The Cryosphere Discuss., 8, C151–C155, 2014
www.the-cryosphere-discuss.net/8/C151/2014/

The Cryosphere
Discussions
Open Access

Interactive comment on "Soil erosion and organic carbon export by wet snow avalanches" *by* O. Korup and C. Rixen

O. Korup and C. Rixen

oliver.korup@geo.uni-potsdam.de

Received and published: 6 March 2014

Authors' Reply to Review by Anonymous Reviewer 2

We appreciate the referee's detailed and encouraging suggestions for improving our manuscript. Most of the points raised have made us re-think both our approach and the interpretation of our results. Below we respond to each individual review comment. Overall we have aimed at specifying the relevance of wet snow avalanches for soil erosion and organic carbon mobilisation for the catchments that we studied, and toning down any potential misinterpretation with regard to the overall validity of our results.

Response to Specific Comments:

P3L23: We do not see a major difference between avalanche impact ponds and plunge

pools. The terminology here seems to be quite colourful, so we have simply replaced the "and" by an "or", and added the Luckman et al. (1994) reference as suggested.

P3L19: Unfortunately we did not get the meaning of this suggestion. The suggested text matches that in the original discussion paper.

P4L11: We have completely rewritten this sentence to better stress our focus on snow bridges and to highlight that we did not sample comprehensively throughout the eastern Swiss Alps: "Using field sampling, we focus on the fine fractions of sediment and organic carbon entrained in those avalanches that formed snow bridges in the area around Davos, eastern Swiss Alps." The referee may concede that is very difficult to estimate the fraction of snow-bridge forming avalanches from the total population of avalanches for a given season. We concentrated on spring-season wet avalanches, and establishing the full number of events for a greater region is quite challenging despite detailed avalanche databases for the region. These focus largely on damaging snow avalanches, however, and rarely contain information about whether the avalanches were coupled with the drainage network or not.

P4L26: Sure, the thickness of the organic debris cover on the avalanche cones was what motivated us to carry out these measurements in the first place (see Fig. 1C and D). However, we also recorded spots with little or no sediment cover: These patches make up the bulk of our data (Fig. 3B). We have specified our statement to: "Clearly visible and locally dm-thick patches of sediment and organic detritus had accumulated on the deposit surfaces, making them amenable targets for field sampling. Assuming that this sediment did not undergo any significant sorting during transport (Jomelli and Bertran, 2001), we took 100 point samples of debris-cover thickness per deposit using a ruler at an estimated accuracy to the nearest centimetre with an estimated sampling error of +/–20%. Our measurements also included irregular bare snow surfaces."

P5L1: We used a slightly different "technique" than the one of throwing a stick onto the deposit for plot sampling. Because we needed to carry out virtually hundreds of

measurements while moving (or climbing, let alone crawling) across the avalanche debris, we simply took blindfolded measurements as randomly as we could. We have slightly rephrased this sentence to make this clearer: “We selected these sample points blindfolded and at random while moving across the deposits as to exclude potential bias by spatial autocorrelation.”.

P5L29: Yes, we incorporated the 20% error on the debris-thickness measurements in the Monte Carlo simulations, assuming that the resulting histograms duely approximated the accuracy of our thickness measurements (P6L5-10).

P6L4: This is a good point, and we are well aware that our assumption that the contributing catchment area sets the maximum limit to snow-avalanche deposit area is quite simplistic. However, this appears to us as the most objective and replicable method to approach the problem. We have now emphasized this by adding: “. . .which we assumed as an approximate upper limit to avalanche-deposit area in order to make our calculations objective and replicable”. The resulting yields may indeed be lopsided more to the minimum side of things, although this is something that had stated several times in the manuscript.

P6L10: This is per site as we had stated in the original manuscript. In any case, the differences between pooled and per-site simulations turned out to be negligible given the number of runs.

P7L2: Good catch! Yes, we meant Fig. 3A, and changed this accordingly.

P7L24: Thanks for the encouragement. We have thought of rephrasing this to: “Before discussing these yields further, we emphasise that our results are first-order estimates and subject to a number of caveats. Most importantly, our yield estimates are based on a novel approach of statistically extrapolating randomly selected plot samples.”.

P8L12: Good point. We have rewritten this to: “we have obtained a large number of random samples from different snow-avalanche deposits”.

P8L16: We have chosen a more specific description: “Thus our estimated specific yields may encompass multiple superimposed avalanche deposits locally, although few of the dissected deposits showed any clear evidence of layering or buried debris.”.

P8L26: Yes, it never really was our intention to compare soil erosion with bedrock erosion. We realise that our statement was maybe not clear enough and have rephrased this to: “. . .the highest specific sediment yield from snow avalanches would have attained 0.5 mm yr^{-1}. Whether this involves significant amounts of bedrock erosion remains open for future research: The few available bedrock erosion rates by snow avalanches. . .”.

P9L10: We have added: “In this context, shallow landslides are additional erosion processes that deserve better quantification in order to more objectively gauge the contribution of snow avalanches.”.

P9L11: We appreciate this comment and point out that most of the snow bridge remnants shown in Fig. 1D are well within flood level of the river shown. The same goes for many of the other snow bridges, where direct melt out, surface runoff, and stream flow help entrain fine organic debris. An accurate quantification of how much material is lost to the drainage network per unit time would require yet another set of detailed plot studies with the same known limitations. We do acknowledge, however, that POC measurements in the rivers during and shortly after the spring avalanche season may be elucidating. In any case, we had stated in the original text that “most of the material is likely to be readily flushed downstream and exported from the drainage basins”. We argue that the probability density estimates of our yields span several orders of magnitude such that misestimates regarding the amount of material exported by rivers may be comparatively minor.

Fig. 3A: We had tried several types of graphs and would like to stick with this one. Surely we do not show any continuous data, but the legibility for this type of graph is highest in our opinion. We have also corrected the caption: “Histogram of debris-cover

thickness measured blindfolded and randomly on all avalanche surfaces (n = 2,800 point measurements)."

Fig. 4: We added "in the area around Davos" here and in Fig. 5 to specify our results. The most likely values are indeed given by the peaks in distributions. Please note that avalanche area refers here to the debris-covered area (which we used for the Monte Carlo simulation). We have now highlighted this in the caption and in the text, and added an explanation that we are dealing with log10-transformed data here. The bimodality is intriguing, although we cannot distinguish at this stage whether this is real or brought about by the Monte Carlo simulations.

Technical Corrections: Carried out as suggested.

We hope that this reply sufficiently addresses the reviewers' suggestions, and appreciate this thorough examination of our work.

Interactive comment on The Cryosphere Discuss., 8, 1, 2014.