Comments to anonymous referee's review

We would like to thank an anonymous referee for his additional and constructive remarks about GPR technique.
We answer along his text.

Comments related to GPR:

1. P. 3605, L. 4...P. 3606, L. 5: From the given information it is difficult to judge the success of the hyperbola fitting and interpolation procedure as the results will strongly depend on the distribution and quality of the hyperbolas along the transects -information which is not shown so far. Please add a figure showing the non-migrated radargram and indicate the hyperbolas that were used for the evaluation. It might be that the radargram is too long to resolve all the hyperbolas. Then an additional cutout from the radargram showing a representative distribution of features over the complete depth range could solve this issue.

Our answer: This is a good suggestion. We will add a figure with the distribution of the hyperbolae used for the work. We are perfectly aware that the use of hyperbolae for velocity modelling is a method depending on some extent on their distribution and on the quality of the subsequent interpolation. In our study, however, the quantity and distribution of the hyperbolae was good enough and the quality of the interpolation was controlled using leave-one-out cross validation.

2. P. 3607, Section 4.3: Please relate these results to those derived from the analysis of the lateral profiles. This should at least be possible for transect L#2 where the CMP position is very close to the measurement line.

Our answer: OK.

3. P. 3608, L. 9...12: This could also be caused by a larger uncertainty in velocity estimation due to rather flat-shaped hyperbolas at this depth; remove „small" in L. 11.

Our answer: OK.

4. P. 3608, L.24.25: How can a change in velocity be determined without data? Please do not show velocities in Figs. 7 and 8 for sections that are not confirmed by measurements.

Our answer: We meant that a lower density of hyperbolae in the deeper part of the profiles could have led to strengthen the decrease in velocity in these parts. The matching of the limits of the depicted velocity distribution with the initial hyperbolae distribution has been matched.

5. Section 4.5: In this section, the authors compare the stratigraphic information from the migrated radargrams with the morphological divisions and the estimated 2D velocity images for transect L#1 and L#2. Comparing the structural information from the migrated radargrams with the 2D velocity profiles, I would have expected more consistency between the still rather smooth velocity structure and the very dynamic stratigraphic structure revealed by the migrated radargram. For the first 100 m of both longitudinal radargrams, the velocity structure nicely follows the shape of the basal reflector. Further downslope, the velocity profile is often oriented perpendicularly to the structures imaged in the radargram. Reflections are caused by changes in permittivity (= velocity), hence they should somehow correspond to each other. What is the process making the velocities cut the stratigraphic structures? This requires a more detailed discussion.

Our answer: Indeed, especially for the profile LP#1 in its upper half, we observe discordance between the concave, spoon-shaped reflectors and the velocity distribution. Sincerely, we expected a bit what the referee would have expected. However, 1) the decrease in velocity is confirmed before the interpolation; 2) the result is not illogical: the decrease in velocity (that

leads to values close to 0.10-0.12 m/ns – not so low – at the base of the stratigraphic structure) is to be related to an increase in the water (and secondarily debris) content at the base of the massive ice body. This is absolutely consistent considering that in permafrost structures only a small increase in the water content can be responsible for a dramatic rise in permittivity and thus a drop in the velocity.

Specific and technical comments related to complete paper:

P 3598, L. 14: significance with respect to what? Please specify.
Geomorphological significance

P. 3599, L. 9: please correct: morphologically OK

P. 3599, L. 18: Humlum (2000) missing in reference list Thanks for noting this lack

P. 3599, L. 26: again: significance with respect to what? Geomorphological significance

P. 3601, L. 17: please correct: „...on *it's* western flank...“ Yes (its western flank)

P. 3603, L. 15: please add reference to Fig. 5 According to comments of one of the two reviewers, this part will be modified.

P. 3604, L. 6: please add „... and lateral margins of the glacier.“ OK

P. 3604, L. 14: Here I would prefer „components“ OK

P. 3604, L. 23: Here I would prefer „volumetric liquid water content“ to separate it from the permittivity of glacier ice which is almost the other extreme. Yes

P. 3605, L. 6: please correct „...by the GPR software...“ and add reference for the software (I guess it is Sensors and Software (2003) as provided in the reference list) OK

P. 3605, L. 20: I am not sure if I get the context correctly. If the sentence starting with „We especially...“ refers to the analysis introduced right before, I suggest to replace „We especially used...“ by „This consisted of using...“ to clarify the context. Yes, good suggestion.

P. 3612, L. 13: Please provide a number for the dielectric permittivity of permafrost material. A large range of values (K=4-8) is generally found in the literature.

P. 3613, L. 26: Please replace „challenge“ by „challenges“. OK

Figure 2: The figures and labels are way too small to be read in detail. Please make sure that they are large enough in the final version of the paper. We will pay particular attention to the size of labels in new versions of the figures.

Figure 7, 8 and new, unmigrated figure: Please indicate the position of the CMP measurement on transect LP#2. OK

All Figures: Please make sure that labels are large enough. Yes