First of all, we would like to thank both referees (Salvatore Manfreda and one anonymous referee) that they invested their time and reviewed our manuscript in great detail to provide very constructive comments. We gladly consider each note to improve our submission.

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The main contribution of the present manuscript is oriented in exploring surface flow velocities and discharge estimations using fixed cameras and UASs devices. A full and automatic workflow is introduced for the estimation of the variables mentioned above. Two case studies are considered for validation purposes, namely the Wesenitz (paved) and Freiberger Mulde (natural). ADCP data were collected for benchmarking purposes. The manuscript is almost well written and easily understandable. Its length is also appropriate.

Major comments:

Section 2.2.1 Reference data: The authors stated that surface flow velocities were extrapolated using ADCP measurements. However, they do not say anything about the process. Please, add information on the extrapolating process. Additionally, at Wesenitz case study, only one cross-section was measured. Why such a decision? (consider that for a rigours comparison between image-velocimetry results and reference velocities is better not to use only local reference velocities).

- Thank you for your comment. We will clarify in the revised manuscript how the ADCP measurements were extrapolated. Extrapolation of surface flow velocities was performed by a procedure suggested by Adler (1993) and also described in Morgenschweis (2010). The procedure is implemented in the AGILA software; thus we believed that further details were not required. In general, it approximates a power function to the measured vertical velocity profile for each ADCP ensemble individually. Then, surface velocity (vs) is calculated by:

  vsi = ai * hi^(1/6)

  with h – water depth and
  a – factor (determined from measured depth-depended velocities) for each ADCP ensemble, with
  i – number of the ensemble, representing the position within the cross section.

  This means, that surface velocities were extrapolated using all velocity measurements of the ADCP. At the Wesenitz site, ADCP cell sizes of 3 centimetres were used, which resulted in up to 10 depth-depended velocity measurements per ensemble.

  - Adler, M.: Messungen von Durchflüssen und Strömungsprofilen mit einem Ultraschall-Doppler-Gerät (ADCP). Wasserwirtschaft (83) 1993, H. 4, S. 192–196.
  - Morgenschweis, G.: Hydrometrie, Springer-Verlag Berlin Heidelberg, S. 582, 2010. DOI: 10.1007/978-3-642-05390-0_1

- The Wesenitz study site is located at the gauging station. It is a straight channel with paved, trapezoidal cross sections and nearly uniform flow conditions. Thus, surface velocities vary only slightly and one cross section seems to be representative. We performed more measurements with different water depths and locations showing similar results. But we did not want to put so much focus on this because the idea of the manuscript is to compare measurements with different sensors and platforms under uniform and non-uniform flow conditions.

Section 2.2.2 Image-based data: The authors used a low-resolution camera for video acquisitions at the Freiburger Mulde case study. Justify such a decision considering that low-cost smartphones can reach a better resolution.

- Indeed, the authors used a low-resolution camera. The specific camera was originally chosen because it is also able to record high speed videos. However, analysis of these videos revealed that high speed frame rates do not necessarily improve the tracking quality but increase processing time significantly. Thus, we focused on the video with the lower frame rate, although the image resolution was low. Nevertheless, comparing our results to the ADCP measurements could still reveal the high accuracy potential highlighting that even low-resolution cameras can be used for the task of flow velocity and discharge measurements. In addition, the SLR cameras at the Wesenitz study site enabled a detailed analysis of image velocimetry with imagery with higher resolutions.

Section 2.4.3 Feature tracking: The authors stated, 'In this study, features are tracked for 20 frames and new features are detected every 15th frame'. Is there any reason for these numbers? Why did the authors decide a new detection every 15 frames?

