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North Atlantic climate and deep water variability since 600 AD

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An increasing number of paleoclimate archives provide evidence that there is significant natural climate variability on multi-decadal to millennial timescales. Understanding the source and expression of these low frequency modes of natural climate variability is crucial for determining their role in current and future climate changes. The most recently recorded climate oscillations such as the Little Ice Age (LIA) are particularly well described and thus offer a natural starting point for understanding how they come about. Low frequency climate oscillations are often postulated to result from changes in the ocean's meridional overturning circulation (MOC). Testing this hypothesis for historically recorded climate changes such as the LIA requires decadally resolved constraints on the state of ocean circulation spanning these events. Here a 41.5 cm long sediment core (Multicore GS06-144 03 MC A, 57°29'N, 48°37'W, 3432 m) from the Eirik drift south of Greenland is studied to infer the timing, amplitude, and nature of deep water changes since 600 AD. The Eirik drift accumulates rapidly due to the influx of sediment eroded from the Denmark Strait and eastern Greenland margin suspended in Denmark Strait Overflow Water (DSOW). DSOW combines with Iceland-Scotland Overflow Water (ISOW) and other deep water masses to form nearly mature North Atlantic Deep Water (proto NADW) before flowing over the study site within the Deep Western Boundary Current (DWBC). Thus, this location is well situated to monitor changes in the past circulation and properties of nearly mature NADW along its western boundary flow path. We use foraminiferal oxygen and carbon isotopic records (C. wuellerstorfi) to reconstruct the physical and chemical properties of the lower branch of the MOC (the deep overflowing branches from the Nordic Seas). The changes in surface hydrography co-registered in the planktonic foraminiferal isotopic records (N. pachyderma (sin.) and G. bulloides) are used to assess possible linkages between MOC and climate. The foraminiferal oxygen isotopic results reveal significant centennial-scale variability in the near-surface and the deep water masses over the past 1400 years, suggesting a large magnitude natural variability similar to that found in many of the more sensitive climate models. Superimposed on the centennial variations are higher frequency oscillations, which are similar in duration and amplitude to those of the Atlantic Multidecadal Oscillation (AMO). The oxygen isotope records resolve several distinct cooling episodes, the most pronounced being an abrupt cooling around 1400 AD in both surface and deep water records. Thus, there is evidence for persistent deep water circulation and temperature (or salinity) changes over the past 1400 years, suggesting an active role for deep water - surface coupling in shaping our climate on multidecadal to centennial timescales. In particular, the results of this study highlight that the convergence of both internal (MOC) and external (solar & volcanic) forcing around 1400 AD may have triggered the particularly widespread and severe cooling initiating the Little Ice Age.