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Multi-Centennial Variability Controlled by Southern Ocean Convection: Mechanisms and Global Impacts

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A quasi-oscillatory multi–centennial mode of open ocean deep convection in the Atlantic Sector of the Southern Ocean is described in the Kiel Climate Model. The quasi–periodic occurrence of the deep convection with a timescale of 300 to 500 years causes global climate variability which includes surface air temperature, sea-ice coverage, sea surface height, the Antarctic Circumpolar Current and Atlantic Meridional Overturning Circulation. The oscillation of the deep convection is driven by the competing roles of heat content changes at mid–depth and salinity changes at the surface on the stability of the water column. The accumulation of heat during the non-convective regime and its subsequent release to the atmosphere during the convective regime can be viewed as a non–linear recharge oscillator. The slow recharge process, involving large parts of the global thermohaline circulation, is responsible for the multi-centennial time scale of the phenomenon. The shutdown of the convection is caused by the coincidental occurrence of a sufficiently strong build-up of heat and a strong freshening at the sea surface. Additional numerical experiments reveal that sea ice has an important effect on the frequency of occurrence and intensity of the deep convection. Further, we find similarities to the Weddell Sea polynya observed in the 1970s.