- The decision for tracking for 20 frames and detecting features every 15 frames was chosen after evaluating different choices for tracking and detection. Although, other choices were possible (e.g. 10 frames tracking and every 10 frames detection), we settled with these settings as the results revealed steadiness and processing time was acceptable. This choice was therefore based on our experience with both rivers.
- The more frames are tracked across; the more reliable and robust tracking results are possible because the later filtering will have a larger sample for processing. However, the longer features are tracked the longer the processing time is going to be. Choosing feature detection every 15 frames allowed us to densify the final feature tracks. Features can change and new features enter the area of view although the already detected features are still tracked. Thus, it can be suitable to detect features more frequently than the number of frames they are tracked across. Thank you for highlighting the lack of explanation in the manuscript. We will add this information to the revised manuscript.

Section 2.4.4 Track filtering: This subsection is relevant and deserves a better explanation of the filtering criteria. For example, it would be positive to add a figure showing an example of application of the different filtering criteria (e.g. what is the reference for the angles?).

- Thank you for your comment. In fig. 5 we already implemented four sub-figures, which show how the different filtering steps improve the tracking results. However, we can add two more sub-figures to highlight more specifically, how the consideration of sub-track directions and the deviation from the average flow direction. At the moment these filtering steps are merged in one figure (5 d).
- The reference for the angles are chosen differently. The average flow direction is calculated from all tracks and then a buffer value is chosen to exclude tracks that exceed the average flow direction by a specified threshold. This threshold has to be defined considering the general variability of the river surface flow pattern. The other criteria concern the steadiness of the tracks. If the standard deviation of the sub-tracks is above a specific value, they are excluded because we assume a steady flow for a track. Again thresholds are chosen considering the general flow characteristic of the observed river. We will add some more information to the revised manuscript regarding the choice of the thresholds.

Section 2.4.5 Velocity retrieval: The authors stated: 'The threshold is defined as the sum of the average velocity with a multiple of its standard deviation'. Please, add information about the 'multiplying factor' of the standard deviation.

- The multiplying factor has to be chosen according the quality of the filtering results. If the factor is set to a high value only a few values, which deviate strongly from the average velocity, are removed. And if a low value is chosen, many more tracks are filtered out, which might be wanted in situations, when solely the most reliable tracking results are aimed for. We will add this information to the revised manuscript.

Section 2.4.5 Velocity retrieval: The authors stated: 'For a better visualisation, final flow velocity tracks are rasterized'. Please, add information about the block assumed for the rasterizing process. If the comparison of estimated velocities is made with the rasterized velocities, please mention it and discuss implications.

- In this study we assumed a block of 20 pixels. However, we did not compare the rasterized velocities. We only used the original velocity tracks for comparison to the reference to avoid inaccuracies due to interpolation errors. In this study, the rasterized data is only considered as a visualisation tool and therefore we will remove it in the revised manuscript to avoid confusion.

Instead, we will implement a figure that contains the final tracks and the location of the ADCP track including a buffer to identify, which features were used for velocity comparison.

Section 3.2 Flow velocity measurements at the Wesenitz: The authors stated 'However, it is difficult to perform exact comparison to the ADCP measurements because the precise location of the ADCP cross-section in the local coordinate system of the river reach is not known as the ADCP boat was not equipped with any positioning tool and its movement across the water surface was neither tracked nor synchronised. Therefore, the accuracy assessment of the spatial velocity pattern is limited'. This is a critical issue that may limit the validation of the procedure. Do you have any alternative strategy to quantify ADCP positions in order to allow a realistic comparison?

- In this study, we were able to identify the start and end points of the cross-sections in the imagery at the shore. Therefore, we could approximately estimate the locations of the cross-sections. However, the location could only be estimated in the dm-range, which allows for velocity comparison if the surface flow velocity pattern does not become too variable within shortest distances. We just wanted to highlight that this has to be kept in mind. We will add this info to the revised manuscript.

Minor comments:

Page 2, Line 2: '. . .observe flash floods. And Le Coz et al. . .'. Please, remove the point before 'and'

- Thank you for the comment. We will change this in the revised version.

Page 2, Line 22: Please, consider starting a new paragraph after '. . .then searched for in the subsequent images.'.

- Thank you for the comment. We will add a new paragraph in the revised version.

Page 3, Line 4: '. . .flow conditions. And Costa et al. (2000). . .'. Extra point into the sentence.

