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Interactive comment on "Evolution of ice-shelf channels in Antarctic ice shelves" *by* R. Drews

Anonymous Referee #1

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This paper presents complementary observations and model results of the formation of channels below ice-shelves. Observations have been collected on Roi Baudouin Ice Shelf. The modelling is done using the full-Stokes Elmer/Ice model. Conclusions, if not completely originals, are in line with previous works as underlined in the manuscript. The strength of the work is certainly to couple both observations and modelling.

I am not specialist of observations and will then comment more on the modelling. I have three main points and some minor comments.

Main points:
1 - The fact that the ice-shelf is not at the hydrostatic equilibrium is not only true in the channels vicinity. This is also occurring in the vicinity of the grounding line (GL), and

can be shown both on observations [e.g. Anandakrishnan et al., 2007] and modelling [Lestringant, 1994; Durand et al., 2009]. The point is that specificity is not accounted for in the modelling as it seems that at the inflow BC (at the GL), the ice thickness is imposed to the floatation thickness. This is not clearly specified (it is only said that the mass flux is specified at this boundary). I would first suggest to be more precise on the landward BC. What is the horizontal velocity profile (homogeneous i guess)? Is only the horizontal velocity imposed? Not the vertical and lateral? Is the ice thickness imposed? Then, I am wondering how strong is this latter hypothesis. From Figs. 2 and 3, one can see that the melt is not imposed right at the GL, but few km downstream (how many?). Why? How are influenced the results if the melt is imposed closer to the GL, as expected from observations. My understanding is that by prescribing the ice thickness at the GL, the hydrostatic equilibrium is forced there and the melt has then to be artificially shifted downstream the GL if one wants to observe the bridging effect. I think this modelling point should be at least mentioned and the influence of a fixed geometry at the GL discussed.

2 - My second main concern is about the use of the surface topography in the vicinity of the channels and how it compares from the observation and the modelling. From Fig. 1 it is obvious that these channels are visible from the surface. I am then wondering why the measured surface topography (especially the one transverse to the channels) is not compared to the modelled one? I agree that the real surface topography is not only the result of the channels but also the perturbation of the accumulation distribution by the presence of a depression above the channels, which is certainly too complex to be accounted for in the modelling. But, it might be that some signatures of the surface topography are still observable and could be compared to the modelling. At least, this should be discussed.

3 - As I said in the introduction, the strength of the work is certainly to couple both observations and modelling. In some sense this is also its weakness because the modelling should have been performed using the Roi Baudouin Ice Shelf geometry,

which would have allow to get more specific conclusions (about melt rate for example) on the observed channels. I know it would have been a more challenging modelling effort, but the choice of a simplified and synthetic geometry should be better justified.

Minor points:
- page 1604, line 9: Inverting surface elevation for ice thickness -> Inverting surface elevation assuming hydrostatic equilibrium for ice thickness

- page 1604, line 22: I am not sure the Schoof (207) reference is relevant for this sentence.

- page 1605, line 16: entirely Rignot and Steffen (2008). -> entirely (Rignot and Steffen, 2008).

- page 1608, line 25: the choice of $\rho_i = 900$ kg/m^3 should be discussed. Other works related to ice-shelves hydrostatic equilibrium, as the cited one by Holland et al. (2011), are using a higher value.

- page 1610, line 20: from crevassetops -> from crevasse tops

- page 1611, 2.4 Model setup: missing information should be added (see main point 1). Also, I guess that as in the previous works using Elmer/Ice, you have specified a viscous spring at the base of the ice-shelf to account for the depth dependency of the sea hydrostatic pressure? This should be mentioned.

- page 1613, line 19: the choice of applying or not the lateral friction is not clearly

discussed. It seems that it is switched on or off in an ad hoc way, but its effect is not really discussed. Would the results be similar if instead of applying lateral friction to decrease the main flow the inflow flux itself would simply be decreased (and no lateral friction applied)? In other words, are there other effects induced by lateral friction than decreasing the main ice flow of the ice-shelf?

- page 1615, line 22: which is too large at the channel trough, and too small at the channel flanks -> (?) which is larger at the channel trough, and smaller at the channel flanks

- page 1615: I am wondering if having two channels in one model conducts to the same results/conclusions than having two simulations of one channels at a time. In other words, are the two channels interacting and influencing each other, or are they sufficiently distant not to interact? Is the purpose of having two channels with different melt distribution for the modelling MS4 only to have one plot showing two channels at a time? This point should be discussed/specified.

- Table 1: I would suggest to add a column with the number of channels (1 except for MS4 for which it is 2)

- Figure 2: I would suggest to remove the unnecessary black background

- Figure 3c: is the channel amplitude α? It is not clear from the legend of the figure.

- Figures 4 and 5 are two small. The axe texts are difficult to read. I understand the paper was initially prepared for GRL, which has a limited number of figures. I would suggest to split these two figures in four figures to make them more readable. It should be also specified in the Legend of Fig. 4 that the two channels for the case MS4 have

different melt distribution, as specified in Table 1.

References:

Anandakrishnan, S., G. Catania, R. Alley, and H. Horgan (2007), Discovery of till deposition at the grounding line of Whillans Ice Stream, Science, 315, 1835–1838, doi:10.1126/science.1138393.

Durand G., O. Gagliardini, B. de Fleurian, T. Zwinger and E. Le Meur. 2009. Marine Ice-Sheet Dynamics: Hysteresis and Neutral Equilibrium, J. of Geophys. Res., Earth Surface, 114, F03009

Lestringant, R. (1994), A two-dimensional finite-element study of flow in the transition zone between an ice sheet and an ice shelf, Ann. Glaciol., 20, 67–71.

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