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Interactive comment on "Interaction of marine ice-sheet instabilities in two drainage basins: simple scaling of geometry and transition time" *by* J. Feldmann and A. Levermann

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J Feldmann and A Leverman present a flow-line (in effect) model study of the interaction between two drainage basins (l and r) with partly retrograde beds. One basin (r) is forced, by shelf thinning, into unstable marine ice sheet retreat, which results in long-term ($\sim$ 10 kyr, but more quickly in some cases) motion of the ice divide and in some cases unstable marine ice sheet retreat in the other basin.

I think the subject matter is interesting and the material that is included is of good quality on the whole, but I would like to encourage the authors to broaden or deepen their investigations.

I can speculate on some lines of investigation that might benefit the paper. I am not suggesting that all of these or any in particular, should be carried out.

Buttressing. The authors suggest this could be important, and I agree. If full map plane modeling is too computationally expensive perhaps the l shelf could be given a non-zero drag along the lines of the Nick/Vieli flowline model, to see how that affects the time scale and stability.

Deeper analysis. The present analysis shows that PISM can be described, for this experiment, by fitting a curve to parameters that are not known a-priori, so it is hard to see how this might be linked to observations or even if it should apply to other models or PISM configurations. I would suggest that what we are seeing can be linked to the motion of the ice divide under unequal fluxes. Schoof 2007 tells us (for SSA) that the equilibrium H_f is given by

$$\int_{x_{\text{divide}}}^{x_{\text{gl}}} a \mathrm{d}x = q(H_f(x_{\text{gl}}), ...) \tag{1}$$

so that motion of the divide toward l can result in retreat (and unstable retreat ig H_f implied a retrograde slope). Could the Bueler 2014 analytic solution for flowline problems mentioned in the text be useful ? I have not seen this yet, so it might not be useful for this experiment.

SSA + SIA vs SSA : The SIA will presumably do a better job of divide motion than the SSA, but how are the timescales and stability affected if PISM is run with just SSA?

Periodic perturbations. If r fluctuates on decade/century timescales over many periods, do we see an appreciable response in l, or does it respond only to millenial scale fluctuations?

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Specific Comments

Physics of unconfined ice shelves

It seems that one drainage basin (r) is forced into retreat by thinning a non-buttressed, flowline ice shelf (the manuscript says “the model is set up in flow line, hence there is no variation in cross-flow direction”, the shelf does not have any ice rumples etc, and I did not notice, say, an effective drag being added to the shelf) In the 1D SSA case this should not happen because the stress at the grounding line is the same whatever the shape of the shelf (see e.g Schoof 2007). So, does PISM calculate retreat in this case because of perturbations in the SIA flux? If so, does this expose a weakness of the SSA or the SIA? For example the SIA flux has higher power terms in $|\nabla s|$ that are valid only at very low aspect ratios, while the SSA neglects vertical shear entirely. Neither model includes bridging stress. How does a flowline Stokes model respond? Gagliardini 2010 (Geophys. Res. Lett, vol 37 p L14501, doi:10.1029/2010GL043334) includes something along these lines and says:

“The ice shelf thins dramatically if melting is prescribed, ... However, no retreat of the grounding line is observed and changes in the grounded ice volume are insignificant in this case ... Further increase of the melt rate would lead to disappearance of the ice shelf, but no movement of the grounding line would precede the break off.”

This does not make much difference to the experiment, because retreat on the r side just a plausible mechanism to stimulate retreat in the other (l) basin. Still, I think it is worth a little discussion, because here we see an SSA+SIA model behaving differently from other models, and if nothing else others might not be able to reproduce the experiment.

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Other minor comments

Abstract, p20 : “We conclude that for the three-dimensional case the possibility of such drainage basin interaction cannot be excluded and hence needs further investigation.”

I think that the results suggest a timescale (< 1 kyr) over which drainage basin interaction can be neglected.

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