Author comment on anonymous referee C1791 (09 Nov 2011)

J.H.C. Bosmans and co-authors

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1 First point

The referee suggests repeating the simulations at a lower resolution in order to justify the advantage of using the higher-resolution model over the generally lower-resolution PMIP models.

Performing a lower-resolution experiment would certainly shed more light onto the role of resolution in modelling the monsoonal response to Mid-Holocene orbital forcing. However, due to lack of computing power we are not able to perform such a lower-resolution experiment. This will be mentioned in the discussion of the revised article. Also, there is currently no other resolution available of the EC-Earth version that is used in our study.

The role of resolution in improving modelled monsoons has already been shown in studies of present-day monsoons (e.g. Sperber et al. 1994; Zhou and Li 2002; Kobayashi and Sugi 2004; Gao et al. 2006), as is mentioned in the introduction of our article.

2 Second point

The referee suggests that the 50 year integration might be too short for the ocean surface to be in equilibrium and asks to examine the evolution of ocean surface properties (such as SST).

We know that 50 years is too short to get the full ocean into equilibrium, but we believe it is sufficient for the ocean surface to reach equilibrium, which is of importance to the monsoon systems. Figure 1 shows trends in sea surface temperature over the tropics. It shows that the variability and trends in SST are comparable to those in T2M (Figure 5a in our article), with a smaller variability in SST (in both Figures the range on the y-axis is 1°). This figure will be included in the revised article in Figure 5 (which will then contain 5 subfigures: trends in T2M, SST, surface heat flux, TOA net flux and precipitation).

3 Third point

The referee suggests to check the tendency term of surface temperature dT/dt, which, if not near zero, needs to be taken into account in the heat budget analyses in e.g. Section 3.1.

We have calculated dT/dt ($T_{i+1} - T_{i-1}/t_{i+1} - t_{i-1}$) of the annually and globally averaged surface air temperatures, which is near-zero (on the order of 10^{-9} K/year) and shows no trend throughout the pre-industrial and Mid-Holocene experiments. Also, Figure 5d in the article (trends in TOA net flux) shows that although there is still a small trend towards 0, the fluxes are only off by approximately 0.5 Wm^{-2}. This amount is small compared to the heat budget terms discussed in Section 3.1 (in the order of tens of Wm^{-2}).

Figure 2 shows trends in surface air temperature for the whole Earth (as opposed to Figure 5a in our article which focusses on the tropics). For the Mid-Holocene the trend is small, while for the pre-industrial a small positive trend can be seen. This is related to temperature changes over the polar areas, especially Antarctica, where temperature trends are relatively large. As stated before, trends over the tropics, our area of interest, are sufficiently small. This will be made more clear in the revised version of the article.

4 Fourth point

The referee asks what conclusions can be drawn from our study regarding the Mid-Holocene precipitation increase over the Sahel / Sahara and suggests a more comprehensive comparison with previous studies.

Our results are indeed similar to previous (PMIP-) modelling results, and can therefore be seen as a confirmation of these previous results. One difference, however, is that we find a larger northward extend of the summer monsoonal precipitation over North-Africa. This could be related to the higher resolution as well as the accurate parametrizations of atmospheric and surface processes (as the atmospheric part is based on a weather forecast model). To investigate the exact roles of resolution and parametrizations, further sensitivity experiments are needed, but we do not currently have the calculation budget to perform such experiments. However, given that the resolution and parametrizations are good enough to resolve the orography over North-Africa (including the Atlas, Tibesti, Ahaggar and East African mountains) and to capture the present-day precipitation patterns well (Figure 1 in our article), we think that the lack of precipitation over the Sahara in the Mid-Holocene in models is not so much related to insufficient resolution or the accuracy of parametrizations, but to the lack of interactive vegetation. We will state this more clearly in the revised article. The role of interactive vegetation needs to be investigated further, because it involves various important effects (such as the albedo-feedback, evapotranspiration, see e.g. Kutzbach et al. 1996; Bonfils et al. 2001; Levis et al. 2004; Su and Neelin 2005; Patricola and Cook 2007; Braconnot et al. 2007; Dallmeyer et al. 2010; Vamborg et al. 2011), as stated in Sections 4.1 and 5 of the article. It would certainly be interesting to perform a coupled-vegetation experiment with EC-Earth, but the interactive vegetation has not been coupled to the model yet.

