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Geoscientific Model Development Discussions

Interactive comment on "Representing icebergs in the *i*LOVECLIM model (version 1.0) – a sensitivity study" *by* M. Bügelmayer et al.

Anonymous Referee #2

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In "Representing icebergs in the iLOVECLIM model (version 1.0) – a sensitivity study" Bügelmayer, Roche and Hansen discuss results from simulations with a recently extended earth system model of intermediate complexity (EMIC) that now also includes interactive ice sheets as well as icebergs. The new model is also presented in Roche at al. (2013) and Bügelmayer et al. (2014) of which the former paper has been accepted while the latter is still under review/discussion. The present manuscript focuses on the sensitivity of the EMIC to the iceberg component. However, considering the two publications above and that the iceberg component has been applied to various sorts of model environments before (see references in Section 2.3) the work presented here lacks novelty. Besides this issue I am also not comfortable with the experimental set up. The authors study the influence of atmospheric and oceanic forcing on the iceberg momentum balance by comparing the large-scale spatial distribution of icebergs

between simulations in which the one or the other forcing is artificially neglected. However, the spatial resolution of the model grid used (atmosphere: 5.6 deg and vertical 3 layers; ocean: 3 deg and 20 layers) is hardly sufficient to resolve local characteristics of winds and currents around Greenland and to draw conclusions that would be applicable beyond this particular model. The model set up further lacks Antarctic ice sheet and icebergs that, however, may well influence the Atlantic Meridional Overturning Circulation and hence imprint on the climate in the northern North Atlantic, which is studied here, in multi-centennial to millennial integrations. Finally, the null-hypothesis that the iceberg size distribution might have a greater influence on the climate over Greenland than strong (70 vs 1120 ppm CO2) changes in radiative forcing is provocative at best. Considering the model has been presented already in earlier publications and the weakness in scientific merit of the sensitivity simulations presented here, I cannot recommend publication of the manuscript.

Nevertheless, I do think that iLOVECLIM is a valid model and one can make valuable contributions to the current scientific discussion with it. Including interactive ice sheets as well as icebergs in AOGCM is an important step forward. I thus would like to encourage the authors to rethink their experimental set up and research questions posed. Hoping that the authors submit a revised version later I add some detailed comments below.

Detailed comments: page/line(s)

4354/3 these examples of icebergs effects are not self-explanatory. Please think of a generally more agreeable opening.

4354/6 rewrite to "... atmospheric and oceanic forces acting ..."

4354/10 replace "To address these shortcomings, ..." with "To study the sensitivity of the modeled iceberg distribution to initial and boundary conditions, ...". Your previous sentence does not necessarily list shortcomings.

4354/12 rewrite to "... atmospheric and oceanic forcing fields ..."

4354/22 At this point it is unclear how icebergs feedback on the ice sheet they calved from, i.e. why the authors assume that there is a feedback.

4355/6 update reference. Rignot et al. 2013 recently showed that in some places ice-ocean melt dominates calving. Rignot, E., S. Jacobs, J. Mouginot, B. Scheuchl, 2013, Ice Shelf Melting Around Antarctica, Science Express, DOI: 10.1126/science.1235798.

4355/8 replace "take up" with "uptake"

/11 remove "thereby"

4365/15ff please rephrase (be careful about the advancements made with each study). I suggest: "In the latter study, the icebergs were seeded based on a prescribed constant calving flux based on observational estimates but moved according to the modeled winds and currents and interacted with the model atmosphere and ocean. Martin and Adcroft (2010) then implemented the iceberg model into a coupled global climate model (CGCM) using the model's variable runoff as a calving flux though still lacking an ice sheet component. Most recently, Bügelmayer et al. (2014) took the next step by using an EMIC with both dynamically coupled ice sheet and iceberg model components."

4357/4 "... on the atmospheric and oceanic forces acting on the icebergs."

4357/5ff Although I generally agree with the assessment of uncertainties in this paragraph I believe that uncertainties inherent to the empirical relationships contained in the iceberg model of Bigg and Gladstone and others, which is used here, are much greater. However, we lack observations, in particular on iceberg decay, to reliably estimate these. Nevertheless, I think this should be noted here.

