Dear Reviewer,

Thank you very much for your insightful and constructive comments.

Specific Comments

1: The following assumptions of the model need to be addressed:

1a: Steady state model assumption (p.895, line 3). At 10:15 LT the debris will be warming rapidly in response to solar heating, hence it is not in a steady state. As the debris warms there is flux of heat energy into the debris, or change of stored heat flux, which is omitted in equation 1. The non-linear temperature profiles in Figure 4 show that as you move down the profile, the conductive heat flux decreases markedly, but the model doesn't explain where this missing energy goes, violating the principle of conservation of energy. I suspect that the Gratio multiplier (equation 9) is actually accounting for the omitted change in stored heat flux. This requires a different explanation of how the model represents the surface energy balance.

> - The aim of this model was to develop a simple surface energy balance that could be used to derive thermal resistance. The control volume came into play when developing a way to account for the latent heat flux. However, as discussed in response to comment 1c, the latent heat flux has been removed from the model and assumed to be zero, since the debris in the upper 10 cm is dry. With the removal of the latent heat flux term, the model now simplifies to a surface energy balance. G_{ratio} is used to estimate the conductive heat flux into the debris caused by the rapid warming in response to solar heating.

1b: Neglect of a stability correction for the turbulent heat flux/neutral atmosphere assumption (equation 3). Although no surface or air temperature data are presented (see point 3 below), the likelihood is that with relatively high debris temperature and low air temperature there will be a steep vertical temperature gradient and an unstable atmospheric surface layer above the debris. Hence, the sensible heat flux will be strongly underestimated by the neutral atmosphere assumption and a correction for surface layer instability should be applied.

> - The model was initially developed assuming a neutral atmosphere and correcting for the unstable atmosphere using equations for turbulent heat fluxes from Nicholson and Benn (2006) and Reid and Brock (2010). The results from the neutral atmosphere models were the only ones reported in this study because the unstable atmosphere corrections yielded unreasonable results. These results are discussed below and a portion of them will be added to the revised paper.
>
> The turbulent heat fluxes for an unstable atmosphere were modeled using the same equations as Reid and Brock (2010). The resulting sensible heat fluxes assuming $z_0 = 0.016$ ranged from -378 to -1,194 W m^{-2} with an average of -750 W m^{-2} (Table C1). These sensible heat fluxes are unrealistic and caused the net

energy flux (net radiation + sensible heat flux), to be negative in almost all of the pixels. As a result, 91% of the pixels in the focus area were undefined (10% of the pixels are undefined to do the malfunctioning of the scan line corrector (SLC) on Landsat 7).

Table C1. Debris thickness and sensible heat flux in the focus area as a function of surface roughness length (z_0) assuming a neutral and unstable atmosphere

Model	**$T_{air} = f(T_s)$?**	**z0 [m]**	**Average (Range) Debris Thickness in Focus Area [m]**	**% undefined[#]**	**Average (Range) -Sensible Heat Flux in Focus Area [-W m^{-2}]**
Neutral Atmosphere (Nicholson and Benn, 2006)	No	0.0035	0.17 (0.11 - 0.36)	10	122 (54 - 251)
		0.0063	0.20 (0.12 - 0.52)	10	148 (65 - 305)
		0.01	0.25 (0.14 - 0.82)	11	175 (77 - 360)
		0.016	0.29 (0.16 - 0.64)	14	211 (93 - 435)
		0.02	0.39 (0.18 - 1.19)	15	232 (102 - 478)
Unstable Atmosphere (Reid and Brock, 2010)	No	0.001	0.47 (0.21 - 1.34)	20	303 (153 - 482)
		0.0035	0.68 (undefined - 1.99)	54	435 (219 - 692)
		0.0063	0.88 (undefined - 1.96)	72	528 (266 - 840)
		0.01	0.85 (undefined - 3.39)	84	623 (314 - 992)
		0.016	0.20 (undefined - 2.35)	91	750 (378 - 1194)
	Yes*	0.016	0.25 (0.14 - 0.58)	11	201 (9 - 442)

*relationship between air and surface temperature from Foster et al. (2012)

[#] minimum of 10% undefined due to scan line corrector (SLC) on Landsat 7 malfunctioning

Foster et al. (2012) encountered a similar problem, where the sensible heat fluxes initially derived using the instability correction ranged from -586 to -839 W m^{-2}. To overcome this problem, they developed an empirical relationship between air temperature and surface temperature with the justification that air temperature would be strongly controlled by surface temperature in the morning due to strong solar heating.

$$T_{air} = 7.0 + 0.32 * T_S$$

When this relationship is applied to the unstable atmosphere model in the focus area with $z_0 = 0.016$, the sensible heat flux on average is -201 W m^{-2} and ranges from -9 to -442 W m^{-2}. These sensible heat fluxes are similar to the values obtained using the neutral atmosphere model without the relationship between surface temperature and air temperature being used (Table C1). The overall effect of using this relationship between surface temperature and air temperature is to reduce the gradient between air temperature and surface temperature thereby reducing the sensible heat flux.

