**Climate
of the Past
Discussions**

Interactive comment on "Early and mid-Holocene climate in the tropical Pacific: seasonal cycle and interannual variability induced by insolation changes" *by* Y. Luan et al.

Anonymous Referee #2

It is uncertain how the tropical Pacific climate and its associated ENSO characteristic will respond in the future to anthropogenic warming. Current studies show no consensus of whether there will be an increase, decrease or no change in ENSO variability and amplitude. As a result efforts are focussed on looking at events in the geological past to try and understand the response of the tropical Pacific to changes in climate.

This paper examines the response of the tropical Pacific climate to insolation changes during the Holocene in term of mean climate characteristics and inter-annual variation. The authors analyse simulations that have already been published, in terms of the processes that affect the climate via changes in insolation by considering the surface

radiative fluxes. They also examine the differences between the early Holocene and Mid-Holocene. Finally, they look at the sensitivity of the climate to the precession and obliquity parameters. They find that there is a decrease in the annual mean SST across the tropical Pacific and that seasonal cycle changes in SST are consistent with changes in the insolation forcing. Furthermore, the reduction in SST is more evident in the east Pacific. Although the insolation is zonally uniform across the tropics, they attribute the more pronounced changes in the east to a zonally asymmetric heat flux response induced by cloud radiative forcing in the west during the winter. They also find that the precession parameter is more important when considering the response of the tropical Pacific to changes in insolation during the Holocene.

The paper is informative for the ENSO/tropical Pacific and palaeo-climate communities and the methodologies are standard. As such, material and scope of the paper is suitable for publication in Climate of the Past. Before it can be accepted for publication, however, I feel a number of structural and presentational issues need to be addressed. The paper is based on simulations previously published in Braconnot et al. (2011) and repeats several of the conclusions. It is difficult to determine what analysis or results are new. I believe that the obliquity sensitivity is a new simulation but this is not highlighted particularly clearly. I also feel that it could be considerably shortened since it is a follow up paper. I also notice that several sentences appear to have almost been lifted from the previous paper (e.g. the final concluding line on p 528, lines 13-16) resulting in repetition and lack of new insight. It is important to highlight why you needed to do more exploration of the results and the implications these results might have for future ENSO predictability since this is the focus of studying palaeo-ENSO as you noted in the Introduction.

Below are several specific comments which need to be addressed:

1. The abstract is quite vague in places. For example "...thermodynamics and dynamical processes strengthen the SST response". Firstly, you need to state in

what direction the response is strengthened. Secondly where are the thermodynamical processes: the atmosphere, ocean? Furthermore, you state that the simulations show that ENSO strengthens across the Holocene consistent with data. However, this is not discussed in the Discussion and Conclusions Section (it is mentioned in the results section). Indeed you only discuss that ENSO is reduced in the Holocene. I realise that the strengthening is relative being observed between early Holocene and mid Holocene but this might not be clear to the reader. If you are going to include it in the Abstract you should also include it in your discussion since you clearly think it is an important result.

2. The introduction is difficult to follow in places with a confusing order mixing discussion of data and previous modelling results. It might also be worth highlighting the new analysis as a series of bullet points so that the reader can see what is new compared with the previous paper.

3. I believe the obliquity experiment is a new result. This should be very clearly highlighted. Also, move the discussion of the experiment from Section 5 to Section 2.

4. There is quite a long discussion of other model's preindustrial climates in terms of the tropical Pacific in Section 3. What is the significance of including this as it does not appear in any further discussion as far as I am aware. Since these results have already been published I would have expected the model's performance to already have been evaluated.

Technical Corrections
Please check through the manuscript carefully for any inconsistencies and grammatical errors. Several have been corrected below but the list is not exhaustive.

Abstract:
P506, line 15: replace "by" with "from"

P506, line 15: Change "coral data or lake sediments" to "coral data AND lake sediments"
P506, line 17: Insert "the" before ITCZ
P506, line 19: Insert "the" before eastern
P506, line 20: Briefly explain why precession is the more important parameter that affects tropical climate for clarity.

Introduction:
P506, line 25: Insert "the" before "tropics" and "extra-Tropics"
P506, line 26: Elaborate briefly on why ENSO is of vital importance for numerous countries
P507, line 2: Change to "...deep convection are shifted TOWARD the central equatorial Pacific..."
P507, line 3: Change "water" to "waters"
P507, line 5: Remove "to" after "resembling..."
P507, line 6: Perhaps change "enhanced trade wind" to "strengthening of the easterly trade wind" and insert equatorial before Pacific.
P507, line 13: Change "model" to models and "reproduces" to "reproduce"
P507, line 15: Perhaps also include Collins et al. (2010) as an additional reference to the IPCC.
P507, line 15 to 16: Some models do not show any significant difference in future ENSO (see Collins et al. 2010). Include this as well.
P508, line 12: Insert "other" before "high-resolution"
P508, line 13: Remove "the" before ENSO.
P508, line 13-14: Are these climate modelling studies? Please reword this sentence as it is a little awkward to read.
P508, line 16: Change to "...is the main factor that reduces the amplitude ..."
P508, line 18: Insert "the" before bjerkness" and elaborate very briefly what this feedback is P508, line 21: Capitalise "northern"

P508, line 23: Insert "in response..." before "...to mid-Holocene"
P508, line 28: Remove "epochs". This implies the Holocene comprises epochs when it is itself an epoch!
P509, line 2: Why are the hypotheses mentioned not fully supported in the PMIP simulations?
P509, line 8: Insert "have" before "become"
P509, line 23: Remove "has" from "...has used..."
P510, line 6: What surface fluxes are you considering? Please define.
P510, line 6: EH and MH have not yet been defined. Please define.

