July 20th 2014

Reply to the editor (L. Skinner)

Dear Luke Skinner,

Thank you very much for your comments on our manuscript. Please find below our responses to these remarks. In brief, we have answered all comments raised by the two reviewers in our reply to their reviews (separate document). We have changed the manuscript accordingly.

First, we have largely increased our ^{17}O-excess dataset that now covers three additional Dansgaard-Oeschger events, from GI-7 to GI-13 (instead of GI-7 to GI-10). We have also increased the resolution of the measurements covering GS-9: there is now a data point every 55 cm, corresponding to the highest possible resolution so far (the sampling resolution for water isotopes in the NEEM ice core was 55 cm). We have also provided in the introduction a much stronger background on the use of ^{17}O-excess and presented the results obtained from existing studies of ^{17}O-excess in polar regions (Greenland, Antarctica).

The title, the discussion and the conclusion parts have all been changed to tone down the interpretation and to present it clearly as speculative. The discussion concerning the MSA proxy has been entirely removed from the manuscript, and this proxy has also been removed from all figures. The discussion concerning GS-13 has been strongly toned down (no 3-phase identification is proposed anymore).

Based on our extended ^{17}O-excess data set and combined with several ice core proxies (certainly not ^{17}O-excess alone, and we have tried to make this clearer in the revised version), we have proposed that a specific fingerprint during GS-9 cannot be found in the preceding or following stadials.

Concerning the discussion about sediment cores, we have looked more deeply in the existing bibliography, searching for papers suggesting a 3-phase sequence during stadial 9 based on marine sediment cores, as it was suggested such papers existed. In addition of the paper from Naughton et al., 2009 that we already cited in the submitted manuscript, we have found a study from Daniau et al., 2009 proposing a 3 phase identification during stadial 9 based on charcoal and pollens records from core MD04-2845 (off France), as well as a study from Voelker et al., 2006, focused on past Mediterranean outflow variations.

Figure 5 in the revised version (former Figure 6) is not aimed at proving the existence of a 3 phase structure over GS 9 but at better showing that some decoupling during GS 9 are evidenced from multi-proxies studies of marine cores on the European margins. This decoupling is evidenced from the different delays between the IRD layers and the cold conditions during stadial 9.

Concerning the Iberian margin, the identification of Heinrich events is indirect for most sediment cores, based on sea surface temperature or salinity proxies, as IRD are much less abundant than in the Ruddiman belt, and could also be of gravitational origin due to sea-level increase. Without a clear

Laurentide IRD identification for H4 and H5, it is therefore not possible to know if we are in the stadial or in the Laurentide IRD layer. Thouveny et al., 2000 still showed that for the major H4 event in particular, IRD from the Laurentide could be identified on the Iberian margin (in cores MD95-2042 and MD95-2039) based on several parameters including rock magnetic properties (episodes of high magnetic susceptibility, with a coarser grain size, and in which the biggest grains (more than 60 or more than 130 microns) have been identified as quartz, silicate and magnetite). For cores MD95-2006 and MD95-2002, H4 in particular as well as H5 have been specifically identified (Austin et al., pers.com., Peters et al., 2008, and Auffret et al., 2002). This identification is reported in Figure 6 using blue areas.

Focusing on GS-9 and comparing the position of the blue areas compared to the temperature proxy record (here, percentage of *Neogloboquadrina pachyderma* sinistral), it is clear that in core MD95-2006 there is a long delay of the Laurentide IRD layer behind the *N. pachyderma* decrease, while this delay looks much shorter for the southernmost core MD95-2040. In the same way, there is a clear delay of the *N. pachyderma* increase after the end of the Laurentide IRD layer for core MD95-2006, while this delay is much shorter to inexistent in core MD95-2040. The discussion in Section 3.3 has been rewritten to better explain these observations.

We hope that you will find this revised and improved version of interest to be published in Climate of the Past.

With best regards,

Myriam Guillevic