We thank reviewer Nicholas Holschuh again for his very detailed and helpful comments. We reply to all comments below. Revised text in the manuscript is highlighted with red.

Reviewer #1, Nicholas Holschuh

General Comments:
This work focuses on the implementation of an isochrone dating method for 3D ice sheet models, which solves for the evolving thickness of englacial layers (and therefore the depth-age scale) avoiding the numerical diffusion of existing Eulerian and Lagrangian tracer methods for constraining layer ages. After the revisions, I have two minor points requiring clarification (discussed below), but the reorganization of this manuscript together with the added text and figures makes the message very clear. The authors do a great job of explaining the coupling between the ice sheet model and the layer following module, such that it can be easily implemented by other modelers going forward. I would be happy to recommend it for publication once the points below are clarified.

Technical Comments:
My two remaining questions are, to a certain extent, updates to questions I asked in the first review. The first point is primarily a clarification of what seems like a discrepancy in the figures, while the second is a suggestion to remove any ambiguity in the discussion of model bias:

1. Figures 5, 6, and 7 – I am having difficulty rectifying the cross-section you've provided [F7] with the map differences presented earlier [F5-6]. Using your cross-section for the 11.7 ka layer, I find that the BEST_all Δdepth should have values of about ~250 m through the full central part of Greenland, but the map appears to have values of ~100 m at most? Could you verify that those values are being plotted the way you expect? I also think it would be helpful if you could expand the Δdepth color scale so that Figure 5 is not entirely saturated – the point that it is uniformly positive could still be made while illustrating the magnitude of the deviation (which, right now, can only be inferred to be >= 320 m).

Figures 5 and 6 show the difference in isochrone depth below the surface while figure 7 shows the surfaces at an absolute elevation scale. Note that $BEST_{all}$ simulates a lower surface topography, which explains the mismatch. We added a short explanation to the end of the caption of figure 7.
With regard to the color scale in figure 5 and 6, it was carefully chosen as a) a compromise that works for both figures so that they can be compared, and b) so that the Δdepth scale is 1/10 of the total depth, using this relative mismatch as an intuitive reference. When finding a scale that works for both figures, a slight preference was given to figure 6 and the visibility of depth anomalies in $BEST_{all}$, because it is the more important simulation.

2. Figure 11 and line 332 – I understand the distinction you've made in the response to the previous review regarding "younger" vs "older" when describing bias, but I still stumble quite a bit with the language describing the orange curve in Figure 11. Here, you state there is an old bias (line 332). It would be helpful to be explicit about what specifically you are describing as biased (the Eulerian derived ages or the true model) and what they are biased relative to (the observed ages at those sites, the true ages of the model selected as optimal using the layer following scheme, or the true ages of the model selected based on the optimal Eulerian derived ages). By the

time I get to this sentence, I am already convinced by the previous paragraph that the Eulerian method calculates inaccurately old ages, so I don't think it adds value to say here that the Eulerian method is biased relative to the layer following method. Instead, the new piece of information is in the resulting ice sheet model bias. If you optimize your model to match the Eulerian ages to the observed ages, your model will actually produce an ice sheet that is younger than the true ice sheet (because the Eulerian ages that you've fit to are older than the true ages of the ice sheet, as shown by the layer following scheme). Phrasing things this way has the advantage that it is immediately apparent from Figure 11 -- the orange curve falls to the left of both the solid blue and the black curve.

Thank you very much for these comments. We followed the suggestions closely.

Beyond these two points of clarification, I only have a few line-item comments. I really enjoyed the paper!

Line-Item Corrections:
Page #: 2
Line #: 55
I'm not sure what you mean here by "spatial patterns that differ on the various isochronal surfaces." Patterns of what? Do you mean spatial patterns for isochrone depth error? It would help to be specific here.

This has been changed to "... spatially complex patterns of isochrone depth …".

Page #: 3
Line #: 72
It might be worth mentioning that N is the effective pressure assuming no support from a pressurized subglacial hydrologic system, just to be clear that effective pressure could have another term that is omitted here.

Done

Page #: 10
Line #: Figure 4
I think this is a great addition! I had one clarifying question -- the vertical interpolation you refer to here is for the Yelmo velocities, right? If so, should that either be in blue, or be the step following the input of the velocities from Yelmo? It might be helpful to state what is being interpolated and what is being advected in those two boxes, just to be totally explicit.

It is true that the previous version of the figure was not optimal. This has been changed now.

Page #: 11
Line #: 229
You're missing the section reference here -- I think it should read: "... by discussing two examples from the ensemble in section 3.1, followed by..."

Done

Page #: 12
Line #: Figure 5
As mentioned above, I think it would be helpful to expand the color scale here so that the interior values are not saturated (to get a sense for the full magnitude of the error).

Please see our answer above. We prefer to keep the figure unchanged.

Page #: 13
Line #: Figure 6
The panel showing error for the 11.7 ka error seems to have values with a maximum between 80 and 160 m in the Greenland interior, but that is quite different from the ~250 m errors shown in Figure 7. Is there something I'm missing here?

Please see our answer above. The figures are correct.

Page #: 17
Line #: 301
The word "perspective" here is vague -- I think it might be better to rephrase to something more specific, for example: "... the high resolution of our model in the temporal domain allows for a different and complementary analysis, using the full age profile at certain locations to constrain model performance."

Done

Page #: 17
Line #: 317
To assist the reader and maintain parallel structure here, it would be useful to point out that the Eulerian tracer is the dashed blue line in Fig. 11 and the isochronal tracing scheme is solid blue. The sentence as written references both methods but only one line in the figure, which can be confusing. IE: "Comparison between the Eulerian age tracer (dashed blue line) and the ioschronal age tracer (solid blue line) applied to the BEST_all simulation shows clear disagreement between the two methods for defining the depth-age scale."

Done

Page #: 17
Line #: 325-332
This is the section that I got a bit hung up on. I apologize if I said the opposite of this in my previous review (I think I might have...), but I realize now this sentence would be clearer if you talked about it in terms of parameter selection instead of model calibration. I tried my hand at rephrasing to clarify the points that confused me, with the hope that my attempted rephrasing will help you see where my issues were: "The spurious bias toward older ice with the Eulerian scheme has a noticeable effect on model behavior when parameter optimization is based on its output ages (as in the model plotted in orange, Fig. 11). Here we show the ages generated using the isochronal scheme, derived from model output from an ice sheet simulation using parameters chosen to optimize the quality of fit for isochrones generated using the Eulerian age tracer. Note that this is a different simulation from the one plotted in blue, which uses parameters chosen based on quality of fit for isochrones generated using the isochronal scheme."

Then, in line 332, I think the salient point is that models which optimize their boundary conditions using Eulerian derived ages will produce ice sheets with true ages that are younger than observations (as shown in Figure 11). This makes a clear distinction with the previous paragraph. There, you show that the Eulerian method produces older ages than the isochronal method -- here you show that model optimization based on Eulerian ages biases the ice sheet toward younger ice deeper in the column.

We followed these suggestions closely in our revised text.