Reviewer 1 - specific comments

Abtstract: You should rearrange the abstract to discuss the methodology first, and the application next. For example, l 10-13 should be moved to the end of line 4.

Abstract has been adjusted and arranged as suggested.

Section 3.1: I dont quite understand the value of $\mathbf{A}_G$ here (except for visualization) and the connection with the following methods. What is for example the link with $\mathbf{A}$ in equation 1? Why is $\mathbf{A}_G$ filled with 1 whereas the text says "individual days are specified"? Do you assume 1-day pairs in this example?

The adjacency matrix is a simple matrix representation which encompasses the structure of a network. Maybe the beauty of its connectivity to equation 1 is not clearly emphasized in the manuscript. But the relational structure of displacements is similar to a leveling network. Hence, the design matrix is the incidence matrix, see section 8.3 in Strang and Borre [1997]. However, the incidence matrix is very big in our case, and it is difficult to illustrate the open (concave) and closed (convex) configuration in this way. Therefor, the adjacency matrix is used. It has now been clarified in the text.

Section 3.2: Some information is missing to fully understand the methods described here. The Hough transform proposed here is not standard and should be better introduced. At the moment, it is not possible to understand how Figure 2b is generated. For example, I understand that a pair that overlap only with $\mathbf{x}_1$ (resp. $\mathbf{x}_2$) is associated with a vertical (resp. horizontal) line, but how is the diagonal line ($d_{32,64}$ - $d_{0,32}$) obtained? Also introduce $\mathbf{x}_1$ and $\mathbf{x}_2$.

An additioinal paragraph about the Hough transform is added. The figure is now updated, and in addition to the toy example, also an annotation is added to clarify the relational property. This example is also highlighted in the text.

Section 3.3: Equation 2 needs to be fully explained, as of now, most elements are never introduced. What is x (the variable to be smoothed?), i (the pixel index?), hat operator (smoothed variable?) ? The smoothing only considers 1 dimension here, how do you consider the 3 dimensions (space + time)? I dont fully understand figure 4. Why is the variogram (4a) a scatter plot, I would expect a line. Does it show different samples or is the variability from one point to another very large? In this case, maybe use a larger step? Why are all dots of the same color, shouldnt the color scale be linked to the value of the variogram (y axis)? What is the unit of the color scale? The terms "nugget", "still" and "range" are never mentioned anywhere, either introduce or delete. Rewrite the caption to clearly explain panels a and b.Finally, after reading the variograms, I still dont understand why the "anisotropy factor" is set to 4.

The symbols are now explained in the text, and also emphasizing this is a one dimensional example. In reality the smoothing is done by taking all three dimensions into account (space + times). This is why the spatial temporal variance is plotted, this is in order to look at the amount of influence of neighboring points in space and time.
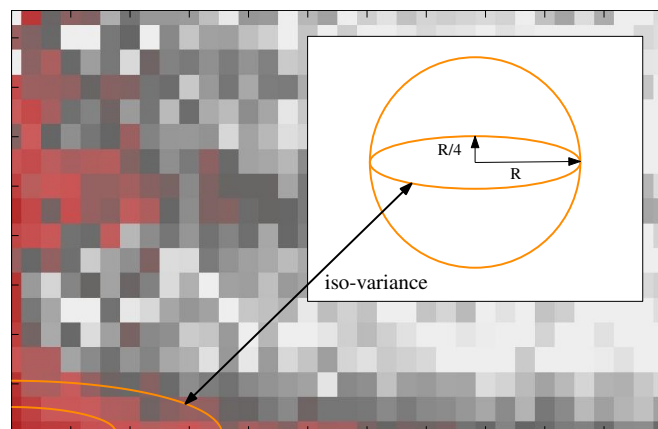

The figure above shows an ellipse which tries to follow the contour of equal variance. Its relation is one over four, as is tried to be visualized in this figure, this is where this anistropic correction factor comes from.

In the new manuscript the kriging terms are removed and an exponential function is plotted through the scatter.

Section 4.1: A more quantitative analysis would be expected here, and some sort of conclusions. For example, lines 17-19, I would like to see more qualitative measures of how the open vs closed configuration compare in term of coverage and noise in the stable grounds. Figure 5, 6 and 7 need to be improved significantly. It is sometimes impossible to see the differences between 5a and 5b or 6a and 6b discussed in the text. The panels must be either enlarged or zoom to specific areas should be provided. Here are some suggestions: - increase the size of the panels by removing redundant axes and color scales - merge figures 5 and 6 into 1? I dont even understand the difference between panels 5b and 6a, should they not be the same? You discuss coverage, but the figures dont show any no data, is 0 no data? What period are the velocity fields extracted from? I would like to see a comparison with an individual velocity field here. The whole discussion is somewhat informative but remain very theoretical without any good reference field.

