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Climate of the Past Discussions

Interactive comment on "A multi-model CMIP6 study of Arctic sea ice at 127 ka: Sea ice data compilation and model differences" *by* Masa Kageyama et al.

Anonymous Referee #2

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Kageyama et al. present the results of CMIP6-PMIP4 LIG simulations from 12 models and analyse them in terms of Arctic sea ice changes. They also present a new compilation of LIG sea-ice proxy data which they compare the model results with. While the discrepancies between simulations and proxy data, as well as within proxy data and within simulations, prevent any unambiguous identification of LIG sea-ice changes, the author provide valuable insights into the parameters that may influence sea-ice dynamics through their analysis of inter-model differences.

I find the manuscript well-structured and written in a concise and convincing way, and I only have minor concerns about how the proxy reconstructions were transferred into

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Discussion paper

values of sea-ice concentration and duration (as described below). I thus recommend this manuscript for publication with minor revisions.

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Major comments about proxy data (mostly section 2.2):

I really like the author's cautious approach to provide common and clear definitions, based on sea-ice cover duration and sea-ice cover concentration, of ice-free / seasonal / perennial sea ice that facilitate data-data and model-data comparison. However, it is not always clear for me how such values have been obtained for the proxy data:

- For dinocysts: the explanation is very clear, but I miss the info on how the min and max values have been obtained (are those the min and max values of the 5 (?) best analogues? The minimum and maximum monthly sea-ice cover durations? The range of variability within the LIG time slice? Other?).

- For other proxies:

> I understand the authors attributed values of 0.15 and 0.95 for min and max sea-ice concentration at sites where sea ice was interpreted to be perennial, but I miss the info on how those values were defined for other sea-ice categories (or what are the sea-ice states corresponding to the 3 other min-max SIC combinations: 0.3-0.95, 0.3-0.6 and 0.1-0.3).

> The rationale for the attribution of min and max sea-ice cover durations is also not clear to me (in section 3.3 the authors mention they "define perennial sea ice to have at least 9 months of coverage", but I am confused because sites with min-max sea-ice concentrations of 0.15-0.95 have either min-max sea-ice cover durations of 9-12 mth/yr for IP25 or 3-11 mth/yr for faunas).

- Regarding the sites with PIP25-based interpretations, have the attributed min-max range of sea-ice concentration values been compared to some sea-ice concentration quantifications based on the calibrations recently proposed

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(Xiao et al., 2015, http://dx.doi.org/10.1016/j.gca.2015.01.029; Smik et al., 2016, http://dx.doi.org/10.1016/j.orggeochem.2015.12.007) to see if both methods yield rather similar results?

- Could it be specified in Table 1 whether it is IP25 and/or PIP25?

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Minor comments:

- At my first reading (but not the following), it was not always clear whether it was referred to sea-ice cover duration, concentration or simply sea-ice cover. Maybe SIC, SICc and SICd abbreviations (or something similar) could be used to help with this?

- L18: what is 21C?

- L69: “PI” abbreviation used as “pre-industrial” but defined as such only L133.

- Table 1: maybe it would be clearer to specify “duration” in the “sea-ice cover” column (or cf. my first minor comment), as well as “per year” for the unit.

- L90: The error of prediction for sea-ice cover concentration is indicated, but not that for sea-ice duration.

- Table 2: some info missing for CESM2 boundary conditions and LIG simulation length, LOVECLIM1.2 physical core components and LIG simulation length, and NESM3 boundary conditions and LIG simulation length.

- L134: GHG abbreviation not defined

- L156: should the reference to Figure 3 here be to Table 4 instead, as Figure 3 is referred to 4 lines after when talking about the “The detail of the geographical distribution of sea ice”?

- L175-177: maybe it would be clearer to mention that the reduction is “between the PI and LIG” in the first sentence rather than/in addition to in the second sentence (as

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done in the conclusion).

- L178: 12 rather than 13 models?

- L178-181: maybe specify that the third model is NESM3 and refer to the section above regarding the reason why it does not realistically capture the PI Arctic?

- L188-191 and Figures 6 and 7: “the reconstructed values, classified into 3 categories: perennial cover (9 to 12 months), seasonal cover (3 to 9 months), ice free state (0 to 3 months)” –> how were the reconstructions based on the same proxy with e.g. (from Table 1) 3 to 12 months/year classified? Does “ambiguous interpretations” (here but I also mean in general in the MS) refer to those from the same core/area and based on different proxies (which is what I understand) or does it also refer to reconstructions from the same core and same proxy? If so, maybe it would be worth clearly mentioning it too, as it also plays a role in the difficulty to compare model and data (and highlight the proxy limitations from this other perspective) and in model-data discrepancies.

- L191: the first “to” may be removed in “it is not possible to for any one model to match”

- L192: maybe something like “comparison between the PI and LIG model *results* and PI and LIG sea ice *proxy* data” would be clearer

- L209-210: I understand that the authors do not want to solve this here, and I think it is not necessary as the focus of this paper is on the models. That said, given the proxy and model dataset presented here, and the authors being one of the world experts on these proxies, I have to admit that I was kind of expecting / hoping for this initially. . . :-)

- L213: “we” instead of “to”

- L224: SW abbreviation not defined

- L276: no need to redefine LIG abbr.

- L281: I would maybe rather say “These southern sea ice records are (or “correspond to” or equivalent) quantitative estimates based on dinoflagellate cysts (dinocysts)” to

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avoid confusion.

- L288-289: there has been a shortcut, “periods” does not refer to anything here.

- L299: 12 models + no need to redefine MMM abbr.

- L305-306: needs to be rephrased

- Figure 1: the colour code for the cores is missing + why are there only some cores labelled? If this is a matter of space, numbers could be used in Table 1 and Figure 1.

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