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The Cryosphere Discussions

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Interactive comment on "Geophysical mapping of palsa peatland permafrost" *by* Y. Sjöberg et al.

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We are grateful for the constrictive comments by Anonymous Referee 2 on our manuscript. Below are our replies (in italics) to the reviewer's comments. A pdf version of the manuscript with tracked changes is also provided as a separate file.

Page 4, Line 20: I am not convinced that vulnerability was thoroughly estimated in this study. Based on the results presented, on case of warming was tested in a back-of-the envelope model using one example permafrost thickness based on one measurement from an ERT line. This resulted in an estimate of 175 years to thaw under the warmer climate scenario (along with hand-waving order of magnitude uncertainty), but I do not believe this is comprehensive enough to be considered a vulnerability estimate.

This sentence has been rephrased to avoid confusion with estimations of vulnerability.

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Page 8, Lines 11-20: I have some concerns with this application of CMP geometry for estimating velocity. Since CMP data is not displayed in a figure it is difficult to assess the quality of the dataset and effectiveness of this application. My first concern is that relatively low frequency 100 MHz and 200MHz antennas were used in a case where the reflector may have been as little as 50cm from the surface (in the case of the active layer). This could have resulted in waveguide behavior or refractions that would have made traditional CMP analysis unreliable. I suggest that a CMP dataset and associated semblance plot is provided by the authors.

Section 3.1 (concerning the GPR velocity estimates) has been rewritten for clarification (see response to referee 1). As a velocity for only one material (maximum velocity in saturated mineral substrate) was obtained from the CMP analyses we have chosen to not expand on the description of the CMP analysis in section 3.1. Instead, an appendix (Appendix A) has been added describing the CMP analysis in more detail and containing a figure including the CMP radargram and a semblance plot. To clarify, the CMP analysis was not used to obtain signal velocities in the upper soil layers, such as the active layer. The shallowest reflector used was found at circa 1.75 m depth.

Page 12, Line 17: ": : :thought experiment: : :" This seems to be a 'back of the envelope" calculation, not a thought experiment. I suggest reconsidering use of the term "thought experiment" throughout the manuscript.

We have changed the wording throughout the manuscript as suggested.

Page 13, Line 8: The lack of reflections is surprising (particularly from taliks that should have had clear contrasts in physical properties throughout the winter). I suggest that either winter data is included or all mention of the winter data is removed from the manuscript.

Winter data have been removed from the manuscript. The lack of clear deeper reflections in the winter images was most likely due to high scattering of the radar signal in the frozen active layer which could have had high variability in ice content (for example *due to ice lens formation).*

Page 15, Line 6: How is the 15.3 m average thickness calculated? Based on previous remarks in the manuscript, the ERT imaged 15.8 m to more than 25 m.

The average depth at which the permafrost base was found (with DOI<0.1) was 15.8 m and the average thickness of the active layer was ca 0.5 m, which yields an average permafrost thickness of 15.3 m for the locations where both the permafrost table and base could be observed. Of course, along most of the transects the uncertainty was too great (i.e., DOI>0.1) and the permafrost base was too deep to be identified by our methods, at most >25 m. Only the locations where the permafrost base could be identified were used to calculate the average thickness of permafrost.

Page 15, Line 22-25: The estimated ice fraction calculation should be presented earlier in the manuscript and in more detail to help the reader understand what goes into the calculation and what it means.

We have added the equation for how excess ice fractions (EIFs) were calculated to this section (EIF = palsa height/permafrost thickness). The aim of this study was not to estimate EIFs and our data for most parts of the transects are not well suited for this as it was collected for other purposes. Therefore we do not feel it relevant to expand this part of the manuscript beyond a simple comparison in the discussion section. We do however think that it is an interesting comparison to make in the discussion on ground ice and permafrost distributions in these types of landscapes, as it provides some insight to how this site compares to similar sites in (for example) Canada. Our belief is that with the clarification of this simple equation for EIFs and the (previously) presented data from our site the reader should be able to get a better understanding of the permafrost and possible ground ice distributions in Tavvavuoma without needing further clarifications in the other sections of the manuscripts, as this would fragment the focus of the paper. We have rephrased this paragraph for clarity.

Page 16, Line 10-12: Another reason for this could be that the authors did not calcu-

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late the uncertainty in this estimate. I suggest a sensitivity analysis and uncertainty quantification to help place these thaw advance estimates better into context.

We have added a range of likely thermal conductivity values to account for some of the uncertainty in this estimate.

