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Millennial-scale ocean current intensity changes off southernmost Chile and implications for Drake Passage throughflow

F. Lamy (1), H.W. Arz (2), R. Kilian (3), O. Baeza Urrea (3), M. Caniupan (4), C. Kissel (5), and C. Lange (4)

(1) Alfred Wegener Insitute for Polar and Marine Research, Germany (Frank.Lamy@awi.de), (2) Institute for Baltic Sea Research, Warnemünde, Germany, (3) University of Trier, Germany, (4) COPAS, Concepcion, Chile, (5) LSCE, Gif-sur-Yvette, France

The Antarctic Circumpolar Current (ACC) plays an essential role in the thermohaline circulation and global climate. Today a large volume of ACC water passes through the Drake Passage, a major geographic constrain for the circumpolar flow. Satellite tracked surface drifters have shown that Subantarctic Surface water of the ACC is transported northeastward across the Southeast Pacific from ~53°S/100°W towards the Chilean coast at ~40°S/75°W where surface waters bifurcate and flow northward into the Peru Chile Current (PCC) finally reaching the Eastern Tropical Pacific, and southwards into the Cape Horn Current (CHC). The CHC thus transports a significant amount of northern ACC water towards the Drake Passage and reaches surface current velocities of up to 35 cm/s within a narrow belt of ~100-150 km width off the coast. Also at deeper water levels, an accelerated southward flow occurs along the continental slope off southernmost South America that likewise substantially contributes to the Drake Passage throughflow.

Here we report on high resolution geochemical and grain-size records from core MD07-3128 (53°S; 1032 m water depth) which has been retrieved from the upper continental slope off the Pacific entrance of the Magellan Strait beneath the CHC. Magnetic grain-sizes and grain-size distributions of the terrigenous fraction reveal large amplitude changes between the Holocene and the last glacial, as well as millennial-scale variability (most pronounced during Marine Isotope Stage). Magnetic grain-sizes, silt/clay ratios, fine sand contents, sortable silt contents, and sortable silt mean grain-sizes are substantially higher during the Holocene suggesting strongly enhanced current activity. The high absolute values imply flow speeds larger than 25 cm/s as currently observed in the CHC surface current. Furthermore, winnowing processes through bottom current activity and changes in the availability of terrigenous material (ice-sheet extension and related supply of silt/clay, efficiency of the fjords in trapping sediment) might have contributed to the observed grain-size variations. Assuming that surface and bottom current strength changes are the major controlling factors, our data suggest a strongly enhanced CHC and deeper flow during the Holocene compared to the mean of the last glacial. During MIS 3, several phases of stronger current flow mostly correlate with warm sea surface temperatures at the site and, within age uncertainties, with millennial-scale warm phases in Antarctic ice cores.

Taken together our data can be interpreted in terms of strongly reduced contributions of northern ACC water to the Drake Passage throughflow during the glacial in general and during millennial-scale cold phases in particular. At the same time, advection of northern ACC water into the PCC was probably enhanced. These results are consistent with model runs showing largely reduced volume transport through the Drake Passage during the last glacial maximum and an increasing throughflow during the last deglaciation that might have affected the strengthening of the Atlantic Meridional Overturning Circulation.