

Interactive comment on “Effects of orbital forcing on atmosphere and ocean heat transports in Holocene and Eemian climate simulations with a comprehensive Earth system model” by N. Fischer and J. Jungclaus

Anonymous Referee #2

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The paper focuses on the change of oceanic transports in simulations of past warm periods with an ocean-atmosphere-vegetation 3D model. The periods chosen are pre-industrial, mid-Holocene and Eemian. These periods are addressed by many simulations and paper, mainly related to the PMIP intercomparison projects. But few authors examine ocean dynamics. The present study is then original, and a good complement to existing literature, and within the scope of Climate of the Past. I have three major concerns that should be corrected before publication in Climate of the Past.

Major concerns :

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1) The discussion is not very convincing. The feedback loop (page 2325 / line 25 and following) is not really supported by the results shown within the text. Most of the transport and transport changes in the Nordic seas are due to the gyre component rather than MOC. Is the MOC change really impacting the heat transport ? Over the ISR, MOC increase is not clear. The existence of the alleged feedback loop needs to be clarified. Some quantification is needed. A feedback due to the northward shift of wind and storm tracks could be, and probably is, active in the simulations, through the gyre heat transport in North Atlantic. This should be clarified.

2) Cooling in monsoon region is attributed to albedo changes (page 2318 / line 5). The vegetation is dynamic. This implies a possible change of the evaporation process between soil and atmosphere (page 2325 / line 10), which can impact the simulated climate. The relative effect of the albedo feedback and the evaporation feedback should be quantified, even though the albedo is underestimated, the soil albedo being fixed.

3) The bibliography is missing some papers relevant to the subject : in the introduction, the paper reads that there is no bibliography about ocean dynamic change in simulations of these periods, except Rensen et al (2006). However, some references can be found in the literature about ocean dynamics change and its effects at the Holocene (the following list is probably not comprehensive) :

Change of global transport in atmosphere and ocean : Braconnot P., Joussaume S., Marti O and de Noblet N (2000). Impact of ocean and vegetation feedback on 6ka monsoon changes. Third PMIP Workshop, La Huardière, Canada, WCRP.

Change of deep temperature, vertical velocity, etc ... : Liu Z., E. Brady and J. Lynch-Steiglitz, 2003b: Global ocean response to orbital forcing in the Holocene. *Paleoceanography*, 18 (2), 1041, doi:10.1029/2002PA000819. Liu Z., J. Kutzbach and L. Wu, 2000: Modeling climatic shift of El Niño variability in the Holocene. *Geophys. Res. Lett.*, 27, 2265-2268.

Change of transport and mixed layer depth in the Tropics : Zhao Y, Braconnot P, Marti

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O, Harrison SP, Hewitt C, Kitoh A, Liu Z, Mikolajewicz U, Otto-Bliesner B and Weber SL (2005). A multi-model analysis of the role of the ocean on the African and Indian monsoon during the mid-Holocene. *Clim Dyn* 25(7-8):777-800

Relation between mixed layer depth and monsoon : Braconnot P and Marti O (2003). Impact of precession on monsoon characteristics from coupled ocean atmosphere experiments: changes in Indian monsoon and Indian ocean climatology. *Marine Geology* 201(1-3):23-34 Braconnot P, Marzin C, Gregoire L, Mosquet E and Marti O (2008). Monsoon response to changes in Earth's orbital parameters: comparisons between simulations of the Eemian and of the Holocene. *Climate of the Past* 4(4):281-294

Minor concerns

The paper focuses on changes between pre-industrial and the paleo periods. Are changes significant ? As the simulations are quite long, I guess they are for most of the variables. I'm less certain about the change of 0.1 PW in heat transport at Eemian (page 2320 / line 5) ? But please give some indication on how significance has been checked.

Figures are small. I've looked at them by zooming on a big screen, but a paper reader could find them hard to understand. Color palette with one color per sign does not help to see details.

Page 2315 / Line 25 : the sentence suggests that the grid spacing is reduced in latitude, giving isotropic resolution. It is true ? Please be more specific.

Page 2316 / Line 14: coupling frequency should be specified (it is the actual time step of the whole model : the period at which all individual process are resolved at least once).

Page 2317 / Line 5 and following. The control run is "assumed" to be in equilibrium. Please specify some quantitative indication of the model drift (deep ocean temperature and salinity are the relevant ones).

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Page 2318 / Line 4. The cooling south of Iceland is not visible on the figure 1b. But is present in figure 2b. Is there a problem in the figures ?

Page 2318 / Line 17. The ITCZ shift is something that can be quantified in a GCM. Please give the ad hoc diagnosis. (e. g. : Results of PMIP2 coupled simulations of the Mid-Holocene and Last Glacial Maximum - Part 2: feedbacks with emphasis on the location of the ITCZ and mid- and high latitudes heat budget, *Climate of the Past*, Volume 3, Number 2, 279-296, 2007, P. Braconnot, B. Otto-Bliesner, S. Harrison, S. Joussaume, J.-Y. Peterschmitt, A. Abe-Ouchi, M. Crucifix, E. Driesschaert, Th. Fichet, C. D. Hewitt, M. Kageyama, A. Kitoh, M.-F. Loutre, O. Marti, U. Merkel, G. Ramstein, P. Valdes, S. L. Weber, Y. Yu, and Y. Zhao).

Page 2318 / Line 23. Precip in Antarctica are small. A relative change could be important whereas change in mm/day is small, and not visible on the figures. Please give some precision.

Page 2320 / Line 13. hight -> height ?

Page 2323 / Line 7. Could you explain how Tref is used in the heat transport computation ? Have you a net volume transport through Bering ? If so, a reference temperature is probably also needed in equation 2 ?

Page 2323 / Line 20 and following. The heat transport change in BAR is larger than the volume transport, and the explanation is OK. But this is not true for ISR. Your explanation is not correct here. Heat transports leaving the basin are increased by the temperature effect. Transport entering the basin are more correlated to volume transport. Please correct this section, to be coherent with the explanation that follow.

Bibliography

Page 2329 / Line. 2007 -> 2007b Berger (1978) is missing (cited page 2316 / line 18)

Interactive comment on *Clim. Past Discuss.*, 5, 2311, 2009.

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