Multi-proxy records of Holocene Atlantic overturning and its components

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Climate models project a ~11-34% weakening of the Atlantic Meridional Overturning Circulation (AMOC), a key component of the global climate system, through the 21st century. Model simulations suggest that melting ice-sheets caused a similar magnitude AMOC weakening during the early stages of the current interglacial epoch (the Holocene; 0-11.7 thousand years before present (ka)). Records of past changes in the AMOC can be used to test the ability of models to accurately simulate AMOC changes. Here we develop 53 new paleoclimate records from 34 sites, combined with published datasets (totalling 82 records), to produce a coherent, multi-proxy based synthesis of the strength of the AMOC and its individual components throughout the Holocene. The synthesis reveals that despite enhanced meltwater flux, the AMOC was ~10% stronger than average during the early Holocene (9-11 ka), due to strong Denmark Straits Overflow Water (DSOW) and Labrador Sea Water (LSW). On millennial timescales, Holocene changes in DSOW and LSW strength appear controlled to a greater extent by atmospheric forcing. In contrast, Iceland-Scotland Overflow Water (ISOW) strength appears tightly coupled to freshwater fluxes. Increased Arctic sea-ice and freshwater fluxes to the Nordic Seas during the late Holocene have culminated in exceptionally weak ISOW during the industrial-era. In combination with a centennial-scale weakening of LSW, this has caused AMOC strength during the industrial-era to be at a Holocene minimum, 10% weaker-than-average. Overall, our study highlights the varying controls and responses of individual AMOC components to different climate forcing and the need to correctly model these behaviours to accurately simulate past and future AMOC changes.