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Earth Surface Dynamics Discussions

Interactive comment on "Basal shear stress under alpine glaciers: Insights from experiments using the iSOSIA and Elmer/ICE models" *by* C. F. Brædstrup et al.

Anonymous Referee #1

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esurfd-2015-17 *"Basal shear stress under alpine glaciers: Insights from experiments using the iSOSIA and Elmer/ICE models"* - Brædstrup et al.

There are two parts in this paper. The first part objective is to investigate the difference in basal shear stress from two models, one solving the Stokes equations (Elmer/Ice) and the second based on the 2nd order shallow ice approximation (iSOSIA), assuming the same glacier geometry. In the second part, using the iSOSIA model only, three different friction laws are compared on transient simulations accounting for bedrock erosion. The first part is used as a "validation" of the lower order model for the second part.

My main concern is on the way the two models are compared using vertically averaged velocity and stress, which looks not correct. For erosion, because processes take place at the interface between the ice and the bed, the quantities should not be vertically averaged, but instead one should take care to use the local values estimated at the bed/ice interface. I therefore not understand the necessity of averaging the velocity and stress from Elmer/Ice for the comparison with iSOSIA. Moreover, I suspect that by doing so, the differences between both models are decreased. The reverse should be done instead: the iSOSIA bedrock velocity and stress should be evaluated (this is always possible from a vertically integrated model to estimate the 3D velocity field, and then the 3D stress field), and the comparison conducted using velocity and stress at the bed.

Other remarks

all along the manuscript, Elmer/ICE should write Elmer/Ice (see e.g. Gagliardini et al., 2013).

title: the title is a bit restrictive to the first part of the paper. You might think to a more general one that would include both objectives of the paper.

p. 1144, l. 13: suble should be subtle?

p. 1145, l. 16: These shear stress values should really be seen as mean value over a relatively large distance (>10m) as we know that, induced by cavitation for example, stress might concentrate at much higher values (e.g. Gagliardini et al., 2007), and that this stress concentration might play a key role in glacial erosion.

p. 1148, 2.2: it should be mentioned if iSOSIA is a finite-element or finite-difference model.

p. 1148, l. 18: Stoke should write Stokes

p. 1150, l. 2: the elevation used to compute the local temperature should not be bedrock elevation but the ice elevation when the bed is ice covered.

p. 1151, Eqs. (6) and (7): what does justify the choice of an exponent 2 for the Weertman and Empirical sliding laws? In absence of cavitation, the exponent in the Weertman sliding law should be the Glen's exponent, so 3. I would suggest to adopt a different notation for Cs as the values are different for all three laws.

p. 1152, l. 14: extruded is may be more adapted than expanded. Also the number of vertical layers should be specified.

p. 1152, Eq. (10): doing the comparison on vertically averaged values is not correct (see main point).

p. 1153, Eqs. (11) and (12): "$\times$" should be replaced by "$\cdot$".

p. 1154, l. 20: I would suggest to plot relative difference instead of absolute one.

p. 1155, l. 18: remarkable should be remarkably

p. 1157, 3.3: Some explanation should be given on the way the sliding law parameters have been chosen. Did you try to get similar velocities for the initial geometry? Similar final geometries?

p. 1158, l. 4: $m = 1$ is in contradiction with what is specified in the Legend of Fig. 8 ($m = 2$). This should be corrected. If $m = 2$ in this experiment, then the sensitivity of the erosion exponent is not studied. You might think adding an experiment for all 3 friction laws with $m = 1$ (which must exist as you have results plotted in Fig. 9) .

p. 1158, l. 12: I would suggest to use equation instead of rule.

p. 1161, l. 5-16: this is an important point which is discussed here, but I think it should not restricted to the Coulomb-friction law only. The parameter in all 3 friction laws would evolve if the bedrock topography evolve, but this is true that it is certainly at a sub-grid scale.

Figs. 7 and 8: For an easier comparison, the output should be produced for the same stages of glacial erosion (20, 60, 80, 100 for example).

Table 1: "yr" should be "a"

Fig. 9: does it make sense to use normalised mean velocity here as the erosion is function of the absolute value of the velocity. At least, it should be mentioned how different are the mean velocity for the 3 friction laws at the beginning of the experiment.

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