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Interactive comment on "Supraglacial debris thickness variability: Impact on ablation and relation to terrain properties" *by* Lindsey I. Nicholson et al.

Anonymous Referee #2

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Authors have interesting story in this paper. They focused on the thin debris zone as 'ablation hotspot' at debris-covered glaciers. They evaluated the effect of 'ablation hotspot' when we estimate ablation under the debris layer based on the observed debris thickness frequency. Estimation of debris thickness have been tried using surface terrain properties. And they concluded that 'ablation hotspot' are possible to appear from the analysis of debris stability. There are several kinds of biases to estimate ablation of debris-covered glaciers using satellite thermal images. And evaluation of thin debris zone ('ablation hot spot') is one of the most significant factor to cause bias. I think this paper have demonstrated important issue to estimate ablation of debris-covered glaciers using satellite images. I have some main and specific comments as

follows.

<Main comments>

1) Author have analyzed debris thickness frequency which are measured by GPR, theodolite, SfM-MVS and excavation. I can imagine point measurements of debris thickness were carried out by theodolite, SfM-MVS and excavation. But, this paper have no information about the GPR. GPR also measure DT at each point or at some ranges in horizontal (depend on the debris thickness??)?

2) You have classified stable and unstable debris-covered area at just 27 degree in slope gradient. But, usually, steep slope have low accuracy in satellite- or SfM-DTM. Margin site might have no oversteepened grids if you change the critical value of slope.

<Specific comments>

Please consolidate the location name. Even all expressions are summarized in Line199-201, different expressions at each figure are not easy to understand for readers. You have wrote 'Gokyo' and 'Margin' in Fig. 2, 4, 6c, 6d and 9, but expressed by distance from terminus in Fig. 5. Please check other part in the manuscript. 'lower' 'middle' and 'upper' were also found in Line 382.

L120 Please add information of altitudes at each three site.

L163 Author have wrote that 'McCarthy et al (2017) and range from 0.14-0.83 m, generally increasing with debris thickness' How much minimum thickness can be detect by GPR? Author have depicted Fig. 5, percentage frequency histgrams of debris thickness in 0.05 m. Thin debris are important for following analysis.

L175 '4.2 Ablation modelling' » It seems that temperature difference due to elevation difference at each three site have not been considered in this calculation. I think it is not necessary to consider the temperature difference, because the target of this calculation is to indicate the effect of debris thickness variability on ablation. But, you have to write that you have assumed that temperature were same with the Pyramids (?) at all sites.

L239-240 There are no information of data source of air photographs taken in 1984.

L299-301 'the debris was generally too thick. This means there is the possibility of a slight thin bias in the data. However, penetration depth was often greater than 7 m, which is likely near the maximum debris thickness.' » Those sentences have been written subjectively without support information. Authors cannot declare without some references.

L307 'see Section 5.3 and Fig. 6' » 'see Section 5.3 and Fig. 7'?

L343 I cannot find Fig. 2b.

L354 If you have assumed that temperature difference depending on the altitude were not considered for the estimate of ablation, you have to add the information here. If you take into account the temperature difference, you have to add altitude at each three sites and temperature lapse rate.

L355 and 362 The unit of vertical axis in Fig. 6c were mm day-1. but, 'm' in the manuscript. If both values indicate same things (I believe this), please consolidate. This figure and calculated values are very important in this paper.

L360 ' 1, 3 and 7 km respectively.' »' 1, 2 and 7 km respectively.' ???

L370-373 These sentence indicates very significant things to estimate ablation under debris-layer based on mean debris thickness. I recommend that each percent of debris thickness frequency between 0-0.5 m in debris thickness and each calculated ablation ratio between 0-0.5 m in debris thickness at each three site should be shown in the text.

L389 'Visual inspection of the radargrams indicates that the thinnest debris cover occurs on steep slopes (Fig. 7a and b).' » I cannot agree with this sentence. For me, by visual inspection, it seems that depression of ice surface are filled with debris, as a result, debris surface have flatter features than that of ice surface under the debris. All example show such tendency in Fig. 7.

Line394 'the debris surface is approximately parallel to the ice surface,' » This sentence does not conflict with previous sentence 'Visual inspection of the radargrams indicates that the thinnest debris cover occurs on steep slopes' at Line 389 ??

L390 '(Fig. 7a and b).'» '(Fig. 7a and c).'???

L397 'Modelled surface flowpaths (Fig. 7b) cross-cut the GPR transects where these depressions are located, indicating that they were likely incised by meltwater.' » I'm confused when I checked the cross section of Fig. 7c and f. You have calculated the flowpath based on DEM from Pleiades. But, the surface features indicated by GPR cross section do not represent cross section of flowpath (no depression). The surface elevation of debris is not true?

L417 and Fig. 7h » How did you detect the location of former pond? 'Former pond' in Fig. 7h means pond in 1984 ?

L434-435 'Binning the thickness data with respect to slope indicates a step decrease in debris thickness above surface slope angles of around 20-23 Íę (Fig. 8a).' » I recommend that difference between debris thickness at steep slope and those at gentle slope were significant or not statistically.

L434- As I wrote at Line 394, it seems that depression of ice surface are filled with debris, as a result, debris surface have flatter features than that of ice surface under the debris from Fig. 7 by visual inspection. Then, ice surface (not debris surface) curvature might have relation with debris-thickness. Probably I think some relation can be found between ice surface curvature and debris-thickness by optimizing the scale of curvature. But, it's not your purpose, and the analysis is limited at the GPR survey lines.

L448 'This effect is observable in global radiation data (Fig. 8d).'» If you add calculated solar radiation at the top of the atmosphere in Fig. 8d, it is easy to understand.

Fig. 4 Shore lines of ponds are unclear for me because they are overlapping. I recom-

mend that only shore lines are depicted in this figure. And add the information of the background images.

Fig. 5 There is no information about the intervals of debris thickness in d-f. And please add the information that 'Dashed vertical lines indicate mean debris thickness' or something.

Fig. 7 Locations of Fig. 7b, f, h are required.

Table 2 I recommend that percentage of thin debris thickness frequency are necessary in Table 2. For example, the range between 0-0.25 m and 0.25-0.5 m in debris thickness. Because, the thin debris layer effect the bias of ablation and surface temperature.

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