Comment on ‘Incorporating moisture content in surface energy balance modeling of a debris-covered glacier ‘ by Giese et al.

In this paper, authors applied ISBA model to debris-covered ice. The model include moisture transport and phase changes in the debris layer. They used observed temperature in the debris layer and melt amount in 2013 as validation. Then, they also carried out sensitivity test for six elements.

But, I think some explanation and discussion are not sufficient in the manuscript. I hope my comment will help to improve your paper.

Main comments

1. There is no ‘observed data’ section. Observed glaciological or meteorological data are important to establish model as not only input data (AWS) but also validation (ablation). Even some data are already published, I think authors need to describe what kind of observed data authors have. I recommend to add one section of observation.
2. Authors describe in the conclusion ‘Snow is a strong insulator, and any error in simulated occurrence of snowfall will cause error in the surface temperatures and underlying debris temperature profile simulated by ISBA-DEB (e.g. Figure 6).’ In P29 Line24. But, they did not discussed about the snow cover effect in the discussion. Snow cover makes high albedo over the debris, which inhibits ice melting. Snow cover makes no temperature gradient in the debris layer. And meltwater from the snow cover will be important moisture source of debris layer. Therefore, reconstruction of snow cover duration is significant to estimate ablation under the debris. Authors have nice observed data, and simulated data, then they can discuss about the snow cover effect.

Specific comments

P3 Table 1 > multiplication should be presented as ‘×’ not ‘*’.

P4 L9 > I think ‘It lies 200 m southeast of’ should be southwest. or I misunderstand them?

P4 Fig.1 > There are no description of the location of ‘‘West Changri Nup and North Changri Nup glaciers’ in the map. So, I cannot detect those locations. Further, location of measurement site of debris temperature are necessary.

P5 L22 ‘Glacier melt enters the debris at the base, and rain and snowmelt enter the debris at

the surface.' > better to add water like 'Glacier melt water, snowmelt water'

P6 Figure 2 > The small letters (Ex. dz varies, n layers) in the left side of this figure can not be read, when the figure has been shrunk.

P7 Figure 3 > I found several 'Table A1' in the manuscript. But, there is no table that shown as 'Table A1'. Revise all 'Table A1'.

P8 L7-8 'We neglect energy carried by precipitation' > But, there are arrow of 'Rain &snowmelt' in the Figure2. Please explain the detail, how did you treat the penetrated water

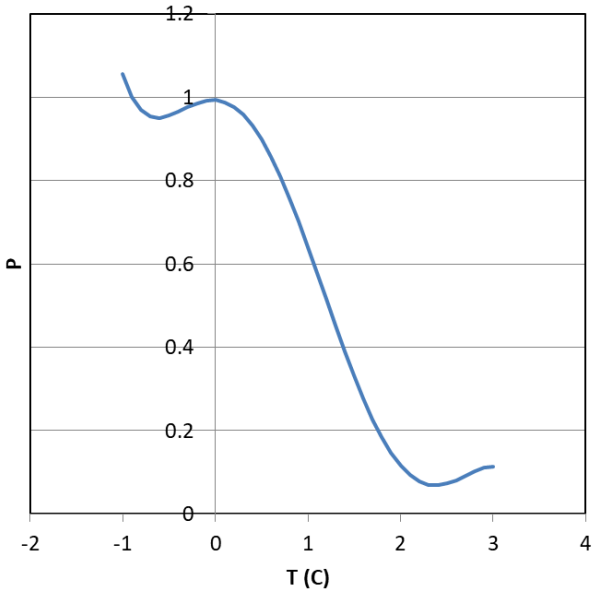
P10 L11 'τ_α... defining the runoff timescale from….' > $\tau_\alpha$is important in this paper. Then, I recommend that detail explanation of τ_α are necessary here. For example, *** become larger with increasing τ_α and so on.

P11 Figure 4 I recommend to change the unit of τ_α in hour rather than in second, because in the text you have discussed the τ_α in hour.

P12 Line5 I recommend that all meteorological variables are described in the supplement.

P12 L13 There are no description about how did you measure the debris temperature and debris density and porosity.

P12 L21 I estimate you used eq.(1) in Wagnon et al.(2009) here. But please draw the equation between -1 to +3 ºC. The equation has no simple relation. I can't imagine why you have to use the complicate relation. Or you have applied for the temperature range between 0 and +2 C ?



P12 L22 ‘minor adjustments based on SR50 measurements.’ > There is no detail information on the adjustments. I can estimate that measurement of precipitation using Geonor T200B has relatively small error because it can measure weight of precipitation directly. On the other hand SR50 measure only surface elevation change, which is not equal to amount of precipitation. So, why you should adjust using SR50 ?

