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Interactive comment on "Representing moisture fluxes and phase changes in glacier debris cover using a single-reservoir approach" *by* E. Collier et al.

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This paper is the first attempt I've seen to include detailed simulation of moisture fluxes in a glacier debris layer when calculating surface mass balance. The resulting changes relative to a 'dry' model are found to be quite small for the test site, but could be more important in other areas, so the findings have wide relevance for future distributed glacier melt modelling. I find it particularly interesting that mass losses due to surface vapour fluxes more than compensate any reduced ice melt due to water in the debris layer.

The modelling, writing and presentation in the paper are outstanding and based on

very sound data, so my comments below are on fairly minor technical points, typos and asking for a bit more detail in some modelling assumptions. I thoroughly recommend publishing the paper in the Cryosphere once these points are addressed.

Best wishes, Tim Reid

Abstract line 11: say 'The former year' rather than 'The former simulation' otherwise this is confusing.

p1596, line 26: 'zair', use subscript as defined.

p1597, line 2: 'a minimum debris water content of 2 kg mˆ-2' – I'd like more detail on why this figure was chosen. What field measurements were taken, and how? It needs at least a reference.

Eq. 5 and related text: This is an interesting approach for estimating surface vapour pressure. However I feel it needs a more firm justification here in terms of theory and/or data. Is the linear relationship backed up by any field measurements, or theory e.g. from soil science or other fields? Also – I may be misunderstanding, but it seems that using the fractional fullness of the reservoir (F_res) might not be appropriate for layers of different thickness. E.g. a 1m layer with F_res=0.6 would have a distance of 40cm between the top of the reservoir and the debris surface, whereas in a 10cm layer with the same F_res it would only be 4cm away. Wouldn't the reservoir then have a much bigger effect on the surface vapour pressure in the thinner debris layer? It seems to me that debris thickness should be included in the equation and not just F_res.

p1597, line 20: 'where [what?] is. . .'

p1597, line 25: no 'the' needed before 'determining'.

p1598, line 3: Define AWS for first time use.

p1600, first sentence (started p1599) is not a sentence! Needs a verb somewhere.

p1600, line 16-18: I have some data from a thermistor profile that might back up this

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model finding, I'll be in touch separately.

p1600, line 20: I've never tried to measure this, but 60% porosity seems very high for the piles of clasts I've seen on Miage! If I were to guess I'd have said it couldn't be more than 40%, definitely not more than 50% because surely that would defy some mathematical stacking laws (and I don't think the clasts themselves are very porous)? I'd like to see more detail on how the authors made these measurements to justify such a high number, and if indeed it is too high then they could do a small sensitivity analysis to see how it affects their final numbers on mass balance.

p1602, line 15: Should it say 'source' rather than 'sink' for QPRC? (I suppose this depends on whether air or surface temperature is higher?)

p1603: Lots of undefined and lower-case acronyms on this page, please check thoroughly.

Table 1: A third column showing some sources for these numbers would be nice.

Table 4: Is there a +/- typo on the second line, for longwave?! This is a big difference between the two models!

Fig. 3b: It's not clear if the line for the first period (modelled wind speed I presume) is grey or black. Also the caption would benefit from an explanation that this was modelled from ERA (or however it was acquired. . .).

Fig. 6b&10b: I'm curious as to how deposition is modelled? This isn't mentioned in the text and it could benefit from a sentence or two.

Fig. 8a-c: Would these look more intuitive with flipped axes? (i.e. depth going down the side as in Fig. 9?)

Fig. 9b is an excellent illustration of how moisture cools the debris. I wonder if you could make the colour scale a bit wider so that the small differences are highlighted better? It all looks more or less the same blue at the moment. Not essential though.

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Fig. 11: No units on y axes. I like this figure as a demonstration of refreeze, but it is quite difficult to understand – I think it would benefit from showing the full CMB-DRY temperature profile, as well as CMB-RES and the difference between the two.

One general comment: Please give a detailed explanation of what happens to precipitation in CMB-DRY. Is it somehow added on to the mass balance? I am assuming not, because the refreeze in Table 4 is zero. So does it pass straight through the debris layer without making the debris wet and runs straight off? (It would be worth noting that this is what the Reid and Brock 2010 model, and maybe some others, did). The reason I ask is that the significant loss of mass by vapour fluxes in CMB-RES comes from evaporation of water in the debris BUT this is water that wouldn't be present in CMB-DRY if it's all assumed to runoff there. So is the mass balance comparison of the two models (i.e. Fig. 5b) actually fair – i.e. should the mass balance of CMB-DRY be more negative because it has no input from precipitation? Sorry if I've got confused – none of this stops CMB-RES being the most detailed and accurate representation!

To summarise the above comment, I'd like a more detailed explanation of how mass balance is calculated, taking into account these three factors:

- Mass gain due to debris being wet and thus lowering sub-debris ice melt

- Mass loss due to vapour fluxes at surface

- Mass gain due to precipitation (?)

Interactive comment on The Cryosphere Discuss., 8, 1589, 2014.