

Interactive comment on “Regional climate model experiments to investigate the Asian monsoon in the Late Miocene” by H. Tang et al.

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We thank Alan Haywood for the positive and constructive comments.

(1)“To be fair to the authors they do try to address this in terms of justifying the larger scale variations they make to the TP. However, I would appreciate some discussion on the potential magnitude of the errors on these estimates. If they are significant it would raise the question of why were more simulations were not carried out to explore this uncertainty more fully?”

There are indeed large variations and uncertainties on the estimates of the palaeo-altitude of the TP in the Tortonian, which would have impact on the simulated Asian

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monsoon climate. To fully address this question is beyond the scope of this first regional modeling study. A more detailed study on this aspect is part of ongoing work.

(2) “I would appreciate some discussion though on how well the global model performs against Miocene proxies - it does after all provide the lateral boundary conditions for the higher resolution study”

We agree with Alan Haywood that some knowledge about the model’s performance is helpful and have added a few sentences on this point in the revised manuscript. The global model is largely consistent with proxy data, although there are some discrepancies. Compared to previous experiments, the AOGCM performs better.

(3) “The integration time is stated as being 10 years with the final 9 being used for the analysis. This is a very short spin up time. I think the authors might want to include some diagnostics (perhaps of soil moisture in the region in question) to demonstrate that the model has in fact reached equilibrium and that no trends in the data are observed which might have a bearing on their data/model analyses.”

The time that the soil moisture needs to reach equilibrium depends critically on the depth of soil examined. For the surface soil (i.e. less than 1 m depth), the soil water content of our regional model domain can arrive at a relatively steady state in 1 year with its seasonal cycle also being realistically represented (see Fig. 1 in this reply, which has also been included in the supplementary materials of the revised manuscript). However, for the soil water content of greater depth, it would take several years or more to get equilibrium. Because the initial adaptation of the upper soil moisture requires only a few months, many studies with CCLM use a spin-up time of less than 1 year (e.g. Kaspar & Cubasch 2008, Rockel & Geyer 2008, Suklitsch et al 2008).

To further confirm that the choice of spin-up time does not affect our results and conclusions, we checked the results with only the last 5 years of integration being analyzed (i.e. assuming 5-year spin-up time), and compared the result with that of the 9

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years (i.e. assuming 1-year spin-up time). The 5-year-averages are consistent with the 9-year-results (data not shown here). This reassured us of that our results are not biased by a too short spin-up time.

(4) “think that the difference made by moving to higher resolution for the Tortonian Stage could potentially have been made more clearly if the authors had performed an inter-mediate experiment between GTORT and TORT in which the TP is retained at 70% of the present-day height. As it is there are two changes to pull apart 1) the change in resolution and 2) the change in the details of the orography. It is difficult to assess the real impact (gain) of moving to higher resolution on its own given the current experimental design.”

This comment raises an important question. If we understand correctly, the referee is concerned with how different mechanisms contribute to the difference between the results of TORT-CTRL and GTORT-GCTRL. Is it largely due to the high resolution of the regional model, or due to the more detailed prescription of the orographic changes in TORT, i.e. the lower northeastern TP but higher southern TP? To understand this, the referee suggests to conduct an regional experiment for the Tortonian with the TP roughly reduced to 70% of the present day, which is more similar to that in GTORT (referred to as TORT70 hereafter). The difference between the results of TORT70-CTRL and GTORT-GCTRL can be assumed to reflect the pure effect of the change in resolution, while the difference between the results of TORT70-CTRL and TORT-CTRL can reflect the effect of the detailed changes of the orography. After all, this is a question of how the different configurations of the orography in the regional model would affect the simulated monsoon climate in it (i.e. TORT-TORT70).

