A Major change in NA deep water circulation during the Early Pleistocene transition 1.6 Ma
Khelifi and Martin
Climate of the Past
Revise

The manuscript by Khelifi and Martin presents Nd isotopic data from three sites in the North Atlantic (Sites 610, 980 and 900) over the past 4 my and highlights variations in the overflow from the GIN Seas along with relative mixing proportions between northern and southern sourced waters. The main point is that there is an overall transition to less radiogenic values at all three sites followed by greater water column stratification beginning at 1.6 Ma, which they attribute to reduced overflow from the Nordic Seas and reduced vertical mixing. Their data appear to support this interpretation and it is an important point for people working on variations in Nordic overflow and North Atlantic circulation. A more interesting question, of course, is how this change in circulation impacts or is impacted by climate and I think the authors could do a better job of setting up that point and making the connections between circulation and climate.

Both the Abstract and Introduction start with very broad statements about the importance of deep ocean circulation as a driver for climate change. In contrast, the main point of the paper is that changes in the climate system (the Earth's response to obliquity forcing) led to changes in circulation (climate forcing circulation rather than circulation forcing climate). Khelifi and Martin speculate in the conclusions that the resulting change in circulation may have set up the Late Pleistocene Transition, but other than timing I missed the argument for that connection. The manuscript would be significantly improved by a clearer statement in both the abstract and introduction about why they undertook this study over this time interval in this area. Clearly they were targeting something more specific than the global link between climate and circulation.

Part of my dissatisfaction with the very general climate-circulation set up is that the introduction never specifically explains what the goals of the project were. Instead the introduction consists of two paragraphs; the first covers the large scale link between the AMOC and climate, and the second explains the use of Nd isotopes as a tracer for water mass and water mass mixing. I had never heard the phrase "Early Pleistocene Transition" before and assumed I'd find out what it is, why it is important and what is known about it and what are the outstanding issues in the introduction, but it turns out that phrase only occurs in the Title, Abstract and Conclusions. I had to work fairly hard to understand the major contribution is of this work and its relevance because they never laid it out specifically in the paper. A stronger Introduction would resolve that problem.

Nd isotopes really only provide information about water mass distribution, which means that researchers are left to speculate on the possible connections to climate and then support those theories with other evidence and correlations. Khelifi and Martin do this very well for some aspects of the study, such as pointing out evidence from d13C that supports the idea of increased mixing with LSW and NADW in the North Atlantic at 1.6 Ma, but the supporting evidence for other interpretations is less clear. For example, the evidence that specific positive excursions in the Site 980 record correlate to specific glacial events was a bit tenuous. Do they really have an age model for Site 980 that is robust enough to support those correlations? Is there anything that

is actually unique about the intervals they refer to as "key glacials" in the figure caption? Some do stand out as more dramatic events, but several of them (G20, 70, 58) do not. Why did these glacials produce especially strong overflow of Nordic waters and why does that overflow appear to last longer than the glacial interval? I also was not clear about the link between the 1.65 – 1.4 Ma event and the increased amplitude of obliquity forcing as well as the climate response to obliquity forcing (p. 6503, lines 20-23). I understand there is a correlation in terms of time, but I didn't follow why the changes in obliquity would lead to reduced overflow. They suggest stronger obliquity forcing should have led to cooling of the Nordic seas (line 25), but unless there was significant sea ice development, why would cooling reduce overturning and overflow? In fact, they imply (line 27) that cooling in the Southern Ocean would be expected to produce more southern sources waters. Why isn't the same true for northern sourced waters? I don't work on glacial time scales very often, so maybe I'm just missing an obvious point.

I think the correlation between Nd isotopes from different sites (especially 610 and 980) and between foram and bulk sediment leaches is convincing evidence that the data are recording seawater. Therefore it was surprising to see that they were using Sr isotopes to make that argument. Gutjahr et al. (2007) demonstrated convincingly that Sr isotopes are not a particularly good test for preservation of the seawater signal. In their defense, Gutjahr et al. did show that alteration of the seawater Sr isotope signal does not imply alteration of Nd. Thus, the data in the supplement don't hurt their argument, but I don't think the Sr argument is a particularly useful argument for a seawater signal.

More minor comments are below:

- 6500, line 3- needs to clarify that the Holocene signature at Site 610 is extracted from bulk sediment.
- The sentence that spans page 6500 and 6501 needs clarification. It seems to imply that the more radiogenic values at Site 900 are due to erosion of Holocene sediments and not contamination by basaltic material, but I'm not sure what the erosion of Holocene sediments is all about or where it is supposed to have taken place.
- 6501, line 15- the comment about 3 eNd unit glacial/interglacial shifts in the younger part of the record seems like a bit of an overstatement. Some of the glacial samples they analyzed are 3 units lower than some of the interglacial intervals, but they don't appear to have actually sampled across a glacial/interglacial transition and there is some noise just in the interglacial record. Therefore, their data doesn't clearly define the offset for particular glacial transitions.
- 6501, line 21- refers to the general similarity between the records for 610 and 980, which is true, but what jumps out to me when I look at those records is the offset between those two records between 2.5 and 2 Ma. It would be worth commenting on what that offset indicates and how that fits into their argument about circulation.
- 6501, line 27 states that Site 900 data record a similar decrease in Nd isotopes from 1.65-1.35. The magnitude of the decrease is similar, but the shape is distinct.
- 6502, line 23- specify which bottom water is referred to.
- 6503, line 20- "In contrast" seems like the wrong wording. In addition? Actually I'm not sure what the preceding sentence is about. Are they implying the MPT is only linked to changes in ice sheet dynamics?

- 6504, line 7- Would it be more accurate to say Site 900 experienced a “diminished admixture of Nordic waters” rather than an “enhanced admixture of southern sourced waters?

In summary, this is an interesting data set and the authors have interesting ideas to explain the variations and the resulting implications for climate, but they need to set up the problem clearly and concisely in the introduction and make sure that the abstract and conclusions then focus on the issues presented in the introduction. The sources and mixing of deep waters may not be well understood, but they need to highlight why we want to understand circulation specifically at this time in this place rather than in vague, general terms. Several of the other points of confusion are probably a matter if rephrasing to make it a concept clearer and more accurate.