Dear Reviewers,

Thank you for your insightful and constructive comments on our manuscript. Here we provide the final response to your comments. We are happy to revise our manuscript according to the reviewers' suggestions.

****

Referee #1

General Comments
The paper is organized and easy to follow. It starts with a brief description of sector collapses and how hummocks have been used to understand the emplacement kinematics and dynamics of avalanches. Within the introduction is a discussion on the lack of high resolution images to be used for studying hummocks and how RPAS, SfM-MVS photogrammetry can be used to fill this gap. A detailed methodology for image acquisition, description of hummocks and source area reconstruction for volume estimation follows. Results giving a detailed description of the morphology and spatial distribution of hummocks and volume estimate then follow. While the description of hummocks and volume were used as main evidence for the extremely long runout of this avalanche. A more in-depth discussion on the effect of structural constraints (caldera wall and precollapse faults/lineaments) on the emplacement and flow during avalanche would be interesting. This paper has a potential to make an important contribution on the effects of confinements on the debris avalanche emplacement and flow processes, which are less described in existing works.

> **[A1.1] Thank you for your constructive comments. As noted later, the discussion part will further be expanded to discuss the effect of structural constraints on the debris avalanche flow. (see also A1.4., 1.5., and 1.6)**

Title imply a focus on hummock morphology but the manuscript has a lot of important informatios and discussion on the avalanche itself, such as volume and possible extent of deposition.

> **[A1.2] We will revise the title as follows:**
> **"*Characteristics of debris avalanche deposits inferred from source volume estimate and hummock morphology around Mt Erciyes, central Turkey*"**

Specific Comments
It is not clear why is there no hummock less than 11 km from the source?

> **[A1.3] As we mentioned in 5.2. of the present manuscript, the debris avalanche could have had low viscosity with high water content at its initial stage. We assume that such the condition of the debris avalanche could have prohibited the formation of the hummocks in the near-source area. This point will be further discussed in our revised manuscript.**

Is it possible that the hummocky area is an area of accumulation, where sliding materials are confined and movement downstream slowed down as the avalanche materials go through a neck by the narrow valleys downstream?

[A1.4] As mentioned in Paguican et al. (2014), topographic constrains can control the formation of a certain type of hummocks by the stretch and compression of the avalanche flows. Although such a complex case with both barriers (caldera wall) and exits (valley) like this study has not well been reported in the other studies, we will add more discussion on this issue.

Is there any evidence that the confinng caldera has decreased the flow of the material as it flows east to north? Is there run-ups or accumulation zones observed that could be evidence of confinement as the flow direction shifted from east to north?

[A1.5] Unfortunately, we could not find any evidence (outcrops) in the field, such as abutting deposits on the caldera wall east of the source. However, the possible remnant of the dammed lake by the debris avalanche, located in the south of the bend of the DAD (D in Fig. 1), would suggest the confinement of the flow at this portion. Although the present lake is artificially modified and still hard to find sedimentary evidences, we will add descriptions on this issue in the Study area section.

How did the flow dynamics change thoughout the DAD? How does the confinement by the caldera wall affect this change in flow dynamics? Can it be reflected by the size and distribution of hummocks?

[A1.6] Following your suggestions above (A1.3-1.5), the effect of structural constraints on the emplacement and flow during the avalanche will be further discussed in the revised manuscript. The distance-size relationship of hummocks was our original intention to examine in this study site, but as shown in Fig. 9, the location of hummocks is limited and it is hard to discuss the dynamics of the debris avalanche flow from this distribution. Nevertheless, we will be able to discuss the flow dynamics by not only the presence of the hummocks, but also their absence in the 0-11 km from the source.

Technical Corrections
Please see supplement pdf file

[A1.7] Thank you for your thorough corrections. We will check all the comments and revise our manuscript accordingly.

****

Referee #2

This paper is well written and easily to understand. The paper shows a number of methods to analyze topography of volcanoes and debris avalanches. It will be a good textbook to analyze similar topographies.

[A2.1] Thank you for your constructive comments.

If the authors have a chance, I hope that they show more description and discussions about smaller topography of hummocks. I think the RPAS method has advantages for analyzing smaller topography than about 5 m, it looks the authors do not use this advantage.

[A2.2] We agree with the reviewer in that the RPAS is advantageous for the detailed analysis of small topography. In our case, however, we did not perform geometric analyses at a highest resolution for the studied hummocks, because previous studies have not provided such detailed information on hummock shapes – it has been general to investigate hummocks using aerial photographs, but not at the resolution higher than 5 m. Therefore, we cannot compare the detailed topographic characteristics of hummocks with the other cases. This is the reason why we carried out the morphological analysis of hummocks at a medium resolution. Nevertheless, in the study site, this was the best method to obtain the topographic data of and around the hummocks. No aerial photos and topographic data that are suitable for the identification of such 10- to 100-m scale hummocks are available. We will add this point in the Introduction section.

I could not understand why the authors studied the hummocks by using displacement angle of measure axis and I could not get that mean and importance of this analysis.

[A2.3] The displacement angle of hummocks is an important measure to know the flow dynamics of debris avalanche (e.g., Yoshida, 2014). We will add the description of the significance of that index in the Method section (3.1).

Some comments;
Page 1, line 34: I agree this analysis is important to know such destructive hazards. But, I could not get the mean that how this insights help mitigation of potential disasters of this study area.

[A2.4] We will show the importance of this work on the disaster mitigation in this area. We will expand the description at the last paragraph of Conclusions, and add some more descriptions in Introduction.

Page 4, Figure 1: I think the figure should be understandable by itself. Show the mean of letters "A", "B", "C", "D" in its caption. The area of A to C should be more clearly, I cannot see the boundary between the are A and B.

[A2.5] We will revise the figure following the suggestions.

Page 5, Figure 2: Perhaps subfigure c, d and e are not needed. Instead, the authors can show a scale or description of size of hummocks in subfigure b. If you try to discuss micro topography of the hummocks or inner structures of hummocks, you should show subfigures c, d, e. But you did not discuss about them. In addition, I did not see the locations of these subfigures. Show them in Figure 1.

[A2.6] As the reviewer pointed out, we do not actually discuss neither microtopography nor inner structures of hummocks. We will remove the subfigure e. However, we think the ground-based or close-range pictures are useful to show the actual situation of the hummocks. Therefore, we would like to

retain the subfigures c and d. We will also add the location of these pictures in Fig. 1 (and in Fig. 5 for c and d).

Page 6, line 33: what is unit of (>1.0).

[A2.7] It is pixels. We will add this.

Page 7, line 14: please explain "geometrical index".

[A2.8] We will rephrase here.

Page 11, figure 6: explain "displacement angle" in this caption.

[A2.9] We will add the explanation in the figure caption.

Page 12, figure 7: I cannot see the location of the main course in Figure 1.

[A2.10] We will show the main course in Fig. 1.

Page 14, figure 9: The tendency of the hummock sizes of Erciyes is quite different from others. I think the authors should show this reason well.

[A2.11] Also regarding the response to the Reviewer #1 (A1.6), we will further discuss the relation between debris avalanche flow dynamics and hummock formations.