The problem with this relationship is that it was empirically derived for Miage glacier and its transferability to other regions has not been tested. Unfortunately, the weather station that was set up on Imja-Lhotse Shar glacier during the same period as the debris temperature sensors malfunctioned, so this data was unable to be collected in this study. Nonetheless, a relationship between the surface temperature from the Landsat images used in this study and the air temperature at Pyramid Station can be examined to determine if the same trend observed by Foster et al. (2012) applies to Imja-Lhotse Shar glacier (Figure C1).

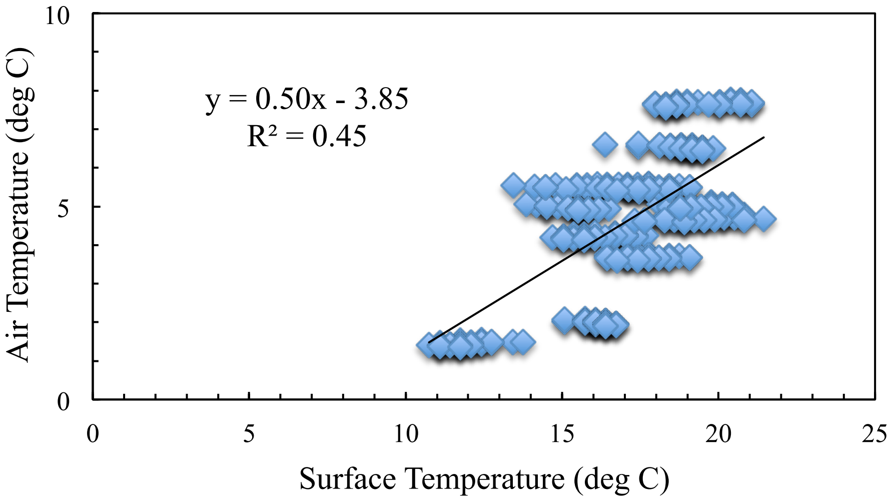

Figure C1. Relationship between air temperature from Pyramid Station and surface temperature from the Landsat images used in this study

Figure C1 shows a weak correlation ($R^2 = 0.45$) between surface temperature and air temperature, where the surface temperature is typically 10 – 15 degrees warmer than the air temperature. Furthermore, the derived relationship from this data does not agree well with the relationship found by Foster et al. (2012). There are two potential reasons that the relationship does not agree well: (1) the relationship may not be transferable to other regions and/or (2) the air temperature data comes from a weather station that is above grass at Pyramid Station as opposed to debris cover on a glacier. It seems likely that a similar relationship would exist due to the strong solar heating in the morning, but the data presented above does not support its use in this study.

The data from Nicholson (2005) was also analyzed to determine the relationship between air temperature and surface temperature on Ngozumpa glacier based on data from the melt season in 2002 (Figure C2). Figure C2 also shows a weak correlation ($R^2 = 0.30$) between surface temperature and air temperature at 10:15 when the satellite images are measured. This data in addition to the relationships found in our study suggest that the relationship derived from Foster et al. (2012) is not applicable to debris-covered glaciers in the Everest region. If the relationship derived from Nicholson (2005) is applied, the average sensible heat flux is -654 W m^{-2} and ranges from -296 to -997 W m^{-2}.

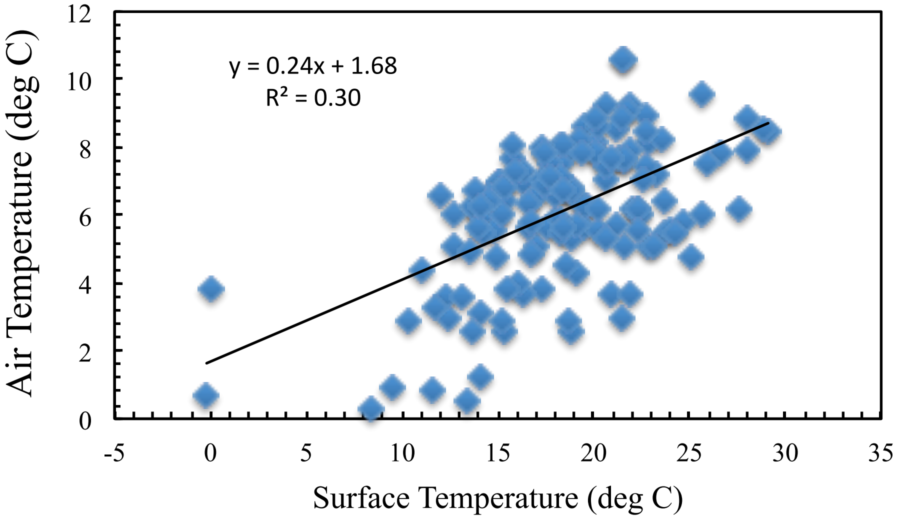

Figure C2. Relationship between air temperature and surface temperature on Ngozumpa glacier at 10:15 during the 2002 melt season.