Page 18, Line 10: "...provide orthogonal views..." Perhaps I just don't understand what the authors intend the word "orthogonal" to mean in this case, however looking at Figure 1, no geometrically orthogonal lines we measured so I don't know what this is referring to. I suggest rewording for clarity.

We have reworded this sentence.

Figure 3: Depth axes should be carefully calculated and displayed on this figure.

The idea of this figure is to, as clearly as possible, show the GPR data and its visible reflections before further interpretations. By converting the time axis to depth, using the varying velocities for the different ground materials, these images get distorted so that some of the reflections are more difficult to see (see response to previous referee). As such, rather than add depth axes to these figures we have complemented these figures with line plots of the surface topography to provide a better context of the images for the reader. Depth converted GPR data interpretations are instead provided in figure 5.

Figure 5: Where does the GPR uncertainty estimate come from? Just the potential variability in velocity?

The uncertainty estimates come from the different estimated velocities (minimum, representative, and maximum) of the radar signal through the different ground materials (see for example Table 1 and section 3.1). The caption has been reworded to clarify this.

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/8/C2863/2015/tcd-8-C2863-2015-

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supplement.pdf

Interactive comment on The Cryosphere Discuss., 8, 5137, 2014.

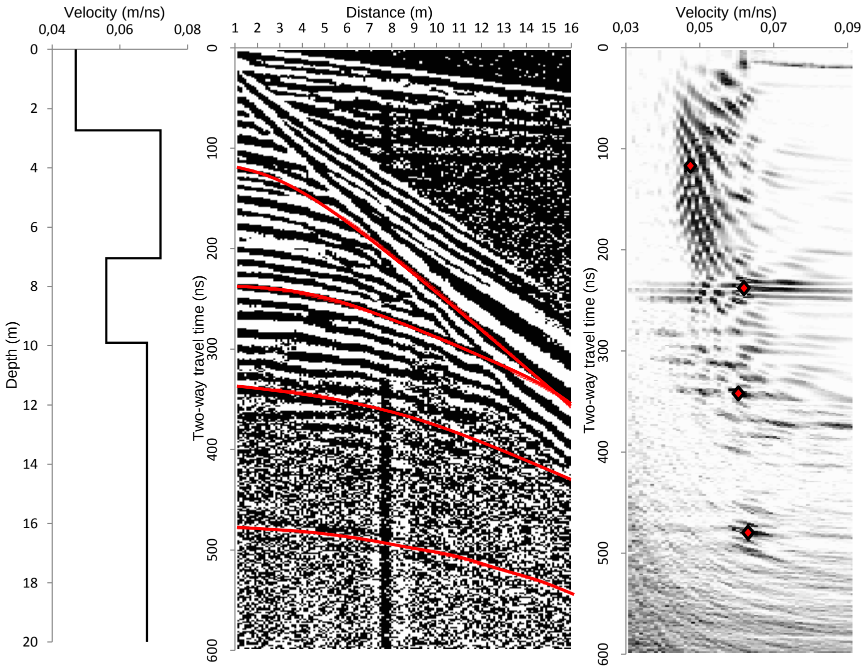

Fig. 1. Figure A1.

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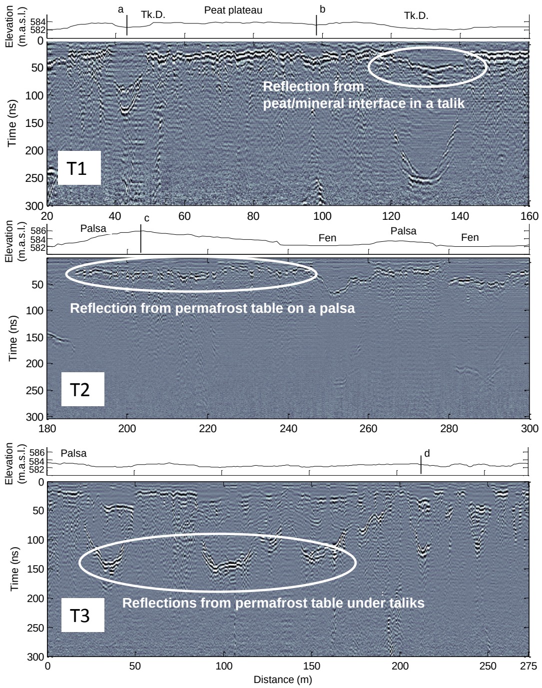

Fig. 2. Figure 3.

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