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The Cryosphere Discussions

Interactive comment on "Pine Island Glacier ice shelf melt distributed at kilometre scales" *by* P. Dutrieux et al.

Anonymous Referee #1

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General comments

The paper provides detailed calculations of basal melt beneath the Pine Island Glacier ice shelf. Understanding the ice/ocean interaction in such regions as this is very important for understanding how the system might respond to changes in the ocean, and this paper provides a step forward in our understanding of the scales at which interactions take place. The paper also introduces an alternative method for considering ice shelf change which has not been used before. As a result the paper represents a valuable addition to the literature.

However, because the paper is introducing a new method to this area, the paper could be more friendly to non-specialists. I have a limited amount of experience with Langrangian methods, and found the methods difficult to follow, especially as it combines

both Langrangian and Eularian methods. As a result, the importance of using the approach does not perhaps come across as strongly as it could. Given that the paper is under consideration for a journal with a generalist audience, rather than an audience familiar with the methods, I suggest more background is given to the method, and more help/narrative given to the reader as to why each calculation is being carried out. I have also highlighted the parts I found difficult to follow below, and have given suggestions for how it could be made clearer, assuming I am interpreting it correctly!

My other concern relates to the fairly major assumption that the ice is floating in hydrostatic equilibrium, which the authors go on to demonstrate is not actually a valid assumption in the region. The authors dismiss this fairly easily at the end of the discussion section, without making any attempt to quantify the impact of the assumption violation on the results, just that it smooths the result a bit. I strongly recommend that a quantification of the impact of this assumption is carried out to provide an error estimate due to this assumption.

Specific comments

Section 2.2: Add a paragraph to the start of this section which introduces the Lagrangian approach (and eularian too, readers may not be familiar with this term either) more thoroughly and how it compares with a eularian approach. You have briefly introduced it in the intro and earlier in the methods section, but it needs further description, for example introducing the notation (see next point). Perhaps the section from p1597, section 2.4 might be more appropriate in here to set up why you are doing a Langrangian approach, and what extra information you can gain in comparison with previous studies, though this may not work as you need to have introduced the terms.

P1595, line 20: this would be clearer written as "…from melt or accumulation, either surface or basal"

P1595, line 18: specify somewhere in the section that DH/Dt (capital D) is Langrangian notation, and put brackets around the divergence operator and .U in eq 1 to make it easier to see that the divergence is associated with the velocity, and not the ice thickness.

P1595, line 24, as above, add the brackets.

P1597, eq 4 and generally. It would be useful to have both the words and the mathematical notation for each of the terms, to help keep track of which is which, this could replace the “second term in equation . . .” bit in parentheses.

P1597, eq 4, is this (u.div)h? brackets again would help with understanding this.

P1597, suggestion for modification of paragraph (changes in <>): “Previous studies of this and other ice shelves have employed an Eulerian framework, where the Lagrangian elevation change (the first term in Eq. 2, <Dh/Dt>), is decomposed into two terms: the Eulerian elevation change <(dh/dt)> and the surface height advection <(u.div)h)>, following

(eq 4)

The Eulerian elevation change (dh/dt) <can be> measured by satellite altimeters and combined with precipitation estimates to infer ice shelf thinning rates (Pritchard et al., 2012; Shepherd et al., 2001, 2010; Wingham et al., 2009). Alternatively, <in order to calculate meltrates>, the <thickness> advection and <velocity> divergence (H(div.U), second term in Eq.<1>) are calculated together as the ice flux divergence, which gives the melt rate if the ice is assumed to be in steady state <(i.e. dH/dt = 0)> (e.g. Rignot and Steffen, 2008). If changes in flux divergence are neglected <(i.e. H(div.U) = 0)>, thinning rates <(DH/Dt)> can then be associated with changes in melting <(M)> (e.g. Shepherd, 2004). To illustrate the benefits of the Lagrangian methodology presented here <i.e. you don’t have to assume a steady state ice shelf>, both the Eulerian elevation change and the <surface> height advection will be computed here.”

Section 2.5, some more narrative distinguishing why/what is Lagrangian and Eularian would be helpful.

Section 2.5, eq 7, again, some brackets around the divergence operators would help to understand this equation.

P1598, line 4, “so that substituting Eq. (5) and Eq (4) into Eq. 2”

P1598, line 8: “medium scale surface height advection”

P1598, line 22: clarify where “these” areas are.

P1599, section 3.2: more narrative is required here as to why you are doing these calculations and why you are doing it in the Eularian framework.

P1599, line 22: you talk about extending the basal melting extent over the entire trunk, but don’t show a figure for this?

Figures: There I some inconsistency is the size and layout of the figures, figures 3&4 could be laid out in a 2x2 format rather than a 1x3 format which would allow them to be larger.

Interactive comment on The Cryosphere Discuss., 7, 1591, 2013.