

The Cryosphere Discuss., referee comment RC2
<https://doi.org/10.5194/tc-2021-325-RC2>, 2022
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Comment on tc-2021-325

Anonymous Referee #2

Referee comment on "Uncertainties in mass balance estimation of the Antarctic Ice Sheet using the input and output method" by Yijing Lin et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-325-RC2>, 2022

The study from Lin et al touches on a very important topic that certainly would fit well within the remit of The Cryosphere. The manuscript provides an in depth assessment on the uncertainties associated with calculating ice sheet mass balance using the input (SMB) and output (ice discharge) method. It is true that some aspects of the uncertainty analysis has been covered in some detail in other studies, but I feel that this study has the added benefit of combing all of this analysis into one paper, but also includes some novel analysis on factors not considered/addressed in other studies e.g. grounding line position.

Therefore, I do think the concept of the study presented has the potential to be a nice contribution to The Cryosphere. However, at the moment I do not think that the manuscript has reached this potential and there are some major issues that need to be addressed before publication can be considered, that are detailed below.

Difficult to follow

My main concern with the manuscript is that I found it very difficult to follow and I feel that the manuscript could benefit from a slight restructuring and having a greater focus on hammering home the key points.

- Small things such as re-structuring the manuscript so it goes through all the

uncertainties associated with ice discharge first (e.g. scaling, velocity, ice thickness and grounding line) and then the SMB stuff could make the manuscript easier to follow. At the moment the manuscript is ordered: ice discharge scaling -> SMB -> and then back to other ice discharge stuff, sometimes individual paragraphs contain information on both ice discharge and SMB methods, that makes it difficult to follow.

- For example in the methods section you could have new subsections 2.3 Ice Discharge – where you would go through systemically, paragraph by paragraph, what the manuscript focusses regarding ice discharge (e.g. scaling, velocity, ice thickness and grounding line). You could also do the same for a new subsection (2.4) on SMB. You could then structure the results section in a similar manor.
- The results section should stick to results and not wonder off into speculative discussions
- I think the discussion needs to be more streamlined and more to the point. At the moment it is lengthy and contains a lot of numbers and other bits of text that really don't add anything. I do not think it hammers home the key points. Which brings me to the question what are the key points? Is scaling suitable? What is the dominant source of uncertainty, SMB? Is it imperative that even small grounding line changes are accounted for? Please let the reader know in a concise manor.

Unclear on some aspects of the methodologies/ important omissions

Discharge scaling factor

You compare discharge using the full pixel values and using a scaling method. I think this is potentially a valuable contribution and I agree there is an unknown impact of using this scaling, particularly going back in time where velocity data is more sparse. But I am not entirely sure how you have done this:

- Presumably in the innterannual mosaics used for this experiment there are plenty of data gaps, with some regions presumably having no data at some time periods. How do you account for this? How do you get a seemingly ice sheet wide estimate of ice discharge using the pixel value when some of the mosaics will have very large data gaps. More precisely what is a pixel scale estimate, is this simply taking the velocity value directly at the grounding line. A better explanation is needed here.
- Why did you choose only 100 m, what is the reason for this? For me 100 m yr is still

relatively slow flowing ice.

- How do you treat the Antarctic Peninsula which has some difficult topography (e.g. narrow fjords) and how does this compare to other studies e.g. (Gardner et al., 2018)?

SMB

What about other SMB models apart from RACMO? I think some analysis of this has already been done, so it is not necessary to repeat. But I am certainly surprised not to see any mention of the below paper at all in the manuscript, it seems highly relevant.

Mottram, R., Hansen, N., Kittel, C., van Wessem, J. M., Agosta, C., Amory, C., Boberg, F., van de Berg, W. J., Fettweis, X., Gossart, A., van Lipzig, N. P. M., van Meijgaard, E., Orr, A., Phillips, T., Webster, S., Simonsen, S. B., and Souverijns, N.: What is the surface mass balance of Antarctica? An intercomparison of regional climate model estimates, *The Cryosphere*, 15, 3751–3784, <https://doi.org/10.5194/tc-15-3751-2021>, 2021.

Ice thickness

I agree with reviewer 1 that it is odd not include some analysis on the uncertainty product associated with BedMachine.

Line comments

Line 63-69: It is not clear to me what the 'maximum difference' is here? The difference to what exactly?

Line 67-69: Over what time periods are these comparisons made? Are you directly comparing the average mass balance from the entire rignot record (1979-2017) to the much shorter record of Shen or Gardner (2008-2015), I can not tell? For example, for Pine Island because it is changing so rapidly different estimates of mass balance would be expected over different timescales. So this is not really a fair comparison.

Line 83: I am not sure what you mean by an uncertainty analysis framework.

Line 125: More detail on the scaling factor is needed (See main comments)

Line 133: New paragraph as you move onto SMB

Line 167: What is the source for the original flux gate

Line 176-177: Probably a point for the discussion. Also, this is a large number, why is this? I presume it is something to do with the ice thickness used to calculate D – Rignot uses SMB as a base ice flux from the 1970s where there is no suitable ice thickness data?

Line 188 – discharge, not 'mass balance'

Line 195: This sentence seems out of place

Figure 3: Specify in caption on figure that the multi-year average is 12 years

Line 255: 'cannot be ignored' – or confirms internal variation in ice discharge driven by climatological factors

Line 279 – 285: This is speculative discussion and should not be in the results. Also I would certainly disagree that ice shelves such as the Ross Ronne and Amery are 'significantly thickening', likewise for 'significantly thinning' ice shelves in Wilkes Land – much depends on what timescales you are referring too. I do not think this is a valid conclusion.

Line 303: I was not aware that the Measures grounding line covers the whole ice sheet? Are there not gaps? What did you use for the gaps?

Line 308-310: Again this is discussion. Furthermore, I don't think I understand what you are trying to say in this point

Line 318-329; Example of text that is arguably not needed, most of it is repeated elsewhere in the manuscript

Line 336-337: I am not sure of the relevance of this sentence. Slow flowing ice only accounts for a small portion of the total discharge of Antarctica, So in absolute terms faster flowing ice is always going to have larger interannual variability.

Line 343: 'The annual SMB data are probably closer to the real values' – I do not understand what you mean here

Line 318-435: In general this discussion needs to be more streamlined and have less of a focus on repeating points made earlier in the manuscript.