We thank Benjamin Wallis for his careful reading, his detailed comments and help in improving our manuscript. We have made all the changes suggested. Please find below our answers (in black).

Summary:

In this manuscript Charrier et al. present TICOI (Temporal Inversion using Combination of Observations and Interpolation) an open-source package in Python for the post-processing of ice-velocity observations derived from satellite observations. This TICOI package uses the principle of temporal closure of velocity measurements and builds on previous work by several of the authors which demonstrated this technique's application to ice velocity. This manuscript substantially develops this technique by introducing methodological developments to address shortfalls in previous versions, producing an open-source Python package to implement the method, and validating against GNSS glacier motion measurements.

Overall, in my opinion, this is an excellently written manuscript. I found the explanation of the TICOI method to be easy and intuitive to follow with an appropriate level of detail. The presentation of the results is clear, and the performance of the package is impressive, particularly when applied to retrieve sub-annual velocity fluctuations from long temporal baseline measurements. The authors provide a transparent and balanced assessment of the performance of their method, including a comparison to a conventional moving average smoother and using multiple datasets as inputs. I was also pleased to see a thorough discussion of the errors associated with remote-sensing ice velocity measurements, as this is overlooked in many studies.

I am confident that the method and software package described in this manuscript will be of interest to anyone in the Cryosphere community who works with remotely sensed ice velocity datasets. Adoption of this method would improve the velocity products produced in the community, in terms of accuracy and the representation of errors. This has great potential to be valuable to downstream users of these data for applications such as the study of processes influencing ice motion and modelling glacier and ice sheet behaviour.

Additionally, the authors say they will make their TICOI python package available online upon publication of a final manuscript, however, the package is already available at the link provided in the manuscript. Therefore, I took a brief look to assess the quality of the author's python package at this early stage. Even at this point before publication, the TICOI package is well documented including example code. The authors may choose to develop the presentation and documentation of the package further before publication, but as it stands, I have no concerns about the code and data availability. This is an excellent example of how to present open-source code. I applaud the authors for their effort in this regard.

I have a couple of small general comments regarding how the clarity of figures, terminology, and options for shortening the manuscript. After that, I have given line-by-line comments on more specific points. I hope these will be useful for improving the manuscript. See below:

Overall comments:

Figures: The quality of figures in this manuscript is very high. However, there are a few places where I think small changes would significantly improve the clarity and usability of the figures.

The choice of grids and map projection should be made more consistent. In Figure 2, the plots are given with a lat/lon border grid, but Figures 3 and 6 use an x/y grid. I would recommend maintaining the same coordinate system across these plots for better interpretability. Likewise, the units and map projection for Figure 3 are not given in the caption. I assume it is EPSG:3260 like Figure 6, but this isn't clear.

We thanks the reviewer for giving us the opportunity to improve the coherence of the coordinate system used in our Figures. We have modified all the grid to a EPSG:4326 grid. We provide coordinates with a suffix, and 2 significative number. We also specify the map projection in the caption of Fig 3 and 6.

It can be hard to read the figures in this paper when they are presenting large volumes of ice velocity data (eg. Figure 3c, Figure 8a, Figure 11). Could these figures be expanded to the full width of a page, or use vertically stacked separate axes for the image-pair velocities and TICOI results? Similarly, the red/pink/orange colour scheme is difficult to read, especially in Figure 8a. I appreciate that presenting this volume data on one plot is always difficult.

We thanks the reviewer of this suggestion. We splitted Figure 3c in two plots, and increase the size of the two other figures.

Length: The manuscript is somewhat long with 12 figures and 2 tables. Moving some of the figures to the supplementary material could address this and make the paper more focussed on the key results and takeaway messages. Specifically, I would suggest figures 5, 7, 10 and 12.

As suggested by the reviewer, we have moved Figure 5, 7 and 12 to the supplementary material. We kept Figure 10 in the main manuscript to facilitate the interpretation of the spatio-temporal profile.

Use of the term 'regularized': The term 'regularized' is used early on (line 58) here to refer to an even temporal sampling, but later in the manuscript is used for regularization in the context of solving an ill-posed problem. The latter usage is what I would expect the term to refer to in a scientific paper, and I think most readers would approach it this way, too. I think it's okay to use regularized to refer to even temporal sampling where it is clearly explained, like it is with the brackets in line 58. However, in some places in the manuscript it is ambiguous, for example 'regularized' and 'regularization' in the title and abstract could refer to either aspect. For the sake of clarity, the authors could consider choosing a different term to refer to sampling the data on a regular time-step. For example, something like 'temporal standardization'. Although I concede this is not as catchy.

