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Interactive comment on "Evaluating post-glacial bedrock erosion and surface exposure duration by coupling in-situ OSL and ^{10}Be dating" *by* Benjamin Lehmann et al.

Anonymous Referee #1

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Lehmann et al present a novel way of constraining bedrock erosion rates by combining luminescence rock surface exposure dating (using the IR50 signal of feldspar) with cosmogenic radionuclide dating (10Be from quartz dissolution). They go through an intensive modelling effort and exploit the different but complementary spatial sensitivities that differ by an order of magnitude. In a given rock surface the buildup of 10Be is occurring in the top ca. 1-2 m, while the bleaching of the IR50 signal affects the topmost millimeters to centimeters only, making the luminescence rock surface exposure dating approach particularly sensitive to surface erosion.

The strength of this paper lies in the fact that Lehmann et al. recognize and sys-

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tematically exploit these methodological differences. It thus represents an important contribution to the growing number of OSL rock surface dating studies and clearly shows (i) the limitation of the luminescence rock surface approach as a tool for purely obtaining exposure histories, particularly for older rock surfaces or environments with intensive surface erosion, (ii) opens up a way to check for the importance of erosion on a given rock surface and (iii) allows obtaining information on surface erosion. Lehmann et al show that their erosion rates from post LGM glacially polished rock surfaces obtained via their modelling and experimental data are sensible. Indeed, over millennial timescales such data are hardly obtainable via other techniques. This approach might also provide independent constraints for correcting terrestrial cosmogenic radionuclide ages. A note of caution: only two samples are included in the current study, and a more extensive dataset (both CRN and luminescence data) will be required to test the robustness of the modelling framework of Lehmann et al.

The main shortfall of the current version of the manuscript is the way the complex and interwoven modelling steps are presented. While many sections of the manuscript are clear and concise some other parts are hard to follow and in my opinion too brief, hence unclear and also sometimes inconsistent, particularly section 3.1. and the immediately following section 3.4 (sections 3.2 and 3.3 are missing or sections are mislabeled). Figures 6 and 7 could also be improved and linked with the text more intimately, thus improving the clarity of the presentation and comprehensibility of the modelling framework. I detail my main concerns in the following and append a list of smaller hiccups at the end.

Main issues – description and comprehensibility modelling steps and modelling framework (section 3):

p. 12, section 3: it would be helpful to define / explain the essence of the terms “forward model” and “inverse model” (e.g forward in time?) and the workflow in general terms before diving into details. This will help removing abstractness from your explanations.
p. 13, section 3.1: please be more specific: first sentence “... a series of synthetic

luminescence profiles were generated ...” – refer to Figure and profiles (green dots, red lines, dotted lines, black lines?) What exactly is “a single experiment” – the generation of one synthetic luminescence profile? A set of modelling steps that result in Fig. 7a-d, respectively? How do your “experiments” differ from a “model” in line 21? Would it be better to talk about scenarios? These terms as well as the subsequent modelling steps and model setup are not always well defined yet. You go on in line 16: “In the first experiment ... (→ results in dashed line in Fig. 7a-d)” ... and in line 17: “In the second experiment ... “ but what does this now result in? the green dots, the red curves in Fig. 7a-d? At the end of this paragraph you introduce the reference luminescence profiles (black lines) → would be helpful to move this upward and mention it together with e.g. constant erosion scenarios (dashed lines) before going into the more complex scenarios where erosion varies through time. Line 18: tc – is this the corrected TCN age? From Figs. 7a-d (text within figure) it looks like; but from Table 1 not necessarily so!? You introduce Fig. 7 in section 3.1 first; then you hop to Fig. 6 (that is unmentioned in the text up to this point) – this out of sequence move is a bit confusing. You have to elaborate on the concept of varying the erosion rate through time and on Fig. 6. The time axis in this figure needs to be read from right to left (because it is a forward model!?). The rational for using such step functions is not clear (here and in the related explanations on p. 9. L. 15) – what do you actually intend; to simulate climatic transitions e.g. from Pleistocene – Holocene in addition to capturing transient states? Sentence starting in line 18 onward: “Initially between... This is illustrated in Fig. 6” is unclear. Maybe you can improve Figure 6 (make a Fig. 6a and b out of it) and come up with a worked example illustrating how the scenarios in current Fig. 6 translate into a plot like Fig. 7a, b, c or d (which could become Fig. 6b?). In this context: my thinking was that the indicated values in fig. 7a-d (text within figure) for ts of 1 year and 100 years, respectively, should also be reflected in the tc versus the t0 ages (text within figure). Maybe this could be clarified with a Fig. 6a+b solution too. p. 14 line 6: it reads like the reference signal (what is the reference signal here? Black line in Fig. 7a-d? pls specify) is at 17 mm depth. But you actually mean