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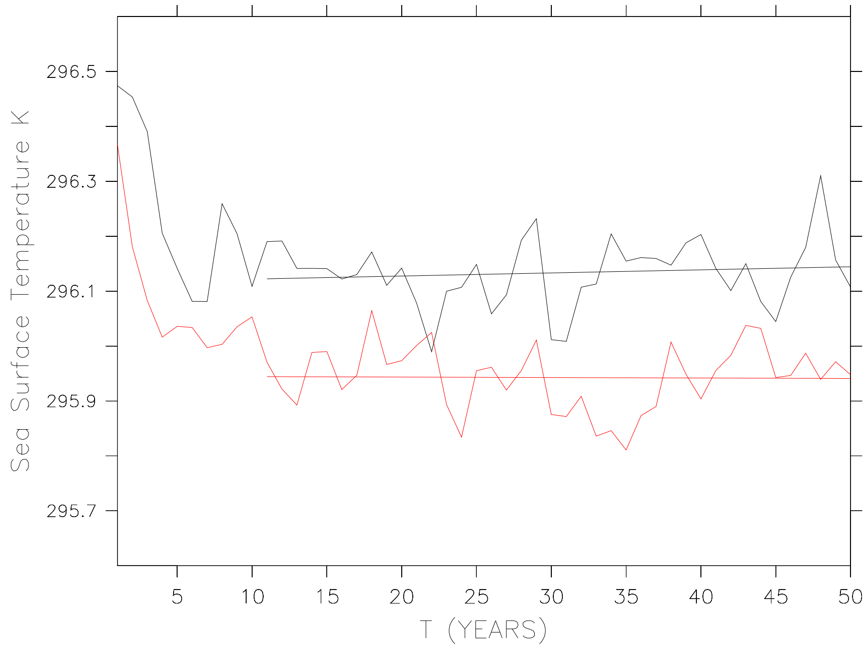

Figure 1: Trends in 40N:40S sea surface temperature (SST). Black line is for pre-industrial, red line is for Mid-Holocene.

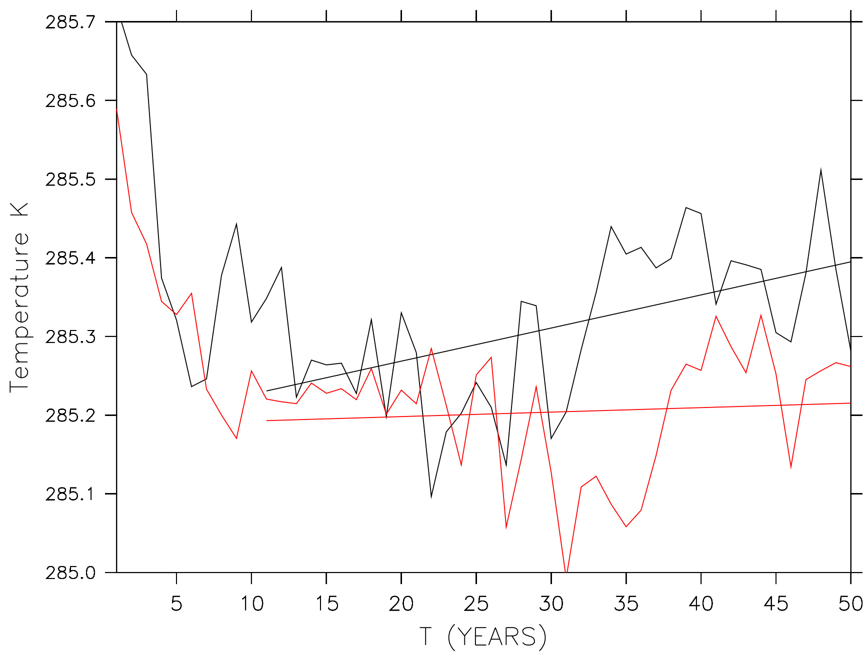

Figure 2: Trends in global surface air temperature (T2M). Black line is for pre-industrial, red line is for Mid-Holocene.