

## ***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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Please note: author reply in between « and »

The manuscript seeks to quantify the effect of post-LGM changes in sediment loading around Fennoscandia upon estimates of relative sea level, crustal motion and gravity changes. Sediment loading has only been addressed in a few papers, and this seems to be the first treatment for this region. The work is based on existing theory, although newly implemented within the authors' code. The conclusions are the effects of sediment loading are generally small, but may be important for present-day GPS and likely important for interpreting present-day gravity changes. The paper was written in a way that suggested it was put together in a rush. The major changes I request below are

C1

largely related to figures and presentation. The English also needs some tightening up. I did not see any major flaws with the paper otherwise.

« We thank the reviewer for the effort and for the comments, which helped us a lot to improve the manuscript. »

Major remarks:

1. Figure 3 is not a scientific figure. it is a perspective image, but cannot be interpreted. it needs colours scale, graticule, length-scale, axis labels etc.

« The figure has been improved and moved to a new appendix B »

2. Figure 4 is not appropriate. the authors have digitised this, so replace with the two variants of the reconstruction shown properly.

« We removed the figure »

3. the authors use a sediment density of 2300 kg m<sup>-3</sup> but this choice is not defended or uncertainty tested. I presume sediment from different geological regions will have different densities.

« Amantov et al. (2011) provide water equivalent thickness and this is the load that is applied in the model. The statement about sediment density is removed because it is not relevant. Sediment density of 2300 kg/m<sup>3</sup> is also used for the Sed1/2/3 models, this is explained in p 8 | 9 »

4. I believe there is work on pro-glacial lake loading (Fleming et al?) that is possibly relevant to mention.

« we searched but did not find relevant work from either the author or on pro-glacial lake loading that we thought was relevant to sediment loading »

5. the authors present two models with sediment flux and other models that focus on offshore load changes, but do not present a sum of the two - it wasn't clear why

C2

« We think that the models are both equivalent in that they represent estimates of sedimentation and therefore they should not be added. The models Sed1/2/3 include local events as well as constant flux and conserves mass from source to sink areas (appendix B). The model of Amantov et al. (2011) is mass conserving but does not include large-scale failures which are added here (appendix B.2) »

P1 L15 "smaller features" - smaller than what? (also later in the paper)

« 'smaller' replaced by 'local' »

L19: "older data" - older than what? vague.

« rephrased to 'errors are larger for older data increase with time before present' »

"the maximum effect..." needs some geographical context.

« rephrased to 'reaches a few tenths of mm yr<sup>-1</sup> in large parts of Norway and Sweden' »

P2 L10: relative sea level does not go with "present-day" earlier in the sentence and so this needs a rewrite

« done p2 bottom »

P3 Eq 4 - lower case delta is used instead of upper I think. h and C are not defined. S should be SL

« lower case is used for change over a time step. h and C are now defined, S was correct and is defined below equation 2. »

second last sentence : "parameters, the viscosity of the Earth, and the ice and ..."

« done »

final sentence: how are marine grounded ice sheets handled - this is worth explicit mention given recent controversies (Purcell et al)

C3

« text added below equation 4. The description of Kendall et al. (2005) is followed »

P4 L2: "is degree 256 and the ..." - not clear what the grid is

« added p5 l13 »

L7/8: move "in Root ..." to "been shown by Root et al to. I note here these studies do not use sediment loading, so there's some issue here.

« done. Explanation added p5 l22 »

L18: not clear if the timesteps refer to the input ice loading or something to do with the computation

« clarified, p6 l6 »

P5: L3: "for the entirety of ..."

« changed to "all of" following another reviewer »

L12: "Large scale ..." - sentence begins without context.

« numbers are added to make clear that the parts refer to the itemization in the first paragraph »

This paragraph would benefit from the distance of the sediment transport being quantified. Figure 2 lacks any length-scale. it seems like a screenshot from Google Earth

« The source and sink areas that are used to create the sediment model are shown in the improved figure B.1 »

P6L6: the sediment loading is taken to be up to present-day. Could the authors clarify how this change in rate corresponds with completion of deglaciation? surely the change in sediment loading scaled down as the ice sheet decayed? Or is some sediment transported by melt-water of subglacier outburst floods?

« basin flux in the Sed1/2/3 models is enhanced before 10 ky before present, and has

C4

a small value thereafter (p7110). Sediment transport in the Amantov model is assumed here to follow ice mass change which means it is zero when deglaciation is complete in the region (appendix B.2)

L14: are -> were

« done »

L16: add comma after "sediment"; remove next comma.

« sentence rewritten, now on p23 l2 »

There are no contours on Fig 3.

« values within the shape are constant. A legend is added to what is now figure B.1 »

L18: what is the resolution of the grid?

« added 'in the 256x512 spatial grid' p23 l4 »

P7L7 find -> digitise.

« done »

L8: reference Fig 5 here.

« done »

L11: geoid shift - unclear what this means. over what period?

« added p23 l19 »

L13: 'the fact' - really a fact? is it linearly proportional or non-linearly? how may that affect sediment transport rates?

« the sentence is rephrased p 23 l 22 »

Figure 5: suggest this can move to supplementary material. suggest you make a proper map in QGIS! it needs a colour scale

C5

« figure moved to appendix »

P9L2 results -> model input

« the sentence is removed »

L5: M4-160-80 is not a sediment model.

« replaced with 'viscosity profile' »

when is "displacement" relative to?

« 'sentence rephrased to agree with figure caption p9 l9 »

Table 1: sed1, 2,3 are not referred to in the text and need descriptions. the box described in the caption could be shown on a figure

« sed 1,2,3 now mentioned on p8 l7 box added to new figure 6 »

Figure 6 caption: clarify this is LGM to present loading changes

« done »

Figure 7: suggest a second set of y-axis to show the difference between the two curves

« done »

P11L8: could the authors give an example of where people have used GPS to infer ice load?

« rephrased and reference added p11 l14 »

Figure 8: the locations of the Lidberg GPS should be shown here or elsewhere

« locations are added to figure 5 »

P12L2: residuals of what?

« rephrased to 'residuals obtained after fitting a trend, secular and annual signal to the monthly gravity fields' p12 l14 »

C6

L6: around the same magnitude? ;how much larger?  
« 'around' replaced by 'at the level of' »  
L6-8: would be useful to understand typical % of signal  
« numbers are inserted p 13 l 5 »  
L13: effect is small on what?  
« added 'on present-day GIA observables' p 13 l 16 »  
L14: place over a large  
« done »  
L15: higher signal than what?  
« added 'near areas of sediment deposition' p 13 l 19 »  
L16: affects->affected; delete location  
« done »  
L18: suggest quantify the RSL effect here  
« results added p13 l22 »  
L22: not sure if these locations are all on figures  
« Nova Zembla should be Svalbard, thanks for noticing »  
L26: in -> from  
« done »  
L27: the \*present-day\* uplift  
« done »

C7

Please also note the supplement to this comment:  
<http://www.solid-earth-discuss.net/se-2017-18/se-2017-18-AC3-supplement.pdf>

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Interactive comment on Solid Earth Discuss., <https://doi.org/10.5194/se-2017-18>, 2017.

C8