that the luminescence depth-profile is brought 7.8 mm closer to the surface relative to its former position, thus lying at 17mm absolute depth! Pls improve wording. Line 8: depth (instead of deep) line 9 onward to rest of this section: pls refer to figures whenever you actually discuss data/scenarios that are visualized in the respective Figures and thus link text and Figures much more closely than is currently the case! line 9: "... is applied for a duration of 1a" – unclear: does this mean that (referring to Fig. 6) the erosion only started 1 year (or 100 years in the case of fig. 7b and d) before sampling? i.e. for 16454 yrs no erosion; 1 year erosion of 1mm? – can this be integrated into a worked example (e.g. Fig. 6b, see above?) line 9: " ...and integrated over its specific corrected exposure age" what exactly do you mean with integrated; with corrected for erosion 10-2 = tc max in Fig. 7a? pls specifiy p. 15 line 7: ts times 5x10-1 a = 182 days but in line 16 the same ts is 110 years!? Line 28: "which should be recovered in the inversion" = green dots in Fig. 7a-d? pls specify p. 16, line 7: "..... the would reproduce this specific lum signal (Fig. 7e)" = yellow triangle in Fig? pls specify Ad Fig. 7 e-h: what is the axis label of the colour bar at the right? What are the units?; green dots hard to see (better white?) Ad Fig. 7a-d: red lines – inferred solutions: are these the fits to the synthetic data? Pls explain in text; Fig. 7d: where is the dashed line – overlapping with red line? pls offset slightly. p. 18, line 5: by applying a constant erosion rate Line 8: what do you mean by insets here?; d and c have to be swapped.

Minor issues: p. 1 line 14: TCN abbreviation not explained here or in text p. 1, line 33: (Figs 1a and b) to a coarse-grained rough surface (Figs. 1c and 1d). p. 2 line 2-3: (e.g. deterioration .... Breakdown) – is this degree of detail really needed? You do not specify these terms and it thus remains unclear what the differences between these specific processes are... can be simplified. Line 10: erosion. Here you actually mean erosion of rock surfaces! Pls specify p. 3 line 15: burying them under sediment. No I think it was the other way round i.e. the sediment that is buried (sealed) due to large boulders (rock fall event) pls check. p. 3 last sentence: pls specify (cite) already here which papers / equations you are actually gonna review, because you start from established models. In the next and subsequent sentences you talk about

the proposed model – here you mean your own; or Sohbati or someone else? . . . so it is unclear what you are gonna review and how this will link with your own stuff. p.5 line 12: IRSL – it might be beneficial to briefly explain in the intro already that there are several signal that can be targeted depending on the mineral, rather than just hopping onto IR50 with preparing the reader for it. Line 12: Sentence: "Shobati et al., (2011, 2012a,b) introduced. . .duration". Is this the model you show below (Equation 1)? If yes pls specify (which paper?). In entire paragraph it is not quite clear from where equation 1 is taken from, of if you added some aspect to it!? And what Huntley′s contribution to this specific equation exactly is. p. 5-6: suggestion: describe equation trems 1-4 first and explain Ou et al. + Sohbati′s solution of equation therafter. p. 6 line 7: these parameters. Mü or what? p. 7 line 7: what is the fading term her in terms of g-value p. 9 line 19: NLS. Abbreviation not introduced in main text (only in fig caption) p. 20. Line 18: no figure 8 with IRSL curves in text of supplement! P 23. Line 22: show; ". . . that OSL-exposure can be sued to identify multiple burial and erosion events. . ." – but actually these approaches are not a pure OSL rock surface exposure approach but rather an OSL rock surface burial approach – which is not quite the same.

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