

Clim. Past Discuss., referee comment RC2
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Comment on cp-2022-70

Anonymous Referee #2

Referee comment on "Modelling feedbacks between the Northern Hemisphere ice sheets and climate during the last glacial cycle" by Meike D. W. Scherrenberg et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2022-70-RC2>, 2022

Review of: Scherrenberg et al. Interactions between the Northern-Hemisphere ice sheets and climate during the Last Glacial Cycle

Summary:

This study uses the climates simulated by a number of general circulation models from the 3rd phase of the Paleoclimate Modeling Intercomparison Project (PMI3) to reconstruct the Northern Hemisphere ice sheets in the last glacial period. To this end, the authors use the simulated climates at the Last Glacial Maximum (LGM) and the pre-industrial era as proxies for *extreme cold* and *extreme warm* climate states over the last glacial period; intermediate climate states (i.e., any interval from inception to glacial maximum) are derived from these climate extremes using both an "index method" and a "matrix method". Subsequently, the climate fields are used as forcing in an offline ice-sheet model to simulate the Northern Hemisphere ice-sheet history over the last glacial period.

The authors conclude that the matrix method results in a more realistic volume and extent of the Northern Hemisphere ice sheets compared to the index method. There are also large differences between individual general circulation models, with some models failing to build large ice masses, while the climate from other models leads to too much ice at the LGM.

The study is novel and the manuscript is well written. It also deals with a topic that is of potential interest to the broader (quaternary) paleo-climate research community. I recommend publication, subject to some intermediate revisions.

General comments:

(i) The discussion section is relatively weak in its current form and could benefit from some revisions. For example, you mention that both the index and the matrix methods are missing certain processes and cannot realistically represent abrupt circulation changes. I agree with this statement, and I would like to see a more thorough discussion on how this shortcoming is (potentially) influencing your results. Here are a few papers that have examined and at least partially explained abrupt changes in the large-scale atmospheric circulation in the last glacial period:

<https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017GL074274>

<https://journals.ametsoc.org/view/journals/atasc/73/8/jas-d-15-0295.1.xml>

<https://cp.copernicus.org/articles/12/1225/2016/>

(ii) The manuscript could benefit from including a supplementary document that shows the simulated model climates (pre-industrial and LGM), and at least a few snapshots of the ice sheets prior to the LGM. I would suggest showing the ice sheets every 30 kyrs or so. It could also be good to compare these fields with some proxy data to better understand the quality of the simulation and what errors the different methods introduce.

(iii) What is the reason for using PMIP3/CMIP5 models instead of the updated PMIP4/CMIP6 models (documented here:

<https://cp.copernicus.org/articles/17/1065/2021/>)? Do you have any reasons to assume that the results are robust/not robust across PMIP generations? The paper by Kageyama et al (2021) should be cited no matter what as it documents similarities and differences between the LGM simulations in the older PMIP3 (used here) and the newer PMIP4 models.

(iv) This study is suggesting that the Eurasian Ice Sheet was at maximum extent/volume around 60 ka. This is not captured in your results at all. Is this a result of the lack of "realistic" circulation changes?

<https://cp.copernicus.org/articles/9/2365/2013/>

Line comments:

Line 1: The title is a bit misleading since you didn't really study coupled interactions between ice sheets and climate. Consider changing the title to be a bit better suited for your study

Line 11: pre-industrial should not be capitalized

Line 12: computationally unfeasible

Line 22: exceeds --> exceed

Line 23: Specify that this is referring to ice sheet volume

Line 40: Rearrange the sentence to increase readability

Line 42: There are newer references that are more appropriate here:
<https://www.nature.com/articles/s41586-020-2617-x>
<https://cp.copernicus.org/articles/18/1883/2022/>

Lines 50-54: These types of sentence constructions are difficult to read. Please consider reformulating in a more general way that is not including both cases.

Line 84: A similar technique was employed in:
<https://gmd.copernicus.org/articles/7/1183/2014/>

Lines 110-113: This preamble is not necessary and should be deleted

Lines 115-125: There are several abbreviations here that are not defined: IMAU-ICE; SIA/SSA; PISM; CISM

Line 123: The abbreviation ELRA is only used here and should be omitted

Lines 160-161: Did you test the sensitivity of this assumption?

Lines 174-174: How is the planetary albedo calculated? Clouds will affect the amount of insolation at the surface...

Lines 180-181: This preamble is not necessary and should be deleted

Lines 196-197: I assume that the PI simulations included the observed ice caps on these islands. Thus, the climate is already primed (through albedo effects) to grow ice there. Perhaps a small point, but potentially important to comment on here and in the discussion section.

Table 1: The LGM simulation with CNRM-CM5 didn't include the ice sheets! Therefore, you may wanna exclude that model from the study. See point 19 here: <https://www.umr-cnrm.fr/cmip5/spip.php?article24>