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Interactive comment on "Sediment loading in Fennoscandia during the last glacial cycle" *by* Wouter van der Wal and Thijs IJpelaar

Wouter van der Wal and Thijs IJpelaar

w.vanderwal@tudelft.nl

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The main purpose of this study is to quantify sea-level responses to sediment redistribution caused by ice sheets in Fennoscandia over the last glacial cycle. To do so, the authors apply a recent sea-level model (Dalca et al., 2013), which computes sealevel responses to sediment erosion and deposition. The main finding is contained in Figure 7, which shows that sea-level responses to sediment redistribution are small in this region, such that accounting for sediment redistribution does not significantly help resolve differences between observed and modeled relative sea-level histories. This is a useful finding and the main strength of this study.

The manuscript has several weaknesses that I suggest the authors address before

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Discussion paper

publication, most of which have to do with the presentation of the material. As I describe below, a number of items in the text are unclear, and most of the figures require major modification before they can be understood, particularly Figures 3-5. I do not have major scientific concerns about the study, but two minor concerns are that the study did not conserve sediment mass, and it's not clear how eroded material was spatially distributed, which would make it difficult to reproduce the results of this study. I suggest the authors expand on these points in the text. Overall, I suggest that this study will be of interest to a number of readers in Solid Earth after major revision.

« We thank the reviewer for the thoughtful review. We have improved the presentation following your comments and those of the other reviewers. The issue of mass conservation was, we think, sufficiently addressed in the manuscript (now in appendix B.2) and the other reviewers seem to agree. Indeed the sediment models would be difficult to reproduce as there is some 'hand picking' to derive contours, because of unavailability of source data. It would be hard to describe the redrawing procedure. We will make our sediment distribution available on our institution website such that they can be used or checked. A brief discussion on the issue of spatial pattern of deposition and erosion is added in Appendix B.1 »

Additional comments Page 1, line 17: I suggest specifying the timescale over which changes in relative sea level can be as large as several meters. Is this the integrated sea-level change from the Last Interglacial to the present?

« added 'in the last 6000 years' p1 l18 »

Page 1, line 25: I suggest rephrasing this sentence, since glacial erosion is not always faster than non-glacial erosion. Glaciers frozen to their beds, for example, can inhibit erosion, rather than accelerating erosion.

« changed to 'can be' p1l28. The relation to run-off is mentioned in the next sentence. »

Page 2, line 1: Does “that amount” in this sentence refer to subsidence rates due to sediment deposition? If so, then I suggest rephrasing this sentence, since it makes it sound like subsidence rates can be no faster on 0.5 mm/yr, but subsidence rates depend on deposition rates, and thus could be faster in places with faster deposition.

« text added in p2 l10-13 which hopefully makes clear that the viscous effect is referred to »

Page 2, lines 17-19: It’s not clear what is meant by the 40% in this sentence. I suggest clarifying this.

« rephrased p3 l8 »

Page 2, line 25: I suggest changing “potential field” to “gravitational potential field”, to be clear.

« done »

Equations 1 and 2: Technical point: The sea-level model computes changes in sea level due to changes in load, rather than the magnitude of sea level itself (see Equations 10 and 17 in Dalca et al., 2013). That is, in that notation, it computes Delta SL rather than SL, and it does so from Delta L rather than L. I suggest modifying Equations 1 and 2 in the the Methods section to clarify this.

« Thank you for pointing that out. The method section is improved, also in response to the other reviewers »

Page 6, Figure 2: I suggest increasing the font size. The labels are too small to read easily in this map.

« We have enlarged the figure somewhat and will reproduce the figure with better quality if necessary. »

Page 7, lines 12-14: I suggest specifying how the eroded material was spatially distributed in the model. If it were proportional to ice sliding speed, then the eroded

thickness would depend on spatial variations in ice sliding speed, which would require an ice flow model. Was that done? If so, how? Was it assumed that erosion under the ice sheet was spatially constant? If so, I suggest specifying that.

« What is referred to in the text as the Amantov model is output of the model of Amantov et al. (2011) which includes an ice flow model. Some more details on the Amantov model are now given in appendix B.2. »

Page 7, Line 12: Contrary to this statement, recent evidence suggests that basal erosion scales with glacier sliding velocity squared, not sliding velocity to the first power (Herman et al., 2015, Science, v. 350, p. 193-195).

« The reference has been added p23 l23. We used the proportionality between erosion and sliding velocity loosely to obtain a time series of deposition. The relation between ice volume change and sliding velocity is also unknown. »

Page 7, Figure 3: Please add latitude and longitudes and a colorbar that defines what the colors mean.

« done, please see new figure B.1 »

Page 8, Figure 4: It's hard to tell where this is and what the scale is. Please modify this figure to include latitude and longitude.

« The figure is removed »

Page 8, Figure 5: It's unclear what the colors and numbers represent. I suggest adding latitude and longitude grids and a colorbar, and expanding the text in the figure caption to explain what the colors and numbers mean.

« done, please see new figure B.2 »

Page 9, line 17: What is the time at which there are measurements? Is it the maximum at any time over the last _10 kyr? Or the average over that time? Or the present? I suggest clarifying this in the caption.

« reference to figure 5 is added in the caption of table 1 »

Page 9, line 18: I suggest changing “gravity rate” to "rate of change of gravitational acceleration" for clarity.

« done »

Page 9, lines 18-21: It would be useful to show these boxes in a map in one of the figures to help show where these sites are.

« figure 7 has been added »

Page 10, Figure 6 caption: I suggest specifying exactly what time LGM is taken to be here, since the timing of LGM is not universally agreed upon elsewhere in the literature.

« added ‘(26,000 years B.P. in the ICE-5G model)’ to the caption of figure 6 »

For clarity, I also suggest changing “locations of Relative Sea Level data used in Fig. 7” to "Numbered black dots show locations of Relative Sea Level data in Figure 7."

« added to what is now figure 4 »

Page 10, Figure 7: In most panels it’s impossible to see a blue line. I assume that’s because the red line and blue line are so close to one another that they overlap almost perfectly. If that’s true, I suggest stating that in the figure caption.

« A dashed line and a line with the difference is added »

Page 12, line 12: This states that the effects of sediment redistribution on sea level are comparable to those produced by water loading. This requires a citation, since changes due to water loading weren’t shown in this study.

« the statement is removed »

Page 12, line 20: I suggest noting that several tenths of a mm/yr is not negligible relative to modern globally averaged rates of sea-level change.

« added p 14 l 10 »

Please also note the supplement to this comment:
http://www.solid-earth-discuss.net/se-2017-18/se-2017-18-AC5-supplement.pdf

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