

***Interactive comment on* “Monitoring of active layer dynamics at a permafrost site on Svalbard using multi-channel ground-penetrating radar” by S. Westermann et al.**

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Review of manuscript entitled ‘Monitoring of active layer dynamics at a permafrost site on Svalbard using multi-channel ground-penetrating radar’ by S. Westermann, U. Wollschläger, J. Boike. TCD 4. 287-319. 2010

-GENERAL COMMENTS-

The paper describes the use of multi-channel ground-penetrating radar (GPR) to monitor summer thaw depth progression and soil water content over permafrost in Svalbard. Thaw depth mapping using multi-channel GPR has been described by Gerhards et al (2008) and Wollschläger et al (2009), but in contrast to these papers the present paper

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includes the time aspect through repeating surveys. The results are used further in an interesting discussion on the active layer latent heat content and identification of spots where the permafrost is particularly vulnerable to degradation.

The paper is well written and should be of interest for the readers of The Cryosphere. I recommend acceptance of the manuscript after some changes have been made.

The weaknesses in this manuscript are in my opinion:

[1] Thaw depth vs. active layer thickness monitoring.

In the introduction chapter the active layer thickness and its role as an 'early warning system' is presented along with monitoring programs such as the CALM program. The active layer is defined as the end-of-season thaw depth. The rest of the paper, however, shows how the thaw front propagates downwards in the late thaw season. Thus the monitoring aspect here relates to seasonal thaw depth progression and not inter-annual variations in active layer thicknesses as may be anticipated from the introduction chapter. The difference between the two should be made clearer in the manuscript. A discussion on the accuracy of the GPR method in relation to reported inter-annual variations in active layer thicknesses (e.g. the Permafrost and Periglacial Processes 15(2) Special Issue 'Circumpolar-Active-Layer-Monitoring (CALM) Workshop' and the Polar Geography 28 Issue 4) could be included to bridge this gap between the introduction and the rest of the manuscript.

[2] Monitoring period.

The monitoring period can not easily be extended in the present case, but for future monitoring projects a period covering the entire thaw season would be beneficial. An increase in thaw depth of about 0.2 m was found over the five weeks of monitoring in Aug.-Sep. 2008. This is relatively small compared to the measurement accuracy of 5-10 cm and inhibits calculation of thaw rates.

[3] Validation.

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Validation of the thaw depths is limited to one point where temperature is monitored in a profile through most of the active layer. The fit at this point is however good. At least another 2-3 independent validation points would have been beneficial (1-2 points for each transect). Frost tubes is a cheap alternative to thermistors. Validation of the soil water content is also lacking except for the calculation of a simplified water budget.

-SPECIFIC COMMENTS-

Title

Perhaps use 'thermal dynamics' instead of 'dynamics', to avoid confusion with studies of cryoturbation etc.

Abstract

Line 6. What is the material type? That is relevant in explaining deep thaw

Introduction

Reported active layer thicknesses in Svalbard could be referred to here (Åkerman 2005, starting in 1972, and Christiansen et al 2008). Page 289 Line 20. misspelling: 'Nordenskiöld Land' Page 291 line 17 '...five weeks'. Time period?

Methods

Page 292 line 20. misspelling: 'MALÅ'

Results

Page 296 line 8. How were the antenna separations chosen? Page 297 line 22. This is obviously a potentially large error source and should be elaborated further. How large was the path deviation? How can future surveys be planned to minimize this source of error? This could be included in a new section called 'method evaluation' or similar in the discussion chapter. Page 299 line 5. Referring to the above comment (page 297 line 22) Page 300 line 5-7. Saturated conditions at 28% vol. water content points to a

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lower porosity than assumed in page 294 line 14 and page 296 line 27.

Discussion

As also stated above, I suggest a short section on method evaluation. Here the uncertainty of the method could be evaluated and discussed in the light of reported variation in active layer thicknesses. A short note on the efficiency of multichannel GPR compared to 'traditional' CMP-surveys could also be given. Page 300 line 17. The TSP Norway data should be cited as 'Permafrost Observatory Project: A Contribution to the Thermal State of Permafrost in Norway and Svalbard. Year of dataset release. Borehole/minilogger name, borehole/minilogger ID. The Norwegian Permafrost Database, Geological Survey of Norway (NGU), Trondheim, Norway. Date at which you accessed the dataset' (cf. the NORPERM database at www.ngu.no/norperm) Page 300 line 15. See Christiansen et al 2010 table 2 for recently published active layer thicknesses from some of the TSP Norway boreholes in Svalbard, including one site in Ny-Ålesund. Page 300 line 19-22. . . .and in agreement with an increase in active layer thickness (Åkerman 1972). Page 301 line 2: When air temperatures drop in the autumn and the meltwater contribution to streamflow in the Bayelva river ceases, is it possible that the river drains the near-river active layer before significant ground freezing? That would give more similar active layer ice content along the transects in winter and explain a more uniform thaw in the summer (my speculations). Extending the monitoring period in the autumn could shed light on that. Page 303 line 6. If my reasoning in the previous point is reasonable, some runoff should be expected at least for parts of transect T2 Page 303 line 16-19. How would you calibrate your heat flow model with only non-invasive methods?

Figures

Figure 1. It is difficult to read the figure, but I assume it will appear in a larger version for the final paper. The figure should also include a small inset map to show the position of the site in Svalbard. A terrestrial photo of the ground conditions along the transects

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(material type, obstacles etc) would be informative.

References

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Christiansen, H.H., Humlum, O. 2008. Interannual Variations in Active Layer Thickness in Svalbard. Ninth International Conference on Permafrost, Proceedings. Fairbanks, Alaska.

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Wollschläger, U., Gerhards, H., Yu, Q., Roth, K. 2009. Multi-channel ground-penetrating radar to explore spatial variations in thaw depth and moisture content in the active layer of a permafrost site. The Cryosphere Discussions 3, 919-946

GOOD LUCK WITH THE REVISION!

Interactive comment on The Cryosphere Discuss., 4, 287, 2010.

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