Without the use of this relationship, the values of sensible heat flux remain unrealistically high using the unstable atmosphere model. The other model parameter that may be altered to reduce the sensible heat flux is the surface roughness length (z_0). Table C1 shows that a value of z_0 of 0.001 m reduces the sensible heat fluxes to reasonable values. However, this value of z_0 is an order of magnitude lower than that calculated on Miage glacier (Brock et al., 2010). In the Everest region, Takeuchi et al. (2000) found z_0 to be 0.0063 m on the Khumbu glacier, and Inoue and Yoshida (1980) found z_0 to be 0.0035 m and 0.06 m for small schist with bare ice and large granite debris, respectively. However, it is important note that these values of z_0 were calculated assuming neutral conditions.

The other option to reduce the sensible heat flux is to use the assumption of a neutral atmosphere. Table C1 shows that the sensible heat fluxes derived using the neutral atmosphere model with $z_0 = 0.016$ were similar to those derived using the relationship between surface temperature and air temperature. As the reviewer commented, it is likely that these fluxes would be underestimated, which would cause the thermal resistances to be underestimated as well. Therefore, since the relationship between air temperature and surface temperature derived from Foster et al. (2012) does not appear to apply to debris-covered glaciers in the Everest region and the relationship derived from the data from Nicholson (2005) still yields unrealistic sensible heat fluxes, the most reasonable approach for modeling the turbulent heat fluxes is assuming a neutral atmosphere. The results using the instability correction will be added to the revised paper and discussed such that readers will understand the reasons behind using the neutral atmosphere model in this study. Future work should seek to measure z_o in this region as its value has a significant impact on results.

1c: Latent heat flux at the debris surface. Latent heat of evaporation is consumed where water evaporates from a surface. There cannot, therefore, be a latent heat flux at a dry debris surface where there is no available water to evaporate. It is likely, however, that water does evaporate (or condense) at the saturated horizon within the debris, which you suggest is commonly at a depth of about 10 cm. Since you effectively use the 10 cm saturation vapor pressure (equation 6) as model input, this 'within debris' latent heat flux is what you model, albeit forced with an atmospheric wind speed that is likely to be much too high. However, since you use (satellite) measured surface temperature as model input, I would suggest that the cooling effect due to within-debris evaporation will already have been accounted for in this surface temperature measurement. My concern is that introducing the latent heat flux term in the model amounts to double-counting of this energy flux. This additional calculated latent heat flux may be compensating for probable underestimation of the sensible heat flux due to neglect of atmospheric instability (point 2 above).

> - This is an excellent point that the latent heat flux is likely being double-counted and that the estimated latent heat flux would be too high due to the use of the atmospheric wind speed. In response to these comments, the latent heat flux has been assumed to equal zero due to the upper 10 cm of debris being dry.

1d: Longwave radiation calculation. There appears to be a mistake in the longwave radiation calculation in equation 2 where the measured incoming longwave radiation is multiplied by emissivity. This final term should read +Lincoming – sigma.epsilon.Ts^4. I assume this is a typographical rather than model error.

> - The model is done properly as explained by Hartmann (1994).

2: How is air temperature extrapolated from Pyramid Station across the study area? The distances and elevation ranges are huge (10s of km and 100s or 1000s of m). There doesn't appear to be any method here, not even the application of a simple elevation lapse rate. Consequently, air temperatures applied in the model must be unrepresentative of most, possibly all, of the model pixels across the study area. The temperature errors are likely to be much larger than the modest +/- 2 degrees in the sensitivity analysis. Given this, it is questionable whether the turbulent heat flux is modeled accurately at the study basin. Also, can we be sure that decreasing thermal resistances upglacier (Figures 5 and 6) represent real patterns on the glaciers and not a gradually increasing error in sensible heat flux due to progressive air temperature over/under-estimation?

> - The model used a temperature lapse rate. Previously, the lapse rate was only mentioned in section 3.1 (p896, line 14). In the revised paper a sentence will also been added in section 2.1 as well stating "the air temperature was adjusted based on the elevation of each pixel using a lapse rate of 6.5 K km^{-1}". As the elevation range of the debris-covered region is only 15m different from the elevation where

> the temperature is being recorded at Pyramid Station, the air temperatures in the model should be fairly well represented. A more thorough description of the glacier and focus area has also been added to discuss this point in the revised paper in response to comments 3a and 3c. Furthermore, the surface elevation gradient at the study site is very low (less than 2°), so there is not a great difference in elevation until after the confluence of the Lhotse Shar and Imja glaciers, considerably upglacier from the study area. This has been mentioned in section 2.3 in response to comment 3a.

2a: Given the large uncertainties in points 1 and 2 above, there is some question over whether the agreement between model output and measured thermal resistance is actually due to good model performance or fortuitous error compensation in the model.

> - As discussed in response to comments 1, the model was developed such that the values of sensible heat fluxes were realistic lending confidence to the modeled thermal resistances. In response to comment 2, a temperature lapse rate was applied, which should alleviate most of the concerns with respect to air temperature.

