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# Astronomically paced middle Eocene deepwater circulation in the western North Atlantic

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The role of the Atlantic Meridional Overturning Circulation (AMOC) as a key player for abrupt climatic changes (e.g. Heinrich Stadials) during the Pleistocene is relatively well constrained. However, the timing of the onset of a „modern“ North Atlantic Deepwater (NADW) formation are still debated: Recent estimates range from the middle Miocene to the Early Eocene [Davies et al., 2001, Stoker et al., 2005, Hohbein et al., 2012] and are mainly based on the seismic interpretation contourite drifts. Another understudied aspect of the AMOC is its behavior during climatic variations on orbital time scales and under different climatic boundary conditions (icehouse vs hothouse). IODP Expedition 342 drilled carbonate-rich sequences from sediment drifts offshore Newfoundland that cover the middle Eocene with high sedimentation rates (∼3 cm/ kyr). We present a ∼2 Myr long stable carbon and oxygen isotope record of benthic foraminifera nuttalides truempyi spanning magnetochron C20r in unprecedented resolution (< 2 kyr/sample), sufficient to resolve dominant Milankovic frequencies.
Data from Site U1410 (3400m water depth) indicate an active overturning in the North Atlantic during the middle Eocene, sensitively responding to variations in Earth′s axial tilt (obliquity).
Experiments in a GCM (ECHAM5 – MPIOM, OASIS 3 coupled) indicate that temperatures in the Norwegian and Labrador Sea could have allowed for sea ice during winter in a minimal obliquity setting (22.1°), whereas temperatures are too high to allow sea ice formation under maximum obliquity (24.5°) winter conditions depending on Eocene boundary conditions (atmospheric $CO_2$ concentration). We hypothesize that the combined effect of low temperatures in the sinking areas, an increased latitudinal SST gradient seasonal, and the potential formation of sea ice during obliquity minima results in an initial shallow NADW formation during the middle Eocene. This hypothesis is in accordance with the astronomical imprint observed in the data from IODP Site U1410.

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