4358/5 The methods section lacks detail and relies heavily on Bügelmeyer et al. (2014) instead, which is a paper still under review. I suggest to either add considerable detail to the present paper to make it independent or wait until the former has been accepted.

/12 I must say that I have considerable trouble with the idea of estimating the uncertainty of iceberg distribution due to the atmospheric forcing using a model with such very coarse resolution of 5.6 deg and only 3 layers.

/24 same holds for the coarse ocean grid.

4359/15 When running millennial control simulations one should take the Southern Hemisphere into account. Icebergs in the Southern Ocean affect the stratification and thus bottom water formation, which may impact on the AMOC. AMOC variability forced in the South can emerge in the North Atlantic within a century.

/17 This statement is inconsistent with Table 2, where you list iceberg thicknesses of up to 300m. Please check that this is not an inconsistency in the model code.

/19 Why does the ice sheet model exchange fluxes with the iceberg model only once per year?

4360/8 I think Martin and Adcroft presented two opposing seasonal cycles, one for iceberg calving and one for iceberg melt. I believe observations rather support enhanced calving in summer (melt water lubricates and lets ice move faster; lack of stabilizing sea ice cover) and fall (refreezing of melt water in cravasses). Add a note about the shape of the seasonal cycle you applied.

/17 Why don't you put the melt water at the respective depth in the ocean?

/27 But doesn't an offset in ice sheet thickness potentially bias the feedback to variations in iceberg distribution that you do study? An error of 1/3 seems a lot to me. I think you need to argue why this does not affect your results.

4361/19 please add at end of paragraph an introduction of experiment COM, e.g.: "In experiments called COM the combined atmosphere and ocean forcing is applied, i.e. all terms of (1) are used."

Question: In order to truly assess the impact of atmospheric vs. oceanic forcing

wouldn't you need to split the melt functions as well? For instance bottom melt is ocean forcing but erosion due to waves is a function of wind speed, i.e. atmospheric forcing.

4362/11 I strongly recommend to re-arrange your results section in the sense that you first discuss the control simulation CTRL-COM and then discuss deviations from these results. With respect to Figure 1, start with panel 1g, then discuss 1a and 1d in section 3.1.1. Introduce new section 3.1.2 that discusses BIG and SMALL runs, again first BIG-COM and SMALL-COM, then the other cases. Rearrange Figure 1 accordingly. (Section 3.1.2 Lifetime of icebergs would become new section 3.1.3.)

/19 remove "(Fig. 3)" in favor of addressing figures in the correct sequence. I think a reference to Fig. 3 is not necessary here. Lifetime of icebergs is discussed in a later section.

/20 I am confused. I would expect that BIG icebergs provide a greater area and higher freeboard for the wind stress to act on. Then, why is the "atmospheric forcing not strong enough"? Please explain.

4365/12 suggest to revise section titles to "Experiments with high radiative forcing" . . .

4366/8 . . . and "Experiments with low radiative forcing"

4367/13 While I think that it is worth exploring the impact of atmospheric vs. oceanic forcing in order to understand the spatial distribution of icebergs, a discussion with respect to climate impacts is purely hypothetically since icebergs are driven by both atmospheric as well as oceanic forces. I recommend to limit the climate sensitivity discussion to the BIG and SMALL scenarios.

4368/14 This is why I think the experiments could have been chosen more carefully. Maybe you also need to consider Antarctic sized tabular icebergs, i.e. bigger than BIG, for the cold climate.

4374/Tab.1 I don't understand this table. My first impression was that since all cells only

contain "x" all scenarios are the same. Now I suggest, if I interpret this table correctly, to remove line "Experiment name" and column "Name" and instead write the respective full experiment name in each cell, i.e. BIG-ATM, BIG-OCE, BIG-COM, BIG-HIGH, BIG-LOW for the "Big Bergs" row. In fact, "COM" should be in the first column and CTRL the first row. Please provide more information in the caption.

4376/Tab.3 add lines every third row (grouping CTRL, BIG, and SMALL); also replace "0.00" by "-" for all CTRL cases, since it is the respective reference.

4378/Fig.2 I find this graph confusing.

4379 & 4380 Switch figures 3 and 4 as this would suite the presentation of results better.

Regarding Fig. 4 Are the differences between COM, ATM, and OCE significant with respect to the internal (inter-annual) variability? Same for CTRL, BIG, and SMALL.

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