3: Basic information about the field area and measurements needs to be presented. Pyramid Station, please show its location on Figures 1 and 5 and provide information in Section 2.1 about how far in horizontal and vertical distances it is from the study glacier. Also, in Section 2.1 explain what methods were used to extrapolate meteorological variables to the study glaciers, or else make it clear that unmodified data from Pyramid Station were applied to all pixels.

> - The field data paragraph in Section 2.3 has been revised to add a detailed description of Imja-Lhotse Shar glacier as follows:
>
> "Field research was conducted in September 2013 on the debris-covered portion of Imja-Lhotse Shar glacier (27.901°N, 86.938°E, ~5050 m a.s.l.). Imja-Lhotse Shar glacier refers to two debris-covered glaciers, Imja glacier (the southeastern component; ~4.5 km to the confluence) and Lhotse Shar glacier (the northeastern component; ~3.5 km to the confluence), that converge and terminate into Imja Lake (Figure 1). The third glacier present south of Imja Lake is Ampu glacier, which appears to no longer contribute to Imja-Lhotse Shar glacier. Imja and Lhotse Shar glacier are both avalanche fed and extend from the calving front of Imja Lake (5010 m) up to elevations of 7168 and 8383 m for Imja and Lhotse Shar glacier, respectively. The thickness of debris cover on Imja-Lhotse Shar glacier increases towards the terminal moraine of the glacier and is primarily composed of sandy boulder-gravel (Hambrey et al., 2008). The debris cover extends up to elevations of 5200 and 5400 m on Imja and Lhotse Shar glacier, respectively. From the calving front of Imja Lake to the confluence of the glaciers, the elevation increases less than 50 m, which is consistent with the findings of Quincey et al. (2007) that the tongue of the glacier is relatively

stagnant with a surface gradient less than 2°. The debris cover has a hummocky terrain with melt ponds and exposed ice faces scattered throughout."

The location of Pyramid Station has been added to the revised figures. Figure C3 shows the changes made to Figure 1 that will be used in the revised paper. The horizontal and vertical distances from Pyramid Station to Imja-Lhotse Shar glacier are shown via the scale bar in Figure C3. The distance is approximately 10 km southeast. Figure 5 has also been redone to include coordinates, north arrow, etc. as shown in Figure C4. One important note is that in response to a comment by the other reviewer, the incoming solar radiation (S_{in}) is initially computed at each pixel with a 5 m resolution. The values of S_{in} in each pixel are then averaged over a 30 m pixel to be consistent with the resolution of the thermal band. The same is done for air temperature (T_{air}), and pressure (P). The energy balance is then applied at a 30 m resolution.

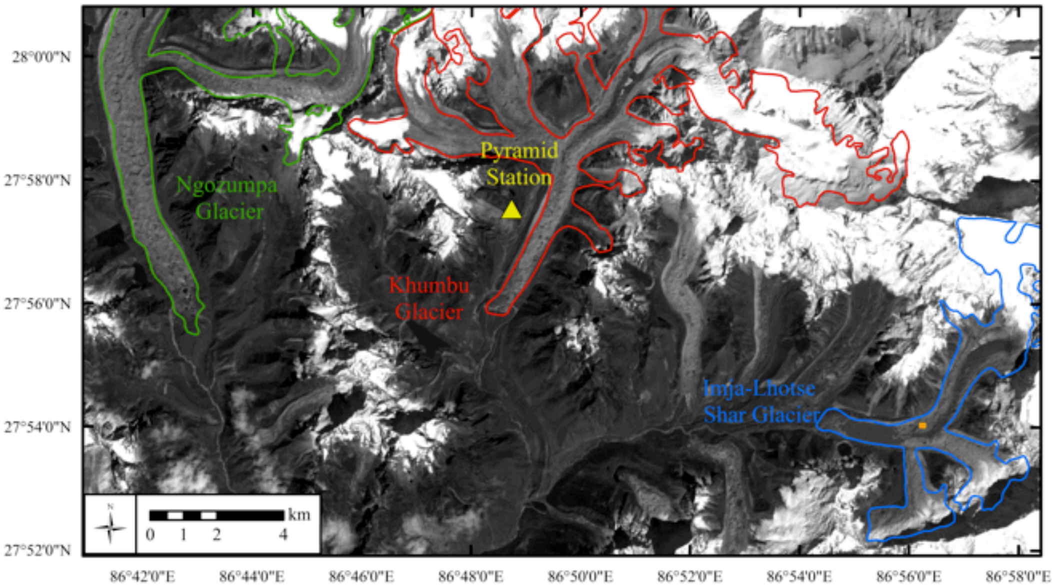

Figure C3. Panchromatic band from Landsat 7 on 04 Oct 2002 showing Imja Lake amongst debris-covered glaciers in the Everest region and Pyramid Station.

