

Interactive comment on “Environmental controls on the thermal structure of alpine glaciers” by N. J. Wilson and G. E. Flowers

Anonymous Referee #3

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General Comments

Overall, this paper is complex, involved and intricate, and on occasions, as a result of this, it is sometimes a little tricky to follow. However, at the same time it is revealing and enlightening, and introduces some really interesting ideas that are well-explored and well-researched. I think that the difficulties in always following the text comes about because there is so much material here. The authors do a decent job of trying to structure it clearly, and overall, I think they do a fairly good job. My own lack of modelling expertise prevents me from being able to comment with any great confidence on the modelling procedure outlined and followed. On that basis, I think that it is vital that the manuscript is also reviewed by someone with greater expertise in this area. However, on the assumption that the modelling is correctly carried out, then I believe

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this works makes a significant and important contribution to our understanding of the complexities associated with the way in which small(er) glaciers might respond to a warming climate. Although there are a number of significant points that I believe need addressing (outlined below), I would ultimately like to see this paper published, as I think it makes an important contribution, providing some very interesting insights, particularly in terms of the variability in future changes in polythermal glaciers we are likely to see as climate changes.

I would also like to congratulate (and thank) the authors for their hard work from a proof-reading point of view. It is virtually flawless when it comes to grammatical errors (a few minor points as listed below), and is generally very well written. As a result, there are only a small number of minor issues listed.

Specific Comments

1. P3783, L1-3 – you need to explain why understanding thermal structure in smaller ice masses is important.
2. P3783, L10 – I struggle to understand this section...i.e. how can a model of polythermal structure ‘neglect the presence of temperate ice’? Isn’t this pretty fundamental when modelling polythermal glaciers? If it does indeed neglect temperate ice, then surely it’s not a polythermal model!
3. P3783 L15-18 – following on from the comment above, I really struggle to understand how a cold ice model can predict more temperate ice! If it is a cold ice model, how can it predict temperate ice? I accept that it may be my weakness that prevents me from understanding this better, but I would still like to see a fuller explanation. Finally re. this comment, you say that investigating the use of a cold ice model for polythermal glaciers hasn’t been thoroughly investigated. Surely, however, it would be wrong to do this.
4. P3783, L27 – brief mention needed that some heat sources would be entirely unaf-

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ected by climate (e.g. geothermal).

5. P3784, L5 – I'm not sure I really like your definition of thermal structure. You say that it refers to the 'distribution of englacial heat which affects temperature in cold ice and water content in temperate ice'. I find this a little confusing, since surely englacial temperate also affects whether the ice is temperate or cold in the first place! Your definition implies, somewhat, that the distribution of temperate and cold ice is fixed, and that it is the temperature within this that varies, but to me, thermal regime or structure is about the distribution of warm and cold ice (which is defined according to temperature). I think that there needs to be greater clarity here.

6. Pp3875-3878 and 3790-3792 – I would strongly urge that these equations (and indeed those that also appear later on) are checked thoroughly by someone more qualified to do so than myself. To me, they seem to be okay (no obvious, glaring errors, as far as I can tell), but this needs to be more rigorously checked.

7. P3790, L21 – as a non-modeller, I am always suspicious of such statements...i.e. that something in a model is not 'physically meaningful'. What are the 'real' implications of such a consideration? I'd like this better explained.

8. P3792, L11-12 – 'neglecting sliding' here seems to be important, and although this is acknowledged, I think that greater consideration of how this impacts on the outcomes is needed.

9. P3792, L1-4 – I have no understanding of this discussion of 'upwinding'...this needs to be checked by someone else.

10. PP3795-3797 – I think these statements of the purpose of each experiment are very neat and concise!

11. P3796, L14 – although you state that considering these parameters in isolation is not strictly accurate, since they are not independent, you nevertheless go on to do this. Can you comment on how useful this actually is?

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12. P3796, L18 – you say that the importance of advection as compared to diffusion varies widely from glacier to glacier, yet there is no supporting evidence for this statement (or indeed further explanation). Can you please provide further support and explanation?

13. P3801, L6-10 – I wonder if there just needs to be a very brief mention of subtler changes that might arise in terms of future climate – i.e. that changes may be more complex and therefore perhaps more or less pronounced in different seasons, as opposed to just a simple overall climate warming (e.g. the role of changing precipitation patterns).

14. P3802, L13-19 – I find this passage a little confusing. I don't understand how there can be a higher fraction of temperate ice if the equilibrium line elevation is increased and the size of the accumulation zone decreases. In this same section, I don't follow the logic that the ablation zone cold layer thins because there is more water that must refreeze...does it refreeze, or are you saying that there is too much to do so? I'm also not clear what your 'starting' thermal structure is here. I feel this section needs further clarification.

15. Figure 7 – can enthalpy, as plotted here, at all be recast as temperature (in some way)? If so, it may be more useful.

Technical Corrections

1. P3782, L6 – I don't really like the use of the term 'flowband' in the abstract. Why not use 'glacier'? You were happy to use this term in the title!

2. P3782, L12/13 – 'volume of temperate ice...' relative to the volume of cold ice presumably?

3. P3783, L6 (and elsewhere) – the referenced paper is Rippin et al., 2011...NOT Rippen.

4. P3794, L19 – 'of' is missing from after 'quantity' and before 'meltwater'.

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5. P3798, L1 – seems odd to use ‘a’ here instead of ‘years’! I’d prefer to see ‘years’.

Interactive comment on The Cryosphere Discuss., 6, 3781, 2012.

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