Clim. Past Discuss., 10, C2002–C2008, 2014
www.clim-past-discuss.net/10/C2002/2014/

Climate of the Past Discussions

Interactive comment on "Subsurface North Atlantic warming as a trigger of rapid cooling events: evidences from the Early Pleistocene (MIS 31–19)" *by* I. Hernández-Almeida et al.

Anonymous Referee #2

Received and published: 28 November 2014

Review Hérnandez-Almeida et al. Subsurface North Atlantic warming as a trigger of rapid cooling events: evidences from the Early Pleistocene (MIS 31-19).

Hérnandez-Almeida et al. present a new record of Mg/Ca-derived temperature of the subsurface dweller Neogloboquadrina pachyderma sinistral for core U1304 for the time interval 1069-779 ka. The Mg/Ca-derived record is furthermore used to deconvolved the sea water d18O and temperature component from the previously published N. pachyderma d18O record and obtained indirect indications about subsurface salinity changes. These new records (subT, d18Osw) are used in combination with previously published (by the same authors and collaborators) records of planktonic and benthic stable isotopes and IRD counts to infer increases in subsurface temperature and salin-

ity in connection with IRD events due to reorganizations of the AMOC. Similar subsurface developments have been reported during MIS 3 also in relation to IRD discharges and AMOC reorganization. To my knowledge, this is the 1st time that such events are described for the around-MPT world and show that climate instability is the norm rather than the exception of glacial times. The manuscript will be of interest for a wide audience of Climate of the Past and I recommend publication after moderate revisions.

I find that the main point of the manuscript, warmer+saltier subsurface water accompanying IRD events can be more elaborated to describe differences between different periods. It seems tricky to make a generalization of this mechanism to all the IRD events since some of them happen during interglacials, when maybe there was indeed no sea ice cover for the warm subsurface waters to flow underneath and destabilize. For example 4040-6 "many of the IRD events", it is probably more precise to leave it more open, "a number of the IRD events", "some of the IRD events" and subsequently try to group them and describe which fit in that mechanism of which do not. You could prepare a table in which the information listed below is included (and other info you consider relevant).

IRD ca 1060-1050 ka (MIS 30): warming yes, salt yes, increase plk d13C (=ventilation) yes, also increase in plk d18O (not seen in benthic d18O), likely related to salinity. IRD started before, during cooling.

IRD ca 1033 (MIS 29): warming no, salt yes? (difficult to see in Fig.2), ventilation yes, also increase in plk d18O not seen in benthic d18O, likely related to salinity

IRD ca 1020 (MIS 29): warming no, salt yes, ventilation yes, also increase in plk d18O

IRD ca 1012 (MIS 28): warming very small, salt very small, ventilation yes, no really increase in plk d18O,

IRD ca 1008 (MIS 28): warming yes, salt yes, ventilation yes, before IRD discharge

IRD ca 995 (MIS 27): warming yes, salt yes, ventilation yes, before IRD discharge,

benthic d18O ca 3.5 per mil

IRD ca 982 (MIS 27): warming yes, salt yes, ventilation yes, increase in plk d18O, benthic d18O ca 3.5 per mil

IRD ca 970 (very small one, MIS 27): warming yes, salt yes, ventilation yes, increase in plk d18O, benthic d18O ca 3.5 per mil

IRD ca 963 (MIS 26): warming yes, salt yes, ventilation no, increase in plk d18O, this could be related to salinity

IRD ca 935 (very small one, MIS 24): warming yes, salt yes, ventilation yes, no increase in plk d18O, abrupt surface cooling

IRD ca 924 (MIS 24): warming yes, salt yes, ventilation no, no increase in plk d18O different from d18Oben

IRD ca 910 (MIS 23): warming small, salt yes, ventilation small, increase in plk d18O, surface cooling, ben d18O above 3.5 per mil

IRD ca 888 (MIS 22): warming yes, salt yes, ventilation no, increase in plk d18O,

IRD ca 870 (MIS 22): warming yes, salt yes, ventilation yes, no increase in plk d18O, IRD discharge started before, continuous along MIS 22

IRD ca 842 (MIS 21): warming no, salt yes, ventilation yes, increase in plk d18O, likely related to salinity

IRD ca 830 (MIS 21): warming no, salt yes, ventilation yes, increase in plk d18O, likely related to salinity

IRD ca 828 (MIS 21): warming no, salt yes, ventilation yes, increase in plk d18O, likely related to salinity

IRD ca 820 (MIS 21): warming no, salt yes, ventilation yes, increase in plk d18O, likely related to salinity

IRD ca 817 (very small, MIS 20): warming yes, salt yes, ventilation yes, no increase in plk d18O

