Response to Anonymous Referee #2: "Interactive comment on *An ice sheet model validation framework for the Greenland ice sheet*"

We thank the reviewer for the detailed comments, each of which is addressed in our response below. For some comments, it was not entirely clear what the reviewer was requesting. We state where this is the case and note that we are happy to address any additional concerns once we better understand what those concerns are.

Response to General Comments

The currently included and in the future planned observations are based on satellite products, which biases the observation-based validation towards surface properties, such as elevation and its change. What's about ice sheet-internal properties such as temperature profiles from existing ice cores or radar detected layers, that could help to verify the internal structure, which may be important for the susceptibility of the ice sheet to applied forcing in the future?

We agree with the reviewer that remote sensing observations reflect a bias for the ice sheet surface, and that exploiting internal information (e.g., layer structure, such as that of MacGregor et al., 2015) is a logical next step. At present however, we have chosen to first exploit our core strengths, which are surface-based remote sensing data from space. While exploiting the wider suite of geophysical observations remains a long-term goal of the CmCt, in the present paper we have chosen to focus only on the current and near-term capabilities.

Response to Specific Comments

L52: Could you please add after web-address that the service is available after registration.

In order to not clutter the paper with minor details, we'd prefer to leave this information out. Once going to the link, it is made clear that one must register for an account before using the service. We are confident that the registration requirement will not deter potential users.

L90-21: I'm sorry, but I haven't understood without a doubt what is meant. Please clarify.

Unfortunately, it is not clear what lines the reviewer is referring to here. We are happy to clarify once we found out what the problem is.

L101-107: You may add a quantity such as "number of good data points" to guide the user to identify "good" years as the mentioned years 2003, 2004 and 2007.

It's not clear to me what the reviewer is asking for here. In the lines pointed to, we make

it clear what factors led us to choose observations from years 2003, 2004, and 2007. Note that the data files returned to the user from the CmCt include information on the number of observational ("good") data points used in the model-to-observation comparison.

L141: Since some may think instead of the calendar year (starting 01.Jan) about the hydrological year (starting 01.Sept). Therefore, could you please clarify.

We have changed the preceding sentence as follows: "The monthly data are annually-averaged (based on the calendar year), …"

L151: Interpolation are bi-linear, conservative, ...?

We've clarified that bilinear interpolation was used when creating the initial condition data sets.

L154: Interpolation are bi-linear, conservative, ...?

We've clarified that SMB data were interpolated onto our ice sheet grid using barycentric interpolation (this was necessary because the RACMO2 grid is not perfectly regular).

L166: Do you mean:"... and another that evolves its surface elevation only according to ... ."?

Yes. We have updated the text in this sentence to be clearer.

L206: Do you mean:"... and optimization of sliding parameters to meet observed velocities, the ... ."?

Yes. This sentence has been updated as suggested.

L229-234: Ice beyond the flux gates are not taken into account for the comparison. Does it still exists and interacts with the ice flow upstream?

Yes. As written, we think it is clear that the removal of ice downstream of the flux gates is done as a post-processing step, thus implying that it does not affect the model during runtime.

L243: Do you mean:"... changes in ice thickness are always an order of magnitude ... ."?

Yes. We've added the word "always".

L250: The application of the mask to remove ice beyond the initial footprint acts as a sink. How large is this sink term? How large is its factional size compared to the applied total SMB.

In general, relative to the total (area integrated) SMB during any time step this term is negligibly small. As noted in the paper, this procedure is largely in place to deal with the limited footprint of existing SMB data, which would lead to unchecked growth and

advance for any ice that advances beyond the (fixed) coverage of the RACMO2 SMB data. This is discussed in detail in the 2nd to last paragraph of section 3.2.

L252-254: You may split the sentence in two pieces:"... advance in limited marginal regions. In reality, strong negative mass balance at ... ."

This sentence is grammatically correct as written, in which case we prefer to leave it as is.

L261: Have I understood you correctly:"... steps, RACMO2 SMB fields are applied to either increase (positive SMB) or decrease (negative SMB) the ice thickness accordingly." ?

Yes. We think that the positive or negative action of applying the surface mass balance field is implicit in the sentence as currently written.

L276-277: How large are the 2% compared to the other presented mass changes?

It's unclear what "other presented mass changes" are being referred to by the reviewer. The point is simply that 0.2% of the ice sheet area present in the initial condition is not used when comparing the model output to observations (this area of the ice sheet is not included in either the model or observational data). So this number does not really represent a mass change in any physical sense of the word. Also, note that the number presented in the paper is **0.2%** rather than **2%**.

L281-284: Are corner points needed for each grid box. If optional, would the tool box than perform conservative interpolation?

Corner points are not needed by the CmCt. Also, while not discussed, we have tried a number of different interpolation schemes at the stage discussed in this part of the paper (bilinear, nearest neighbor, conservative) and found the results to be either trivially changed or not at all changed.

