Geoscientific

Model Development

Discussions

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Interactive comment on "IPSL-CM5A2. An Earth System Model designed for multi-millennial climate simulations" *by* Pierre Sepulchre et al.

Anonymous Referee #1

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Review

IPSL-CM5A2. An Earth System Model designed for multi-millennial climate simulations

By Pierre Sepulchre et al.

Summary:

This paper provides a comprehensive description and analysis of the IPSL-CM5A2 model developed primarily for deep time paleoclimate applications, and/or multi-millennium simulations where very long integrations are required. It includes 1) technical and performance descriptions, including model tuning decisions, 2) documentation by comparison to observations, and 3) a deep time case study designed to show this model is fit for purpose.

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Discussion paper

Overall Comments:

I applaud the authors for this very impressive and detailed work. The paper covers a lot of ground and will appeal to a diverse audience including computational scientists and software engineers (technical and performance analysis), model developers (tuning decisions and model details), climate scientists (model validation against observations and similar earth system models), and finally, paleoclimate modellers and developers (deep time case study).

I do have a number of suggestions, however, which are detailed below. Primarily, they are mostly minor, but important to improve the readability of this manuscript. Inconsistencies in organization and figures must be addressed before full publication.

As the focus in main paper on scientific improvements, the authors may want to consider moving the performance-related discussion to the appendix, and climate state figures back into the main text. Another idea might be to keep the appendix material themed; something like (a) performance analysis and (b) modes of variability. Although both of these topics are very important, if the main paper covers the main model improvements and climate state analysis, it may help to tighten up the manuscript.

Lastly, although the authors note that the case study is not meant to be an evaluation of the IPSL model with the Cretaceous time period, I would like to see more discussion on how it compares to proxy data (or other published work).

Specific Comments:

Introduction:

Somewhere in the introduction, the acronym IPSL should be defined.

Lines 20-66: The CESM system has been run for multi-millennia for CCSM3, and now, currently with CESM1 under the TraCE project. Although this is not continuous in that the model is stopped, adjusted, and restarted for separate timeslices, it is a multi-millennia simulation nonetheless. For CCSM3:

http://www.cesm.ucar.edu/working_groups/Paleo/documentation/sims-projects/trace-21ka/ and Feng He Phd dissertation (U. Wisconsin, 2011); for CESM1, contact Dr. He.

Line 39: Define "branched". Even for climate modellers, this term can be a source of confusion.

Paragraph Line 67: For those not familiar with the IPSL model, a better overview of the original model is needed for the introductory context, i.e. a mention of all model components (are there not sea ice and river runoff in NEMO?). The Dufresne et al reference is not enough.

From IPSL-CM5A to IPSL-CM5A2:

Section 2.1. It would be very useful to see a table summarizing this information including how each component has changed (or not changed), including resolutions.

Table 1: What is the significance of the bolded information? Please note in the table caption. Also, JOILOT-CURIE has not been mentioned yet. Adding the heading "supercomputer" to this column would help.

Sections 2.2 and 2.3. These sections would work just as well as an appendix.

Tuning

Table 2 needs units. How are the Trenberth estimates used here?

Lines 268 and 280: change "insure" to "ensure".

Comparison with observations

Line 323. There is no figure showing spatial biases, so please add "not shown".

Line 351. "every region. . ."

Line 377, Figures 7, 8, 9. It isn't clear when you are referring to Figure 7 or 8, or Figure 7 or 9 in the text, thus making these sections hard to follow. Also, Line 377 refers to Fig

15, when I think the authors mean Fig 9. Please review text and figures for consistency. Also, please make IPSL-CMA titles in the figures consistent with one another. Figs 8/9 uses "LR" when others do not.

Figure 10. This is more than just a Hovmueller (only panels c and d).

Paragraph Line 396 and Figure 11. Consistently refer to figures here as in the manuscript, i.e. use the lettering a,b,c,d. Also, please use the dataset name in the figure caption, rather than simply "data". For surface temperature, I assume this is HadiSST? What is used for observation for the salinity, WOA2013? I don't see this information in text either.

Line 426- 429 and Figure 15a. The figure caption needs to be improved. It is clear that 15b, the colors are the differences from the two models, but not so with 15a. If the purpose is to highlight the improvement in AMOC for 15a, then a figure showing the timeseries of AMOC, maximum below 500, between the two models, could be an alternative figure.

Section 4.2.4 and Figure 17. Consistency between this figure and others in this manuscript regarding lettering or positional references, and labeling of models is needed. Also, the caption needs to be improved to include years and model names. For the text, some discussion with observations in needed for context.

Figure A5. What is the difference between the gray and black lines in the power spectra? Also, labelling of appendix figures needs to be consistent with the rest of the manuscript.

Figure A6. Consistency in labelling.

Deep time case study

Line 503. "..ran a 3000-year long..."

Section 5.1 and Figure 18. I am not sure what I am looking at in Figure 18a. Are

the white areas supposed to be the grey-shading for the refinement? (This could be a document format issue so, perhaps noting the refinement areas with a black box rather than colored shading would be better). Also, for Figure 18b, my recommendation would be to make this with the cretaceous continental outlines, not modern. I think the discussion of pole and refinement placement would be much clearer to readers who have never modified grids for deep time if the paleo outlines were used.

Section 5.2. What did you use for other important forcings, such as solar input and methane? Should we assume that all else is based on pre-industrial forcings? Does this model prescribe or predict aerosol emissions? Dust, sea salt, carbon from fire, and other biogenic aerosols such as secondary organic aerosols (isoprene, etc), may also be extremely important climate forcings, even for deep time.

Line 580. I suspect the "?" was meant to stand in for something? Please fix.

Line 582 and Figure 19. Should this be Fig 19a? Given that 19b is discussed first, a and b should be swapped in Figure 19.

Line 592. Have the authors worked on applying the dynamic vegetation to the Cretaceous? Dynamic vegetation capabilities are highly valued in the deep time modelling community.

Line 607 and Figure 20. Define T2M. Is it 2-meter air temperature, same as "t2m"? Please make consistent throughout the manuscript. Also, I would not consider 20e a "trend" plot as the figure caption states. Although trend can certainly be implied, but the variable being plotted is a whole value as it varies through time, the unit being degC (or Joule).

Figure 21. Assuming this is annual mean. How many years (the final 100?) went into this plot?

Line 635. Fill in Supplemental Figure XX. Is this referring to figures A8 and A9?

Figure A8 and A9. Please label consistently. Briefly note/explain why you chose JMA

and JAS and northern/southern hemisphere winter.

Conclusions

Line 645. "This article aims. . ."

I would recommend changing the title of this section to "Conclusions and Discussion" because of 1) the inclusion of new appendix material and 2) the relevance of the new material to the overall discussion on challenges for (deep time) paleoclimate modelling.

Appendices

An appendix section describing the many acronyms in this paper would be helpful.

Appendix organization needs to be fixed. There are two A1's. Also, only the first A1 includes text to introduce the appendix figures. A few sentences introducing each appendix section would greatly improve the readability of this appendices.

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2019-332, 2019.