We have changed the figures considerably, to make the difference more clear. Firstly, we took a timeslice out of the data-cube, which has two different data densities. That is to say, the western part has less velocity data then its eastern part. In this way the difference between both configurations can be seen more clearly. The "open" and "closed" configuration have different enhancements, and to make this more clear, zoom-ins have been created. Some of these are in the new manuscripts, others are at the end of this text. I hope these figures give a better understanding of the differences between both schemes, and their sensativity to data density.
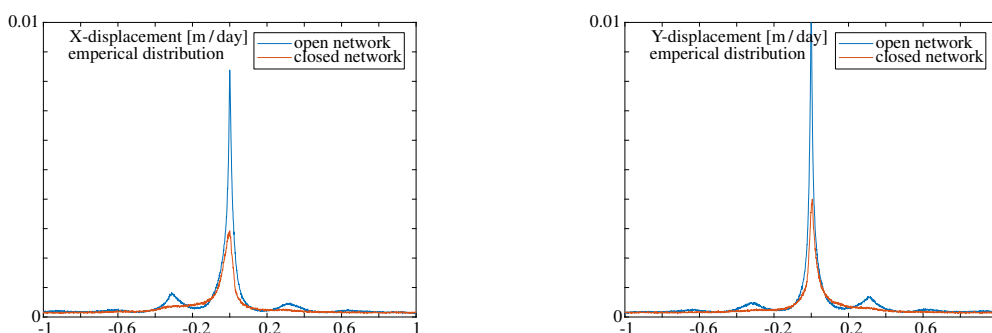
The figures above show the histograms of velocities through least-squares consensus for the x- and y- direction. For the "closed" configuration the amount of NaN's is 17.8%, while the "open" configuration has for 8.7% no data. The distribution of the "open" configuration is more concentrated towards no-movemnt, apart from a systematic bias towards integer values. Hence, there is an improvement when the "open" configuration is used, both qualitatively and quantitatively.

Section 5: This whole section should be moved before the glaciological interpretation in section 4.2.
done

Section 5.1: This part puzzles me. Until this section, I am convinced that the methodology is a step forward, but after this section I am not so convinced anymore. I understand the arguments that the result of the voting is obtained fully automatically and that it is limited because of gaps in the network, but (and Im being voluntarily provocative here) if the result is not more satisfying than an individual field, why not just find a method to select the best field instead? What is the difference between figures 5, 6a and 11 and why do the results look much worse on the latter? Is a larger period considered in figures 5 and 6? Or are the results on these figures not better? In which case this confirms the need to improve figures 5 and 6, in particular enlarge and add a no data color. Also the authors decided not to make this choice, how would the results change with a slight (as in not very strict threshold) filtering before the voting, or a weighting, based for example on the correlation score. I would think this help removing a large part of outliers, in particular in cloudy or sea areas, that seem to cause a lot of gaps. On the same topic, the results for the individual field (GoLive) and median are usually filtered post-processing using for example the cross-correlations score. It would be interesting to show such results. This would probably remove outliers at the expense of coverage, giving maybe more importance to your results? This would also highly reduce the MAD...

Now that the bug in the code has been resolved, the new results look better than the old ones. It is not as good as a clear velocity field, but there is a consistent estimate. In this study we have explicitly moved away from methods that rely on correlation scores, as this information is already used in the image matching. Hence, we wanted to explore and exploit a different property, and approach velocity data in a fresh and new way. This is a design issue, and for glaciers it might be true the median might be very robust to get the general flow.

Section 5.2: Again, move this section after describing the methods. P 16 last line "the distribution also show a clear improvement". Improvement to the voting but what about compared to the individual fields, or other methods such as median? This kind of analysis could also be used to discuss the open vs closed network.
A distribution plot of the voted estimate and the best GoLIVE data out of the stack are shown in Figure 9c. It does show the voted estimate preforms worse than this *lucky pair*. Comparing this, results in a known answer, but this is not the aim of this study. Half if not more of the 2000+ velocity fields are full of errors, smearing with a median does give a meassure to compare against.

Appendix: It took me a while to realize that the figures were described in the text. Move every description of the figures to the figures captions. Figures A should be merged together rather than being scattered on several pages. Figures B: Explain the boxplot. What is the red box (IQR?), red circle with black circle inside (median?) ? The reader does not have to guess. These figures should be improved for readability too: - simplify the boxplot, maybe show only IQR and median? - make the plots wider - for the scatter plot, change the x limits so that the scatter plot occupies the whole figure instead of 1/4 of it. Since you show the 1:1 line, there is no problem in using axes with different scales.
Done, plots have been improved and reduced.

