Earth Surf. Dynam. Discuss., 3, C245–C248, 2015
www.earth-surf-dynam-discuss.net/3/C245/2015/

Earth Surface Dynamics Discussions
Open Access

Interactive comment on "The periglacial engine of mountain erosion – Part 1: Rates of frost cracking and frost creep" *by* J. L. Andersen et al.

J. L. Andersen et al.

jane.lund@geo.au.dk

Received and published: 12 August 2015

We thank the reviewer for the many constructive and supportive comments. We find that the insightfull remarks have helped us to strengthen the manuscript.

In this reply we comment on all remarks given by the reviewer and present the associated changes to the manuscript. The comments have been copied into this document in grey and are marked with C for comment and a sequential number. The corresponding response is marked with R.

Reviewer 4: S. Brocklehurst

This manuscript is a concise, well-written account of a newly-developed numerical model that explores the competing effects of frost cracking and frost creep in periglacial

landscapes. A companion manuscript inserts the model described here into a broader landscape evolution model. This manuscript has a firm basis in the existing literature, and implements sensible, substantial advances on existing models. The numerical experiments are elegant, and the outcome is significant insight into the controls on the key processes operating in periglacial landscapes. I enjoyed the manuscript, and I find little to criticise. On the whole, the account of the numerical model is comprehensive, but there are a couple of minor omissions;

C-4.1: strictly, rho and c are not defined, and it would be helpful to have a more explicit definition for wf.

R-4.1: Comment refers to section 3.1. This is an error propagating from an early draft of the manuscript. We have now changed the text and table, so it consistently refers to the volumetric heat capacity, C. Thank you for noting this! The water fraction wf is the unfrozen fraction of the porespace, we have added this explicit definition to the manuscript.

C-4.2: The model necessarily contains a series of parameters for which there are few constraints, and the primary motivation here is to demonstrate the importance of acknowledging, for example, that flow restriction is important, and that it is different in different materials. Nonetheless, it would be helpful if the authors could provide more discussion on the basis of their choices, e.g., the four values of flow restriction for unfrozen sediment, frozen sediment, unfrozen bedrock and frozen bedrock. Section 4.3.3 and Figure 11 document what happens without considering flow restriction, or when holding it uniform across all materials, but it would be good to see discussion of the significance of the choices when all four materials are assigned unique values for flow restriction.

R-4.2: We agree that this part of the manuscript could be strengthened, and we have attempted to do so. Please see responses to comment C-2.2 by J. Roering and comments C-3.1 – C-3.3 by T. Hales.

ESurfD

3, C245–C248, 2015

C-4.3: Similarly, it would be good to expand upon "variable moisture content... could potentially influence..." in section 5.2.

R-4.3: We have re-phrased the paragraph in which the sentence occurs. It is now clearer that the paragraph refers to seasonal moisture variations.

C-4.4: Some minor comments: Section 3.1. It reads a little strangely that the movement of water is a key component of the frost cracking model, yet the authors "ignore the thermal effect of fluid advection". I doubt this is a concern as far as the model is concerned, but it would be helpful to have a little further content here to support this assumption.

R-4.4: We understand that this may seem as an inconsistency. However, the effects of fluid flow on frost cracking and the temperature field are two very different things. In particular, the rates of fluid flow due to ice segregation are likely to be too slow to have a significant thermal effect. However, when it comes to faster fluid flow, such as that arising from rainwater infiltration, this is not so obvious. In general advection will work towards a reduction of the thermal gradient, which might potentially lead to a reduction of frost-cracking intensity, depending on the timing and magnitude. However, fluid advection is likely to be both site specific and dependent on local precipitation, we have therefore not attempted to include these effects in the present more general study, but we have emphasised the limitations of the thermal model in section 3.1.

C-4.5: Section 3.2. Perhaps alert the reader at first mention of vw that water availability is considered carefully in the discussion.

R-4.5: We refer to this discussion later in the same section (p. 295, l. 18).

C-4.6: Section 3.3. "silt-sized" is mentioned rather apologetically here, yet the grainsize of the sediment would seem to be a key control on frost creep behaviour. This is indeed explored in the discussion of the companion manuscript (Egholm et al., p. 346), yet not considered further here. Could the authors explore this theme here, too?

ESurfD

3, C245–C248, 2015

R-4.6: We agree that grain-size is important for frost creep behaviour. In our model, this effect is represented by the parameter β. We have strengthened the description of β and the discussion of grain-size affects. See also the response to comment C-3.5 by T. Hales.

C-4.7: Also, the formatting of the equation on p. 296, l. 19 is rather untidy.

R-4.7: We have simplified the deviation of this equation. See also response to comment C-2.3 by J. Roering.

C-4.8: Section 4.3.3. Vcw is given with units of mËĘ2 in Table 1, but here it is in cm.

R-4.8: Unit in table+text has been changed to m.

C-4.9: Fig. 10. What do the arrows labelled "snow" represent?

R-4.9: We can see that the meaning of the arrows was unclear. We have adjusted the caption to emphasise that the arrows delimit the timing of the snow-cover effect.

C-4.10: Fig.12. Using the same colour scale for (a) and (b) might help to illuminate the differences between the two results.

R-4.10: There was an error in the colour scale for (a) (0.05 in stead of 0.57). This has been corrected. Using the same colour scale for a) and b) is difficult however because the max value in (a) is 5 times higher than in (b) and too many details would be lost. The difference in colour scales is emphasised in the caption.

Interactive comment on Earth Surf. Dynam. Discuss., 3, 285, 2015.