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Interactive comment on "Changing basal conditions during the speed-up of Jakobshavn Isbræ, Greenland" *by* M. Habermann et al.

Anonymous Referee #1

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TC-2013-73 *"Changing basal conditions during the speed-up of Jakobshavn Isbrae, Greenland"* - Habermann et al.

This paper presents the inversion of the basal conditions of Jakobshaven glacier for 5 dates from 1985 to 2008. The inversion is performed using a forward SSA model and adding regularisation terms to the cost function on the form of a Euclidian L^2 norm and a Sobolov H^1 norm. Sensitivity of the results to the Glen's law parameter value, the form of the norm, the prior estimate and the regularisation parameter is studied. The inversion allows to reconstruct the evolution of the basal shear stress from 1985 to 2006, and shows a marked decrease of τ_b since 2000 in the vicinity of the grounding line. This decrease is further partly explained by a decrease in the effective pressure,

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decrease induced by the thinning of the glacier near the front and associated decrease in ice overburden pressure.

I found the paper well written and the obtained results interesting. Nevertheless, I have some comments and questions that should be addressed before final publication.

Major remarks

My first major remark concerns the dataset and the fact that all the DEMs and velocity fields are not synchronous. For sure, we have to deal with the available datasets, but my concern is how much the results are influenced by using asynchronous datasets. In the present paper, for each inversion (for each date) one need a surface DEM, a surface velocity field and a contour of the glacier.

Which contour are used for each date is not clearly explained in the paper: it seems from the figure that the glacier contour, and especially the front of the glacier, is always the same. Is that correct? As discussed in the introduction, changes in the ice-shelf buttressing may partly explain the increase of velocity, so that the inverted basal shear stress might be strongly influenced by a change of the glacier front position. Sensitivity of the result to this geometry uncertainty might be inferred by inverting τ_b for different front contours.

Only the 1985 and 2007 DEMs are available over this period, and it seems that the DEM at each date are constructed using dh/dt maps. Because velocity fields are obtained as the difference between two successive measurements, which date was used to produce the surface DEM? How sensitive are the results to small changes (in the order of error measurements) in surface elevation?

To conclude on that point, I would suggest to add a tabular containing for each inverted date, i) the period covered by the velocity field (and reference), ii) the precise date(s) of the surface DEM and how it was obtained, iii) the date of the contour of the glacier and reference.

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My second major remark is about the choice of the inverted parameter (τ_c). I guess that in fact what is inverted is the β parameter of a linear friction law $\tau_b = \beta u$. Is that correct? (if not, forgot about what is proposed hereafter, but then which parameter is really inverted and how should be clearly explained in the paper). It is well know that we don't expect a linear friction law, and that in fact β encompasses the complexity of the basal friction processes (non linearity, water pressure dependency, threshold velocity, ...). Because the inversion can give access to only one parameter, the reconstruction of a more complex friction law is only speculative and is based on assumptions that have to be discussed. In Jay-Allemand et al (TC, 2011), almost the same approach is proposed to invert for the evolution of the basal shear stress at the base of Variegated glacier over a 10-year period. In a first step, only the evolution of β is presented and then using a more complex friction law, these changes in β are explained in term of changes of basal water pressure. I would suggest that a similar approach is adopted here, explaining clearly that the first key parameter inverted is β and then that this β encompasses more complexity, and that, assuming a till friction law, changes in β can be explained by changes in τ_c.

Other minor remarks

page 2155, lines 9-20: At the list of the potential processes, you might also add an increase in basal water pressure by a change of the hydrological system (increase of runoff) and a decrease of the lateral resistance by again an increase of runoff (and increase in water in the crevasses of the lateral shear bands of the glacier).

Equation (1): the choice $u_{\text{threshold}} = 100$ m a^{-1} and $q = 0.25$ should be discussed (give some references here).

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page 2157, line 23: is it really τ_c that is inverted? (see second major remark)

page 2159, line 8: as stated in my first major remark, the error induced by the ice geometry should be discussed more deeply.

page 2159, line 26: the L-curve analysis has been used previously in other glaciology related applications that might be cited here (e.g. Jay-Allemand et al., TC 2011; Gillet-Chaulet et al., TC 2012)

page 2160, line 13: why the datasets are interpolated to a 500 by 500 m grid should be discussed. What is the grid size of the model itself is also important and should be given (might justify this interpolation?).

page 2161, line 2: what about the boundary of the domain? (see first major remark).

page 2162, line 8: which dates of the dataset are used for the choice of the model parameters should be specified in the text.

page 2162, line 20: I don't see many other parameters for the forward model?

page 2163, line 10: the spin-up experiments purpose was to compute a temperature field and see how the ice viscosity vary spatially? Correct? You might specify that not only the ice flow but also the temperature field were computed during these spin-up experiments.

page 2163, line 12: p.72ff (?)

page 2163, line 23: the temperature corresponding to the adopted ice softness should be given and compared to the measured temperature by Lüthi et al. (2002).

Equation (5): ice thickness has already been defined page 2157.

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page 2170, line 20: and what about the firn density. Are you accounting for firn in the chosen ice density (which value should be given).

page 2171, line 4: no b mark in Fig 12.

Fig 1: the two bends indicated in Fig 7 should be marked by two points on the flowline.

Fig 6: this figure is too small to really see the differences between the different dates. Also, it seems that the front position is the same for the 5 dates?

Fig 7: why the velocity are decreasing toward zero at the front except for 1985? We don't expect the velocity to be zero at the front.

Fig 9: I cannot see the red dashed line.

Fig 10: I cannot see the green thin solid line on this figure.

Fig 12: it is difficult to figure out what is the geometry of the glacier from this figure. May be, the glacier contour should be added.

Fig 13: labels should be a, b, c and d.

Interactive comment on The Cryosphere Discuss., 7, 2153, 2013.