- Thank you for the comment. We will remove the extra point in the revised version.

Page 4, Line 12: 'Here, average water level and discharge are 48 cm and 2.2 m 2 /s, respectively.' Mean annual variables?

- Indeed, these are annual averages. Thank you for highlighting this. We will add this information in the revised version. However, please see the next comment for further details.

Page 4, Line 19: 'During this day discharge and water level were 5.7 m 3 /s and 68 cm. Considering the information provided before (Average discharge and water levels are 6.9 m 3 /s and 66 cm, respectively), why a decrease from 6.9 m3/s to 5.7 m3/s (17% of difference) is creating an increment from 66 cm to 68 cm in terms of water levels?

- We checked the numbers again. They are correct. The measured values at that day (5.7 m^3/s and 68 cm) were obtained by continuous water level measurement and application of the rating curve, which was valid during that time. However, average discharge and water levels are long-term averages based on more than 50 years of measurements. In comparison with the values of that day, we see two effects, which are responsible for the differences. First, rating curves are changing over time (At the moment, a discharge of 5.7m^3/s is assigned with a water level of 66 cm). Second, rating curves reveal a nonlinear behaviour. With increasing water level, the discharge increases stronger, which has an impact on the averages. Thus, direct comparison of both pairs of values is not possible. However, to avoid this confusion we will compare the values of that day to the average values of the hydrological year 2016, which are 5,6 m^3/s discharge and 65 cm water level, which will also change for the Wesenitz case study to obtain consistency.

Page 5, Line 19: '. . .the performance of different cameras (fig. 1b). Two. . .'. Fig. 1a?

- Indeed, this would be figure 1a. Thank you for noticing. It will be changed in the revised manuscript.

Page 6, Line 31: '. . .to matching failure. And if moving. . .'. Extra point into the sentence.

- Thank you for your comment. We will correct this in the revised version.

Page 9, Line 10: '. . .suitable at the Wesenitz. But at the Freiberger. . .'. Extra point into the sentence.

- Thank you for your comment. We will correct this in the revised version.

Table 2: What is s0?

- s0 is sigma 0 and it is a resulting quality parameter of the adjustment of the spatial resection. It provides information about how well observed values fit to the adjusted values.

Page 11, Line 29: '. . .2.7 m 3 /s, which corresponds to the velocity measured by the ADCP. . .'. Discharge.

- Thank you for noticing. We will change this to discharge in the revised version.

Some hints regarding author's changes in the revised manuscript have already been given in the comments section. Here, a summary of author's intended changes to the manuscript based on comments of both referees is given.

- Focus stronger on the tool itself and its usage, thus be more specific regarding the tool (keep information about each processing stage not just in the tutorial).
- Explain in more detail limits/constraints (e.g. wind, shore visibility, ...), pre-requisites/ needed input (e.g. camera orientation/position or GCPs, ...), and expectable results of the tool.
- In general, explain more detailed how setting of thresholds influence tracking result and what parameters should be considered depending on the flow characteristics at different sites.
- More detailed explanation regarding the parameter choices for feature detection and tracking (i.e. detection every nth feature and tracking for n number of features).
- More detailed explanation regarding the individual thresholds for track filtering.
- Clarification of the threshold (multiplying factor) definition of the statistical outlier filter.
- Clarification of the ADCP extrapolation.
- More guidance regarding computational time for filtering considering frame rate and image resolution.
- Explanation of the limits for the image-based to ADCP based velocity comparison due to the accuracy of the position estimation of the ADCP.
- Add in figure 1 image area extents of each camera.
- Addition of sub-figures (in fig. 5) that show the results of the different feature track filtering steps.
- Removal of the figures with the rasterized velocities (fig. 8 and 9) and instead add figure with the final tracks. In addition, add to this figure location of ADCP cross-section(s).
- Improve the readability of the manuscript.
- Include an appendix with information about accuracies for estimation of exterior camera geometry
- Provide the manual of the tool as a separate supplement (in addition to the huge supplemental zip-file)