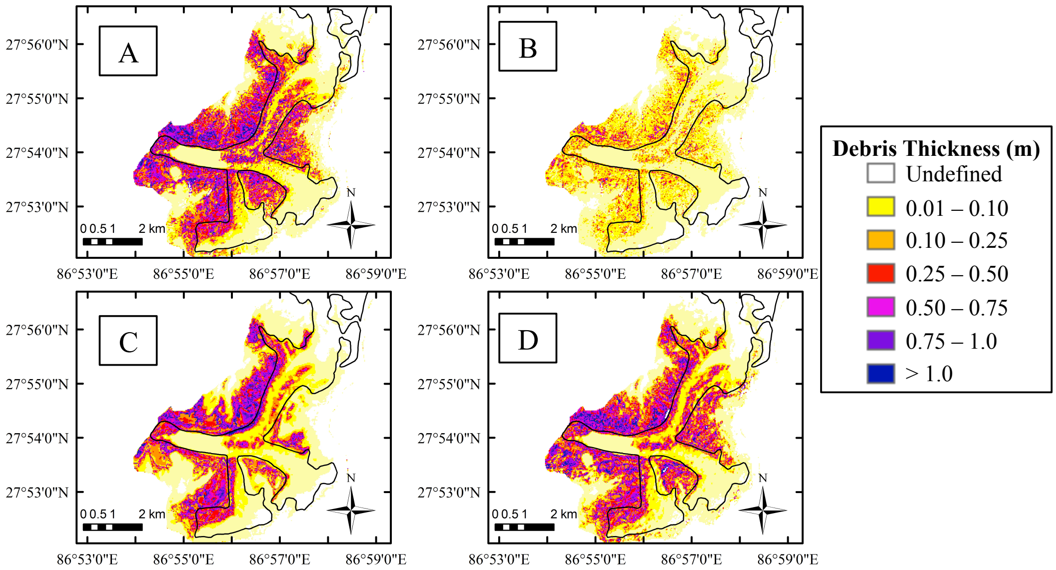

Figure C4. Debris thickness in meters assuming an effective thermal conductivity of 0.96 W m^{-1} K^{-1} using the high resolution DEM (Lamsal et al., 2011) with the (A) nonlinear sloped model, (B) linear sloped model, (C) nonlinear flat model, and (D) the ASTER GDEM with the nonlinear sloped model

The methods that were used to extrapolate measurements from Pyramid Station onto the glaciers have been discussed in response to comment 2a. The following sentence has been added to the revised paper to thoroughly address this comment:

"All the meteorological data are assumed to be constant over the Khumbu region, except for shortwave radiation in the sloped model and air temperature. In the sloped model, the incoming shortwave radiation term was corrected for the effects of topography, altitude, and shading similar to the methods of Hock and Noetzli (1997). The air temperature was adjusted based on the elevation of each pixel using a lapse rate of 6.5 K km^{-1}."

3a: Section 2.3, basic information about the study area is missing. What are the sizes, elevation ranges and aspects of the study glaciers? What are the debris-covered areas? Are there any known patterns in debris cover and debris thickness?

- Information about the study area has been added to the revised paper and is discussed in comment 3.

3b: p. 894 top, what were the debris thickness at the thermistor sites?

- The debris thickness at sites LT1, LT2, LT3, and LT4 were 31, 47, 36, and 40 cm, respectively. This has been added to the revised paper.

3c: p. 894 paragraph 2, what is the area of the melt basin and over what area were thickness measurements made? What are elevations of the measurement points and their elevation difference from Pyramid Station?

> - Page 894, paragraph 2 has been revised to include additional information with respect to the melt basin by adding the reference coordinates of the melt basin (27.901°N, 86.938°E, 5045-5055 m a.s.l.). A thorough description of the melt basin has also been added as follows:
>
> "The melt basin was approximately 120 m long and 60 m wide with a topographic low in the center of the basin (5045 m a.s.l.) and a topographic high on the perimeter of the basin (5055 m a.s.l.). The elevation of the melt basin was only 10-20 m higher than the elevation of Pyramid Station."

3d: You should present some meteorological data from the station and a surface temperature map for at least one of the Landsat images. The reader would then be able to evaluate the odd statement at p.904, 11-12. If there isn't any variation in surface temperature, then presumably there isn't much variation in debris thermal resistance either?

> - Figure C5 has been added to the revised paper to show an example of the surface temperature map from the Landsat image and the corresponding meteorological data associated with one of the twelve dates used in this study. The comment of the lack of variation in surface temperature was meant to refer to the study area, where little variation in surface temperature was observed in the satellite images (all surface temperatures were typically within 2 K). However, the study area is small in comparison to the entire debris-covered glacier and the reviewer is correct that this was a poor statement and could be misleading. The lack of knowledge about albedo is a limitation of this study. Therefore, the statement and the one preceding it p.904 9-12 have been deleted in the revised paper.

