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Alternative mechanisms explaining the complex pattern of Heinrich events in the North Atlantic mid-latitudes

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The comparison between the Iberian margin multi-proxy record (MD99-2331) and other available palaeoclimate sequences from the North Atlantic region (18-75˚N and 0-75˚W) allows us to recognise a two-phase pattern within Heinrich events 4, 2 and 1 in the mid- and subtropical latitudes outside the IRD belt and to propose potential mechanisms explaining this complex scenario. H4, H2 and H1 events are characterised by two main phases in the outside regions of the IRD belt between 45 and 18˚N. The first phase is marked by low IRD deposition, extremely cold Sea Surface Temperatures (SST), relatively wet and very cold atmospheric conditions in the eastern mid- and subtropical latitudes while the few available data from the western part shows insignificant IRD deposition, cool SST and continental dryness. Although the second phase is characterised by a strong IRD deposition in the eastern part of the North Atlantic and cool SST in both the western and eastern North Atlantic mid/subtropical latitudes, the western Iberia, Mauritania and France experience an extreme continental dryness and the western subtropical region is marked by a relatively wet period.

During the first phase of H4, H2 and H1 iceberg melted preferentially in the IRD belt and released large amounts of IRD and freshwater weakening the thermohaline

circulation (THC) and triggering a substantial drop of SST which favoured the southward displacement of the polar front until 35˚-37˚ N. Although THC was slowdown, an increase of wet conditions in western Iberia and France was detected during the first phase of H4, H2 and H1. The observed western-eastern mid-latitude thermal contrast led to North America westerlies intensification favouring this moisture transfer. During the second phase of H4, H2 and H1, palaeoclimatic records reveal an intensification of the trade winds in the Mauritanian margin, a reduction of westerlies in the subtropical western North Atlantic and their northward displacement in the eastern North Atlantic mid-latitudes contributing to an extreme dryness of western Iberia and France. This scenario can be explained by both the decrease of oceanic thermal contrast between the subtropical western North Atlantic and Iberian margin and the THC slowdown producing a strong pole-to-equator temperature gradient triggering the southward displacement of the Intertropical Convergence Zone (ITCZ). This climatic scenario is supported by recent climate simulations which detect a southward displacement of the ITCZ and associated changes in tropical atmospheric circulation during Heinrich events by using initial Last Glacial Maximum conditions and an input of anomalous freshwater pulses into the North Atlantic.

Wet and dry conditions in the Iberian Peninsula detected during the first and second phases of H4, H2 and H1, respectively, can also be explained by changes in the two prevailing operating modes of the North Atlantic Oscillation-like (NAO-like). Furthermore, changes between these two modes could also explain the complex character of IRD deposition in the North Atlantic region. This hypothesis of a NAO-like operating mechanism is supported by the climatic asymmetry observed between mid- and subtropical eastern North Atlantic latitudes (wet/dry) and the Blake Outer Ridge (dry/wet).