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The Role of the Southern Ocean in the World Ocean Deepwater Circulation

The North Atlantic and its associated deepwater formation has been the consensus focal point of variability of the ocean deepwater circulation for decades. However, new analyses indicate that the southern deepwater source can also change dramatically on millennium and shorter time scales. Based on a series of numerical experiments, we show that for the present-day sea surface conditions, freshening of the Southern Ocean can lead to a strong restructuring of the global thermohaline conveyor and result in substantial abyssal warming. Hypothesized freshening of the high latitudes around Antarctica may result from different events linked to global climate warming (reduced brine rejection due to reduced sea-ice formation, melting of the sea ice and sea-based ice shelves, or melting of the West Antarctic Ice Sheet). The potential for melting of sea ice and ice sheets in Antarctica associated with global warming can cause a further slowdown of the southern deepwater source. These results demand an assessment of the role of the Southern Ocean in driving changes of the global ocean circulation and climate. Our experiments demonstrate that meltwater impacts in one hemisphere may lead to a strengthening of the thermohaline conveyor driven by the source in the opposite hemisphere. This, in turn, leads to significant changes in poleward heat transport. Further, meltwater events can lead to deep–sea warming and thermal expansion of abyssal water, that in turn cause a substantial sea level change even without a major ice sheet melting**.** Meltwater events in the North Atlantic lead to warming at intermediate depths but cooling of the deep ocean due to increased AABW incursion. Hence, the teleconnections between AABW and NADW controlled largely by sea-surface density in the Southern Ocean are the key element in governing the thermal character and dynamics of the deep ocean. A warming of abyssal waters by as much as 10 degrees results in experiments with a prescribed reduction of sea surface salinity around Antarctica of 1 psu (relatively small change in the view of the southern ice reserve). Warming occurred without any change in the prescribed sea surface temperature, and is the result of strong northward cross-equatorial heat transport during the southern meltwater episodes. Associated sea level rise due to warming of the deep ocean can be tens of centimeters to 1 m or more, without any additional water input from melting ice sheets.