The Cryosphere Discuss., 6, C954–C957, 2012
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The Cryosphere Discussions

Interactive comment on "Effects of nonlinear rheology, temperature and anisotropy on the relationship between age and depth at ice divides" *by* C. Martín and G. H. Gudmundsson

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Received and published: 5 July 2012

This is a clearly written manuscript on the effects of nonlinear anisotropic rheology, temperature and fabric on the age field in the vicinity of ice divides. Not all technical details are described but they are usually properly referenced (except for the inference of β). This is a follow-up of Martin et al. (JGR, 2009). The main differences with respect to this paper are:

- verification of the results with another code (ELMER-ICE). This is good to know, also it probably does not justify in itself a publication

- inclusion of the temperature field, which has an effect on rheology. Qualitatively, the

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shapes of the isochrones are unchanged with respect to the isothermal simulation. This should be clearly stated in both the abstract and the conclusion.

- comparison of modeled vertical velocity and age profiles with the analytical solutions of Johnsen and Lliboutry. It is shown that, while these analytical solutions are valid for the flank, they are not for the dome, even when adjusting the parameters of the analytical solutions. This is an important result for people using these analytical models to date the ice at a dome. For the flank, the authors should give what are the best parameters to fit their simulations (z_k for Johnsen, p for Lliboutry).

- Inclusion of both the case $\alpha = 0$ (Taylor model) and $\alpha = 1$ (static model) in the evolution of fabric. The authors show that the double Raymond bumps are wider in the case $\alpha = 0$ than in the case $\alpha = 1$. This is an important result of this manuscript and it opens the prospect of inferring α from isochrones data around divides. This result is not enough emphasized in the current manuscript. Also, the choice of α is not discussed with respect to other studies (e.g. Gillet-Chaulet et al., PhD) based on the VPSC model.

Major comments:

- rewrite abstract: "we also show that divides... at the flanks" This is already discussed in Martin et al. (JGR, 2009), so I would remove this sentence. "In addition, these divides... radar data" ditto, already discussed in Martin et al. (JGR, 2009), so please remove. the fact the width of the Raymond bump depends on the α parameter is missing from the abstract, please add it.

- rheology: why using the static model and not the more realistic VPSC model as used by Gillet-Chaulet et al.?

- discussion, first §: the fact that β is inferred from comparison to data is only briefly mentionned here. It should be already described in the previous sections and with more detailed. There are only references to three papers. Two are submitted or in

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preparation and the third one (Martin et al., JGR, 2009) does not describe the choice of β, as far as I could check. I reckon γ has been chosen to 1 but this is not really discussed. So I would dedicate a entire (sub)section on the inference of α, $\beta and \gamma$ from comparison to data.

- discussion, p. 2236, l. 6: It is not clear that the divide is really the best position for getting old ice. Is not one of the double bumps the best?

- rewrite summary: First sentence OK. Second sentence: the fact that "the anisotropy description is compatible with laboratory measurements of rheology" is not a result from this manuscript. This should be removed. The fact that "the variation in modeled fabric distribution with depth agrees closely with comparable ice core measurements" is not a result from this paper. This should be removed. third and fourth sentences OK. Add a sentence to tell that the α parameter influences the width of the double bumps.

- fig. 3: for the Liboutry model, w is outside the range of possible solutions even for t=0, but this is not the case for the age. So it seems there is something wrong in the calculation of the age in at least one of the two methods.

Minor comments:

- p. 2230, l. 5: maybe you can add a ref to Parrenin Hindmarsh (JG, 2007) where this formula is explicitely written.

- results, p. 2230, l. 20-21: tell the reader that it means your total ice volume in the domain is constant through time.

- results, p. 2233, l. 3-7: this paragraph is not clear and should be rewritten. "First, ..." age always increases with depth, there is no maximum in fig. 3!

- fig. 1, legend: I reckon you meant "... of five time the initial ice thickness", since because ice thickness evovles with time, your x-axis range would also change with time.

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- fig. 2: left panel should be λ_3, not $a_{3,3}$, since it is the eigenvalue.

- fig. 3, legend: mention that Johnsen is left and Lliboutry is right.

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