The Little Ice Age cooling and 20th-century warming recorded in deep Northeast Atlantic sediments

Authors: Wanyi Lu, Delia W. Oppo, Geoffrey Gebbie, David J. R. Thornalley, Brynnydd Hamilton

Imbalances in radiative forcing at the Earth's surface are modulated by ocean heat uptake and storage. Direct observations of temperature change in the deep (> 2 km) ocean are extremely limited, both temporally and spatially, and so our understanding of the ocean's role in dampening modern global warming is still imperfect. Scant observations can be supplemented by paleoceanographic reconstructions, both across earlier transitions of surface radiative imbalance like the Medieval Climate Anomaly (MCA) - Little Ice Age (LIA) transition, and for the post-1850s global warming. Subsurface data from regions like the high-latitude North Atlantic, where anomalous surface heat is transported to and sequestered at by the descending limb of the AMOC are especially important for understanding the deep ocean's role in modulating surface climate. Here we report δ18O variations recorded in the shells of ocean-bottom-dwelling (benthic) foraminifera from 11 Northeast Atlantic sediment cores, ranging in water depth from 1031 to 2274 m, and with ages spanning the last 500–2000 years. These δ18O variations reflect changes in bottom water temperature and the δ18O of seawater, the latter influenced by salinity. In cores deeper than ~1200 m, we find significant benthic δ18O increases (0.03–0.14 ‰) starting at ~1350 (the beginning of LIA), and a rapid benthic δ18O decrease (0.05–0.16 ‰) since ~1950. Assuming no salinity changes, these δ18O changes would correspond to 0.1– 0.6 oC LIA cooling and 0.2–0.7 oC industrial warming in the deep ocean. We infer that the AMOC transmitted surface ocean temperature changes to the deep Atlantic with little delay, consistent with evidence from an ocean model inversion. Other insights from the data-model comparison, for example, whether a better fit to paleoceanographic data could be achieved by a variable AMOC, and the potential benefit and complications of using these paleoceanographic data to constrain ocean heat uptake and AMOC, using an ocean model inversion, will be discussed.