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The Cryosphere Discussions

Interactive comment on "Manufactured analytical solutions for isothermal full-Stokes ice sheet models" *by* A. Sargent and J. L. Fastook

Anonymous Referee #1

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1 General Comments

The paper, in a clear and detailed manner, presents the techniques to construct analytical solutions to mechanical flow problems of shear-thinning fluids with free surfaces - in this particular context: ice sheets. This is not a new technique for itself, but the authors enhance the method such that results resemble setups that have been used in the ISMIP-HOM inter-comparison suite. This provides the community with the possibility to test the behaviour of full-stress (aka. full-Stokes) models in a more realistic, ISMIP-HOM-ish, way.

I, personally, would have seen journals like *Geoscientific Model Development* (GMD) to be a better forum for this article. But I am also aware that this paper should be

seen in the context of a (partly emotional) discussion in the wake of the ISMIP-HOM inter-comparison article published in this very journal. Hence, I am surprised not to have seen a more vital open discussion phase. With respect to this aspect, I am of the opinion that *The Cryosphere* is the right journal to publish this contribution and I only have comments on **minor changes**.

2 Detailed Comments

On a general impression, your figure-annotations are hard to read (looks like low-res screen shots). Additionally, you should include units (even a [-], if non-dimensional) on the axis or at least the colour-bars.

Other issues:

- Your sliding condition on the lower surface is rather a Robin condition than a Neumann condition (as both, velocity and its gradient occur). This occurred twice, first on page 500, line 13 and thereafter 503, line 10.
- Page 501 lines 5-9: From the Dirichlet condition presented here, I conclude that you claim that setting the value for the pressure, $\tilde{p}$, along a whole boundary (i.e., in more than one point of the domain) is feasible. To my understanding this, in combination with an incompressible fluid, is an ill-posed problem.
- I know that this is less of an issue in the ISMIP-HOM context, as you apply periodic boundaries (except for experiment E, of course). But, ice sheets and glaciers tend to have the following situation at their margins $b = s$ or $s - b = 0$. Could you elaborate on the question whether the limit $s \rightarrow b$ causes any issues in your method, as I see a lot of $1/(s - b)$ expressions?

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- The ISMIP-HOM setups have zero accumulation. You presented one case on page 519 with am over x varying accumulation. But what happens if your accumulation/ablation pattern has an explicit dependency on the vertical coordinate? As I see it, this would introduce an additional contribution

$$-\frac{\partial \dot{a}}{\partial z}\frac{z-b}{s-b}$$

in equation (31). What would be the implications if you would account for that?

- I tried to copy-and-paste the F77-code in the Appendix C and gave up after a while, because it needed too much editing to get it compiled. I do not know if TDC provides the possibility of a supplement, but TC does. So, please, put the code into the supplement, also with respect that it shortens the length of the paper.

- With respect to the close context to ISMIP-HOM, I would also recommend to include the following paper in your references:
Gagliardini, O. and Zwinger, T., 2008, The ISMIP-HOM benchmark experiments performed using the Finite-Element code Elmer, The Cryosphere, 2, 1, 67–76

Interactive comment on The Cryosphere Discuss., 4, 495, 2010.