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The role of Southern Ocean winds, upwelling and CO2 in glacial abrupt climate change

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The last glacial period (ca. 110-10 kyr before present, hereafter kyr BP) is characterized by substantial climate instability, manifested as climatic variability on millennial timescales. Two types of events dominate this variability: Dansgaard-Oeschger (DO) events, which involve decadal-scale warming by more than 10K, and Heinrich events, massive iceberg discharges from the Laurentide Ice Sheet at intervals of ca. 10 kyr during peak glacial conditions. Both DO and Heinrich events are associated with widespread centennial to millennial scale climatic changes, including a synchronous temperature response over the North Atlantic and an anti-phase temperature relationship over Antarctica and most of the Southern Ocean, as revealed by a wealth of deep sea sediments and terrestrial record. Recent studies indicate CO2 changes during deglaciation and, possibly, during glacial abrupt climate changes were preceded by significant increases of Southern Ocean upwelling caused by an enhancement and/or a shift of surface winds over that region. The proposed hypothesis is that periods of halted or reduced North Atlantic deep water (NADW) formation resulted in warming of the Southern Ocean through the bipolar see-saw effect leading to a reorganization of Southern Hemisphere (SH) surface winds, and thereby enhanced upwelling and atmospheric CO2 concentrations. Here, the role of SH surface wind and CO2 changes in the Atlantic meridional overturning circulation (MOC) is analyzed in a coupled climate model of intermediate complexity. We investigate whether changes in the former could eventually trigger an intensification of the Atlantic overturning circulation and a northward shift of NADW formation, which would allow to explain glacial abrupt climate changes as the result of an oscillation which involves the MOC, CO2 and the winds.