

Review: Carter et al, tc-2015-17

Dear colleagues,

The paper “Active lakes in Antarctica survive on a sedimentary substrate I: Theory” by Carter et al. is a very interesting contribution to the understanding of the hydraulics of the subglacial environment of Antarctica, and maybe ice sheets in general. However, in the present state the manuscript is lacking clarity and details in several crucial sections, and should be considerably improved before publication.

Sincerely, Martin Lüthi

General comments

T-channels are not a new invention of this article. Subglacial waterways eroded from sediments have been termed “canals” (e.g. Ng, 2000), and have been theoretically treated in some detail. Reference to parts of this earlier literature is given in the technical parts of the manuscript, but I feel that it should already be properly referenced in the introductory part.

A major problem with this paper is the clarity of presentation. Results of the model are presented under the heading “Model execution” which is a subsection of “Model description”. This section clearly belongs to into “Results”. Then again, the “Results” section reads in places like it should be part of the “Discussion” section. It would be very helpful to present a concise modeling strategy, and then present the model descriptions and the results within this framework. Only after this, sensitivity tests should be presented (section 4.2).

The presentation of the model equations is confusing, partly because symbols are not consistently used, partly because symbols are not introduced (and also not listed in the list of symbols), and partly because it is not clear which equations are drawn from other sources, and what are the changes unique to the present model.

A severe flaw in the model formulation is in my opinion the lack of the C_{VR} term in equation (8). Also in the case of a sediment channel, the ceiling consists of ice which will erode thermally, and more importantly, flow into the channel once the ice pressure exceeds the channel water pressure. Maybe there are some arguments that show that the C_{VR} term is negligible, but these should be clearly stated and carefully evaluated.

Also, one wonders whether there is a balance of sediment mass, or how this till mass redistribution works. Is this solely described locally by Eqs. (8a) and (8b)?

Several times the paper by Le Brocq et al is referenced using wording like “casts doubts on the study by Le Brocq et al. (2013)”. I think this is not helpful, especially since the processes considered in their paper are very different from the sediment channels discussed in this paper. Sub-shelf circulation is something completely different than subglacial circulation. The possible implications of the present model results for shelf circulation, if any, should be clearly stated in the Discussion, and if there is a strong case against the Le Brocq interpretation, this should be carefully stated. As presented now this discussion is not convincing. To me it seems that convection within the ice shelf cavity due to fresh meltwater as driver is completely ignored, although this is probably the dominant mechanism for heat advection under an ice shelf.

Specific comments

- 2057 28 “Kyrke”. This type should not happen with Bibtex.
- 2061 14 “erosion rate” and “deformation rate C_{VR} ”
- 2061 15 should this be a m_R ?
- 2061 15 should this be a ρ_i ?
- 2061 15 should this be a C_{VR} ?
- 2061 17 what is k_n ? Why is it 0.309 as given in the table?
- 2061 19 what is K_R ? (missing definition, value)
- 2062 2 explain that this term describes the water exchange between sheet and channel. This general setup (sheet, channel, sediment) should also be motivated in the beginning.
- 2062 13 “Kyrke”. This type should not happen with Bibtex.
- 2062 16 What is viscous sediment? How can this be implied, and what experimental evidence does exist for this?
- 2062 17 as mentioned above, the C_{VR} term is missing. The channel roof will creep in (or out) by viscous ice flow.
- 2063 4 what is μ_w ?
- 2063 4 is ρ_T changing with till water content?
- 2063 4 which quantity is changing in Eq. (8c)?
- 2063 6 what is μ_T ?
- 2063 6 shouldn't there be some slope, or pressure gradient, dependence in this equation? What is the motivation for this formulation?
- 2064 4 missing word between “the will”
- 2064 15 why is there an underscore under f_T ?
- 2065 2 write the derivative as fraction $\frac{\partial \Theta_s}{\partial x}$
- 2065 1014] This comment is completely out of place, and should probably got into the Discussion.
- 2065 19 why is there a z_{stf} ? Should this be z_s ?
- 2066 6 “both models”: which models?
- 2066 12 “m.w.e.” there should be no dot after “meter” (as with all SI units)
- 2066 14 “Till” should be lowercase
- 2066 25 a missing “is minimized” in this sentence?
- 2069 1 “Model execution” is not a good name. This whole section should go into the “Results”.

- 2070 These sections should go into the Discussion.
- 2071 15-22 First show the reference results, then start comparing them to other model runs. This is really confusing.
- 2073 5 do you mean “stretch the coordinates”? There should at least be a “multiply by a constant factor”.
- 2073 10 What is a “dramatic” lake drainage? (leave away)
- 2074 12-18 Also this paragraph belongs into the Discussion.
- 2074 24 “paradoxically” why? The system is less nonlinear and more diffusive, so I would expect that result.
- 2075 9ff This is a strange and very qualitative discussion. Of course does model resolution (i.e. grid spacing) affect runtime.
- 2076 13 Here the same statement is made twice.
- 2076 21ff As mentioned in the General Comments, this handwaving discussion should be either substantiated, or discarded entirely.
- 2079 21 “our model”
- 2088 what are “M”, “L”, “T”? Presumably mass, length, time.
- 2088 Pascals are abbreviated as Pa (not pa), why this value for A_i .
- 2088 what is H_L ? Lake height should be in meters?
- 2088 the latent heat of fusion also contains the unit K, therefore the middle column is wrong.
- 2089 the densities should be given by ρ , not p
- 2094 Very sketchy description of the figure, this should be considerably expanded.
- 2094 Missing description on vertical axis.
- 2097 “Relative lake volumes”: relative to what? There should be no units if this is relative (i.e. a fraction). Maybe this is volume difference? Since the lake does not change its area in the model, this could also be given as lake water height (units m).
- 2098 (a) should this be R_1 (subscript).
- 2098 (c) is this Q_M ? Please indicate.

References

Ng, F. (2000). Canals under sediment-based ice-sheets. *Annals of Glaciology*, 30:146–152.