

Interactive comment on “Multi-channel ground-penetrating radar to explore spatial variations in thaw depth and moisture content in the active layer of a permafrost site” by U. Wollschläger et al.

Anonymous Referee #2

Received and published: 9 February 2010

The authors describe the interpretation of multi-channel ground-penetrating radar data measured over a permafrost site to explore the spatial changes in thaw depth and permittivity variations from which moisture content variations are derived.

This paper is based the multi-channel evaluation procedure for GPR inversion described by Gerhards et al. 2008 (first two authors are the same). In this former paper it was mentioned that “the interpretation of the explored permafrost processes is not the focus”. The current manuscript is a logical follow up focusing on the interpretation of the observations. The new GPR data are of high quality and the inverted relative

C569

permittivity seems reliable. The manuscript clearly shows the potential of multi-offset GPR to efficiently map the thaw depth and permittivity (soil moisture content). The paper is well written and the figures clearly support the main findings. The discussion indicates that more research is needed to completely understand the influence of all the complicated interactions of the different processes taking place. This manuscript sets a clear direction for further research.

Below I have given some comments to improve the manuscript:

The discussion is difficult to understand and should be rewritten. Especially p934 line 16 – p935 line 3 are confusing and seem to be speculative. Can the presence of vegetation also be an important reason for a reduced soil water content? Is the observed reflector mainly due to the thaw depth or can it be linked to the groundwater table which was observed at 0.76 m depth in a borehole some hundred meter away from the measurements (Why was this borehole not made within the survey area for ground truth?) Clearly missing are additional data and/or ground truth to confirm the hypotheses.

New data are measured without comparison with the older data and without discussing in detail what the differences are. The new data were acquired with 3 source-receiver antennas, whereas the old data were measured with 2 source-receiver antennas. It would be good to compare the new data with the old data and discuss in detail what the differences are. From the pictures, it seems like both datasets were measured at the same site or at least very close to each other.

The conversion of permittivity into soil water content using a constant porosity of 0.4 is questionable since the porosity is most probably changing from the vegetated fine sand area (p. 933 line 16) and the low average pore size of the road bed (p. 934 line 9). How sensitive are the inversion results on the assumed value of 0.4 for the porosity?

The presentation of the results could be improved by indicating line numbers in Figure 2 and 6. Include with dashed circles the areas of vegetation which were also shown in Figure 5.

C570

The summary and conclusions should describe the reliable results observed with GPR: shallow thaw depth and low permittivity were obtained below the sand-covered vegetation area, intermediate thaw depth was obtained along the gravel road and a deep thaw depth in the bare soil terrain.

More specific comments:

p. 923 line 2 mention the strong dielectric contrast explicitly p. 923 line 2 change “an” into “and” I do not understand why the position of the reflector of the laser tachimeter was used as reference position. I assume that the data was resorted and the assumed reflection position of the CMP is used as reference position.

p. 925-929: Split up the section “materials and methods” into two separate sections: Method and measurement setup, since both are mixed which results in repetition:

p. 926 line 25-26 and p. 927 line 9-10 discuss the same information: One could rewrite this sentence as “resorting the measured data such that they share the same common midpoint and reflections occur from a similar area of the reflector (see Figure 3c).”

p. 927 line 11: do you mean with “clipping” time windowing?

p. 929 line 3: It seems like actually 6 channels are used: 6 antennas are connected to the console (3 sources and 3 receivers) resulting in 9 possible transmitter-receiver combinations (see Figure 3).

p. 929 line 21: Why are you using a velocity of 0.1 m/ns for the topographic correction while the actual measured velocity is 0.08 m/ns? Describe more specifically which data are shown in Figure 4 and do not call them “example radargrams”. Better is to indicate line numbers in Figures 2 and 6.

p. 929-930: Repetition occurs in p. 929 line 24-25 and p. 930 lines 26-27.

p. 930 line 4: Is Figure 4 showing the data after the topographic correction? If so: mention this.

C571

P 930 line 10 change “an” into “and”

Interactive comment on The Cryosphere Discuss., 3, 919, 2009.

C572