Geoscientific
Model Development
Discussions

Interactive comment on "A hybrid GCM paleo ice-sheet model, ANICE2.1 – HadCM3@Bristolv1.0: set up and benchmark experiments" *by* Constantijn J. Berends et al.

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Author comment replying to the referee comments by F. Saito

We'd like to thank the reviewer for their comments on the manuscript and would hereby like to address the concerns they raised.

In italics the comments, below our rebuttal. Page and line numbers refer to the revised manuscript.

Abe-Ouchi et al (2013) use a different approach to force an ice-sheet model, in which a series of GCM snapshots are used to separate orbital, CO2, albedo etc effects on ice-

sheet surface temperature. The method is not the same as two approaches (glacial index method and ESM coupling), and also not the same as the approach of the present paper. This study is limited to the northern hemisphere, but if the authors agree (I am not sure whether it is fair to tell this, because I am one of the authors of the paper), the authors may include the study as yet another example of hybrid GCM ice-sheet model application. In addition, several processes not included in the model are discussed in conclusion (around p13), which are discussed in Abe-Ouchi (2009, 2013).

We agree that this is a very interesting and relevant study and will include a reference to it in the Introduction and Conclusions sections of our manuscript. P2, L27: Added a reference to the work by Abe-Ouchi et al. (2013). P14, L27: Added a few lines discussing the results reported by Abe-Ouchi et al. (2013).

As far as I understand, since ice sheet evolution is computed on the four separate regions, there is no chance to connect two ice sheets, e.g., Greenland and North America. In Fig. 4 the northwest part of Greenland seems to connect with NA ice sheet. I wonder how to handle this situation.

It is true that the Greenland and Laurentide ice-sheets cannot connect in our model – in the North America module, the bedrock of Greenland has been manually lowered to well below sea-level, and vice versa in the Greenland module. This was done first by de Boer et al. (2013) to enable them to run the Greenland module at a higher resolution and more importantly with a mass balance module dedicated specifically for Greenland and one for the North America module. The large-scale behaviour of the two ice-sheets in terms of sea-level contribution, which is the main focus of our model, is not significantly affected by this and so we decided not to change this in our model version.

Moreover, also in Fig. 4 or 7, simulated NA ice sheet extends on Eurasia. How to treat this? I suspect the model domain of NA ice sheet cover until East Siberia. Of course it is reasonable to assume that Siberia has been ice-free, in principle this is just

an specification of the model of this paper. It is better to clarify these configuration. Possibly, it is enough to describe the four separated domain on the map.

Although this is not mentioned in the text, Figure 5 is the North America grid of the model. It does indeed cover the entire Bering Strait, as well as a very small portion of north-east Siberia. Since that area of the world is very dry, none of our simulations have ever encountered ice at the edge of the model grid. We will refer to a figure of the grid as presented in Fig. 3 in de Boer et al. (2014) which displays the same grid as used here. P5, L10: Added a reference to the relevant figure from de Boer et al. (2014).

p1 L10 'all ice' it too much. as far as I understand, neither glacier nor sea ice is included.

We agree that this statement is incorrect. We will correct this in the manuscript. P1, L10: changed the statement to correctly describe what ice is simulated by the model: "...thermodynamic ice-sheet-shelf model calculating the four large continental ice-sheets (Antarctica, Greenland, North America and Eurasia), ..."

p3 L5 LGM should be defined here (now defined at L29).

We agree, and will correct this in the manuscript. P3, L24: Added the definition of LGM P4, L16: Removed the definition of LGM

p4 L4 degree C should be K.

We agree, and will correct this in the manuscript. P4, L22: Changed degree C to K.

p14 Eq A4, etc. write exp instead of exp if using LaTeX.

We agree, and will correct this in the manuscript. P16, L17 (Eq. A5): Changed "exp(...)" to " e(...)".

p15 L1. 2e-11, etc, should be written as 2 times 10Ë Ę-11.

We agree, and will correct this in the manuscript. P16: Corrected all exponents.

C3

p15 L25 refer Table 1 after c3.

We agree, and will correct this in the manuscript. P17, L25: Added a reference to Table 1 for values of parameter c3.

Fig.1. Need to describe the color as bedrock elevation where not covered by ice. Fig.5,8,9. Need to describe the contour lines (thickness or surface elevation?)

We agree, and will add this information to the figure captions. Fig. 1, 4, 5, 7, 8, 9: Added description of the colormap and contour lines to the figure captions.