Author comment on referee D. Jiang, C2017 (12 Dec 2011)

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The referee suggests that we compare our results in more detail to PMIP1 and PMIP2 results, in order to specify what new knowledge can be gained on Mid-Holocene monsoons from our study.

We believe this is a valid point, and we will try to extend comparisons to PMIP2 results. PMIP1 models are (mostly) atmosphere-only at low resolutions, and we therefore do not intend to compare our model results to PMIP1. Our aim is to show the results of the EC-Earth model and place them in a framework of comparable (i.e. ocean-atmosphere coupled) studies. Also, comparisons between PMIP1 and PMIP2 have been performed extensively by Braconnot et al. (2007a,b); Zhao and Harrison (2011).

As previously stated in our article, the EC-Earth results generally show similar patterns of change in temperature and precipitation over the monsoonal regions as PMIP2 studies. The difference with previous studies is that EC-Earth produces output at a higher resolution, which results in a more detailed pattern of precipitation changes and the dynamic mechanisms behind these changes. For instance, for the Indian monsoon, we find that the largest precipitation increase is located exactly on the southern rim of the Himalayas. Also, we find that local recyling over land does not play a role, which contradicts previous results, and we do not find increased precipitation over the western tropical Pacific ocean competing with precipitation increases over the Asian continent.

The largest differences in precipitation changes, however, are over North-Africa, where precipitation changes are unprecedentedly large in EC-Earth and extend up to present-day Morocco (Figure 6b in our article). Figure 1 shows the same Figures as 6a, 9a and 12a in our article, with the inclusion of precipitation differences in PMIP2. These are given as PMIP2 averages (thick blue dashed lines) and the two models with the most extreme (lowest and highest) precipitation changes for JAS (Africa and Asia) and JFM (South America). For Asia and South America, EC-Earth is not far from the average PMIP2 results and mostly within the model spread. For North-Africa, however, precipitation increases in EC-Earth are more than twice as high as the PMIP2 average and also higher than the largest increase modelled within PMIP2. These PMIP2 precipitation differences will be added to Figures 6a, 9a and 12a. The precipitation increase in EC-Earth compared to PMIP2 models is also illustrated by Figure 15 in our article.

In agreement with conclusions drawn from previous from PMIP studies (Braconnot et al., 2007b), the large precipitation increase and northward shift over North-Africa is related to a relatively large and northern position of the SST

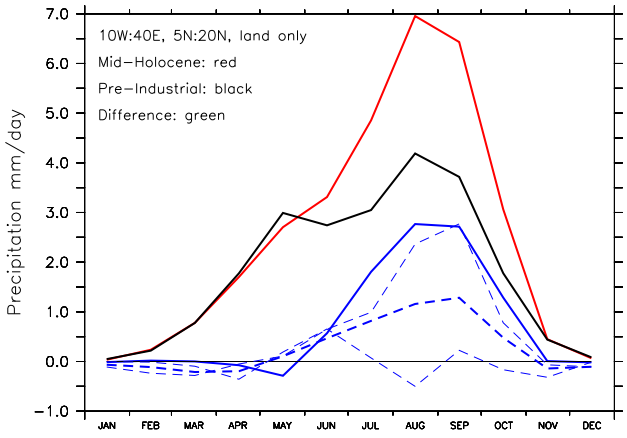
dipole in the Atlantic. Also, instead of a simple intensification of the land-sea pressure gradient due to insolation changes, we find a more meridional pattern of changes in surface pressure and temperature over North-Africa as well as Asia. For South-America, our results are in general agreement with previous studies.

References

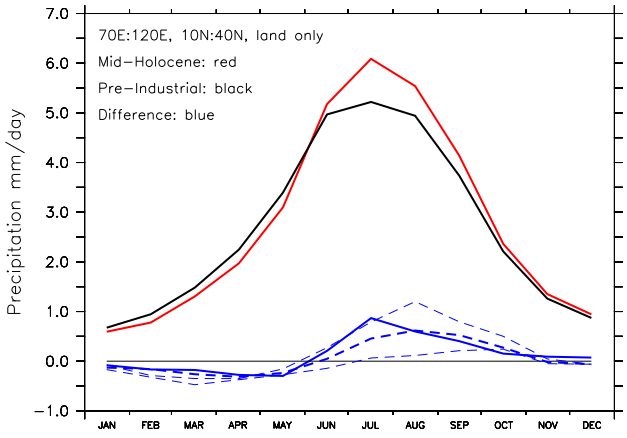
Braconnot, P., Otto-Bliesner, B., Harrison, S., Joussaume, S., Peterchmitt, J. Y., Abe-ouchi, A., Crucifix, M., Driesschaert, E., Fichefet, T., Hewitt, C. D., Kageyama, M., Kitoh, A., Laine, A., Loutre, M. F., Marti, O., Merkel, U., Ramstein, G., Valdes, P., Weber, S. L., Yu, Y., and Zhao, Y.: Results of PMIP2 coupled simulations of the Mid-Holocene and Last Glacial Maximum Part 1: experiments and large-scale features, Climate Of The Past, 3, 261–277, 2007a.

Braconnot, P., Otto-Bliesner, B., Harrison, S., Joussaume, S., Peterchmitt, J. Y., Abe-ouchi, A., Crucifix, M., Driesschaert, E., Fichefet, T., Hewitt, C. D., Kageyama, M., Kitoh, A., Laine, A., Loutre, M. F., Marti, O., Merkel, U., Ramstein, G., Valdes, P., Weber, S. L., Yu, Y., and Zhao, Y.: 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, 3, 279–296, 2007b.

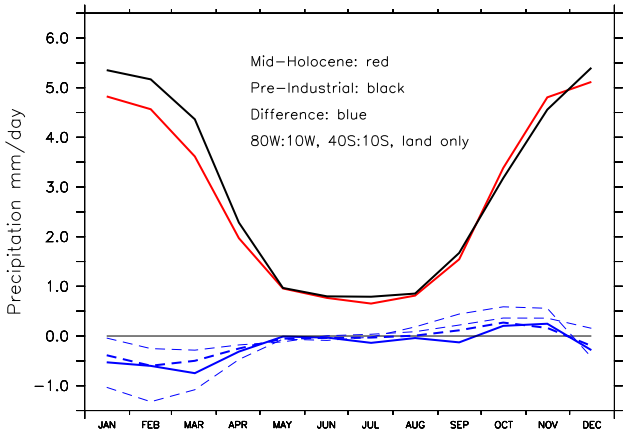
Zhao, Y. and Harrison, S. P.: Mid-Holocene monsoons: a multi-model analysis of the inter-hemispheric differences in the responses to orbital forcing and ocean feedbacks, doi:10.1007/s00382-011-1193-z, 2011.



(a) North Africa



(b) Asia



(c) South America

Figure 1: Precipitation in Mid-Holocene (red), pre-industrial (black) and difference MH-PI (blue). The dashed blue lines are differences in the PMIP2 models: the thick dashed blue line is the average of 12 PMIP2 models (see Figure 15 in our article). The thin dashed blue lines are individual model results with the largest and smallest changes in JAS for North Africa and Asia, and in JFM for South America.