Creep enhancement and sliding in a temperate, hard-beded alpine glacier

Summary

The manuscript titled "Creep enhancement and sliding in a temperate, hard-beded alpine glacier" by Roldán-Blasco et al. examines the basal sliding and internal ice deformation of an alpine glacier. The authors observe an increasing creep factor with depth, which they attribute primarily to changes in water content. However, they suggest that seasonal changes are more likely due to variations in stress distribution within the glacier, as neither the increase in water content nor the stress change alone fully accounts for their observations.

The study is based on approximately 20 tiltmeter measurements along a borehole over an 8-month period. These data are complemented by glacier flow velocity measurements from the glacier surface and bed. Additionally, the authors employ a modeling approach to better understand stress distribution within the glacier. By connecting the modeling output with the tilt and discharge measurements, they quantify the Glen's flow law creep factor, investigate the water content within the ice relative to depth, and analyze stress distribution within the glacier. Finally, they link their findings to the state and evolution of the subglacial water system.

Overall, this manuscript presents significant observations regarding Glen's flow law creep factor and the seasonal evolution of the subglacial water system. Minor comments for improvement focus mainly on enhancing readability.

Manuela Köpfli

General questions

- Would you assume to see similar inclinometer measurements for all boreholes, if they would have worked properly and the installation/drilling would have been perfect?
- I understand that you mainly focus on the tilt measurements. If possible, I would appreciate seeing a figure of the initial and final borehole shape as Figure 1.b but also showing the final borehole shape.
- In Figure 2, BH3 shows this larger value at depth around -160m. Do you think this is real? If so, do you have any explanation for that since your boreholes BH2 and BH3 are very close?
- In Figure 5 you show your data with a daily resolution. Would it be possible to to "zoom in" to the first half of May and have a higher time resolution for velocities and discharge. It would be very interesting to see, if you see a delay between glacier speed up and discharge.

Comments Text

Note: I recognized that you used different ways to write a date: 15th of February, 15th February, 15th February. Maybe you choose one format and keep it through the whole manuscript. I just wrote "date" and the corresponding line.

Title: I would use "bedded" instead of "beded"

L.32-35: I would break the sentence into two sentences.

L.94: date

L.139: date

L.201: To me, the 2020 is a bit misleading. I would exchange it with something like "over one year (2020)" or "over eight months (2020)" or even remove the 2020 completely.

L.205: To me, there are no residuals of the reconstructed velocities. As I understand, the residuals are more between the reconstructed and observed velocities

L.214: I don't really understand the word "threshold" in this context.

L.214-215: unit goes over the line and exponent is not really an exponent (for both units: m a-1 and m3 s-1)

L.223-237: I'm a bit confused by n and m. If they are not the same, could you add a sentence and describe the difference?

L.228: I would write *m* italic that it is immediately clear that you are not talking about meters (like L. 235)

L.236: Normally you used Eq. instead of Eqn.

L.242: I prefer the italic writing of parameters: *A(z)*

L.246: Maybe change this sentence to: "Averaged deformation rate profiles, computed from tilt measurements (see methods in Section 3.1) at BH2, BH3, and BH4 between February 15 and October 15, 2020, are shown in Figure 2."

L.247: date

L.275: October 1st to 31st (second superscript is missing), date

L.298: Normally, you wrote section starting with a capital letter

L.307: date

L.313: Normally, you wrote section starting with a capital letter and italic du/dz

L.314: Italic du/dz

L.345: For these reasons we do not include Lliboutry and Duval (1985) ~~is not included~~ in Table 2…

L.364: … either a stress … OR a change…

L.397: use % instead of writing percent

Comments Figures

Figure 1: Make sure that all blue dots are visible (especially BH1). Maybe use a different color for the label of the GPS station "ARG1" so that it is immediately clear that this is something different and there is no blue dot behind the green dot. Add to the last sentence in the figure caption, why you start your analysis on 15th of February. date (in the figure caption)

Figure 2: Start figure caption with a capital letter. I would rewrite the figure caption as "Average measured deformation rate profiles ~~with monthly minima and maxima~~ at BH2, BH3 and BH4 including the monthly minima and maxima for BH2. ~~The continuous lines show the average measured deformation rate profile at each borehole for the period~~ between the 15th February and the 15th October 2020~~, and the shadowed region the range between monthly averaged~~

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~~minima and maxima deformation rate values (shown only for BH2).~~ Every symbol represents a tiltmeter." date (in the figure caption)

Figure 4: Labels a), b), c) are missing in the figure. Is in subplot c) W only inferred for the orange markers? Is the assumption for the blue line, C & P (2010), that W is constant. If so, I would change the label of the orange line/markers also to A(z) and only mention the water content W in the figure caption (as you do).

Figure 5: I would use a different color for the discharge vs basal velocity, just for clarity. Maybe you want to mention again, that you convolved/averaged your data on a daily basis and you did the same for the discharge? Because, I would assume some daily variation in the discharge over the melting season.

Figure 6: date (in the figure caption)

Figure 7: It is correct what you are saying in your figure caption but when I first read that, I did not believe that you wanted to say that the friction increases during melting. To avoid that, I would add that this is due to "efficient drainage" or an "evolved drainage system".

Comments Supplement

Figure S9: I would use Δt instead of "Delatat" and du/dz instead of dud and decide if Error should have a capital letter or not (title vs. color bar label)

Figure S10: Again, i would prefer Δt instead of "Delatat" and u_d instead of "du"

Figure S11: I'm not sure if you need that many positions after decimal point for the std.

Figure S16: The orange line is hard to see. Also the label for (a) is missing. I would suggest making two figures out of the one figure, just take your figure S16a as one figure and add S16b as S17. This allows you to make S16a bigger and easier to understand. Please check the linewidth of the orange line or change the order you are plotting the lines sot that blue and orange are in the front.