

Reply to the Interactive comment on “Stratification of surface waters during the last glacial millennial climatic events: a key factor in subsurface and deep water mass dynamics” by M. Wary et al., by Anonymous Referee #2, Received and published: 15 July 2015

Referee #1: General appreciation

This paper presents foraminifera-based analyses combined with previously published data on dinoflagellate cyst-based transfer functions results to document the episodic changes in surface/subsurface circulation patterns in the North Atlantic during the late Pleistocene, in relation to the episodic warm and cold episodes associated with Greenland stadials and interstadials, Heinrich events, etc.

The manuscript is well written in correct English, but I made a few suggestions to improve the language. The manuscript should be read by someone with good English prior to the final submission. It follows a logical progression, and presents interesting new data on the mechanisms responsible for such changes at secular/millennial timescales in the North Atlantic Ocean. However, in its present form, I failed to see the novelty of the data as the emphasis is placed on previously published data (dinocyst-derived reconstructions) rather than on the new foraminifera data. Therefore, I suggest the paper to be modified to place the emphasis on the new data. The conclusions are supported by the data presented, although some aspects of the methodology and trends in the foraminifera data need more detailed explanations. The figures are well drafted and all useful for the comprehension of the text. However, some need modifications as suggested in the detailed comment section. I think that the mechanism put forward by the authors to explain the changes between warm and cold episodes (GIS–GS) is really interesting and definitely deserves to be published, following major (I would rather qualify them as moderate) revisions.

We thank Referee #2 and appreciate his/her precious advice. We fully agree and will take them all into account for the revised version of the manuscript. Below are our short comments to the main points raised by Referee #2.

Referee #2: Detailed comments

- The paper presents new data on FORAMINIFER and uses previously published data on dinocyst assemblages and transfer functions results, and this is not obvious from neither the abstract nor the Material and methods section. This is particularly evident in the introduction (lines 79-82) where dinocyst data from two previously published studies are mentioned BEFORE the new data presented in this manuscript: “...Our study uses a direct proxy of surface sensu stricto conditions, i.e. dinoflagellate cyst (dinocyst) assemblages, coupled to other proxies that give access to subsurface (foraminifera assemblages and geochemical analyses on their shells) and deep water mass dynamics (sediment grain-size measurements and magnetic susceptibility).” I suggest focusing on the new data only in the material and methods section.

Reply: Efforts will be done to place emphasis on foraminifera and grain-size data in the whole manuscript. In addition, as suggested by Referee#1, Methods and Results sections related to dinocysts will be deleted.

Incidentally, the information on the foraminifera database is not readily available and more information should be added to the Material and methods section regarding this

matter. Foraminifera are presented here as “subsurface proxies” (figure 5), but no indication as to which depth range they represent. Presently there is more information on dinocyst reconstructions than on foraminifera reconstructions.

Reply: We are sorry that the referred publication containing technical information on foraminifera transfer function/database/etc. is not freely accessible. We will cite additional papers where the method/database employed here is described. We mentioned (p 2092, lines 9-11) that planktonic foraminifera assemblages (as identified in our study) are potentially representative of the 0-300 m section of the water column. However, it is within the discussion section, so we propose to also mention it in the Material and methods sections to make it clearer. As already mentioned in our reply to Referee#1’s comment, we will also add mention and reference to the depth range attributed to the species *N. pachyderma* (s).

[...]

- I do not see very well the concordance between dinocyst-based reconstructed salinities and that derived from the foraminifera-based $\delta^{18}\text{OSW}$ (figure 3), although both seem to vary at millennial timescales.

Reply: Nor do we (see for example page 2092 lines 1-4). Presently, we cannot find any mention of such concordance in the manuscript (and if we did it was a mistake) but we will check again. Or maybe you meant two other parameters?

[...]

- Lines 452-459: The authors state that higher magnetic susceptibility and higher concentrations of benthic foraminifera both indicate higher bottom water energy or higher bottom current intensity. However, in their diagrams 4g and 4h, the maximum signal of both indicators occur at different periods, the maximum magnetic susceptibility occurring during the LGM, with a general increasing trend toward the top of the record, while maximum benthic foraminifera concentrations occur much earlier in their records (below HS3), with a decreasing trend toward the top of the record. Wouldn’t one expect to see both indicators varying together rather than at different time periods and with opposing trends like it is the case presently?

