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Southern Ocean Deep Convection Forcing of North Atlantic Centennial Variability

Torge Martin (1), Wonsun Park (2), and Mojib Latif (2)

(1) University of Washington, Applied Physics Laboratory, Polar Science Center, Seattle, United States (torge@apl.washington.edu), (2) GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany

We present an oceanic teleconnection associated with the Southern Ocean Centennial Variability (SOCV). The SOCV is driven by internal multi-centennial variability of open ocean deep convection in the Atlantic sector of the Southern Ocean, which forces significant variations in the strength of the Atlantic Meridional Overturning Circulation (AMOC) in control simulations with the Kiel Climate Model employing present climate greenhouse gas concentrations. The deep convection is stimulated by a strong built–up of heat at mid–depth and lasts until this heat reservoir is virtually depleted. The heat originates from relatively warm deep water formed in the North Atlantic. The several decades lasting recharge process sets a minimum time between convection events. Stochastically occurring, favorable sea ice conditions as well as coincidental strong surface freshening are further factors influencing the timing of convection onset and shutdown. The deep convection flip–flop has intriguing similarities to the Weddell Polynya observed during the 1970s.

The state of Weddell Sea deep convection strongly influences the northward extent of Antarctic Bottom Water (AABW). The retreat of AABW results in an enhanced meridional density gradient that drives an increase in the strength and vertical extent of the North Atlantic Deep Water (NADW) cell. This shows, for instance, as a peak in AMOC strength at 30°N about a century after Weddell Sea deep convection has ceased. The stronger southward flow of NADW is compensated by an expansion of the North Atlantic subpolar gyre and an acceleration of the North Atlantic Current, indicating greater deep water formation. Contractions of the North Atlantic subpolar gyre enable anomalously warm water to penetrate farther to the north, eventually weakening the AMOC and closing a quasi–centennial cycle.

In our simulation the SOCV is associated with sea level variations in the order of 10 to 30 cm/century in the North Atlantic and Southern Ocean, which is due to subpolar gyre extent and oceanic heat content changes, respectively. This suggests that internal variability on long time scales cannot be neglected a priori in assessments of 20th and 21st century AMOC and regional sea level change.