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Discussions

Interactive comment on "Basal sliding of temperate basal ice on a rough, hard bed: pressure melting, creep mechanisms and implications for ice streaming" *by* M. Krabbendam

M. Krabbendam

mkrab@bgs.ac.uk

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Reply to interactive comment by D Cohen (referee) on "Basal sliding of temperate basal ice on a rough, hard bed: pressure melting, creep mechanisms and implications for ice streaming" by M. Krabbendam

Thank you very much for a very constructive and helpful review, this will help me to provide a better paper.

It was not my intention at all to deconstruct or criticise Weertman's original model; all I wanted to do is to point out it is not applicable to temperate ice with the original assumptions, which, unfortunately, are at times still perpetuated in probably inappropri-

ate conditions. I will reword and rephrase, where appropriate, to be more respectful to Weertman's original model, which of course was pioneering, and has become classic.

I agree that, for larger-scale obstacles, creep is more important than pressure melting against the obstacles: in a sense the order in which I presented the manuscript probably had more to do with the order of my thinking, rather than the order in which the ideas are best presented. It is possibly better to start dealing with the creep component (which will become somewhat longer due to the comments of the other reviewer). So I've decided to re-arrange the manuscript as follows:

1 Introduction

2 Basal meltwater production by frictional sliding

3 Growing and maintaining a temperate ice layer

4 The creep component in temperate ice (this will be expanded to take care of M Montagnat's comments)

5 The pressure melting component

6 Stoss-side pressure melting in temperate ice

7 Effect of surface water input on temperate ice on a rough bed

8 Critical obstacle size

9 Discussion

10 Conclusions

The critical obstacle size will indeed need to be discussed, and I will make a comparison with the classic Weertman sliding model. In doing so, if one say assumes that pressure melting in temperate ice will be twice as fast for a given height of an obstacle, but the creep rate is say about 5x as fast, than the critical obstacle size will in fact be lower than in the classic Weertman model. Having said that, Kamb and LaChapelle

(1964) noted that whilst qualitatively Weertman's theoretical concept is correct, in nature and experiment their critical obstacle size is much larger (about 1 metre). Overall, for metre-scale obstacles, creep probably dominates, but pressure melting may well be crucial for debris, which normally is < 1m across.

As to the specific comments; these all make sense, and I will deal with these, mainly through rewording or rephrasing. Two deserve some reply:

"Page 5 Line 2. The vertical stress could even be higher than the effective pressure since, due to melting, there is a component of ice flow towards the bed that creates a vertical downward force on the debris. This force could be significant and further increase basal friction".

Yes, that is strictly true, but that concerns the very localised contact stress of a debris cobble onto the bed. On this contact the friction coefficient would also be much higher (rock on rock friction), probably in the order of mu = 0.5 or so. Since I use the low friction coefficient averaged over a large area, I have also used the vertical stress over a large area, rather than looking at the very localised stresses.

"Page 6 Line 11 (ii). Strictly speaking this is not true. There will be differences in temperature in temperate ice due to differences in stresses (if only with depth). These temperature differences will cause thermal gradients and heat fluxes (arguably small). These gradients will only serve to melt ice or freeze water. See Lliboutry 1993.".

Again, this is strictly true, but here I'm referring here to a bulk thermal gradient, capable of transporting significant heat from the base to the CTB. This bulk thermal gradient is zero (or rather it is slightly negative, due to the increase in cryostatic pressure). I will reword this, to make it clear.

Again, thank you very much for a thoughtful review

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