Impact of time-dependent data assimilation on ice flow model initialization: A case study of Kjer Glacier, Greenland
– Authors' response (RC1) –

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This paper presents results from a transient inversion scheme which utilises automatic differentiation to initialise an ice flow model using multiple years of observed velocity data. Analysis is carried out to determine the effects of different lengths of observed data records, and whether the control variables are constant or varying in time. Comparisons are made with the more commonly used "snapshot" inversion, using only a single observational year. The conclusion is that the transient inversion method produces better results for capturing current trends and simulating the evolution of future ice flow, even with a fairly short observational record.

The manuscript is well written, and the premise of this study is very interesting. There are some nice results presented comparing the different approaches to transient inversion, and figures which display the information clearly. The subject matter is an important topic, and certainly within the scope of The Cryosphere.

We thank the reviewers for reviewing this manuscript and their constructive comments.

However, there is one major issue which I feel must be addressed. A notable difference between the snapshot and transient inversions in this study is that the snapshot inversion only inverts for C, keeping the value of B acquired from an estimate based on temperature. Meanwhile, the transient inversions invert for both B and C. I did not find any justification for this choice, which I imagine could be quite important. Without comparing a snapshot inversion which also inverts for both B and C, it appears to me that the comparison of methods is not like-for-like. Some proportion of the difference could (and I would have thought must) be due to the different treatment of B. It is noted by the authors in their discussion that some parts of the shear margins have a 45% reduction in the value of B after the transient inversions, which use the temperature-based estimate as an initial value. Unless I've missed something, from the information given in the current version of the paper,

there is no reason to think that a similar difference wouldn't occur when using a snapshot inversion if the value of B was also inverted for in that case.

For me to find the results to convincingly support the conclusion in regard to snapshot vs. transient inversion I would like to see the snapshot inversion performed inverting for both B and C, and then one of the following as appropriate:

1. *Results from the new snapshot inversion compared with the existing one to demonstrate that inverting for B causes negligible difference.*
2. *The result from the new snapshot used in the comparisons against the transient inversion results.*

That being said, I do not contest that the transient inversion method does a good job, or that it will likely still do better than a snapshot also inverting for B. I like the overall presentation of this study, and believe other conclusions regarding the different approaches to transient inversion are well supported. I was interested to see an inversion approach to calving parameters also, which is an interesting addition to the study. I find very few issues with the rest of the manuscript and would like to see it published, but have to recommend revision first to address my major issue above.

We agree with the reviewer. We will run the new snapshot experiment that includes an inversion for both B and C, and add new results for that.

Specific comments

Line 55 – "ice sheet models"

We will change this in the revised text, as suggested.

Figure 1 – It would be helpful to include the white line (2007 ice front, I assume, though this should be clarified in the caption) underneath the coloured ice fronts in panel (b) for easy reference between the two panels.

We will add this to the revised text, as suggested.

Line 92 – BedMachine citation appears to be in the wrong format.

We will fix this in the revised text.

Line 153 – Could the equation or chosen value for R be shown?

We will add the equation for R, as suggested.

Line 154 – For completeness, it would be good to show the L-curves and chosen values of γ in an appendix/supplement.

We will add the L-curves to the revised text, as also suggested by the reviewer 2.

Line 179/Table 1 – Why is B not a control variable for the snapshot inversion? It is included in Eq.5, and inverted for in all other experiments. It's not clear to me why the temperature-based estimate is not used as an initial value as it is for the transient inversions. This relates to my major issue with the manuscript, detailed above.

We will add this to the revised text as suggested.

Figure 3 – While it is well explained in the caption, I wonder if a visual key/explanation could be added in some of the empty space of panel (a) to make it clear at a glance what the colours represent. Same for similar figures later on.

We will add the legend for colors to the panel (a).

Line 210 – "there still remain"

We will fix this in the revised text, as suggested.

Line 274 – I don't think "compared to the northern branch" is needed here, since it is immediately discussed in the next sentence. And comparing it to a low bar could detract from the point that the result for that area is quite good.

We will fix this sentence in the revised text to make it clear.

Figure 11 – Could this be displayed side by side with observed ice fronts for easy comparison? It would avoid having to scroll back up to Fig. 1!

We will add the observed ice front positions next to the modeled ice front positions.

Line 344-6 – The point about softening of the shear margins again draws my attention to the fact that B was not treated in the same way in snapshot and transient inversions. Perhaps the shear margins would have been softened to some extent in a snapshot inversion for B?

We will explain this along with the revisions for new comparison between snapshot and transient inversions above.