We thank the reviewer for highlighting this point! We have replaced 'regularized' with 'regular' (i.e. sampled at regular time steps) in the manuscript.

Line-by-line comments:

135: There is a hard limit of u =10 for iterations. Can you comment on how often this limit is reached? What is the average number of iterations required?

This limit is rarely reached. The average number of iterations required is about 5 to 6, in our test sites.

156: Could you also comment here on how this RMSE convergence behaves for faster glacier flow, e.g. the > 1000 m/yr speeds that are common for outlet glaciers?

We thanks the reviewer and added : « Note that this asymptote could be reached with a smaller temporal sampling for faster glaciers. »

206: Can you comment on how the VVC metric is affected by changes in ice flow direction? This can be significant on ice-shelves particularly around rifts.

The VVC is only used to select an optimal regularisation coefficient by looking at the inflection point of the VVC curve. If there is a real change in the glacier flow direction (e.g. around a rift, over parts of the ice front or glacier convergence areas), the solution will still converge to a plateau, which has a lower value than for the case of a constant flow direction. In any case, it is advisable to calculate the VVC over relatively large areas (such as a whole massif) in order to be more robust. Lastly, it's important to emphasise that TICOI never restricts the direction of the flow.

We added in the text, at the end of section 2.4:

If there is a real change in velocity direction over time, the VVC curve will converge before 1, but the curve will still have an inflection point. For better robustness, it is advisable to calculate the VVC over a relatively large area.

231: Should be ‘validated’ not ‘validates’

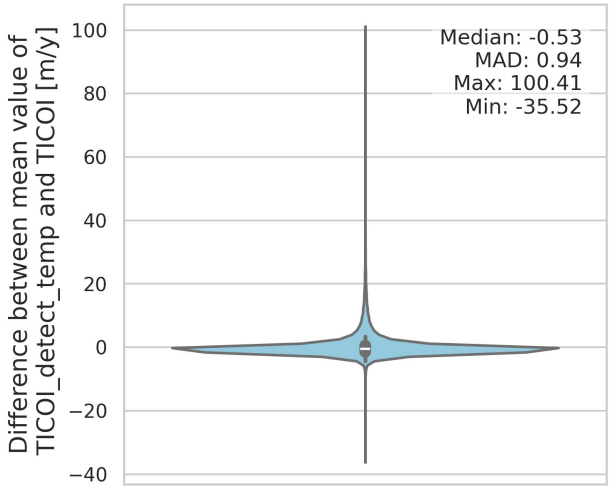
Corrected.

293: In this section, it would be insightful if you were able comment on how the different algorithms perform, ie what are their strengths and weaknesses? They are quite different, so this may be helpful to a reader who is not familiar with these datasets.

We thanks the reviewer for this recommandation and added a few lines :
The strength of ITS_LIVE is to be available worldwide in open access from 1980s to 2023, while the IGE dataset, published in \citet{millan2019mapping}, covers only two years. The strength of the IGE dataset is its spatial resolution (50 m against 240 m) which allows velocities of relatively small glaciers to be captured. A more detailed comparison is beyond the scope of this paper.

347: I don’t think that Figure 3a supports the statement that ‘Over stable areas, the difference has median values of 0.0 m/yr’. In Figure 3a it appears that most of the areas outside the glacier outlines have a negative value, as shown by the general blue shading. Can you explain this difference and clarify this point in the manuscript?

We thanks the reviewer for this comment. We have checked our analysis. After reprojecting the raster of differences, the border of the images included nodata with a value of 0. This was taken into account in the analysis. After correcting that the violon graph over the area is:



However, we removed this graph and added a comparison of the statisitcs in stable areas, as suggested by reviewer 2:

