Response to Anonymous Referee #1

We appreciate the efforts of both reviewers to critically evaluate the manuscripts and provide constructive suggestions for improvements. We have responded to each comment in detail below. Our responses are formatted in italics.

Anonymous Referee #1 Comments

This is an easily readable paper to which I have only a few comments.
The effect of a thin debris layer to increase melting as indicated by Figure 5 is rather small in my opinion. The maximum effect is ~10% increase for ~1 cm thick debris compared with clear ice. I don't have a good reference but I would have expected (much) higher values for thin debris that is as an average only a mm or even less in thickness (this is based on my experience and the experience of colleagues with variation of calibrated degree-day factors in ablation areas with and without volcanic debris in the ice). Maybe the authors could comment on this in the final version of the paper.

We will include a short discussion about the effect of thin debris layers. In fact this effect is difficult to address by field measurements with natural debris cover, because natural debris cover usually shows large variations. Very thin debris covers therefore can vary from no debris at all, to patchy debris cover and fully covered ice surfaces in very short distance, with a large variety of grain sizes. Therefore single measurements of thin debris covers only match some of the conditions in reality. Fortunately this is not significant for ablation calculations, because the areas of enhanced melt are usually much smaller than the areas of debris cover with thicknesses of more than the critical thickness.

On page 412 near the top it is described that the melt model underestimates snow melt in year 2003 and it is stated that a higher degree-day factor is need to model the melting during this year. The reason for this is not clear. This year is then excluded from the analysis. This is not a good reason to exclude an apparently good data point. Why not just keep this data point and accept the higher errors? If no reason for the higher error in year 2003 is found, it seems that the error is higher than obtain only from the years
2000 to 2002 when the model fits the observation better.

We will reconsider the case of year 2003. For this purpose we analysed again the available climate data and found no obvious reason for this model result. Because we will in any case introduce a discussion about the effect of snow cover variability, we will also discuss this in respect to the model result for 2003.

The reference "Knap and Reijmer, 1998" on p. 412 is missing in the list of references.

This reference will be included.

I don't understand the argument presented near the top of page 413: "because the temperature of melting ice is limited to 0°C and higher radiation amounts cannot be fully exploited". Radiation absorbed by a melting ice surface is used for melting and I do not see how the temperature of 0 °C limits the amount of absorbed radiation energy.
Following this it is stated that: "In the case of sub-debris melt, the debris surface temperatures can reach rather high values; thus we estimate the effect of the enhanced radiation on ice melt to be about 90% in this case." It is true that higher surface temperature increases conduction of heat into the lower debris layers and underlying ice and thereby increases melt. However, the higher surface temperatures also lead to a greater loss of heat to the surroundings by greater longwave radiation from the surface and greater heat conduction to the surrounding air so it is not obvious why a greater radiation should be more effectively used for melting for debris-covered ice compared with clear ice from these arguments. A greater albedo of the ice is, however, a valid argument for a less effective use of additional radiation energy for melting.

This paragraph is also criticised by reviewer 2 and we will rewrite the entire section in order to avoid future misunderstandings. The wording was probably not very well chosen, but we will introduce a short description about the role of energy fluxes through the debris cover and the influence of air temperature, albedo, debris surface temperature and radiation on the heat budget of the debris cover. High debris surface temperatures will of course also increase the *emission of long wave radiation from the debris surface. But the effect of heat conduction into the debris cover is a major component of the energy balance at the debris surface.*

In table 1, the interval 1996-2008 in the heading of the 6th column should be 1966-2008.

Will be corrected.

The English language could be improved in many places.

We will involve a fluent English speaker in order to improve the language.