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The Cryosphere Discussions

Interactive comment on "Temperature variability and thermal offset in steep alpine rock and ice faces" *by* A. Hasler et al.

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Answers to referee 1 (B. Etzelmuller)

(Comment of Referee signed with "")

General comment

"However, there are some minor to major issues that should be addressed before publishing, which I think would increase the value of the paper. In the following, I will give some from my view important points for potentially addressing during the revision, while minor issues I have marked directly in the pdf and uploaded as supplementary information."

For the major issues see the comments below. The minor issues mentioned in the pdf where considered. These considerations are: a) introduction of text elements in figure and table captions b) introduction of additional references (Pogliotti, 2011; Isaksen et al., 2011) c) clarification of abbreviations d) rephrasing or removal of text sections

Major issues

1) "Abstract: Give main results there, no “for instance”. "

Rephrased.

2) "Give a key map, with site location in Switzerland, and the location of all the names you use in the paper."

We avoided an additional figure for conciseness reasons and because it does not provide decisive information for this article (the horizontal distance and orographic position is a factor of minor importance for this study). The important characteristics and topographic situations are better represented with the given figures. We included the names used in the text in Figure 1 and Figure 2.

3) "Introduction: It is rather long, and much of the last paragraph might be better within the “Discussion”. "

Adapted.

4) "Consider to join chapters 2 and 3, and call it “Methods and data pre-processing”, and try to reduce it in size a bit."

We made the distinction of the methods (and site description) in two parts by intention. The first part aims to describe what we measure and briefly how this is done (acquisition method; however here we refer mainly to other publications) so it is mainly a site description. Chapter 3 is then a description of the processing methods and the characteristics of the derived data that is presented and discussed in the following Chapters. We clarified this with modifying the Chapter headings. We slightly reduced the size by

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considering your comments in the pdf.

5) "Error propagation (eq. 1): Very nice to address the uncertainties through the error propagation law. However, you should mention that Umat and Uto increases if some of the parts included in eq. 1 are correlated with each other, following the general error propagation laws."

We introduced “independent” on P731 L5 to limit the validity of this calculation. In case of eq. 2 we refer to the correlation of the two uncertainties in T1 and T4 that result from the data gaps. These uncertainties are positively correlated but T1 and T4 are subtracted from each other, hence the resulting uncertainty is smaller than the ones of individual components. However, this case is not explicitly considered in eq. 2 because the quantification of Ugap was performed only for T1 (upper most thermistor) where the uncertainty is largest (due to larger amplitude) and this value is considered as worst case for Ugap of T1–T4 (P731 L9–L11). As the uncertainty introduced by the gap filling is minor, this is not decribed in more detail in the manuscript.

6) "About filling data gaps: Why not using some sort of simple or multiple regression to data series with no gaps, to produce a series there, with a measurable level of confidence?"

Yes, this may be a nice solution to produce time series that look more realistic and produce reasonable daily fluctuation within the data gaps. We decided for the described simple gap filling because of: 1. Simple procedure and no dependence on the availability of correlated data (Note: Synchronous gaps at the Matterhorn field site). 2. Clear visualization of interpolated data. 3. Sufficient accuracy (Ugap < 0.1 °C) for this purpose. 4. No problem of interdependency as compared to the data produced the regression model. 5. Simple quantification of the uncertainty.

The last two points may be the most important for this article. If we produce synthetic datasets based on correlations with other data and compare them later to the same data, this comparison has the problem of an inherent dependency of the two datasets.

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We do not know whether the used regression model is valid for the time span of the gap (e.g. locations with difference in snow cover) and hence the comparison is biased by this effect. Further the quantification of the uncertainty is difficult because the variation of the regression model for different seasons is hardly quantifiable in the time series of the given length. For these reasons we keep the gap filling algorithm as described in the manuscript.

7) "TO: I think this approach of data analysis is nice and very valuable. In relation to former publications, the TO of course is an equilibrium term, averaged over e.g. a normal period, and TO has inter-annual variations. However, the value is a signiïňĄcant measure to address ground thermal processes. In Fig. 8 you give TO as absolute differences, but the depth over which the differences are calculated varies as far as I can see (e.g. for the firn deeper than for the holes). Either calculate the TO over the same range of depth, or give normalised values, e.g. oC/m. You can evt. Make to ïňĄgures, one for the 1 m depth and one for the 5 m depths. Further : You are aware that the TO is related to TTOP (Temperature of top of per- mafrost) in literature. As far as I can see, your deepest loggers are not on top of the permafrost. Maybe the expression TO is then a bit misleading (as you discuss in the introduction), and should be re-considered to e.g. "thermal gradient" or ∆MGT or so. The message would be the same. You discuss this matter in the introduction, however, as literature clearly discusses extensively the TTOP-approach, the terms should be used according to that. If you re-consider, the title should be changed by substituting "thermal offset" with e.g. "thermal gradient" or "temperature differences". "

All reviewers mentioned this deviation from common use of the term "thermal offset" in the literature. Because of this we decided to modify the term to: "temperature offset" which has a similar meaning but does not refer to a term that is commonly defined differently in the literature. Title and text are adapted accordingly. To replace these absolute differences by a thermal gradient would make the comparison to the effects of surface variability difficult and may lead to unrealistic estimates if the temperature

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would be extrapolated to other depths. Especially in case of the cleft temperatures, a gradient is misleading because it suggests a continuous temperature field.

8) "Discussion: The discussion is relevant, however, partly difiňĄcult to follow. I would suggest to re-structure or sub-divide the discussion in a technical discussion (accuracy, representativeness etc) and a scientiïňĄc discussion (T-gradients, causes for the variability, implication for numerical modelling etc.). AND: You use some space to address the uncer tainties etc. Why are they not further discussed?"

We subdivided the discussion. However the titles are chosen differently from your suggestion because the technical discussion is not included in this chapter but other subdivisions have been made. The uncertainties are addressed in the results section with the term “significant”. We clarified this in section 3.4 (last sentence).

9) "Conclusions: Relevant conclusions, very nice. However, the last paragraph on p. 738 is a discussion and should be treated as that."

We intended this paragraph as the perspectives (or outlook) resulting from this study. Here we describe how the findings listed above could be applied and what limits their validity. Further we sketch possible ways to generalize these findings with future studies. Therefore these “perspectives” are placed after the conclusions. To account for your comments we slightly shortened the paragraph and rephrased it to make its link to application and future research more clear. The heading is “Conclusions and perspectives” accordingly.

10) "Finally, the use of the temperature abbreviations, MAT, MAAT, MAGT, MAGST, TO,. I was a bit confuses how you deïňĄne all this terms, and what is what. You should systematically go through your text and address this matter, and, when used the ïňĄrst time, give the full name and explanation."

Implemented.

Interactive comment on The Cryosphere Discuss., 5, 721, 2011.