We thank both reviewers for their insightful and constructive feedback. In the response below we have copied the original comments of reviewers followed by our response in **bold**, original text in grey and changes made to the manuscript in red. Page/line numbers refer to the original manuscript under review at https://doi.org/10.5194/tc-2017-214.

Reviewer 2: Huw J. Horgan

Davies et al use repeat radio echo sounding profiles to investigate how the shape of the bed of Pine Island Glacier has changed (or has not changed) over an interval during which the glacier has accelerated and thinned significantly. This study is notable for several reasons. First, Pine Island and the neighboring Thwaites Glacier have experienced substantial mass loss over recent decades and will continue to form a major component of Antarctica's mass balance for the foreseeable future. Second, ground based geophysical observations from this region are rare and provide important constraints on bed structure and properties that influence ice flow. Third, repeat geophysical observation are extremely rare, and are the most practical way of assessing changes at the bed.

This study is topical, well conceived, and generally well presented. The comments I make in the following are intended to support and clarify the manuscript.

We are grateful to the reviewer for his comments and for enabling us to improve the clarity of the technical aspects relating to the radar systems.

Comparing repeat geophysical surveys. Comparing different frequencies of RES is tricky due to the dependence of resolution on frequency. Considering the commonly used resolution limits illustrates the problem. In theory, for a circular wavefront, bed features with a horizontal extent less than $\sqrt{2d\lambda + \frac{\lambda^2}{4}}$ will appear as point diffractors. At these depths (d ~ 2070 m), a 1.2 MHz wavelet will image features smaller than 1025 m as point diffractors, and a 3 MHz wave will do the same for features smaller than 645 m. This is not to say that these features will not be resolved at all, but the bed will appear different at different frequencies depending on how rough it is. Vertical resolution is also frequency dependent. Vertically, layers thinner than λ/30 will not be resolved (8.3 m at 1.2 MHz, 3.3 m at 3 MHz). This is perhaps not important when considering an abrupt change in dielectric properties at the base of the ice sheet but a layered or gradual bed will resolve differently.

The main conclusion of this paper is, however, that the bed has not changed along the profiles beyond the resolution limits. With a little additional wording regarding the different resolution of the two vintages I have not issue with this conclusion and the resulting interpretation. The reader is, however, drawn to the one location where a change is shown. Resolution differences should be considered here. Also, as pointed out in the manuscript, navigation is a concern. The cross over analysis is useful, but I don't think the method used (mean of the standard deviation of for available intersecting lines) does provide `the maximum variability in bed elevation'. To add confidence in the interpretation a simple subplot showing minimum distance between the two profiles along the profile would be helpful. This would make it clear to the reader that the region where the bed is different does not correspond to a region of large navigation mismatch.

Based on the above, we have expanded on the caveats with regards to the differences in the frequency of the radar systems in the section 2.3.

P4 L31-37 modified as follows: 'As we are unable to recover absolute elevation change, in this study the horizontal resolution is more important than the vertical range precision. Differences in the morphology of the basal reflector need to be considered along with consideration of the different frequencies used in repeat surveys (1.2 and 3 MHz). This is best illustrated using commonly adopted resolution limits. For a circular wavefront, features at the bed with a width less than $\sqrt{2d\lambda + \frac{\lambda^2}{4}}$ will appear as point diffractors. For a bed at a depth of 2000 m, a 1.2 MHz (λ_{ice}=250 m) wavelet will image features with a width <1008 m and a 3 MHz (λ_{ice}=100 m) will image features with a width <634 m. These differences may affect the appearance of the basal reflector depending on the roughness of the bed. For these reasons we express caution when considering subtle changes in basal morphology.'

With regards to comments concerning navigational divergence, we have removed the crossover analysis from the table and text and added profiles showing the minimum distance between survey profiles alongside plots of bed elevation and bed pick correlation in Figs. 2 and 3.

P5 L1-5 removed the following text: "We assessed the variability in bed topography by analysing nine additional intersecting radar lines driven orthogonal to repeat survey lines (three per repeat survey line). We calculated a mean of the standard deviation of bed elevation for available intersecting lines within 50 m, east and west of repeat survey lines (Table 2). From this analysis we find that the maximum variability in bed elevation within the range of navigational divergence between repeat surveys is just over a metre (Table 2)."

P5 L1 added the following text: "In order to visually assess whether navigational divergence affects observed bed change we have provided plots of minimum distance between repeat surveys alongside plots alongside bed elevation profiles in Figs. 2 and 3."

