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MELTWATER CATASTROPHES IN THE NORTH ATLANTIC AND THEIR EFFECT ON THE CARBON CYCLE

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North Atlantic Deep Water (NADW) is playing an important role in modern thermohaline circulation (THC) of the ocean. High-resolution benthic $\delta^{13}C$ records indicate pronounced changes in THC, which took place during Heinrich events and the transition from the Last Glacial Maximum (LGM) to the Holocene. During both Heinrich events and the early deglacial melt of continental ice caps (~13.5 ^{14}C ka BP) large amounts of iceberg-derived freshwater debouched into the North Atlantic near the glacial sites of NADW formation and led to a complete shut-down of the THC. After the dissipation of the early deglacial meltwater input the THC was almost instantaneously re-established leading into the massive warming of the Bølling. We expect that these changes in THC strength and structure strongly affected the marine carbon cycle and, hence, the partial pressure of atmospheric carbon dioxide.

A combination of various modeling approaches were used to assess the ocean circulation and its effect on ocean chemistry: 1) A global coarse-resolution ocean general circulation model (OGCM) shows the pronounced differences in the intensity of the THC, marking the regimes of the LGM, the Heinrich-1 meltwater event (MWE), and today. In particular, the THC in the Atlantic was completely shut-down during the MWE and weakened during the LGM. 2) A global semi-Langrangian trajectory tracing model helped to visualize the 3D-water transports in the OGCM. 3) A 16-box model of the marine carbon cycle was coupled to the OGCM and revealed that, different from today, the North Atlantic did not act as sink for atmospheric carbon dioxide during the MWE. Instead, the Southern Ocean became the only oceanic sink for atmospheric carbon. The MWE shut-down of the NADW formation in the Atlantic resulted in deep-water residence times that were almost identical for the Atlantic and Indo-Pacific. This led to a shift of about 180 Gt carbon from the deep Indo-Pacific to the Atlantic ocean. At the transition from the MWE to the Bølling interstadial the model ocean has the potential to release about 45 Gt carbon within 200 years to the atmosphere. 4) The addition of an iceberg model to a regional high-resolution OGCM of the North Atlantic simulates both the extent and thickness of Heinrich sediment layers. This model setup further indicates that iceberg armadas from northern Europe are more effective in suppressing NADW formation than the input of pure meltwater and are capable of reversing the current system in the Nordic Seas within two decades.