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Climate of the Past Discussions

Interactive comment on "The transient impact of the African monsoon on Plio-Pleistocene Mediterranean sediments" *by* Bas de Boer et al.

Anonymous Referee #1

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In this paper the authors compare previously performed transient CLIMBER-2 climate model simulations with marine sedimentary records over the time interval from 3.2 to 2.3 Ma. This time interval includes the Pliocene-Pleistocene transition with the initiation of Northern Hemisphere glaciation. The analysis is focused on North Africa, in particular the Sahara and Sahel regions. Two sedimentary records, one in the Mediterranean (Ti/Al at ODP 967) and one in the Atlantic (dust at ODP 659), are compared with modelled runoff. The Ti/Al record is an extension to 3.2 Ma of an already published record from 2.4-2.9 Ma. The dust record of site 659 has been retuned for the purpose of this paper. The study shows that model and sedimentary records correlate relatively well and show a consistent response to orbital forcing, mainly precession. The last part of the paper is devoted to an analysis of the transient behavior of model-proxy relation.

The paper is of general interest for readers of Climate of the Past and fits into the scope of the journal, but I have a few major comments that need to be addressed before the paper is suitable for publication.

Major comments

My major concern about this paper is that it is at least partially based on a comparison between apples and pears. Runoff from the CLIMBER-2 model is compared to sediment records representing a combination of runoff and dust deposition (Ti/Al record of site ODP 967) and dust deposition (ODP 659). Since dust emissions are a strongly non-linear function of ground cover, wind and soil moisture, comparing runoff with dust deposition is hardly justified. They are of course related, during dry periods you expect less runoff and more dust, but their relation is probably far from linear. A direct comparison of runoff with the Ti/Al record is partly justified, because the Ti/Al record is expected to be also a proxy for runoff. This could also be the reason for the higher correlation of CLIMBER-2 runoff with the Ti/Al record compared to the correlation with the dust record at ODP 659. In principle the CLIMBER-2 model output probably includes all variables needed to diagnose the dust emission flux using e.g. the simple model described in Bauer & Ganopolski, 2010. This would allow a more straightforward comparison between model and the sedimentary records presented in the paper.

Because of its important effect on both the water cycle and dust emissions, I'm missing a description of what happens to the vegetation over the Sahara and Sahel in the model over the simulation period and how that could have affected runoff and dust and therefore the comparison with the sediment records.

A discussion of uncertainties in the forcings is missing. There are for example large uncertainties in the atmospheric CO2 concentration. Proxy reconstructions show a large uncertainty, particularly in the amplitude of 'glacial-interglacial' CO2 variability. The paper by Stap et al. 2016, just to name a model-based reconstruction where two of the authors of this paper are co-authors, shows a very different CO2 trajectory

across the Pliocene-Pleistocene transition than that used in the simulations presented in this paper. I'm not saying that CLIMBER-2 should be re-run with all these alternative forcings, but a critical discussion of the possible impact that the choice of a particular forcing could have on the results presented in the paper is needed.

Minor comments

lines 27-29: What is meant by 'completely'? There are plenty of other studies that could be cited here, showing that, at least if CO2 is low enough, orbital variations are enough to get pronounced glacial cycles: e.g. Abe-Ouchi et al., 2013 and Ganopolski & Calov 2011.

line 88: what does 'quality' mean here?

lines 104-106: sentence is unclear

lines 126-127: how has the tuning been done? Moreover that the LR04 stack has almost no precession for the early Pleistocene.

lines 136-139: Would be interesting to see the time series for precipitation, evaporation and runoff for the two grid cells. Also, what is happening to vegetation in these grid cells? Could it be that the increase in evaporation is related to an expansion of vegetation in the Sahara grid cell? If vegetation is growing over the Sahara I guess that more water should be available to evaporate because roots have access to deeper soil layers...?

lines 142-143: is this possibly related to changes in Atlantic meridional heat transport and subsequent changes in the position of the ITCZ when NH ice sheets start to grow and decay?

Fig. 3: Please mention in the caption that the y-axis for precession is reversed in 3a. It took me a while to figure out that maxima where actually minima.

lines 149-152: I have read this sentence 10 times, but still do not understand what it

means.

line 155: 're-tuned age model of Sites 659'. It is not a spectrum of the age model, but of the dust record, right?

line 254: 'we correlation combined': rewrite

line 257: 'which representing' -> representing

line 259: 'that indicating' -> indicating

Fig. 9d: and how are lags and leads represented? Please add a legend with arrow directions to clarify. Color scale is missing in d.

References

Stap, L. B., de Boer, B., Ziegler, M., Bintanja, R., Lourens, L. J. and van de Wal, R. S. W.: CO2 over the past 5 million years: Continuous simulation and new δ11B-based proxy data, Earth Planet. Sci. Lett., 439(April), 1–10, doi:10.1016/j.epsl.2016.01.022, 2016. Bauer, E. and Ganopolski, A.: Aeolian dust modeling over the past four glacial cycles with CLIMBER-2, Glob. Planet. Change, 74(2), 49–60, doi:10.1016/j.gloplacha.2010.07.009, 2010. Abe-Ouchi, A., Saito, F., Kawamura, K., Raymo, M. E., Okuno, J., Takahashi, K. and Blatter, H.: Insolation-driven 100,000-year glacial cycles and hysteresis of ice-sheet volume., Nature, 500(7461), 190–3, doi:10.1038/nature12374, 2013. Ganopolski, A. and Calov, R.: The role of orbital forcing, carbon dioxide and regolith in 100 kyr glacial cycles, Clim. Past, 7(4), 1415–1425, doi:10.5194/cp-7-1415-2011, 2011.

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