

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-183

Anonymous Referee #1

Referee comment on "Overestimation and adjustment of Antarctic ice flow velocity fields reconstructed from historical satellite imagery" by Rongxing Li et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-183-RC1>, 2021

General comments

The paper by Li et al., 2021 presents an innovative method that aims at correcting glacier velocity overestimation, that are due to accelerations, when using long timespan. The paper is well presented with a clear structure, well written and the Figures are relatively clear.

A large share of the paper is dedicated to the description of the method, which is simple in principle, but that could be ambiguous to understand clearly. Consequently, I have few comments that I hope, will help to make the paper more understandable.

Among those comments, the definition of the different Premises needs a bit of clarification, and particularly on their area of validity (see below). The discussion also needs to be supplemented with an overview of the method applicability to different glacier types, and specifically fast flowing glaciers (e.g Jakobshavn Isbrae), or with a more complex geometry (e.g Zachariae Isstrøm ice shelf, Getz Ice Shelf or George VI ice shelf). Another interesting point of discussion is the impact of the glacier seasonal variability. Are the corrections significant with respect to the natural variability of glacier flow? While, seasonal signals are not really pronounced in Antarctica, variability can be much greater in Greenland (cf. Joughine et al., 2020).

For example, using a 1-year velocity reference for a glacier like Jakobshavn Isbrae, might not be ideal, as the glacier is flowing at more than 15 km/yr (which increases the chances of acceleration along a flowline). Similarly does the premises still holds, for glaciers that are changing directions and not flowing in a straight line (for example the ice shelf of Zachariae Isstrøm before 2000)?

Finally, while the authors are discussing the large overestimation error on Pine Island glacier (36%), they are presenting a first application of the method on Totten glacier. Hence, I think that it would increase the paper's logic and readability to keep this example for the application part (Totten could be put in the supplementary material). With such a high overestimation, I expect the results to be spectacular.

Comments.

L45. This is a citation for the Landsat-8 program. Not appropriate here.

L46. "3 to 15 years", is not accurate. Bindschadler and Scambos., 1991 used a cross-correlation algorithm on two images separated by roughly 1 year. Similarly, Bindschadler et al., 1996 also uses 1 year image-pairs (see Table 1 of their paper). Wulder et al does not contain ice velocity maps prior to the 1990s.

L46. Can you define after which time span the overestimation is significant? (2 yr, 3yr ?). I found the use of images acquired more than 2 years apart quite rare, or limited to few points (large rifts for example).

L49-51. From these lines it is a bit difficult to understand the overestimation issue. Please, extend a bit this description with more details, and split the sentence in two or three part.

L52. Greene et al., 2020b; the reference list just says (Personnal communication, comments on a manuscript), which I found a bit weak for a reference of a concept that is the base of this paper.

L53. The overestimation calculation over Pine island glacier is derived later in the manuscript, hence remove this part of the sentence.

L54. I would like to see a complete comparison of the simple method from Berthier et al., 2003, with the approach proposed here in the discussion section.

L108. Please add reference to Figure 1a,b,c to help the reader's understanding of the whole concept.

L110. Here and in the remaining of the manuscript you use 1 year ice velocity as a

reference map. But does your method still apply for very fast glaciers? For example Jakobshavn Isbrae (Greenland), or Penguin gl. (Patagonia) are flowing at speeds that are exceeding 10 km/yr, hence there is good chances of acceleration along flowlines within that year. Can you please discuss this point here? And better specify the use of a 1 year ice velocity map as a reference for your method.

L114-115. Does it depends on the speed of the glacier ? i.e this assumption still hold for Jakobshavn Isbrae flowing at more than 15 km/yr ? Or Penguin gl. In Patagonia (12 km/yr) ?

Section 2.2. I am getting lost with the notation, between the U, S, Map, V.... What do you mean by Maps ? Maps of ice velocity I guess, than why introducing Maps if you have later V ? Why not just using V, and add E and L for Eulerian and Lagrangian as indice (V_E and V_L).

Figure 2. Please give a more comprehensive caption of Figure2. This one is just not enough to understand what is there. What the difference between the two Lagrangian lines mean? See earlier comment on the writing of equation to simplify the text and improve the understanding the paper. I guess you have Map_{0-1} to specify that the Lagrangian is only calculated with Map_{0-1} ? This should be specified in the caption.

L125-155. I think that the choice of hyperscript and subscript in equations could be simplified for the seek of the reader's understanding. First, ice velocity maps are defined as Map_{0-i} , V is used for Eulerian ice velocity and U is used for Lagrangian ice velocity. All of these are referring to ice velocities, so I suggest you switch to V for the velocity maps, $V_{E(0-i)}$ for the Eulerian speeds and $V_{L(0-i)}$ for the Lagrangian ones. You could also do V_{0-1}^L and V_{0-1}^E , since I don't think that the use of J at line 240 is necessary for understanding (you could just say in the text that you calculate the overestimation of all sub-images).

