RESPONSES TO DR. PAOLO PARON COMMENTS ON "ASSESSING THE QUALITY OF DIGITAL ELEVATION MODELS OBTAINED FROM MINI-UNMANNED AERIAL VEHICLES FOR OVERLAND FLOW MODELLING IN URBAN AREAS"

The authors thank the reviewer for taking the time to review this manuscript and for helpful and insightful comments and suggested manuscript improvements.

1. **This manuscript presents the results of SfM vs Lidar DEM: in both cases none of the parameters used in running methods is explained. In this way it is impossible to replicate the experiment. Both SfM software (in this case Pix4D, but could also be valid if using, for instance, Photoscan) have many small parameters that can be chosen and that make a large difference in the final output. Just to mention one of these is the number of triangular faces in the TIN generation.**

   Answer: A new section (Section *3.4.2 Data preparation*), including a new table with the processing settings used to generate the UAV DEMs in Pix4D (Table 3), has been added to the manuscript. Unfortunately, we were not able to find information on how the LiDAR DEM was produced. Since it comes from an official body and was not generated by us, we take it as-is; a sentence on this was also added in Section 2.2.: *"Swisstopo LiDAR data is acquired in mid-summer, but the detailed processing method of the data for creating the LiDAR DEM is not published"*.

2. **The study uses an off-the-shelf point and shoot camera (in this case the Canon Ixus 127 HS). Being this a fully automatic camera it is plausible to assume that during the flight the camera has acquired photos using different focal length, shutter time and possibly ISO. The GSD of pixels is a function of focal length, elevation, ccd sensor size, and number of pixels on the sensor. None of these parameters have been presented nor discussed in this paper. On the other hand the research only explores 4 flight parameters such as: (1) altitude (very relevant), (2) overlapping (relevant), (3) pitch (irrelevant, due to the fact that SfM can take any camera pitch in the processing), and (4) weather conditions (slightly relevant, due to the fact that some darker spots could affect the recognition of pixelpairs, but it is not significant as weather conditions do not change rapidly during the flight of such a small area). More relevant would be to know the time of the day to be able to understand the amount of shadowing from tall objects.**
   a. **In my opinion the paper should discuss more in detail the camera parameters that are responsible for the determination of the pixel size.**

   Answer: The time of day has been included in Section 3.3.: "*The flights were conducted on the 29th and 30th of January 2014 between 11:30 and 13:30 local time (solar noon on those days was around 12:40 local time).*". We would like to clarify that weather did seem important to mention since there were substantial differences between flights (although as the reviewer correctly pointed out, weather was stable during any given flight). We did expect camera pitch to have an effect on DEM quality, since greater camera pitch translates to i) greater parallax and ii) more information on building facades.
   a. Section 3.1.2 *Camera* was extended to discuss in more detail the camera parameters. Because the camera parameters (zoom, aperture, shutter speed, ISO) are set automatically with the camera we had for the experiment, pixel size (GSD) is modulated by flight altitude primarily. The relationship between flight altitude and GSD can be seen in the table describing the different flight characteristics.

3. **The accuracy of the DEM is largely influenced by the accuracy of the GCP (in xyz). There is no information about the method used to georeferenced the GCPs nor to their accuracy.**

    a. **Add details and description of this parameters.**

Answer: Information regarding the source and accuracy of the GCPs has been added in Section 3.4.1: "*The control points used were official survey points (LFP3) with a vertical accuracy of 3.7 cm and a horizontal accuracy of 3 cm. Since the points are protected with access covers, it was the access covers that were used for georeferencing the images. It was assumed that the cadastral points were directly underneath the center of their cover*". Figure 3 was also updated in order to illustrate better how the GCPs were used.

4. **The UAV-SfM generated DEM has been resampled to 2 m pixel size. There is no mention to which method has been used**
    a. **My suggestion is to be more accurate here and describe which spatial analysis method has been used.**

Answer: A simple average was used to downsample the UAV DEM. This information has been added to the text (Section 4.2): "*Because the two DEMs have different resolutions and we wanted to compare the two datasets on a pixel by pixel basis, we downscaled the UAV DEM to match the resolution of the LiDAR DEM, using the arithmetic average to compute new pixel values."*

5. **To compare two DEMs you need an as accurate as possible co-registration of the two DEMs. In this manuscript there is no mention to coregistration procedures.**
    a. **My suggestion is to add a description of this process.**

Answer: The two DEMs are both georeferenced in the Swiss LV03 coordinate reference system. This is the reference system of the GCPs used to georeference the UAV DEM, and also the system in which the LiDAR DEM is delivered. Co-registration is therefore implicit. A short explanation has been added to the manuscript in Section *3.4.2 Data preparation*: "*Co-registration of the UAV DEM with the LiDAR DEM is done implicitly by georeferencing the point clouds with the official survey points. By doing so, the generated UAV DEM is also georeferenced and can be directly overlaid with the LiDAR DEM, which is provided in the same coordinate reference system*.".

6. **It is not clear why you did not perform a disaggregated analysis of slope and aspect (as you did for elevation)? I mean why did you analysed Elevation differences on different portions fo the study area and you did not do it for slope and aspect?**

Answer: This comment is answered by the action taken to resolve reviewer's comment 9 (please refer to the answer to comment 9). The DEM comparison was limited to the area free from buildings, vegetation and other man-made features.

7. **Under paragraphs 4.2.4 for the first time in the manuscript you mention also two other pixel sizes of the DEM downscaled from the UAV-SfM (that is of 0.5 m and 1.0 m). Why you did not use these resolution before? And what is the meaning of using these to**

delineate flow path if you want to compare the UAV-SfM DEM with the Lidar that comes only at 2.0 m pixel size?

Answer: The reason why showing these different spatial resolutions was to see the effect of downsampling the UAV DEM on flow path delineation. The authors consider that no action would be necessary regarding this comment.

8. **Chapter 4.3 is not a Discussion, as already mentioned by other reviewers.**
    a. **My suggestion is to improve it or redistribute some of its content to Introduction.**

Answer: The suggestion was accepted and the text in the *Discussion* section was distributed to the *Introduction* and *Results* sections. Most of the changes were conducted in the *Introduction* section: a couple of new sub-sections (*1.2. UAV applications and operational challenges* and *1.3. Urban drainage models input elevation data and UAVs*) were added to receive most of the content from the *Discussion* Chapter.

9. **Comparing Lidar against any other DEM Generation method is a general approach in many studies attempting to compare the quality of DEM. Nevertheless this is only partially valid, in this specific case, due to the different ways of DEM production and different type of errors implied in the DEM generation processes.**
    a. **My suggestion is to limit the comparison to open air areas like the one identified with a dotted line in figure 7. The other areas by design would have very large differences, so are not worth the comparison.**

Answer: The reviewer's suggestion was accepted. The results obtained from the comparisons between the UAV and LiDAR DEMs was limited to the open air area. Section *4.2 Comparison between UAV DEM and LiDAR DEM* was completely re-written to accommodate these changes. New figures (maps and histograms) were also generated.