We have performed several regional model sensitivity experiments for the Tortonian with different configurations of the orography, including general lowering of the TP (but not exactly 70% of the present-day height) and the differentiated lowering of the subregions of TP. Based on these experiments, we believe that the effect of lowering of the whole TP to 70% of the present-day height on the Indian and E-Asian summer mon-

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soon should be generally similar to that when the northern TP is lower but the southern TP is higher, as we prescribed in TORT (Fig. 12 in our manuscript). There might be some difference in the magnitude, for instance, the weakening of the summer monsoon in N-India may be stronger if the whole TP is reduced to 70% of the present-day height, due to the lower southern TP and the Himalayas (Boos & Kuang 2010). However, such differences do not affect the major results shown in TORT-CTRL in our manuscript. It is expected that the large climate pattern in TORT70 and TORT would be quite similar. The difference between the results of TORT-CTRL and GTORT-GCTRL, therefore, can be largely attributed to the change in the resolution rather than that in the details of the orography.

The influence of different orographic configurations on the Asian monsoon climate in the Miocene will be addressed more fully in the future. As suggested by the referee, we have added some discussion of the possibilities for future work in the Discussion and Conclusions of the revised manuscript. Reporting the experiments such as the suggested one will form part of a separate study.

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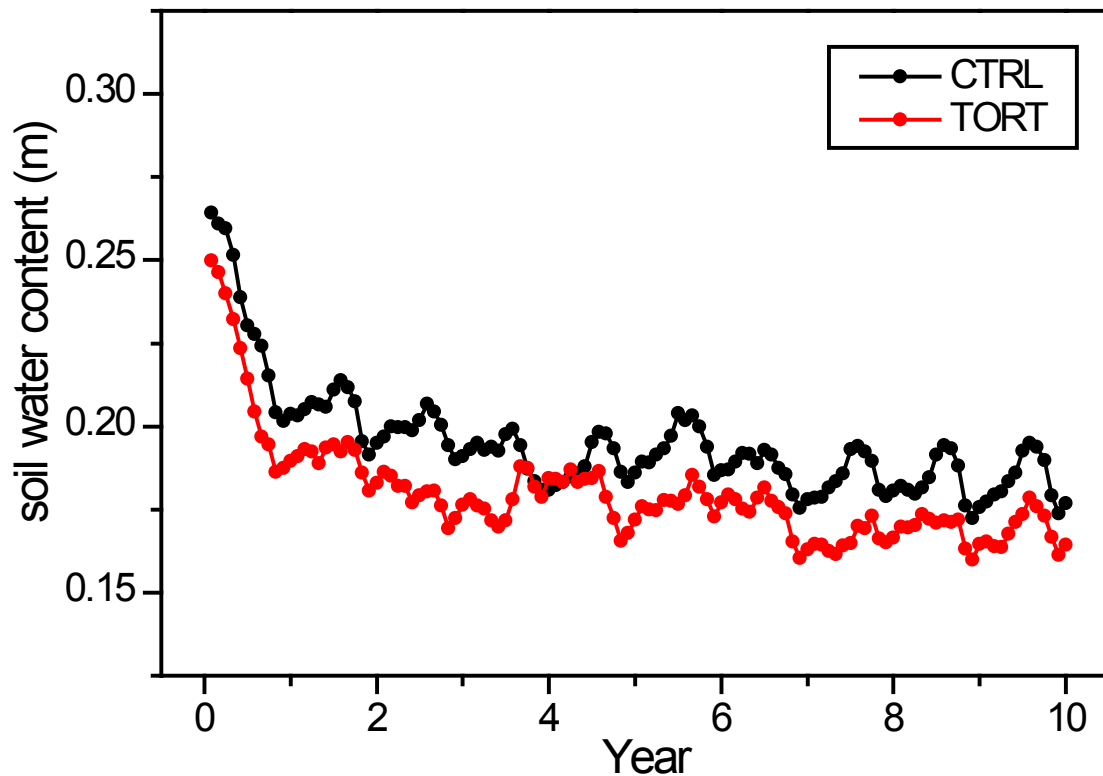
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Fig. 1. Monthly evolution of the domain averaging soil water content (m) in the upper soil level (0 - 1 m) for the 10-year regional model integration.

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