Reply: In the study area, magnetic susceptibility is clearly related to bottom current strength (Kissel et al., 1999). Benthic foraminifera concentrations are related to bottom conditions, i.e. oxygenation (through ventilation by newly formed bottom flows in our case) AND bottom productivity (e.g. Rasmussen et al., 1999). Rasmussen et al. (2002) evidenced similar trends of benthic concentrations in a nearby core (ENAM33, located southwest off Faeroes) and one retrieved from the Reykjanes Ridge (DS97-2P) and interpreted them as the result of decreasing bottom productivity during the late MIS3 and MIS2. The decreasing trend observed in our core is thus also probably related to decreasing bottom productivity.

Furthermore, Rasmussen et al. (1997, 1999, 2002) and Rasmussen and Thomsen (2004) deeply investigated the changes in composition (and concentration/fluxes) of benthic foraminifera fauna in many cores retrieved in the study area (southern Norwegian Sea and northeastern North Atlantic) with focus on the millennial climatic variability of the last glacial period. They all evidenced, during GI, high benthic concentrations and the occurrence of peculiar species that they related to bottom conditions similar to the present ones, i.e. characterized by active bottom current and high supply of food. They evidenced a reverse scheme during GS, with low concentrations and the occurrence of an “Atlantic

species group” typifying a stop of the overflow and the intrusion of Atlantic Intermediate Water. Hence, in the study area, changes in benthic foraminifera concentrations during DO, even if influenced by changes in bottom productivity, seem to be related to changes in the bottom current activity.

[...]

- The concentrations of *Pediastrum* are illustrated on figure 3, and very briefly mentioned in the text (lines 153 and 312), but no explanation is given on their usefulness in the present work.

Reply: We fully agree. They are only used as an additional argument in favor of low SSS during GS, but we can delete this curve and related mentions in the text or conversely slightly expand the discussion related to this proxy.

Concerning the cut remarks (replaced hereafter), mainly concerning language errors, reformulation, figure modification, etc., we are thankful to Referee#2 and we will take them into account as they will substantially improve our manuscript.

- Line 82: I would not call this “a high temporal resolution”. I suggest modifying the sentence as follows: “Analyses were conducted at centennial to millennial time scales on core MD99-2281 located southwest off Faeroes Islands.”
- Lines 208-209: “...not fully understood and discrepancies still existing between the various sea-level reconstructions...”
- Line 254-255: “...all data will be here presented and discussed **according to a cal BP age scale.**”
- Line 354: “...derived hydrological signals share **common** features ~~in common~~ but also differ in some points ...”
- Lines 439-441: “**Beside**, grain-size analyses on pretreated samples were ~~besides~~ conducted on the core section where the content of CaCO₃ (data not shown) **displays** the largest variations and attains its maximal...”
- Line 462: “~~This~~ **These** results are in accordance with findings...”
- Not being a fan of acronyms, this papers contains too many of them. Also, the same expression is used in different forms throughout the text: Dansgaard-Oeschger events are referred to as DO, DO cycles, and DO events, which contributes to the confusion with the acronyms.
- Line 515: “However, a **detailed** ~~scrupulous~~...”
- Line 575: “...depicted during GS, and characterized by the presence of a fresh **water** lid...”
- Lines 618-619: with classical disruptions of the overturning circulation at the ~~end and the~~ **beginning and the end** of the event interrupted
- Lines 650-651: Once again, the emphasis is place on dinoflagellate cyst assemblages despite the fact that the present study is about foraminifera analyses. Please rephrase to put the emphasis on the new analyses presented here, and coupled to dinocyst transfer functions results
- Figure 2: the choice of colors for the curves and titles of these curves should be revised. The pale blue and light brown-orange (diagrams c, e and f) make it difficult to see on the

screen, even more on paper. Try using more contrasting colors and/or thickening the curves. On that same figure, diagram a, the significance of acronyms (LGM, HS1, etc.) and numerals 1 through 10 on the curve should be indicated in the figure caption.

- Figure 3. The same comment about the color choice in figure 2 applies to this figure, especially the pale yellowish-green and pale blue, and also in figures 4-5. Try using more contrasting colors and thickening the curves.
- The addition of raw foraminifer counts would be nice, possibly in “additional material” section