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Interglacial Climate Variability in the Mid-Latitude North Atlantic

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It is widely believed that the last interglacial period had significantly elevated temperatures relative to the Holocene, and sea levels were around 6m above the modern level due to the partial melting of the Greenland Ice Sheet and the West Antarctic Ice Sheet. A pattern of enhanced peak interglacial warmth is particularly evident in the Arctic region, but these differences are thought to be significant at a wider scale as global mean surface temperatures were raised by around +2°C (Otto-Bliesner et al., 2006). Elevated last interglacial temperatures are likewise evident in the deep ocean. The positive temperature anomalies and changes in ocean circulation patterns have largely been ascribed to differences in the distribution of insolation. In this study we use high resolution records of last interglacial climate to examine the extent of variability in the subpolar North Atlantic, corresponding to the Marine Isotope Stage (MIS) 5e interval. Sea surface temperature (SST) estimates are calculated using a variety of planktonic foraminiferal transfer functions, based on faunal assemblage counts, which together with stable isotope and ice rafted debris (IRD) data are used to reconstruct surface hydrography. Benthic stable isotope data provide stratigraphic control and allow us to assess the relative dominance of northern waters of the North Atlantic Deep Water (NADW) in comparison to southern source waters such as the Antarctic Bottom Water. These records provide a detailed picture of climate variability for the period from 65 to 140 ka (approximately from the end of MIS 6 to early MIS 4). Last Interglacial temperature estimates also are compared to the previous and subsequent periods of interglacial warmth to assess the scale and extent of regional variability within the surface ocean environment. Our results highlight two features of particular interest: the internal variability of the MIS 5e period and the pronounced climate fluctuations during the MIS 5/4 transition.

The SST records spanning the MIS 5e interval and isotopic data from planktonic foraminifera, together with an extremely high resolution sediment greyscale record, indicate that the climate of the last interglacial was not stable. In this region of the North Atlantic, the interval corresponding to the MIS 5e plateau can be separated into three distinct periods. The initial period is one of maximum warmth represented by a dominance of Neogloboquadrina pachyderma (dextral-coiling). This is followed by a cooler period characterised by increases in sub-polar species such as Globigerina bulloides and a decrease in N. pachyderma (dextral). The most convincing evidence for this climatic deterioration is the presence of low but significant amounts of IRD and an increase in the polar species N. pachyderma (sinistral-coiling). Benthic carbon isotope values suggest that some of these events were accompanied by changes in NADW production. The final part of the MIS 5e plateau shows a recovery to warmer conditions and stronger NADW production before the transition and multi-event, stepped cooling into MIS 5d. Surface conditions through the remainder of MIS 5 were appreciably cooler than the last interglacial period. Climate records across the MIS 5/4 transition reveal two distinct, extreme shifts in climate, apparently corresponding to extreme stadial-interstadial fluctuations in the Greenland ice cores, with oceanic SST reconstructions being charcterised by unusual interstadial warmth. Stadial coolings are preceded by small peaks in IRD, coincident with a freshening of surface waters. This signal is also translated to the deeper ocean, where benthic carbon isotope reductions of around 0.75 per mil suggest a significant reorganisation of NADW production.