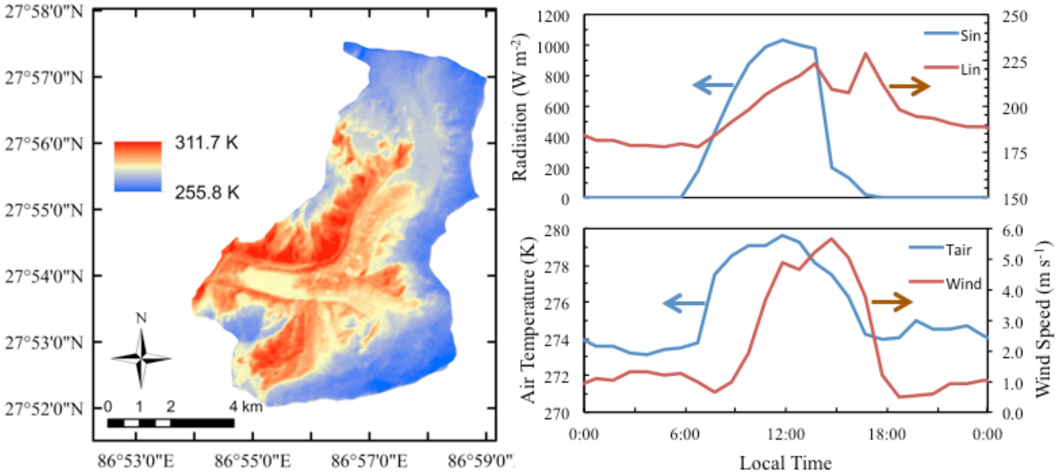

Figure C5. Surface temperature derived from Landsat 7 imagery (left) and corresponding meteorological data (right) on 04 Oct 2002.

4: Gratio. The Gratio multiplier is the main innovation in the paper and hence some further analysis and discussion regarding its calculation, variability, and transferability is warranted.

- This is addressed in the comments below.

4a: The selection of the upper 10 cm of debris for the 'nonlinear' temperature gradient is fairly arbitrary and seems justified mainly because there happens to be a thermistor at this depth. What happens to the Gratio if different depths, e.g., 1, 2, 3, 4, 5, 15 are used instead? Can you provide a physical justification for the 10 cm depth and would this be universal or would different depths be appropriate for different types of debris cover? What would be the appropriate depth for debris less than 10 cm thick?

- This is an excellent comment. The depth used to approximate the nonlinear temperature gradient was found to greatly influence G_{ratio}, where G_{ratio} decreased as the depth increased (Figure C6). This relationship was expected because as the depth used to calculate G_{ratio} approaches the thickness of the debris, G_{ratio} will approach a value of 1. Ideally, the nonlinear temperature gradient would be approximated by a linear temperature gradient in the upper 1 cm of the debris or smaller. However, these measurements could not practically be performed in the field. Figure C6 shows that the values of G_{ratio} derived using depths of 5 and 10 cm (2.9 ± 0.8 and 2.7 ± 0.4, respectively) are similar; however, the standard deviation associated with those derived from 5 cm is much larger than those derived from 10 cm. As the two were similar, G_{ratio} derived from a depth of 10 cm was used in this study.

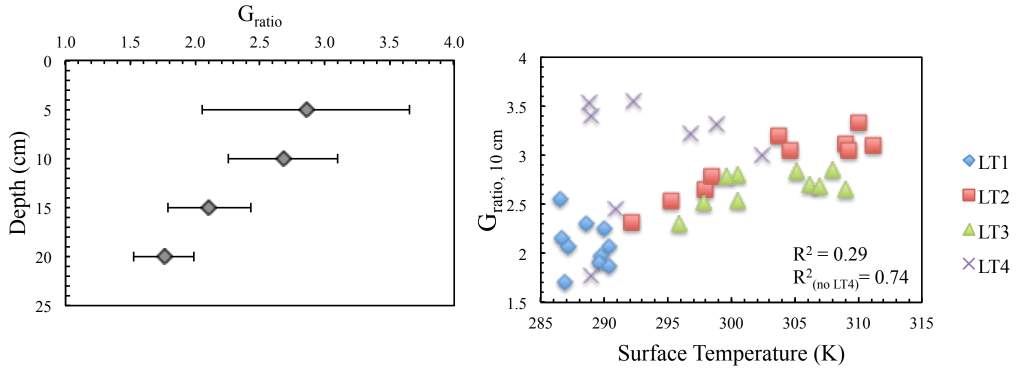

Figure C6. Average value of G_{ratio} and associated standard deviation as arrow bars for each depth (left) and corresponding G_{ratio} values at 10 cm depth for each sensor (right)

The other trend that may be expected is for G_{ratio} to increase as the surface temperature increases. However, Figure C6 shows that there is little correlation ($R^2 = 0.29$) between surface temperature and G_{ratio} based on the data from all four sites. When the G_{ratio} values from site LT4 are removed, there appears to be a stronger relationship ($R^2 = 0.74$), but there is no physical justification for removing these data. Therefore, this study uses an average value of G_{ratio} of 2.7. Conway and Rasmussen (2000) is the only other study, to the authors' knowledge, that has measured temperature profiles in the Everest area with a small enough spacing (maximum 10 cm) between thermistors to compute G_{ratio}. The values derived from their temperature profiles at Everest Base Camp on May 21-23, 1999 were 3.0, 2.6, and 2.6, respectively. This good agreement lends confidence to the use of G_{ratio} in the Everest area. For regions with much smaller debris thicknesses, e.g. Miage Glacier (Reid et al., 2012), where a significant amount of the debris is less than 10 cm thick, it is possible that G_{ratio} will be different. Future work should determine the value of G_{ratio} for thin debris layers in addition to determining how G_{ratio} varies over the melt season and how G_{ratio} is influenced by temperature. This discussion will be added to Section 4.3 in the revised paper.

