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Interactive comment on "Assessment of the Greenland ice sheet – atmosphere feedbacks for the next century with a regional atmospheric model fully coupled to an ice sheet model" *by* Sebastien Le clec'h et al.

Anonymous Referee #2

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1 General Comments

The paper claims to be focused on assessment of the future of the GrIS through 2150. But in fact, it seems more focused on assessment of a new technique for RCM-Ice Model coupling. Throughout the paper, focuse shifts back and forth between the two. The experiment is to run a future simulation of the GrIS using MAR coupled with GRISLI in three different ways, and then compare/analyze the results. from each other.

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Discussion paper

The coupling method is interesting, but the GrIS is more interesting. I believe the paper would be better if it would keep its focus firmly on the GrIS, while keeping the methods separate. I ultimately want to know, what do we learn about Greenland? Unfortunately, the figures do not really support that. Figures 1-4 do in a way; but the rest of the figures only really tell us about technical differences between coupling technique.

The experiments in the paper show that the different coupling techniques provide different answers. Unfortunately, it is hard to know which answers are closer to the truth, because there are no controls. I came into this believing that the most sophisticated copupler would produce the most melt and also be more accurate; but I had no proof on the accuracy part. This paper has reinforced my prior assumptions, without providing any additional evidence on accuracy. I am therefore hard pressed to say what it has added to my understanding of coupling technique.

I did learn some things about the future Greenland itself, in spite of the figures not really helping with this. I learned:

1. Expect a steeper slope and stronger katabaic winds, in addition to the expected smaller ice sheet. This will result in colder (not warmer) temperatures near the coast.

2. In parts of Greenland, the ELA could be as high as 3000m by the year 2150. I find that idea astounding, at 77 degrees North latitude. Some discussion of this result would be really interesting.

3. Expected sea level rise contribution of Greenland in 150 years is 20cm; and the rate of melting will be continuing to rise at that point.

4. Ice loss and SMB are highly correllated over the next 150 years; so much so that plots of the two look highly similar. Unfortunately, the paper does not try to quantify the correllation.

For the record, here's what I learned about coupling techniques:

1. Integrating SMB over a fixed ice mask over time is a poor way to calculate total SLR

contribution, due to the changing ice mask.

2. The 2w case melts more than the 1w or NC case in the RCP8.5 scenario.

3. Full Stokes solvers might yield better results.

Overall... I think this paper has done some interesting modelling runs, but so far has mostly failed to draw interesting conclusions from those runs, and to focus the reader's attention on those conclusions. I would suggest the authors think through the question "What have we learned about Greenland;" and then re-do the figures and commentary to support that learning, and focus the reader's attention on it. The paper will also need significant disucssion of these Greenland results, in comparison with other papers that have looked at the future of Greenland; for example, Vizcaino et al 2015. Especially interesting would be places where this paper predicts something DIFFERENT from those other papers, and why? In this way, the reader needs to be drawn to focus on the most interesting things — the surprises! — first, without having to dig for them.

Once the paper has focused primarily on Greenland, I would then think about how to add discussion of a new coupling technique, without taking away from the main scientific focus of the paper. But in the absence of any solid provable way to prove that one coupling technique is better than another, I would avoid making too many claims about the 2w coupling; just that you think it is better, and it certainly melts more ice. In the parts (bulk) of the paper focused on Greenland, I would use whatever coupling technique you think is most realistic.

A secondary issue: the paper reports many numbers, and only a few of them have error bars. Where did those error bars come from, and why are error bars not reported for other numbers? Would it be possible to get error bars for other numbers?

2 Specific Comments

p.2l.24: Studies by Vizcaino et al (and also at GISS; see Fischer Nowicki 2014) use elevation classes to develop an SMB. Elevation classes are mathematically equivalent to custom-designed gridcells that follow elevation contours. They are therefore able to offer high resolution in the direction of the slope gradient, while continuing with low resolution perpindicular to the gradient.

p.8 l.25: I have traditionally used different labels for the different coupling strategies described. Your "NC", I have traditionally called "1-way coupling." Your "2w", I would call "serial 1w coupling". Your "1w coupling," I would call "corrected 1w coupling." Given the differences in terminology, it's probably best to describe what each of your schemes is (which you do), but don't assume that others would use the same names. BTW, none of the coupling schemes here conserve energy, in the sense that two-way couplers (say) between the ocean and atmosphere typically do conserve energy. Therefore, I would be reluctant to call any of them true "two-way coupling."

p.9 l.7: Why is the 2w scheme more expensive? I see that you have to run the GCM and ice model together, rather than separately. But is any more expense actually involved?

p.9 l.21: Fig. 1 does not support the text. Now I see Fig. 1 is reporting anomalies; but I think it would be more interesting (and no less informative) if it would report actualy Temperature.

p. 10 l.2: Cause-and-effect is backwards. Actually, the lower SMB is the CAUSE of the ELA shift.

p. 10 section 4.1.2: This is the one section of the paper with error bars. How were those error bars computed, it didn't say? Unfortunately, some of the values reported are not statistically significant; and many others are barely. A more clear way to report the reports in this section would be something like "we saw no statistically significant change in the GRISLI ice sheet in the years 2000-2050." This conclusion is already

pretty apparent in the figure: the "interesting stuff" happens further out in time, especially with the more advanced coupling.

p.10 l.12-24: This looks like an explanation for the increased slope; but I'm not following it.

p. 10: In general, please report ice loss in dual units: both Gt, and mm of sea level rise. If this were done consistently, then section 4.2.3 would barely be needed.

