The Cryosphere Discuss., 8, C2305–C2311, 2014
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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.

Anonymous Referee #1

Received and published: 10 November 2014

General comments:

This manuscript presents a joint application of GPR and ERT to map active layer depth and permafrost base at a palsa peatland at Tavvavouma, N-Sweden. The estimated depths are finally used for a simple calculation of permafrost thaw based on the Stefan equation. The study shows nicely the value of a combination of different geophysical measurement techniques to understand permafrost conditions in heterogeneous environments and the paper fits well into the scope of The Cryosphere.

Overall, I think the study is well suited for publication. However, I have a number of items which should be worked out to improve the clarity of the paper, some of them requiring major revisions. I would like to encourage the authors to do these revisions, and then I am looking forward to seeing this study published in TC.

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Interactive Discussion
Discussion Paper

Major comments:

1. CMP velocity estimates (P 5144, L 23-29):
It is very reasonable to provide minimum and maximum values for the velocities of the various substrates, however, the description of the procedure to estimate representative, min and max values requires clarification: Add a figure showing the CMP measurements and discuss difficulties and "unrealistic velocities" in the interpretation of the results which needed to be compensated by literature measurements (Table 1). Especially the sentence on P5144, L27-29 requires clarification.

The materials and velocities defined in Figure 2 and Table 1 need explanation: The chosen names for the materials are somewhat unfortunate (according to Fig 2, talik peat and talik mineral also belong to the active layer). The definitions/names could be more self-explaining by providing information about substrate, water content and freezing conditions (see text on P 5145) since these are the main factors determining the dielectric permittivity of the ground, e.g. one could use (i) dry peat on palsa and peat plateau surfaces, unfrozen (ii) (saturated (?)) peat in fens and under surface depressions, unfrozen (iii) (saturated (?)) talik mineral soils, unfrozen, (iv) frozen ground. The distribution of the different landforms which are related to distinct velocities should also be indicated along the x-axes of Figures 3 and 5 for better understanding.

Methods for velocity determination (Table 1): As far as I understand Table 1, velocity estimates were not only compiled from CMP measurements and literature information but also by relating GPR-measured travel times to active layer thicknesses measured with the steel rod or information from a soil core. Please expand Section 3.1 with related information. Also add information why exactly these values for representative, min and max were chosen

2. Resistivities for permafrost identification (P 5146, L 22 – P 5147, L10):
This section is somewhat confusing. I expect, the authors define a lower (1000 Ohm.m) and an upper (1700 Ohm.m) for the transition from unfrozen to frozen conditions while

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all resistivities > 1700 Ohm.m indicate permafrost. However, the paragraph reads as if there is a range in resisitivities (i.e. 1000-1700 Ohm.m) for identification of permafrost and all values above are no permafrost again. Please clarify.

3. Calculation of thaw rates:
The authors carry out a very simple calculation of permafrost thaw for the investigated site, which of course, is afflicted with considerably uncertainty. The study would strongly benefit if the authors would provide an estimate for this uncertainty as they do nicely for the GPR and ERT measurements.

4. Figures 3-5:
P 5166 - 5168, Fig 3 - Fig 5: For ease of interpretation: Please add information about the different landforms along the x-axes (e.g. on top) of these two figures. Also indicate positions of sediment cores. If possible, it would also be helpful to have the topography included in the radargrams and ERT sections.

Specific comments:

P 5138, L 19-20: I don't understand this sentence. What are areas "climatically marginal to permafrost" and why do the peatlands occur there "due to the thermal properties of peat"? Please clarify and provide a reference for this type of distribution.

P 5138, L 22: Please clarify: "... and therefore permafrost is sensitive..."; and "In addition, permafrost distribution and thawing..."

P 5138, L26: better: "Due to these interactions, peatlands are often..."

P 5139, L 12: What is meant by "condition"? Thermal state? Please clarify.

