Review: "High resolution boundary conditions of an old ice target near Dome C, Antarctica"
Duncan A. Young, et al., *The Cryosphere*

Summary:

This paper presents the results of a densely spaced ice-penetrating radar survey near Dome C in East Antarctica. The survey connects to the location of the oldest ice core record available at the present day, EPICA Dome C, although the main body of the survey is displaced somewhat relative to that core. The survey was conducted for the purpose of evaluating potential drill sites for a new oldest ice core. The hope is that the new ice core will recover stratigraphically intact ice dating to 1.5 Ma, before the mid-pliestocene transition when the Earth's climate system switched from 40 ka ice age cycles to 100 ka cycles. Such a core would represent a substantial improvement over the 800 ka record recovered from EPICA Dome C.

The authors identify five candidate locations (A-E) based on regions identified as cold-based in previous modeling work. The authors find that no drill location is perfect and make no explicit endorsement of any individual drill location. However, Candidate A receives a much higher proportion of their attention and analysis, and the paper therefore reads as implicitly endorsing Candidate A. Candidate A is by far the largest cold-based region in the model, and the survey grid is designed to be densest over Candidate A. The authors find that Candidate A has rugged basal topography and isolated subglacial lakes likely to cause stratigraphic disturbances in the basal ice, and the authors also observe some evidence of this disturbance in the form of a basal ice unit. Nonetheless, the authors find that Candidate A has "some promising sites" where conditions are favorable to recovering an old ice core.

Major Comments:

My biggest criticism of this paper is that it lacks interpretation and discussion of the geomorphology or glaciology of the survey area. The paper reads as a limited technical report of a site survey without much scientific interpretation. Large portions of the results are presented in what is essentially an extended methods section, while the actual results section is barely half a page long and a discussion section is completely absent. *This paper needs a discussion section.* Section 5 briefly alludes to fractal measurements of landscapes, but this analysis is not expanded on in any way. The readers are left wondering, "so what?" The scientific quality of this paper can be greatly improved by including analysis of the subglacial landscape and overriding ice sheet. For example, the authors could interpret the landscape in terms of physical processes, such as subglacial erosion versus preglacial erosion, or tectonic deformation. The authors could present the locations of the subglacial lakes that they allude to, and discuss the relationship between their findings and the extensive literature on subglacial lakes that already exists. Either of those possibilities, or other possibilities that the authors feel would be more appropriate, would help to place the paper within a broader scientific context and expand it's appeal beyond the ice core community.

In addition, the authors should do a better job of owning their preference for Candidate A. Candidate A was the primary target of the survey and received by far the most attention in the paper. I think that this preference is justified- as I mention below, the other candidates are only a few grid cells wide and therefore cannot be considered reliable predictions of the numerical model- but the authors need to explicitly own this preference. The conclusions mention "some promising sites" within Candidate A, but the paper spends little if any time exploring these sites. The results section could

easily be expanded to investigate several sites within Candidate A; call them Candidate A1, Candidate A2, etc. This would move the ice core conversation forward, from “which candidate?” to, “where specifically within Candidate A are we going to drill?”

Minor Comments:

Note on line numbering: The line numbers restart at the beginning of each page, rather than counting from the start of the document. I therefore include both a page number and a line number in my comments.

P 1, L 3-4: “We find under the primary candidate region elevated rough topography, near a number of subglacial lakes, but also regions of smoother bed.”
This wording is awkward and requires several readings to understand. One possible rephrasing is, “We find that the primary candidate region contains elevated rough topography interspersed with scattered subglacial lakes and some regions of smoother bed.”

P 1 L 15-18: requirements for an intact ice column
Requirements 1 and 5 (low geothermal flux and low ice thickness) are really part of the same requirement: that the ice must be cold-based. Cold-based conditions require that the geothermal (and frictional) heat flux be low relative to the conductive heat flux, which is inversely proportional to ice thickness. The stated threshold of 2500 m is really a function of the geothermal flux. In addition, the cold-based requirement is in conflict with the low accumulation requirement, as lower accumulation rates tend to produce a warmer ice column and higher accumulation rates produce a colder ice column. A sentence or two outlining the physics behind these requirements would be useful here.

