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Interactive
Comment

Interactive comment on "Parameterising the grounding line in ice sheet models" *by* R. M. Gladstone et al.

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This paper presents a series of numerical parameterizations that permit grounding line migration in fixed-grid ice sheet models along a flow line using a one dimensional, vertically integrated ice stream model (MacAyeal type). These parameterizations include several types of ice thickness interpolation around the grounding line in combination with basal drag interpolations, all within the zone between the last grounded grid point and the first floating one. A series of sensitivity experiments is carried out for different numerical resolutions and combination of parameterizations. The paper is well written and structured. There are only minor remarks to be considered before the paper is acceptable for publication (see below).

Remarks

Page 1079: The determination of steady state is obtained by a visual inspection of the evolution plots. By definition, a steady state is a situation in which the ice sheet geometry does not change anymore with time. Fixing the run time to 35 and 80kyr, respectively is not equivalent to a steady state, which is confirmed by my *visual inspection* of the experiments displayed in Figure 2 for instance: the 35kyr experiments are clearly *NOT* in steady state. Comparing these results with analytical steady state solutions is therefore strongly biased, since the difference is not only resolution dependent or influenced by numerics, but also by the time-dependency. If the authors do not want to run the experiments again to reach a properly defined steady state (say, by stopping the calculation when $|\partial H/\partial t| < \epsilon$), they should reformulate the steady-state issue. It should then be stated that experiments were run for 35kyr which is close to but not necessarily a steady state. Furthermore, a mention should be made that the differences with analytical (Schoof) results are also due to the *almost* steady-state condition.

Page 1081: As shown by Durand et al. (JGR), advance and retreat paths may differ quite a lot using a full stokes ice sheet model. Not only is there a significant difference with the results from boundary layer theory (Schoof), the divergence is also a function of model resolution. Although Durand et al. applied the MISMIP 3 experiment (with upsloping and downsloping beds), these issues remain valid for the stable downsloping case as well. The return solution generally lies closer to the analytical solution than the advance solution, although the differences decrease with higher resolution. Taking the mean of advance/retreat is not appropriate, as the *correct* solution is not necessarily the mean, but lies closer to the retreat solution for low resolutions. The reason for this is something that will be explored further in the MISMIP intercomparison. A metric for advance and retreat separately is probably more appropriate. The comparison with the analytical solution is appropriate if it is mentioned that the differences may also result from the non-steady state condition.

Page 1088: The analytical solution from boundary layer theory does however only evaluate steady state positions of grounding lines; not the transient state. This should be mentioned.

Minor remarks

Page 1067, Line 9: no new paragraph necessary.

Page 1068, Eq 4: this equation could be written more concise, i.e., $A^{-1/n}\left|\frac{\partial u}{\partial x}\right|^{(1-n)/n}$

Page 1068, Line 20: either put this sentence between brackets or start the phrase with something like "The reader is referred to Gladstone et al. . ."

Page 1069, Line 6: "grounded" instead of "landward"

Page 1069, Line 17: "from the edge of the domain": should be précised which edge this is; presumably the ice divide

Page 1078, Line 6-7: I agree that the true velocity profile in the vicinity of the grounding line is not linear, but this applies to all other interpolated parameters as well, such as ice thickness, and gravitational driving stress. The statement should therefore be removed. One can however be more precise by stating that an improvement to the basal friction interpolation can be obtained through an interpolation of the ice flux / ice velocity.

Page 1081, Line24: *We* instead of *we*

Page 1082, Line 3: *The* instead of *They*

Page 1085, Line 20: The reference to the previously published GLP PA–B1 is not entirely correct: Pattyn et al. (2006) indeed use the PA interpolation for *thickness*, but the B1 parameterization is not the same in the paper, where an exponential function is applied near the grounding line instead of a linear interpolation on basal friction.

Page 1087, Line 4: what is precisely meant by very high resolution? 2km, <1km, 0.1km?

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Figure 2: Using a *thick* line is not appropriate to represent an analytical solution, which is supposed to be correct. It is not possible to see what experiment is closest to the analytical solution, as there seems to be quite a bit of overlap. Therefore, the graph layout should be revised.

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