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Interactive comment on "Glacier thickness estimations of alpine glaciers using data and modeling constraints" *by* Lisbeth Langhammer et al.

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In this manuscript, Langhammer and colleagues present a new method to compute the distributed ice thickness of glaciers under observational constraints. I enjoyed reading the manuscript, and especially the second part introduces new methods and insights that could be useful elsewhere. I have a couple of recommendations below (I wrote them without reading the two other reviews: you might notice some overlap).

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General comments

Calibration of the regularization parameters and model validation

This is the part that most confuses me. I'm not sure as to what the respective λ_i experiments tell us, and I wonder if there could be a more systematic, quantitative way to calibrate these parameters. The first method that comes to mind is to use cross-validation instead of the current "step-test-stop" implementation. As an example from the machine learning literature, implementations of regularization in LASSO algorithms often use cross-validation to determine λ. In your case, you have three free parameters which are likely to compensate each other, but currently we actually don't know if this is the case or not.

This brings me to the second point: at line 300, you write: *"we conclude that the GlaTE inversion approach works well"*. But how do we know this, and what does "work well" mean? Since the lambda parameters are chosen in a way that almost all GPR measurements are fit perfectly, yes the model "works well" but it might be over-fitted despite of the other constraints (for example, in one experiment λ_2 even goes to zero, meaning that the algorithm becomes a mere interpolation). Here again, cross-validation could help to assess the robustness of the model for regions where no GPR data is available (note that it should be another cross-validation loop than the one used to calibrate λ, i.e. with truly unseen data).

Given my late review and the fact that I don't know how computationally demanding your inversion method is, the comments above can be understood as a "recommendation" more than a "must do". I believe however that the question: "how well does GlaTe really work with unseen data" should be addressed at L300 or in the discussion.

Code and data availability

According to this journal's data policies (https://www.the-cryosphere.net/about/data_policy.html), code and data should be made available if possible. I cannot enforce these rules but I strongly recommend them: are your GPR data available, and if yes where? The GlaThiDa database would be a good place for them, although they do no guarantee attribution. Would you consider sharing your model code under an open-source license? I believe that both would be a strong asset for the community and would increase the visibility of your work.

Specific comments

L117 Glacier flowsheds. Do the flowsheds create discontinuities in the apparent MB field and therefore in h? I would assume they do, e.g. at a junction between two glacier branches. Is this a problem?

L131, Eq. 3 to compute the apparent MB with the equilibrium assumption you still need to use a specific function for the MB. E.g. linear, or linear with with two slopes, etc. Give more details about what is tuned here. In particular, mention what you do in the case of the glacier cluster case study: I assume that Ω_G is computed for each entity independently? And what about α_G, is it the same for all glaciers?

L147 "lower boundary of Di". How is this computed? Is this equivalent to the grid spacing of the gridpoint i?

Equation 6 which slope is θ? Is it the same as ϕ, introduced above?

L167 parameter α. Another approach would be to use α as a correction factor for the uncertain parameters, for example A. In this case the calibration function is not linear anymore, but it would be more physically consistent with the uncertainties in A.

L170 shouldn't the equation be mean(abs(diff)), i.e. the mean absolute deviation (MAD)? With your formulation you are only minimizing the overall bias, which

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would allow strong deviations at individual points. (but maybe this is what you intended).

Solver can you add an example about the dimensionality of the LSQR problem in one of the three cases, and of the time needed to solve it?

Figure 1 Text and legend seem to have inverted b) and c)

L431 if I understand well, the distance between profiles is not taken into account, right? So the flight time from one profile to another does not enter the cost function?

L553-L557 just a comment: as someone who actually tried to do this, let me say that it is very unlikely to work like that... I'd be glad to be proven wrong though!

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