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Interactive comment on "Permian Megamonsoon Sensitivity to Paleo-Tethys Warm Pool: Model Simulations using CCSM3" *by* Christine A. Shields and Jeffrey T. Kiehl

Anonymous Referee #2

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Overview of the paper:

In this study a series of interesting simulations of the late Permian was undertaken to ascertain the dominant forcing mechanisms on the Permian northern hemisphere 'Megamonsoon' (e.g. CO2 or paleogeography) through a series of sensitivity studies. It was found that the removal of equatorial islands which were a physical barrier to the Paleo-Tethys warm pool played a crucial role in the characteristics of the monsoon.

General comments:

I think a section right at the beginning is required to define what is meant by a monsoon in these simulations thought use of a monsoon index (e.g. Wang, et al. 2005. Global

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monsoon: Dominant mode of annual variation in the tropics.) as well as what is meant by a “megamonsoon”. I wonder whether some of the sensitivity studies will show that the megamonsoon becomes more tropical precipitation which is suggested in figure 9 with a strong expansion of out of season precipitation. If so, this would still be a very interesting result.

I do agree that the warm pool will play a significant role in the dynamics of the region, as it does today (specifically reorganising the zonal atmospheric circulation). It would be nice in the case of removing the peninsula to show the 850mb wind vectors too. However, there does seem to be a response in precipitation with the removal of the peninsula (although not stated it is assumed the warm pool stays in the same location) precipitation does shift eastwards suggesting that the land-sea contrast may be playing a significant role.

The dynamics sections could do with some improvements. What does the Hadley and Walker circulation look like compare to the modern? How do they respond to increased CO2 forcing? Some dynamical analysis on surface convergence and divergence aloft is undertaken, however I feel more could be done, for instance looking at the complete vertical structure of the Hadley/Walker circulation and how these change between the different experiments, maybe changes in atmospheric jets, rossby wave source from which will likely be closely linked to the migration of the warm pool and associated atmospheric heating, etc... I am not suggesting it should all be done, but it would be nice to have a bit more grounding in the dynamical response to these very interesting simulations.

I do also wonder if the high topography to the North-west and west of the peninsula is playing a role and acting as an elevated heat pump, a similar role as with the Tibetan-plateau. It would be nice to see the JJA/DJF 850mb wind and precipitation for the ‘NoIsle’ experiment to see what is happening over land for comparison. However, the regional topographic height has not been investigated.

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Specific comments:

i) The last paragraph of the introduction emphases the importance of the PT extinction event at this time, however it feels like this is shoe horned into the manuscript as it does not link to the importance or relevance of the need to better understand the monsoon system. Maybe one or two linking sentences would be appropriate here.

ii) A proper evaluation of the model in generating the observed monsoon system is required or at least referred to from previous studies using the model (e.g. Sperber, 2012; DOI 10.1007/s00382-012-1607-6).

iii) Did you have the same response with the removal of the peninsula at 1xPI-CO2 as well as in the 10xPI-CO2 or was this simulation not performed?

iv) How is a monsoon being defined (let alone a megamonsoon?) in this paper? A map with the global monsoon would also be highly beneficial to the reader.

v) Needs to be a justification as to why the Indian monsoon system is being evaluated in the model as opposed to other monsoon systems like the East Asian Monsoon.

vi) An evaluation of the paleogeography used in the model is needed. It might be that this has already been undertaken in a previous paper, if so this should be stated.

vii) More information on the experiment design would be desirable. For instance, It would be nice to show or at least state what is meant by “equilibrated state”? Is it equilibrated in the ocean surface or at intermediate depth or ocean bottom or perhaps it is in energy balance at the surface (Gregory plot) for the KS2005 simulations. What is the topography of the paleogeography? How robust is the topographic reconstruction (granted this far back in time there will be many uncertainties) as this can have a significant impact on the monsoon system, especially regionally. What solar constant was used, how was it derived? I suspect these are stated elsewhere (perhaps in KS2005?), but it would be nice if so, to have that stated here too and added to table 2. Why are 1xPI CO2 and 10xPI CO2 useful end members to investigate the monsoon in this time?

A line justifying this and the concentrations would be useful. Was vegetation fixed or was an interactive vegetation-land surface scheme used?

viii) It would be interesting to know whether there is a change in the warm pool where only the peninsula removal experiment? Further, would it not be more accurate to say that the warm pool expands westwards in the 'NoIsle' experiment rather than migrates as well, as it still covers the same region in the control.

ix) It would appear from comparison of figures 2 (top left) and Figure 9 that the monsoon has weakened, is there any potential explanation for this?

Technical corrections (typo's, errors, etc. . .):

P.1 (Line 21) – "The nature of monsoons has been studied extensively in the scientific community because of its significance in dominating regional weather and climate and its impact on society" A reference at the end as an example would be useful.

P.1 (Line 25) – "Analyzing the underlying mechanisms behind the monsoon in past climates gives us a deeper understanding of what drives the present-day monsoon." An example reference of how some paleoclimate research has informed present-day understanding of monsoon dynamics/model evaluations would be useful.

P.2 (Line 10) – The Berner reference publishing date of 2002 in the main text, however in the references it is given as 1999. This needs to be resolved.

P.2 (Line 21) – "provides a realistic climate solution". A reference here is required.

P.2 (Line 19) – The Herold, et al. 2011; 2012, Shellito, et al. 2009 and Otto-Blieser are missing in the reference list. I suspect these were accidentally removed from earlier edits of the manuscript.

P.5 (Line 17) – "To assess the atmospheric dynamics related to monsoonal circulation, the seasonal cycle of velocity potential is shown" Do you mean the seasonal difference and not cycle?

P.6 (Line 22) – “In the original simulation” Should be changed to “In the 10x PT control simulation” to avoid any potential confusion.

P.8 (Line 7) ‘alters’, not “alterations”.

Figure colour bars could do with having the units expressed beside them.

Figures 3, 8, 9 – The b30.11/b30.116 simulation description could do with being changed to something more easily understandable as done in Figure 2.

Figures 3, 8 – The contour intervals are rather odd, although I assume this is done to aid interpretation of the plots to highlight the centre of the warm pool in the different CO2 states. For figure 3 It might be interesting to show the present-day simulation next to these as well to highlight the difference.

Figure 6 – Please state what pressure level was used to diagnose the upper-level divergence.

Figure 10 – What is the vector length used for the divergent flow?

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