

Interactive comment on “Ice stream or not? Radio-echo sounding of Carlson Inlet, West Antarctica” by E. C. King

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In the full review and interactive discussion the referees and other interested members of the scientific community are asked to take into account all of the following aspects:

1. Does the paper address relevant scientific questions within the scope of TC? Yes.
2. Does the paper present novel concepts, ideas, tools, or data? Yes, novel data.
3. Are substantial conclusions reached? Instead of clear conclusions the paper rather reaches a hypothesis.
4. Are the scientific methods and assumptions valid and clearly outlined? Yes.

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5. Are the results sufficient to support the interpretations and conclusions? Not entirely sure.
6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? Yes, mostly (see below).
7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution? Yes, mostly.
8. Does the title clearly reflect the contents of the paper? Yes, but the question mark has not really been resolved.
9. Does the abstract provide a concise and complete summary? Yes.
10. Is the overall presentation well structured and clear? Yes.
11. Is the language fluent and precise? Yes.
12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? Yes.
13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? Yes - figures should be clarified (see below).
14. Are the number and quality of references appropriate? Yes, mostly (see below).
15. Is the amount and quality of supplementary material appropriate? N/A.

General Comments

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This paper describes the location, acquisition and processing of the radar data. The description of the internal radar layers leads to the interpretation that the past flow regime represented in the data is pretty much the same as the current flow regime. The age of the radar layers is then estimated by applying a 1-D thermo-mechanical model to quantify the time span shown by the radar layers. A discussion follows with some speculations by the author to explain some observed features in the radar profiles.

There is not much to criticise about this paper as it is well written and presented and the interpretation is plausible. However, I feel that the interpretation of some features is ambiguous. Some layering structures in the radargram need to be better explained how they fit the chosen hypothesis, as they could be used to explain a different hypothesis. The paper did not entirely persuade me that my doubts are unfounded. I would like the author to explain in more details some features in the radargram in order to make a stronger statement. Additionally, I would like the author to make it clear in the paper that the reached hypothesis remains to be further tested.

Specific Comments (referenced by page and line numbers)

p.1223, l.3-5: Difficult to locate NW and SE on Figure 1, it is not clear where these geographic directions are. Improve Figure.

p.1224, l.5: It would be helpful to label 'J2925' on Figure 2a too. The indication of flow speed on top of the radar profile is very helpful.

p.1224, l.14-15: I found the change in flow direction from Figure 2a (out of the page) and 2b (into the page) quite confusing, especially that sometimes the Figure is

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described from left to right (Figure 2a) and then from right to left as in the main text and caption for Figure 2b starting with Fletcher Promontory first. I believe it would be easier to have them all showing the same ice flow direction and describing the location from left to right. If this is not possible it would help to label the radargram side in Figure 2b with the names of the ice rises, as in Figure 3.

p.1224, l.26-28: The resemblance in shorter-wavelength in section 12 to 17 km in Figure 3 is, to me, stronger with radargram J2925 at 22 to 24 km than with the northern margin of radargram J501.

To me the northern end (0 to 3 km) of radargram J501 resembles the layers along km 25 to 30 in radargram 145.

The margin in Figure 3 seems to be more towards 15 km (just where the layers move up again as in Figure 2a) for the deeper layers.

Comparing in Figure 4b the Figure 4a superimposed on the MODIS surface I get the impression that the modern margin has moved towards the Fletcher Promontory compared to the Margin (line D) of the isochrone at 200 m depth. This is not discussed in the paper.

p.1225, l.18: The 3-D view in Figure 4 is fascinating. It would be good to add the sections A to E in Figure 3 too for easy comparison of the evolution of the different zones in the vertical direction.

p.1225, l.26-27: In all Figures of Carlson Inlet (Figures 2a, 2b and 3) I can see a distinctive zone just below 400 m depth where the folding of the radar layers seems to be stronger. Is this just the effect of the layers flattening towards the surface (as this is always a horizontal line) or does this show a change in the past? This zone is also

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extended into Rutford Ice Stream. In the northern end of J501 it is below this zone where the narrower folds in the layers are found.

