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A two-phased Heinrich Stadial 11 as revealed by alkenone-based temperature record from the western tropical North Atlantic

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Paleo-data and models show that reductions in the strength of the Atlantic meridional overturning circulation (AMOC) lead to significant subsurface warming in the western tropical North Atlantic. The thermal response at the sea surface is less constrained due to the competing nature of the atmospheric and oceanic processes that produce opposite signs of temperature change. Here, we used alkenone unsaturation in sediments to reconstruct sea surface temperature (SST) evolution in the southeastern Caribbean (core MD99-2198, 1330 m water depth) during the last glacial-interglacial cycle, including Heinrich Stadial 11, which was a period of intense AMOC weakening. Our data show a 1 °C SST warming associated with the onset of Heinrich Stadial 11, and a 1 °C cooling during the late Heinrich, followed by a gradual 1 °C warming during the early last interglacial. Although stadial events are generally associated with wind-induced surface cooling in the tropical North Atlantic, the positive Caribbean SST anomaly during Heinrich Stadial 11 is consistent with previous findings. It likely originates from the upwelling of subsurface water that warmed in response to the initial AMOC weakening. Reduction in the Caribbean SST during the late Heinrich, associated with a particularly weak AMOC strength as suggested by our benthic d13C values, can indicate that the subsurface warming has diminished in the tropical North Atlantic possibly due to a general cooling in the source region (i.e., the subtropical gyre). A two-phased Heinrich is supported by the planktic foraminifera assemblage data, indicating that cooling occurred in the late Heinrich. In addition, this late phase is characterized by coarser sediments, which can be due to a strongly reduced outflow of the Orinoco and a particularly southern position of the intertropical convergence zone. For the last interglacial, our alkenone-derived SST record suggests stable conditions. However, the obtained interglacial values are characterized by very high alkenone unsaturation indexes that can incorporate large measurement and calibration errors due to the lack of Caribbean sediment traps and core-top data. These results, therefore, emphasize the need to better quantify the effectiveness of alkenones in reconstructing interglacial SST history in the Caribbean.