concentration of CO_2. However, global climate has many possible influences on Antarctic Zone conditions, with the potential for interactions between ice, winds and circulation that, in turn, influence the biogeochemistry and carbon budget of the Antarctic Zone surface. In a sediment core from the polar Antarctic Zone, we analyzed diatom-bound nitrogen isotopes to reconstruct surface nitrate concentration, which reflects the balance between biological productivity and the flux of subsurface nitrate into the Antarctic surface. The record covers the last 150 kyr, which includes two peak glacial periods and the subsequent deglaciations and interglacials. During each glacial period, the data support prior interpretations of lower surface nitrate concentrations and reduced circulation-driven nitrate supply to the Antarctic surface, although the change appears to be weaker at this polar Antarctic Zone site than in records from further north in the open Antarctic Zone. Early in each deglaciation, there is a further decline in surface nitrate concentration, reflecting a rise in density stratification. This is followed by an increase in nutrient supply in each of the two interglacials, signaling more vigorous surface-subsurface exchange than during the glacials or the early deglaciations. Combining the data with other Antarctic records further from the continent, the deglacial changes echo model simulations of ongoing global warming, in which upwelling increases near the Polar Front, while subsurface influx to the surface closer to the Antarctic continent decreases in response to ice sheet melting. The findings have implications for the cause of the observed rise in atmospheric CO_2 concentrations during deglaciations and also warrant consideration with regard to the future of the ocean's uptake of global warming heat and fossil fuel-derived CO_2.