L 133. What do you define as a "short" lagrangian trajectory? This should depend on the glacier speed (see earlier comments on fast flowing glaciers), hence the distance where this premise holds decreases when the glacier speed increases (which is in part linked to the local bedrock slope). Furthermore, this premise holds if you assume that the point moved on a straight line within this short time span.

What do you define as short time span? If I assume this is 1 year, this premise might be true for some ice shelves, but what happens if the flow changes direction? This might happen within 1 year for example for George VI, Abbott, Dotson/Crosson or the Getz ice shelves in Antarctica.

L134-136. Here the use of the $i=1,2,...,n$ is confusing. You are describing the case of a short time span, hence why not just using the V_{0-1} and U_{0-1} (as you just said in the

previous lines)? Or V_{i-i+1} ? What is a short time span on Figure 2? All of this Premise holds in what you define as a "limited time span" and "short L trajectory" (which should be straight). Please clarify these points

The author choosed to make a clear distinction between the theory vs the application, which I think was a good idea, but here, it would help the readers to have some more self-explanatory examples, as it is done in section 2.3.

L 137. This could be reformulated, for the more clarity, to "In reality, the available historical images only allow us to produce eulerian velocity maps with a long timespan, i.e Map_{0-n} which leads to the maximum overestimation value as defined in equation 2"

L138. "As we can only use Map_{0-n} , the lagrangian velocity, for a long time span, is defined as follow". Please also add a reference to the line in Figure 2.

L 141. "Consequently, the 1 year L-velocity U'_{0-1} ..."

L145. What do you define again as a limited time span? If you compare Map_{0-1} and Map_{0-n} , then you are comparing the smallest and largest time span, hence the use of the term "short timespan" is a bit confusing

L145. I guess that the magnitude of the velocity Map_{0-n} should be larger than Map_{0-1} , but the pattern is similar? Can you provide a figure example with velocity direction to illustrate this point?

L148. The first part of the sentence can be removed since it has been described earlier, before Premise II. Then, you can just start with: "Hence, based on Premise II, we have..."

L150. Again, the $U_{0-n}=V_{0-n}$ is based on the fact that you are considering only short timespan. But is that the case if you use "0-n"? (see earlier comment)

L 151. I would reformulate this sentence to remind the reader about the aim of this paper : "Consequently, using the map with the longest timespan, we can go back to V_{0-1} using a Correction term defined as $Correction=V_{0-n}-U'_{0-n}$ ".

L 164. What does it mean to interpolate the positions to the sub grid-level? Does it make

any sense to interpolate the position at a higher level of resolution than the velocity field?

Figure 3. Please add a general Figure of the entire Pine Island glacier, to check out where the location of your flowline is (similar as Figure 4).

L179-180. What about orthorectification errors in historical images ?

Acceleration computation: this has already been described L147. I would suggest to move this part earlier (or remove it).

Section 3.1. Since section 2.3 shows an example over Pine Island glacier, I don't know why the author didn't continue using this example. Since the overestimation is quite spectacular, I would strongly suggest to use Pine Island instead of Totten here.

L213. Why did you choose a 7 year trajectory ?

L217. See previous comment on the choice of symbols in equations.

L215. Do you generate the map separately or over the entire glacier directly ?

L225. I am surprised about the error estimation here. Millan et al., 2019; had some smaller number for 1 year map of ice velocity using Landsat-8. Can you discuss why is that ? How does your map compare with available NSIDC data ? What is the difference with recent map assembled from sar interferometry ? (see Mougnot et al., 2019)

L239. Is it "faster than" or "close" ?

L240. I think that the use of "J" in exponent is adding to much complication (see earlier comment). You can just specify that you do the calculation for all sub-images.

L257. The "apparent parallelity" is quite subjective I think. Is the premise II validated for case 2c and 2a?

Figure 5. Add the direction of the flow in the sub-images. You could also consider using different symbols for the 7 yr and 1 yr trajectory and use a color gradient for the position of the points that changes with the year. This "year" color could then also be used in the scatter plots.

Table 1. Please add more details on the caption of the Table, ie, the content of each column.

L302. The acronym OE has been defined before.

Section 4 Discussion. Can you discuss the performance of your method, with the relatively simple approach defined by Berthier et al., 2003 ? I think that the section is missing some discussion on the applicability of the method to 1) fast glacier, 2) the glacier geometry, which can be much more complex than the glaciers that were used here to validate the method (not straight) (see earlier comment). An additional discussion about the significance of the correction, with respect to the seasonal variation in ice flow velocity of the glacier should also be discuss, if the method is expected to be applicable in Greenland. Specifically, does the magnitude of the correction could exceed the natural variability of the glacier? I guess that the amount of acceleration with a flowline would need to be significant in order to induce a correction that would exceed the variability of the seasonal signal ?

Figure 5-6. Can you provide a figure of the corrected ice velocity? Maybe a difference map