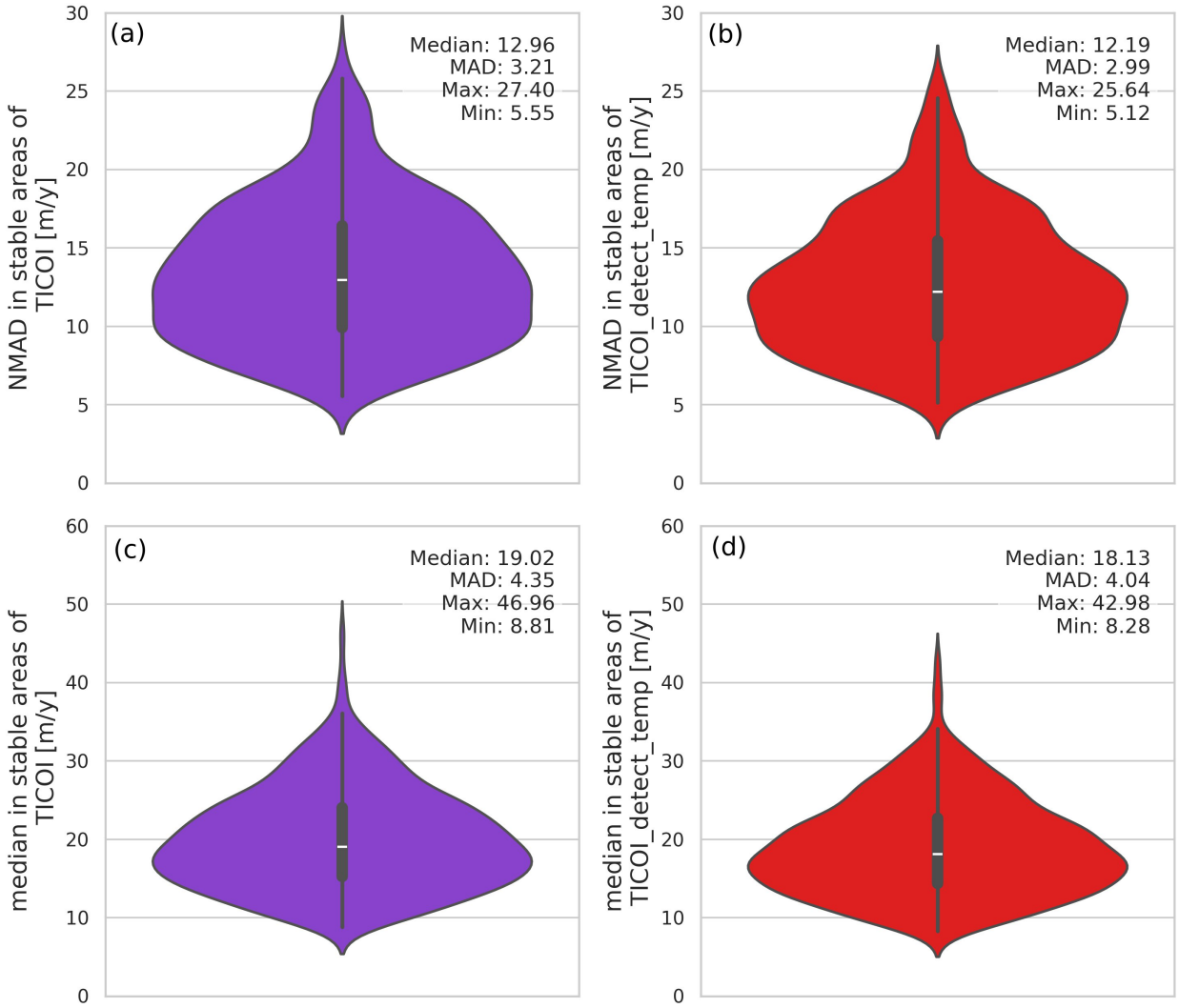


Figure 3 caption: The caption refers to white lines for glacier outlines, but they are grey in the figure.

Modified to grey

Figure 3 caption: From the figure and caption it's not obvious to me if the difference being plotted is TICO – TICOI_detect_temp or TICOI_detect_temp – TICOI. Based on Figure 3c I think it's the latter, because this value is positive and point A is red on the map, but it's not clear to me. This should be clarified in the caption.

We thanks the reviewer for spotting this error. The caption was accurate but not the legend of the figures. We are ploting the difference betwen TICOI with and without an automatic detection of temporal decorrelation.

369: In this paragraph including some absolute values as well as % change could be useful for giving the reader a better understanding of the results.

We thanks the reviewer for this suggestion. We added absolute values for RMSE and KGE. We removed the absolute values for the KGE as suggested by the other reviewer.

370: It's confusing to say KGE increased if the range includes a negative percentage.

We modified « an increase in KGE up to 87\%, with a median improvement of 62\% ».

371: In my opinion it is best if the term 'significant' is reserved to refer to specifically to statistical significance. I would consider choosing a different term where possible, also on lines 387 and 445.

We have modified 'significant' and 'significantly' to important, large and drastically.

Figure 9 caption: The caption refers to a logarithmic scale in a), but the colourbar isn't logarithmic.

Thanks for spotting this error.

477: I think this should read 'RMSE even slightly increases'?

We have corrected this error.