

## ***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 considers the impact upon glacial melt rates caused by water within a glacier's surface debris layer. The paper follows on from the authors previous work in the subject area, and begins to open up a larger discussion about what is actually going on within a debris layer; this is not an easy subject to approach due to many unanswered scientific questions regarding the multiple energy transfer processes, often turbulent. The paper appears to primarily be a modelling paper, which is applied to data from the Miage glacier, France. In general it is clearly written, although I need to see much more detailed information regarding the appropriateness of the underlying

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mathematical model, before I can make an informed judgement upon the contribution of the paper.

Within the introduction, the authors rightly point out many of the complexities within this subject area. However given the paper's reliance upon an externally derived software package, it is hard to see exactly whether or not the model is actually capable of meeting these complexities. What I need to see within the paper -so that I can make a much more informed judgement and replicate the results- is a clear set of paragraphs explaining precisely what the underlying model is. I'm not asking for pages, but something that I can at least get a feel of what the model actually is, and how it works (given it's importance, a simple reference is not enough). For example, the authors say the model has been adapted to include a debris layer. Fine. But if we look at the conservation of heat equation (2), we see that  $z$  is not defined. This might appear a simple oversight. However, if the computer package has the  $z$  coordinate taken from a fixed reference point (as one would probably choose if writing the code for a non-debris covered glacier), then equation (2) would be incorrect. This is because the derivation of the heat equation would need to utilise the 'convective derivative' (basically a moving co-ordinate system), which would introduce an additional derivative term, and thus the heat equation is fundamentally altered. Another example of my concern is given on page 1595, in which the model only appears to be able to deal with 1 cm step sizes. Is this true? In which case the model may not be amazingly appropriate for examining the debris layer of a glacier. If it is possible to run further simulations, it would be good to see a convergence test conducted, where the grid size is decreased to the mm level. If the package does not permit it to go smaller, then give a convergence test down to the cm level to show whether the 1 cm level is OK. This would give the utilisation of the software package much more credibility (after all, a single cm may sound small, but the maths don't care how things sound). Hopefully these points highlight my concerns with using a software package without going into clear details regarding the model's appropriateness. It may well be the case that all of my concerns vanish with a few choice sentences describing the conversion of the software into a debris covered situation

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-hopefully this is the case, as the paper is otherwise well constructed.

Technical Comments: -1598. Programming error - of what? The AWS (which needs defining) or the software package? If the former then fine, if the latter then the results should be redetermined. -1600 second para. You say boundary conditions are given by a temperature. You may find a flux better to use (i.e. temperature gradient), as this will be less sensitive to the arbitrary choice of depth. -1603. At this point I'm unsure as to how the thermal conductivity is calculated. Presumably it is a function of  $z$ , thus reflecting the moisture within the lower part of the debris? A clear equation showing how  $k$  is determined is certainly needed. -The discussion section does not seem to discuss much! It would be nice to see warts-and-all suggestions about the model limitations/ appropriateness/further work.

Specific Comments: -Abstract, remove 'sophisticated' from the abstract. History can decide if it is sophisticated. -Page 1592. Line 15. Clarification of the what actually 'total input' means, is required. -page 1595. Third paragraph down. I have no idea what is going on here, but it seems to be important. More information and a significantly clearer explanation is required. -page 1596. line 26. typo. -page 1596 (or maybe earlier). A clear definition of what a 'single reservoir' model means, needs to be made.

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