RESPONSES TO REVIEWER #3 COMMENTS ON "*ASSESSING THE QUALITY OF DIGITAL ELEVATION MODELS OBTAINED FROM MINI-UNMANNED AERIAL VEHICLES FOR OVERLAND FLOW MODELLING IN URBAN AREAS*"

(0) The paper discusses the advantage of DEM derived from UVA compared to the Lidar DEM; and analyzes the performance and application of UVA DEM. The paper does not seem to bring any advancement in the knowledge of UAV DEM mainly because only simple comparisons are conducted without any quantitative analysis. Here are some suggestions:

Answer: We would like to thank the reviewer for taking the time to read the manuscript. We regret that he does not have the same viewpoint as the other reviewers and will try our very best to convince him about the novelty and scientific soundness of our work. We think that addressing his constructive criticism will improve the focus and clarity of the revised manuscript. However, we would like to stress that the reviewed manuscript contained a quantitative statistical analysis (see sub-section 2.1.3).

(1) The authors need to explain what is the innovation of this paper, which should be clear in Section 1.

Answer: As outlined in the introduction on sub-section 1.4, our study has three innovative elements: (i) uses for the first time DEMs produced from UAV photogrammetry in the context of urban drainage – more specifically on overland flow modelling; (ii) presents dedicated field experiments specifically tailored to understand how UAV flight parameters affect DEM quality and, eventually, overland flow representation, and (iii) compares the quality of the UAV obtained DEM with a DEM used by Swiss engineers (LiDAR-based DEM).

These novel aspects will be highlighted in the Section 1 of the revised version of the manuscript.

(2) The overlapping degree is one of the most important parameters for high-res DEM generation, which should be discussed deeply.

Answer: We fully agree with this comment, because it also corresponds to our experience and expectation when we conducted the study (all flights conducted in this study have a frontal and lateral overlapping larger than 70%). Thus, to our surprise the influence of the overlap was not statistically significant in the statistical analysis conducted in this study. To make this point clearer, we will (i) include more results to support this finding and (ii) extend the discussion about the importance the overlapping degree for generation of HR DEMs from photogrammetry in the revised version of the manuscript.

(3) In page 15, above section 5, what is the virtual flight purpose? And why was it made virtual for flight 14 and 11? Please clarify.

Answer: This is a good point. Actually, the two additional virtual flights were created to (i) increase the number of "flights" used in the statistical analysis with different parameters and (ii), specifically, to investigate the effect of image overlapping on the quality of UAV imagery DEMs. This contributed to a more robust statistical analysis of the impact of UAV flight

parameters on DEM quality (based on the selected DEM evaluation metrics). In the revision we will provide more detail on this and why we used material from flight 14 and 11.

(4) Lidar DEM is a completely different type of technology, while UVA DEM is from low height UVA. If this Lidar was mounted on the UVA, the comparison would have more fair. The results are not comparable.

Answer: we agree that LiDAR and photogrammetry are different methodologies to generate elevation data (e.g., DEMs) and airplanes and UAVs are also different platforms (with different parameters, such as flight altitude). We should have emphasised that the results are indeed comparable, not by technological standards, but by practical use in engineering projects. In our experience, urban drainage consultants in practical projects hardly ever perform a dedicated DEM generation, but rather use what the available data sets. We will clearly state that the focus of the present study is not on the comparison of methodologies and platforms, but instead on the evaluation of UAV DEMs to other products which are practically available. And for CH, this is the Swisstopo product based on LIDAR.

(5) In section 4.2.1, the river is clear from Lidar DEM; why does it disappear from UVA DEM?

Answer: We thank the reviewer to point out this interesting detail. In the LiDAR DEM, the surface of the river is also not visible due to trees located along the water stream. The fact that the river is also not visible in the UAV DEM is due to the lack of matching points in this area due to the high visual complexity created by tree branches and twigs present in the photos used to generate the DEM: this resulted in a small number of points used in the interpolation – clearly visible in the UAV DEM. We will add a couple of sentences on this in the discussion.

(6) In section 4.2.3, the argument is focused on the tree (line 11, page 19); some quantitative analysis should be presented.

Answer: Unfortunately, we disagree with the reviewer who might have missed our description of the quantitiative statistical analysis. Indeed, the results of our regression analysis are presented in Table 4. In this table we quantitatively evaluate the slope differences between the two DEMs and for three types of areas in the study area (all areas, roads and buildings). Nevertheless, we will improve the presentation of the regression analysis during the revision.

(7) In page 21, the first conclusion is obvious and basic knowledge for a researcher. Furthermore, the Lidar can now be easly mounted on UVA, so it is not really a challenge for Lidar (in line 15).

Answer: To our knowledge, this study is the first time DEMs produced based on photogrammetry utilising UAV imagery are used in the context of urban drainage, more specifically on overland flow modelling. Although we agree that some experiences have been carried out using LiDAR mounted on quadcopter-type of UAVs with a comparable reach, this is still not possible with mini-UAVs such as the one used in this study. To the best of our knowledge, LiDAR equipment is still heavier and consumes much more power than a mass-consumer point&shoot camera. As this type of mini-UAV is very lightweight, which is an

important characteristic due to safety issues, especially in urban areas, its load capacity is not yet LIDAR-ready. We will add this in the Discussion section.

(8) From the Figure7, the difference between is UVA DEM and Lidar DEM is more than 20m, which influences the flowing overland flow model seriously. In this paper, the actual experiment, should be carried to validate the UVA DEM 's performance. The analysis in the paper is rather simple; it cannot support the authors' view-of-point.

Answer: although we generally understand the concern of the reviewer with this comment, we do not entirely understand which specific improvement he or she suggests with "*the actual experiment, should be carried to validate the UVA DEM 's performance"*.
We also agree with the point that the DEM differences lead to substantial flow differences. Nevertheless, we still consider that our approach, its results and the drawn conclusions are valid. From Figure 5a, we can see that (i) the major differences located along the water stream are due to the presence/ absence of tree-leaves and (ii) some other considerable elevation differences are located in the buildings surroundings. The area without buildings or trees (left-centre of the figure) has elevation differences of less than 1 m. This is not a problem of the UAV DEM used, but more an issue of the LiDAR DEM; As mentioned above, the LiDAR DEM was acquired for multi-purposes and during a leaves-on conditions. It is expected that it shows some problems when used on urban overland flow applications.

(9) Please check references and citations.

Answer: See comment (6) of reviewer #1.