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Bipolar seesaw control of glacial Atlantic overturning

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The last glacial period was characterised by abrupt climate and environmental changes on millennial time scales. Two types of events dominate this variability: Dansgaard-Oeschger (DO) events, which involve decadal-scale warming by more than 10 K, and Heinrich events, consisting of massive iceberg discharges from the Laurentide Ice Sheet during peak glacial conditions. Both DO and Heinrich events are associated with widespread 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. During the past decades important progress has been made regarding the description and understanding of glacial abrupt climate changes, leading to the prevalent paradigm that these were caused by reorganisations of North Atlantic deep water formation (NADW) and the Atlantic meridional overturning circulation (AMOC). However, important questions remain open. Most notably, the ultimate causes for the ocean circulation reorganisations remain unknown. Recent studies have suggested CO_2 increases during deglaciation, as well as during glacial abrupt climate changes, were preceded by increases of Southern Ocean upwelling in response to an enhancement and/or shift of surface winds over that region. The proposed hypothesis is that periods of halted or reduced NADW formation resulted in warming of the Southern Ocean through the bipolar seesaw effect leading to a reorganisation of Southern Hemisphere surface winds, and thereby enhanced upwelling and atmospheric CO_2 concentrations. Here, a coupled climate model of intermediate complexity is used to assess the relevance of the aforementioned relationship between CO_2, Southern Ocean winds and AMOC variations for glacial abrupt climate changes. Starting from a background glacial climate, a suite of simulations has been performed by linearly increasing CO_2, Southern Ocean winds, and both. Our results confirm the possibility of triggering an abrupt warming in Greenland by forcing the system with CO_2 and/or wind. Preliminary results indicate the underlying mechanism is related to a change in the North Atlantic freshwater balance, involving mainly changes in southward sea-ice advection from the Arctic. Our results thus point to a mechanism in which glacial abrupt climate changes are the result of an internal oscillation which involves changes in CO_2, surface winds and AMOC.