Section 2.2:
Mention that Candidate A is favorable because it is the largest candidate. The other candidates are only a few grid cells large, and are therefore unreliable. The thermomechanical model used to define the candidates is a continuum model, and therefore cannot be expected to accurately describe features on the grid cell scale. Candidate A is the only candidate that is much larger than the grid size, and is therefore the only candidate that can be considered a robust prediction of the model. This is actually the most powerful argument in favor of Candidate A.

P 4 L 6: “...basal ice likely traverses the...”
The basal ice traversed the trough in the past, replace with “has likely traversed”.

P 4 L15 – P 5 L2: “...while in the bottom 500 m, a region of more diffuse englacial scattering is present. This distinct zone of basal ice is also apparent in McCoRDS radar data that operates at a higher frequency.”
This is a good place to reference Bell et al., 2011. The diffuse englacial scattering is similar to what they described as “valley wall” accretion ice near Dome A.

P 7 L21: “We...maintain a strict first return policy.”
In an area of rough basal topography, there is a good chance that the first return may come from off-nadir bed returns. In fact, this is almost certainly what happened, given the results of Section 5. It might be good to include a sentence here mentioning that this first return policy likely resulted in picking off-nadir returns as the bed, and that you explore this in greater detail in the next section.

Section 5:
A large amount of the material in this section would be more suitable for the results section.

P 10, L5-12:
Why not compute H for this dataset (or for the subset of this dataset within Candidate A)? You could determine how RMS roughness varies as a function of window size, and perhaps use this information to say something about the processes responsible for shaping the landscape. This goes to my major comment above.

P 10, L13: "Figure 6 shows the relationship between RMS deviation at 1600 m length scale..."
The axes label of Figure 6 says 800 m length scale.

P 10, L15-16: "A stronger relationship is seen for the focused data than for the pik1 data, primarily due to the larger crossover differences seen in the focused data."
First comment: the sentence would be clearer if you said "...seen for the focused data than for the unfocused data..." rather than using code ("pik1").
Second comment: The second half of this sentence would be more compelling if you said "primarily due to the geometric arguments given earlier". The crossover differences are larger for the focused data than for the unfocused data because the unfocused data includes off-nadir returns in both the along-track and across-track directions, but the focused data only has off-nadir returns in the across-track direction.

Figures

The map figures need to have some indication of latitude and longitude.

Figure 1:
Specify in the caption that the "candidates" refer to the cold-based regions. I was looking for specific dots on the map.

Figure 2:
The 10 m contours are extremely difficult to see in a printout. The inset map of Antarctica would be better suited for figure 1. Overlay the boundary of Candidate A.

Figure 3:
Add more x-axis labels (say, every 10 km). Put the units (dB) on the colorscale. Indicate the boundaries of Candidate A. Add a note to the top left or bottom left corner of the image indicating the direction to Dome C.
It might also be helpful to show the echogram going all the way to Dome C. This will allow the x-axis scale to begin at zero, and (more importantly) it will allow the reader to assess how the continuity of the internal layers in Candidate A compares with the continuity of the internal layers at Dome C. If the echogram is expanded this way, you should also add a vertical line indicating the location of the Dome C ice core (or the closest approach to the core), with a tick indicating the lowest depth from which stratigraphically intact ice was recovered.

Figure 4:
It might be helpful to show another set of histograms where the range has been truncated at ±100 m, so that the scale is not distorted by a few large outliers.

Figure 5:
It is hard to see both the crossovers and the bed elevation, as both have similar color scales. It might be better to have the bed elevation in black and white. Alternately, it might be good to have two separate panels, one showing the bed elevation and one showing the crossovers. Consider merging figure 7 with this figure in that case.

Figure 6:
It is hard to tell the two colors apart, and most of the figure space is blank white space. Consider splitting foc1 and pik1 into separate subplots. Also, consider using log-log axes to more efficiently use all of the space. In addition, the caption says that the RMS window was 1600 m, while the axis label says it was 800 m.

Figure 7:
See my note above about potentially merging this figure with figure 5.

Figure 8:
Again, was the lengthscale 800 m or 1600 m?
The MOA background adds nothing to the figure, as it is a uniform gray. Consider using Bedmap2 as the background, with the same grayscale as the new bed elevations.