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Interactive comment on "The influence of a model subglacial lake on ice dynamics and internal layering" *by* E. Gudlaugsson et al.

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General comments:

In this paper the authors investigate the influence of a sudden drop in basal resistance, in this case a subglacial lake, on the architecture of internal layers by means of a 3D full-system numerical ice model including thermo-mechanics. The novelty of this approach is that the dip in layers at the no-slip/slip transition and the rise at the slip/no-slip transition - the so called 'Weertman effect' - has been investigated by a model solving the full equations and accounting for the changes in the temperature within the ice. This has effects on the viscosity of the ice and therefore on ice deformation and its internal layers. In a second experiment the authors look at the transient effect of a draining lake varying in size on the internal layers, which has - to my knowledge - never

been investigated.

The paper is adding to the increased awareness that the layers at the base of an ice sheet can show disturbances lasting for a long time originating from simple causes such as a change in flow pattern. Overall the paper is carefully written, well structured and of good quality. The figures and tables are informative. Nevertheless I have some points that in my view need to be addressed.

Specific comments:

For the first experiment suite, a steady state experiment, the resulting surface velocities and topography as well as the internal layers are obtained for different sized lakes. The effect of a different viscosity on the surface topography and the vertical distribution of horizontal velocity is studied. However we do not see how a different viscosity affects the internal layers. If there is no change this should be mentioned in the text.

In the second experiment, a transient experiment, the authors look at how the internal layers evolve under a lake drainage happening over 10 years (compared to the ice velocity this is seen as an instantaneous drainage). However the lake surface is not a free surface in the vertical direction as it is fixed to the bed plane and only changes in the horizontal extend. What effect does this have on the internal layering? Furthermore it is not clear to me if the water that drains from the lake has been accounted for the ice downstream of the lake, which would affect the internal layering, e.g. by melting ice. Nevertheless the drainage experiment is interesting, but to me it is not entirely clear if the comparison with the work by Wolovick et al. (2014), where a slip boundary is moving WITH the ice can be compared to the downstream boundary of the draining lake that is moving UPSTREAM. I feel that there the interpretation of the observed result is going too far and is too speculative. However, the discussion under which conditions the modelled signature in the internal layers - a travelling wave - might be observable with radar is good. The question however is how long is it visible? I find Figure 5 not yet that clear in showing the travelling wave. Maybe you could add a later time frame or show the last graph with the initial internal layers to better visualise the contrast.

Technical corrections:

P3860, L2: odd wording: 'subsequent draw-down of isochrones and cold ice from the surface'. An increase in velocity leads to a thinner ice body because it's faster. The cold ice is still at the surface, but the temperature gradient does change. The maximum change in elevation of the isochrones is found at about a third of the ice thickness (see Leysinger Vieli et al., 2007) - this is where you would find the largest effect of temperature change - but it's not surface ice. What you mean here is the 'Weertman effect'. But this becomes only clear later in the text.

P3860, L31: what is 'rapid'?

P3862, L14: Comma after 'hydrostatic equilibrium'?

P3862, L19: 'Leysinger Vieli' without hyphen, studied the effect of areas with basal sliding or melting on internal layer architecture, but not explicitly a subglacial lake.

P3864, L3-5: could be written a bit clearer as you explain terms in an equation of an equation. Maybe it's easier to explain it after each other?

P3864, Equation 8: I believe here is something missing e.g. H > ....

P3867, L21: Is the ice thickness realistic for Greenland or Antarctica? What effect does the ice thickness have on the result?

P3869, L8-12: Refer to Figure 2b?

P3870, L10: In order to know what viscosity is used in the other experiments one needs to look it up in Table 1, but it is never referred to in the text.

P3870, L26-28: Can you visualise the traveling wave better, e.g. at a later stage when the isochrones around the lake fully recovered?

P3872, L9-11: Is this so? Why?

P3872, L15: Here you describe the Weertman effect.

P3873, L20: Both boundaries move but not in the same direction. It is rather a narrowing of the area.

P3873, L23: 'affects' instead of 'effects'.

P3873, L24-23: I'm not sure you can compare this to Wolovick's et al. (2014) work, as your downstream boundary is moving in opposite direction to the ice.

P3877, L24: 'Leysinger Vieli' remove hyphen.

P3880: Refer to Table 1 in the text.

P3883: Fig. 2b - not sure what colour-bar is for what. Are both colour-bars / colour-scales true everywhere or is one for the inlet figure only? Caption: Maybe along flow profile is a better expression than cross-sectional? I was always thinking at an across profile. Mention what the black lines are (it's mentioned in the text but would be useful information in the caption too.) Mention in the caption the lake size you are showing.

P3884: Caption: again I find along flow profile over the lake easier to understand. Replace 'vertical bar' with 'horizontal bar' Not clear with what viscosity case this has been calculated (n=3?).

P3885: Caption: You are showing the 'vertical profile of the scaled horizontal velocity' but in a way you are saying it but as it reads I understood it for c) only.

P3886: Figure: The grey colour-bar is a bit odd - not clearly visible in the figure. Caption: what do you mean by 'yellow' lines? They are not visible. With 'black' lines you mean the grey scale colors? Mark the travelling wave - e.g. by an arrow, or show the initial isochrones together with the isochrones of the t=2000 case. Or could you show an even later stage?

Interactive comment on The Cryosphere Discuss., 9, 3859, 2015.