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Sea-ice Induced Southern Ocean Subsurface Warming and Surface Cooling in a Warming Climate

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Much of the Southern Ocean surface south of 55° S cooled and freshened between at least the early 1980s and the early 2010s. Many processes have been proposed to explain the unexpected cooling, including increased winds or increased surface freshwater fluxes from either the atmosphere or glacial meltwater. However, these mechanisms so far failed to fully explain the surface trends and the concurrently observed warming of the subsurface (100 to 500 m). Here, we argue that these trends are predominantly caused by an increased wind-driven northward transport of sea ice, enhancing the extraction of freshwater near Antarctica and releasing it in the open ocean. This conclusion is based on factorial experiments with a regional ocean model. In all experiments with an enhanced northward transport of sea ice, the open-ocean surface between the Subantarctic Front and the sea-ice edge is cooled by strengthening the salinity dominated oceanic stratification. The strengthened stratification reduces the downward mixing of cold surface water and the upward heat loss of the warmer waters below, thus warming the subsurface. This sea-ice induced subsurface warming mostly occurs around West Antarctica, where it likely enhances ice-shelf melting. Moreover, it could account for about 8±2% of the global ocean heat content increase between 1982 and 2011. Antarctic sea-ice changes thereby may have contributed to the slowdown of global surface warming over this period. The important role of sea-ice in driving changes in the high-latitude Southern Ocean are robust across all considered sensitivity cases, although their magnitude is sensitive to the forcing and the role of salinity in controlling the vertical stratification in the mean state. It remains yet unclear whether these sea-ice induced changes are associated with natural variability or a response to anthropogenic forcing.