Model Description:
P510, line 21: Replace "with the one" with "as the one"
P511, line 24: What is the OPA system for the non-specialist?
P511, line 6: I assume vegetation is not allowed to evolve. Please clarify.
P511, line 8: Change dynamic to dynamics and the same for thermodynamic.
P511, line 11: Remove "developed at CERFACS (France)"
P511, line 17-19: Please rephrase these sentences, they do not make sense!
P512, line 2: What do you mean by the "global energetic of the model..."

Characteristics of Preindustrial Climate:
P512, line 17: Change produced to reproduced.
P513, line 15: Why do you define sea surface temperatures here when you mention SST plenty of times before. Make sure you define it at the first occurrence.
P513, line 15: Insert "the" before "pre-industrial"
P513, line 25: Insert "However" before "The model's tropical..."
P514, line 4: Please define the Nino3 index, what region it covers etc.
P514, line 6: Why do you choose 1.2 times the standard deviation?
P514, line 17: The month of May is not actually observed in Figure 2.

P514, line 21: Change "peaking" to "peak"
P515, line 4: The acronym SSTA is not used anywhere else. Please remove.

Simulated changes for the early and mid-Holocene:
P515, line 22: What do you mean by the end of an El Nino Year? Please clarify.
P516, line 1: Insert "compared with.." after "lags by about one month..."

Simulated changes for the early and mid-Holocene
P516, line 6: In the title insert "radiative" before "surface fluxes"
P516, line 12: Insert "the" before "eastern Pacific"
P516, line 17: What do you mean by the latent heat being more efficient?
P517, line 12: Remove "in the" before north of the equator
P517, line 15: Remove "In the" before "south of"
P518, line 10: Insert "up to.." before "about 10 Wm-2"
P518, line 15: Please rephrase this sentence as the use of "SST drop" is a little awkward
P518, line 17: Insert "depth" after 300m
P518, line 22: Change HadCM3.0 to HadCM3
P519, line 3: Please give example references after "some papers"
P519, line 13: Change "than in the western Pacific" to "compared with the western Pacific"
P520, line 23: Change to "causes the thermocline TO (20deg isotherm) DEEPEN"
P520, line 26: I think you mean "damp" instead of "dump"
P520, line 26: Change "all those" to "all these"
P522, line 5: Please modify "depicted by the eyes". This is very awkwardly worded and not particularly scientific. I actually couldn't depict this very easily either.
P522, line 6: Which coast do you mean?
P522, line 8: Remove "a" before "positive precipitation"

P523, line 3: A steady increase in what?

P523, line 5: Replace "gets" with "receives"

P523, line 13: Be careful using phrases such as "this is certainly...." maybe change to "this explains why the timing..."

P523, line 17: Differences are significant: do you mean statistically?

The role of obliquity:

P524, line 9: Change to "absence OF FULLY interactive ocean dynamics"

P524, line 19-20: This comment is not particularly obvious from Fig.15.

P525, line 10: Is 0.2 deg C cooling statistically significant?

P525, line 14-21: Please read through this section carefully and clarify. It does not make a lot of sense.

Discussion and Conclusions:

P526, line 10: Insert "is" after "ENSO amplitude..."

References:

P529, line 16: "2007, 2007b". Remove the first 2007.

Table 1.

Expand on the caption to say something like "Summary of previous paleo-ENSO simulations for the Holocene adapted from..." Also it may be worth removing the references to the LGM in the table columns.

Table 2

In your definition of western Pacific and the Nino3 box you have written 5 deg S - 5 deg "E" change to 5deg S – 5deg "N".

Figure 2

In the caption please refer to the model output as "right" and the data as "left"

Figure 4

There is an absence of referral to (a), (b) etc in the caption. Please revise. Also the difference in colour between LW and LE is difficult to distinguish. Please modify.

Figure 6

Please make it clear in the caption that these plots are anomalies of Holocene minus preindustrial.

Figure 12

Please expand on which variables are being shown.

Figure 13

What level of significance did you choose?

Figure 15

Please refer to (a) and (b) in the caption.

Figure 16

Please put (a) and (b) labels on the figure.

Figure 17

Please refer to (a) and (b) in the caption. Also consider removing one of the legends from the subfigures- I do not think you need it twice.

Additional references

Collins M, An SI, Cai WJ, Ganachaud A, Guilyardi E, Jin FF, Jochum M, Lengaigne M, Power S, Timmermann A, Vecchi G, Wittenberg A (2010) The impact of global

warming on the tropical Pacific ocean and El Nino. *Nature Geoscience* 3 (6):391-397. Doi: 10.1038/Ngeo868

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