Looking at Figure 1 it seems that the catchment area of Carlson Inlet is rather small and the inflow is concentrated along the narrow region to the right of Kealy Ice Rise. Flowing into the main part of Carlson Inlet the ice has more space to take up and this might lead to lateral stretching (flattening) of the existing folds in the layers.

p.1226, I.2-4: I am not sure what the effect of the ice flow from the steep ice rise is on the ice in Carlson Inlet. How fast would the ice come down from the ice rise? Is it faster than the ice in the Carlson Inlet?

In Figure 3 on the Fletcher Promontory side - what do you mean by convergence flow? Is it the compression from ice flowing off the adjacent ice rise that you mean here? Please clarify.

p.1226, I.6-8: Here I think you should cite *Martin, C., G.H. Gudmundsson, H.D. Pritchard, and O. Gagliardini (2009), JGR, 114, F04001, doi:10.1029/2008JF001204*. In their paper about effects of anisotropy at ice divides they show that ice divides with concave shoulders, as seen on the satellite imagery (here in Figure 1 and Figure 4b), are divides of long-term stability. They calculate the characteristic timescale for Kealy Ice Rise and Fletcher Promontory as 1.25 and 1.36 kyr, respectively. Their modelling study suggests that concave shoulders are obtain at 4 times the characteristic timescale (5 and 5.44 kyr).

p.1226, I.8-10: '... resultant driving stress induces a component of lateral compression at the margins of Carlson Inlet ...'. Looking at Figure 3 on the Fletcher Promontory side I do see that there seem to be several margins at different depths (at 800, 600 and 500 m), with the deepest at 25 km and others at 29 and 31 km along profile.

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Dating the top layers of these margins with Figure 5a (depth of the layers taken at 29 km where ice thickness is approximately 1700 m as used in age-depth calculation; depths of approximately 1100, 600 and 440) gives ages of 3600, 1200 and 800 years approximately.

I was wondering if this could be old flow margins between Rutford Ice Stream and Carlson Inlet at a time where Rutford Ice Stream was wider and the margin was nearer to Fletcher Promontory (see the lateral cuts on the right side of Fletcher Promontory). That these regions represent stages of the margin moving from Carlson Inlet towards Rutford Ice Stream and that what we see are bands of previously fast flowing ice next to the margin, which have been transported down Carlson Inlet along the margin of Fletcher Promontory. However, radargram J501 does not show signs of this feature, which means it would only work if for some time period in the past faster flow existed, allowing it to be advected past J501 by today. The chaotic pattern at the top of the right side of radargram 145 would be from the ice of the Fletcher Promontory flowing into the Carlson Inlet.

An indication of change in flow margin is seen in Figure 2a where below 400 m right of the 'Margin' (vertical dashed line) we see a fold pointing upward where the bed is sloping down. Maybe this was the old margin.

An alternative explanation could be that these margins show the ice from Fletcher Promontory flowing into the Carlson Inlet, where new ice pushes the old margins inwards, which are then subsequently covered by accumulation. However, it is not clear to me how for such a case the radar layer pattern is influenced.

The question remains how the feature in radargram J501 (northern end) is explained - what pulls the layers down? Is it faster flow? Is it possible that a narrow band of faster ice moved down along Kealey Ice Rise at the same time as the margin of Rutford Ice Stream changed?

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p.1230, I.7-10: The 3-D grids indeed are valuable methods to learn more about the past flow. Another valuable method is using numerical modelling of internal layers, where hypotheses such as made in this paper could be tested. I believe it would be good to mention somewhere in the text that the hypotheses made remain to be tested.

Technical Corrections

p.1223, I.9: Missing bracket here - I believe after 'Sounder'.

p.1233, Figure 1: State units of tick marks.

p.1237, Figure 4: Replace 'Fletcher Ice Rise' with 'Fletcher Promontory'. Tick labels on Figure 4b are not visible enough - larger Figure?

Interactive comment on The Cryosphere Discuss., 5, 1219, 2011.