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The Cryosphere Discussions

Interactive comment on "The evolution of the western rift area of the Fimbul Ice Shelf, Antarctica" *by* A. Humbert and D. Steinhage

Anonymous Referee #1

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This paper takes a detailed look at the structure of part of Fimbul Ice Shelf, including an analysis of satellite imagery and airborne ice-penetrating radar data. The study divides the western area of Fimbul into sections, providing a detailed commentary on the structure of the ice thickness and isochrones observed in each section.

My overall impression of the paper is that it probably deserves to be published in The Cryosphere eventually but the current manuscript is an unexciting read and perhaps not the greatest advance in knowledge. I was left thinking that the paper provided neither new theoretical insight into rifts (the final hypothesis for downwarped isochrones, a very interesting observation, was unconvincing) or even a well-motivated and comprehensive overview of this particular location (why should we be interested? what about the east of Fimbul? what about the modelling?). There are also significant deficiencies

in the interpretation of the data, particularly relating to interaction of Fimbul rifts with the ocean. The use of English is imperfect. I would suggest major revisions at the very least.

Larger points

The paper contains no motivation. The introduction launches straight into the detail of previous work on Fimbul, without explaining sufficiently well why we might be interested in it, and in particular only its western section. The 'evolution' of the rift area (as alluded to in the title) is not discussed.

The observation of downwarped isochrones coinciding with basal crevasses is fascinating – I'm not aware of such an observation elsewhere? However, it is not mentioned in the abstract or conclusions and is not satisfactorily explained in the paper. It's not particularly well displayed in the figures either. The best explanation offered is that there is increased melting within crevasses, but it is an observed fact that the ocean freezes in Fimbulisen crevasses, rather than melting them (e.g. Khazendar & Jenkins JGR 2003). It is possible, I suppose, that higher melting occurs on the sidewalls of a rift than under the 'flat' ice outside crevasses, and this might downwarp the isochrones. If this is the case, then 'older' crevasses (further downstream from the rift) should have more downwarped isochrones, since the melting has been going on for longer – it doesn't look like that is the case but it is hard to tell from the figures? It is also possible that simple ice dynamics are responsible for the downwarping – e.g. Leysinger-Vieli et al Ann. Glac. 2007. Can the opening of a crevasse cause a downwarping due to ice divergence in the lower part of the ice column in the same way as the transition from sticky to slippery basal drag causes a downwarping, I think due to horizontal divergence of ice that increases with depth? That would give a downwarping that happens only on crevasse formation, so the downwarping remains constant with crevasse 'age' (distance downstream) which is agreement with the observations as far as I can see.

Another apparently key observation is that the isochrones converge vertically. I can't

see this in the figures. Similarly, what are the hyperbolae high up in the ice column? Do the figures show an example of one anywhere? I would suggest that example figures need to be added showing detail of downwarping, isochrone convergence, and hyperbolae at different depths.

The existence of ocean-sourced marine ice in Fimbul (Khazendar & Jenkins) is never mentioned in the paper, despite its ability to explain many of the observations. In particular, I suspect that units 18 and 16 host large deposits of marine ice. They have no basal radar return and originate in shallow ice downstream of a peninsula between two flow units, which is the classical location for marine ice formation. See e.g. GRL paper by Holland et al 2009. The marine ice couples the flow of Jutulstraumen to that in the west. P1105, L7-8 mentions that thinner ice implies greater melting – why? I would suggest that basal freezing might be filling in the crevasses.

I don't really see the point of setting up hypotheses i-iv on page 1104 when it is obvious from the start that most of them cannot work. The hyperbolae imply crevasses, which rules out ii and iii immediately. I don't understand how adjustment to hydrostatic equilibrium would make layers sink, since surely a region thinned equally from the top and bottom would move up, not down? That rules out hypothesis iv so I think you could just state your final hypothesis to begin with.

Smaller points

Throughout:

looses -> loses

builts -> builds

hyperbolas -> hyperbolae

alteration -> alternation

downwrapped -> downwarped

bended -> bent

Page 1090, Line 4: Fimbulisen

P1094 L12: why use 8.8m? At the very least a reference is needed.

P1097 L20: why leap to figure 7 here? Please re-order figure numbers to be in the order they are referenced in the text.

P1097 L26: I think you mean perpendicular to the flow?

P1098 L7-12: I think there are 4 inaccuracies here. The ice thickness does vary across the grounded area in your figure, but this doesn't mean it isn't an ice rumple! Similarly, an ice rumple is overflown by ice, and your cracks do not imply that it is not overflown.

P1098 L20: alternate

P1099 L13: what is the relevance of tidal displacement?

P1101 L8: what does 'is adjoining northwards' mean?

P1104 L13: becomes critical

P1106 L20: parallel to the flow?

P1107 L14: surely the difference between properties east and west of the ice rumple is just due to the different stress regimes, not to any difference in the homogeneity of the flow units?

P1108 L1-3: I can't see this in the figures.

P1108 L9-11: why would lateral stretching couple the flows?

Figure 2b: The colouring of ice thickness is very poor and as a result it is impossible to tell whether the arguments made in the text are true. Ice thickness is highly relevant for some of the arguments, and the airborne data are quite dense, so I think the authors should produce a grid of ice thicknesses and include a figure showing it with a full

colour scale.

Figure 7: It is very hard to make out the flow units, so this figure should be replaced with a zoomed version, like in figure 2a. Also, the numbering is strange – what happened to units 1-3, 23?

Interactive comment on The Cryosphere Discuss., 5, 1089, 2011.