One last note on the differences between the two data vintages. The 2013/14 data (Fig5c) show more spatial variability in the picks than the 2007/08 data. This may be due simply to signal to noise ratio being lower in the higher frequency 2013/14 data but it would be nice to see a right hand panel showing representative wiggle traces for each of the data vintages. That way the reader could be assured that similar waveforms are being compared.

We have added inset plots of representative wiggle traces of 2007/08 and 2013/14 data to figure 5b and c.

Subglacial deformation. Would we expect a change in bed morphology to result from a change in ice surface elevation and ice velocity?

Estimates of subglacial sediment transport vary widely with the thickness of mobile till and the velocity profile within the till both poorly known. What is accepted is that the till velocity is a function of the overriding ice velocity. Simplistically, a uniform change in ice velocity will result in a uniform change in sediment transport, with no resulting change in bed morphology. If sediment deformation is occurring, as indicated by active source seismic constraints, the total transported through the profile must however have changed and some change in the bed morphology must be taking place upstream and downstream. To address this some discussion of sediment deformation would be useful as would some comment on how uniform the changes in surface elevation and velocity have been.

We have responded on similar points that were raised by Reviewer #1 – see our responses to the last "General Comments" from Reviewer #1 above.

Minor Points

Pg 3 L 28. `5 m intervals' Ambiguous, change to 5 m horizontal intervals

This change is incorporated into the next point.

Pg 3 L 29. Please define automation method (e.g. cross correlation).

P3 L35–37 modified as follows: 'The onset time of the bed reflector was determined at 5 m horizontal intervals at the peak in the amplitude of the bed reflector using a semi-automated "phase follower" picking procedure that allows automatic assignment of picks to a selected phase. These picks were checked and edited using manual picking where necessary.'

Pg 3 L 30. `of 0.168 m ns^{-1}' and no additional firn correction.

Done

Pg 3 L 33-37. I can appreciate that the differences in firn composition, and triggering could result in a static shift between the two systems. To clarify this, you should state here that the difference is a constant shift as you don't expect the firn to have varied spatially.

P4 L5-7 modified as follows: 'Firstly, we do not have the data to assess whether firn properties, that impact upon radar wave speed, changed over the periods between repeat surveys. However we do not expect firn properties to have varied spatially on the scale of our surveys.'

Pg 4 L 1-2. Again, I understand what you have done, but as worded it doesn't as quantitative as it is. You have static corrected both surveys to a common bed-datum, allowing direct comparison.

P4 L10-11 modified as follows: 'Therefore we compare relative bed profiles by applying a static correction to a common bed datum (0 m) for both surveys.'

Pg 4. L 21. `±3 m' Worth a note here that this is not the same as repeatability or resolution. This also depends on what part of the wavelet is being picked. When picking the peak amplitude the wavelet shape will matter. Showing typical wavelets will help with this.

We have addressed this comment by adding subplots of wiggle traces to address the previous general comment.

Pg 6. L 22. High temporal resolution

Done

Pg 6. L35. In the absence of a dynamic hydrological system sediment mobility is also likely to be more stable over time.

P7 L16-17 modified as follows: 'may be restricted and likely be more stable over time, thereby limiting…'

Pg 7. L 10. `erosion/deposition' erosion and deposition.

Done.

Pg 7. L 19-21. Here's it's probably worth having caveats regarding navigation and the differing resolutions of the two vintages of RES.

We have addressed this comment by adding more text to the methods section to clarify challenges with comparing different frequencies and added wiggle trace plots to Fig. 5.

Pg 8. L 1. `..'.
Pg 8. L5 `an' a.
Pg 8. L 31. 'seismic survey' seismic surveying.

All done.

Figures

Figure 1. Is there a good reason to have Antarctica oriented in this direction. We have enough issues with 180 degree ips causing confusion.

Our figures are oriented to have true north pointing vertically upwards over PIG, following a convention typical in many maps. This orientation is also used in several other papers concerned with the Amundsen Sea Embayment.

Caption: `dashed lines' can't tell they are dashed at this resolution, perhaps gray contours?

Figure caption modified as suggested.

Figure 2d should have the same x-axis as b,c,e, and f.

Figure axis modified to the same labelling format.

Figure 3. Caption `2km' 2 km

Changed.

Figure 5a. If it doesn't clutter the figure, can you show the bed prior to smoothing?

We feel this will clutter to the figure so would prefer to leave this as shown.

Figure 5b 5c, show characteristic traces so we can assess waveform similarity and peak amplitude picking suitability.

Done.

In closing, I thank the authors for their well considered and presented study.

Sincerely, Huw Horgan