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The Cryosphere
Discussions

Interactive comment on "Dating the ice of Gauligletscher, Switzerland, based on surface radionuclide contamination and ice flow modeling" *by* Guillaume Jouvet et al.

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Jouvet and colleagues make use of Uranium and Plutonium tracers deposited in the 1950's and 1960's on the Gauligletscher (Switzerland) due to the fallout of nuclear weapons tests. They use these tracers to identify isochrones and benchmark their high resolution glacier model against them. They argue, that using these isochrones as a data benchmark to tune against provides a more stringent constraint on model parameter uncertainties compared to traditionally used tuning targets such as DEMs and surface velocity maps and their results make a compelling point.

The manuscript is well written, with high quality figures and a logical structure which

is easy to follow. Its content fit well into the scope of The Cryosphere as they show convincingly, that their methodology can be used to improve the parameterisation of glacier models significantly.

I congratulate the authors on a really nice manuscript and only have some minor comments/questions followed by stilistic/spelling edits.

-Given the large improvement of the overall model performance due to parameter optimisation a natural question would be how projections of the glacier's evolution would change compared to the old parameter set. Maybe the authors could speculate as to how they think the new parameters might change the expected mass loss in the future or whether they plan to carry out further simulations in this direction.

- To illustrate the effect of the model optimisation an additional figure showing the spatial expression of ice thickness and surface velocity model mismatches with respect to observations (percent, relative change) for the old and new model setting would be nice.

- it is interesting to see in Figure 7, that the parameter optimisation seems to have a moderate effect on RMSE (thickness) compared to the change in observed and modelled glacier length. However, this might be a misinterpretation. As mentioned in the comment above, a 2D figure of the model mismatch for old vs new model would be helpful.

- on page 16 you mention that uncertainties in the bedrock topography could be causing the exaggerated flow asymmetry. This raises the question as to what extent the bedrock topography can be used as a "tuning" parameter to improve the velocity patterns. It probably depends on whether there is a systematic uncertainty in the bedrock topography which would offset the flow asymmetry? In general, modifying the bedrock topography to match flow patterns would be inadvisable unless one knows the actual bedrock topography. But then you would use the corrected bedrock topography in the first place. You re-iterate this point in the discussion by stating that

"Here we have shown that our bedrock is likely too shallow on the north-east side and too deep on the other side"

However, to me it is unclear how you get to that conclusion. The poor model prediction regarding line 1 and 5 might have other causes? Also bedrock uncertainties are to be assumed for the whole glacier area, why should they be especially relevant in case of line 1 and line 5? Please elaborate.

-on page 17 you mention the interesting fact that the model isochrones shift from a U- (after 1970) to a V- shape (before 1970) without giving an explanation. Isn't this just due to the narrowing channel the glacier is pushing through? I would intuitively assume that the glacier moves more homogeneously across a given horizontal transect in the upper part compared to the lower part (where glacier flow is confined on both sides)? A short interpretation as to why the shape changes would be helpful.

minor edits:

p2, l47 I suggest to add

Parennin et al 2017, "Is there 1.5-million-year-old ice near Dome C, Antarctica?" (TC) and Passalacqua et al. 2018, "Brief communication: Candidate sites of 1.5 Myr old ice 37 km southwest of the Dome C summit, East Antarctica" (TC)

p2, l50 combining what to an ice flow model?

p3, l61: ... percolation water remains up to debate.

p3, l74: ... is being expected ...

Figures 3,5,9,10: please include a scale so the reader can appreciate the spacial extent of the glacier.

As a general point I would suggest to introduce the term "contaminated" in the sense that the ice samples are contaminated by U/P, as the casual reader might mistake the term contaminated (e.g. in Figure 5) for an indication that the sample couldn't be used

due to contamination as opposed to the "uncontaminated" samples.

Figure 5: suggest to enlarge the dots in the legend and put "L2" above isochrones and next to "1954".

p7,l 135: ... thick compared to the rest of the glacier? unclear.

p12, l253: unclear what you mean by "associate" here. The 1963 isochrone is associated with a pm 2 year uncertainty?

p15, l292: to a lesser extent

p15, l301: We therefore selected this parameter combination as our best guess set.

Figure 7: for the sake of readability I suggest to make the small markers (discarded runs) semi-transparent. Same fro Figure 8

p15, l305: "displays"

p16, l 306: ... using the original and the revised best-guess model, respectively, and confirms the ...

p16, l311: replace "and then" with "i.e."

p16, l314: to a lesser extend

p17, l325: I suggest to rephrase to: "Ice with radionuclide contamination above 0.25mBq/kg has the same pattern and mostly appears to be band-wise (Fig. 5)"

p17, l329: this corresponds to a mean ?surface? ice flow of ...

p17, l330: suggest to rephrase: However, as the ice was thicker in the past it most likely exhibited faster flow as well.

p18,l1: corresponds to a ...

p18, l345: ...downstream compared to the lateral flowlines and the ... p19,l1: running an ice flow model p19,l366: Furthermore, snow-covered ...

p19,l377: Here, the bedrock was inferred ...

p19, l380: our bedrock data

p19, l386: ... Alpine glacier. It is important to note, that other tracers ...

p22, l440: suggest to rephrase: In this study, we successfully used Plutonium and Uranium contaminations in an Alpine Glacier induced by the 1950s and 1960s atmospheric nuclear weapon tests to date the ice of the glaciers ablation zone.

p22,l445: The combination

p22, l457: this part is a little implicit. Why is it remarkable? I would assume (correct me if I am wrong) that the climatic conditions of Aletschgletscher changed similarly to the Gauligletscher, so the correction factors should be similar. What are the qualitative differences of Aletschgletscher compared to Gauligletscher (except for the size) which would make a similarity of parameters surprising? I agree with the authors, that isochrones should be utilised to constrain model simulations. However, in this case "traditional" tuning targets for the Aletschgletscher seemed to have produced similar results compared to the fine tuning against isochrones for the Gauligletscher? Or was the 2011 model also optimised with respect to isochrones?

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