

Interactive comment on “Modelled subglacial floods and tunnel valleys control the lifecycle of transitory ice streams” by Thomas Lelandais et al.

Anonymous Referee #2

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This paper describes an analog experimental model for ice flow over sediments and water, and uses the results of the experiments to describe a transitory lifecycle of an ice stream. The paper is short; it identifies some of the known features of modern and paleo ice streams, discusses the combination of conditions that are thought to play a role in the dynamics of ice streams, describes the experimental setup, the results of an experiment, and the inferred ‘lifecycle’ behaviour of an ice stream.

The experimental approach is quite novel (though not without precedent; notably the paper of Catania & Paola (2001) is absent from the references and deserves comment) and I think it is welcome. You might also reference the laboratory work of Kowal & Worster (2015), which has some similar results. The setup appears to be quite sophisticated, allowing detailed mapping of elevation changes and velocities. There therefore

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appears to be considerable scope with this approach. However, the current manuscript is somewhat lacking in detail and I think there needs to be more scientific discussion about the extent to which the experiment does and does not represent the real world. There also is relatively little data presented on the detailed measurements that have evidently been taken. At present, it reads like a re-hash of a submission to Nature, and I think it needs a bit of expansion to fill in some details for the more discerning reader.

The paper is nevertheless well written and interesting, and I think with improvements it can be a valuable contribution to the literature.

Specific points

- The experimental approach is advocated partly on the basis that numerical modelling and field observations are not able to include all the coupled components of the ice-stream, sediment, water system. However, there is almost no discussion given to the drawbacks of an experimental approach; in particular, the issues of things that are missing (the analog 'ice' does not change phase for example), and the extent to which the processes can be scaled down. There should be more attention given to this. For example, what is the Reynolds number of the subglacial water flow? Are the dimensions of the 'tunnel valleys' that form comparable to real tunnel valleys (relative to ice thickness, say), and does the grain size of the sand not have some effect.

- How was the flow-rate of water to be injected chosen, and are the results sensitive to this? Is it realistic? (In terms of water flux as compared to ice flux, say). How is it decided when to start injecting the water? Does this make a difference?

- How much of the water flow is through the permeable sediments and how much in a film at the sediment/silicon interface? How thick is the water layer? Are the sediments in suspension or carried as bedload?

- Only one particular experiment is described in any detail. It is not clear how repeatable this is except for the comment on I190 that the observed lifecycle is the same for 12

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identical runs; but it is hard to imagine that the development of the three ‘tunnel valleys’ is exactly the same each time. Is there really always two stages of streaming? Do they always appear on the same sides of the experiment? How different are the plots in figure 3 between different experiments (in terms of peak velocity for example)? There should be more discussion of the other experiments.

- Figure 2. It is not completely clear what is shown in the first column, and the color scale chosen is not particularly suited to showing elevation changes (e.g. it is quite unclear where zero is). Given that there are negative values, this is presumably an elevation change from some reference? What is taken as the reference, given that the silicon is anyway spreading (and presumably lowering?) before injection starts?

- The surge of the Variegated glacier referenced on line 219 was, as I understand it, accompanied by a decrease in the outlet discharge of subglacial water rather than an increase. A subsequent increase in discharge, with the development of a more efficient drainage system, accompanied the termination of the surge. So I am not sure this is quite the same behaviour as seen in your experiments.

- The slow-down of the ice stream is attributed to a lowering of subglacial water pressure together with the growth of tunnel valleys, but presumably in the experiments there is also an influence of the changing silicon geometry which is driving the flow. The surface is lowered over the central part of the dome and the driving stress is therefore reduced. What is the evidence that the ageing of the ice stream is not simply due to this effect? (which is also present in the real ice-stream problem too).

References

Catania & Paola 2001 Braiding under glass. *Geology* 29, 259–262

Kowal & Worster 2015 Lubricated viscous gravity currents. *J. Fluid Mech.* 766, 626–655

Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-71>, 2018.

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