Geosci. Model Dev. Discuss., 2, S64–S66, 2009
www.geosci-model-dev-discuss.net/2/S64/2009/

Geoscientific
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Discussions

Interactive comment on "Derivation of a numerical solution of the 3D coupled velocity field for an ice sheet – ice shelf system, incorporating both full and approximate stress solutions" *by* T. J. Reerink et al.

T. J. Reerink et al.

Received and published: 4 June 2009

The aim of this paper is to present a framework in which physical decisions about excluding certain stress terms and about numerical decisions concerning an implicit/explicit approach for instance, can be made. A large variety of combinations is possible. With the simplification coefficients the common stress approximations can be obtained from the velocity representation, and besides these coefficients label the stress terms in such a way that several of them can be included or excluded with the same model code. In case these simplification coefficients equal all one, no sheet or shelf specific assumption is made.

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Certainly not all combinations of the simplification coefficients make sense, e.g. by adjusting them all to zero two velocity equations would vanish. Taking $f_0 = 0$ uncouples the vertical velocity from the horizontal velocities, requiring a different but similar implementation indeed.

In our derivation we choose the general case, so all possible transformations and discretizations (see appendices B and C) had to be developed. And by taking all linear derivative terms (simultaneously) implicit the matrix contains many diagonals and is quite large because it contains all equations at the 3D grid. Having worked through this general case all possible obstructions were encountered and solved (appendices B, C and E). Other implicit choices will change the implementation, but can benefit from this work as well and turn out to be a slightly easier case. Just to underline, we intend with this work to give a clear starting point from which several numerical approached could be followed. We think this result in itself deserves publication.

Of course a working application convinces mostly, however we think the intermediate steps (not always shown like here) are worth discussing in case they are derived mathematically step by step. Both the reviewers ask for the much simpler application with $f_0 = 0$, this is an option but wouldn't proof a large part of our general case.

Concerning the boundary conditions: In our model set up the whole domain is always covered with at least a 10 cm thick ice layer. At the grid edges usually only this thin layer is present, in either case at the grid edges Neumann conditions are used, this was meant in Eqs. (3.27-3.28). Because in this set up we do not really have a shelf front we do not use the water pressure to balance it. The remark about Deponti et al. (2006) will be removed. With the free surfaces in Eq. (3.29) also Neumann conditions in the vertical direction are meant, although I think for the bottom surface a Dirichlet condition similar to Eq. (3.32) would be better for the vertical velocity. In a next version I will clarify this section.

In response to Anonymous Referee 1, we certainly do not expect that this approach will

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overcome all difficulties simulating the grounding line, see p104.l6-8. For our current horizontal grid spacing I think using Eq. (3.1) is sufficient, the Durand et al. (2009 Ann Glaciol) is still not available, however I could find the draft of Durand et al. (2009 JGR accepted) and will keep it in mind.

In response to Anonymous Referee 3, I will revise the manuscript using the specific comments. E.g. p100.l20 should be corrected in: from Table 3 in Appendix C. P91.l1 in: "Even in the case that the vertical stresses are relative important". P91l23-25 and Appendix A: I think that $\tau'_{ii} = 0$ represents incompressibility quite literally, the concept of hydrostatic equilibrium in Appendix A2 is used in Appendix A4 in words. Moreover with the incompressibility as in Eq. (A5) and hydrostatic equilibrium as in Eqs. (A3-A4) it is easier to estimate the importance of certain stress terms.

I thank the two reviewers for their critics, with which I hope to improve the manuscript.

Interactive comment on Geosci. Model Dev. Discuss., 2, 81, 2009.

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