4b: The definition of Gratio (897, 14-15) seems wrong to me. There is no 'nonlinear' temperature gradient here – both gradients in your ratio are linear. Please define carefully what Gratio actually is.

- G_{ratio} is a multiplier, as the reviewer noted, that is used to approximate the nonlinear temperature variation in the debris. The nonlinear temperature variation in the debris is approximated using a linear temperature gradient in the top 10 cm of the debris. To help clarify what G_{ratio} is, the nonlinear "correction" factor, has been changed to the nonlinear "approximation" factor. Furthermore, the definition of G_{ratio} (897, 12-15) will be modified in the revised paper to clearly state that a linear temperature gradient in the upper 10 cm is used to approximate the nonlinear temperature variation in the debris as follows:
"G_{ratio} is used to approximate the nonlinear temperature variation in the debris. A linear temperature gradient in the upper 10 cm of the debris is used to make this approximation. G_{ratio} is therefore defined as the ratio of the linear temperature gradient in the upper 10 cm of the debris to the linear temperature gradient throughout the entire debris."

4c: Can you justify estimating Gratio to 2 significant figures (p. 899)?

- No we cannot justify 2 significant figures as the thermistors measured temperature to 0.1 °C. Therefore, G_{ratio} has been changed to only have 1 significant figure.

5: There appears to be some misunderstanding about the latent heat flux, and indeed range of applications of the model, on page 904 lines 21-25. Bare ice faces and ponds don't have any debris on them, so modeling the latent heat flux on these surfaces would require a bare ice energy balance model, not a debris model. However, this is not the point here, the effect of water and bare ice areas is to reduce the overall temperature the satellite records in an individual pixel leading to a decrease in thermal resistance estimate. This is a mixed pixel problem, not a problem with the calculation of latent heat flux.

> - The discussion on page 904 lines 21-25 was meant to discuss the influence of bare ice faces and melt ponds on the energy balance. Bare ice faces and melt ponds are present throughout the debris-covered surface; however, the resolution of the satellite imagery is too poor to identify them unless they are very large. As the reviewer comments, if these ice faces and melt ponds could be identified the latent heat flux would not be modeled by a debris model, but by a bare ice face energy balance model or an open water model that would account for evaporation of the melt ponds. This will be clearly stated in the revised paper. The point of this comment was to discuss that in addition to the mixed-pixel effect reducing the surface temperature of the pixel, which is how its been used in the past, the mixed pixel effect is also going to cause bare ice faces and melt ponds to be characterized as debris. Since the latent heat flux of debris is assumed to be zero, the latent heat flux associated with the bare ice faces and melt ponds (which would have to be modeled differently than the debris) is not accounted for. Therefore, the latent heat flux in a mixed-pixel is going to be underestimated. As a result, the mixed-pixel effect reduces the surface temperature, which also reduces the sensible heat flux and underestimates the latent heat flux. All three of these components cause the modeled thermal resistances to be underestimated. This will be clarified and explicitly stated in the discussion about the latent heat flux.

Tables and Figures

Table 2. What data are shown in this table? Are these averaged field data, model data for part of or the whole of the glacier? Or data for one point with a modified slope angle?

> - These are average values of the modeled thermal resistances, average values of surface temperature from the Landsat images, and average net radiation after the slope corrections are performed for each 5 m pixel in the focus area. A new title will be given to the table to clarify this as follows:
>
> "Table 2. Trends in average modeled thermal resistance, average surface temperature, and average net radiation with respect to slope and aspect using a sloped model and a flat model for the 5 m resolution pixels in the focus area."

Figure 1. The left panel needs a scale and orientation arrow. The right panel needs some indication of distance. The left panel should be annotated to show the locations of Pyramid Station and the outline of Imja-Lhotse Shar glacier and the location of the study melt basin. Main glaciers should be labeled.

- These changes have been made to the figure on the left as shown in Figure C3. The right portion of the figure has been removed such that the left image may be enlarged and contain more relevant information.

Figure 5. Please add glacier outlines so that it is easy to identify glacier and extraglacial areas. Again, scale and orientation needs to be added, as well as units for the key. Some more discussion of these results is needed in the text. Judging from the outlines on Figure 6, the debris cover distribution is rather unusual: high resistance debris on what looks like a tributary glacier flowing from the north and then an abrupt change to very low resistance debris on a west flowing glacier with values rising quite suddenly again on the snout.

