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Climate of the Past Discussions

Interactive comment on "Mid-Pliocene shifts in ocean overturning circulation and the onset of Quaternary-style climates" *by* M. Sarnthein et al.

Anonymous Referee #2

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General comments

The recent review by Molnar (2008) challenged the generally accepted view that the closing Central American Seaway played a decisive role for the onset of Northern Hemisphere glaciation in the Pliocene. The contradicting results by using paleontological or geochemical evidence, the problem of exact timing of the different processes involved, as well as the opposing results of various ocean circulation and climate modelling experiments led Molnar to question whether the closing of the Central American Seaway have played any role. Sarnthein and co-authors present a new line of evidence suggesting that the poleward heat and moisture transport may have triggered the onset of Northern Hemisphere glaciation due to enhanced precipitation over NW Eurasia and a consequent decrease in sea surface salinity of the Arctic Ocean, which in turn

increased its sea-ice cover and hence albedo. Furthermore, the doubled throughflow from the Bering Strait is supposed to have led to a cooling of the East Greenland Current thereby promoting the formation of a Greenland ice sheet. The consequences for future climate predictions are discussed.

In general it is a well organized and presented paper. The figures are fine except for minor changes, maybe the number of figures can be reduced as suggested below. New data are not presented in this manuscript, instead many actual publications and some model experiments are cited to support the new line of argumentation. However, the given interpretations are not always supported by the data, and the following considerations may help to improve the paper:

1 Introduction: Of course, a better understanding of climate processes will always help to improve the prediction of future climate change. However, I think, it is widely accepted that the processes which led to the onset of Northern Hemisphere Glaciation provide no analogue for the consequences of modern global warming. I therefore suggest that the motivation of the presented paper should be oriented towards the above cited criticism by Molnar (2008).

2 Conceptual models... The citation of pCO2 decrease as a trigger for NHG is a bit confusing. The paper by Pagani et al. (2005) does not show any pCO2 data for the Plio/Pleistocene, and the discussion by DeConto et al. (2008) is focused more on an early NHG in the Paleogene. Furthermore, it is contradicting whether the authors trust in pCO2 as a trigger (p. 256 lines15-19) or object to it (p.255 lines 24-29). To better follow this discussion, it would be nice to have the pCO2 record of Foster et al. (2008) included in Figure 12 (if the authors get access to the data). However, the idea of CAS closing and reopening driving AMOC and hence the carbon cycle and climate cooling is interesting and should be addressed in more detail.

3 Models and concepts... p- 257 line 19: Taken the graph of Fig. 7, significant changes in NADW production already occurred at a CAS sill depth of 550 m, not only in the

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upper 250 m. The authors should explain, how they calculated the % sub-SSS contrast. Furthermore, from Fig. 14 it is evident that some of the early glaciations around 3.3, 3.15 and 3.05 Ma have been associated with a low SSS gradient between the Caribbean and the E Pacific. How does this observation fit to the general concept of the role of AMOC for NHG? p.258 line 8-10 The authors wonder whether Lunt et al. (2008) sufficiently considered the sea-ice based albedo effect. Since this is a crucial point for the role of the freshwater fluxes on NHG, it should be checked and discussed in more detail.

4 Sediment records ... p.259 line 15 The paper of Huybrechts et al. (2004) is not the right citation for the argument of the changing poleward heat flow induced by the closing CAS.

5 North Atlantic sediment records ... p.260 line 5ff I do see the 907 IRD increase following the increase in the Caribbean-Pacific SSS gradient around 3.2 Ma, but I cannot see such pattern at 2.95 and 2.65 Ma. If a northward heat transport out of the Caribbean is seen as a driver for glaciation on Greenland, why there should be a 40 ky lag between these proxies? This should be explained. Similarly, the 1307 IRD record seems to lead the SSS gradient, which is rather unlikely. To be sure that it's not just an artefact of mismatching stratigraphy, the authors should present in a separate figure the newly tuned d18O records of the discussed sites.

6 Sediment records showing ... p.261 line 6 ff I do see the remarkable coherence of the ODP 609 SST record with the SSS gradient between the Caribbean and the Pacific (Fig. 13), however, the distinct 609 SST maximum at 3.25 Ma and the minimum at 2.65 Ma have no analogues in the SSS gradient. Again a mismatch in stratigraphy?

7 Sediment records of poleward... The argument of an enhanced Arctic throughflow as a trigger for establishing an East Grenland ice sheet is convincing. However, if the age model of Site 1307 is correct, the -6°C cooling and +1 psu freshening of the EGC occurs at a time when the SSS gradient between the Caribbean and the Pacific was

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low. How to explain the increase in steric height in the North Pacific then necessary to increase the Bering Strait lowsaline water export?

FIGURES

Figure 1 is obsolet, if the introduction is focused more to the review by Molnar (2008)

Figure 10 The LSR04 stack should be added to the SSS gradient record to better follow the discussion.

Figures 12 to 14 are somewhat redundant and should be combined to one full page figure

Figure 15 The figure caption should be more precise with regard to the settings: Is it a difference plot between modern and CASopen situation? Why the modern sealevel has been used? I'd rather prefer to see a difference plot in steric height, using Pliocene sealevel.

Furthermore, Prange is a co-author, so this figure need not to be cited as unpublished (p.262 line 12)

Interactive comment on Clim. Past Discuss., 5, 251, 2009.