P13 Table 2 You should write name of instrument at the ‘Instrument’ for example Pyranometer for shortwave radiation.

Campbell SR50 can not measure ablation or accumulation directly. It can measure only elevation change, then, you should assume snow or ice density to estimate accumulation or ablation.

P14 Figure 5c It seems that many point of rainfall have been overlaid by those of snowfall. I think these two data should be shown separately. The label of x-axis should rotate 90 degree. Vertical writing for label of x-axis is easy to detect the exact location.

There are rainfall, but no snowfall during winter (from Jan 2014 to around March 2014). Is that possible? Please check.

P15 L17 ‘2013 ablation’ > There is no information of the observation of 2013 ablation. Location? Duration? Frequency of measurement ? How much is the debris

thickness? How did you measure? And the location of ablation measurement were same with that of measurement of debris temperature ?

P15 L18 ‘using an RMSE calculation to capture the magnitude of temperature.’ >> I recommend to write them specifically.

P16 Figure 6 I recommend that daily average data both observation and calculation are plotted in one graph. I cannot compare if those data are shown in different graph. Further, many points are overlapped in Fig. 6, then, daily average are necessary. And I also recommend that scatter plot of the observed and simulated debris temperature are valid to compare and analyze.
And how much is the debris thickness? 12.5 cm ?

P16 Figure 6 ‘(having insufficient snowfall to produce the observed persistent snowcover)’ > It might be possible that model overestimate the melt rate of snow cover. I think reconstruct of duration of snow cover during the melting season is significant (see main comment).

P17 Figure 7 In the explanation, ‘(a) Temperatures in debris (top 12.5 cm)’ I can’t understand the ‘top 12.5 cm’. This points location of interface between debris and ice ?

‘… below the black line indicates…’ > ‘below’ ?

P17 L3 Figure A2 > Figure 2

P 18 Figure 8 I recommend to describe those data is simulated data.

P20 Figure 10 There is no calculated data shown in Figure 8 (calculation of moisture integrated model). Why? It seems that the calculated ablation using moisture integrated model (Figure 8) have similar value with ‘dry’ and ‘partially saturated’. And in this section (P20 L1-8), there is no discussion about the difference between three case calculated data and measured data. Measurement value was corresponded with the value of assuming fully saturated, not dry or partially saturated.

P21 Figure 11 This is a minute thing、but as for color bar, ‘No moisture’ are colored by light red. I think the color should be white.

P22 Figure 12 I recommend to add cumulative melt (like Fig. 8).

In the last sentence of the explanation, there are ‘A greater latent heat flux corresponds to a lower conductive heat flux through…’ > There are multiple latent heat fluxes in this system. Please write specifically.

P24 Table 3 ‘% Change’ > What is the change ? Change of ablation ?

P28 L12 ‘75.3±20 cm (2012 – 2013) and 47.1±20 cm (2013 – 2014)’ > Here, I have noticed that you have observed data not only 2012 – 2013 but also 2013 – 2014. Why you did not compare observed data and simulated data 2013 – 2014? Because you have tuned parameter 2013 – 2014? But, you have tuned parameter τ_α fitting simulated debris temperature to observed debris temperatures. Not ablation amount.

Observed data of ice melt under debris layer are very few, even though those data have large uncertainty.

P29 L23 ‘more detailed assimilation of the snow rate with the SR50 data.’ > Still I don’t know the location of the measurement of ablation and debris temperature. Then, my comments might not appropriate. I would like to ask the surface temperature at AWS (SR50 measurement) can be assumed to be same condition with that at ablation measurement site? If you can assume same condition, you can analysis the albedo of AWS using observed SRs downward and upward and weather there is snow cover or not.

P29 L24 ‘Snow is a strong insulator, and any error in simulated occurrence of snowfall will cause error in the surface temperatures and underlying debris temperature profile simulated by ISBA-DEB (e.g. Figure 6).’ > I recommend to discuss about the snow cover during summer season in the discussion section. Because you have observed data of temperature of debris as shown in Fig.6.

P29 L26 ‘ISBA-DEB may be used to explore past or future changes in sub-debris melt. Reanalysis data, such as that of ERA Interim, provides all variables necessary to drive the model.’ > ERA Interim do not include debris-thickness or particle size of

debris, which is important for permeability (thermal conductivity) of debris and also surface roughness, those parameter have high sensitivity in ISBA-DEB model in your result. How will you apply the ISBA-DEB model to other debris-covered area? I recommend that you have to better to consider application to other debris covered part.