

Interactive comment on “Modelling a century of soil redistribution processes and carbon delivery from small watersheds using a multi-class sediment transport model” by Florian Wilken et al.

Anonymous Referee #1

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General comments

The paper presents a new approach where selective water erosion is studied using a model which considers episodic erosion events and selective sediment and carbon uptake. The novelty lies in this combination, and in the consideration of different types of carbon. The hypotheses and underlying theory are well explained. However, several aspects of the paper are still unclear and need extra explanation or additions: 1) the Methodology section misses explanation of some essential processes and steps. 2) the Results and Discussion section misses information on spatial patterns of sediment redistribution and requires more supporting literature. Therefore I suggest minor revisions to improve the coherence and understandability of the paper.

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1) Methodology

- When considering longer time-scales, processes other than erosion start affecting the carbon and sediment distribution. One important process is carbon uptake. However, this is not mentioned in the paper. Please reconsider the potential effect of carbon uptake processes and include them, or elaborate on why leaving out is permitted.
- In the discussion you mention that underestimation of the breakdown of aggregates might have led to underestimation of the clay enrichment ratio (P.9, I.31-33 P.10, I.1). However, the Methods section does not mention how this breakdown is modelled. Please add a section where you explain how the model handles (micro- and macro-)aggregates, the ratio between loose sediments and aggregates, incorporation of OM in aggregates and how aggregate breakdown is organized.
- The model erases the network of rills and ephemeral gullies by tillage operations (P.6, I.19-21). However, the paper doesn't mention that tillage also induces erosion, although that can be expected in an area with steep, convex slopes. Is this incorporated, and how does this influence the results and comparison with the other catchments?
- Topographical properties like slope and catchment area have a major influence on erosion properties. Small differences in these parameters can result in different enrichment ratios and erosion patterns. Therefore I would like to see more information on the topographical and soil properties (e.g. area, slope) of the two monitored catchments which were used for model evaluation (P.7, I.22-25). You can present them in a Table, which also includes the properties of the modelled catchment.
- You aggregate run-off events on a monthly basis and use these monthly recurrence intervals for the frequency analysis (Sect. 2.5) However, I'm concerned

that with a monthly aggregation, you average out too much of the extremes and therefore too much of the erosion is attributed to smaller events. I would advise to use a smaller time-step, like 1 or 2 weeks, if the length of the longest events permit that, or add the reason why you use a monthly average. Next to that, in Sect. 3.4 you speak of events and event frequency, while you explicitly say that you will use the monthly recurrence intervals (P.8, l.1-2). Please correct this inconsistency.

- Fig. 3 is used to illustrate sediment and carbon fractionation. However, it is not clear which part of the Figure is used for this fractionation. This makes it difficult to understand what the Figure shows and how it is used in your paper. More explanation in the text or omitting an unused part of the Figure would increase its quality.

2) Results and Discussion

- The selective redistribution of carbon and sediments leads to depletion and enrichment at certain locations. These spatial patterns are in my mind one of the aspects of the objective to “improve our mechanistic understanding of sediment redistribution and carbon delivery” (P.3, l.29) and are useful for understanding variation in hydraulic properties and soil fertility. Therefore I would like to see some maps of clay and carbon redistribution in the study area and a discussion on what the consequences are of this redistribution.
- Most references in this chapter only support your results or methodology. However, I am missing references supporting your interpretation of the results. Please complement those sections with more references. Examples are the role of event size (P.8, l.26-29) and selective uptake by interrill erosion and unselective uptake by rill erosion (P.9, l. 13-15).

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Specific comments

- You mention that “the Hairsine-Rose model provides accurate physically based description of sediment transport and deposition for multiple sediment classes that differ in terms of settling velocities” (P.5, l.4-5). However, this contradicts with P.9, l.19-20: “The Hairsine-Rose theory does not appropriately predict the depositional behavior of the fine fractions”. Please consider this disadvantage in the introduction.
- P.5, l.10-11: unclear what the α -parameter does. Can you provide a better explanation?
- P.7, l.13-14: “the POM fraction was enriched in SOC relative to the bulk soil...”. Unclear what you mean by that.
- The definition of sediment delivery ratio is given on P.10, l.21. However, the term is used earlier in the paper (P.3, l.10;P.8, l.25-26). Please move the definition to one of those parts.
- P.11, l.29-30: “Moreover, the episodic nature of soil organic carbon redistribution is particularly important when considering the effects of SOC input to surface water bodies”. Why is this so important and how do you conclude this from your research?
- Table 1: include a column with the symbols as they are used in the text. I also suggest to add all other model parameters and inputs (e.g. soil texture) for a complete overview.
- Fig. 2 and Fig. 3: I understood that these Figures came from other research. Please add a reference in the caption to show that the work was not carried out by you.

- Check the Methods section for past tense (e.g. P.7, l.22: “We evaluate the...”, but also P.9, l.2: “assumptions ... are made” and P.1, l.18: “we apply an ...”)

Technical corrections

- P.4, l.27: “in each raster cell”. Change to: “for each raster cell”
- P.6, l.15: shouldn't this be 1898-1997 in order to reach the 100 years?
- P.19, l.6: The carbon enrichment ratios displayed in Fig. 5 are between 1 and 8. Not between 1 and 9, as is mentioned in the text.
- P.14, l.5. Reference is not in alphabetical order

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