

The Cryosphere Discuss., referee comment RC1  
<https://doi.org/10.5194/tc-2021-325-RC1>, 2022  
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## Comment on tc-2021-325

Anonymous Referee #1

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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-RC1>, 2022

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### General comments

This manuscript assesses some of the uncertainty in estimating mass balance of the Antarctic Ice Sheet using the input/output (IO) method. The authors distinguish between method uncertainty (model resolution, scaling discharge, etc.) and data uncertainty (e.g. which data products are used for velocity, grounding line, ice thickness, etc.).

I'm a big fan of proper treatment and discussion of uncertainty. I like the idea behind this paper. Unfortunately I have significant issues with the implementation of the idea. Specifically, the work is incomplete, and difficult to understand. All work could be considered incomplete because any effort can always be done a bit more or better, but by my understanding of uncertainty analysis this work leaves out a lot of sources of uncertainty, and ignores ways that many scientist reduce uncertainty. Or maybe it is there, but suffers from my second issue - it is difficult to understand.

I think there needs to be a significant effort added to the discussion of random errors vs. systematic bias. Many scientists assume errors are random, and then use this and the mathematical treatment of uncertainty to reduce errors by summing or averaging over many small regions with random error. This may or may not be correct, but should be discussed in detail in this paper. Limited discussion on the distinction between these two types uncertainty, and their treatments in other works, is problematic.

Other general comments include,

+ The authors make some questionable decisions on use of data to assess uncertainty. For example, they use BedMachine and BedMap, but do not address the uncertainty field provided by BedMachine.

+ The authors continually refer to an 'uncertainty analysis framework'. What is this? Is 'framework' just a different way of saying 'method'? An "introduction" suggests something new or not seen before. I do not see anything particularly novel in this work. Therefore, if it is not novel, it should at least be comprehensive, but it is not that either.

+ Finally, I feel that the summary of this work could be a simple and clear table showing the uncertainty from different sources in both absolute (Gt/decade?) and relative (% of total uncertainty) terms. Table 3 lists "data uncertainties" but not "method uncertainties" and not relative amounts.

### **Specific comments**

+ The 15 gt/yr target has a reference, but it is not clear that this target is necessary. Furthermore, the reference for that states,

*Determine the changes in total ice-sheet mass balance to within 15 Gton/yr over the course of a decade and the changes in surface mass balance and glacier ice discharge with the same accuracy over the entire ice sheets, continuously, for decades to come.*

And it isn't clear to me how to parse that. Is this 15 Gt/year average over a decade? Or 150 Gt/decade? Or 15 Gt/decade? Something else?

+ Authors use terms without defining them. For example "scale effect" on L22.

+ What does it mean to have an uncertainty on an uncertainty? For example, L24 reports "Uncertainties of [...]  $X \pm Y$  Gt/yr".

+ There is often reference to "future D". But everything else is using present or historical data. Why is "D" discussed predictively?

+ L73 is a motivation for the entire work, "the dominant factors influencing the uncertainties in the MB estimation of the AIS remain unclear." I disagree, the dominant factors are known. Perhaps not their relative scales?

+ L83 "We introduce an uncertainty analysis framework" <-- where?

+ L96 "SMB (input)" SMB is output too (runoff, sublimation, evaporation) although runoff is small in Antarctica.

+ L104 D equation also uses ice density.

+ L168 Which "original raster" is extended? The velocity raster? thickness? Both?

+ L190-195: This sentence seems out-of-place. It's not about your methods or results of your methods, it is instead about anomalous years. I am unable to see the relevance to the surrounding text or the paper.

+ L447-449: "The strategy of using the yearly averaged SMB instead of the annual SMB is acceptable for decadal MB estimation to constrain variability when the long-term trend is required. However, if the research is related to short-term, regional snowfall events, it is better to use the annual SMB to determine the annual variability." <-- but the motivation for this whole paper is about a 15 Gt/year decade average. In several places there is mention of "annual variation" (see also L467). It isn't clear to me that annual variation matters based on the target "15 Gt/year over the course of a decade". Can these annual variations be considered random and therefore reduce when averaged over a decade?

+ L454 - again mention of "future D". Why not also mention "future SMB"?

+ L464 "Even ice thickness data with a 100-m precision" What is 100 m precision? Is that

like "thick\_100 = round(thick/100)\*100" ?

### **TC review questions**

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

Yes

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

No

3. Are substantial conclusions reached?

No

4. Are the scientific methods and assumptions valid and clearly outlined?

Yes, but they are incomplete.

5. Are the results sufficient to support the interpretations and conclusions?

Yes

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

Yes

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

Mostly, except the "introduce a new framework" suggests something original which I could not find.

8. Does the title clearly reflect the contents of the paper?

Yes

9. Does the abstract provide a concise and complete summary?

Yes

10. Is the overall presentation well structured and clear?

No

11. Is the language fluent and precise?

No

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

Yes