P 5139, L 20: Suggestion: replace "modeling" by "models"

P 5142, L 19-20: What exactly should be observed during wintertime conditions? Please add explanation/examples. Or: since the wintertime measurements have not

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been evaluated, I'm wondering if it is necessary to mention them at all.

P 5142, L 24 – P 5143, L 7: Please add information at which lengths [from . . . m to . . . m] along the profile the different landforms (thermokarst depressions, fen, stream, palsa) were located.

P 5144, L 1-7: Please provide information about types of antenna used (manufacturer, shielded/unshielded, . . .). Also add information about measurement setup (length of traces in ns, stacks, . . .).

P 5144, L 7: What was this correction aimed for? Please explain.

P 5144, L 15-16: How do these CMP measurements contribute to the velocities listed in Figure 2 and Table 1? Please clarify using same nomenclature for profiles. See also major comment about CMP velocities.

P 5145, L 5-9: Select another name for "active layer velocities". The talik peat and talik mineral velocities are active layer velocities as well. If the talik velocities are all assumed to be saturated or wet, this should be stated in the text.

P 5145, L 23: replace "pore size" by "porosity"

P 5145, L 23 – 25: Here also the ice content should be added since the transition from water to ice is most responsible for the increase in resistivity.

P 5146, L1-2: Add information about instrument used for ERT measurements and measurement settings.

P 5146, L 5, L 9: suggestion: use "inversion" or "inverse modelling"

P 5146, L 9: add reference for Res2dinv

P 5148, L 11: better: "sandy soil" or "sand"

P 5149, L 8-12: I suggest to either add some winter radargrams and related interpretation to the paper or remove this paragraph completely.

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P 5149, L 14: suggestion: replace “results from the ERT data modelling” by “inverted resistivity sections”

P 5150, L 18-19: In the range of the ERT uncertainty, the taliks are almost at the same depth.

P 5164, Tab. 2: Where does 17.3 m as maximum value for the permafrost base result from? The 1000 Ohm.m for the permafrost base is not reliable as the DOI value is > 0.1 at this depth of the profile. In addition, this value does not correspond to the 25 m maximum depth provided on P 5150, L 8.

P 5166, Fig. 3: I know it is difficult because of the different velocities for unsaturated, saturated and frozen conditions but it would be nice to have a depth axis added to Fig 4 especially for better comparison with Fig 5.

P 5167, caption Fig 4: please correct: DOI < 0.1

P 5168, Fig. 5: I expect that in the ERT permafrost boundary the uncertainty for the transition from unfrozen to frozen conditions is indicated. I suggest to rename this coding to “ERT permafrost table uncertainty”. Also indicate in the figure caption that the lower permafrost boundary cannot clearly by identified as shown by the high DOI values displayed in Fig 4. Probably it is also reasonable to add the depth of the DOI = 0.1 line to Fig. 5 as lower limit of permafrost identifiability.

Technical corrections:

P 5138, L 3: offer “a” possibility

P 5138, L 5: remove “surface”

P 5138, L 14: remove “out”

P 5138, L 16: pan-Arctic

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P 5139, L 12: to date

P 5139, L 21: important “for” regions

P5139, L 23: Giesler

P 5140, L 18: remove “surface”

P 5140, L 21: complementary

P 5142, L 16: slightly

P 5144, L 4: measurements

P 5144, L 8: depths

P 5144, L 14: offsets

P 5145, L 21: suggestion: write “lateral and vertical direction”

P 5146, L 7: replace “that” by “where”

P 5147, L 20: delete “the”

P 5147, L 20: delete one “v”: Tavvavuoma

P 5148, L 19: delete “out”

P 5149, L 1: transects

P 5149, L 1: correct: “At” the beginning . . .

P 5149, L 21: suggestion: replace “counter to this” by “in contrast”

P 5151, L 5: delete “out”

P 5152, L 19: delete “out”

P 5154, L 15: pan-Arctic

P 5164, Tab. 2: align “Representative”

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P 5164, Fig. 1: add degrees to longitude axis

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