

***Interactive comment on* “Impact of model resolution on Holocene climate simulations of the Northern Hemisphere” by Axel Wagner et al.**

Anonymous Referee #2

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This is an interesting study that looks at the effect of model resolution in ECHAM5 on simulated mid-Holocene surface air temperatures. It is clear to follow and quite succinct. I did, however, find it overly vague and sweeping in places. The phrase ‘beyond the scope of the present paper/study’ is used twice, but in truth I found it hard to actually understand what the scope, or even direct purpose of the present study was. I do believe it needs to go further than showing/describing the simulated surface air temperature anomalies with vague speculations as to the cause, and the two points identified by the authors (a ‘detailed model-data comparison’ and ‘systematic analysis of the atmospheric dynamics’) are both good ways to achieve this (I think one or the other might be adequate, both would be better). In general, the current manuscript is vague and often reads like a series of disjointed statements, especially the introduction

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and discussion sections. The reader needs to work quite hard to join the dots. Some of the discussion seems quite abstract without explicitly explaining how it relates to the results. The introduction is similarly presented and the result feels like a list of bullet points rather than a flowing explanation. For example, line 228-230: how does this relate to the results presented here? Little context is given -> why study the mid-Holocene at all? What specific problems is it hoped that the authors will solve with this study? Are those problems solved? Is it just a validation of the extensive [cited] list of previous studies that found increasing atmosphere model resolution improves simulations? Are there only improvements demonstrated in the existing literature? Is it simply an exploration of 'what happens if?', but then again I come back to the question of why do this for the mid-Holocene and not simply repeat it for the pre-industrial? I am left with quite a few similar questions, which makes me think I really did miss the point of this study, though I looked for it. More specific comments follow, but in short, while I find the potential behind this manuscript interesting, I am left wondering really what was the point of it? I think there is merit here, and therefore it is just a case of rewriting the manuscript and presenting more analysis with these questions in mind. The differences plotted in the figures are certainly clear, they just need more context in a better defined investigation.

Specific comments:

- The abstract is rather vague, why not contextualise some of the conclusions – give numbers? E.g. does the effect of resolution match the change from mid-Holocene to pre-industrial because the change is small, or because the effect of resolution is big?
- The abstract should also explain why it is interesting to do this for the mid-Holocene.
- The intro/discussion are too disjointed (see comments above), the information in previous studies has not been properly synthesised or presented with clear relevance to this study. I really ma left with a very long reading list to understand the present manuscript and therefore the background and discussion sections are incomplete (the

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manuscript needs to work relatively stand-alone).

- Several acronyms appear to be undefined before they are used.
- Figure order is wrong: in the text they appear 2, 1, 3
- There is almost no information about the mid-Holocene in the introduction; why study it? what outstanding questions are you hoping to answer?
- The results are structured oddly. I suggest restructuring so that the chain of events (from perturbation to result -> i.e. change in T2m) are tracked through: X causes Y resulting in Z (and however many other steps in between). This would be a clearer way to present the underlying mechanisms (not explored enough in the current manuscript version) and how the change in model resolution results in significantly different surface air temperatures. For example, section 3.4 could come first in the results section.
- Line 27-29: this is very vague. The whole paragraph is sweeping, but this sentence is particularly vague.
- Line 51-52: vague – needs explaining.
- Line 55: ‘intermodal differences’ -> such as? What is the point being made here, I suggest focussing on these and drawing them out, using the previous studies to construct your argument/narrative so that the reader can follow the picture outlined by these previous studies and how your work builds on them.
- Line 63: ‘nonlinear processes of medium scales’, what are these? This whole paragraph is also too vague and abrupt
- Line 65: by this point the list of studies and their key findings (vaguely and briefly presented) is becoming repetitive. Could you group this work, synthesise and summarise it, and then use the citations as examples/to illustrate the points being made, rather than listing the findings for each individual study? The list-format is difficult to read and for me to keep focussed on.

