RC1 Point-by-point response

Process-oriented modelling to identify main drivers of erosion-induced carbon fluxes

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We are happy that the referee acknowledges the relevance of the study and support the publication. However, we carefully revised the manuscript according to the given recommendations. The referee misses explanation about the potential effect of mineralization during transport and the seasonal distribution of soil conditions due to tillage operations. We gratefully thank the reviewer for the careful advices and changed the manuscript accordingly. Please see the detailed answers (in italics) to the comments below:

Major comments

While the authors did a good job in isolating erosion-induced C fluxes from the entire vertical C fluxes, all the fluxes were mainly based on erosional and depositional sites through dynamic replacements via monitoring yields and manure inputs (excuse me if I misunderstood you). The potential C fluxes during transport could arguably also play a role in vertical C fluxes, especially when taking aggregation levels into account. The de-/re-aggregation processes occurring during transport, and the accordingly induced mineralization and encapsulation, could potentially skew the overall C balances in individual catchments (see literature: Billings et al., 2010; Hu et al., 2016; etc.). To better justify the implication of this study, it would be nice to add some discussions on the possible impacts of mineralization during transport.

We are well aware of the discussion regarding potential C mineralisation during transport. However, for the small catchments transport as such will only take place for a few hours and during this time C mineralisation via microbes is limited due to water saturated conditions. Hence, we do not expect any substantial C mineralisation during the short transport time. However, there might be an additional mineralisation following erosion, transport and deposition processes. Especially, at depositional sites there are some results from literature which imply a slight increase in SOC mineralisation of deposited material shortly after deposition (Hu et al. 2016; Van Hemelryck et al. 2010; 2011) but this additional mineralisation is small and governed by several side conditions (e.g. soil moisture of upper millimetre of soil; soil crusting and breakdown of crusts; transport of macro aggregates; Van Hemelryck et al. 201). Therefore, we did not include this in our modelling approach. However, we thank the reviewers for their important comment and we will added some information to the discussion section 4.1:

"The model also does not account for changes in C mineralization at depositional sites that may occur as a result of aggregate breakdown shortly after deposition (Hu et al., 2016; Van Hemelryck et al., 2010; 2011). However, the potential underestimation of C mineralisation at depositional sites is assumed to be small (< 2% at a loess site in Belgium; Van Hemelryck et al., 2011). In addition, various drivers of additional C mineralisation at depositional sites have been discussed in literature (soil moisture, crusting and crust recovery, deposition of large macro aggregates; Van Hemelryck et al., 2010; 2011) but there is still a substantial lack in process understanding. At this moment, this issue makes it difficult to transfer the specific experimental results into a modelling framework addressing other environmental conditions."

The tillage component in the modeling set of this study is mainly adapted from a model derived from topography and tool-specific tillage erosion coefficients. Just out of curiosity, does it take into account for seasonal coincidence of tillage practices and rainfall frequency? For instance, is it possible that the tillage/water erosion effects to be enhanced when bare soil after tillage practices in spring receives frequent rainfall events (no need to be heavy)? Will these coupling effects have impacts on lateral and vertical C fluxes? Is it possible to be accounted for in current or future modeling settings?
Tillage operations widely influence simulated water erosion due to changes in soil cover, crusting, roughness and manning's n. Hence, the tillage has a wide effect on lateral C fluxes, but the vertical C fluxes are calculated annually.
An important process which is not included is that the model does not account for tillage-induced changes in the soil physical properties that may influence the erodibility and infiltration of the soil itself. Fiener et al. (2013) showed that the time since tillage is one of the controlling parameters for the infiltration. The referee raised a good point and the following sentence is included to the section 4.2:
"Static soil parameters are to some extent an oversimplification and ignore feedback mechanisms that might be considered in future modelling studies of coupled water and tillage erosion (e.g. soil stability due to disruption, infiltration capacity; Fiener et al., 2013)."

Minor Comments

Just a personal suggestion, not a request, it may be better to include some keywords in the manuscript title to reflect your key findings.
Thank you for this hint! We extensively discussed this, but concluded that we would prefer to keep the title as short as it is.

Better to have consistent terms when coming to "inter-field" or "intra-field" connectivity.
Thank you! We mill consistently use the term inter-field connectivity.

Page 10, from L7 to L11: it is just too long a sentence. Better to split into two.
Indeed, this sentence is much too long. We split the sentence:

"Catchment C1 follows the expected behaviour, i.e. decreasing SOC enrichment with increasing event size (Auerswald and Weigand, 1999; Menzel, 1980; Polyakov and Lal, 2004; Sharpley, 1985), and is in good agreement with the results of Wang et al. (2010) for similar soils in the Belgian loam belt. In contrast, event size had hardly any effect on the SOC enrichment in catchment C2, where any larger particles, including aggregates, are deposited in the grassed waterway due to consistently high hydraulic roughness throughout the year."

References

Auerswald, K. and Weigand, S.: Eintrag und Freisetzung von P durch Erosionsmaterial in Oberflächengewässern, VDLUFA-Schriftenreihe, 50, 37-54, 1999.

Fiener, P., Auerswald, K., Winter, F., and Disse, M.: Statistical analysis and modelling of surface runoff from arable fields in central Europe, Hydrol. Earth Syst. Sci., 17, 4121-4132, 2013.

Hu, Y. X., Berhe, A. A., Fogel, M. L., Heckrath, G. J., and Kuhn, N. J.: Transport-distance specific SOC distribution: Does it skew erosion induced C fluxes?, Biogeochemistry, 128, 339-351, 2016.

Menzel, R. G.: Enrichment ratios for water quality modeling. In: CREAMS, Knisel, W. G. (Ed.), USDA Cons. Res. Rep., 1980.

Polyakov, V. O. and Lal, R.: Soil erosion and carbon dynamics under simulated rainfall, Soil Sci., 169, 590-599, 2004.

Sharpley, A. N.: The selective erosion of plant nutrients in runoff, Soil Sci. Soc. Am. J., 49, 1527-1534, 1985.

Van Hemelryck, H., Fiener, P., Van Oost, K., Govers, G., and Merckx, R.: The effect of soil redistribution on soil organic carbon: an experimental study, Biogeosciences, 7, 3971-3986, 2010.

Van Hemelryck, H., Govers, G., Van Oost, K., and Merckx, R.: Evaluating the impact of soil redistribution on the in situ mineralization of soil organic carbon, Earth Surf. Processes Landforms, 36, 427-438, 2011.

Wang, Z., Govers, G., Steegen, A., Clymans, W., Van den Putte, A., Langhans, C., Merckx, R., and Van Oost, K.: Catchment-scale carbon redistribution and delivery by water erosion in an intensively cultivated area, Geomorphology, 124, 65-74, 2010.