Anonymous Referee #2 (RC2)

Dear Anonymous Referee #2

Thank you for your constructive review of our paper.

We have provided answers to your questions and suggestions (your comments in italics) below:

> *The manuscript aims at providing insights into the DEM generation process by various approaches and the effect of DEM resolution on the subsequent numerical modeling. The manuscript is well written and well organized, and the methods are well explained. The work is interesting; however, some minor parts have to be improved.*

1. *Page 11, Line 285: "Holes were filled consistently by applying a max hole-filling threshold of 100 m2,.....". It is a little bit unclear to me. What is the smallest and largest size encountered? What does it mean by "max hole filling threshold of 100 m2", is this the largest hole size that can be filled? What technique is used? What are the advantages and drawbacks of the hole filling technique used? What impact did the hole-filling have on the modeling results? Also, any reference to available literature will be sufficient.*

Holes, or data voids, are primarily created when terrain is occluded from the sensor (in the case of TLS and SPM) or when there is low image contrast or clouds present in the image (in the case of SPM). Terrain occlusions are more acute with terrestrial sensors where the oblique angle to the terrain creates shadows behind topographic features and above-ground objects (Currier et al., 2019; Bühler et al., 2016). The high relief in our study site also created terrain occlusions to the satellite sensor, however this was in the terrain adjacent to the avalanche path and not in the path itself (see Figure 3). TLS-derived holes were mitigated by combing multiple scans taken from different locations in the study site into a composite point cloud before interpolation. Nonetheless occluded terrain remained in the TLS composite scan.

We took a conservative hole-filling approach to minimise the interpolation for areas lacking elevation measurements. We used a maximum 100 m^2 threshold for the occluded terrain that would be interpolated. This threshold came from a 5x5 cell window, based on the full-resolution SPM 2 m DSM. The aim was to fill holes in microtopography and avoid filling leaving larger holes where interpolation may affect the representation of the surface and modelling results. As in other topographic modelling applications where DEMs are conditioned to remove holes, pits and other interpolation artefacts and errors (Reuter et al., 2007), dynamic hazard models such as RAMMS require the use of a hole-filled DEM. Without hole-filling we would not have been able to conduct the sensitivity test with RAMMS. We believe the impact of hole-filling on the modelling results was minimal as we were targeting microtopographic features. However, we would advise caution for hole-filling large areas inside the RAMMS modelling domain as it creates a risk of over-smoothing the true terrain represented by the DSM. Coarser resolution DSMs will be less prone to the influence of hole-filling as they will already more smoothly represent the terrain compared with a high-resolution DSM.

Our hole-filling occurred during the interpolation from the source point cloud to the DSM with ASP's *point2dem* tool (Beyer et al., 2019; specific tool documentation: https://stereopipeline.readthedocs.io/en/latest/tools/point2dem.html). Holes are filled using neighboring cell values up the maximum number of cells specified.

As with Reviewer #1 comment, we will expand and clarify section 2.1.4 on hole-filling.

2. *Page 11, Line 272: In reference to comment #1, if there were holes encountered in the DEMs then how can be classified as "State of the art DEMs"?*

As discussed in response to previous comment, holes in high-resolution DSMs are common. We took a conservative approach to filling holes in microtopography while leaving the larger holes unfilled to avoid mis-representing the terrain since the study focused on best-representing the topography on which the avalanche flowed. However, we agree *state-of-the-art* is a subjective term and we will remove it from the paper.

3. *2: demarcate the release zone and show the runout direction.*

We will update Figure 2 to show the approximate delineation of the release zone and the runout direction.

4. *Page 14, Line 354: Please provide the respective DOD and corresponding information.*

We report on the results of the DoD in the Results section (Section 3.4, lines 478-486; Figure 8) which we feel is the appropriate place for the co-registration quality values, rather than in the Methods section. We will clarify the point in this section.

5. *4: it would be better to replace the figure with the time-lapse for the complete runout.*

We agree it would have been preferred to have a sequence of images showing the complete runout and final debris, however this is not available. The images in this figure came from a camera located down valley in safe zone where the final debris was not visible. We chose these frames as the core ejects over the lower cliff and splashes across the valley to coincide with the calibration RAMMS simulation.

6. *Please provide the RAMMS input parameters in a tabulated form.*

This is a good idea and was also requested by Reviewer #1. We will provide the RAMMS parameters in a table in the appendix.

References

Beyer, R., Alexandrov, O., and McMichael, S.: NeoGeographyToolkit/StereoPipeline: Ames Stereo Pipeline, v2.7, https://doi.org/DOI:10.5281/zenodo.3247734, 2019.

Bühler, Y., Adams, M. S., Bösch, R., and Stoffel, A.: Mapping snow depth in alpine terrain with unmanned aerial systems (UASs): potential and limitations, The Cryosphere, 10, 1075–1088, https://doi.org/10.5194/tc-10-1075-2016, 2016.

Currier, W. R., Pflug, J., Mazzotti, G., Jonas, T., Deems, J. S., Bormann, K. J., ... & Lundquist, J. D. (2019). Comparing aerial lidar observations with terrestrial lidar and snow-probe transects from NASA's 2017 SnowEx campaign. Water Resources Research, 55(7), 6285-6294.

Reuter, H. I., Nelson, A., & Jarvis, A. (2007). An evaluation of void-filling interpolation methods for SRTM data. International Journal of Geographical Information Science, 21(9), 983-1008.