- Glacier outlines have been added to Figure 5 in addition to a scale, north arrow, and units. After the confluence of the glaciers there is a region of greater thermal resistance. This is likely a result of two factors: (1) the slope is more gentle and (2) the debris from both Imja glacier and Lhotse Shar glacier are combining thereby causing greater thermal resistances in the middle of the glacier and smaller thermal resistances closer to the lateral moraines. However, little is known about the dynamics and interactions of these two glaciers and how they influence the distribution of debris cover or the thickness of glacier ice below their confluence. Figures 5 and 6 also show that the thermal resistances on Lhotse Shar glacier are smaller in the center of the glacier compared to the sides, which is likely due to the sides being closer to the avalanche-prone cliffs. Figure 6 also shows a region of low thermal resistance near the terminal moraine of Ngozumpa glacier, which is where Spillway Lake is currently developing. This discussion of Figures 5 and 6 will be added to the revised paper.

Figure 6. Again a total lack of basic annotation.

- Figure 6 has been updated by Figure C7 with proper annotation. The modeled results are also shown in debris thickness based on a comment from the other reviewer to report results in debris thickness because it is more intuitive for readers.

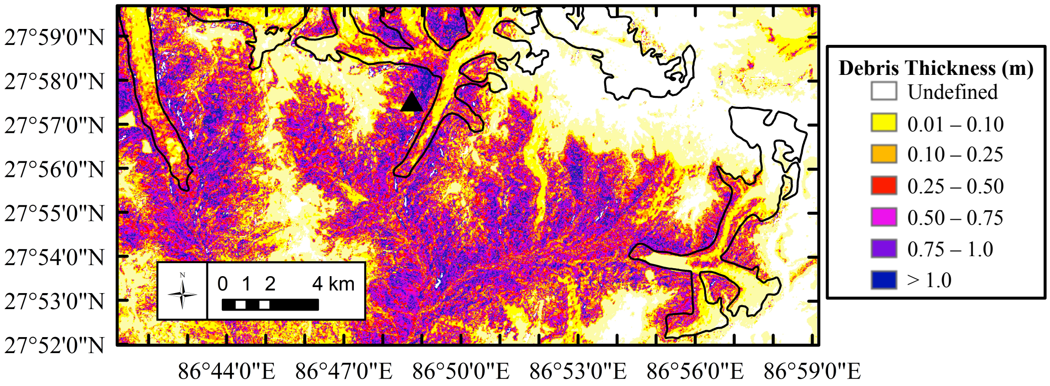

Figure C7. Debris thickness in meters assuming an effective thermal conductivity of 0.96 W m^{-1} K^{-1} using the ASTER GDEM and nonlinear sloped model for debris-covered glaciers in Everest region with Ngozumpa, Khumbu, and Imja-Lhotse Shar glaciers (left to right) highlighted using GLIMS outlines and Pyramid Station depicted as the black triangle.

Technical Corrections:

Abstract and throughout paper, remove terms ‘accurate’, ‘validate’, and ‘transferable’ as none of these claims are justified by the analysis.

- These terms have been removed from the paper. In place of the terms ‘accurate’ and ‘validate’ when comparing the modeled results with the measured debris thickness, the term ‘reasonable’ has been used.

888, 2: remove many

- Deleted.

888, 4: apostrophe in glacier’s

- Apostrophe has been added as glaciers’, since it was plural.

890, 6: Lejeune et al. J. Glaciol., 59(214), 2013 should be added to this list.

- This reference has been added.

890, 12 and elsewhere: ASTER should be capitalized.

- It has been capitalized throughout the text.

892, 13-14: ‘… above freezing…’, is this true even at night?

- As the sentence was written, this is not correct as the surface temperature does drop below freezing at night. The sentence has been revised to state the "daily mean temperature in the debris was above freezing".

892, 26: '… data were taken…' (correct data as a plural noun throughout the paper).

- This has been done.

894, 12-13: Sentence beginning 'Of the 25…' needs rephrasing to avoid ambiguity

- This sentence has been changed as follows, "Measurements were conducted via manual excavation using a tape measure at 23 of the 25 sites."

895, 15: Justify the emissivity value of 0.95

- The value of emissivity was selected to be consistent with the study by Nicholson and Benn (2006). Their value of 0.95 was justified in Nicholson (2005) with reference to (Arya, 2001), which reported most natural soil or rock surfaces have an emissivity of 0.9 – 1.0. Furthermore, they cited Oke (1987) as pale, or dry, soil surfaces having an emissivity of 0.9, and dark or wet, soils having an emissivity of 0.98. Therefore, the value of 0.95 is between these two values.

897, equation 9: k is not defined

- Defined a k is the effective thermal conductivity (W m^{-1} K^{-1})

901, 27: '… directly behind the glacier…' please clarify.

- The sentence has been revised as '… and behind the calving front…' for clarification.

904, 2-5: There is no basis for this statement. If there is a bias in the difference in meteorological conditions between Pyramid Station and the glacier, then it doesn't matter how many images you use, they will not compensate for this error.

- This sentence has been deleted.

References

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Best regards,

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