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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.

Anonymous Referee #1

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General appreciation

This is an interesting paper showing for the first time the complex interaction of ice flow with subglacial lakes by focusing on temperature-induced changes and their effects on ice viscosity for a synthetic model setup. The authors clearly demonstrate the mechanisms behind observed topographic features, such as hummocky surface depressions as surface expressions of the limits of subglacial lakes. To this purpose, they use a full-Stokes model (which is a major improvement compared to previous subglacial lake model studies). Moreover, using an enthalpy description of the temperature field they properly take into account the heat and water balance at the base of ice sheets. While a subglacial discharge experiment is carried out, this does not actually involve changes in the lake geometry. The paper is clearly written and the figures are of overall good

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quality.

The sensitivity experiments comprise changes in lake size and different flow law exponents. Lake discharge is also simulated for different lake sizes. Since the results appear to show that the most critical area where changes occur is at the boundary between the lake and the surrounding ice sheet, i.e., a boundary between free slip and high friction, I would have liked to see a sensitivity on the contrast between both. The used friction factor of C=1e13 is a rather high factor and three orders of magnitude larger than the friction one may expect under ice streams. It seems necessary in the general discussion of the observed features, such as the hummocky surface anomaly and the viscous heating at the contact between the lake and the surrounding ice sheet, that the sensitivity is enlarged to different factors of of slipperiness. This would not only make the paper richer, it would also explain features of other types of subglacial lakes encountered in Antarctica (and Greenland). A question that arises is whether at lower C-contrasts the hummocky feature is still prevalent, whether the viscous features play a similar role or not, and if internal layer anomalies show similar characteristics.

Detailed remarks

P3860, L8-9: rephrase 'A question is what effect this would have on internal ...'

P3860, L33: past discharge events?

P3862, L14: The hydrostatic equilibrium of subglacial lakes may well be a function of their size. Since you use a full Stokes model, you can demonstrate whether this is the case for event the smallest lakes sizes in your sample.

P3868, L8: Are 15 layers really enough? Have you tested this with more? Moreover, in the discussion you base your analysis on just two layers with temperate ice (70m). I am afraid that the undersampling may have an influence on the results.

P3868, L25: What 'considerable' distance? be precise. Is this so-called considerable distance a function of ice thickness/size of lake? Does slipperiness play a role?

P3869, L16: I suppose that this concentrated deformation is very much a function of the basal sliding law and coefficents used outside the lake. The value of C is also very high (3 orders of magnitude higher than that of an ice stream) which implies a sharp transition between the ice flow across the lake and the surrounding ice. See my general remark.

P3870, L8: Could the dip and ridge feature also be a function of bridging stresses in the full Stokes, besides a strain-induced flow-law effect?

P3870, L27: The travelling wave is surely an interesting phenomenon and would have had more value if this has also been detected in radargrams. I understand that it is probably difficult to detect when topography is rough. This would certainly be an added value to the paper.

P3871, L18: See previous remark on undersampling (2 vertical cells seems to me very narrow to base conclusions on).

P3872, L13-14: remove both commas

P3872, L24: change 'everywhere the same' in 'constant'.

P3873, L6: The sharp transition in sliding velocity is not tested. It is only an experiment with a sharp transition and should be compared to a less sharp transition to make this hard.

P3874, L24: replace 'so this', by 'which'

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