Answers to the comments from referee #1

We would like to sincerely thank the reviewer for their valuable suggestions and comments. In the following sections we have tried to address all of them and have made appropriate changes to the manuscript itself.

On the "U" in UAS

As the authors of the manuscript, we wholeheartedly support the motion for increased inclusivity in science. At the moment of the submission we were not all aware of the brochure that EGU had published (https://blogs.egu.eu/geolog/2021/01/13/accessibility-at-egu-promoting-inclusive-language-an-incomplete-guide-2/) to which the handling Editor had pointed us to. This brochure could not be found on the HESS website, and no mention of it was made in the HESS Guidelines for Authors (https://www.hydrology-and-earth-system-sciences.net/submission.html#english). The brochure also does not appear to mandate the use of such terms but rather encourages and suggests it – something that we, as a team, recognize and support. Hence, it could be argued that HESS, as a journal, does not mandate the use of such terms either and that they are not part of the journal's standard. After the publication of the incomplete guide (v1) on February 2020 different papers have been published in HESS containing the term "unnamed". Here are some examples:

> https://doi.org/10.5194/hess-2020-271
>
> https://doi.org/10.5194/hess-24-3643-2020
>
> https://doi.org/10.5194/hess-24-5173-2020

Decision to submit our work to HESS was made exclusively based on the basis of the exceptional scientific reputation of the journal. For all these reasons we have decided to focus primarily on the scientific content of the reviewer's comments, leaving the decision on the linguistic issues in the hands of the Editor. However, we have included several alternative terms for "unmanned" in the Introduction section when it first appears, in order to suggest that there are other terms indicating the same technology.

Specific comments from the supplementary PDF

Responses to the comments made by the reviewer are prefixed with the term **Authors** in a new line. References to specific lines are with regards to the unrevised version of the manuscript. Text in [square parentheses and in orange] are inserted by the Authors for clarification where needed.

Line 40: "See my comment/response to the authors' preference for this term."

Authors: We have written a substantial answer in the previous section of this document. In the revised manuscript we have added additional/alternative terms for "unmanned" in the parentheses.

Line 63: "You might also mention that generally one wants to maximize the viewing area, so often there is only the water surface in view (or just barely some non-moving parts). this complicates many things."

Authors: We agree with the reviewer, and we have added the following sentence: "*In order to maximize the amount of available information in the ROI (i.e., pixels per cm), the size of static areas in the image is often kept as low as possible (giving more space to the water surface) which also limits the applicability of 3D stabilisation methods.*"

Line 64: "Can this be quantified? i.e. it would be great to provide an estimate, perhaps based on literature, how much horizontal movement there is in comparison to vertical movement or rotation. is it 10-1? 5-1? 100-1?"

Authors: As the ratio of horizontal to vertical movement of the UAV depends both on the technical specification of the aircraft, as well as the local conditions, such estimate would be difficult to substantiate. Looking at the manufacturer's brochures, the horizontal positioning accuracy in hover mode appears to be around 3 times as much as the vertical positioning accuracy. Also, the amount of rotation (pitch, roll) is far more difficult to predict, and cannot be directly compared to the amount of translation due to different nature of the motion. However, additional sentence is added to clarify this issue: "*For the aircrafts used in this investigation, manufacturer specifies that the positioning accuracy in hover mode is three times higher in vertical direction, when compared to the horizontal.*"

Line 104: "Any comment on lens or perspective distortions? It might not be in the scope of the paper, but perhaps add a sentence that mentions how these are issues that will not be addressed in the current paper."

Authors: We agree with the reviewer that this is worth mentioning. Two additional sentences are added to the paragraph: "*The issues of camera calibration – estimation of internal camera parameters such as the focal length, optical centre position, radial and tangential distortion parameters – were not addressed in this research, but can be found in literature (Mathworks, 2021a). Images used in this investigation have had the camera distortion removed prior to the analyses.*"

Line 171: "Might be confusing to use this term [interrogation area, IE], as the same term and abbreviation is used for pattern-matching regions using PIV. In fact this whole sentence is confusing - are you referencing looking for particle displacement to measure velocity? You refer to static-feature displacement to measure frame movement (which is very similar to measuring flow velocity) but this is potentially confusing."

Authors: Indeed, most of the tools presented in this manuscript are mechanically similar to some of the image velocimetry methods, especially PIV and PTV. We intentionally used the same terms when describing the delineation of images into subregions containing static features (IA, SA), hoping that the readers with knowledge on velocimetry methods would be able to understand the mechanics of these stabilisation methods as well. However, as the reviewer pointed out, this may be confusing for some readers, so the following sentence was added later in the paragraph: "*This approach to the*

estimation of the static feature displacements is very similar to some image velocimetry approaches (such as the PIV) which pattern-match the interrogation areas (IAs) from one frame to the broader search areas (SAs) in the following frame to estimate the displacement of tracer particles. Due to such mechanical similarity, we have used the same terms (interrogation and search area) when describing some stabilisation tools in this paper."

Line 205: "This is probably not the place to mention it [SA update limitations of FFT-DCH tool], but what about when the apparent movement is different in each location? This has happened to me when the movement is 3D, which actually does occur frequently."

Authors: This sentence was added by the author of the tool in question in order to immediately and truthfully recognise some of its current limitations, especially with regards to the statement in lines 174-175: "*Once the new feature positions are estimated, the positions of the search areas are usually updated for the following image…*". This does mean that in cases with significant camera motion (such as in the Basento river case), this tool would not be able to consistently follow the motion of the static features across the entire video and to stabilise accordingly. The sentence in question is now expanded to properly explain our intentions: "*At the time of the analysis, the available version of the tool did not allow the search areas to be updated with the positions of tracked features from the subsequent frames, which limits its applicability to those cases where the camera frames do not deviate significantly from the initial frame of the video.*"

Line 313: "Why? yes the gimbals help, but careful – in windy conditions, for example, you can get a fair amount of pitch and roll."

Authors: We acknowledge the comment of the reviewer and have hence added a sentence to the end of the paragraph: "*In cases where pitch- and roll-type rotation of the camera can be identified (e.g., strong wind conditions), the use of perspective transformation method is necessary in order to ensure proper stabilisation.*"

Line 319: "Any recommended tools for this?" [removal of the camera distortion]

Authors: Two appropriate references are added: (1) Matlab's Camera Calibration Toolbox, and (2) Python's OpenCV library.

Line 457: "It should say in the caption that this is for the Kolubara case."

Authors: This is indeed the case, and the reference to Kolubara river case study is now added to the caption of the Table 2.

Line 578: "What does this indicate to you? something about the area, or something about the raw video? Might want to expand on this, if you haven't in the discussion."

Authors: The exact cause of such results was not properly identified in the investigation. One of the explanations could correlate the lower contrast in those areas, compared to the other parts of the

image, to the difficulty of identification of feature displacements inside of them. Other explanations, related to the flight conditions or camera itself would be unsubstantiated, and are probably better left out. An additional sentence is now added to the paragraph: "*The exact cause of higher displacements of static features in these regions (compared to the features in other sections of the images) was not definitively identified in this study, and it could be related to both flight and/or ground conditions.*"

Other minor changes have been made to improve readability as per reviewer's suggestions.