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Interactive comment on "Short Communication: Optimizing UAV-SfM based topographic change detection with survey co-alignment" *by* Tjalling de Haas et al.

Anonymous Referee #1

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The manuscript discusses the advancement of the already introduced method of time-SIFT/ co-alignment to improve multi-temporal changed detection with SfM. The authors investigate the differences in performance when using the common approach of change detection (reconstructing and referencing each dataset separately), a co-alignment approach with more than two datasets and an approach that co-aligns and implements GCPs. Their results suggest a performance improvement of the latter two methods. The manuscript is well structured and written in a manner that makes the content easy to understand.

I do like the idea that this study eventually implements GCPs, which was thus far miss-

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ing in the previous studies introducing time-SIFT. This consideration would be needed to highlight that the usage of co-alignment should be preferred over the standard workflow (i.e. separately processing each dataset) as long as sufficient stable areas are visible in the area of interest. However, to indeed evaluate how the usage of GCPs in time-SIFT might outperform the common approach the comparison with an independent method is missing. For instance, the usage of check points (which are GCPs that are not implemented in the bundle adjustment to reconstruct the 3D geometry) or TLS datasets would be a possibility to check whether the final models processed with time-SIFT and GCPs reveal similar or better absolute accuracies compared to the common approach. The authors have distributed quite a few GCPs and could therefore consider using some off them as check points.

The authors do compare their methods using the average of all models of stable points in the area of interest. This is very sufficient to investigate whether relative changes are detected correctly. However, it is not possible to assess absolute accuracies of change detection, as the scale can still be wrong. By implementing GCPs an improvement of absolute accuracies and thus potential scaling errors should be mitigated, which can remain when co-alignment is used without geo-referenced markers and solely relying on the camera positions of poor quality (if not RTK or PPK capable UAVs are considered). Without geo-referencing (directly or indirectly) absolute magnitudes of change still might be false. In the current manuscript version, the authors solely see an improvement regarding the relative accuracy by using GCPs as they do not compare it to independent data, but the actual potential improvement regarding scale/absolute orientation accuracies is yet to be shown. And the improvement of relative accuracies has already been demonstrated by Cook & Dietze (2019) and Feurer & Vinatier (2018). Furthermore, the illustrated improvement of relative change detection when using GCPs in time-SIFT does not seem to be statistically proven (when looking at the average change and its standard deviation in figure 3, where the latter is larger than the former). Did the authors check whether the difference between approach 2 and 3 is significant?

The authors further highlight that they use not just two datasets but in total nine, which allows to also improve surveys with weak image geometries. This is an important note. The authors nicely illustrate that the higher the number observations (i.e. number of tie points across more images) the better the reconstruction (which is well-known to photogrammetry). However, I think the manuscript would benefit if the authors might also have a closer look at that finding by gradually increasing the number of surveys to check (for their case study) if there might be a point after which further survey implementations do not improve the accuracies anymore. Please, see some more specific comments below.

Minor comments:

18-20 But only for scenarios with enough stable areas?

34-35 Maybe refer to direct and indirect referencing, respectively.

36-38 Besides georeferencing accuracy also the image geometry is important for a successful reconstruction.

41-42 Please, also refer to time-SIFT as it describes the same approach and was introduced first.

46-47 The mentioned study could not describe how well it performs absolutely because the showcase had no absolute references. But the relative error assessment was possible. – I would use the terms absolute and relative accuracy here.

51 The authors claim to assess the influence of a larger number of surveys. But I think, they need to show this aspect in a more detailed analysis, e.g. considering the gradual increase of surveys.

58 Is the workflow indeed fully automatic. E.g. how did the authors split the model after alignment (via the python API?) or how did they provide the GCPs (did they use automatic detection of coded markers?)?

90-91 Why did the authors not use photogrammetric markers (especially considering that they went around the area of interest anyway to measure points) which are known to improve the reconstruction accuracy significantly due to subpixel measurement capabilities in image?

96-97 Please, explain how these error metrics are computed.

98 What is the advantage of adaptive camera model fitting? What is the difference to the standard approach?

89-99 Why are GCPs added between filter step 3 and 4 and not just after filtering?

100 Why is the orthophoto with sparse points used instead of dense? You can expect quite a lot of artefacts because the true 3D geometry is smoothed too strongly/not captured with enough resolution with the sparse point cloud.

103 What are the low noise points?

106 How does the lasground tool work?

109 How was the point cloud rasterized (e.g. using IDW)?

115 What is expected by increasing the number of surveys? The explanation of the reason for investigation is missing here. Do the authors expect an improvement due to even more potential tie points across more images?

110-120 Are the GCPs measured in all images across time or only in one survey? Please, also assess the latter case because this could be a significant improvement regarding the time and potential availability of GCPs (e.g. maybe it is not possible to set them up each time).

126 Thus, you evaluated the precision (if you compare the distances to the mean of the entire dataset) rather than the accuracy.

126-128 Please, also refer to the already existing literature discussing the error depen-

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dence to the distance to the GCPs. For instance, see Tonkin & Midgley (2016).

128-129 I am not sure if this sentence is correctly stated because you do compare the point clouds directly using the mean of all nine point clouds at your selected points. Might you mean that you do not compare entire regions rather than just single points?

135-137 What is the difference between reprojection error and mean reprojection error? If the authors refer to the value provided by MetaShape it would be root means squared reprojection error.

146-147 This finding is not new and well known in conventional photogrammetry as well as more recent work. Please, refer to these studies (e.g. Tonkin & Midgley (2016) and/or standard work (e.g. Kraus, 2007)).

165-169 I do not understand this statement. How does a small (thus local) portion of the survey influence the entire/global change detection?

170-171 As shown by Cook & Dietze (2019) and Feurer & Vinatier (2018)

171-173 However, the comparison to independent references is still missing, which might indicate the more important aspect if the integration of GCPs does improve the absolute accuracy as well as the scaling of the combined model, which would be important for the volumetric change calculation.

176-177 I might rephrase this sentence stating that the used co-alignment allows for more reliable change detection because during the reconstruction all images (from all surveys) are optimized within the same adjustment, using homologous image points covering several time-steps and therefore resulting in a joint camera geometry. Potential systematic errors are therefore spatially consistent.

References:

Tonkin, T., Midgley, N. (2016). Ground-Control Networks for Image Based Surface Reconstruction: An Investigation of Optimum Survey Designs Using UAV Derived Imagery and Structure-from-Motion Photogrammetry. Remote Sensing

Kraus, K. (2007). Photogrammetry: Geometry from Images and Laser Scans, 2nd edition, De Gruyter, Berlin, Germany

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