L298: I guess you mean:"... averaged weighted by grid size."?

We don't actually mean that here, because at present, the CmCt is only set up to work with uniform resolution grids. Eventually, when the tool is altered to allow for the use of variable resolution grids, we would need to apply some weighting based on grid cell size.

L299-301: Do you mean:"... cells by the ratio of the ice-covered model grid area in that cell to the total cell area... ."?

Yes. We've made that clarification in the revision.

L302: Is it possible to change the density of the ice on the web page?

Currently, the ice density is not a configurable parameter in the GRACE processing module. As more functionality is added, we will consider making the ice density a

configurable parameter.

L355: You may dropped the closing bracket:"... of time (e.g. Figure 11), and ... ."?

Corrected.

L380: You mean probably mean:" ... of at least 15 cm of water over the period 2003-2012 ... ."?

Yes. We have added this clarification in the revised text.

L385: You may change:"... GRACE observations has a PVE=100 at each location ... ."?

We've changed the text to the following: "A model which perfectly reproduces the GRACE observations has a PVE=100 in each 0.5 x 0.5 degree bin."

L388: Since math (equation 4) is clear you may change:" ... the observed variance exhibit negative PVE values"

It's not exactly clear where the reviewer is suggesting a change be made. Further, we think the sentence being pointed to adequately explains how a negative PVE value should be interpreted.

L391: You may replace M_{Trend} with δM_{Trend} to highlight that it is a difference between two trends.

As this is merely a matter of preference, we prefer to leave the definition as is. The "M" is in reference to "metric", and the subscript "trend" clearly indicates that this metric is with respect to the mass trends.

L426: You may write:" ... may be too small that they ... ."?

We think this sentence is clear enough in meaning as written (and "… may be too small that they …" does not appear to be grammatically correct).

L436: You may emphasize:"... hat initially good match (Figure 8) on a period covering a decade."

It's not clear that the suggested revision improves the clarity of the existing sentence, so we prefer to leave it as is.

L510: This, of course, only applies if the driving model climate is identical or at least very similar to the current climate. Otherwise I expect that coupled climate-ice sheet models would lead to an ice sheet geometry that differs from the observed state.

We agree. What we meant here by "more meaningful" was that the examples discussed in the paper were mainly meant for illustration purposes, but that the tool could be far more useful if the goal was to assess performance of a model receiving its forcing through

coupling to an ESM (no changes were made to the manuscript).

L569-694: Reference. What's the style and sorting criteria for Geoscientific Model Development? If none, please sort using the last name and also have a consistent way to write the first names.

Corrected (an incorrect style file was used in the submitted version of the manuscript).

Response to comments on Tables

Table 1 and 2: Please give a remark that "Pers" means persistence and you may also indicate "CISM" as Community Ice Sheet Model and RACMO2 as regional model.

Both tables now contain information to this effect in their captions.

Response to comments on Figures

Figure 1: Could you add to the color bar of the first two left sub-figures (observed and modeled velocities) a second row that lists instead of log10(v) the actual velocity (v)?

In order to avoid cluttering the figure further, we would prefer not to add an additional colorbar (note that the colorbar showing the difference between the model and observations is in linear units).

Figure 1: In the right figure (velocity difference) the black dots representing the flux gates and the negative velocity differences (blue color) are hard to distinguish. What's about adding a tick ("-") slight away from the ice margin to indicate the locations of the flux gates?

In response to reviewer no. 1, we have added a zoom to the figure, showing in more detail what a single flux gate looks like. We prefer not to clutter this already busy figure with too much additional information.

Figure 3: To avoid any ambiguity you may change the caption slightly:"... from greatest (Jakobshavn) to least (Nordre) flux in 1999."

The caption has been corrected as suggested.

Figure 4: Could you increase the line thickness please?

Line thickness has been increased.

Figure 7: Since all dots seem to fall within -300 and 300, you may reduce the ordinate axis to this range.

The extent on the vertical axis of this figure has been changed to +/- 500 m.

Figure 8: What do you think about increasing the size of the black entire ice sheet symbols?

We prefer to leave the symbols the same size, as it might not be clear why one set of symbols was larger than the other.

Figure 9: Since the figure caption indicates a mass change the unit shall be accordingly. You may write:"... Units are meters of water equivalent height / 10 years." or "... Units are meters of water equivalent height for the given period."

The caption is correct as written. The mass change shown is the *total mass change* (as written) occurring from 2003-2012.

Figure 11: You may change the caption:"Observed and modeled, cumulative whole-ice sheet trends ... "?

Changed as suggested.

Figure 12: To guide the read just spotting the figures what is meant, you may add:" ... percent of GRACE variance (Eqn 4) explained by ... ."?

Changed as suggested.

References

MacGregor, J. A., and Coauthors, 2015: Radiostratigraphy and age structure of the Greenland Ice Sheet. *J Geophys Res-Earth*, **120**, 212–241, doi:10.1002/2014JF003215.