IRD ca 800 (MIS 20): warming no, salt yes, ventilation yes, increase in plk d18O

On view of this listing, my impression is that the subsurface mechanism operated during glacial periods or mild interglacial periods (pre-MPT) when the ice sheets were still close to the critical mass defined by McManus (ben d18O 3.5 per mil) for instability. The IRD events during MIS 21 do not relate with subsurface warming and were more likely caused by the surface cooling described in the 2012 paper. In that paper all IRD were related to surface cooling so it would be good to integrated both interpretations here, for example playing with the critical mass of ice sheets, how a big ice sheet allow to growth sea ice, do we then need the subsurface warming to break that sea ice? Can any of the salt anomalies be related to brine rejection and not to entering of subsurface subtropical derived waters? In general I miss the integration of the nicely presented previous records (MAT-SST, radiolaria and opal for productivity) and I think that the discussion could benefit from some mentioning to those. I suggest a bit more of elaboration on the differences of the events rather than putting them all in the same box.

Comments to the text:

4034: Please note that paleoceanographers have a tendency to use the term AMOC as a synonym of NADW convection. Sensu stricto AMOC refers to latitudinal transports in the Atlantic and there is such latitudinal transport at surface and subsurface (northward) and at depth (southward), being both connected. In this regard it is contradictory to say (4034-10) “enhanced northward transport of subsurface waters in periods of reduced AMOC”. You probably mean here periods of reduce NADW/NAIW (NCW) formation. If this is the case, I have difficulties understanding the mechanism that would lead to increase transport of subsurface waters to the north; to my understanding the more NADW convection, the more feeding waters are needed to be transported to the

north and subsequently sunk. To me it would make more sense to think that the warm, salty subsurface waters accumulate below the sea ice because they do not sink as NCW (and it is not necessary that more volume is transported). Idem for 4041-17,18.

4036-10, I think that 200 m is the top of the thermocline and not the base (which is at some 1000 m according to your figure 1). Please rephrase.

4037-25. Idem, according to figure 1 N. pachy inhabits (200 m), the upper thermocline.
4037-27. at the upper thermocline

4041-14. Sensu stricto you cannot speak here of intermediate waters because your Dd13C gradient is between subsurface (ca 200 m) and deep waters and not between intermediate and deep waters. Please rephrase.

Typos, minor edits and rewording:

Please remove the spaces in Mg / Ca, i.e. write Mg/Ca throughout.

4034-5/6, rephrase, it is repetitive, for example: We used Mg/Ca-based temperatures of Neogloboquadrina pachyderma sinistral, a deep dwelling planktonic foraminifera, and paired measurements of Mg/Ca-based temperatures and d18O to estimate d18O of sea water at site U1314.

4034-19, spell out MIS in 1st use in abstract and main text

4035-20, symbol in d18O is missing

4037-3, sensu estricto this referencing is not correct because Paillard and Yiou, 1996 do not present Analyseries 2.0 but 1.0, you can circumvent that by saying only using the Analyseries software.

4037-19, southwards

4037-27, phrase does not read correct. Rephrase, for example “on deep dwelling plk foraminifera N. pachy sin. which inhabits and calcifies. . .”

4038-3. Wording. “Around 50-60 well-preserved test of plk foraminifera N. pachy sin. (> 150 micras) were analysed in 542 samples for Mg/Ca ratio following Pena′s et al (2005) procedure”

4038-4, I infer that you used N. pachy sin. non encrusted? Please mention, this information is also missing in the 2012 paper and encrusted and non-encrusted may represent different environmental conditions.

4038-16 to 26, is this detailed description necessary? The records are published and the methods described in the original publications. It would be enough with a sentence referring to those publications otherwise it is misleading and it seems that these records are also new here.

4038-28. Reword. Example: Seawater d18O was calculated introducing paired Mg/Ca-bsed temperatures and calcite d18O in the paleotemperature equation of Shacklenton (1974).

4039-21,22: it is not clear what you mean, since MIS 25 d18Osw increased by 0.5per mil and T by 0.5°C, towards present?

4039-27: Wording. Shortly after the iceberg discharge started

4040-27. they exhibit?

4043-14,15, wording + please see considerations about AMOC above

4044-14. Wording, divide sentence.

Caption Figure 2. For c) benthic d13C the reference Hernández-Almeida et al. 2013a (P3) is missing.

Both, Hernández-Almeida et al. 2013a (P3) and 2013b (Boreas) are missing in the reference list.

Figure 3. vertical axis:Mg/Ca (a is missing in Ca)

Figure 4. A running mean though the curve would help readers to pick up the general trends. A color shading for either glacial or interglacial times would also be helpful to evaluate whether there are tendencies with G-I cyclicity (this also for figure 2).

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