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Overturning Circulation in the North Atlantic Ocean During Marine Isotope Stage 11c

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With a duration of 28 ky Marine Isotope Stage (MIS) 11c was the longest lasting interglacial of the last 1 My. It had eccentricity values similar to the Holocene and is therefore often used for comparison between these two interglacials. Here we combine new benthic and planktic foraminifer proxy records from sites drilled during IODP Exp. 303 and 306 with published data to map hydrographic conditions in the surface and deep waters of the North Atlantic Ocean and thus the state of the overturning circulation. The combined sites cover water depths from 1145 to 4595 m and are from key positions that allow to monitor changes along the major surface and deep-water current pathways.
Along the Gulf Stream, North Atlantic Drift and Portugal Current, surface water conditions were similar between 426 and 398 ka and surface and thermocline waters experienced only minor variations throughout the interglacial interval. The G. inflata Mg/ Ca records of IODP Site U1313 at 41°N shows, however, that the winter mixed layer started to cool already after 404 ka, i.e. 6 ka earlier than the demise of the interglacial. In comparison to the open North Atlantic surface waters, sites in the Labrador Sea and under the influence of the polar West Greenland (IODP Site U1305) and Labrador Currents (IODP Site U1303) recorded millennial-scale oscillations and surface waters here were less well ventilated until 408 ka. Similar oscillations were also documented at IODP Site U1308 by the polar species N. pachyderma (s), which at this site most likely reflects winter conditions, hinting at a potential signal transfer from the Labrador Sea through the subpolar mode water.
In the deep ocean oxygen isotope values were at a similar level for the sites bathed by upper and lower North Atlantic Deep Water (NADW) throughout MIS 11c. Only IODP Site U1305 from 3518 m water depth off southern Greenland and recording the Denmark Strait Overflow Water (DSOW) reveals slightly heavier values pointing to a cold DSOW. Ventilation at the different deep water levels, however, and thus convection depth or strength varied. Throughout MIS 11c, the best ventilated water mass was the lower NADW and like today ventilation was slightly better in the western than the eastern basin. Nevertheless, DSOW at site U1305 was well ventilated only after 407 ka, so that the good ventilation of the lower NADW must derive from the Iceland Scotland Overflow Water pointing to deep convection in the Norwegian Sea. The upper NADW was well ventilated only after 418 ka, potentially as a result of the variable surface water conditions in the Labrador Sea that could have inhibited deep convection. Below 4000 m ventilation also increased only after 418 ka but these levels still experienced periods with a stronger Antarctic Bottom Water influence until 409 ka. Overall the combined data reveals that the North Atlantic overturning circulation was at its strongest level between 409 and 400 ka contemporary with highest sea level. The colder winter mixed layer temperatures at site U1313 during this period could actually indicate a better preconditioning for the deep convection.

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