Secion 4.2: Now, the paper stops telling us about Greenland, and analyzes minute differences between the coupling techniques Not so interesting.

p.11 l.20: The word "probably" is used. This indicates a hypothesis; how can that hypothesis be tested?

p.12 section 4.2.2: Ice thickness and SMB maps are highly correllated throughout this paper. For that reason, section 4.2.2 says pretty much the same thing as section 4.2.1. It would be better to (a) talk about the correllation explicitly, even quantify it, and then (b) keep ice thickness and SMB together in one section every time it is discussed in the results.

p.12 l.30: I appreciate that doing wrong calculations will give the wrong answer. I'm glad that you are not doing that. But is this worth half a section to explain? It seems you are going out of your way because someone else did something fishy.

p. 13 l.2: the last sentence of this paragraph is the most important. Don't "bury the leded"... put it up at the front.

p.14 l.15: I don't believe this argument on ice-ocean feedback. We know that tidewater glaciers retreat VERY quickly once they become imbalanced. How many tidewater glaciers will be left for us to simulate in the year 2050, 2100 or 2150? And what about going beyond that — when the REALLY interesting things start to happen? I just don't believe that ocean coupling is very important for GrIS.

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Discussion paper

** Any idea what happends beyond the year 2150? I know it's outside the scope of this paper. But this paper opens up more tantalizing questions by simulating a non-steady-state process just a little bit of the way — to a point where the changes are continuing to accelerate. What does this simulation look like in 500 years? 1000 years? 5000 years? How important are the feedbacks on that timescale?

Fig 6A: Why is there a vertical-stripe pattern in western Greenland? That makes me suspicious of the model. Please explain...

** Figures: Please make sure of the following in figures:

a) Avoid the rainbow color scale in most cases (Fig 4). There are better choices.

b) If you do use the rainbow, avoid splitting green at zero (Fig 4A). One figure has green fo both positive and negative numbers; not cool.

c) Avoid a color scale that's read on one end and violet on the other; because then the smallest and largest values look almost the same.

d) When using color scales with red on one end and blue on the other, make sure that red always corresponds to places that are melting / getting warmer / losing mass; and blue corresponds to the opposite. Reverse the color scale if needed, in order to keep this consistent.

e) The figures in this paper all use different color scales and conventions, for no apparent reason. It looks like they don't belong together. Please make them more uniform, unless there's a good reason for the difference.

f) Please put a title on top of every plot, in font large enough to read. Make sure that every plot has units on every axis (either the color scale, or the x-y axis. Most fonts on most figures need to be larger.

3 Review Questions

Does the paper address relevant scientific questions within the scope of TC?

Yes

Does the paper present novel concepts, ideas, tools, or data?

Yes

Are substantial conclusions reached?

The could be, but they are not currently explained well.

Are the scientific methods and assumptions valid and clearly outlined?

Partly. Problems: (a) no control on the novel methods, and (b) some hypotheses thrown out there without even a suggestion on how they would be tested.

Are the results sufficient to support the interpretations and conclusions?

Partly. I would start with writing more interesting and specific conclusions; and then working harder to support them based on the experiments, as well as comparisons to similar conclusions of other studies.

Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?

yes

Do the authors give proper credit to related work and clearly indicate their own new/original contribution?

yes

Does the title clearly reflect the contents of the paper?

no. The title claims to be about GrIS; but the paper is more titlted toward method comparison

Does the abstract provide a concise and complete summary?

The first half is clear and concise. The second half gives too much detail for an abstract; it would be easiesr to read if the main qualitative results were stated, without quantitative detail (which the reader can find by flipping into the results / conclusion sections).

Is the overall presentation well structured and clear?

no

Is the language fluent and precise?

yes

Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?

mostly. Figures need better unit labelling. There are two formulas, neither of which is necessary. Formula 1 (p. 5) is just one formula of how a dynamic ice model works; why was this one just taken out of context and placed here in a generally non-formula paper? I don't think it adds much. Formula 2 (p. 8) would be more clear if it were just described in words.

Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?

yes. Avoid repetitive sections analyzing first SMB and then ice sheet thickness (which is highly correllated to SMB). Re-do figures to tell us more about Greenland itself, rather than the difference in coupling methods. Talk more about the key interesting points, and less about minor details of differences between coupling methods.

Are the number and quality of references appropriate?

yes

Is the amount and quality of supplementary material appropriate?

yes

Please also note the supplement to this comment:
https://www.the-cryosphere-discuss.net/tc-2017-230/tc-2017-230-RC2-supplement.pdf

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Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2017-230, 2017.

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