Reviewer 1 - detailed comments
p.1 l.5-7: "'The visualization tool ... as glacier surge' Keep this sentence for the main text but remove from the abstract."
It is removed from the abstract, and placed in the conclusions.
p.1 l.9-11: "this paragraph is important since it tells the reader in one line what you are going to do. Rewrite because it is too vague right now."
changed to: "Our methodology is robust as it is based upon a fuzzy voting scheme applied in a discrete parameter space, in order to filter multiple outliers".
p.1 l.18: "'they can contribute considerably' → 'they contribute considerably'"
done.
sec.2.1: "What is the maximum time span in the GoLive products? Specify in the text."
included: "At the time of writing, displacement products can cover a time interval from 16 days up to 96 days.".
p.4 l.3: "You mean 42 000 km^2"
You are right, reduced the number.
p.4 l.4: "'the glaciological distribution of glaciers is diverse' Please explain, are you talking about ocean- vs land-terminating? Size? Aspect?"
changed to: "The glaciers in this area are diverse, as a wide range of thermal conditions (cold and warm ice) and morphological glacier types (valley, icefields, marine terminating) occur in these mountain ranges.".
p.4 l.5-7: "'at least two acquisitions' It is a weird statement, I assume you want to encompass the triplets in Altena and Kääb 2017? I think what is important is that the measure represents a time span (as opposed to instantaneous measure)."
Not necessarily, therefor included another sentence to be more clear. "When imagery from multiple time instances are used, combinations of displacements, with different (overlapping) time intervals can be constructed.".
p.4 l.16: "'multiple combinations of ... 16 days' Rephrase as it is a bit clumsy."
changed to "the 16-day revisit makes several matching combinations of integer multitudes of 16 days possible".
p.1 l.19: "'In this network every acquisition' → 'In this network, every acquisition'. Here and in many places, a comma is missing which makes it harder to understand."
Adjustements have been made throughout the text.
fig.2: "Just a warning, the figure does not show correctly depending on the pdf viewer. In the caption: 'at the right'

$\rightarrow$ 'On the right'."

Caption has been changed. Also the figure was been changed, so hopefully it will now work for any viewer.

eq.1: "use v instead of x? This makes more sense since you are talking about velocity."

The terminology for the unknown has been changed throughout the text, equations and figures..

p.8 l.6: " 'Resulting in a spatio-temporal stack...' This sentence has no subject and does not make sense."

changed to: "This least squares adjustment with voted displacements results in a spatio-temporal stack of velocity estimates that have a regular temporal spacing.".

eq.2: "again, introduce all terms here."

done.

p.9 l.26: "it took me a while to understand this sentence, rephrase or cut with punctuation, in particular 'surrounding of glaciers are stable or slow moving terrain' confused me."

changed to: "In the smoothing procedure the surroundings of glaciers, which are stable- or slow moving terrain, are included. Consequently, high speed-ups such as on the surge bulge on the Steele glacier (E) are dampened, as in this case it has a confined snout within a valley.".

p.10 l.7: " 'stable terrain, which has no movement' a bit redundant..."

removed "stable" and changed to "surrounding", and included "glacier velocities" for completeness.

p.11 l.17: " 'as the surge front progresses' It seems like the sentence was not finished..."

Added: "downwards".

p.12 l.5: " 'but seems to slow down' I would add, 'as shown by the break in slope' so that the reader understand what you are referring to."

Changed.

p.12 l.6: "I don't understand how you come to these conclusions, please explain or remove"

has been adjusted.

p.12 l.7: "Which figure is showing the speedup?"

The surge front is visible in figure 12.

p.12 l.10-11: "I dont understand these sentences. Please rephrase, some sentences are incomplete."

From a fluid mechanical point of view a moraine band is a streakline, when flow is steady streamlines and streaklines are similar. Looking at the patterns of moraines, it is therefor possible to assess, through a different concept, if the insights from the velocity fields make sense.

p.13 l.1: "I dont understand this sentence. Please rephrase, sentence is incomplete."

In the figure of the Klutlan surge, it is now indicated what is meant with upstream propagation.

fig.10: "caption: mentioin the period here"

done.

fig. 11: "half of the color scale for the velocity is saturated, please use a different one. It also looks like the 'voting' and 'median' results are much higher than the GoLive but this might be mostly due to the choice of the color scale?"

done.

fig.12(d): " 'GoLive' $\rightarrow$ 'Voting'. The title should be 'voting vs RapideEye' (y vs x) not the opposite, same for panel c"

figures have been adjusted.

p.17 l.10-16: "A suggestion would be to calculate a sigma that would be the (squared root) sum of the measurement error (that decreases with the time span) and the natural variability (that increases with the time span)."

True, the first term (measurement error over time) is now only included, however to put a number on the second term is challenging.

p.18 l.24: "Here and other places, you discuss the benefits of adding data from other sensors (e.g. Sentinel). I expect velocities obtained from different sensors, with different resolution and hence sensitivity to different features, to be quite different (as shown by figure 11 between RapidEye and GoLive for example). Would that not hamper the combination of the velocities?"

The radiometric resolution and spectral windows of Sentinel-2 and RapidEye are similar. Thus the features will have a similar *fingerprint*, however the resolution is not the same. A simple work around would be to do down-grading of the imagery.

References

G. Strang and K. Borre. *Linear algebra, geodesy and GPS*. Wellesley-Cambridge Press, 1997. ISBN 0961408863.