We appreciate the time the reviewer took to review the manuscript and thank the reviewer for their constructive comments. We have tried to address them all and feel that they have improved the manuscript.

The reviewer's comments are in black italics, followed by our responses in blue. A revised manuscript with tracked changes is also included.

Anonymous Referee 3

This paper present new amino acid data from a series of sediment cores from the Arctic Ocean and the Nordic Seas. The new data include analyses of the planktonic species N. pachyderma and the benthic species C. wuellerstorfi and it is focused on the racemization reaction of Aspartic and Glutamic acid. The results are discussed in the context of the challenges in establishing robust chronologies for Arctic Ocean deep sea sediments. The paper is well written and has a sound scientific approach and should definitely be published. However, after reading the paper I think the authors should be a little bit stronger on their conclusion regarding the implications of their findings. To me it seems clear that the results suggest that either the established chronology is to young or the bottom waters have been warmer.

In the revision of the paper I would like the authors to consider expand with the following:

1. It is fine that the aa data generally support the correlation of cores based on density. However, merging all data on the depth scale of the ACEX core may introduce more scatter and uncertainty than needed.

> **We have considered this, however, there is insufficient geochronological control for the individual cores, so we are taking advantage of firm correlations to combine the data from multiple cores onto a single age scale. The illustrated correlation uses bulk density – because it is very straightforward to interpret. We also state, and have shown in past work, that this correlation is consistent with XRF based geochemistry (Zr, Ti, Mn, K), and grain size. References are provided for these works. We do not display all these correlation lines and data sets as it becomes rather untidy. We also acknowledge in the text that some scatter may arise from uncertainties in the correlation, but these are generally small (few cm) compared to the large scatter in the derived AAR ages. Understanding the origin of this scatter, and assessing whether it is greater than in other deep sea sites outside the Arctic, is a key step in future research.**

2. Present all Arctic Ocean cores with the basis for correlation also on depth scales.

> **We now include bulk density data displayed on individual core depths (Figure 2).**

3. Expand the section with some hard data on the basis for the ACEX established chronology and expand the discussion of the aa results relative to the other methods used.

> **A description of how the age model for the central Arctic cores was developed is on lines 130-145: "The currently accepted age model for the ACEX sedimentary sequence was developed using cyclostratigraphic analysis (O'Regan et al., 2008) and produced similar estimated Quaternary sedimentation rates as obtained by the decay of beryllium isotopes (Frank et al., 2008). The late Quaternary chronology (MIS 1 – 6) for ACEX included constraints from 14C dating, the correlation with nearby records AO96/12-1PC (Jakobsson et al., 2001) and PS2185 (Spielhagen et al., 2004), where MIS 5 was identified based on the occurrence of the calcareous nannofossil *Emiliania huxleyi* (Jakobsson et al., 2001), and further supported by results from optically stimulated luminescence dating of quartz grains (Jakobsson et al., 2003). The age model of core LOMROG07-PC04 is based on correlation with PS2185 (Hanslik et al., 2013)."**

Possibly this section was overlooked by the reviewer, but with more specific instructions on the kind of details that they want added, we would be happy to try and expand on this.

4. A review/figure/profile depicting the present main water masses in the Arctic Ocean may be useful. Perhaps some references to modelling work concerning possible temperature conditions in the Arctic ocean during the glacial stages may be useful-

We do not really know how water temperatures varied over the past. This is partly due to the chronological challenges associated with sediments from the central Arctic Ocean. We refer to Jones (2001) for a summary of water masses in the Arctic Ocean, and to the study by Cronin et al. (2012), who used numerical modelling to show that intermediate depth warming occurred during glacial conditions.

Miinor suggestions on text

30 *... bottom water temperatures may have been similar.*

Changed.

33 *....models. Also a better understanding of temperature histories at the investigated sites and other possible environmental factors that may influence rasemisation rates in the central Arctic ocean, is needed.*

Changed.

64 *Bottom water of Atlantic and Pacific sites are presently generally a few degrees warmer than the Nordic Seas and Arctic ocean.*

Added, "despite the cold bottom water in the central Arctic Ocean"

100 *.....influence of Atlantic surface water, and…*

Changed.

110 *...cores have been developed….*

Changed.

141 *..with 21(?) samples…*

A total of 95 stratigraphic depths were sampled resulting in 95 samples in total.

172 *Where the reversal confirmed for both species at the same level?*

Clarified by adding, "These include five samples of *N. pachyderma* and three *C. wuellerstorfi.* Of these, two samples contained sufficient tests of both species to analyse AAR, but only *C. wuellerstorfi* were stratigraphically reversed."

214 *Considering what we know about past and present hydrography the samples from the Nordic Seas most likely have been exposed to the same water masses through time. Also the datapoints you have, seems not allow for establishing different pathways at the two sites. Suggest you make one polynomial fit but keep the coloring of points.*

We consider it important to show that they independently follow similar trends.

249 *This is surprising taken into account that the temperatures potentially have been lower than the "global" ocean.*

Indeed.

Fig. 2
Suggest that the density data is plotted on individual core depths with correlation to ACEX indicated with lines.

We now include bulk density data displayed on individual core depths (Figure 2).

Fig. 5
It would have been nice to see the data for each core plotted on core depth in a separate figure.

We have provided this in Figure 2.