

Geosci. Model Dev. Discuss., referee comment RC2  
<https://doi.org/10.5194/gmd-2021-136-RC2>, 2021  
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## Comment on gmd-2021-136

Anonymous Referee #2

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Referee comment on "A Gaussian process emulator for simulating ice sheet–climate interactions on a multi-million-year timescale: CLISEMv1.0" by Jonas Van Breedam et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-136-RC2>, 2021

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This paper describes a novel method for ice sheet model forcing using a gaussian process emulator, presents new simulations using this method and performs sensitivity analyses. This is a useful contribution that seeks to overcome the limitations of ice sheet climate coupling when performing multi-million year simulations. It is a well thought out study and I recommend it for publication. I have some minor comments to improve the clarity of the article.

Minor Issues:

L106: I understand how this approach works with an atmosphere-only GCM, how does this differ for a slab-ocean model? If SSTs are prescribed what is the slab ocean doing? Unless I've misunderstood this, in which case clarification would be useful

L106: I'm not suggesting doing this here, but for a true simulation of the EOT would two emulators be needed, one with late Eocene and one with early Oligocene SSTs?

L118: How is ungrounded ice treated? I imagine there isn't much with the Wilson et al., topography that is being used, but this needs stating.

Figure 7: To aid clarity of this figure can you sort the x-axes based on agreement? This would make it easier to compare the different methods.

L250: Can the emulator be used to predict a spatially and temporally varying lapse rate?

L307: Could be worth mentioning that another problem of the single ice sheet parameter (that is common to the matrix method) is that there is no guarantee that ice is growing in the same place in the ice sheet model as is prescribed in the climate model (Figure A2). I.e. a feedback from growing ice on the Antarctic Peninsula could be applied to the Transantarctic Mountains. Is there anyway of overcoming this? E.g. having a regional ice sheet parameter?

L310: How much slower is the model with these different coupling timesteps?

Figure 14: There are a lot of color-blind unfriendly colors. Here you could just show one of the emulators, rather than two.

Figure 17: Can just show one of these subplots as the impact of the timestep already explored.

L487: This suggestion of using a direct mass balance calculation comes very late, it might be worth expanding on this point more or removing.

There are supplementary videos which are not available to review, can these be uploaded to GMD rather than zenodo?

Typos, etc:

L9: "considering" to "using"

L12: "from" to "in"

L12: Sentence starting "The sensitivity..." is hard to follow. Suggest rewriting, or adding comma ", and to the coupling time".

L42: "ran" to "run"

L56: "paleoclimate" to "climate during the Pleistocene"

L64: need reference for these CO2 changes.

L142: "amount" to "number"

L180: (Eq 2.)

L234: "Poorly"

L235: "ran" to "run"

L235: "warm-biased", "cold-biased"

L236: remove "locally"

L259: "The notion of an"

L286: "with up to" to "by up to"

L290: "mostly follows"

L425: "GP" define or change to "gaussian process"