Response to Anonymous Referee #3: "*Interactive comment on* "A comparison of two Stokes ice sheet models applied to the Marine Ice Sheet Model Intercomparison Project for plan view models (MISMIP3d)" *by* Tong Zhang et al."

Response to Major Comments

This manuscript aims at a numerical comparison of a new computational code FELIX- S to the already published computational code Elmer/Ice. Both codes ("models") are based on the same equations: the Stokes equations with grounding-line type boundary conditions. The present code FELIX-S is based on the Hood-Taylor finite elements (second order) while Elmer/Ice is based on the mini-finite element (first order). The dynamic grounding line conditions (friction conditions on the left, floating conditions on the right plus a contact threshold condition) are implemented slightly differently. The two different implementations are presented. The numerical comparisons are made both for prognostic and diagnostic MISMIP3d benchmarks. The two computational codes give reasonably similar results in all cases; the observed discrepancies are very likely due to the difference in the implementation of the friction boundary condition and the accuracy difference of the two finite elements used. In this sense, this new Stokes code ("model") is interesting for the glaciology community since it proposes an additional computational code solving the Stokes equations with friction and dynamic grounding line.

But the crucial scientific questions and issues are not addressed; in particular the convergence of these codes when refining the mesh in the grounding line vicinity. Such a convergence study is the first step to assess any numerical model before interpreting the results in terms of physics. The close agreement in model outputs between the present two codes demonstrate that they probably do not contain any programming bugs; but it does not demonstrate the validity and reliability of their results in terms of modelling since the two models are the same. (Note that in the manuscript the terminology "model" is inadequately employed since the two codes consider exactly the same physical model solved by very similar numerical methods). These two Stokes models could give reference solutions for the crucial and difficult grounding line problem, in particular when comparing to asymptotic shallow models (SSA), if their assessments would have been complete. To my knowledge that is not fully the case yet, since the crucial issue of convergence seems to remain.

Initially in response to reviewers 1 and 2, we have added a new section and two new figures, demonstrating (1) the convergence of the FELIX-S code with respect to along-flow grid resolution (for the Elmer/Ice code, convergence has been discussed and published in a number of previous papers, e.g. Durand et al. (2009) and Gagliardini et al. (2016)), and (2) that the results for Elmer/Ice and FELIX-S also converge with increasing resolution to within the previously published truncation error for the Elmer/Ice model. As in our discussion and response to reviewers 1 and 2, we feel that our revised manuscript addresses the concerns of reviewer 3 with respect to numerical convergence.

In short, this manuscript is a good description of a new and additional computational *code solving the complete Stokes system; it is nicely compared to the Elmer/Ice code. But this manuscript does not address the question of the grounding line modelling nor does it answer the crucial issue of non convergent models. This is the reason why this manuscript version cannot be considered as a research publication; it may be suitable for the Geoscientific Model Development journal.*

As noted above, we feel that our revised manuscript now does address the issues of model convergence that are of concern to this reviewer. As for the last criticism, we disagree that this paper is not valid as a research contribution to *TC*. In our revised manuscript, we show that the two codes demonstrate convergent behavior, at least to within the level of truncation error found for the Elmer/Ice model (if the error were smaller for FELIX-S, it would not matter since the models can only be compared to within the larger of the two errors). This provides a strong argument for continuing the practice of treating Stokes model solutions as an accuracy metric in ongoing and future model intercomparison exercises, a conclusion that should be of wide interest to the ice sheet modeling community and the audience of *TC*. We also note that recently published papers in *TC* (Gagliardini et al., 2016) are similar in nature in that they discuss and explore different choices in model implementation and the impacts they have on modeled GL position. These same choices will have significant impacts on model solutions as part of ongoing community intercomparison projects (e.g., MISMIP+ and MISOMIP, Asay-Davis et al. (2016)) and realistic simulations conducted for research purposes (e.g., estimation of ice flux and GL evolution in basin-scale experiments of Antarctica and Greenland). Therefor, we feel that our results will be of great interest to many regular readers of *TC*.

References

Durand, G., O. gagliardini, B. De Fleurian, T. zwinger, and E. Le Meur, 2009: Marine ice sheet dynamics: Hysteresis and neutral equilibrium. *J Geophys Res-Earth*, **114**, –, doi:10.1029/2008JF001170.

Gagliardini, O., J. Brondex, F. gillet-Chaulet, L. Tavard, V. Peyaud, and G. Durand, 2016: Brief communication: Impact of mesh resolution for MISMIP and MISMIP3d experiments using Elmer/Ice. *The Cryosphere*, **10**, 307–312, doi:10.5194/tc-10-307-2016-supplement.