Response to Reviewer 2

General Comments

Reviewer Point P 2.1 — The author presents a new software for the determination of river surface flow velocities and river discharge using videos. It is based on a combination of optical flow and automated corner point detection algorithms. The underlaying detection algorithm used is the Good Features To Track and the tracking is done by using the Kanade Lucas Tomasi method. The software is freely available, it has a clean and intuitive graphical interface. It has a very good set of options for camera calibration / stabilization. To my knowledge there is no freely available software which uses the same method, hence it is a good addition to the already available tools. The author has also done a good work on keeping the amount of parameters to a minimum and giving default values for them. The paper is clearly written, with a good description of the software functionalities.

Reply: I would like to extend my thanks to the reviewer for the detailed comments and suggestions made, all of which have enabled the improvement of this manuscript. In this document I will respond to each comment individually, and outline the changes made to the revised submission.

Specific Comments

Reviewer Point P 2.2 — My main comments are related to the validation and limitations of the software and of the algorithms implemented in it.

The author presents two case studies, the first one, the River Feshie where 10 videos taken from a fix camera and 4 videos from UAS were processed. The results are used to fit a rating curve, the deviations between the reconstructed rating curve and the measurements is mentioned to be 4%. However, it would be desirable to have a comparison against a different methodology e.g. ADCP. Has the author performed such comparison?

Reply: At the locations of the two case studies presented in this article, I have not been able to acquire velocity measurements using standard methods whilst concurrently capturing footage for image velocimetry analysis. Within the Methods sections (Lines 163–166) and in the newly introduced Section 5: 'Challenges and Future Development' (Lines 485–487), findings presented by the Pearce et al (2020) study are introduced. These are the only published inter-comparisons between KLT-IV and other approaches at this time. This lack of formal assessment will be addressed in further works.

Reviewer Point P 2.3 — In Figure 4 it can be observed that the measured discharges deviate the most from the rating curve at low flows. It seems that the implemented method gets less accurate results for lower velocities. This brings me to my second comment. The paper is missing a section where the software limitations are explained, for example what are the minimum velocities? Are there a minimum set of characteristics to be fulfilled, e.g shadows, glare, type of flow, minimum camera angle, minimum video duration, etc.?

Reply: As a complete assessment of KLT-IV's performance at this site relative to standard techniques has yet to be completed, it is difficult at this point to draw conclusions about its performance. This is currently the subject of further assessment and research. I have now added a section which goes into some detail about the limitation of the software. In Section 5: 'Challenges and Future Development' (lines 475–504). I present guidance related to the minimum required image resolution, requirements related to the presence and distribution of features to track, considerations relating to image illumination, and I also note a key limitation of the software, namely the lack of post-processing options for filtering spurious trajectories. An objective of future works will be to assess the sensitivity of the software to varying levels of seeding densities, clustering, image illumination, etc. across a range of flow conditions.

Reviewer Point P 2.4 — The results from processing a video recorded with a fixed camera and with an UAV at the same river stage are shown in Figure 5. The trajectories are qualitatively different, what is the reason for that? Is it because of the angle of view of the fix camera? Is it related to the orthorectification process? What are the limitations?

Reply: The dataset from the fixed camera is certainly noisier than that acquired from the UAS and this is likely to be due to several factors, not least the short duration fixed camera video (10-s) relative to the UAS (60-s). Furthermore, at this site, under the high-flow conditions presented in Figure 5, the water surface deviates from the planar assumption that is required for the analysis. The UAS footage will be less sensitive to these local changes in water surface elevations than the fixed camera. Therefore, the oblique camera angle of the fixed camera is likely to produce less favourable results. This information has been incorporated into the manuscript text at Lines 387–395).

Reviewer Point P 2.5 — It would also be nice to see some insights on the uncertainty of the model and sensitivity of the parameters. This would help to chose the right value for them.

Reply: Analysis of the sensitivity of KLT-IV to the two main user defined parameters has been undertaken for three of the fixed camera videos acquired at the River Feshie. Results are presented in Appendix C, and a discussion of this is presented at lines 396–402. The text reads: 'An illustration of how the generated outputs vary with changes to user-defined settings of extract rate (s) and block size (px) are demonstrated for a selection of the fixed videos acquired at the Feshie monitoring station (Appendix C). Generally, varying these two parameters results in relatively small changes to the velocity profile, with the mean values of the reconstructed velocity profile ranging from 0.89–$0.94\,\mathrm{m\,s^{-1}}$ (Video 8), 1.18–$1.29\,\mathrm{m\,s^{-1}}$ (Video 2), and 1.68–$1.80\,\mathrm{m\,s^{-1}}$ (Video 6). In each of these examples, the selection of a broad range of input settings resulted the cross-sectional average velocity varying by less than 10%. Of note however, is that deviations in the velocity profile are most sensitive to changes in these parameters in the near-field where features may transit the scene rapidly, and the far field where features are difficult to resolve.'

Technical Corrections

Reviewer Point P 2.6 — In line 140 it is mentioned that the free-surface image velocity measurements must be translated into a depth-averaged velocity, however it is never explicitly mentioned that the Alpha value in the GUI is meant for that.

Reply: This was accidentally omitted from the original submission and has been added at Lines306–308. The newly inserted text reads: ' Finally, an Alpha value needs to be provided. This is the ratio used to convert the measured surface velocities to depth-averaged velocity, which is then used in the calculation of discharge. A default value of 0.85 is generally appropriate if no supplementary data is available to inform the user (see Section 1.3 for more information).'

Reviewer Point P 2.7 — Line 188. It is mentioned that the mode 'Single video' is the default one, but there no other modes. This should be mentioned here or, if possible, change this field in the GUI until another mode is implemented.

Reply: To ensure that the user interface does not vary too much from version-to-version, the video mode was inserted into v1.0 despite no other alternative. In v1.1 'Multiple videos' will be enabled. The text at Line 190–193 has been modified to read: 'The first section: Video Inputs, is where the video acquisition details are provided. Within v1.0 of the software, only 'Single Video' mode can be selected, meaning that only one video at a time can be analysed, and this video may be selected using the file selection dialog box.'

Reviewer Point P 2.8 — Lines 410-455 (discussion section) I think it would be better to focus this section on the limitations and accuracy of the software, or to add that to the discussion.

Reply: Please see response to P 2.3.

Reviewer Point P 2.9 — Line 479. Add the word "software"

Reply: This has been modified to read 'Software and Hardware Requirements' (Line 527).

Reviewer Point P 2.10 — I tried to ran some cases but I could only process one: /Feshie/FixedCam/Video_02, for all the other cases that I tried, the software crashed, without much information about the source of the crash. For the case that I was able to process, I got a value which was out of the reconstructed rating curve, probably one of the provided files is not correct.

Reply: I hope to be able to understand the nature of the issues encountered more fully to hopefully resolve this. If possible, please could you provide more information as a comment, or post to the software forum at: `https://groups.google.com/forum/#!forum/klt-iv-image-velocimetry-software` with more information.
