Complex pattern of Heinrich events in the mid-latitudes of the North-east Atlantic explained by oceanic and atmospheric mechanisms

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Direct correlation between marine and terrestrial proxies from MD99-2331 deep sea core, retrieved off Galicia (42˚ 09' 00 N, 09˚ 40' 90 W), shows two main vegetation phases in north-western Iberia linked to the complex imprint left by Heinrich events in the Iberian margin.

The first phase, before the maximal arrival of icebergs into this margin, is marked by extremely cold sea surface temperatures indicated by the planktonic foraminifera assemblages and δ^{18}O analyses together with Uk^{37} measurements and by the strong cooling of the adjacent continent revealed by the *Pinus* forest decline. *Calluna* expansion in concert with the highest total pollen concentration indicates moisture increase during this phase. The second phase, associated with the maximum arrival of icebergs into the Iberian margin, is characterised by less cold sea surface and atmospheric conditions and by an increase of dryness identified by the development of semi-desert plants.

During Heinrich events (H4, H2, H3 and H1) the introduction of large amounts of freshwater via Northern Hemisphere icebergs drifting and consequent melting triggered a shutdown of the Atlantic Meridional Overturning Circulation (MOC) and a drop of SST in the North Atlantic region. This produced ocean-atmosphere rapid reorganizations which allows the fast transfer of cold conditions into north-western Iberia

triggering *Pinus* forest decline.

Besides this oceanographic mechanism, changes of prevailing (negative and positive) North Atlantic Oscillation (NAO)-like index seems to have played a crucial role for explaining the complex pattern of the typical Heinrich events (H4, H2 and H1) in north-western Iberian margin and in the adjacent continent.

Indeed during the first phase of H4, H2 and H1, prevailing negative NAO-like index likely triggered the increase of winter precipitation in Iberia and enhanced river flow favouring the seaward pollen transfer. These prevailing conditions, favoured iceberg melting in the IRD belt (where sea surface temperature was relatively warm) preventing their southern migration to the mid-latitudes.

During the second phase of H4, H2 and H1, prevailing positive mode of NAO-like index leads to westerlies intensification and northward displacement triggering an increase of dryness in Iberia. These prevailing conditions contribute for a southern displacement of warm sea surface conditions to the mid-latitudes of the North Atlantic favouring the southward migration of the icebergs to the mid-latitudes sites.

H3 is an exceptional case of prevailing wet conditions during almost the entire event probably due to maintaining reduced westerlies in this region.