EGUsphere, referee comment RC1
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Comment on egusphere-2022-195

Anonymous Referee #1

Referee comment on "Thermal regime of the Grigoriev ice cap and the Sary-Tor glacier in the inner Tien Shan, Kyrgyzstan" by Lander Van Tricht and Philippe Huybrechts, EGUsphere, https://doi.org/10.5194/egusphere-2022-195-RC1, 2022

General comments

This manuscript presents a detailed exploration of the thermal regime of the Grigoriev ice cap and the Sary-Tor glacier, which are located in the Inner Tien Shan in Kyrgyzstan. Using a wide range of observations, such as observed temperature profiles and GPR profiles, model parameters are tuned and subsequently evaluated against observations. The study finds that the Sary-Tor can always be considered a polythermal glacier unlike the Grigoriev ice cap which can always be considered as a cold structure. It is also suggested that the found parameters can be generalized to similar type of glaciers in the region.

The author(s) did a great job reviewing and referencing previous work. Overall this was found to be a very extensive and thorough study.

Specific comments

Geothermal heat:

The Geothermal heat flow parameterization used seems too casual. The study is using the same constant value for the geothermal heatflux for both the valley glacier and the ice cap, however, it has been showed that geothermal heatflux is focused in valleys like Sary-Tor and diminished on ridges, like Grigoriev Ice Cap. It is possible that Grigoriev Ice Cap has double the heat flow as Sary-Tor. See the papers by Colgan et al. 2020 (doi:10.1029/2020JF005598), section on topographic correction and Van der Veen et al. 2007 (doi:10.1029/2007GL030046).

The chosen value for the geothermal heat boundary condition of 50mW/m2 seems quite high given the altitude of the glaciers. Another study by Zhong et al. 2013 from Journal of glaciology doi:10.3189/2013JoG12J202, studying the East Rongbuk Glacier, have derived a lower geothermal heatflux value of approximately 19mW/m^2.

Line 650-655: There is something unclear in this section. First it is described that average ice temperatures are most sensitive to changes in geothermal heat, but the paragraph is ended with 'geothermal heatflux do not have any major influence'. I assume the latter statement is the conclusion the author draws from the sensitivity analysis, and the former just means that relative to the other tested parameters geothermal heat influence the mean temperature the most. Maybe the section can be written slightly different?

Temperature calculations:

As far as I can tell the ice flow model is a 'cold ice' model like most ice flow models. Modelling the flow of temperate and polythermal ice is different to modelling cold ice since it is essential to know the spatial distribution of the water content in the ice (See Dynamics of Ice sheets and Glaciers by Ralf Greve and Heinz Blatter). According to a study by Andy Aschwanden (doi:10.3189/2012JoG11J088) 'cold-ice' models are not energy-conserving when used with temperate ice since they cannot account for the part of the internal energy which comes from latent heat of liquid water. This could be included as a discussion point.

Technically both glaciers could be considered polythermal, following the IACS glacier terminology Cogley 2011.

Line 309-311: The explained effect is also described in Hooke 1976 J. glaciology, study of Barnes ice cap. It might be good to cite that paper.

General questions and comments on unit, equations and notation:

There are many parameters and m appears several times it might be nice to include an annotation table for clarity? This could also help to clearly define units of every variable. Sometimes variables in text does not have units e.g. the melting point depression factor, gamma in line 198.

How is the internal heat production P from equation (9) calculated?

Where does equation (15) come from?

Equation (16) The last term of the surface temperature (Ts) parameterization for H<ELA does not seem to have units of degree if ms has units of m w.e. pr yr? units don't seem to match with Ts having units of degree celcius.

Mass balance model section:

The introduction mentioned that Grigoriev Ice Cap is losing mass by calving, but this is not mentioned in the mass balance model section. Does the 'm_s at the front' in table 2 refer to mass loss from calving? What do the tuning parameters c0 and c1 represent, I don't think they are explained fully in the text? It seems like one would have to read Van Tricht et al. 2021b to understand it the section does not stand completely on its own. It might be helpful to explain a bit further?

Line 396: could we get more information on how the mass balance correction works? I assume it is not spatially constant correction in order reach the 1990 geomtery but the text says 'constant correction'?

Other:

Line 415-418: No error bars are given on the area and volume estimates?

Figure 5. Very nice sensitivity plot – as I understand from the figure these values are constant in space and time? It might be nice to make that clear in the text, it also means there is potential for further work for examining the spatial variability of the parameters i_s and w_f.

Line 512: why is the enhancement factor chosen to be different (3 and 4 respectively) for 2 glaciers which are stated to be similar?

Would it be possible to include an evaluation of modelled velocities against observed velocities e.g. using the ITS_LIVE product? If it was showed the velocities were reasonably well captured this would also strengthen the confidence in the calculated temperatures.

approximately line 540

Line 569: It is written that: ‘the difference between the thermal regime of the two ice masses can be attributed to several factors’ – this also includes geothermal heat focused in valleys like Sary-Tor and diminished on ridges like Grigoriev ice cap (see Colgan 2021, JGR), topographic corrections.

It would be helpful if you include a description of how it possible to distinguish between temperate and cold ice from the radagram.

Financial support section: Kumtor mining company has been funding glaciology in this valley. Maybe include a clear statement that no industry funding was used or who did pay for the logistics of the field work?

(Minor) Technical corrections and suggestions

Line 38: using GPR abbreviation but it is not explained until line 64-65.

Line 117: ‘down to a depth’ instead of ‘up to a depth of 102 m’?

Line 135: ‘down to bedrock’ instead of ‘up to bedrock’?

Line 136: ‘depth’ missing p

Line 164 +166: include Eq. when referring to equation (2) and (4) to be consistent with the other times you refer to an equation.

Line 289: ‘assumed not to be’ instead of ‘to be not’

Line 440: ‘On’ instead of ‘At’ in sentence ‘At the other hand…’

Line 511: the number of decimal places vary

Line: 622: write ‘1960’ instead of ‘the sixties’

Line 669: missing space between table and 1.

If possible it would be nice to see the location of the observed temperature profiles on a map.

Equation (7) should be A(T_pmp) instead of A(T)

Figure 1: The light blue colour indicating the glaciers are not very clear, it is very similar to the blue showing lower elevations of the background map.

Figure 5 right figure: suggest removing ‘at 10-15m depth’ from the x-axis label

Figure 8:

- subfigure c has wrong label of the flowline, should be C and D instead of A and D to fit subfigure d.
- figure text missing f in flowlines in line starting with (b,d) Horizontal ice velocities along the flowlines
- plot elevation on y-axis of subplots (b,d) to be consistent with the other similar figures

Table 3:

- Initial values for Sary-Tor glacier have %value on top and temperature below to be consistent
- Suggestion: include the actual parameter values in the table not just the relative change