- Line 77: 'Here, we...dependent results'. What does this sentence actually mean?
- Line 81: 'Low model versions'. What does this mean, low resolution?
- Line 83: 'large discrepancy'. Quantify
- Line 84-85: 'more realistic precipitation patterns' -> very vague. In what sense? More information needed.
- Line 91: add PMIP4 reference: Otto-Bliesner, B.L., Braconnot, P., Harrison, S.P., Lunt, D.J., Abe-Ouchi, A., Albani, S., Bartlein, P.J., Capron, E., Carlson, A.E., Dutton, A., Fischer, H., Goelzer, H., Govin, A., Haywood, A., Joos, F., LeGrande, A.N., Lipscomb, W.H., Lohmann, G., Mahowald, N., Nehrbass-Ahles, C., Pausata, F.S.R., Peterschmitt, J.-Y., Phipps, S.J., Renssen, H., Zhang, Q., 2017. The PMIP4 contribution to CMIP6 – Part 2: Two interglacials, scientific objective and experimental design for Holocene and Last Interglacial simulations. Geoscientific Model Development 10, 3979–4003. <https://doi.org/10.5194/gmd-10-3979-2017>
- Line 96-98: I don't think you mean 'Chapter's, maybe 'sections'
- Line 111: why not PMIP4?
- Line 115-116: 'i. e. 100 orbital years', actually I do not understand why 10 model years correspond to 100 orbital years
- Line 122: 'realistic variability in SST and SI model forcing fields', according to what?
- Line 151-152: far too vague, explain precisely what causes the changes
- Line 154-156: this is not convincing. Can you investigate and explain the mechanism rather than simply assume, based on spatial correlation. How do you know that the T change is not driving the cloud cover change? I'm not saying you are wrong, I'm just saying that there is not enough evidence for me to see this is right.
- Line 166: '...leads to less pronounced...' how and why?

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- Line 194-195: why does this amplification happen?
- Line 199: ‘...same order of magnitude...’ (this is repeated quite a few times and I actually got this point the first time, so please remove at least some of the subsequent repetitions). Why is this important? What does it tell us?
- Line 200: ‘changes in atmospheric circulation’, what changes?
- Line 235-236: this is hard to follow. What is the significance of this statement?
- Line 236-238: so what if they discuss it? Specifically what was learned and how/why is it relevant here? Also seems like a new discussion point that is separate from the previous sentences in the paragraph (new paragraph needed?)
- Line 239: ‘advantage’ – what advantage?
- Line 246-256: this information should be in the introduction, not first mentioned here
- Line 246: in what way are they in line?
- Line 258: ‘influenced’ how?
- Line 261: ‘...treatment of the processes on different scales’: this is very vague
- Line 264-266: this is also very vague!
- Line 266-271: how does all of this relate to your findings?
- Line 279-280, so what does explain the differences? Is it the changes in stationary wave patterns mentioned in the next sentence? The link is not made clear.
- Line 282-290: can this comparison be plotted? i.e. the ‘proxy’ data and your model results.
- Line 292: ‘Compared to...’ what is compared to the proxy data? Also, most of this paragraph (info on climate proxies) should at least be in the introduction
- Line 301: ‘However...’ but there is almost no comparison to the data. Why look at the

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mid-Holocene at all? What is learned that couldn't be learned from the pre-industrial, for example.

- Line 305-306: in ECHAM5, or can you relate your results to other models (not done in the present manuscript)?
- Line 310 'in a similar way as described in other contexts' -> far too vague
- Line 311-313: this is not convincing from the present manuscript
- Line 314-315: Can you demonstrate this, then? e.g. show similar signals in anomalies between PMIP models? That is an important thing to show if you want to make this point. Otherwise, it is not really implied at all.
- Line 318-320: it is inappropriate to suddenly introduce atmospheric blocking for the first time at this very late stage in the manuscript, it should be discussed (and in the intro, and in your results) earlier.
- Line 323-325: 'For palaeoclimate intercomparison studies...circulation models': this can be removed since it is already said in the previous sentence. In general the conclusions are weak and possibly need rewriting once the purpose of the study has really been made clear in the preceding text to answer some of the questions outlined/address that purpose.

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